AN ASSESSMENT OF THE EAST QUEENSLAND INSHORE GILLNET FISHERY

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Brisbane, revised June 1988

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SUMMARY

The inshore gill net fishery in tropical Queensland is one of the State's most valuable fishery resources. The fishery has been split into two entitlement zones: the Gulf of Carpentaria and north eastern coast; and the remainder of the east coast south to Bundaberg. In 1986 there were 269 fishermen with east coast endorsements and a further 113 fishermen endorsed to work in the Gulf of Carpentaria. The quantity of barramundi fillet landed on the east coast in 1986 was about 65 tonnes, around a quarter of the Gulf of Carpentaria catch (260 tonnes). As a result, many east coast fishermen are involved in other fisheries (for example, crab trapping, beam trawling and bait fishing).

The east coast gill net fishery is a multispecies fishery in which fishermen may take up to 50 different species. They commonly use monofilament gill nets of 10 to 20 cm stretched mesh but there has been a recent trend towards larger mesh sizes (up to 30 cm). Barramundi (Lates calcarifer) is the single most important species of this fishery both by weight and value. It's range includes the entire east coast entitlement zone but is more commonly caught north of Rockhampton. There is evidence that many gill net fishermen target for barramundi and that catches of other fish are (in many cases) incidental. Studies undertaken into the biology of barramundi have largely supported management strategies already in force although minor alterations have been suggested. Biological data are also presented on the other major commercial fish species (for example, threadfin salmons (Polynemidae) and grunter (Pomadasyidae) and these will be available for use in future management strategies. A voluntary logbook scheme which was initiated in 1981 among select commercial fishermen in order to collect fishery data was made permanent. This was regarded as an essential requisite for ongoing management of the fishery.

A series of changes to the current management strategy for the east coast gill net fishery have been recommended. These include:

- an increase in the present minimum net mesh size from 11.5 to 15 cm for use in estuaries;
- an increase in the minimum legal size of barramundi to at least 55 cm;
- identification and protection of barramundi nursery areas; and
- a review of all estuarine netting closures.

It is also recommended that further studies be done on the economics of the fishery and the effects of coastal stream barriers on the movement of fish. The east coast gill net fishery management plan should be regarded as dynamic and subject to regular review.

INTRODUCTION

Most of the world's marine fish harvest still comes from coastal waters despite the rapid development of distant-water fishing fleets (McHugh, 1967). Fish yields from estuaries and lagoons are generally high, due to factors such as shallowness, inflow of nutrients from rivers, and the influence of large quantities of plant materials (particularly mangroves) received from their shorelines (Makten and Polovina, 1982). Techniques developed to harvest fish from these areas include trawling, line fishing, trapping, seine netting and gill netting.

In Queensland, commercial fishing by means of seine nets or gill nets involves a minimum of 400 fishermen or 21% of the total number of master fishermen (Queensland Fish Management Authority, personal communication). A substantial recreational fishery also exists for estuarine and coastal fishes.

For some years, both commercial and recreational fishermen have complained of decreasing estuarine and coastal fish catches, particularly of the more commercially attractive species such as barramundi (Lates calcarifer). In response, the Queensland Government, with the aid of a Fishing Industry Research Trust Account (FIRTA) grant, initiated a three-year premanagement study of barramundi in 1978. This aimed primarily to collect the information necessary to make management decisions for the barramundi fishery. As a result of this work, certain management initiatives were implemented (see Regulations section), but there was (and still is) a need for an ongoing assessment of their impact. Further information was needed on the barramundi fishery to aid in the evaluation of these management strategies, and the effect these initiatives had on the overall east coast inshore net fishery - a multispecies fishery - was unknown. In recognition of this need for further information the DPI initiated a FIRTA-assisted research programme in 1981.

Programme objectives

The broad goals of this research programme were:

- to collect, collate and analyse biological information on the east coast gill net fishery so as to acculumate a store of biological baseline data for management purposes; and

- to monitor and assess aspects of the current management regime for the fishery.

More specifically the objectives were:

- to determine catch composition with respect to species, sizes of fish, seasonality and habitat of the commercial fishery. Aspects of the biology of selected species were also to be investigated;

- to determine the effect of current gear restrictions, seasonal and area closures on catch composition and on the commercial viability of fishermen; and

- to investigate alternative strategies for management, including alterations in restrictions and design of fishing gear.

A report detailing the results of the research programme was submitted to FIRTA in January, 1986. This current assessment of the fishery is an expanded and updated version of the original FIRTA report.

Structure of the fishery

Three important aspects of the fishery are:

- the fishing methods and equipment;
- the areas fished; and
- regulations governing type and use of gear.

Gear

Gill nets are widely used in Queensland to catch commercial fish species in estuaries and on coastal foreshores. A gill net consists of a sheet of netting hung with floats. Leads along the bottom of the net enable it to hang vertically in the water. The netting material used may be multifilament, kuralon or nylon but is more commonly monofilament. Mesh size is measured as stretched mesh from centre knot to centre knot. Nets are usually set with anchors, or with one end tied to a tree or solid structure and the outer end anchored, in a place where fish are thought to move. Nets are usually set at right angles to the bank. They may be set on the surface or sunk in deep holes. Fish become tightly wedged, or enmeshed in the webbing, tangled by projecting spines or teeth or bridled with a mesh caught in the mouth. Nets are serviced at regular intervals with fish being removed, processed (filleted or gilled and gutted) and chilled on ice or placed in a freezer.

Netting areas

In eastern Queensland, nets may be used in estuaries or along coastal foreshores, subject to seasonal closures. An estuary is defined in the Fisheries Act as the part of a river or inlet up to the limit of tidal influence. In estuaries, nets are usually set in channels or in deep holes. Areas with obstructions such as rocks or in the vicinity of fallen timber are favoured as netting locations. On foreshores, a number of different general habitats are favoured as netting locations. These are mud flats, river mouths, beaches and rocky headlands.

Regulations

The inshore net fishery is controlled by regulations set out in the Fisheries Act (1976 to 1984) and the Fishing Industry Organisation and Marketing Act (1982-1984). Only endorsed master fishermen may participate. Management measures taken to conserve the fishery include:

- a closed season on the taking of barramundi from November to January inclusive;
- the establishment of two limited entry fisheries for the east coast and Gulf of Carpentaria;
- a weekend closure in most rivers and creeks on the east coast to reduce conflict between amateur and commercial fishermen;
- area closures, both total fishing and partial netting bans;
- identification and declaration of habitat reserves for the preservation of fish nursery grounds; and
- a bag limit for barramundi on amateur fishermen (which applies only to the east coast).

Past commercial landings

Prior to 1981 there was no official monitoring of total barramundi catches in Queensland. The only figures available were landings made at Queensland Fish Board Depots in major centres (Table 1). These probably bear little resemblance to actual total catches as fish were also marketed through many other outlets. The Fish Board statistics do, however, give an indication of relative landings at various east coast centres. Landings are higher in the northern centres and decrease with increasing latitude. Maryborough and Bundaberg have low landings. Total landings for all east coast centres fell from 94.4 tonnes in 1977 to 50.7 tonnes in 1981.

Landings at some centres - Cairns for example - may be inflated due to transport of fish from other areas, such as the Gulf and Princess Charlotte Bay. It is difficult therefore to accurately gauge the relative quantities of fish caught on the east coast and Gulf of Carpentaria.

In 1981, a compulsory catch-log scheme was introduced into the Gulf of Carpentaria limited entry gill net fishery with a similar scheme introduced on the east coast in 1985. Despite some early teething problems with the catch-log scheme on the east coast, reliable statistics for barramundi and other species are available for 1986 and 1987 (Table 2).

Table 1. Fish Board landings (kilograms of fillet) for the major east coast depots north of Maryborough for 1977 to 1981. The percentage for each centre of total annual Fish Board landings is given in brackets. Weights have been rounded to the nearest kilogram. Total weights may not necessarily equal the sum of individual landing weights.

	1977	1978	1979	1980	1981
Cairns	36 468 (26.6)	22 174 (13.4)	2 818 (1.7)	28 756 (21.3)	23 378 (19.8)
Innisfail	4 273 (3.1)	4 791 (2.9)	3 265 (1.9)	4 823 (3.8)	3 297 (2.7)
Townsville	27 966 (20.4)	18 574 (11.2)	11 960 (7.1)	17 560 (13.0)	8 412 (7.1)
Bowen	1 585 (1.2)	91 (0.1)	77 (0.1)	27 (0.1)	186 (0.2)
Mackay	6 362 (4.6)	5 690 (3.4)	5 679 (3.4)	3 894 (2.9)	3 342 (2.8)
Rockhampton	8 028 (5.9)	9 100 (5.5)	8 621 (5.1)	8 429 (6.2)	7 256 (2.73)
Yeppoon	3 921 (2.0)	3 942 (2.4)	3 388 (2.0)	1 629 (1.2)	849 (0.7)
Rosslyn Bay	166 (0.1)	4 (0.1)	164 (0.1)	33 (0.1)	224 (0.19)
Gladstone	3 750 (2.7)	5 444 (3.3)	5 041 (3.0)	2 429 (1.8)	2 236 (1.9)
Bundaberg	976 (0.7)	6 227 (0.4)	2 257 (1.3)	496 (0.4)	568 (0.6)
Maryborough	872 (0.6)	1 145 (0.7)	1 493 (0.9)	930 (0.7)	911 (0.7)
Total (east coast)	94 367 (69.0)	77 182 (46.7)	44 763 (26.7)	69 006 (51.2)	50 659 (42.9)
Total Fish Board	136 948	165 256	167 675	134 865	118 019

Table 2. Landings (in kilograms of fillet) for barramundi and other major commercial fish species from east coast waters. Data were extracted from compulsory logbook returns.

	Fillet Weight (Kg)			
Year	Barramundi	King Salmon	Blue Salmon	Other Species
1986	72 786	20 178	33 582	358 981
1987	50 486	13 808	26 828	205 343

There is vitually no information available on landings by recreational fishermen.

METHODS AND TECHNIQUES

In order to assess the inshore gill net fishery data were collected in two ways: catch and effort information was obtained directly from selected commercial fishermen using a voluntary logbook scheme; and through a research netting programme. The logbook scheme was initiated in August 1981 and terminated in July 1984. It involved up to 19 fishermen completing monthly returns on their fishing activities. No attempt was made to collect data on the recreational fishery. Details of the research netting programme are as follows.

Study sites

The topography of eastern Queensland is dominated by the Great Dividing Range, which closely follows the coastline for most of its length. Most of the rivers and streams which flow to the east of the Dividing Range into the Coral Sea are relatively short. In the study region (Cairns to Baffle Creek), there are two major exceptions to this: the Burdekin and Fitzroy Rivers.

To achieve the objectives of this study, an intensive research field-programmme was designed and implemented. A series of sites represaentative of commmercial fishing grounds in east Queensland were chosen for detailed examination (Figure 1). A number of locations and/or habitats (for example, river, river mouth and foreshore) were examined within each site. Fifteen permanent sites were established, while other sites were spot-sampled at irregular intervals. Geographically close areas were arbitarily grouped into eight study areas. A map showing the location of these study areas is given in Figure 2.

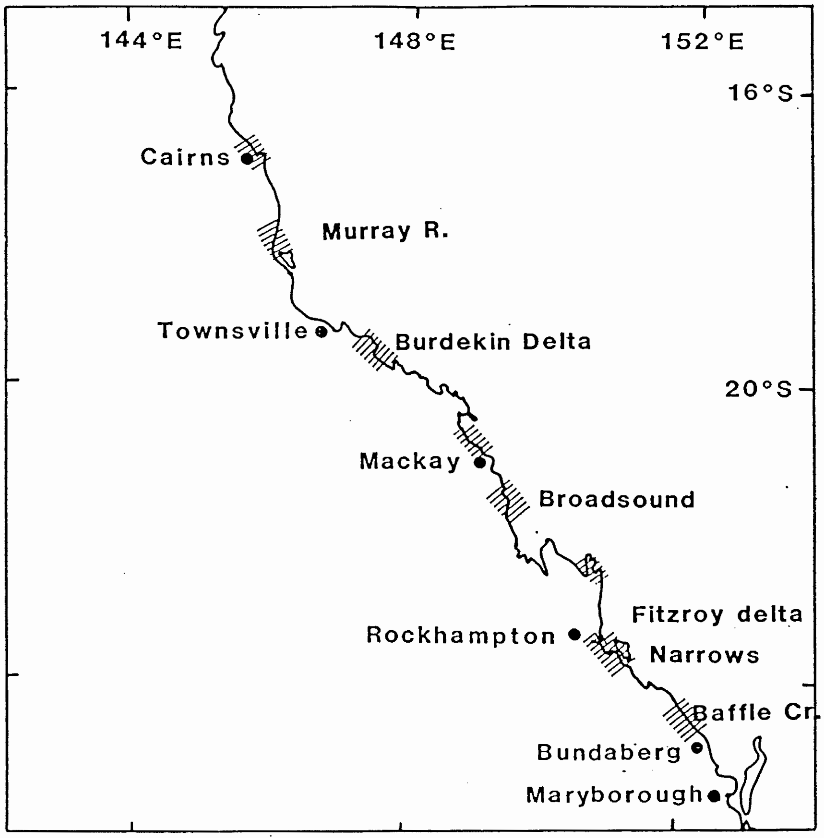


Fig 1
Location of study areas on east Queensland coast.

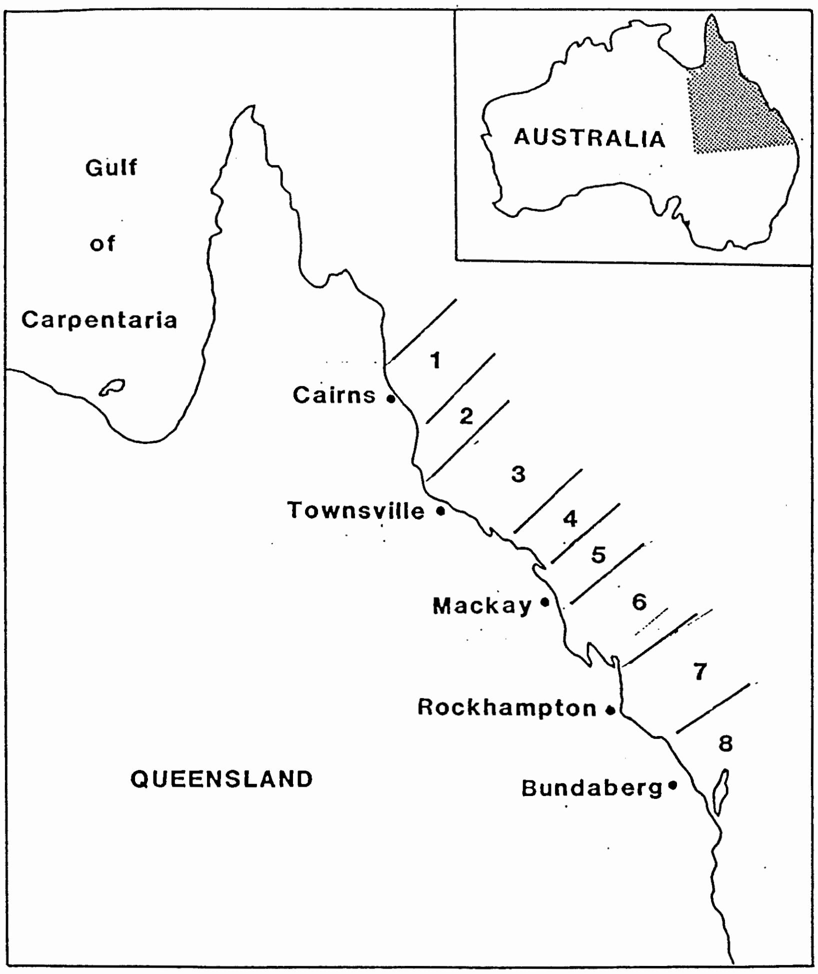


Fig 2
Location of the logbook regions on the east Queensland coast.

Sampling Period

During the period July 1981 to the end of February 1983, 10 permanent sites from Cairns, south to Mackay were routinely visited every one or two months. At the end of this period, sampling of all these, with the exception of the Cairns sites, was terminated. A new series of five sites from Bundaberg to Mackay was then established and sampled monthly from March 1983 until April 1984.

Netting Operations

Sampling was undertaken by a three-man research team using a four-wheel-drive vehicle and small aluminium dinghies. At each site a selection of gillnets, which were specially designed and built for the project, were set in both estuarine and foreshore habitats. Net sizes (which ranged from 100 to 20 cm stretched mesh), type and construction were similar to those commonly used in the commercial fishery. The technique for the placement of nets was as outlined in the introduction (page 2). Mainly monofilament nets were used, but a small trial was carried out with multifilament mesh. Nets were generally set in the late afternoon and retrieved the next morning since most commercial catches are made at night. On a number of occasions the sampling time was shortened to around 6 hours. The nets were checked about every two hours to clear tangled fish and to see if the net was functioning properly.

Processing of Catch

With the exception of barramundi (which were tagged and then released) all fish were measured (total length or fork length to nearest 0.5 cm), weighed to the nearest 100 g and then dissected to determine their sex and gonad development. In the field, the gonad development of each fish was assessed. Barramundi tissue specimens were routinely collected and processed in the laboratory for microscopic examination, which confirmed field observations, and checked for sex inversion. A gonosomatic index (percentage of gonad weight in total body weight) was also calculated for each barramundi sampled.

Tagging

Only barramundi, <u>Lates calcarifer</u>, were tagged during this study. Gill netting was used to capture most fish for tagging, but a few fish were also tagged by amateur fishermen angling with lures.

To tag the fish, the net was carefully cut away and the fish's suitability for tagging visually assessed. Factors such as current velocity, water temperature, captive time in the net, and damage sustained while in the net all contributed to the overall condition of the fish. If the fish was judged to be suitable it was immediately weighed, measured, checked for reproductive status (for example, a running-ripe fish) and then tagged and released. To minimise chances of immediate recapture, the release site was usually at least 100 m from the net.

Two tag types were used - dart tags and metal-headed tags. A dart tag has a plastic barb which holds the tag in place when it is injected through the dorsal musculature just below the posterior half of the first dorsal fin. The applicator used for this operation is a stainless steel tube sharpened at one end with a diameter only a fraction larger than that of the tags. The tag and applicator are inserted into the fish and the applicator withdrawn leaving the tag in position. Where possible the tags were positioned in such a way as to allow the anchor to lodge behind the pterygiophores associated with the dorsal spine. As this was not always possible, particularly with larger fish, efforts were made to leave the barb embedded as deeply as possible in the muscle.

With the metal-headed skin tags, a blade of stainless steel (0.8 cm by 3.5 cm) was shallowly implanted into the musculature. A specially designed applicator was needed for this operation.

Both tag types were essentially tubular, coloured plastic streamers, between 100 and 15 cm long which, when applied, protruded externally from the fish. Each tag had printed on it a unique four- or five-digit number, an address (Q'ld Fish. c/- P.O. BUNGALOW) and then the number repeated.

Successful communication with the fishing public is an essential element of tagging programmes which rely on industry and public cooperation for tag return data. Considerable effort was put into a publicity campaign involving addresses to amateur and professional fishing bodies and media releases. A reward poster was also distributed (see Appendix 1). This publicity campaign was devised to make the public aware that there was a tagging programme underway, and to inform them of the research objectives, where to look for tags and what to do if a tagged fish was caught. In the event of the recapture of a tagged barramundi the following information was sought:

- tag number or (preferably) return of the actual tag;
- date and place of recapture;
- length and weight of the barramundi;
- sex of the fish (if easily determined); and
- fishing method.

A nominal reward of $5 was offered for the return of each tag. A personal letter was forwarded to each fisherman who returned a tag giving details of the movements and growth of that tagged fish. As well, details of recaptures were put in an irregular newsletter sent to participants in the commercial logbook programme.

Reproductive studies

The volumetric method of sub-sampling eggs, similar to the technique described by Moore (1980), was used to estimate barramundi fecundity. The ovary was first fixed in 10% formalin. A nett displacement (V) was calculated for the fixed ovary (without the ovary wall). Samples of eggs were taken and the eggs counted so that an average number per sample (N) could be caculated. Small, underdeveloped eggs were not counted and only mature ovaries were used. The fecundity was then calculated using the formula F = 5x(NxV).

Gonads were examined microscopically after sections were cut (four microns thick) and stained with Harris's haemotoxylin and eosin.

In the field, gonads of all commercial fish species were given an index of maturity based on a six-stage classification scheme. The scheme was as follows:

1 immature;

2 resting / slight development;

3 maturing early;

4 mature;

5 running ripe; or

6 spent.

A detailed description of the morphology of barramundi gonads during each of these stages is given by Davis (1982). In a number of species, difficulty was experienced in differentiating stage 6 males from stage 2 and 3 males. When such difficulties were encountered the fish were described as stage 2.

Physical Parameters

At each netting location, measurements of surface water temperature, salinity and turbidity were made. A mercury-in-glass thermometer was used to measure surface water temperature at each sampling location. This measurement was always made at dusk regardless of tide. A vial of water from each location was returned to the laboratory and salinity determined using a temperature-compensated optical salinometer (American Optical Corporation). The water sample was always taken as close to the high tide as practicable. The turbidity of this water sample was determined using a Hach turbidity meter.

Data Processing

Data was processed on microcomputers using both off-the-shelf software and specially designed programs written by Branch staff. James Cook University's PDP10 mainframe computer was also used for more involved analytical procedures.

RESULTS AND DISCUSSION

Commercial Fishery

Data on a total of 1571 fishing days was supplied by 19 commercial fishermen working in areas 1-7 (Figure 2). It should be noted that these logbook regions differ from the study areas previously described for the sampling programme. Most of the commercial fishermen surveyed operated only in one region, generally close to their place of residence. Only two fishermen worked in more than one region, travelling by boat or truck to their fishing grounds. In 1982, a census of all Queensland commercial fishermen by the Queensland Fish Management Authority (QFMA) found that there were no itinerant net fishermen.

Four of the fishermen had large displacement boats similar to those used by net fishermen in the Gulf of Carpentaria. As well as gill netting the boats were used in other fisheries such as beam trawling and reef-bottom fishing. The remaining fishermen worked out of either small, aluminium dinghies or, in two cases, larger fibreglass or aluminium speedboats.

The close proximity of markets and the easy accessibility of most fishing grounds made extended fishing trips unnecessary. Consequently, the number of maintenance and travelling days was relatively low at 572 (36%). For every 2.7 days spent fishing one day was spent in maintenance and travel. This did not take into account time lost through unfavourable fishing conditions such as poor weather, presence of jellyfish and weed, and unsuitable tides. Master fishermen either operated alone or with one or more assistant fishermen. It was unusual for two or more master fishermen to work together for extended periods. Fishermen processed their catch on the fishing grounds either by filleting or by removing the viscera from the fish. The fish were then placed in a freezer or an icebox.

Capital investment

Capital investment by net fishermen is low when compared to that needed in other fisheries (for example, otter trawling). Operating expenses in this type of fishery are also relatively low. For the basic unit outlined above, variable costs would include outboard fuel, ice, and general maintenance. Fixed costs would include compulsory fees and registration, depreciation on fishing equipment and interest payments on loans. As the operation becomes more sophisticated, the operating expenses increase. For example, an assistant fisherman may be employed in a larger operation. He may be paid a flat wage or (as is more common) be given a percentage of the profits.

Participation in other fisheries

In the 1982 census of Queensland fishermen by the QFMA, 229 fishermen gave their primary fishing method as set gill netting and a further 94 gave gill netting as a non-primary fishery in which they participated. No data on participation in other fisheries were specifically asked for in the gill net catch return questionnaire, but a number did supply this information. As a result of these data and from fishermen interviews it would appear that very few fishermen, if any, were solely involved in gill netting. In fact, information available suggests that some fishermen may supplement their income by seasonally working in three or four alternate fisheries. These include ring netting, bait fishing, crab trapping, demersal and pelagic line fishing, beam trawling and even otter trawling. During this study it was not uncommon to observe commercial fishermen simultaneously involved in gill netting and other estuarine fisheries such as crab trapping.

Alternative estuarine fishing techniques

While detailed examination of these methods was beyond the scope of this project their existence and use in the commercial fishery must be acknowledged. Other fin fishing methods presently being used in inshore waters include trapping, ring or seine netting and line fishing. These are used mainly to augment rather than to replace gill netting. Whereas gill netting can be used in a wide variety of habitats under diverse conditions these alternate techniques are somewhat limited in where and when they can be used and what species can be caught.

Trapping. Arrowhead traps, traditionally constructed from wire mesh and mangrove stakes, have been used commercially throughout Queensland for many years. They are almost always confined to protected foreshores (for example, beach foreshores) and are not suited for operating in creeks and rivers because of problems caused by runoff, strong currents and excess debris. Species caught in foreshore nets would be similar to those caught in arrowhead traps. If traps are not serviced regularly, fish spoilage quickly results. In high tidal areas, it is difficult to locate traps with receival boxes below the low water mark. The number of operational traps has been gradually reduced, with only 11 now remaining. Under the Fisheries Act no fish traps are permitted south of Rockhampton in central Queensland.

Ring netting or seine netting. Beach seine-netting can be used most profitably for species which travel inshore in large schools and which can be located visually. This technique is used very successfully on sea mullet (Mugil cephalus) in southern Queensland (see section on sea mullet, page 36). Apart from mullet and bait species, there would appear to be few commercial fishes on which the technique could be profitably and consistently used. Seine netting is very difficult in mud estuaries. Ring netting, which is a combination of seine netting and gill netting, can be used in estuaries and also in certain foreshore situations. It involves encircling areas with a net where fish are thought to be concentrated and then disturbing the enclosed water by some means, for example, with an outboard motor. The disturbance results in fish being frightened or chased into the net where they are enmeshed. This method is practised widely in regions 5 to 8 (see Figure 2), and it's success was dependent on negligible current (it is generally done on low tide inside estuaries). Threadfin salmon, barramundi, banded grunter, mullet and flathead are among the species which can be caught this way but the catch per unit of effort is generally low.

Commercial line fishing. Inshore commercial line fishing was not widespread. Much of the commercial line fishing was in estuaries, specifically for barramundi. It involved using a live bait (fish or prawn) on a hook with a heavy gauge line.

Other techniques. Other fishing methods which have potential for use in this fishery include tunnel netting and drift netting. Drift netting with small mesh nets was used successfully for bait fishing and was used to a limited extent for food-fish species such as threadfin salmon and some mackerels. The author is unaware of tunnel netting being used north of the Hervey Bay area. The technique was used very successfully in catching yellow-fin bream (*Acanthopagrus australis*). This species was not a major component in gill net catches in the study areas, and it is not known if major species of this fishery would be vulnerable to tunnel netting. Its potential should be investigated, with particular attention being given to the by-catch, which may include juveniles of commercial fish species. Both of these techniques would be suited to open flats inside large rivers or protected foreshores. In estuaries which have strong currents or which are obstructed with rocks or fallen timber, such methods would be unsuitable.

Commercial Gill Nets

In rivers, the most commonly set gill nets were monofilament with mesh size ranging from 11.5 cm to 21.5 cm stretched mesh. On foreshores, monofilament nets from 10 cm to 21.5 cm stretched mesh were most widely used. Twine diameters varied according to mesh size, with the larger meshes of line 70 and 90. Two fishermen in the Burdekin region (area 3) regularly used monofilament nets of 23 cm, 24 cm, 25.5 cm and 30 cm stretched mesh in both river and foreshore situations. While net material was not specified in the gill net return form, it is known that most of the fishermen in the survey exclusively used monofilament nets. Some of the larger nets were three-stranded monofilament, which was needed to hold the larger fish. Monofilament nets have the advantages of being easily compacted, are light when wet, are rot resistant, and are of low visibility in the water. Average length of net set varied with situations and habitats, although maximum lengths and numbers are controlled by regulations. Over the period of this study those commercial fishermen who forwarded returns set a total of 494 194 m of net.

Target Species

A wide diversity of fish species are meshed in gill nets, particularly on foreshore sets. Commercial species caught in gill nets during this study are listed in Appendix 2. While gill nets are not selective in the species they catch (Clay, 1981) a fisherman may select for fish size by using different mesh sizes. Smaller species should not mesh in large mesh nets although some species do bridle. The total weights of species caught in the seven logbook regions are shown in Table 3.

The importance of barramundi in the commercial catch can be seen from the ratio of barramundi caught to all other species. In areas 2 and 3 the weight of barramundi and the total weight of all other fish species caught were equal or nearly equal.

When these data from the voluntary catch log scheme were compared with more recent data from the compulsory log book programme (Table 2) some striking similarities and differences were seen. The ratios of the weights of both blue salmon and king salmon to barramundi were similar but the compulsory log book data showed relatively more fish landed in the "other species" category. This was almost certainly because fishermen were declaring species caught using methods other than gillnetting (R. Quinn, personal communication).

Table 3. Total fillet weight of species caught by commercial fishermen participating in the logbook programme.

		Fillet Weight (kg)				
Area	Period (days)	Barramundi	King Salmon	Blue Salmon	Others	Ratio of Barra to all other fish
1	1.00	0.00	5.00	5.00	0.00	
2	476.00	3887.92	329.77	1253.17	2801.32	1:1.13
3	259.00	2680.12	73.04	354.15	2257.97	1:1.00
4	101.00	570.54	54.98	318.98	1097.50	1:2.58
5	202.00	3223.65	363.24	2057.64	4501.50	1:2.14
6	301.00	2103.00	939.00	2513.00	2366.00	1:2.77
7	231.00	808.00	1549.00	31.00	42.00	1:2.00
TOTAL	1571.00	13273.23	3314.03	6532.94	13066.29	1:1.73

Catch Statistics

The catch per unit effort (CPUE) of commercial net fishermen

Analyses of logbook data were undertaken for the main fish categories: barramundi; king salmon; blue salmon; and all other species. Log(total weight for fish caught) was regressed on log(number of days fished). Attempts were then made to improve these models by including terms for geographic area and proportion of time involved in river fishing. After finalisation of these models, the coefficient of log(number of days fished) was tested for any difference from one. If the coefficient is one then the weight of the catch is proportional to the number of days fished when the other terms in the model were kept fixed. Hence CPUE is a meaningful quantity. For all fish categories the coefficient was found to be acceptable as close to one. Point estimates and 95% confidence intervals (CI) of the median CPUE for operators were then calculated by back-transforming sample means and confidence intervals on the log scale (Table 4).

Table 4. Median CPUE of operators for each species.

Species	Model terms		Calculated median	95% CI
Barramundi			8.00	(5.44, 11.54)
King Salmon	areas	(2 to 4)	0.69	(0.46, 1.04)
	areas	(5 to 7)	3.56	(2.36, 5.38)
Blue Salmon			3.50	(1.56, 7.86)
Other Species	Percent River Fishing			
	0%		11.03	(5.79, 21.02)
	50%		5.64	(2.97, 10.11)
	100%		2.88	(0.94, 8.83)

Barramundi. There was no indication of any effect on CPUE due to area or proportion of time involved in river fishing. The confidence interval was wide due to large variability in CPUE between fishermen (Table 3).

King Salmon. After exclusion of a number of operators because of atypical catches, data indicated that there was a strong geographic effect on the catches. On further analysis it was clear that the study region from Cairns to Baffel Creek could be divided geographically into two:

- north coast - areas 2, 3 and 4; and
- south coast - areas 5, 6 and 7.

There were no apparent differences between regions within either the north or south coast and no indications of any effects related to the number of river days or to the proportion of river days fished. The CPUE for king salmon caught in southern areas (5, 6 and 7) was approximately five times as great as that in northern waters (areas 2, 3 and 4) for the number of days fished (Table 4).

Blue Salmon. Several fishermen were not included in the analysis because they were either inefficient at catching blue salmon compared to most other fishermen (that is, low catches for the number of days fished) or because reliable information on their catches was not available. There were no indications of any river days or area effects.

Other Species. After a number of exclusions a total of 12 fishermen were used in the analyses. There was no evidence of any area effect. However there was evidence of an effect of proportion of days river fished on CPUE. It appeared that the median CPUE decreased as the percentage of river fishing (Table 4) increased. This implies the more time spent foreshore fishing, the higher the catch of mixed species.

A comparison was made of CPUE of the foreshore and river fishing operations of individual fishermen who worked in both habitats. Sample size was too small and variability too wide to come to any definite conclusions.

Seasonal variation in CPUE

Logbook data were analysed to determine if there were any seasonal effects associated with the catches by gill net fishermen. Catches were allocated to three seasons which were defined for the purposes of this study as:

- autumn (February to April);
- winter (May to July); and
- spring (August to October).

Only a small amount of fishing was recorded for the period of November through to the end of January - the closed season on barramundi. For this reason data obtained for these three months were excluded from the analyses. Examination of data for all fish categories showed that it was acceptable to use log(catch per day), that is, log(CPUE), for seasonal effects after allowing for an operator blocking effect. These analyses were considered as a randomised blocks analysis and were completely balanced and orthogonal.

Barramundi. There was evidence of a seasonal effect ($p<.05$) due to catch per day being much greater in autumn than either winter or spring (Table 5). The autumn CPUE was almost twice that for winter or spring.

King Salmon. No evidence was found of any seasonal effect on the catches of king salmon.

Blue Salmon. There was clear evidence ($p<.05$) of a seasonal effect producing a higher blue salmon catch per day in winter. The CPUE in winter was more than double the CPUE in autumn and spring.

Other Species. After what was considered to be an unusually large catch was excluded from the data, no evidence was found of any seasonal effect on the CPUE for other species.

Table 5. Median CPUE of operators catching the major groupings of fish by season. No data were available for summer - the period of the barramundi closed season. SE(Diff) is the standard error of difference after log transformation.

	Autumn	Winter	Spring	SE(Diff)
Barramundi	10.02	6.26	5.32	0.20
King Salmon	1.64	1.48	1.37	0.16
Blue Salmon	3.10	7.17	2.64	0.34
Other species	7.55	11.36	10.98	0.24

Fishermen CPUE - differences between river and foreshores

Logbook data were used to compare CPUE for gill net fishermen who undertook foreshore and river fishing. Operators who totally fished in either river or foreshore habitats were not included as they provided no information on the comparison between river and foreshore fishing within operators. No data obtained during the closed season on barramundi were included. The log(CPUE) was analysed using a paired t-test with pairing based on the operators.

Barramundi. There was no evidence that the log(catch per day) was different between those operators who undertook both river and foreshore fishing. The 95% confidence interval for the ratio of the river mean to the foreshore mean for catch per day was calculated (Table 6). The ratio was close to one, indicating that fishermen who fished in both habitats (river and foreshore) chose whether they fished rivers or foreshores on the basis of barramundi catch.

King salmon, blue salmon and other species. Analyses of log(catch per day) were performed for each catch type. No evidence was found for any differences between river and foreshore fishing for any of these species. In all cases, the 95% confidence intervals were too wide to be of practical use (Table 6). The river to foreshore ratios for catch per day were much more variable between operators for catches other than barramundi. Again this suggested that many operators tended to treat the inshore gill net fishery as a barramundi fishery and caught other species primarily in the process of catching barramundi.

Table 6: Ratio of river mean to foreshore mean CPUE (catch per day).

	Ratio	95% CI *
Barramundi	1:1.25	0.85, 1.82
King salmon	1:1.36	0.47, 3.92
Blue salmon	1:1.57	0.35, 6.98
Other species	1:0.56	0.14, 2.31

* C.I. = confidence intervals

Species composition in the research netting programme

The species and their occurrence in the research catches varied from area to area, and within an area from habitat to habitat. While species numbers in most areas were generally high, the bulk of the weight of the overall catch was usually attributed to only a few species.

Cairns (area 1). Species numbers along the foreshore (30 species) were higher than the river habitats (15 species). Barramundi (Lates calcarifer) made up the bulk of the estuarine catch (75% by weight) while on the foreshores, barramundi, king salmon (Polynemus sheridani) and blue salmon (Eleutheronema tetradactylum) were the major components. There was no significant difference in the mean length of barramundi ($p>.05$) and blue salmon ($p>.05$) caught on the foreshores and in the river estuary. King salmon caught on the foreshore were longer than those caught in rivers ($p<.05$).

Murray River (area 2). A total of 22 species was recorded from this river estuary and its adjacent foreshores. On the foreshore, 17 species were recorded with 21 found in the river. By weight, barramundi (46%) and blue salmon (22%) accounted for most of the estuarine catch, and similarly on the foreshore the main components were barramundi (26%) and blue salmon (32%). There was no difference in the mean lengths of blue salmon ($p>.05$) caught in either habitat, but barramundi caught in the foreshore were significantly larger ($p<.05$) than those caught in the rivers.

Burdekin Delta (area 3). A total of 26 species were caught in the Burdekin area, with 23 of these being recorded from foreshores and 20 from rivers. Major component species of the river catch were blue salmon (15%), barramundi (58%) and banded grunter (Pomadasys kaakan) (10%), while blue salmon (30%) and barramundi (49%) dominated the foreshore landings. Mean lengths of all three main species were significantly greater ($p<.05$) on the foreshores than inside the rivers.

Mackay (area 4). Twenty species were caught in gill nets in the Mackay study areas, with 18 of these recorded from rivers and 14 along foreshores. In rivers, barramundi (50%), king salmon (10%) and blue salmon

(12%) made up the bulk of the total catch. Similarly on the foreshores, the major species were barramundi (29%), king salmon (13%) and blue salmon (24%). Mean lengths of all three species from rivers and foreshores were not significantly different (p>.01).

Broadsound (area 5). Of the 24 commercial species recorded from this area. 16 were taken in river habitats and 16 from foreshores. Seven species were exclusive to foreshores and a further 7 exclusive to rivers. In the rivers, 70% of the live weight of fish caught were barramundi, while on the foreshore barramundi (45%), king salmon (11%) and banded grunter (11%) were dominant. Mean length of barramundi caught on the foreshore was significantly higher (p<.05) than those caught in rivers, while blue salmon showed no significant difference (p>.05).

Fitzroy Delta and Gladstone Narrows (area 7). All netting locations for this area were within the Fitzroy delta or sheltered waters of the Narrows separating Curtis Island from the mainland. No strictly foreshore areas were sampled. Only nine species were recorded from this area with barramundi (70%) being the main component (by weight) of the catch. Minor species were blue salmon (8%), king salmon (11%) and spotted jewfish (Johnius dicanthus) (9%).

Baffle Creek mouth (area 7). Twenty-four species were taken in commercial-sized nets from this location with barramundi (38%) and sea mullet (Mugil cephalus) (23%) being the major components. Surf prevented foreshore netting. It is notable that sea mullet, which were insignificant components of the catches in other areas, were a major species in this location. Baffle creek is at the northern extremity of the eastern Australian mullet fishery. (See sea mullet section, page 36).

Biology of Barramundi Lates calcarifer

Barramundi are caught in rivers, creeks, coastal foreshores and on nearshore islands along the Queensland coast north of Maryborough, in the south-east corner of the state. It is an extremely popular angling and commercial species and grows to in excess of 70 kg in weight. The average length of 845 fish caught in gill nets was 69.8 cm while Figure 3 shows the length-frequency distribution of all barramundi caught during this study. Aspects of the biology of barramundi which were closely examined were reproduction and movements.

Tagging

A total of 552 barramundi were tagged and released in all study areas. Of these, 138 (27.0%) were subsequently recaptured by professional and amateur fishermen and the research team. Many of the fish recaptured by the last two groups were re-released, resulting in twelve being recaptured for a second time and one for a third time. Table 7 is a summary of the fish tagged and recaptured in each area.

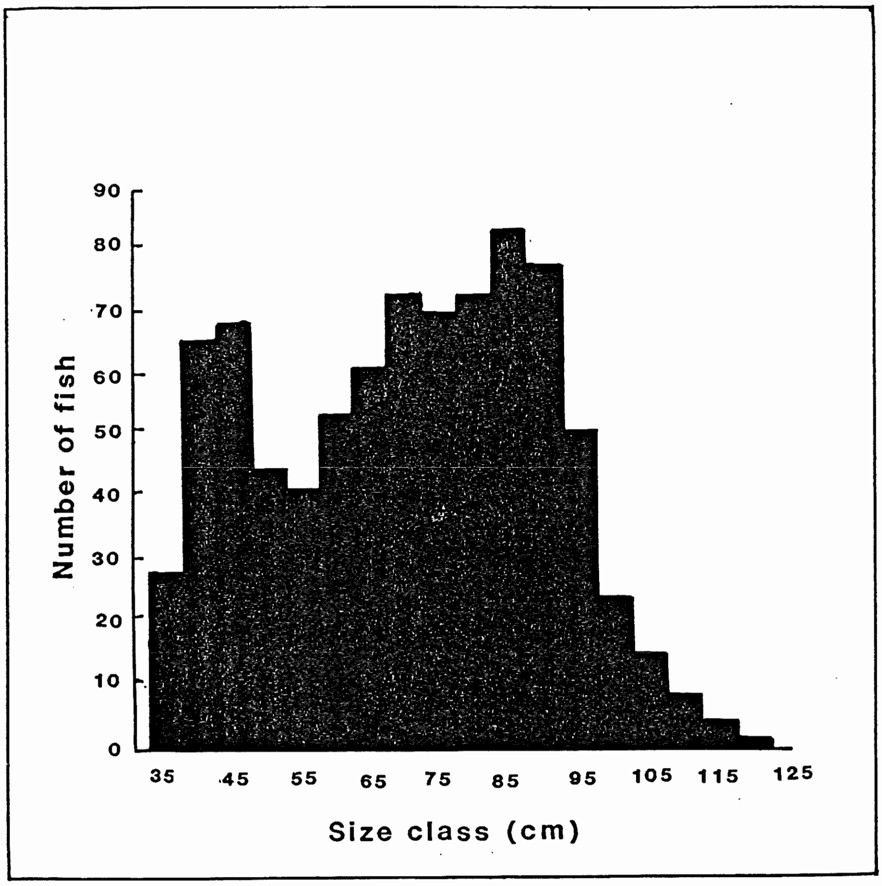


Fig 3

Size-frequency distribution of all barramundi captured by the research team using commercial gill nets.

Table 7. Statistics of barramundi tagging in eastern Queensland from January 1982 to October 1984. No tagging was done in area 4.

	Area						
	1	2	3	5	6	7	8
Number tagged	169	149	128	45	78	24	31
Fish recaptured once	44	13	39	13	17	4	8
Fish recaptured once (%)	26	27	30	29	22	17	26
Number recaptured twice	7*	0	4	0	1	0	1

* - Includes a fish recaptured a third time.

Recapture rates between areas varied from 17% to 30%. Recapture rates were generally higher in areas which were close to cities or large towns (areas 1-5 and 8) recapture rates were very high (up to 28.6%) but were slightly lower in more sparsely populated areas (6 and 7).

Amateur versus commercial fisheries

Data on the type of fisherman who recaptured tagged fish are given in Table 8. Three categories of fishermen - amateur, commercial and the research team - are listed. Amateur fishermen used line fishing as the primary capture method while the other two groups used mainly gill nets.

Table 8. Percentage of tag recaptures from each of the main fishing groups by region. No tagging was undertaken in area 4.

	Region							
	1	2	3	5	6	7	8	Total
Amateur anglers	24	0	19	0	6	0	11	15
Professional fishermen	26	92	53	77	44	25	44	48
Research team	50	8	28	23	50	75	44	37

The percentage of tag returns from the amateur fishery was greatest in the Cairns and the Burdekin areas (areas 1 and 3). In southern areas (5-8) the return rate was relatively low. The percentage of amateur returns from area 8 (11%) was exaggerated by the low number of total returns from that area. Only a single fish was caught by an amateur in area 8. Tag returns from the commercial fishery were highest in the Burdekin (area 3) and at Mackay (area 5). Overall, for each tagged fish caught by amateur fishermen, 3.2 were caught by professionals. In the Northern Territory, Griffin (1982) estimated that the amateur barramundi catch in some areas was as high as 30% of the commercial catch. In the present study the average weights of tagged fish caught was: amateurs (4.96 kg, n=15); professionals (6.47 kg, n=38); and research team (5.42 kg, n=45). For a number of reasons, caution must be exercised before extrapolating these data to the overall barramundi fishery. Gill netting - the sampling technique used to capture fish for tagging - was highly selective for fish sizes. While such a technique would successfully sample fish available to the commercial fishery, it may not have supplied an unbiased sample of fish in the amateur fishery, which would be expected to include fish of a smaller average size. Another factor was non-reporting of the recapture of tagged fish. While no actual data are available, it appeard that on a number of occasions professional fishermen and illegal net fishermen have recaptured tagged fish which were not subsequently reported.

Movements

Some nett movement had occured in the majority of reported tag recaptures. However, in most instances (82%) this nett movement was less than 5km, usually within the estuary or to or from an adjacent coastal foreshore. This was in agreement with the results of other studies being conducted simultaneously in north-eastern Queensland and in the Gulf of Carpentaria (R. Garrett, personal communication). There were, however, instances of fish movement into adjacent estuaries, into freshwater, or along coastal foreshores. Studies conducted in the Burdekin delta in particular showed such movements and these are illustrated in Figure 4. The general trend of these movements appeared to be southwards, towards the mouth of the Burdekin River. Two fish moved 50 km up the Burdekin into freshwater and were recaptured below the Clare Weir. No tagged fish were recaptured upstream of this weir despite the presence of a fish ladder.

Most of the fish were tagged either in an estuary or on a coastal foreshore adjacent to an estuary. Little tagging was done in other habitats such as nearshore islands and rocky headlands, which are known to support populations of barramundi. Consequently, while the results suggest a non-migratory behaviour of barramundi resident in estuaries, no such conclusions can be reached about fish in other habitats. In earlier work on barramundi in Queensland, Dunstan (1959) documented an annual spawning migration from freshwater to coastal areas. As well as for spawning, this behaviour may also serve to replenish estuarine stocks of barramundi. It is likely that fish from other habitats mentioned above may also enter estuaries at certain times, for example to spawn. This could be an important replenishment mechanism for areas without large freshwater catchments.

Recapture intervals

Table 9 shows the time period from release to date of first recapture for barramundi tagged during the study.

Table 9. Number of barramundi recaptured at given intervals tagging for each of the study regions. Only data for first recapture are shown.

	Area							
Period (Days)	1	2	3	5	6	7	8	Total (%)
0 - 90	17	2	12	7	5	2	1	46 (33)
91 - 180	10	0	6	5	4	1	0	26 (19)
181 - 365	7	3	15	1	4	1	2	33 (24)
366 - 545	7	4	4	0	1	0	0	18 (13)
546 - 730	0	1	1	0	1	0	2	5 (4)
> 731	3	3	1	0	0	0	3	10 (7)

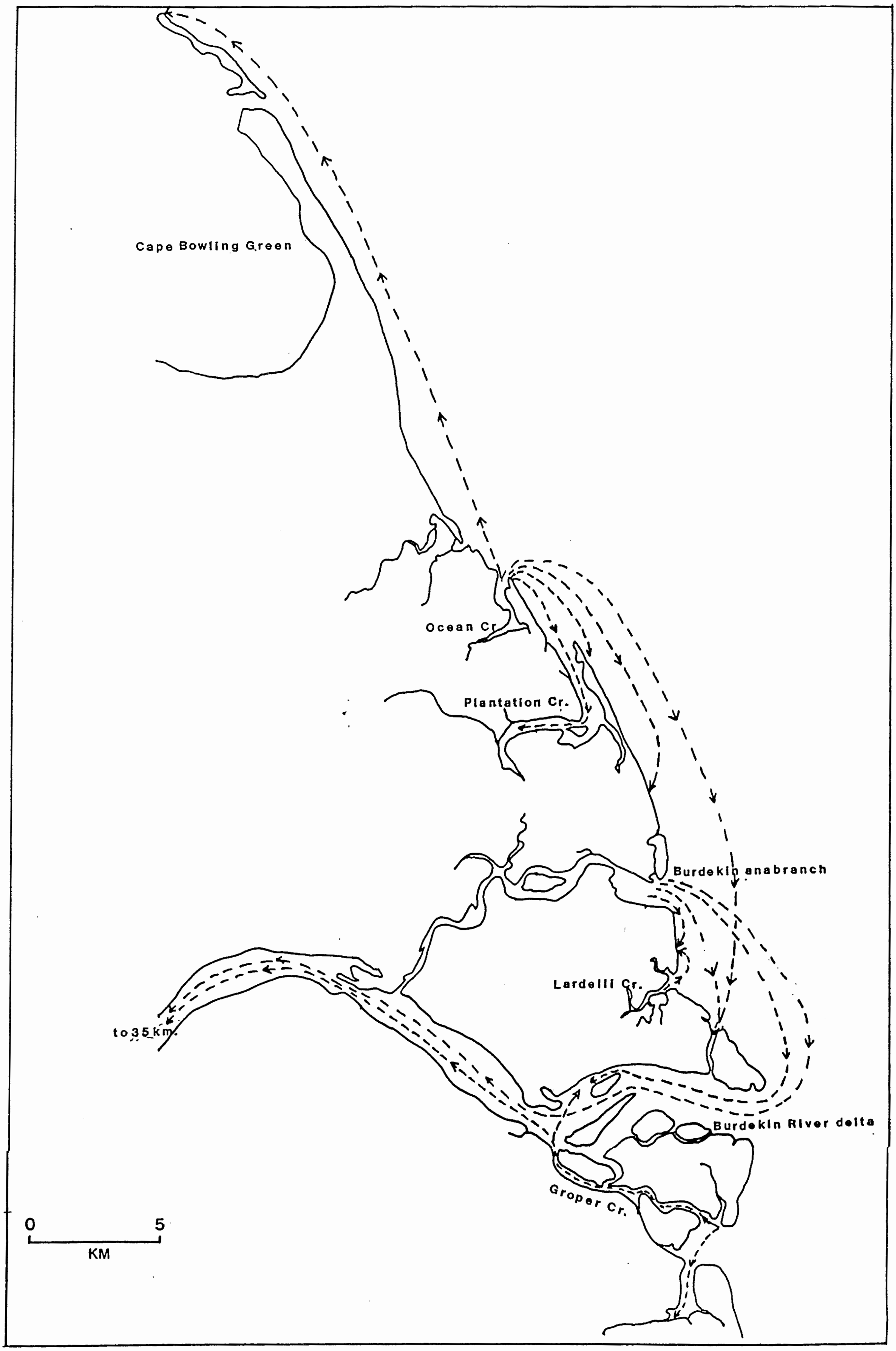


Fig 4 Barramundi movements in the Burdekin delta as determined by tag recoveries. Broken lines represent the movements of individual fish or groups of fish.

Most of the recaptures (76%) occurred within a year of being tagged; 33% were recaptured within the first three after release. Only 10 fish were at liberty for more than two years of which two were at large for more than three years.

Average time (± S.E.) of liberty for all 139 barramundi recaptured once was 257.5 ± 23.6 days. For the Cairns area, 45 recaptured fish had an average release period of 236.6 ± 45.5 days and for the Burdekin it was slightly less at 228.8 ± 38.3 days. Kesteven (1953) proposed a method of estimating average life expectancy by adding the average age at release to the average period of liberty. This was interpreted as the average life expectancy of the fish beyond the release age. The average age of fish tagged during this study using age-length data from barramundi in the Gulf of Carpentaria (Davis and Kirkwood, 1984) and unpublished data from the east coast was 3.5 years. Using Kesteven's method, an estimate of average life expectancy for east coast barramundi was about 4.2 years.

Tag shedding and tag mortality

No attempt was made to estimate tag shedding rates for either of the tag types used. Sufficient information is available in the literature on tag shedding of dart tags (Floy Ft-2) from barramundi. Davis and Reid (1982), using a double tag experiment, determined that immediate tag shedding of dart tags was negligible and the instantaneous daily shedding rate was 0.00057. Davis and Reid (1982) concluded that Ft-2 dart tags were most suitable for the size range of barramundi on which they were used (i.e. larger fish) and appeared to have a much lower shedding rate when compared with opercular tags. No data were available on tag shedding from metal-headed skin tags, but it was assumed to be low. Tag induced mortality for the FT-2 tags was probably quite low (Davis and Reid, 1982). Every effort was made to screen for fish which had suffered major damage during the capture process and these were not tagged.

Reproductive biology

Work undertaken in Papua-New Guinea (Moore, 1979), and later in the Northern Territory and eastern Gulf of Carpentaria (Davis, 1982), suggested that barramundi undergo natural sex inversion from male to female. Garrett and Russell (1982) found indirect evidence for sex inversion in barramundi stocks in north-eastern Queensland. The present study confirmed the wider occurrence of sex inversion in east Queensland barramundi stocks.

Figure 5 shows that the percentage of female fish present in a given size class changed with size. The percentage of females in the lower size classes was small, but the percentage progressively increases with size until in the 105 cm size group all fish were female. This distribution is an indication of sex inversion. Histological examination of gonads collected over the period of study identified three transitional testes, directly supporting evidence for sex inversion.

Tagged fish were always checked for reproductive activity (i.e. running ripe with milt or eggs) before being released. Two fish, identified as running males at time of tagging, were recaptured, after periods of 13 and 18 months at liberty, as females.

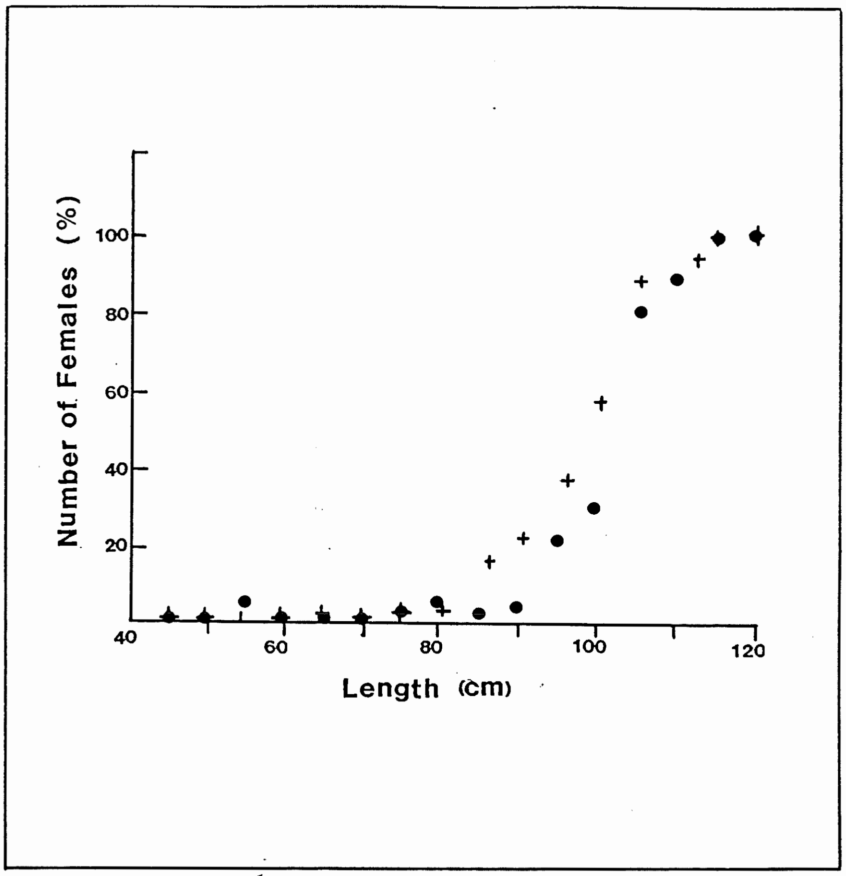


Figure 5. The percentage of female barramundi in each 5 cm size class.
(● are data obtained from this study and + are from Davis' (1982) work in the Gulf of Carpentaria.)

Length at first maturity. There was little variation in gonosomatic indices of fish with total lengths of less than 55 cm. The smallest sexually active male found was 54.5 cm, indicating that the median length at first maturity was greater than the present 50 cm minimum legal length. Davis (1982) found that in the Gulf of Carpentaria, mature males first appeared at 55 cm length.

Fecundity. Estimates were made of the fecundity of eight barramundi ranging from 14.4 to 20 kg in total weight. Figure 6 is a plot of total weight against fecundity. The fecundity of barramundi is very high.

Reproductive seasonality. An accurate knowledge of the reproductive processes and spawning season of barramundi is of great importance to current management strategies. While some small, local variations in spawning times were recorded, the main spawning period in all areas was from about November to February. Figure 7 shows the gonosomatic indices for male and female barramundi gradually increasing from September and peaking in November and December. This is supported by the monthly data on gonadal development of barramundi shown in Figure 8.

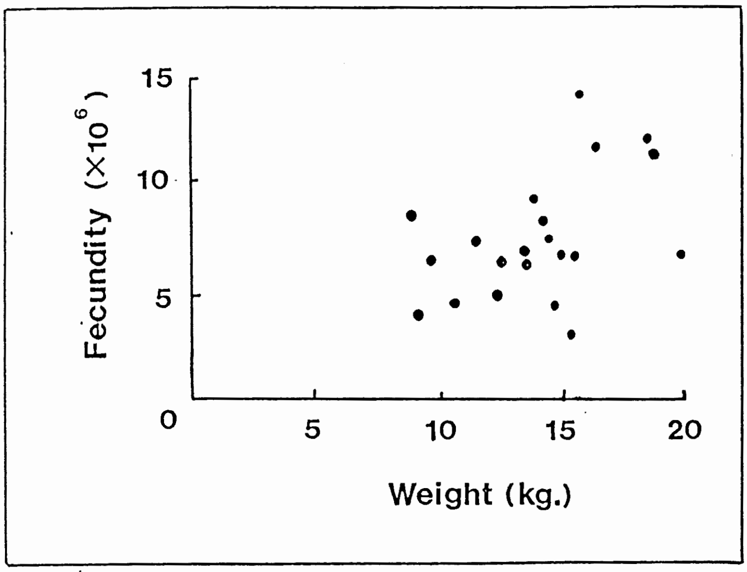


Fig6

Plot of total weight of individual barramundi against their estimated fecundity.

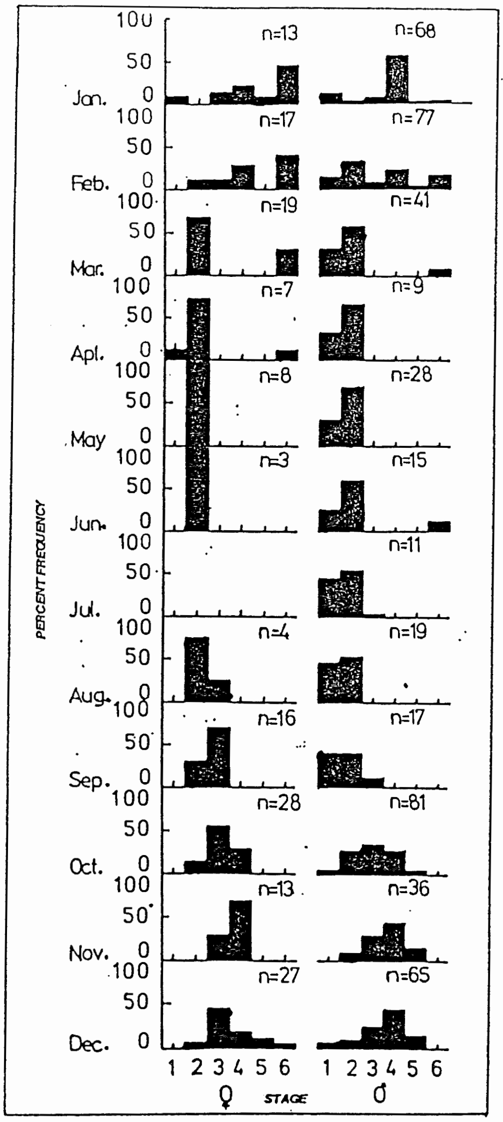


Fig 8

Grouped monthly gonad maturation stages of 622 mature Lates calcarifer from gill net catches in all study areas.

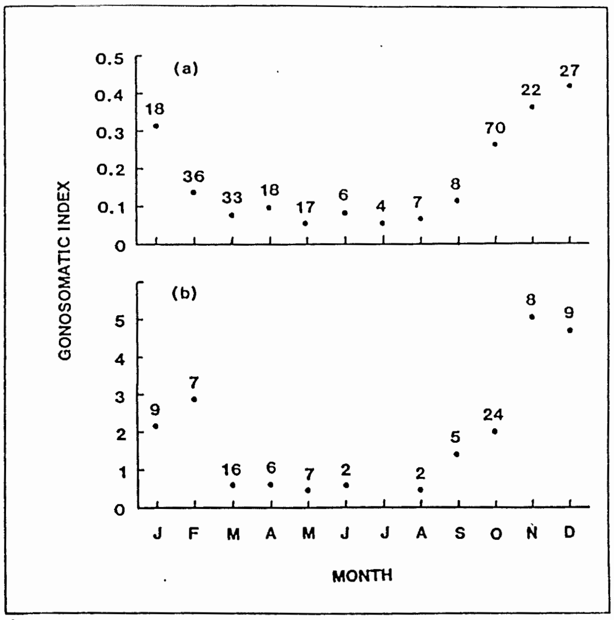


Fig 7

Monthly average gonosometric indices of male (a) and female (b) barramundi.

Spawning aggregations and sites. On a number of occasions small groupings or schools of near-ripe or running ripe barramundi (both males and females) were encountered, usually in or just outside the mouths of creeks and rivers. Such locations were reported as barramundi spawning grounds in earlier studies (e.g. Dunstan, 1959). These aggregations were characterised by a high ratio of male to female fish. On one occasion, seven males were caught to each female. Several females discharged eggs while being released from nets. These unfertilised eggs were rounded, translucent, contained a single oil globule and measured about 0.08 cm in diameter. They had only a slight negative bouyancy but normal water movements would have been enough to keep the eggs in suspension.

Biology of other major species

In a management context, a knowledge of elements of the biology of other major target species, besides barramundi, is also essential. Aspects of the biology of six of the more important species in the inshore mixed fishery are discussed below.

King Salmon <u>Polynemus</u> <u>sheridani</u>

In terms of value to the fishery, king salmon is second only to barramundi. Its range extends from south-eastern Queensland through tropical Australia and possibly into Papua New Guinea (Grant, 1982). It is caught by both anglers and commercial net fishermen on foreshores and (less commonly) in rivers. It is also taken in upper estuaries using both set and ring netting techniques.

The largest fish caught was 120 cm in length at caudal fork (LCF). Unconfirmed reports from fishermen indicate the species may uncommonly exceed 150 cm LCF. Figure 9(a) shows the length-frequency distribution of the 254 captured fish. The mean length was 59 ± 19 cm.

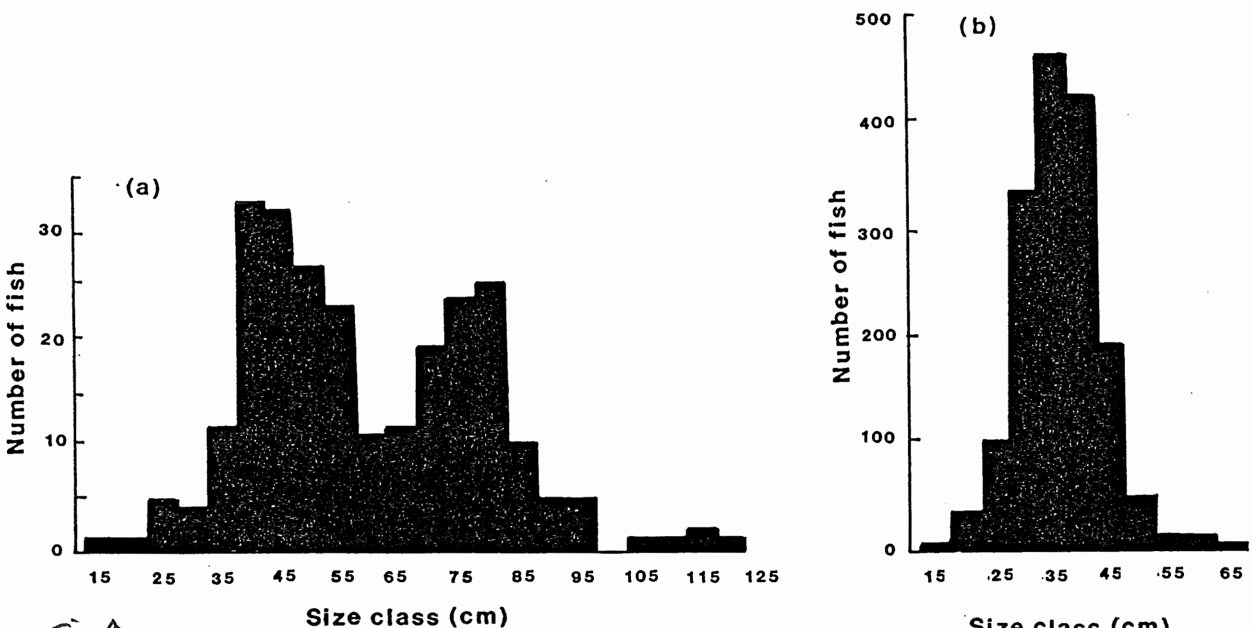


Fig 9

Length frequency of (a) king salmon and (b) blue salmon caught during this study.

Hermaphrodism (both male and female tissue in the one gonad) occurs in this species, as it does in many of the Polynemids (Kagwade, 1970). Three hermaphrodites in the size range 780 to 84.5 cm were sampled. The ratio of males to females was 1:6.8. About 44% of all males were immature. The size at first maturity is about the present minimum legal length of 40 cm.

The large number of immature fish in the catch made determination of the spawning season difficult, but it is probably in summer from about October/November to March (see Figure 10).

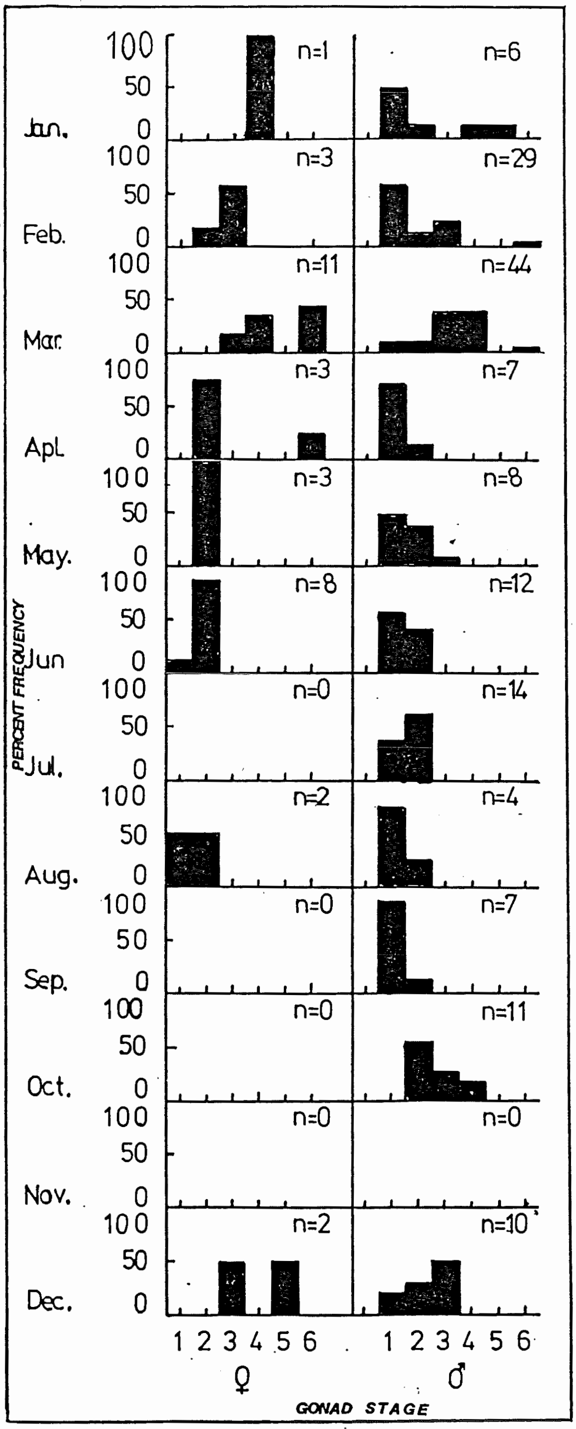


Fig 10

Pooled monthly gonad maturation stages of 185 Polynemus sheridani caught in the gill net sampling.

Blue Salmon <u>Eleutheronema tetradactylum</u>

Blue salmon are caught along coastal foreshores and in estuaries over the entire study area. Blue salmon are the mainstay of the mixed fish catch in foreshore gill nets. They are known to grow up to 122 cm (Grant, 1982) although during this study the largest specimen caught was 65 cm. The mean size (± S.D.) was 36 ± 6 cm. Figure 9(b) shows the length-frequency distribution of 1633 captured blue salmon.

The occurrence of hermaphroditism in this species is well documented (Kagwade, 1970, Patnaik, 1967 and Stanger, 1974). In north-eastern Australia, inversion from males to hermaphrodites occurs around April-May with the hermaphrodite condition being maintained until after the spawning season when inversion to females is thought to occur (Stanger, 1974). This prolonged period of transition explains the high proportion of hermaphrodites (16%) in the catch. Mean length of males was 30.2 cm, hermaphrodites 34.4 cm and females 40.2 cm.

Many of the hermaphrodites were functional males. The ratio of males to females in the catch was 1:1.86, however if all hermaphrodites are included with the males then the ratio is reduced to 1:1.18.

Stanger (1974) suggested that the spawning season is prolonged. Data from this study supports this with spent females being found from August until April (Figure 11). October to December appears to be the peak spawning time.

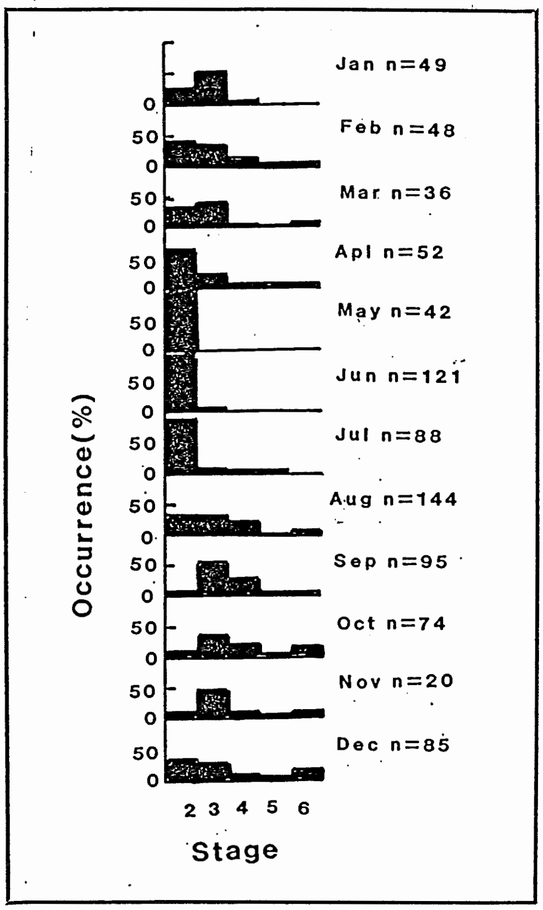


Fig 11

Pooled monthly female gonad maturation stages for blue salmon taken from gill net catches in all areas.

Mud Flathead Platycephalus fuscus

Platycephalus fuscus was taken in gill nets over the entire study area from Cairns to Baffle Creek. It was most commonly caught in lower estuaries and on coastal flats, usually in shallow water over a sandy bottom. Occasional specimens were caught in the upper reaches of estuaries. It is a demersal, non-schooling species usually taken in the bottom of gill nets near the lead line.

A total of 278 mud flathead were sampled, with data on gonad maturation available from 267. Figure 12 shows length-frequency distributions for male and female flathead. The mean sizes of females and males was 55.7 cm, and 46.3 cm respectively. These mean values are significantly different ($p<.01$). The ratio of males to females caught during the study was 1:6.85. Similar observations were made by Dredge (1976) who concluded that sex ratios in age 4-plus fish (that is, a mean length for males of 44.5 cm and for females 43.2 cm) were heavily biased towards females, with no males older than 4-plus being taken.

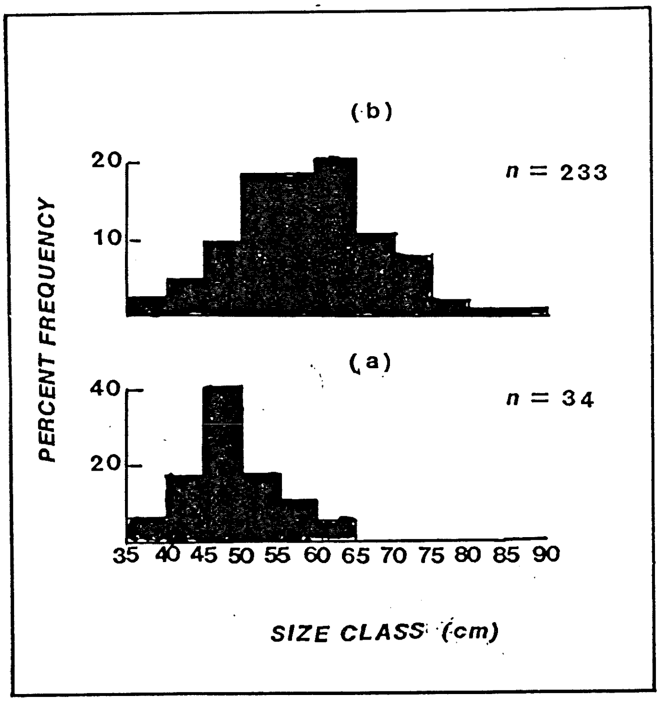


Fig 12
Length-frequency distributions for 267 (a) male and (b) female flathead.

Dredge (1976) also suggested that mud flathead are protandrous and cited studies by Lewis (1971) describing protrandry in two of the five species of Platycephalidae found in Moreton Bay. While no direct (histological) evidence of protandry was uncovered in the present study, the high male to female sex ratio and the significant difference in mean sizes indirectly support the theory of sex reversal. The possibility of different growth rates in male and female flathead cannot be discounted.

Only two female flathead taken were considered immature. This suggests that the median length at first maturity is probably below the size that is commonly caught in commercial gill nets in Queensland. The legal minimum size of flathead in Queensland is 30 cm, which is smaller than any flathead caught during this study.

The presence of stage 5 and 6 ovaries indicated that spawning occurred in the period from September through to March (see Figure 13). Dredge (1976) identified the spawning season of mud flathead in Moreton Bay to be between November and February. If the spawning season of this species is temperature dependent, then it is conceivable that spawning in tropical waters commences several months earlier than in the more temperate Moreton Bay. The data presented in Figure 13 support that hypothesis.

In the non-spawning months (April to August) ovarian development was shown not to be static at Stage 2, but to progressively develop to Stage 4.

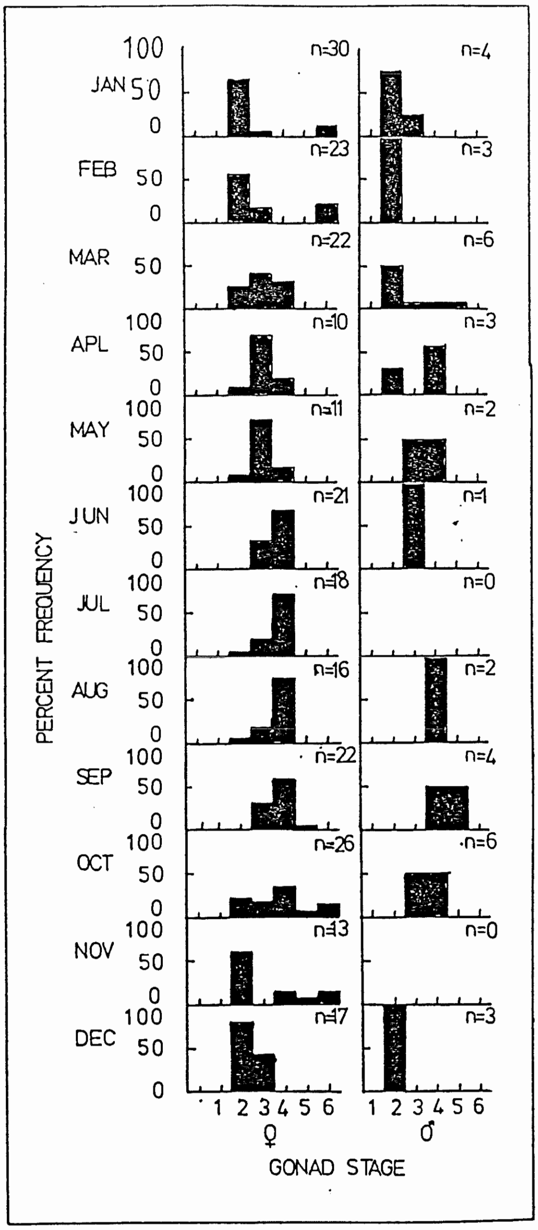
No spawning sites were positively identified, although running-ripe fish were found in shallow water in the lower estuaries and on coastal foreshores.

Banded Grunter <u>Pomadasys</u> <u>kaakan</u>

Banded grunter are a valuable recreational and commercial species caught in lower estuaries and along coastal foreshores, particularly rocky headlands (Grant, 1982). Schools of banded grunter were frequently netted along beaches in the Burdekin district.

Individual - mostly larger - specimens were caught in large mesh nets set in the middle and upper reaches of estuaries. The species ranged over the entire study area, although it was more commonly taken north of Broadsound. Grant (1982) considers it a northern species but has recorded occasional specimens as far south as the Noosa River. In this study specimens were caught in Baffle Creek - the most southerly sampling station. This species feeds on fish, crustaceans and molluscs. Gut contents were often found to include mollusc shells which had been crushed by the fishes strong pharyngeal teeth. Grant (1982) has recorded specimens to 60 cm TL.

A total of 383 specimens were caught, with gonad maturation records available for 354. Length-frequency distributions (in 5 cm size classes) for male and females are given in Figure 14. Mean sizes of males and females were 32 cm and 37.6 cm respectively. The mean size of females was significantly higher than males ($p<.01$). The ratio of males to females was 1:4.6. Only six female banded grunter were considered sexually immature, suggesting that average length at first maturity was well below immature, suggesting that average length at first maturity was well below the average size of fish caught in commercial catches. The minimum legal length of this species in Queensland is 30 cm.(TL), while the median length of fish caught in this study was 34 cm (LCF). No conversion between fork and total length is available. The above data suggest that, with present commercial gear, fewer than half, and probably only a small fraction of the commercial catch is less than the statutory minimum legal size.



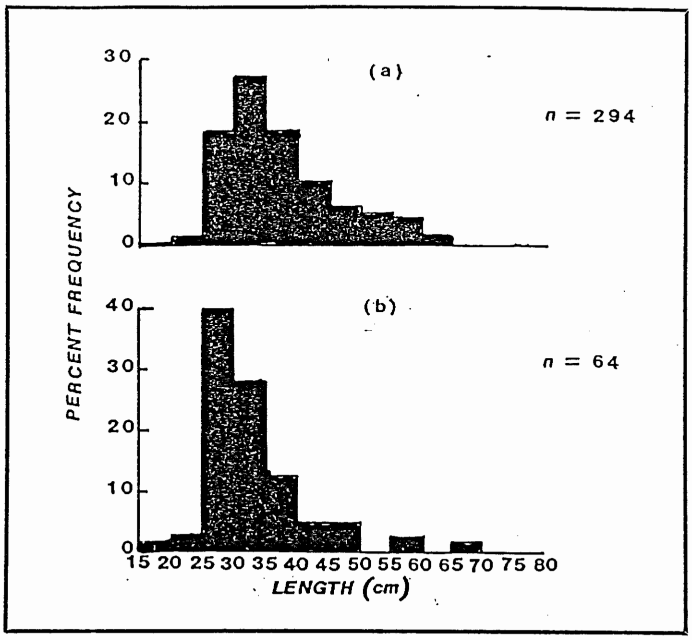


Fig 14
Length-frequency distributions of 358 (a) female and (b) male Pomadasys kaakan.

Fig 13
Pooled monthly gonad maturation stages for all mature flathead caught in gill net sampling.

Figure 15 illustrates monthly gonad stages for 354 mature banded grunter. The presence of advanced female gonad stages (5 and 6) suggests a prolonged summer spawning season between September and March. A lack of stage 5 and 6 gonads in November and February could simply be a result of the small sample sizes in those months or could indicate spawning peaks or pulses.

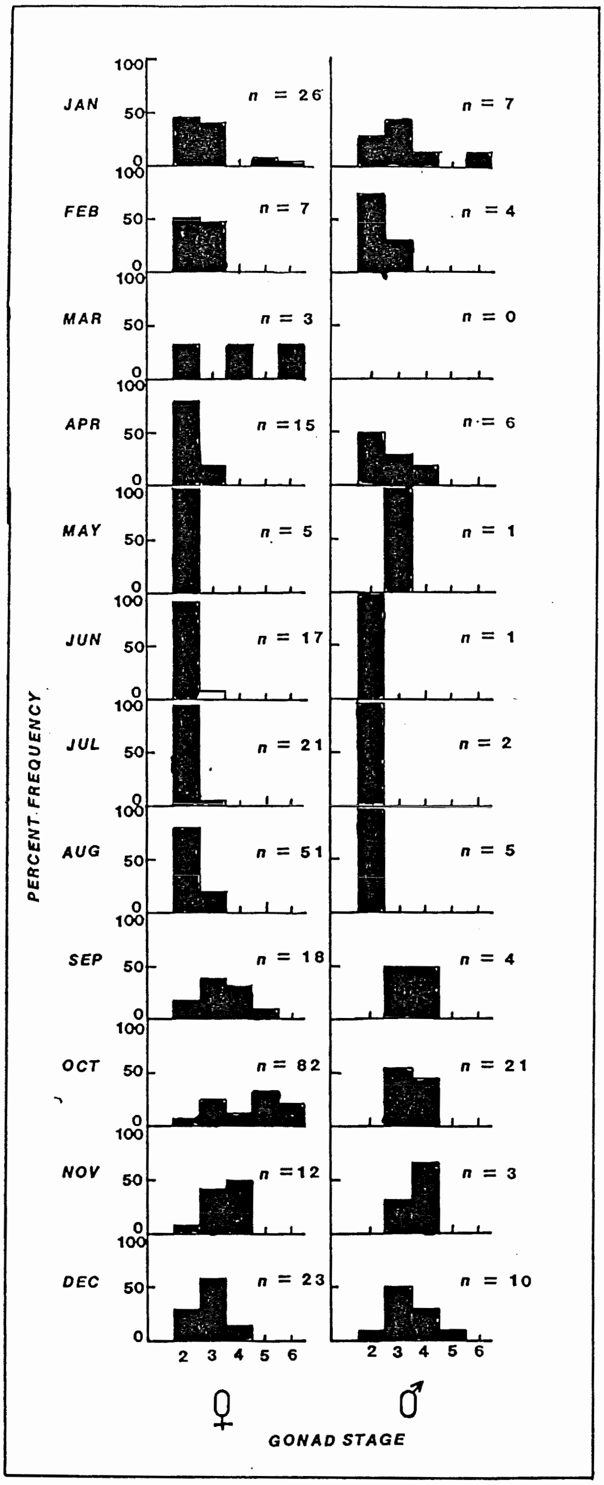


Fig 15

Pooled monthly gonad maturation stages for 354 <u>P. kaakan</u> caught in the gill net sampling.

Silver Jewfish Nibea soldado

This small sciaenid is found mainly over sand or mud substrates along northern coastal foreshores and also in lower estuaries. It is caught by both recreational anglers and net fishermen. The latter catch silver jewfish with long foreshore set nets usually of 100 to 12 cm stretched mesh. Some commercial fishermen do not regard them as a worthwhile target species (mainly because of low market value), but they are generally processed and marketed as part of the mixed fish catch.

The silver jewfish has a broad geographic distribution (Indo-Pacific) and while it is found over the entire study area, it appears more abundant north of the Burdekin River. Some confusion exists about the taxonomy of the family. Grant (1982) described another sciaenid, Johniops vogleri, as being similar in appearance, but having a distribution in rivers and estuaries from Rockhampton south to Brisbane. Only small numbers of silver jewfish were sampled in this geographic region and no attempt was made to separate the latter species.

A total of 404 silver jewfish were sampled, 305 of which were mature females and 82 mature males. Of the remainder, nine were immature (both males and females) and eight were not sexed. Size-frequency distributions of males and females are illustrated in Figure 16. Mean lengths of male and female components of the sample were 25.1 cm and 32.9 cm respectively. Female fish were found to be significantly longer than males ($p<.01$). The ratio of male to female to immature fish was 1:3.7:0.1. The reason for such a high male to female ratio in the catch is unclear. It is possible that there was a differential size structure between sexes and net selectivity tended to mask the true sex ratio. Another possible reason for this high ratio is sex inversion. Although this phenomenon is known to occur in many Australian estuarine fish species (Dredge (1976); Davis (1982); Pollock (1984)), there is little evidence supporting its occurrence in this species.

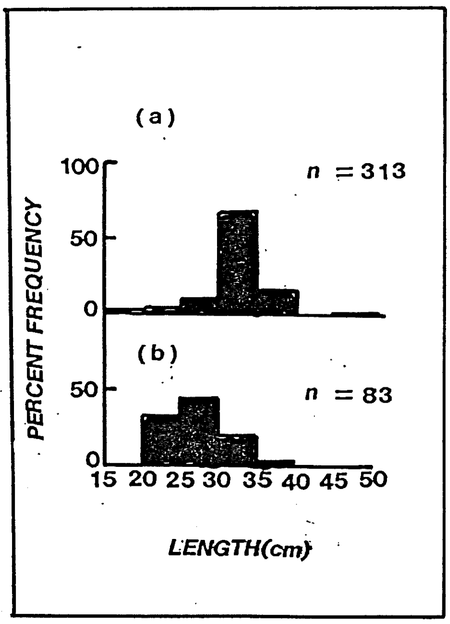


Fig 16

Length-frequency distribution of (a) female and (b) male silver jewfish.

The low number of immature fish in the catch showed that most individuals were sexually mature at the size at which they entered the fishery. Figure 17 illustrates the monthly progression of gonad development in silver jewfish. The presence of stage 5 and/or stage 6 gonads during most months from August to March inclusive was evidence of a prolonged spring-summer spawning season. During four months of the year there was no spawning, with increased gonadal activity in July.

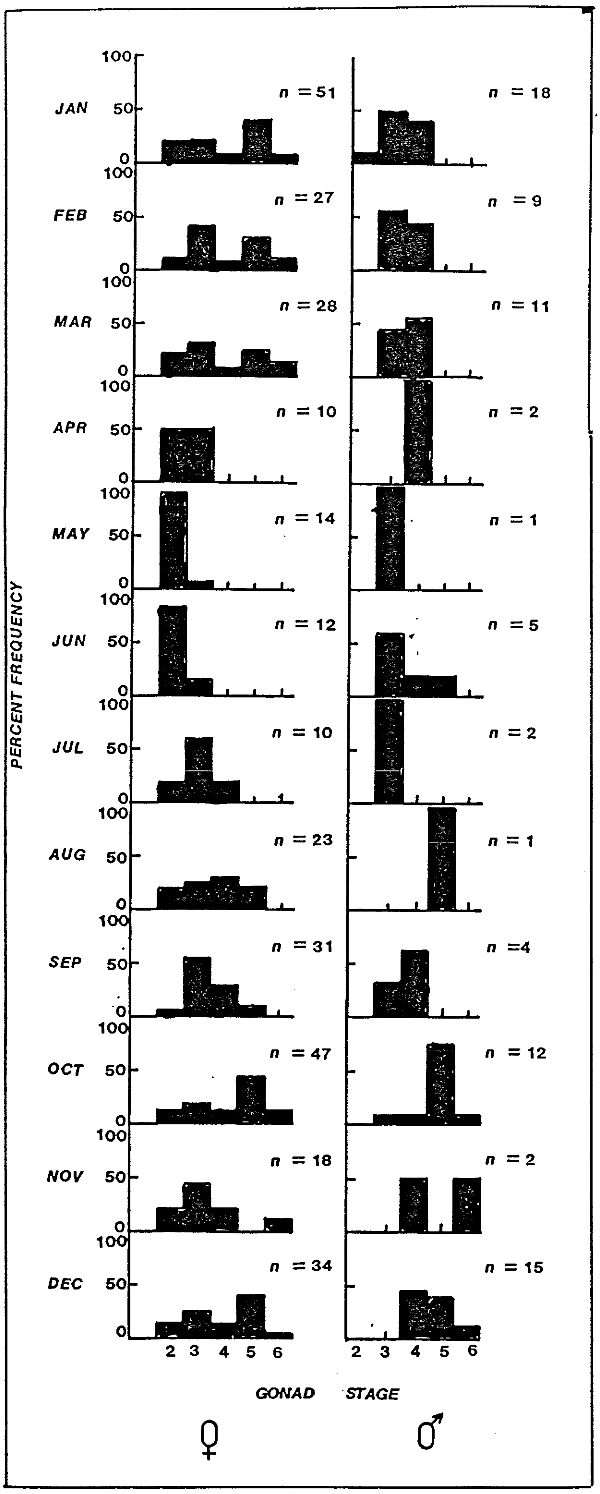


Fig 17
Pooled monthly gonad maturation stages for male and female jewfish.

Sea Mullet *Mugil cephalus*

Although catches of mullet were made in all study areas, large numbers were recorded only at the southern sites, particularly Baffle Creek. Commercial mullet fishermen use ring nets in the estuaries and seine nets along beaches to capture mullet. Gill netting is not a popular technique for commercial mullet fishing, and ring netting appears to be more efficient probably because of the predictable nature of mullet schools. During autumn, mullet descend out of freshwater into estuaries, where they congregate into shoals before their northward breeding migration in winter (Grant, 1982). It is from this movement that beach fishermen take most of their catch. While extraordinary individual hauls of up to 25 tonnes (Grant 1982) may be taken, lesser catches are more common. During this study, a commercial 'gang' at Rule's Beach north of Baffle Creek, made a catch of 5 tonnes. Rule's Beach was the most northerly known location where specialist mullet fishing gangs operate. Large catches of sea mullet were made occasionally in the vicinity of Gladstone and as far north as Mackay. Kesteven (1942) identified Mackay as the northern limit of commercial sea mullet stocks.

While gill nets are not recognised as commercial gear for target mullet fishing, one catch of several hundred kilograms was made with research nets.

Mesh Selectivity

Fish are normally caught in gill nets by either gilling or wedging and tangling. Tangling is more important in species with spines (for example, catfish) than smooth bodied fish (for example, salmon and barramundi) which make up the bulk of the east coast fishery. For the purposes of mesh selectivity analyses, tangling has been ignored. A third way by which nets catch fish is by bridling or 'lipping' of fish. Fish caught in this way are usually insecurely hooked by mouth parts. Threadfin salmons are commonly bridled in the net.

Gill nets catch fish of different sizes with unequal success. For each species there is an optimum size that will be retained by a net of a particular mesh size. Above and below this optimum length, the ability of the net to catch fish decreases. Smaller fish pass through the meshes, while larger fish can either break through the net or may not become properly enmeshed. Net-mesh size regulations can, and have been, used as an effective management tool for controlling the size and numbers of fish caught.

Length-frequency histograms for barramundi, king salmon, blue salmon and banded grunter over a range of mesh sizes are given in Figures 18 to 21. The relationships between mean lengths of these four species and mesh size is shown in Table 10.

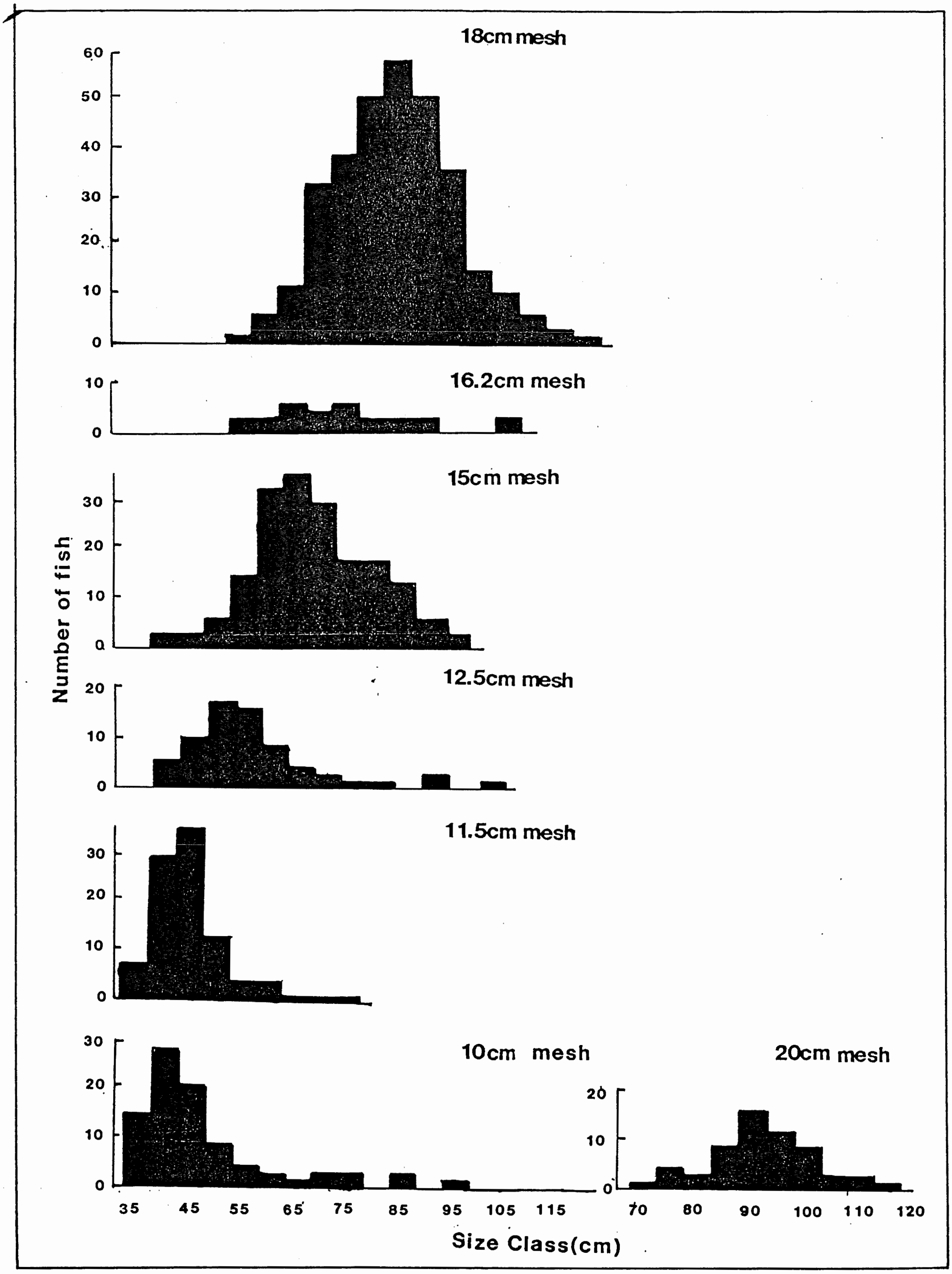


Fig 18

Size frequency distributions for barramundi caught in a range of mesh sizes used commonly in the commercial fishery.

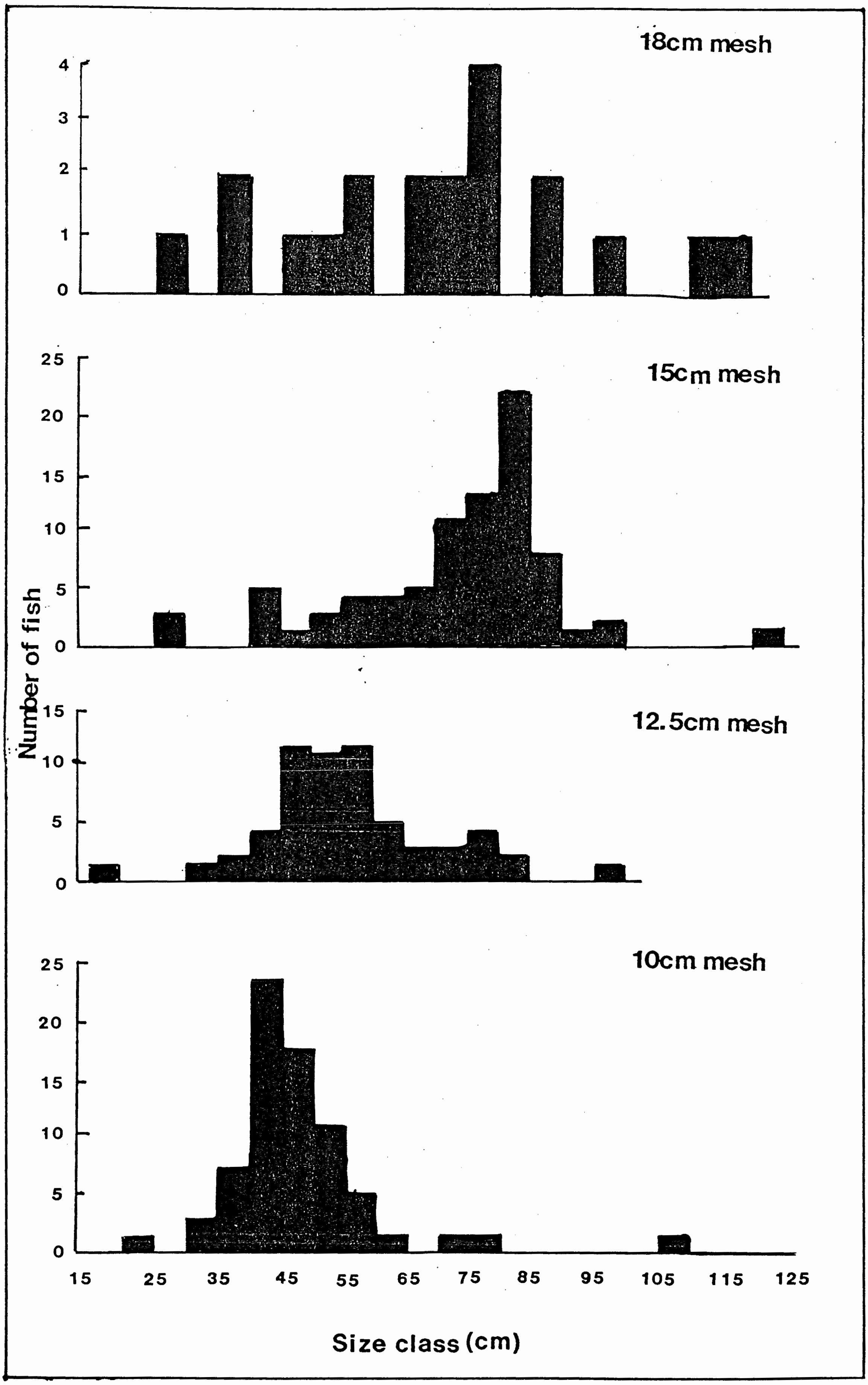


Fig (9)
Size frequency distributions for king salmon caught in a range of mesh sizes used commonly in the commercial fishery.

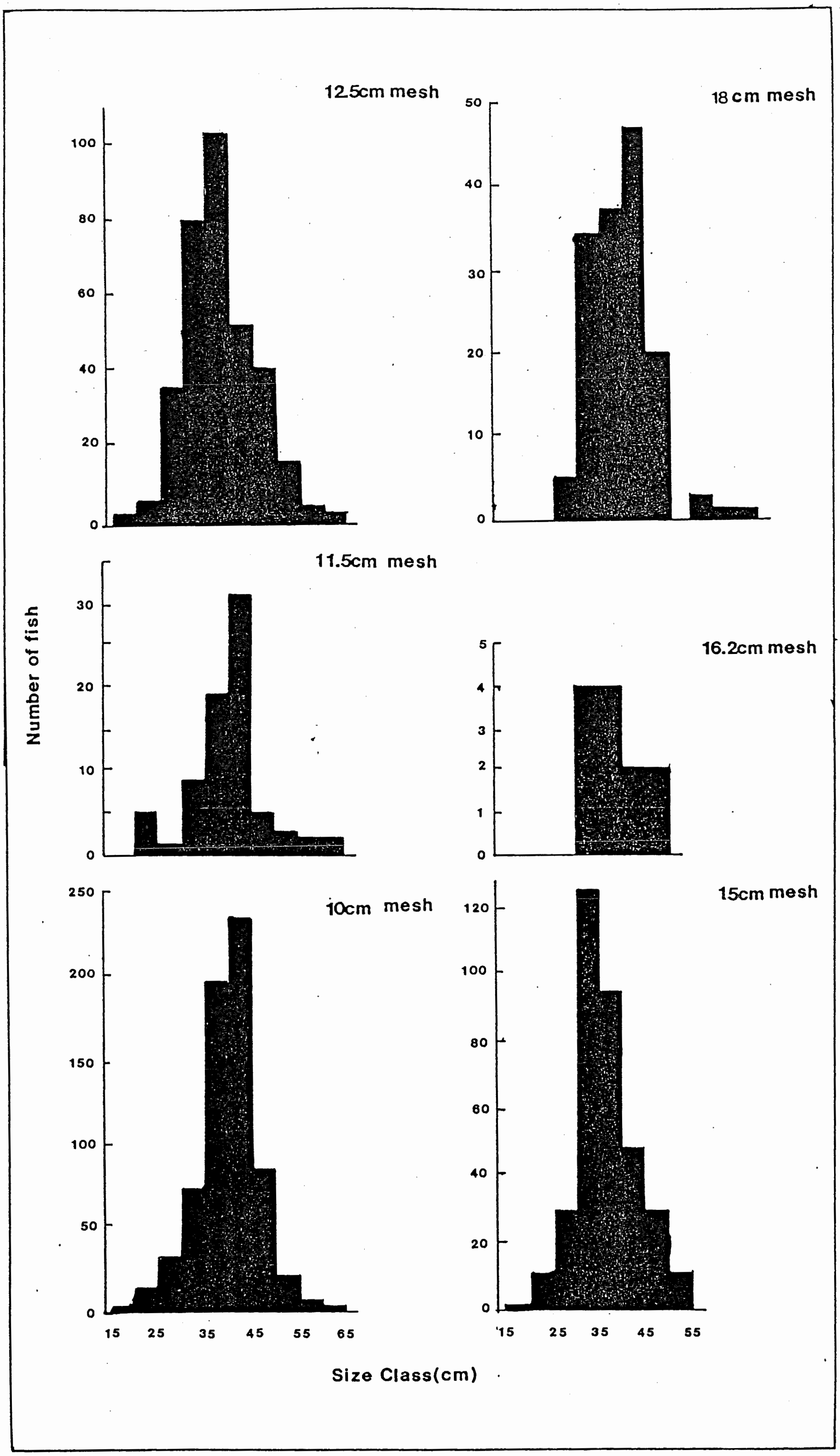


Fig 20 Size frequency distributions for blue salmon caught in a range of mesh sizes used commonly in the commercial fishery.

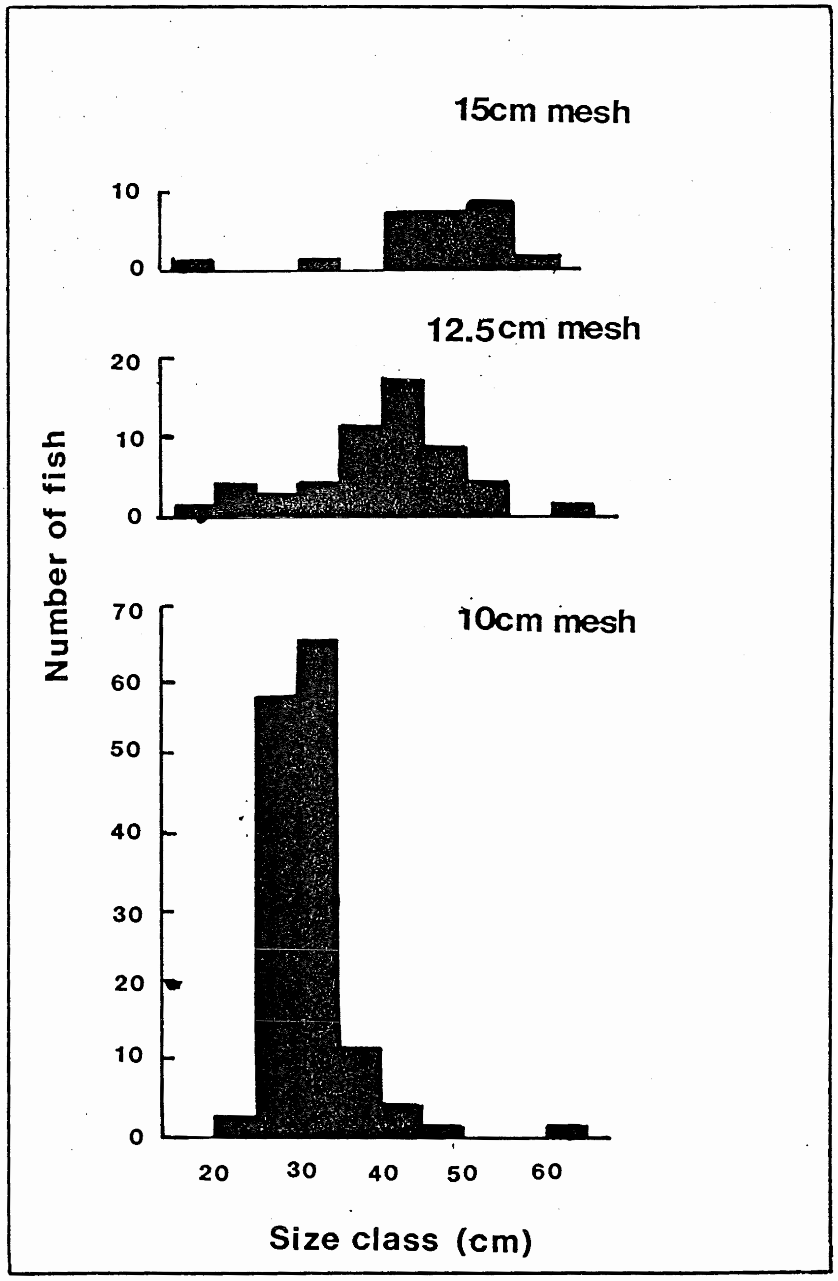


Fig 21.

Size frequency distributions for javelin fish (Pomadasys kaakan) caught in a range of mesh sizes used commonly in the commercial fishery.

Table 10. Mean length (mm) and standard deviation (in brackets) of fish caught in various mesh sizes; n.a. indicates not enough data were available for analyses. Data were pooled by site and sex.

Species	Mesh Size (cm)						
	10.0	11.5	12.5	15.0	16.2	18.0	20.0
Barramundi	46.4 (12.3)	45.3 (7.2)	55.1 (11.8)	68.3 (10.6)	74.5 (12.6)	84.3 (6.4)	92.1 (9.1)
King salmon	44.7 (11.0)	n.a.	55.7 (13.5)	70.4 (16.5)	n.a.	68.0 (23.8)	n.a.
Blue salmon	37.3 (6.3)	37.7 (8.0)	35.4 (7.7)	33.9 (6.7)	35.8 (5.6)	37.2 (6.7)	n.a.
Banded grunter	28.8 (4.8)	n.a.	37.5 (8.8)	48.8 (8.1)	n.a.	n.a.	n.a.

The mean length of barramundi and banded grunter generally increased with increasing mesh size, but this is not the case for the threadfin salmons, particularly blue salmon. This was probably because of a disproportionate number of smaller fish being caught by bridling, rather than by wedging.

Relationship between minimum legal length and mesh size. A large proportion of the barramundi caught in the 10 cm mesh (71%) and the 11.5 cm mesh (75%) was below the statutory legal size of 50 cm. With increasing mesh size this proportion decreased to 23% for 12.5 cm mesh and to 2% for 15 cm mesh. In blue salmon and king salmon the miniumum legal length is taken as the total overall length, but measurements in this study were taken as length-to-caudal-fork (LCF) for these species. In both species the LCF is roughly 85% of the T.L.. The mean LCFs for king salmon caught in all mesh sizes were certainly all well above the minimum legal size (40 cm). The minimum legal length of 40 cm for blue salmon approximates 34 cm LCF, which is below all the mean values obtained for all mesh sizes. The mean length of banded grunter caught in 10 cm nets (28.8 cm TL) is slightly less than the statutory legal length of 30 cm TL. Mean lengths obtained for other mesh sizes (12.5 and 15 cm) were well above 30 cm.

Sex selectivity. As discussed previously, sex reversal has been established or suspected in a number of the key target species including barramundi, blue salmon and mud flathead. In all these species, fish mature as males and later change to females. It was expected that mesh selectivity would result in more males being caught in smaller mesh sizes and more females being caught in larger mesh nets. This was certainly the case for barramundi (See Table 11), in fact many of the fish caught in the 10 cm to 12.5 cm mesh sizes were not mature.

Table 11. Frequency of occurrence of mature male and female barramundi in different mesh sizes. If mesh sizes larger than 20 cm were to be trialled it would be expected that a higher percentage of females would be caught.

	Mature Barramundi		
Mesh Size (cm)	Female	Male	Total Number
10.0	0.1	0.9	5
11.5	0.1	0.9	2
12.5	0.0	1.0	7
15.0	0.01	0.99	81
16.2	0.11	0.89	14
18.0	0.2	0.8	165
20.0	0.44	0.66	35

Table 12 shows the relationship between mesh size and sex of blue salmon caught during the study. With the exception of the 15 cm mesh-size group, females made up the highest proportion of the catch. Males made up only a small fraction of the catch in most mesh sizes. This was most certainly related to the small size at which sex inversion occurs.

Smaller sample sizes for the other major target species prevented the establishment of similar relationships between sex and mesh size.

Table 12. Frequency of occurrence of mature male, mature female and hermaphrodite blue salmon in a range of gill net sizes.

	Blue salmon			
Mesh size (cm)	Female	Male	Hermaphrodite	Total Number
11.0	0.63	0.22	0.15	643
11.5	0.62	0.21	0.16	66
12.5	0.51	0.31	0.17	334
15.0	0.36	0.47	0.16	348
16.2	0.5	0.17	0.33	12
18.0	0.6	0.24	0.15	145
20.0	0.68	0.09	0.23	22

Relative efficiency of multifilament and monofilament nets. Monofilament and multifilament nylon were the two most common webbings used in the inshore gill net fishery. In recent years monofilament has become the dominant webbing. Monofilament nets have advantages over multifilament nets; they can be set and retrieved faster and they are lighter which makes them easier to transport and allows a greater length of net to be set. Fish can be removed more efficiently and the incidental catch of crabs and debris is reduced. Pristas and Trent (1977), using a technique for assessing damage to nets from normal fishing activity, found the average damage was 0.16% for monofilament and 0.24% for multifilament webbing. The disadvantages of monofilament compared to multifilament nets were: greater cost per kilogram; more storage room required; and problems with repairing webbing due to knot slippage (Pristas and Trent, 1977)

The biggest advantage of monofilament over multifilament nets is its higher catch per unit length of net. Collins (1979) when comparing the two gears for catching lake whitefish found monofilament nets were 1.8 times more efficient. Pristas and Trent (1977) found in Florida that catches of fishes were higher in monofilament webbing than multifilament webbing for eight of the 12 most abundant species. Over 58% of the 12 most abundant species and over 71% of the four most abundant food and recreational fishes were caught in monofilament nets. In the United Kingdom the use of monofilament nets increased the CPUE on bass (Dicentrachris labrax) from around 200 lb/boat/day to around 6000 lb/boat/day, an increase of about 3000% (Lilygreen and Meade, 1982). The superior efficiency of monofilament netting has prompted some governments to plan for, or to actually place severe restrictions on its usage in inshore waters (for example Lilygreen and Meade, 1982).

FISHERY MANAGEMENT

The east coast gill net fishery is a multi-species fishery composed of nearly 50 different species, with barramundi, threadfin salmon and banded grunter being the main target fish. Of these, barramundi was the most important species both by weight and value at the time of this study. With the exception of the south-east corner, it is commercially caught along the entire Queensland coast.

The problems associated with effectively managing such a multi-species fishery are considerable. Beddington and Rettig (1984) discuss problems associated with tropical multi-species trawl fisheries. Problems they identified included declining catch rates with an increased effort, and ecosystem overfishing, where the species composition of the community moves from one dominated by large teleostean fish, to one dominated by smaller fish and invertebrates. While there was no direct evidence that either of these processes was occurring in the east coast gill net fishery, (mainly because of lack of long-term fishery statistics), there was some indirect evidence (see Introduction page ?), and considerable anecdotal evidence, that total catches (particularly barramundi catches) had declined in the period prior to the introduction of the current fishery management strategies in 1981. Management of the east coast gill net fishery has been essentially a strategy of controlling fishing effort. Controls have been placed on the number, mesh sizes and length of nets that may be used and the areas where, and times when, fishing may be conducted. Limits have also been placed on the number of participants in the fishery.

The main intention of the present management strategy has been directed towards conserving stocks of the primary target species, barramundi. However a prudent combination of area and gear restrictions, particularly regarding the mesh sizes which can be used in rivers and along foreshores, has resulted in little impediment to the harvesting of other target species.

There was no evidence that the stocks of any other fish species beside barramundi were under heavy fishing pressure. This situation is probably the result of a number of factors. Barramundi is predominantly estuarine and is subject to higher fishing intensity than the other species, which are mainly caught in foreshore coastal habitats. Logbook data indicated that most commercial gill net fishermen target specifically for barramundi. Barramundi also commanded a higher price which undoubtedly contributed to the higher fishing intensity. Barramundi is a relatively long-lived fish not maturing as a male until about three to four years old, while in general the other target species have a relatively short life span and therefore are less vulnerable to fishing pressure. While the present management strategy has an inherent bias towards the barramundi component of the fishery, it should be recognised that the fishery is dynamic, and future pressure on stocks of other species may necessitate major management changes. Biological and fishery data in this report should provide a basis for making such decisions.

Changes to the management plan

The current management strategy can benefit from some 'finetuning'. There are also some areas which require further investigation. Consideration should be given to :

Minimum mesh sizes in rivers. At present, 11.5 cm is the minimum mesh size allowed for set nets inside river estuaries. They may only be used from April to September ostensibly for catching threadfin salmon. When used in rivers this mesh size caught more undersized barramundi than any other species (see Mesh selectivity section, page 27). The logbook data showed that this mesh size was rarely used inside rivers by those commercial fishermen who participated in the voluntary scheme. The general minimum mesh size for river set nets should be universally increased to 15 cm bringing it into line with regulations in the Gulf of Carpentaria fishery. It should be left to the industry to nominate for exemption, important salmon-fishing areas (if any) which are presently subject to river fishing regulations. No such areas were identified during this study. It may be necessary to reassess the criteria used for determining where river fishing regulations take force in areas such as Broadsound and Shoalwater Bay where river mouths are very large.

Minimum legal size of barramundi. Size at first maturity of barramundi is well above the present minimum legal size for the species. In other fisheries, and indeed in the barramundi fishery in the Northern Territory, size at first maturity is an important criterion for determining minimum legal size. Data presented by Davis (1982) showed that the size of earliest maturity in the Gulf of Carpentaria was 55 cm TL, a finding supported in this study, where the smallest sexually active male found was 54.5 cm.

Maximum size of barramundi. Management of the barramundi fishery is complicated by sex inversion whereby males change to females. Fish of lengths greater than 110 cm were generally females (see Reproductive biology, page 24). Arguments have been advanced to enforce a maximum size limit on barramundi thus protecting breeding females and ensuring adequate recruitment to the fishery. Conversely it has been argued that females should be afforded no special protection as the huge fecundity of the species means only a relatively few fish are needed to ensure maximum recruitment.

Mathematical models of recruitment are commonly used in fisheries research. Theoretical consideration of these models recognise that there is an upper limit to recruitment regardless of how large is the population of spawners (Tyler and Gallucci, 1980). There is also a critical stock size below which reproductive processes may be density-independent and which can result in inadequate recruitment to perpetuate the stock (Tyler and Gallucci, 1980). There is anecdotal information that crashes have occurred in barramundi stocks in India due to overfishing. No Australian barramundi stocks are known to be under such a threat.

It is worth noting that there is increased interest among fishermen on the east coast and in the Gulf of Carpentaria in using large mesh gill nets - in some cases up to 30 cm stretched mesh. At the moment, the overall capital invested in these nets is small. Large mesh nets target specifically for large female barramundi, which normally would have a reasonable chance of avoiding capture in smaller nets. Barramundi stocks in east coast areas already heavily fished and/or under pressure from other factors (such as environmental degradation) may well be particularly susceptible to an increased fishing pressure on female barramundi. In the event of measures being introduced to protect female barramundi, rather than imposing a politically unpopular and virtually unenforceable maximum legal size on barramundi, it would be more efficient to control effort by selecting a maximum mesh size to be used in inshore waters and estuaries. While a few east coast fishermen have always used large mesh nets, most use mesh sizes up to 20 or 21.5 cm. A maximum mesh size of 20 cm would ensure that most barramundi caught would be males (see Mesh selectivity, page 27).

Area closures. In Queensland all freshwaters are closed to commercial fishing, a weekend netting closure is enforced for most east coast estuaries, and certain estuaries or sections of estuaries have been closed to all net fishing or in rare instances, to all forms of fishing. The weekend closure and many of the estuarine closures were introduced to limit potential conflicts between amateur and professional fishermen. Such closed areas are usually adjacent to large towns or cities. After representations from commercial fishermen the QFMA. reviewed the weekend closure in central Queensland. This review identified areas which were sufficiently isolated to allow them to be reopened to net fishing on the weekends.

Rivers, in the past, have been closed to netting using the rationale that they may then act as replenishment areas for the fish fauna of surrounding streams. Movement studies on barramundi, the dominant species of the estuarine gill net fishery, have shown that there is minimal movement between rivers. In view of this and the contention that closed rivers are more susceptable to illegal fishing, such replenishment strategies must be questioned.

Area closures can be used effectively in protecting certain stages in the life history of fish. An example is some estuarine supralittoral swamps and lagoons which have been identified as nursery grounds for barramundi (Moore, 1982; Russell and Garrett, 1983, 1985). Some such nursery areas have been protected as habitat reserves or wetland reserves, but there is a need for more work to identify such habitats, particularly along the more densely populated section of the east coast where there is a high risk of environmental degradation.

Physical barriers. Another area where habitat disruption is an issue for concern on the east coast, is the construction of coastal steam barriers. These interfere with the migratory patterns of commerical fish species such as barramundi and sea mullet. Fish ladders which are supposed to allow for fish movement in both directions, have been incorporated into the design of many stream barriers. This may, in fact, not be happening and the suitability of the designs of some ladders to Australian native fish have been questioned. Stream barriers with an ineffective fish ladder or no fish ladder prevent many migratory fish from utilising large areas of freshwater habitat. Kowarsky and Ross (1981) in a year-long study of fish movements in the fish ladder on the Fitzroy River Barrage near Rockhampton, found only five sub-adult barramundi moving upstream. There is a need to assess the effectiveness of other coastal fish ladders and to determine which design is most suitable for native fishes. Fish often congregatate in sections of rivers immediately upstream and downstream of coastal stream barriers on their migratory routes where they are especially vulnerable to fishing. While some closures are already in effect, consideration should be given to placing a moratorium on all fishing within a determined distance of coastal stream barriers, including the fish ladders.

Closed Season. Spawning grounds can be protected by area closures, but this is probably more appropriate in the fisheries where there are central spawning grounds. Most of the species in the fishery apparently do not have central spawning grounds to which they migrate. Very little is known about the spawning grounds and requirements of most east coast commercial fish species. Spawning stocks of barramundi are protected by the closed season and by a closure of all rivers to fishing during that season. Data obtained during this study suggest that a river closure does not greatly affect the fishery for other species. The period set aside for the barramundi closed season generally coincided with the peak spawning periods of many of these other species. While there are some regional differences, no consideration should be given at this time to staggered geographical closures.

Fishery Statistics. The establishment of a sound database for the fishery is essential for future management. This seems assured as the voluntary logbook programme initiated in 1981 as part of this research project has now been replaced by a compulsory scheme. Until adequate fishery statistics are available it is recommended that there be no increase in effort in the fishery.

Fishery Economics. This project has dealt primarily with the biology of species and the gear used in the east coast gill net fishery. Management should not be based solely on these factors. Sociological considerations and particularly the economics of the fishery should be integrated into management strategies. There is a need for a detailed study to define economic parameters of the fishery.

Stock enhancement

The present management strategy for the east coast gill net fishery has been in force for about seven years. During this time there have been reports by fishermen of large numbers of juvenile barramundi in estuaries, indicating that the strategy is working. There is a considerable lag between the time of recruitment of juvenile fish into the stock and the time at which they subsequently become available to the fishery. It may be some years yet before the effects of the 1981 management measures follow through to the fishery. The concept of stock enhancement using hatchery-reared barramundi fry is (superficially) an attractive proposition. The cost of such estuarine stocking would be considerable and prior research would be required to determine optimal stocking rates. There is also a possibility of some type of genetic contamination of the indigenous population. Very serious consideration should be given to the economic and possible biological consequences of such a proposition.

RECOMMENDATIONS

- The strategy of using effort restrictions to regulate the fishery should be retained.
- Moves to increase effort in the fishery at this time should be resisted.
- The management plan should be regarded as dynamic and subject to regular review.
- The compulsory logbook scheme should be a permanent part of the management plan.
- An economic survey of the fishery should be undertaken.
- The minimum mesh size for use in east coast estuaries should be conditionally increased to 15 cm stretched mesh.
- All river closures to the commerical fishery should be assessed.
- The closed season on barramundi should be retained as a key component of the overall strategy.
- Potential effects of an increased usage of large mesh nets on numbers of female barramundi should be carefully investigated.
- Consideration should be given to increasing the minimum legal size of barramundi to at least 55 cm TL to correspond with size at first maturity.
- There is a need to identify and protect important nursery habitats for barramundi.
- The effect of coastal stream barriers on migratory fish and the effectiveness of fish ladders needs to be investigated.
- Consideration should be given to a total fishing closure on sections of river immediately upstream and downstream of coastal fish ladders.

PUBLICATION OF RESULTS

In addition to this report, results and data generated from this study have been made available to the industry, particularly participants in the logbook scheme, through a series of irregular newsletters. Over the duration of the project, efforts have been made to inform the industry and general public of the progress of research work. A seminar on the project was presented to the annual meeting of the Australian Society of Fish Biology in August 1985.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the technical assistance given by Messrs P. R. Cooper and C. Turnbull and Ms M. Reid. Messrs R. N. Garrett, R. Pearson and Dr R. Coles provided useful comments on earlier drafts of this manuscript. Ms K. McKauge provided valuable assistance in preparing this manuscript for publication. Mr K. Butler did the analyses of the logbook statistics.

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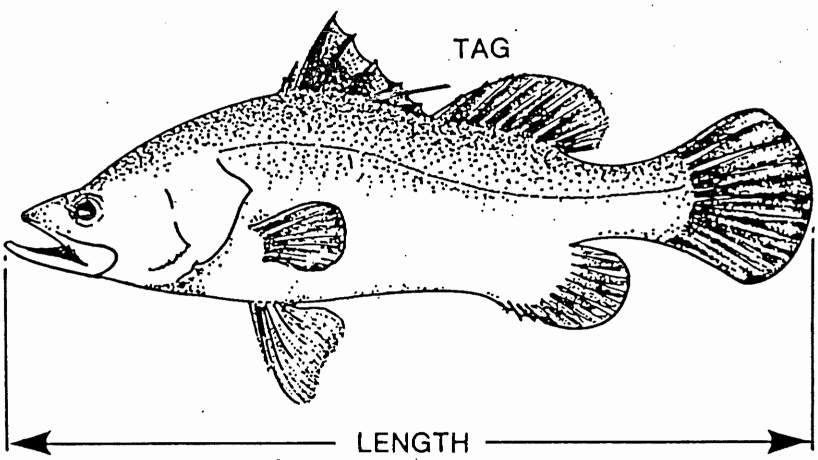
APPENDIX I

Barramundi reward poster

REWARD

TAGGED BARRAMUNDI



A REWARD OF $5.00 IS PAID FOR EACH TAG RETURNED WITH INFORMATION

What to do:

RETURN TAG TO — NORTHERN FISHERIES RESEARCH CENTRE,
QUEENSLAND FISHERIES SERVICE,
C/- POST OFFICE, BUNGALOW, QLD., 4870
PHONE CAIRNS 51 5588

OR — CONTACT NEAREST FISHERIES INSPECTOR.

AND PROVIDE

i) PLACE AND DATE OF CAPTURE.
ii) LENGTH OF FISH FROM TIP OF LOWER JAW TO TAIL.
iii) WEIGHT OF FISH, IF POSSIBLE.

BARRAMUNDI ARE BEING TAGGED BY THE NORTHERN FISHERIES RESEARCH CENTRE TO STUDY GROWTH RATE, POPULATION DENSITY, FISHING EXPLOITATION AND MIGRATORY PATTERNS.

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Appendix 2

Common species of commercial value taken in inshore gill nets of eastern Queensland

Family	Genera and Species	Common Name
Platycephalidae	*Platycephalus fuscus*	mud flathead
	Platycephalus indicus	bar tailed flathead
Centropomidae	*Lates calcarifer*	barramundi
Serranidae	*Epinephelus tauvina*	estuary cod
Sillaginidae	*Sillago* spp.	whiting
Parastromateidae	*Parastromateus niger*	black pomfret
Scombridae	*Rastrelliger kanagurta*	striped mackerel
Thunnidae	*Kishinoella tonggol*	northern blue fin tuna
Carangidae	*Caranx* sp.	trevally
	Chorinemus lysan	queenfish
	Trachinotus blochi	snub nose dart
	Trachinotus russelli	swallow tail dart
	Trachinotus anak	oyster cracker
	Scomberomorus semifasciatus	grey mackerel
	Scomberomorus queenslandicus	school mackerel
	Scomberomorus munroi	spotted mackerel
Rachycentridae	*Rachycentron canadus*	black kingfish
Lactariidae	*Lactarius lactarius*	milk trevally
Lutjanidae	*Lutjanus argentimaculatus*	mangrove jack
	Lutjanus russelli	red bream
	Lutjanus johni	big spot bream
Lobotidae	*Lobotes surinamensis*	triple tail
Pomadasyidae	*Pomadasys kaakan*	striped grunter
	Pomadasys argenteus	school grunter
Plectorhynchidae	*Pseudopristipoma nigra*	brown sweetlip
Sparidae	*Acanthopagrus australis*	yellowfin bream
	Acanthopagrus berda	pikey bream
Sciaenidae	*Nibea soldado*	silver jewfish
	Johnius antarctica	mulloway
	Johnius diacanthus	spotted jew
	Sciaena spp.	striped jew
	Otolithes argenteus	three-toothed jew
Pempheridae	*Leptobrama mulleri*	beach salmon

Mugilidae	*Liza dussumieri*	green backed mullet
	Liza vaigiensis	diamond scale mullet
	Liza strongylocephalus	round headed mullet
	Mugil cephalus	sea mullet
	Valamugil seheli	blue-tail mullet
	Valamugil buchanani	black mullet
Sphyraenidae	*Sphyraena jello*	barracuda
Polynemidae	*Eleutheronema tetradactylum*	blue salmon
	Polynemus sheridani	king salmon