Queensland **the Smart State**

Fisheries Long Term Monitoring Program

Mud Crab (*Scylla serrata*) Report: 2000–2002

Queensland Government
Department of Primary Industries and Fisheries

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Contents

Acronyms

DPI&F	Department of Primary Industries and Fisheries, Queensland
LTMP	Long Term Monitoring Program, DPI&F
CFISH	Commercial Fisheries Information System, DPI&F

Summary

The Queensland Department of Primary Industries and Fisheries (DPI&F) manages the harvest of Queensland's fish, mollusc and crustacean species and the habitats they live in and is committed to monitor the condition and trends in fish populations and their habitats. This information is used to assess the effectiveness of fisheries management strategies ensuring that the fisheries continue to be ecologically sustainable.

Two species of mud crab, *Scylla serrata* and *S. olivacea*, are found in Queensland waters (Keenan *et al.* 1998). The most abundant of these species in Queensland is *S. serrata*. The annual Queensland harvest of mud crabs, primarily *S. serrata*, has been steadily increasing from approximately 200 t in 1988 to around 1000 t in 2000 - 2001. Commercial catch rates remained relatively constant at about 20 kg/day until 1997, increasing to 26 kg/day in 2000 - 2001. The high value of the fishery ($10.4 M) (Williams 2002), increasing catch rates and increasing total effort combined with general public pressure to review the suitability of current management arrangements, resulted in mud crabs being included in the DPI&F, Long Term Monitoring Program (LTMP).

The objectives of the mud crab monitoring was to obtain fishery-independent catch per unit effort data to estimate annual changes in relative abundance, record size frequency and sex ratios for long-term comparison of population structure and population sustainability indicators, and to record changes in habitat, water quality, effects of fishing pressure and several additional abiotic variables.

The sampling design included 17 regions statewide, from the Gulf of Carpentaria in north-western Queensland to Moreton Bay in south-eastern Queensland. Each region was stratified into four locations - foreshore, mouth, mid- and upper-estuarine. Standard commercially available Munyana© brand crab pots are used to conduct 20 pot sets annually at each location.

Bycatch (species not targeted and not kept) in the mud crab fishery, is relatively low in both amount and diversity when compared to other fisheries (Barker *et al.* 2004). Bycatch retained in pots is predominantly alive and can be released in good condition at the point of capture. The setting of pots to reduce exposure during periods of low tide can reduce the mortality of bycatch species.

The statewide summary of water quality data yields few correlations between the various water quality parameters and mud crab catches. However, there is anecdotal evidence from LTMP staff, researchers and recreational and commercial fishers that water quality does effect the location, sex and number of crabs that can be caught.

Significant differences in mean carapace width were observed between male and female crabs, between regions and between locations. However, the magnitude of these differences was often small. The size frequency of male crabs declines sharply above the 150 mm minimum carapace width where as female crabs show a bimodal size frequency distribution. This correlates with the minimum legal size, and it is likely the size frequency of male crab is influenced by fishing mortality. The difference in mean carapace width between locations showed a trend towards smaller crabs the further upstream the sampling occurred.

Investigation of mean standardised catch rates shows lower catch rates and lower proportions of female crabs in the Gulf of Carpentaria than on the east coast. There were higher proportions of sub-legal male crabs than legal male crabs in close proximity to major urban areas a result that suggests fishing pressure (commercial and recreational) is higher in these areas.

Long Term Monitoring Background

The Department of Primary Industries and Fisheries (DPI&F), Queensland, manages the State's fish, mollusc and crustacean species and their habitats. As part of this commitment, DPI&F monitors the condition of, and trends in, fish populations and their associated habitats. This information is used to assess the effectiveness of fisheries management strategies and helps ensure that the fisheries remain ecologically sustainable.

DPI&F uses the information to demonstrate that Queensland's fisheries comply with national sustainability guidelines, allowing exemption from export restrictions under the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999*.

DPI&F initiated a statewide Long Term Monitoring Program (LTMP) in 1999, in response to a need for enhanced data used in assessment of Queensland's fisheries resources. The LTMP is managed centrally by a steering committee with operational aspects of the program managed regionally from the Southern and Northern Fisheries Centres located at Deception Bay and Cairns respectively. The regional teams are responsible for organising and undertaking the collection of data used for monitoring key commercial and recreational species, and for preparing data summaries and preliminary resource assessments.

The LTMP collects data for resource assessment (ranging from analyses of trends in stock abundance indices to more complex, quantitative stock assessments) and management strategy evaluations.

Stock assessment models have already been developed for saucer scallops, spanner crabs, stout whiting, mullet, tailor, barramundi, tiger and endeavour prawns, redthroat emperor, and spotted and Spanish mackerel. In some cases management strategy evaluations have also been completed and the data collected in the LTMP proved integral to these activities.

The assessments and evaluations have allowed for improvements to the management of Queensland's fisheries resources. Enhancements to ongoing monitoring have also been identified, particularly to address the increasing demand for high quality data for dynamic fish population models.

Through the ongoing process of collecting and analysing LTMP data and incorporating these data into regular assessments and refining monitoring protocols as required, DPI&F is enhancing its capacity to ensure that Queensland's fisheries resources are managed on a sustainable basis.

Introduction

In Australia mud crabs occur in estuarine and coastal marine habitats from the Exmouth Gulf, Western Australia, eastwards along the northern coastline to Cape York and south down the east coast to the New South Wales - Victorian border (Kailola *et al.* 1993).

Two species of mud crab, *Scylla serrata* and *S. olivacea*, are found in Queensland waters (Keenan *et al.* 1998). The most abundant of these species in Queensland commercial and recreational catches is *S. serrata*. The annual Queensland harvest of mud crabs, primarily *S. serrata*, has steadily increased from approximately 200 tonnes to around 1000 tonnes since 1988. Commercial catch rates remained relatively constant at about 20 kg/day until 1997, increasing to 26 kg/day in 2000-2001. Coinciding with increasing catch rates is an increase in total effort from 12,000 days fished in 1988 to 40,000 days fished in 2001 (CFISH database).

The Queensland mud crab fishery is primarily a pot/dilly fishery, with the use of hooking prohibited since 1995. Mud crabs are taken by commercial, recreational and indigenous fishers. Crabbing is generally carried out in association with other forms of fishing, such that pots are set and left while carrying out other activities like netting (commercial) or line fishing (recreational or commercial). Mud crabs are also caught as bycatch in the Queensland set gillnet fishery.

Management of the commercial mud crab fishery is based on data from the Commercial Fisheries Information System (CFISH) logbook. Gear restrictions are enforced on the type and number of pots allowed, size restrictions (15 cm minimum legal carapace width), sex restrictions (only males to be taken) and bag limits on the recreational fishery (Fisheries Regulation 1995).

The LTMP mud crab monitoring program provides data for the Queensland fishery (both east coast and Gulf of Carpentaria) by surveying key river systems throughout the state. A 'fixed' sampling design, where the same site locations are surveyed each year, was chosen to control for high variation in abundance.

The objectives of this research was to obtain fishery-independent catch per unit effort data, to estimate annual changes in relative abundance, record size frequency and sex ratios for long-term comparison of population structure and population sustainability indicators, and to record changes in habitat, water quality and fishing pressure and several additional abiotic variables.

Methods

Sites

Sampling sites were selected to complement the major river catchments and correspond to areas of high commercial catches. Four regions were sampled in each of the Gulf of Carpentaria and the north east coast of Cape York. Three regions were sampled in each of the Gladstone, Hervey Bay and Moreton Bay areas (Figure 1).

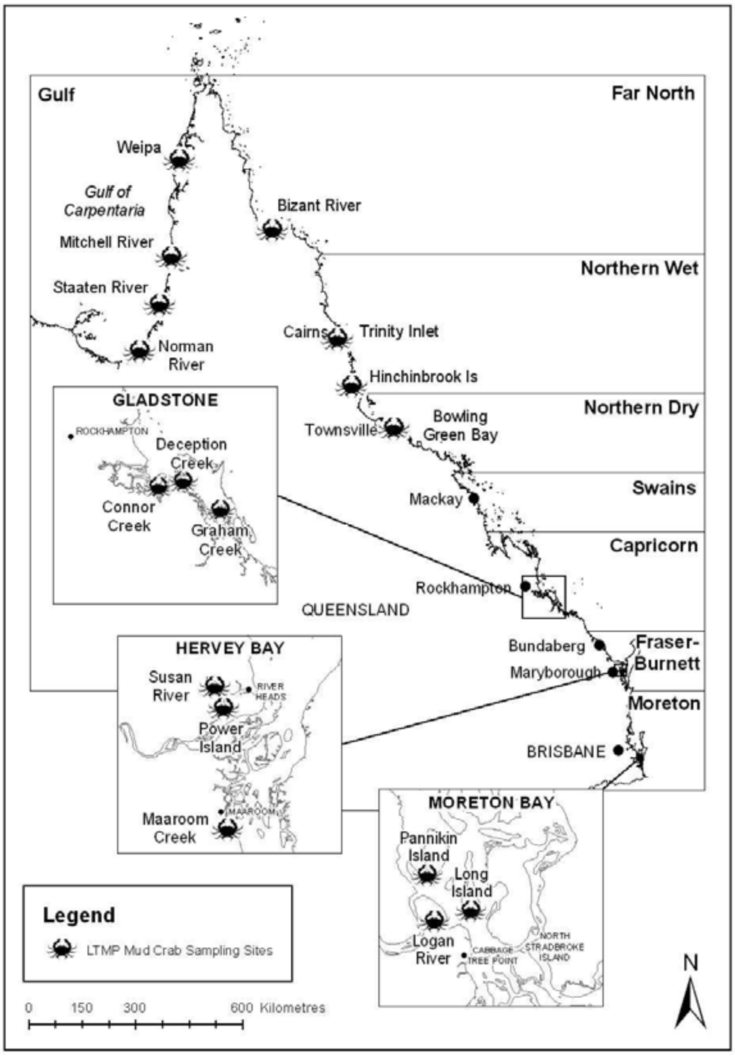

Figure 1. Map showing statewide distribution of mud crab sampling regions and commercial catch data summary regions.

In each region four locations were chosen to represent each of the key habitat areas. The four locations were identified as foreshore, mouth, mid- and upper-estuarine. The exact positioning of pots within each of these locations was subject to consultation with local crabbers. River systems such as Weipa, Trinity Inlet, Hinchinbrook, Long Island, Pannikin Island and Bowling Green Bay are large complex estuaries that do not have a defined river structure. In these systems, sites were selected that best represent either the foreshore, mouth, mid- and upper-estuarine based on water quality and habitat in the area.

Times

Sampling dates and times were determined by lunar and tidal cycles. In the Gulf of Carpentaria and north east coast regions where very large tides and strong tidal currents restrict the use of mud crab pots, sampling was conducted around the low tide during the neap tide period. In the central and south east coast regions where tidal flows are smaller and larger than average tides are required to gain vessel access to the sampling locations, sampling was conducted around the spring tides.

Trinity Inlet, Hinchinbrook and Bowling Green Bay were sampled in March each year. Gladstone, Hervey Bay and Moreton Bay were sampled in January and February. Discussions with local fishers suggested this as the optimal sampling period to maximise catches of mud crabs.

The Gulf of Carpentaria systems and Princess Charlotte Bay were sampled in May each year after the wet season. The freshwater flows will have decreased in the rivers by this time allowing the crabs to move back into the rivers.

The sequence in which locations were sampled was identical between years to reduce variability associated with the tidal cycle. The start date of the surveys varied between years to coincide with the phase of the tidal cycle in the previous year. Survey dates for 2000, 2001 and 2002 are listed in Table 1.

Table 1. Mud crab survey start dates and length of survey (days) at each region from 2000 to 2002.

	2000		2001		2002	
Region	**Start date**	**Days**	**Start date**	**Days**	**Start date**	**Days**
Norman River	13 May 00	3	8 May 01	3	29 Apr 02	3
Staaten River	3 Jun 00	2	4 Jun 01	2	13 May 02	2
Mitchell River	31 May 00	2	22 May 01	2	26 May 02	2
Weipa	11 May 00	2	21 May 01	2	23 May 02	2
Bizant River	24 Jun 00	2	16 May 01	2	19 May 02	2
Trinity Inlet	14 Mar 00	2	4 Mar 01	2	7 Mar 02	2
Hinchinbrook Island	25 Mar 00	1	3 Mar 01	2	6 Mar 02	2
Bowling Green Bay	27 Mar 00	1	28 Feb 01	2	22 Mar 02	2
Conner Creek	7 Apr 00	1	21 Feb 01	1	9 Feb 02	1
Deception Creek	6 Apr 00	1	23 Feb 01	1	8 Feb 02	1
Graham Creek	5 Apr 00	1	20 Feb 01	1	7 Feb 02	1
Susan River	3 Apr 00	1	9 Feb 01	1	30 Jan 02	1
Power Island	4 Apr 00	1	10 Feb 01	1	29 Jan 02	1
Maroom Creek	2 Apr 00	1	11 Feb 01	1	30 Jan 02	1
Long Island	27 Mar 00	1	5 Feb 01	1	25 Jan 02	1
Pannikin Island	29 Mar 00	1	6 Feb 01	1	26 Jan 02	1
Logan River	30 Mar 00	1	7 Feb 01	1	24 Jan 02	1

Catch sampling

Round, collapsible Munyana© crab pots were used to capture the crabs, as they are easily transportable and readily available. Twenty pots were set at each of the four locations within a region. Pots were set along both sides of the creeks and rivers or one or both sides of the foreshore, parallel to shore. Depending on the available habitat either 50 or 100 m spacings are used (DPI&F 2005). Each pot was marked with a float and DPI&F label which was individually numbered, this ensures missing or displaced pots can be easily identified. Pots were baited with bait bags containing mullet.

In the Gulf of Carpentaria and the north east coast pots were set approximately three hours before the low and checked approximately three hours after the low allowing a soak time of approximately six hours for each pot. In Gladstone, Hervey Bay and Moreton Bay pots were set as close as practicable to the top of the evening high tide and retrieved approximately 12 hours later on the top of the morning high tide. Total catch figures for Munyana© pots show no difference in either number, size or sex ratio of crabs retained in pots set for either 6 hours or 12 hours (E. Jebreen, DPI&F, unpublished data). Several reasons could explain the drop in catch rate after six hours the most likely being that once several crabs are in the pot the rate of escape increases to match the rate of capture (E. Jebreen, DPI&F, unpublished data).

All mud crabs (*Scylla* spp) caught were sexed, their carapace width measured and inspected for injury (loss of appendages, deformity or obvious parasites). Measurements of both tip to tip (tip of the largest opercular spine) and notch to notch (base of largest opercular spine) carapace widths were made on 542 crabs to investigate the relationship between the two measurements and to permit conversion between the two. All crabs caught in the research pots were released.

In 2001, the LTMP team also collected crab samples in the Staaten River as part of the 'white spot' virus survey. In 2002 the total number of each species of bycatch captured in the pots was recorded.

Water quality

Water quality information may explain some of the temporal variability associated with the research catch numbers and the population size structure

Measurements of conductivity (mS/cm), salinity (ppt), turbidity (NTU), dissolved oxygen (mg/L), temperature (°C) and pH were recorded at the pot furthermost upstream and the pot furthermost downstream at each location. Water quality was measured at approximately 0.5 m below the water surface. If the water depth at this point was greater than three meters, water quality was also recorded at the bottom. Parameters were measured using a water quality meters, calibrated both before and during each survey. Dissolved oxygen was converted from milligrams per litre (mg/L) to a percentage using the following formula:

$$DO\% = DO\ mg/L \times 100 / \{(14.3289-(0.3253*T)) + (0.0032*T^2)\}$$

DO is dissolved oxygen and T is temperature.

Dissolved oxygen levels and pH recorded during the crab surveys were compared to the guidelines set by the ANZECC and ARMCANZ (2000). These guidelines suggest the pH in estuarine waters in Queensland should be between 7 and 8.5 and dissolved oxygen should be 80 - 120% in tropical north Queensland and 80 - 110% in southern Queensland.

Data summaries and analysis

Catch data was included for analysis where pots were classified as fishing correctly. Catch from pots that were identified as having been robbed, or fouled, were not included in the analysis.

Size frequency

Linear regression was used to analyse the relationship between tip to tip and notch to notch carapace width measurements (Figure 2).

A generalised linear model was used to test the null hypotheses that mean carapace width does not vary between year, sex or location. The final model chosen excluded region as a main effects term and the analysis was repeated for each region. The model structure included year, sex and location as main effects, with the interactive terms year by location and location by sex.

Predicted mean carapace widths, with associated 95% confidence intervals were calculated for each region.

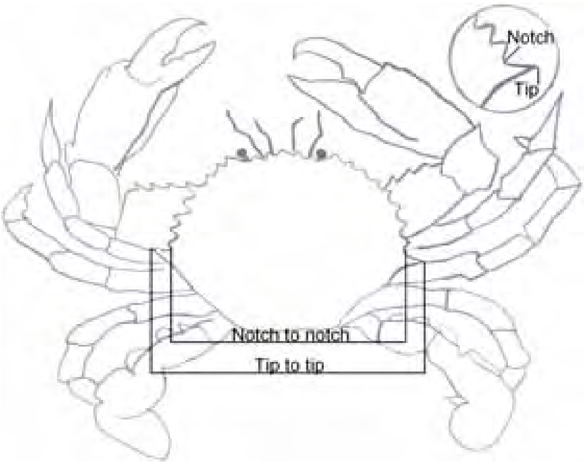

Figure 2. Crab size (carapace width) measurements from the tip to tip (distance between the points of the largest opercular spine on each side of the carapace) and notch to notch (distance between the notches above the largest opercular spines).

Catch rate

Mud crab catch rates expressed as the number of crabs, by sex (female, legal male and sub-legal male), were analysed using a generalised linear model with a negative binomial distribution and a logarithm link function. The model main effects were region (including all 17 regions sampled in Queensland), year (2000, 2001 and 2002), and the four locations within each region. The interaction terms, region by year and region by location were also modelled. The response variable was standardised by the number of pot lifts that contributed to the catch by including a count of pot lifts as the first main covariate effect. The null hypothesis tested was that the number of crabs caught does not vary by region, year, location or sex.

Predicted mean catches and 95% confidence intervals were calculated for each region, for sex by location and sex by year.

Sex ratios

The proportion of crabs of each sex (female, legal male and sub-legal male), of the total number of crabs caught was modelled with a binomial distribution and a logit link function. The analysis main effects were region (including all 17 regions), year (2000, 2001 and 2002), and the four locations within each region. The interaction terms region by year, and region by location were also included in the model. As the numbers of pot lifts does not affect the sex ratios, this effect was not included in the model. The null hypothesis tested was that the proportion of crabs caught of a particular sex does not vary by region, year, or location.

Predicted probabilities of each sex were calculated for each region, for the interactive terms sex by location and sex by year.

Bycatch

The number of bycatch species and the numbers of individuals captured for each of these species is reported by region and state. The number of individuals of each species is also reported as the percentage of total number of bycatch animals captured.

Water quality

Conductivity was measured in micro-Siemens per centimetre (µS/cm) for regions south of Bowling Green Bay and in milli-Siemens per centimetre (mS/cm) in the northern region. All measurements have been presented as the latter. Where several measures of water quality parameters were taken for one location, the values were averaged.

Commercial catch data summary

Two main data sets were used for an overall summary of historical commercial mud crab catches for Queensland. The first are records from annual Queensland Fish Board Reports, and represent the annual reports of various fish boards responsible for marketing and distributing fish in Queensland between 1936 and 1981. This data may not include all Queensland catches, does not include reference to catch location, nor the fishing effort expended in obtaining the recorded catch and was only used in our analysis as an indication of total catch.

A seven year gap exists in the historical data series from 1981 when the Queensland Fish Board Records ceased, until 1988 when the Queensland CFISH compulsory log book program began. The CFISH data set includes information on the location of the catch, total catch in whole weight kilograms and the amount of fishing effort in boat days required to obtain the recorded catch. In compiling summary information in relation to the catch of mud crabs some assumptions/criteria have been applied to this data set to remove potential errors These were:

Where a fishing end date has a value of 9999 this was equated to 1 day fished

Where days fished for a single record is more than 100 the record was excluded

Pot lifts were calculated as the larger of pot numbers or pot lifts. Where pot numbers and pot lifts were both null the number of pot lifts was assumed to be equal to the number of days fished x 50 (representing the maximum legal number of pots per fisher)[1]

Catch weight equals catch numbers for records where the catch weight equals zero (Gribble and Helmke, 1998).

Annual statewide summaries of total catch and catch rates have been compiled for this report using the fish board and CFISH data sets. Regional summaries of total annual catch, average daily catch rate, total annual effort and total annual participation as recorded in the CFISH database, are presented based using the geographic boundaries outlined by the Tropical Resource Assessment Program (TRAP) (Gribble 2004) (Table 2).

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[1] Due to the difficulty in calculating the numbers of pot lifts, fishery-dependent data in this report is presented as catch per day not per pot lift. The methods used for calculating pot lift numbers have been included for future reference.

Table 2. Regional boundaries for summaries of commercial mud crab catch data (Source: Gribble 2004).

Region	Description	Min	Max	Min	Max
Gulf	NT Border to west of Cape York	10.5	18.5	138	142.5
Far North	east of Cape York to Cape Flattery	10.5	15	142.5	155
Northern Wet	Cape Flattery to Paluma River	15	18.5	142.5	155
Northern Dry	Paluma River to Cape Conway	18.5	20.5	142.5	155
Swains	Cape Conway to Cape Manifold	20.5	22	142.5	155
Capricorn	Cape Manifold to Baffle Creek	22	24.5	142.5	155
Fraser-Burnett	Baffle Creek to Rainbow Beach	24.5	26	142.5	155
Moreton	Rainbow Beach to NSW border	26	28.5	142.5	155

Recreational catch data summary

Recreational catch and effort data collected during the 1997 and 1999 Recreational Fisheries Information System logbook and telephone surveys is presented for each of the same fishing regions as the commercial catch data. Effort is represented as a percentage of the total number of trips for a particular region within a given year and catch as the percentage of total catch kept, by weight, for a particular region for a given year.

Results

Long Term Monitoring Program survey

Size frequency

Linear regression assessing the relationship between tip to tip and notch to notch carapace (Figure 2) width measures yielded an $R^2 = 0.987$, indicating a very tight relationship between the two measures (Figure 3). Subsequently notch to notch measures of carapace width have been converted to tip to tip measures for analysis and presentation, maintaining consistency and relevance to current minimum legal size restrictions on the take of male mud crabs.

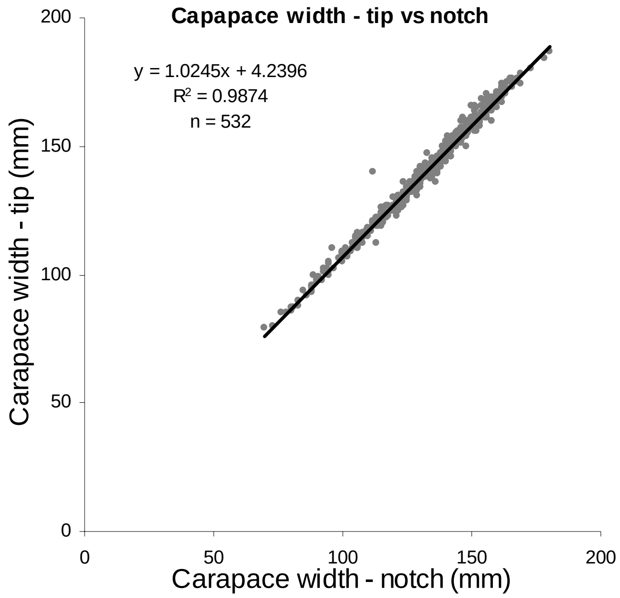

Figure 3. Linear regression of tip to tip and notch to notch mud crab carapace width measurements.

Carapace width ranged from 70 to 200 mm for female crabs and 60 to 190 mm for male crabs. The size frequency distribution of female crabs was broad with a slight bimodal distribution. Males showed a typically normal distribution with a definite peak between 130 and 140 mm. The male size frequency distribution declines sharply above the 140 mm size class possibly representing the impact of the 150 mm minimum legal size for the take of male crabs (Figure 4).

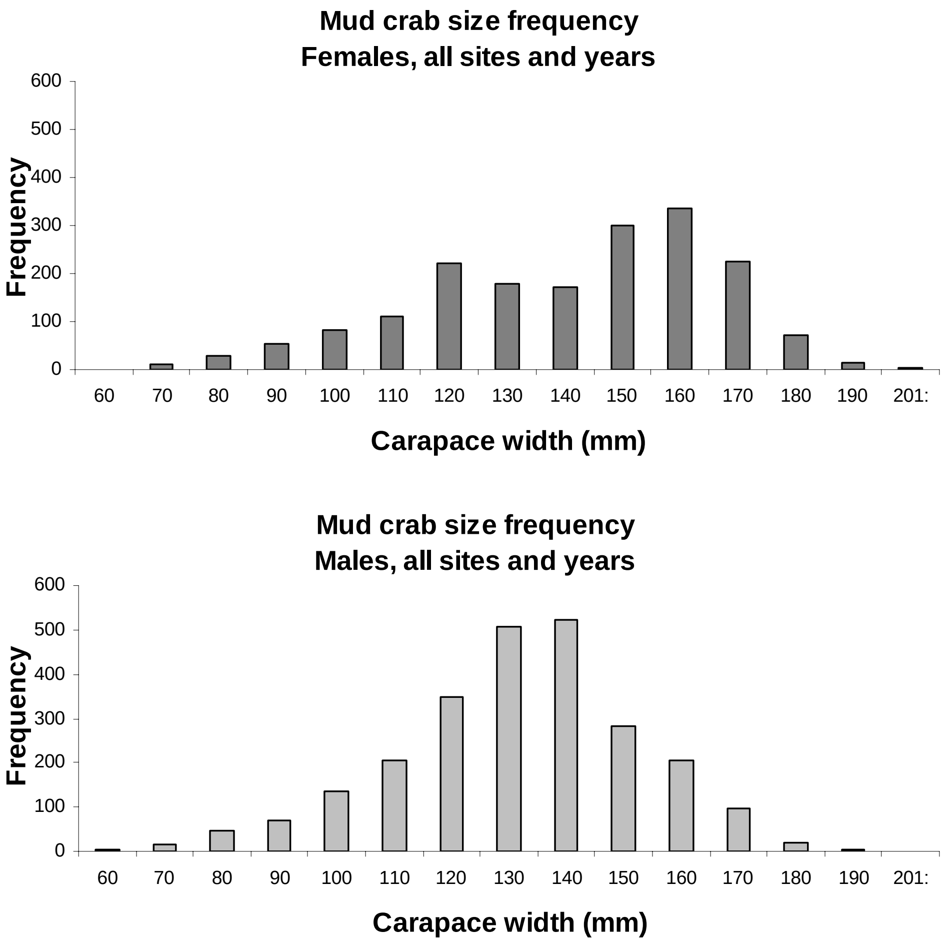

Figure 4. Mud crab size frequency for all years and regions by sex.

Catch rates

The analysis of survey catch rates standardised by number of pot lifts, region, year and location permits the direct comparison of catch rates across the state. The catch rates of females varied significantly between regions (df=17,95; F=3.47; p=<0.001), but did not vary significantly between years or locations within regions (Figure 5). The catch rate of legal male crabs varied significantly between regions (df=17,95; F=3.18; p=<0.001) but did not vary significantly with year or location within region. However, the interaction term region by year was significant (df=31,95; F=1.51; p=0.034), indicating that although catch rates did vary significantly between regions, this variation was not consistent across years (Figure 5). The catch rate of sub-legal males varied significantly between region (df=17,95; F=5.72; p=<0.001) and year (df=2,95; F=4.22; p=0.015). However, the interaction term region by year was again significant (df=31,95; F=1.78; p=0.005), indicating the variation in catch rates between regions was not consistent across years (Figure 5). Given the significance of the interaction terms for both legal and sub-legal males, the predicted mean catch rates for each sex for years and locations have been presented by regions. Valid comparisons can be made between these estimates for all regions.

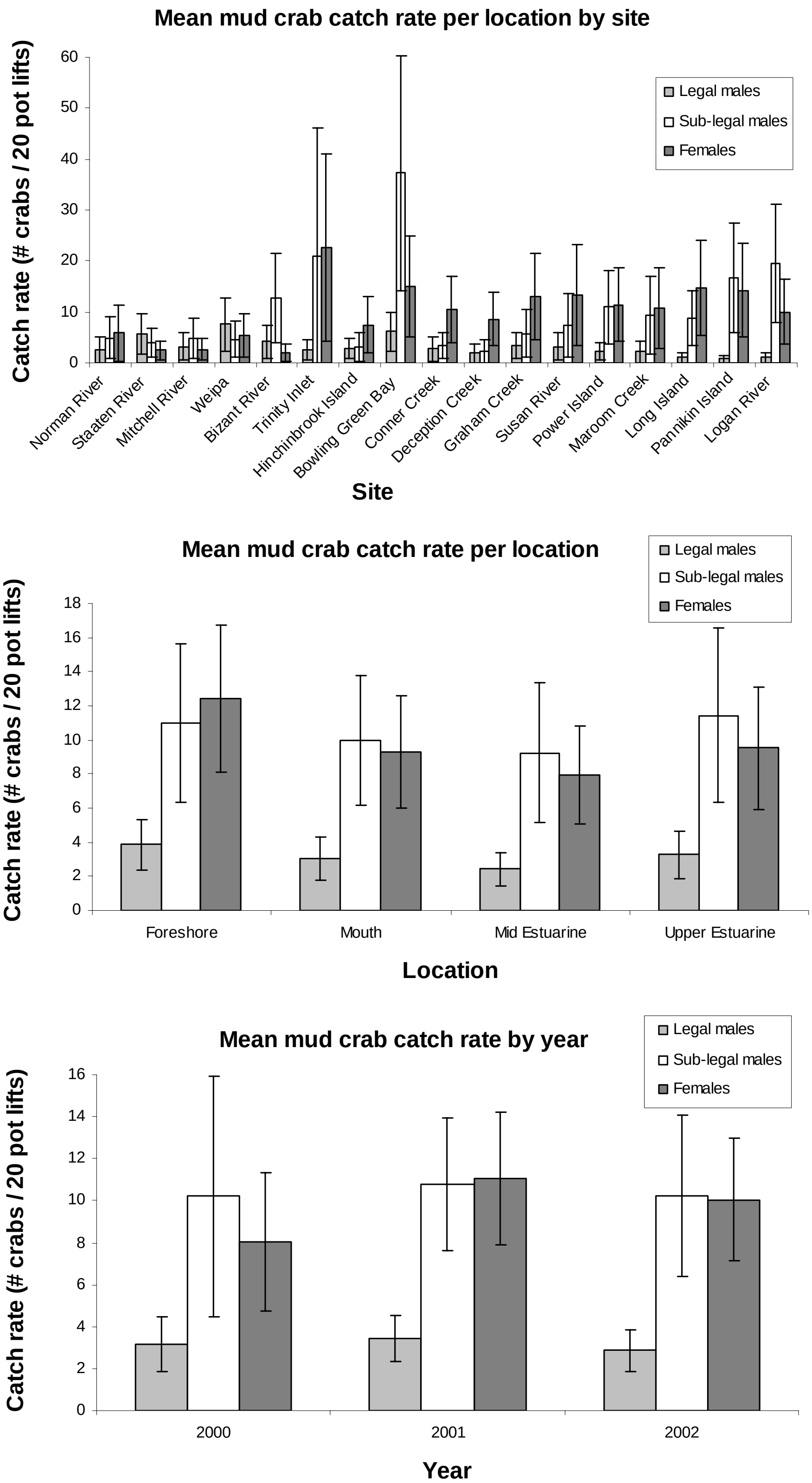

Figure 5. Predicted mean mud crab catch rates and 95% confidence interval per region, location and year by sex.

Sex ratio

The analysis of survey catch sex ratios standardised by region, year and location permits the direct comparison of catch proportions across the state. The proportion of total catch that were female crabs varied significantly between region (df=16,96; F=18.32; p=<0.001) and location (df=3,96; F=4.04; p=0.009). However, both interaction terms, region by year (df=31,96; F=2.75; p=<0.001) and region by location (df=48,96; F=1.65; p=0.019) were significant making interpretation of the main effect term uncertain (Figure 6). The significant interaction terms suggests that although the variation in the proportion of total catch that were female crabs was significant between regions, this was not consistent between years or location. The proportion of total catch that were legal male crabs varied significantly between regions (df=16,96; F=17.47; p=<0.001). However, the interaction term region by year was again significant (df=31,96; F=1.87; p=0.011), indicating that differences between regions were not consistent across years (Figure 6). The proportion of total catch that were sub-legal males varied significantly between region (df=16,96; F=20.64; p=<0.001) and location (df=3,96; F=5.67; p=0.001). However, both of the interaction terms region by year (df=31,96; F=3.08; p=<0.001) and region by location (df=48,96; F=2.17; p=<0.001) were significant (Figure 6). The significant interaction terms suggests that although the variation in the proportion of sub-legal male crabs caught was significant between regions, this was also not consistent between years or location.

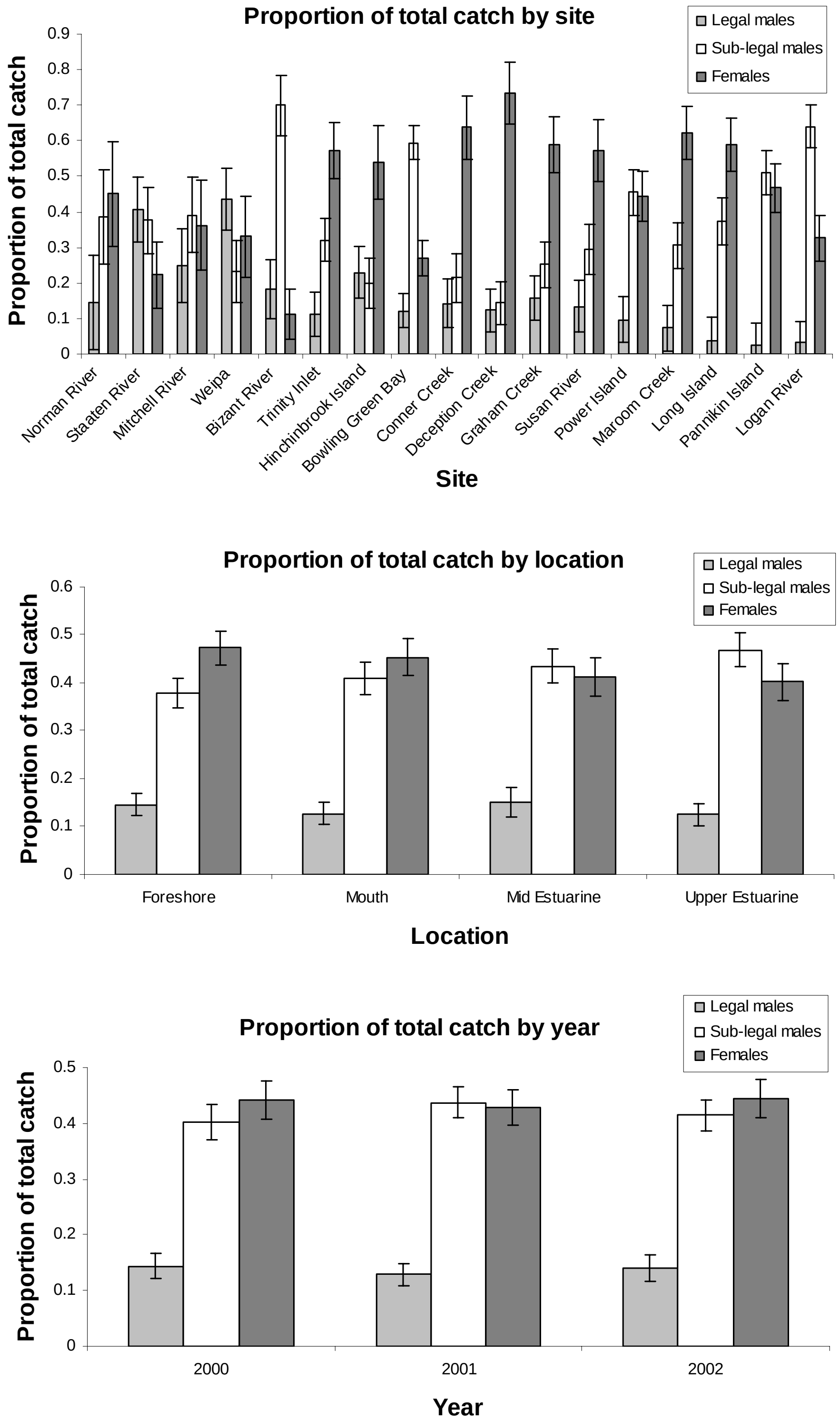

Figure 6. Predicted proportions of mud crab total catch and 95% confidence interval by sex for region, location and year.

Bycatch

A total of 505 animals other than *S. serrata* from 36 different species were caught and released alive (Table 3). Bycatch diversity was greatest in the northern regions (Gulf of Carpentaria and north east coast). The greatest numbers of bycatch individuals were caught in the Gladstone and Hervey Bay region.

Table 3. Number of individuals and bycatch taxa caught during the 2002 mud crab surveys.

	No. of individuals		No. of taxa
Gulf of Carpentaria	99	20%	18
north east coast	92	18%	20
Gladstone	118	23%	10
Hervey Bay	81	16%	6
Moreton Bay	115	23%	6
Total	**505**		**36**

Blue swimmer crabs (Portunus pelagicus) and yellow-finned bream (Acanthopagarus australis) were the most common species in the bycatch (Appendix A).

The greatest amount of bycatch by number of individuals was caught in south east Queensland in Graham Creek (13.7%), Long Island (10.9%) and Maroom Creek (8.91%). The largest number of bycatch species was caught in Bowling Green Bay (9), the Bizant River (8) and Conner Creek (8) (Table 4).

Table 4. Number of individuals and bycatch taxa caught during the 2002 mud crab surveys.

Region	No. caught	No. of taxa	% of total
Norman River	31	7	6.14%
Staaten River	19	4	3.76%
Mitchell River	24	7	4.75%
Weipa	25	7	4.95%
Bizant River	17	8	3.37%
Trinity Inlet	24	7	4.75%
Hinchinbrook Island	32	7	6.34%
Bowling Green Bay	19	9	3.76%
Graham Creek	69	5	13.66%
Deception Creek	29	5	5.74%
Conner Creek	20	8	3.96%
Power Island	8	5	1.58%
Susan River	28	3	5.54%
Maroom Creek	45	3	8.91%
Long Island	55	4	10.89%
Logan River	30	5	5.94%
Pannikin Island	30	4	5.94%

Water quality

Water quality parameters varied within expected limits with the exception of some low salinity (<5 ppt) and correspondingly low conductivity (<5 mS/cm) (Figure 7). Water temperature varied from 17 to 33°C, pH from 7 to 8.8, turbidity was generally low between 20 and 80 NTU and dissolved oxygen ranged from 3 to 10 mg/L (Figure 7).

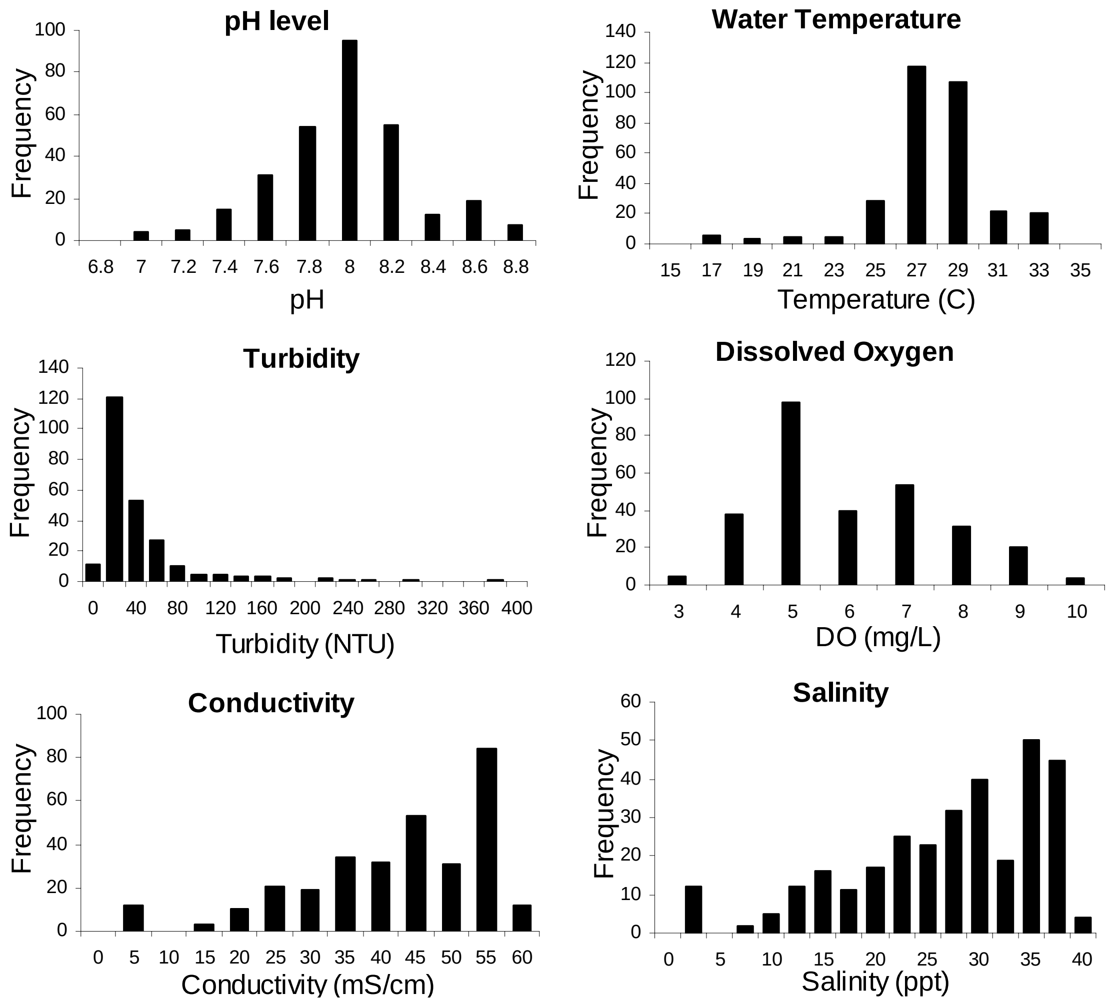

Figure 7. Water quality parameters for all years and regions.

Fishery-dependent data

Commercial catch

Queensland Fish Board records show a stable total mud crab catch of approximately 125 t between 1961 and 1981 (Figure 8). CFISH records indicate an increase in total catch from 247 t in 1988 to a maximum annual catch of 1034 t in 2000. Total catch for 2001 was slightly lower than in 2000 at 1029 t and figures for 2002 were incomplete at the time of analysis. Average daily catch rate, expressed as kilograms per boat day, remained relatively stable between 18 and 22 kg/day from 1988 until 1997. Average daily catch rate then increased from 19 kg/day in 1997 to 25 kg/day in 2000. The average daily catch rates appear to have stabilised at this level with a similar figure of 26 kg/day for 2001. Average daily catch rates for 2002 are artificially inflated due the incomplete data set for this year (Figure 8).

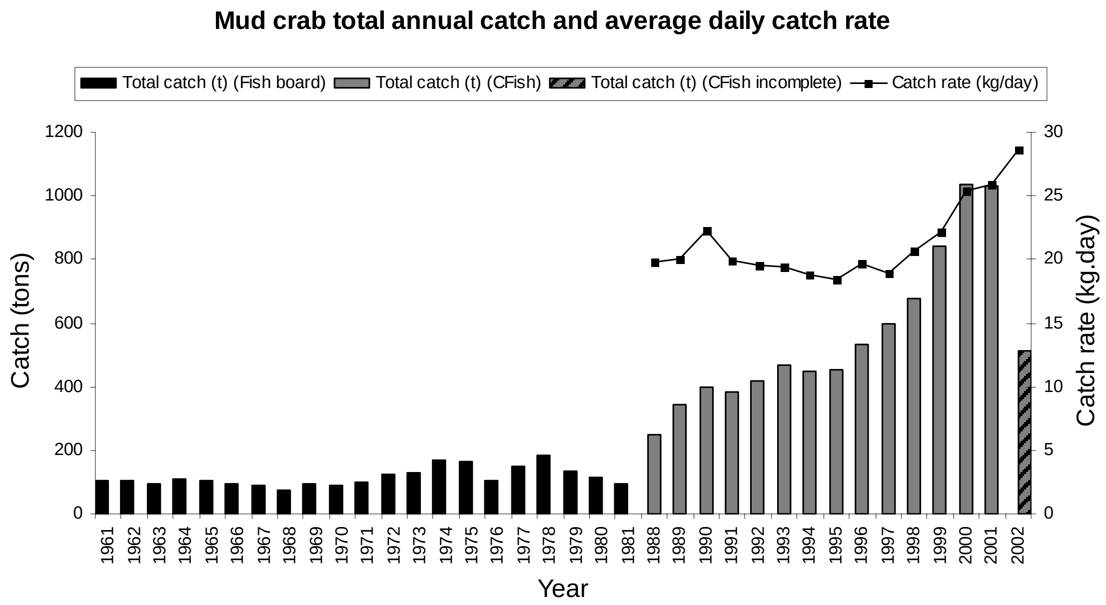

Figure 8. Queensland mud crab annual total catch and average daily catch rates (Source: Queensland Fish Board and Commercial Fisheries Information System) Note: no data is available for 1982-1987.

The effort component of the average daily catch rate figures shows that despite stable catch rates between 1988 and 1997, total effort and the total number of participants increased from 12,456 days and 345 participants in 1988 to a maximum annual effort of 40,637 days and 538 participants in 2000 (Figure 9). Corresponding to the slight drop in total catch and possibly a stabilisation of daily catch rates in 2001 (Figure 8), total effort and participation in 2001 was 39,784 days and 558 participants respectively (Figure 9).

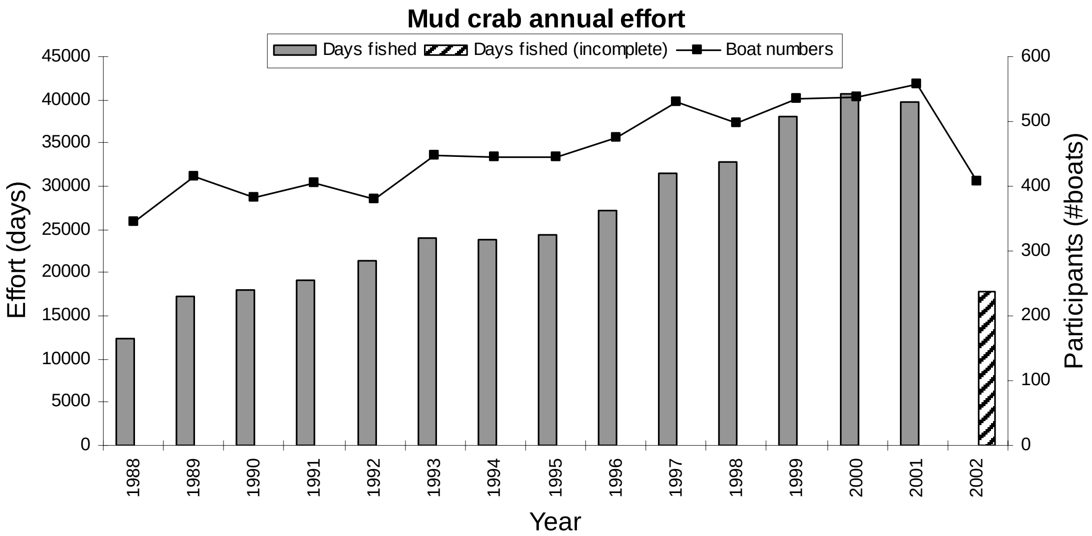

Figure 9. Queensland mud crab annual total effort and participation (Source: Commercial Fisheries Information System).

On a regional basis commercial data indicates that the largest contributions to statewide total catch and effort came from the Gulf of Carpentaria, Northern Dry and Capricorn regions (Figure). Moreton region shows an increase in effort without a corresponding increase in catch (Figure). The total increase in participation observed on a statewide level (Figure 9), appears to be the cumulative effect of slight increases for most of the regions, as opposed to a significant increase in a single region (Figure).

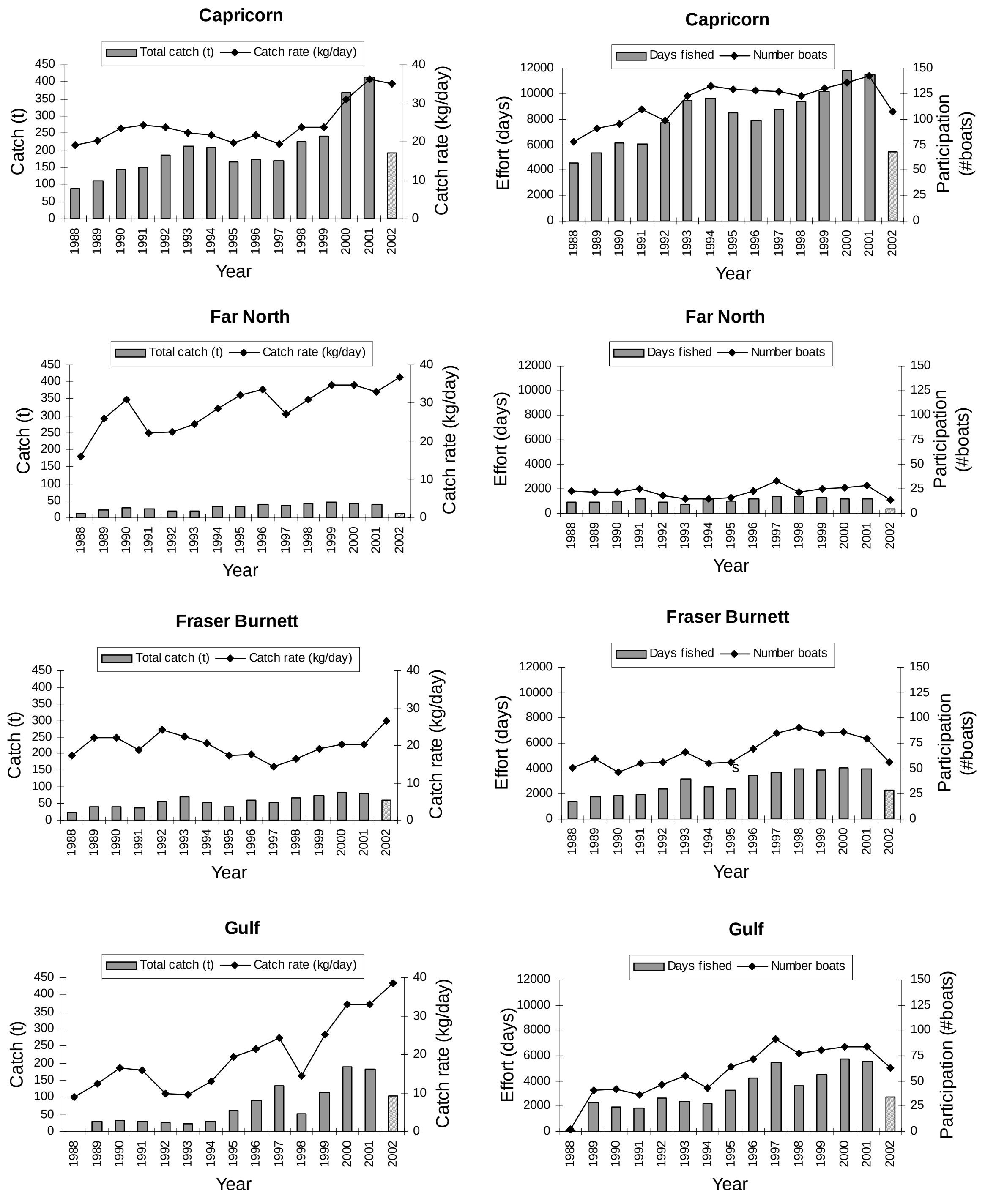

Figure 10. Regional summary of commercial mud crab total annual catch, average daily catch rate, total annual effort and annual participation. Data for 2002 was incomplete at the time of preparation of this report. (Source: Commercial Fisheries Information System).

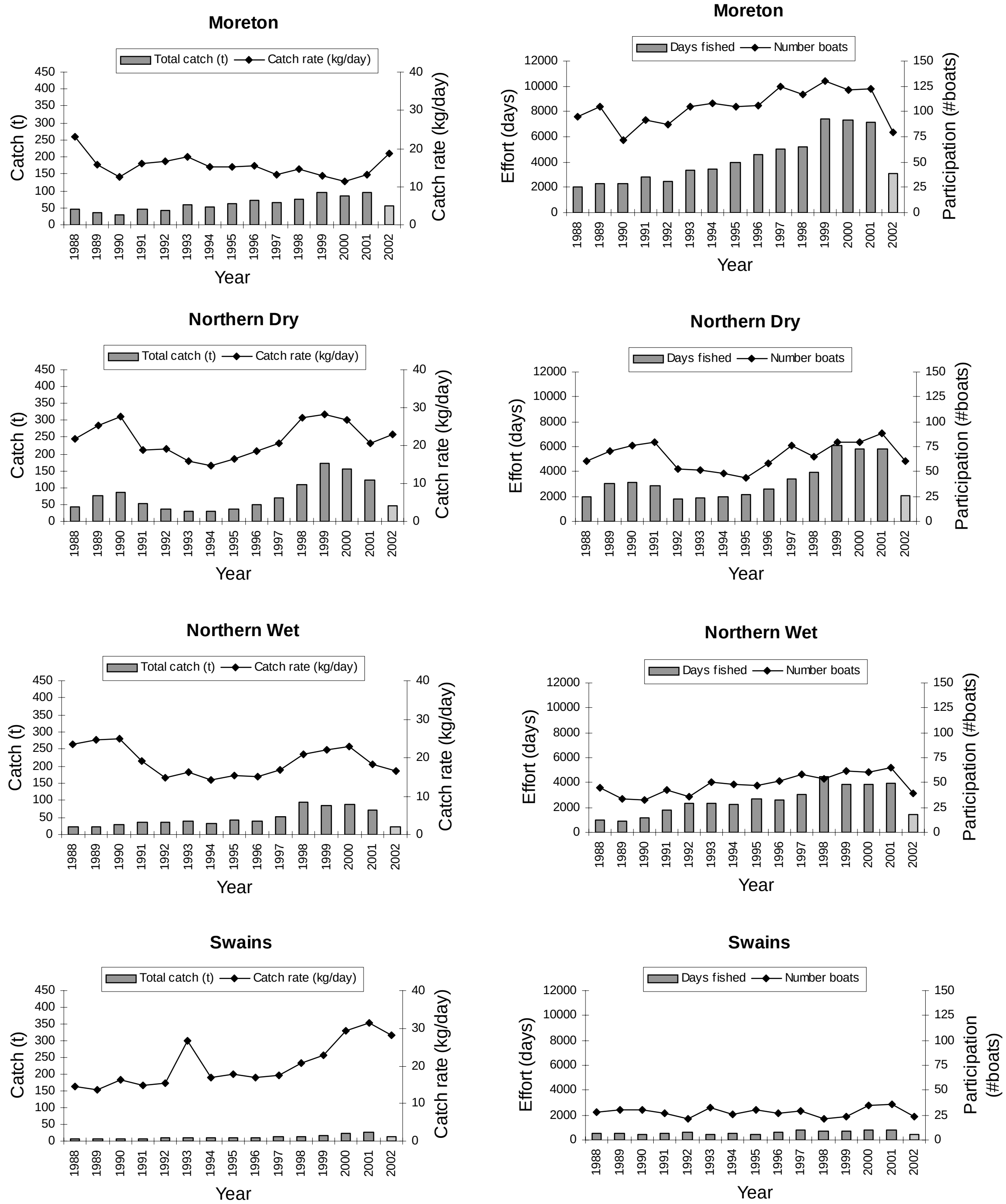

Figure 10 cont. Regional summary of commercial mud crab total annual catch, average daily catch rate, total annual effort and annual participation. Data for 2002 was incomplete at the time of preparation of this report. (Source: Commercial Fisheries Information System).

Recreational catch

Recreational catch statistics show approximately 50% of total catch and 60% of total effort occur in close proximity to the major east coast urban centres of Cairns, Townsville and Brisbane. In contrast between 40 and 60% of commercial catch and effort is located in the remote regional communities of the Gulf of Carpentaria and the Capricorn region on the central east coast. Recreational catch data for the Far North Region is shown as zero percent for both catch and effort statistics, most likely due to its small population leading to an under representation in the recreational survey .

Table 5. Recreational and commercial catch presented as a percentage of the total catch, by weight, retained for each region in 1997, 1999 and commercial catch only 2001. (Source: Recreational and Commercial Fisheries Information System).

Catch	Recreational		Commercial		
Region	**1997**	**1999**	**1997**	**1999**	**2001**
Gulf	5%	5%	22%	14%	18%
Far North	0%	0%	6%	5%	4%
Northern Wet	4%	11%	9%	10%	7%
Northern Dry	20%	29%	12%	20%	12%
Swains	11%	4%	2%	2%	3%
Capricorn	17%	15%	29%	29%	40%
Fraser-Burnett	10%	16%	9%	9%	8%
Moreton	34%	20%	11%	11%	9%

Table 6. Recreational and commercial effort data presented as a percentage of the total effort in numbers of trips or numbers of days fished respectively, for each region in 1997, 1999 and commercial only 2001 (Source: Recreational and Commercial Fisheries Information System).

Effort	Recreational		Commercial		
Region	**1997**	**1999**	**1997**	**1999**	**2001**
Gulf	3%	3%	17%	12%	14%
Far North	0%	0%	4%	3%	3%
Northern Wet	3%	8%	10%	10%	10%
Northern Dry	16%	20%	11%	16%	15%
Swains	9%	4%	2%	2%	2%
Capricorn	14%	12%	28%	27%	29%
Fraser-Burnett	12%	18%	12%	10%	10%
Moreton	42%	35%	16%	20%	18%

Discussion

The DPI&F manages the harvest of Queensland's fish, mollusc and crustacean species and the habitats they live in. It is committed to monitor the condition and trends in fish populations and their habitats through a long term monitoring program. Information from this program is used to assess the effectiveness of fisheries management strategies and to ensure that fisheries continue to be ecologically sustainable. The LTMP data is used in conjunction with surveys and logbook data from recreational and commercial fishers.

Mud crabs were included in this LTMP because of the high value of the fishery to local economies ($10.4 M) (Williams 2002), increasing catch rates and increasing total effort and general public pressure to review the suitability of current management arrangements.

The objectives of the mud crab monitoring was to obtain fishery-independent catch per unit effort data to estimate annual changes in relative abundance, to record size frequency and to measure sex ratios for long-term comparison of population structure and population sustainability indicators. Changes, water quality and fishing pressure and several additional abiotic variables were also collected.

Although total catch increased, commercial catch rates remained relatively constant at about 20 kg/day until 1997, and then increased to around 26 kg/day in 2000-01. There is no evidence to suggest trapping equipment or fishing methods have improved through this time. An explanation for catch rates improving as total catch increases is that access to more remote parts of the coast has become easier through demographic change and/or that effort has expanded to fish previously unexploited or poorly exploited populations.

Differences in mean carapace width were observed between male and female crabs, between regions and between locations. However, the magnitude of these differences was often small. The size frequency of male crabs declines sharply above the 150 mm minimum carapace width where as female crabs show a bimodal size frequency distribution. This correlates for male crabs with the minimum legal size, and it is likely the size frequency of male crab is influenced by fishing mortality. There are indications from the bimodal nature of the female crab carapace width data that mid sized female crabs are underrepresented in the catches and they may move or migrate away from inshore areas at this time.

The difference in mean carapace width between locations appeared to show a preliminary indication of size specific habitat utilisation. However locations were chosen to represent a habitat type and were not necessarily up or down-stream from each other.

In the Gulf of Carpentaria, which has no major urban centres, catch rates were lower than on the east coast and the catch rates of females were lower than male catch rates in the fishery-independent sampling. The total catch rates in independent sampling of sub-legal male crabs increased and legal male crabs decreased with proximity to major urban centres (Trinity Inlet, Bowling Green Bay and Hervey and Moreton Bays). No correlation was apparent between the catch rates of female crabs and proximity to urban centres. Queensland legislation prohibits keeping female crabs of any size and male crabs with a carapace width less than 150 mm. This leads to a bias in fishing pressure to larger males. Near urban centres the populations have more female crabs and a greater proportion of male crabs are small.

The habitat information collected as part of the LTMP study was not sufficient to address the issue of relative productivity between the Gulf coast and the east coast. It is possible to speculate however that the low water inflows, high temperatures and mostly sandy nature of the gulf coast are not as conducive to mud crab populations as the large extent of the mangrove forests would suggest. Catch rates from the LTMP were highest in large north facing bays (Trinity Inlet, Bowling Green Bay and Moreton Bay) that have previously been identified as highly productive for marine plant communities such as seagrass (Coles *et al.* 1993)

Bycatch (species not targeted) in the mud crab fishery, was relatively low in both amount and diversity when compared to other fisheries (Barker *et al.* 2004). Bycatch retained in pots was predominantly alive and released in good condition at the point of capture. The setting of pots to reduce exposure during periods of low tide can reduce the mortality of bycatch species. Blue swimmer crabs, yellow-fin brim, and forktailed catfish were by far the most common fish. Occasional sharks and rays enter pots but at extremely small numbers. No bycatch is of significance as a species of conservation interest.

The statewide summary of water quality data yields few correlations between the various water quality parameters and mud crab catches. However, there is anecdotal evidence from, researchers and recreational and commercial fishers that water quality does effect the location, sex and number of crabs that can be caught. It is possible that the effect of water quality has influence at finer spatial and temporal scales than could be addressed in this statewide survey approach. Further analysis of this data is required to further understand the relationship between water quality and mud crab movements and catch rates.

The long term monitoring program, mud crab monitoring, has delivered an initial data series of size and sex ratio data coupled with fishery independent catch rate data for a number of important mud crab fishery regions statewide. Further standardisation of the fishery independent catch rate data with associated abiotic factors collected at the time of sampling will greatly enhance the importance of this data set for future analysis and regional population assessments.

References

ANZECC and ARMCANZ (2000). 'Australian and New Zealand Guidelines for Fresh and Marine Water Quality'. National Water Quality Management Strategy Paper No.4., Volume 1 (Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand: Canberra).

Barker, J., O' Sullivan, S., Jebreen, E.J, Roy, D., and Kennedy, C. (2004). Fisheries Long-Term Monitoring Program, Benthic Marine Fauna Composition in the Scallop Fishery Area in 2000 and 2002, Department of Primary Industries and Fisheries, Brisbane, Australia.

Coles, R.G., Lee Long, W.J., Watson, R.A., and Derbyshire, K.J. (1993). Distribution of seagrasses, and their fish and penaeid prawn communities, in Cairns Harbour, a tropical estuary, northern Queensland, Australia. *Australian Journal of Marine and Freshwater Research*. 44, 193-210.

Department of Primary Industries and Fisheries (2005). Fisheries Long Term Monitoring Program Sampling Protocol – Mud Crab (2000-2005). Department of Primary Industries and Fisheries, Queensland, Brisbane, Australia.

Fisheries Regulation 1995, subordinate legislation of the Fisheries Act 1994, Office of the Queensland Parliamentary Council.

Gribble, N.A. (Ed) (2004). Tropical Resource Assessment Program Final Report (Qld inshore fish stocks): Phase I, Collation and assessment of available fisheries information. Phase II Model application and validation. FRDC 1999/125 Final Report. Queensland Department of Primary Industries Information Series. Cairns, Australia.

Gribble, N., and Helmke, S. (1998). Tropical Resource Assessment Program: Summary of mud crab distribution in Tropical Queensland. Department of Primary Industries, Brisbane, Australia.

Kailola, P., Williams, M.J., Stewart, P., Reichelt, R., McNee, A., and Grieve, C. (1993). 'Australian Fisheries Resources.' (Bureau of Resource Science, Department of Primary Industries and Energy: Canberra).

Keenan C.P., Davie, P.J.F., and Mann, D.L. (1998). A revision of the genus *Scylla* De Hann, 1833 (crustacean: Decapoda: Brachyura: Portunidae). *Raffles Bulletin of Zoology* **46**, 217–45.

Williams, L.E. (2002). 'Queensland's fisheries resources - Current condition and recent trends 1988 – 2000.' (Department of Primary Industries: Brisbane).

Appendix

Table 7. Bycatch species caught in mud crab pots during 2002 surveys.

Scientific Name	Common Name	Norman River	Staaten River	Mitchell River	Weipa	Bizant River	Trinity Inlet	Hinchinbrook Island	Bowling Green Bay	Conner Creek	Deception Creek	Graham Creek	Susan River	Power Island	Maroom Creek	Long Island	Pannikin Island	Logan River	**Total number caught**
Portunus pelagicus	blue swimmer crab			7	7		13	17	3	8	18	7	3	1	12	43	17	8	**164**
Acanthopagrus australis	yellow-fin bream								1	2	3	42	24	1	10	9	11	19	**122**
Arius spp.	forktail catfishes	18	14	6	9				4	3	3		1	4				1	**63**
Thalamita crenata	crenate swimming crab							3			2	1			23	2	1	1	**33**
Epinephelus coioides	estuary cod				3	8		2	4			12							**29**
Xanthidae - undifferentiated	crabs					1	6	1		1	3	7							**19**
Acanthopagrus berda	pikey bream	5		1		2	1		2										**11**
Paguridae - undifferentiated	hermit crabs				2	1		6											**9**
Epinephelus malabaricus	malabar grouper				2	1	1		2										**6**
Nibea squamosa	jewel fish		3	2															**5**
Protonibea diacanthus	black jewfish			5															**5**
Scatophagidae - undifferentiated	scats	2				2													**4**
Brachaelurus waddi	blind shark									3									**3**
Dasyatidae - undifferentiated	stingrays				1			2											**3**
jelly fish	jelly fish	2	1																**3**
Triodontidae - undifferentiated	three-toothed puffers	2					1												**3**
Carcharhinidae- undifferentiated	requiem sharks				1			1											**2**
Monacanthus chinensis	fanbellied leatherjacket															1	1		**2**
Nibea soldado	silver jewfish			2															**2**
Ambassis spp.	glassfishes						1												**1**
Amniataba percoides	banded grunter	1																	**1**
Aptychotrema vincentiana	western shovelnose ray									1									**1**
Carcharhinus macloti	hardnose shark													1					**1**
Eleutheronema tetradactylum	blue salmon			1															**1**
Epinephelus spp.	rockcods					1													**1**
Halophryne diemensis	banded frogfish								1										**1**
Latridae - undifferentiated	trumpeters								1										**1**
Microcanthus strigatus	stripey																	1	**1**
Muraenesox cinereus	dagger tooth pike conger													1					**1**
Netuma thalassinus	giant seacatfish	1																	**1**
Platycephalus arenarius	sand flathead									1									**1**
Platycephalus spp.	flatheads								1										**1**
Pomadasys agenteus	small spotted grunter bream						1												**1**
Pomadasys spp.	grunter breams									1									**1**
Soleidae - undifferentiated	soles		1																**1**
Uranoscopidae - undifferentiated	stargazers					1													**1**
Total		**31**	**19**	**24**	**25**	**17**	**24**	**32**	**19**	**20**	**29**	**69**	**28**	**8**	**45**	**55**	**30**	**30**	**505**