Research for Allocation of North-West Marine Finfish resources among Diverse User Groups

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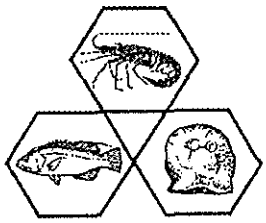

FISHERIES DEPARTMENT
OF WESTERN AUSTRALIA

FISHERIES
RESEARCH &
DEVELOPMENT
CORPORATION

Project 91/28

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INTRODUCTION

The Australian marine finfish industry exploiting demersal scalefish in the north west shelf operated at a very low level, using handline only, until the introduction of trapping in the mid-1980s. Recreational fishing also intensified in the 1980s, being particularly heavy in the Shark Bay and Ningaloo regions and Dampier Archipelago. This period also saw increasing interest in conservation with one marine park declared and several others proposed.

During the 1980s the Taiwanese pair-trawl fishery on the NW Shelf gradually reduced its effort and the area where foreign trawling was permitted was progressively reduced by the Commonwealth Government as Australian interest in using the tropical finfish resource developed. Initially, fish trapping was introduced to the NW Shelf by Shark Bay Snapper fishermen but was soon adopted by local handline fishermen. Subsequently, prawn trawl fishermen on the Pilbara coast saw the potential for fish trawling using modified prawn trawl vessels. Throughout this period, a number of charter boat operations had continued, usually working as commercial handline boats when there were no charters.

Commercial fishing of the Australian North-west Shelf began in the early 1960s with a Japanese stern trawl fishery targeted on lethrinids in the area north of Dampier. The lethrinid stocks were depleted in a few years and the fishery ceased. A Taiwanese pair-trawl fleet began fishing in the early 1970s over a wider area but with the centre of fishing effort again north of Dampier and retaining a much wider range of species (Jernakoff and Sainsbury, 1990). The pair-trawl fishery peaked in both catches and fishing effort in the early 1970s and its access to the grounds was progressively restricted over the period 1986-1990 after which foreign fishing on the NW Shelf ceased.

Australian vessels began trapping on the NW Shelf in 1984 and stern trawling in 1989. The trawl fishery has since expanded rapidly. As the commercial finfish fisheries developed and intensified, the Western Australian Government moved to limit the number of licences for each fishery.

In managing the trap and trawl fisheries, some protection has been given to the inshore areas which are more accessible to recreational, charter and commercial handline fishing through inshore closures. Nevertheless, sources of conflict are generally perceived by the less efficient recreational, charter and commercial handline

fishers against the more efficient trap and trawl methods. Concerns that have been expressed include:

- that trap and trawl fishing are over-exploiting species and localities important to recreational fishing;

- that traps and trawls destroy the habitat, and thence the fishing;

- that prawn trawlers catch and trash juveniles of important recreational and commercial species;

- that traps and fish trawls catch juveniles of important species;

The objectives of this project were to provide information to managers for rational allocation of access to the marine finfish resources of NW Australia. The management aims are to minimise conflict between user groups; maximise efficiency and viability of the industry; and ensure sustainablility by limiting the impacts of fishing on the stocks and their supporting environment. Specifically, this project aimed to:

1. Estimate the degree of overlap in resource usage among the diverse commercial and recreational user groups of the north-west marine finfish stocks.

2. Relate the degree of damage sustained by the habitat, to the level of trawling or trapping effort, using standard and "low-impact" gear designs.

3. Investigate the distribution of juveniles of major species, and the vulnerability of juveniles to the various gear types.

The date set for completion of the project was 30 June 1994 and all of the actual data gathering was complete by that time. A number of factors have however affected the time to finalise this report. The research scientist in charge of the project was transferred to a policy position in the Fisheries Department in late June 1994 and has had limited time available to devote to analysis and writing up. Objective 2 required development of new techniques using underwater video in the field and in analysis of the video material back in the laboratory. Development of these techniques has of necessity continued after the end of the project period. Interaction between the project leader and managers of the fisheries involved has, however, occurred throughout the

project and results have been used in the management of the fisheries as they became available.

Interim results of this project have led to the timely identification of the need for specific projects on the relationship between fish trawl effort and fishing mortality to enable management to prevent serious overfishing in the Pilbara trawl fishery; and to gather the basic data on the resource in the Kimberley demersal fishery.

This project did not attempt to study the developing Australian shark fishery in the north-west, nor the troll fishery for spanish mackerel and related pelagic species.

It is anticipated that the results of the project will be formally published in full detail as a series of Western Australian Fisheries Department research reports.

OVERLAP IN RESOURCE USAGE AMONG THE DIVERSE COMMERCIAL AND RECREATIONAL USER GROUPS OF THE NORTH-WEST MARINE FINFISH STOCKS

INTRODUCTION

There has been in the past, and continues to be, a perceived overlap in the use of demersal finfish resources in the northern half of Western Australia which the users of the less powerful fishing methods see as being to their detriment. Recreational fishers generally view all commercial fishermen as responsible for catches not being as good as they used to be. They focus especially on trap and trawl fishing which they see as being destructive to habitat as well as taking large quantities of fish, and on prawn trawling which they are aware incidentally takes small fish of a variety of species which they assume are juveniles of their target species. Many commercial line and charter operators share the recreational fishers' views of trapping and trawling.

An objective of this project is to provide factual data on overlap between user groups in terms of species fished and areas fished. We were also seeking evidence of downstream effects, for example one user group taking young fish which, if they were allowed to survive, would form a major part of the catch of another user group.

The methods used were analysis of logbooks and monthly fishing returns of commercial operators; interviews with recreational fishers; and sampling of catches both for species and size composition. The area studied was the extensive coastline between Shark Bay and Broome.

Previous work on the major finfish species had established that, although there was evidence that adults of major species tended to remain in a particular locality, there was no evidence that any of the species was divided into smaller stocks in the genetic sense (Johnson et al. 1993). This means that unless different user groups are actually fishing the same grounds, they are probably not competing directly with each other for adult fish. However, if any group depletes a population of fish to the extent that the reproductive output of that population is seriously reduced, any consequent reduction in recruitment of young fish is likely to affect all users, whether or not they are fishing the same grounds.

The results are presented by region as direct effects of competition for the resource are likely to be confined to within a region. The regions are:

Shark Bay	23°30'S to 26°30'S
Ningaloo	23°30'S to 114°E
West Pilbara	114°E to 116°E
East Pilbara	116°E to 120°E
Kimberley	120°E to 129°E

SHARK BAY REGION

The major demersal finfish resource in the Shark Bay region, 23°30'S to 26°30'S, (Fig. 1.) is the pink snapper, *Pagrus auratus*. A commercial fishery has focussed on this species at least since the 1950s and large catches of snapper are mentioned in the early exploration reports and throughout the written history of Shark Bay. There is an unusual situation whereby the truly marine stock of snapper is a separate breeding stock from the stocks in the inner gulfs of Shark Bay (Johnson et al., 1986). The commercial fishery on the marine stock has been managed as a limited entry fishery since 1987 and the catch limited by partial quota management since 1988. The commercial snapper fishery has been stable since the introduction of quotas with annual catches of 500-530 tonnes.

The snapper fishery began as a seasonal (winter) handline fishery on breeding aggregations close to the mainland and the islands which bound Shark Bay. Trapping for snapper was started by rock lobster fishermen in 1959 and has been controversial for decades. The (non-transferable) permits to trap snapper were limited when the management of the fishery began in 1987 and, with licence transfers, the number of boats permitted to trap has fallen to one. The one boat permitted to trap does not do so, as the premium quality snapper required by the export market cannot be produced by trapping. The commercial fishery is now a mechanised handline fishery.

Other major demersal species taken in the commercial line fishery are lethrinids (sweetlip emperor, *Lethrinus miniatus*; spangled emperor, *L. nebulosus*; and lesser spangled emperor, *L. choerorynchus*); serranids (Estuary cod, *Epinephelus coioides*; and rankin cod, *E. multinotatus*); lutjanids (red emperor, *Lutjanus sebae*) and a variety of carangids (trevally). The recreational and charter fisheries take the same species, in similar proportions. Although they also take mainly pink snapper, there is

overlap in species with these fisheries and virtually none with the recreational small boat fishery. It has no overlap in terms of area worked. While there is some concern about the trawler from recreational fishers, this is based on misunderstanding at seeing the trawl catch unloaded over the beach at Coral Bay rather than any real source of conflict.

There is plentiful anecdotal evidence that the recreational fishery inside Ningaloo reef is nowhere near as good as it used to be. Apparently a decade or so ago, one could catch a bag limit of large spangled emperor within half an hour on virtually any evening. Now only a small proportion of people take their daily bag limit. However, the recreational fishing there now is still excellent by most standards.

Of greater concern is the possible depletion of the nearshore stocks on the continental shelf outside the reef by fish trapping in the late 1980s. While the evidence for this is not conclusive, it is worth bearing in mind in considering long-term access for fish trapping in this area where the continental shelf is narrower than anywhere else on the WA coast.

WEST PILBARA

The west Pilbara region, 114 - 116° E, contains Zone 1 of the Pilbara Trap Fishery (Fig 9). Trap fishing began in this area in 1984 as an offshoot of the Shark Bay snapper fishery and rapidly took over from commercial line fishing as the major finfish fishery. The trap boats operated in a similar manner to the line boats before them. The skipper would look for promising ground with his echo sounder; this meant hard bottom, preferably a lump or ledge which provided the vertical relief to attract reef fish; he would fish there for a few hours or days until the catch rates fell, then look for another lump.

The area from NW Cape up to Rankin Bank has many lumps and edges and patches of hard ground, but a much greater area of poor ground where aggregations of fish worth line or trap fishing are not found. The trap fishery continued at a steady level through the mid 1980s then saw a big increase in catch and effort for a few years before falling to a low level. Many fishermen virtually stopped fishing or moved on to more easterly regions and generally considered the trapping grounds depleted. The introduction of limited-entry management came after the peak and subsequent decline in trap fishing.

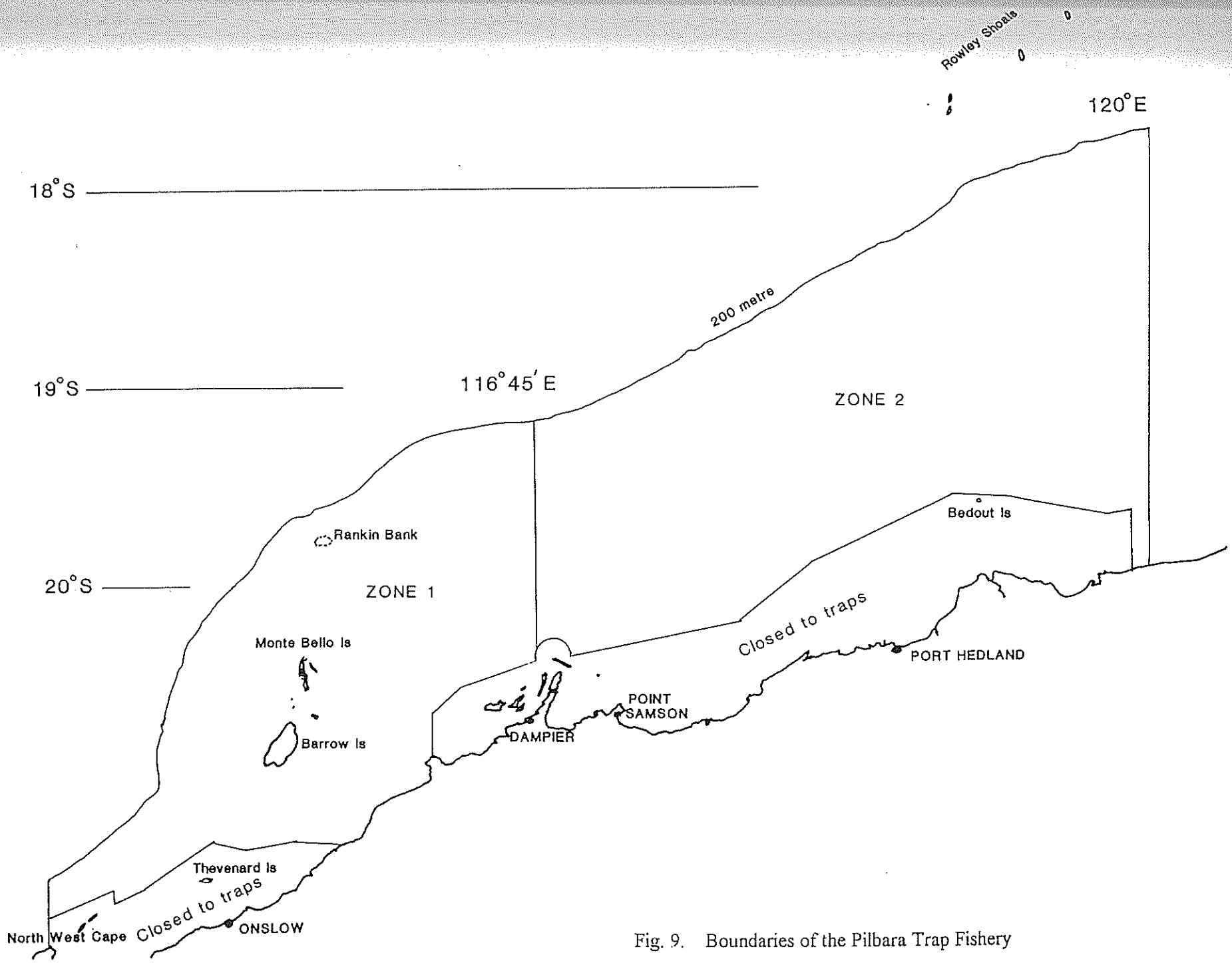
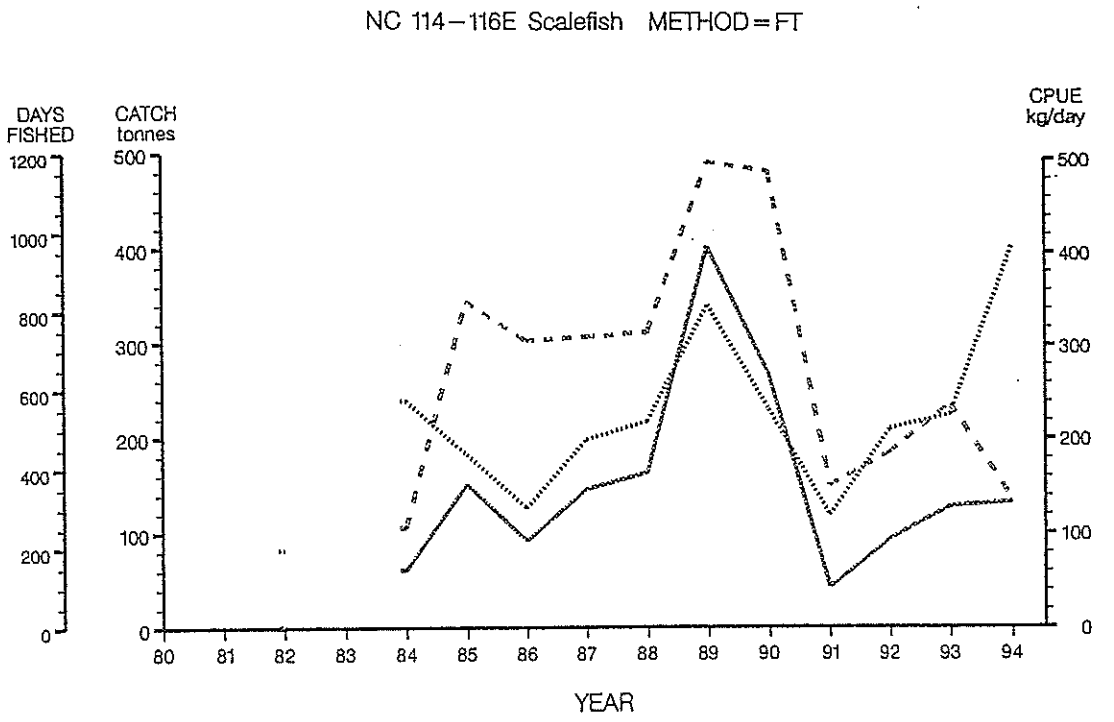
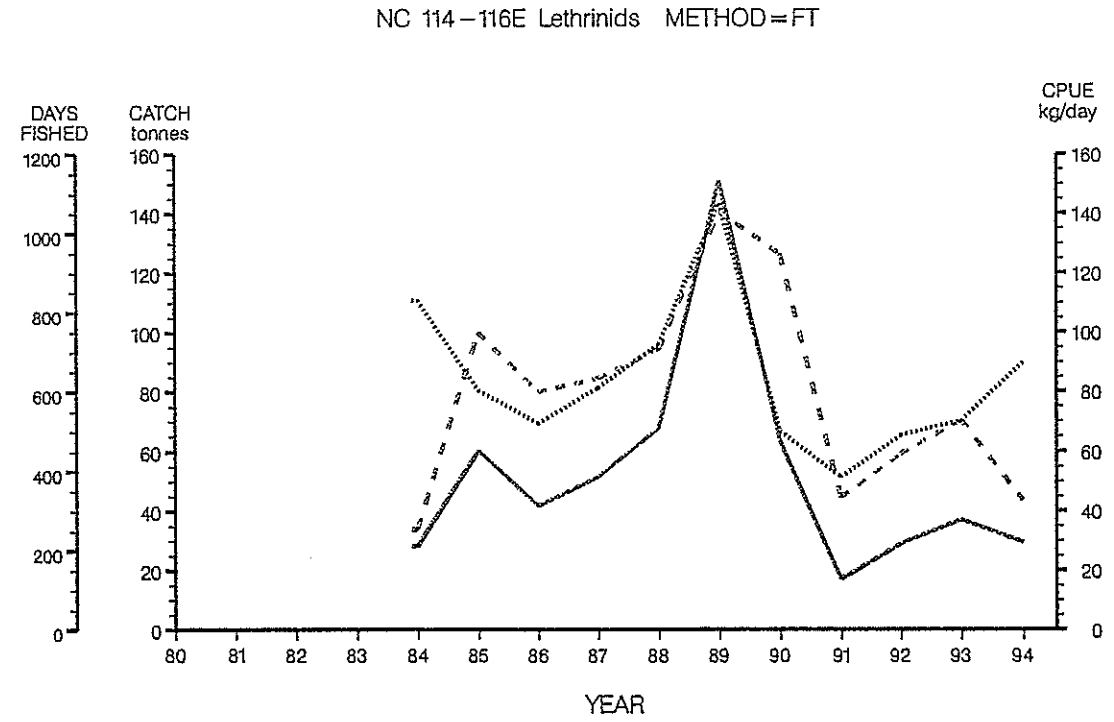


Fig. 9. Boundaries of the Pilbara Trap Fishery





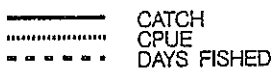


Fig. 10. Time series of catch / effort by fish trap, West Pilbara: all fish and lethrinids

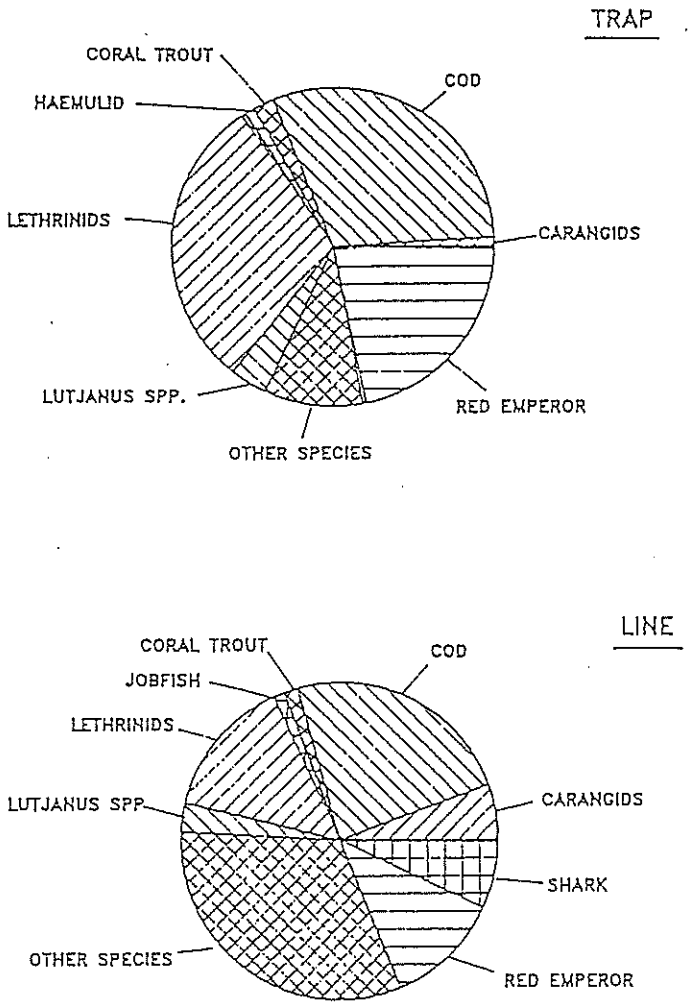


Fig 11. Comparison of species composition of the trap and line catches, West Pilbara, 1990.

PILBARA TRAP 114-116E

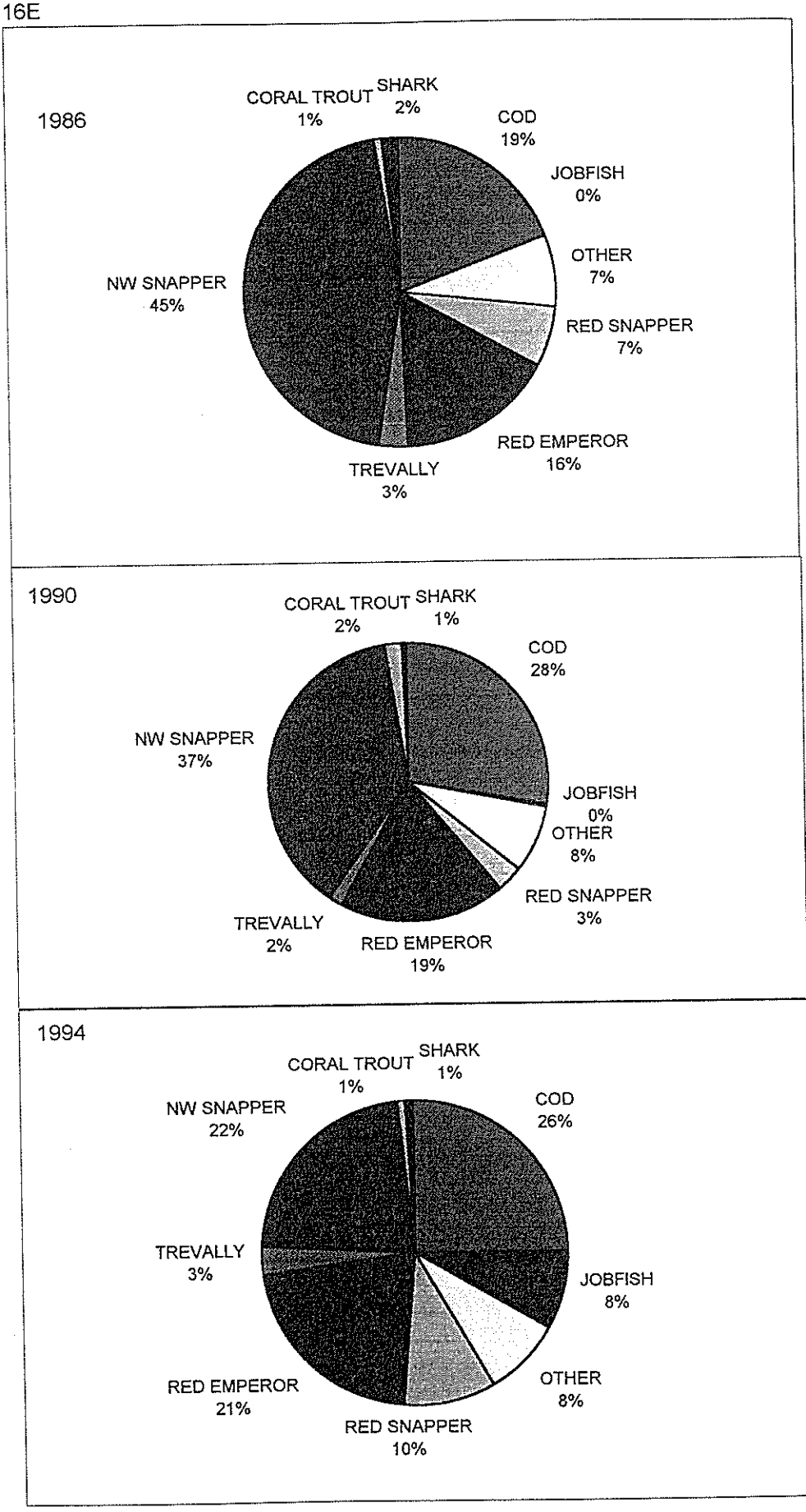


Fig 12. Species changes through time. West Pilbara.

Both Onlsow and Exmouth had trap boats and charter/commercial line boats in the mid to late 1980s, with Onslow being the main trap centre and Exmouth the main charter boat centre. Charter boat owners have generally viewed trap boats as potentially or actually over-depleting the demersal fish resource, though a few charter boats switched to trapping for a time. The two groups fish the same type of ground and take the same species of fish. Now there is little fish trapping out of Exmouth and the grounds between 114 and 115°E are worked mainly by the charter/commercial line boats while the grounds between 115° and 116°E are worked more by trap than charter boats. The main species are large spangled emperor, *Lethrinus nebulosus*, red emperor *Lutjanus sebae* and rankin cod *Epinephelus multinotatus*. Smaller species of lethrinids, lutjanids and serranids are also important
in the catch and as in Shark Bay, greater catches of *Lethrinus choerorynchus* could probably be taken if there was sufficient market demand.

There is an inshore closure to trap fishing to protect the line fishers from competition by the trapping boats (Fig 9). Inside this closure are the islands which run in a chain from NW Cape up to Barrow Island. In addition to the charter boats, recreational fishers in small boats fish around these islands from both Onslow and Exmouth, with one island (Thevenard) having a holiday camp where recreational fishers stay. The recreational catch is the same in species composition to the charter and commercial line fishing catch. The trap boats catch the same species but also catch some large lutjanids such as *Lutjanus malabaricus*, *L. erythropterus* and *Pristipomoides multidens* (jobfish).

The trap fishery went through a peak in catch and effort in the late 1980s. This was followed by a number of the fishers leaving to work in other fisheries, such as trapping farther north. There was a change in species composition from the first years of the trap fishery, with *L. nebulosus* becoming much less abundant (Fig 12). It is very likely that there was overfishing for the larger species during this period. The Fisheries Department is currently addressing the issue of excess latent and actual effort in the Pilbara trap fishery. The trap fishers have always combined some trolling for spanish mackerel with their trap fishing. There has been a trend in recent years to also dropline for jobfish in the deeper water as occurs in the Timor Box area in Northern Territory waters.

Fish trawling by Australians on the NW Shelf began in the West Pilbara region. In the early 1980s when the Exmouth Gulf prawn fishery had a depleted tiger prawn

stock, the boats in that fishery were encouraged to diversify into fish trawling. The gear used was modified prawn nets and the species composition was dominated by small species such as nemipterids. At that time there was very little overlap between the species composition of fish trawls and that of any other demersal fishing methods. The amount of fish trawling at that time was small and did not persist after 1983.

When fish trawling re-emerged in the late 1980s, one boat was permitted to work the grounds west of 116°E and it was restricted to a narrow longitudinal strip to reduce conflict with the trap fishery (Fig 13). The gear used this time was proper fish trawl nets and a prawn trawler was modified extensively for fish trawling. The species composition had a much greater overlap with that of line and trap fishers than did the early fish trawling attempts, though there were species in the trawl catch such as javelin fish *Pomadasys kaakan* which were not caught by other methods.

There is an intensive prawn trawl fishery in Exmouth Gulf with some stocks extending outside the management boundary to be taken by trawlers from Onslow. Sampling of the trawl bycatch in Exmouth Gulf did not show any significant quantity of commercial fish species important to the commercial or recreational demersal finfish fisheries.

EAST PILBARA

The eastern part of the Pilbara zone of the NW Shelf extends from 116 to 120°E. The major finfish fishery in this area is the Pilbara trawl fishery. There are two full time trawlers and 10 prawn trawlers from the Nickol Bay prawn fishery which currently have six months access per year to the fish trawl fishery. All of these boats are modified for fish trawling with proper fish trawl nets. There is a maximum boat size of 375 boat units and there has been a progressive replacement of the smaller trawlers used in the Nickol Bay prawn fishery with large boats formerly in the Northern Prawn Fishery which are at or close to this size limit.

There is an inshore boundary to fish trawling near the 50 m depth contour, and an inshore boundary to trapping which approximates the 30 metre contour. Thus the inshore area is reserved for commercial and recreational line fishing, the 30 to 50 metre zone for trap and line fishing. The trawl fishery currently works to about 100 metres depth.

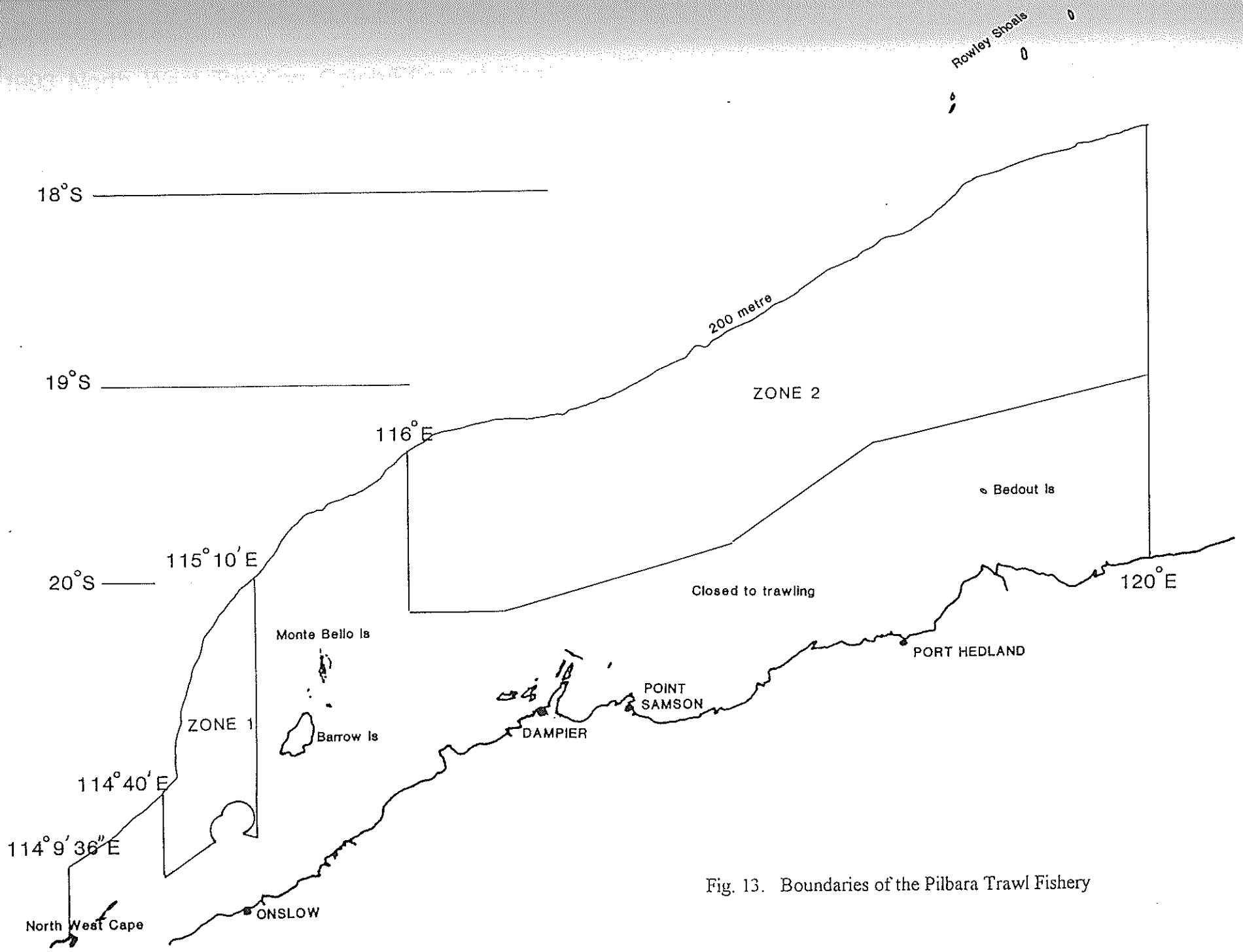


Fig. 13. Boundaries of the Pilbara Trawl Fishery

Table 1. Finfish catches by method on the NW Shelf off the Pilbara and Kimberley coasts, 1985 to 1993.

CATCH (tonnes)

PILBARA (west of 120°E)

YEAR	LINE	TRAP	TRAWL	TOTAL DEMERSAL	SCOMBRIDS (TROLL)
1985	165	170	7	342	132
1986	58	111	8	177	85
1987	58	189	12	259	116
1988	110	274	15	399	74
1989	81	456	133	670	113
1990	147	402	454	1003	208
1991	197	120	795	1112	191
1992	262	148	1355	1757	115
1993	159	122	1591	1872	157

KIMBERLEY (east of 120°E)

YEAR	LINE	TRAP	TRAWL	TOTAL DEMERSAL	SCOMBRIDS (TROLL)
1985	10	4	0	14	99
1986	9	1	0	10	79
1987	29	0	0	29	50
1988	10	11	1	22	116
1989	24	27	4	55	100
1990	6	204	4	214	102
1991	26	318	0	344	231
1992	55	686	0	741	172
1993	31	737	10	778	340

Fig. 14 1993 North West Trawling Catch/Effort of Fleet

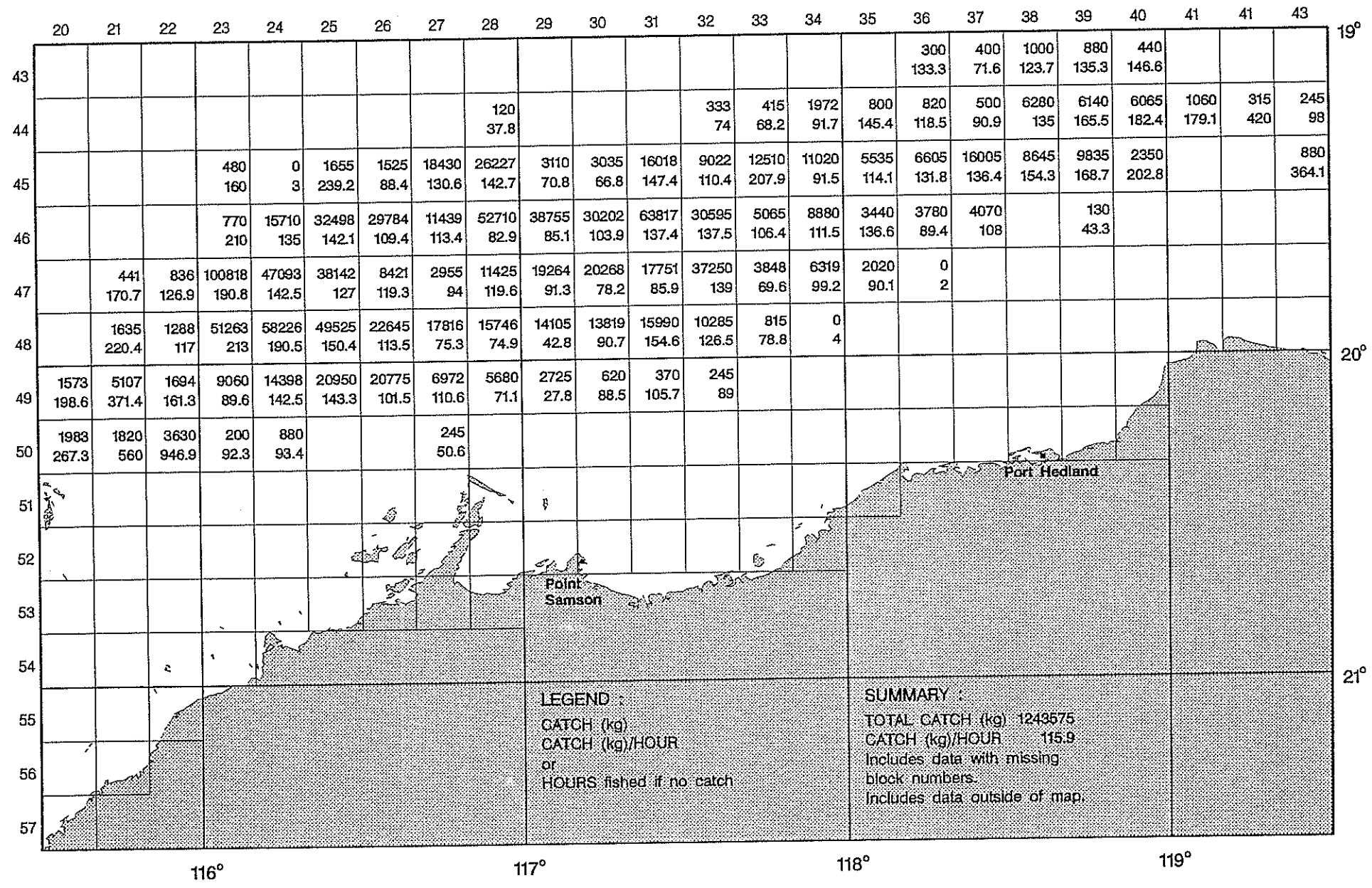


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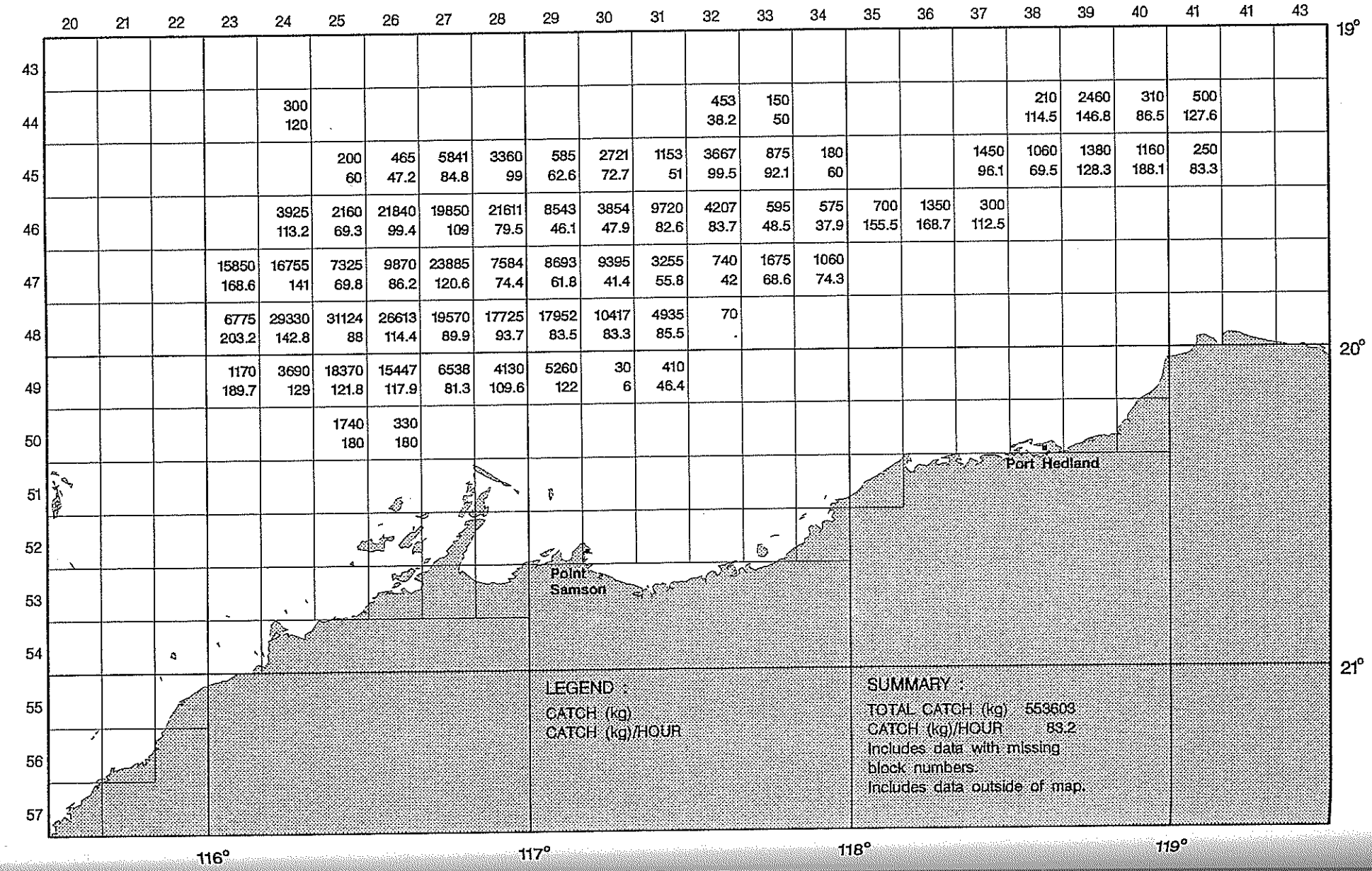
Fig. 15 1992 North West Trawling Catch/Effort of Fleet



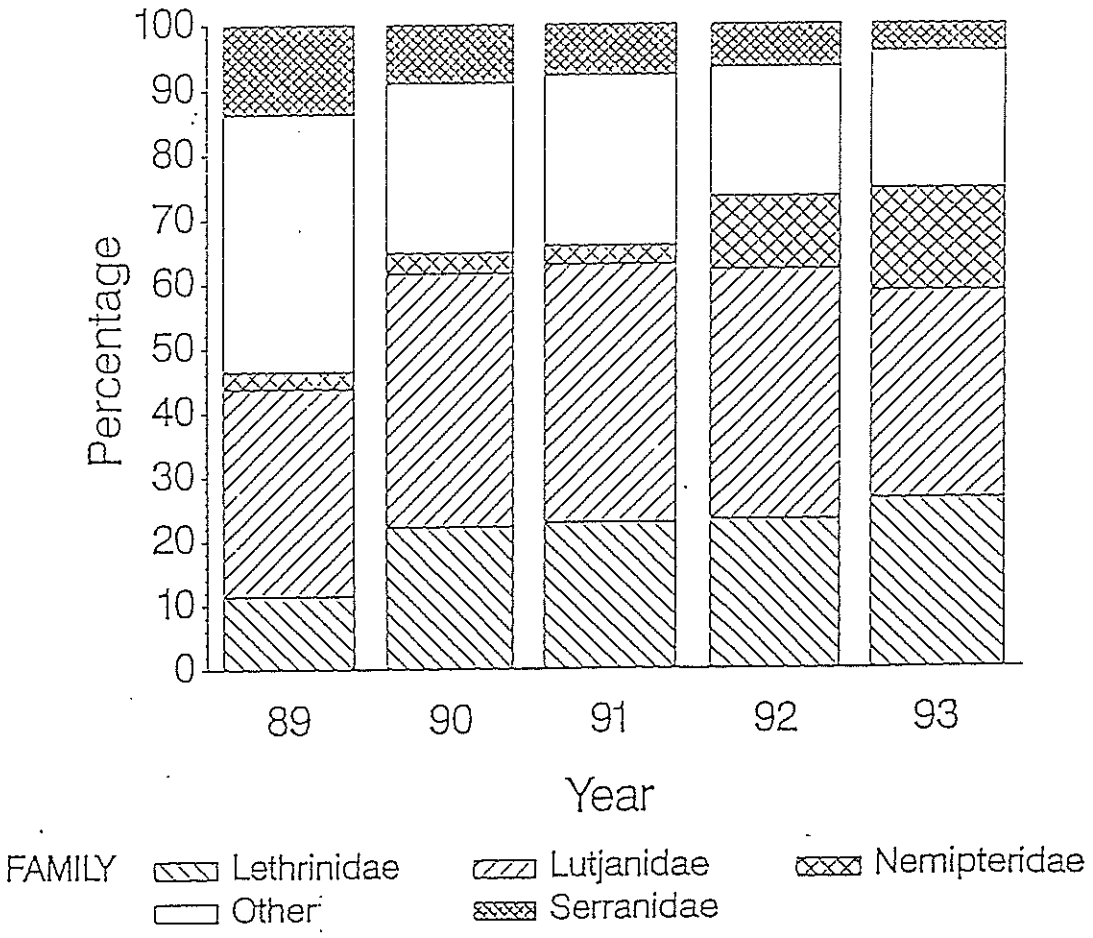
Prior to the development of the trawl fishery there was some fish trapping. A number of the Nickol Bay prawn fleet tried fish trapping but generally found their boats unsuitable and only one trawler persisted. Recently there has been no trapping from Point Samson in the area between 116 and 118°E where the trawl fishery has concentrated but a small number of trap and commercial line boats have worked out of Port Hedland in the area between 118 and 120°E, mainly on grounds near Bedout Island but also on patches of good trapping habitat near the inner boundary of the trawl fishery near the 50 m depth contour.

The fish trawlers take all of the species taken by the trap and line fisheries. In the early years of the Australian trawl fishery the species retained and targeted were almost completely the same as those taken by the trap fishery. In the last few years, however, marketing of the smaller species such as threadfin bream *Nemipterus furcosus* and small species of lethrinids and lutjanids such as *Lethrinus choerorynchus*, *L. lentjan* and *Lutjanus vittus* has improved and the trawl fishery now retains almost all of its catch of these species. The trawl fishery takes much greater quantities than the trap and line fisheries of the species taken by those fisheries. It is very likely that the trawl fishery, with only partial dependence on the reef fish, has out-competed trap and line boats on the grounds trawled most heavily between 116 and 118°E.

The recreational fishery in the Dampier Archipelago is probably one of the most intensive in the north-west. The Dampier-Karratha area is said to have the highest rate of boat ownership in Western Australia. Boats are launched mainly from ramps in Dampier harbour but many are also launched at Point Samson. The many islands and reefs in the area make this region an angler's paradise. As in Shark Bay and Ningaloo, local people provide anecdotal evidence that the fishing was much better a decade or so earlier. The species composition is very varied, dominated by lethrinids, lutjanids and serranids but noticeably different from Ningaloo in having a higher proportion of the prized coral trout *Plectropomus maculatus*. There is a small and variable charter fleet. Probably chartering is less popular than at Exmouth and Shark Bay because this area is less of a tourist destination and the residential fishers have their own boats or a friend with a boat.

The recreational fishery out of Port Hedland is much smaller than that in the Dampier Archipelago and there is no permanent charter boat fleet. Nevertheless, the reefs are highly valued by the local recreational fishing population.

Fig. 16. Changes in species composition of the Pilbara trawl catch through time.



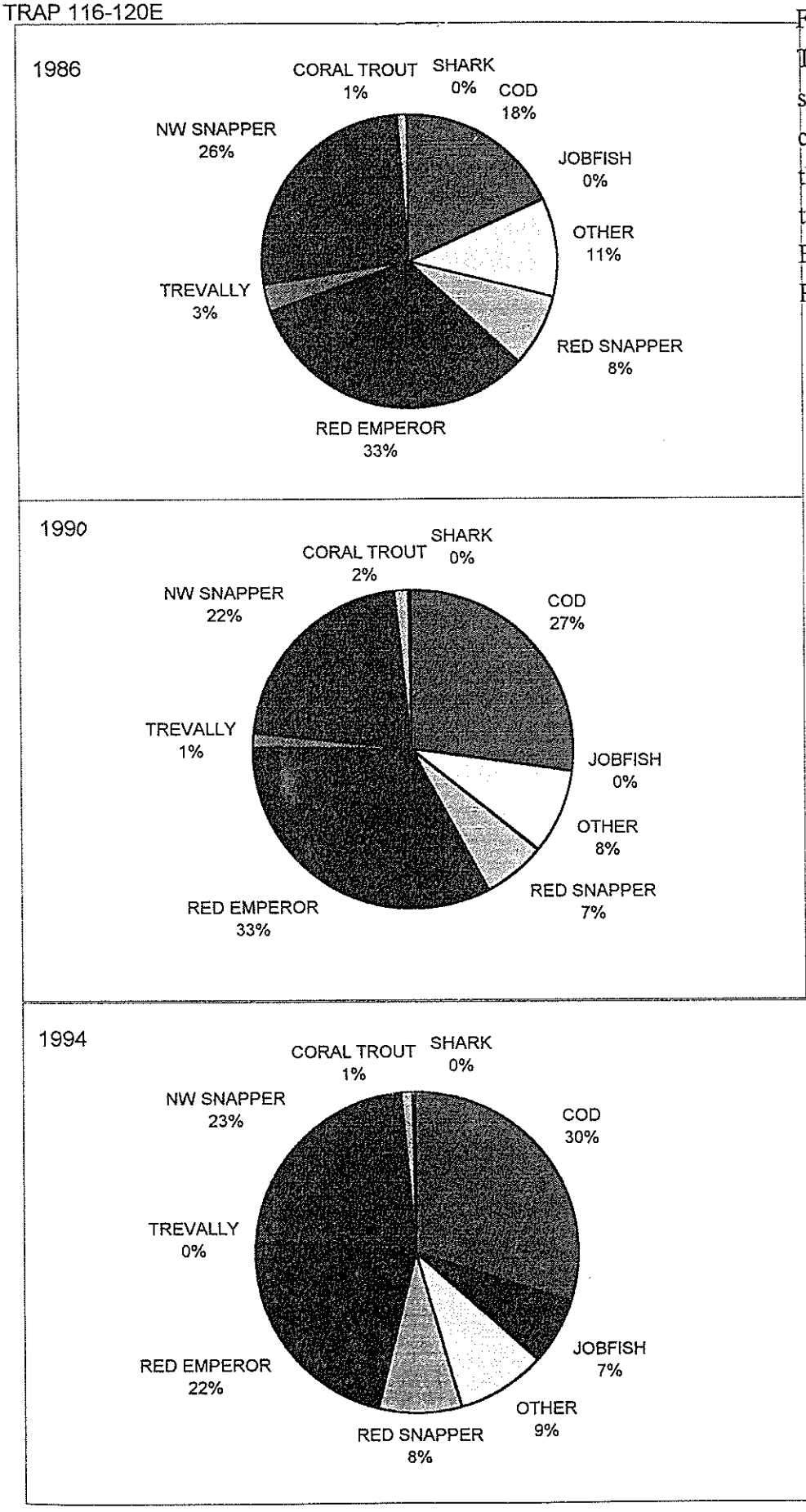


Fig. 17. Trap species changes through time: East Pilbara

In 1994 the trawl fishery was restricted to the area between the Rankin gas pipeline and 117° 30'E for an experimental estimation of the relationship between trawl fishing effort and fishing mortality. While this was the main area worked by the fishery prior to the experiment, the fishing effort in the area increased markedly, probably as a result of the replacement of small with large boats that are more efficient and can spend more days at sea. At the end of the experiment in early 1995, the grounds between 117° 30'E and 120°E were reopened to trawling and the trawl fleet responded by leaving the area it had trawled heavily for a year and worked the newly reopened area.

This markedly increased presence in the eastern area has resulted in complaints from commercial trap and line fishers and recreational fishers that the trawlers are destroying the reefs and taking all the fish.

The prawn fishery in this area is known as the Nickol Bay prawn fishery. While there is a variable banana prawn fishery in Nickol Bay itself, most of the trawling is done at a variety of grounds with suitable prawn habitat along the whole coastline of this area. The most abundant species of commercial finfish in the bycatch of the prawn fishery are juveniles of the large lutjanids *Lutjanus erythropterus* and *L. malabaricus* which are important in both the fish trawl and fish trap fisheries but not the recreational or commercial line fisheries.

KIMBERLEY

The major fishery in the Kimberley region from 120° to 129°E is the trap fishery (Fig 18). This fishery has expanded rapidly since 1990 but has now been contained by a freeze on licences.

While Western Australia controlled trap fishing in the Kimberley prior to 1995, it only controlled fish trawling as far east as 123° 45'E, and did not control line fishing at all outside the 3-mile limit. These methods were under Commonwealth jurisdiction. Although the Commonwealth tried to encourage fish trawling with environmentally friendly trawl gear in the eastern area (Timor Sea), there was not much interest. One long-line vessel was licensed by the Commonwealth to fish the Kimberley waters.

In early 1995 the Commonwealth passed jurisdiction for all demersal scalefish in the Kimberley region to Western Australia. The whole area is now closed to fish trawling

but the longline boat is continuing to fish on the basis that its Commonwealth licence has not expired. Line fishing has in 1995 been restricted to certain boats while awaiting formulation of a demersal fishing management plan for the Kimberley.

The recreational fishery and charter fishery in waters close to Broome are growing with the town's increasing popularity as a tourist destination. To protect the recreational fishers from direct competition from the trap boats, the area within the 30 metre depth contour close to Broome has been closed to trapping.

The trap fishery based on Broome began by working close to the town, but for the past few years has worked at increasing distances, up to two days travel northwards. Although the catch-rate has not declined markedly (Fig 19), the increasing distance travelled to fish is indicative of depletion of the closer grounds. A few boats fish from Darwin, sometimes in the area adjacent to the Northern Territory's Timor Box trap and line fishery, and sometimes travelling long distances westwards to the grounds fished by the Broome-based boats. There is a large area of the Timor Sea that these boats cross to reach their westerly grounds, indicating that the Timor sea close to 129°E is not good trapping ground. Ramm (1991, pers comm.) has conducted trawl surveys in that area and calculated that there may be a sustainable yield of large lutjanids on the order of 1000 tonnes per year. This exceeds the current annual catch from the trap fishery in a much bigger area. It is possible that there is a demersal resource in this area which cannot be taken by the current trap and line methods and may only be harvestable by trawling.

While there is probably not a great deal of latent effort in the trap fishery, unless line fishing can be limited adequately, the realisation of latent linefishing effort may result in a total demersal fishing effort too great for the reef fish stock.

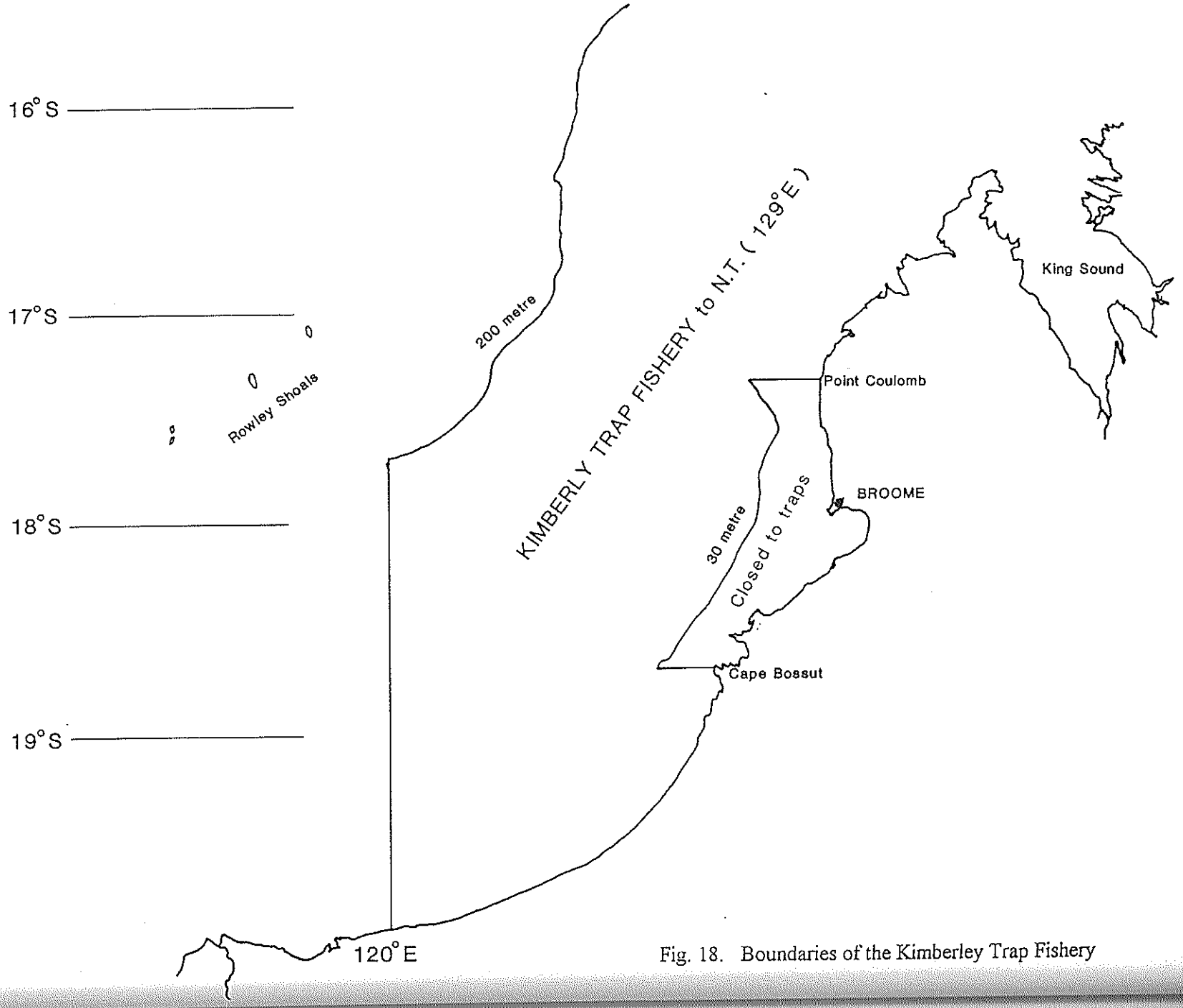


Fig. 18. Boundaries of the Kimberley Trap Fishery

EFFECTS OF FISHING GEAR ON THE BENTHIC HABITAT

INTRODUCTION

Commercial fishing of the Australian North-west Shelf began in the early 1960s with a Japanese stern trawl fishery targeted on lethrinids in the area north of Dampier. The lethrinid stocks were depleted in a few years and the fishery ceased. A Taiwanese pair-trawl fleet began fishing in the early 1970s over a wider area but with the centre of fishing effort again north of Dampier and retaining a much wider range of species (Jernakoff and Sainsbury, 1990). The pair-trawl fishery peaked in both catches and fishing effort in the early 1970s and its access to the grounds was progressively restricted over the period 1986-1989 after which foreign fishing on the NW Shelf ceased. Australian vessels began trapping on the NW Shelf in 1984 and stern trawling in 1989. The trawl fishery has expanded rapidly since then.

There were a number of research trawl surveys by various nations over this period, culminating in CSIRO surveys when the Australian Fishing Zone was declared in 1979. Sainsbury et al.(in press) found that the catches of sponges and other macrobenthos declined markedly in the fishing area over the duration of the pair-trawl fishery. Investigating the change in species-composition of research vessel trawl catches from dominance by lutjanids and lethrinids to dominance by saurids and nemipterids, Sainsbury examined a number of hypotheses and concluded that the most likely was that the habitat had been modified by the pair trawling such that the large macrobenthos habitat preferred by lethrinids and lutjanids had been replaced by a sparse macrobenthos habitat which favoured the saurids and nemipterids. This raised the possibility that if the habitat was allowed to return to its former state, the fish stocks may be more profitably exploited by a trap fishery on lethrinids and lutjanids than by a trawl fishery.

Stern trawling is likely to be very different from pair trawling in its effects on macrobenthos, though large quantities of sponges, etc can be caught in stern trawls. Sainsbury et al (in press) have estimated that a demersal otter trawl could detach 89% of the benthic organisms in the path of the net. They did not estimate the additional effects of the sweeps in detaching benthos. Mounsey and Ramm (1991) developed and tested a semi-pelagic trawl net, called the Julie-Anne trawl, and found that in the waters off the Northern Territory, the new net could catch similar quantities of fish to a standard demersal trawl while taking much less benthos. The high fish catches of the

Julie-Anne trawl were partly due to its better manoeuvrability which enabled better targeting and repeated shots through schools of red snapper, Lutjanus malabaricus.

Fish trapping has also been alleged to cause damage to macrobenthos. These allegations usually come from commercial or recreational line fishers. Moran & Jenke (1989) used underwater video to study grounds near Shark Bay which had been intensively trapped and found these grounds appeared to have at least as dense and varied a macrobenthic community as nearby grounds which had been subjected only to line fishing. They also observed the motion at the sea bed of traps being set and pulled, and found the motion to be gentle and unlikely to damage most benthos.

The major objective of the research to be reported here was to investigate the level of destruction of macrobenthos by a standard demersal trawl, as used by Australian trawlers on the NW Shelf.

The semi-pelagic trawl was found by Mounsey & Ramm to catch only around 3% of the quantity of benthos caught by a demersal trawl. This relates only to the damage to benthos done by the net itself. Fish trawl nets have on each side of the net long sweeps which brush the sea bed, raising a curtain of suspended sediment which is thought to herd the fish into the net. If damage to the benthos is being caused by the sweeps, the evidence would not show up in the net. Also, a semi-pelagic net requires more careful tuning than a demersal net to ensure that it is high enough above the sea bed so that it is not destroying benthos but it is not so high that it allows a high proportion of fish to escape beneath the foot-rope. The semi-pelagic net can be fished hard on the bottom as though it was a demersal net. We aimed to examine the effects on the benthos of a well-tuned semi-pelagic net, including effects of the sweeps, and to study the effects of tuning the net on fish and benthos catches.

The evidence against significant trap-caused benthic habitat damage obtained by Moran & Jenke (1989) was circumstantial and the view that traps do cause damage is still held by many line fishers. As part of this work, therefore, trap-caused damage to benthos was also estimated experimentally.

DISCUSSION

A major finding of this work is the estimate of mortality of benthic fauna such as sponges, soft corals and gorgonians in the path of a fish trawl. Our findings, which include the effects of the sweeps as well as the net, support those of Mounsey & Ramm (1991) that semi-pelagic trawls, fished with the foot-rope above the sea-bed, are much less damaging to benthos than demersal trawls. However, a semi pelagic net, fished just above the sea-bed, catches much less fish than a demersal net.

Mounsey & Ramm (1991) found in the Arafura Sea that fish catches in a demersal net were of similar weight to those of a semi pelagic net. The high catch rate of the semi-pelagic net was largely due to the fact that it could be used to target schools of *Lutjanus malabaricus* because the net was more manoeuvrable than a demersal net and the boat could quickly turn to make repeated passes through the school. Our difference from Mounsey & Ramm's (1991) result is probably due to the absence of large schools of *Lutjanus malabaricus* on the NW Shelf, in contrast to the Arafura sea.

There is no practical way to ensure that fishermen will tune their nets to fish 15 cm above the seabed. As they would naturally operate the net at a height to maximise catches, we do not believe that semi-pelagic trawls are a solution to habitat damage on the NW Shelf as they are in the Arafura Sea where schools of large lutjanids occur. If standard demersal trawls continue to be used on the NW Shelf, the level of effort could be limited so that each piece of sea bed was only trawled rarely enough to be sustainable depending on benthos regeneration rates. The problem is that the regeneration rates of these benthic organisms are unknown. Sainsbury et al (in press) estimate that the time for recovery is well in excess of ten years.

While fish trawling is much more damaging environmentally than the other methods of catching demersal scalefish, it takes species which are not taken by other means, such as the threadfin bream, pearl perch and frypan snapper. Prohibiting trawling in an area is very likely to leave a valuable resource such as this unexploited. On the NW Shelf a practical compromise may be to limit trawl fishing to the area currently worked between 116° and 120°E. An exception could be made in areas where the habitat is completely sand or mud as may be the case in some of the grounds between 127° and 129°E. Environmental surveys should certainly be a prerequisite to opening up more trawl areas. The interactions of the fish populations with the benthic fauna are unknown, although Sainsbury's work indicates that a change in the benthos due to

the decades of Taiwanese pair trawling could have caused major changes in the fish community.

In the Shark Bay region, the demersal fish stocks of the oceanic part of the region are in a healthy state. There is little impact of the recreational and commercial fisheries on each other despite a large overlap in both species taken and area fished. The commercial fishery for the major species, pink snapper, is tightly constrained by quota management. There is potential for increased effort by commercial fishermen who do not have snapper quota and by charter operators unless these are limited in some way. There is a certainty of increasing recreational effort as the population increases and a method of constraining the catches of the recreational sector must be found in the future to prevent overfishing to the detriment of both the commercial and recreational sectors. A number of species in this region are likely to be currently under-exploited. These include the lesser spangled emperor, pearl perch, frypan snapper and trevally. There is potential for exploiting some currently unexploited species in the deeper water (more than 150 metres) by trawling without impacting the linefishing species.

Ningaloo is predominantly a recreational fishing area. The Fisheries Department's policy is to phase out commercial fishing in the marine park in consultation with the licence holders. As tourism grows, so will recreational fishing effort. There is anecdotal evidence that recreational fishing on inshore stocks of species such as spangled emperor has already caused depletion in the area inside the reef. Bag and possession limits should be reviewed at intervals of about five years to prevent serious overexploitation. Means of reducing the dependence of the charter boats on the commercial linefishing part of their business should be sought, as the income from chartering provides a better economic return for the fish caught. Commercial linefishing at some level is still desirable as there will always be a need for fresh-caught local fish in the tourist/restaurant trade. The best overall solution may be a limited number of charter boats in the region with some or all of them having the ability to fish commercially for local needs.

Fish trapping in the inner shelf waters outside Ningaloo reef had a peak in catch and effort in the late 1980s and has now dwindled to nothing as a result of depletion of stocks to unattractive levels. Since fish trapping both in Shark Bay and Ningaloo has wound down of its own accord, it is an opportune time to extend the area currently closed for fish trapping on the west coast by moving its northern boundary from 26° 30'S (below Shark Bay) to 114°E (North West Cape).

The fish trawler in the deep water (100 to 200 metres) outside Ningaloo Marine Park, while not affecting other user groups, should be monitored to detect any overfishing in its prescribed area. No additional trawlers should be permitted in this area until its productive capacity and the status of the benthos are known.

In the western Pilbara, the area directly to the north of Exmouth Gulf is no longer a major commercial trap fishing area and could be excised from the commercial trap fishery. As Ningaloo bag and possession limits already apply in this area and will be subject to future reviews, the area could, for fishing purposes, become part of the marine park as a recreational and charter fishing area with a small amount of commercial linefishing.

The western zone of the Pilbara Trap Fishery has persisted as a fishery though many of the licensees have moved north to the Kimberley or simply ceased to fish. Catches have consequently declined to a low level. The main problem in this fishery is that too many licences were granted in the limited-entry fishery for the trappable fish resource. A lesser problem was the permission given to a fish trawler to operate in part of the trapping grounds to the west of Barrow Island, where there is a substantial species overlap between the trawl and trap catches.

The small fish-trawling area west of Barrow Island was granted initially because the base of the trawler was Exmouth and packing the trawl fish was important to the factory there. There is a significant overlap in trawl species composition with the trap fishery in the same area. Since the trawler no longer works from Exmouth, the justification for trawl access to this area no longer exists. If the area were removed from the trawl fishery, it would be to the benefit mainly of the trap fishery and to a lesser extent the recreational fishery.

The rapid increase in catch and effort in the Pilbara Trawl Fishery has led to concern about sustainability of the fish stocks. A separate research programme is calculating the appropriate level of effort in this fishery. There is some conflict between the trawl fishers and other commercial fishers (trap and line) and recreational fishers in the eastern Pilbara. There are a number of patches of reef at about 50 metres depth which the trap and line fishers believe should not be trawled but the trawl fishers consider should be within their area. Trap fishing in the eastern Pilbara has virtually ceased as the trawl fishery developed. Although trawling over the rough bottom which favours trap and line fishing should be minimal to prevent net damage, it does occur and the trawl fishery catches all the trap and line species very efficiently. It cannot be proven

that the trawl fishery has made trap and line fishing unprofitable but on circumstantial evidence it appears very likely.

In Dampier Archipelago, fish trawling and trapping are prohibited, and although commercial linefishing is permitted it does not currently occur. The archipelago is primarily a recreational fishing area and anecdotal evidence indicates that the stocks of demersal fish have become greatly depleted during the last two decades. A higher order of management of recreational fishing in this area is probably justified. There is currently conflict between commercial and recreational rock lobster fishermen in the Dampier region and an increase in commercial linefishing would be very likely to lead to conflict over demersal fish also.

The closure to trapping around Broome has been adequate to prevent conflict between commercial and recreational fishers to date. However, charter fishing from Broome is growing with the development of tourism in the town and, if commercial linefishing in the area intensifies, it may be appropriate to change the trapping closure to a general commercial demersal fishing closure to prevent over-depletion of the area.

Latent effort from linefishing is probably the main future problem for management of the fish stocks on the NW Shelf outside of the fish trawl area. The Western Australian fishing industry has a policy that linefishing generally should not be restricted. Even though hand-line fishing is generally less efficient than trapping or trawling, mechanised lines can be just as or more effective than trapping. Management of a demersal resource should encompass all methods capable of taking that resource and limit the total fishing effort from the combined methods to a sustainable level. Currently, except for the Kimberley, there are no limits on commercial linefishing anywhere and any licensed Western Australian fishing boat can fish with any type of line.

The fish trawl fishery is the subject of a current research program to determine an appropriate level of fishing effort. The growth of effort in that fishery has been rapid and may be cause for serious concern, both in terms of the stocks of the larger species and the benthos. Future growth of this fishery should be directed at the smaller species such as threadfin bream which are probably being under-exploited while the larger species are being over-exploited. Research into a fishing gear solution to this problem may be productive.

The incidental take of juveniles of commercially and recreationally important finfish species by prawn trawlers is not known to be having a serious impact on any of the demersal finfish user groups. While it is straightforward to measure the abundance of juveniles of important species in the trawl bycatch, the reduction this causes on availability of fish for exploitation as adults is very difficult to determine. In Shark Bay, snapper and bream are a small but significant part of the bycatch which is nearly all non-commercial species. In Exmouth Gulf, commercially and recreationally important species were not significant in the bycatch and in the Pilbara the main commercial bycatch species are juvenile *Lutjanus malabaricus* and *L. erythropterus*. These two species are important to the fish trawl fishery and were a major component of the trap fishery in the eastern Pilbara when it was active. While the juvenile mortality due to prawn trawling cannot be proven to be having adverse effects on the finfish fisheries, clearly it should be minimised if possible. As the technology of fish escape panels for prawn trawls improves, they may provide a solution to this aspect of prawn trawl fisheries.

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