Fishery Assessment Report for PIRSA

South Australian Giant Crab (*Pseudocarcinus gigas*) Fishery

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April 2009

SARDI Publication No. F2007/000698-2

SARDI Research Report Series No. 345

This publication may be cited as:
Currie, D.R. and Ward T.M. (2009). South Australian Giant Crab (*Pseudocarcinus gigas*) Fishery. Fishery Assessment Report for PIRSA. South Australian Research and Development Institute (Aquatic Sciences), Adelaide. SARDI Publication No. F2007/000698-2
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SARDI Aquatic Sciences Publication No. F2007/000698-2

SARDI Research Report Series No. 345

Printed in Adelaide April 2009

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Signed:
Date: 3 April 2009
Distribution: PIRSA Fisheries, SARDI Aquatic Sciences Library
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EXECUTIVE SUMMARY

1. This fishery assessment report updates the 2008 report and assesses the current status of the South Australian Giant Crab Fishery (SAGCF).
2. Due to the relatively small size and value of the fishery, data and information for assessment are limited. This lack of data and information prevent an unambiguous assessment of the fishery's current status.
3. During the 2007/08 season, 19.7 tonnes of giant crab were harvested from South Australian waters. Most of this catch (72%) was harvested by two miscellaneous licence holders. Rock lobster fishers with giant crab quota entitlements accounted for 18% of the total, while the remainder (10%) was taken as by-product by commercial rock lobster fishermen not holding giant crab quota.
4. The majority of the catch in 2007/08 (11.3 tonnes; 57%) was harvested from eight offshore Marine Fishing Areas (MFAs) in the Northern Zone (NZ), while the remainder (8.4 tonnes; 47%) was harvested from four MFAs in the Southern Zone (SZ).
5. Total catch has remained relatively stable since the introduction of sectoral quotas in 2002/03, but in most recent seasons the TACC (22.1 tonnes) has not been harvested. During 2007/08, targeted giant crab catches were approximately 16% and 3% less than the TACC for the NZ and SZ, respectively.
6. Total fishing effort declined by 79% between 1994/95 and 2006/07. However, it increased by ~88% between 2006/07 and 2007/08.
7. Overall catch rates have progressively increased since the commercialisation of the fishery. During 2007/08, average CPUE was highest in the miscellaneous licensed sector (3.35 kg.pot lift^{-1}), and substantially lower in the rock lobster quota and rock lobster by-product sectors (0.63 and 0.10 kg.pot lift^{-1}, respectively).
8. In the NZ, declining catches and fishing effort over the last seven years have resulted in a marginal decline in CPUE. In contrast, stable catches and declining effort have resulted in substantial (two-thirds) increases in CPUE in the SZ over the same period.
9. The mean weights of landed giant crabs have declined in the NZ and increased in the SZ over the last seven-year period. During 2007/08, for the first time on record, mean landed weights were higher in the SZ (2.94 kg) than in the NZ (2.81 kg).
10. Data were available to assess fishery performance against six of the seven interim performance indicators (PI) in each zone. Five of these PI (mean weight in NZ and SZ, catch rate in NZ, fishing effort in the SZ, and total targeted catch in the NZ) were below the interim lower reference points. On balance, the stock status of the SZ appears stronger than the NZ.
11. This assessment would be enhanced by 1) clarification of the reasons why the TACC has not been harvested in either zone since 2001/02, 2) assessment of the suitability of the interim PIs and associated reference period and reference ranges, 3) interrogation of the commercial catch and effort data at finer spatial scales, and 4) collection and analysis of spatially-explicit commercial length-frequency data.

1 INTRODUCTION

1.1 Overview

This fishery assessment report for the South Australian giant crab fishery updates previous reports for this species (Currie and Ward, 2005; Currie *et al*., 2006; Currie, 2008) and is part of SARDI Aquatic Science's ongoing assessment program for this fishery. The primary aims of the report are to assess the current status of the resource, identify any uncertainty associated with the assessment, and identify management implications and future research needs for the fishery.

This report covers the period 1 January 1986 – 31 May 2008, and is divided into four sections:

- Section 1 is a general introduction and includes an outline of the aims and structure of the report. It also describes the fishery's history, current management arrangements and biological performance indicators. In addition, the introduction summarises biological knowledge and provides a synopsis of previous stock assessment reports.

- An assessment of the fishery-dependent data from 1986 to 2008 is provided in Section 2. This includes spatial and temporal analyses of catch, effort and catch-per-unit effort (CPUE).

- In Section 3, the performance of the fishery is assessed against the performance indicators identified in the interim management plan.

- Section 4 is a general discussion that synthesises the information presented in the previous sections. In particular it highlights gaps in current knowledge, comments on the status of the resource, and outlines future research requirements for the fishery.

1.2 Description of the Fishery

Giant crabs (*Pseudocarcinus gigas*) are endemic to Australian waters and are distributed from southern Western Australia to central New South Wales (Kailola *et al*., 1993). While they occur at depths ranging from 20 m to 600 m, the highest population densities are found at the edge of the continental shelf in a depth of approximately 200 m. Giant crabs have been taken as a by-product of rock lobster fishing operations in southern Australia for over 80 years. Targeted commercial fishing for giant crabs was initiated in Tasmanian waters in 1990 and began in South Australian waters in 1992 (Sloan, 2003).

During the mid 1990s, two South Australian based fishers began targeting giant crabs in Commonwealth waters adjacent to South Australia under the provision of Commonwealth Fishing Permits. These two fishers were subsequently issued with South Australian miscellaneous fishing licences in January 1997 to harvest giant crab (Sloan, 2002). Under the provisions of the Fisheries Act, 250 commercial rock lobster licence holders may also harvest giant crab from South Australian waters. Presently, 16 of these licence holders (5 Northern Zone + 11 Southern Zone) hold transferable giant crab quota units, while the remainder are permitted to retain 5 giant crabs per trip as a by-product.

Steel-framed lobster pots fitted with moulded plastic necks and covered in 50 x 75 mm plastic mesh are usually used in the fishery (Figure 1). Some operators that target giant crab use purpose built traps. However, all pots and traps must comply with regulations specifying the maximum dimensions and weight, single entrance and escape gaps. The pots are baited with kangaroo meat or a range of fish products, and are usually set overnight and hauled at first

light. Any undersized crabs (<150 mm carapace width) captured are returned to the water whilst the legal quota are transported in live holding tanks back to shore.

Figure 1. Steel-framed pot with plastic mesh employed by commercial giant crab fishers in South Australia.

The fishery operates between 1 October and 30 April in the Southern Zone and 1 November and 31 May in the Northern Zone, with the fleet working from a number of ports in South Australia between Port Macdonnell and the far west coast. Vessels are restricted to 18 metres in length and a total engine capacity of 1,200 brake horsepower. In recent years, faster vessels, enabling greater fishing coverage over a given period, have replaced traditional displacement vessels. These technological changes have also resulted in an increased level of capital investment by licence holders and increased profit expectations (Ward and Loiterton, 2000). In 2006/07, 18.4 tonnes of giant crab were harvested in the South Australian fishery at an estimated value of $0.22 million. Most of this catch is exported to southeast Asia in live, pickled, green (uncooked) or cooked form.

1.3 Environmental Impacts

The direct and indirect effects of giant crab fishing on the ecology of South Australia's coastal marine environment are largely undetermined. Potential impacts may include direct disturbances to benthos, the removal of non-target species, and entrapment and entanglement of seals, whales, dolphins and turtles. Indirect effects may include changes to the population structure of other motile invertebrates and fish that scavenge on discarded baits or depend on giant crabs as a source of food. While most anecdotal evidence suggests that the environmental effects of giant crab fishing are relatively benign, there are no empirical data to support these assertions.

Since 1999, the export of giant crab has been controlled under the wildlife protection provisions of the *Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act 1999* (DEH, 2004). Under this act, giant crabs are recognised as a controlled species. To maintain export exemption status under the act (Part 13 and 13A), PIRSA Fisheries has been required to demonstrate to the Commonwealth Department of Environment and Heritage that the harvesting strategies for the giant crab fishery are ecologically sustainable. This includes demonstrating that giant crab fishing operations are managed to minimise impacts on the structure, productivity, function and biological diversity of the ecosystem.

1.4 Management of the Fishery

Prior to 1992, the Commonwealth Government controlled access to giant crabs off the South Australian coast. A joint management regime was established during 1992. Since January 1997, the South Australian Government has managed giant crabs targeted off the South Australian coastline under an Offshore Constitutional Settlement arrangement between the South Australian and Commonwealth Governments.

Licence holders with giant crab access operate under a pot licence issued pursuant to either the *Scheme of Management (Rock Lobster Fisheries) Regulations 1991* or the *Scheme of Management (Miscellaneous Fisheries) Regulations 1984*. The fishery has been separated into two discrete fishing zones for the purpose of management since 1997 (Figure 2). These two zones have been further divided into a series of nominally rectangular Marine Fishing Areas (MFAs) that constitute the primary units for reporting and monitoring catch.

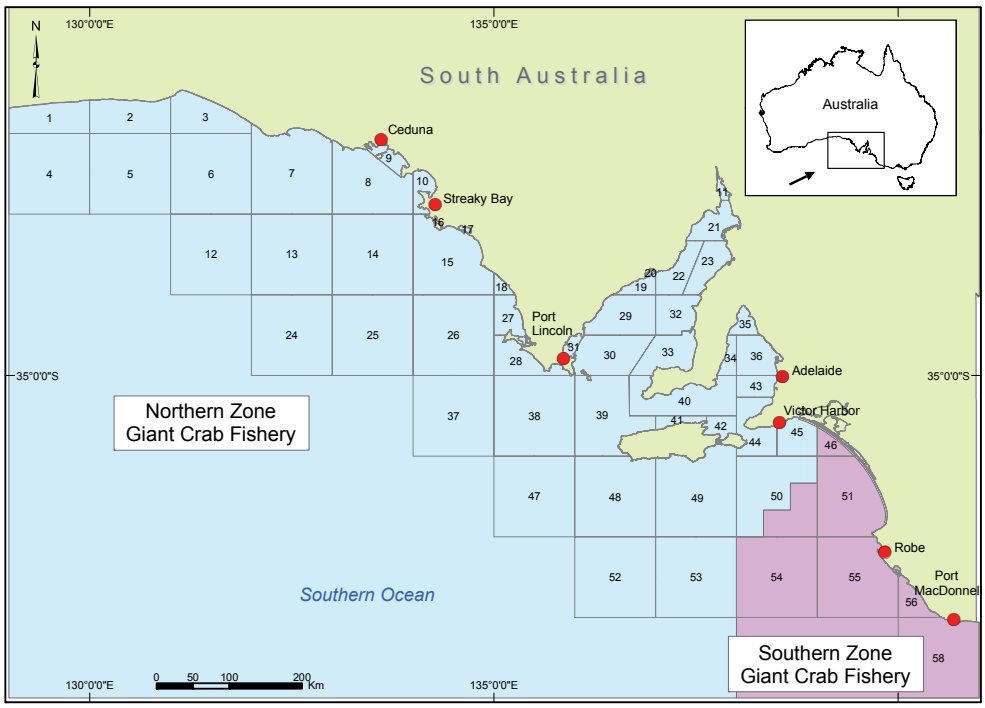

Figure 2. Southern and Northern management Zones for the South Australian giant crab fishery. Note that the numerical codes presented refer to the identities of 58 separate Marine Fishing Areas (MFAs).

The Northern and Southern Zone Rock Lobster Management Committees provide advice to the Minister for Agriculture, Food and Fisheries on the management and administration of the South Australian giant crab fishery. The committees have an independent chairperson and selection of members is expertise-based. The committees are responsible for ensuring regular consultation with all stakeholders and for providing transparent decision-making. Furthermore, the committees are responsible for publishing all agreed decisions and developing, in conjunction with PIRSA Fisheries, annual reports and an approved management plan.

Since taking over the management responsibility of the South Australian giant crab resource, PIRSA Fisheries has worked towards implementing a management system based on individual transferable quota units to ensure the long term sustainability of the resource. The fishery now operates under this output-control based management system with a Total Allowable Commercial Catch (TACC) of 13.4 and 8.7 tonnes for the Northern and Southern

Zones, respectively. The TACC for each zone is allocated among licence holders, with an allocation set aside for by-product taken by rock lobster fishers. A suite of input controls complements these arrangements. Management controls that currently apply to the fishery are provided in Table 1.

Table 1. Current management controls for the South Australian giant crab fishery.

Management Arrangement	Control
1) Limited entry	• 2 miscellaneous – GC quota holders • 5 Northern Zone lobster – GC quota holders • 11 Southern Zone lobster – GC quota holders • 64 Northern Zone lobster – GC by-product • 170 Southern Zone lobster – GC by-product
2) By-product limits for rock lobster licences	• All rock lobster licence holders without giant crab quota holdings may take up to 5 crabs per trip as a by-product
3) TACC	• Northern Zone (13.4 tonnes); Southern Zone (8.7 tonnes)
4) Seasonal closures	• Southern Zone (1 May – 30 September); Northern Zone (1 June – 31 October)
5) Quota holding limits per licence	• No limits
6) Minimum legal length (both sexes)	• 150 mm Carapace length (both zones)
7) Maximum pot numbers	• 100 pots per licence
8) Pot specifications	• Maximum diameter 1 m; maximum height 1 m; maximum weight 40 kg; single top entrance; mesh size 50 mm or escape gaps 55 x 150 mm
9) Egg-bearing females	• No retention at any time
10) Spatial closures	• No dedicated giant crab fishing within a depth of 60 fathoms
11) Vessel Monitoring System (VMS)	• Required by all dedicated giant crab fishers and Northern Zone rock lobster fishers
12) Single trip fishing	• Rock lobster fishers with giant crab quota are only permitted to fish for either crabs or lobster on a single fishing trip
13) Catch and effort data	• Daily logbook submitted monthly
14) Catch and Disposal Records (CDR)	• Daily CDR records upon landing
15) Maximum vessel length	• 18 metres
16) Maximum engine capacity	• 1,200 brake horsepower

The current compliance and monitoring program is focussed on monitoring landings to ensure adherence with individual quota limits. At the point of landing, licence holders that target giant crab are required to complete a giant crab Catch and Disposal Record (CDR). The fishers record information such as estimated weight of the giant crabs, port and time of landing, name of the receiving processor and if the crabs are cooked or live. The CDR then accompanies the giant crab to the processor where immediately upon receiving the giant crab, the processor must accurately weigh the catch and complete Part B of the CDR with the certified accurate weight. The CDR is then forwarded to the Fisheries Compliance Office by the fish processor within 24 hours. CDR information is entered into a database and individual catches recorded against allocated quotas.

There are currently no bag or boat limits in place for the recreational sector, on the basis that giant crab are rarely caught by recreational fishers due to the inaccessibility of the fishing grounds. Recreational fishers are required to purchase a gear registration for a maximum of two rock lobster pots per person, which is the only recreational device with a capacity to catch

giant crabs. Recreational rock lobster pot fishers are surveyed periodically to determine levels of catch and fishing effort within the sector (Currie *et al*., 2006).

The South Australian giant crab fishery is one of several State-managed fisheries for *Pseudocarcinus gigas*. In Western Australia a multi-species deep-sea crab fishery for *P. gigas*, snow crab (*Chaceon bicolour*) and spiny crab (*Hypothalassia armata*) operates under an input control system. In the south-east, Tasmanian and Victorian giant crab fisheries (which are both closely linked to State-managed rock lobster fisheries) operate under a quota management system. Co-ordination among jurisdictions occurs through various southern State and national fisheries management forums.

1.5 Biology of Giant Crabs

Giant crabs are long-lived, slow growing species that generally inhabit soft sedimentary environments and feed on sessile or slow-moving benthic species including gastropods, asteroids and other decapods. The sexes are separate, with males (Figure 3) growing to more than twice the size of females and reaching at least 13 kg. Approximately half of all females reach sexual maturity at 125 mm carapace length (Levings *et al*., 1996), and proceed to mate during the months of June and July. Females only bear eggs in non-moulting years, and the clutch sizes can range from approximately 0.5 to 2.0 million eggs. The eggs are carried by the female for up to 4 months, and as hatching approaches (October to November) females are thought to migrate to the continental shelf break (Kailola *et al*., 1993).

The genetic structure of the population is poorly understood, but studies using allozyme and DNA techniques have indicated a genetically homogeneous stock (Levings *et al*., 2001). Factors including a 3 – 4 month planktonic larval phase and adult movements of up to 400 km are thought to contribute to dispersion and mixing within the stock.

Figure 3. Assessing the carapace length of a male giant crab (*Pseudocarcinus gigas*) off the Bonney coast, South Australia.

1.6 Stock Assessment

SARDI Aquatic Sciences undertakes assessments of the South Australian giant crab fishery. This includes assessing performance of the fishery against the suite of interim performance indicators for the fishery. The first report was completed in 2000 (Ward and Loiterton, 2000) and this has since been regularly updated (e.g. Sloan 2002; Sloan 2003; Currie and Ward, 2005; Currie *et al*., 2006; Currie, 2008).

The interim performance indicators used to assess the performance of the fishery include catch per unit effort, total effort, total catch relative to TACC, and mean crab weight (Table 2). Other less direct indicators comprise estimates of the reproductive potential of the stock, including sex ratios and the relative abundance of mature females in the population.

Table 2. Interim performance indicators and estimation methods for the South Australian giant crab fishery.

Performance Indicator	Description	Measurement
1) Catch Rate	• Reflects the catch (kg) per pot lift taken in the fishery, and is linked to the relative abundance of giant crabs	• Nominal average catch rate as recorded in logbooks
2) Mean Weight	• Used to indicate change in the stock structure (size and age)	• Nominal average mean weight recorded in logbooks
3) Annual Commercial Catch *vs*. TACC	• Indicator of the relative abundance of giant crabs and the capacity of the fleet to catch the established TACC	• Recorded total catch by weight and numbers in logbook. Can also be validated by CDR records
4) Effort	• Indication of the amount of effort required to catch the established TACC	• Recorded in commercial logbooks
5) Sex Ratio	• Provides an indication of the reproductive capacity of the population	• Recorded in commercial logbooks
6) Pre-recruit Abundance Index	• Provides a measure of inter-annual changes in recruitment (undersized abundance) recorded in the commercial catch each year	• Recorded in commercial logbooks
7) Spawning Female Abundance Index	• Provides an indication of inter-annual changes in the abundance of spawning females in the population	• Recorded in commercial logbooks

An interim reference period from 1999/00 to 2002/03 has been selected to assist in the annual assessment of the performance of the fishery (Table 3). This period was chosen because it represents a period of relative stability following the introduction of a quota system incorporating a TACC for each zone. The reference period and performance indicators will be reviewed when a formal assessment process and a management plan for the fishery is developed (Sean Sloan, PIRSA Fisheries, personal communication).

Table 3. Reference range (interim) for key performance indicators for the South Australian giant crab fishery.

Performance Indicator	Reference Range
1) Total Average Catch Rate (kg.pot lift^{-1})	• 1.5 – 3.0
2) Mean Weight (kg)	• 2.96 – 3.65
3) Annual Commercial Catch *vs*. TACC	• Total catch within 15% of TACC
4) Effort	• Undefined
5) Sex Ratio	• Undefined
6) Pre-recruit Abundance (undersize crabs/pot lift)	• 1.6 – 1.7
7) Spawning Female Abundance	• Undefined

1.7 Research and Monitoring

Most of the field-based research conducted on giant crabs in southern Australia (Deakin University, Tasmanian Fisheries and SARDI Aquatic Sciences) has been reviewed by Kennelly (2000). This review concluded that the research provided considerable information on the biology and ecology of the giant crab (e.g. Gardner, 1997; Gardner *et al*., 1998; Levings *et al*., 1999; McGarvey *et al.*, 1999) that facilitated the establishment of a suitable minimum legal size (150 mm), but provided little information that could be used to establish total allowable catches. Research designed to assist the development of the aquaculture sector has also been conducted (Gardner and Northam 1998; Gardner and Maguire, 1998). More contemporary information on giant crab stocks has been provided in reports to the Fisheries Research and Development Corporation (Levings *et al*., 2001) and the Tasmanian Department of Primary Industries, Water and the Environment (Gardner *et al*., 2004).

From a fisheries management perspective, one of the most useful documents available on giant crabs is the report by McGarvey *et al*. (1999). This document provides a yield-per-recruitment analysis for Western Australia, South Australia and Victoria that suggests that the legal minimum length is appropriate for females but may only protect the first mature male instar. This assessment led to the recommendation that females should be monitored for decreasing numbers and sizes of spermathecae as a way to monitor the possible impact of the size limit on reproductive success (Kennelly, 2000). Most recent information (Levings *et al*., 2001) suggests that such monitoring may be of limited benefit as the functional maturity of crabs in a population may vary between locations and over time and may be density-dependent.

Kennelly (2000) also recommended that the most suitable direction for future research was for the Tasmanian Aquaculture and Fisheries Institute (TAFI) to develop a population model using both data from State-based programs and those obtained by Deakin University. It was suggested that this approach would overcome the current lack of information available for setting total allowable catches. It was recommended that the model should be developed in conjunction with a project to establish an industry-based sampling program to provide additional data. Upon completion of the model and establishment of the industry-based sampling program, it was suggested that these be adopted by other State agencies.

An integrated, length-based stock assessment model (Gardner *et al*., 2006) was applied to a broad range of data from the South Australian giant crab fishery during 2006. However, this model failed to provide any biologically meaningful outputs (Currie *at al.,* 2006). Several probable causes were identified, but attempts to overcome these were unsuccessful. As a consequence, it was recommended that future assessment modelling was not warranted, particularly given the small scale and low GVP of the fishery. necessary

Commercial fishers in South Australia have indicated a desire to undertake research to determine a suitable escape-gap size for pots, to allow pre-recruits to be released prior to pot hauling, and to ensure that interactions with other species are minimised. Although no specific by-catch studies have been conducted on giant crab fishing operations in South Australia, companion studies have been undertaken on the South Australian rock lobster fishery. This research suggests that the main by-product species taken in the giant crab fishery are octopus (*Octopus maorum*), rock lobster (*Jasus edwardsii*) and pink ling (*Genypterus blacodes*) (Brock *et al.*, 2004).

2 FISHERY STATISTICS

2.1 Introduction

Data on commercial giant crab catches and fishing effort in South Australian waters were drawn from compulsory logbooks filed by each commercial fisher. Fishers are required to provide information on fishing location, number of pots, depth, soak time, sex ratio, number of soft, berried, undersized and dead crabs, and catch weight. Currently, daily data are reported in the logbook and these are submitted at monthly intervals to SARDI Aquatic Sciences (Sloan, 2003). Logbooks used by rock lobster fishers have included information on both catch by number and catch by weight of giant crabs since 1994. Two dedicated giant crab licence holders have collected the same information since 2000. However, these licensees did not record detailed information on crab numbers prior to 2000.

For the purpose of these analyses, fishing effort has been determined as the number of pots deployed on each fishing trip. This metric assumes that pots were only deployed on one occasion on each fishing trip, and does not take into account variation in the duration of the deployment (soak time) nor the size of the pots employed.

Biases associated with such variables may be significant, particularly when the differential fishing practices of dedicated crab and rock lobster licence holders are considered. Dedicated crab fishers, for example, generally use large pots and have soak periods of several days when targeting giant crab; rock lobster fishermen by comparison, use relatively smaller pots, and deploy these for shorter periods (usually overnight). In an effort to account for this potentially large sectoral variation in catch rate, temporal and spatial summaries of catch and effort have been presented both collectively and separately for dedicated crab and rock lobster licence holders.

Before summarising catch and effort statistics from the database, several adjustments were necessary. These included the identification and correction of data entry and transcription errors, and the prediction of fishing effort for a small number of dedicated crab licence entries ("Miscellaneous" - Commonwealth endorsed) in the period between 1993 and 1997. This latter estimate was derived from the only reported measure of effort (number of boatdays) recorded during the period, and was included in all calculations, as crab landings during this period were historically high.

Measures of giant crab catch (weight in kg) and fishing effort (number of pot lifts) were aggregated by month, financial year and Marine Fishing Area (MFA). These classifications were chosen as inconsistent reporting frequencies by fishermen (daily to monthly) precluded any shorter-term comparisons, and because seasonal closures to the fishery were temporally and spatially confounded.

While every effort has been made to correct inaccuracies in the datasets, it should be noted that the data examined for this report have been collected by the commercial licensees and not by independent observers. Any errors in catch and effort (inadvertent or otherwise) cannot be differentiated from *bona fide* observations and therefore constitute a potential but indefinable error in the precision of the estimates provided. It should be further noted that less than 0.03% of entry fields in the data set contained zero returns (i.e. indicated that no crabs were taken). This extremely low ratio suggests that licensees either invariably catch crabs during each fishing trip, or alternatively, do not report fishing effort when no catches are recorded. If the latter is true then measurements presented for fishing effort will be underestimated while catch per unit effort (CPUE) will be overestimated in this report.

2.2 Catch, Effort and CPUE

2.2.1 Inter-annual Variation in Combined Catch, Effort & CPUE (1986 – 2008)

The total annual catch of giant crab landed by the commercial sector (i.e. dedicated "miscellaneous" licence holders + rock lobster licence holders with giant crab quota + rock lobster licence holders with crab by-product entitlement) has varied markedly since 1986/87 (Figure 4a). In the earliest years of the fishery less than 500 kg of crab were taken annually, but as markets developed for live product in the early 1990's, landings increased sharply to 7.4 tonnes in 1992/93. Catches continued to rise over the next two seasons and reached 28 tonnes in 1994/95. This decreased over the next two seasons but reached a historical high of 34.6 tonnes during 1998/99. While catches gradually declined over the following four seasons, they have remained relatively stable since 2002/03, at between 18 - 20 tonnes.

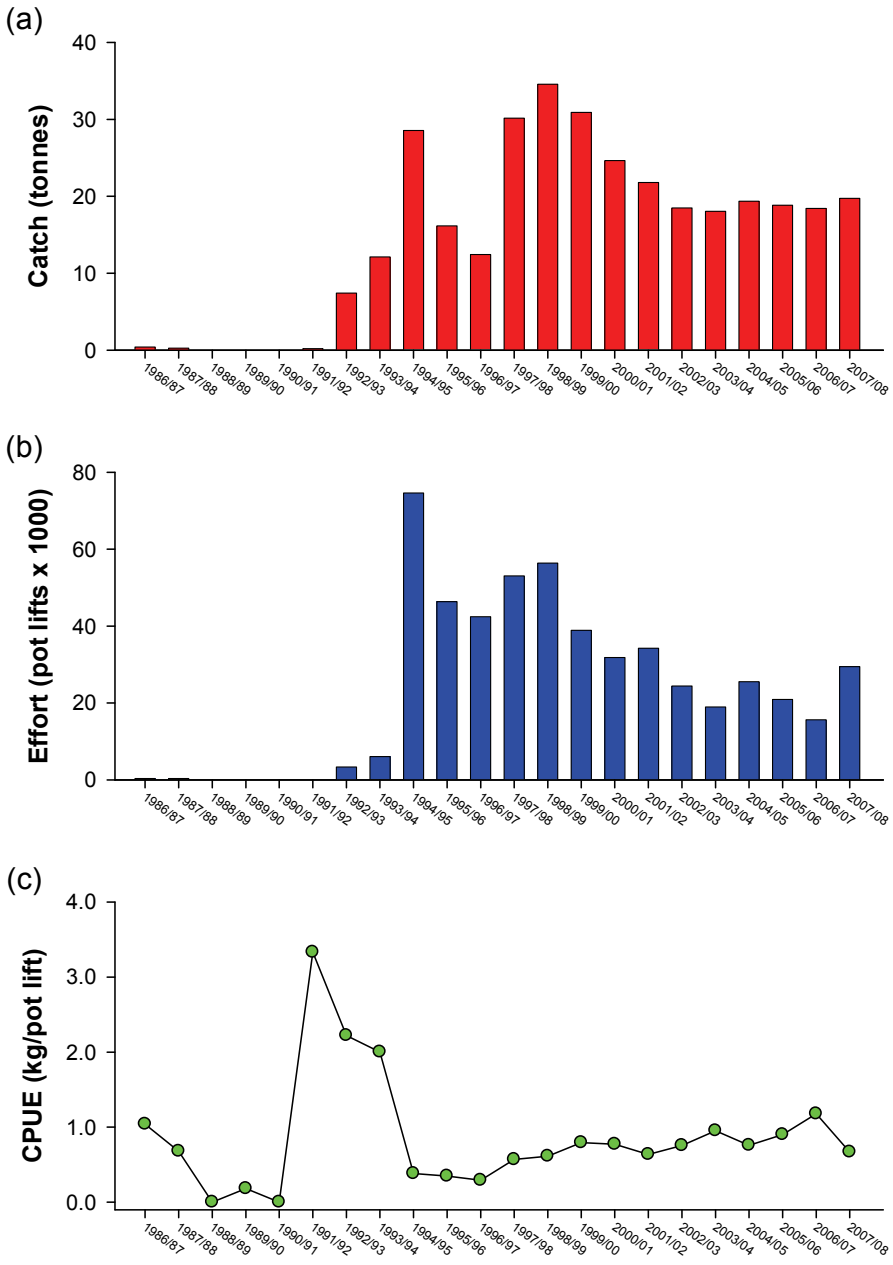

Figure 4. Inter-annual variation in a) total catch, b) fishing effort, and c) catch per unit effort (CPUE) for giant crab *Pseudocarcinus gigas* in South Australian waters.

Recent declines in crab landings are partly due to quota management arrangements introduced in 1999 to restrict future catches (Table 4). During 1999/00, almost 31 tonnes of crab were landed (19% more than the total seasonal quota of 26 tonnes). Of this total, most crab (64% by landed weight) was taken by miscellaneous licence holders principally engaged in fishing activities in the Northern Zone. A further 24% of the total catch during 1999/00 was taken by rock lobster licence holders with giant crab quota, while the remaining 12% was taken as by-product by lobster-only licence holders. During the following season (2000/01), the TACC was reduced by 3.9 tonnes to 22.1 tonnes. In response, total crab landings during this season dropped to 24.6 tonnes (approximately 12% more than the allotted quota). Over subsequent seasons crab catches were 1%, 16%, 18%, 12%, 15%, 17% and 11% less than the TACC. Miscellaneous licence holders took the greatest proportion of crab during the latest fishing season (2007/08; 72% of the landed weight, Table 4). By comparison, rock lobster quota holders and by-product-only fishers accounted for relatively lower proportions of the total landings during the 2007/08 season (18% and 10% of the total landed weight respectively).

There are several possible explanations for why the TACC has not been fully harvested in either zone since 2002/03. This may have been due to a range of market externalities (e.g. changing fuel costs and factors affecting demand such as the SARS virus outbreak in Asia and the downturn in global economic growth) that significantly altered the landed value of many seafood exports (e.g. giant crabs, lobster, prawns etc.). Over this period, fishers in a number of State fisheries decided to stop fishing because the cost of fishing was greater than the landed value attainable (Sean Sloan, PIRSA, personal communication). An alternative explanation is that the shortfall in catch is due to reduced stocks of giant crab, however recent trends in fishing effort and associated CPUE suggest this may not be the case.

Table 4. Total catch (kg) of giant crab taken in South Australian waters in each fishing zone since the establishment of TACC's in 1999. Note that no sectoral quotas are allocated prior to 2002/03, as the fishery was operated under a fully competitive TACC.

Season	Commercial Sector	Northern Zone	Southern Zone	Total Catch	Allocation
1999/00	Miscellaneous	15,104	4,535	19,639	-
	Rock Lobster Quota	3,254	4,082	7,336	-
	Rock Lobster By-product	1,081	2,843	3,924	-
	Total	19,439	11,460	**30,899**	-
	Total Allowable Commercial Catch (TACC)	13,400	12,600	26,000	-
2000/01	Miscellaneous	11,600	7,176	18,776	-
	Rock Lobster Quota	1,862	1,442	3,304	-
	Rock Lobster By-product	1,595	969	2,564	-
	Total	15,683	8,961	**24,644**	-
	Total Allowable Commercial Catch (TACC)	13,400	8,700	22,100	-
2001/02	Miscellaneous	9,016	5,514	14,530	-
	Rock Lobster Quota	2,478	1,329	3,807	-
	Rock Lobster By-product	1,984	1,457	3,441	-
	Total	13,478	8,300	**21,778**	-
	Total Allowable Commercial Catch (TACC)	13,400	8,700	22,100	-
2002/03	Miscellaneous	7,473	6,421	13,894	14,069
	Rock Lobster Quota	1,203	799	2,002	6,926
	Rock Lobster By-product	1,880	710	2,590	1,105
	Total	10,556	7,930	**18,486**	22,100
	Total Allowable Commercial Catch (TACC)	13,400	8,700	22,100	
2003/04	Miscellaneous	7,814	6,407	14,221	14,565
	Rock Lobster Quota	2,033	149	2,182	6,430
	Rock Lobster By-product	1,290	363	1,653	1,105
	Total	11,137	6,919	**18,056**	22,100
	Total Allowable Commercial Catch (TACC)	13,400	8,700	22,100	
2004/05	Miscellaneous	7,056	6,311	13,367	14,565
	Rock Lobster Quota	3,223	9	3,232	6,430
	Rock Lobster By-product	2,521	230	2,751	1,105
	Total	12,800	6,550	**19,350**	22,100
	Total Allowable Commercial Catch (TACC)	13,400	8,700	22,100	
2005/06	Miscellaneous	7,430	8,664	16,084	16,065
	Rock Lobster Quota	1,522	14	1,536	4,930
	Rock Lobster By-product	805	415	1,220	1,105
	Total	9,757	9,093	**18,850**	22,100
	Total Allowable Commercial Catch (TACC)	13,400	8,700	22,100	
2006/07	Miscellaneous	8,016	8,313	16,329	16,151
	Rock Lobster Quota	1,423	12	1,435	4,844
	Rock Lobster By-product	500	156	656	1,105
	Total	9,939	8,481	**18,420**	22,100
	Total Allowable Commercial Catch (TACC)	13,400	8,700	22,100	
2007/08	Miscellaneous	6,597	7,521	14,118	16,151
	Rock Lobster Quota	3,558	59	3,617	4,844
	Rock Lobster By-product	1,151	851	2,002	1,105
	Total	11,306	8,431	**19,737**	22,100
	Total Allowable Commercial Catch (TACC)	13,400	8,700	22,100	

The pattern in effort has broadly mirrored that of catch over the last two decades (Figure 4b). Since 1986/87, most fishing effort has been undertaken in the marine fishing areas (MFA's) comprising the Southern Zone of the giant crab fishery (Figure 5). The Southern Zone MFA's have also yielded historically higher catches than their Northern Zone counterparts, with the highest overall catch (81.7 tonnes of giant crab) for the period 1986/87 to 2007/08 being obtained from MFA 54. While similar total catches have been taken from both the Northern and Southern Zones since the commencement of the fishery (183.4 *vs*. 149.1 tonnes respectively), it is clear that the Southern Zone has historically constituted a more productive region, given that the total area fished is less than 1/5 of that fished in the Northern Zone. It should be noted, however, that the Southern Zone TACC is currently set at a lower level (8.7 tonnes) than that of the Northern Zone (13.4 tonnes), in recognition of the fact that greater fishing pressure was expended in the Southern Zone during the early developmental stages of the fishery, and to allow for further exploratory fishing in the NZ.

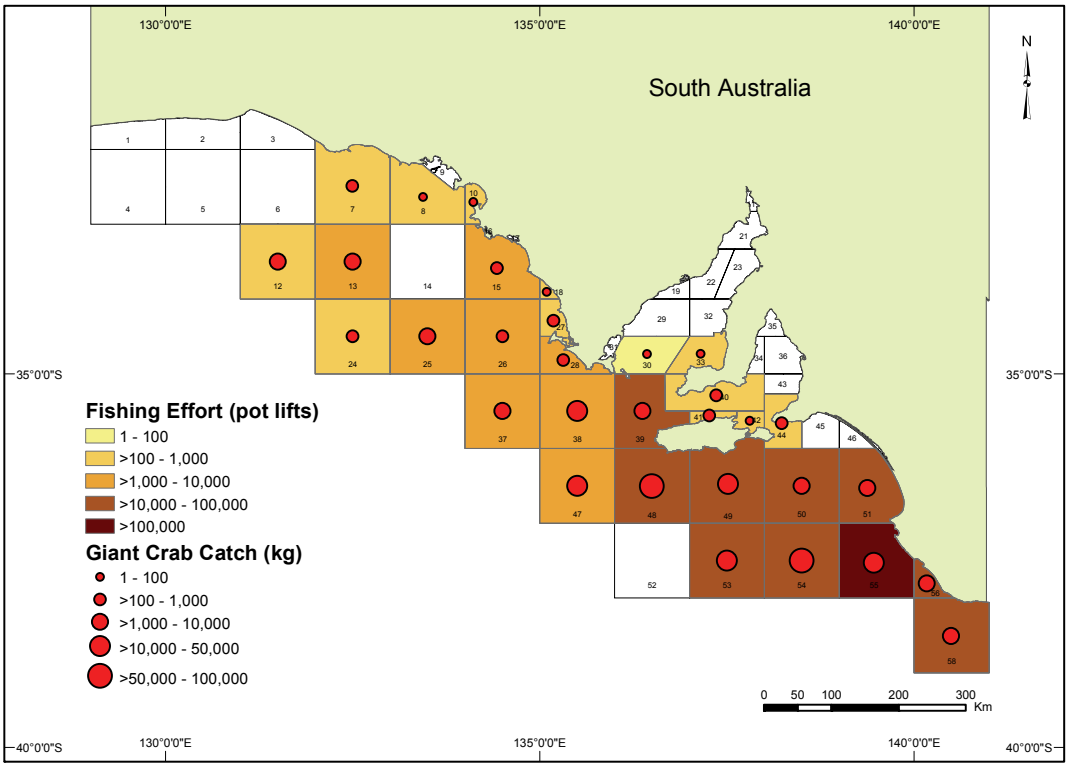

Figure 5. Distribution of total fishing effort and total giant crab catch for South Australian waters between 1986/87 and 2007/08. Numerals presented in each block denote the identity codes for each MFA.

Patterns in catch and effort have resulted in a gradual increase in the catch rate of giant crabs between 1994/95 and 2007/08 (Figure 4c). Distributional patterns in CPUE for the period 1986 to 2008 indicate that catch rates are generally higher in deeper offshore MFA's than in shallow nearshore waters (Figure 6). This gradient appears to hold true in both the Northern and Southern Zones, and presumably reflects habitat preferences and associated higher densities (or weights) of giant crabs near the edge of the continental shelf. A regression analysis of CPUE against depth (Figure 7a) confirms the strength of this relationship, and demonstrates that catch rates are higher on average in the deeper MFA's.

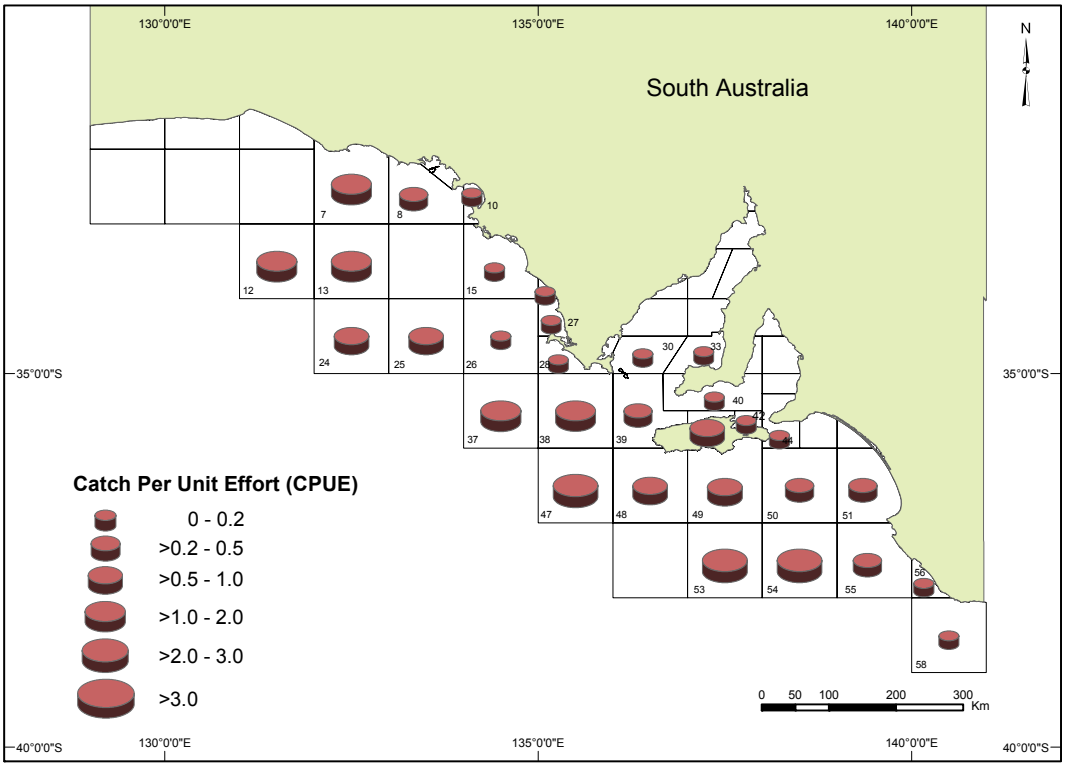

Figure 6. Distribution of total giant crab catch per total fishing effort (kg.pot lift^{-1}) for South Australian waters between 1986 and 2008.

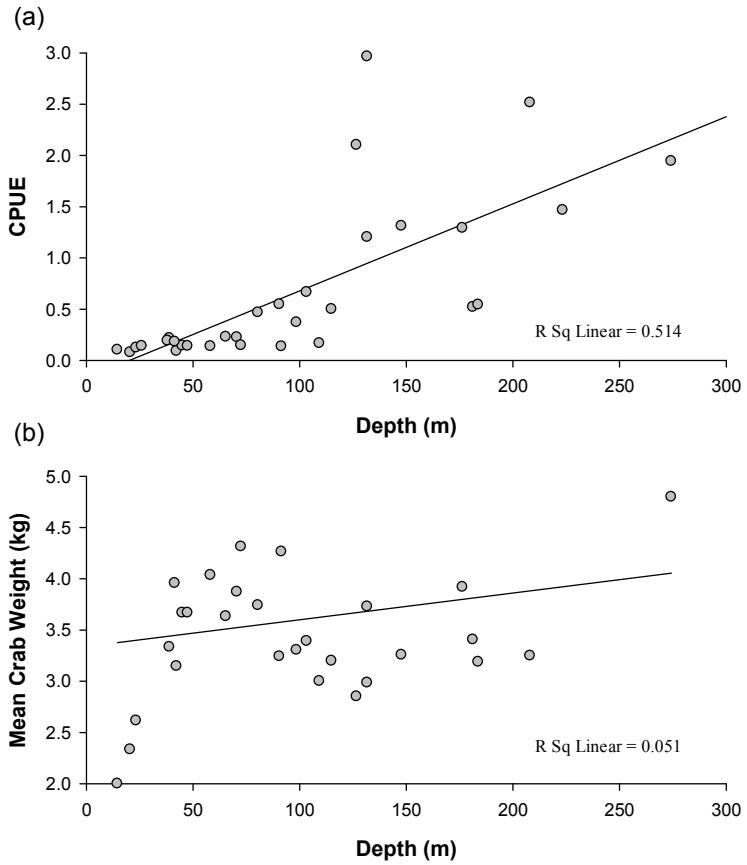

Figure 7. Plots showing the relationship between the average depth at 31 regional marine fishing areas and a) average catch per unit effort (CPUE) and b) mean weight of giant crab between 1986 and 2008.

Distributional maps showing the average crab weight caught in each fishing area did not show any clear geographic pattern (Figure 8). Regression analyses were therefore conducted to determine whether the elevated levels of CPUE in deeper habitats were a function of higher crab densities or higher crab weights (Figure 7b). Because this test failed to demonstrate any association between average crab weight and depth, it appears that higher rates of CPUE in deeper offshore waters reflect greater crab densities in these areas. Of course, several other variables (including depth related differences in trapping efficiency) may influence CPUE, but remain unmeasured.

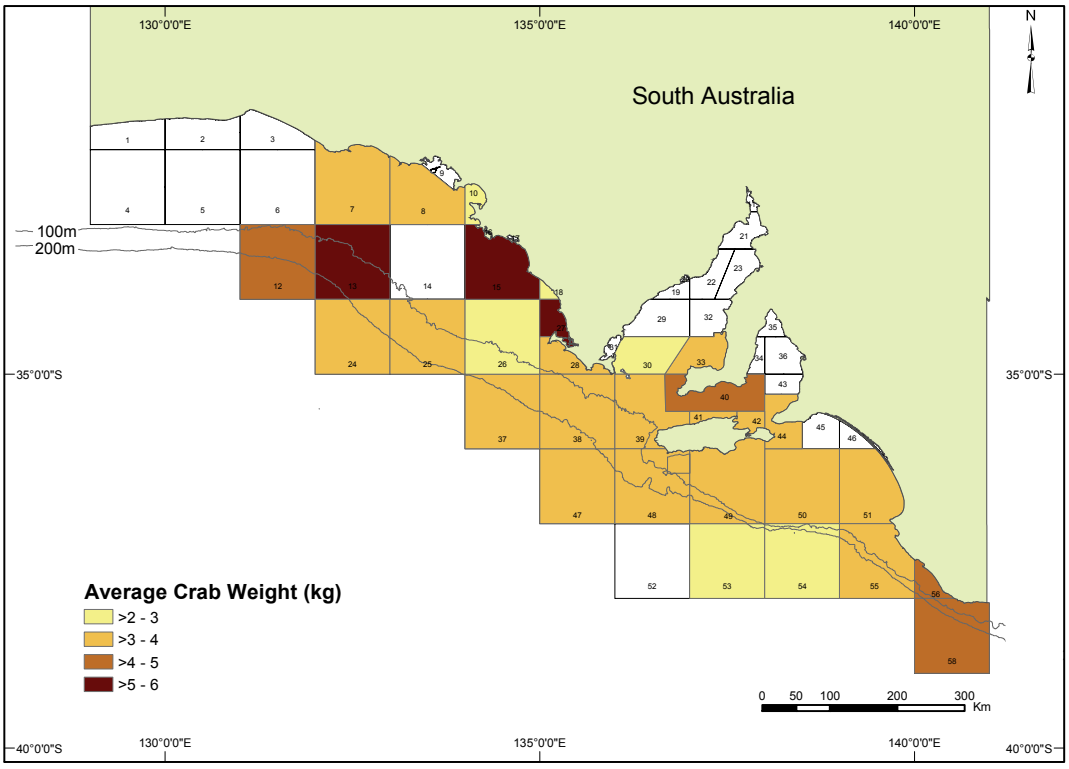

Figure 8. Map showing the average weight (kg) of giant crab taken in each commercial fishing sector in South Australian waters between 1986 and 2008.

Regional development of the fishery and associated exploitation of virgin crab stocks in previously unfished areas, have a capacity to markedly affect measures of CPUE. In 1992/93, at the commencement of a period of expansion, commercial giant crab fishing was concentrated in only 7 MFA's located principally in inshore waters (Figure 9). By 1994/95, however, areas targeted by commercial fishermen had expanded nearly 4 fold to 26 MFAs (almost half of which were located in offshore waters >100 m deep). Since then, a further 5 MFA's have been targeted, most recently MFA 7 & 12 in Northern Zone shelf-waters towards the Head of the Bight (Figures 2 & 9). Since the introduction of quotas in 1999, the number of MFA's fished has remained relatively stable (12 – 19), however the areas targeted are increasingly concentrated in the southeast of the State.

It is of some note that CPUE has broadly increased since the introduction of quotas, but it remains uncertain whether this trend underpins improvements in stocks. One possible explanation for the increase in CPUE may be the harvesting of virgin crab stocks in previously unfished areas. It is also possible that the recent trend of increases in CPUE represent increasing knowledge and experience among fishers regarding the locations of high-density giant crab populations.

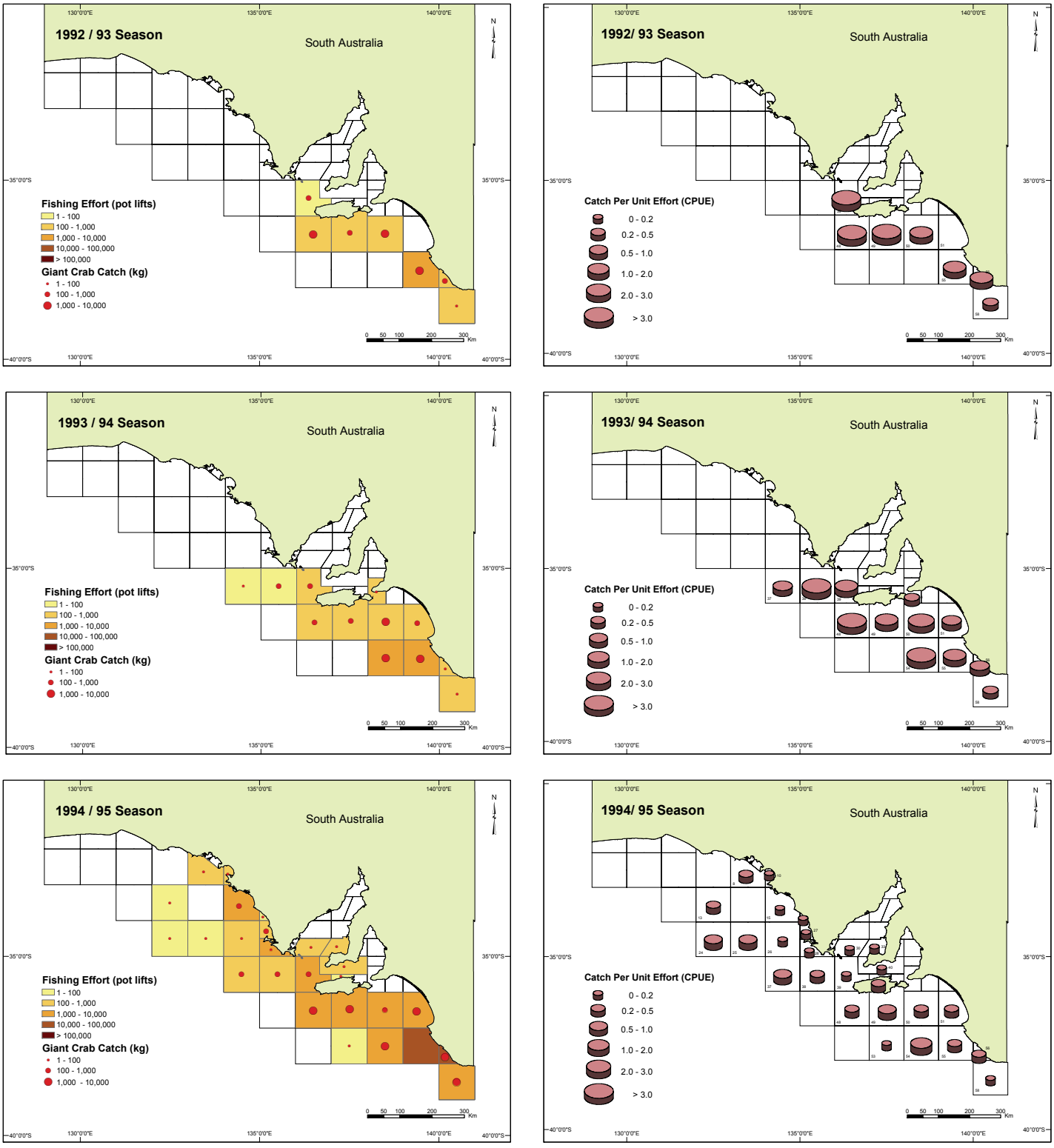

Figure 9. Distributional maps showing inter-annual variation in giant crab catches, fishing effort and catch per unit effort (kg.pot lift^{-1}) in South Australian waters between 1992 and 2008.

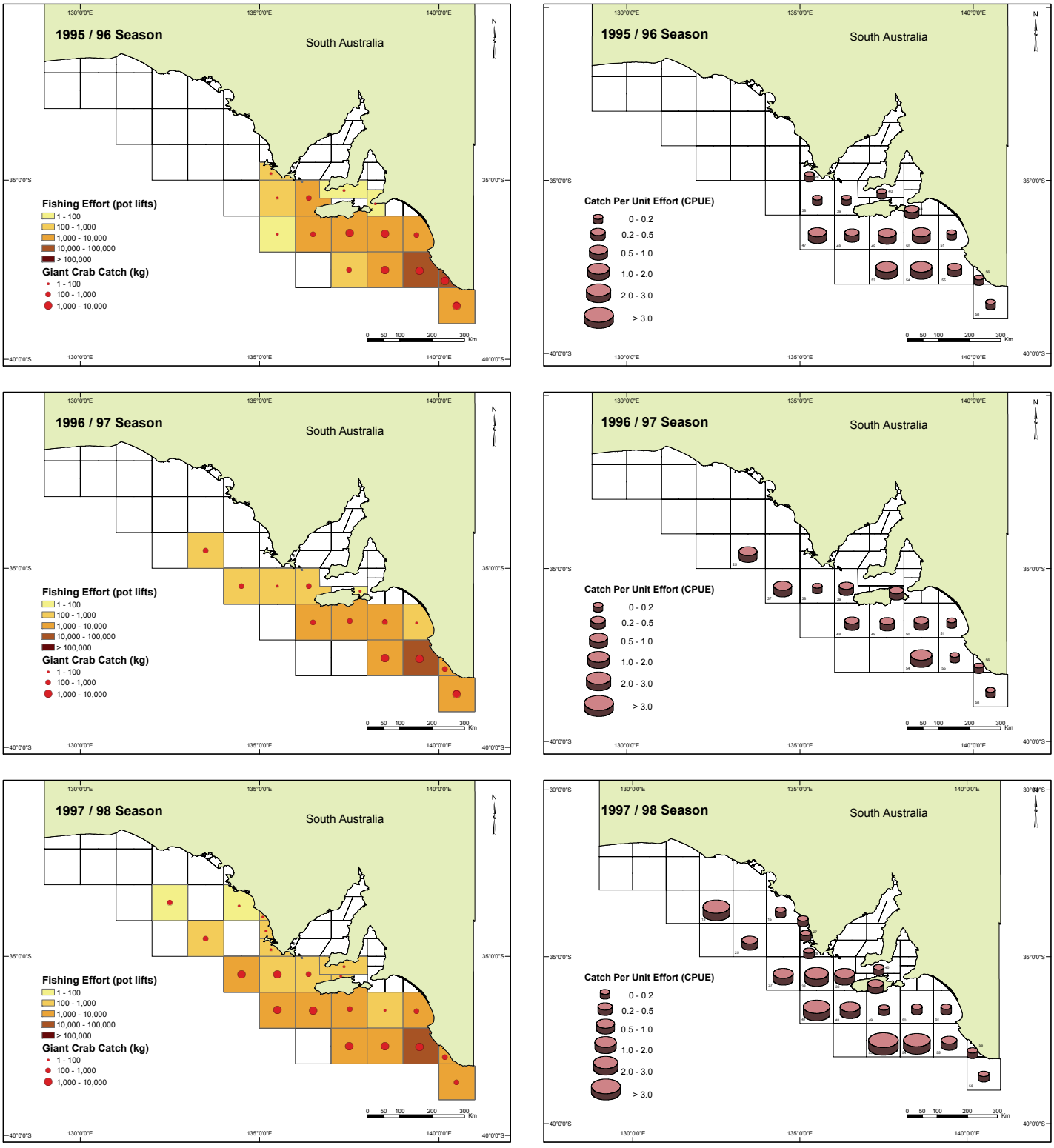

Figure 9 (continued). Distributional maps showing inter-annual variation in giant crab catches, fishing effort and CPUE in South Australian waters between 1992 and 2008.

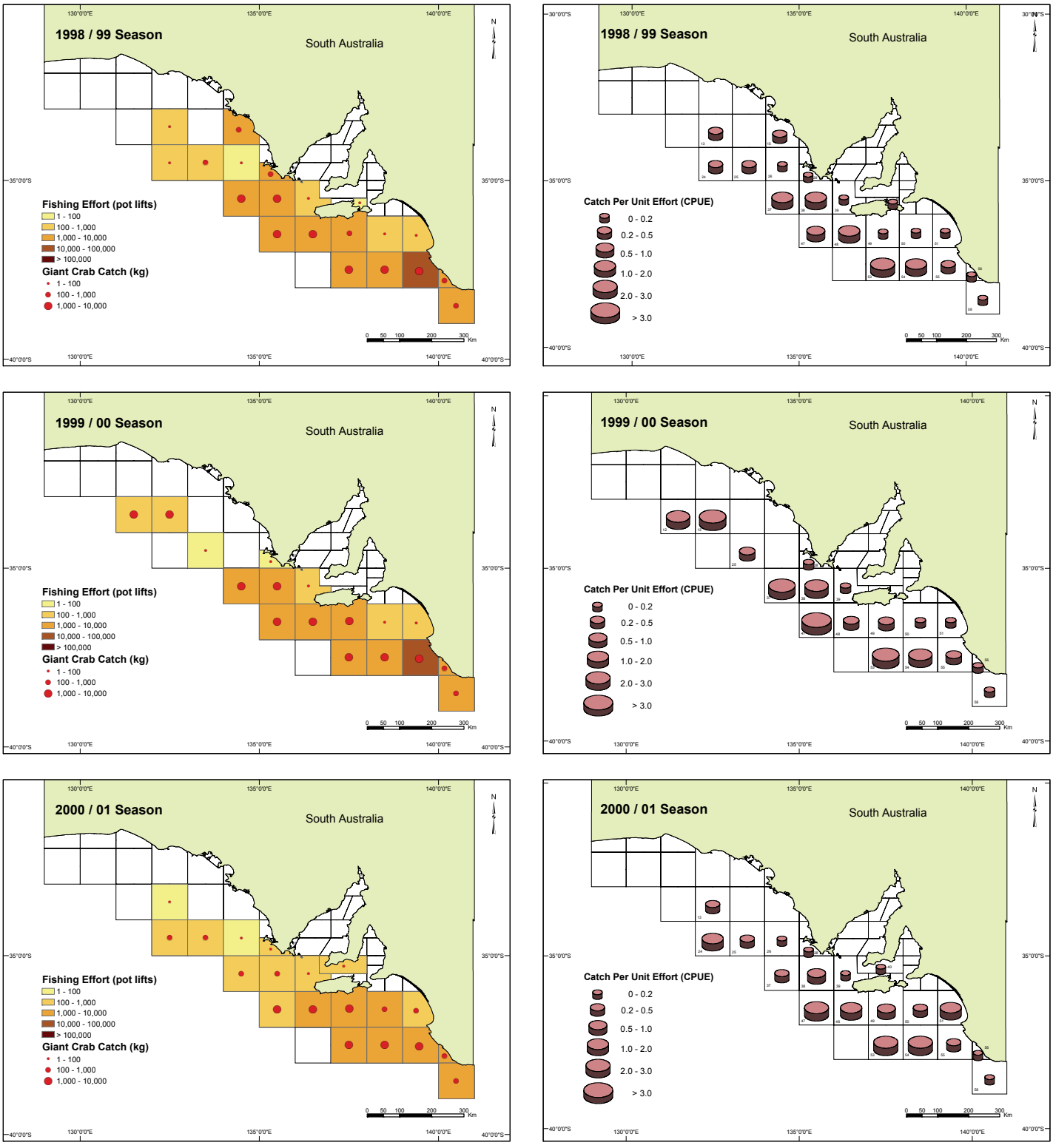

Figure 9 (continued). Distributional maps showing inter-annual variation in giant crab catches, fishing effort and CPUE in South Australian waters between 1992 and 2008.

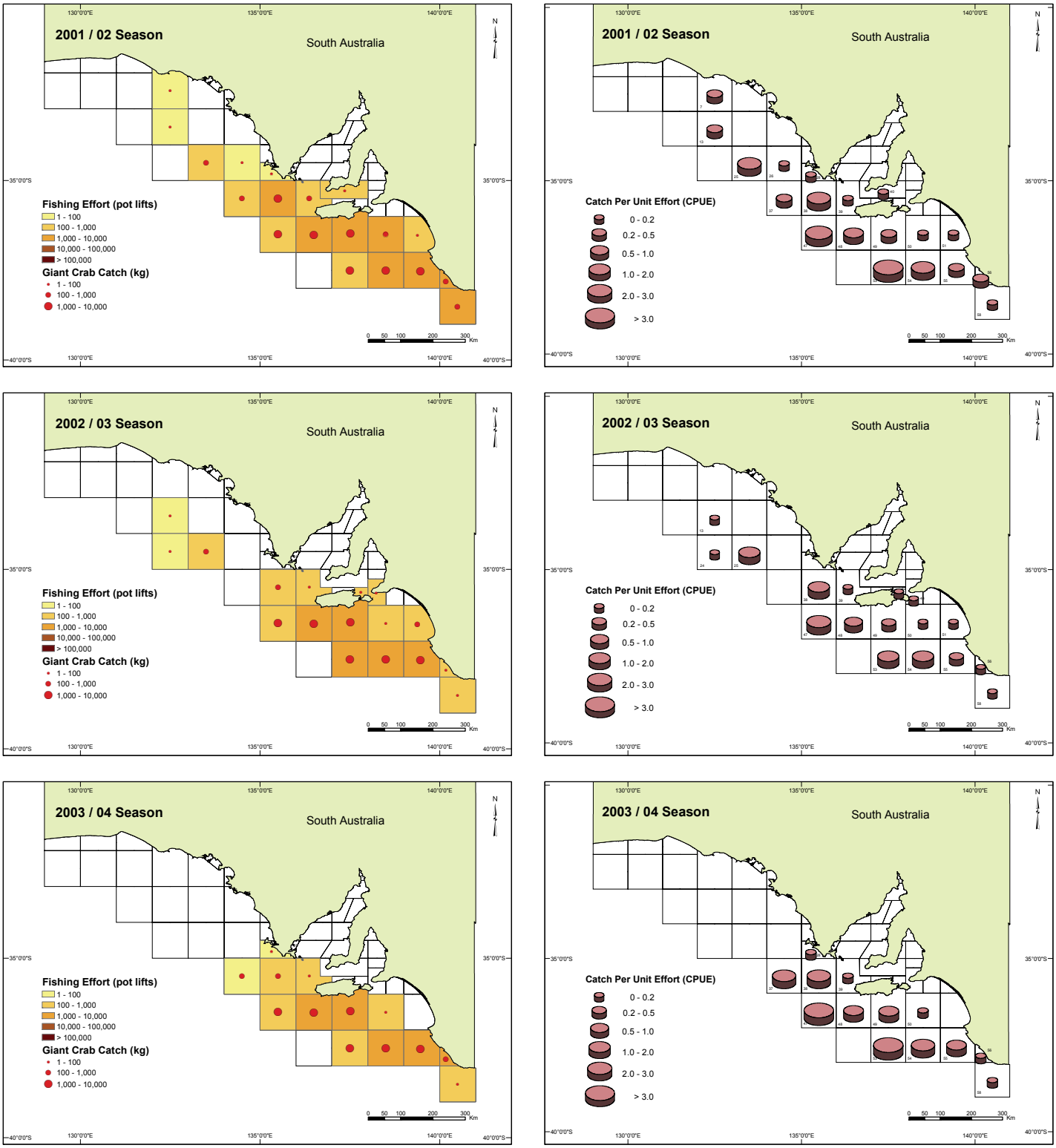

Figure 9 (continued). Distributional maps showing inter-annual variation in giant crab catches, fishing effort and CPUE in South Australian waters between 1992 and 2008.

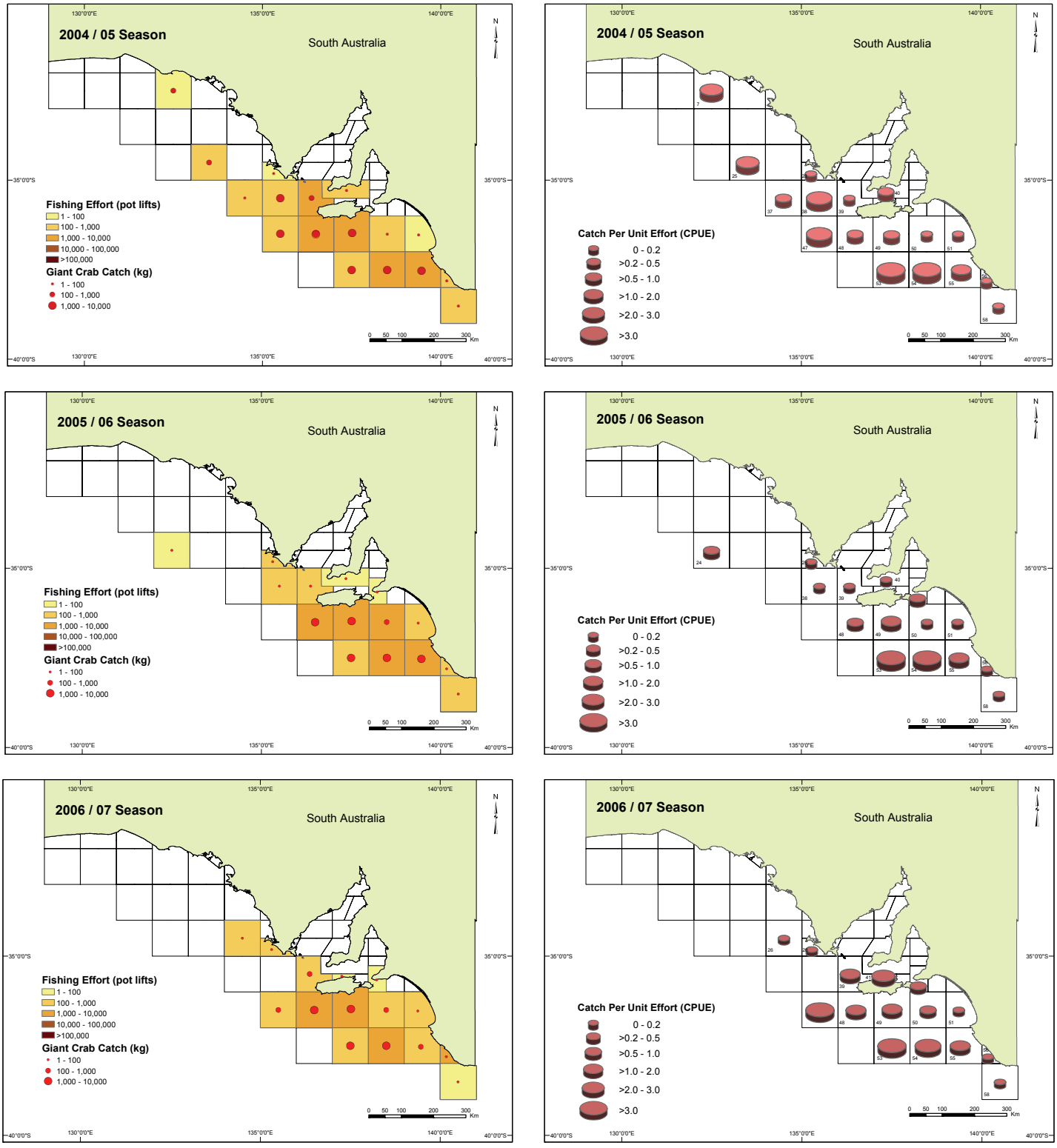

Figure 9 (continued). Distributional maps showing inter-annual variation in giant crab catches, fishing effort and CPUE in South Australian waters between 1992 and 2008.

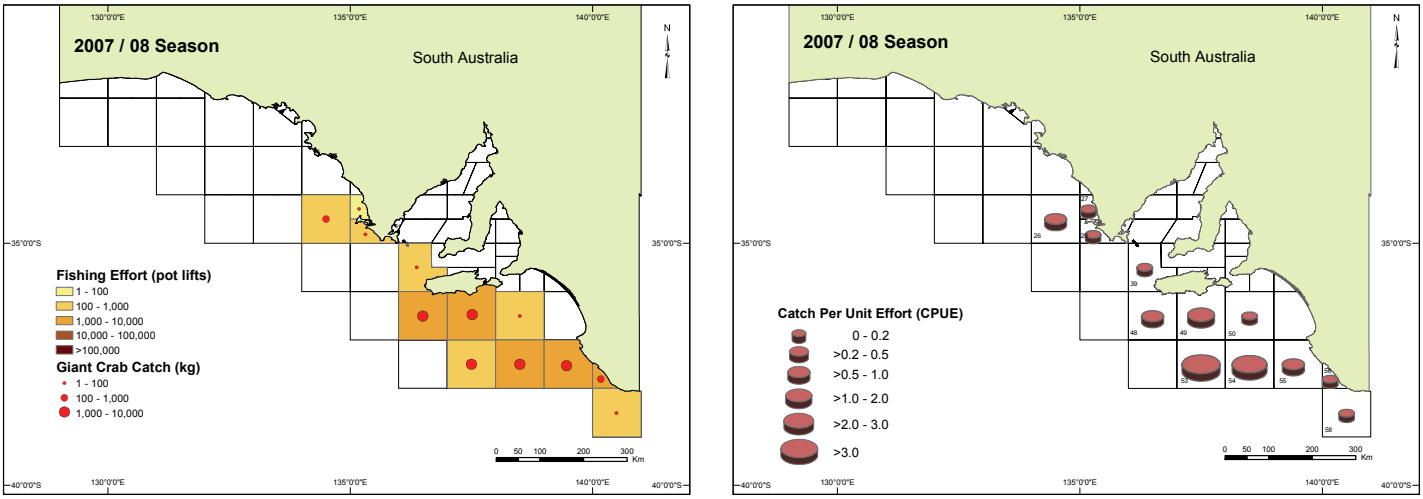

Figure 9 (continued). Distributional maps showing inter-annual variation in giant crab catches, fishing effort and CPUE in South Australian waters between 1992 and 2008.

2.2.2 Seasonal Variation in Combined Catch, Effort & CPUE (1986 – 2008)

Fishing during the 1980's and 1990's was conducted all year round although the majority of the catch was taken during the summer months. In 2000, seasonal closures were implemented between 1 May and 30 June in the Southern Zone, and 1 June and 31 October in the Northern Zone. These closures were designed to protect crab recruitment, and correspond with periods during which the highest proportion of female giant crabs carry eggs. They are also consistent with the moulting period and low market value. Since 2000, the proportion of catch taken during the summer months (November-January) has declined, however this period is still the main harvesting time (Figure 10). In the most recent fishing season (2007/08), crab landings varied little among months, but the collective catch for summer was still higher than that taken throughout autumn (i.e. 10.3 tonnes November-January *vs.* 7.5 tonnes February-April).

Seasonal trends in fishing effort have changed markedly between seasons since the start of the fishery, and particularly since the expansion of the industry in 1992 (Figure 10). In 1992/93, for example, most fishing effort occurred during May. By comparison, effort reached a peak in February during 1994/95, and was greatest in December during 2000/01. There are several possible explanations for these differences. Such shifts in effort may reflect the vagaries of the weather and number of fishable days in any given month or year. Alternatively, levels of fishing effort may reflect changing market values and demands for the product. There is, however, little evidence to suggest that seasonal and interannual variations in catch are due to differential catch rates. This is evidenced by the fact that catch has broadly paralleled effort between seasons and years since 1992/93 (Figure 10).

No consistent seasonal trends in CPUE were evident in the early years of the fishery (1992 to 1999; Figure 11). Over this period, CPUE fluctuated markedly and irregularly, and catch rates attained seasonal highs in excess of ~8 kg.pot lift^{-1} during several different months (October, May and December) in different years. In contrast, CPUE has remained relatively stable since the introduction of quotas in 1999 (Figure 11). Indeed, over the period 1999 – 2008, the collective monthly CPUE has consistently ranged between 0.3 and 2.6 kg.pot lift^{-1} during the fishing season.

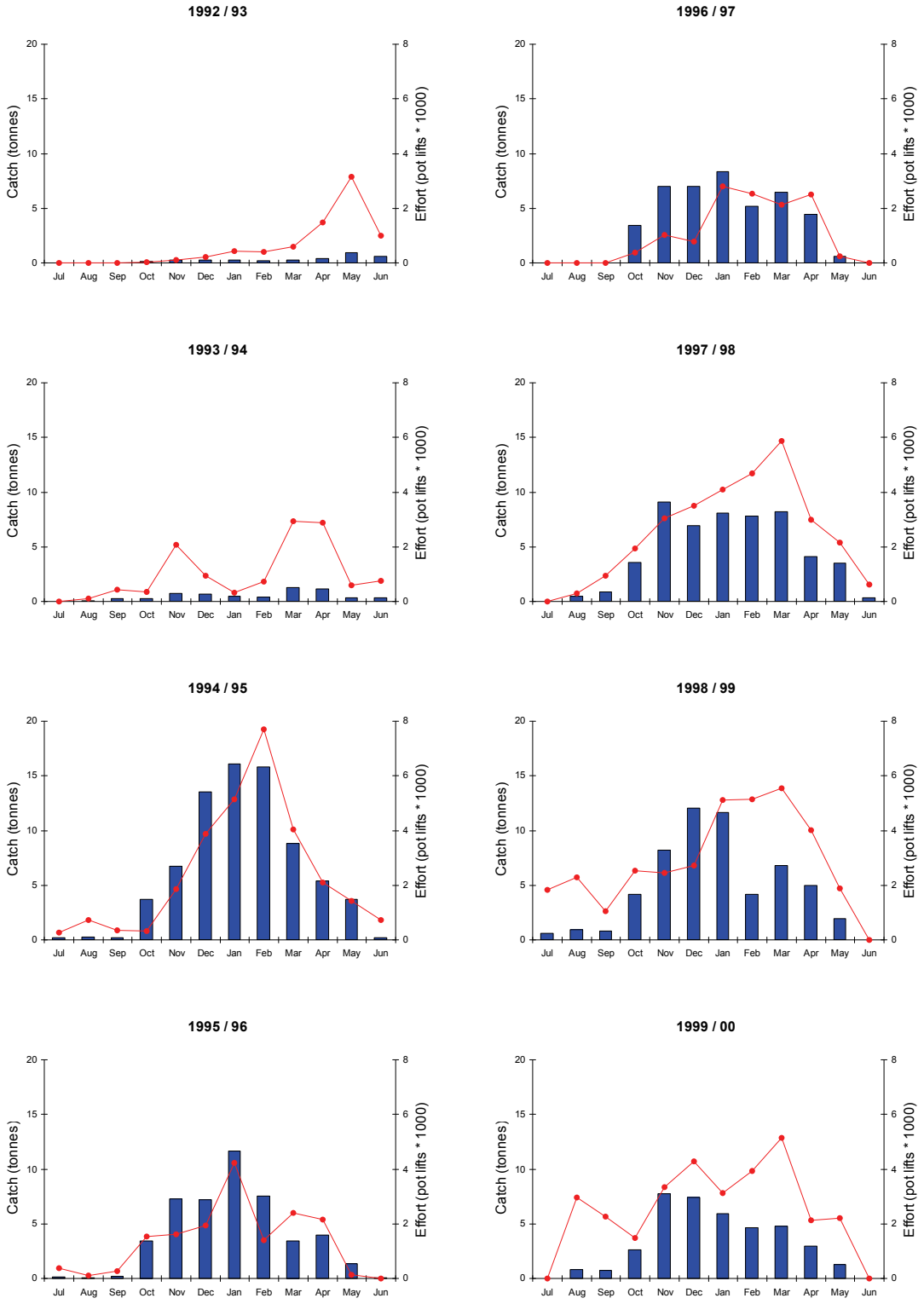

Figure 10. Within season variation in giant crab catches (solid blue bars) and fishing effort (solid red lines) between 1992 and 2008. Summary statistics presented for each month and financial year are state-wide totals for the combined commercial catch.

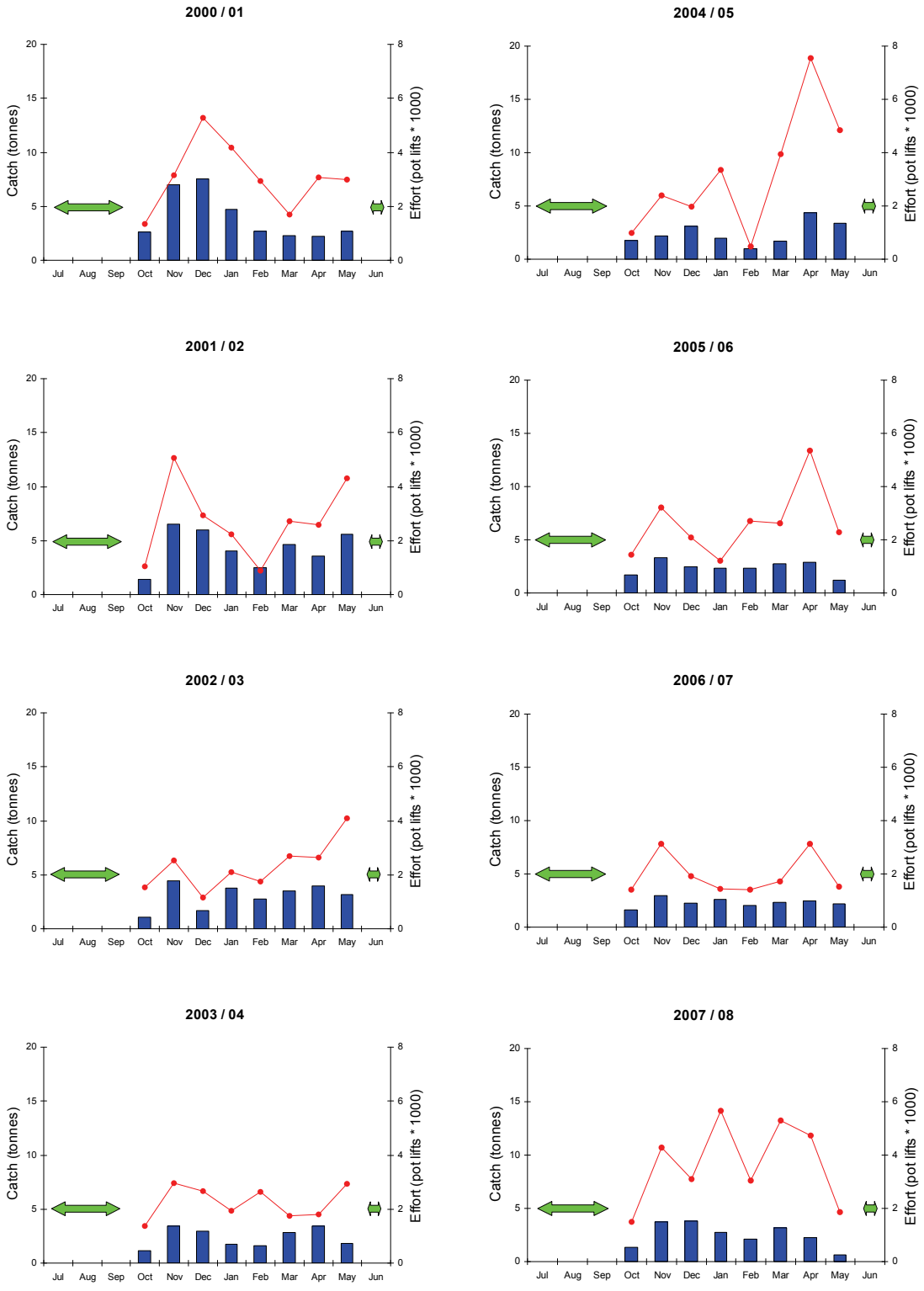

Figure 10 (continued). Within season variation in giant crab catches (solid blue bars) and fishing effort (solid red lines) between 1992 and 2008. Summary statistics presented for each month and financial year are state-wide totals for the combined commercial catch. Green arrows indicate seasonal closures introduced in June 2000.

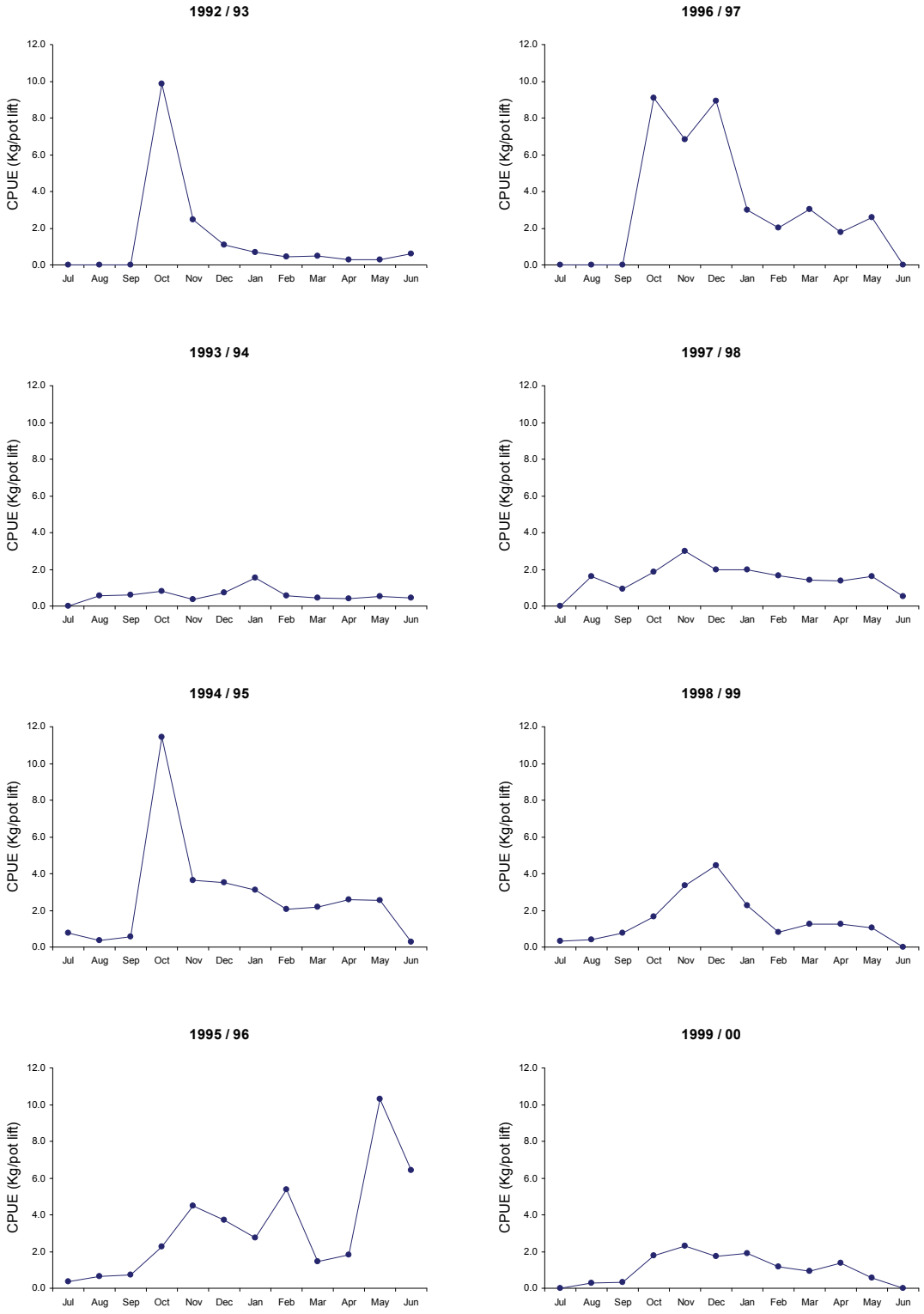

Figure 11. Seasonal variations in giant crab catch per unit effort (CPUE) between 1992 and 2008. Summary statistics presented for each month and financial year are derived from state-wide totals for the combined commercial catch.

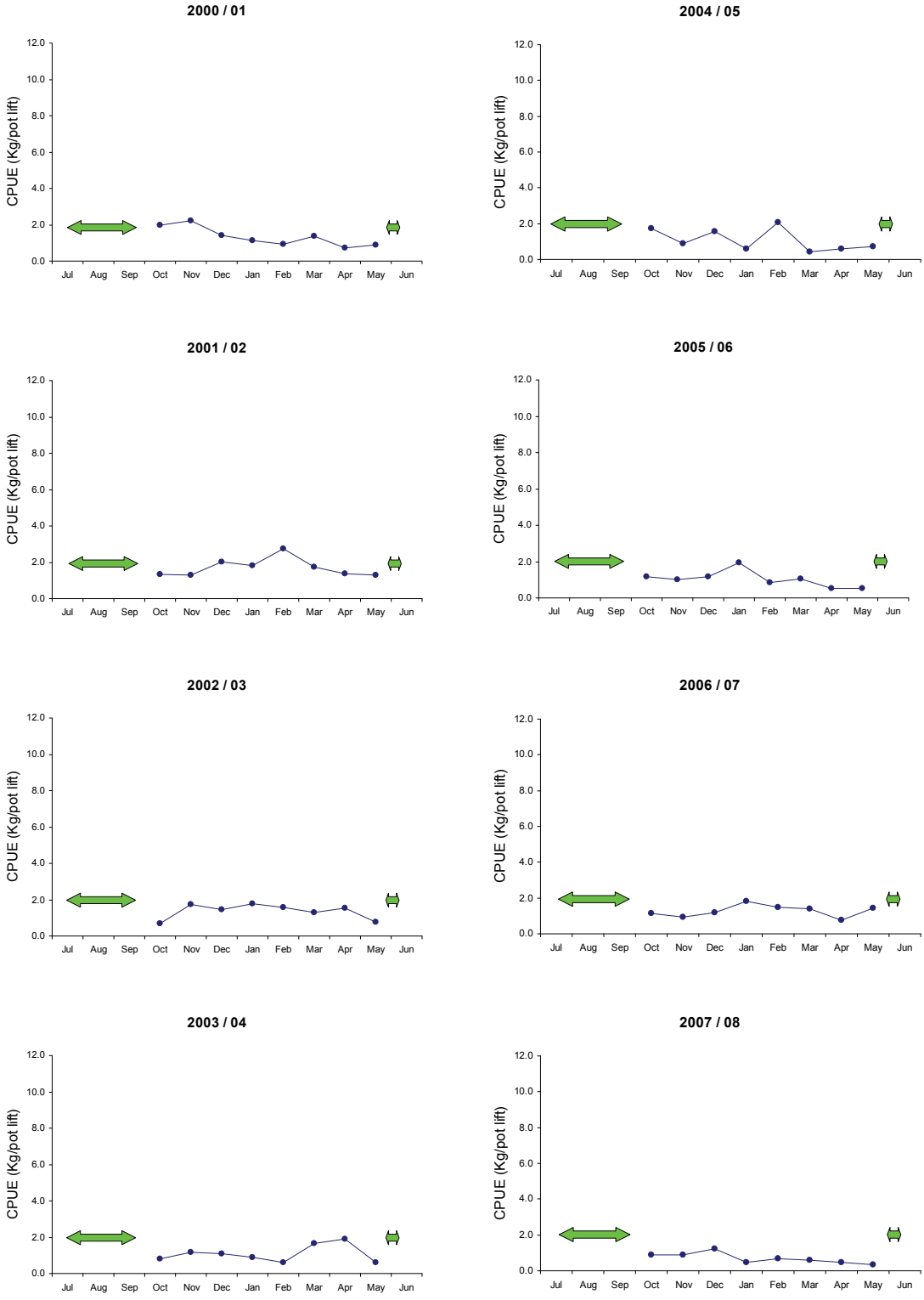

Figure 11 (continued). Seasonal variations in giant crab catch per unit effort (CPUE) between 1992 and 2008. Summary statistics presented for each month and financial year are derived from state-wide totals for the combined commercial catch. Green arrows indicate seasonal closures introduced in June 2000.

2.2.3 Inter-annual Variation in Catch, Effort and CPUE by Fishing Sector

Since the introduction of quotas in 1999, the proportion of the total catch landed by each commercial sector has remained relatively stable in the Northern Zone, but has varied considerably in the Southern Zone (Figure 12a). In the Northern Zone, seasonal landings by miscellaneous licence holders have ranged from 55–81% of the total catch, whilst rock lobster quota and rock lobster by-product sectors have taken 12–31% and 5–20% of the catch, respectively. In contrast, the relative catch landed by the miscellaneous sector in the Southern Zone has increased considerably in relation to both the rock lobster quota and rock lobster by-product sectors. During 1999/00, miscellaneous licence holders accounted for less than 40% of the catch, but by 2001/02 landings by this sector had increased to 66%. The proportional catch taken by the miscellaneous sector has subsequently increased in the Southern Zone. In 2006/07, >89% of all giant crab landed were caught by miscellaneous licence holders.

Changing levels of catch by each sector in the Southern Zone are consistent with shifts in the level of fishing effort applied by each sector. In 1999/00, the rock lobster by-product fishery accounted for 65% of the total effort in the Southern Zone (Figure 12b). Since then, the number of pots fished each season by this sector has gradually decreased. Between 1999/00 and 2006/07, effort in the Southern Zone rock lobster by-product fishery fell by more than 85%, and during 2006/07 represented just over 40% of the total fishing effort. Similar declines in effort have also occurred in the southern rock lobster quota fishery over the same period, while actual effort has remained relatively stable in the Southern Zone miscellaneous fishery (Figure 12b). By exception, a large increase in effort during the 2007/08 season by the rock lobster by-product sector has reversed the trend of diminishing effort for this group of fishers.

Although the share of catch taken by each fishing sector in the Northern Zone has remained relatively constant since 1999/00, the level of fishing effort applied annually by each sector has varied inconsistently among years (Figure 12b). In 1999/00, a similar number of pots (~5000) were deployed by all commercial sectors but by 2001/02 fishing effort was dominated by the rock lobster by-product sector (58%). In the Northern Zone during 2007/08, the rock lobster quota, rock lobster by-product and miscellaneous fisheries comprised 32% 58% and 10% of the total effort respectively.

Over the last nine seasons, catch rates in the miscellaneous fishery (i.e. Northern and Southern Zones) have been at least 4 times higher than those of the rock lobster quota fishery, and over 10 times higher than those in the rock lobster by-product fishery (Figure 12c; Table 5). This wide gap in catch rates among sectors reflects inherent approaches to fishing between the *ad hoc* by-product fishery and the targeted quota and miscellaneous fisheries. As a result, shifting levels of effort in the miscellaneous fishery have the most profound outcome on catch. During 2007/08, catch rates for the miscellaneous fishery were higher in the Northern Zone (4.03 kg.pot lift-1) than in the Southern Zone (2.92 kg.pot lift-1).

Table 5. Average catch rates (kg.potlift^{-1}) of giant crab taken in South Australian waters in each fishing zone and sector since the establishment of TACC's in 1999.

Commercial Sector	Northern Zone 1999-2008	Southern Zone 1999-2008	Average CPUE
Miscellaneous	2.99	2.56	2.79
Rock Lobster Quota	0.51	0.65	0.55
Rock Lobster By-product	0.18	0.12	0.15

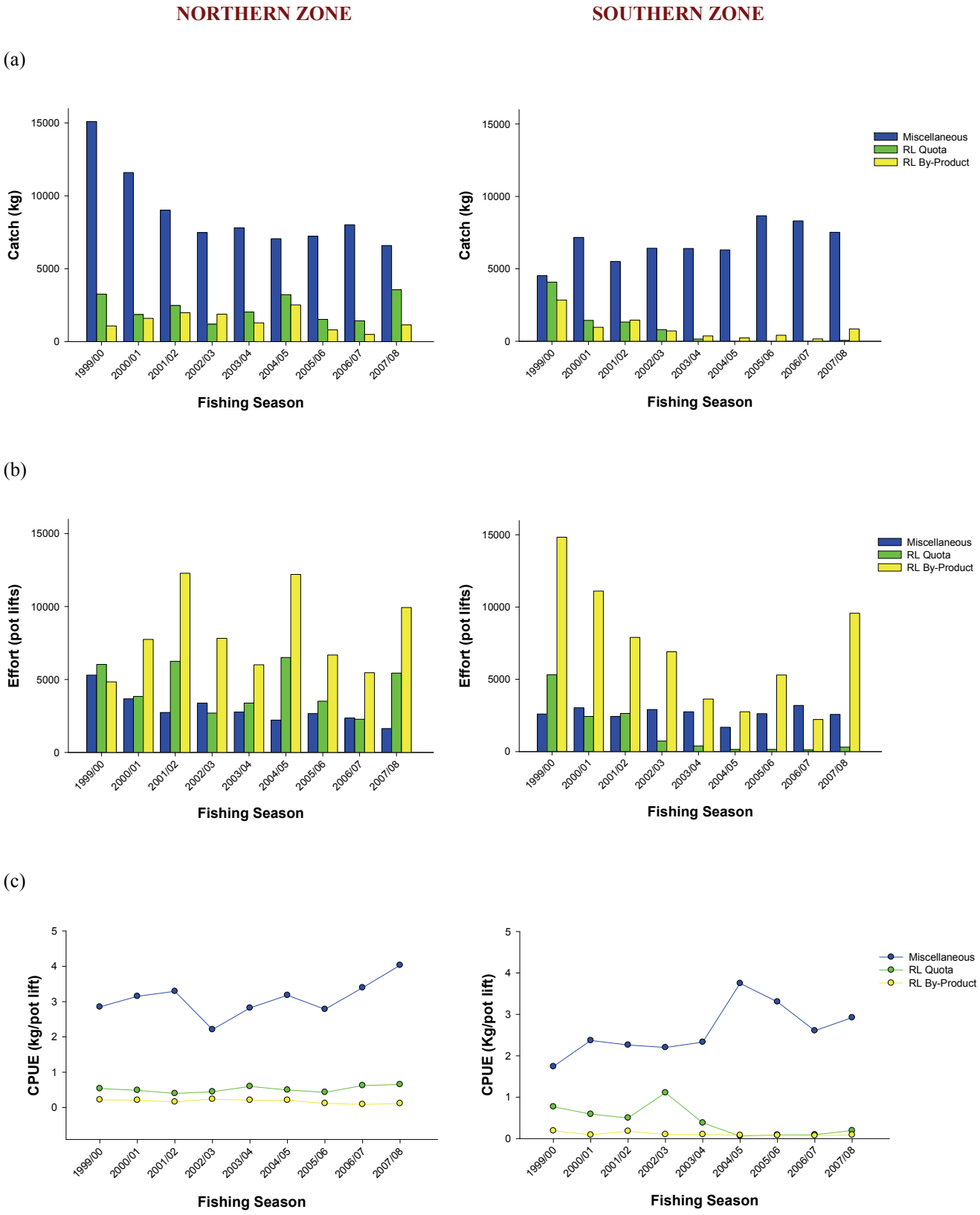

Figure 12. Plots of inter-annual differences in a) total giant crab catch, b) total fishing effort, and c) catch per unit effort between different fishing sectors (Miscellaneous, Rock Lobster Quota, and Rock Lobster By-product) and fishing zones (Northern and Southern) over the period 1999 to 2008.

2.3 Changes in Quota Holdings

Marked changes in quota holdings have occurred between fishing sectors since 2002/03, with rock lobster quota holders transferring permanently and leasing temporarily progressively larger volumes of their allocated catch to the miscellaneous sector (Table 6). As a result of permanent quota transfers, the total quota held by the miscellaneous sector has increased by 15% (2.1 tonnes) over the last six seasons. Most of this increase has resulted from quota transfers by rock lobster quota holders in the Southern Zone (1.5 tonnes), with transfers by quota holders in the Northern Zone accounting for less than a third of the total increase (0.6 tonnes).

Recent changes in quota holdings between the two principal commercial sectors (miscellaneous and rock lobster quota) appear to have had little direct effect on annual giant crab landings. Such changes may, however, be obscured by coincidental declines in crab landings within the by-product sector. Irrespectively, approximately 15% of the combined TACC has remained un-harvested each season since 2002/03. Most of this shortfall can be attributed to under-catch in the rock lobster quota sector. Over the last six seasons, 30-70% of the catch allocated to the rock lobster quota sector (4844-6926 tonnes) has not been landed. In 2007/08, 0.5 tonnes of crab in the Northern Zone, and 0.7 tonnes of crab in the Southern Zone remained uncaught by the rock lobster quota sector. By comparison, the catch allocated to the miscellaneous sector over the last six seasons has generally been landed.

Table 6. Giant crab quota (tonnes) allocated to each fishing sector and zone since the establishment of TACC's in 1999. No sectoral quotas are allocated prior to 2002/03, as the fishery was operated under a fully competitive TACC.

Season	Quota		Miscellaneous		By-product		Total
	NZ	SZ	NZ	SZ	NZ	SZ	
1999/00	-	-	-	-	-	-	26,000
2000/01	-	-	-	-	-	-	22,100
2001/02	-	-	-	-	-	-	22,100
2002/03	4,690	2,236	8,040	6,029	670	435	22,100
2003/04	4,690	1,740	8,040	6,525	670	435	22,100
2004/05	4,690	1,740	8,040	6,525	670	435	22,100
2005/06	4,190	740	8,540	7,525	670	435	22,100
2006/07	4,104	740	8,626	7,525	670	435	22,100
2007/08	4,104	740	8,626	7,525	670	435	22,100

3 PERFORMANCE INDICATORS

This section provides a report on the performance of the fishery against the interim performance indicators and reference points for the giant crab fishery as defined in Sloan (2003) and documented in Table 2 (Section 1.5). Insufficient data were available to assess the abundance of spawning females. Further, no upper or lower reference points are defined for sex ratio or spawning female abundance. Values of each PI in 2007/08 were derived from data provided by the miscellaneous and rock-lobster quota licence holders only.

3.1 Northern Zone

There are seven biological PI's specified for giant crabs in the NZ (Table 7; Figure 13). Data are available to assess fishery performance against six:

The targeted catch in the NZ in 2007/08 was 10.16 tonnes (Table 7). This represented 75.8% of the TACC (13.4 tonnes). This is below the lower reference point (85% of the TACC).

Total effort in the NZ was 7,082 potlifts in 2007/08. This value was within the reference range (6,076 – 11,331 potlifts).

During 2007/08, the catch rate in the NZ was 1.43 kg.potlift^{-1}. This value was outside the reference range (1.5 – 3 kg.potlift^{-1}), but did not exceed the lower reference point by >15%.

The mean weight of crabs harvested in the NZ in 2007/08 was 2.81 kg. This value was outside the reference range (2.96 – 3.65 kg), but did not exceed the lower reference point by more than 15%.

During 2007/08, the pre-recruit abundance in the NZ was 2.32 crabs.potlift^{-1}. This value was outside the reference range (1.6 – 1.7 crabs.potlift^{-1}), and more than 15% greater than the upper reference point.

The sex ratio (males:females) in the NZ in 2007/08 was 1:0.98.

3.2 Southern Zone

There are seven biological PI's specified for giant crabs in the SZ. Data are available to assess fishery performance against six:

The targeted catch in the SZ in 2007/08 was 7.58 tonnes (Table 7). This represented 87.1% of the TACC (8.70 tonnes). This exceeds the lower reference point (85% of the TACC).

Total effort in the SZ was 2,880 potlifts in 2007/08. This value was outside the reference range (3,637 – 7,910 potlifts), and was more than 15% below the lower reference point.

During 2007/08, the catch rate in the SZ was 2.63 kg.potlift^{-1}. This value was within the reference range (1.5 – 3 kg.potlift^{-1}).

The mean weight of crabs harvested in the SZ in 2007/08 was 2.94 kg. This value was outside the reference range (2.96 – 3.65 kg), but did not exceed the lower reference point by >15%.

During 2007/08, the pre-recruit abundance in the SZ was 2.22 crabs.potlift^{-1}. This value was outside the reference range (1.6 – 1.7 crabs.potlift^{-1}), and more than 15% greater than the upper reference point.

The sex ratio (males:females) in the SZ in 2007/08 was 1:1.01.

Table 7. Key performance indicator estimates for the South Australian giant crab fishery in 2007/08. Note that all estimates presented here are derived from the miscellaneous and rock lobster quota fisheries only, and do not include information obtained from rock lobster by-product sector. Note also that the reference points for fishing effort have been calculated for the period 1999/00 – 2003/04, as they were not defined in the management plan. Values below the lower reference point are highlighted in red, while values exceeding the upper reference point are highlighted in green.

Location	Indicator	Upper Reference Point	Lower reference Point	Value in 2007/08
NZ	Catch (tonnes)	TACC	85% of TACC	75.8% of TACC
	Effort (pot lifts)	11331	6076	7,082
	Catch rate (kg.potlift^{-1})	3	1.5	1.43
	Mean weight (kg)	3.65	2.96	2.81
	Pre-recruit abundance (no.potlift^{-1})	1.7	1.6	2.32
	Sex ratio (M:F)	Not defined	Not defined	1:0.98
	Spawning female abundance	Not defined	Not defined	No data
SZ	Catch (tonnes)	TACC	85% of TACC	87.1% of TACC
	Effort (pot lifts)	7910	3637	2,880
	Catch rate (kg.potlift^{-1})	3	1.5	2.63
	Mean weight (kg)	3.65	2.96	2.94
	Pre-recruit abundance (no.potlift^{-1})	1.7	1.6	2.22
	Sex ratio (M:F)	Not defined	Not defined	1:1.01
	Spawning female abundance	Not defined	Not defined	No data

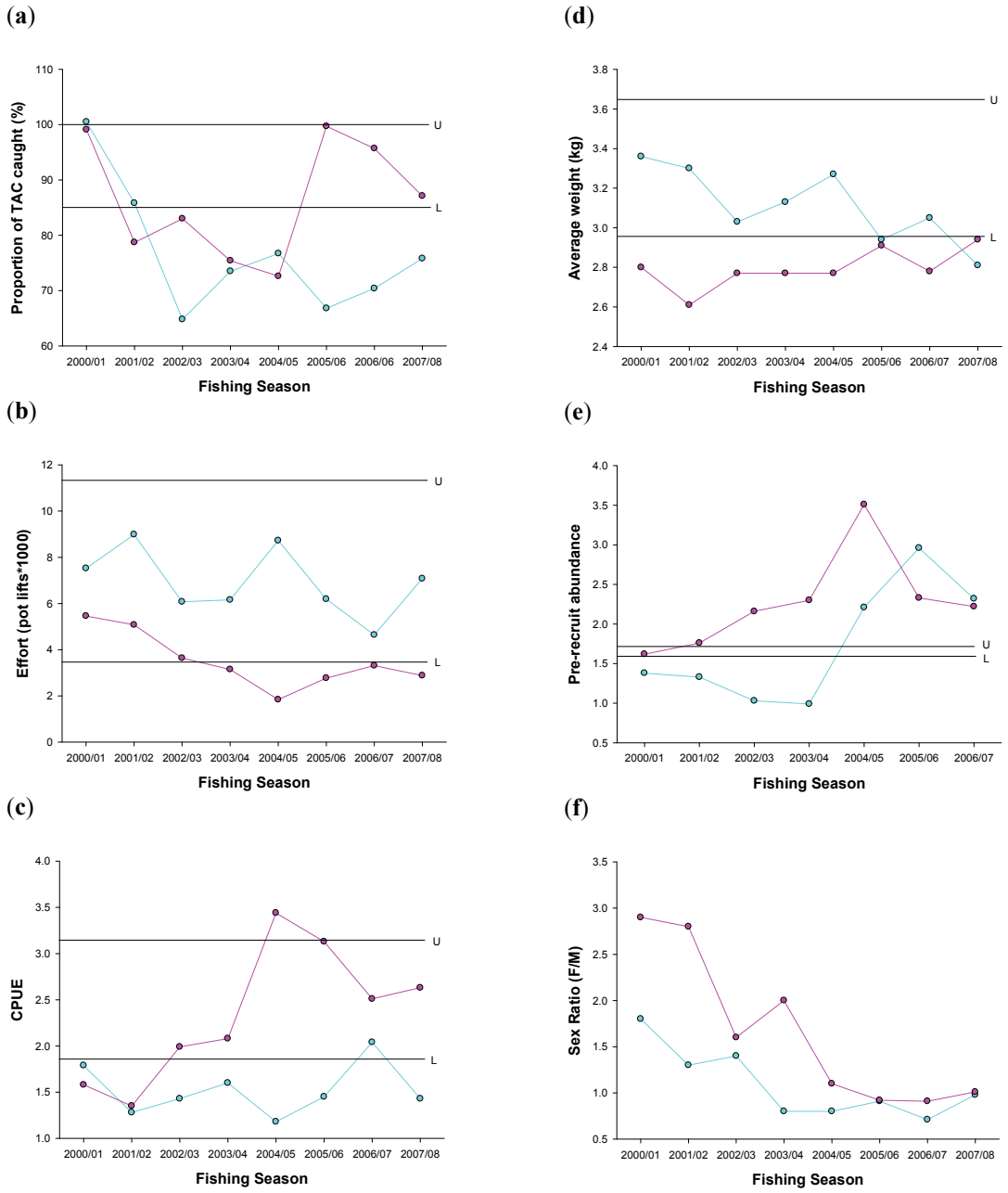

Figure 13. Plots of inter-seasonal differences in key performance indicators for the Northern Zone fishery (solid blue lines) and Southern Zone fishery (solid purple lines). Plots include a) catch as percentage of the TACC, b) fishing effort, c) catch per unit effort (kg.pot lift^{-1}), d) mean crab weight ± s.e., e) abundance of undersized (<150mm) crabs per pot lift, and f) the sex ratio. Horizontal lines in each graph indicate the upper (U) and lower (L) performance reference points. Note that all estimates presented here are derived from combined miscellaneous and rock lobster quota data only (i.e. they do not include information obtained from the rock lobster by-product sector).

4 DISCUSSION

4.1 Status of the Giant Crab Fishery

Assessment of the South Australian giant crab fishery is entirely dependent on the analysis and interpretation of fishery-dependent (catch and effort) information. Furthermore, data are primarily limited to the miscellaneous and rock lobster quota licence holders that presently harvest ~ 90% of the total catch. As in all fishery assessment reports, the available data and information are used within the limitations governed by their level of uncertainty.

In this assessment, we have used catch-per-unit-effort (CPUE), along with other measures, to assess stock status. The use of CPUE as an index of abundance is reliant on the assumption that changes in CPUE reflect changes in the size of the fishable stock. Unfortunately, CPUE can also be strongly influenced by numerous other factors, including changes in fisher participation, changes in fishing efficiency and variations in fisher knowledge. Furthermore, measures of CPUE integrate spatial variation, and so high CPUE in previously unfished MFAs or unfished areas within MFAs may mask possible declines in CPUE in areas that have been fished more consistently. The poor understanding of the relationships between CPUE and stock abundance in this fishery highlight the need to monitor a range of appropriate fishery performance indicators.

4.1.1 Whole Fishery

Total catch increased substantially from <10 tonnes.yr^{-1} prior to 1993/94 to ~35 tonnes in 1998/99. Thereafter, catches declined annually but have remained relatively stable since 2001/02, at between 18 - 20 tonnes. Despite this recent stability, the TACC has not been harvested since 2001/02; the fraction of the TACC not harvested has exceeded 11% since 2001/02.

Patterns in effort are similar to those of catch, and have generally decreased over the last decade. These patterns in catch and effort have resulted in a general increase in the catch rate of giant crabs between 1994/95 and 2007/08. While these patterns are difficult to interpret, the increase in catch rate over this period most likely reflects improvements in effective fishing effort rather than substantial increases in the biomass of giant crabs.

Few consistent patterns in the data for each of the two zones were observed, which further complicates this assessment. For example the mean weight of crabs harvested since 2000/01 has declined in the NZ but increased in the SZ. In addition, the numbers of pre-recruits captured have followed quite different seasonal trends in both the NZ and SZ. The exception is that the fraction of the catch comprising females has declined in both zones over the last seven years. If the observed reduction in the proportion of females harvested reflects a real change in the population structure of the crab stock, then reduced levels of recruitment may be predicted for the fishery.

4.1.2 Northern Zone

Targeted catches in the NZ have declined over the past seven years and, with declining levels of effort, have resulted in a marginally lower CPUE. Furthermore, the TACC has not been harvested since 2000/01. In 2007/08, <80% of the TACC was harvested. The reasons why the catch rate has marginally declined and the TACC has not been harvested should be identified because, in combination, these patterns suggest the exploitable biomass of giant crabs in this zone may have declined during the last seven years. The increase in pre-recruit abundance between 2003/04 and 2007/08 could suggest that recruitment levels in the NZ have increased over this period, but may also indicate increased entry rates of small crabs into pots containing fewer large crabs.

4.1.3 Southern Zone

In contrast to the NZ, targeted catches in the SZ have increased over the last seven years. During the same time period, effort has decreased. This combination has resulted in substantial increases in catch rate, with CPUE in 2007/08 almost twice that observed in 2000/01 (but still 30% below 2004/05). These data suggest that 1) the exploitable biomass of giant crabs in the SZ may have increased in recent years, 2) that effective effort has increased, or 3) some combination of these two factors. Given these observations, it should also be noted that there has been a small under-catch in the SZ during four of the last six seasons (8% of targeted TACC not harvested during 2007/08). As for the NZ, the reasons why the TACC has not been harvested should be determined and documented.

In summary, the paucity of data available for this fishery prevents an unequivocal assessment of the status of the giant crab resource. The high proportion of the TACC not being harvested in the NZ is concerning, as is the decline in numbers of females and mean weights. While the remaining data provide limited guidance in regard to stock status, there is evidence of differences in fishery performance between the zones. Overall, the stock status of the SZ appears stronger than the NZ.

4.2 Current Performance Indicators

The current Performance Indicators for this fishery include a wide range of fishery-dependent data. These include catch, effort, catch rate, mean weight, pre-recruit abundance, sex ratio and abundance of spawning females. The absence of any PI based on fishery-independent data is justified by the small size and low value of the fishery. However, assessment of fishery performance could be enhanced by explicitly defining the data and methods that should be used to calculate the PI and reference points in the Management Plan.

4.3 Future Research Needs

The major research needs for this fishery are: 1) determination and documentation of the reasons why the TACC has not been harvested since 2001/02 in either zone, 2) a review of the current Performance Indicators and associated reference period and reference ranges, 3) interrogation of the commercial catch and effort data at finer spatial scales, and 4) collection, collation and analysis of spatially-explicit commercial length-frequency and sex-ratio data to provide representative information on the length-frequency distribution and sex ratio of the catch.

5 REFERENCES

Brock, D., Hawthorne, P., Ward, T. and Linnane, A. (2004). Species composition and spatio-temporal trends in by-catch from the South Australian rock lobster (*Jasus edwardsii*) fishery as estimated using two monitoring options. Final report to PIRSA fisheries. 36p.

Currie, D.R. and Ward, T.M. (2005). South Australian Giant Crab (*Pseudocarcinus gigas*) Fishery. Fisheries Assessment Report to the Department of Primary Industries and Resources, South Australia. SARDI Aquatic Sciences, Adelaide, RD04/0215-2. 27p.

Currie, D.R., Sorokin, S.J. and Ward, T.M. (2006). Survey of Recreational Rock Lobster Fishing in South Australia during 2004/05. Report to the Department of Primary Industries and Resources, South Australia. SARDI Aquatic Sciences, Adelaide, RD04/0228-2. 29p.

Currie, D.R., Mayfield, S., McGarvey, R. and Gardner, C. (2006). South Australian Giant Crab (*Pseudocarcinus gigas*) Fishery. Fisheries Assessment Report for PIRSA. South Australian Research and Development Institute (Aquatic Sciences), Adelaide, RD04/0215-3. 37p.

Currie, D.R. (2008). South Australian Giant Crab (*Pseudocarcinus gigas*) Fishery. Status Report for PIRSA Fisheries. South Australian Research and Development Institute (Aquatic Sciences), Adelaide, F2008/000067-1. 9p.

DEH (2004). Assessment of the South Australian Giant Crab Fishery. Department of Environment and Heritage, Australian Government, Canberra. 30p.

Gardner, C. (1997). Effect of size and reproductive output on giant crabs *Pseudocarcinus gigas* (Lamarck): Oziidae. Marine and Freshwater Research. 48: 581-587.

Gardner, C. and Maguire, G.B. (1998). Effect of photoperiod and light intensity on survival, development and cannibalism of larvae of the Australian giant crab, *Pseudocarcinus gigas* (Lamarck). Aquaculture. 158: 203-214.

Gardner, C. and Northam, M. (1998). Use of prophalactic treatment for larvae rearing of giant crabs, *Pseaudocarcinus gigas* (Lamarck, 18818) (Decapoda: Oziidae) reared in the laboratory. Journal of Plankton Research. 20 (6): 1169-1188.

Gardner, C., Rush, M. and Bevilacqua, T. (1998). Non-lethal imaging techniques for crab sparmathecae. Journal of Crustacean Biology. 18 (1): 64-69.

Gardner, C., Mackinnon, C., Burch, P. and Bermudes, M. (2004). Tasmanian Giant Crab Fishery 2002/2003. Fisheries Assessment Report. Tasmanian Aquaculture and Fisheries Institute. 36p.

Gardner, C., Haddon, M., Hobday, D. and McGarvey, R. (2006). Development of the tools for long term management of the giant crab resource: data collection methodology, stock assessment and harvest strategy evaluation. Final report to the Fisheries Research and Development Corporation, Australia. Project No. 2001/042. 150p.

Kailola, P.J., Williams, M.J., Stewart, P.C., Reichelt, R.E., McNee, A. and Grieve, C. (1993). Australian Fisheries Resources. Commonwealth of Australia. 422p.

Kennelly, S.J. (2000). A review of research on the giant crab fishery. Final unpublished report to PIRSA Fisheries. 14p.

Levings, A., Mitchell, B.D., Heeren, T. and Austin, C. (1996). Fisheries biology of the giant crab (*Pseudocarcinus gigas*, Brachyura, Oziidae) in Southern Australia. In: High Latitude Crabs: Biology, Management and Economics. Fairbanks, Alaska, USA. pp 125-151.

Levings, A., Mitchell, B.D., Heeren, T., Austin, C., Matheson, J. (1999). Size Distribution, Reproductive Stage, Movement and Depth: a Preliminary Model of the Fisheries Biology of the Giant Crab. Preliminary report to the Fisheries Research and Development Corporation, Australia.

Levings, A., Mitchell, B.D., McGarvey, R., Mathews, J., Laurenson, L., Austin, C., Heeron, T., Murphy, N., Miller, A., Rowsell, M. and Jones, P. (2001). Fisheries Biology of the Giant Crab *Pseudocarcinus gigas*. Final report to the Fisheries Research and Development Corporation, Australia, for projects 93/220 & 97/132. Deakin University.

McGarvey, R., Mathews, J.M. and Levings, A. (1999). Yield-, Value- and Egg-Per-Recruit of Giant Crab, *Pseudocarcinus gigas.* Preliminary report to the Fisheries Research and Development Corporation, Australia. 73p.

Sloan, S. (2002). A report prepared for Environment Australia on the Management of the South Australian Giant Crab (*Pseudocarcinus gigas*) Fishery. For the purposes of section 303FN (Approved Wildlife Trade Operation) of the Environment Protection and Biodiversity Act 1999. 31p.

Sloan, S. (2003). Ecological Assessment of the South Australian Giant Crab (*Pseudocarcinus gigas*) Fishery. Assessment report prepared for Commonwealth Department of the Environment and Heritage, against the 'guidelines for the ecologically sustainable management of fisheries'. For the purposes of part 13 and 13 (A) of the Environment Protection and Biodiversity Conservation Act 1999. 43p.

Ward, T. and Loiterton, B. (2000). Management Program for Giant Crab (*Pseudocarcinus gigas*) in South Australia. Primary Industries and Resources South Australia. 27p.

6 ACKNOWLEDGEMENTS

Research presented in this report was commissioned by PIRSA Fisheries using funds obtained from licence fees paid by participants in the South Australian giant crab fishery. SARDI Aquatic Sciences provided substantial in-kind support. Spatially-explicit data in this report could not have been analysed and presented without the co-operation of Bill Clarke and Kenneth Mathison, and we are most grateful to them for this. We are also very much indebted to John Feenstra (SARDI Aquatic Sciences) for undertaking all database queries associated with the project. Finally, we would like to thank Stephen Mayfield and Adrian Linnane (SARDI Aquatic Sciences) and Sean Sloan (PIRSA) for reviewing and editing earlier drafts and substantially improving the quality of the report.