Monitoring and assessment of by-catch and by-product species of the Spencer Gulf Prawn Fishery

Report to PIRSA

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EXECUTIVE SUMMARY

1. This report documents the distribution and abundance of by-catch in the Spencer Gulf Prawn Fishery from surveys conducted by prawn fishers since 1994, fishery-independent surveys conducted by SARDI during 2004/05, and commercial logbook information collected since 2002.

2. The aims of the report were to: determine the species composition and relative abundance of by-catch; determine the distribution, abundance and size frequency of common by-catch species; determine appropriate indicator species; and identify key elements of a future by-catch monitoring program.

3. Fish, sponges, blue crabs, sharks and rays dominated the total weight of by-catch. Relative abundance of each species or species group varied among regions. Total by-catch was highest in northern Spencer Gulf, and significantly lowest in the Middlebank/Shoalwater region.

4. Considerable data on the distribution and abundance (catch rate) of some common by-catch species were available, though replication was poor. Abundance of blue crabs, cuttlefish, snapper, flatfish and flathead were highest in the North. No spatial trends were apparent for calamary or King George whiting. Cuttlefish and snapper abundance was greater in February than November.

5. Data were used to develop a list of potential indicator species that included: calamary, slipper lobster, blue crabs, King George whiting, snapper, flounder, flathead, cuttlefish, sand trevally, Degen's leatherjacket, Port Jackson shark, elephant fish and smooth stingray. Historic abundance data were inadequate to determine statistically significant long-term trends in abundance.

6. Substantial size-frequency data were available for cuttlefish, calamary, snapper, flounder and King George whiting. Temporal variation may limit its use as a performance indicator of population health.

7. Calamary shows few temporal or spatial trends in abundance and changes in calamary catch may not be a likely consequence of changes in harvest strategies. Slipper lobsters were most abundant in northern Spencer Gulf during November and December. Prawn harvest strategies that minimise fishing in these locations and months would reduce the risk to slipper lobster populations.

8. A by-catch monitoring program for the Spencer Gulf Prawn Fishery is urgently required, the components of which should include: a pilot fishery-independent by-catch study to finalise the indicator species list and determine their performance measures; an on-going by-catch survey at an appropriate scale, and; an observer program to measure the correlation between survey and fishing data, validate commercial logbook data, and determine rates of by-product species discarding. The establishment of mandatory reporting systems for interactions with endangered, threatened and protected species by commercial fishers is also a high priority.

1 GENERAL INTRODUCTION

1.1 Background

Prawn species are globally distributed, and as such, commercial prawn trawl fisheries affect a large variety of coastal ecosystems. Common to all prawn fisheries are issues regarding the capture of non-target "by-catch" species (see review by Andrew and Pepperell, 1992). By-catch usually includes species of important economic significance to the commercial and/or recreational fishing sectors. It can also include species of ecological significance, such as protected, threatened or endangered species. The effect of removal of large amounts of by-catch from the ecosystems that prawns inhabit is generally poorly understood.

Within Australia, prawns are commercially harvested in both tropical and temperate waters, in oceanic and embayment habitats. Consequently the composition, distribution and abundance of by-catch species from Australian prawn fisheries are highly variable. Indeed, studies have shown that within fishery variation is also high. In a study of oceanic trawling in New South Wales at four locations over 8 seasons between 1990 and 1992, Kennelly et al (1998) found that species-specific variations in abundances were detected at all spatial and temporal scales. Thus quantification of the effects of trawling on the ecosystem is likely to require considerable resources.

South Australia has the only single species prawn fisheries in Australia, targeting the Western King prawn, *Melicertus latisulcatus*. Of the three commercial prawn fisheries in South Australia, Spencer Gulf is the largest in terms of total area and production (Dixon et al 2005). The fishery began in 1968 and the Spencer Gulf and West Coast Prawn Fishermen's Association (SGWCPFA) has worked with scientists and managers in developing the fishery throughout its history.

Significant improvements in the understanding of the fishery began in 1982, when prawn stock assessment surveys were introduced in Spencer Gulf from collaboration between SARDI Aquatic Sciences and the SGWCPFA. These surveys had the primary aim of developing harvest strategies that have since ensured the sustainable fishing of prawns (Dixon et al 2005). The industry has also been cognisant of issues surrounding by-catch of the fishery and has expended considerable resources in by-catch mitigation technology (McShane et al 1997, Carrick 2003), modification of commercial logbooks to include by-catch and by-product reporting, and ad-hoc by-catch research that aimed to determine the composition of by-catch, and the distribution, abundance and biology of several by-catch species.

1.2 Need

The implementation of the *Environment Protection and Biodiversity Conservation (EPBC) Act (1999)* required the Commonwealth Government to ensure the ecologically sustainable management of Australia's export fisheries. In 2003, PIRSA Fisheries provided the Commonwealth Department of Environment and Heritage (DEH) with an ecological assessment of South Australia's prawn trawl fisheries (Anon 2003) to gain export approval for these fisheries. In response, a strategic assessment was developed by the DEH (Anon 2004) that provided a set of recommendations to improve management arrangements and further increase the likelihood of ecologically sustainable fishing. Exemption from export controls was granted for all three South Australian prawn fisheries for a five-year period, with progress toward these recommendations providing the foundation for reassessment of their export status after 3 November 2009.

Of the 12 recommendations provided by the DEH, several relate specifically to the ongoing monitoring and reporting of by-catch for South Australian prawn fisheries. These include: a) the development and implementation of harvest strategies for all by-product species, b) monitoring of by-catch indicator species to detect long-term trends, and c) mandatory reporting of interactions with endangered, threatened or protected species. Considerable unpublished data exists for the Spencer Gulf Prawn Fishery that may aid the development of an appropriate by-catch monitoring program to address these recommendations for the fishery.

1.3 Definition of terms

Addressing the DEH recommendations relating to by-catch requires the definition of key terms. Definitions were sought from appropriate literature or were provided by the authors for the purposes of this report.

a) *The development and implementation of <u>harvest strategies</u> for all <u>by-product species</u>.*

- *<u>By-product species</u>* are those by-catch "retained because they are commercially valuable but are not the main target species" (Environment Australia 2001). Two species of by-product may be retained in Spencer Gulf: southern calamary (*Sepioteuthis australis*) and slipper lobster (*Ibacus* spp).
- In the Spencer Gulf Prawn Fishery *<u>harvest strategies</u>* relate to structured fishing effort using spatial and temporal closures developed through the real-time management system. Harvest strategies aim to ensure sustainable fishing of prawn stocks whilst maximising economic return of the catch.

b) *Monitoring of by-catch indicator species to detect long-term trends*.

- *By-catch* species are those "discarded from the catch or retained for scientific purposes, and that part of the catch that is not landed but is killed as a result of interaction with fishing gear. This includes discards of by-product species" (Environment Australia 2001).
- *Indicator species* are those species deemed important to monitor to ensure their long-term sustainability. These include species of ecological significance and species of economic significance such as by-product species and important recreational or commercial species.
- Indicator species must be captured at a frequency that enables statistical assessment of *long-term trends*. Abundance is the most important long-term trend to detect in populations of indicator species and changes in abundance can only be rigorously determined by statistical assessment from data obtained consistently over extended periods. As such, infrequency of capture is likely to preclude threatened, protected and endangered species from statistical assessment of long-term trends in abundance. Other population parameters may be considered for statistical assessment of long-term trends, such as changes in size distribution.

c) *Mandatory reporting of interactions with endangered, threatened or protected species*.

- *Interactions* include both direct (capture) and indirect (non-capture) interactions with fishing gear and or vessels (i.e. vessel collision is a non-capture interaction).

1.4 Aims and Objectives

This report provides a synthesis of historic information to specifically address the DEH recommendations relating to by-catch for the Spencer Gulf Prawn Fishery. This will be achieved by:

1. describing the species composition and relative abundance of by-catch,
2. describing the distribution, abundance (catch rate) and size-frequency of common by-catch species,
3. determining appropriate indicator species, and
4. identifying key elements of a future by-catch monitoring program.

1.5 Sources of data

Data were available from three main sources: by-catch data collected during surveys conducted by the Spencer Gulf prawn fishers (referred to herein as "prawn surveys"); by-catch data obtained during targeted fishery-independent by-catch surveys (referred to herein as "by-catch surveys"); and commercial logbook data.

1.5.1 Prawn surveys

Prawn surveys, using industry vessels with observers, have been conducted at up to 300 fixed stations since February 1982. These surveys were conducted with the primary aim of determining the status of prawns stocks for the development of harvest strategies. Detailed survey methodology is provided in Dixon et al (2005). In November 1994, by-catch data were collected in supplement to stock assessment survey data. In subsequent years, various by-catch studies were opportunistically conducted to collect data on: species composition and relative abundance of total by-catch (Section 2); distribution and abundance of individual species (Section 3), and; length-frequency of individual species (Section 4). Data were collected in all regions of Spencer Gulf except the Thistle Island region (Figure 1.1).

1.5.2 By-catch surveys

By-catch surveys were carried out in Spencer Gulf using RV Ngerin during October 2004 (7–15) and January 2005 (23–28) as a part of the FRDC project "Prawn Fishery By-catch and Discards: marine ecosystem analysis – population effects" (FRDC 03/023). Surveys were conducted at five sites (Figure 1.1) representing regions that contribute the majority of catch from the Spencer Gulf Prawn Fishery (Dixon et al 2005). Data collected provide information on species composition and relative abundance of total by-catch (Section 2), and distribution and abundance of individual species (Section 3).

1.5.3 Commercial logbook data

In 2002, commercial logbooks were modified to include information on by-catch and by-product. By-catch data are voluntarily recorded for each trawl shot. A table of species codes and quantitative categories (Appendix 1) are provided in the logbook, enabling the recording of data on sharks and rays, teleost fish, crabs, cephalopods, turtles, syngnathids, sponge, sea cucumber, bryozoans, gorgonians and stony coral. Fishers are permitted to take two "by-product" species: slipper lobster (*Ibacus* spp) and southern calamari (*Sepioteuthis australis*). It is only mandatory to report the retained portion of daily catches of slipper lobster and calamari in logbooks, hence data do not reflect the total catch of these species. Commercial logbook data are presented in Section 3.

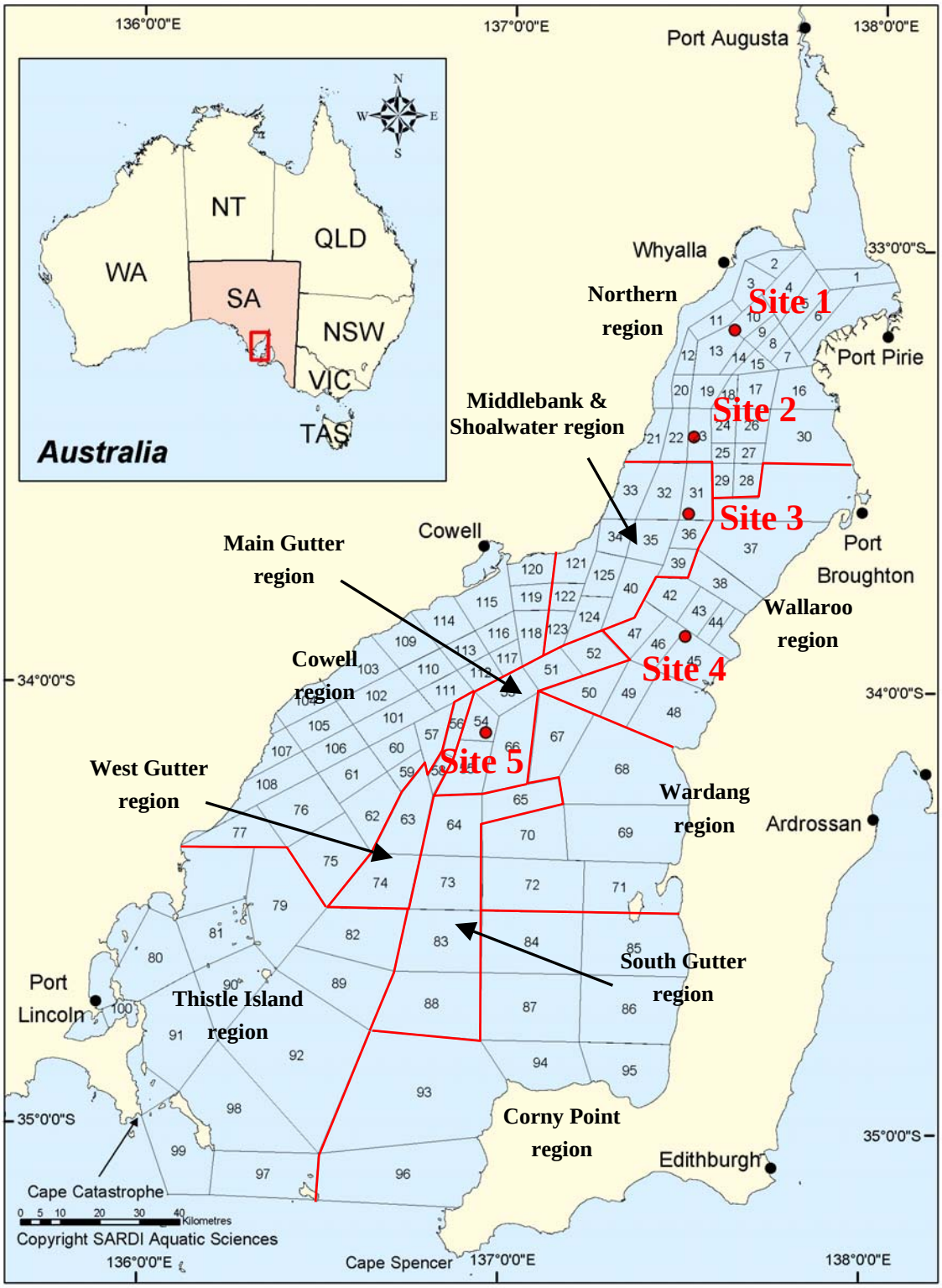

Figure 1.1 Fishing blocks, trawl regions, and fishery-independent by-catch survey sites (red) in Spencer Gulf.

2 SPECIES COMPOSITION AND RELATIVE ABUNDANCE OF BY-CATCH

2.1 Introduction

The species composition and relative abundance of by-catch from the Spencer Gulf prawn fleet is poorly documented. Carrick (1997) provided preliminary analysis of by-catch data obtained during prawn surveys conducted at 32 stations in Spencer Gulf during February 1996. Species composition and abundance data presented in this section were collected from prawn surveys conducted in February 2000 and by-catch surveys conducted in October 2004 and January 2005. These data are used to assess potential by-catch indicator species and to provide a baseline assessment of the abundance of indicator species for the development of performance indicators for on-going monitoring.

2.2 Aims

This section of the report a) describes the composition and relative abundance of by-catch in Spencer Gulf from both prawn surveys and by-catch surveys, and b) assesses potential indicator species.

2.3 Methods

Prawn surveys

Species composition and relative abundance of by-catch was collected from prawn surveys during February 2000 from 17 trawl shots in the North, 5 trawl shots in Middlebank/Shoalwater and 9 trawl shots in the Main Gutter regions (Figure 1.1). The total weight, and in some cases number of each species or species group (Table 2.1) was recorded for each trawl shot. Data were summarised by region for spatial comparisons in species composition and abundance.

A lack of documentation necessitated the development of several important assumptions for analyses including: data collected were from one net only; each trawl was 30 minutes in duration; abundance data (count and weight) included all individuals captured in that trawl, and; catch composition data include all species captured.

Table 2.1 Species grouped or treated singularly for by-catch data collected during prawn surveys during February 2000 in Spencer Gulf.

Species group or common name	Group composition
Fish	All teleost fish
Rays	All stingrays and skates
Sharks	All species of sharks including elephant fish
Sponges	All species
Starfish	All species
Octopus	All species
Mussels	All species
Scallops	All species
Sea cucumbers	All species
Sea squirts	All species
Cuttlefish	*Sepia nova* and *S. aparma*
King prawn	Single species
Calamary	Single species
Slipper lobster	Single species
Blue Crabs	Single species

By-catch surveys

By-catch surveys were conducted during October 2004 (7–15) and January 2005 (23–28). During each survey eight 30-minute trawl shots (four at day and four at night) were carried out at five sites (Figure 1.1), using one standard prawn trawl net with a headline length of 14.63 m and a 4.5 cm diamond mesh cod end. Trawl speed was maintained at 3 knots. The eight trawl transects at each site were selected haphazardly in the vicinity of fixed GPS positions, avoiding trawling over transects previously sampled during that survey.

The sampling design of by-catch surveys enabled a full-factorial ANOVA with survey, site, and time of day as the main factors. The presence of large elasmobranchii (particularly smooth stingrays and Port Jackson sharks) in some samples but not in others caused large variances that could not be validly transformed. Thus non-parametric tests were used for statistical comparisons of abundance. Post-hoc comparisons were done using an SNK-test.

After each 30-minute trawl shot the catch was sorted and species were identified and weighed either individually or in species groups (Table 2.2).

Table 2.2 Species grouped or treated singularly for ANOVA from fishery-independent survey by-catch data collected from Spencer Gulf.

Species group or common name	Group composition
Miscellaneous teleosts	Bullseye, hardyhead, soldierfish, etc.
Miscellaneous elasmobranchii	Sparsely spotted stingaree and shovelnose ray
Benthos	Sponges, bryozoans, molluscs, etc.
Cephalopods	Calamary and cuttlefish
Blue crab	Single species
Slipper lobster	Single species
King prawn	Single species
Degens leatherjacket	Single species
Sand Trevally	Single species
Snapper	Single species
Port Jackson shark	Single species
Australian Angel shark	Single species
Elephant fish	Single species
Cobbler Wobbegong	Single species
Melbourne Skate	Single species
Fiddler Ray	Single species
Smooth Stingray	Single species
Black Ray	Single species
Eagle Ray	Single species

2.4 Results

Prawn surveys

Species composition and mean abundance of trawl by-catch was highly variable among regions of Spencer Gulf surveyed during prawn surveys conducted in February 2000, despite only small differences in catch weight of prawns (Figure 2.1, a and b). The most abundant group by weight was teleost fish, although average catches ranged from 6–58 kg per trawl shot in Middlebank/Shoalwater and Main Gutter regions respectively. Catches of blue crabs and sponges were high (>20 kg) in the North. Catches of rays were highest in the Middlebank/Shoalwater region, although they were quite variable. Catches of calamary, sea cucumbers, sea squirts, bugs, starfish, scallops and starfish averaged <1 kg per trawl shot in all surveyed regions.

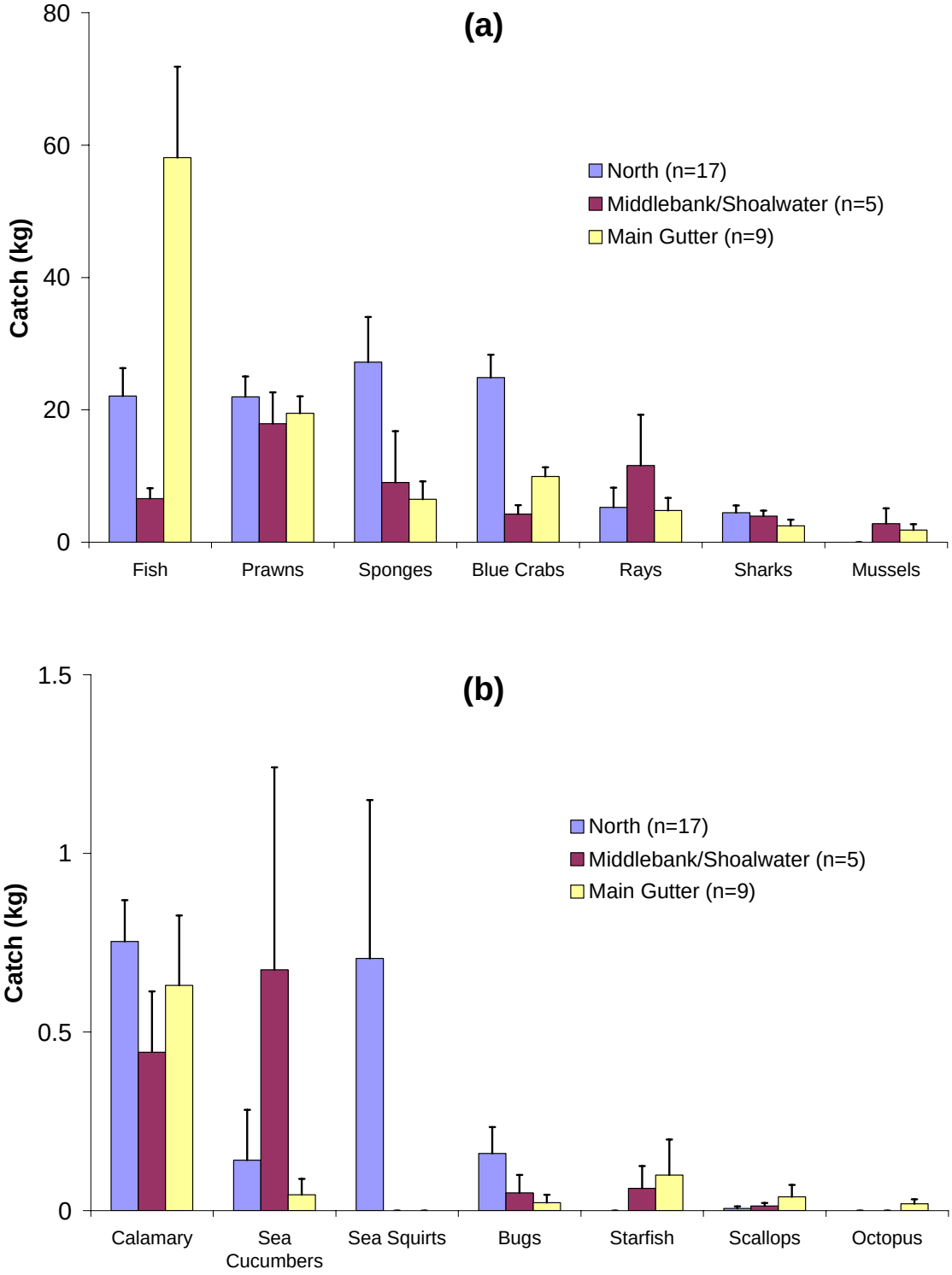

Figure 2.1 Average catches per trawl shot for species with an average catch (a) >1 kg and (b) <1 kg captured in the North, Middlebank/ Shoalwater and Main Gutter regions during February 2000.

By-catch surveys

By-catch surveys showed differences in species composition and their relative abundance among sites (Figure 2.2). At Sites 1 and 2 benthos dominated catches, followed by blue crabs, miscellaneous fish and sand trevally. Eagle rays were also abundant at Site 2. At Sites 3 and 4 the abundance of benthos was relatively low thus increasing the relative abundance of blue crabs, sand trevally (Site 3 only), Port Jackson sharks and miscellaneous fish. At Site 5, sand trevally and smooth stingray dominated relative abundance, with smaller contributions from miscellaneous fish and Degens leatherjacket. In general, relative abundance by weight was strongly affected by the occurrence of large elasmobranchii in some samples.

There was no statistical difference in catch rate of total by-catch between by-catch surveys conducted in October 2004 and January 2005 (Mann-Whitney U-test, Z=-0.170, P=0.865). As a result data from both surveys were combined in further analyses. There was also no statistical difference in the catch rates of total by-catch between day and night trawling (Mann-Whitney U-test, Z=0.050, P=0.960), and as before all data were combined for further analyses. Comparisons of by-catch data suggested that significant differences existed among sites (Kruskal-Wallis Test, χ^2=45.059, df=4, p<0.05; Figure 2.3). An SNK test separated Site 3 from Site 2 and Site 1, 4 and 5 combined. No significant differences were found between Sites 1, 4 and 5.

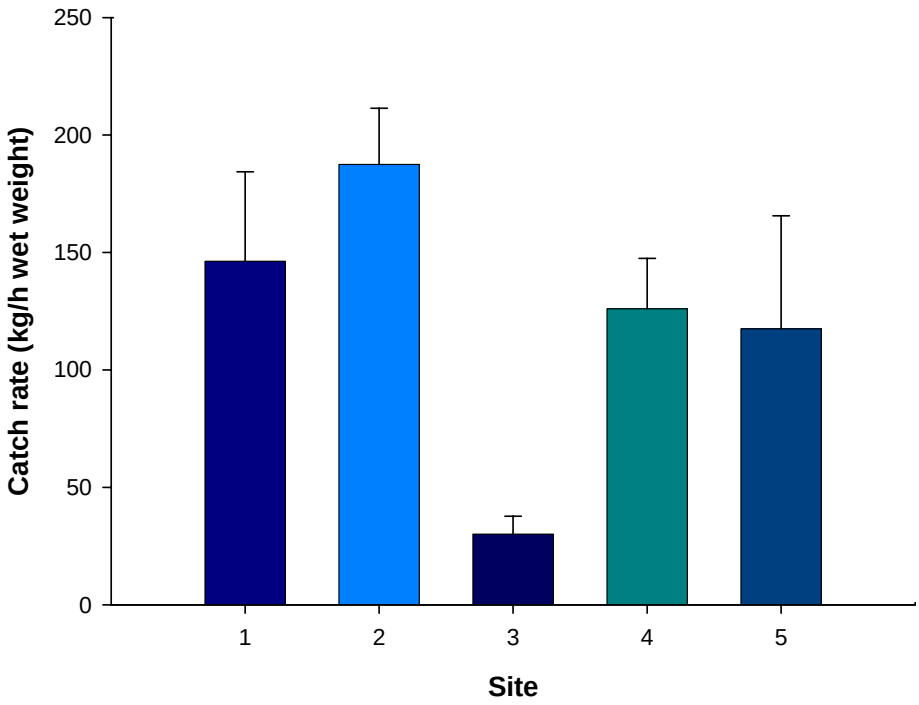

Figure 2.3 Average catch rates (kg/h wet weight + 95% CI) of by-catch (all species except prawns) obtained at five sites during two day and night by-catch surveys conducted in Spencer Gulf.

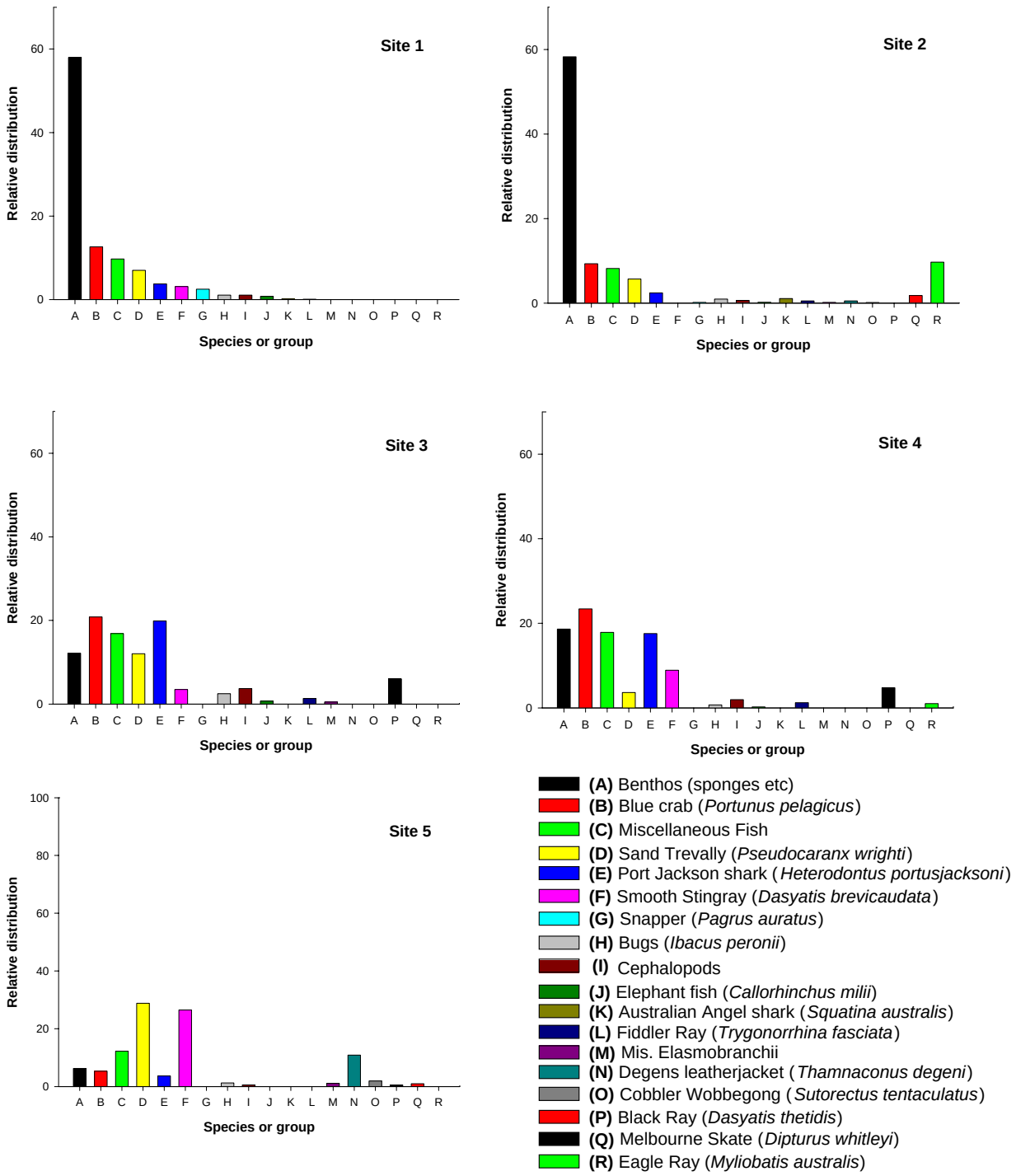

Figure 2.2 Species composition and relative abundance (% of total) of by-catch species or species groups from by-catch surveys conducted at five sites in Spencer Gulf.

2.5 Discussion

Limited data on the composition and abundance of by-catch were available for the Spencer Gulf Prawn Fishery. Prawn survey data are available from only 32 stations documented by Carrick (1997) and 31 stations during February 2000 presented in this report. Uncertainty in the interpretation of results arises from the limited number of sites surveyed, particularly when the data are aggregated by region. Further, the necessity of combining numerous species into species groups also reduces the resolution within the data.

By-catch surveys provided useful information from fished areas. Uncertainty in the interpretation of species abundance from by-catch surveys arises from the combining of data from surveys conducted in different months and at different times of day. Whilst statistical tests showed that there were no temporal differences in total by-catch weight between months or time of day, there are insufficient data to determine whether temporal differences exist for individual species or species groups. A pivotal assumption of by-catch surveys was that sites were representative of regions fished. As with prawn survey data, various individual species were combined into species groups.

Fish, benthos, blue crabs, sharks and rays dominated by-catch, although relative abundance of each group varied among regions. Variation in abundance also existed between data sources, however direct comparisons were complicated by differences in the number and location of sites surveyed and the aggregation of individual species into different species groups. In general, fish were most abundant in the Main Gutter region, benthos (sponges) was dominant in the North region, and blue crabs were most abundant in the North region during prawn surveys and the Wallaroo region during by-catch surveys. The abundance of sharks and rays varied considerably between data sources and among regions, predominately due to the presence of large rays that dominated by-catch weight. Mean total by-catch weight at Middlebank/Shoalwater was approximately 50% of that captured in the Main Gutter and North regions.

Total by-catch from by-catch surveys was also clearly lowest in the Middlebank/Shoalwater region with mean catch rates <25% of mean by-catch from other regions. Site 2 in the North region had significantly greater catch rates of total by-catch than all other sites, primarily due to the high abundance of benthos, including sponge. There was no significant difference in the catch rate of total by-catch from Site 1 in the North, Site 4 at Wallaroo, and Site 5 in the Main Gutter, although the composition at each site was variable with a high abundance of benthos

at Site 1, blue crabs, fish and Port Jackson sharks at Site 4 and sand trevally and smooth stingray at Site 5.

The DEH recommendations (Anon 2004) include the assessment of long-term trends in by-catch indicator species. The first step toward achieving this recommendation is the development of an appropriate indicator species list. Some species were listed in the ecological assessment of South Australia's prawn trawl fisheries (Anon 2003) but it was noted that development of a long-term monitoring program would require "an evaluation of data and the rationale for selecting indicator species".

In this report species were deemed as potential indicators if they were of ecological importance or of economic importance such as by-product, commercial and recreational species. Whilst economically important species are easy to identify, determining important species in ecological terms is more difficult to define and may require subjective assessment in some cases.

To determine long-term trends in abundance it is paramount that indicator species are captured at sufficient frequency to enable robust statistical assessment. Whilst by-catch species composition and relative abundance data are an ideal data source to make such an evaluation, the poor replication of historic data from Spencer Gulf at all spatial and temporal scales prevented statistical assessment. As a result the historic data presented in this report were used only to evaluate potential indicator species.

Both by-product species permitted for capture in Spencer Gulf are potential indicator species. Slipper lobster (*Ibacus* spp) were captured in moderate abundance in both by-catch and prawn surveys in each surveyed region. Calamary (*Sepioteuthis australis*) were captured in moderate abundance during prawn surveys, whilst cephalopods (calamary and cuttlefish) were captured in moderate abundance during by-catch surveys.

Species composition and abundance data obtained from both prawn and by-catch surveys were useful for the identification of some commercial and recreational species. From the available data blue crabs (high abundance in both prawn and by-catch surveys) and snapper (moderate abundance in by-catch surveys) are potential indicator species. The grouping of individual species into species groups hindered the selection of other potential indicator species.

Whilst the establishment of important species in ecological terms is difficult to determine, species that are either regularly or sporadically high in abundance are likely to be important to the gulf's ecosystem. Although historic species composition and relative abundance data were limited by the combining of individual species into species groups, several consistently abundant species can be added to the potential indicator species list including: sponges, sand trevally, Degen's leatherjacket, smooth stingray and Port Jackson shark. Of note, large catches of black ray and eagle ray were made at one of the five by-catch survey sites, however this was due to their large mass and not their frequency of capture. Low levels of capture such as these would certainly preclude statistical assessment of trends in abundance over time. Furthermore, no endangered, threatened or protected species were captured during prawn or by-catch surveys. Therefore endangered, threatened and protected species should not be included as indicator species and alternative methods for assessing their interactions and capture should be sought.

Due to the inability to provide statistical assessment of abundance of potential indicator species from historic data, a substantial by-catch pilot study is required: to determine the appropriate number of sites to be surveyed; to refine the potential indicator species list by determining species that are captured at a frequency to enable statistical assessment, and; to determine the performance measures of indicator species.

3 DISTRIBUTION AND ABUNDANCE OF COMMON BY-CATCH SPECIES

3.1 Introduction

The distribution and abundance (assumed equal to catch rate) of common by-catch species is poorly documented for the Spencer Gulf Prawn Fishery. Carrick (1997) presented limited information on snapper, whiting and blue crabs from prawn surveys conducted at 32 stations in Spencer Gulf during February 1996. Data on the distribution and abundance of species presented in this section of the report were obtained from prawn surveys, by-catch surveys, and commercial logbook data. These data are useful to determine commonly captured species that may be appropriate indicator species, and to provide a baseline assessment of their abundance to detect long-terms changes in population size.

3.2 Aims

This section of the report a) describes the distribution and abundance (catch rate) of common by-catch species, b) assesses potential indicator species, and c) assesses the use of historic abundance data to provide a baseline assessment of abundance of indicator species.

3.3 Methods

Prawn surveys

Data on the abundance of eight important by-catch and by-product species were sporadically collected during seven prawn surveys conducted between November 1994 and December 2002. Data were collected from all regions of Spencer Gulf except Thistle Island (Figure 1.1). The species measured were snapper, King George whiting, flatfish (flounder and sole), flathead, calamary, cuttlefish (*Sepia apama* and *S. nova* combined), blue crabs and sponges. Data collected during November 1994 was limited to total counts per species, with all subsequent surveys including total counts and total weight per species. Data are presented using GIS software to provide a visual analysis of the spatial and temporal distribution of catch weight for eight species when data were collected from >30 trawl shots per survey.

From November 2001 to December 2002 the species composition and abundance (by count only) of elasmobranchii (sharks, rays and skates) was recorded from 515 trawl shots conducted in nine regions of Spencer Gulf. Data for the three most abundant species were summarised by survey and region to examine trends in their temporal and spatial distribution.

A lack of documentation necessitated the development of several important assumptions for analyses including: data collected were from one net only; each trawl was 30 minutes in

duration; abundance data (count and weight) included all individuals captured in that trawl; all "blank" data in the database meant data for that species and trawl shot was treated as "not collected"; all "0" data in the database meant that data for that species and trawl shot was treated as "nothing captured", and; all measurements were in consistent units.

By-catch surveys

Sampling methods for by-catch surveys were described in section 2.3. Data from all surveys and times of day were combined (see Section 2.4) and compared among each of the five sites. Relative abundance of cephalopods (calamary and cuttlefish), slipper lobster, sharks and rays, blue crabs, and benthos are presented. Data presented for sharks and rays includes all elasmobranchii listed in Table 2.2.

Commercial logbook data

The retained catch of the by-product species southern calamary (*Sepioteuthis australis*) and slipper lobster (*Ibacus* spp) was obtained from commercial logbooks from 2002 to 2004. Catches were reported for each nights fishing, whereas prawn catch, effort and fishing block fished (see Figure 1.1) were recorded for each trawl shot. In cases where more than one region was fished for one night, the proportion of effort applied in each region was used to apportion the by-product catch to each region. Annual, inter-annual and regional trends in catch rates of each species are presented. Mean catch rates and their associated standard errors were calculated after Rice (1995).

3.4 Results

Prawn surveys

By-catch data were collected during prawn surveys from November 1994 to December 2002 (Table 3.1). The abundance in number and weight of up to nine different species was measured from >400 trawl shots conducted during nine stock assessment surveys. Most frequently recorded were snapper, King George whiting, flatfish (flounder and sole), calamary, cuttlefish and blue crabs. Sponges were only recorded during 55 trawl shots over three separate surveys. In general the number of trawl shots conducted and the timing of data collected was poorly replicated.

Table 3.1 Number of trawl shots undertaken during prawn surveys where by-catch species were counted and weighed between November 1994 and December 2002. * Survey with counts only.

Species	Nov94*	Nov97	Feb98	Nov99	Feb00	Oct00	Nov01	Nov02	Dec02
Snapper	33	52	129	61	152	11	104	140	
KG Whiting	33	52	142	60	67	21		182	
Flatfish	33	51	9	62	152	11		140	
Flathead	2							137	
Calamary		52	151	59	145	14			
Cuttlefish		52	174	53	151	11		11	
Blue crabs				5	134	11	104	4	
Sponges						10		11	34

3.4.1 Calamary

Prawn surveys

Catches of calamary for 30-minute trawl shots from one net did not exceed 5 kg per shot during prawn surveys conducted between November 1997 and February 2000 (Figure 3.1). Catches >1 kg were obtained from most regions and periods surveyed. Zero catches were rare in November 1997 and February 2000, though some zero catches were obtained in Middlebank/Shoalwater, Main Gutter and Cowell regions during February 1998, and the Northern region in November 1999. In general there were no apparent trends in spatial or temporal distribution of the catch.

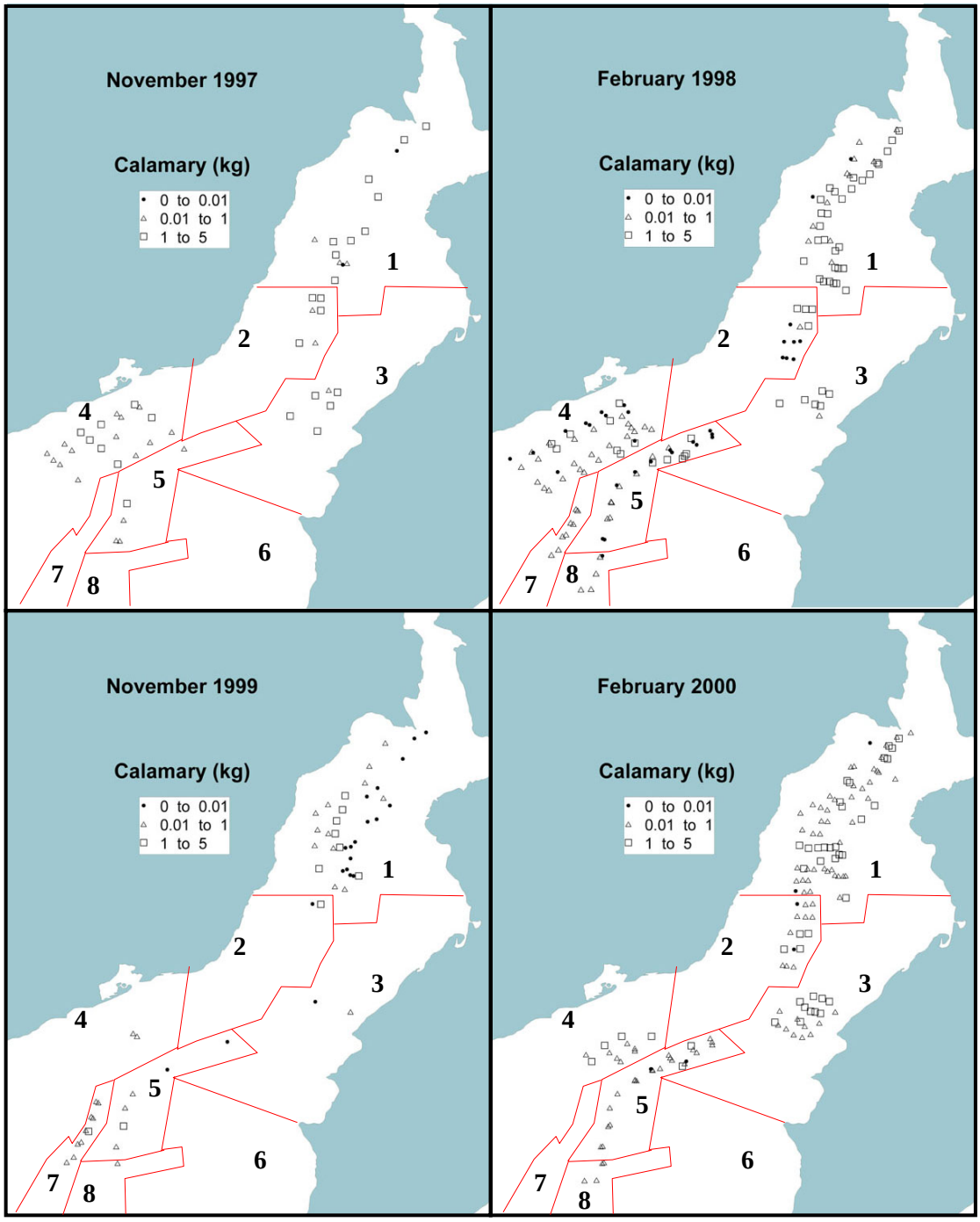

Figure 3.1 Weight of calamary caught in 30 minutes from one net during prawn surveys conducted in Spencer Gulf between November 1997 and February 2000. Regions: 1= North, 2= Middlebank/Shoalwater, 3=Wallaroo, 4=Cowell, 5=Main Gutter, 6= Wardang, 7=West Gutter, 8= South Gutter.

Commercial logbook data

Reported commercial catch rates of calamary were between 0.5–1.0 kg/hr in all regions of Spencer Gulf during 2002 (Figure 3.2). Catch rates were generally higher in 2003, particularly in the Cowell (~2.2 kg/hr) and Shoalwater/Middlebank (~1.7 kg/hr) regions. During 2004 catch rates exceeded 1.5 kg/hr in Northern, Shoalwater/Middlebank, Wallaroo and Cowell regions. In general catch rates of calamary were marginally higher in Northern regions.

Reported commercial catch rates of calamary were also between 0.5–1.0 kg/hr in all months fished during 2002 (Figure 3.3). During 2003 catch rates were approximately 1.5 kg/hr in April, May and June. In December 2003 catch rates did not exceed 0.5 kg/hr and during 2004 catch rates exceeded 1.3 kg/hr in all months fished. Catch rates approaching 2.0 kg/hr were obtained during April, May and November. In general reported calamary catch rates increased from 2002–2004, but showed no consistent temporal trends within years.

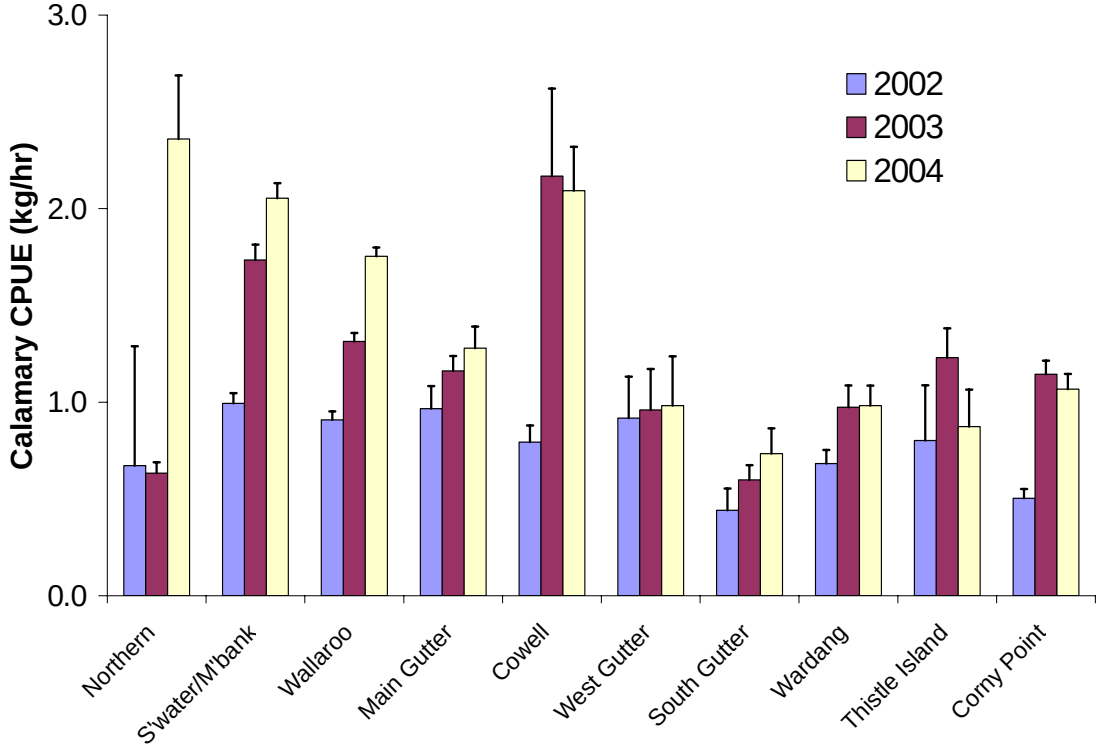

Figure 3.2 Catch rate of calamary from regions of Spencer Gulf obtained from prawn fishery commercial logbook data provided between 2002–2004.

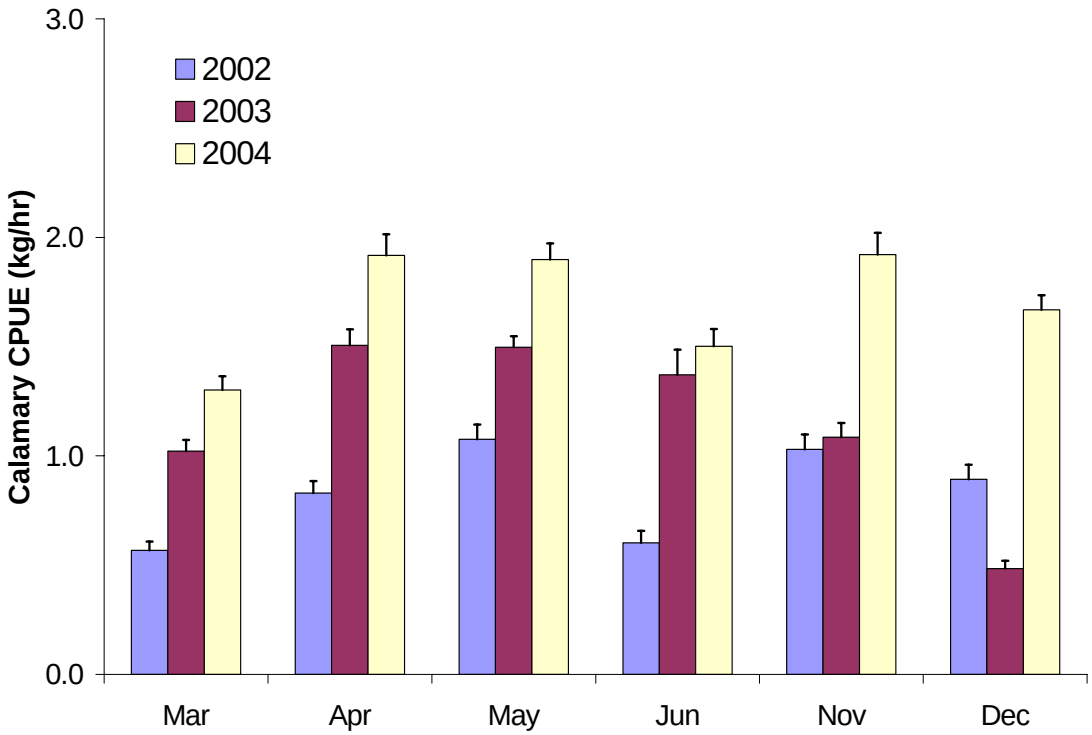

Figure 3.3 Catch rate of calamary in Spencer Gulf obtained from prawn fishery commercial logbook data during the six months fished from 2002–2004.

3.4.2 Slipper lobster

By-catch surveys

Catch rates of slipper lobster obtained from by-catch surveys were >1 kg/hr at both Northern region sites 1 and 2. Catch rates were <0.3 kg/hr at sites 3, 4 and 5 in Middlebank/Shoalwater, Wallaroo and Main Gutter regions respectively (Figure 3.4). Catch rates were highly variable at all sites.

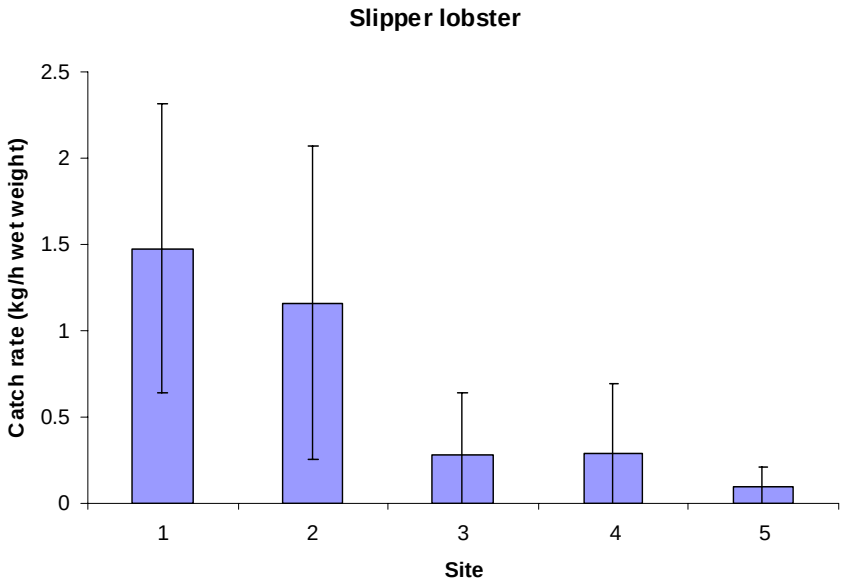

Figure 3.4 Mean catch rates (kg/h wet weight + 95% CI) of the group "slipper lobster" from by-catch surveys conducted at five sites in Spencer Gulf.

Commercial logbook data

Reported commercial catch rates of slipper lobster were <0.3 kg/hr in all regions of Spencer Gulf during 2002–2004 (Figure 3.5). Catch rates were variable both between years and between regions. Catch rates were consistently highest in North and Middlebank/Shoalwater regions, with sporadic high catch rates in Cowell and Wardang regions.

Reported commercial catch rates of slipper lobster were low and consistent in all months fished during 2002 (Figure 3.6). During 2003 and 2004 catch rates were low from March-June, and highest in November and December.

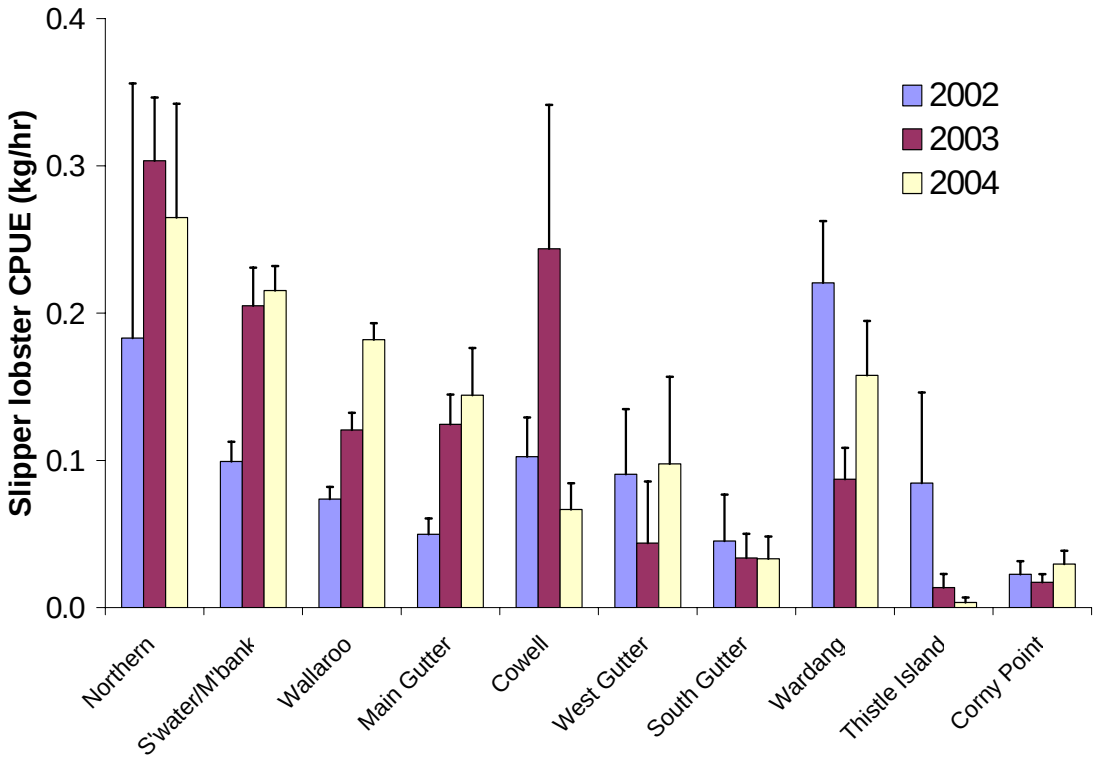

Figure 3.5 Catch rate of slipper lobster from regions of Spencer Gulf obtained from prawn fishery commercial logbook data provided between 2002–2004.

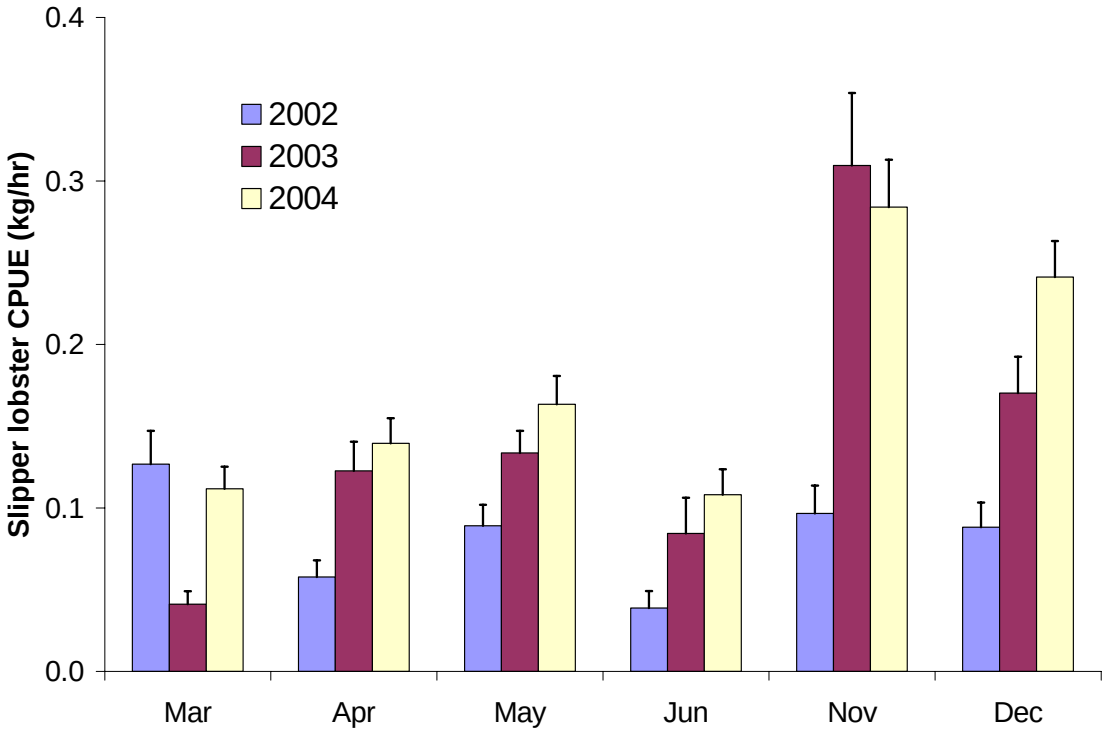

Figure 3.6 Catch rate of slipper lobster in Spencer Gulf obtained from prawn fishery commercial logbook data during the six months fished from 2002–2004.

3.4.3 Elasmobranchii (sharks and rays)

Prawn surveys

From November 2001 to December 2002 a total of 2,090 elasmobranchii (sharks and rays), comprising 25 different species, were captured from 515 surveyed stations (Table 3.2). Sharks comprised >77% of all elasmobranchii captured. The most abundant species was Port Jackson sharks (~1.8 per trawl shot), followed by elephant fish (~0.9 per trawl shot) and smooth stingray (~0.3 per trawl shot). All other species averaged <0.15 per trawl shot.

Table 3.2 Total number of elasmobranchii captured during 515 survey trawl shots conducted in Spencer Gulf between November 2001 and December 2002.

Species (common name)	Total count (515 trawl shots)
Port Jackson shark	928
Elephant fish	440
Smooth stingray	144
Fiddler Ray	76
Eagle ray	71
Cobbler carpetshark	64
Angelshark	56
Gulf Wobbygong	45
Black stingray	44
Coastal stingaree	40
Shovelnose shark	36
Sandyback stingaree	33
Skate	29
Gummy Shark	17
Saw shark	13
Spiked dogfish	12
Torpedo ray	12
Gulf stingray	11
Magpie Fiddler	6
Rusty catshark	6
Ground shark	3
Gulf catshark	1
Leopard shark	1
Numfish	1
Seven gilled shark	1

Mean catches of Port Jackson sharks were consistent over each of the four surveys (Figure 3.7). In contrast, elephant fish were only captured during November of 2001 and 2002 and smooth stingrays were consistently captured in low numbers during November 2002 but rarely captured on other occasions.

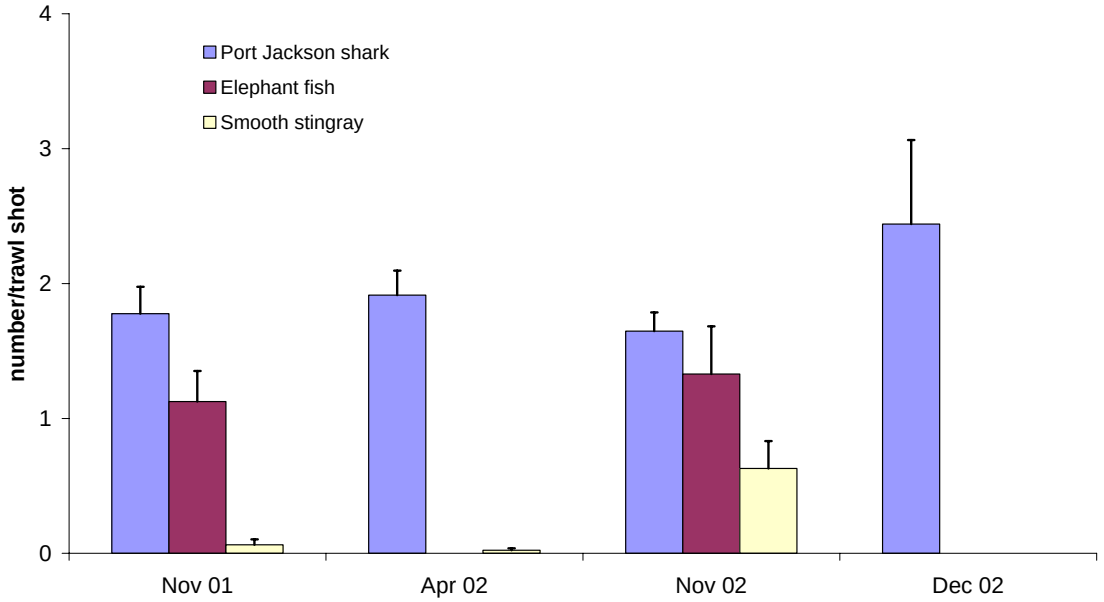

Figure 3.7 Mean (± s.e.) numbers of Port Jackson shark, elephant fish and smooth stingray from survey trawls conducted between November 2001 and December 2002.

Port Jackson sharks were captured in all regions except Corny Point, with the highest abundance in the Main Gutter (Figure 3.8). Elephant fish were abundant at Cowell and West Gutter, with infrequent catches in all regions other than South Gutter and Corny Point. Smooth stingrays were very abundant in South Gutter and moderately abundant in Main and West Gutter, with infrequent catches in Middlebank/Shoalwater, Wallaroo and Cowell.

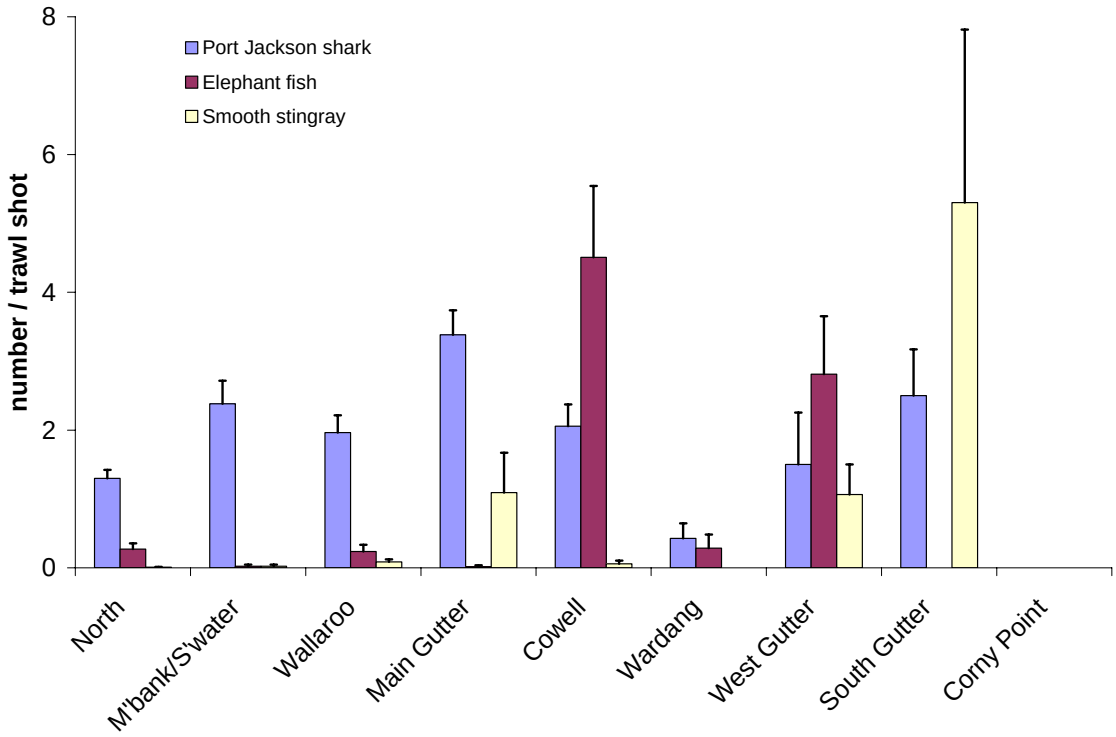

Figure 3.8 Mean (± s.e.) number of Port Jackson shark, elephant fish and smooth stingray from survey trawls conducted in regions of Spencer Gulf between November 2001 to December 2002.

By-catch surveys

The catch rate of sharks and rays obtained from fishery-independent surveys was highest at Site 4 (Wallaroo), 5 (Main Gutter) and 2 (North, Figure 3.9). The large variances at all sites, in particular Site 5, are caused by the occasional capture of large individual sharks and rays.

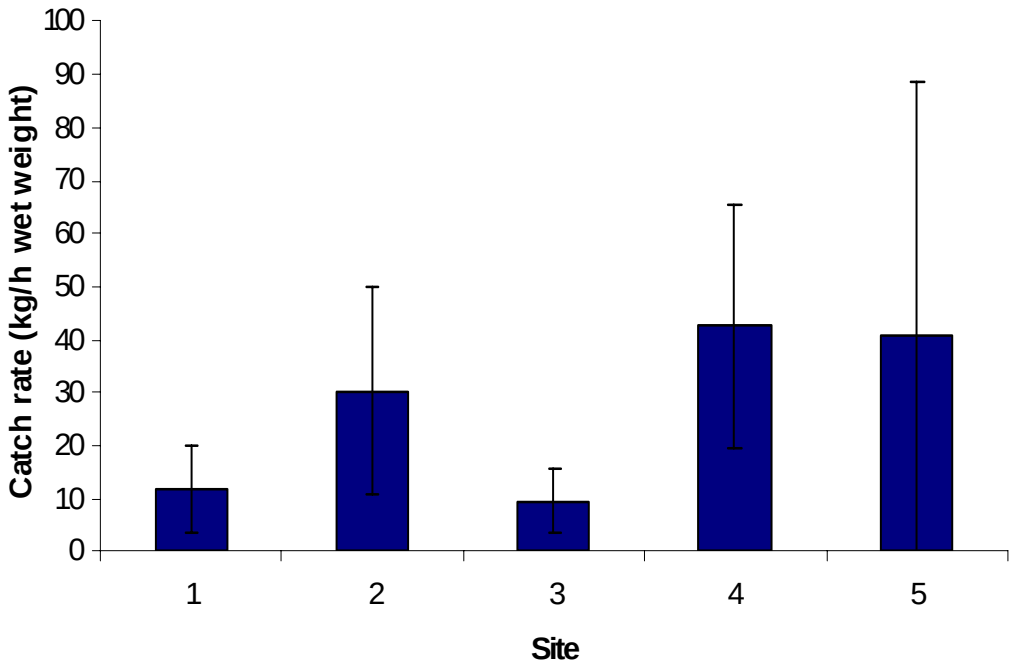

Figure 3.9 Mean catch rate (kg/h wet weight + 95% CI) of the group "elasmobranchii" from by-catch surveys conducted at five sites in Spencer Gulf.

3.4.4 Blue crabs

Prawn surveys

Catches of blue crabs up to 173 kg (1,320 individuals) were taken during November 2001 and up to 98 kg (446 individuals) February 2000 (Figure 3.10). During February 2000 catches of blue crabs were spread throughout the gulf, with catches between 20 and 100 kg found predominately in North and Wallaroo regions. During November 2001 the same trend of increasing abundance from south to north was evident, with total catches from the three most northern sites exceeding 100 kg. However catches had reduced in all regions other than the North, which increased substantially. Of note, 3240 blue crabs weighing 384 kg were captured at Wallaroo in November 2002. During this survey blue crab data were recorded at only 4 of 193 stations surveyed, with catches >25 kg in each instance, suggesting that data was probably recorded at these stations because of their high abundance.

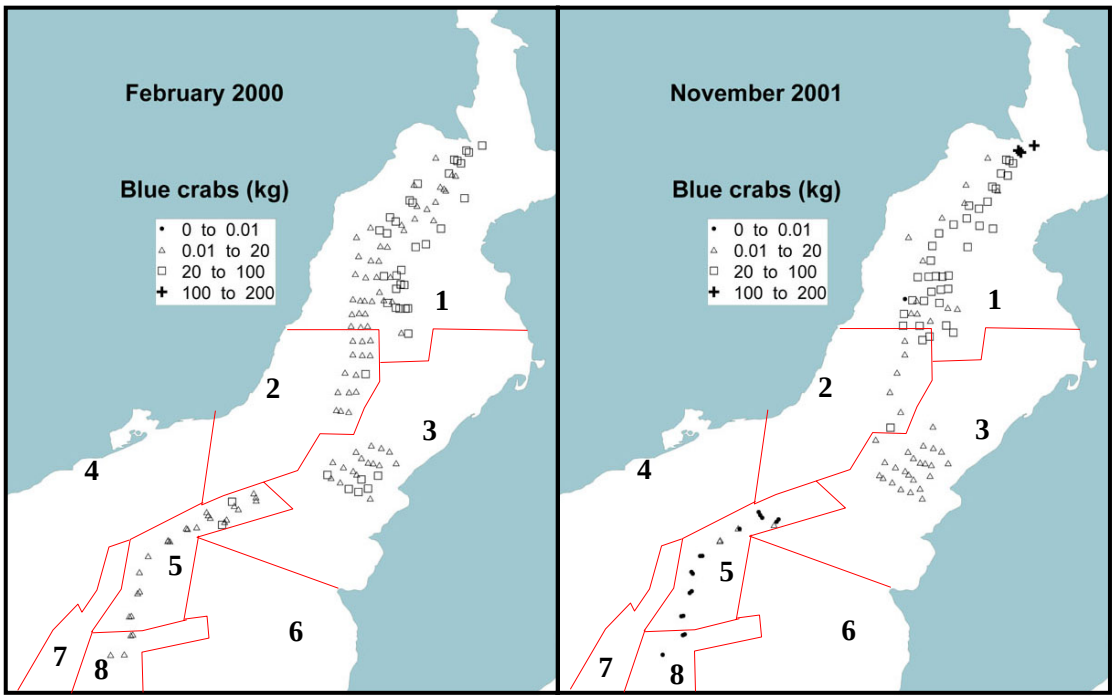

Figure 3.10 Weight of blue crabs caught in 30 minutes from one net during prawn surveys conducted in Spencer Gulf during February 2000 and November 2001. Regions: 1= North, 2= Middlebank/Shoalwater, 3=Wallaroo, 4=Cowell, 5=Main Gutter, 6= Wardang, 7=West Gutter, 8= South Gutter.

By-catch surveys

The catch rate of blue crabs was highest at Site 4 at Wallaroo (29.51 kg/h), followed by Sites 1 and 2 in the North, (Figure 3.11) and lowest at Sites 3 and 5.

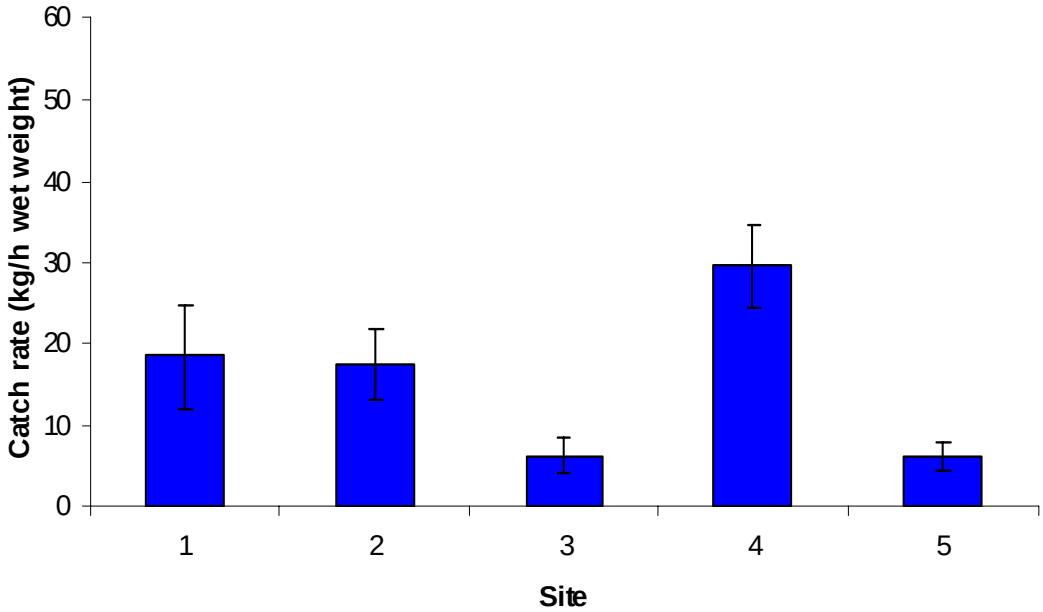

Figure 3.11 Mean catch rate (kg/h wet weight + 95% CI) of blue swimmer crabs from by-catch surveys conducted at five sites in Spencer Gulf.

3.4.5 Cuttlefish

Prawn surveys

Catches of cuttlefish were <7 kg between November 1997 and February 2000 (Figure 3.12). Abundance of cuttlefish was greater in February than November, however fewer stations were surveyed during November of 1997 and 1999. Abundance was highest in the North and Wallaroo regions, with few trawl shots of zero catch in the North region during February 1998 and 2000. Catches in regions other than North and Wallaroo rarely exceeded 1 kg.

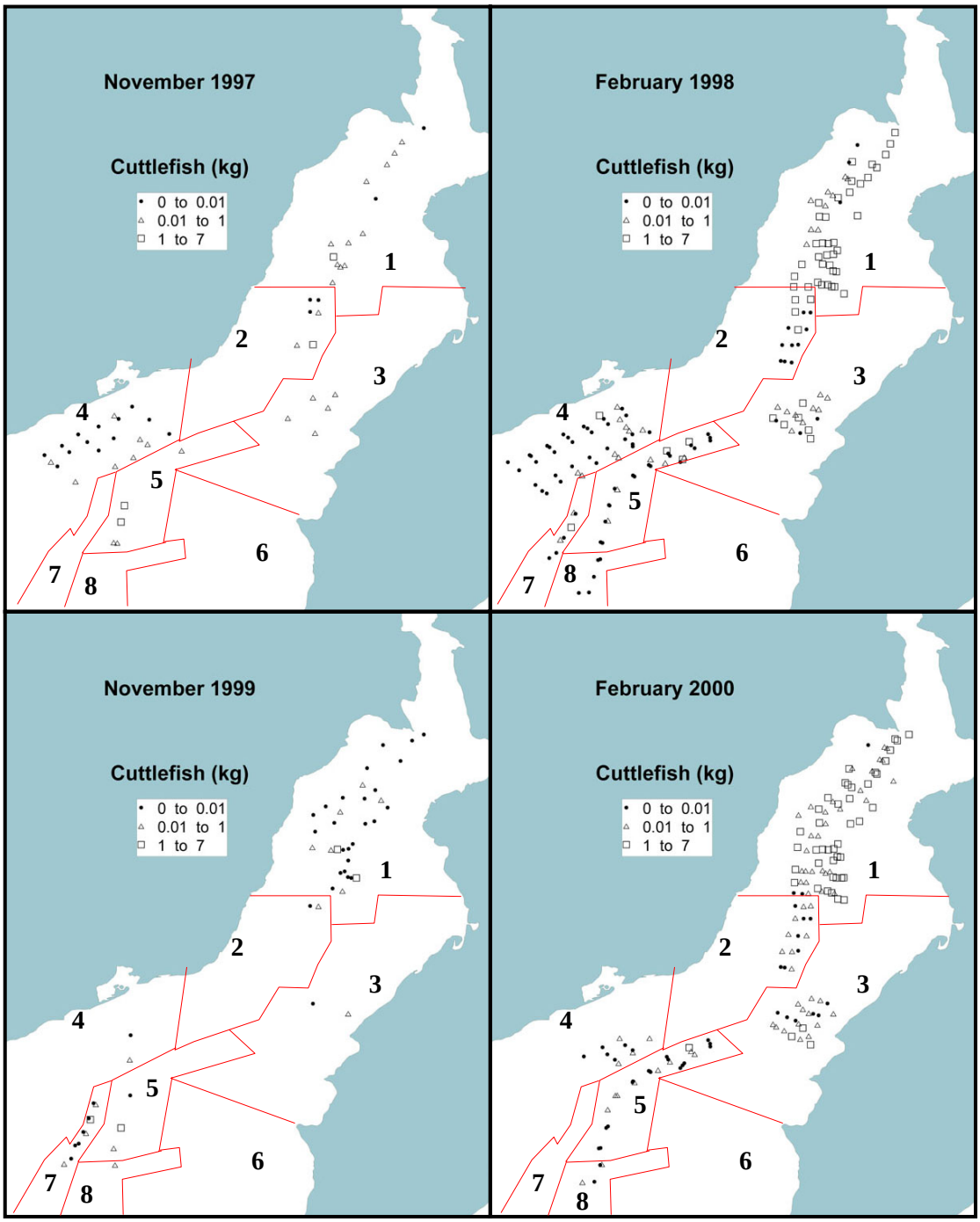

Figure 3.12 Weight of cuttlefish caught in 30 mins from one net during prawn surveys in Spencer Gulf between November 1997 and February 2000. Regions: 1=North, 2=M'bank/S'water, 3=Wallaroo, 4=Cowell, 5=Main Gutter, 6=Wardang, 7=West Gutter, 8=South Gutter.

3.4.6 Snapper

Prawn surveys

Catches of snapper up to 15 kg in total were recorded during prawn surveys conducted between November 1997 and 2002 (Figure 3.13). Catches were higher during February than November, and generally reduced from north to south. During the four November surveys catches of snapper were rare, with the exception of 1999 when approximately half of the stations in the North recorded catches between 0.1 and 2.0 kg. Length frequency data suggest that the majority of snapper captured during surveys were juveniles <20 mm total length (See Section 4 of this report).

By-catch surveys

Mean catch rate of snapper from by-catch surveys was highly variable at site 1 and low and consistent at Site 2. No snapper were caught at Sites 3, 4 and 5.

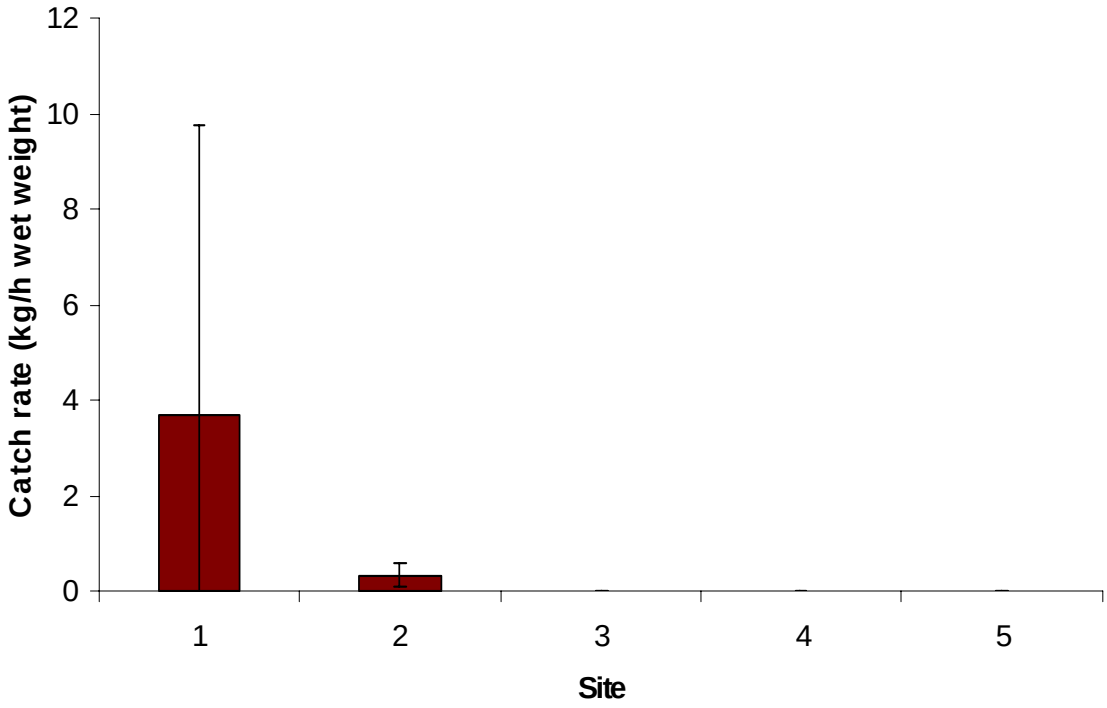

Figure 3.14 Mean catch rate (kg/h wet weight + 95% CI) of snapper from by-catch surveys conducted at five sites in Spencer Gulf.

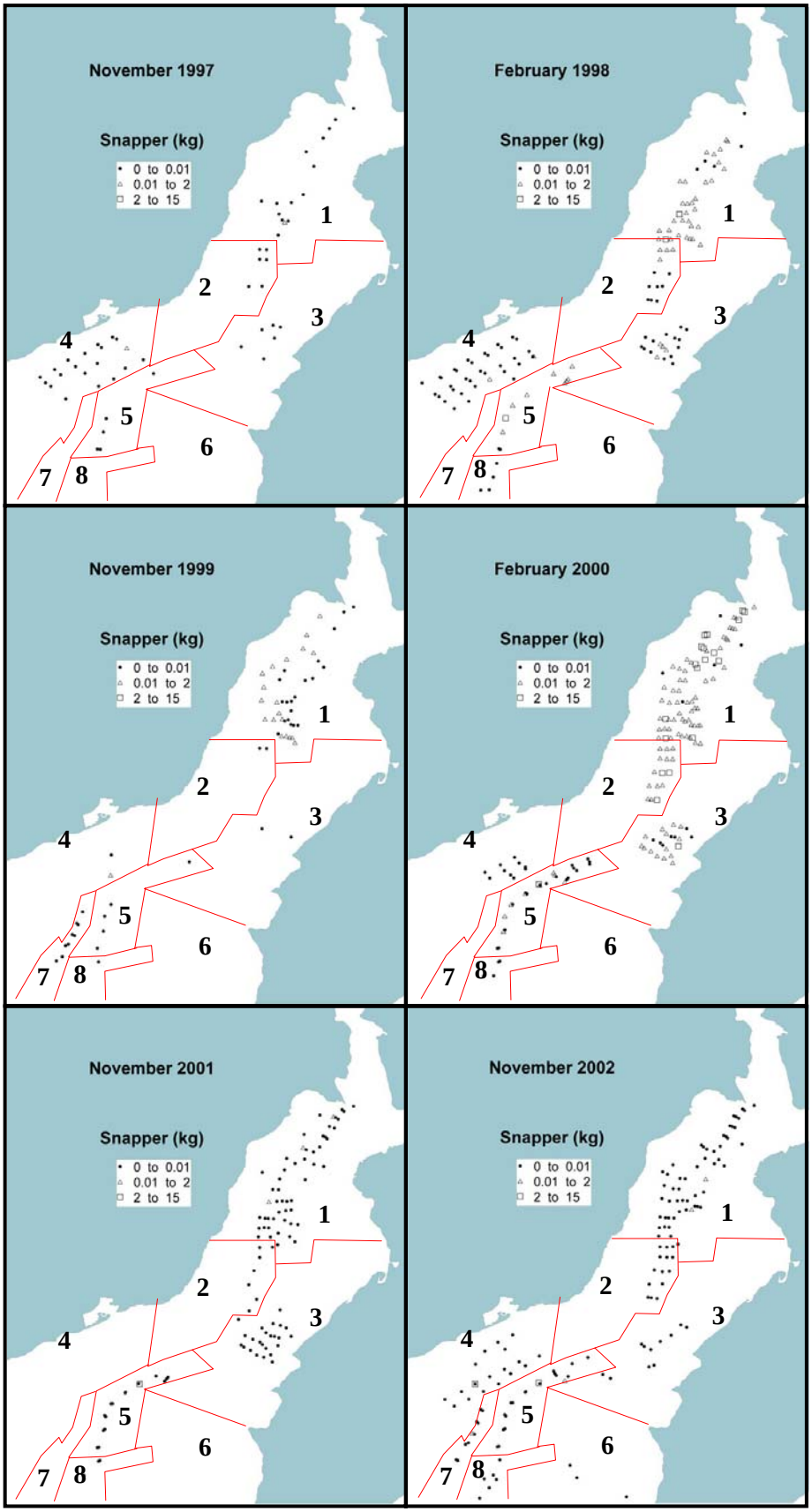

Figure 3.13 Weight of snapper caught in 30 minutes from one net during prawn surveys conducted in Spencer Gulf between November 1997 and November 2002. Regions: 1= North, 2= Middlebank/Shoalwater, 3=Wallaroo, 4=Cowell, 5=Main Gutter, 6= Wardang, 7=West Gutter, 8= South Gutter.

3.4.7 King George whiting

Prawn surveys

Catches of King George whiting up to 6 kg total were recorded during prawn surveys (Figure 3.15). The spatial and temporal replication of surveyed stations was poor, and impedes assessment of the distribution of King George whiting. During all surveys zero catches were predominant. Catches exceeding 1 kg were found in most surveyed regions, with no apparent spatial or temporal patterns. Reported catches of whiting were all zero at all stations during November 1997.

3.4.8 Flounder

Prawn surveys

Catches of flatfish (flounder and sole) up to 25 kg total were recorded during prawn surveys in November 1997, 1999 and 2002, and February 2000 (Figure 3.16). In general catches reduced from north to south. Catches exceeding 5 kg were only recorded in the North. During November 1997 recorded catches were zero for all stations. In most cases there were two years between surveys, making interpretation of the considerable spatial and temporal variation in abundance more difficult to assess.

3.4.9 Flathead

Prawn surveys

During prawn surveys conducted in November 2002 catches of flathead up to 8 kg were recorded in all surveyed regions (Figure 3.17). Catches exceeding 2 kg were scattered throughout the gulf, however the most northern stations produced consistently high catches. There were several stations where no flathead were caught.

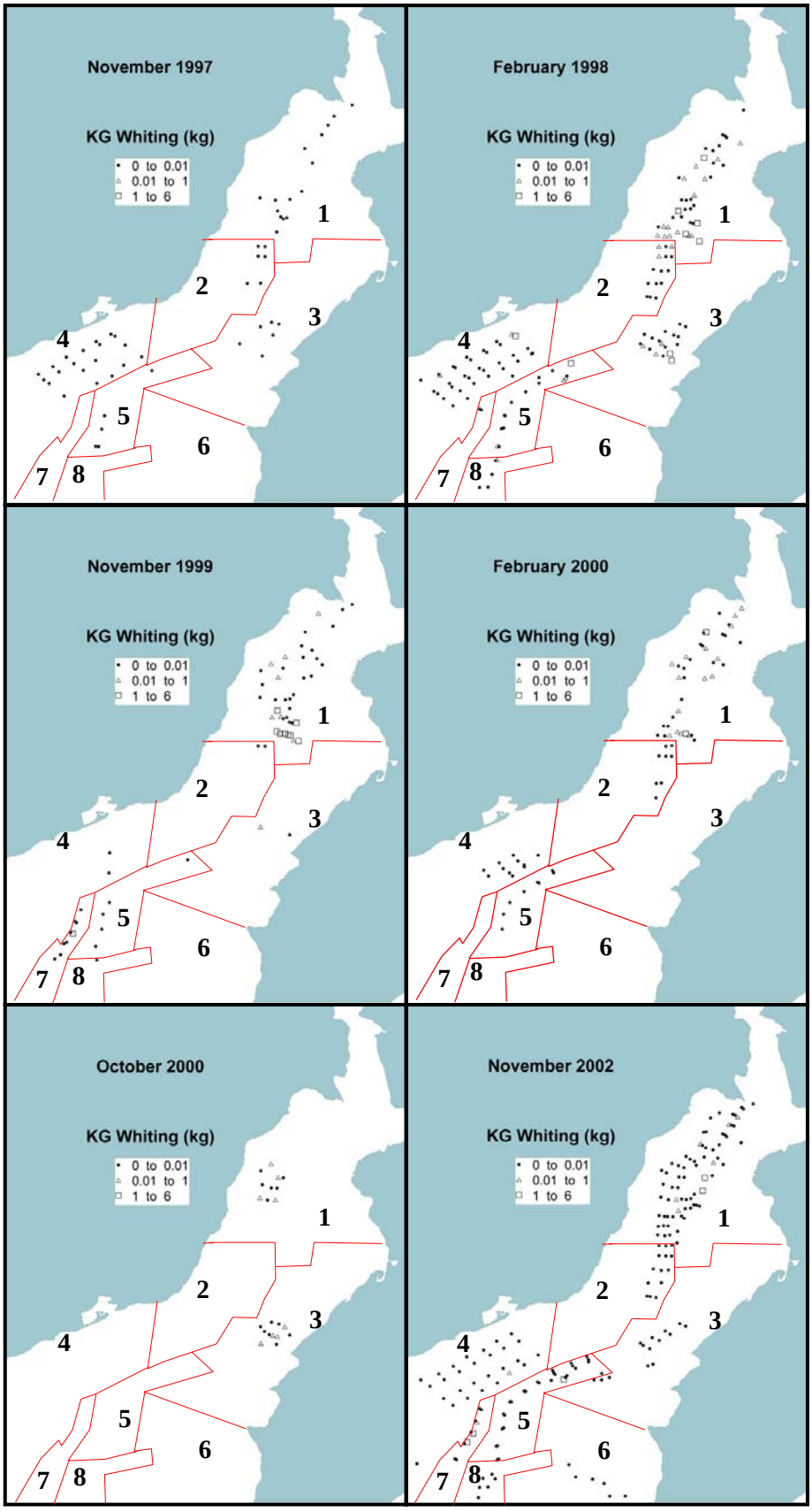

Figure 3.15 Weight of King George whiting caught in 30 minutes from one net during prawn surveys conducted in Spencer Gulf between November 1997 and November 2002. Regions: 1= North, 2= Middlebank/Shoalwater, 3=Wallaroo, 4=Cowell, 5=Main Gutter, 6= Wardang, 7=West Gutter, 8= South Gutter.

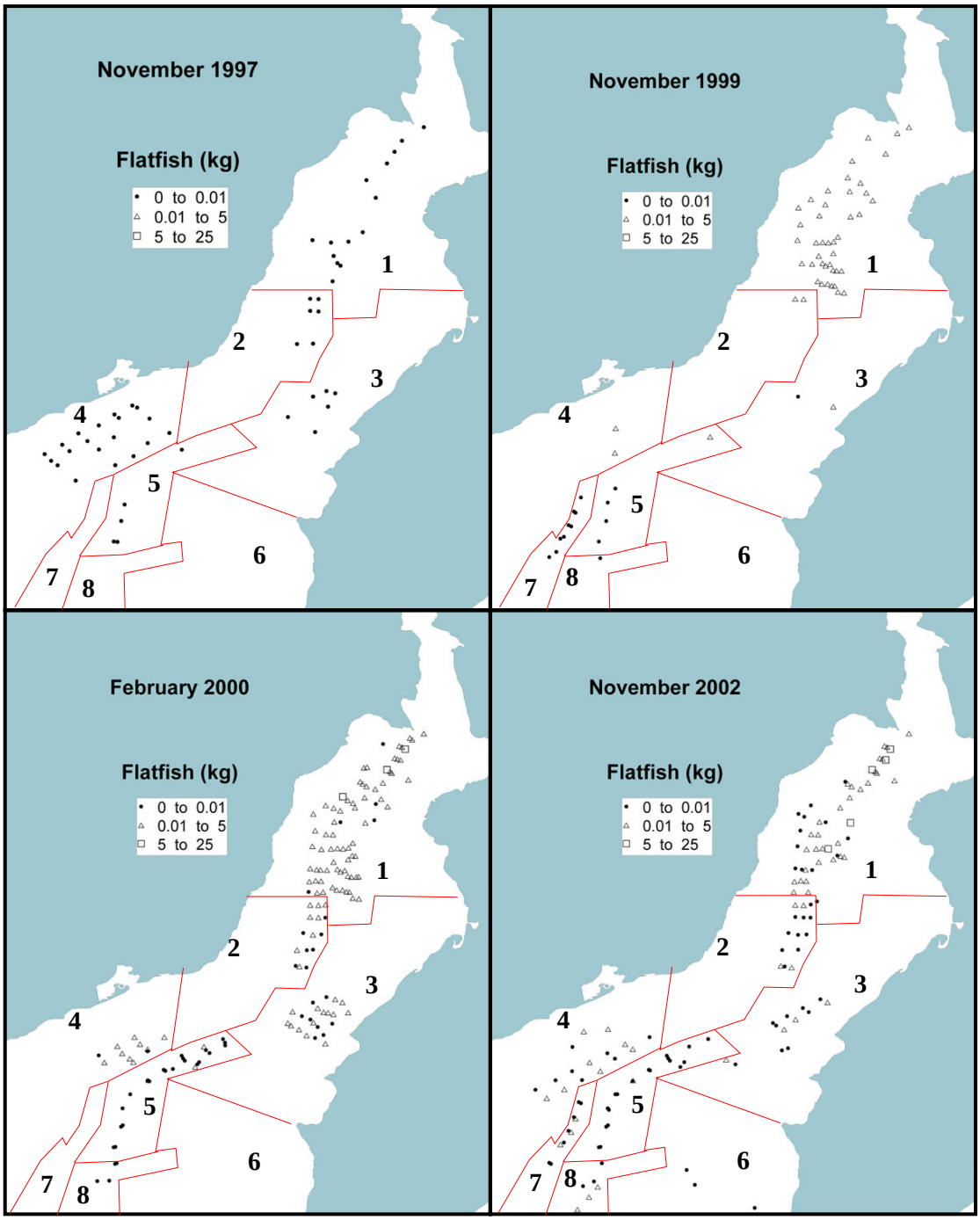

Figure 3.16 Weight of flatfish (flounder and sole) caught in 30 minutes from one net during prawn surveys conducted in Spencer Gulf between November 1997 and November 2002. Regions: 1= North, 2= Middlebank/Shoalwater, 3=Wallaroo, 4=Cowell, 5=Main Gutter, 6= Wardang, 7=West Gutter, 8= South Gutter.

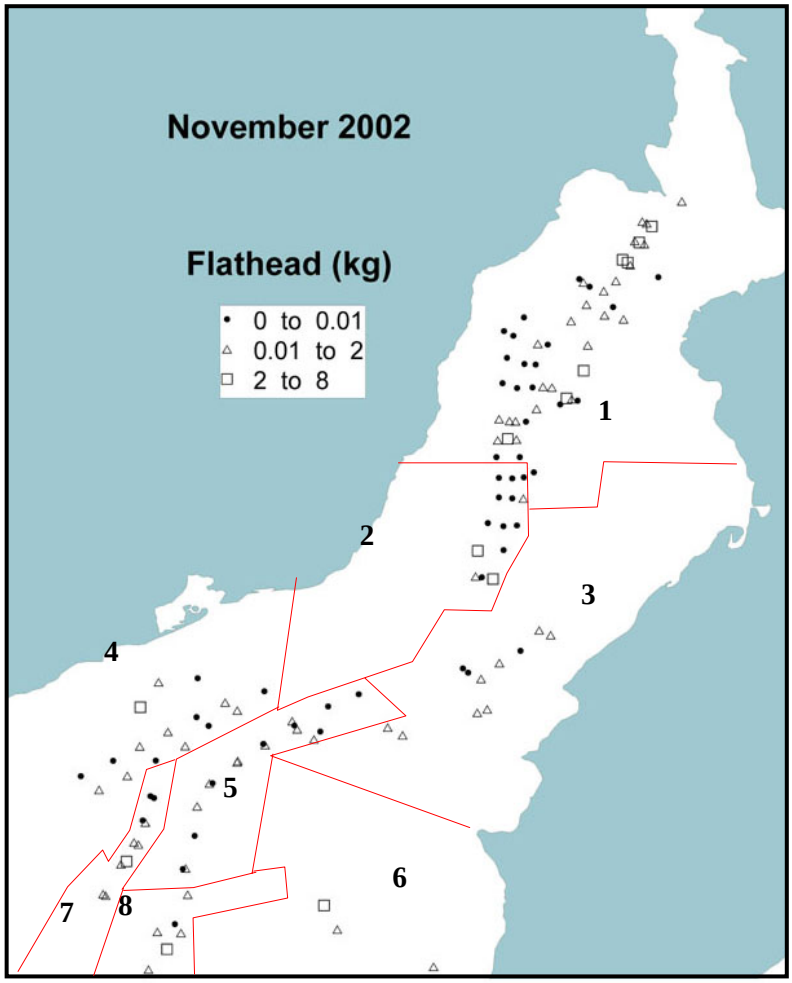

Figure 3.17 Weight of flathead caught in 30 minutes from one net during prawn surveys conducted in Spencer Gulf during November 2002. Regions: 1= North, 2= Middlebank/Shoalwater, 3=Wallaroo, 4=Cowell, 5=Main Gutter, 6= Wardang, 7=West Gutter, 8= South Gutter.

3.4.10 Sponge

Prawn surveys

During prawn surveys conducted during December 2002 catches of sponges up to 125 kg were recorded at 34 stations in the North (Figure 3.18). Of those surveyed, the largest catches of sponge by weight occurred in the southern portion of the region surveyed.

By-catch surveys

The catch rate of benthos from by-catch surveys was highest at sites 1 and 2 (84.82 and 109.24 kg/h, respectively; Figure 3.19) and lowest at sites 3 and 5. At the northern sites, sponges and patches of the bearded mussel, *Trichomya hirsutus* were abundant. Further south at sites 4 and 5 patches of sponges and bryozoans were the dominant component of the benthos.

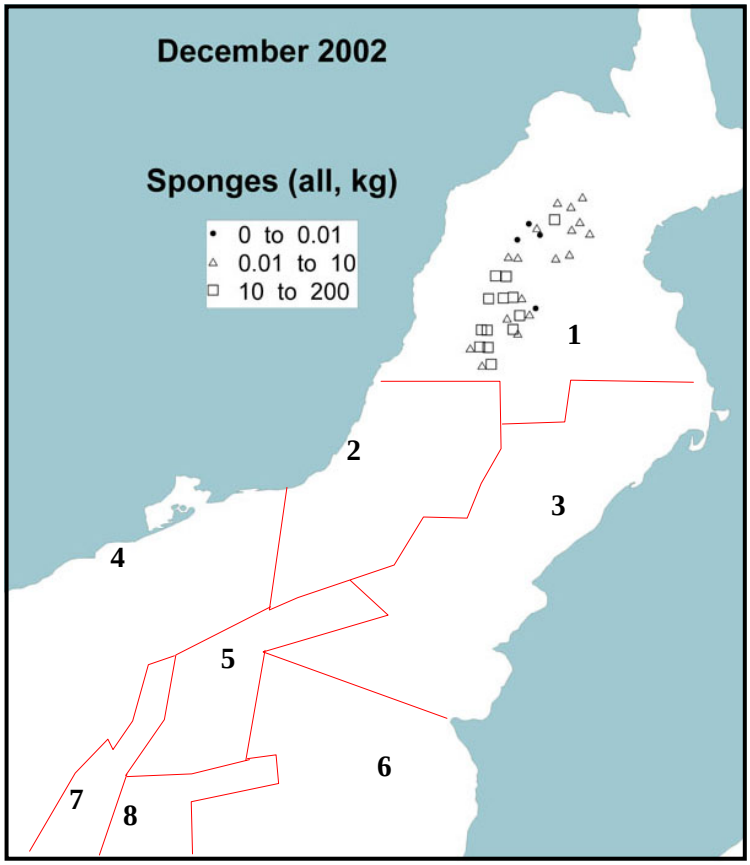

Figure 3.18 Weight of sponge caught in 30 minutes from one net during prawn surveys conducted in Spencer Gulf during December 2002. Regions: 1= North, 2= Middlebank/Shoalwater, 3=Wallaroo, 4=Cowell, 5=Main Gutter, 6= Wardang, 7=West Gutter, 8= South Gutter.

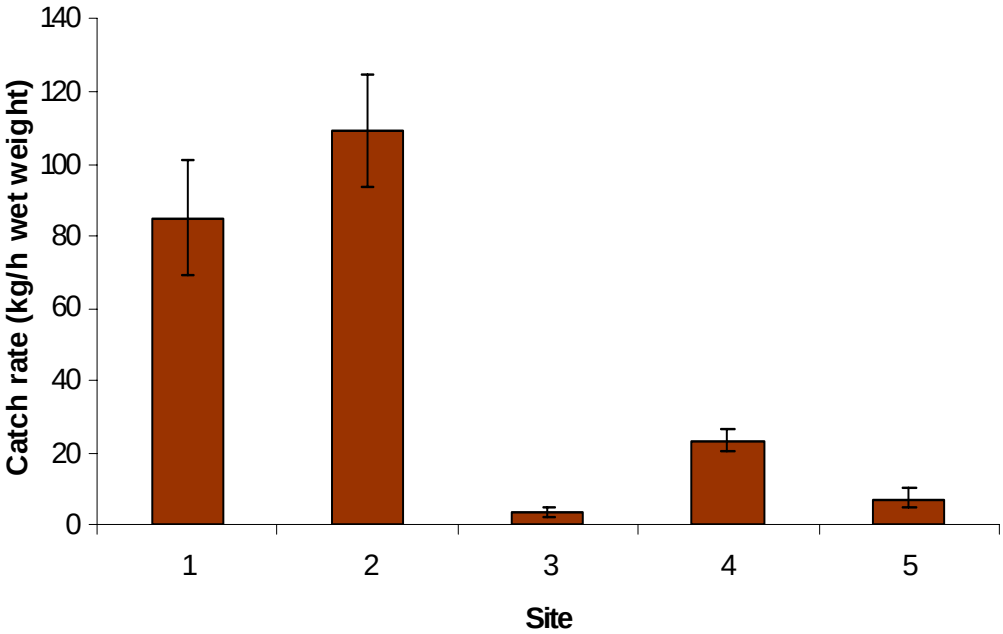

Figure 3.19 Mean catch rate (kg/h wet weight + 95% CI) of the group "benthos" from by-catch surveys conducted at five sites in Spencer Gulf.

3.5 Discussion

Considerable data were available for determining the distribution and abundance of common by-catch species. Prawn survey data were available for calamary, blue crabs, cuttlefish, snapper, King George whiting, flounder, flathead, sponge and 25 species of elasmobranchii (sharks and rays). By-catch survey data were available for slipper lobster, blue crabs and snapper, as well as the species groups sharks and rays, and benthos (predominately sponge). Commercial logbook data for the by-product species calamary and slipper lobster were available from 2002 to 2004.

A lack of replication prevented statistical comparison of by-catch survey data from different months and times of day at the species level, and thus results presented for individual species must be treated with caution. The grouping of individual species also limits interpretation of species distribution and abundance from by-catch surveys. Interpretation of species distribution and abundance from prawn survey data was limited by poor spatial and temporal replication, reflecting the ad-hoc nature of prawn surveys designed for harvest strategy development during this period (see Dixon et al 2005). Whilst it is unclear if all by-catch data collected during prawn surveys were available at the time of reporting, the addition of similar, poorly replicated data may not add greatly to the assessment.

Poor documentation of survey methods necessitated the use of several important assumptions for analyses. Of particular concern was the use of “0” and “blank” data in the database for ad-hoc studies on individual species. If “blanks” were encountered in the database it was assumed that data were not being collected for that species on that trawl. For “0” entries it was assumed that data was being recorded and the catch was zero. During the November 1997 survey of 53 stations, zero catches were recorded for flatfish and King George whiting at all stations, and for 51 of the 53 stations for snapper. Given the results of all other surveys for these species, these anomalous results were probably caused by entry of “0” values instead of “blanks”. Whilst the results of November 1997 could be ignored, the real consequence of this result is the doubt that it casts on “0” values for all other surveys and species.

Catches of by-product species reported in commercial logbooks are likely underestimates of total by-product catch because only retained portions of the catch must be reported. The proportion of by-product retained and discarded is unknown, though the frequency of reporting has increased since 2002 (Dixon et al 2005). As catches of by-product were recorded as daily values, regional catches were estimated based on the proportion of effort spent in each region during a nights fishing. This assumption was not likely to cause large

errors in estimates as the proportion of nights when more than one region was fished were low. Finer scale spatial analysis (i.e. fishing blocks) would be likely to create greater uncertainty in this assumption, because several fishing blocks are usually fished in one night.

Data for the by-product species calamary were obtained from prawn surveys and commercial logbooks. Prawn survey data for calamary showed no distinct trends in distribution or abundance either temporally or spatially, however the replication of surveys was poor. Commercial logbook data suggested that average catch rates of calamary rarely exceeded 2.0 kg/hr at the regional or monthly scale. As with survey data, there were no strong temporal or spatial patterns in catch rates. Commercial logbook catch rates and survey catch rates cannot be compared as commercial catches include the retained portion of the catch only.

Data for the by-product species slipper lobster was obtained from by-catch surveys and commercial logbooks. By-catch surveys showed that catch rates of slipper lobster were >1.0 kg/hr at both sites in the North region, and were <0.3 kg/hr at Middlebank/Shoalwater, Wallaroo and Main Gutter regions. Commercial logbook data showed that in general, catch rates were higher in northern Spencer Gulf, with sporadic high catch rates in the Cowell and Wardang regions. Consistent temporal trends were not evident, however catch rates were noticeably higher in November and December 2003 and 2004. Once again direct comparisons of catch rates were not appropriate.

Considerable data were available for several common by-catch species including blue crabs, snapper, King George whiting, flounder, flathead and cuttlefish. Some general trends in abundance were apparent, with catches of blue crabs, cuttlefish, snapper, flatfish and flathead all reducing in abundance from north to south of the gulf. No spatial trends in abundance were found for King George whiting. Abundance of cuttlefish and snapper appeared greater in February than November. No other temporal trends were evident.

Of the 25 species of sharks and rays captured during 515 trawl shots, Port Jackson sharks (44%), elephant fish (21%) and smooth stingray (7%) were most abundant. Port Jackson sharks were captured in most fished regions on all surveys, whereas both elephant fish and smooth stingray were highly variable between surveys and among regions. That elephant fish were not assessed as abundant from by-catch surveys (see Section 2) was caused by the limited spatial and temporal replication of by-catch surveys and the high variability in elephant fish abundance.

Historic data were useful to further define the potential indicator species list. Some commonalities were found between these data and those presented in Section 2, with similar patterns in abundance of calamary, slipper lobster, blue crabs, snapper, sponge, Port Jackson shark and smooth stingray. Data on the distribution and abundance from prawn and by-catch surveys suggests that King George whiting, flounder, flathead, cuttlefish and elephant fish should also be included as potential indicator species.

Historic data for commonly captured species from both prawn and by-catch surveys were poorly replicated at all spatial and temporal scales and were limited by the aggregation of individual species into species groups. Further, poor documentation of prawn survey methods necessitated assumptions that cast doubt on the accuracy of abundance data of some species. Although these limitations prevented statistical assessment of abundance over time, prawn survey data may be useful as a baseline if the sites and times of these surveys can be replicated in the future.

4 SIZE-FREQUENCY OF POTENTIAL INDICATOR SPECIES

4.1 Introduction

Changes in the size-frequency distribution of a population are often the first indication of substantial shifts in its dynamics. This may result from external factors such as over-fishing, or intrinsic factors such as recruitment failure. Regular measurement of the size-frequency of a population can enable the establishment of performance indicators to assess its health. Length-frequency data are presented in this section for a number of potential indicator species from prawn surveys conducted between November 1997 and October 2000.

4.2 Aims

This section of the report describes available size-frequency data for potential indicator species to assist the development of performance indicators for a by-catch monitoring program.

4.3 Methods

Size-frequency data were recorded for some indicator species including calamary, cuttlefish (*Sepia apama* and *S. nova*), snapper, flounder and King George whiting, from prawn surveys conducted between November 1997 and October 2000. It was assumed that length frequency data were representative of the catch, and that mantle length was recorded for the three cephalopod species, and total length was recorded for the scalefish species. The number of length measurements for each species and survey are tabulated. Data are presented for each survey for the cuttlefish *Sepia apama*, calamary, snapper and flounder when >300 individuals were measured for that survey. Measurements of the cuttlefish *S. nova* and King George whiting did not exceed 300 per survey and as a consequence data were pooled.

4.4 Results

Between November 1997 and October 2000 12,293 length and 2,690 weight measurements were recorded for six different species (Table 4.1). The largest number of length measurements was recorded during November 1999. Calamary comprise >64% of all length measurements, with the three finfish species (snapper, flounder and King George whiting) comprising <20% of all length measurements.

Table 4.1 Number of individual length measurements for various species surveyed between November 1994 and October 2000. *Sepia apama* and *Sepia nova* are both species of cuttlefish.

Species	Nov 1997	Feb 1998	Nov 1999	Feb 2000	Oct 2000	Total
Calamary	864	389	3689	2438	506	7886
Sepia apama	18	952	12	560		1542
Sepia nova	138	211	47	74		470
Snapper	2	318	543	495		1358
Flounder		428		427		855
King George whiting		19		163		182

The mantle length of cuttlefish *Sepia apama* ranged from 3–28 cm with >90% of those measured being between 7–14 cm. *S. apama* were larger in February 1998 with a modal size-class of 11–12 cm compared to 9–10 cm in February 2000 (Figure 4.1). *S. nova* were generally smaller in size, ranging from 3–18 cm in length. The modal size-class was 7–8 cm, however *S. nova* 9–10 cm were similarly abundant. Temporal trends in abundance could not be determined. The mantle length of calamary measured during surveys ranged from 3–26 cm. The size distribution of calamary was similar during surveys conducted in February 1998, February 2000 and October 2000, with a modal size-class of 7–8 cm. Calamary captured during November 1997 and November 1999 were considerably larger with a modal size-class of 9–10 cm compared to 7–8 cm during other months. and many more captured >14 cm mantle length. Snapper ranged from 7–28 cm in total length, with a modal size-class that varied considerably from surveys conducted in February 1998, November 1999 and February 2000. Few snapper >18 cm were measured. The total length of flounder ranged from 7–39 cm, with a modal size-class of 19–21 cm. The distribution was right skewed, increasing sharply in abundance from 16–21 cm. There were no apparent differences in the size distribution of flounder captured during November 1999 and February 2000. The total length of King George whiting ranged from 16–42 cm, and was normally distributed with a modal size-class of 25–27 cm. Temporal trends in abundance could not be determined.

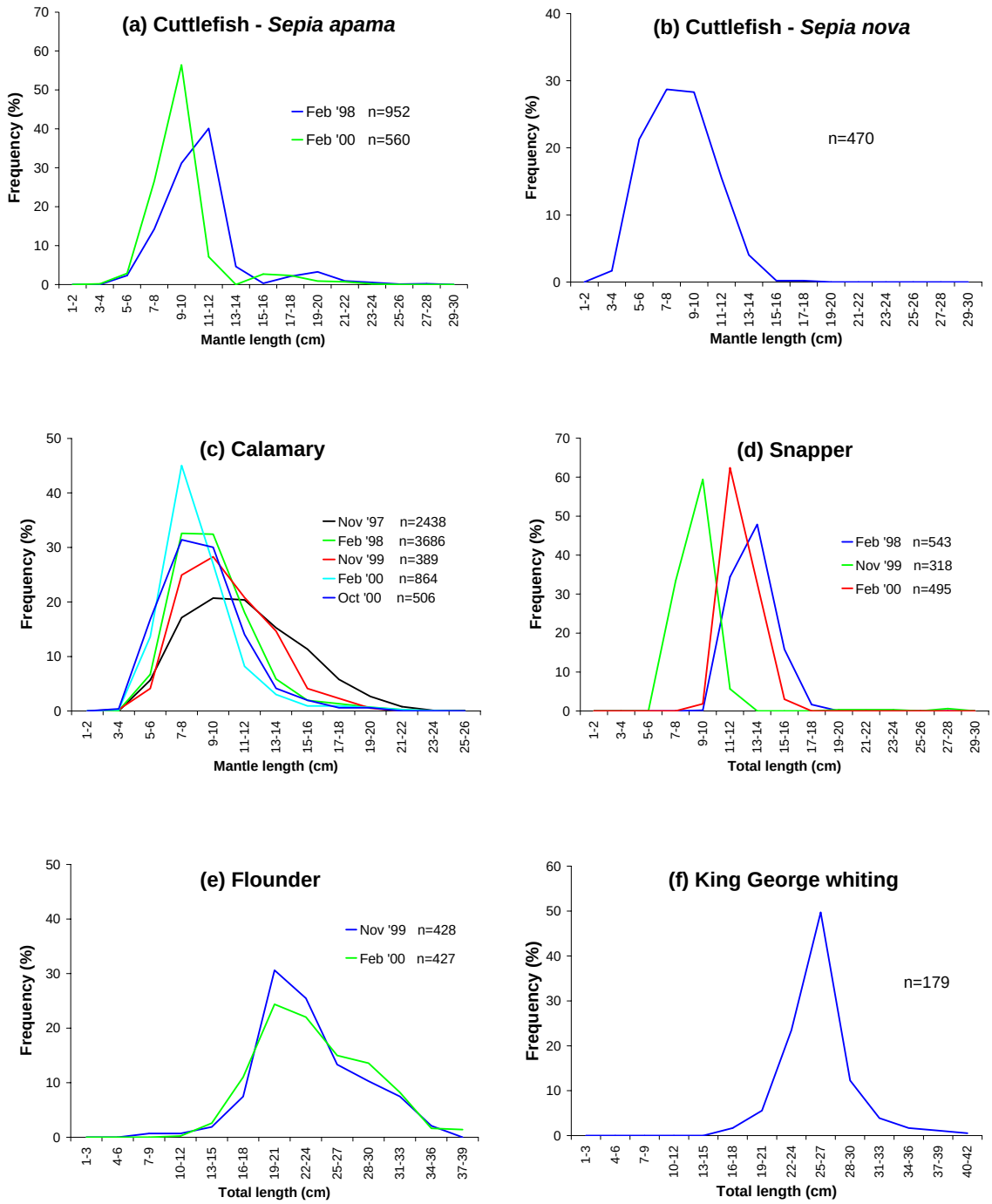

Figure 4.1 Length frequency of (a) cuttlefish – *Sepia aparma*, (b) cuttlefish – *Sepia nova*, (c) calamary, (d) snapper, (e) flounder and (f) King George whiting from individuals measured during prawn surveys conducted from November 1997 to October 2000.

4.5 Discussion

Length frequency data were available for cuttlefish (*S. apama* and S. *nova*), calamary, snapper, flounder and King George whiting. Temporal variation was examined for *S. apama*, calamary, snapper and flounder, but spatial comparisons were not possible for any species. Individual weight data were also obtained on some occasions, however they are not presented as they do not provide additional information useful for the development of performance indicators. All analyses assume that available data are representative of the size distribution of species captured.

A high proportion of cuttlefish (both species) and calamary were in the size range 5–13 cm mantle length. *S. apama* showed considerable annual variation in size between surveys conducted in February 1998 and 2000. Calamary also showed considerable variation over five surveys. Catches of snapper were predominately of the size range 7–16 cm total length. The lack of large snapper caught is likely to reflect capture probability, whilst the tight and variable size distributions indicate a single year-class of snapper recruits. The size distribution of flounder was similar over two surveys, however they were conducted only three months apart. A wider size range of both flounder and King George whiting were captured compared to snapper.

The highly variable size distributions for cephalopod species and snapper are likely caused by seasonal and annual variation in growth. Such variation creates difficulties in establishing meaningful performance indicators for size. Further data are required for other indicator species as well as King George whiting and flounder to ascertain whether temporal changes in size distribution occur.

In summary, historic size-frequency data provide important information on the temporal variation in four potential indicator species, and pooled information for King George whiting and one species of cuttlefish. However, the considerable temporal variation that does occur in the size distributions of some species may preclude statistical assessment of changes in size frequency distribution through time. Size-frequency data are a basic requirement in understanding the population dynamics of fish, and can be useful for a number of reasons including the interpretation of changes in annual abundance (e.g. recruitment failure) and determining the effectiveness of by-catch mitigation technology. As such, size-frequency data should comprise an integral component of a future by-catch monitoring program for all indicator species even though its measurement may not be an informative indicator of population health.

5 GENERAL DISCUSSION

In 2004 the Commonwealth DEH provided a set of management recommendations to aid ecologically sustainable fishing of South Australia's prawn fisheries and in doing so ensure their exemption from the export controls of the EPBC Act (1999). These recommendations included three specifically related to the ongoing monitoring of by-catch in each fishery. The SGWCPFA and SARDI Aquatic Sciences have obtained considerable historic data on by-catch from the Spencer Gulf Prawn Fishery. In this report these historic data were examined to: determine the species composition and abundance of by-catch; document progress toward the DEH recommendations regarding by-catch, and; identify key elements of a future by-catch monitoring program.

By-catch data were available from prawn surveys conducted since 1994, by-catch surveys conducted during 2004/05, and commercial logbooks from 2002–2004. The data collected includes composition and relative abundance of by-catch, distribution and abundance of some common by-catch species, and size-frequency information.

Data to specifically assess the composition and relative abundance of by-catch in the Spencer Gulf Prawn Fishery were limited. Prawn survey data from 31 stations surveyed in February 2000 and by-catch survey data from October 2004 and January 2005 were assessed for several important fishing regions. Despite poor spatial and temporal replication of the surveys these data were useful in determining some general trends in composition and relative abundance among regions. Although these limitations prevented robust statistical assessment of abundance, data were useful to identify potential indicator species.

Considerable data were available on the distribution and abundance (catch rate) of common by-catch species in Spencer Gulf. Interpretation of prawn survey data was limited by poor spatial and temporal replication and considerable uncertainty in the reliability of some of the available data. The poor spatial and temporal replication reflected the ad-hoc nature of prawn surveys during this period more so than incomplete information. By-catch data were available for a number of individual species and species groups, however the grouping of species and the grouping of survey data at various temporal scales limited interpretation. Further, by-catch data assume that the sites surveyed are representative of the regions fished. Once again the considerable limitations of the data prevented statistical assessment of abundance, however data were useful to identify potential indicator species.

Commercial logbook data were available for both by-product species (calamary and slipper lobster) from 2002 to 2004. Reported catches are likely underestimates, as only the retained catch must be recorded. Size-frequency data were available for calamary, cuttlefish (two species), snapper, flounder and King George whiting. It was assumed that available data were representative of the size distribution of the species captured. Temporal variation in most species measured suggested that statistical assessment of changes in size distribution over time is not practical.

In Australia there are two approaches for the assessment of trawling on by-catch species populations. The first is a risk assessment approach following Fletcher et al (2002) that has been adopted by the Shark Bay, Exmouth Gulf, Broome and Kimberly Prawn Fisheries of Western Australia. This approach involves examining information such as the frequency of capture, discard survival rates, and the distribution of the species in fished and unfished areas, to assess the risk that prawn trawling poses to their ongoing survival. Whilst a risk assessment was made for individual threatened, protected or endangered species, generally other species were assessed in groups such as "invertebrates" and "fish".

For the Shark Bay Prawn Fishery the group "fish" were considered at moderate risk of overfishing. Following this, the sustainability of individual fish species was assessed using the approach of Stobutzki et al (2001), who examined 411 fish species encountered in the Northern Prawn Fishery and ranked them according to a) their susceptibility to capture and mortality from prawn trawling and b) the population's ability to recover after depletion. From these additional criteria individual fish species at greatest risk for the Shark Bay Prawn Fishery were determined.

Stobutzki et al (2001) reported that the ranking of species must be assessed with considerable caution due to the substantial assumptions of the assessment. In general the approach tends to identify species at greatest risk as those of benthic or demersal origin, that are highly susceptible to capture, primarily reside in soft sediments and whose biological characteristics lead to slow regeneration of population numbers. The least susceptible species tend to be those that are pelagic, whose primary habitat was not in trawl grounds, and whose biology suggested potential for rapid regeneration. This qualitative risk assessment approach has considerable limitations and is more likely to incorrectly identify risk to by-catch species than the quantitative approach of monitoring abundance. However, for fisheries with highly diverse and abundant by-catch, such as those in northern and western Australia, it is more economically feasible than quantitative methods.

In contrast the Spencer Gulf Prawn Fishery is conducted in relatively cold water with low species diversity and a lower total by-catch to prawn catch weight ratio (Carrick 2003). As such, quantitative assessment is highly feasible and may provide a sound and robust statistical assessment of population abundance of by-catch species through regular monitoring. Such an approach, with informative and measurable performance indicators, is far more robust than a qualitative risk assessment.

Whilst the quantitative monitoring of long-term trends in indicator species populations is the preferred approach for the Spencer Gulf fishery, the simultaneous conduct of a complementary risk assessment could provide several beneficial outcomes. Firstly, it may aid identification of important environmental indicator species for long-term monitoring by identifying abundant species deemed as high risk from overfishing. Secondly, it provides an alternative method for assessing the risk to those species whose trends in population abundance cannot be determined statistically. Finally, used in combination these approaches would provide an assessment of the effect of trawling on by-catch species that would be superior to any other conducted in Australia.

5.1 Assessment against the DEH recommendations

The DEH assessment (Anon 2004) includes three recommendations that relate specifically to the ongoing monitoring and reporting of by-catch for South Australian prawn fisheries. The following section of the report provides a synopsis of available information for each of these recommendations.

5.1.1 *The development and implementation of harvest strategies for all by-product species*

Historic data for the by-product species calamary and slipper lobster were available from prawn and by-catch surveys and more recently from commercial logbook data. Fishery-independent data on abundance at appropriate temporal and spatial scales are generally lacking. Whilst some biological information are available for calamary, data on the basic biology of slipper lobster are urgently required.

Fishery-dependent information has been obtained from logbooks since 2002, however fishers are only required to report the retained portion of by-product catch. As a result these catches are likely to be an underestimate of the total by-product catch. Further, there are no published data on the rates of by-product retention or the survival of discarded by-product to more accurately assess annual catch. Such information could only be obtained from compulsory

logbook reporting of all by-product catch, or through the conduct of an independent observer program.

Harvest strategies in the Spencer Gulf Prawn Fishery are established using spatial and temporal closures to structure fishing effort in a manner that ensures both the sustainable fishing of prawns and the maximising of economic returns. Generally, the capture of by-product species is not considered. Consideration of by-product species in prawn harvest strategies is only necessary if the effort distribution could lead to unsustainable catches of by-product species. Without information on by-product sustainability, prawn harvest strategies that lead to increased annual catches of by-product should be avoided.

Data available from all sources suggested that catches of the by-product species slipper lobster and calamary were obtained throughout the year in all regions of Spencer Gulf. There were no clear temporal or spatial patterns in the distribution or abundance of calamary catches and as such changes in effort distribution are unlikely to substantially influence total catches of calamary.

In contrast, large catches of slipper lobster in northern Spencer Gulf during November and December gives potential for an increased annual slipper lobster catch if harvest strategies are developed that target these regions and/or fishing periods. Continuation of recent practices to reduce fishing effort in northern regions (Dixon et al 2005) and minimising pre-Christmas catches at or below the historic average should be encouraged.

In summary, there is a clear need for independent information on by-product abundance at appropriate temporal and spatial scales to ensure that changes in effort distribution as a result of harvest strategies do not consequently increase the capture of by-product species. Appropriate information on the basic biology of by-product species, particularly slipper lobster, is urgently required to understand the population dynamics of these species in Spencer Gulf. Also, changes in commercial logbook reporting or the implementation of an independent observer program is essential to determine the annual catch of by-product in the Spencer Gulf Prawn Fishery. Of note, there are currently no formal restrictions on the capture of slipper lobster or calamary, such as size limits or return of berried females.

5.1.2 *Monitoring of by-catch indicator species to detect long-term trends*

Progress toward this DEH recommendation requires the selection of an appropriate indicator species list and the definition of the long-term trends to be measured. Data were available on by-catch abundance from historic prawn and by-catch surveys conducted since 1994 and, although poorly replicated, these data were useful to aid the selection of appropriate by-catch indicator species and to determine the long-term trends that would provide an indication of population health. Voluntary by-catch abundance data have been recorded in commercial logbooks since 2002, however <10% of fishers contributed information in each year and thus results were uninformative and not presented in this report.

Anon (2003) documented a list of potential indicator species, however it was noted that "an evaluation of data and the rationale for selecting indicator species" was needed. Critically, the selection of appropriate indicator species hinges on the ability to statistically detect the long-term trends to be measured. The most important "long-term trend" to detect is abundance, whilst other measures may include changes in the size structure of the population. To detect these long-term trends the indicator species must be captured at a frequency that enables appropriate statistical assessment.

Due to poor temporal and spatial replication, historic data on the abundance of by-catch species in Spencer Gulf could not be used for statistical assessment of abundance for commonly captured species. Therefore outcomes of this report were limited to the selection of a list of potential indicator species.

Species were deemed as potential indicators if they were regularly or sporadically captured and were of ecological or economic importance. Evaluation of historic prawn and by-catch survey data against these criteria led to the development of a list of potential indicator species that included: calamary, slipper lobster, blue crabs, cuttlefish, snapper, King George whiting, flounder, flathead, sand trevally, Degen's leatherjacket, Port Jackson shark, elephant fish, smooth stingray and sponge. With the exception of cuttlefish and sponge, all other species listed are single species and therefore the development of appropriate species groups is required to account for all other by-catch. These groups may be best categorised as "other teleost fish", "other sharks", "other rays", "other invertebrates" and "other benthos". This list of potential indicator species and species groups should be separately assessed in a pilot by-catch study that aims to finalise the indicator species list and determine appropriate performance measures of abundance.

The potential indicator species listed in Anon (2003) included calamary, blue crabs, King George whiting, snapper, flounder, flathead, cuttlefish, syngnathids, sharks, rays and skates, and sponges. Aside from the non-selection of slipper lobster, sand trevally, Degen's leatherjacket, Port Jackson shark, elephant fish and smooth stingray as indicator species, notable differences include the selection of the group "syngnathids". Whilst this group includes protected and endangered species (i.e. sea-dragons), they are not appropriate indicator species as their capture frequency is sufficiently low to preclude statistical assessment. A risk assessment in combination with mandatory reporting by commercial fishers may be the best approach for assessing interactions with and capture of endangered, threatened and protected species.

Historic size frequency data were available for several potential indicator species. Temporal variation appears to limit the use of these data for statistical detection of long-term changes in size structure of indicator species populations. Regardless, these data should be routinely collected during ongoing monitoring as they can provide invaluable information for interpretation of changes in abundance over time (e.g. changes in size structure of the catch caused by recruitment failure or introduction of by-catch mitigation technology).

The detection of long-term trends in indicator species populations cannot be achieved unless regular monitoring is conducted. Initially a by-catch pilot study is needed to define both the indicator species list and the performance measures by which they are to be assessed. These data will also inform the level of replication needed (i.e. number of sites that need to be surveyed) for on-going monitoring and form the basis for a qualitative risk assessment. Voluntary logbook data on by-catch requires increased participation by fishers on a consistent basis if this data source is to be useful for future assessment.

5.1.3 *Mandatory reporting of interactions with endangered, threatened or protected species*

Interactions with endangered, threatened or protected species includes both capture and non-capture disturbances (e.g. collision with a vessel). The endangered, threatened or protected species with potential to interact with the Spencer Gulf prawn fleet include berried blue crabs, syngnathids (sea dragons, seahorses and pipe fishes), blue groper, marine turtles, white sharks, dolphins, seals and whales. Currently the only measures of interactions with these species are through voluntary commercial logbook entries. To date few fishers have provided this information and the quality of data is unknown. The only published documentations of interactions with endangered, threatened or protected species was Carrick (1999) who demonstrated that the capture of marine turtles in Spencer Gulf was extremely rare and Svane

(2005) who demonstrated that dolphins were substantial consumers of prawn trawl by-catch during hauling.

As the DEH has requested mandatory reporting of such interactions from South Australia's prawn fisheries by December 2006, a strategy to ensure reliable capture of this data is a high priority. Whilst a by-catch monitoring program would provide an independent assessment of interactions with these species, structured by-catch surveys may not accurately represent the level of interactions during fishing. Mandatory reporting by commercial fishers in combination with an independent observer program would be likely to provide the most accurate estimates of these interactions. Given the poor response to provision of voluntary commercial logbook data, education of fishers is likely to be necessary to ensure useful and accurate data collection.

5.2 Future research

There is an urgent need for a dedicated, systematic and strategic by-catch research program in the Spencer Gulf Prawn Fishery to address the DEH recommendations regarding by-catch within the specified time frames. Whilst considerable by-catch data have been collected for the fishery, these data were not appropriate for long-term monitoring and assessment of the health of important by-catch species. A by-catch research program designed to specifically address the DEH recommendations requires at least three components: ongoing fishery-independent by-catch surveys; a fishery-independent on-board observer program, and; collection and analysis of commercial logbook data, with particular reference to mandatory reporting of interactions with endangered, threatened and protected species.

Firstly, a pilot fishery-independent by-catch survey must be conducted to finalise a list of appropriate indicator species for long-term monitoring, to quantify performance measures for these indicator species, to determine appropriate levels of survey replication, and to develop a qualitative risk assessment. Survey methods must be determined that enable identification and measurement of total by-catch species to at least the indicator species or species group level. The survey design should also consider the distribution of historical survey data to utilise this information as a baseline assessment of abundance where possible. Annual conduct of by-catch surveys would enable quantification of the abundance and size frequency of indicator species to address two of the three DEH recommendations relating to by-catch.

A fishery-independent observer program can ensure that by-catch surveys are representative of fishing activities by comparing the relative catch rates of by-catch. Further, they can aid

assessment of commercial logbook data such as interactions with endangered, threatened or protected species, and rates of discarding of by-product species. Previous studies on southern rock lobster showed that combining observer, logbook and catch sampling methods substantially improved estimates of by-catch capture (Brock et al 2004).

Finally, logbooks must be modified to ensure mandatory reporting of interactions with endangered, threatened or protected species. This recommendation is common across other state fisheries and therefore a sensible approach may be to create a single logbook for the reporting of interactions with endangered, threatened and protected species for all South Australian fisheries. An observer program run in conjunction with logbook reporting by fishers could enable validation of these commercial logbook data.

In conclusion, the combination of these approaches will provide a robust and world-class framework for determining the effect of prawn fishing on important by-catch species in Spencer Gulf. In doing so it will demonstrate considerable progress toward the DEH recommendations for ecological sustainable fishing.

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7 APPENDIX

7.1 Appendix 1: Voluntary by-catch logbook for commercial fishers

SPENCER GULF PRAWN FISHERY TRAWL DISCARDS LOG BOOK CODES-VOLUNTARY MONITORING SYSTEM

GROUP	COMMON NAME	CODE	ESTIMATE
Sharks, Rays & Skates	Port Jackson Shark	PJS	Count
	Cobbler Carpet Shark	COBS	Count
	Gulf Wobbegong	GWOB	Count
	Wobbegong	WOB	Count
	Bronze Whaler	BWSK	Count
	Gummy Shark	GSK	Count
	School Shark	SSK	Count
	Fiddler Ray	FID	Count
	Shovelnose Shark	SEX	Count
	Saw Shark	SAW	Count
	Numbfish	NUM	Count
	Bango Ray	BR	Count
	Angel Shark	ASK	Count
	Elephant Shark	ELS	Count
	Skates	SK	Count
	Eagle Ray	EAGR	Count
	Black Ray	BLR	Count
	Other Rays	OTHR	Count

GROUP	COMMON NAME	CODE	ESTIMATE
Marine Turtles (Endangered species)	Leatherback	LBT	Count
	Loggerhead	LHT	Count
	Green	GT	Count
Leafy Sea dragons, Seahorses and Pipefish	Leafy Sea Dragons	LSD	Count
	Sea Horse	SH	Count
	Pipefish	PF	Count
Stony Coral (Stones)	Stones	STN	Count
	Great White Pointer Shark	GWP	Count

Note: Leafy Sea dragons and White pointers are protected species

***Marine Turtles are rare in Spencer Gulf, and if capture or sight a turtle, please record and contact SARDI or NPWS. Diagrams of species outlined in the table are provided and recording of daily logbook information is voluntary except for Calamary and Balmain Bugs which are retained as bycatch, and is required by the Fisheries Act to be recorded in the daily log book form provided.*

			VERY HIGH (VH)	HIGH (H)	HIGH/MEDIUM (HM)	MEDIUM (M)	MEDIUM/LOW (ML)	LOW (L)	ZERO (Z)
Teleost Fish	Leather Jackets	LJS	> 1 tonne	1000-500 kg	500-300 kg	300-50 kg	50-10 kg	< 10 kg	0
	Trevally	TREV	>1 tonne	1000-500 kg	500-300 kg	300-50 kg	50-10 kg	< 10 kg	0
	Stripped Trumpeter	STR	> 1 tonne	1000-500 kg	500-300 kg	300-50 kg	50-10 kg	< 10 kg	0
	Red Mullet	RM	> 200 kg	100-50 kg	50-20 kg	20-10 kg	10-5 kg	<5 kg	0
	Sand Whiting	SW	> 500 kg	1000-500 kg	500-300 kg	300-50 kg	50-10 kg	<10 kg	0
	Flathead	FH	> 500 kg	300-100 kg	100-50 kg	50-10 kg	10-5 kg	<5 kg	0
	Flounder	FL	> 100 fish	100-50 fish	50-20 fish	20-10 fish	10-5 fish	< 5 fish	0
	Soles	SOL	> 100 fish	100-50 fish	50-20 fish	20-10 fish	10-5 fish	< 5 fish	0
	Gurnards	GN	> 150 kg	100-50 kg	50-20 kg	20-10 kg	10-5 kg	<5 kg	0
	King George Whiting	KGW	> 100 fish	100-30 fish	30-10 fish	10-5 fish	5-2 fish	1 fish	0
	Snapper	SNAP	> 500 fish	500-250 fish	250-100 fish	100-25 fish	25-5 fish	<5 fish	0
	Pilchard	PIL	> 500 kg	500-100 kg	100-50 kg	50-20 kg	20-5 kg	<5 kg	0
	Ling	LG	>50 fish	50-20 fish	20-10 fish	10-5 fish	10-2 fish	1 fish	0
	Stink Fish (Red, White)	SF	>200 kg	200-50 kg	50-20 kg	20-10 kg	10-5 kg	<5 kg	0
Crabs	Blue Swimmer crab	BC	> 10 baskets	10-5 baskets	5-2 baskets	2-1 baskets	1-0.5 baskets	< 0.5 basket	0
	Sand Crab	SC	> 10 baskets	10-5 baskets	5-2 baskets	2-1 baskets	1-0.5 baskets	<0.5 basket	0
Cephalopods	Cuttle fish	CF	> 20 kg	20-10 kg	10-5 kg	5-2 kg	2-0.5 kg	<0.5 kg	0
	Octopus	OCY	> 100 animals	100-50 animals	50-25 animals	25-10 animals	10-5 animals	<5 animals	0
Sponge	Sponge	SPG	> 10 baskets	10-5 baskets	5-2 baskets	2-1 baskets	1-0.5 basket	<0.25 basket	0
Sea Cucumber	Sea Cucumber	SEC	>100 animals	100-50 animals	50-20 animals	20-10 animals	10-5 animals	< 5 animals	0
Bryazoa	Cornflake Coral	CC	> 10 baskets	10-5 baskets	5-2 baskets	2-0.5 baskets	0.5-0.25 basket	<0.25 basket	0
Gorgonians	Gorgonia	GOR	> 5 baskets	5-3 baskets	3-2 baskets	2-0.5 baskets	0.5-0.25 basket	<0.25 basket	0