Final Report

Resource Monitoring of the Jack Mackerel Purse Seining Fishery in South Eastern Australia

FIRTA Project 85/77

Howel Williams, Grant Pullen,Gwiedo Kucerans and Carl Waterworth

Final report to the Fishing Industry Research Committee

1989

CONTENTS

Page

Abstract 3
Introduction 3
1 Management 6
2 Fishing operations 6
2.1 Processors 6
2.2 Vessels 7
2.3 Fishing method, gear and auxiliary equipment 8
3 Methods 8
3.1 Logbooks 9
3.2 Observer program 9
3.3 Market measuring 9
3.4 Laboratory analysis 11
3.5 Data compilation 12
4 Results 12
4.1 Temporal and spatial distribution of fishing activity and catch 12
4.11 Distribution of catch and effort 12
4.12 Assisted and unassisted fishing associated with surface and subsurface schools 19
4.13 School size and catchability 21
4.2 Biology of the jack mackerel and by catch species 23
4.21 Size structure of the catch 23
4.22 Length-weight relationships 29
4.23 Length-age relationships 32
4.24 Age structure of the catch 32
4.25 Mortality 38
4.26 Gonad development and condition 41
4.3 Interannual variability 43
5 Discussion 44
Acknowledgements 45
References 45
Appendix 1 Total landings per month by species 48
Appendix 2 Publications resulting from this study 49

Resource Monitoring of the Jack Mackerel Purse Seining Fishery in South Eastern Australia

Howel Williams, Grant Pullen, Gwiedo Kucerans and Carl Waterworth

ABSTRACT

A purse seine fishery for jack mackerel, *Trachurus declivis*, started on the east coast of Tasmania in 1985. Since fishing began the Department of Sea Fisheries has conducted a monitoring program on the fishery with funding from the Fishing Industry Research Trust Account. This report presents the results of the program up to June 1988.

This program has collected data on the development and performance of the fishery, as well as biological data relevant to assessment of the impact of fishing on the exploited population.

The development and operation of the fishing and processing sectors of the fishery are described as are the development and implementation of jack mackerel management in Tasmania.

Biological data presented for jack mackerel include size structure of catch, length-weight relationships, catch age structure and reproductive development. Estimates for the Von Bertalanffy parameters L_∞, K and t_0 are presented. Problems encountered estimating mortality rates are discussed and preliminary estimates given.

The by catch species redbait, *Emmelichthys nitidus*, and blue mackerel, *Scomber australasicus*, make up approximately 5% of the landed catch. Some biological information on these two species is also presented.

The discovery of several adult Peruvian jack mackerel *Trachurus murphyi* raises questions as to the importance of this species, if any, in the fishery. These samples constitute the most westerly reports of this species distribution.

The importance of inter-annual variability in this fishery is discussed with reference to examples in the short history of the fishery.

INTRODUCTION

Trachurus declivis is an abundant neritic pelagic species, distributed throughout Australia's southern waters and around New Zealand. For much of the year the fish is present in Tasmanian waters in large surface and subsurface school. This schooling behaviour makes the jack mackerel highly vulnerable to capture by purse seining. Whilst the potential for a fishery based on this resource has long been recognized, the development of the fishery has only occurred recently.

In the early 1970's the resource was subjected to a short episode of fishing. A fish reduction plant was built at Triabunna on Tasmania's central east coast in 1973. From this base a fleet of three purse seiners operated, landing fish caught in an area from southern New South Wales to southern Tasmania. These vessels took 6,200 tonnes of jack mackerel over an eleven month period. Limited success was had in reducing the fish to fish protein concentrate (F.P.C.) and due to manufacturing problems the processing plant was scrapped and the vessels moved to other fisheries. The limited duration of this fishing venture was not enough to establish whether a viable fishery could be based on the resource. Further development was retarded because of the large capitalisation required on a speculative proposal.

In 1985 a new fish mealing venture started operation at Triabunna. A fish meal processing barge was installed at the site of the original reduction plant. Once again a fleet of three purse seiners fished to the processing plant. At the time that this venture commenced the profitability of an Australian based fish mealing industry was increased by the deregulation of the Australian dollar. Up until that time the demand for fish meal on Australian markets was satisfied by relatively cheap foreign imports. As a result there were no Australian producers of fish meal. Foreign imports became more expensive with deregulation. Furthermore, the development of Atlantic salmon aquaculture in Tasmania in 1985 led to a local demand for a reliable supply of high quality fish meal for salmon fodder. Consequently a Tasmanian based fish meal producer would have reliable markets and no significant competition.

In the first four months of fishing 6,000 tonnes of fish were landed. Since then landings have been 22,936, 41,481 and 37,809 tonnes in the 1985/86, 1986/87 and 1987/88 seasons respectively. These landings contribute an average 23% by volume of the total Australian fisheries landings and make it the largest volume fishery in Australia. The chief products marketed are fish meal, fish oil, baitfish and canned pet food.

The fleet now comprises nine purse seiners and two carrier vessels. Two groups of fish spotters and three light aircraft are used to assist in fishing operations. The main fishing areas are in coastal waters from northern Tasmania to Bruny Island on the south eastern coast. The main reduction plant is still located at Triabunna, while a smaller plant has been constructed at Beauty Point on the north Tasmanian coast. Fishing is targetted on jack mackerel which constitutes 95% of landings. Bycatch species are redbait (*Emmelichthys nitidus*) and blue mackerel (*Scomber australasicus*) comprising 2.6% and 2.4% of landings respectively.

In 1985 the Tasmanian Department of Sea Fisheries (DSF) initiated a monitoring program to collect catch and effort and biostatistical data from the developing fishery. The program was jointly funded by the Tasmanian Government and the Fishing Industry Research Trust Account. Research at this stage of the fisheries development was seen to be desirable as no baseline data was available on the biology of the species within Tasmanian waters or of the populations response to fishing pressure.

Prior to 1985 work on jack mackerel was restricted to distributional studies (Williams, 1981) and some basic descriptions of biological parameters (Maxwell, 1979; Stevens and Hausfeld, 1982; Stevens *et al.* 1984). In addition, the Department of Primary Industry examined aspects of the economics of the fishery including marketing potential (Anon, 1975, 1979). A synopsis of biological data collected on jack mackerel up to 1985 was prepared by Williams and Pullen (1986).

By the end of 1986 it was apparent that a considerable risk of over-capitalization existed within the fishery. At this time commercial development plans were being formulated which in total required catches far in excess of the prudent levels suggested by research advice. Furthermore, an excess of capacity in purse seine vessels in the adjacent southern bluefin fishery was produced as a result of decreases in tuna quota. The jack mackerel fishery was the only alternate purse seine fishery in Australia in which these vessels could be deployed. As a result of these concerns, entry into the fishery was frozen in 1987, to allow a management plan to be developed and installed. To simplify enforcement, Tasmania sought management jurisdiction for jack mackerel in Commonwealth waters adjacent to Tasmania, however, this approach was unsuccessful. Up to this time 99.6% of all jack mackerel caught in Australia was caught in Tasmanian waters. It was therefore possible to institute management in Tasmanian waters and effectively manage the fishery. In 1988 a management plan was declared for Tasmanian waters with catches controlled by individual non-transferable quota. Quota in the fishery represents a percentage share of an annually reviewed Total Allowable Catch.

The lack of any controls on mackerel fishing in Commonwealth waters adjacent to Tasmania is of concern. It is hoped that compatible arrangements will be adopted in the near future. These arrangements are essential to the enforcement of the quota system and to reduce the threat of poaching.

A potentially important discovery was made in 1988 when several very large jack mackerel were given to the DSF by fishermen. These fish were around the 60 cm mark, which is appreciably bigger than is the norm for mackerel caught in Tasmania (Williams et al 1986 & 1987). These fish were identified as specimens of the Peruvian jack mackerel *Trachurus murphyi*. The identification of these specimens constitutes the most westerly reported distributional record of this species. The find has important ramifications to research and management in this fishery. Screening of catches over the next few years will ascertain if the Peruvian jack mackerel makes up an important part of the mackerel fishery, or if the recorded specimens were vagrants on the edge of the species distribution.

Interim reports of the Department's research on this fishery have been published annually by Williams *et al.* (1986, 1987).

1 MANAGEMENT

A management plan was developed in 1987 by the DSF in consultation with the Tasmanian Fishing Industry Council (TFIC). The plan was implemented at the beginning of the 1988/89 jack mackerel fishing season. The management plan segregates the fishing fleet into specialised purse seine vessels and smaller multi-purpose vessels. Tasmanian licensed vessels under 20 meters may participate in the fishery with no restrictions. However if the catch of this class of vessel exceeds 5,000 tonnes in any year then management of this sector of the fishery will be reviewed.

The catches of vessels over twenty metres are controlled by individual non-transferable quota. The quota represents a proportion of a Total Allowable Catch (TAC) that is set yearly. Access to quota in future years is based on two mechanisms. Firstly, eighty percent of the TAC will be allocated on the basis of the performance of vessels in taking their quota in previous years. Secondly, if the TAC is increased, twenty percent of the TAC will be available as quota that will be distributed by auction.

The auction mechanism was seen as a method by which entry could be gained to the fishery without the need for establishing entry criteria. This factor is important as the fishery is considered to be still developing. Although management was implemented because of concerns of overcapitalisation, it was recognised that the fishery was not fully developed and that the full potential of the fishery was unknown. Given that the TAC in a developing fishery is likely to increase, a mechanism is required by which existing investment is protected whilst not encouraging a monopoly based on prior involvement or an entrenchment in low value added products. The auctioning of quota will allow new participants to enter the fishery on the basis of highest economic return on quota.

2 FISHING OPERATIONS

2.1 Processors

During the first year of the fishery one processor operated in the fishery. Spring Bay Fisheries based their operation in Triabunna processing fish into a 65 metre, 3,500 tonne floating fish-processing factory, the *Protangue*. The barge was capable of processing fish at a rate of approximately 20 tonnes/hour. The fish were reduced to fish meal by a process of pressing, cooking and drying. The fish-meal was then pumped on-shore and stored in a warehouse. Fish oil extracted during the reduction process was an additional commercial product. Subsequently the company expanded it's operation to include shore-based packing facilities and holding freezers. A substantial shore-based facility to replace the floating processing facility is presently under construction on the same site.

Two other processing companies have entered the fishery since 1985. These processors have landing and processing facilities in Beauty Point and Port Huon. Both of these processors produce products suitable for the frozen bait and pet food markets. The requirements for freshness in the pet food market has meant that refrigeration is necessary from the time that fish are caught and throughout their subsequent transport and storage. This factor has changed the catching ability of vessels working to these processors as refrigeration is required from point of capture, the fish are stored in refrigerated sea water (RSW). Storage in RSW reduces the holding capacity of the vessels and consequently the trip tonnages are smaller. Fish have been landed in Triabunna, Hobart, Beauty Point and Geelong.

2.2 Vessels

Nine vessels and two carrier vessels have participated in the jack mackerel fishery (Table 1). Three Nordica class vessels that began fishing in March 1985 were supplemented by a further three vessels during the 1985/86 season. Seven vessels fished during the 1986/87 and 1987/88 seasons. During the 1986/87 season carrier vessels were introduced to the fishery.

Name	Gross Tonnes	Overall Length (m)	Hold Carrying Capacity (tonnes)
Purse seine vessels			
Diana Avril	219	25.9	102
Lella	219	24.3	100
Vivianne Jane	219	24.5	85
Marine Countess	135	27.0	130
Maria Louisa	319	42.0	400
Leonard Star	175	28.7	200
Khalf 5	218	29.5	150
Khalf 4	218	29.5	150
Tasman Dawn	830	47.3	500
Carrier boats			
Ocean Lady 3	70	18.0	45
Kurri Pearl	210	32.1	95

Table 1. Specifications of the boats which have operated in the jack mackerel fishery.

Of the nine vessels that have fished in the Tasmanian jack mackerel fishery, six are fully committed to the jack mackerel fishery whilst the remainder participate in other fisheries such as the southern bluefin tuna and pilchard fisheries on the mainland.

2.3 Fishing method, gear and auxilliary equipment

The efficiency of searching for fish is central to the success of fishing operations. In the jack mackerel fishery the distribution of fish is very patchy and given the mobility of the fish their distribution can change significantly from day to day. Vessels search with sonar for subsurface schools and by eye for surface schools. Tell tale signs of fish schools, such as the occurrence of flocks of birds, are also noted. The close cooperation of vessels within the same fleet ensures that information is shared. Spotter planes based in Triabunna and Hobart are used to locate surface schools and direct vessels to them. Satellite images of sea surface temperature may also be used to predict where fish may be found.

All vessels are equipped with single bunt purse-seine nets with mesh sizes around 38mm. The size of the net depends on the size of the vessel and the preference of the skipper. Nets range from around 500 to 800 meters long with a fishing depth from 50 to 70 meters.

Vessels use either stern thrusters or motorised skiffs to prevent the boat drifting or being pulled over the net during the fishing operation. After the net has been pursed the majority of the net is retrieved, trapping the catch in the bunt alongside the vessel. The fish are pumped onboard by a hydraulic pump and the resulting mixture of sea water and fish is then separated in a dewaterer. At the dewaterer the sea water is returned over board whilst the fish are directed down a shute into a hopper sitting above the holds. Doors in the bottom of the hopper allow fish to fall through into the holds below. The fish are either bulk stored (for fish mealing) or stored in refrigerated sea water if they are to be used for pet food.

3 METHODS

The DSF's monitoring program has two primary objectives. The first is to collect catch and effort data. This has involved the development and implementation of a logbook and the maintenance of a data base. The second objective is to gather biological data on the jack mackerel. This has been of particular importance as an invaluable opportunity to obtain information from the virgin stock and to continue to gather data as the fishery developed existed.

3.1 Logbook programs

A new logbook was designed specifically for the fishery and was introduced in August 1985. The log format is a combination of CPUE data, catch composition information and a deck log. The data is collected on a shot by shot basis. The format of the 'Purse Seine Daily Fishing Log' has been detailed in Williams *et al.* (1986).

Maintenance of the logbook has been successful with a 100% participation rate and a high degree of consistency in the data collected. The successful introduction of the logbook has been assisted by an observer program which has maintained close contact between the research program and the fishermen.

During the 1986/87 season a voluntary log was introduced to the aerial spotters. This log has been well supported by all of the spotter aircraft who record 100% of their flights. The logbook is a simple map of the principal fishing grounds on which the spotter marks his flight path and the location and estimated size of surface schools spotted. Time of take-off and landing and some meteorological data is also recorded (Figure 1).

3.2 Observer program

The objective of this program is to support the logbook program, measure the length frequency and species composition of catches and collect field samples for laboratory analysis.

Biological information is collected on a shot by shot basis. Length frequency measurements were collected on board. A random sample of fish was removed from the fish-shute or hopper. From this sample approximately fifty jack mackerel were then sexed and the fork length (FL) measured to the nearest centimetre. This procedure was repeated for other species such as redbait and blue mackerel when they were present in the catch. One other random sample was recovered by this method, bagged and labelled before returning it to the DSF laboratories for further analysis.

3.3 Market measuring

To complement the length frequency data collected by observers, a market measurement program collects information on fish sizes as they are landed. Samples are

Department of Sea Fisheries, Tasmania

Nº 02456

MARINE AERIAL SURVEY LOG - South east coast

DAY MONTH YEAR

AIRCRAFT

VH

TAKEOFF

LAND

FLYING TIME

HRS MIN

BAROMETER ______________________

WIND DIRECTION AND SPEED ______________________

WEATHER AND SEA CONDITION ______________________

EST. TONNAGE JACK MACKEREL SPOTTED ....

COMMENTS:

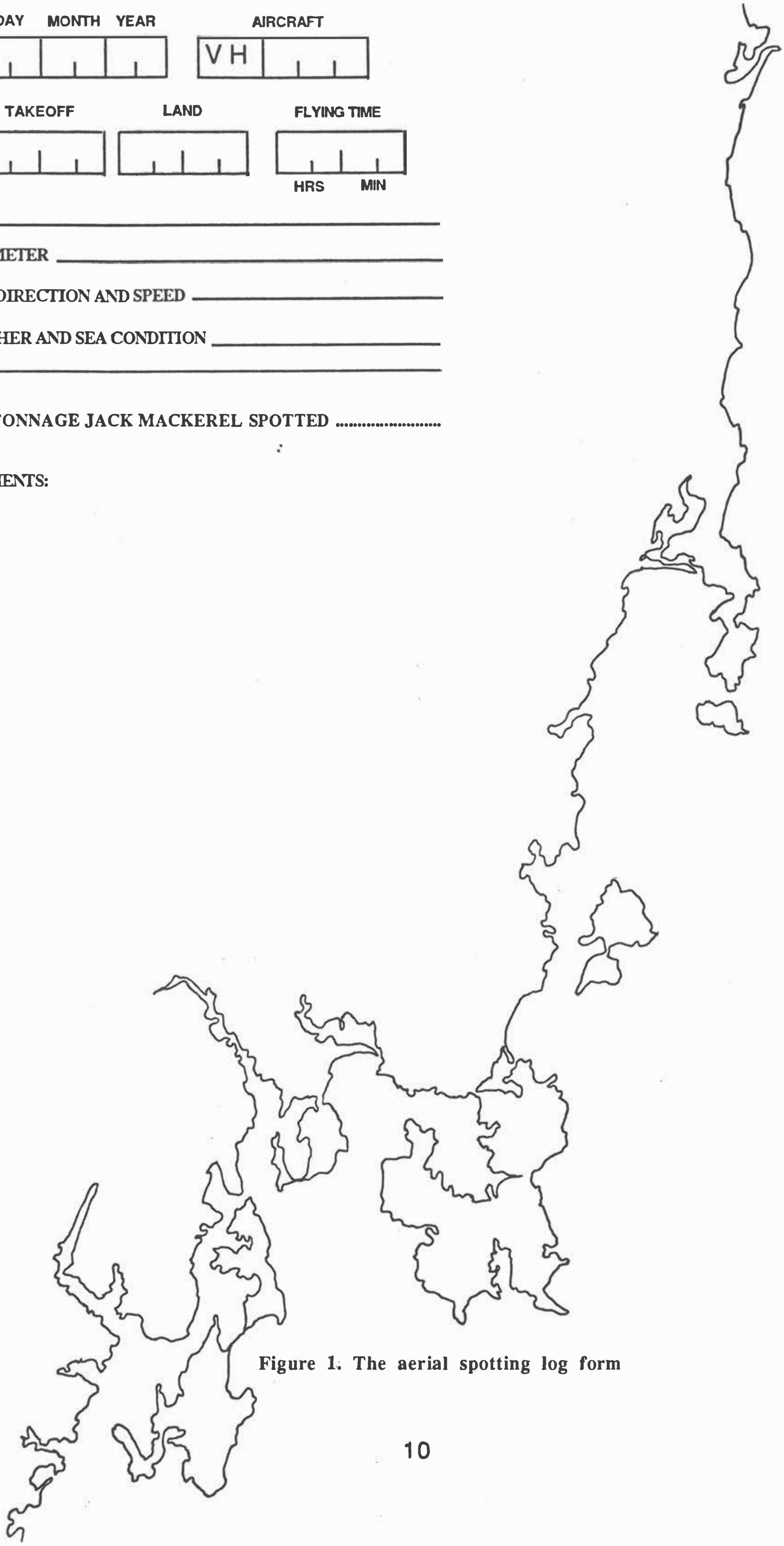


Figure 1. The aerial spotting log form

taken as the fish are off-loaded from the vessels. Fork length (to the nearest cm) is recorded as are the fishing location and vessel. Market measuring was carried out at Triabunna and Beauty Point.

3.4 Laboratory analysis.

As well as measurements made by the observers on board the fishing vessels, samples were collected for later laboratory examination. The samples were usually random for the major species caught in a set. However, selective samples including representative specimens of all the species and size groups caught were taken to supplement ageing and gonad condition studies. Selective samples were not included in length frequency analysis. Fish are frozen and returned to the DSF Marine Laboratories, where they are stored in a -18°C freezer.

Analysis of these samples involved ageing, sexing, weighing and staging gonads and recording body length (FL to the nearest mm) and weight (g). Viscera, gills and livers or gonads were also collected for stock discrimination studies.

Jack mackerel otoliths are read whole in water using transmitted light to a dark background. Otolith and ring radii are routinely measured using micrometer eyepiece units. The otolith radius is measured from the nucleus to the posterior tip of the otolith, whilst otolith radii are measured from the nucleus to the outer posterior edge of each successive opaque zone. Validation for the annual deposition of growth rings for the south east Australian jack mackerel stocks has been previously demonstrated (Webb and Grant, 1979; Stevens and Hausfeld, 1982).

During the course of this study the lengths of 13,552 fish have been measured, full biological information was collected from 8,252 of these fish. Over the same time period 4006 pairs of otoliths have been collected and read.

Two stock discrimination studies are presently underway and are supported by separate FIRTA grants. The University of Queensland is undertaking a study of parasite markers whilst the University of Tasmania is examining the mitochondrial DNA in the livers or gonads of the mackerel.

3.5 Data compilation.

A data base (PUSSY, PUrse seine Storage SYstem) has been developed for the storage and analysis of information from the log books, biological and market measuring data collection programs (Williams, 1986).

4 RESULTS

4.1 Temporal and spatial distribution of fishing activity and catch

4.11 Distribution of catch and effort

Fishing effort has been concentrated mainly around Maria Island and the Tasman Peninsula on Tasmania's east coast. The extreme range of fishing over the past three seasons has been from southern New South Wales to Bruny Island. Fishing activity ranged over a wider area during the 1985-86 season than in following years principally due to exploratory fishing carried out in an attempt to increase the length of the fishing season. Figures 2 to 7 present the catches and number of sets by fishing block for the 1985 and 1985-86, the 1986-87 and the 1987-88 fishing seasons.

During the last three seasons the majority of fishing effort has been concentrated around Triabunna. Fish are susceptible to capture in that area during most of the fishing season, and the grounds are in close proximity to the major processing plant. During the 1986-87 season however, some vessels began operating from other ports such as Hobart and Geelong. The bulk of the catch has continued to be landed in Triabunna.

There is a marked concentration of catches close to shore in waters less than 50 meters deep. During the 1986-87 season for example over 99% of the catch was taken in Tasmanian state fishing waters.

Fishing seasons ran from March - June 1985, September 1985 - June 1986, September 1986 - May 1987 and November 1987 - June 1988. A breakdown of landings of jack mackerel by month is given in Figure 8 and for all species by month in Appendix 1.

The trend that can be observed in the 1985-86 and 1986-87 seasons is a steady increase in the monthly landings during the season followed by a drop in the catch in the last month of operations before the season ends. A marked contrast can be observed in the monthly landings in the 1987-88 season from the preceding two fishing seasons. The 1987-88 season started two months later than previous seasons and landings exhibit a

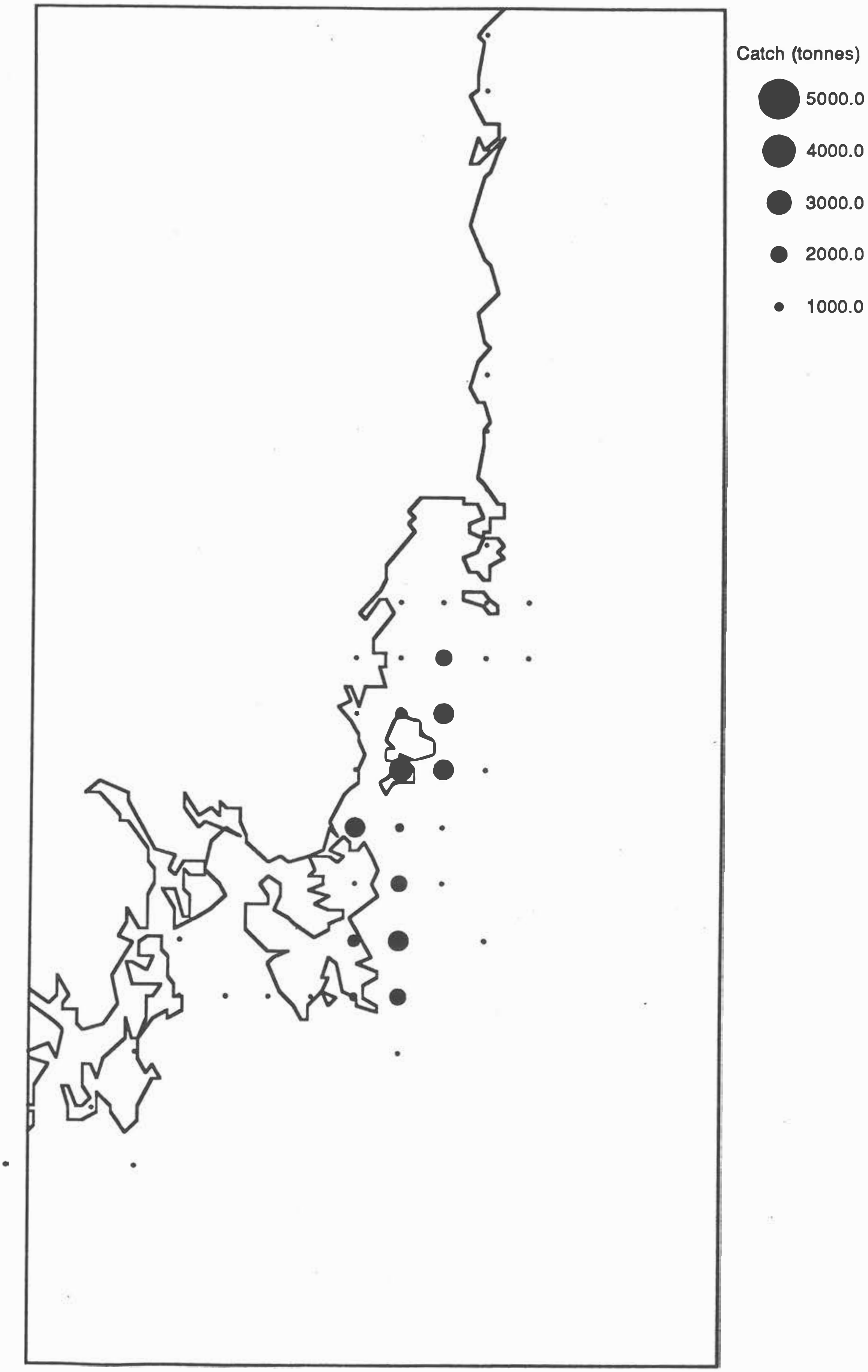


Figure 2 Total catches for both 1985 and 1985-86 seasons

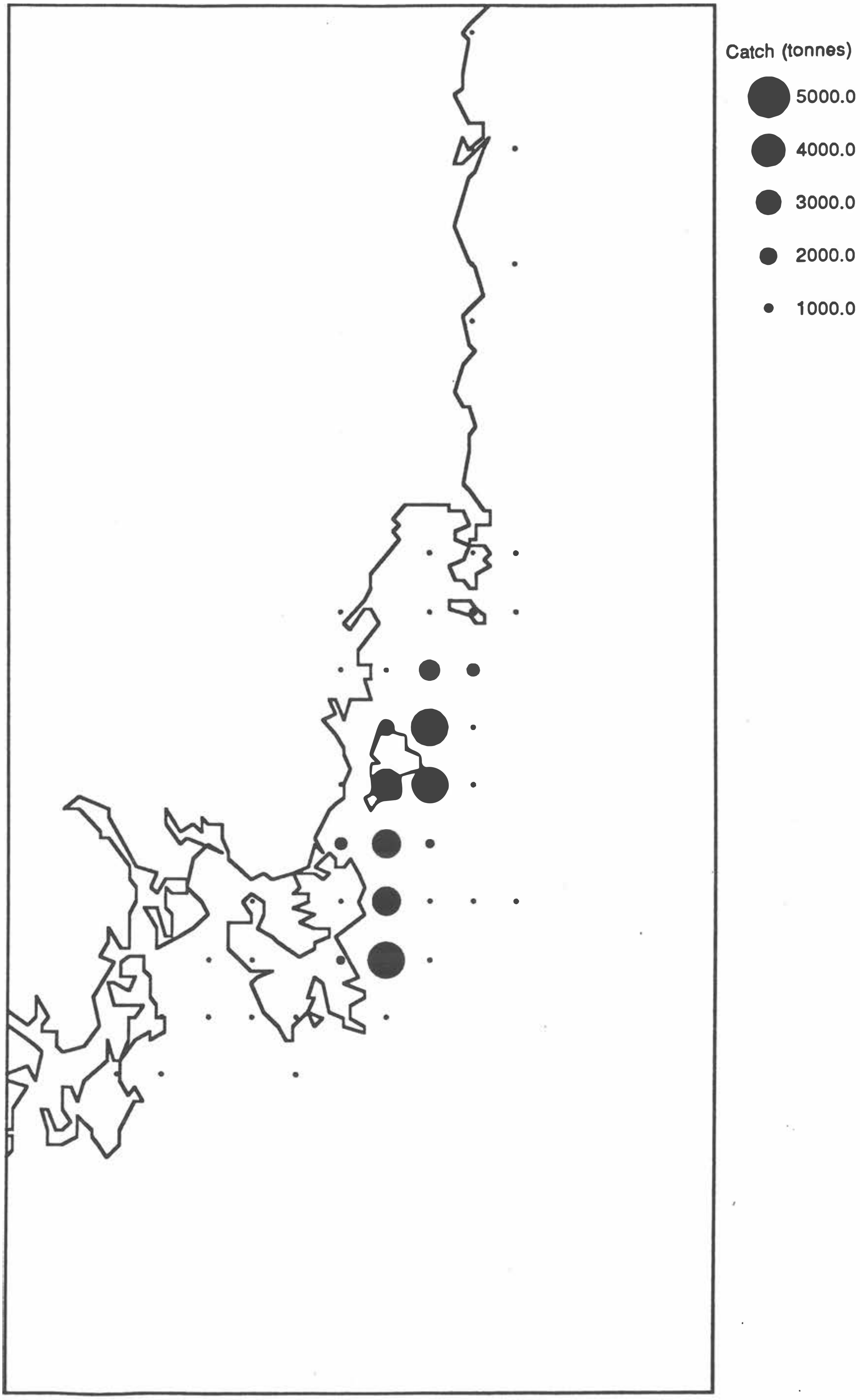


Figure 3 Total catches for 1986-87 season

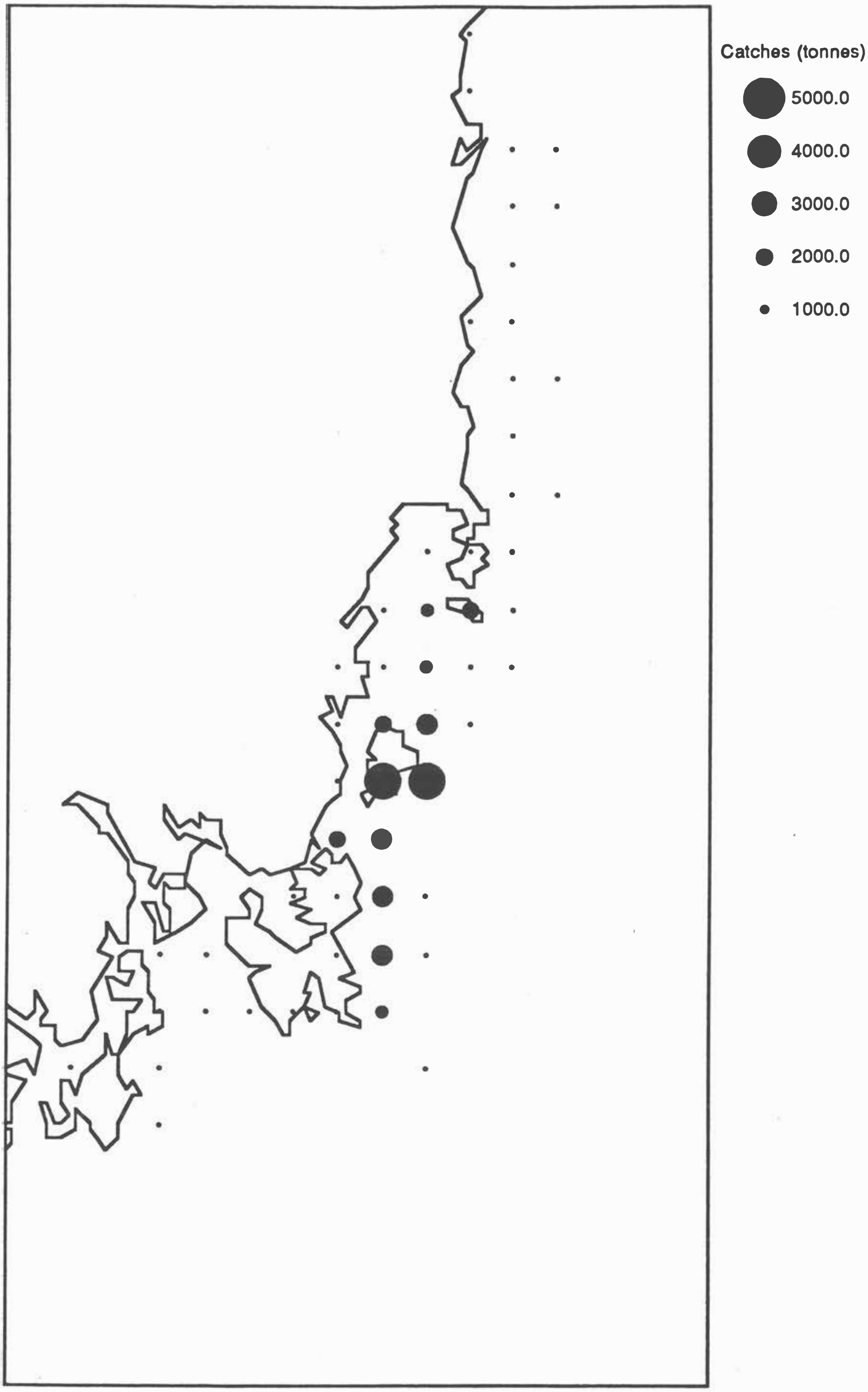


Figure 4 Total catches for 1987-88 season

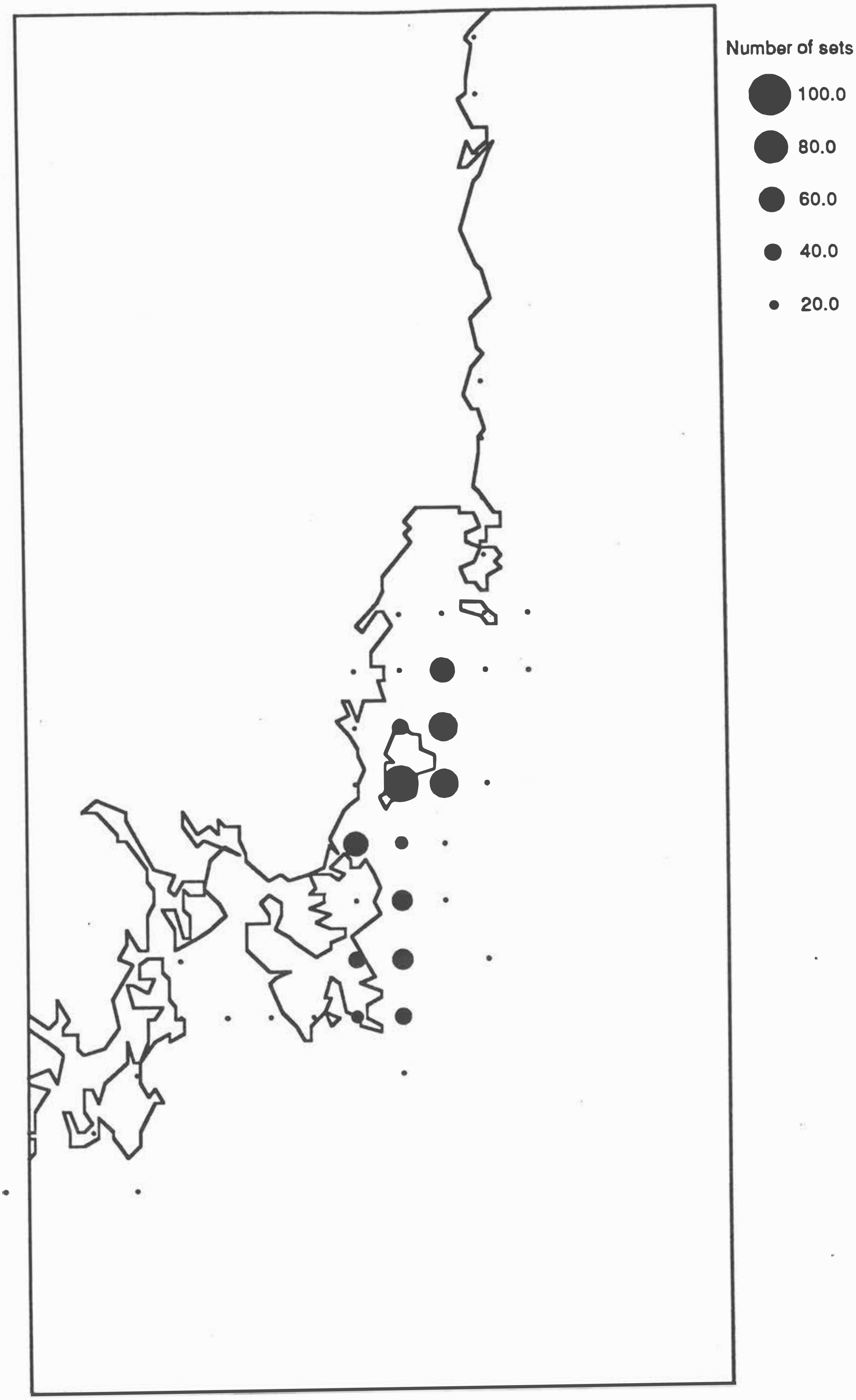


Figure 5 Total number of operations in both 1985 and 1985-86 seasons

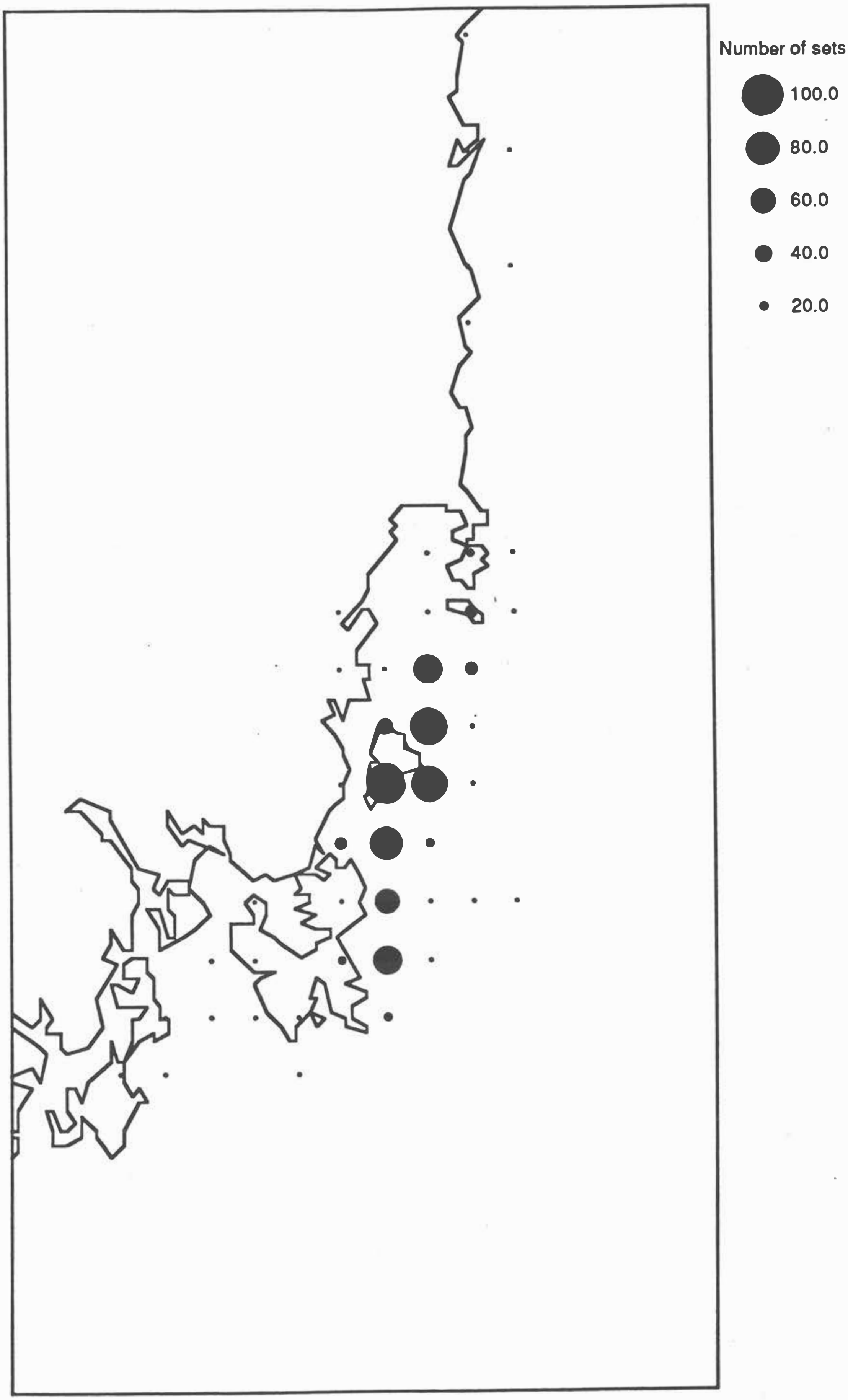


Figure 6 Total of number operations in 1986-87 season

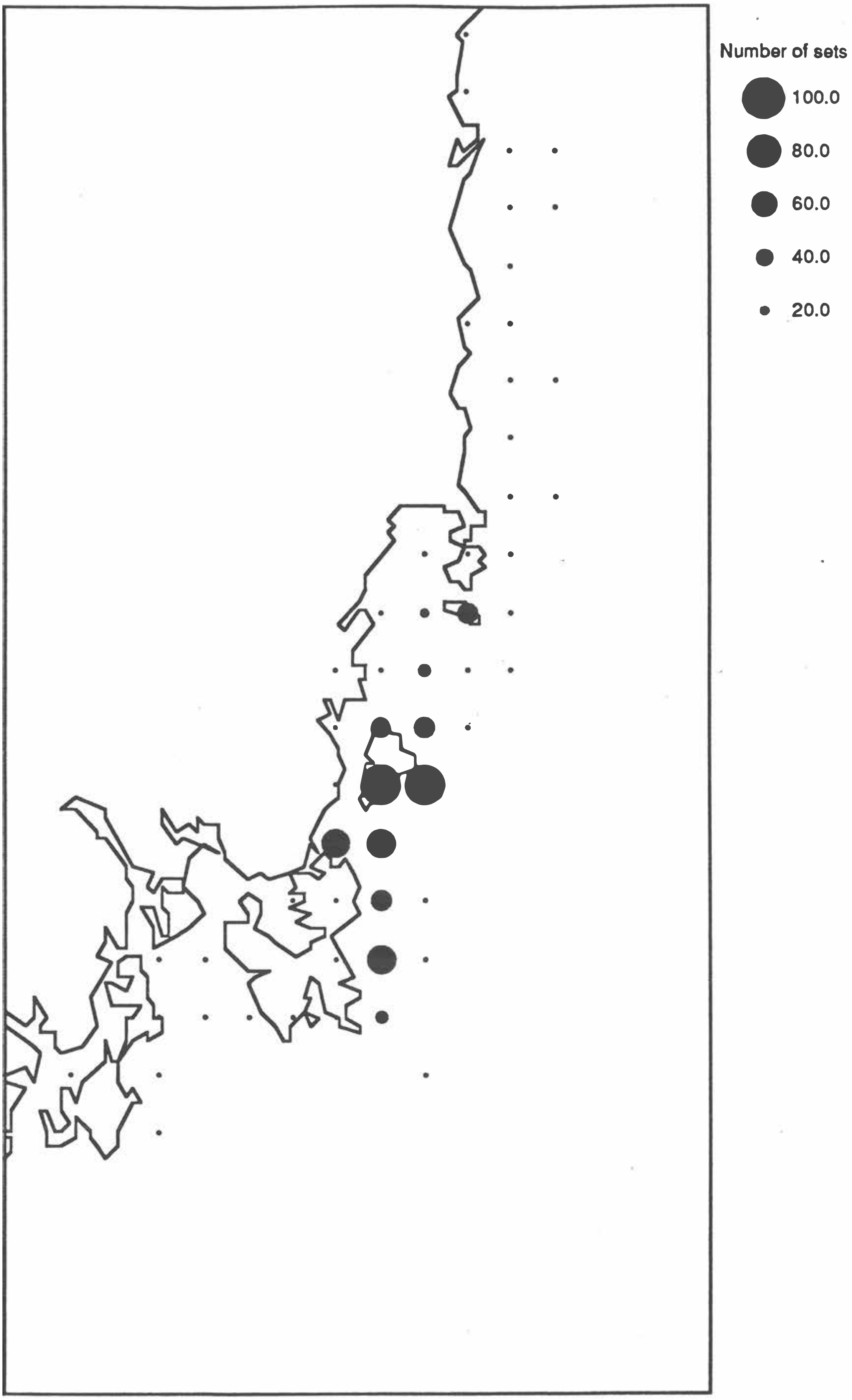


Figure 7 Total number of operations in 1987-88 season

marked slump between February and April. In the two preceding seasons landings were increasing substantially over this time. Significant catches were taken in June 1988 while in previous seasons catches had finished by May. In all seasons large catches have been taken in the last months of the season, the success of fishing in the later portion of the season is seen to be crucial to the success of the fishing season.

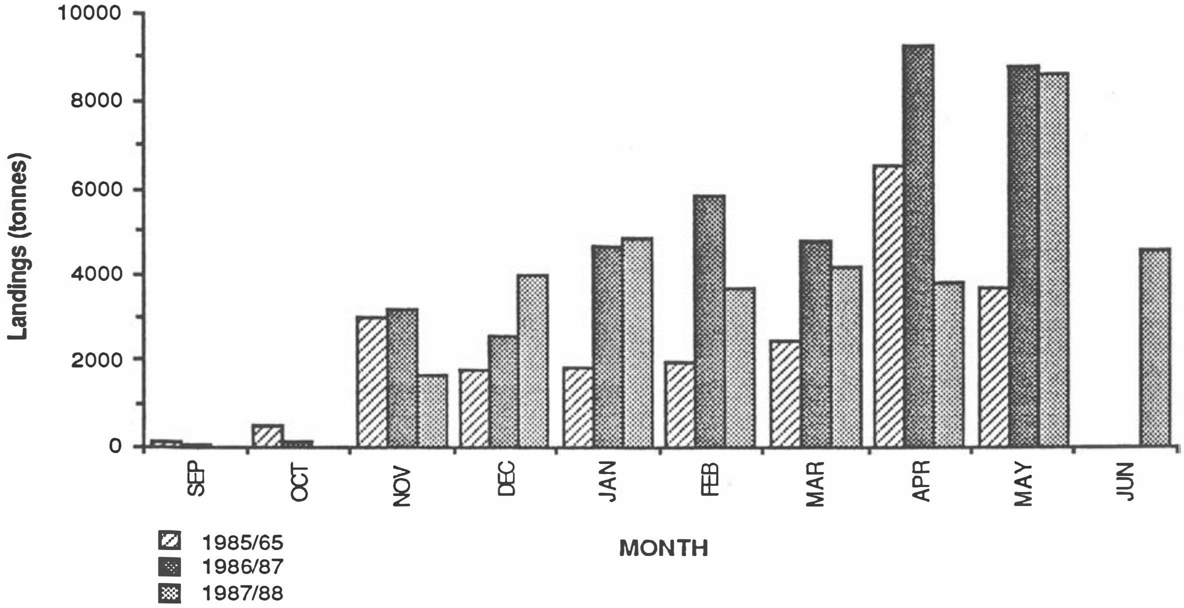


Figure 8. Monthly landings of jack mackerel for the 1985/86,1986/87 and 1987/88 seasons.

4.12 Assisted and unassisted fishing associated with surface and subsurface schools

Fishing operations may be designated as either assisted or unassisted sets. Unassisted sets occur when a vessel sets on schools located either by spotting from the vessel or searching with sonar or sounder. Assisted sets occur when a vessel sets on a school it has been directed to by advice from a spotter plane or another vessel. In most cases unassisted sets would follow in an area following an assisted set.

The value of aerial assistance to fishing operations is directly related to the schooling behaviour of the mackerel. The form of schooling significantly affects the vulnerability of mackerel to the purse seine method. Surface schools are more easily found than are subsurface schools, as visual spotting from either the vessel or a spotter plane gives a large search area compared to hydroacoustic techniques. Subsurface schools may only be found by searching with hydroacoustic assistance. Consequently when surface schooling is prevalent, the searching efficiency is very high. In addition surface schools are more successfully captured than are subsurface schools. Fishermen derive a great deal of information from a visual inspection of surface schools. This information assists in the encirclment of the school within the purse seine net, and also helps in taking action to hinder the escape of schools from the net.

The formation of surface schools appears to be associated with a water temperature threshold of 14°C. Temperature records from an oceanographic station at Maria Island (Harris *et al.* 1987) show that sea temperatures in excess of 14°C are normally encountered between December and May. This period loosely corresponds to the increasing abundance of surface schooling seen in the area.

The proportion of sets made from advice and the proportion of sets made on surface schools are given in Figures 9 and 10. It can be seen that the majority of sets are made from advice. Unassited fishing, however, is important to the fishery as a means of increasing the length of the season in months when surface schooling is less common. In the early months of the season around September and October when surface schools are relatively less common unassisted sets makes up the bulk of the fishing effort.

A marked drop in the proportion of sets made on surface schools and the proportion of sets made from advice can be observed in March 1985. This is the result of night fishing activities on large subsurface schools at that time. Night fishing has not been an important factor in subsequent seasons.

Apart from night fishing, the proportion of sets made on surface schools has remained fairly similar during the three full seasons completed. The proportion of sets made from advice has increased since the first full fishing season in 1985/86, a factor attributable to the growing reliance on aerial spotting.

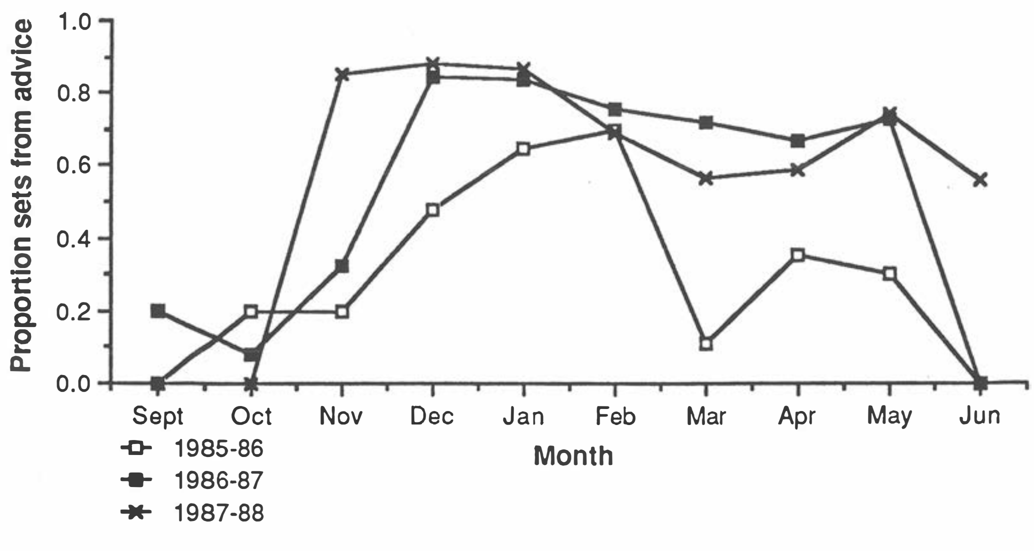


Figure 9. Proportion of sets made in the purse seine fishery resulting from advice, by month and fishing season.

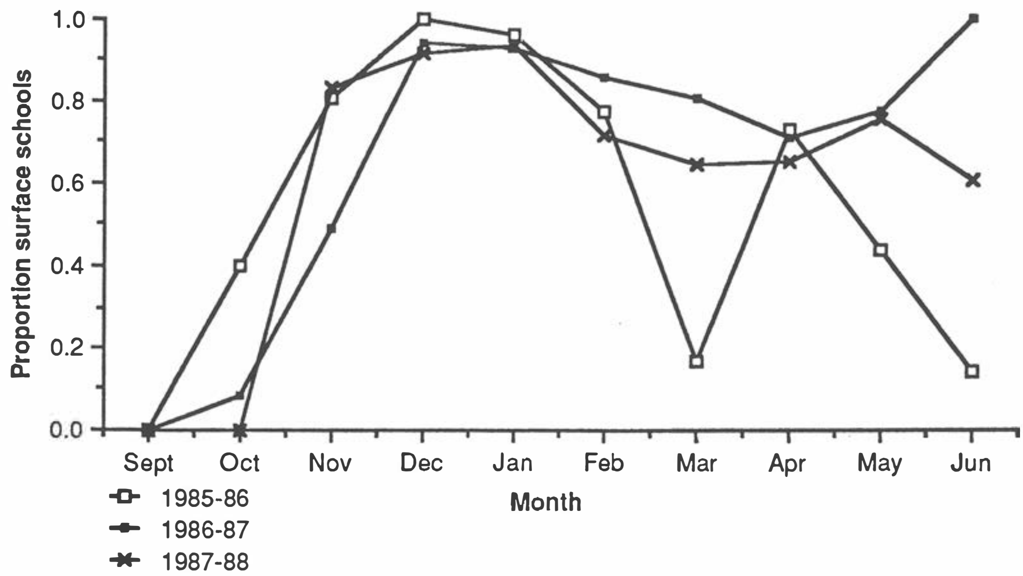


Figure 10. Proportion of sets in the purse seine fishery made on surface schools, by month and fishing season.

4.13 School size and catchability

School size is estimated from the logbook data as the size of the catch adjusted by the skipper's estimate of how much of the targetted school was captured. The mean school size encountered by purse seiners by month is given in Figure 11. Generally the size of schools increases from the beginning of the season and reaches a peak in the last two productive months of the season. The school size then decreases during the last few weeks of the season before fishing ceases. In the 1987/88 season school size decreased during April and May before peaking in June.

In the last few months of the 1985/86 and 1986/87 seasons very large schools of fish (with a surface area of several square kilometres) were reported by both the fishing vessels and the aerial spotters.

The school-catchability is calculated as the monthly mean of the estimated proportion of a school captured in a set and is given in Figure 12. The trend exhibited is a steady increase in school-catchability during the first half of the season peaking in the summer months. During the autumn months there is a wide variation in school-catchability between seasons. The values of school-catchability for the autumn months in the 1985/86 and 1986/87 seasons will, however, be biased. The cause of this bias being the inability of the fishermen to estimate the proportion captured from a very large school of fish. It is likely that values for the 1987/88 season are accurate over the entire season as large schools were not encountered.

The catchability of schools is directly related to the schooling behaviour of mackerel. The time of least catchability is associated with subsurface schools when sets must be made with the aid of sonars and echo sounders rather than by direct visual observation when the school is on the surface.

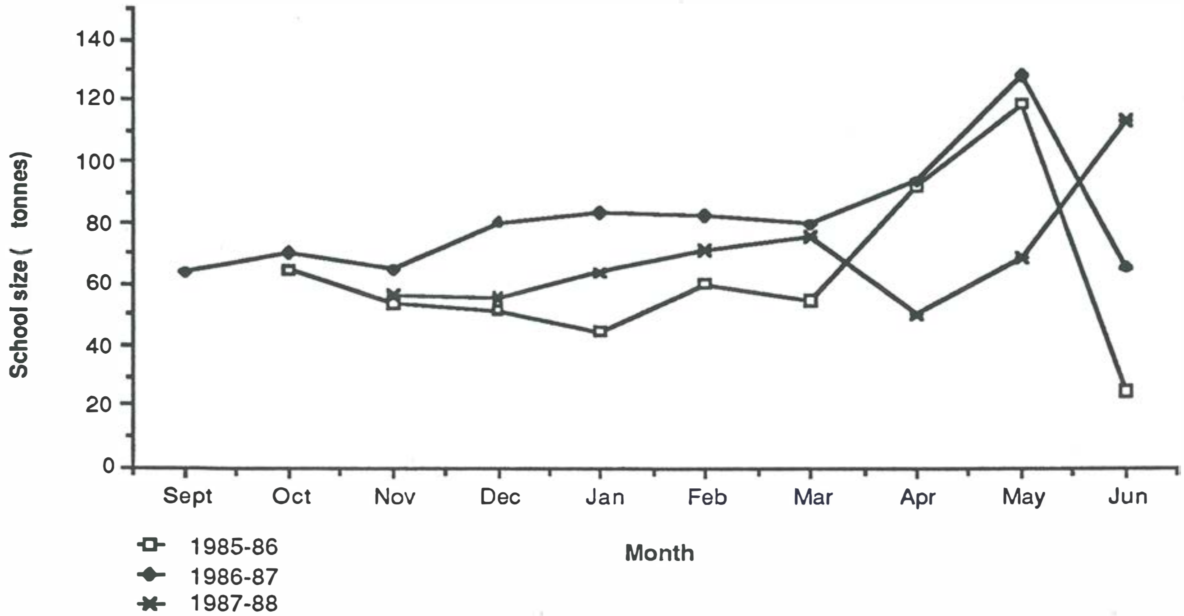


Figure 11. Mean school size by month and season.

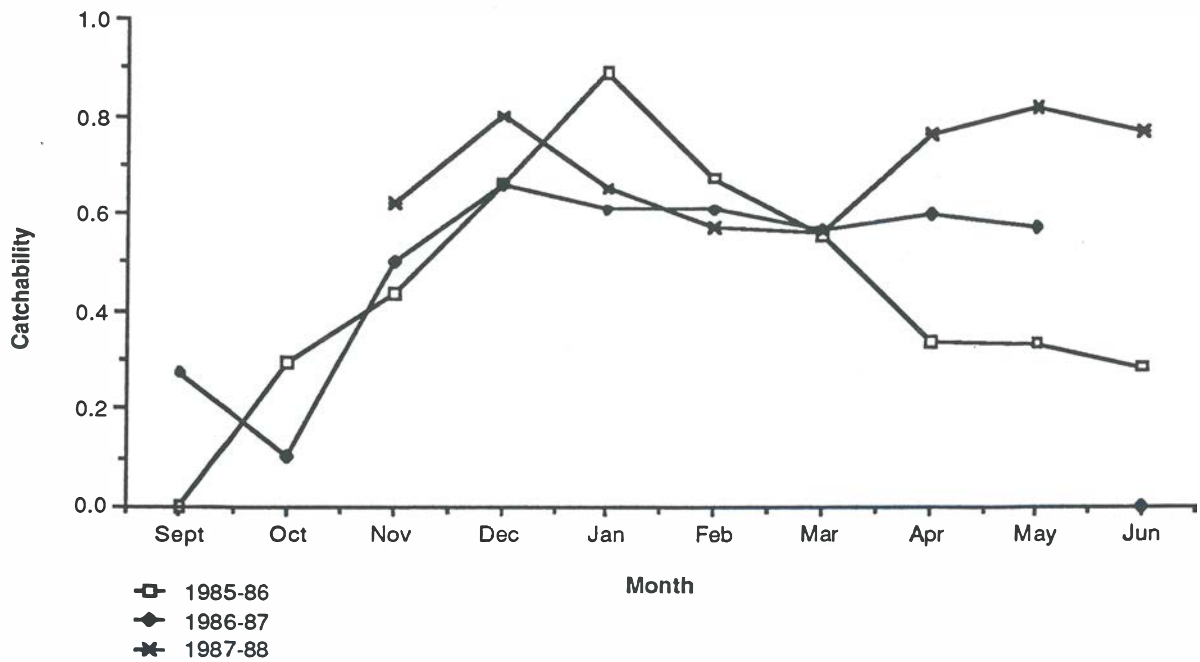


Figure 12. Catchability of schools in the purse seine fishery, by month and season

4.2 Biology of the jack mackerel and by catch species

4.21 Size structure of the catch

1 Jack mackerel

The monthly length frequency totals for jack mackerel by month for 1985, 1986, 1987 and 1988 are given in Figures 13 to 16. The range in size of fish that have been recorded is 12cm to 44 cm (FL) with the majority of fish recorded from 25 to 37 cm (FL).

The mean length of jack mackerel by month for the three full fishing seasons is presented in Figure 17. Consistent changes in the size of fish caught during the season can be observed. The general trend in mean length is one of decrease towards mid-summer after which mean length increases back to the mean length encountered in November/December. This trend can be observed in all three fishing seasons to date. This data is also consistent with the variation in mean age of fish caught in the fishery (Figure 23) which exhibits a similar pattern.

Few spawning fish have been caught by the fishery which indicates that spawning may take place in an area not accessible to the fishery. If spawning fish leave the fishing grounds, the larger and older mature fish would become less abundant on the fishing grounds, resulting in a decrease in overall fish length and age in the fishery. This pattern is observed around mid-summer. Spent fish are found in the fishery in autumn at which time the mean length and age increases. The low mean length of 15.5 cm recorded in October 1986 is the result of samples collected from a shot of small fish taken at the beginning of the season. Catches of such small fish are uncommon.

2 Redbait

Due to the lower frequency of redbait in the purse seine catches the data for this species is more sparse than that for jack mackerel (see Appendix 1). Monthly mean length for redbait has been pooled for 1985 to 1988 and is presented in Figure 18. The resulting trends in mean length are similar to those seen for jack mackerel. In this species however the increase in the occurrence of smaller fish and the reduction in frequency of the larger fish occurs earlier around November. The size range of redbait vulnerable to the fishery is 19 to 29 cm.

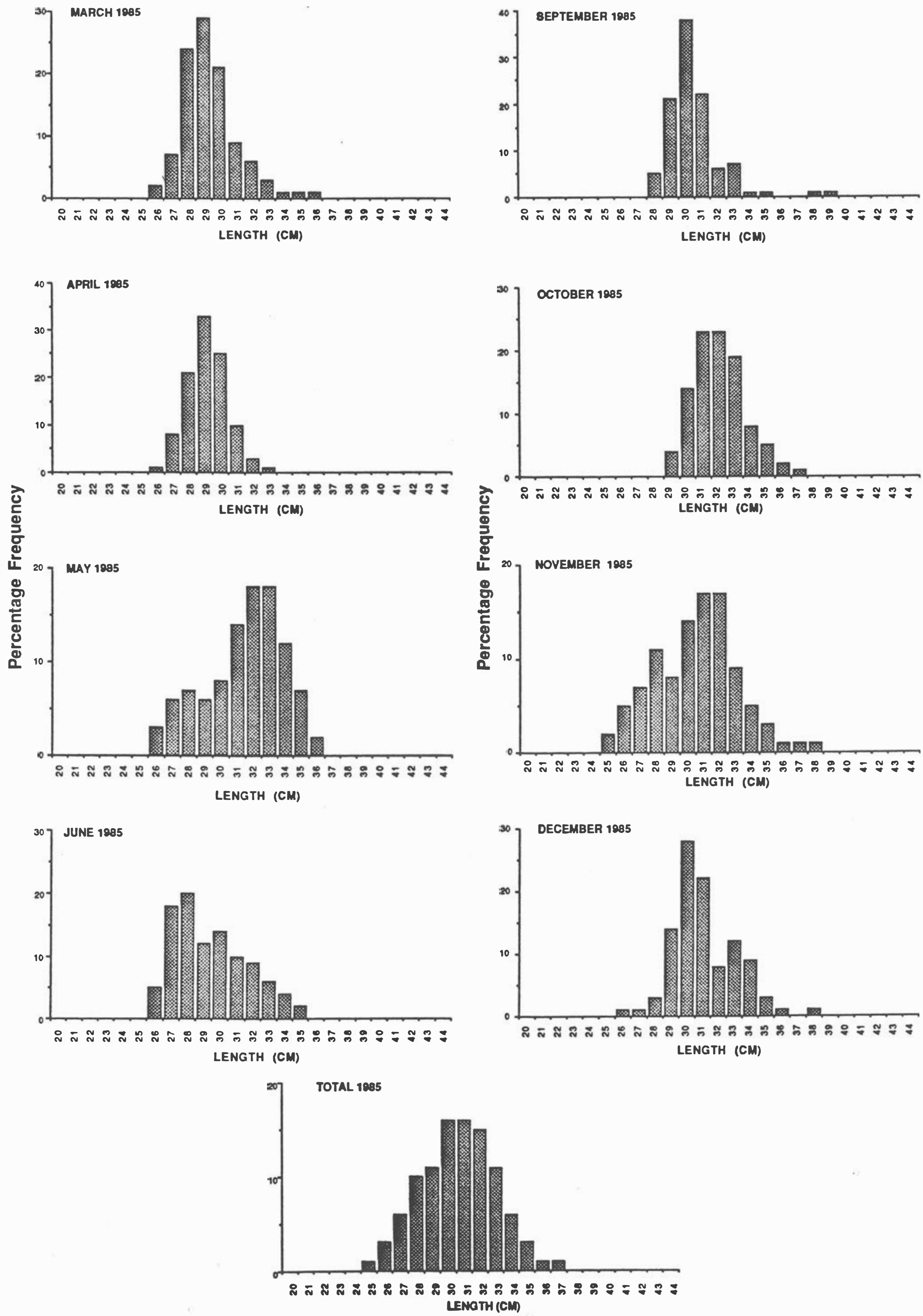


Figure 13. 1985 monthly percentage length frequencies (FL) for Jack mackerel

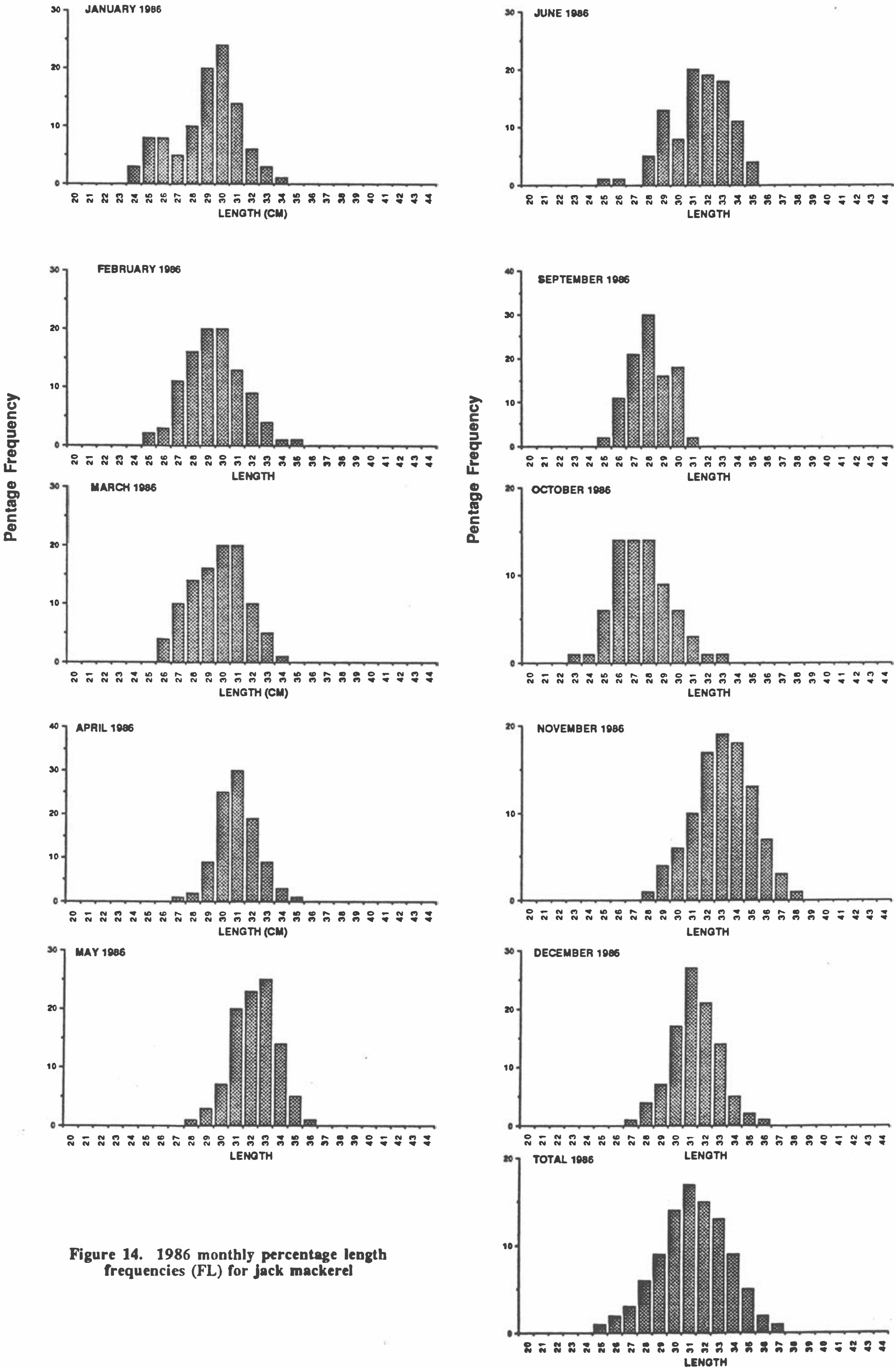


Figure 14. 1986 monthly percentage length frequencies (FL) for jack mackerel

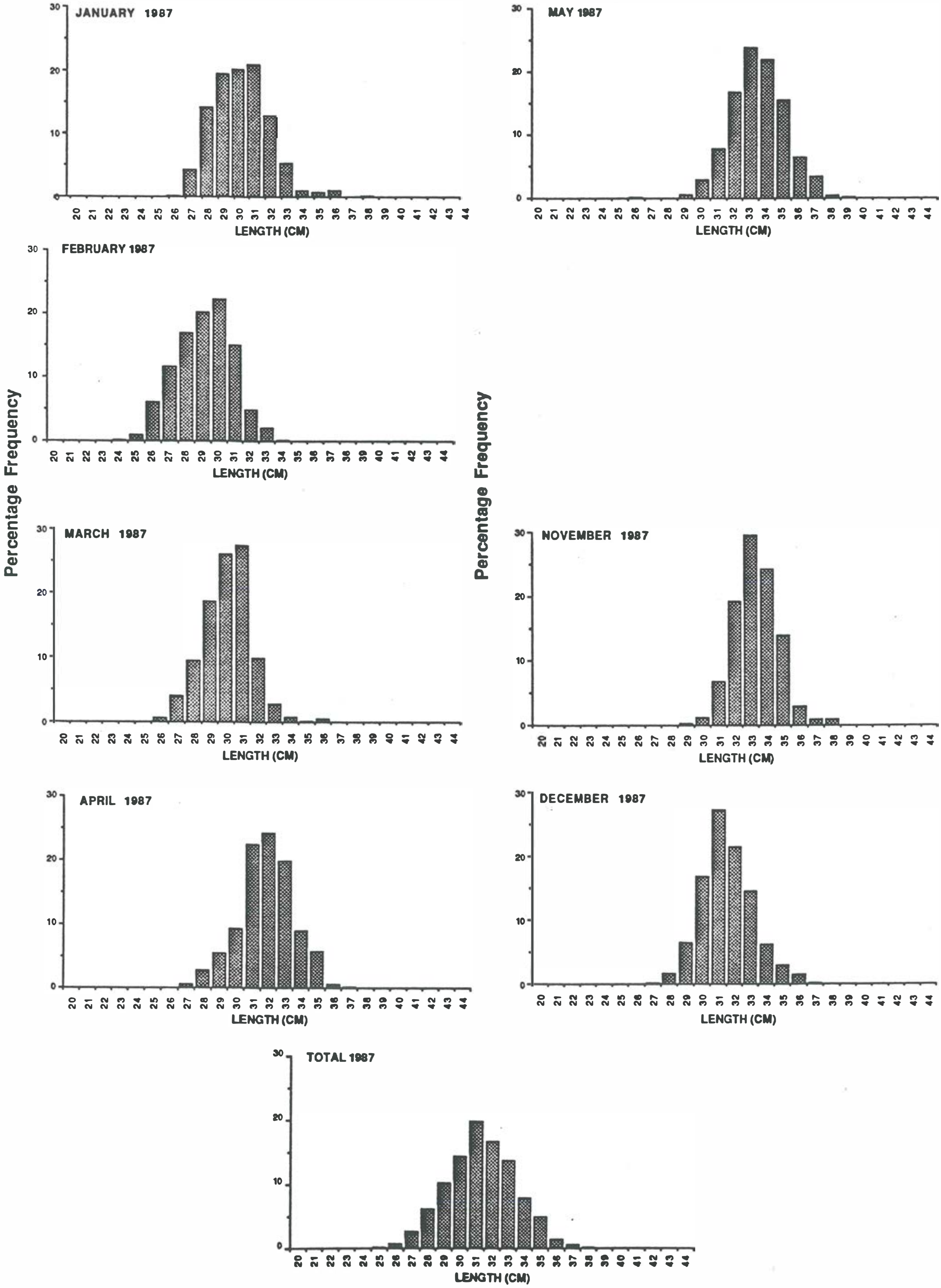


Figure 15. 1987 monthly percentage length frequencies (FL) for Jack mackerel

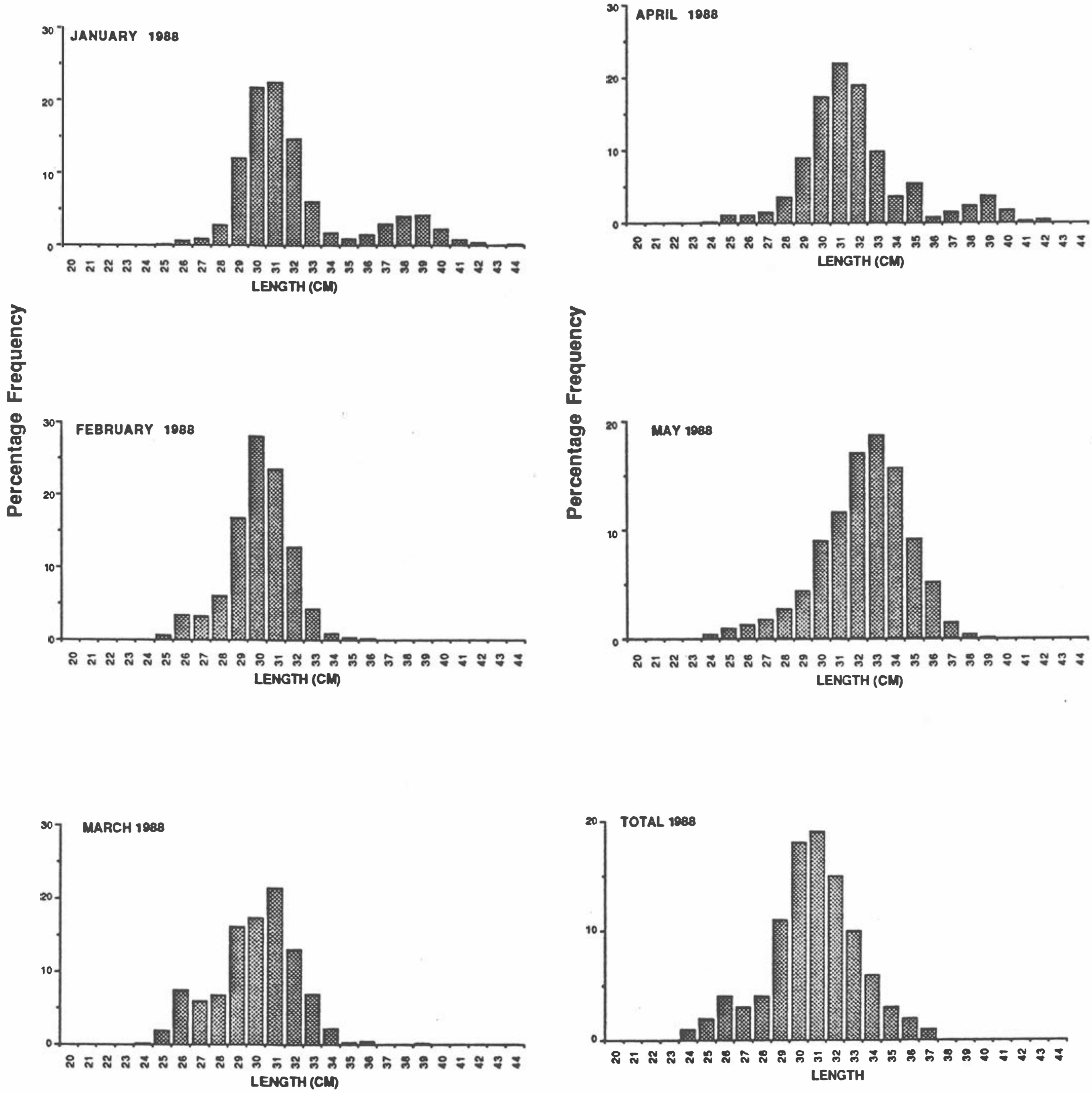


Figure 16. 1988 monthly percentage length frequencies (FL) for jack mackerel

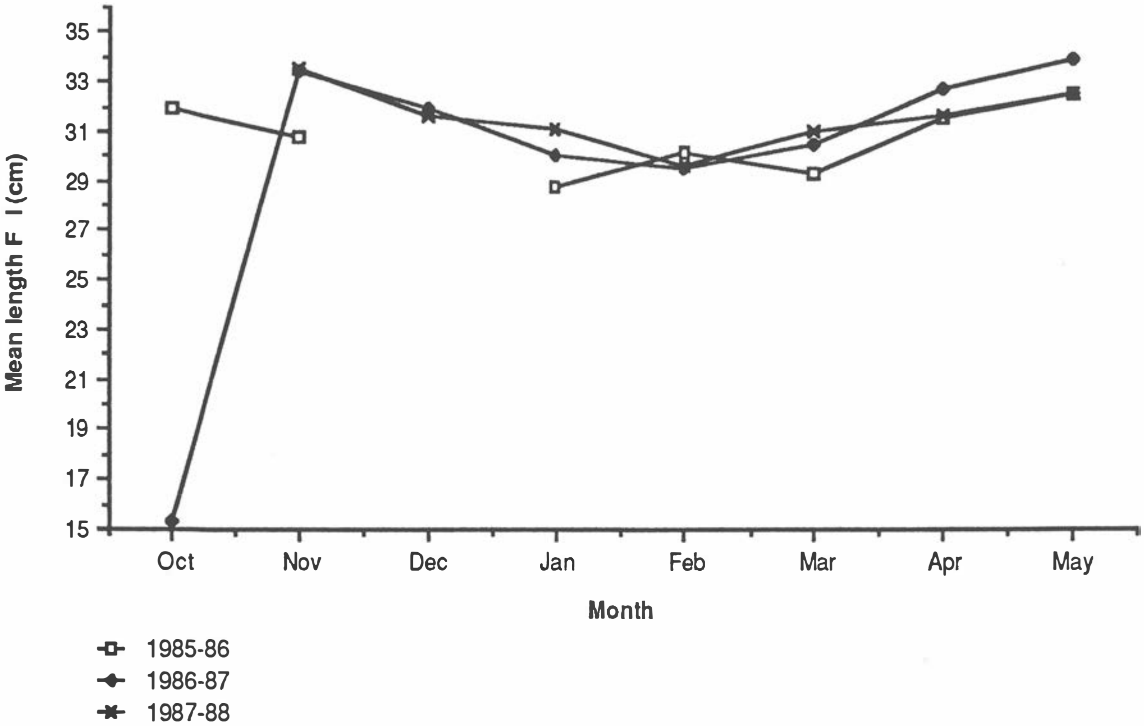


Figure 17. Mean length (Fl) of jack mackerel caught by the purse seine fishery, by month and season.

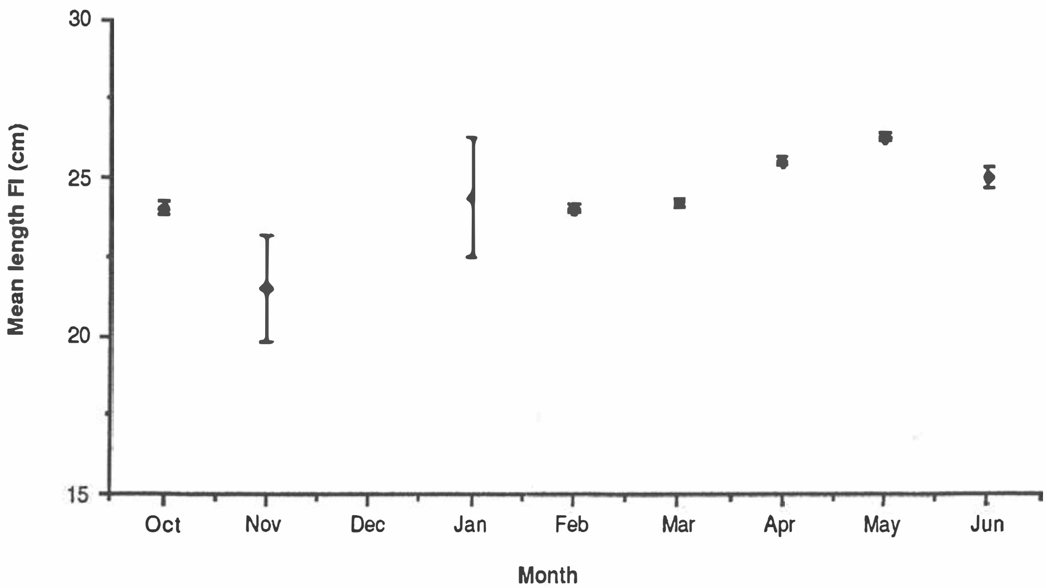


Figure 18. Mean length (Fl) of redbait caught by the purse seine fishery by month from 1985-87. Bars indicate 1 SE.

3 Blue mackerel

The catches of blue mackerel were quite unpredictable both spatially and temporally. The size range of blue mackerel vulnerable to the fishery is 28 to 40 cm.

4.22 Length-weight relationships

Length to weight data is presented for jack mackerel and redbait in Figures 19 and 20 respectively. For each species and year a linear regression was fitted to log transformed length and weight. This gave the following results,

1 Jack mackerel

1985 $\log(\mathbf{W}) = -1.825 + 2.952 \log(\mathbf{L})$, $r_{(878)} = 0.94$, $P \ll 0.001$

1986 $\log(\mathbf{W}) = -2.034 + 3.09 \log(\mathbf{L})$, $r_{(2428)} = 0.99$, $P \ll 0.001$

1987 $\log(\mathbf{W}) = -1.475 + 2.739 \log(\mathbf{L})$, $r_{(1485)} = 0.95$, $P \ll 0.001$

2 Redbait

1985 $\log(\mathbf{W}) = -2.274 + 3.301 \log(\mathbf{L})$, $r_{(78)} = 0.96$, $P \ll 0.001$

1986 $\log(\mathbf{W}) = -1.98 + 3.087 \log(\mathbf{L})$, $r_{(564)} = 0.97$, $P \ll 0.001$

1987 $\log(\mathbf{W}) = -1.418 + 2.695 \log(\mathbf{L})$, $r_{(324)} = 0.95$, $P \ll 0.001$

where **W** is weight in grams and **L** is length (FL) in cm. In all cases the regressions are highly significant.

The relationships found here for jack mackerel were used in the analysis of age composition of the catch (see Section 5.24).

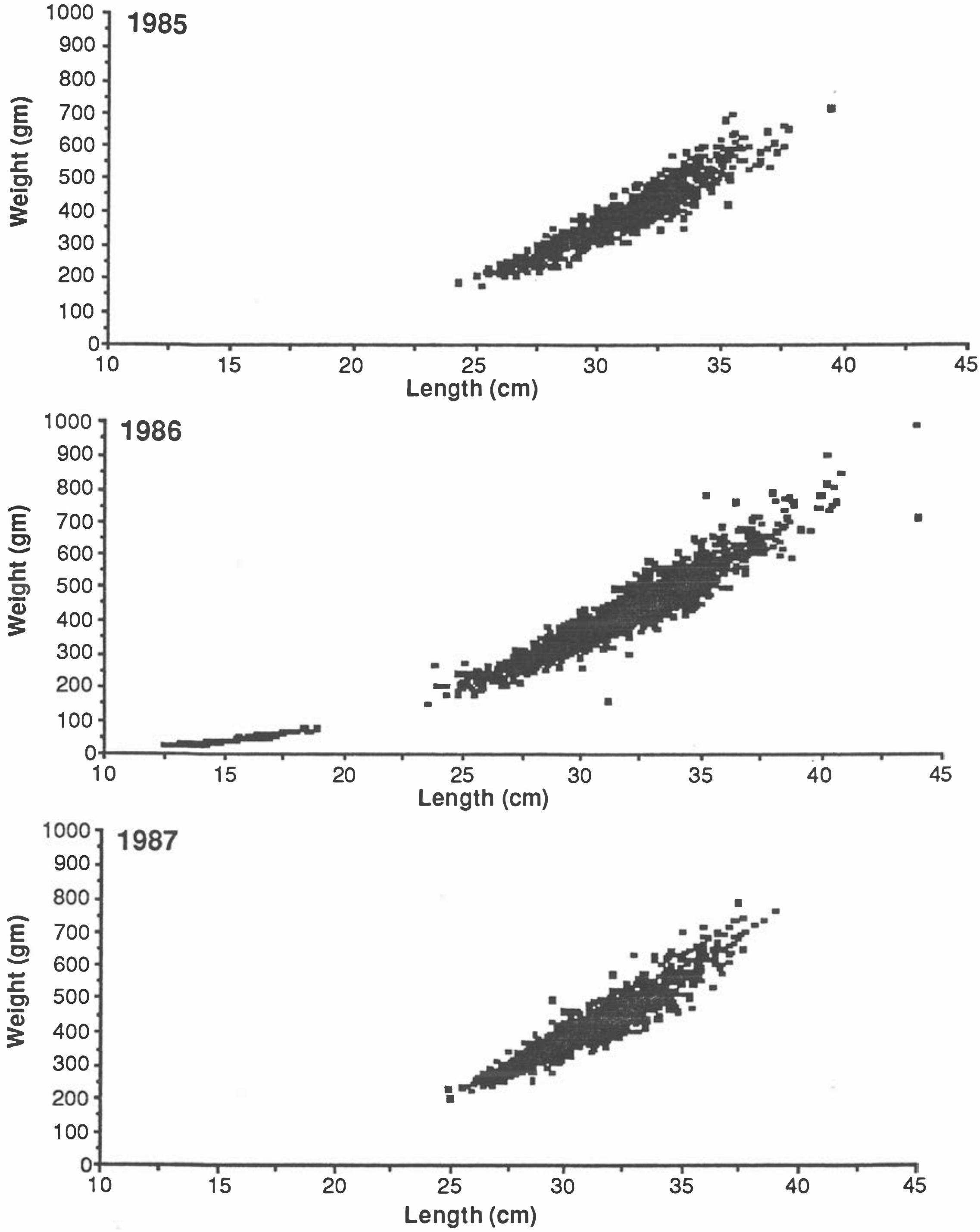


Figure 19. Length weight relationships for jack mackerel caught by the purse seine fishery for 1985, 1986 and 1987.

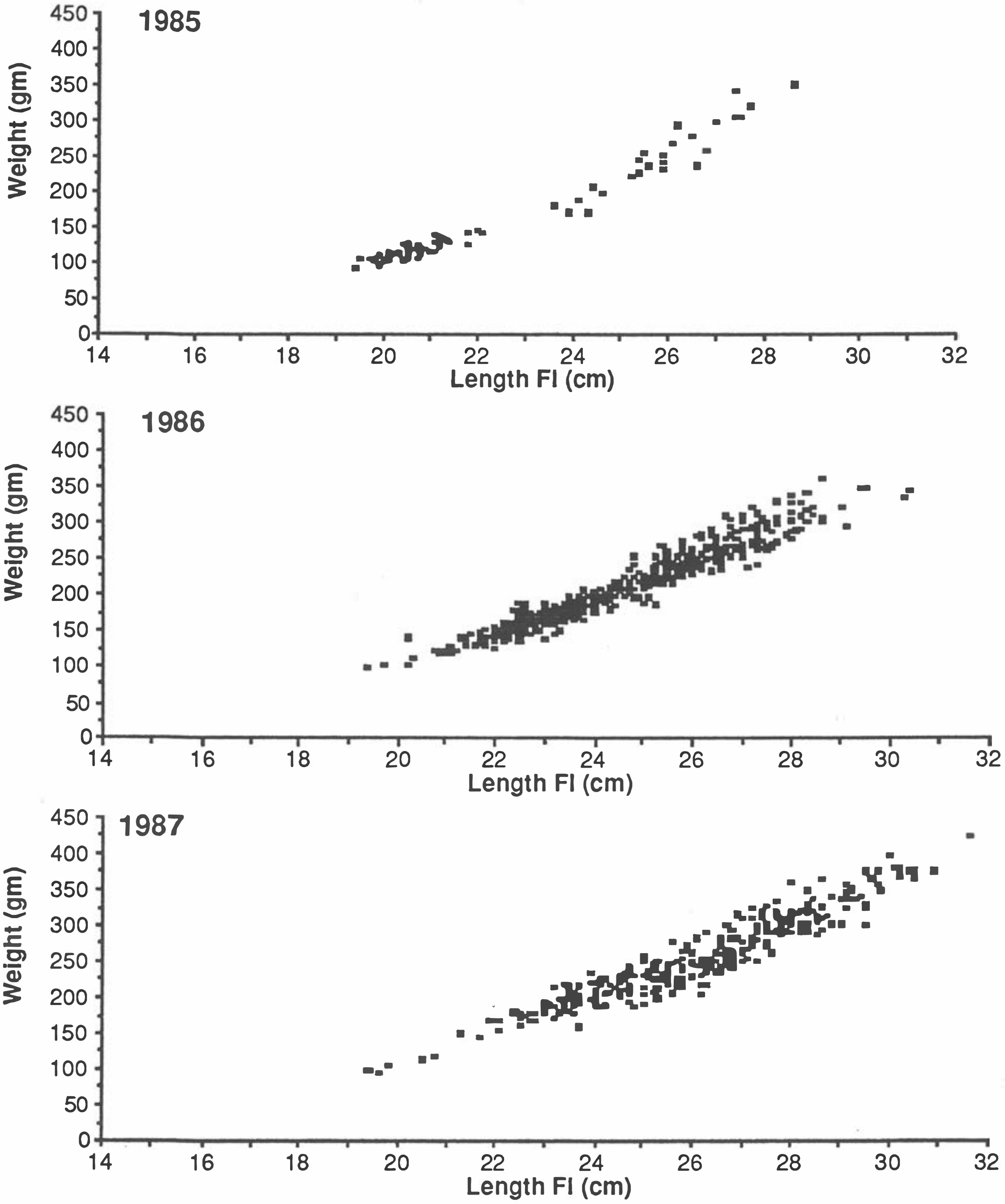


Figure 20. Length weight relationships for redbait caught by the purse seine fishery for 1985, 1986 and 1987.

4.23 Length-age relationships

An arbitrary birthday of January 1 has been used in all the ageing work described here. Age at length data for jack mackerel caught in 1985, 1986 and 1987 are presented in Figure 21. The data was fitted to the Von Bertalanffy growth model by non linear regression. The data for 1987, however, did not produce a reasonable regression due to a small data spread. The Von Bertalanffy curve takes the form $\mathbf{L_t} = \mathbf{L_\infty}[1\text{-}e^{-\mathbf{K}(\mathbf{t}-\mathbf{t_0})}]$; where $\mathbf{L_\infty}$ is the asymptotic length, **K** is a growth coefficient and $\mathbf{t_0}$ is the time (**t**) at which length $\mathbf{L_t} = 0$. The population parameters have also been calculated from data pooled over the three year period. Ten data points for each length (measured to the mm) were retained and fitted to the Von Bertalanffy equation. Regressions yielded the values for $\mathbf{L_\infty}$, **K** and $\mathbf{t_0}$ given in Table 2. Differences in estimates arise from variation in the quantity of smaller fish sampled during the year. Because small fish (generally less than 4 years) are not generally caught by the fishery this data was not normally available.

Age length relationships for redbait for 1985, 1986 and 1987 are presented in Figure 22.

	L_∞	K	t_0
1985	44.6	0.18	-1.5
1986	37.3	0.5	1.4
Pooled	48.8	0.17	-0.33

Table 2. Von Bertalanffy growth parameters for jack mackerel for 1985, 1986, and pooled data.

4.24 Age structure of the catch

The age composition of the annual jack mackerel catches for 1985, 1986 and 1987 are given in Figure 24. The monthly length frequency data was weighted by the relative catch for each month for this analysis. The age length keys used in this process are given in Table 3 (a-c). The majority of the catch taken in the fishery is made up of 4 to 6 year old fish. The oldest fish found to be available to the fishery are 13+ years old, whilst the youngest caught are 3 years old.

The mean age of jack mackerel caught is presented by month in Figure 23. A consistent trend for each season completed can be observed. The mean age decreases rapidly at the beginning of the season from November. A low point is reached around January/February after which time mean age increases gradually for the rest of the season. This trend is notable for its consistency over the three seasons presented.

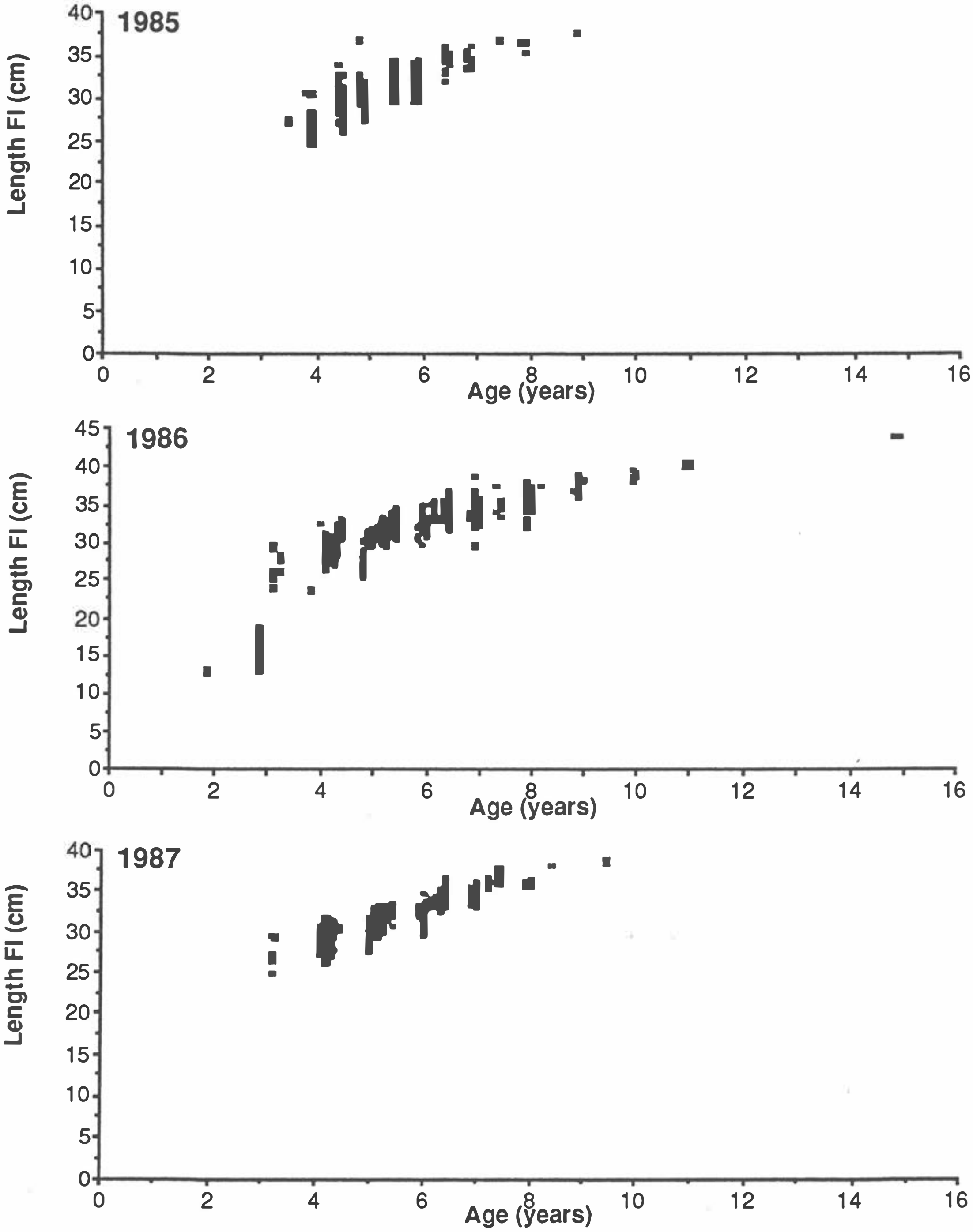


Figure 21. Age length relationships for jack mackerel for 1985, 1986 and 1987

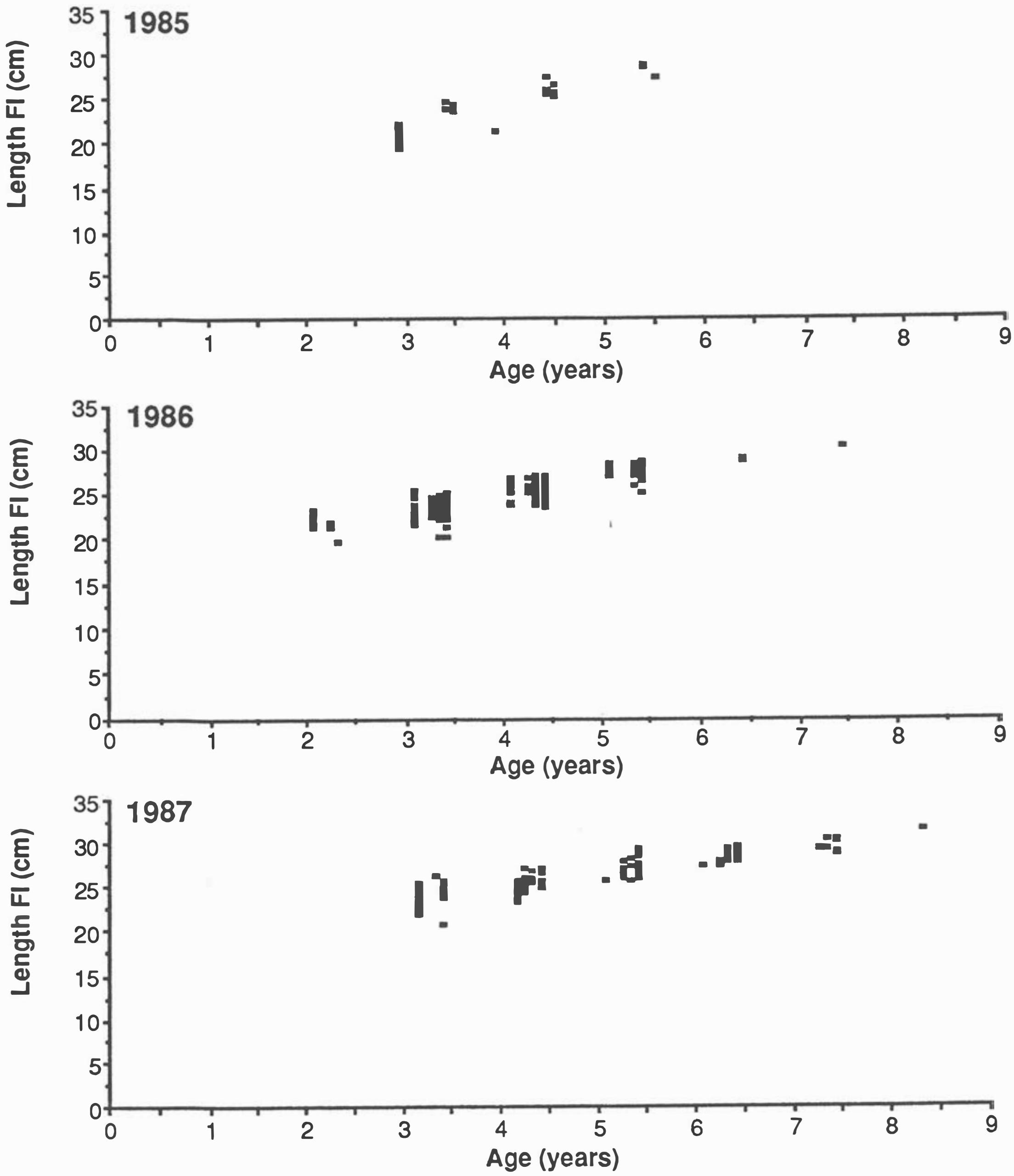


Figure 22. Age length relationships for redbait for 1985,1986 and 1987

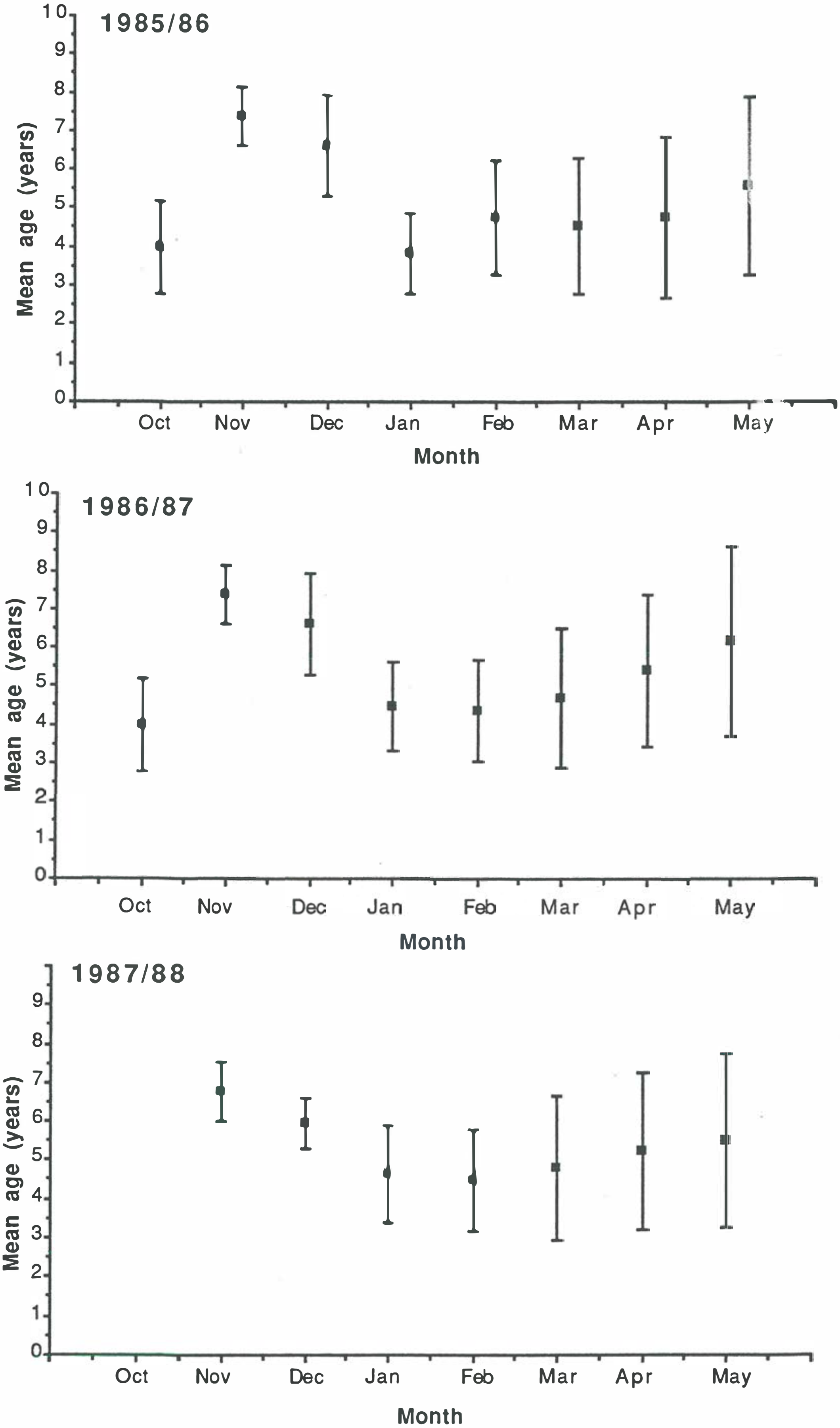


Figure 23. Mean age of jack mackerel landed by month for the purse seine fishery in the 1985/86, 1986/87 and 1987/88 seasons. Bars indicate standard error

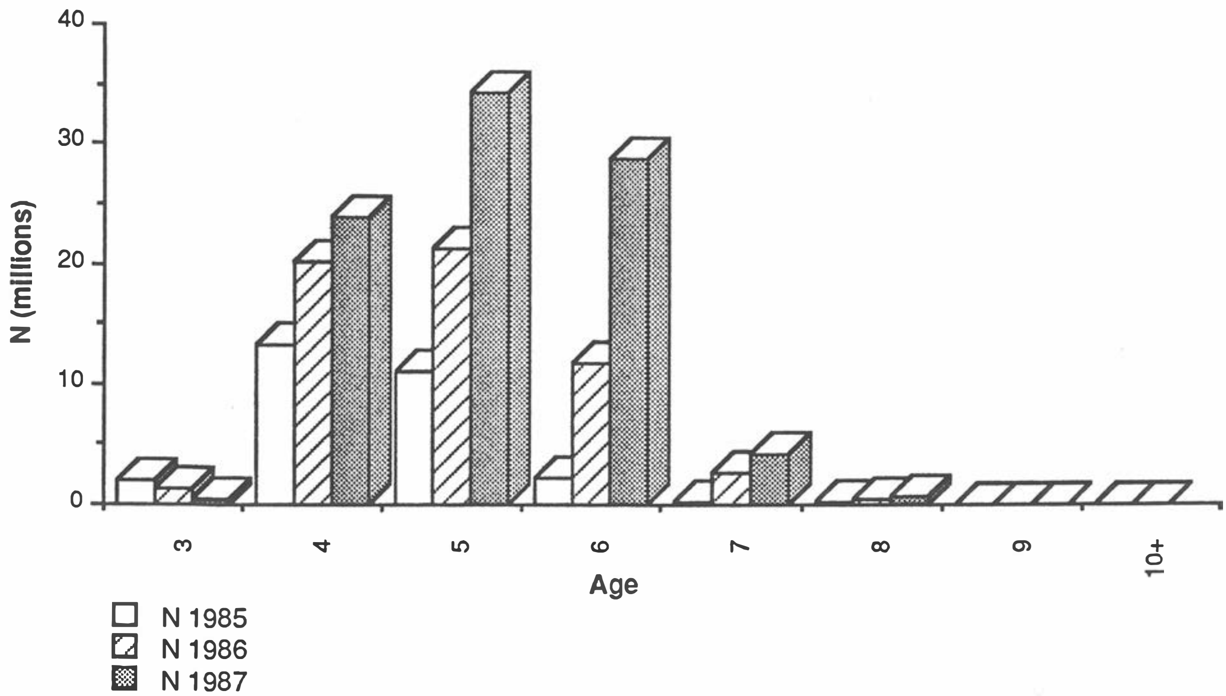


Figure 24. Age composition of the purse seine jack mackerel landings for 1985,1986 and 1987

Length (cm)	Age class 3	4	5	6	7	8	9	10+
20	1.00							
21	1.00							
22								
23								
24	1.00							
25	1.00							
26	0.77	0.23						
27	0.46	0.54						
28	0.09	0.91						
29		0.91	0.09					
30	0.05	0.73	0.22					
31		0.39	0.61					
32		0.12	0.88					
33		0.03	0.91	0.06				
34			0.46	0.54				
35				0.88	0.13			
36				0.50	0.50			
37						1.00		

Table 3a. Age-length key for jack mackerel for 1985 landings.

Length (cm)	Age class 3	4	5	6	7	8	9	10+
23	1.00							
24	0.50	0.50						
25	0.63	0.38						
26	0.42	0.58						
27	0.06	0.94						
28	0.03	0.97						
29	0.04	0.77	0.17	0.02				
30		0.66	0.32	0.03				
31		0.19	0.70	0.11				
32		0.03	0.73	0.20	0.04			
33		0.01	0.22	0.67	0.10			
34			0.07	0.79	0.12	0.02		
35				0.55	0.39	0.05		
36				0.13	0.67	0.20		
37				0.04	0.63	0.33		
38				0.05	0.05	0.37	0.42	0.11
39							0.33	0.66
40								1.00
41								
42								
43								1.00
44								1.00

Table 3b. Age-length key for jack mackerel for 1986 landings.

Length (cm)	Age class 3	4	5	6	7	8	9	10+
23	1.00							
24								
25	1.00							
26	0.10	0.90						
27	0.05	0.90	0.05					
28		0.94	0.06					
29	0.03	0.81	0.14	0.03				
30		0.48	0.44	0.08				
31		0.08	0.70	0.22				
32			0.77	0.22	0.01			
33			0.23	0.72	0.06			
34				0.89	0.11			
35				0.76	0.22	0.03		
36				0.42	0.54	0.04		
37					1.00			
38						0.50	0.50	
39							1.00	

Table 3c. Age-length key for jack mackerel for 1987 landings.

4.25 Mortality

Difficulties have been experienced producing unbiased estimates of mortality from the data. Several methods have been trialled to estimate total and natural mortality, however, the methodology to produce accurate estimates of mortality is still in the process of development.

Estimates of instantaneous mortality were made from the age composition data by catch curve analysis. The first potential source of bias that became obvious was that unless the length frequency data was weighted by the relative catch for each month the age composition of months of low catches would be over-emphasised. Weighting was carried out as explained in section 4.24 to estimate the catch composition by age without this bias.

A further source of potential bias was suggested by examination of the mean length and mean age of fish landed by the fishery by month (Figures 17& 23). This data suggests that older larger fish are less vulnerable to the fishery from January to March than at the beginning and end of the season. This trend may be due to spawning fish leaving the fishery at this time to spawn. Regardless of the reason, the result is that the mid-season landed catch may not be a true representation of the age composition of the population. A mortality estimate based on this data would therefore be biased. To overcome this bias the procedure described above was repeated using data from October and November only which would comprise of pre-spawning fish.

Results of both the above procedures are presented for comparison.

To linearise the data, the numbers of fish caught in each age class were transformed with natural logarithms. For the fully recruited age classes (6+), the transformed data was regressed against age.

Figures 25 and 26 present the natural log of the numbers in each fully recruited age class for the full years and for pre-spawning fish respectively. Regressions of the data produced the following relationships.

1985 Full year $\ln(N) = 20.932 - 1.122A$, $r_{(5)} = 0.982$, $P<0.001$
1985 Pre-spawners $\ln(N) = 19.115 - 1.006A$, $r_{(5)} = 0.976$, $P<0.001$

1986 Full year $\ln(N) = 25.414 - 1.547A$, $r_{(5)} = 0.970$, $P<0.001$
1986 Pre-spawners $\ln(N) = 22.666 - 1.299A$, $r_{(5)} = 0.964$, $P<0.001$

1987 Full year $\ln(\mathbf{N}) = 32.02 - 2.419\mathbf{A}$, $r_{(4)} = 0.985$, $P<0.001$

1987 Pre-spawners $\ln(\mathbf{N}) = 24.112 - 1.624\mathbf{A}$, $r_{(4)} = 0.989$, $P<0.001$

where **N** is the number of fish landed (in units of millions) of age **A** years.

The slope of the lines gives the instantaneous total mortality rate (**Z**), which produces the following results:

Year	Z Full Year	Z Pre-spawners
1985	1.1	1.0
1986	1.6	1.3
1987	2.4	1.6

Table 3.Comparison of estimates of instantaneous total mortality (Z). Estimates are presented for the full season and for pre-spawning (Oct-Nov) fish

Table 3 shows significant differences in estimates of **Z** obtained by analysis of a full years data from analysis of pre-spawning fish only . Although both methods produced similar estimates in 1985 estimates for 1986 and 1987 are appreciably different. Using the full years data very high estimates of **Z** were obtained. The 1987 value of 2.4 which equates to a yearly mortality of 91.1% is highly unlikely. The bias introduced by changes in age composition during the year appears to render this method unreliable unless further weighting or correction factors can be developed. The estimates of **Z** using pre-spawning data only are far more reasonable and will be used for the discussion that follows.

The 1985 estimate of **Z** of 1.0 from this study is similar to that obtained by Steven and Hausfeld (1982) of 1.16. However, using Pauyl's method Stevens and Hausfeld estimated **Z** to be 0.7. Similarly Webb estimated **Z** from a fishery based study to be 0.71 (Williams and Pullen 1986).

In 1985 the fishery was newly established on a near virgin stock. The estimate of 1.0 for **Z** in 1985 may also be considered equal to instantaneous natural mortality, **M**.

An alternative estimate of natural mortality may be obtained using Pauly's method (1980) that utilizes mean environmental temperature and population parameters. Figure 27 presents estimates of **M** over a temperature range of 10° Celsius using values of L_∞ and **K** from pooled data from 1985-87 (Table 2). An estimate for **M** of 0.35 is obtained assuming an average temperature of 14°C.

The two methods used to estimate **M** in this study, and in other literature, exhibit a wide range of fluctuation. This study produced estimates of 1.0 from the catch curve analysis and around 0.35 using Pauly's method. Stevens and Hausfeld (1982) estimate **M** to be between 0.63 and 0.7. As Webb's estimate of **Z** of 0.71 was from a virgin fishery this may also considered to be an estimate of **M**.

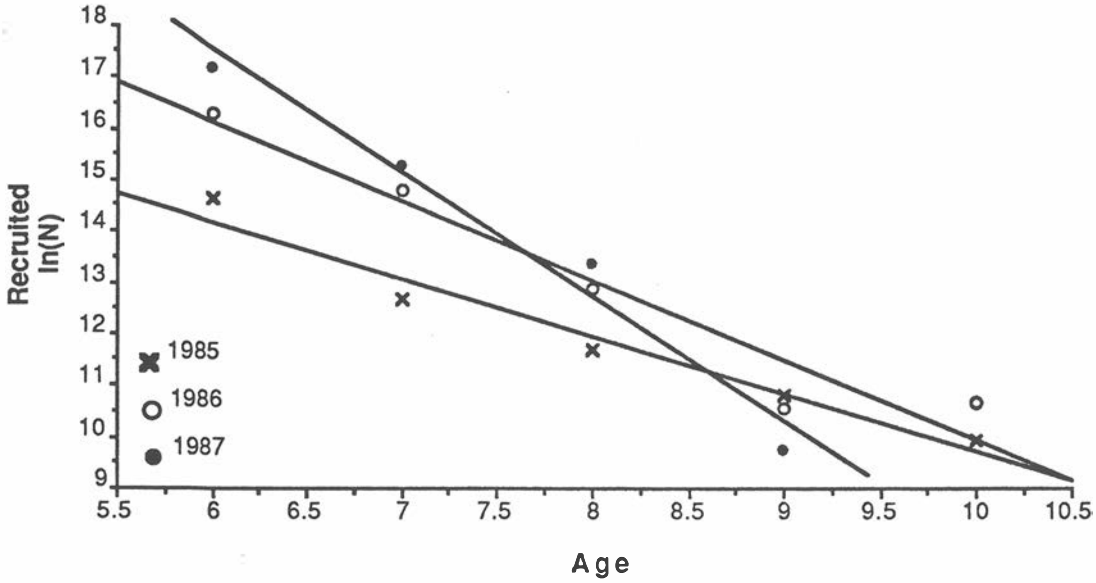


Figure 25. Linear regressions of ln(N) against age class for fully recruited age classes of jack mackerel in the 1985, 1986 and 1987 landings.

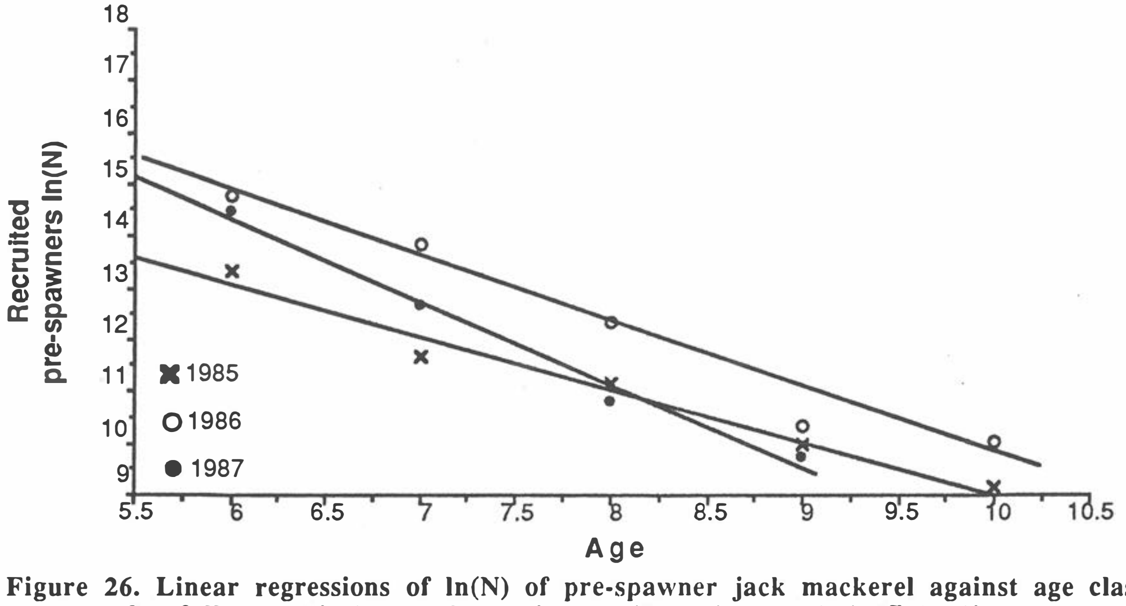


Figure 26. Linear regressions of ln(N) of pre-spawner jack mackerel against age class for fully recruited age classes in the 1985, 1986 and 1987 landings.

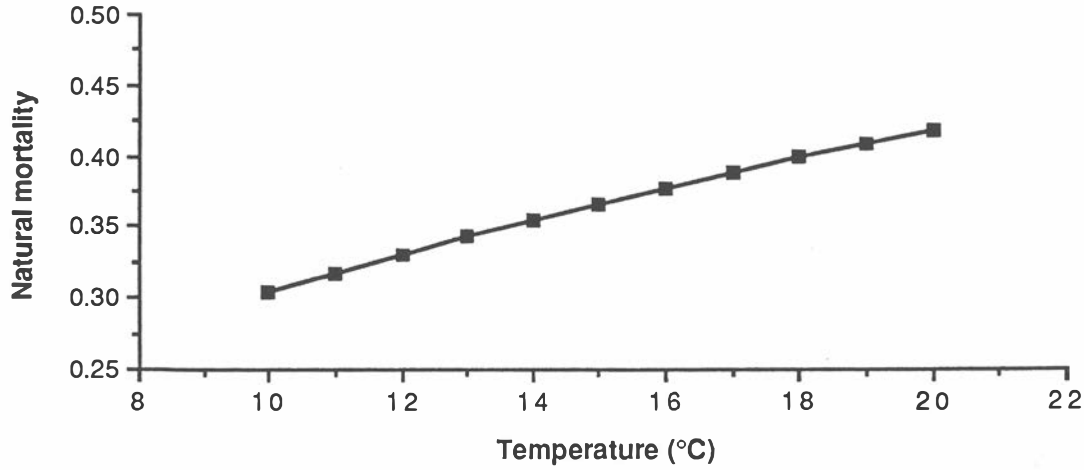


Figure 27. Estimates of natural mortality derived from the Pauly method against average environmental temperature

The estimates of **Z** and **M** obtained so far by this study are considered provisional by the authors. Estimates from the literature vary considerably which suggests these values should also be viewed with caution. Further efforts will be made to fine tune mortality estimates to clarify which figures are most accurate. One avenue of research will be refinement of the catch curve analysis to account for seasonal variation in the catch composition. Results will be published as soon as practicable.

4.26 Gonad development and condition

The highest gonad weights recorded for males and females from 1985 to 1988 were 26.4 gm and 46.8 gm respectively. The highest GSI recorded over this period was 6.1 for males and 8.3 for females. However, very few running ripe and few ripe fish have been recorded from the catches. A plot of the gonad somatic index (G.S.I.) against month for females over 30 cm is given in Figure 28. The data is presented for fish over 30 cm to present GSI data for larger mature fish only. It should be noted that spawning fish may not be represented in this data. The G.S.I. is calculated as,

$$\mathbf{G.S.I.} = [\mathbf{W}_g / (\mathbf{W}_b - \mathbf{W}_g)] \times 100$$

where $\mathbf{W}_b$ is total body weight in grams and $\mathbf{W}_g$ is gonad weight in grams.

It can be seen from Figure 28 that maximum development of fish caught in the fishery may vary from December to March. The 1986 and 1988 data exhibit peaks in February/March. The data for 1987, however, shows earlier development of jack mackerel in the fishery that year. The high figure shown in November 1987 is the result of limited sampling in this month with a predominance of developed fish in that sample.

Gonad stages have also been collected since mid 1986 using the criteria of Blackburn and Gartner (1954) which utilizes seven stages for both males and females. Stage 5 corresponds to ripe fish, stage 6 running ripe and stage 7 to spent fish. This data for females is presented in Figure 29. The lack of small fish make it difficult to draw concrete conclusions regarding the lower limits of age at maturity. However, the spread of data suggests fish mature between 26 and 28 cm. Webb (1976) found that the majority of jack mackerel matured at around 27 cm (corresponding to a weight of approximately 275 g and 4 years old).

The lack of spawning fish sampled from the fishery suggests that the fish are not vulnerable to fishing at this stage. As explained in section 4.25 the larger older fish which would be spawning fish are less common in samples from mid summer. The younger fish predominating catches in mid summer may not be mature enough to participate in spawning given a length of maturity of 27 cm. This evidence suggests that the ripe/running ripe fish move out to deeper water, spawn, and return to the fishing area in a spent condition generally around April. Preliminary results from recent larval sampling, however, suggests that spawning may take place in the mid-shelf area (Jenkins pers comm). Further collection and analysis of larval data should clarify this situation. The GSI of fish caught in the fishery may not be reliable for predicting the exact spawning time of jack mackerel . It should, however, indicate the relative time schedule of development in that year.

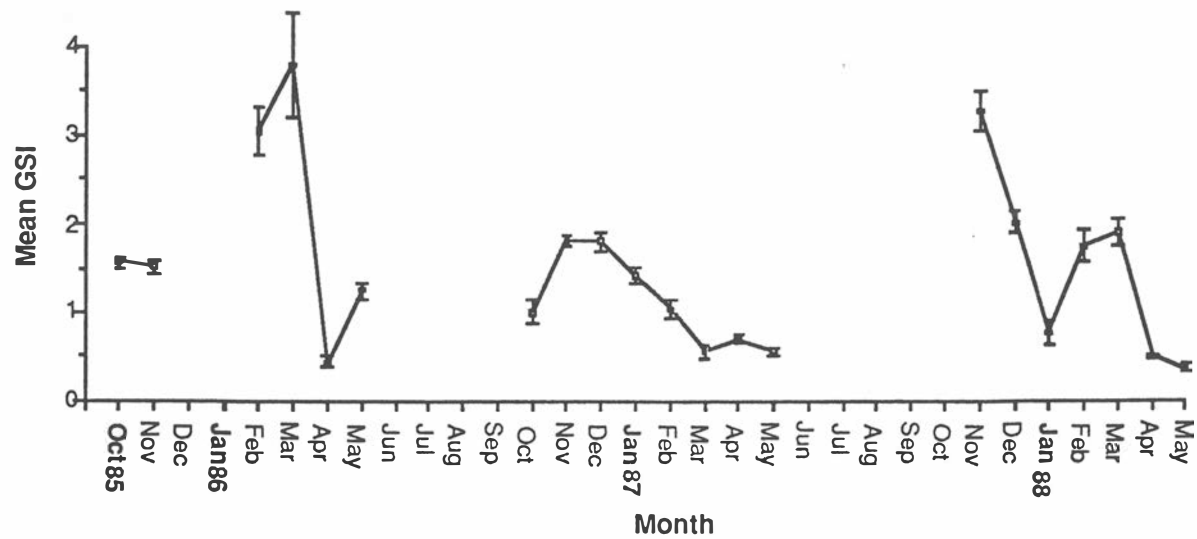


Figure 28. Mean GSI for females over 30 cm by month for 1985-1988. Bar indicate standard error.

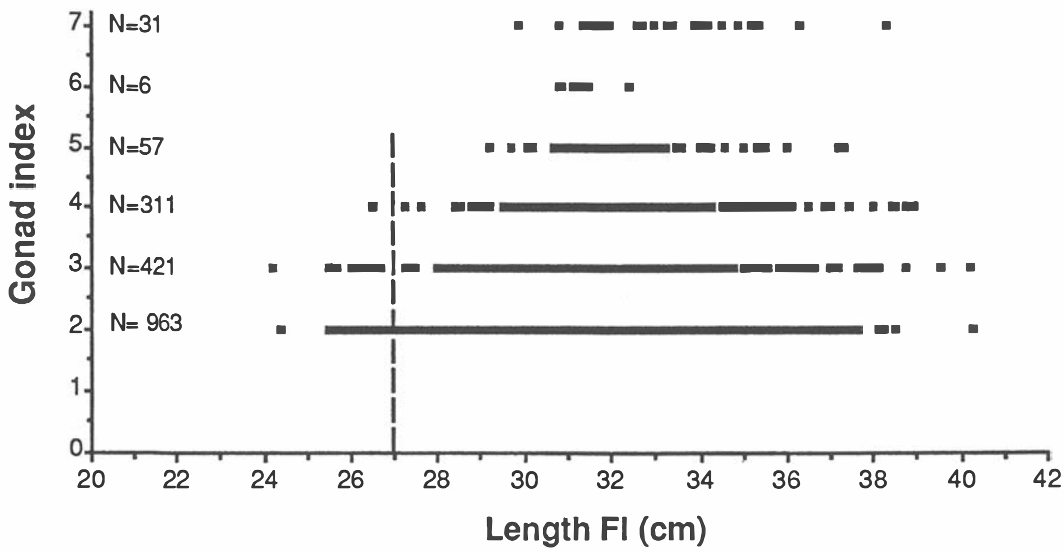


Figure 29. Gonad index versus length for females from mid 1986-1988. The dotted line shows the length of maturity estimated by Webb (1976)

4.3 Interannual variability

Many examples of variation in abundance and distribution of pelagic fisheries can be found in the literature (Tanaka 1983, Hayasi 1983, MacCall 1983, Serra 1983, Crawford et al 1983 & Jones 1983). Although there has been debate over the relative importance of environmental factors and fishing pressure as causal mechanisms for some of this variation, it is recognised that environmental factors play an important role in pelagic fisheries.

With only a short data set from the fishery an understanding of what is normal or abnormal in this fishery is difficult. However, even the short data set collected since the start of the fishery exhibits seasonal variation. Anecdotal evidence from other fishermen regarding surface schooling behaviour is a source of long term information that also suggests substantial seasonal variation.

The 1987/88 fishing season produced the first evidence of variation in the jack mackerel fishery.The 1987/88 season began over a month later than the two previous seasons, the first catches being taken in November. Between February and April catches slumped dramatically when by past experience catches should have been high. The large increase in school size normally experienced in the latter months of the season occurred three months later than previous seasons. Huge schools reported by spotters at this time in previous seasons were not reported during the 1987/88 season. The effects of these factors on the fishery was that very few schools were located when in past seasons large surface schools were easily found and caught. A likely explanation for this phenomena is an increase in the water temperature at this time. The waters around Tasmania at this time have been reported as being 2° C higher than in previous years (Harris pers comm.).

Changes in water temperature could significantly affect the distribution and behaviour of the species in the future. The waters on the east coast of Tasmania have demonstrated a long term warming with 10-15 year cyclic fluctuations since records have been taken at Maria Island in 1946.(Harris et al 1987)

Further variation in seasonal vulnerability was experienced during the latter months of 1988. By February 1989 no commercial landings of jack mackerel had been made some five months after landings would normally be expected.. The cause(s) of this substantial departure from previous patterns is speculation at present but is being investigated by several institutions.

Seasonal variation is a big challenge to future research in this fishery. It is likely that temperature may drastically affect the behaviour of this species. The affect that environmental variables may have on the biology of the species, however, is unknown. It is likely that distribution, spawning, larval survival and recruitment could be affected by such variables as temperature, nutrient levels, timing of the spring bloom and krill population levels. Factors that affect the distribution and population levels over several years are of greater concern than short term behavioural changes.

5 DISCUSSION

The Tasmanian jack mackerel fishery has developed quickly in the few years of operation to date. Interest in the fishery has increased dramatically since 1985 when a single operator pioneered this fishery. In retrospect the freeze on Tasmanian purse seine licences was introduced at an opportune time. Substantially more effort may have entered the fishery had the freeze not been introduced. The management plan being implemented in this fishery aims to allow development and consolidation in the industry during the next few years in what is still a young fishery. It is hoped that compatible management arrangements will be put into place for Commonwealth waters adjacent to Tasmania.

This report presents data and some results from the first three full fishing seasons of the Tasmanian jack mackerel fishery. Although only a short data set has been collected from the fishery so far this study has provided a valuable opportunity to collect data from the start of exploitation of this species. The 1989/90 season will be the first season that recruitment will occur from a spawning of the exploited stock. Data collected as the effects of fishing pressure flow through will be of great value.

Sampling from the commercial fleet has proven a valuable cost effective method of obtaining large numbers of regular samples. The drawback of this method of sampling is that only fish vulnerable to the fishery are collected. As fish recruit to the fishery between three and six years old young fish are represented only in small numbers. Spawning fish also may not be vulnerable to the fishery. The small spread of data makes some analysis, such as length/age regression, difficult. In an effort to overcome this shortcoming trawling activities have been undertaken to supplement data collection.

While analysis some of the data is considered provisional methodology and results will be refined as more data becomes available. The data will continue to be utilised and examined to continually improve the information obtained. During the coming year the information collected by this study will form the basis of a series of papers on the biology of the jack mackerel to be published in the appropriate journals

The DSF has a continuing research effort in this fishery. The DSF will continue to monitor the fishery and collect logbook and biological data. State and Commonwealth funds are being directed into a second branch of research on the jack mackerel. This effort is aimed towards developing fishery independent methods for assessing the jack mackerel fishery. This project will also investigate seasonal variability that is proving an important and challenging factor in this fishery.

ACKNOWLEDGEMENTS

We would like to thank the skippers and crews of the purse seiners, the aerial spotters and the shorebased personnel for their cooperation and contributions to this program. This work was supported by a grant from FIRTA.

REFERENCES

Anonymous (1975) Purse seining for jack mackerel in south eastern Australian waters. *Aust. Dep. Agriculture, Fish. Div. Rep.* **14**

Anonymous (1979) Overseas marketing for jack mackerel. *Dept. Prim. Ind., Fish. Div. Rep.* **27**

Blackburn, M and Gartner, P. E. (1954) Populations of barracouta, *Thyrsites atun* (Euphrasen), in Australian waters. *Aust. J. Mar. Freshw. Res.* **5**, 411-68

Blackburn, M and Tubb, J. A. (1950) Measurements of abundance of certain pelagic fish in some south-eastern Australian waters. *CSIRO Aust. Bull.* **251**

Butcher, A. D. (1967) Miscallaneous Fisheries 4. Jack Mackerel. Subject Collator A. D. Butcher. *Aust. Fish. Devel. Conf.* (Mimeo) Canberra

Crawford, J. M., Shelton, P. A. and Hutchings, L. (1983) Aspoects of variability of some neritic stocks in the southern Benguela system. In Proceedings of the expert consultation to examine changes in abundance and species composition of neritic fish resources. *FAO Fisheries Report* No. 291, Vol 2: 407-448

Hanson, S. W. F. and Olley, J. (1963) Application of the Bligh and Dyer method of lipid extraction to tissue homogenates. *Biochem J.* **89**, 101

Harris, G., Nilson, C., Clementson, L. and Thomas, D. (1987) The water masses of the east coast of Tasmania: Seasonal and interannual variability and the influence on phytoplankton biomass and productivity. *Aust. J. Freshw. Res.* **38**, 569-90

Hayasi, S. (1983) Some explanation for changes in abundances of major neritic-pelagic stocks in the northwester Pacific Ocean. In Proceedings of the expert consultation to examine changes in abundance and species composition of neritic fish resources. *FAO Fisheries Report* No. 291, Vol 2: 37-55

Hynd, J. S. and Robins, J. P. (1967) Tasmanian tuna survey. Report of first operational period.*Tech. Pap. Div. Fish. Oceanogr. CSIRO* **22**

Jones, R. (1983) The decline in herring and mackerel and the associated increase in other species in other species. In Proceedings of the expert consultation to examine changes in abundance and species composition of neritic fish resources. *FAO Fisheries Report* No. 291, Vol 2: 507-520

MacCall, A. D. (1983) Variability of pelagic fish stocks off California. In Proceedings of the expert consultation to examine changes in abundance and species composition of neritic fish resources. *FAO Fisheries Report* No. 291, Vol 2: 17-36

Maxwell, J. G. H. (1979) Jack mackerel. *CSIRO Div. Fish. Oceanogr. Fishery Situation Report* **2**

Miezitis, O. and Wright, A. D. (1979) Variations in the chemical composition of jack mackerel *Trachurus declivis* (Jenyns) from commercial fishing for FPC production 1973-1974. *Tas. Fish. Res.* **22** 30-9

Newman, G. G., Crawford, R. J. M. and Centurier-Harris, O. M. (1979) Fishing effort and factors affecting vessel performance in the South African purse seine fishery, 1964-1972. *S. Afr. Sea Fish. B. Invest. Rep.* **120**

Pauly, D. (1980) On the interrelationships between natural mortalty, growth parameters, and mean enviromental temperature in 175 fish stocks. *J. Cons. int. Explor. Mer.* **39(2)** 175-192

Serra J. R. (1983) Changes in the abundance of pelagic resources along the Chilean coast. In Proceedings of the expert consultation to examine changes in abundance and species composition of neritic fish resources. *FAO Fisheries Report* No. 291, Vol 2: 255-284

Stevens, J. D. and Hausfeld, H. F. (1982) Age determination and mortality estimates on an unexploited population of jack mackerel *Trachurus declivis* (Jenyns, 1841) from south-east Australia. *CSIRO Marine Labs. Rep.* **148**

Stevens, J. D., Hausfeld, H. F. and Davenport, S. R. (1984) Observations on the biology, distribution and abundance of *Trachurus declivis*, *Sardinops neopilchardus* and *Scomber australasicus* in the Great Australian Bight. *CSIRO Marine Labs. Rep.* **164**

Tanaka, S. (1983) Varaition of pelagic fish stocks around Japan. In Proceedings of the expert consultation to examine changes in abundance and species composition of neritic fish resources. *FAO Fisheries Report* No. 291, Vol 2: 17-36

Webb, B. F. (1976) Aspects of the biology of jack mackerel *Trachurus declivis* (Jenyns) from south-east Australian waters. *Tas. Fish. Res.* **10** 1-14

Webb, B. F. (1977) Moon's influence on shoaling of pelagic fish species. *Aust. Fish.* **September** 8-11

Webb, B. F. and Grant, C. J. (1979) Age and growth of jack mackerel *Trachurus declivis* (Jenyns), from south-eastern Australian waters. *Aust. J. Mar. Freshw. Res.* **30** 1-9

Williams, K. (1981) Aerial survey of pelagic fish resources off south east Australia 1973 - 1977. *CSIRO Marine Labs. Rep.* **130**

Williams, H. (1986) Collection and storage of data in the trawl, purse seine and drop-line fisheries. *DSF Tech. Rep.* **8**

Williams, H. and Pullen, G. (1986) A synopsis of biological data on the jack mackerel *Trachurus declivis* Jenyns. *DSF Tech. Rep.* **10**

Williams, H.,Kirkwood, R., Pullen, G. and Kucerans, G. (1986) The jack mackerel purse seine fishery in Tasmania, 1985-86. *DSF Tech. Rep.* **13**

Williams, H., Pullen, G., Kucerans, G. and Waterworth, C. (1987) The jack mackerel purse seine fishery in Tasmania, 1986-87. *DSF Tech. Rep.* **19**

Wolfe, D. C. (1971) Pelagic fish survey. 1. Seasonal availability of fish schools in in-shore waters. *Tas. Fish. Res.* **5**, 2-11

APPENDIX 1 Total landings per month by species.

Month	Tonnes Landed		
	Jack mackerel	Redbait	Blue mackerel
1985			
March	588	8	0
April	1492	52	0
May	3489	141	0
June	200	30	0
September	135	0	0
October	505	0	0
November	2991	5	0
December	1793	0	0
1986			
January	1873	37	15
February	1972	163	67
March	2449	388	16
April	6491	60	489
May	3677	41	0
September	57	20	0
October	158	20	0
November	3233	0	0
December	2595	16	156
1987			
January	4690	10	52
February	5830	37	282
March	4751	106	411
April	9286	592	72
May	8787	291	29
November	1674	0	0
December	4020	0	0
1988			
January	4852	2	216
February	3647	234	373
March	4174	199	420
April	3806	182	63
May	8604	463	50
June	4569	198	60

APPENDIX 2 Pulications resulting from this study.

Department of Sea Fisheries Technical Reports.

Williams, H. and Pullen, G. (1986) A synopsis of biological data on the jack mackerel *Trachurus declivis* Jenyns. *DSF Tech. Rep.* **10**

Williams, H.,Kirkwood, R., Pullen, G. and Kucerans, G. (1986) The jack mackerel purse seine fishery in Tasmania, 1985-86. *DSF Tech. Rep.* **13**

Williams, H., Pullen, G., Kucerans, G. and Waterworth, C. (1987) The jack mackerel purse seine fishery in Tasmania, 1986-87. *DSF Tech. Rep.* **19**

In press

Williams, H., Pullen, G., Kucerans, G. and Waterworth, C. (1989) The jack mackerel purse seine fishery in Tasmania, 1985-88. *DSF Tech. Rep.*

Articles

Mackerel Study shows two species bi-catch. *FINTAS* Vol **8**, No.4. Dec 1985

Purse seine catch tops 41,000 tonnes in record 86-87 season. *FINTAS* Vol **10**, No.3, Sept 1987

Annual mackerel TAC likely to vary, says DSF specialist. *FINTAS* Vol **10**, No.3, Sept 1987

Edible catch not sought by seiners. *FINTAS* Vol **10**, No.3, Sept 1987

Mackerel plan allows fishing by both big and small boats. *FINTAS* Vol **10**, No. 4, Dec 1987

Double catch likely to speed data collection. *FINTAS* Vol **10,** No. 4, Dec 1987

Jack mackerel go walkabout. *Fishing Today*, Feb-March 1989

Journal papers
In press

Williams, H. and Pullen, G. Seasonal variation in schooling behaviour and vulnerability to purse seine fishing of jack mackerel *Trachurus declivis* (Jenyns) in south eastern Australian waters.

Pullen, G. and Williams, H. Age growth, mortality and reproduction of redbait (*Emmelichthys nitidus)* taken by purse seine off the east coast of Tasmania

During the coming year much of the data presented in this report and previous technical reports will be used as the basis of a series of papers on the biology of the jack mackerel and the by catch species in the fishery. Topics will include age and growth, reproduction, mortality and schooling

FINTAS Vol 8, No.4. Dec 1985

Mackerel study shows two species bi-catch

AN assessment of the initial stages of Tasmania's big new jack mackerel fishery has shown the only significant bi-catch to comprise red bait and slimy mackerel.

As a result both these species have been included in the resource assessment research supervised by DSF marine biologist Howel Williams with joint Tasmanian government and FIRTA funding.

In its first three months, from March to June, the company exploiting the jack mackerel, Australian Fisheries Development, took delivery of 6000 tonnes of fish from the purse seiners Diana Avril, Vivienne Jane, Maria Luisa and Marine Countess.

This, says Howel Williams, puts the venture on target for an expected annual catch of 25,000 tonnes.

A further two seiners, the Lella and the Leonard Star, are expected to swell the catching fleet to six for the coming season.

For the DSF survey catches are monitored through fishing log books and by DSF researchers manning the seiners to collect fish for analysis.

FIRTA funding for the assessment programme is expected to continue for three years.☐

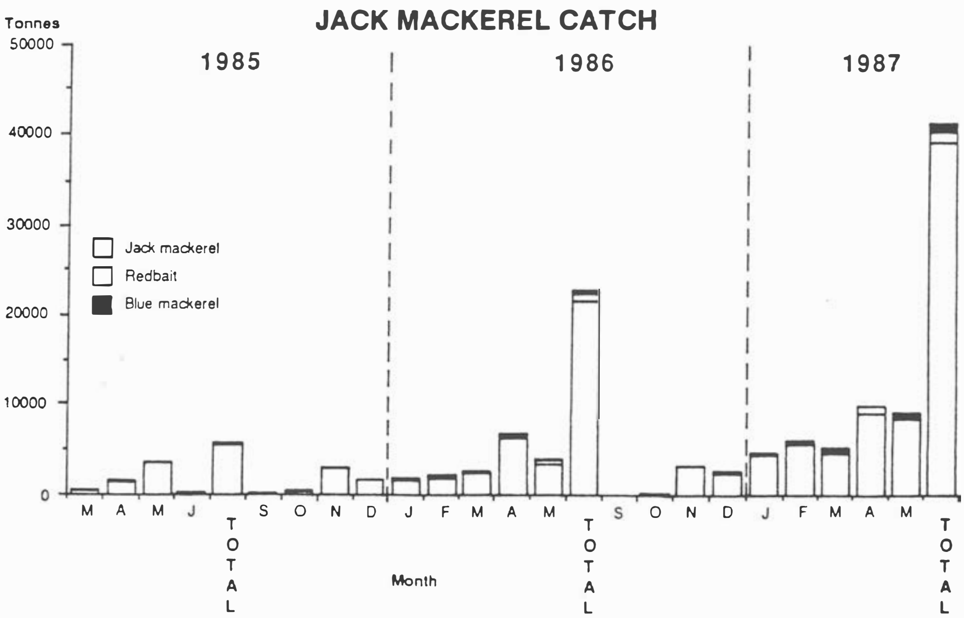
Purse seine catch tops 41,000 tonnes in record 86-87 season

THE seven purse seiners in Tasmania's jack mackerel fishery caught a total of 41,400 tonnes in the year to the end of last June. This almost doubled the previous year's catch of 23,100 tonnes, from five boats and, according to DSF scientists, further underlines the need for a cautious management approach in the nation's single biggest fishery.

The present jack mackerel fishery began in March 1985, with three seiners catching a total of about 6000 tonnes in four months. Since then the operation of Australian Fisheries Development Pty Ltd at Triabunna has gone from strength to strength.

AFD's quick success has attracted the interest of other catchers and processors, notably the operators of idle interstate tuna purse seiners and the Melbourne-based pet food supplier Trawl Industries of Australia, which has asked the Tasmanian government for an annual catch quota of 25,000 tonnes, in return for setting up a processing operation in the state.

The DSF has already signalled its opposition to the Trawl Industries request on the grounds that such an allocation would greatly exceed the currently accepted 'safe' maximum catch.



"Pelagic fisheries vary greatly in size year by year", said DSF pelagic biologist Howel Williams.

"Overseas experience in similar fisheries points firstly to over-capitalisation, followed by a series of bad years which together put excessive pressure on a limited resource.

"In the Peruvian anchovy and sardine fisheries the end result in each case was total collapse of the fishery", Mr Williams said.

To head off similar problems in Tasmania the government last May decided to freeze the issue of purse seine licences and other pelagic trawl licences that could be used for jack mackerel.

The Australian Fisheries Service was asked to implement a complementary freeze on Commonwealth licences. Contrary to a report in the previous edition of FINTAS, the AFS has not yet agreed to do so.

In the meantime Tasmania will continue with its interim freeze policy, which effectively limits licences to boats which had been actively fishing for mackerel before the freeze was announced.

This still allows companies such as Trawl Industries access to the resource through seiners such as the Leonard Star. This boat, originally working to AFD at Triabunna, began landing fish in Hobart for Trawl Industries before the freeze was announced.

For the DSF, which hopes to take over management of the fishery from the Commonwealth, the two major research problems are the virtual impossibility of quickly calculating the size of the jack mackerel resource and the annual variation in recruitment that results from environmental causes.

Howel Williams says great variations in annual recruitment are likely to result from yearly fluctuations in sea surface temperatures, which have a direct influence on spawning and larval survival.

Until sufficient baseline data are collected, the DSF management strategy will be very much aimed at resource conservation and against industry over-capitalistion.□

Annual mackerel TAC likely to vary, says DSF specialist

THE Tasmanian jack mackerel fishery has had a spectacular beginning. Starting in early 1985 it has developed from an unexploited virgin stock to Australia's biggest fishery, with landings of 41,000 tonnes for the 1986/87 season. In economic terms the fishery is already very valuable. Its major product is fish meal, with smaller markets for pet food, and bait.

● Howel Williams

The value of the fishery will increase when other markets for the catch are found. Already the by-catch species of redbait is sought for rock lobster and dropline bait and it is likely that blue mackerel will be used for fresh and smoked products. As there were 1,000 tonnes of each of these species caught in the past season these markets are likely to be significant in their own rights.

ENVIRONMENTAL conditions can cause great fluctuations, year to year, in jack mackerel numbers, says DSF Pelagic Fisheries Biologist HOWEL WILLIAMS. Because of this, he says, future management will probably be based on TACs which will also vary annually to compensate for changes in fish numbers.

The aim of both the DSF and the industry is to develop this resource into an efficiently exploited fishery, that will remain viable for the long term benefit of Tasmania. To do this it is necessary to understand both the basic biology of the fish and the catching power of the fishery. Although a great deal of scientific work has been done on jack mackerel in the past, little of this is of any use at present because the work was not based around a commercial fishery. In addition, no work has previously been done on redbait.

In order to collect useful data a joint DSF-FIRTA-funded programme was started in 1985. This study has two major objectives. Thev are to:

- monitor the catch level
- assess the basic biological features of jack mackerel.

The research is important not only in gaining an understanding of how much fishing the resource can bear but also because fisheries scientists are usually involved with research on developed fisheries. The new jack mackerel fishery offers a rare opportunity to measure parameters such as distribution, abundance, recruitment, and mortality as the stock develops from a virgin state to an exploited state.

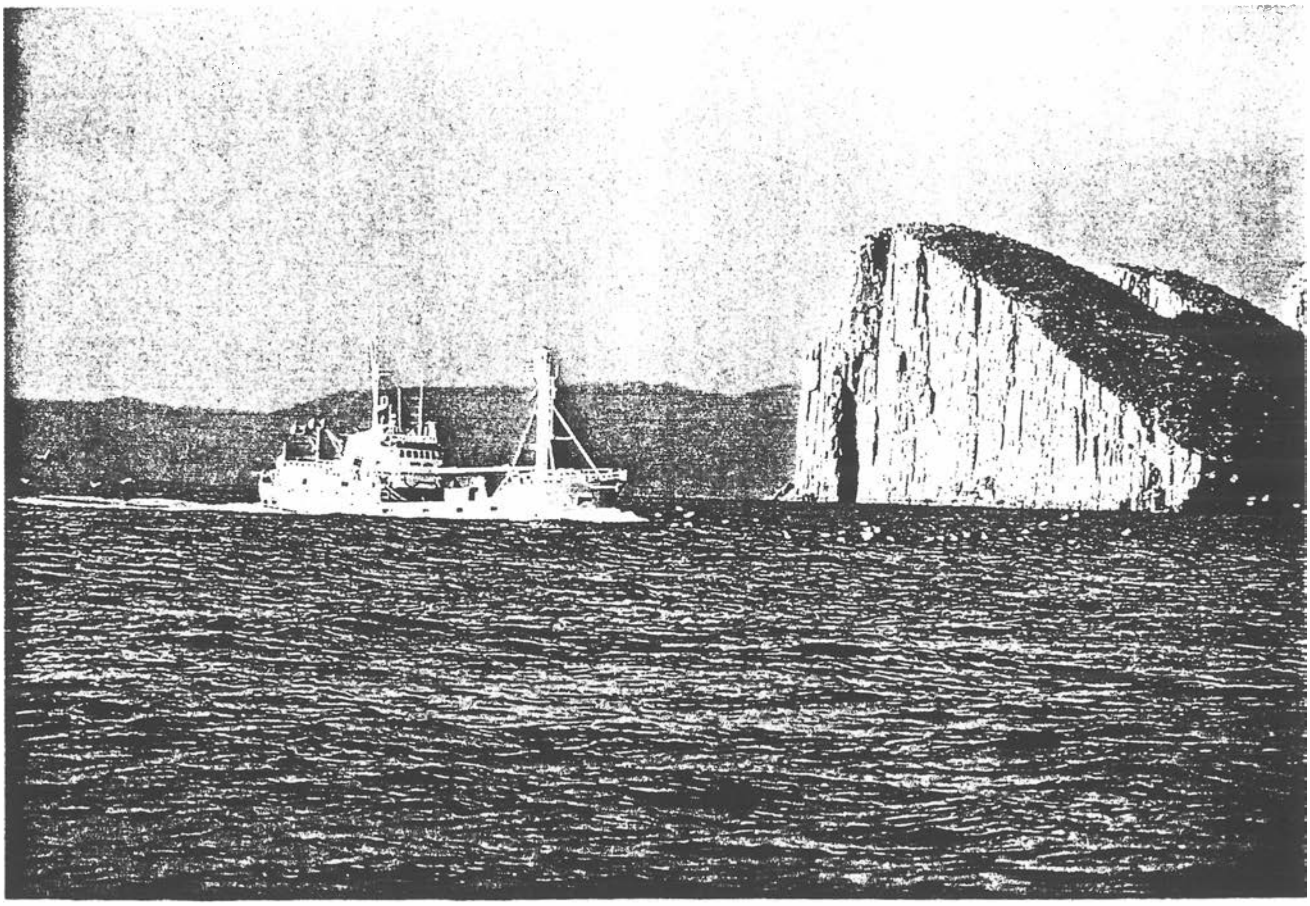
The current research programme deals with the quantity of fish being caught and the effect this has on the population. However we have no idea of the size of the existing population. There are also special problems associated with pelagic fish such as mackerel which make them very difficult to assess.

Unlike trawl fish it is impossible to estimate the actual size of pelagic populations from research surveys. This is because the schools of fish are not distributed evenly around the coast. To overcome this we are trying to develop reliable methods of making relative assessments of population size. This means we will be able to measure changes, but not the absolute size of the changes.

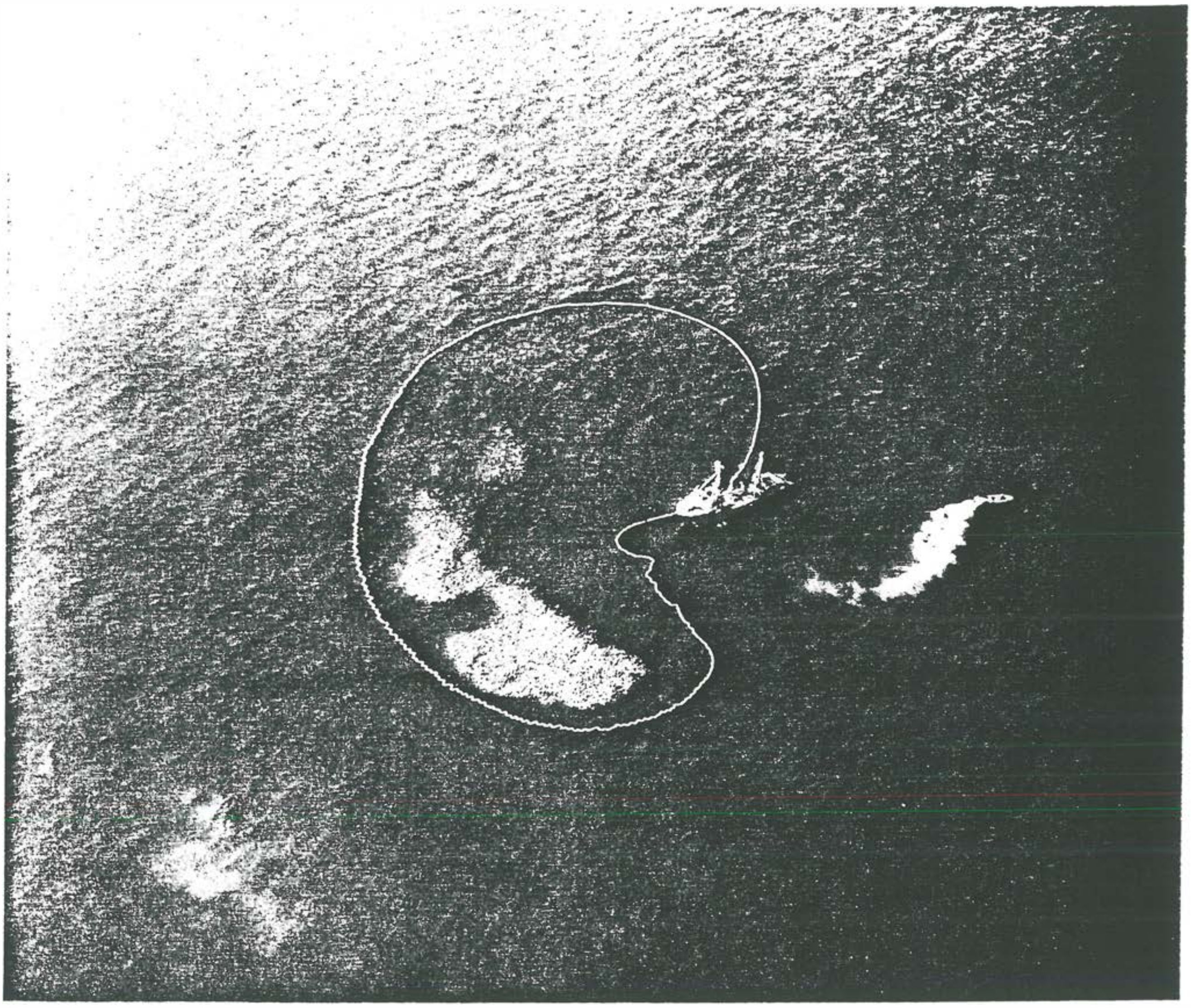
To complicate matters the total numbers of pelagic fish such as jack mackerel can vary greatly year to year due to environmental effects. The annual variation in environmental conditions such as sea surface temperature have an immediate effect on recruitment. In fact the effects of environmental changes on pelagic fisheries are often greater than those caused by fishing pressure. For example the effects of El-Nino events on the Californian sardine fishery and the Peruvian anchovy fishery have led to sharp declines in landings.

Knowing this the DSF is developing a research programme that will help measure changes in the population and monitor changes in the environment that may affect the size of the fish population.

In coming months the DSF research vessel *Challenger* will use a midwater trawl net off the east coast to sample deep schools of jack mackerel and other schools not accessable to the Triabunna-based purse seiners. This work will be undertaken in conjunction with a sonar survey of pelagic fish stocks and a hydrological survey.



● **The Maria Luisa off the Hippolytes.**



● The Leonard Star closing its purse seine on 70 tonnes of jack mackerel. A tow line to the skiff, at right, prevents the seiner drifting into its own net.

Funds have been made available from the Reserve Bank of Australia's Rural Credits scheme to buy a sophisticated sonar for this work. It is hoped that the information collected will indicate the sites and nature of jack mackerel spawning and provide better overall understanding of the potential of this significant resource.

The DSF is also monitoring sea surface temperature (SST), using data provided by the CSIRO Division of Atmospheric Physics and the Trawler Owner Association. These data should help us understand the relationship between temperature and the success of spawning fish and thus the number of fish that will join the fishery when they are at recruitment age.

The jack mackerel fishery is largely under Tasmanian jurisdiction as about 99 per cent of catches are made in Tasmanian waters. Negotiations are underway with Canberra to transfer management responsibility for all relevant coastal waters to the state. If these negotiations are successful a management plan will be formulated by the DSF in consultation with the industry.

Because of the variability of the resource it is likely that management will rely on the setting of annual Total Allowable Catches (TACs) which would vary year to year in line with expected fluctuations in jack mackerel numbers, as indicated by continuing research. This should allow for efficient management which both conserves a viable population and maximises the commercial catch.☐

Edible catch not sought by seiners

TASMANIA'S previous jack mackerel fishing venture in the mid-70s had big problems remaining viable because its boats were also trying to catch skipjack tuna.

The present operator, AFD, is geared only for catching jack mackerel for fish meal and lately, the production of bait. This operation is designed to catch industrial quality fish in bulk and cannot easily be adapted to catch and land fish of a quality suitable for human consumption.

To fish seriously for other species would require brailing and a completely different holding system on boats which currently have only about 100 tonnes of unrefrigerated bulk storage. This is clearly impractical.

The total number of shots by the purse seine fleet in the past season was just in excess of 830. The major species caught were jack mackerel, 39,400 tonnes; redbait, 1100 tonnes; and blue mackerel, 1000 tonnes.

Of all these sets only one caught snottys — a catch of 40 tonnes. So one shot in 830 caught 1:1000 of the total landings from this fishery. Given the fishing intensity, this catch was clearly incidental and accidental.

In autumn couta is sometimes caught. It constitutes such a small catch that its presence is measured in single fish rather than weight. The number seldom exceeds 10.

The jack mackerel fishery is large and intense. Landings of by-catch species are tiny in comparison to the target species and are not a significant part of the commercial operation.

It is not in the interests of this fishery to catch fish such as tuna, trevally and couta as the handling and landing techniques are not suitable for routinely processing them to a quality suitable for human consumption. — *Howel Williams, DSF Pelagic Biologist.*

FINTAS Vol **10**, No.3, Sept 1987

Mackerel plan allows fishing by both big and small boats

THE major overall objective is to maximise the long term benefit of the resource to the Tasmanian community. Therefore the plan should:

- Give traditional Tasmanian fishermen the option of participating in the fishery as part of their diversified operation.
- Address the problem of obtaining scientific data so that management decisions can be based on the biological characteristics of the fishery.
- Accommodate annual access rights rather than property rights.
- Protect investments made by existing operators, provide for orderly development of the fishery and allow for planned capital investment.
- Allow the most cost-effective management strategy.

FACTORS AFFECTING MANAGEMENT

As well as the clear objectives outlined above, the plan aims to accommodate other factors of importance to the fishery. These include:

- The fishery may fluctuate from year to year.
- Markets for the product are changing and developing.
- The concern that the jack mackerel fishery will have a significant impact on other species such as warehou and Australian salmon.
- The small scale surround netting fisheries for a variety of species.

A PLAN for the management of the jack mackerel fishery in Tasmanian waters provides access for both big and small boats. An annual TAC will be set for the big boats, but boats of 20m and less will not be bound by the TAC nor by individual quotas. The plan has been produced by the DSF in consultation with industry and has been provisionally approved by TFIC.

- The costs of outlays for participants in the fishery.

Regulations and management measures already exist for purse seine fishing on the east coast of Tasmania. Most operators hold a Commonwealth fishing boat licence, a Tasmanian fishing boat licence, a Tasmanian purse seine licence and a Tasmanian fisherman's licence. The issue and transfer of Tasmanian purse seine licences have been frozen since May 1 this year.

For the management plan to be efficiently enforced the area in which mackerel fishing currently exists and areas important to the viability of the mackerel resource must be brought under single jurisdiction.

THE PLAN

It is proposed that there be one fishing zone covering all Tasmanian coastal waters. It is proposed that the fishery be clearly partitioned into two sections by boat size and that separate controls be imposed on the two fleets. All boats shall hold a Tasmanian fishing boat licence.

SMALL BOATS

Any boat 20m LOA or less with a Tasmanian fishing boat licence and the appropriate gear licences, that is a Tasmanian purse seine licence or a Tasmanian pelagic trawl licence, may catch jack mackerel in Tasmanian waters.

If the total catch by this sector of the fishery exceeds 5,000t in any one season then the management plan shall be reviewed. Catches from this sector of the industry will not be considered as part of the TAC set for the mackerel fishery (unless a boat is acting as a carrier vessel for a boat in excess of 20m LOA) nor will it be constrained by size limits.

BIG BOATS

For boats over 20m the management plan will guarantee participants annual access rights to the resource. Access rights will be given by a non-transferrable tonnage allocation from an annual TAC. The TAC will be determined by the Minister for Sea Fisheries.

The TAC will apply to all catches of jack mackerel, redbait, blue mackerel, and other oily pelagic fish. Only jack mackerel over the size at first maturity (27cm LCF) may be targeted and landed.

In summary the process of licensing and distribution of quota will be:

- A TAC for the current season is determined.
- Quota tonnage from the TAC is distributed to boat owners by allocation and auction.
- Boat owners nominate the vessel to be licensed and the quota attached to it.

ANNUAL QUOTAS

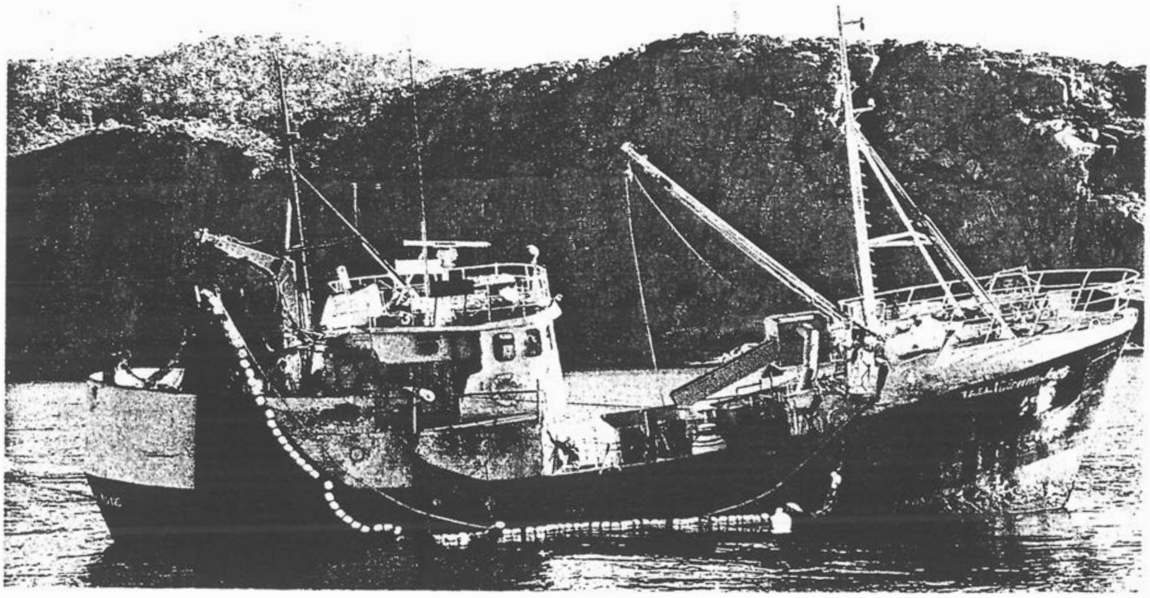
Once a TAC has been determined for boats over 20m, potential participants will register their interest with the DSF. To qualify, they must hold valid fishing boat licences and will be known as nominees.

The total annual tonnage determined from the TAC will be split into two. The majority (80%) will be for allocation to nominees and shall be called *allocated tonnage.* The lesser portion (20%) shall be auctioned to nominees and shall be called *auction tonnage.*

The total allocated tonnage and the auction tonnage held by a nominee will then be distributed to a nominee's boats at the nominee's direction. Tonnage distributed in this way shall be called the quota tonnage as it refers to a boat's quota of the TAC. Holders of quota tonnage will then be issued with a Tasmanian mackerel fishing licence. They will then be called licensees.

INITIAL ALLOCATION

In the first year of the management plan the distribution of allocated tonnage will be determined by the Tasmanian Fishing Industry



● **The Vivienne Jane, working off the east coast.**

Council to the satisfaction of all nominees. If such agreement cannot be reached then allocation shall be by a formula based on investment and catch history.

This formula would give equal weight to a nominee's catch and investment history. A vessel's total mackerel catch as a proportion of all mackerel fishing since 1985 would be added to the proportion of investment in the catching and processing sector of the Tasmanian industry. This would be halved to give a value of mean involvement, then it would be multiplied by the value of the TAC available as allocated tonnage and calculated to the nearest tonne.

Catch history would be determined from purse seine daily fishing log returns. Investment would be determined from an audited statement of the nominee's current investment in mackerel fishing.

Where a nominee has more than one qualifying vessel, investment and catch history would be pooled and one allocation made. This allocation may then be distributed to one or more of the nominee's vessels at his direction. Notification of the desired distribution, stating the vessel's name and the quota tonnage allocated, would be required by the DSF before a Tasmanian mackerel fishing licence would be issued.

SUBSEQUENT ALLOCATION

All rights to catch jack mackerel expire at the end of the season, and no quota tonnage may be carried over into subsequent seasons. An appropriate TAC for the next season will be determined by the DSF and recommended to the Minister for Sea Fisheries at the end of a season. It will then be divided into allocated tonnage and auction tonnage. The distribution of tonnage will follow these guidelines:

- Where there is an increase in the TAC from the previous season, those who held a TMFL in the past season will have the option of receiving allocated tonnage on the basis of formula (2). Unaccepted allocated tonnage will be pooled with the remaining tonnage (due to TAC increase) and treated as auction tonnage.
- Where the TAC remains the same as in the previous season, those who held a TMFL in the past season will have the option of receiving allocated tonnage on the basis of formula (2). Unaccepted allocated tonnage will be treated as auction tonnage.
- Where there is a decrease in the TAC from the previous season, those who held a TMFL in the past season will have the option of receiving allocated tonnage on the basis of formula (2). Any unaccepted allocated tonnage will be treated as auction tonnage.

The formula (2) to be followed in assessing a nominee's optional offer of allocated tonnage will take account of changes in the TAC and the ability of a nominee to catch his quota in the previous season.

This shall be done by dividing the difference the current TAC by the previous season's TAC. This factor will then be multiplied by a vessel's total catch in the previous season, assessed from logbook returns divided by the previous season's quota tonnage and will be calculated to two decimal places. (If the previous season's catches are in excess of their quota tonnage for that season then this term shall be set to the value of 1.00).

The resulting factor will then be multiplied by a nominee's allocated tonnage for the previous season. The result will be a nominee's optional share of the allocated tonnage calculated to the nearest tonne.

Where a nominee owns more than one qualified boat, then for the purposes of allocation previous season vessel catches and quota tonnages will be pooled and one allocation will be made. This allocation may then be distributed to one or more of the nominee's vessels at his direction. Notification of the desired distribution, stating the vessel's name and the quota tonnage allocated must be given to the DSF before a Tasmanian mackerel fishing licence will be issued.

LICENCES

The taking of jack mackerel and associated natural by-catch species by any vessel greater than 20m LOA will be prohibited unless that vessel holds a Tasmanian mackerel fishing licence. This licence will allow a vessel to catch jack mackerel and its natural by-catch species by any legal fishing method, with catches limited to the quota tonnage stated on the licence.

Licences will be issued with the following conditions:

- To be valid from August 1 to the following July 31.
- Will be non-transferrable.

- Holding a TMFL will not give the licensee any claim to a similar licence in subsequent years.
- A vessel's total catch will be limited to the quota tonnage stated on the licence.

To be eligible for the issue of a TMFL a vessel to be licensed must hold quota tonnage from the current TAC, which will be endorsed on the licence and hold a valid fishing boat licence.

A valid licence will be either a Tasmanian fishing boat licence or a conditional Tasmanian fishing boat licence, issued to boats brought to Tasmania specifically for the jack mackerel fishery and confined to catching jack mackerel or its natural by-catch species.

In future the Tasmanian purse seine licence and the Tasmanian pelagic trawl licence will not be valid for taking jack mackerel and associated species by boats greater than 20m LOA.

In addition to the licence fees payable for fishing boat licences a variable fee will be payable for a Tasmanian mackerel fishing licence. This fee will be calculated as a multiple of the quota tonnage allocated to a vessel. The Minister for Sea fisheries will set and vary the multiple.

SURRENDER OF TONNAGE

A licensee may surrender some or all of his quota tonnage to the DSF. If the surrender occurs before February 1 in the current fishing season, fees collected for the quota tonnage shall be refunded. If a licensee has not begun to use that quota tonnage by March 1 in the current fishing season, then all that quota tonnage shall be surrendered to the DSF without refund and the tonnage treated as auction tonnage.

TONNAGE TRANSFER

The transfer of allocated, auction or quota tonnage between nominees and licensees is prohibited.

However transfers of quota tonnage will be allowed between qualified vessels owned by the same licensee. Such transfers will be subject to a transfer fee.

PENALTIES

Penalties will be imposed:

- If catches exceed the quota allocated.
- For dumping fish on land or at sea.
- For talsifying or failing to furnish information to the DSF as required.
- For making false or inaccurate logbook entries.

OTHER WATERS

Any vessel landing jack mackerel in Tasmania that have been caught in waters not covered by this management plan must notify the DSF in advance of the place and time of landing, make available the consignment for inspection and pay inspection fees.

If the vessel holds a Tasmanian mackerel fishing licence the landing will be treated as part of the allowed catch and deducted from the current quota tonnage for that vessel.

MISCELLANEOUS

The DSF will determine the definition of a metric tonne of jack mackerel in its various storage states.

There are no limitations on a licensed fishing vessel carrying jack mackerel caught by another licensed boat. Where this occurs the fish will be treated as catch from the other boat, made from its quota tonnage.□

Double catch likely to speed data collection

EVIDENCE suggests that several mackerel stocks exist in southern Australian waters, with the greatest concentration off Tasmania, according to DSF pelagic fisheries specialist HOWEL WILLIAMS. In his background to the mackerel management plan Mr Williams outlines a fast-track method of gaining necessary information about the resource: Doubling the catch for a single season then measuring the impact on the species.

THE need for a management plan does not indicate concern about the biological status of the jack mackerel stock. Rather it is due to a desire to see an orderly development of the industry, to avoid the over-capitalisation and threat to investment so common in pelagic fisheries in other countries.

Jack mackerel are widely distributed through southern Australian coastal waters, scientific evidence suggesting the existence of several stocks. The stock in Tasmanian waters is thought to be distinct from those in the Great Australian Bight and off the east coasts of Victoria and New South Wales.

Aerial survey data collected by the CSIRO off New South Wales, Victoria and Tasmania demonstrate that surface schooling fish are concentrated in Tasmanian waters. This suggests that the species is most abundant in this area. Other data show that *Nyctiphanes australis,* the major feed species of jack mackerel, is also concentrated here.

Until 1985 jack mackerel was an unexploited resource protected from foreign fishing by a global TAC of 30,000 tonnes. This figure was set to exclude foreign fishing and was not based on any strong scientific evidence.

In 1985 a fish meal factory was installed at Triabunna on Tasmania's east coast and a fleet of four purse seiners started operating. Annual catches grew steadily — the latest is 41,000 tonnes. This total is largely made up of jack mackerel, *Trachurus declivis,* although two significant by-catch species also contribute. These species are redbait, *Emmelichthys nitidus* and blue mackerel, *Scomber australasicus.* About 1000 tonnes of each have been landed.

The purse seine fleet has grown, especially in the past season and seven boats are now involved. Jack mackerel is mainly used for the production of fish meal, but in the past season markets for bait and canning also were developed.

● **Howel Williams**

Biological assessment of this fishery has been a major commitment by the DSF, with a research programme running since the start of the 1985 season. There is no reason to be concerned at current fishing levels but further development should proceed with caution.

It has been the experience in many other pelagic fisheries that stock collapses occur due to an annual variability in population size. Pelagic fish are often sensitive to environmental changes, causing a high degree of instability in stock size. If the fishing power is too great then the capacity to decrease fishing effort is limited. This leads to a dangerous condition of synergistic attrition on the stock by both excessive fishing pressure and adverse environmental conditions.

As this fishery is very young, the fishery data are also limited to a short time span. Using traditional fisheries analysis, appropriate advice on catch levels will not be available within this century. However if novel techniques are used advice will be available in the short term. For example, recent advice has demonstrated the value of perturbation experiments as a means of providing rapid assessments of fish stocks and their population dynamics.

The commisioning of a shore factory at Triabunna while the fish processing barge is still in operation will provide an opportunity to substantially increase the catch in one season without increased capital expenditure. Thus in that season the catch could be doubled. The impact of this on the stock would be assessed in succeeding seasons, when fishing mortality returned to the pre-experimental level.

The return of fishing effort to the normal level after the experiment is guaranteed by the planned relocation of the processing barge. This unique opportunity may allow an assessment of the stocks to be made within three to five years of this experiment.□

Jack mackerel go walkabout

Howel Williams

The annual catch of feeding schools of jack mackerel off the east coast of Tasmania is billed as Australia's largest single fishery. Over the last three years, six purpose built trawlers of Spring Bay Fisheries (now Industrial Fish Tasmania) have hauled 100,000 tonnes of this migratory species from the continental waters surrounding Maria Island, with most of this catch being processed into fishmeal pellets at nearby Triabunna for the burgeoning local fish farm industry.

The future looked very bright indeed until fickle nature stepped in to order a temporary halt to proceedings. This season was due to start last September, but virtually no jack mackerel has been caught, and DSF and CSIRO personnel have been combing the waters to find out why.

"It seems to be the result of food shortages," says Howel Williams, the DSF jack mackerel specialist. "Jack mackerel become available to the fishery when they start feeding on krill, congregating in dense feeding schools. This year, krill is in short supply.

"It's not as if the jack mackerel aren't

Where are they?

The absence of large surface and shallow sub-surface schools poses the questions:

- why have the fish changed their normal behaviour?
- where are the fish now?
- what effect will this years variation have on future seasons?

On this last point scientists at the DSF were concerned that long term effects could arise from the changes seen in this season. This is because experience in other pelagic fisheries indicates that environmental factors can substantially reduce spawning as well as survival of young fish. If this was to occur, the effects would be felt in the fishery three to four years hence.

To shed some light on these issues, the DSF research vessel *Challenger* undertook two research cruises in January as part of the ongoing research. Larval samples and temperature profiles were collected on the east coast of Tasmania from Eddystone Point to Storm Bay.

And the result? Good news, for although the samples collected will take some time to be fully sorted, provisional "eyeballing" has revealed large quantities of larvae ranging from only a day or two old up to several weeks have been caught - larvae older than these are able to avoid capture by the larval net.

These results prove:

- that jack mackerel have been present off the east coast,
- that spawning had successfully taken place over the previous few weeks.

Furthermore the larvae are surviving in numbers, at least up until a few weeks old. Survival during this period in the fishes development is critical to the eventual number of fish entering the fishery.

The large quantity of larvae caught (over 750 in one sample) suggests that spawning fish must have been present in large numbers. However, if the fish have been present on the east coast over this period why have they not schooled up?

The answer seems to be that whereas large swarms of krill are usually present at this time of the year, this season krill are in short supply, and schooling jack mackerel feed on krill - no krill, no schooling mackerel.

Instead, it may be that the mackerel are feeding on lanternfish in deeper waters. This will be checked in a trawling survey to be conducted from the *Challenger* in the next few weeks.

Pelagic fisheries around the world naturally exhibit high levels of variation in stock size and changes to the distribution of fish. Induced by environmental change, such variability may occur repeatedly at intervals of several years. The current problems in the jack mackerel fishery prove it to be no different from the rest, and highlights the importance of flexibility in its management .

A poor season such as this will occur again.

Grant Pullen, Greg Jenkins, and Howel Williams, DSF.

Two larval nets are hauled up onto *Challenger*.

there at all. A recent trawl survey has indicated that they are to be found dispersed in deeper waters, and therefore inaccessible to the highly efficient purse-seining techniques used in this fishery."

The problem appears to be that the water on that section of the continental shelf has not been replaced or replenished by surrounding oceanic waters in the past year. Consequently, it may be that the amount of nutrients available to the diet species, the krill, is very low.

So, with little nutrient to feed the annual 'crop' of krill, the krill population this year is very scarce, and the jack mackerel have little incentive to school in the surface waters.

Whilst severe at present, the setback is only temporary according to Dr Williams.

"Fisheries such as this one are known to be highly variable worldwide. A famous example is of course the anchovy fishery of South America and its relationship with the El Nino current.

"Our job now is to use the information that we are now getting to help build a forecast capability for jack mackerel catches in future."