West Coast Prawn (*Melicertus latisulcatus*) Fishery

Fishery Assessment Report to PIRSA Fisheries

February 2006

Dixon, C.D. and Roberts, S.D.

This Fishery Assessment Report updates the 2005 status report for the West Coast Prawn Fishery and is part of SARDI Aquatic Sciences ongoing assessment program for South Australia's Prawn Fisheries. The aims of the report are to synthesise information for the West Coast Prawn Fishery, to assess the current status of the resource and consider the uncertainty associated with the assessment, to comment on the current biological Performance Indicators and Reference Points, and to identify future research needs for the fishery.

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EXECUTIVE SUMMARY

1. This report updates the 2005 fishery status report and is part of SARDI Aquatic Sciences ongoing assessment program for the West Coast Prawn Fishery (WCPF). It aims to (1) synthesise and assess the information available for the WCPF from 1968–2004, (2) assess the status of the resource and consider uncertainty associated with that assessment, (3) comment on current biological Performance Indicators for the fishery, and (4) identify future research priorities.

2. Since its inception in 1968 the WCPF has been characterised by declines and increases in catch. Annual catch was >50 t during the periods 1969–1975, 1980–1991 and 1994–2001. Catches were <14 t in 2003 and 2004.

3. Most of the historic catch was harvested from the Venus Bay region (66%), followed by the Ceduna region (28%) and Coffin Bay region (6%). During 2001, 78 t was harvested from the Coffin Bay region, a catch six times larger than its previous peak annual catch.

4. Nominal CPUE generally increased over time, probably reflecting increases in the fishing power of the fleet. CPUE trends over shorter time scales (i.e. between years) fluctuated substantially and closely followed trends in catch.

5. There were few observed trends in catch, effort or CPUE data to aid explanation of the catch declines that led to low catch periods during 1977–79 and 1992–93. Without commercial size data it is difficult to determine if these declines were associated with overfishing and/or extrinsic factors (such as Sea Level Height and Sea Surface Temperature).

6. Prawn size data obtained from the commercial catch between 1996 and 2004 showed that high catches of extra large prawns were harvested from the fishery during 1996 and 1997, particularly in the Venus Bay region. Thereafter, the abundance of extra large prawns in the catch reduced steadily and substantially. High catches of small prawns were harvested from the Ceduna region during 1996, 1998 and 2001. Consistently high catches of small prawns were harvested from the Venus Bay region between 1996 and 2001, despite substantial reductions in the catch of larger prawns during this period.

7. The third catch decline and subsequent low-catch period (2002–current) was probably related to a combination of high catches of extra large prawns during 1996 and 1997, high catches of small prawns from 1996–2001, and unfavourable environmental conditions for recruitment.

8. The Performance Indicators (PIs) of “fishing effort” and “prawn size” were within the reference range from 2002–2004. The PIs “recruitment index” and “% virgin spawning biomass” could not be calculated from the available data. The current suite of PIs need to be reviewed.

9. The stock upon which the fishery is based is currently in its weakest position for at least 11 years and possibly since the inception of the fishery. Conservative harvest strategies, particularly during the spawning period, would enhance the potential for stock recovery.

1. GENERAL INTRODUCTION

1.1 Overview

This Fishery Assessment Report for the West Coast Prawn Fishery is a “living” document that is part of SARDI Aquatic Sciences ongoing assessment programs for South Australian Prawn Fisheries. It updates the previous stock assessment report for this fishery (Svane & Barnett 2005). The aims of the report are: (1) to synthesise information for the West Coast Prawn Fishery from 1968–2004; (2) to assess the current status of the resource and consider the uncertainty associated with the assessment; (3) to comment on the current biological Performance Indicators and Reference Points; and (4) to identify future research needs for the fishery.

The report is divided into five sections. The first section is the General Introduction that: (1) outlines the aims and structure of the report; (2) describes the fishery including the West Coast environment and the fishery’s history; (3) outlines current management arrangements; (4) identifies the Biological Performance Indicators (PI) and Target and Limit Reference Points; (5) summarises the biological knowledge of West Coast prawns; (6) provides a synopsis of previous stock assessment reports for the fishery; and (7) outlines the current research program.

Section two presents the analyses and interpretation of fishery-dependent logbook data from 1968–2004, documenting trends in catch, effort, CPUE and prawn size. Analyses of fishery-independent data on catch rate and prawn size from stock assessment surveys conducted between 1989 and 2004 are provided in section three.

Section four provides assessment of the fishery against the biological Performance Indicators outlined in the Management Plan. The final section, section five, (1) summarises the information available for stock assessment of the West Coast Prawn Fishery, (2) assesses the status of the resource and comments on the uncertainty associated with that assessment, (3) assesses the current harvest strategies of the fishery, (4) identifies the limitations of the current PI and suggests an alternative approach and (5) outlines future research needs to improve stock assessment for this fishery.

1.2 Description of the fishery

1.2.1 Fishery location

There are three commercial prawn fisheries in South Australia: Spencer Gulf, Gulf St. Vincent and the West Coast (Figure 1.1). The West Coast Prawn Fishery is the smallest of these in terms of production and number of licence holders.

The West Coast Prawn Fishery includes the waters east of the meridian of longitude 131° east to 137° east, excluding the waters of Spencer Gulf. The three main fishing grounds are the Ceduna region, Venus Bay region and Coffin Bay region (Figure 1.1).

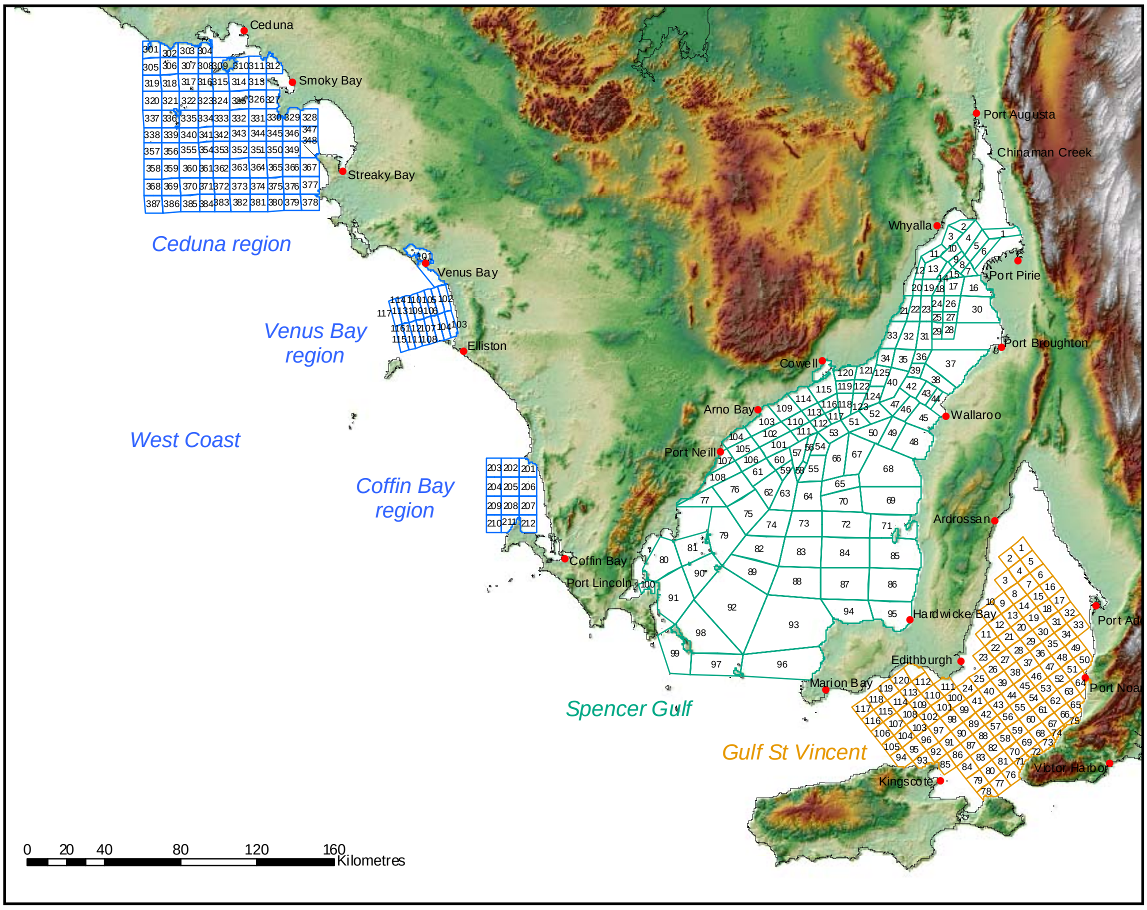

Figure 1.1 Location of South Australia's three western king prawn fisheries.

1.2.2 The West Coast environment

The West Coast Prawn Fishery occurs in an oceanic environment that is vastly different to South Australia's gulf prawn fisheries. In general, the main oceanic currents of the region run north-west to south-east in the winter and south-east to north-west in the summer (Middleton and Platov 2003).

The West Coast fishery is associated with significantly lower temperatures and salinities compared to the Spencer Gulf (Zed 1977; Carrick *et al.* unpublished). Figure 1.2 illustrates the generally cooler waters of the West Coast during summer, where only the major bays are of similar warmer temperatures to the Spencer Gulf and Gulf St Vincent.

West Coast fishers generally fish in deeper water and on harder and coarser substrate than those of either gulf fishery. Also, the species composition of the West Coast marine environment differs substantially than that of the gulfs, affecting both the composition of the by-catch and the magnitude of prawn mortality from predation.

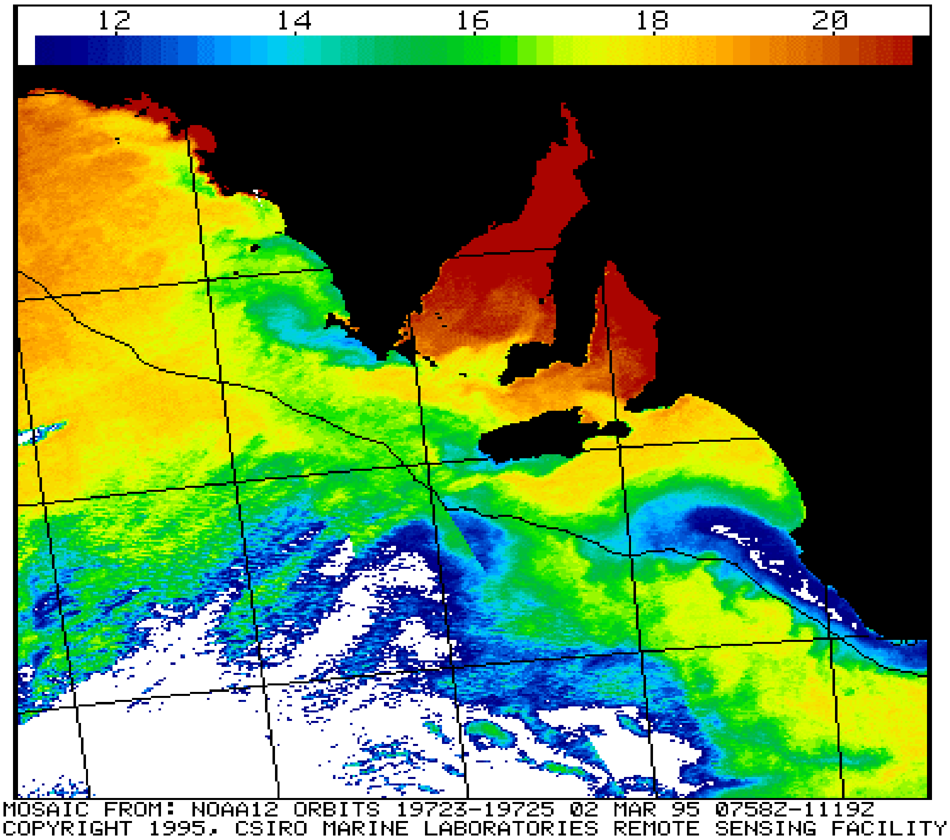

Figure 1.2 Sea-surface temperatures over the continental shelf of South Australia during late summer/early autumn, 1995. A colour-coded key in degree Celsius is situated at the top of the map. Figure from Linnane *et al.*, (2005).

1.2.3 Nursery Areas

Bryars (2003) provided a detailed inventory of important coastal fisheries habitats in South Australia. The entire South Australian coastline was divided into a number of Fisheries Habitat Areas (FHA) that corresponded to each of the 3 South Australian prawn fisheries as follows:

1) West Coast Prawn Fishery: FHA 1–6, 8–12, 14–17, 19 (Nullabor to Sleaford Bay)
2) Spencer Gulf Prawn Fishery: FHA 20,23,25–37 (Thorny Passage to Formby Bay)
3) Gulf St Vincent Prawn Fishery: FHA 38–45, 55, 54, 62 (Foul Bay to Yankalilla Bay, and north-eastern Kangaroo Island)

Each FHA has a comprehensive description, including colour-coded maps of up to 12 habitat types (Bryars 2003). Of these, the habitat types ‘tidal flats’ and ‘mangrove forests’ were determined as appropriate juvenile prawn habitat. ‘Tidal flats’ included mud flats, sand flats and intertidal unvegetated soft bottoms. It was noted by Bryars (2003) that these tidal flats were often associated with adjacent mangrove forests. ‘Tidal flat’ habitat also included intertidal seagrass meadows and intertidal macroalgal environments. ‘Mangrove forest’ were characterised by a soft sediment substratum in the upper intertidal zone dominated by a vegetative cover of the grey mangrove (*Avicennia marina*). The proportion of the coastline for each FHA containing these two habitat types was estimated to the nearest 10% from the maps (Bryars 2003), enabling estimation of the length of coast for each habitat type. These estimates were summed across each fishery. The total length of coastline for each fishery was calculated from satellite imagery (http://earth.google.com). Table 1.6 provides habitat summary estimates for each fishery and for the fished regions of the West Coast.

Table 1.1 The number of Fishery Habitat Area’s (Bryars 2003) and the estimated proportion and distance of coastline of tidal flat and mangrove habitat types for each of South Australia’s three prawn fisheries, and for coastlines adjacent to fished regions of the West Coast.

Fishery	# FHA’s	Coastline (km)	Tidal flat		Mangrove	
			%	km	%	km
Spencer Gulf	15	992	76	753	25	245
GSV	11	551	55	304	14	79
West Coast	16	1310	27	355	3	45
- Ceduna (FHA 5,6,8)	3	288	58	167	14	39
- Venus Bay (FHA 11,12)	2	109	90	98	5	6
- Coffin Bay (FHA 15,16)	2	193	47	90	0	0

Of the 1310 km coastline of the West Coast between the Nullabor and Sleaford Bay, 355 km (27%) was tidal flat habitat and 45 km (3%) was mangrove forest (Table 1.6). The Ceduna region contained the greatest amount of juvenile prawn habitat (167 km of tidal flats and 39 km of mangrove forest), followed by the Venus Bay (98 km of tidal flats and 6 km of mangrove forest) and Coffin Bay regions (90 km of tidal flats and 0 km of mangrove forest). These data, and data on prawn size (see Section 3.2.2) and tag movement (see Section 1.4.9) suggest that Ceduna is the main recruitment region for the West Coast Prawn Fishery.

Although the Spencer Gulf coastline totalled only 75% of that of the West Coast, tidal flat and mangrove habitat were 180% and 444% more abundant, respectively. The Gulf St Vincent coastline, including north-eastern Kangaroo Island from Cape Dutton to Kangaroo Head, totalled only 42% of that of the West Coast. Despite this, tidal flat habitat in GSV was similarly abundant (304 km GSV, 355 km WC), and mangrove habitat was almost twice as abundant (79 km GSV, 45 km WC). The extent of available juvenile habitat appears to correlate well with production from each fishery, particularly with respect to mangrove habitat. Of note, the importance of mangrove habitat for prawn recruitment has long been debated (see Lee 2004). The low production of the West Coast Fishery in comparison to GSV (each has similar juvenile habitat available) is likely due to the oceanic nature of the West Coast fishery and its influence on recruitment success.

1.2.4 Commercial fishery

The West Coast Prawn Fishery is a single species fishery based on the western king prawn *Melicertus (Penaeus) latisulcatus*, previously known as *Penaeus latisulcatus* (see Perez Farfante & Kensley 1997). A smaller penaeid, *Metapenaeopsis crassima*, occurs in South Australian waters but is of no commercial value. The West Coast Prawn Fishery was established in 1968 when commercial quantities of prawns were first harvested by the vessels ‘Tekoura’ and ‘Osprey’ in the Venus Bay region (Wallner 1985). In these early years of the fishery, Spencer Gulf trawlers made winter trips to this region as catch rates in Spencer Gulf were depressed during winter months. In 1973, the annual production of the Venus Bay region peaked at approximately 290 t with up to 16 Spencer Gulf fishers operating at one time. After exploratory trawls in the Ceduna region identified good prawn trawling grounds, the first permit was granted for commercial trawling in this region in 1974. From 1974 onwards catches in the Venus Bay region plummeted, reaching a low of only 16.4 t in 1978. In this year it was agreed that the Spencer Gulf fleet would not fish the West Coast and in 1979 the West Coast became a limited permit fishery with three license holders.

Prawns are harvested at night using demersal, otter-trawl, double-rig gear (Figure 1.3). Considerable technological advancements have been made in the fishery including the use of "crab bags" to exclude mega-fauna by-catch (Figure 1.4), "hoppers" for efficient sorting of the catch and rapid return of by-catch (Figure 1.3), and "graders" to sort the prawns into marketable size categories (Figure 1.3). Of the three vessels in the West Coast Prawn Fishery, all are fitted with crab bags and a grader, although only one is fitted with a hopper.

The West Coast Prawn Fishery is the smallest prawn fishery in Australia (Table 1.1). South Australian prawn fisheries (Spencer Gulf, GSV and West Coast) are the only single species prawn fisheries in Australia. *M. latisulcatus* are also a target species of the Shark Bay (78% of total catch) and Broome fisheries (44% of total catch).

Table 1.2 Production figures and species harvested in major Australian prawn fisheries. * includes by-product.

Fishery	Year	Production (t) (% W. king)	Value $000,000	Vessels	Prawn sp. harvested
Northern	2001–02	8,742*	135*	95	Banana, tiger, endeavour
North Qld	2003	9,348*	110*	630	Banana, tiger, endeavour, king, bay
NSW	2000–01	3,411*	32*	238	Eastern king, school
Shark Bay	2001	1,696 (78%)	25.2	27	Western king, tiger, endeavour, coral
Broome	2001	142 (44%)	1	5	Western king, coral
Spencer Gulf	2003–04	1,939 (100%)	40.1	39	Western king
GSV	2003–04	172 (100%)	3.1	10	Western king
West Coast	2003–04	15 (100%)	0.2	3	Western king

1.2.5 By-product and by-catch

West Coast prawn fishers are permitted to sell several "by-product" species: slipper lobster (*Ibacus* spp), scallop (Pectinidae), octopus (*Octopus* spp.), southern calamary (*Sepioteuthis australis*) and arrow squid (*Nototodarus gouldi*). The life history and population status of these species on the West Coast of South Australia is poorly understood. Commercial fishing logbooks have been recently updated to include mandatory reporting of by-product species in response to DEH recommendations for South Australian prawn fisheries (Anon 2004).

1.2.6 Recreational, indigenous and illegal catch

Significant recreational catches of *M. latisulcatus* are precluded by current fisheries regulations that require recreational prawn catches to be taken from waters >10 m in depth using hand held nets. Levels of indigenous and illegal fishing are considered negligible (Anon 2003).

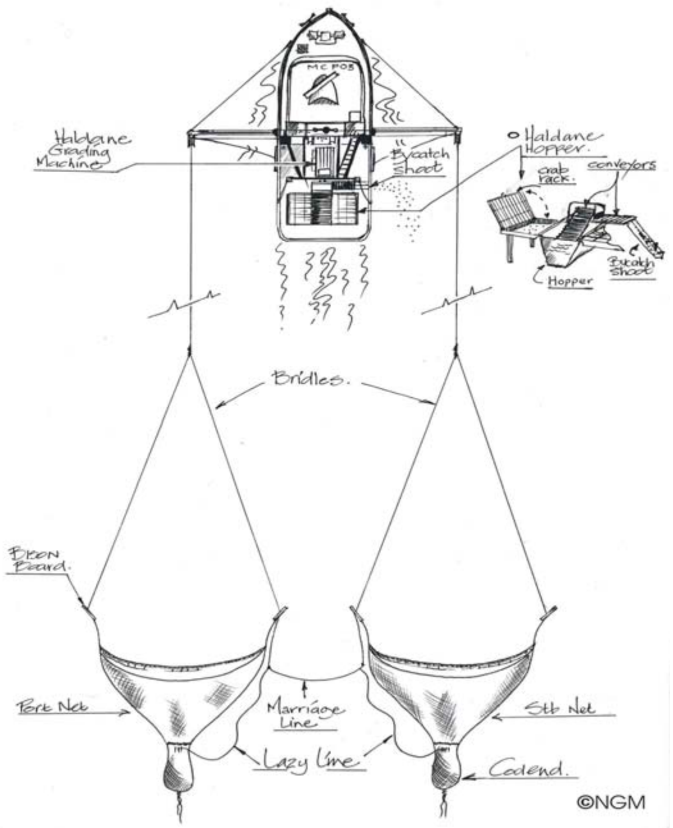

Figure 1.3 Double rig trawl gear and location of hopper sorting and prawn grading systems. Figure from Carrick (2003).

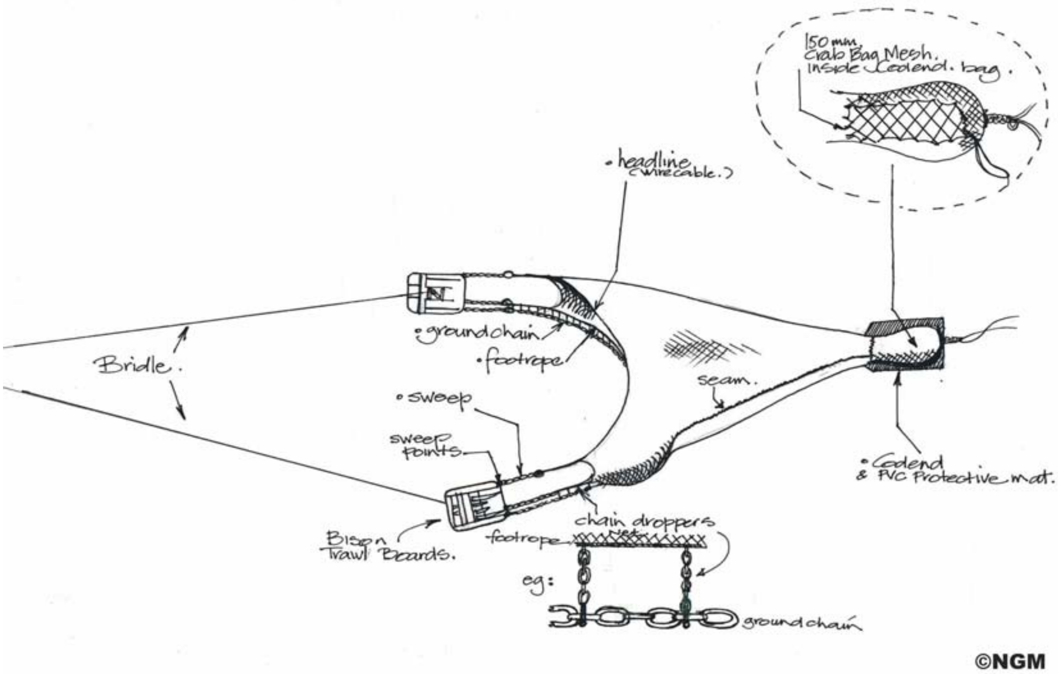

Figure 1.4 Trawl net configuration showing trawl boards, head rope, ground chain and cod end with crab bag. Figure from Carrick (2003).

1.3 Management of the fishery

The West Coast Prawn Fishery is managed by Primary Industries and Resources South Australia (PIRSA) under the framework provided by the *Fisheries Act 1982*. General regulations for South Australia's prawn fisheries (commercial and recreational) are described in the *Fisheries (General) regulations 2000*, with specific regulations located in the *Scheme of Management (Prawn fisheries) Regulations 1991*. These three documents provide the statutory framework for management of the West Coast Prawn Fishery.

1.3.1 Current fishery management

The West Coast Prawn Fishery is a limited entry fishery with three licensed operators. Trawling activities are banned during daylight hours and must be conducted in waters >10m depth. Effort is restricted both spatially and temporally throughout the fishing-year by fishery closures. Effective effort (fishing power) is restricted by gear restrictions including vessel size and power, type and number of trawl nets towed, maximum headline length and minimum mesh sizes. Current management arrangements are summarised in Table 1.3.

Table 1.3 Current management arrangements

Prawn fishery management strategy	Specification
Limited entry	Yes
Number of licences	3
Corporate ownership of licences	Yes
Licence transferability	Yes
Permitted prawn species harvested	*Melicertus latisulcatus*
Permitted by-product species harvested	*Ibacus* spp., *Sepioteuthis australis, Nototodarus gouldi, Octopus* spp., Pectinidae,
Maximum number of days fishing	120
Minimum depth trawled	10 metres
Method of capture	Demersal Otter Trawl
Maximum length of vessel	22 metres
Maximum engine capacity	272 kW
Trawl net configuration	Single or double
Maximum total headline length	29.26 metres
Minimum mesh size	4.5 cm
Catch and effort data	Daily logbook submitted monthly
Catch and disposal records	Daily CDR records
Recreational fishery	Depth> 10 metres, hand nets only
Recreational licence	Not required

Fishing takes place between sunset and sunrise, from the last quarter of the moon through to the first quarter, generally in the months of November, December, March, April, May and June. Harvest strategies for each period are either based on catches from the previous period, or data collected during fishery-independent and fishery-dependent surveys.

1.3.2 Prawn Fishery Management Plan

The Management Plan for the West Coast Prawn Fishery (MacDonald 1998) was developed by the Prawn Fishery Management Committee (PFMC). This plan provides guideline policies, objectives and strategies for the sustainable management of the fishery. The biological and ecological objectives and strategies are relevant to this report and are summarised in Table 1.4.

Table 1.4 Biological and ecological objectives and strategies of the Management Plan (MacDonald 1998) for the Spencer Gulf and West Coast prawn fisheries

Objective	Strategy
Biological	
Maintain 50% virgin spawning biomass Prevent growth overfishing and capture of small prawns	• adopt a precautionary approach • collect catch, effort and fishery-independent data to assess against the performance indicators • maintain sustainable exploitation rates • monitor effort levels • produce annual stock assessment reports to determine subsequent harvest levels • annual review of research • improve harvest practices and strategies
Ecological	
Minimise the impact of trawling on the environment Minimise trawl by-catch Monitor marine environment	• monitor and assess trawl by-catch • improve technology to minimise environmental impacts • minimise impacts on other fisheries • communicate with other user groups of Spencer Gulf waters • promote conservation of seagrass and juvenile prawn habitats

1.3.3 Performance Indicators and Reference Points

The Management Plan specifies Performance Indicators (PI) and Reference Points that form the basis upon which performance of the fishery is assessed (Table 1.5). “Target Reference Points” define the desirable management target. “Limit Reference Points” define the level where intervention is required to prevent long-term stock decline. Caddy and McMahon (1995) provide detailed background into the conceptual and applied aspects of Reference Points for fisheries management.

Table 1.5 Summary of the biological and economic Performance Indicators and Reference Points for the West Coast Prawn Fishery (MacDonald 1998).

Performance Indicator	Target Reference Point	Limit Reference Point
Effort (days)	100-110	120
% Virgin Spawning Biomass	50%	40%
Recruitment Index (juv./shot)	40	35
Size at capture	<40 per kg	ƒ40 per kg

1.4 Biology of the Western King Prawn

1.4.1 Distribution and taxonomy

The western king prawn, *M. latisulcatus,* is distributed throughout the Indo-west Pacific (Grey *et al.* 1983). Its distribution in South Australia is restricted to waters of Spencer Gulf and Gulf St Vincent and along the west coast including the commercially fished areas of Ceduna, Venus Bay and Coffin Bay.

M. latisulcatus is a benthic species that prefers sandy areas to seagrass or vegetated habitats (Tanner & Deakin 2001). Both juvenile and adult prawns show a strong diel behavioural pattern of daytime burial and nocturnal activity (Rasheed & Bull 1992; Primavera & Lebata 2000).

The distribution and abundance of *M. latisulcatus* within gulfs and estuaries is affected by salinity and the presence of sandy substratum (Potter *et al.* 1991). Higher abundances are associated with salinities above 30‰ (Potter *et al.* 1991). In physiological studies on *M. latisulcatus*, optimal salinity ranged from 22–34‰, and 100% mortality occurred at salinities below 10‰ (Sang & Fotedar 2004). Juvenile *M. latisulcatus* are more efficient osmoregulators than adults, tolerating greater variation in salinity. Important nursery areas in Western Australia and South Australia are characterised as being hyper-saline (35–55‰) (Carrick 1982; Penn *et al.* 1988).

1.4.2 Reproductive biology

In the West Coast Prawn Fishery adult prawns aggregate, mature, mate and spawn in deep water (>10 metres) between September and March, peaking in November/December (Wallner 1985). During mating the male transfers a sperm capsule (spermatophore) to the female reproductive organ (thelycum). The success of this insemination depends on the female prawn having recently moulted. In GSV, females were shown to release between 80,000 and 600,000 eggs in a single spawning event (Kangas & Stewart-Rowe unpublished data), with larger females producing proportionally more eggs than smaller females.

During the peak spawning period, the sex ratio of *M. latisulcatus* caught in West Australia (WA) was shown to significantly change to that of a female biased catch. This was attributed to a higher catchability of females due to increased foraging-feeding activity necessitated by food requirements during ovary development (Penn 1976; Penn 1980). Similarly, during the months of November and December, female biased populations of *M. latisulcatus* have been documented in Gulf St Vincent (Svane 2003; Svane & Roberts 2004).

Spawning and fecundity is affected by water temperature with the minimum for spawning being 17°C for *M. latisulcatus* in WA (Penn 1980). The peak reproductive period in Queensland (QLD) populations of *M. latisulcatus* was between June and July when water temperature dropped below 25°C (Courtney & Dredge 1988). Thus, the ideal temperature range for spawning in *M. latisulcatus* appears to be 17–25°C.

Spawning and fecundity in *M. latisulcatus* is also affected by body size. The smallest ripe female recorded in QLD populations was 34 mm CL (Courtney & Dredge 1988), while in WA the smallest ripe female was 29 mm CL (Penn 1980). In South Australia, the smallest observed ripe female was 26 mm CL in Spencer Gulf (Roberts pers obs). While *M. latisulcatus* females can mature at a small size, insemination rate increases with size. Courtney & Dredge (1988) showed that ~50% of females were inseminated at 34 mm CL, while ~95% were inseminated at 42 mm CL. Thus larger prawns make a greater reproductive contribution due to greater insemination rates, as well as greater fecundity (Penn 1980; Courtney & Dredge 1988; Carrick 1996).

Crocos & Coman (1998) found year-old broodstock of *Penaeus semisulcatus* outperformed 6-month olds regardless of season in parameters such as maturation rate, spawning rate, fecundity, hatch rate, larval survival rate, and larval production rate. However, in the eastern king prawn (*P. plebejus*) it was found that females greater than 50 mm CL contribute little to egg production, while the bulk of the eggs are produced by middle to upper size ranged prawns of 35–48 mm CL (Courtney *et al.* 1995). Such ovarian senescence in large (old) female *M. latisulcatus* has not been documented.

The timing of spawning for *M. latisulcatus* was related to the timing of moulting in several previous studies (Penn 1980; Courtney & Dredge 1988). This was inferred from three independent observations: an absence of well-developed (stage 3 or 4) ovaries in recently moulted females (Penn 1980; Courtney & Dredge 1988); females lost the spermatophores with the exuvium at moult (Penn 1980) and; the average interval for both moulting and spawning was the same in tagging experiments (Penn 1980).

The average moult interval for mature untagged females in WA populations during the spawning season was estimated at 30–40 days (Penn 1980). Thus spawning events can occur on multiple occasions throughout the spawning season. Evidence supporting the occurrence of multiple spawning include: the gonad score stage 5 (spent) is difficult to identify because immediate ovary development meant that prawns are classified as stage 2 (Penn 1980; Courtney & Dredge 1988); in an experiment where ripe females were tagged and released, 15 re-captured individuals were found to have spawned and moulted, and had ovaries at an early stage of development during the same season (Penn 1980) and; artificial multiple spawning of *P. orientalis* was conducted in aquaria using eyestalk ablation (Arnstein & Beard 1975).

Parasite load and disease status is a limiting factor in marine animal populations, although generally overlooked in fisheries management (Harvell *et al.* 2004). Courtney *et al.* (1995) showed that parasitisation by bopyrid isopods affected the reproductive output of *P. plebejus*. Bopyrid isopods have been observed to parasitise South Australian population of *M. latisulcatus* (Roberts pers. obs.). In *F. indicus*, it was shown that viral infections affected moulting and reproduction (Vijayan *et al.* 2003). In addition, environmental pollution from coastal industry or even chemical spills from marine vessels can increase the susceptibility of prawns to disease and reduce reproductive output (Nash *et al.* 1988). These issues are poorly understood and hold implications for the management of prawn fisheries in South Australia.

1.4.3 Larval and juvenile phase

The lifecycle of *M. latisulcatus* is divided into a pelagic larval phase, an inshore juvenile (nursery) phase and finally an offshore adult phase (Figure 1.5). Prawn larvae undergo metamorphosis through four main larval stages: nauplii, zoea, mysis and post-larvae. The length of the larval stage depends on water temperature and food availability, with faster development in warmer nutrient rich waters (Hudinaga 1942). It was previously suggested that the larval period of *M. latisulcatus* in Spencer Gulf could exceed 40 days, where water temperatures over the main spawning and larval period range from 19–25° C (after Shokita 1984, cited in Carrick 2003). Carrick (2003) suggested that spawning stock status, wind-driven and tidal currents, latitude, water temperature and salinity all affected the distribution and abundance of larvae. Wallner (1985) showed that post-larvae were present in the water column between December and March in fished regions of the West Coast.

In South Australia, juvenile *M. latisulcatus* occur predominately on intertidal sand- and mud-flats, generally located between shallow subtidal / intertidal seagrass beds and mangroves higher on the shoreline (Kangas and Jackson 1998; Tanner and Deakin 2001). Juvenile prawn abundances in the Spencer Gulf were significantly greater in the mid intertidal zone compared to the lower and upper zones (Roberts *et al.* 2005). Carrick (1996) showed that post-larvae settled in inshore nursery areas of the Spencer Gulf when 2–3 mm CL and remained there for up to 10 months, depending on the time of settlement. The post-larvae produced from early spawning events settled in nursery areas during December or January where they grew rapidly and then emigrated to deeper water in May or June. Alternatively, post-larvae produced after January settled in nurseries from March. These late season post-larvae grow slowly and "over-winter" in the nursery areas before recruiting to the trawl grounds in February of the following year (Carrick 2003). The effect of over-wintering on adult growth and survival are unknown.

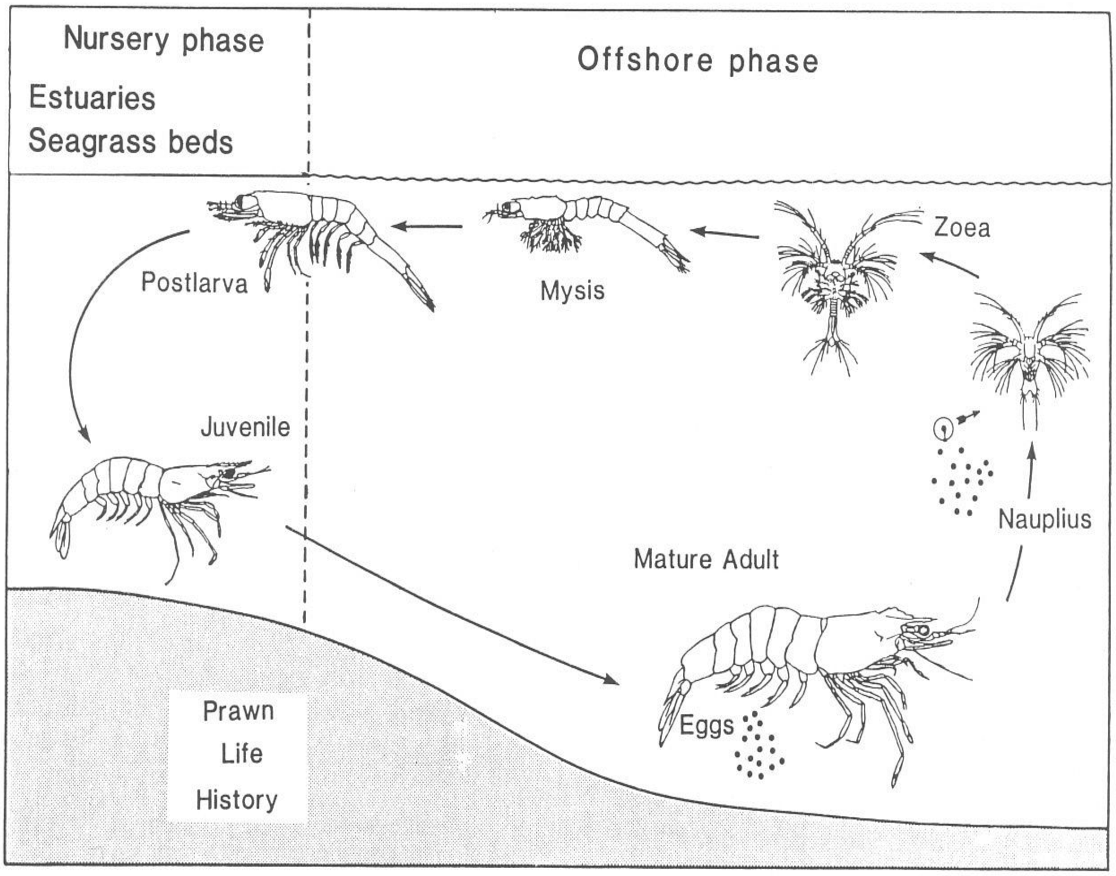

Figure 1.5 Life cycle of *M. latisulcatus* (Carrick 2003).

1.4.4 Growth

As with other crustaceans, prawns undergo a series of moults to increase their size incrementally. The shedding of hard body parts during moulting means that the age of individuals cannot be reliably determined as is possible for teleost or cartilaginous fishes, through the examination of otoliths or vertebrae. The inability to directly age prawns has increased the reliance on tag-recapture and cohort analysis for the determination of growth rate. Each of these methods was applied by Wallner (1985) to estimate growth rates for prawns of the West Coast Fishery.

During 1983 and 1984 a total of 4670 tagged and measured prawns were released in the Ceduna and Venus Bay regions. Of these, 510 prawns were recaptured within one year, from which the von Bertalanffy growth parameters K and L_∞ were estimated (Table 1.7). Analysis of length frequency cohorts obtained monthly between May 1984 and March 1985 in the Venus Bay region provided additional estimates of K and L_∞ (Table 1.7). Comparison of these estimates showed considerable differences between methods, with tagging data providing depressed estimates of growth rate compared to cohort analysis for both sexes (Figure 1.6). Uncertainties associated with each method of growth estimation included:

- growth suppression by the tagging process (Penn 1975; Menz & Blake 1980),
- short time at liberty for tag-recaptures influenced by seasonal growth,
- bias in size at release and time at liberty during tag-recapture experiments,
- ability to distinguish cohorts, effect of catchability, and net migration on cohort analysis,
- measurement error (both methods).

Table 1.6 Sex-specific growth parameters for *M. latisulcatus* estimated from tag-recapture and cohort analysis in the West Coast (Wallner 1985) and from tag-recapture in Spencer Gulf (Carrick 2003) and Gulf St Vincent (Kangas & Jackson 1997).

Fishery	Method	Sex	Growth parameters	
			K (yr^{-1})	L_∞ (mm)
West Coast	Cohort	Male	0.73	44.1
		Female	0.88	53.9
West Coast	Tag	Male	0.83	39.4
		Female	0.36	60.4
Spencer Gulf	Tag	Male	0.86	46.1
		Female	0.61	64.0
GSV	Tag	Male	0.62	47.2
		Female	0.54	65.3

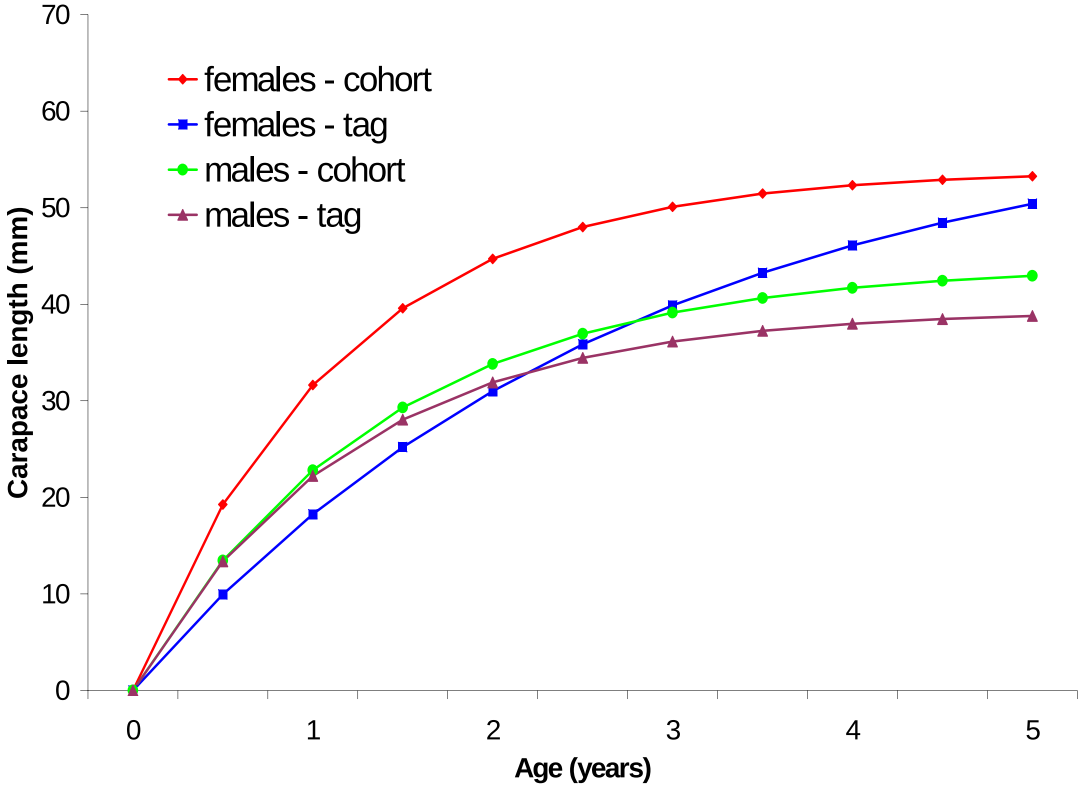

Figure 1.6 Sex-specific growth curves for *M. latisulcatus* in the West Coast from tag-recapture and cohort analysis (Wallner 1985).

Carrick (2003) estimated growth rates from >9,000 tag-recaptures in Spencer Gulf and Kangas and Jackson (1997) estimated growth rates from 464 recaptures in GSV (Table 1.7). In each fishery, growth rates were seasonal, peaking in late summer and autumn and negligible from July to December. Growth was strongly seasonal because winter water temperatures are at the lower limits of their preferred temperature range (Wu 1990).

Comparison of growth rate estimates for each sex and each fishery suggest that prawns attain a smaller size and grow at a slower rate in the West Coast than South Australia's other prawn fisheries (Figure 1.7). Whilst this may be an artefact of the associated uncertainty previously described for the Wallner (1985) estimates, growth may be slower due to the likely cooler water temperatures of the West Coast's oceanic environment.

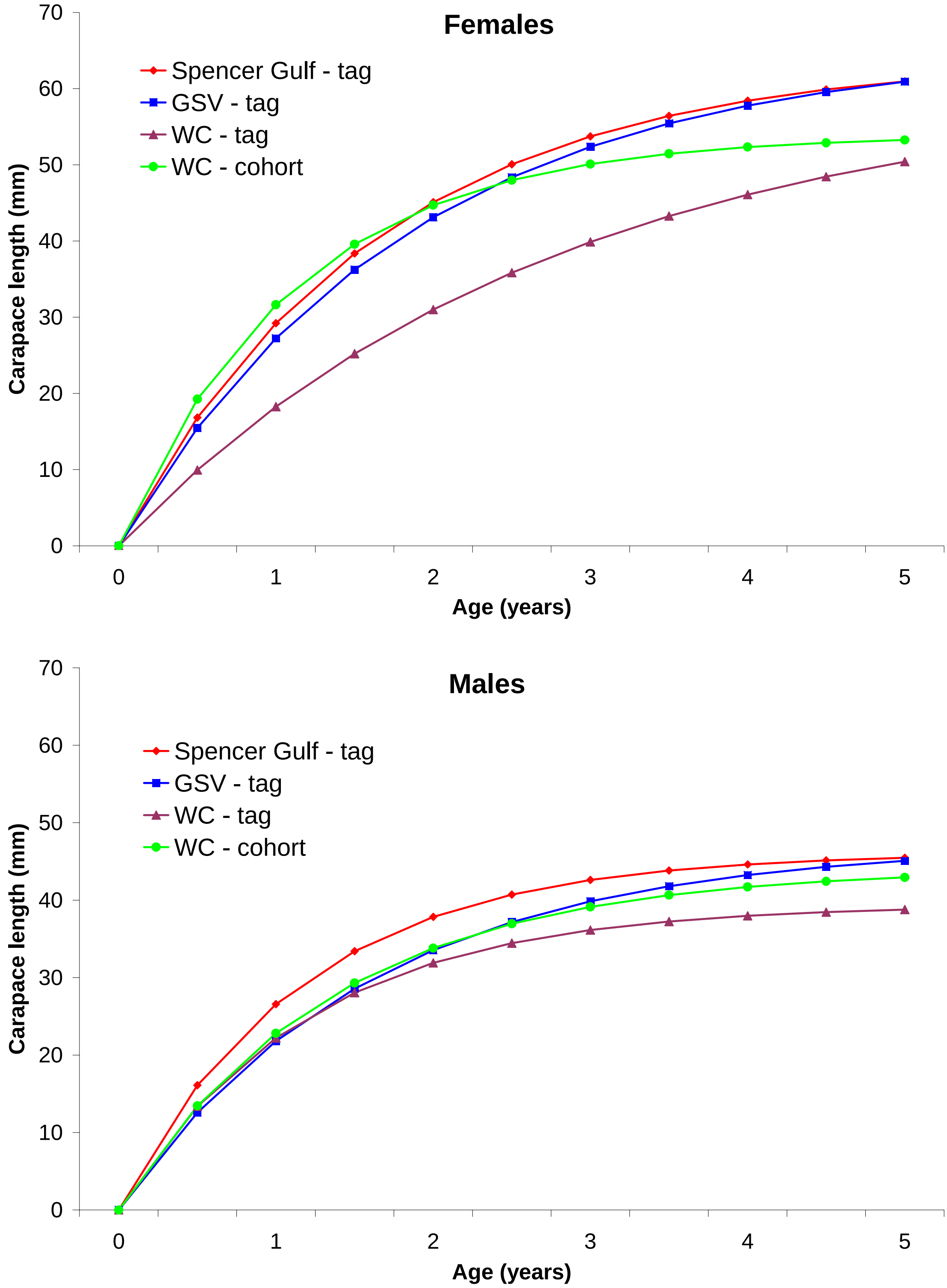

Figure 1.7 Sex-specific growth curves for *M. latisulcatus* estimated from tag-recapture and cohort analysis in the West Coast (Wallner 1985) and from tag-recapture in Spencer Gulf (Carrick 2003) and Gulf St Vincent (Kangas & Jackson 1997).

1.4.5 Length weight relationship

Length weight relationships have not been documented for the West Coast Prawn Fishery. The relationship between prawn carapace length (CL, mm) and weight (g) from Spencer Gulf was determined from a sample of over 2,000 prawns (Carrick 2003). The power relationship described by the equation "Weight = a × carapace length^ b" varies between males (a= 0.00124, b=2.76) and females (a= 0.00175, b=2.66).

1.4.6 Size at maturity and fecundity

Neither size at maturity nor fecundity relationships have been documented for the West Coast Prawn Fishery. Carrick (1996) found complex relationships between maturity and size among spawning periods and areas in Spencer Gulf. The relationship between CL and proportion mature for female prawns in Spencer Gulf may be estimated from the logistic equation:

$$\text{Proportion mature} = 8.3\times10^{-6} + \left[\frac{1}{1+e^{-(0.277(CL-36.45))}}\right]$$

Table 1.8 presents the results of fecundity studies for *M. latisulcatus* undertaken in Gulf St. Vincent, South Australia (Kangas and Stewart-Rowe 1997, cited in Carrick 2003), and Shark Bay, Western Australia (Penn 1980).

Table 1.7 Fecundity relationships for *M. latisulcatus* populations in Gulf St. Vincent and Shark Bay. Fecundity = *a* × carapace length^ *b*

Location	a (± SE)	b (± SE)
Gulf St. Vincent	0.794 (0.006)	3.462 (0.002)
Shark Bay	0.070 (0.0002)	2.916 (0.001)

1.4.7 Movement determined from tagging studies

Between October 1983 and February 1985 over 6,500 tagged prawns were released in the Ceduna and Venus Bay regions (Wallner 1985). Recaptures generally indicated a southerly offshore pattern of migration. A second tagging study was carried out in 1990, with 5,000 tagged prawns released in Venus Bay. Again results showed a net offshore S/SE direction of movement (Carrick & Ostendorf 2005).

In a larger scale tagging experiment, 10,000 tagged prawns were released in March 2002 in the Ceduna region. From 20 recaptures >8 months after release, 17 were caught in the Venus Bay and Coffin Bay regions, again providing evidence for substantial migration south-eastward along the coast. A further 10,000 tagged prawns were released in March 2003 in the Ceduna region, with eight recaptures obtained >9 months after release. Of those recaptured, seven were caught in the Ceduna region and, despite the reduced distance of travel, a general S/SE direction of movement was still apparent. Approximate movements from these contemporary tag-recapture experiments are plotted in Figure 1.8.

Each of these tag-recapture experiments was substantially affected by the magnitude and distribution of commercial fishing effort following release. On all occasions the status of the resource was poor relative to periods of good historic catches. This causes uncertainty in the interpretation of results including: the proportion and magnitude of movements within and between regions; the effect of population density on movement within and between regions; levels of dispersal and mortality, and; the distribution of prawns outside of fished regions.

In summary, tag-recapture experiments in the West Coast indicate general localised inshore to offshore movement with a south-easterly direction of migration along the coastline that enables movements between regions. Future tagging experiments should be carried out when the fishery has recovered to increase the chance of recapture during commercial fishing and ensure that the results are pertinent to those of a healthy stock.

It should be noted that while the use of external tags improves tag-sighting probability, they have been associated with higher prawn mortality rates (Benzie *et al*. 1999) and suppressed growth rates (Penn 1975; Menz & Blake 1980), particularly for small prawns. These effects can be reduced with the use of antibiotic/antifungal ointment on the tag to reduce post-tag mortality from infection (Courtney *et al.* 2001) and selective tag colour to reduce prawn predation (Benzie *et al*. 1995).

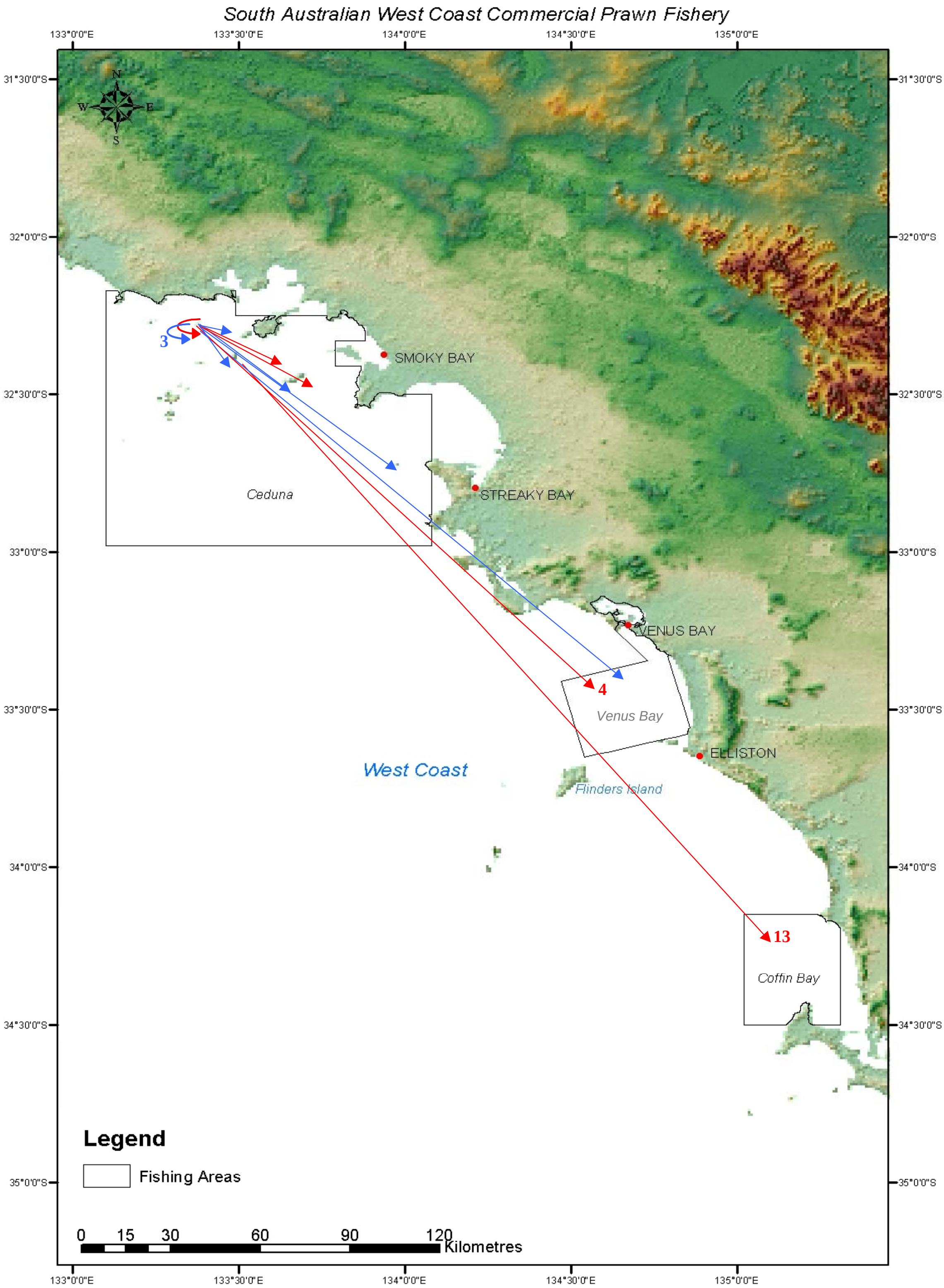

Figure 1.8 Approximate vectors indicating prawn movement from recaptured tagged prawns released in the Ceduna region during 2002 (red) and 2003 (blue). Numbers indicate more than one recapture in that area, while circular arrows indicate recaptures caught close to the release site. Within region recapture positions were provided only for the Ceduna region.

1.4.8 Natural mortality

Wallner (1985) estimated daily instantaneous rates of natural mortality of prawns on the West Coast to be between 0.001 (inshore populations) and 0.014 (offshore populations). These values are consistent with other natural mortality values for this species in Spencer Gulf (0.003 to 0.005; King 1977), Gulf St Vincent (0.003; Kangas & Jackson 1997) and Western Australia (0.002 to 0.005; Penn 1976).

Natural mortality (*M*) of juvenile prawns was determined in Spencer Gulf from June to November between 1992 and 1994 (*M*=0.05/week, Carrick 2003). Natural mortality for juvenile *M. latisulcatus* in Spencer Gulf prawn nurseries was found to be lower than that for other prawn species (Carrick 1996).

1.4.9 Prawn health

The health of West Coast populations of *M. latisulcatus* and the potential effects of coastal pollutants, parasites and disease on growth, survival and reproduction is poorly understood. In Spencer Gulf juvenile habitats appear to have been influenced by oil spills (Roberts *et al.* 2005) and industrial effluent (Carrick 2003). Although the West Coast Prawn Fishery is at a lower likelihood of risk from coastal pollutants, its small extent of suitable juvenile prawn habitat (see Section 1.2.3) increases the consequence of such an event. Whilst bopyrid isopods have been noted to parasitise South Australian population of *M. latisulcatus* (Roberts pers. obs.), the effects of these and other parasites and disease are unknown.

1.5 Stock Enhancement

Stock enhancement is defined as a process whereby the abundance of free-living juveniles is supplemented by the release of juveniles reared in hatcheries or captured elsewhere (Munro & Bell 1997). In recent years, the Spencer Gulf and West Coast Prawn Fisherman's Association has been interested in the potential for stock enhancement to supplement the West Coast Prawn Fishery.

Stock enhancement using hatchery-produced juveniles began in the late 1870's with Atlantic cod (*Gadus morhua*) and was mainly conducted in the Untied States and Norway (Kitada 1999). Since then, a variety of species have been captured and cultured worldwide for the purpose of enhancing natural populations. Several programs for stock enhancement of demersal marine species have documented encouraging results with reported economic viability. In other cases, high production costs, and/or low survival rates, indicate that stock enhancement is not viable (see Munro & Bell 1997).

The earliest recorded restocking of prawns was in Japan in 1964 (Kurata 1981). Stock enhancement of penaeid prawn fisheries has since been used around the world for the purpose of increasing fishery yields, rebuilding over exploited stocks and dampening natural fluctuations in catch. China has been successfully restocking its white prawn (*Penaeus chinensis*) populations on a commercial scale since 1984. Semi-enclosed bays are intensively seeded at about 2.5 billion juveniles (8–10 mm carapace length) per year, increasing commercial catches as much as five-fold at an estimated 10% recapture rate. Restocking in China is economically viable because it is a by-product of the aquaculture industry (which produces close to 200,000 t per year), where excess post-larvae are raised at a marginal cost (AUS 0.1 cent each) (Rothlisberg *et al.* 1999). Restocking of penaeid prawns has also occurred for *P. japonicus* and *Metapenaeus monoceros* (Japan), and *P. monodon* (Taiwan) with varying degrees of success, and attempted and discontinued for *P. aztecus*, *P. setiferus*, *P. duorarum* (USA) and *P. semisulcatus* (Kuwait) (see Munro & Bell 1997; Su & Liao 1999; Loneragan *et al.* 2003). Munro & Bell (1997) noted that there is relatively little definitive information on the economic viability of stock enhancement for marine species in the literature, despite the number of attempts.

For a stock enhancement program to be both economically and ecologically successful, several key factors need to be taken into account (Munro & Bell 1997; Kitada 1999; Rothlisberg *et al.* 1999; Su & Liao 1999; Loneragan *et al.* 2003). These include:

- Methods and costs for producing, harvesting, transporting and releasing juveniles

- Release strategy (including optimum release site and time)
- Carrying capacity of release site
- Optimum release size and number of juveniles
- Survival rate (including rate of predation)
- Methods of monitoring and assessing the success of release (ie. tagging)
- Conservation of wild stock (disease free juveniles released, genetic preservation)
- Ecosystem impacts

In Australia, scientists and industry have been interested in the possibility of enhancing prawn stocks since the early 1990s (Loneragan *et al.* 2003). In 1993, a workshop was held to assess the potential for enhancement of *M. latisulcatus* in Venus Bay. The workshop represented an initial examination of the feasibility of restocking Venus Bay by producing simple bioeconomical models (unpublished report). Three methods for restocking were proposed; 1) send wild captured broodstock to an already established prawn hatchery, ie. in Queensland, for larval and post larval production, 2) on-site propagation of prawn larvae where wild captured broodstock are kept in sea-pens or ponds in Venus bay, or 3) build prawn hatchery facilities and associated infrastructure at Venus Bay. While Method 1 eliminates the large capital cost of building the required infrastructure for a prawn hatchery, it would rely on high captive survival rates and involve the risks of introducing diseases from Queensland prawn stocks. Methods 2 and 3 represent large capital costs, the latter in particular, and would have greater cost-benefit ratios than Method 1. However, the calculated marginal returns over the costs of purchase and harvest (Method 1) and the uncertainties in regard to mortality rates for Venus Bay and its stocking capacity, led workshop participants to conclude that commercial venture, or even an experimental restocking program, should not be contemplated before further research was carried out.

Following this workshop, an FRDC funded feasibility study into enhancing the brown tiger prawn (*P. esculentus*) trawl fishery in Exmouth Gulf (Western Australia) was conducted (Loneragan *et al.* 2003). This fishery was chosen for its geography, the extensively published research on the fishery and the capacity to develop suitable infrastructure at reasonable cost close to the release sites. The long-term commercial objectives of the program were to decrease the inter-annual variation in catches and increase the long-term average catch by at least 100 t (about 25% of the average annual catch). However, the initial outputs from the bio-economic model indicate that the probability of enhancement being economically viable in Exmouth Gulf is low, given the current values for the product, the costs of juvenile production and the estimated natural mortality rates.

1.6 Stock Assessment

Wallner (1985) produced the first stock assessment report for the West Coast Prawn Fishery. It was a comprehensive report that included analyses of commercial catch and effort data as well as studies on prawn larvae, juvenile abundance and habitat, growth, mortality, recruitment, migration and reproduction. Stock assessments for the West Coast Prawn Fishery were combined with Spencer Gulf assessments in 1998 (Carrick and McShane 1998), 2000 (Carrick and Williams 2000) and 2001 (Carrick and Williams 2001), the latter two being the first to consider the biological Performance Indicators of the fishery. Boxshall (2001) was the first contemporary independent report, and those subsequent have been presented in the form of status reports (Svane 2003; Svane & Barnett 2004, 2005). This stock assessment report utilises the information presented in these previous reports and provides substantial updates on historic research, commercial logbook data from 1968–2004, survey data collected since 1989, and prawn size data obtained from the commercial fishery since 1996.

1.7 Current Research and Monitoring Program

The current research program conducted by SARDI Aquatic Sciences in support of the West Coast Prawn Fishery comprises five components. These are: (i) administer a daily logbook program (ii) collate catch and effort information (iii) conduct independent stock assessment surveys to inform harvest strategies and assess the fishery against the performance indicators, (iv) manage and analyse databases of by-catch, juvenile sampling and tagging and (v) produce an annual report that assesses the status of the West Coast Prawn Fishery, including assessment of the fishery against the Performance Indicators defined in the Management Plan.

1.7.1 Catch and Effort Research Logbook

Licence holders are required to complete a daily and monthly logbook after the completion of fishing in each month. The logbook has undergone several modifications throughout time to improve the information available for assessment. Recent changes to the logbook include incorporation of size-grade data of the prawn catch, and reporting of retained by-product. The catch and effort data for the West Coast Prawn Fishery are analysed in Section Two of this report.

2. FISHERY STATISTICS

2.1 Introduction

This section of the report presents summaries and analyses of the catch and effort data for the West Coast Prawn Fishery. Data were obtained from two sources: annual data from 1968 to 1972 and monthly data from January 1973 to June 1980 were obtained from SAFIC annual reports (1975 to 1980); and daily data from July 1980 to December 2004 from daily logbooks. Daily logbook data from July 1980 to November 1986 are presented although they are not yet fully validated (discrepancies in annual catch between daily logbooks and various summaries were <5 t in all years). Daily logbooks provide data for each trawl shot including trawl time, estimated prawn catch and fishing block. Estimated prawn catch for each shot was adjusted using validated post-harvest catches reported in monthly logbooks. Catch-per-unit-effort (CPUE) was calculated as total catch (kg)/total effort (hrs).

2.2 Catch and effort

2.2.1 Inter-annual trends

The catch and effort history of the West Coast Prawn Fishery is punctuated by rapid declines and increases in production. For the purposes of this report periods where catches consecutively exceeded 50 t will be referred to as “high-catch” periods, and periods where catches were consecutively <50 t will be referred to as “low-catch” periods.

Modest catches of prawns were first commercially harvested from the West Coast in 1968 (Figure 2.1). Both catch and effort increased rapidly, with effort peaking at ~10,000 hrs in 1970 and catch peaking at ~290 t in 1973. The first high catch period lasted from 1969–1976 (mean annual catch = 183 t) and was followed by a 3-year low catch period. Catches recovered rapidly and were maintained from 1980–1991 (mean annual catch = 134 t). The second decline was more rapid with catches declining from ~180 t in 1991 to <10 t the following year. High catches were obtained from 1994–2001 (mean annual catch = 134 t) before another rapid decline from ~140 t in 2001 to ~30 t in 2002 and <5 t in 2003. The fishery remained in low production during 2004.

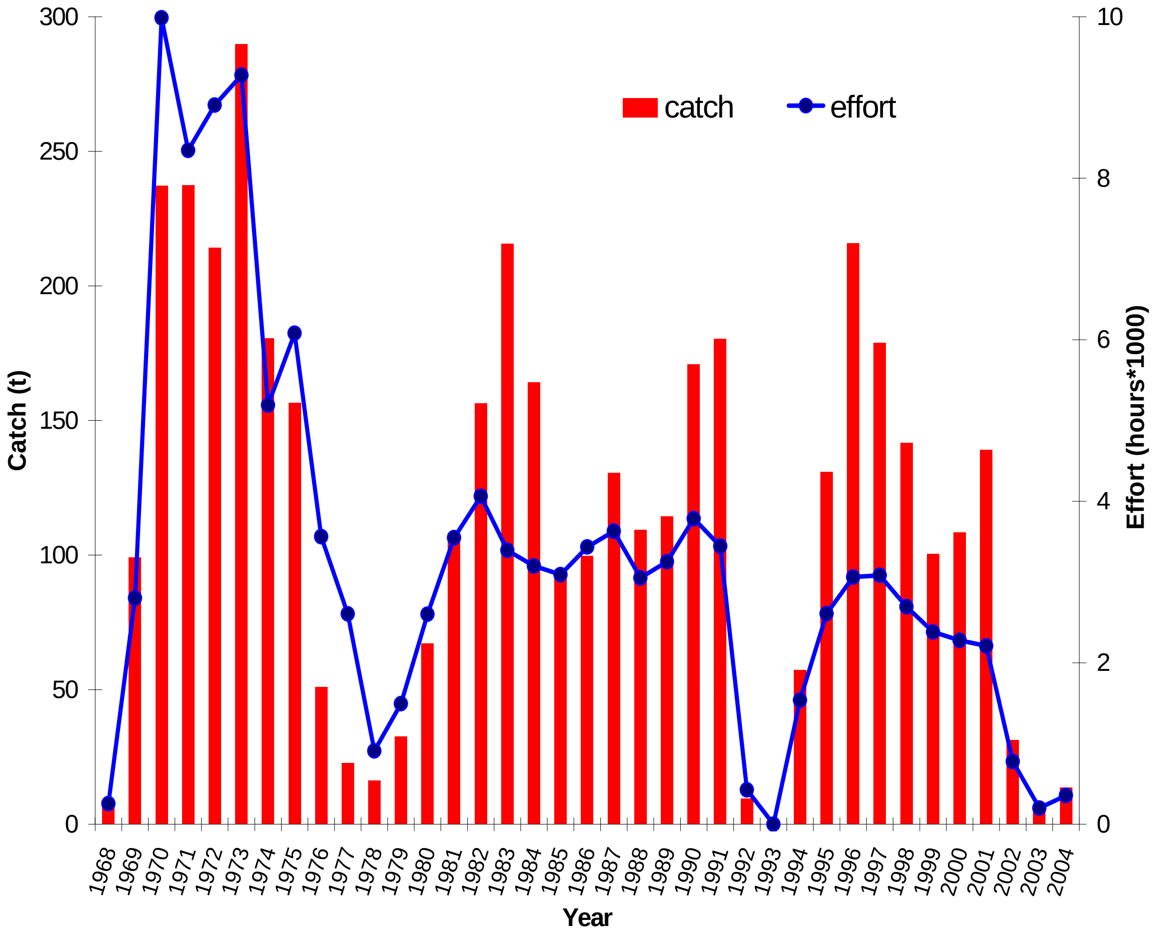

Figure 2.1 Catch (t) and effort (hrs) for the West Coast Prawn Fishery from 1968–2004.

2.2.2 Temporal trends in catch within high-catch periods

The distribution of mean monthly catches during periods of high catch (>50 t) has been highly variable since 1973 (Figure 2.2). In general the highest catches have been obtained consistently in June and July, with sporadic catches in all other months between catch periods. From 1973–1975 catches were highest from May-July and lowest in February-April. From 1980–1991 mean monthly catch peaked in June, however substantial catches were obtained in all months except May, September and October. From 1994–2001 catches were highest in June and July with only low and sporadic catches in January, May and October.

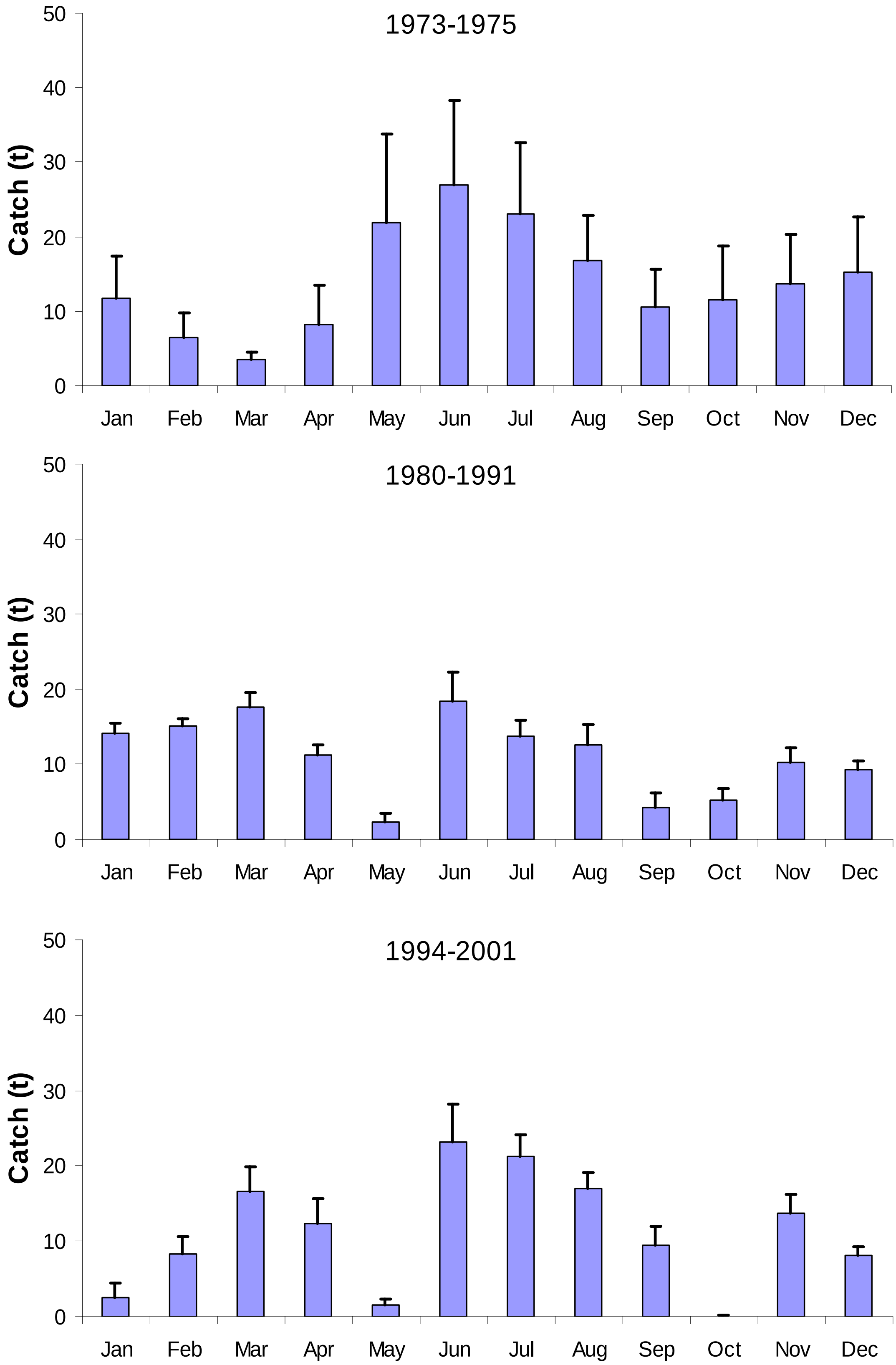

Figure 2.2 Mean (± SE) monthly catches since 1973 from the West Coast Prawn Fishery for periods of high catch (annual catch >50 t).

2.2.3 Trends in catch among regions

The spatial distribution of catches from the West Coast Prawn Fishery has varied since 1980 (Figure 2.3). During this period >65% of the total catch was harvested from the Venus Bay region, ~28% from the Ceduna region and ~6% from the Coffin Bay region. From 1981–1991 annual catches ranged between 47–180 t (mean= 97 t) in the Venus Bay region and 25–62 t (mean= 41 t) in the Ceduna region. Catches from the Coffin Bay region during this period exceeded 2 t only during 1991 (9 t), the year prior to dramatic declines in total catch.

Following the low catch period of the early 1990's, catch from the Venus Bay region increased to ~38 t in 1994. From 1995–2001 catches ranged between 48–150 t (mean= 90 t), and again declined rapidly to 9 t in 2002. During 2003 and 2004 <1 t has been harvested from the Venus Bay region. Catches from the Ceduna region did not again attain historic levels until 1995. Whilst catches ranged between 24–70 t (mean= 46 t) from 1995–2000, catch declined steadily from 1998–2001. Catch from the Ceduna region has not exceeded 15 t since 2000. Catch from the Coffin Bay region ranged between 0–13 t (mean= 6 t) from 1994–2000. During 2001 an unprecedented 78 t was harvested from the Coffin Bay region, an annual catch 13 times greater than the previous 7-year average. Catches were again well above historic averages during 2002 (22 t), however did not exceed 2 t during 2003 and 2004.

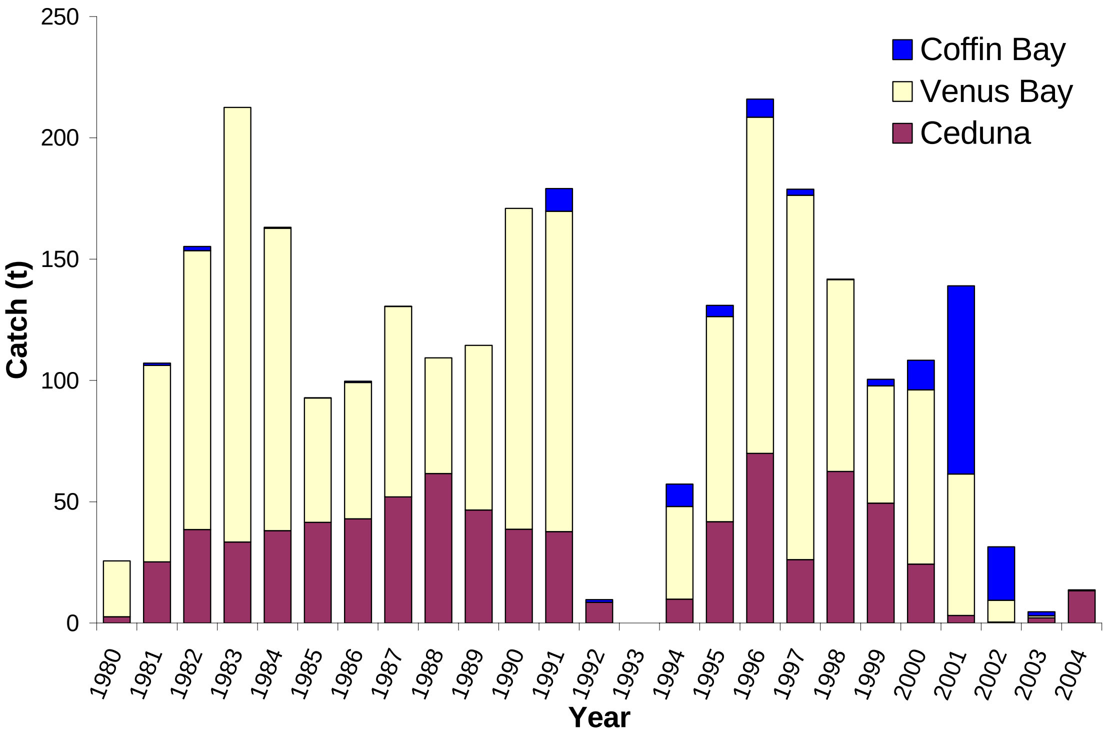

Figure 2.3 Annual catches from regions of the West Coast Prawn Fishery from 1980–2004 (1980 catch from July to December only).

2.2.4 Trends in effort within years and among regions

The distribution of mean monthly effort within regions has varied substantially since 1980 during periods of high catch (Figure 2.4). From 1980–1991 mean effort was spread across the year, peaking during June and lowest during May. In the Venus Bay region effort was highest in winter and lowest during summer. In the Ceduna region mean effort was highest from January-March and lowest from May-October. Effort in the Coffin Bay region was relatively low, peaking in December. From 1995–2001 total effort peaked during June-August and was lowest during October and May. Effort occurred mostly during June-August in the Venus Bay region, from November-April in the Ceduna region and from June-September and November-January in the Coffin Bay region.

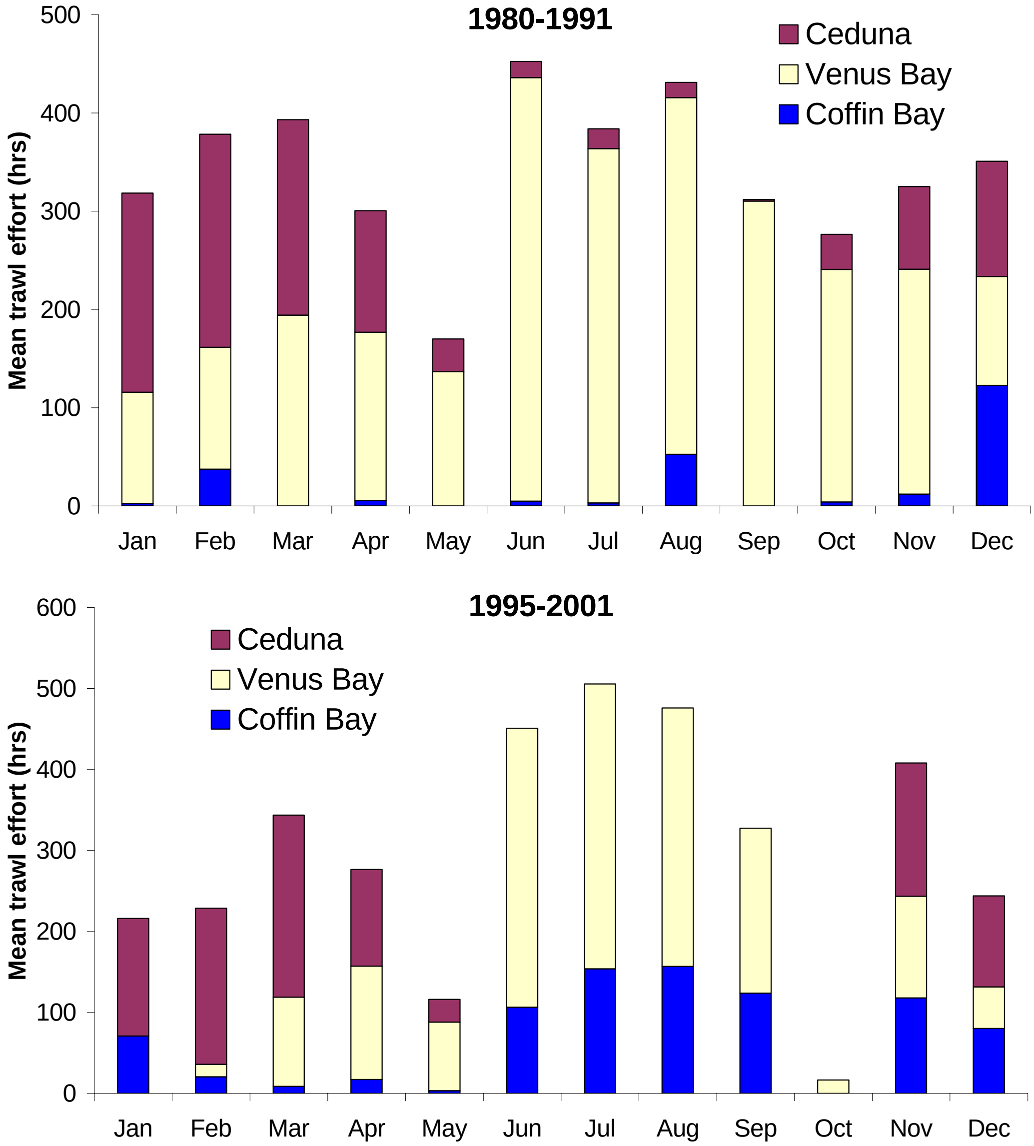

Figure 2.4 Mean monthly effort since 1980 from regions of the West Coast Prawn Fishery for high catch periods (annual catch >50 t).

2.2.5 Catches during the spawning season

The spawning period for *M. latisulcatus* in the West Coast Prawn Fishery extends from November to March. Hence catches obtained during these periods are important for the sustainability of the fishery. Figure 2.5 shows the proportion of annual catch harvested during early spawning (November-December), late spawning (January-March) and non-spawning periods (April-October) from 1973–2004.

Since 1973 ~42% of the total catch from the West Coast Prawn Fishery has been harvested during spawning periods. Of this, ~16% was harvested during November and December and ~26% was harvested during January-March. In general the amount of catch harvested during spawning periods has not changed substantially over time (Figure 2.5). Prior to the first decline (1977–1979) early spawning catches peaked at 61 t in 1973, however it is difficult to determine the effect of this on recruitment. Before the second decline (1992–1993) catches during both the early and late spawning seasons were consistent and did not appear to cause the decline. Early spawning catches in 2001 reached a contemporary peak of 37 t in 2001, immediately prior to the most recent decline. During 2002 >50% of the small total catch was harvested during the early spawning season (17 t).

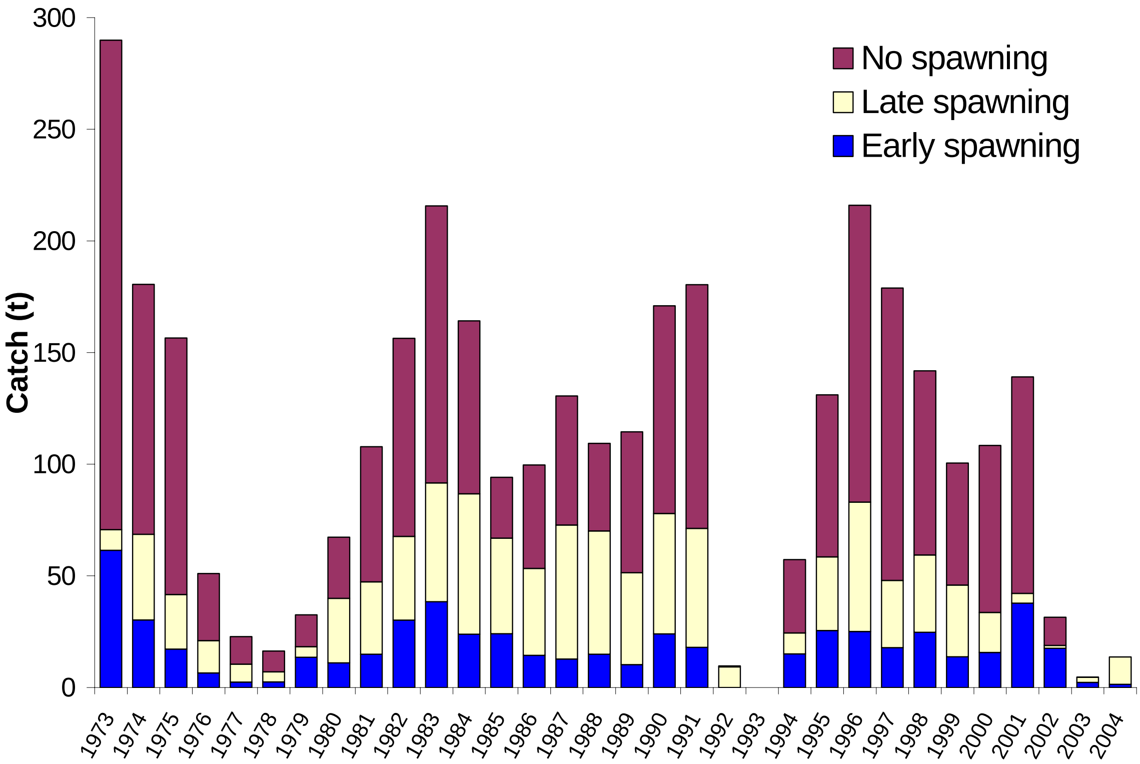

Figure 2.5 Catches during early spawning (November-December), late spawning (January-March) and non-spawning (April-October) periods from 1973–2004 for the West Coast Prawn Fishery.

2.3 Catch-per-unit-effort (CPUE)

2.3.1 Inter-annual trends

Trends in annual (nominal) CPUE have closely followed trends in catch since 1974 (Figure 2.6). Catches exceed 90 t from 1969–75 and annual CPUE varied between 23 and 36 kg/hr (mean = 28 kg/hr) before declining rapidly with annual catch until 1977. From 1981–1991 CPUE varied between 29 and 64 kg/hr (mean = 41 kg/hr) before again declining in 1992. From 1995–2001 CPUE varied between 42 and 71 kg/hr (mean = 55 kg/hr) before again declining in 2002. Annual CPUE did not exceed 41 kg/hr from 2002–2004.

The general increase in CPUE over time mainly reflects increases in the fishing power of the fleet and consequently CPUE does not accurately reflect prawn abundance over the entire history of the fishery. However, changes in fishing power over shorter periods (ie between years) are relatively small and thus the substantial inter-annual changes in CPUE observed since 1974 are likely reflective of real changes in localised abundance.

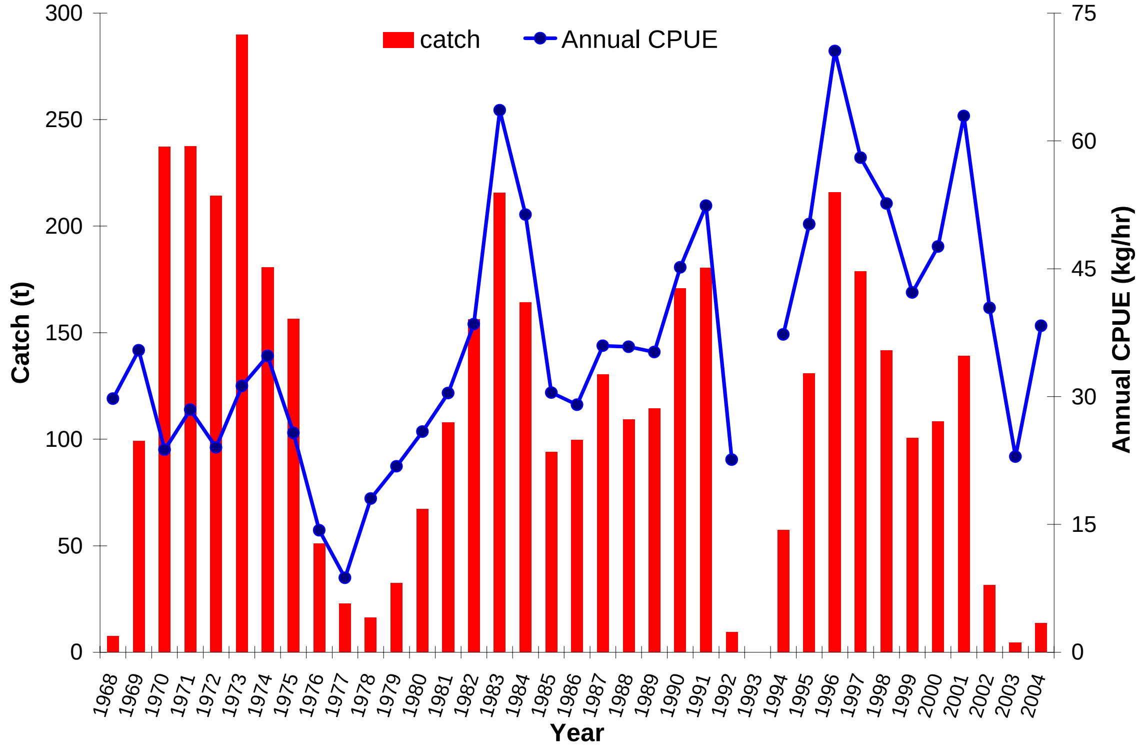

Figure 2.6 Annual catch and catch-per-unit-effort (CPUE) for the West Coast Prawn Fishery from 1968–2004.

2.3.2 Temporal trends in CPUE within high catch periods

In general, there were few temporal trends in CPUE during high catch periods (annual catch >50 t) since 1973 (Figure 2.7). During 1973–1975 mean monthly CPUE ranged from 17–34 kg/hr with no clear seasonal patterns. Similarly, from 1980–1991 CPUE showed no clear seasonal patterns and ranged from 31–46 kg/hr. From 1994–2001 CPUE was highest during June and July (67 and 61 kg/hr respectively) and ranged from 35–53 kg/hr during all other months.

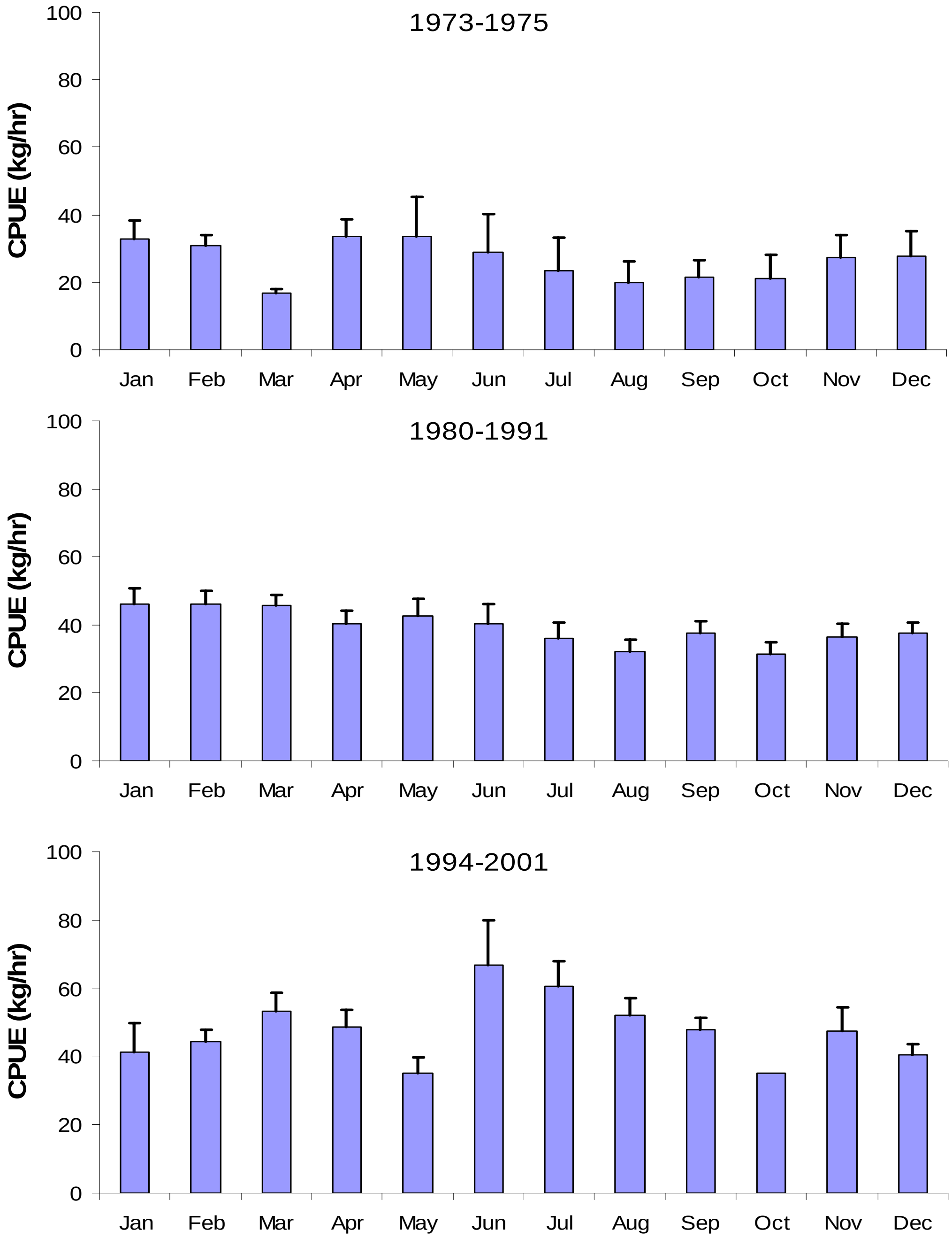

Figure 2.7 Mean (± s.e.) monthly catch-per-unit-effort (CPUE) since 1973 from the West Coast Prawn Fishery for high catch periods.

2.4 Prawn size

Data on prawn grades for the West Coast Prawn Fishery were obtained for the period 1996–2004. Grades were determined from the number of prawns to the pound (i.e. U10 = under 10 prawns per pound, etc) and thus reflect mean prawn size. Daily catch was recorded as the number of cartons per prawn grade. All graded cartons weighed 10 kg each with the exception of those in the U8 and U10 categories after April 1999, when the carton weight was 9 kg.

From January 1996–March 1999 prawn grades included U8, U12, 12–18, 16–20, 19–25, 26+ and Soft & Broken. Counts of the number of prawns in one 10 kg carton from each grade were obtained on a daily basis during this period. From April 1999–March 2004 prawn grades included U8, U10, 10–15, 10–20, 20–30 and Soft & Broken. Counts of the number of prawns in 1 pound from each grade were obtained on some days during this period. These counts per graded carton and per graded pound were used to determine the mean number of prawns per kilogram for each prawn grade (Table 2.1). Hereafter, prawns in the U8, U10 and U12 grades are referred to as the size category "extra large", those in the 10–15, 10–20, 12–18 and 16–20 grades as "medium-large", and those in the 20–30, 19–25 and 26+ grades as "small" (Table 2.1). Soft & Broken prawns were excluded from all analyses, as were years and regions with less than five nights fished.

Estimates of the number of prawns captured per grade per day were obtained by multiplying the daily grade weight (kg) with the mean number of prawns/kg for that grade (Table 2.1). From this, graded abundance of the catch was compared between years for each region. Mean annual prawn size (prawns/kg ± SE) was defined as the number of prawns captured for all grades per year / total weight of all grades per year, computed using the mean ratio estimator (after Rice 1995). This estimator avoids the bias associated with calculating the average of mean daily prawn size.

The relative size composition of the total annual catch from the West Coast Prawn Fishery was compared between years for the 1996–2004 period, and compared with commercial prawn size data from Spencer Gulf during 2002/03 and 2003/04 (Dixon *et al.* 2005).

Mean daily prawn size was calculated as the number of prawns captured for all grades / total weight of all grades for each daily catch. Mean daily prawn size data from the West Coast Prawn Fishery during 1996–2004 were compared in relative terms to equivalent data obtained from the Spencer Gulf Prawn Fishery during 2002/03–2003/04.

Table 2.1 Prawn grades and associated number of prawns per kg calculated from a) prawn counts per 10 kg carton (Jan 1996–Mar 1999) and b) prawn counts per pound (April 1999–March 2004).

Grade (category)	Years collected	Mean (± s.e.) prawns per kg	Sample size
U8 (extra large)	1996–2004	15.2 (0.05)	117
U10 (extra large)	1999–2004	19.4 (0.19)	31
U12 (extra large)	1996–1999	20.8 (0.40)	229
10–15 (medium-large)	1999–2004	27.1 (0.30)	66
10–20 (medium-large)	1999–2004	35.8 (0.44)	63
12–18 (medium-large)	1996–1999	32.7 (0.05)	259
16–20 (medium-large)	1996–1999	36.8 (0.80)	2
20–30 (small)	1999–2004	54.9 (0.50)	65
19–25 (small)	1996–1999	46.7 (0.09)	222
26+ (small)	1996–1999	49.5 (0.18)	3

2.4.1 Inter-annual trends in graded abundance and weight by region

Extra large prawns were highly abundant in the catch from the Venus Bay region during 1996 and 1997 (Figure 2.8a), peaking at >450,000 prawns harvested during 1997. This equated to >40% of the catch by weight in each of these years (Figure 2.8b). From 1998–2002, the number of extra large prawns harvested reduced steadily from ~150,000 to <25,000, reflecting 13–31% of the total catch by weight. Medium-large prawns were generally the most abundant in the catch, except for 2000 when small prawns were more abundant. The abundance of medium-large prawns was greatest during 1996 and 1997, and was similar from 1998–2001, declining rapidly thereafter. Small prawns were similarly abundant during 1996–2001, despite considerable reductions in the number of extra large and medium-large prawns. Of note, the greatest abundance of small prawns was harvested during 2000, equating to 34% of the annual catch by weight and 48% by abundance. This resulted in the lowest mean annual prawn size harvested for the period in this region (39.1±0.5 prawns/kg; Figure 2.8b).

Extra large prawns were rarely harvested in the Ceduna region from 1996–2004 (Figure 2.9a). Catch abundance was dominated by small prawns in most years. This resulted in a lower mean annual prawn size in the Ceduna region compared to Coffin Bay and Venus Bay regions during all years (Figure 2.8b, 2.9b and 2.10b). High catches of small prawns were obtained from the Ceduna region during 1996, 1998 and 1999. The number of medium-large and small prawns harvested declined steadily from 1998–2001.

Total annual catch from the Coffin Bay region was greatest during 2001 (Figure 2.10b). In this year, catch was dominated by medium-large prawns in terms of weight (59%) and abundance (57%; Figure 2.10a). Similarly, medium-large prawns comprised the majority of catch in terms of abundance and total weight in most other years. There were no discernable trends in mean annual prawn size during this period (Figure 2.10b).

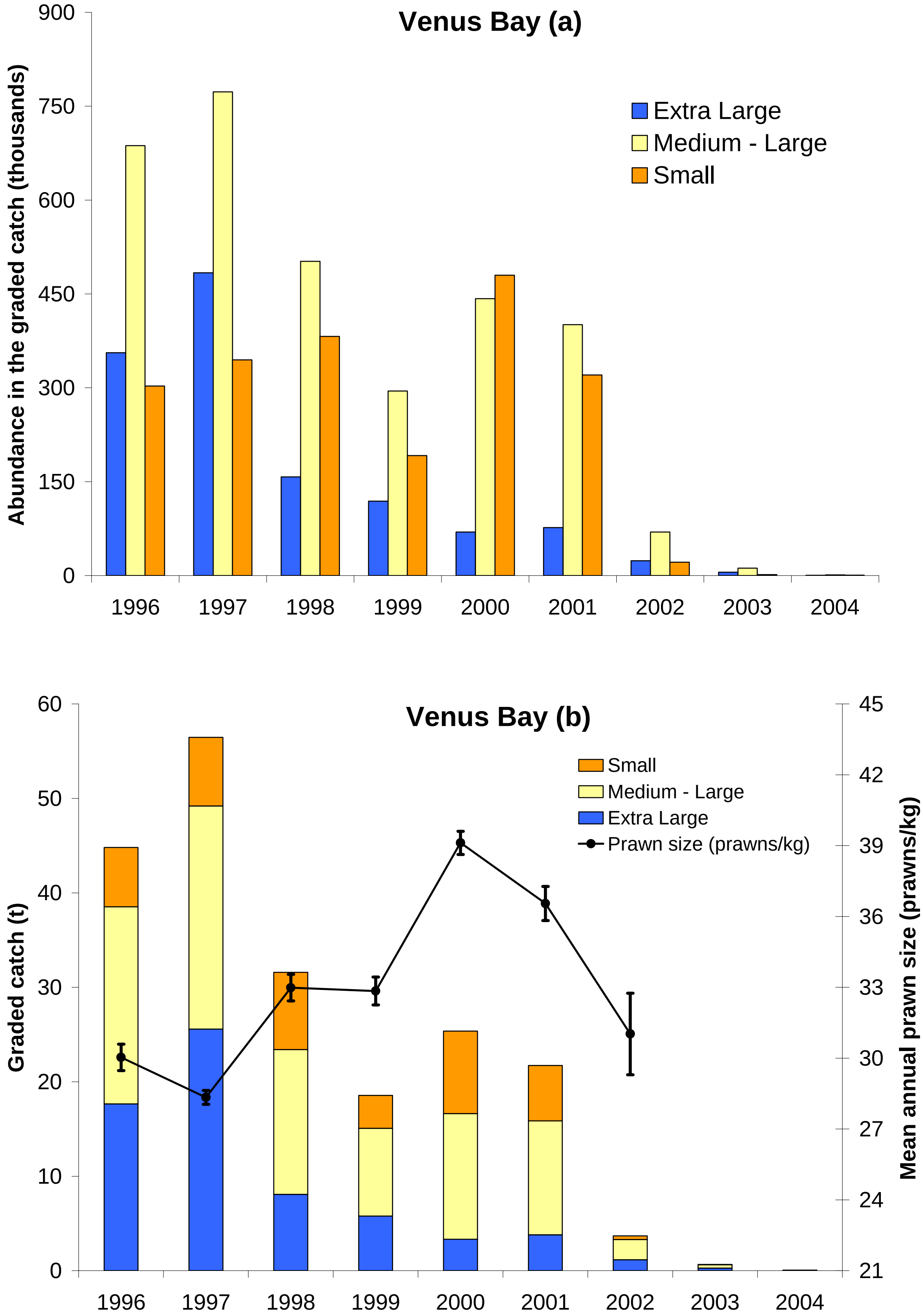

Figure 2.8 Abundance in the graded catch by size category (a), total graded catch by size category and mean annual prawn size (prawns/kg ± SE) of the graded commercial catch (b) from the Venus Bay region of the West Coast Prawn Fishery during 1996–2004.

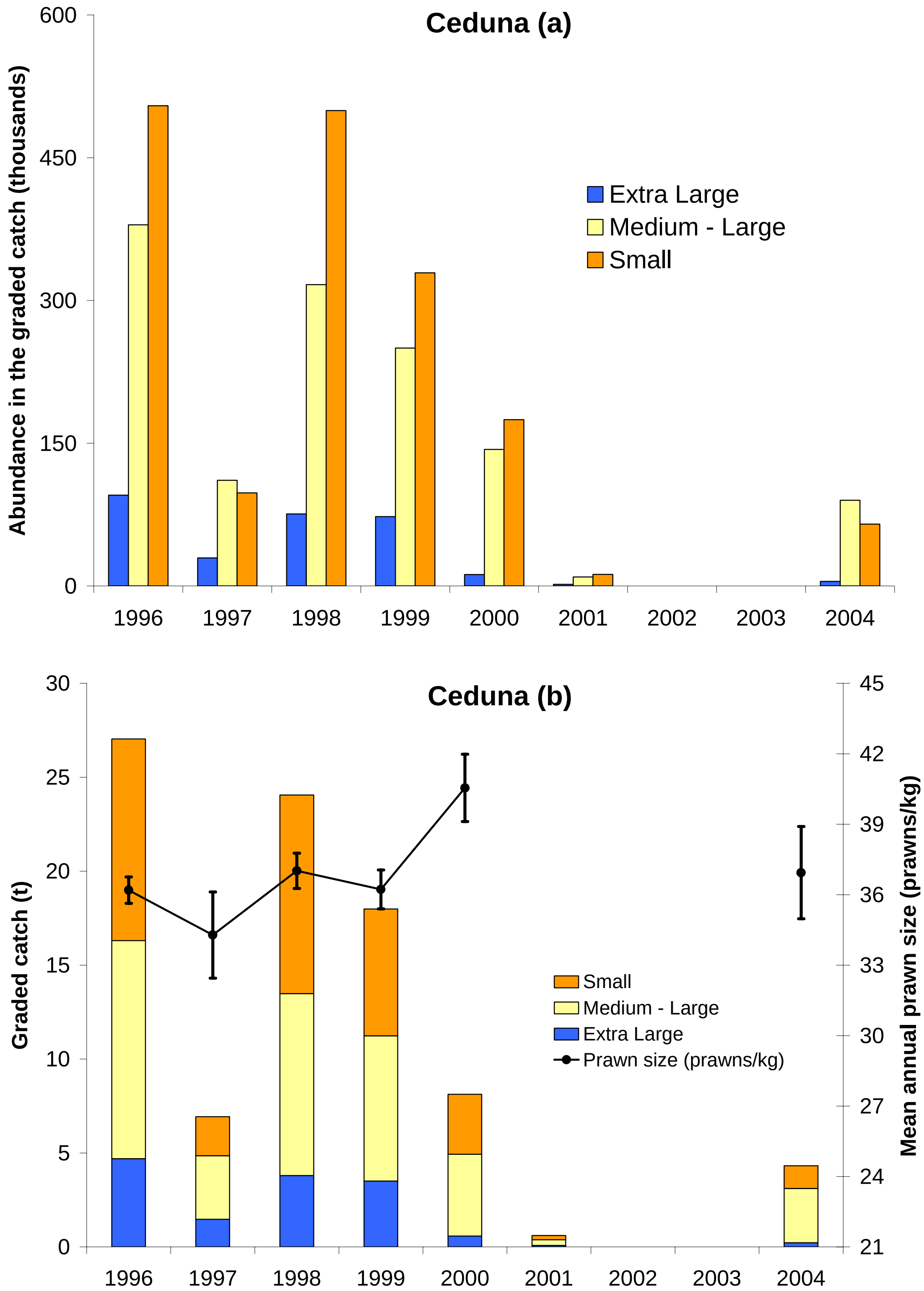

Figure 2.9 Abundance in the graded catch by size category (a), total graded catch by size category and mean annual prawn size (prawns/kg ± SE) of the graded commercial catch (b) from the Ceduna region of the West Coast Prawn Fishery during 1996–2004.

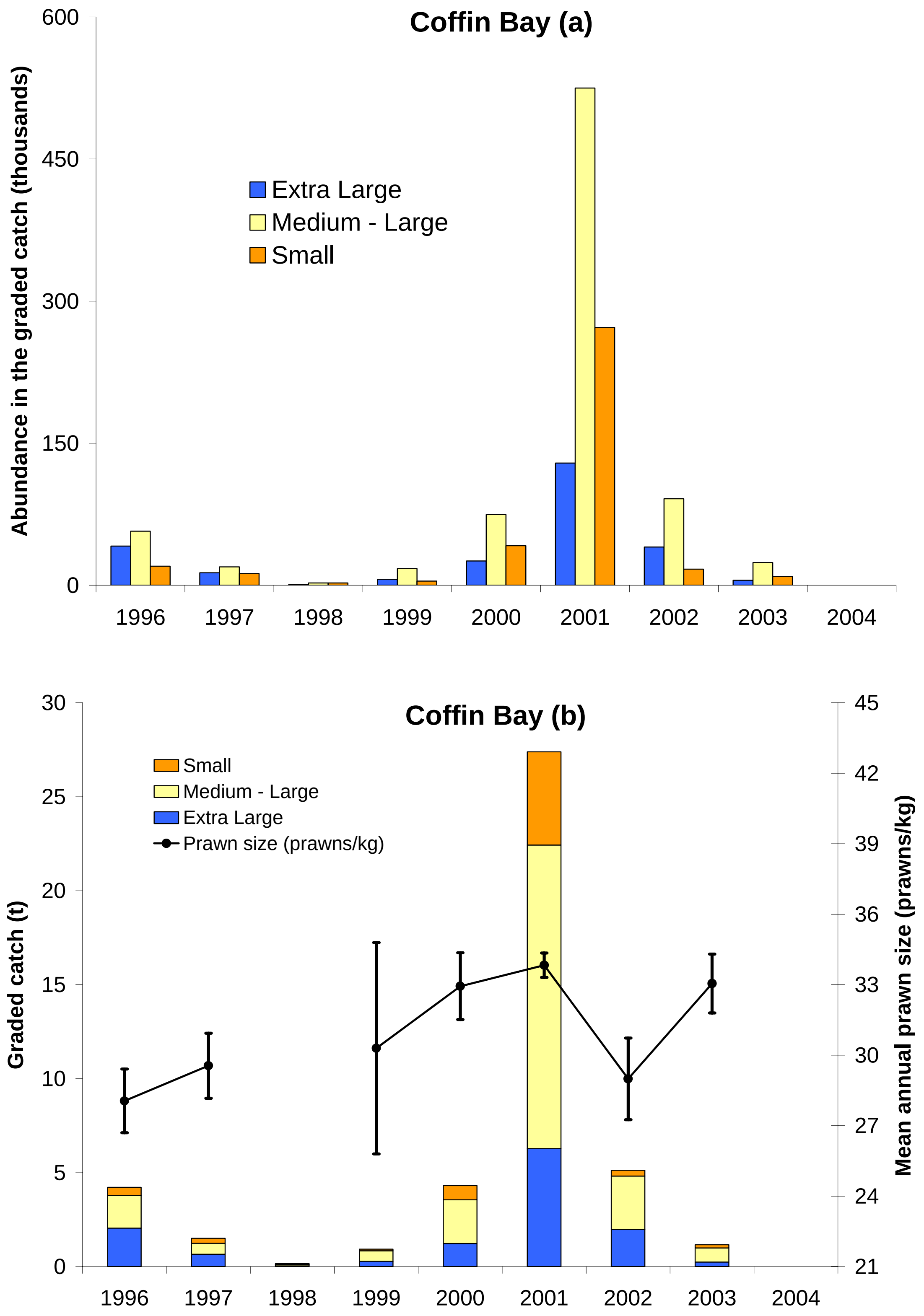

Figure 2.10 Abundance in the graded catch by size category (a), total graded catch by size category and mean annual prawn size (prawns/kg ± SE) of the graded commercial catch (b) from the Coffin Bay region of the West Coast Prawn Fishery during 1996–2004.

2.4.2 Relative size composition of the graded catch

The relative size composition of the graded catch from the West Coast Prawn Fishery has varied greatly between years, and also differs considerably from that of the Spencer Gulf Prawn Fishery (Figure 2.11). In all years the proportion of small prawns harvested from the West Coast fishery (7–34%) was greater than that from Spencer Gulf (<6%). The proportion of extra large prawns in the catch of the West Coast Fishery was highly variable, ranging from 6–43%. In general, a higher proportion of extra large prawns were harvested during periods of high annual catch (1996 and 1997). In comparison with Spencer Gulf, the proportion of extra large prawns in the catch was higher for the West Coast fishery during years of high catch (1996 and 1997) and similar in most other years.

The high proportion of small prawns harvested in the West Coast fishery may be due to: a) the real-time management arrangements of the Spencer Gulf Prawn Fishery that aim to minimise the proportion of small prawns harvested (Dixon *et al.* 2005); or b) a higher degree of mixing of size classes in the West Coast Prawn Fishery trawl grounds.

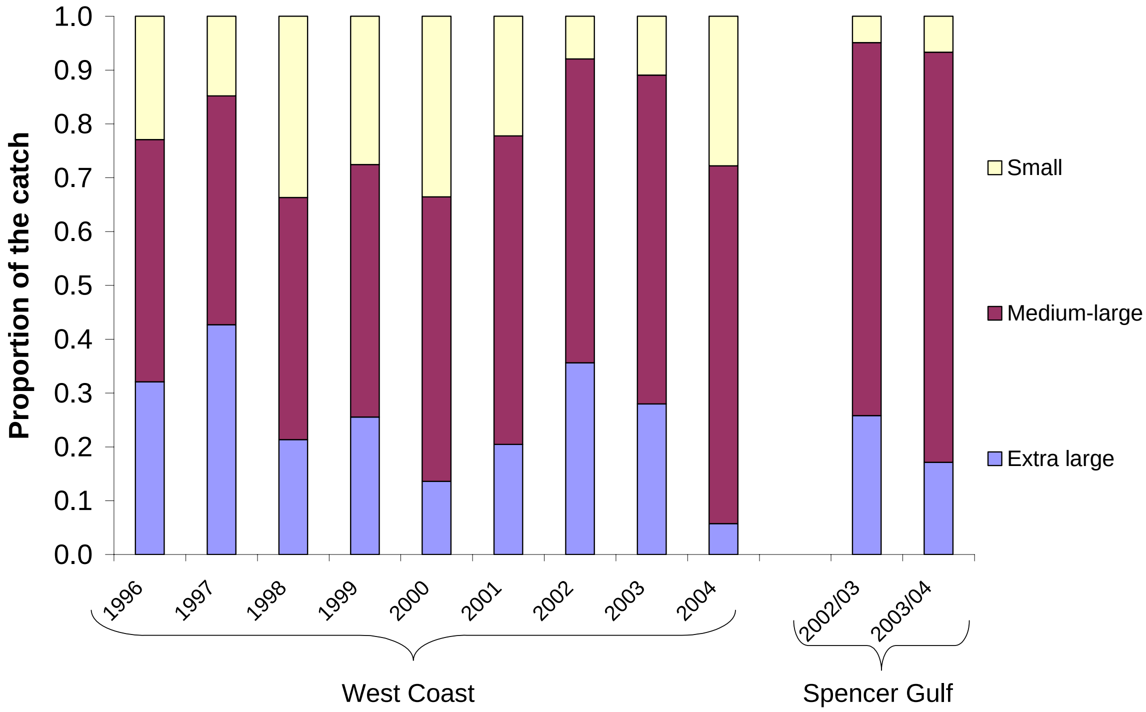

Figure 2.11 Size composition of the commercial catch from the West Coast Prawn Fishery during 1999–2004 and the Spencer Gulf Prawn Fishery during 2002/03 and 2003/04.

2.4.3 Mean daily prawn size

Despite the differences in sampling period, commercial size structure data for the West Coast and Spencer Gulf Prawn Fisheries (Figure 2.12) provide useful information on the size distribution of the catch and the harvest strategies of each fishery. The average size of prawns harvested from the West Coast was substantially smaller than that of Spencer Gulf. Notably, average daily prawn size from the West Coast Prawn Fishery was no larger than 25 prawns per kg on any night between 1996 and 2004. In comparison, ~23% of nights fished in the Spencer Gulf Prawn Fishery exceeded this mean size during 2002/03 and 2003/04. Mean daily prawn size was 33.5 and 28.5 prawns per kg for the West Coast and Spencer Gulf fisheries respectively. The limit reference of 40 prawns per kg was exceeded on ~12% of all nights fished in the West Coast Prawn Fishery from 1996–2004.

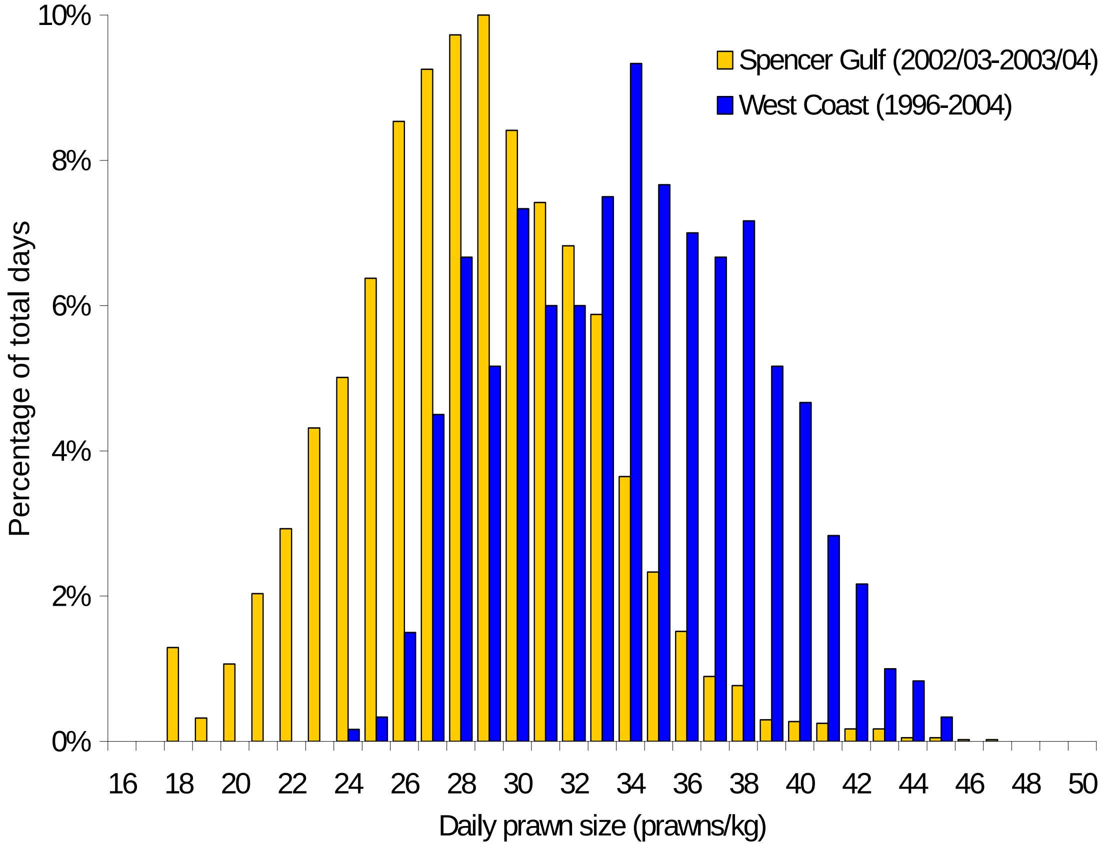

Figure 2.12 The proportion of nights fished at various mean daily prawn sizes from the West Coast and Spencer Gulf Prawn Fisheries.

3. STOCK ASSESSMENT SURVEYS

3.1 Introduction

Stock assessment surveys, using industry vessels (with observers) have been undertaken since 1989. A summary of the number of survey trawl shots conducted within regions of the West Coast Prawn Fishery is provided in Table 3.1.

Survey shots are done at semi-fixed sites. Each skipper begins a survey shot as close as possible to a fixed Global Position System (GPS) position and then continues in a particular direction for a specified length of time (usually 30 minutes). The distance trawled depends on trawl speed, which is influenced by vessel power, tide and weather conditions. The accuracy of distance measurements and starting positions improved when GPS and computer technology were introduced into the fishery. The data collected during surveys include total catch, trawl time, trawl distance and water temperature. Sub-samples were counted and weighed to determine mean prawn weight.

Surveys were conducted from 1989–1997 and during 2003 and 2004 (Table 3.1). The timing of surveys was variable, occurring most regularly during February (7 years), June (6 years), April (5 years) and November (4 years). Venus Bay and Ceduna regions were surveyed on most occasions with up to 26 and 17 sites surveyed on each occasion. Coffin Bay was only surveyed during 2003 and 2004 with up to 10 sites surveyed.

Table 3.1 Number of stock assessment survey shots done in fishing regions of the West Coast Prawn Fishery from November 1989 to October 2004.

Year	Month	Ceduna	Venus Bay	Coffin Bay	Total
1989	Nov	7	19		26
1990	Feb	6	20		26
	Apr	6	20		26
	Jun	6			6
	Nov	7	20		27
1991	Feb	17	20		37
	Apr	17	20		37
	Jun	17	20		37
	Nov	16	11		27
1992	Feb	17	20		37
	Apr	17	20		37
	Jun	17	20		37
	Jul	9	12		21
	Oct	16	20		36
1993	Feb	17	20		37
	Apr		11		11
	Jun	17	20		37
1994	Jun		20		20
1995	Jan	16			16
	Feb		20		20
	Jul		26		26
1996	Feb	16	19		35
1997	Feb		22		22
2003	Jul		14		14
	Oct	9	10	10	29
	Nov	7	9	10	26
2004	Apr		13		13
	Jun	9	13	8	30
	Oct	9	11	9	29

3.2 Annual trends

3.2.1 Mean catch rate

Catch rates from prawn surveys have been highly variable, ranging from 5 kg/hr in 1993 to 72 kg/hr in 1990 (Figure 3.1). Survey and fishing catch rates were significantly correlated (LR: $r^2 = 0.64$, df = 9, P<0.01; Figure 3.2) and closely follow trends in annual catch. Low catch rates observed during 1992–1994, 2003 and 2004 relate to years of low catch. The high correlation between survey and fishing catch rates suggest that the low catch periods observed since surveys began in 1989 is likely to reflect declines in population abundance.

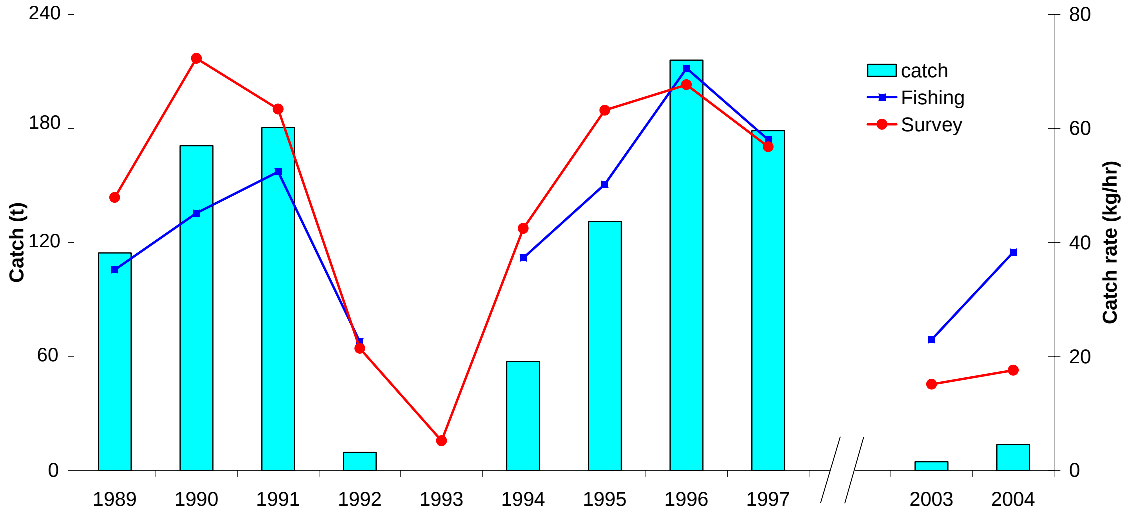

Figure 3.1 Total catch and mean annual catch rate during surveys and fishing in the West Coast Prawn Fishery from 1989–2004. No fishing was done in 1993.

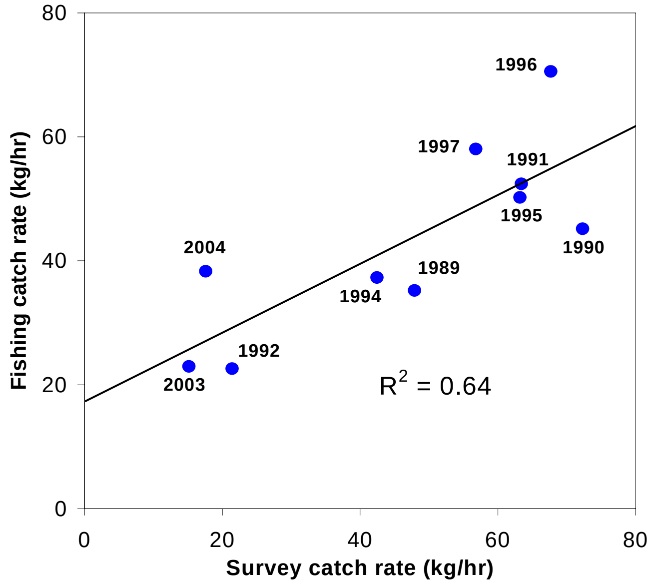

Figure 3.2 Correlation between survey and fishing catch rates for the years 1989–1992, 1994–1997, 2003 and 2004.

3.2.2 Prawn size

The mean size of prawns measured on surveys varied between regions (Figure 3.3). Prawns in the Ceduna region were smaller than those in the Venus Bay region in all years. The difference in size was most apparent during 1990 and 1991. Surveys were only conducted in the Coffin Bay region during 2003 and 2004 and during these years the mean size of prawns was similar to that observed in Venus Bay.

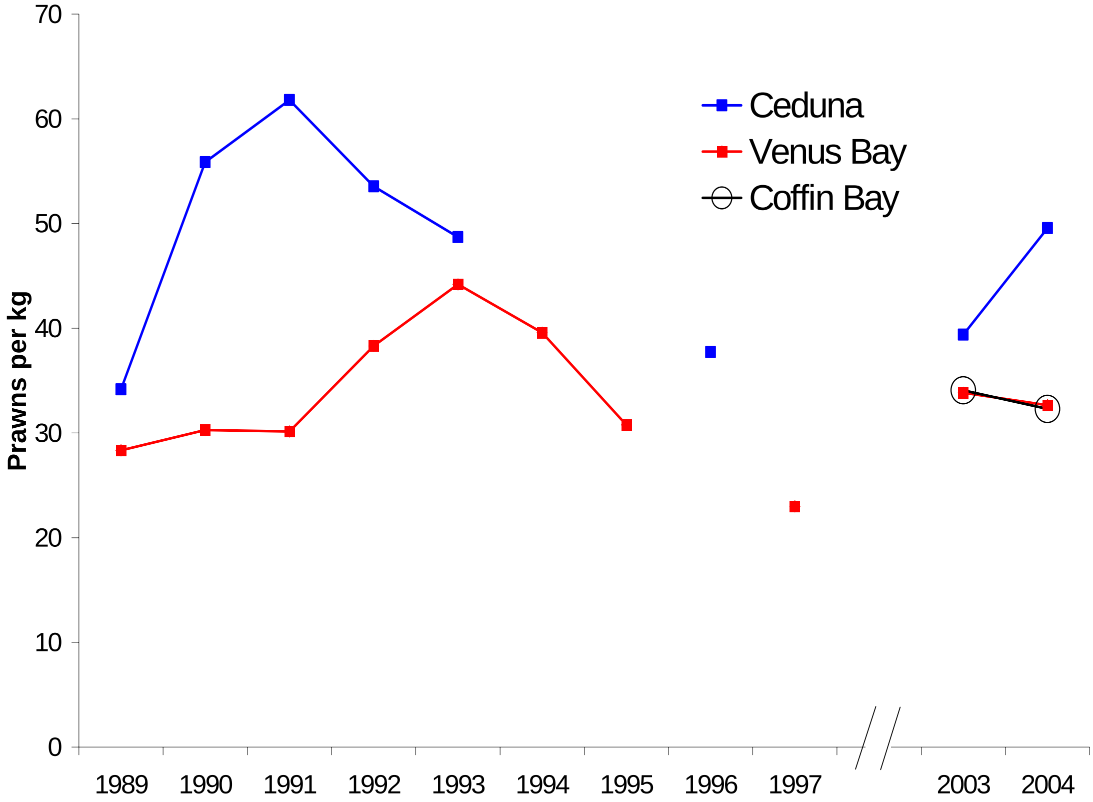

Figure 3.3 Mean size of prawns measured during surveys from 1989–1997, 2003 and 2004 in regions of the West Coast Prawn Fishery.

4. PERFORMANCE INDICATORS

4.1 Summary

Performance indicators (PI) in the Management Plan (MacDonald 1998) are calculated for 2002–2004 (Table 4.1).

Table 4.1 Summary of Performance Indicators (PI) and Reference Points (RP) from 2002–2004 for the West Coast Prawn Fishery (MacDonald 1998).

PI	Target RP	Limit RP	2002	2003	2004
Effort (days)	100–110	120	35	11	16
Size at capture (prawns/kg)	<40/kg	>40/kg	29.9	31.1	36.3
Recruitment indices	40	35	NA	NA	NA
% Virgin spawning biomass	50%	40%	NA	NA	NA

4.2 Fishing effort

Fishing effort was reported as nominal effort for each vessel over the calendar year and does not include survey nights. From 2002–2004 effort was well below both the target and limit reference points. During this period effort was highest during 2002 (35 days) and lowest in 2003 (11 days). Fishing effort in 2004 (16 days) was only marginally greater than that expended during 2003.

4.3 Size at capture

Average size at capture was within the target and limit RP for this PI during 2002–2004. Mean prawn weight was greatest during 2002 (29.9 prawns/kg) and lowest in 2004 (36.3 prawns/kg). The limit reference of 40 prawns/kg was not exceeded on any individual night for which there were data during this period.

4.4 Recruitment indices

Recruitment indices could not be calculated from the available data.

4.5 Proportion of virgin spawning biomass

The proportion of virgin spawning biomass could not be calculated from the available data.

5. DISCUSSION

5.1 Information available for assessment of the West Coast Prawn Fishery

There are substantial data available for assessment of the West Coast Prawn Fishery. Annual catch and effort information is available since the inception of the fishery in 1968. Daily logbook data are available from 1980, however, data from the period 1980–1986 requires additional validation.

Data on prawn size are available from one fisher for the period 1996–2004 and represent approximately one third of the historic catch during this period. Given the nature of the fisher behaviour (i.e. all three fishers usually fish in the same region at the same time), these data are considered representative of the catch.

Prawn surveys were conducted for the periods 1989–1997 and 2003–2004. Although surveys were only conducted in the Venus Bay and Ceduna regions prior to 2003, these regions have accounted for approximately 94% of the historic catch. Survey and fishing catch rates are well correlated, suggesting that survey shots are likely to be representative of the fishing grounds. This also suggests that changes in either fishing or survey catch rates are likely to represent localised changes in abundance over short time scales (i.e. a few years). Extrapolation of this assumption over longer time periods is likely to be affected by changes in gear efficiency. Survey data also provide useful information for the development of harvest strategies. Despite their usefulness for stock assessment and harvest strategy development, historic data collection methods do not enable assessment of the fishery against the Performance Indicators of the Management Plan (McDonald 1998).

Additional data are available on several other aspects of the stock and fishery. Considerable effort has been expended on tagging studies since the early 1980's, providing valuable data on both growth and movement. Although limited data on larval and juvenile abundance, reproductive status and natural mortality have been previously reported (Wallner 1985), more contemporary and comprehensive datasets for these parameters would substantially improve stock assessment.

There are considerable knowledge gaps in the fishery, particularly with regard to the spatial extent of the stock. Tagging studies suggest that the principal prawn migration occurs in a south-easterly direction (from the Ceduna region to both Venus and Coffin Bay regions), however the extent and distribution of prawn stocks between regions and further south of Coffin Bay is largely unknown. Although anecdotal evidence suggests that the majority of these areas are unsuitable for trawling, the knowledge of various fishers regarding these regions should be documented to improve understanding of the fishery and the stock.

West Coast prawn fishers are entitled to harvest a number of by-product species. As with prawn fishers in Spencer Gulf and Gulf St. Vincent they are entitled to harvest slipper lobster (*Ibacus* spp.) and southern calamary (*Sepioteuthis australis*). In addition West Coast prawn fishers may retain Scallop (Pectinidae), Octopus (*Octopus* spp.) and Arrow squid (*Nototodarus gouldi*). Recently, a new logbook has been designed for West Coast fishers that requires them to report all retained by-product. A lack of historic data on the by-product and by-catch species of the West Coast Prawn Fishery significantly impedes its assessment.

5.2 Current status of the West Coast Prawn Fishery

The history of the West Coast Prawn Fishery is characterised by dramatic increases and decreases in catch. Several previous reports have suggested that the most likely explanation for the observed fluctuations in catch is changes in environmental parameters (Wallner 1985; Carrick and Williams 2000, 2001; Svane and Barnett 2004; Carrick and Ostendorf 2005). Whilst this report is the most thorough stock assessment conducted for the fishery since Wallner (1985), analyses of extrinsic effects on production, such as Sea Level Height and Sea Surface Temperature (see Carrick and Ostendorf 2005), are beyond its scope.

Prawns were first harvested from the West Coast in 1968. Catches increased rapidly and a period of high catches (>50 t) was observed from 1969–1976. The last four years of this high-catch period showed a rapid decline in catches from the historic peak of ~290 t in 1973 to ~50 t in 1976. The average annual catch during this first high-catch period was 183 t, ~50 t greater than the two subsequent high catch periods. Whilst these high average catches may have contributed to the first decline of the fishery, it is difficult to determine the relative impact of fishing and extrinsic factors on recruitment.

The first decline was followed by a 3-year period of low catches (16–33 t) from 1977–1979. Population, and hence catch, recovery occurred as rapidly as the decline, with catch attaining a contemporary high (215 t) in 4 years. The second high-catch period lasted 12 years (1980–1991) and catches appeared stable before the second and swiftest decline, which saw catches drop from ~180 t in 1991 to <10 t the following year. There were no observed trends in catch, effort or CPUE data to explain the rapid decline, suggesting that extrinsic factors probably played a substantial role in reducing recruitment. The absence of commercial or fishery-independent size data during the first two catch declines severely limits assessment of the impact of fishing and of the extent and duration of recruitment failure.

Following the low catch in 1992, no fishing was conducted in 1993 and an immediate recovery ensued. Within three years catch again attained a contemporary high of 215 t in 1996. During 1996 and 1997 high catches of extra large prawns were harvested from the Venus Bay region, comprising 40 and 46% of annual catch respectively. Thereafter, catches of extra large prawns declined steadily, until they comprised only 14% of the catch during 2000. Concurrent to the declining catches of extra large prawns, high catches of small prawns were obtained from the Ceduna region during 1996, 1998 and 1999. Catches of small prawns from the Venus Bay region were maintained at a high level during 1996–2001 despite reducing abundance of extra large and medium-large prawns.

The high catches of extra large prawns in 1996 and 1997 in the Venus Bay region may have resulted in recruitment overfishing. Carrick and Ostendorf (2005) documented a preliminary study of a spawner recruit relationship and the influence of the environment on prawn recruitment to the Venus Bay region. Results indicated that recruitment was dependent on both the size of the spawning stock and Sea Level Height (SLH). These authors suggested that maintaining a minimum threshold spawning density (50–150 prawns per nautical mile dependent upon the size of spawners) would reduce the likelihood of recruitment failure in years of unfavourable SLH. Whilst density estimates could not be calculated from the data available for this assessment, such high catches of large prawns may well have reduced the spawning biomass below the threshold level necessary for recruitment success. Further, the high catches of small prawns harvested on several occasions was likely to have resulted in growth overfishing and further reduction in the potential spawning biomass.

Coinciding with the decline in catch from the Ceduna and Venus Bay regions, catches in the Coffin Bay region peaked at 80 t in 2001; more than 6 times the previous historic peak catch for the region. This dramatic increase in catch was likely to have resulted from changes in population distribution rather than effort distribution. The effect of this change in distribution of large prawns on recruitment to the fishery is unknown, although it should be noted that during the spawning period oceanographic currents are predominantly wind-driven in a south-east to north-west direction. Thus, larvae produced from the Coffin Bay region could potentially settle in juvenile habitats near Ceduna and Venus Bay.

Catches in 2003 and 2004 have not exceeded 14 t and, although not presented in this report, indications are that the fishery remains in low production (SARDI unpublished data). There are several lines of evidence to suggest that the current status of the stock upon which the fishery is based is in its weakest position for at least 11 years and possibly since the inception of the fishery. These include: a) annual catch has not exceeded 50 t for the last four years, the longest duration of the three historic low-catch periods; b) catch rates from recent prawn surveys are the lowest since 1993, and; c) annual CPUE from 2002–2004 was low (34 kg/hr) relative to the most recent high catch period (1994–2001: 53 kg/hr). Given the poor status of the resource, stock recovery would be facilitated by conservative harvest strategies.

5.3 Current harvest strategies for the West Coast Prawn Fishery

Harvest strategies for the West Coast fishery are based upon the results of prawn surveys conducted by West Coast fishers and are developed under the guidelines of the Management Plan (MacDonald 1998). The key mechanisms that aim to ensure the sustainable management of the fishery are temporal and spatial closures and harvest size of prawns. These mechanisms are the same as those adopted in the Spencer Gulf Prawn Fishery (SGPF), however the SGPF implements these rules through a Real Time Management system under the guidance of a Committee at Sea (see Dixon *et al.* 2005). The success of the SGPF, in terms of its sustained historic catch and management within performance criteria, provide a useful benchmark within which to contrast the performance of South Australia's other prawn fisheries.

Effort in the SGPF is controlled by moon and seasonal closures. Moon closures prevent fishing over the full moon period when catch rates are lower. The same closure periods are applied to the West Coast fishery. There are two seasonal closure periods in the SGPF. Firstly, the fishery is closed from July to October during the period of coldest water temperatures and lowest catch rates. Unlike the SGPF, catch rates do not reduce dramatically during the winter months in the West Coast fishery and thus fishing occurs throughout most of the year. Secondly, the SGPF is closed during January and February to minimise the impact of fishing effort on the spawning biomass. Historically, substantial catches have been harvested from the West Coast fishery during these months.

Dixon *et al.* (2005) showed that the amount of prawns harvested during the early spawning period in the SGPF significantly affected the level of recruitment to the fishery in subsequent years. This recruitment overfishing was observed during years of substantial increases in the November and December catch, and as a consequence of these analyses Spencer Gulf fishers recently agreed to a maximum catch strategy for these fishing periods.

Analyses of logbook data for the West Coast fishery provide little evidence of such recruitment overfishing during high-catch periods. However, substantial catches of large prawns were harvested during the early spawning period in the Coffin Bay region in 2001, 2002 and 2005, under the assumption that spawning biomass from this region was unlikely to contribute significantly to recruitment. As previously discussed, oceanographic data suggest that larvae sourced from the Coffin Bay region have the potential to settle in the important Ceduna recruitment grounds. In the absence of further knowledge on recruitment, recovery of the declined population would be best facilitated by minimising catches during the spawning period, regardless of the region fished.

In both the West Coast and Spencer Gulf prawn fisheries, spatial closures are generally determined from the results of prawn surveys. However, on occasions fishing does occur in unsurveyed areas based on historic expectation. The SGPF develops short-term spatial closures at particular times of the year, usually for 4 or 5 nights fishing prior to the conduct of prawn surveys on the new moon. These strategies are developed from the results of previous surveys and in the knowledge of a favourable stock status. The West Coast Fishery develops occasional harvest strategies in the absence of survey data. Given the lack of historic survey data and the poor status of the West Coast Fishery currently, this policy needs review.

The harvest size of prawns in the SGPF is controlled by RTM. Whilst the limit reference for prawn size is 40 prawns per kg in the Management Plan, the SGPF targets much larger prawns during each fishing period. Although data on commercial prawn size have only been obtained since 2003, these data show the effectiveness of RTM in maintaining an appropriate commercial harvest size for the fishery (Dixon *et al.* 2005).

Prawn size data from the commercial catch of the West Coast fishery were available from 1996–2004. Prawns harvested from the West Coast Fishery are smaller on average than those harvested from Spencer Gulf. Whilst the proportion of extra large prawns (U10 or larger) was similar or even greater in the West Coast fishery in most years, the difference in average size was caused by the high abundance of small prawns in the West Coast catch during every year. This difference may have resulted from a) the RTM practices of the Spencer Gulf Prawn Fishery that aim to minimise the harvest of small prawns, or b) the fished population in the West Coast grounds contains an unavoidably higher mix of sizes than the fished grounds in Spencer Gulf. Unfortunately length frequency data have not been obtained on a regular basis during West Coast surveys to inform the latter, and this should be a priority for future research. Further, the appropriateness of the current limit reference for prawn size in the West Coast Prawn Fishery must be critically reviewed.

5.4 Performance Indicators

The current suite of Performance Indicators (PIs) includes: effective effort (days); mean size at capture (prawns/kg); recruitment (males <33 and females <35 mm CL per nautical mile); and percent virgin spawning biomass. Unlike previous reports (Carrick and Williams 2000, 2001; Boxshall 2001; Svane 2003; Svane & Barnett 2004, 2005), PIs were calculated for the calendar year to reflect the pattern of effort distribution of the fishery. The suitability of each of these PIs for assessing the status of the West Coast Prawn Fishery needs to be reviewed as a high priority and the need for modified and additional PIs considered.

The PI for effort is useful only when the fishery is not in decline. In recent years the number of days fished has been well below the target reference. Also, the PI is currently based on nominal, not effective effort, as calculations for vessel power in the West Coast Fishery have not been documented.

The PI for mean size is useful, but may need to be refined. It is unclear whether a single mean value for prawn size across the entire fishery is sufficiently informative to provide a sound basis for assessing the status of the fishery. Furthermore, the target and limit Reference Points for mean size (i.e. 40 and >40 prawns/kg) are relatively high and may warrant reconsideration, especially in the light of evidence for growth overfishing and the recent reductions in the price of small prawns.

The PI for recruitment cannot be calculated from the available data. In the absence of this historic information, suitable PI and target and reference points need to be defined.

There are several reasons why the PI for percentage virgin spawning biomass is problematic and should be replaced. Firstly, the “virgin spawning biomass” of this fishery is unknown and cannot be calculated reliably. Secondly, the relevance of percentage virgin spawning biomass is questionable, especially given the lack of information regarding the percentage that is needed to ensure adequate recruitment. A better option may be to establish a PI or PIs for abundance based explicitly on the results of surveys. For this approach to succeed, it will be important to ensure that the sampling design for surveys remains consistent between years, which in itself could be problematic given the state of the resource.

5.5 Future research

Clearly, there is an immediate need to determine the environmental parameters crucial to the population dynamics of the fishery in order to understand its potential sustainability. The recently submitted FRDC application "Effects of environmental variability on recruitment to fisheries in South Australia" aims to address some of these questions by compiling an integrated spatial database of environmental variables and relating these to population data from South Australia's major fisheries. In particular, an improved understanding of the effect of oceanic currents on the spatial distribution of prawn larvae and subsequent recruitment to the fishery is poorly understood.

The historic information obtained on prawn surveys has not enabled calculation of relevant PI for the fishery. Future surveys should include the collection of size distribution data for each shot (grade weights or length frequency data). Surveys should continue to be regularly conducted for determination of appropriate harvest strategies and to inform stock assessment. The rationale for the current survey design should be assessed.

The recent strategic assessment of South Australia's prawn fisheries by the Commonwealth Department of Environment and Heritage (Anon 2004) identified several issues that need to be addressed for the fishery (see Appendix). These include: the development and implementation of harvest strategies for all by-product species; identification of by-catch indicator species; monitoring and assessment of by-catch indicator species, in particular interactions with endangered, threatened or protected species; conduct of a by-catch risk assessment, and; continued adoption and development of by-catch mitigation technology.

The low value of the West Coast Prawn Fishery limits the research potential. SARDI will continue to provide independent observers for prawn surveys and analyse and report on these and logbook data. Recent changes in logbook design will improve reporting on retention of by-product species and commercial prawn size data from all vessels. The limited resources available for research will continue to inhibit effective by-catch assessment for the fishery.

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7. APPENDIX

Recommendations from the Executive Summary of the DEH Assessment of South Australia's Prawn Fisheries (Anon 2004).

1. PIRSA to advise DEH of any material change to the management arrangements for the Spencer Gulf Prawn Fishery, Gulf St Vincent Prawn Fishery and the West Coast Prawn Fishery that could affect the criteria on which EPBC decisions are based, within 3 months of that change being made.

2. The current review of South Australia's *Fisheries Act 1982* should provide for the inclusion of general community and conservation interests on fisheries management committees. PIRSA to ensure that general community and conservation interests are provided the opportunity to engage regularly with the Prawn Fisheries Management Committee. Greater efforts should also be made to increase conservation and general community involvement in stock assessments and research priority setting processes.

3. By December 2005, PIRSA to develop and implement a compliance strategy for the South Australian Prawn Fisheries that is reviewable and publicly available, to address compliance and enforcement risks identified in the compliance risk assessment of the prawn fisheries.

4. By the end of 2005, PIRSA to ensure that information on the size composition of prawn catch is collected and monitored on an ongoing basis in the Gulf St Vincent Prawn Fishery and the West Coast Prawn Fishery.

5. By December 2005, PIRSA to review the performance indictors and performance measures used in the assessment of Western King prawns stock status in the Gulf St Vincent Prawn Fishery and the West Coast Prawn Fishery to ensure that they are appropriately precautionary and sufficient to detect significant changes in stock status.

6. PIRSA to ensure that the recreational harvest of Western King prawns is monitored and factored into the management of the Spencer Gulf Prawn Fishery and the Gulf St Vincent Prawn Fishery.

7. PIRSA to develop and implement harvest strategies for all by-product species taken in the Spencer Gulf Prawn Fishery, Gulf St Vincent Prawn Fishery and the West Cost Prawn Fishery within two years. Harvest strategies should clearly articulate performance

indicators and performance measures and any specific management arrangements to be applied to by-product species permitted in the fisheries.

8. By December 2006, PIRSA to develop a system for the ongoing collection and monitoring of information on bycatch and by-product species taken in the Gulf St Vincent Prawn Fishery and the West Coast Prawn Fishery sufficient to enable identification of long-term trends in bycatch and by-product. In the event that catch levels of any bycatch or by-product species change, PIRSA will investigate suitable management responses.

9. PIRSA to conduct a bycatch risk assessment in the Gulf St Vincent Prawn Fishery and the West Coast Prawn Fishery and develop suitable management responses for any species identified as high risk.

10. PIRSA to continue to pursue reduction in the amount of bycatch taken in the Spencer Gulf Prawn Fishery, Gulf St Vincent Prawn Fishery and the West Coast Prawn Fishery through the adoption and refinement of bycatch mitigation technology and to investigate methods for increasing the survivability of bycatch species. Any suitable methods identified will be implemented in a timely manner.

11. By December 2008, PIRSA to specify bycatch indicator species for the Gulf St Vincent Prawn Fishery and the West Coast Prawn Fishery to be used to monitor the impact of the fisheries on bycatch species and/or species groups.

12. By December 2005, PIRSA to introduce mandatory structured reporting of all interactions between the Spencer Gulf Prawn Fishery, Gulf St Vincent Prawn Fishery and the West Coast Prawn Fishery and endangered, threatened or protected species. To complement such a reporting system, PIRSA to also ensure that an education program for fishers is developed and implemented to promote the importance of protected species protection and accurate incident reporting.