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CHANGES IN SPANNER CRAB (RANINA RANINA) STOCKS IN SOUTHERN QUEENSLAND : EVIDENCE FROM COMMERCIAL LOGBOOKS

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Changes in spanner crab (*Ranina ranina*) stocks in southern Queensland: evidence from commercial logbooks.

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Introduction

Spanner crabs are distributed throughout the tropical Indo-Pacific from the east coast of South Africa through the Indonesian Archipelago to Japan and Hawaii (Tinker 1965, Onizuka 1972, Healy and Yaldwyn 1970). In Australia they have been recorded from northern tropical and Barrier Reef waters south to Sydney Harbour (Healy and Yaldwyn 1970).

The species (known locally as the "kona" crab) has been fished around the Hawaiian Islands since before the second World War (Onizuka 1972). Catch statistics compiled by the Hawaii Division of Fish and Game indicate an average annual production of around 10 t, with a peak of 35 t in 1972 (Brown 1985). Tahil (1983) reported a catch of 4.7 t of *R. ranina* in the central Philippine province of Tawi Tawi during 1979-80, and the species is also exploited off the southern coast of Japan (Sakai 1971, Sakai et al. 1983). Little is known of the distribution or commercial potential of spanner crabs in either the tropical west Pacific or Indian Oceans.

The Queensland fishery

The by-catch of offshore prawn trawlers frequently includes spanner crabs, but rarely in significant quantity. Trawler operators originally regarded the crabs as a nuisance (because of the difficulty in untangling them from inside the net), or at best a curiosity, rather than a potentially valuable resource. The crabs' apparent rarity was due to their ability to bury in the substrate when alarmed, avoiding capture by the trawl net.

A commercial fishery targetted specifically on spanner crabs began to develop in 1978-79 when it was discovered that the tangle nets or dillies used by recreational fishermen to catch mud crabs (*Scylla serrata*) and sand crabs (*Portunus pelagicus*) in estuaries were also suited to capturing spanner crabs further offshore.

The fishery first became established in the area between Mooloolaba and Moreton Island (latitudes 26° 45′ S to 27° 00′ S), but has subsequently extended north to Bundaberg (24° 50′ S) and south to Ballina (28° 50′ S) in northern New South Wales.

No official statistics are available for either total catch or total effort, but the annual catch during 1983-84 was estimated at 300 t (Brown 1984). This is an order of magnitude greater than the highest annual landings reported in the Hawaiian fishery between 1945 and 1980 (Onizuka 1972, Uchida 1986), although the Hawaiian figures have almost certainly been under-reported (Brown 1985).

While commercial kona (spanner) crab fishermen in Hawaii work depths to around 200 m (Fielding and Haley 1976), the species is rarely found deeper than about 80 m off the Queensland coast, and the most productive depths are from about 30 to 60 m. The animals do occur in shallow water, (Grant 1986) and strandings in the intertidal zone of ocean beaches have been reported.

Skinner and Hill (1986) reported a strong seasonal pattern in spanner crab catch rates from an area east of Mooloolaba (26° 40′ S) during 1982 and 1983. This pattern was characterised by an August/September peak in both years. The authors found no significant correlation between CPUE and water temperature, and concluded that the pattern was the result of behavioural changes related to the reproductive cycle rather than a direct metabolic-rate effect. During a brief study of the fishery in the Philippines, Tahil (1983) reported that catches reached a seasonal maximum between September and December, and also attributed the pattern (at least partly) to the reproductive cycle.

The Queensland spanner crab fishery is characterised by a relatively high turnover of fishermen, many of whom operate seasonally in other local fisheries. Partly for this reason only one of the nine fishermen participating in the logbook programme in 1987 had been involved previously. It is possible that observed changes in CPUE may have resulted from changes in the composition of the fishery, location of major fleet bases, or general fishing strategy (Miller 1983).

A voluntary logbook programme was instituted as part of a broader research effort into the fishery and biological characteristics of the spanner crab stock in southern Queensland from 1982 to 1984. The logbooks were trialled in the latter half of 1982 and the programme operated during 1983 and 1984. Following a two-year lapse (for which no fisheries data are available), the programme was re-commenced in January 1987, in response to concern amongst some crab fishermen about an alleged decline in catch rates.

This study investigated the significance of changes in catch-per-unit-effort in the commercial spanner crab fishery since 1982, and examined the source of "seasonality" in catch data obtained from a much wider geographical range than that used by Skinner and Hill (1986). The implications of changes in individual fishing effort and apparent differences in fishing strategy were also investigated.

Methods

Logbooks were designed to accommodate daily catch and effort information. Catches were recorded as the numbers of legal-size crabs ("keepers") and the numbers of under-size crabs ("discards"). The catch of marketable crabs was usually estimated (directly by count, or on the basis of the number of cook-baskets used) at the time of cooking. Methods for estimating the number of discards were, however, more variable and undoubtedly much less reliable, since undersize crabs are normally thrown overboard immediately after removal from the net. Two measures of fishing effort were used, and their effects on CPUE values contrasted. The first was the "fishing day", and the second the "net drop", calculated by multiplying the number of nets per set or group and the number of sets per day.

Daily catch and effort statistics were associated with up to three ten-minute square grid blocks. The grid area from which statistics were obtained (Figure 1) extended approximately from Double Island Pt, Qld (26° 00' S) to Brunswick Heads, N.S.W. (28° 30' S). In cases where a fisherman indicated that he had worked more than one block during a particular day, the catch and effort values were apportioned equally amongst the blocks since greater resolution was not possible.

To test whether changes in CPUE were real or merely an artifact of fleet disposition, the annual mean catch rates from a subset of grid blocks were compared. The blocks were chosen on the basis of having been subject to a significant proportion of the total annual fishing effort in 1987 as well as 1982-84.

Results

a) Catch per day

During the course of the logbook programme the reported catch of marketable crabs increased from about 29 000 in 1982 to more than 276 000 in 1987 (Figure 2). To account for changes in the number of fishermen participating in the logbook programme from year to year, and variation in the amount of time individual fishermen actually spent fishing for spanner crabs (as distinct from other species), catches must be related to some index of effort.

Increasing annual catches were clearly linked to a substantial rise in total effort (number of spanner crab fishing days each year) (Fig. 2). The average daily catch of marketable crabs rose from 345 in 1982 to a little over 500 in 1984, then fell to 400 in 1987.

b) Catch per net

Between 1983, '84 and '87 there were significant increases in the mean number of net drops per fisherman per day (Table 1), which would not have been accounted for in the previous measure of effort. By increasing the number of nets deployed in a set and/or by setting them more frequently, fishermen effectively lifted 60% more nets each day in 1987 than they did in 1984, and over twice as many as in 1982-83.

Table 1. Changes in mean annual individual effort (net-drops/day).

YEAR	Number of fishermen	Mean No. drops/day	95% conf. range
1982	1	91.8	+ 6.2
1983	10	90.0	+ 4.4
1984	7	122.9	+ 4.8
1987	9	198.0	+ 7.1

The frequency distribution of daily catch-per-unit-effort (CPUE) indices approximated the negative binomial, requiring logarithmic transformation of the data prior to parametric statistical analysis (Sokal and Rohlf 1969, Elliott 1977). Means and associated statistics involving catch per net drop in the following results section have been calculated on the basis of X=log((catch/effort)+1) and back-transformed appropriately.

Catch rates calculated on the basis of net drops (Figure 3) decreased more steeply than did those based on fishing days (Figure 2). During 1982-84 annual CPUEs varied around 4 legal-sized crabs/net, but by 1987 they had dropped to slightly less than 2. The separation of confidence ranges in Fig. 3 demonstrates the statistical significance of this difference. Over the same period effort had increased nearly four-fold from 38 000 to over 137 000 net-drops.

c) Seasonality

Single classification ANOVA demonstrated statistically significant differences in mean log-transformed CPUE (crabs/net) between pooled 2-monthly groups. The data for each of the years 1983, 1984 and 1987 were analysed separately, and in all cases the F-ratio was highly significant (Table 2).

Table 2. Results of analysis of variance in CPUE between seasons. For all values of F, $p<0.001$.

CPUE	YEAR	F	d.f.
Keepers	1983	9.94	5, 287
	1984	5.21	5, 303
	1987	17.27	5, 687
Discards	1983	13.38	5, 287
	1984	18.45	5, 303
	1987	10.68	5, 687
Total	1983	14.38	5, 287
	1984	11.49	5, 303
	1987	15.62	5, 687

However there was no obvious consistent trend from year to year in the two-monthly group mean CPUEs for marketable crabs (Figure 4). In fact the 1987 "seasonal" pattern was almost the inverse of that in 1983, and neither bore much relationship to the 1984 pattern.

In contrast, the average catch rate of undersize crabs varied in a similar manner in each of the three years (Figure 5), with a peak CPUE occurring early each spring (September/October). The absolute catch rate values in 1983 and 1984 were surprisingly similar (considering the probable estimation error in determining catch) with peaks close to 3.5 crabs/net. Catch rates for undersize crabs were substantially lower in 1987 than in 1983-84, and the September/October peak was also less pronounced, although analyses of variance showed that the differences were still highly significant (Table 2).

d) Geographical influences

Pooled catch and effort data from four blocks north of Moreton Island (1302, 1303, 1402, and 1403; Figure 1) were analysed to show whether the changes depicted in Fig. 3 could have been influenced by geographical shifts in the concentration of effort, or whether they were representative of trends in consistently-fished localities.

The annual mean CPUEs for the subset of blocks (Figure 4, dotted line) were very close to those for all blocks pooled (Figure 4, solid line). During the first three years the two data sets were statistically homogeneous, but in 1987 the subset mean was significantly lower than the overall mean (1.2 and 1.9 crabs/net respectively).

Details of changes in catch rate between blocks and between years are shown in Table 3. The CPUEs varied between blocks within years by factors of up to eight, but the feature of greatest significance was a general tendency for localities which were fished in the early 1980s to yield much lower catch rates in 1987. In the northern section of the fishery (which is believed to have been exploited for a longer time than the southern section) CPUEs were also generally lower than they were in the south.

e) Fishing strategies

Cursory examination of the raw data revealed that the numbers of nets per set, and to a lesser extent the number of sets effected per day, varied considerably between fishermen. This suggested that different fishermen may employ different fishing strategies, a factor of potential relevance to the interpretation of logbook statistics. To test this, each contributor was assigned to one of three effort groups on the basis of the average number of nets he deployed per day during 1987, and the group mean CPUEs were computed and compared by ANOVA. The mean number of net-drops per day ranged from 139 to 336, and the group limits were specified as <200, 201-250, and >250 net drops/day.

The high-effort group achieved an average catch rate of 1.04 crabs/net (n = 149 days), but in the low-effort group CPUEs were more than double, averaging 2.32 (n = 434). Catch rates for the intermediate-effort group were mid-way between the others, at 1.52 crabs/net (n = 110). These differences were found by ANOVA to be highly significant (F = 55.9 with 2 and 690 d.f.; $p \ll 0.001$).

Discussion

It must be recognised that the data used in these analyses were derived from a relatively small and changing subset of the total spanner crab fleet, and provide only "snapshots" of the situation at two discrete periods in time. The information is possibly more reliable than might be the case from a compulsory fisheries return system, but it suffers from the lack of an accurate estimate of either total catch or total effort for the entire fleet.

Nevertheless, assuming that CPUE (in this case the number of crabs per net-drop) is a reasonable estimator of population density, there is strong evidence that the south Queensland spanner crab stock has declined significantly since the tangle-net fishery was established during the late

1970s. While the fishery was developing, catch rates averaged about 4 crabs per net, but after only two years this rate had halved. It is not known whether annual CPUEs had dropped progressively over that period or whether the 1987 value was an "improvement" on a lower value in 1986, but the former is suspected.

Table 3. Effort (net drops) and catch rate or CPUE (numbers of marketable crabs per net) recorded by crabbers cooperating in the voluntary logbook programme.

BLOCK	1982		1983		1984		1987	
	DROPS	CPUE	DROPS	CPUE	DROPS	CPUE	DROPS	CPUE
0100							288	1.4
0901					102	1.3	60	0.8
0902	50	0.8					100	1.4
1001	50	0.8			102	1.3	2106	1.5
1002							152	2.1
1101			381	3.4	473	4.6		
1102			367	3.5	563	5.0	221	0.7
1103			48	2.0				
1201			547	5.7	60	0.8		
1202	870	2.4	2077	4.0	3759	3.7	2549	0.7
1203	30	2.5	510	8.0	1675	5.2	2201	0.9
1204							105	0.3
1301	50	2.5	252	1.7	60	2.2		
1302	1980	2.8	9238	4.1	13603	3.7	14400	1.1
1303	2678	3.9	2789	3.6	1990	3.8	13448	1.2
1304	50	2.3						
1402	120	3.3	2490	4.8	3611	3.8	2916	0.8
1403	1698	3.9	5180	4.9	9729	3.9	26775	1.5
1404			72	2.8				
1502			144	4.0	918	3.0		
1503	40	2.3	1528	4.4			873	0.9
1504			30	0.9				
1603			264	5.4	1260	6.2	1640	1.8
1604			196	3.5			75	2.0
1703			244	2.4	80	6.3		
1704							8140	2.1
1803							980	0.9
1804							1168	1.1
1903							9298	3.8
1904							6700	1.7
2003							7718	2.6
2004							9616	2.5
2103							1700	0.6
2104							7328	2.3
2105							90	3.1
2204							10133	1.8
2205							1290	1.7
2304							4068	1.6
2305							1088	1.8

Logbook CPUEs in 1982 and 1983 from grid blocks east of Mooloolaba (Fig. 1 and Table 3) were considerably lower than those recorded by Skinner and Hill (1986) at the same time. The reasons for this are probably twofold - Skinner and Hill (1986) used the total catch of crabs (of all sizes) in their calculations, and also standardised the index to a catch per net per hour. Since the soak time for spanner crab tangle nets is rarely more than 45 min, these computational differences adequately account for the discrepancy between the two sets of results.

In Hawaii, Vansant (1978) obtained a crude measure of effort (number of trips per year) for a vessel which had regularly fished the Penguin Banks since 1967. From this he calculated a CPUE (weight of crabs per trip) to assess the extent of annual changes in stock density. Catch rates ranged from 131 kg/trip (n = 19 trips) in 1967 to 268 kg/trip (n = 50) in 1974, with an average over the 8 yr period of 193 kg/trip. Assuming an average crab weight of 400 g, the mean catch rate (480 crabs/day-trip) is intermediate between the 1984 and 1987 values obtained in southern Queensland. Vansant (1978) considered catch rates in Hawaii to have been relatively stable over the period of his investigation, and interpreted it as indicating stability in population size. Observed variations in annual landings were attributed to changes in effort (numbers of boats) rather than stock abundance. However it might be argued that a 100% increase in CPUE between 1967 and 1972 could indeed reflect a (positive) change in the size of the crab stock, provided the number of nets deployed daily by the vessel concerned had not changed significantly.

A more appropriate measure of effort (the net-hour) was used by Vansant (1978) in an analysis of catch rates over the first six months of 1974. CPUEs varied little (range: 0.31 kg/net-hr [May] to 0.38 kg/net-hr [January]), providing scant evidence of seasonality despite the author's previous assertion of a pre-spawning peak in catch rates. These figures (again assuming an average crab weight of 400 g) would equate to about 0.8 crabs per net-hr, or 0.5 crabs per net for a 40-min set, which is well below the catch per net in any but one of the 30 grid blocks worked by the Queensland logbook contributors during 1987 (Table 3).

Skinner and Hill (1986) concluded that catch rates followed a strong seasonal cycle linked to the cycle of reproductive development, with a maximum CPUE just prior to spawning, in August/September. Tahil's (1983) catch data for the Philippines fishery were not accompanied by any estimate of effort, so it is impossible to know whether the variations in catch were related to the level of reproductive activity (as hypothesised), or were merely due to effort changing in response to economic and meterological circumstances.

The Queensland logbook data provided no evidence of consistent seasonal patterns in the catch rate of marketable crabs, but the CPUE for undersize crabs showed a distinct September/October peak in each of the three years, suggesting a pulse of recruitment of small animals into the fishery at that time. The descending right-hand limb of the recruitment mode probably represents the transition (by growth) of an increasing proportion of the subadults into the marketable, or legal sized, component of the crab population. Since the CPUEs of Skinner and Hill (1986) included small as well as legal-sized crabs, their observed seasonal trend in catch rate could well have been due to this recruitment pulse rather than a behaviourally-mediated change in the catchability of adult crabs.

Differences in fishing strategy, among other things, can confound the interpretation of logbook data (Miller 1983). Variation between crabbers in the average number of nets set per day, even amongst the small group of fishermen participating in the logbook programme, suggests the existence of radically different fishing strategies. Fishermen who set small numbers of nets were presumably able to spend more time searching (i.e. dropping a few nets in one area and moving on until good patches of crabs were found) than those who used large numbers. The advantage to using a large number of nets in a set is obvious, but there must be a cost in terms of time. This might be manifest as a reduction in soak-time (the interval between setting and retrieving the fleet of nets), searching time, or operational range.

The logbook data appear to show that the high-effort strategy (large number of net-drops per day) is less than half as efficient, in terms of catch per net, as the low-effort strategy. The difference in effort levels between the two extreme groups was about 1:2, so in terms of actual daily take-home catch the two would seem to have achieved much the same final result. Many factors, including vessel size and speed, distance from port to the fishing grounds, and personal gear preferences influence a particular fishermen's choice of operational strategy which may also change with time. There is some evidence that the southern part of the spanner crab fleet comprises more high-effort strategists than does the northern section. If this is so, it may not be possible to separate the effects of crab population density and operational efficiency on CPUE.

Despite the limitations of the data, there is some cause for concern about apparent trends in the spanner crab resource in southern Queensland and northern New South Wales. It is possible that, through much more intense exploitation over a shorter space of time, the local situation may have paralleled the longer-term development and decline that occurred in the Hawaiian fishery. However the Hawaiian data are insufficiently precise to allow more than a general comparison between the two.

Existing management controls in Queensland include a minimum legal size (10 cm C.L.), prohibition on taking ovigerous females, a bag limit for recreational fishermen, and a recently introduced closed season from 20th November to 20th December to protect spawners. Access to the fishery is now more tightly controlled than it has been, and the introduction of a State-wide compulsory fisheries logbook system in Queensland may provide broader coverage of the fleet, as well as essential estimates of total landings. All available data from the fishery should be closely monitored within the next few years to ascertain whether the current low CPUE levels indicate inadequacies in the present management plan, reflect a population characterised by large natural variations in size, or represent the sorts of catch rates which might be expected in a relatively new fishery reaching a point of stability.

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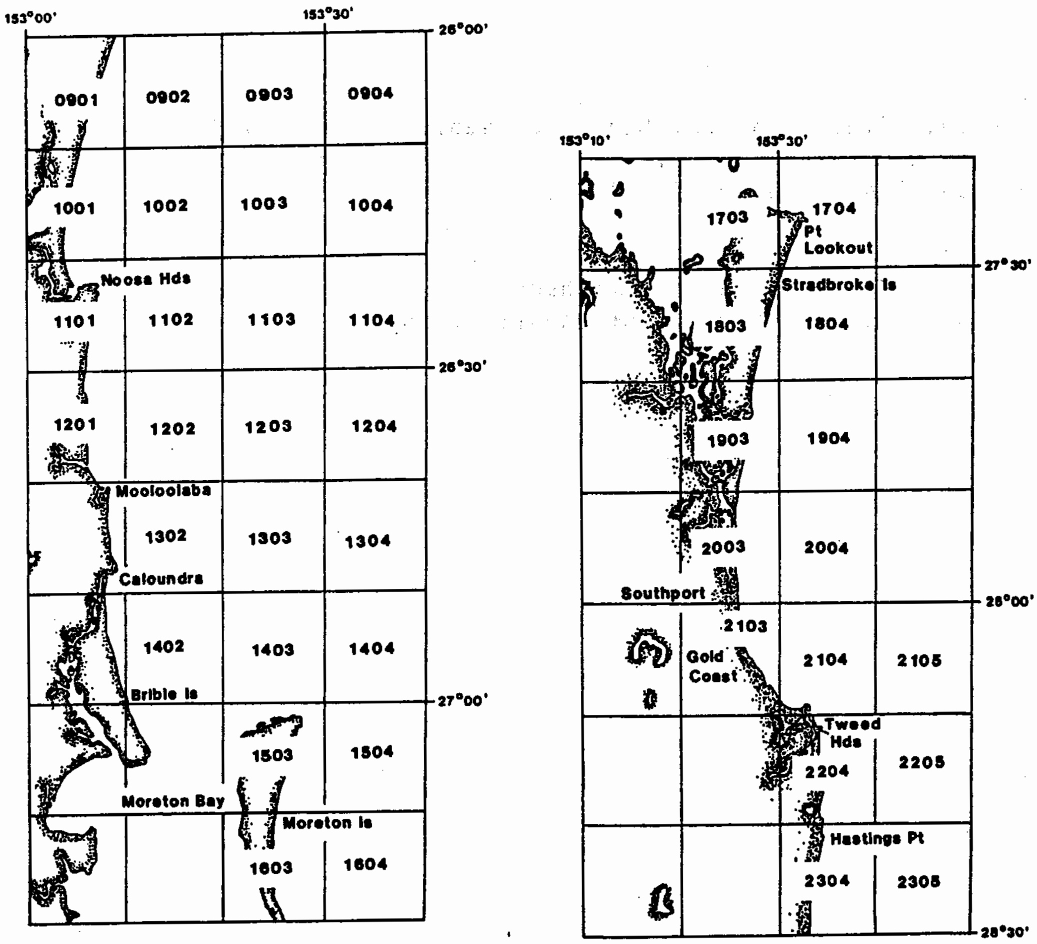

Figure 1. Grid area in south Queensland and northern New South Wales covered by fishermen contributing to the logbook programme between 1982 and 1987.

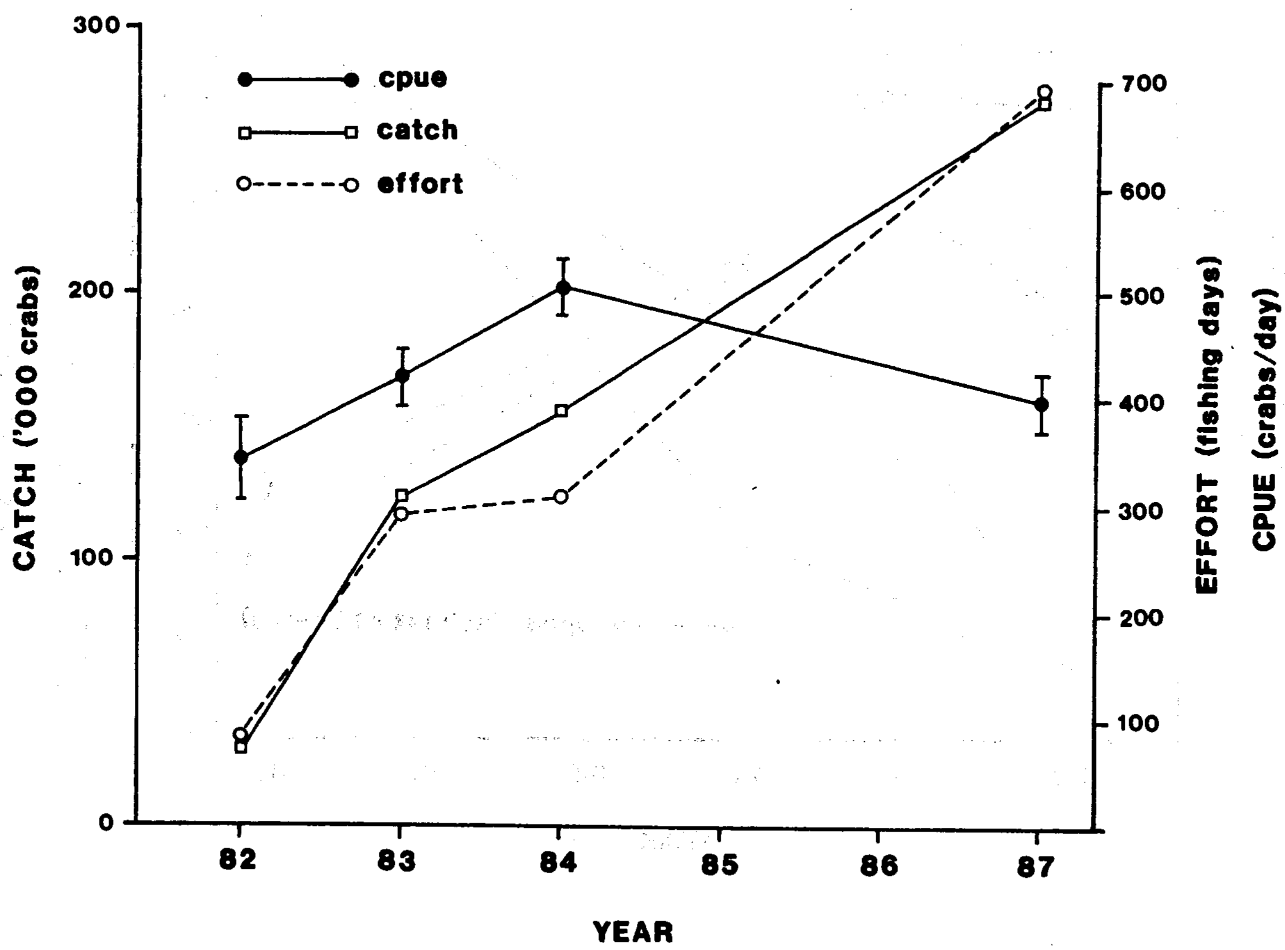

Figure 2. Annual changes in catch (thousands of crabs), effort (number of fishing days), and CPUE.

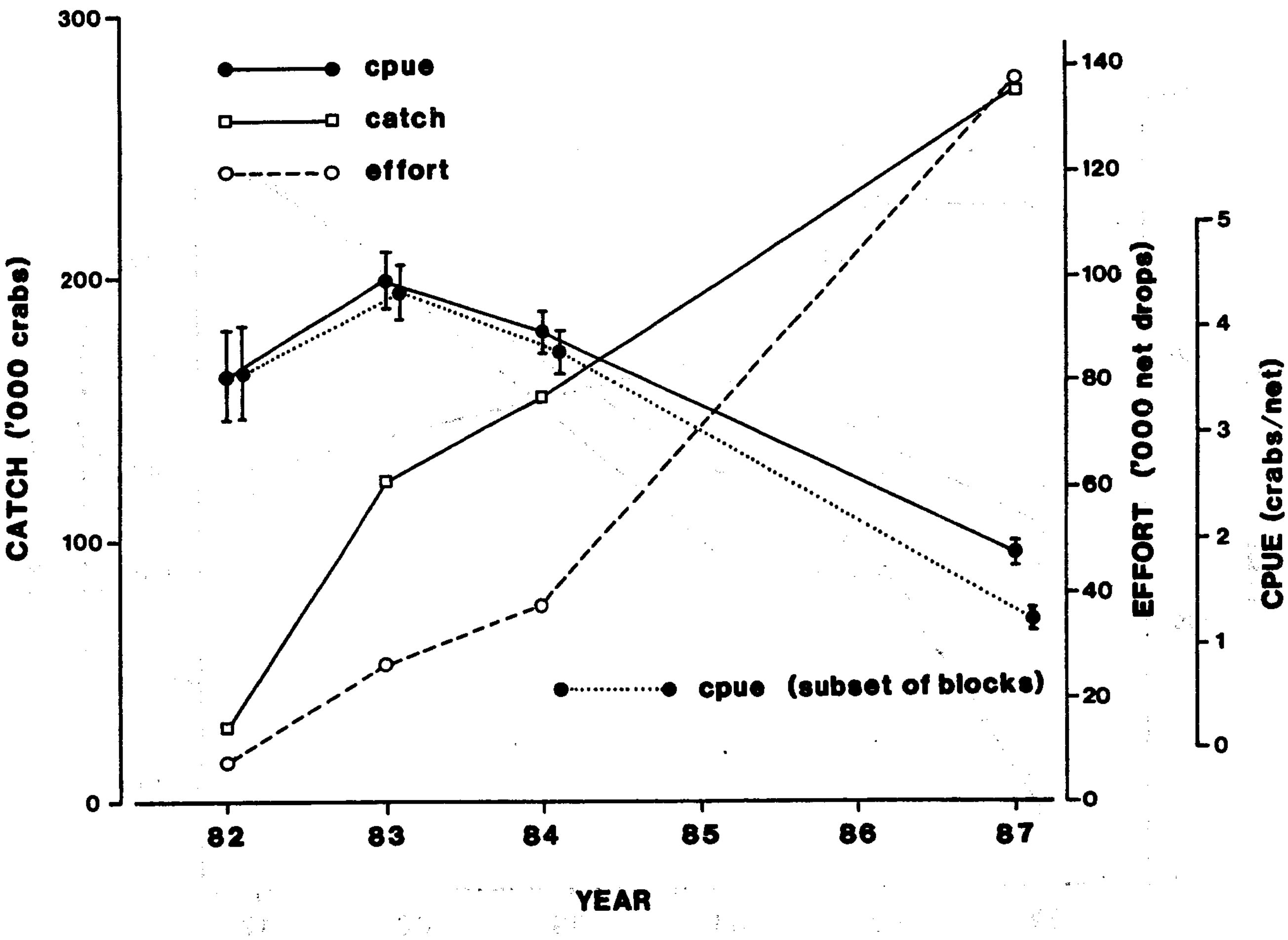

Figure 3. Annual changes in catch (thousands of crabs), effort (thousands of net-drops), and CPUE (crabs per net). CPUE changes in a small subset of grid blocks are also shown.

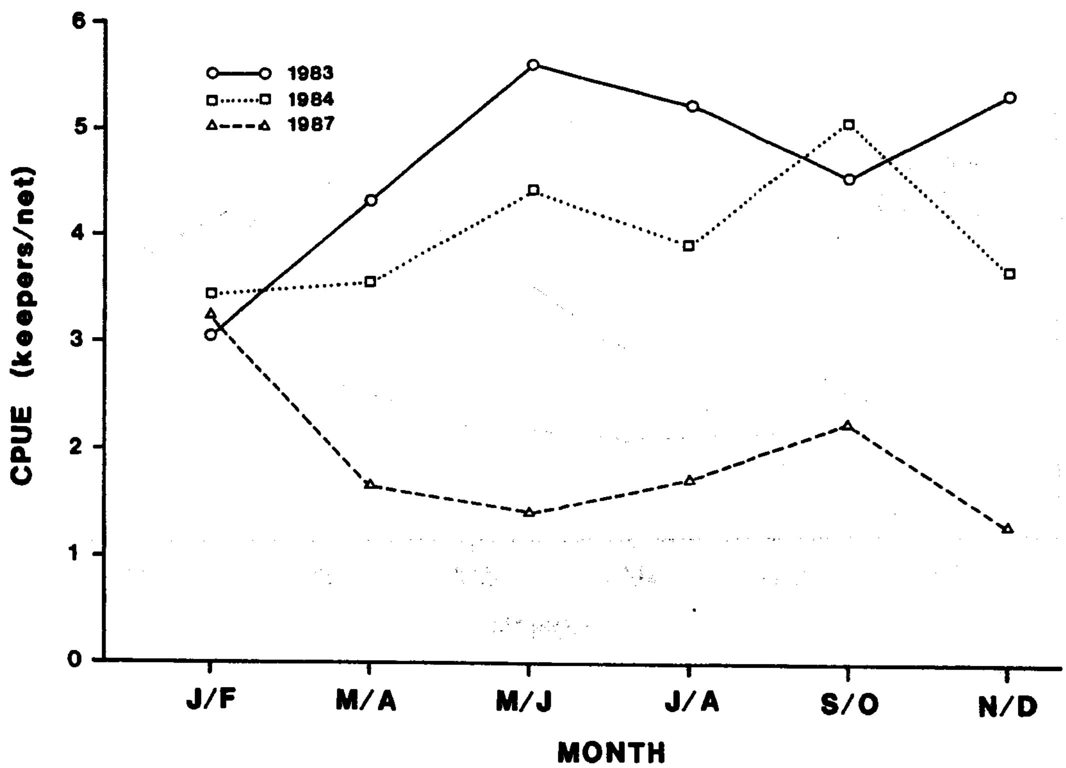

Figure 4. Seasonal changes in the catch rate of legal-sized crabs.

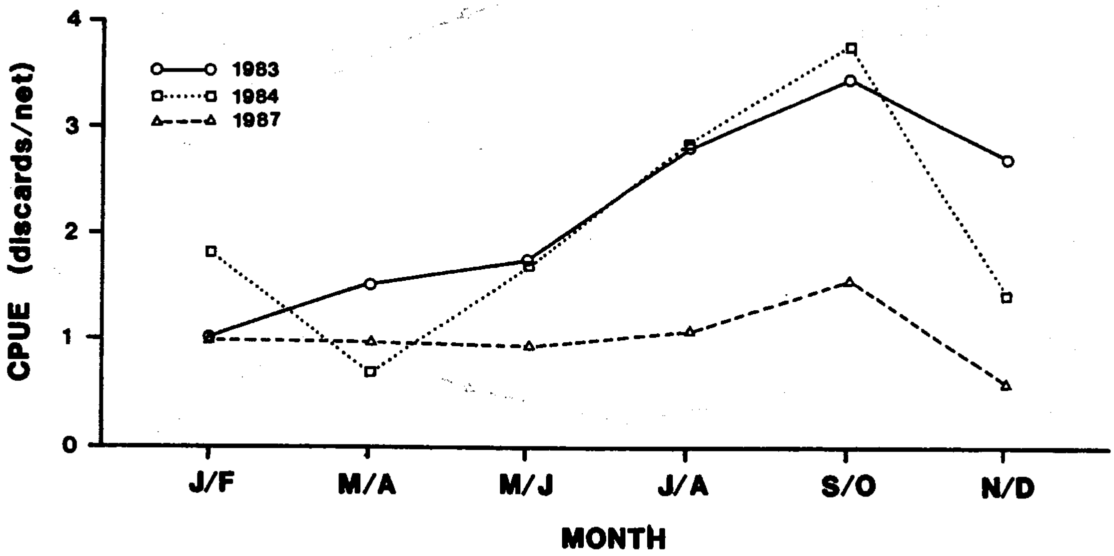

Figure 5. Seasonal changes in the catch rate of small crabs (discards).