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ASSESSMENT OF OFFSHORE CRAB RESOURCES IN SOUTHERN QUEENSLAND

FINAL REPORT

TO THE FISHING INDUSTRY RESEARCH COMMITTEE

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1. INTRODUCTION

The existence of several edible crab species in southern Queensland offshore waters has become known as a result of the activity of trawlers, which take coral crabs, spanner crabs and spider crabs as a by-catch in their prawn nets. While the quantities of crabs caught by trawlers is rarely very large, evidence from the recently established spanner crab fishery suggests that the trawl catch is not necessarily a good indicator of the size of the crab stock.

The spanner crab fishery was initially rather localised in the areas off Mooloolaba and northwest of Moreton Island. Very little was known about the geographical distribution of the stock, but the bathymetry of the shelf and the substrate types recorded on various navigational charts suggested that the potential fishing grounds might be quite extensive. Prior to the Project's commencement, the question of the size of the crab resource was of great interest to spanner crab fishermen. Clearly, if the resource was limited geographically the stock would probably be small, and the fishery might not be able to develop to any great extent. The "worst case" situation may be that even moderate fishing pressure could force the stock down to a level where commercial fishing would be uneconomic.

Commercial spanner crab fishermen at that stage had not reported catching significant numbers of crabs other than spanner crabs in their tangle nets. However, it was considered that an investigation covering a broader area and range of depths may indicate whether or not the other species were present in quantities sufficient for a commercial operation using the same sort of gear. Additionally, a survey of this type could provide some useful information on the distribution and abundance of spanner crabs which are currently being subjected to locally intense, completely unregulated exploitation.

Offshore crab fishing operations in southeast Queensland would face a number of constraints - not the least important being the need to compete with the well established estuarine sand crab *(Portunus pelagicus)* and mud crab *(Scylla serrata)* fisheries. While there is some evidence that mud crab catch rates are declining, Queensland DPI Fisheries studies have indicated that the total annual catch is fairly steady. The landed sand crab catch is probably increasing as more and more trawler operators are finding it financially beneficial to market their by-catch. Moreover the offshore crab fishery is attractive to commercial fishermen because of the small scale of the operation (and hence the need for minimal capital investment), but precisely for this reason the fishing unit is highly subject to local weather patterns. Thus, to enter a competitive market and introduce unfamiliar species caught in an area where weather conditions can severely restrict fishing time, large catches of crabs would need to be obtained, at least until the market was established. On the other hand, such a fishery would be a very attractive proposition to fishermen presently involved in other small scale seasonal fisheries.

This project was aimed at determining which edible crab species could be caught in commercial quantities by the small boat operator in the area from Stradbroke Island to Sandy Cape, and to provide a better understanding of how the potential stocks (if any) are distributed with respect to seasonal and geographic factors. A concurrent FIRTA project (under the direction of Fisheries Research Branch personnel) was oper-

ating in a more restricted area to investigate in greater detail the population structure and biology of one of the species in question. The two project teams liaised continuously and worked co-operatively on some specific problems.

2. THE SURVEY AREA

The study area included a length of coastline extending some 170 nautical miles (315km) from Point Lookout, Stradbroke Island (27°26'S) to Sandy Cape, Fraser Island (24°42'S). A small section of the north-eastern part of Hervey Bay was also incorporated in the study area. The region was divided into 10' x 10' grid blocks from 152°50'E beyond the 100m isobath to 154°00'E. The original intention was to sample every block in which there was a sufficient depth of water (excluding those within Moreton Bay), at least out to the 100m depth contour. There were, theoretically, about 60 grid blocks amounting to a total area of 18,480 sq. km which fell within these criteria (Fig. 1).

The slope of the continental shelf ranged from about 1:90 immediately east of Cape Moreton to 1:630 off Double Island Point. Bottom sediments consisted primarily of sand, with patches of reef and heavy gravel or coral rubble bottom. Currents and tidal streams were variable, the dominating factor being a general southerly set resulting from the East Australian Current. Tidal flows were significant in the vicinity of bars, bays, river mouths and headlands, and strong currents were often experienced in deeper water towards the edge of the continental shelf.

3. MATERIALS AND METHODS

3.1 THE PROJECT VESSEL

A 24' welded alloy hard-chine "StarFlite" fishing boat powered by a 185HP "Mercruiser" stern-drive petrol engine was used for the survey. With a fuel capacity of 300 litres and a cruising speed of about 25kt, the vessel had an operating range 200 nautical miles. Initially a small electric line-hauler was used, but the need for very long buoy-lines when working in deep water (>100m) required a hauler of greater capacity. An hydraulic drum winch capable of hauling and stowing 1.2km of 5mm synthetic rope at 1.3 metres/sec. was constructed by a local company and mounted on the transom so that the trap-lines could be set directly over the stern. Additional equipment carried on the vessel included a "GME" 27 MHz radio and a "Fuso 1800" echo sounder reading to 280m.

3.2 FISHING GEAR

The gear used throughout the project was essentially a series of baited tangle nets (locally known as inverted dillies or "witches' hats") of a design similar to that used at the time by commercial spanner crab fishermen in the Mooloolaba area. Each net consisted of a 1-metre

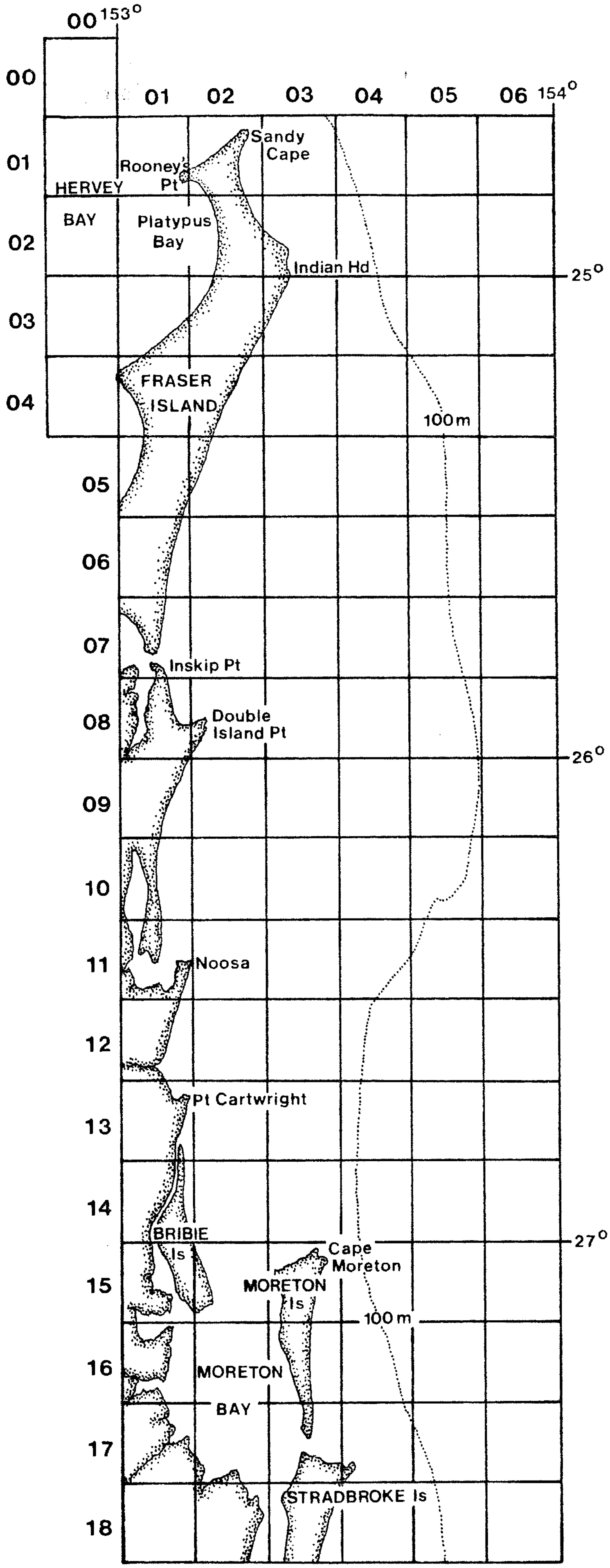


Figure 1. Chart of the survey area showing position of the 100 m depth contour.

diameter ring made from 12mm steel reinforcing rod and covered with a loose layer of synthetic multi-filament mesh. The mesh was gathered in the centre and supported by a small cork net float forming a low cone (Fig. 2). Although various mesh sizes from 25 to 100mm were tried, the optimum range was found to be between 35 and 50mm. The smallest mesh sizes (<30mm) appeared to catch fewer large crabs, while large mesh webbing (>50mm) tended to tangle the crabs excessively, making it difficult to clear the nets and resulting in greater damage both to the crabs and to the fabric.

Since the commencement of the project commercial crab dilly design has undergone a process of evolution, and now most operators use the flat Hawaiian-style nets with webbing stretched tightly over the metal frame. Conical dillies, however, were used throughout the duration of the project to ensure continuity of sampling effort.

In addition to the standard sampling gear, a small dredge (fabricated by Fisheries Research Branch staff) and a scaled-down trawl net were used in an attempt to capture juvenile crabs which for some reason do not appear to be taken in the dillies. The 70 x 30 x 80cm metal frame dredge was equipped with a set of 5cm steel teeth projecting from the lower leading edge, and a 30mm mesh bag or cod-end attached inside the front edge of the frame.

3.3 FIELD OPERATIONS

Weather conditions usually dictated which area could be fished on any given day. Having reached the desired grid block by dead-reckoning navigation, the vessel's position was checked by reference to depth soundings and compass bearings on identifiable landmarks. The dillies were then baited and set, typically in a line of eight dropped about 150m apart. The direction of set was usually determined by sea conditions. As each individually numbered marker-buoy was dropped, a note was made on the field data sheet (see Appendix 1) of the depth and time of set. The soak time, or length of time the nets were left fishing, varied to some extent, but averaged 0.86 hr (approx. 50 minutes). As the nets were lifted, the time of retrieval was recorded. An assessment was made of the condition of each net, and if there was any noticeable damage an appropriate code was entered on the field sheet. The crabs were then removed from the net, counted, and in the case of spanner crabs, sexed. Female spanner crabs were also examined to determine whether or not they were carrying eggs, and the relevant data recorded. After the complete set had been lifted, the vessel was moved 3 or 4km away and the nets reset. The whole process was continued (usually in the same grid block) for the remainder of the day, or until the weather made conditions unworkable.

3.4 DATA STORAGE AND ANALYSIS

All field data except those relating to the dredge and try-net trials were keyed on to disk file by staff at the Southern Fisheries Research Centre, Deception Bay. A sample listing of a portion of the database is attached (see Appendix 2). Analyses of the survey data were carried out by one of the authors (IWB) using specifically developed

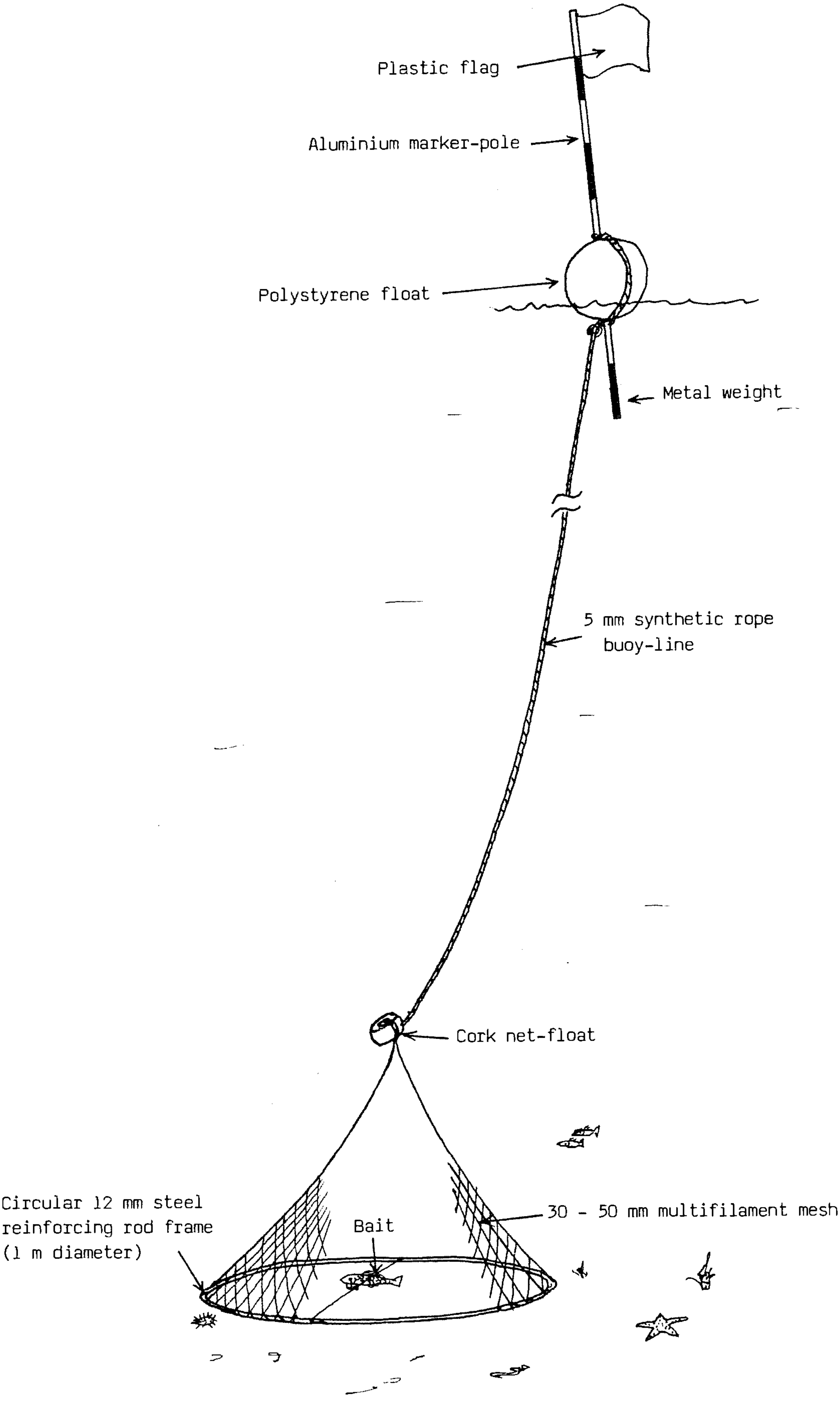


FIGURE 2. Semi-diagrammatic representation of a typical spanner crab dilly of the type used during the project. (not to scale)

BASIC software on an SR-72 floppy-disk based 64K microcomputer at SFRC.

A realistic idea of apparent stock density or relative abundance can only be gained by comparing catch rates, or catch-per-unit-effort indices (CPUE). Because of the need to take account of varying soak times, the computed CPUE was not simply the total number of crabs divided by the total number of drops, but incorporated an adjustment to standardise the catch to a 1-hour time base. Given the range and distribution of both soak times and CPUE data, it was considered statistically reasonable to treat the adjusted catch rates as individual variates for the purpose of computing means. This also allowed the calculation of sample variances and confidence intervals, enabling an assessment of the significance of differences between means.

4. RESULTS

4.1 DISTRIBUTION OF FISHING EFFORT

Sampling was carried out in 35 ten-minute square grid blocks covering an area of approximately 10,815 sq. km. As can be seen from Fig. 3 the amount of sampling effort (as measured by the number of drops) varied considerably from block to block. The area east of Fraser Island could not be sampled effectively because of large expanses of reef and heavy rubble bottom. Distance and travelling time from the nearest safe port also presented problems, and the Tin Can Bar at Inskip Point could often not be crossed due to foul weather. The paucity of information from that area represents an unfortunate gap in the project data, although this is compensated for to some extent by additional sampling in the northeast part of Hervey Bay.

The total number of drops (1,865) represents an actual fishing effort of about 1,490 net hours. However, some of the nets set were either lost completely or damaged as a result of hook-ups or attack by sharks and turtles, and in a few cases the times were not recorded. In all, a little over 11% of the records were "doubtful" (for the above reasons) and were therefore excluded from the subsequent analysis.

4.2 FACTORS ADVERSELY AFFECTING THE PROJECT

Two factors - the weather and mechanical problems with the vessel - had a detrimental effect on the conduct of the Project.

It was found difficult, if not impossible, to work in winds exceeding about 15 kt. With the exception of the northwest shore of Fraser Island, the entire project area is very exposed to prevailing southeast and northeast winds. Even short periods of freshening wind can whip up a surface chop which is very uncomfortable and potentially dangerous to small vessels. Moreover such conditions make it difficult to locate marker-buoys, and this can often result in the loss of gear. Bad weather thus accounted for a large number of lay-days during the project period.

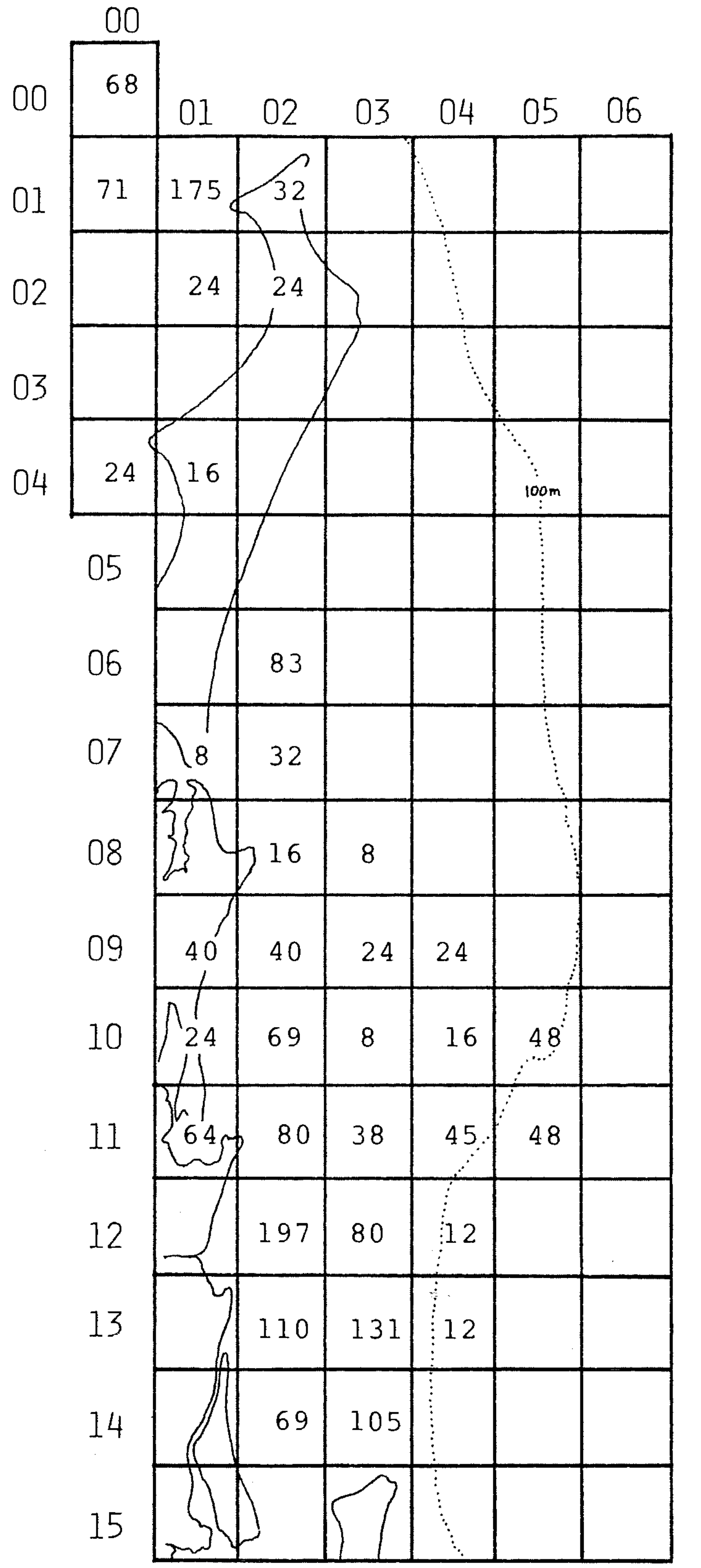


Figure 3 Geographical distribution of sampling effort (total numbers of drops) throughout the study area.

Problems with the vessel's motor and stern drive unit were also responsible for a significant loss of fishing time. One incident involving a broken camshaft resulted in the vessel's being out of operation for nearly 10 weeks while parts were located and shipped from the USA. However during this period some experimental work was able to be carried out with the assistance of an obliging commercial fisherman at Mooloolaba.

4.3 SPECIES COMPOSITION OF THE CATCH

Spanner crabs were by far the most abundant species taken in the dillies, nearly 6,000 individuals having been caught in 1,652 effective drops. A more detailed analysis of the distribution and abundance of this species appears subsequently. The other crab species represented only an insignificant "by-catch" and the apparent size of their stocks indicates that they are unlikely ever to become target fisheries in their own right.

4.3.1 Sand Crabs *(Portunus pelagicus)*

Despite their abundance and commercial importance in Moreton Bay, inside the North Banks east of Bribie Island, and in parts of Hervey Bay, sand crabs were caught surprisingly rarely during the survey period. A mere 42 individuals appeared in the catch, from a variety of depths ranging from 9 to 71m (Table 1). There was no apparent significance either in the localities or the times at which these crabs were caught. It is interesting to note that prawn trawlers operating in offshore waters catch sand crabs regularly. While such catches are not great, they certainly exceed the spanner crab trawl catch. A possible explanation for this might be that *P. pelagicus* is more active at night (when most of the offshore trawlers fish for prawns) than is *R. ranina*, which, from our accumulated experience, appears to feed during daylight hours. Dillies designed for recreational sand crab fishing generally have a rather larger mesh size than typical spanner crab nets because sand crabs are not as readily meshed by their (slender) legs, and a large mesh is needed to entangle their carapace spines. This may also account for the lower dilly catch of this species in offshore waters.

4.3.2 Three-spot Crabs *(Portunus sanguinolentus)*

The total catch of this swimming crab was only slightly greater than that of its congener *P. pelagicus* (Table 2). Again, there did not appear to be any recognisable pattern to its distribution with respect to depth, season or locality, although they seemed slightly more abundant in the northern part of the study area than in the south.

4.3.3 Spider Crabs *(Cyrtomaia sp.)*

Contrary to initial expectations, the total catch of spider crabs was effectively zero. Only two were caught; both on 3.9.81 in block 1104.

Table 1. Numbers of sand crabs caught during the project period, showing localities, dates and depths.

BLOCK	DATE	DEPTH (m)	NUMBER
0101	21.10.82	24	2
0101	21.10.82	34	1
0101	21.10.82	31	3
0101	9.11.82	31	2
0602	16.2.82	44	1
0602	16.2.82	45	1
0602	17.2.82	47	2
0602	18.2.82	47	1
0701	11.2.82	41	1
0702	12.2.82	44	1
0901	30.10.82	44	1
0904	20.4.82	71	2
1002	18.9.81	55	1
1101	25.6.82	25	2
1103	17.6.82	62	2
1103	17.6.82	63	1
1202	30.7.81	9	1
1203	10.3.82	56	1
1302	13.5.82	43	3
1302	13.5.82	45	2
1302	9.6.83	45	1
1302	9.6.83	44	1
1303	28.7.81	57	2
1303	29.6.82	62	2
1303	29.6.82	60	4
1403	12.8.81	49	1

Table 2. Numbers of three-spot crabs caught during the project period, showing localities, dates and depths.

BLOCK	DATE	DEPTH (m)	NUMBER
0101	9.11.82	30	1
0602	15.2.82	44	1
0602	15.2.82	46	1
0602	16.2.82	43	1
0602	16.2.82	44	1
0602	17.2.82	46	2
0602	18.2.82	46	2
0701	11.2.82	40	2
0701	11.2.82	41	1
0702	12.2.82	40	1
0702	12.2.82	42	1
0702	12.2.82	44	2
0702	12.2.82	45	1
0702	12.2.82	46	1
0901	30.10.81	38	1
0901	30.10.81	30	1
0901	30.10.81	45	1
0902	30.10.81	33	1
0903	7.5.82	60	1
0904	20.4.82	68	4
0904	20.4.82	67	1
1001	29.10.81	33	1
1101	26.5.82	30	2
1101	26.5.82	22	1
1101	25.6.82	28	6
1101	25.6.82	23	1
1101	25.6.82	22	5
1202	30.7.81	9	1
1202	30.7.81	10	2
1302	10.5.82	11	2
1302	10.5.82	15	1
1403	24.8.81	23	1
1403	24.8.81	19	1
1403	24.8.81	18	3

This block includes the 100m isobath, and the specimens were collected from 106 and 112m on the edge of the continental slope. While the amount of fishing effort expended in this depth zone was far less than in shallow and intermediate depths, the 103 effective drops in water deeper than 90m failed to yield anything but these two crabs.

4.3.4 Coral Crabs *(Charybdis cruciata)*

Throughout the entire project period only one coral crab appeared in the catch. This individual was captured in 20m on the Hervey Bay side of Fraser Island (block 0202) on 21.11.81.

4.3.5 Other Species

In addition to the edible crab species listed above, numerous small non-commercial crabs (mainly *Matuta sp.*) were meshed, particularly in the shallow water shots.

4.4 SPANNER CRAB ABUNDANCE/CATCHABILITY PATTERNS

The total catch of spanner crabs from 1,652 effective drops (equivalent to a total soak time of 1,409.7 net hours) was 5,775. Of these, 4,647 were males, and 1,120 (including eight ovigerous crabs) were females. The overall catch rate or catch-per-unit-effort was 3.5 crabs per drop or, more reliably, 4.1 crabs per net hour.

4.4.1 Geographic Influences

The catch (numbers of crabs) taken in each of the grid blocks fished is shown in Figure 4. Obviously much of the variation in catch can be accounted for by differences in the amount of sampling effort as illustrated in Figure 3. However, Figure 5 clearly indicates that catch-per-unit-effort was far from uniform throughout the survey area. Average catch rates per block varied from zero in the deepest water sampled to 11.42 crabs/net hr in block 1402 northeast of Bribie Island. This particular block is part of the area currently being fished commercially. The next highest CPUE was recorded in block 0000 northwest of Sandy Cape (in the northern part of Hervey Bay) where no prior commercial exploitation had taken place.

The most consistently productive area was between 26°30'S and 27°00'S, in depths from 20 to 50 metres. This is the region where most of the commercial spanner crab fishing effort is concentrated. Catches in the vicinity of Noosa Heads were poor, but further north off Cooloola and the Coloured Sands the mean CPUE indicated exploitable concentrations of crabs. Around Double Island Point (25°55'S) crabs appeared to be particularly scarce, although it must be pointed out that sampling effort was very low in this region (see Figure 3), and the results may not be entirely indicative of the actual situation. A small number of crabs was caught in block 0702 east of Inskip Point, and a reasonable number

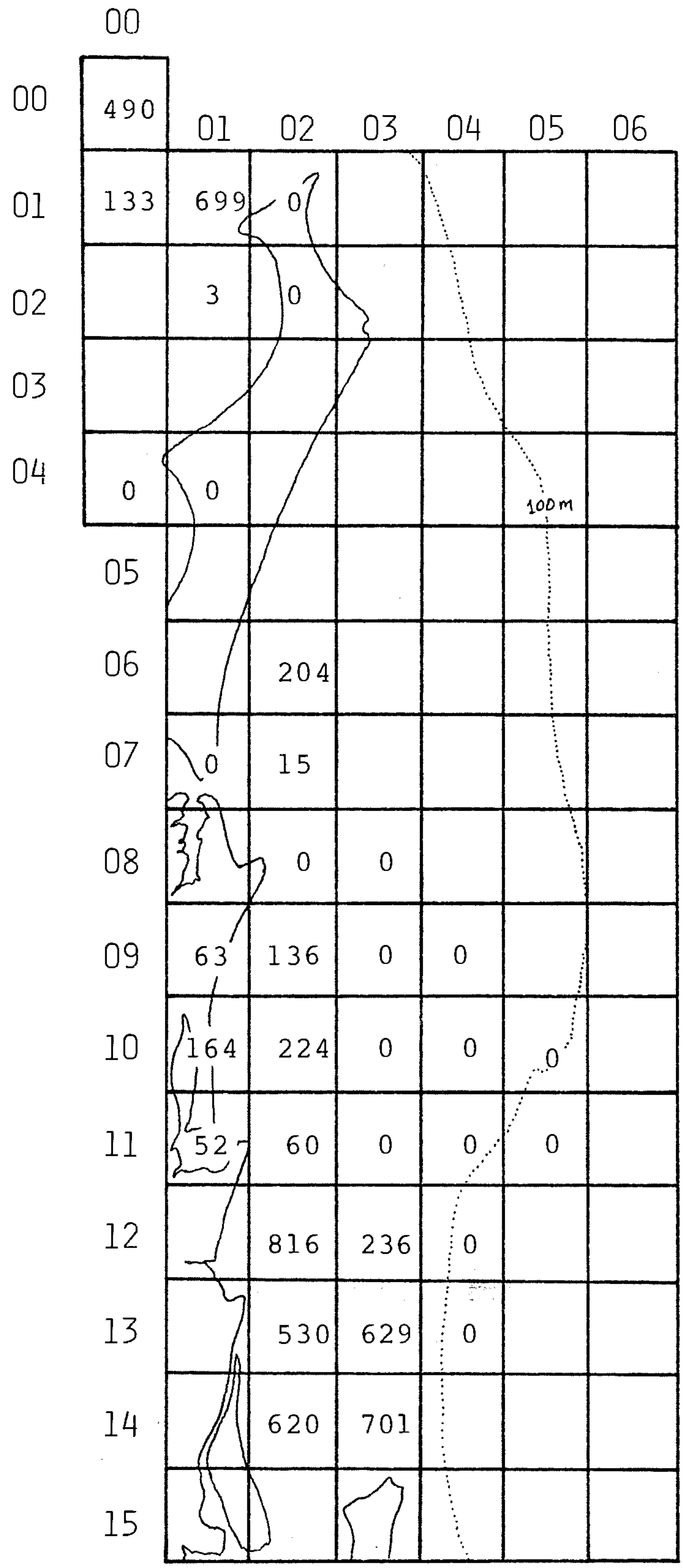


Figure 4 Geographical distribution of the total catch of spanner crabs (numbers of crabs, M+F).

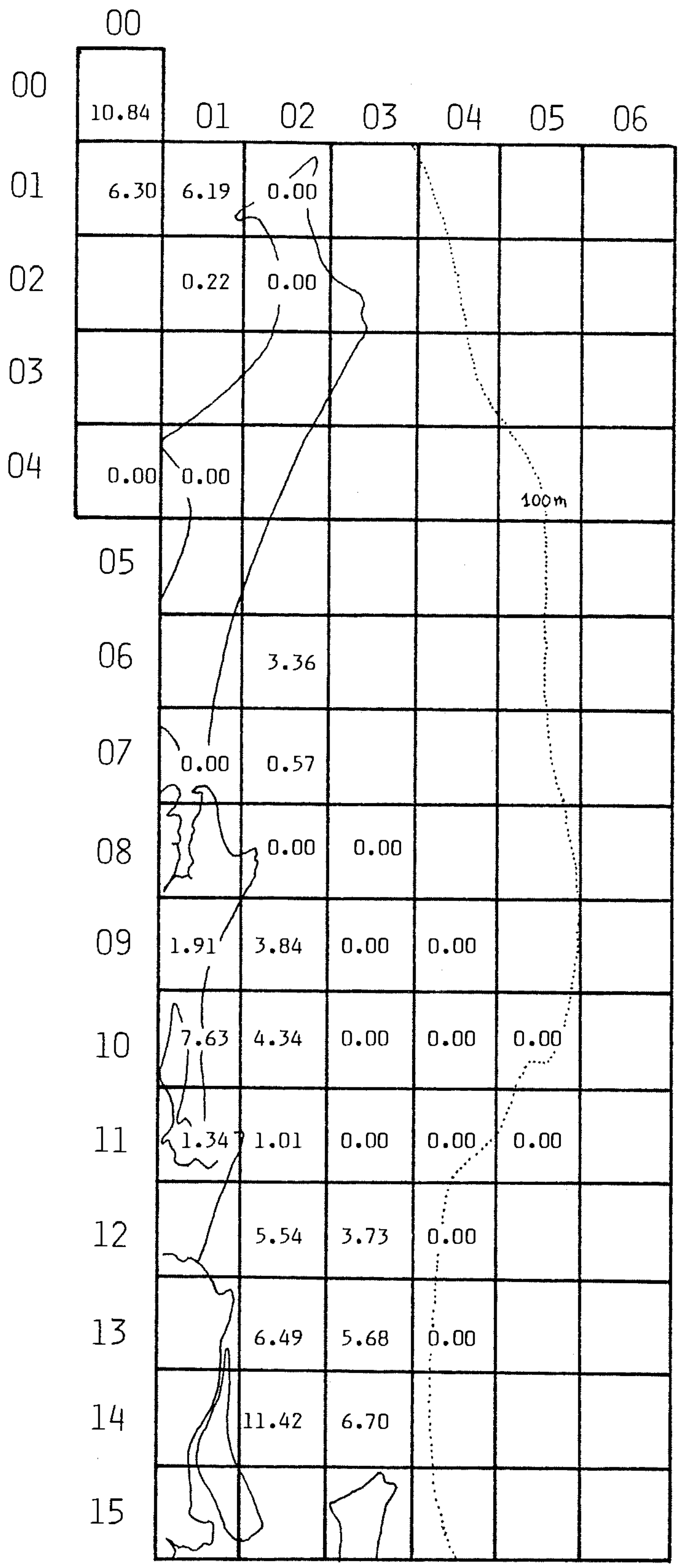


Figure 5 Geographical distribution of apparent stock density of spanner crabs as measured by catch per unit effort (CPUE = numbers of crabs [M+F] per net-hour).

appeared in the adjacent block to the north, off the southern end of Fraser Island. Here a total of 71 effective drops yielded 204 crabs, 189 of which were males. The catch rate of about 3.4 crabs/net hr in this block indicates a sufficient abundance for commercial exploitation, although the area is remote and really only accessible to boats based at Tin Can Bay.

No crabs were caught in the shallows around the northern end of Fraser Island (block 0102), but the project team did find evidence that crabs exist there or very close by (see Section 4.7). However significant catches were made in three grid blocks to the west and northwest of Rooney's Point. These are in the northernmost part of Hervey Bay, and although block 0000 is north of the latitude of Sandy Cape, it is protected from oceanic swells by the extensive system of sandbars, shoals, and semi-permanent sand islands known as Breaksea Spit. The catch rate in this general area was highest in the grid block most exposed to oceanic conditions (10.84 crabs/net hr), but the two blocks west of Rooney's Point both yielded, on average, catches in excess of 6 crabs/ net hr. Further south in the more protected part of Hervey Bay the catch rate was very much reduced (0.22 crabs/net hr in the deeper regions of Platypus Bay), and off Moon Point (blocks 0400 and 0401) no spanner crabs were caught at all.

4.4.2 Seasonal Effects

The results of this survey suggest that there is a seasonal pattern in the population density or vulnerability of spanner crabs, with catch rates in the latter half of the year (June-December) being substantially greater than those during the period January-May (Figure 6). CPUEs in June, July, September, October and December were not significantly different, the collective mean being slightly greater than 6 crabs/net hr. The apparently significant lower value obtained during August can probably be accounted for by the fact that sampling effort was not spread equally over time and geographical area. In other words, some bias has been introduced because more effort was expended in less productive areas during that month. The other aberrant sample (November) may, however, be significant, since there is some evidence from elsewhere of a pre-spawning reduction in feeding intensity.

While Figure 6 indicates statistically significant monthly differences in CPUE within the January-May period, these, too, can probably be attributed to a non-uniform distribution of effort. It would certainly be misleading to suggest, for example, that spanner crabs cannot be caught in January and April. To provide a better understanding of the combined effects of area and season, the data have been re-organised in Figure 7 to show seasonal trends in CPUE in three subdivisions of the project area: north and north-central, south-central, and south. Despite some missing data points, the figure shows similar trends in each of the three zones. Significantly, the highest CPUE in each case was recorded during September-October, and in the early part of the year catch rates were comparatively low. The zero value for March-April in the southern zone (Point Cartwright to Moreton Island) is probably not representative, being based on a sample size of only seven effective drops.

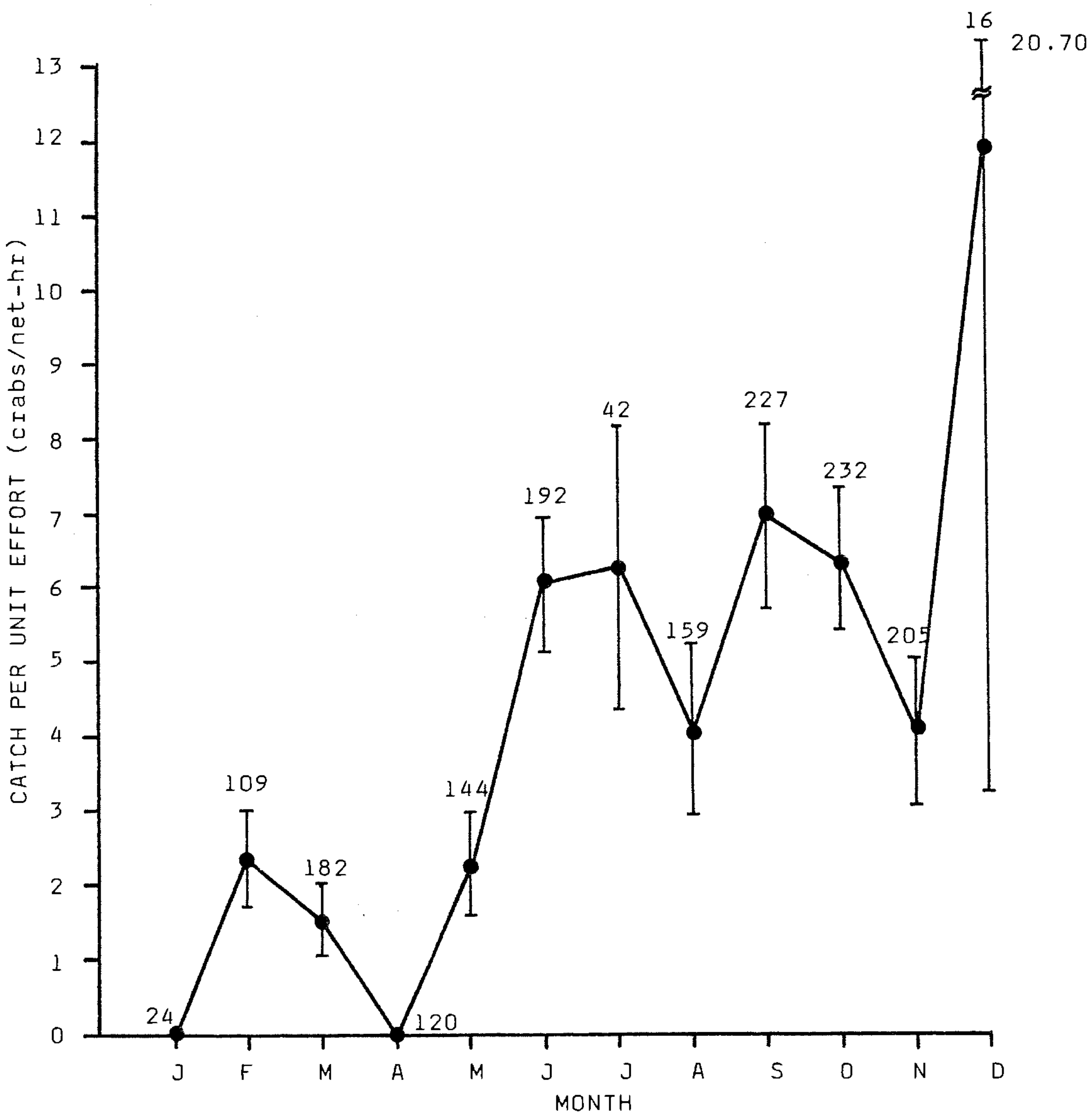


Figure 6 Seasonal variation in mean spanner crab catch rate (data from all blocks combined). Sample sizes are shown, and vertical bars represent 95% confidence intervals on either side of the mean.

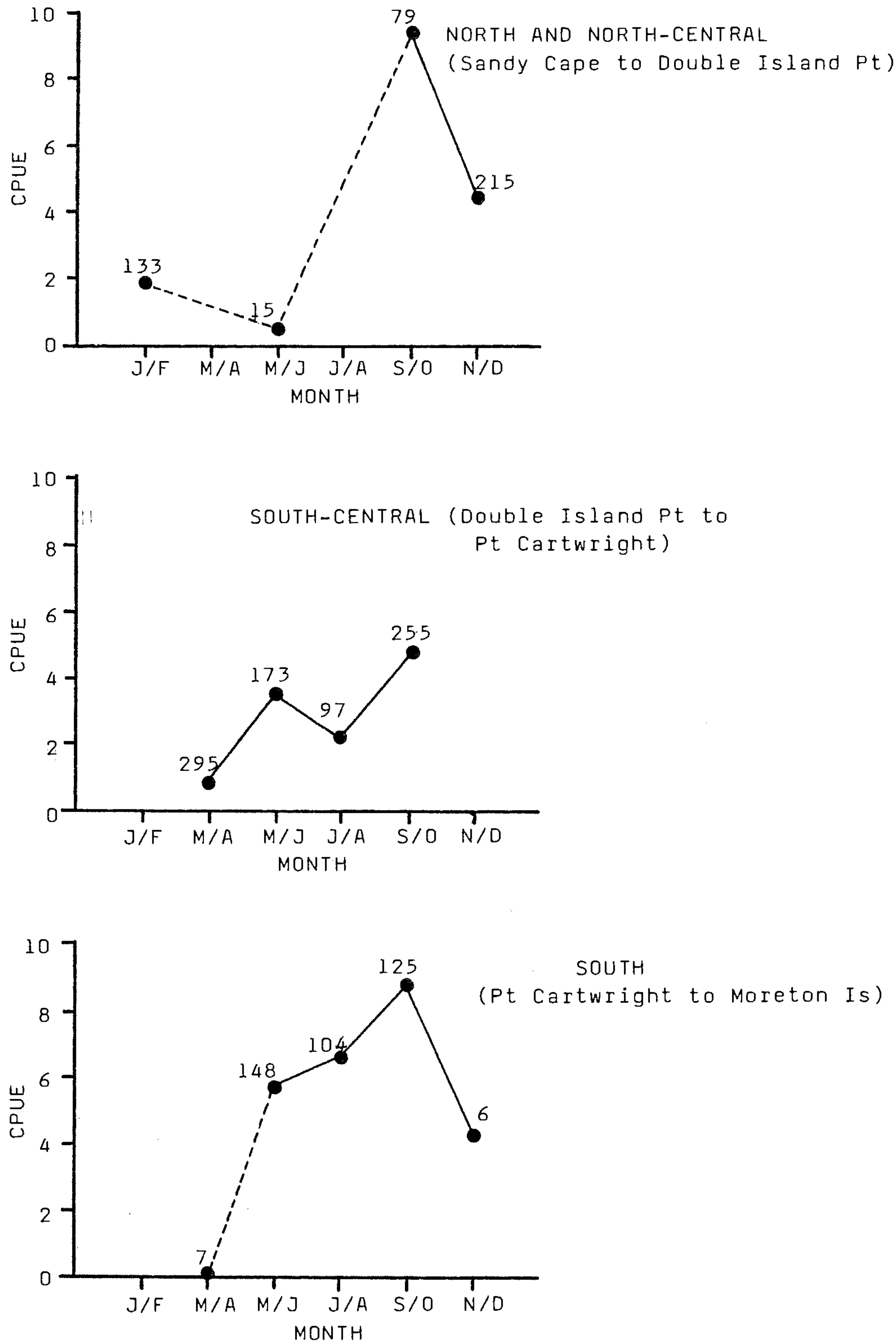


Figure 7 Seasonal changes in the catch rate of spanner crabs in three subdivisions of the study area.

4.4.3 Influence of Depth on CPUE

The depth-distribution of spanner crabs within the survey area appears quite distinct and straightforward. Disregarding possible complicating effects of season and locality, the CPUE data (grouped by 10 metre depth interval) are shown in Figure 8. No crabs were caught in the 25 effective drops in water shallower than 10 metres. The catch rate increased regularly in relation to depth, reaching a peak of 7.3 crabs/net hr in depths between 30 and 40m. A corresponding decrease in CPUE occurred in progressively deeper water down to about 70m, and in the 141 drops in depths exceeding 70m no spanner crabs were caught at all. It is pertinent to note that the mean CPUE of each depth sample was significantly different from that of its nearest neighbour, at least for depths less than 60m. This suggests that if there are any other factors influencing the depth distribution pattern, they will probably have an effect on magnitude, rather than direction. Figure 9 shows the pattern of depth-distribution of CPUE in three latitude zones. While the catch rates at all depth intervals appear higher in the southern zone than in either of the northern zones, the common form of the curves is clearly apparent.

An analysis of CPUE by depth-range and "season" simultaneously will clearly result in a certain lack of precision because of reduced sample sizes, but Figure 10 suggests that there are some slight seasonal effects in the depth distribution of the spanner crab stock. In autumn and early winter the best catch rate (more than 8 crabs/net hr) was recorded in the 40-50m depth zone. During the following three month period (July-September) the peak CPUE occurred in shallower water (30-40m), while the catch rates in 50-60m increased from less than 2 to about 6 crabs/net hr. Reasonable catches (>4 crabs/net hr) were still made in the shallowest depth range (<20m). The major change during October-December was a substantial decrease in the shallow water catch, and this was also apparent in the summer (January-March) sample. Very few crabs were caught during the summer period in depths greater than 50m, suggesting that the population is concentrated at that time in a fairly narrow depth band from about 30 to 45 metres.

4.4.4 Effects of Time on CPUE

Several commercial spanner crab fishermen are of the opinion that catch rates are best in the morning and drop off around midday. To test this hypothesis, the catch data were grouped in two hour time intervals and the mean CPUE calculated for each period. Catch rates (for all months and areas combined) were not significantly different after about 0900 hr (Figure 11), averaging approximately 4 crabs/net hr. Between 0700 and 0900 the mean CPUE was somewhat greater (5.4), while the few nets set prior to 0700 yielded a considerably poorer result (2.2).

However this trend did not appear to be consistent between grid blocks. Data from three blocks in which there was a relatively high level of sampling effort are also shown in Figure 11. The situation in block 1302 was totally different from the overall mean, with a fairly consistent upward trend in CPUE between 0800 and 1400 hr. The results from block 1202 approximated the overall average, but in block 0101 the highest CPUEs were experienced in the afternoon.

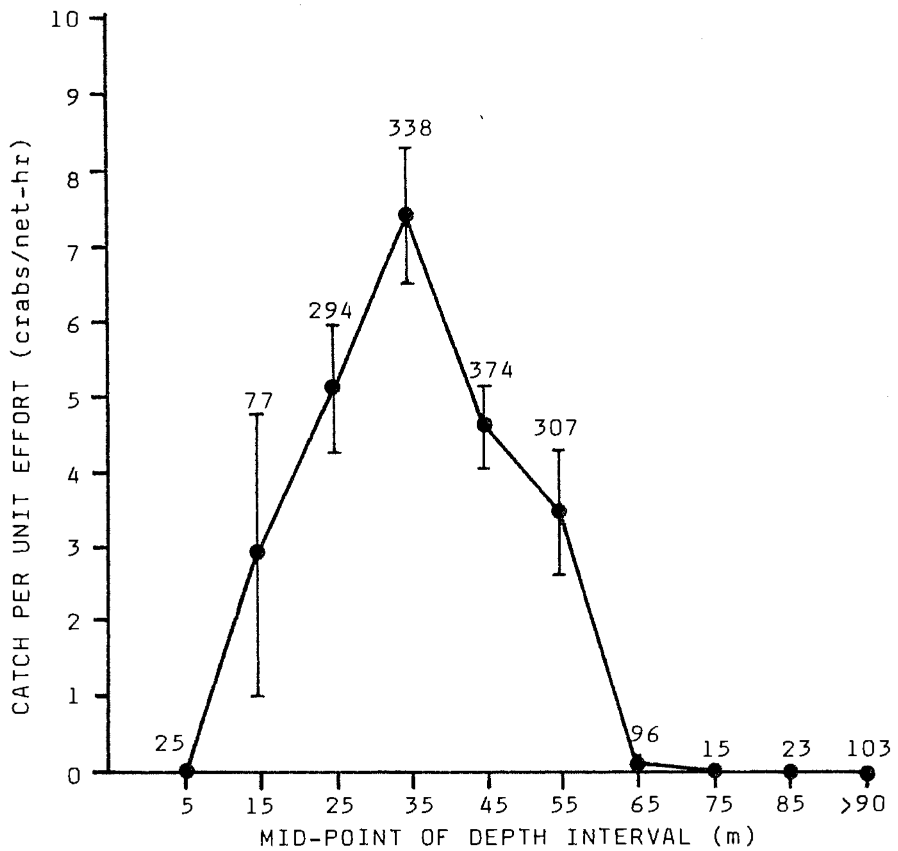


Figure 8 Relationship between depth and spanner crab catch rate. Data from all blocks and months have been pooled. Means, 95% confidence intervals and sample sizes are shown.

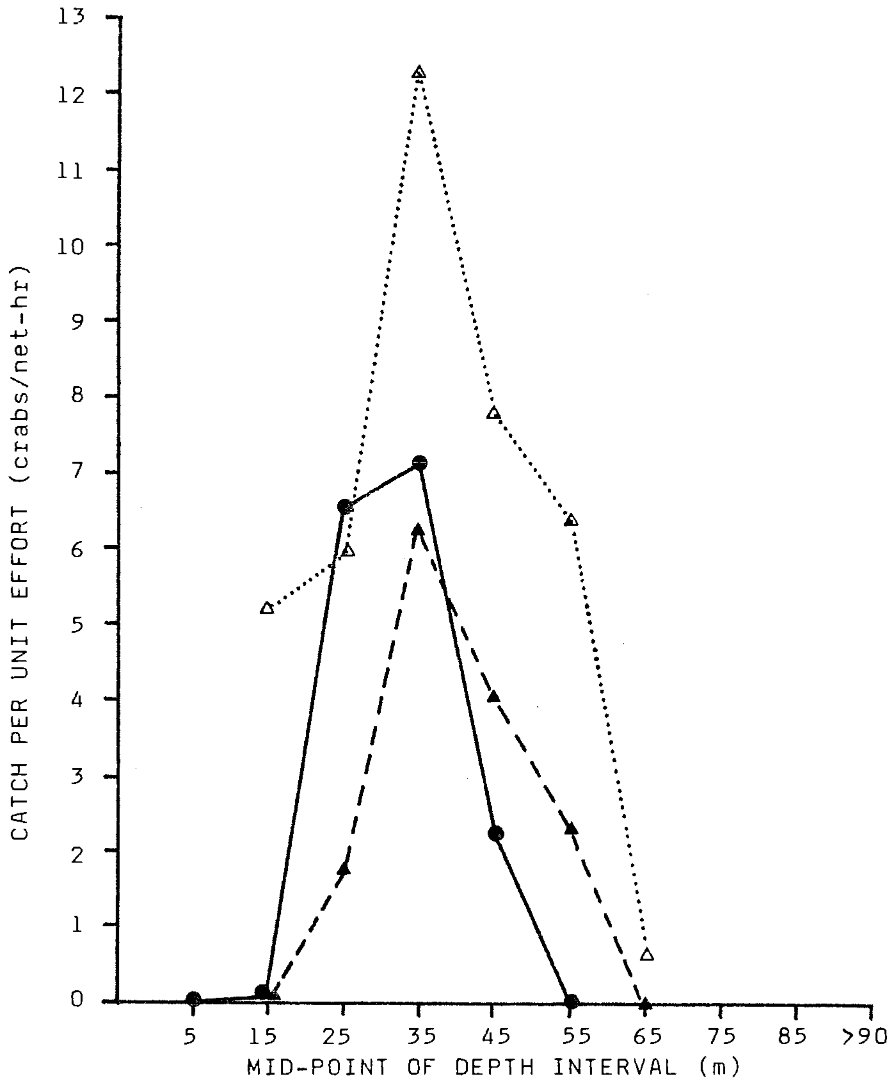


Figure 9 Relationship between spanner crab catch rate and depth in three zones of the study area.

●——● North and north-central
▲– – –▲ South-central
△........△ South

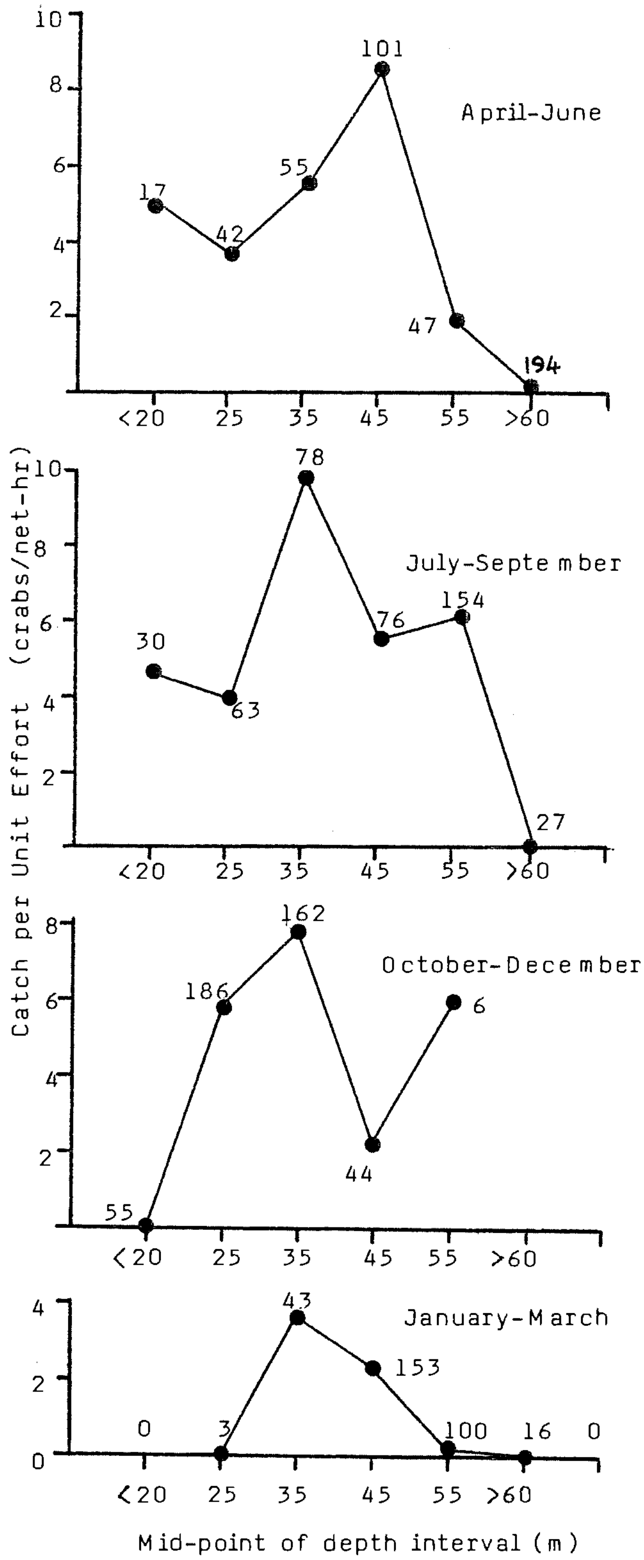
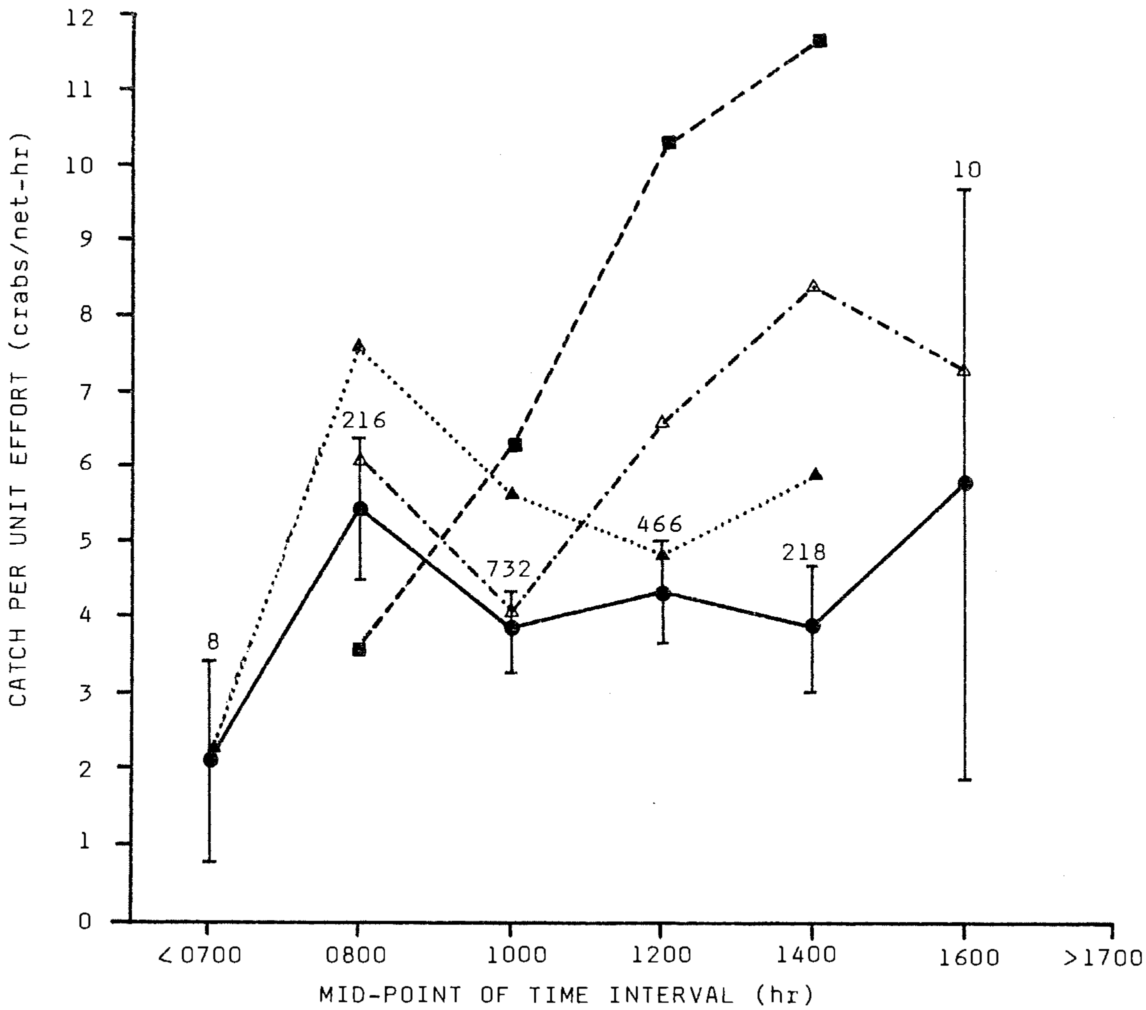


Figure 10. Seasonal changes in the depth distribution of Spanner crab catch rate (CPUE). Sample sizes are shown above the data points.



<u>Figure 11</u> Effect of time of day on the catch rate of spanner crabs. The grand mean rate is shown (solid line) with 95% confidence intervals and sample sizes. The other three curves represent the catchrate-time relationship in three individual grid blocks:

■— — — — —■ Block 1302
△—·—·—·—·△ Block 0101
▲··············▲ Block 1202

4.5 VARIATION IN SPANNER CRAB SEX RATIO

There is a marked dimorphism between the sexes in mature spanner crabs. Apart from the usual characteristics which distinguish male crabs from females, male spanner crabs are on average significantly larger than females. Insufficient is known at this stage to say whether this is due to a difference in growth rate and asymptotic size, or a sex-selective mortality favouring the survival of large males. The first explanation is considered the most likely, but whatever the reason, there is some commercial significance attached to this size-differential phenomenon since the proposed size limit of 10cm will effectively remove females completely from the (legal) commercial catch. It may thus be of considerable interest to the fishery to know if there are any variations in the sex ratio which can be identified with particular characteristics of depth, season or locality.

The total sex ratio (M:F) over all areas, months and depths, was 4.15:1. Throughout most of the year (March to October) the proportions remained rather stable at a little over 3:1, but in November the ratio increased dramatically to 32:1 (Figure 12). Given that the November CPUE was actually lower than that of the previous couple of months (see Figure 6), this increase in the proportion of males must have been due to a drop in the absolute number of females in the catch. Evidence from aquarium studies (D. Skinner, personal communication) suggests that female spanner crabs become quiescent and exhibit a much reduced level of general activity immediately prior to spawning. If this reduction in activity affects feeding behaviour, it seems quite likely that it could explain the paucity of females and hence the high sex ratio in the November catch. The only month in which the sex ratio fell below unity (i.e. females outnumbered males), was December, when the ratio was approximately 0.9. A possible explanation of this is that after some weeks of reduced feeding and the expenditure of more than usual amounts of energy during the final stages of egg maturation and spawning, the female crabs might require an unusually large food intake. The associated increase in foraging activity could render them particularly susceptible to capture.

Even though there are still no regulations governing the minimum size of spanner crabs that may legally be taken, many fishermen understand the biological and ultimate financial advantage of returning very small crabs to the water. Consequently a large proportion of the female component of the catch is liberated. It is therefore of interest to see if there are any differences in sex ratio between various parts of the study area, which includes regions subjected to a variety of exploitation levels from minimal to quite heavy.

Figure 13 shows the sample sex ratios from five zones of latitude. Although the northernmost group of grid blocks produced a sex ratio somewhat lower than that of the north-central group, a general trend in decreasing M:F ratio from north to south was evident. Bearing in mind that the main centres of commercial spanner crab fishing effort are in the south-central and southern zones, and that the population north of 26°10' is virtually unexploited, these differences may provide some idea of the extent to which the male crabs have already been "fished down" by commercial and recreational tangle netting activity. The data also support the view that the stock as a whole is not particularly mobile.

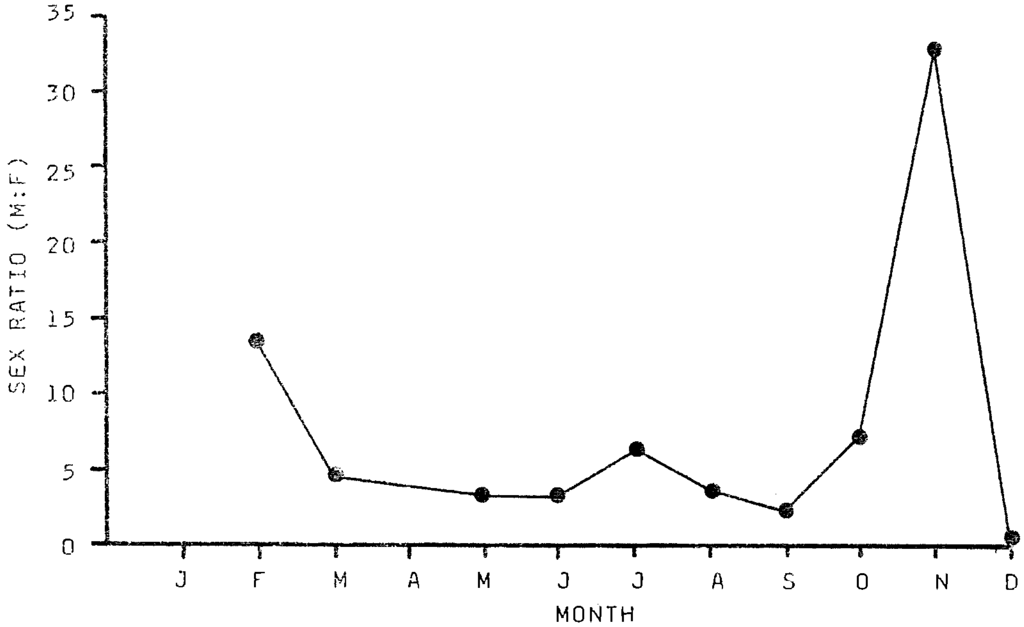


Figure 12 Seasonal changes in spanner crab sex ratio (M:F)

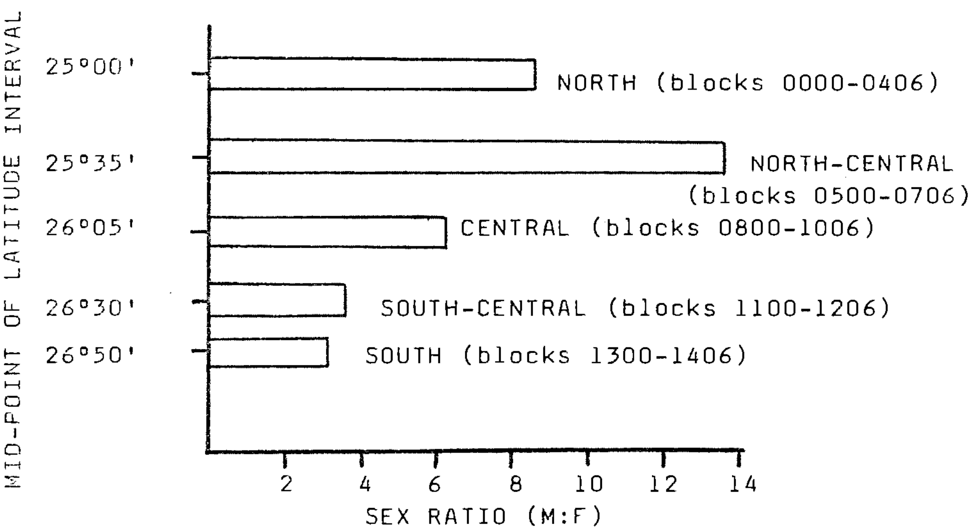


Figure 13 Geographical variation in sex ratio of spanner crabs.

4.6 DREDGING AND TRAWLING TRIALS

Soon after the project commenced it became clear that the baited dillies being used as the standard sampling units were selectively fishing the older age-classes in the spanner crab population. Very rarely did crabs less than about 6cm carapace length appear in the catch. In terms of commercial fishing activity this is obviously an advantage, because it means that small juveniles are not subject to heavy fishing mortality, and fishermen are not faced with the problem of having to clear large numbers of very small crabs from their nets. It does, on the other hand, present difficulties in identifying larval settlement times and localities, and obtaining reliable data on the length of the postlarval/ juvenile phase of the life cycle.

Prawn trawlers are known occasionally to catch considerable numbers of "matchbox-sized" spanner crabs at particular times of the year, in areas where they might be expected to appear in the baited dillies but apparently do not. In an attempt to obtain material and information about these elusive age groups the project team, in co-operation with SFRC personnel, ran a series of trials with other sorts of sampling devices including a small benthic dredge and a try net.

Dredge trials were carried out during December 1981 and September/ October 1982 in the area between Point Cartwright and Moreton Island. Sampling depths ranged from 5 to 45 metres and the dredge was towed over distances of up to 0.4km. No intact spanner crabs were taken in any of the 35 or so dredge samples, although on a couple of occasions some pieces of broken carapace appeared in the cod end, presumably as a result of severe damage to a live crab by the dredge teeth. There is no doubt that the dredge was fishing effectively on the bottom, as a wide range of benthic invertebrates including starfish, sea urchins, shells and small crabs of various species, as well as demersal fish such as flounders and flathead, were regularly encountered.

Failure of the dredge to catch juvenile spanner crabs prompted some experimentation with a "try net" (scaled down otter trawl) which was initially rigged, for ease of handling, as a plumbstaff beam trawl. Some 25 shots with the beam trawl during January 1983 yielded only one small spanner crab (about 30mm CL), and an occasional piece of broken carapace. Again the net was obviously fishing on the bottom, as numerous small crabs of various types, ophiuroids, starfish, sand dollars, shells and flatfish were captured. The trawl was towed for 20 to 40 minutes in depths between 10 and 40 metres off the beach south of Point Cartwright, and north of Moreton Island.

At the end of January the net was re-rigged, this time as an otter trawl with a pair of small boards attached by a bridle to a single towing warp. This configuration proved much more successful in catching spanner crabs. About 50 small individuals ranging in length from 41 to 58mm CL were captured in 17 trawl shots. Most of these were taken in 20m of water south of Point Cartwright during February and March, and were presumed to be "young of the year" resulting from the previous November spawning.

4.7 "BEACHED" SPANNER CRABS

A peculiar aspect of this species' behaviour, which still defies adequate explanation, relates to the occasional emergence of crabs on to the beach. Reports of such behaviour have come from several different reliable sources, indicating that crabs of a variety of sizes sometimes appear intertidally in (or on) the moist sand of beaches as widely geographically separated as Round Hill Head (24°10'S) and Yellow Patch, Moreton Island (27°02'S).

While working around the northern end of Fraser Island, the project team learned from local beach fishermen that considerable numbers of crabs could be collected from one or two small sand islands in the Breaksea Spit area north of Sandy Cape. The crabs were reputedly to be seen either buried in or walking over the moist sand above tide level. These reports were followed up by investigations of the area during a three week period in August/September 1982, and again in December the same year. Adult crabs of both sexes were seen on the sand island about 2km north of Sandy Cape in August and September. About 10 crabs were observed: some were discovered buried beneath a pancake-like disc of moist sand protruding slightly above the level of the surrounding beach, while others were seen wandering apparently aimlessly about on the beach. When disturbed, the crabs tended to bury themselves immediately and very quickly in the sand rather than try to escape by heading towards the sea.

During the visits in December (on one of which SFRC/FIRTA project staff were present), much more effort was put into searching the beaches from Sandy Cape west to Rooney's Point and then south to Wurtumba Creek along the shore of Platypus Bay. On December 2, 16 juvenile crabs (8 males, 8 females) were collected from the beach south of Rooney's Point. The remains of several others, which had apparently been attacked by sea birds, were also discovered. The individuals collected ranged in size from 42 to 51mm CL, and there did not appear to be any significant difference in size between the sexes. Later in December another 15 juveniles (8 males and 7 females; 38-58mm CL) were collected, mostly from the beach south of Rooney's Point. On average, these were a few millimetres longer than those in the previous sample.

The most interesting finding, however, was an abundance of juvenile spanner crab moult shells along the tide line. Nearly 180 intact carapaces, some as small as 14mm, were collected and measured. The small shells were particularly fragile, and innumerable broken pieces were also scattered along the tide line. The presence of juvenile moult shells has not been reported elsewhere, and to our knowledge this is the first substantiated evidence of the possible location of a larval settlement area. For such a large number of the frail shells to have survived being washed up on the beach by wave action, there is presumably a "nursery area" somewhere close to the northern end of Fraser Island, probably in shallow water on the Hervey Bay side of Breaksea Spit. It is interesting to note that, while live crabs were being picked up from the beach, dillies set in the shallows up to 500m from the same shore failed to catch anything whatsoever.

5. DISCUSSION

The catch rate for species other than spanner crabs was disappointingly low. It is possible that the type of gear in use during the project was not ideally suited to the capture of portunids (sand, coral and three-spot crabs) as their uniformly tapered leg segments are less prone to catching in the mesh than are the asymmetric terminal dactyli or "spades" of the spanner crabs. Notwithstanding this, we believe that if the population densities of these other species had been significant, then a far greater catch would have been obtained. Spider crabs, which appear to inhabit the deeper waters along the edge of the continental shelf and slope, were likewise either very sparsely distributed or not susceptible to capture by baited dillies. None of the deep water sets was done at night, and it is possible that this species is a nocturnal forager. However, even if it could be demonstrated that spider crabs can be caught during the hours of darkness, this would hold little attraction for the crab fishermen because of the impossibility of operating small vessels with any degree of safety in such exposed areas at night-time.

Spanner crabs have been reported from a wide range of localities throughout the Indo-Pacific region from Hawaii through Japan, the Philippines and northern Australia to east Africa. It is therefore not unreasonable to expect commercially fishable quantities of spanner crabs on other parts of the Queensland coast. Bottom conditions between Cape Moreton and Sandy Cape seem, from the admittedly sparse detail provided on Admiralty and bathymetric charts, to be fairly homogeneous. There are several systems of shoals, banks and reefs in the northern part of the survey area which are avoided by prawn trawlers, but there is nevertheless a good deal of flat trawlable ground in between. It was initially thought that these interstitial areas might prove to be quite productive spanner crab grounds, but it soon became apparent that there was much more rubble and gravel bottom than generally realised.

Although the project was not designed to collect environmental data, there was abundant evidence that spanner crabs have specific requirements in terms of substrate type. Reefy bottom was detectable from echo soundings, and often resulted in hook-ups and major gear damage or loss. In situations like that, reef fish occasionally became meshed in the dillies but crabs were very rarely caught. Rubble or gravel substrates could often be identified by the presence of sea urchins, pieces of stone etc. caught in the nets, and again the crab catches were exceptionally poor. By and large, this species of crab is found only on relatively clean, fine sand, which is not surprising considering its propensity for spending a large amount of time buried in the substrate. The non-uniform distribution of catch rates experienced across the survey area can therefore be attributed in large part to substrate heterogeneity.

The project data suggest that there is some seasonality in spanner crab catchability, higher catch rates occurring generally in the latter half of the year. Why apparent foraging activity should increase as ambient water temperatures decline is difficult to explain, unless it is associated with the onset of gonad maturation and reproductive behaviour patterns.

Population density showed a fairly consistent trend in relation to

depth, with intermediate depth ranges generally yielding the highest catches. The logical explanation for this is that crabs are most plentiful in areas of abundant food supply. Little is known at this stage about the animals' natural dietary preferences, but SFRC staff have found evidence of heart urchins and polychaete worms in the foregut inclusions of a number of spanner crabs. The only published reference to this species' (presumed) diet appears in "Guide to Fishes" (E.M. Grant, 1982) which indicates that they capture small live fish, but it seems highly unlikely that this is correct. Their obvious prediliction for a variety of dead fish baits suggests that, in addition to their natural food, spanner crabs may also utilise trash fish discarded by the many prawn trawlers working at night in the south-central and southern parts of the study area. It is interesting to consider the possibility that prawn trawling may actually benefit the crab stocks, and conceivably have allowed a previously sparse stock to build up to an exploitable level. Unfortunately there are no historical data with which to test this theory.

There is clearly a sub-population with commercial potential in the northern Hervey Bay region. The collection of ovigerous female crabs northwest of Rooney's Point and juvenile moult shells on the Fraser Island foreshore points to there being a spawning population and a "nursery area" in that region. We suspect that the stock could extend a good deal further north, perhaps as far as the Swains Reefs, but the present small boat fishing unit could not work these areas effectively because of the distances involved. Larger seaworthy vessels with a significantly greater payload capacity would be needed for such long trips to be economically viable. However since the project identified the existence of good quantities of crabs in northern Hervey Bay, at least one local fisherman has started to exploit that part of the stock.

Commercial crabbers often complain about gear damage and loss from shark and turtle attacks. During the survey some gear was lost or ruined as a result of these predators eating the bait and/or crabs out of the net, sometimes severing the buoy-line in the process. The main areas where this problem occurred were Hervey Bay and in the vicinity of the Freeman Channel northwest of Cape Moreton. Predator attack is probably more frequent in the commercial operation where, once a productive area is located it is fished intensively, and discarded small crabs may tend to attract sharks and turtles to the fishing area. Gear losses also occurred when occasional sudden increases in tidal current dragged the surface floats underwater.

Localised intensive fishing by commercial operators may explain the alleged drop in catch rates around midday. Survey results indicated a high degree of variation in the relationship between catch rates and time of day, but there was no consistent evidence of a noon decrease when the nets were always reset in different localities.

Project personnel believe that it is high time some management controls were introduced into the spanner crab fishery. Several recommendations (including a minimum legal size of 10cm, an amateur bag limit, and a prohibition on the taking of ovigerous females) were made as long ago as 1981, but these have yet to be implemented. We also believe that commercial fishermen who are not already doing so should be urged to use monofilament fabric in their nets, as experience has shown that the least amount of damage to meshed crabs occurs with monofilament webbing of less than 50mm stretched mesh.

OFFSHORE CRAB RESOURCES SURVEY: FIELD DATA SHEET

DATE: ___ (yr) ___ (mo) ___ (day)   GRID Nº: ______

Gear condition code
0 : no damage   1 : slight damage
2 : major damage or loss

Other crab species codes
1 : sand   2 : spider
3 : three-spot   4 : coral
5 : mud   6 : any else

SET Nº	BUOY Nº	DEPTH (metres)	TIME OF SET	TIME OF LIFT	GEAR	SPANNER CRABS Nº males	SPANNER CRABS Nº females	SPANNER CRABS Nº berried	OTHER CRABS code	OTHER CRABS Nº	OTHER CRABS code	OTHER CRABS Nº	OTHER CRABS code	OTHER CRABS Nº	COMMENTS

Appendix 1. Field data recording sheet used during the project.

7 22.10.81

Appendix 2. Sample listing of part of the project field data-base held on floppy disk at DPI's Southern Fisheries Research Centre, Deception Bay.

Year, Month, Day, Block No., Set No., Buoy No., Depth (m), Set time, Lift time, Gear condition code, Males, Females, Oviger-ous (Spanner crabs), Code, No., Code, No., Code, No. (Other species)

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FIRTA PROJECT 81/17

ASSESSMENT OF OFFSHORE CRAB RESOURCES IN SOUTHERN QUEENSLAND

FINAL REPORT

TO THE FISHING INDUSTRY RESEARCH COMMITTEE

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October 1983

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1. INTRODUCTION

The existence of several edible crab species in southern Queensland offshore waters has become known as a result of the activity of trawlers, which take coral crabs, spanner crabs and spider crabs as a by-catch in their prawn nets. While the quantities of crabs caught by trawlers is rarely very large, evidence from the recently established spanner crab fishery suggests that the trawl catch is not necessarily a good indicator of the size of the crab stock.

The spanner crab fishery was initially rather localised in the areas off Mooloolaba and northwest of Moreton Island. Very little was known about the geographical distribution of the stock, but the bathymetry of the shelf and the substrate types recorded on various navigational charts suggested that the potential fishing grounds might be quite extensive. Prior to the Project's commencement, the question of the size of the crab resource was of great interest to spanner crab fishermen. Clearly, if the resource was limited geographically the stock would probably be small, and the fishery might not be able to develop to any great extent. The "worst case" situation may be that even moderate fishing pressure could force the stock down to a level where commercial fishing would be uneconomic.

Commercial spanner crab fishermen at that stage had not reported catching significant numbers of crabs other than spanner crabs in their tangle nets. However, it was considered that an investigation covering a broader area and range of depths may indicate whether or not the other species were present in quantities sufficient for a commercial operation using the same sort of gear. Additionally, a survey of this type could provide some useful information on the distribution and abundance of spanner crabs which are currently being subjected to locally intense, completely unregulated exploitation.

Offshore crab fishing operations in southeast Queensland would face a number of constraints - not the least important being the need to compete with the well established estuarine sand crab *(Portunus pelagicus)* and mud crab *(Scylla serrata)* fisheries. While there is some evidence that mud crab catch rates are declining, Queensland DPI Fisheries studies have indicated that the total annual catch is fairly steady. The landed sand crab catch is probably increasing as more and more trawler operators are finding it financially beneficial to market their by-catch. Moreover the offshore crab fishery is attractive to commercial fishermen because of the small scale of the operation (and hence the need for minimal capital investment), but precisely for this reason the fishing unit is highly subject to local weather patterns. Thus, to enter a competitive market and introduce unfamiliar species caught in an area where weather conditions can severely restrict fishing time, large catches of crabs would need to be obtained, at least until the market was established. On the other hand, such a fishery would be a very attractive proposition to fishermen presently involved in other small scale seasonal fisheries.

This project was aimed at determining which edible crab species could be caught in commercial quantities by the small boat operator in the area from Stradbroke Island to Sandy Cape, and to provide a better understanding of how the potential stocks (if any) are distributed with respect to seasonal and geographic factors. A concurrent FIRTA project (under the direction of Fisheries Research Branch personnel) was oper-

ating in a more restricted area to investigate in greater detail the population structure and biology of one of the species in question. The two project teams liaised continuously and worked co-operatively on some specific problems.

2. THE SURVEY AREA

The study area included a length of coastline extending some 170 nautical miles (315km) from Point Lookout, Stradbroke Island (27°26'S) to Sandy Cape, Fraser Island (24°42'S). A small section of the north-eastern part of Hervey Bay was also incorporated in the study area. The region was divided into 10' x 10' grid blocks from 152°50'E beyond the 100m isobath to 154°00'E. The original intention was to sample every block in which there was a sufficient depth of water (excluding those within Moreton Bay), at least out to the 100m depth contour. There were, theoretically, about 60 grid blocks amounting to a total area of 18,480 sq. km which fell within these criteria (Fig. 1).

The slope of the continental shelf ranged from about 1:90 immediately east of Cape Moreton to 1:630 off Double Island Point. Bottom sediments consisted primarily of sand, with patches of reef and heavy gravel or coral rubble bottom. Currents and tidal streams were variable, the dominating factor being a general southerly set resulting from the East Australian Current. Tidal flows were significant in the vicinity of bars, bays, river mouths and headlands, and strong currents were often experienced in deeper water towards the edge of the continental shelf.

3. MATERIALS AND METHODS

3.1 THE PROJECT VESSEL

A 24' welded alloy hard-chine "StarFlite" fishing boat powered by a 185HP "Mercruiser" stern-drive petrol engine was used for the survey. With a fuel capacity of 300 litres and a cruising speed of about 25kt, the vessel had an operating range 200 nautical miles. Initially a small electric line-hauler was used, but the need for very long buoy-lines when working in deep water (>100m) required a hauler of greater capacity. An hydraulic drum winch capable of hauling and stowing 1.2km of 5mm synthetic rope at 1.3 metres/sec. was constructed by a local company and mounted on the transom so that the trap-lines could be set directly over the stern. Additional equipment carried on the vessel included a "GME" 27 MHz radio and a "Fuso 1800" echo sounder reading to 280m.

3.2 FISHING GEAR

The gear used throughout the project was essentially a series of baited tangle nets (locally known as inverted dillies or "witches' hats") of a design similar to that used at the time by commercial spanner crab fishermen in the Mooloolaba area. Each net consisted of a 1-metre

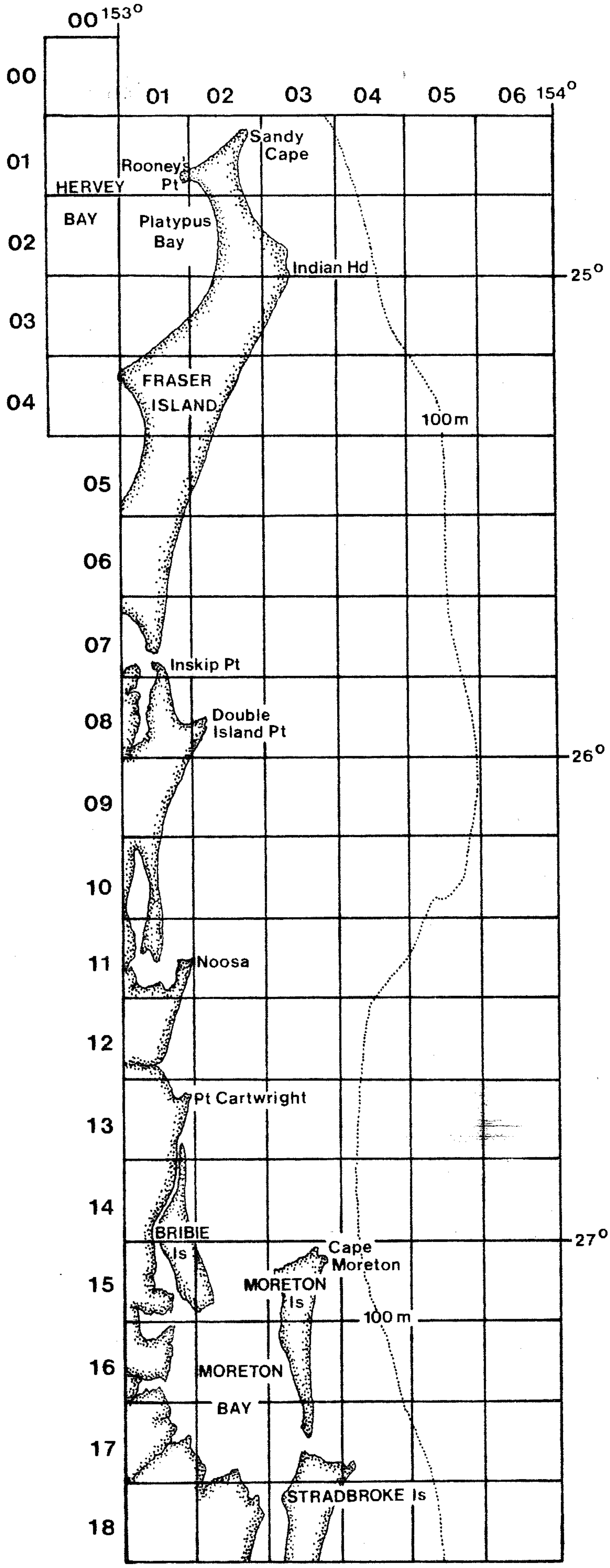


Figure 1. Chart of the survey area showing position of the 100 m depth contour.

diameter ring made from 12mm steel reinforcing rod and covered with a loose layer of synthetic multi-filament mesh. The mesh was gathered in the centre and supported by a small cork net float forming a low cone (Fig. 2). Although various mesh sizes from 25 to 100mm were tried, the optimum range was found to be between 35 and 50mm. The smallest mesh sizes (<30mm) appeared to catch fewer large crabs, while large mesh webbing (>50mm) tended to tangle the crabs excessively, making it difficult to clear the nets and resulting in greater damage both to the crabs and to the fabric.

Since the commencement of the project commercial crab dilly design has undergone a process of evolution, and now most operators use the flat Hawaiian-style nets with webbing stretched tightly over the metal frame. Conical dillies, however, were used throughout the duration of the project to ensure continuity of sampling effort.

In addition to the standard sampling gear, a small dredge (fabricated by Fisheries Research Branch staff) and a scaled-down trawl net were used in an attempt to capture juvenile crabs which for some reason do not appear to be taken in the dillies. The 70 x 30 x 80cm metal frame dredge was equipped with a set of 5cm steel teeth projecting from the lower leading edge, and a 30mm mesh bag or cod-end attached inside the front edge of the frame.

3.3 FIELD OPERATIONS

Weather conditions usually dictated which area could be fished on any given day. Having reached the desired grid block by dead-reckoning navigation, the vessel's position was checked by reference to depth soundings and compass bearings on identifiable landmarks. The dillies were then baited and set, typically in a line of eight dropped about 150m apart. The direction of set was usually determined by sea conditions. As each individually numbered marker-buoy was dropped, a note was made on the field data sheet (see Appendix 1) of the depth and time of set. The soak time, or length of time the nets were left fishing, varied to some extent, but averaged 0.86 hr (approx. 50 minutes). As the nets were lifted, the time of retrieval was recorded. An assessment was made of the condition of each net, and if there was any noticeable damage an appropriate code was entered on the field sheet. The crabs were then removed from the net, counted, and in the case of spanner crabs, sexed. Female spanner crabs were also examined to determine whether or not they were carrying eggs, and the relevant data recorded. After the complete set had been lifted, the vessel was moved 3 or 4km away and the nets reset. The whole process was continued (usually in the same grid block) for the remainder of the day, or until the weather made conditions unworkable.

3.4 DATA STORAGE AND ANALYSIS

All field data except those relating to the dredge and try-net trials were keyed on to disk file by staff at the Southern Fisheries Research Centre, Deception Bay. A sample listing of a portion of the database is attached (see Appendix 2). Analyses of the survey data were carried out by one of the authors (IWB) using specifically developed

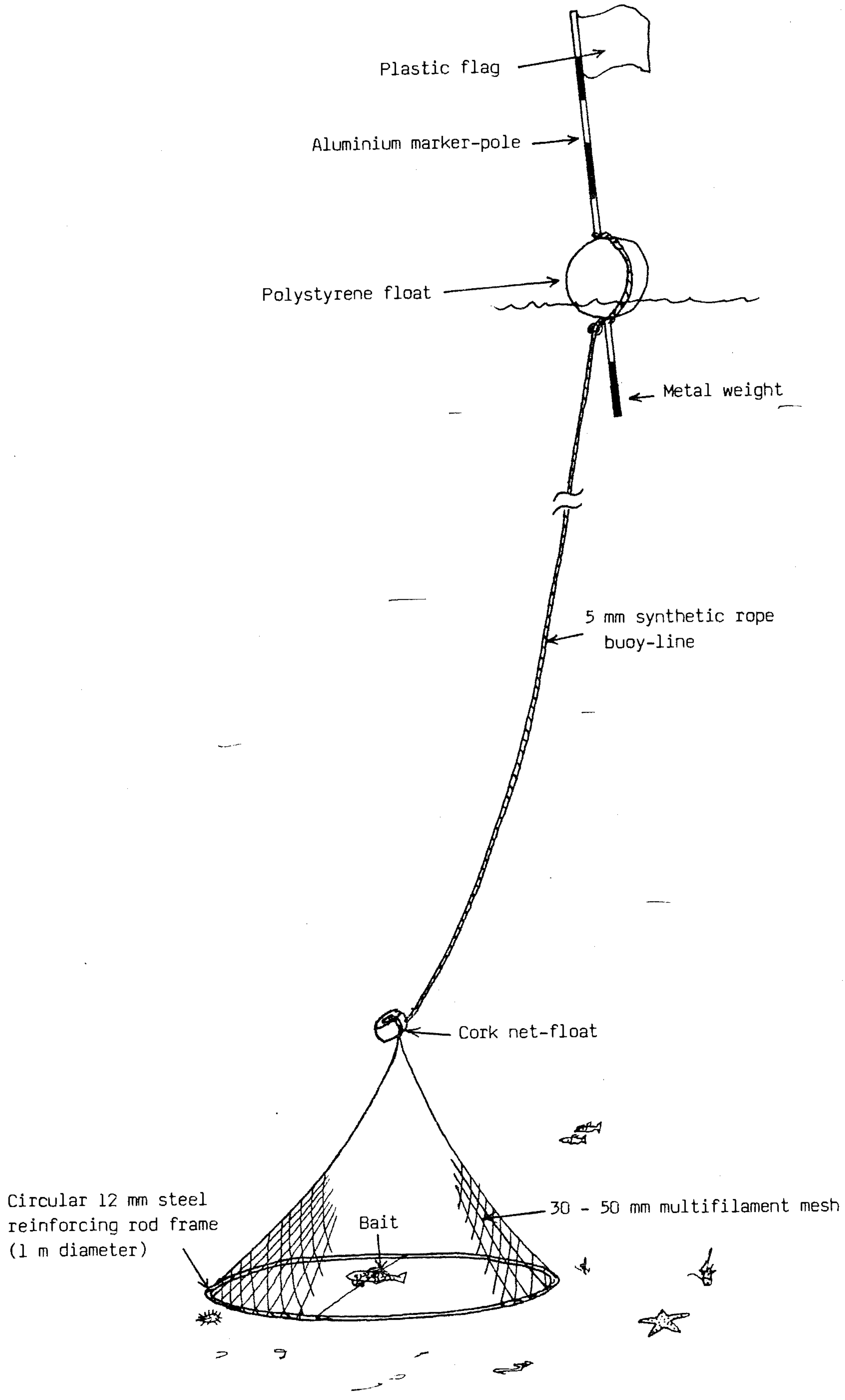


FIGURE 2. Semi-diagrammatic representation of a typical spanner crab dilly of the type used during the project. (not to scale)

BASIC software on an SR-72 floppy-disk based 64K microcomputer at SFRC.

A realistic idea of apparent stock density or relative abundance can only be gained by comparing catch rates, or catch-per-unit-effort indices (CPUE). Because of the need to take account of varying soak times, the computed CPUE was not simply the total number of crabs divided by the total number of drops, but incorporated an adjustment to standardise the catch to a 1-hour time base. Given the range and distribution of both soak times and CPUE data, it was considered statistically reasonable to treat the adjusted catch rates as individual variates for the purpose of computing means. This also allowed the calculation of sample variances and confidence intervals, enabling an assessment of the significance of differences between means.

4. RESULTS

4.1 DISTRIBUTION OF FISHING EFFORT

Sampling was carried out in 35 ten-minute square grid blocks covering an area of approximately 10,815 sq. km. As can be seen from Fig. 3 the amount of sampling effort (as measured by the number of drops) varied considerably from block to block. The area east of Fraser Island could not be sampled effectively because of large expanses of reef and heavy rubble bottom. Distance and travelling time from the nearest safe port also presented problems, and the Tin Can Bar at Inskip Point could often not be crossed due to foul weather. The paucity of information from that area represents an unfortunate gap in the project data, although this is compensated for to some extent by additional sampling in the northeast part of Hervey Bay.

The total number of drops (1,865) represents an actual fishing effort of about 1,490 net hours. However, some of the nets set were either lost completely or damaged as a result of hook-ups or attack by sharks and turtles, and in a few cases the times were not recorded. In all, a little over 11% of the records were "doubtful" (for the above reasons) and were therefore excluded from the subsequent analysis.

4.2 FACTORS ADVERSELY AFFECTING THE PROJECT

Two factors - the weather and mechanical problems with the vessel - had a detrimental effect on the conduct of the Project.

It was found difficult, if not impossible, to work in winds exceeding about 15 kt. With the exception of the northwest shore of Fraser Island, the entire project area is very exposed to prevailing southeast and northeast winds. Even short periods of freshening wind can whip up a surface chop which is very uncomfortable and potentially dangerous to small vessels. Moreover such conditions make it difficult to locate marker-buoys, and this can often result in the loss of gear. Bad weather thus accounted for a large number of lay-days during the project period.

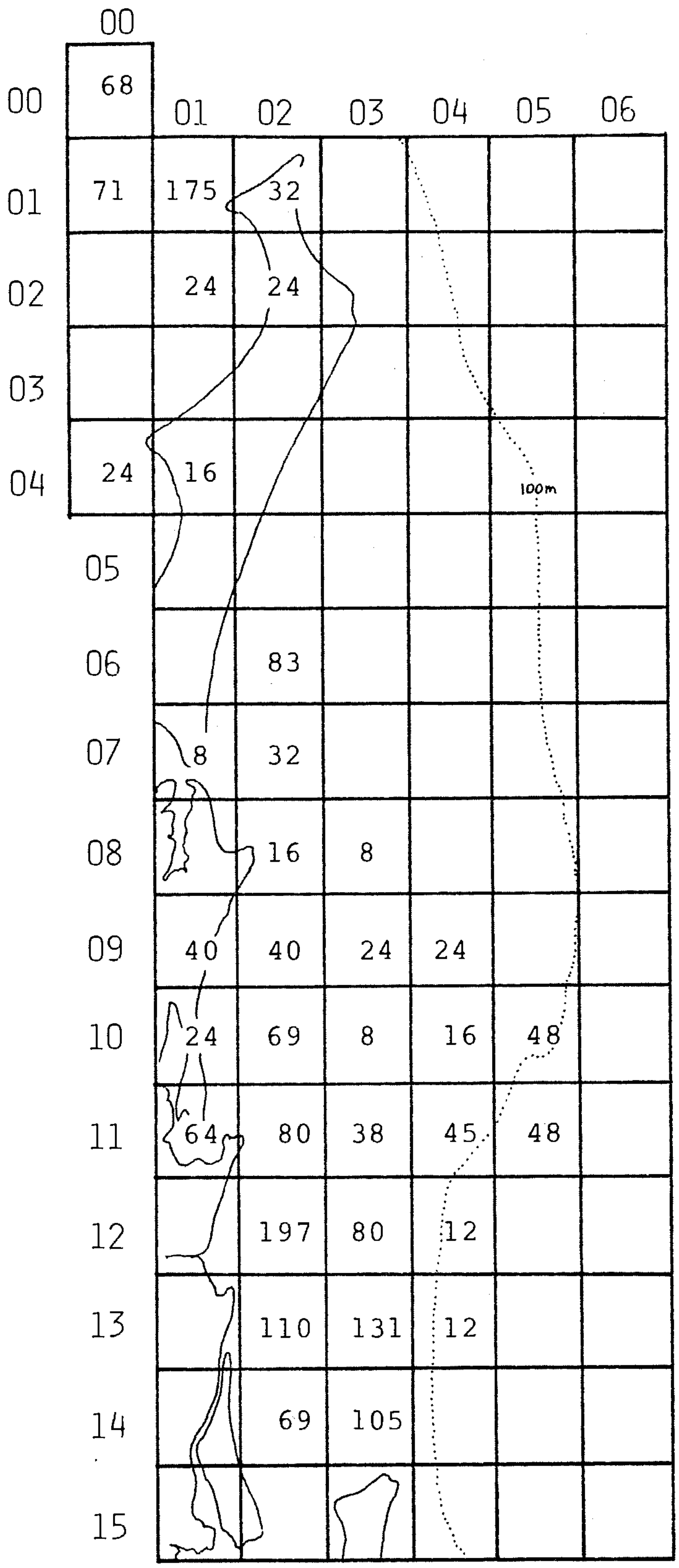


Figure 3 Geographical distribution of sampling effort (total numbers of drops) throughout the study area.

Problems with the vessel's motor and stern drive unit were also responsible for a significant loss of fishing time. One incident involving a broken camshaft resulted in the vessel's being out of operation for nearly 10 weeks while parts were located and shipped from the USA. However during this period some experimental work was able to be carried out with the assistance of an obliging commercial fisherman at Mooloolaba.

4.3 SPECIES COMPOSITION OF THE CATCH

Spanner crabs were by far the most abundant species taken in the dillies, nearly 6,000 individuals having been caught in 1,652 effective drops. A more detailed analysis of the distribution and abundance of this species appears subsequently. The other crab species represented only an insignificant "by-catch" and the apparent size of their stocks indicates that they are unlikely ever to become target fisheries in their own right.

4.3.1 Sand Crabs *(Portunus pelagicus)*

Despite their abundance and commercial importance in Moreton Bay, inside the North Banks east of Bribie Island, and in parts of Hervey Bay, sand crabs were caught surprisingly rarely during the survey period. A mere 42 individuals appeared in the catch, from a variety of depths ranging from 9 to 71m (Table 1). There was no apparent significance either in the localities or the times at which these crabs were caught. It is interesting to note that prawn trawlers operating in offshore waters catch sand crabs regularly. While such catches are not great, they certainly exceed the spanner crab trawl catch. A possible explanation for this might be that *P. pelagicus* is more active at night (when most of the offshore trawlers fish for prawns) than is *R. ranina*, which, from our accumulated experience, appears to feed during daylight hours. Dillies designed for recreational sand crab fishing generally have a rather larger mesh size than typical spanner crab nets because sand crabs are not as readily meshed by their (slender) legs, and a large mesh is needed to entangle their carapace spines. This may also account for the lower dilly catch of this species in offshore waters.

4.3.2 Three-spot Crabs *(Portunus sanguinolentus)*

The total catch of this swimming crab was only slightly greater than that of its congener *P. pelagicus* (Table 2). Again, there did not appear to be any recognisable pattern to its distribution with respect to depth, season or locality, although they seemed slightly more abundant in the northern part of the study area than in the south.

4.3.3 Spider Crabs *(Cyrtomaia sp.)*

Contrary to initial expectations, the total catch of spider crabs was effectively zero. Only two were caught; both on 3.9.81 in block 1104.

Table 1. Numbers of sand crabs caught during the project period, showing localities, dates and depths.

BLOCK	DATE	DEPTH (m)	NUMBER
0101	21.10.82	24	2
0101	21.10.82	34	1
0101	21.10.82	31	3
0101	9.11.82	31	2
0602	16.2.82	44	1
0602	16.2.82	45	1
0602	17.2.82	47	2
0602	18.2.82	47	1
0701	11.2.82	41	1
0702	12.2.82	44	1
0901	30.10.82	44	1
0904	20.4.82	71	2
1002	18.9.81	55	1
1101	25.6.82	25	2
1103	17.6.82	62	2
1103	17.6.82	63	1
1202	30.7.81	9	1
1203	10.3.82	56	1
1302	13.5.82	43	3
1302	13.5.82	45	2
1302	9.6.83	45	1
1302	9.6.83	44	1
1303	28.7.81	57	2
1303	29.6.82	62	2
1303	29.6.82	60	4
1403	12.8.81	49	1

<u>Table 2.</u> Numbers of three-spot crabs caught during the project period, showing localities, dates and depths.

BLOCK	DATE	DEPTH (m)	NUMBER
0101	9.11.82	30	1
0602	15.2.82	44	1
0602	15.2.82	46	1
0602	16.2.82	43	1
0602	16.2.82	44	1
0602	17.2.82	46	2
0602	18.2.82	46	2
0701	11.2.82	40	2
0701	11.2.82	41	1
0702	12.2.82	40	1
0702	12.2.82	42	1
0702	12.2.82	44	2
0702	12.2.82	45	1
0702	12.2.82	46	1
0901	30.10.81	38	1
0901	30.10.81	30	1
0901	30.10.81	45	1
0902	30.10.81	33	1
0903	7.5.82	60	1
0904	20.4.82	68	4
0904	20.4.82	67	1
1001	29.10.81	33	1
1101	26.5.82	30	2
1101	26.5.82	22	1
1101	25.6.82	28	6
1101	25.6.82	23	1
1101	25.6.82	22	5
1202	30.7.81	9	1
1202	30.7.81	10	2
1302	10.5.82	11	2
1302	10.5.82	15	1
1403	24.8.81	23	1
1403	24.8.81	19	1
1403	24.8.81	18	3

This block includes the 100m isobath, and the specimens were collected from 106 and 112m on the edge of the continental slope. While the amount of fishing effort expended in this depth zone was far less than in shallow and intermediate depths, the 103 effective drops in water deeper than 90m failed to yield anything but these two crabs.

4.3.4 Coral Crabs *(Charybdis cruciata)*

Throughout the entire project period only one coral crab appeared in the catch. This individual was captured in 20m on the Hervey Bay side of Fraser Island (block 0202) on 21.11.81.

4.3.5 Other Species

In addition to the edible crab species listed above, numerous small non-commercial crabs (mainly *Matuta sp.*) were meshed, particularly in the shallow water shots.

4.4 SPANNER CRAB ABUNDANCE/CATCHABILITY PATTERNS

The total catch of spanner crabs from 1,652 effective drops (equivalent to a total soak time of 1,409.7 net hours) was 5,775. Of these, 4,647 were males, and 1,120 (including eight ovigerous crabs) were females. The overall catch rate or catch-per-unit-effort was 3.5 crabs per drop or, more reliably, 4.1 crabs per net hour.

4.4.1 Geographic Influences

The catch (numbers of crabs) taken in each of the grid blocks fished is shown in Figure 4. Obviously much of the variation in catch can be accounted for by differences in the amount of sampling effort as illustrated in Figure 3. However, Figure 5 clearly indicates that catch-per-unit-effort was far from uniform throughout the survey area. Average catch rates per block varied from zero in the deepest water sampled to 11.42 crabs/net hr in block 1402 northeast of Bribie Island. This particular block is part of the area currently being fished commercially. The next highest CPUE was recorded in block 0000 northwest of Sandy Cape (in the northern part of Hervey Bay) where no prior commercial exploitation had taken place.

The most consistently productive area was between 26°30'S and 27°00'S, in depths from 20 to 50 metres. This is the region where most of the commercial spanner crab fishing effort is concentrated. Catches in the vicinity of Noosa Heads were poor, but further north off Cooloola and the Coloured Sands the mean CPUE indicated exploitable concentrations of crabs. Around Double Island Point (25°55'S) crabs appeared to be particularly scarce, although it must be pointed out that sampling effort was very low in this region (see Figure 3), and the results may not be entirely indicative of the actual situation. A small number of crabs was caught in block 0702 east of Inskip Point, and a reasonable number

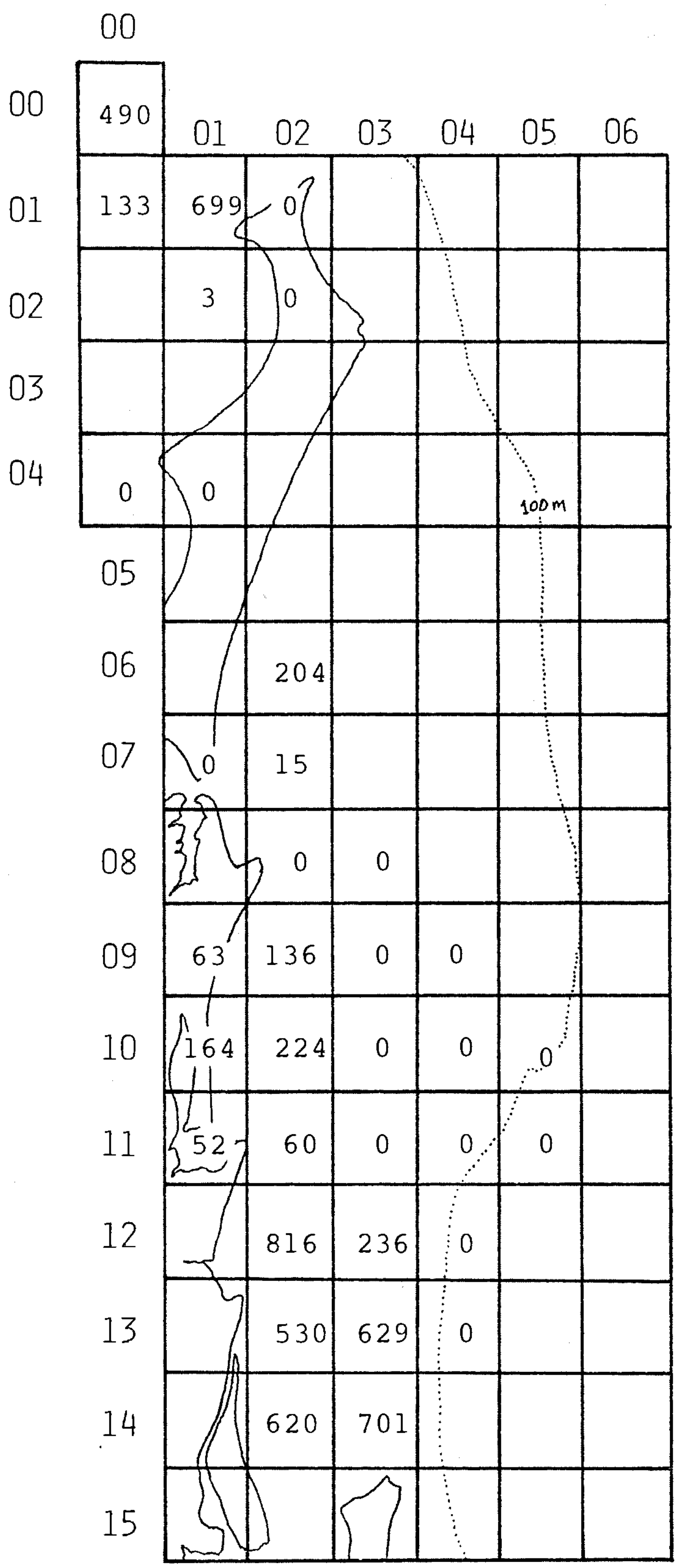


Figure 4 Geographical distribution of the total catch of spanner crabs (numbers of crabs, M+F).

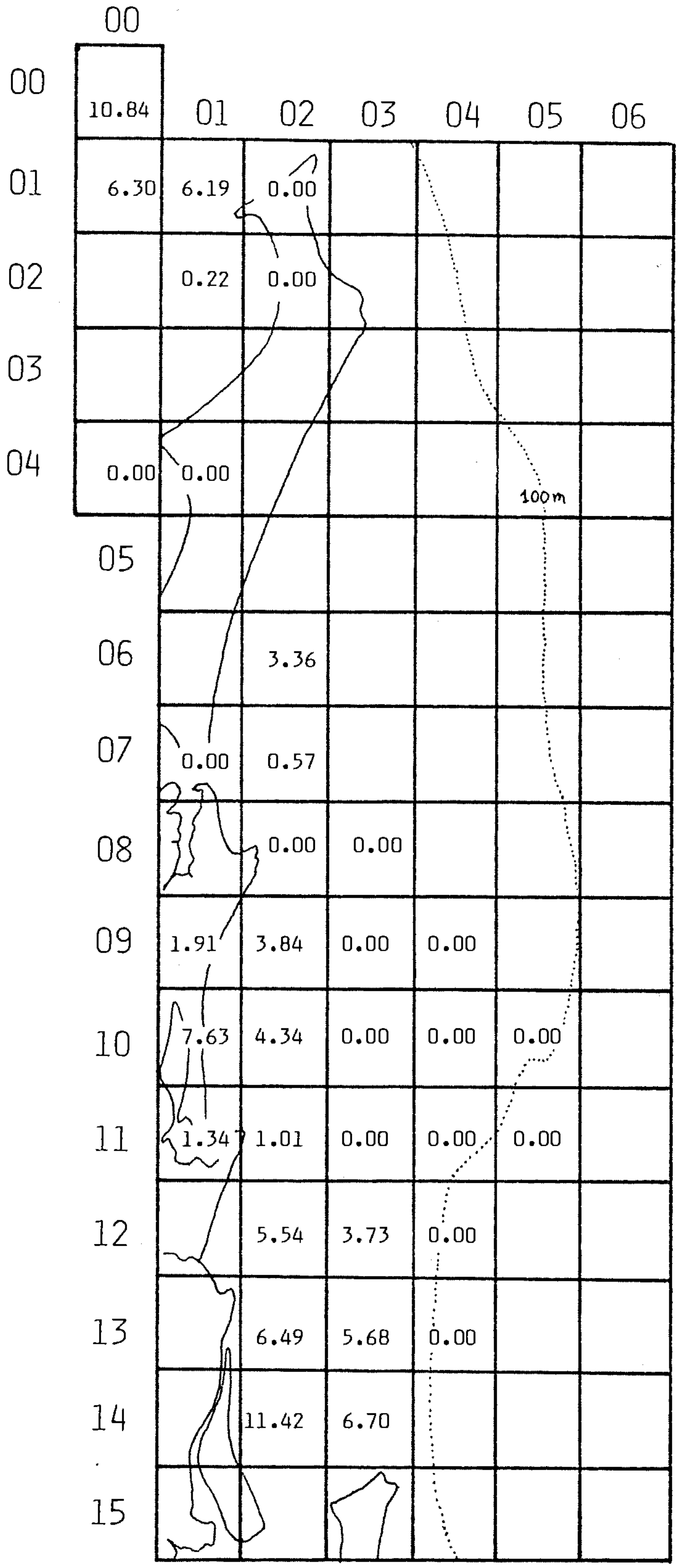


Figure 5 Geographical distribution of apparent stock density of spanner crabs as measured by catch per unit effort (CPUE = numbers of crabs [M+F] per net-hour).

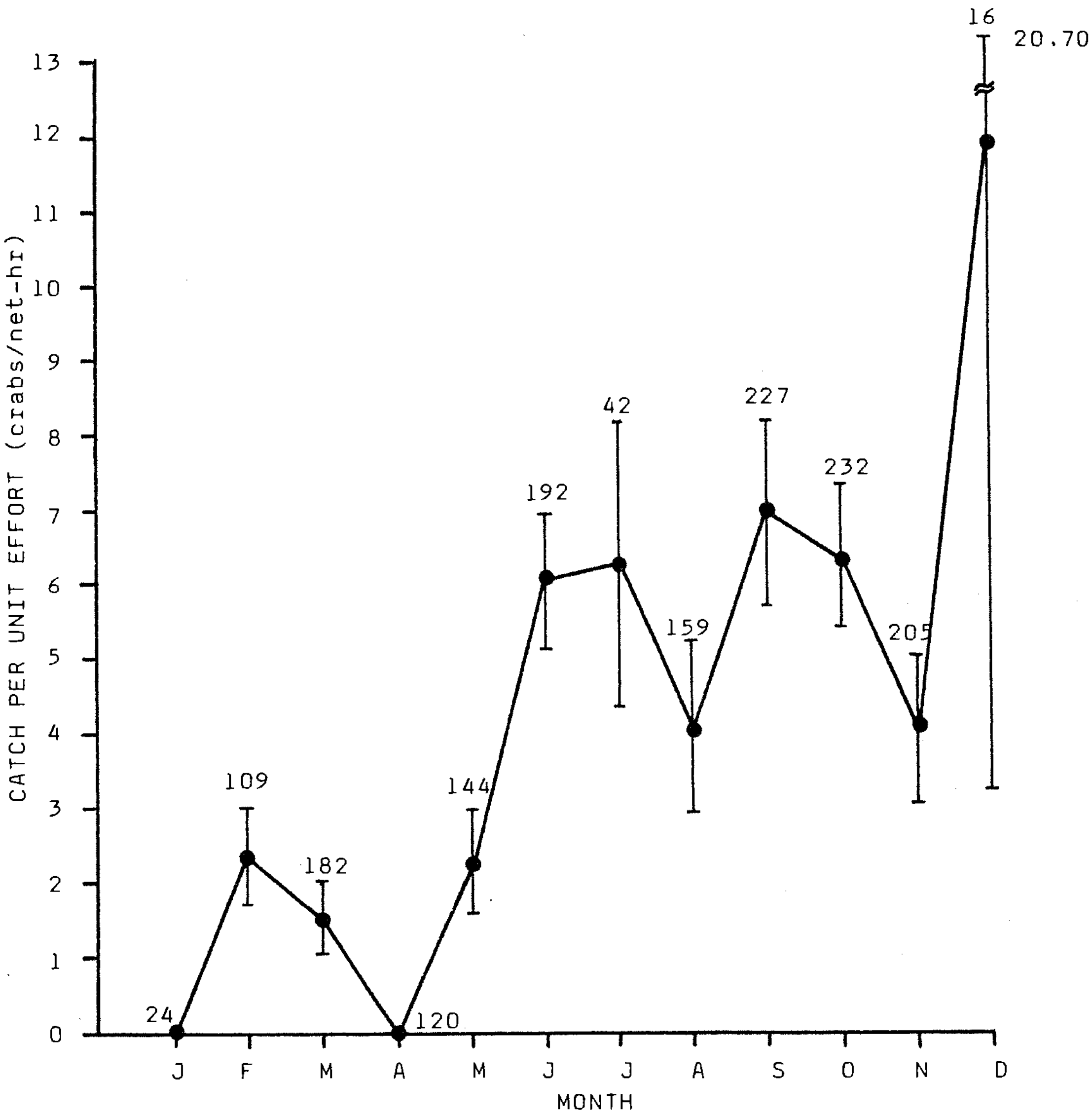
appeared in the adjacent block to the north, off the southern end of Fraser Island. Here a total of 71 effective drops yielded 204 crabs, 189 of which were males. The catch rate of about 3.4 crabs/net hr in this block indicates a sufficient abundance for commercial exploitation, although the area is remote and really only accessible to boats based at Tin Can Bay.

No crabs were caught in the shallows around the northern end of Fraser Island (block 0102), but the project team did find evidence that crabs exist there or very close by (see Section 4.7). However significant catches were made in three grid blocks to the west and northwest of Rooney's Point. These are in the northernmost part of Hervey Bay, and although block 0000 is north of the latitude of Sandy Cape, it is protected from oceanic swells by the extensive system of sandbars, shoals, and semi-permanent sand islands known as Breaksea Spit. The catch rate in this general area was highest in the grid block most exposed to oceanic conditions (10.84 crabs/net hr), but the two blocks west of Rooney's Point both yielded, on average, catches in excess of 6 crabs/ net hr. Further south in the more protected part of Hervey Bay the catch rate was very much reduced (0.22 crabs/net hr in the deeper regions of Platypus Bay), and off Moon Point (blocks 0400 and 0401) no spanner crabs were caught at all.

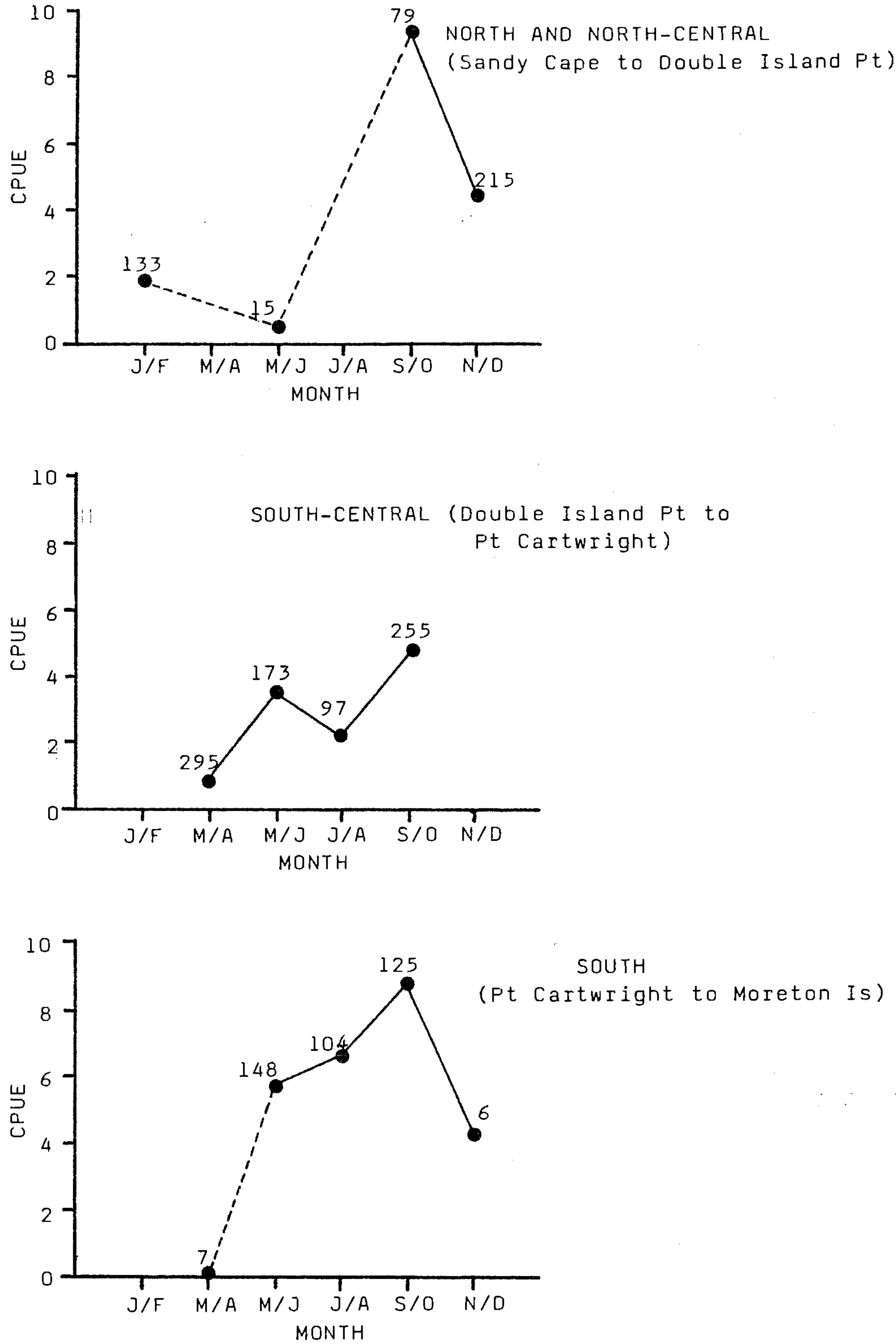
4.4.2 Seasonal Effects

The results of this survey suggest that there is a seasonal pattern in the population density or vulnerability of spanner crabs, with catch rates in the latter half of the year (June-December) being substantially greater than those during the period January-May (Figure 6). CPUEs in June, July, September, October and December were not significantly different, the collective mean being slightly greater than 6 crabs/net hr. The apparently significant lower value obtained during August can probably be accounted for by the fact that sampling effort was not spread equally over time and geographical area. In other words, some bias has been introduced because more effort was expended in less productive areas during that month. The other aberrant sample (November) may, however, be significant, since there is some evidence from elsewhere of a pre-spawning reduction in feeding intensity.

While Figure 6 indicates statistically significant monthly differences in CPUE within the January-May period, these, too, can probably be attributed to a non-uniform distribution of effort. It would certainly be misleading to suggest, for example, that spanner crabs cannot be caught in January and April. To provide a better understanding of the combined effects of area and season, the data have been re-organised in Figure 7 to show seasonal trends in CPUE in three subdivisions of the project area: north and north-central, south-central, and south. Despite some missing data points, the figure shows similar trends in each of the three zones. Significantly, the highest CPUE in each case was recorded during September-October, and in the early part of the year catch rates were comparatively low. The zero value for March-April in the southern zone (Point Cartwright to Moreton Island) is probably not representative, being based on a sample size of only seven effective drops.



<u>Figure 6</u> Seasonal variation in mean spanner crab catch rate (data from all blocks combined). Sample sizes are shown, and vertical bars represent 95% confidence intervals on either side of the mean.



<u>Figure 7</u> Seasonal changes in the catch rate of spanner crabs in three subdivisions of the study area.

4.4.3 Influence of Depth on CPUE

The depth-distribution of spanner crabs within the survey area appears quite distinct and straightforward. Disregarding possible complicating effects of season and locality, the CPUE data (grouped by 10 metre depth interval) are shown in Figure 8. No crabs were caught in the 25 effective drops in water shallower than 10 metres. The catch rate increased regularly in relation to depth, reaching a peak of 7.3 crabs/net hr in depths between 30 and 40m. A corresponding decrease in CPUE occurred in progressively deeper water down to about 70m, and in the 141 drops in depths exceeding 70m no spanner crabs were caught at all. It is pertinent to note that the mean CPUE of each depth sample was significantly different from that of its nearest neighbour, at least for depths less than 60m. This suggests that if there are any other factors influencing the depth distribution pattern, they will probably have an effect on magnitude, rather than direction. Figure 9 shows the pattern of depth-distribution of CPUE in three latitude zones. While the catch rates at all depth intervals appear higher in the southern zone than in either of the northern zones, the common form of the curves is clearly apparent.

An analysis of CPUE by depth-range and "season" simultaneously will clearly result in a certain lack of precision because of reduced sample sizes, but Figure 10 suggests that there are some slight seasonal effects in the depth distribution of the spanner crab stock. In autumn and early winter the best catch rate (more than 8 crabs/net hr) was recorded in the 40-50m depth zone. During the following three month period (July-September) the peak CPUE occurred in shallower water (30-40m), while the catch rates in 50-60m increased from less than 2 to about 6 crabs/net hr. Reasonable catches (>4 crabs/net hr) were still made in the shallowest depth range (<20m). The major change during October-December was a substantial decrease in the shallow water catch, and this was also apparent in the summer (January-March) sample. Very few crabs were caught during the summer period in depths greater than 50m, suggesting that the population is concentrated at that time in a fairly narrow depth band from about 30 to 45 metres.

4.4.4 Effects of Time on CPUE

Several commercial spanner crab fishermen are of the opinion that catch rates are best in the morning and drop off around midday. To test this hypothesis, the catch data were grouped in two hour time intervals and the mean CPUE calculated for each period. Catch rates (for all months and areas combined) were not significantly different after about 0900 hr (Figure 11), averaging approximately 4 crabs/net hr. Between 0700 and 0900 the mean CPUE was somewhat greater (5.4), while the few nets set prior to 0700 yielded a considerably poorer result (2.2).

However this trend did not appear to be consistent between grid blocks. Data from three blocks in which there was a relatively high level of sampling effort are also shown in Figure 11. The situation in block 1302 was totally different from the overall mean, with a fairly consistent upward trend in CPUE between 0800 and 1400 hr. The results from block 1202 approximated the overall average, but in block 0101 the highest CPUEs were experienced in the afternoon.

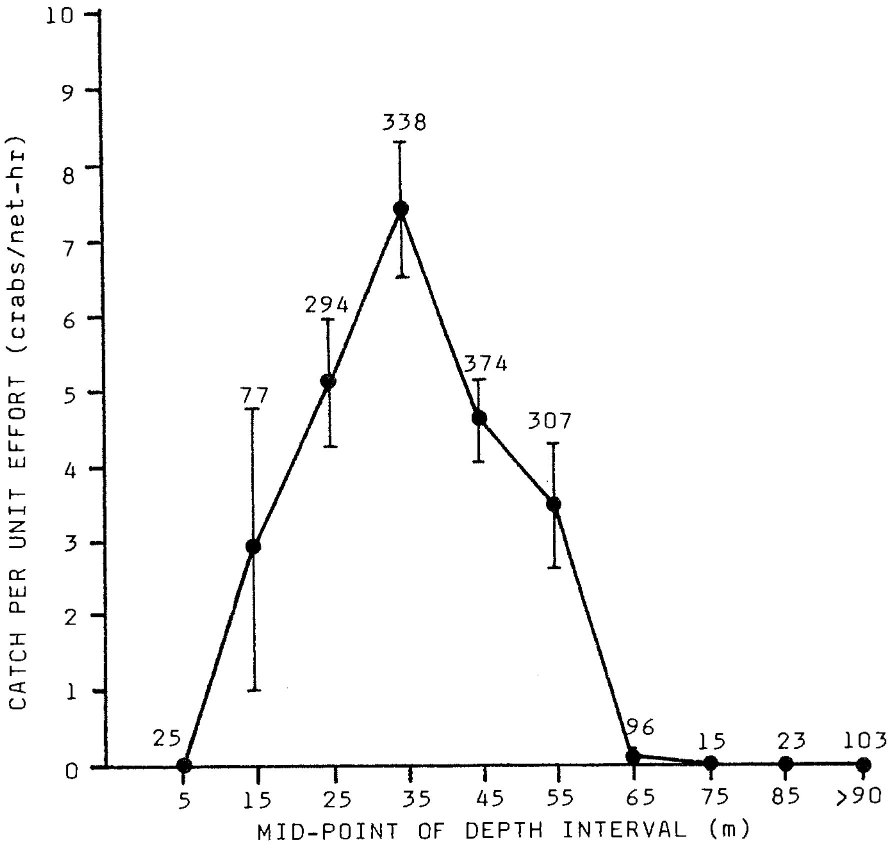


Figure 8 Relationship between depth and spanner crab catch rate. Data from all blocks and months have been pooled. Means, 95% confidence intervals and sample sizes are shown.

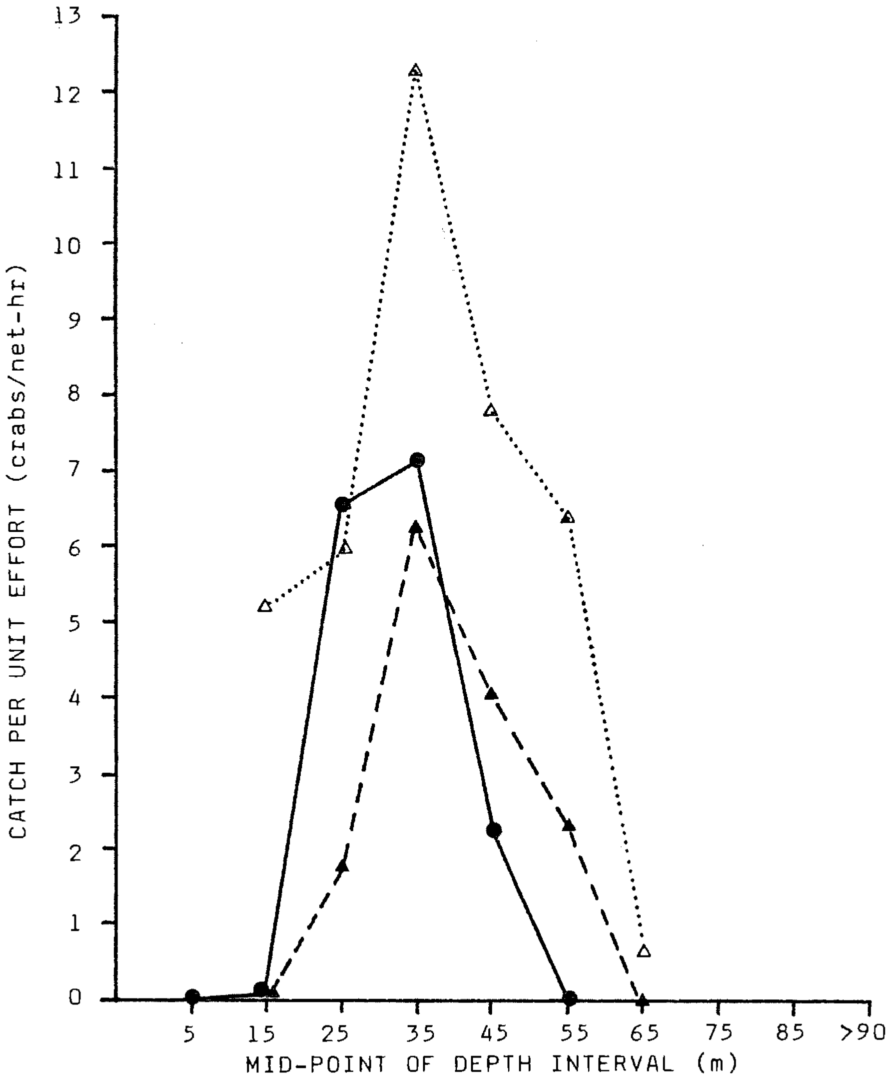


Figure 9 Relationship between spanner crab catch rate and depth in three zones of the study area.

●——● North and north-central
▲– – –▲ South-central
△⋯⋯△ South

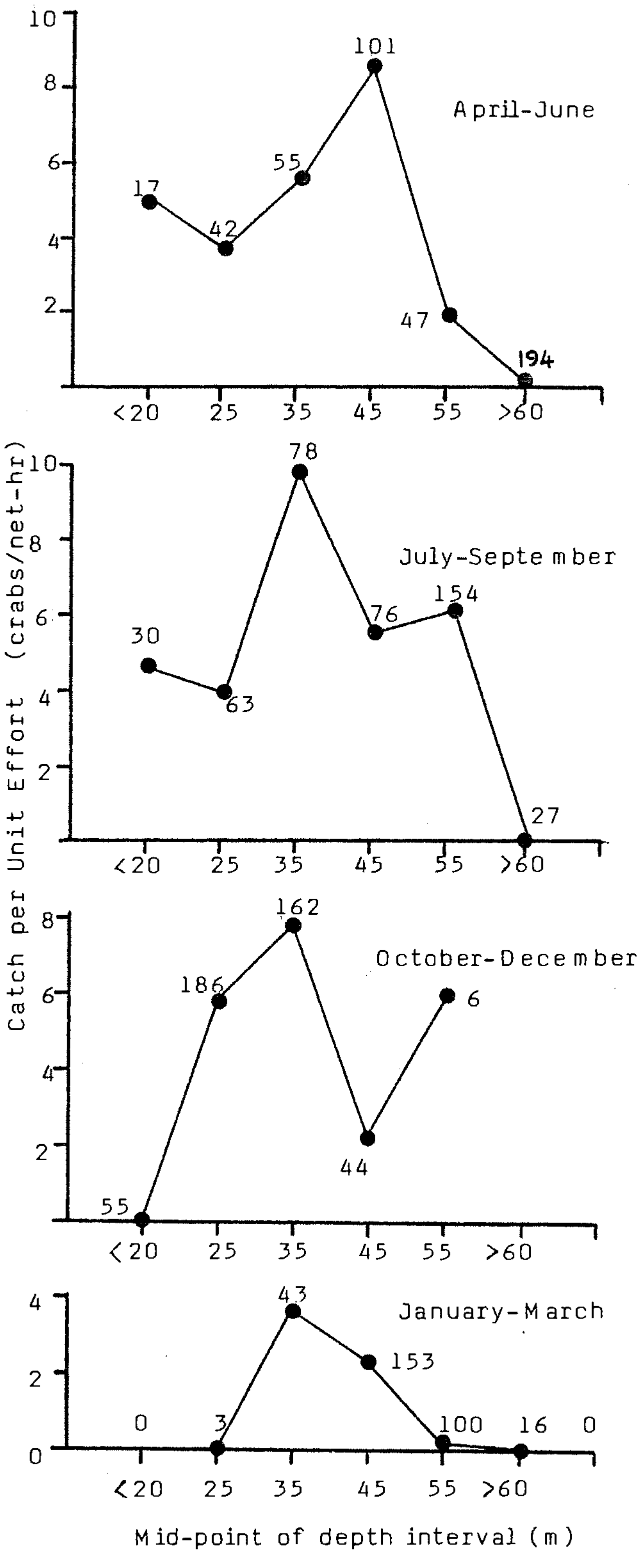


Figure 10. Seasonal changes in the depth distribution of Spanner crab catch rate (CPUE). Sample sizes are shown above the data points.

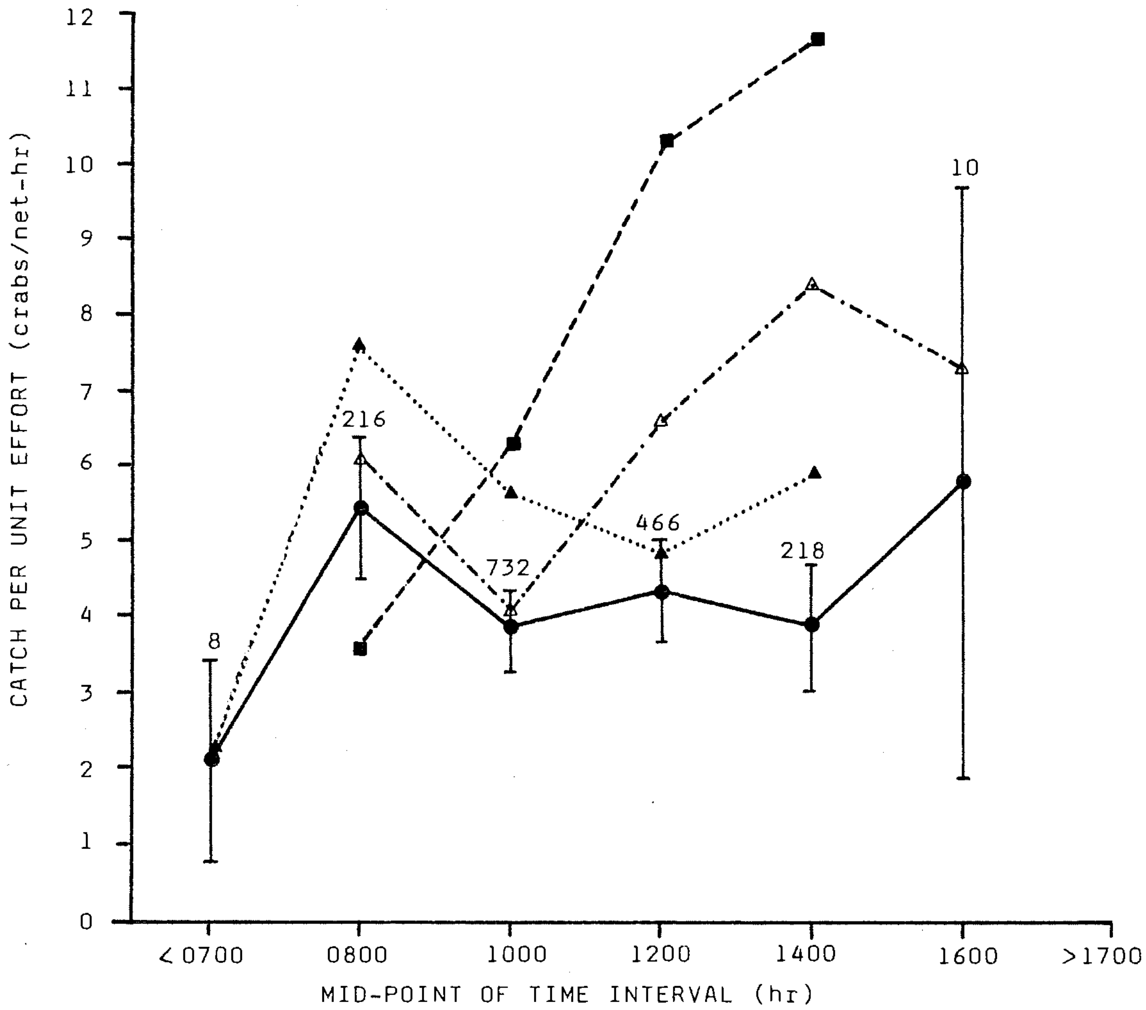


Figure 11 Effect of time of day on the catch rate of spanner crabs. The grand mean rate is shown (solid line) with 95% confidence intervals and sample sizes. The other three curves represent the catchrate-time relationship in three individual grid blocks:

■— — — —■ Block 1302
△—·—·—·—△ Block 0101
▲··············▲ Block 1202

4.5 VARIATION IN SPANNER CRAB SEX RATIO

There is a marked dimorphism between the sexes in mature spanner crabs. Apart from the usual characteristics which distinguish male crabs from females, male spanner crabs are on average significantly larger than females. Insufficient is known at this stage to say whether this is due to a difference in growth rate and asymptotic size, or a sex-selective mortality favouring the survival of large males. The first explanation is considered the most likely, but whatever the reason, there is some commercial significance attached to this size-differential phenomenon since the proposed size limit of 10cm will effectively remove females completely from the (legal) commercial catch. It may thus be of considerable interest to the fishery to know if there are any variations in the sex ratio which can be identified with particular characteristics of depth, season or locality.

The total sex ratio (M:F) over all areas, months and depths, was 4.15:1. Throughout most of the year (March to October) the proportions remained rather stable at a little over 3:1, but in November the ratio increased dramatically to 32:1 (Figure 12). Given that the November CPUE was actually lower than that of the previous couple of months (see Figure 6), this increase in the proportion of males must have been due to a drop in the absolute number of females in the catch. Evidence from aquarium studies (D. Skinner, personal communication) suggests that female spanner crabs become quiescent and exhibit a much reduced level of general activity immediately prior to spawning. If this reduction in activity affects feeding behaviour, it seems quite likely that it could explain the paucity of females and hence the high sex ratio in the November catch. The only month in which the sex ratio fell below unity (i.e. females outnumbered males), was December, when the ratio was approximately 0.9. A possible explanation of this is that after some weeks of reduced feeding and the expenditure of more than usual amounts of energy during the final stages of egg maturation and spawning, the female crabs might require an unusually large food intake. The associated increase in foraging activity could render them particularly susceptible to capture.

Even though there are still no regulations governing the minimum size of spanner crabs that may legally be taken, many fishermen understand the biological and ultimate financial advantage of returning very small crabs to the water. Consequently a large proportion of the female component of the catch is liberated. It is therefore of interest to see if there are any differences in sex ratio between various parts of the study area, which includes regions subjected to a variety of exploitation levels from minimal to quite heavy.

Figure 13 shows the sample sex ratios from five zones of latitude. Although the northernmost group of grid blocks produced a sex ratio somewhat lower than that of the north-central group, a general trend in decreasing M:F ratio from north to south was evident. Bearing in mind that the main centres of commercial spanner crab fishing effort are in the south-central and southern zones, and that the population north of 26°10' is virtually unexploited, these differences may provide some idea of the extent to which the male crabs have already been "fished down" by commercial and recreational tangle netting activity. The data also support the view that the stock as a whole is not particularly mobile.

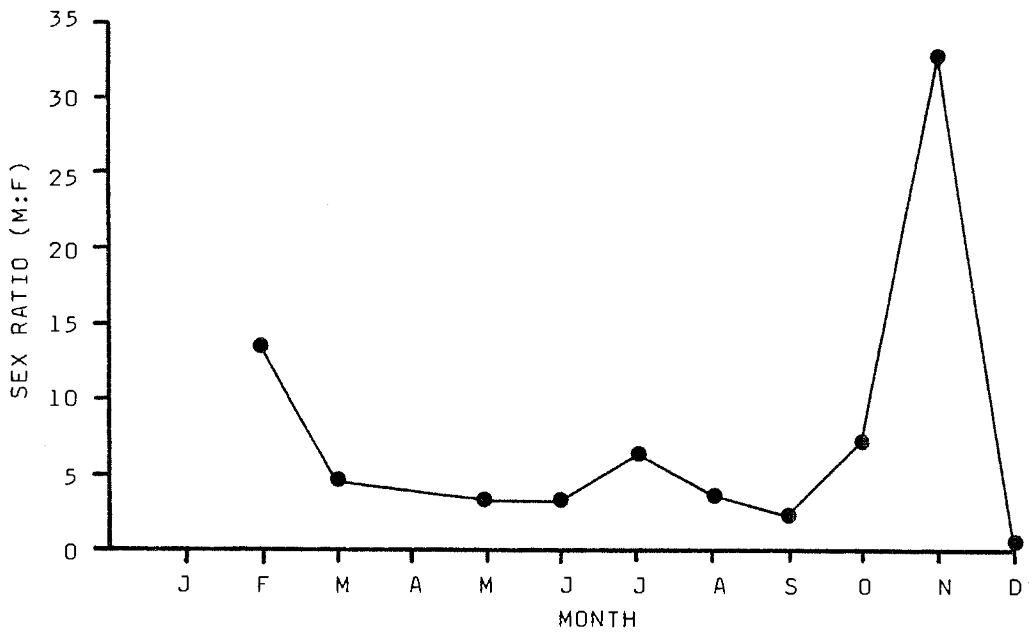


Figure 12 Seasonal changes in spanner crab sex ratio (M:F)

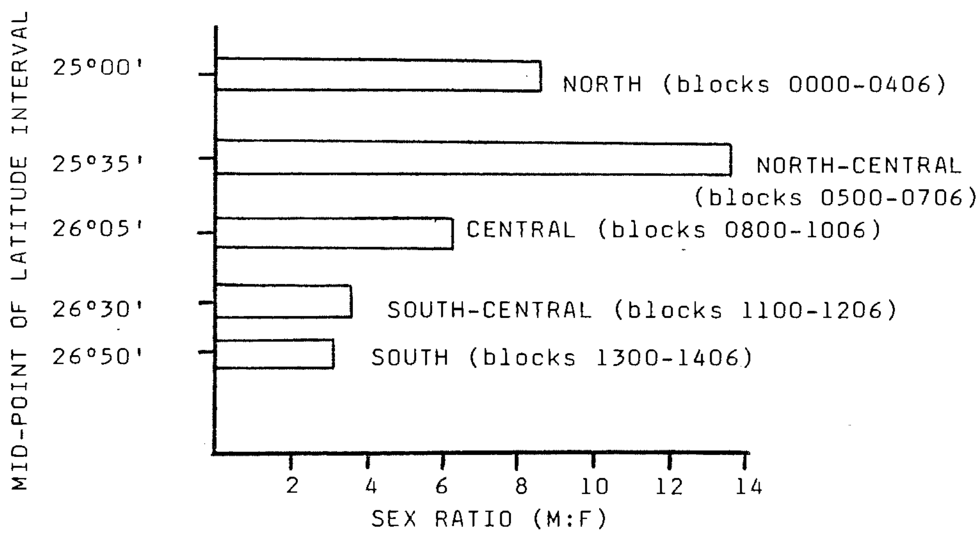


Figure 13 Geographical variation in sex ratio of spanner crabs.

4.6 DREDGING AND TRAWLING TRIALS

Soon after the project commenced it became clear that the baited dillies being used as the standard sampling units were selectively fishing the older age-classes in the spanner crab population. Very rarely did crabs less than about 6cm carapace length appear in the catch. In terms of commercial fishing activity this is obviously an advantage, because it means that small juveniles are not subject to heavy fishing mortality, and fishermen are not faced with the problem of having to clear large numbers of very small crabs from their nets. It does, on the other hand, present difficulties in identifying larval settlement times and localities, and obtaining reliable data on the length of the postlarval/ juvenile phase of the life cycle.

Prawn trawlers are known occasionally to catch considerable numbers of "matchbox-sized" spanner crabs at particular times of the year, in areas where they might be expected to appear in the baited dillies but apparently do not. In an attempt to obtain material and information about these elusive age groups the project team, in co-operation with SFRC personnel, ran a series of trials with other sorts of sampling devices including a small benthic dredge and a try net.

Dredge trials were carried out during December 1981 and September/ October 1982 in the area between Point Cartwright and Moreton Island. Sampling depths ranged from 5 to 45 metres and the dredge was towed over distances of up to 0.4km. No intact spanner crabs were taken in any of the 35 or so dredge samples, although on a couple of occasions some pieces of broken carapace appeared in the cod end, presumably as a result of severe damage to a live crab by the dredge teeth. There is no doubt that the dredge was fishing effectively on the bottom, as a wide range of benthic invertebrates including starfish, sea urchins, shells and small crabs of various species, as well as demersal fish such as flounders and flathead, were regularly encountered.

Failure of the dredge to catch juvenile spanner crabs prompted some experimentation with a "try net" (scaled down otter trawl) which was initially rigged, for ease of handling, as a plumbstaff beam trawl. Some 25 shots with the beam trawl during January 1983 yielded only one small spanner crab (about 30mm CL), and an occasional piece of broken carapace. Again the net was obviously fishing on the bottom, as numerous small crabs of various types, ophiuroids, starfish, sand dollars, shells and flatfish were captured. The trawl was towed for 20 to 40 minutes in depths between 10 and 40 metres off the beach south of Point Cartwright, and north of Moreton Island.

At the end of January the net was re-rigged, this time as an otter trawl with a pair of small boards attached by a bridle to a single towing warp. This configuration proved much more successful in catching spanner crabs. About 50 small individuals ranging in length from 41 to 58mm CL were captured in 17 trawl shots. Most of these were taken in 20m of water south of Point Cartwright during February and March, and were presumed to be "young of the year" resulting from the previous November spawning.

4.7 "BEACHED" SPANNER CRABS

A peculiar aspect of this species' behaviour, which still defies adequate explanation, relates to the occasional emergence of crabs on to the beach. Reports of such behaviour have come from several different reliable sources, indicating that crabs of a variety of sizes sometimes appear intertidally in (or on) the moist sand of beaches as widely geographically separated as Round Hill Head (24°10'S) and Yellow Patch, Moreton Island (27°02'S).

While working around the northern end of Fraser Island, the project team learned from local beach fishermen that considerable numbers of crabs could be collected from one or two small sand islands in the Breaksea Spit area north of Sandy Cape. The crabs were reputedly to be seen either buried in or walking over the moist sand above tide level. These reports were followed up by investigations of the area during a three week period in August/September 1982, and again in December the same year. Adult crabs of both sexes were seen on the sand island about 2km north of Sandy Cape in August and September. About 10 crabs were observed: some were discovered buried beneath a pancake-like disc of moist sand protruding slightly above the level of the surrounding beach, while others were seen wandering apparently aimlessly about on the beach. When disturbed, the crabs tended to bury themselves immediately and very quickly in the sand rather than try to escape by heading towards the sea.

During the visits in December (on one of which SFRC/FIRTA project staff were present), much more effort was put into searching the beaches from Sandy Cape west to Rooney's Point and then south to Wurtumba Creek along the shore of Platypus Bay. On December 2, 16 juvenile crabs (8 males, 8 females) were collected from the beach south of Rooney's Point. The remains of several others, which had apparently been attacked by sea birds, were also discovered. The individuals collected ranged in size from 42 to 51mm CL, and there did not appear to be any significant difference in size between the sexes. Later in December another 15 juveniles (8 males and 7 females; 38-58mm CL) were collected, mostly from the beach south of Rooney's Point. On average, these were a few millimetres longer than those in the previous sample.

The most interesting finding, however, was an abundance of juvenile spanner crab moult shells along the tide line. Nearly 180 intact carapaces, some as small as 14mm, were collected and measured. The small shells were particularly fragile, and innumerable broken pieces were also scattered along the tide line. The presence of juvenile moult shells has not been reported elsewhere, and to our knowledge this is the first substantiated evidence of the possible location of a larval settlement area. For such a large number of the frail shells to have survived being washed up on the beach by wave action, there is presumably a "nursery area" somewhere close to the northern end of Fraser Island, probably in shallow water on the Hervey Bay side of Breaksea Spit. It is interesting to note that, while live crabs were being picked up from the beach, dillies set in the shallows up to 500m from the same shore failed to catch anything whatsoever.

5. DISCUSSION

The catch rate for species other than spanner crabs was disappointingly low. It is possible that the type of gear in use during the project was not ideally suited to the capture of portunids (sand, coral and three-spot crabs) as their uniformly tapered leg segments are less prone to catching in the mesh than are the asymmetric terminal dactyli or "spades" of the spanner crabs. Notwithstanding this, we believe that if the population densities of these other species had been significant, then a far greater catch would have been obtained. Spider crabs, which appear to inhabit the deeper waters along the edge of the continental shelf and slope, were likewise either very sparsely distributed or not susceptible to capture by baited dillies. None of the deep water sets was done at night, and it is possible that this species is a nocturnal forager. However, even if it could be demonstrated that spider crabs can be caught during the hours of darkness, this would hold little attraction for the crab fishermen because of the impossibility of operating small vessels with any degree of safety in such exposed areas at night-time.

Spanner crabs have been reported from a wide range of localities throughout the Indo-Pacific region from Hawaii through Japan, the Philippines and northern Australia to east Africa. It is therefore not unreasonable to expect commercially fishable quantities of spanner crabs on other parts of the Queensland coast. Bottom conditions between Cape Moreton and Sandy Cape seem, from the admittedly sparse detail provided on Admiralty and bathymetric charts, to be fairly homogeneous. There are several systems of shoals, banks and reefs in the northern part of the survey area which are avoided by prawn trawlers, but there is nevertheless a good deal of flat trawlable ground in between. It was initially thought that these interstitial areas might prove to be quite productive spanner crab grounds, but it soon became apparent that there was much more rubble and gravel bottom than generally realised.

Although the project was not designed to collect environmental data, there was abundant evidence that spanner crabs have specific requirements in terms of substrate type. Reefy bottom was detectable from echo soundings, and often resulted in hook-ups and major gear damage or loss. In situations like that, reef fish occasionally became meshed in the dillies but crabs were very rarely caught. Rubble or gravel substrates could often be identified by the presence of sea urchins, pieces of stone etc. caught in the nets, and again the crab catches were exceptionally poor. By and large, this species of crab is found only on relatively clean, fine sand, which is not surprising considering its propensity for spending a large amount of time buried in the substrate. The non-uniform distribution of catch rates experienced across the survey area can therefore be attributed in large part to substrate heterogeneity.

The project data suggest that there is some seasonality in spanner crab catchability, higher catch rates occurring generally in the latter half of the year. Why apparent foraging activity should increase as ambient water temperatures decline is difficult to explain, unless it is associated with the onset of gonad maturation and reproductive behaviour patterns.

Population density showed a fairly consistent trend in relation to

depth, with intermediate depth ranges generally yielding the highest catches. The logical explanation for this is that crabs are most plentiful in areas of abundant food supply. Little is known at this stage about the animals' natural dietary preferences, but SFRC staff have found evidence of heart urchins and polychaete worms in the foregut inclusions of a number of spanner crabs. The only published reference to this species' (presumed) diet appears in "Guide to Fishes" (E.M. Grant, 1982) which indicates that they capture small live fish, but it seems highly unlikely that this is correct. Their obvious prediliction for a variety of dead fish baits suggests that, in addition to their natural food, spanner crabs may also utilise trash fish discarded by the many prawn trawlers working at night in the south-central and southern parts of the study area. It is interesting to consider the possibility that prawn trawling may actually benefit the crab stocks, and conceivably have allowed a previously sparse stock to build up to an exploitable level. Unfortunately there are no historical data with which to test this theory.

There is clearly a sub-population with commercial potential in the northern Hervey Bay region. The collection of ovigerous female crabs northwest of Rooney's Point and juvenile moult shells on the Fraser Island foreshore points to there being a spawning population and a "nursery area" in that region. We suspect that the stock could extend a good deal further north, perhaps as far as the Swains Reefs, but the present small boat fishing unit could not work these areas effectively because of the distances involved. Larger seaworthy vessels with a significantly greater payload capacity would be needed for such long trips to be economically viable. However since the project identified the existence of good quantities of crabs in northern Hervey Bay, at least one local fisherman has started to exploit that part of the stock.

Commercial crabbers often complain about gear damage and loss from shark and turtle attacks. During the survey some gear was lost or ruined as a result of these predators eating the bait and/or crabs out of the net, sometimes severing the buoy-line in the process. The main areas where this problem occurred were Hervey Bay and in the vicinity of the Freeman Channel northwest of Cape Moreton. Predator attack is probably more frequent in the commercial operation where, once a productive area is located it is fished intensively, and discarded small crabs may tend to attract sharks and turtles to the fishing area. Gear losses also occurred when occasional sudden increases in tidal current dragged the surface floats underwater.

Localised intensive fishing by commercial operators may explain the alleged drop in catch rates around midday. Survey results indicated a high degree of variation in the relationship between catch rates and time of day, but there was no consistent evidence of a noon decrease when the nets were always reset in different localities.

Project personnel believe that it is high time some management controls were introduced into the spanner crab fishery. Several recommendations (including a minimum legal size of 10cm, an amateur bag limit, and a prohibition on the taking of ovigerous females) were made as long ago as 1981, but these have yet to be implemented. We also believe that commercial fishermen who are not already doing so should be urged to use monofilament fabric in their nets, as experience has shown that the least amount of damage to meshed crabs occurs with monofilament webbing of less than 50mm stretched mesh.

OFFSHORE CRAB RESOURCES SURVEY: FIELD DATA SHEET

DATE: yr | mo | day

GRID Nº

Gear condition code
0: no damage 1: slight damage
2: major damage or loss

Other crab species codes
1: sand 2: spider
3: three-spot 4: coral
5: mud 6: any else

SET Nº	BUOY Nº	DEPTH (metres)	TIME OF		GEAR	SPANNER CRABS			OTHER CRABS						COMMENTS
			SET	LIFT		Nº males	Nº females	Nº berried	code	Nº	code	Nº	code	Nº	

Appendix 1. Field data recording sheet used during the project.

7 22.10.81

Appendix 2. Sample listing of part of the project field data-base held on floppy disk at DPI's Southern Fisheries Research Centre, Deception Bay.

										Spanner crabs			Other species					
Year	Month	Day	Block No.	Set No.	Buoy No.	Depth (m)	Set time	Lift time	Gear condition code	Males	Females	Ovigerous	Code	No.	Code	No.	Code	No.
81	07	28	1303	1	01	062	1005	1040	0	00	00	00	0	00	0	00	0	00
81	07	28	1303	1	02	058	1010	1050	0	00	02	00	0	00	0	00	0	00
81	07	28	1303	1	03	057	1015	1055	0	09	02	00	0	00	0	00	0	00
81	07	28	1303	1	04	057	1020	1115	0	00	02	00	0	00	0	00	0	00
81	07	28	1303	1	05	057	1025	1120	0	01	00	00	1	01	0	00	0	00
81	07	28	1303	1	06	055	1030	1125	0	03	03	00	0	00	0	00	0	00
81	07	28	1303	1	07	055	1035	1135	1	23	01	00	0	00	0	00	0	00
81	07	28	1303	1	08	054	1040	1145	1	11	01	00	0	00	0	00	0	00
81	07	28	1303	2	01	058	1105	1200	0	06	03	00	0	00	0	00	0	00
81	07	28	1303	2	02	058	1108	1205	0	14	00	00	0	00	0	00	0	00
81	07	28	1303	2	03	057	1110	1215	0	07	02	00	0	00	0	00	0	00
81	07	28	1303	2	04	054	1145	1250	2	12	03	00	0	00	0	00	0	00
81	07	28	1303	2	05	055	1148	1255	0	09	04	00	0	00	0	00	0	00
81	07	28	1303	2	06	054	1150	1307	1	11	01	00	0	00	0	00	0	00
81	07	28	1303	2	07	054	1152	1318	0	14	01	00	0	00	0	00	0	00
81	07	28	1303	2	08	054	1155	1330	0	23	02	00	0	00	0	00	0	00
81	07	28	1303	3	01	057	1205	1345	0	01	05	00	0	00	0	00	0	00
81	07	28	1303	3	02	059	1208	1350	0	05	02	00	0	00	0	00	0	00
81	07	28	1303	3	03	057	1217	1355	0	00	00	00	1	01	0	00	0	00
81	07	28	1303	3	04	054	1300	1415	0	11	02	00	0	00	0	00	0	00
81	07	28	1303	3	05	054	1310	1425	0	18	01	00	0	00	0	00	0	00
81	07	28	1303	3	06	053	1315	1430	1	13	00	00	0	00	0	00	0	00
81	07	28	1303	3	07	055	1325	1435	1	03	01	00	0	00	0	00	0	00

ating in a more restricted area to investigate in greater detail the population structure and biology of one of the species in question. The two project teams liaised continuously and worked co-operatively on some specific problems.

2. THE SURVEY AREA

The study area included a length of coastline extending some 170 nautical miles (315km) from Point Lookout, Stradbroke Island (27°26'S) to Sandy Cape, Fraser Island (24°42'S). A small section of the north-eastern part of Hervey Bay was also incorporated in the study area. The region was divided into 10' x 10' grid blocks from 152°50'E beyond the 100m isobath to 154°00'E. The original intention was to sample every block in which there was a sufficient depth of water (excluding those within Moreton Bay), at least out to the 100m depth contour. There were, theoretically, about 60 grid blocks amounting to a total area of 18,480 sq. km which fell within these criteria (Fig. 1).

The slope of the continental shelf ranged from about 1:90 immediately east of Cape Moreton to 1:630 off Double Island Point. Bottom sediments consisted primarily of sand, with patches of reef and heavy gravel or coral rubble bottom. Currents and tidal streams were variable, the dominating factor being a general southerly set resulting from the East Australian Current. Tidal flows were significant in the vicinity of bars, bays, river mouths and headlands, and strong currents were often experienced in deeper water towards the edge of the continental shelf.

3. MATERIALS AND METHODS

3.1 THE PROJECT VESSEL

A 24' welded alloy hard-chine "StarFlite" fishing boat powered by a 185HP "Mercruiser" stern-drive petrol engine was used for the survey. With a fuel capacity of 300 litres and a cruising speed of about 25kt, the vessel had an operating range 200 nautical miles. Initially a small electric line-hauler was used, but the need for very long buoy-lines when working in deep water (>100m) required a hauler of greater capacity. An hydraulic drum winch capable of hauling and stowing 1.2km of 5mm synthetic rope at 1.3 metres/sec. was constructed by a local company and mounted on the transom so that the trap-lines could be set directly over the stern. Additional equipment carried on the vessel included a "GME" 27 MHz radio and a "Fuso 1800" echo sounder reading to 280m.

3.2 FISHING GEAR

The gear used throughout the project was essentially a series of baited tangle nets (locally known as inverted dillies or "witches' hats") of a design similar to that used at the time by commercial spanner crab fishermen in the Mooloolaba area. Each net consisted of a 1-metre

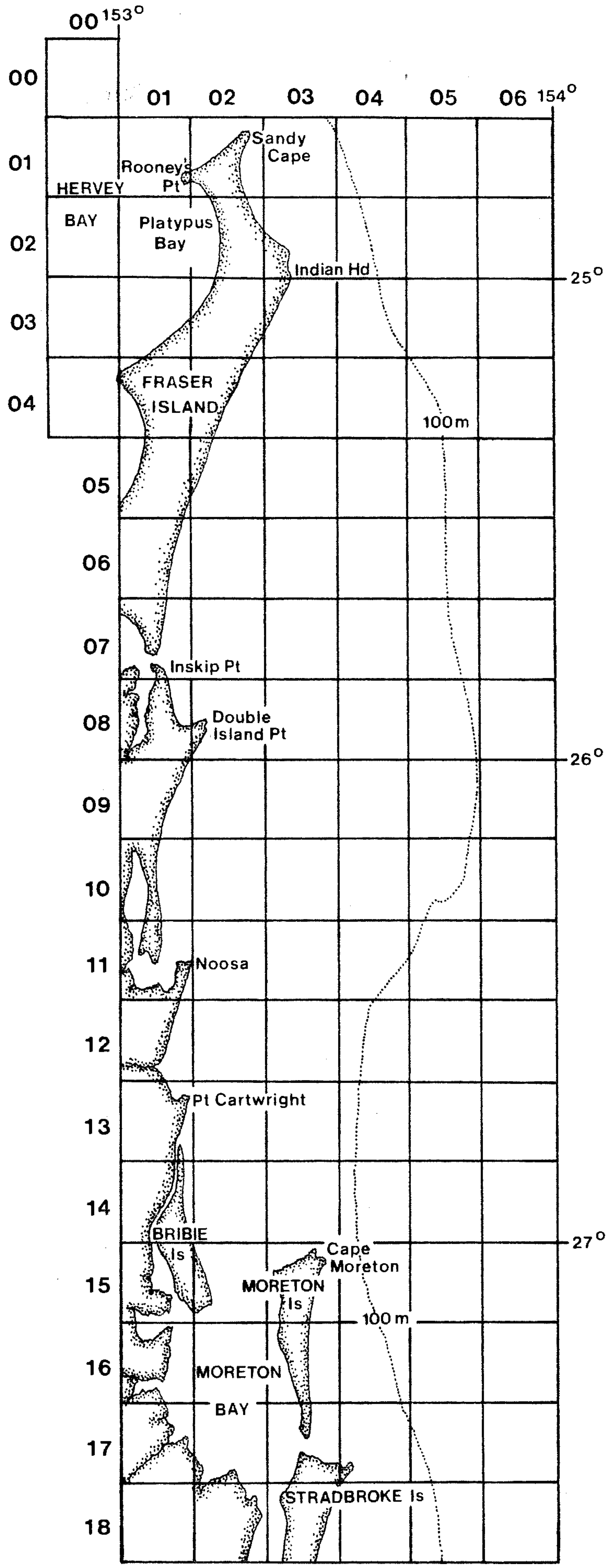


Figure 1. Chart of the survey area showing position of the 100 m depth contour.

diameter ring made from 12mm steel reinforcing rod and covered with a loose layer of synthetic multi-filament mesh. The mesh was gathered in the centre and supported by a small cork net float forming a low cone (Fig. 2). Although various mesh sizes from 25 to 100mm were tried, the optimum range was found to be between 35 and 50mm. The smallest mesh sizes (<30mm) appeared to catch fewer large crabs, while large mesh webbing (>50mm) tended to tangle the crabs excessively, making it difficult to clear the nets and resulting in greater damage both to the crabs and to the fabric.

Since the commencement of the project commercial crab dilly design has undergone a process of evolution, and now most operators use the flat Hawaiian-style nets with webbing stretched tightly over the metal frame. Conical dillies, however, were used throughout the duration of the project to ensure continuity of sampling effort.

In addition to the standard sampling gear, a small dredge (fabricated by Fisheries Research Branch staff) and a scaled-down trawl net were used in an attempt to capture juvenile crabs which for some reason do not appear to be taken in the dillies. The 70 x 30 x 80cm metal frame dredge was equipped with a set of 5cm steel teeth projecting from the lower leading edge, and a 30mm mesh bag or cod-end attached inside the front edge of the frame.

3.3 FIELD OPERATIONS

Weather conditions usually dictated which area could be fished on any given day. Having reached the desired grid block by dead-reckoning navigation, the vessel's position was checked by reference to depth soundings and compass bearings on identifiable landmarks. The dillies were then baited and set, typically in a line of eight dropped about 150m apart. The direction of set was usually determined by sea conditions. As each individually numbered marker-buoy was dropped, a note was made on the field data sheet (see Appendix 1) of the depth and time of set. The soak time, or length of time the nets were left fishing, varied to some extent, but averaged 0.86 hr (approx. 50 minutes). As the nets were lifted, the time of retrieval was recorded. An assessment was made of the condition of each net, and if there was any noticeable damage an appropriate code was entered on the field sheet. The crabs were then removed from the net, counted, and in the case of spanner crabs, sexed. Female spanner crabs were also examined to determine whether or not they were carrying eggs, and the relevant data recorded. After the complete set had been lifted, the vessel was moved 3 or 4km away and the nets reset. The whole process was continued (usually in the same grid block) for the remainder of the day, or until the weather made conditions unworkable.

3.4 DATA STORAGE AND ANALYSIS

All field data except those relating to the dredge and try-net trials were keyed on to disk file by staff at the Southern Fisheries Research Centre, Deception Bay. A sample listing of a portion of the database is attached (see Appendix 2). Analyses of the survey data were carried out by one of the authors (IWB) using specifically developed

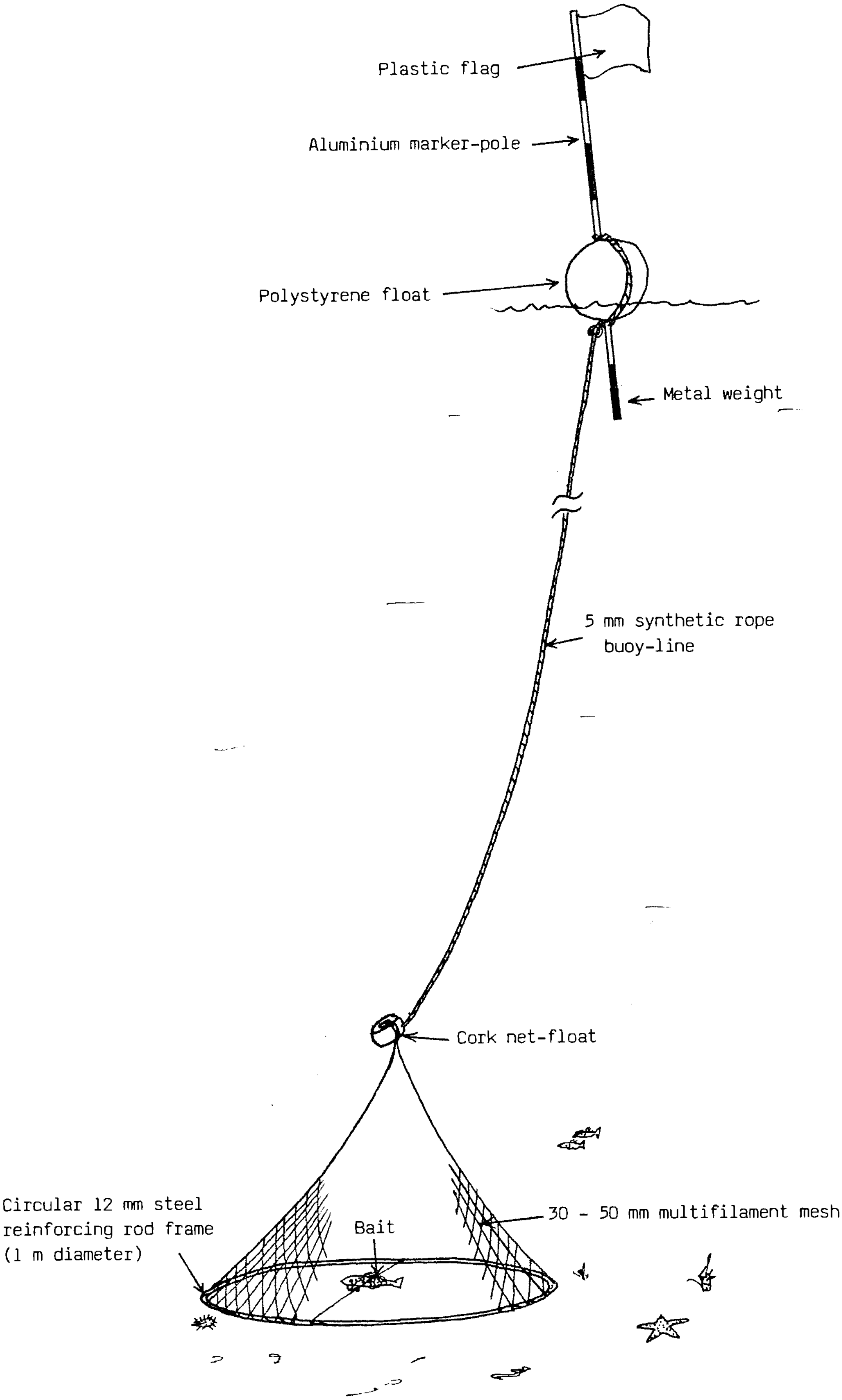


FIGURE 2. Semi-diagrammatic representation of a typical spanner crab dilly of the type used during the project. (not to scale)

BASIC software on an SR-72 floppy-disk based 64K microcomputer at SFRC.

A realistic idea of apparent stock density or relative abundance can only be gained by comparing catch rates, or catch-per-unit-effort indices (CPUE). Because of the need to take account of varying soak times, the computed CPUE was not simply the total number of crabs divided by the total number of drops, but incorporated an adjustment to standardise the catch to a 1-hour time base. Given the range and distribution of both soak times and CPUE data, it was considered statistically reasonable to treat the adjusted catch rates as individual variates for the purpose of computing means. This also allowed the calculation of sample variances and confidence intervals, enabling an assessment of the significance of differences between means.

4. RESULTS

4.1 DISTRIBUTION OF FISHING EFFORT

Sampling was carried out in 35 ten-minute square grid blocks covering an area of approximately 10,815 sq. km. As can be seen from Fig. 3 the amount of sampling effort (as measured by the number of drops) varied considerably from block to block. The area east of Fraser Island could not be sampled effectively because of large expanses of reef and heavy rubble bottom. Distance and travelling time from the nearest safe port also presented problems, and the Tin Can Bar at Inskip Point could often not be crossed due to foul weather. The paucity of information from that area represents an unfortunate gap in the project data, although this is compensated for to some extent by additional sampling in the northeast part of Hervey Bay.

The total number of drops (1,865) represents an actual fishing effort of about 1,490 net hours. However, some of the nets set were either lost completely or damaged as a result of hook-ups or attack by sharks and turtles, and in a few cases the times were not recorded. In all, a little over 11% of the records were "doubtful" (for the above reasons) and were therefore excluded from the subsequent analysis.

4.2 FACTORS ADVERSELY AFFECTING THE PROJECT

Two factors - the weather and mechanical problems with the vessel - had a detrimental effect on the conduct of the Project.

It was found difficult, if not impossible, to work in winds exceeding about 15 kt. With the exception of the northwest shore of Fraser Island, the entire project area is very exposed to prevailing southeast and northeast winds. Even short periods of freshening wind can whip up a surface chop which is very uncomfortable and potentially dangerous to small vessels. Moreover such conditions make it difficult to locate marker-buoys, and this can often result in the loss of gear. Bad weather thus accounted for a large number of lay-days during the project period.

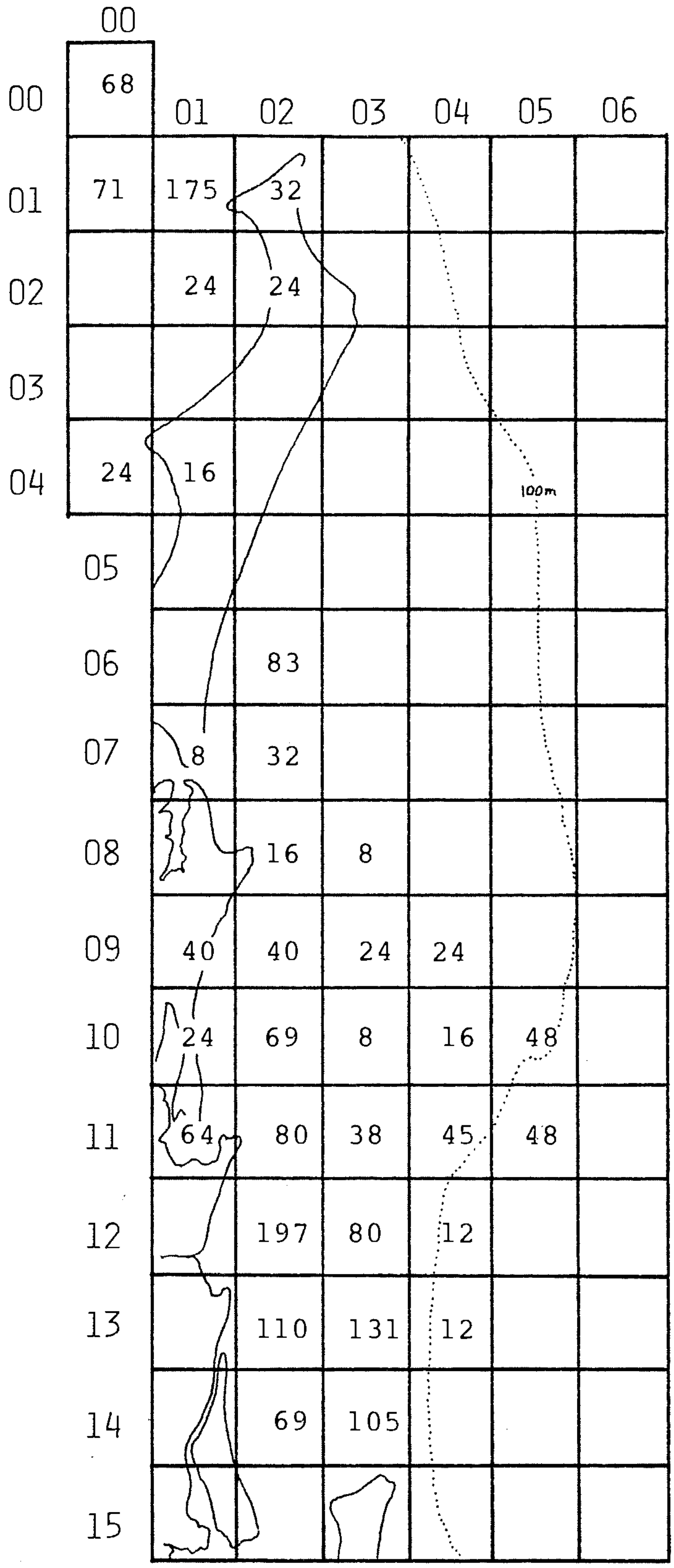


Figure 3 Geographical distribution of sampling effort (total numbers of drops) throughout the study area.

Problems with the vessel's motor and stern drive unit were also responsible for a significant loss of fishing time. One incident involving a broken camshaft resulted in the vessel's being out of operation for nearly 10 weeks while parts were located and shipped from the USA. However during this period some experimental work was able to be carried out with the assistance of an obliging commercial fisherman at Mooloolaba.

4.3 SPECIES COMPOSITION OF THE CATCH

Spanner crabs were by far the most abundant species taken in the dillies, nearly 6,000 individuals having been caught in 1,652 effective drops. A more detailed analysis of the distribution and abundance of this species appears subsequently. The other crab species represented only an insignificant "by-catch" and the apparent size of their stocks indicates that they are unlikely ever to become target fisheries in their own right.

4.3.1 Sand Crabs *(Portunus pelagicus)*

Despite their abundance and commercial importance in Moreton Bay, inside the North Banks east of Bribie Island, and in parts of Hervey Bay, sand crabs were caught surprisingly rarely during the survey period. A mere 42 individuals appeared in the catch, from a variety of depths ranging from 9 to 71m (Table 1). There was no apparent significance either in the localities or the times at which these crabs were caught. It is interesting to note that prawn trawlers operating in offshore waters catch sand crabs regularly. While such catches are not great, they certainly exceed the spanner crab trawl catch. A possible explanation for this might be that *P. pelagicus* is more active at night (when most of the offshore trawlers fish for prawns) than is *R. ranina*, which, from our accumulated experience, appears to feed during daylight hours. Dillies designed for recreational sand crab fishing generally have a rather larger mesh size than typical spanner crab nets because sand crabs are not as readily meshed by their (slender) legs, and a large mesh is needed to entangle their carapace spines. This may also account for the lower dilly catch of this species in offshore waters.

4.3.2 Three-spot Crabs *(Portunus sanguinolentus)*

The total catch of this swimming crab was only slightly greater than that of its congener *P. pelagicus* (Table 2). Again, there did not appear to be any recognisable pattern to its distribution with respect to depth, season or locality, although they seemed slightly more abundant in the northern part of the study area than in the south.

4.3.3 Spider Crabs *(Cyrtomaia sp.)*

Contrary to initial expectations, the total catch of spider crabs was effectively zero. Only two were caught; both on 3.9.81 in block 1104.

Table 1. Numbers of sand crabs caught during the project period, showing localities, dates and depths.

BLOCK	DATE	DEPTH (m)	NUMBER
0101	21.10.82	24	2
0101	21.10.82	34	1
0101	21.10.82	31	3
0101	9.11.82	31	2
0602	16.2.82	44	1
0602	16.2.82	45	1
0602	17.2.82	47	2
0602	18.2.82	47	1
0701	11.2.82	41	1
0702	12.2.82	44	1
0901	30.10.82	44	1
0904	20.4.82	71	2
1002	18.9.81	55	1
1101	25.6.82	25	2
1103	17.6.82	62	2
1103	17.6.82	63	1
1202	30.7.81	9	1
1203	10.3.82	56	1
1302	13.5.82	43	3
1302	13.5.82	45	2
1302	9.6.83	45	1
1302	9.6.83	44	1
1303	28.7.81	57	2
1303	29.6.82	62	2
1303	29.6.82	60	4
1403	12.8.81	49	1

Table 2. Numbers of three-spot crabs caught during the project period, showing localities, dates and depths.

BLOCK	DATE	DEPTH (m)	NUMBER
0101	9.11.82	30	1
0602	15.2.82	44	1
0602	15.2.82	46	1
0602	16.2.82	43	1
0602	16.2.82	44	1
0602	17.2.82	46	2
0602	18.2.82	46	2
0701	11.2.82	40	2
0701	11.2.82	41	1
0702	12.2.82	40	1
0702	12.2.82	42	1
0702	12.2.82	44	2
0702	12.2.82	45	1
0702	12.2.82	46	1
0901	30.10.81	38	1
0901	30.10.81	30	1
0901	30.10.81	45	1
0902	30.10.81	33	1
0903	7.5.82	60	1
0904	20.4.82	68	4
0904	20.4.82	67	1
1001	29.10.81	33	1
1101	26.5.82	30	2
1101	26.5.82	22	1
1101	25.6.82	28	6
1101	25.6.82	23	1
1101	25.6.82	22	5
1202	30.7.81	9	1
1202	30.7.81	10	2
1302	10.5.82	11	2
1302	10.5.82	15	1
1403	24.8.81	23	1
1403	24.8.81	19	1
1403	24.8.81	18	3

This block includes the 100m isobath, and the specimens were collected from 106 and 112m on the edge of the continental slope. While the amount of fishing effort expended in this depth zone was far less than in shallow and intermediate depths, the 103 effective drops in water deeper than 90m failed to yield anything but these two crabs.

4.3.4 Coral Crabs *(Charybdis cruciata)*

Throughout the entire project period only one coral crab appeared in the catch. This individual was captured in 20m on the Hervey Bay side of Fraser Island (block 0202) on 21.11.81.

4.3.5 Other Species

In addition to the edible crab species listed above, numerous small non-commercial crabs (mainly *Matuta sp.*) were meshed, particularly in the shallow water shots.

4.4 SPANNER CRAB ABUNDANCE/CATCHABILITY PATTERNS

The total catch of spanner crabs from 1,652 effective drops (equivalent to a total soak time of 1,409.7 net hours) was 5,775. Of these, 4,647 were males, and 1,120 (including eight ovigerous crabs) were females. The overall catch rate or catch-per-unit-effort was 3.5 crabs per drop or, more reliably, 4.1 crabs per net hour.

4.4.1 Geographic Influences

The catch (numbers of crabs) taken in each of the grid blocks fished is shown in Figure 4. Obviously much of the variation in catch can be accounted for by differences in the amount of sampling effort as illustrated in Figure 3. However, Figure 5 clearly indicates that catch-per-unit-effort was far from uniform throughout the survey area. Average catch rates per block varied from zero in the deepest water sampled to 11.42 crabs/net hr in block 1402 northeast of Bribie Island. This particular block is part of the area currently being fished commercially. The next highest CPUE was recorded in block 0000 northwest of Sandy Cape (in the northern part of Hervey Bay) where no prior commercial exploitation had taken place.

The most consistently productive area was between 26°30'S and 27°00'S, in depths from 20 to 50 metres. This is the region where most of the commercial spanner crab fishing effort is concentrated. Catches in the vicinity of Noosa Heads were poor, but further north off Cooloola and the Coloured Sands the mean CPUE indicated exploitable concentrations of crabs. Around Double Island Point (25°55'S) crabs appeared to be particularly scarce, although it must be pointed out that sampling effort was very low in this region (see Figure 3), and the results may not be entirely indicative of the actual situation. A small number of crabs was caught in block 0702 east of Inskip Point, and a reasonable number

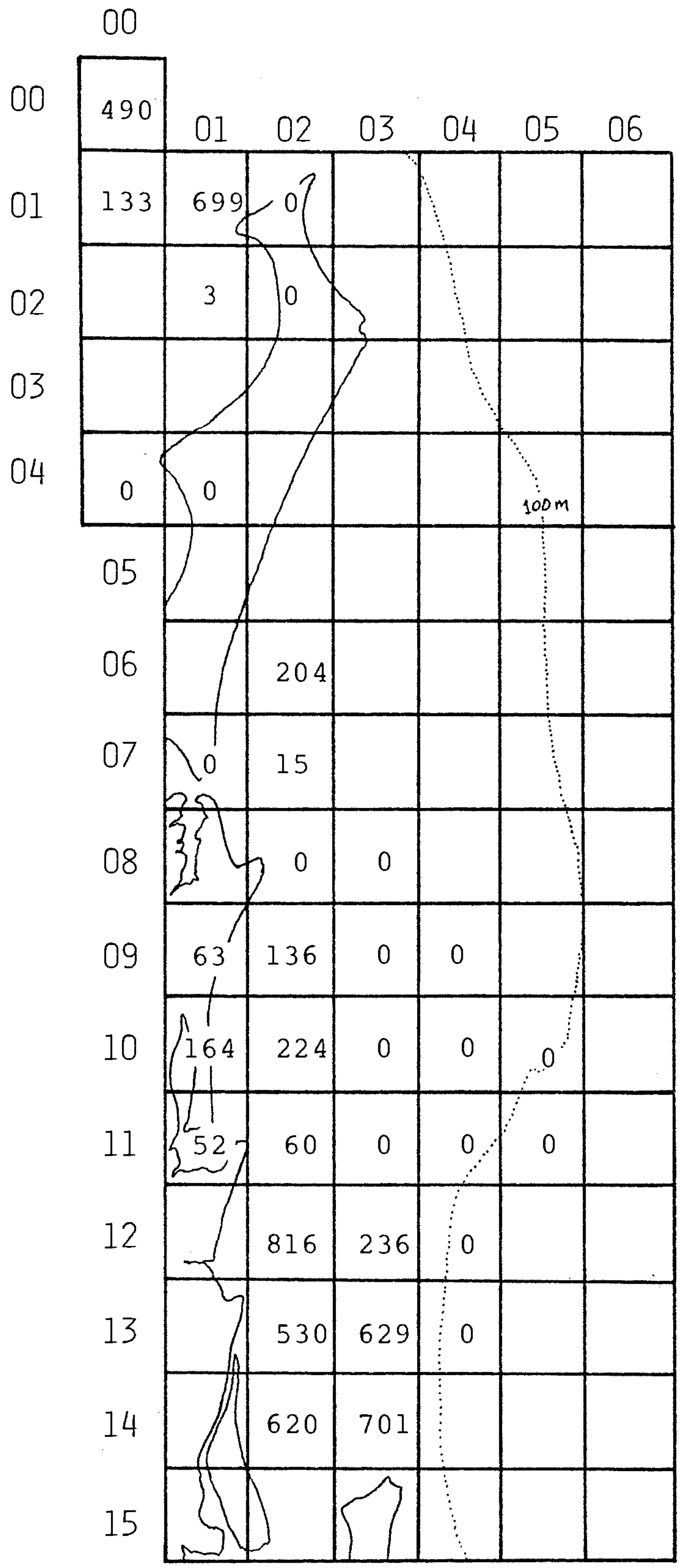


Figure 4 Geographical distribution of the total catch of spanner crabs (numbers of crabs, M+F).

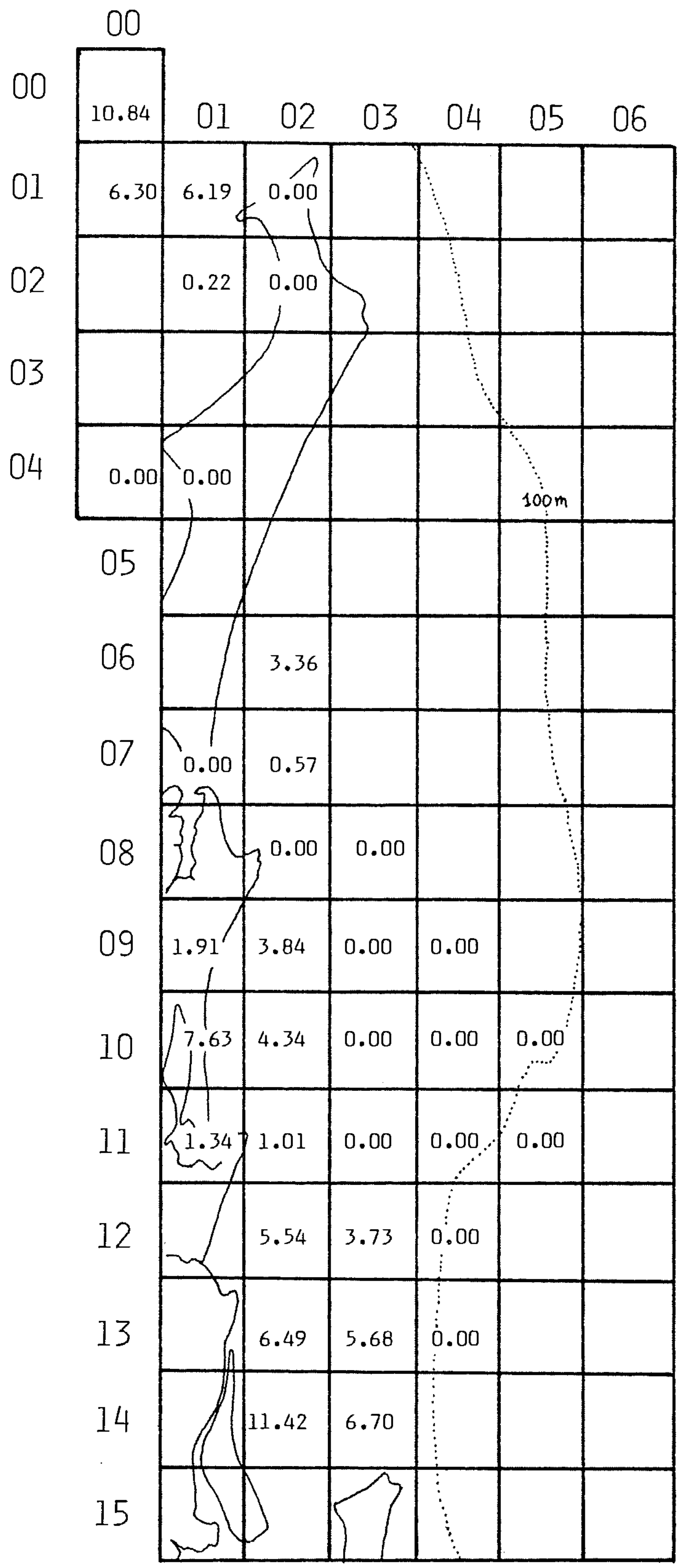


Figure 5 Geographical distribution of apparent stock density of spanner crabs as measured by catch per unit effort (CPUE = numbers of crabs [M+F] per net-hour).

appeared in the adjacent block to the north, off the southern end of Fraser Island. Here a total of 71 effective drops yielded 204 crabs, 189 of which were males. The catch rate of about 3.4 crabs/net hr in this block indicates a sufficient abundance for commercial exploitation, although the area is remote and really only accessible to boats based at Tin Can Bay.

No crabs were caught in the shallows around the northern end of Fraser Island (block 0102), but the project team did find evidence that crabs exist there or very close by (see Section 4.7). However significant catches were made in three grid blocks to the west and northwest of Rooney's Point. These are in the northernmost part of Hervey Bay, and although block 0000 is north of the latitude of Sandy Cape, it is protected from oceanic swells by the extensive system of sandbars, shoals, and semi-permanent sand islands known as Breaksea Spit. The catch rate in this general area was highest in the grid block most exposed to oceanic conditions (10.84 crabs/net hr), but the two blocks west of Rooney's Point both yielded, on average, catches in excess of 6 crabs/net hr. Further south in the more protected part of Hervey Bay the catch rate was very much reduced (0.22 crabs/net hr in the deeper regions of Platypus Bay), and off Moon Point (blocks 0400 and 0401) no spanner crabs were caught at all.

4.4.2 Seasonal Effects

The results of this survey suggest that there is a seasonal pattern in the population density or vulnerability of spanner crabs, with catch rates in the latter half of the year (June-December) being substantially greater than those during the period January-May (Figure 6). CPUEs in June, July, September, October and December were not significantly different, the collective mean being slightly greater than 6 crabs/net hr. The apparently significant lower value obtained during August can probably be accounted for by the fact that sampling effort was not spread equally over time and geographical area. In other words, some bias has been introduced because more effort was expended in less productive areas during that month. The other aberrant sample (November) may, however, be significant, since there is some evidence from elsewhere of a pre-spawning reduction in feeding intensity.

While Figure 6 indicates statistically significant monthly differences in CPUE within the January-May period, these, too, can probably be attributed to a non-uniform distribution of effort. It would certainly be misleading to suggest, for example, that spanner crabs cannot be caught in January and April. To provide a better understanding of the combined effects of area and season, the data have been re-organised in Figure 7 to show seasonal trends in CPUE in three subdivisions of the project area: north and north-central, south-central, and south. Despite some missing data points, the figure shows similar trends in each of the three zones. Significantly, the highest CPUE in each case was recorded during September-October, and in the early part of the year catch rates were comparatively low. The zero value for March-April in the southern zone (Point Cartwright to Moreton Island) is probably not representative, being based on a sample size of only seven effective drops.

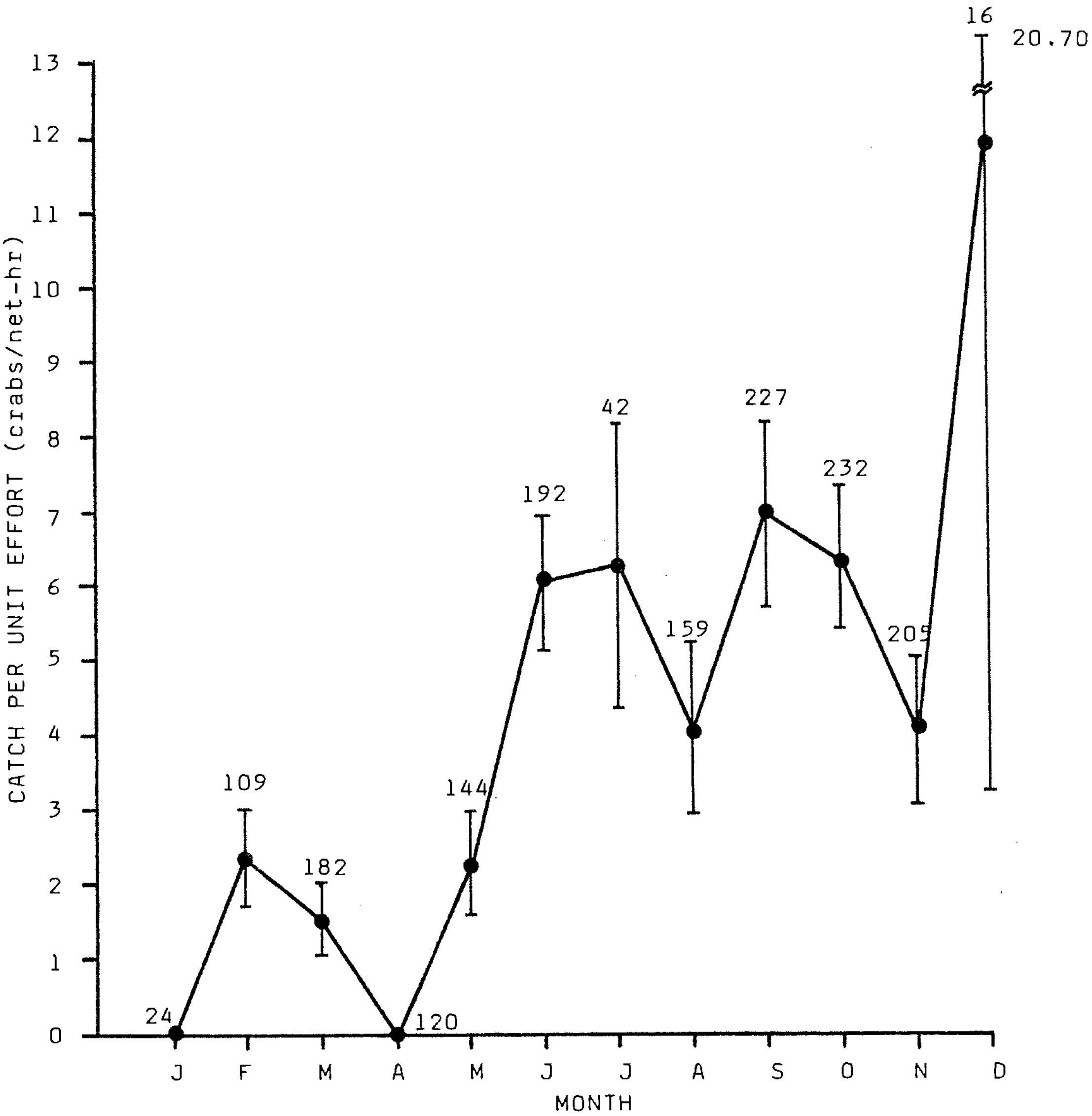


Figure 6 Seasonal variation in mean spanner crab catch rate (data from all blocks combined). Sample sizes are shown, and vertical bars represent 95% confidence intervals on either side of the mean.

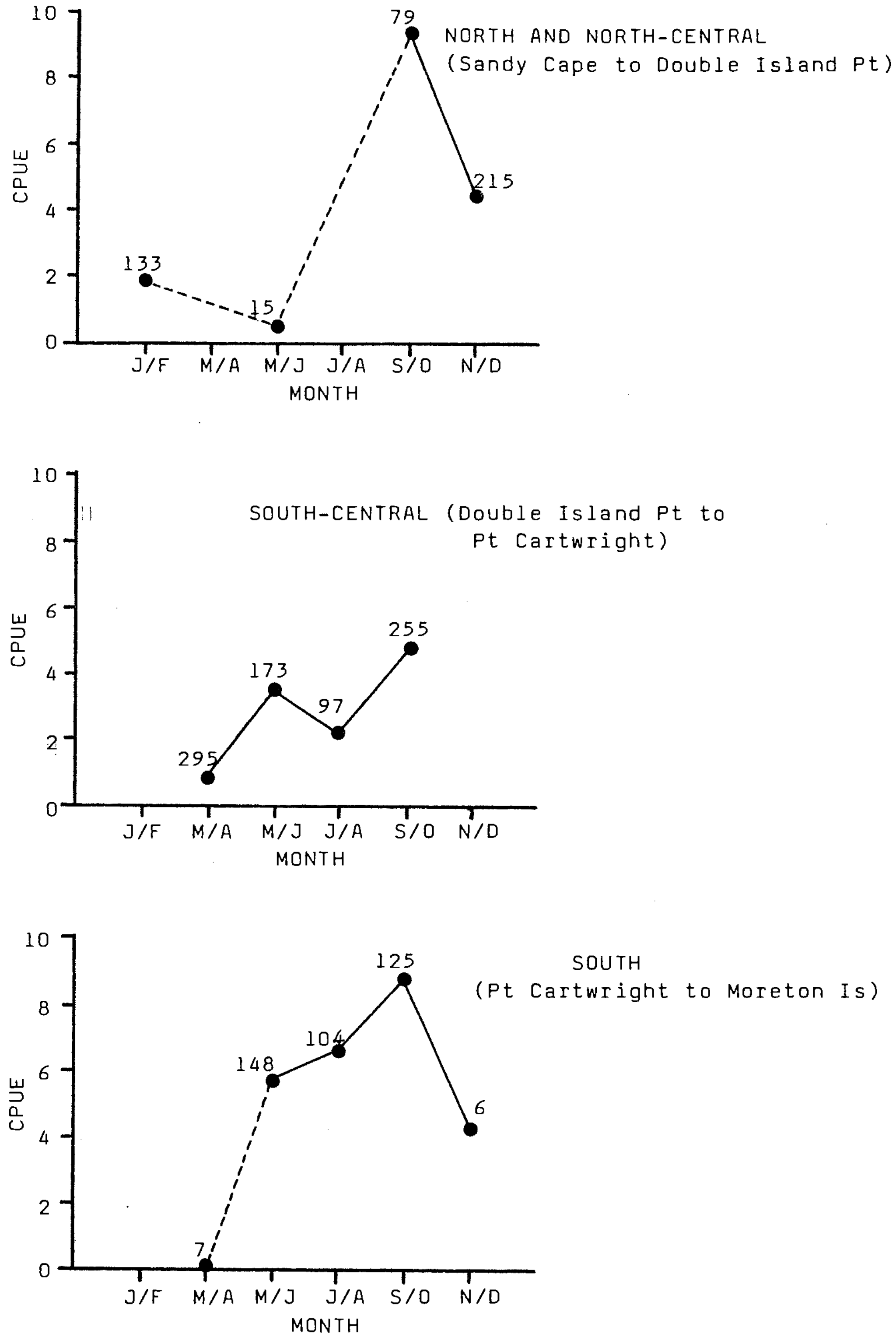


Figure 7 Seasonal changes in the catch rate of spanner crabs in three subdivisions of the study area.

4.4.3 Influence of Depth on CPUE

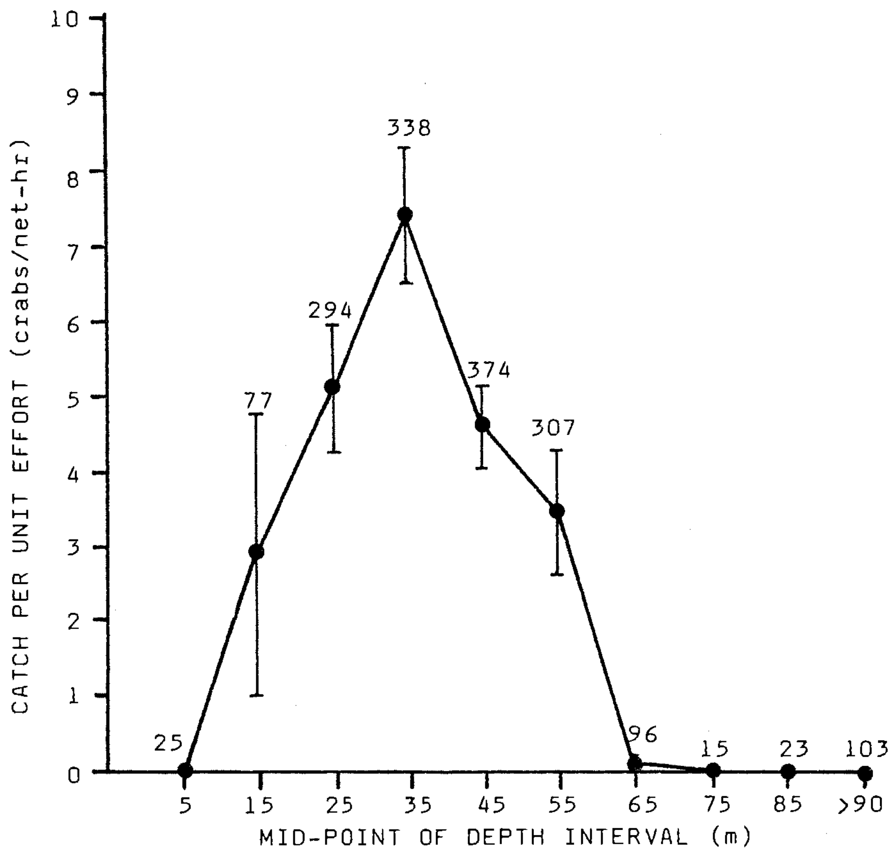
The depth-distribution of spanner crabs within the survey area appears quite distinct and straightforward. Disregarding possible complicating effects of season and locality, the CPUE data (grouped by 10 metre depth interval) are shown in Figure 8. No crabs were caught in the 25 effective drops in water shallower than 10 metres. The catch rate increased regularly in relation to depth, reaching a peak of 7.3 crabs/net hr in depths between 30 and 40m. A corresponding decrease in CPUE occurred in progressively deeper water down to about 70m, and in the 141 drops in depths exceeding 70m no spanner crabs were caught at all. It is pertinent to note that the mean CPUE of each depth sample was significantly different from that of its nearest neighbour, at least for depths less than 60m. This suggests that if there are any other factors influencing the depth distribution pattern, they will probably have an effect on magnitude, rather than direction. Figure 9 shows the pattern of depth-distribution of CPUE in three latitude zones. While the catch rates at all depth intervals appear higher in the southern zone than in either of the northern zones, the common form of the curves is clearly apparent.

An analysis of CPUE by depth-range and "season" simultaneously will clearly result in a certain lack of precision because of reduced sample sizes, but Figure 10 suggests that there are some slight seasonal effects in the depth distribution of the spanner crab stock. In autumn and early winter the best catch rate (more than 8 crabs/net hr) was recorded in the 40-50m depth zone. During the following three month period (July-September) the peak CPUE occurred in shallower water (30-40m), while the catch rates in 50-60m increased from less than 2 to about 6 crabs/net hr. Reasonable catches (>4 crabs/net hr) were still made in the shallowest depth range (<20m). The major change during October-December was a substantial decrease in the shallow water catch, and this was also apparent in the summer (January-March) sample. Very few crabs were caught during the summer period in depths greater than 50m, suggesting that the population is concentrated at that time in a fairly narrow depth band from about 30 to 45 metres.

4.4.4 Effects of Time on CPUE

Several commercial spanner crab fishermen are of the opinion that catch rates are best in the morning and drop off around midday. To test this hypothesis, the catch data were grouped in two hour time intervals and the mean CPUE calculated for each period. Catch rates (for all months and areas combined) were not significantly different after about 0900 hr (Figure 11), averaging approximately 4 crabs/net hr. Between 0700 and 0900 the mean CPUE was somewhat greater (5.4), while the few nets set prior to 0700 yielded a considerably poorer result (2.2).

However this trend did not appear to be consistent between grid blocks. Data from three blocks in which there was a relatively high level of sampling effort are also shown in Figure 11. The situation in block 1302 was totally different from the overall mean, with a fairly consistent upward trend in CPUE between 0800 and 1400 hr. The results from block 1202 approximated the overall average, but in block 0101 the highest CPUEs were experienced in the afternoon.



<u>Figure 8</u> Relationship between depth and spanner crab catch rate. Data from all blocks and months have been pooled. Means, 95% confidence intervals and sample sizes are shown.

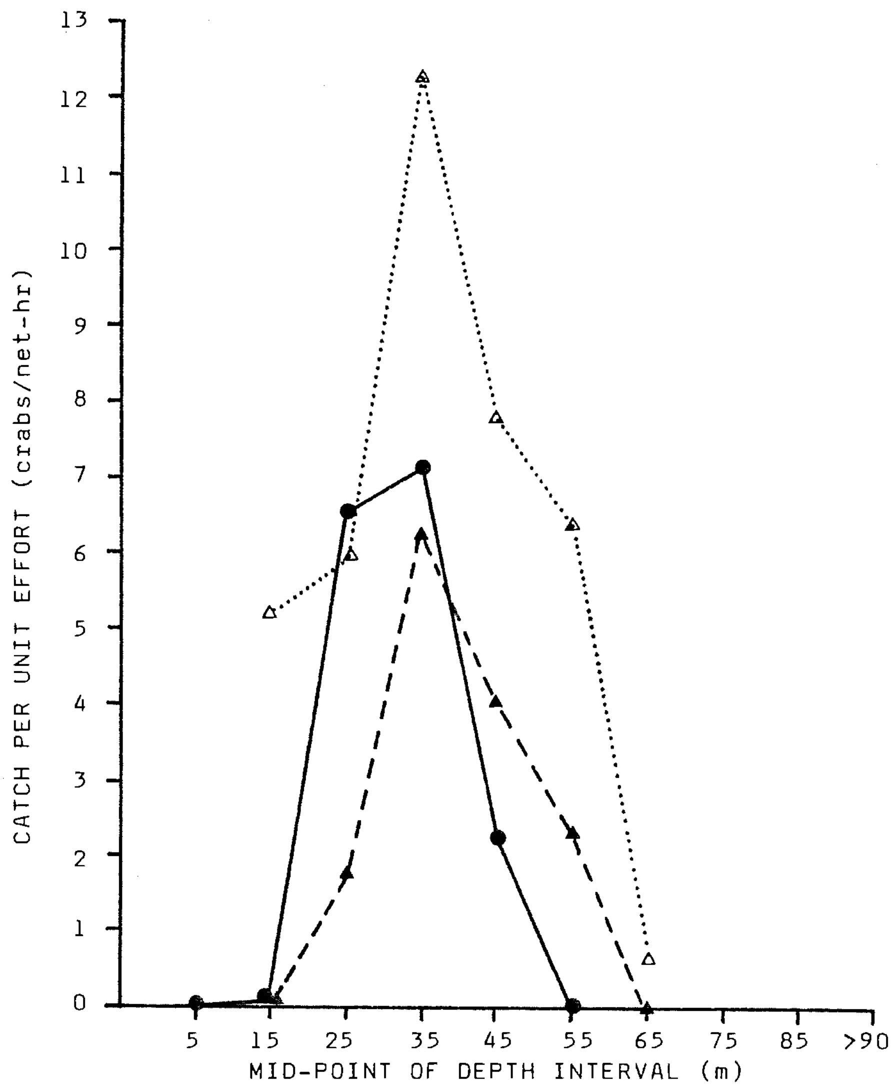


Figure 9 Relationship between spanner crab catch rate and depth in three zones of the study area.

●——● North and north-central
▲– – –▲ South-central
△………△ South

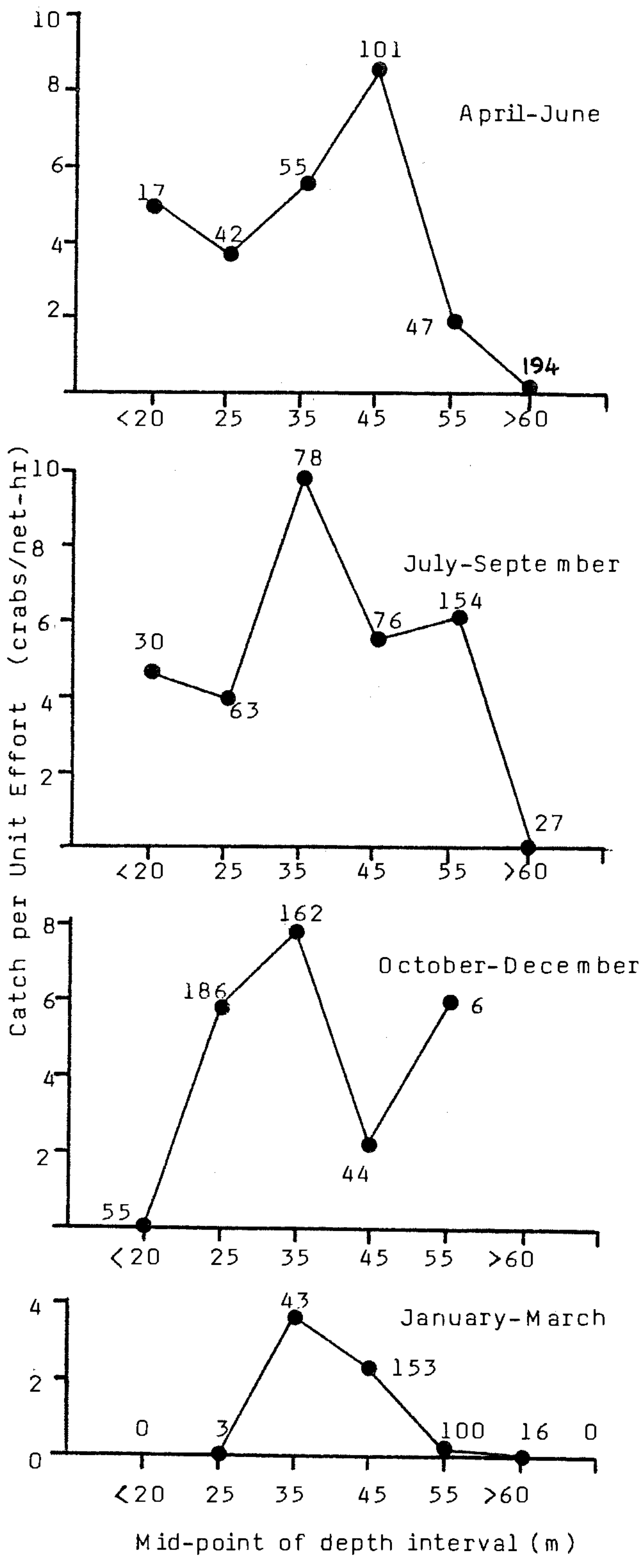


Figure 10. Seasonal changes in the depth distribution of Spanner crab catch rate (CPUE). Sample sizes are shown above the data points.

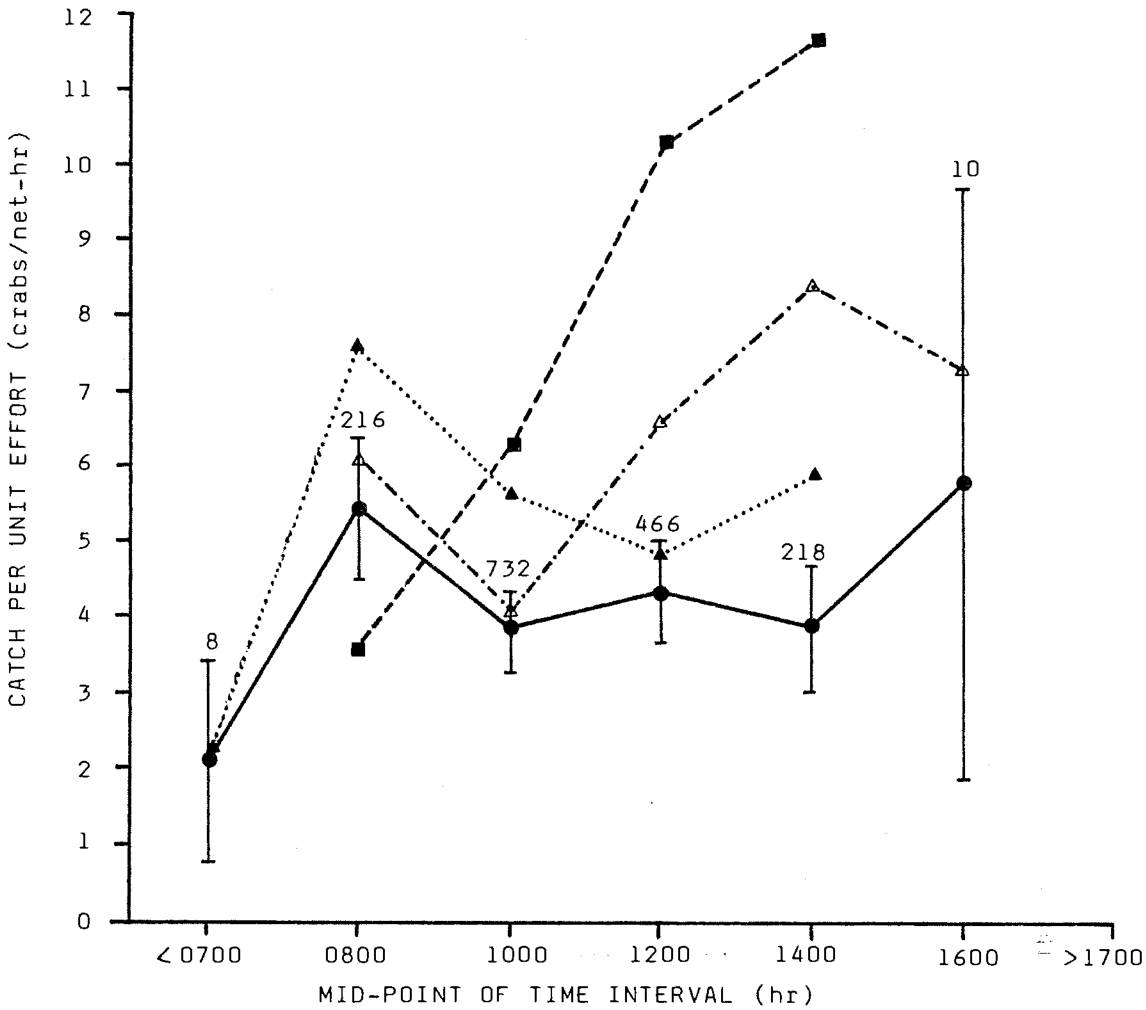


Figure 11 Effect of time of day on the catch rate of spanner crabs. The grand mean rate is shown (solid line) with 95% confidence intervals and sample sizes. The other three curves represent the catchrate-time relationship in three individual grid blocks:

■— — — — —■ Block 1302
△—·—·—·—△ Block 0101
▲··············▲ Block 1202

4.5 VARIATION IN SPANNER CRAB SEX RATIO

There is a marked dimorphism between the sexes in mature spanner crabs. Apart from the usual characteristics which distinguish male crabs from females, male spanner crabs are on average significantly larger than females. Insufficient is known at this stage to say whether this is due to a difference in growth rate and asymptotic size, or a sex-selective mortality favouring the survival of large males. The first explanation is considered the most likely, but whatever the reason, there is some commercial significance attached to this size-differential phenomenon since the proposed size limit of 10cm will effectively remove females completely from the (legal) commercial catch. It may thus be of considerable interest to the fishery to know if there are any variations in the sex ratio which can be identified with particular characteristics of depth, season or locality.

The total sex ratio (M:F) over all areas, months and depths, was 4.15:1. Throughout most of the year (March to October) the proportions remained rather stable at a little over 3:1, but in November the ratio increased dramatically to 32:1 (Figure 12). Given that the November CPUE was actually lower than that of the previous couple of months (see Figure 6), this increase in the proportion of males must have been due to a drop in the absolute number of females in the catch. Evidence from aquarium studies (D. Skinner, personal communication) suggests that female spanner crabs become quiescent and exhibit a much reduced level of general activity immediately prior to spawning. If this reduction in activity affects feeding behaviour, it seems quite likely that it could explain the paucity of females and hence the high sex ratio in the November catch. The only month in which the sex ratio fell below unity (i.e. females outnumbered males), was December, when the ratio was approximately 0.9. A possible explanation of this is that after some weeks of reduced feeding and the expenditure of more than usual amounts of energy during the final stages of egg maturation and spawning, the female crabs might require an unusually large food intake. The associated increase in foraging activity could render them particularly susceptible to capture.

Even though there are still no regulations governing the minimum size of spanner crabs that may legally be taken, many fishermen understand the biological and ultimate financial advantage of returning very small crabs to the water. Consequently a large proportion of the female component of the catch is liberated. It is therefore of interest to see if there are any differences in sex ratio between various parts of the study area, which includes regions subjected to a variety of exploitation levels from minimal to quite heavy.

Figure 13 shows the sample sex ratios from five zones of latitude. Although the northernmost group of grid blocks produced a sex ratio somewhat lower than that of the north-central group, a general trend in decreasing M:F ratio from north to south was evident. Bearing in mind that the main centres of commercial spanner crab fishing effort are in the south-central and southern zones, and that the population north of 26°10' is virtually unexploited, these differences may provide some idea of the extent to which the male crabs have already been "fished down" by commercial and recreational tangle netting activity. The data also support the view that the stock as a whole is not particularly mobile.

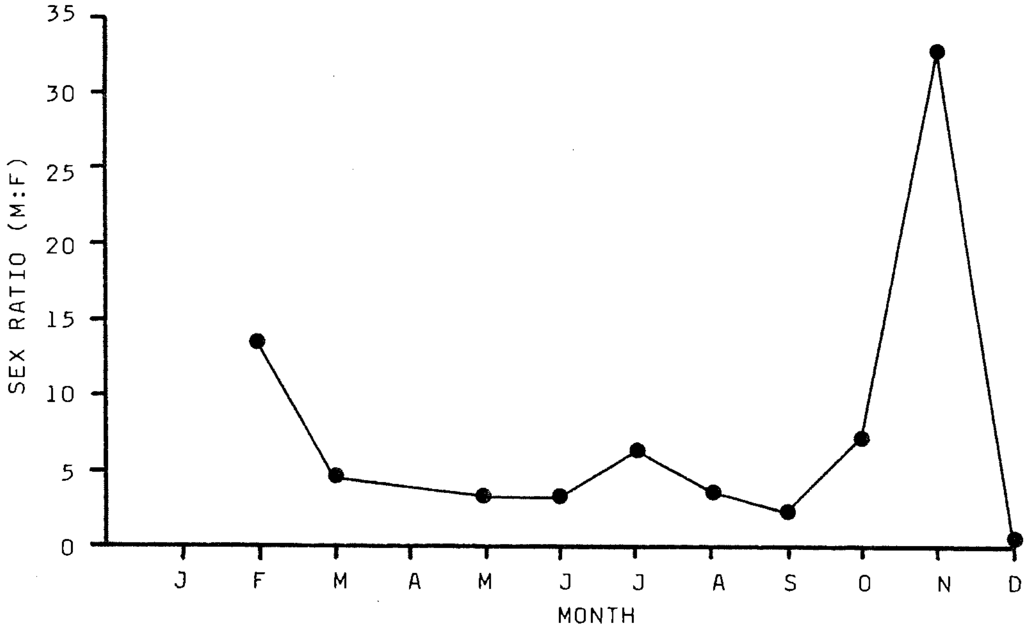


Figure 12 Seasonal changes in spanner crab sex ratio (M:F)

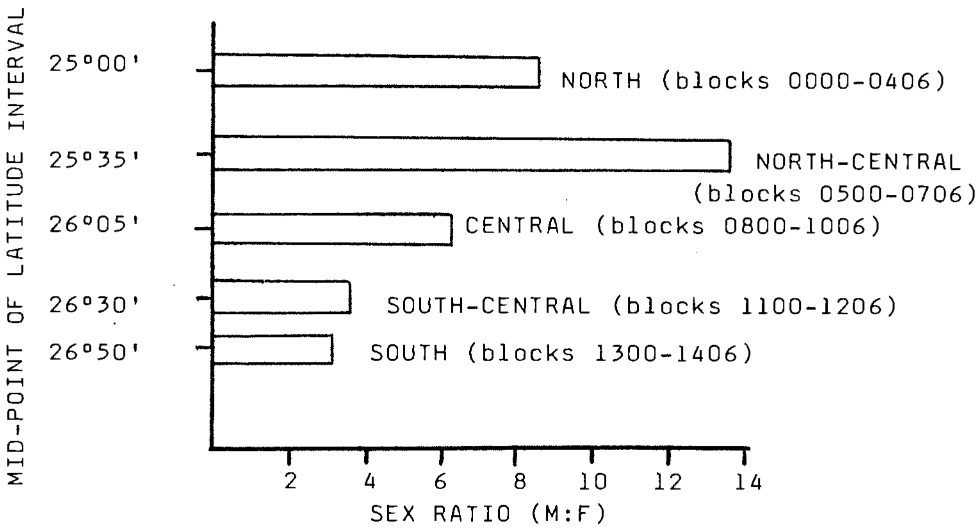


Figure 13 Geographical variation in sex ratio of spanner crabs

4.6 DREDGING AND TRAWLING TRIALS

Soon after the project commenced it became clear that the baited dillies being used as the standard sampling units were selectively fishing the older age-classes in the spanner crab population. Very rarely did crabs less than about 6cm carapace length appear in the catch. In terms of commercial fishing activity this is obviously an advantage, because it means that small juveniles are not subject to heavy fishing mortality, and fishermen are not faced with the problem of having to clear large numbers of very small crabs from their nets. It does, on the other hand, present difficulties in identifying larval settlement times and localities, and obtaining reliable data on the length of the postlarval/ juvenile phase of the life cycle.

Prawn trawlers are known occasionally to catch considerable numbers of "matchbox-sized" spanner crabs at particular times of the year, in areas where they might be expected to appear in the baited dillies but apparently do not. In an attempt to obtain material and information about these elusive age groups the project team, in co-operation with SFRC personnel, ran a series of trials with other sorts of sampling devices including a small benthic dredge and a try net.

Dredge trials were carried out during December 1981 and September/ October 1982 in the area between Point Cartwright and Moreton Island. Sampling depths ranged from 5 to 45 metres and the dredge was towed over distances of up to 0.4km. No intact spanner crabs were taken in any of the 35 or so dredge samples, although on a couple of occasions some pieces of broken carapace appeared in the cod end, presumably as a result of severe damage to a live crab by the dredge teeth. There is no doubt that the dredge was fishing effectively on the bottom, as a wide range of benthic invertebrates including starfish, sea urchins, shells and small crabs of various species, as well as demersal fish such as flounders and flathead, were regularly encountered.

Failure of the dredge to catch juvenile spanner crabs prompted some experimentation with a "try net" (scaled down otter trawl) which was initially rigged, for ease of handling, as a plumbstaff beam trawl. Some 25 shots with the beam trawl during January 1983 yielded only one small spanner crab (about 30mm CL), and an occasional piece of broken carapace. Again the net was obviously fishing on the bottom, as numerous small crabs of various types, ophiuroids, starfish, sand dollars, shells and flatfish were captured. The trawl was towed for 20 to 40 minutes in depths between 10 and 40 metres off the beach south of Point Cartwright, and north of Moreton Island.

At the end of January the net was re-rigged, this time as an otter trawl with a pair of small boards attached by a bridle to a single towing warp. This configuration proved much more successful in catching spanner crabs. About 50 small individuals ranging in length from 41 to 58mm CL were captured in 17 trawl shots. Most of these were taken in 20m of water south of Point Cartwright during February and March, and were presumed to be "young of the year" resulting from the previous November spawning.

4.7 "BEACHED" SPANNER CRABS

A peculiar aspect of this species' behaviour, which still defies adequate explanation, relates to the occasional emergence of crabs on to the beach. Reports of such behaviour have come from several different reliable sources, indicating that crabs of a variety of sizes sometimes appear intertidally in (or on) the moist sand of beaches as widely geographically separated as Round Hill Head (24°10'S) and Yellow Patch, Moreton Island (27°02'S).

While working around the northern end of Fraser Island, the project team learned from local beach fishermen that considerable numbers of crabs could be collected from one or two small sand islands in the Breaksea Spit area north of Sandy Cape. The crabs were reputedly to be seen either buried in or walking over the moist sand above tide level. These reports were followed up by investigations of the area during a three week period in August/September 1982, and again in December the same year. Adult crabs of both sexes were seen on the sand island about 2km north of Sandy Cape in August and September. About 10 crabs were observed: some were discovered buried beneath a pancake-like disc of moist sand protruding slightly above the level of the surrounding beach, while others were seen wandering apparently aimlessly about on the beach. When disturbed, the crabs tended to bury themselves immediately and very quickly in the sand rather than try to escape by heading towards the sea.

During the visits in December (on one of which SFRC/FIRTA project staff were present), much more effort was put into searching the beaches from Sandy Cape west to Rooney's Point and then south to Wurtumba Creek along the shore of Platypus Bay. On December 2, 16 juvenile crabs (8 males, 8 females) were collected from the beach south of Rooney's Point. The remains of several others, which had apparently been attacked by sea birds, were also discovered. The individuals collected ranged in size from 42 to 51mm CL, and there did not appear to be any significant difference in size between the sexes. Later in December another 15 juveniles (8 males and 7 females; 38-58mm CL) were collected, mostly from the beach south of Rooney's Point. On average, these were a few millimetres longer than those in the previous sample.

The most interesting finding, however, was an abundance of juvenile spanner crab moult shells along the tide line. Nearly 180 intact carapaces, some as small as 14mm, were collected and measured. The small shells were particularly fragile, and innumerable broken pieces were also scattered along the tide line. The presence of juvenile moult shells has not been reported elsewhere, and to our knowledge this is the first substantiated evidence of the possible location of a larval settlement area. For such a large number of the frail shells to have survived being washed up on the beach by wave action, there is presumably a "nursery area" somewhere close to the northern end of Fraser Island, probably in shallow water on the Hervey Bay side of Breaksea Spit. It is interesting to note that, while live crabs were being picked up from the beach, dillies set in the shallows up to 500m from the same shore failed to catch anything whatsoever.

5. DISCUSSION

The catch rate for species other than spanner crabs was disappointingly low. It is possible that the type of gear in use during the project was not ideally suited to the capture of portunids (sand, coral and three-spot crabs) as their uniformly tapered leg segments are less prone to catching in the mesh than are the asymmetric terminal dactyli or "spades" of the spanner crabs. Notwithstanding this, we believe that if the population densities of these other species had been significant, then a far greater catch would have been obtained. Spider crabs, which appear to inhabit the deeper waters along the edge of the continental shelf and slope, were likewise either very sparsely distributed or not susceptible to capture by baited dillies. None of the deep water sets was done at night, and it is possible that this species is a nocturnal forager. However, even if it could be demonstrated that spider crabs can be caught during the hours of darkness, this would hold little attraction for the crab fishermen because of the impossibility of operating small vessels with any degree of safety in such exposed areas at night-time.

Spanner crabs have been reported from a wide range of localities throughout the Indo-Pacific region from Hawaii through Japan, the Philippines and northern Australia to east Africa. It is therefore not unreasonable to expect commercially fishable quantities of spanner crabs on other parts of the Queensland coast. Bottom conditions between Cape Moreton and Sandy Cape seem, from the admittedly sparse detail provided on Admiralty and bathymetric charts, to be fairly homogeneous. There are several systems of shoals, banks and reefs in the northern part of the survey area which are avoided by prawn trawlers, but there is nevertheless a good deal of flat trawlable ground in between. It was initially thought that these interstitial areas might prove to be quite productive spanner crab grounds, but it soon became apparent that there was much more rubble and gravel bottom than generally realised.

Although the project was not designed to collect environmental data, there was abundant evidence that spanner crabs have specific requirements in terms of substrate type. Reefy bottom was detectable from echo soundings, and often resulted in hook-ups and major gear damage or loss. In situations like that, reef fish occasionally became meshed in the dillies but crabs were very rarely caught. Rubble or gravel substrates could often be identified by the presence of sea urchins, pieces of stone etc. caught in the nets, and again the crab catches were exceptionally poor. By and large, this species of crab is found only on relatively clean, fine sand, which is not surprising considering its propensity for spending a large amount of time buried in the substrate. The non-uniform distribution of catch rates experienced across the survey area can therefore be attributed in large part to substrate heterogeneity.

The project data suggest that there is some seasonality in spanner crab catchability, higher catch rates occurring generally in the latter half of the year. Why apparent foraging activity should increase as ambient water temperatures decline is difficult to explain, unless it is associated with the onset of gonad maturation and reproductive behaviour patterns.

Population density showed a fairly consistent trend in relation to

depth, with intermediate depth ranges generally yielding the highest catches. The logical explanation for this is that crabs are most plentiful in areas of abundant food supply. Little is known at this stage about the animals' natural dietary preferences, but SFRC staff have found evidence of heart urchins and polychaete worms in the foregut inclusions of a number of spanner crabs. The only published reference to this species' (presumed) diet appears in "Guide to Fishes" (E.M. Grant, 1982) which indicates that they capture small live fish, but it seems highly unlikely that this is correct. Their obvious prediliction for a variety of dead fish baits suggests that, in addition to their natural food, spanner crabs may also utilise trash fish discarded by the many prawn trawlers working at night in the south-central and southern parts of the study area. It is interesting to consider the possibility that prawn trawling may actually benefit the crab stocks, and conceivably have allowed a previously sparse stock to build up to an exploitable level. Unfortunately there are no historical data with which to test this theory.

There is clearly a sub-population with commercial potential in the northern Hervey Bay region. The collection of ovigerous female crabs northwest of Rooney's Point and juvenile moult shells on the Fraser Island foreshore points to there being a spawning population and a "nursery area" in that region. We suspect that the stock could extend a good deal further north, perhaps as far as the Swains Reefs, but the present small boat fishing unit could not work these areas effectively because of the distances involved. Larger seaworthy vessels with a significantly greater payload capacity would be needed for such long trips to be economically viable. However since the project identified the existence of good quantities of crabs in northern Hervey Bay, at least one local fisherman has started to exploit that part of the stock.

Commercial crabbers often complain about gear damage and loss from shark and turtle attacks. During the survey some gear was lost or ruined as a result of these predators eating the bait and/or crabs out of the net, sometimes severing the buoy-line in the process. The main areas where this problem occurred were Hervey Bay and in the vicinity of the Freeman Channel northwest of Cape Moreton. Predator attack is probably more frequent in the commercial operation where, once a productive area is located it is fished intensively, and discarded small crabs may tend to attract sharks and turtles to the fishing area. Gear losses also occurred when occasional sudden increases in tidal current dragged the surface floats underwater.

Localised intensive fishing by commercial operators may explain the alleged drop in catch rates around midday. Survey results indicated a high degree of variation in the relationship between catch rates and time of day, but there was no consistent evidence of a noon decrease when the nets were always reset in different localities.

Project personnel believe that it is high time some management controls were introduced into the spanner crab fishery. Several recommendations (including a minimum legal size of 10cm, an amateur bag limit, and a prohibition on the taking of ovigerous females) were made as long ago as 1981, but these have yet to be implemented. We also believe that commercial fishermen who are not already doing so should be urged to use monofilament fabric in their nets, as experience has shown that the least amount of damage to meshed crabs occurs with monofilament webbing of less than 50mm stretched mesh.

OFFSHORE CRAB RESOURCES SURVEY: FIELD DATA SHEET

DATE (yr)	DATE (mo)	DATE (day)	GRID No

Gear condition code
0: no damage 1: slight damage
2: major damage or loss

Other crab species codes
1: sand 2: spider
3: three-spot 4: coral
5: mud 6: any else

SET No	BUOY No	DEPTH (metres)	TIME OF SET	TIME OF LIFT	GEAR	SPANNER CRABS No males	SPANNER CRABS No females	SPANNER CRABS No berried	OTHER CRABS code	OTHER CRABS No	OTHER CRABS code	OTHER CRABS No	OTHER CRABS code	OTHER CRABS No	COMMENTS

Appendix 1. Field data recording sheet used during the project.

7 22.10.81

<u>Appendix 2</u>. Sample listing of part of the project field data-base held on floppy disk at DPI's Southern Fisheries Research Centre, Deception Bay.

Year
Month
Day
Block No.
Set No.
Buoy No.
Depth (m)
Set time
Lift time
Gear condition code
Spanner crabs: Males, Females, Ovigerous
Other species: Code No., Code No., Code No.

```
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No 19..80/.13.....

- ☐ NEW PROPOSAL
- ☐ CONTINUING PROJECT
- ☒ FINAL REPORT
- ☐ PROGRESS REPORT

FISHING INDUSTRY RESEARCH TRUST ACCOUNT

TITLE OF PROPOSAL/PROJECT: A STUDY INTO THE CAUSE OF MORTALITY OF THE CULTURED PEARL OYSTER IN WESTERN AUSTRALIA

ORGANISATION: WA DEPARTMENT OF FISHERIES

PERSON(S) RESPONSIBLE: DR DA HANCOCK

FUNDS SOUGHT/GRANTED

YEAR	SOUGHT	GRANTED
1980/81		$38 518
1981/82		$43 933
1982/83		$47 977

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