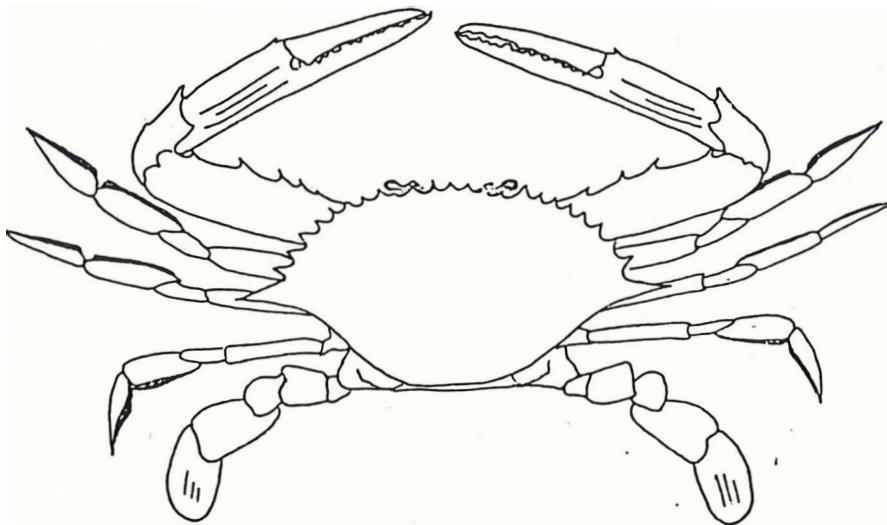


**A STUDY OF THE SAND CRAB  
(Portunus pelagicus) AND ITS  
EXPLOITATION IN A  
SUBTROPICAL MULTISECTOR  
FISHERY.**

**FIRTA PROJECT 84/23  
FINAL REPORT**



**M.A.POTTER & W.D.SUMPTON**

**QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES**

**SEPTEMBER 1986**

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## SUMMARY

Based on logbook records the sand crab commercial pot fishery in Moreton Bay is worth in the vicinity of \$2 million wholesale annually. Sand crabs are also taken as an incidental by-catch by otter trawlers and in addition Moreton Bay supports a substantial recreational fishery.

Sand crabs are caught throughout the year but fishing effort is greatest from October to June. Peak catches in the pot fishery occur during March and April when daily catch rates may exceed 3 legal males per pot. Gravid females are present throughout the year but the highest proportion of egg bearing females is found in the population during August and September. Peaks in mating activity occur in autumn and spring with recruitment of juvenile crabs commencing in November. The parasitic barnacle Sacculina granifera infects 3% of all sand crabs in Moreton Bay and a previously unreported microsporidian parasite is found in 0.7% of the population.

Tagging studies show that fishing effort and mortality of sand crabs is highly variable throughout the Bay. Recapture rates for different areas vary from 1% to 65% with an overall return rate of 14%. The pattern of tag returns does not indicate any ordered directional movement of crabs either into or out of the Bay.

Male and female sand crabs exhibit differences in preferred habitat. Large males are generally more abundant in deeper water, whereas females predominate in shallower water, particularly on the top of sand banks.

Management recommendations arising from the project work include a change in the method of sand crab measurement to the width at the base of the antero-lateral spines, lowering of the existing size limit, the

introduction of a bag limit for recreational fishermen and an abolition of the prohibition on taking females provided that suitable management conditions can be maintained.

## INTRODUCTION

The sand crab (Portunus pelagicus) also known as the blue crab, blue swimmer or blue manna crab is an important edible crab throughout the Indo/West Pacific region. FAO fishery statistics estimate that over 27 000 tonnes of Portunus spp. (mainly P. pelagicus) were caught in this region in 1983. Australian production was not included in these figures, but sand crabs are caught by commercial fishermen in Queensland, New South Wales, Western Australia and South Australia. Using available production figures (V. McDonall, pers. comm.; Anon. 1985; H. Norris, pers. comm.) and an estimate of the Queensland catch based on logbook records, the Australian commercial catch appears to be a minimum of 900 tonnes approximately half of which comes from Queensland.

In Queensland the major fisheries for sand crabs are in Moreton Bay and Hervey Bay (Williams, 1980). In these areas they are taken by commercial pot fishermen, by trawlers (as a by-catch of prawn trawling operations) and are actively sought by recreational fishermen using dillies.

Regulations controlling the fishery in Queensland include a limitation on the number of pots (50) which may be used by commercial fishermen; a limitation on the number of pots or dillies (4) which may be used by each recreational fishermen; a size limit for male sand crabs of 150mm carapace width and a total prohibition on the taking of females.

In 1983, concern was expressed by some members of the Queensland Commercial Fishermen's Organization (QCFO) that catches and earnings of commercial pot fishermen were declining. These concerns were supported in an economic survey conducted by Pashen and Quinn (1984). To improve fishermen's earnings it was proposed by the crab fishermen's delegate to the Moreton

Bay Advisory Committee that (i) the legal size for male sand crabs be reduced and (ii) that the prohibition on the taking of female crabs be removed.

There were no reliable fisheries statistics available on catches and effort which could be used to examine trends within the fishery. Apart from Thomson's (1951) paper there was no published information on the fishery in Queensland - although papers have been published on aspects of sand crab populations especially the rhizocephalan parasite Sacculina (Bishop & Cannon, 1979; Phillips & Cannon, 1978).

The lack of catch records and published information on the biology of local populations made it difficult to predict the effects on the fishery of these proposed changes to the regulations. Comparison with other portunid crab fisheries both in Australia and overseas suggested that the Queensland regulations were conservative. Size limits in other Australian fisheries are smaller and the taking of females is not prohibited. In the largest fishery in the world for portunid crabs, the US fishery for the Atlantic blue crab Callinectes sapidus, size limits vary according to the moult condition of the crab and retention of berried females is generally prohibited. Although the Queensland regulations thus appear to be conservative, the possibility remained that the suggested changes would have detrimental effects on the resource. It was therefore considered that the most responsible action was to investigate the fishery and biology of the sand crab relevant to fisheries. With information on the status of the fishery and the resource, the management of the fishery could be reviewed and appropriate changes to the regulations recommended.

#### **Research Objectives**

An application was made to the Commonwealth Fishing Industry Research Trust

Account for funds to support a two year study of the fishery with the following objectives:

- i) to compare and contrast the life history parameters of the sand crab in subtropical southern Queensland with those of stocks in the tropical Gulf of Carpentaria, and with published information on Australian temperate water stocks;
- ii) to assess the status of the Moreton Bay sand crab stocks;
- iii) to assess the relative impact of the recreational fishery, the otter trawl fishery and the commercial pot fishery on the resource; and
- iv) to evaluate the effectiveness of existing management strategies and the likely effect of alternate management options.

This application was successful and work commenced in July 1984.

#### **Methods**

To achieve these objectives several approaches were used. Samples of sand crabs previously collected in the Gulf of Carpentaria by the FRV "Gwendoline May" as by-catch in a prawn research programme were measured for morphometric analysis.

To describe the commercial pot fishery a logbook programme was instituted. Combined with sampling of pot fishermen's catches for the past two seasons, these two programmes have provided a valuable short term picture of the pot fishery - where and when the fishery operates, what catches are taken and the effort required to take those catches.

No detailed logbook programme was instituted for the trawl fishery where sand crabs are primarily a by-catch product. Fisheries Management Branch of the Queensland Department of Primary Industries introduced a limited trawl logbook programme at about this time, but there was considerable reluctance on the part of the trawl fishermen to record their sand crab

catches. This attitude resulted from the interpretation of the Queensland Fisheries Regulations, which considered that trawlers were not legally entitled to take sand crabs. Not surprisingly, many fishermen thought that recording their sand crab catches in Government logbooks was an unwise action in this situation. Several trawl fishermen returned logbooks rather than complete them.

As logbook data on trawl catches was difficult to obtain the 13m FRV "Bar-  
ea-mul" undertook a commercial trawl sampling programme to provide some data on trawl catch rates. Gear used was twin 4 fathom "Yankee Doodle" otter prawn trawls as commonly used by Moreton Bay otter trawlers. A separate trawl sampling programme designed to sample sand crabs in various habitats throughout Moreton Bay (Fig. 1) and in nearby inshore ocean waters was also conducted. This was done to provide data on seasonal patterns of abundance, distribution and reproduction.

An intensive two phase tagging programme was also undertaken. The aims of this programme were to investigate the spatial pattern of returns from the recreational and commercial fisheries to gain a clearer picture of the usage of areas, particularly by recreational fishermen; to compare the relative levels of returns by commercial pot fishermen, trawler operators and recreational fishermen; to assess the level of fishing mortality in different areas; and to analyse movement patterns of sand crabs in the Moreton Bay population. Following the reported success of a tag lottery run in conjunction with prawn tagging studies in South Australia, a tag lottery was organised for the second phase of the tagging programme. As Queensland Art Union regulations precluded the offering of cash as a prize in a lottery, gold bullion was substituted. Three prizes were offered - \$3 000, \$2 000 and \$1 000 in gold bullion for 1st, 2nd and 3rd respectively - a total of \$6 000 which was the amount originally set aside for paying



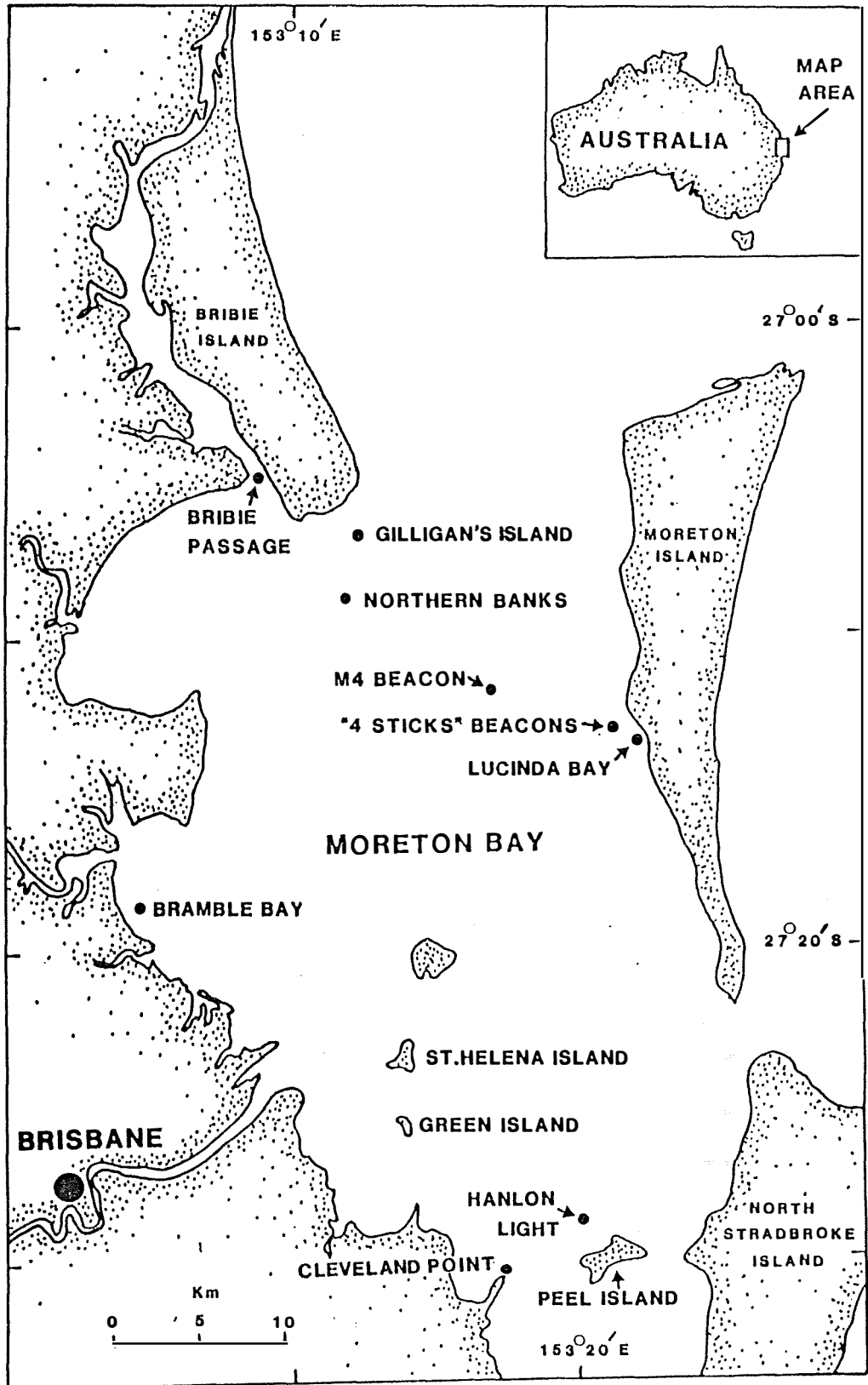


Figure 1. Map of Moreton Bay showing locations mentioned in the text.

tag rewards.

During the course of the study evidence arose which suggested that male and female crabs may have differences in preferred habitat. Because this possibility was seen as having important management implications an additional segment was added to the study to investigate seasonal differences in depth distribution of male and female crabs.

The combination of these approaches was seen as providing a vastly improved information base by which the existing regulations in the fishery could be reviewed.

## **Results and Discussion**

### **Logbook Information**

Logbooks were voluntarily filled in by 23 of the known 50 full time commercial pot fishermen. The information they provided has been used in several analyses.

The pot fishing season in Moreton Bay generally commences in October and continues through to June. In 1985 the mean daily catch per pot at the peak of the season in March was 2.9 legal males per pot (Fig. 2). By contrast in 1986 the season did not reach a peak until April and the mean daily catch rate at the peak was less - only around 2.3 crabs per pot. Catch rates also varied between areas - areas 1 and 5 having the highest catch rates in the fishery (Fig. 3). The number of soft or mutilated reject crabs was highest in October each year with a secondary peak around the peak of the fishing season (Fig. 4). As the number of reject crabs is strongly correlated with moulting activity this suggests that the pot fishing season commences with the moulting activity in October when

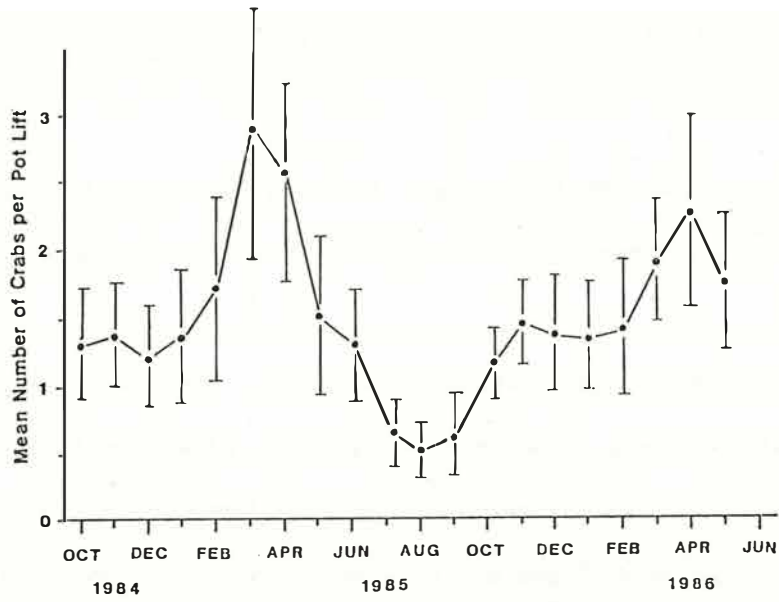


FIGURE 2. Mean numbers (and sd) of male sand crabs (> 150mm cw) caught per pot lift in Moreton Bay.

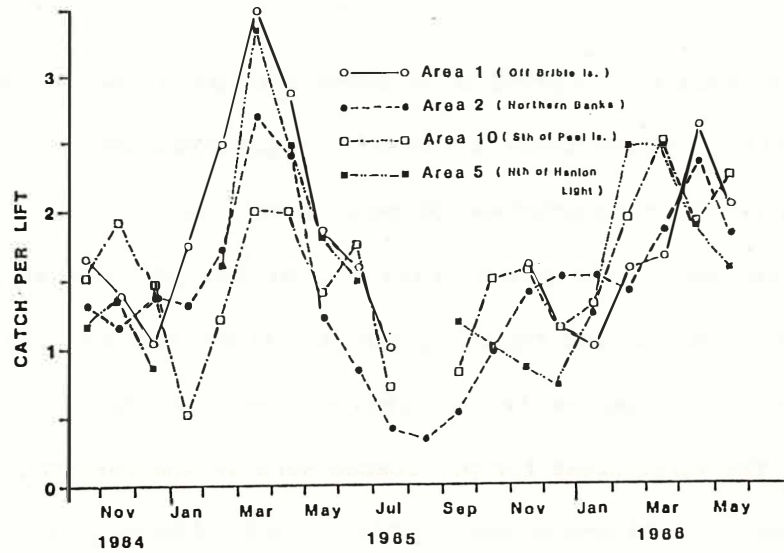


FIGURE 3. Mean numbers of male sand crabs (> 150mm cw) caught per pot lift in four areas of Moreton Bay.

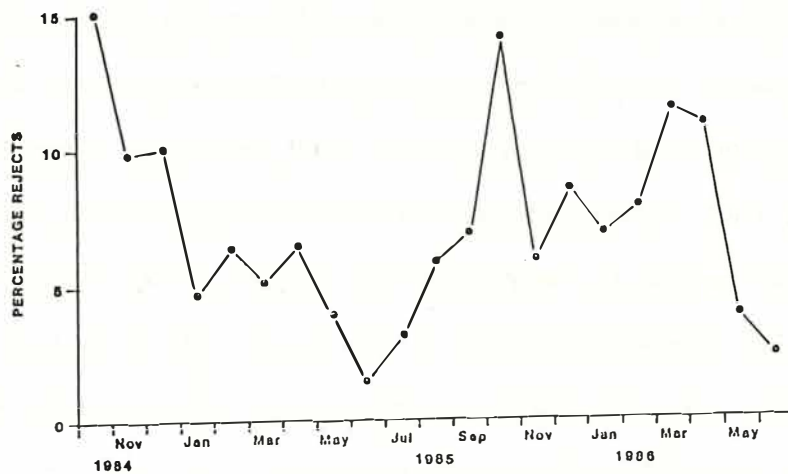


FIGURE 4. Percentage of male sand crabs (> 150mm cw) rejected from commercial pot catches in Moreton Bay.

undersize crabs moult to legal size. Peak seasonal catch rates may be caused by a further flurry of moulting activity at that time.

In addition to information on catches, the logbooks also provided information on pot fishermen's activities. Fishermen lost an average of 5 days per month due to bad weather with the worst loss in the two year period of 10 days in one month recorded in March 1985 - coincidentally at the peak of the season. Those fishermen who continued to work in the off-season worked less - only around 12-15 days per month compared with around 19-22 days per month during the season (Fig. 5).

Pot losses are also a problem for commercial pot fishermen, and are a cause of conflict between trawl fishermen and pot fishermen in some areas. The highest pot loss recorded was 38 pots in one night. This loss was known to have been caused by prawn trawlers, as the particular pot fisherman concerned did not heed the direction of a trawl fisherman to move his pots from that area. On another occasion another fisherman lost 27 pots in one night. The worst areas for pot losses were in the eastern part of Moreton Bay around the M4 beacon and the "four sticks" beacons. The average number of pots lost by a fisherman during the season was 84 pots.

#### **Commercial Pot Sampling**

Seven pot fishermen participated in this section of the study. From the beginning of the 1984/85 season until June 1986 these fishermen were accompanied by a research officer once a month on their fishing trips. Data on their catches and environmental conditions were recorded and the non-legal portion of their catch was returned to the laboratory for further analysis. The minimum size of crabs that were normally taken in the commercial pots sampled was approximately 120mm carapace width. A few smaller crabs were taken on some occasions.

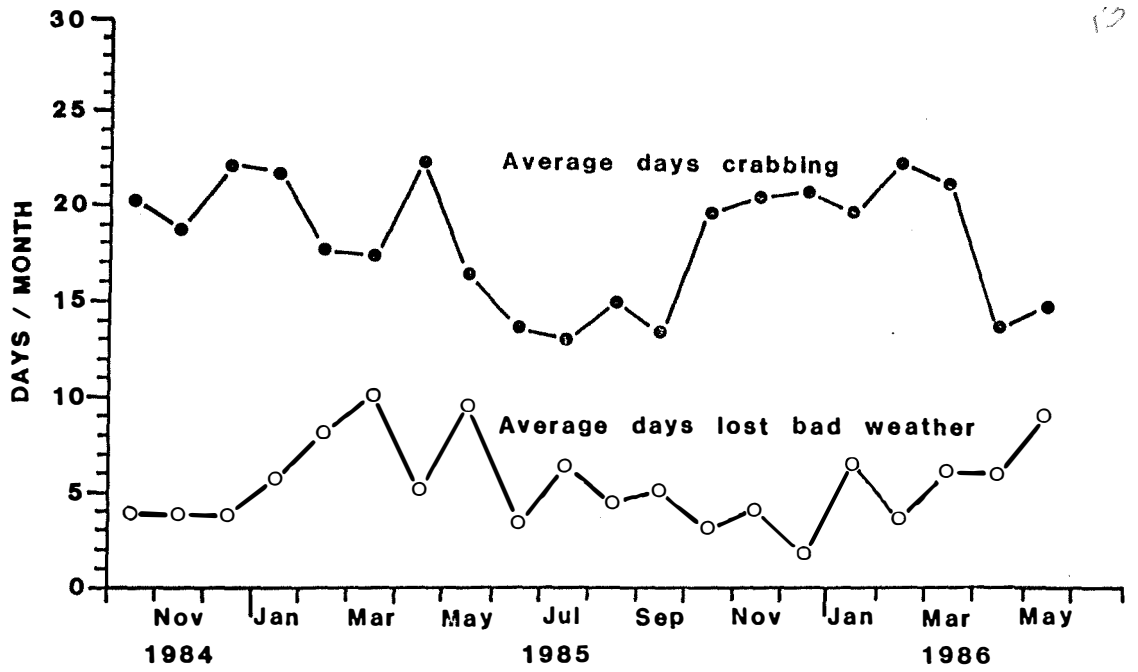


FIGURE 5. Mean days fished and mean days lost per month by Moreton Bay pot crabbers.

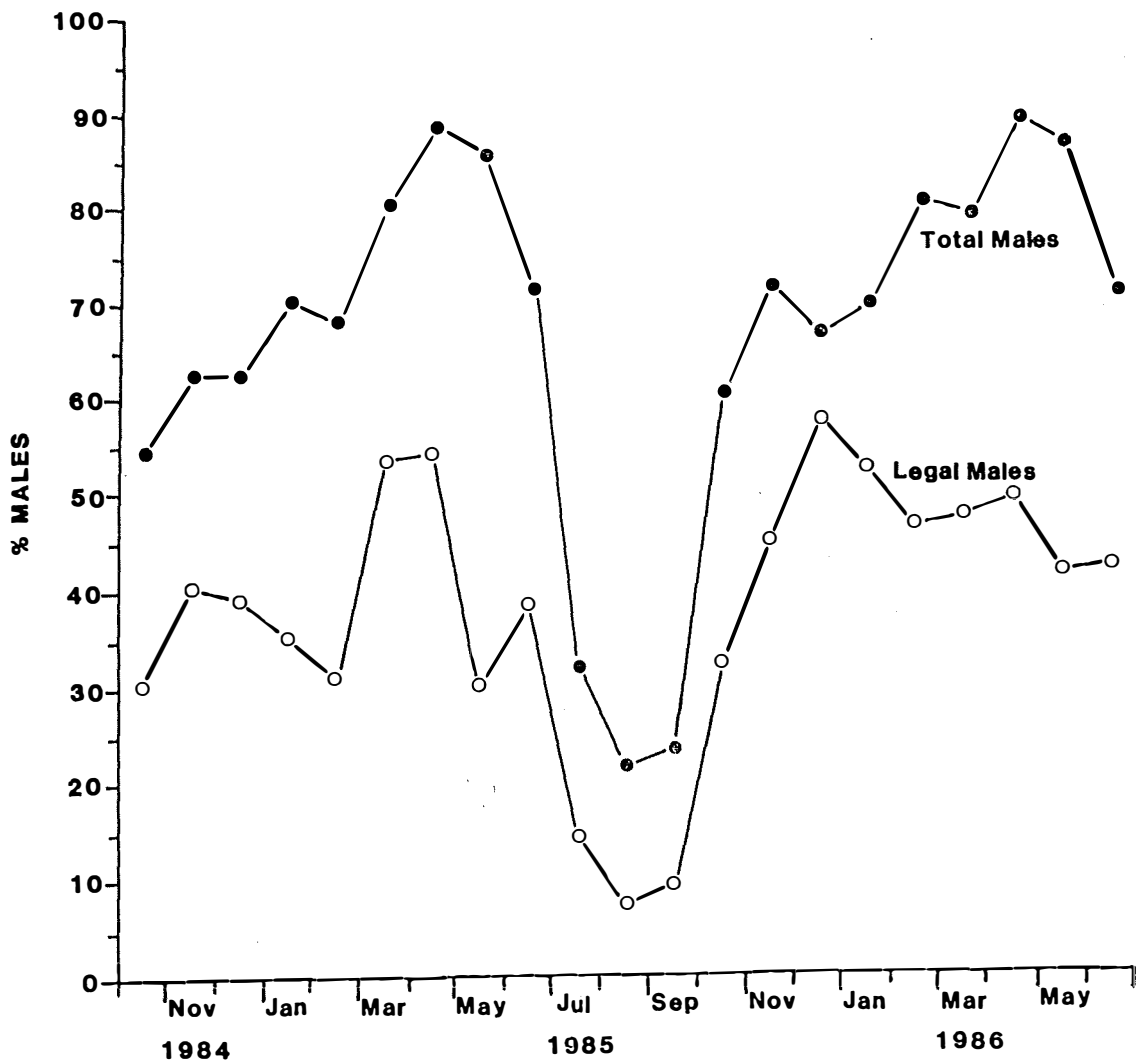


FIGURE 6. Percentage total and legal male sand crabs in commercial pot catches.

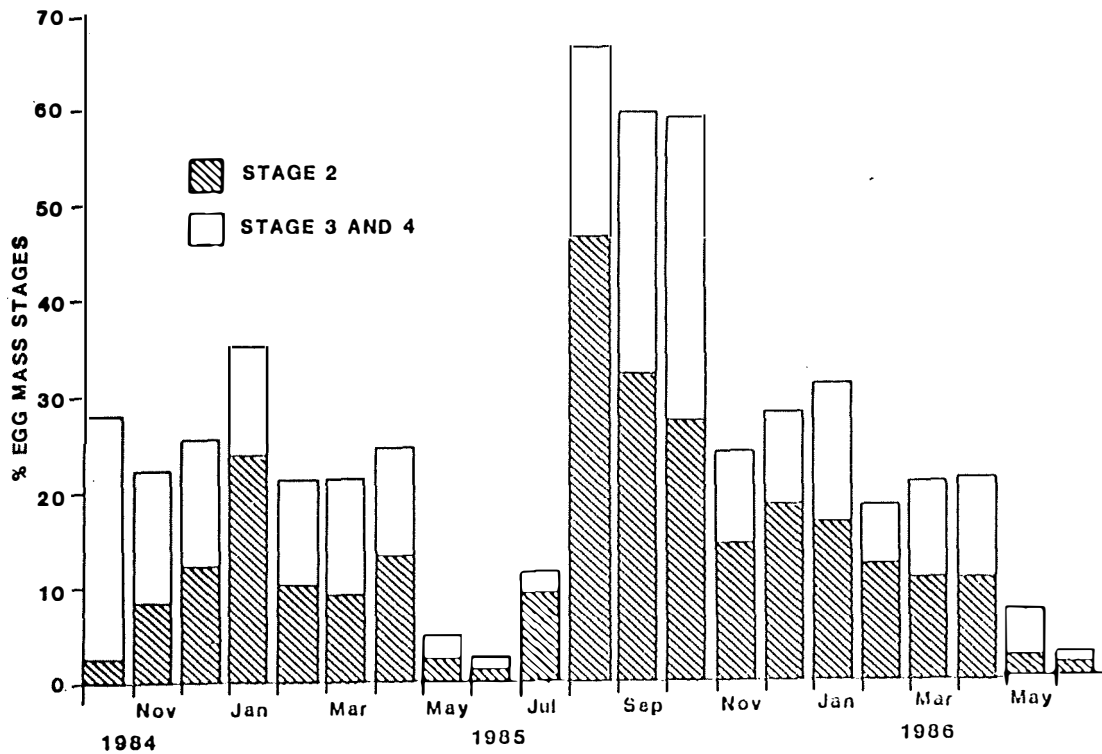


FIGURE 7. Percentage female sand crabs in gravid condition (data from commercial pot catches).

TABLE 1. Seasonal numbers of male sand crabs in three size categories caught by pot fishermen in Moreton Bay.

Size	1984/85 Season		1985/86 Season	
	Oct-Jan	Feb-Jun	Oct-Jan	Feb-Jun
Sub-legal (<150mm cw)	304	678	370	1089
Seconds (150-160mm cw)	236	416	229	533
Firsts (>160mm cw)	191	326	142	250
	731	1420	741	1872

The proportion of male crabs taken in pots increased from 55-60% at the beginning of the season to 90% at the peak of the season and declined sharply at the end of the season to less than 35% during the off-season (Fig. 6).

A strong cohort of sub-legal males was evident in catches sampled late in the 1986 season. Catches of these crabs were approximately 60% higher than for the same period the previous season (Table 1).

Female crabs carrying egg masses were found throughout the sampling period in commercial pot catches. The highest proportions of mature females carrying eggs occurred in August and September (Fig. 7). All soft (recently moulted) mature female crabs examined carried sperm plugs indicating that they had been inseminated.

#### **Trawl Sampling**

Mature male sand crabs predominated over mature females in trawl samples (Fig. 8). Juvenile crabs commenced recruitment to the fishery from shallow bay areas in November 1984 and peaked in February 1985. Recruitment was negligible in April and May (Fig. 9). In the 1985/86 season recruitment started a month later but again peaked in February.

The general pattern of occurrence of soft male crabs in trawl catches compared well with the pattern in pot catches apart from a discrepancy in the first sampling month (Fig. 10). Female crabs tended to have peaks in the occurrence of soft crabs at different times. Particularly in 1985/86 catches, it was evident that soft male crabs were rare when soft females were most abundant. As soft female crabs require hard intermoult males for effective mating, this observation is not surprising. Gonad development in male crabs reflected this observation (Fig. 11).

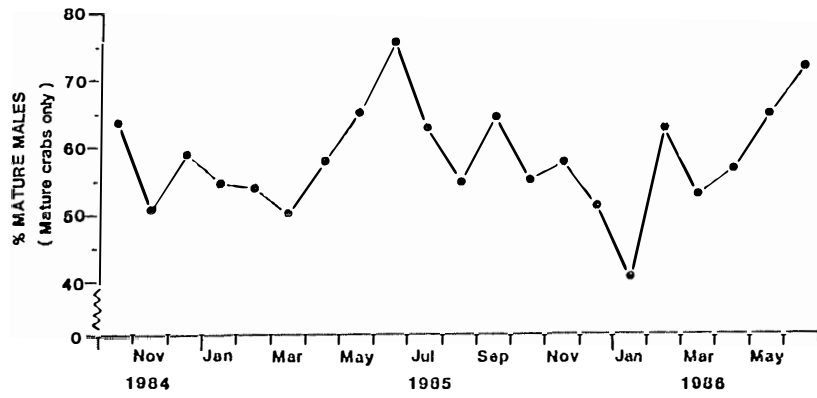


FIGURE 8. Sex ratio of mature sand crabs in otter trawl samples taken by FRV "Bar-*ea*-mul" in Moreton Bay.

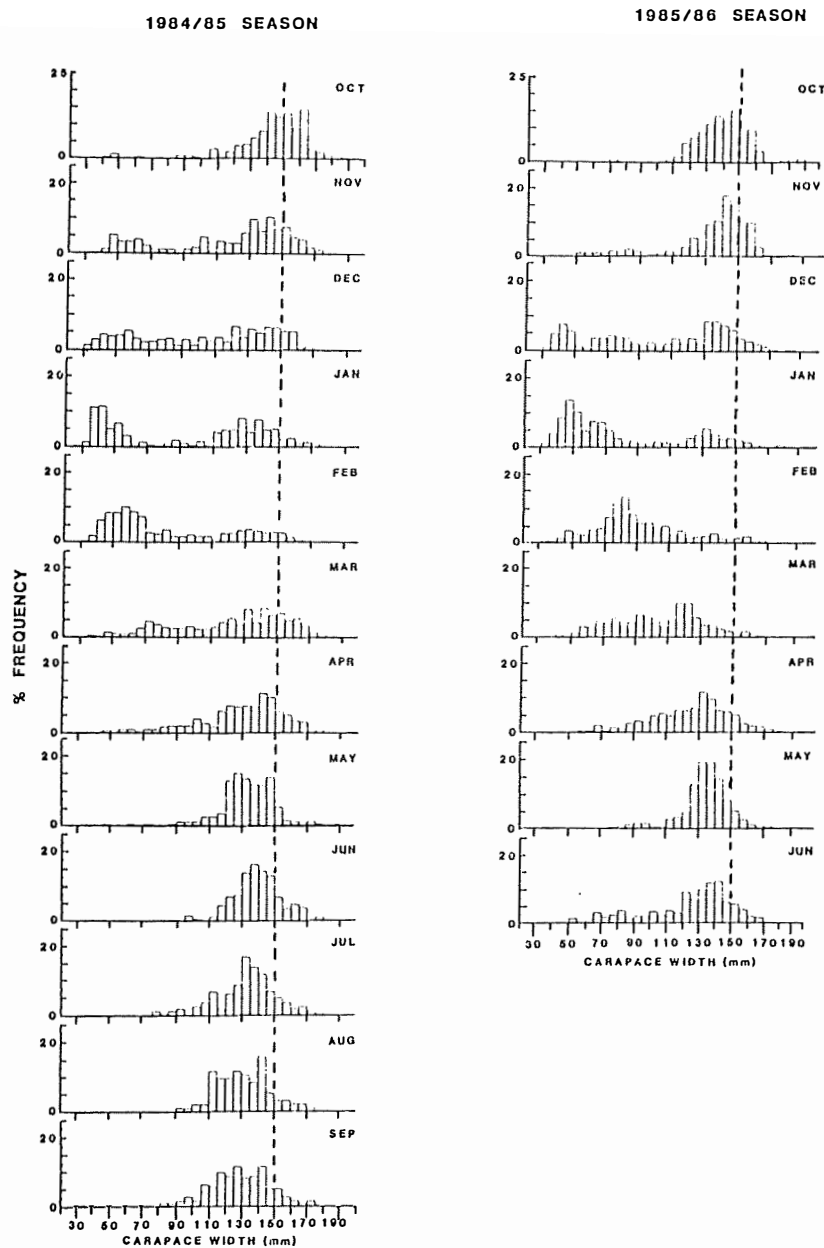


FIGURE 9. Length frequency distributions of male sand crabs in otter trawl catches taken by FRV "Bar-*ea*-mul" in Moreton Bay.



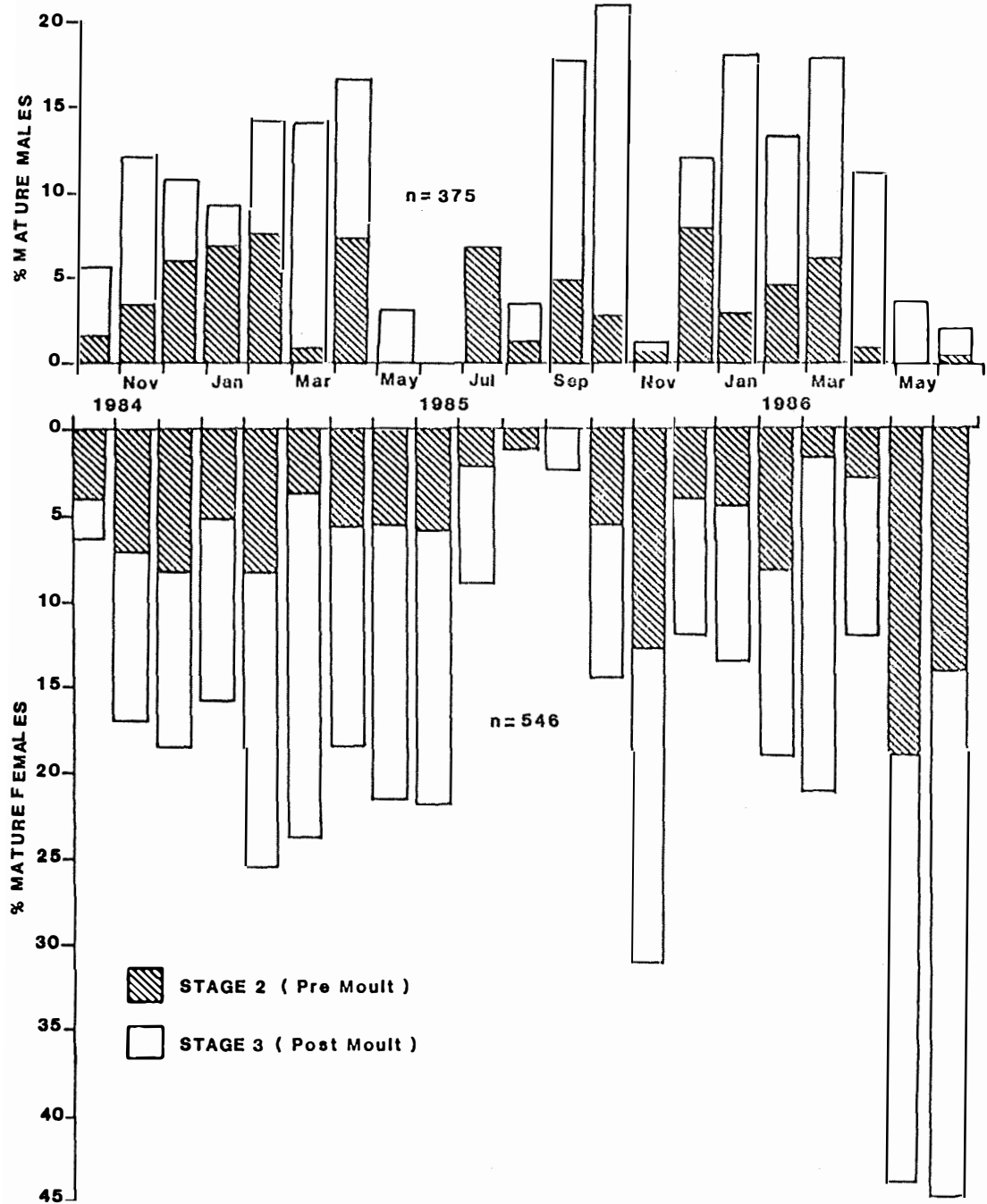


FIGURE 10. Percentage male and female mature sand crabs in pre- and post-moult condition.

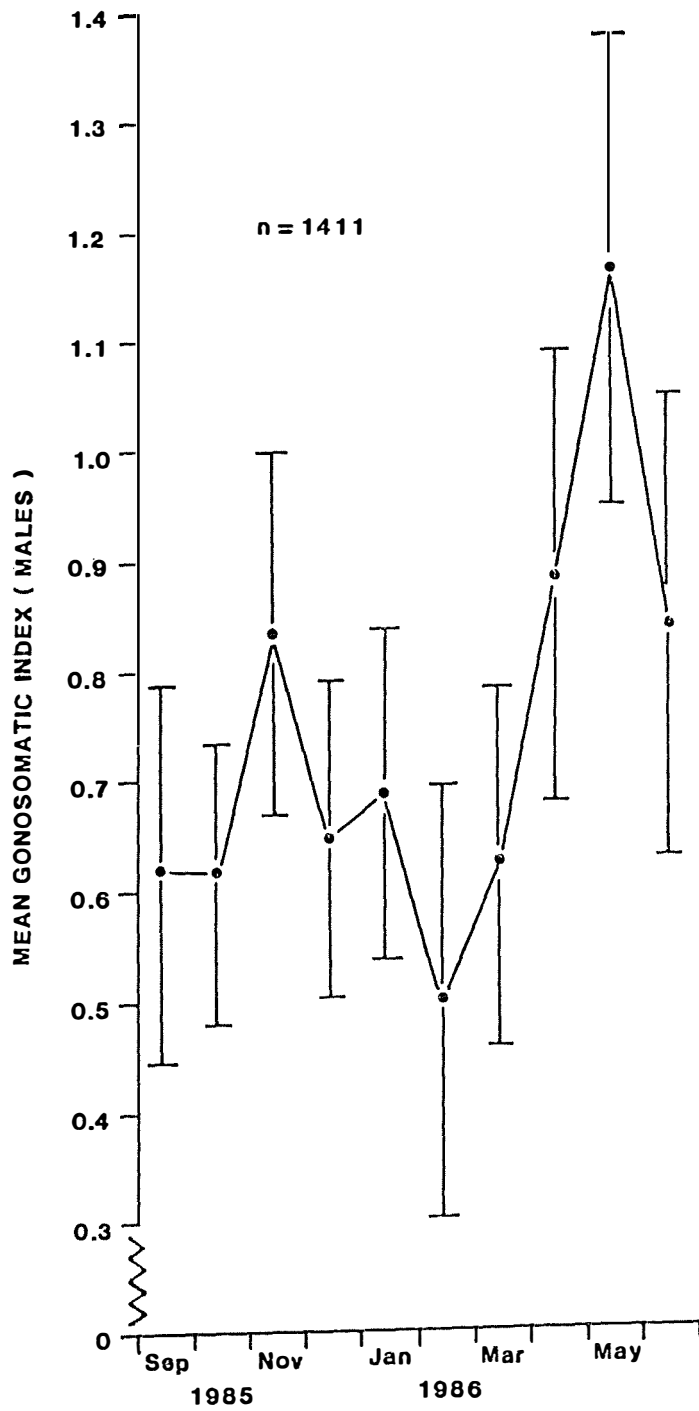


FIGURE 11. Seasonal change in reproductive condition of mature male sand crabs (mean GSI and sd).

Egg production by females taken in trawl samples reflected the pattern of those taken in commercial pot catches, with a peak in August/September (Fig. 12).

In samples from the Gulf of Carpentaria the highest proportions of gravid (egg bearing) females were taken between July and October. Gulf females matured at a slightly smaller size (68mm carapace width) compared with 82mm cw in Moreton Bay. By comparison, in temperate water stocks, Smith (1982) reported that in South Australia the highest incidence of females in berry occurred in November. In Western Australia, Potter et al (1983) reported that the major egg-bearing period was much later, ie, January and February, in an estuarine situation, although Penn (1977) found that it occurred in early summer in the more oceanic influenced waters of Cockburn Sound.

Comparisons between Moreton Bay and Gulf of Carpentaria samples were complicated by the unrepresentative nature of Gulf samples. The latter were collected in conjunction with a prawn sampling programme and crabs from those areas sampled may not have been indicative of the entire population.

The parasitic barnacle Sacculina granifera was externally visible in about 3% of all sand crabs in Moreton Bay and 9.5% of mature crabs. The relative abundance of infected crabs showed a seasonal pattern with infected crabs more abundant during the warmer months (Fig. 13). Parasitism was higher in southern Moreton Bay where infection rates in some months reached 17% for male crabs and 50% for female crabs. In comparison, Thomson (1951) found S. granifera infection rates varied with locality from 4% to 29%, although no overall incidence was reported.

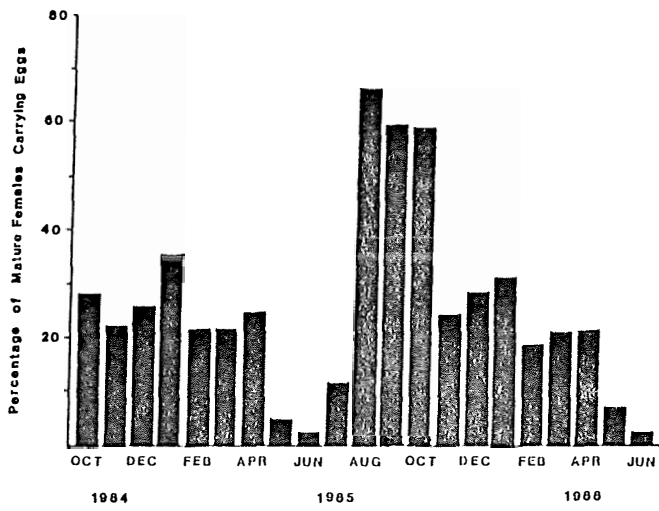


FIGURE 12. Percentage female sand crabs in gravid condition (data from other trawl samples).

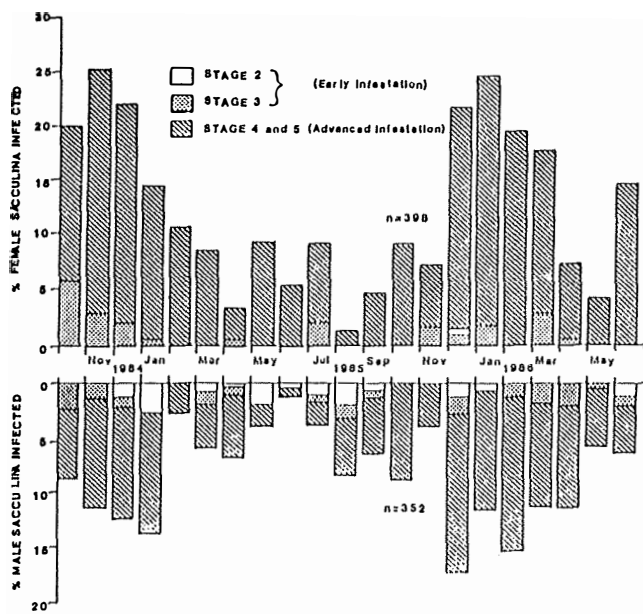


FIGURE 13. Incidence of *Sacculina granifera* infestation in male and female sand crabs taken in otter trawl samples.

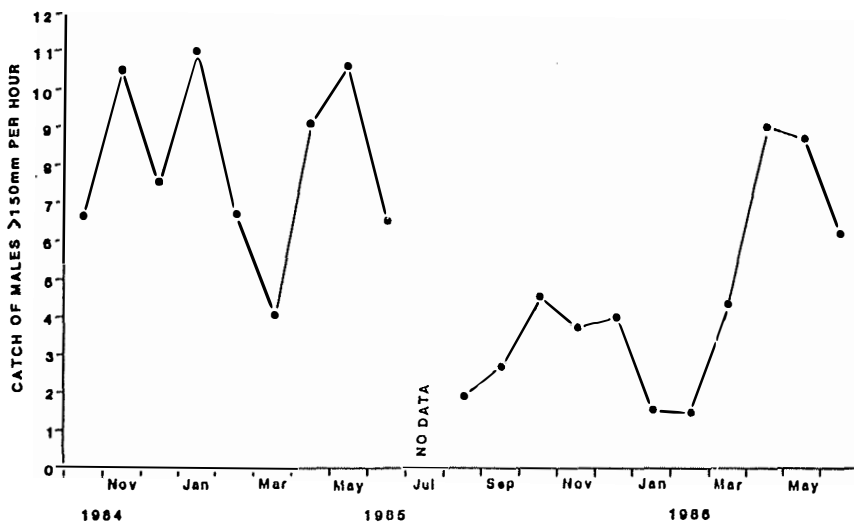


FIGURE 14. Monthly mean catch rate of legal male sand crabs trawled by FRV "Bar-ee-mul" in commercial samples.

A previously unreported microsporidian parasite was also found in a number of crabs. This parasite turned the muscle blocks from their normal translucent appearance to opaque white. The blood of many infected crabs was also milky. This parasite affected 0.91% of all males examined and 0.52% of all female crabs.

#### **Commercial Trawling Trials**

FRV "Bar-ea-mul" undertook two days trawling per month attempting to maximise its catch of legal size male sand crabs. This provided some data on trawl catch rates. Catch rates proved to be highly variable (Fig. 14). This may have been partly caused by the methodology used in that the skipper did not trawl daily on a commercial basis, and was therefore not personally familiar with catch trends in different areas. To minimise this effect, good communications were maintained with several commercial prawn trawlers to identify best catching areas. The results indicate that trawl catches are quite variable during the year and target trawling for legal size male sand crabs on a commercial basis would not generally be a viable proposition unless much more effective gear than that on FRV "Bar-ea-mul" was used.

#### **Tagging Studies**

Field tagging experiments using Floy anchor tags were conducted in two phases. The first phase involved pilot field experiments in March, April and May 1985, in which both male and female sand crabs from 120mm carapace width up were tagged. These trials indicated that return rates for female sand crabs were extraordinarily low and therefore there was little point in tagging females. The low return rates were believed to be due both to a reluctance by all fishermen to return tagged females, and the fact that they are rarely scrutinised by commercial fishermen before returning them to the water. A number of recreational fishermen reported recapturing

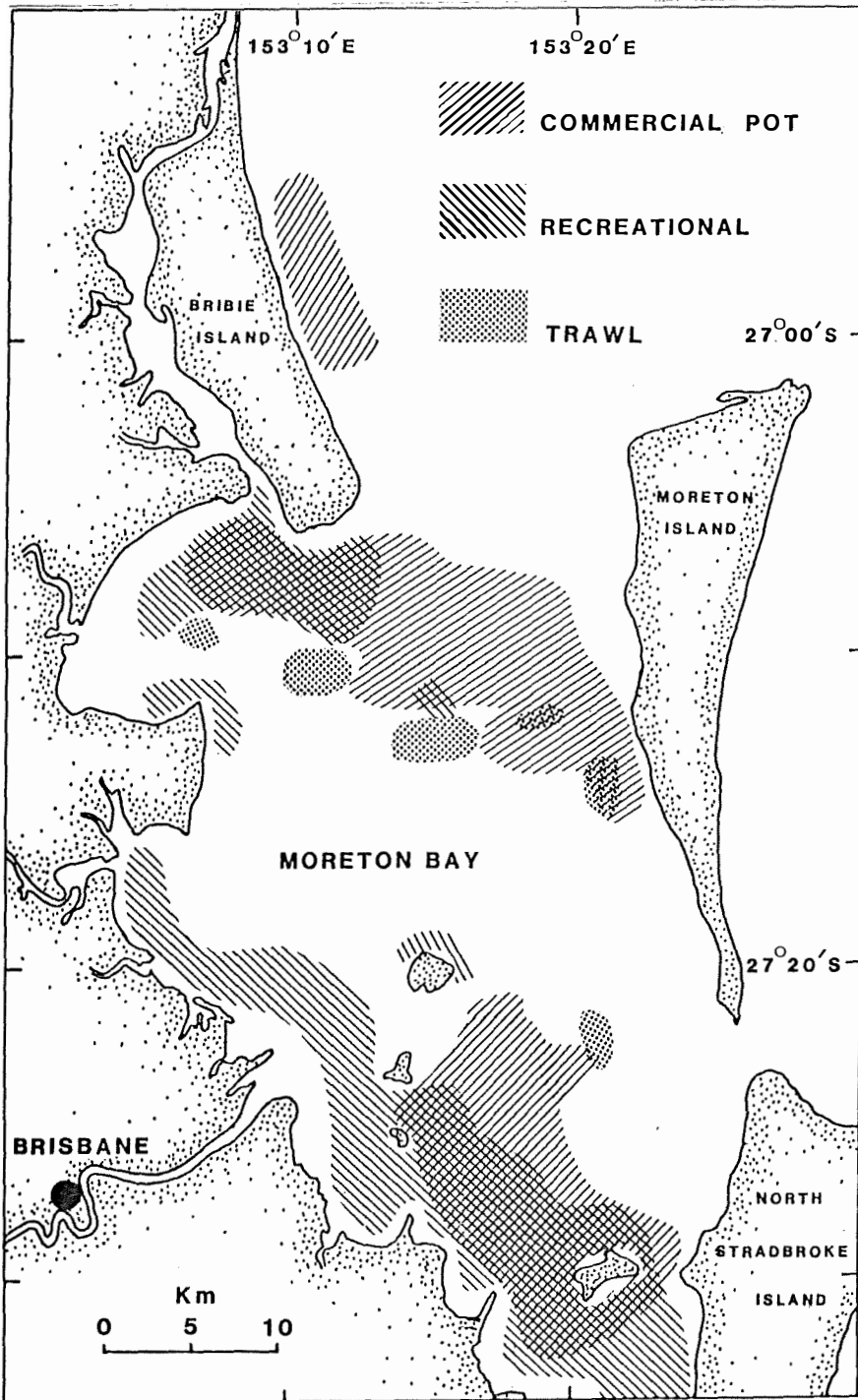


FIGURE 15. Areas from which tag returns were received from pot, trawl and recreational fishermen.

tagged females, but returned them to the water rather than keeping them. Return rates were also low for small males - possibly also a result of poor examination as they were obviously well below legal size.

Early laboratory experiments to examine the effects of the tag on crabs showed negligible mortality due to the tag. Later experiments however, showed an appreciable tag mortality possibly due to bacterial infection around the tag wound.

The second phase of tagging experiments commenced in October 1985. Following the results of the earlier tagging trials, only male sand crabs of approximately 140mm carapace width up were tagged.

Seven thousand seven hundred crabs were tagged and released throughout Moreton Bay. Generally returns by recreational fishermen came from the southern, western and northwestern inshore areas of the Bay while commercial pot fishermen also returned tagged crabs recaptured in more exposed offshore waters (Fig. 15).

Overall, commercial pot fishermen returned 70% of all recaptures, trawl fishermen returned 12% and recreational fishermen 18% for a total of 1 046 returns. As far as can be determined, the number of tags returned by pot fishermen represented virtually all tags recaptured by pot fishermen. The number of returns from trawl and recreational fishermen may be less than the numbers actually recaptured by those groups. Historically some trawl fishermen are reluctant to return tags in case this information is used against them. This may have depressed returns by trawl fishermen. Several recreational fishermen mentioned difficulty in contacting the research team to report recaptures despite widespread publicity in both the electronic and printed media. Others reported recapturing tagged crabs that were

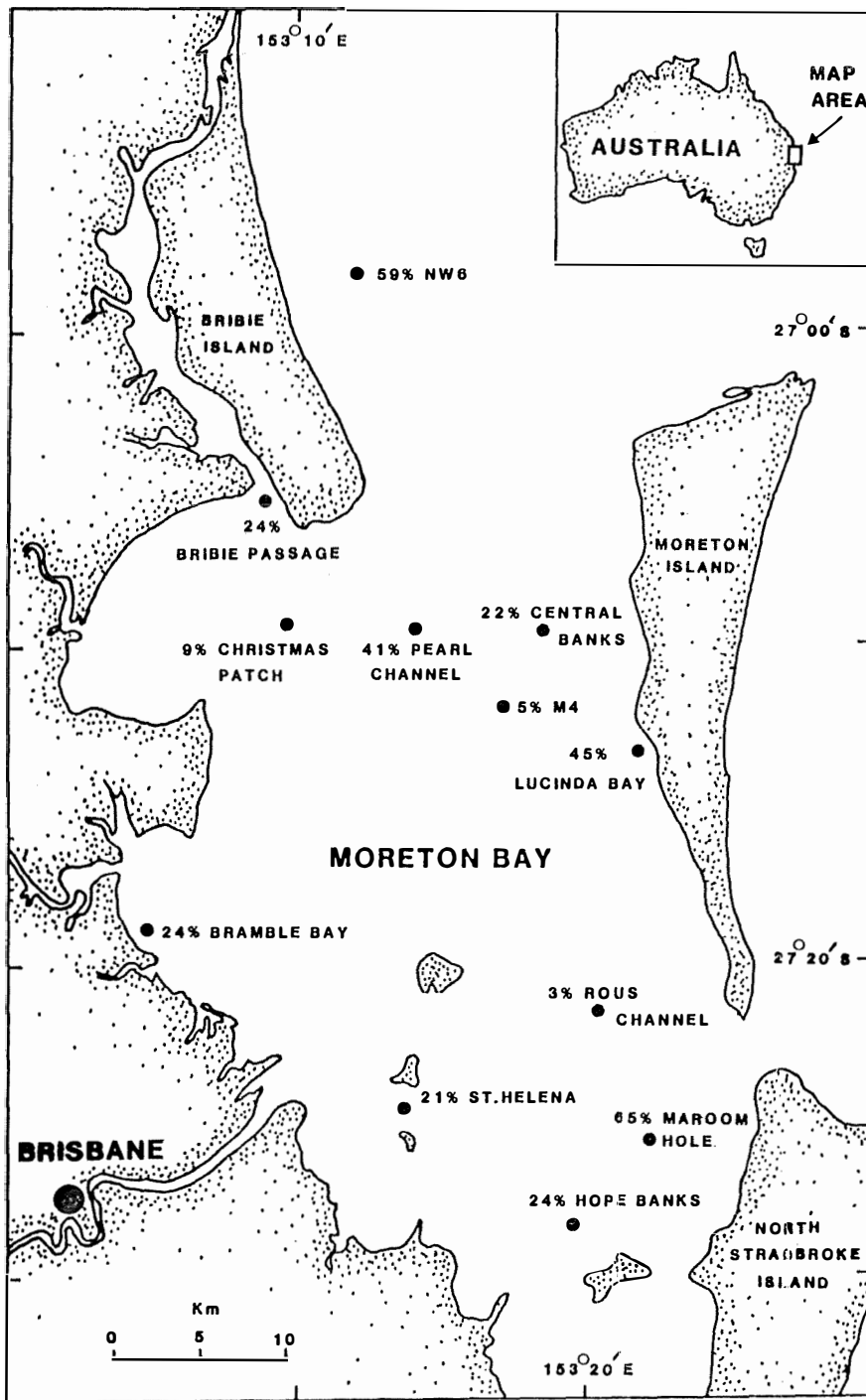


FIGURE 16. Percentage tagged sand crab recaptures in selected areas of Moreton Bay.



smaller than the legal size which they subsequently returned to the water. For both these reasons it seems likely that the number of returns by recreational fishermen understates the actual number of recaptures made by this group.

The overall return rate for crabs tagged in the second series of experiments was 14%. However return rates from different areas varied tremendously from around 1% to 65%. Return rates for a number of experiments are given in Fig. 16. Highest returns came from areas primarily fished by commercial pot fishermen, while low returns generally came from areas fished by trawlers. Some areas favoured by recreational fishermen, eg, Bribie Passage, Bramble Bay and St Helena/Green Island also had quite high return rates. Of the many recreational fishermen who returned tags, 116 were also interviewed and their total catch of "keeper" sand crabs taken on the day of capture of the tagged crab was noted (mean 19.1 crabs/day). Mean daily catches for Bribie Passage, Bramble Bay and St Helena/Green Island areas were 13, 16 and 23 crabs respectively.

The tag return data indicated that commercial pot fishermen in some areas caught a surprisingly high proportion of the liberated male tagged crabs. However logbook records of male crab catches in those areas remained relatively stable. This indicated that crabs removed by fishing were being replaced by new recruits moving in from less heavily fished areas. Because tag mortality was high (up to 50% in five weeks from tank experiments) and variable, no estimation could be made of fishing mortality and stock size. However the high tag return rates (up to 65%) for some commercially fished pot areas indicates heavy fishing pressure in parts of Moreton Bay.

Of 1 086 tagged male sand crabs returned, only 20 (1.8%) had moulted. The mean size of these crabs at release was 143mm carapace width. At recapture

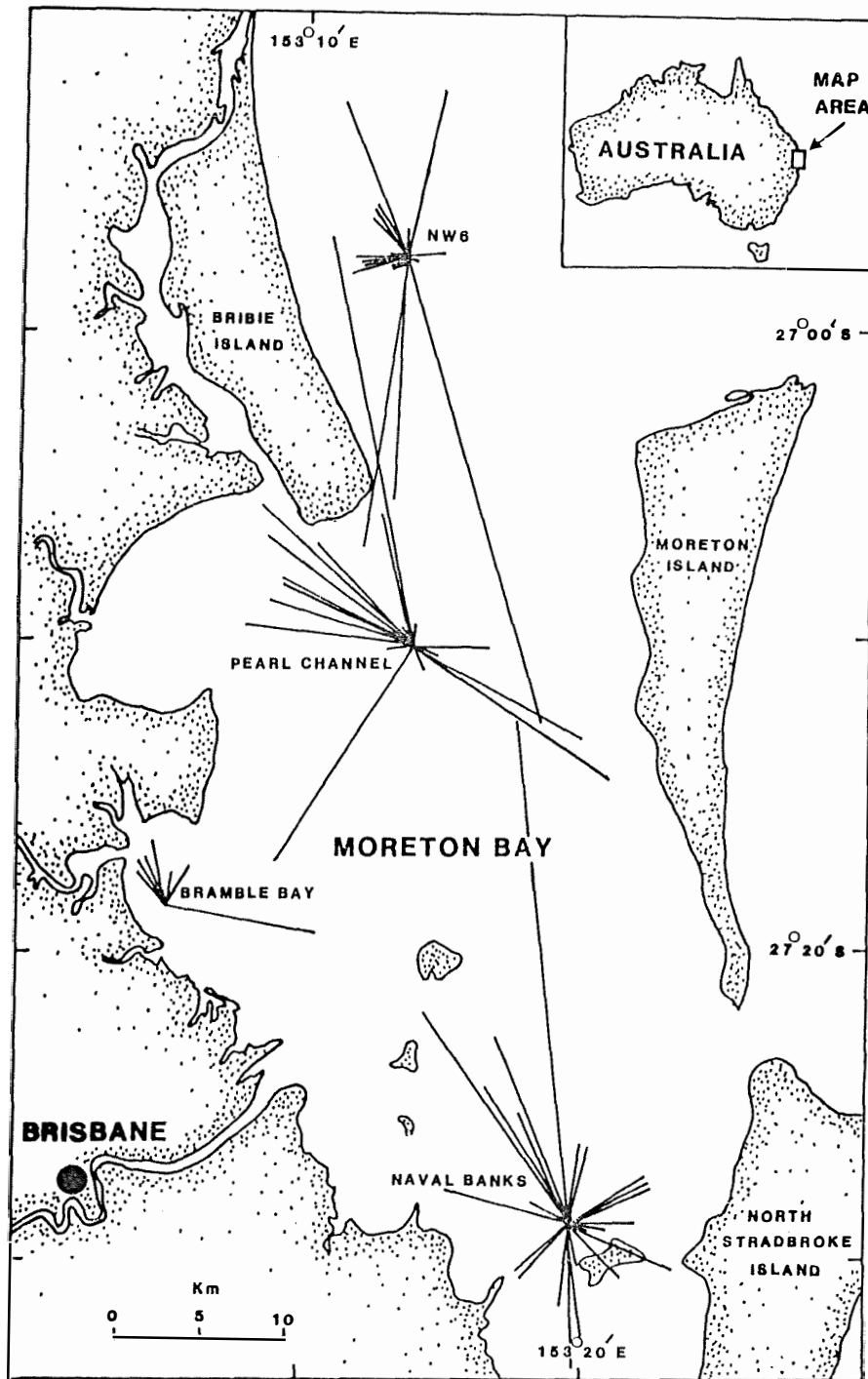


FIGURE 17. Examples of movement vectors of sand crabs released in different areas of Moreton Bay.

the mean size was 163mm, an average increase of 14%. The estimation of moult increments was critical to the development of growth and recruitment models of the fishery. Since only a small proportion of tagged crabs moulted and increments were in disagreement with laboratory estimates by G. Campbell (pers. comm.), accurate modelling of the fishery could not be attempted.

Most tagged sand crabs (82%) were recaptured within 2km of their release site. Movement vectors of tagged male crabs from four release sites are shown in Fig. 17. Movement of male tagged crabs showed no clear trend that would indicate a seasonal migration either into or out of Moreton Bay and movement within the Bay appears to be random.

#### **Spatial Segregation of Sexes**

During the course of the study it became apparent that male and female crabs may have different habitat preferences. Experiments, using commercial pots, were conducted at four sites in Moreton Bay - at the mouth of Bribie Passage, near Gilligans Island, in Lucinda Bay near Moreton Island and northeast of the Hanlon Light at Peel Island - to establish whether there were differences in sex or size of crabs caught in different depths within a small area. No clear pattern was discernible at the Gilligans Island site. This may have been related to the strong tidal currents in that area and may not represent the rest of Moreton Bay. At the other three sites more males were found in deeper water in September, November and May (Fig. 18) and fewer in February. Males in deeper water at each site were also generally larger (Table 2). Females were more prolific on shallow banks - except in February, when best catches of females were taken in intermediate depths. Sizes of female crabs in all depths were similar.

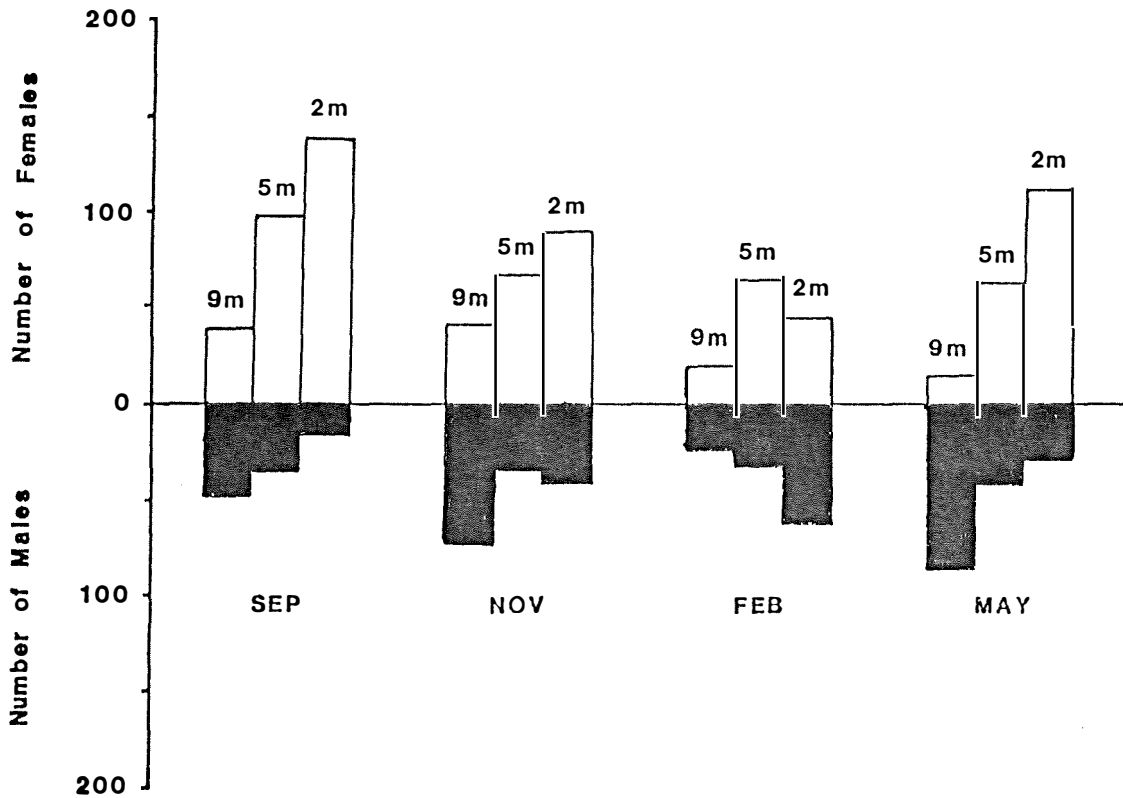


FIGURE 18. Numbers of male and female sand crabs caught at three depths in Bribie Passage.

TABLE 2. Differences in mean size (cw) of sand crabs caught at three depths in Bribie Passage.

Depth	September		November		February		May	
	Male	Female	Male	Female	Male	Female	Male	Female
9m	154	151	155	150	150	146	148	154
5m	149	154	149	145	143	147	143	151
2m	143	151	144	142	148	145	142	151
SIGNIFICANCE	**	NS	**	*	*	NS	***	NS

This information tended to confirm earlier casual observations that large catches of female crabs could be taken by trawling adjacent to or on shallow banks. FRV "Bar-ee-mul" has taken such catches on several occasions when working in the vicinity of banks. However it was not possible to use "Bar-ee-mul" in this investigation as trawl sampling in these areas would, at certain times, have interfered with the operations of commercial pot fishermen.

### Future Research

During the project four areas of future research were identified.

- i) Research into the influence of temperature on feeding and activity patterns of male and female sand crabs should be undertaken. This would greatly enhance our understanding of the seasonal variation in catch rates.
- ii) Further information on the agonistic behaviour of male and female sand crabs, particularly in relation to trap entrance behaviour, would aid in the interpretation of the highly variable pot catch composition.
- iii) Knowledge of recruitment to the pot fishery would be improved by research into moulting increments of male sand crabs, particularly around the legal size.
- iv) Little is known of the biology and morphometry of mature sand crabs in other areas of the State. Samples from the Gulf of Carpentaria and the tropical east coast would greatly supplement our present knowledge of the Statewide resource. An electrophoretic study of all Australian stocks would clarify the relationships between these stocks.

## **Management**

There are a number of issues that should be raised when discussing the overall management of the fishery, and the data gathered by this project enables a more detailed discussion of some of them. The principal regulations controlling the sand crab fishery at the present time have already been outlined.

### **Fishing Area Conflicts**

Discussions with commercial fishermen revealed that there is a degree of competition for fishing areas between commercial pot fishermen and trawl fishermen. The loss of, or even risk of pot loss to trawlers appears to be at least partly responsible for the distribution of the present pot fishery. Some areas, primarily in eastern Moreton Bay are still utilised by both groups, but at a cost to the pot fishermen in increased loss of gear as shown by logbook records. Fishing in the same area causes lost fishing time for trawl fishermen when extricating pots from their nets, and some trawl fishermen avoid fishing near pots for that reason. The conflict is a difficult one to resolve, but the present situation does not seem to be satisfactory. It may be possible to develop better arrangements by mutual discussions that would allow both groups to utilise these areas at different times.

### **Effort**

Effort is highly seasonal but the maximum level of effort (around March and April) in the commercial pot fishery at present is approximately 3 500 pots per day. This figure is calculated from the number of commercial pot fishermen, their assistants (each entitled to 50 pots) and from logbook records. Although effort exerted by both commercial sectors (pot and trawl) is not strictly comparable, estimates of the trawl catch from Fish

Board records place the Moreton Bay trawl catch of sand crabs at approximately one third to one half that of the pot fishery. The present level of effort in the recreational fishery is almost impossible to estimate but is likely to be considerable. For example, observations have at times shown over 200 dillies distributed between Peel Island and Cleveland Point.

Although there is little historical data on catch and effort trends in the crab fishery, Fish Board records presented by Thomson (1951) indicate at least a fivefold increase in catch over the past 35 years. The introduction of trawlers into Moreton Bay during the 1950s, as well as the use of winches and speedboats by pot fishermen has greatly increased fishing effort. Recreational fishing effort has also dramatically increased. Motor boat registrations in Queensland have risen by 230% between 1971 and 1981 and many of these are based in the southern part of the State. The modal size for male crabs sampled by Thomson (op. cit.) was 154mm compared with 153mm obtained in the present study (Fig. 19). Although Thomson used imperial units of measurement and his graph was difficult to convert accurately to a metric equivalent, the similarity in modal size suggests that at the present level of effort there is no recruitment overfishing.

An endorsement to operate in the pot fishery as a secondary fishery is held by 162 other commercial fishing vessels (mostly trawlers) in the Moreton Bay region (from QFMA records) - each vessel having an entitlement to use up to 50 pots per licensed fisherman. There is therefore a further potential or latent effort exceeding 8 000 pots which could be applied to the pot fishery. Although the use of a substantial proportion of this effort is at present unlikely, changes to the viability of either the pot or trawl fishery may cause part of this latent effort to be applied.

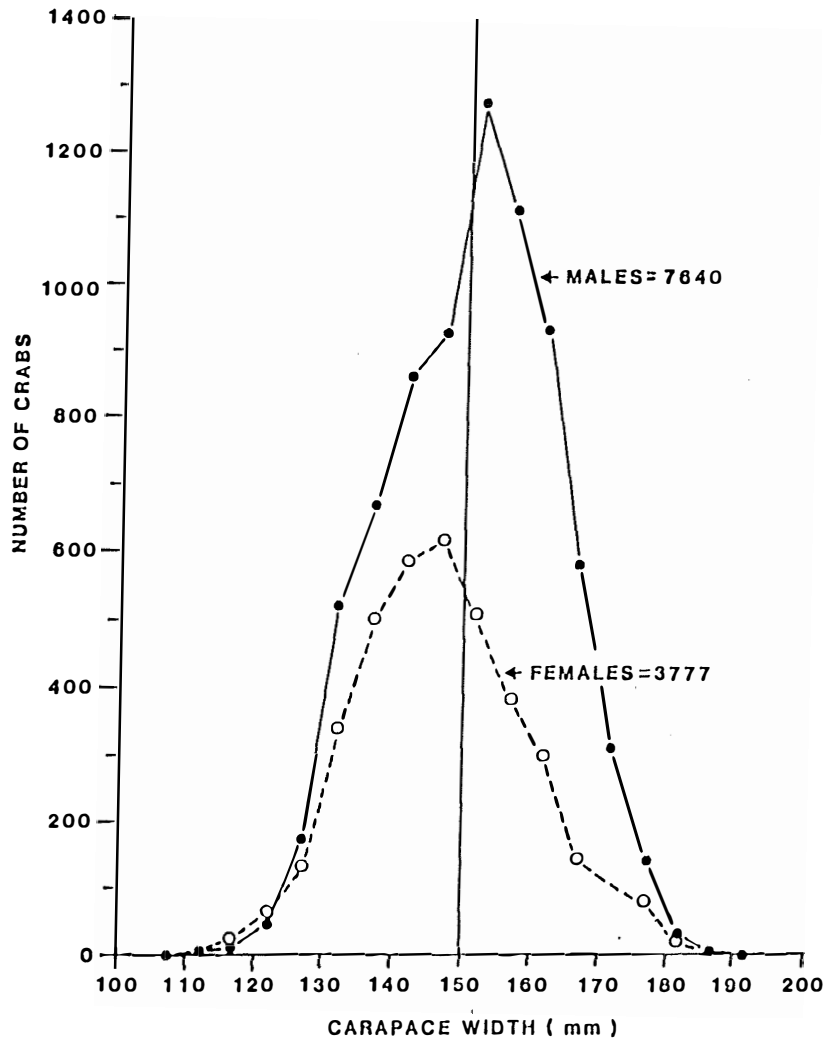


Figure 19 Length frequency distribution of male and female sand crabs taken in commercial pot catches.



Based on over 100 trips with commercial pot fishermen, overcrowding of pots can be so intense that at times lines of pots may be only 10m apart. In addition the area actually utilised by the commercial pot fishery is relatively small (see Fig. 15). As a result of this crowding some fishermen are forced to expand into areas where there is a conflict with trawler operators. The entry of other existing or new fishermen into the pot fishery would only serve to exacerbate this situation. If this occurred as a result of recommendations contained in this report (retention of females by the pot fishery and lowering of existing size limit) which would make the fishery more attractive, then the commercial pot fishermen the new measures should assist would instead be adversely affected.

The recommendations arising from this research programme are based on the assumption that the level of effort in the fishery remains at or about the present level. Therefore because (a) the pot fishery is already physically crowded and (b) there is the apparent potential for the effort to more than treble in the pot fishery, no new fishing vessel licences should be endorsed to operate in the sand crab pot fishery. Further, the number of existing secondary endorsements to operate in the pot fishery should be drastically reduced.

#### **Legal Size Measurements**

The present method of crab measurement, the maximum carapace width, ie, tip of antero-lateral spine to tip of antero-lateral spine has been in use for many years. It is a simple and quick measurement to use but does have some shortcomings. It is common for spines to be chipped, broken or malformed making an accurate legal measurement difficult. Of 15 025 male sand crabs sampled from pot fishermen's catches, 459 (3%) had damaged spines, whereas only 3 (0.02%) had the area at the base of the spine damaged. Spine damage is higher for trawled crabs. Spine length also varies considerably in

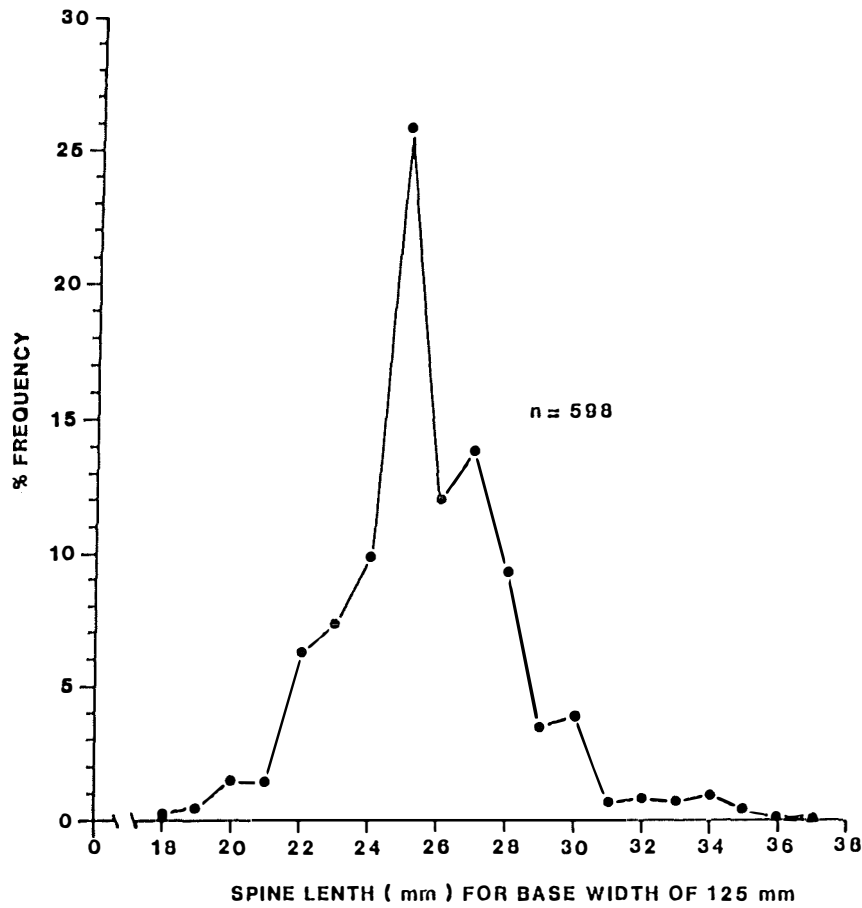


FIGURE 20 Variation in spine length for male sand crabs with a base width of 125mm (n = 598).

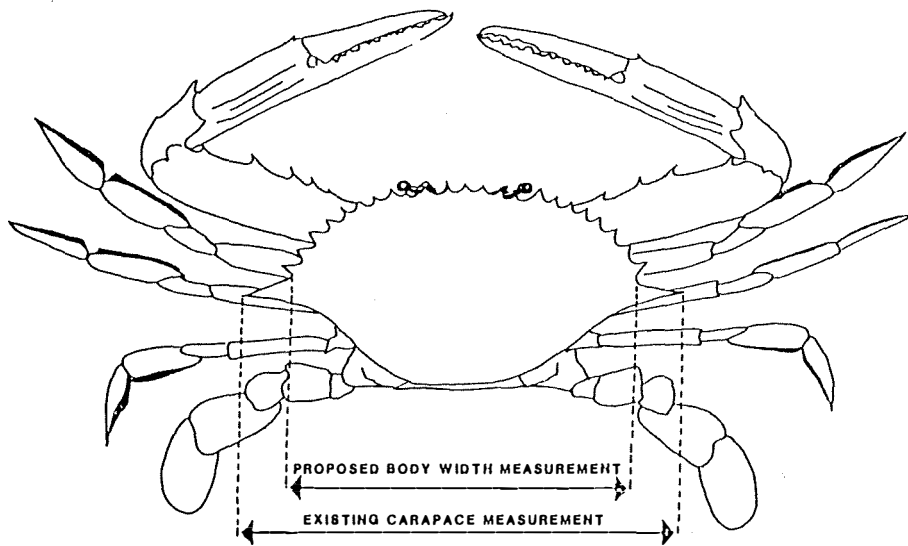


FIGURE 21 Diagram showing position of base width measurement.

normal crabs (Fig. 20), and crabs that look to be legal size but have short spines, can be several millimetres less than the legal width. Conversely crabs that look undersize but have long spines can easily make the measure.

An improved method of measurement that would reduce problems of this sort would be to adopt the method of width measurement used for P. pelagicus in South Australia. There a crab is measured from the base of the antero-lateral spine on one side to the base of the spine on the other side (Fig. 21). This base measurement has a better correlation with body weight than the spine measurement. The present carapace width measurement and this base of the spine measurement are related by the equation

$$\text{Base} = 0.938 (\text{CW}) - 16.04$$

which gives a base measurement of 125mm for the current legal carapace width of 150mm. Discussions with commercial pot fishermen have shown a ready acceptance to such a change in the method of measurement.

There is also an alternate legal size measurement in Queensland of 3.7cm measured from the notch at the base of the claw to the notch at the base of the third walking leg. This underbody measurement (BM) was introduced to provide a measurement that could be used on damaged or broken up crab bodies. The two legal measurements are related (Williams & Lee, 1980) by the equation

$$\text{BM} = 0.31 (\text{CW}) - 0.61$$

Using this equation the legal underbody measurement is equivalent to 139mm cw - obviously considerably less than the legal carapace width measurement of 150mm. Due to spine length variations (as discussed earlier) it is not feasible to alter this equation since some presently legal male crabs (by the spine measurement) would not pass the underbody 3.7cm measurement. The equation was calculated on a 95% confidence level that the damaged crab measured by the underbody measurement would be legal.

As a result of this anomaly, there has been an increasing trend in the fishery for crabs which fail to make the normal legal width of 150mm to be "backed", ie, to have the carapace removed, if they pass, or are likely to pass on the underbody measurement. Some fishermen now carry a size gauge for both measurements. Most crabs thus affected have been in the 140-150mm cw size range. Although not all fishermen are now indulging in this practice, the likelihood is that it will become more widespread, and the anomaly thus represents a de facto lowering of the size limit.

Apart from the size consideration, the practice almost certainly leads to inferior meat quality in crabs treated in this way. The disruption of the hepatopancreas by the act of backing releases enzymes into the tissues of the crab which tend to make the meat mushy. (Post-harvest handling of sand crabs is the subject of a separate FIRTA funded study being conducted by the Queensland Department of Primary Industries' Food Research Branch.) So the practice is undesirable from a quality point of view.

#### **Review of Size Limit**

The impetus for a reconsideration of the legal size limit for male sand crabs came from Moreton Bay commercial pot fishermen through the QCFO. This original proposition is not simple to resolve. Fishing effort is far from uniform over Moreton Bay and tagged crabs did not disperse into the general population. Most were caught close to where they were released. Logbook records showed that the maintenance of good catch rates, even in locations where the pot fishery was intense, indicated that continual recruitment into those areas was occurring. So the assumptions required to calculate an overall exploitation rate for the whole population do not hold because of the nature of the fishery and the behaviour of the crabs.

Sampling of commercial pot catches and data collected during the trawl

sampling indicated that a reduction in the size limit to 140mm cw (or equivalent base measurement) would, when introduced, temporarily increase the numbers of marketable crabs in pot fishermen's catches. Dependent on season and area and assuming that these crabs are not already being caught and backed this increase would be between 35% and 75% (at least until the effects of fishing pressure were felt). Unlike fish, growth in sand crabs is discontinuous and involves moulting. Although fewer tagged crabs than expected moulted, the data indicated that a crab of approximately 140mm would moult to approximately 160mm at the next moult (based on a 14% increase as discussed earlier). Thus a reduction of the legal size limit to 140mm would decrease the number of crabs caught at 160mm or larger. The proportion of these large crabs in catches taken by pot fishermen is less than 40% of the total marketable catch. Growth increments of untagged male sand crabs kept in the laboratory (G. Campbell, pers. comm.) have been up to double those of tagged crabs in the field. Therefore if tagging had a negative effect on growth, the proportion of large crabs affected by the lowered size limit may be less than 20% of the marketable catch.

The argument for lowering the legal size limit involves a trade-off between the increased numbers of smaller crabs that would be caught and the reduction in the catch of "first grade" crabs (generally 160mm cw and larger). "Seconds" (150-160mm cw) would be largely unaffected. During monthly sampling with commercial pot fishermen it became evident that a high proportion of catches of male crabs in the 140-150mm cw range are now being taken as backed crabs. There have not been reports from fishermen that the numbers of "first grade" crabs have been drastically reduced. However, pot sample catches of "first grade" crabs in 1986 were 25% less than 1985, although overall catches of legal crabs were almost identical (see Table 1). Differences between catches in both seasons may have environmental origins and the extent to which the reduction in the catch of

first grade crabs can be attributed to the taking of backed crabs is not clear. However the practice of backing crabs has been occurring in the fishery for at least two seasons and to date has not produced a catastrophic reduction in the numbers of male crabs >150mm cw.

In these circumstances the size limit could be lowered to 140mm cw or preferably the equivalent spine base measurement of 115mm. (This is still larger than the legal size measurements in New South Wales, South Australia and Western Australia.) If an effective logbook programme could be implemented, particularly for the pot fishery, then the size limit could be reviewed if records show that the size reduction has had a negative effect on commercial pot fishermen's catches and incomes.

Recreational fishermen would also benefit from the size reduction. Boat ramp surveys by the Fisheries Management Branch of recreational fishermen's sand crab catches have shown that most of their catches are small with a high proportion of sub-legal male crabs in the 140-150mm cw size range (N. Moore, pers. comm.).

If the legal size limit was reduced to 115mm (spine base measurement) the anomaly created by the existing underbody legal measurement would be largely removed. From a product quality point of view it would be better to prevent the breaking up (including meating and backing) of green crabs on fishing vessels. This would also simplify enforcement of the regulations and has been suggested on a number of occasions by officers of the Queensland Boating and Fisheries Patrol.

#### **Taking of Females**

Although the existing fishery targets for male crabs, female crabs predominate in commercial pot catches during the winter months. However,

if the prohibition on the taking of females was removed, the numbers of females taken could be increased by the relocation of pots into shallower areas. Otter trawlers also could markedly increase their catches of females by fishing in shallow areas on or near banks. This would be liable to cause further conflict with the pot fishing sector in competition for fishing areas, and may be at the expense of that sector.

Other Australian and overseas fisheries for portunid crabs allow the taking of female crabs except, in most cases, when the female is carrying eggs (Smith, 1982; Millikin & Williams, 1984). The stock/recruitment relationship for the sand crab is unknown and more research is required in this area, but it is probable that large numbers of females could be taken without causing problems for the stock. Balanced against this are (a) the difficulties in predicting the level of female catches, and (b) the likely changes in the fishing patterns of otter trawlers which may disrupt the existing commercial pot fishery if the prohibition was removed. Further, the initial request by commercial sand crab fishermen to review the ban on taking females was prompted by a desire to take females in the off-season, when females predominate in pot catches. However both pot and trawl sampling have shown that most females in August/September were carrying eggs when it would be undesirable to harvest them.

With the present prohibition on the taking of females, it is difficult to envisage any future stock/recruitment problems for this fishery. If the ban were to be removed then the fishery should be more closely managed with a pot fishery logbook programme to ensure the continued health of the stock. With the present Government philosophy of "user-pays" it is possible that any increased costs in research, management and logbooks would be passed on to commercial fishermen.

There are some serious problems associated with allowing trawlers to retain females. As mentioned earlier, catches of females can be extremely high if trawlers wish to target for them and work in shallow areas. If trawlers were allowed to retain females this could represent a major change in the fishery and one whose effect would be difficult to monitor. Such a change may cause the distribution of trawling effort both spatially and in intensity to alter, to the detriment of stocks.

If otter trawlers were prohibited from retaining female crabs then the above problems as well as the potential for territorial conflict with the pot fishery would be largely avoided. Combined with a prohibition on the taking of gravid females and a size limit which would enable females to complete one maturity moult and the four associated egg extrusions (Campbell, 1984), this would represent a conservative set of rules allowing for the safe exploitation of females.

Such a size limit for females would be 150mm cw (equivalent to 125mm base width). With the present distribution of pot effort this size would allow the taking of less than 30% of females caught in pots but would increase a pot crabber's overall catch by 25%.

Concern has often been raised over the fate of undersize and female crabs incidentally caught by commercial trawling and subsequently returned to the water. Although this question was not addressed in the present study, work by the CSIRO (Ted Wassenberg, pers. comm.) has shown that providing crabs were returned to the water within 30 minutes of being placed on the sorting tray their survival was between 80% and 90% even during summer evenings. The survival rate would be somewhat less during the day, however most trawling in Moreton Bay is conducted at night. This high survival rate negates the argument that trawl caught crabs do not survive being returned



to the water and thus should be retained.

### **Bag Limits for Recreational Fishermen**

The regulations pertaining to the number of pots or dillies that can be used by commercial and recreational fishermen are presently difficult to enforce. Generally speaking it is simple to police them only at boat ramps, or where fishermen are actually caught in possession of a greater number of pots or dillies than they are permitted to use. It is quite easy to circumvent the regulations. Recreational fishermen using pots, for example, could take out four pots each trip and as long as the pots were set some distance apart, the breach of the regulations would be difficult to detect, particularly if the floats were different and marked with different names. The intention of the limit of four dillies or pots for recreational fishermen is to prevent them from retaining a larger number of crabs than they would require for personal or family use. If recreational fishermen set out to catch large numbers of crabs or to illegally market their catch they could be described as quasi-professional or "sham-amateur" fishermen. This regulation for recreational fishermen could be supported by introducing a bag limit as an additional measure - as already applies to the spanner crab fishery in Queensland.

Although there is no biological data indicating declining CPUE trends in the sand crab fishery, such a limit would greatly assist in the enforcement of regulations. Interviews with 116 recreational fishermen who returned tagged crabs showed that the average daily catch of sand crabs per boat was 19.1 and only 6% had total catches in excess of 40 per boat. A bag limit of 20 crabs per person with a maximum of 40 per boat would thus not seriously disadvantage the average recreational fisherman but would aid in the detection of a minority of fishermen who deliberately set about to break the regulations and who illegally market their catch to the detriment

of the commercial fisherman.

### **Tangle Nets**

A further measure that deserves consideration is to progressively implement the banning of tangle nets for taking sand crabs - in this case "suicide" dillies or "witches' hats". These dillies are very popular with recreational fishermen and the boating public generally, because they are inexpensive and a compact, effective apparatus for taking crabs. However, when used properly they are very time-consuming to clear, and crabs left in suicide dillies for any length of time can become horrendously entangled. Limited studies have been undertaken on clearing dillies and at times up to 15 minutes were required to clear two entangled undersize crabs that had been caught in a dilly for less than one hour. The temptation to clear undersize or female crabs quickly and roughly, thus damaging or killing them, can be considerable - and no doubt commonly occurs. In this sense, the use of dillies as an acceptable fishing gear seems contrary to the spirit of the regulations protecting undersize males and females. Alternate compact pot and dilly-pot combination designs are available which are simple and quick to clear - although they are somewhat more expensive initially.

### **Management Recommendations**

- i) (a) That no further primary entitlements be issued to new or existing fishermen to operate in the sand crab pot fishery in the Moreton Bay region, other than those currently pot fishing as their primary activity.
- (b) That the number of endorsements to operate in the fishery as a secondary activity be drastically reduced in order to remove this latent effort.

- ii) That the method of measurement of sand crabs (Portunus pelagicus) be altered so that the measurement is taken at the base of the antero-lateral spines across the carapace (see Fig. 21).
- iii) That the legal size limit for male sand crabs be reduced to 115mm measured at the base of the spines (equivalent to 140mm carapace width). Provided however, that logbook or catch records are completed by commercial pot fishermen.
- iv) That the breaking up of sand crab bodies on board commercial and recreational fishing vessels be prohibited. However, consideration should be given to the fisherman who breaks up crab bodies on board a vessel for his personal consumption.
- v) That the introduction of a bag limit for recreational fishermen of 20 sand crabs per person with a maximum of 40 per boat be considered.
- vi) That the banning of all tangle nets, eg, suicide dillies, for the taking of sand crabs be progressively implemented.

#### **Provisional Management Recommendations**

After relevant discussions with industry and recreational fishermen the above recommendations could be progressively implemented. While it is recognised that the fishing and marketing of female crabs has social and economic problems, there is no biological reason why female sand crabs should not be fished. Therefore the following recommendations should only be implemented when an effective regulation has been introduced to prevent otter or beam trawlers from retaining female crabs.

- vii) (a) That the prohibition on the retention of female sand crabs be removed, for fishing methods other than otter or beam trawling.
- (b) That a size limit of 125mm (measured at the base of the antero-lateral spines and equivalent to 150mm carapace width) be introduced for female sand crabs.

- (c) That the taking of gravid female sand crabs (ie, carrying eggs) be prohibited.

### Conclusions

The conclusions to the Research Objectives (p. 5) in sequence are as follows:

- i) Sand crabs in Moreton Bay have a more extended spawning period than temperate Australian sand crab stocks and are subject to infection by the rhizocephalan Sacculina granifera. This parasite apparently does not infect sand crabs in temperate Australia. Because of the unrepresentative nature of Gulf of Carpentaria sand crab samples, no meaningful differences between subtropical and tropical stocks were noted.
- ii) The fishery for sand crabs in Moreton Bay has developed rapidly, particularly over the past 40 years. Despite being heavily fished, the stocks are healthy and show no signs of either recruitment or parent stock overfishing.
- iii) Results of tagging studies show that the greatest impact on the resource is exerted by the commercial pot fishery. The recreational fishery also contributes a significant proportion of the total fishing mortality. Based on tag returns the commercial trawl fishery had the least impact, however tag returns were probably understated for that fishing sector.
- iv) Four main areas of management were identified for improvement:
  - (a) Under the present system which allows secondary endorsements to operate in the fishery, there is the potential for a massive increase in fishing effort which, if exerted, would seriously affect stocks.
  - (b) The method of legal sand crab measurement (currently distance

across the lateral spines) is ineffective because spine length varies considerably and spines are readily chipped and damaged. By changing to a "base width" measure these difficulties would be largely eliminated.

(c) Based on regulation comparisons with other Australian States, the current size limit also appears conservative. Although the stock-recruitment relationship for sand crabs is unknown the potential exists for an overall increase in the sand crab catch. The size limit could be lowered and the fishery monitored in order to detect any detrimental effects of such a lowering.

(d) Female sand crabs are at present an unexploited resource. Although there are a number of social and economic problems associated with their exploitation, biologically there is no reason why females cannot be fished, providing the fishery can be properly monitored and managed.

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### Acknowledgements

This research programme was made possible by a grant from the Fishing Industry Research Trust Account. Funding was also made available from the Queensland Fisheries Research Fund. The financial support of both of these funds is gratefully acknowledged.

The technical assistance in the field and laboratory of Mr Glen Smith is also gratefully acknowledged. Mr Phill Smith, skipper of the FRV "Bar-ea-mul" worked tirelessly collecting samples for the project.

Thanks are also due to a number of pot crabbers for assistance, but particularly to Messrs P. Conaty, C. Davenport, R. Fursey, A. Groves, R. Honey, D. and G. Smith and F. Somers, from whose boats much of the samples were collected.

### Publications

Several scientific papers are being prepared on the information collected and experiments conducted during the course of this programme. Copies of these papers will be forwarded to the Fishing Industry Research Committee as they become available.

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