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New Zealand Fisheries Assessment Research Document 88/28

Tarakihi

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Tarakihi Fishery Assessment - 1988

I. INTRODUCTION

(a) Overview

This document contains background data and analyses for the fisheries assessment for tarakihi, Nemadactylus macropterus. Included in the document are:

- brief description of the fishery
- literature review
- landings data for the domestic and foreign fleets
- description of stock structure
- summary of biomass estimates
- estimates of short-term sustainable yield
- discussion of management implications of the current TAC

(b) Description of the fishery

Tarakihi are caught by commercial vessels from the Three Kings Islands in the north to Stewart Island in the south. They are normally caught in depths between 100-200 m, with greatest catches from depths over 100 m. The main fishing method is trawling, but they are also caught by set nets and lines. The main fishing grounds are: the east coast of Northland, the western Bay of Plenty to Cape Kidnappers, Cook Strait, Cape Campbell to the Canterbury Bight, and Jackson Head to Cape Foulwind.

The landings of tarakihi caught in FSU fishing return areas during the three years 1983/84 to 1985/86 are shown in Fig. 1. Tarakihi are summer-autumn spawners, and many of the major fisheries are associated with fish moving to or from the spawning grounds.

The main times of the year when tarakihi were caught from the main fishing grounds over the three years from 1983/84 to 1985/86 are summarised in Table 1. This summary is a generalization for the three years, so does not account for between year variations in peak catches. Pre and post refer to pre- and post-spawning periods, respectively. The major tarakihi spawning areas are marked with an asterisk. The area numbers refer to FSU fishing return areas.

The fishery is managed primarily through TACs and mesh size limits on trawl and set net gear. One area has been closed to fishing to protect tarakihi stocks. This is the area near Separation Point in Tasman/Golden Bays, which is an important nursery area for juvenile tarakihi and other species. There are no seasonal closures or other management measures designed to protect tarakihi stocks.

The gazetted TACs by Quota Management Area (QMA) for 1987/88 are as follows:

Quota Management Area	Quota Management Area Number	TAC(t)
Auckland (East) and Auckland (West)	1 & 9	1210
Central (East)	2	1410
Central (Egmont)	8	190
Challenger/Central (Plateau)	7	930
South-East (Coast)	3	970
South-East (Chatham Rise)	4	300
Southland and Sub-Antarctic combined	5 & 6	140
Kermadec	10	10

(c) Literature Review

Considerable research on tarakihi was carried out during the 1960s and 1970s by staff at FRD, especially Len Tong and Carel Vooren. The reasearch included studies on reproduction, eggs and larvae, juveniles and their nursery grounds, stock structure, movements, recruitment, age and growth, mortality, ecology, and descriptions and analyses of the fishery. The results of these and other studies on the biology and fishery of tarakihi have been reviewed by Annala (1987) and are described below.

II. REVIEW OF THE FISHERY

(a) Catch and landings data

Domestic fishery

The importance of tarakihi to the New Zealand domestic fleet has changed through the years. Unitl the mid 1970s, tarakihi was the third most important fish species behind snapper and trevally in terms of landed weight (King 1985). However, landings of species such as barracouta, red cod, and kahawai have since increased, and many coastal vessels have geared up to fish in deeper water for species such as orange roughy. Consequently, in 1983 tarakihi were ranked only seventh in landed weight (King 1986).

Domestic landings of tarakihi by fishing region by calendar year for 1931-85 are given in Table 2. Domestic landings by port of landing by calendar year for 1974-85 for ports contributing more than 1 % of total landings are given in Table 3.

Domestic landings in 1985 were 4298 t, 270 t less than the 1984 landings and very similar to the 1983 landings. Landings declined from 1984 to 1985 for the Hauraki Gulf, Bay of Plenty, and west coast of the South Island, increased for the Canterbury Bight, and remained about the same for the other fishing regions. Landings by FMA decreased slightly from 1984 to 1985 for Auckland, increased slightly for Central and South -East, decreased substantially for Challenger, and remained about the same for Southland. Because of various problems with the 1985 statistics, landings for Challenger may have been substantially underestimated.

Domestic landings by FSU fishing return area fished for the 1983/84, 1984/85, and 1985/86 fishing years (1 Oct--30 Sep) are shown in Fig. 1. Domestic landings by FSU fishing return areas for the same three years are grouped by QMA in Table 4. Because of the large percentage of landings with unknown area fished, these data are of limited value for assessment purposes. However, landing trends can be detected. Catches decreased in Auckland East (area 1) and Challenger/Central(Plateau)(7); remained about the same for Central (East)(2), Southland (5), and Auckland (West)(9); and increased for South-East(Coast)(3) and Central(Egmont)(8). Landings for Challenger/Central(Plateau) in 1985/86 may also have been substantially underestimated.

The history and state of the tarakihi fishery on a New Zealand wide basis have been described by Vooren(1974a), Tong(1979), and McKoy(1985).

Vooren (1974a) analysed the statisitcs on the fishery during 1936-69. Between 1940 and 1969 tarakihi constituted at least 40% of all wetfish landings into Gisborne, Napier, and Wellington. Between 1967 and 1969 landings decreased for all the important traditional fishing areas: Bay of Plenty, East Cape, Hawke Bay, Cook Strait, Pegasus Bay, and Canterbury Bight. The decrease in landings from the Bay of Plenty may have been due to a shift in effort to shallower, inshore grounds to target fish for snapper and trevally, rather than to a decrease in tarakihi abundance. The East Cape and Hawke Bay areas experienced a decline in abundance beginning in 1960 and 1964, respectively, which may have resulted from an increase in fishing effort in earlier years. As a result of this decline, the fishing fleets diverted their effort to concentrate on other species. The decrease in fishing effort in the East Cape area between 1964 and 1967 reflected the withdrawal of Auckland, Tauranga, and Napier trawlers. The decrease in landings from Cook Strait was probably not the result of a decrease in abundance, but a result of a decrease in fishing effort. Similarly, the decline in landings from Pegasus Bay and Canterbury Bight partly resulted from the departure of many vessels for the Chatham Islands rock lobster fishery. Tarakihi in the Canterbury Bight may also have decreased in abundance because of the effects of foreign fishing.

Tong (1979) assessed the status of the tarakihi stocks and fishery during 1978 by using the percentage of fish in the catch over 10 years old as the main criterion of the status of the fishery. The percentages in various years for the following fisheries were: East Cape (1971), 7.8%; Cape Campbell (1978), over 20%; Pegasus Bay (1970 and 1978), over 20%; west coast of the South Island (1972 and 1977), 54 and 28%. He concluded that the fishery was still healthy around New Zealand, and that the East Cape fishery was fully exploited, Cape Campbell could withstand heavier exploitation, and Pegasus Bay and the west coast of the South Island were underexploited. From landings data up to 1977, Tong (1979) concluded that Vooren's (1973) estimate of sustainable yield for the East Cape area of 1000-1500 t per year was correct.

McKoy (1985) assessed the status of the tarakihi stocks and fishery up to December 1984 for the purposes of recommending Total Allowable Catch (TAC) levels. This assessment was based on previous work, new data on catch and effort from the fisheries statistics scheme, and estimates of abundance from various trawl survey programmes (Hurst and Fenaughty 1985).

The following are summaries of the status and history of the most important tarakihi fisheries.

Bay of Plenty - Landings in the Bay of Plenty decreased between 1967 and 1969. Fishing effort shifted into shallower waters during those years, at the same time as the demand for

snapper and trevally increased. The shift in fishing effort may have been caused by this change in demand, rather than by a decrease in abundance of tarakihi (Vooren 1974a).

East Cape - The East Cape fishery is the most important tarakihi fishery in New Zealand, with landings from Cape Runaway to Mahia Peninsula constituting about 20% of the total New Zealand tarakihi landings during 1983-84. This is less than the 30-40% during the 1960s (Vooren 1974a).

Vooren (1973, 1974b) presented detailed assessments of the East Cape tarakihi fishery. Between 1962 and 1973 landings declined by 54%, whereas fishing effort decreased by only 17%. The decline in yield after 1966 did not appear to be caused by a major decline in recruitment; it was of the type expected in a developing fishery on an unexploited stock and was considered inevitable. The stabilization of CPUE between 1964 and 1970 suggested that a state of equilibrium may have been reached and that stock abundance was not decreasing further. Fishing mortality rate and age of recruitment were considered to be nearly optimal, and the catches since 1968 suggested a maximum yield for the East Cape fishery of 1000-1500 t per year.

Kaikoura - Irwin (1981) found that the catch of tarakihi from the Kaikoura fishery by set nets increased from 2.6 t in 1974 to 289.2 t in 1980.

East coast South Island - Fenaughty and Bagley (1981), in their analysis of tarakihi landings for Lyttelton and Timaru during 1938-80, suggested that the observed peaks and troughs in landings showed the presence of strong year classes on a 4-6 year cycle. In both ports a downward trend in landings took place after the departure of many larger trawlers for the Chatham Islands rock lobster fishery. The by-catch of tarakihi by foreign trawlers may have contributed to the decline in landings into these ports during the 1970s. Between 1972 and 1977 the reported Japanese tarakihi by-catch exceeded the total tarakihi landings into east coast South Island ports for the same years. If the Soviet catches were similar to those of the Japanese, the total foreign catch would have been more than twice the domestic catch.

Sullivan (1981) suggested that the trawl fishery for tarakihi in the Canterbury Bight depended on few age classes, and years of good catches probably resulted from strong year classes spawned 4-5 years earlier. CPUE in this fishery declined sharply from 227 kg per day in 1963-66 to 124 kg per day in 1970-73. The decline in catches may have been caused by the depaerture of many Timaru boats for the Chatham Islands rock lobster fishery during the late 1960s and the large catches of tarakihi taken by foreign vessels in the 1970s.

West coast North Island - Tarakihi catches in the Auckland west coast trawl fishery declined between 1953 and 1958 (Reid 1969).

Foreign fishery

Landings by foreign licensed and New Zealand chartered vessels from 1970 to 1985/86 are shown in Table 5. These data are plagued with a number of problems, such as being unsourced for some years, being comprised of Japanese data only through 1977/78, and numerous changes to the months used for the fishing year. However, despite these limitations, it is clear that landings of tarakihi by foreign vessels were substantial during the mid-1970s. Most of the reported foreign catch was taken from divisions D2 and D7 (Japanese fishing areas used during 1968-77) and EEZ areas D and H (used from 1977/78 until the start of the ITQ scheme) off the east and west coasts of central New Zealand near major domestic fisheries for tarakihi.
In 1977 the reported Japanese catch of 2259 t was 54% of the reported domestic landings of 4185 t. No data are available on the catches of tarakihi by Soviet trawlers fishing these grounds, but they were probably substantial. Since the area and by-catch restrictions came into effect with the introduction of the EEZ in 1978, tarakihi landings by foreign licensed and chartered vessels have decreased, and in 1985/86 totalled 535 t.

Domestic and foreign landings combined

Domestic and foreign landings combined from 1983/84 to 1986/87 and the TAC for 1987/88 grouped by QMA are shown in Table 6.

(b) Other information

Data on the size and age of tarakihi were collected from some of the major fisheries during the catch and market sampling programmes of the 1960s and 1970s (MAFFish, unpubl. data). Data on size and age of the commercial catch are also available in a number of the studies described in the previous section.

(c) Recreational and Maori fisheries

Tarakihi are taken by recreational fishermen using lines and set nets. Although no data are available on the quantity of tarakihi caught, it may be substantial in some areas. The results of the recreational fishing survey (Sullivan 1988) indicate that tarakihi was the ninth most frequently reported species caught.

Of the 270 tarakihi tagged in Tasman and Golden Bays in March 1986, 7 had been returned by 29 February 1988, 6 of which came from recreational fishermen. Of the 2920 tarakihi tagged near Kaikoura during 1986 and 1987, 67 had been returned by 29 February 1988, 9 (13%) of these coming from recreational fishermen.

There is no information on the nature and extent of Maori fisheries for tarakihi.

III. RESEARCH

(a) Stock structure

On the basis of allele frequencies at the phosphoglucomutase locus, Gauldie and Johnston (1980) proposed the following stock boundaries: western Bay of Plenty, eastern Bay of Plenty, Cook Strait, south of the Otago Peninsula, east of Bluff, near Bruce Bay, north of New Plymouth, and south of Reef Point. However, they concluded that " while there are certain regions in New Zealand waters that contain ensembles of species that are genetically distinct from their neighbouring ensembles, those differences are more likely to constitute selective clines than genetically isolated stocks of fish."

Returns from tarakihi tagged during 1986 and 1987 (Annala, unpubl. data, see below) show extensive movements of adult tarakihi between areas. These movements, when combined with the long pelagic larval phase of 7-12 months, and the lack of identified genetically isolated stocks, suggest that there are probably no distinct stocks of tarakihi, at least around the North and South Islands. Therefore, for stock assessment purposes, tarakihi around the North and South Islands can be considered as one stock, whereas those from the Chatham Islands can be considered as a separate stock.

(b) Resource surveys

The only recent survey designed to assess the tarakihi resource was cruise J05/87, whose main aim was to determine the distribution and abundance of spawning tarakihi between Cook Strait and Pegasus Canyon. Spawning tarakihi were found at most locations between Cook Strait and Pegasus Canyon, with highest concentrations on the Conway Rise and off Point Gibson. Because of vessel breakdown, the suitability of using the various techniques proposed (acoustic survey and bottom and mid-water trawling) for estimating spawning tarakihi abundance could not be assessed. This programme has now been terminated.

The results of earlier surveys are described below in sections (c) Other studies and (d) Biomass estimates.

(c) Other studies

(i) Life history summary

Tarakihi are summer--autumn spawners which spawn in several areas around New Zealand. The three main identified spawning grounds are Cape Runaway to East Cape, Kaikoura to Pegasus Bay, and the west coast of the South Island near Jackson Bay (Vooren 1975). Sexual maturity is reached at a length of 25-35 cm at an age of 4-6 years (McKenzie 1961, Tong and Vooren 1972, Vooren and Tong 1973).

Few larval and postlarval tarakihi have been caught and identified. The postlarvae appear to be pelagic, occur in offshore waters, and are found in surface waters at night. Postlarval metamorphosis to the juvenile stage occurs in spring or early summer when the fish are 7-9 cm long and 7-12 months old (Vooren 1972, Tong and Saito 1977, Robertson 1978).

Several juvenile nursery areas have been identified in shallower, inshore waters, including the south-west coast of the North Island, Tasman Bay, near Kaikoura, northern Pegasus Bay, Canterbury Bight, Otago, and the Chatham Islands. Juveniles move out to deeper water at a length of about 25 cm at an age of 3-4 years. Only a small proportion of tarakihi found in commercial catches are immature, suggesting that they do not become vulnerable to fishing operations until they are sexually mature (Vooren 1975).

(ii) Movements

More than 15,000 tarakihi were tagged during the 1950s, 60s, and 70s to determine movements. Most of the tarakihi tagged were trawl caught, initial mortality rates of tagged fish were very high (up to 70%), and the tagging programmes had limited success.

During 1986 and 1987 tarakihi were tagged after being caught using set nets and fish traps (Annala, unpubl. data). Iniitial tagging mortality appeared lower and return rates more encouraging than the results from previous studies. The returns from the 1986-87 tagging programmes through 29 February 1988 are summarised in Table 7.

A number of the tagged tarakihi recaptured outside the tagging area moved long distances. Of those moving north, 2 were recaptued near Great Barrier Island, 1 near Waiheke Island, 1 near Whale Island, 7 between Table Cape and Lottin Point, 6 between Cape Campbell and Cape Turnagain, 1 near Kaipara Harbour,

and 2 between Mana Island and Otaki. Three of the returns which moved south were recaptured between Banks Peninsula and Timaru.

Commercial fishermen from the Gisborne area reported an apparent migration of tarakihi along the east coast of the North Island between about Cape Kidnappers and Lottin Point during 1986. Schools of tarakihi were located in southern areas beginning in June-July and followed in a northwards direction until about September-October. Two of the returns are known to have come from these migrating schools. The two tagged tarakihi recaptured near Great Barrier Island were taken during January and March 1987, which suggests that the migration may have carried on further north.

(iii) Age and growth

Tarakihi are generally regarded as slow-growing, long-lived fish. McKenzie (1961) estimated the age of tarakihi using annual rings on scales. They were estimated to reach the minimum legal size of 10 inches by the end of the fourth year, and most of the catch was of 7-9 year old fish. Most fish matured in the fourth or fifth year, after which the growth rate slowed.

Age and growth were estimated for fish from the Bay of Plenty during 1968-69 (Tong and Vooren 1972) and from the East Cape area during 1971 (Vooren and Tong 1973) using annual rings on otoliths. In both areas most of the fish caught were aged 3-9 years. The growth rates of both sexes decreased rapidly from age 6, more so for males. For fish of age 6 and older, females were larger and made up a significant proportion of the larger fish. This difference in growth rate was attributed to the earlier age at first maturity of males.

In a study of age and growth of lightly exploited populations along the west coast of the South Island and around the Chathams, Vooren (1977) observed a large proportion of fish older than 10 years. Growth rate decreased more rapidly in males after age 5, and the growth rate declined more rapidly for both sexes after age 10. Growth continued up to at least 30 years.

Von Bertalanffy growth equations (Table 8) have been calculated to estimate size at age for both sexes combined for the Bay of Plenty (Tong and Vooren 1972) and East Cape (Vooren and Tong 1973). Estimates of age at length for both sexes combined for four different areas are shown in Fig. 2; there were no obvious differences between areas.

(iv) Mortality

Vooren (1973) estimated the annual instantaneous natural mortality rate (M) of an unexploited population at Kaikoura during 1970-71 was 0.15. The estimated annual instantaneous

total mortality rate (Z) for an exploited population at East Cape during 1971 was 0.75 or 0.50, depending on the assumed age at recruitment (Vooren 1973). The annual instantaneous fishing mortality rate (F) was estimated from the equation F = Z-M and was 0.60 or 0.35.

Vooren (1977) estimated mortality rates from lightly exploited populations along the west coast of the South Island and at the Chatham Islands. At the Chathams Z and M were assumed to be equal, because the population was virtually unfished, and were estimated to be 0.08. Along the west coast of the South Island the estimate for Z was 0.13, and if the Chatham Islands estimate of M = 0.08 was assumed to apply here as well, F = 0.05.

(v) Recruitment

The pelagic larval phase has been estimated to extend for 7-12 months, which would allow time for extensive larval drift from the spawning grounds until the postlarvae settled in the nursery areas. Vooren (1972, 1975, 1977) suggested several different recruitment mechanisms for tarakihi around New Zealand. He suggested that Tasman Bay could be the nursery for tarakihi spawned on the west coast of the South Island between Jackson Head and Cape Foulwind, with the postlarvae being carried north by the Westland Current to Tasman Bay. Mature fish leaving the Tasman Bay nursery grounds at 4-6 years could migrate against the current to the spawning grounds further south. Some of the postlarvae may be carried across Cook Strait by the D'Urville Current and settle off the Manawatu coast, where the juveniles may be a mixture of locally spawned fish and fish from the west coast of the South Island.

Vooren (1975) also suggested that the juveniles along the east coast of the South Island from Cape Campbell to the Otago Peninsula were spawned off Kaikoura, in Pegasus Bay, and in the Canterbury Bight, and, therefore, that the fish spawned on this coast remained on the same coast. However, Vooren (1972) suggested the presence of juveniles around the Otago Peninsula and in Pegasus Bay indicated there may be spawning grounds in the Stewart Island-Fiordland region and in the Canterbury Bight, respectively, and that the postlarvae had drifted in the northward water movement along the south and east coasts of the South Island. Robertson (1978) supported this with the suggestion that the prejuveniles which occurred in Otago and Canterbury waters in the late spring and early summer were probably spawned in southern Fiordland the previous summer and autumn and had spent the following 7-10 months drifting in the Southland current.

Vooren (1975) suggested that the long duration of the pelagic phase would allow the offspring of the spawning stock in the Bay of Plenty and East Cape enough time to drift or swim

southwards to at least Castlepoint. Vooren (1975, 1977) further suggested that the juveniles on the nursery grounds at the Chatham Islands originated from the spawning population at the Chathams. However, no data were presented to show that tarakihi spawn there.

Recruitment variability has been observed in three different studies. Vooren (1975) found substantial year to year variation in the number of 0-group fish moving into Tasman Bay. Fenaughty and Bagley (1981) suggested that the peaks and troughs in tarakihi landings into Lyttelton and Timaru showed the presence of strong year classes on a 4-6 year cycle. Sullivan (1981) suggested that the tarakihi fishery in Canterbury Bight appeared to depend mainly on a few good age classes.

(d) Biomass estimates

Biomass estimates for tarakihi (Table 9) are available from various trawl surveys (Hurst and Fenaughty 1985). The biomass estimates in Table 9 use an area swept based on wingtip spread (the distance between the wingtips). However, when these biomass figures are used as estimates of absolute biomass for the estimation of yields of tarakihi, the average of the wingtip and doorspread estimates are used. This allows for some herding by the doors and sweeps and partial escapement.

(e) Yield estimates

The tarakihi fishery was assessed in 1985 (McKoy 1985) in order to recommend TAC levels. The bases for the recommended TACs were:

1. Stocks did not appear to be under severe stress in any area.

2. There was a possibility of moderate overfishing on stocks in the East Cape area and the Kaikoura-Cook Strait area (though the steady decline in landings in the Cook Strait area suggested that the fishery may be overexploited and may not be able to sustain, on average, even current levels of fishing mortality).

3. No significant increase in catches over those for 1983 should be allowed in the meantime.

McKoy's (1985) assessment was not changed during the following two assessments (Annala 1986, 1988), except for the East Cape and Kaikoura-Cook Strait fisheries. After re-evaluation of existing data and the inclusion of new data on landings and fishing patterns, Annala (1986) concluded there was

no reliable evidence to suggest overfishing on stocks in the East Cape and Kaikoura-Cook Strait areas.

(i) Estimation of maximum constant yield (MCY)

North and South Islands combined MCY = 4034 t

MCY was estimated from the equation, MCY = $c\bar{Y}$.

Method 6 in the Guide to Biological Reference Points for the 1988 Fishery Assessment Meetings (McKoy 1988) was used because the catch data showed no trend during a period when their was no consistent trend in fishing effort. Y was the average of the combined domestic and foreign landings data during 1968-85 (5042 t). This period was chosen because landings had declined after the initial exploitation of the fishery and were relatively stable. Effort and fishing mortality were assumed relatively constant. Natural mortality rate is low (0.08-0.15), the species is long-lived (40+ years), and there are generally 10+ year classes in the fishery (Annala 1987, and references therein). Therefore, c is estimated as 0.8.

MCY = 0.8 * 5042 t = 4034 t

The current TAC = 4860 t

Chatham Islands MCY = 235 t

MCY was calculated from the equation, MCY = F0.1 1/2 MBav.

Method 1 in the Guide to Biological Reference Points for the 1988 Fishery Assessment Meetings (McKoy 1988) was used because it is a developed fishery and estimates of biomass are available. An estimate of F0.1 was not available, so it was replaced with an estimate of M.

M for the Chatham Islands was estimated as 0.08 (Vooren 1977). Another way of estimating M is to divide ln 100 by the oldest age in the catch. The oldest fish from the catch in Vooren's sample was 41 years. ln 100/41 = 0.11. Based on these two estimates, M was set equal to 0.10 for the calculation of MCY.

B was calculated from the average of the doorspread and wingtip biomass estimates from the 1984 and 1985 "Akebono Maru" surveys of the Chatham Islands area and equals recruited biomass. Because tarakihi are known to occur over foul ground, the biomass estimate was adjusted, by assuming equal catch rates, to include the foul ground areas within the survey area which could not be sampled. B_{av} was estimated by averaging the 1984 estimate of 3223 t and the 1985 estimate of 6169 t and equalled 4696 t.

MCY = 0.10 * 0.5 * 4696 = 235 t

The current TAC = 300 t

(ii) Estimation of current annual yield (CAY)

Cannot be estimated.

(iii) Other yield estimates

North and South Islands combined

In the absence of any quantitative stock assessment data, the technique developed by Shepherd (1984) to estimate the status quo catch (SQC) from catch or landings data has been used to estimate the total yield available from the tarakihi "stock" around the North and South Islands combined. The SQC technique appears appropriate for the tarakihi fishery because landings and fishing effort appear to have been fairly stable since the early 1970s. The SQC is the estimated short-term catch when fishing mortality is held constant at the most recent level, and is probably an adequate first step for the short-term TAC management of most fisheries.

A single estimate of the SQC is not considered appropriate because of the developmental changes experienced by the fishery and the differences in the availability and accuracy of the commercial landings data through time. Therefore, the SQC was estimated using four different data sets to provide a range of estimates.

1) Domestic landings only for 1949-85. The beginning year for this data set was 1949 because landings peaked in this year after the initial developmental phase of the fishery. SQC= 4474 t

2) Domestic landings only for 1972-85. The beginning year was 1972 because landings had decreased from the initial high levels of the 1950s and 1960s and remained relatively stable after this year. SQC = 4228 t.

3) Domestic and foreign landings (excluding area D3 or D) combined for 1972-85. The beginning year was 1972 for the same reason as stated in 2) above. SQC = 4954 t.

4) Domestic and foreign landings (excluding area D3 or D) combined for 1968-85. The beginning year was 1968 because it was the first year for which data were available on foreign catches of tarakihi. SQC = 5034 t.

Note: The data used here differ from the data used in the previous assessment (Annala 1988) because more data have become available and existing data have been updated.

The estimates of SQC are considered to be reasonable approximations to the short-term sustainable yield that can be taken from the tarakihi fishery. The "best" estimates of SQC (and yield) for the North and South Islands combined are those made from the combined domestic and foreign landings data. Therefore, short-term sustainable yield is estimated to be between 4954--5034 t, rounded to 5000 t.

(f) Models

Not applicable.

IV. MANAGEMENT IMPLICATIONS

North and South Islands combined

The current gazetted TAC for the North and South Islands combined (excluding the Chatham Rise) is 4860 t, which is 20% greater than the estimate of MCY (4034t). Landings during 1968-85 were relatively stable at an average value (5042 t) greater than the current TAC. Because the current TAC is so close to the long-term average landings and greater than the estimate of MCY, stock size is unlikely to increase rapidly, if at all if the current TAC is maintained. However, an increase in long-term yield may be possible by decreasing short-term yield to rebuild the stock. To ensure that no "substocks" are overexploited, yield should be allocated in proportion to the 1983-85 landings from each QMA.

Chatham Rise

The current gazetted TAC for the Chatham Rise is 300 t. The biomass estimates for the Chatham Islands are probably under-estimates because the trawl surveys were not aimed at tarakihi, and the catchability of tarakihi was probably low with the gear used. Therefore, the estimate of MCY is probably an under-estimate, and the current TAC is probably sustainable. However, at the current TAC level the population will probably not grow rapidly, if at all.

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Table 1. Times of the year when tarakihi were caught from the main fishing grounds during 1983/84 to 1985/86. * = major tarakihi spawning grounds

North Cape to Cavalli I.(Area 2) - winter, spring
Cavalli I. to Great Barrier(3) - pre, post, winter, spring
Great Barrier to Shoe I.(8) - winter
Shoe I. to Whakatane R.(9) - post, winter
Whakatane R. to Cape Runaway(10) - post
Cape Runaway to Tolaga Bay(11+12) - pre, post, winter *
Tolaga Bay to Cape Kidnappers(13) - year-round
Cook Strait(16+17) - pre, summer
Kaikoura(18) - pre, post, summer *
Pegasus Bay(20) - post, winter, spring
Canterbury Bight(22) - post, winter, spring
Cascade Point to Cliffy Head(33) - post, spring *
Cliffy Head to Cape Foulwind(34) - post, spring
Tasman Bay(38) - pre, post
Manakau Harbour to North Cape(45-47) - winter, spring

TABLE 2: Domestic landings (t) of tarakihi by fishing region, 1931-85

	1931	1932	1933	1934	1935	1936	1937	1938
East Northland	8							-*
Hauraki Gulf	1 202	607	547	727	920	1 268	1 231	1 145
Bay of Plenty	59	43	46	39	27	24	15	6
East coast-Hawke Bay			148	291	403	11	171	279
Cook Strait	4	839	420	612	946	1 088	943	807
Canterbury Bight			152	127	284	283	208	471
Southland								
West coast		2	3		2	2	8	9
Tasman Bay							-	
West Auckland	3	3	1	3	2	-		-
Total	1 276	1 494	1 317	1 799	2 584	2 676	2 576	2 717

	1939	1940	1941	1942	1943	1944	1945	1946
East Northland	-	4	1	-	1	2	1	1
Hauraki Gulf	1 066	670	654	837	616	929	1 217	1 412
Bay of Plenty	22	17	5	15	1	61	67	101
East coast-Hawke Bay	209	312	516	547	410	742	815	967
Cook Strait	951	623	434	168	46	53	864	1 087
Canterbury Bight	239	655	620	505	408	481	513	381
Southland				-		-	-	
West coast	1	1	1	2	-	-	-	-
Tasman Bay	-					-	-	
West Auckland			-			-		-
Total	2 488	2 282	2 231	2 074	1 482	2 268	3 477	3 949

	1947	1948	1949	1950	1951	1952	1953	1954
East Northland	2	2	5	16	2	1	-1	1
Hauraki Gulf	1 132	865	1 148	1 559	1 719	1 833	1 643	1 493
Bay of Plenty	104	265	542	506	378	319	429	309
East coast-Hawke Bay	1 172	1 466	1 241	1 168	1 270	1 046	1 074	1 006
Cook Strait	1 150	1 205	1 620	1 397	1 377	1 822	1 753	985
Canterbury Bight	1 015	823	1 009	773	805	969	805	513
Southland	-	-	1	-	-	-		-
West coast	30	36	53	100	59	31	15	10
Tasman Bay	42	56	12	-			2	7
West Auckland		9	10	6	5	7	146	23
Total	4 647	4 727	5 641	5 525	5 615	6 028	5 868	4 347

	1955	1956	1957	1958	1959	1960	1961	1962
East Northland	2	4	1	1	1	-	26	20
Hauraki Gulf	1 569	1 109	943	781	1 078	856	861	587
Bay of Plenty	474	541	321	322	475	460	384	433
East coast-Hawke Bay	1 166	1 658	1 536	1 473	1 900	2 231	2 401	2 470
Cook Strait	1 707	1 331	1 457	1 155	1 190	1 383	1 058	1 525
Canterbury Bight	524	360	1 078	1 301	1 244	819	991	1 063
Southland			-	1	-	4	6	-
West coast	12	10	14	43	83	47	42	14
Tasman Bay	3	-	-	11	8	11	6	10
West Auckland	223	287	186	216	186	165	157	159
Total	5 680	5 300	5 536	5 304	6 165	5 976	5 932	6 281

TABLE 2: Domestic landings (t) of tarakihi by fishing region, 1931-85 (continued)

	1963	1964	1965	1966	1967	1968	1969	1970
East Northland	16	18	18	18	51	44	38	48
Hauraki Gulf	674	506	531	346	226	331	214	296
Bay of Plenty	467	576	650	522	515	372	445	512
East coast-Hawke Bay	2 073	2 194	2 675	2 656	2 359	1 663	1 532	1 731
Cook Strait	1 255	1 106	890	942	716	722	603	655
Canterbury Bight	955	1 255	1 131	1 546	487	591	430	644
Southland	1	-	2	18	2	4	2	10
West coast	14	41	32	85	112	61	147	236
Tasman Bay	15	17	7	12	1 703	1 729	116	865
West Auckland	228	158	78	100	156	86	80	213
Total	5 698	5 871	6 014	6 245	6 327	5 603	3 607	5 210

	1971	1972	1973	1974	1975	1976	1977	1978
East Northland	77	61	26	33	34	44	68	126
Hauraki Gulf	252	322	190	139	170	136	123	231
Bay of Plenty	444	330	380	260	150	250	376	478
East coast-Hawke Bay	1 793	1 763	1 314	1 786	1 654	1 464	1 785	1 547
Cook Strait	670	528	664	485	450	626	764	586
Canterbury Bight	938	742	703	523	502	388	337	229
Southland	4	3	3	21	4	51	39	26
West coast	162	92	36	129	267	179	193	257
Tasman Bay	651	339	341	291	170	307	432	550
West Auckland	240	153	111	92	31	48	57	59
Total	5 231	4 333	3 768	3 814	3 440	3 509	4 185	4 189

	1979	1980	1981	1982	1983	1984	1985†
East Northland	165	94	89	107	89	112	101
Hauraki Gulf	325	417	348	307	427	458	311
Bay of Plenty	475	528	483	480	554	627	544
East coast-Hawke Bay	1 207	1 195	1 184	1 188	1 184	1 197	1 220
Cook Strait	538	780	950	830	705	926	927
Canterbury Bight	491	778	666	340	319	377	633
Southland	21	49	48	20	32	29	36
West coast	261	150	278	351	503	516	242
Tasman Bay	304	297	562	305	169	154	132
West Auckland	157	326	205	161	236	170	145
Total	4 046	4 740	4 825	4 217	4 256	4 568	4 298

* Less than 1 t.
† Provisional.

TABLE 3: Domestic landings (t) of tarakihi, 1974-85*

	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974
A: Region												
North Island												
Whangaroa	-	-	-	-	-	-	103	-	-	-	-	-
Whangarei	-	-	-	-	-	48	-	-	-	-	-	-
Auckland	310	458	421	309	347	416	325	230	119	134	169	139
Manukau	129	167	233	161	205	326	157	53	56	48	-	97
Mercury Bay	-	91	81	61	125	294	209	150	75	-	-	-
Tauranga	421	431	387	372	259	234	266	328	274	223	134	256
Opotiki-Whakatane	90	106	87	97	99	92	-	50	-	-	-	-
Gisborne	1 099	966	942	998	973	1 061	1 083	1 247	1 467	1 194	1 485	1 490
Napier	121	231	242	205	212	135	124	301	317	269	169	301
Wellington	405	320	302	180	328	420	417	466	620	492	374	415
Paremata	54	45	52	-	-	-	-	-	54	66	-	-
South Island												
Motueka	-	55	68	-	54	76	67	112	75	-	35	-
Nelson	94	95	95	284	502	206	217	429	354	275	135	288
Kaikoura	424	528	320	576	511	291	62	-	-	-	-	-
Lyttelton	397	159	195	135	156	137	102	-	-	62	175	247
Timaru	108	139	45	119	247	369	318	143	200	89	108	106
Oamaru	62	-	-	-	71	112	51	-	53	114	93	54
Port Chalmers	-	-	-	-	160	138	59	-	42	85	99	98
Bluff	-	-	-	-	-	48	-	-	-	45	-	-
Greymouth	211	435	479	360	273	149	258	254	180	177	263	116
Other regions (<1%)	373	342	307	360	303	188	228	426	299	236	201	207
Total	4 298	4 568	4 256	4 217	4 825	4 740	4 046	4 189	4 185	3 509	3 440	3 814
B: Fishing method												
Pair trawl	116	147	208	232	355	464	347	323	229	121	37	56
Single trawl	3559	3 716	3 562	3 220	3 786	3 823	3 511	3 668	3 770	3 319	3 365	3 700
Set net	517	594	403	683	622	399	136	161	170	47	23	12
Line fishing	102	104	80	72	61	52	50	33	15	12	10	16
Other methods	4	7	3	10	1	2	2	4	1	10	5	30

* Landings are for ports contributing more than 1% of total landings.

TABLE 4: Domestic landings (t) of tarakihi by fishingyear (1 Oct-30 Sep). Landings by fishing return area grouped into Quota Management Areas (QMA). - = no data

QMA	Domestic landings (t) 1983/84	1984/85	1985/86
Auckland			
East (1)	1 035	770	750
West (9)	210	180	211
Combined (1 + 9)	1 245	950	961
Central			
East (2)	1 118	1 129	1 318
Egmont (8)	28	30	45
Combined (2 + 8)	1 146	1 159	1 363
Challenger/Central (Plateau) (7)	724	473	442
South-East (Coast) (3)	878	1 105	1 091
South-East (Chatham Rise) (4)	1	1	1
Southland + Sub-Antarctic (5 + 6)	28	31	31
Kermadec (10)	-	-	-
Area unknown	677	434	686
Totals	4 700	4 153	4 575

TABLE 5: Japanese and foreign fishing vessel catches of tarakihi from 1968 to 1985-86; data from 1968 to 1978-79 are from unsourced Japanese fishing statistics held at FRC; data from 1979-80 to 1985-86 are FRC statistics for all foreign-licensed and joint-venture vessels

Japanese vessels only[1]

Area	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
D1	-*	-	7	6	4	-	-	17	20	1
D2	71	178	382	155	624	322	573	375	415	1 000
D3	-	-	-	0	12	-	0	0	0	267
D4	6	100	13	3	71	30	107	301	60	88
D5	-	-	-	-	-	13	-	13	207	0
D6	-	-	-	10	6	-	3	123	65	10
D7	-	79	11	155	131	113	635	530	314	687
D8	3	118	26	142	249	193	162	142	100	206
Undefined	-	-	-	-	-	-	-	-	-	-
Total	80	475	439	471	1 097	671	1 480	1 501	1 180	2 259

* No data.
1 Fishing year 1 Jan-31 Dec.
2 Fishing year 1 Apr-31 Mar.
3 No data for the entire year.
4 Fishing year 1 Apr-30 Sep.
5 Fishing year 1 Oct-30 Sep.

TABLE 5: Japanese and foreign fishing vessel catches of tarakihi from 1968 to 1985-86; data from 1968 to 1978-79 are from unsourced Japanese fishing statistics held at FRC; data from 1979-80 to 1985-86 are FRC statistics for all foreign-licensed and joint-venture vessels (continued)

All foreign-licensed and joint-venture vessels

EEZ area	1977-78[2] (Japanese only)	1978-79[2] (Japanese only)	1979-80[2]	1980-81[3]	1981-82[2]	1982-83[2]	1983-83[4]	1983-84[5]	1984-85[5]	1985-86[5]
A	-	-	-	-	-	-	-	-	-	-
B	7	6	2	-	-	-	-	-	-	-
C	628	28	36	10	1	38	24	178	56	
D	832	-	117	64	113	2	286	131	172	
E	-	-	-	-	77	29	26	12	1	
F	14	22	25	66	33	1	61	57	16	
G	485	25	86	53	25	36	91	64	59	
H	482	159	32	173	200	17	244	215	231	
Undefined	-	-	-	2	-	-	-	5	-	
Total	2 448	238	298	368	449	123	732	664	535	

Table 6: Domestic and foreign landings combined (t) from 1983/84 to 1986/87 and TACs (t) for 1987/88 grouped by Quota Management Area (QMA). Landings data from 1983/84 to 1985/86 from FSU fishing return forms. Landings data for 1986/87 from Quota Monitoring Reports.
- = no data.

	Domestic and foreign landings (t)				TAC
QMA (Area no.)	1983/84	1984/85	1985/86	1986/87	1987/88
Auckland					
East (1)	1035	770	750		
West (9)	291	252	288		
Combined (1+9)	1326	1022	1038	924	1210
Central					
East (2)	1118	1129	1318	1383	1410
Egmont (8)	109	102	122	188	190
Combined (2+8)	1227	1231	1440	1571	1600
Challenger Central Plateau (7)	896	609	519	907	930
South-East Coast (3)	902	1283	1147	946	970
South East Chatham Rise (4)	287	132	173	80	300
Southland + Sub-Antarctic (5+6)	115	100	48	42	140
Kermadec (10)	-	-	-	-	10
Area unknown	677	439	686	-	-
TOTALS	5430	4816	5051	4470	5160

TABLE 7: Returns of tarakihi tagged during 1986 and 1987 through 29 February 1988

Date	Area	No. tagged	No. returned (% returned)	No. recaptured outside tagging area and direction moved (% moved outside tagging area)
1986				
Feb	Kaikoura	1 350	42 (3.1%)	17N, 3S (47.6%)
Mar	Tasman/Golden Bays	270	7 (2.6%)	0 (0%)
Apr/May	Kaikoura	910	8 (0.9%)	1N (12.5%)
1987				
Apr	Kaikoura to Pegasus Bay	128	5 (3.9%)	0 (0%)
May	Kaikoura	532	12 (2.3%)	3N, 1S (33%)

Table 8. Parameters of the von Bertalanffy growth equation for both sexes combined for Bay of Plenty (Tong and Vooren 1972) and East Cape (Vooren and Tong 1973).

Area	L	K	t
Bay of Plenty	39.9	0.26	-0.49
East Cape	50.3	0.1	-4.3

Table 9. Biomass estimates (t) for tarakihi using wingspread as the area swept measurement. All estimates are from Hurst and Fenaughty (1985), except for "Akebono Maru", Chatham Islands, Dec 1985, which is from Hurst and Bagley (unpubl. data).

Vessel	Area	Date	Biomass (t x 10)	CV(%)
Shinkai Maru	E-F	Feb 1981	1.2	58
		Mar-Apr 1982	0.4	84
		Apr 1983	0.7	91
		Oct-Nov 1983	0.1	71
W.J. Scott	West coast South Island	Jun-Aug 1981	11.3	22
		Sep-Feb 1982	9.7	11
		Mar-Jul 1982	9.3	18
		Jul-Oct 1982	9.8	11
		Oct-Feb 1983	8.8	13
		Feb-Apr 1983	5.7	20
James Cook	West coast South Island	Sep-Oct 1983	7.1	20
		Aug-Sep 1984	3.6	19
Tomi Maru	Central west coast	Dec 1980-Feb 1981	16.9	15
Shinkai Maru	Central west coast	Oct-Nov 1981	16.5	13
James Cook	Canterbury Bight	Mar 1980	2.5	32
		Dec 1980	0.7	74
		Feb 1981	1.8	50
		May 1981	0.3	57
		Dec 1981	0.9	59
		Jan 1982	1.5	41
		May 1982	1.5	49
		Sep 1982	1.2	86
		Dec 1982	1.1	52
Shinkai Maru	Chatham Rise	Mar 1983	4.8	33
		Nov-Dec 1983	1.1	61
Akebono Maru	Chatham Islands	Dec 1984	3.9	28
		Dec 1985	2.7	16

Figure Captions

Fig. 1. Domestic landings(t) of tarakihi for 1983/84, 1984/85, 1985/86 fishing years (1Oct-30Sep) by fishing return area. Area not known-- 1983/84 = 677 t, 1984/85 = 434 t, 1985/86 = 686 t. 0 = < 1 t; - = no landings reported.

Fig. 2. The relationship between size and age of tarakihi (both sexes combined) from four areas around New Zeland. (Fig. 4 in Annala 1987).

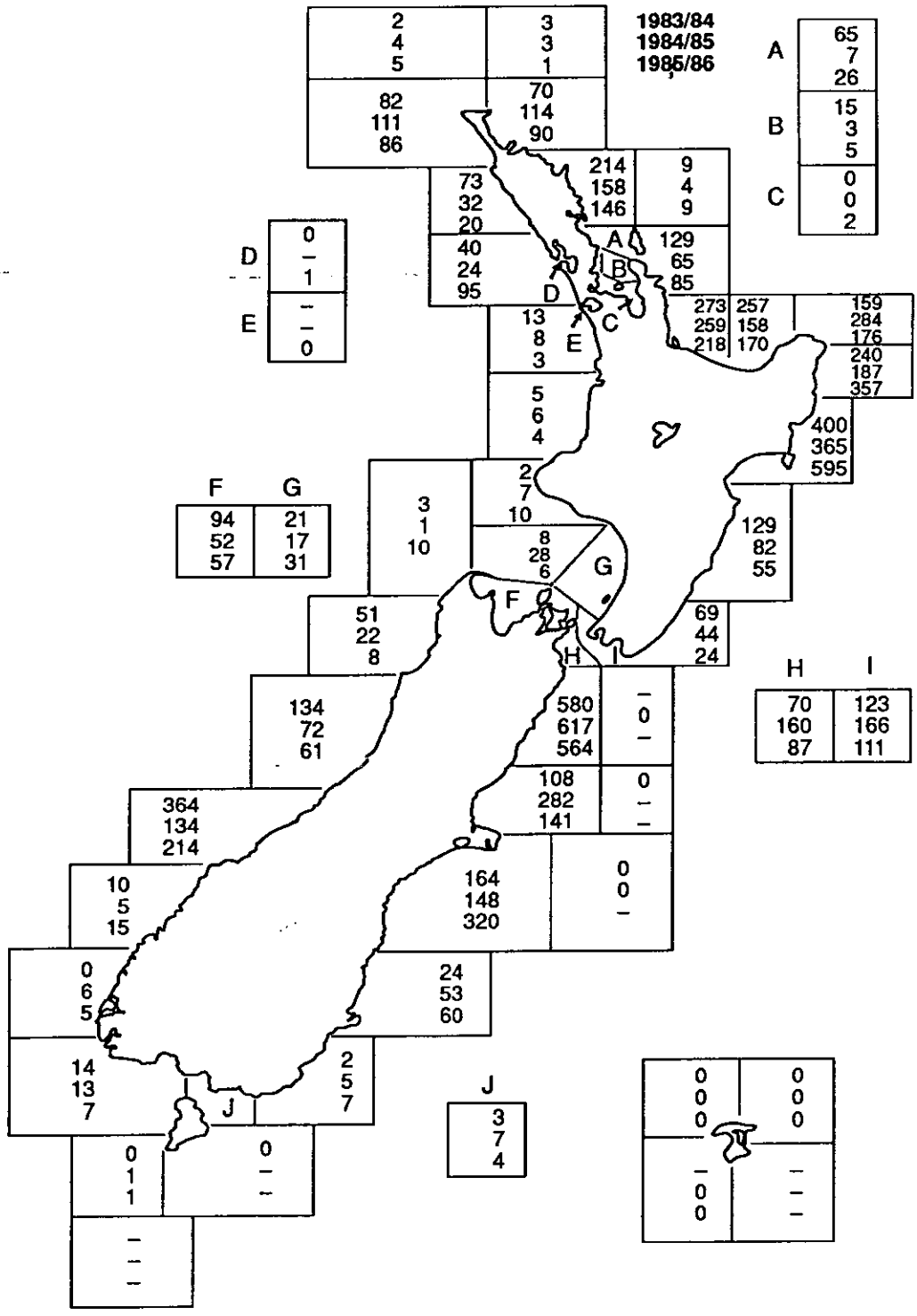
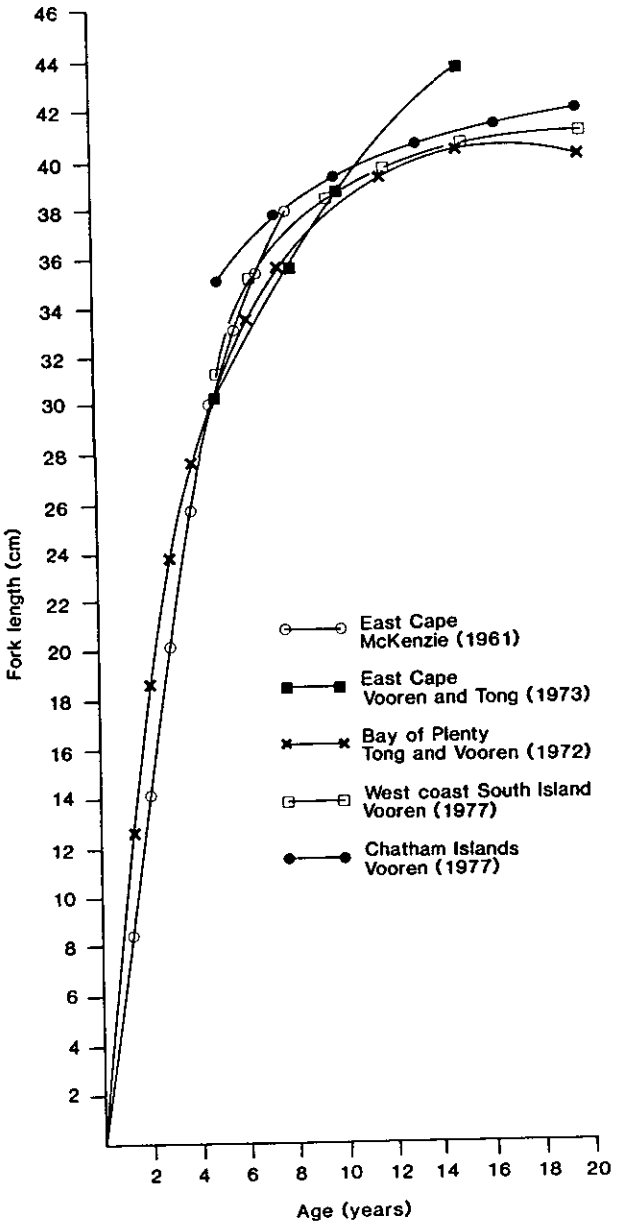


Fig. 1

Fig. 2


Fork length (cm)
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
2
4
6
8
10
12
14
16
18
20
Age (years)
East Cape
McKenzie (1961)
East Cape
Vooren and Tong (1973)
Bay of Plenty
Tong and Vooren (1972)
West coast South Island
Vooren (1977)
Chatham Islands
Vooren (1977)