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EAST COAST PRAWN RESEARCH PROJECT

CONCLUDING REPORT OF THE PROJECT LEADER, P. C. YOUNG

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INTRODUCTION

The East Coast Prawn Research Project was initiated on January 1, 1967, following an agreement between the Queensland Government and the Executive of CSIRO. Formal terms of reference were not set up; however, a memorandum of understanding was agreed upon in which the programme of research to be followed would be recommended by officers nominated by both parties.

The project envisaged the continuation of the highly successful co-operation on prawn research between these two authorities which commenced with a study of the prawns of the Gulf of Carpentaria.

The project was a cooperative enterprise: a Project Leader (Dr. A.J. Bruce) was nominated by CSIRO in 1967, and professional and technical staff were provided by both authorities. An executive committee was formed to whom the Project Leader reported. In 1969, Dr Bruce resigned and was replaced by Dr P.C. Young as Project Leader in 1970.

The Queensland Government, Department of Primary Industry, built a research laboratory at Deception Bay, Queensland in 1971, and laboratory equipment and vehicles were provided by CSIRO, with a supplement towards the cost of providing aquarium equipment. Administrative and maintenanee staff for this laboratory were provided by the Queensland State Government.

FACILITIES

Laboratory

The Queensland Department of Primary Industry designed the laboratory as a single floor structure (Fig. 1). The main building contained four laboratories, two aquarium rooms, a dark aquarium room, specimen store room, a cold room, library and conference room, chart room, instrument room and dark room. Eight offices were provided for scientists and administrative staff, with tea room and toilet facilities. Adjoining the main building is a smaller complex, containing workshop, boat store, store shed, and a plant and machinery room housing air conditioning plant, pumps and control gear.

Vehicles

CSIRO provided two four wheel drive vehicles for towing boats, and two station sedans, and a utility for transport to and from fishing ports with samples.

Vessels

CSIRO provided two major vessels, the 'Kalinda', a 70 ft offshore research trawler, (Fig. 2) and the 'Penaeus', a 38 ft planing hull launch for work within Moreton Bay (Fig. 3). As well as these, three smaller working vessels and a number of dinghies were supplied to the project by CSIRO.

STAFF

Staff numbers varied with a maximum in the latter stages of the project of six full time scientific, eleven technical, four administrative and four seagoing staff. A contract worker was also employed at each of the six major prawn landing ports (Tin Can Bay, Mooloolaba, Scarborough, Sandgate, Southport, Coolangatta).

SCIENTIFIC STAFF

(a) Full Time

Queensland Department of Primary Industry

Period of employment in Project	Name	Position	Field of Research in Project
1967-68	I. Kirkegaard B.Sc.	Fisheries Biologist I	Larvae of penaeid prawns
1971-73	M.A. Potter B.Sc.	Fisheries Biologist II	Population dynamics and migration routes
1972-75	C.P. Lee B.Sc.	Fisheries Biologist II	Experimental growth of postlarvae. Distribution of planktonic postlarvae

CSIRO, Division of Fisheries and Oceanography

1967-69	A.J. Bruce M.D.	Senior Research Scientist	Project Leader
1967-69	R. Walker B.Sc.	Experimental Officer	Juvenile prawns
1967-69	D. Tuma B.Ag.Sc.	Experimental Officer	Juvenile prawns
1968-71	C. Lucas B.Sc Ph.D.	Experimental Officer	Population dynamics
1968-71	J. Brundritt B.Sc.	Experimental Officer	Prawn behaviour
1970-75	P.C. Young B.Sc. ARCS, Ph.D.	Senior Research Scientist	Project Leader, Ecology of epibenthic post-larval prawns
1971-75	I. Somers B.Sc.	Experimental Officer	Ecology of epibenthic postlarval prawns
1971-75	H. Kirkman B.Ag.Sc.	Experimental Officer	Seagrass ecology
1971-75	W.E. Barber B.Sc. Ph.d.	Research Scientist	Adult biology, distribution of planktonic postlarvae

(b) Part Time

CSIRO, Division of Fisheries and Oceanography

1967-70	B.S. Newell B.Sc. M.Sc.	Senior Research Scientist	Water Chemistry
1972-75	S.M. Carpenter B.Sc. M.Sc.	Experimental Officer	Statistics
1972-73	D.F. Smith M.Sc.Ph.D.	Senior Research Scientist	Modelling
1973-75	C. Lucas B.Sc.Ph.D.	Research Scientist	Population dynamics

RESEARCH

The south east coast fishery consists mostly of eastern king prawns (*Penaeus plebejus* Hess). Other penaeid prawn species caught commercially in the area include tiger prawns (*P. esculentus* Haswell), endeavour prawns (*Metapenaeus endeavouri* Schmitt), school prawns (*Metapenaeus macleayi* Haswell), greasyback prawns (*Metapenaeus bennettae* Racek and Dall), hardback prawns (*Trachypenaeus anchoralis* Bate, *Trachypenaeus fulvus* Dall), New Guinea prawns (*Metapenaeus novaeguineae* Haswell), cherry prawns (*Atypopenaeus formosus* Dall) coral prawns (*Parapenaeopsis sculptilis* (Heller)). "Clickers" (*Alpheus stephensoni* Banner, *Alpheus distinguendus* de Man) both belonging to the family Alpheidae are also caught in Moreton Bay.

From 1970 the research programme was designed to investigate aspects of the ecology and population dynamics of *P. plebejus*, however, aspects of the ecology of associated biota were examined where relevant to the study. The study was resolved into a number of topics, each determined on the basis of its relevance to the total study.

The bulk of the field work has now been completed and many of the studies have been published (Appendix I). A number (Appendix II) is still to be published and one section (Section 4 - Population Dynamics) is to be continued until ten years have elapsed. The data will then be analysed and interpreted. The results of the population dynamics work to date are summarised in Section 4.

1. LITERATURE REVIEW

At the start of the study a bibliographical investigation was made of species likely to be found in the study area. Relevant information was gathered on *P. esculentus* (Kirkegaard and Walker 1969), *P. plebejus* (Kirkegaard and Walker 1970a), *M. macleayi* (Kirkegaard and Walker 1970b), *M. bennettae* (Kirkegaard and Walker, 1970c), and *Parapenaeopsis sculptilis* (Kirkegaard and Walker 1970d). It was determined that generally very little ecological information was available on these species, with the exception of *P. plebejus*, on which a limited amount of information was published.

2. ENVIRONMENT

Adult *P. plebejus* are found on the continental shelf from Fraser Island, Queensland southwards as far as Eden, N.S.W. The postlarval and juvenile stages occur in estuaries. A study area was selected (Moreton Bay and offshore areas) (Fig. 4), in which an extensive fishery for both juvenile and adult prawns occurred, and the salinity/temperature regime of the deeper water and littoral and infralittoral waters was examined. The water chemistry of the major rivers flowing into Moreton Bay, and that of the Bay itself, was also examined and a transect of stations was sampled across the Continental Shelf eastwards from Cape Moreton.

The structure of the littoral and infralittoral sediments was investigated, and a detailed study made on the seagrass composition of these areas.

2.1 Moreton Bay salinity/temperature regime

2.1.1. Deeper waters

The salinity/temperature regime was investigated by Newell (1971a, 1971b) who described the annual temperature range as 16-29°C at the surface and 17-26°C at 21 m. The annual chlorinity range was 10.5-19.6°/oo at the surface and 17.5-19.6°/oo at 21 m. Maximum temperature (29°C) was in January and minimum (16°C) in August. Maximum tidal currents decreased from about 2kt in the east to about 1kt in the centre and 0.5kt in the west. Time series observations showed an irregular distribution of chlorinity and temperature unrelated to tidal phase. Across the northern entrance to Moreton Bay there existed a pronounced gradient in temperature and chlorinity for most of the year, indicating the continual escape of Deception Bay water northwards past Bribie Island. This bay water sometimes reaches right across the easternmost end of the entrance to Moreton Bay (Newell 1971b). Newell's results have since been generally confirmed by Radok (1973) and Milford and Church (1977).

2.1.2. Littoral and infralittoral water

All lowest salinities occurred in the western and southern part of Moreton Bay and the highest occurred along the eastern fringe and over the band of live coral on Peel Island (Young, in prep.). Typically, during the winter the salinity in the south and west increased until it reached that of the eastern fringe. After the summer rains it varied with the influxes of freshwater from the rivers of the southern and western shores.

The temperatures in winter were similar throughout Moreton Bay and range between 15-20°C with a minimum in late June. In summer the eastern fringe ranged between 23-29°C whilst the western and southern fringes ranged between 21° and 30°C. Temperatures and salinities of all littoral and infralittoral regions were greatly influenced by rainfall.

Multivariate classification of experimental sites indicated that five major littoral and infralittoral environments occurred: (1) the north western embayments, (2) the sheltered southern delta, (3) the south eastern and north western fringe, (4) shallow sand banks of the east and (5) deeper infralittoral "lagoons" of the east (Young in prep.).

2.2 Littoral and infralittoral sediment analyses of Moreton Bay

The sediments of Moreton Bay are contributed to by wind blown sand from the eastern barrier dune islands, which is subsequently transported by tidal currents, and also by silt and clay from the western and southern river systems (Maxwell 1970).

A multivariate classification of the sediments of littoral and infralittoral sites throughout Moreton Bay indicated that those of the western and southern shores were clearly differentiable from those of the east and north (Young in prep.). Coarse sand predominated in the latter with percentages by weight of up to 88%. Within each of these types sheltered locations were differentiable from exposed ones mostly by greater proportion of fine to coarse sand in the north and east, and greater quantities of clay in the south and west (Young in prep.).

2.3 Moreton Bay water chemistry

Subsequent to the studies by Newell (1971a, 1971b) a study commenced in 1972 to analyse the water chemistry of Moreton Bay and that of the major rivers contributing to the bay. This study is in the process of being written up.

2.4 Seagrass communities of Moreton Bay

The littoral and infralittoral seagrass communities of Moreton Bay were examined and described (Young and Kirkman 1975). Five distinct communities were discovered; of these, four were restricted to the northern and eastern parts of Moreton Bay. The fifth, *Zostera capricorni* (Aschers) and *Halophila ovalis* (R. Br. Hook. F.) was distributed throughout the entire Bay. Significant differences were found in dry weight biomass both between stations and at different times of the year. A catastrophic mortality of *Z. capricorni* was examined along the foreshores of Deception Bay, and this was found to be due to siltation (Kirkman 1976).

Investigations were also made into the biology and transplantation of seagrass (Kirkman, 1976).

3. THE ECOLOGY OF POSTLARVAL AND JUVENILE PRAWNS

The immigration of postlarvae, their growth, and distribution and abundance within Moreton Bay were examined.

3.1 Immigration

The immigration of king prawn postlarvae into estuaries was examined (Barber and Lee 1975), (Young and Carpenter in press). Postlarvae of this species entered the estuaries on the flood tides mainly at night and settled on the littoral sand banks and sand flats, most in locations closest to the ocean. Their seasonal changes of immigration and those of tiger and greasyback prawns also were examined. During an extensive sampling period extending over 1972/73, king prawns were shown to reach the estuarine nursery areas throughout the year, with two peaks of abundance, the larger being from July to September. Tiger prawns and greasyback prawns showed only one peak, in January/February for tiger prawns and March to May for greasyback prawns. Recruitment to the nursery areas was thought to be largely dependent upon the tidal currents in Moreton Bay.

3.2 Growth

The growth rate of postlarval king prawns was estimated from a form of cohort analysis of length frequencies from field data. It was found to be temperature dependent (Somers 1975). This was confirmed by extensive laboratory experiments which also showed growth to be insensitive to salinity (Lee and Barber in prep.).

3.3 Distribution and abundance

Postlarvae of king, tiger, greasyback and school prawns were examined for distribution and abundance in each of the major geographical areas of Moreton Bay (Fig. 5). Substantially more postlarvae of these species were in littoral sampling sites than on infralittoral sites (Table 1). Invariably greater numbers were found on seagrasses than on adjacent bare substrates. The number of immigrant postlarval king prawns was greatest at sampling sites nearer to the ocean (Peel Island, Pelican Banks, Southport Broadwater, Welsby Light), whilst those of greasyback prawns generally increased at sites of a more estuarine nature (Southport Broadwater, Southern Delta, Toorbul Point). Tiger prawn postlarvae were found in substantial numbers only on estuarine seagrasses and school prawns were found only in the Southport Broadwater (Young 1975a, Young in prep.).

King prawn postlarvae appeared to show no preference for seagrassed rather than bare substrate when settling. However, greater numbers of larger postlarvae were found on seagrasses. As they grew, migration to deeper water also occurred. However, because their growth rate was related to water temperature, immigrants from any autumn recruitment to the nursery areas grew very little during winter and consequently reached the Moreton Bay fishery only a matter of weeks before any spring recruitment. This results in a fishery in Moreton Bay for juveniles which extends from October to February.

4. THE POPULATION DYNAMICS OF COMMERCIALLY EXPLOITED KING PRAWNS

4.1 Growth

During the spring and summer, juveniles (smaller than 77 count per kilogram) were abundant in the estuaries of southern Queensland and New South Wales. These disappeared in autumn at which time there was an offshore fishery on sub-adults and adults (12-66 count per kilogram). The fishing ends by late winter by which time the prawns have grown to maturity. A small but distinct peak in length frequency information from deep water catches off Mooloolaba and Southport suggested a number (less than 5%) survives to a second year. More detailed information on rates of growth has been determined from recaptures of measured tagged prawns (Lucas 1975b, Somers 1975).

Such recaptures have confirmed the hypothesis that growth to maturity occurs in one year. Although the initial growth of these tagged prawns released in spring and summer was very rapid, it has been indicated by several workers (Somers 1975, Lee and Barber (in prep.)) that growth of this species was related to temperature, and as such, would be retarded in the event of a late winter.

4.2 Migration patterns

Several tagging experiments to trace migrations of king prawns were carried out over the period 1970 to 1975. A summary of release and recapture information is given by Lucas (1975c) and Potter (1975).

The results of the tagging experiments varied from season to season with relation to the extent and direction of dispersal of tagged prawns.

All experiments showed distinct movement out of Moreton Bay with some northerly movement offshore. Experiments in 1971/72 showed a much more marked northerly movement of juveniles and sub-adults than was the case in 1970/71, while similar experiments in 1973/74 show much more dispersion than in both previous seasons.

The adult stocks off southern Queensland showed no directional migration in any experiment but rather a more random mixing between the deep water grounds off Cape Moreton and off Southport and Tweed Heads.

Ruello (1975) reports the results of similar experiments in New South Wales estuaries. A feature of this work has been the extensive migrations some king prawns make up the east coast into Southern Queensland waters. Although the number of recaptures were small, they did indicate that juveniles from New South Wales estuaries made a contribution to the stock off southern Queensland and in particular the grounds from Burleigh Heads to the deep water off Cape Moreton. The recaptures were too few to determine any quantitative estimate of the contribution which may vary significantly from year to year in response to environmental factors.

4.3 Emigration rates

As with migration patterns, it would also appear that the rates of migration out of Moreton Bay vary considerably from year to year. There is some evidence to suggest that more rapid movement follows heavy rainfall (Potter 1975). The major Brisbane floods of January 1974 provided further evidence in this regard. No recaptures were made in Moreton Bay after the onset of flooding while the number of weekly recaptures offshore increased markedly. During the 1970/71 tagging experiments, furthermore, a significant number of recaptures (up to 12 per week) continued to be taken in Moreton Bay at a time after release equivalent to the time of the onset of flooding in 1974.

Varying emigration rates have important implications for management. A hot dry summer may produce the effect of fast growth with little emigration and consequently in many areas of Moreton Bay (even presently closed areas) relatively large prawns may be present. In the summer of 1976/77, fishermen have reported quantities of relatively large prawns in some of the closed areas of Moreton Bay. Conversely, a late winter with heavy rain may result in very small prawns being available in deeper waters (beyond closed areas) of Moreton Bay as was reportedly the case in 1975/76. Fishermen also reported large quantities of very small prawns just outside the Tin Can Bay and Jumpinpin Bars in the spring of 1967.

4.4 Catch and effort data

Catch and effort data have been collected from fishermen's log books since late 1969. Smoothed curves of average catch rate are given in Figures 6, 7 and 8. Much of the inherent statistical variation has been removed by averaging over three months. A major feature of all areas is that there was no downward trend in average catch rate. In Moreton Bay, the catch rates were quite stable with the average peak summer catch rate just below 90 kg/night.

There was more variability in other areas however. In particular, the offshore catch rate at Mooloolaba in 1972 was considerably higher than in 1971 and 1973, which was consistent with the hypothesis based on tag-recapture data that there was significantly more immigration from southern estuaries in 1972 than in the other two years.

Maximum catch rates in all offshore areas occurred in 1974, which could be linked to a rapid migration out of the estuaries owing to the major flooding.

Catch rates for other commercial species in Moreton Bay are given in Figures 9 and 10. Catch rates of greasyback prawns increased dramatically in January and February 1974 in response to the heavy flooding.

It may be a little premature to attribute any cause to the obvious decline in the tiger prawn catch rates in the last few years, or even to suggest a permanent decline. It has been shown, however, that the postlarvae are very specific to seagrass nursery areas and would thus be sensitive to the decline in the total area of such zones.

4.5 Exploitation rate

Exploitation rates (the percentage of the available stock which are caught) for Moreton Bay and adjacent offshore areas near Mooloolaba and Cape Moreton have been calculated. The value for Moreton Bay in 1969-70 was 17% while offshore in the same season it was 26%. The effect of hypothetical changes in fishing effort in the total catch and individual catch per boat has been calculated (Lucas 1974a).

Furthermore, it was shown (Lucas 1975d) that the total catch for the whole fishery was insensitive to the level of fishing effort in Moreton Bay although the relative catch in each sector would change accordingly.

4.6 Optimum size of first capture

When the mortality and growth rates of a stock are known, a size of first capture which optimises the total yield per recruit may be obtained. Such a calculation for king prawns is given by Lucas (1975b). A notable feature was that at the level of effort in Moreton Bay, the total yield per recruit was not very sensitive over quite a wide range of size of first capture.

In such a case, economic reasons will prevail in determining the optimal size of first capture.

5. CONCLUSIONS AND RECOMMENDATIONS

A. The littoral sand banks and flats, particularly the areas covered by seagrasses, form the habitat for postlarval prawns. The areas of greatest importance are:-

(i) for king prawns - Peel Island, the tidal delta of South Passage, (Welsby Light), Pelican Banks and the Southport Broadwater.

(ii) for tiger prawns - Toorbul Point, the Southport Broadwater, and Pelican Banks.

(iii) for greasyback prawns - the Southern Delta, Southport Broadwater, Toorbul Point, Bramble Bay and Deception Bay.

(iv) for school prawns, the Southport Broadwater.

These areas need to be preserved in order to maintain present stock levels. Any destruction by filling or dredging will have a corresponding effect upon the total yield of each prawn species.

B. Maximum economic benefit can be attained by not taking small king prawns. As minimum mesh sizes are only partially effective in maintaining this, it appears as though closed areas will be most effective in this regard. It should, however, be recognised that because of annual variability in growth and migration rates, the "best" closed areas may differ each year.

C. The offshore fishery is contributed to by all estuaries in southern Queensland and in New South Wales. Although the relative contributions are not known, it is expected there would be considerable variation from year to year.

D. The combined offshore and Moreton Bay catch is relatively insensitive to changes in effort within Moreton Bay. An increased effort producing an increased catch in Moreton Bay will result in a compensating decrease in catch in the offshore fishery.

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APPENDIX I

PUBLICATIONS BY STAFF OF THE PROJECT

Barber, W.E. and Lee, C.P. (1975). Preliminary analysis of physical factors influencing the ingress of planktonic king prawns *(Penaeus plebejus)* postlarvae into Moreton Bay. In P.C. Young (Ed.) *National Prawn Seminar Maroochydore, Queensland 1973*. (A.G.P.S.: Canberra 1975). 345 pp.

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APPENDIX II

PUBLICATIONS BY STAFF OF THE PROJECT IN PRESS OR PREPARATION

Barber, W.E. and Lee, C.P. Factors influencing the ingress of postlarval king prawn, *Penaeus plebejus* into Moreton Bay.

Kirkman, H. (a). Decline of seagrass in Moreton Bay, Queensland.

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Table 1. Mean number of prawn postlarvae ($\geq$ 10 mm carapace length) caught per 50 m^2 from fortnightly samples at the time of major recruitment to the nursery areas (July, 1972 - March, 1973).

Location in order of marine influence	King prawns				Greasyback prawns				Tiger prawns				School prawns			
	Littoral Sites		Infralittoral Sites		Littoral Sites		Infralittoral Sites		Littoral Sites		Infralittoral Sites		Littoral Sites		Infralittoral Sites	
	Seagrassed	Bare	Seagrassed	Bare	Seagrassed	Bare	Seagrassed	Bare	Seagrassed	Bare	Seagrassed	Bare	Seagrassed	Bare	Seagrassed	Bare
Deception Bay	*	66.0	*	50.4	*	9.0	*	2.1	*	0.1	*	0.0	*	0.0	*	0.0
Bramble Bay	*	68.1	*	35.4	*	29.1	*	34.4	*	0.0	*	0.0	*	0.0	*	0.0
Southern Delta	99.2	52.7	*	53.1	269.2	41.3	*	15.8	5.8	0.3	*	0.0	0.1	0.1	*	0.2
Southport Broadwater	236.0	173.6	261.5	*	43.1	7.5	4.0	*	23.7	0.7	1.5	*	35.6	5.5	2.3	*
Toorbul Point	113.9	*	50.3	*	76.4	*	4.4	*	19.8	*	6.8	*	0.1	*	0.0	*
Pelican Banks	294.6	162.2	*	*	21.1	3.6	*	*	13.2	0.1	*	*	0.1	0.0	*	*
Peel Island	*	208.4	*	*	*	2.3	*	*	*	0.1	*	*	*	0.0	*	*
Welsby Light	395.3	*	27.2	*	5.0	0.3	*	*	1.1	*	0.2	*	0.1	*	0.0	*
Moreton Island	*	*	4.7	11.8	*	*	0.0	0.1	*	*	0.0	0.0	*	*	0.0	0.0

* This type of substrate was not sampled, because of its absence or relatively infrequent occurence in the geographic area.

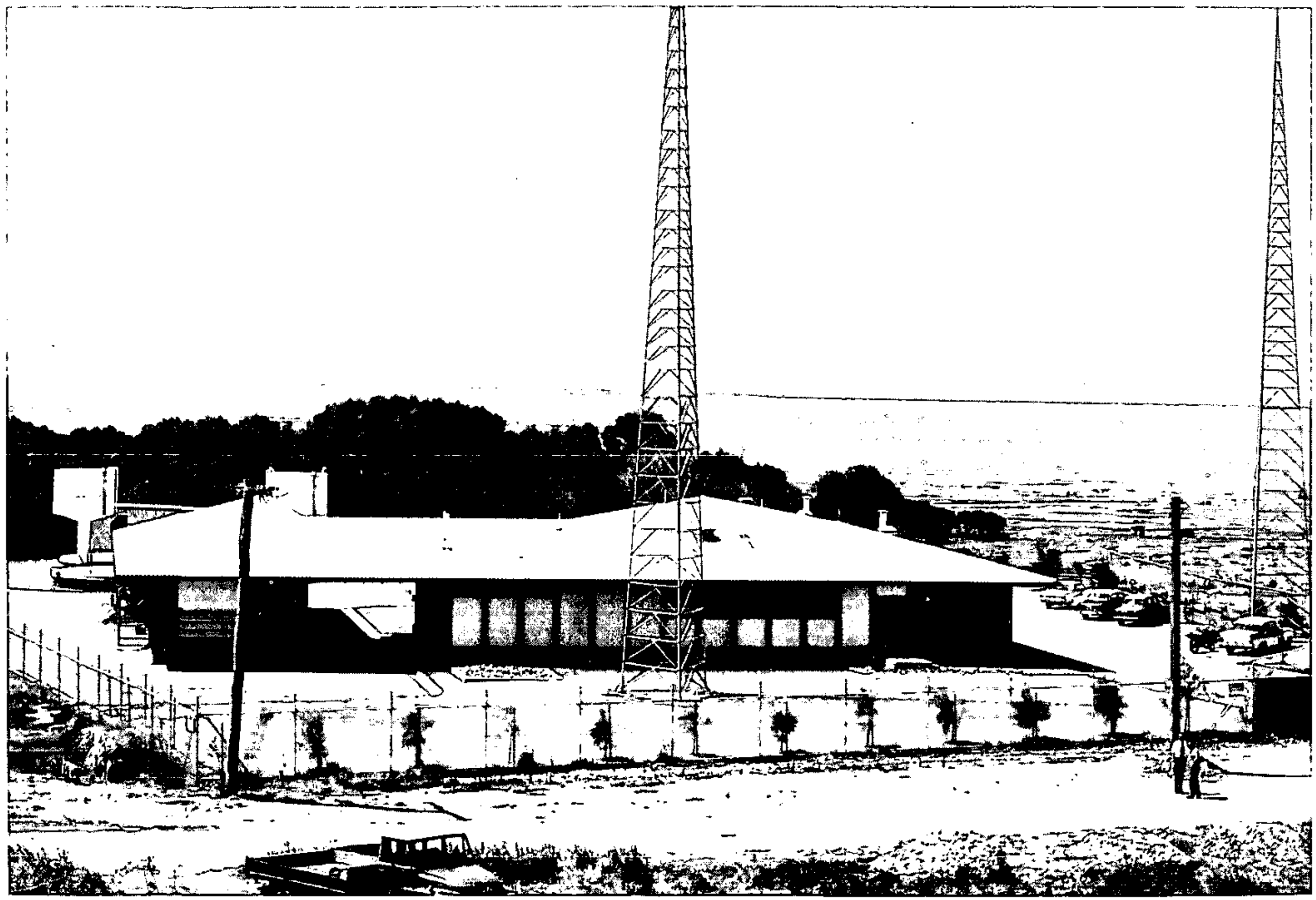

Figure 1.   Fisheries Research Station, Deception Bay.

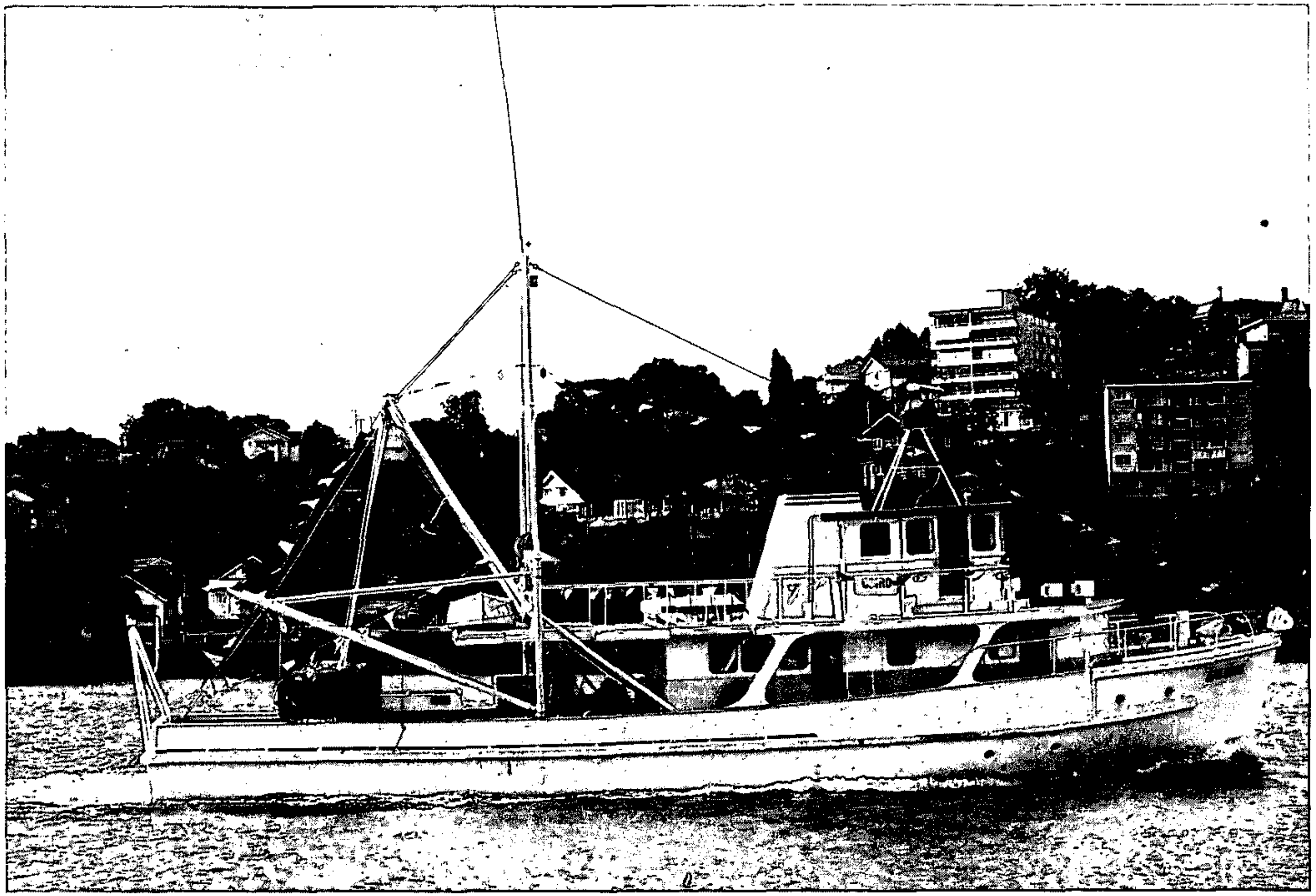

Figure 2. Research Vessel *Kalinda*

Figure 3. Research Vessel *Penaeus*

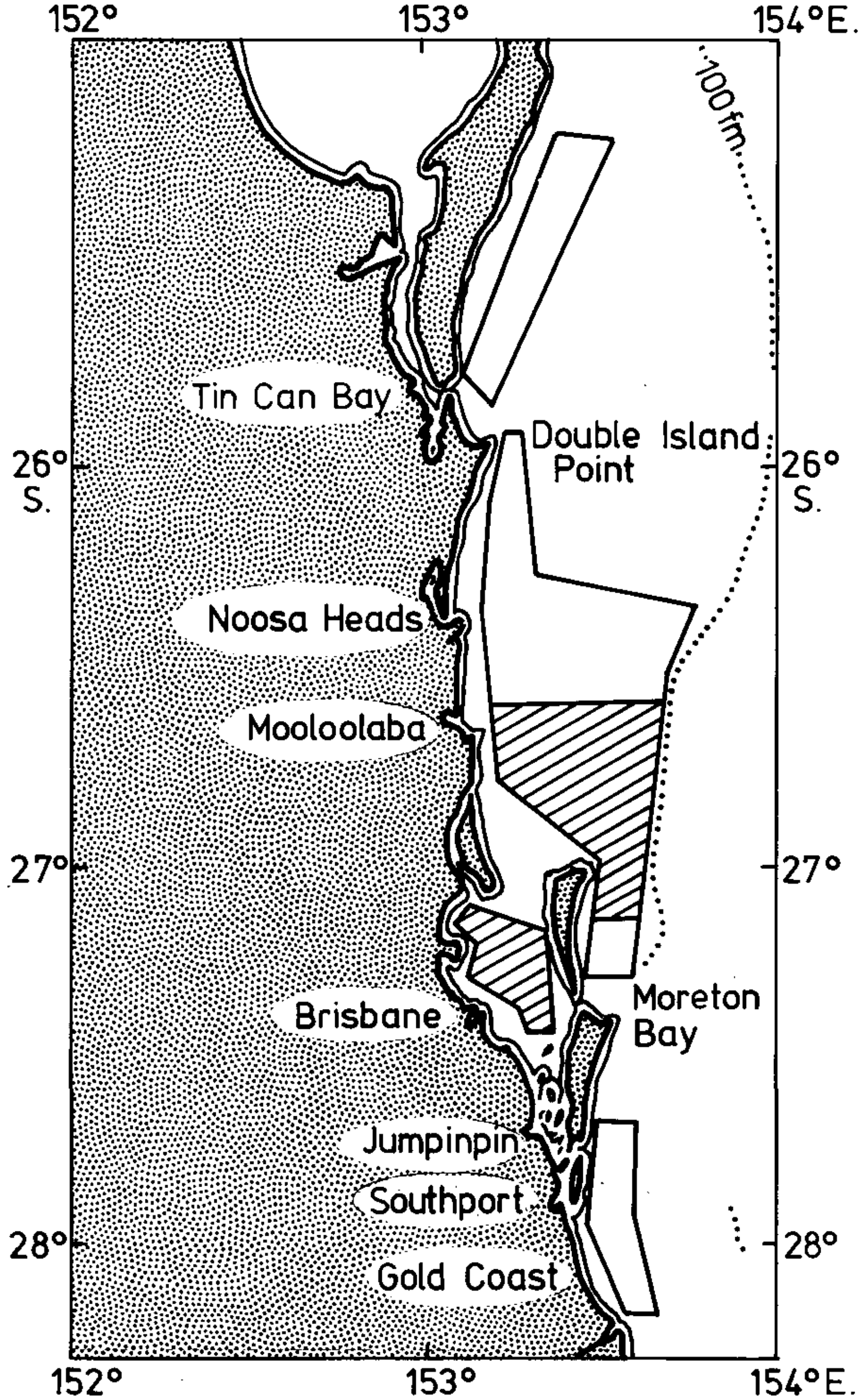

Fig. 4. Geographical location of the trawling grounds. Fishing is concentrated in the shaded section (Moreton Bay and adjacent offshore area).

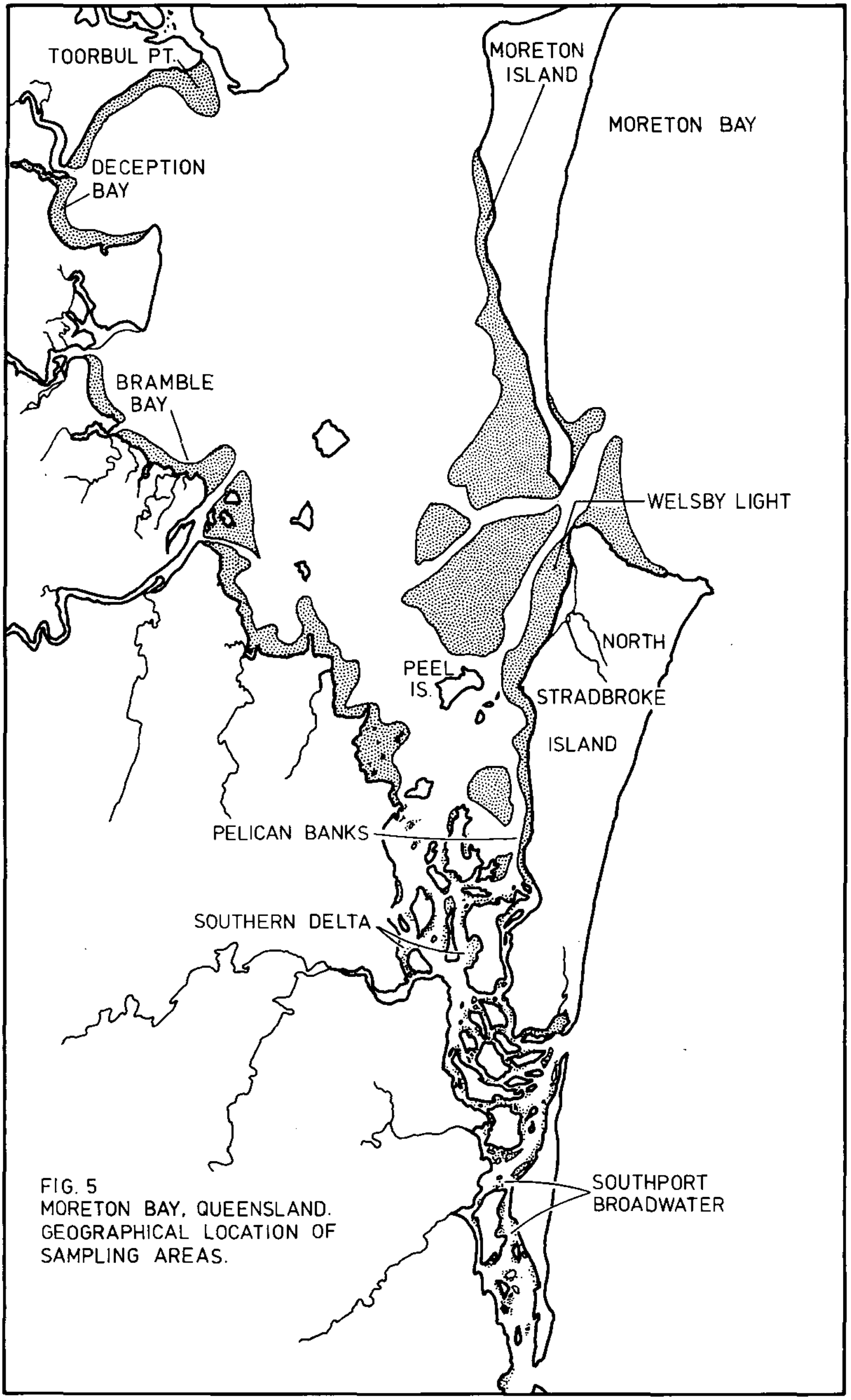

FIG. 5
MORETON BAY, QUEENSLAND.
GEOGRAPHICAL LOCATION OF
SAMPLING AREAS.

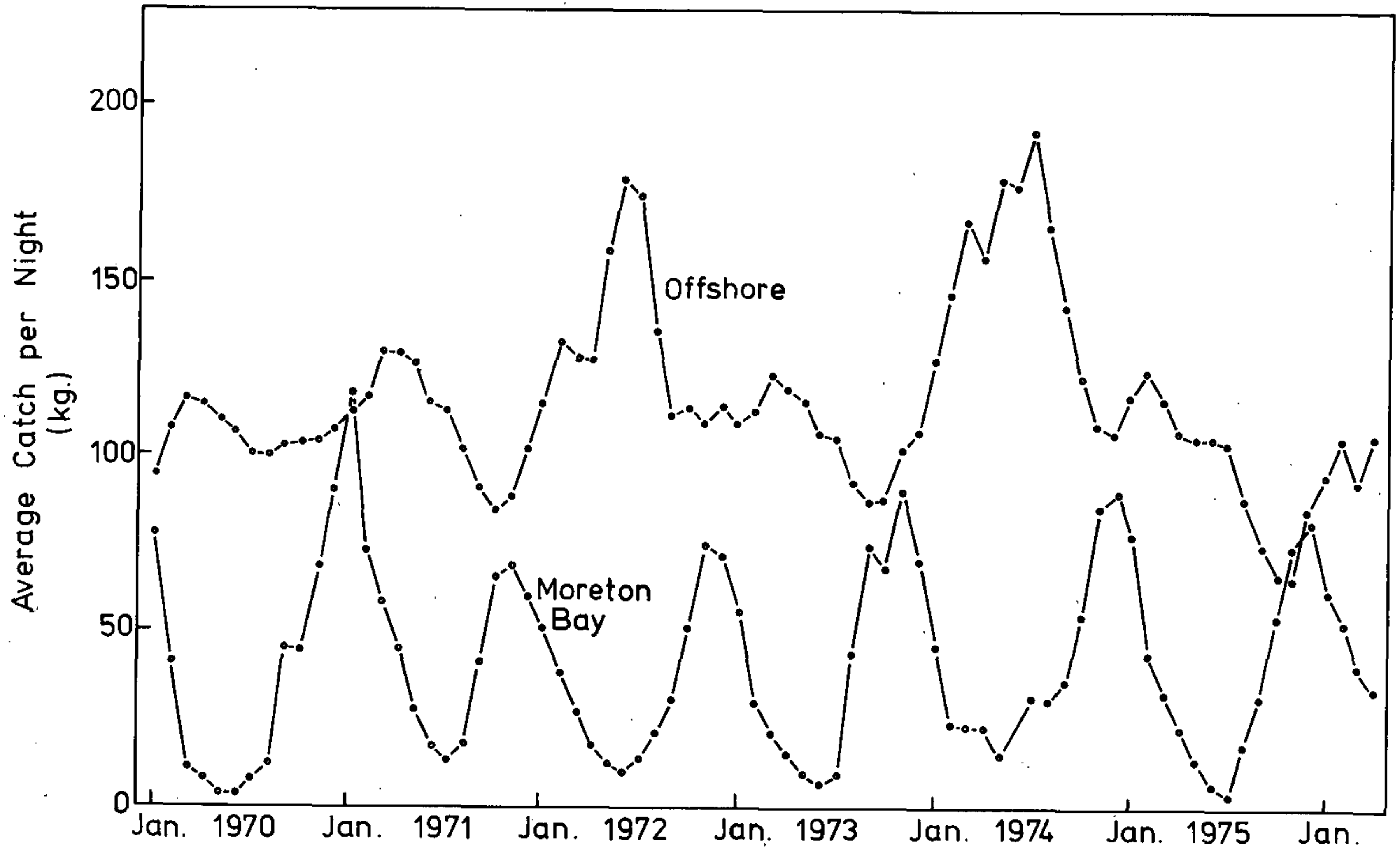

Fig. 6. Monthly average catch per boat per night for king prawns from Moreton Bay and adjacent off-shore grounds (Grid 8-14).

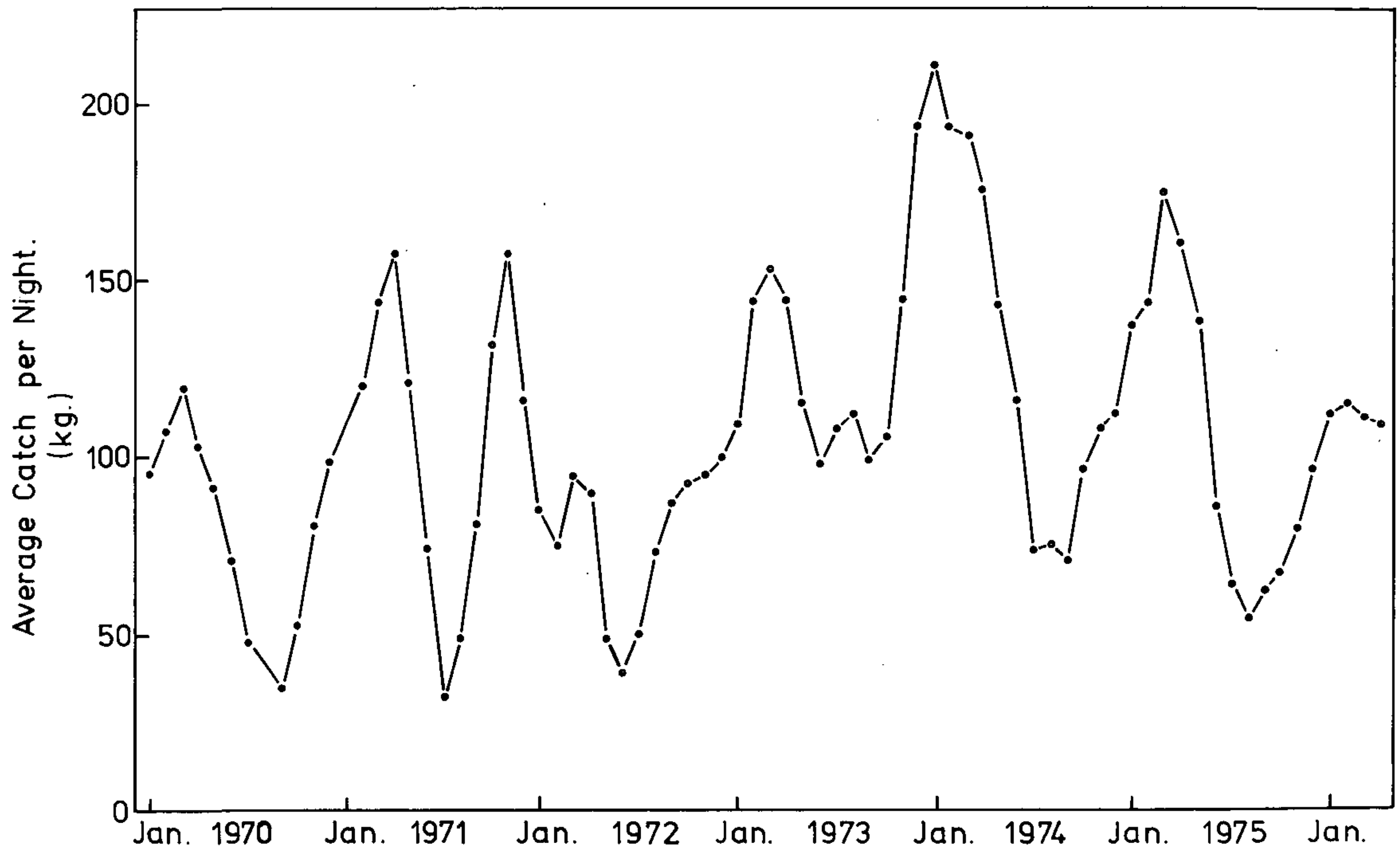

Fig.7. Monthly average catch per boat per night for king prawns from Tin Can Bay grounds (Grids 1-7).

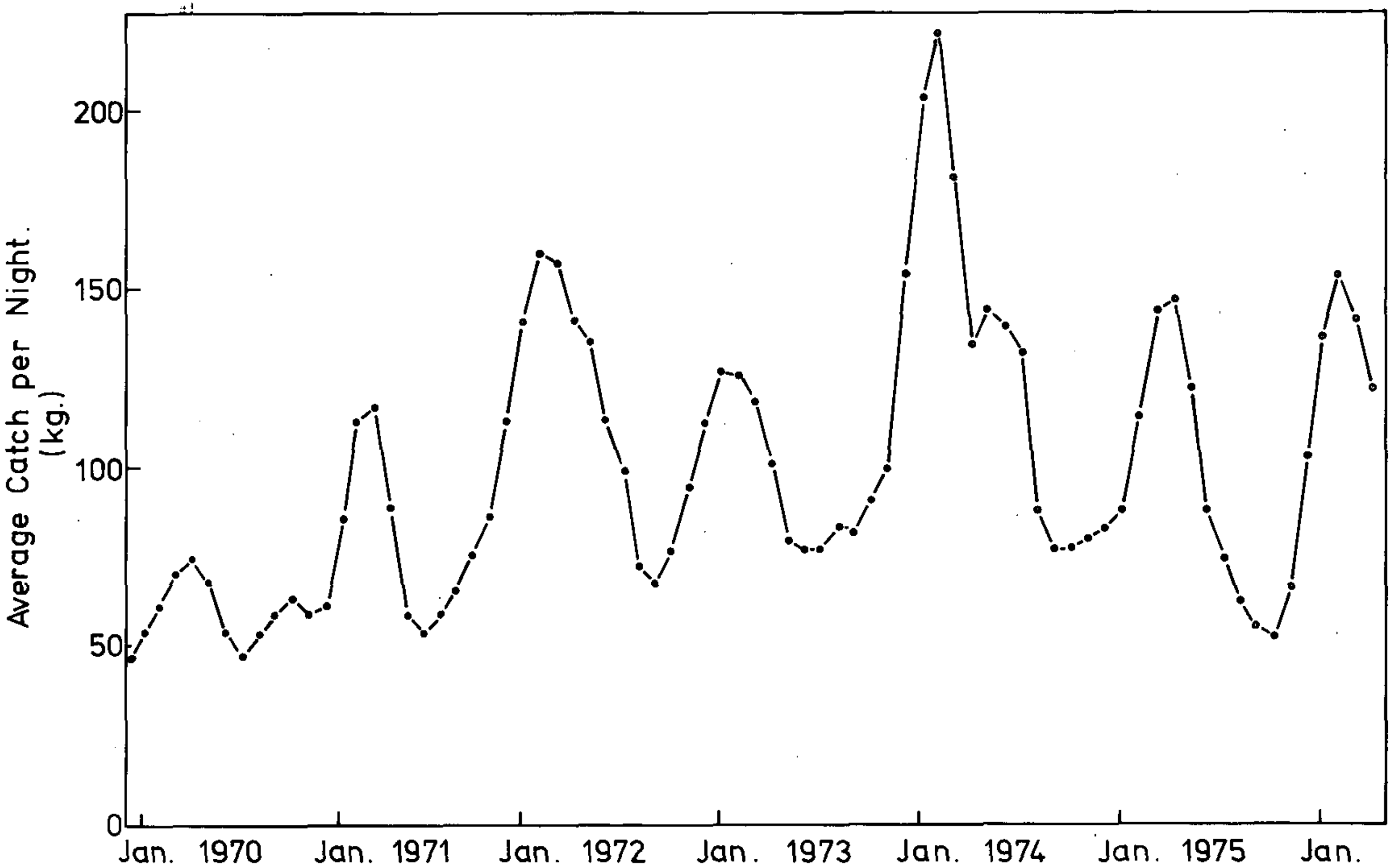

Fig. 8. Monthly average catch per boat per night for king prawns from Tweed Heads and Southport grounds (Grids 15-20).

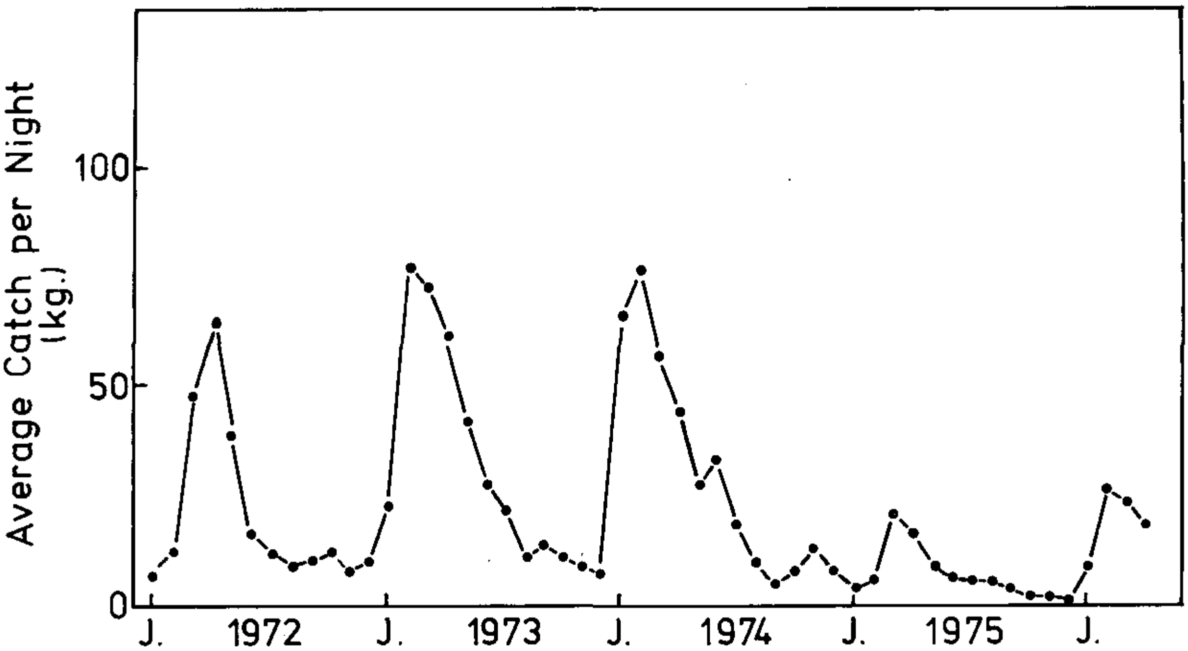

Fig.9. Average catch per boat per night for tiger prawns from Moreton Bay (from logbooks).

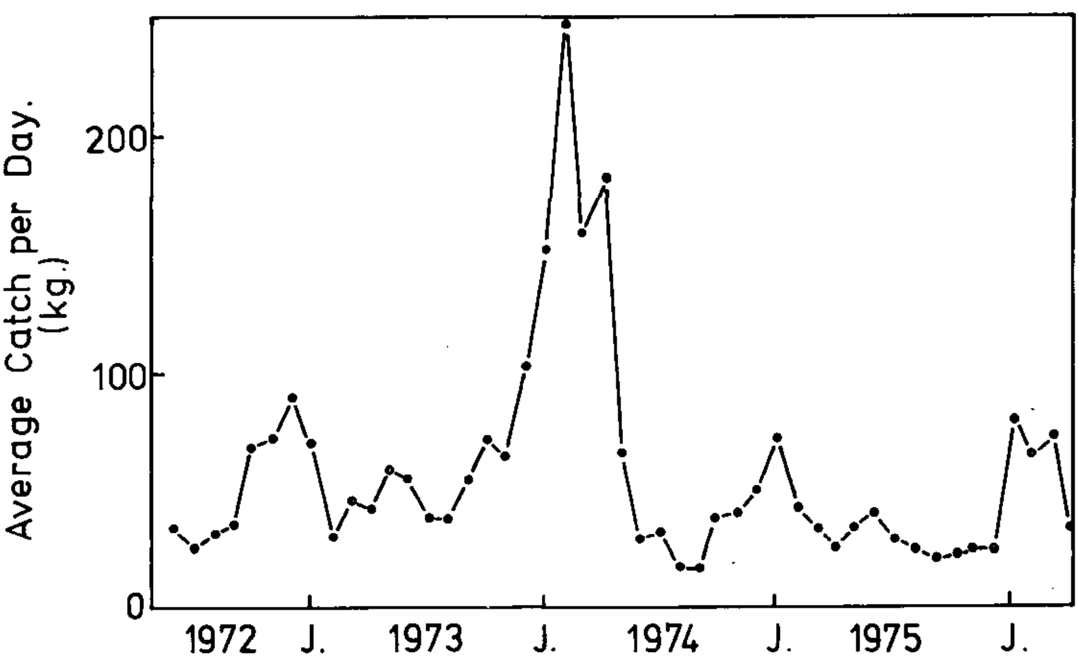

Fig.10. Average catch per boat per day for greasyback prawns from Moreton Bay (from logbooks).