New Zealand Fisheries Assessment Research Document 88/27

School shark

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SCHOOL SHARK

(*Galeorhinus galeus*)

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1. INTRODUCTION

1.1 Overview

This document reviews the New Zealand school shark fishery, with particular reference to recent trends in the main regional fisheries, including CPUE data for 1983-87. It comments on deficiencies in the available catch data, and our relatively meagre information on the life history of this species. It then describes the derivation of yield (MCY) estimates, and concludes with a summary of those interrelated research and management issues which are relevant to the question of sustainable yields.

1.2 Fishery

This is now one of New Zealand's moderately important coastal fisheries. Some 3000-5000 t of school shark has been taken annually in recent years. The species reached sixth place in terms of landed weight in the domestic fishery in 1984, but has since receded because of a decline in catch and a shift by the fleet towards other, largely deeper water species. More recent comparisons are misleading because the fleet now contains large chartered trawlers, but provisional landing figures for 1986-87 (QMRs) place school shark 18th (at just under 2000 t) of all species under quota, but about 10th in terms of New Zealand's traditional coastal species.

Although these landings are not large, the school shark fishery is significant in being quite evenly distributed around New Zealand, helping support many fishermen. It has constituted a significant management problem in recent years, because from the late 1970s onwards fishing effort was being redirected into this fishery as stocks of other, traditionally more popular coastal fishes declined. Catches during the early 1980s were probably higher than could be sustained, but it was - and remains - difficult to find good fisheries data to support this.

Total reported landings in 1983-85 were almost twice the estimated yield values, resulting in severe reductions in catches in order to meet the TACs gazetted in 1986. These required cutbacks were greatest in northern and central New Zealand. Trawl surveys indicated a reasonably large dispersed stock offshore from southern New Zealand, which meant that catches here were more likely to be sustainable at recent levels.

School shark are believed to migrate considerable distances, which makes the concept of discrete stocks unlikely. However, heavy localised fishing is known to be capable of over-fishing shark populations in general, so it has been deemed prudent to manage school sharks on a regional basis. The FMAs, which in general now equal the QMAs, have been used as management units. There are difficulties with the boundary lines around Cook Strait, so in this paper some analyses of the data use alternative regions.

1.3 Research

There has been little detailed research on school shark in New Zealand. Olsen (1984) has reviewed the species biology and fishery in Australia, and much of this knowledge is probably applicable here. Most New Zealand references contain only repetitive fragmentary or generalised information. Material that is relevant to understanding and managing the fishery is summarised in recent TAC Background Papers (Seabrook-Davison *et al.* 1985, Paul and McGregor 1986, 1988). Work in progress includes some tagging to determine migrations, and hence stock boundaries (if any), and examination of catch rates in the fairly new and important southern South Island fishery.

The name *Galeorhinus galeus* is used here, following Compagno (1984). Most recent accounts have used *G. australis*, but this Australasian species is now believed to be simply a southern form of the widespread *G. galeus*.

2. THE FISHERY

2.1 Inshore Domestic

2.1.1 Total catch

Recorded landings start in 1945 (Fig. 1), but are quite misleading until at least 1955. This first fishery was largely for liver-oil; the livers were landed and the majority of fish carcasses discarded at sea. From the late 1950s to the early 70s some 300-500 t was reported landed annually, but because of poor keeping qualities and low demand considerable quantities were still discarded at sea. There were some successful small fisheries, with line vessels landing their catch daily either into the local fish-and-chip retail trade or for processing and export to Australia. The flesh mercury-level scares in 1972 and 1978 were also likely to have depressed both actual and reported shark landings. For all these reasons, the apparently steep rise in landings from 1980 onwards is almost certainly an exaggeration of the real trend in catches.

Considerable caution must be exercised when interpreting these historical landings data. Over the years there has been varying inclusion of other shark species in the figures; mako are sometimes mentioned, but rig are known to have been included (in 1973 the entire rig catch was officially combined with school shark), and there is a strong probability that small trimmed hammerhead and bronzewhaler carcasses have been landed as school shark. There have also been inaccuracies and anomolies in the recording of landed state (trimmed or whole)= green)) and in conversion factors used.

Landings rose steeply from 1979 to 1984. The 1985 landings dropped 13% from the 1984 peak, and the 1986 landings were down 33% from 1985. These are in terms of calendar years. In terms of October to September fishing years, introduced in 1983(-84), the decline from 1983-84 to 1986-87 is even more marked (provisional data in Fig. 1). Catches dropped 6% in 1984-85, 17% in 1985-86, and 48% in 1986-87. The latter presumably reflects the introduction of reduced individual quotas in October 1986.

2.1.2 Catch by method

This has traditionally been a target longline fishery, with some school shark taken as a by-catch by trawlers. Target set netting for the species became important in the late 1970s, but reliable data on catch by method during this period are not readily available. From 1983 set netting has been the dominant method (Fig. 2), providing just over half the total catch. Lining contributes about one-third, and the trawl by-catch about 15%. There are, however, large variations to this in different regions. Around south-east and southern New Zealand netting is dominant at over three-quarters of total landings, whereas along the eastern North Island, through Cook Strait, and down the western South Island line fishing is most important at about half the catch.

2.1.3 Catch by area

The school shark fishery is most important in the west and south (Fig. 3). Of the mean 1983-86 landings, 38% came from the Central (Egmont) and Challenger regions, and 32% from the South-east Coast and Southland regions. Provisional 1986-87 QMR data show a similar pattern. The distribution of landings by FMA/QMA is given in Table 1, together with the percentage declines in recent years.

Catch by fishing area is only readily available from 1983 onwards. For longer time series of regional catches reference must be made to port landings (Table 2). The most useful period is from the mid 1970s (Fig. 4). With relatively few exceptions all regions, and their major ports, show similar trends in catch over time.

2.1.4 Catch by season

There is a strong seasonal pattern in the total New Zealand landings of school shark (Fig. 5), with peak landings in summer (Dec-Feb) declining to a low in late winter or early spring (Jul-Sep). This must partly be due to the increased abundance and availability of school shark in coastal waters during the warmer months, particularly of mature females moving inshore to release their young. It must also be influenced by the seasonal shift that many fishermen make into alternative fisheries, e.g. those for rock lobster, dredge oyster, etc., and by the generally diminished fishing effort during winter. As a result, reported fishing effort associated with school shark landings varies seasonally, and catch and CPUE values trend fairly closely together (see section 2.2).

There is some regional variation in the timing and extent of this seasonal variation in catches (Fig. 6). On the north-west coast the peak catches generally occur one or two months earlier than elsewhere, perhaps reflecting an earlier inshore movement of females. In both northern regions (i.e. the north-west and north-east coasts of the North Island) the seasonal variation in catches is less marked than in central and southern regions. It is tempting to suggest that the sharks are more regularly present throughout the year in northern waters, and only seasonally present or available in the south, but other factors (e.g. weather, alternative fisheries) must also be considered. No conclusions are possible at present. The relatively smaller catches on the west coast of the South Island are less regularly seasonal.

These total school shark catches combine target line and net fisheries with by-catches in the domestic trawl fishery. It is more appropriate to look for seasonal trends in the main regional line and net fisheries separately (Figs 7,8).

North-west lines. The north-west line fishery (Fig 7, top) has a strong single or double summer peak in landings, which has varied in strength during the years shown. Closer analysis shows that this region has two shark fisheries: one in Kaipara Harbour based largely on mature females, and a coastal one around Cape Egmont probably based on a more varied population (but there are no data). The Kaipara fishery has a regular but slowly declining summer (Dec-Feb) peak, probably reflecting traditional fishing activity. The Cape Egmont fishery generally peaks in the warmer months, but is more irregular and probably results from erratic fishing effort. Both fisheries contribute to the drop in landings which sometimes occurs in January; this reflects a drop in effort (probably because of holidays).

Cook Strait lines. The shark fishery in and around Cook Strait (Fig. 7, centre) is strongly seasonal, peaking in Dec, Jan, or Feb, with a low in May to Sep.

South-west lines. The smaller line fishery along the west coast of the South Island (Fig. 7, lower) has quite irregular peaks, which may reflect the variety of seasonally alternative fisheries that fishermen from this region participate in.

Four regional net fisheries are shown in Fig. 8.

North-west nets. The north-west net fishery is less seasonal than the line fishery in this area, but higher catches do generally occur over the warmer months, with a decline in winter. The Kaipara Harbour net fishery is more distinctly seasonal, peaking in Nov, Dec, or Jan (paralleling the line fishery here).

Cook Strait nets. The Cook Strait net fishery is similarly less clearly seasonal than the equivalent line fishery, but does decline each winter (Jul-Sep). A significant part of the catch (about half) comes from the Kaikoura area where the net fishermen have a number of target species (rig, tarakihi, kahawai, ling, gropers, moki) of similar or greater importance than school shark. Their fishing season is presumably relatively longer than elsewhere, and they take school shark as a useful by-catch over a longer period.

South-west nets. The net fishery on the South Island's west coast is smaller, and has similar but more erratic seasonal trends in 1983-84, but only slight indications of a seasonal pattern subsequently.

South-east nets. The south-eastern net fishery, from Banks Peninsula to Fiordland, has a very strong seasonal pattern, with peak landings in summer and sometimes autumn. The causes for this have not been investigated but may include: fishermen switching to the alternative lobster and oyster fisheries, school shark migration and seasonal abundance within this region, and weather limitations on the southernmost grounds. Subdivision of this large area into smaller fisheries might be useful in future analyses.

In the regional line and set net data (Figs 6-8) as well as the total New Zealand combined methods data (Fig. 5) the seasonal patterns apparent from 1983 to mid-1986 disappear in 1986-87. This results from the introduction of the ITQ system in October 1986; fishermen generally had lower shark quotas, their traditional patterns of fishing very probably changed under the new management system, and they were required to report their catches through the new QMS/ITQ system making inadvertent under-reporting through the older FSU system likely.

Under-reporting has always been a problem in this fishery, and the succession of different reasons for this, and the changing levels of catch understatement, have made stock assessment (of necessity based largely on the reported level of regional catches and landings) particularly difficult.

2.2 Catch per unit of effort

The CPUE analyses presented by Seabrook-Davison *et al.* (1985) for some regions for the years 1976-83 (see Fig. 4, Paul and McGregor 1986) are not easy to interpret. Some regions show declining catch rates, some show stable catch rates, and in others the catch rate is rising. Interpretation of the true fishing effort directed at school shark is difficult because:

1. School shark are available year-round in some areas, but only seasonally in others.

2. New grounds are progressively being located and worked.

3. Many fishermen are only "part-time" shark fishermen, seeking school shark only seasonally or intermittently, generally in off-seasons for other species.

4. School shark are taken incidentally in other target fisheries.

Other problems arise because of changes in the recording system. For pre-1983 data CPUE analysis must still be compiled manually from fishermen's monthly returns. Data from 1983 onwards are on the FSU computer file. A good knowledge of regional fishing trends is required for proper interpretation of both data sets.

Pressures within the fishing industry must also be considered. The 1983-85 data, in particular, are from a volatile and difficult time in New Zealand's coastal fishery (notable events have included a moratorium on licences, the removal of most part-time fishermen from the fishery, and the development of the individual transferable quota (ITQ) concept). Cynics have remarked on the likelihood that fishermen who underreported in the past (to avoid tax, levies, and paperwork in general) now had some incentive to overreport (to establish a good fishing history on which future personal quotas could be based); it is difficult to judge how true this might be. The ITQ system itself, introduced in 1986, may also hinder interpretation of CPUE values by further altering effort patterns, and the Quota Monitoring System (a new administrative system of reporting commercial catches) may also influence the level of recorded landings.

Despite these difficulties, some progress is being made in understanding the school shark fisheries off southern and south-eastern New Zealand:

Canterbury Bight; Much of the catch is taken as a by-catch by trawlers, and catch rates are therefore not easily interpreted; the rest is taken by a set net fishery during summer. Peak catches over the last 7 years (1978-85) have remained reasonably stable (McGregor, unpublished data).

Southland FMA; Peak catch rates in the set net fishery during the 3 years 1983-85 appear to be steady, but at a slightly lower level than in 1981 and 1982, when the fishery was new, the fishing season was shorter, and fewer boats were fishing (see Fig. 6 in Paul and McGregor 1988).

A more general analysis has been made of monthly CPUE trends in three of the larger regional fisheries: the south-eastern net fishery (which incorporates the Southland fishery described above but covers a larger area); the Cook Strait net fishery; and the Cook Strait line fishery. The data used are the monthly catch and effort by method values from the FSU data base from all vessels reporting school shark landings, and are thus influenced to an unknown extent by the inclusion of vessels targetting considerable effort at other species and making small by-catches of school shark. Effort is shown here as the number of boats fishing which report school shark in their catch; the alternative measure of number of days fished (not shown) gave an almost identical pattern.

South-east nets. Canterbury, Otago, and Southland, areas 20-32 (Fig. 9). The seasonal trends in catch (top) generally seem to follow the trends in effort (centre), with both peaking in summer but not necessarily in the same month. The CPUE measure (catch-per-boat, bottom) is more sensitive, however, and shows a more variable seasonal pattern, with the CPUE trend sometimes paralleling that for catch, and sometimes moving in the opposite direction. The only generalisation (although it is not strictly true for all years) is that CPUE is lowest in Oct-Nov, at the beginning of the main fishing season, and then rises during the season to peak some months after the season has finished. There is only a weak positive correlation between monthly catch and CPUE (see Fig. 12). There are probably a number of reasons for this, related to the behaviour of fishermen as well as the abundance of fish. It would be preferable to remove from analysis the catch and effort from boats which work only part-time or do not target school shark, but this has not yet been done. There is some indication of a small overall increase in CPUE from 1983 to 1986, as previously noted for the Southland fishery (Paul and McGregor 1988, Fig. 6). The 1986-87 drop in catch seems largely due to the decline in effort.

Cook Strait region, nets. South Taranaki Bight, Tasman Bay, and southern Wairarapa to Kaikoura, areas 15-18, 37-39 (Fig. 10). The seasonal trends in catch (top) closely follow the trends in effort (centre), with a relatively long, usually bimodal season from spring to autumn followed by a low in late winter (Jul-Oct). The seasonal fluctuations are less marked than in the south-east net fishery. The CPUE values (bottom) follow the catch trend fairly closely, although there are some erratic winter peaks in 1985, 86, and 87 which are probably spurious artefacts of low nominal effort. Apart from these, there is a strong positive correlation between monthly catch and CPUE (see Fig. 12). There is an increase in CPUE from 1983 to 1985, followed by a slight decline in 1987; this decline is less than the drop in catch or effort, which suggests that the more efficient boats stayed in the fishery after the introduction of ITQs.

Cook Strait region, lines. South Taranaki Bight, Tasman Bay, and southern Wairarapa to Kaikoura, areas 15-18, 37-39 (Fig. 11). There are very strong seasonal trends in catch (top), with a peak in spring-summer and a low in winter. The trend in effort is fairly similar, although nominal effort increases during each season as the catch is falling; this produces a high CPUE at the beginning of each season

(Nov-Feb) with a subsequent decline during the summer and autumn. This pattern changes in 1986, probably because of the introduction of the ITQ scheme in October. The winter low is much less pronounced, probably reflecting a continuation of moderate fishing activity right up to the imposition of quotas (to some extent shown by the effort data, centre). The 86-87 summer peak barely materialised, undoubtedly for several reasons (e.g. the Cook Strait school shark quota was set lower than recent catches, and fishermen who had little or no school shark ITQ would have been strongly tempted to either dump or under-report it). There is a strong positive correlation between monthly catches and CPUE (see Fig. 12), with an interesting change in 1986. In the July 86-June 87 year a higher mean monthly CPUE was achieved at similar catch levels, suggesting either that the less efficient boats had been retired, or that boats making small catches - perhaps by-catches - were not reporting them. There is a general increase in CPUE from 1983 to 1986. Although this might be taken as showing no change in the school shark stock level, it probably also reflects an increase in experience and efficiency in this relatively new fishery, and a longer retention of the more committed shark fishermen.

2.3 The Deepwater Fishery

School shark are taken in the deepwater trawl fishery around New Zealand, but reliable figures cannot yet be obtained. During the 1970s they were included in the broad category "sharks and rays", or perhaps "miscellaneous". The former category rose from about 500 t to about 1500 t per year, but school shark would have been outweighed by the more abundant spiny dogfish, ghost sharks, skates, etc. In 1978 and 1979 only 11 and 8 t of "shark" was listed (King *et al.* 1985), but this was clearly underreporting. In 1983 there was 450 t of "shark" reported (King 1986); it was listed as school and mako shark combined, but may also have included other species.

The observer teams on deepwater vessels are now gathering better data, but no results are yet available.

2.4 Size and Age Composition of Commercial Catches

No data are available.

2.5 Maori and Recreational Fisheries

School shark (kapeta) were valuable to the early Maori. The flesh was dried for long storage, and the liver oil used in cosmetics, traditional ceremonies, and (mixed with pigments) in painting canoes, houses, and carvings. In northern New Zealand good fishing grounds were jealously guarded, and fishing expeditions were attended by great ceremony and enthusiastic rivalry. A vivid account of such an expedition to Rangaunu Harbour was given by Matthews (1911) and summarised again by Keene (1963) and Orbell (1985). From the quantity reported caught it is clear that school shark must have been a staple food item at times, and in dried form they are likely to have been traded with inland tribes. Many accounts of Maori life mention "shark", and much of this was undoubtedly school shark.

Although not universally sought by recreational fishermen, school shark are regularly caught. Some are undoubtedly discarded, but they are increasingly being accepted as a food fish. There are periodic "shark fishing" contests by fishing clubs, with school shark (with rig and spiny dogfish) being a major catch component. They are recognised gamefish (as tope), and there appears to be increasing interest in seeking record light-tackle catches (Feldman 1987). However, there are no data on the size of the recreational catch, and there are big regional and local variations in the attitude of recreational fishermen to school shark.

3. RESEARCH

3.1 Stock Structure

No data.

3.2 Resource Surveys and Biomass Estimates

There has been no research effort directed specifically at school shark, but trawl surveys (for other target species) have been used to establish or modify some regional yield estimates. The available information was presented by Paul and McGregor (1988), and a summary of available trawl survey data is presented in Table 3.

3.2.1 Stewart-Snares shelf

Some results of southern trawl surveys, summarised by Seabrook-Davison *et al.* (1985), were used in establishing the Southland FMA TAC of 600 t. The highest mean doorspread-wingspread biomass estimate (8730 t) from four *Shinkai Maru* surveys was chosen as the basis. The two surveys in 1986, one by *Shinkai Maru* and one by *Akebono Maru No. 3*, gave mean doorspread-wingspread biomass estimates of 17 100 and 9200 t. The higher values for these later surveys are partly accounted for by inclusion of those parts of the Stewart-Snares shelf which are within the 12 mile limit.

3.2.2 Chatham Rise

In 1985 *Akebono Maru No. 73* repeated a 1984 survey around the Chatham Islands. The mean doorspread-wingspread biomass estimate of 1760 t from this survey was higher than the estimate from the 1984 survey (1050 t), but the coefficients of variation (18 and 19% respectively) were such that the difference was not significant. In the 1985 survey the school shark taken were predominantly (96%) males, the females perhaps being further inshore than the 50 m limit of the survey (Hurst pers. comm.), December being the time they drop their young in shallow water. A survey over a larger area of the Chatham Rise in 1986 gave a doorspread-wingspread biomass of 5800 t.

3.3 Other Studies

3.3.1 Tagging

Relatively small numbers of school shark have been tagged in New Zealand, chiefly to determine the extent of migration between different fishing grounds. Results from a project concentrating on the Stewart-Snares shelf in 1986 and 1987 showed that school shark are very mobile, most moving moderate distances within the area. Other individuals have moved substantial distances up and down the east coast of the South Island, one has moved north to Tory Channel in Cook Strait and another to north of Cape Egmont.

4. MANAGEMENT IMPLICATIONS OF RECENT STUDIES

4.1 Background to the Yields and TACs, 1985-87

Most of the yield estimates for school shark have been based on trends in the recorded regional landings, there being little other information. It is appreciated that there are two important but unavoidable difficulties with this approach: (1) These recorded landings are often not reliable records of the quantities of fish actually caught, and (2) For some areas there has been only a short recent period of intensive fishing.

In general terms, yields were assessed at about half the level of recorded 1983 catches, as a somewhat generous compromise between the known historical level of sustainable landings (see Fig. 1) and the period of high landings in the early 1980s (see Fig. 4). Other considerations included the apparent size of potential fishing grounds in each area, and (for southern areas) some trawl survey biomass estimates on offshore grounds and the potential for migration to coastal waters.

There was also a general caution derived from studies of shark fisheries elsewhere in the world (e.g. see Holden 1977), where high initial catches have almost always proved unsustainable because of the tendancy for shark stocks to have a low natural productivity (most species have low fecundity and a slow growth rate). If overfished, shark stocks take a long time to recover and rebuild. The productivity of New Zealand school shark has been assumed to be 0.05, or 5% of the recruited biomass, the lowest of the three-step scale listed by Hurst (1985).

The yield estimates for central and northern areas, being based on commercial landing trends, did not include any provision for recreational fishing catches; this is probably immaterial because of all the other uncertainties and sources of error. The yield estimates for southern areas (Southern and Southland-Subantarctic), being partly based on trawl surveys, did take potential recreational catches into account.

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

	Reported landings Oct-Sep fishing years				Yields estimated in			TACs Gazetted for fishing years	
	83-84	84-85	85-86	86-87	1985	1986	1987	1986-87	1987-88
Kermadec	0	0	0		-	-	-	10	10
Auckland:									
East	553	437	392						
West	534	424	395						
[Total	1 087	861	787	418	550	550	550	560	560]
Central:									
East	298	237	214	137	150	150	150	150	160
Egmont	694	698	652	229	300	300	300	310	310
Challenger/Central (Plateau)	1 039	1 030	851	454	460	460	460	470	470
South-east:									
Chatham Rise	8	12	23	19	100	200	200	120	200
Coast	630	505	370	284	260	260	260	270	270
Southland	792	995	647)						
			)	385	600	600	600	610	610
Subantarctic	0	0	0)						
Area not known	228	163	173						
Domestic	4 781	4 501	3 715	1 926 (1 944)		2 520	2 520	2 510	2 590
Chartered	192	0	24	n.a.					
Foreign licensed	0	0	20	n.a.					
Total	4 973	4 501	3 759	n.a.	2 520	2 520	2 520	2 510	2 590

Notes:

Landings for 1983-84 to 1985-86 from commercial fishing returns to FSU.

Landings for 1986-87 from Quota Monitoring System, mostly Quota Monitoring Reports but (1 944 t) total from Licensed Fish Receiver reports.

Landings reported by Chartered and Foreign Licensed vessels almost certainly involve underreporting.

Estimated yields are listed in the 1985 and 1986 TAC background papers as recommended TACs.

4.2 Yield Estimates, and Factors Influencing Stock and Yield Assessments

In the 1988 Fisheries Assessment Meeting a new approach was taken to the estimation of yields, to better accommodate the naturally fluctuating size and production of fish stocks. This produced a two-tier system of yields:

Maximum constant yield (MCY), the maximum constant catch that is estimated to be sustainable at all probable future levels of biomass.

Current annual yield (CAY), the one-year catch which can be taken from a fish stock whose current size is known; in almost all cases this will be higher than the MCY catch, but it will probably vary from year to year. It is calculated by applying a reference fishing mortality to an estimate of the fishable or recruited biomass which will be present during the next fishing year.

4.2.1 Estimation of Maximum Constant Yield (MCY)

There are two methods of determining the MCY for school shark: the level of catches over a period of time when there was little consistent change in fishing effort, and extrapolations from trawl surveys of fish stock biomass.

Catch levels: The requirement is for a sequence of catch data during a period when there has been no consistent change in fishing effort and/or fishing mortality (see Para 6, Report from the Fishery Assessment Meeting April-May 1988, p.10). MCY is then calculated as cY, where Y is the average catch and c is a measure of catch variability and species longevity (0.6 for high variability and short-lived, 0.9 for low variability and long-lived).

For school shark, landings data are available from 1945, but a distinction must be made between catch and landings. Until the mid-50s school shark were mainly caught for their livers (for oil, hence vitamin A) and the fish discarded, and because the livers of several fish species were combined it is almost impossible to determine the level of shark catches. From the mid-50s school shark were caught and landed mainly for food, and although fishing effort undoubtedly varied it probably did so in a random fashion until the late 70s, when it increased sharply. In summary, catches were high but largely unrecorded 1945-55, relatively stable 1955-75, and rapidly rising then falling 1975-86. Under-reporting (for a variety of reasons) has occurred at all times, but is probably less of a problem during the period 1955-75. These years were therefore used for the determination of Y, 360 t. A c value of 0.9 was used for a long-lived species with little catch variation during the period chosen.

$MCY = c\bar{Y}, \quad = 0.9 \times 360, \quad = 325$ t (rounded to nearest 5 t)

Trawl biomass surveys: Alternatively, some biomass estimates from trawl surveys can be used, although the fishing grounds surveyed cover only part of the school shark's distribution around New Zealand. The surveys selected for analysis were restricted to sets which had covered different areas during the same season, to avoid the possibility of double-counting fish which had migrated between these areas. There are four appropriate sets, over the period 1981-86, covering different combinations of the Chatham-Rise, the Stewart-Snares shelf, and the central west coast (northern South and southern North Island). The combined biomass estimates from these areas (using the standard calculation of mean wingspread-doorspread ground coverage) for the four survey sets were 3000, 12 000, 21 000, and 22 000 t. The highest of these values, using the formula 0.5 * M * B (where M = 0.1, and B is less than virgin biomass), gives an MCY of 1100 t for these regions only. It would seem reasonable to double this to account for the other regions which were not surveyed: Canterbury coast, Cook Strait, and most of the North Island, and areas such as that inside the 12 mile limit which were often not included in the individual surveys.

MCY = >1000 t, perhaps 2000 t.

<u>Summary</u>: Because of the recognised underreporting of catches the MCY derived from these is much too low, and the MCY determined from trawl surveys also has severe limitations; together they can be interpreted as indicating a MCY somewhere between 1000 and 2000 t.

4.2.2 <u>Estimation of Current Annual Yield (CAY)</u>

Unfortunately, this is not possible from existing information.

4.2.3 <u>Factors influencing stock and yield assessments</u>

(1) Because the historical catch information is so sketchy it is difficult to estimate how much the school shark biomass has been reduced from its virgin state over the past few decades. This fishery comes close to the category of the worst possible case for determining an MCY, with unreliable landings data over almost its whole history, a recent short period of rapidly increasing fishing effort and catch, and little data on the extent of changes in effort which are known to have occurred.

(2) Information on the same and similar species elsewhere, particularly Australia, show that the school shark is slow-growing, long-lived, with a low fecundity. It is likely to be susceptible to over-fishing, requiring a lengthy period for stock rebuilding. However, its presumed migratory nature is likely to minimise localised over-fishing.

(3) The identity and interdependence of regional stocks around New Zealand is unknown.

(4) School shark have become more important economically to many fishermen in recent years as the stock sizes and catches of more traditional species have declined.

(5) School shark are an unavoidable by-catch in many coastal and offshore trawl fisheries. In some recent years this by-catch approximated the estimated total yield. It should be properly quantified and considered, together with the catch from target shark fisheries, in future yield estimates and TAC allocations.

(6) The extent of present day Maori interest in fishing for school shark is unknown.

(7) Although a listed gamefish and regularly caught by recreational fishermen, the school shark is not a particularly popular species at the present time. There is little public concern at the level of commercial shark fishing.

4.2.4 Other research and management issues

(1) Because of the low fecundity of this species it would be prudent to consider regulations directed at protecting pupping females in shallow water. There is also a significant loss of juveniles taken accidentally in inshore set nets, but it will be difficult to prevent this without disrupting other net fisheries.

(2) There is a restriction on the sale of (mainly large) school shark with a mercury content over 0.5 ppm, which might be influencing fishing, discarding, and reporting practices. This remains an unclear area of fisheries and/or public health enforcement.

(3) More information is required on the level of school shark by-catch in all fisheries, but particularly those operating on the outer shelf and offshore grounds.

(4) More information on the movement of school shark between regions, e.g. from the recapture of tagged fish, could provide the option of reducing the number of management areas. Information on age, growth, and reproduction would be useful in establishing a firmer level of "productivity" for this species. There should be a further effort to analyse the existing CPUE data, looking particularly for serious declines in target fisheries which might indicate over-fishing.

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Table 1. Distribution of school shark landings by Fisheries Management Area, and percentage declines from 1983/84 to 1986/87.

Fisheries Management Area	Proportion of total New Zealand domestic school shark landings (%)				Tonnage decline from previous year (%)		
	1983-84	1984-85	1985-86	1986-87	1984-85	1985-86	1986-87
Auckland East	12	10	11	22	21	10	47
Auckland West	11	9	11		21	7	
Central East	6	5	6	7	20	10	36
Central (Egmont)	15	16	18	12	(+1)	7	65
Challenger	22	23	23	24	(+1)	17	47
South-east Coast	13	11	10	15	20	27	23
Southland	17	22	17	20	(+26)	35	40
TOTAL					6	17	48

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TABLE 2

Table 2. School shark landings (t) by port and FMA (or subdivision of FMA), 1974-86. For earlier data see Seabrook-Dawson et al. (1985, Table 1).

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Hokianga		-*	-*	4	-	-	1	1	13	7	2	10	1
Kaipara	20	13	126	120	2	2	29	36	16	130	180	172	49
Manukau	25	15	26	26	-	50	204	142	136	196	169	124	110
Raglan	-	-	10	3	4	-	1	2	5	9	17	7	10
Kawhia		2	-	6	-	-	2	2	2	11	4	1	4
WEST AUCKLAND	45	30	162	159	6	52	237	183	172	353	372	314	174
Mangonui	19	14	47	52	18	70	304	253	101	290	241	163	145
Whangaroa	1		18	5	-	1	5	17	31	60	78	44	31
Russell	-		-	10	1	1	8	21	10	15	48	18	8
Whangarei	-	8	8	44	2	3	10	21	19	35	50	28	19
EAST NORTHLAND	20	22	73	111	21	75	327	312	161	400	417	253	203
Auckland + Leigh	27	20	55	70	10	51	79	68	71	175	161	158	168
Thames		12	27	20	-	1	7	18	10	33	51	33	11
Coromandel	-	1	1	3	-	-	1	4	-	2	5	4	2
HAURAKI GULF	27	33	83	93	10	52	87	90	81	210	217	195	181
Mercury Bay	-	6	48	119	5	6	13	20	6	83	85	43	36
Tauranga	1	11	6	7	1	2	7	15	51	51	86	71	46
Whakatane	-	2	7	2	1	2	8	17	17	28	28	14	20
BAY OF PLENTY	1	19	61	128	7	10	28	52	74	162	199	128	102
Gisborne	9	4	-	1	5	5	8	68	63	91	89	59	60
Napier	25	21	15	15	6	7	26	26	43	68	87	18	26
Castlepoint	2	4		8	4	5	4	3	5	10	24	9	10
Wellington	15	28	30	13	8	21	41	9	11	69	79	57	62
Makara	-	-	-	-	-	-			-	3	8	7	4
CENTRAL EAST	51	57	45	37	23	38	79	106	122	239	287	150	162
New Plymouth	9	46	46	82	39	31	46	243	132	139	171	161	88
Wanganui	22	24	25	21	5	1	22	165	194	283	532	551	261
Manawatu	-	1	-	43	-	1	1	2	5	5	3	2	1
Paraparaumu	-		8	3	1	-			2	8	3	1	2
Paremata	6	1	1	1	1	1	1		4	3	13	21	17
CENTRAL WEST	37	72	80	150	46	34	70	410	337	436	722	736	369
Pelorus	11	12	45	30	4	24	22	33	37	45	69	79	47
Picton	104	129	106	166	-	25	236	224	439	418	354	386	353
Blenheim	5	10	25	38	1	15	20	19	37	2	31	-	2
Nelson	36	18	68	98	5	35	61	130	98	78	161	75	82
Motueka	5	3	27	6	5	7	15	19	33	54	17	18	5
Golden Bay	-	-	-	10	11	15	33	28	75	26	41	80	78
Westport	2	1	-	2	-	8	8	19	133	167	187	165	147
Greymouth	12	15	24	30	4	-	55	150	296	299	282	298	112
CHALLENGER	175	188	295	380	30	129	450	622	1148	1089	1142	1101	826
Kaikoura	4	10	11	11	-	38	114	166	134	129	178	142	79
Lyttelton	21	18	10	17	9	23	53	88	100	110	127	111	96
Akaroa	4	1	4	4	-	5	16	29	35	40	46	51	16
Lake Ellesmere			-			-		2	1	2	3	-	-
Timaru	29	19	7	4	-	18	76	103	189	169	153	92	77
Oamaru	-	4	4	12		-	5	15	17	49	78	40	28
Moeraki		1	-	-			1	3	5	11	25	10	7
Karitane		2	1	-		-	3	6	8	43	19	12	6
Port Chalmers	12	7	10	8	-	-	21	41	31	59	57	55	61
Taieri Mouth	-	-	-	3	3	-	2	5	2	5	1	1	3
Nuggets					-	1	1	2	2	3	1	1	2
Waikawa	-		1	2	-				1	5	9	4	8
SOUTH-EAST COAST	70	62	48	61	12	85	292	460	525	625	697	519	383
Riverton	-	4	22	84	4	4	113	96	83	73	307	147	90
Bluff + Stewart I	13	22	42	28	1	-	69	227	129	393	557	710	371
Milford				2			35	157	38	20	32	53	8
SOUTHLAND	13	26	64	114	5	4	217	480	250	486	896	910	469
Chatham Is										5	8	13	22
NEW ZEALAND TOTAL	439	509	911	1345	165	479	1787	2715	2870	4005	4957	4319	2887

* less than 0.5 t.

Table 2. School shark landings (t) by port and FMA (or subdivision of FMA), 1974-86. For earlier data see Seabrook-Dawson et al. (1985, Table 1).

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	19
Hokianga		-*	-	4	-	-	1	1	13	7	2	10	
Kaipara	20	13	126	120	2	2	29	36	16	130	180	172	
Manukau	25	15	26	26	-	50	204	142	136	196	169	124	1
Raglan	-	-	10	3	4	-	1	2	5	9	17	7	
Kawhia		2	-	6	-	-	2	2	2	11	4	1	
WEST AUCKLAND	45	30	162	159	6	52	237	183	172	353	372	314	
Mangonui	19	14	47	52	18	70	304	253	101	290	241	163	
Whangaroa	1		18	5	-	1	5	17	31	60	78	44	
Russell	-		-	10	1	1	8	21	10	15	48	18	
Whangarei	-	8	8	44	2	3	10	21	19	35	50	28	
EAST NORTHLAND	20	22	73	111	21	75	327	312	161	400	417	253	
Auckland + Leigh	27	20	55	70	10	51	79	68	71	175	161	158	
Thames		12	27	20	-	1	7	18	10	33	51	33	
Coromandel	-	1	1	3	-	-	1	4	-	2	5	4	
HAURAKI GULF	27	33	83	93	10	52	87	90	81	210	217	195	
Mercury Bay	-	6	48	119	5	6	13	20	6	83	85	43	
Tauranga	1	11	6	7	1	2	7	15	51	51	86	71	
Whakatane	-	2	7	2	1	2	8	17	17	28	28	14	
BAY OF PLENTY	1	19	61	128	7	10	28	52	74	162	199	128	
Gisborne	9	4	-	1	5	5	8	68	63	91	89	59	
Napier	25	21	15	15	6	7	26	26	43	68	87	18	
Castlepoint	2	4		8	4	5	4	3	5	10	24	9	
Wellington	15	28	30	13	8	21	41	9	11	69	79	57	
Makara	-	-	-	-	-	-			-	3	8	7	
CENTRAL EAST	51	57	45	37	23	38	79	106	122	239	287	150	
New Plymouth	9	46	46	82	39	31	46	243	132	139	171	161	
Wanganui	22	24	25	21	5	1	22	165	194	283	532	551	
Manawatu	-	1	-	43	-	1	1	2	5	5	3	2	
Paraparaumu	-		8	3	1	-			2	8	3	1	
Paremata	6	1	1	1	1	1	1		4	3	13	21	
CENTRAL WEST	37	72	80	150	46	34	70	410	337	436	722	736	
Pelorus	11	12	45	30	4	24	22	33	37	45	69	79	
Picton	104	129	106	166	-	25	236	224	439	418	354	386	
Blenheim	5	10	25	38	1	15	20	19	37	2	31	-	
Nelson	36	18	68	98	5	35	61	130	98	78	161	75	
Motueka	5	3	27	6	5	7	15	19	33	54	17	18	
Golden Bay	-	-	-	10	11	15	33	28	75	26	41	80	
Westport	2	1	-	2	-	8	8	19	133	167	187	165	
Greymouth	12	15	24	30	4	-	55	150	296	299	282	298	
CHALLENGER	175	188	295	380	30	129	450	622	1148	1089	1142	1101	
Kaikoura	4	10	11	11	-	38	114	166	134	129	178	142	
Lyttelton	21	18	10	17	9	23	53	88	100	110	127	111	
Akaroa	4	1	4	4	-	5	16	29	35	40	46	51	
Lake Ellesmere			-			-		2	1	2	3	-	
Timaru	29	19	7	4	-	18	76	103	189	169	153	92	
Oamaru	-	4	4	12		-	5	15	17	49	78	40	
Moeraki		1	-	-			1	3	5	11	25	10	
Karitane		2	1	-		-	3	6	8	43	19	12	
Port Chalmers	12	7	10	8	-	-	21	41	31	59	57	55	
Taieri Mouth	-	-	-	3	3	-	2	5	2	5	1	1	
Nuggets					-	1	1	2	2	3	1	1	
Waikawa	-		1	2	-				1	5	9	4	
SOUTH-EAST COAST	70	62	48	61	12	85	292	460	525	625	697	519	
Riverton	-	4	22	84	4	4	113	96	83	73	307	147	
Bluff + Stewart I	13	22	42	28	1	-	69	227	129	393	557	710	
Milford				2			35	157	38	20	32	53	
SOUTHLAND	13	26	64	114	5	4	217	480	250	486	896	910	
Chatham Is										5	8	13	
NEW ZEALAND TOTAL	439	509	911	1345	165	479	1787	2715	2870	4005	4957	4319	

* less than 0.5 t.

Table 3. School shark biomass and yield estimates (t) from trawl surveys

Vessel	Date	Region	12 mile zone included*	Rough ground included	Areas excluded	Biomass estimates†			c.v. (%)	Yield estimates§	Data source¶
						Wing	Door	Mean			
Shinkai Maru	Feb 81	Stewart-Snares-Aucklands		Yes	Puysegur Solander	10 800	2 500[1]	6 700[1]	21	340	a
Shinkai Maru	Mar-Apr 82	Stewart-Snares-Aucklands-Campbell Plateau-Bounties		Yes	Puysegur Solander	3 200	800[1]	2 000[1]	19	100	a
Shinkai Maru	Apr 83	Stewart-Snares-Aucklands		Yes	Puysegur Solander	14 100	3 400[1]	8 800[1]	14	440	a
Shinkai Maru	Oct-Nov 83	Stewart-Snares Aucklands-Campbell Plateau-Bounties		Yes	Puysegur Solander	2 600	900[1]	1 800[1]	33	90	a
Shinkai Maru	Jun 86	Stewart-Snares-Puysegur	Yes			27 800	6 300	17 100[1]	18	860	b
Akebono Maru 3	Nov 86	Stewart-Snares-Puysegur	Yes			14 200	4 100	9 200[1]	31	460	b
Tomi Maru	Dec 80-Feb 81	Central west coast		Yes		19 700	8 600[1]	14 200[1]	11	710	a
Shinkai Maru	Oct-Nov 83	Central west coast		Yes		25 300	6 000[1]	15 700	11	790	a
Shinkai Maru	Mar 83	Chatham Rise		Yes		2 200	500[1]	1 400[1]	34	70	a
Shinkai Maru	Nov-Dec 83	Chatham Rise		Yes		800	300[1]	600[1]	38	30	a
Shinkai Maru 73	Jul 86	Chatham Rise	Yes	Yes		9 600	2 100	5 800	25	290	d
Akebono Maru 73	Dec 84	Chatham Islands	Yes Yes	Yes Yes		1 600 2 200[1]	500[1] 700[1]	1 000 1 500	19 19	50 80	e
Akebono Maru 73	Dec 85	Chatham Islands	Yes	—		2 800[1]	800	1 800	18	90	c

* Rough ground not trawled, but biomass calculated for the entire area assuming equal density of fish on clear and rough ground.
† Biomass figures marked [1] are calculated; others are compiled from the original data sources and rounded to the nearest 100 t; doorspread biomass = wingspread biomass divided by the doorspread-wingspread ratio given in the source documents; mean is the simple mean of both biomass values.
§ Yield estimate is calculated here as 5% of the mean biomass, an assumed low productivity rate, probably characteristic of most sharks.
¶ a, Hurst and Fenaughty (1985); b, Hurst (notes for 1987 TAC meeting); c, Hurst (notes for 1986 TAC meeting); d, Livingston (unpublished data prepared for 1987 TAC meeting); e, Hurst and Bagley (1987).

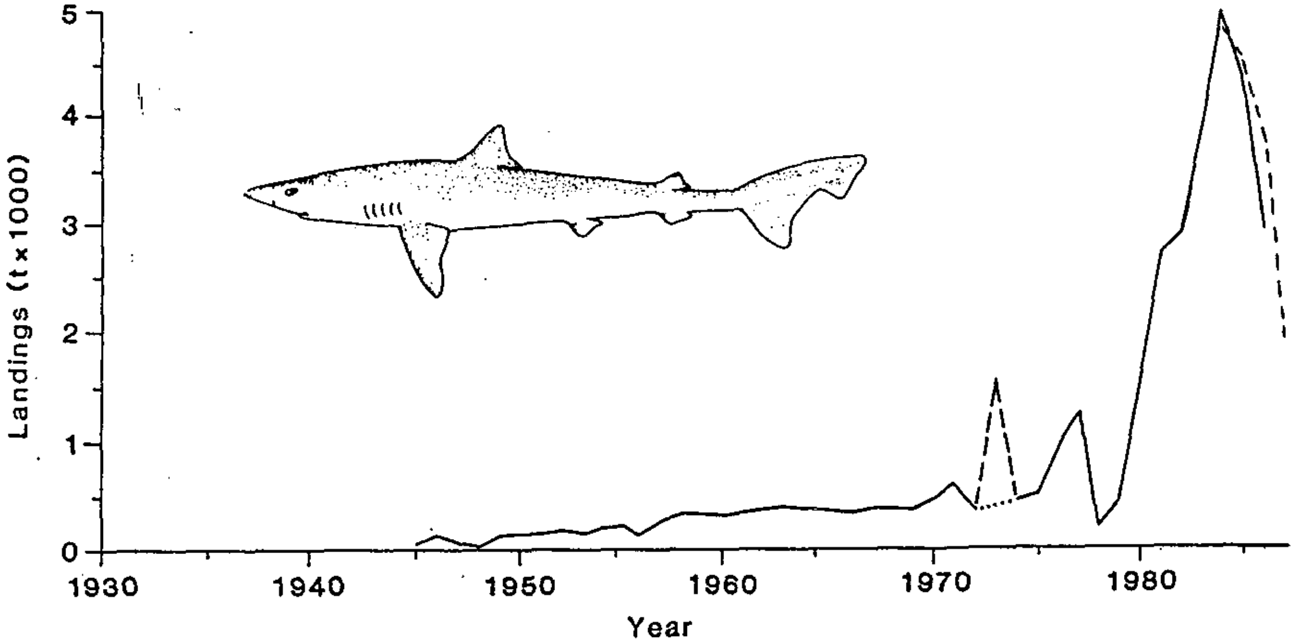


Fig. 1: Total New Zealand landings (t) of school shark, domestic vessels, 1945-87. Calendar years to 1986 (solid line); Oct-Sep fishing years 1983-84 to 1986-87 (dashes) are also shown. 1945-86 data from FSU; 1986-87 provisional value from QMS. Notes: During the liver-oil fishery from 1945 to about 1955 shark catches were much higher than recorded landings. The 1973 peak is false; the value includes rig.

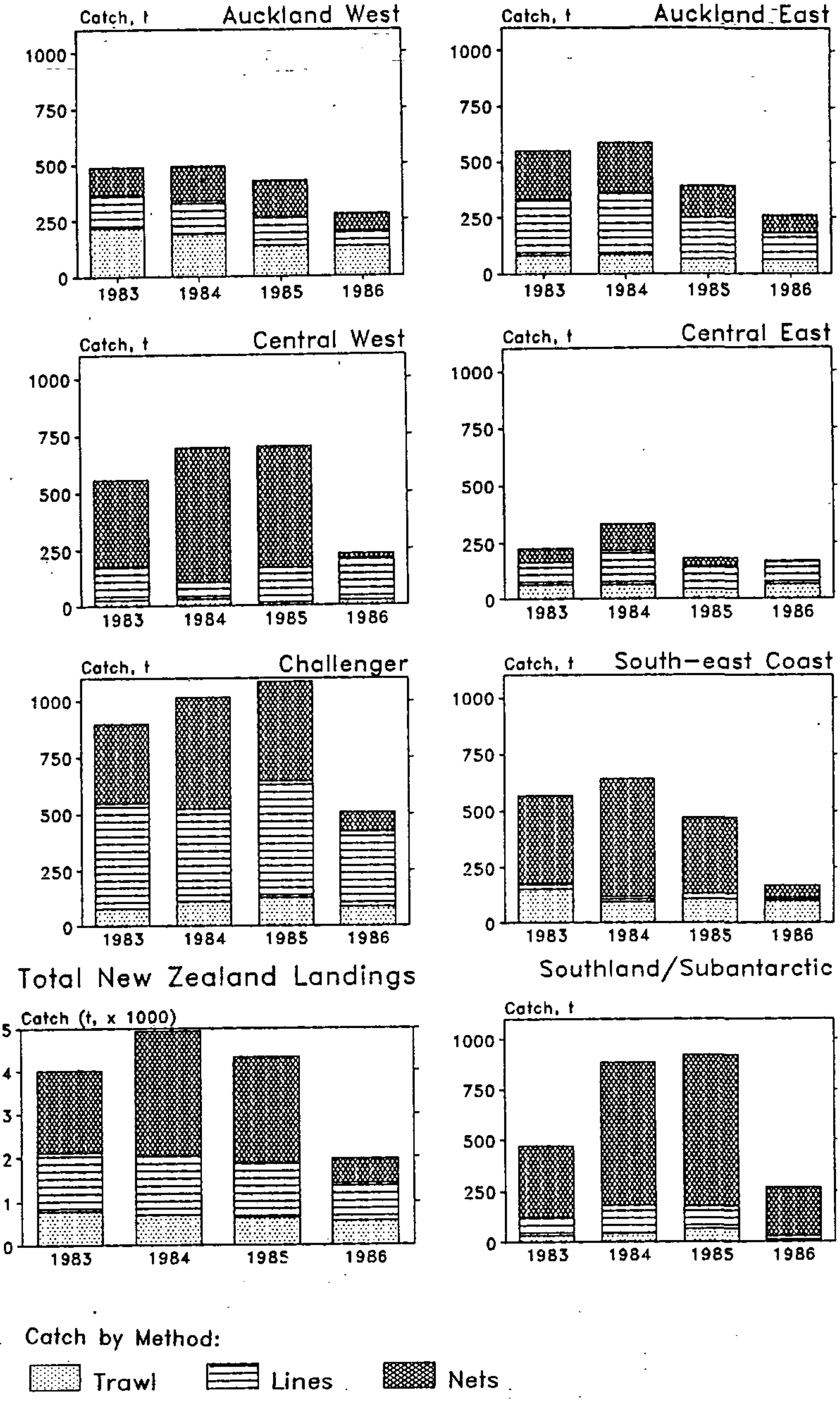


Fig. 2: School shark landings by fishing method, calendar years 1983-86, by Fisheries Management Area or subarea. Also (lower left) total New Zealand school shark landings, including area not known, by method.

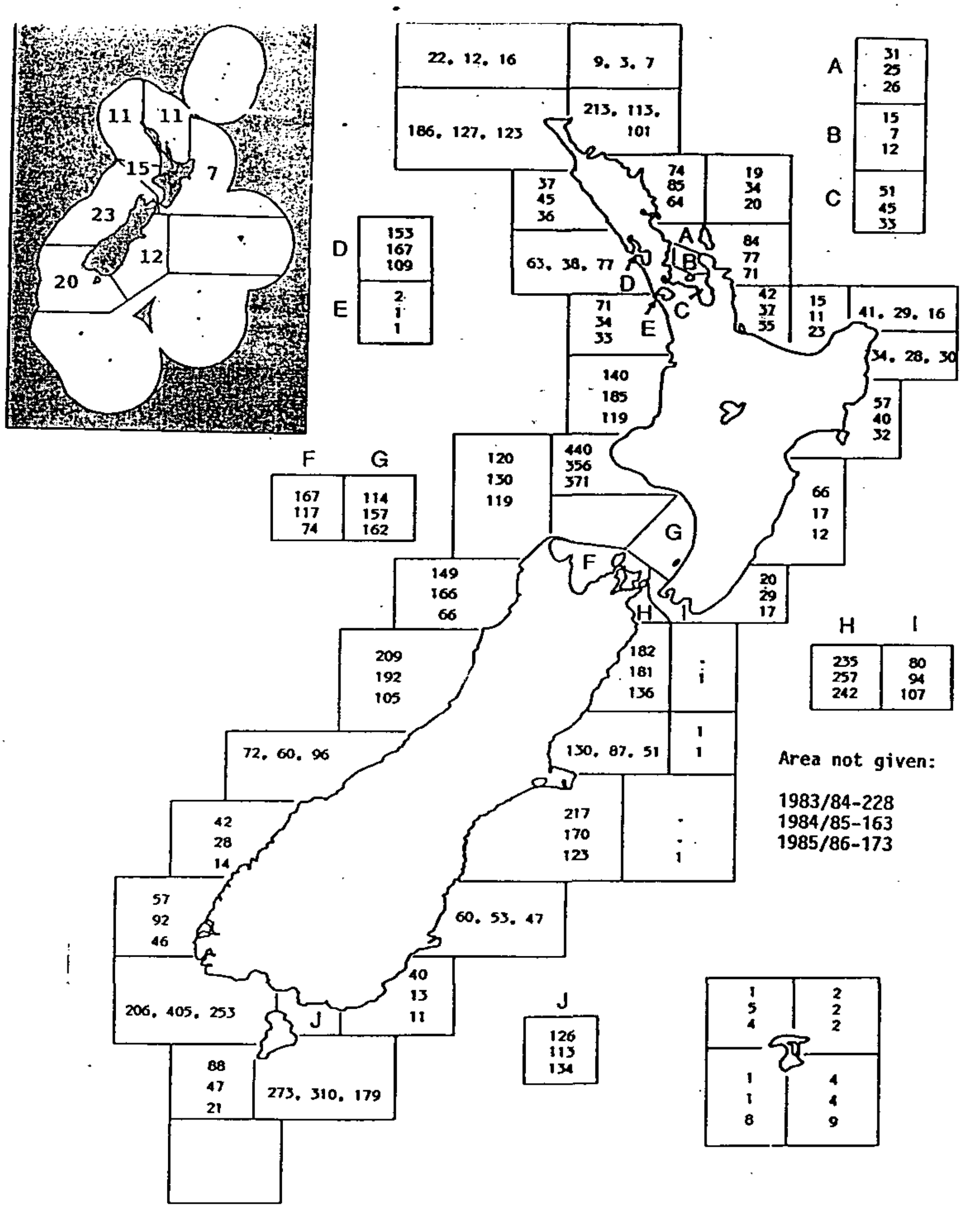


Fig. 3: Domestic landings (t) of school shark for the fishing years 1983-84, 1984-85, and 1985-86, by fishing return area. (Area not known, 1983-84 = 228 t, 1984-85 = 163 t, 1985-86 = 173 t.) Inset (top left): Mean 1983-86 catch (%) by Fisheries Management Area.

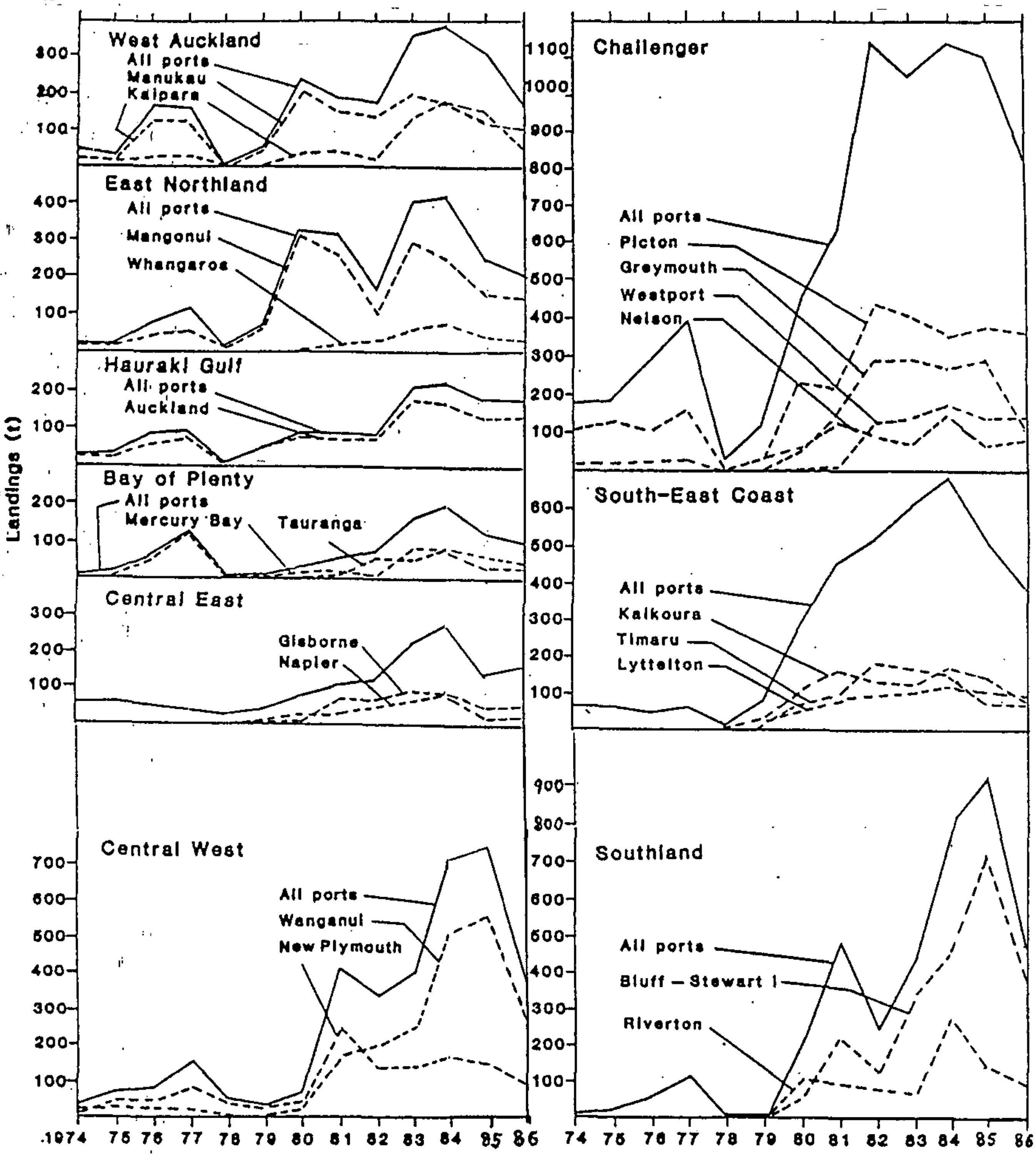


Fig. 4: School shark landings (t) within each Fisheries Management Area, and at the main ports within these areas, calendar years 1974-86. Based on ports of landing data, as in Table 2.

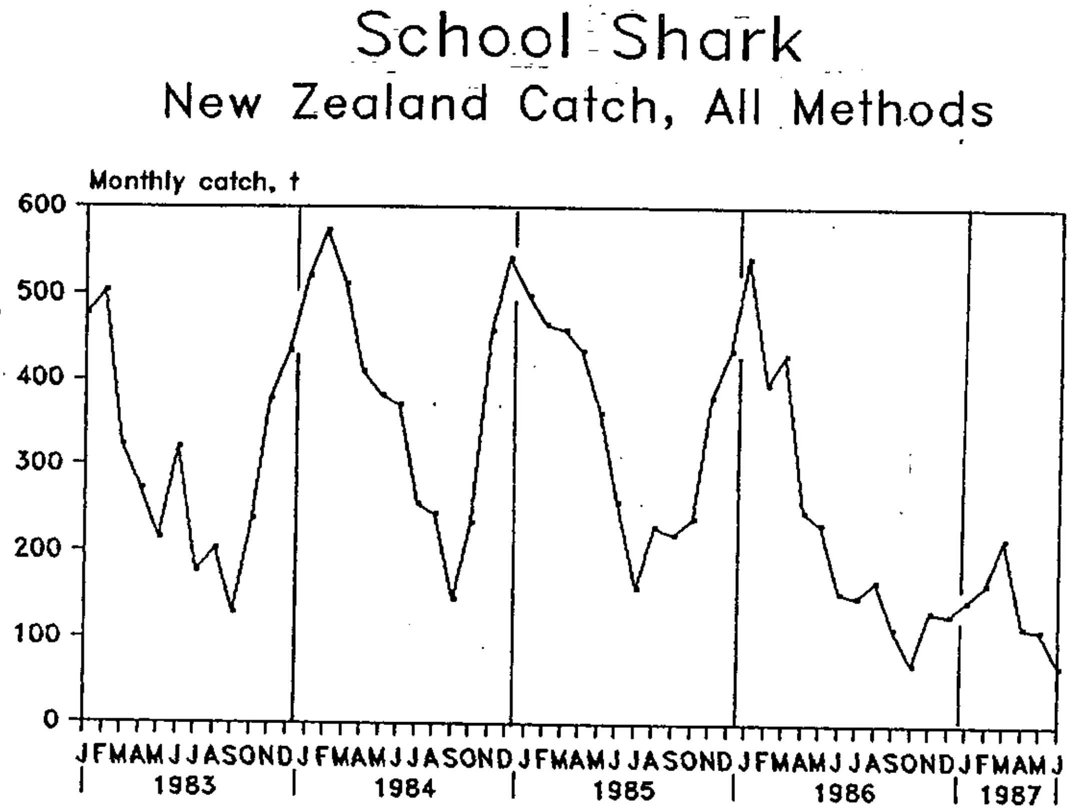
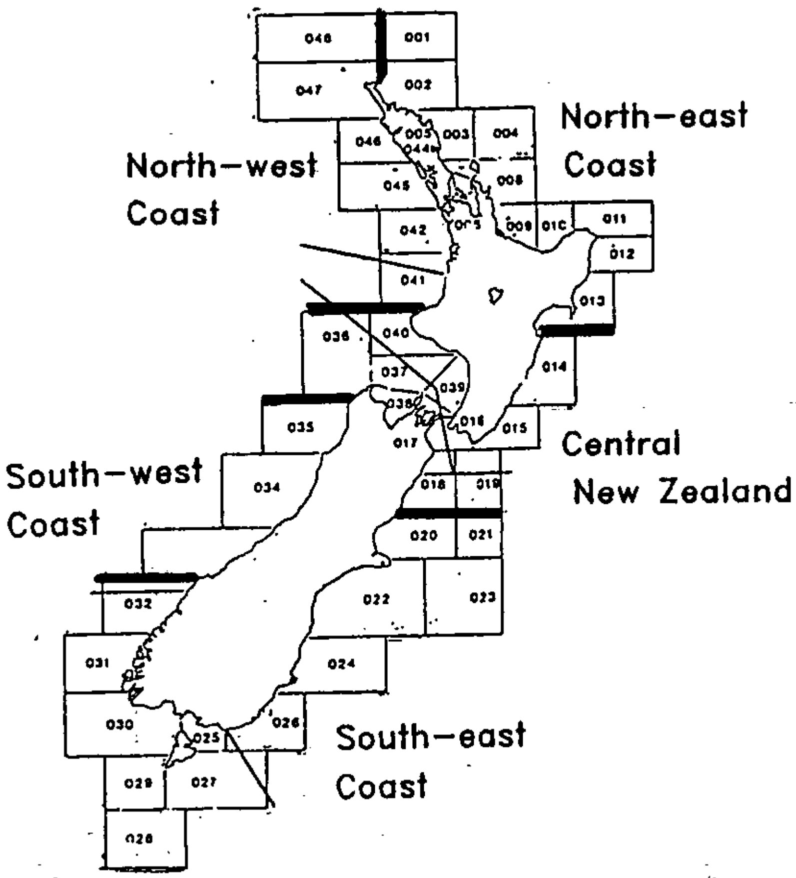


Fig. 5: Monthly landings (t) of school shark, domestic vessels, all areas and methods, 1983-87. Data from FSU.



Regional groupings of Fishing Return Areas used in Fig. 6, monthly landings (t) of school shark, domestic vessels, all methods, by region, 1983-87.

Note: These regions are not the same as the Fisheries Management Areas in Figs. 2 and 4, or the smaller regions used in detailed catch and CPUE analyses, Figs. 7-12.

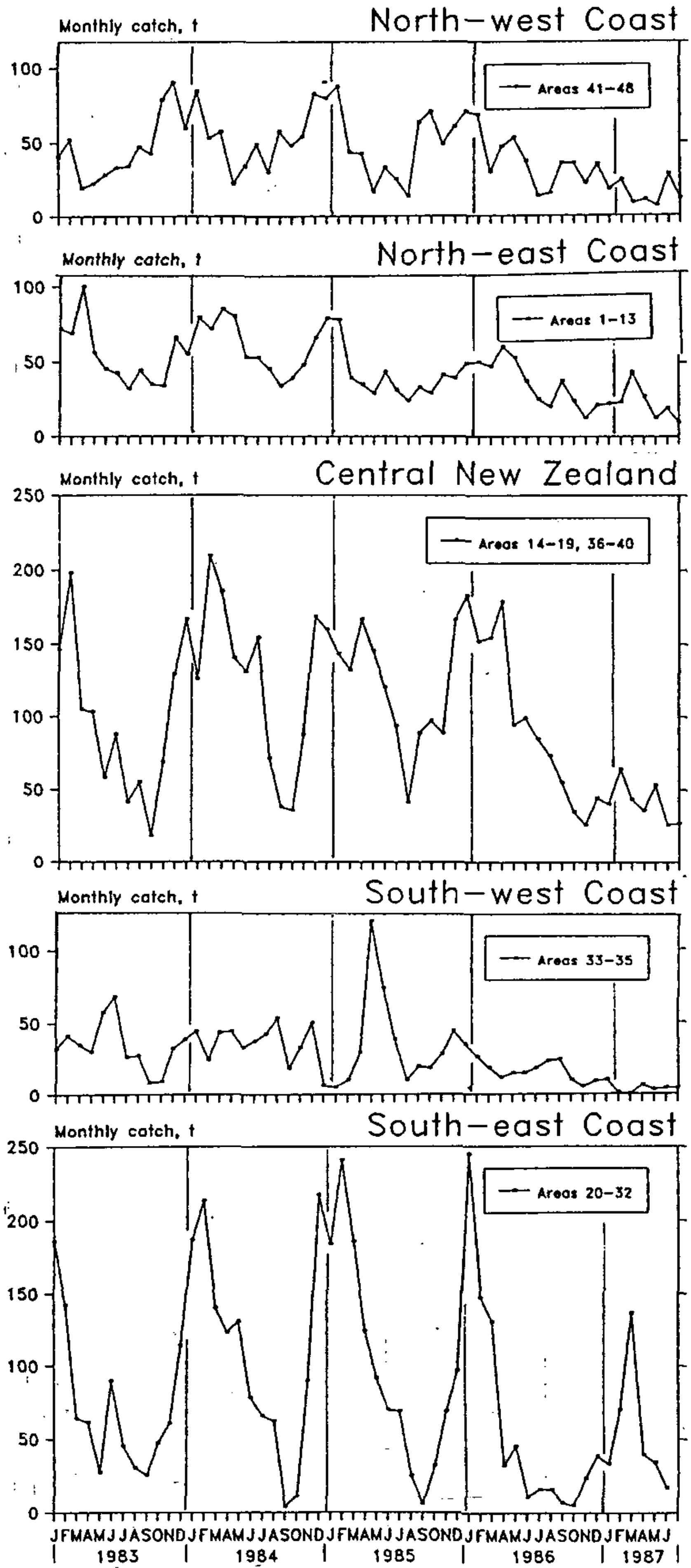
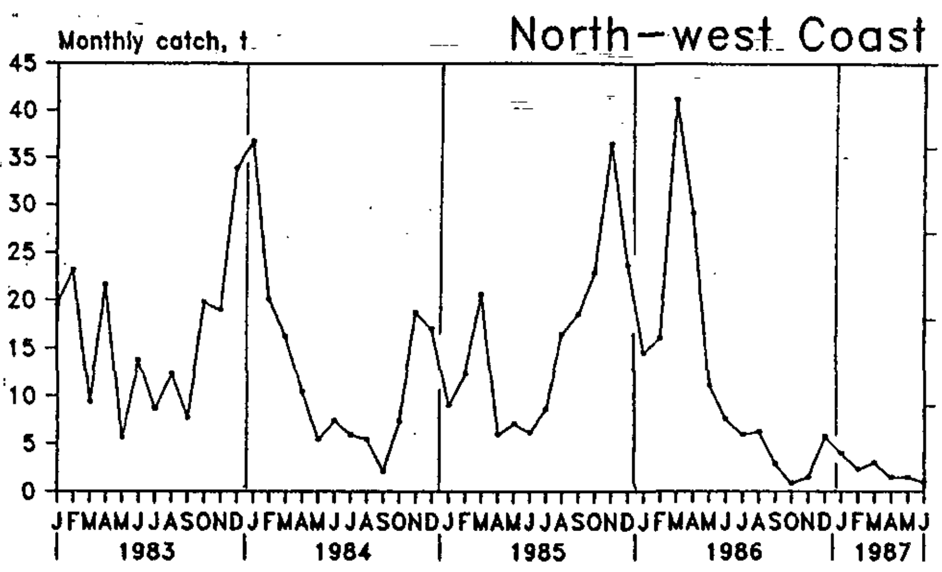
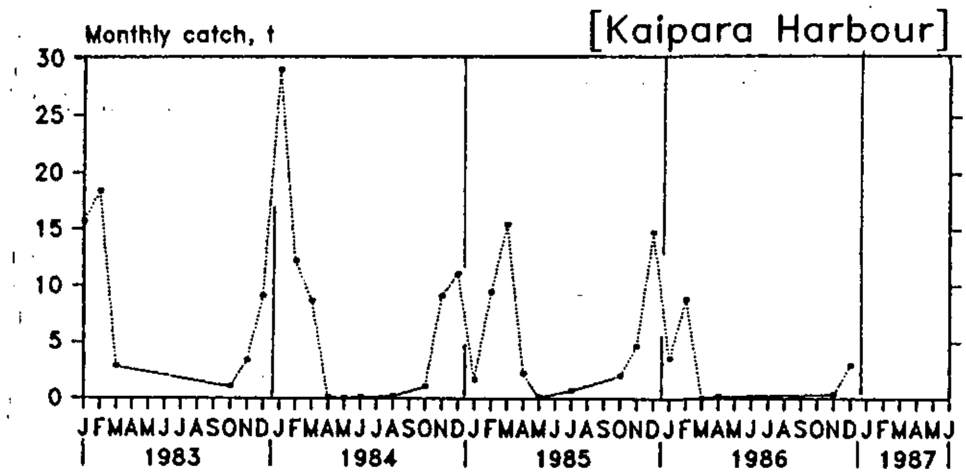


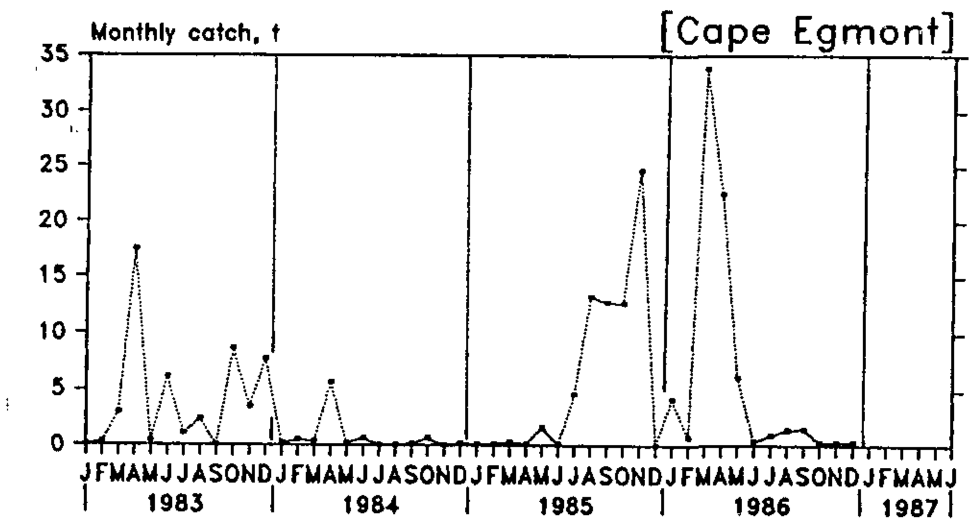
Fig. 6: Monthly landings (t) of school shark, domestic vessels, all methods, by region, 1983-87.



Fishing Return Areas 40–48



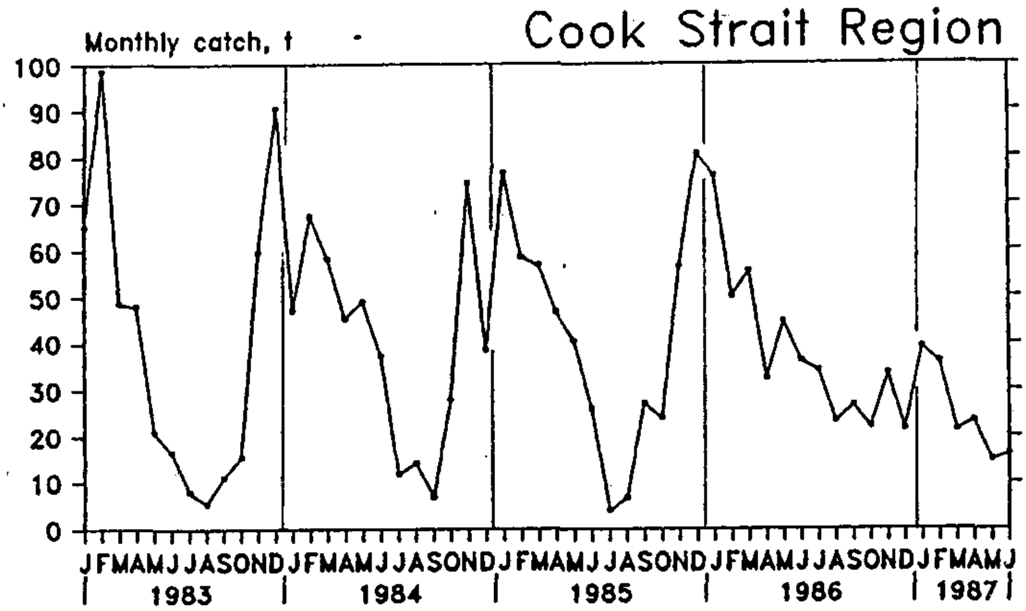
Fishing Return Area 44



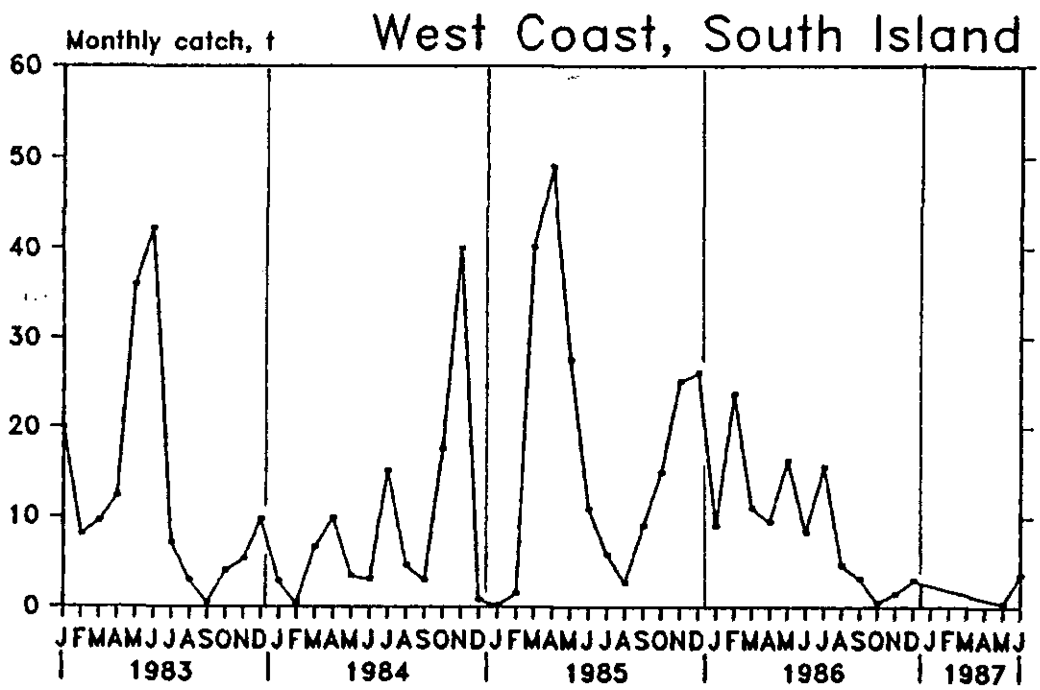
Fishing Return Areas 40–41

Fig. 7: Monthly landings (t) of school shark, domestic vessels, in the three main line-fishing regions: North-west coast North Island, Cook Strait, and West coast South Island.

Lines



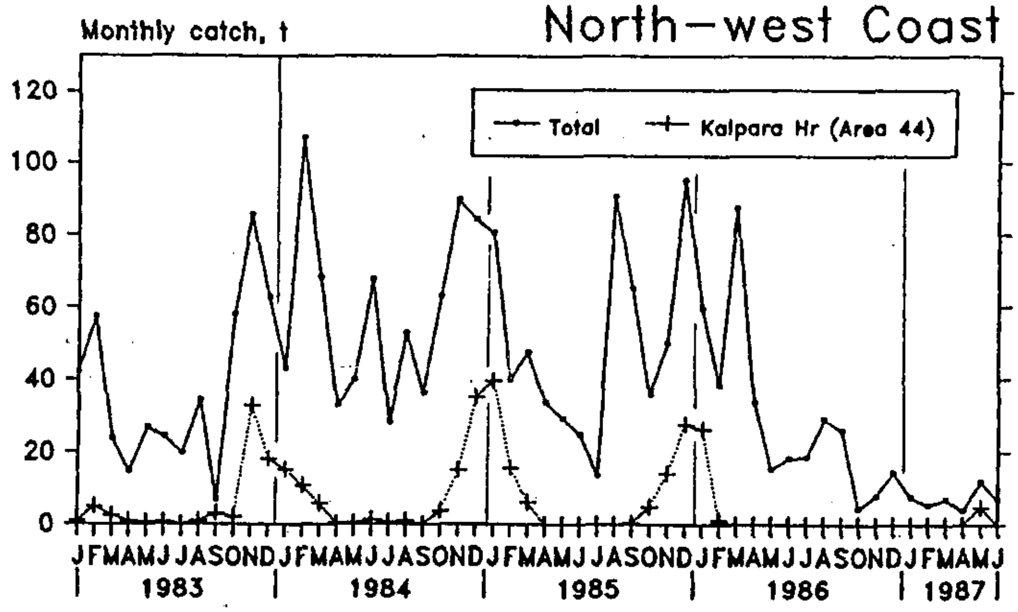
Fishing Return Areas 15–19, 37–39



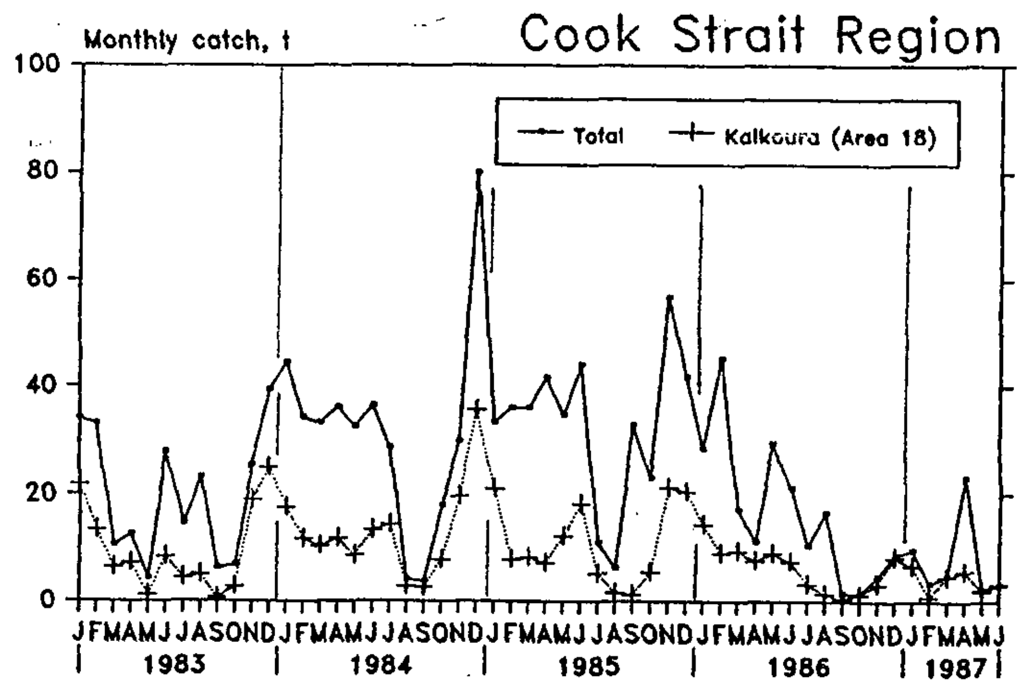
Fishing Return Areas 33–36

Fig. 7: (Continued)

Nets



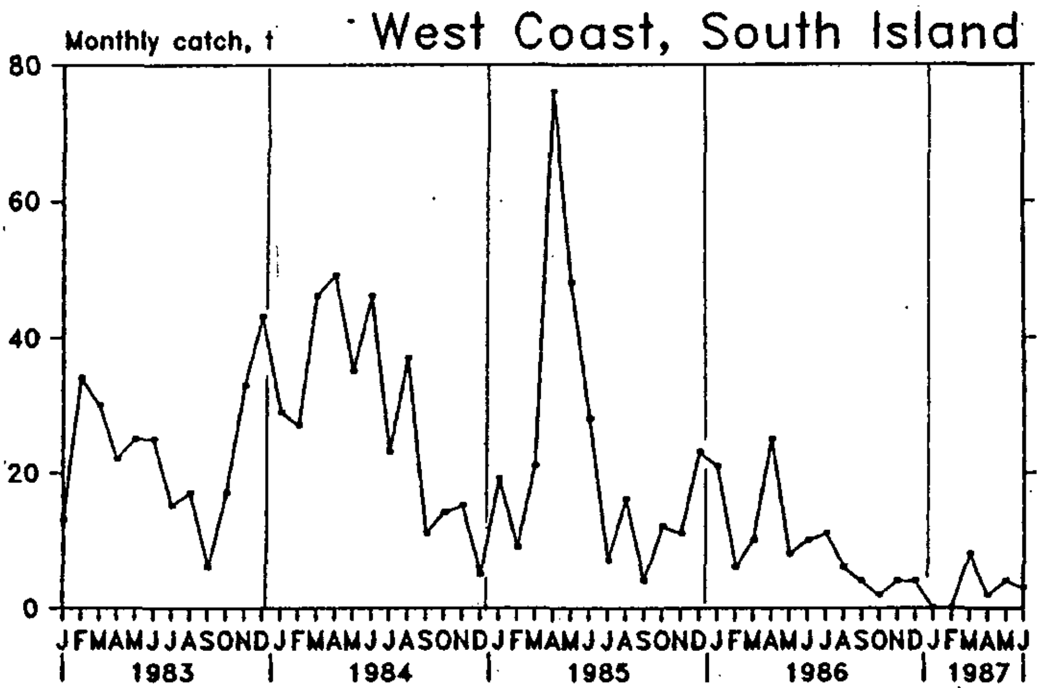
Fishing Return Areas 40–48



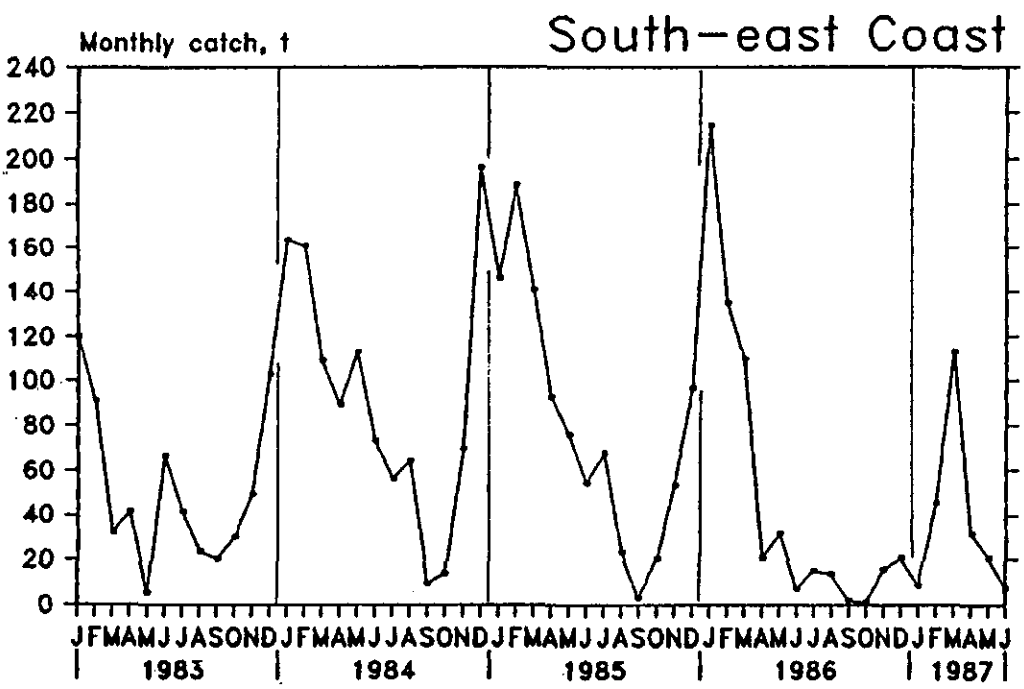
Fishing Return Areas 15–18, 37–39

Fig. 8: Monthly landings (t) of school shark, domestic vessels, in the four main set-net fishing regions: North-west coast North Island, Cook Strait, West coast South Island, and South-east coast South Island.

Nets



Fishing Return Areas 33–36



Fishing Return Areas 20–32

Fig. 8: (Continued)

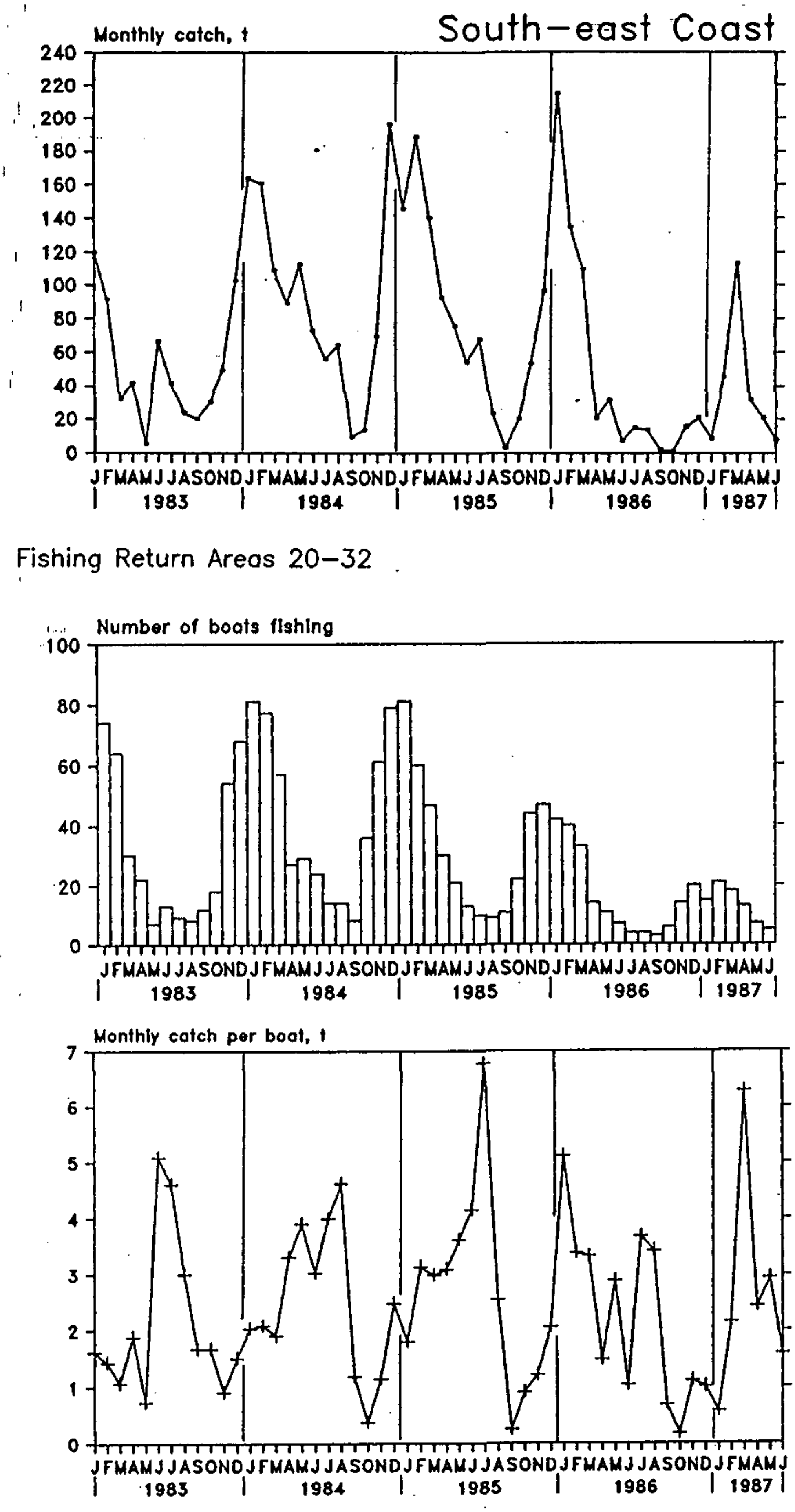


Fig. 9: Monthly school shark catch, effort, and CPUE (t) for the South-east coast South Island set-net fishery, 1983-87.

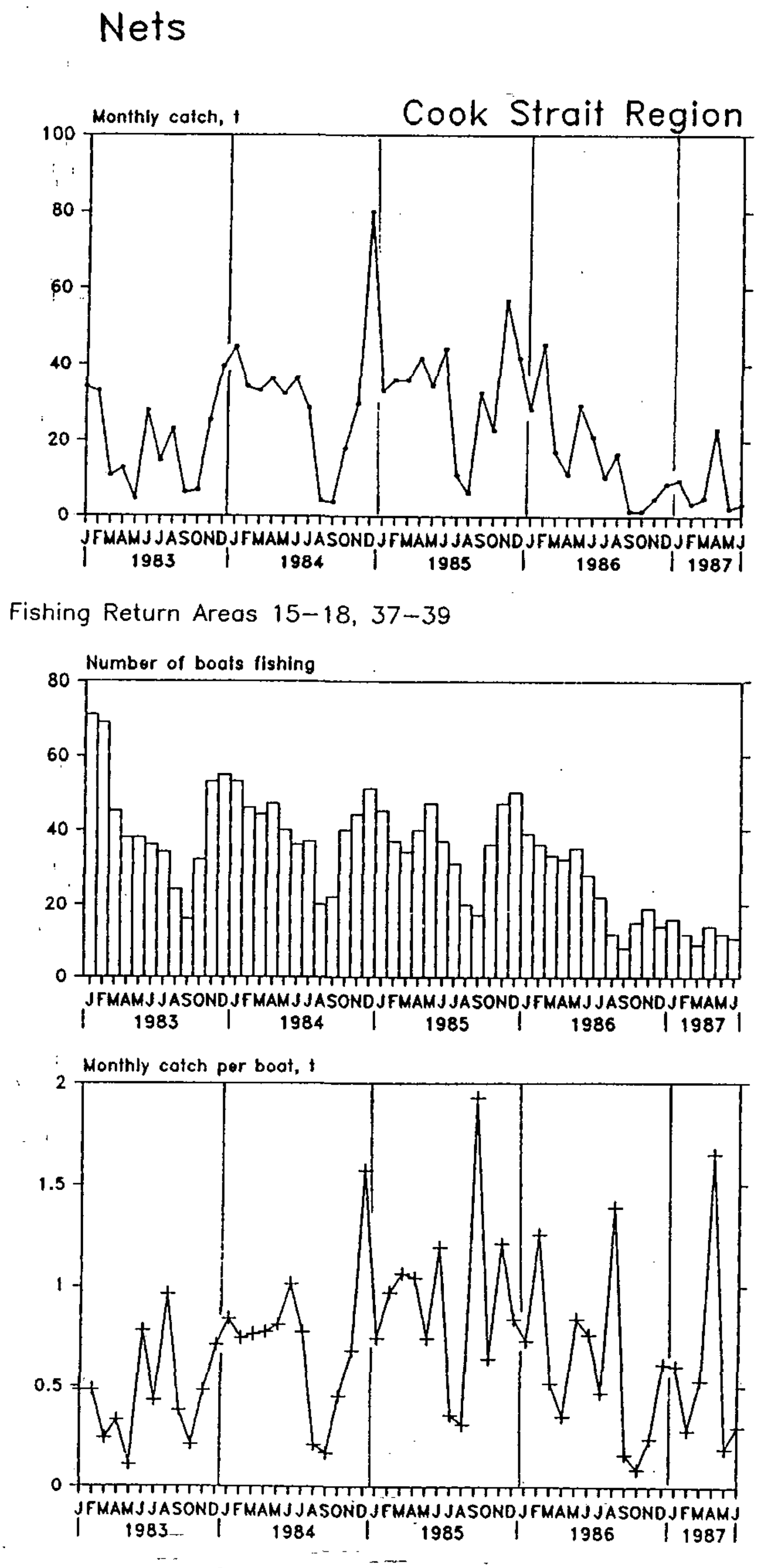


Fig. 10: Monthly school shark catch, effort, and CPUE (t) for the Cook Strait region set-net fishery, 1983-87.

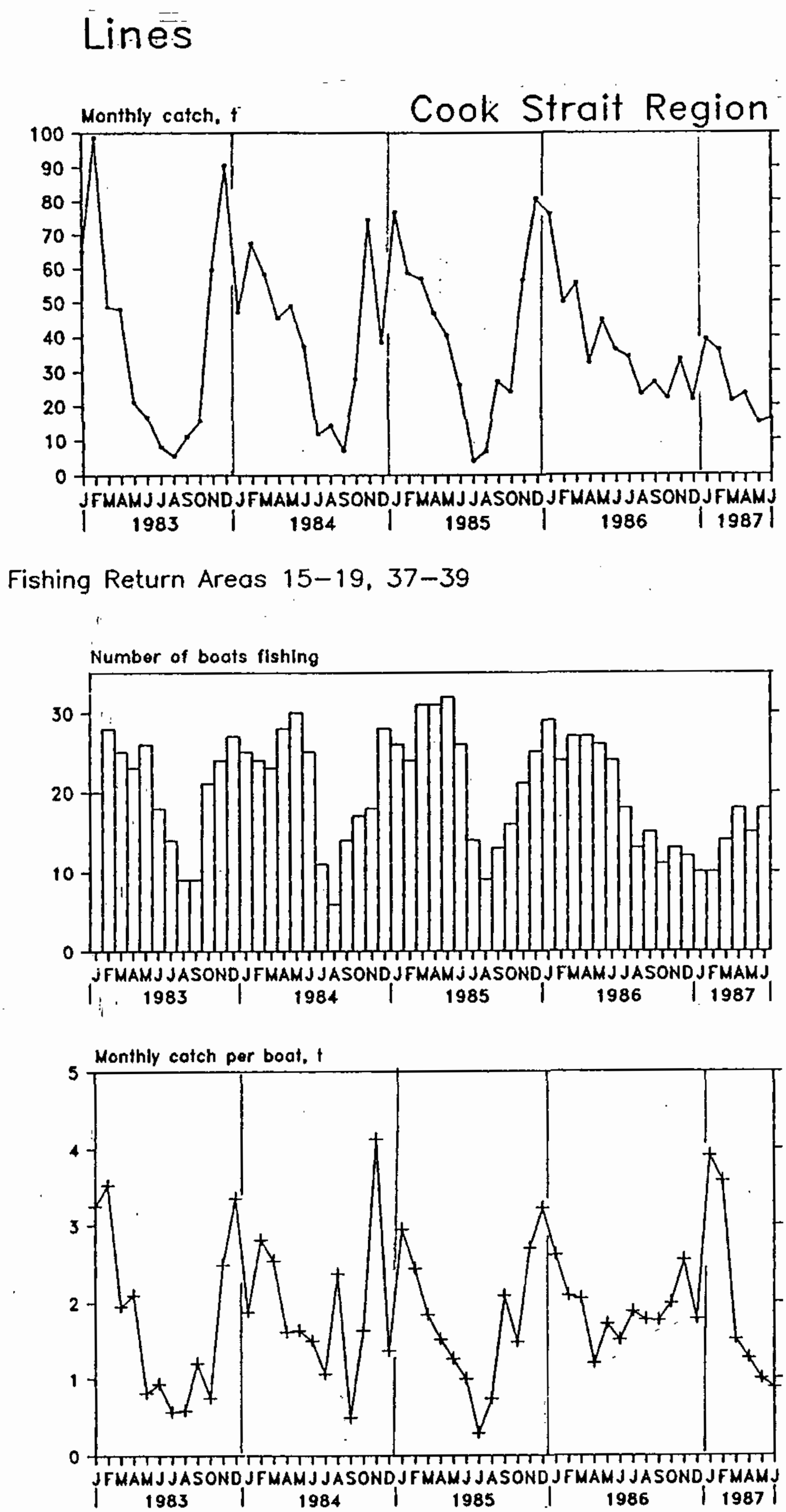


Fig. 11: Monthly school shark catch, effort, and CPUE (t) for the Cook Strait long-line fishery, 1983-87.

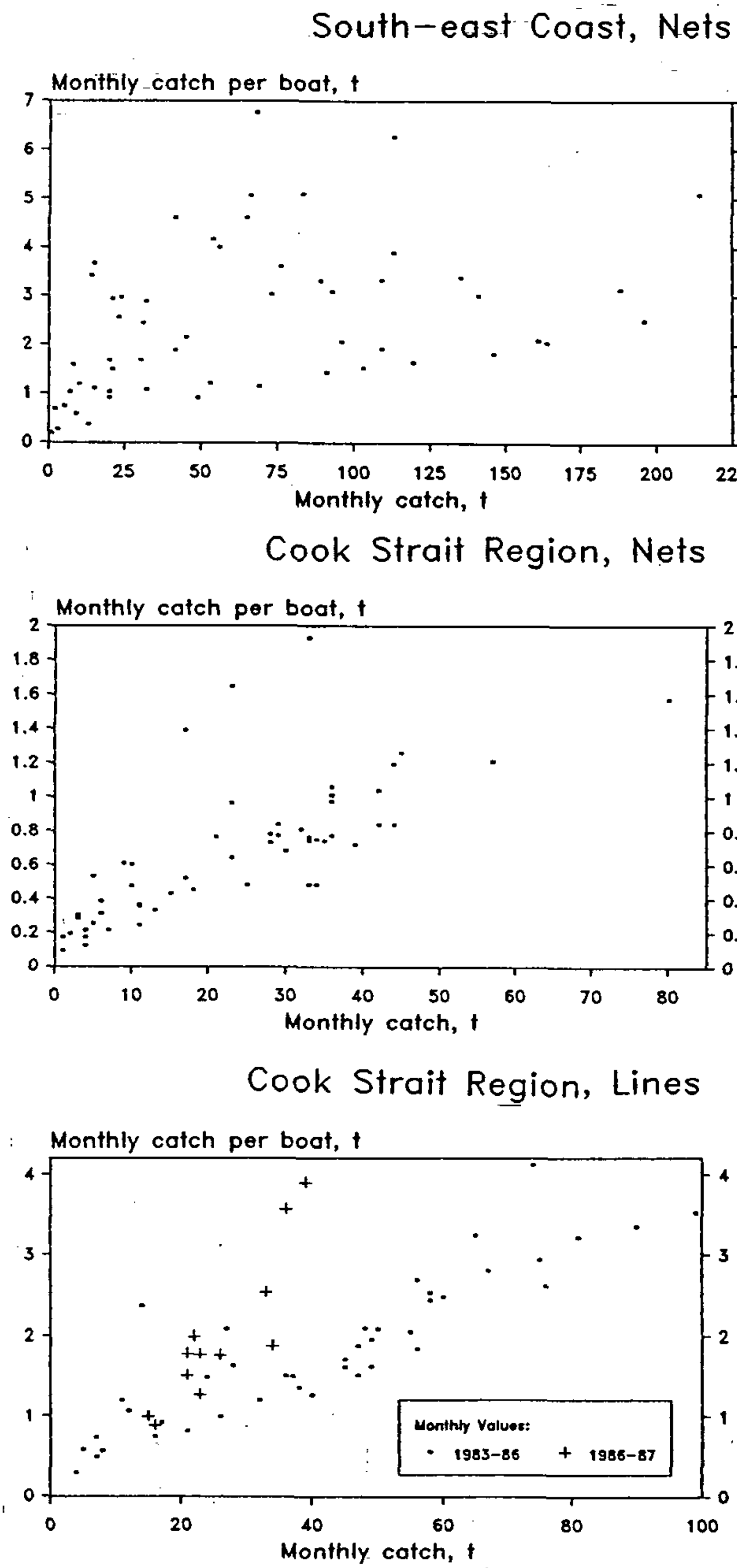


Fig. 12: Catch and CPUE relationships in the three school shark fisheries shown in Figs. 9-11.