R2006/833 | 28/05/2008

Australian Government
Australian Fisheries Management Authority

Resource Survey of the Great Australian Bight Trawl Fishery 2008

Ian Knuckey, Russell Hudson and Matt Koopman

2008

fishwell CONSULTING

GABIA

Resource Survey of the Great Australian Bight Trawl Fishery – 2008

Ian Knuckey, Russell Hudson and Matt Koopman

AFMA Project R2006/833

2008

Resource Survey of the Great Australian Bight Trawl Fishery – 2008

Ian Knuckey, Russell Hudson and Matt Koopman

AFMA Project R2006/833

2008

Published: Fishwell Consulting Pty Ltd
22 Bridge St Queenscliff VIC 3225

ISBN: 978-0-9756006-6-5

General disclaimer

This publication may be of assistance to you but the Fishwell Consulting and its employees do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.

Preferred way to cite:

Knuckey, I., Hudson, R., and M. Koopman (2008). Resource Survey of the Great Australian Bight Trawl Fishery 2008. AFMA Project R2006/833. Fishwell Consulting 20pp..

Executive Summary

The Great Australian Bight Trawl Fishery (GABTF) targets two main species, deepwater flathead (*Neoplatycephalus conatus*) and Bight redfish (*Centroberyx gerrardi*). Industry-based fishery-independent resource surveys of the Great Australian Bight (GAB) have been conducted since 2005 with the primary goal of obtaining robust annual indices of relative biomass of these two main species. These indices are incorporated into formal stock assessments, which were previously hampered by input data with little contrast.

The Great Australian Bight Industry Association (GABIA) supported the implementation of the industry-based fishery-independent resource survey of the GABTF, driven largely by industry's desire for a better understanding of the extent of shelf resources of their main target species. Surveys are conducted during February–April each year using a 'standard research' net. Relative biomass estimates are calculated using swept area calculations, avoiding the need to make assumptions regarding the catchability and efficiency of the gear. Industry observations, supported by preliminary analysis of data from the 2005 survey, showed large diurnal effects on catch rates of Bight redfish, but not deepwater flathead. Consequently, only data from night shots (when catch rates are higher) are used in calculations of relative biomass estimates of Bight redfish, but data from both day and night shots are used in calculations for deepwater flathead.

This report details the results of the 2008 GABTF resource survey – the fourth consecutive annual survey.

Two industry-based fishery-independent trawl surveys were successfully conducted in selected strata within the GAB during February and March 2008. Deepwater flathead and Bight redfish occurred in 100% and 95% respectively of the seventy-six valid survey tows that were completed.

Relative biomass indices with CVs<0.3 were obtained for deepwater flathead, Bight redfish and other main species within the survey area using swept area estimates from trawl shots in a stratified random survey design. The relative biomass estimate of Bight redfish for 2008 was 14,591 t (CV = 0.11), which is 43% lower than the 2007 estimate and 30% lower than the 2005 estimate. Estimates of relative biomass of bight redfish in 2005, 2006 and 2007 were 20,887 t (CV = 0.13), 25,380 t (CV = 0.16) and 25,713 t (CV = 0.16) respectively. The relative biomass estimate of deepwater flathead during 2008 was 7,725 t (CV=0.06). This is 10% lower than the 2007 estimate and 36% lower than the 2005 estimate. Estimates of relative biomass of deepwater flathead in 2005, 2006 and 2007 were 12,152 t (CV = 0.05), 8,415 t (CV = 0.06) and 8,540 t (CV = 0.05) respectively.

Bight redfish comprised the greatest portion of the catch (20%–26%) in each year the survey has been conducted. Deepwater flathead, ocean jacket, wide stingaree and latchet were the next most commonly caught species each year.

Length frequency measurements were made on 1552 deepwater flathead and 1300 Bight redfish. Modal length of Bight redfish was smaller in samples from 2008 (31 cm) than in previous years (34–35 cm). Modal length of deepwater flathead from 2008 samples (45 cm) was greater than those from 2006 and 2007 samples (43 cm).

Otolith samples of 254 deepwater flathead and 294 Bight redfish were also collected during the survey.

The results of this survey provide the fourth year of a fishery-independent index of abundance for both deepwater flathead and Bight redfish and other important species in the GABTF.

Table of Contents

List of Tables

List of Figures

Introduction

The Great Australian Bight Industry Association (GABIA) has supported the implementation of an industry-based fishery-independent resource survey of the Great Australian Bight Trawl Fishery (GABTF). This has been largely driven by industry's desire for a better understanding of the extent of shelf resources of their main target species, deepwater flathead (*Neoplatycephalus conatus*) and Bight redfish (*Centroberyx gerrardi*), and the level of impact that fishing might be having on these resources.

Until 2006, the GABTF was managed by input controls limiting the number of operators in the fishery to ten. Only a small number (typically 4-5) of the ten SFR holders had been active in the fishery during any one year over the decade to 2002. Catch and effort data from these vessels' logbooks showed no overall trend in catch rates for either deepwater flathead or Bight redfish and there remained little contrast in these data. Time series of length- and age-frequency data do not indicate any significant impact on the resources from this level of fishing either. Stock assessment models up to 2006 for Bight redfish and deepwater flathead were advanced, but suffered from the lack of contrast in any of the main fishery indicators. As a result, there was considerable uncertainty surrounding model outputs including estimates of stock biomass.

There was increased participation in the fishery and increases in fishing effort and fishing efficiency of active vessels during 2003 – 2005. Given the uncertain status of the stocks at this time, this raised concerns about future sustainability of the shelf resources. Under this scenario, industry agreed that quota management of the main target species would be introduced from 2006. They also agreed on equal allocation of quota between the ten SFR holders.

With the pending introduction of quotas during 2006, there was concern that low TACs would be introduced based on the high uncertainty of biomass estimates resulting from stock assessment models and this may inhibit the sustainable development of the fishery. Moreover, once quotas were introduced it was believed the use of commercial CPUE data as the main index of abundance in these models would be compromised and unlikely to provide the contrast that is needed to improve model outputs.

Industry investigated the feasibility of conducting a fishery-independent survey to provide a time-series of relative abundance indices for deepwater flathead and Bight redfish that can be used as an input to stock assessment models (FRDC Project 2002/072). Preliminary surveys of the main shelf areas of the fishery were successfully conducted during 2005 (Knuckey et al, 2006), and continued during 2006 (Knuckey and Hudson, 2007a) and 2007 (Knuckey and Hudson, 2007b). Continuing the random stratified survey during 2008 extends the time series of relative biomass estimates of Bight redfish and deepwater flathead and provides further evidence of whether appropriate TACs have been set.

Objectives

1. Determine a relative abundance index for Bight redfish and deepwater flathead in the current region of the main GABTF shelf fishery during 2008.
2. Collect biological and population data on these species.
3. Determine a relative abundance index of other main species in the current shelf fishery.

Material and Methods

Survey Design

Detailed description of survey design and vessel and gear specifications are reported in Knuckey et al, (2006). A briefly description is given below.

Although fishing for shelf species occurs outside of these areas, the survey was restricted to depth of 120–200 m and between longitude 126º00' and 132º30'. The longitudinal range was divided into four primary strata; 126º00'–127º45'(West2), 127º45'–129º00' (West1), 129º00'–130º15' (Central1), 130º 45'–132º30' (Central2) (Table 1). This represents the main fishing areas of the shelf component of the fishery. Catch rates of Bight redfish fluctuate throughout the year, being highest during February–April. Catch rates of deepwater fathead also fluctuate seasonally, however, not as much as Bight redfish. Consequently the survey is conducted during February–April.

Initial analyses of the catch and effort data indicated catch rates for Bight redfish were not affected by time of day of the shot, while catches of deepwater flathead were higher during the day from February to April. However, results from the preliminary survey during 2005 indicated catches of Bight redfish were higher during night shots, and future analyses of Bight redfish should only include night shots (Knuckey et al, 2006). For deepwater flathead there was no significant difference between day and night shots, and further analyses of this species would pool all shots. These indications have proven correct in subsequent years, so survey design and methods have been repeated annually based on these analyses.

Analysis of the catch and effort data suggested the variation of catch rates for Bight redfish was higher for trawl durations <2.5 hours (including setting and retrieving net). A similar result was observed for deepwater flathead but was not as pronounced. To maintain a consistent sampling time it was agreed for each survey shot the net should be trawled for 2.5 hours and time setting and retrieving the net not included.

Analysis of logbook data indicated a minimum of 76 shots would be needed to achieve a CV of <20% for Bight redfish. This analysis was based on combining both day and night shots. After the preliminary survey was conducted in 2005, it was observed the number of 0 catches (a contributing factor to a high CV) of Bight redfishes was not as high as expected, and hence an analysis of only night shots (approximately half of the 76 shots) has provided an acceptable CV (Knuckey et al, 2006).

Number of shots allocated to each of the primary strata was proportional to the catch-weighted standard deviation of CPUE. Shot locations were selected randomly. A shot is deemed to be acceptable if the shot passes within 500 m of the selected position. If the shot has to be abandoned due to gear problems, it can still be considered acceptable if towed for a minimum of 1 hour and passed through the position. The start and finish position of each shot was recorded along with minimum and maximum depths, average trawl speed, environmental conditions and direction of tow.

The tows were completed in a specified order to reduce temporal biases in the data collection, though the order of several tows was rearranged for logistical reasons. Tows were conducted at a speed ranging 3–3.2 knots, with the skipper deciding on the starting position and direction of the tow. When the tow was completed, the net was hauled aboard and the catch emptied on to the deck. Commercial species were gathered in fish bins and approximate weights of each species estimated. Discarded bycatch were identified to species where possible and an approximate weight of each species estimated. When the catch was unloaded in port the correct weights of Bight redfish and deepwater flathead were obtained and compared to the

survey estimates. If there was a difference of ± >2% then the survey estimates were adjusted. Length measurements were collected randomly during the survey for deepwater flathead and Bight redfish, the total length measured for flathead and fork length for redfish. Otolith samples of the two species were also collected randomly during the survey recording the length and sex of each sample.

Calculation of Relative Biomass and Coefficient of Variation

The estimation of the relative biomass is based on the method adopted by Schnute and Haigh (2003), where in simplistic terms, typical surveys consist of numerous tows, each tow giving a biomass density estimate

$$Density = \frac{biomass\ captured}{area\ swept\ by\ net}$$

And total biomass (abundance) estimated by calculating the mean density (with an associated coefficient of variation) from all tows and applying that to habitat or stratum area:

$Biomass = density \times area$ (Schnute and Haigh, 2003)

Determining the density

For tows where Bight redfish and deepwater flathead are present in the catch (non-zero measurements), the mean density for each stratum is

$$\mu_h = \frac{1}{n_h}\sum_{i=1}^{n_h}\mu_{hi}$$

The squared inverse of the CV is

$$v_h = \mu_h^2 / s_h^2$$

The mean density of measurements for each stratum is

$$\delta_h = (1 - p_h)\mu_h$$

The variance of density of measurements each stratum is

$$\sigma_h = \sqrt{\left((1 - p_h)(1 + p_h v_h)\left(\mu_h^{\,2} / v_h\right)\right)}$$

The estimated biomass of each stratum *h* is

$$b_h = A_h \delta_h$$

The CV of biomass estimate of each stratum is

$$cv_h = \sqrt{\sigma_h} / b_h\, n_h$$

Where p_h is the proportion of hauls with zero catch for the species in stratum h, μ_h is the mean kgs per area swept (m^2) of species where catch >zero, s_h is the std kgs per area swept (m^2) of species where catch >zero, A_h is the total area of stratum, n_h is the number of tows and b_h is the estimated relative biomass.

Total relative biomass and CV for each species were calculated as follows;

$$B = \sum_h b_h$$

$$cv = \sum_h cv_h$$

The number of shots, n_h, in each stratum that produced the desired coefficient of variation, cv_h, was randomly allocated within each stratum.

Relative biomass was estimated using the swept area method.

The density measure was estimate as follows:

$$\mu_{hi} = C_{hi} \Big/ v_{hi} d_{hi} E_{hi}$$

Where each shot i in spectrum h has a known catch of C_{hi}, effort (tow duration hour) E_{hi}, vessel speed (m/hour) v_{hi} and door spread d_{hi}.

The swept area of the trawl net can be expressed as either the area swept by the net or the area swept by the net. Net width was estimated as 50% of the headline length while door width involved measuring the distance between the warps at the pulleys (blocks) then 1 metre along the warps towards the trawl net. The difference in width would then be multiplied by the length of the warp let out:-.

$$d = (w_1 - w_2) \times WL + (w_2)$$

where w_1 is the distance between the warps one meter down from the blocks, w_2 is the distance between the warps at the back of the blocks and WL is the warp length.

Results

Survey Coverage

The surveys were successfully completed for each of the survey strata well within the time frame and budget allocated. The random stratified survey sampled 76 sites during February and March 2008 (Figure 1). One alternate shot (tow 7) was made due to a pin-up. The mean tow lengths in the four strata were 14.1 km (Central 1), 15.2 km (Central 2), 15.0 km (West 1) and 15.1 km (West 2) (Table 2).

Gear Performance

Door spread was estimated on 10 occasions. Door spread measurements ranged 98–110 m reflecting the uncertainty and difficulty in measuring the distance between warps to the nearest centimetre a metre from the blocks. Mean door spread was 104.5 m ($\pm$ 3.8 m SD).

Catch Composition and Length Frequencies

The total catch during the February and March surveys combined (63.3 t) comprised 90 identified species or species groups with the largest catches occurring in the Central1 stratum (Table 3). Bight redfish 13.0 t (20%), ocean jacket 10.0 t (16%) and deepwater flathead 9.3 t (15%) made up the majority of the catch, followed by wide stingaree 7.1 t (11%), and latchet 4.3 t (7%) (Figure 2). Deepwater flathead and Bight redfish occurred in 100% and 95% of tows respectively during 2008.

Catches of Bight redfish varied more than catches of deepwater flathead (Figure 3, Figure 4,

Table 4). Four hauls contained more than 500 kg of Bight redfish while over a third (37%) contained catches ranging 0–50 kg, and 76% of the hauls caught between 50–150 kg of deepwater flathead.

Catches of Bight redfish varied considerably with time of day. Tows commencing during 1800 hours and 0600 hours caught three times more Bight redfish than catches between 0600 hours and 1200 hours (Figure 5). However, the mean catch between 1200 hours and 1800 hours was similar to that of night shots and contained a very large amount of error. This is due to one very large catch (1,710 kg) taken during that time. Three shots also conducted during that time contained 0 kg of Bight redfish. In contrast there was no difference in catches of deepwater flathead between night and day tows (Figure 6).

The lengths of 1,300 Bight redfish were measured during the 2008 surveys (Table 5). Lengths ranged 23–54 cm, however, most fish measured were between 28–39 cm (Figure 7). The modal length was 31 cm.

The lengths of 1,552 deepwater flathead were measured during the 2008 surveys (Table 5). Lengths ranged 30–79 cm, however, most fish measured were between 38–48 cm (Figure 8). The modal length was 45 cm.

A total of 254 otoliths were collected from deepwater flathead, while 294 were collected from Bight redfish (Table 5).

Relative Biomass Estimates

Using only night shots (1800–0600 hours) and net-width in swept-area calculations, the relative biomass estimate of Bight redfish for the 2008 survey is 14,591 t with a CV of 0.11 (Table 6). The relative biomass estimate for 2008 is 43% lower than the 2007 estimate of 25,713 t, and 30% lower than the 2005 estimate of 20,887 t (Figure 9).

Using both day and night time shots and net-width in swept-area calculations, the relative biomass estimate of deepwater flathead for the 2008 survey is 7,725 t with a CV of 0.06 (Table 6). The relative biomass estimate for 2008 is 10% lower than the 2007 estimate of 8,540 t, and 36% lower than the 2005 estimate of 12,152 t (Figure 9).

Relative biomass estimates for a number of other important GABTF species were also calculated (Table 6). CVs of these species were generally below 0.30. Other species with the greatest relative biomass estimates during 2008 were ocean jacket (7,709 t) and latchet (3,688 t). Trends in relative biomass estimates varied from species to species (Figure 9 and Figure 10). Species that showed a decrease in relative biomass estimates during 2005–2008 were common sawshark, gummy shark, latchet, ornate angelshark and spikey dogfish. Relative biomass estimates of ocean jacket, jackass morwong and knifejaw were similar between 2005 and 2008 surveys.

Discussion

Survey Coverage

The primary objective of the random stratified survey was to determine a relative abundance index for Bight redfish and deepwater flathead in the current region of the main GABTF shelf fishery. No attempts have been made to estimate absolute biomass from the survey results. The survey was also designed to collect biological and population data on these species, and to determine a relative abundance index of other main species in the current shelf fishery. All of these objectives were met, with 76 sites successfully surveyed during February and March 2008, adding to the existing three-year time series.

Gear Performance

It has been continually stressed that there are many uncertainties and assumptions regarding herding, escapement and catchability associated with trawl nets and use of the GABTF trawl survey results as an absolute index of abundance (eg. Knuckey and Gason 2006; Knuckey *et. al.* 2006). Additional uncertainties relate to species' population dynamics and that the survey strata do not encompass the entire population of either Bight redfish or deepwater flathead either spatially or temporally. One example is the fact that deepwater flathead, Bight redfish and other shelf species are regularly caught in depths to at least 250 m, but survey coverage is only between 120–200 m depth in each stratum. Importantly, because of diurnal migrations of Bight redfish through the water column, relative biomass estimates for that species are calculated from night shots only.

For the above reasons, the data collected during these surveys are only intended to be used as a relative index of biomass to be input into the stock assessment models. With respect to performance of the gear, therefore, it is only necessary to ensure that it performs consistently from year to year. Door spread is the main measure of gear performance during the survey. Although it would be preferable to have the Net-sonde equipment to continually monitor the survey net characteristics, this equipment has regularly failed to work. Measurements of warp angle, however, have allowed estimates of door spread and the 2008 results appear to be consistent with previous years'.

Catch Composition and Length Frequencies

Bight redfish have comprised the largest portion of the catch in all surveys (apart from the December 2005 survey); 22% in 2005 (Knuckey *et. al.* 2006), 26% in 2006 (Knuckey and Hudson, 2007a), 25% in 2007 (Knuckey and Hudson, 2007b) and 20% in 2008 (Figure 2). The proportion of the total catch comprising deepwater flathead has decreased from 19% in 2005 to 15% in 2008. Ocean jacket were the second most commonly caught species during 2008 (16%), and have been large components of the catch in each year of the survey.

Modal lengths of Bight redfish measured during 2005, 2006, 2007 and 2008 surveys were 35 cm, 35 cm, 34 and 31 cm respectively. The decrease in modal size during 2008 is consistent with the high proportion of fish less than 30 cm measured during 2007, suggesting possible evidence of some recruitment.

Modal lengths of deepwater flathead measured during 2005, 2006, 2007 and 2008 surveys were 46 cm, 43 cm , 43 cm and 45 cm respectively. Length-frequency distribution in 2008 is similar to that from 2007, containing a small proportion of large fish than in 2005 and 2006 surveys.

Relative Biomass Estimates

Bight redfish

The 2008 relative biomass estimate of Bight redfish of 14,591 t was almost 30% lower than the 2005 estimate (20,887 t) and 43% lower than the 2007 estimate of (25,713 t). These estimates were based on night shots only.

The CV for night shots during 2008 (0.11) was the lowest of all surveys conducted. CVs in other years ranged 0.13–0.16. The low CV during 2008 is a result of getting very few large catches of Bight redfish; only one catch greater than 800 kg was recorded.

Deepwater flathead

The relative biomass estimate for deepwater flathead (day and night combined) during 2008 (7,725 t) is about 36% lower than the 2005 February and March estimate (12,152 t), and 8–

10% lower than the 2006 and 2007 estimates (8,415 t and 8,540 t). It is unclear whether the decline in relative biomass estimates represents a decline in the population or simply seasonal variability in the estimate.

The CV obtained for relative biomass estimates during 2008 for day and night shots combined (0.06) was similar to CVs in other years which ranged 0.05–0.06.

Other species

There was considerable annual variation in relative biomass estimates of other main species. Common sawshark, gummy shark, latchet, ornate angelshark and spikey dogfish have showed an overall decrease in relative biomass estimates since 2005. Relative biomass estimates of ocean jacket, jackass morwong and knifejaw have changed very little over the four survey years.

Conclusions

The 2008 Great Australian Bight resource surveys achieved all objectives. The target CVs for relative biomass estimates were achieved for both Bight redfish and deepwater flathead and the relative biomass estimates were comparable to results from previous years. In addition, relative biomass estimates of other main species were estimated with low to medium CVs. Sufficient length-frequency and otolith samples were collected for both target species.

The survey also demonstrated that a scientifically rigorous fishery-independent survey can be consistently conducted by the fishing industry.

Acknowledgments

We wish to thank the owner, Mr Semi Skoljarev, and the skipper and the crew of the Explorer S for their professional approach to conducting the 2008 survey, and Dr Mike Burge and Dr Paul Starr for assistance with the design of the survey.

References

Hudson, R.J. and Knuckey, I. A. (2005). Herding models and their application to Bight redfish and deepwater flathead. GABRAG paper September 2005, 17 pp.

Knuckey, I, and Hudson, R. (2007a). Resource Survey of the Great Australian Bight Trawl Fishery - 2006. Fishwell Consulting, 20pp.

Knuckey, I, and Hudson, R. (2007b). Resource Survey of the Great Australian Bight Trawl Fishery - 2007. AFMA Project R2006/833. Fishwell Consulting 20pp.

Knuckey, I., Koopman, M., Gason, A. and Hudson, R. (2006). Resource survey of the Great Australian Bight Trawl Fishery. Fishwell Consulting / Primary Industries Research Victoria, Queenscliff, 40pp.

Knuckey, I.A. and Gason, A.S.H. (2006). Assessing the feasibility of an industry-based fishery independent survey of the South East Fishery. Fisheries Research and Development Project 2002/072 Final Report. Fishwell Consulting, 55pp.

Schnute, J.T. and Haigh, R. (2003). A simulation model for designing groundfish trawl surveys. Can. J. Fish. Aquat. Sci. 60:640-656.

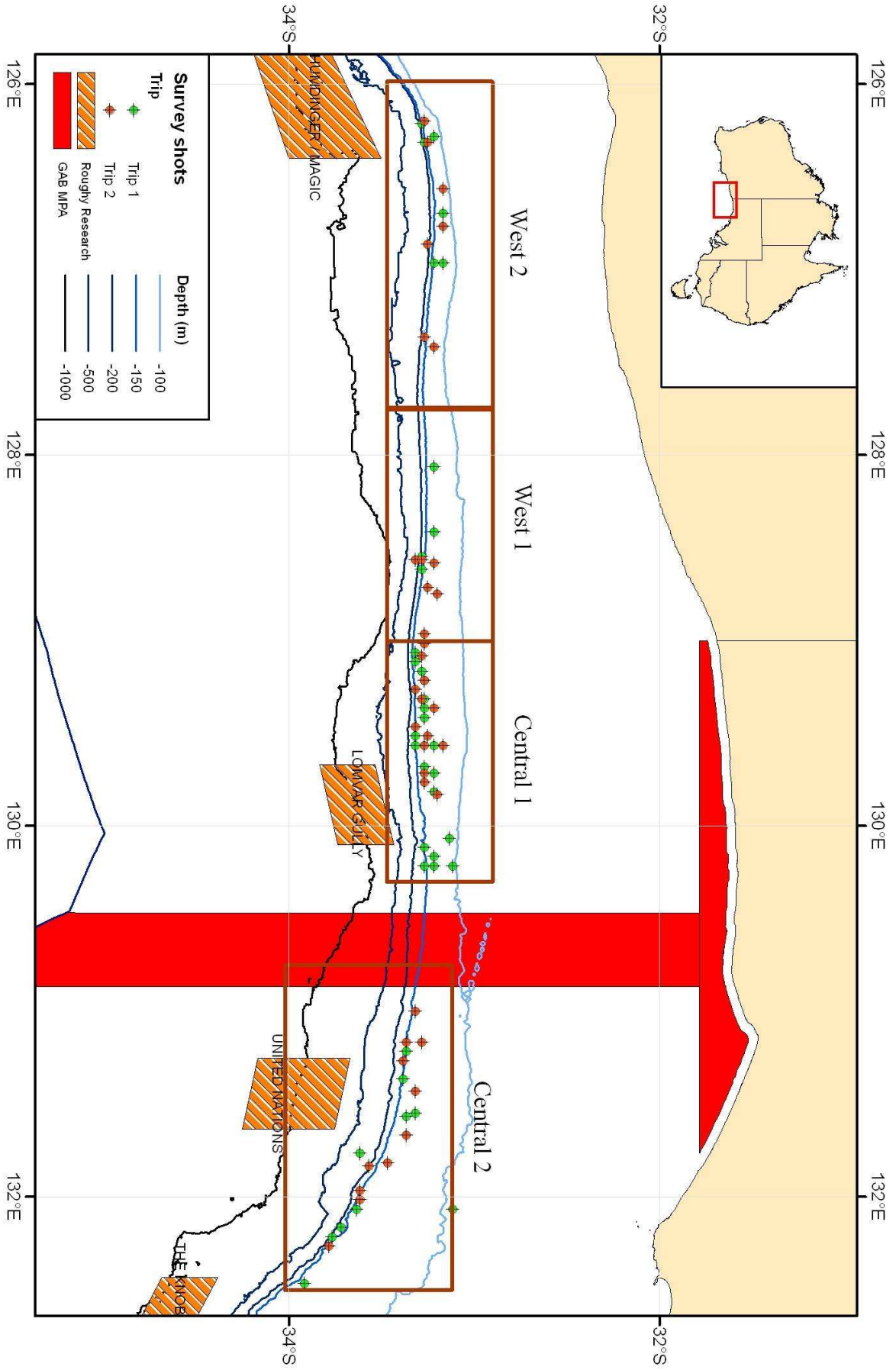

Figure 1. Survey strata and shot locations of trawl survey.

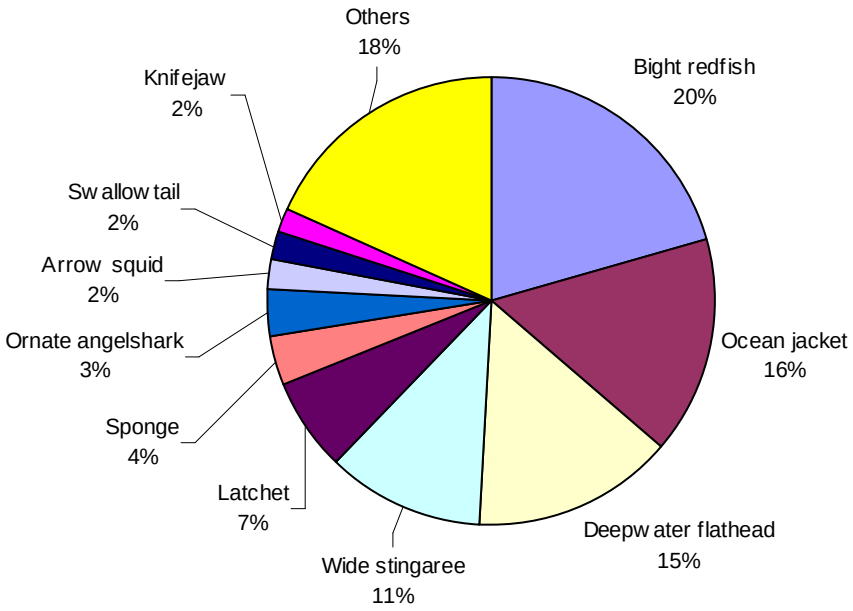

Figure 2. Proportion (of weight) of major species captured during the 2008 survey.

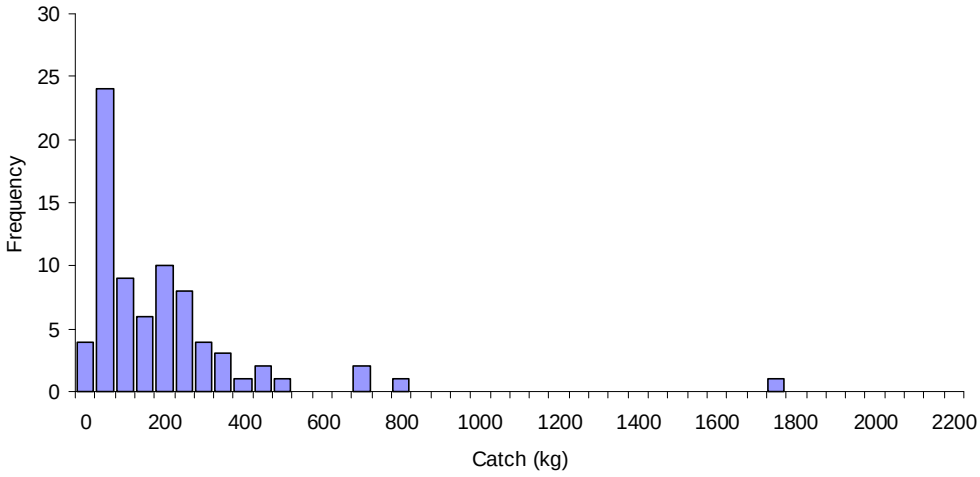

Figure 3. Frequency of catches (kg) of Bight redfish during the 2008 survey.

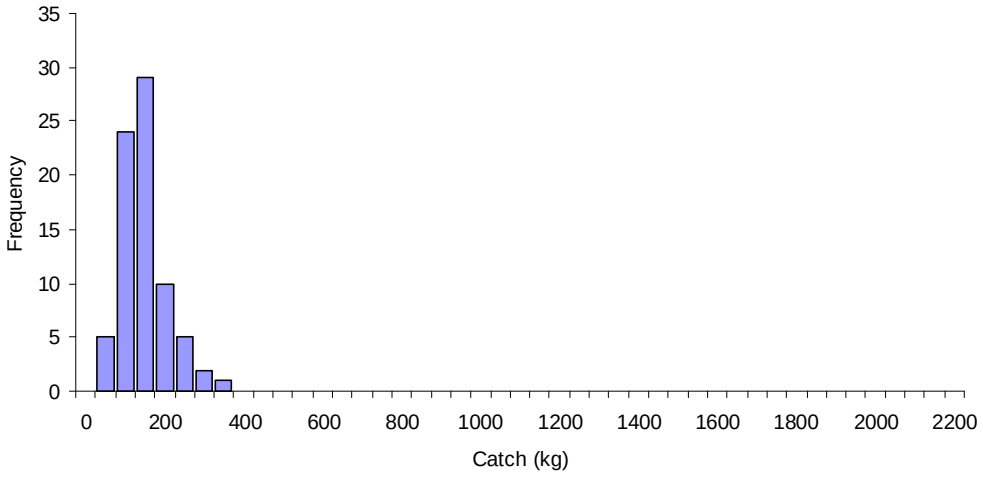

Figure 4. Frequency of catches (kg) of deepwater flathead during the 2008 survey.

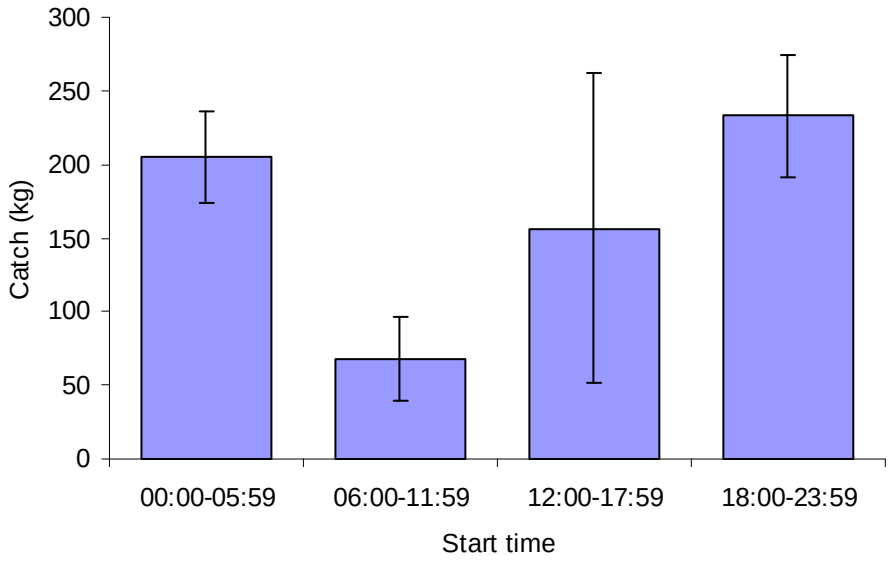

Figure 5. Mean and standard error of Bight redfish catches by time of day during the 2008 survey.

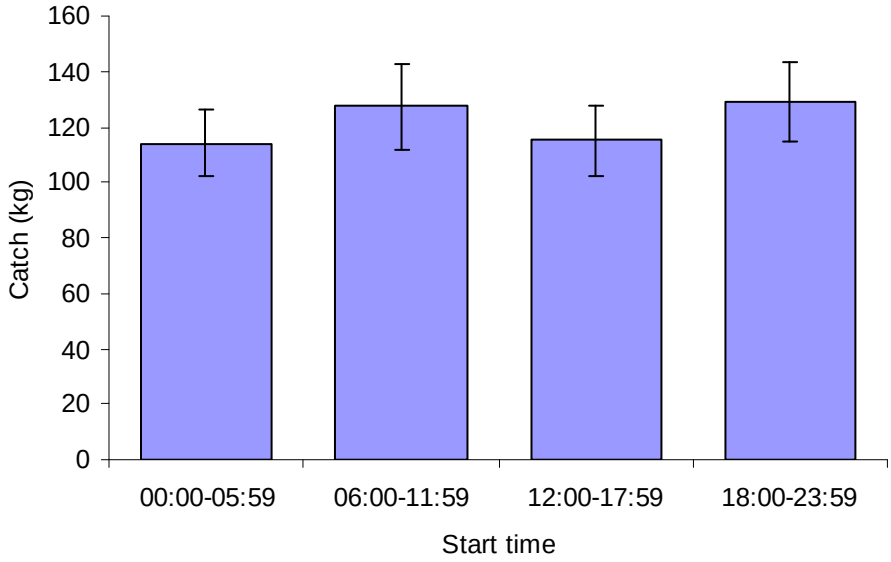

Figure 6. Mean and standard error of deepwater flathead catches by time of day during the 2008 survey.

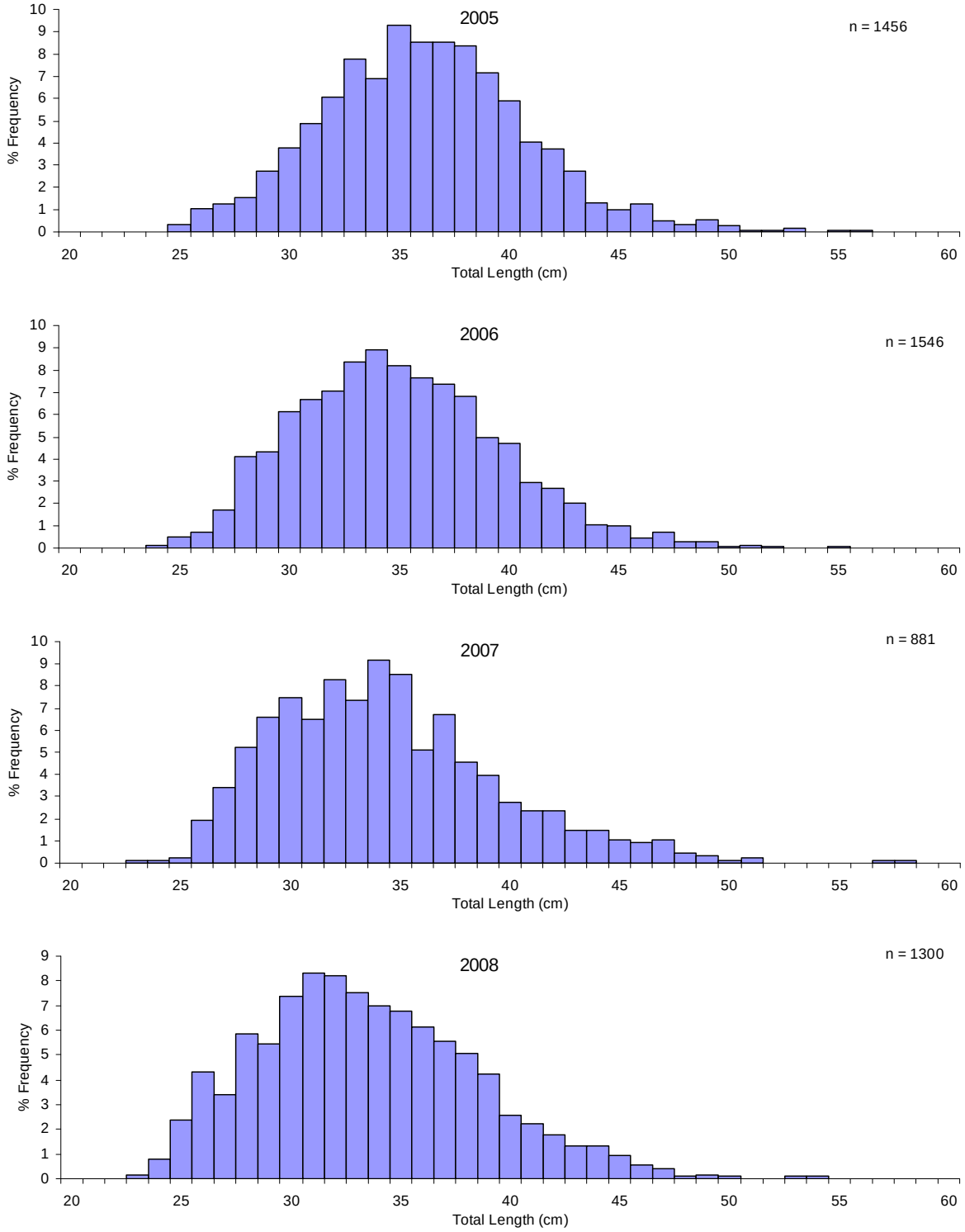

Figure 7. Length-frequencies of Bight redfish during the 2005–2008 surveys.

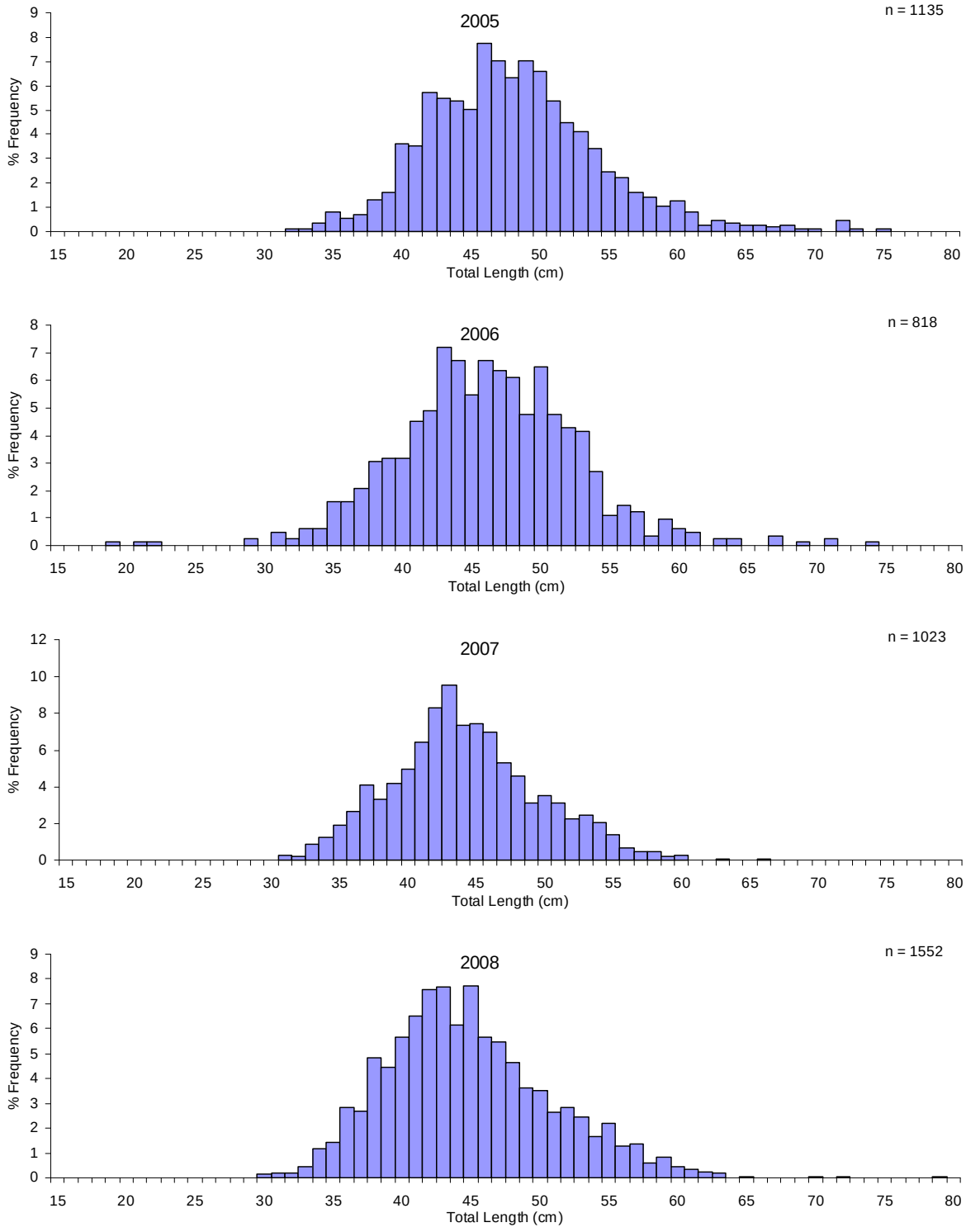

Figure 8. Length-frequencies of deepwater flathead during the 2005–2008 surveys.

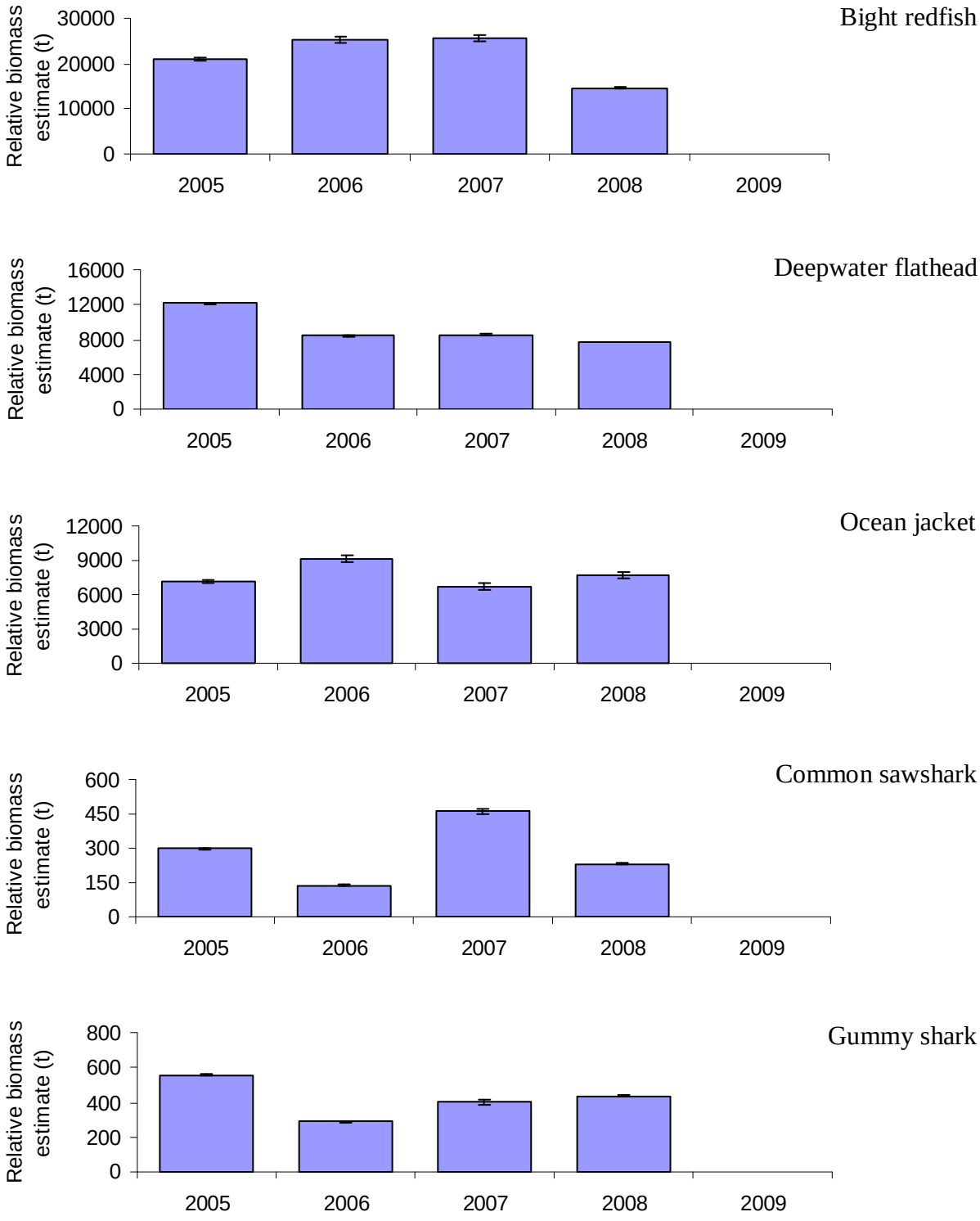

Figure 9. Relative biomass estimate (t ±SE) of Bight redfish, deepwater flathead, ocean jacket, common sawshark and gummy shark from annual surveys.

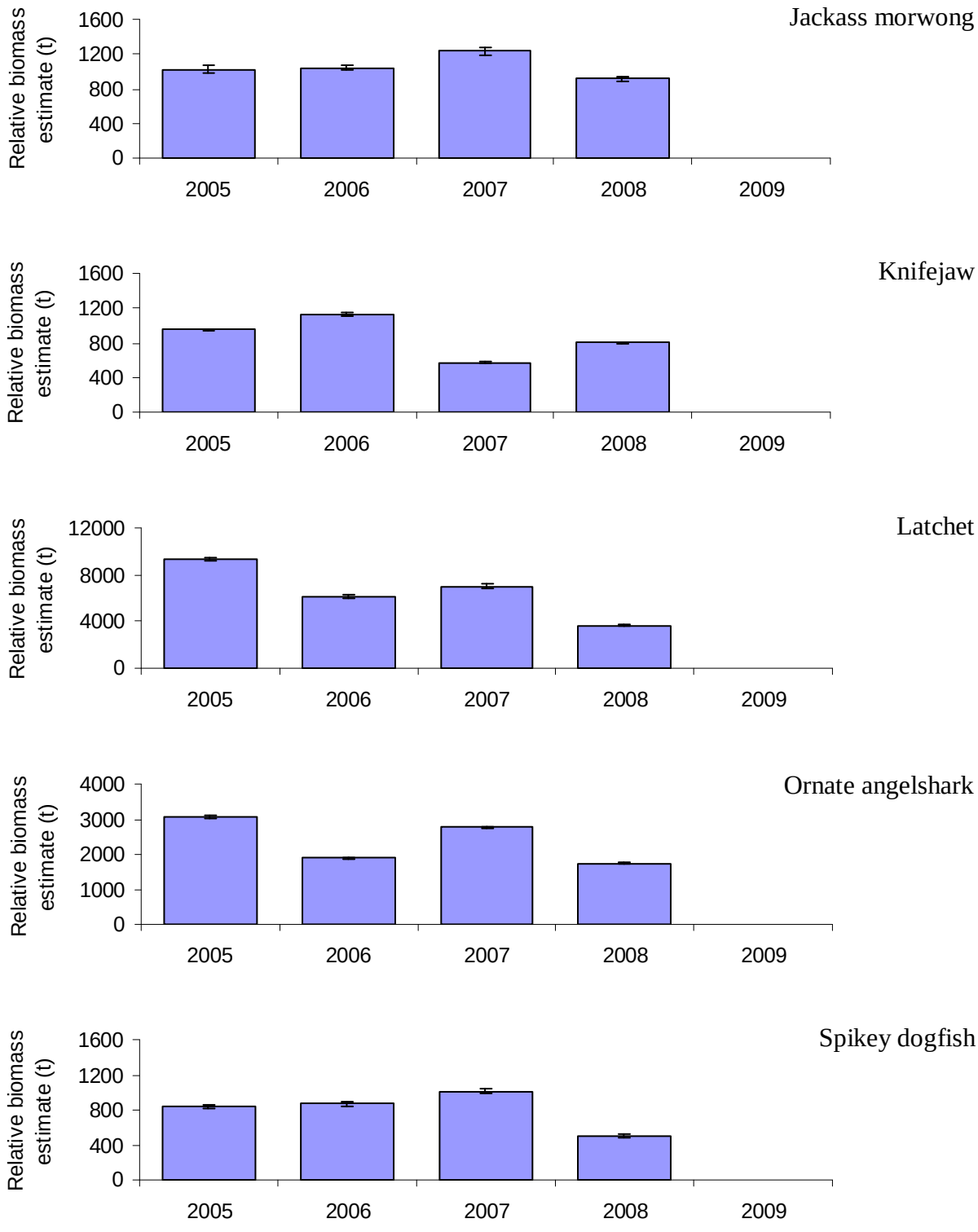

Figure 10. Relative biomass estimate (t ±SE) of jackass morwong, knifejaw, latchet, ornate angelshark and spikey dogfish from annual surveys.

Table 1. Description of strata sampled during the 2008 survey.

Stratum	Depth (m)	Longitude	Area (km^2)	Number of shots
Central 2	120–200	130.75–132.50	5720	22
Central 1	120–200	129.00–130.25	3965	31
West 2	120–200	127.75–129.00	2700	10
West 1	120–200	126.00–127.75	2600	13

Table 2. Mean and standard deviation (SD) length (m), swept area (km^2), speed (knots) and depths (m) of tows in each stratum.

Stratum	Month	Tow length		Area swept†		Tow speed		Tow depth	
		Mean (m)	SD	Mean (km^2)	SD	Mean (knots)	SD	Mean (m)	SD
Central 1	Feb	14743	845	0.240	0.007	3.18	0.05	134	8
Central 2	Feb	14981	675	0.238	0.004	3.15	0.05	140	8
West 1	Feb	14667	1143	0.239	0.015	3.23	0.05	130	7
West 2	Feb	15716	440	0.251	0.007	3.33	0.10	136	15
Central 1	Mar	13933	2580	0.229	0.036	3.17	0.06	131	6
Central 2	Mar	15262	439	0.240	0.003	3.20	0.00	138	11
West 1	Mar	15334	445	0.244	0.006	3.24	0.07	128	5
West 2	Mar	14767	719	0.241	0.001	3.20	0.00	133	13

† Note: Area swept calculated using width of net (16.3 m)

Table 3. Total catch (kg) of all species in each stratum and across all strata during the 2008 survey.

Species	Catch (kg)				
	Central 2	Central 1	West 2	West 1	Total
Barracouta	340	258	123	170	891
Bight redfish	5098	3834	2956	1091	12979
Blackspotted gurnard perch	88	96	51	6.8	241.8
Blue morwong	232	158	151	111	652
Calamari	6	3			9
Cardinalfishes				1	1
Southern chimaera				6	6
Common bellowsfish	1.1	2.2	0.1	1	4.4
Common sawshark	18.2	154.7	51.2	88.8	312.9
Coral	20	0.5	2		22.5
Cucumberfishes	1				1
Cuttlefish	28.8	40.2	11	7	87
Deepwater bug	12.1	2.6	0.2		14.9
Australian burrfish	90	125.2	26	80.5	321.7
Deepwater flathead	2863	3524	1099	1790	9276
Deepwater stargazer	86	82	15	62	245
Bluefin leatherjacket		7	1		8
John dory	7.8	5.8	4.7	21	39.3
Silver dory	40	38	16	11	105
Eel unknown	1				1
Conger eel	20	40	5	21	86
Elephantfish	2				2
Tiger flathead	1				1
Footballer sweep	2			2	4
Gemfish	6	2	32	38	78
Greeneye dogfish	8	2.5		3	13.5
Gummy shark	53	248.7	72.8	194	568.5
Red gurnard	74	91.6	32	63.1	260.7
Spiny gurnard	38	9	8	11	66
Hairtails				4	4
Hapuka			51	10	61
Hermit crab		1	1		2
Jack mackerel	516	250	71	136	973
Jackass morwong	235.2	233.1	294.5	229.6	992.4
Knifejaw	220	408.8	150	215	993.8

Species	Catch (kg)				
	Central 2	Central 1	West 2	West 1	Total
Latchet	1374	987	385	1507	4253
Sixspine leatherjacket		10			10
Velvet leatherjacket	2	17	10		29
Leatherjacket		2.5	2	3	7.5
Bigspine boarfish	136	142.5	72	133	483.5
Blue mackerel	5	1	11	5	22
Ocean jacket	1139	5209	2139	1524	10011
Ocean perch	5	27	68.5	2	102.5
Oreodories	2				2
Ornate angelshark	309	978	452	437	2176
Slender orange perch			0.5		0.5
Splendid perch		3	1.5		4.5
Eastern fiddler ray		2			2
Southern fiddler ray	55	72	34	50	211
Torpedo rays and Numbfishes	4				4
Red cod	5	12	9	16	42
Redbait	5	27	18		50
Ringed toadfish	53	145	58	76	332
Southern round skate	24.5				24.5
Bigscale rubyfish	17	8	11	107	143
Rusty carpetshark	50.5	97	20	90.5	258
Samsonfish	16		16		32
Sandpaper fish	4	12.5	232	7	255.5
Southern sawshark	11	8	20	65.5	104.5
Sawtail catshark	3				3
Seastars	3.2	0.4		5	8.6
Sergeant baker	41	35	27	36	139
Bronze whaler		60			60
Port Jackson shark	62	49	17	14	142
School shark	13	8.8			21.8
Sydney skate	5				5
Melbourne skate	80			9	89
Legskates	20				20
Smooth stingray	20	68		36	124
Snapper	15	18	5	4	42
Southern rock lobster			1	3.3	4.3
Spikey dogfish	232	117	39	168	556
Spiny boxfish	8.4	16.7	4.5	3.7	33.3
Sponge	1243	371	295	325	2234
Arrow squid	150	578	177	457	1362
Black stingray	105	178	106	98	487
Swallowtail	36	459	342	365	1202
Tarwhine	1		0.2	1	2.2
Thetis fish	34.1	29.5	8	12	83.6
Silver trevally	12	112.8	80	129	333.8
Tusk	37.2	101.1	31	25	194.3
Common veilfin	4	2	1	32	39
Volute shell				1	1
Blue warehou	21	9.5	16		46.5
Whitebarred boxfish	16.5	8		7	31.5
King George whiting				1.2	1.2
Wide stingaree	441	119	318	6285	7163
Spotted wobbegong			25	40	65
Yelloweye redfish	7	125	523	72	727
Yellowspotted boarfish	66	75.5	16	49	206.5
Total	16001.6	19919.7	10815.7	16575	63312

Table 4. Catch (kg) Bight redfish and deepwater flathead for each stratum point sampled during the 2008 survey.

Shot code	Shot	Stratum point		Shot date	Time of shot	Start Point		Finish Point		Catch (kg)	
		Lat	Long			Lat	Long	Lat	Long	Bight redfish	Deepwater flathead
C2-01-2008	1	33°55'	132°28'	13/02/2008	17:49	33°55.20'	132°28.20'	33°50.40'	132°21.00'	243	285
C2-02-2008	2	33°43'	132°10'	13/02/2008	21:45	33°46.20'	132°15.00'	33°40.80'	132°07.20'	278	71
C2-03-2008	3	33°07'	132°04'	14/02/2008	0:50	33°30.00'	131°55.80'	33°25.20'	131°48.00'	195	245
C2-04-2008	4	33°37'	131°46'	14/02/2008	6:34	33°25.80'	131°45.60'	33°27.00'	131°36.60'	217	167
C2-05-2008	5	33°23'	131°22'	14/02/2008	10:17	33°24.00'	131°28.80'	33°22.80'	131°19.20'	12	145
C2-06-2008	6	33°16'	130°13'	14/02/2008	17:21	33°16.20'	130°20.40'	33°16.20'	130°10.80'	109	78
C1-07-2008	7	33°07'	130°13'	14/02/2008	20:53	33°22.20'	131°13.80'	33°21.60'	131°04.20'	15	56
C1-08-2008	8	33°16'	130°07'	14/02/2008	0:03	33°16.20'	130°09.00'	33°14.40'	130°18.00'	271	167
C1-09-2008	9	33°13'	129°49'	15/02/2008	3:05	33°13.80'	129°57.00'	33°13.20'	129°48.00'	130	89
C1-10-2008	10	33°16'	129°41'	15/02/2008	6:42	33°12.00'	129°48.00'	33°07.80'	129°56.40'	163	145
C1-11-2008	11	33°13'	129°34'	15/02/2008	12:10	33°10.80'	129°42.00'	33°13.80'	129°33.00'	65	279
C1-12-2008	12	33°16'	129°25'	15/02/2008	15:30	33°13.80'	129°31.80'	33°15.60'	129°26.40'	6	134
C1-13-2008	13	33°16'	129°19'	15/02/2008	18:58	33°16.20'	129°22.20'	33°16.20'	129°12.00'	163	167
C1-14-2008	14	33°17'	129°10'	15/02/2008	22:08	33°16.20'	129°12.60'	33°18.60'	129°03.00'	163	112
C1-15-2008	15	33°19'	129°04'	15/02/2008	1:15	33°19.20'	129°04.20'	33°18.00'	128°55.20'	43	22
W2-16-2008	16	33°17'	128°33'	16/02/2008	6:06	33°17.40'	128°35.40'	33°16.20'	128°25.80'	217	123
W2-17-2008	17	33°13'	128°04'	16/02/2008	10:19	33°13.20'	128°10.80'	33°13.20'	128°00.60'	43	67
W1-18-2008	18	33°10'	126°58'	16/02/2008	18:10	33°09.60'	126°59.40'	33°12.00'	126°49.80'	8	78
W1-19-2008	19	33°16'	126°19'	16/02/2008	22:57	33°13.80'	126°27.00'	33°16.20'	126°18.00'	434	167
W1-20-2008	20	33°17'	126°13'	17/02/2008	2:06	33°16.80'	126°13.20'	33°18.60'	126°05.40'	109	112
W1-21-2008	21	33°13'	126°17'	17/02/2008	5:15	33°16.80'	126°09.00'	33°12.60'	126°17.40'	217	167
W1-22-2008	22	33°10'	126°42'	17/02/2008	10:02	33°10.20'	126°37.80'	33°10.20'	126°48.00'	2	167
W1-23-2008	23	33°13'	126°58'	17/02/2008	13:23	33°12.00'	126°52.20'	33°13.20'	127°01.80'	4	134
W2-24-2008	24	33°13'	128°25'	17/02/2008	11:20	33°12.60'	128°24.60'	33°14.40'	128°34.20'	87	67
W2-25-2008	25	33°17'	128°37'	18/02/2008	14:17	33°16.20'	128°35.40'	33°17.40'	128°46.20'	195	33
C1-26-2008	26	33°19'	129°07'	18/02/2008	18:53	33°19.20'	128°58.80'	33°18.60'	129°09.60'	98	67
C1-27-2008	27	33°16'	129°13'	18/02/2008	21:55	33°15.60'	129°06.00'	33°15.00'	129°15.00'	56	67
C1-28-2008	28	33°16'	129°22'	18/02/2008	0:55	33°17.40'	129°16.80'	33°15.00'	129°25.80'	30	100
C1-29-2008	29	33°19'	129°31'	18/02/2008	4:15	33°15.60'	129°27.00'	33°19.80'	129°34.20'	0	78
C1-30-2008	30	33°19'	129°34'	18/02/2008	7:17	33°19.20'	129°33.60'	33°15.00'	129°40.20'	20	100
C1-31-2008	31	33°13'	129°43'	18/02/2008	10:15	33°15.00'	129°40.80'	33°07.80'	129°43.80'	130	134
C1-32-2008	32	33°08'	130°04'	19/02/2008	N/A	33°09.00'	129°44.40'	33°10.20'	129°54.00'	130	134
C1-33-2008	33	33°13'	130°10'	19/02/2008	17:07	33°12.00'	130°00.60'	33°13.20'	130°10.80'	163	134
C1-34-2008	34	33°13'	130°13'	19/02/2008	20:05	33°12.60'	130°11.40'	33°13.80'	130°21.00'	43	89
C2-35-2008	35	33°22'	131°13'	19/02/2008	3:13	33°21.60'	131°09.00'	33°22.20'	131°18.60'	0	134
C2-36-2008	36	33°22'	131°34'	19/02/2008	6:15	33°21.60'	131°30.00'	33°22.20'	131°39.60'	326	67
C2-37-2008	37	33°19'	131°33'	19/02/2008	9:15	33°24.00'	131°43.80'	33°28.80'	131°52.20'	434	112
C2-38-2008	38	33°38'	132°04'	20/02/2008	13:50	33°33.60'	131°59.40'	33°39.60'	132°06.60'	217	112
C2-39-2008	39	33°46'	132°13'	20/02/2008	16:52	33°41.40'	132°07.80'	33°47.40'	132°16.20'	20	223
C2-40-2008	40	33°47'	132°16'	19/03/2008	19:27	33°48.00'	132°16.80'	33°42.00'	132°10.20'	45	170
C2-41-2008	41	33°37'	131°58'	19/03/2008	22:54	33°40.20'	132°06.60'	33°36.60'	131°57.60'	660	149
C2-42-2008	42	33°28'	131°49'	20/03/2008	2:08	33°33.60'	131°49.20'	33°27.60'	131°48.60'	390	191
C2-43-2008	43	33°19'	131°26'	20/03/2008	6:11	33°20.40'	131°35.40'	33°19.20'	131°25.20'	270	66
C2-44-2008	44	33°22'	131°10'	20/03/2008	9:29	33°22.80'	131°19.20'	33°21.60'	131°09.60'	5	70
C2-45-2008	45	33°19'	131°00'	20/03/2008	12:27	33°20.40'	131°09.00'	33°18.60'	130°59.40'	9	105
C1-46-2008	46	33°16'	129°46'	20/03/2008	20:29	33°16.20'	129°54.60'	33°15.60'	129°44.40'	64	210
C1-47-2008	47	33°16'	129°34'	20/03/2008	23:31	33°15.00'	129°43.20'	33°15.60'	129°33.00'	320	88
C1-48-2008	48	33°15'	129°31'	21/03/2008	2:51	33°15.00'	129°31.20'	33°11.40'	129°25.20'	192	105
C1-49-2008	49	33°13'	129°22'	21/03/2008	5:30	33°12.00'	129°24.00'	33°16.20'	129°16.20'	160	105
C1-50-2008	50	33°19'	129°16'	21/03/2008	8:35	33°19.20'	129°16.20'	33°17.40'	129°07.80'	480	103
C1-51-2008	51	33°17'	129°05'	21/03/2008	11:36	33°17.40'	129°07.20'	33°16.80'	129°03.60'	4	38
W2-52-2008	52	33°16'	128°58'	21/03/2008	13:40	33°16.20'	129°04.20'	33°15.60'	128°52.20'	270	88
W2-53-2008	53	33°15'	128°43'	21/03/2008	17:06	33°15.00'	128°45.60'	33°15.00'	128°36.00'	96	175
W2-54-2008	54	33°19'	128°34'	21/03/2008	20:26	33°16.20'	128°36.00'	33°16.20'	128°25.80'	64	105
W1-55-2008	55	33°13'	127°25'	22/03/2008	5:36	33°13.80'	127°28.20'	33°12.00'	127°19.20'	50	35
W1-56-2008	56	33°15'	126°52'	22/03/2008	11:29	33°10.20'	126°46.20'	33°09.60'	126°36.00'	0	64
W1-57-2008	57	33°10'	126°34'	22/03/2008	14:30	33°09.60'	126°34.20'	33°12.00'	126°25.20'	0	70
W1-58-2008	58	33°16'	126°12'	22/03/2008	19:42	33°16.20'	126°12.00'	33°15.00'	126°21.60'	96	315
W1-59-2008	59	33°15'	126°19'	22/03/2008	22:50	33°15.00'	126°18.60'	33°13.20'	126°28.80'	61	140
W1-60-2008	60	33°10'	126°46'	23/03/2008	4:09	33°09.60'	126°45.00'	33°12.60'	126°54.60'	101	131
W1-61-2008	61	33°16'	127°22'	23/03/2008	9:24	33°15.60'	127°20.40'	33°16.20'	127°30.60'	9	210
W2-62-2008	62	33°17'	128°34'	23/03/2008	17:07	33°16.20'	128°19.80'	33°15.00'	128°29.40'	1710	235
W2-63-2008	63	33°13'	128°35'	23/03/2008	20:00	33°15.00'	128°28.20'	33°12.00'	128°36.60'	34	140
W2-64-2008	64	33°12'	128°45'	23/03/2008	0:07	33°11.40'	128°42.00'	33°14.40'	128°51.00'	240	66
C1-65-2008	65	33°16'	129°01'	23/03/2008	3:46	33°15.60'	128°55.20'	33°16.20'	129°05.40'	330	98

Shot code	Shot	Stratum point		Shot date	Time of shot	Start Point		Finish Point		Catch (kg)	
		Lat	Long			Lat	Long	Lat	Long	Bight redfish	Deepwater flathead
C1-66-2008	66	33°16'	129°13'	24/03/2008	6:55	33°18.00'	129°05.40'	33°16.20'	129°13.80'	229	105
C1-67-2008	67	33°17'	129°19'	24/03/2008	10:25	33°17.40'	129°13.80'	33°16.80'	129°23.40'	38	175
C1-68-2008	68	33°19'	129°28'	24/03/2008	13:30	33°18.00'	129°23.40'	33°15.60'	129°30.60'	4	38
C1-69-2008	69	33°10'	129°34'	24/03/2008	16:57	33°09.60'	129°34.20'	33°16.20'	129°30.00'	4	105
C1-70-2008	70	33°16'	129°43'	24/03/2008	20:10	33°16.20'	129°34.20'	33°15.00'	129°44.40'	160	140
C1-71-2008	71	33°12'	129°50'	24/03/2008	23:41	33°12.00'	129°48.00'	33°12.00'	129°58.80'	160	140
C2-72-2008	72	33°17'	131°10'	25/03/2008	9:07	33°16.80'	131°03.00'	33°18.00'	131°13.20'	672	70
C2-73-2008	73	33°23'	131°16'	25/03/2008	12:20	33°18.00'	131°13.20'	33°18.00'	131°18.60'	210	82
C2-74-2008	74	33°22'	131°40'	25/03/2008	15:40	33°21.60'	131°32.40'	33°22.20'	131°42.00'	3	107
C2-75-2008	75	33°34'	131°50'	25/03/2008	19:34	33°31.20'	131°45.60'	33°35.40'	131°54.00'	3	105
C2-76-2008	76	33°37'	132°01'	25/03/2008	22:35	33°37.20'	132°19.20'	33°40.80'	132°08.40'	780	109

Table 5. Species and numbers of fish for which length, sex, and otolith samples were collected during 2008 survey.

Species	Length frequency (unsexed)	Otoliths collected
Deepwater flathead	1552	254
Bight redfish	1300	294

Table 6. Estimated total relative biomass (t) with coefficient of variation (c.v.) of major commercial species in across all strata from 2005, 2006, 2007 and 2008 surveys assuming net width of 16.3 m.

Species	Estimated Relative biomass							
	2005		2006		2007		2008	
	t	c.v.	t	c.v.	t	c.v.	t	c.v.
Bight redfish [A]	20887	0.13	25380	0.16	25713	0.16	14591	0.11
Deepwater flathead	12152	0.05	8415	0.06	8540	0.05	7725	0.06
Ocean jacket	7163	0.14	9111	0.26	6701	0.37	7709	0.29
Common sawshark	298	0.16	138	0.23	462	0.24	231	0.14
Yellowspotted boarfish	349	0.19	181	0.15	142	0.26	170	0.25
Gummy shark	558	0.17	288	0.25	402	0.23	434	0.14
Jackass morwong	1025	0.34	1037	0.23	1236	0.31	916	0.30
Knifejaw	955	0.12	1133	0.14	570	0.13	806	0.11
Latchet	9401	0.13	6135	0.25	7040	0.21	3688	0.17
Ornate angelshark	3078	0.09	1887	0.10	2770	0.11	1742	0.10
Spikey dogfish	834	0.24	867	0.30	1006	0.23	508	0.33
Other species	11693	0.13	14405	0.14	22990	0.14	17558	0.12

[A] night hauls only