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Blue Crab (*Portunus armatus*) Fishery 2009/10

Fishery Assessment Report to PIRSA Fisheries and Aquaculture

C.D. Dixon and G.E. Hooper

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PO Box 120 Henley Beach SA 5022

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EXECUTIVE SUMMARY

1. This fishery assessment report assesses the current status of the Blue Crab Fishery in South Australia up to July 2010.

2. In 2009/10, 86.0% of the Total Allowable Commercial Catch (TACC) was harvested, with Spencer Gulf (SG) and Gulf St Vincent (GSV) pot fishing sectors harvesting 99.9% and 65.5% of allocated TACC, respectively. The pot fishing sector currently holds >99% of the TACC.

3. Available data suggest that the blue crab stock in SG is currently in its strongest position since the introduction of quota. Supporting evidence includes: high relative abundance of legal-size crabs in fishery-independent surveys (FIS); TACC harvested with less effort than the two previous years; Catch-per-unit effort (CPUE) from 2nd potlifts (short soak-times) was higher than for 1st potlifts; monthly CPUE peaked in June (the end of the quota period), and; pre-recruit abundance from surveys, pot-sampling and commercial logbooks showed increasing trends that indicate a positive outlook for the fishery.

4. The July 2010 fishery-independent survey (FIS) in GSV indicated an increase in abundance of legal-size crabs compared to 2009. Pre-recruit abundance increased to the second highest level recorded. Pot-sampling and commercial logbook data also indicated increases in pre-recruit abundance and together these measures indicate an improved outlook for the fishery in 2010/11.

5. Commercial catch measures for GSV during 2009/10 were poor as demonstrated by: a low total catch; similar boat-day and potlift effort to 2008/09, and; the lowest commercial potlift CPUE since the introduction of quota. Of the three active fishers in GSV during 2009/10, two accounted for 88% of total effort. The low effort (and catch) by one fisher likely contributed to maintenance of a low but stable CPUE from February to June 2010.

6. Of the three Performance Indicators (PIs) for Spencer Gulf, legal-size abundance from FIS was above the reference range and pre-recruit abundance from FIS and legal-size abundance from CPUE were within the reference range. All three of these PIs were within the reference range for Gulf St Vincent.

7. “Stock status” of the resource should be assessed using the primary measures of legal-size and pre-recruit abundance from FIS. Commercial logbook and pot-sampling data provide informative supplementary measures. The development of a framework to objectively assess stock status is a high priority for the fishery.

1 INTRODUCTION

1.1 Overview

The first report on the South Australian Blue Crab Fishery (BCF) was published in 1987 by the South Australian Department of Fisheries (Grove-Jones, 1987). The fishery was later reviewed in 1994 by Baker and Kumar (1994). SARDI completed the first fishery assessment report for the BCF in 1998 (Kumar, *et al.,* 1998) based predominately on summaries of catch and effort information. These brief reports were then published annually until 2003 (Kumar *et al.,* 1999a; Kumar *et al.,* 1999b; Boxshall *et al.,* 2000; Boxshall *et al.,* 2001; Hooper and Svane, 2003).

This report is the seventh version of a "living" document that has been updated annually since 2004 as part of SARDI Aquatic Sciences ongoing assessment program for the BCF. The report aims to: (1) synthesise information for the BCF in each of the Spencer Gulf and Gulf St Vincent regions; (2) assess the current status of the resource and consider the uncertainty associated with each assessment; (3) comment on the current biological Performance Indicators and Reference Points for the fishery; and (4) identify future research needs.

Since 2004, this report has documented the biology and management of blue crabs in South Australia, presented analyses of commercial logbook and fishery-independent survey data, and provided assessment against the Performance Indicators of the Management Plan (Svane and Hooper, 2004; Currie and Hooper, 2006; Currie *et al.*, 2007, Dixon *et al.*, 2008, Dixon and Hooper, 2009, and Dixon and Hooper, 2010). Since 2008, the report has presented information and conclusions for each gulf separately and also included information gathered from the pot-sampling program. The 2010 report was the first to provide explicit spatial information, at the fishing block scale, for commercial catch and effort data.

Important additional research conducted for the South Australian BCF includes an independent review of the research program (Scandol and Kennelly, 2001) and a review of blue crab biology in South Australia (Svane and Cheshire, 2005).

1.2 History of the Fishery

1.2.1 Commercial Fishery

Blue swimmer crabs *Portunus armatus* (previously *Portunus pelagicus*) were first harvested as by-product in South Australian prawn and marine scalefish fisheries in the 1970's. In 1981, an experimental trawl fishery with four licensed fishers was established in northern Spencer Gulf. This approach was abandoned and in 1983 six experimental pot fishing permits were offered to marine scale fishers. In 1985/86 the number of experimental licences was increased to 12: four in the West Coast, six in Spencer Gulf, and two in Gulf St. Vincent. In 1986 the West Coast fishery declined and the four licence holders surrendered their entitlements. Also during 1986, the sale of blue swimmer crabs as by-product from the prawn fishery was prohibited.

In June 1996, management arrangements for a fully commercial Blue Crab Fishery were established. A management strategy and research program was implemented to support the development of a sustainable fishery. In 1997, PIRSA Fisheries proposed a 3-year development strategy where the capacity for expansion of the fishery was to be determined through research and commercial fishing.

The BCF is based on the capture of a single species, *Portunus armatus,* although other crab species may also be landed. There are two fishing zones; Spencer Gulf and Gulf St Vincent (Figure 1.1). There is a single TACC for the fishery with separate quota units for each zone. The *Fisheries Management (General) Regulations 2007* state that blue crabs may also be taken from State waters within three nautical miles of the coast west of longitude 135 degrees East. The "West Coast" region is not subject to the quota system.

Commercial pot fishers generally haul their gear once or twice every 24 hours using specifically designed crab pots covered with netting. Commercial marine scalefish fishers use either hoop or drop nets hauled every 20-30 minutes. Crabs can be stored live in tanks, iced down uncooked or cooked before being landed in port.

Most of the commercial catch is marketed in Australia, primarily in the Sydney and Melbourne fish markets. In 2009/10, 658 tonnes of blue swimmer crab valued at approximately $5.47 million were harvested from State waters in South Australia (Knight and Tsolos, 2011). This value includes commercial quantities of blue crabs taken from the West Coast.

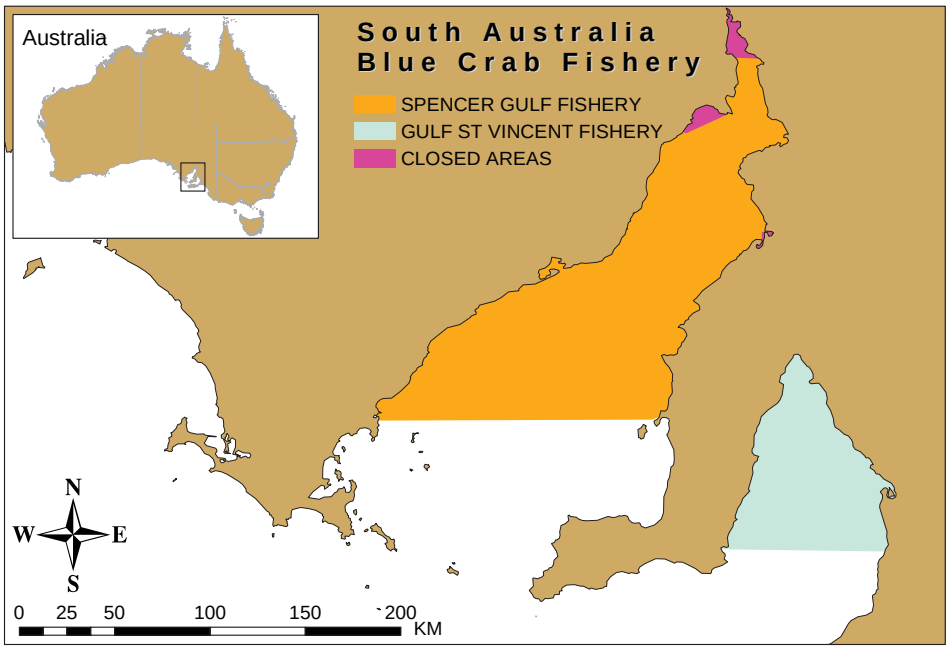


Figure 1.1. The location of blue crab fishing regions in South Australia.

1.2.2 Recreational Fishery

PIRSA conducted a State-wide assessment of recreational fishing in South Australia from November 2007 to October 2008 (Jones 2009). Blue crab retained catch was estimated as 1,144,837 individuals for this period, with an estimated weight of 283.7 t. This represents 29.8% of the total annual catch if added to the commercial catch of 2007/08 (Table 9: Jones 2009). Of this total weight, 48% was harvested from Spencer Gulf, 46% from Gulf St Vincent and Kangaroo Island and 6% from the West Coast. The average weight of harvested crabs was much higher in Spencer Gulf and the West Coast compared to Gulf St Vincent and Kangaroo Island.

Two previous recreational fishing surveys were undertaken in South Australia. A National Recreational and Indigenous Fishing Survey (Henry and Lyle, 2003) was conducted between May 2000 and April 2001. The annual catch taken by recreational fishers in South Australia was estimated at 389.8 t. This suggests that the recreational harvest was 37.5% of the total catch during 2000/2001. A further 31.7% of the total catch was released after capture (Anon, 2003). Also, McGlennon and Kinloch (1997) estimated a total catch of 161.2 t per year, of which 115.8 t was taken in Gulf St Vincent and 45.4 t in Spencer Gulf. Thus, the recreational catch was estimated to be 32.9% in Gulf St Vincent, 10.8% in Spencer Gulf and 20% of the overall TACC. This estimate was derived from a boat survey only and does not include the recreational shore-based fishery. This precludes direct comparisons with contemporary surveys.

1.3 Management

The Blue Crab Fishery is managed by Primary Industries and Resources South Australia (PIRSA) under the framework provided by the *Fisheries Management Act 2007*. General Regulations pertaining to commercial and recreational harvest of blue crabs in South Australia are described in the *Fisheries Management (General) Regulations 2007*, with specific legislation located in the *Fisheries Management (Blue Crab Fishery) Regulations 1998*, and the *Fisheries Management (Marine Scale Fisheries) Regulations 2006*. These documents provide the statutory framework for management of South Australia's blue crab resources.

1.3.1 Management History

Several fishing sectors have had historic access to blue crab resources in South Australia, including marine scale fishers and prawn trawlers. The commercial blue crab fishery was established in 1996, with formalised management arrangements that included pot restrictions, splitting of the fishery into two zones (Spencer Gulf and Gulf St Vincent) and a single Total Allowable Commercial Catch (TACC) that was allocated into quota units for each zone. Quota is transferable between the pot fishing and marine scalefish sectors.

Since the implementation of the TACC in the South Australian BCF in 1996/97, there has been a transfer of fishing effort from the MSF to the pot fishing sector (Figure 1.2). The number of MSF licences fishing blue crab quota has decreased from 29 to one during this period. When quota was first introduced, there were four licensed pot fishers in Spencer Gulf (SG) and two in Gulf St Vincent (GSV). Additional licences were added to the SG fishery in 2001/02 and GSV fishery in 2002/03 and 2007/08.

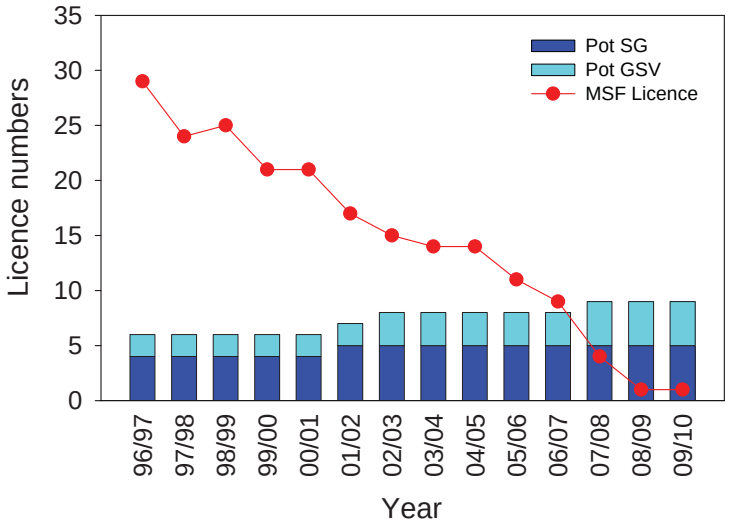


Figure 1.2. Number of active licence holders in the commercial Blue Crab Fishery.

1.3.2 Current Management Arrangements

The TACC was initially set by PIRSA at 520 t for the 1996/97 fishing season. Over the next four seasons the TACC gradually increased until it reached 626.8 t in 2000/01, where it has remained ever since.

The fishery operates with a minimum legal-size of 110 mm carapace width, which is measured at the anterior base of the first spine. The commercial fishery also has closed seasons (21 Dec-19 Feb in Spencer Gulf, and 1 Nov-15 Jan in Gulf St Vincent) and fishers are not permitted to retain egg-bearing females. Recreational fishers are subject to a daily bag limit of 40 crabs (blue crabs and/or sand crabs) per person per day. A boat limit of 120 crabs per day also applies.

1.3.3 Blue Crab Fishery Management Plan

A draft Management Plan (PIRSA 2011) (referred to hereafter as the Plan) has recently been developed by the Fisheries Council of South Australia as required under the Fisheries Management Act 2007. It is due to be completed by June 2011.

The primary goals and objectives for the BCF as provided in the Plan are:

- Ensure the Blue Swimmer Crab resource is harvested within ecologically sustainable limits
- Allocate access to Blue Swimmer Crab resources to achieve optimum utilisation and equitable distribution to the benefit of the community
- Minimise impacts on the ecosystem
- Cost effective and participative management of the fishery

In this report, the fishery is assessed against the Performance Indicators of the draft Management Plan (Table 1.1).

Table 1.1 Draft key performance indicators for the Blue Crab Fishery

Region	Relative abundance from FIS (crabs/potlift)				Commercial CPUE (kg/potlift)	
Limit reference point	Pre-recruit		Legal-sized		Legal-sized	
	Lower	Upper	Lower	Upper	Lower	Upper
Spencer Gulf	2	9	5	8	2	4
Gulf St Vincent	1.5	8.5	1.5	4	2	4

1.4 Biology of the blue swimmer crab

1.4.1 Description

The blue swimmer crab (*Portunus armatus,* A. Milne-Edwards 1861) is a true crab (Brachyura) belonging to the family Portunidae. Blue swimmer crabs have five pairs of legs. The first pair are chelae or claws, the following three pairs are walking legs and the last pair are modified as swimming paddles. The carapace is rough in texture, broad and has a prominent projection/spine on each side. They are active swimmers, but bury in the sediment while resting, with only eyes, antennae and gill chamber openings uncovered. Males are blue and have larger claws than females, which are green-brown in colour (Figure 1.3). A detailed description of this species is provided by Stephenson (1972).

Figure 1.3. Male (top) and female (bottom) blue swimmer crabs *Portunus armatus* (A. M.).

1.4.2 Distribution and stock structure

Portunus armatus is distributed throughout the coastal waters of the tropical regions of the western Indian Ocean and the Eastern Pacific (Kailola *et al.*, 1993); they are adapted to a life in warmer waters. In the relatively colder, temperate parts of Australia, the life cycle has evolved to increase growth and reproduction during the warmer part of the year when water temperatures increase to those similar in tropical regions. Activity reduces during the colder winter months.

P. armatus occurs in a wide range of algal and seagrass habitats and on both sandy and muddy substrata, from the intertidal zone to at least fifty metres of depth (Williams, 1982; Edgar, 1990). In coastal waters, smaller crabs are found in shallow waters, while adults are found in comparatively deeper waters. Juvenile crabs occur in mangrove creeks and mud flats for eight to twelve months by which time they attain a size of 80 to 100 mm carapace width. Within South Australia, there is a distinct seasonal pattern of adult crab movements into shallow inshore waters during the warmer months of September to April and to deeper offshore waters during the colder months of May to August (Smith, 1982).

Using allozyme markers, Bryars and Adams (1999) determined that the populations of *P. armatus* within Spencer Gulf, Gulf St Vincent and the West Coast regions of South Australia, represented separate sub-populations with a limited gene flow. They also found that inter-regional larval dispersal is restricted, and each sub-population must be dependent on its own larval supply.

In a study using microsatellite markers, Chaplin *et al.* (2001) found that the assemblages of *P. armatus* in different embayment's in South Australia often constitute genetically different meta-populations. The level of migration between these populations is probably limited and likely to be determined by local factors.

1.4.3 Reproductive biology

Male and female *P. armatus* generally reach sexual maturity at respective sizes of 70 to 90 mm in carapace width, when they are approximately one year old. The male and female will form a pre-corpula for eight to ten days before ecdysis of the female. After female ecdysis, when the female is soft-shelled, copulation takes place over a six to eight hour period (Meagher, 1971).

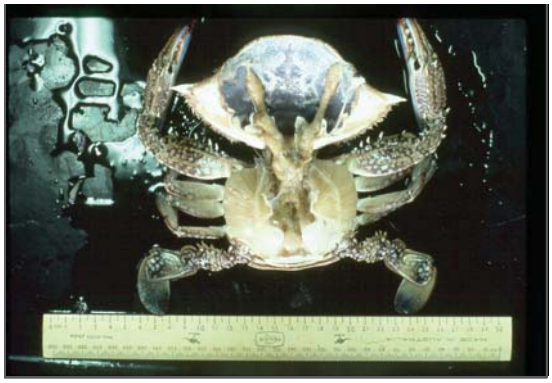
The spawning season lasts for 3 to 4 months over the summer/autumn period. The duration of the growing season varies among individuals because those settling in early summer have a longer growing season than those settling in mid-to-late summer. In South Australian waters, crabs close to the minimum legal-size (110 mm) are approximately 14 to 18 months old, sexually mature, and females have produced at least two batches of eggs within one season (Kumar *et al*., 2000, 2003).

Development of the ovaries appears to be triggered by rising water temperature in spring. During copulation, the spermatophore is transferred to the female spermatheca. The eggs are subsequently fertilised on extrusion (Smith, 1982). Van Engel (1958) found that the sperm in the spermatheca of female *Callinectes sapidus* could remain viable for at least 12 months. This is likely to also be the case for *P. armatus*. Egg extrusion is independent of the timing of copulation.

Ovarian development can be classified by five visually distinguishable stages (see Sumpton *et al*., 1994 and Figure 1.4):

Stage 1 (S1): Gonad immature, white or translucent
Stage 2 (S2): Gonad maturing, light yellow/orange, not extending into hepatic region
Stage 3 (S3): Gonad maturing, yellow/orange not extending into hepatic region
Stage 4 (S4): Gonad mature, dark yellow/orange extending into hepatic region
Stage 5 (S5): Ovigerous, female bearing fully matured eggs (pale to dark yellow eggs) externally.

The fourth stage of ovarian development was observed in late October to November in conjunction with rising seawater temperatures. Kumar *et al*. (2000) demonstrated that during November, more than 40% of crabs were in advanced Stage 4, and 80% caught were between Stages 3 and 4.

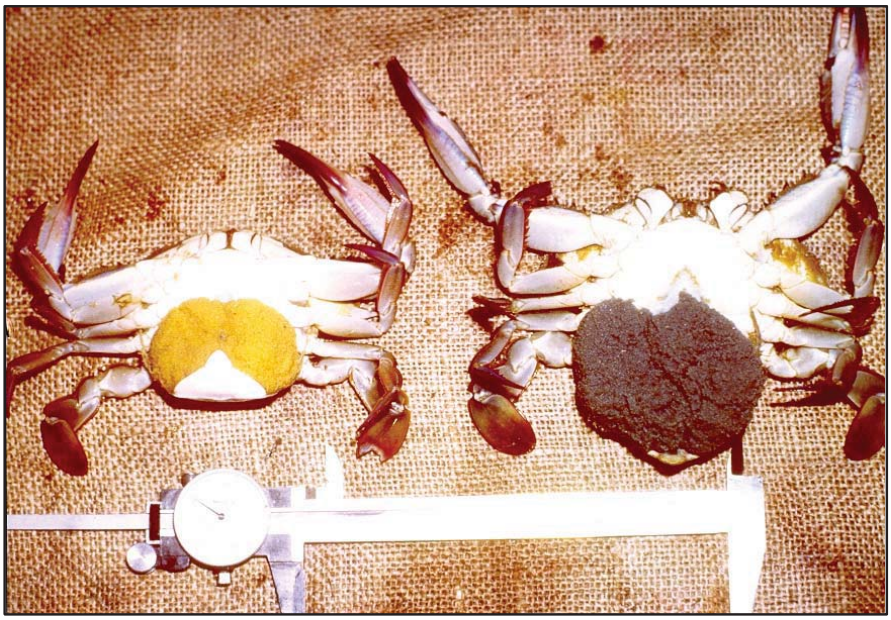


Stage 1

Stage 2

Stage 3

Stage 4



Stage 5

Figure 1.4. Ovarian stages of the blue swimmer crab (from Kumar *et. al.*, 2000).

In tropical waters, female blue swimmer crabs carry eggs throughout the year however seasonal variation in the number of egg-bearing females can be observed (Kumar *et al.,* 2000). During embryonic development (Stage 5), the colour of the eggs changes from yellow to a dark grey (Figure 1.4).

In South Australia, egg-bearing females are observed throughout the year but peak in late spring. Commercial logbook data from July 1997 to June 2005 indicate that high proportions of berried females appear in the catch in October in GSV and November in SG (Figure 1.5). This pattern was consistent between years.

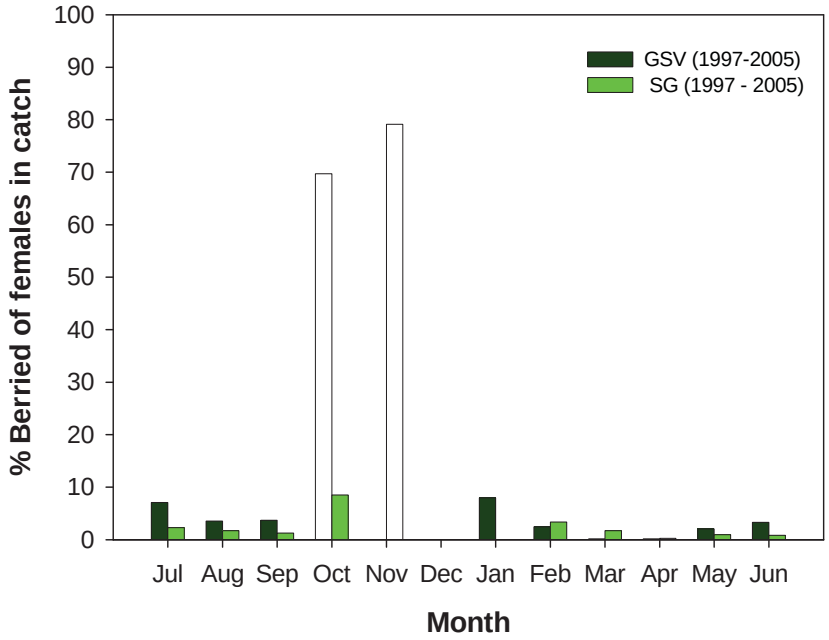


Figure 1.5. Mean monthly percentage of berried females in catches from 1997-2005.

Fecundity is calculated as the number of eggs carried externally by the female. Kumar *et al.* (2003) found that the fecundity of female crabs was size-dependent, increasing up to a carapace width of 134 mm and decreasing thereafter. Fecundity increased by 83.9% from 105 mm to 125 mm, implying that a single large female could produce as many eggs as two small females. Kumar *et al.* (2000) found that a female blue crab can produce between 650,000 to 1,760,000 eggs per spawning.

P. armatus can spawn more than one batch of eggs in a season. Eight to ten days after spawning the first batch of eggs, the female may ovulate and fertilise a second batch (Meagher, 1971). On examination of berried females, some carried developing oocytes at stages 2 and 3 in the ovary whilst also carrying an external egg mass (Kumar *et al*., 2003). While blue crabs are capable of producing more than one batch of eggs in a season, successive ovulations do not always occur (Meagher, 1971).

1.4.4 Length weight relationship

The relationship between blue crab carapace width (CW, mm) and weight (g) from Spencer Gulf and Gulf St Vincent was determined for a sample of 582 individuals of size range 52-149 mm (SARDI unpublished data, 2009) and was described by the power curve: "Weight = *a* × carapace length^ *b*". The length to weight relationship differed among the sexes but was consistent among gulfs (Figure 1.6). In each gulf, male blue crabs grew to a larger total weight for a given carapace width.

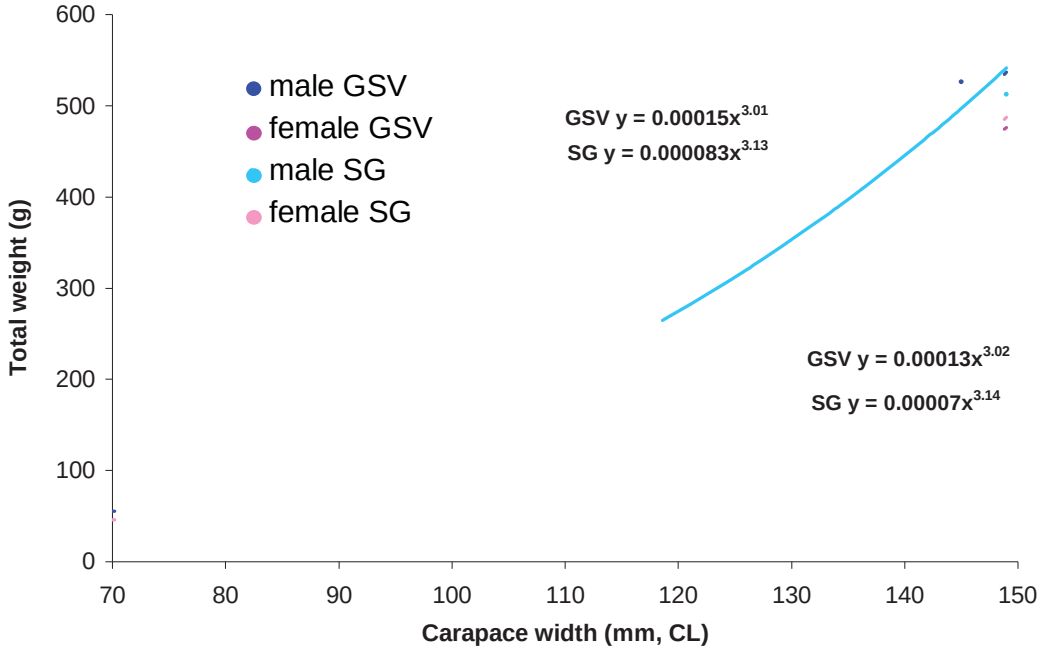


Figure 1.6. Length-weight relationship of *Portunus armatus* measured from samples collected during fishery independent surveys in Gulf St Vincent and Spencer Gulf.

1.4.5 Parasites

The parasites of some decapod crustaceans are known to cause sterilisation of their host, and can therefore have an important impact on the population of infested species (Gaddes and Sumpton, 2004). The barnacle, *Sacculina granifera,* is a known parasitic castrator of *P. armatus*, and can have a marked effect on gonad development and growth in Australian populations (Shields and Wood, 1993). Levels of parasitism in South Australian blue crab populations have yet to be examined.

2 METHODS

2.1 Overview

This assessment uses information from three different sources: fishery-independent survey data; fishery-dependent commercial logbook data, and; fishery-dependent pot-sampling data.

Fishery-independent survey data are the most reliable source of information for assessment and provide a snapshot of the biomass across the full extent of the fishery at the end/beginning of the quota season (June/July). Two key measures are determined from surveys: 1) the relative abundance of legal-size crabs, and; 2) the relative abundance of pre-recruit crabs. The primary uncertainty in the interpretation of pre-recruit abundance results from differences in the timing of surveys and the timing of peak recruitment to the fishery. Other uncertainties include: the employment of different fishers between and within years; extrinsic factors such as weather and water temperature, and; differences in the spatial distribution of survey pots.

Commercial logbook data provide useful supplementary measures of relative abundance of both legal-size and pre-recruit crabs, as well as information on the sex-ratio of the commercial catch. The primary uncertainty associated with logbook data regards the interpretation of commercial CPUE data which may be influenced by: changes in fisher demographics and experience; temporal and regional shifts in the distribution of catch and effort; changes in the frequency of second potlifts; differences in gear types and vessel technology; selectivity of commercial pots, and; crab behaviour.

The fishery-dependent pot-sampling program began in 2006 and involves the recording of catch data from one small mesh pot (i.e. smaller escape gaps) each fishing day. This provides useful supplementary information on pre-recruit abundance and sex-ratio of the population. The pot-sampling program avoids the biases associated with commercial large mesh pots however the current frequency of sampling is low.

Fishery assessment is primarily based on interpretation of legal-size and pre-recruit abundances from these three sources in a hierarchical manner. Data is analysed and presented for each gulf separately using the same methods presented in the remainder of this section.

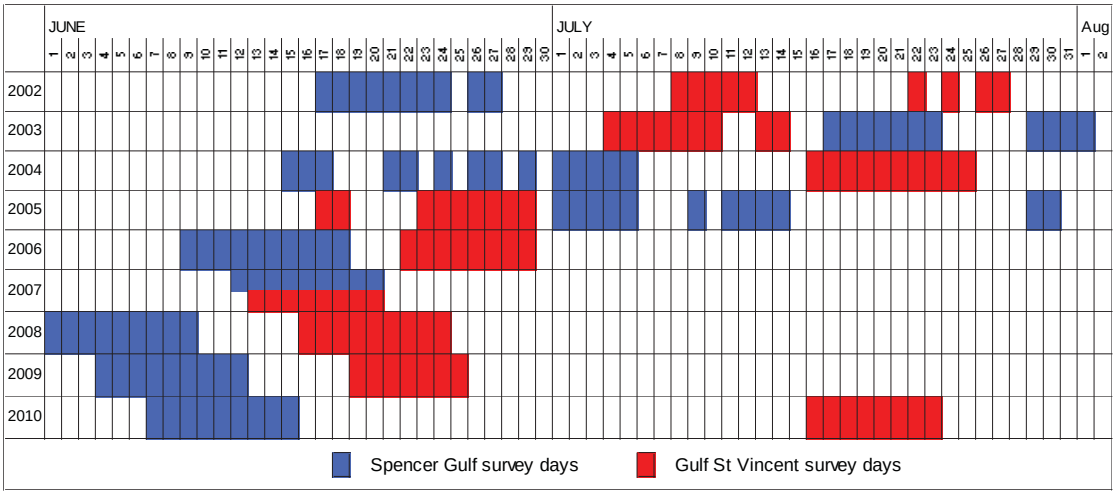
2.2 Fishery-Independent Survey Data

Fishery-independent surveys (FIS) for the Blue Crab Fishery have been conducted on an annual basis during June/July from 2002 (Table 2.1). The primary aim of FIS is to collect data on the spatial abundance and size composition of blue crabs in Spencer Gulf and Gulf St Vincent during winter, when juvenile crabs generally recruit to the fishery. This also coincides with the end/beginning of the quota season.

The timing of surveys in Spencer Gulf was variable, particularly between 2002 and 2005 (Table 2.1). Whilst most surveys were conducted in June and early July, surveys were held in late July to early August in 2003 and were extended throughout July in 2005. In Gulf St Vincent, surveys were conducted in July from 2002 to 2004, and June thereafter.

The surveyed area covers waters with depths ranging from 3 m to 22 m northwards of a line from Wallaroo to Cowell in Spencer Gulf (Figure 2.1) and northwards of line from Glenelg to Port Vincent in the Gulf St Vincent (Figure 2.2). Sampling sites were determined based on fisher knowledge and historical catch and effort data. From these recommendations, four sites were selected in each fishing block to be surveyed.

Table 2.1. Dates of fishery-independent surveys conducted in Spencer Gulf and Gulf St Vincent from 2002 to 2010.



Fewer potlifts were done during 2002 than in subsequent years. Prior to the 2008 survey, the location of survey sites was modified by SARDI, PIRSA and Industry to provide a more accurate representation of the blue crab biomass in each gulf. These changes included: removal of all sites from some fishing blocks; addition of new sites within previously unsurveyed fishing blocks, and; movement of sites within fishing blocks. A summary of the changes to survey sites for Spencer Gulf (Figure 2.1) and Gulf St Vincent (Figure 2.2) is provided.

At each site, both commercial crab pots (Figure 2.3) and small mesh pots (Figure 2.4) were set and hauled on a daily basis. Commercial pots have a diameter of 1.2-1.4 m, a height of 50 cm, and are covered with a 90 mm mesh. Small mesh pots, designed specifically for surveys, have a diameter of 1.4 m, a height of 50 cm, and a smaller mesh covering of 55 mm. At each survey site, five sets of gear were deployed along a line, each comprising one commercial and one small mesh pot. Each pot was separated by 40 m of rope and each set of gear spaced 150 m apart. Pots were baited with fresh Australian salmon, sardines or striped trumpeter, and were hauled from dawn each day.

A global positioning system (GPS) was used to locate the gear, and depth was recorded for each site. Blue crabs were measured using Vernier callipers (carapace width, mm), and details of sex (male or female) and condition (dead, soft, berried) were recorded. Data on by-catch species was collected during the survey, however they are not presented in this report. An assessment of by catch data from 2002 to 2006 was presented in Currie *et.al* (2007).

Relative abundance was represented by survey CPUE, calculated as the mean number of pre-recruit and legal-sized crabs caught per pot (small mesh pots only) for each FIS. The survey design was modified in 2008 with the removal, shifting and addition of potlift locations. Relative abundance data are analysed for all potlifts conducted from 2002 to 2010, and for a set of standardised potlifts that were surveyed during all years.

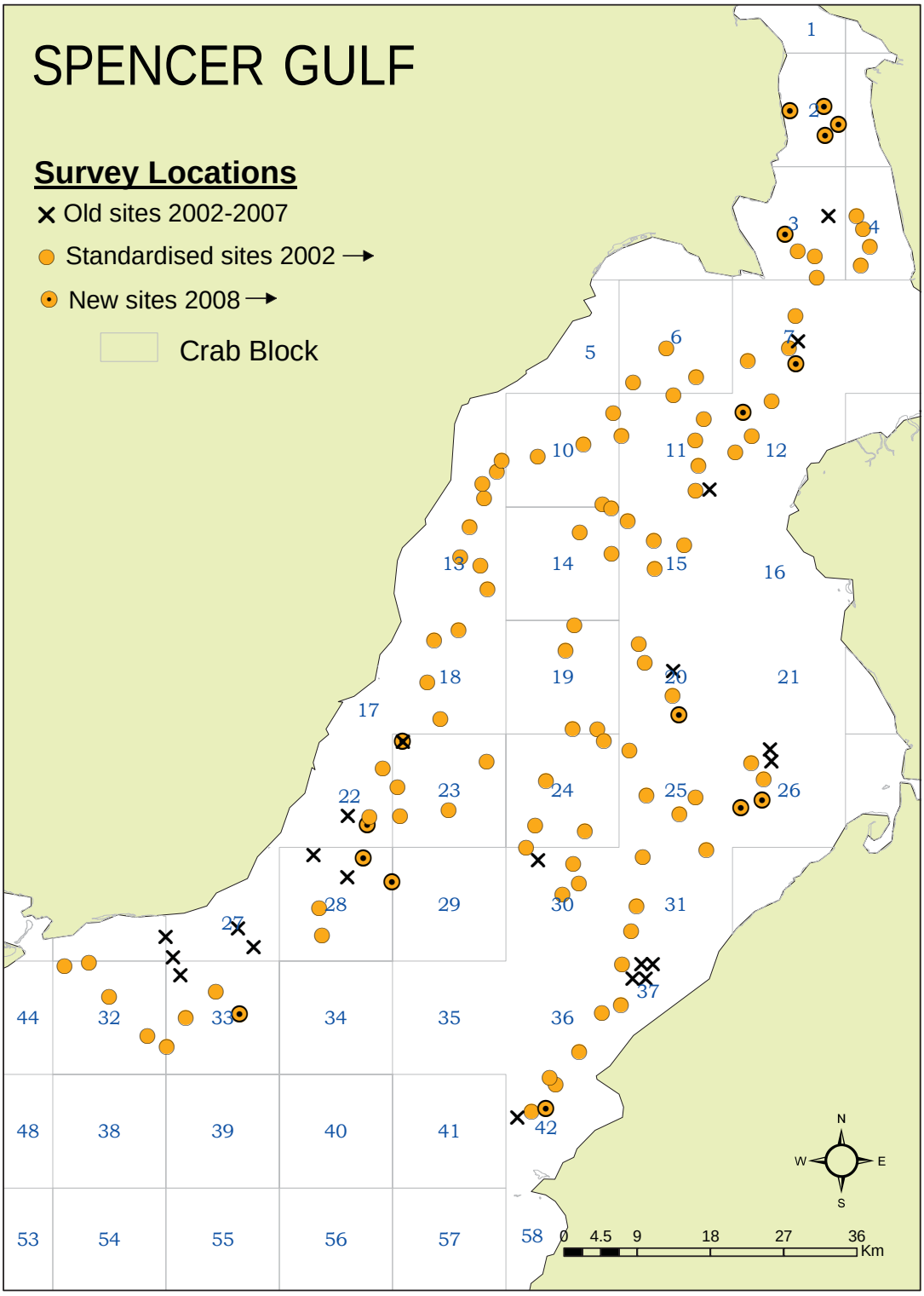


Figure 2.1. Commercial fishing blocks (squares), and survey locations for the blue crab fishery in Spencer Gulf.

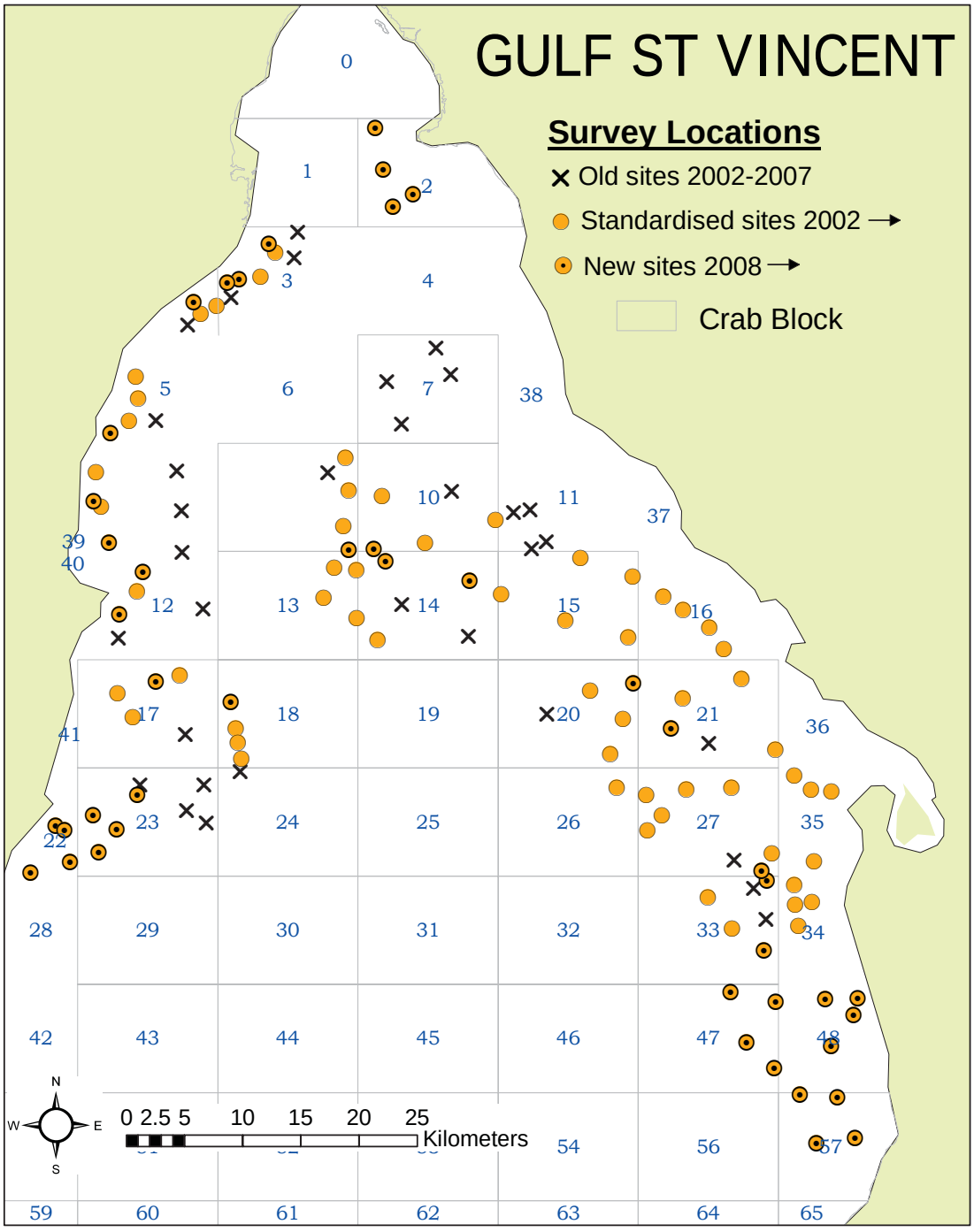


Figure 2.2. Commercial fishing blocks (squares), and survey locations for the blue crab fishery in Gulf St Vincent.

Figure 2.3. Commercial crab pot (mesh size of 90 mm).

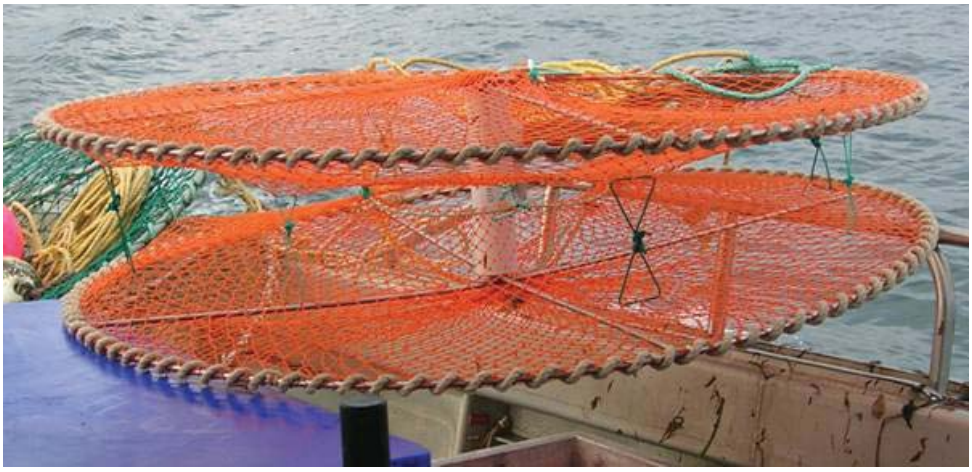


Figure 2.4. Small mesh crab pot (mesh size of 55 mm).

2.3 Fishery-Dependent Data

2.3.1 Commercial logbooks

SARDI maintains a comprehensive catch and effort database for the BCF using data from the compulsory fishing logbook system. Each gulf is divided into a series of administrative fishery blocks. Data provided includes: fishing block, depth, effort, catch weight by sex and catch number. Catch and effort data also includes separate information for the conduct of second lifts where pot fishers may lift and reset their gear twice in the one day. Under these circumstances, soak time for the first lift is generally 18–20 hours and 4–6 hours for the second lift. Commercial logbooks also provide data on the number of undersized crabs and berried females. These data were first obtained in the 1996/97 fishing season. Historical data from the fishery were recorded into the GARFIS catch and effort database of the South Australian Fisheries Department from 1983/84. Commercial logbook data provided by the marine scalefish sector are included only in the fishery overview (Section 3).

Analyses of catch and effort for the pot fishing sectors include data on i) total catch (kg) in the first set of potlifts, ii) total catch (kg) in the second set of potlifts, iii) total number of first potlifts, iv) total number of second potlifts and v) total number of boat-days. Catch and effort data are presented on an annual scale, seasonal scale (monthly) and as a series of maps on catch distribution.

Catch per unit effort (CPUE) data is determined as a) mean catch per pot lift and b) the mean catch per day and are presented in five ways:

1) mean annual catch per potlift $CPUE_L$ (total catch/total potlift effort),
2) mean annual $CPUE_{L(F)}$ for first potlifts (total catch first potlifts/total effort first potlifts)
3) mean annual $CPUE_{L(S)}$ for second potlifts (total catch second potlifts/total effort second potlifts)
4) mean monthly $CPUE_L$ (monthly catch/monthly potlift effort)
5) mean daily catch $CPUE_D$ (mean of the total catch per boat day).

The recruitment index was derived as the mean number of undersize crabs per commercial potlift during June and July each year.

Information on sex ratio was obtained from the daily catch weight by sex. To model monthly and annual estimates of sex-ratio by weight, several assumptions were necessary.

- When male catch weight was not provided (but female was) or male + female weight did not sum to the total, estimates of female weight and total weight were assumed correct.
- When neither male nor female catch weight was provided (but total was), two scenarios were determined: 1) assume that all catch was male (minimum % female) and 2) assume that days of missing data were the same % female as all days for that month where % female data were available.
- When modelling monthly estimates, where neither male nor female catch weight was provided (but total was) for that entire month, the proportion of females in the catch was assumed from other comparable data.

2.3.2 Pot-sampling

The pot-sampling program collects fishery-dependent data from small mesh pots on abundance and size composition of blue crabs throughout the fishing season to inform on recruitment strength and sex-ratio.

Pot-sampling data have been collected since May 2006 in Spencer Gulf and since July 2006 in Gulf St Vincent. Sampling was voluntarily undertaken from one small mesh pot and one commercial pot each fishing day. Since May 2008, data have been collected from small mesh pots only in each gulf. Data collected includes: date, licence number, fishing block, GPS co-ordinates of pot locations, depth, water temperature, and the sex and size of individual crabs (see Appendix 9.1).

3 FISHERY OVERVIEW

3.1 Total catch and effort

Data on total catch and effort includes pot fishers in Spencer Gulf and Gulf St Vincent, and the marine scalefish (MSF) sector. Currently, the number of MSF participants precludes independent, non-confidential assessment of the data and thus MSF catch and effort are presented only in this section of the report. Detailed analyses on the pot fishing sector in Spencer Gulf and Gulf St Vincent since the introduction of quota (1996/97) are provided in Sections 4 and 5, respectively.

Catches of blue crabs were first recorded in 1983/84, when 26.9 t of crabs were harvested from 530 boat-days (Figure 3.1), most of which was harvested by the marine scalefish sector. Over the following twelve years catches progressively increased, particularly for the pot fishing sectors, and reached a historical high of 651.3 t in 1995/96. The introduction of quotas in the following season resulted in a 29% reduction in catch, with 462.4 t being harvested during 1996/97. Catches generally increased up to 2007/08 but have declined in the last two years.

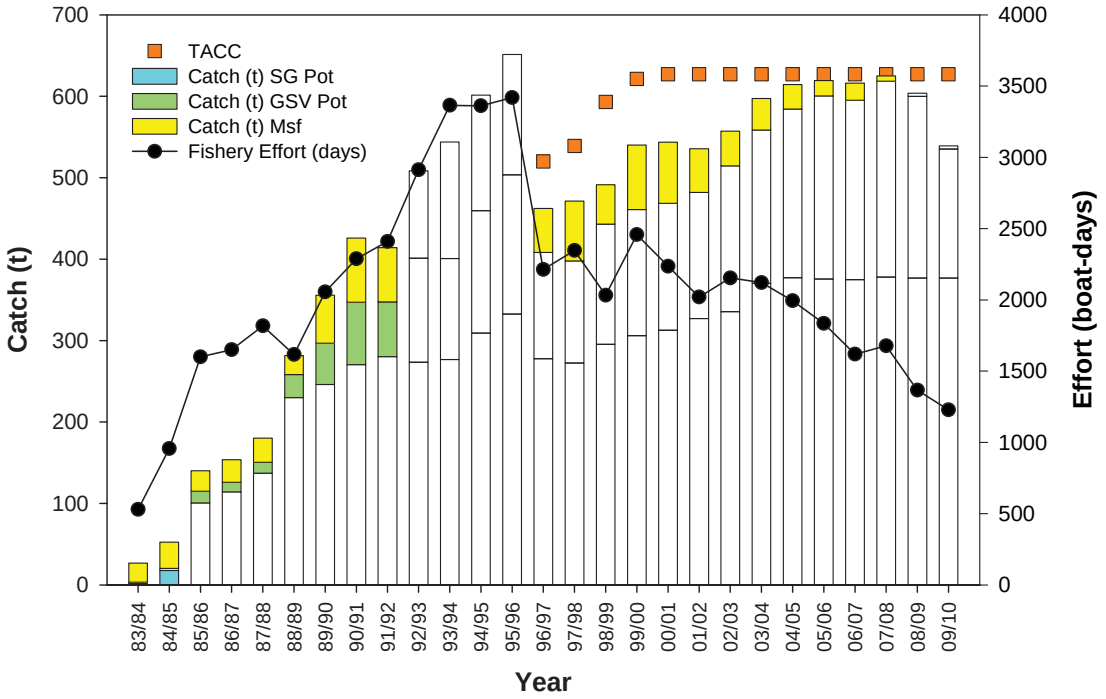


Figure 3.1. Commercial catch (t) from the Spencer Gulf (blue) and Gulf St Vincent (green) pot fishing sectors and the marine scalefish (yellow) sector, TACC (squares, t) and fishing effort (line, boat-days) for the Blue Crab Fishery from 1983/84 to 2009/10.

Over the past nine years the TACC has been set at 626.8 t. The total catch during 2009/10 was 539.1t, with >99% harvested by the pot fishing sector. This catch

represented 86% of available quota and was 10.7% less than that harvested in 2008/09.

Prior to the introduction of quota, trends in commercial catch generally followed trends in effort (boat-days). During 1996/97, effort was 2,213 boat-days, rising to a maximum (post TACC) of 2,458 boat-days in 1999/00. Since then, effort has decreased, with the number of boat-days fished during 2009/10 (1,215 days) being half that expended during 1999/00 and 11.1% less than during 2008/09. The decline in effort was due mostly to the transfer of quota from the MSF to pot fishing sector and the introduction of multiple potlifts per day.

4 SPENCER GULF POT FISHING SECTOR

4.1 Commercial logbook data

4.1.1 Catch and Effort

4.1.1.1 Annual catch and effort

Blue crab pot fishers in Spencer Gulf held 377 t of the 626.8 t TACC during 2009/10 (source: PIRSA Fisheries), almost all of which (376.6 t) was landed. Catch from this sector has been stable since 2003/04 at a level ~38% higher than 1997/98 (272.4 t, Figure 4.1).

For the first five years following quota implementation, the number of boat-days remained relatively constant with an average of 993 days fished (Figure 4.1). Boat-days increased sharply in 2002/03 when a new licence was issued in February 2002, and have generally decreased since. In 2009/10, the number of boat-days (691) decreased by 30% compared to 2008/09 (840 days) and was the lowest recorded.

The number of total potlifts was relatively constant from 2002/03 to 2006/07 and increased sharply in 2007/08 to 161,230 potlifts, the highest recorded since TACC was introduced. Total potlifts fell by 5.6% from 2008/09 (147,666) to 2009/10 (139,330 potlifts) and was at a similar level to the period from 2002/03 to 2006/07. Between 1998/99 and 2004/05 the number of total potlifts followed a similar trend to the number of days fished. Thereafter, total potlifts have remained similar, while total boat-days have decreased.

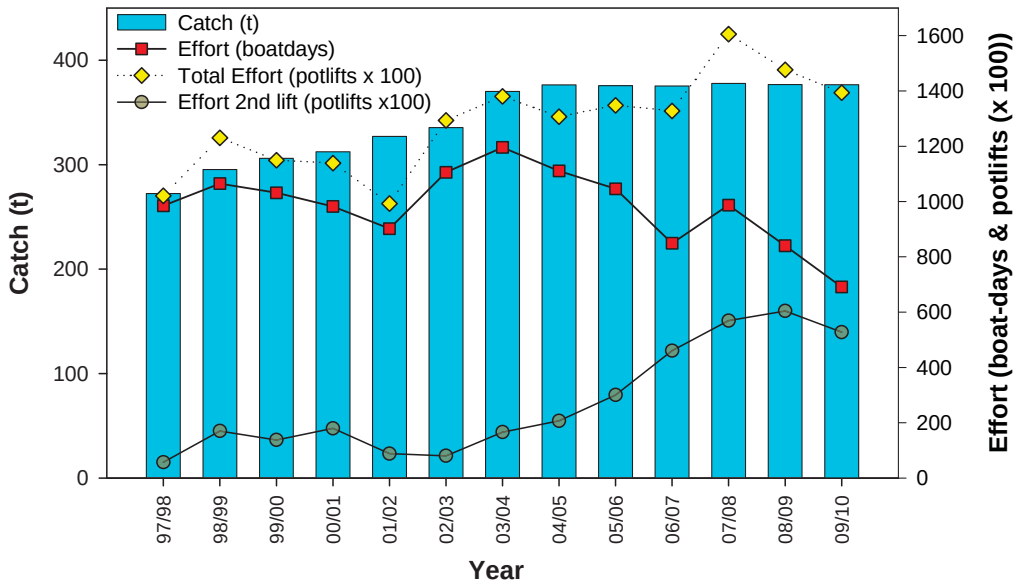


Figure 4.1. Total catch (t) and effort (boat-days, total potlifts and second potlifts) for the commercial pot fishing sector in Spencer Gulf from 1997/98 to 2009/10.

The number of second potlifts completed was relatively stable from 1997/98 to 2002/03, representing 6–16% of total annual potlifts and increased considerably thereafter. During 2009/10, the number of second potlifts decreased (52,393) compared to 2008/09 (60,398). The percentage of second potlifts also decreased from 41% of total potlifts in 2008/09 to 38% in 2009/10.

4.1.1.2 Spatial distribution of the annual catch

In the first three years after the introduction of quota, the number of blocks fished was low (<20 total) and most of the catch was taken from these few blocks (Figure 4.2). Since 2000/01, the number of blocks with catch <5 t has increased substantially (3 blocks in 1997/98 to 22 in 2007/08). These increasing trends are reflective of 1) the exploratory patterns of fishing new areas and 2) the overall increase in quota harvested by the Spencer Gulf pot fishing sector. Since quota introduction, the number of blocks with high and intermediate catches harvested (>5 t) has been relatively consistent (combined range of 10–19 blocks annually, Figure 4.2) but the distribution of these blocks has varied (Figure 4.3).

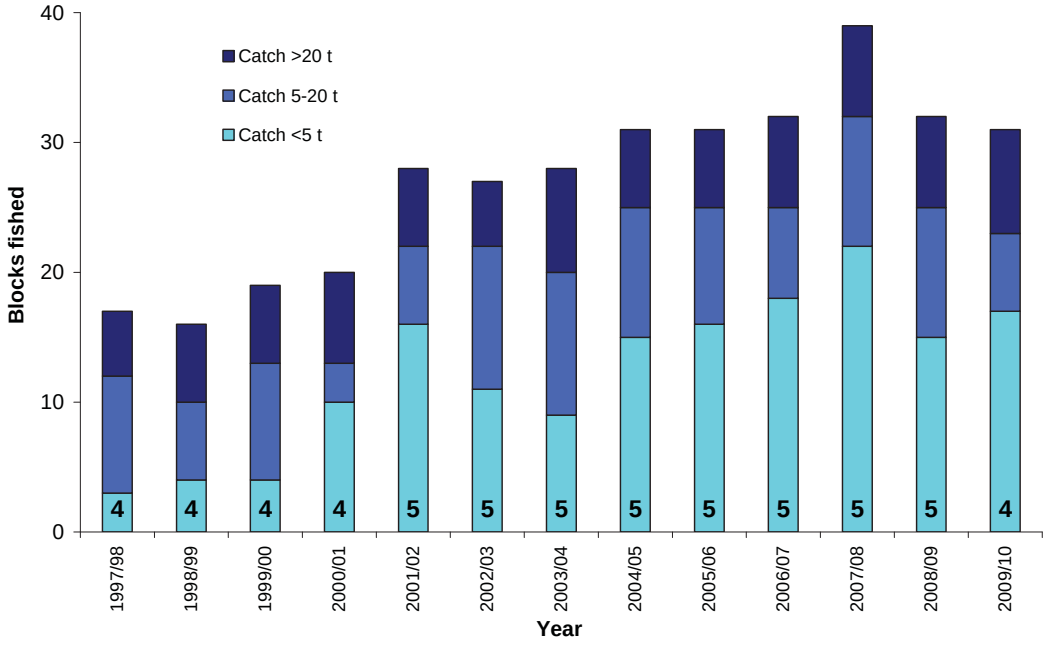


Figure 4.2. The number of blocks fished in Spencer Gulf with catches of <5 t, 5–20 t and >20 t harvested from 1997/98 to 2009/10. Labels indicate number of licences fishing.

The spatial distribution of catch has been variable since the introduction of quota, with the exception of consistent catches in some blocks in northern Spencer Gulf (Figure 4.3). Initially, catches were restricted to several blocks in northern Spencer Gulf but over time there has been a gradual spread of catches further south. During 2009/10, catches were harvested from a range of blocks throughout the fishery.

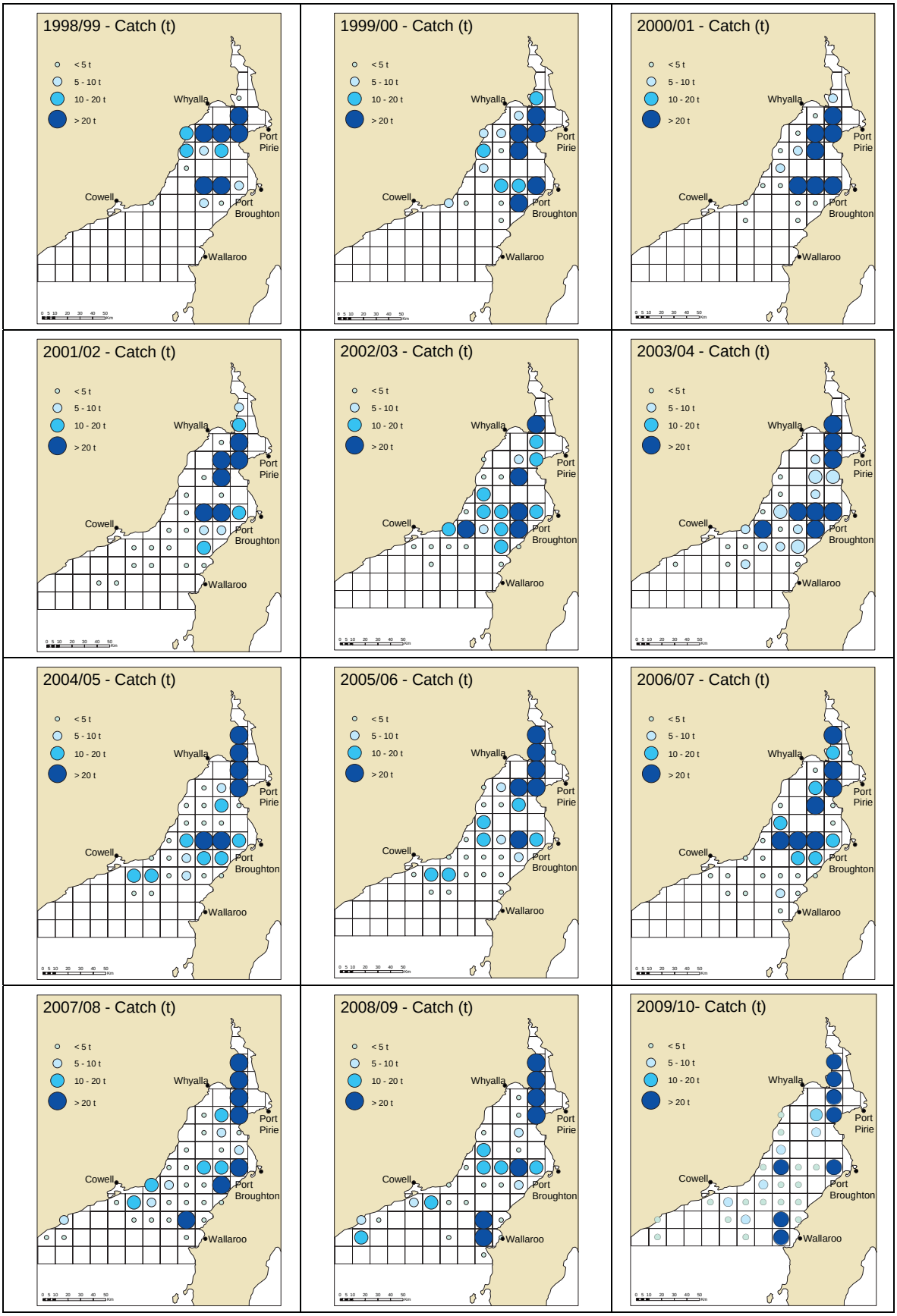


Figure 4.3. Spatial distribution of commercial catch for the Spencer Gulf pot fishing sector from 1998/99 to 2009/10.

4.1.1.3 Monthly catch and effort

Commercial pot fishing in Spencer Gulf occurs throughout the year, except during the closed season (currently 21 December to 19 February).

From 1997/98 to 2005/06, seasonal catch and effort showed similar trends among years (Figure 4.4). Generally, catches were lowest during June and highest during March. During 2009/10, monthly catches were highest in July (58 t) and decreased until December. Only a part of February was fished and catches were then consistent from March to June (range: 26.9–30.3 t). Trends in effort were different to recent years, peaking in July (19,259 potlifts) and generally decreasing thereafter.

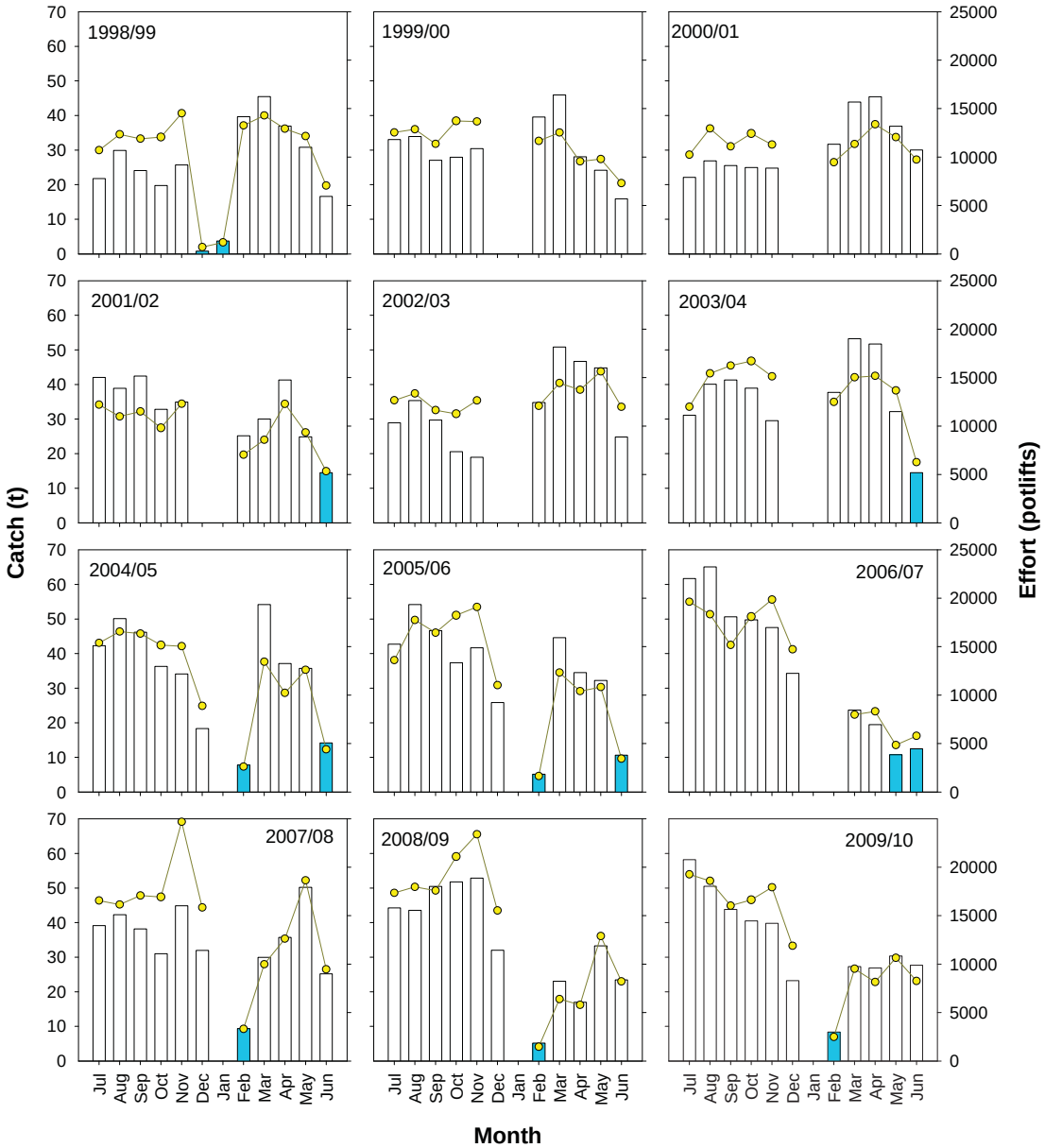


Figure 4.4. Monthly catch (t) and effort (potlifts) for Spencer Gulf from 1998/99 to 2009/10.

4.1.2 Catch per Unit Effort

4.1.2.1 Mean annual $CPUE_L$

Mean annual $CPUE_L$ for the Spencer Gulf pot fishing sector was highest during 2001/02 (3.34 kg/potlift) and stable from 2002/03 to 2006/07 (Figure 4.5). During 2007/08, $CPUE_L$ decreased by 17.5% from the previous to 2.38 kg/potlift, the lowest mean annual $CPUE_L$ since the TACC was introduced. $CPUE_L$ increased by 4% from 2008/09 (2.57 kg/potlift) to 2009/10 (2.66 kg/ptlift) and remains slightly below the ten year average of 2.78 kg/potlift.

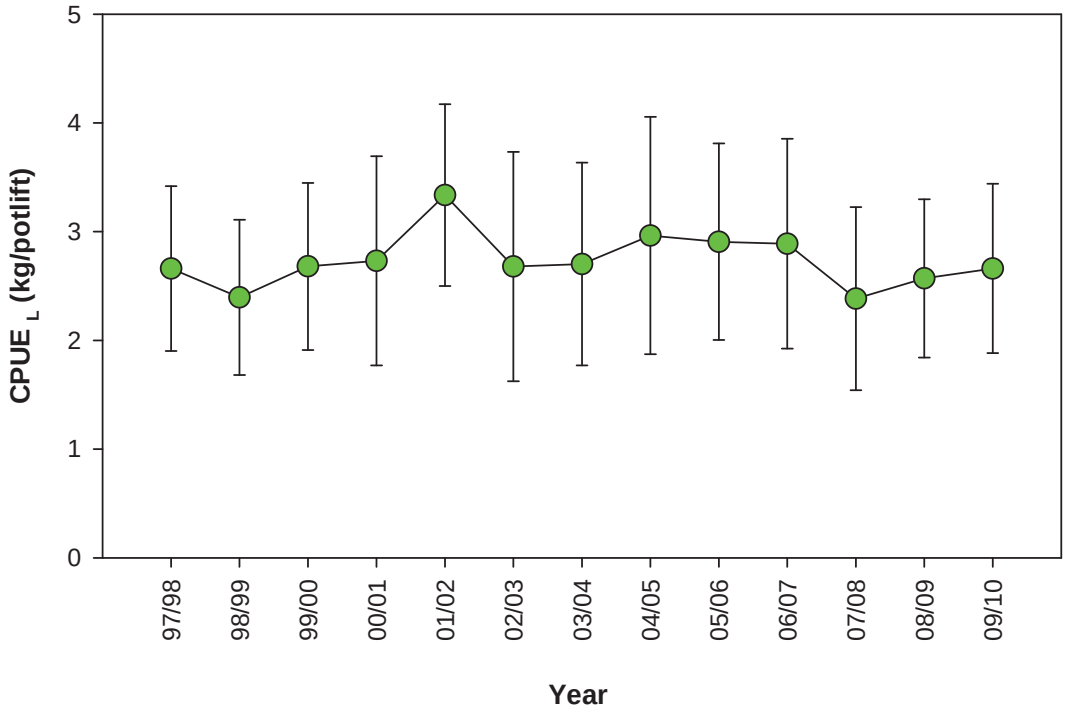


Figure 4.5. Mean (SD) annual $CPUE_L$ (kg/potlift) in the commercial Spencer Gulf pot fishing sector from 1997/98 to 2009/10.

4.1.2.2 Spatial distribution of mean annual $CPUE_L$

$CPUE_L$ was highly variable, spatially and temporally, in Spencer Gulf from 1997/98 to 2009/10 (Figure 4.6). High catch rates (>3 crabs per potlift) of crabs were distributed throughout the gulf in 2001/02 and from 2003/04–2006/07. In other years, high catch rates were observed at various locations on the eastern and western shoreline. There were few consistent trends in the distribution of high $CPUE_L$ fishing blocks. However, it is worth noting that when comparing total catch and CPUE distribution maps, blocks with high total catch (>20 t) do not necessarily reflect high CPUE (>3 crabs per potlift). The lower number of blocks with high catch rates in recent years likely reflects the increase in second potlifts during this period.

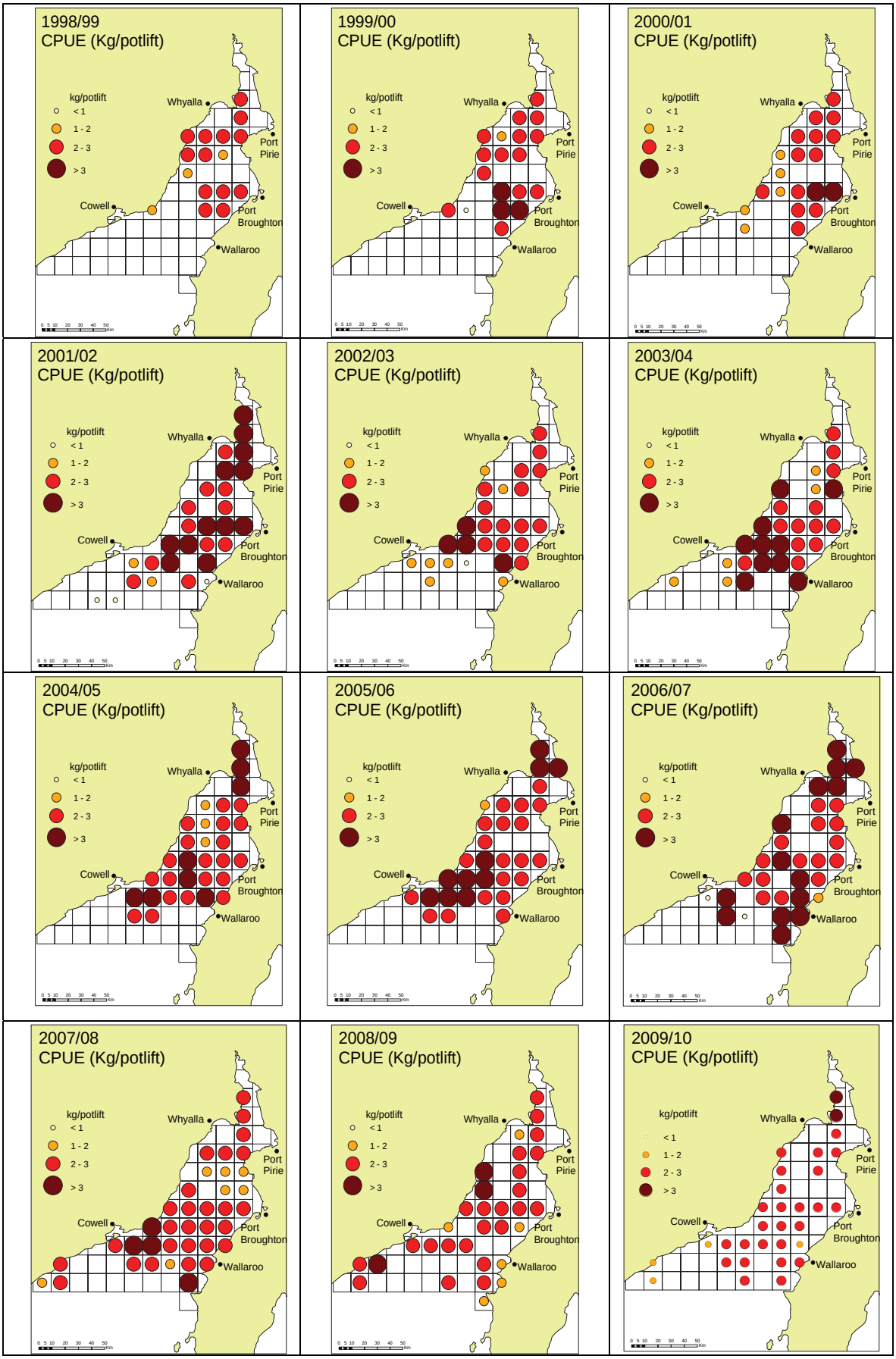


Figure 4.6. Spatial distribution of commercial $CPUE_L$ for the Spencer Gulf pot fishing sector from 1998/99 to 2009/10.

4.1.2.3 Mean annual $CPUE_L$ for first and second pot lifts

Mean annual first potlift ($CPUE_{L(f)}$) was greater than that for the second potlifts ($CPUE_{L(S)}$) in all years except 2009/10 (Figure 4.7). The difference in CPUE is primarily due to the difference in soak time (longer soak times for first potlifts). During 2009/10 the average soak time for second potlifts was 6.2 hours, which was a substantial increase from the average second lift soak time from 2004/05 to 2008/09 (range 4.3 to 4.9 hours).

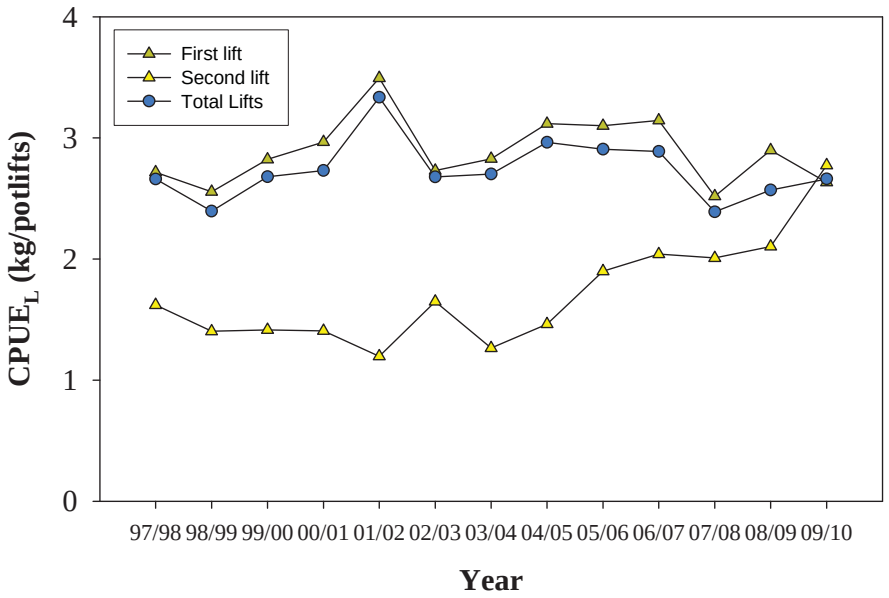


Figure 4.7. Mean $CPUE_L$ (kg/potlift) in the Spencer Gulf pot fishing sector for first potlifts, second potlifts and total potlifts from 1997/98 to 2009/10.

4.1.2.4 Mean monthly $CPUE_L$

Seasonal patterns in $CPUE_L$ were highly variable in Spencer Gulf (Figure 4.8). Generally, $CPUE_L$ was high during the start of the quota period (July) and declined until the closure (December). In most years, $CPUE_L$ increased immediately after the closure (January), was highest during February or March and then gradually declined until the end of the quota year (June). However, during 2009/10 $CPUE_L$ remained high from February to June. Annual $CPUE_L$ peaked in June (3.4 kg/potlift) which was the only time this has occurred in the past 13 years.

4.1.2.5 Mean daily catch $CPUE_D$

Mean daily catch ($CPUE_D$) has increased considerably since the introduction of quota (Figure 4.9). The greatest increases have occurred since 2002/03 which coincides with an increase in second potlift effort. The increase in standard deviation of the mean (SD) in recent years indicates that daily catches have become more variable and maximum daily catches higher. The mean daily catch of 545 kg/boat-day in 2009/10 was the highest recorded for the fishery.

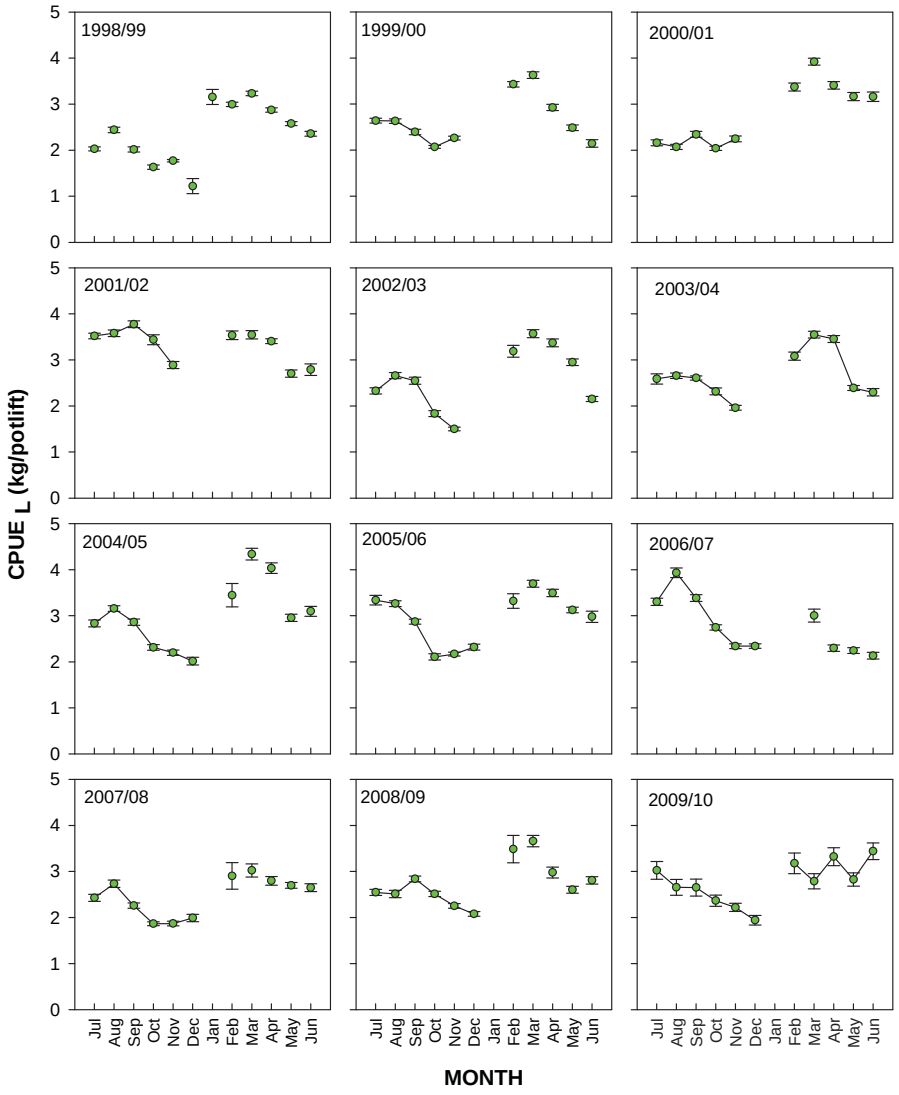


Figure 4.8. Mean (SE) monthly $CPUE_L$ (kg/potlift) for Spencer Gulf from 1997/98 to 2009/10.

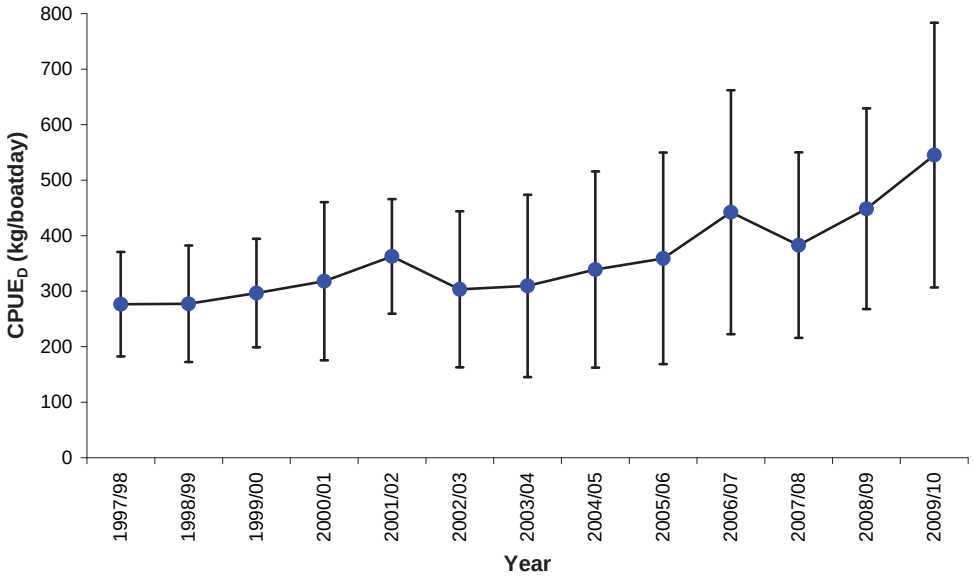


Figure 4.9. Mean (SD) $CPUE_D$ (kg/boat-day) for the commercial Spencer Gulf pot fishing sector from 1997/98 to 2009/10.

4.1.3 Pre-recruits

The catch rate of pre-recruit crabs in Spencer Gulf was highly variable between 1998 and 2009, ranging from 1.2 crabs per potlift in 2001 to 7.0 crabs per potlift in 1998 (Figure 4.10). During 2010, pre-recruit abundance was 3.9 crabs per potlift.

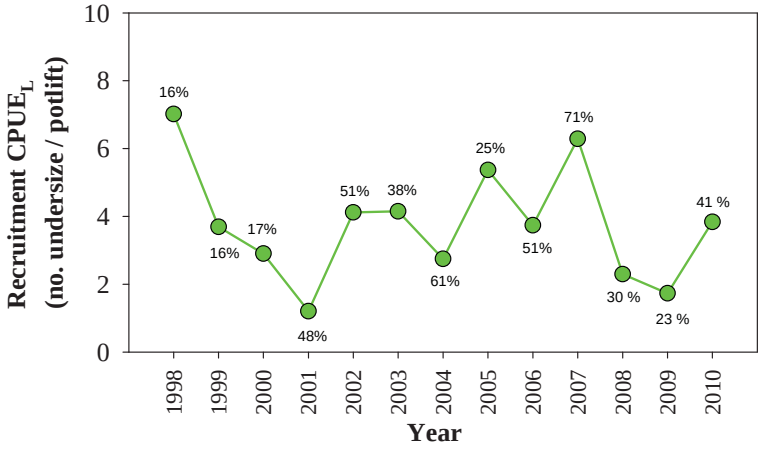


Figure 4.10. Trends in pre-recruit $CPUE_L$ (no./potlift) in Spencer Gulf during June/July from 1998 to 2010. Labels indicate the % of days when pre-recruit data were recorded in logbooks.

4.1.4 Sex-ratio

The weight of male crabs dominated the catch annually (Figure 4.11). Under the assumptions that missing data on daily catch by sex were 1) all male (lower female estimate) and 2) an equal proportion to available data for each month (upper female estimate), the percentage of female crabs in the total annual catch between 1997/98 and 2009/10 varied from 1) 4–18% (annual mean=11%) and 2) 4–29% (mean=19%). Uncertainty in estimates of sex-ratio results from incomplete logbook data.

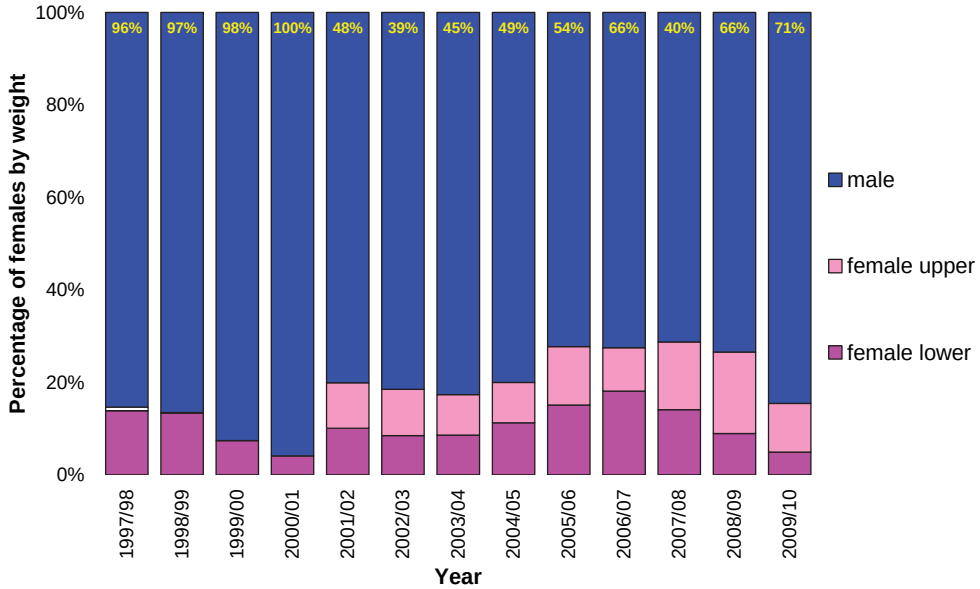


Figure 4.11. The proportion of females (pink bars) and males (blue bars) by weight in Spencer Gulf from commercial logbook data from 1997/98 to 2009/10. Labels indicate the proportion of data upon which estimates were based.

Generally, catches of female crabs were highest between July and November in Spencer Gulf (Figure 4.12). Few female crabs were retained during February, March and April in any year. These differences in the proportion of females in the catch suggest that the timing of capture exerts a strong influence over the proportion of females harvested in any year. For example, during 2006/07 when a high proportion of females were harvested from the annual catch (18–27%, Figure 4.11) very little catch was harvested from February to June.

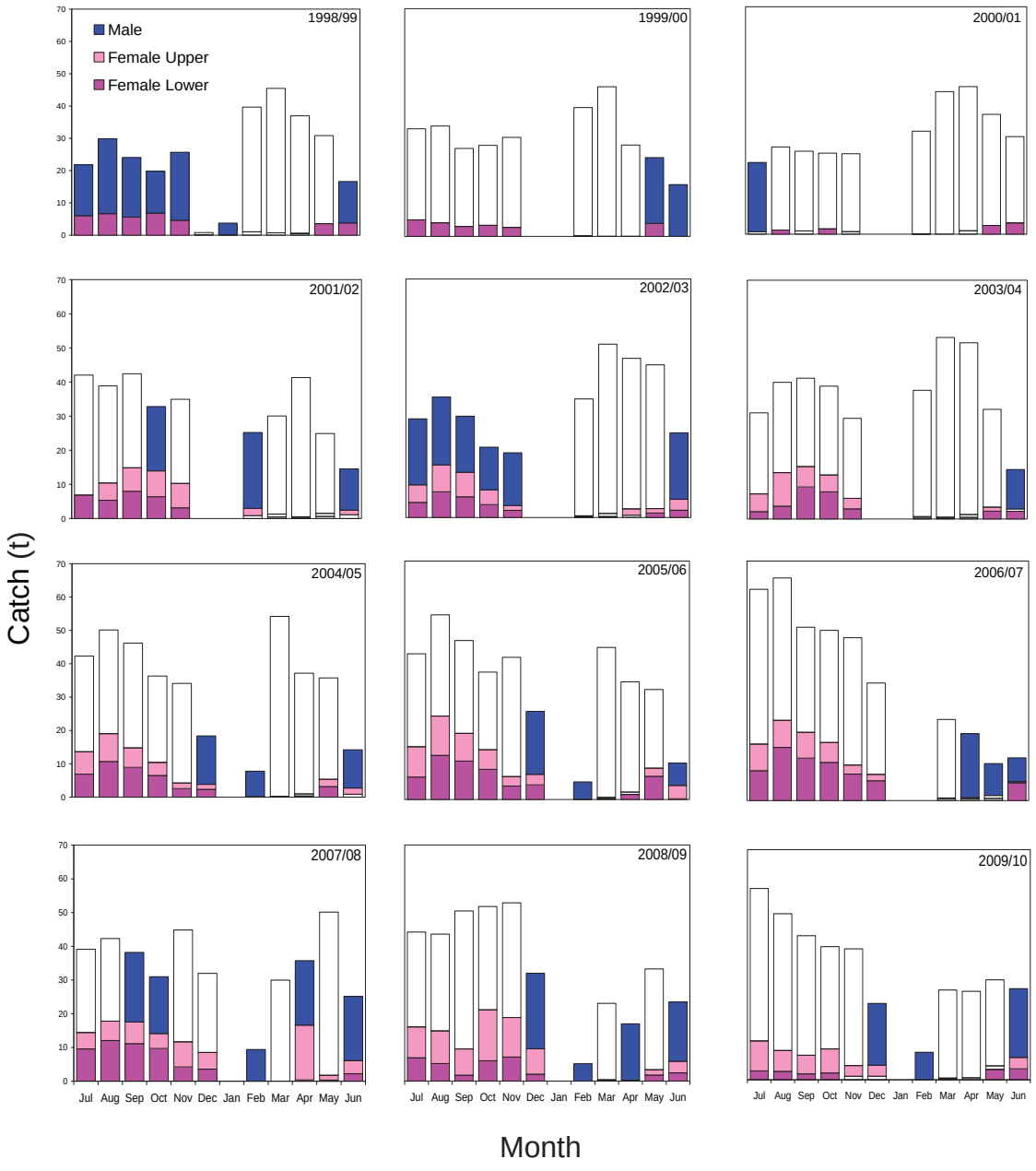


Figure 4.12. Reported monthly catch weights of male (blue) and female (pink) crabs in Spencer Gulf from 1998/99 to 2009/10.

4.2 Pot-sampling data

Pot-sampling since May 2006 has provided information on recruit abundance and sex-ratio throughout the year. Currently, fishers are required to provide data from one small mesh pot per fishing day. As the number of samples collected during 2006 and 2007 was low (Table 4.1), these data were excluded from analyses. Sampling frequency has improved substantially in recent years, with data provided for 71% of days fished during 2010 (up to and including July).

Table 4.1. Statistics on pot-sampling data collected from May 2006 to July 2010.

	2006	2007	2008	2009	2010
Number of licensed fishers	5	5	5	5*	5*
Number of fishers providing data	3	3	4	4	4
Number of boat-days during the sampling period	764	859	971	701	299
Number (and % of total) of boat-days sampled	41 (5%)	39 (5%)	434 (45%)	522 (74%)	212 (71%)
Number (and % of total fished) of blocks sampled	6 (22%)	18 (55%)	28 (72%)	20 (63%)	12 (57%)
Number of crabs measured	845	1267	8527	8748	4355

* One fisher was catching quota from two licences

4.2.1 Pre-recruit abundance

Reliable pot-sampling data have been collected by commercial fishers using small mesh pots since 2008. These data can be used to inform pre-recruit abundance during June and July (Figure 4.13). Pre-recruit catch rate was higher in 2008 (9.9 pre-recruits per potlift) and 2010 (9.3) than 2009 (5.8).

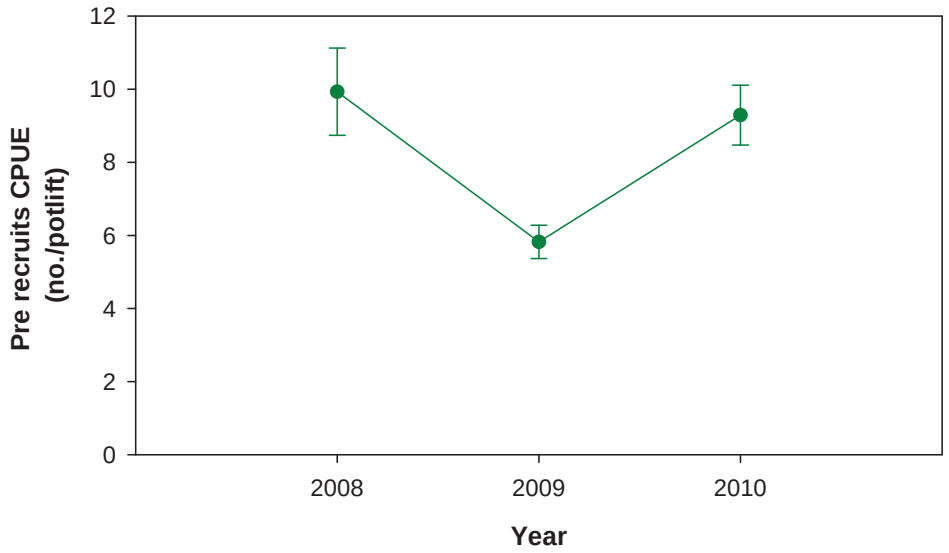


Figure 4.13. Mean (SE) pre-recruit $CPUE_L$ (no./potlift) from pot sampling undertaken in June/July from 2008–2010.

Importantly, pot-sampling data have shown seasonal trends in pre-recruits since 2008, with annual peaks generally occurring in July of each year (Figure 4.14). This has implications for the interpretation of fishery-independent survey data that are usually gathered in June.

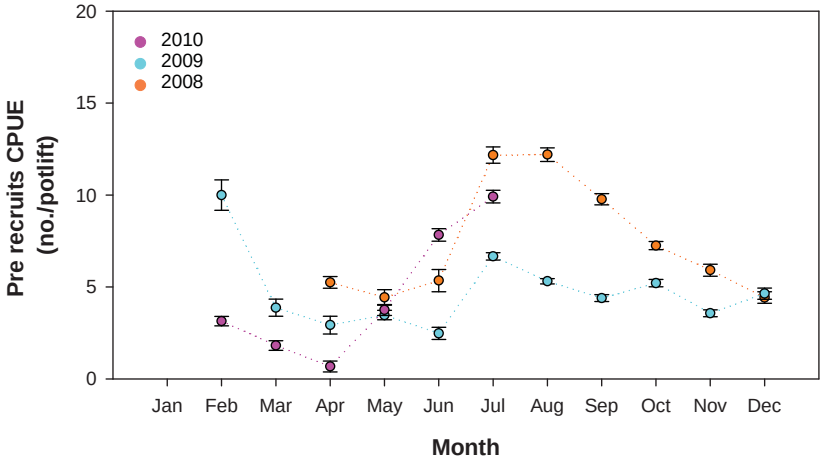


Figure 4.14. Mean (SE) monthly trends in pre-recruit $CPUE_L$ (no./potlift) from 2008 to 2010.

4.2.2 Sex-ratio

Sex-ratio data were available from March 2008 to August 2010 (Figure 4.15). Female crabs were generally captured in high proportion from July to December, sometimes exceeding 50% of the catch by weight. Females were rarely harvested during February and March, with a small proportion captured from April to June.

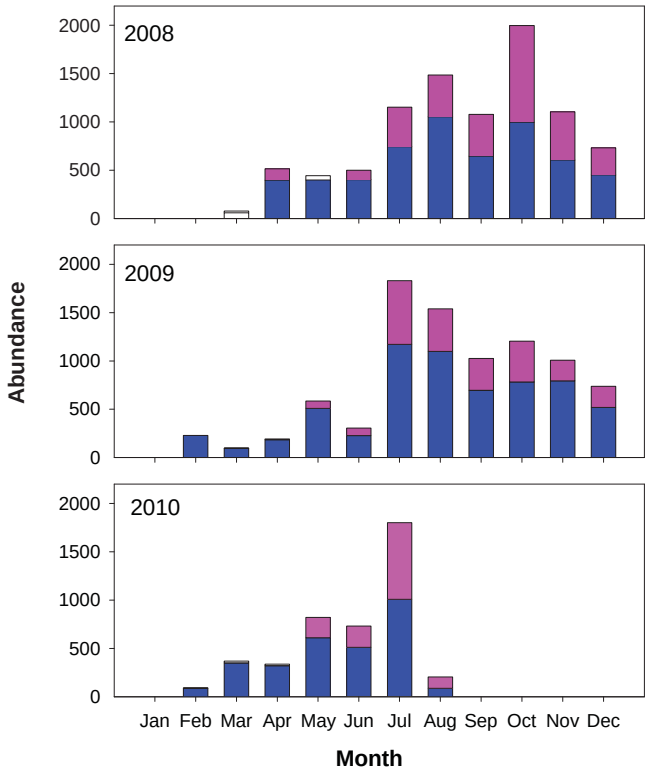


Figure 4.15. Trends in sex-ratio (males-blue, female-pink) from small mesh pots deployed during pot-sampling in Spencer Gulf from 2008 to 2010.

4.3 Fishery-independent surveys

4.3.1 Relative abundance of legal-size

Legal-size abundance in Spencer Gulf was lower for all potlifts combined than for standardised potlifts from 2002 to 2007. The converse was true for all potlifts combined from 2008 to 2010 (Figure 4.16). Standardised abundance was lowest in 2003 (5.1 crabs per potlift), was highest in 2009 (9.0 crabs per potlift) and 2010 (8.9 crabs per potlift).

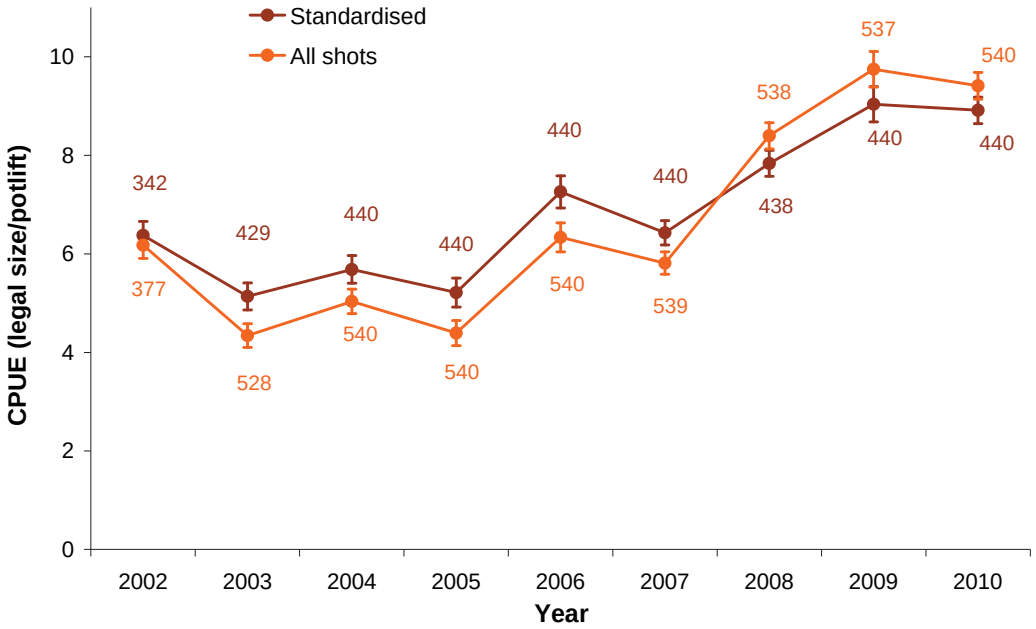


Figure 4.16. Mean (SE) CPUE (crabs/potlift) of legal-size crabs for all potlifts and for standardised potlifts, from fishery-independent surveys conducted in Spencer Gulf between 2002 and 2010. Labels indicate the number of potlifts.

4.3.2 Relative abundance of pre-recruits

Pre-recruit abundance in Spencer Gulf was lower for all potlifts combined than for standardised potlifts in all years but the difference between the two measures was small (Figure 4.17). Standardised abundance generally declined from 2002 (6.9 crabs per potlift) to 2005 (2.3 crabs per potlift) and then increased rapidly to its highest level in 2007 (10.1 crabs per potlift). Standardised abundance declined during 2008 and 2009 but increased substantially during 2010 (7.9 crabs per potlift) and was the second highest recorded.

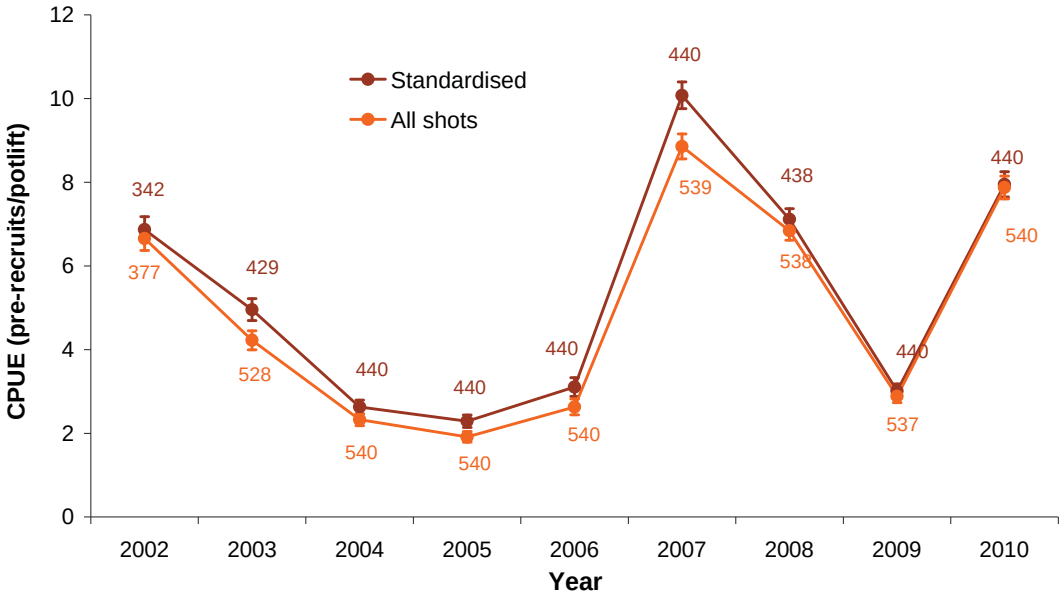


Figure 4.17. Mean (SE) CPUE (crabs/potlift) of pre-recruit crabs for all potlifts and for standardised potlifts, from fishery-independent surveys conducted in Spencer Gulf between 2002 and 2010. Labels indicate the number of potlifts.

4.3.3 Spatial distribution of legal-size

Legal-size crabs were broadly distributed throughout the surveyed region in most years (Figure 4.18). Very high abundance (>10 crabs per potlift) was observed most consistently in Block 3 in upper Spencer Gulf (in 8 of 9 years), and sporadically in several other blocks throughout the survey period (Blocks 4, 7, 11, 12, 14, 15, 18, 23, 24, 26, 28, and 31). High or very high abundance (>5 crabs per potlift) was observed during all years in Blocks 3, 4, 11, 12, 14, 24 and 25.

Abundance tended to be lowest (<2 crabs per potlift) on the western shoreline of Spencer Gulf in Blocks 9, 13, 22 and 33. Abundance was also low in Block 28 in every year except 2003, 2009 and 2010. New survey blocks north of Point Lowly and adjacent to Cowell showed very high and high abundance of legal-size crabs during 2010, respectively.

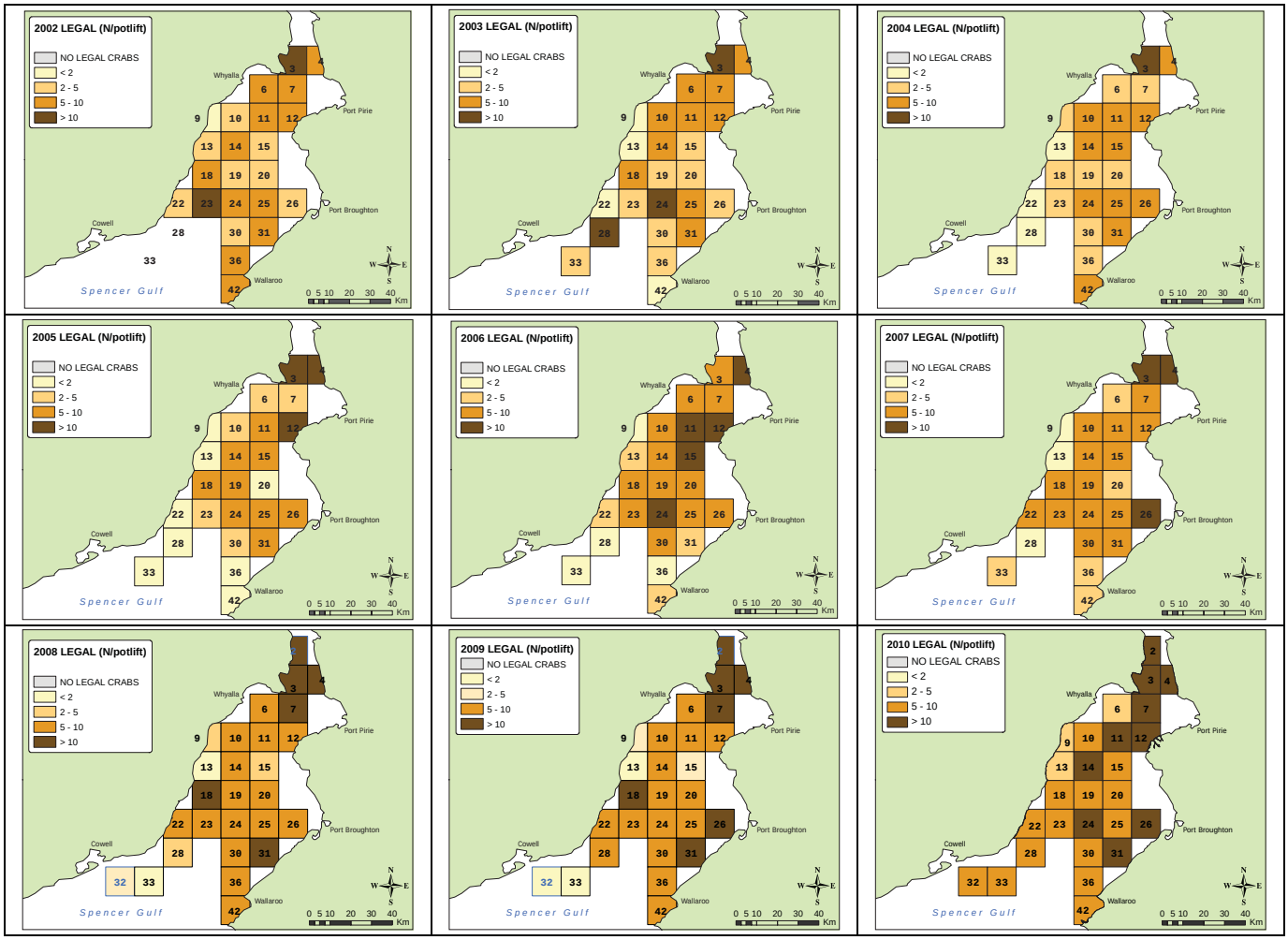


Figure 4.18. Spatial distribution of legal-size abundance (CPUE) from standardised potlifts during fishery-independent surveys conducted in Spencer Gulf during June or July from 2002 to 2010. Note: 2008 - 2010 maps also include new blocks surveyed (2 and 32).

4.3.4 Spatial distribution of pre-recruits

The abundance of pre-recruit crabs was spatially and temporally variable (Figure 4.19). Nevertheless, pre-recruit crabs were broadly distributed throughout the surveyed region and there was a general trend of decreasing abundance from north to south during most years with the exception of 2010, when abundances of juvenile crabs were highest in several southern blocks.

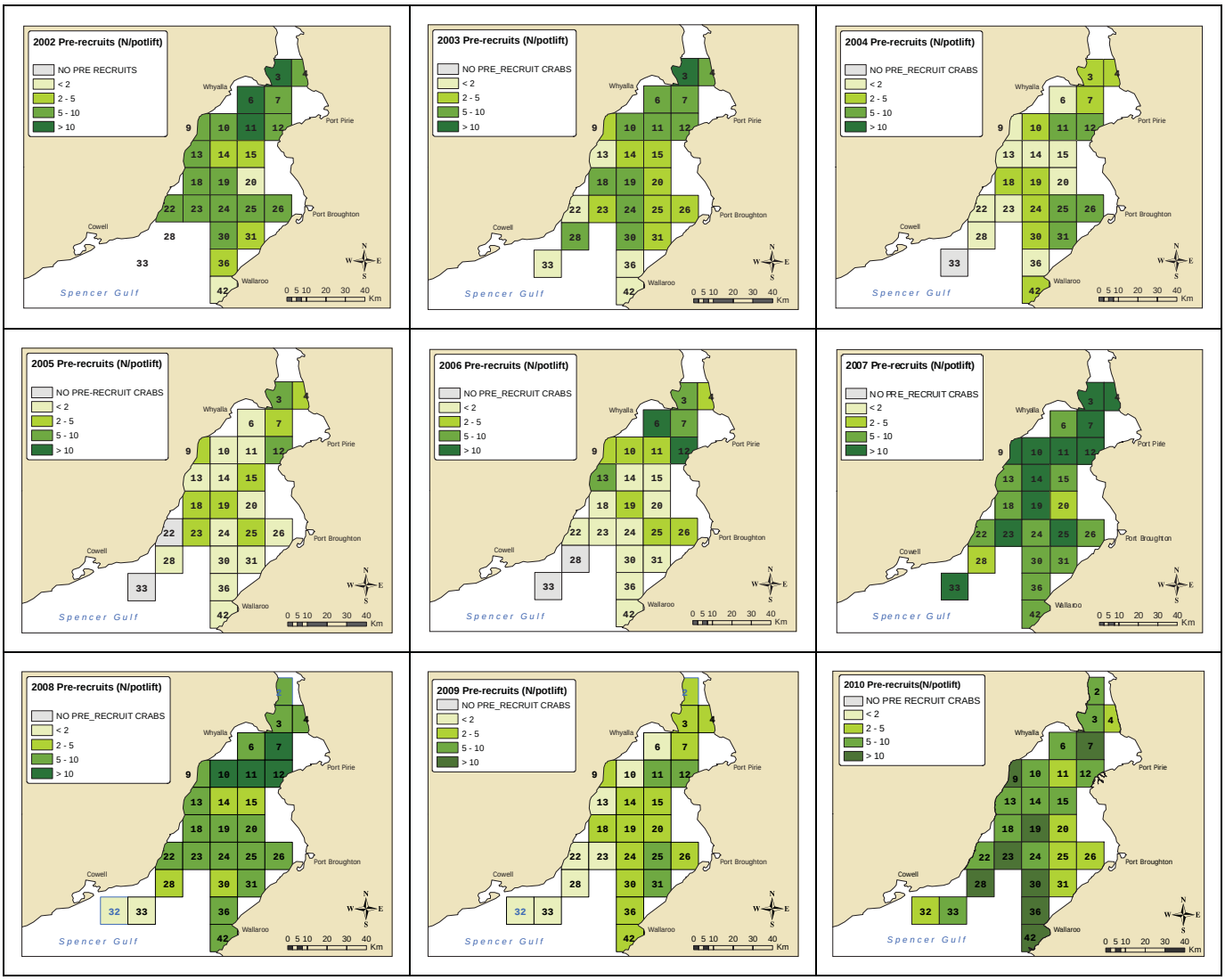


Figure 4.19. Spatial distribution of pre-recruit abundance (CPUE) from standardised potlifts during fishery-independent surveys conducted in Spencer Gulf during June or July from 2002 to 2010. Note: 2008 - 2010 maps also include new blocks surveyed (2 and 32).

4.3.5 Crab size

The size-frequency distribution of surveyed crabs varied substantially among years in Spencer Gulf (Figure 4.20). The modal size of crabs was 100–109 mm in 2002 and 2007, 110–119 mm in 2003, 2004, 2008 and 2009, and 120–129 mm in 2005, 2006 and 2010. The abundance of very large crabs (>130 mm) was clearly highest during 2006. During the same year there was also a relatively high abundance of very small crabs (<79 mm), with an apparent bi-modal distribution suggesting a large recruitment event. Further evidence of this recruitment was apparent in the following year (2007), with high abundances of crabs just below the size limit (90–109 mm).

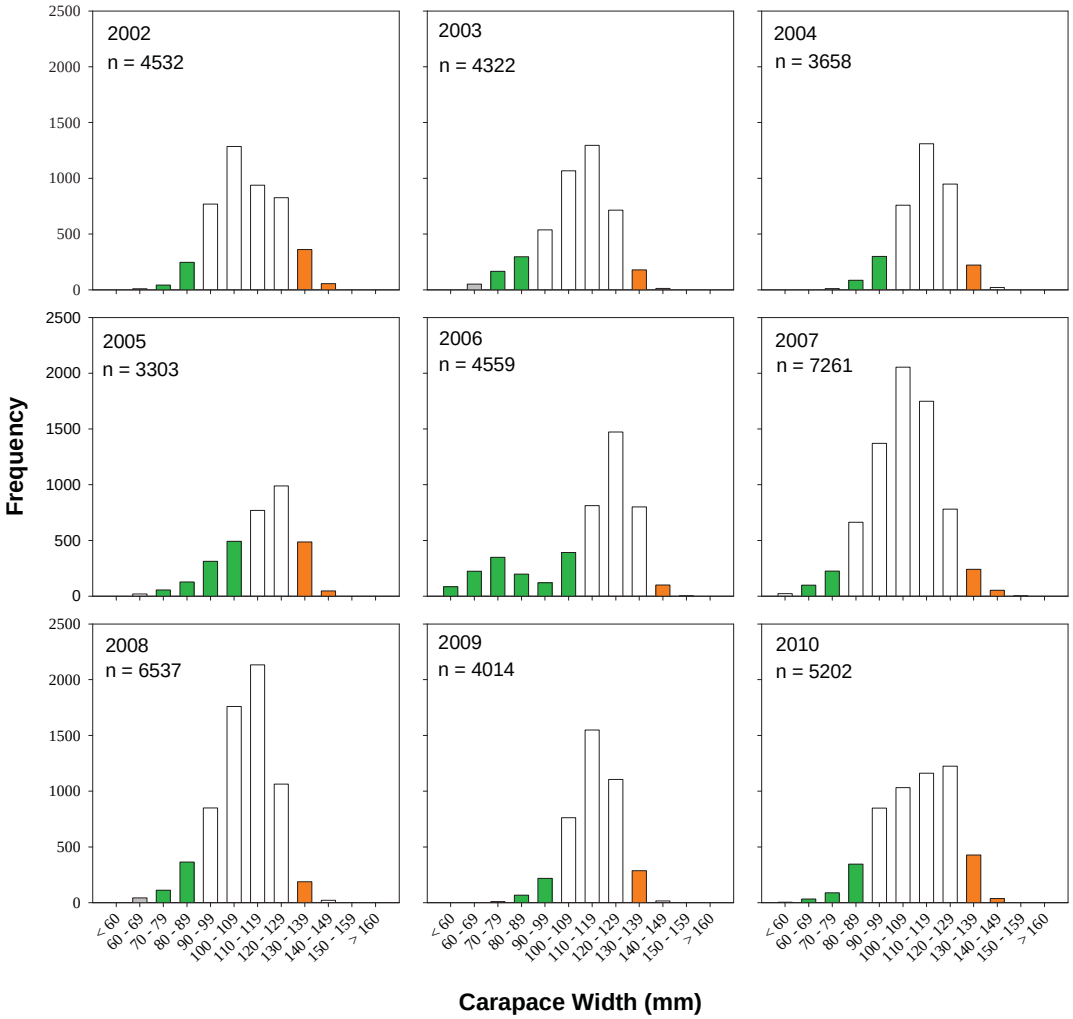


Figure 4.20. Size-frequency distributions of crabs caught in small mesh pots during surveys conducted in Spencer Gulf from 2002 to 2010. Green bars denote pre-recruits, orange bars denote legal-size. Note, 30% less pots were surveyed during 2002.

4.4 Discussion

Assessment of the Spencer Gulf pot fishing sector is based on fishery-independent survey data and fishery-dependent data from commercial logbooks and a pot-sampling program. All available data indicate that the biomass upon which the fishery is based is currently in a strong position.

Legal-size abundance from fishery-independent surveys during 2009 and 2010 were the highest levels recorded. Size-frequency data from surveys indicate that a high proportion of the population is comprised of large crabs greater than 120 mm CL. These high abundances of large crabs were distributed throughout northern and southern fishing blocks, continuing the recent trend of an increasing abundance and range toward the southern extent of the fishery.

Pre-recruit abundance from fishery-independent surveys during 2010 was the second highest recorded and was well above the long-term average abundance. High abundances of pre-recruit crabs were also distributed throughout the Gulf, and for the first time abundances of pre-recruits were generally higher in southern fishing blocks compared to the north. While the reasons for the shift in distribution of pre-recruit and legal-size blue crabs are not well understood, this may be influenced by changes in water temperature and or salinity associated with climate change. Trends in pre-recruit abundance from commercial logbooks and pot-sampling during 2009/10 support the increasing trends observed during surveys.

Since 1996/97, total catch from the Spencer Gulf pot fishing sector has increased by ~100 t and in 2009/10 99.9% of the quota was harvested. In the first years after quota introduction, most of the catch was harvested from the northernmost parts of the Gulf. However, in recent years substantial catches have been harvested as far south as Cowell and Wallaroo, reflective of the changes in observed distribution of the surveyed population.

Effort in boat-days and potlifts was lower during 2009/10 than the previous year and this resulted in an increase in commercial $CPUE_L$ (catch per potlift). During 2009/10, $CPUE_L$ from second potlifts was higher than $CPUE_L$ from first potlifts, which was the first time this has occurred for the fishery. The higher $CPUE_L$ also resulted in the highest average daily catch for the fishery since quota was introduced. Finally, monthly $CPUE_L$ peaked in June 2010 (at the end of the quota season) for the first

time for the fishery, which may suggest that legal sized crabs were more abundant on the fishing grounds at the end of the quota period than for the same time in previous years.

Fishery dependent data from commercial logbooks and pot-sampling provide good agreement on the trends in proportion of females caught throughout the year. In general, catches of female crabs are lowest from February to April and highest from July to December. Thus, changes in the temporal distribution of catch should be monitored as this will likely affect the proportion of female crabs caught in a quota year. Of note, despite the high proportion of catch harvested from July to December in 2009/10, the overall proportion of females harvested was much lower than most previous years. The reasons for the lower proportions of females in the catch during 2009/10 are not well understood.

In summary, all sources of available data indicate that adult biomass of blue crabs in Spencer Gulf is currently in its strongest position since the introduction of quota. This includes data from fishery-independent survey and commercial catch and effort (CPUE). All measures of pre-recruit abundance indicate that recruitment to the fishery in the immediate future is likely to be strong, which should maintain the positive outlook for the fishery. It should be noted that under the rules of the proposed Management Plan a fishery-independent survey will not be required in Spencer Gulf during June/July 2010. Given the strong position of the resource and the stability in quota, this decision is unlikely to compromise assessment of the sustainability for the fishery for the 2010/11 quota period.

5 GULF ST VINCENT POT FISHING SECTOR

5.1 Commercial logbook data

5.1.1 Catch and Effort

5.1.1.1 Annual catch and effort

The Gulf St Vincent pot fishing sector in 2009/10 held 241.9 t of the 626.8 t TACC (source: PIRSA Fisheries) of which 158.5 t (65.5%) was landed (Figure 5.1). The annual catch was similar to that obtained from 1998/99 to 2001/02 but was lower than all years from 2002/03 to 2008/09.

During the first six years following the implementation of quota, the number of boat-days remained relatively constant (Figure 5.1). Boat-days increased sharply when a new licence was issued in 2002/03 and was stable thereafter until 2007/08, despite the introduction of a new licence in 2007/08. The number of boat-days fished was substantially lower in 2008/09 (471) and 2009/10 (466). While the number of pot lifts followed a similar trend to boat-days from 1997/98 to 2004/05, there has been an increasing trend in the number of potlifts relative to boat-days thereafter. In 2009/10 there were 66,435 pot lifts, a 1% increase compared to 2008/09. While total potlift effort was similar during the last two years, the distribution of effort among fishers varied considerably, with 88% of total boat-days being shared among two of the three fishers. Second potlift effort also decreased between years (20% in 2008/09, 8% in 2009/10).

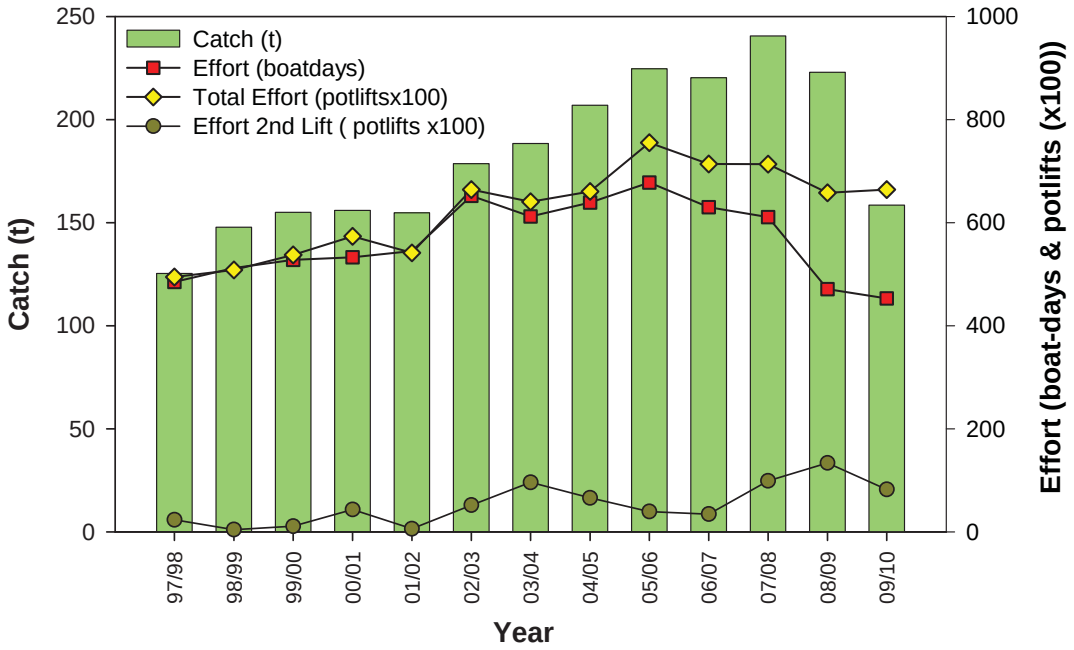


Figure 5.1. Total catch (t) and effort (boat-days, total potlifts and second potlifts) for the pot fishing sector in Gulf St Vincent from 1997/98 to 2009/10.

5.1.1.2 Spatial distribution of the annual catch

The spatial distribution of commercial catch has changed since 1997/98 (Figure 5.2, Figure 5.3). There were two licences for the first five years of quota and during this period the number of blocks fished and the amount of catch harvested from these blocks were similar (Figure 5.2). The introduction of a new licence in 2002/03 coincided with an increase in the number of blocks fished, particularly those with low catch. Trends in the number of fished blocks stabilised thereafter until the introduction of another new licence in 2007/08, when the number of blocks with >20 t harvested was doubled. In 2008/09 and 2009/10, there was a substantial increase in the number of blocks fished, particularly those of low catch. This likely reflects the generally lower abundance of crabs observed for this period (see pot-sampling and fishery-independent survey data).

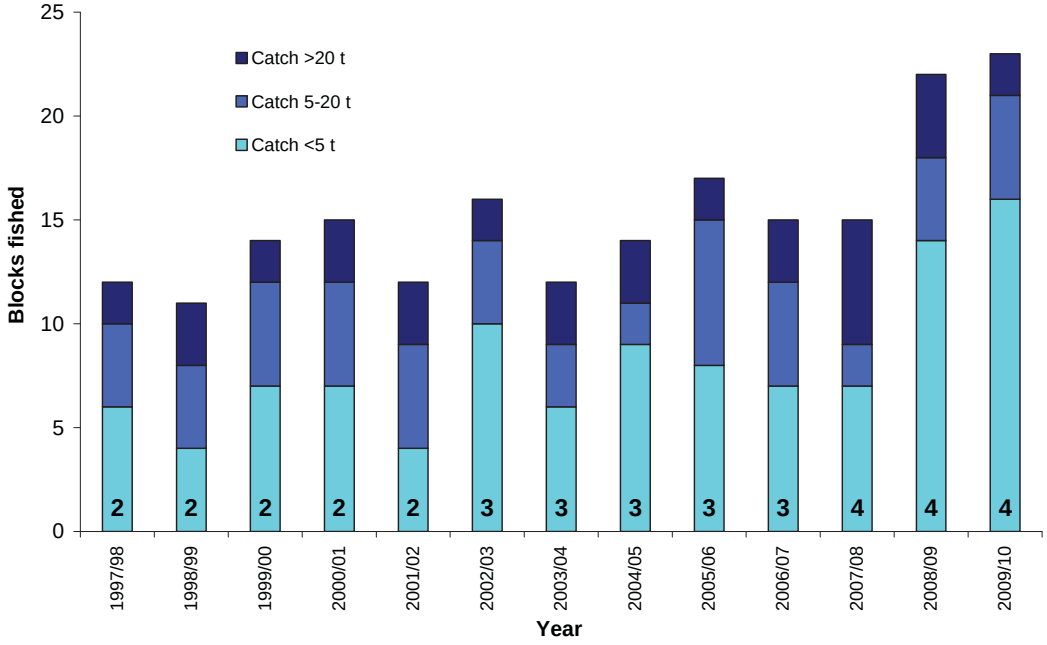


Figure 5.2. The number of blocks fished in Gulf St Vincent with catches of <5 t, 5–20 t and >20 t harvested from 1997/98 to 2009/10. Labels indicate number of licences.

Generally, most of the catch has been harvested from fishing blocks adjacent to the western shoreline between Ardrossan and Port Vincent and from fishing blocks immediately to the north and south of Port Adelaide on the eastern shoreline of GSV. From 1997/98 to 2001/02, catches were generally equally distributed between both shorelines. Since 2002/03, the majority of catch has been harvested from fishing blocks near to Port Adelaide. During the last 13 seasons there has been a general trend of increasing catches from blocks north of Port Adelaide to blocks south of Port Adelaide. When combined with the spatial assessment of CPUE data (see Figure 5.6) this trend is likely to reflect a southward shift in the distribution and abundance of blue crabs in GSV.

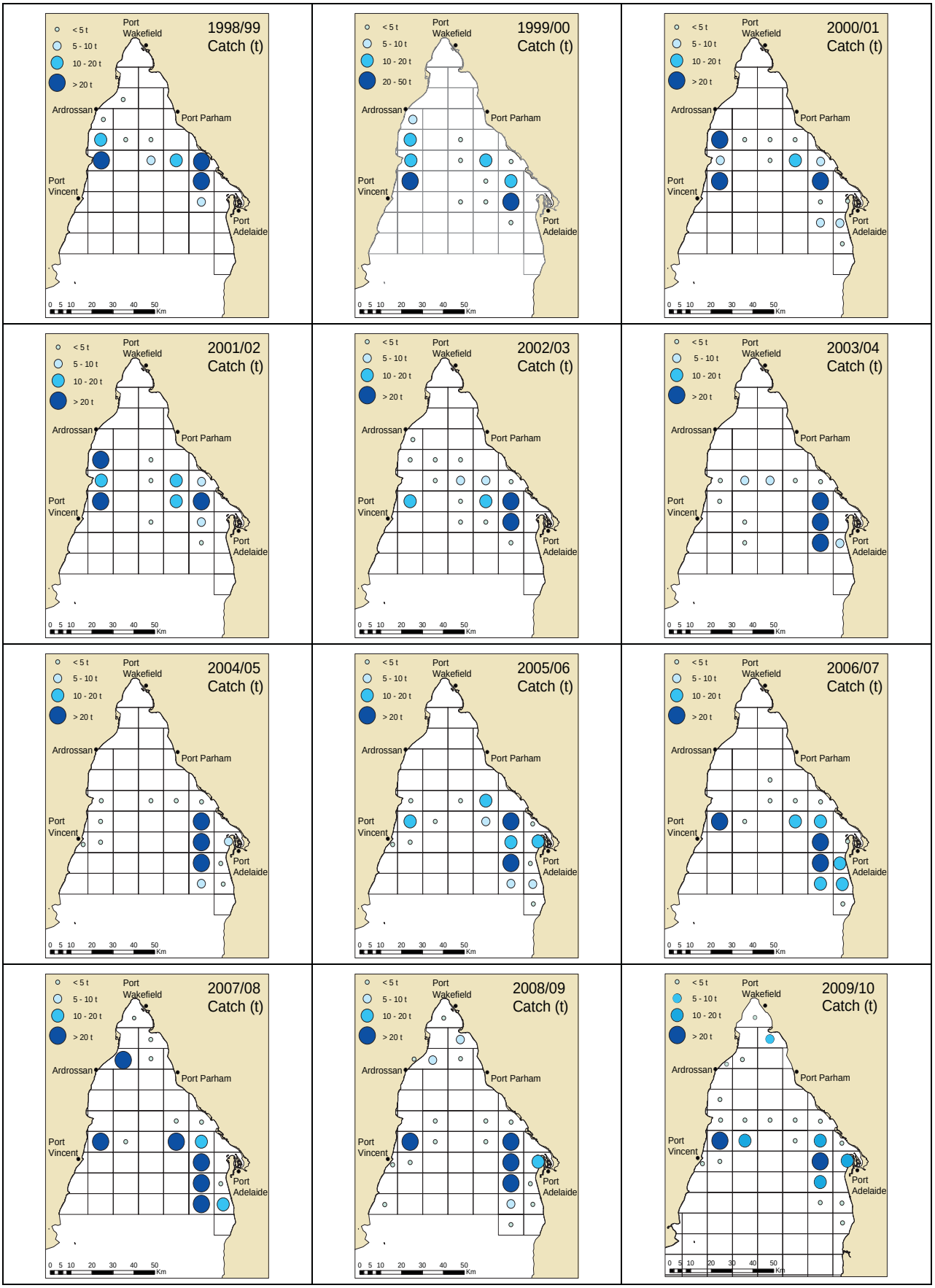


Figure 5.3. Spatial distribution of commercial catch for the Gulf St Vincent pot fishing sector from 1998/99 to 2009/10.

5.1.1.3 Monthly catch and effort

The commercial pot fishing sector in GSV is closed between November 1 and January 15. Since 1997/98, catch and effort between July and October has ranged from 5–30 t and 2,000 to 8,000 potlifts, respectively, each month (Figure 5.4). Catch and effort was more variable among years for the period between January and June. Generally, peak catches were harvested during February, with declining monthly catches thereafter. While total monthly catches were lower for most months during 2009/10 compared to recent years, the lowest relative catches were clearly from February to April which is a period when the majority of commercial catch has been harvested in recent years. It should be noted that from January to June one of the three fishers in GSV fished <30% of available days.

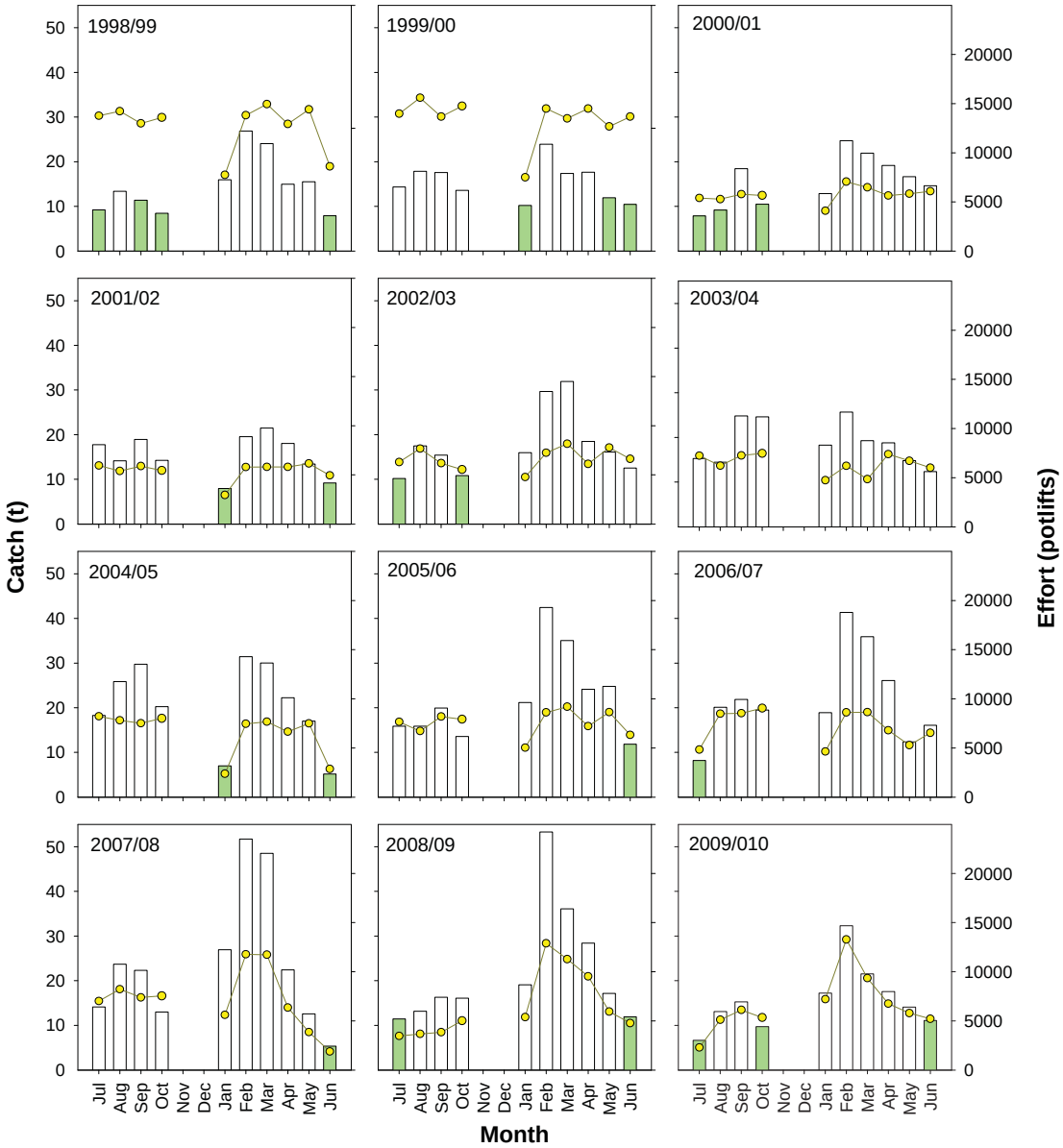


Figure 5.4. Monthly catch (t) and effort (potlifts) for the Gulf St Vincent pot fishing sector from 1998/99 to 2009/10.

5.1.2 Catch per unit effort

5.1.2.1 Mean annual $CPUE_L$

Mean annual $CPUE_L$ for the Gulf St Vincent pot fishing sector generally increased from 1997/98 to 2008/09 (Figure 5.5), ranging from 2.54 kg/potlift (1997/98) to 3.33 kg/potlift (2007/08). Mean annual $CPUE_L$ declined by 26% to 2.44 kg/potlift in 2009/10 which was the lowest observed for the fishery.

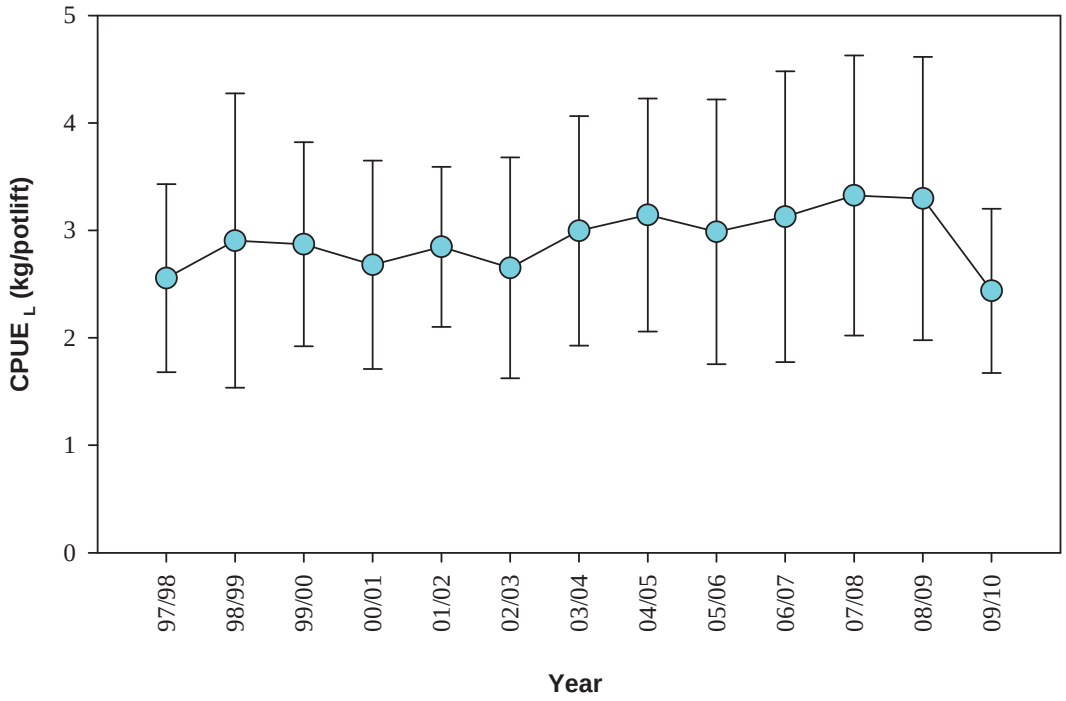


Figure 5.5. Mean (SD) annual $CPUE_L$ (kg/potlift) in the commercial Gulf St Vincent pot fishing sector from 1997/98 to 2009/10.

5.1.2.2 Spatial distribution of mean annual $CPUE_L$

$CPUE_L$ was spatially and temporally variable in Gulf St Vincent from 1997/98 to 2009/10 (Figure 5.6). In general, catch rates were higher near Port Adelaide than on the western shoreline between Ardrossan and Port Vincent in most years. However, during 2009/10 moderate catch rates (2–3 kg/potlift) were reported from most fished blocks throughout GSV. During the survey period, $CPUE_L$ data show a progression of increasing catch rates to the south of Port Adelaide, supporting the hypothesis that the distribution and abundance of blue crabs has moved toward the south during the last 13 years.

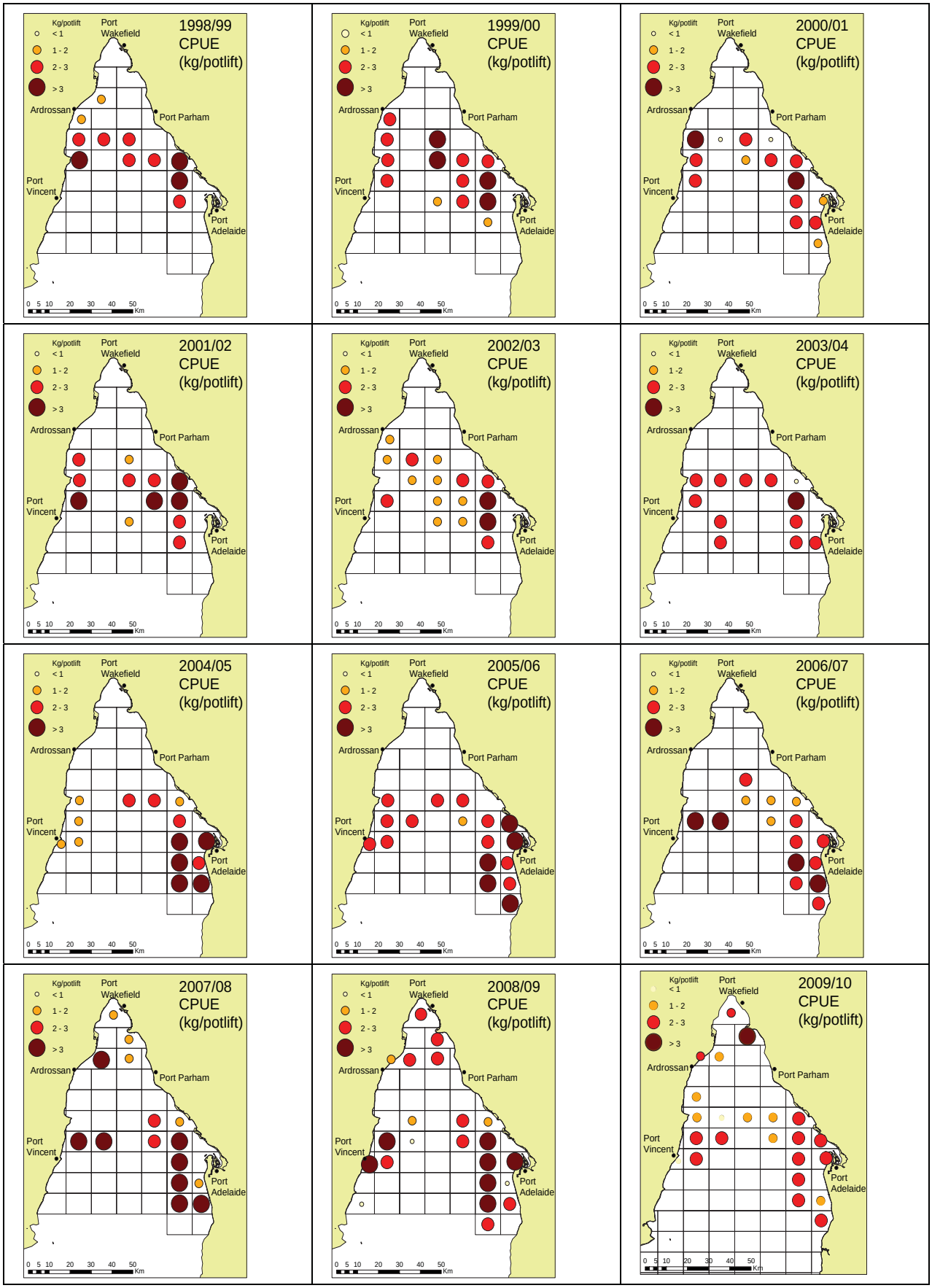


Figure 5.6. Spatial distribution of commercial CPUE for the Gulf St Vincent pot fishing sector from 1998/99 to 2009/10.

5.1.2.3 Mean annual $CPUE_L$ for first and second pot lifts

Mean annual first potlift $CPUE_{L(f)}$ was greater than that for the second potlift ($CPUE_{L(S)}$) in all years except 2002/03 (Figure 5.7). While the difference is primarily due to the difference in soak time (generally 19–20 hours first lift and 4–5 hours second lift), second potlifts have a much higher $CPUE_L$ per hour of soak time. From 2004/05 to 2008/09, trends in mean annual $CPUE_{L(F)}$ and $CPUE_{L(S)}$ were relatively stable. During 2009/10, CPUE decreased substantially for both first and second potlifts. It is difficult to interpret trends among first and second potlifts in GSV as there were few second potlifts attempted in most years.

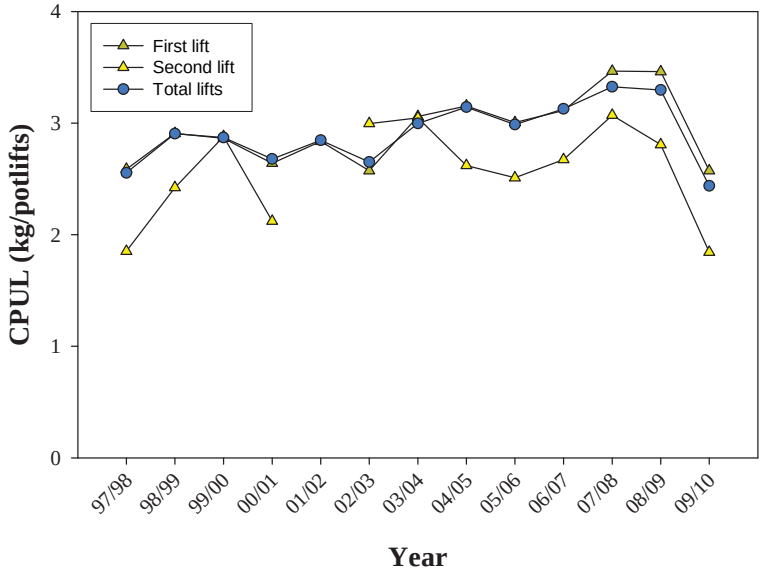


Figure 5.7. Mean $CPUE_L$ (kg/potlift) in the Gulf St Vincent pot fishing sector for first potlifts, second potlifts and total potlifts from 1997/98 to 2009/10.

5.1.2.4 Mean monthly $CPUE_L$

In most years, $CPUE_L$ was low at the start of the quota period (July), increased until September and declined rapidly prior to the closure in November (Figure 5.8). $CPUE_L$ increased substantially after the closure (January), was highest during February and then declined continuously until the end of the quota year (June). However, in 2009/10 $CPUE_L$ was generally low throughout the year, ranging from 1.8 kg/potlift in October to 3.5 kg/potlift in July. $CPUE_L$ was low but stable from January to June 2010.

5.1.2.5 Mean daily catch $CPUE_D$

Mean daily catch ($CPUE_D$) increased from 259 kg/day in 1997/98 to 473 kg/day in 2008/09 but decreased in 2009/10 to 350 kg/day (Figure 5.9). The increase in standard deviation of the mean (SD) in 2007/08 and 2008/09 indicates that daily catches became more variable and maximum daily catches higher. It should be noted that the mean and SD of the daily catch in 2009/10 was similar to that obtained during 2006/07 (and prior).

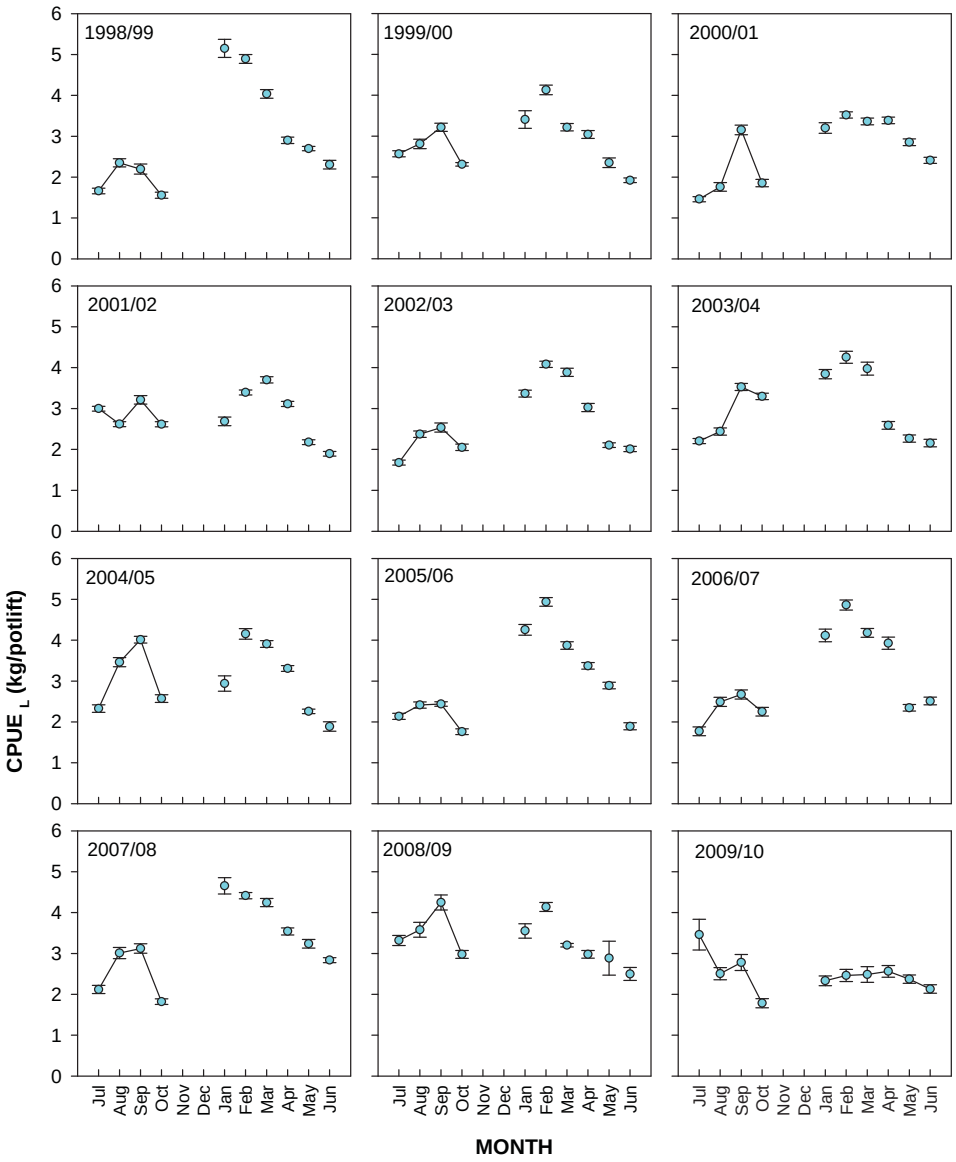


Figure 5.8. Mean (SE) monthly $CPUE_L$ (kg/potlift) for Gulf St Vincent from 1998/99 - 2009/10.

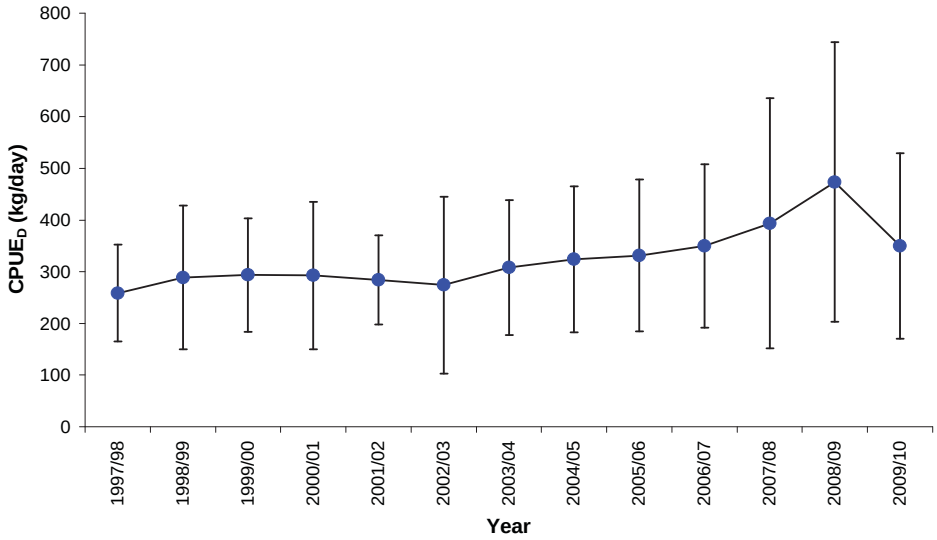


Figure 5.9. Mean (SD) $CPUE_D$ (kg/boat-day) for the commercial Gulf St Vincent pot fishing sector from 1997/98 to 2009/10.

5.1.3 Pre-recruits

The catch rate of pre-recruit crabs in GSV was high during 1998 (5.3 crabs per potlift) and then ranged from 0.3–3.8 crabs per potlift from 1999– to 2009 (Figure 5.10). During 2010 pre-recruit abundance was the highest recorded (12.1 crabs per potlift).

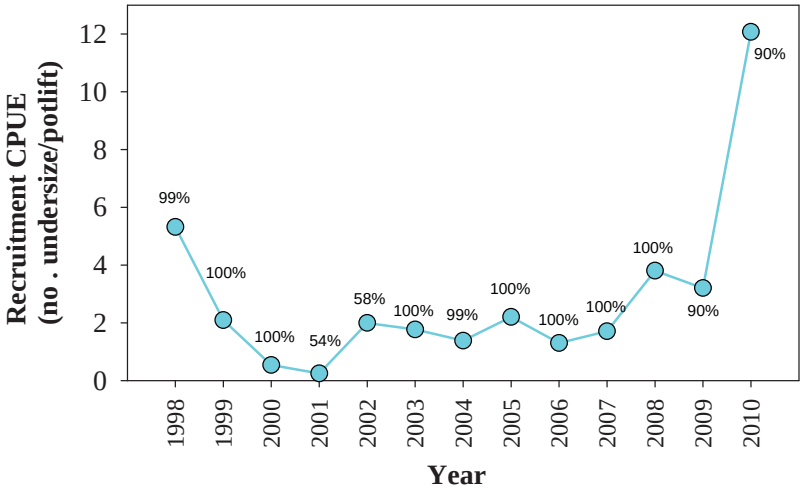


Figure 5.10. Trends in pre-recruit $CPUE_L$ (no./potlift) in Gulf St Vincent during June/July from 1998 to 2010. Labels indicate the % of days where pre-recruit data were recorded.

5.1.4 Sex-ratio

The weight of male crabs dominated the catch annually (Figure 5.11). Under the assumptions that missing data on daily catch by sex were 1) all male (lower female estimate) and 2) an equal proportion to available data for each month (upper female estimate), the percentage of female crabs in the total annual catch between 1997/98 and 2009/10 varied from 1) 5–22% (annual mean=14%) and 2) 8–29% (mean=17%). Uncertainty in estimates of sex-ratio results from incomplete logbook data.

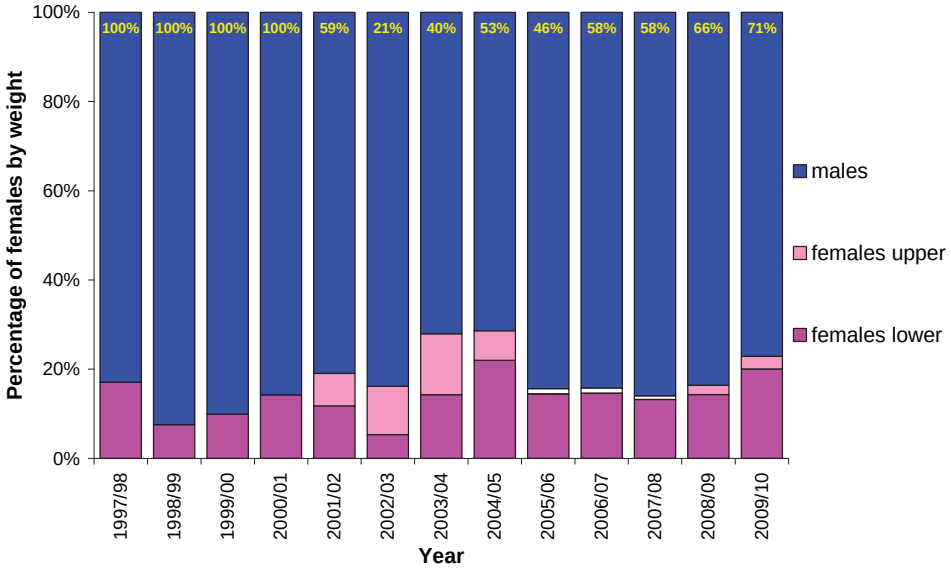


Figure 5.11. The proportion of females (pink bars) and males (blue bars) by weight in Gulf St Vincent from commercial logbook data from 1997/98 to 2009/10. Labels indicate the proportion of data upon which estimates were based.

Generally, catches of female crabs were highest between May and October in Gulf St Vincent (Figure 5.12). Few female crabs were retained from January to April in any year. Like Spencer Gulf, the timing of capture exerts a strong influence over the proportion of females harvested in any year.

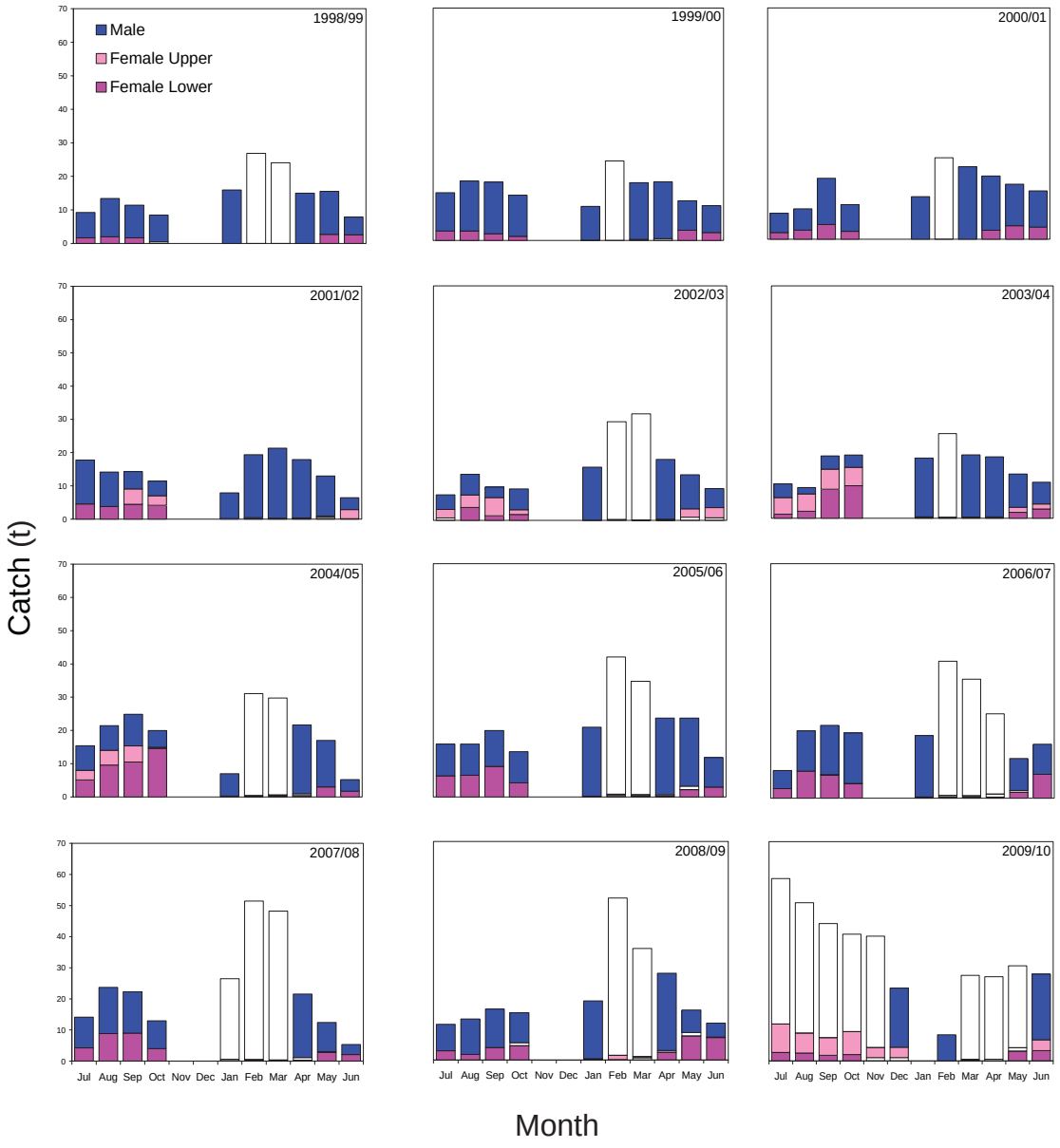


Figure 5.12. Reported monthly catch weights of male (blue) and female (pink) crabs in Gulf St Vincent from 1998/99 to 2009/10.

5.2 Pot-sampling data

Pot-sampling data, collected since July 2006, provide information on recruit abundance and sex-ratio throughout the fishing season. Currently, fishers are required to provide data from one small mesh pot per fishing day. As the number of samples collected during 2006 and 2007 was low (Table 5.1) these data were excluded from analyses. Sampling frequency has improved substantially in recent years, with data provided for 81% of days fished during 2010 (up to and including July).

Table 5.1. Statistics on pot-sampling data collected from July 2006–July 2010.

	2006	2007	2008	2009	2010
Number of licensed fishers	3	3	3	4*	4*
Number of fishers providing data	1	3	3	3	3
Number of boat-days during the sampling period	259	640	443	496	332
Number (and % of total) of boat-days sampled	13 (5%)	35 (5%)	169 (38%)	330 (67%)	270 (81%)
Number (and % of total fished) of blocks sampled	3 (23%)	8 (53%)	10 (71%)	14 (61%)	16 (73%)
Number of crabs measured from small mesh pots	336	789	3485	5473	5369

* One fisher was catching quota from two licences

5.2.1 Pre-recruit abundance

Pot-sampling data are used to inform pre-recruit abundance during the peak recruitment period (June/July, Figure 5.13). Pre-recruit catch rate was higher in 2008 (11.6 pre-recruits per potlift) than 2009 (7.1) and 2010 (8.0).

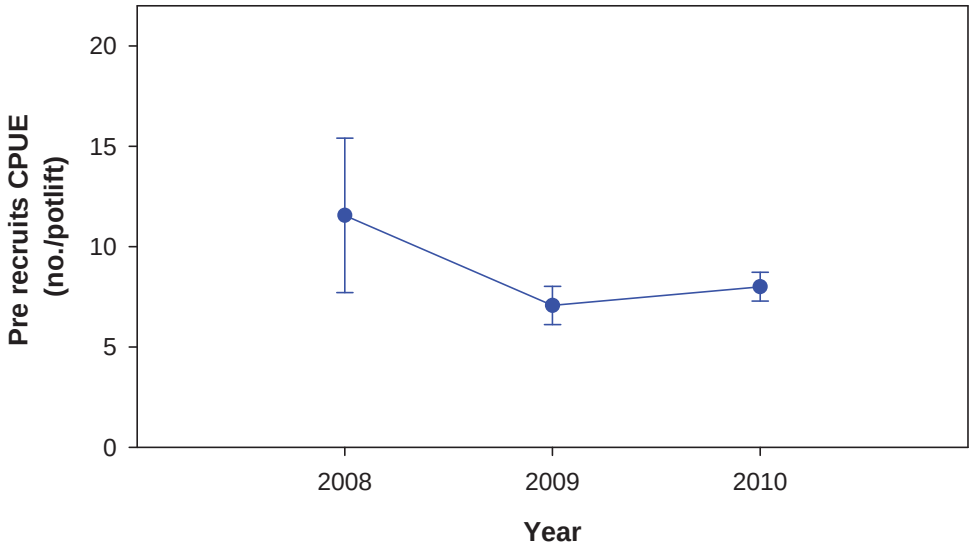


Figure 5.13. Mean (SE) pre-recruit $CPUE_L$ (no./potlift SE)) from pot-sampling undertaken in June and July from 2008–2010.

Monthly pre-recruit estimates were variable among years (Figure 5.14). During 2008 pre-recruit abundance was highest from July to October. Trends in pre-recruit abundance were similar from March to July during 2009 and 2010, with relatively high abundances occurring during June in each year.

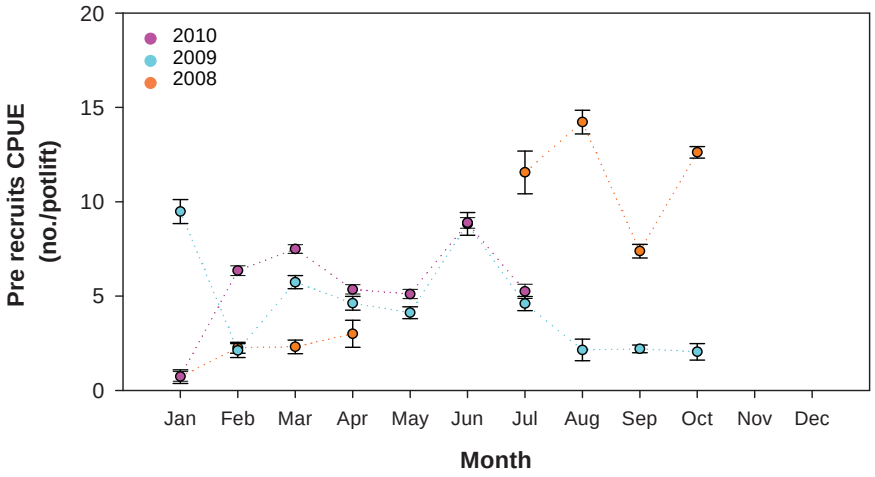


Figure 5.14. Mean (SE) monthly trends in pre-recruit $CPUE_L$ (no./potlift) since July 2007.

5.2.2 Sex-ratio

Sex-ratio data from pot-sampling were available for most months between July 2006 and July 2009 (Figure 5.15). Female crabs were rarely captured from January to March but their proportion increased during May to October and approached 50% of the catch by number on some occasions.

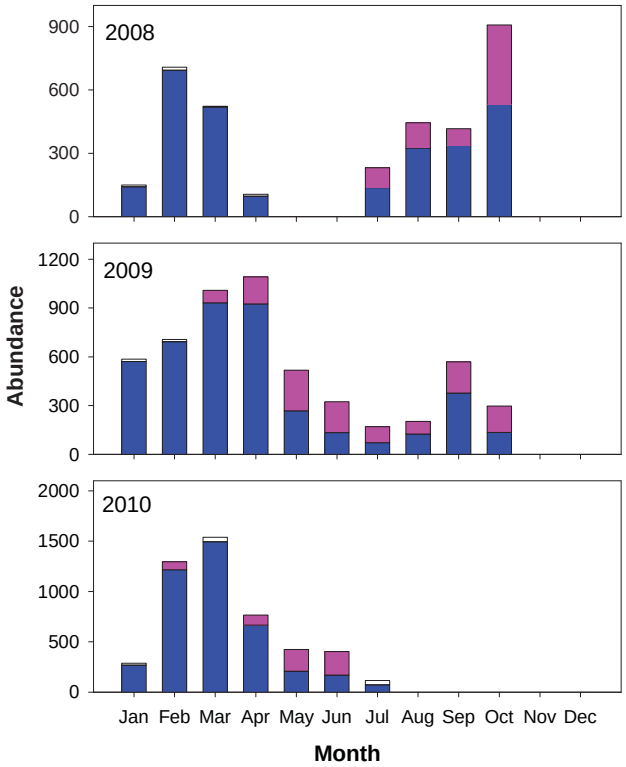


Figure 5.15. Trends in sex-ratio (males-blue, female-pink) from small mesh pots deployed during pot-sampling in Gulf St Vincent from 2008–2010.

5.3 Fishery-independent surveys

5.3.1 Relative abundance of legal-size

Legal-size abundance in GSV was lower for all potlifts combined than for standardised potlifts in all years (Figure 5.16). Standardised abundance was lowest in 2004 (1.6 crabs per potlift) and highest in 2006 (4.7 crabs per potlift). Abundance declined consecutively from 2006 to 2009 (2.2 crabs per potlift) but increased in 2010 to 3.1 crabs per potlift which approximates the long-term average (3.2 crabs per potlift).

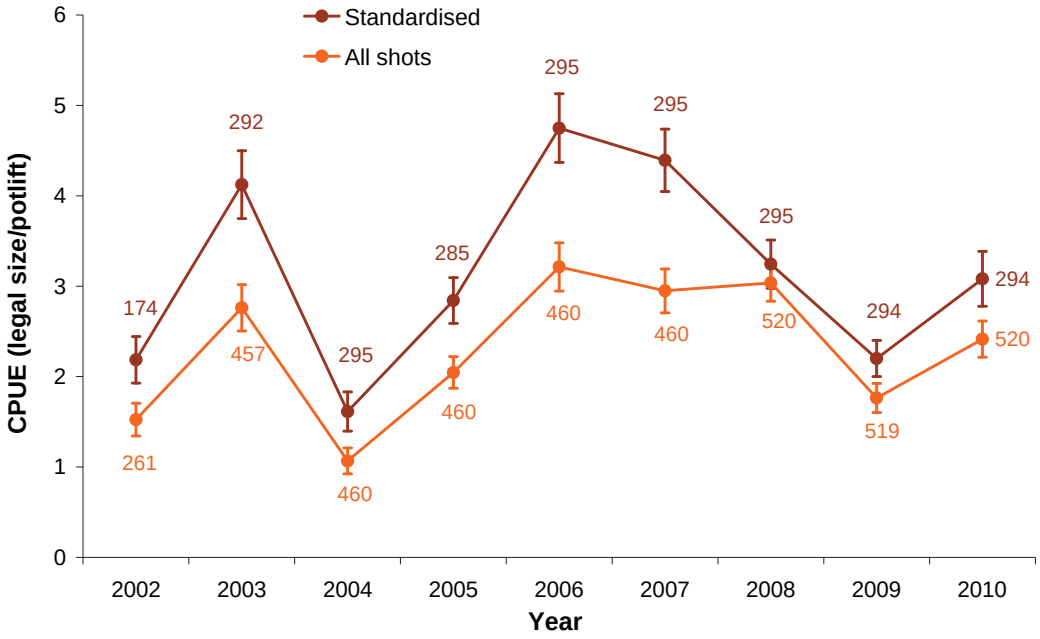


Figure 5.16. Mean (SE) CPUE (crabs/potlift) of legal-size crabs for all potlifts and for standardised potlifts, from fishery-independent surveys conducted in Gulf St Vincent between 2002 and 2010. Labels indicate the number of potlifts.

5.3.2 Relative abundance of pre-recruits

Pre-recruit abundance in GSV was lower for all potlifts combined than for standardised potlifts in all years (Figure 5.17). Standardised abundance was lowest in 2004 (0.4 crabs per potlift) and highest in 2006 (10.7 crabs per potlift). As with legal size abundance, the abundance of pre-recruits declined consecutively from 2006 to 2009 (1.3 crabs per potlift) and then increased in 2010 to 7.3 crabs per potlift which was the second highest level observed and well above the long-term average (4.4 crabs per potlift).

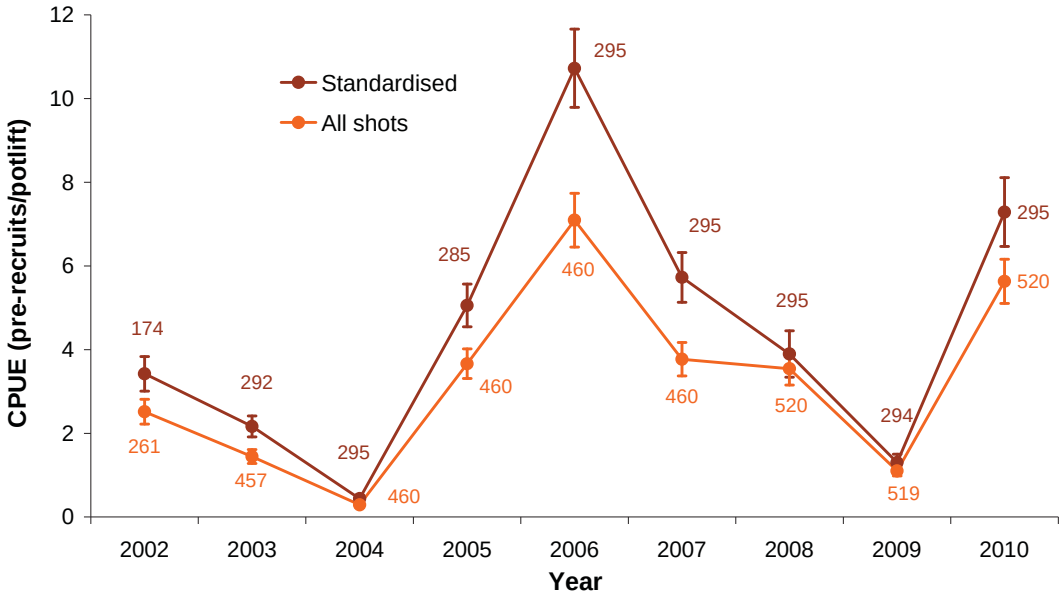


Figure 5.17. Mean (SE) CPUE (crabs/potlift) of pre-recruit crabs for all potlifts and for standardised potlifts, from fishery-independent surveys conducted in Gulf St Vincent between 2002 and 2010. Labels indicate the number of potlifts.

5.3.3 Spatial distribution of legal-size

The distribution of legal-size crabs was spatially and temporally variable in GSV (Figure 5.18). Whilst abundance was patchily distributed, there was a general trend of increasing abundance from north to south.

Very high abundance (>10 crabs per potlift) was observed in block 27 on four occasions (2003 and 2005–2007) and in blocks 13, 17, 18, 33, 34 and 35 on one occasion each. There were no blocks with very high abundance north of Pine Point during any year. High abundance was observed in blocks adjacent to Port Adelaide and Port Julia on some occasions. Abundance was low (<2 crabs per potlift) on at least five of the six survey occasions in blocks 3, 9, 10, 12, and 20. No legal-size crabs were caught in 4 blocks during 2009 and 2010 with blocks 3, 12 and 18 producing no legal size crabs in either year.

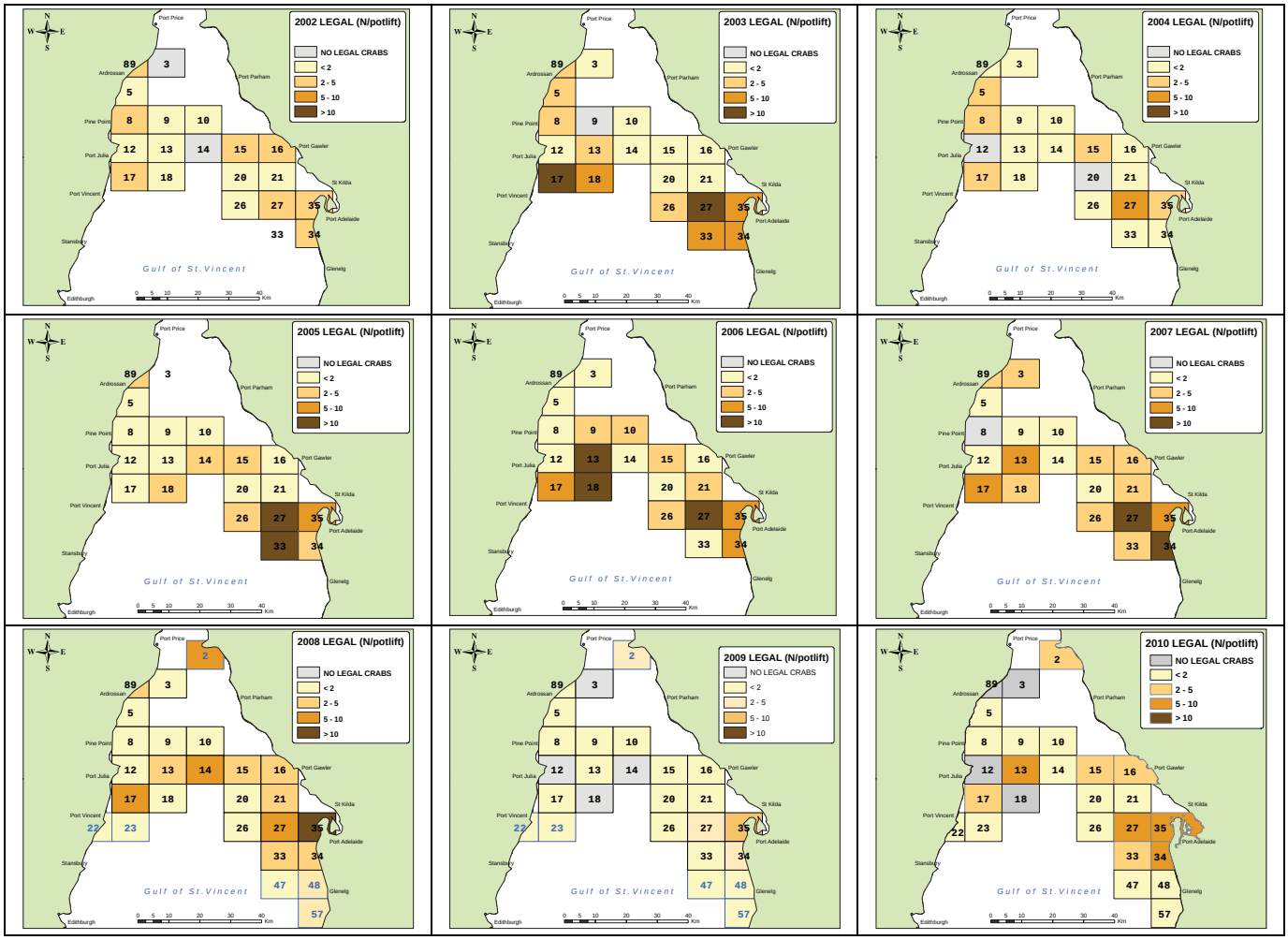


Figure 5.18. Spatial distribution of legal-size abundance (CPUE) from standardised potlifts during fishery-independent surveys conducted in Gulf St Vincent during June or July from 2002 to 2010. Note: 2008 - 2010 maps also include new blocks surveyed (2, 22, 23, 47, 48 and 57).

5.3.4 Spatial distribution of pre-recruits

The distribution of pre-recruit crabs was spatially and temporally variable in GSV however in 2010 there were good catch rates of pre-recruits spread throughout the gulf (Figure 5.19).

While few consistent trends were evident, the most productive blocks were 13, 27 and 35, each of which had >5 pre-recruit crabs per potlift on at least six of the nine survey occasions. Abundance (from standardised sites) was generally lowest in the blocks of GSV that were directly adjacent to the coast on the western side of the surveyed region.

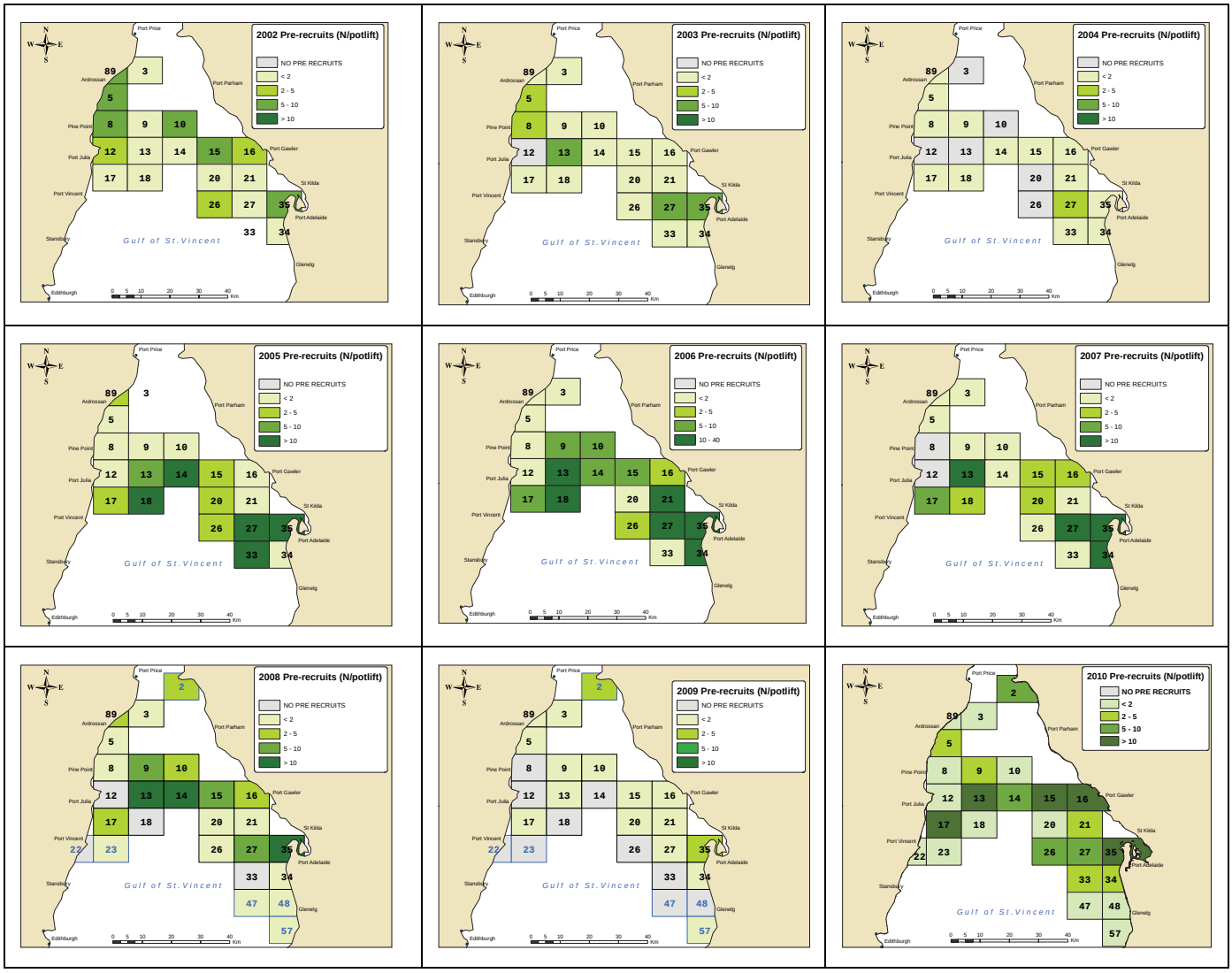


Figure 5.19. Spatial distribution of pre-recruit abundance (CPUE) from standardised potlifts during fishery-independent surveys conducted in Gulf St Vincent during June or July from 2002 to 2010. Note: 2008 - 2010 maps also include new blocks surveyed (2, 22, 23, 47, 48 and 57).

5.3.5 Crab size

The size-frequency distribution of surveyed crabs was generally similar among years (Figure 5.20). The modal size of crabs was 100–109 mm during 2002, 2005–08 and 2010 and was 110–119 mm during 2003, 2004, and 2009. The abundance of pre-recruit crabs was highest during 2006, and lowest during 2004, when very few pre-recruit crabs were caught. The abundance of large crabs (120–130 mm) has been similar for the last four years. In all years crabs larger than 130 mm were rare, as were crabs less than 79 mm.

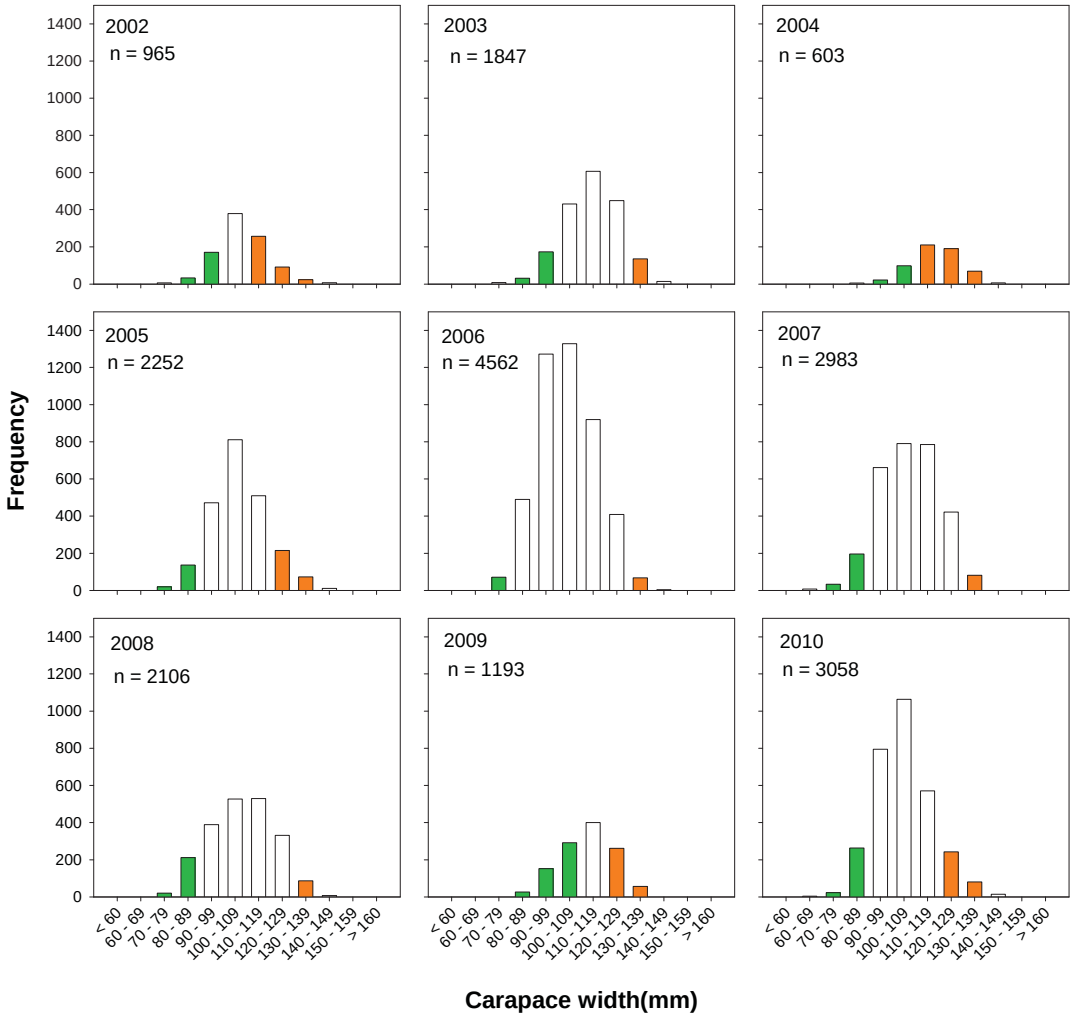


Figure 5.20. Size-frequency distribution of crabs caught in small mesh pots during surveys conducted in Gulf St Vincent from 2002 to 2010. Green bars denote pre-recruits, orange bars denote legal-size. Note, 42% fewer pots were surveyed during 2002.

5.4 Discussion

Assessment of the Gulf St Vincent pot fishing sector is based on fishery-independent survey data and fishery-dependent data from commercial logbooks and a pot-sampling program. The 2010 assessment report indicated that the fishery was in a weak position at the end of the 2008/09 season. Commercial logbook data indicate that the 2009/10 season was the poorest since the introduction of quota. However, current fishery independent survey, commercial logbook and pot-sampling data indicate that recent recruitment to the fishery was strong and subsequently the outlook for the fishery is positive.

Fishery-independent survey data collected in July 2010 provide an important snapshot of the status of the resource throughout the fishery at the end of the quota season. During 2010, legal size abundance increased by 40% compared to 2009 and approximated the long-term average abundance. More importantly, survey pre-recruit abundance increased substantially during 2010 and was the second highest level recorded. The high abundance of pre-recruits in July 2010 was also supported by data from commercial logbooks and pot-sampling.

The GSV pot fishing sector held 241.9 t of quota during 2009/10 of which only 158.5 t (65.5%) was landed. This represents a substantial decrease in both total catch and the proportion of the TACC landed compared to recent years. While the total number of boat-days decreased slightly in 2009/10, total potlift effort was similar to 2008/09 levels. Importantly, considerable additional effort could have been imparted on the fishery, as 88% of the total boat-days for the fishery were conducted by two of the three fishers.

Annual commercial catch per potlift ($CPUE_L$) increased from 2.54 kg/potlift in 1997/98 to 3.39 kg/potlift in 2008/09 but declined substantially during 2009/10 to 2.44 kg/potlift. There was also a substantial decline in average daily catch between years. Low catch rates were observed throughout all fishing blocks and the declines were consistent for both first and second potlift effort.

In recent years, a high proportion of the annual catch has been harvested from February to April. During 2009/10 the total catch harvested during this period was substantially lower despite similar total potlift effort i.e. the reduction in catch was the result of lower monthly $CPUE_L$. On a positive note, although commercial $CPUE_L$ during this period was low, it remained stable (~2 kg/potlift) for the following months until the end of the quota period. During the previous 12 quota seasons this is a period where

$CPUE_L$ is high initially and then declines to 2–2.5 kg/potlift in June. Importantly, one of the three commercial fishers in GSV fished <30% of available days during this period. The stable $CPUE_L$ from February to June may not have been maintained if the latent effort in the fishery had been imparted. It is likely that this low effort and total catch was an important contributor to the improvement in legal-size abundance observed during the July 2010 survey.

In summary, although commercial fishing measures for 2009/10 were the poorest in recent history, the immediate outlook for the pot fishing sector in GSV has improved considerably. The decrease in total catch during 2009/10, particularly from February to April, has likely contributed to the improved status of the legal size biomass at the end of the 2009/10 quota period. More importantly, strong evidence of high abundances of pre-recruit crabs indicates that fishery performance is likely to improve substantially during 2010/11.

6 PERFORMANCE INDICATORS

This section provides a report on the performance of the fishery against the performance indicators (PIs), target and limit reference points defined in the draft Management Plan (Table 6.1).

Table 6.1. Assessment against the Performance Indicators of the draft Management Plan for the blue crab fisheries of Spencer Gulf and Gulf St Vincent. All values are measured as kg/potlift.

Area	Performance Indicator	Source	Reference Range		2009/10
			Lower	Upper	
SG	Pre-recruit abundance	FIS	2	9	8.0
	Legal-size abundance	FIS	5	8	8.9
	Legal-size abundance	CPUE	2	4	2.7
GSV	Pre-recruit abundance	FIS	1.5	8.5	7.3
	Legal-size abundance	FIS	1.5	4	3.1
	Legal-size abundance	CPUE	2	4	2.4

Of the three PIs for Spencer Gulf, legal-size abundance from FIS was above the reference range and pre-recruit abundance from FIS and legal-size abundance from CPUE were both within the reference range.

All three PIs for Gulf St Vincent, legal-size abundance from FIS, pre-recruit abundance from FIS and legal-size abundance from CPUE were all within the reference range.

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7 GENERAL DISCUSSION

7.1 Available data and uncertainty in the assessment

Assessment of the Spencer Gulf and Gulf St Vincent pot fishing sectors is based primarily on indices of relative abundance of legal-size and pre-recruit crabs measured during fishery-independent surveys conducted annually throughout each gulf. Interpretation of these indices and the status of the resource is augmented by fishery-dependent information provided through commercial logbooks and pot-sampling.

The reliance on fishery-independent survey data is partly due to the short history and highly evolving nature of the commercial pot fishery which imparts considerable uncertainty on interpretation of commercial logbook data. Since the introduction of quota in 1997/98, there have been both increases in total quota and substantial transfer of quota from marine scale to pot fishers. Changes in the distribution of the population and catch, along with changes in active fishers and evolving gear technologies further complicate this picture.

Consequently, the principal indices of relative abundance of legal-size and pre-recruit crabs are survey catch rates. Surveys provide a snapshot of the full spatial extent of the fishery at the beginning of the quota season and the period of peak recruitment i.e. July. Uncertainty in estimates of pre-recruit abundance arises from variation in the timing of surveys i.e. surveys have been conducted during June. The location of survey sites was rationalised prior to the 2008 survey to ensure that surveys adequately represent the current harvestable biomass. A subset of “standardised” sites consistently surveyed since 2002 were analysed to provide meaningful comparisons over time. Also, data from research pots only are assessed to provide an unbiased index of relative abundance, particularly for pre-recruit crabs. Whilst the current approach to surveys provides a reliable index of abundance, survey data would be further improved by applying data standardisation techniques.

Commercial logbook data has been collected for the fishery since the introduction of quotas in 1997/98. The pot-sampling program was established in 2006, with an objective of obtaining catch information (size and sex) from one small meshed pot for each day’s fishing. Current participation rates for pot-sampling provide a useful data source to augment assessment of the fishery.

Interpretation of temporal trends in legal-size abundance from commercial CPUE data is currently impeded by uncertainty associated with: changes in fisher demographics and experience; changes in gear and vessel technology; temporal and regional shifts in catch and effort, and; the changes in potlift behaviour such as conducting second potlifts.

Pot-sampling and commercial logbooks provide additional sources of data on pre-recruit abundance that augment assessment of survey data. Commercial logbook data are biased underestimates as commercial crab pots are highly selective and relatively few small crabs are captured. Also, there is some limited evidence to suggest that the abundance of adult crabs may reduce the capture probability of juvenile crabs, particularly for commercial pots. The use of small pots in the pot-sampling program overcomes much of the catchability issues of commercial logbook data, but the available data are limited spatially and temporally due to the low number of fishers in each gulf.

Sex-ratio varies throughout the year in the catch and population of each gulf, as shown by data from commercial logbooks and pot-sampling, respectively. Incorporation of alternate data sources such as processor grade information should be considered for historic analyses.

7.2 Status of the Blue Crab Fishery

7.2.1 Spencer Gulf pot fishing sector

All available data on the status of the blue crab resource in Spencer Gulf indicate that the biomass upon which the fishery is based is in its strongest position since the introduction of quota. Evidence to support this position includes data from: fishery-independent surveys; commercial logbooks and; pot-sampling.

Legal-size abundance from fishery-independent surveys was at its highest levels in 2009 and 2010. The population comprised a high proportion of large crabs which were distributed throughout all fished regions. Annual CPUE, measured as catch per potlift and catch per day, both increased from 2008/09 to 2009/10. Pre-recruit abundance from fishery-independent surveys increased considerably during 2010 and was the second highest level recorded. This increase in abundance was supported by data from pot-sampling and commercial logbooks and suggests that recruitment to the fishery in 2010/11 should be strong.

During 2009/10 all available TACC was caught in fewer boat-days and with less potlifts than the two previous years. During 2010 the number of boat-days was the lowest recorded since the introduction of quota. This was reflected in the highest daily average catch for the fishery of 545 kg/boat-day. For the first time the catch rates from second potlifts were higher than for first potlifts. This may have resulted from an increase in second potlift soak-time and a high abundance of adult crabs. Finally, monthly CPUE peaked in June at the end of the quota year for the first time in the fishery's history.

Optimistic trends in legal-size and pre-recruit abundance, combined with positive measures of commercial fishery performance, indicate that the Spencer Gulf pot fishing sector is currently in a strong position. Recently developed decision rules for the fishery enable a fishery-independent survey to be skipped if the TACC is maintained and the status of the fishery is unlikely to be compromised. Missing the June/July 2011 survey in Spencer Gulf is unlikely to greatly increase uncertainty associated with fishery status for the 2011/12 quota year.

7.2.2 Gulf St Vincent pot fishing sector

The 2010 fishery assessment report (Dixon and Hooper 2010) indicated that the resource upon which the Gulf St Vincent (GSV) pot fishing sector is based was in its weakest position for several years, perhaps since the introduction of quota. Commercial fishing during 2009/10 reflected this status however the current outlook for the fishery has improved considerably.

Fishery-independent surveys conducted at the end of the quota period indicated that the abundance of legal-size crabs was approaching average historic levels. Importantly, pre-recruit abundance increased substantially and was the second highest level recorded. Pot-sampling and commercial logbook data also indicated increases in pre-recruit abundance.

During 2009/10, only 158.5 t of the available 241.9 t of the TACC was harvested despite boat-days and total potlift effort being similar between years. There was a substantial decline in commercial CPUE for both potlifts and daily catch. While total effort was similar, there was considerable latent effort in the fishery as one of the three fishers contributed only 12% of total effort. The reduced effort by one fisher was probably important in maintaining commercial $CPUE_L$ at ~2 kg/potlift from February to June, a period when monthly $CPUE_L$ has substantially declined in all previous years.

In summary, while the 2009/10 quota season was poor from a commercial fishing perspective, the reduction in effort and catch by one fisher, combined with the optimistic trends in pre-recruit abundance suggest that the outlook for 2010/11 has improved.

7.3 Performance indicators

A revised Management Plan for the South Australian Blue Crab Fishery was released to public comment during 2010 and is currently undergoing final review (Keith Rowling, PIRSA pers. comm.). Assessment against the draft PIs in this report indicated that all measures were within or above the reference ranges for 2009/10. The current draft of the Plan indicates that triggering limit reference points leads to a review of the status of the fishery rather than prescriptive management actions. This acknowledges that an improved understanding of the PIs and their associated reference ranges is required prior to establishing formal decision rules regarding changes in TACC. Continued evaluation of these measures will be an important component of future assessment reports.

Appropriately, the primary PIs of biological “stock status” of the resource are measures of legal-size and pre-recruit abundance from fishery-independent surveys. In combination, assessment against these two measures could enable the status of the resource to be defined. For example, if upper trigger reference points for both measures were exceeded during any single survey, the status of the resource could be considered “underfished” and decision rules could allow for a TACC increase or removal of a fishery-independent survey. The development of a framework to objectively assess stock status is a high priority for the fishery.

Several other measures should continue to be assessed as potential supplementary indicators for assessment. Useful measures of pre-recruit abundance are obtained from pot-sampling and to a lesser extent commercial logbook data. In recent years, consistent trends in pre-recruit abundance among FIS, pot-sampling and logbook data sources have become evident, which provides greater certainty in the assessment of pre-recruit abundance. In contrast, nominal commercial CPUE is an uninformative index of adult biomass. Standardisation of CPUE should be undertaken however given the low number of active fishers and the highly evolving nature of the fishery this may not greatly improve the uncertainty associated with this measure.

Estimates of sex-ratio that are representative of the population could be determined from a combination of fishery-independent survey and pot-sampling data. Estimates of

sex-ratio from commercial logbooks could be assessed against these population estimates to inform on harvest practices of the fishery e.g. release of berried females, targeting specific sexes for market purposes. There is considerable uncertainty in the effects of changes in sex-ratio of the catch on the blue crab resource. In the absence of this knowledge, it is difficult to determine meaningful trigger and limit reference values.

7.4 Future research needs

This report identifies several elements of research required to reduce the uncertainty associated with assessment of the Blue Crab fishery. Of primary importance, standardisation techniques should be applied for all measures that use catch rates as an index of abundance. It should be noted that standardisation of commercial CPUE data may not improve the uncertainty associated with this measure due to the low number of active fisheries and the short and highly evolving history of the fishery.

One of the greatest contributors to the variation associated with nominal commercial CPUE is the conduct of second potlifts. Studies on the effects of soak-time for pot fisheries are common in the literature (e.g. Robertson, 1989; Loewenthal *et. al.*, 2000) and a project established to specifically address this issue would not only enhance the standardisation process, but would also shed light on the incidental mortality rates previously reported for the blue crab fishery by Kumar *et al.* (1999a).

Continued investment into the pot-sampling program by commercial fishers is essential. Participation rates have increased in recent years and trends (i.e. increase/decrease) among years appear to be consistent among these and commercial logbook and survey data. Continued participation is required to ensure meaningful results, particularly as the number of active fishers in the fishery has reduced in recent years.

Historic analyses of sex-ratio of the catch need to be improved. The possibility of utilising processor information to augment commercial logbook data should be investigated. Future research should aim to 1) improve historical estimates of sex-ratio of the catch and 2) determine appropriate reference levels for the proportion of females harvested.

Table 7.1 Potential performance indicators for assessment of the pot fishing sector in Spencer Gulf and Gulf St Vincent.

PI value	PI measure	Data source	Measure	Comments
Primary PI of stock status	Legal-size abundance	Fish. Ind. Surveys	Catch (legal)/potlift	Independent "snapshot" of legal-size abundance across the entire fishery. Based on small mesh pots. Surveys conducted since 2002. Data available now to determine reference points.
	Pre-recruit abundance	Fish. Ind. Surveys	Catch (pre-rec.)/potlift	Independent "snapshot" of pre-recruit abundance across the entire fishery. Based on small mesh pots. Surveys conducted since 2002. Data available now to determine reference points.
Supplementary measure	Legal-size abundance	Comm. logbook	Daily catch (legal) /daily pot effort	Annual CPUE is an insensitive measure of abundance. Long history of data collection. Monthly CPUE may be a useful measure to augment independent survey legal-size abundance estimates. Should consider the effect of second potlifts.
	Pre-recruit abundance	Pot-sampling	Catch (pre-rec.)/potlift	Based on small mesh pots. Should be consistent daily coverage from all fishers. Available data not suitable for performance assessment. Monthly data would augment survey data by providing comparisons.
	Pre-recruit abundance	Comm. logbook	Daily catch (pre-rec.) /daily pot effort	Incomplete data records in Spencer Gulf. Useful data available for GSV. Issues of bias with estimates of pre-recruit abundance from commercial pots. Not the preferred measure.
	Sex-ratio	Fish. Ind. Surveys	% of females in the catch	Independent "snapshot" of legal-size abundance across the entire fishery. Based on small mesh pots.
		Pot-sampling	% of females in the catch	Based on small mesh pots. Should be consistent daily coverage from all fishers. Available data not suitable for performance assessment. Monthly data would augment survey data.
		Comm. logbook	% of females in the catch	Incomplete data records in both gulfs. Uncertainty associated with retention of berried females etc.
	Commercial catch	Comm. logbook	% of the TACC	Useful indicator of fishery performance, not a robust indicator of biomass.

8 REFERENCES

Anonymous (2003). Interim results of the National Recreational & Indigenous Fishing Survey. Southern Fisheries Magazine, Autumn 2003.

Baker, J.L. and Kumar, M. (1994). Review of the Blue Crab (*Portunus pelagicus*) Fishery in South Australia. SARDI Research Report Series. No. 9.

Boxshall, S., Hooper, G. and Williams, H. (2000). Blue Crab. Fishery Assessment Report to PIRSA for the Blue Crab Fishery Management Committee. South Australian Fisheries Assessment Series 00/01.

Boxshall, S., Hooper, G. and Williams, H. (2001). Blue Crab. Fishery Assessment Report to PIRSA for the Blue Crab Fishery Management Committee. South Australian Fisheries Assessment Series 01/02.

Bryars, S. and Adams, M. (1999). An allozyme study of the blue swimmer crab, *Portunus pelagicus* (Crustacea: Portunidae), in Australia: stock delineation in southern Australia and evidence for a cryptic species in northern waters. Marine and Freshwater Research. 50: 15-26.

Chaplin, J., Yap, E.S., Sezmis, E., and Potter, I.C. (2001). Genetic (microsatellite) determination of the stock structure of the blue swimmer crab in Australia. FRDC project 98/118.

Currie, D.R. and Hooper, G.E. (2006). Blue Swimmer Crab (*Portunus pelagicus*) Fishery 2004/05. Fishery Assessment Report for PIRSA. South Australian Research and Development Institute (Aquatic Sciences), Adelaide. RD 03/0274-3.

Currie, D.R., Hooper, G.E. and Ward, T.M. (2007). Blue Swimmer Crab (*Portunus pelagicus*) Fishery 2005/06. Fishery Assessment Report for PIRSA. South Australian Research and Development Institute (Aquatic Sciences), Adelaide. RD 03/0274-4. SARDI Research Report Series No. 204.

Dixon, C.D., Hooper, G.E. and Ward, T.M. (2008). Blue Crab (*Portunus pelagicus*) Fishery 2006/07. Stock Assessment Report to PIRSA Fisheries. South Australian Research and Development Institute (Aquatic Sciences), Adelaide. F2007/000729-4.

Dixon, C.D. and Hooper, G.E. (2009). Blue Crab (*Portunus pelagicus*) Fishery 2007/08. Stock Assessment Report to PIRSA Fisheries. South Australian Research and Development Institute (Aquatic Sciences), Adelaide. F2007/000729-5.

Dixon, C.D. and Hooper, G.E. (2010). Blue Crab (*Portunus pelagicus*) Fishery 2008/09. Stock Assessment Report to PIRSA Fisheries. South Australian Research and Development Institute (Aquatic Sciences), Adelaide. F2007/000729–6.

Edgar, G.J., (1990). Predator-prey interactions in seagrass beds. II. Distribution and diet of the blue manna crab *Portunus pelagicus* Linnaeus at Cliff Head, Western Australia. Journal of Experimental Marine Biology and Ecology. 139: 23-32.

Gaddes, S.W. and Sumpton, W.D. (2004). Distribution of barnacle epizoites of the crab *Portunus pelagicus* in the Morton Bay region, eastern Australia. Marine and Freshwater Research. 55: 241-248.

Grove-Jones, R. (1987). Catch and effort in the South Australian blue crab (*Portunus pelagicus*) fishery. South Australian Department of Fisheries, Adelaide.

Henry, E.W. and Lyle, J.M. (2003). The National Recreational and Indigenous Fishing Survey. FRDC project No.99/158.

Hooper, G. and Svane, I. (2003). South Australian Blue Crab (*Portunus pelagicus*) Fishery. South Australian Fisheries Assessment Series 02/02.

Jones, K. (2009) South Australian Recreational Fishing Survey. PIRSA Fisheries, Adelaide, 84 pp. South Australian Fisheries Management Series Paper No 54.

Kailola, P.J., Williams, M.J., Stewart, P.C., Reichelt, R.E., McNee, A. and Grieve, C. (1993). Australian Fisheries Resources. Bureau of Resources and the Fisheries Research and Development Corporation, Canberra, Australia, 422pp.

Knight, M. and Tsolos, A. (2011). South Australian Wild Fisheries Information and Statistics Report 2009/10. South Australian Research and Development Institute (Aquatic Sciences), Adelaide, F2008/000804-3. SARDI Research Report Series No. 521.

Kumar, M. (1997). Proceedings of the First National Workshop on Blue Swimmer Crab *Portunus pelagicus*. SARDI Research Report Series No.16, ISSN 1324-2083.

Kumar, M.S., Ferguson, G. and Boxall, V. (1998). Blue Crabs. South Australian Fisheries Assessment Series 98/1.

Kumar, M.S., Xiao, Y., Williams, H., Ferguson, G., Hooper, G. and Venema, S. (1999a). Blue Crab fishery, South Australian Fishery Assessment Series 99/02.

Kumar, M.S., Xiao, Y., Williams, H., Ferguson. G., and Venema, S. (1999b). Blue crab – Assessment Update and Review of Biological Indicators and Reference Points. South Australian Fishery Assessment Series 99/02-2.

Kumar, M.S., Ferguson, G., Xiao, Y., Hooper, G. and Venema, S (2000). Studies on reproductive biology and distribution of the blue swimmer crab (*Portunus pelagicus*) in South Australian waters. SARDI Research Report Series No. 47.

Kumar, M.S., Xiao, Y., Venema, S. and Hooper, G. (2003). Reproductive cycle of the blue swimmer crab, *Portunus pelagicus*, off southern Australia. Journal of the Marine Biological Association of the UK. 83: 983-994.

Loewenthal, D., Mayfield, S. and Branch, G.M. (2000). Improving the catch efficiency of the West Coast rock lobster, Jasus lalandii, Marine and Freshwater Research. 51: 613-17.

McGlennon, D. and Kinloch, M.A. (1997). Resource allocation in the South Australian Marine Scalefish Fishery. FRDC project 93/249.

Meagher, T.D. (1971). Ecology of the crab *Portunus pelagicus* (Crustacea: Portunidae) in South Western Australia. Unpublished. PhD Thesis, University of Western Australia, Australia.

Robertson, W.D. (1989) Factors affecting catches of the crab *Scylla serrata* (Forskal) (Decapoda : Portunidae) in baited traps: soak time, time of day and accessibility of the bait. Estuarine, Coastal and Shelf Science. 29: 171-82.

Scandol, J.P. and Kennelly, S.J. (2001). Blue crab fishery biological research review. Centre for Research on Ecological Impacts of Coastal Cities. University of Sydney.

Shields, J.D. and Wood, F.E.I. (1993). Impact of parasites on the reproduction and fecundity of the blue sand crab *Portunus pelagicus* from Morton Bay, Australia.

Smith, H. (1982). Blue swimmer crabs in South Australia - their status, potential and biology. Safic. 6: 6-9.

Stephenson W., (1972). An annotated check list and key to the Indo-West-Pacific swimming crabs (Crustacea: Decapoda: Portunidae). Bulletin of the Royal Society of New Zealand. 10: 1-64.

Sumpton, W.D., Potter, M.A. and Smith, G.S. (1994). Reproduction and growth of the commercial sand crab, Portunus pelagicus (L.) in Moreton Bay, Queensland. Asian Fisheries Science 7:103-113.

Svane, I. and Hooper, G.E. (2004). Blue swimmer crab (Portunus pelagicus) fishery. Fishery Assessment Report to PIRSA for the Blue Crab Fishery Management Committee. SARDI Aquatic Sciences Publication No. RD03/0274-2.

Svane I. and Cheshire, A. (2005). Fisheries biology and spatial modelling of the blue swimmer crab (Portunus pelagicus). Fisheries Research and Development Corporation Project No. 1998/116. SARDI Aquatic Sciences Publication No. RD98/0200-2.

PIRSA (2006). Draft Management Plan for the Blue Crab Fishery. Department of Primary Industries and Resources South Australia. Webpage listing of document at: http://www.pir.sa.gov.au/__data/assets/pdf_file/0015/12750/bcfmcdraft.pdf

Van Engel, W.A. (1958). The blue swimmer crab and its fishery in Chesapeake Bay, Part 1. Reproductions, early development, growth and migration. Commercial Fisheries Review. 20: 6-17.

Williams, M.J. (1982). Natural food and feeding in the commercial sand crab Portunus pelagicus Linneaus, 1766 (Crustacea: Decapoda: Portunidae) in Moreton Bay, Queensland. Journal of Experiential Marine Biology and Ecology. 59: 165-176.

9 APPENDICES

9.1 Voluntary pot-sampling data sheet.

Blue Swimmer Crab Pot Sampling Sheet

Licence No:				**Licence Name:**			
Date:				**Date:**			
Fishing Block:				**Fishing Block:**			
Latitude:				**Latitude:**			
Longitude:				**Longitude:**			
Depth (m):		**Wtemp:**		**Depth (m):**		**Wtemp:**	
MALES		**FEMALES**		**MALES**		**FEMALES**	
1	36	1	36	1	36	1	36
2	37	2	37	2	37	2	37
3	38	3	38	3	38	3	38
4	39	4	39	4	39	4	39
5	40	5	40	5	40	5	40
6	41	6	41	6	41	6	41
7	42	7	42	7	42	7	42
8	43	8	43	8	43	8	43
9	44	9	44	9	44	9	44
10	45	10	45	10	45	10	45
11	46	11	46	11	46	11	46
12	47	12	47	12	47	12	47
13	48	13	48	13	48	13	48
14	49	14	49	14	49	14	49
15	50	15	50	15	50	15	50
16	51	16	51	16	51	16	51
17	52	17	52	17	52	17	52
18	53	18	53	18	53	18	53
19	54	19	54	19	54	19	54
20	55	20	55	20	55	20	55
21	56	21	56	21	56	21	56
22	57	22	57	22	57	22	57
23	58	23	58	23	58	23	58
24	59	24	59	24	59	24	59
25	60	25	60	25	60	25	60
26	61	26	61	26	61	26	61
27	62	27	62	27	62	27	62
28	63	28	63	28	63	28	63
29	64	29	64	29	64	29	64
30	65	30	65	30	65	30	65
31	66	31	66	31	66	31	66
32	67	32	67	32	67	32	67
33	68	33	68	33	68	33	68
34	69	34	69	34	69	34	69
35	70	35	70	35	70	35	70

** * Only Measure crabs from the RESEARCH POT to the nearest mm - carapace width * **

Labels - D=Dead, B=Berried