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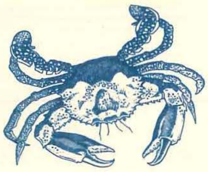

Status of Gulf of Carpentaria *Mud Crab* stocks

Establishing a benchmark for Albatross Bay, Weipa

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Status of Gulf of Carpentaria Mud Crab Stocks:

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Project Report

SA Helmke, NA Gribble and SF Gould

November 1998

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Status of Gulf of Carpentaria Mud Crab Stocks:

Establishing a Benchmark for Albatross Bay, Weipa.

Project Report

This report was prepared by the Department of Primary Industries and Weipa Catchment Coordinating Group to the Queensland Fisheries Management Authority and CrabMAC.

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Supporting Organisations

Queensland Fisheries Management Authority
Department of Primary Industries
Weipa Catchment Coordinating Group
Comalco
Napranum Aboriginal Community Council
Australian National Sportsfishing Association

Summary

Increasing demands on local mud crab (*Scylla serrata*) stocks have given rise to concern in the Weipa community about the condition of the mud crab fishery in the area. It is possible that community perceptions of resource depletion are simply caused by changes in the resource allocation between indigenous, recreational and commercial crabbers. However, the level of access by different user groups to harvest the resource should be addressed by fisheries managers and mechanisms established to allocate the resource equitably. For the Gulf of Carpentaria Mud Crab Fishery Management Plan to deliver sustainable levels of harvesting and equitable resource sharing, information is urgently needed about the condition of the wild mud crab resource in Albatross Bay.

The Weipa Catchment Group, with assistance from the Department of Primary Industries, approached the QFMA, through CrabMAC, with a research project proposal to address community concerns. The project was undertaken to establish the current status of wild mud crab stocks in Albatross Bay estuaries and to estimate the level of harvest by all user groups. This progress report presents results from an intensive mud crab sampling survey conducted by Weipa Catchment Group volunteers in May 1998, as part of the project. It also describes the mangrove habitat characteristics in the estuaries.

Anecdotal information from commercial fishers, and QFMA Qfish log book data suggest that mud crab catches this year have been unusually low, compared to previous years. The water pH, temperature and salinity levels during the time of the study should not have affected the catchability of the crabs. However, anecdotal information from fishers in the area suggests that the uncharacteristic rainfall earlier in the year may have affected the mud crab recruitment into the fishery.

Due to the low catches and recapture rates of crabs, it was not possible to determine the abundance of mud crabs in Albatross Bay from the intensive surveys. A tagged crab recapture rate of at least 10% is required to determine abundances using depletion experiments. The recapture rate of tagged crabs during the intensive survey was between 3% and 8%, which meant that the depletion models could not be completed.

The logistics and operations of the intensive surveys were however a success due to the involvement and enthusiasm of the Weipa volunteers. It is hoped that future intensive surveys can be conducted to obtain abundance estimates based on fishery independent surveys.

A total of 203 mud crabs (0.7 crabs per pot lift) were caught during the survey. The average (1988–96) commercial catch of mud crabs in the Weipa region during May is approximately 0.8 tonne/1000 lifts (Gribble et al. 1997) which is considerably higher than the 0.2 legal crabs/lift (equates to 0.2 tonne/1000 lifts) caught during the survey.

Due to the low numbers of crabs caught during the intensive survey, an alternative fishery dependent method to estimate mud crab abundance was used. This estimate was calculated from commercial crab catches and extrapolates these catches based on the area of available mangrove habitat.

Approximately 180km^2 of the Albatross Bay catchment is made up of mangrove habitat. Based on these habitat estimates and the QFMA Qfish logbook data, legal-size male mud crab biomass, for the Weipa region, ranged from about 17.4 tonnes to 21.3 tonnes, while the yearly commercial catch from 1989 to 1997 was about 13 tonnes. This would indicate that the Weipa commercial catch is within long-term sustainable limits. However, to the commercial catch must be added to the unknown recreational and indigenous catch, which may take the total exploitation level closer to the available biomass of legal-size male crabs each year. If so, the situation in Weipa may be approaching that of Northern Territory where the majority of a year's legal-size crabs are caught in that year.

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Introduction

In the Gulf of Carpentaria, wild stocks of mud crabs (*Scylla serrata*) are increasingly sought after by commercial crabbers, charter fishing operators and recreational crabbers. The commercial crab catch is valued at over $1 million Gross Vessel Production (GVP) in the Gulf of Carpentaria and about $3 to $5M (GVP) to Queensland annually. Mud crabs are also a significant food source for local indigenous people, who have a semi-subsistence lifestyle.

Increasing demands on local mud crab stocks have given rise to concern in the Weipa community about the condition of the local fishery (Golden and Dickenson 1996). Many long-term residents claim that their mud crab catches have declined over the last five years, leading to fears that local mud crab stocks are being depleted and to claims that the current level of harvesting is unsustainable. As a result, calls have been made for the Queensland Fisheries Management Authority (QFMA) reduce the level of commercial harvesting. Community perceptions of resource depletion and demands for changes in resource allocation are causing conflict between resource user groups (indigenous, recreational and commercial crabbers) in the Gulf region, especially in the Weipa area.

Community perceptions of resource depletion may result from changes in the resource allocation between user groups. However, their level of access to harvest the resource should be considered by fisheries managers, and mechanisms established to allocate the resource equitably. For sustainable levels of harvesting and equitable resource sharing to be established in the Gulf of Carpentaria Mud Crab Fishery Management Plan, information is urgently needed on the condition of the wild mud crab resource in Albatross Bay.

The Catchment Group, with assistance from the Department of Primary Industries, Queensland (DPI), approached the QFMA, through CrabMAC, with a proposal to address some of the community concerns outlined above. This project aims to determine the current status of wild mud crab stocks in the Albatross Bay estuaries and to estimate the level of harvest by all user groups. The results will provide a benchmark against which the QFMA can test the performance of strategies introduced to manage the mud crab fishery in the Gulf of Carpentaria.

This report presents results from the intensive mud crab sampling survey conducted by the Weipa Catchment Group volunteers in May 1998 and describes the characteristics of mangrove habitat in these estuaries. The aim of the project was to estimate the size of the mud crab population in Albatross Bay. This estimate was then to be extrapolated by integrating abundance data from the intensive surveys with area estimates of available mangrove habitat. However, low crab catches, meant it was not possible to determine the mud crab abundance in Albatross Bay.

Therefore, some of the reasons for the lower than average mud crab catches were documented, and improvements in sampling strategy suggested, for use if the project is repeated. Estimates of legal mud crab abundance (or potential harvest) based on commercial crab catches are also presented and extrapolates of these results based on the area of available mangrove habitat.

Project objectives addressed in this report:

- Estimate the area of mud crab habitat in the Albatross Bay area from satellite photography and identify representative creeks based on habitat and topography.

- Count, measure, sex and tag all mud crabs in three 0.5 km sections of representative creeks in the Albatross Bay estuaries.

- Integrate the mud crab abundance, size and sex information with the habitat information to estimate the total number of mud crabs and mud crab population structure in Albatross Bay.

- Make this information available to QFMA for consideration in developing a Fisheries Management Plan for the Gulf of Carpentaria mud crab fishery.

Methods

Survey sites

Northern Fisheries Centre staff, Sue Gould (Weipa catchment coordinator) and Peter Tonon (commercial crabber), conducted a reconnaissance prior to the survey to select sites based on habitat and practical considerations. Aerial photographs and topographic maps were also assessed to determine which sites would be suitable for the intensive mud crab surveys.

Sites viewed during the reconnaissance were selected by Peter Tonon based on his knowledge of areas where he has previously caught mud crabs.

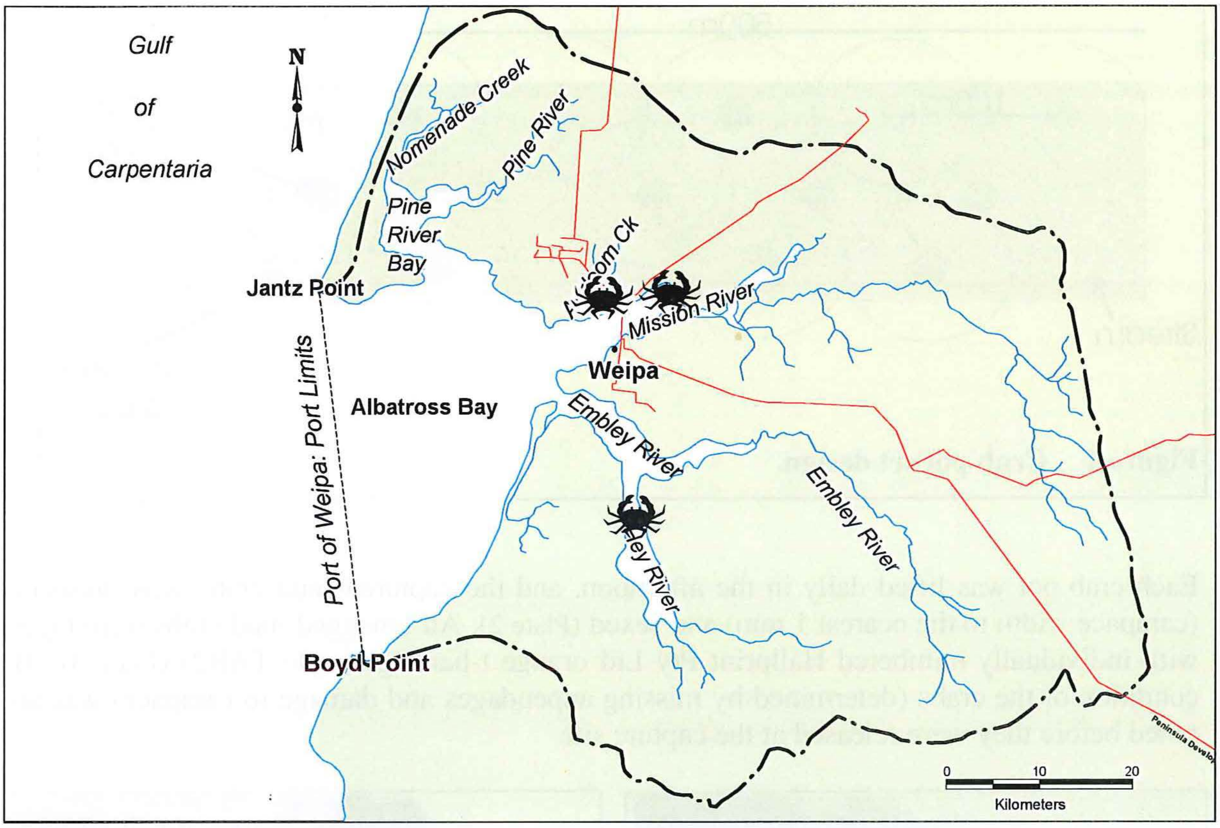
Habitat in Albatross Bay where mud crabs are caught include mangrove-lined creeks and muddy foreshores. The foreshore areas are logistically difficult to survey as they lack defining limits. Mangrove-lined creeks, with defined banks and site boundaries, were logistically more feasible to sample.

Mud crab survey sites were selected on the following habitat criteria:

- similarity of mangrove habitat (dense stands of *Rhizophora*, *Ceriops* and *Avicennia*);
- possession of defined banks to act as study site boundaries (creeks);
- similarity of stream width (between 50–100 m);
- similarity of stream depth (approximately 2–3 m near stream bank).

Other considerations of importance when selecting the sites included travelling time to sites and access to boat ramps, as the survey relied on volunteers with other time commitments.

Based on these criteria, the three survey sites were Andoom Ck, a tributary of the Mission River and a tributary of the Hey River (Map 1). Each location is a tributary of Albatross Bay. In this study, Albatross Bay will refer to the estuarine waterways of the catchment.



Map 1 Albatross Bay mud crab survey sites

Survey period

Intensive mud crab surveys were conducted between 10 and 17 May 1998. Local crabbers recommended these survey dates as optimal for catching mud crabs.

Survey methods

Fifteen 'Munyana' crab pots were set at 100 m intervals within a 500 m stretch of creek at each survey site. Williams and Hill (1982) recommended the 100 m pot interval as the optimal distance for setting crab pots to ensure that they attract crabs from the entire survey area (Figure 1). Each pot was baited with fresh red meat encased in a bait bag before being set (Plate 1).

Plate 1 Weipa volunteer, Keith Withers baiting a Munyana crab pot.

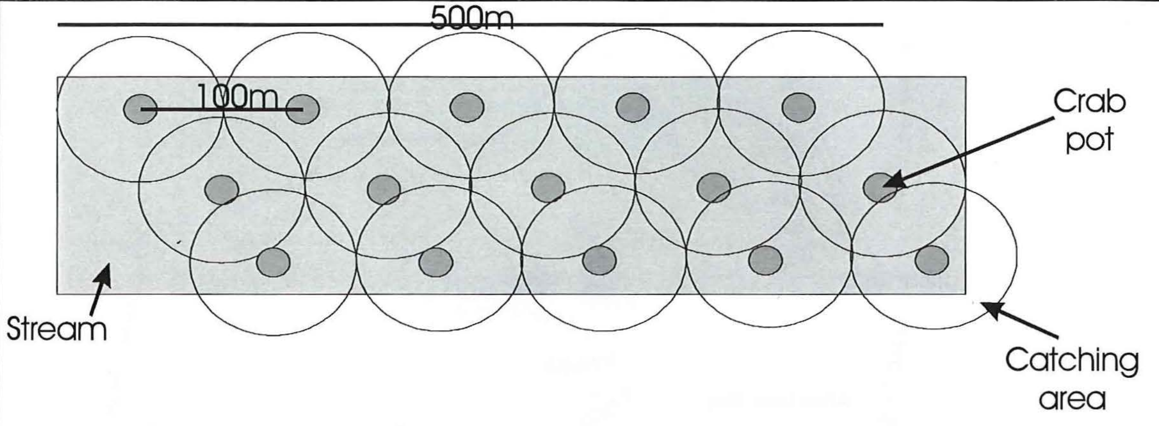


Figure 1 Crab pot set design.

Each crab pot was lifted daily in the afternoon, and the captured mud crabs were measured (carapace width to the nearest 1 mm) and sexed (Plate 2). All untagged mud crabs were tagged with individually numbered Hallprint Pty Ltd orange t-bar tags (style TAB2) (Plate 3). The condition of the crabs (determined by missing appendages and damage to carapace) was also noted before they were released at the capture site.

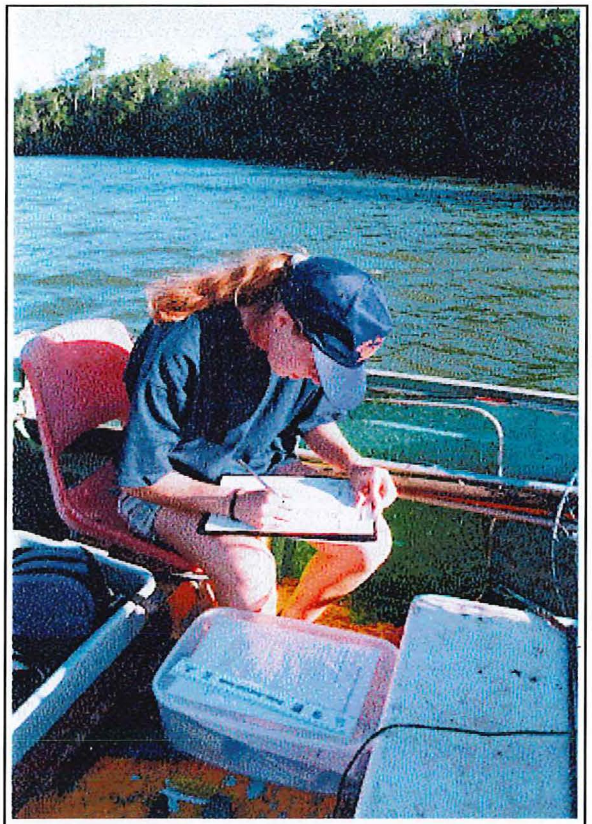


Plate 2 Weipa volunteer, Fiona Long, recording mud crab carapace width measurements.

Plate 3 Weipa volunteer, Doug Croker, with a tagged male mud crab about to be released.

Tagged crabs recaptured during the survey period were remeasured and released at the recapture site. Crabbers in the Weipa region were relied upon to return information on tagged crab recaptures to the 1800 telephone number on each tag. Recapture information requested from the crabbers included the tag number, date and location (within a 1 km grid system) of the recapture, and the size, condition and fate of the crab.

Crab pots were rebaited daily, during checking, and then returned to the location from which they were lifted.

Commercial catch records

Commercial crab catch records were obtained from commercial logbook information stored on the QFMA Qfish database. Details on the catch (kg) and effort (number of boat days and number of pot lifts) from January to August were obtained from 1991 to 1998. Only data from January to August were available for 1998. Therefore, to make the data comparable, records from January to August from 1991–97 were used, rather than full year's catch and effort data.

Training workshop

Volunteers were called on to assist in the research exercise. All volunteers were asked to attend a training workshop held in Weipa on the 8 May 1998. At the workshop:

- Northern Fisheries Centre staff, briefed volunteers on study methods, study site locations, completing data recording sheets, data required and tagging procedures.
- The Weipa catchment coordinator (S.F. Gould) explained the operation of the water quality monitoring equipment and the conditions attached to the research permit.
- A local commercial crabber (P Tonon) demonstrated mud crab handling techniques to minimise the risk of injury to the volunteers and the crabs (Plate 4).

Plate 4 Weipa commercial fisherman, Peter Tonon, demonstrating mud crab handling techniques to Weipa volunteers.

A field kit, containing tagging equipment, water quality monitoring gear and data recording sheets was distributed to each site supervisor. The site supervisor was responsible for passing on the data sheets to the Weipa catchment coordinator and distributing the field kit to the volunteers under their supervision.

Volunteers also had the opportunity to ask questions, tie and tag crabs and operate water quality equipment.

At the end of the workshop, a volunteer roster was organised to ensure that volunteers knew the days they would be sampling the sites.

Water quality

Comalco supplied the three types of water quality equipment used during the survey.

The Mission River site was sampled using a Sondes YSI 6920 meter, the Andoom Creek site using a Sondes 6000 UPG meter and the Hey River site using a 600XL meter with 610DM hand logger.

The Sondes meters were programmed daily to record information at one-minute intervals during the time at which pots were to be lifted. Information from the 600XL was recorded manually onto the data recording sheets during pot lifts.

Parameters measured at each site included pH, conductivity, temperature, dissolved oxygen and turbidity.

All equipment was initially calibrated for pH, conductivity and dissolved oxygen. During the study period all equipment was recalibrated once for conductivity and daily for dissolved oxygen. A surface (approximately 30 cm below the water surface) and a bottom measurement for each parameter were recorded at each site daily. Data were downloaded daily from Sondes meters to a computer, while data from the hand logger were recorded manually at the time of measurement.

Habitat mapping

Danaher (1995) mapped mangrove vegetation in the Weipa region using 1:250 000 TM Satellite Imagery. These data were imported into MapInfo for analysis by the Northern Fisheries Centre staff. Details on the type and area (km^2) of mangrove vegetation surrounding the survey sites were collated using thematic mapper and SQL queries in MapInfo.

Data analysis

All crab survey data were entered into a Microsoft Access database and analysed using Microsoft Excel and GenstatV.

Crab catches over the seven sampling days from the three sites were analysed using a GenstatV. A generalised linear model with a Poisson distribution, and a process of backward stepwise elimination, were used to determine if there were any differences in the catches between days and sites.

Commercial catch and effort information was summarised using Microsoft Excel.

Leslie/DeLuri depletion models

The results from the crab survey were analysed using the Leslie and DeLuri depletion models to determine crab population size.

Depletion models are 'fish down' experiments, in which it is assumed that a known amount of fishing effort over a known time interval would significantly reduce the population numbers (and catch-per-unit-effort). It is possible to calculate the initial population size from the magnitude of the observed depletion: for example, if the initial population is large then the depletion will be relatively small and vice versa. The Northern Territory Fisheries (NTF) Department has successfully used these models in a study of mud crab abundance in a tributary of the Adelaide River, Northern Territory (T. Hay, NTF, pers. comm.). This information was used to estimate the total mud crab population in the NT (Walters 1996). The experimental protocol used in the Albatross Bay study was modified from that used in the N T to give greater scientific rigour and confidence in the results.

NTF estimated mud crab abundance in a single stream, using a 1.5 km stretch of stream with a central section and guard bands. Crabs caught in the central section of the stream were measured, sexed and removed from the study areas. Crabs caught in 'guard bands', at either end of the central section, were tagged to estimate their movement (immigration) into vacated territories in the central section.

In our study, three streams were sampled to allow for replication and calculation of an average and variance on the abundance estimate. Due to logistics, shorter 0.5 km stretches of stream were sampled. All crabs caught were tagged and released on site, which meant that crab territories were not vacated, negating the need for guard bands.

For the Albatross Bay study there were three possible situations influencing the estimation of crab abundance:

1. If the crab population was resident and crabs were not affected by tagging, then catch per unit effort (CPUE) would remain constant, but there would be an increasing proportion of tagged crabs on subsequent days of sampling.

2. If the crab population was resident and crabs were affected by tagging (and were no longer available to the pots), then the experiment would follow the traditional course (Ricker, 1975) and there would be a decrease in crab numbers and CPUE on subsequent days of sampling.

3. If migration was high, no depletion estimate could be made and the experiment would devolve to a simple 'Petersen mark and recapture' estimate of general population abundance (Ricker, 1975), based on three sites and seven marking events at each site. Again replication would give some statistical rigour to these estimates.

The depletion models used (Ricker 1975 and Pauly 1984) were the Leslie and Deluri methods.

Leslie method

$$\frac{c_t}{f_t} = qN_t$$

where:
c_t is catch (number of untagged crabs caught each day) for that time *(t)*
f_t is effort (pot lifts) during time *(t)*
q is the catchability—the fraction of the population taken by 1 unit of effort
N_t is the population at time *t*.
t is the time (days)

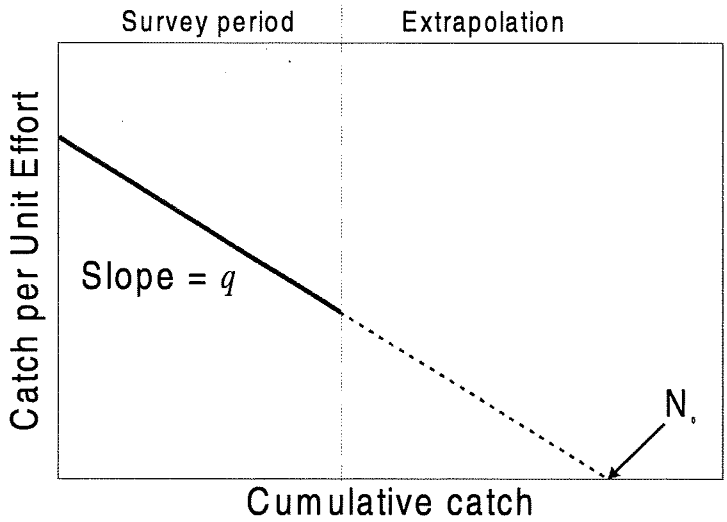


Figure 2 Diagrammatic representation of the Leslie method

The CPUE is plotted against cumulative catch over a known time interval). The resulting fitted straight line (usually descending) gives an initial population estimate at the point where the line cuts the cumulative catch axis). The slope of the line estimates catchability (Figure 2).

DeLuri method

$$\frac{c_t}{f_t} = qN_o\left(\frac{N_t}{N_o}\right)$$

where:
c_t is catch (number of untagged crabs caught each day) for that time *(t)*
f_t is effort (pot lifts) during time *(t)*
q is the catchability—the fraction of the population taken by 1 unit of effort
N_o is the initial population
N_t is the population at time *t*
t is the time (days)

The logarithm of the CPUE is plotted against the cumulative effort. The intercept with the y-axis (log CPUE) gives $q\ N_o$. The slope of the line gives $0.4343q$, which allows both q and N_o to be calculated.

Refinements to these methods allow tagging data to be used directly. Hilborn and Walters (1992) describe a multiple-regression method that can incorporate a certain amount of recruitment (i.e. an open rather than discrete population).

Abundance estimates of legal mud crabs

It is also possible to estimate legally-sized male mud crab abundance (or potential harvest) using catch data from the commercial logbook records and the total area of mangrove habitat. The steps in this form of analysis are simple and relatively straightforward.

1. Estimate the total area of mud crab habitat in Albatross Bay estuaries.

   For this study, mud crab habitat was taken as the area of mangrove identified from satellite imagery (Danaher 1995), plus the length of all streams multiplied by 0.05 km (this is an arbitrary figure to represent the average stream width) to give an area estimate of in-stream habitat. The length of stream adjacent to mangrove areas was calculated from AUSLIG maps of creek systems.

$$A_m = \text{Area of mangrove (km}^2\text{)}$$
$$A_r = \text{Area of river (km}^2\text{)}$$
$$A = A_m + A_r$$

2. Estimate the weight of crabs taken per pot lift and the number of pot lifts in the Weipa region.

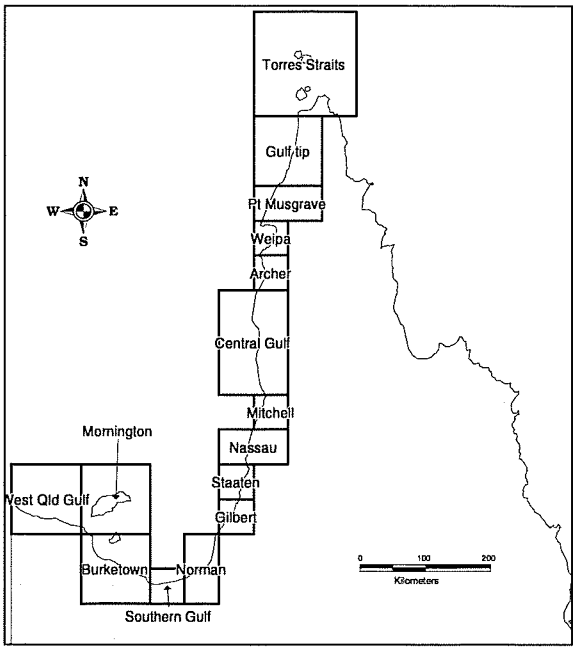
   This information was calculated from QFMA Qfish logbook information (Map 2).

   C = average annual catch between 1989 and 1997 (tonnes)
   E = average annual effort between 1989 and 1997 (number of pots per year)
   L = number of pot lifts per day, assumed to be 1 for the Gulf of Carpentaria.

3. Estimate the 'drawing area' of a crab pot.

   The optimal setting distance is one pot every 0.1 km (Williams and Hill, 1982). Each pot draws crabs from a 0.05 km radius or 0.0079 km^2.

$$A_p = \text{pot drawing area (km}^2\text{)}$$
$$= Pi * r^2$$
$$= Pi * 0.05^2$$
$$= 0.0079\ \text{km}^2$$



Map 2 Commercial log book grids used to calculate legal mud crab abundance in the Gulf of Carpentaria.

4. Divide the area of mangrove habitat by the drawing area of a crab pot and multiply this by the average weight of crabs taken per lift. This would give the potential harvest (tonnes) of legally-sized male mud crabs in the population, assuming that a legally-sized mud crab weighs about 1 kg.

PA = number of pot areas
= Am/Ap (method 1)
= A/Ap (method 2)

Potential harvest = C/(E*L)*PA

Results and discussion

Catch rates

A total of 203 mud crabs (0.7 crabs per pot lift) were caught during the survey. Anecdotal information from commercial crabbers indicates that this catch rate is low compared to that expected by commercial and recreational crabbers in the area during May. The average commercial catch of mud crabs in the Weipa region during May is approximately 0.8 tonne/1000 lifts (Gribble et al. 1997) which is considerably higher than the 0.2 legal crabs/lift (equating to 0.2 tonne/1000 lifts) caught during the survey.

The catches with the highest proportion of legal crabs were made in Andoom Creek (Table 1). The percentage of legal crabs caught in the Hey and Mission Rivers were similar to each other but lower than Andoom Creek.

Table 1 Total number and proportion of legal and non-legal crabs caught during the 7-day potting survey.

Site	Total	Not legal	Legal
Andoom Creek	50	32 (64%)	18 (36%)
Hey River	38	28 (74%)	10 (26%)
Mission River	87	66 (76%)	21 (24%)
Total	175	126 (72%)	49 (28%)

Note: Data include only those crabs that were measured and for which sex could be determined).

The number of crabs caught per pot, per day was significantly different between sites (df = 2, $p<0.05$). More crabs were caught per day in the Mission River site than in Andoom Creek or the Hey River site (Figure 3).

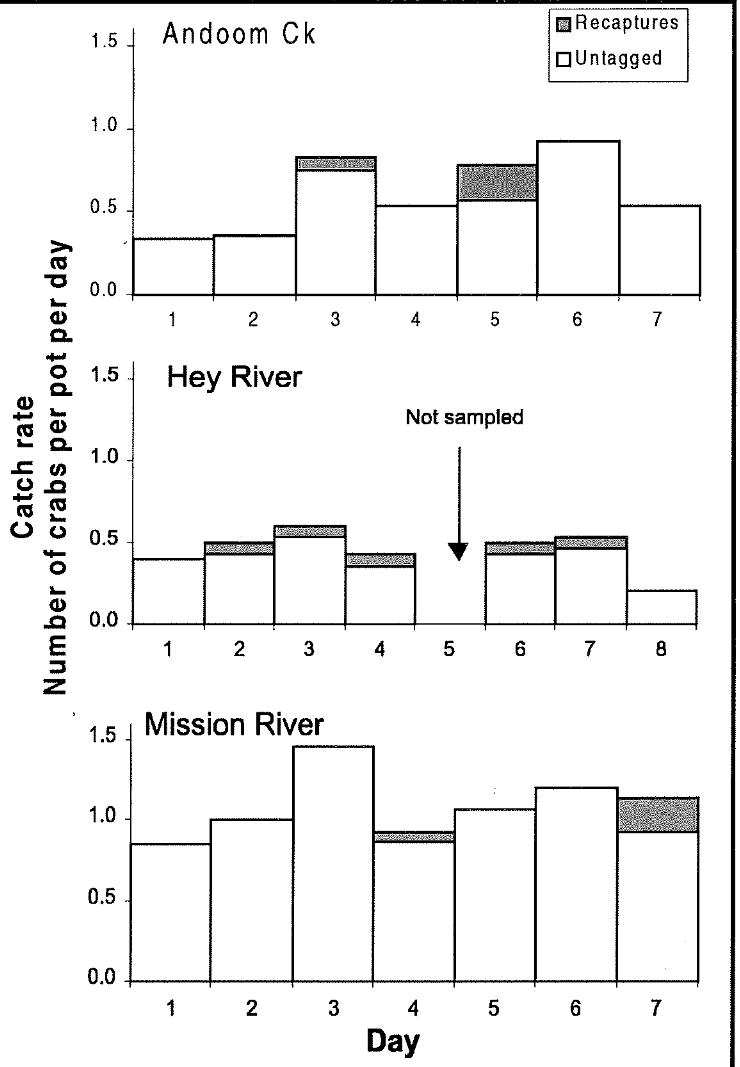


Figure 3 The number of tagged and untagged crabs caught per pot per day at the Andoom Creek, Hey River and Mission River study sites.

There was no significant variation in crab catches between days during the survey period (df = 12, p>0.05).

Tag recaptures

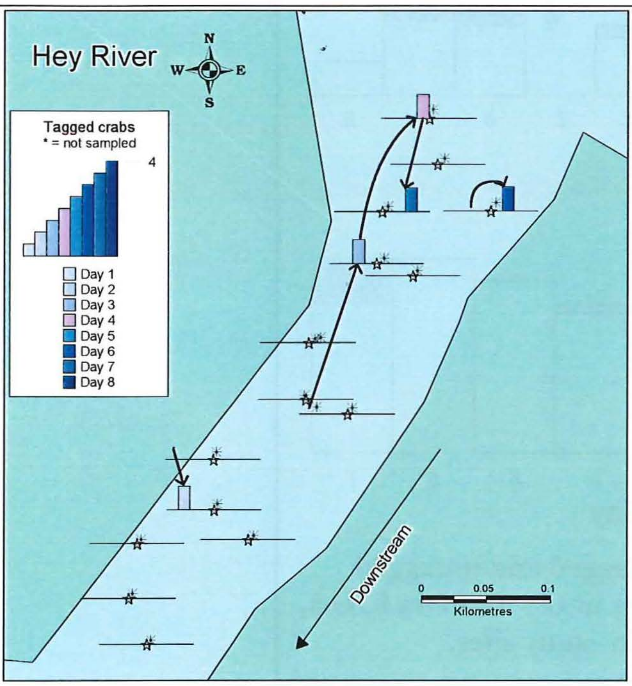
The number of tagged crabs recaptured by project volunteers over the survey period was low; only 12 tagged crabs were caught. Although the recapture rate in the Hey River appears to be high at 13%, one crab was caught three times, reducing the actual tag recaptures to 8% (Table 2).

Table 2 Percentage of tagged crab recaptures at the three sites.

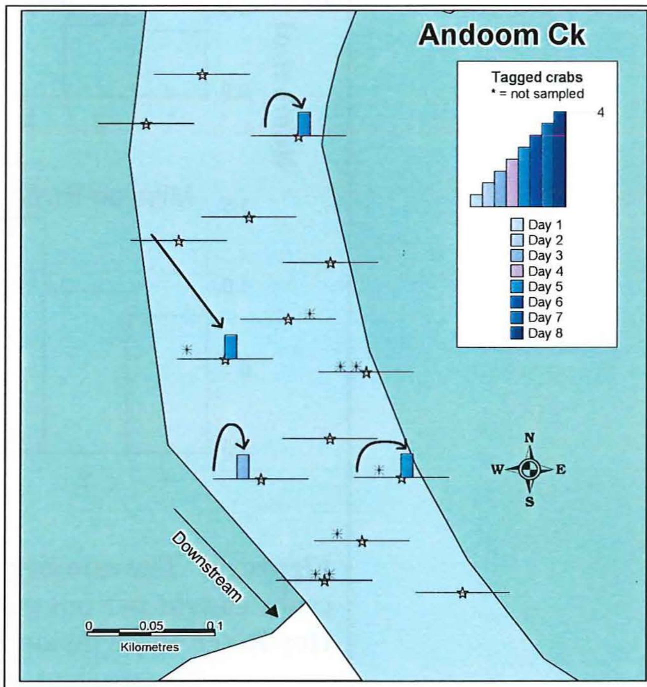
	Tagged	Recaptures		Unique recaptures*	
	Number	Number	%	Number	%
Andoom Creek	53	4	8	4	8
Hey River	40	5	13	3	8
Mission River	104	3	3	3	3

* Unique recaptures exclude crabs that were recaptured more than once.

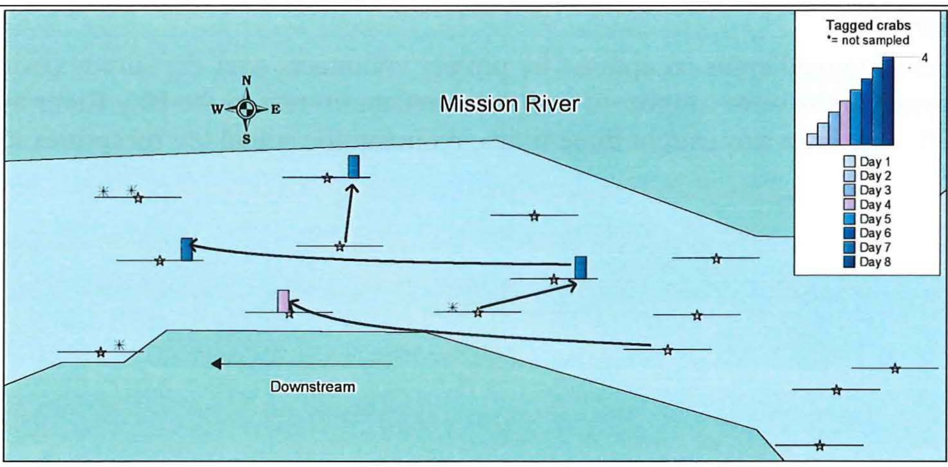
No discernible pattern could be inferred from the movement of recaptured crabs during the survey period (Map 3, Map 4, and Map 5).



Map 3 Movement of tagged crabs in the Hey River



Map 4 Movement of tagged crabs in Andoom Creek



Map 5 Movement of tagged crabs in the Mission River.

Hill (1978) tracked crabs in South Africa using ultrasonic transmitters and noted that crabs moved an average of 461 m a day. The crabs tended to remain in a general area although they would move considerable distances overnight. Hill (1978) documented three types of movement:

(i) restricted (centres around a permanent home site);
(ii) free ranging (extends over greater areas to forage);
(iii) migratory (usually associated with spawning).

Due to the low number of recaptures, it was not possible to determine the type of crab movement that occurred during the study.

Recreational crabbers recaptured four additional tagged crabs up to two weeks after the survey. These recaptured crabs had not moved out of the survey area.

Sex Ratio

More males were caught at all three sites (Figure 4) than either females or unknowns (crabs for which the sex could not be identified). A large number of crabs caught in the Mission River were classified as unknown. It is unclear if the crabs were actually hermaphrodites or if they were just too small to be identified as either male or female.

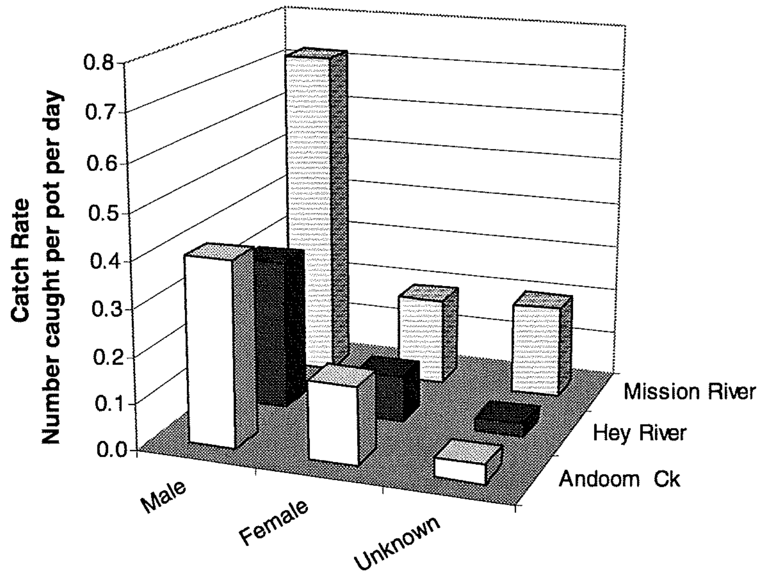


Figure 4 Number of male, female and unknown (crabs for which the sex could not be identified) crabs caught per pot per day at the three study sites.

Size Structure

The number of males caught was higher than females caught in all size classes and at all sites (except the 10 cm size class in the Hey River) (Figure 5). The size range of crabs varied from 6 cm in the Mission River to 18 cm in Andoom Creek and the Hey River (Figure 5).

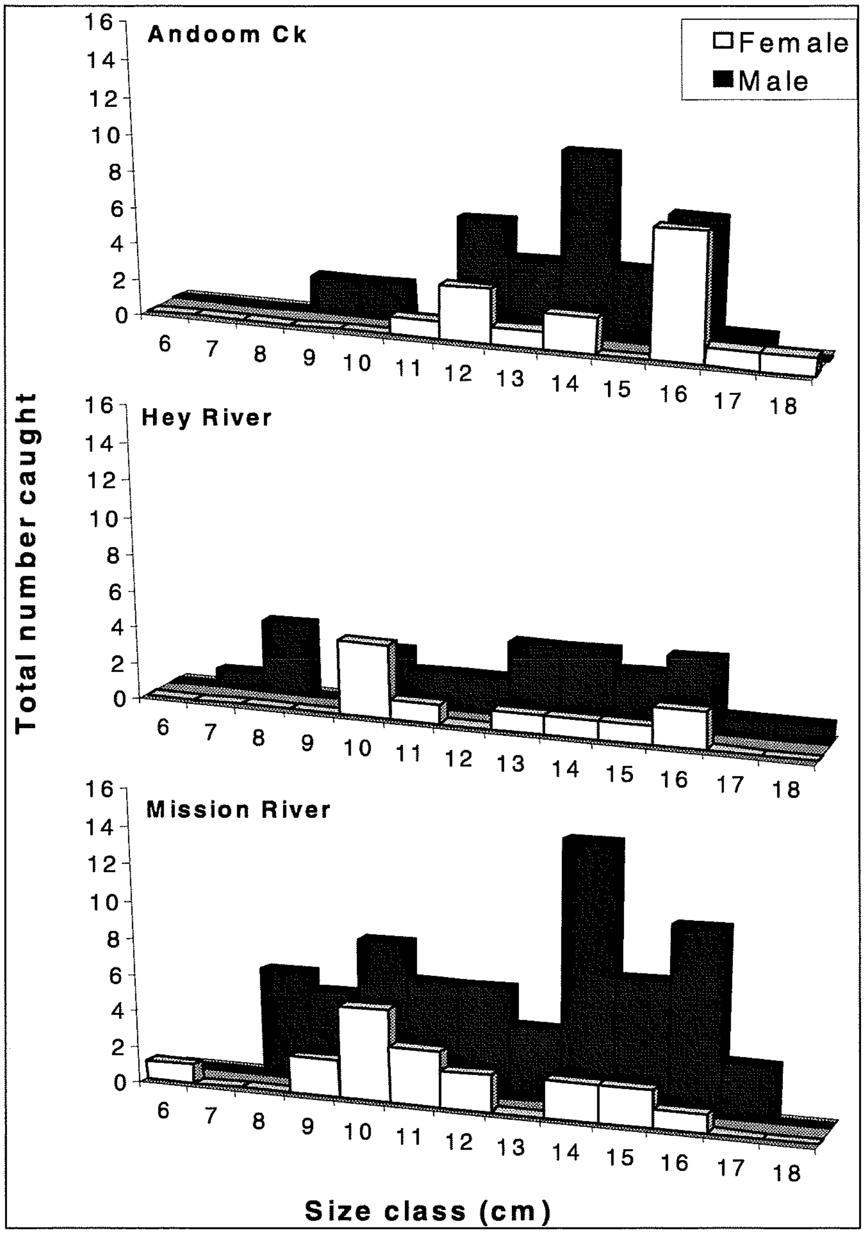


Figure 5 Size frequency of male and female mud crabs caught in the Hey River, Andoom Creek and the Mission River.

The number of crabs captured in each of the size classes was relatively constant in the Hey River, while the Mission River exhibited bimodal size frequency distributions (Figure 5).

Water quality

Due to equipment faults and differences between the three types of water quality meter, complete data sets were only achieved for depth, temperature, salinity, and pH.

Surface water temperatures were consistently higher than bottom temperatures at all sites (Table 3). Little variation in water temperature occurred between the sites during the survey period; a maximum variation of 1.9°C was recorded. Water temperatures during the survey were greater than 20°C and should not have affected the catchability of the crabs (Hill, 1980).

Table 3 Average and range of water temperature (°C) during the survey period.

	Average surface temperature (°C)	Average bottom temperature (°C)	Minimum temperature (°C)	Maximum temperature (°C)
Mission River	29.9	29.4	29.1	30.4
Andoom Creek	29.4	29.4	29.1	30.0
Hey River	29.4	29.2	28.4	30.2

Surface pH was consistently lower than pH at the bottom of the water column (Table 4). The values recorded are consistent with previous studies that found bottom waters in the Weipa region were more alkaline than surface waters (for example: Larcombe and Taylor, 1997). Variation in pH values suggests a groundwater influence and the mixing between freshwater and saltwater within any one system. Previous studies have found that the pH of waters upstream is lower (more acidic) than pH of seawater, which is normally between 8.1–8.3 (Larcombe and Taylor 1997). The pH values recorded at potting sites during the survey are within normal ranges and should not have affected crab catches (Mann 1995).

Table 4 Average and range of pH during the survey period.

	Average surface pH	Average bottom pH	Minimum pH	Maximum pH
Mission River	7.4	7.5	6.9	8.0
Andoom Creek	8.3	8.4	7.2	8.8
Hey River	7.6	7.6	7.3	7.8

The average salinity at all sites is within values recorded in previous studies for the Albatross Bay estuary (Larcombe and Taylor 1997). The range in salinity values across all data sets was 21.08 ppt. Surface salinity was consistently lower than salinity at the bottom of the water column, possibly reflecting the freshwater run-off from recent rains in the area. The salinities during the survey were all between 17 ppt and 39 ppt and should not have affected crab survival (Mann, 1995).

Table 5 Average and range of salinity (ppt) during the survey period.

	Average surface salinity (ppt)	Average bottom salinity (ppt)	Minimum salinity (ppt)	Maximum salinity (ppt)
Mission R	21.3	25.3	17.6	30.3
Andoom Ck	22.5	24.7	20.5	28.6
Hey R.	30.7	32.9	27.4	38.7

Commercial crab catch per unit effort

The annual crab CPUE from January to August 1998 fell by 50% in the Weipa area (12.25°S to 13.05°S) from 1997–1998 (Figure 6). This is consistent with commercial crab catch records from the Torres Strait (10.75°S) to the Nassau River (16.00°S) where catches decreased by 38% from 1997 to 1998. These data support reports by commercial crabber that catches have been much lower during 1998 than in the previous five years.

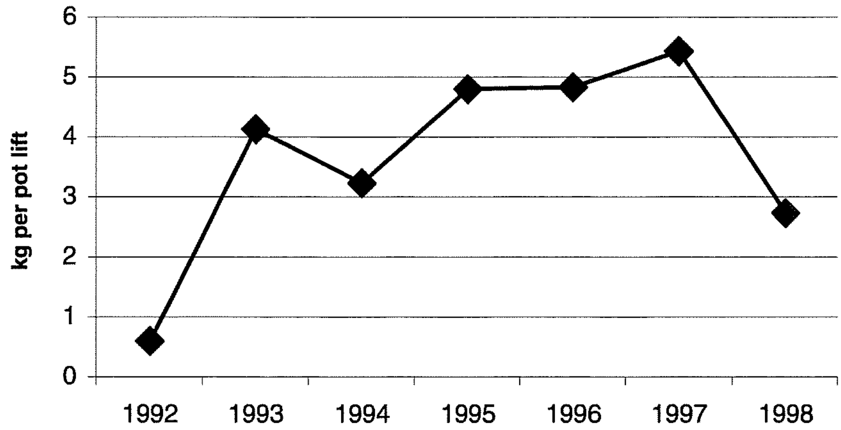


Figure 6 Commercial mud crab catch per unit effort in the Weipa area (12.25°S to 13.05 °S) from January to August between 1992 and 1998.

Anecdotal reports from crabbers in the region also support this significant decline in mud crab catch in 1998. At the annual QCFO meeting in Karumba, 2nd October 1998, a number of experienced commercial crabbers commented on the drop in the number of crabs caught along the northern Gulf coast, although good numbers were still being caught at the southern end of the Gulf. A variety of explanations were put forward, including that the long period of rain early in the year, and an extended period of freshwater run-off from the streams is the likely cause. During this period, adults may have been flushed out into the Gulf and then tried to return into successive estuaries as they moved down the coast. Another explanation was a failure of recruitment in the north caused by high rainfall two years ago. The dependence of the mud crab catch on environmental factors was generally accepted.

Depletion Experiment

Mud crab abundance could not be estimated from the survey data as the tag recaptures at all three sites were lower than the 10% value recommended by Otis et al. (1978, In Williams and Hill 1982) (Table 2). They suggested that a minimum recapture rate of 10% was required for population abundance estimates to be calculated.

Scenarios for the very low percentage of tag recaptures in the three streams studied are:

- Recently tagged crabs become unavailable for recapture as they either hide or simply will not enter pots again. This behaviour has not been reported in earlier tagging programs in Queensland (Williams and Hill 1982, Hyland et al. 1984) or in the Northern Territory (I. Knuckey, pers. comm.). Furthermore, if reduced availability, caused by tagging, was the only factor affecting the recapture rate, then there should have been a depleted number of crabs caught each day. This was not the case.

- There could have been thousands of crabs in the area and the probability of catching the same crab twice was actually as low as the 3–8% suggested from the raw tag-recapture data. However, the low number of crabs caught in total does not support this explanation.

- Crabs were migrating through the study sites at the time of the study. The low tag recapture rate indicates a high migration rate. Anecdotal information from local crabbers and commercial logbook data, from January to August 1998, shows a marked reduction in total landings and CPUE for crabbers in the Weipa region, compared to previous years. Both the anecdotal information and commercial logbook data indicate unusual crab behaviour during the time of study; possibly linked to the long period of freshwater run-off that local crabbers believe causes crabs to move.

In our opinion, the third scenario is the most likely explanation for the low recapture rate of tagged crabs during the study.

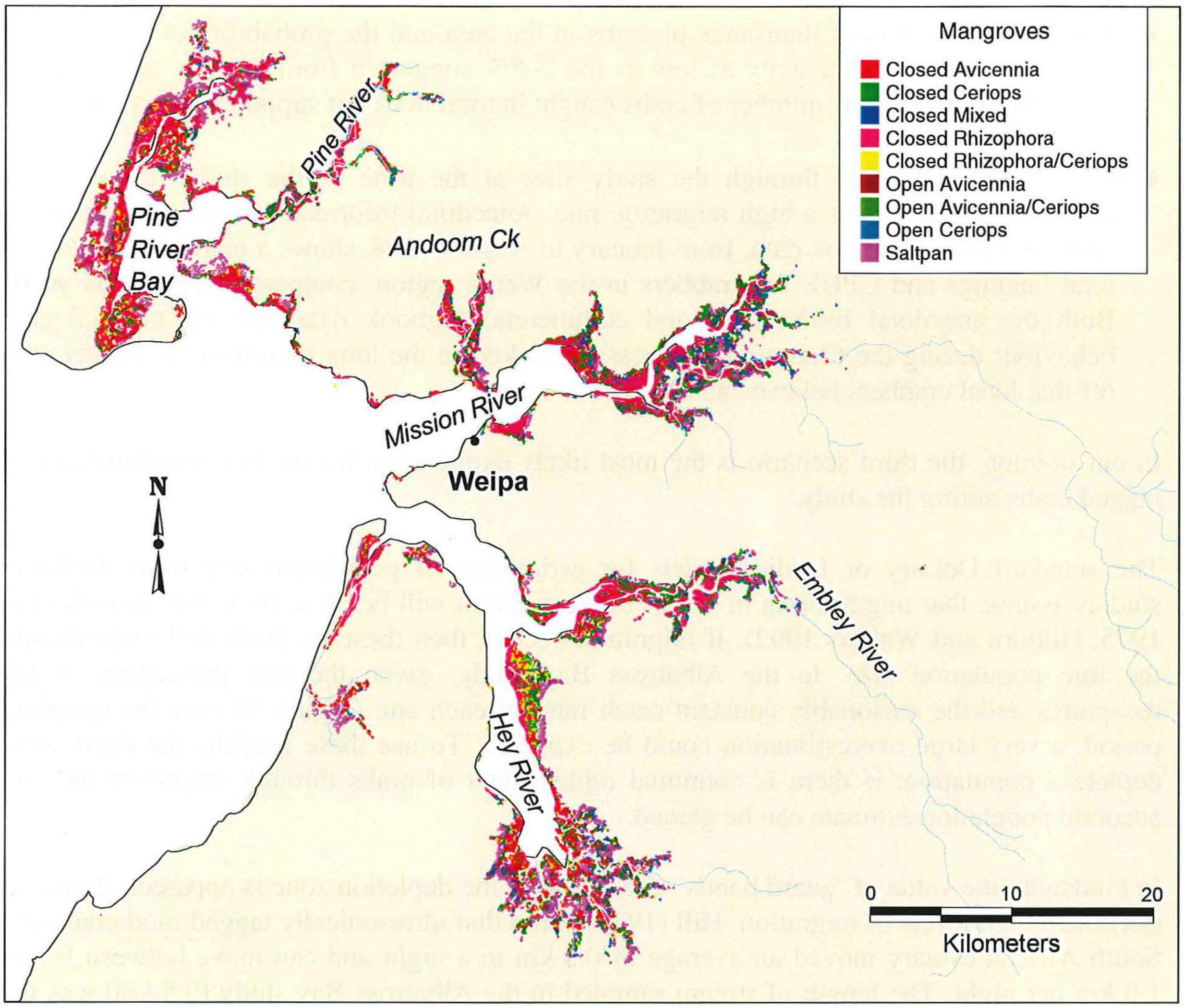
The standard DeLury or Leslie models for estimation of population size from depletion studies assume that migration in or out of the population will be close to, if not, zero (Ricker 1975, Hilborn and Walters 1992). If migration occurs, then these methods will overestimate the true population size. In the Albatross Bay study, given the low percentage of tag recaptures and the reasonably constant catch rates at each site (Figure 3) over the sampling period, a very large overestimation could be expected. To use these models, the study must deplete a population; if there is continual replacement of crabs through migration then no accurate population estimate can be gained.

In hindsight, the value of 'guard bands' either side of the depletion zone is apparent, if only to document high levels of migration. Hill (1978) noted that ultrasonically tagged mud crabs in a South African estuary moved an average of 0.5 km in a night and can move between 0.2 to 1.0 km per night. The length of stream sampled in the Albatross Bay study (0.5 km) was the minimum that could be expected to give viable results (based on the average distance moved by a crab) but sampling a longer stretch would obviously increase the confidence in the results. There will need to be a trade-off between cost, logistics and statistical rigour. Hill (1978) also described three types of crab movement; homing to a general territory, general movement not tied to a territory, and migration for breeding. Depletion studies could only estimate that part of the population displaying the first type of behaviour, however the inclusion of guard bands could give an indication of the size and importance of the other two sections of the population.

Therefore, analysis at this stage will most likely be in the form of a 'Petersen mark and recapture' estimate of general population abundance (following the technique given in Ricker, 1975), based on three sites and seven marking events at each site. Tag recapture information (from the study and from SunTag) can be used assuming that the amount of crabbing effort to gain the recaptures can be estimated. Commercial crabbing effort can be estimated from the QFMA Qfish logbook information. Recreational crabbing effort can be obtained from the voluntary logbooks (being filled out as part of this study) and possibly the QFMA Rfish program.

Habitat composition

Approximately 6% of the Albatross Bay catchment is mangrove habitat of which closed *Rhizophora* spp. forest (27%) and saltpan (18%) are the predominant mangrove types (Map 6 and Table 6).



Map 6 Mangrove vegetation in the Albatross Bay estuary. Source: Danaher (1995).

Table 6 Area (km^2) of mangrove vegetation in the Albatross Bay catchment. (Source: Danaher, 1995).

Type	Area (km^2)	Percent
Closed *Rhizophora*	65.09	27%
Saltpan	42.45	18%
Closed *Ceriops*	38.78	16%
Closed *Avicennia*	36.97	15%
Closed mixed	17.88	7%
Unknown	16.40	7%
Open *Avicennia*	11.00	5%
Closed *Rhizophora/Ceriops*	6.85	3%
Open *Avicennia/Ceriops*	4.69	2%
Open *Ceriops*	0.90	0%
Total	**241.00**	

Total abundance estimates

While the current depletion study is unlikely to yield estimates of crab density abundance in Albatross Bay, other means are available to derive population estimates. Estimates of mud crab abundance in Albatross Bay and the entire Queensland Gulf of Carpentaria are presented in Table 7.

Table 7 Estimates of total biomass (tonnes) of mud crab based on habitat aliases and commercial logbook catch rates.

	Method 1 (mangrove only)			Method 2 (mangrove plus river)		
	Weipa	Port Musgrave	All Gulf Totals	Weipa	Port Musgrave	All Gulf Totals
Area of mangrove (km^2)	164.4	128.65	556.67	164.4	128.65	556.67
Area of river (km^2)				37.13	28.75	269.5
Combined areas (km^2)				201.53	157.4	826.17
Average annual catch (t)	13.02	9.54	42.43	13.02	9.54	42.43
Average number of pots/yr	15709.8	13117.8	69070.2	15709.83	13117.8	69070.22
Lifts per day (estimated)	1	1	1	1	1	1
1) Area of pot drawing effect (km^2)	0.0079	0.0079	0.0079	0.0079	0.0079	0.0079
2) Number of pot areas	20932	16381	70877	25659	20041	105191
3) Potential number of crabs (t)	17.4	11.9	43.5	21.3	14.6	64.6

Estimates of potential mud crab catch for Weipa, Port Musgrave (just to the north of Weipa), and for the entire Queensland Gulf of Carpentaria (Map 2) and the average yearly catch for each area are presented in Table 7. To smooth inter-annual variation, the average annual catch is used rather than the 1997 catch. All estimates use habitat as an alias of crab abundance, which has the inherent problem of correctly defining mud crab habitat. Two measures are presented; the area of mangroves (Method 1), and the combined area of mangroves plus in-stream habitat (Method 2). These measures may be conservative because local crabbers emphasise the importance of open flats as areas where mud-crabs are routinely caught and this habitat type is under-represented in the estimates.

Estimates of the legal-size male mud crab biomass for the Weipa region ranged from 17.4 tonnes to 21.3 tonnes, while the yearly commercial catch from 1989 to 1997 was about 13 tonnes (Table 7). This would indicate that the Weipa commercial catch is within long-term sustainable limits. However, the commercial catch must be added to the unknown recreational catch, which may take the total exploitation level closer to the yearly 'legal-size male' biomass. The situation may be approaching that of the Northern Territory where the majority of a year's legal-size crabs are caught in that year.

Conclusion

Density estimates for the three sites in Albatross Bay, even if they had been successful, would have been confounded by apparently abnormally low numbers of crabs in the 1998 season. Anecdotal sources and commercial catch statistics indicate that the abundance of crabs is much less this year than in previous years, due possibly to climatic variation. Therefore, 1998 density estimates may not have been representative. The low tag recapture rates within all three streams studied are consistent and suggestive of a high migration of mud crabs through these study sites.

Estimating the mud crab abundance in Albatross Bay, independent of the commercial fishery data, is not possible at this time as the number of tagged crab recaptures is currently too low. Returns from commercial and recreational crabbers subsequent to the depletion experiment, recorded in voluntary logbooks and the AUSTAG information, may allow a future estimate to be made. The 'mud-crab habitat' method for estimating the potential legal mud crab biomass, which is dependent on commercial fishery data, indicates that the Weipa commercial catch is within long-term sustainable limits. However, the commercial catch must be added to the unknown recreational catch, which may take the total exploitation level closer to the yearly legal-size male biomass. The situation may be approaching that of the Northern Territory where the majority of a year's legal-size crabs are caught within the same year and are therefore 'fully exploited'.

Overall, using volunteers to conduct the tagging experiment was very successful. Not only were the volunteers familiar with the area and local conditions but they also ensured the successful cooperation of the Weipa community in the tagging program. The involvement of the Weipa Catchment Group also assisted the project in gaining community support and awareness of the program. Community awareness was, and remains, critical for the successful return of tagged crab recapture information.

It is hoped that due to the success of the logistics and operations during the intensive survey, that the surveys could be repeated at a later date to obtain estimates of mud crab abundance based on fishery-independent data. A modified sampling technique, including guard bands, an extended survey period and possibly an increase in length of stream assessed could be trialed in future surveys.

Although the results from the abundance estimation study are not as expected due to an unusual sampling season; information on the sites surveyed, crab catches, sex ratio and size frequency are still useful for management plans. Catch and effort, movement and growth information still being obtained from other sections of this study, will provide more detailed information on the Weipa mud crab fishery. That information, in combination with information from this survey, will assist in determining mud crab abundance and behaviour in Albatross Bay.

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