

NORTHERN TERRITORY  
MUD CRAB  
FISHERY INVESTIGATION

BY

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## EXECUTIVE SUMMARY

Between October 1987 and September 1988 a Mud Crab Fishery Investigation was undertaken in the Northern Territory, on behalf of Primary Industry and Fisheries. Funds to undertake the project were made available from the Commonwealth Fishing Industry Trust Account and Northern Territory Budget allocation.

Fishermen who had control of thirty-five licences along with six local buyers and eleven interstate wholesalers which make up the industry, were consulted. Field observations and basic biological experiments were carried out in estuaries adjacent to Darwin and Borroloola. Marketing procedures and the methods of transporting crabs within the Northern Territory and interstate were evaluated, along with problems relating to crab mortalities and industry management.

The mud crab fishery has recently developed from a minor fishery to the Northern Territory's most valuable inshore fishery after barramundi.

The major objectives of the project have all been accomplished. These included reporting on:

1. trends in catch
2. mortality rates
3. marketing procedures
4. effects of interstate legislation
5. proportion of post-moult crabs in the catch
6. factors bearing upon the management of the fishery.

Work towards the secondary goals such as improving marketing/handling techniques and minimising mortality rates has begun, but as yet has not had an impact on the industry.

Market prices for mud crabs are increasing, since demand is generally greater than supply. Although this has resulted in increased catch and effort over the past 4 years, the corresponding catch per unit effort has dramatically decreased, along with a higher percentage of poor quality crabs reaching interstate markets.

If the current trends continue and no new influencing factors occur, the major problems which will confront the Northern Territory mud crab fishery are:

1. the risk of the established resources becoming economically unviable;
  2. a market resistance towards Northern Territory mud crabs, especially during the early months of each year;
- and
3. friction among crab fishermen leading to serious problems at the peak of the crabbing season when areas become congested with pots.

## SUMMARY FINDINGS

Until 1985 the mud crab fishery was virtually unregulated. In 1985 a few regulations were introduced after Government discussions with industry personnel. These regulations were not based on scientific or commercial facts but more to limit the possibility of uncontrolled exploitation of the fishery.

The mud crab investigation project, analysed each of the regulations from a fisherman's point of view, as well as from a future commercial viability point. The project was too short to undertake detailed biological analyses, but areas for future research were identified, and activities which help to support the crab fishery were looked into.

The following are summary findings deriving from projects:

1. to keep the number of pots at 60 per endorsement, (see section Present Mud Crab Fishery, [Fishing Gear and Methods, paragraph 3 and 7.])
2. to keep the size limit of 130mm across the carapace, (see section on Management [Size Limit], Fishermen's Interviews [Size Limit], Interstate Markets [Size Limit and Sex] for mud crabs [Scylla serrata] but to remove the size limit from all other crabs; as most other species will not obtain a maximum size of 130mm across the carapace in Northern Territory waters).
3. to still allow the taking of female crabs, (see sections on Fishermen's Interviews [Taking of females] and Management Protection of Females and Interstate Markets [buyers]).
4. to retain present areas closed to commercial crabbers, (see section on Fishermen's Interviews [General Discussion 4]).
5. to amend the law to enable crab endorsement holders to leave their pots unattended for up to three days, (see Appendix 1 Mud Crab Mortality in Unattended Pots).
6. that the Department of Primary Industry and Fisheries assist in an attempt to open up new grounds in aboriginal reservations (see section on Management [Catch and effort]) to retain the annual catch at around 100 tonnes, in order to maintain the fishery landings and allow for development of areas to reduce possible localised over-exploitation.



7. that a closed season be enforced on a two year trial basis during the months of January and February. (See sections on Present Mud Crab Fishery [Fishing Season], Observations [Moulting, Empty Crabs and Fishing Pressure], Fishermen's Interviews [Moulting and Closed season]. Management [Marketing of Post Moults Crabs]). To prevent the capture of large quantities of empty crabs.
8. that the Northern Territory be split into two or three separate crabbing zones to help prevent areas becoming congested with pots and to relieve fishing pressure on some areas. (See sections on Fishermen's Interviews [Congested Fishing Areas] and Observations [Fishing Pressure]).
9. that the Department of Primary Industry and Fisheries not allow any new crab endorsements to be issued and investigate methods of relieving fishing pressure on existing grounds.
10. that the sale of crab meat or crab pieces from Scylla serrata be totally banned; as it only encourages fishermen to retain empty, sick or undersize crabs. (See section on Management [marketing of Crab Meat]).
11. that the use of any crab catching device which entangles crabs be banned, for both professional and amateurs. (See section on Management [limitations of Amateur Legislation]).
12. that a bag limit be introduced for amateur crab fishermen, to aid police to control illegal crabbing. (See section on Management [Limitations of Amateur Legislation]).
13. that a short term tagging program commence to assess the viability of the close season or fattening techniques. (See section on Management [Marketing of Post Moults Crabs]).
14. that the Department of Primary Industry and Fisheries assist crab fishermen to develop a new effective method of gathering fresh bait. (See section on Present Mud Crab Fishery [Bait]).
15. that the Department of Primary Industry and Fisheries assist the Commercial Crab Fishermen's Association with the formulation of a Code of handling practices for Northern Territory Mud Crabs.

## 1. INTRODUCTION

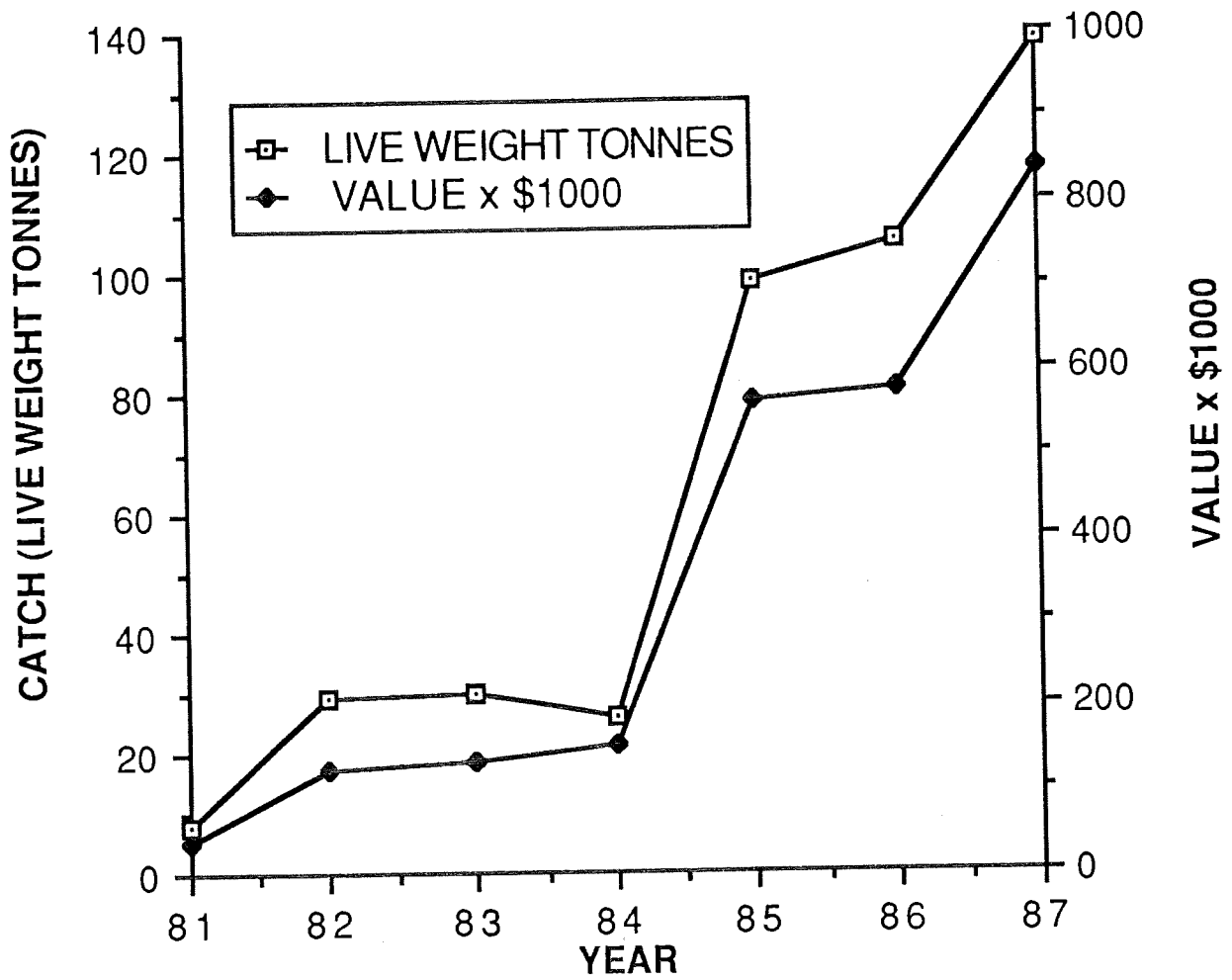
### 1.1 Background

The mud crab (Scylla serrata) is widely distributed throughout the Indo-pacific region and forms the basis for valuable fisheries in Queensland, New South Wales and presently in the Northern Territory. Wherever the species occurs it is exploited by both commercial and recreational fishermen and is in high demand because of its good flavour and the fact that it can be kept alive for days without the need for specialised equipment. The crab lends itself to easy exploitation as it normally lives in shallow estuarine areas which are accessible to small boats and can be attracted into baited pots which do not require constant tending. Catching of mud crabs can be an enterprise requiring low capital investment with a potentially high return. The high demand for mud crab from the restaurant trade has resulted in a high value outlet for crabs. There is considerable interstate transportation of crabs particularly from the Northern Territory to New South Wales, Victoria and Queensland.

The Northern Territory crab fishery has experienced a substantial increase in production in the past 5 years. Annual liveweight landings have increased from 9.8 tonnes in 1981/82 to 129.3 tonnes in 1986/87. Over the same period the value of the landings increased from \$41 300.00 to \$830 000.00 (see fig. 1).

Management of the fishery in the Northern Territory was maintained at a relatively low level until the introduction of a moratorium on the issue of licences in 1985. This moratorium was applied at the request of the industry in light of the apparent increase in number of operators and a perceived threat to the viability of existing licences. As a consequence of the moratorium, a review of the fishery was undertaken and a management package was developed in association with the newly formed Northern Territory Crab Fishermens Association. This package included the limitation of entry to the fishery, limitation on the number of pots to be held per licence, and the introduction of a minimum legal carapace width (130mm) for all species of crab.

Figure 1. NT CRAB FISHERY CATCH AND VALUE  
1980/81 TO 1986/87



Although much of the management package was introduced with the approval of the crab fishermen, little of it was based on sound biological, economic or social reasoning. Accordingly it was recognised that in light of the rapidly escalating catches, an assessment of the fishery must be undertaken and the need, if any, for further research assessed.

## 1.2 Outline of Official Arrangements

The project was authorised to commence its 12 months of operations during June 1987, by the Northern Territory Government/Implementing agency - Department of Primary Industry and Fisheries, Fisheries Division and the Commonwealth funding agency - F.I.R.T.A. The contract was signed on behalf of F.I.R.T.A. on the 26-3-87 and by the Northern Territory Government on the 2-6-87.

The total Northern Territory Government contribution was a combination of cash and services, while the Fishing Industry Research Trust Account's input, amounted to \$49 325.00.

The project officially started on the 13th of October 1987 and finished on the 12th of October 1988.

## 1.3 Objectives of the Project

The major objective (of the project) was to assess the status of the industry through personal contact with Industry personnel and to report the findings to the Northern Territory's Department of Primary Industries and Fisheries.

The immediate objectives were:

- a) To investigate and report on:
  - trends in catch and effort by fishing area over time;
  - size, sex and species composition of commercial catch;
  - mortality of crabs in unattended pots;
  - handling, storage, transport and marketing procedures;
  - effect of established minimum legal carapace width with regard to interstate legislation and marketing;

- proportion of landings of immediate post moult crabs;
  - seasonality in catch rate and condition;
  - other factors bearing upon the management of the fishery
- b) To provide recommendations on needs for additional scientific, economic or marketing research as a consequence of the above investigations.
- c) To prepare a summary document on the mud crab fishery in the Northern Territory.

#### 1.4 General

The mud crab fishery is relatively inexpensive to enter, with the potential of a high capital return. Normally working conditions are isolated and uncomfortable because of the lack of development along the Northern Territory coast, plus the fisherman is often plagued by insects and oppressive heat.

In 1987 there were 49 mud crab licence endorsements, controlled by approximately 35 persons. The vast majority of these endorsements were operated in the Darwin and Borroloola areas (South east coast). Most of the commercial crab fishermen normally use their regulation limit of 60 pots per endorsement.

The tonnage of crabs landed in the Northern Territory over the past 4 years has increased by more than 1 500 per cent and this is causing concern as to the possibility of over exploiting the resource.

The Southern interstate market demand appears to be outweighing the supply, especially during the winter months, which is Queensland's (Northern Territory's major competitor) off season. Recent shipments of Northern Territory live crabs to Japan have been encouraging and if this market develops it could put more pressure on the catching sector. There is presently too much fishing pressure being targeted at the Darwin and Borroloola areas, and if, past trends continue, this pressure is likely to keep on increasing until the fishery collapses or new viable areas are made accessible.

At present the fishery is only concentrated in two main areas. This has resulted in vast areas of the Northern Territory, being under exploited. Although little research has been conducted in these inaccessible areas (Aboriginal lands etc) it is known crabs do exist in many of them and that their natural enemies including crocodiles, fish, birds, parasites etc. are in similar numbers to other parts of the coast. With this in mind, it is highly likely that these areas act as huge refuges and that the overall mud crab stock of the Northern Territory is quite stable.

Mortality rates during storage and transport are at times unacceptably high. Wholesalers, retailers and consumers don't want dead crabs. Project experiments have proven that healthy crabs cared for out of the water can live for at least 32 days. But still commercial mortality rates are at times, as high as 45%, and rates of 5% to 15% are regarded as acceptable by a few groups of Northern Territory crabbers. This is not only uneconomical, it is a waste of a valuable Northern Territory resource.

The main factors causing high mortality rates are soft crabs being captured during the peak moulting season, high temperatures over the dry season and low temperatures at the southern markets in winter. The problem has recently become so great during the wet season that the majority of the fishermen interviewed in mid 1988 (13 out of 16) felt that it was essential that a closed season be introduced early in the year if future stocks and markets are to be maintained.

The commercial crab fishermen also generally felt that existing regulations with regards to size and the taking of females should remain the same. These were also the conclusions of project findings. The fishermen agreed, that at times certain areas become congested with pots, causing friction among competing groups of crabbers and that the problem should be resolved.

The marketing of Northern Territory crabs, has caused no legal problems in Melbourne or Sydney where the majority are sold. But in Queensland there are restrictions on females and a larger size limit for males, and these restrictions have caused minor problems for Northern Territory suppliers.

The amateurs are basically very conscientious with regards to the laws governing the mud crab stocks, but it has been observed by project staff and reported by commercial crabbers, that at

times amateurs do put undue extra fishing pressure on some crab populations. The use of suicide dillies (witch's hats) and the fact, there are no bag limits for amateurs are possibly two major areas where changes to existing laws could help.

There are other concerns within the industry, like 'the illegal use of bait nets' and 'Kakadu National Park phasing crab fishing out from within it's boundaries', but overall the industry has had four good years of growth plus established itself as one of the Northern Territory's major fisheries. It is now time to curtail the current trends which could adversely effect the industry's viability and to assist with the development of under-exploited areas.

## 2. DESCRIPTION OF FISHERY

### 2.1 Number of Fishermen

There were 49 Mud Crab endorsements issued for 1987 and 1988. During June 1988, 46 of the endorsements were controlled by 32 Persons and 3 by two companies. On an average between April and August, 45 persons were involved in the catching of crabs. This included endorsement owners, lessees and crew. The majority of mud crab fishermen operate in the South east (Table 1). Until 1988 the North East area supported the highest number of mud crab fishermen, but because of higher catch rates now being recorded in the south east, the trend is for more fishermen to work the Gulf region. It should be noted, that the wet season effects, where the majority of crabbers work. If the Gulf country experiences heavy rain falls during the wet season, it is quite likely none or very little crab fishing would take place in the area before April.

Table 1: Estimated number of Mud Crab licence endorsements operating in the three main areas of the NT at the peak of the crabbing season (June/July).

AREA NO.	BOUNDARIES	1986	1987	1988
1	Queensland border to the Roper River (South East area)	13	12	22
2	Cobourg Peninsula to Bynoe Harbour (North West area)	29	28	20
3	Bynoe Harbour to Western Australian border (Western area)	3	3	7

NB: Three to five endorsements were not actively involved during June/July of each year.



Approximately one third of the crab fishermen roam around the Northern Territory coast, but normally crab the same areas each year during mid season. The Darwin area attracts a large number of fishermen because of ease of transporting and marketing live crabs.

## 2.2 Fishing Areas

Although it is known that mud crabs are caught from the Western Australian border to the Queensland border, at present only the Southern Gulf of Carpentaria and the North West coastal area regularly support commercial catches. Other areas could quite possibly support commercial operations, but most are in aboriginal lands, or are inaccessible with regards to effectively transporting live crabs to Darwin.

Catch return data sheets, represent the only information on commercial crab catches, by area. A lack of high quality data on the crab fishery prior to 1984, has meant that proper analysis prior to then could not be achieved. The total crab effort and landings for 1985, 1986 and 1987 as shown in Fig 2 to 13 indicate the Gulf of Carpentaria (southern area), and the North West corner of the Northern Territory as the major fishing areas. These areas can be sub divided into major river systems. In the Gulf country, the Roper River has recently been the major producer of crabs, followed by the McArthur system, the Limmen Bight River and the Wearyan River. In the North West region, the Adelaide River, South Alligator, Wildman, Finnis River, Bynoe Harbour, Shoal Bay and Chambers Bay are consistently productive.

These areas generally produce commercial catches of Mud Crabs within a 1 kilometre radius of coastal mangrove trees, although in a few areas (e.g. Finnis River) commercial operations take place up to 10km away from the nearest mangrove tree on sandy/muddy bottom. The catching sites within a specified area, depends upon the seasonal movements of the crabs. Observations have found that generally juvenile crabs remain in sheltered areas while sub-adult crabs normally congregate together in shallow water and adults are caught throughout a wide range of areas.

Crabs are sometimes caught in commercial quantities on sandy or rocky bottoms, but they are more consistently taken in muddy areas containing mangrove trees. They can be caught in various depths of waters but the majority are taken in shallow water, close to the river banks or on the mud banks.

Most crabbers relocate the pots regularly as they believe nearly all the hungry crabs within an area, will find and enter the baited pots within one or two days. Exceptions to this occur when a migratory path is discovered (quite often at the mouth of a creek or channel) and the pots may continue catching for weeks or even months. The density of crabs in an area regulates the spacing between pots. When a fisherman is searching for new ground he normally spaces the pots out over a large area and then homes in on possibly high yield pockets.

Figure 2. CRAB LANDINGS -TOTAL FISHERY 1985-87

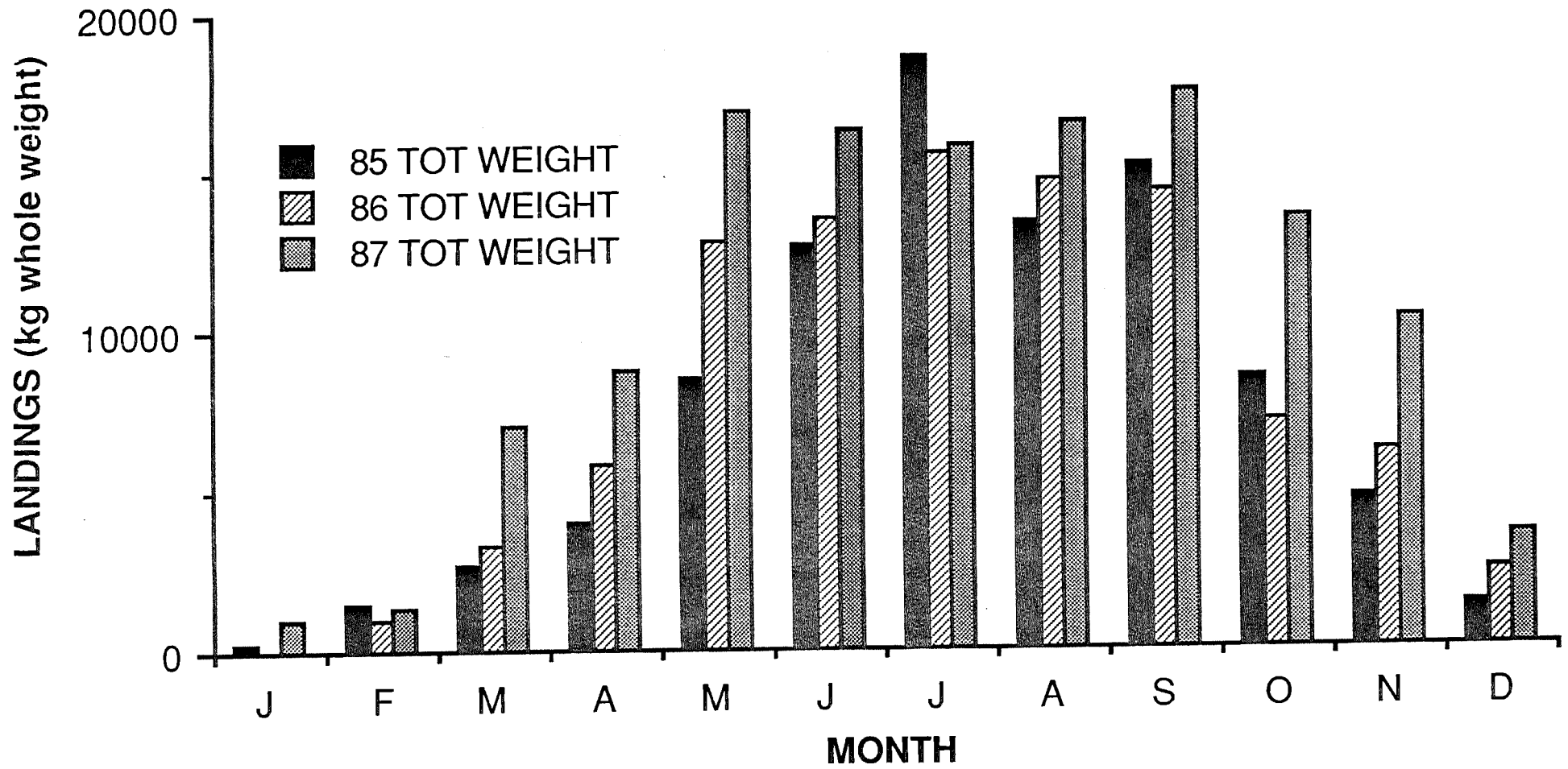
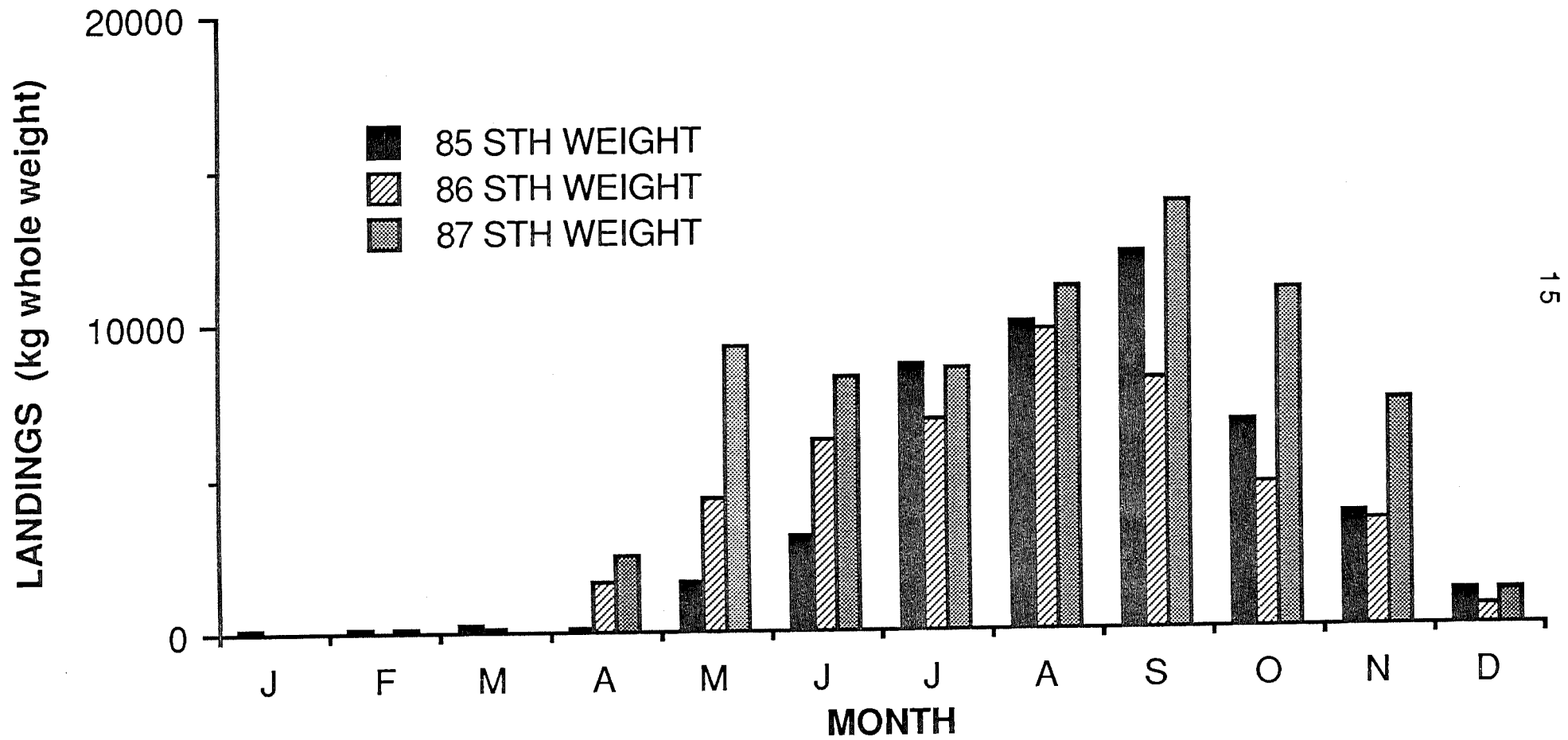


Figure 3. TOTAL CRAB LANDINGS - SOUTHERN AREA 1985-87



**Figure 4. TOTAL CRAB LANDINGS - NORTH WEST AREA 1985-87**

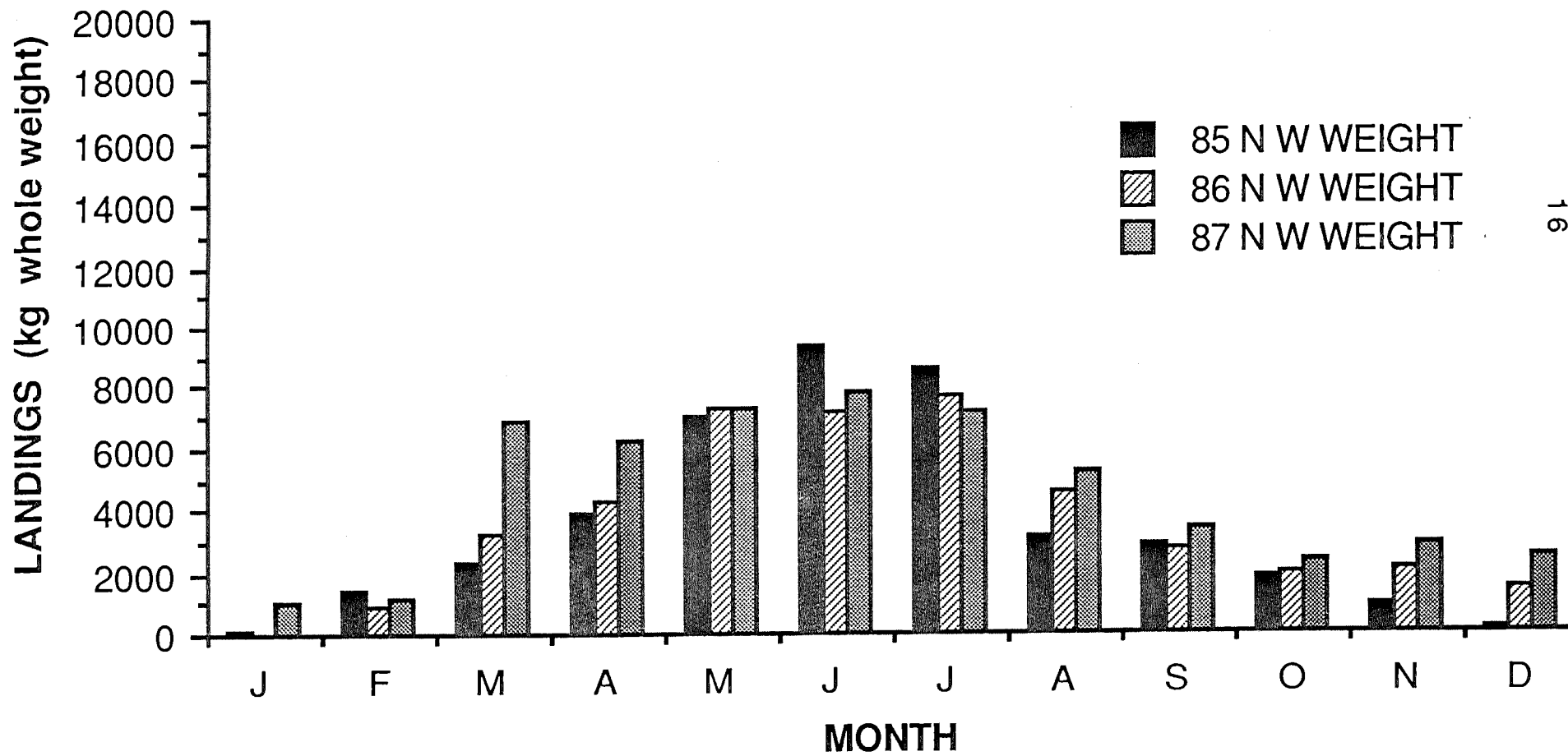


Figure 5. TOTAL CRAB LANDINGS -WESTERN AREA 1985-87

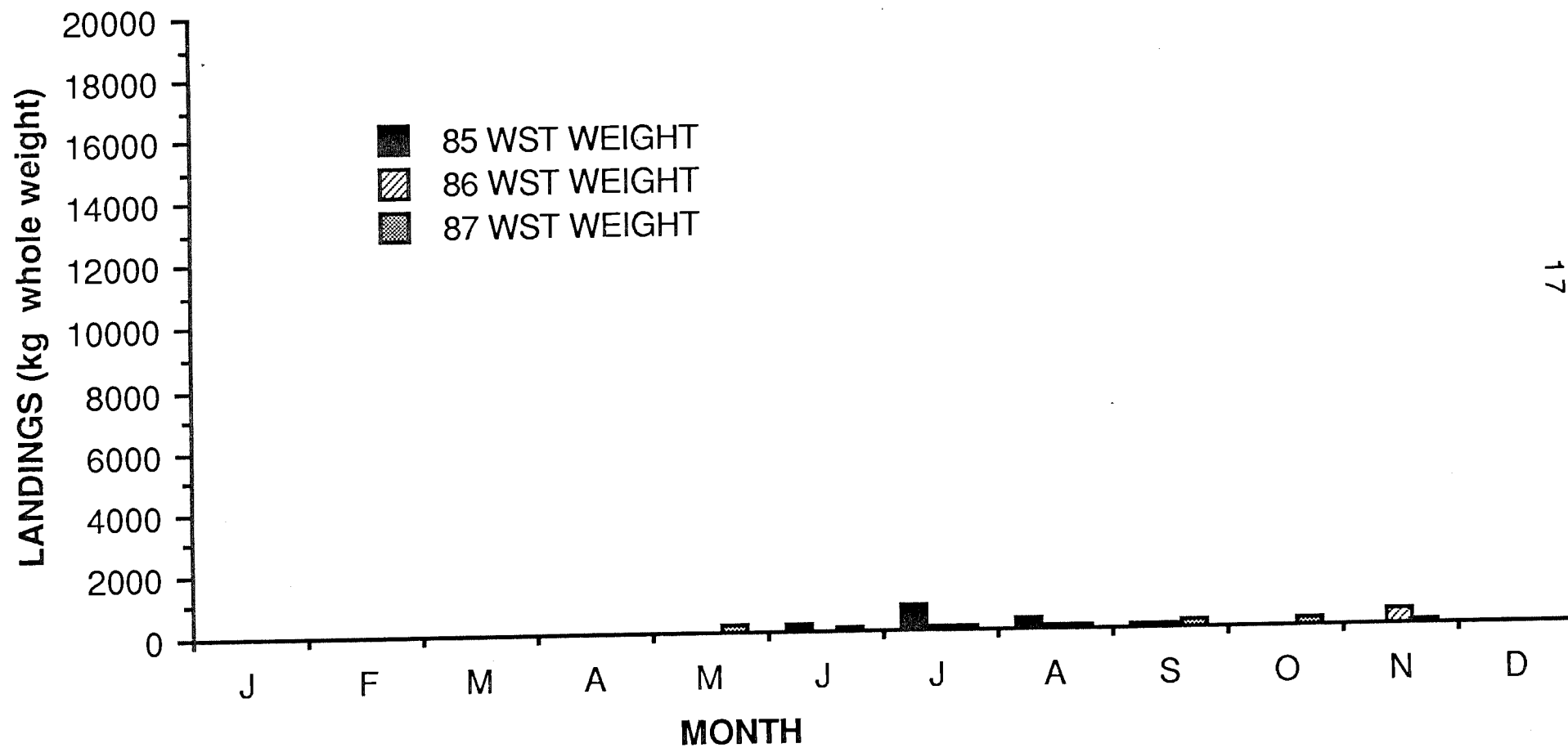


Figure 6. CRAB EFFORT - TOTAL FISHERY 1985-87

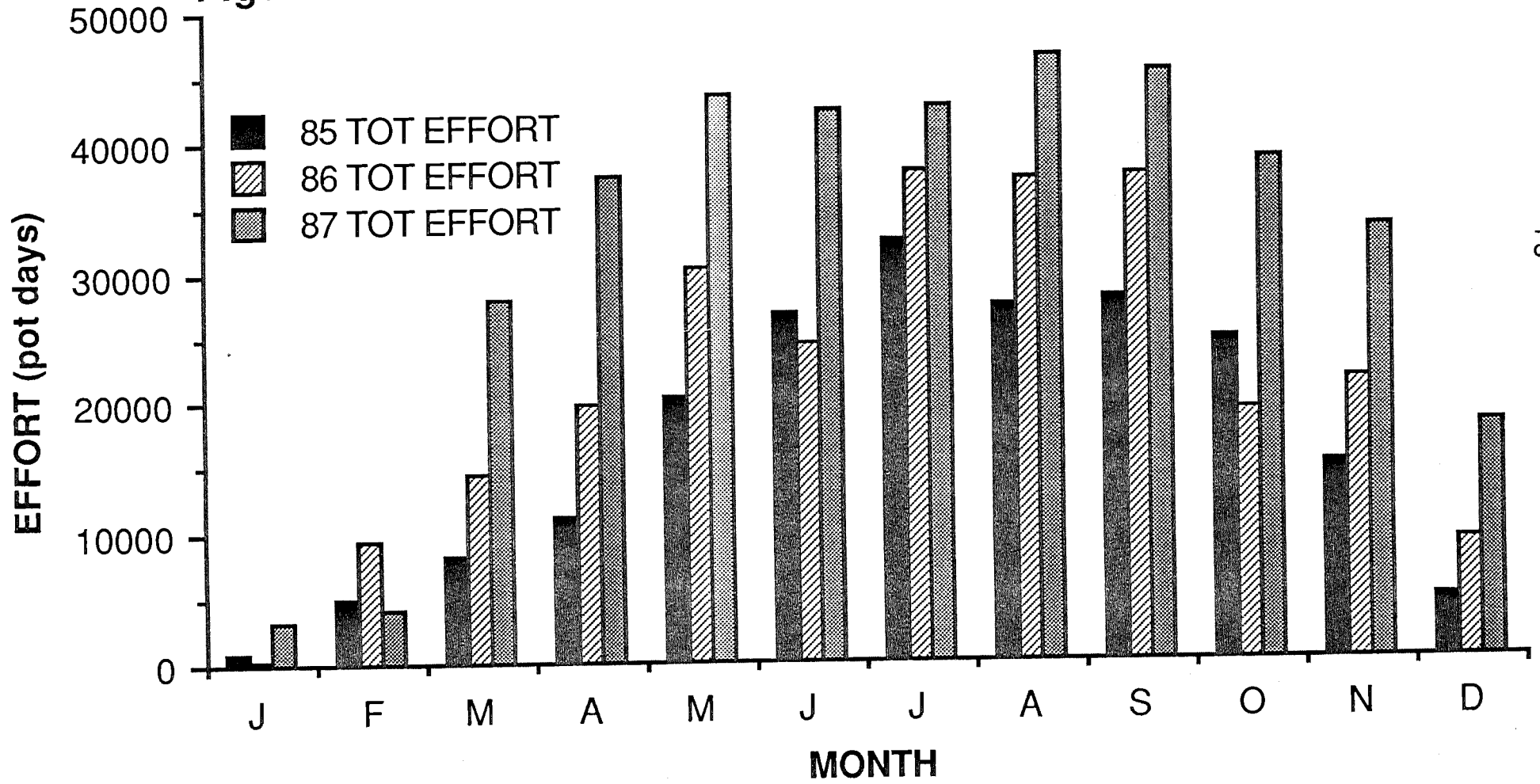


Figure 7. TOTAL EFFORT IN THE CRAB FISHERY - SOUTHERN AREA 1985-87

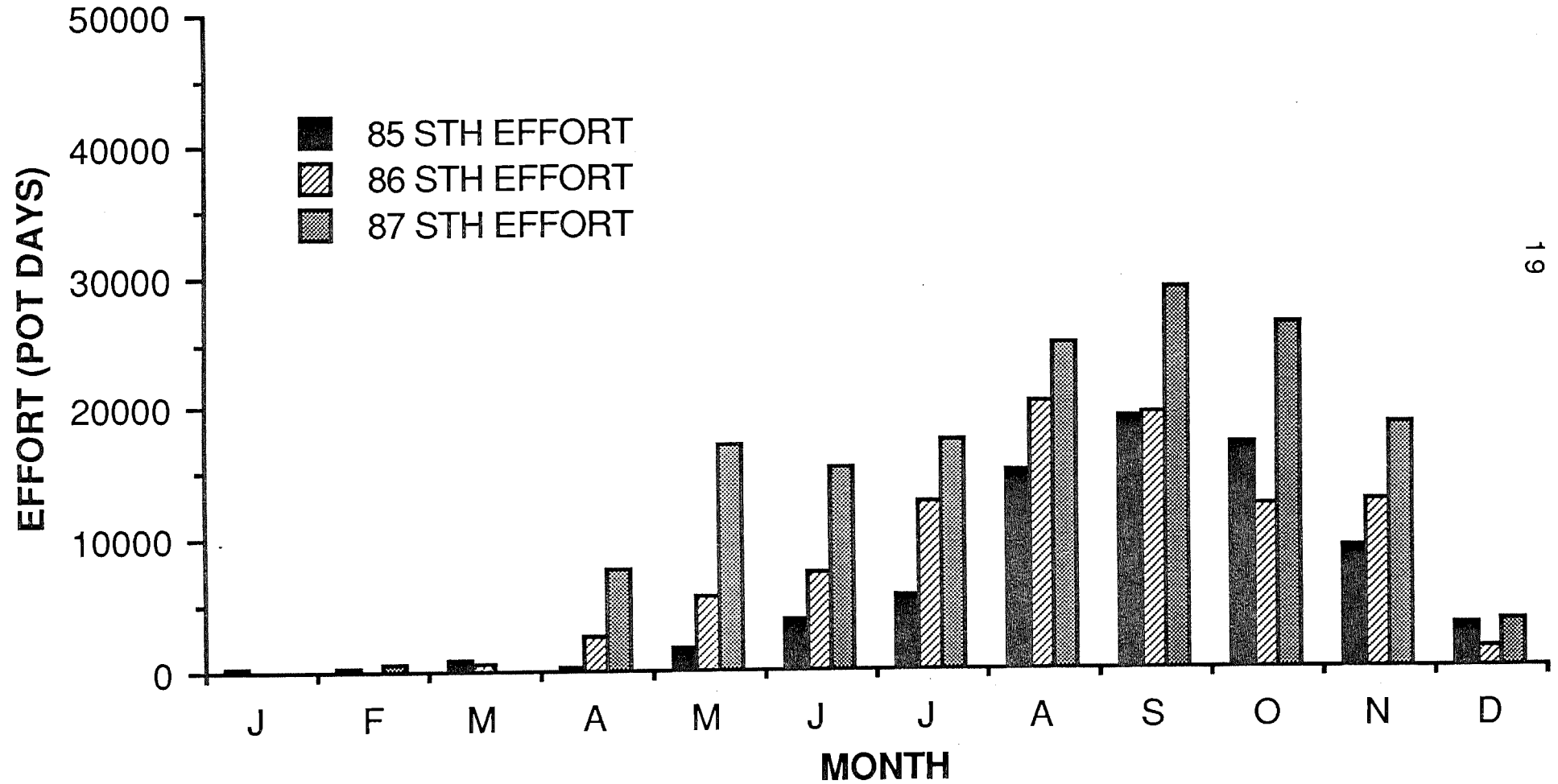




Figure 8.

TOTAL EFFORT IN THE CRAB FISHERY - NORTH WEST AREA 1985-87

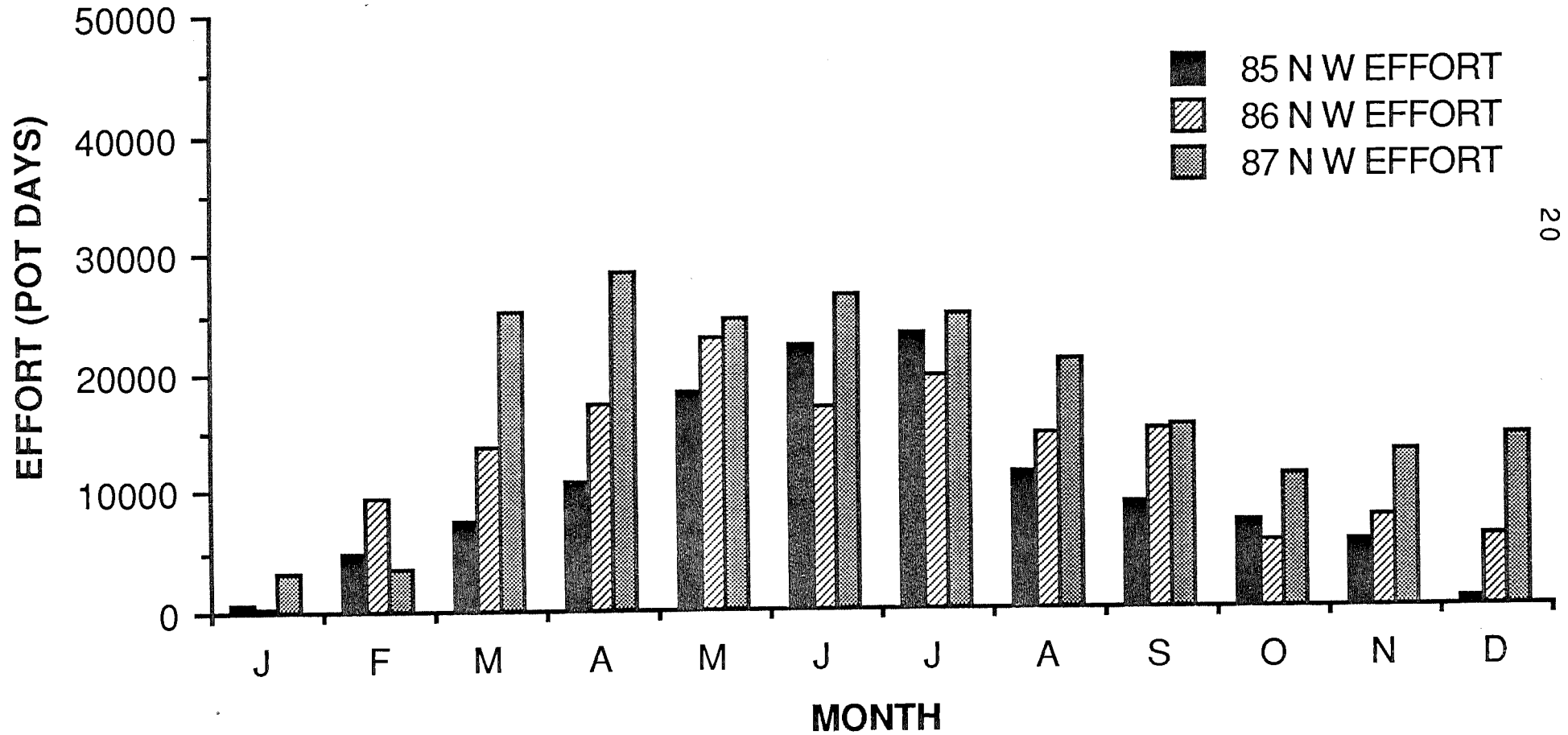


Figure 9. TOTAL EFFORT IN THE CRAB FISHERY - WESTERN AREA 1985-87

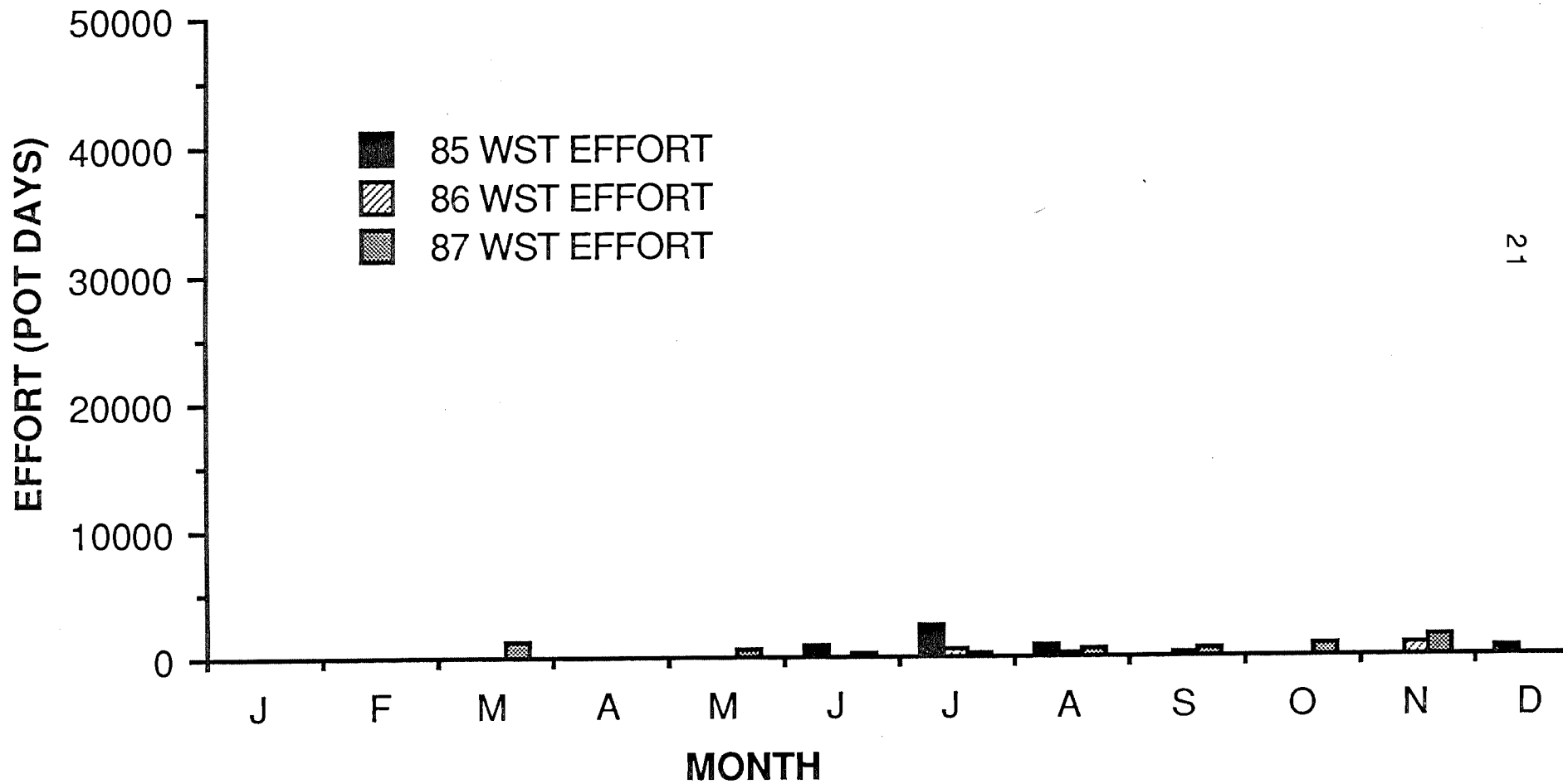


Figure 10.

### CPUE FOR THE TOTAL NT CRAB FISHERY 1985-7

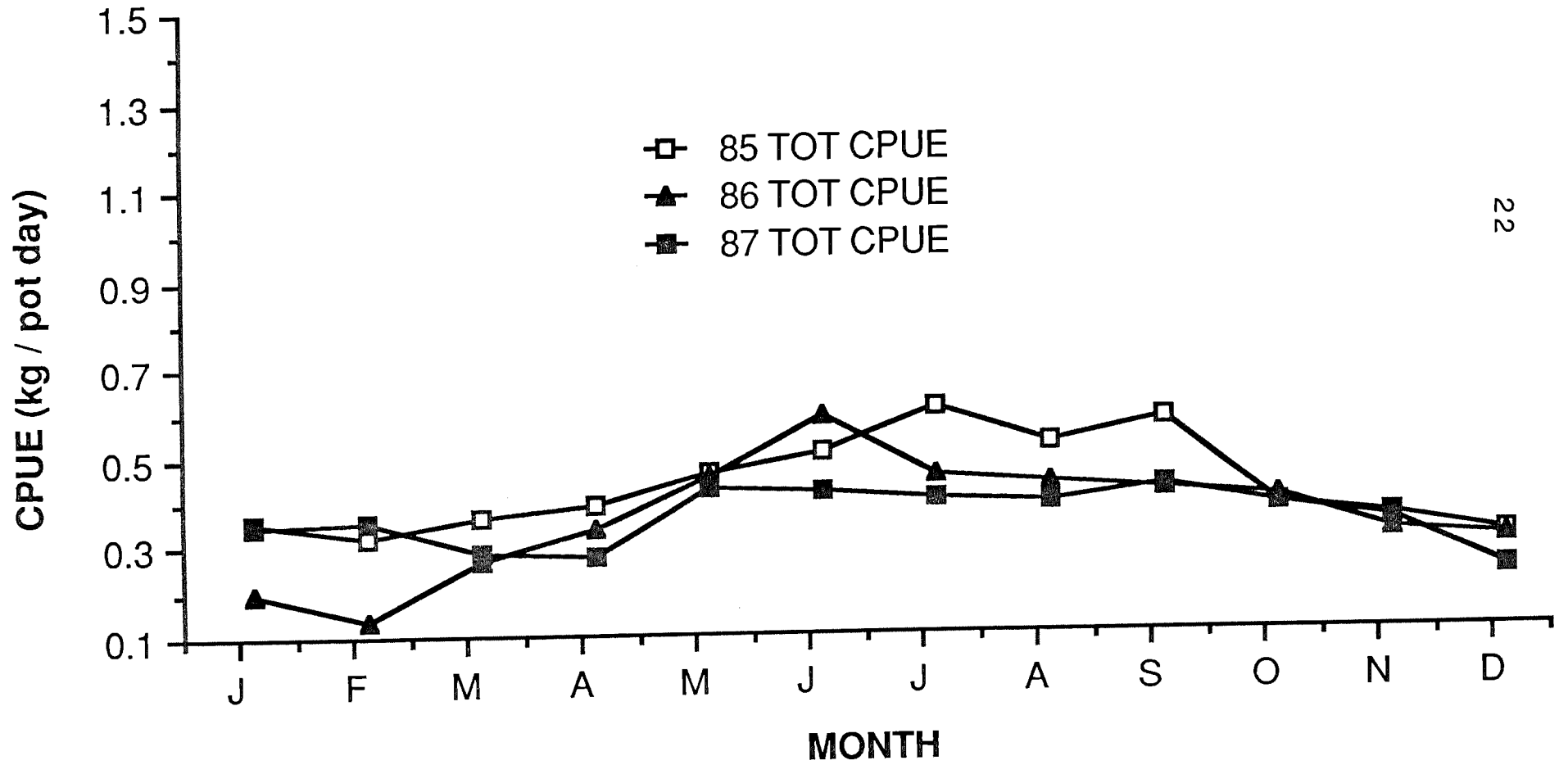


Figure 11.

CPUE FOR THE CRAB FISHERY - SOUTHERN AREA 1985-87

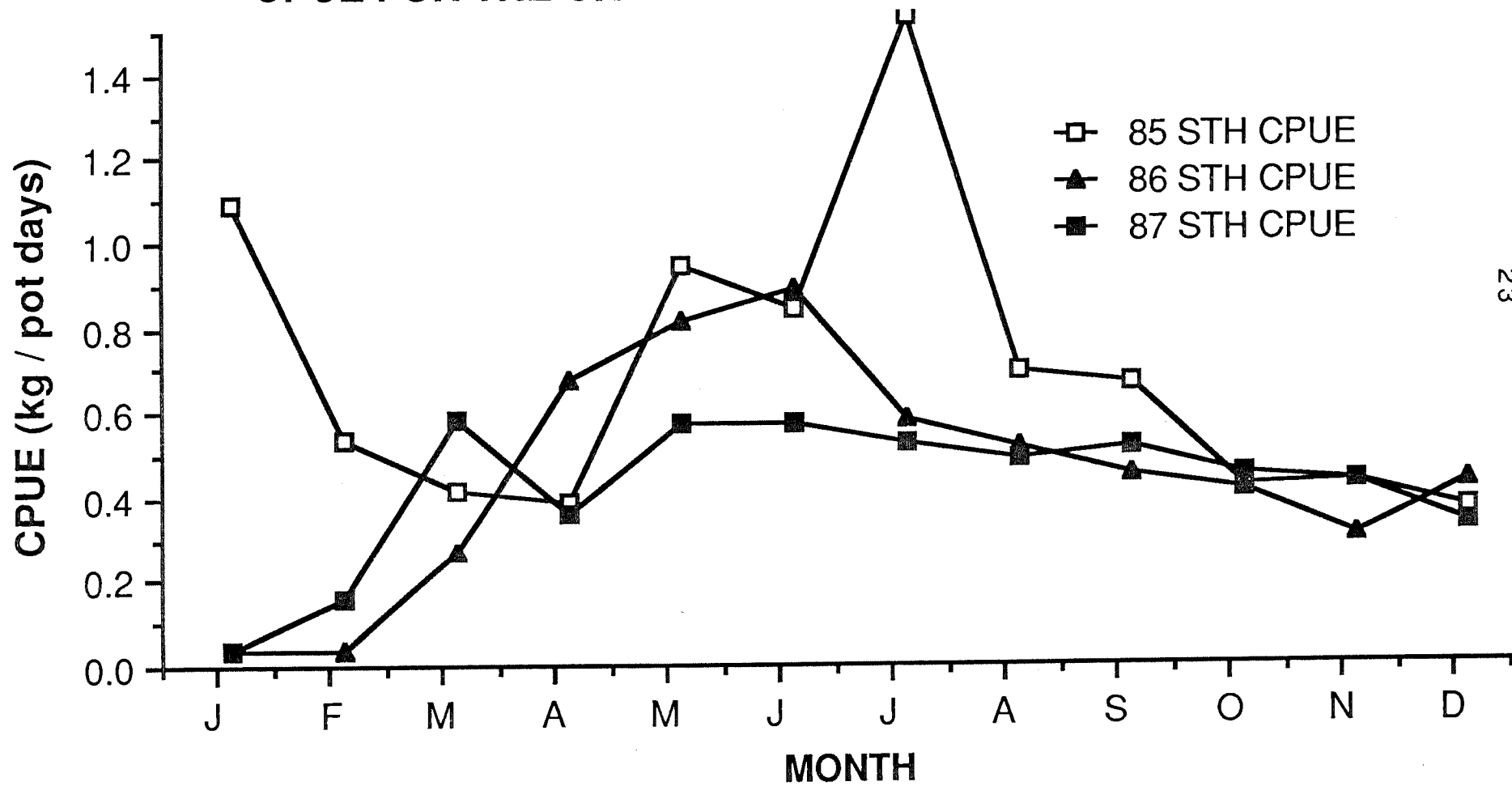


Figure 12.

CPUE FOR THE CRAB FISHERY - NORTH WEST AREA 1985-87

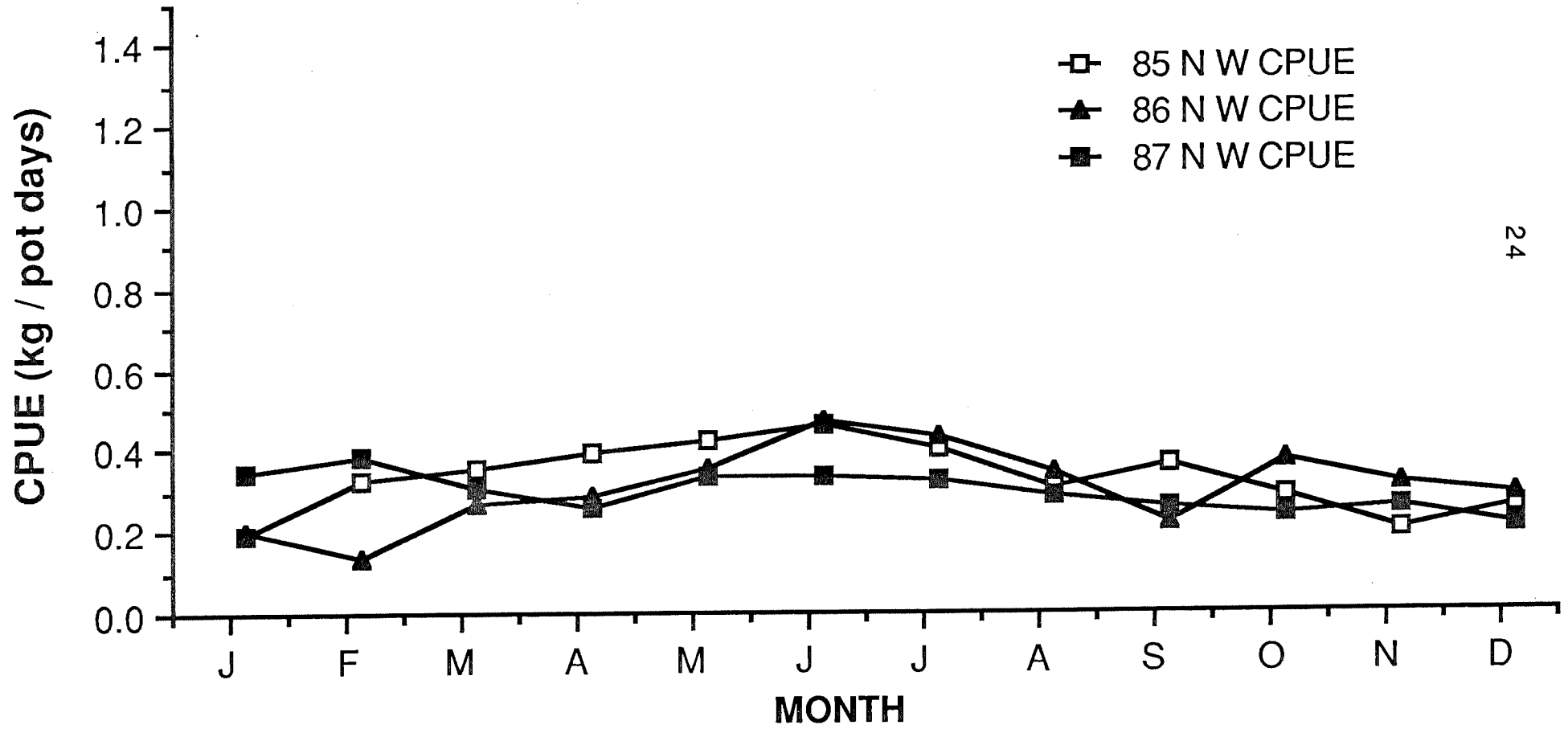
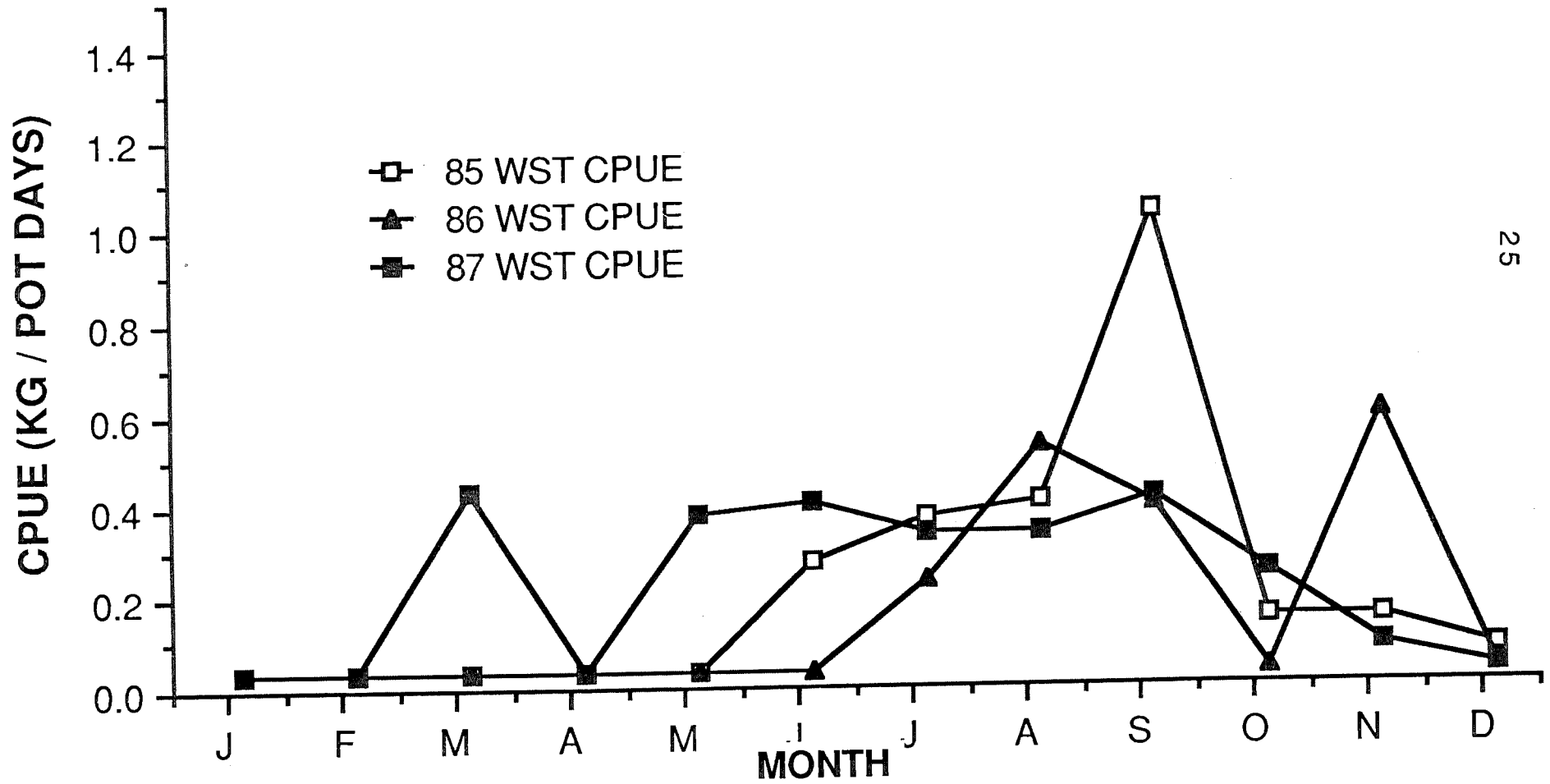


Figure 13.

CPUE FOR THE CRAB FISHERY - WESTERN AREA 1985-87



### 2.3 Fishing Season

Landings of mud crabs show a strong seasonal trend. Total landings for 1985, 1986 and 1987 as indicated in Fig 2, show the peak of the season for all the Northern Territory is between May and October, this is also confirmed by the catch per unit effort Fig 10. The seasonal peak is the converse to the observed by Queensland crabbers. This in turn helps Northern Territory crab fishermen receive a high price for their product and encourages effort in the fishery during the dry season.

Although, nowadays crabs are caught commercially throughout the year, very few are usually landed during December, January, February and sometimes May. There appears to be three main reasons for this:

1. The wet season quite often starts in December, which makes it impossible to transport live crabs out of remote catching areas;
2. The fertile female crabs migrate to sea during these months to spawn; and
3. The female crabs, followed by the male crabs have a high tendency to moult during this period (up to 80% of the catch) making them unacceptable to markets.

Fig's 2 and 3 give evidence that crab landings are higher about the North West area in the first half of the season and in the southern area during the second half. At this stage there is not enough data to predict when crab fishing would be at its peak in the Western area or along the Arnhem land coast.

The 1988, wet season in the southern area has been minimal and because of ease of access to and from the fishing grounds, far larger quantities of crabs have been caught during the early months of this year. But the high percentage of soft shelled crabs are there as normal and there has been a tendency to sell these inferior meat content crabs, which in turn has created marketing problems.

### 2.3 Working Conditions

Basically mud crabs are caught in two environmental areas, tidal mangrove river/swamps and coastal mud/sand flats. The crab fishermen continually have to contend with swarms of biting insects, blistering hot sun, rough seas and unpredictable tides.

The living conditions during the season vary from people living in airconditioned comfort, in a permanent dwelling on or near a launching site, to plastic tents pitched on the edge of a mangrove swamp. A few operate from large vessels.

Generally speaking the Asian crabbers, especially the ones that move continually to where crabs are being caught, live a very basic existence and the people who stop in an area for more than six months, live a remote but comfortable life style.

The crabs are normally transported to Darwin twice weekly and thus fresh supplies are always at hand.

#### 2.4 Commercial Viability

No economic survey of mud crab fishermen in the Northern Territory has been carried out, but it is known that a number of crabbers are able to maintain a fairly high living standard from crabs alone.

The overall catch recorded for 1987 was 129,300kg; the number of crab fishing endorsements was 49, and the average price paid for whole crabs was \$6.48/kg. This averages out an approximately \$17,100 per endorsement before operating expenses. Thus the overall picture is of a very low income industry. Where as at least 10 endorsements are controlled by barramundi fishermen who catch a minimal amount of crabs, or by people with other sources of income, who crab more or less as a hobby. This alone would adjust the figure to over \$21 000 per endorsement.

Also many crabbers lease more than one endorsement, with six being the most held by an individual during 1986, and eight in 1988.

Capital investment is generally low when compared to many other fishing operations. Most of the boats are small (4.3 to 5.3m) with 35 to 50 hp outboard motors. Between \$5 000 and \$7 500 would normally cover the price of a new suitable boat and motor. The crab pots cost around \$17 to \$21 each if constructed by the fishermen. The loss or destruction of these pots, by crocodiles, sharks, strong currents and theft are quite common, with a loss rate of around 2 a week per endorsement being normal.

As with most fishing operations, fuel is the major expense. Outboard motor fuel, ranges from 61c per litre to 65c/lt and diesel or petrol for



a vehicle to carry the crabs from the catching site is around 55¢/lt. Considering that the majority of the catch is caught in the Gulf country and nearly all the crabs are flown to interstate markets from the Darwin airport, the amount of fuel required to transport the crabs can be quite considerable.

The handling of the catch is simplified by the ability of mud crabs to survive for days out of the water when kept damp and cool. The crabs sent to interstate markets are packed in wax boxes which are bought in bulk for about \$2.00 each, then flown to the markets for around \$1.00 per kg. If sold at auction in the markets, between 6 - 12% of the price received is retained by the auctioneers as a fee.

Crab prices vary throughout the year because of fluctuations in landings, competition from other states, quality of crabs and varying demands. The price paid to crabbers who sold their product to fish mongers in the Northern Territory during 1987, ranged between \$4.50/kg and \$7.50/kg, while the crabbers who sold directly to interstate markets received between \$6.00 and \$13.00/kg.

It should be noted that endorsements are transferable with a present transfer fee of around \$16 000 payable to the ex-owner. Also many endorsements are leased to suitably qualified fishermen for around \$150/week. Quite often a group of 2, 3 or 4 crab fishermen will team-up to reduce expenses.

## 2.5 Fishing Gear and Methods

In the Northern Territory, mud crabs are captured by professional crabbers almost entirely in pots. The amateurs use a combination of pots, dillies and witches hats.

To a far lesser extent hooks and spears are used mainly by the Aboriginal people.

Originally all the commercial pots were made from cane, wood or a steel frame covered with chicken wire or welded mesh. Nowadays nearly all the pots are frameless and made from weld mesh with two hard plastic mesh entrances. The pots are normally 70cm long x 60cm wide x 25cm high. The only regulations relating to their design, require them not to exceed 0.5m<sup>3</sup> or 0.5 cubic metres in dimension and to have no more than two entrances. There are no requirements for the provision of escape gaps to permit undersize crabs to escape. It has been found that most

pots are selective and very few undersized crabs are caught. A similar study in Queensland, documented in 1984, also found the catch biased towards large crabs. A study of 746 crabs taken by commercial crabbers in the Gulf of Carpentaria and crabbing areas around Darwin in October/November 1987 and another 667 crabs in similar areas during May/June 1988 indicated that more than 85% were in excess of the size limit of 130mm across the carapace.

A study of the probability of capture of various crab sizes in different wire weld mesh, size pots, showed that no matter how small the mesh size became, the probability of catching sub-legal size crabs was never better than one in four.

The investigation also found that normally sub-adult crabs tend to stay together in isolated pockets along the coast and river systems and the crabbers become aware of these areas and stay clear of them.

Present regulations allow all fishermen to hold one or more crab endorsements. Each endorsement entitles the use of 60 pots. There are at present 49 endorsements available to the industry. Controlling the numbers of crab pots per endorsement is an accepted method of restricting effort, but in practice it is difficult to police. If for example, 10 endorsements are operating in a large river mouth system, covering possibly 200kms of water way (e.g. creeks, channels, gutters, etc), it is virtually impossible for a normal police patrol to check on all the pots in any one day. However, field observations during the study indicated that only a few crabbers might work one or two extra pots, while the majority operate below the maximum limit. The reason some use less than their entitlement, is that for a few, crabbing is only a hobby or part time job and the serious crabbers are continually losing pots because of crocodiles, sharks and strong tidal movements.

Generally the pots are set for 24 hours, but a small percentage of crabbers check their pots twice or more per 24 hours. In the northern and western areas the tide falls as much as 8 metres. This usually means the pots are out of the water for long periods and the crabbers have no option but to check their pots once a day.

In the Gulf region the rise and fall is much smaller and crabbers in some areas continually check their pots.

Fishermen who alone operate more than one endorsement have a tendency to only check the pots once daily. If the restriction of the number of pots decreased, it would not necessarily coincide with a decrease in effort, as most likely, many crabbers would begin to haul and re-bait the pots more often. There is also a tendency for fishermen, who alone operate two endorsements, to use only 90 to 100 pots instead of the legal 120. On the other hand, crabbers who have control of more than three endorsements, employ a crew and the full complement of pots are used.

## 2.6 Bait

Crabs are lured into pots by bait; contrary to some opinions, fresh bait is more effective than rotten bait. The more often the bait is changed the better the pots catching ability, and thus, pots should be rebaited twice daily. If not, the high water temperatures can quickly spoil the bait, or crabs which have entered, consume the bait and often escape. In certain areas, at various times, it is only possible to change the bait once daily because of the extreme tidal movements. Under these circumstances, the bait should be contained in a wire or plastic bait saver. Experiments have shown that crabs are less likely to escape from a pot while it retains bait. Another alternative is to use bones or tough fish heads, which the crabs are unable to consume.

A steady supply of good fresh bait is a major concern for crab fishermen. They require access to a fairly substantial source of bait. The type of bait (e.g. meat-bones, fish or poultry) does not appear to be a critical catching factor, although fishermen have particular favourites. Most Northern Territory crabbers prefer fresh cat-fish.

70% of mud crab fishermen have entitlements to use bait nets. The nets are haul-nets with the following dimensions; 300 metre long with a maximum mesh size of 65mm. Although these nets can be an effective means of gathering a steady supply of fresh fish, it is not always possible to use them in a legal fashion. The nets aren't allowed to be used in rivers and it is very difficult to operate them in soft muddy areas. The alternative to using bait nets is to purchase meat-bones from an abattoir or to kill and butcher animals in the wild. (NB most discarded chickens are used in the crocodile industry). This adds to the expense of operating; plus a

good power supply is required to keep the meat refrigerated and this again substantially adds to the operating expenses.

### 3. FIELD OBSERVATIONS

#### 3.1 Natural Predators

Mud crabs (*Scylla serrata*) have five distinct life cycle stages (egg, zoeal, megalopa, juvenile crab and adult crab) and at all stages they are vulnerable to larger predators. In the egg and zoeal stages they are drifting in the ocean and are possibly consumed by large filter feeding marine species.

During these early stages they require high salinity (around 30 ppt) and high water temperatures (26 C - 30 C), but they have no control over their broader surroundings. Their migratory movements are governed by natural environmental conditions (e.g. wind, tides, etc). Considering each fertile female is capable of extruding 2 to 6 million eggs at a time, and they can produce more than one batch of eggs from a single mating, it is highly likely the egg and zoeal stages are the most vulnerable, to predators and unfavourable conditions.

The megalopa is the first stage to have claws. It is aggressive and cannibalistic. The megalopa along with juvenile crabs are a source of food for many wading birds and small fishes. While the adult stage, is known, through observations, to have various predators feeding on them, possibly the crocodile, rock-cod, catfishes, sharks and rays, are the adult mud crabs most feared enemies.

Stomach contents of 289 salt water crocodiles (*C. porosus*), that were analysed from the coastal areas of the Northern Territory, by Janet Taylor, from the University of Sydney, in 1975-76, indicated that all crocodiles of less than 180cm, contained foods consisting of mainly crustaceans and insects; of which mud crabs made up a considerable proportion.

On two occasions during the project, large salt water crocodiles were spotted consuming crabs. Help to confirm the theory that mud crabs are part of a crocodile's natural diet, came from numerous crabbers complaining about crocodiles destroying unbaited pots and holding cages to get at the crabs.

Rock-cod (*Epinephelus tauvina*) which commonly occurs in estuaries and reaches a length of 2.1m and a weight of 230kg is probably the most efficient predator of both small and large mud crabs. This cod is commonly taken up to a weight

of 7kg in baited crab pots. E.M. Grant in his book 'A guide to Fishes', mentions this cod is partial to large live mud crabs, and that a hook baited with a live crab is possibly the best way to catch them.

These cod are very common in crabbing areas throughout the Northern Territory and are quite often used in the pots as bait. Nearly all the cod observed during the project contained the remains of either small or large mud crabs in their stomachs.

In the dry season (June, July, August) when the waters in the estuaries and river mouths were crystal clear, numerous sharks, rays and sawfish were seen feeding on mud crabs. The most common species noticed, were Green sawfish (*Pristis zijsron*), Tiger shark (*Galeocerdo cuvieri*) and the common shovel-nosed ray (*Rhinobatos batillum*).

Various catfish including Blue catfish (*Neoarius australis*), Eel tailed catfish (*Euristhmus lepturus*) and Salmon catfish (*Netuna thalassina*) have been observed with the remains of small mud crabs in their stomachs. All these catfish are commonly found in mud crab 'country' and are excellent crab bait.

Although it was not observed or reported, it is highly likely mud crabs are a basic food for most large fish, inhabiting estuaries, including the Northern Territories number one sports fish 'Barramundi'.

### 3.2 Burrowing

Observations indicated Northern Territory mud crabs burrow for at least three different reasons. First and possibly the most important, is for protection. This is best observed when a crab is cornered. The crab will quickly burrow into the sand or mud, totally covering itself, to escape capture. The second is for temporary shelter. This has been witnessed during the cooler months of the year. The crabs, especially the males leave the shelter of rivers and mangrove areas because of cold water and congregate along the ocean, sand/mud banks, where the water is warmer. They dig shallow temporary burrows around 50cm deep to retain warm water at low tide and to shelter from direct sunlight and predators. The third and most commonly observed burrows, appear to be permanent structures, used by successive generations of mud crabs. Although there doesn't appear to be a lot of these burrows, when compared to the Queensland east

coast, they are certainly noticeable in mangrove lined tidal creeks. The average burrow extends into the creek bank at roughly 35 degrees below the horizontal, to a depth of around 1 metre or more. They extend below the low tide water table and always contain salt water. The burrows are usually occupied during the warmer months when they may act as havens of cooler, more saline water. They could also protect the crabs during moulting and possibly mating.

### 3.3 Recruitment

No work has been done on mud crab (*Scylla serrata*) recruitment along the Northern Territory coast. Very little is known about its spawning and larvae cycles. It is known, from information gained by crab fishermen and off-shore prawn trawler fishermen, that mature females move out of the river estuarine areas to spawn in oceanic waters where the eggs and larvae are released into the plankton chain. It has been discovered through rearing experiments the planktonic larvae, known as zoeal, grow by moulting. After the fourth moult they reach the megalopa stage, then begin to move inshore to settle in the mangrove habitats (Queensland Mud Crab Fishery 1984). These post larvae (30mm - 40mm carapace width) continue moulting up to 17 times before assuming the adult crab characteristics.

Very little time was available to investigate recruitment, but on the 20th and 21st of May 1988, large numbers of small crabs/final stage megalopa were observed congregating along the seaward side, of all the sand bars which surround the mouth of the Roper River. Eighty seven of these animals were captured by a scoop net at five different sites. Their carapace widths ranged from 2cm to 7cm and the sex ratio was 40 males to 47 females. Numerous other small mud crabs were observed in commercial pots towards the upper reaches of creeks. Most of these crabs fell through the wire mesh, but the 31 crabs retained, ranged in size from 60cm to 130cm and were 75% male.

### 3.4 Reproduction

A male mud crab can only inseminate a female crab while she is in the soft shell condition. From observations in salt water tanks the new shells lose their soft rubbery texture after 2 to 3 days. It is the belief of many people, that only small female crabs are capable of reproduction. The reason being that normally only small females are seen being cradled by male crabs, prior to

her moulting and copulation. In fact, this was also observed on numerous occasions during the project, but what most people do not observe, is the massive increase in size of females after moulting, e.g. a 30mm plus increase across the carapace, being normal. The average size male crab spotted mating was approximately 160mm while the average female before copulation was 110mm and after 140mm plus. Generally in Northern Territory waters, the females are slightly smaller than males. On occasions both smaller and larger crabs of either sex were observed in the mating ritual.

When copulating the newly moulted female is inverted beneath the male and her abdomen, which is lifted during copulation, can be seen protruding above the male. Spermatopheres are transferred, via the males two pleopods to the female's oviducts, where they are stored and can remain viable for many months. The spacing of the pleopods and oviducts would make it difficult for two crabs of a large size difference to effectively copulate.

Although mating was observed during all months except January, February and March, it was definitely more evident towards the end of the year. Very few berried females were observed; in fact only three. Two in the mouth of the Roper River during November and one in the McArthur in December 1987. The eggs were adhered to the pleopod feathers under the female abdomen flap. They were yellowish-orange in colour and probably numbered several million.

Mating in (S.serrata) may precede spawning by as little as 5 weeks or as much as 7 months (Du Plessis, unpublished data). Mating may also occur between free-ranging partners or within the confines of inter-tidal burrows; (Heasman 1980). Detection of mating activity by using conventional baited-trap sampling techniques is confined to a period of 2-7 days preceding copulation (Du Plessis) during which time the male alone may continue to move about and to feed while carrying and protecting the female. Therefore, catches of pubescent females may be largely incidental.

### 3.5 Parasites

Throughout the project, the two most prominent parasites observed were parasitic barnacles. One of these, 'Oclolasmis' is commonly found in the gill chamber of mature crabs and the other 'Loxothylacus iklei, is related to Sacculina;- a



common parasite on sand crabs. The *Loxothylacus* parasite was discovered in our northern area in 1949 by Boschma. It is believed to be an evolutionary development of the barnacles which used to filter feed on the outside of the crab. This parasite forms a large sac on the ventral surface of the abdomen of its host. The sac is quite often mistaken as a crab's egg case. The parasite enters the crab and causes it to behave as an ovigerous female, but in doing so renders the host incapable of reproduction, through a process generally called 'parasitic castration'.

In all the areas surveyed it was present and found to infest approximately 10% of undersize females. No large females were caught containing the parasite. Only around 1 in 100 legal size females were caught who had rid themselves of the barnacle. These females were not fertile and appeared more like a male crab than a female, e.g. big claws and back. When the 1 in 100 is compared to the 1 in 10, it is reasonable to assume the parasite kills most of the females it attaches to; or at least prevents normal growth.

The *Octolasmis* barnacle was observed on numerous occasions infesting the gill chamber of what appeared to be old crabs. The barnacles were not discovered in large concentrations in any immature crabs. It appears the crabs are able to rid themselves of these barnacles each time they moult, until they have their final moult, which happens towards the end of the crab's natural life.

### 3.6 Moulting

Mud crabs grow by moulting (shedding the old shell and then forming a new and larger shell). The new shell is initially soft but hardens within a couple of days after moulting. Since the new shell is larger than the old one it takes sometime for the crab to fatten and fill its new shell.

Very little is known about the incidents of moulting of small crabs in the Northern Territory. Observations of 16 crab catches during 1987 and 1988 (see graph A) indicated a peak moulting season during January, February and March. Although some males and females were found to be in the newly moulted condition throughout the year, there was a tendency for newly moulted females to be caught during November, December and January and over a 60% chance of catching legal size males during the first three months of the year.

On 8/11/88 a small female (110mm across the carapace) was observed in a pot, in the premating position with a male. Twelve hours later the female had moulted and was mating with the male. The old shell was still in the pot. The female was very soft and had increased in size by 31mm to 141mm.

On another occasion a 136mm male crab was placed in a salt water tank. The two large claws were removed along with 3 legs. The crab was not fed for 10 days, then force fed small fish for 31 days. Small transparent sacs formed where the two large claws had been and also where two of the three legs were removed.

On the 31st day at 1100h the rear upper carapace began to slowly split. The process continued for around seven and a half hours with the crab lying quiet for about 20 minute intervals, then rapidly thrashing in the tank for 2 to 3 minutes. The crab puffed its new inner shell with water during the last half hour of moulting and retreated backwards out of the old shell. Two new legs were present and two claws. The claws were still small and wrinkled, but 10 hours later they were fully formed. They were about 2/3's full size. The overall size across the carapace had increased to 149mm. The moulting process was captured on video.

A research report from the Thailand Fisheries dealing with crab culture, reported that mud crabs will moult every 45 days. In the wild it is possible it would take longer, depending on the food supply and environmental conditions.

### 3.7 Empty Crabs

As noted in the previous section on moulting, a mud crab cannot grow while it is enclosed in its hard shell. To increase in size it must shed this outer shell and expand its body and limbs before a new shell hardens. Once the crab is free of the old shell, fluid is taken up to expand the new larger shell while it is still soft. Over the following weeks the crab feeds and the water in the shell is slowly replaced by meat.

These post-moult crabs are of little commercial value, as buyers are reluctant to purchase water filled crabs. Thousands of these crabs are caught around December to March each year. At times as high as 90% of the catch. In the past; crabbing operations virtually ceased during this time of the year, but in 1988 there was a much

bigger effort and a large number of empty crabs have reached both local and interstate markets.

These empty crabs did not help the good reputation, the Northern Territory crabs have had in the past, and along with the large supply of good crabs available from Queensland, the crab fishermen experienced difficulties at times selling their catches.

There are ways to define these newly moulted empty crabs e.g. pale colouring, flexible shell and no wearing on the inside of the claws, but when up to 90% of the catch should be returned to the water, many crabbers retained crabs, they would normally release.

Another problem with empty crabs is that they don't travel well. They are generally weaker than full crabs, they dehydrate quicker and their shells break easily, causing them to bleed to death.

Some attempts have been made by fishermen to hold and fatten the crabs, but as yet nothing has been successful in a commercial sense.

The female crabs when returning from the sea, presumably after spawning, were also quite often empty (February, March, April).

The only other empty crabs regularly observed during the project were very large old males. Possibly these crabs were nearing the end of their life and were too weak to feed properly.

#### 4. INDUSTRY VIEWS

##### 4.1 Interview Procedures

Between October 1987 and September 1988, 20 crab fishermen, who had control of 35 endorsements were visited and interviewed. Their responses to questions regarding trends in catch, effort, mortality, movements, mating, spawning, moulting, areas etc., were recorded.

Time enough, was spent at each crab camp site to actually witness operating procedures. This time with the fishermen in their working environments helped to break the ice, which sometimes exists between government officials and commercial fishermen. The objective of the interviews was to gain individual thoughts on the fishery and to compare these to find if definite trends were evident. Alternatively, the crabbers could have been interviewed in groups, but it was felt, many are not accustomed to public discussion and would not have voiced their personal opinions.

The fishermen interviewed were very cooperative. They were all informed that they were not obligated to respond to the interview, but there was not one negative response to the 36 points, unless the crabber concerned did not truly have an answer or opinion.

##### 4.2 Trends In Catch

All the crabbers interviewed were asked if the seasons have any effect on the size, sex, species and locality of crabs. The responses were all a bit different, but the general trends were:

1. more males are caught during the first half of the year; females around mid year; and 50-50 towards the end of the year.
2. the size was virtually undetermined, with possibly more crabs around the 90 to 130cm size taken towards the end of the year.
3. more crabs are caught on the mud-flats during the coldest months and wet season, while the rest of the year the crabs are spread, throughout the mangrove tidal areas.
4. only one species of mud crab, (*Scylla serrata*) is abundant, with only isolated reports of a brown mud crab being captured in the Darwin area. Graphs A, B and C, show the trends in catch of eight crabbers, who were interviewed in the 'Gulf Country'.

Figure 14. POST MOULT CRABS, GULF OF CARPENTARIA

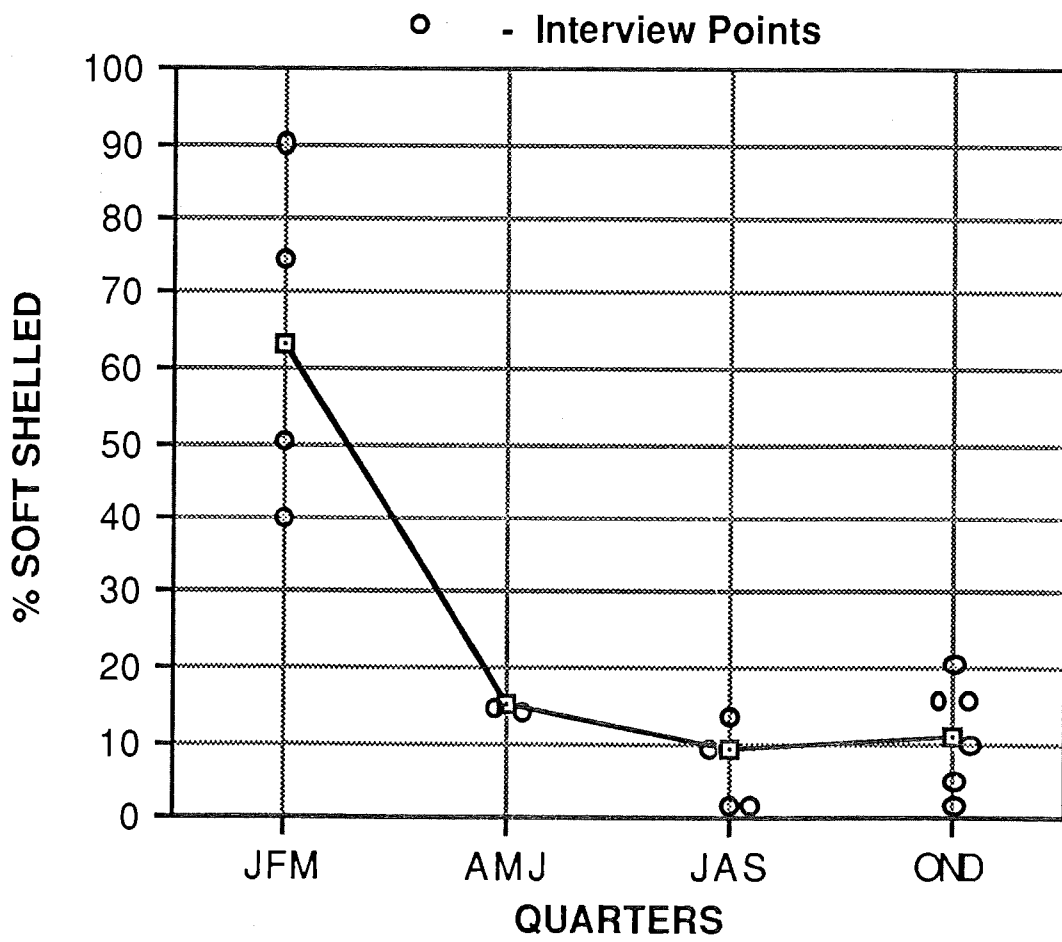
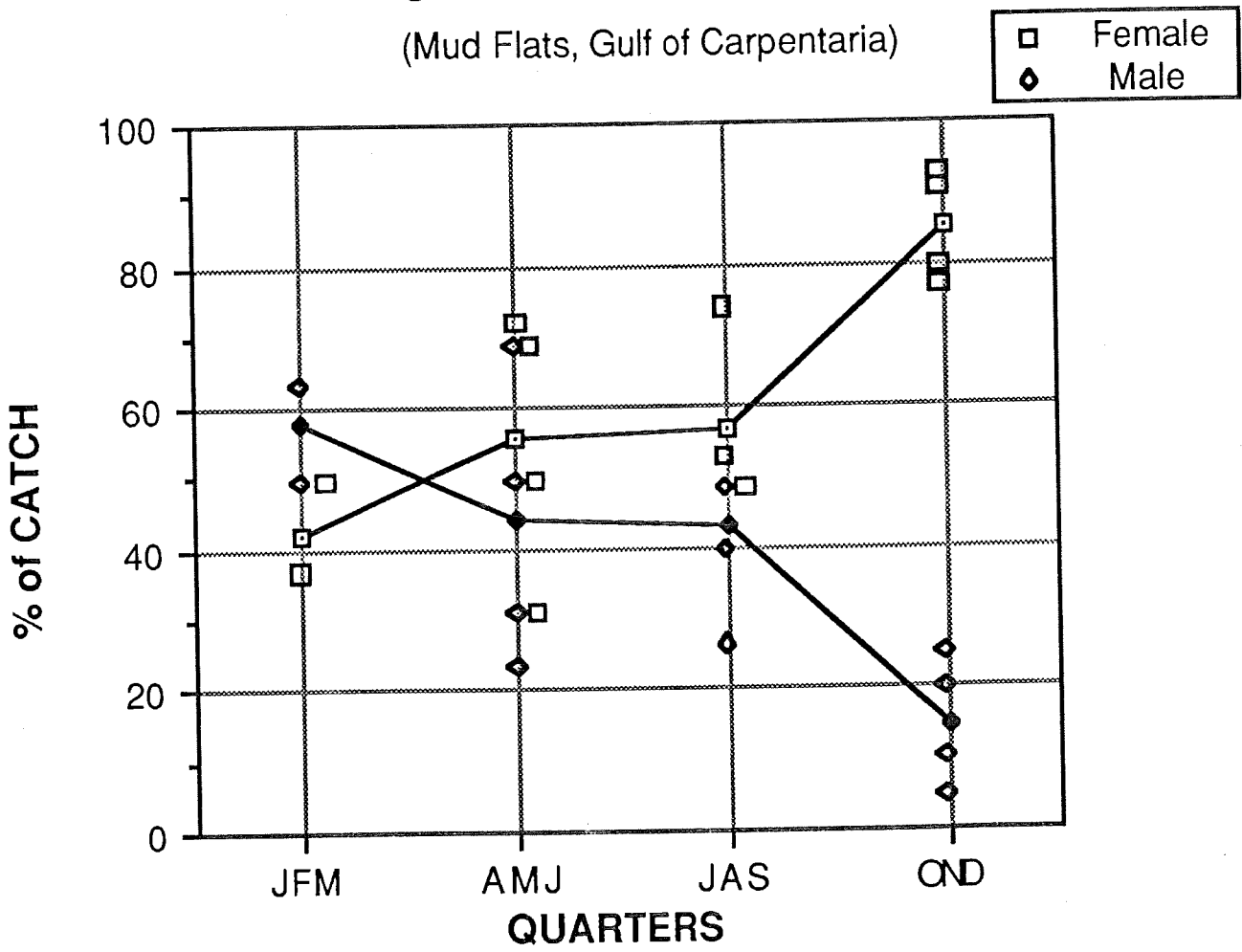
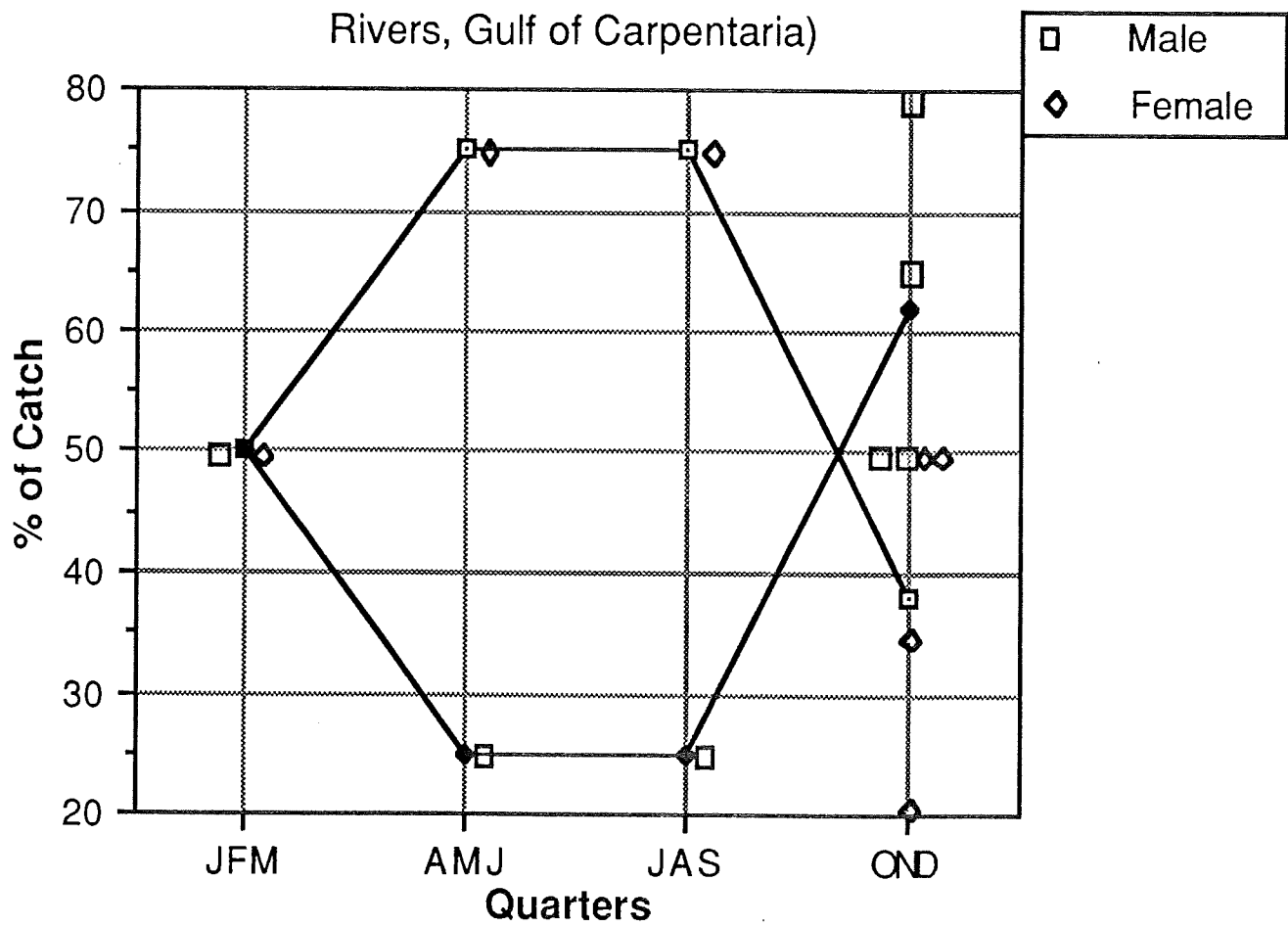


Figure 15. %MALE AND FEMALE  
(Mud Flats, Gulf of Carpentaria)



**Figure 16. % of MALE and FEMALE CRABS**  
Rivers, Gulf of Carpentaria)



#### 4.3 Increases In Effort

The twenty crabbers interviewed were asked to estimate what increases in catching effort they would have made over the last three years; excluding the number of extra days now spent crabbing (this is available from return-sheets). The determination of effort came from a combination of, how often the pots are now hauled and rebaited per day, how often are the pots now relocated, what distance do they now travel in search of new grounds, how many employees do they now have and what equipment changes and improvements have they made to increase catch efficiency.

Two (10%) felt their effort is the same as always, another two (10%) were unable to comment, as it was their first year in the industry. Five (25%) thought their effort per day would have at least doubled, while 11 (55%) were sure their workload per day had increased by 3 to 4 times.

#### 4.4 Congested Fishing Areas

At times, various crabbing areas became congested with pots. This happens, when, virtually all the endorsements are being used over the peak of the season and again, at times, during the wet season when only a few areas are accessible by road.

In July/August 1988, sixteen crabbers expressed their opinions on the problems of congested areas. Eleven, felt the number of endorsements allowed into certain areas should be limited. Four were of the opinion that things weren't all that bad and normally sorted themselves out. While one crabber admitted there was a serious problem but didn't know the solution.

#### 4.5 Closed Season

During late 1987, the few crabbers interviewed generally felt that a closed season was unnecessary. Their reasons being that the wet season forces most crabbers to stop working for a few months; plus the majority of the crabs are empty and thus uneconomical.

In 1988 many crabbers worked over the wet season and large quantities of partially empty crabs were landed.

Of the sixteen crabbers interviewed in July/August 1988 only two felt it was not necessary to have a closed season; one was not sure and thirteen felt it to be essential if



future stocks and market prices are to be maintained.

#### 4.6 Size Limit

The legal size for both male and female mud crabs in the Northern Territory is 130mm across the carapace. Only one crab fisherman thought that this was too small and should be increased to 140mm. All the remaining crabbers, interviewed, felt the existing size was okay and that if the minimum limit was increased, it would place an unnecessary burden on the industry.

#### 4.7 Taking of Females

In the two States bordering the Northern Territory, namely Western Australia and Queensland, restrictions are enforced with regards to the taking of female crabs. As yet, the Northern Territory Fisheries section has found no conclusive evidences to support the introduction of a ban on the taking of females.

All of the twenty crabbers interviewed felt, that the taking of females was essential, to maintain a viable crab industry. Their reasons were mainly centred around the marketing aspect of the industry.

#### 4.8 Mortality Rates

Commercial observations, along with project experiments have shown that the average mortality rate for one days fishing, to be negligible. All the crabbers agreed, this is the case for most of the year, but warned the rate could be significant on one or two days each year, when the temperature becomes extremely high, just prior to the beginning of the wet season.

The main mortality problems facing all crab fishermen are during transporting and storage. Most of the crabbers were unsure of their individual death rates, while at the base camp. They all agreed that crabs should be moved to the markets within four days of capture and that they should be held in a dark moist environment. The mortality rates at the camp storage sites, were indicated to range between zero and three percent. Information obtained during the project revealed incidents of 100% mortality at times. A few crabbers mentioned, the mortality rate could increase during the hot months (up to 10%). It is therefore possible that a mortality rate of 5% would be close to the actual rate throughout the year.

Mortality rates during transport from the landing sites to the markets, were at times unacceptably high. Crabs, which were caught in the Darwin area generally had very low, mortality rates, while crabs coming from the 'Gulf Country' to Darwin, then on to interstate markets were known to experience death rates as high as 45%, with 5 to 15% not being unusual.

#### 4.9 Crab Movements

Most of the crabbers were unsure as to all the crab's movement habits. Seventeen (85%) felt female crabs are caught in rivers, through June to September. Nine (45%) were confident that small crabs normally stay together in isolated pockets, either in small shallow creeks or close to the coast. Three (15%) thought that a quarter of the catch was normally undersize and the area didn't have a significant effect.

When the water in the river and mangroves drops below 20 C, eight (40%) of the crabbers were sure they would find the crabs congregating on the flats. Another two (10%) were convinced, the crabs go into holes when the temperature becomes excessively high, while two (10%) thought water temperatures had no effect on the crabs.

A third of the crabbers (35%) thought that crabs bury into the mud at low tide. Only two (10%) felt they move in and out with the tides.

During the wet season, 18 (90%) believed the females migrated to sea. None were very positive about what happens to the males over the same period.

#### 4.10 Moulting

All the crabbers interviewed responded to the question on, what percentage of the catch was made up of soft or empty crabs. The year was split into quarters and although the answers varied somewhat, there was a distinct trend noticeable. Some answers were uniformly high while others were uniformly low, but they all indicated that the majority of soft shelled/empty crabs were caught, during January, February, March then tapered off to a minimum around July, August and September.

The range quoted by each crabber varied considerably.

The overall range for each quarter is as follows:

<u>MONTH</u>	<u>% OF CATCH SOFT SHELLED</u>
January, February, March	10% to 75%
April, May, June	0% to 30%
July, August, September	0% to 10%
October, November, December	2% to 15%

The average percentage of soft shelled crabs for each quarter was 41%, 16%, 4% and 8% respectively.

The crabbers were unable to positively distinguish between male and female moulting seasons.

#### 4.11 Mating and Spawning

Surprisingly, most of the crabbers knew very little about mating and spawning in mud crabs. Eight of them knew nothing, but have witnessed the precopulation activities without knowing its significance. Another eight had actually seen females in spawn, while most, had, at times mistaken the parasite *Loxothylacus ilke* as an egg-case.

It appears approximately 50 females had positively been observed carrying spawn over the past 10 years. Their size, seems to have ranged between 120mm and 150mm. They were all hard shelled and carried millions of yellowish, orange to light brown eggs. Most of them were caught towards the end of the year, in rivers and the ocean, up to a depth of 12 metres.

Only two of the crabbers had actually witnessed copulation between a male and a soft shelled female. The others, except for possibly one, had all observed the premating ritual of the male holding the female. The amount of times this ritual was seen, ranged from, only twice a year, to 100 times a year, to every day towards the end of the year.

It was discovered that some crabbers remove the male from the female, then replace the female in the pot to lure more males.

#### 4.12 Natural Food

Although the water is normally murky where mud crabs are caught, at times, one may observe their habits in clear water. Laboratory observations have shown, crab stomachs to contain the remains

of fish, shell fish, weed and a gelatin substance.

Six of the crabber had never seen crabs feeding in the wild. The remaining fourteen had. Eight were very definite that crabs, commonly eat large white mushroom shaped jellyfish. A couple mentioned they quite often set pots in shallow bays where jelly-fish are trapped.

As would be expected six had noticed crabs feeding on dead animals, two had seen crabs eating other crabs and one believes he has observed them eating seaweed.

None had noticed crabs eating shell fish, shrimp or fish in the wild (other than offal from a fishing operation).

#### 4.13 General Discussions

Other topics touched on during the interviews included, the number of endorsements, pot numbers, amateurs, closed areas, marketing and enforcement.

Although individuals varied somewhat on different aspects of the above, the general feelings were:

1. 49 endorsements were not too many for the industry, so long as there was not a concentrated effort within an individual's operating area.
2. 60 pots per licence was an adequate number.
3. Amateurs caused only minor problems, with regards to stealing crabs from pots, catching too many crabs by abusing their crabbing rights and selling crabs.
4. the closed areas allotted to amateurs are okay, so long as the amateurs use them.
5. The markets are basically stable and are influenced by supply and demand.
6. discussions with regards to police enforcement, were mixed. Approximately 1/3 thought enforcement was being handled well at present, another 1/3 would like to see more police presence, while the remainder felt the police were unduly harassing them.

## 5. MARKETS

### 5.1 General

During 1987, over 90% of all the mud crabs caught in the Northern Territory were sold live to local and interstate outlets. The demand for live crabs has caused both problems and benefits for the commercial crabbers.

The benefits include higher interstate prices, less labour involved, scrubbing, washing, cooking, killing, packing and freezing, as well as not having to operate a portable blast freezer. On the other hand, the major problem created is the high mortality of crabs from the time they are caught, to the actual time the consumer receives them. Also, now more empty crabs are sold which would have normally been spotted floating during the washing stage.

With Sydney and Melbourne's Asian population now purchasing a larger and larger percentage of the catch, the traditional demand for the large frozen cooked male crab is being replaced by a demand for smaller live crabs, especially females. The laws in Queensland along with its tourist trade, makes it an exception and there is still a demand for large but live males.

It appears that the 1988 season will again see a further increase in the demand for live crabs to interstate destinations. With this in mind, an effective economically hygienic means of storage and transporting should be encouraged throughout the industry.

### 5.2 Storage and Transport

The majority of crabs caught in the Northern Territory are marketed live. They are caught in small wire traps and held live at the camp sites by various methods. The most common method is to tie the crabs claws hard against it's body, then to place them in plastic fish baskets lined and covered with wet hessian bags. Some camps keep the crabs in hessian rooms with a sprinkler system operating, while the majority simply leave the baskets in a shady area and occasionally wet them.

Other methods of storage at the camp site include:

1. Packing untied crabs in large wire baskets lined with hessian bags, with a thick layer of mangrove leaves between each layer of crabs (good for up to 7 days).

2. Packing tied crabs in plastic rubbish bins with flyscreen net on top (4 days only).
3. Packing tied crabs in 0.5m<sup>3</sup> wire cages and placing them on tidal flats (this method is difficult to access, as the hot sun could kill the crabs, they could have their legs bitten off by large fish or are scared to death by predators, but most of the time this method is quite alright for a couple of weeks).
4. Packing tied crabs in above ground swimming pools with holes 4 to 5cm in the wall above the floor so that the crabs could still breath air when necessary (good for 5 to 7 days).
5. Possibly the no 1 method, but the most labour intensive, is to place each untied crab into a plastic garbage bin containing a few centimetres of water. Place the bins in a cool shady area and change the water every second day (good for 2 weeks).

It appears the best method to store crabs at camp sites is to keep them wet, (not submerged), in a dark shady area, separate from each other and not to tie their claws. But of course crabbers would require hundreds of garbage bins, large shady areas and have a full time job changing water, so most tie the claws (this puts stress on the crabs) and pack them together and attempt to market them every 3 or 4 days.

Most crabs caught in isolated areas throughout the Northern Territory are sent to Darwin by open tray four wheel drive vehicles. A few are flown in by light aircraft. More often than not the roads leading out of the fishing camps are extremely rough. The crabs are normally packed in plastic fish boxes lined and covered with wet hessian bags. If the drivers are not extra careful, these sections of road can cause physical damage as well as stress to the crabs. The crabs should also be transported at night and the hessian bags not allowed to dry.

An improvement would be to place a layer of mangrove leaves between each layer of crabs to prevent them grinding against each other and help retain moisture. The problem being, quite often, there is not enough room on the vehicle to safely put another crab on-board, let alone a thick layer of leaves between the crabs.

For crabbers working within 200 kilometres of Darwin, there appears little problem getting healthy crabs to Darwin within 4 days of capture, so long as the crabs are in a good condition when removed from the pots and are stored in a damp shady spot before being driven to town in the cool of the night or at least damp and well covered during the day.

As for crabs in the Gulf of Carpentaria region, again they should not be stored for more than 4 days, especially during the hotter part of the year. This area is quite often 10 C hotter than the Darwin area and some type of crab cooling system should be incorporated at each landing/storage site.

The best method to transport crabs to Darwin from the 'Gulf Region' is by small aircraft, which only takes around 1½ hours compared to 8 to 14 hours by road.

On reaching Darwin the crabs are either sold to local buyers or packed in waxed lined cardboard boxes, ready to be air-freighted south. Because the crabs could be in a stressful condition from being out of the water too long or from a long and rough road trip, it is quite likely anything between 2 and 20% will die before reaching their destination.

One operation in Darwin refreshes the crabs by placing them in large concrete holding tanks, for at least 24 hours before boxing them and shipping south.

There are three main air-couriers handling crabs out of Darwin. The price charged to send crabs to Melbourne, Sydney and Brisbane is approximately \$0.85/kg with an initial fee of around \$10.00. Some services are slightly quicker than others but the average time for crabs flown from the Darwin depot, is 7 hours to Melbourne depots, 8 hours to Sydney depots and 4 hours to Brisbane depots.

The crabs are packed in the unpressurized cargo holds, in 13 to 15kg boxes. The temperature in the hold drops during the flight to around 14°C to 18°C at cruising altitude, but may drop to near zero on the tarmac during the night at Alice Springs or Melbourne over the winter months.

There are a few problems involved with air-freighting the crabs south but the airlines are pleased to obtain the back loading. An airline spokesman admitted that on rare occasions

the airlines may have contributed to the loss of some crabs. Example: a crabber may have his crabs packed and delivered to the airport, when a last minute flight change may occur. The crabber has the choice of retaining his crabs in Darwin, or they could stay overnight on the tarmac in Alice Springs or Brisbane before being reloaded onto an aircraft heading south.

Crabbers are also warned, that if crabs die and begin to stink during transport they could be dumped at the crabbers' expense. Although this has rarely happened, there was one occasion in 1987 when a load of crabs were off-loaded in Cairns because of the stink. Airline staff tried to help the crab fishermen involved by selling the catch to local merchants. The staff were unaware some of the crabs would most likely have been illegal in Queensland, but luckily no legal action arose.

On another occasion, a load of Northern Territory crabs being transferred to another flight at the Brisbane airport were seized and dumped in the Brisbane River (the authorities didn't appear worried about possibly spreading parasitical diseases).

It appears the problems concerning dead crabs could be worse in this 1988 season. As stated earlier, there is a growing tendency for certain groups of crabbers to keep empty crabs. The cool dry season seems to have been relatively short this year and it looks like, the critical hot period will be long. There is also a definite correlation between crabs dying during air-freight and unhygienic backyard, packing operations as well as poor storage techniques.

### 5.3 Markets Local

A local marketing survey was conducted in accordance with the project criteria. Darwin, Katherine, Mataranka, Elliott and Tennant Creek were investigated with respect to the impact local crabs were having on these markets.

Eight fish buyers who handle, or have in the past handled crabs were interviewed and their responses documented.

The general feeling of the buyers was that the recent high prices being paid interstate has virtually squeezed local marketing out of the mud crab industry. Only in Darwin are locals purchasing crabs from fishermen, but again the majority of these crabs are resold interstate or



overseas. The pubs and restaurants are generally by-passing the middlemen and purchasing direct from the fishermen.

The Asian communities in the Darwin area are being supplied directly from the Asian fishermen and in most country centres, crabs are normally impossible to obtain.

It is possible to buy frozen crabs in Darwin and sometimes in Katherine but generally it is difficult to purchase live crabs within the city limits.

The facts, that interstate buyers have pushed crab prices so high and that it is still relatively simple for Territorians to legally catch a good feed of crabs, have discouraged local fish shops to involve themselves with mud crabs.

As stated previously, the few outlets which do handle crabs, concentrate on interstate markets and act more as agents than retailers. There are at least two buyers in the Darwin area who have exported crabs to Japan. To date this has not grown into a big market but it is certainly showing a lot of potential.

#### 5.4 Interstate Markets

##### 5.4.1 General

An interstate marketing survey was conducted in accordance with the project criteria. The two major centres (Melbourne & Sydney) purchasing Northern Territory mud crabs were investigated with respect to the impact local crabs were having on these markets.

Eleven buyers who normally handle in excess of 20 000kg per month of Northern Territory, New South Wales and Queensland mud crabs, willingly responded to the interviews.

Findings were, that the constant demand is presently not being satisfied, for mud crabs in Sydney and Melbourne and the Sydney price is slightly lower than in Melbourne. Northern Territory crabs encounter more competition in Sydney from Queensland and New South Wales crabs, but there appears to be potential for the Northern Territory to increase supply, especially from Easter through to Christmas.

The mortalities are too high during winter and again late in the year and a program should begin with the aim to reduce this death rate.

#### 5.4.2 Purchasing and Selling

All the crabs from the Northern Territory were purchased live. They were flown from Darwin packed in cardboard boxes with wax liners. Other than the crabs which died during transport and handling, all the crabs were sold live. Most of the crabs from Queensland and Northern New South Wales were road transported to Sydney in styro foam boxes. Only a very small percentage were precooked and auctioned at the Fish Market. The crabs that were cooked, fetched very low prices. By far the majority of all crabs sold in Sydney are to Asian restaurants (58%). Around 22% are sold to smaller retail fish shops and approximately 20% directly to the consumer. In Melbourne the majority (75%) are sold to Asian restaurants. Only about 2% to retail shops and the remainder are sold in open air markets.

#### 5.4.3 Buyers Sydney

The Sydney buyers preferred females not more than 0.75kg (150mm carapace) and the males less than 1kg (160mm carapace). Fish market personnel mentioned that female crabs brought higher prices and the buyers preferred crabs that were orange or brown on their undersides.

Of the six buyers who regularly handle Northern Territory mud crabs, 3 had had problems with the crabs, from the same group of Northern Territory crabbers (mainly high death rates, maggots and soft crabs). The others were pleased with the quality, supply and service they received, when purchasing crabs which had been freshed up in ponds before the flight south.

#### 5.4.4 Size Limit and Sex

In Victoria the sea water is too cold to support mud crabs, therefore, the Government has not placed a size or sex limit on the crabs.

In New South Wales the size on mud crabs is measured length ways along the carapace. In fact the actual size allowed in New South Wales is lightly smaller than the Northern Territory; around 128mm across the carapace. Females are not restricted, therefore the Northern Territory's present restrictions are quite in line with New South Wales laws. If the size limit on Northern Territory crabs were removed or lowered, marketing problems could arise.

#### 5.4.5 Empty and Soft Shelled Crabs

Generally all the buyers interviewed agreed that on, odd occasions, usually at the beginning of the year, empty crabs were a problem, but not from all Northern Territory sources. Crabs from Queensland definitely have higher percentages of empty crabs than that of the Northern Territory. They agreed the bigger the crab the more inclined it is to be empty. The people doing the complaining are normally Australians who boil or buy large cooked crabs. Whereas the Asian community prefer small crabs, which they break into pieces before cooking. They don't particularly worry about the meat content, but a full rich flavour which combines with other foods.

#### 5.4.6 Mortalities

All the buyers interviewed reported mortalities which ranged between an average of 0% and 30% of a consignment. The inspectors at the Sydney fish market produced records showing mortality rates as high as 47%. Both the inspectors and buyers agreed that the cold climate during winter nights in Sydney and Melbourne (as low as zero degrees and averaging around 8°C) killed the crabs soon after landing, and that crabs which arrived dead were more of a problem towards the end of the year, especially from the Northern Territory.

Some buyers mentioned, that during winter, if they received crabs that appeared weak, they revived most of them, by placing them in shallow water and slowly increasing the temperature. All buyers interviewed stated they could not accept mortalities higher than 5%, if so they would not pay for the dead ones, especially towards the end of the year when the dead ones stunk and quite often were fly blown. One buyer notice, crabs which were fresh out of the water and subjected to immediate road transport, were more inclined to release a black vile, which stained themselves and other crabs in the box. He suggested crabs be held for 2 days in a damp quiet environment, close to the place of capture, to allow the undigested bait in the crab's stomach to dissolve.

Interestingly, only one buyer refused to pay fishermen or agents for dead crabs in winter. Most buyers cooked the few dead crabs and sold them at half price. They felt the crabs were still consumable because they had only been dead a couple of hours in a cool environment.

The buyers who purchased crabs in large lots and took a couple of days to dispose of them, naturally had larger mortality problems.

#### 5.4.7 Demand

The demand in Melbourne and Sydney for Northern Territory crabs appears to be relatively high throughout the year, with a possible peak at Chinese New Year, Christmas holiday periods and the Queensland/New South Wales off season (April through to November).

#### 5.4.8 Increase Supply

Three of the four Melbourne buyers thought they could handle an extra 100 to 200kgs per week but would have to be sure of a steady supply, good quality and a stabilisation of price. In Sydney at least three of the buyers were sure they could handle an extra 200kg to 600kg per week in the near future, once they had set-up suitable holding tanks. Another two thought they could handle more crabs per week if they were sure of a steady supply and a guarantee on quality.

## 6. MANAGEMENT

### 6.1 Interstate Legislation

Commercial quantities of mud crabs are taken from three Australian states along with the Northern Territory. These are Western Australia, Queensland and New South Wales. The remaining states do not have mud crab fisheries and thus no legislation exists.

The Western Australian market for mud crabs is very limited and is normally satisfied by its own crab fishery. The majority of the crabs sold interstate are to Victoria, New South Wales and Queensland.

In Victoria and New South Wales there are no conflicting legislations which could disrupt the marketing of legal Northern Territory mud crabs. In Queensland the minimum size crab is 150mm across the carapace and the possession of all females is illegal. This means that only male Northern Territory mud crabs greater than 150mm are marketed in that state.

Luckily for the industry, most crabs are sold to Chinese Restaurants in Melbourne and Sydney where the demand is for small female crabs, whereas in Queensland the demand is for large males, for the tourist trade.

The only problems which have arisen concerning the Queensland legislation, are a few isolated cases of Northern Territory crabs, enroute to Sydney via Queensland, being confiscated by Queensland Fisheries officer because the crabs were accidentally unloaded in Queensland.

### 6.2 Northern Territory Legislation

#### 6.2.1 Commercial

The following is a brief version of the main Northern Territory Fish and Fisheries regulations with regards to the Commercial mud crab industry:

1. An A1 licence may be endorsed with one or more endorsements, each authorising the licence holder to use 60 pots in the crab fishery.
2. The rights and powers conferred by a crab pot endorsement may be transferred to the holder of a Class A1 licence if the whole of those rights and powers are transferred.

3. All waters subject to tidal influence are open to the taking of crabs by an endorsed A1 licensee, except the waters of:
  - i. Port Darwin; enclosed by a straight line drawn between the most landward point on the seaward side of the Mandorah jetty and the northern most point on Lee Point within the Port; and
  - ii. Buffalo Creek, Mecketts Creek, King Creek, the Howard River and Headers Creek.
4. Where a person is licensed to engage in the Crab Fishery, it is a condition of the licence that the licensee shall mark with a consecutive number each pot he is licenced to use, as well as the licence number on each float.
5. The licensee shall not:
  - take a crab by the use of a net;
  - take a crab by the use of a pot that has:
    - i. a capacity of more than 0.5m<sup>3</sup>; or
    - ii. more than 2 openings into any one enclosure.

#### 6.2.2 Amateur

1. Amateur fishermen may take mud crabs, using up to three (3) pots per person. The owner's name must be clearly marked on the float of each pot. Crab pots may be of any design provided that they are no longer than one metre on any side and do not exceed one half of one cubic metre in capacity.

An amateur fisherman who is a member of a fishing party can work all of the pots belonging to that party, provided that the number of pots do not exceed three (3) times the number of fishermen in that party.

Any crab of less than 130mm across the carapace must be returned to the water immediately or as soon as practicable after the crab is taken.

#### 6.2.3 Limitations of Amateur Legislation

2. Basically, the amateurs are very conscientious with regards to the law and conserving the mud

crab stocks, but it has been observed by project staff and reported by commercial crabbers, that at times amateurs do put undue extra fishing pressure on some crab populations.

Possibly the use of inverted dilly pots, also commonly known as witch's hats or suicide dillies, are the most destructive legal method used by amateurs. These dillies tangle the crabs and quite often undersize crabs are caught. The process of freeing the crabs from the netting is difficult and many die, even if released. The dillies continue to ghost fish if lost. A large number of these lost dillies were found to contain, both old and fresh crabs and fish.

Another problem encountered was that pots are quite often not identified. Some amateurs have been observed in possession of dozen of crabs and knowing the catch rates of the area it is unlikely the crabs were taken from a legal number of pots. A better method of policing and controlling would be to allow a bag limit on the number of crabs, either per boat or per person.

### 6.3 Crab Landings

In 1981, 8.3 tonnes of mud crabs were landed and recorded. In 1984, 28.2 tonnes worth \$152 000 were caught. In 1986, 104.5 tonnes worth \$571 000 and in 1987, 129.3 tonnes with a value of \$830 000.

The 1987 catch, once again represents an increase over the previous year with a 31.7 percent increase in landing and a 45.4 percent increase in value. The increase in catch over the past few years, appears to be directly attributed to a massive increase in effort and technology since 1984. A study of 50% of the licensed crabbers who have been in the industry for more than 3 years, has shown an increase in effort of around 200 to 300% (e.g. increased pot numbers, more fishing days, bigger and faster boats and better bait, etc).

Fish landings reported by Northern Territory Al Fishermen, (excluding the Northern Prawn Fishery) showed that mud crabs in 1987 were the most valuable species caught, after barramundi, and that the landings of barramundi were decreasing while mud crab landings were increasing.

The total number of pot days (P.D.) for 1987, increased 46.8% on the 1986 figure to 382 256, with a large proportion of this extra, expended in the last quarter of the year, whereas the catch per pot day decreased by only 0.03kg, to 0.34kg of crab.

Although the figures quoted and the graphs 1 to 12 indicate a healthy viable fishery, it should be noted that pockets within both the Southern and North West areas produced little or no crabs during the last couple of years, forcing crabbers to move to new, previously inaccessible areas for months at a time. Both these reasons have helped to keep the catch per pot day high and should be seriously considered when management plans are looked into.

In the absence of any accurate long term data it is not possible to support or refute claims from fishermen or anglers that the mud crab fishery is declining. Graph 9 indicates a steady decline in the catch per unit effort from 1985 to 1987 but no accurate knowledge of the catch rate for the previous ten years is known, therefore the decline maybe a seasonal trend and not an effect of over fishing. To date, wherever mud crabs have been caught around Australia, no rigid relationship between future harvest and harvest history is evident.

#### 6.4 Catch And Effort

Data from Fishermens' return sheets over the past few years has shown increases in catch, corresponding with increases in effort and an overall slight decrease in the catch per unit effort. In actual fact the real effort which includes hours worked, fuel, pot hauls per day, opening up new grounds etc, has increased at a much higher rate than is indicated. This means the catch per unit effort is actually a lot lower than thought.

Even with this increase in effort it appears the catch is stable at around the 100 tonne mark per year and that the fishery is not on the verge of collapse. On the other hand crabbers are now desperately running out of new grounds to open up (e.g. they are now working all the productive areas not restricted by land rights or isolation and have chain-sawed their way into nearly all the small creeks and swamps) unless spawn recruitment is extremely good or new grounds are opened to crabbers in the future, it is quite likely a reduction in the catch will occur.



## 6.5 Fishing Pressure

Without a detailed stock assessment and a practical knowledge of what effects natural recruitment to an area, it is virtually impossible to work out an optimum fishing level an area can effectively maintain.

Data from crab fishermen, fish return sheets (see graphs 1 to 12), basically indicate the crab fishery is stable, so long as natural involvements remain constant. But in actual fact, the data doesn't show the massive increase in effort and the constant opening of new grounds.

The competition in the industry, has forced many crabbers to disregard the habit of looking after an area. In the past most crabbers released crabs which were legal but a bit on the small side. They didn't take crabs which were not quite full, but now keep them because they fear their competitors are doing the same. Also many of the crabbers wouldn't keep females, especially small ones, but now the southern markets are demanding these crabs.

Individual commitments to the industry have seen, fishermen hauling and rebaiting pots 2 or 3 times a day, burning up far larger quantities of fuel to find new grounds, and some are now carrying chain-saws to cut their way into new creeks and tidal swamps.

None of the above effort is recorded in the catch data sheets. The only information on local catch is, the general area crabbed, the number of pots used per day and the quantity caught.

With the above in mind, it is quite likely areas are being over exploited, especially from an economical stand, if not a biological one. At times in 1987-88 crabbing areas, including the Roper River, McArthur River, Wearyan River, Bynoe Harbour and the Adelaide River to name a few, became congested with crab pots. This crowding of an area coincided with the catch rate per pot drastically reducing, making it uneconomical for many crabbers to operate. This in turn, caused friction between competitive groups of crabbers and a few unwanted ugly incidents eventuated.

In 1987, the return sheets, indicated that once an area became saturated with pots, the crabbers either stopped working or moved to other grounds and the catch rate per pot increased proportionally to the removal rate of pots from

the area. Although the sheets indicated an area could only economically maintain a certain number of pots, it should be noted that when the catch rates dropped, it normally coincided with a drop in water temperature and vice versa. Documentation from Queensland mentions, that in their state, during the winter months, when the water is coldest, the crabs reduce their feeding and very few are caught in pots.

This congestion problem in the middle of the year, when the majority of the crab endorsements are being used, is more of an economical, rather than a biological problem. But during the remainder of the year, when extreme efforts are being adopted to open new grounds, and the taking of vulnerable soft/small crabs is happening, it could be having serious biological effects, with regards to habitat destruction and short term recruitment of full large mature crabs.

It appears the new grounds available in the future are almost exhausted and this is likely to bring about a down turn in the industry, unless environmental conditions improve (e.g. better natural recruitment) or new grounds are made accessible (e.g. Aboriginal lands, Victoria River system etc).

Another problem seriously facing the commercial crab fishermen, is the possible expulsion of all crabbing operations within the borders of the Kakadu National Park. If this eventuates, it will not only effect the licences, which have been operating in the area over the last couple of years, but also crabbers in other areas if the Kakadu fishermen are forced to move in on them.

The only type of gear which did appear to ghost fish, was the suicide dilly, also known as inverted dilly or witch hats. These dillies are used by amateurs and tangle the crabs which are attempting to get the bait. They are really small tangle nets using bait to lure the crabs. They indiscriminately catch small and large crabs as well as a variety of fish. Quite often the crabs are killed when being removed from the netting, as it is difficult to untangle them. Small crabs released back into the water are at times dead or dying.

Nearly all the disregarded suicide dillies discovered during the project contained dead crabs and fish.

#### 6.6. Protection of Females

Present legislation in the Northern Territory allows the taking of female mud crabs. To date there is no definite biological evidences, that the protection of females would improve or stabilise the wild stocks.

Heasman (1980) questioned the merits of protecting female mud crabs. He raised three point on this matter. Firstly mud crabs are highly fecund producing 1 to 7 million eggs per spawning. Thus it is not necessary to have a large number of spawners. Secondly, because of natural mortality, most mud crabs do not live beyond their third year regardless of legal protection. Thirdly, adult crabs compete with juveniles and sub-adult for food and so reduction in the number of large females may result in the survival of more juveniles and sub-adults.

The number of spawners necessary for maintaining the mud crab population is not known and would be difficult to estimate. In most South East Asian countries, female mud crabs are preferred for eating, those with mature ovaries being especially prized. Despite this preference and a complete absence of any protection for mud crab stocks, mud crabs have not been fished out, although heavy fishing pressure appears to have reduced catch rates.

The fact that the Northern Territory has so much Aboriginal land and more recently, national parks which are virtually closed to commercial crabbing, it raises the probability that the major catching areas may be receiving larvae from eggs hatched off the Arnhem Land coast and other protected areas. If this is occurring, then the complete removal of females from existing crab grounds may not affect recruitment.

So long, as the Northern Territory has these non commercialized breeding grounds, it appears there will be a naturally occurring recruitment rate to the majority of the coast which is dependent on environmental conditions.

#### 6.7 Size Limit

The size limit of 130mm across the carapace was introduced to satisfy a market demand. In Queensland the limit is 150mm across the carapace and initially the market demand was only for large males. With the increase in immigrants to Australia, especially from Asia, the demand is now focused on small/female crabs.

Queensland introduced the size limit many years ago and it would now be a difficult thing to lower or remove it, even if biological evidences proved it unwarranted. The Northern Territory size limit only came into effect recently (3 years ago) and already there is a feeling of resistance among commercial crabbers and the general public about lowering or removing it.

A lot more research, with regards to the natural mortality; growth and recapture rate is needed to fully understand what effects the present size limit is having on the crab populations. Considering, that commercial crab pots predominately take large crabs and the market demand is for medium to small crabs, there appears to be very little evidence that any size limit is required. Although the outcry that would surely come from concerned persons, probably means it would be best to retain the present limit, if for not other reason than to keep the peace.

#### 6.8 Marketing of Post Moults Crabs

Post moults crabs are also known as empty crabs, soft crabs or water crabs. Their capture has been increasing over recent years as the fishing season has extended, to cover major moulting periods early in the year. The expense of operating a vessel during this early part of the year is just as high as any other time. The percentage of the catch in the post moults condition can be as high as 90% and many of the crabbers do retain crabs which they know should be returned to the water, to fatten up. Economics and fear that their fellow crabbers will keep the empty ones, has brought about a possible destructive, 'catch 22', situation.

These post-moults crabs are of little commercial value, as buyers are reluctant to purchase water filled crabs. These empty crabs are not helping the good reputation, the Northern Territory crabs have had in the past, plus the fishermen are having difficulties selling them. Post-moults crabs don't travel well. They are generally weaker than full crabs, they dehydrate quicker and their shells break easily, causing them to bleed to death.

Some attempts have been made by fishermen to hold and fatten the crabs, but as yet nothing has been successful in a commercial sense. The general feeling in the industry is to introduce a closed season. But it may be commercially more viable to attempt to develop a fattening method in

conjunction with a short term tagging program. If the tagging program indicates that a large majority of the post-moult crabs returned to the water are recaptured at a later date full of meat, then possibly a closed season would be viable. On the other hand, if most of the crabs are not recaptured and fall victim to natural predators, there are good grounds to support the idea of retaining these crabs and developing fattening techniques.

#### 6.9 Marketing of Crab Meat

By far, the most viable way to sell legal full crabs is live, but at present considerable quantities of crab meat are marketed by certain fishermen. It is doubtful whether the price obtained for meat would justify the cost of separating the meat from the shell, if the crabs were legal size, full crabs. It is obvious that most crab meat comes from sick, empty or small crabs. With the recent developments of improved handling and high prices available, it makes the practice of meat extraction unnecessary.

#### 6.10 Fattening and Grow out of Mud Crabs

As previously mentioned in the section of post moult crabs, the fattening of 'empty' crabs maybe a viable proposition, but many governing factors would have to be considered. The proportion of empty crabs in the catch is highly variable, ranging from an average high of around 50% in January to a low of around 3% in June-August. This variation imposed upon the seasonal catch rate implies that supplies of empty crabs would not be continuous and the fattening operation may only be viable for 4 to 6 months of the year. Other considerations are the cost to build the enclosures, food supply, water supply, predators and labour requirements.

Fattening and grow-out culture is being carried out in many Asian countries, including Taiwan, Thailand and the Philippines. These countries have low labour costs and collect most of the small crabs for grow out culture, from the wild stocks. At present, reliable supplies of juvenile hatchery reared crabs are not always available in Australia and a potential crab farmer would probably require access to the wild juveniles. This would cause concern throughout the industry and mean the granting of special permits to catch under size crabs and grow them.

If and when the hatchery culture of mud crabs is established in Australia, the Northern Territory

would most likely be a suitable place for large culture operations.

## MUD CRAB MORTALITY IN UNATTENDED POTS

### Introduction

Four separate studies were carried out into crab mortality rates in unattended pots. The work, observed crabs confined in pots for seven days in simulated commercial operations. The areas covered were river systems and ocean mud/sand banks during the wet and dry seasons. The study sites included Wood Inlet on the western side of Darwin Harbour during January 1988; Apa Bay on the Cox Peninsula during February/March; the northern approaches to the mouth of the Roper River in the Gulf of Carpentaria during May and 35kms upstream from the mouth of the Limmen Bight River in the Gulf country during July 1988.

Various types of commercial pots were used. A total of 167 crabs were observed in 83 pots. Of this, only 6% of the crabs died (or were killed by other crabs) within seven days. The escape rate was 39% (normally within the first couple of days), while the survival rate was 55%.

### Pots

The crab pots used were similar to those used by commercial crabbers throughout the Northern Territory. The four most common designs used by local operators were constructed for the experiments. Both the flat plastic interlocking crossover entrances (eg. the crabs push their way in through the entrance and it closes behind them), commonly worked by the Asian crabbers, and the tapered cone shaped plastic funnels were used. No significant difference in catching ability was observed, but the crossover entrances had a slightly lower crab escape rate eg. 37% as compared to 41%.

Weld mesh pots of various dimensions were experimented with. The smallest being 16cm high by 60cm wide by 70cm long, and the largest 30cm x 70cm x 90cm. The average size used by professional crabbers was 25cm x 60cm x 65cm. The larger pots definitely caught more crabs per 24 hours, in areas where crab densities were high. This happened only if the bait remained in the pots, (eg. a wire bait-saver). Although the larger pots caught more crabs on occasions, they were more expensive to construct and difficult to relocate; as only a few at a time would fit in the dinghy.

No difference was noticed in the escape rate for various size pots. The most crabs caught by a large pot that was set overnight, was 16 large males and 2 large females inside the pot, plus another two large males, which came aboard hanging onto the outside of the pot.

Observation of professional crabbing indicated that the few crabbers who use large wide funnel openings, do catch crabs quicker, but have to spend more time checking the pots, as the crabs can and do, escape quickly.

#### Sampling: Method and Procedure

An attempt was made to gain accurate mortality rates in the two main crabbing areas of the Northern Territory, eg. the north west coast and the south east coast, and to see if the wet or dry seasons play a significant roll as to mortality rates; along with investigations into the differences between crabs caught in river systems as compared to ocean mud flats.

The four individual studies lasted an average of 10 days. The actual data recorded was for 7 days, while the remaining days were used to locate suitable study sites. Approximately 20 pots were used during each experiment. The pots were limited to 20 because of the limitation of space available in the trailerised 5 metre aluminium dinghy and the twin cabin 4 x 4 Toyota Hilux, assigned to the project.

The first day or two of each trip were used to find a suitable crabbing spot, which had a relatively good crab population and was concealed enough to prevent amateur fishermen finding and interfering with the experiment. The pots were baited with fish and the doors on the pots were tied with fine grey cotton to indicate whether the crabs escaped through the funnels or removed by unknown persons. The bait was contained in plastic mesh 'savers' and held in place on the floor of the pot by a rubber strap. All the pots were identified with a number and had NT FISHERIES branded on the marker floats.

Once a crab had entered a pot, its size, sex, shell condition and any identifying marks were recorded, along with the pots number. If the pot was moved, it was quickly replaced back as close as possible to its original position. The old bait was not replaced. Most of the pots were checked each day while they were high and dry on the banks. If a recorded crab was observed still in the pot, the pot was tapped with an ore to see if it was still alive, and was otherwise not disturbed. If the pots didn't come out of the water at low tide, they were checked from the boat, taking care not to excite the crabs too much.



Surface water and air temperatures were recorded throughout the experiments. Water temperatures ranged from 18°C to 44°C, while air ranged from 12°C to a high of 36°C in the shade. Salinity was recorded and varied from 2.2‰ to 32.5‰ but didn't appear to have any effects on the crabs.

### Stage 1

The first study was carried out in Woods Inlet of the western side of Darwin Harbour in two creeks on the southern side of the inlet. The study covered mortality rates of crabs caught in river systems during the wet season. The period of time covered was from 18th January to 28th January 1988.

The type of areas crabbed were two narrow creeks which nearly dried out at low tide. The pots averaged 2 to 4 hours out of the water during the day. The water temperature varied from 31°C in the early morning, up to 44°C in the shallow water during the afternoon. The air temperature ranged between 25°C and 36°C in the shade. The crabs in the pots were exposed to direct sunlight for roughly 2 hours a day, while the mangroves shaded them for the remainder of the time they were out of the water. The salinity decreased from 3.0‰ to 2.2‰ as the experiment progressed.

A total of 36 crabs were observed in 22 pots. All the crabs were above legal size (130mm) only 22% were female and approximately 50% of the total number appeared to have new shells. 12 crabs escaped within 2 days, 2 died after 3 days (cause unknown) and the remaining 22 were still alive in the pots after 7 days.

The overall mortality rate of unattended pots for 7 days was 5.6%; the escape rate was 33.3% and the survival rate was 61.1%.

### Stage 2

The second study was carried out on the northern side of Tapa Bay on the Cox Peninsula. The study covered mortality rates of crabs caught on mud flats during the wet season. The period of time covered was from 24th February to 4th March 1988.

The type of area crabbed was sand/mud flats, about 50 metres seaward from the mangrove shoreline. The pots averaged 6 to 7 hours out of the water during the day. The water temperature varied from 30°C to 34°C. The air temperature ranged from 24°C overnight to a high of 34°C in the shade. The crabs were exposed to direct sunlight for the whole of the 6 to 7 hours they were out of the water. Most crabs hid under the funnels to gain a little shade, while 6 crabs were observed flinging sand and mud on their backs to possibly

insulate themselves from the direct rays of the sun. The salinity in the area increased from 2.7‰ to 3.2‰ during the 7 days the crabs were observed.

A total of 40 crabs were caught in 21 pots. All except two of the crabs were above the legal size, only 15% were female and all the females appeared hard shelled in the pre-moult condition. Of the males, 30% appeared to have new shells. 16 crabs escaped within 6 days, four died within 6 days and the remaining 20 were still alive after 7 days.

The overall pot mortality rate of unattended pots for 7 days was 10%.

The escape rate was 40% and the survival rate was 50%.

### Stage 3

The third study was carried out on the northern approaches to the mouth of the Roper River in the Gulf of Carpentaria. The study covered mortality rates of crabs caught on mud/sand flats during the dry season. The period of time covered was from 16th May to 25th May 1988.

The type of area crabbed was a sand/mud bank. The pots began close to the mangrove shore and extended seawards along a mud/sand bar for 0.8kms. The pots averaged 2 to 3 hours out of the water each day and 3 to 4 hours each night. The water temperature varied from 24°C to 27°C on the afternoon high tide. The air temperature ranged between a low of 14°C overnight to a high of 32°C in the shade during the day. The crabs were exposed to direct sunlight for the whole of the 2 to 3 hours they were out of water. Throughout the experiment, the salinity in the area remained constant at around 3.25‰.

A total of 41 crabs were observed in the 20 pots. All the crabs studied were above the legal size limit. Only four were female (10%) and were all hard shelled. Of the remaining males, 50% appeared to have new shells (post-moult).

From the 41 crabs observed; 19 escaped within 6 days, two died within 6 days and the remaining 20 were still alive in the pots after 7 days.

The overall pot mortality rate of unattended pots for 7 days was 4.9%.

The escape rate was 46.3% and the confinement survival rate was 48.8%.

#### Stage 4

The fourth and final study was carried out in the Limmen Bight River, approximately 35kms upstream from the mouth; near the junction with the Nathan River. It dealt with crabs caught in a simulated commercial operation in the upper reaches of a tidal river during the coldest time of the year. The period covered was from 7th July to 17th July 1988.

The type of area crabbed was a muddy river bank. Nine of the 20 pots used, averaged 4 to 5 hours out of the water each night (note: there were only two tides every 24 hours) the other 11 stayed submerged. The water temperature varied from 18°C to 22°C. The air temperature ranged between a low of 12°C overnight to a high of 29°C in the shade during the day. The crabs were never exposed to direct sunlight, but the ones that were out of the water during the night had to contend with heavy dews and fogs. Throughout the experiment, the salinity in the area remained constant at around 31‰.

A total of 50 crabs were observed in the 20 pots. No undersize crabs were recorded. Only 12 of the 50 crabs caught were female (24%). They were all in the hard shell (pre-moult) stage. Of the 38 males, only two appeared to have new shells (post-moult).

From the 50 crabs observed, 18 escaped within 6 days, two died after 2 days and the remaining 30 were still alive after 7 days.

The overall pot mortality rate of unattended pots for 7 days was 4%.

The escape rate was 36% and the survival rate was 60%.

## APPENDIX 2

STYRO FOAM BOX EXPERIMENTS

It was decided to conduct experiments using styro foam boxes, after studying results from the Melbourne and Sydney interstate Marketing Survey.

The report showed that the general opinion of interstate buyers was that the cold climate during southern winter nights (as low as zero degrees and averaging around 8°C) killed the crabs. It was suggested, that foam boxes be used to insulate the crabs, as it has been documented that crabs can sustain enough oxygen in normal insulate boxes for 18 hours.

Procedure

On the 28/3/88 twelve crab pots set in Tapa Bay (30km due west of Darwin). The following morning they were hauled and 10 healthy male green mud crabs were caught. Their claws were tied and they were packed in a plastic fish box and covered with wet bags. The pots were reset and the following morning (30-3-88) another 20 (16 males, 4 females) were caught and handled in the same manner.

The crabs were driven back to Darwin (3 hours) and stored in the Fisheries Research Building. The bags covering them were kept wet. The following day, at noon, sixteen crabs (12 males, 4 females) weighing a total of 15 kilograms were washed and packed in a styro foam box. The box was a Cullaform Plastic ice-pack, with outer dimensions of 58cm x 38cm x 27cm and 2cm thick walls and lid.

The inside of the box was lined with a thin plastic sheet (to keep the inside clean in case it was to be used again) and two sheets of damp newspaper were placed top and bottom of the crabs. This was done to maintain humidity inside the box. A maximum/minimum thermometer was placed inside the box and another taped to the outside.

The box was sealed airtight. The temperature in the shed and also in the box at the time of sealing (noon) was 28°C. The crabs were driven to the Darwin Airport (8km) and remained at the terminal in a temperature averaging 35°C for 1 3/4 hours.

The box arrived in Melbourne in good condition. On arrival in Melbourne the maximum/minimum thermometer

which was attached to the outside of the box, showed a temperature range of 42°C to 16°C. The 16°C was also the actual temperature at the Melbourne Airport, which indicated that the temperature in the airplane hold at 30 000 feet was greater than 16°C. The 42°C was most likely the temperature on the tarmac at Darwin Airport.

At 0030 hours Melbourne time (12 hours after sealing) the box was opened. The inside temperature was 27.5°C, the outside was 15°C. All the crabs were checked. None showed signs of stress or weakness.

They were replaced back in the box and the lid was again sealed. They were checked every 12 hours and allowed fresh air for the next 4 days. The temperature outside the box dropped as low as 8°C. The box was never open long enough for the crabs body temperatures (checked by feel) to dramatically decrease. They were sprinkled with a little warm water each time the lid was removed and the temperature finally dropped to 20.5°C inside the box. On the fourth day the experiment was terminated. Throughout the experiment only one crab on the last day showed signs of stress. It was beginning to bubble which is normally a sign the crab could die within the next day or so.

On the 20th of May 1988 two more experiments using styro foam boxes were carried out at a camp site on the Roper River, approximately 700km south east of Darwin, using a five day old commercial catch. The first experiment was similar to the one already described, only 14 crabs (6 female, 8 male) were not transported but were sealed off from oxygen for 18 hours. The result was that the crabs appeared a bit sleepy but soon revived when exposed of fresh air.

The second experiment was the same as above, but the 14 crabs (7 female, 7 male) were sealed off from fresh air for 24 hours. The result was that 2 male crabs were dead and half of the remainder were fretting, which was indicated by the bubbles being released from their mouths.

### General

The experiments have shown that crabs can definitely survive 12 hours sealed in a styro foam box and that the temperature control appears to help the crabs stay healthy. Considering most flights to Melbourne and Sydney take between 7-8 hours including stops, it is likely that using foam boxes will increase the survival rate. But because there have been occasions when a load of crabs have had to wait at the airport overnight and it is known the crabs cannot stay safely sealed for more than 18 hours, it may be necessary for airline personnel to open each box for a few minutes.

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