The biology and fishery of tarakihi, *Nemadactylus macropterus*, in New Zealand waters

by
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Abstract

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Tarakihi, *Nemadactylus macropterus*, are widely distributed around New Zealand. They are important to both commercial and amateur fishermen and are normally caught in depths of 10–200 m, with the greatest catches from depths over 100 m. They are generally summer-autumn (January-June) spawners, and there are several known spawning areas. Sexual maturity is reached at about 25–35 cm long, at about 4–6 years old. The pelagic larvae and postlarvae drift extensively in open water for 7–12 months. The postlarvae settle to the bottom and begin the juvenile phase at 7–9 cm. Several juvenile nursery areas have been identified in shallower, inshore waters. Juveniles move out to deeper waters at about 25 cm long, at about 3–4 years old. Evidence on genetic structure suggests that area differences constitute selective clines rather than genetically isolated stocks. Tag return data revealed that most fish showed only localised movements during the first year, but extensive movements during later years. The growth rate decreased rapidly at sexual maturity, more so for males, and mature females were larger and more abundant in larger size classes. The annual instantaneous natural mortality rate was estimated as 0.08–0.15. Tarakihi eat a wide range of polychaetes, crustaceans, echinoderms, and molluscs. Until the mid 1970s tarakihi were the third most important fish species for the domestic commercial fishing fleet in terms of landed weight. In 1983 tarakihi ranked seventh. Foreign fishing activity in the late 1970s probably had a large impact on tarakihi abundance, and landings by foreign-licensed and joint-venture vessels have subsequently declined. Tarakihi stocks do not appear to be under severe stress, though the East Cape and Kaikoura-Cook Strait areas may be moderately overfished.

Introduction

Tarakihi, *Nemadactylus (Cheilodactylus) macropterus*, are percoids belonging to the family Cheilodactylidae (Fig. 1). They are important to both commercial and amateur fishermen around New Zealand. Their biology and fishery were investigated during the late 1960s and early 1970s; however, little work has been done since.

This publication summarises the available information on the biology and fishery of tarakihi up to 1985 from both published and unpublished sources. Where appropriate, the available information is synthesised and new hypotheses are put forward.

Distribution

In New Zealand tarakihi are found from the Three Kings Islands south to the Snares Islands and east to the Chatham Islands (Fig. 2). This species is also found off southern Australia (Han 1964), around Amsterdam and St. Paul Islands in the Indian Ocean (Angot 1951), and off the southern coast of South America (Berg (1895) *in* Tong and Vooren (1972)).

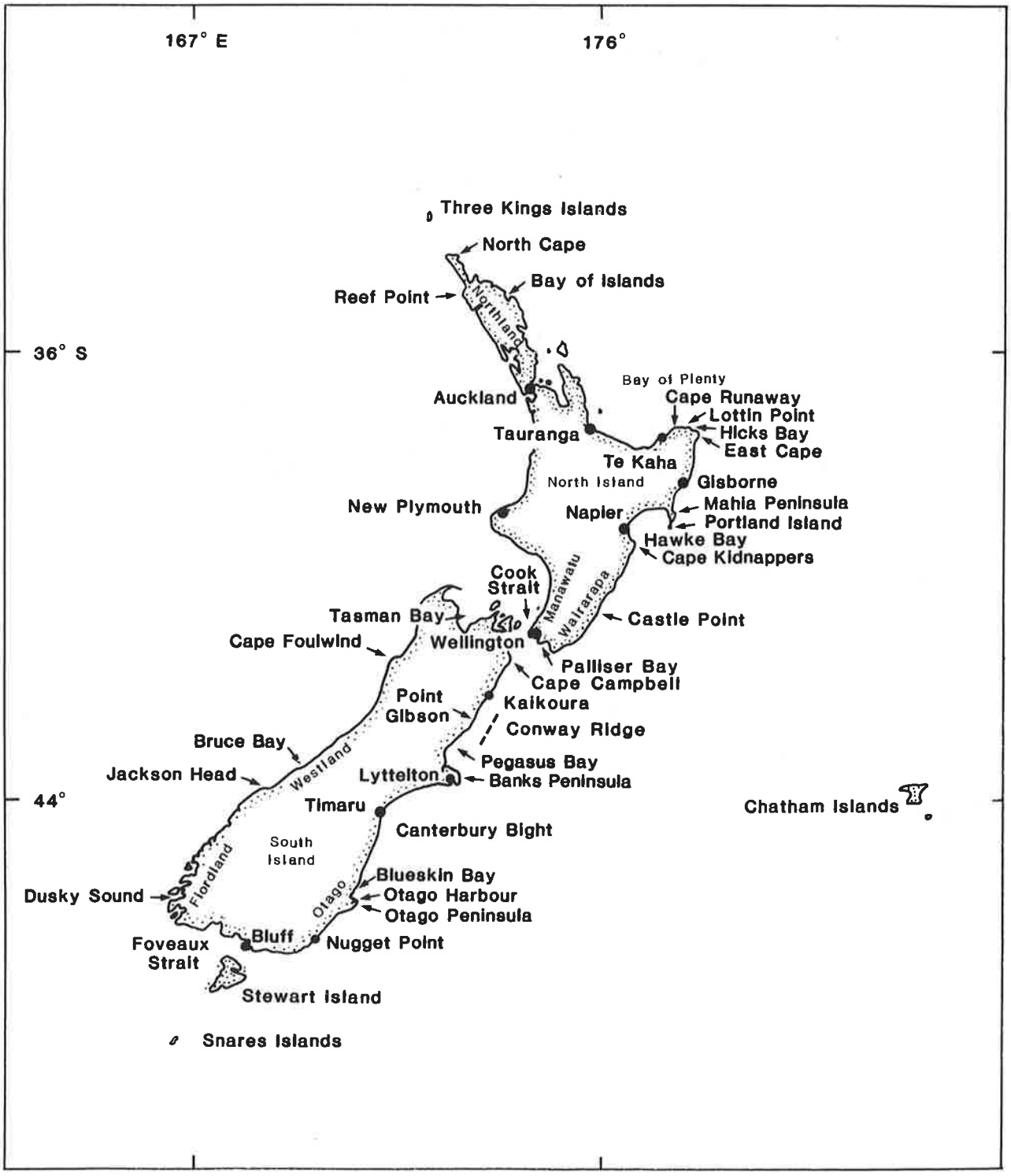

Fig. 2: Localities mentioned in the text.

Tarakihi are normally caught in depths of 10–200 m, with the greatest catches from depths over 100 m. Ayling and Cox (1982) stated that tarakihi were most abundant over soft mud bottoms in the East Cape area and on the east and west coasts of New Zealand. However, Graham (1956) reported that, though they were found on all bottom types, they preferred a bottom with much gravel.

Tong and Elder (1968) described the distribution of tarakihi in the Bay of Plenty from trawl surveys between 1961 and 1963. Tarakihi were most abundant at depths over 50 fathoms (fm) (about 90 m), though they moved into 25–50 fm during the winter, and they were more likely to be found over muddy bottoms. There were no seasonal differences in the total catch, and few fish less than 25 cm long were caught.

Fenaughty and Bagley (1981) described the distribution of tarakihi along the east coast of the South Island between Cape Campbell and Nugget Point from a continual trawl survey between 1978 and 1980. The most consistent trawl grounds for this species were in northern Pegasus Bay, including the Conway Ridge. The sea floor in this region was covered with polychaete worms. Catch rates were highest in the shallow, 76–125 m interval, peaked in the early morning and late afternoon, and declined in the middle of the day. There was little variation with moon phase, though small peaks occurred in the first and last quarters. Catches outside northern Pegasus Bay were generally small and scattered.

Paul, Roberts, and James (1983) described the distribution of tarakihi from trawl surveys off the west coast of the North Island during 1971–72. They were common throughout the area, down to the maximum depth sampled (about 250 m). Most specimens found inshore (especially in Tasman Bay) were juveniles, whereas most on the central and outer shelf were adults. There were no apparent seasonal changes in distribution or abundance.

Biology

Reproduction

Tarakihi spawn in several areas around New Zealand. The first recorded observation of spawning was by Graham (1939), who reported a specimen with a ripe roe taken off the Otago coast in 100 fm during December 1932. McKenzie (1961) observed that spawning between Hicks Bay and Lottin Point generally took place during April. Tong and Vooren (1972) reported spawning near Lottin Point from February onward, in the western Bay of Plenty from March to June, and on the Conway Ridge from January-February onward.

Robertson (1978) stated that tarakihi spawn at least in the sounds of Fiordland, from outer Pegasus Bay to Cook Strait, and from Mahia Peninsula to the western Bay of Plenty, and that they are summer-autumn spawners. Robertson (1973) suggested tarakihi did not spawn along the east coast of the South Island from Banks Peninsula to Dusky Sound, probably because of the cooling influence of subantarctic surface water. Robertson (1978) also found no evidence of spawning in Otago waters during 1970–72, though Graham (1939) had reported a ripe female being caught off Otago.

Vooren (1975) suggested tarakihi spawn in the following areas around New Zealand: East Cape, west coast of the South Island, off Kaikoura, Pegasus Bay, Canterbury Bight, and the Chatham Islands.

Fenaughty and Bagley (1981) reported that the two major spawning grounds along the east coast of the South Island were off Cape Campbell and in northern Pegasus Bay, including the Conway Ridge. Running ripe fish were observed in January and February between Cape Campbell and Point Gibson.

In a detailed study of tarakihi spawning, Robertson (1978) obtained plankton samples from Kaikoura, East Cape, Fiordland, Otago, Castle Point, Bay of Islands, and North Cape and found tarakihi eggs only in the first three areas. Spawning took place mainly at night, and in the Kaikoura area it occurred in mid water (54–67 m), but it may have occurred closer to the surface near East Cape. Once fertilised, the eggs rise slowly to the surface and disperse.

Tong and Vooren (1972) reported that tarakihi around New Zealand release more than one batch of gametes each season; i.e., they are serial spawners. Han (1964) found similar results in Australia.

Tong and Vooren (1972) suggested that final maturation and ripening of the gonads were probably related to a drop in seawater temperature. Ripe tarakihi occurred in catches in the western Bay of Plenty in 1968 and 1969 when the bottom temperature had fallen from a summer maximum of about 17 °C to about 16 °C in April. Irwin (1981) presented data from Kaikoura to support the claim that spawning was triggered by a temper-

ature decrease after a summer peak. Tarakihi appeared on the fishing grounds when the temperature increased to 11.0–11.5 °C during September-October and left (presumably for the spawning grounds) between February and April.

McKenzie (1961) found that most fish in the Lottin Point-Hicks Bay area matured in their fourth and fifth years and that the growth of mature fish was slower than immature fish. Tong and Vooren (1972) found that for the western Bay of Plenty no fish were mature at 3 years, and all were mature at 6 years. For males, the length at first maturity was 25 cm; at 50% maturity, 27 cm; and at 100% maturity, 31 cm. For females, the same lengths were 24, 28, and 35 cm. In the East Cape area males and females matured at the same age and length, generally between 4 and 6 years old and between 23 and 36 cm long (Vooren and Tong 1973).

Size and age at maturity also affect growth rate: there is a decrease in growth rate at about 5–6 years of age, after full maturity is reached. After 4 years the growth rates diverge, and females are slightly larger for each age group (Tong and Vooren 1972).

Maturity also affects the behaviour of the fish. The low proportion of sexually immature tarakihi in commercial catches suggests that they do not become vulnerable to fishing operations until they are mature (Tong and Vooren 1972).

In summary, tarakihi are summer-autumn spawners which spawn in several areas around New Zealand. They are serial spawners which appear to form aggregations in mid water in at least one area. Both sexes reach sexual maturity at 4–6 years of age and are then vulnerable to the commercial fishery.

Larvae and postlarvae

Few larval and postlarval tarakihi have been caught and identified. Evidence suggests that the postlarval stage is pelagic, occurs in offshore waters, and is found in surface waters at night. Vooren (1972) collected postlarvae and stages intermediate between postlarvae and juveniles in Blueskin Bay in 1968 and Pegasus Bay in 1969. Tong and Saito (1977) identified 13 postlarvae between 14 and 68 mm standard length in plankton samples taken just beneath the surface from around New Zealand between 1971 and 1974. Robertson (1978) collected 30 prejuveniles with a mean length of 33 mm at the surface in Blueskin Bay on the night of 30 November 1970 by use of a light and a dip net. Postlarval metamorphosis occurs in spring or early summer, when the fish are 7–9 cm long and 7–12 months old.

Juveniles

Vooren (1975) suggested tarakihi nursery grounds occurred at depths of 20–100 m and mostly 10–30 km offshore. He identified the following nursery grounds: south-west coast of the North Island, Tasman Bay, near Kaikoura, northern Pegasus Bay, Canterbury Bight, Otago, and the Chatham Islands. Graham (1956) saw abundant tarakihi 2–3 in (5–8 cm) long in Otago Harbour during January-March. Fenaughty and Bagley (1981) saw concentrations of juveniles along the entire east coast of the South Island, especially south of Banks Peninsula. Speculation by Vooren (1975), and casual observations by Fisheries Research Division staff (including the author), suggest that, in addition to the previously identified nursery grounds, juvenile tarakihi are probably abundant in many rocky, inshore areas around New Zealand, where they are not available to sampling by trawls.

The most intensively studied nursery ground was that in Tasman Bay (Vooren 1975). The nursery was at 20–45 m depth and had an extremely rich epifauna of sponges and small corals. The youngest age groups first appeared in the research trawls between November and June, and during January and February they were just less than 1 year old, with a modal length of 9.5 cm. The data available suggested a substantial year to year variation in the number of 0-group fish moving into Tasman Bay. The fish stayed in the nursery until age 3, moved into deeper water off the nursery at ages 4–5, and left the area after attaining sexual maturity during the sixth year.

Stocks

The iron content of tarakihi otoliths has been examined for its possible use as a population marker. It varied in a clinal pattern, and New Zealand was divided into three regions: north, with boundaries south of Reef Point and in the Bay of Plenty; south-east, with boundaries south of Banks Peninsula and in South Otago; and the remaining east and west coasts area (Gauldie and Nathan 1977, Fig. 5). They believed that circumstantial evidence suggested the existence of three separate stocks. Further analysis of the data showed a significant positive relationship between otolith iron content and seawater temperature (Gauldie, Graynoth, and Illingworth 1980).

On the basis of allele frequencies at the phosphoglucomutase locus, Gauldie and Johnston (1980) proposed the following stock boundaries for tarakihi: 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, comparison of allele frequencies at all stations where tarakihi were found, with allele frequencies of the 1966–73 year classes from one of the stations (Pegasus Bay), showed that variation over the whole region was not significantly different from the yearly variation at Pegasus Bay. 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."

Movements

Tagging tarakihi to determine movements has had limited success. Tagging started in 1953, and 8500 fish were tagged up to 1961 (Allen 1963). Of the 3363 fish tagged with Peterson tags joined with monofilament nylon, 76 (2.3%) were recovered.

An overall recovery rate of 2.1% was reported from 4500 fish tagged between East Cape and Cape Kidnappers during 1953–59 (McKenzie 1961). Most of the first year returns did not show extensive movements, but had moved only a few miles along the coast or in an inshore-offshore direction. However, returns from later years did reveal extensive movements. Two fish were caught more than 200 miles (320 km) from their release points: one tagged at Cape Kidnappers was caught off Te Kaha, and the other tagged near Portland Island was recaptured in Cook Strait. Four others were caught over 100 miles from the tagging site. Most of the recoveries were made north of the release points, many of them on, near, or beyond the spawning grounds west of East Cape around the time of the spawning season.

Between 1969 and 1973, 7040 tarakihi were tagged at various sites around the North and South Islands (Crossland 1982, Tong unpublished data). All but 16 of the tagged fish were trawl caught, many in deep water (down to 180 m). Recapture rates were low, with only 34 (0.5%) of the tagged fish being returned. The low return rates were probably the result of mortality sustained from stress and damage while in the trawl net. Initial tagging mortality of a trawl-caught sample from Tasman Bay was estimated at 40–70%. In contrast, of the 16 fish that were line caught, 5 (31%) were returned.

Recruitment

The estimated pelagic phase of 7–12 months 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. The postlarvae would be carried by the northward flowing Westland Current (Fig. 3) 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

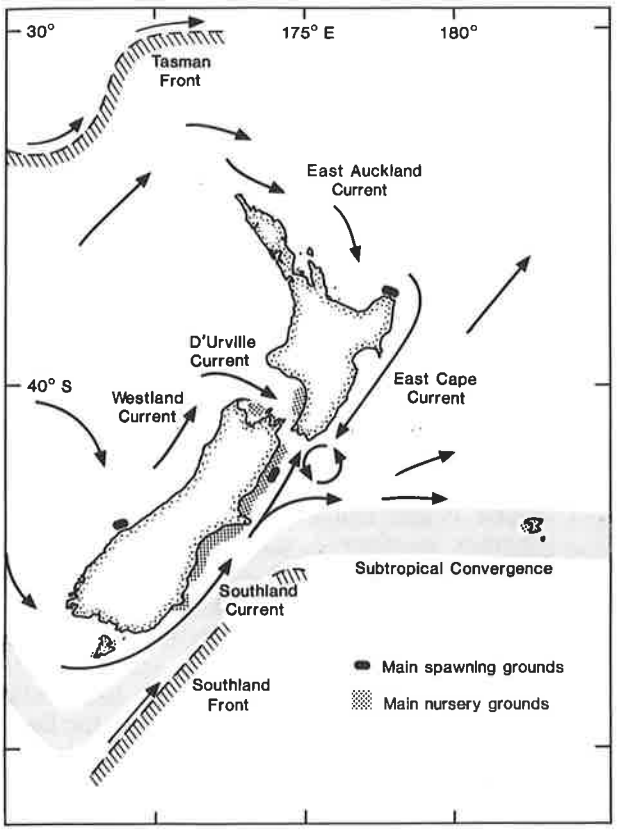

Fig. 3: Major spawning and nursery grounds of tarakihi and main current systems (after Heath 1985, Fig. 2) around New Zealand.

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 Castle Point. 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.

A synthesis of the published and unpublished information on the recruitment of tarakihi with recently published information on current systems around New Zealand (Heath 1985, Barnes 1985) has resulted in the following hypothesised recruitment mechanisms; for each mechanism, the late juveniles and young adults migrate against the pre-

vailing current to their parental spawning grounds. The major spawning and nursery grounds for tarakihi and the main current systems are shown in Fig. 3.

1. The larvae produced by the spawning stock off Fiordland and South Westland can be transported north or south. Those carried north by the Westland Current settle in Tasman Bay and along the west coast of the North Island, and some may be carried through Cook Strait. Those carried south settle in Foveaux Strait or are carried east and then north by the Southland Current and settle mainly along the Otago coast and in the Canterbury Bight. The northward extent of the Southland Current, and the position of the eddy system off the east coast of the North Island (Barnes 1985), will influence whether postlarvae settle in Pegasus Bay, Cook Strait, or the southern east coast of the North Island. Because of the long larval life, some of these larvae may reach the Chatham Islands.
2. Larvae from the East Cape-Bay of Plenty spawning grounds are transported by the East Cape Current south along the east coast of the North Island, east towards the Chathams by the eddy system, and then north by the counter current offshore. Larvae settle along the entire east coast of the North Island on their way south and may be carried around the whole system back to the parental spawning grounds. Some larvae may reach the Chathams.
3. The Conway Ridge-Pegasus Bay spawning population may be an important link between tarakihi "stocks". Because of the complicated nature of the current systems in this area (Heath 1985), larvae may be transported out and settle along the east coast of central New Zealand from Pegasus Bay to the Wairarapa coast, be carried through Cook Strait, be entrained in the eddy system off the east coast of the North Island and carried north towards East Cape, or be carried out to the Chathams.
4. Spawning in the Chatham Islands has not been confirmed. Larvae may be transported to the Chathams from the North and South Islands or may be produced by a resident spawning population at the Chathams.

Age and growth

Tarakihi are generally regarded as slow-growing, long-lived fish. Graham (1956) reported that the maximum size observed off Otago during 1930–34 was 28 in (71 cm) and 9 lb (4 kg); the previous maximum size recorded was 42 in, weighing 18 lb.

The first study of age and growth of tarakihi was in the East Cape area (McKenzie 1961). From the number of annual rings on scales, tarakihi were estimated to reach the minimum legal size of 10 in 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.

The aging of tarakihi by use of otoliths and other techniques has been described in detail (Tong and Vooren 1972). 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). 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.

Tong and Vooren (1972) inferred from the Bay of Plenty samples that there were two bursts of growth: a major one during spring-summer (September-January) and a minor one in autumn (April-May), with little growth in between. The cessation of growth in February-March coincided with the rapid increase in gonad weight before spawning and may have been connected with spawning.

In a study of age and growth in 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 rapidly for both sexes after age 10. Growth continued up to at least 30 years.

Von Bertalanffy growth equations 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. 4; there were no obvious differences between areas.

Mortality

Few estimates of mortality rates of tarakihi are available. 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. The annual instantaneous fishing mortality rate (F) was estimated from the equation $F = Z - M$ and was 0.60 or 0.35.

Vooren (1977) also 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 is assumed to apply here as well, F is 0.05; the variables are all low for these lightly fished populations.

Ecology

Little is known about the ecology of tarakihi. Thomson (1891) recorded the following food items from tarakihi: shellfish, fish, seaweed, crustaceans, squid, and sandworms. Phillipps (1926) examined the stomachs of 20 tarakihi trawled from Palliser Bay in April 1922. They appeared to have fed on sand formations on the bottom, and 15 of the stomachs contained algae, which constituted most of the contents. Less than half the stomachs contained worms or spatangoid sea urchins.

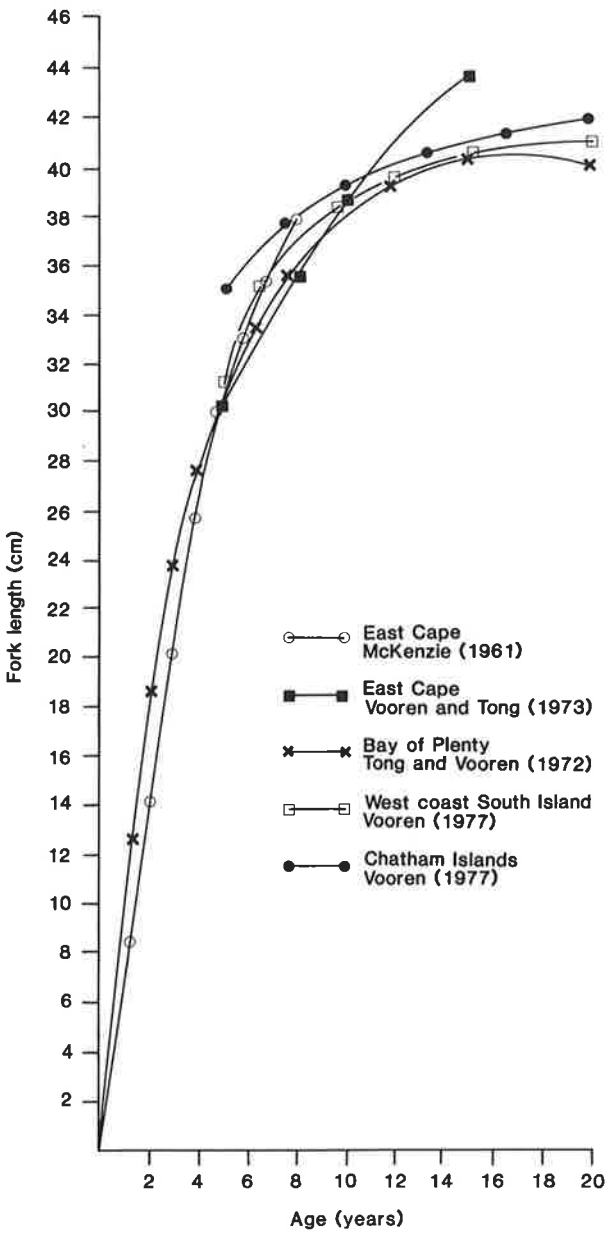

Fig. 4: The relationship between size and age of tarakihi (both sexes combined) from four areas around New Zealand.

Graham (1956) observed that no fish were found in the stomachs of tarakihi collected in the Otago area. Bottom and swimming crabs were favourite food items, especially the latter, but *Munida*, isopods, and amphipods were also eaten.

McKenzie (1961) observed that tarakihi in the East Cape area fed on various benthic invertebrates, including shallow-burrowing and tube-forming worms, echiurids, brittle stars, holothurians, various bottom-dwelling crustaceans, and shellfish. The nature of the gut contents suggested that the fish gulped at the bottom rather than selected their food items. However, they fed extensively on pelagic fauna at certain times, and the stomachs of a whole catch of fish were fully distended with the euphausid *Nyctiphanes* during April. Fenaughty and Bagley (1981) reported that the tarakihi stomachs they examined from the east coast of the South Island contained mostly small crustaceans and worms.

In a detailed study of the food and feeding of tarakihi in the western Bay of Plenty and Tasman Bay, Godfriaux (1974a) found that polychaetes, crustaceans, echinoderms, and molluscs were generally the main food groups. Crustaceans were the dominant food of individuals less than 15 cm fork length and polychaetes the dominant food of those greater than 15 cm. Length of specimen, sampling depth and area, geographical region, and time of day affected the food taken, but sex and season did not.

Godfriaux (1974b) also investigated the feeding relationships between tarakihi and snapper in the western Bay of Plenty. Of the two most important food groups (polychaetes and crustaceans) in the diets of both species, tarakihi more strongly selected polychaetes than crustaceans, whereas snapper more strongly selected crustaceans. Competition for food was probably minimal because both species consumed various foods and fed at different times of the day.

Vooren and Tracey (1976) studied the parasites in tarakihi from three areas around New Zealand. They presented a species list with a distribution and suggested that quantitative data on parasites may provide useful information on stock units of tarakihi around New Zealand.

Fishery

Tarakihi are caught by commercial vessels in all areas of New Zealand from the Three Kings Islands in the north to Stewart Island in the south. The main fishing method is trawling, but they are also caught by set nets and lines. From the 1983–84 fisheries statistics, 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 importance of tarakihi to the New Zealand domestic fleet has changed through the years. Until 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). Nevertheless, they are still important in many areas. Domestic landings of tarakihi for 1974–84 are given in Table 1.

Domestic fishery

The state of the tarakihi fishery was assessed by Vooren (1974a), Tong (1979), and McKoy (1985).

Vooren (1974a) analysed the statistics 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 efforts 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 a 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 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.

The status of the tarakihi stocks and fishery was assessed up to December 1984 for the purposes of recommending total allowable catch (TAC) levels (McKoy 1985). 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 bases for the recommended TAC levels 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.

Bay of Plenty

The only published information available on this fishery is that from Vooren (1974a). 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.

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 stabilisation of catch per unit of effort 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 at 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

In a detailed study of the Kaikoura fishery, Irwin (1981) found that the catch of tarakihi by set nets increased from 2.6 t in 1974 to 289.2 t in 1980. In 1980 tarakihi was the major species caught from December to June, almost to the exclusion of other species. Tarakihi appeared during September-October each year and disappeared during June-July. Between February and April catch rates dropped for about a month, and it was assumed that the fish had left to congregate on the Conway Ridge to spawn. Irwin suggested two possible reasons for the increased abundance of tarakihi during summer: the fish were following a slow, southward migration from northern nursery and feeding grounds to spawning grounds on the Conway Ridge; or they moved to Kaikoura during spring, summer, and autumn to feed on the rich waters of the convergence zone.

East coast South Island

Fenaughty and Bagley (1981), in their analysis of tarakihi landings for Lyttelton and Timaru during 1938–80, suggested the coincident peaks and slumps 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.

In a detailed study of the Canterbury Bight trawl fishery, Sullivan (1981) suggested the tarakihi fishery appeared to depend on few age classes, and years of good catches probably resulted from strong year classes spawned 4–5 years earlier. Most tarakihi were landed during February-September, and they were more abundant at depths over 100 m. Fish sampled from commercial catches from Oamaru in 1976 were mainly 4 year olds, which suggested that tarakihi moved from nursery grounds in Blueskin Bay north into the

TABLE 1: Domestic landings (t) of tarakihi, 1974–84 (after King 1985)

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

Canterbury Bight. Catch per unit of effort 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 departure 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

In a study of the Auckland west coast trawl fishery, Reid (1969) observed that tarakihi catches declined between 1953 and 1958. The fishing fleet trawled for snapper for 9 months of the year (June-February). During the tarakihi schooling period (March-May) the fleet fished for both snapper and tarakihi. At this time, tarakihi were more abundant in 50–80 fm and catch rates were higher at night.

Foreign fishery

Vooren (1974a), Fenaughty and Bagley (1981), and Sullivan (1981) described the impact of foreign fishing fleets on the tarakihi fishery along the east coast of the South Island. They concluded that the by-catch of tarakihi taken by foreign trawlers may have contributed to the decline in landings by the domestic fleet from this area during the 1970s.

Reported catches of tarakihi by foreign vessels have been substantial, especially during the 1970s (Table 2). Data on catches during 1968–77 are available for Japanese vessels only, whereas data from 1978–79 to 1983–84 are available for all foreign-licensed and joint-venture vessels. Most of the reported foreign catch was taken from divisions D2 and D7 (Japanese fishing areas used during 1968–77) and Exclusive Economic Zone (EEZ) areas D and H (used since 1978–79) off the east and west coasts of central New Zealand (Fig. 5), where major domestic fisheries for tarakihi are located. 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

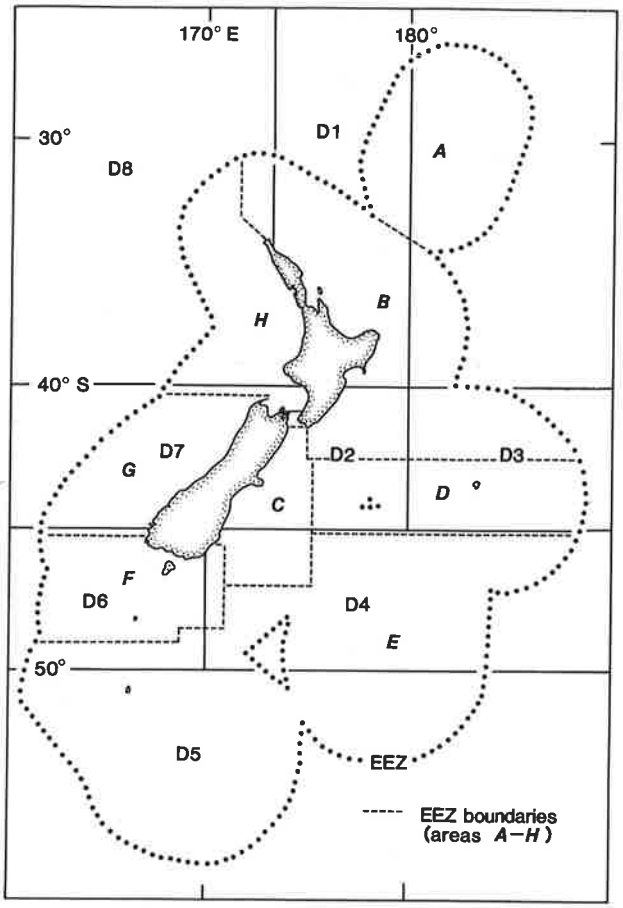

Fig. 5: Japanese fishing areas (D1–D8) and EEZ areas (areas A–H).

tarakihi by Soviet trawlers fishing these grounds, but they were probably substantial. Thus, foreign fishing activity probably had a large impact on tarakihi abundance in these areas. However, since the area and by-catch restrictions came into effect with the introduction of the EEZ in 1978, tarakihi landings by foreign-licensed and joint-venture vessels have decreased, and in 1983–84 they totalled 732 t.

TABLE 2: Japanese and foreign fishing vessel catches of tarakihi from 1968 to 1983–84*

	Japanese vessels only†									
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	414	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
Total	80	475	439	471	1 097	671	1 480	1 501	1 180	2 259

	All foreign-licensed and joint-venture vessels							
EEZ area	1977–78§ (Japanese only)	1978–79§	1979–80§	1980–81‖	1981–82§	1982–83§	1983¶	1983–84**
A	–	–	–	–	–	–	–	–
B	7	–	2	–	–	–	–	–
C	628	8	36	–	10	1	38	24
D	832	54	117	–	64	113	2	286
E	–	–	–	–	–	77	29	26
F	14	–	25	–	66	33	1	61
G	485	–	86	–	53	25	36	91
H	482	–	32	–	173	200	17	244
Total	2 448	62	298	–	366	449	123	732

* Data for 1968–77 are from Japanese statistics only; data from 1978–79 to 1983–84 are Fisheries Research Division statistics for all foreign-licensed and joint-venture vessels.
† Fishing year 1 Jan-31 Dec.
‡ No data.
§ Fishing year 1 Apr-31 Mar.
‖ No data for the entire year.
¶ Fishing year 1 Apr-30 Sep.
** Fishing year 1 Oct-30 Sep.

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