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Snapper

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SNAPPER
(*Chrysophrys auratus*)

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1. INTRODUCTION

1.1 Overview

This document reviews the New Zealand snapper fishery, with particular attention to recent trends in the major regional fisheries, including CPUE data for 1983-86. It describes the overfished nature of most stocks, although this is not really apparent in the CPUE data - the most serious declines having occurred some years previously. The fisheries are now reasonably stable, but at relatively low catch levels; an important requirement of management will be to ensure stock recovery. The document then reviews the more recent research programmes, avoiding detail because of the very extensive nature of this research. It emphasises the studies which are most relevant to current MAFFish efforts to establish sustainable yields from regional stocks. It finally discusses, region by region, the way in which this research on snapper has been combined with studies on trends in the actual fisheries to derive the various yield estimates which then lead to TAC figures. This final section draws heavily upon, and attempts to integrate and summarise, the snapper documents prepared for the last three fish stock, sustainable yield, and TAC workshops (Sullivan 1985, Hore *et al.* 1986, Sullivan *et al.* 1988).

1.2 The fishery

For several reasons snapper has always been one of New Zealand's most important coastal species.

Until the mid 1970s snapper generally ranked first in the country's wetfish landings, comprising one-third to almost one-half the reported marine fish catch. Reported tonnages increased from about 4000 in 1931 to almost 18 000 in 1978 (Fig. 1). There were declines in landings in the early 1940s and early 1950s, but the most dramatic decline has occurred since 1978, with landings dropping steadily to about 6000 t in 1986. In addition to this absolute decline, snapper landings have fallen in relative importance as other, mainly deeper water fisheries have developed (Fig. 2). From about 45% of total landings in 1935 (and probably higher in earlier unrecorded years) snapper has fallen to under 10% of the traditional shelf and shelf-edge fishery species in 1985, and to about 3% of the total New Zealand fishery (i.e. including deepwater species). However, it remains a high-value fish, with a considerable proportion of the catch exported to Australia and Japan.

Snapper has always had a high profile in fisheries management programmes. The northern snapper fishery centred on Auckland and the Hauraki Gulf has been heavily regulated from about 1900 onwards, partly in order to conserve the stocks from excessive "power fishing" methods (trawling and Danish seining) and partly to give some separation to competing fishing methods within the Gulf and along the adjacent north-eastern coasts. The Gulf fishery became New Zealand's first controlled fishery for finfish in 1982, involving limited entry by permit based on previous history in the fishery. This led to difficulties in adjacent areas, with perceived inequality where Gulf fishermen could fish elsewhere but other fishermen were excluded from the Gulf. A general New Zealand-wide moratorium on the issuing of fishing permits followed later in 1982, prompted partly by the realisation that the whole northern snapper fishery was under extreme pressure and was almost certainly over-fished in some regions. Debate and investigation of management options intensified, leading eventually to the adoption of an Individual Transferrable Quota (ITQ) scheme (now known as the Quota Management System (QMS) for most of the important coastal species in 1986.

Snapper is popular with recreational fishermen, particularly around northern New Zealand where it is one of the best-known and most sought-after species. There has always been debate and controversy over the relative merits and values of the commercial and recreational fisheries, with supporters of the latter regularly calling for the reduction of commercial fishing on inshore grounds.

As an inshore species extensively fished by the Maori people, snapper is also close to the centre of the present Maori claims to New Zealand's fisheries.

1.3 Snapper research

Snapper have been studied extensively and their biology is now reasonably well understood. During the 1960s and 70s research programmes concentrated on reproductive biology, age determination and growth rates, genetic variability, and seasonal movements. This led to an appreciation that recruitment was environmentally controlled and potentially predictable, allowing some forward forecasting of annual variation in stock size. Research continues in the Hauraki Gulf on egg and larval survival in relation to hydrology, and on juvenile recruitment processes. There is also considerable emphasis on stock assessment and the estimation of sustainable yields, mostly from trawl surveys and tagging programmes. Because the species is relatively well understood, snapper is also proving to be a useful case study for the understanding of fish population dynamics and for modelling the response of fish stocks to environmental change and fisheries exploitation. An introduction to the large literature on snapper research can be found in Crossland (1981), Sullivan (1985), and Gilbert (1986).

2. THE FISHERY

2.1 Inshore domestic

2.1.1 Total catch. Recorded landings increased from about 4000 t in 1931 to almost 18 000 t in 1978, then declined to around 6000 t in 1986-87 (Fig. 1). Information on catch-per-unit-effort over this period is sketchy (see Paul 1977, 1982), but suggests that CPUE trends generally follow the total catch, and because snapper is the target species in many fisheries the trends in total catch generally reflect changes in abundance. There are a few exceptions, as discussed below.

Fig. 1 also shows a temperature curve for the same period, a running 5-year mean of Auckland November-December air temperatures, lagged 5 years from the catch figures. Because of the strong air-sea temperature relationship, this represents spawning season temperatures near the main spawning and nursery grounds, projected ahead to the potential impact this environmental variable will have, either directly or indirectly, on the abundance of 5-10 year old fish in the commercial catch. There is some merit in discussing this in relation to the fluctuations in recorded snapper landings. Generally, warmer years subsequently produce higher catches, when the strong year classes recruit to the fishery 5-6 years later.

Total landings were low in the early 1930s for a number of economic reasons linked to the Depression years. A recovery i$the late 1930s was followed by a decline through to 1944, resulting from a general fisheries decline in the war years, loss of steam trawlers, minefield closures, etc. Catches rose again until 1948, but then dropped to another low in 1952; this partly resulted from redeployment and subsequent phasing out of steam trawlers at Auckland, but it seems reasonable to attribute some of this decline to a sequence of cool springs during the 1940s. Catches then followed the temperature curve upward into the 1960s, but at a lower rate; this period was notable for limits placed by Auckland fish merchants on peak summer catches (particularly from Danish seiners) because they could not process high volumes. As predicted by temperatures CPUE fell from 1970 onwards (Paul 1982), but landings remained high at 12 000 to 14 000 t until 1977, buoyed up by improved Danish seine nets, the advent of pair trawling, high export prices, the development of a whole fish export market which reduced the processing bottleneck, and increased processing capacity in new and upgraded factories. This increased efficiency within the industry, coupled with a mid 1970s rise in line fishing over rough ground in northern New Zealand, took heavy catches from what was probably a declining stock. In the Hauraki Gulf alone, catches were above the calculated sustainable yield (Elder 1979). The "improved" line fishing and pair trawling methods took higher proportions of the larger and older adult fish which had traditionally helped sustain catches during periods of low recruitment.

Temperature records suggest that the snapper stock should have increased to peak in the late 1970s. The catch did peak in 1978, and then followed the temperature curve downwards to around 9000 t in 1983-85. This decline, predicted by Paul (1982), must in part be due to the variety of more restrictive management procedures being implemented over these years, as well as to a shift by some of the larger fishing companies into deepwater fishing, but a significant part must have resulted from over-fishing during the 1970s and then falling recruitment during the early 1980s.

Reported snapper catches from the mid 1970s onwards are almost certainly inaccurate for several reasons. A new fishing statistics recording scheme introduced in 1974 was not fully supported by fishermen. Also, the increasing number of snapper fishing vessels owned privately (although often landing into established companies) had a greater incentive for underreporting catches to minimise taxes and levies. Also, from 1978 onwards a snapper quota was imposed in the Hauraki Gulf, and fishermen were concerned that if their reported catches reached this level the Gulf would be closed to them. However, it must be remembered that many coastal fisheries show an increase in catches in the early 1980s, as fishermen endeavoured to improve their catching histories in anticipation of allocated quotas; the continuing decline in snapper landings seems likely to be real.

The calendar year catch for 1986 was 6500 t, a return to the level of 1955. The fishing year catch for 1985-86 was 8600 t, a slight decline from the catch for the previous two years of about 9200 t. The reported catch for 1986-87 was 5400 t from Quota Management Reports, 5700 t from the Licensed Fish Receiver reporting system, well under the gazetted TAC of 6540 t and clearly strongly influenced (in fact controlled) by this. Given the misunderstandings and deliberate breaches of this new catch reporting system, it seems likely that actual catches were somewhat higher.

2.1.2 Catch by method. Snapper has been taken by almost all the main commercial fishing methods over the years, with considerable variation over time. The predominant methods have always been trawling, Danish seining, and longlining (Table 1). Single trawling (including large steam trawlers to 1951) was the dominant method from 1950 until 1975, taking up to 75% of the catch in the mid 60s; in 1975 it was surpassed by pair trawling. Pair trawling became dominant in the late 1970s with over 50% of the catch, but subsequently declined as inshore grounds were closed to this method. In the most recent years pair trawling and single trawling have taken 20-25% of the catch each. Danish seining was the main fishing method until 1950, taking up to 80% of the catch, but then steadily declined - as small trawlers became more efficient - to only 10% in 1967. There was a revival in Danish seining from 1968 to 1973 with the introduction of a larger and improved net, but then many seine vessels switched to pair trawling and the percentage catch by seining declined again to around 10%. Line fishing has generally taken between 10 and 20% of the snapper catch, but with the advent of an export market for prime quality fish the catches by line increased sharply from 1980 to reach 37% in 1986. From 1983 long-lining has been the dominant method, and with the present emphasis on economic efficiency and a quality product, seems likely to remain important. Net fishing (mainly setnets or gillnets, but some beach seines) has contributed 2-14% of total snapper landings. Snapper were taken in teiche or box nets for a few years in the 1970s, and were purse seined in Tasman Bay for a few years around 1980.

Catch by method is discussed further in the accounts of regional fisheries (2.2).

2.1.3 Catch by area. The main snapper fisheries occur around the northern half of the North Island; there are smaller fisheries from East Cape to Hawke Bay, and from Cape Egmont to Cook Strait and in Tasman Bay and the Marlborough Sounds. While there are a few natural subdivisions, many of the areas used for regional fishery reviews and the estimation of yields have been subjectively chosen, and different boundaries have been used at different times.

For the first estimation of yields (Anon 1983), 10 geographical areas were used for all coastal species, 7 containing significant snapper fisheries (Fig. 3). These regional landing figures were based on groupings of ports of landing.

Subsequent determination of yields by Fisheries Management Areas, and their integration with regional Fisheries Management Plans required an evaluation of catch trends within these areas (Fig. 4). Again, these have been based on groupings of ports of landing (Table 2).

This new subdivision left the north-eastern areas - East Northland, Hauraki Gulf, and Bay of Plenty (combined as Auckland East) - unaltered. It unfortunately divided the West Auckland area between Auckland (West) and Central (Egmont), with the latter picking up some small south-west North Island landings. The Challenger region, with some justification, enlarged the previous smaller Tasman Bay area.

Catches from smaller fishing areas (Figs. 5-9) are available from 1983 onwards. These can be grouped into either of the previous subdivision systems, but there are some inevitable discrepancies between the catches by area and landings by area.

The longer time series (Figs. 3, 4) are based on calendar year values. The most recent data (from Oct. 1983) in Figs. 5-9 are for Oct-Sept fishing years.

In all these data, however, it is clear that the decline in landings from the late 1970s onwards has been widespread.

2.1.4 Catch by season. In most regions the snapper catch is strongly seasonal, peaking in spring and early summer as the fish congregate to spawn and then move inshore to feed. There are some exceptions to this, generally relating more to the fishing patterns of the fishermen, which are mentioned in the regional accounts below.

2.1.5 Catch per unit of effort. Over the historical time series CPUE has tended to approximate the trends in total landings (Paul 1974, 1977, 1982). For shorter time series e.g. the west Auckland pair trawl fishery (Sullivan 1985, Fig. 14) more extensive analysis of data reveals some very clear and significant declines in catch rate which are not apparent in total catch figures. There is undoubtedly scope for further similar analysis of the various catch data sets held by MAFFish.

An analysis of annual trends in the main snapper fisheries for the three years 1983-4 to 1985-6 (in a few cases to 1986-7) is presented in Fig. 11. Three (or even four) years is too short a time to recognise any trend other than a dramatic change in CPUE. However, there seems to be a decline of about 20% over 4 years in the East Northland line fishery, and a rise of 10% over 3 years in the Hauraki Gulf single trawl fishery. As the effort value currently available is only "number of boats fishing" these results are not conclusive.

These CPUE analyses also provide some useful information on a monthly basis, and help demonstrate seasonal fishing patterns. They are considered in more detail in the following section.

2.2 Regional Fisheries

2.2.1 East Northland

This subdivision of the Auckland (East) FMA, comprises fishing areas 1-3 and the ports Mangonui, Whangaroa, Russell, and Whangarei.

Before 1970, snapper landings into east Northland ports were below 500 t per year, although considerable (but unknown) quantities of snapper which had been caught in the region were landed in Auckland (by trawlers.) There are extensive rough bottom areas along this coastline, with clear areas suitable for single trawling in bays and on the outer shelf. Snapper were relatively protected in these natural refuges, and the stock appeared to be only lightly exploited.

From 1970 landings into local ports increased steadily, reaching 1000 t in 1976 and over 2000 t in 1979. Much of this increase resulted from the introduction of pair trawling in 1973, with these vessels able to work much closer to the rough ground avoided by single trawlers. The returns from this method gradually became less attractive as catches (and presumably CPUE) declined and costs (notably fuel) increased. The fleet declined from 14 pairs in 1979 to one pair in 1983. In 1984 the development of near-bottom pair trawling above rough ground revived interest in this method. From the late 1970s a longline fishery for snapper developed along the east Northland coast, in parallel with similar fisheries elsewhere, to take advantage of the high prices that top-quality line-caught snapper were obtaining in Japan. A large increase in lining effort occurred on previously unexploited fishing grounds, and landings from this method partly compensated for the decline in pair trawl landings.

2.2.1.1 Seasonal catch and CPUE

Pair trawl. Fig. 12. The main catches are made in spring and summer, with peaks in October and February, with a low during winter. This is clearly dependent on fishing effort, as CPUE changes less markedly. There are considerable differences between years, but no evidence for a decline over the period 1983-86. The drop from October 1986 is probably due to the introduction of the QMS.

Single trawl. Fig. 13. The main catches are made in winter, the reverse of pair trawling, but at a lower level (c. 20 t per month cf. 100 t or more) and at a lower catch per boat (1-2 t cf. 5-7 t). This mainly represents the trawler pairs splitting to fish separately on a more dispersed stock during winter. There are less marked variations, except for a lower catch in late 1986. There is no information on any longer term change in CPUE.

Longline. Fig. 14. The main catches are made in spring and early summer, undoubtedly taken from spawning aggregations. Peak catches have steadily declined from 1983-84, with a lesser decline in CPUE until 1986.

2.2.2 Hauraki Gulf

This subdivision of the Auckland (East) FMA, comprises fishing areas 5-7 and the ports Auckland, Leigh (often combined with Auckland), Thames, and Coromandel.

The Hauraki Gulf contains the most important snapper fishery in New Zealand, with grounds that have been fished commercially for over 80 years. The large fleet based at Auckland pioneered most of the expansion in the northern snapper fishery during this time, but some of the later developments were introduced or quickly adopted by fishermen in other ports from Whakatane in the south-east to Manukau in the west. Consequently, there are difficulties in distinguishing trends in Gulf port data which apply specifically to Gulf grounds from those which more generally cover the northern fishery.

The Hauraki Gulf fishery has been extensively documented elsewhere (Paul 1974, 1977, 1982, Paul and Elder 1979, Paul unpublished), and the details need not be re-examined here. Because it is the major New Zealand snapper fishery many of the comments in the previous section apply specifically to this area.

The fishery has a long history of management measures which were designed partly to conserve the stock by protecting spawning and nursery grounds, and partly to resolve conflicts between fishermen employing different fishing methods. The pattern of the present fishery is the result of an evolutionary process of seasonal or area closures to different methods of fishing and sizes of vessel. For many years single trawling and Danish seining were the dominant methods, with some lining and netting. Pair trawling became important in the late 1970s, and more recently line-fishing for prime export fish has become the dominant method, taking 44-53% of the snapper catch in areas 5-7 in the four calendar years 1983-86 (see Figs. 6-8). Concern over the state of the resource increased during the 1970s, together with claims of unfair allocation to various fishing methods. In 1977 a quota of 3500 t was introduced for trawl and Danish seine catches in area 6 (the central Gulf), and in 1981 this was raised to 3800 t but extended to cover all commercial methods. Further restrictions on areas, methods (pair trawl and pair seine), vessel size, and trawl mesh size, have been progressively introduced.

Snapper catches into Gulf ports have ranged between 3000 and 8000 t (Fig. 3, Table 3), with about two-thirds of this coming from the Gulf grounds. Following a decline from the peak of 8400 t in 1971 there was a recovery to 6400 t in 1979, then a fluctuating decline to 3400 t in 1986 (calendar years) (Fig. 4). Provisional (Quota Management Report) figures for the fishing year 1986-87 list 4100 t for the whole Auckland (East) region, less than the gazetted TAC (4710 t) and presumably representing a further drop in catch from the Gulf area and/or the landings into Gulf ports.

2.2.2.1 Seasonal catch and CPUE

Single trawl. The main catches are in spring and summer, with a winter (June-August) low (Fig. 15). CPUE shows a similar pattern. There is a steady decline in catches from 1983 to 1986, but the mean CPUE has risen slightly (Fig. 9). The most recent figures are influenced by the introduction of the QMS.

Danish seine. The main catches are in spring (October-December), taken from schooling and spawning fish, with a second important peak in April (Fig. 16). CPUE shows the same trends. The autumn landings peak does not show in data from 1967-73 (Paul 1974, Fig. 5), and may be a result of new fishing patterns; the reason is unknown. There is a slight fall in CPUE from the 1983-84 to the 1985-86 season (see also Fig. 11), but better effort data are needed to determine the significance of any decline.

Longline. The main catches are made in spring (November), with lower catches extending through summer and autumn (to April) (Fig. 14). CPUE closely follows landings trends, with annual CPUE rising from 1983-84 to 1986-86. The drop in 1986-87 may simply reflect the new management regime.

2.2.3 Bay of Plenty

The Bay of Plenty subdivision of the Auckland (East) FMA comprised fishing areas 4, 8-10 and the ports Mercury Bay, Tauranga, and Whakatane.

Landings of snapper into Bay ports increased steadily from about 1950 as trawl effort increased (Fig. 3), with additional catches in the area being landed in Auckland. The fishery is based largely on trawling. The number of local trawlers rose during the 1970s, and the introduction of pair trawling with high opening nets pushed landings up to a peak of over 2000 t in 1978. From December 1983 pair trawling was banned through most of the Bay. Landings have declined from the 1978 peak to 900-1000 t in 1983-87 (Fig. 4). Single trawling remains the dominant method, although longlining is important in area 8, adjacent to Whitianga (Figs. 6, 9).

2.2.3.1 Seasonal catch and CPUE

Single trawl. The main catches are in summer and autumn, with low catches in winter and spring, but the peaks are somewhat irregular (Fig. 17). To some extent this results from the pattern of effort, with the number of boats declining each spring. The CPUE trend is more regular, with summer peaks, perhaps reflecting a spawning/schooling season somewhat later than in more northern waters. This whole analysis is influenced, however, by the fishery for tarakihi, trevally, or red gurnard, where snapper is taken as a by-catch. Annual CPUE values from 1983-84 to 1985-86 show a slight increase.

Longlines. In contrast with east Northland and Hauraki Gulf, Bay of Plenty landings generally show no seasonal pattern, apart from a small spring peak in 1985 (Fig. 14). The annual CPUE was higher this season, but otherwise no trend is apparent. The catch dropped sharply in late 1986 although CPUE remained relatively stable. The reason for the absence of a strong spring peak is probably that the main longling activity in the north-western Bay does not operate on spawning schools typical of the Hauraki Gulf and east Northland. The main spawning and nursery grounds for snapper in the Bay are at the eastern end.

2.2.4 East Cape-Hawke Bay

This comprises fishing areas 11-14 and the ports Gisborne and Napier. The southern part of this area yields virtually no snapper landings.

Landings of snapper steadily increased from 1950 to reach over 800 t in 1972 (Fig. 3), and then declined to a level of about 200 t from 1982 onwards (Fig. 4). The fishery is essentially based on trawl caught fish landed at Gisborne and Napier (see Paul and Tarring 1980). Pair trawling was introduced to the area in the late 1970s, but was subsequently banned when the stocks appeared to be declining in abundance and there was conflict with fishermen using other methods. Pair and single trawlers target fished for snapper in shallow waters, but some was also taken as a by-catch in the more important trawl fishery for tarakihi.

2.2.4.1 Seasonal catch and CPUE

Because a significant part of the small snapper landings are taken as a by-catch, CPUE analysis was not attempted.

2.2.5 West Auckland

This comprises fishing areas 42, 45-47 and the ports Hokianga, Kaipara, Manukau, and Kawhia/Raglan. Areas 43 and 44 are not covered in this analysis because they comprise small and specialised harbour fisheries. The northernmost area 48 is excluded because of insignificant catches (as is area 1 in east Northland).

A trawl fishery targetting on snapper and tarakihi developed along the north-west coast during the 1950s. A few small trawlers had operated out of New Plymouth, Kawhia, and Raglan for some years prior to this, and it had also been customary for Auckland trawlers fishing east Northland to take advantage of fine weather to top up their loads with a few shots along the Ninety Mile Beach grounds before returning to port. In 1952 these Auckland-based trawlers were permitted to land into Manukau. Recorded landings at this port increased sharply (the previous west coast catches were recorded as Auckland landings) and then more steadily to reach about 1600 t in 1971 and 1972 (Fig. 3). The Hauraki Gulf fishery was showing signs of over-fishing at about this time (Paul 1974), and considerable Auckland-based trawl effort was diverted to the west coast. The catch jumped to over 3000 t in 1973, at which time pair trawling was introduced (Table 1). By the end of 1975 most of the vessels were pair trawling, and by the late 1970s snapper landings into West Auckland ports had peaked at almost 4000 t (Table 2). Actual catches from these grounds were even higher (Sullivan 1985), with additional snapper catches taken by Japanese trawl and line vessels. Subsequent landings have steadily declined to about 700 t in 1986 (Fig. 4), and a provisional QMR value of about 900 t (but including the Central (Egmont) area) in the fishing year 1986-87. Pair trawling dominates the landings from this region at 80-90%; Sullivan (1985) gives 75% for a larger region including the Egmont area.

2.2.5.1 Seasonal catch and CPUE

Pair trawl. The catch is strongly seasonal, peaking in spring (November-December) as spawning schools of snapper congregate outside the Manukau and Kaipara harbours (Fig. 18). The effort (as numbers of boats or days fishing) is also very seasonal, so the CPUE trend is less strongly seasonal than the total catch. Sullivan *et al.* (1988, Fig. 7) presented data on annual CPUE trends for 1974-85 showing a steady decline from 1975 to 1981, and then stabilising at about 30-40% of the original level with a slight recovery in 1985. There is no evidence in the 1986 data presented here of any significant change.

2.2.6 Egmont

This comprises fishing areas 39-41 and the ports New Plymouth, Wanganui, Manawatu, Paraparaumu, and Paremata. In most respects this region is continuous with West Auckland and shows similar trends. It is described separately here only because of its existence as a separate FMA, and its intermediate geographic position between the West Auckland and Tasman Bay fisheries. Yields and TACs are combined with Auckland (West).

The decline in landings has been of the same order as that for West Auckland (Fig. 4).

2.2.6.1 Seasonal catch and CPUE

Pair trawl. Trends are similar to those in West Auckland, with a strong spring peak and a secondary autumn fishery (Fig. 19). Annual CPUE varies but with no general trend.

2.2.7 Tasman

Tasman represents the majority of the Challenger FMA, comprising the fishing areas (35-38) in which significant snapper catches are made, and the ports Pelorus, Picton, Blenheim, Nelson, Motueka, Golden Bay, Westport, and Greymouth.

Landings of snapper in this region fluctuated around 500 t from the late 1940s until the early 1970s, with the exception of the three years 1966-68 when two large stern trawlers worked out of Nelson. During the 1970s most trawlers converted to pair trawling, particularly during the spring spawning season for snapper, and annual landings increased to about 900 t (Fig. 3). In 1978 this fishery was revolutionised by the aerial spotting of subsurface schools and the subsequent capture of large tonnages of big adult snapper. These concentrations of fish, which had presumably previously avoided capture by conventional trawl methods, including bottom pair trawl, were able to be captured in substantial quantities in 1978 and 1979 by purse seine and surface-towed pair trawl. In 1978 snapper spawned twice in Tasman Bay, in January and November (Sullivan 1985), giving two seasonal peaks in one calendar year. Total landings for the region in 1978 were about 2700 t, a four-fold increase from the previous year (Table 2, Fig. 4). Because of the vulnerability of snapper to surface fishing, the undesirability of allowing large catches and likely fish wastage, and the strong likelihood of over-fishing, a quota was introduced to this fishery in December 1978. (The inner part of Tasman Bay is closed to trawling when the quota is reached). The quota has been progressively reduced over subsequent years. Landings have also steadily declined (Fig. 4), to some degree reflecting the falling inner Bay quota, but also indicative of the declining abundance of fish.

2.2.7.1 Seasonal catch and CPUE

Pair trawl. The catch is strongly seasonal, peaking in November and/or December (Fig. 20). The sharp drop in January or February results from the quota closure operating. Catches have declined regularly from 1983, but so has effort; annual CPUE over these years has remained fairly constant (see also Fig. 11).

2.3 The Deepwater Fishery

As a shallow coastal species snapper is not abundant in deepwater, but it is convenient to discuss foreign catches under this heading. Snapper was probably the first New Zealand fish to attract foreign fishermen to this country. Japanese mother ships and longlining dories operated around our northern coastline from about 1960, but this attracted such opposition and controversy that New Zealand and Japan reached an agreement to withdraw this fleet to 6 miles in 1966 and to stop fishing completely within 12 miles by 1970. This effectively closed the main snapper grounds to them, and this fishing ceased. Their recorded catches for this period are not available. From the late 1960s Japanese trawlers worked on New Zealand's continental shelf outside 12 miles, principally on the western shelf from South Taranaki Bight to Northland, targetting jack mackerels but undoubtedly catching moderate quantities of snapper, tarakihi, and other coastal demersal species. Catch data from several sources are summarised in Table 4, showing peak catches of 1000-1500 t in the early and mid 1970s. In the mid 1970s several foreign nations intensified their fishing around New Zealand in anticipation of claims to traditional fishing rights when the 200-mile EEZ was declared (in 1978). There are unsubstantiated reports of over 2000 t of snapper caught by renewed Japanese longlining in 1976 and 1977, over 2800 t caught during a few months of intense fishing by Koreans in 1977, and a few hundred tonnes of "sea bream" (but probably including tarakihi) by Soviet trawlers in 1972, 1976 and 1977. Since 1978 the reporting of snapper catches by chartered and foreign licensed trawlers has been equally unreliable. This is in order to minimise the reported level of by-catches of important coastal species. Reported landings declined from about 200 t in 1979 to 100 t or less in subsequent years.

At present there are minor allocations (5 t units) of snapper to Korea and Japan to cover by-catches in their trawl fisheries off the west coast of the North Island and the east coast of the South Island.

2.4 Size and Age Composition of Commercial Catches

There are extensive length-frequency and age-composition data available, both in a number of published papers on snapper fisheries and in a variety of unpublished data sets held at the Fisheries Research Centre. These come from several catch-sampling and market-sampling programmes dating from the 1960s. There has been no continuous programme, but from the numerous samples some useful time series can be assembled for many regions. These data could be augmented by even larger numbers of samples measured during a variety of research trawl survey programmes around New Zealand over the last 40 years.

Length-frequency data are available from 1948. Scale samples for age determination were first collected in any numbers in 1964, and otoliths in 1970.

Until the late 1970s most commercial snapper samples contained a wide range of fish sizes and ages. Although most ages were probably in the range 5-15 years, fish up to age 30 or 40 were not uncommon, and some ages extended to the mid 50s. The 1980s have seen a very significant shift towards smaller sizes and younger ages (4-10 yrs). Several fisheries are clearly now much more dependent on the recruitment strength of young year-classes.

2.5 Maori and Recreational Fishing Patterns

2.5.1 Maori fishing

As an abundant and easily captured coastal species present in shallow waters along the coastline where the Maori people were most densely settled, snapper were undoubtedly utilised in large quantities.

Snapper are often mentioned among the fish species caught and sold to the explorers and early settlers. More detailed published ethnographic accounts are not readily available, but the regular presence of snapper bones in Maori middens is documented in a large archaeological literature. For example, at a coastal Northland site (Mt Camel) the bone material from about 2500 fish represented 2300 snapper, 100 trevally, 50-80 kahawai, and 50 fish of about 10 other species (Davidson 1982). Snapper are often incorporated in popular accounts of Maori fishing; e.g. Rountree (1985) clearly illustrates (but does not name) a catch of snapper being cleaned and hung on a drying rack.

2.5.2 Recreational fishing

In most northern areas snapper are probably the most widely sought and prized marine fish species, although they may be outnumbered by other species (e.g. kahawai) in the catch. Almost all books on sport fishing in New Zealand have major sections on snapper fishing, and there is an extensive fishermen's lore of snapper behaviour in relation to season, moon phase, weather, tide, and feeding patterns. The occasional capture of a very large snapper features in daily newspapers as well as in sport fishing magazines.

There have been no comprehensive surveys to assess the total catch of snapper by recreational fishermen, but a number of tagging programmes over the years have provided some indication. In areas utilized by both commercial and recreational fishermen (although commercial fishing extends into deeper water) the proportion of tagged fish returned by recreational fishermen is in the order of 20-30%. Three recent large tagging programmes in northern New Zealand have given similar results (Sullivan *et al.* 1988). In the Bay of Plenty in 1984 recreational fishermen returned 32% of the tagged fish by number, 30% by weight. In the Hauraki Gulf in 1985 22% by number and 20% by weight were returned, representing a non-commercial catch of 830 t compared with the commercial catch of 3317 t. In east Northland in 1985 19% by number and 17% by weight were returned, representing a non-commercial catch of 368 t compared with the 1851 t commercial catch.

A tagging programme completed in 1986/87 in Tasman Bay indicated about 10% of recaptures reported by the non-commercial fishery. The only main snapper area not yet surveyed in this way is the north-west coast. The recreational catch here is likely to be proportionately lower, given the lower level of offshore recreational fishing activity along this exposed coastline. However, there are several harbour fisheries as well as surfcasting from sandy and rocky shores, and there is frequent controversy over the impact that inshore trawling is having at Ninety Mile Beach where fishing contests are regularly held.

3. RESEARCH

3.1 Stock Structure

Several methods have been used to distinguish stock units. The stocks so far identified are closely related, and cannot be regarded as entirely separate entities. However, for the purpose of yield estimation and associated management measures for the snapper fishery it is convenient to assume boundaries between them.

3.1.1 Growth rates. Longhurst (1958) demonstrated a difference in growth rate between east and west coast snapper (the latter grow faster), and this has been confirmed in all subsequent studies. Several of these studies have also shown that Tasman Bay snapper grow faster than those on the west coast of the North Island. There are two possible causes for the observed differences: (1) the stocks are in fact genetically different, either having separate spawning sites or undergoing different genetic selection following spawning at common sites, or (2) the different geographic areas the fish inhabit provide different food and other conditions for growth. Whichever of these applies, it is still possible to regard the eastern and western populations as sufficiently separate to be managed as separate stocks.

3.1.2 Age distributions. Some areas have been shown to have identifiably different age structures. Tasman Bay snapper can be separated from the rest of the west coast by the extreme variation of year-class strength within the population. Year-classes which are weak elsewhere are generally absent here. These year-class patterns are consistently found from one year to the next (Sullivan 1985, Fig. 2).

3.1.3 Genetic differences. Smith *et al.* (1978) reported differences in the genetic make-up of snapper populations around New Zealand. They concluded that the west coast, north-east coast, and Hawke Bay snapper could be treated as separate stocks, but that Tasman Bay fish seemed to be similar to other west coast snapper. Their data also indicated an area of mixing at Ninety Mile Beach between the east and west coast stocks.

3.1.4 Spawning areas. Spawning grounds have been identified in many areas, and used as an indication of separate spawning units. However, a fairly long spawning season, the many small bays which are suitable for spawning, and the moderate distances moved by some snapper to reach their spawning site seem likely to obscure any clear-cut separation between stocks. The Hauraki Gulf is the largest and most important spawning ground, and there is some movement between east Northland, the Gulf, and the Bay of Plenty. Separate spawning areas are known in the eastern Bay of Plenty, Hawke Bay, along the east Northland coastline (notably Bream Bay, Bay of Islands, Doubtless Bay, and Great Exhibition Bay). On the west coast spawning occurs off Ninety Mile Beach, outside the Kaipara and Manukau Harbours, near New Plymouth, Wanganui, and further south in Tasman Bay and the Marlborough Sounds.

3.1.5 Tagging indication of movement. Snapper tagging has been carried out in several regions to study movements of fish and more recently in order to estimate the stock size from recapture ratios. Paul (1967) reviewed early studies which generally yielded low recapture rates but demonstrated that most of the snapper tagged at shallow inshore localities moved very little. Crossland (1982) summarised the results up to that time, which provided very similar conclusions. Several large tagging programmes have since been completed. Tasman Bay and Marlborough Sounds 1981-84 and 1986-87; Bay of Plenty 1983; and Hauraki Gulf and east Northland 1984.

The Hauraki Gulf and Bay of Plenty snapper populations showed the closest relationship; about 10% of Gulf fish moved to the Bay, and a smaller proportion moved in the opposite direction. East Northland and Gulf fish intermixed less than this, and similarly there was little movement from the east to the west coast. There proved to be little mixing between Tasman Bay and Marlborough Sounds snapper (Drummond and Mace 1984), although there was some seasonal movement between Tasman Bay and the Westland coast. There was very little movement detected from Tasman Bay to the west coast of the North Island.

On the basis of our present knowledge, snapper have been divided into seven "stocks" for the purpose of deriving yield estimates. In the future it may be possible to define smaller units, or it may be found practical to combine two or more if they are subjected to a common fishery and appear to react in a similar way. The divisions are based partly on biological differences and partly on reasonably separate geographical areas:

East Northland	West coast, North Island
Hauraki Gulf	Tasman Bay
Bay of Plenty	Marlborough Sounds
Hawke Bay	

3.2 Resource Surveys and Recruitment Indices

There has been significant research effort in this field over many years, and only a brief summary is possible here.

General trawl surveys have been conducted in the Hauraki Gulf from the 1950s, in the Bay of Plenty in 1961-62, and east Northland 1963-64 (Fisheries Research Centre, data on file). These were followed by surveys directed at measuring juvenile snapper abundance in more detail, first along the north-eastern coastline from North Cape to the eastern Bay of Plenty in 1968-75, and then in Hauraki Gulf in 1976-80. This work located nursery grounds and demonstrated the dependence of snapper year-class strength, and hence recruitment, on factors at least linked to climatic variability. A trawl survey of the north-western coastline in 1971 located nursery grounds and measured year-class variability there.

More recently there has been a series of random-station trawl surveys in Hauraki Gulf (1982 -1988) and the Bay of Plenty (1983 and 1985), directed principally at measuring snapper biomass in these regions but probably being more successful at establishing the strength of incoming juvenile recruitment.

There have been other series of trawl surveys for juvenile snapper off New Plymouth in 1984-85 (Horn 1986) and in Tasman Bay in 1982-86.

Some of this work has been published, and the data sets will continue to be used as a time series in future stock assessment work.

3.3 Other Studies

3.3.1 Reproduction. Snapper school for spawning near the centre of relatively large and sheltered embayments. They spawn serially, releasing many batches of eggs over an extended season during spring and summer. Cassie (1956a, 1956b) first studied their reproduction, and his work was followed up by Crossland (1977a, 1977b) who described their spawning cycle and the distribution and abundance of eggs, mainly in the Hauraki Gulf but with some work along east Northland. He made an estimate of the Hauraki Gulf spawning stock size from planktonic egg abundance (Crossland 1980a). Present research includes a study of hormonal activity in relation to gonad development, egg ripening and serial release (Pankhurst, unpublished) and population ovarian cycles (Zeldis, unpublished).

3.3.2 Larval and juvenile ecology. There is a programme underway in the Hauraki Gulf exploring the relationships between spawning success, as measured by egg numbers released into the plankton and their survival through to late larvae, and environmental factors such as temperature, currents, water column structure, food abundance and the general weather regime, aiming to clarify the general correlation of "warm springs, strong year-classes". A separate programme is examining in some detail the habitat requirements and survival of 0-year snapper as they enter the demersal phase, as well as their change in distribution and abundance and any habitat shift over the succeeding two years.

This work links the earlier smaller-scale work on the habitat on 0-year snapper, with the present larval ecology programme, and with past and present trawl survey studies of juvenile distribution and abundance.

3.3.3 Mark-recapture. Recent studies have been summarised above. Further details on the analyses resulting from the Bay of Plenty tagging in 1983 are given by Hore et al (1986), with emphasis on developing a productivity model of the stock and deriving a suitable rate of exploitation. The 1984 Hauraki Gulf and east Northland tagging programme is described by Sullivan *et al.* (1988), leading to a yield-per-recruit model and a discussion of optimum rates of exploitation. The 1986-87 Tasman Bay snapper tagging results are presented in Kirk *et al.* (1988). A separate age-validation study is also utilising these recaptured fish.

3.3.4 Biomass Estimates. There are ongoing efforts to update biomass estimates, principally using trawl survey and mark-recapture data (see above). Use of the egg production method for spawning assessment is being investigated (Zeldis, unpublished).

3.3.5 Modelling Studies. In addition to the largely unpublished results from trawl survey and mark-recapture data sets, mentioned above, there have been attempts to model the Hauraki Gulf snapper fishery (Vooren and Coombes 1977, Elder 1979), and a stock reduction analysis of Bay of Plenty snapper has been completed (Gilbert 1986). There has also been some work on modelling alternative management strategies for snapper stocks, principally to determine the long-run recovery time from an over-fished condition (Gilbert, 1988 and unpublished).

4. Management Implications of Recent Studies

4.1. Summary of Recent Catches, Yields, and TACs

A summary of recent catches, estimated yields, and TAC values subsequently established, is provided in the following table:

	Catches				Estimated Yields			Gazetted TACs	
	83/84	84/85	85/86	86/87	1985	1986	1987	1988	1987
Kermadec	0	0	0	0				10	10
Auckland:									
(E. Northland)					1000	1500	1900		
(Hauraki Gulf)					3200	2900	2900		
(Bay of Plenty)					500	300	300		
East	6539	6898	5876	4086	3800	4200	4700	4710	4710
West	1269	995	1471)		)	1100	1100)		
Central:			)	892	)1800			)1330	1330
Egmont	421	498	343)		)	260	260)		
East	145	163	177	147	120	120	120	130	130
Challenger/Central									
(Plateau)	410	308	222	263	320	320	320	330	330
South-East:									
Chatham Rise	0	0	0		)	)	)		
Coast	2	2	0		)	0)	0)	30	30
Southland					)	)	)		
Subantarctic					)	)	)		
Area not known	344	304	536						
Total Domestic	9128	9174	8609	5388		6000		6540	6540

4.2 Stock Assessments and Yield Estimates

This section reviews estimates of biomass and sustainable yield for each snapper stock. Background information on the estimation of yields and derivation of TACs between 1985-87 is presented in the Appendix.

Yield estimates were made using a two-tier approach (McKoy 1988) and are shown in Table 5 for each QMA.

(a) The first tier is the maximum constant yield (MCY) which represents the maximum constant catch that would be sustainable at all probable future levels of biomass. It accepts a loss in potential yield by employing a management strategy of constant catch. Therefore the estimates of MCY presented below are generally lower than previous yield estimates for snapper.

(b) The second tier is the current annual yield (CAY) which corresponds closely to the present sustainable yield (PSY) concept used previously. The use of CAY will produce a higher average yield than MCY from any stock by employing a management strategy of constant fishing mortality.

4.2.1 Auckland East

Sullivan *et al.* (1988) presented the results of three large tagging programmes carried out in this area in 1983 and 1984. After allowance was made for 10-15% under-reporting of tag recaptures by the commercial fishery, the biomass of snapper in Auckland East was estimated to be in the range 52,000-55,000 t. Based on proportional tag recaptures, the non-commercial fishery was estimated to take up to 20% of the total catch.

Maximum constant yield (MCY)
MCY was calculated as $F_{max} * B_{min}$ where the estimate of biomass from the tagging programmes was considered to be the historic minimum biomass. F_{max} appears to be safely sustainable in this fishery, as previous rates of exploitation greatly exceeded this level without causing dramatic declines in stock size. F_{max} was calculated at 0.1 from a yield-per-recruit model (YPR), assuming a natural mortality rate of 0.06 (Sullivan *et al.* 1988). The range of B_{min} was 52 000-55 000 t.

MCY = 5200-5500 t.

Current annual yield (CAY)
The biomass of snapper was projected forward to the 1988-89 fishing year to estimate CAY for this area. The following assumptions were made:

- Non-commercial catch was 1300 t per year;
- The commercial catch in the 1987-88 year was equal to the TAC;
- Annual productivity (representing growth, recruitment, and natural mortality) was 15%.

The 1988-89 recruited biomass of snapper was estimated to be 57 000-62 000 t. CAY was calculated as $F_{max} * B_{current}$.

CAY = 5700-6200 t.
This includes yield taken by non-commercial users. Allowances of 1300 t for the non-commercial catch leaves 4400-4900 t as CAY available to the commercial fishery. The current TAC is within this range, but as this stock is depleted in some areas, rebuilding of the population to greater biomass levels would allow greater long-term yields.

Long-term equilibrium yield
The East Northland stock is not considered to be below optimum size, but the Hauraki Gulf and Bay of Plenty stocks have been reduced to levels lower than optimal. Rebuilding of the Hauraki Gulf and Bay of Plenty stocks to levels 50% higher than the current stock size could result in long-term yields in excess of 8000 t. This yield would need to be shared between commercial and non-commercial users.

4.2.2 West coast North Island

The current TAC of 1330 t from this area applies to Auckland (West) and Central (Egmont) combined. The stock is currently depleted and long-term yields should increase substantially after stock rebuilding.

Maximum constant yield
MCY was calculated as 2/3 of current surplus production (CSP). The biomass of snapper was projected forward to the 1988-89 year, using a stock reduction analysis. CPUE data from the pair trawl fishery, and total catch information from the west coast were used to model the decline in biomass from 1974 to 1981, and to project forward to the current situation. Natural mortality was assumed to be 0.06.

No account was taken of non-commercial catch in this analysis. Non-commercial users are thought to take less than 10% of the annual yield from the fishery. Reports of snapper catches in the Recreational Survey indicate that this area is much less important than the east coast for non-commercial users (Sullivan 1988).

The recruited biomass of snapper in the 1988-89 fishing year was estimated to be 12 000-15 000 t. CSP was assumed to be 12% of current biomass.

MCY = 950-1200 t.

Current annual yield
CAY was estimated as F_{max} * $B_{current}$. F_{max} was calculated at 0.1 from a YPR model and $B_{current}$ was in the range 12 000-15 000 t.

CAY = 1200-1500 t.

Long-term equilibrium yield
The stock reduction analysis modelled the decline in the west coast snapper stock from the early 1970s to the present time. Prior to the introduction of the pair-trawl fishery, stock biomass was possibly over 30 000 t. The unexploited population could have been as large as 40 000 t. The model indicates that the optimum stock size would be in the range 20 000-25 000 t, with an equilibrium yield of 2000-2500 t.

4.2.3 Hawke Bay

The biomass of snapper in this region is not known, and no stock assessment has been made. Based on historical catch levels, long-term yields in the commercial fishery may be 300-400 t. However, during the 1970s the stock was depleted by heavy fishing (especially pair-trawling) and the current stock size cannot support this level of catch.

MCY was calculated as 0.9 times the average yield in the fishery from 1982 to 1986.

MCY = 175 t.

The current TAC is set below this level to allow the stock to rebuild. No consideration has been given in the figures above to the catch by non-commercial users. The proportion of catch taken by this sector is likely to have remained fairly constant in recent years.

CAY cannot be estimated.

4.2.4 Challenger

Preliminary results of the 1986 tagging programme indicate that the current recruited stock size of snapper in the Tasman Bay stock is about 1500 t (Kirk *et al.* 1988). MCY was calculated as $F_{0.1}$ * $B_{current}$. $F_{0.1}$ was estimated to be 0.07 from a YPR model, with a natural mortality rate of 0.06. $B_{current}$ is believed to be the minimum historic level of stock size.

MCY = 0.07 * 1500 = 105 t.

Because of the extreme variability in year-class strength in the Tasman Bay snapper population, $F_{0.1}$ has been used in preference to F_{max} (as used in the northern stocks). Pre-recruit surveys in recent years show that some good year-classes are now entering the fishable population.

In the Marlborough Sounds, no estimate of stock size of snapper is available. MCY was calculated at 0.9 times the average commercial catch from 1965 to 1985.

MCY = 0.9 * 81 = 73 t.

The recreational catch from the Tasman Bay stock is estimated from the tagging results to be about 8% of the total. Separate MCY (and CAY) values are thus available for this area's commercial and recreational fisheries. The CAY for the Tasman Bay stock is the same as MCY, but no estimate is possible for the Sounds stock.

Long-term yields from the Challenger stock are likely to be of the order of 400-600 t, based on a long history of fishing at this level. However, the stock is severely depleted at present and rebuilding of the population biomass is required.

The current TAC exceeds the CAY, and a reduction in the TAC would help the stock rebuild. The success of future recruitment will determine the time-frame in which the stock may recover, but reductions in current commercial catches are required to prevent further depletion of the resource.

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Appendix 1

Background to the Yields and TACs, 1985-87

This section describes how the 1985-87 regional yield estimates and TACs were derived from the variety of available information. Further detail is provided by Sullivan (1985), Hore *et al.* (1986), and Sullivan *et al.* (1988), and in a number of unpublished papers related to these documents.

Sustainable yields for the various snapper stocks have been determined from a wide range of biological research data, as well as historical trends in commercial landings. The general nature of most of our snapper stocks is understood; they are over-fished and the population biomass is depleted. Some stocks have been both fished and researched for longer periods and are consequently better understood than others. However, all the yield estimates must be treated with some caution, and it must be remembered that the stock size will cycle naturally because of varying recruitment, as well as its response to recent exploitation levels.

The estimates given here are for the commercial fishery. A significant catch is taken by recreational fishermen in some areas; present data suggest 20-30%, and perhaps more in the Bay of Plenty. However, if these catches continue at previous levels they should not unduly influence the yield estimates, particularly where these are based largely on commercial data.

Two yield estimates were generally made. The "present sustainable yield" (PSY) represents the maximum yield the present stock can sustain. In earlier papers it was sometimes unclear whether this made any allowance for rebuilding the population biomass from an overfished condition, and in a few cases this point still requires clarification. In most cases the PSY is much lower than the "long term yield" (LTY) which could be harvested from a healthy stock.

Auckland East FMA

East Northland

This fishery really only developed after 1970, and the long-term effects of recent and current levels of exploitation may not become apparent for many years. In 1985 a conservative yield estimate of 1000 t was made principally to provide a warning that the fishery (then taking about 2000 t a year) was probably overfishing the stock and should not be developed further. In 1986 the results from the tagging programme were available, and showed that the current level of exploitation, about 8% for the commercial fishery, was similar to that in the Hauraki Gulf. It was argued that there should perhaps be comparability between yields and current catches in these two regions. In the Gulf the yield was 83% of current catch, whereas in east Northland it was only 48%. The latter was considered too conservative, and the yield (and recommended TAC) was raised to 1500 t. (In 1986 the catch from the region declined, presumably independently from this recommendation, to about 1700 t.)

Further analysis of the tagging data in a yield-per-recruit model in 1987 (Sullivan *et al.* 1988) allowed a refinement of this yield estimate. The total yield was estimated at about 1900 t, with the commercial sector component of 1585 t (based on a subdivision of tag returns). The stock was not considered to have been fished below the optimum biomass, so the PSY and LTY should be similar.

Hauraki Gulf

The Hauraki Gulf snapper population has been extensively studied over the last 25 years, and several attempts have been made to quantify the abundance of snapper and the level of sustainable yield.

Vooren and Coombs (1977) used an analytical model to determine the effects that age of recruitment to the fishery and the level of fishing mortality had on yield-per-recruit. The optimum rate of exploitation was estimated to be 5% per year, assuming natural mortality of 5% for the older age classes.

Elder (1979) used a surplus production model to analyse catch and effort data from the commercial fishery from 1960 to 1974. He estimated a maximum sustainable yield for this population of 4150 t per year.

Crossland (1980a) calculated the stock size of snapper, from egg surveys in 1974-75 and 1975-76, at 56 000 t, but gave no error bounds and did not estimate the sustainable yield. Crossland (1980b) also produced estimates of the numerical population size of snapper based on tag returns by commercial and recreational fisheries. This study's results were lower than the egg survey results, and it had to assume a very high (40%) level of under-reporting of catch for longline and setnet methods.

More recently there have been some detailed trawl surveys in the Gulf in order to estimate adult biomass and determine levels of recruitment, and a large tagging programme in 1984.

In 1985 it was judged from the current rates of exploitation and recruitment to the fishable population that the PSY should be 3200 t. The resource had been overfished in the recent past and was probably still in a stressed state, so that after rebuilding it should be possible to arrive at a higher LTY.

In 1986 it was confirmed from the tagging programme results that the stock could support a commercial fishery at the current estimate of PSY at 3200 t, but that to allow stock rebuilding and to compensate for an anticipated reduction in recruitment over the next two years the TAC should remain at 2900 t. It was predicted that when the stock had been rebuilt to optimum biomass levels it should support an annual yield of up to 4000 t.

In 1987 further analysis of the tagging results gave similar results. The stock size was estimated at 32 300 t, which at an exploitation rate of 10% would provide a PSY of 3230 t, or some lesser figure (perhaps 2 800 t) depending on the level of tag underreporting (Sullivan *et al.* 1988). It was predicted that within the Auckland (East) TAC of 4710 t, some 3000 t or less would be taken commercially from the Gulf, plus 800-900 t by the non-commercial sector. The LTY was revised to around 5000 t, and it was stressed that continuing conservative management was required for the stocks to regain a position from which they could supply this. In particular, the catch from separate regions within the Auckland FMA needed to be carefully balanced, given the key role of recruitment within the Gulf in not only rebuilding its own stock but supplying emigrant fish to the Bay of Plenty.

Bay of Plenty

This stock has a long history of exploitation, and in recent years has been severely depleted. Research work has included trawl surveys for estimating biomass and recruitment trends, a stock reduction analysis (Gilbert 1986), and a large tagging programme.

The stock reduction analysis indicated an LTY of about 800 t. However, the population biomass has steadily declined since the early 1970s and cannot now sustain this yield. CPUE data from the trawl fishery showed annual declines of 10-30% from 1974 to 1980, while landings continued to be over twice the optimum level (Sullivan 1985). Trawl surveys revealed poor recruitment levels for the mid 1980s. The tagging results to 1985 indicated an exploitation rate of at least 12%, and more probably 15-20%, which was clearly not sustainable. In 1985 the recommended PSY was 500 t, and it was observed that poor recruitment was going to depress the adult stock even further, at least in the short term, before rebuilding could occur.

In 1986 further analysis of the tagging data (Hore *et al.* 1986) essentially confirmed this position. The stock size at the end of 1985 was estimated at 5700 to 7200 t, which at a productivity of 12% would give a PSY of 680-860 t, probably less after allowing for poor recruitment. Apportioning this between commercial and recreational sectors at a 2:1 ratio gave a commercial yield of 450-575 t. Because of the fishery's recent dependence on only a few strong year-classes, with predicted poor future recruitment, and the very clear need to rebuild stocks, a PSY of 300 t was recommended. An LTY of 800 t could still be anticipated.

In 1987 there was an upward adjustment in the mean calculated biomass to between 6600 and 7300 t, through using a better measure of the abundance of large (over 45 cm) snapper derived from longline catches. Making an allowance of 10-15% for underreporting of tags gives a PSY range of 600-650 t. An LTY of 800 t was still considered feasible, so to allow stock rebuilding the PSY was left unchanged at 300 t.

West coast North Island

The pair trawl fishery based at Auckland's Onehunga port (Manukau Harbour) has been studied from catch and effort data for the period 1974-86 (Sullivan and Gilbert 1979, Sullivan 1985, Sullivan *et al.* 1988). CPUE declined from 1974 to 1981, remained at 30-40% of the original level to 1984, and rose a little in the last (1985-86) season.

In 1985 a stock reduction analysis (Sullivan 1985) produced LTY estimates of 2200-2500 t for the period 1976-81. The stock worked by this pair trawl fleet, extending south to Cape Egmont, was considered to have been depleted further since 1981, and a PSY of 1800 t was recommended. A higher LTY was considered possible, so the recommended TAC of 1360 t was set lower than the PSY in order to permit stock rebuilding. For management convenience it was also subdivided into

TACs for the two FMAs involved: Auckland (West 1100 t, and Central (Egmont) 260 t.

In 1986 no further data were considered, and the recommended yield (expressed as a recommended TAC) was left at the single figure of 1360 t for the west coast of the North Island.

In 1987 further studies on age distribution showed a continuing decline in the proportion of older fish in the catch (Sullivan *et al.* 1988), along with the reduction in total biomass demonstrated by the decline in CPUE. It was suggested that the PSY level might be about the average landings for 1983-85 of 1880 t, but that the LTY should be higher, perhaps up to 2500 t. No change was recommended to the existing yield (1360 t) and TAC (1330 t) values for Auckland (West) and Central (Egmont) combined.

Challenger FMA

Tasman Bay

This area comprises Tasman Bay itself, Golden Bay, the southern part of the South Taranaki Bight, and the Westland coast.

A yield-per-recruit model for this stock indicated an optimum exploitation rate of 12% (Sullivan 1985). In the mid 1960s and mid to late 1970s this level had been exceeded and the stock biomass inevitably declined. However, since the introduction of quotas the fishery has continued at a lower rate of exploitation.

The results from a tagging programme in 1978-82 suggested a PSY of about 400 t, with a higher LTY. However, recruitment to this stock is highly variable, often with long intervals between strong year-classes. The retention of an adequate spawning stock is essential to optimise the chances of producing strong year-classes and to buffer the population against continuing fishing pressure during periods of low recruitment. The 1985 recommended TAC of 250 t was lower than the PSY.

In 1986 there was no further work reported, and no changes were made to recommended figures.

In 1987 there was again no further work reported, but the potential of the current tagging programme for establishing stock size and yields was noted. The PSY was still considered to be 400 t, with a LTY of perhaps 600 t. Because the stock had been depleted it was considered prudent to maintain the TAC at 250 t, below the PSY.

Marlborough Sounds

Little research work beyond the 1978-82 and 1984 tagging has been done in this area, which contains a relatively small population of snapper. There is a small commercial trawl and net fishery, and a more important recreational fishery. Tag returns suggest that the optimum exploitation rate of 12% has been exceeded in recent years. The commercial fishery has taken up to 250 t annually, though not for extended periods, well above the inferred sustainable level of about 100 t. The PSY is almost certainly less, perhaps 70 t, and this has been the recommended yield or TAC value in recent years.

Central (East) FMA

East Cape-Hawke Bay

This fishery, has almost certainly been over-exploited since the mid to late 1960s, with catches falling steadily since, but no detailed assessment of yield has been carried out for this stock. There was a decline in CPUE during the 1970s, consistent with a declining resource (Sullivan 1985). Historical catches have been up to 800 t per year, but appear to have been more stable recently at a level around 400 t. Part of the decline in catches can be attributed to a ban on pair trawling, which may be giving the stock a chance to recover. The level and regularity of local recruitment is unknown, but as some of the snapper in this area are derived from the Bay of Plenty (Paul and Tarring 1980) the low condition of this latter stock suggests that recovery of the east coast "stock" will also be slow.

In 1985 it was estimated that the PSY would be about 200 t, with a higher LTY, and the lower TAC of 120 t was recommended to allow stock rebuilding. The latter was listed without comment in 1986. It was repeated again in 1987, with the suggestion that the LTY should be 300-400 t after stock rebuilding. The recreational catch was estimated at about 20% of the current catch, i.e. 20-30 t.

Other Areas and the Deepwater Fishery

Nominal tonnages have been assigned to the Kermadec FMA (10 t) and the South-east + Southern-Subantarctic FMAs (30 t) to accommodate possible by-catches. The species is only sparsely distributed around southern New Zealand, and is certainly not target-fished. Similar tonnages (10 t units) have been allocated to the Japanese and Korean fishing fleets for the same reasons.

Table 1. Total New Zealand landings (t) of snapper, domestic vessels by method, calendar years 1936-86.
Note: The 1936-43 data are from April-March years.

						Percentage					
Year	Single trawl	Pair trawl	Danish seine	Lines	Nets	Single trawl	Pair trawl	Danish seine	Lines	Nets	TOTAL
1936	1 306		4 585	980	364	18		63	14	5	7 235
1937	525		4 489	925	555	8		69	14	9	6 495
1938	866		4 806	877	452	12		69	13	7	7 000
1939	270		5 049	805	636	4		75	12	9	6 760
1940	79		4 720	814	324	1		80	14	5	5 936
1941	133		4 476	739	292	2		79	13	5	5 640
1942	92		3 876	449	374	2		81	9	8	4 791
1943	61		3 918	463	665	1		77	9	13	5 108
1944	90		4 145	508	795	2		75	9	14	5 538
1945	551		3 717	533	737	10		67	10	13	5 538
1946	1 299		3 636	595	406	22		61	10	7	5 935
1947	2 035		3 484	643	415	31		53	10	6	6 578
1948	2 500		3 643	852	567	33		48	11	7	7 561
1949	2 574		2 744	932	584	38		40	14	9	6 834
1950	2 796		1 753	1 218	461	45		28	20	7	6 228
1951	2 548		1 190	1 142	628	46		22	21	11	5 509
1952	2 616		1 022	841	465	53		21	17	9	4 944
1953	3 135		1 016	923	503	56		18	17	9	5 578
1954	3 573		832	1 201	495	59		14	20	8	6 101
1955	3 680		850	1 476	456	57		13	23	7	6 463
1956	3 862		1 067	1 446	724	54		15	20	10	7 099
1957	4 754		1 353	1 525	638	57		16	18	8	8 270
1958	4 418		1 260	1 277	536	59		17	17	7	7 490
1959	4 708		1 424	1 359	426	59		18	17	5	7 918
1960	4 916		1 376	1 256	417	62		17	16	5	7 965
1961	4 731		1 358	1 140	446	62		18	15	6	7 675
1962	5 183		1 244	1 192	507	64		15	15	6	8 127
1963	5 368		1 333	1 088	586	64		16	13	7	8 374
1964	5 823		899	890	557	71		11	11	7	8 169
1965	6 396		983	815	416	74		11	9	5	8 610
1966	7 652		1 137	1 044	530	74		11	10	5	10 363
1967	7 854		1 078	1 254	325	75		10	12	3	10 510
1968	7 101		1 836	1 221	478	67		17	11	4	10 639
1969	6 644		3 397	972	391	58		30	9	3	11 406
1970	6 478		4 626	1 150	558	51		36	9	4	12 812
1971	7 040		5 310	1 157	585	50		38	8	4	14 092
1972	6 982		4 797	1 150	253	53		36	9	2	13 183
1973	5 593	1 864	4 616	1 527	494	40	13	33	11	3	14 134
1974	5 392	3 842	2 725	1 119	495	39	28	20	8	4	13 880
1975	3 755	4 289	2 114	999	462	32	37	18	9	4	11 638
1976	2 853	7 418	2 296	1 196	571	20	52	16	8	4	14 346
1977	2 095	6 217	1 858	1 305	1 078	17	50	15	10	9	12 559
1978	2 916	9 208	1 790	1 954	1 502	17	52	10	11	9	17 660
1979	2 228	8 882	1 454	2 583	951	14	54	9	16	6	16 379
1980	1 970	5 880	923	2 724	571	16	49	8	23	5	12 073
1981	1 521	5 695	1 103	2 992	610	13	48	9	25	5	11 940
1982	1 643	4 525	662	3 093	760	15	42	6	29	7	10 683
1983	1 437	2 852	785	2 898	797	16	33	9	33	9	8 769
1984	2 015	2 311	1 071	2 946	901	22	25	12	32	10	9 244
1985	2 081	2 604	781	2 928	725	23	29	9	32	8	9 119
1986	1 624	1 315	764	2 378	431	25	20	12	37	7	6 512

Table 2. Snapper landings (t) by port and FMA for the calendar years 1974-86.
Note: The Auckland FMA is subdivided here into West Auckland, east Northland, Hauraki Gulf, and Bay of Plenty.

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Hokianga	2	2	3	1	1	1		4	7	6	3	4	3
Kaipara	6	8	10		5	12	9	19	17	30	45	39	16
Manukau	3616	3150	3468	2570	3038	2473	2350	2355	2041	1242	978	1376	623
Raglan)	168	179	386	245	286	247	364	354	172	177	199	156	65
Kawhia)													
WEST AUCKLAND	3792	3339	3867	2816	3330	2733	2723	2732	2237	1455	1225	1575	707
Mangonui	462	365	464	432	772	859	707	557	525	592	791	696	532
Whangaroa	41	285	178	246	155	339	111	110	148	96	88	83	74
Russell	61	42	64	106	300	324	346	394	377	375	307	248	137
Whangarei	277	234	353	350	565	603	676	628	495	440	462	280	266
EAST NORTHLAND	841	926	1059	1134	1792	2125	1840	1689	1545	1503	1648	1307	1009
Auckland + Leigh	4813	3728	4610	4260	5254	5686	3699	4060	3583	3136	3726	3667	2807
Thames	294	260	239	370	534	308	178	124	165	88	189	180	107
Coromandel	145	185	164	485	498	393	380	616	568	655	675	549	446
HAURAKI GULF	5252	4173	5013	5115	6286	6387	4257	4800	4316	3879	4590	4396	3360
Mercury Bay	211	125	168	240	587	545	394	336	362	288	308	229	143
Tauranga	1245	574	871	925	1212	1058	663	859	818	438	422	614	624
Whakatane	86	96	109	100	251	345	216	188	201	148	173	228	154
BAY OF PLENTY	1542	795	1148	1265	2050	1948	1273	1383	1381	874	903	1071	921
Gisborne	430	520	519	214	209	314	265	169	98	95	129	91	84
Napier	248	152	189	138	188	348	371	114	62	60	96	115	118
Castlepoint	-	-	1	1	1	-	-	-	-	-	-	-	-
Wellington	38	60	23	21	56	-	-	-	-	5	2	2	5
Makara										-	-	-	-
CENTRAL EAST	716	732	732	374	454	662	636	283	160	160	227	208	207
New Plymouth	192	385	768	537	551	459	400	310	309	268	242	221	90
Wanganui)	321	413	677	576	447	261	180	111	90	87	65	70	52
Manawatu)													
Paraparaumu)	35	80	14	12	12	11	6	-	-	4	4	-	2
Paremata)													
CENTRAL WEST	548	878	1459	1125	1010	731	586	421	399	359	311	291	144
Pelorus	64	98	117	72	44	70	137	65	124	98	82	53	14
Picton	-	12	13	9	4	4	7	-	-	3	5	2	1
Blenheim	-	-	1	8	3	8	9	4	3	-		-	-
Nelson	881	484	713	486	1890	1028	103	178	191	156	69	91	68
Motueka	65	178	175	89	718	611	408	314	233	244	139	102	73
Golden Bay	5	12	18	38	61	27	64	31	40	33	24	10	8
Westport	11	5	3	12	-	-	4	-	-	9	19	11	4
Greymouth	-	-	-	-	-	28	-	-	-	1	2	1	-
CHALLENGER	1026	789	1040	714	2720	1776	732	592	591	544	340	270	168
Kaikoura										1	-	-	-
Lyttelton										-	-	-	
Akaroa												-	
Lake Ellesmere										-			
Timaru										-	-	-	-
Oamaru											-		
Moeraki											-		
Karitane													
Port Chalmers										-			
Taieri Mouth										-		2	
Nuggets													
Waikawa													
SOUTH-EAST COAST													
Riverton													
Bluff + Stewart I													
Milford													
SOUTHLAND													
Chatham Is													
NEW ZEALAND TOTAL	13733	11638	14346	12559	17660	16379	12073	11940	10683	8769	9244	9121	6513

* less than 0.5 t.

Table 3. Snapper landings (t) by domestic vessels: Total New Zealand, 1931-86/87; Hauraki Gulf ports (Auckland, Thames, Coromandel, and Whangarei), 1931-80; Hauraki Gulf region (areas 3 in 1960-73, 5-7 in 1980-86).

	Total N.Z.	Hauraki Gulf Ports	Auckland	Hauraki Gulf Area
1931	3 674	2 840	2 190	
1932	3 736	3 141	2 523	
1933	4 374	3 770	3 076	
1934	4 863	4 172	3 477	
1935	5 870	5 245	4 490	
1936	7 235	6 352	5 723	
1937	6 495	5 667	4 943	
1938	7 001	6 050	5 449	
1939	6 760	5 880	5 119	
1940	5 936	5 086	4 640	
1941	5 940	4 798	4 421	
1942	4 791	4 041	3 739	
1943	5 108	4 387	3 818	
1944	5 538	4 719	4 056	
1945	5 538	4 732	4 151	
1946	5 935	5 043	4 765	
1947	6 578	5 498	5 155	
1948	7 561	6 239	5 635	
1949	6 834	5 494	4 687	
1950	6 228	4 572	3 825	
1951	5 614	3 886	3 176	
1952	6 029	3 428	3 039	
1953	5 578	3 727	2 878	
1954	6 101	3 688	3 227	
1955	6 463	3 636	3 093	
1956	7 099	3 977	3 177	
1957	8 270	4 496	3 806	
1958	7 490	4 391	3 777	
1959	7 918	4 789	4 222	
1960	7 965	4 718	4 217	3 001
1961	7 675	4 408	3 976	2 435
1962	8 127	4 667	4 111	2 665
1963	8 374	4 836	4 278	2 813
1964	8 169	4 895	4 372	2 901
1965	8 610	5 092	4 687	2 571
1966	10 363	5 188	4 689	3 238
1967	10 510	5 312	4 914	3 507
1968	10 639	6 227	5 710	4 662
1969	11 406	7 162	6 559	5 010
1970	12 812	7 512	6 281	6 224
1971	14 092	8 605	7 353	7 078
1972	13 183	7 270	6 368	5 515
1973	14 134	6 773	5 597	5 293
1974	13 365	5 507	4 791	
1975	11 638	4 405	3 728	
1976	14 346	5 366	4 610	
1977	12 559	5 465	4 260	
1978	17 660	6 850	5 254	
1979	16 379	6 979	5 685	
1980	12 073	4 808	3 575	4 257
1981	11 940			4 800
1982	10 683			4 316
1983	8 769			3 879
1984	9 244			
1985	9 119			
1986	6 512			
or				
1983/84	9 127			3 342
1984/85	9 172			3 432
1985/86	8 607			2 914
1986/87	5 389			

Table 4. Snapper landings (t) reported by foreign vessels fishing in New Zealand waters, 1968-86. Note: Compiled from various sources, some of which are contradictory; consequently these must be regarded as approximate and in most cases minimum values only.

				Japan - Trawl		Korean	Japan	Soviet	Foreign	Charter/
	N.E. Coast	Central E. Coast	Central W. Coast	N.W. Coast	Total N.Z.	Trawl N.Z.	Lines N.Z.	Trawl N.Z.	Licensed N.Z.	JV N.Z.
1968	1	22	17	309	349					
1969	-	-	251	929	1180					
1970	2	1	131	543	677					
1971	5	-	115	403	523					
1972	1	0	225	1217	1443			<200		
1973	-	3	117	466	586					
1974	-	0	98	363	461					
1975	26	72	8	809	915		1510			
1976	20	133	5	875	1033		2057	<100		
1977	1	1	10	868	880	2840	2208	<300		
1978	0	-	1	30	31					
1979	1	-	-	82	83				162	41
1980									22	
1981									68	34
1982									13	57
1983									9	13
1984									7	16
1985									19	41
1986									1	47

Table 5. Yield estimates (t) for regional (QMA) snapper stocks

	Total		Commercial		Current	Fishstock
	MCY	CAY	MCY	CAY	TAC	Code
Auckland East	5300	5900	4000	4600	4710	1
Auckland West	-	-	1000	1300	1330	8
Hawke Bay	-	-	175	-	130	2
Tasman Bay	500	100	90	90	) 330	7
Marlborough Sounds	-	-	75	-	)	
Other (Kermadec and Southern Areas)					40	3,10
Totals			5340		6540	

Note: Single values are listed for MCY and CAY, rather than the ranges given in the text.
The smaller values are rounded to 5 t.

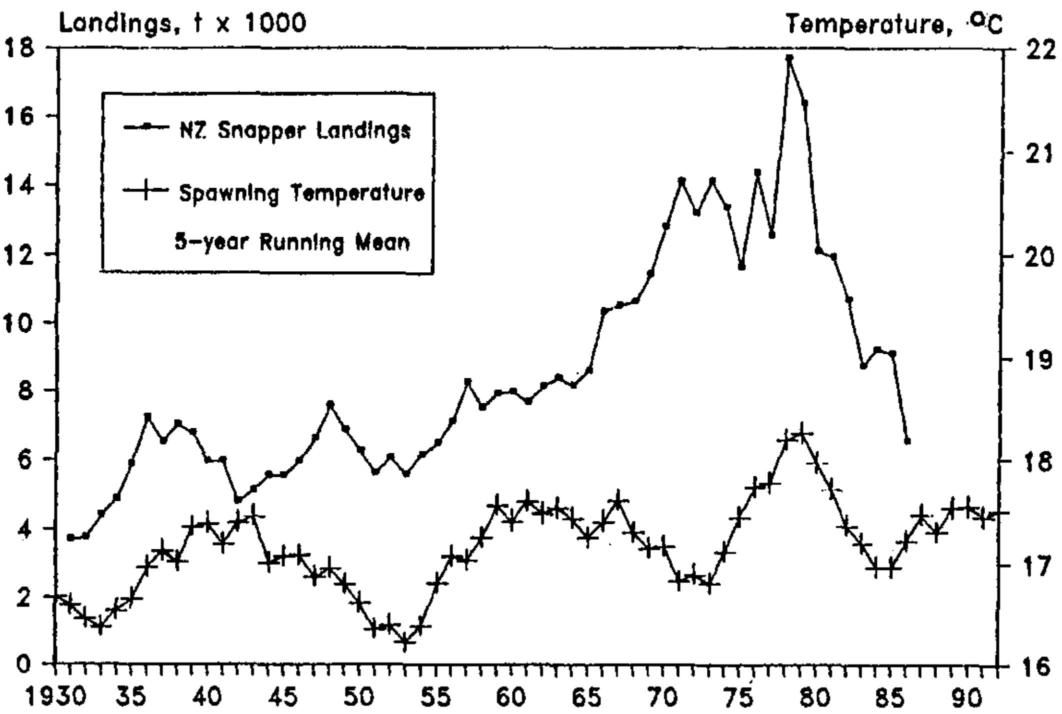

Fig. 1: Total New Zealand landings (t) of snapper, domestic vessels, calendar years 1931-86. Also shown, running 5-year mean spring temperature trends for the Auckland area, lagged 5 years; these data are 5-year running means of mean Nov/Dec Auckland air temperatures, lagged five years, and in theory predict adult snapper biomass changes resulting from variable recruitment.

Note:

Fishing effort and landings declined during the 1939-45 war. Stable landings through the early 1960s partly resulted from Auckland vessels being placed on restricted landings by processors unable to handle large catches. In the early 1970s snapper catches rose because of high export prices, and a shift towards fishing methods (pair trawl and longline) able to work over or near rough-bottom grounds which were previously unexploited. This combination may well have over-fished the stocks during a period of predicted low recruitment. See Paul (1982).

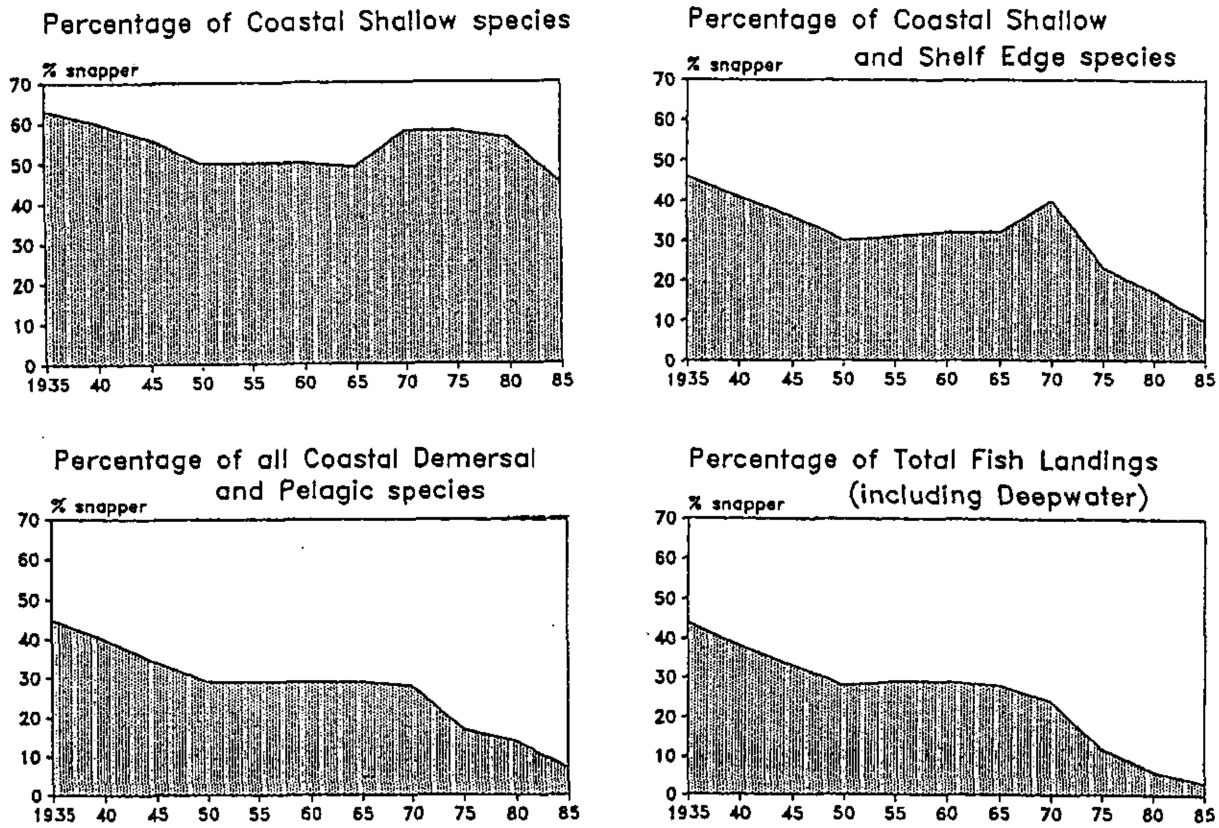

Fig. 2: Snapper landings as a percentage of different sectors of New Zealand's commercial marine fish landings, at 5-year intervals, 1935-85.

Note:

The main species in each sector are:

Coastal Shallow:	Blue cod, blue moki, elephant fish, flounders, John dory, red gurnard, snapper, soles.
Shelf Edge:	Alfonsino, barracouta, bluenose, blue warehou, gemfish, gropers, red cod, rig, school shark, stargazer, tarakihi.
Coastal Pelagic:	Grey mullet, jack mackerels, kahawai, trevally.
Deepwater and Oceanic Pelagic:	Hake, hoki, ling, orange roughy, oreos, silver warehou, southern blue whiting, tunas.

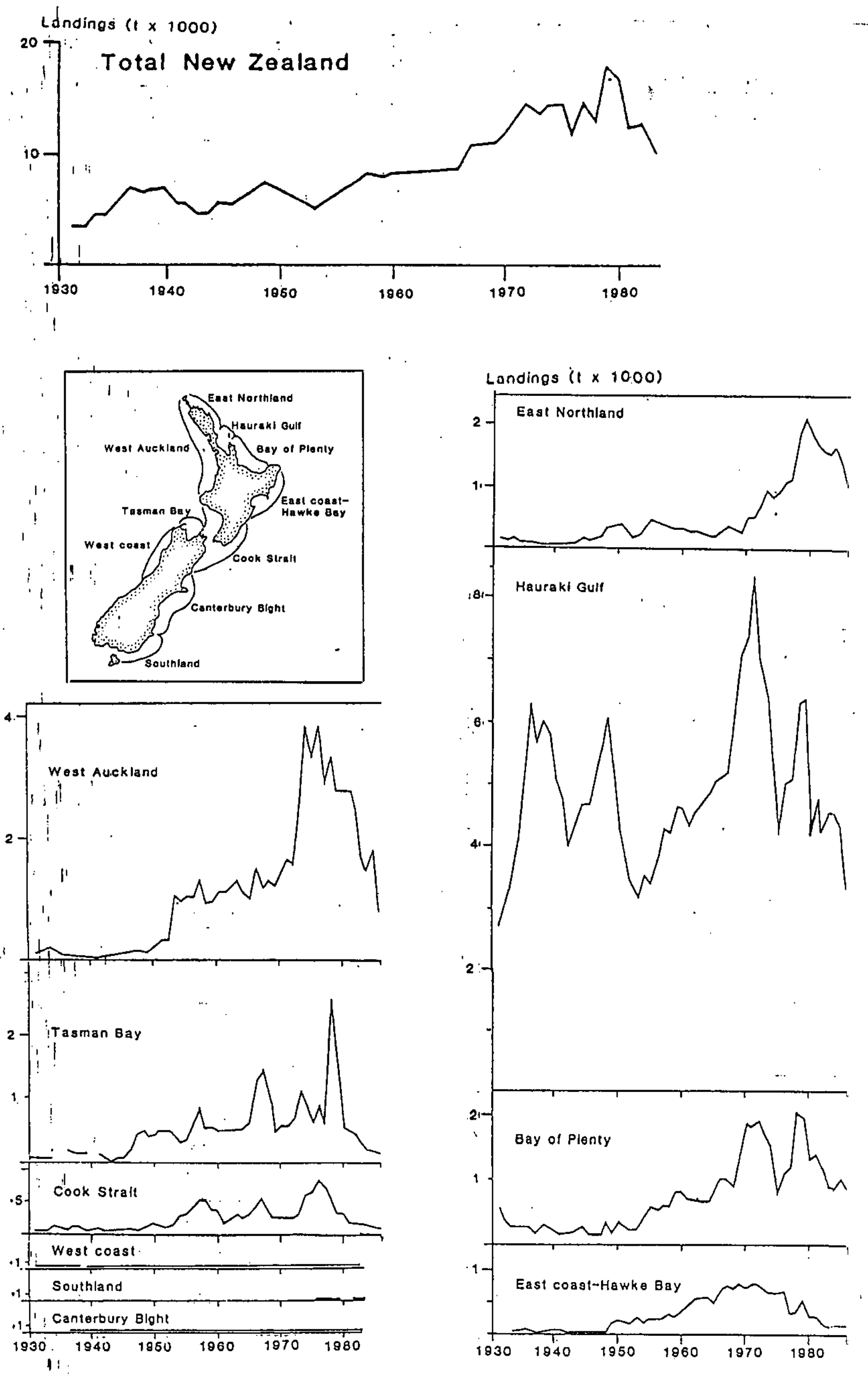

Fig. 3: Total New Zealand and regional landings (t) of snapper, domestic vessels, calendar years 1931-86. Based on ports of landing data, grouped as shown in inset map. <u>Note</u>: The 1931-43 data are from April-March years.

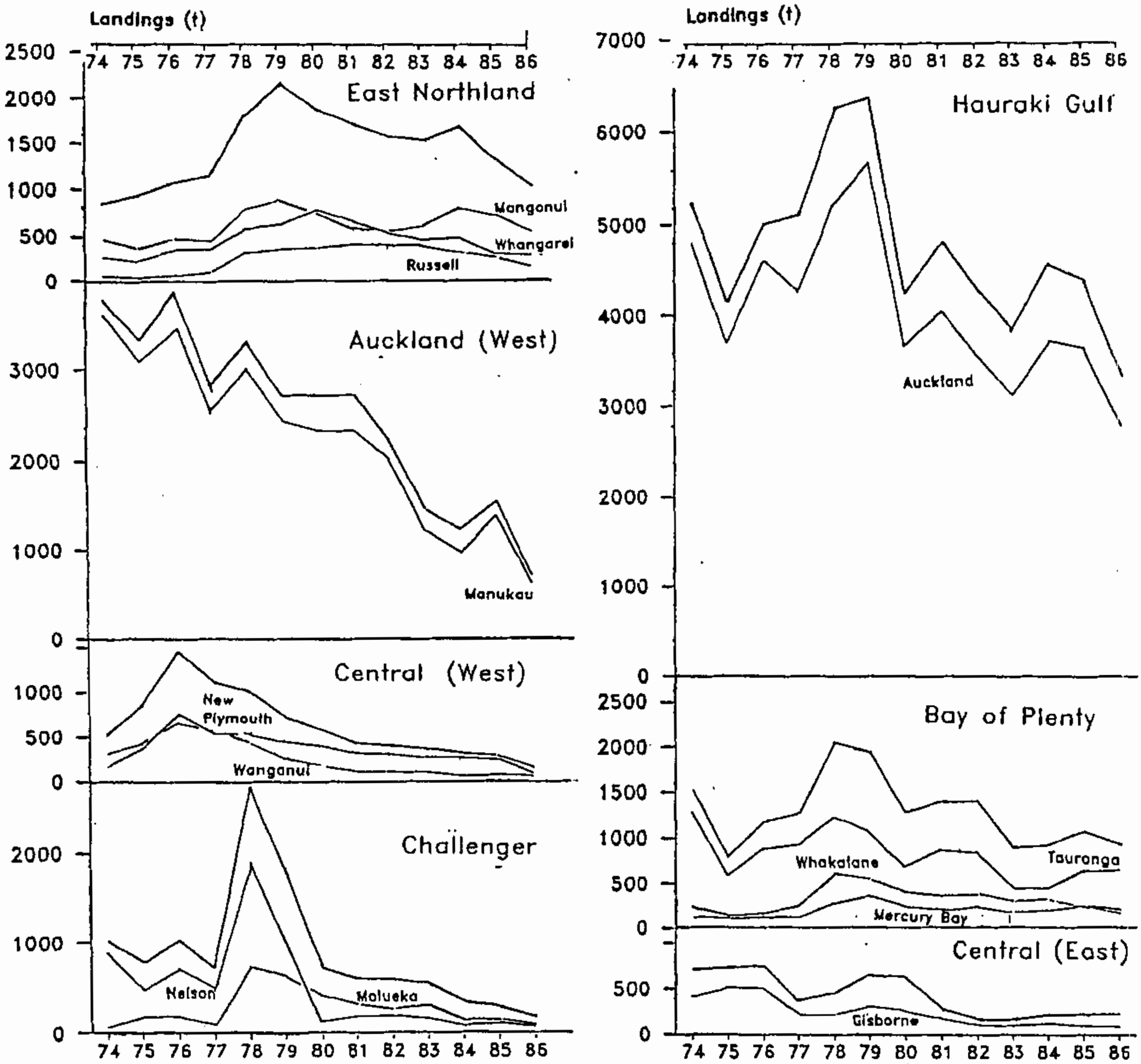

Fig. 4: Snapper landings (t) within the main (central and northern) Fisheries Management Areas, and at the main ports within these areas, calendar years 1974-86. Based on ports of landing data, as in Table 2.

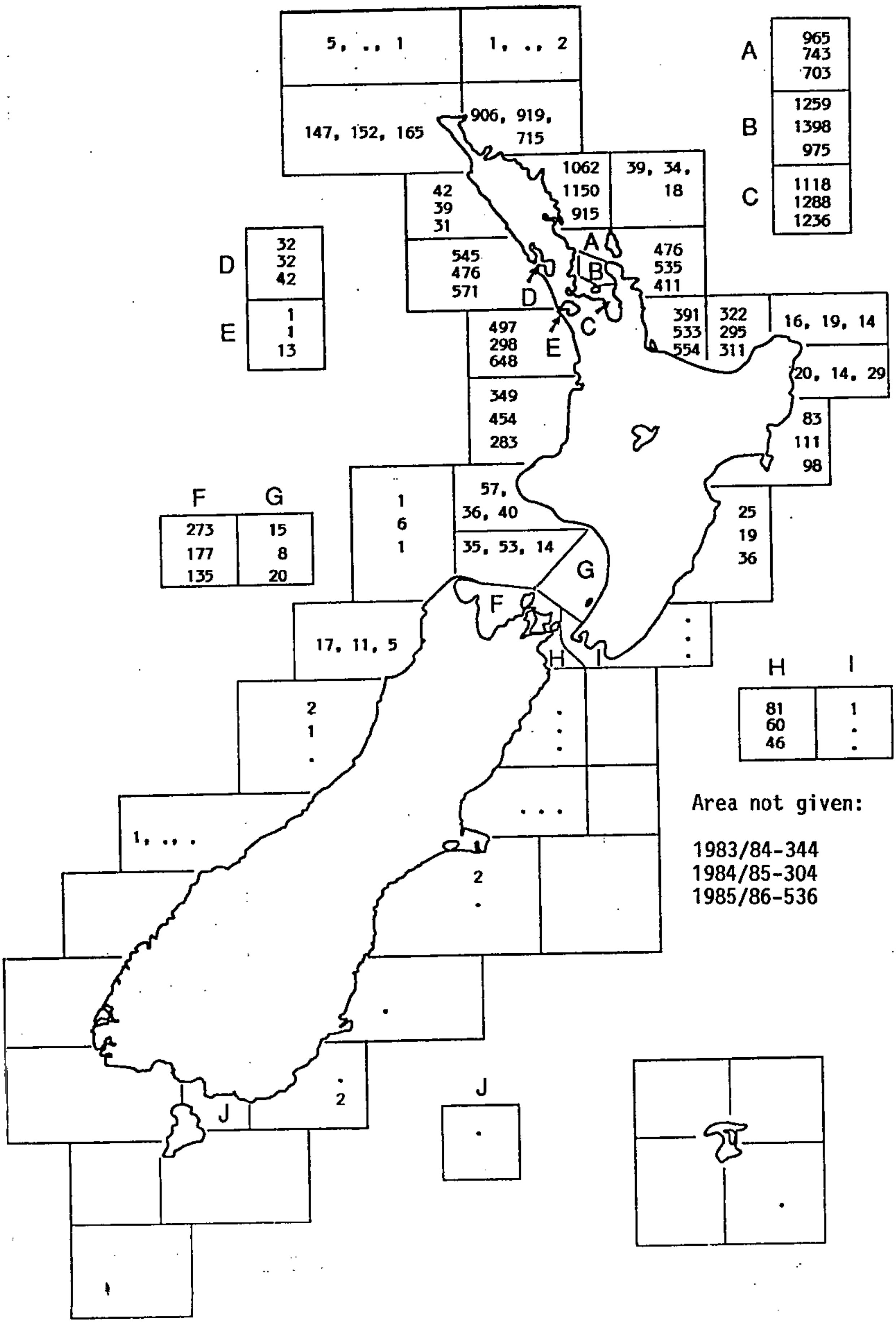

Fig. 5: Domestic landings (t) of snapper for the fishing years 1983-84, 1984-85, and 1985-86, by fishing return area. (Area not known, 1983-84 = 344 t, 1984-85 = 304 t, 1985-86 = 536 t.)

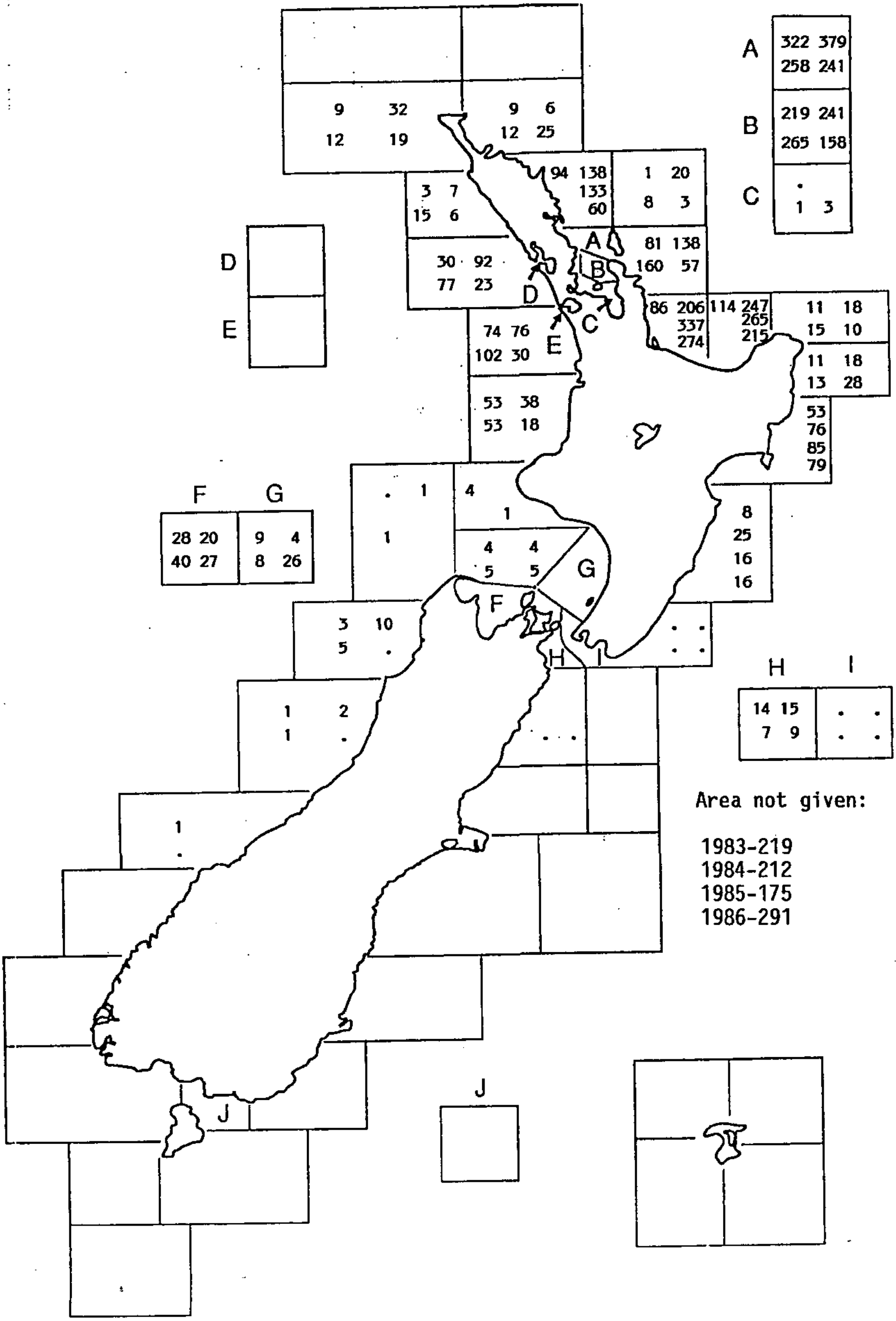

Fig. 6: Domestic single trawl landings (t) of snapper for the calendar years 1983-86, by fishing return area. Note: For fishing return areas (used in Figs 6-9), calendar years provide the most recent information.

Area not given:

1983-95
1984-23
1985-103
1986-53

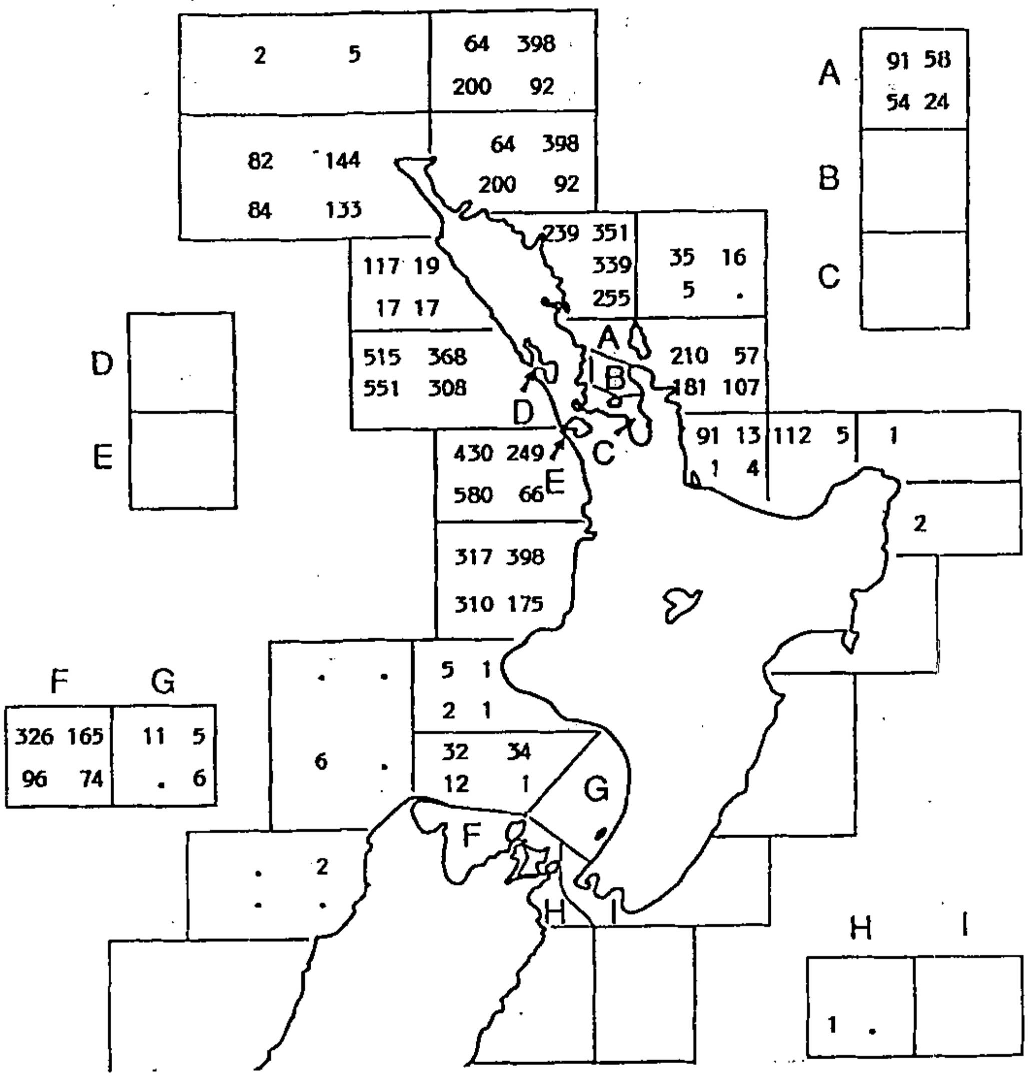

Fig. 7: Domestic pair trawl landings (t) of snapper for the calendar years 1983-86, by fishing return area.

Area not given:

1983-18
1984-34
1985-115
1986-108

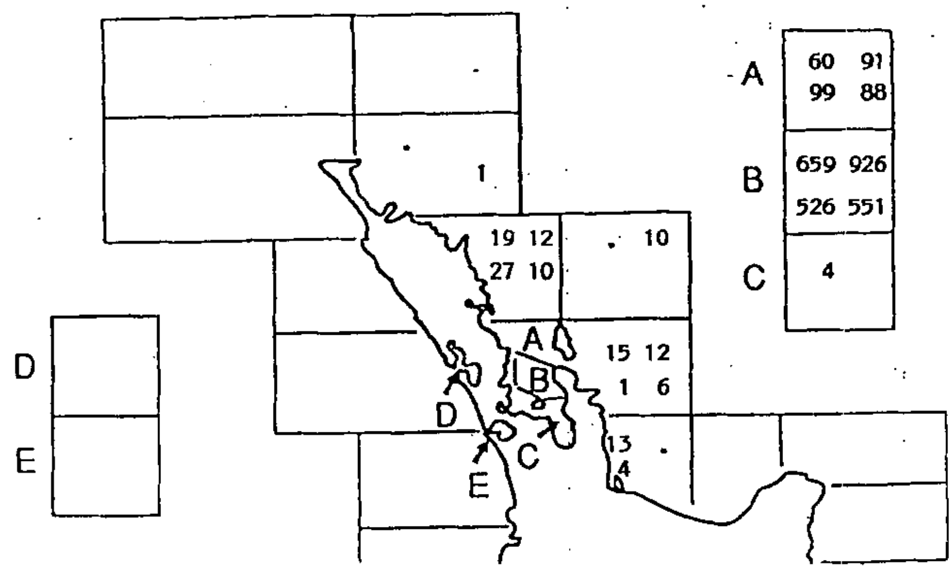

Fig. 8: Domestic Danish landings (t) of snapper for the calendar years 1983-86, by fishing return area.

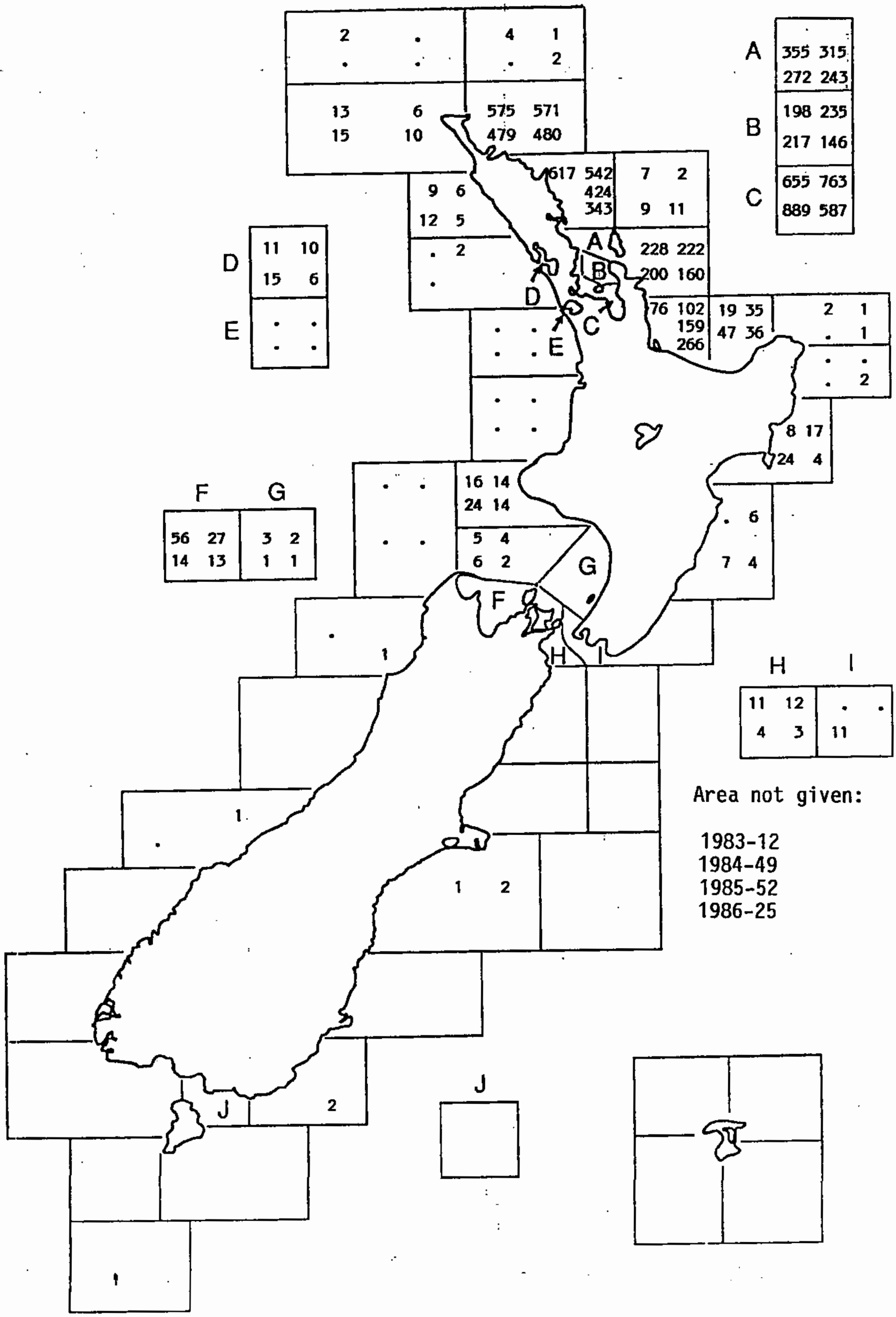

Fig. 9: Domestic longline landings (t) of snapper for the calendar years 1983-86, by fishing return area.

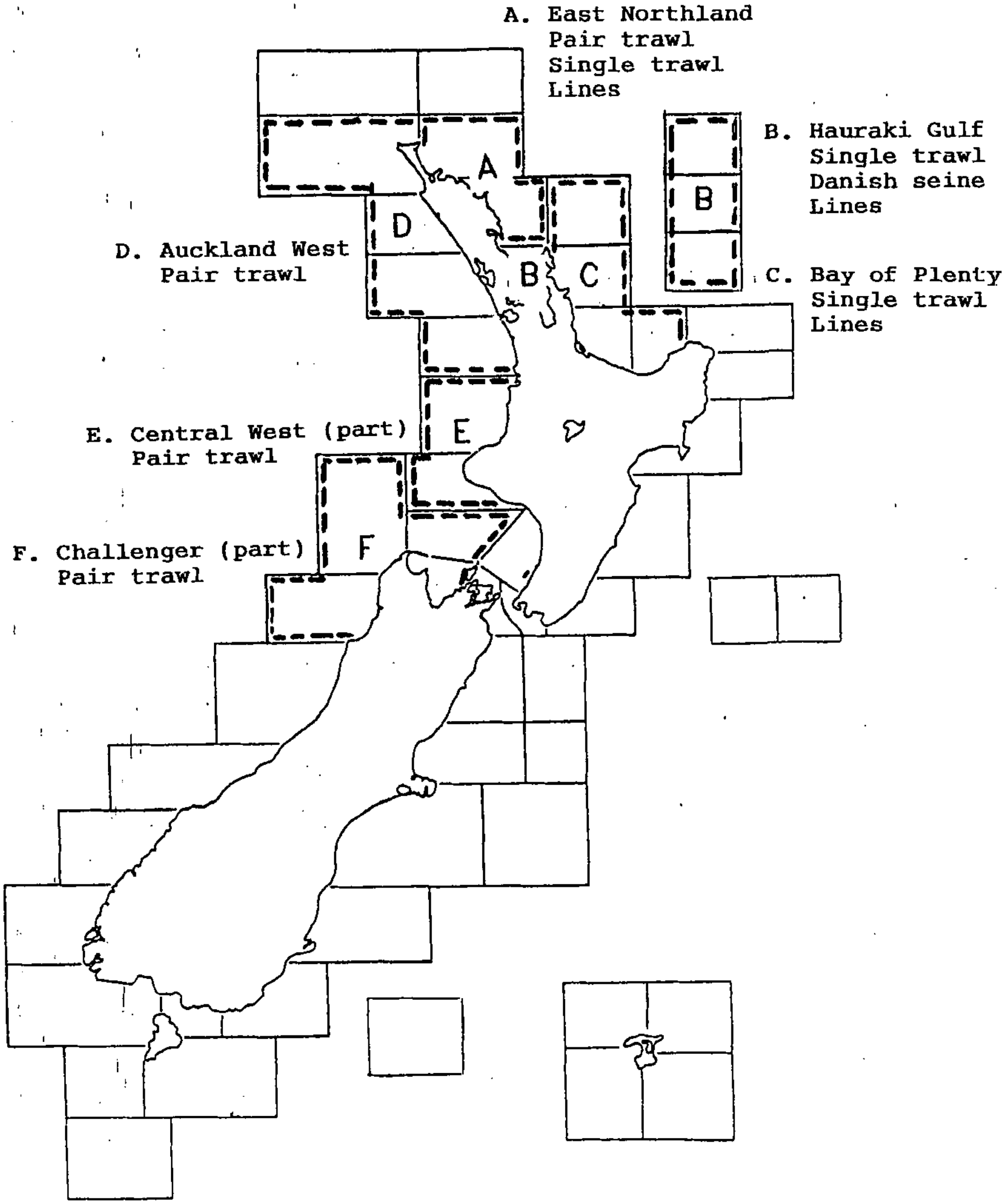

Fig. 10: The regional groupings of fishing return areas used for the CPUE analyses in Figs. 11-20.

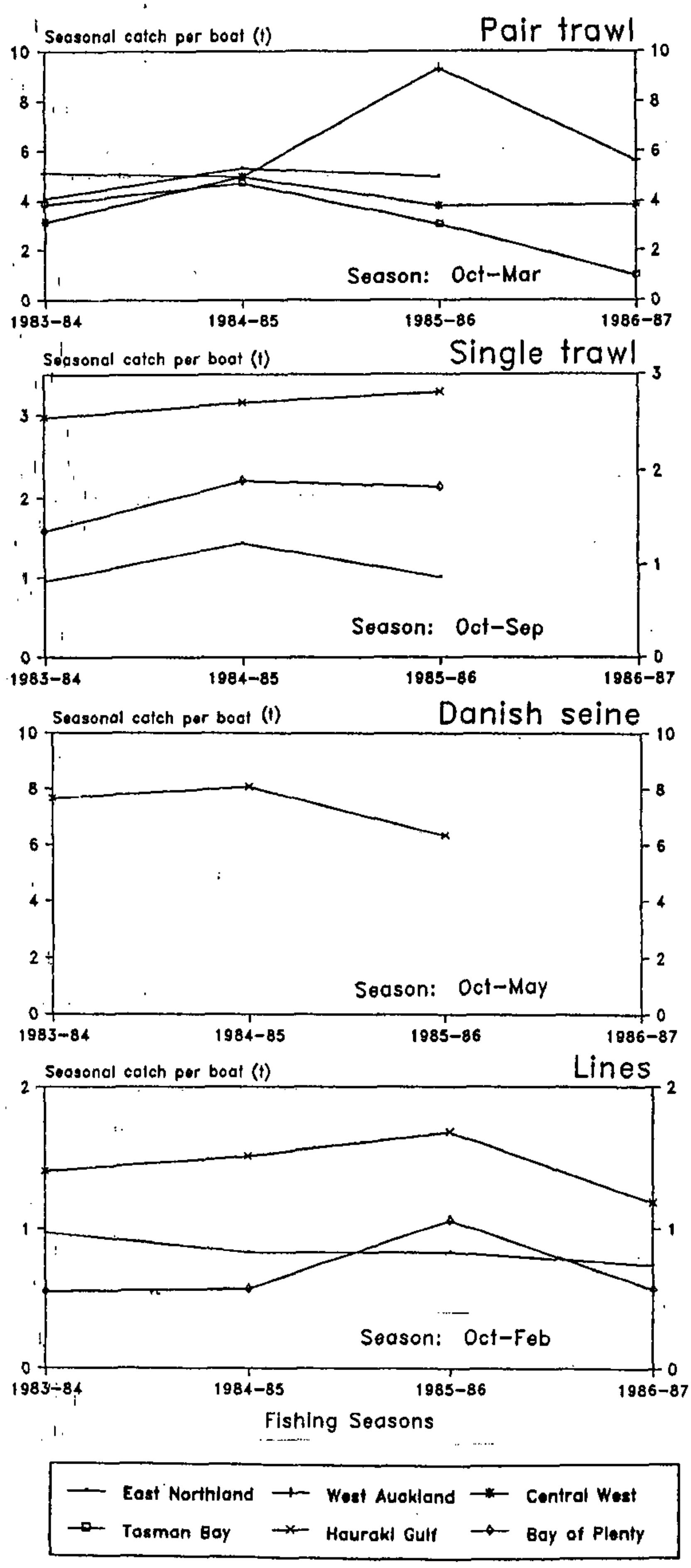

Fig. 11: Mean CPUE values for regional snapper fisheries during the main fishing seasons (as listed), 1983-84 to 1986-87. Monthly data from each fishery are shown in Figs. 12 to 20.

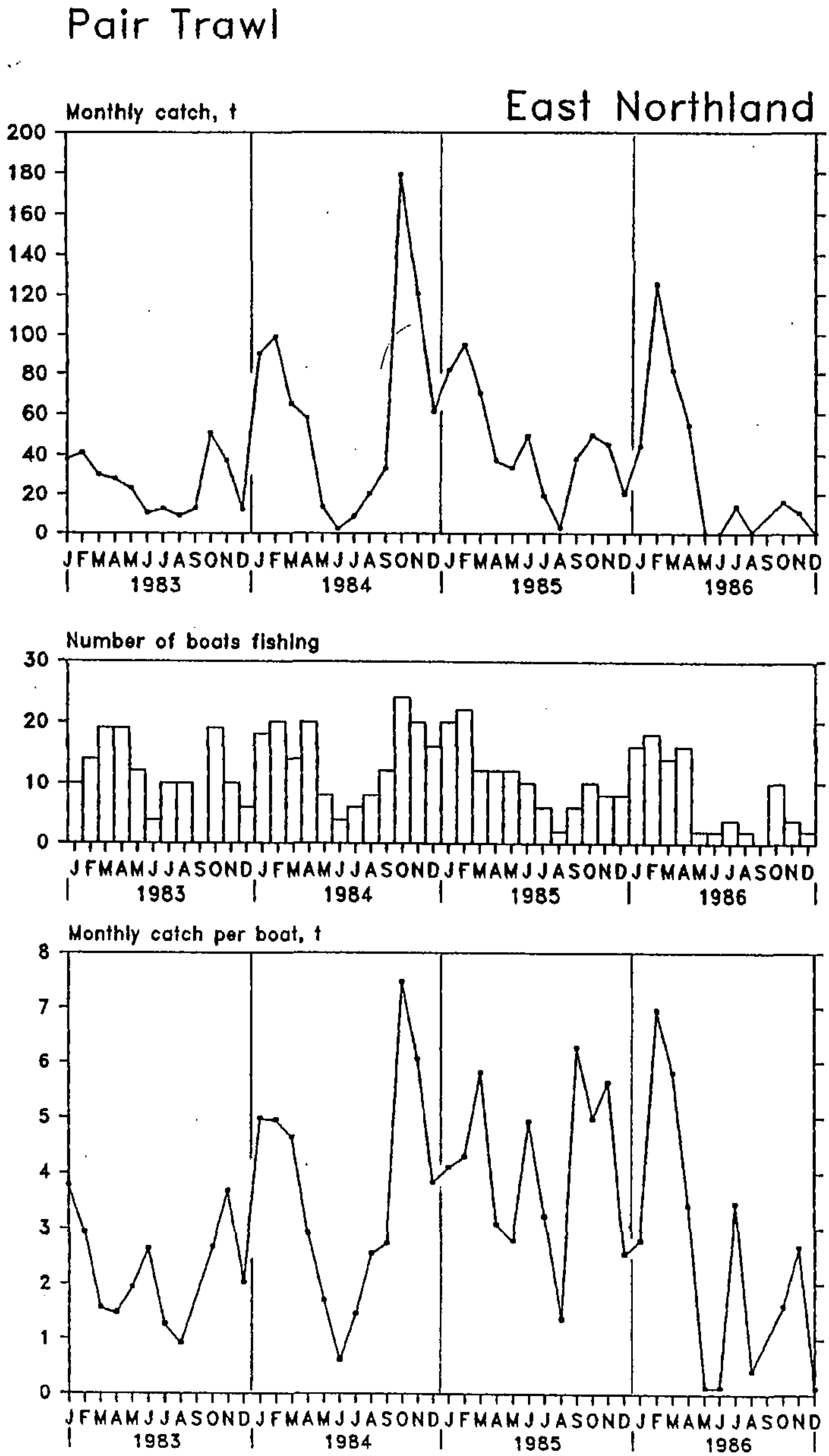

Fig. 12: Snapper catch, effort, and CPUE (t) for the east Northland pair trawl fishery, by month, 1983-86. Fishing return areas 2, 3. Data from FSU.

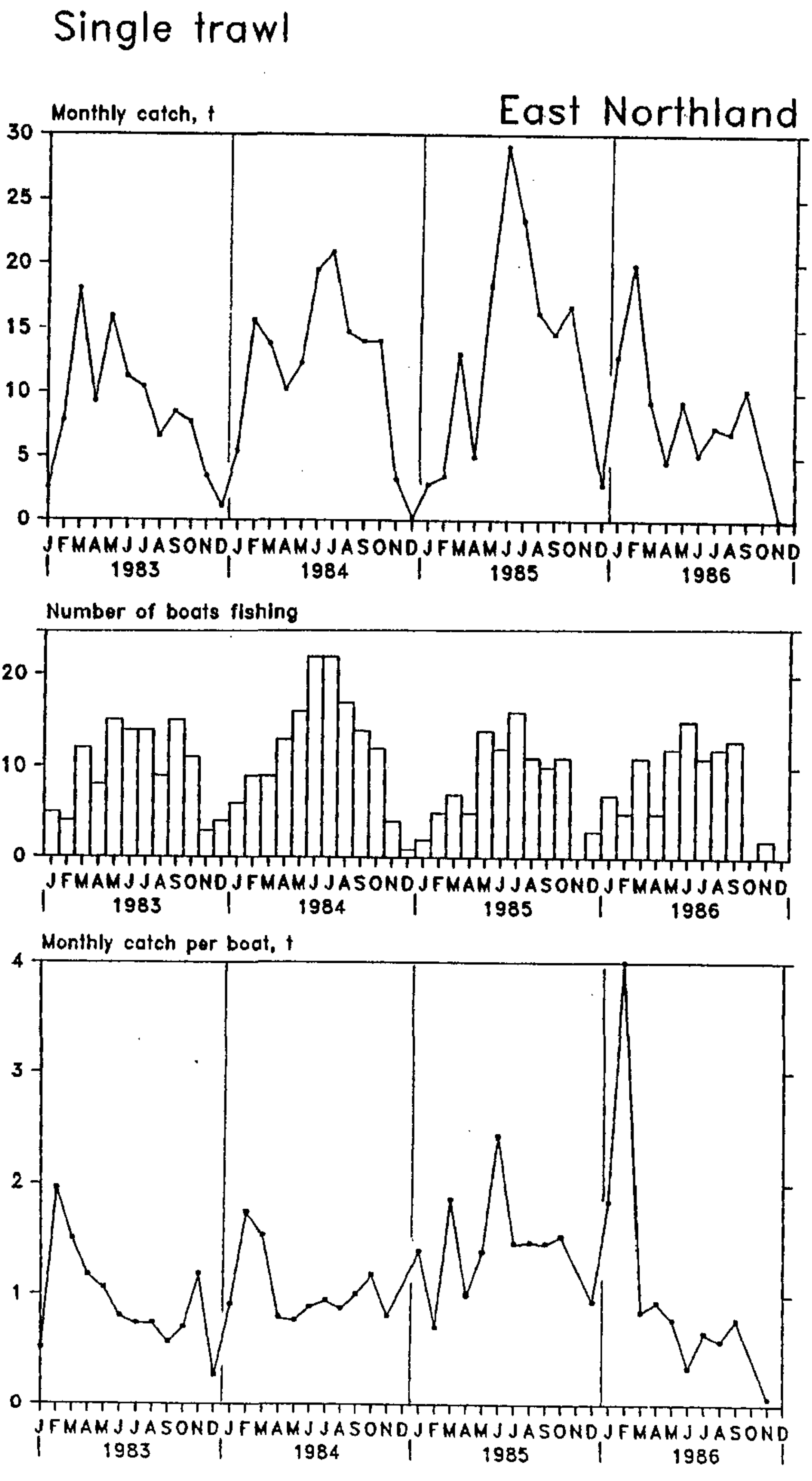

Fig. 13: Snapper catch, effort, and CPUE (t) for the east Northland single trawl fishery, by month, 1983-86. Fishing return areas 2, 3. Data from FSU.

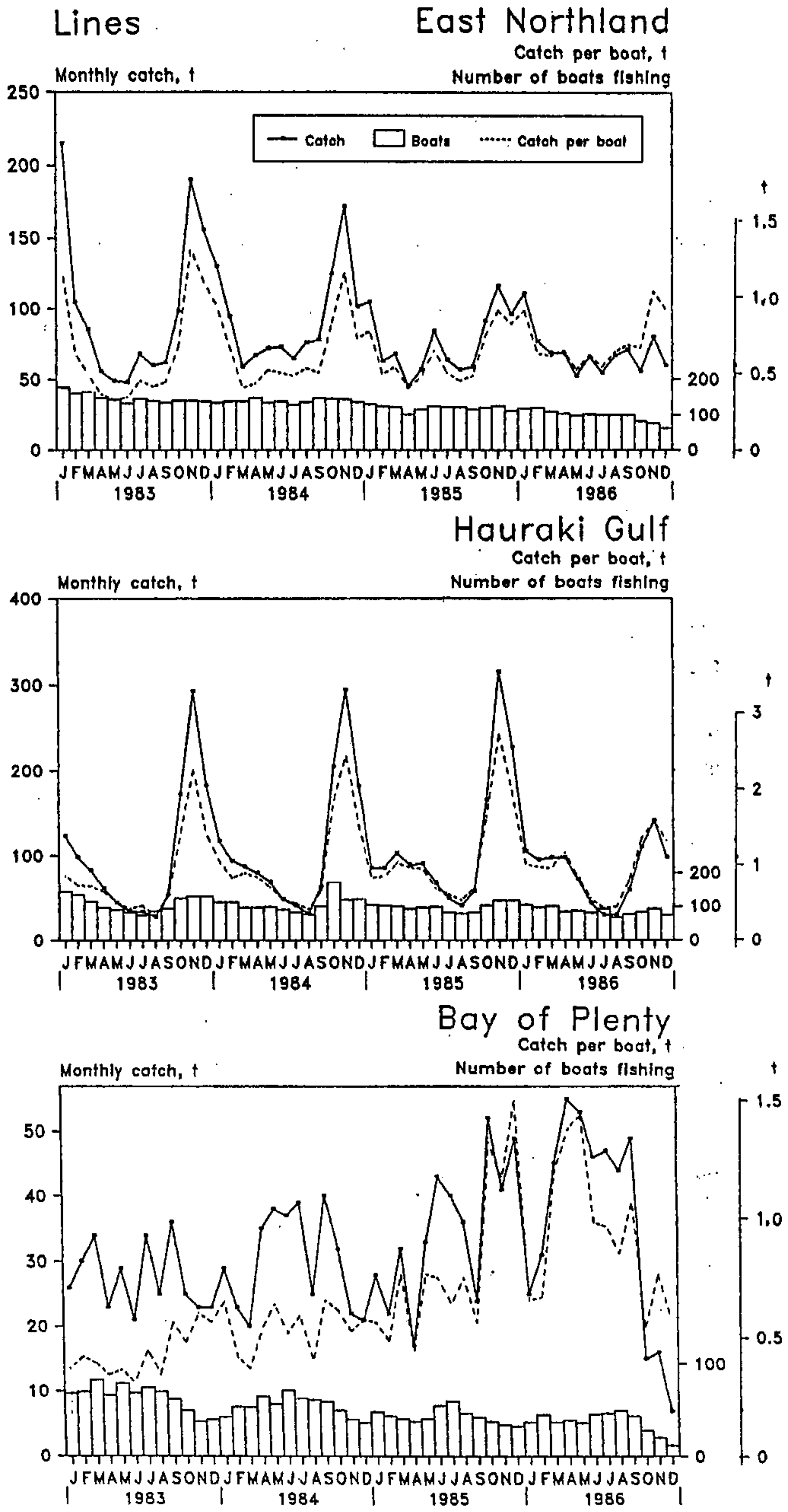

Fig. 14: Snapper catch, effort, and CPUE (t) for the east Northland, Hauraki Gulf, and Bay of Plenty longline fisheries, by month, 1983-86. Fishing return areas 2, 3; 5, 6, 7; 4, 8, 9, 10. Data from FSU.

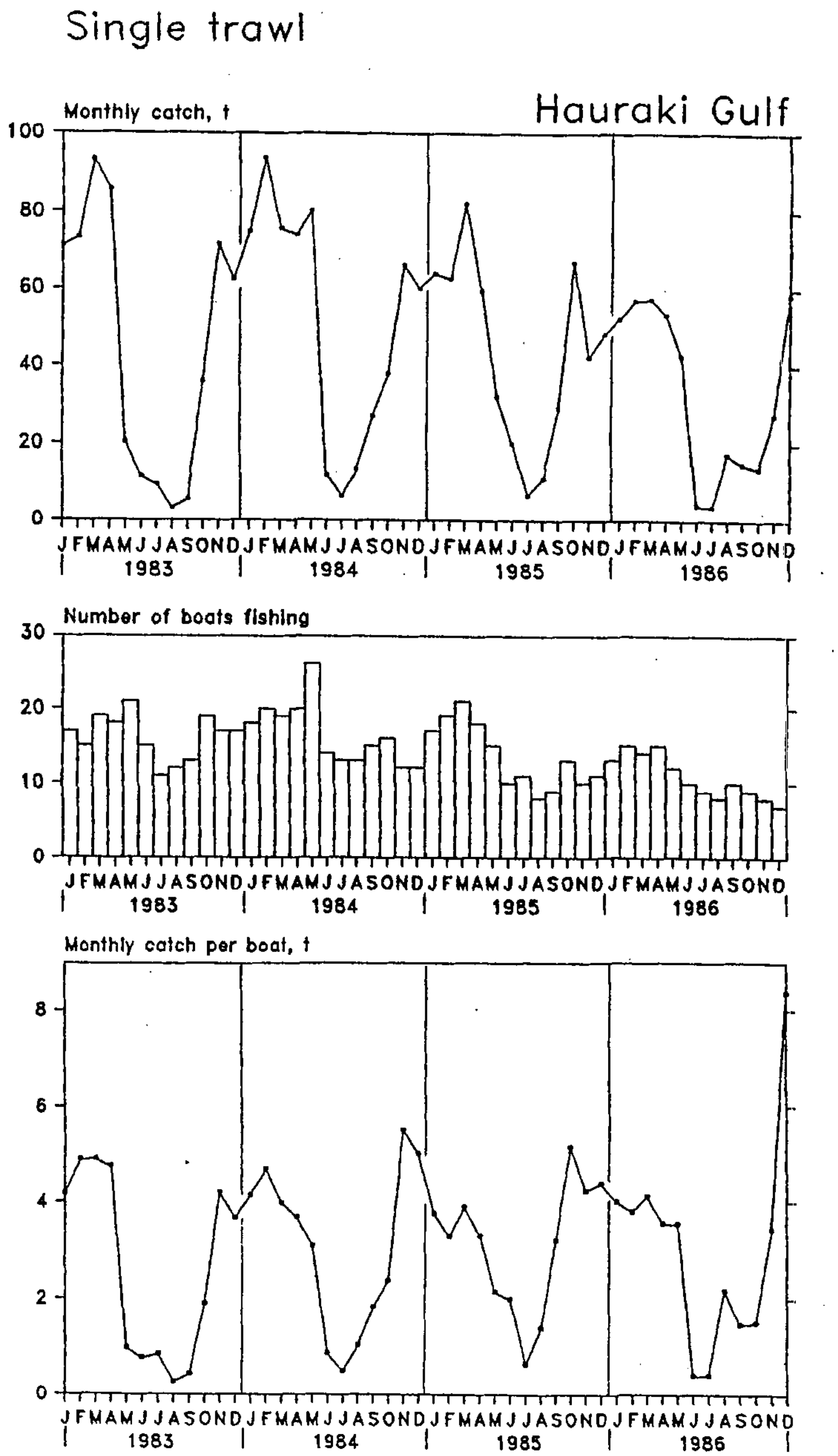

Fig. 15: Snapper catch, effort, and CPUE (t) for the Hauraki Gulf single trawl fishery, by month, 1983-86. Fishing return areas 5, 6, 7. Data from FSU

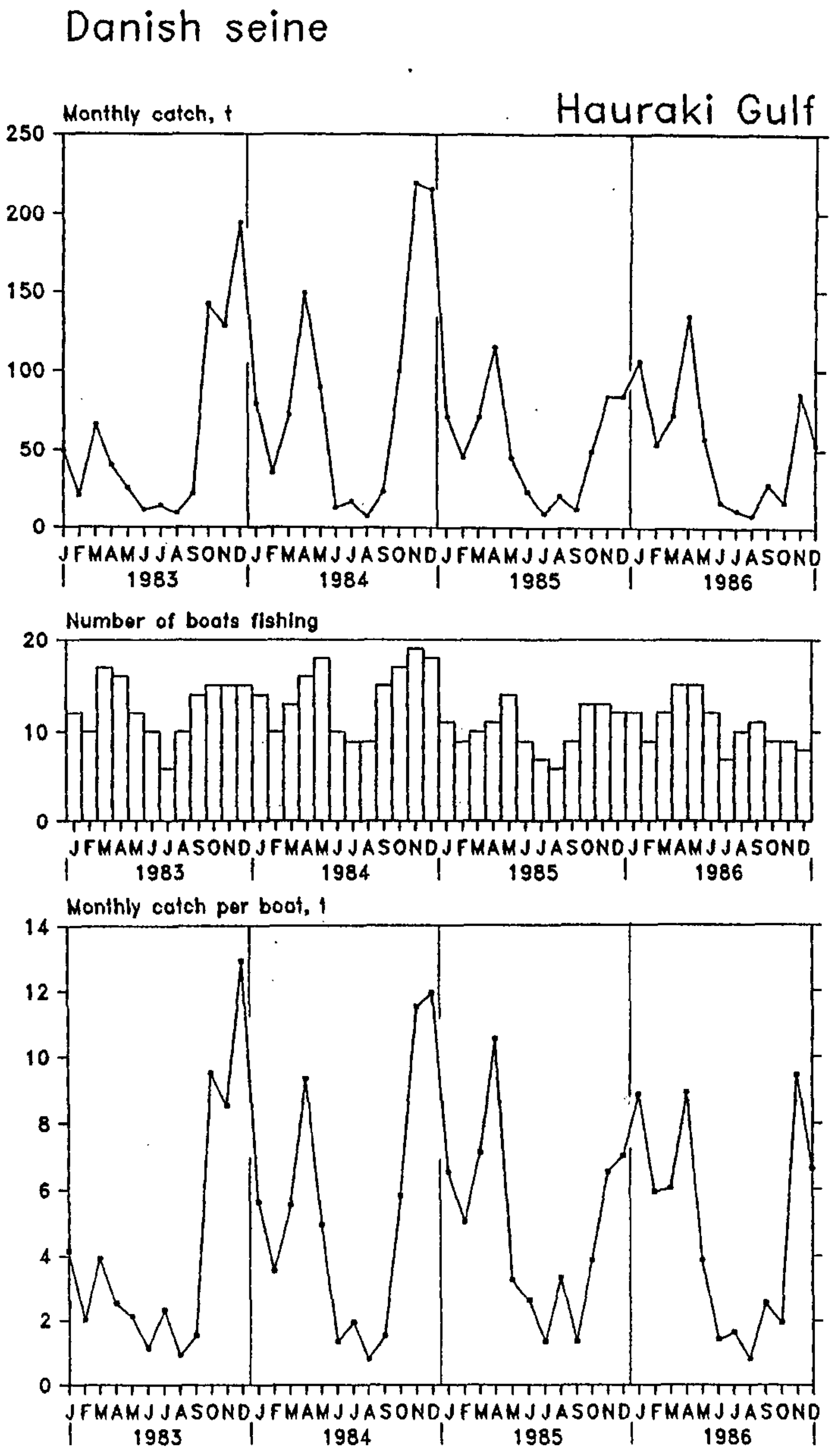

Fig. 16: Snapper catch, effort, and CPUE (t) for the Hauraki Gulf Danish seine fishery, by month, 1983-86. Fishing return areas 5, 6, 7. Data from FSU.

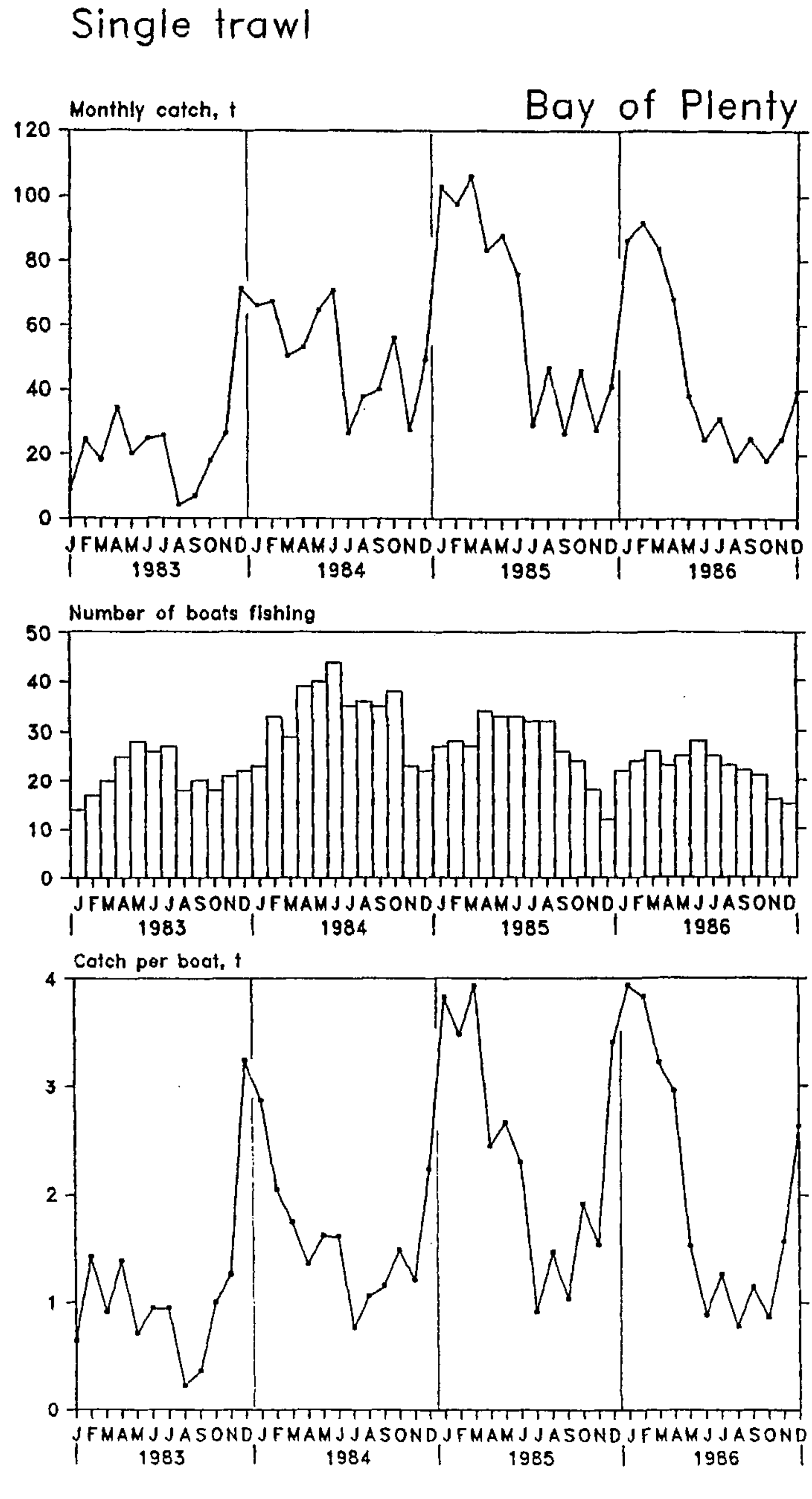

Fig. 17: Snapper catch, effort, and CPUE (t) for the Bay of Plenty single trawl fishery, by month, 1983-86. Fishing return areas 4, 8, 9, 10. Data from FSU.

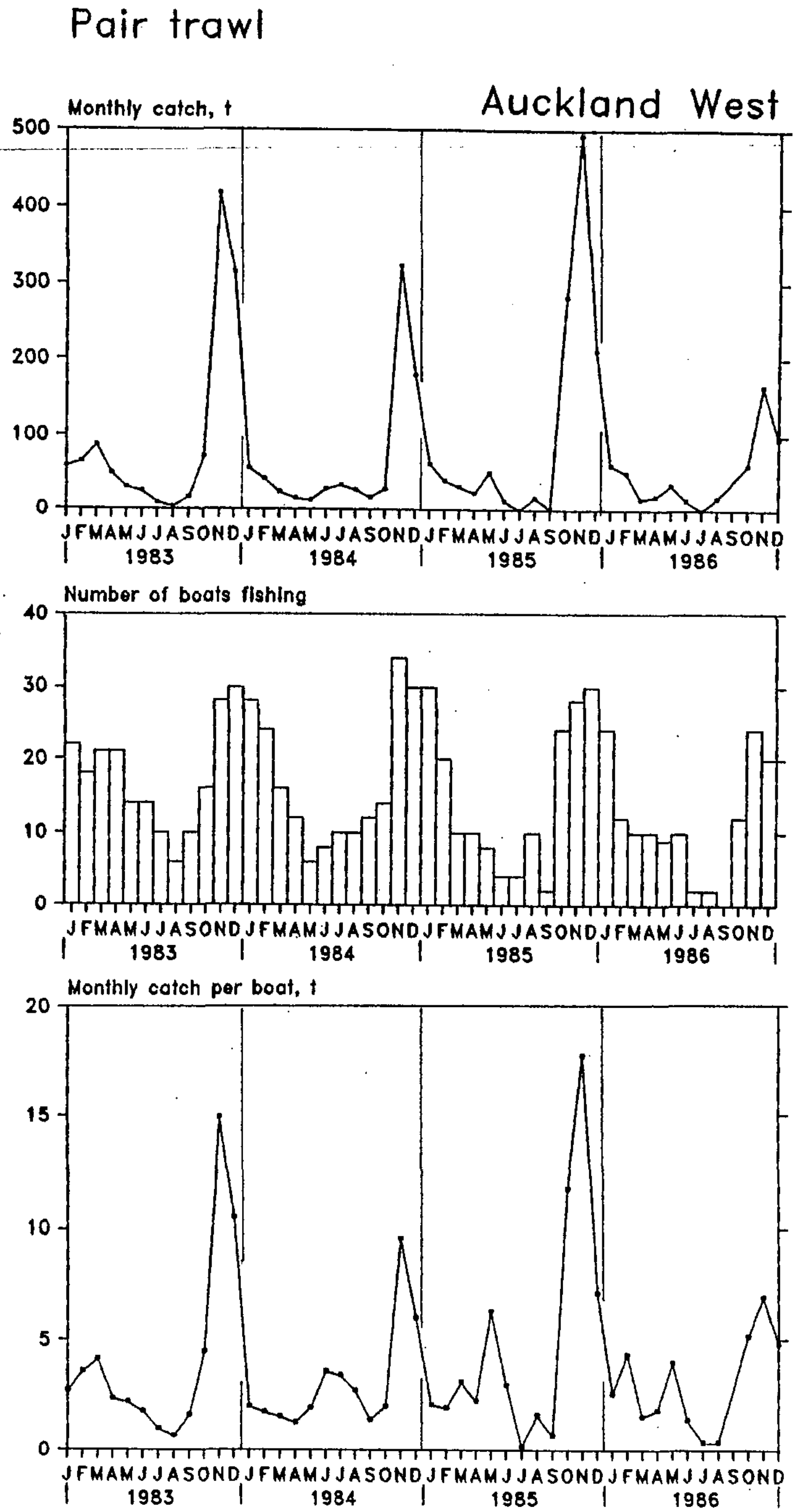

Fig. 18: Snapper catch, effort, and CPUE (t) for the Auckland West pair trawl fishery, by month, 1983-86. Fishing return areas 42, 45, 46, 47. Data from FSU.

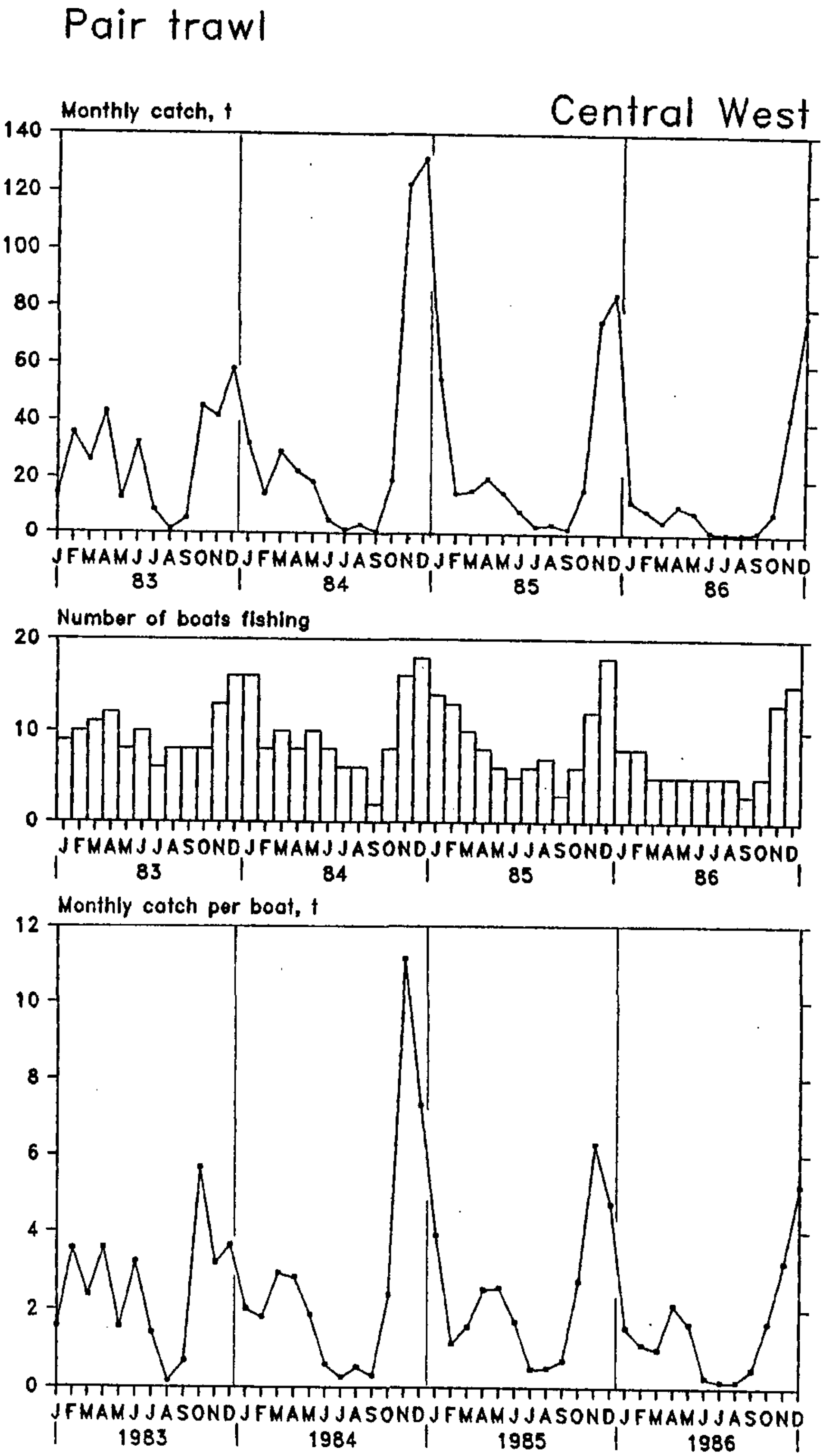

Fig. 19: Snapper catch, effort, and CPUE (t) for the Central West pair trawl fishery, by month, 1983-86. Fishing return areas 40, 41. Data from FSU.

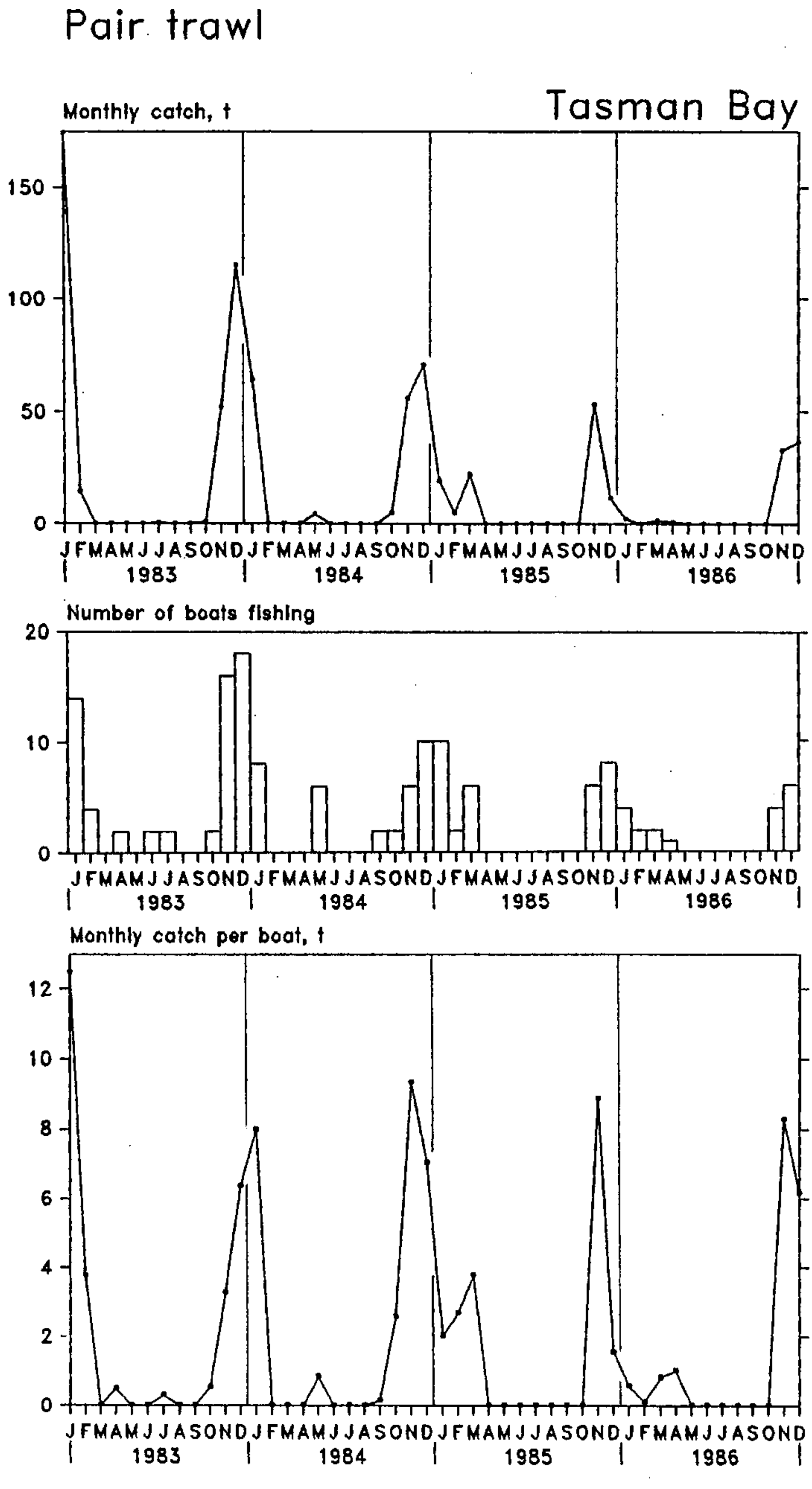

Fig. 20: Snapper catch, effort, and CPUE (t) for the Tasman Bay pair trawl fishery, by month, 1983-86. Fishing return areas 35, 36, 37, 38. Data from FSU.