

Fisheries Long Term Monitoring Program

Summary of spanner crab
(*Ranina ranina*) survey results:
2000–2005

August 2006



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List of Acronyms

CFISH	Commercial Fisheries Information System, DPI&F
CPUE	Catch Per Unit Effort
CrabMAC	Crab fishery Management Advisory Committee
DPI&F	Department of Primary Industries and Fisheries, Queensland
ITQ	Individual Transferable Quota
LTMP	Long Term Monitoring Program, DPI&F
MLS	Minimum Legal Size
TACC	Total Allowable Commercial Catch
SOCI	Species of Conservation Interest

Summary

The Department of Primary Industries and Fisheries manages the harvest of Queensland's fish, mollusc and crustacean species and the habitats they live in. Inherent in this responsibility is a commitment to monitoring the condition and trends in fish populations and their associated habitats. This information is used to assess the effectiveness of fisheries management strategies and contributes to ensuring that the fisheries remain ecologically sustainable.

The spanner crab, *Ranina ranina*, inhabits sandy bottoms on the continental shelf off Australia's east coast, from southern New South Wales, north to the southern Great Barrier Reef. The annual commercial harvest of spanner crabs in Queensland increased rapidly from 1988 to 1994 with fishing effort and catch rates increasing as the fishery expanded into previously unexploited areas. Since 1999, the fishery has been subject to a Total Allowable Commercial Catch (TACC) in Management Area A, divided between the licensed operators by way of Individual Transferable Quota units (ITQ). The current TACC of 1727 tonnes has been in effect since June 2002.

The present TACC setting decision rules are based on performance criteria derived from commercial catch rates. However, there is concern about the reliability of fishery dependent catch rates as indicators of stock abundance, partly because the stock is not uniformly distributed, resulting in fishers targeting aggregations of crabs. In response to these management concerns and the high value of the fishery (approximately \$10 m), spanner crabs were included in the Department's Long Term Monitoring Program (LTMP).

The objectives of the spanner crab monitoring component of this program are to obtain fishery independent catch per unit effort (CPUE) data, record length frequency and sex-ratio data, identify interactions with species of conservation interest (SOCl), and monitor bycatch composition.

The sampling design includes five assessment regions (Regions 2 to 6) comprising of the Queensland Commercial Fishery (Managed Area A), which is subject to the TACC. For the 2005 survey an extra region (Region 7) was added in New South Wales. Fifteen sets per subgrids were conducted, with each set consisting of ten standard commercial spanner crab dillies connected by a 'trot-line' (or single string). Five subgrids were sampled in Regions 2 to 6, and four subgrids in Region 7. This report presents survey results from five years, 2000 to 2003 and 2005.

A total of 19 290 individual dilly lifts have been undertaken by the LTMP fishery independent spanner crab survey. In the Queensland regions observations of fishery bycatch during 2002, 2003 and 2005 show very low catch rates. Most of the bycatch species captured by spanner crab fishing gear are alive, and expected survival rates after release would be extremely high. To date there is not a single record of physical interaction between sampling gear and marine protected species.

Differences in mean carapace lengths were observed between male and female crabs over all regions. Overall, 68.1% of the 23 842 males and 13.0% of the 4193 females captured over the five year survey period were larger than the minimum legal carapace length of 100 mm. Carapace lengths also varied greatly between all regions sampled (Regions 2 to 7); male crabs were smaller in Region 5 compared to other regions and female crabs were largest in Regions 6 and 7.

Overall, catches were dominated by males, which represented 85.0% of the overall catch. Distinct trends were evident in the proportion of the catch represented by males and females in each region and these were relatively consistent across the five year study period. In particular, Regions 6 and 7 had a much higher percentage of females in the catch, 25.5% and 50.9% respectively compared to Regions 2, 3, 4 and 5 (9.6% to 17.6%).

Catch rates of male and female crabs varied between all regions. While catch rates differed among years within regions, differences among regions were generally consistent over the five year study period. Catch rates over the five year period were much higher in Region 4 than all other regions, reflecting the commercial catch data for the same period, which indicated highest catch rates in Region 4.

Analysis of catch rates with respect to the fishing depth and average bottom water temperature indicated that catches were highest at depths of 60 to 69 m for both male and female crabs. Catch rates of male and female crabs were variable with regards to bottom water temperature. However, these relationships were confounded by region to a large extent and were not consistently observed across all regions.

The LTMP spanner crab component, has delivered a time series of size and sex-ratio data coupled with fishery independent catch rate data for the five Queensland assessment regions in Commercial Fishery (Managed Area A). Similar data were collected from NSW in 2005 only, although only for a single year. Further standardization of the fishery independent catch rate with associated biological and physical characteristics will greatly enhance the importance of this data set for future analysis and regional population assessments.

Long Term Monitoring Program background

Introduction

The spanner crab fishery is managed by the Department of Primary Industries and Fisheries (DPI&F) by input and output controls, involving an annually reviewed Total Allowable Catch (TACC) divided between some 240 licensed operators (128 boats) by way of Individual Transferable Quota (ITQ) units. In mid-1999, 100 000 ITQ units were allocated, on the basis of prior history in the fishery. The *Fisheries (Spanner Crab) Management Plan (1999)* sets out the objectives of management, performance indicators and review events.

The present TACC setting decision rules are based on performance criteria derived from commercial catch rates (CPUE), which until further information becomes available, are deemed to be indicative of stock abundance. However, there is concern about the reliability of fishery dependent catch rates as indicators of stock abundance. This is partly because the stock is not uniformly distributed, resulting in fishers targeting aggregations of crabs. Such a fishing strategy is not uncommon, but it means that declining overall abundance may not be revealed as a signal in the commercial catch rates until the stock is very seriously depleted. It is also partly due to the use of a "passive" fishing method, the success of which may vary considerably in response to changes in the behaviour of the target species.

At the Fisheries Research and Development Corporation sponsored Stock Assessment Review Workshop (Southern Fisheries Centre, August 1998 – Dichmont *et al.* 1999) the Spanner Crab Working Group agreed that, largely because of concerns outlined above, one of the most pressing issues for this fishery in Queensland was the establishment of a fishery independent monitoring program. The Crab fishery Management Advisory Committee (CrabMAC) strongly endorsed the need for corroborative data on stock abundance, and incorporated a significant element of cost recovery for such a program in the *Fisheries (Spanner Crab) Management Plan 1999*.

The principal objective of the LTMP surveys was to provide the DPI&F fishery managers through the spanner crab Stock Assessment Group, with independent information about the abundance of spanner crabs in selected regions of the commercial fishery. This information is ultimately to be incorporated, along with fishery dependent CPUE data, into a fishery model to provide a more robust estimate of optimum yield (TACC) than is presently available. The DPI&F is committed to regular assessment of the status of this fishery using the best available scientific information to ensure the fishery remains sustainable.

Objectives

The DPI&F LTMP's principal objective is to provide the Stock Assessment Group to CrabMAC with independent information about the abundance of spanner crabs in selected regions of the commercial fishery. This is achieved by providing information on size and sex composition of the spanner crab catch and CPUE.

In accordance with the Australian Government Department of the Environment and Heritage recommendations associated with the fishery accreditation, (<http://www.deh.gov.au/coasts/fisheries/qld/spanner/decision.html#recommendations>) bycatch is monitored. Bycatch composition is monitored in two out of every five years by recording bycatch species, individual sizes and total weight of species. Interaction of species of conservation interest with the survey operation is also monitored.

Methods

Experimental Design

A detailed description of all methods can be found in DPI&F (2005). The five Queensland assessment regions within the spanner crab Commercial Fishery (Managed Area A) were sampled in May 2000–2003 and 2005 (Figure 1). The survey was not conducted in 2004. Sampling was undertaken aboard commercially licensed spanner crab vessels and research vessels.

Assessment Regions 2–6 encompassed the following areas:

Region 2 23° 00' to 24° 00' S (Yeppoon – Bustard Head [excl. Area B waters])

Region 3 24° 00' to 25° 00' S (Bustard Head – Indian Head)

Region 4 25° 00' to 26° 30' S (Indian Head – Noosa)

Region 5 26° 30' to 27° 30' S (Noosa – Point Lookout)

Region 6 27° 30' to 28° 12' S (Point Lookout – Tweed Heads)

Note: Region 7 is south of 28° 12' S in NSW waters

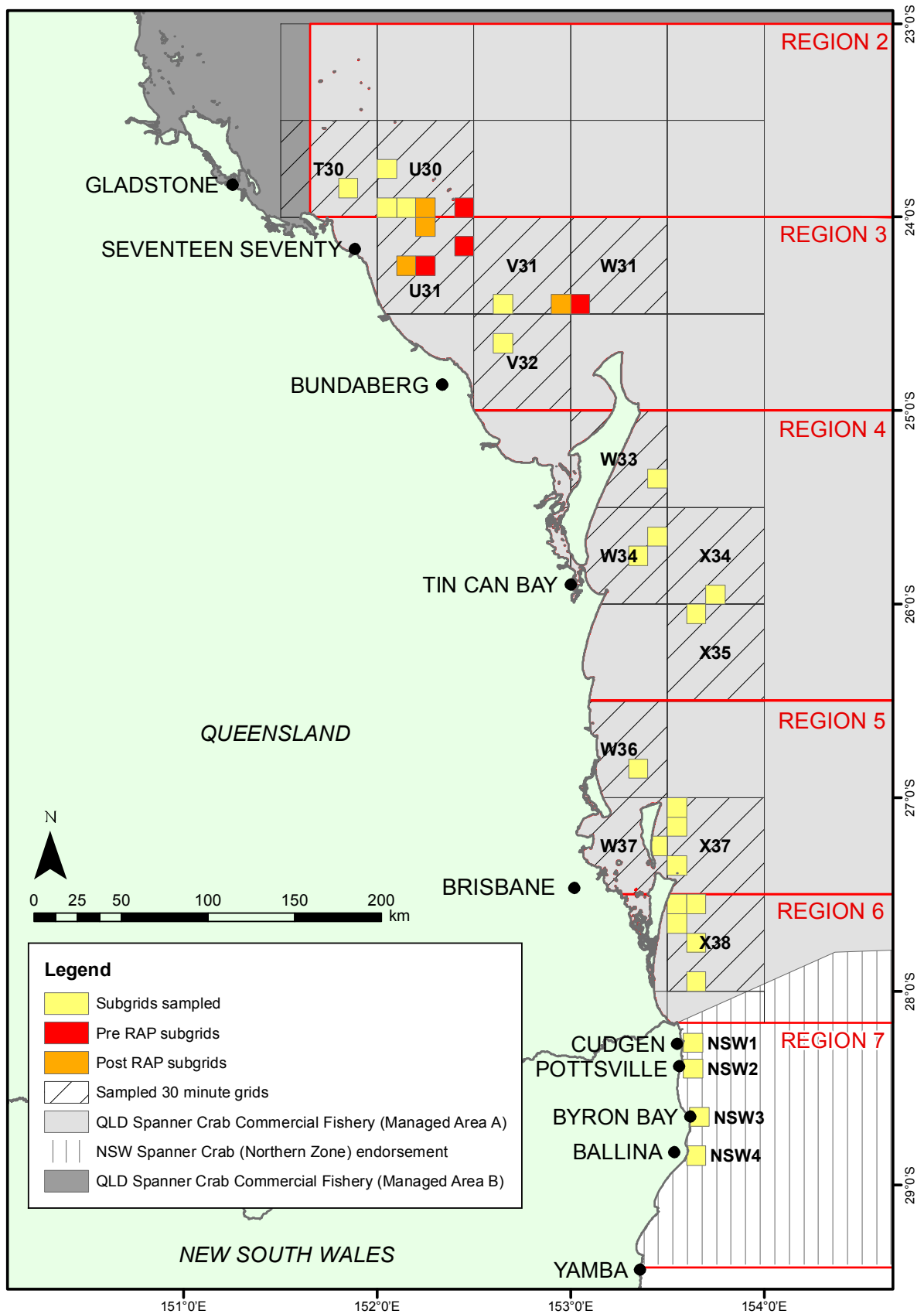


Figure 1. Commercial Fisheries Information System (CFISH) six-minute subgrids sampled in the spanner crab survey, before (2000–2003) and after (2005) the introduction of the Great Barrier Reef Marine Park Authority Representative Area Program (RAP). Region 7 was sampled in 2005 only.

Within each region, five six-minute by six-minute subgrids, corresponding with CFISH gridsites (Table 1), were sampled each year. These were chosen randomly from a list of subgrids with high historical catch rates and fishing effort.

In 2004 the Great Barrier Reef Marine Park Authority implemented a new zoning plan (Representative Areas Program) for the Marine Park. As a result, some subgrids were no longer able to be sampled. These were replaced with the nearest subgrid in a non-protected area of the Marine Park and first sampled in May 2005.

Table 1. Subgrids (corresponding to Commercial Fisheries Information System (CFISH) gridsites) sampled in each of the five assessment regions in Managed Area A. Subgrids marked * were replaced in 2005 and replacement subgrids are shown in parentheses.

Region 2	Region 3	Region 4	Region 5	Region 6
*25U30 (23U30)	22V31	2X35	15W37	6X38
21U30	7V32	23X34	6X37	2X38
22U30	*10U31 (3U31)	20W33	16X37	1X38
11U30	*13U31 (12U31)	14W34	1X37	12X38
19T30	*21W31 (25V31)	10W34	19W36	22X38

In June 2005, four six-minute by six-minute subgrids were sampled in New South Wales, (Region 7). The subgrids were located off Cudgen (NSW 1), Pottsville (NSW2), Byron Bay (NSW3) and Ballina (NSW4) (Figure 1).

Fifteen sites within every six-minute by six-minute subgrid were chosen randomly each year. At each site, a single 500 m long string with 10 evenly spaced dillies was deployed. Dillies were constructed from 8 mm galvanised reinforcing steel bent to form a one metre by one metre frame. Each frame was covered with a single layer of white 32 mm multifilament nylon mesh, hung with no drop. Dillies were baited with frozen pilchards (*Sardinops sagax*). The standard bait quantity was the equivalent of three whole pilchards per bait bag. The depth of water, as indicated by an echo sounder, was recorded at each site as the first dilly was deployed. Temperature-loggers were attached to the first string of dillies set each day (DPI&F 2005).

Data Recording

Dillies were deployed during daylight hours only. Lift time and set time was recorded to calculate a soak time for each string.

Crabs caught per string were grouped as a single sample i.e. no attempt was made to keep each dilly's catch separate (DPI&F 2005). The sex of each crab was determined and recorded, together with the rostral carapace length, which was measured to the nearest millimetre using vernier callipers (DPI&F In Prep.).

In 2001, 2003 and 2005 all animals other than spanner crabs (bycatch) were also sampled in the Queensland regions. The numbers of sand crabs (*Portunus pelagicus*) and three spot crabs (*Portunus sanguinolentus*) were recorded (DPI&F 2005). All other bycatch was retained and in the laboratory it was identified to species level, weighed to the nearest gram, measured to the nearest millimetre and counted (DPI&F In Prep.).

Data Analysis

Spanner crabs CPUE was expressed as the mean number of crabs caught per dilly per hour (crabs/dilly.hour) and was calculated using the following formula:

$$(\text{Number of crabs captured} / \text{Number of dillies retrieved}) / \text{Soak time (hrs)}$$

Sex-ratio of male spanner crabs was calculated by applying the following formula:

$$\text{Number of male crabs} / (\text{Number of male crabs} + \text{Number of female crabs})$$

Mean water temperature was determined for the period, starting 15 min after deployment until the gear was retrieved. The 15 min delay ensured the temperature logger had adjusted fully to the ambient water temperature.

Results

Summary for all survey regions (2 to 7) and years (2000–2003 and 2005)

Set times

Each year most regions took between four and five days to sample. Set time varied between all regions and years and ranged from 25 to 195 min (a total of 1935 sets) with a mean of 52.9 ± 0.31 min. The mean set time for each region for all years ranged from 47 min (Region 2) to 56 min (Region 6).

Length frequency distributions

In total 23 842 male and 4193 female spanner crabs were measured. Carapace lengths ranged from 30 to 162 mm for male crabs (Figure 2) and from 19 to 123 mm for female crabs (Figure 3). The length frequency of male crabs was normally distributed with a peak frequency in the 100 to 109 mm size class, which is greater than the minimum legal size (MLS; Queensland 100 mm rostral carapace length; NSW 93 mm orbital carapace length). Overall 68.1% of male crabs captured were above the MLS (Table 2). This percentage varied greatly between regions, ranging from 44.3% in Region 5 to 90.4% in Region 7.

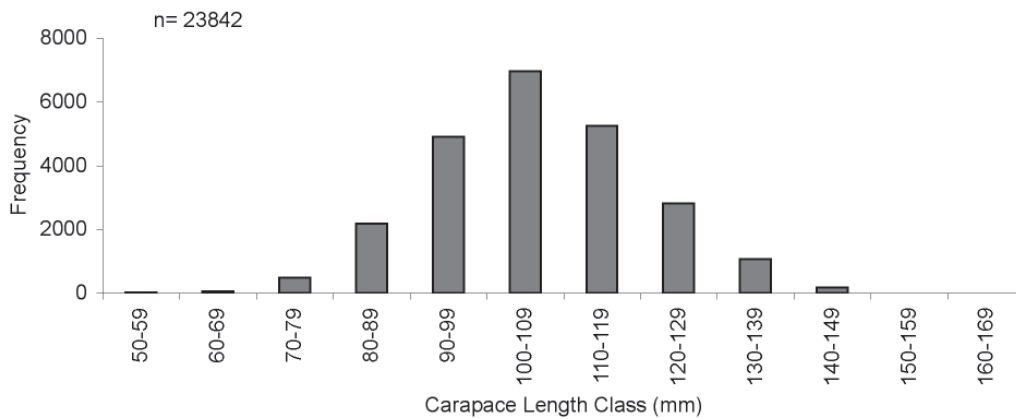


Figure 2. Male spanner crab length frequencies for all years and regions.

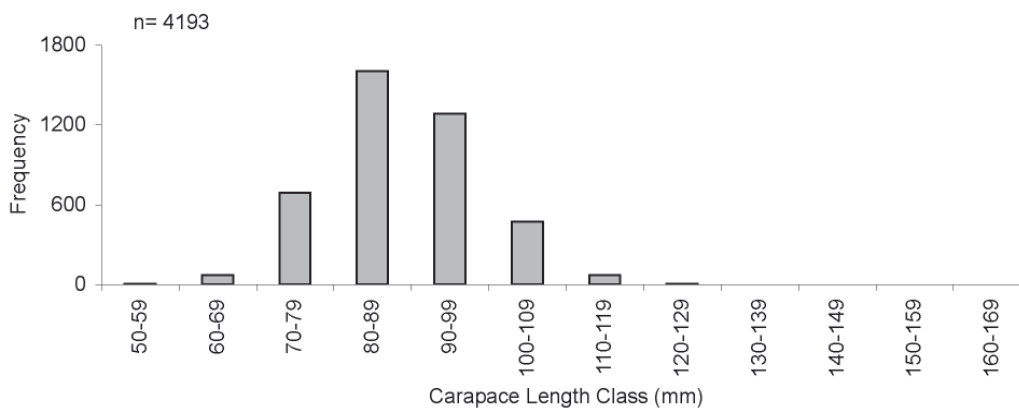


Figure 3. Female spanner crab length frequencies for all years and regions.

The length frequency of female crabs was slightly skewed, with a peak frequency in the 80 to 89 mm size class. Overall, 13.0% of females captured were above the MLS (Table 2). This percentage also varied greatly between regions ranging from 37.8% in Region 7 to 2.0% for Region 5.

Table 2. Percentages of male crabs captured that were above the minimum legal size (100 mm carapace length) in Regions 2 to 6, all years combined, and Region 7 in 2005.

Region	Males		Females	
	No of Crabs	≥100 mm (%)	No of Crabs	≥100 mm (%)
2	3 321	68.4	386	2.6
3	3 437	63.2	543	2.4
4	9 450	74.9	1 014	6.9
5	3 982	44.3	852	2.0
6	3 443	79.9	1 181	29.9
7	209	90.4	217	37.8
Total	23 842	68.1	4 193	13.0

There was substantial variation in the mean size of male crabs within regions (between years) and between regions (all years combined). Variation also existed in the mean size of female crabs between regions (all years combined) however variation within regions (between years) was less pronounced (Figure 4).

Mean size of male crabs was highest in Region 7 (116.03 ± 1.02 mm) and lowest in Region 5 (98.70 ± 0.21 mm). The pattern for females was similar, although less pronounced, ranging from 97.40 ± 0.49 mm in Region 7 to 82.00 ± 0.30 mm in Region 5.

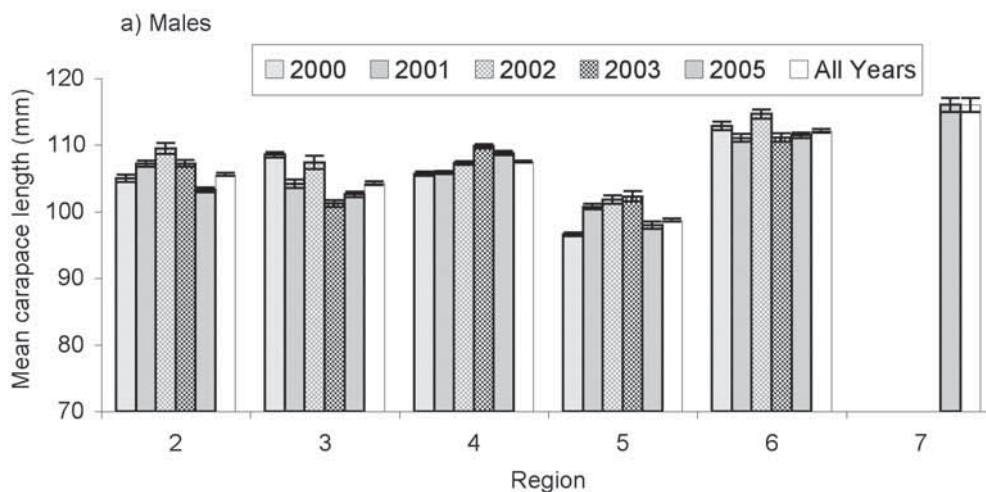


Figure 4. Mean male (a) and female (b) carapace lengths (mm) by region (2 to 7) and year (2000–2003 and 2005) for the Long Term Monitoring Program spanner crab survey. Error bars are \pm standard error.

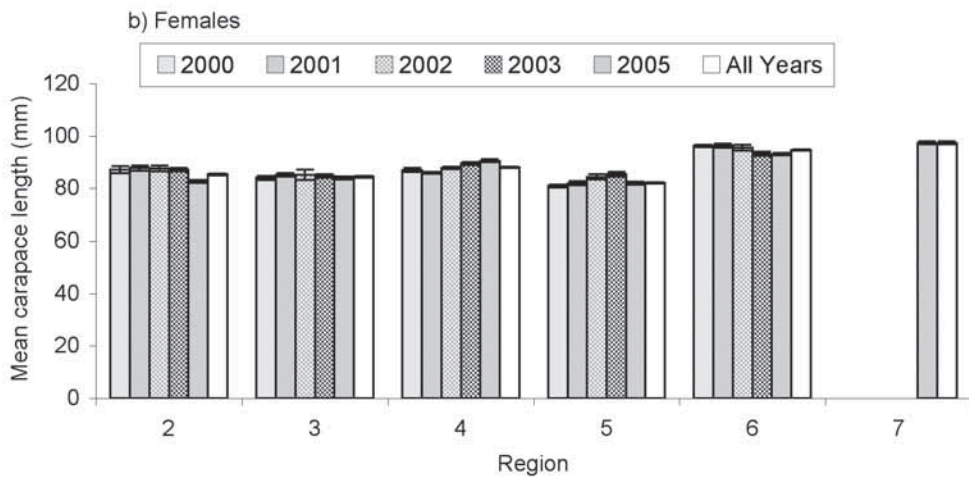


Figure 4 (continued). Mean male (a) and female (b) carapace lengths (mm) by region (2 to 7) and year (2000–2003 and 2005) for the Long Term Monitoring Program spanner crab survey. Error bars are \pm standard error.

Sex-ratios

The overall proportion of males to females varied little between survey years (all regions combined), with males representing 85.0% of the overall catch (Figure 5). Catches were heavily biased towards males in all regions except Region 7 which had a considerably lower proportion of males in the catch (0.49) compared to Regions 2, 3, 4, 5 and 6 (0.74 to 0.90) (Figure 6).

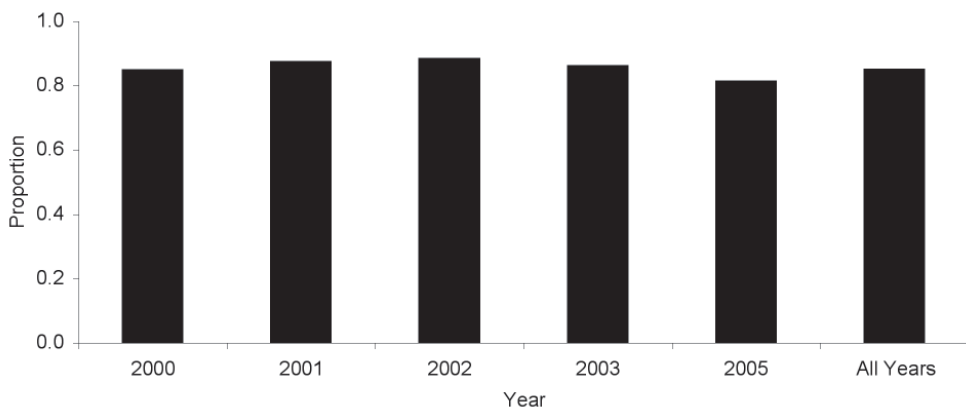


Figure 5. Annual sex-ratio of males to females (all regions combined) for the Long Term Monitoring Program spanner crab survey.

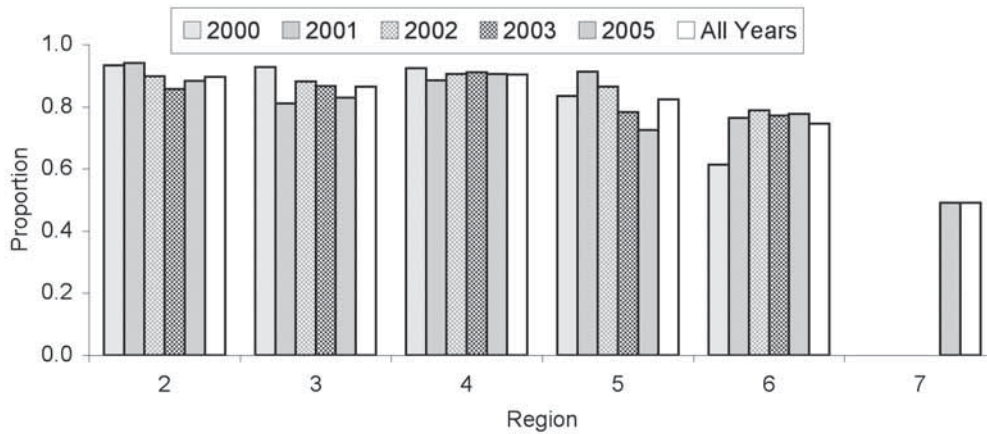


Figure 6. Annual sex-ratio of males to females by region (2 to 7) for the Long Term Monitoring Program spanner crab survey.

Catch rates

Mean catch rates of male and female crabs were lowest in 2002 in most regions (Figure 7). In all regions, mean catch rate was higher in 2005 than in 2002. Further, for both males and females in all regions, except males in Region 5, the mean catch rate in 2003 was between the low in 2002 and the high in 2005.

Mean catch rate of male spanner crabs from Region 4 was greater than two crabs per dilly per hour in all years and was greater than the catch rates of all other regions in all years except 2000. In 2000 the highest mean catch rate of male crabs was observed in Region 5. The mean catch rates recorded for females were lower than those observed for males, ranging from 0.05 crabs/dilly.hour (Region 3, 2002) to 0.52 crabs/dilly.hour (Region 6, 2005).

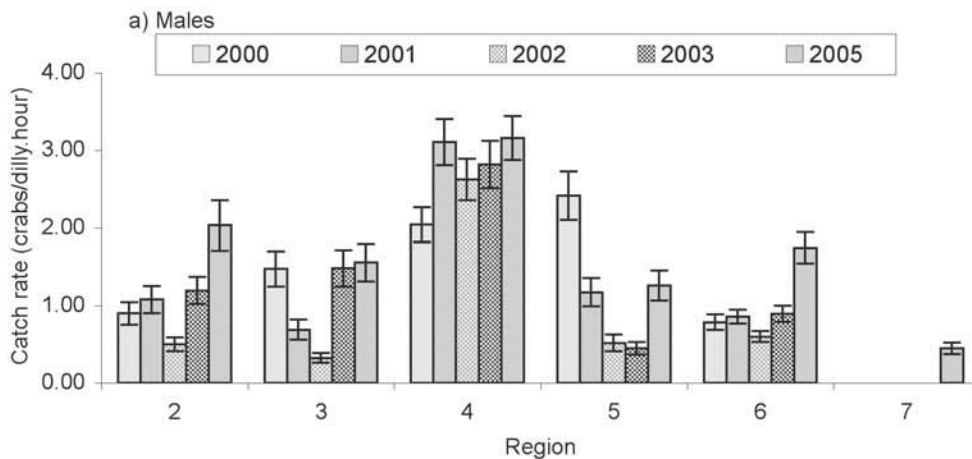


Figure 7. Mean male (a) and female (b) catch rates (crabs/dilly.hour) by region (2 to 7) and year (2000–2003 and 2005) for the Long Term Monitoring Program spanner crab survey. Error bars are \pm standard error.

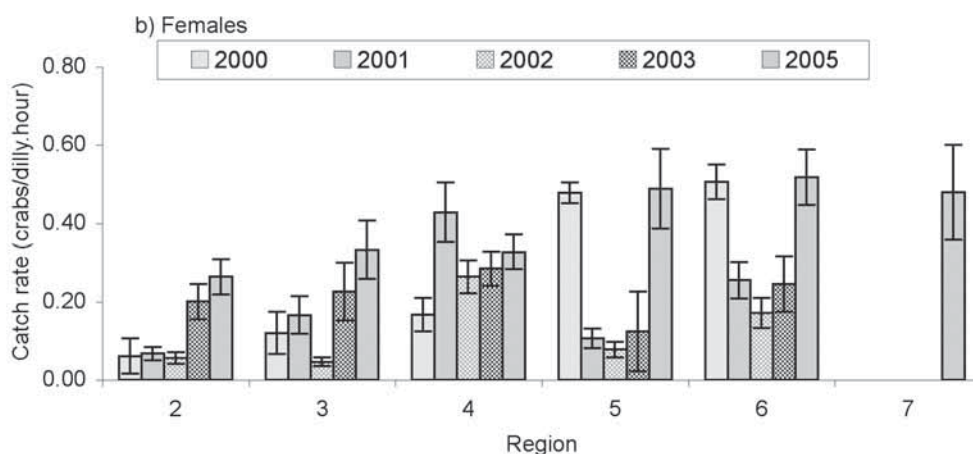


Figure 7 (continued). Mean male (a) and female (b) catch rates (crabs/dilly.hour) by region (2 to 7) and year (2000–2003 and 2005) for the Long Term Monitoring Program spanner crab survey. Error bars are \pm standard error.

Relationships with physical characteristics

Sampling during the survey was carried out in water depths ranging from 4 to 98 m (Table 3). The range of depths differed considerably between regions. For example, all sets in Region 3 were in depths ranging from 15 to 46 m, but sets in Region 4 ranged from 45 to 76 m (Table 3).

Table 3. Minimum and maximum set depths and depth range in which most sets were made for Regions 2 to 6 in all years (2000–2003 and 2005) and Region 7 in 2005 of the Long Term Monitoring Program spanner crab survey.

Region	Minimum set depth	Maximum set depth	Depth range with most sets
2	29	55	30 - 39
3	15	46	20 - 29
4	45	76	50 - 59
5	4	98	40 - 49
6	17	89	80 - 89
7	10	60	50 - 59
All	4	98	30 - 39

Highest mean catch rates were observed in depths of 60 to 69 m for both males (2.28 ± 0.14 crabs/dilly.hour) and females (0.42 ± 0.03 crabs/dilly.hour) (Figure 8). Ninety percent of males and females were caught in depths between 30 and 79 m. This was in part due to the unbalanced nature of the sampling design with 77% of all sets carried out in this depth range.

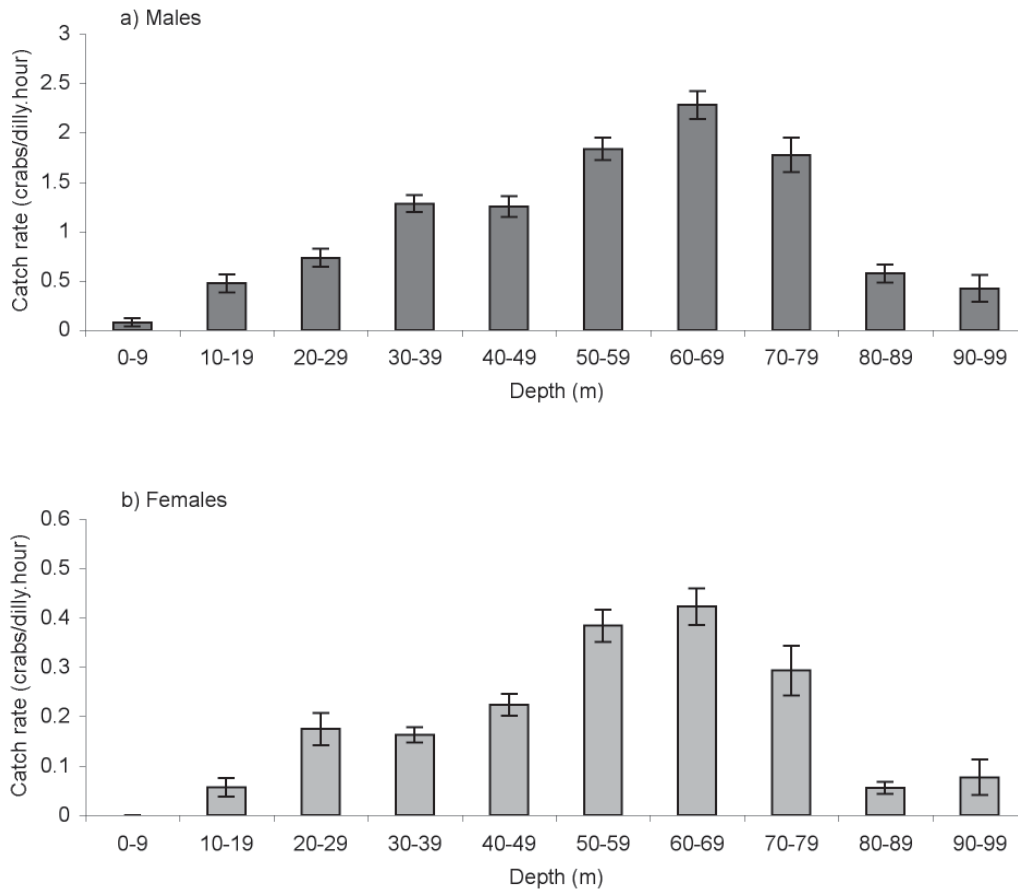


Figure 8. Mean male (a) and female (b) catch rates (crabs/dilly.hour) by depth of the set. All regions and years combined. Error bars are \pm standard error.

Temperature data-loggers were placed on 327 sets over the five year survey period (Table 4). Mean water temperature during sets ranged from 18.7 to 24.8°C.

The highest mean catch rate for males (2.29 ± 0.38 crabs/dilly.hour) was observed at temperatures of 24 to 24.9°C. The highest catch rate from an individual string occurred in the 23 to 23.9°C temperature range. Mean female catch rate was highest (0.29 ± 0.06 crabs/dilly.hour) in the 21 to 21.9°C range (Figure 9). The highest catch rate from an individual string occurred in the 22 to 22.9°C range. There were few observations and low catch rates in the temperature ranges of 18 to 18.9°C and 19 to 19.9°C, $n=2$ and $n=1$ respectively.

Table 4. Minimum and maximum mean water temperatures and the number of sets made with temperature data-loggers for Regions 2 to 6 in years 2001, 2003 and 2005 of the Long Term Monitoring Program spanner crab survey.

Region	Minimum temp (°C)	Maximum temp (°C)	No. of sets with Temp loggers
2	20.3	24.4	78
3	18.7	24.2	69
4	20.7	24.8	78
5	20.4	23.5	48
6	18.8	24.5	54
All	18.7	24.8	327

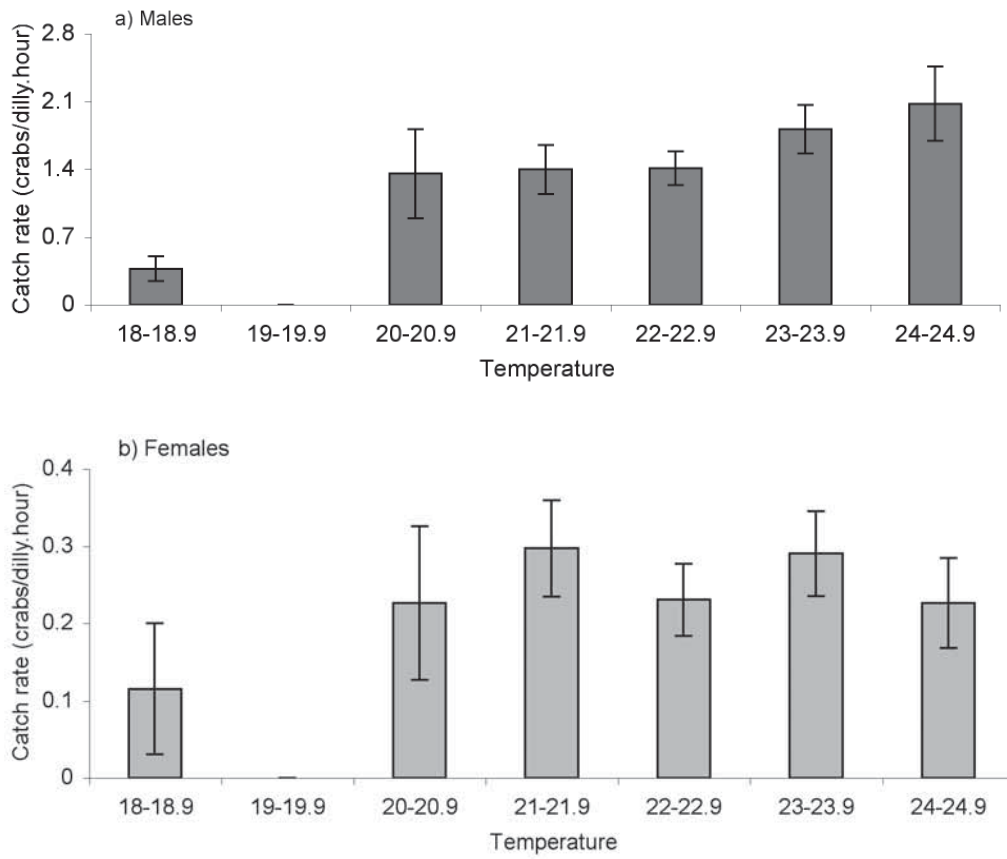


Figure 9. Mean male (a) and female (b) catch rates (crabs/dilly.hour) by mean water temperature. All regions and years combined. Error bars are \pm standard error.

Bycatch and interactions with other marine species

Bycatch species were assigned to broad taxonomic groupings, the catch rates of these groups were very low, ranging from 0.00 to 0.44 individuals per dilly lift (Table 5). There were no recorded interactions with protected species. The only species of conservation interest encountered were sea horses (Syngnathidae). Catch rates of bycatch species per region are presented in Appendix A.

Table 5. Mean catch rates (individuals per dilly lift) of bycatch groups caught during the Long Term Monitoring Program spanner crab survey in 2001, 2003 and 2005 in Regions 2–6. The only species of conservation interest (SOCl) encountered were sea horses (Syngnathidae).

Year	Region	Crustacean	Echinoderm	Fish	Mollusc	Porifera	SOCl
2002	2	<0.01	0.03	<0.01	0.04	<0.01	
	3	<0.01	0.08	0.03	0.04		
	4	<0.01	0.16	0.01	<0.01		
	5	<0.01		<0.01	0.01		
	6	0.05	0.36	0.02		<0.01	<0.01
2003	2	<0.01	0.07	0.01	0.03		<0.01
	3	<0.01	0.02	0.04	<0.01		
	4	<0.01	0.10	<0.01	<0.01		
	5	<0.01	0.01	0.03			<0.01
	6	<0.01	0.28	0.02		<0.01	<0.01
2005	2		0.01	<0.01	0.06	<0.01	
	3	<0.01	0.03	0.02	<0.01	<0.01	
	4	<0.01	0.07	<0.01	<0.01		
	5	0.01	0.12	0.01			
	6	<0.01	0.44	0.02	<0.01		<0.01

Region 2

Size frequency

The carapace length of males captured in Region 2 varied from 72 to 144 mm, with a peak in the length frequency distribution in the 100 to 109 mm class (Figure 10). Female carapace lengths ranged from 69 to 115 mm, with a peak in the length frequency distribution in the 80 to 89 mm class. In Region 2, 68.4% of male crabs captured had carapace lengths greater than MLS compared to female crabs of which only 2.6% were above MLS (Table 2).

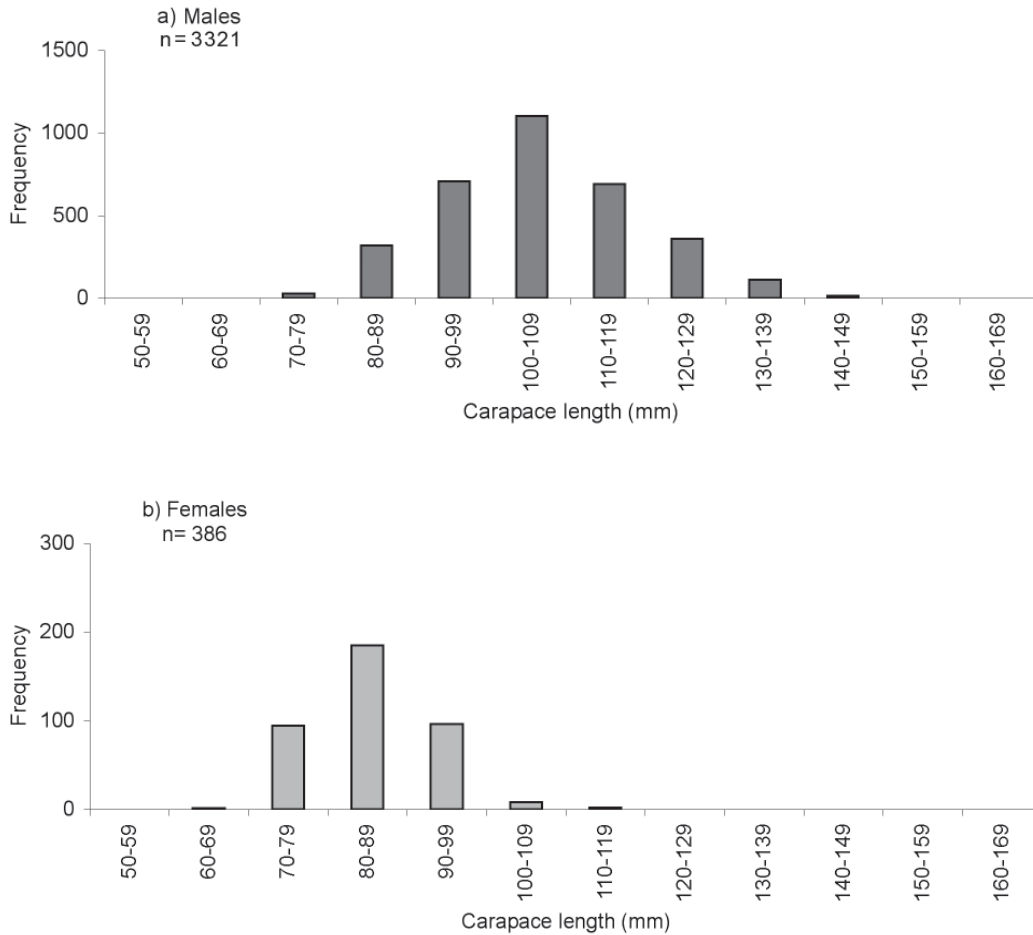


Figure 10. Male (a) and female (b) spanner crab length frequencies for all years in Region 2.

Mean male carapace length was highest in subgrid 19T30 (116.42 ± 0.65 mm) and lowest in subgrid 22U30 (102.44 ± 0.26 mm). Mean female carapace lengths showed little variation between subgrids. The mean carapace length of male and female crabs sampled from the new subgrid 23U30 (introduced in 2005), was slightly smaller than those sampled from the subgrid which it replaced (25U30) (Figure 11).

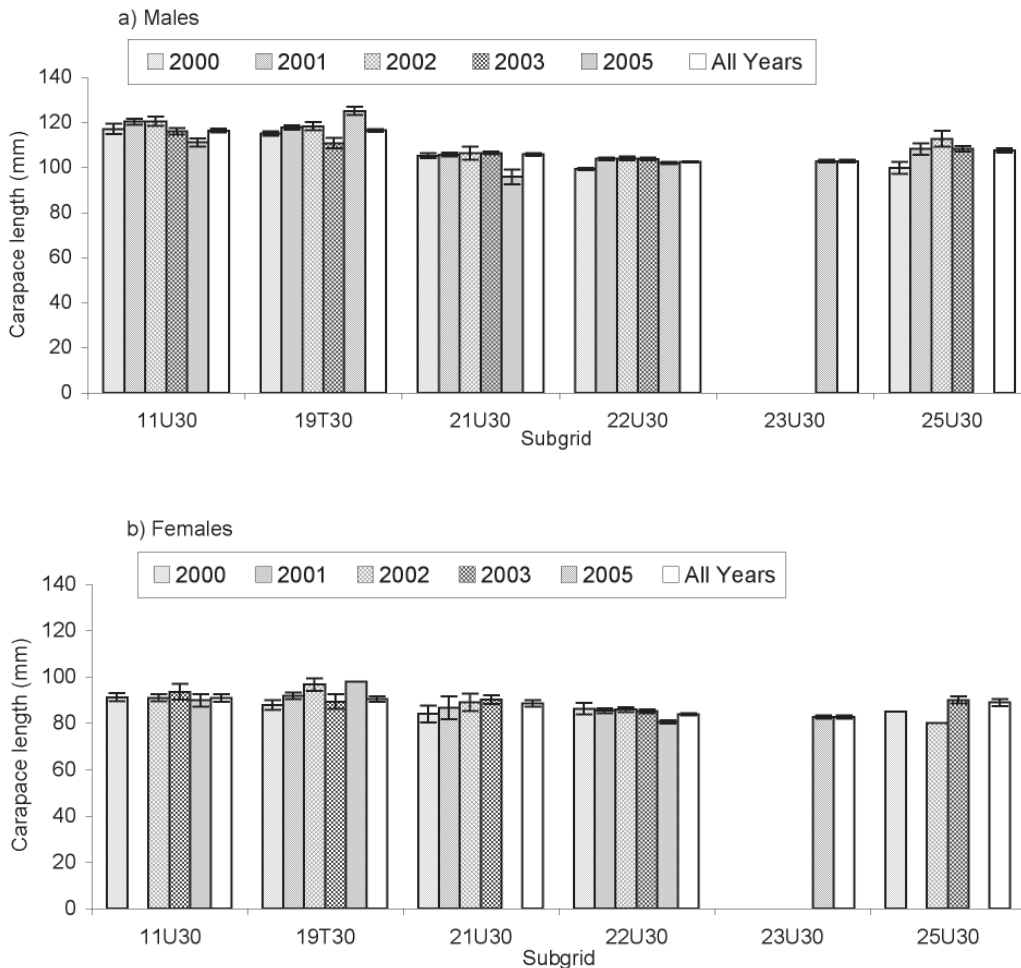


Figure 11. Mean male (a) and female (b) carapace lengths (mm) by year (2000–2003 and 2005) for Region 2. Error bars are \pm standard error.

Catch rates

Mean catch rate of males varied considerably between subgrids in Region 2, ranging from 0.05 to 4.99 crabs/dilly.hour (Figure 12). The mean catch rate of males in all subgrids was less than 1 crab/dilly.hour with the exception of subgrids 22U30 and 23U30 which had mean catch rates ranging from 1 to 5 crabs/dilly.hour. Mean female catch rate also varied considerably between subgrids, ranging from 0 to 0.78 crabs/dilly.hour. The mean catch rate of females followed a similar pattern to males, being highest in subgrids 22U30 and 23U30.

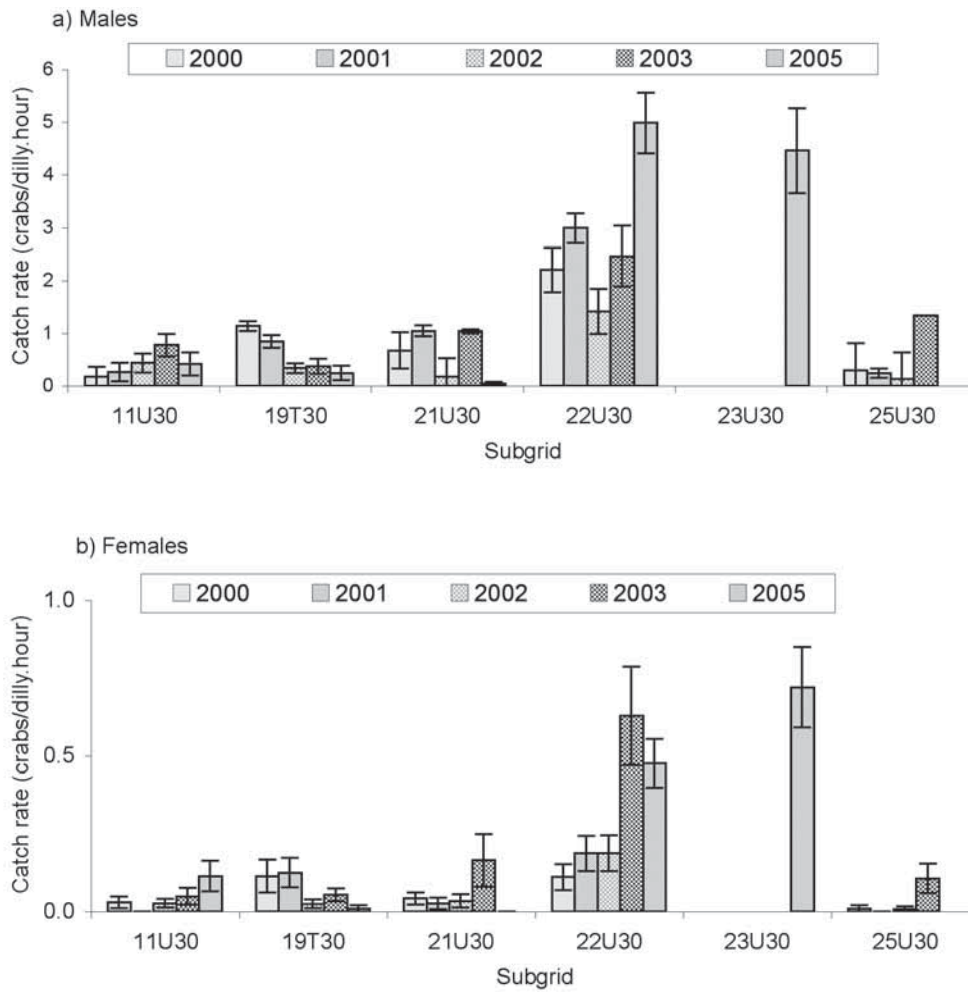


Figure 12. Mean male (a) and female (b) catch rates (crabs/dilly.hour) by year (2000–2003 and 2005) for Region 2. Error bars are \pm standard error.

Sex-ratios

Sex-ratios of spanner crabs captured in Region 2 varied little between the five survey years. Males represented 79 to 100% of the total catch depending on the subgrid and year (Figure 13).

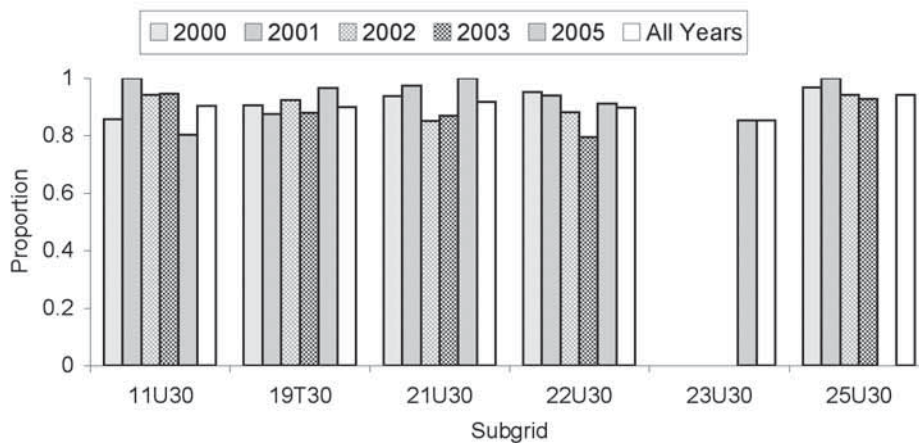


Figure 13. Sex-ratio of males to females by year (2000–2003 and 2005) for subgrids in Region 2.

Relationships with physical characteristics

Depths sampled in Region 2 ranged from 29 to 55 m, with most sets made in the 30 to 39 m depth range (Table 3). Highest mean male catch rates occurred at depths of 30 to 39 m whilst highest mean female catch rates occurred at depths of 20 to 29 m (Figure 14).

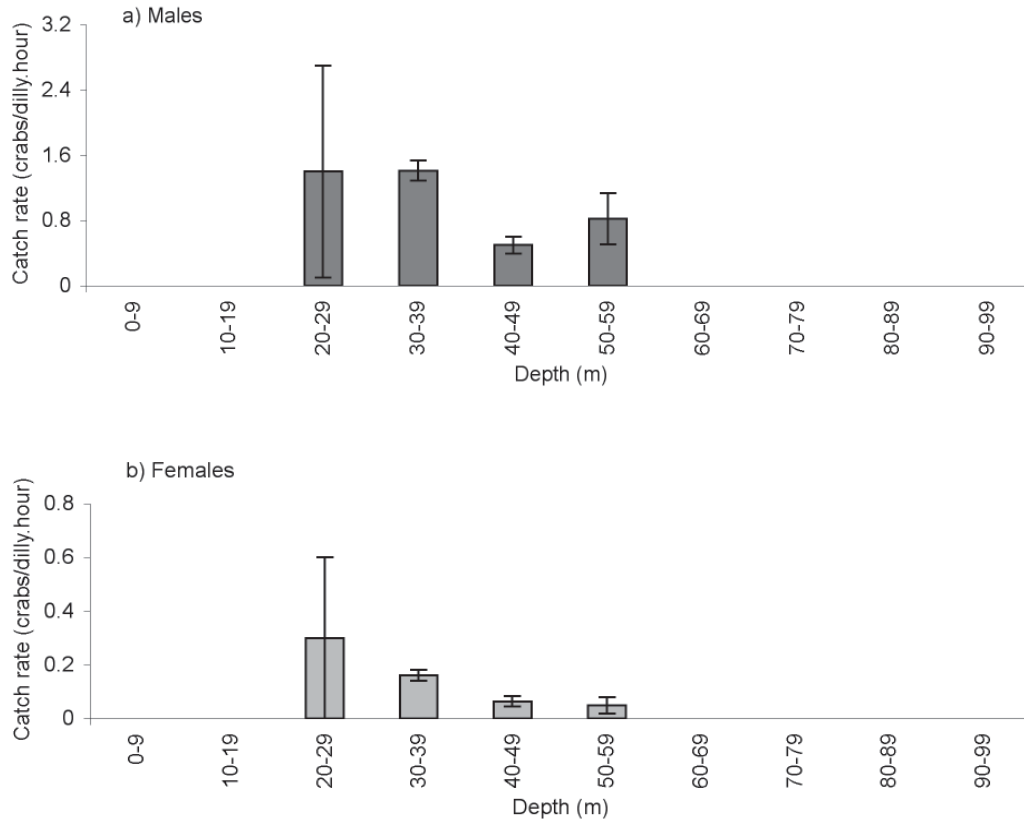


Figure 14. Mean male (a) and female (b) catch rates (crabs/dilly.hour) by depth of set for subgrids in Region 2. Error bars are \pm standard error.

Mean water temperatures observed in Region 2, ranged from 20.4 to 24.4°C (Table 4). During 64% of sets temperatures were recorded in a narrow range from 22 to 23.9°C.

Region 3

Size frequency

The carapace length of males captured in Region 3 varied from 50 to 142 mm, with a peak in the length frequency distribution in the 100 to 109 mm class (Figure 15). Female carapace lengths ranged from 55 to 105 mm, with a peak in the length frequency distribution in the 80 to 89 mm class. In region 2, 63.2% of male crabs captured had carapace lengths greater than MLS, compared to only 2.4% of female crabs (Table 2).

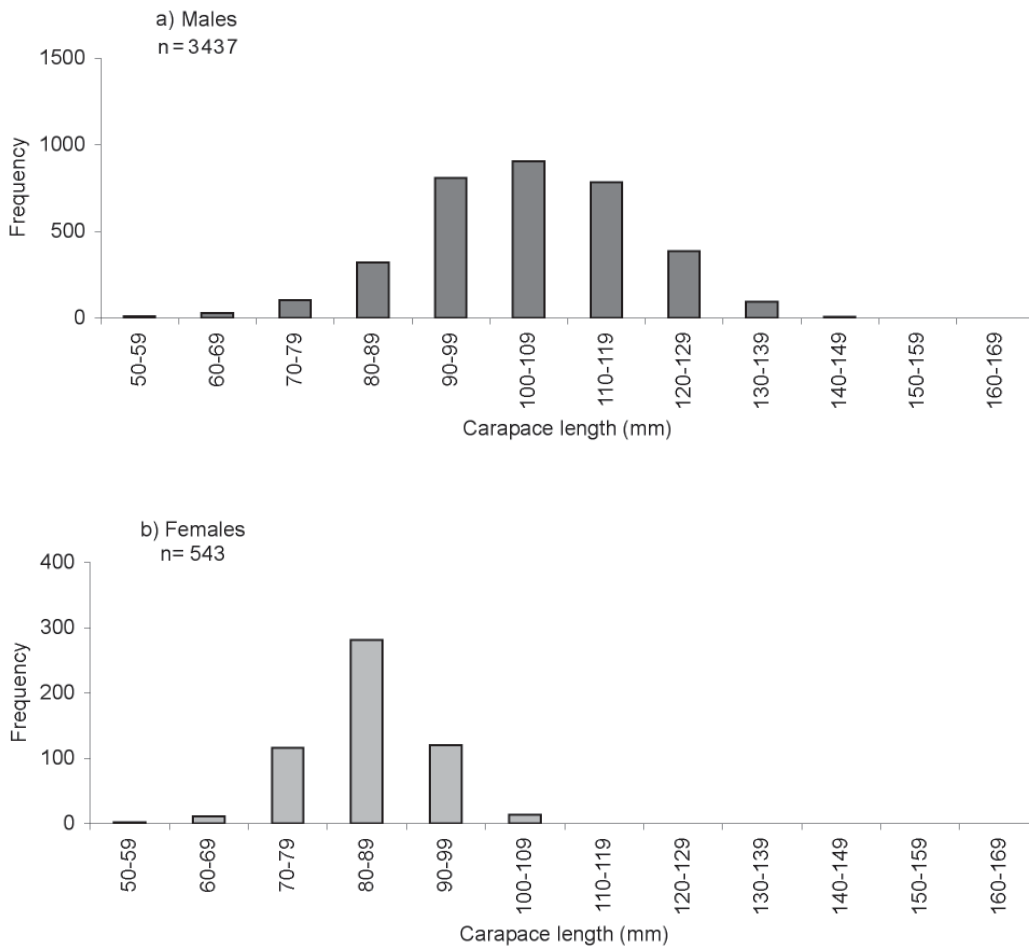


Figure 15. Male (a) and female (b) spanner crab length frequencies for all years in Region 3.

Mean male carapace length was greatest in subgrid 13U31 (112.33 ± 0.80 mm) and was lowest in subgrid 3U31 (99.59 ± 1.30 mm). Mean female carapace lengths were largest in subgrid 7V32 (91.20 ± 3.2 mm) and were lowest in subgrid 3U31 (81.32 ± 0.74 mm) (Figure 16). Within the subgrids first sampled in 2005, male crabs were of similar size or of a smaller size and female crabs were of a similar size.

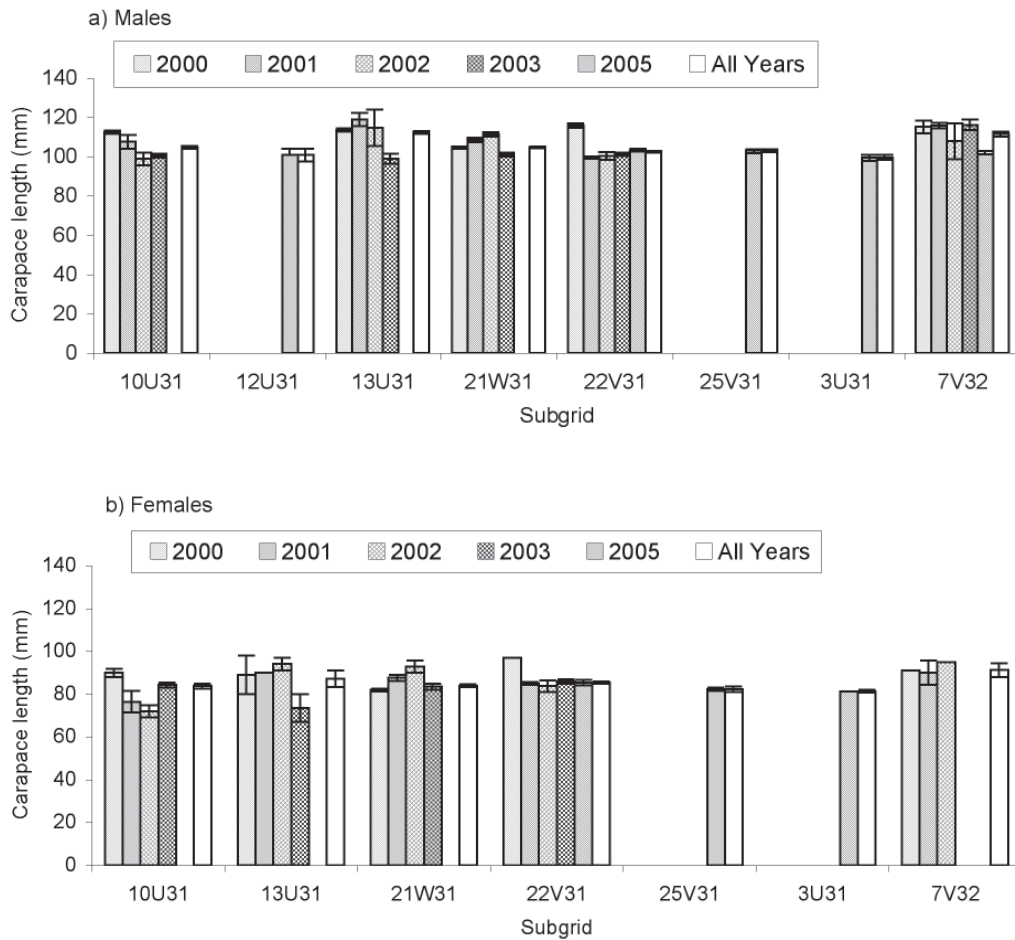


Figure 16. Mean male (a) and female (b) carapace lengths (mm) by year (2000–2003 and 2005) for Region 3. Error bars are \pm standard error.

Catch rates

Mean catch rate of male crabs varied considerably between subgrids in Region 3 and ranged from 0.06-4.04 crabs/dilly.hour (Figure 17). Mean catch rate of males was consistently low over the five years in subgrid 7V32 and was highest in subgrids 21W31 and 22V31. Mean female catch rate also varied considerably between subgrids, ranging from 0-1.01 crabs/dilly.hour. Low female mean catch rates were recorded in subgrids 13U31 and 7V32 across all survey years. Of the new subgrids sampled in 2005, 25V31 and 3U31 showed similar male and female catch rates to the subgrids they replaced. Subgrid 12U31 had very low catch rates for male and female crabs, which did not compare to the subgrid it replaced.

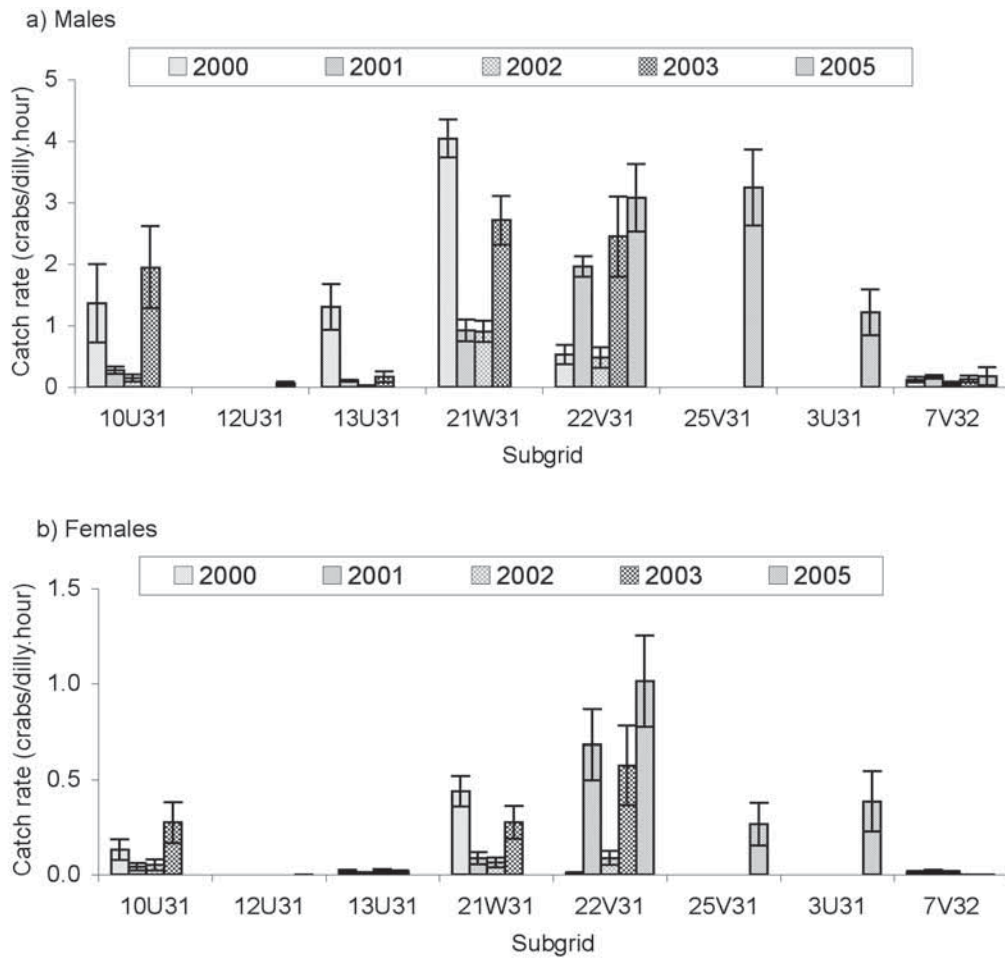


Figure 17. Mean male (a) and female (b) catch rates (crabs/dilly.hour) by year (2000–2003 and 2005) for Region 3. Error bars are \pm standard error.

Sex-ratios

Sex-ratios of spanner crabs captured in particular subgrids in Region 3 generally varied little between the five survey years. Males represented 75 to 100% of the total catch depending on the subgrid and year, with the exception of subgrid 13U31 in 2002 where males represented only 50% of the catch (Figure 18).

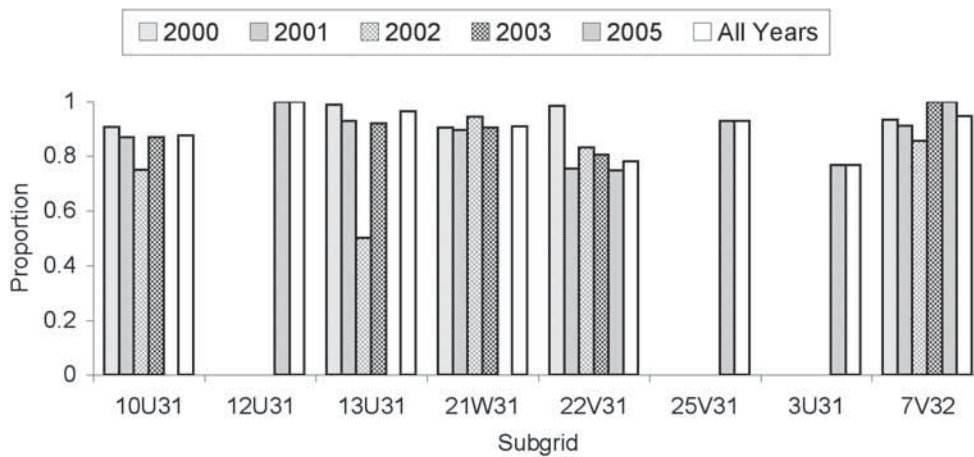


Figure 18. Sex-ratio of males to females by year (2000–2003 and 2005) for subgrids in Region 3.

Relationships with physical characteristics

Depths sampled in Region 3 ranged from 15 to 46 m, with most sets made in the 20 to 29 m depth range (Table 3). Highest mean catch rate for males occurred at depths of 40 to 49 m, whilst mean female catch rate varied little over depths of 20-49 m (Figure 19).

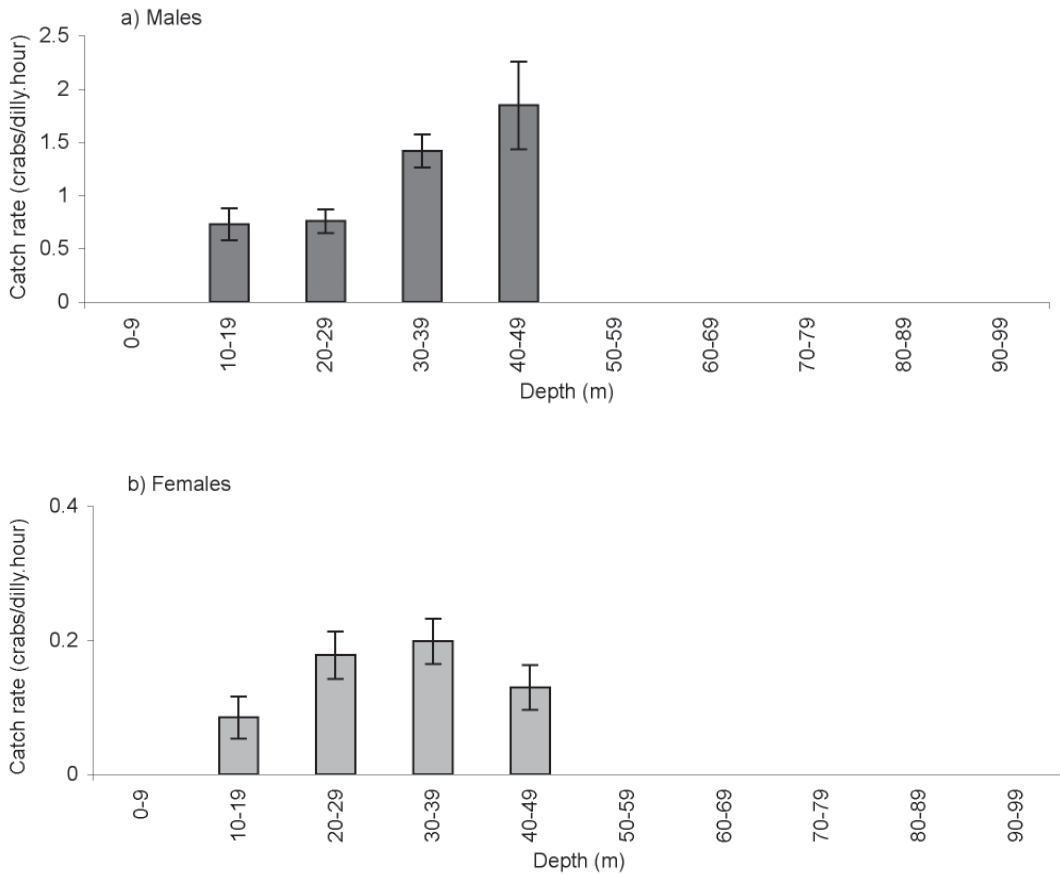


Figure 19. Mean male (a) and female (b) catch rates (crabs/dilly.hour) by depth of set for subgrids in Region 3. Error bars are ± standard error.

Mean water temperatures observed in Region 3 ranged from 18.7 to 24.2°C (Table 4). Temperatures were between 21 to 23.9°C in 86% of the sets.

Region 4

Size frequency

The carapace lengths of males captured in Region 4 ranged from 62 to 162 mm, with a peak in the length frequency distribution in the 100 to 109 mm class (Figure 20). Female carapace lengths ranged from 66 to 121 mm, with a peak in the length frequency distribution in the 80 to 89 mm class. Approximately 75% of male crabs and 5% of female crabs captured in Region 4 had carapace lengths greater than MLS (Table 2).

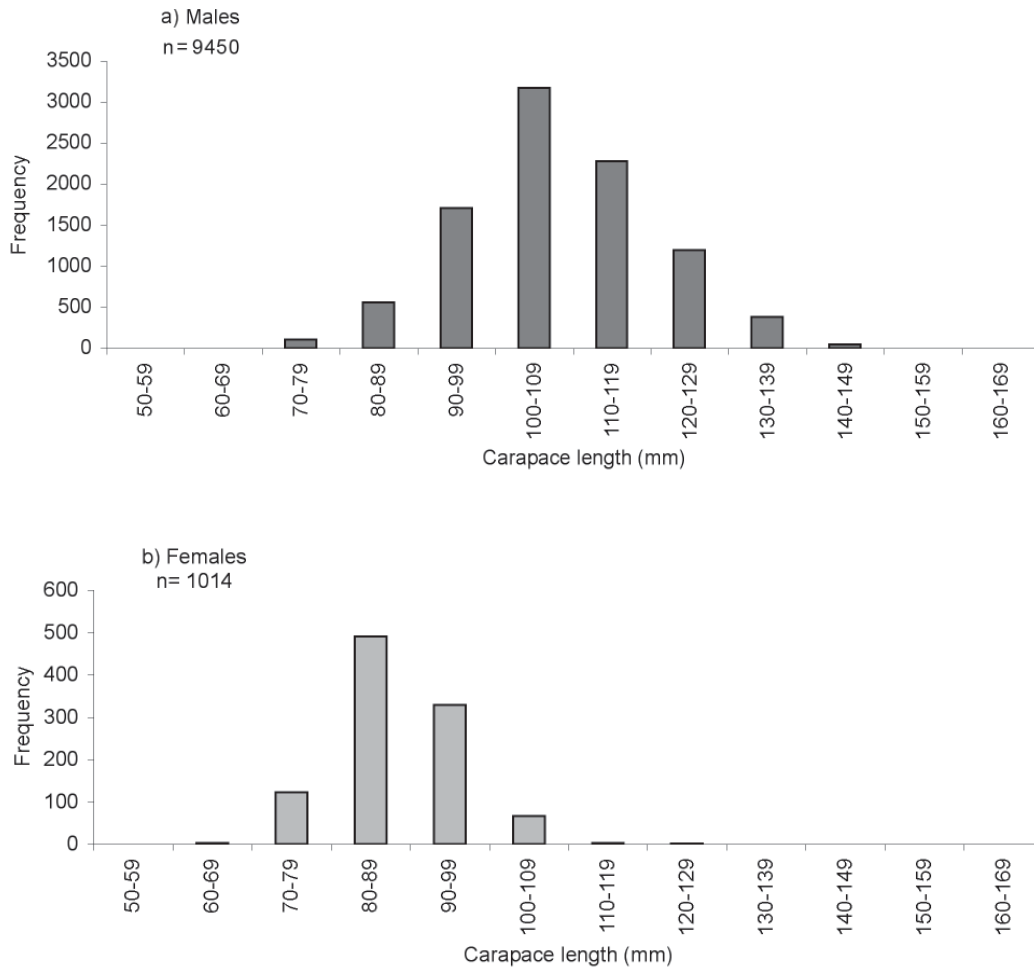


Figure 20. Male (a) and female (b) spanner crab length frequencies for all years in Region 4.

Mean male carapace lengths were greatest in subgrid 14W34, (114.53 ± 0.71 mm) and lowest in subgrid 20W33, (104.39 ± 0.25 mm). Female carapace lengths were highest in subgrid 2X35 (90.97 ± 0.43 mm) and were lowest in subgrid 20W33 (85.53 ± 0.41 mm) (Figure 21). Only one female crab was captured in all survey years from subgrid 14W34.

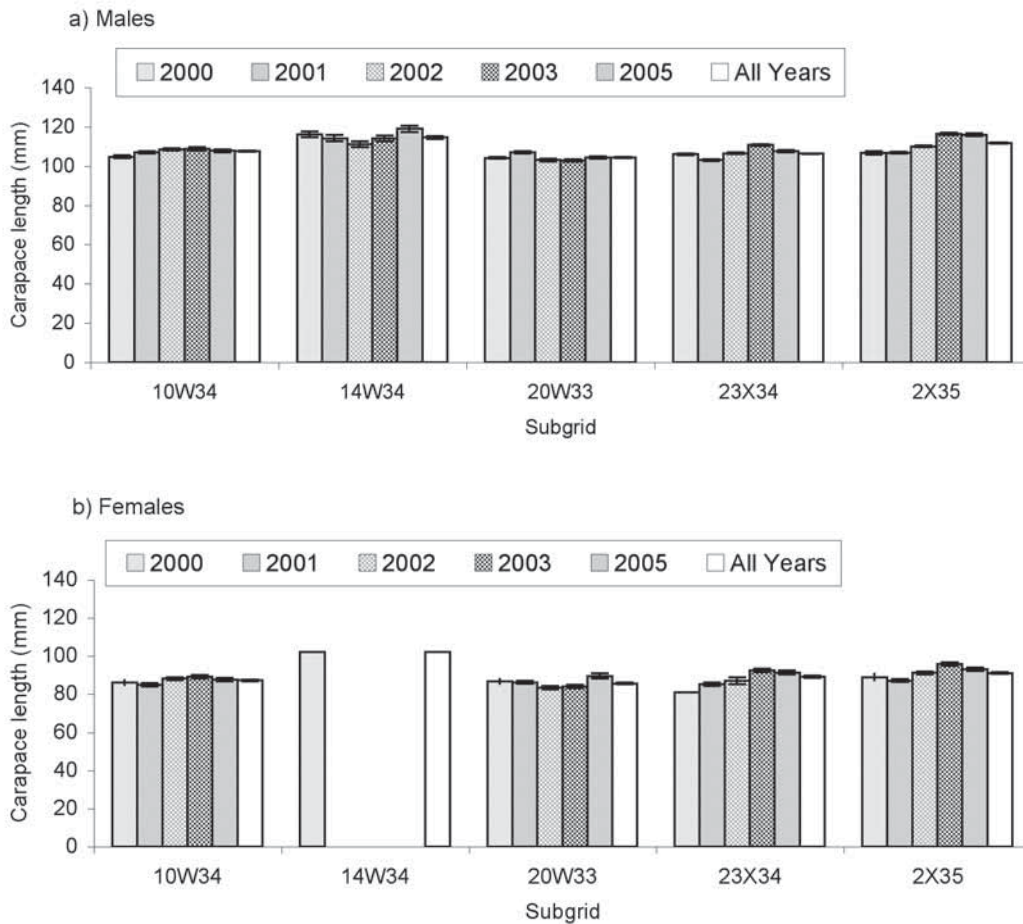


Figure 21. Mean male (a) and female (b) carapace lengths (mm) by year (2000–2003 and 2005) for Region 4. Error bars are \pm standard error.

Catch rates

Mean catch rate of males varied between subgrids in Region 4, ranging from 0.31 to 4.60 crabs/dilly.hour (Figure 22). Mean catch rate of males were consistently lowest over the survey years in subgrid 14W34 (<1.0 crabs/dilly.hour), whilst catch rate varied from 1.74–4.60 crabs/dilly.hour across the other four subgrids. Female mean catch rate also varied between subgrids and was lowest in subgrid 14W34. Mean female catch rates varied from 0–0.59 crabs/dilly.hour, except for subgrid 20W33 in 2001 where 0.97 crabs/dilly.hour were captured.

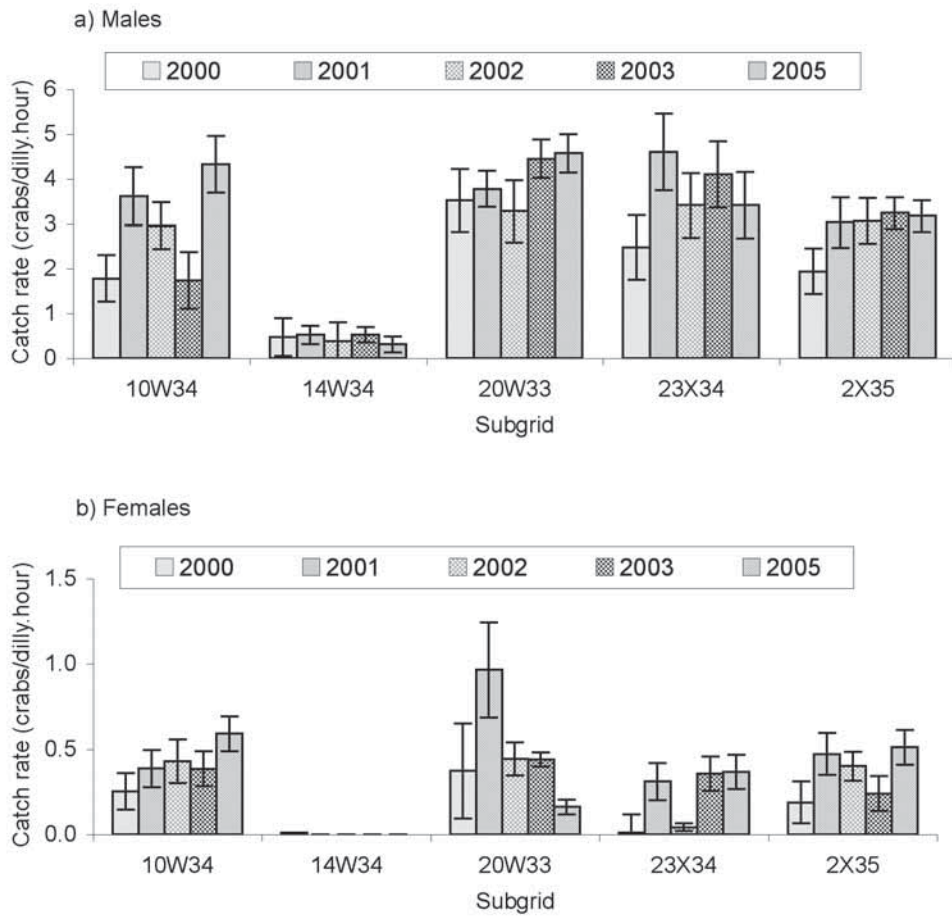


Figure 22. Mean male (a) and female (b) catch rates (crabs/dilly.hour) by year (2000–2003 and 2005) for Region 4. Error bars are ± standard error.

Sex-ratios

Sex-ratios of spanner crabs captured in particular subgrids in Region 4 generally varied little between the five survey years. Males represented 80 to 100% of the total catch depending on the subgrid and year (Figure 23). Males consistently represented a particularly high proportion of the catch in subgrid 14W34 across the five year survey period (98 to 100%).

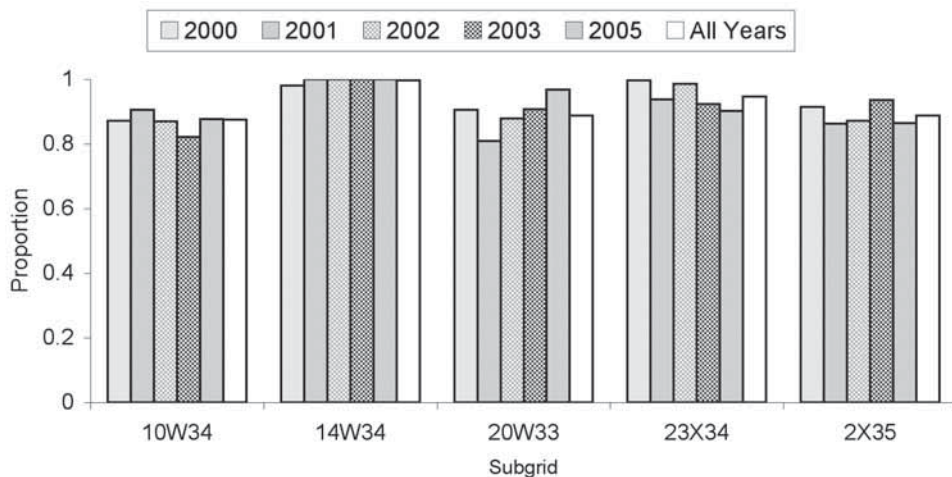


Figure 23. Sex-ratio of males to females by year (2000–2003 and 2005) for subgrids in Region 4.

Relationships with physical characteristics

Depths sampled in Region 4 ranged from 45 to 76 m, with most sets made in the 50 to 59 m depth range (Table 3). Mean catch rate for males was highest in set depths from 40 to 49 m. The highest mean female catch rate occurred at depths of 40 to 49 m (Figure 24). Mean water temperatures observed in Region 4 ranged from 18.6 to 24.5°C (Table 4). Most sets (82%) were made in temperatures ranging from 22 to 24.9°C.

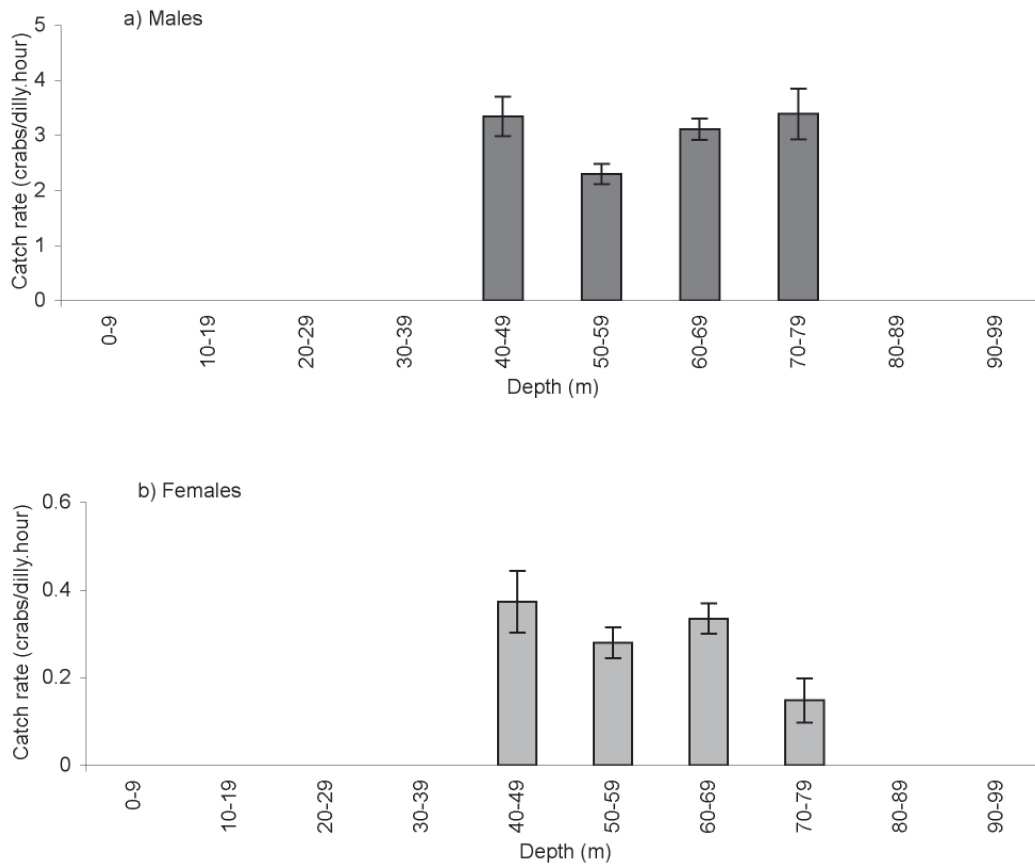


Figure 24. Mean male (a) and female (b) catch rates (crabs/dilly.hour) by depth of set for subgrids in Region 4. Error bars are ± standard error.

Region 5

Size frequency

The carapace lengths of males captured in Region 5 varied from 30 to 146 mm, with a peak in the length frequency distribution across the 90 to 99 mm class (Figure 25). Female carapace lengths ranged from 58 to 118 mm, with a broad peak in the length frequency distribution across the 80 to 89 mm class. The percentage of male crabs captured in Region 5 with carapace lengths greater than MLS was lower than in any other region at 44.3% (Table 2).

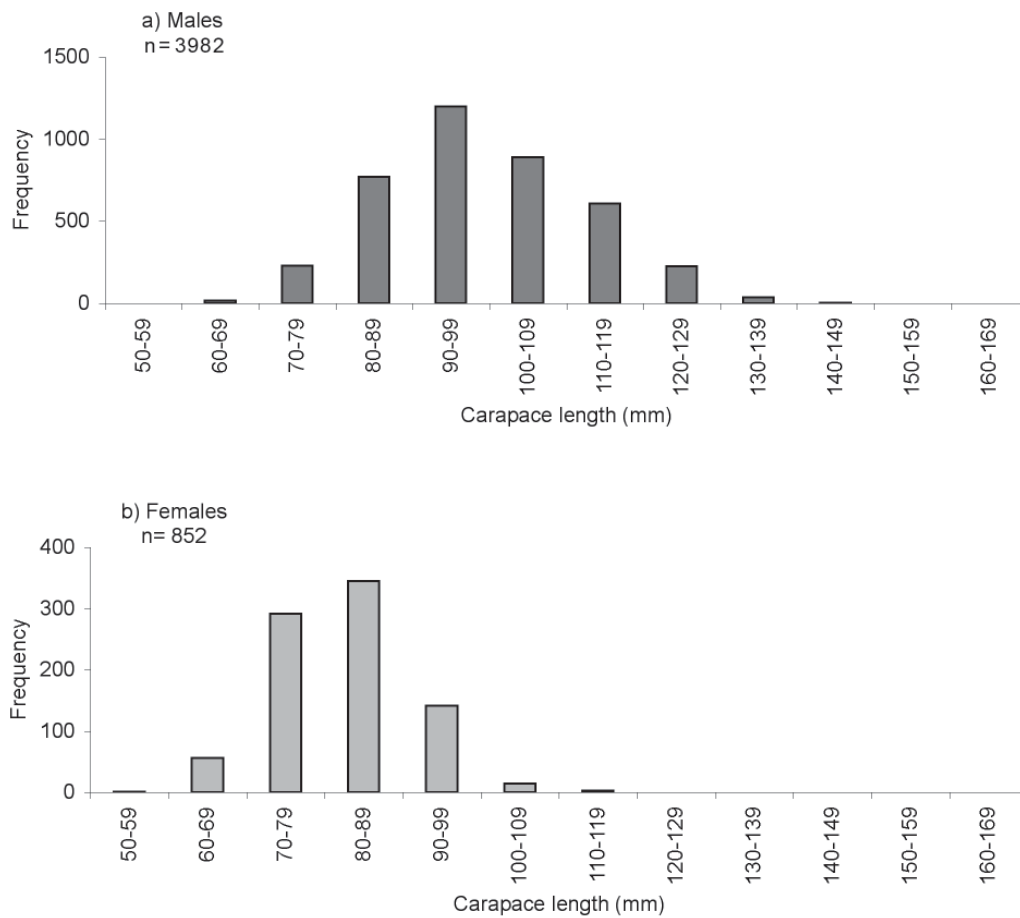


Figure 25. Male (a) and female (b) spanner crab length frequencies for all years in Region 5.

Mean male carapace lengths were highest in subgrid 19W36 (106.14 ± 0.53 mm) and lowest in subgrid 16X37 (95.50 ± 0.28 mm). Mean female carapace lengths were lower in subgrid 1X37 (79.18 ± 0.56 mm) and larger in subgrid 19W36 (88.36 ± 0.60 mm) (Figure 26).

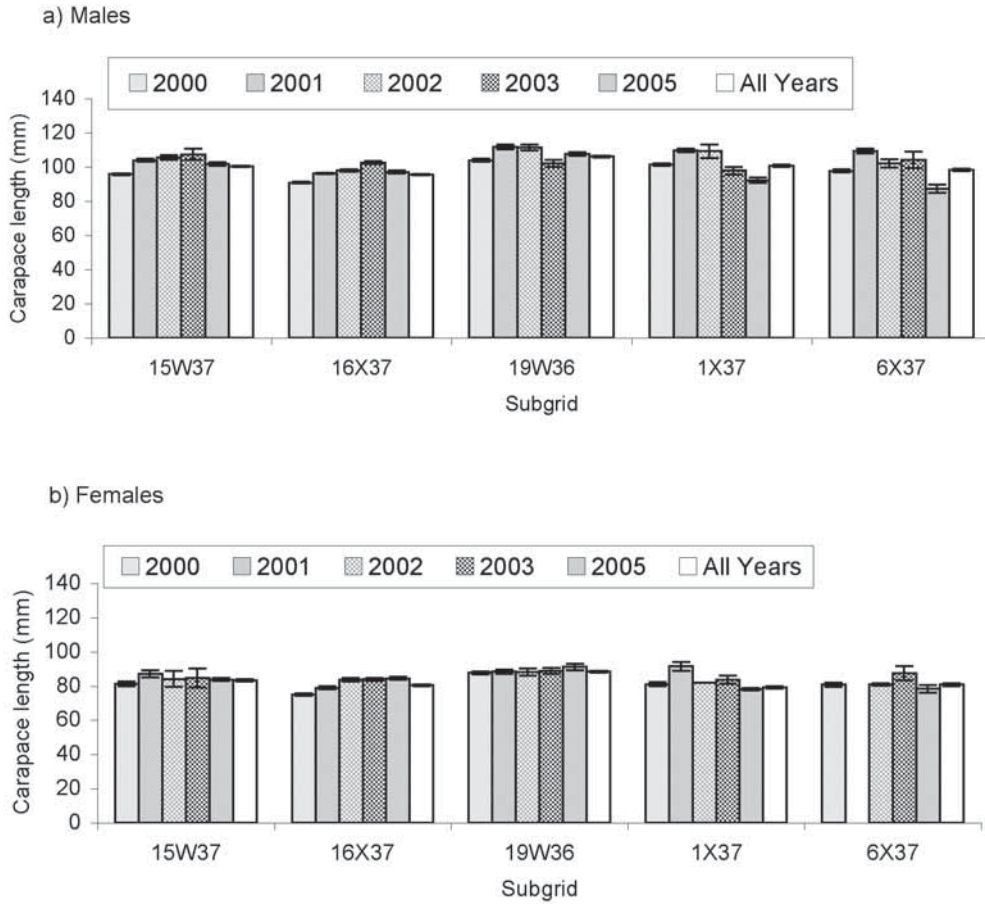


Figure 26. Mean male (a) and female (b) carapace lengths (mm) by year (2000–2003 and 2005) for Region 5. Error bars are \pm standard error.

Catch rates

Male and female mean catch rate in Region 5 showed a similar pattern, substantial variability between subgrids, high mean catch rates in 2000 and 2005 in each subgrid and low mean catch rates in 2002 and 2003 in each subgrid (Figure 27). Mean male catch rate varied from 0.12-3.53 crabs/dilly.hour while mean female catch rate ranged from 0-0.99 crabs/dilly.hour.

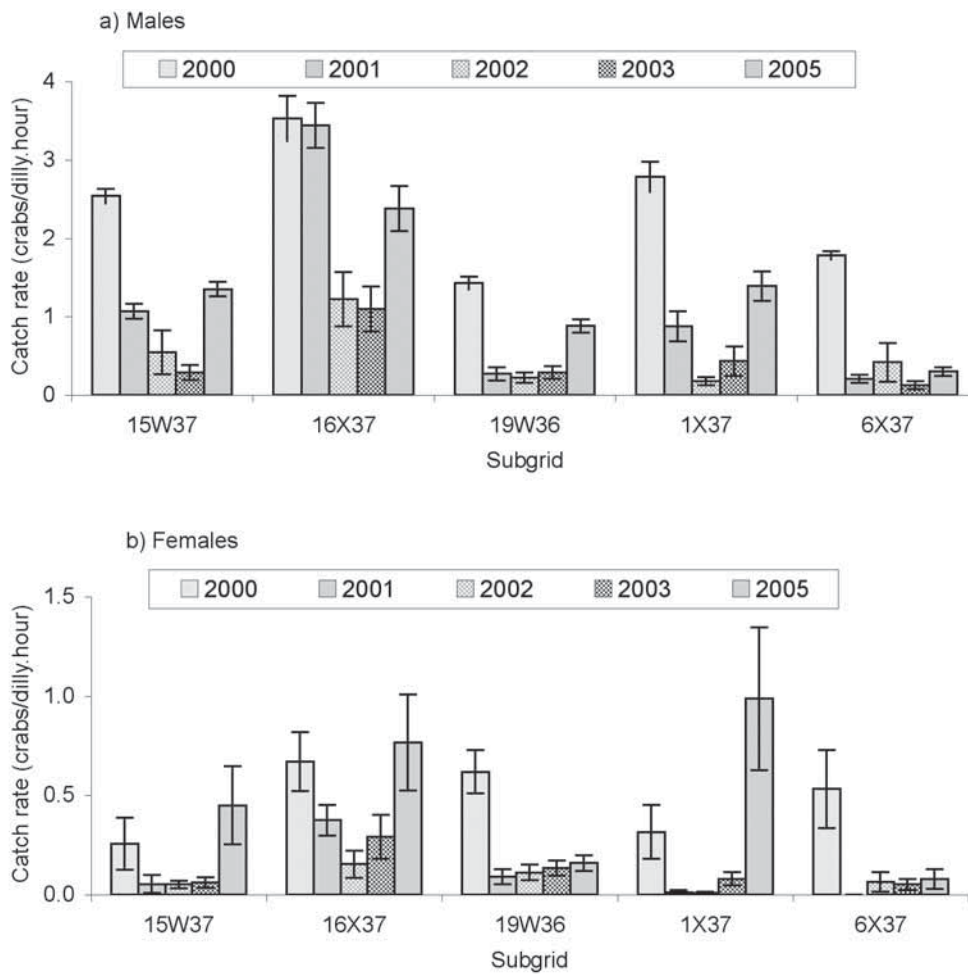


Figure 27. Mean male (a) and female (b) catch rates (crabs/dilly.hour) by year (2000–2003 and 2005) for Region 5. Error bars are \pm standard error.

Sex-ratios

Sex-ratios of spanner crabs captured in Region 5 varied between subgrids and between years for particular subgrids. Males represented 59 to 100% of the total catch depending on the subgrid and year (Figure 28). Males consistently represented a smaller proportion of the catch in subgrid 19W36 than all other subgrids across the five year survey period (66 to 85%).

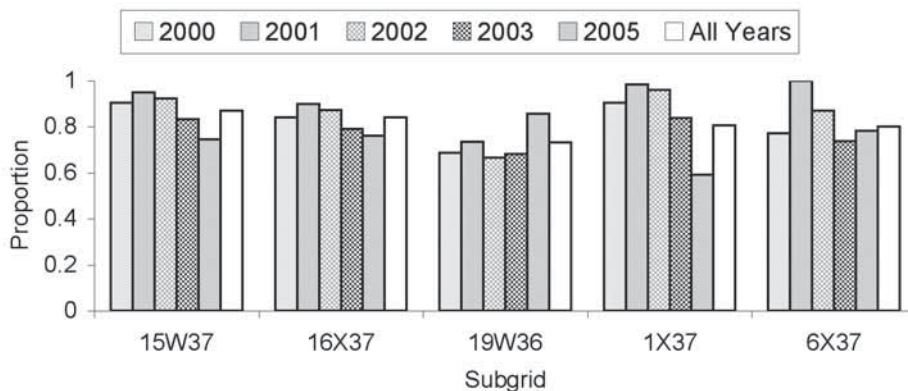


Figure 28. Sex-ratio of males to females by year (2000–2003 and 2005) for subgrids in Region 5.

Relationships with physical characteristics

Depths sampled in Region 5 ranged from 4 to 98 m, with most sets made in the 40 to 89 m depth range (Table 3). Mean male catch rate was highest at depths of 60 to 69 m and female catch rates highest in the 50 to 59 m depth range (Figure 29). Mean water temperatures observed in Region 5 ranged from 20.4 to 23.5°C (Table 4). Most sets (72%) were made in temperatures ranging from 21 to 22.9°C.

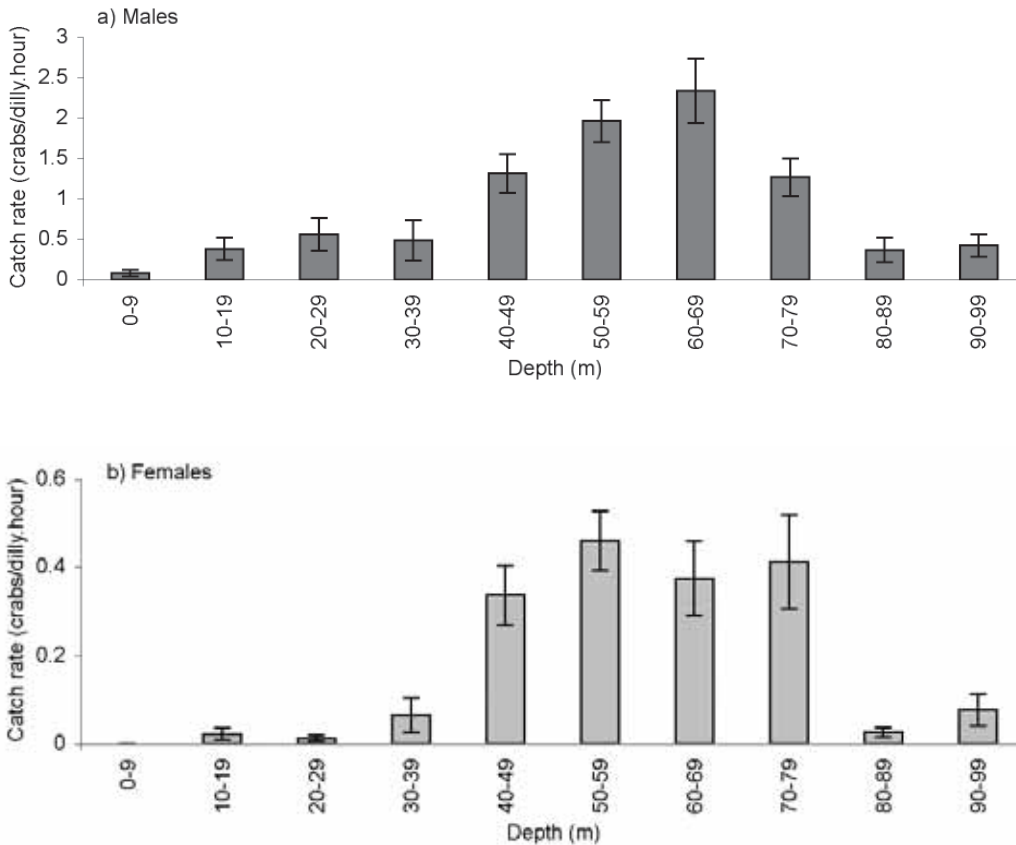


Figure 29. Mean male (a) and female (b) catch rates (crabs/dilly.hour) by depth of set for subgrids in Region 5. Error bars are ± standard error.

Region 6

Size frequency

Carapace length of captured crabs ranged from 71 to 152 mm for males and from 19 to 122 mm for females (Figure 30). The length frequency distribution showed a broad peak in the 110 to 119 mm class for males, with a peak in the 90 to 99 mm class for females. Of all the regions, Region 6 recorded the highest proportions of captured female crabs above the 100 mm MLS at 37.8% (Table 2). Approximately 80% of male crabs captured from this region were above the 100 mm MLS.

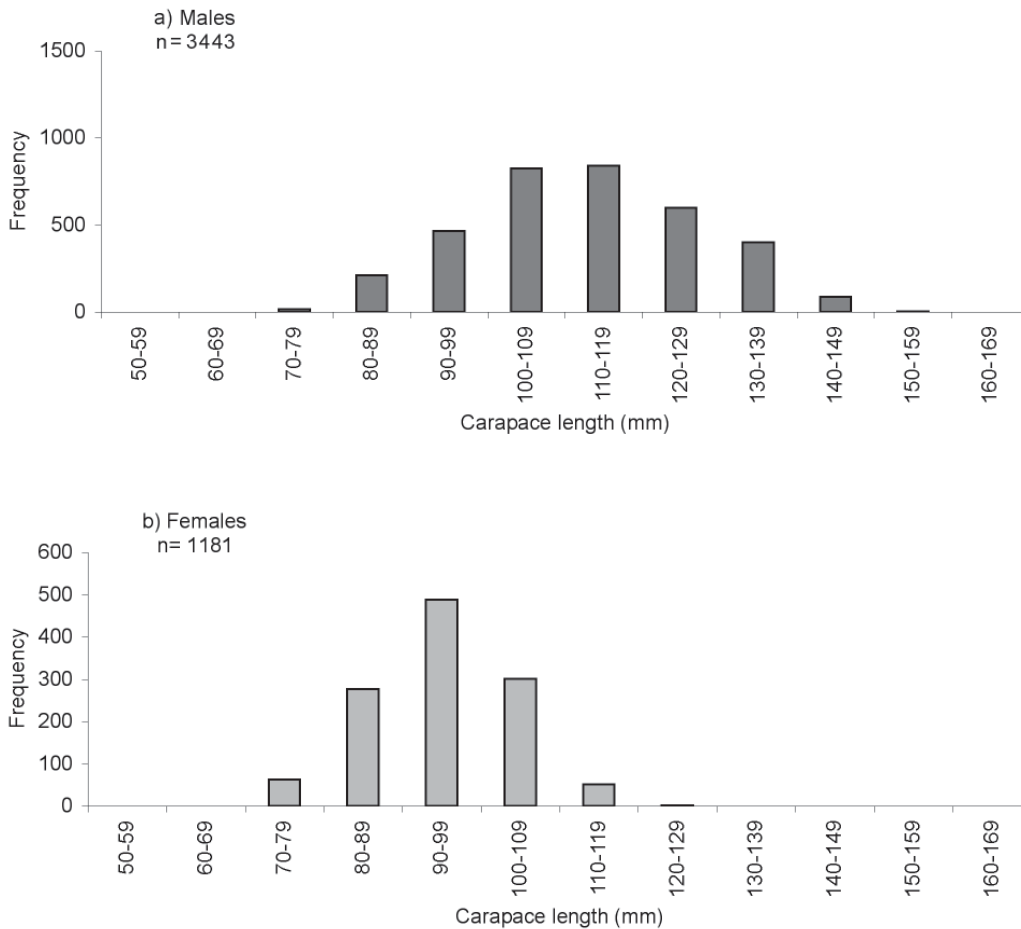


Figure 30. Male (a) and female (b) spanner crab length frequencies for all years in Region 6.

Subgrid 2X38 had the highest mean carapace length of males (113.94 ± 0.69 mm) and the lowest mean carapace length of females (89.27 ± 0.84 mm). Subgrid 22X38 had the highest mean carapace length of females (96.47 ± 0.56 mm) and the lowest mean carapace length for males (113.94 ± 0.57 mm) (Figure 31).

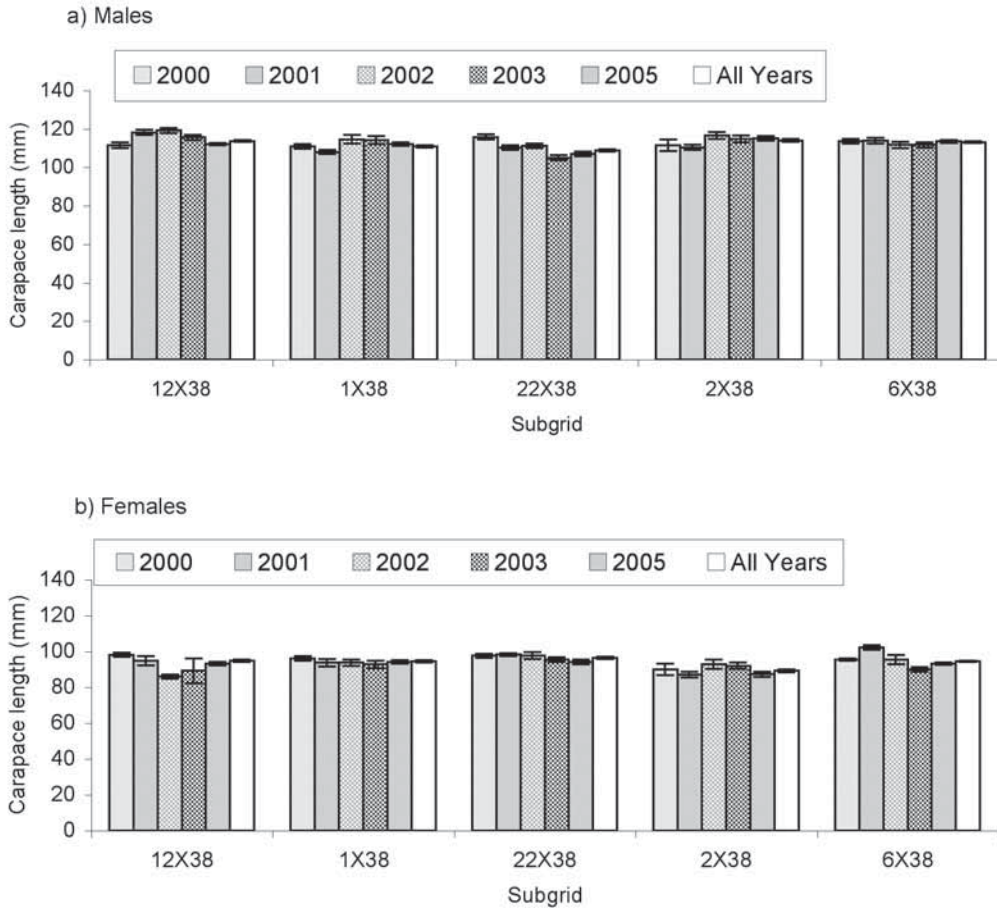


Figure 31. Mean male (a) and female (b) carapace lengths (mm) by year (2000–2003 and 2005) for Region 6. Error bars are \pm standard error.

Catch rates

Male and female mean catch rates from Region 6 showed no consistent pattern over consecutive survey years or within regions. Male catch rates varied from 0.22 to 3.07 crabs/dilly.hour (Figure 32). For all subgrids and years mean catch rates were below 2 crabs/dilly.hour with the exception of subgrid 12X38 in 2005 which was above 3 crabs/dilly.hour. Mean female catch rates generally varied from 0.03 to 1.2 crabs/dilly.hour. Mean catch rate of females was below 0.50 crabs/dilly.hour in all subgrids and years with the exception of subgrid 6X38 in 2000 and 2005 being 1.2 and 0.77 crabs/dilly.hour respectively.

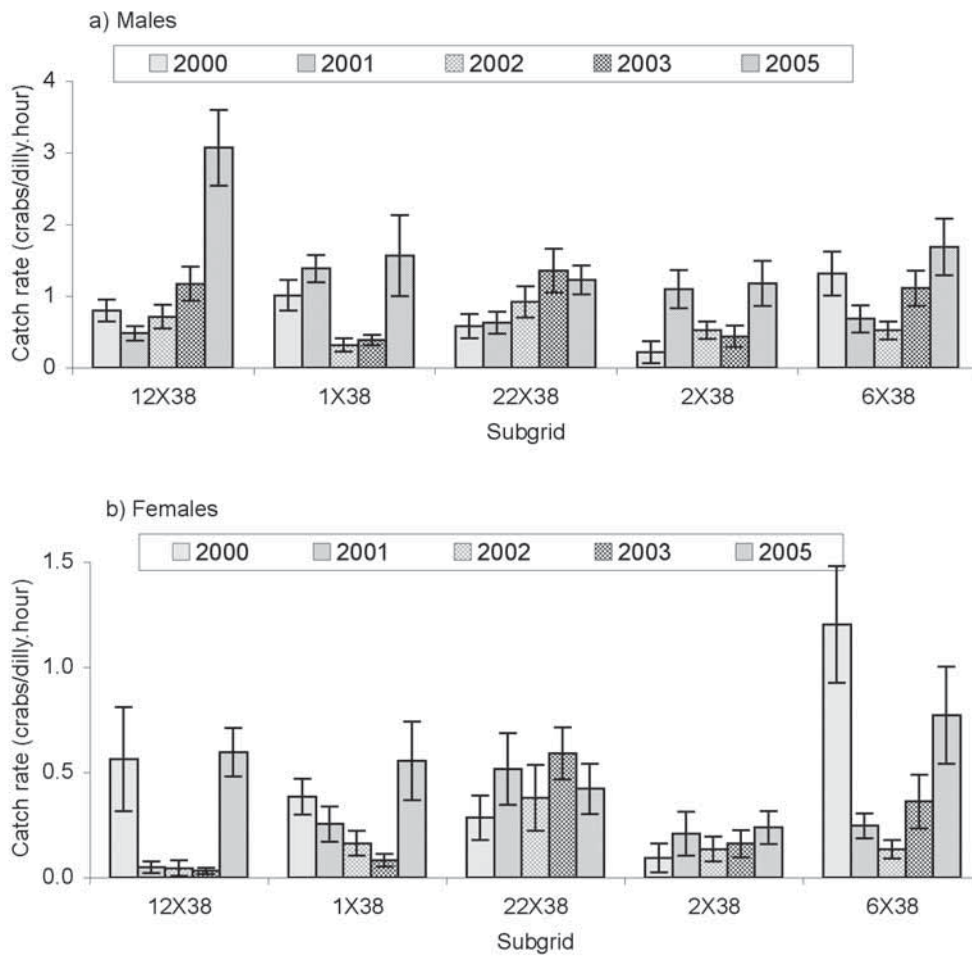


Figure 32. Mean male (a) and female (b) catch rates (crabs/dilly.hour) by year (2000–2003 and 2005) for Region 6. Error bars are ± standard error.

Sex-ratios

Sex-ratios of spanner crabs captured in Region 6 varied considerably between subgrids with no consistent patterns over the five survey years. Males represented 53 to 97% of the total catch depending on the subgrid and year (Figure 33). Over the survey period females crabs consistently represented a higher proportion of the catch in subgrid 22X38 than the other four subgrids, which displayed a greater variability in the sex-ratio of the catch between years.

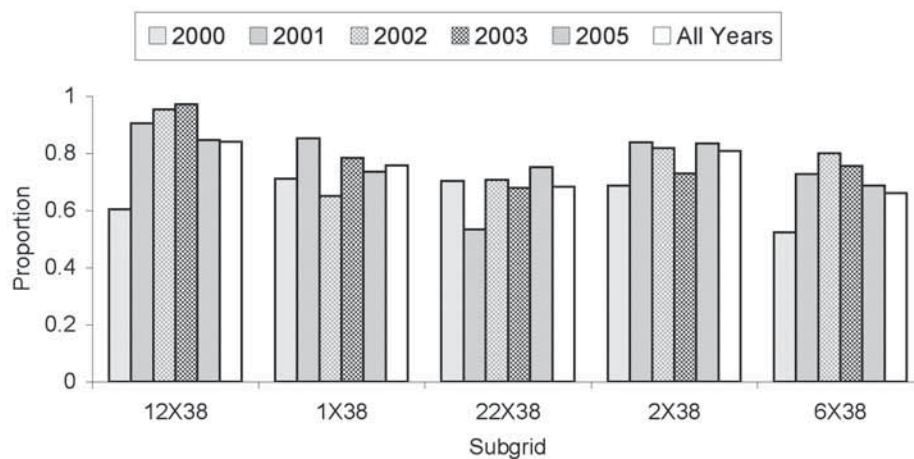


Figure 33. Sex-ratio of males to females by year (2000–2003 and 2005) for subgrids in Region 6.

Relationships with physical characteristics

Depths sampled in Region 6 ranged from 17 to 89 m, with most sets made in the 40 to 89 m depth range (Table 3). Male catch rates varied little across the entire depth spectrum sampled in Region 6, from 10 to 89 m, but were higher in the 70 to 79 m range. The highest female catch rate occurred at depths of 50 to 69 m (Figure 34). No female crabs were captured in the 10 to 19 m depth range. Mean water temperatures observed in Region 6 ranged from 18.8 to 24.5°C (Table 4). Most sets (74%) were made in temperatures ranging from 22 to 23.9°C.

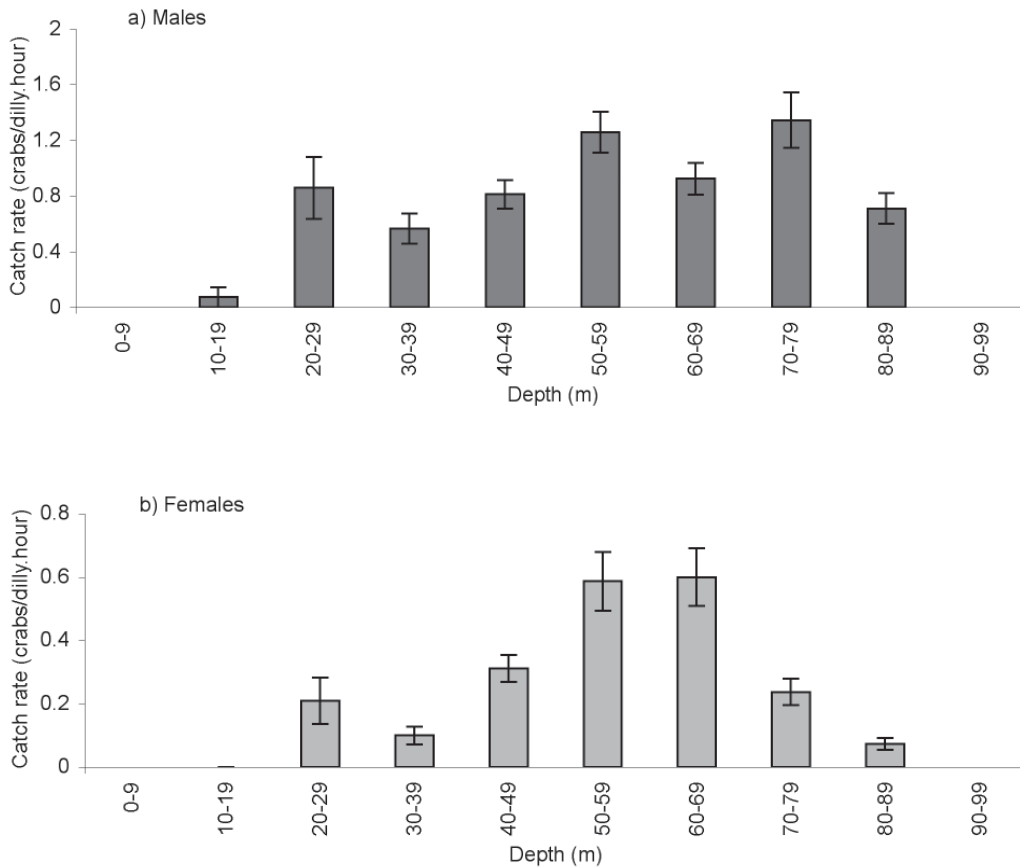


Figure 34. Mean male (a) and female (b) catch rates (crabs/dilly.hour) by depth of set for subgrids in Region 6. Error bars are \pm standard error.

Region 7 (2005 only)

Size frequency

Carapace lengths of captured crabs ranged from 84 to 149 mm for males and from 82 to 123 mm for females (Figure 35). The length frequency distribution for males was skewed and peaked in the 100 to 109 mm class. Female length frequency was also skewed, but to a lesser extent than for males, and peaked in the 90 to 99 mm class. Of all the regions, Region 7 recorded the highest proportions of captured male and female crabs above the 100 mm MLS at 90.4% and 37.8% respectively, (Table 2).

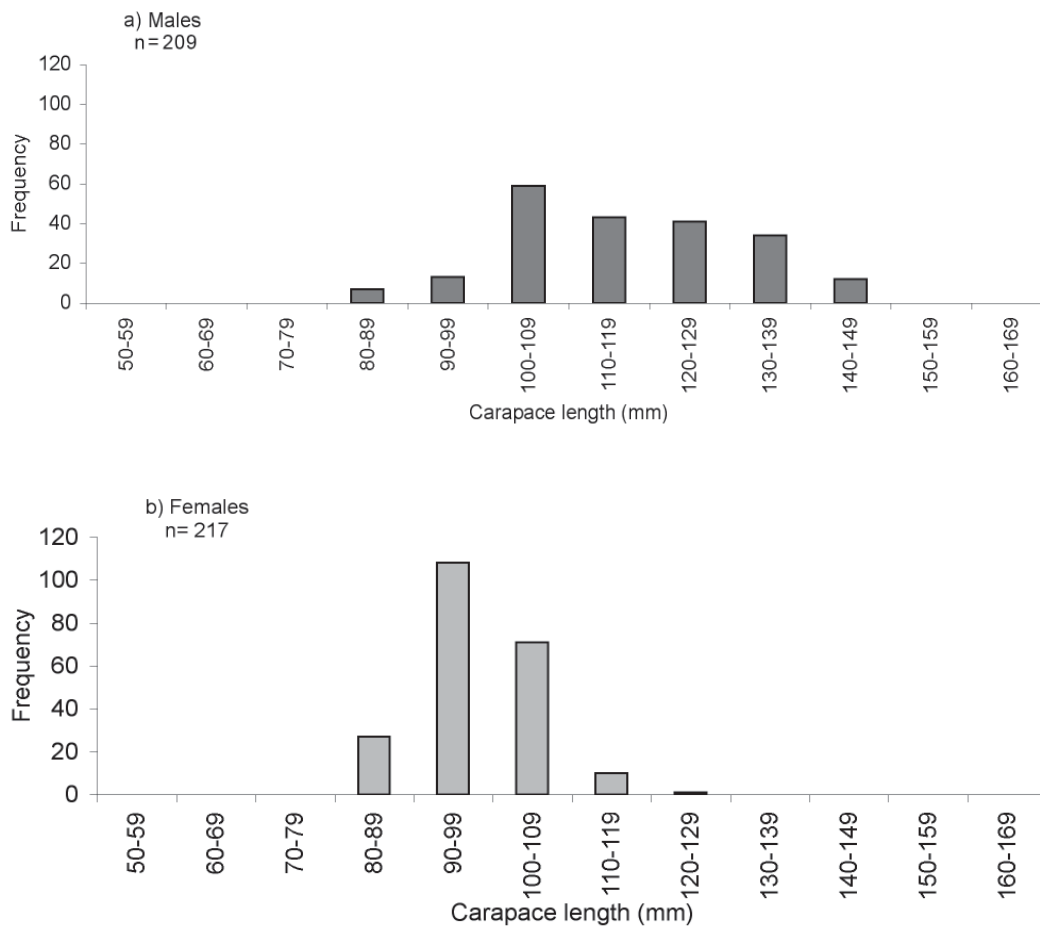


Figure 35. Male (a) and female (b) spanner crab length frequencies for 2005 in Region 7.

Carapace lengths of male crabs were relatively consistent among the different subgrids in Region 7. Mean male carapace lengths were generally in the 111 to 122 mm range. Mean female carapace lengths were generally in the range of 96 to 103 mm (Figure 36).

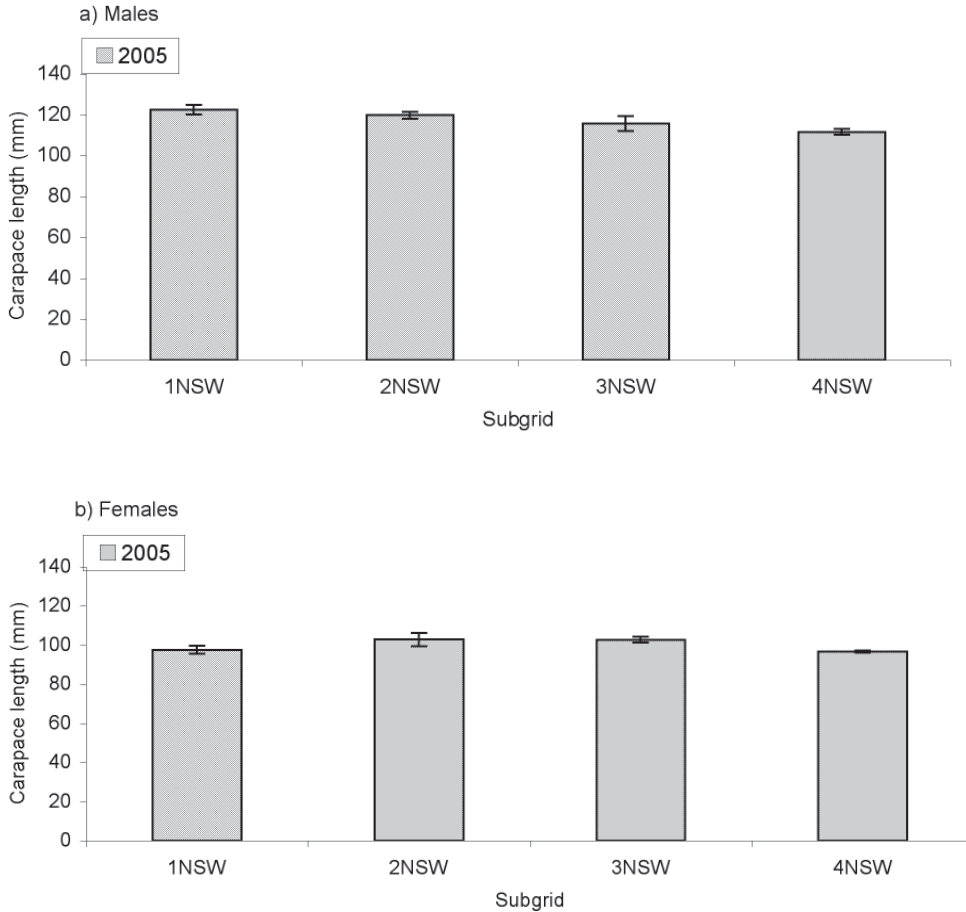


Figure 36. Mean male (a) and female (b) carapace lengths (mm) for 2005 in Region 7. Error bars are \pm standard error.

Catch rates

Mean male and female catch rates varied considerably between subgrids in Region 7. Mean male catch rates ranged from 0.09 to 0.93 crabs/dilly.hour and mean female catch rates ranged from 0.06 to 1.2 crabs/dilly.hour (Figure 37).

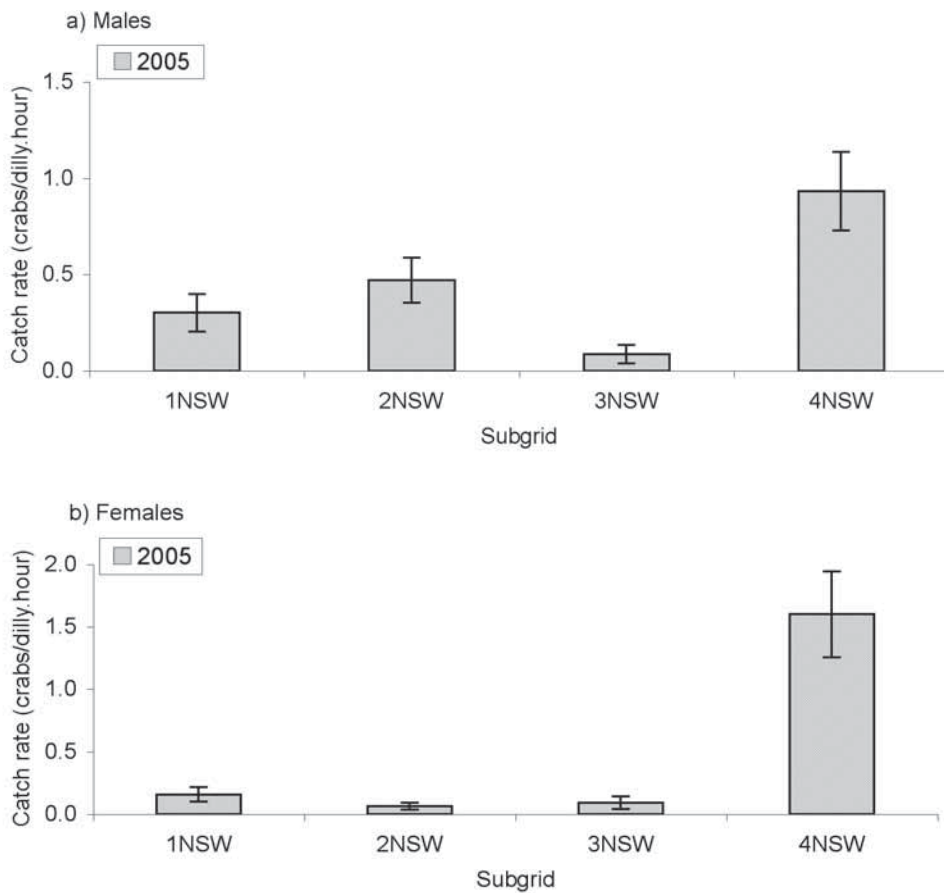


Figure 37. Mean male (a) and female (b) catch rates (crabs/dilly.hour) for 2005 in Region 7. Error bars are \pm standard error.

Sex-ratios

Sex-ratios of spanner crabs captured in Region 7 varied considerably between subgrids. Males represented 36 to 87% of the total catch depending on the subgrid (Figure 38). Females represented 13 to 63% of total catch depending on the subgrid.

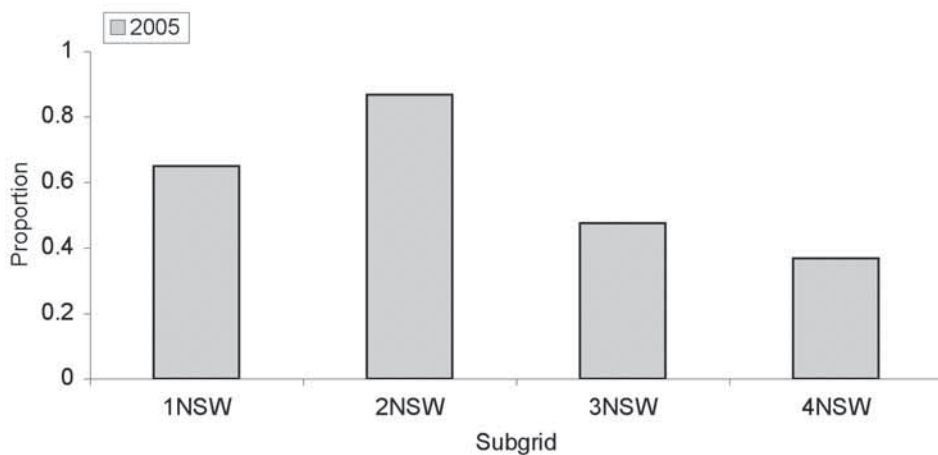


Figure 38. Sex-ratio of males to females for 2005 for subgrids in Region 7.

Relationships with physical characteristics

Depths sampled in Region 7 ranged from 10 to 60 m, with most sets made in the 50 to 59 m depth range (Table 3). Mean male rates varied considerably but were highest at depths of 50 to 59 m whilst female mean catch rates peaked at depths of 20 to 29 m with similar catch rates at depths of 50 to 59 m (Figure 39).

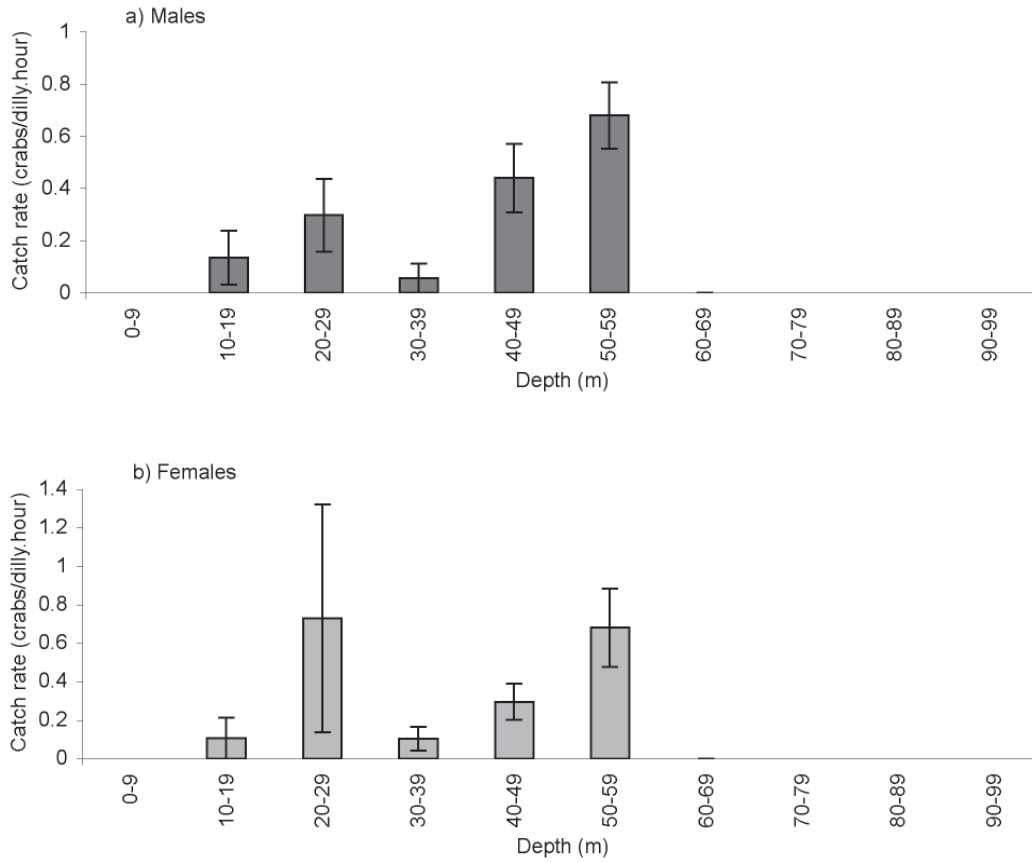


Figure 39. Mean male (a) and female (b) catch rates (crabs/dilly.hour) by depth of set for subgrids in Region 7. Error bars are \pm standard error.

Discussion

Survey technique

The LTMP fishery independent spanner crab survey sampled all five Queensland assessment regions in each year using chartered commercial and research vessels. All sampling was carried out with minimal gear loss or damage. In 2005, Region 7 was included (New South Wales), which was also sampled successfully, although later than intended (June rather than May).

All chartered vessels performed well throughout the duration of the surveys with the only downtime attributable to poor weather conditions at the time of the survey. The extensive scale of the survey enables robust comparisons of catch rates, sex ratios and size frequency distributions between regions and years.

Site-specific characteristics of subgrids in particular regions modified the way certain subgrids were sampled. For example, large areas of some subgrids were deeper than 90 m which precluded sampling. This would have reduced the available area in some subgrids, but the small relative increase in sampling intensity is not likely to have significant consequences for comparisons between regions and years.

Set times

Set times were quite variable ranging from 25 to 195 min. At this stage set time has been used to standardise catch rates, but in the future it may be prudent to investigate the effect of set time on catch rate, length frequency and sex-ratio. This would require a structured sampling design to collect sufficient data over a wide range of set times in all regions and depths. This was not the case during surveys between 2000–2005, where set times varied depending on the weather or the individual fishing pattern of the chartered commercial fisher.

Length frequency distributions

Lengths of male and female crabs were normally distributed for each of the five Queensland survey regions. It would be difficult at this stage to draw any strong conclusions about the length distribution of crabs from Region 7, although it does appear to be skewed. Notably, there was no distinct truncation of the size frequency distribution above the legal size limit (MLS, 100 mm carapace length) for either males or females in any region. The peak frequency for male crabs in all regions was larger than the MLS. This result is opposite to the results from the LTMP mud crab survey (DPI&F, 2005 b) which show very few male crabs above MLS are caught (DPI&F, unpublished data).

Considerable spatial variability existed in the mean carapace length of both male and female spanner crabs between regions. However, patterns in the size data were generally consistent within regions during the survey period. Within Queensland regions, mean male crab size was largest in Region 6 and smallest in Region 5. A high catch rate of smaller crabs from subgrid 16X37 contributed to the low mean size of crabs in Region 5. As the current survey design cannot determine the extent of intra-annual variability, it is uncertain if the low mean size of crabs in region 5 is a real population characteristic.

Crabs from Region 7 were of a larger mean size than all Queensland regions for both males and females. However, this finding was based on only one year of observations for this region. A high proportion of male crabs were of legal size across all Queensland regions (63 to 79%), except for Region 5, where only 44% of males were larger than MLS. Likewise, the spatial pattern in the mean carapace lengths differed between regions for females, with the largest female crabs captured in Region 6 and smallest in Region 5.

Sex-ratios

Catches were heavily biased towards males, which represented 86.5% of the overall catch. This male bias is consistent with previous studies in Queensland and is probably due to the size selective nature of the sampling gear and the dominance of males in the population with increasing crab size (Brown 1986, Brown *et al.* 1999). Therefore, while the sex-ratio of crabs captured during surveys is unlikely to reflect the sex-ratio of the entire population, the change in sex-ratio over a number of yearly surveys may be a good indicator of actual changes in the population.

Trends were evident in the sex-ratio within regions and these were consistent across the five year study period. Regions 6 and 7 had a much higher percentage of females in the catch (28% and 51% respectively) compared to Regions 2, 3, 4 and 5 (10 to 15%). Whether this result is an artefact of the sampling gears selectivity (female crabs are larger in the southern regions and more likely to be captured) or a real representation of the population (there are more females in the population in Regions 6 and 7) is uncertain.

Catch rates

Part of the rationale behind the LTMP spanner crab survey was concern about the reliability of fishery dependent catch rates as indicators of stock abundance for setting of the TACC, as commercial fishers target aggregations of crabs in a stock that is not uniformly distributed.

The survey catch rates presented in this report were standardised per hour of set time and number of dillies, allowing direct comparison of results between regions and years. In contrast, the commercial logbook data (CFISH) are not standardised by set time, only by fishing day, and therefore any comparisons should be undertaken with caution. The number of sets and set duration per day varies between different fishers and different conditions. A comparison of data trends from the fishery independent survey with the trends in the fishery dependent data would be appropriate for the same period.

The survey catch rates varied greatly between the five Queensland regions and differed between years within regions. Catch rates in Region 4 were clearly higher than all other regions and the consistency of this pattern over all years suggests high relative crab abundance. This high abundance may be due to a variety of biological or physical differences such as different habitat quality, larval settlement and juvenile and adult survival rates between regions. The current survey is not designed to investigate these causal relationships.

There was an increase in catch rate for spanner crabs in all regions between the 2003 and 2005 survey, particularly in Regions 5 and 6 where male catch rate nearly doubled. A reduction of commercial effort and possibly fishing mortality (M. Starkey, commercial fisher, pers. comm., April 2005) in these regions due to decreased market demand may have contributed to this pattern. Further, the increases in catch rates evident throughout all regions may indicate a stock-wide increase in abundance.

Preliminary comparisons of the trends in fisheries independent catch rates determined in this survey and the fisheries dependent catch rates determined with commercial data (Brown 2004) indicate a difference exists between the two on a region by region basis.

For example Region 5 shows relatively consistent commercial catch rates over the survey years 2000–2003, whilst the LTMP data indicate a falling catch rate over these same years. Some reasons for the different patterns may include:

- The Long Term Monitoring Program only samples in May.
- Commercial effort data are not standardised by soak time.
- The commercial fishery is mobile and targets aggregations of crabs, potentially maintaining high catch rates while overall population size is decreasing (hyperstability).

Relationships with physical characteristics

A distinct peak in mean catch rate was observed at depths of 60 to 69 m for both males and females. However, as each depth stratum was not sampled equally within each region, caution should be exercised when interpreting the result. When examined on a regional basis, the trends in mean catch rate are less evident, and highlight the unbalanced nature of the sampling regime.

Mean catch rate of male and female crabs seemed to differ with regards to water temperature. Confounding the result are the unequal number observations per region (maximum Regions 2 and 4, 78 observations; minimum Region 5, 48 observations) that may have contributed a higher or lower trend to the temperature data. The unequal number of observations was a result of some temperature-loggers being lost during sampling operations.

A sampling design which samples each depth stratum equally, may give a better indication of any relationship between catch rate and depth. The results of such a study may be useful to further interpret the results of the LTMP surveys and also patterns in commercial logbook data.

Bycatch and interactions with other marine species

Bycatch from the three survey years, fishing with standard commercial spanner crab gear, was low at 1874 individual animals, which in the main, could be released with a high survival expectancy. There were no interactions with protected marine species, but some species of conservation interest were captured (seahorses- Syngnathidae).

Conclusions and Recommendations

The LTMP, spanner crab component, has delivered a time series of size and sex-ratio data coupled with fishery independent catch rate data for the five Queensland assessment regions in Managed Area A of the fishery. In 2005 it delivered similar data from the NSW spanner crab fishery area to be used in a monitoring method comparison between the two states. Further standardisation of catch rates, that will allow comparisons between the fishery dependent and independent data sets, plus the associated biological and physical characteristics, will greatly enhance the importance of this data set for future analysis and regional population assessments.

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Appendix A—Mean catch rates (individuals per dilly lift) of bycatch species caught during the Long Term Monitoring Program spanner crab survey in 2001, 2003 and 2005 per region (2–6).

Appendix A Table 1. Mean catch rates (individuals per dilly lift) of bycatch species caught during the Long Term Monitoring Program spanner crab survey in 2001, 2003 and 2005 in Region 2.

Phylum	Scientific Name	Common Name	2002	2003	2005
Chordata	<i>Ambiserrula jugosa</i>	Flathead	0	0	0.004011
	<i>Apogon nigripinnis</i>	Cardinafish	0	0.001339	0
	<i>Arnoglossus intemedius</i>	Flounder	0.001333	0	0
	<i>Callionymus japonicus</i>	Dragonet	0.001333	0.001339	0
	<i>Cottapistus cottoides</i>	Scorpionfish	0	0.001339	0
	<i>Inimicus caledonicus</i>	Scorpionfish	0	0.001339	0.001337
	<i>Inimicus didactylus</i>	Scorpionfish	0.001333	0	0
	<i>Paramonacanthus japonicus</i>	Leatherjacket	0.002667	0	0
	<i>Paramonacanthus lowei</i>	Leatherjacket	0	0.002677	0
	<i>Paramonacanthus otisensis</i>	Leatherjacket	0	0	0.002674
	<i>Rogadius patriciae</i>	Flathead	0	0.002677	0
	Ascidiacea	Sea Squirt	0.001333	0	0
	<i>Hippocampus</i> sp.	Sea Horse	0	0.001339	0
	Mollusca	<i>Amusium balloti</i>	Scallop	0.001333	0.001339
<i>Chicoreus triplex damicornis</i>		Shell	0	0	0.001337
<i>Malleus albus</i>		Shell	0	0	0.008021
<i>Murex kerslakeae</i>		Shell	0	0	0.004011
Pectinidae		Scallop	0	0.001339	0
Bivalvia		Shell	0.04	0	0
Gastropoda		Shell	0.004	0	0
<i>Spondylus</i> sp.		Shell	0	0.029451	0.050802
<i>Tudivasum</i> sp.		Shell	0	0	0.005348
Echinodermata		<i>Bohadschia marmorata</i>	Sea Cucumber	0	0
	<i>Anthenea</i> sp.	Starfish	0.002667	0	0.001337
	Asteroidea	Starfish	0.017333	0	0
	<i>Astropecten</i> sp.	Starfish	0.005333	0.002677	0
	Crinoidea	Feather Star	0.004	0.014726	0
	Echinoidea	Sea Urchin	0.004	0.053548	0.001337
	Holothuroidea	Sea Slug	0.002667	0	0
	Ophiuroidea	Brittle Star	0	0.002677	0
	<i>Pentaceraster</i> sp.	Sea Urchin	0	0	0.012032
	Cnidaria	<i>Dichotella</i> sp.	Gorgonian	0	0
<i>Junceela</i> sp.		Gorgonian	0	0	0
Arthropoda	Paguridae	Crab	0	0.001339	0
	<i>Thalamita sima</i>	Crab	0.001333	0	0
	Crustacea	Crab	0.002667	0	0
	<i>Cryptopodia</i> sp.	Crab	0.001333	0	0
	<i>Portunus rubromarginatus</i>	Crab	0.001333	0	0

Appendix A Table 2. Mean catch rates (individuals per dilly lift) of bycatch species caught during the Long Term Monitoring Program spanner crab survey in 2001, 2003 and 2005 in Region 3.

Phylum	Scientific Name	Common Name	2002	2003	2005	
Chordata	<i>Ambiserrula jugosa</i>	Flathead	0	0	0.004076	
	<i>Apistus carinatus</i>	Waspfish	0.002677	0.018893	0.01087	
	<i>Aploactis aspera</i>	Velvetfish	0.001339	0	0	
	<i>Apogon nigripinnis</i>	Cardinafish	0	0.00135	0	
	<i>Aseraggodes melanostictus</i>	Flatfish	0	0.002699	0	
	<i>Callionymus japonicus</i>	Dragonet	0	0.00135	0	
	<i>Callionymus limiceps</i>	Dragonet	0.01071	0	0	
	<i>Callionymus sublaevis</i>	Dragonet	0	0.00135	0	
	<i>Engyprosopon grandisquama</i>	Flatfish	0	0	0.001359	
	<i>Inimicus caledonicus</i>	Scorpionfish	0	0.006748	0	
	<i>Inimicus sinemis</i>	Scorpionfish	0.001339	0	0	
	<i>Nemipterus theodorei</i>	Pinky	0	0	0.001359	
	<i>Onigocia macrolepis</i>	Flathead	0	0.006748	0	
	<i>Paramonacanthus japonicus</i>	Leatherjacket	0.001339	0	0	
	<i>Paramonacanthus lowei</i>	Leatherjacket	0	0.002699	0	
	<i>Paramonacanthus otisensis</i>	Leatherjacket	0	0	0.002717	
	<i>Sebastapistes strongia</i>	Scorpionfish	0.001339	0	0	
	<i>Suggrundus isacanthus</i>	Flathead	0.018742	0	0	
	Mollusca	<i>Octopus exannulatus</i>	Octopus	0	0	0.001359
		<i>Spondylus wrightianus</i>	Shell	0	0	0.005435
Gastropoda		Shell	0.049531	0	0	
<i>Spondylus</i> sp.		Shell	0	0.002699	0	
Echinodermata	<i>Anthenea</i> sp.	Starfish	0	0	0.001359	
	Asteroidea	Starfish	0.084337	0	0	
	<i>Astropecten</i> sp.	Starfish	0	0.016194	0.021739	
	Echinoidea	Sea Urchin	0.001339	0	0	
	Ophiuroidea	Brittle Star	0	0	0.001359	
	<i>Pentaceraster</i> sp.	Sea Urchin	0	0.006748	0.012228	
Arthropoda	<i>Matuta planipes</i>	Crab	0	0.00135	0	
	<i>Portunus pelagicus</i>	Sand Crab	0	0	0.001359	
	<i>Scyllarus demani</i>	Crab	0	0.00135	0	
	Crustacea	Crab	0.004016	0	0	
	<i>Cryptopodia</i> sp.	Crab	0	0.00135	0	
	<i>Portunus rubromarginatus</i>	Crab	0.001339	0	0	
Phaeophyta	<i>Lobophora variegata</i>	Brown Algae	0	0.00135	0	

Appendix A Table 3. Mean catch rates (individuals per dilly lift) of bycatch species caught during the Long Term Monitoring Program spanner crab survey in 2001, 2003 and 2005 in Region 4.

Phylum	Scientific Name	Common Name	2002	2003	2005
Chordata	<i>Ambiserrula jugosa</i>	Flathead	0	0	0.00534
	<i>Apistus carinatus</i>	Waspfish	0	0	0.001335
	<i>Callionymus japonicus</i>	Dragonet	0.001333	0	0
	<i>Callionymus limiceps</i>	Dragonet	0.001333	0	0
	<i>Inimicus caledonicus</i>	Scorpionfish	0	0	0.001335
	<i>Paramonacanthus japonicus</i>	Leatherjacket	0.001333	0	0
	<i>Paramonacanthus otisensis</i>	Leatherjacket	0	0	0.001335
	<i>Rogadius patriciae</i>	Flathead	0	0.002674	0
	<i>Suggrundus isacanthus</i>	Flathead	0.008	0	0
Mollusca	<i>Fusinius undulatus</i>	Shell	0	0	0.001335
	<i>Murex acanthostephes</i>	Shell	0	0	0.001335
	<i>Rapana rapiformis</i>	Shell	0	0	0.001335
	<i>Malleus</i> sp.	Shell	0	0.002674	0
	<i>Mitrella</i> sp.	Shell	0	0	0.001335
	<i>Phos</i> sp.	Shell	0	0	0.001335
	Gastropoda	Shell	0.001333	0	0
Echinodermata	<i>Stellaster equestris</i>	Sea Star	0	0	0.021362
	Asteroidea	Starfish	0.042667	0	0
	<i>Astropecten</i> sp.	Starfish	0	0	0.001335
	Crinoidea	Feather Star	0.036	0.044118	0
	Echinoidea	Sea Urchin	0.082667	0.062834	0
	Holothuroidea	Sea Slug	0.002667	0	0.006676
	Ophiuroidea	Brittle Star	0	0	0.009346
	<i>Prionocidaris</i> sp.	Sea Urchin	0	0	0.038718
Cnidaria	Bryozoa	Coral	0	0	0
Arthropoda	Majidae	Crab	0	0.004011	0
	Paguridae	Crab	0	0.001337	0
	<i>Portunus argentatus</i>	Crab	0	0	0.001335
	Crustacea	Crab	0.004	0	0
	<i>Parthenope</i> sp.	Crab	0	0	0.001335

Appendix A Table 4. Mean catch rates (individuals per dilly lift) of bycatch species caught during the Long Term Monitoring Program spanner crab survey in 2001, 2003 and 2005 in Region 5.

Phylum	Scientific Name	Common Name	2002	2003	2005	
Chordata	<i>Ambiserrula jugosa</i>	Flathead	0	0.009333	0.006693	
	<i>Apistus carinatus</i>	Waspfish	0	0	0.001339	
	<i>Callionymus calcaratus</i>	Dragonet	0.001335	0	0	
	<i>Callionymus japonicus</i>	Dragonet	0	0.001333	0	
	<i>Callionymus limiceps</i>	Dragonet	0.00267	0	0	
	<i>Callionymus sublaevis</i>	Dragonet	0	0.002667	0	
	<i>Maxillicosta whitleyi</i>	Scorpionfish	0	0	0.005355	
	<i>Paramonacanthus japonicus</i>	Leatherjacket	0.001335	0	0	
	<i>Parapercis nebulosa</i>	Grubfish	0	0	0.002677	
	<i>Paraplagusia bilineata</i>	Sole	0.00267	0	0	
	<i>Sillago robusta</i>	Stout Whiting	0	0.001333	0	
	<i>Synchiropus rameus</i>	Dragonet	0	0.001333	0	
	<i>Torquigener altipinnis</i>	Toadfish	0	0	0.001339	
	<i>Torquigener pallimaculatus</i>	Toadfish	0	0	0.001339	
	<i>Cynoglossus</i> sp.	Sole	0	0.002667	0	
	<i>Hippocampus</i> sp.	Sea Horse	0	0.002667	0	
	<i>Platycephalus</i> sp.	Flathead	0	0.017333	0	
	Echinodermata	<i>Astropecten</i> sp.	Starfish	0	0.001333	0.004016
		Crinoidea	Feather Star	0	0.002667	0.001339
		Ophiuroidea	Brittle Star	0	0	0.004016
<i>Prionocidaris</i> sp.		Sea Urchin	0	0	0.120482	
Arthropoda	<i>Entomonyx depressus</i>	Crab	0	0	0.002677	
	<i>Hyastenus cambelli</i>	Crab	0	0	0.001339	
	Majidae	Crab	0	0.002667	0.001339	
	<i>Portunus pelagicus</i>	Sand Crab	0	0	0.004016	
	<i>Portunus sanguinolentus</i>	Three Spot Crab	0.001335	0	0.001339	

Appendix A Table 5. Mean catch rates (individuals per dilly lift) of bycatch species caught during the Long Term Monitoring Program spanner crab survey in 2001, 2003 and 2005 in Region 6.

Phylum	Scientific Name	Common Name	2002	2003	2005	
Chordata	<i>Ambiserrula jugosa</i>	Flathead	0	0	0.004	
	<i>Aseraggodes melanostictus</i>	Flatfish	0	0.002674	0	
	<i>Callionymus calcaratus</i>	Dragonet	0.00534	0	0	
	<i>Callionymus japonicus</i>	Dragonet	0.001335	0	0	
	<i>Callionymus limiceps</i>	Dragonet	0.006676	0	0	
	<i>Callionymus sublaevis</i>	Dragonet	0	0.002674	0	
	<i>Centropogon australis</i>	Scorpionfish	0	0	0.001333	
	<i>Cottapistus cottoides</i>	Scorpionfish	0	0.004011	0	
	<i>Dactyloptena papilio</i>	Gurnard	0	0	0.001333	
	<i>Erosa erosa</i>	Stonefish	0	0.001337	0	
	<i>Hippocampus queenslandicus</i>	Sea Horse	0.001335	0	0	
	<i>Hippocampus tristis</i>	Sea Horse	0	0	0.001333	
	<i>Lepidotrigla argus</i>	Gurnard	0	0	0.001333	
	<i>Lepidotrigla umbrosa</i>	Gurnard	0	0.001337	0	
	<i>Paraplagusia bilineata</i>	Sole	0.001335	0	0	
	<i>Platycephalus longispinis</i>	Flathead	0.00267	0	0.009333	
	<i>Scorpaenodes</i> sp.	Scorpionfish	0.00267	0	0	
	<i>Sillago robusta</i>	Stout Whiting	0	0	0.002667	
	<i>Soleichthys heterorhinos</i>	Sole	0	0.001337	0.001333	
	<i>Sphenopus marsupialis</i>	Pike	0	0	0.001333	
	<i>Suggrundus isacanthus</i>	Flathead	0.006676	0	0	
	Blenniidae	Blenny	0.001335	0	0	
	<i>Hippocampus</i> sp.	Sea Horse	0	0.002674	0	
	<i>Platycephalus</i> sp.	Flathead	0	0.008021	0	
	Mollusca	<i>Rapana rapiformis</i>	Shell	0	0	0.001333
		<i>Octopus</i> sp.	Octopus	0.006676	0	0
		Gastropoda	Shell	0.008011	0	0
	Echinodermata	Asteroidea	Starfish	0.012016	0	0.002667
		<i>Astropecten</i> sp.	Starfish	0	0.005348	0
		Crinoidea	Feather Star	0.066756	0.010695	0.004
Echinoidea		Sea Urchin	0.291055	0.266043	0.005333	
Holothuroidea		Sea Slug	0	0.002674	0	
Ophiuroidea		Brittle Star	0	0.001337	0.005333	
<i>Prionocidaris</i> sp.		Sea Urchin	0	0	0.421333	
Cnidaria	Melithaeidae	Sea Fan	0	0	0	
	<i>Fungia</i> sp.	Brain Coral	0	0.004011	0	
	<i>Plumarella</i> sp.	Coral	0	0	0	
Arthropoda	<i>Charybdis feriatus</i>	Crab	0	0	0.001333	
	<i>Dorippe quadridens</i>	Crab	0	0	0.001333	
	<i>Hyastenus diacanthus</i>	Crab	0	0	0.001333	
	Majidae	Crab	0	0.005348	0	
	Paguridae	Crab	0	0.001337	0	
	<i>Parthenope longimanus</i>	Crab	0.001335	0	0	
	<i>Portunus pelagicus</i>	Sand Crab	0.001335	0	0	
	Crustacea	Crab	0.053405	0	0	
Porifera	Porifera	sponge	0.001335	0	0	

