THE WESTERN AUSTRALIAN TRAP AND LINE FISHERY ON THE NORTH-WEST SHELF

FIRTA PROJECT 86/28

FINAL REPORT October 14 1988

by

M. Moran

J. Jenke

C. Burton

D. Clarke

WESTERN AUSTRALIAN MARINE RESEARCH LABORATORIES

FISHERIES DEPARTMENT

Preface

This report details the results of work undertaken under FIRTA project 86/28. It will form the basis of a published WA Fisheries Department Report. This will follow the incorporation of a small amount of data not available in time for inclusion in the present report, such as June 1988 fishermen's monthly returns.

The amount of detail tabulated may seem excessive. This is partly due to the multi-species nature of the fishery but is also a deliberate attempt to provide all the information we think future fisheries scientists may need about this fishery in its early years

CONTENTS

ACKNOWLEDGMENTS

Throughout the period of this study, many people have assisted with the collection of data, the provision of facilities or help with specific aspects of the program.

Special thanks go to the owners of the fish processing establishments on the Pilbara coast for their generosity and assistance with our fish sampling work:

Mick Manifis and staff, Ashburton Fisheries, Onslow.
Peter Prescott, JPR Seafoods, Exmouth.
Bill Millar and staff, Samson Fisheries, Pt.Samson.

Many thanks to the skipper, Theo Berden and crew of 'RV Flinders', the Departmental research vessel, for their help and expertise with the trapping experiments. Thanks to technical officers Rob Tregonning and Greg Davis who supported us in the field and to Dianne Baird for help in data entry.

The collection of data has relied heavily on the commercial fishermen working on the Pilbara coast, in Onslow, Exmouth and Pt.Samson. To these many fishermen we owe a special thanks for their complete cooperation and interest in the research program.

SUMMARY OF MAJOR FINDINGS AND RECOMMENDATIONS

Status of the fishery

1. The catch in the NW Trap and Line Fishery for 1986/87 was 547 tonnes and for 1987/88 was in excess of 550 tonnes.

2. The vessels involved in demersal-fishing with traps and lines also troll for mackerel. The trolling and bottom fishing are not separable as fisheries. The major categories of fish taken are mackerel, NW snapper, red emperor and cod. The main species are:

spanish mackerel	Scomberomorus commerson	31%
spangled emperor	Lethrinus nebulosus	22%
red emperor	Lutjanus sebae	11%
rankin cod	Epinephelus multinotatus	7%

3. The fishery is strongly seasonal at present, peaking in July. No seasonal trend in catch-rates is apparent from the data, though these are crude. The seasonality of the fishery may be partly a function of the weather.

4. While a great size-range of fish is caught by the traps, most of the small fish are small species rather than juveniles of large species. Traps made of larger mesh can avoid the capture of small fish but there appears to be no necessity to use such traps at present.

5. Most of the fishing is on hard-bottom areas to the west or inshore from the main areas worked in the past by the Taiwanese pair-trawl fishery. The predominance of Lethrinus nebulosus in the trap and line fishery and its absence from the pair trawl fishery indicates that the two fisheries operate in different habitats. Most trap and line boats have not been able to work economically on the trawl grounds. Many of the boats are too small to work far offshore, and for the larger boats viable catch-rates only occur on isolated patches of rough bottom.

6. The fishery in the previously untrawled areas appears to be healthy. The potential yield is not known but the vessels are already working most of the available ground in the western areas and fishermen report reduced catch-rates on the most accessible patches. It would be prudent to maintain fishing effort at close to its present level for a period sufficient to assess the response of the stocks. A lesson can be learned from events on the trawling grounds. The Taiwanese appear to have overfished the trawl areas but have never taken the total allowable catch calculated for the area. The productivity of the region appears to have been significantly overestimated.

Future research and monitoring

7. Basic biological characteristics of the main species, such as growth, stock identity and migrations, size at maturity and patterns of sex change, are not well known, especially in Western Australian waters. Such information is essential for fishery managers to set safe minimum lengths of fish for conservation of the stocks and to define appropriately-sized management zones. This should be a priority for future research.

8. Surveys of the species and size-composition of the catch are probably the best means of monitoring the state of the fishery; however these are very time-consuming and expensive if they are to be comprehensive enough to be useful for management. A detailed sampling programme every three to five years should be adequate. General monitoring should rely on fishermen's monthly returns for assessment of annual trends. Modification to enable separation of trap, line and troll effort in the records is required.

Management issues

9. Stern-trawling for finfish is developing in the same depth range as trapping occurs. Given the concerns about destruction of the habitat which supports the community of high-value fish, research should be done on the effects of the various gear types on the habitat. In the meantime, firm controls on fish trawling should be instituted, with provision for the withdrawal of trawl access if habitat damage is at a level thought likely to lead to declines in fish stocks.

10. Gill-nets are not widely used at present. Consideration should be given to restricting or prohibiting their use in the region as they are a wasteful and indiscriminate method of exploiting the fish stocks.

11. The present main mode of fishing is with a few small traps set for 20 minutes to several hours, however these traps allow fish to easily escape if left for extended periods. If the habitats and populations of lethrinids, lutjanids and serranids recover following the withdrawal of the pair-trawlers, further development of the trap fishery should be encouraged. A different type of trap fishery may be required on the trawl grounds as the aggregations of high-value fish may never be as dense as those presently exploited close to reefs. This might involve vessels using many traps, with larger capacity and which retain fish better than the present traps. These could be left down for days rather than hours. Trawling with nets designed for minimal habitat damage may also be a viable option.

1. INTRODUCTION

Until recently, exploitation of North West Shelf multi-species fish stocks was mainly by the Taiwanese pair-trawl fishery, though other foreign vessels had also fished there. Australian finfish fishing in the region was conducted by a small number of line-fishing boats, working close to the mainland and islands. The Australian market was for larger, higher-valued fish than the broad range of species acceptable to the Taiwanese. These larger species have been those most vulnerable to over-depletion by the foreign trawlers.

Serious trap fishing in these waters began in 1984. There had been trapping for pink snapper in the Shark Bay region since 1959 and it was a group of snapper fishermen who introduced traps to the NW Shelf following the 1984 snapper season. The local line-fishermen opposed the trapping mainly on the grounds that it was more efficient than line-fishing and would lead to over-exploitation of the stocks. There was also concern that traps might be less selective than lines and would catch juveniles of the largest, most valuable species. Some of the line-fishermen adopted the trapping method later that year but others, especially those involved in charter fishing and tourism, maintain their opposition.

There was a general expectation that the fishery would grow rapidly, as restrictions were being placed on fishing effort in other fin-fisheries of Western Australia. The W.A. Fisheries Department was at that time defining all the smaller fisheries in the state and examining their suitability for management. The fishing industry selected the Pilbara Coast Trap and Line Fishery as one to be managed. Information on which to base management was almost totally lacking.

The Taiwanese pair-trawl fishery on the NW Shelf had been operating since the early 1970s following over-fishing of the South China Sea by the same fleet. When the Australian Fishing Zone was declared, the trawlers kept operating under licence, with a Total Allowable Catch set by the Australian Government. The Australian Fisheries Service monitored the fishery and CSIRO investigated the biology of the stocks. Because of the extreme unsuitability of traditional single-species methods for stock-assessment, CSIRO proposed an experimental approach. This involved closing part of the area to trawling then monitoring changes in the fish community and habitat in the trawled and closed areas. The area west of 116E was closed in 1985 and this closure was extended to 117 30'E in 1987.

The developing trap fishery was relevant to this experiment in several ways. It enabled assessment of the viability of an Australian trap fishery as an alternative to a foreign trawl fishery. It could provide information on the recovery of stocks in the trawl-closure zone. If it developed too rapidly it could also inhibit the recovery. For these reasons, assuming that the trap fishery would operate at least partly in the previously trawled area, information on the trap fishery was required in addition to the monitoring of the trawl fishery and CSIRO's surveys of the stocks and habitat.

Information required included catches and catch-rates by species, locality and season, fishing effort by locality and season, size-composition of the major species and selectivity of the gear in terms of size and species. As a fishery develops, gear construction and usage are likely to evolve. This process should be recorded since development of rational management measures must depend on a detailed knowledge of how the fishery operates.

Funds were obtained by the WA Fisheries Department from FIRTA to study the trap and line fishery for the related aims of improving the knowledge base for managing the fishery, and helping to understand the dynamics of the stocks which had been depleted by trawling. The project ran from July 1986 to June 1988. Specifically the objectives of the project were to:

1 monitor the Western Australian trap and line fishery on the NW Shelf to obtain information on total catch and catch-rates by area, by month, by species-category and by fishing-method;

2 record the species and size-composition of the catch; catches in this multi-species fishery are recorded by species-categories which need to be sub-sampled to give true catch by species;

3 collect and analyse data on the selectivity of the various types of gear with a view to advising on the effects of trap mesh-sizes or escape gaps on yield from the fishery;

4 maintain a record of the characteristics and operations of the vessels involved in the fishery, in order to provide managers with a realistic picture of the spatial and temporal pattern of deployment of effort, taking into account effects of advances in searching and catching technology.

These objectives have been attained in the course of the two year project; and the results are presented in this report.

2. FLEET CHARACTERISTICS AND OPERATIONS IN THE NW TRAP & LINE FISHERY

The vessels used to catch finfish professionally in the northern waters of Western Australia are very diverse. They range from small fibreglass and aluminium runabouts used for hand lining close to shore, to the largest prawn trawlers and rock-lobster boats (Table 2.1). While vessels are continually entering and leaving the fishery, and no specific permanent fleet can be defined, 50 boats were selected on the basis that they had caught at least 5 tonnes of finfish in the region in any one year, and were active in the fishery in 1986-87. Information on characteristics of these boats was obtained from the records of the Department of Marine and Harbours.

The skippers or owners of 30 of these boats were interviewed to obtain more detailed information. 20 of the 50 boats use traps and all of these are included in the detailed survey so in that sense it is not a representative cross-section of the fleet. However the trap vessels land the bulk of the catch and in that sense they are the core vessels of the fishery. Trolling vessels are, in general, not special-purpose. All trap and line boats troll for mackerel when they are available.

Age, size and construction material of vessels

There is a great range of ages of vessels, only three of the 50 are built later than 84 and only two before 1960. Most (35) were built between 1970 and 1984 (Fig. 2.1).

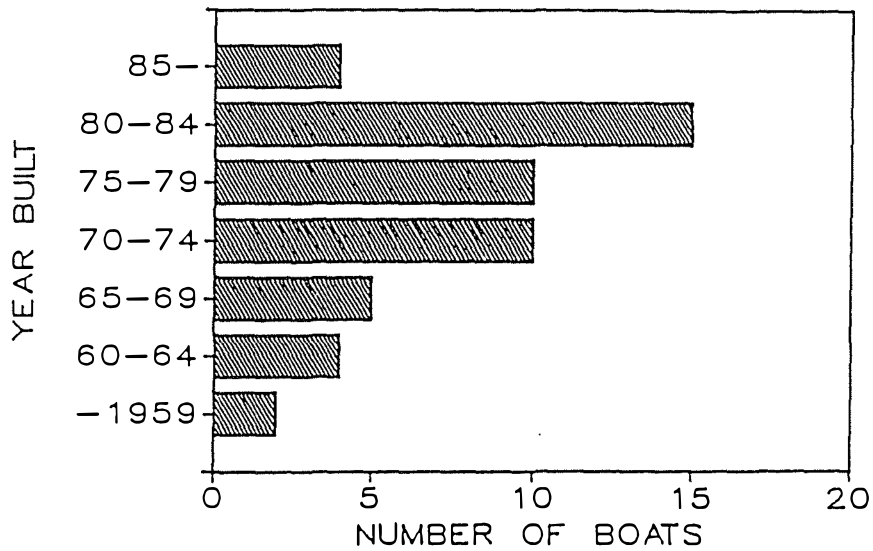


Fig.2.1 Vessels in the NW trap and line fishery 1987. Number of vessels by year of construction.

Less than one-third of the boats are greater than 15 metres in length or 20 tonnes displacement; only two vessels are longer than 20 metres (Table 2.1). Most of the fleet are therefore not suited to fish grounds far offshore and in fact, while they may be absent from port for three weeks at a time, they do daily trips, returning nightly to anchorages in the shelter of islands or the mainland.

TABLE 2.1. Number of vessels by length and weight in the North-western trap and line fishery, by construction-material.

	CONSTRUCTION MATERIAL						
LENGTH METRES	ALUMINIUM	BOND-WOOD	FIBRE-GLASS	FERRO-CEMENT	PLANK	STEEL	TOTAL
5- 9.9	6	3	4				13
10-14.9	7	4	10		1	1	23
15-19.9	1		3	1	4	3	12
20-24.9			1		1		2
WEIGHT tonnes							
0- 9.9	11	5	7				23
10-19.9		1	9			1	11
20-29.9	3	1	1		3	1	9
30-39.9				1	2		3
40-49.9			1			1	2
50-59.9						1	1
60-69.9							0
70-79.9					1		1
TOTAL	14	7	18	1	6	4	50

Electronic equipment

Most boats in this fishery have radar, autopilot and echo-sounders. 67% have monochrome radar, 8% have colour radar, 25% have no radar. 50% have black and white echo sounder, 48% have colour sounder and 2% have none. 75% of the vessels have an auto-pilot, 4% have satellite navigation, one boat has DECCA navigation equipment.

Fish trapping

While in the Shark Bay snapper fishery there is a permitted maximum of 5 traps per boat, there is no limit in the NW Trap and Line Fishery. In general, vessels tend to use as many traps as they can conveniently carry so the number ranges from 2 to 20, depending partly on the size of the vessel (Fig 2.2). The design of the vessel is also important, with open deck space being the main factor.

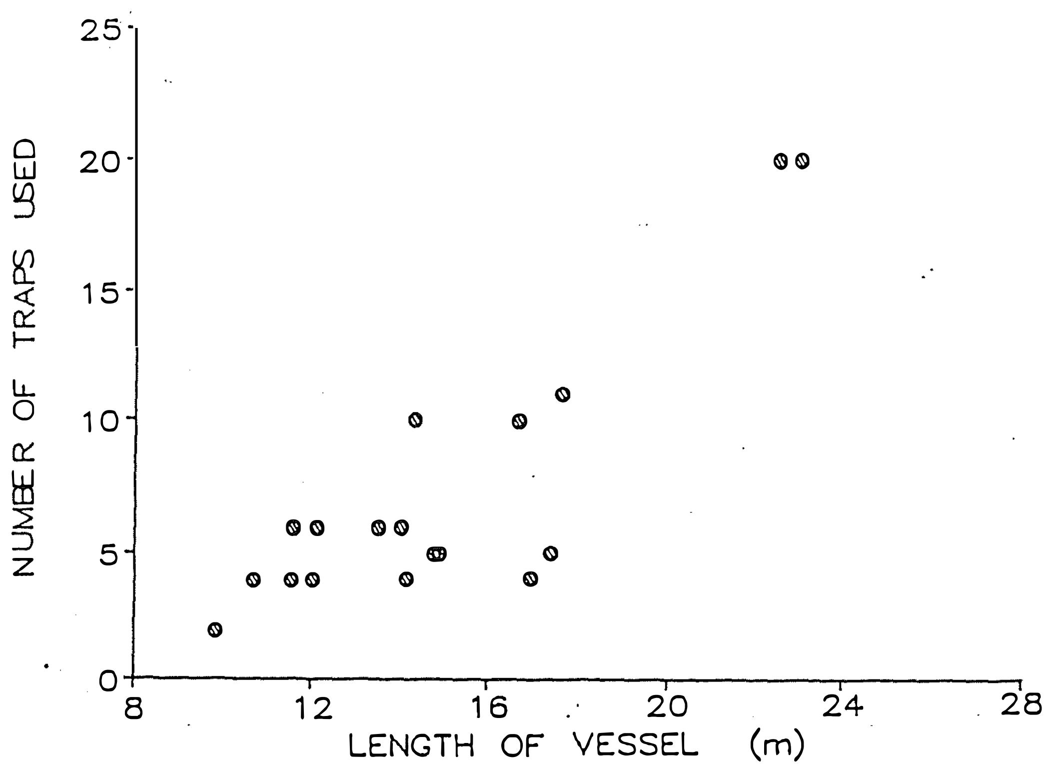


Fig 2.2 Trap-boats in the NW trap and line fishery. Number of traps used by vessels of various lengths.

Number of crew

The number of crew, including the skipper, employed on a boat ranges from 2 to 6. This is determined mainly by how many crew the skipper thinks are necessary to work the boat efficiently and economically, within the constraints of the vessel's accommodation, so vessel size is again important (Fig. 2.3). Crew are usually paid on the basis of a fixed percentage of the catch, the percentage depending on the number of crew and the ability of the crewman.

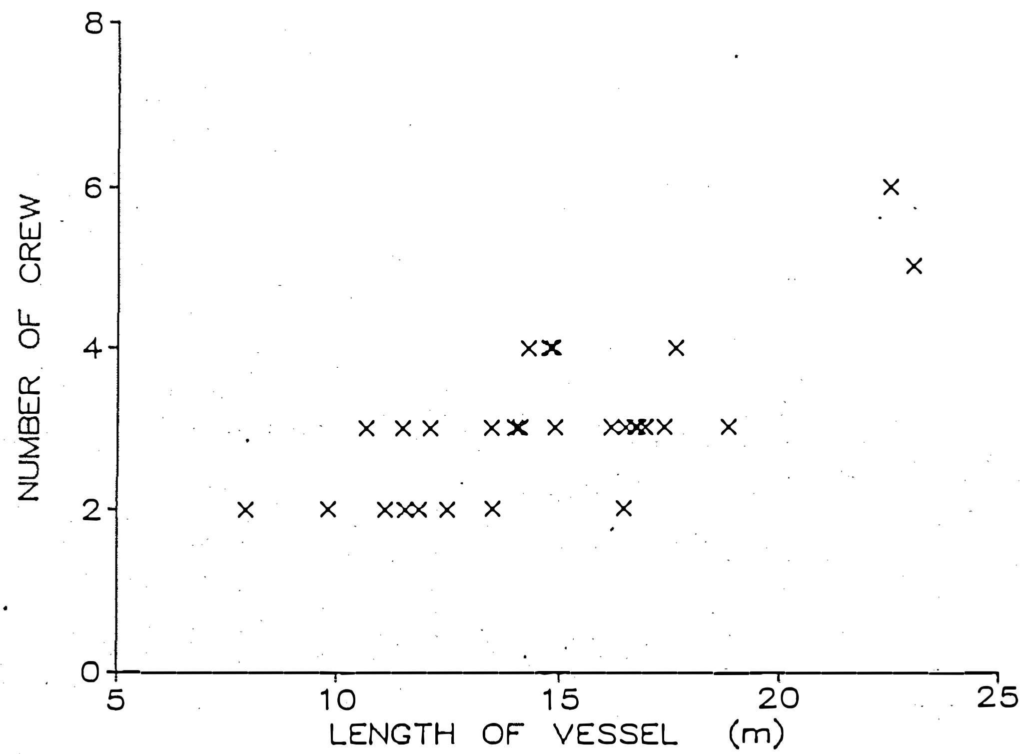


Fig 2.3 The number of crew employed on vessels in the NW trap and line fishery, by length of vessel.

Fish processing and cold storage

Most boats gut the fish as they are caught or put them in brine for gutting later the same day. The fish are then usually stored in ice or a freezer, with few boats storing the fish in brine until unloaded (Table 2.2). Some boats use different processing methods for different species of fish, catering for the demands of their market. The 'iki-jime' method of spiking the fish in the brain to kill it as soon as it is caught has become standard in the adjacent Shark Bay snapper fishery. The improvement in quality due to this practice will probably result in its adoption in the NW Trap and Line Fishery also. There may also be a trend in future towards whole, rather than gutted fish.

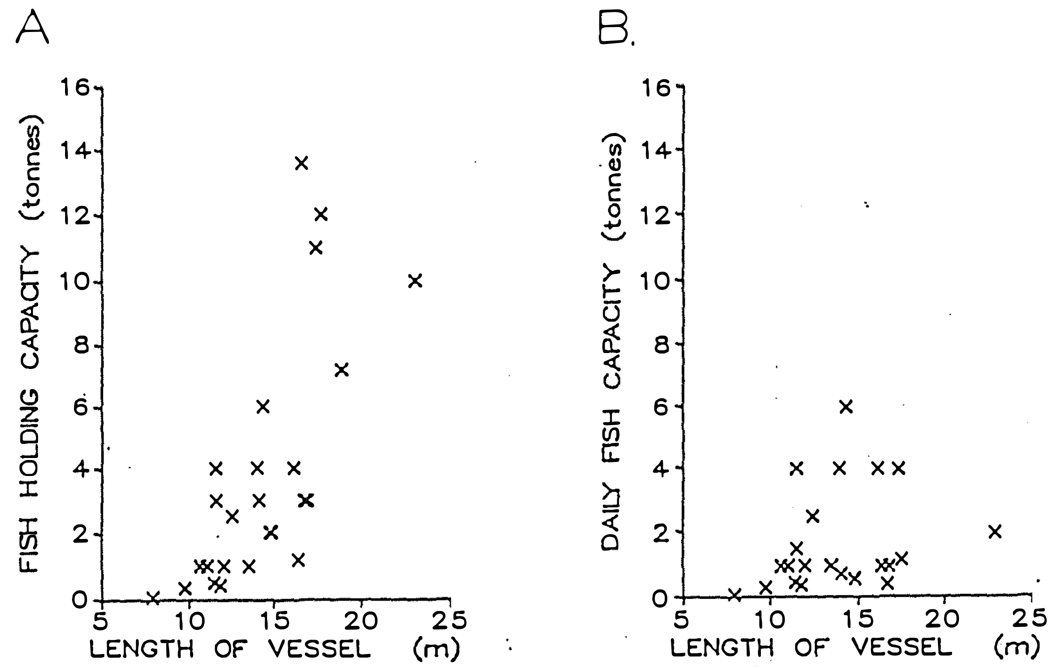


Fig 2.4 Capacity of cold storage for fish in vessels of the NW trap and line fishery : (A) total capacity and (B) daily capacity, by length of vessel.

The length of a trip away from port is limited by the method of chilling the fish and the capacity of the cold-storage. Boats with only an ice-box usually fish for less than a week at a time, whereas those with freezers often fish for three weeks at a time. Total storage capacity is related to the size of the vessel but the amount of fish which can be handled in a day is not (Fig.2.4). Ice-boats can handle their total storage capacity in one day whereas freezer boats are limited by their capacity to snap-freeze or brine the fish to bring down their temperature. Around 20% of the boats have a storage capacity of less than one tonne which limits them to trips of only a few days, some can only make one-day trips. Some of the smaller boats are able to extend their time away from port to three weeks by filleting and freezing their catch.

TABLE 2.2. Numbers of boats in the North-western Trap & Line Fishery, by fish-chilling technique and fish-processing method. Sample = 30 boats.

	CHILLER					
PROCESS	ice	ice + brine	brine	brine + freezer	freezer	TOTAL
fillet			1	1	1	3
gut + fillet	1			1	2	4
gut	7	4	3	5	3	22
gut + whole					1	1
TOTAL	8	4	4	7	7	30

Other fisheries

Of the 50 boats sampled, 7 are also in the Shark Bay snapper fishery, 7 are also charter vessels, 3 trawl for prawns and one is a rock-lobster boat. The charter vessels are mainly based at Exmouth and fish commercially when they do not have a charter. The other fishermen who are in more than one fishery usually fish the NW Shelf during closed seasons for their alternative fishery.

Method of fish-trapping in Western Australia

Typically the traps are circular, occasionally rectangular or rounded-rectangular: construction is of wire mesh or weldmesh wired or welded to a frame of steel rod. Size is generally 0.8 to 1 metre high by approximately 1.5m diameter but this is determined mainly by the size that is convenient to handle on the particular boat.

Bait is held in small-mesh (1-2cm) wire boxes, usually accessible from the outside bottom of the trap. Bait bags made of old codend are sometimes used, tied either side of the trap entrance. Bait used is mainly WA pilchards.

Baited traps are set on marks found using colour echo-sounders and are left from 20 minutes to 12 hours. Normally about 5 traps per boat are used and when fish are plentiful, leaving traps set for only 20 minutes seems to be the most productive. Traps are set so that the fish have to swim up-current into the entrance.

Ropes (12 to 16mm) are tied to the top of the traps and buoyed with 6 floats (150mm diam). On retrieval of the trap the floats are grappled and pulled aboard manually. The bulk of the rope is then hauled in on a hydraulic pot-winch so that the trap comes up onto a pot tipper.

The main skills involved in trap fishing are finding good ground using the echo sounder and the ability to allow for the effects of current when setting the trap.

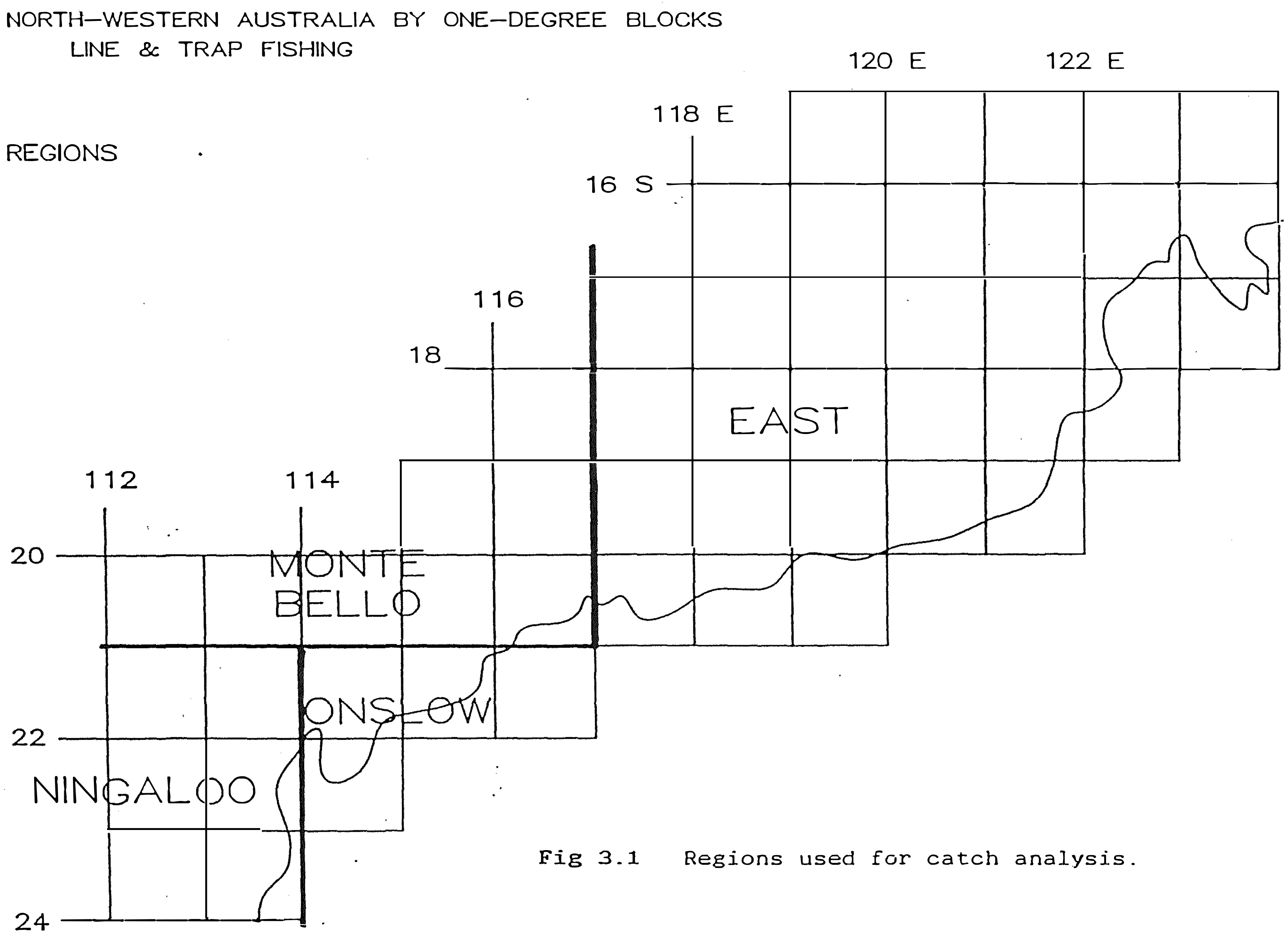


Fig 3.1 Regions used for catch analysis.

3. SPECIES COMPOSITION OF CATCH CATEGORIES

The fishery was divided into four regions for the purpose of analysing catches. These are shown in figure 3.1. While the Onslow and Montebello regions could have been combined, we took advantage of the opportunity to detect any local differences in species composition in this area which produces so much of the catch.

Onslow was the main port sampled for species composition. It receives the catch from the Onslow and Montebello regions and has boats unloading more frequently than the other ports. While nearly as much fish is caught in the Ningaloo and East regions, the catch is spread among a number of ports. Also, some of the main boats working in the latter regions fillet, box and freeze their catch, making it impossible to sample for species or size-composition. Exmouth became a good port to sample part-way through the project due to the opening of a fish-processing factory there. Unloadings at Pt Samson were frustratingly difficult to obtain, despite attempts to work to pre-arranged schedules. In retrospect, we should have sampled more at Carnarvon for catches in the Ningaloo region. In a fishery such as this, with a small number of boats spread over a large and remote area, the only way to sample unloads is to go to the region for a few weeks, driving from port to port to try to meet boats coming in to unload, hoping they stay on schedule. A lot of time is wasted in fruitless driving and waiting. An alternative is to go out on boats and sample as they catch. It is debatable which method is more efficient.

The aim of this sampling was to determine the species composition of commercial categories. Some categories are a single species but most are mixtures, often of related species but sometimes unrelated fish may be pooled together because they are the same price.

The procedure was to sample some or all of each category from each available catch. When not all of a category was sampled, boxes were taken at random and all the contents of that box sampled. Sampling involved recording the species of each fish and, when possible its length and weight. Most fish were gutted and gilled or headed and gutted. Species identifications were made mainly from the books:

" Fishes of Northern and North-Western Australia "
...Sainsbury, Kailola and Leyland

" Trawled Fishes of Southern Indonesia and Northwestern Australia."
...Gloerfelt-Tarp and Kailola

" Grant's Fishes of Australia"
...Grant

When proper species identifications could not be made for whatever reason, usually because the head of the fish was missing, identification was taken as far as possible, to genus or family.

Conversion factors from partial to whole lengths and weights, and length-weight relationships, were calculated for the more abundant species in the fishery. These were based on fish caught by research vessel and measured whole, gutted and gilled, headed and gutted, and filleted (Appendix 1). These factors were used during analysis to calculate whole weight and length to caudal fork (LCF) for fish measured in a processed condition.

12,700 fish were sampled from the unloaded catches in the three regions Ningaloo, Onslow and Montebello. The mean body weight for each species in each region was calculated from the fish that had been measured. The numerical species composition of each category was converted to species composition by weight, using the mean body weights. The percentage compositions by numbers and weight for the three regions are shown in full, together with the data from which they were derived, in Appendix 2.

The most important result is the percentage species composition of each commercial category by weight, as these were required to break down the total catch by categories to total catch by species. The species composition by weight of the major categories, pooled for the three regions, are shown in figures 3.2 and 3.3 .

The category 'NW Snapper' consists mainly of Lethrinus nebulosus in the Onslow and Montebello regions, but in the Ningaloo region this species takes second place to Lethrinus chrysostomus. The main small species are Lethrinus choerorynchus, and L. mahsena. Some of the small lethrinids are placed in the category 'Mixed Reef Fish' nad also there are a few non-lethrinids placed in the category 'NW Snapper'.

The category 'Red Emperor' consists mainly of Lutjanus sebae, most of the remainder being coral trout Plectropomus maculatus. These species are classed together because the same price is paid for them by the processor to the fishermen. Being highly priced, they are targetted by the fishermen when possible.

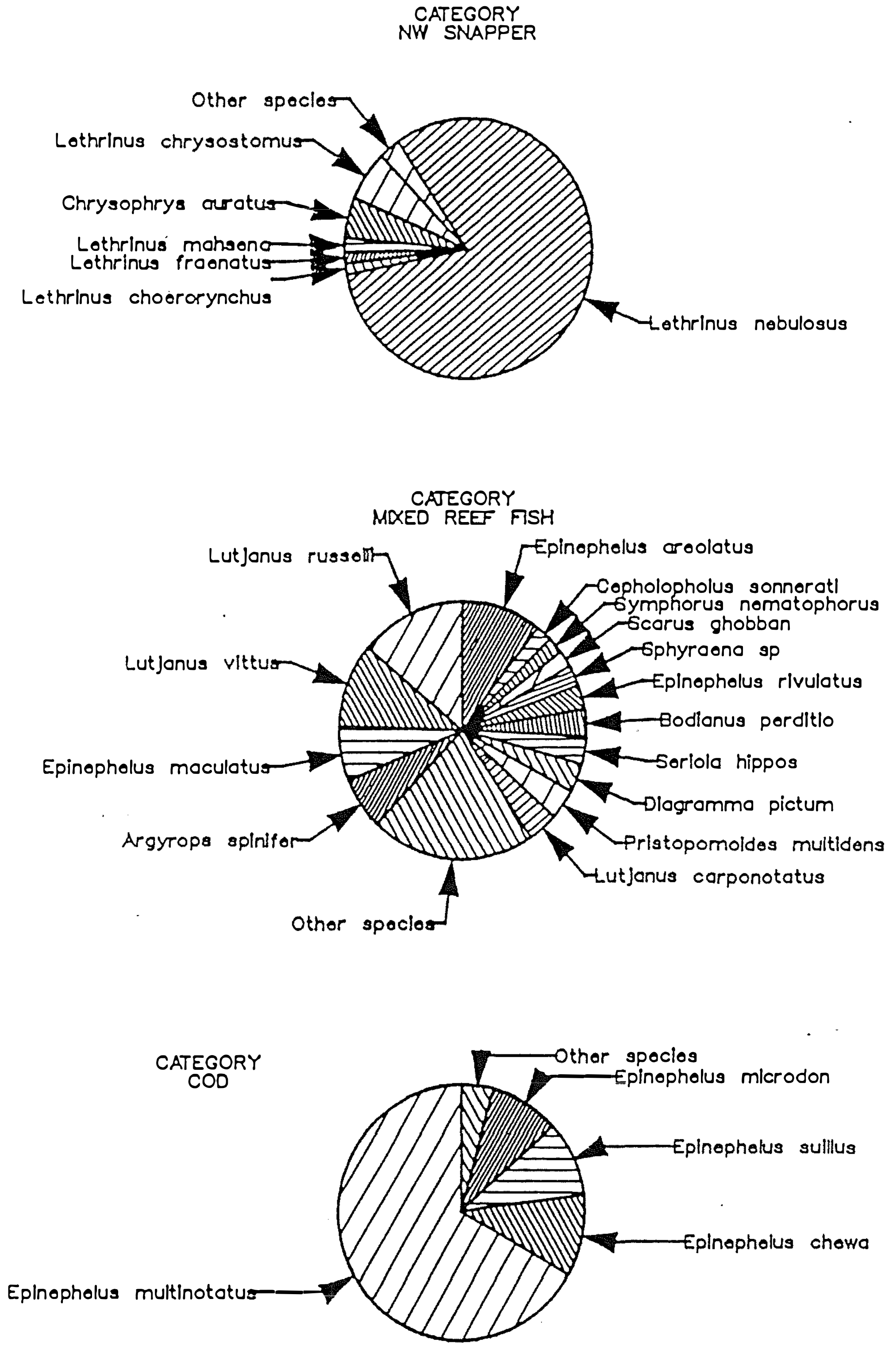


Fig 3.2 Species composition by weight for the categories NW Snapper, Mixed Reef Fish and Cod in the NW trap and line fishery.

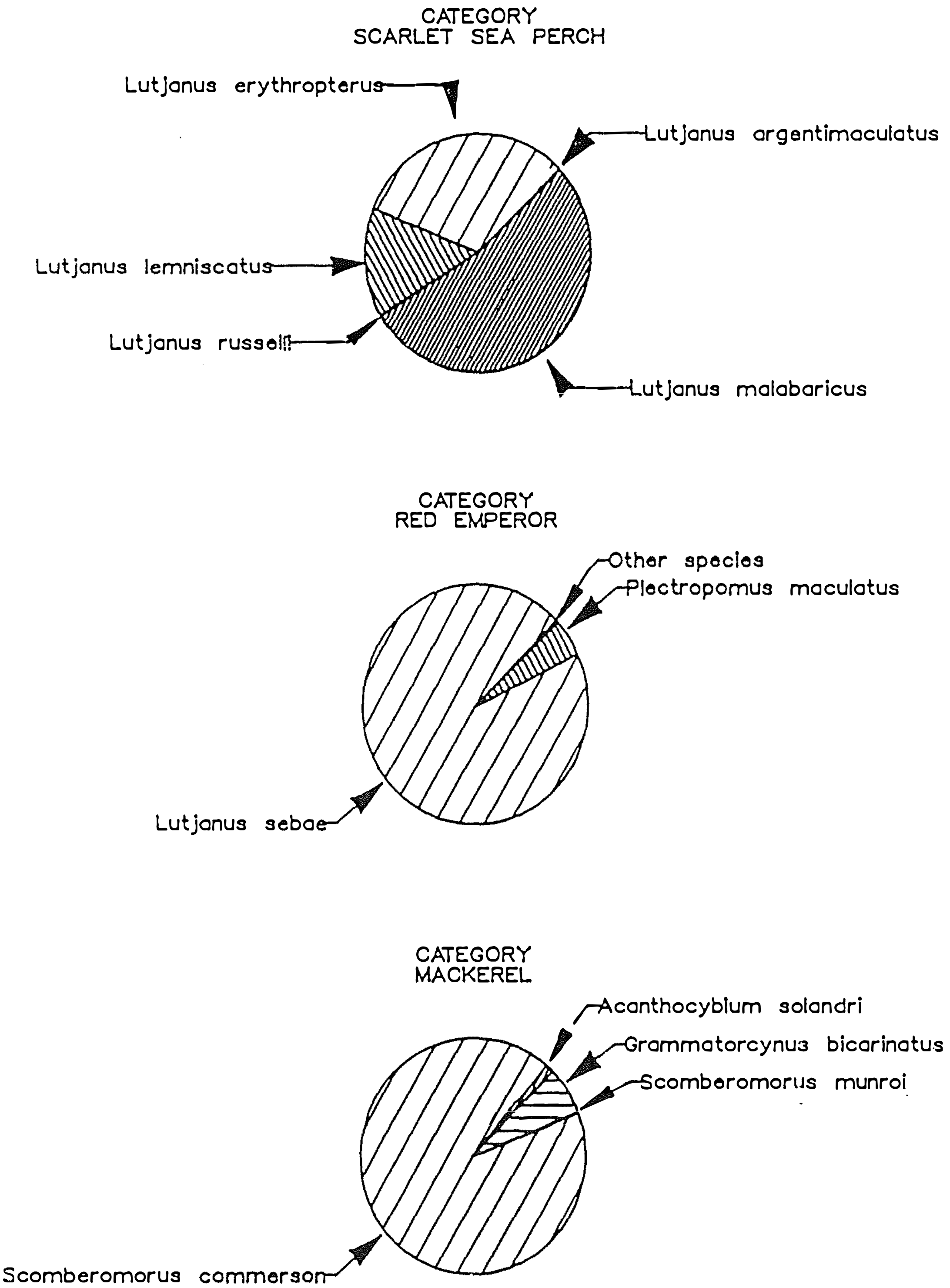


Fig 3.3 Species composition by weight for the categories Scarlet Sea Perch, Red Emperor and Mackerel in the NW trap and line fishery.

The category 'Scarlet Sea Perch' contains the other large species of Lutjanus, L. malabaricus, L. erythropterus, L. lemniscatus, L. bohar and L. argentimaculatus. This category is also known as 'mangrove jack' or 'red sea perch'. The smaller species of Lutjanus are usually placed in the category 'Mixed Reef Fish'.

The category 'Cod' is mainly the larger serranid species, dominated by rankin cod, Epinephelus multinotatus. The other important species in this category are E. chewa, E. microdon and E. suillus. There are a number of small species of serranids which, though numerically significant in the cod category, do not contribute much by weight. These small serranids are also major components of the mixed-reef fish.

The category 'Mixed Reef Fish' is less dominated by a single species than the other categories, and contains many more species. The most abundant are the small lutjanids, Lutjanus russelli and L. vittus; and the small serranids Epinephelus areolatus and E. maculatus.

The category 'Mackerel' is greatly dominated by spanish mackerel Scomberomorus commerson, with shark mackerel Grammatorcynus bicarinatus being most of the remainder.

The trevallys are usually landed in headed and gutted condition which makes most of them unidentifiable to species level. The category 'Trevally' therefore consists mainly of unidentified Carangidae, though the golden trevally, *Gnathodon speciosus*, which is identifiable by colour, is a major component.

Many of the remaining categories are single species. Sharks are landed as trunks, are unidentifiable and are simply called 'sharks', though most are probably small carcharinids.

4. CATCH AND EFFORT IN THE NW TRAP AND LINE FISHERY

Data on catch and effort by trap and line vessels were obtained from fishermen's monthly return forms. Originally it was intended to use catch figures also from processor's return forms but these have proved to be confusing. Some fishermen sell part of their catch to processors and part direct to the public. Processors receive part of their product direct from fishermen and part from other processors. Given the difficulties of ensuring that all catches are recorded, but only once, we have decided to restrict the analysis to the fishermen's returns for this report.

These data also have their problems, mainly with reporting errors and lateness of filing the returns. While we have used all returns available, we feel that those for April, May and June 1988 are incomplete. Figures for 1987/88 are therefore preliminary only. There is a problem with the way fishing effort figures are recorded in a multi-gear fishery. Fishermen may use two fishing methods, e.g. trapping and trolling, in a single day, and four methods in the course of a month. Most fishermen report only a single effort figure for the month and there is no sensible way to partition effort among methods.

Table 4.1 Catch of all species and fishing effort by all methods in the NW trap and line fishery by financial year and region. Figures for 1987/88 are preliminary.

	REGION	CATCH (LIVE WT, kg)	EFFORT (BOAT-DAYS)	C/E
1986/87	EAST	113972	516	221
	MONTEBELLO	175903	1016	173
	ONSLOW	65672	603	109
	NINGALOO	191767	1051	182
	TOTAL	547314	3186	172
1987/88 (preliminary)	EAST	154358	588	262
	MONTEBELLO	159158	878	181
	ONSLOW	65256	461	142
	NINGALOO	175085	906	193
	TOTAL	553857	2833	196

Catches of related species are often grouped by fishermen into related species or simply commercial categories. These categories are reasonably uniform across the regions as they are dictated largely by markets. The species compositions determined in chapter 3 are used here to convert catches by category to catches by species.

The total catch in the fishery in 1986/87 was 547 tonnes from a total of 3186 fishing boat-days which gives an average of 172 kg/boat-day. The preliminary figures for 1987/88 are 554 tonnes and 2833 boat-days, averaging 196 kg/boat-day.

Catch and effort by region, year and method

The large Eastern region produced 114 tonnes in 1986/87 and 154 tonnes in 1987/88 (Table 4.1). This was the biggest change in catches from year to year. The other regions' catches varied approximately 10% from year to year. Effort figures were lower in 1987/88 for all regions except East but it must be remembered that 1987/88 figures are incomplete. Catch per boat-day was higher in 1987/88 for all regions. The pattern of catch per boat-day among regions was consistent from year to year with East being highest and Onslow being lowest. No great significance should be

Table 4.2 Catch of all species in kg, by fishing method and year for each of the four regions. Figures for 1987/88 are preliminary.

		Fishing method				
	Region	LINE	DROPLINE	TRAP	TROLL	TOTAL
1986/87						
	EAST	26719	235	8672	78346	113972
	MONTEBELLO	19814		89220	66869	175903
	ONSLOW	27834	711	18721	18406	65672
	NINGALOO	82896	1436	76534	30901	191767
	TOTAL	157263	2382	193147	194522	547314
1987/88						
	EAST	28251		63392	62715	154358
	MONTEBELLO	8003	216	93451	57488	159158
	ONSLOW	19300		29499	16457	65256
	NINGALOO	64597		75805	34683	175085
	TOTAL	120151	216	262147	171343	553857

Table 4.3 The percentage, in each year, of the total catch by different methods in each region. Figures for 1987/88 are preliminary.

		Fishing method				
	Region	LINE	DROPLINE	TRAP	TROLL	TOTAL
86/87	EAST	23	0	8	69	100
87/88	EAST	18	0	41	41	100
86/87	MONTEBELLO	11	0	51	38	100
87/88	MONTEBELLO	5	0	59	36	100
86/87	ONSLOW	42	1	29	28	100
87/88	ONSLOW	30	0	45	25	100
86/87	NINGALOO	43	1	40	16	100
87/88	NINGALOO	37	0	43	20	100
86/87	Total:	29	0	35	36	100
87/88	Total:	22	0	47	31	100

attached to this as the predominance of different fishing methods varies from region to region (Table 4.2).

The percentage of each region's catch taken by different fishing methods is shown in Table 4.3. Note that percentages taken by handlines fell in all areas from 1986/87 to 1987/88, while the proportion taken by traps increased everywhere. The percentage taken by trolling did not vary much in any region except the East, where trolling fell from 69 to 41% of the catch and trapping increased from 8 to 41% of the catch. This kind of change can be generated by one major mackerel boat ceasing operations and two trap boats beginning to operate. The eastern region was barely trapped at all prior to 1987.

Catch of categories and species by year and region

The dominance of mackerel and NW snapper categories, and to a lesser extent, red emperor and cod, is clear from Figure 4.1. Mackerel are replaced by NW snapper as the main category going from northeast to southwest through the regions. The relative importance of categories within a region is consistent from year to year, with the exception of the East region where the increase in demersal catch and reduction in pelagic catch from 1986/87 to 1987/88 is again evident. Pink snapper is significant only in the Ningaloo region and its catch fell markedly from 37 tonnes in 1986/87 to 12 tonnes in 1987/88, while NW snapper remained stable in the same region at 66-68 tonnes. Pink snapper is at the edge of its geographic range in this area, and perhaps is vulnerable to overfishing; alternatively, this effect may be due to variations in targetting which our effort data are too crude to detect. The data in Figure 4.1 are also shown in Table 4.4 to give greater detail.

Catches by species calculated for the three western regions are shown in Table 4.5. These were derived by multiplying the catch by category from the fishermen's returns, by the proportional species composition (by weight) from the sampling of unloaded catches. Clearly the estimates would not be very precise, especially for the rarer species, but they indicate which are the most important species to the fishery. Averaging the two years, spanish mackerel Scomberomorus commerson is 31% of the catch by weight; Lethrinus nebulosus the spangled emperor is 22%; red emperor Lutjanus sebae is 11%; and rankin cod Epinephelus multinotatus is 7%.

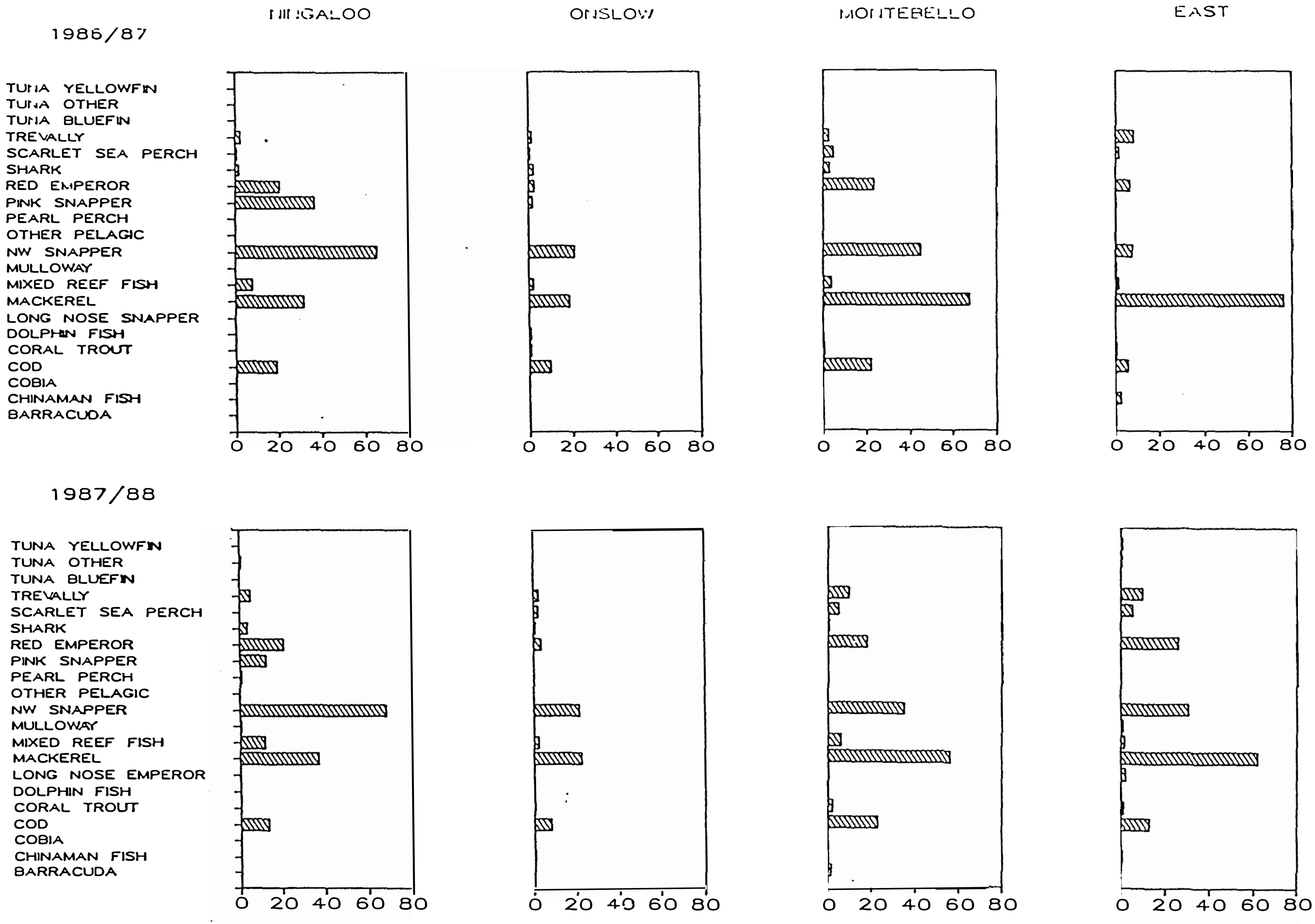


Fig 4.1 Total commercial catch by category and year for each region. Figures for 1987/88 are preliminary.

Table 4.4 The commercial catch for each category by region and year, for the trap and line fishery. Figures for 1987/88 are preliminary.

1986/87 CATCH (Livewt kg)

CATEGORY:	Eastern	Monte Bello	Onslow	Ningaloo	TOTAL
BARRACUDA	136	165	62		363
CHINAMAN FISH	2538		21		2559
COBIA	162	104	15	384	665
COD	5923	22569	10027	19265	57784
CORAL TROUT	410	782	763	122	2077
DOLPHIN FISH			1110	480	1590
LONG NOSE		54		376	430
MACKEREL	76166	67735	18722	32149	194772
MIXED REEF	1501	3963	2401	8488	16353
MULLOWAY	670		150	51	871
NW SNAPPER	7901	45049	21438	65858	140246
OTHER PELAGIC	119		24		143
PEARL PERCH				35	35
PINK SNAPPER	474	60	2100	37080	39714
RED EMPEROR	6584	23555	3202	21061	54402
SHARK	2	3533	2643	1705	7883
SS PERCH	1838	5197	1071	943	9049
TREVALLY	8687	3137	1710	2865	16399
TUNA BLUEFIN	628			515	1143
TUNA OTHER	141		213	240	594
TUNA YELLOWFIN	92			150	242
TOTAL:	113972	175903	65672	191767	547314
1987/88					
BARRACUDA		1178		123	1301
CHINAMAN FISH	706	123	408	59	1296
COBIA			67	186	253
COD	12840	22963	8229	13743	57775
CORAL TROUT	1308	2317	429	142	4196
DOLPHIN FISH				164	164
LONG NOSE	1950	681	46		2677
MACKEREL	61599	56356	22347	36816	177118
MIXED REEF	1902	5859	2334	11454	21549
MULLOWAY	1131	21		580	1732
NW SNAPPER	30220	34827	21234	67671	153952
OTHER PELAGIC	184	180		89	453
PEARL PERCH	45		11	969	1025
PINK SNAPPER	28	388	196	12445	13057
RED EMPEROR	26075	18134	3880	20421	68510
SHARK	122	857	1317	3640	5936
SS PERCH	5356	4908	1929	50	12243
TREVALLY	10002	9717	2741	5255	27715
TUNA BLUEFIN				115	115
TUNA OTHER	500	481	88	1129	2198
TUNA YELLOWFIN	390	168		34	592
TOTAL:	154358	159158	65256	175085	553857

Table 4.5 The commercial catch by year for each species for the regions Ningaloo, Onslow and Montebello. Figures for 1987/88 are preliminary.

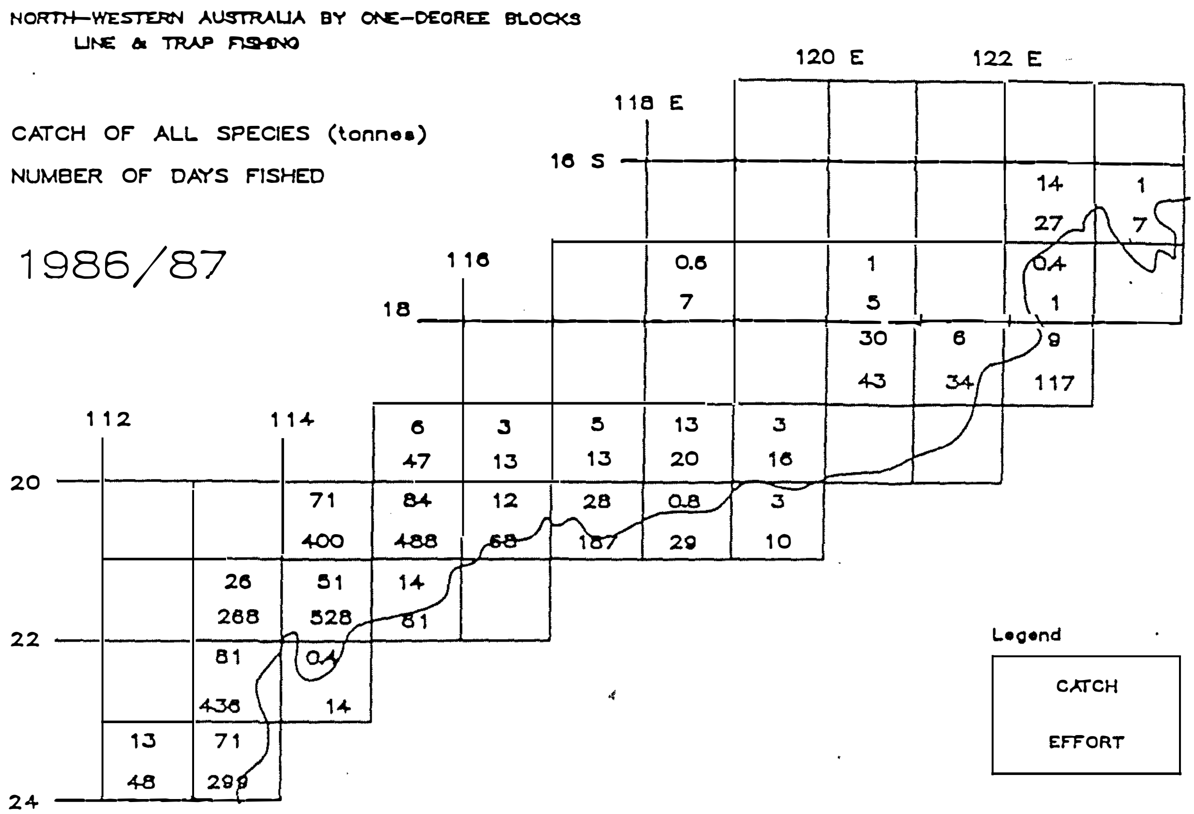
SPECIES	CATCH (Livewt kg) 86/87				CATCH (Livewt kg) 87/88			
	Ningaloo	Onslow	Montebello	TOTAL	Ningaloo	Onslow	Montebello	TOTAL
Acanthocybium solandri		296	504	800		354	419	773
Aprion viriscens	306			306	315			315
Argyrops spinifer		218	168	386		212	249	460
Argyrosomus hololepidotus	51	150		201	580		21	601
Arius thalassinus		24	88	111		23	135	158
Bodianus bilunulatus		4	8	11		4	11	15
Bodianus perditio	175	105	89	369	236	102	131	470
Carangidae	1666	238	1358	3261	3055	368	4207	7630
Carangoides caeruleopinna		17	6	23		27	19	47
Carangoides chrysophrys		175	145	320		260	450	710
Carangoides fulvoguttatus		68	222	290		107	664	770
Carangoides gymnostethus	985	25	10	1020	1807	40	31	1878
Caranx ignobilis		8		8		12		12
Caranx sexfasciatus		58	80	139		94	249	342
Cephalopholis aurantius		17		17		14		14
Cephalopholis miniatus		52		52		46		46
Cephalopholis sonnerati	172	97	92	361	232	89	123	444
Choerodon monostigma		4		4		4		4
Choerodon sp		4		4		4		4
Choerodon sp1		51	104	155		50	153	203
Chrysophrys auratus	38777	3265	2505	44547	14189	1350	2278	17817
Coryphaena hippurus	480	1110		1590	164			164
Decapterus sp		16		16		16		16
Diagramma pictum		142	92	234		138	94	232
Epinephelus areolatus	336	510	285	1132	240	472	419	1130
Epinephelus bleekeri		55		55		46		46
Epinephelus chewa	1238	1119	2328	4686	883	919	2369	4171
Epinephelus maculatus	70	303	710	1081	50	267	949	1267
Epinephelus megachir			8	8			12	12
Epinephelus microdon	465	1198	1863	3526	332	983	1896	3210
Epinephelus multinotatus	15063	5438	16479	36981	10746	4463	16796	32005
Epinephelus quoyanus	87	2	15	104	62	2	22	86
Epinephelus rivulatus		146	406	552		136	454	589
Epinephelus suillus	2006	1564	1376	4947	1431	1284	1407	4122
Epinephelus tukula		99		99		81		81
Euthynnus affinis			59	59			88	88
Glaucosoma burgeri	323			323	1248	11		1259
Gnathodon speciosus	214	1148	1358	2722	393	1838	4155	6386
Grammatorcynus bicarinatus	1033	964	6736	8733	1183	1150	5605	7938
Gymnocranius griseus	311	13	63	388	419	14	83	516
Gymnocranius robinsoni		5	42	47		5	40	45
Gymnocranius sp	32			32	43			43
Lethrinus choerorynchus	3305	251	109	3665	3396	249	87	3732
Lethrinus chrysostomus	17792	651	1091	19534	18282	645	843	19770

Table 4.5 continued

SPECIES	CATCH (Livewt kg) 86/87 Ningaloo	Onslow	Monte bello	TOTAL	CATCH (Livewt kg) 87/88 Ningaloo	Onslow	Monte bello	TOTAL
Lethrinus elongatus	2738	89	93	2920	2427	134	711	3273
Lethrinus fraenatus	91	201	1084	1376	94	199	854	1147
Lethrinus lentjan	370	131	136	637	380	130	105	615
Lethrinus mahsena	2732	465	243	3441	2807	460	244	3511
Lethrinus miniatus		10		10		10		10
Lethrinus nebulosus	34999	18206	39858	93062	35962	18036	30843	84841
Lethrinus rubrioperculatus	397	18	18	433	408	17	20	445
Lethrinus variegatus	1173	40	35	1247	1224	40	45	1310
Lutjanus argentimaculatus	1		17	17			16	16
Lutjanus carponotatus		87	278	365		85	403	489
Lutjanus erythropterus	486	391	1560	2437	192	673	1479	2344
Lutjanus lemniscatus	334	136	1384	1853	251	181	1344	1776
Lutjanus malabaricus	541	665	2351	3557	29	1191	2220	3440
Lutjanus russelli	534	360	689	1582	717	353	996	2067
Lutjanus sebae	20591	3028	22189	45808	19965	3669	17082	40717
Lutjanus vittus		276	517	793		268	752	1021
Mullidae		8		8		7		7
Myripristis melanostictus		3		3		3		3
Nemipteridae		2		2		2		2
Nemipterus furcosus		6	77	83		6	114	120
Nemipterus peronii		1	14	15		1	20	21
Other pelagics		24		24	89		180	269
Parupeneus pleurotaenia		7	9	17		7	14	21
Pentapodus emeryii		2		2		2		2
Platax batavianus		8		8		8		8
Plectropomus maculatus	122	920	2107	3149	142	620	3337	4099
Pristipomoides multidens	2308	150	118	2576	3070	148	157	3374
Pristipomoides typus	983			983	1327			1327
Rachycentron canadus	384	15	104	503	186	67		253
Sargocentron rubrum			6	6			9	9
Scaridae		2		2		2		2
Scarus ghobban		51	222	272		45	312	358
Scolopsis monogramma		4	10	14		4	15	19
Scolopsis taeniopterus			7	7			10	10
Scomberomorus commerson	31116	17499	60495	109110	35633	20871	50332	106837
Scomberomorus munroi		34		34		41		41
Scombrinae sp.	240	213		453	1129	88	481	1698
Seriola dumerili		36		36		58		58
Seriola hippos	2507			2507	3383			3383
Shark	1705	2650	3720	8074	3640	1323	1133	6097
Sphyraena sp	1547	21		1569	2088	21		2109
Symphorus nematophorus	315	205		520	382	586	123	1091
Syphraena barracuda		62	165	227	123		1178	1301
Thunnus albacares	150			150	34		168	202

Table 4.5 continued

SPECIES	CATCH (Livewt kg) 86/87 Ningaloo	Onslow	Monte bello	TOTAL	CATCH (Livewt kg) 87/88 Ningaloo	Onslow	Monte bello	TOTAL
Thunnus tonggol	515			515	115			115
Variola albimarginata		27		27		22		22
Variola louti		5		5		6		6
TOTAL	191766	65668	175905	433338	175083	65263	159156	399507



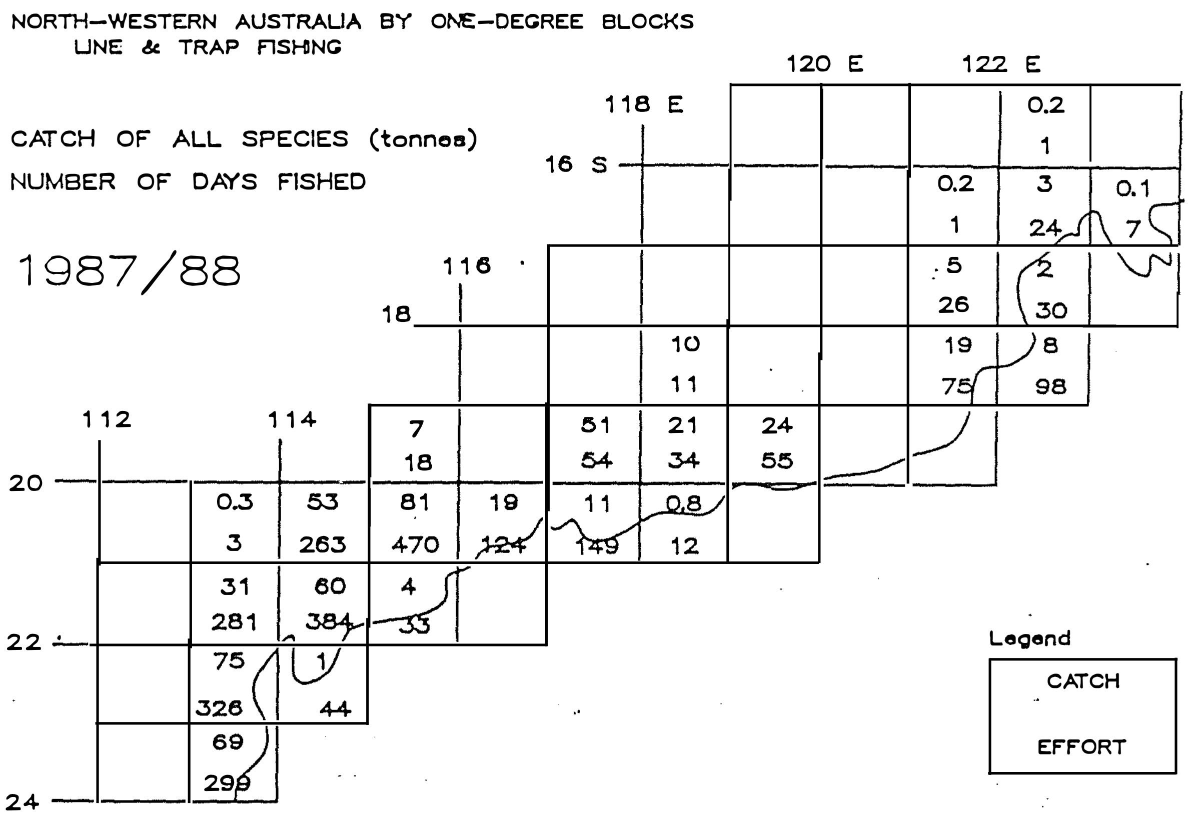


Fig 4.2 Commercial catch (all species) and effort by block and year in the NW trap and line fishery. 1987/88 figures are preliminary.

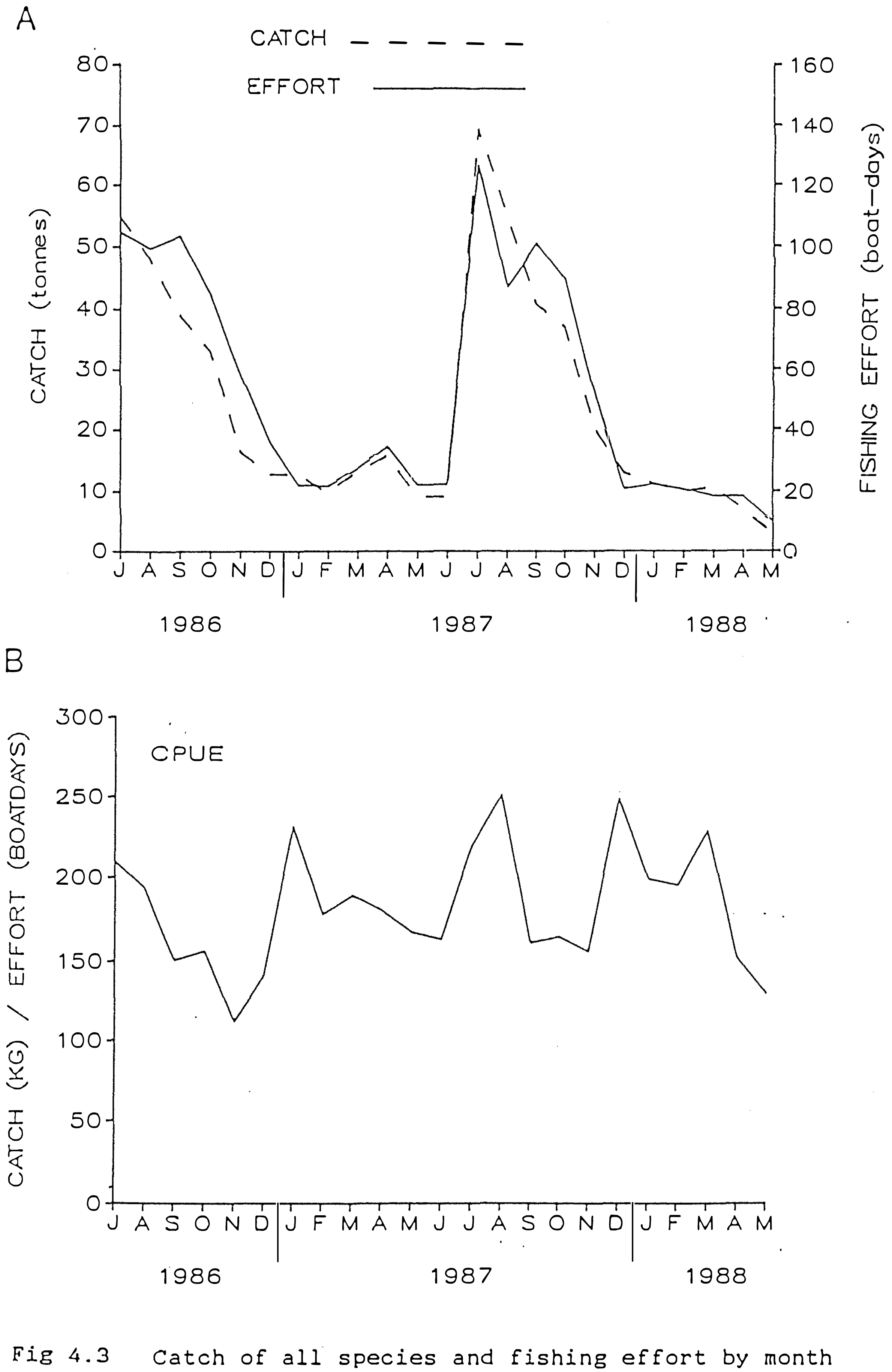


Fig 4.3 Catch of all species and fishing effort by month (A) and catch per unit effort by month (B) from July 1986 to May 1988. April and May 1988 are preliminary.

Catch and effort by one degree blocks

The distribution of catch and effort for each of the two years is shown in Figure 4.2, and the distribution of catch for each of the major fish categories in Appendix 3. The main effort is concentrated south of 20 S around the Montebello islands and off Ningaloo Reef. There is a concentration of trolling effort between 120 and 123 E. The main fishery is away from the grounds trawled heavily by the Taiwanese pair trawlers, though in 1987/88 the demersal catches on the southern edge of the trawl grounds increased markedly.

Seasonality of catch and effort

Catch and fishing effort both show very strong seasonal fluctuations, with July to October being the peak season. Catch per unit effort, though varying over a wide range, does not appear to have a strong regular seasonal component (Figure 4.3). Catches of the categories NW snapper and red emperor follow the fishing effort pattern closely with a peak in July (Figure 4.4). Mackerel is slightly different, peaking in August, The serranid categories, cod and coral trout, show signs of having a later season, which may have some biological basis such as a spawning season. On the

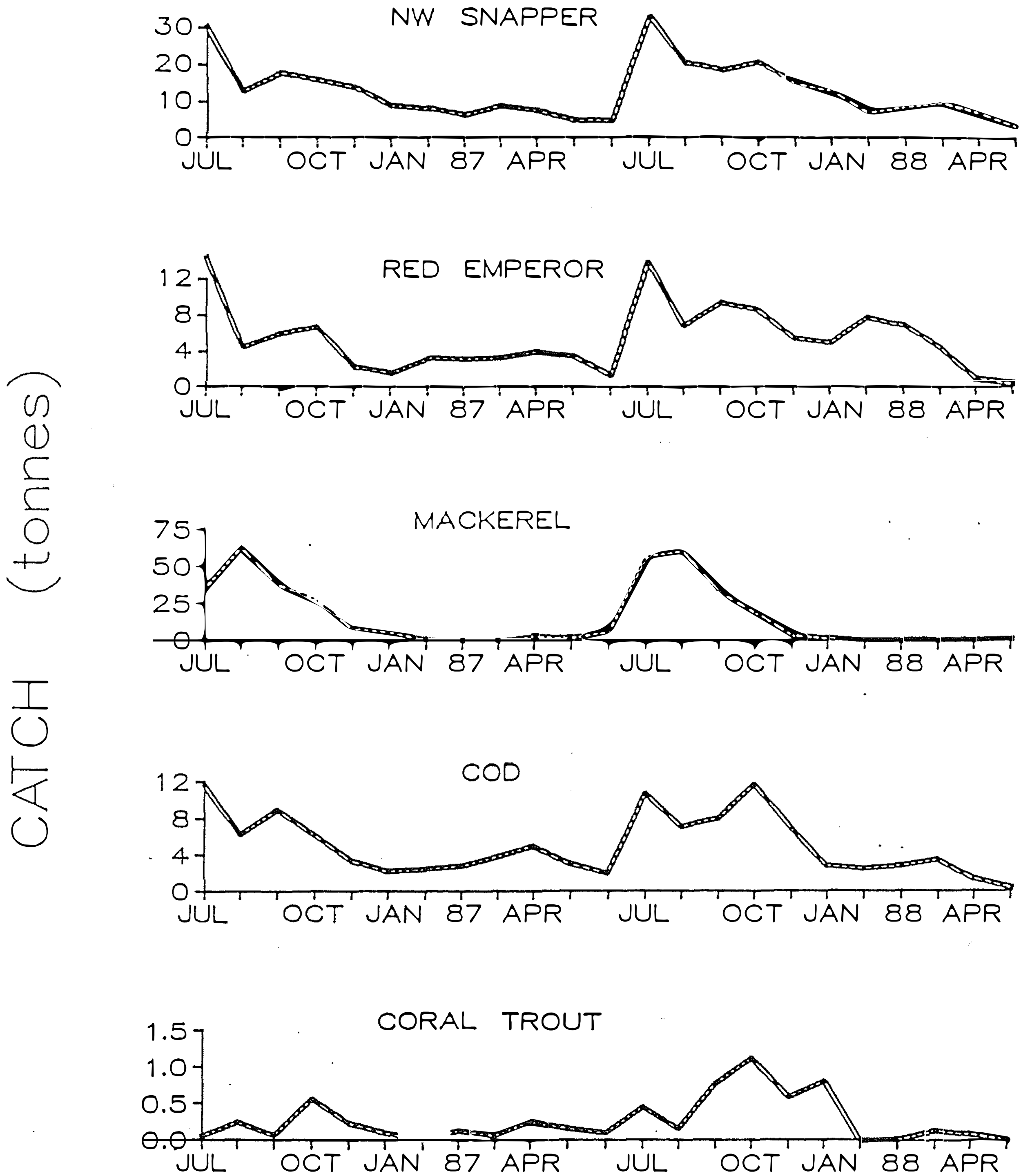


Fig 4.4 Monthly catch of some major categories in the NW trap and line fishery, from July 1986 to May 1988. Figures for April and May 1988 are preliminary.

available data, the seasonality of the fishery as a whole is not based on variation in catch-rates, but may be related to fishermen avoiding the cyclone season.

5. LENGTH FREQUENCIES OF ABUNDANT SPECIES

The main purpose of collecting length data is to provide a baseline against which future length-frequency measurements can be judged to assess the state of the fishery. Lengths of fish were measured whenever possible as part of the sampling of unloaded catches. These measurements are summarised as length-frequency distributions in Figures 5.1 to 5.4, pooling results from all regions. Those species which were sufficiently abundant to summarise by region are also included in Figures 5.5 to 5.7.

The first point to note about the length distributions is that, in general, they do not show distinct polymodal patterns which could be used with any confidence to construct growth curves for the species.

Of the lethrinids, Lethrinus nebulosus, the most abundant species of this family in the catch, is also the largest. Both fishermen and processors prefer large fish because it takes as much effort to process a half kilogram fish as it does a 5 kilogram fish. Abundance in the catch may therefore not reflect abundance in the sea. If profitable markets were to develop for whole small fish, no doubt the proportion of the smaller species in the catch would increase markedly. This highlights the need to understand market trends when interpreting catch statistics.

The same points apply to the serranids and lutjanids as to the lethrinids. Small species occur and could probably be caught in greater numbers; but at present they are mainly a by-catch while fishermen target on the larger species. The difficulty of avoiding catching small members of the large species while retaining the ability to catch the small species is apparent. Only a small proportion of the large species are caught at lengths less than 35 cm (length to caudal fork). Although the optimum length at first capture for species in this fishery is not yet known, it does not appear that catching juveniles of large species is a problem at present.

The length frequencies do show some differences between regions. In particular more small fish of the large species are taken in the Onslow region. This may indicate different distributions of large and small fish, or different age distributions among regions, but is more likely to reflect different practices by fishermen. The fishermen in the Onslow region may simply show less avoidance of local patches of small fish.

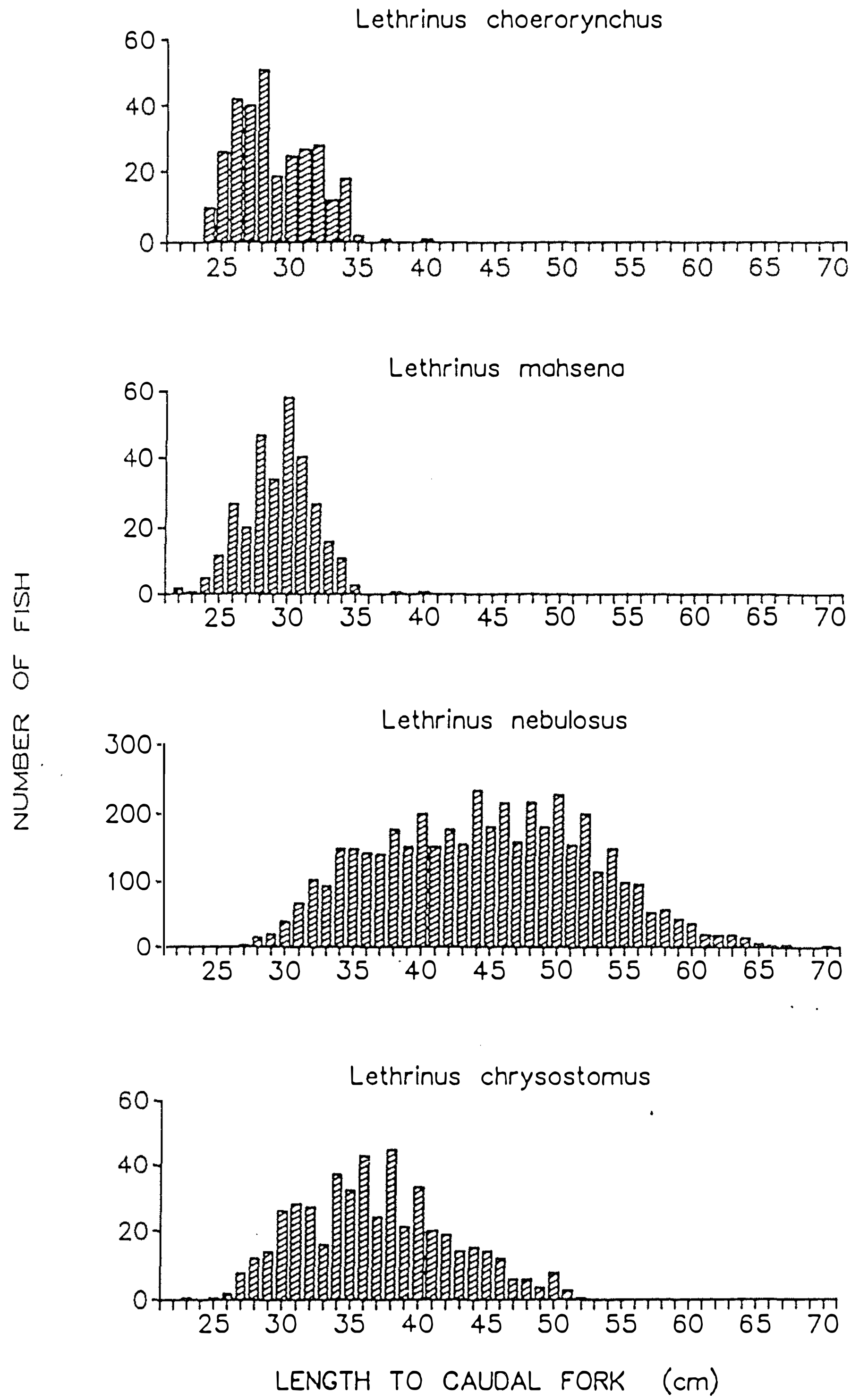


Fig 5.1 Length frequencies for 2 predominant small and large species of lethrinids.

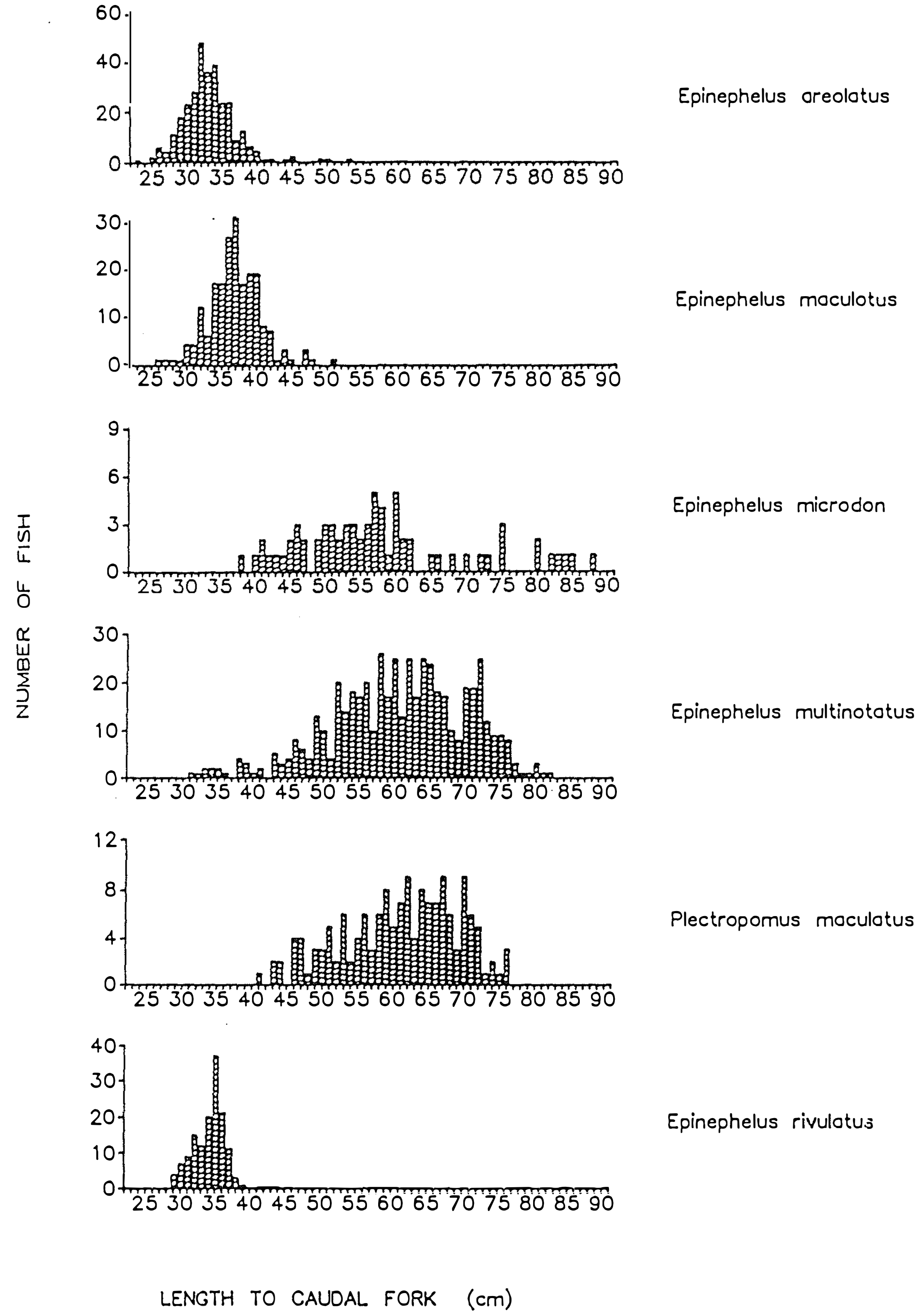


Fig 5.2 Length frequencies for 6 major species of serranids.

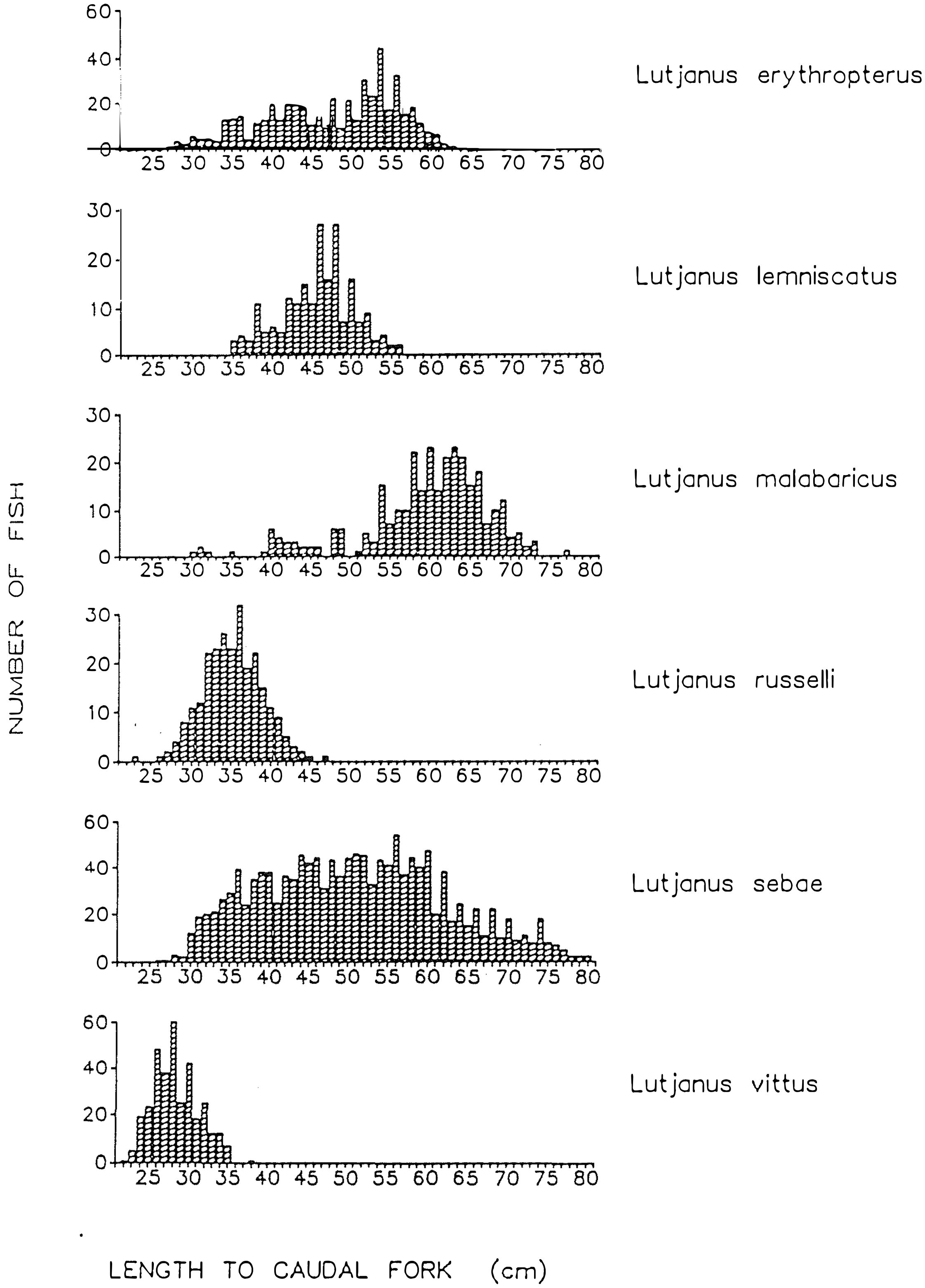


Fig 5.3 Length frequencies for 6 major species of lutjanids.

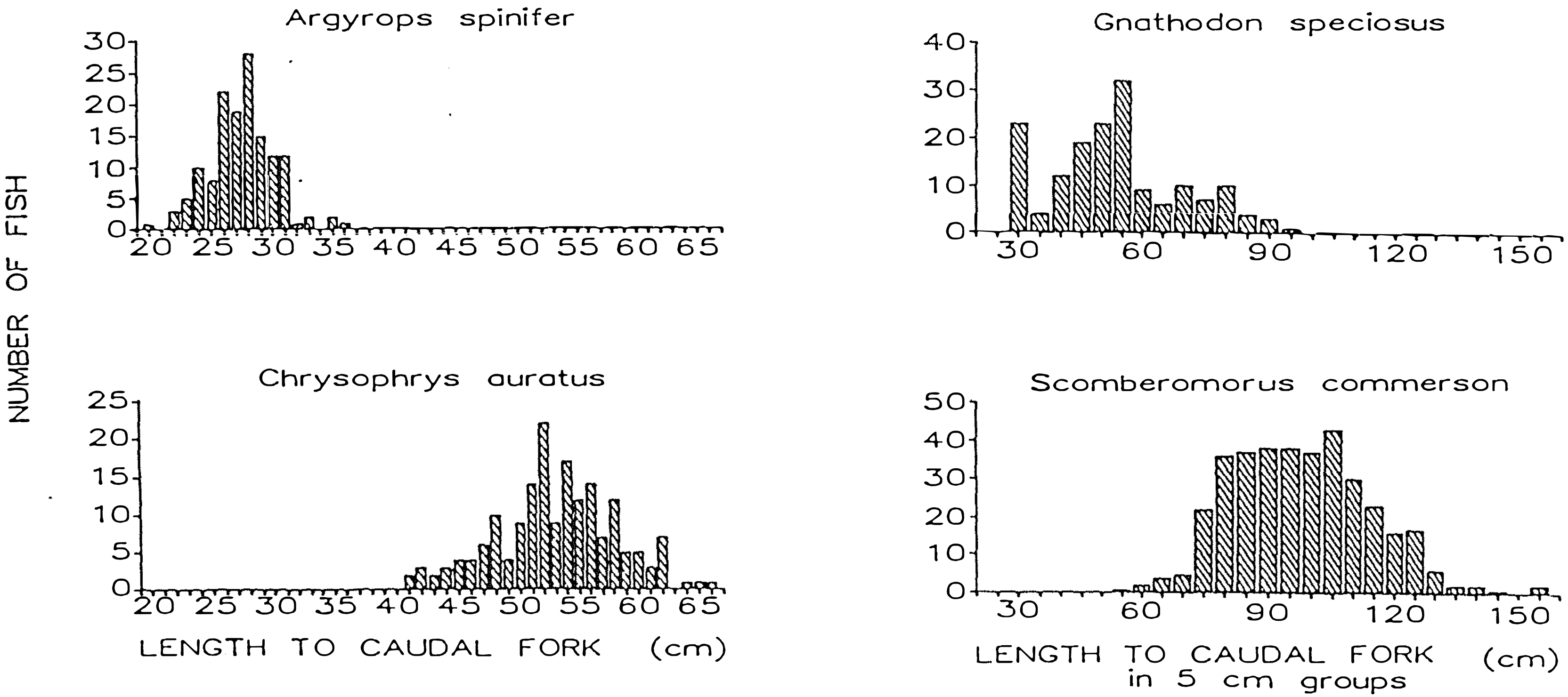


Fig 5.4 Length frequencies of Argyrops spinifer, Chrysophrys auratus, Gnathodon speciosus and Scomberomorus commerson.

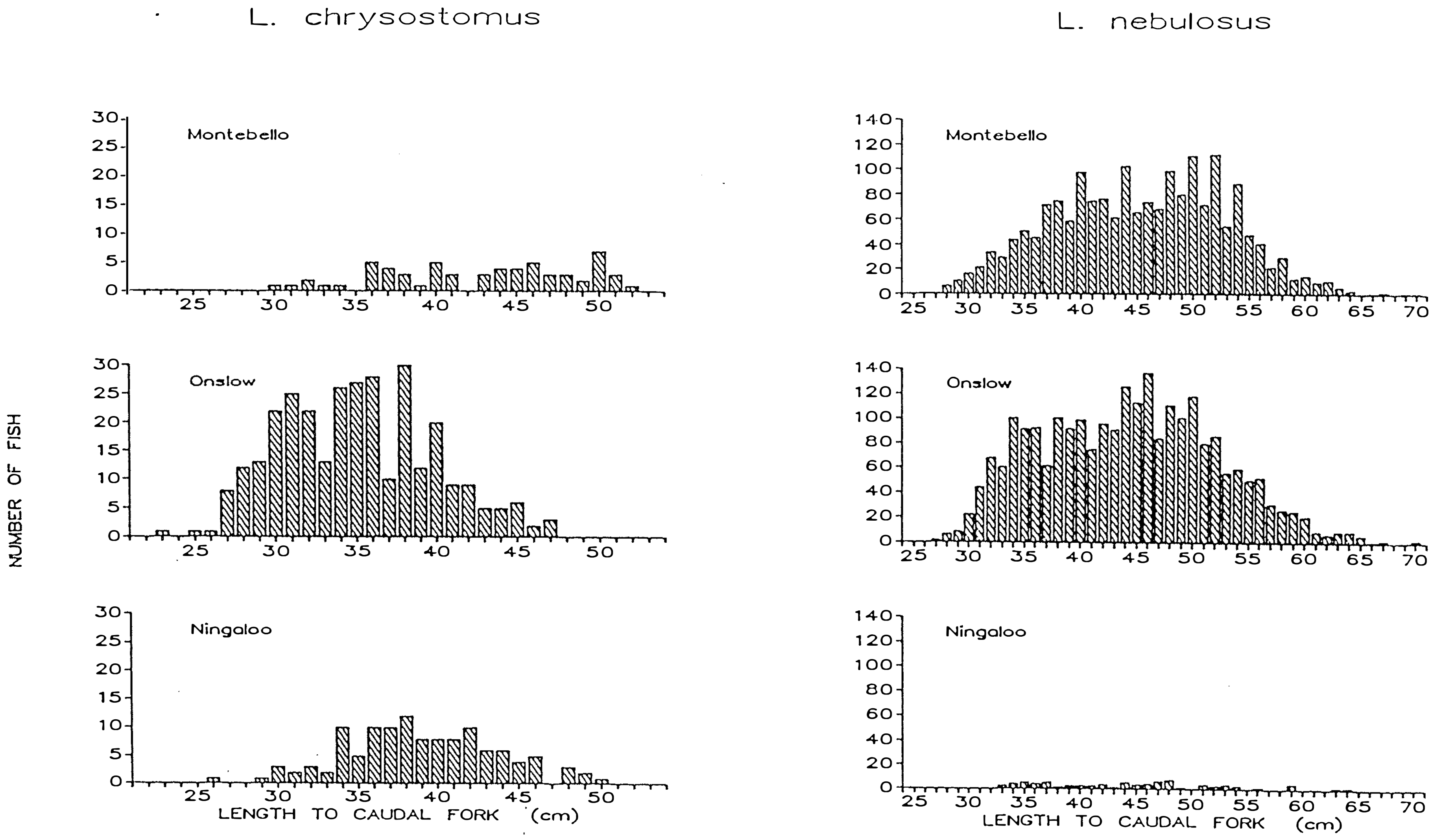


Fig 5.5 Length frequency for the two major lethrinid species: regions Montebello, Onslow and Ningaloo.

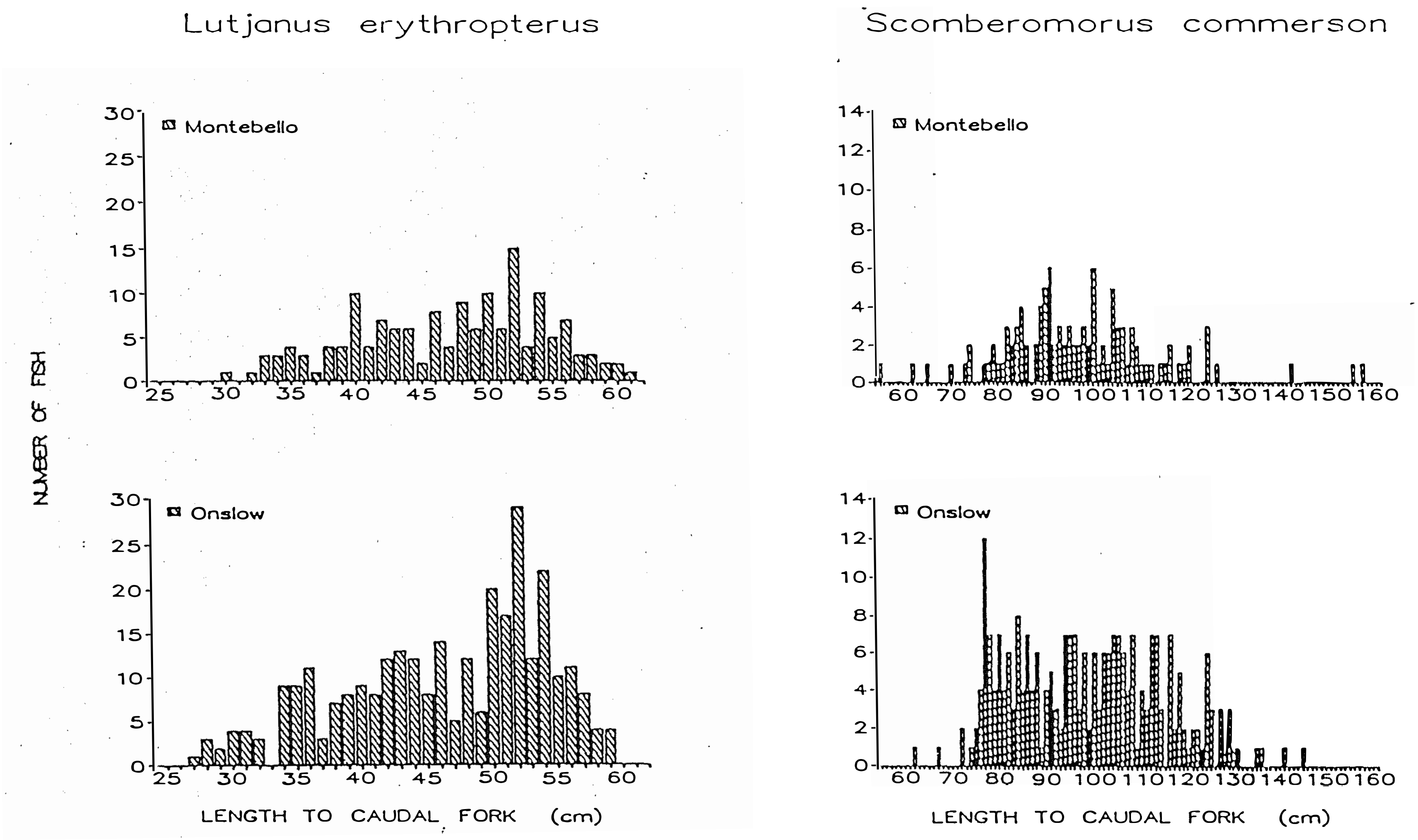


Fig 5.6 Length frequency for Scarlet Sea Perch, Lutjanus erythropterus, and the Spanish Mackerel, Scomberomorus commerson: regions Montebello and Onslow .

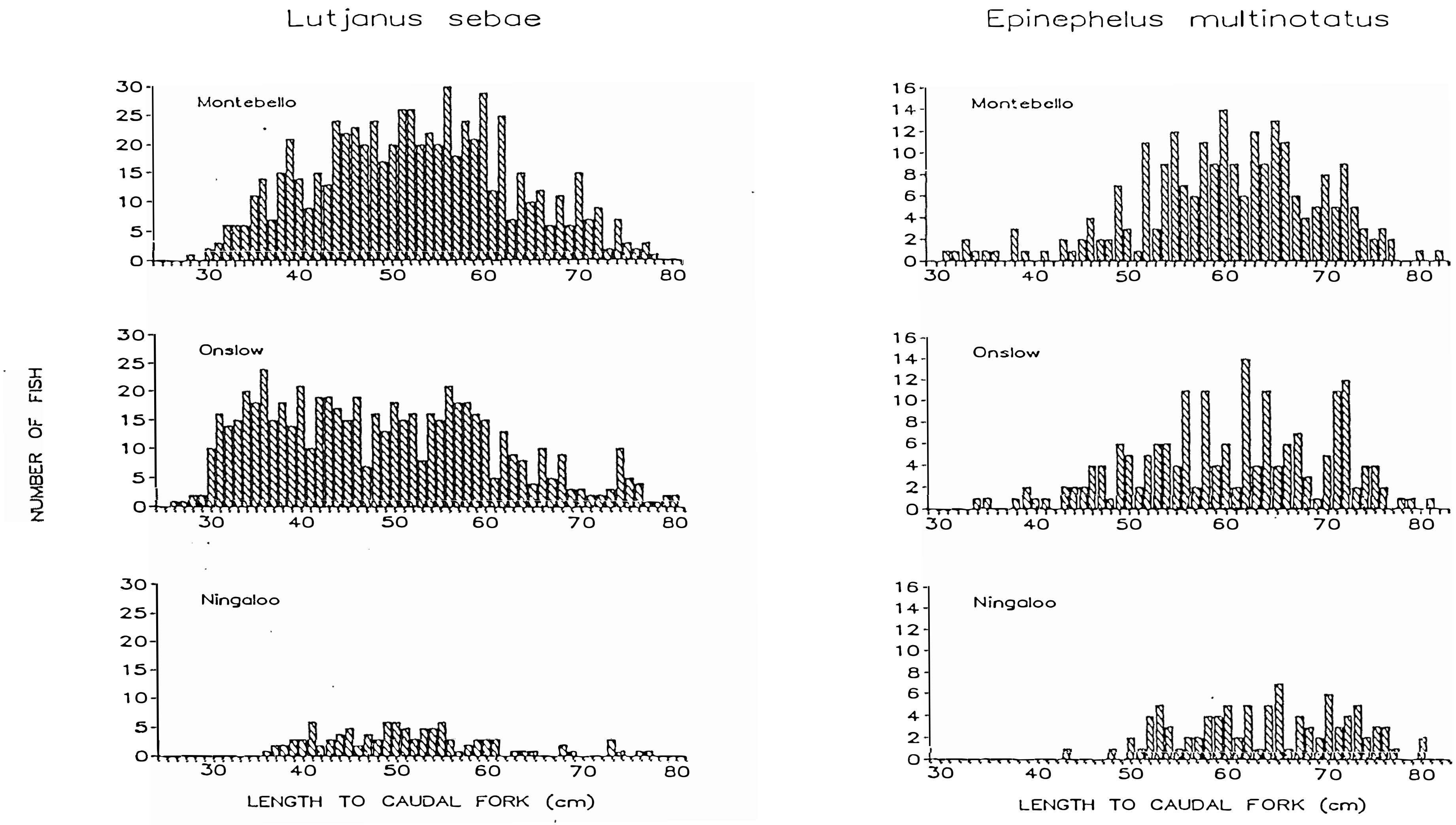


Fig 5.7 Length frequency for Red Emperor, Lutjanus sebae, and Rankin Cod, Epinephelus multinotatus: regions Montebello, Onslow and Ningaloo.

6. EFFECT OF TRAP MESH SIZE ON SIZE AND SPECIES OF FISH

As the fishery with traps began there was concern by line-fishermen that the traps would be non-selective in the size of fish caught and would cause overfishing by catching large numbers of small fish. Experience had shown traps to be capable of catching small lethrinids which were assumed to be juveniles of large species such as Lethrinus nebulosus which are the major component of the demersal fishery.

The standard mesh-size in the fishery is 5 x 5 cm, either chain-link or weld-mesh. The purpose of this section of the study was to determine:

i) whether standard mesh traps catch small fish;

ii) if the number of small fish caught could be reduced by using larger mesh;

iii) if the small fish are juveniles of large species.

Experimental traps were made with weld-mesh of two commercially available mesh-sizes, 10 x 10 cm and 15 x 5 cm. These traps were used, alongside commercial traps of standard design, on the trap fishing grounds of the North West Shelf. Traps were deployed in sets, with all traps used in each set. This was necessary to enable valid comparisons between traps, as catches are very variable with location and time. The traps were dropped on targets identified using the echo sounder.

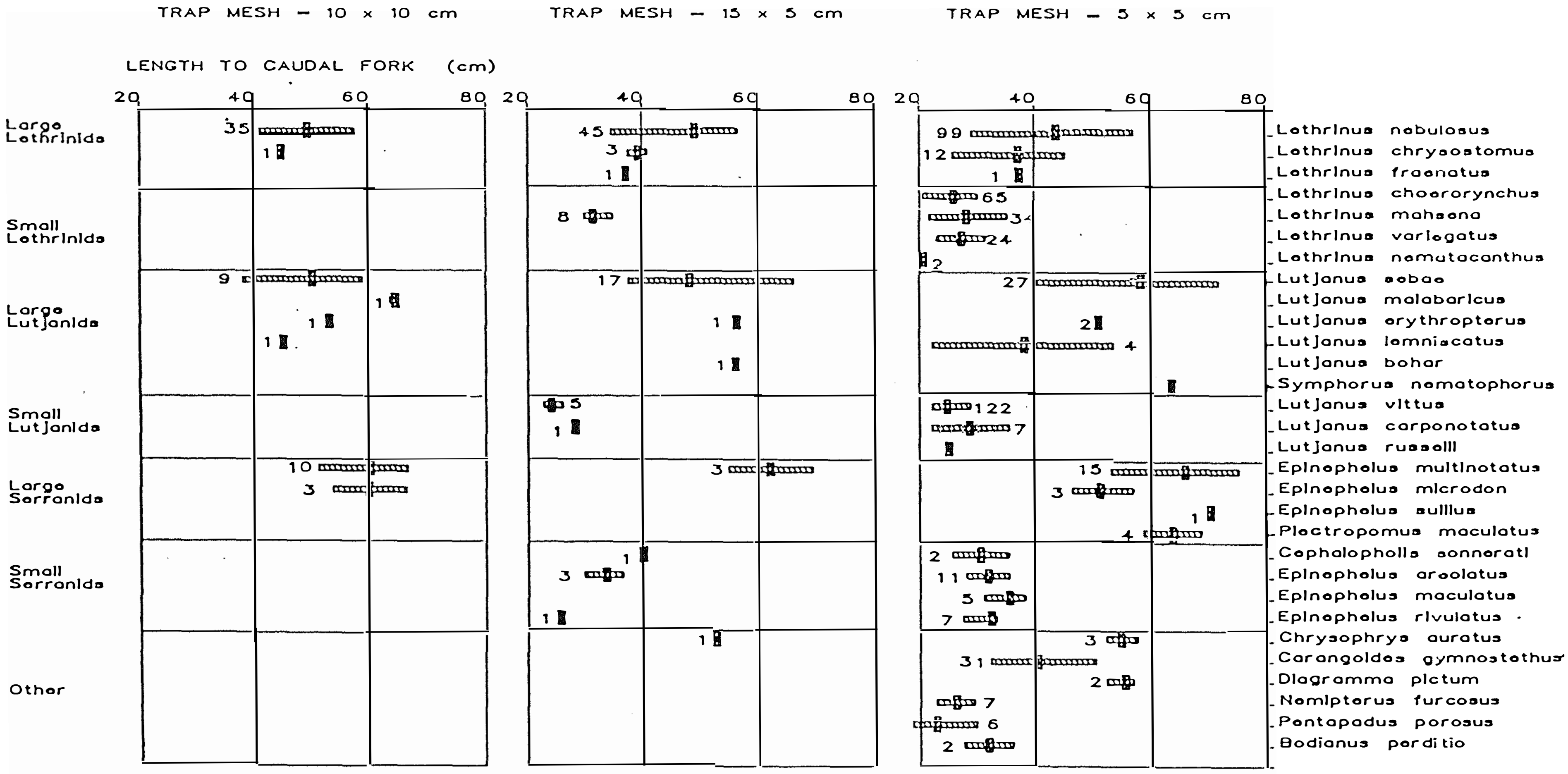


Fig 6.1 The number, mean length and range of lengths of the fish species caught by traps of 3 mesh sizes.

The total number of each species caught by each type of trap is shown in Figure 6.1, as well as the mean length and range of lengths for the species. The fish are divided into large and small species on the basis of the maximum lengths observed for each species in monitoring the commercial fishery.

The length-frequencies of large and small categories of the three main families (Lethrinidae, Lutjanidae and Serranidae) are shown in Figure 6.2 for each type of trap. It is clear that while the 5 x 5 cm mesh commercial trap caught significant numbers of fish less than 35cm (length to caudal fork), most of these fish belonged to the small-bodied species. The 15 x 5 cm mesh trap caught relatively less small lethrinids and lutjanids, but similar proportions of large and small serranids compared to the 5 x 5 cm trap. Catches of large fish were also somewhat less than the 5 x 5 cm trap. No small fish at all were caught by the 10 x 10 cm mesh trap, though again catches of large fish were less than for the commercial trap.

These trends can be summarised by a comparison of catches of all species together for the three trap types (Figure 6.3). While catches of the two large mesh traps are 40 to 60% of that of the commercial 5 x 5 cm trap for fish longer than 35 cm, they fall to less than 10% of the catch of the commercial trap for fish shorter than 35cm for the

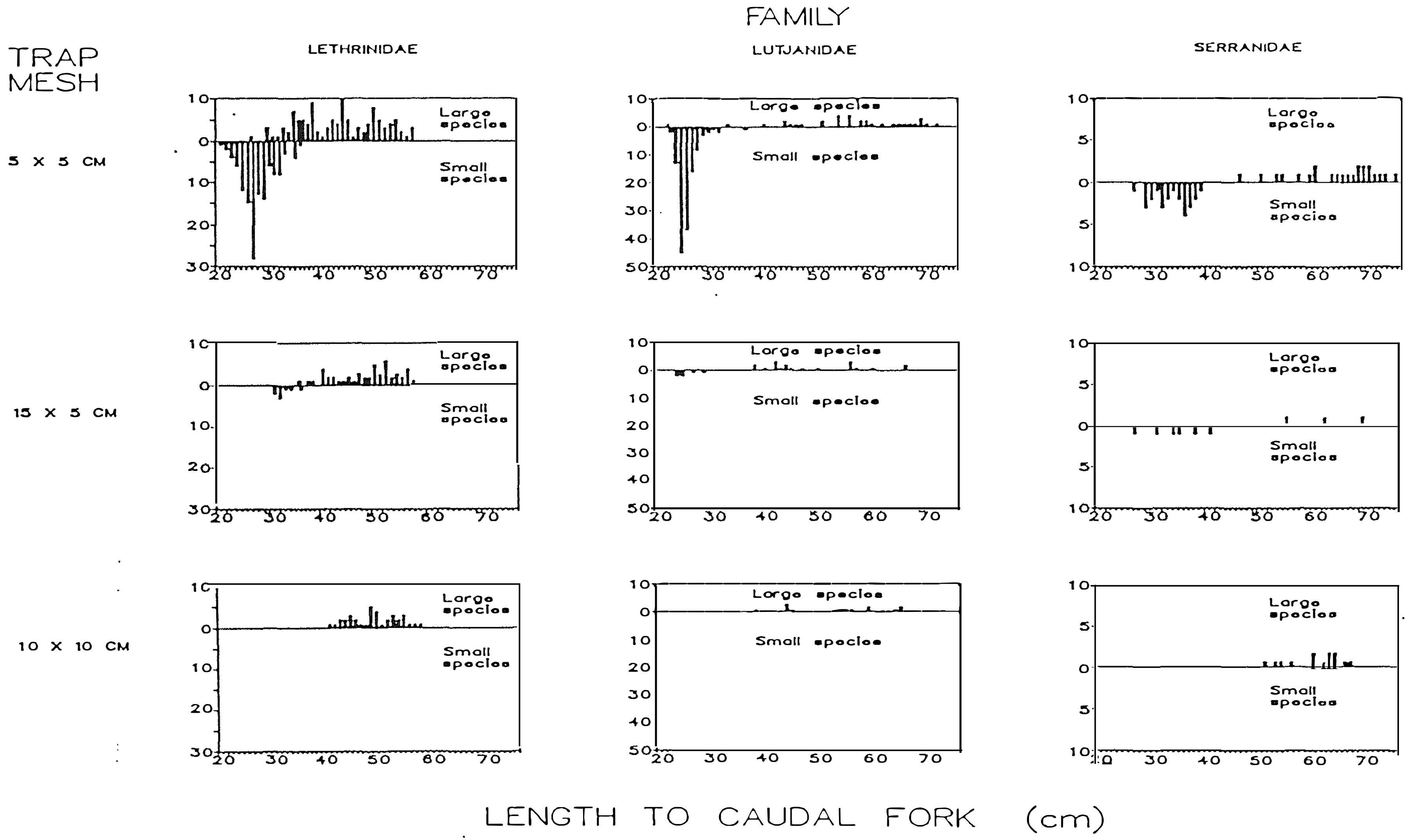


Fig 6.2 Length frequencies of large and small species of fish of the three main families caught by research vessel using traps of three mesh sizes.

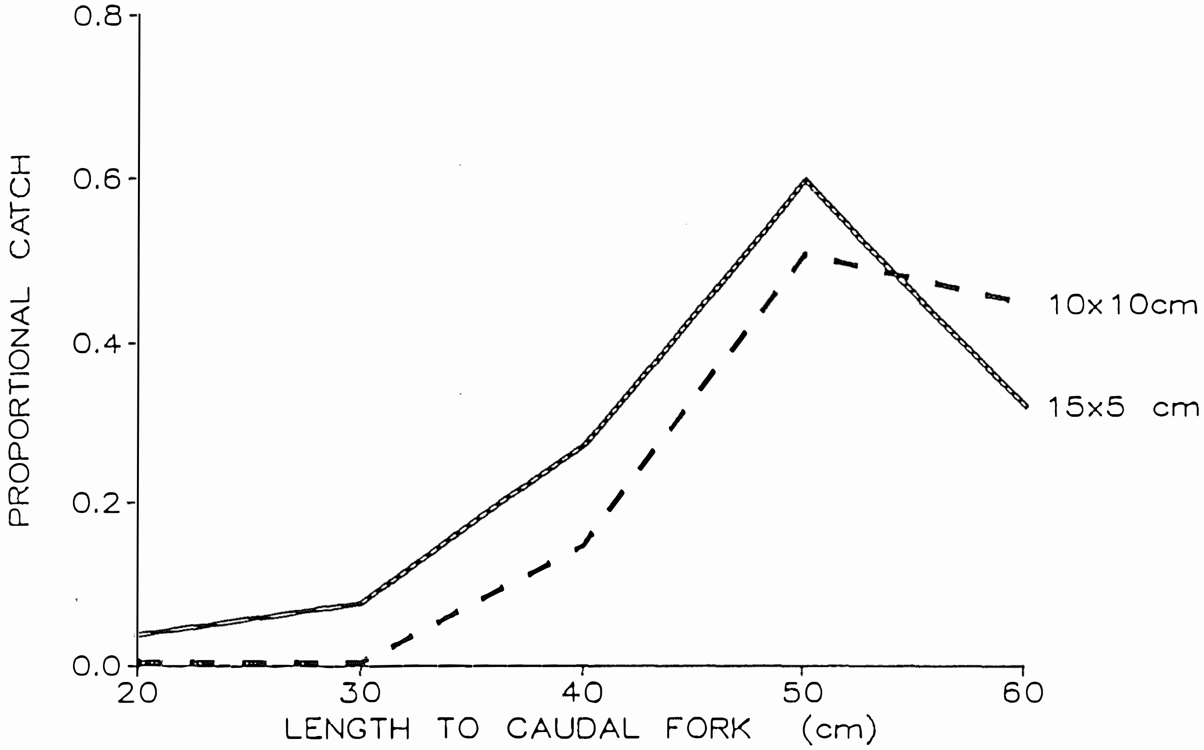


Fig 6.3 Catch rates, by 10cm length-groups of all commercial species of fish taken by traps of 10 X 10cm and 15 X 15cm mesh sizes, expressed as a proportion of the catch-rate of a standard commercial 5 X 5cm mesh trap.

15 x 5 cm mesh and to 0% for the 10 x 10 cm mesh trap.

The two large-mesh traps investigated are very successful in reducing the catch-rates of small fish, compared with commercial 5 x 5 cm mesh traps. However, catch-rates for large fish are also reduced, though to a much less extent. It is very likely that the catch-rates for large fish could be improved while keeping efficiency for catching small fish at a low level, e.g. by constructing a trap of a mixture of large and small mesh sizes. The benefits of developing such a trap are doubtful at this stage, as catches of juveniles of large-bodied species are not considered to be excessive.

7. DISCUSSION

The marine trap and line fishery in the north of Western Australia is a small fishery of approximately 50 vessels producing only 550 tonnes of finfish per year, from the sea adjacent to a coastline of almost half the state. It must be remembered,however, that this fishery is operating on the fringes of an intensive foreign trawl fishery which has been exploiting the North West Shelf for almost two decades. The trawl grounds are thought to be over-exploited and to have sustained habitat damage as a result of the heavy fishing. The predominantly high value fish such as lutjanids,lethrinids and serranids which the trawl fishery took in its early days have declined to give way to lower value species,(K. Sainsbury, personal communication). The Australian fishermen are able to acheive satisfactory catch-rates of high-value fish by working the grounds where the bottom was too rough for intensive trawling or where the foreign fleet was not allowed to operate.

While this project was begun with the intention of describing the demersal trap and line fishery, it became apparent that the trolling fishery for spanish mackerel was not separable from the demersal fishery. All of the demersal trap and line vessels switch to trolling when the mackerel are available. Some set their traps and leave them to catch fish while the the boat trolls for mackerel for a few hours before returning to recover the traps. The demersal and pelagic fisheries should be considered two aspects of one fishery. The Australian fish trawling which is beginning to develop in depths less than 200m should also be considered part of this fishery, as it is likely to operate in the same depth-range and catch many of the same species as the traps.

The species composition of the trap and line fishery over the past two years has been dominated by:

spanish mackerel	*Scomberomorus commerson*	31% of the catch
spangled emperor	*Lethrinus nebulosus*	22%
red emperor	*Lutjanus sebae*	11%
rankin cod	*Epinephelus multinotatus*	7%.

Of the demersal species, the red emperor and the rankin cod were also well represented in the foreign trawl fishery in its early years, as were some species of lethrinids. *L. nebulosus,* however, is not known to have been a major component of the Taiwanese trawl fishery. It may have been greatly depleted by early trawling or may just not be common in that habitat. The extent of its dominance in the demersal trap and line fishery favours the latter explanation.

While the trap and line fleet is composed mainly of boats which are not suitable for operating on the trawl grounds a long way offshore, the few vessels that are capable of working there have found that, apart from on isolated patches of rough bottom, catches of valuable fish are low. The Australian demersal fishery therefore operates inshore from the trawl grounds or on areas of hard, broken bottom. As stocks of valuable fish build up again on the trawl grounds west of 117 30'E, from which foreign vessels have recently been excluded, no doubt the Australian fishery will expand into that area when catch-rates become adequate. There may,however, have to be a change in methodology. The present method of trapping evolved to exploit aggregations of pink snapper schooling at Shark Bay. Those traps are left fishing for a short time and fish are able to enter and escape. Fishing stocks at lower densities may require traps to be set for longer periods, i.e. days instead of hours, and be designed to retain all or most of the fish which have entered the trap. To be viable, a vessel in such a fishery would probably need many more than the four to six traps presently used by most boats.

In addition to working new areas in the future, the fishery also has a lot of scope for working more months per year. While most of the fishermen have the attitude that it is not worth working the summer and autumn, the few who have done so have caught well. The mackerel are reputed to only be catchable in the winter and it may be this as well as avoidance of the hot weather and the cyclone season that is the basis of the present seasonal pattern of fishing.

Although we have no growth or other biological information on which to judge them, the lengths of fish caught do not present any obvious reason for alarm about the state of the fishery. At least, all the large fish have not disappeared from the catch. The main reason for collecting length data was to have a baseline against which future length-frequencies can be judged as an indicator of changes in the fishery. Interpretation of such changes requires a detailed knowledge of the fishery, e.g. the present market prefers large fish but in future a market may develop which prefers small fish and the fishermen will change their targetting strategy to adapt to the market. While there appears to be no urgent need to introduce traps which allow small fish to escape at present, the experimental trap made from 15 x 5 cm mesh shows promise of being of similar efficiency to standard commercial traps for catching large fish without small fish. It could be further improved and made mandatory if necessary in future.

Traps have been seen as a great improvement in efficiency over drop-lines in the northern waters because they do not lose fish to the sharks after capture. The use of pelagic gill-nets has been a problem in the northern waters because of the by-catch of dolphins. Demersal gill-nets are thought to be wasteful because they have a high 'drop-out' rate. Gill nets are not widely used on the North-West Shelf at present. It would seem prudent, rather than leaving the region open to gill-netting, to prohibit the use of the method there now. Anybody who has a good argument for using gill-nets in future could then be allowed to try them under supervision to determine what the problems really are.

Fish-trawling by Australian vessels should similarly be on a controlled and probationary basis. Given the concerns about the effects on the fish community of habitat damage caused by the Taiwanese pair-trawlers, large-scale trawling should not be permitted until research has determined whether the type of trawl gear used by Australians is environmentally destructive.

A traditional stock-assessment such as fitting a surplus-production model would probably never work for the NW fin-fish fishery. The trajectory that the fishery would be likely to follow if there was over-fishing would show the larger species disappearing first and the fishery persisting on the smaller species until, if the situation continued, they disappeared also. Responsible management would not wish the fishery to progress even to the first stage of this process. Possibly the best approach to management of such multi-species fisheries is to manage those species expected to be most vulnerable to overfishing, on the basis that if their stocks are in a healthy state, the other species are likely to be also.

Detection of the level of fishing effort at which to stop the increasing development of the fishery is a problem common to many fisheries. This is made even more difficult in this case with the rate of recovery of the ex-trawl grounds being an unknown factor. One approach is to manage the present areas exploited by the trap and line fishery as though no recovery of the trawl grounds was expected. While the size of the resource available to this fishery may not be known for many years there are some practical management measures which could be used such as preservation of the habitat; protection of nursery areas if any are found; restricting the most efficient fishing gears to the least accessible areas; and setting minimum sizes for species in relation to size at maturity, taking into account the complication that some of the species change sex. While the information is being gathered on which to base these measures, the rate of increase of fishing effort should be kept under control.

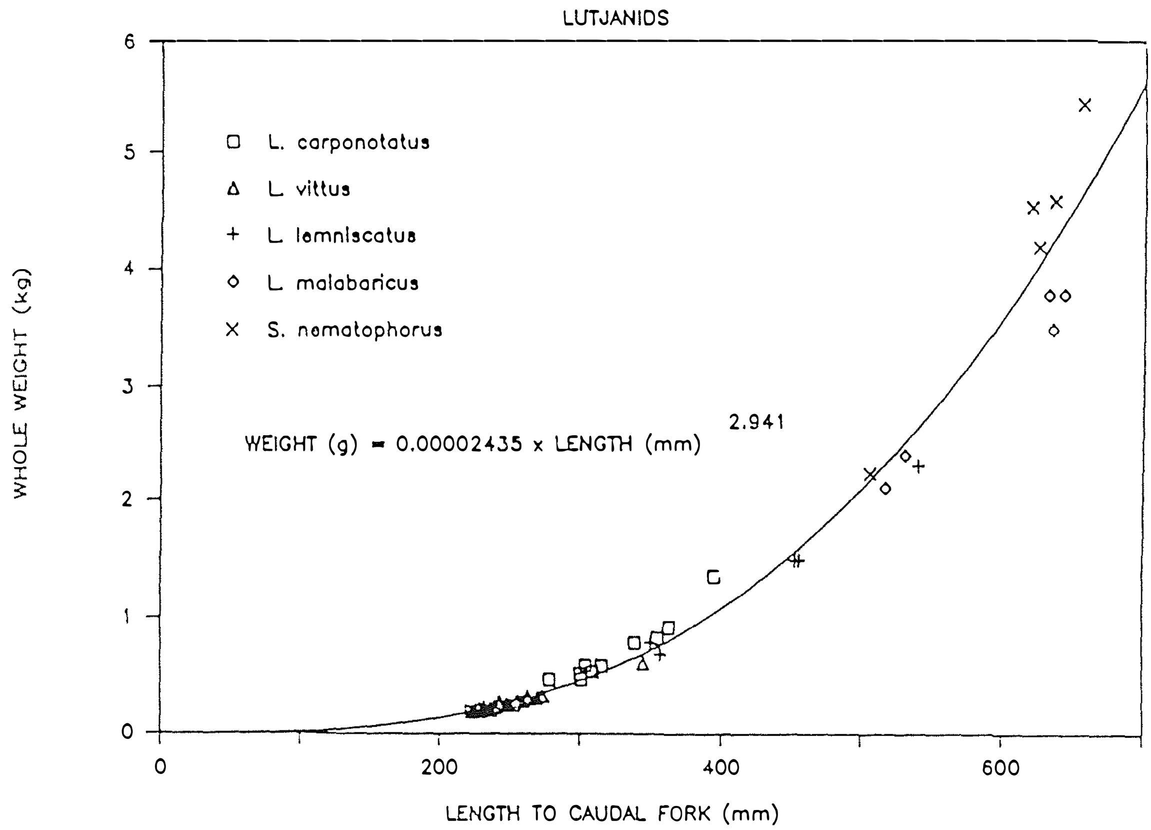
While the fishery is small at present, it has the potential to be a major fishery in the long-term. For this reason it is worth putting in a substantial research effort. Basic biological characteristics of the main species, such as growth, stock identity and migrations, size at maturity and patterns of sex change, are not well known, especially in Western Australian waters. Such information is essential for fishery managers to set safe minimum lengths of fish for conservation of the stocks and to define appropriately-sized management zones. These, together with studies of the effect of the various gear-types on the habitat and thence on the fish community, should be priority areas for future research.

Monitoring of the fishery is made difficult by its sparse nature, with relatively few boats operating over a very large region. Surveys of the species-composition and size-composition of the catch as in the present study are possibly the best means of monitoring the state of the fishery, however these are very time-consuming and expensive if they are to be comprehensive enough to be useful for management purposes. A viable option may be to mount a detailed sampling programme every three to five years, while relying on fishermen's monthly returns for assessment in the intervening years. Modification of these returns to enable separation of trap,line and troll fishing effort is required to allow catch-per-unit-efforts to be calculated for the various components of the fishery.

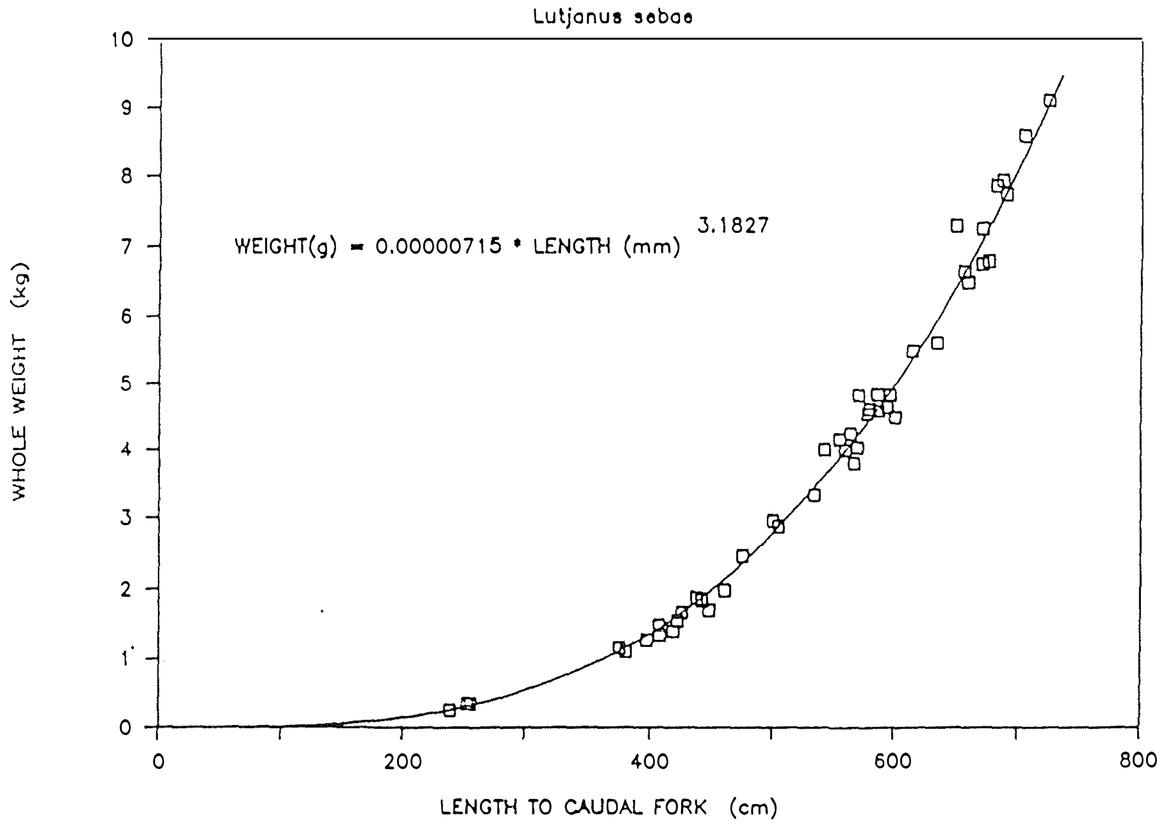
APPENDIX 1. Relationships between whole and partial lengths and weights of major families and species in the NW trap and line fishery.

CATEGORY/ SPECIES	LENGTH mm -WEIGHT g REGRESSION	Fillet wt -->whole wt	gut&gill wt -->whole wt	CONDITION head&gut wt -->whole wt	gut & gill length --> whole	Head&gut length --> whole
LUTJANIDS (not L.sebae)	10^-5 x 2.4L^2.941	2.89	1.12	1.28	0.997	1.6
L.sebae	10^-6 x 7.14L^3.183	2.97	1.13	1.76	.99	1.26
L.vittus	10^-4 x 1.19L^2.65	3.10	1.14	1.65	.998	1.30
LETHRINIDS	10^-5 x 5.12L^2.838	2.99	1.16	1.75	.998	1.32
L.choerorynchus	10^-5 x 5.2L^2.832	2.71	1.14	1.66	.994	1.32
L.mahsena	10^-6 x 4.37L^3.294	3.40	1.14	1.77	.994	1.31
L.nebulosus	10^-5 x 1.24L^3.07	3.03	1.16	1.76	.998	1.32
SERRANIDS	10^-6 x 2.2L^3.313	3.11	1.15	1.78	.997	1.30
P.maculatus	10^-6 x 5.7L^3.152	2.40	1.12	1.54	.996	1.26
E.areolatus	10^-5 x 5L^2.77	3.06	1.12	1.67	1.00	1.30
E.multinotatus	10^-6 x 1.5L^3.38	3.13	1.18	1.80	.996	1.30
CARANGIDS	10^-4 x 4.82L^2.45	2.40	1.11	1.54	.994	1.26
MACKEREL				1.23		

A



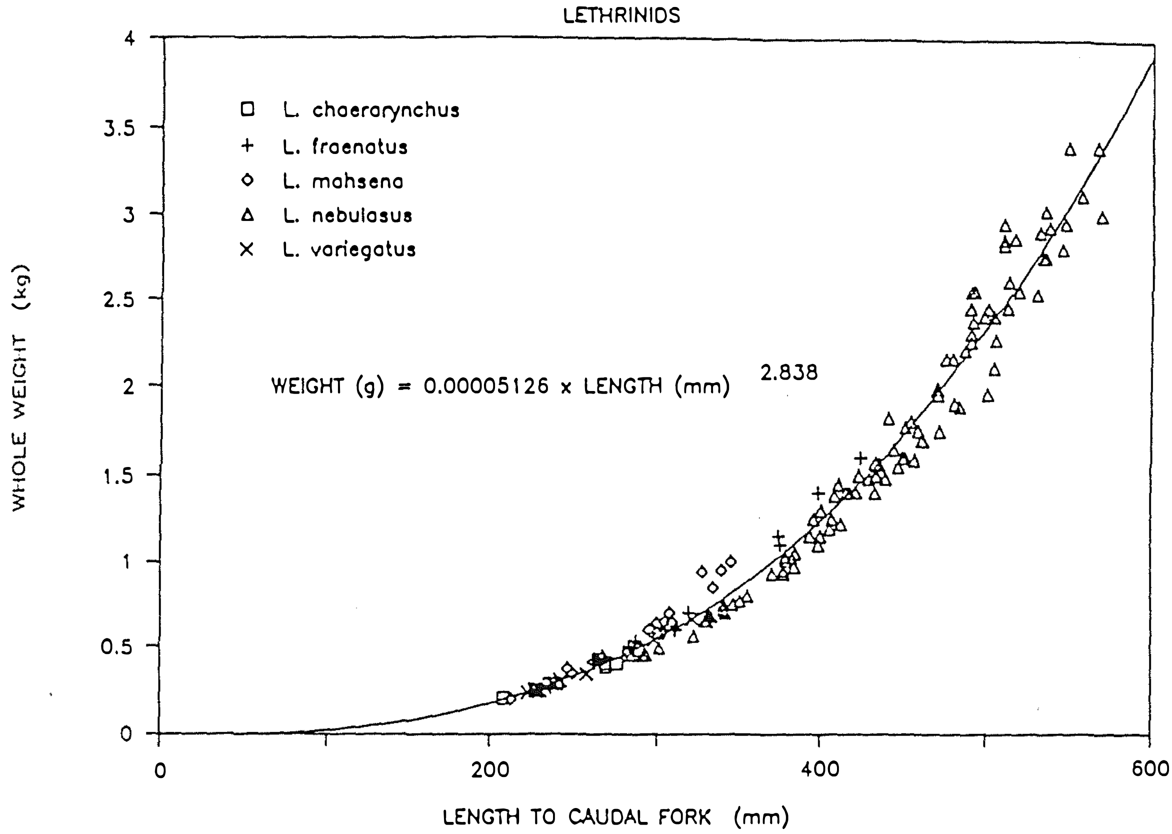
B



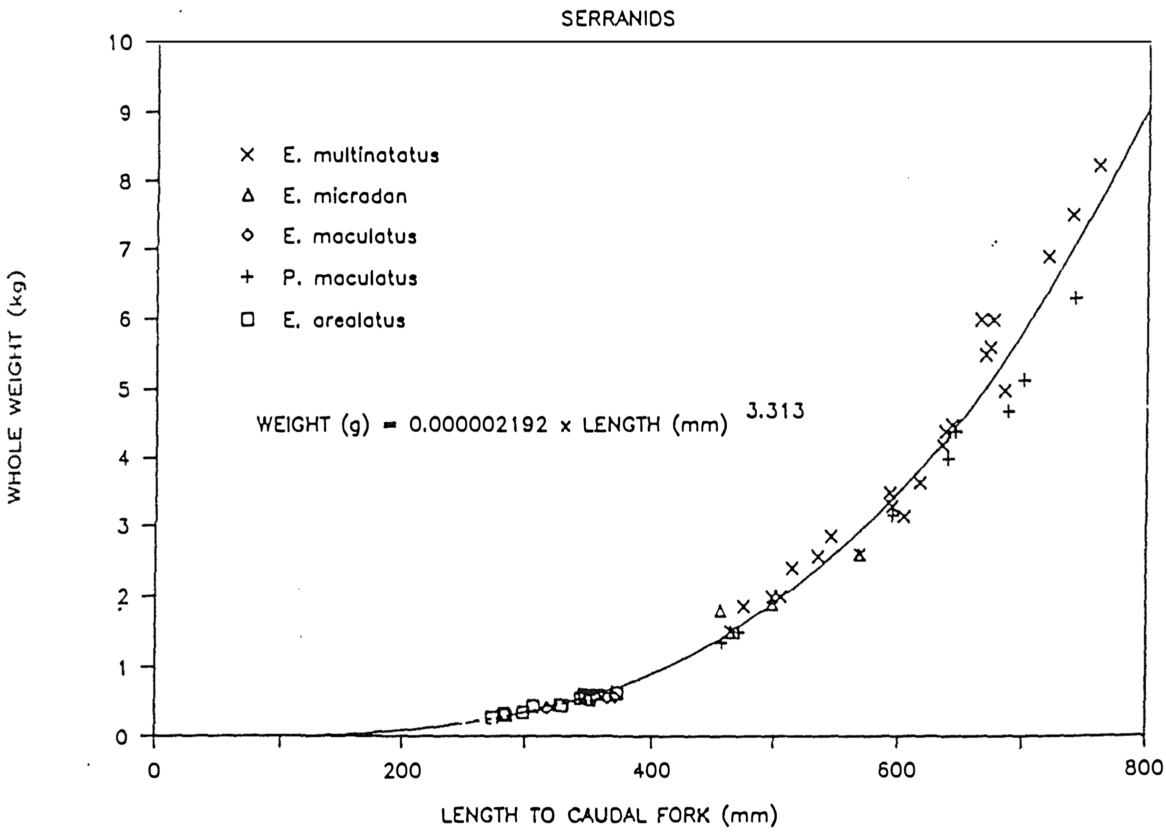
Appendix Fig 1.2 A,B

Length-Weight relationships (A) for the combined lutjanids (except L. sebae) and (B) for L. sebae only.

C



D



Appendix Fig 1.2 C,D

Length-Weight relationships (C) for the combined lethrinids and (D) for the combined serranids, using the predominant species.

APPENDIX 2. Species composition by number, weight and mean body weight, of fish categories by region.

Appendix Table 2.1

Species composition by region for category Snapper

CATEGORY: SNAPPER	Numbers in sample				% of category by number				Mean body weight (g)			% of category by weight			
REGION:	N	O	M	TOTAL	N%	O%	M%	TOTAL%	N	O	M	N%	O%	M%	TOTAL%
SPECIES:															
Chrysophrys auratus	9	96	55	160	0.83	3.32	2.85	2.71	3823	2607	3301	2.58	5.40	5.43	5.01
Diagramma pictum			2	2			0.10	0.03			2211			0.13	0.05
Gymnocranius griseus		1	1	2		0.03	0.05	0.03		451	451		0.01	0.01	0.01
Lethrinus choerorynchus	153	118	12	283	14.13	4.08	0.62	4.79	438	417	641	5.02	1.06	0.23	1.33
Lethrinus chrysostomus	267	161	52	480	24.65	5.57	2.70	8.13	1351	840	1558	27.02	2.92	2.42	6.20
Lethrinus elongatus	8	7	1	16	0.74	0.24	0.05	0.27	5986	2758	2900	3.59	0.42	0.09	0.75
Lethrinus fraenatus	1	28	38	67	0.09	0.97	1.97	1.13	1850	1551	2071	0.14	0.94	2.35	1.33
Lethrinus lentjan	9	33	13	55	0.83	1.14	0.67	0.93	834	857	775	0.56	0.61	0.30	0.49
Lethrinus mahsena	95	164	20	279	8.77	5.67	1.04	4.72	583	579	614	4.15	2.05	0.37	1.75
Lethrinus nebulosus	486	2232	1725	4443	44.88	77.15	89.42	75.24	1460	1762	1714	53.14	84.90	88.39	81.60
Lethrinus rubrioperculatus	10	5	1	16	0.92	0.17	0.05	0.27	805	762	848	0.60	0.08	0.03	0.14
Lethrinus variegatus	40	20	1	61	3.69	0.69	0.05	1.03	563	432	632	1.69	0.19	0.02	0.34
Lutjanus carponotatus		4	1	5		0.14	0.05	0.08	671	718	717		0.06	0.02	0.04
Lutjanus lemniscatus	2	7	2	11	0.18	0.24	0.10	0.19	2424	1532	1188	0.36	0.23	0.07	0.19
Lutjanus russelli		4	2	6		0.14	0.10	0.10		1020	885		0.09	0.05	0.06
Lutjanus vittus			2	2			0.10	0.03			593			0.04	0.01
Pristipomoides multidens	1	11	1	13	0.09	0.38	0.05	0.22	2857	2944	1899	0.21	0.70	0.06	0.40
Symphorus nematophorus	1	2		3	0.09	0.07		0.05	6382	8027		0.48	0.35		0.24
Aprion viriscens	1			1	0.09			0.02	6210			0.47			0.07
TOTAL	1083	2893	1929	5905	100	100	100	100				100	100	100	100

Appendix Table 2.2

Species composition by region for categories Red Emperor and Mackerel.

CATEGORY: RED EMPEROR	Number in sample				% of category by number				mean body weight			% of category by weight			
REGION:	N	O	M	TOTAL	N%	O%	M%	TOTAL%	N	O	M	N%	O%	M%	TOTAL%
SPECIES:															
Gymnocranius griseus		2	1	3		0.32	0.14	0.21		670	1105		0.08	0.04	0.05
Gymnocranius robinsoni			1	1			0.14	0.07			3306			0.13	0.07
Lutjanus sebae	103	603	682	1388	96.26	95.26	94.46	94.94	3035	2748	3507	97.77	94.56	94.20	94.58
Plectropomus maculatus		22	38	60		3.48	5.26	4.10		3911	3759		4.91	5.63	4.96
Glaucosoma burgeri	3			3	2.80			0.21	1457			1.37			0.09
Lutjanus erythropterus	1			1	0.93			0.07	2762			0.86			0.06
Cephalopholus miniatus		4		4		0.63		0.27		970			0.22		0.08
Choerodon spl		1		1		0.16		0.07		1548			0.09		0.03
Variola louti		1		1		0.16		0.07		2560			0.15		0.06
TOTAL	107	633	722	1462	100	100	100	100				100	100	100	100

CATEGORY: MACKEREL	Number in sample				% of category by number				mean body weight			% of category by weight			
REGION:	N	O	M	TOTAL	N%	O%	M%	TOTAL%	N	O	M	N%	O%	M%	TOTAL%
SPECIES:															
Scomberomorus commerson	23	271	180	474	92.00	87.14	83.33	85.87	14276	10941	9859	96.79	93.09	89.31	91.95
Scomberomorus munroi		2		2		0.64		0.36		2905			0.18		0.11
Grammatorcynus bicarinatus	2	36	35	73	8.00	11.58	16.20	13.22	5450	4554	5646	3.21	5.15	9.95	6.76
Acanthocybium solandri		2	1	3		0.64	0.46	0.54		25202	14773		1.58	0.74	1.18
TOTAL	25	311	216	552	100	100	100	100				100	100	100	100

Appendix Table 2.3

Species composition by region for categories
Scarlet Sea Perch and Black Snapper.

CATEGORY: SS PERCH	Numbers in sample				% of category by number				mean body weight (g)			% of category by weight			
REGION:	N	O	M	TOTAL	N%	O%	M%	TOTAL%	N	O	M	N%	O%	M%	TOTAL%
SPECIES:															
Lutjanus erythropterus		166	151	317		42.56	38.62	40.59		1829	1747		32.984	29.845	31.446
Lutjanus lemniscatus		32	125	157		8.21	31.97	20.10		1568	1729		5.4511	24.451	14.758
Lutjanus russelli		2	2	4		0.51				1091	652		0.2370	0.1475	0.1931
Lutjanus malabaricus		190	111	301		48.72	28.39	38.54		2971	3602		61.326	45.234	53.443
Lutjanus argentimaculatus			2	2			0.51	0.26			1420			0.3213	0.1573
TOTAL		390	391	781		100	100	100					100	100	100

CATEGORY: BLACK SNAPPER	Numbers in sample				% of category by number				Mean body weight (g)			% of category by weight			
REGION:	N	O	M	TOTAL	N%	O%	M%	TOTAL%	N	O	M	N%	O%	M%	TOTAL%
SPECIES:															
Diagramma pictum		57	1	58		96.61	100.00	96.67		1861	1776		94.516	100	94.602
Plectorhinchus gibbosus		2		2		3.39		3.33		3077			5.4833		5.3979
TOTAL		59	1	60		100	100	100					100	100	100

Appendix Table 2.4

Species composition by region for category Cod.

CATEGORY: COD	Numbers in sample				% of category by number				mean body weight (g)			% of category by weight			
REGION:	N	O	H	TOTAL	N%	O%	H%	TOTAL%	N	O	H	N%	O%	H%	TOTAL%
SPECIES:															
Cephalopholis aurantius		2		2		0.48		0.17		1533			0.17		0.06
Cephalopholis miniata		7		7		1.68		0.59		1179			0.45		0.16
Cephalopholis sonnerati		7	3	10		1.68	0.46	0.84		1008	1173		0.39	0.12	0.20
Epinephelus areolatus	12	50	1	63	9.76	12.02	0.15	5.31	676	580	1099	1.74	1.59	0.04	0.73
Epinephelus bleekeri		5		5		1.20		0.42		1782			0.49		0.17
Epinephelus chewa	2	18	22	42	1.63	4.33	3.40	3.54	14948	11335	13847	6.43	11.16	10.32	10.27
Epinephelus maculatus	2	46	45	93	1.63	11.06	6.94	7.83	839	709	624	0.36	1.78	0.95	1.19
Epinephelus microdon	5	45	55	105	4.07	10.82	8.49	8.85	2244	4852	4432	2.41	11.95	8.26	9.02
Epinephelus multinotatus	94	191	431	716	76.42	45.91	66.51	60.32	3869	5189	4983	78.19	54.23	72.73	66.77
Epinephelus quoyanus	3			3	2.44			0.25	700			0.45			0.04
Epinephelus rivulatus		12	64	76		2.88	9.88	6.40		705	650		0.46	1.41	0.95
Epinephelus suillus	5	27	26	58	4.07	6.49	4.01	4.89	9687	10559	6851	10.41	15.60	6.03	9.75
Epinephelus tukula		2		2		0.48		0.17		9000			0.98		0.34
Scarus ghobban		2	1	3		0.48	0.15	0.25		2265	4275		0.25	0.14	0.17
Symphorus nematophorus		1		1		0.24		0.08		4087			0.22		0.08
Variola albimarginata		1		1		0.24		0.08		4930			0.27		0.09
TOTAL	123	416	648	1187	100	100	100	100				100	100	100	100

Appendix Table 2.5

Species composition by region for categories
Coral Trout and Chinaman Fish.

CATEGORY: CORAL TROUT	Numbers in sample				% of category by number				mean body weight (g)			% of category by weight			
REGION:	N	O	M	TOTAL	N%	O%	M%	TOTAL%	N	O	M	N%	O%	M%	TOTAL%
SPECIES:															
Gymnocranius griseus			1	1			1.27	1.05			1329			0.48	0.37
Plectropomus maculatus	2	14	78	94	100.00	100.00	98.73	98.95	3732	5250	3535	100.00	100.00	99.52	99.63
TOTAL	2	14	79	95	100	100	100	100				100	100	100	100

CATEGORY: CHINAMAN FISH	Numbers in sample				% of category by number				mean body weight (g)			%of category by weight			
REGION:	N	O	M	TOTAL	N%	O%	M%	TOTAL%	N	O	M	N%	O%	M%	TOTAL%
SPECIES:															
Lutjanus argentimaculatus		1		1		2.27		0.80		5605			3.50		1.13
Lutjanus bohar			2	2			2.53	1.60			3000			1.83	1.21
Lethrinus elongatus		7		7		15.91		5.60		2134			9.32		3.01
Lutjanus lemniscatus		2		2		4.55		1.60		1560			1.95		0.63
Scarus ghobban		2		2		4.55		1.60		2910			3.63		1.17
Symphorus nematophorus	2	32	77	111	100.00	72.73	97.47	88.80	3381	4087	4191	100.00	81.60	98.17	92.84
TOTAL	2	44	79	125	100	100	100	100				100	100	100	100

Appendix Table 2.6

Species composition by region for category Trevally.

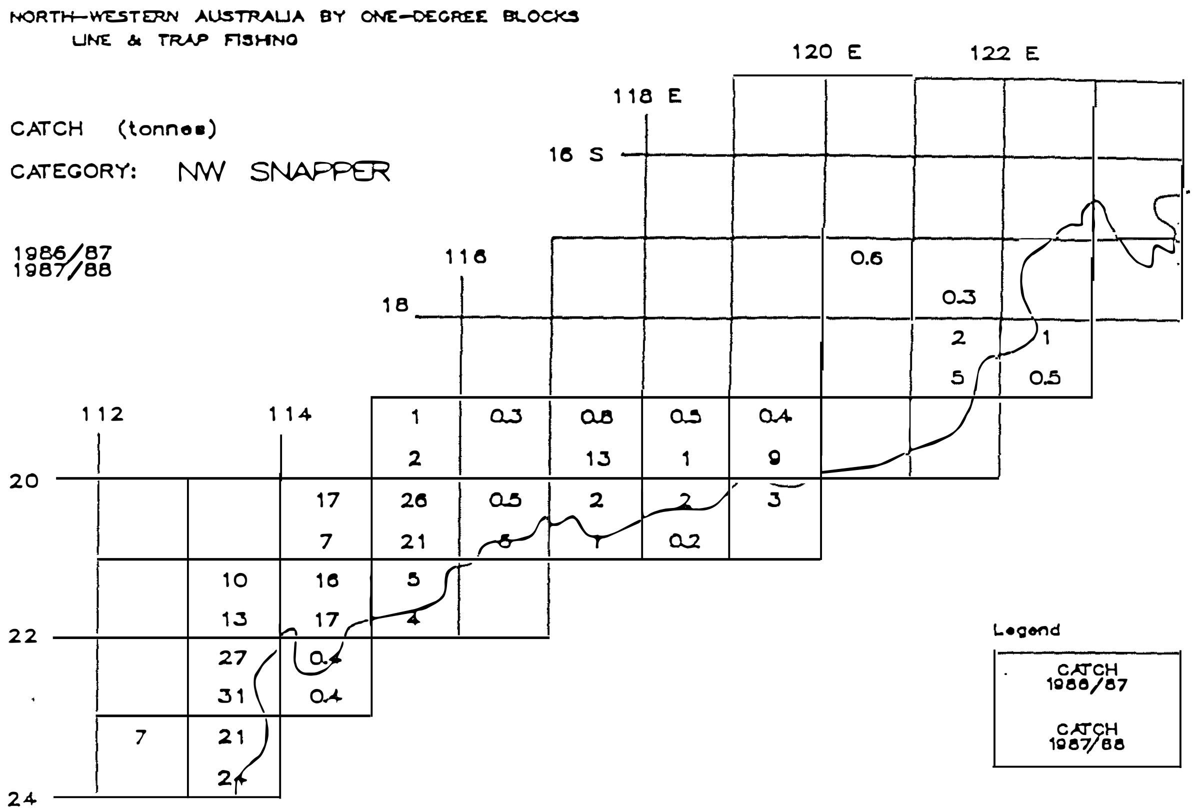
CATEGORY: TREVALLY	Numbers in sample				% of category by number				mean body weight (g)			% of category by weight			
REGION:	N	O	M	TOTAL	N%	O%	M%	TOTAL%	N	O	M	N%	O%	M%	TOTAL%
SPECIES:															
Arius thalassinus			1	1			0.34	0.15			1334			0.12	0.06
Carangoides caeruleopinnatus		12	3	15		3.66	1.02	2.30		752	752		1.00	0.20	0.53
Carangoides chrysophrys		51	14	65		15.55	4.78	9.95		1476	3748		8.30	4.63	6.02
Carangoides fulvoguttatus		7	10	17		2.13	3.41	2.60		4899	7475		3.78	6.60	5.13
Carangoides gymnostethus	16	6	4	26	50.00	1.83	1.37	3.98	1820	2212	902	34.39	1.46	0.32	2.17
Caranx sexfasciatus		8	3	11		2.44	1.02	1.68		3871	9658		3.42	2.56	2.82
Carangidae	15	40	150	205	46.88	12.20	51.19	31.39	3282	2859	3268	58.13	12.61	43.30	30.79
Gnathodon speciosus	1	196	108	305	3.13	59.76	36.86	46.71	6334	3093	4431	7.48	66.86	42.27	51.38
Caranx ignobilis		3		3		0.91		0.46		1344			0.44		0.19
Seriola dumerili		5		5		1.52		0.77		3852			2.12		0.91
TOTAL	32	328	293	653	100	100	100	100				100	100	100	100

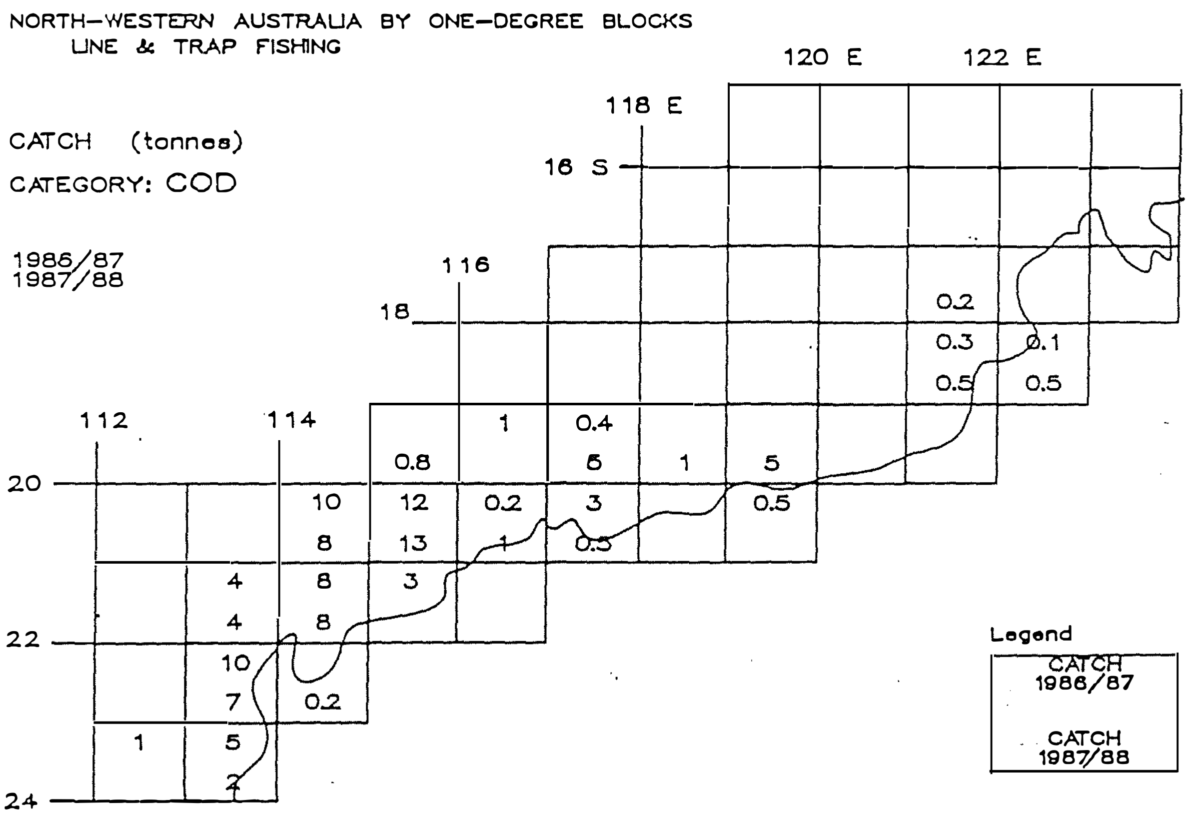
Appendix Table 2.7

Species composition by region for category Mixed Reef Fish.

CATEGORY: MIXED REEF	Numbers in sample				% of category by number				mean body weight (g)			% of category by weight			
REGION:	N	O	M	TOTAL	N%	O%	M%	TOTAL%	N	O	M	N%	O%	M%	TOTAL%
SPECIES:															
Argyrops spinifer		107	33	140		9.93	6.31	8.46		613	528		9.07	4.24	6.46
Arius thalassinus		4	4	8		0.37	0.76	0.48		1775	2168		0.98	2.11	1.23
Bodianus bilunulatus		1	1	2		0.09	0.19	0.12		1088	784		0.15	0.19	0.15
Bodianus perdito	2	37	12	51	3.70	3.43	2.29	3.08	1552	855	767	2.06	4.38	2.24	3.42
Carangoides chrysophrys		15		15		1.39		0.91		658			1.37		0.77
Carangoides fulvoguttatus		2	2	4		0.19	0.38	0.24		415	765		0.11	0.37	0.18
Carangoides sp		4		4		0.37		0.24		1371			0.76		0.43
Caranx sp		1		1		0.09		0.06		1225			0.17		0.10
Cephalopholis sp		1		1		0.09		0.06		1035			0.14		0.08
Cepholopholus sonnerati	3	16	5	24	5.56	1.48	0.96	1.45	1017	1037	1348	2.03	2.29	1.64	2.05
Choerodon monostigma		2		2		0.19		0.12		643			0.18		0.10
Choerodon sp		2		2		0.19		0.12		563			0.16		0.09
Choerodon sp1		20	16	36		1.86	3.06	2.18		728	672		2.01	2.62	1.97
Chrysophrys auratus		1		1		0.09		0.06		2098			0.29		0.16
Decapterus sp		1		1		0.09		0.06		4865			0.67		0.38
Diagramma pictum		22	2	24		2.04	0.38	1.45		1938	1679		5.90	0.82	3.58
Epinephelus areolatus		195	45	240		18.09	8.60	14.50		542	638		14.62	6.99	10.47
Epinephelus bleekeri		1		1		0.09		0.06		1769			0.24		0.14
Epinephelus maculatus		59	57	116		5.47	10.90	7.01		632	899		5.16	12.48	6.89
Epinephelus megachir			1	1			0.19	0.06			811			0.20	0.06
Epinephelus multinotatus			8	8			1.53	0.48			827			1.61	0.52
Epinephelus quoyanus		1	2	3		0.09	0.38	0.18		690	768		0.10	0.37	0.17
Epinephelus rivulatus		50	13	63		4.64	2.49	3.81		605	700		4.18	2.22	3.06
Epinephelus suillus			1	1			0.19	0.06			1535			0.37	0.12
Euthynnus affinis			1	1			0.19	0.06			6133			1.49	0.48
Gnathodon speciosus		3	5	8		0.28	0.96	0.48	615	522	673		0.22	0.82	0.38
Gymnocranius griseus	5	1	5	11	9.26	0.09	0.96	0.66	1101	2660	980	3.66	0.37	1.19	1.02
Gymnocranius robinsoni		2	1	3		0.19	0.19	0.18		747	1109		0.21	0.27	0.20
Gymnocranius sp	1			1	1.85			0.06	570			0.38			0.04
Lethrinus choerorynchus		18	1	19		1.67	0.19	1.15		388	499		0.97	0.12	0.58
Lethrinus chrysostomus		13		13		1.21		0.79		588			1.06		0.60
Lethrinus fraenatus			3	3			0.57	0.18			813			0.59	0.19
Lethrinus mahsena		14	13	27		1.30	2.49	1.63		557	625		1.08	1.98	1.24
Lethrinus miniatus		1		1		0.09		0.06		3121			0.43		0.24
Lethrinus nebulosus		5	7	12		0.46	1.34	0.73		562	608		0.39	1.04	0.55
Lethrinus rubrioperculatus			1	1			0.19	0.06			764			0.19	0.06
Lethrinus variegatus	2		5	7	3.70		0.96	0.42	546		539	0.73		0.66	0.29
Lutjanus carponotatus		28	41	69		2.60	7.84	4.17		795	677		3.08	6.76	3.90
Lutjanus erythropterus		22	2	24		2.04	0.38	1.45		520	490		1.58	0.24	0.97
Lutjanus lemniscatus		9	8	17		0.83	1.53	1.03		929	1044		1.16	2.03	1.30
Lutjanus malabaricus		5		5		0.46		0.30		503			0.35		0.20
Lutjanus russelli	8	139	96	243	14.81	12.89	18.36	14.68	1178	733	709	6.26	14.09	16.58	13.97
Lutjanus vittus		239	95	334		22.17	18.16	20.18		348	546		11.50	12.63	10.52
Mullidae		4		4		0.37		0.24		576			0.32		0.18
Myripristis melanostictus		2		2		0.19		0.12		426			0.12		0.07
Nemipteridae		1		1		0.09		0.06		522			0.07		0.04
Nemipterus furcosus		4	18	22		0.37	3.44	1.33		438	445		0.24	1.95	0.76
Nemipterus peronii		1	3	4		0.09	0.57	0.24		434	468		0.06	0.34	0.14
Pentapodus emeryii		1		1		0.09		0.06		497			0.07		0.04
Parupeneus pleurotaenia		4	2	6		0.37	0.38	0.36		554	492		0.31	0.24	0.25
Pristipomoides typus	9			9	16.67			0.54	1936			11.58			1.36
Platax batavianus		1		1		0.09		0.06		2329			0.32		0.18
Pristopomoides multidens	15		3	18	27.78		0.57	1.09	2561		3190	25.53		2.33	3.74
Seriola hippos	5			5	9.26			0.30	8887			29.54			3.46
Sargocentron rubrum			2	2			0.38	0.12			316			0.15	0.05
Scaridae		1		1		0.09		0.06		544			0.08		0.04
Scarus ghobban		6	6	12		0.56	1.15	0.73		1289	3259		1.07	4.76	2.13
Scolopsis monogramma		2	2	4		0.19	0.38	0.24		552	536		0.15	0.26	0.17
Scolopsis taeniopterus			1	1			0.19	0.06			720			0.18	0.06
Scomberomorus commerson		3		3		0.28		0.18		7143			2.96		1.67
Sphyraena sp	4	1		5	7.41	0.09		0.30	6857	6384		18.23	0.88		2.63
Symphorus nematophorus		6		6		0.56		0.36		4419			3.67		2.06
Shark		1	8	9		0.09	1.53	0.54		1995	2420		0.28	4.71	1.66
TOTAL	54	1078	523	1655	100	100	100	100				100	100	100	100

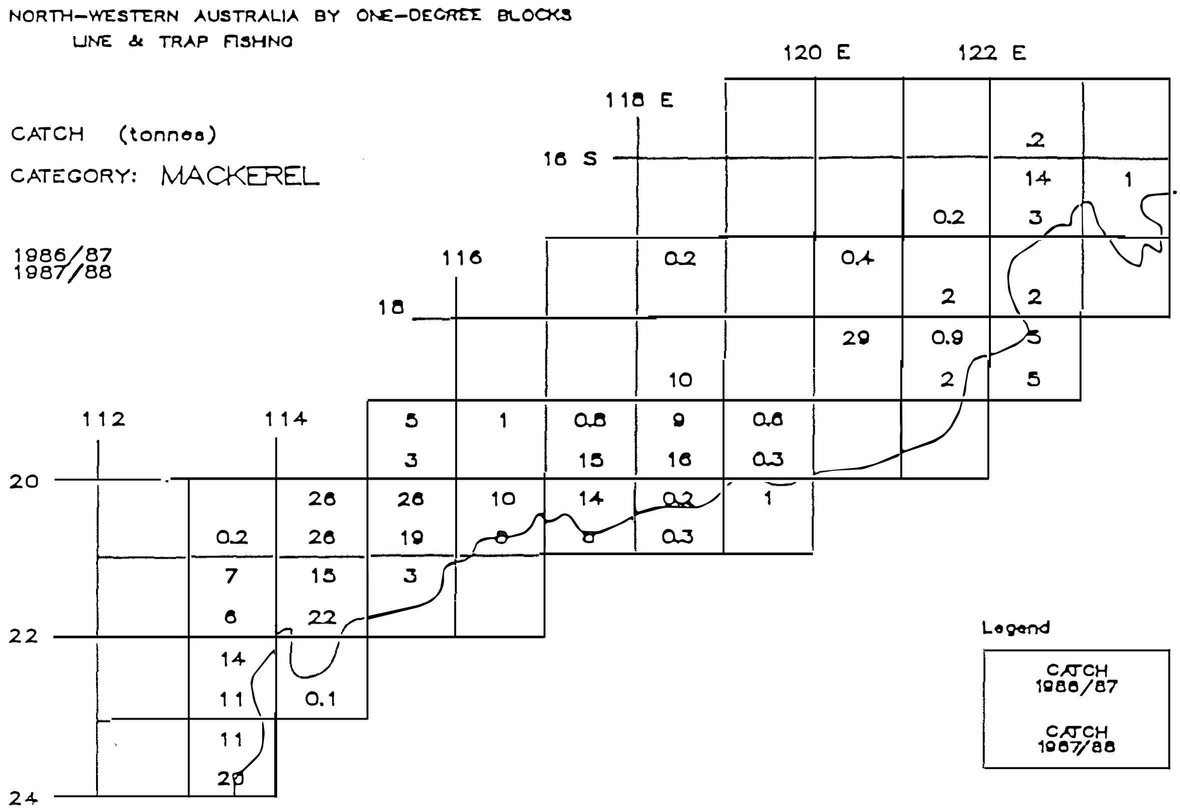
APPENDIX 3. Commercial catch figures by block and year for the major species categories in the NW trap and line fishery. (1987/88 figures are preliminary).

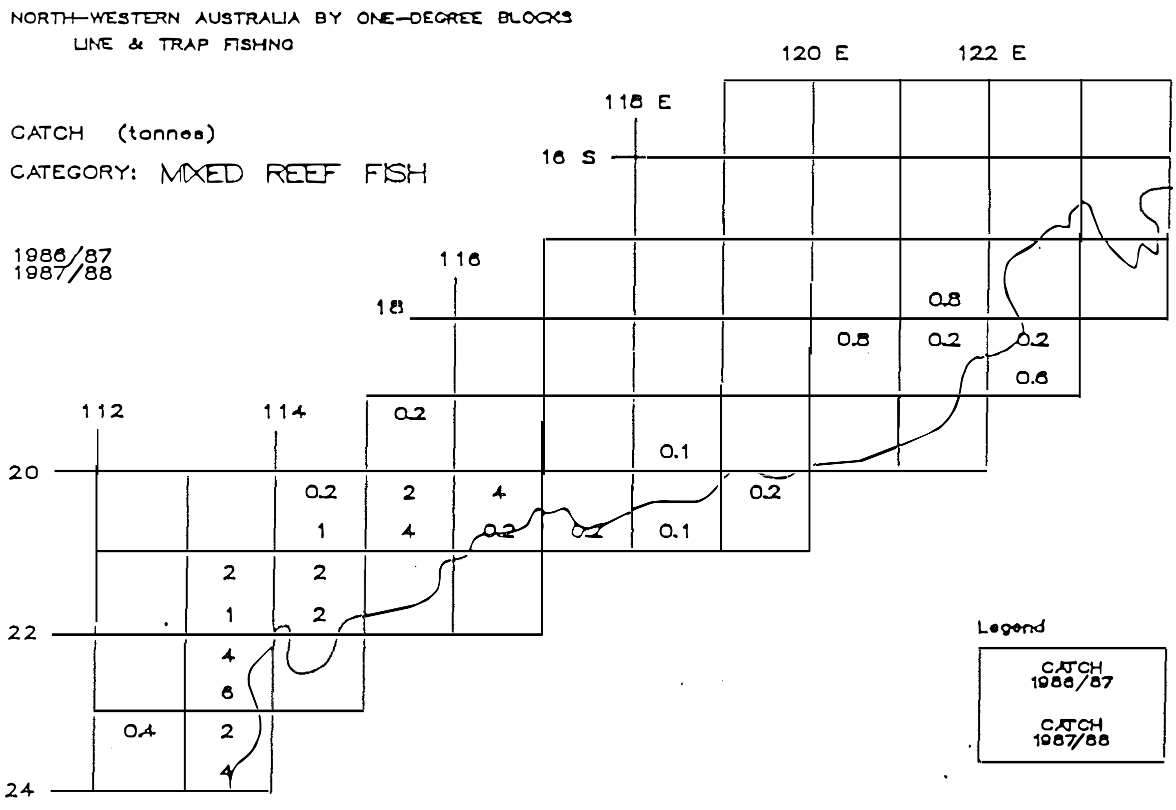




Appendix Fig 3.1

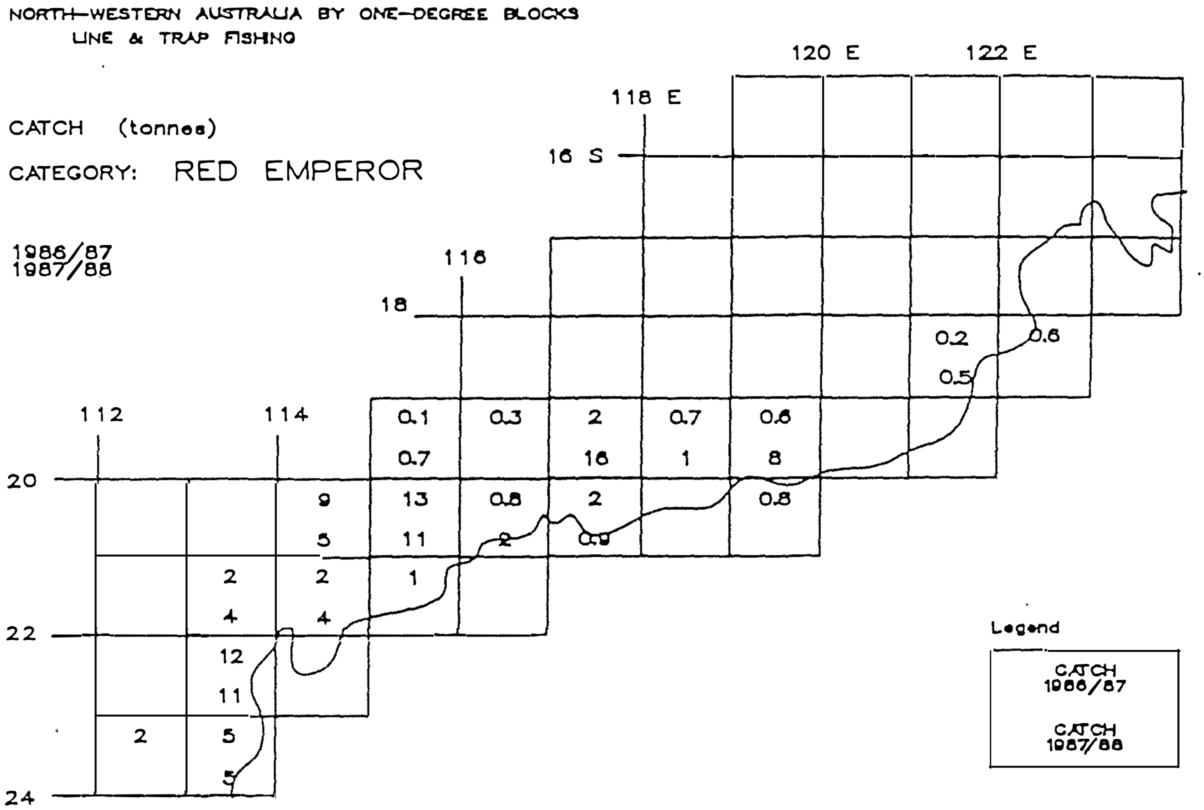
Commercial catch of NW Snapper and Cod categories by block, in the trap and line fishery on the NW shelf:1986/87 and (preliminary) 1987/88.

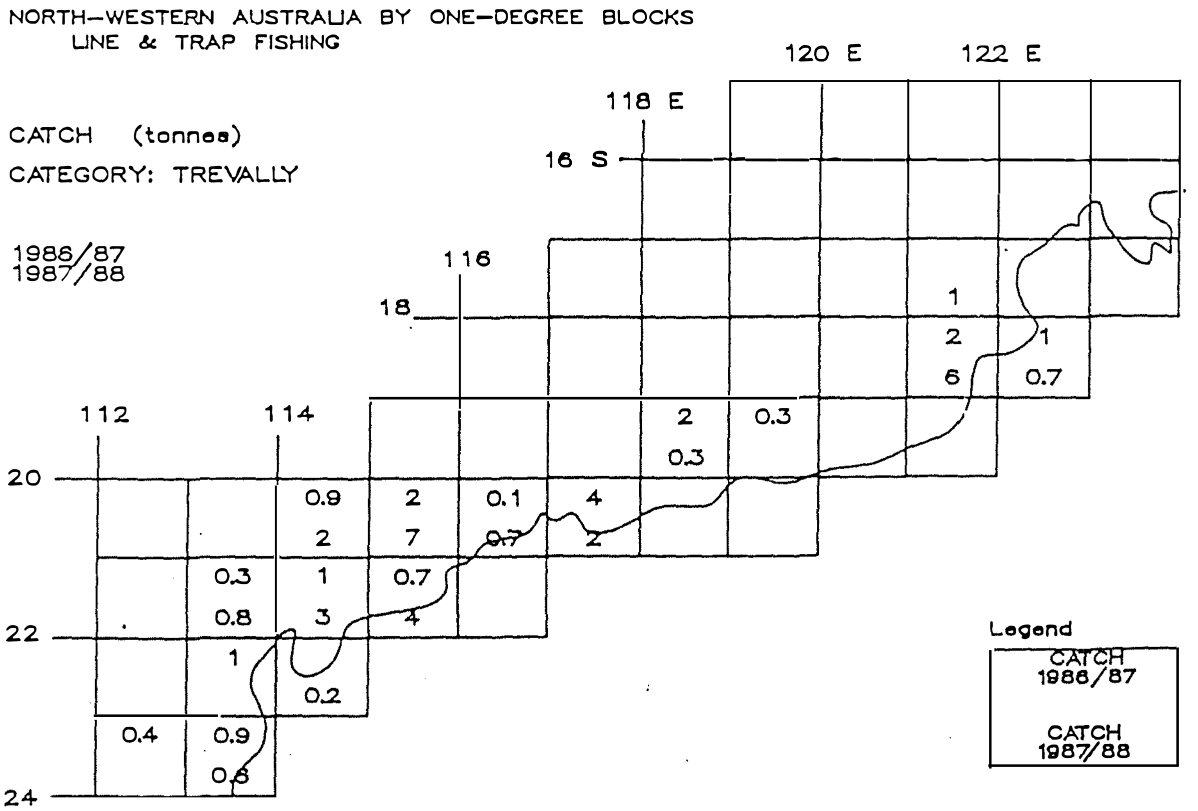




Appendix Fig 3.2

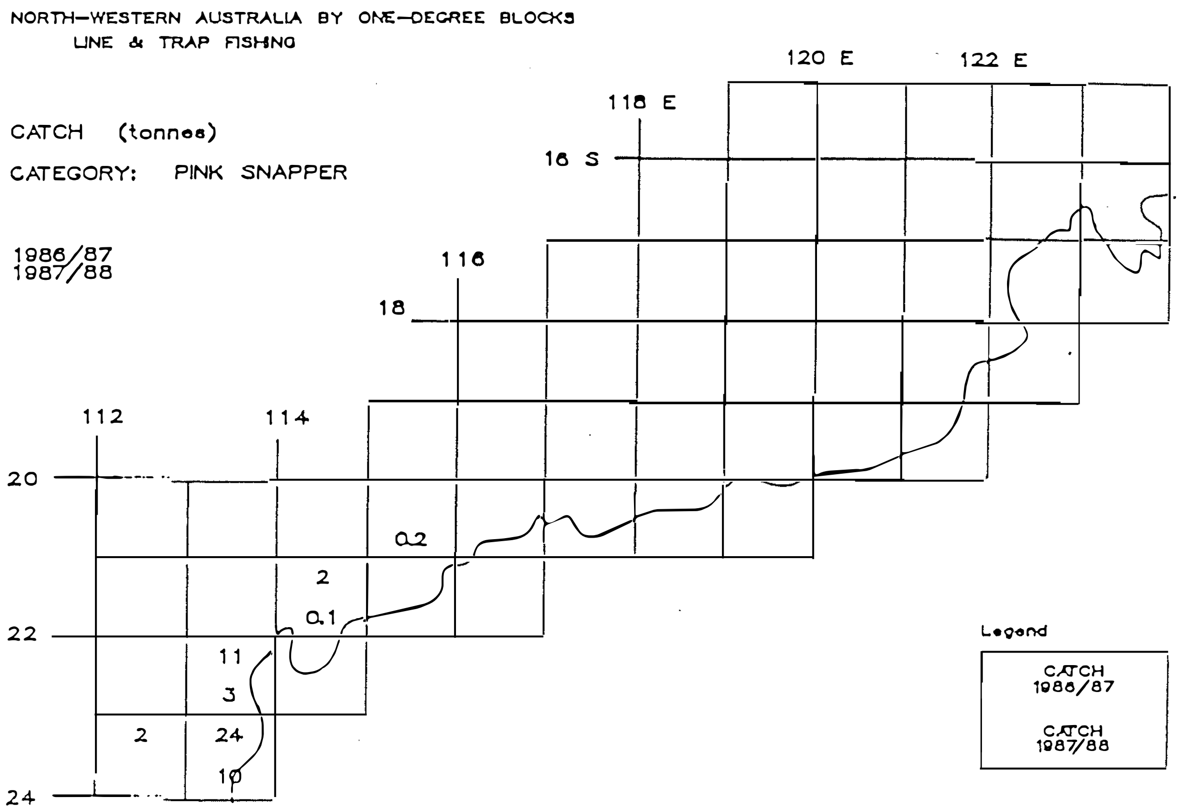
Commercial catch of Mackerel and Mixed Reef categories by block, in the trap and line fishery on the NW shelf: 1986/87 and (preliminary) 1987/88.

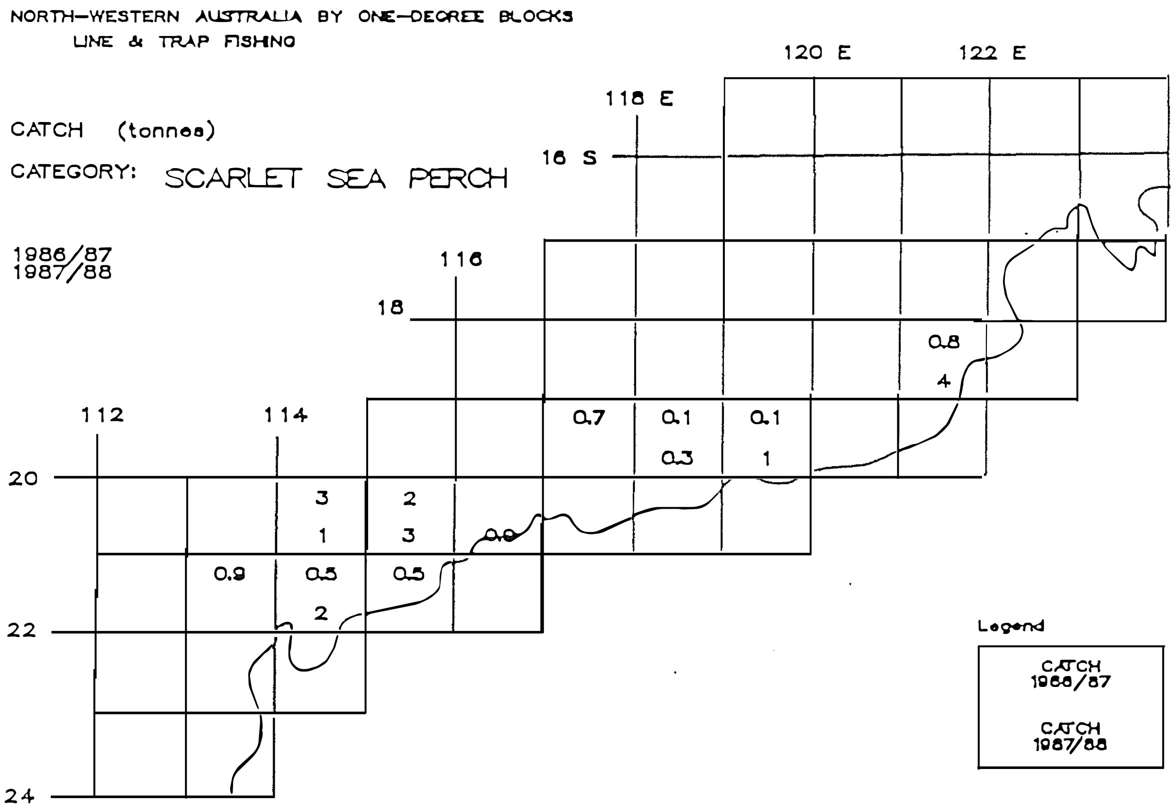




Appendix Fig 3.3

Commercial catch of Red Emperor and Trevally categories by block, in the trap and line fishery on the NW shelf:1986/87 and (preliminary) 1987/88.





Appendix Fig 3.4

Commercial catch of Pink Snapper and Scarlet Sea Perch categories by block, in the trap and line fishery on the NW shelf:1986/87 and (preliminary) 1987/88.

APPENDIX 4.

Table 4.1 Prices per Kg of various categories in the NW trap and line fishery for 1988. Condition is gutted and gilled except where stated otherwise.

CATEGORY	PRICE /Kg
Red Emperor	$4.70
Scarlet Sea Perch	$2.50
NW Snapper	$2.30
Cod (head off)	$2.70
Small whole cod	$2.50
Mixed Reef	$1.80
Trevally (head off)	$1.50
Mackerel (head off)	$3.00
Chinaman Fish	$1.50