Jack mackerels (*Trachurus* spp.) in New Zealand waters

J. B. Jones

New Zealand Fisheries Technical Report No. 23
1990

MINISTRY OF AGRICULTURE AND FISHERIES
TE MANATU AHUWHENUA AHUMOANA

ISSN 0113-2180

Jack mackerels (*Trachurus* spp.) in New Zealand waters

J. B. Jones

New Zealand Fisheries Technical Report No. 23
1990

ISBN 0-477-08278-5

Published by MAF Fisheries
Wellington
1990

Inquiries to:
The Editor, MAF Fisheries Greta Point,
P. O. Box 297, Wellington,
New Zealand.

MAF Fisheries is the fisheries business group of the New Zealand Ministry of Agriculture and Fisheries. The name MAF Fisheries was formalised on 1 November 1989 and replaces MAFFish, which was established on 1 April 1987. MAFFish combined the functions of the old Fisheries Research Division and Fisheries Management Division and the fisheries functions of the old Economics Division.

The *New Zealand Fisheries Technical Report* series in part continues the *Fisheries Research Division Occasional Publication* series. The *New Zealand Fisheries Occasional Publication* series contains mainly conference proceedings and bibliographies.

Edited by I. W. Mackenzie
Set in 10 on 11 English Times
Typeset by Visual Perceptions
Printed by Madison Printing Company Ltd

Contents

Abstract

Jones, J. B. 1990: Jack mackerels (*Trachurus* spp.) in New Zealand waters. *New Zealand Fisheries Technical Report No. 23.* 28 p.

The jack mackerels *Trachurus declivis, T. novaezelandiae*, and *T. murphyi*, together form an important fishery resource within the New Zealand Exclusive Economic Zone (EEZ). The distribution of *T. murphyi* extends to the east outside the EEZ and probably continues along the Subtropical Convergence Zone to South America. There is a large international fishery for this species in the central South Pacific somewhere between New Zealand and 150° W longitude.

The available information on the biology and fishery for these species within the New Zealand zone and the central South Pacific is summarised.

Introduction

Jack mackerels (genus *Trachurus*) are schooling pelagic fish which occur over the New Zealand shelf, and in the waters of the subtropical convergence between New Zealand and South America. Nosov and Platoshina (1975) and Nosov and Shurunov (1975) considered them to be one of the dominant fish on the New Zealand plateau.

The fish are not popular on the New Zealand domestic market and they have commonly been discarded. For this reason domestic reported landings were low, representing bycatch, until the mid 1960s when deliberate attempts were made to catch mackerel by purseseining. At about the same time Japanese bottom trawlers began to take significant tonnages of jack mackerel on the New Zealand shelf (Robertson 1977) and after the declaration of the Exclusive Economic Zone (EEZ) in 1978 this continued with the involvement of foreign licensed and joint venture vessels in the fishery. In 1987/88 the catch from the New Zealand EEZ was over 22 000 t, with the 1988 export of 12 000 t worth in excess of $(NZ)12.5 million.

Research on the jack mackerels in New Zealand waters has been intermittent, and the information is scattered in published papers, unpublished reports, and unpublished raw data. Papers on spawning, seasonal and yearly fluctuations, and stock assessment of *T. declivis* were published by Soviet scientists (Nosov 1975a, b, Nosov and Platoshina 1975, Nosov and Shurunov 1975), by James (1975), and Kerstan and Sahrhage (1980), but their failure to recognise the multispecies nature of the fishery has reduced the value of their observations. A comparison of the biology and behaviour of the then known species (*T. novaezelandiae* and *T. declivis*) was given in Robertson (1978). A third species (*T. murphyi*) appeared in the fishery in the early 1980s.

In the 1970s and 1980s new fisheries for jack mackerel developed in the south Pacific: a trawl and purseseine fishery off Chile and Peru (1986 catch about 2 million t); a purseseine fishery off Tasmania (1986 catch approaching 40 000 t, Anon. 1987); and a trawl (and drift gillnet? — see Kawahara *et al.* 1988) fishery in the central South Pacific.

The biology of *T. declivis* in Australian waters was summarised by Williams and Pullen (1986) and the development of the Australian purseseine fishery is described by Williams *et al.* (1986).

Most of the information available on *T. murphyi* is from coastal Peruvian and Chilean waters, and the literature is extensive. Information on the biology and fishery was summarised by Mendez and Yany (1978) and Serra (1983); age and growth by Carrera and Collantes (1978) and Abramov and Kotlyar (1980); reproduction by Serra (1983), Andrianov (1985), Muck *et al.* (1987), and Evseenko (1988).

The presence of larval and juvenile *T. murphyi* in the central South Pacific (2000 nautical miles off the New Zealand coast) was hypothesised by Gutiérrez (1986) and recorded by Evseenko (1988) and Bailey (1989).

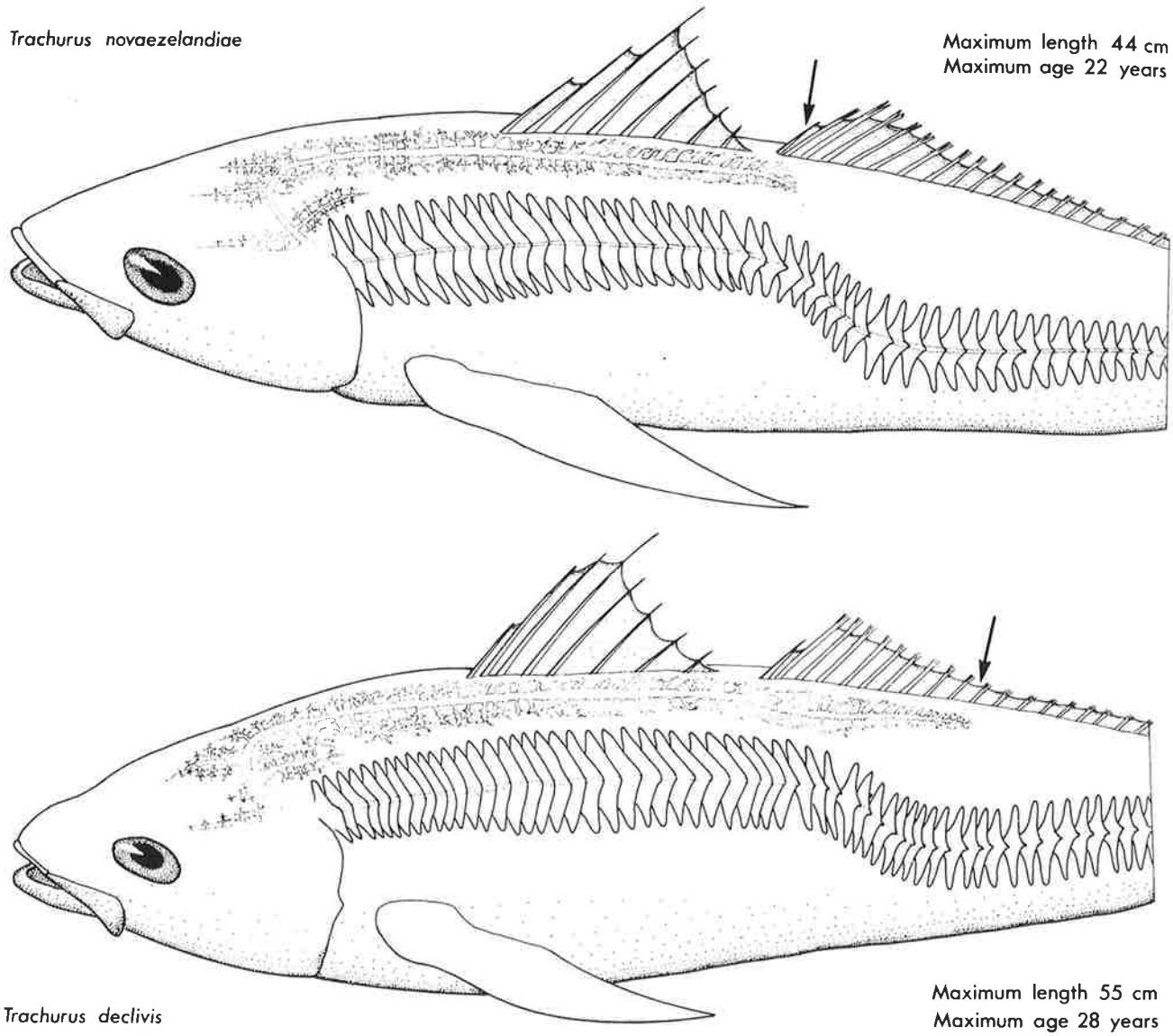


Figure 1: *Trachurus novaezelandiae* **and** *T. declivis*, **showing the distinctive difference in the end point of the accessory lateral line (arrowed) (from Robertson 1978, fig. 1, p. 44).**

This publication summarises the available information on the biology and fishery for jack mackerels in New Zealand and in the central South Pacific from both published and unpublished sources up to 1989.

Taxonomy

Although Hector (1872) and subsequent authors had suggested that there were two species of jack mackerel in New Zealand waters, that was finally confirmed in 1977 using both morphometric (Stephenson and Robertson 1977) and biochemical (Gauldie *et al.* 1977) methods. The taxonomic status and synonymy of the two species, *Trachurus declivis* (Jenyns, 1842) and *T. novaezelandiae* (Richardson, 1843), is presented by Stephenson and Robertson (1977), but their decision to relegate *Trachurus japonicus* (Temminck and Schlegel, 1844) to synonymy with *T. novaezelandiae* has not been accepted by subsequent authors (Shaboneyev, 1980). Kijima *et al.* (1988) concluded from genetic evidence that *T. novaezelandiae* and *T. japonicus* were subspecies.

In 1986 it became apparent that there was a third species present in New Zealand waters, identified as the Peruvian jack mackerel, *T. murphyi* Nichols, 1920, by Kawahara *et al.* (1988).

Parrish (in press) has disputed the specific status of *T. murphyi*, concluding that it is a subspecies of the oceanic horse mackerel (*Trachurus picturatus* Bowdich, 1825).

Large samples of jack mackerel were examined from around New Zealand and from known museum collections as part of the study by Stephenson and Robertson 1977. No specimens of *T. murphyi* were identified and it is suggested (D.A. Robertson pers. comm.) that the species has recently arrived in New Zealand waters, or was extremely rare until recently.

Key to species of *Trachurus* in New Zealand waters

1a. Scutes along lateral line large, depth of scutes in posterior part of lateral line more than 20% of head length, number of scutes less than 89 ...2
b. Scutes small, depth less than 20% of head length, number of scutes 95–106 .....*T. murphyi*
2a. Usually less than 76 scutes along lateral line (range 67–81). Accessory dorsal branch of lateral line extends posteriorly to beneath the first or second dorsal ray of the second dorsal fin. (Figure 1) .....*T. novaezelandiae*
b. Usually more than 76 scutes (range 71–89) along lateral line. Accessory dorsal branch of lateral line terminates under dorsal fin rays 7–9 on second dorsal fin. (Figure 1) .....*T. declivis*

Biology of the species
Family Carangidae
Trachurus declivis (Jenyns, 1842)

Common names: Jack mackerel, scad, horse mackerel

Distribution

Eggs: First described by Robertson (1975), from North Island coastal waters in summer. The egg description was revised by Crossland (1981) who found few eggs in the inner and outer Hauraki Gulf (Figure 2).

Larvae and post-larvae: Larvae tentatively identified as those of *T. declivis* were found by Crossland (1982) off Northland in October 1977.

Juveniles: James (1975) recorded juvenile *Trachurus* (up to 25 cm LCF) in both shallow and offshore surface waters along the west coast north of 41° S, and in Tasman and Golden Bays. The species were not determined. Robertson (pers. comm.) has caught *T. declivis* about 300 miles northeast of East Cape.

Adults: Southern Australia, Tasmania, throughout New Zealand north of subtropical convergence from the surface to 200 m, occasionally to 300 m depth (Figure 3).

Movements

Horizontal: Nosov and Shurunov (1975) made an extensive study of the distribution and spawning of jack mackerel in central New Zealand waters in relation to hydrological conditions. They considered that the general circulation of water in the area was stable, attributing seasonal and yearly fluctuations in the hydrological regime to latitudinal displacement of meterological pressure systems. These fluctuations were believed to strongly influence the spawning and migration of the jack mackerel.

Vertical: Although Robertson (1977) reported that *T. declivis* has not been observed schooling at the surface in New Zealand waters, it has been taken by surface lure (N. W. Bagley pers. comm.). Nosov (1975a) suggested that the demersal and pelagic phases were determined by the environmental conditions both for the "large" and the "small" mackerels (presumably the two species).

Feeding

Stomach contents: Jack mackerel are opportunistic predators. Graham (1956) recorded pilchards (*Sardinops*), sprats (*Sprattus*), witch (*Arnoglossus*), mackerel, squid, octopus, swimming crabs (*Ovalipes*), "whalefeed", and "shrimps" in the stomachs of jack mackerel caught in the vicinity of Otago Harbour. Robertson (1978) found euphausiids and lantern fish to be prey items in the Bay of Plenty. Bailey and Habib (1982) found Amphipoda, *Nyctiphanes, Cavolina*, and small *Trachurus* in the stomachs of the five *T. declivis* they examined.

Proximate analysis: Vlieg (1982a, b) found that the flesh was greater than 21% protein, with a low oil content, and with no correlation between the oil content of the flesh and body length. However, Miezitis and Wright (1979) found that fat content in Australian fish changed seasonally, varying between 2 and 12% of wet weight, apparently independently of fish age.

Age and growth

Robertson (1977) stated that *T. declivis* in New Zealand waters grows to a maximum size of 55 cm LCF and a maximum age of 28 years.

James (1975) provided length frequency data from which growth is inferred for *Trachurus* caught along the west coast of New Zealand, but was unaware that his samples contained more than one species.

Kerstan and Sahrhage (1980) provide length frequency histograms for *Trachurus*, but the species are not separated.

Length frequency raw data has been collected by the Fisheries Observer Programme and on many research cruises, but has not yet been collated.

Stocks

A biochemical study by Richardson (1982) showed that, based on the distribution of gene and genotype frequencies, *T. declivis* from New Zealand and from Western Australia form distinct sub-populations, and that the New Zealand fish were probably distinct from those around southeastern Australia.

The bimodality observed by James (1975) and ascribed to different populations is almost certainly due to his measuring a mixture of *T. declivis* and *T. novaezelandiae*. It is unlikely that separate stocks of jack mackerel species occur in New Zealand waters because of the widespread pelagic distribution of the adults, eggs, and larvae.

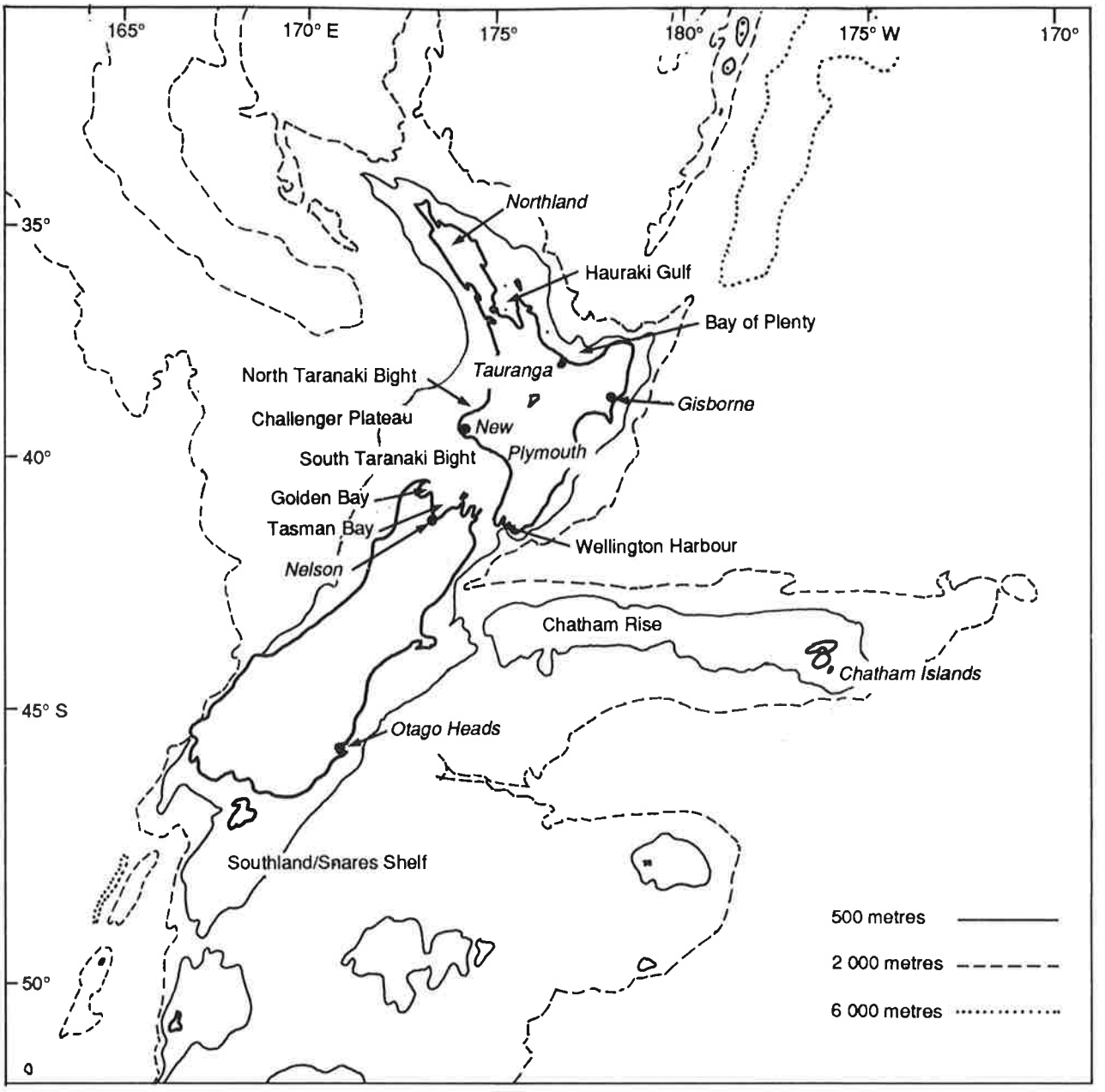


Figure 2: New Zealand showing location of places mentioned in the text.

Predators

Jack mackerel are prey for a wide range of piscivorous fish. Graham (1956) found mackerel in the stomach of porbeagle shark (*Lamna*), kahawai (*Arripis*), trumpeter (*Latris*) and larger mackerel. In the Bay of Plenty, 0.5% of the diet of snapper (*Chrysophrys*) is mackerel (Godfriaux 1974). Other predators are southern bluefin tuna (Robins 1963) and albacore tuna (Bailey 1983) (both *Thunnus*), barracouta (*Thyrsites*) (Whitley 1946), groper (*Polyprion*) (Graham 1956, Johnston 1983), and gemfish (*Rexea*) (N. W. Bagley pers. comm.).

Parasites

MICROSPOREA

Octosporea sp.: around cranial nerves — Jones (1979)

NEMATODA

Anisakis sp. larvae: common, encapsulated on viscera, mesenteries and under peritoneum — Brunsdon (1956), Hurst (1984).

Hysterothylacium sp. larvae: in stomach, intestine and body cavity — Brunsdon (1956).

Ascarophis sp. *i* : stomach — Brunsdon (1956).

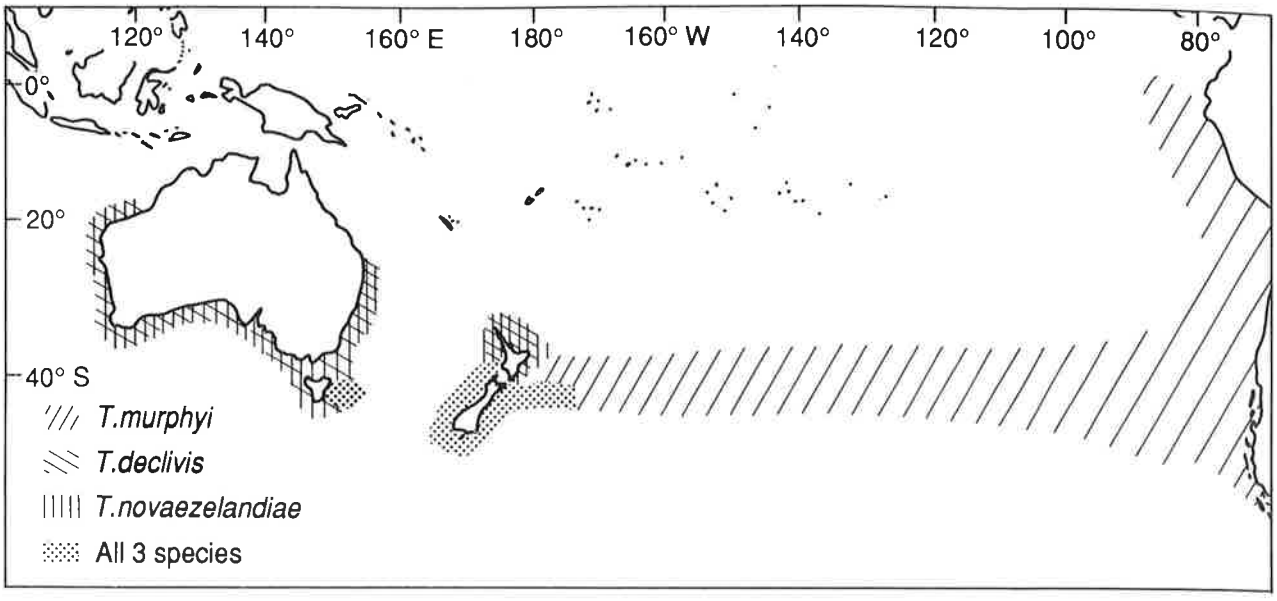


Figure 3: Known distribution of *Trachurus declivis, T. novaezelandiae*, and *T. murphyi*.

ISOPODA

Ceratothoa imbricatus (Fabricus, 1787): common, in buccal cavity — Stephenson (1976). (Stephenson describes the damage done by this parasite. Maxwell (1982) uggests that the isopod lives for at least nine years in the host.)

C. trillesi (Avdeev, 1979): Buccal cavity, Tasman sea — Avdeev (1979).

C. trigonocephala (Leach, 1818): — Avdeev (1978).

Reproduction and early development

Sex composition: Unpublished data shows that although the overall sex ratio is about 50 : 50, the sex ratio does vary from tow to tow. Webb (1976) found in catches of *T. declivis* from southeast Australian waters that the sex ratio varied with fishing method, indicating that there was variation within habitat.

Spawning: Ripe males and females were caught up to 20 inches (51 cm) in length off Otago heads in February 1933, and ripe females had 440 000 eggs (Graham 1956). James (1975) recorded ripe mackerel in Golden Bay/Tasman Bay in December and January.

It is probable that the large accumulation of *T. declivis* in the Taranaki Bight in November/December is a spawning concentration (Nosov and Platoshina 1975), since eggs of "jack mackerel" do occur throughout this area in January (Shuntov *et al.* 1979).

Trachurus declivis spawns three batches of eggs at an interval of about one month or more, and each batch consists of several "microbatches". This, together with a marked lack of synchrony between females, results in an extremely protracted spawning period (Shuntov 1979).

Nosov and Zadorina (in an oral communication reported in Shuntov *et al.* 1981) state that, from their analysis of samples from 1964 to 1977, the most abundant age classes of *T. declivis* appeared in cold years.

Mortality

From unpublished MAF Fisheries age data *M* has been calculated at 0.3 (D. A. Robertson pers. comm.). This compares well with the *M* values calculated by Gasior and Kompowski (1982) for southeast Australian fish which ranged from 0.34 to 0.45 depending on the method used.

Physiology

Hine *et al.* (1987) describe the enzyme cytochemistry of blood leucocytes.

Trachurus novaezelandiae Richardson, 1843

Common names: Jack mackerel, horse mackerel

Distribution

Eggs: The eggs were described by Robertson (1975) (as *T. mccullochi*) and the description was revised by Crossland (1981). Crossland (1982) reported eggs in Hauraki Gulf and east Northland.

Larvae and post-larvae: Crossland (1982) recorded that the larvae were abundant in the Hauraki Gulf in December and February, but in east Northland, where they occurred close to patches of eggs, they were not common. They have been taken in plankton tows in the South Taranaki Bight (MAF Fisheries records).

Juveniles: Have been caught in Wellington harbour, Tasman Bay and Golden Bay, South Taranaki Bight, Bay of Plenty, and Hauraki Gulf (MAF Fisheries records).

Adults: New Zealand and Australian temperate waters (Figure 3). 95% of the catch of *T. novaezelandiae* taken in the *Tomi Maru* and *Shinkai Maru* surveys of the Taranaki Bight were associated with water warmer than 13 °C (Robertson *et al.* 1981). Commonly schooling at the surface in summer, but do occur to about 200 m depth.

Movements

Horizontal: No information.

Vertical: The species has distinct diurnal movements in the water column, ascending at night from the seabed to form dense layers at a depth of 40–60 m where they can be caught by midwater trawl (Robertson 1977).

The fish form dense surface schools in winter/spring to early summer Robertson (1977). Clement (1978) stated that the best months for surface schools of jack mackerels were September — December with numerous schools showing over wide areas from inshore to the shelf edge. Large sightings (maximum daily totals in excess of 7 000 t) were made in the Bay of Plenty in September and October (Clement 1978, Robertson 1978). Surface schools of *T. novaezelandiae* are often mixed schools with other pelagic species such as kahawai, blue mackerel, and trevally in varying proportions (Habib *et al.* 1982).

Tagging: A tagging study in which over 1500 fish were tagged resulted in only one recovery (Robertson 1978).

Feeding

Stomach contents: Euphausiids, anchovy (Robertson 1978). The prey items recorded under *T. declivis* probably apply to *T. novaezelandiae*, which is also an opportunistic predator.

Proximate analysis: Vlieg (1982b) found that the flesh was greater than 20% protein with a low oil content (< 5%) with no correlation between the oil content of the flesh and body length.

Age and growth

Enters the purseseine fishery at 3-4 years of age (Robertson 1977). Length frequencies from purseseine catches in the Bay of Plenty in 1974/75 can be found in Robertson (1978). Maximum size about 44 cm (LCF) and a maximum age of 22 years (Robertson 1977). Length frequency raw data has been collected by the Fisheries Observer Programme and by numerous research cruises, but has not yet been collated.

Stocks

No information.

Predators

Gannets, but also see notes for *T. declivis* as the same predators are probably involved.

Parasites

MYXOSPOREA

Ceratomyxa inconstans Jameson, 1929: gall bladder — Meglitsch (1960).

DIGENEA

Ectenurus lepidus Looss, 1907: stomach — Manter (1954).

Genolopa microsoma Lebedev, 1968: digestive tract — Lebedev (1968).

Lecithocharium genypteri Manter, 1954: stomach — Manter (1954).

Pseudopecoeloides tenuis Yamaguti, 1940: stomach, intestine, and caeca — Manter (1954).

MONOGENEA

Cemocotyle trachuri Dillon and Hargis, 1965: gills — Dillon and Hargis (1965).

Heteraxinoides novaezelandiae Dillon and Hargis, 1965: gills — Dillon and Hargis (1965).

Pseudaxine bivaginalis Dillon and Hargis, 1965: gills — Dillon and Hargis (1965).

CESTODA

Nybelinea (Syngenes?) sp. postlarvae: body cavity — Robinson (1959).

ACANTHOCEPHALA

Australorhynchus tetramorphacanthus Lebedev, 1967: site not recorded — Lebedev (1967).

NEMATODA

Anisakis sp. larvae: common, encapsulated on viscera, mesenteries and under peritoneum — Brunsdon (1956).

Ascarophis sp. i: stomach — Brunsdon (1956).

Hysterothylacium sp. larvae: two types, stomach, intestine and body cavity — Brunsdon (1956).

ISOPODA

Ceratothoa imbricatus (Fabricius, 1787): mouth — Chilton (1911), Hurley (1961).

Reproduction and early development

Sex composition: Single surface schools usually contain equal numbers of males and females (Robertson 1977).

Spawning: Matures at about 20–22 cm in the third year. No other published information.

Mortality

No published information.

Trachurus murphyi Nichols, 1920

Common name: Peruvian jack mackerel, Peruvian scad, horse mackerel

Distribution

Eggs: Found confined to frontal sections of the Subtropical Convergence Zone between 15.6 and 17.0 °C water (Evseenko 1987). Eggs occur near the South American coast in El Nino years when temperatures are abnormally high. When coastal waters are too cold, spawning occurs in oceanic waters (Muck *et al.* 1987).

Larvae and post-larvae: Occur in the central South Pacific, in the Subtropical Convergence Zone (Evseenko 1988), and probably occur along the zone from Chatham Islands to Chile (Bailey 1989).

Juveniles: *T. murphyi* are known to occur along the Subtropical Convergence Zone of the central South Pacific. They are abundant between latitude 34° S and 41° S and longitude 127° W to 165° W (Evseenko 1988, Bailey 1989). A 19 cm (standard length) fish was taken on the Chatham Rise (Kawahara *et al.* 1988).

Adults: Occur both over the shelf and in the open ocean. In New Zealand they have been recorded from Chatham Islands shelf (Hurst and Bagley 1987), Chatham Rise and Mernoo Bank, Southland/Snares shelf (Kawahara *et al.* 1988), Taranaki Bight (pers. obs.). They also occur in the central South Pacific between 40° S–48° S and 125° W–145° W (Kawahara *et al.* 1988), and in the coastal waters of Ecuador, Peru, Chile, Galapagos Islands, and Juan Fernandez Islands (Abramov and Kotlyar 1980; Evseenko 1988). The species is taken in commercial trawls to depths of 300 m off Chile (Serra 1983). Pullen *et al.* (1989) recorded *T. murphyi* off Tasman (Australia). Parrish (in press) recorded that *T. murphyi* occur across the whole Southern Hemisphere West Wind Drift region.

Movements

Tagging studies have been carried out in northern Chile (Gutiérrez 1986), but the study showed no important longitudinal movements for fish that were within 60 miles of the coast. The author suggested from circumstantial evidence that the jack mackerel were carrying out migrations which covered a large portion of the South Pacific.

Feeding

Stomach contents: Around the Chatham Islands *T. murphyi* was found to be feeding on euphausiids and juvenile white warehou (Seriolella caerulea) (N. W. Bagley, pers. comm.).

Proximate analysis: Not done on New Zealand specimens.

Age and growth

Length frequencies of mackerels of 50–65 cm LCF (probably all *T. murphyi*) are provided in Hurst and Bagley (1987).

Stocks

No information.

Predators

Trachurus murphyi juveniles form the major food source of albacore in the central South Pacific (Bailey 1989).

Parasites

No specimens from New Zealand waters have been examined for parasites. *T. murphyi* from Chile and Peru are host to *Lernanthropus trachuri* Brian, 1903. If this copepod occurs on *T. murphyi* in New Zealand waters, it would provide circumstantial evidence of a trans-pacific migration by the host since examination by the author of more than 500 jack mackerel from around New Zealand in 1981 did not produce any parasitic copepods.

Reproduction and early development

Sex composition: No information for New Zealand or the central South Pacific. Sex ratio on the Peruvian shelf remains close to 50 : 50 (Andrianov 1985).

Matures at 25 cm (3 years of age), but the bulk of the population spawn in the fourth year at 35–38 cm (Abramov and Kotlyar 1980).

Spawning takes place from June to March in the open ocean as well as on the Peruvian shelf (Abramov and Kotlyar 1980, Andrianov 1985, Evseenko 1987). Fish caught near the Chatham Islands in December 1984 were ripe or running ripe (Hurst and Bagley 1987).

Mortality

No information for New Zealand or the central South Pacific.

The fisheries

Fishing methods

Purseseine: Experimental purseseining in the 1960s showed that this method could be used in New Zealand to take schooling fishes in commercial quantities.

The fishery which developed is a mixed-species fishery with vessels in Tauranga and Gisborne targeting skipjack (*Katsuwonus*) in the summer and catching jack mackerel (*Trachurus*), blue mackerel (*Scomber*), kahawai (*Arripis*), and trevally (*Pseudocaranx*) when skipjack are unavailable. Most of the mackerel is used for fishmeal. The vessel currently working out of Nelson fishes only for mackerel, blue mackerel, and kahawai.

Purseseine catches of mackerel are given in Table 1.

Trawling: The swimming speed and schooling behaviour of jack mackerels reduce the vulnerability of mackerel to trawl nets, particularly in clear water. Ministry of Agriculture and Fisheries divers have observed jack mackerel schooling in the mouth of trawl nets and then swimming off as they were hauled. The divers have also seen jack mackerel swimming down to the cod end and then back up and out of the net, and small jack mackerel swimming in and out of the meshes. Because of this behaviour, trawlers targeting jack mackerel tow at a faster speed than normal, (Japanese average 4.0–4.5 kts, range 3–6 kts; Robinson and Shearer 1988). The duration of the tow is also considered to be important in wearing down the mackerel, although the importance of tow duration may be affected by the vessel size and thus towing speed, see Anon. (1981) and Robertson *et al.* (1981).

Maori and recreational fishing patterns: There is a recreational fishery based on lining and netting by various ethnic groups, particularly in harbours and estuaries. The quantity taken is unknown. The Maori based their 1987 court injunction against the allocation of jack mackerel (and squid) quota partly on the grounds that they were traditional fisheries.

Around the northeast coast of the North Island, koheru (*Decapterus koheru*) and jack mackerels are sometimes confused by recreational fishermen.

Fishing areas

New Zealand: The main reported commercial catch of jack mackerel is taken almost entirely by Japanese licensed trawlers and foreign charter vessels working that part of the old EEZ management areas H and G (Figure 4) which included the North Taranaki Bight and the Challenger Plateau (Figure 2). The fishery is a summer seasonal one from November to February.

Central South Pacific: The FAO fisheries statistics for area 81 (25° S–60° S; 150° E–105° W) show that Soviet vessels are taking a substantial (1986 = 105 000 t) and increasing catch of jack mackerels from outside the New Zealand zone (Table 2). There is also an increasing difference between the Japanese catch from area 81 and from the New Zealand EEZ. Although this fish is caught well outside the New Zealand EEZ it adds to the growing evidence for a large resource along the subtropical convergence zone to the east of the EEZ as predicted by Evseenko (1987) and Bailey (1989) and which is probably a westward extension of the same resource fished by Chile and Peru.

Table 1: New Zealand domestic fishery. Purseseine catches by calendar year, 1974–1985, showing proportion of mackerel caught. (Source, Fisheries Statistics Unit)

Year	Total P/S catch (t)	JMA P/S catch (t)	JMA as % of P/S catch	Total JMA catch (t) (all methods)	% of JMA caught by P/S
1974	2 000	900	45	1 400	64
1975	1 500	–	–	300	–
1976	2 200	400	18	1 000	40
1977	4 400	1 100	25	1 700	64
1978	6 300	600	9	1 800	33
1979	8 900	2 400	27	3 100	77
1980	10 000	2 600	26	3 300	78
1981	12 000	2 900	24	3 500	83
1982	11 000	2 300	21	2 800	82
1983	13 800	2 100	15	2 600	81
1984	12 900	4 100	32	4 600	89
1985	11 400	3 700	32	4 100	75
1986	17 400	4 200	24	5 500	76
1987	19 900	5 500	27	6 500	84
1988	18 400	5 400	29	n.a.	-

P/S = purseseine.
n.a. = not available
JMA = jack mackerel.
– = < 100 tonnes.

Table 2: Catches (tonnes) of jack mackerel reported to FAO by USSR and Japan for FAO area 81. Catch by these nations from within the New Zealand EEZ has been subtracted

Year	USSR	Japan	Total
1980	0	1 700	1 700
1981	0	4 100	4 100
1982	4 700	4 200	8 900
1983	10 600	6 100	16 700
1984	11 000	11 800	22 800
1985	20 000	3 900	23 900
1986	105 400	8 200	113 400
1987	107 300	5 500	112 800

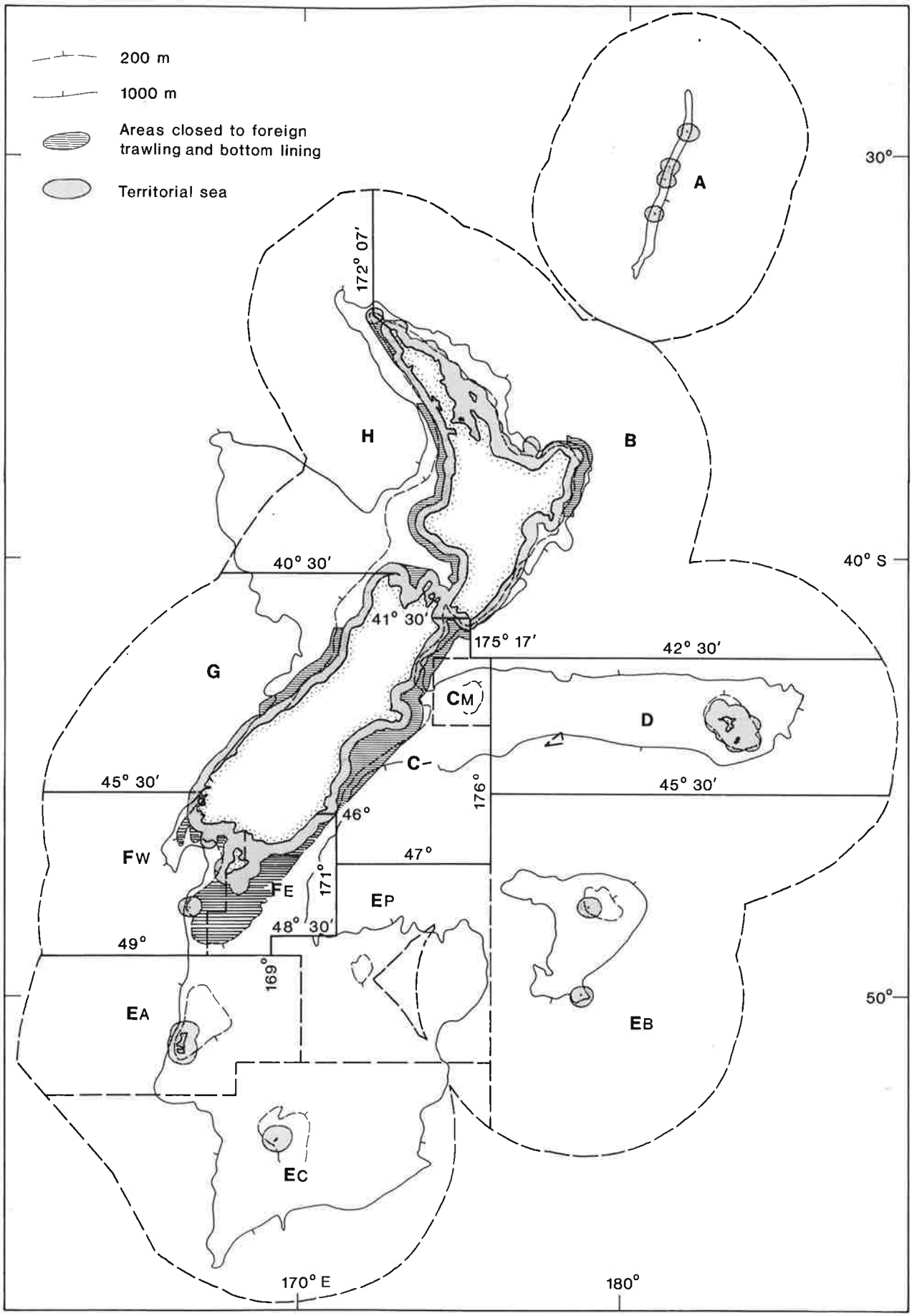


Figure 4: Deepwater and foreign license fisheries management areas (as at October 1983).

Reported catches

New Zealand: Catch data for jack mackerels are available in the Annual Reports of the Marine Department from 1940 to 1970 (Table 3).

The average annual domestic and deepwater catch over the period 1971–87/88, excluding the 3 years after the introduction of the EEZ (when the catch was below 10 000 t), was 16 800 t.

Table 3: Domestic catch of jack mackerels, 1939–1970, from the Annual Reports of the Marine Department

Year*	Landings (t)	Year	Landings (t)
1939	2	1955	16
1940	4	1956	4
1941	2	1957	8
1942	4	1958	10
1943	< 1	1959	3
1944*	10	1960	7
1945	9	1961	7
1946	11	1962	12
1947	19	1963	23
1948	10	1964	21
1949	29	1965	25
1950	17	1966	109
1951	10	1967	502
1952	14	1968	621
1953	13	1969	327
1954	6	1970	250

* Statistical years from 1939 to 1943 end on 31 March of the following year. From 1944 onwards the statistical years end on 31 December.

The total recorded catches for jack mackerels between 1970 and 1988 are summarised in Table 4. The dramatic drop in the Japanese catch after 1977/78 was due to the imposition of a 100 mm cod end mesh and a 5000 t quota after the declaration of the EEZ in 1978. The increases in the New Zealand domestic catch are due to the activities of the purseseine fleet which received a boost in 1976/77 from a joint New Zealand — USA venture and the subsequent importation of 4 additional purseseiners under a duty free incentive scheme (Anon. 1977) (Table 1). There was a slight drop in landings in 1982 and 1983, possibly due to the cessation of the price support scheme for mackerel (see section on marketing).

Catches for the calendar years 1986 and 1987 by domestic fishing return area (Figure 5) show that the main purseseining activity occurs off Tauranga, Gisborne, and Kaikoura.

Catches by foreign licensed and foreign charter vessels are given in Tables 4 and 5, and Figure 6, and this is broken down by area (Table 5), and by month for areas D, F, G, and H, in Figure 7. The 1987/88 season in H was later and more extended than previously. The increasing importance of area D catches is illustrated in Figure 8.

Central South Pacific: Landings have been increasing steadily since 1980 as the fishery has developed (Table 2).

Table 4: Total reported jack mackerel catch in New Zealand EEZ by nation from 1970 to 1986. (Source, principally Fisheries Statistics Unit). No foreign chartered vessels before 1978/79)

Year	Domestic vessels	Foreign chartered vessels	Foreign licensed vessels			Grand total	Total
			Japan	Korea	USSR		
1970*	250		8 128	n.a.	n.a.	8 128	8 378
1971	631		13 301	n.a.	n.a.	13 301	13 932
1972	586		18 070	n.a.	600	18 670	19 256
1973	723		14 964	n.a.	200	15 164	15 887
1974	1 473		17 738	n.a.	100	17 838	19 311
1975	317		13 486	n.a.	n.a.	13 486	13 803
1976	1 044		15 145	n.a.	400	15 545	16 589
1977	1 718		14 539	1 534	700	16 773	18 492
1978	1 817						
1978/79†	1 435	2	4 144	0	0	4 144	5 581
1979/80	3 008	638	1 189	0	1	1 190	4 836
1980/81	3 147	3 361	2 341	0	0	2 341	8 849
1981/82	3 682	3 420	3 583	0	0	3 583	10 685
1982/83	3 082	4 511	4 636	0	0	4 636	12 229
1983/83‡	1 000	228	604	267	0	871	2 099
1983/84§	4 458	8 035	3 552	810	0	4 363	16 856
1984/85	3 363	9 786	5 332	1 091	0	6 423	19 572
1985/86	4 117	8 015	1 573	1 083	0	2 656	14 788
1986/87	7 190	16 022	2 950	595	0	3 545	26 757
1987/88	6 854	13 045	2 106	624	0	2 730	22 629

* = Calendar year.
† = 1 April — 31 March year (1978/79 to 1982/83).
‡ = 1 March — 30 September only.
§ = 1 October — 30 September year from 1983/84.
n.a. = not available.

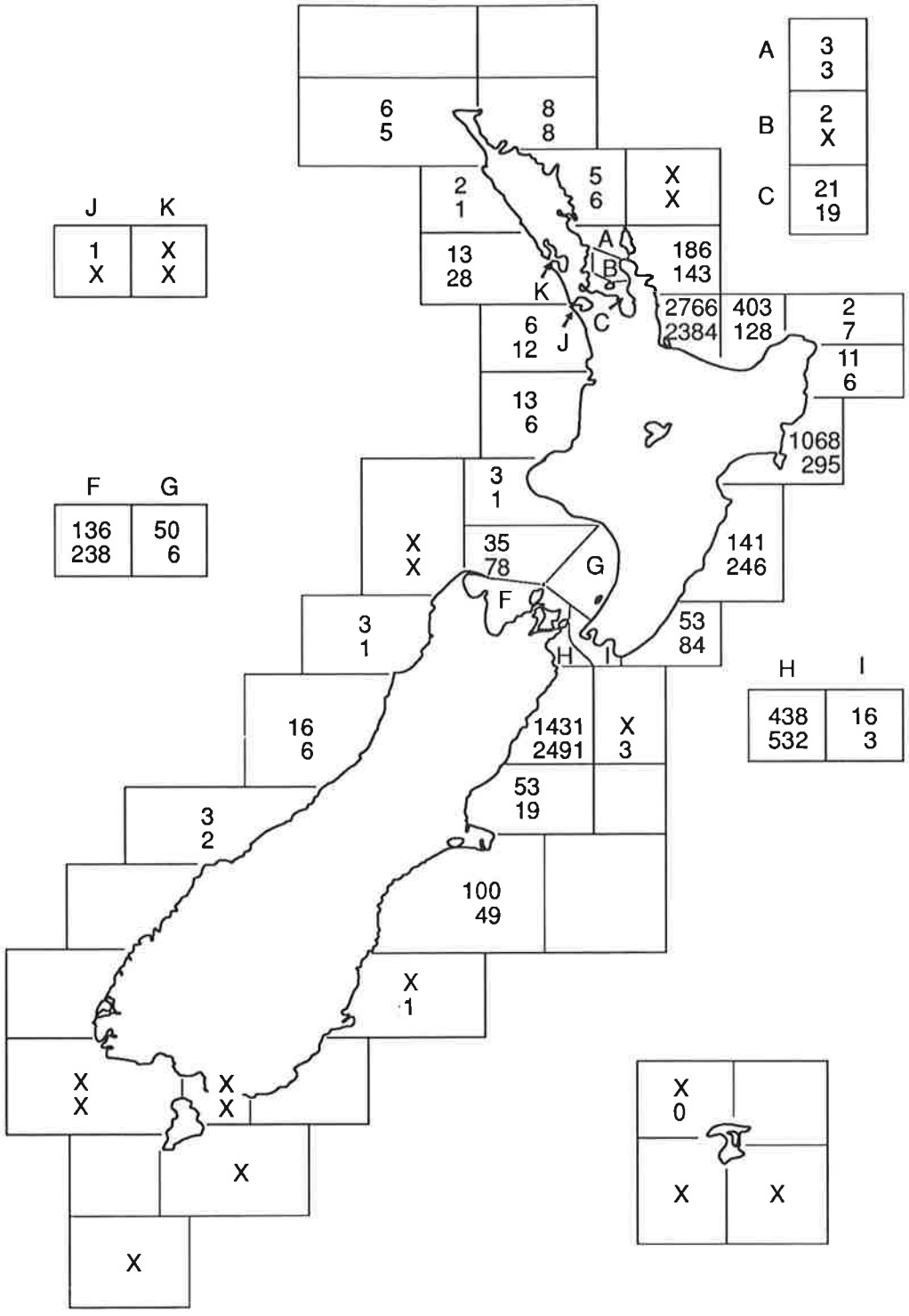


Figure 5: Domestic landings (tonnes) for 1986 calendar year (top figure) and 1987 calendar year (lower figure) for jack mackerels by domestic fishing return area. Not specified by area in 1986 was 81 t, 186 t in 1987. Data for 1988 are not available. (× = less than one tonne).

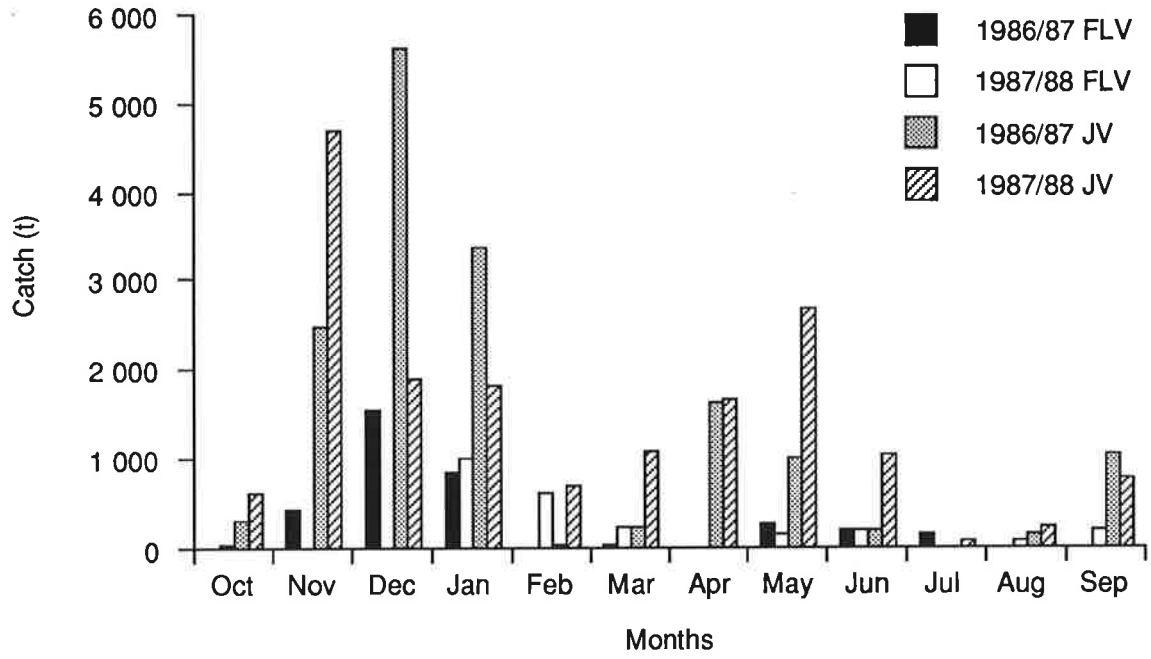


Figure 6: Foreign licensed and foreign chartered vessel catches by month for 1986/87 and 1987/88.

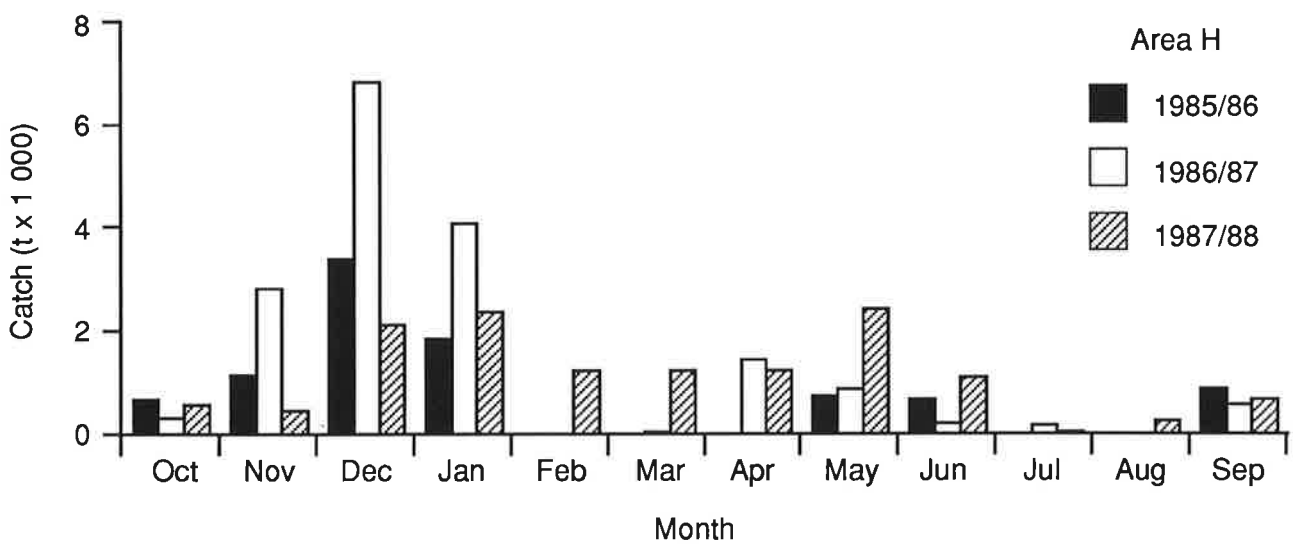
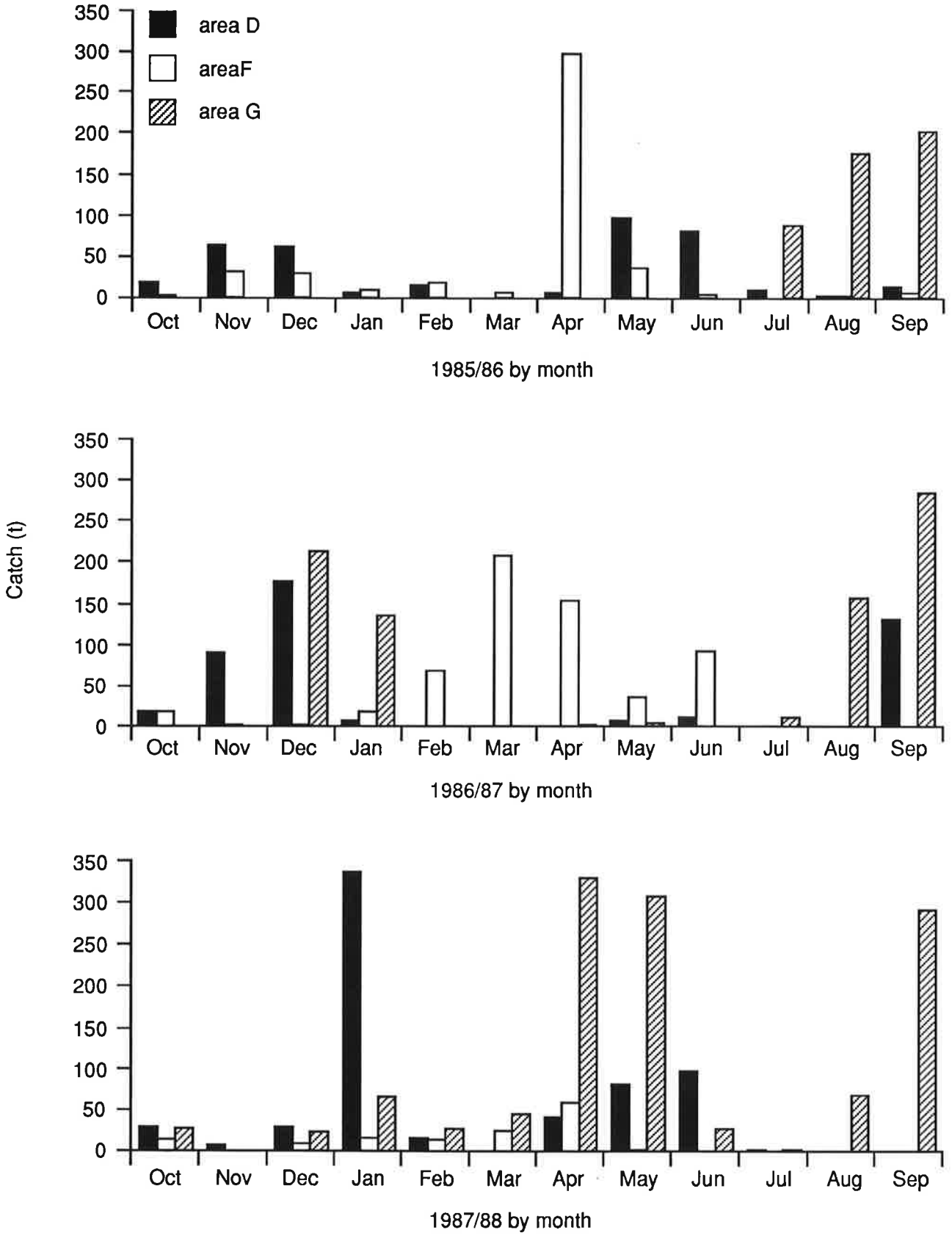


Figure 7: Foreign licensed and foreign chartered vessel catches by month and management area, 1985/86, 1986/87, and 1987/88 (opposite page). Area H catches shown separately (above), note change of scale.


area D
areaF
area G
Catch (t)
350
300
250
200
150
100
50
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
1985/86 by month
1986/87 by month
1987/88 by month

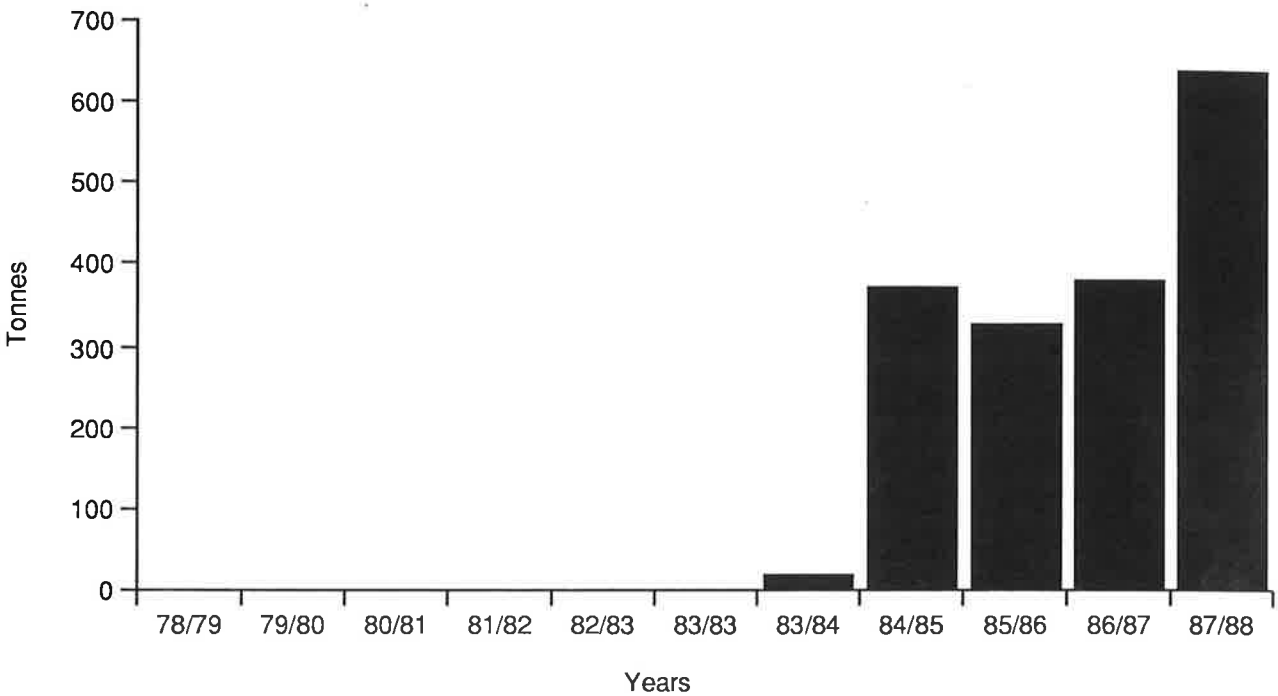


Figure 8: Foreign licensed and foreign chartered vessel catches from area D, 1978/79 to 1987/88. See Table 4 for explanation of "1983 years".

Mesh selection

Trawl: The differences in catch between a 75 mm codend and a 100 mm codend were investigated during the *Tomi Maru* survey of the Taranaki Bight area. From the results it was concluded that the 75 mm codend could catch small sized jack mackerel (less than 30 cm LCF) which were not readily retained by the 100 mm mesh (Figure 9) and for which there is a market in Japan. There was little evidence to suggest that the use of a 75 mm codend would materially increase the bycatch of species of value to the domestic fishery (Anon. 1981).

Gillnets: Gillnet catches of jack mackerel off New Plymouth in 1984 using research nets having joined panels of 90, 118, and 134 mm mesh showed that jack mackerel of 20–50 cm LCF were retained in greater numbers by the 90 mm mesh panels of the nets (Table 6) (author's unpublished data).

Bycatch species

Trawl fishery bycatch species are listed by Robertson *et al.* (1981), Hurst and Bagley (1986), and Robinson and Shearer (1988). The bycatch by year for the Japanese licensed trawlers given by Hurst and Bagley (1986) has been updated (Table 7).

Table 5: Total reported New Zealand catch (tonnes) for 1983/84–1987/88 (October — September fishing year). Catches broken down by EEZ area for foreign licensed and foreign chartered vessels only

	1983/84	1984/85	1985/86	1986/87	1987/88
B	n.a.	n.a.	n.a.	2 439	2 480
C	n.a.	45	117	1 641	2 493
D	18	369	142	206	639
E	100	-	181	1	2
F	148	367	401	541	136
G	437	463	400	704	1 218
H	11 700	15 050	9 415	18 266	14 617
?	455	3 278	4 132	2 959	1 044
Total	16 856	19 572	14 788	26 757	22 629

? = area not recorded.
- = < 1 tonne.
n.a. = not available.

Table 6: Individual sets of 300 m gillnets, each made up of 100 × 5.5 m deep panels of 90, 118 and, 134 mm mesh, showing catch (number) of JMA in each panel for each set. New Plymouth 1984

	Mesh (mm)		
Set	90	118	134
1	3	0	0
2	11	8	5
3	0	1	0
4	3	1	0
5	4	1	0
6	1	2	0
7	1	0	0
8	4	1	1
9	8	0	0
Total catch:	35	14	6
Mean LCF:	34.5	28.6	27.5
± S.D.:	9.8	9.8	10.6

Stock assessments

Since 1978 New Zealand has set Total Allowable Catches (TACs) for fisheries administered within the EEZ. Initially this involved setting a TAC for the overall catch in the EEZ with individual limits on only a few species, but gave impetus to the need to quantify the size of the stocks.

From assumptions based on aerial sightings data and age studies, Robertson (1978) estimated a conservative total New Zealand annual yield of 36 000 t of jack mackerel. (For management purposes the three jack mackerel species are not separated, but are treated as one stock.) After collating Russian and Japanese estimates Robertson and Eggleston (1979) revised Robertson's (1978) estimate to an annual yield for the whole of New Zealand of between 48 000 and 187 000 t.

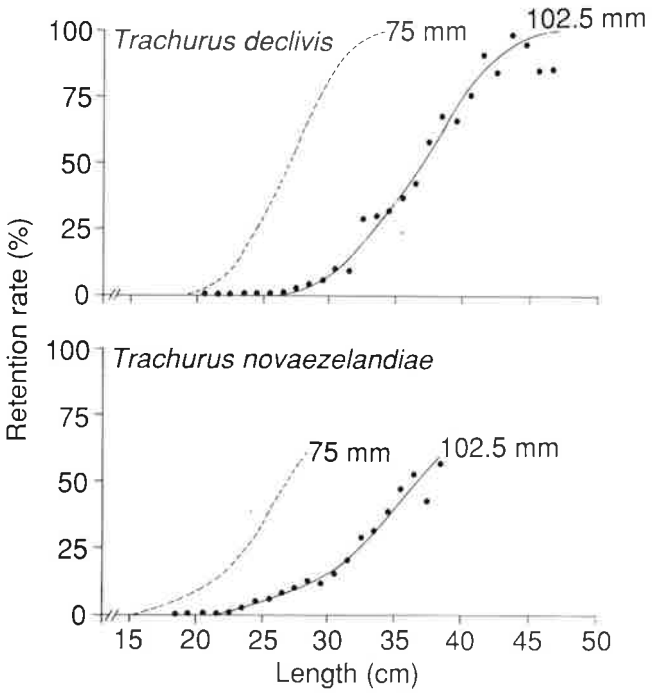


Figure 9: Selection curves of jack mackerels for 100 mm codend (internal mesh size 102.5 mm) and 75 mm codend (internal mesh size).

Because of the need to provide more accurate fish population biomass estimates to manage the fishery, two joint Japanese/New Zealand research surveys of the main commercial grounds (area H and northern area G, between 37° 30 ′ S and 41° 30 ′ S) were carried out. The results from the first, by the stern trawler *Tomi Maru* (350 grt) in the summer of 1980–81, were thought to be a gross underestimation because of the low towing speed (average 3.25 kts) and the exclusion of that portion of the population inside 12 nautical miles. Accordingly, the Japanese made *Shinkai Maru* (3393 grt) available in October — November 1981, and the results from this survey (average towing speed 3.8 kts) are thought to be the most reliable for this area. The biomass estimates (tonnes) for the two species in the area (excluding territorial waters inside the 12 nautical mile limit and outer Tasman Bay) were estimated using the swept area of the net (Robertson *et al.* (1981) and combined to obtain a total biomass for management purposes (Jones 1988).

Results of additional biomass surveys (aimed at other species rather than the jack mackerels) around the South Island, Chatham Rise, and Chatham Islands are shown in Table 8.

There is also a resource of small to medium sized jack mackerel in the Bay of Plenty and Hauraki Gulf, as evidenced by the common occurrence of juvenile jack mackerels in the trawls during snapper surveys, and the frequent sightings of large schools (200–260 t each) by pilots aerial spotting for purseseine vessels. Habib *et al.* (1981) state that up to 18 000 t has been seen on a single aerial spotting flight.

Table 7: Bycatch species as a percentage of jack mackerel tonnage where jack mackerel were the target species. Japanese data for area H only. (Updated from Hurst and Bagley 1986)

	JMA	BAR	GUR	JDO	RCO	SKI	SNA	SQU	SWA	TAR	TRE	MIX	EMA	FRO	OSD	SPD
1981/82	6 629	24.2	0.3	–	–	0.7	0.4	2.5	–	1.2	0.6	13.6	–	2.2	0.6	–
1982/83	8 745	13.4	–	0.1	–	0.3	0.3	2.4	–	1.1	–	3.6	1.4	8.3	0.5	0.2
1983/84	10 752	10.5	0.2	0.3	1.0	0.2	–	2.3	0.2	1.5	–	1.9	0.6	6.9	0.2	–
1984/85	5 313	14.6	0.5	0.5	0.1	0.3	–	0.8	–	1.9	–	–	1.3	5.2	0.3	–
1985/86	1 464	2.2	0.1	0.7	–	–	–	1.9	–	0.8	–	–	0.7	2.6	–	–
1986/87	2 807	15.7	0.1	0.3	–	–	–	3.2	0.4	1.7	–	0.4	3.5	12.2	–	0.7
1987/88	2 064	22.1	0.1	0.5	0.2	–	–	13.4	–	3.8	–	–	7.7	16.8	–	–

Species:

JMA = jack mackerels
BAR = barracouta (*Thyrsites atun*)
GUR = gunard (*Chelidonichthys kumu*)
JDO = john dory (*Zeus faber*)
RCO = red cod (*Pseudophycis* spp.)
SKI = southern kingfish (*Rexea solandri*)
SNA = snapper (*Chrysophrys auratus*)
SQU = squids
– = no observations.
SWA = silver warehou (*Seriolella punctata*)
TAR = tarakihi (*Nemadactylus macropterus*)
TRE = trevally (*Pseudocaranx dentex*)
MIX = mixed fishes
EMA = blue mackerel (*Scomber australasicus*)
FRO = frostfish (*Lepidopus caudatus*)
OSD = other sharks and dogfishes
SPD = spiky dogfish (*Squalus acanthias*)

Figures for the 1986 and 1987 snapper biomass surveys in the Hauraki Gulf have been included in Table 8. These surveys aimed at snapper, using a codend mesh of 40 mm, caught jack mackerels of 5–33 cm LCF (mainly 5–18 cm). Escapement of the small jack mackerel from the codend during hauling is extremely high and the biomass estimates are, therefore, very conservative.

Catch effort data

It is not practicable to calculate catch per unit of effort (CPUE) data for the domestic fishery because of the erratic reporting of the catch and the non-target nature of the fishery.

As part of the annual Japanese/New Zealand fish allocation negotiations, the Japanese have provided

Table 8: Biomass estimates for jack mackerels. Adapted from Hurst and Fenaughty (1985) and Hurst and Bagley (1987). Wings = wingspread biomass, Doors = doorspread biomass, c.v. = coefficient of variation

Area	Vessel	Date	Wings	Doors	c.v.
E/F	*Shinkai Maru*	Jun 86	2 800	965	23
	Akebono Maru	Nov 86	2 200	698	58
WCSI	*James Cook*	Sep/Oct 83	800	161	30
		Aug/Sep 84	1 000	231	17
Central WC	*Shinkai Maru*	Nov 81	208 000	49 500	*
Hauraki Gulf	*Kaharoa*	May 86	2 959	n.a.	25
		Nov 86	6 937	n.a.	48
		May 87	2 926	n.a.	36
		Nov 87	4 832	n.a.	20
ECSI	*James Cook#*	Mar 80	1 600	346	37
		May 81	24 700	5 334	73
		May 82	2 500	540	29
Chatham Rise	*Shinkai Maru*	Mar 83	100	22	73
		Nov/Dec 83	0	0	0
Chatham Island	*Akebono Maru*	Dec 84	1 300	333	35
	Shinkai Maru	Jul 86	2 500	712	21

* = Two species involved. JMN c.v. = 26.
\# = Cruises where c.v. < 50 or biomass estimate > 100 t. Six cruises between 1980 and 1982 are thus excluded.
n.a. = not available.

Table 9: Catch per unit of effort (as kg/hr) for trawlers by week and vessel power for the fishing years 1986/87 and 1987/88. (Source, Robinson 1988, and MAF Fisheries unpublished data)

Week*	Power (kW)	Number of tows 1986/87	Number of tows 1987/88	1986/87 CPUE	1987/88 CPUE
23 Nov — 29 Nov 87	2001–2500	48	9	935	166
	2501–3000	0	8	–	237
	3001–4000	84	33	1203	1501
30 Nov — 6 Dec 87	2001–2500	55	7	1155	259
	2501–3000	2	21	490	209
	3001–4000	91	28	1652	1289
07 Dec — 13 Dec 87	2001–2500	50	25	1200	423
	2501–3000	0	4	680	–
	3001–4000	75	29	2147	1654
14 Dec — 20 Dec 87	2001–2500	42	10	911	461
	2501–3000	5	2	1150	624
	3001–4000	30	25	2100	1139
21 Dec — 27 Dec 87	2001–2500	31	0	850	–
	2501–3000	21	15	780	337
	3001–4000	107	91	1497	544
28 Dec — 03 Jan 88	2001–2500	27	0	1540	–
	2501–3000	22	20	1620	598
	3001–4000	96	112	2477	1025
04 Jan — 10 Jan 88	2001–2500	31	0	1640	–
	2501–3000	17	22	780	398
	3001–4000	87	83	2463	1463
11 Jan — 17 Jan 88	2001–2500	10	0	1370	–
	2501–3000	0	3	–	696
	3001–4000	74	73	1487	1177

* Weeks shown for 1987/88 only. Corresponding week in 1986/87 began one day later.

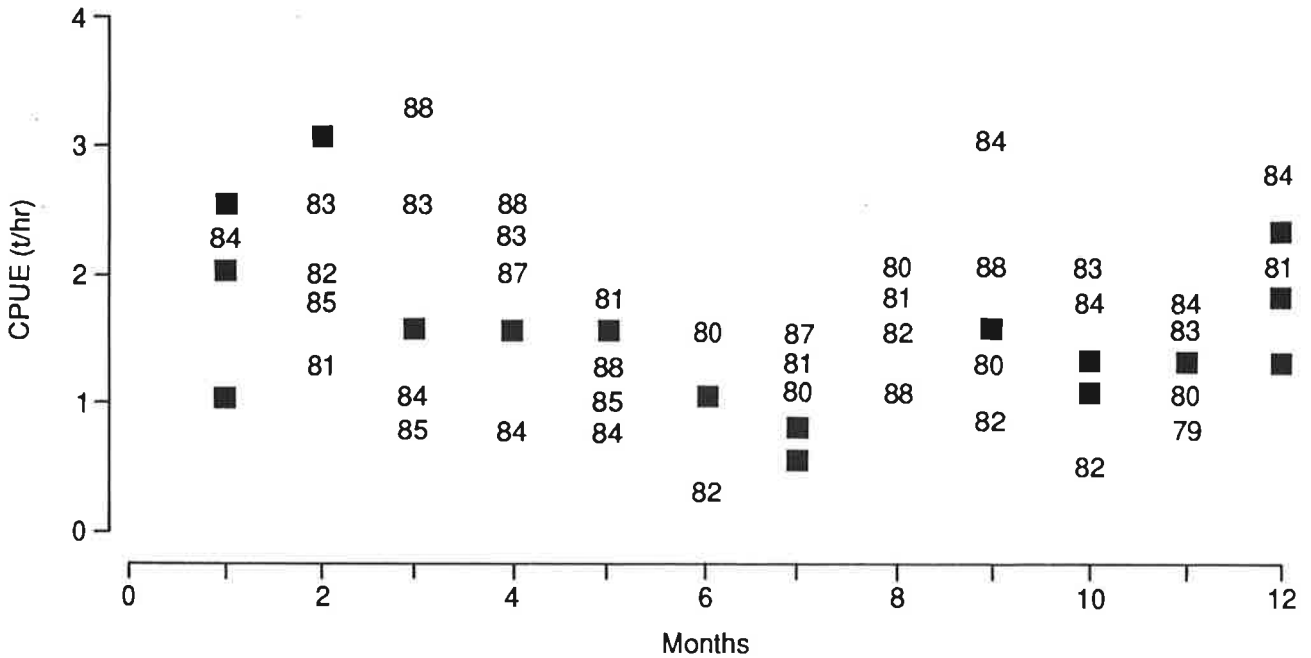


Figure 10: Combined catch/effort (t/h) for foreign licensed and foreign chartered vessels in area H, plotted against month, for vessels whose combined catch for that month was 50% or more JMA. Period covered is 1978/79 to 1987/88 inclusive (source FSU data). Squares indicate more than one year coincides.

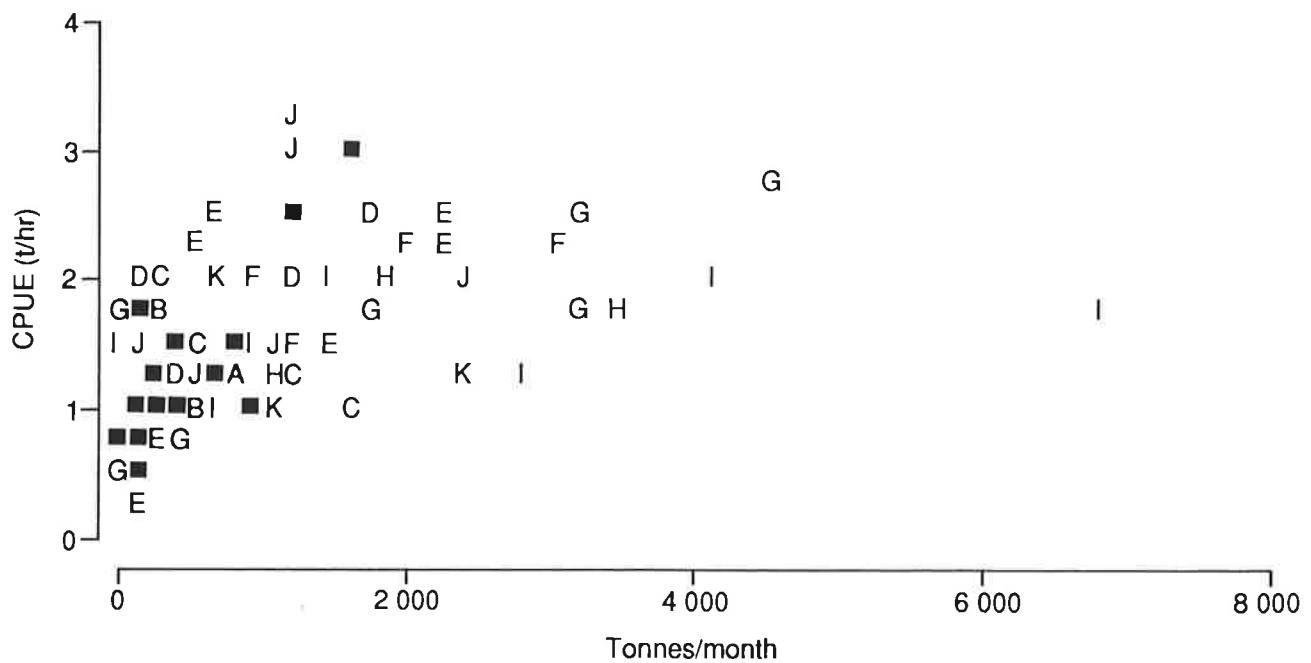


Figure 11: Combined foreign licensed and foreign chartered vessel catch/effort plotted against catch over the period 1978/79 to 1987/88 inclusive (source FSU data). A = 1978/79, B = 1979/80, C = 1980/81, D = 1981/82 E = 1982/83, F = 1983/84, G = 1984/85, H = 1985/86 I = 1986/87, J = 1987/88. ■ = more than one year coincides.

a continuous time-series of CPUE data, beginning in 1970, for Japanese vessels engaged in the jack mackerel fishery on the New Zealand shelf.

There is also a New Zealand commercial catch database available which includes CPUE of both foreign licensed and foreign chartered trawlers since 1978.

Detailed CPUE data by vessel by week has been available through the Fisheries Observer Programme since 1986/87 (Table 9).

Catch per unit of effort data for jack mackerels is influenced by the power of the vessel and thus the towing speed, and also by the time of year (Table 9). A plot of the crude New Zealand CPUE data (tonnes per hour) (both licensed and chartered vessels combined, all power classes combined) for months where jack mackerel comprised over 50% of the catch, shows an increase in CPUE over summer (December — March), falling in winter and with a smaller peak in August — September (Figure 10). A plot of crude New Zealand CPUE data against monthly total catch (Figure 11) shows that the years 1984–88 have a generally higher CPUE and higher catches than earlier years, but to what extent this reflects changes in vessel power, class, or gear technology has not yet been investigated.

Marketing

Mackerel are a widely traded international commodity both in the frozen and canned form. Basic prices are set by supply and demand.

Peruvian jack mackerel has proved itself to be almost as good as Alaska pollack for surimi manufacture (Seafood International 1987).

In New Zealand mackerel has been a low priced and underutilised product. In an attempt to improve the economics of capture, a price support scheme of $(NZ) 0.12 per kilogram whole weight was introduced from May 1979 to May 1980 and again (at the lower rate of $ 0.10 per kilogram whole weight) from mid 1981 to March 1982.

In an effort to develop a high value smoked product, the packaging and consumer acceptability of smoked mackerel products was studied (Hogg *et al.* 1984) and later the processing and storage of the same product was investigated (Scott *et al.* 1986). Despite favourable results from that work, jack mackerel is still seldom seen on the domestic market, but is exported or used for fishmeal and canned petfood.

Management history

Before the introduction of the EEZ the Japanese used a codend mesh of about 60 mm for catching jack mackerel on the New Zealand shelf. With the declaration of the EEZ the mesh size was set at 100 mm for the area north of 48° 30′ S and no less than 60 mm south of that line. Diplomatic approaches were made to reduce the codend mesh limit of 100 mm for this fishery, and during the 1984/85 season selected vessels were permitted to use a 60 mm mesh (by special provisions included on individual vessel permits), but the experiment has not been repeated and the number of vessels involved was not documented.

In 1986/87 a TAC of 30 000 t was imposed on the fishery and in 1987 the fishery was included in the Individual Transferable Quota (ITQ) scheme, using the fishing year commencing 1 October 1986 as the period to be used in determining provisional maximum ITQs. A court injunction taken out against MAF in 1987 by Maori tribal interests affected the full implementation of the ITQ scheme and resulted in the quota for parts of the Auckland region being allocated as annual quota from 18 December 1987, extended for a further year in 1988, and again in 1989.

Current New Zealand management boundaries

Under the Quota Management System four areas are defined. They are Quota Monitoring Area (QMA) 1 — Auckland (East) and Central (East); QMA 3 — South East, Southland, and Subantarctic; QMA 7 — Challenger, Central (West) and part of Auckland (West); and QMA 10 — Kermadec. (Figure 12). The 1987/88 gazetted TAC is shown in Table 10.

The Auckland (West) area is modified by excluding the waters of the territorial sea north of 36° S.

From 1 April 1981, foreign licensed vessels (but not chartered vessels) have been excluded from the area north of 38° S as a condition on their permits.

Table 10: The 1987/88 Total Allowable Catch (TAC) by Quota Management Area

Quota Management Area		Gazetted TAC (tonnes)
1	Auckland E + Central E	5 970
3	South E, Southland + Subantarctic	2 200
7	Challenger + Central W + part Auckland W	20 000
10	Kermadec	10
Total		28 180

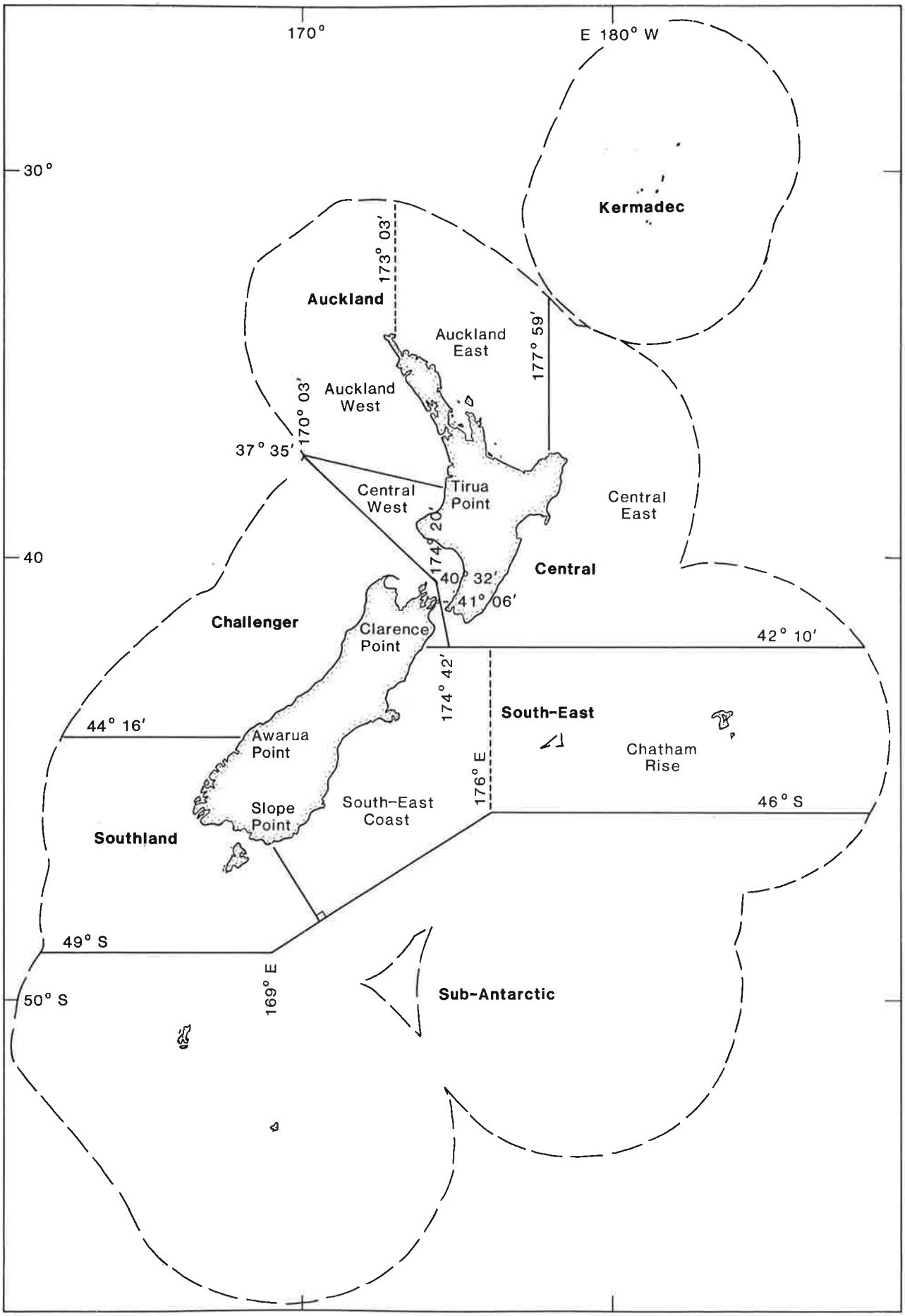


Figure 12: Quota Management Areas for jack mackerel (as at September 1987).

Acknowledgments

I wish to acknowledge the help of N. Bagley, K. Bailey, R. Hurst, P. McMillan, D. Robertson, and M. Robinson who all provided helpful information or unpublished data on jack mackerels.

References

Anon. 1977: Companies take advantage of governments duty free scheme. *Catch '77 4 (1)*: 3–4.

Anon. 1981: Report on the Japan/New Zealand joint jack mackerel survey in areas H and G by *Tomi Maru* No. 55. Japan Marine Fishery Resource Research Centre, unpublished report. June 1981. 33 p.

Anon. 1987: Outlook is promising for a major jack mackerel fishery off Tasmania. *Australian Fisheries 46 (12)*: 54.

Abramov, A. A. and Kotlyar, A. N. 1980: Some biological features of the Peruvian jack mackerel, *Trachurus symmetricus murphyi*. *Journal of Ichthyology 20*: 25–31.

Andrianov, D. P. 1985: Study on the reproduction of the Peruvian scad, *Trachurus murphyi* (Carangidae) of the Peruvian shelf. *Journal of Ichthyology 25*: 32–40.

Avdeev, V. V. 1978: Notes on the distribution of marine Cymothoidae (Isopoda: Crustacea) in the Australian — New Zealand region. *Folia Parasitologiya 25*: 281–283.

Avdeev, V. V. 1979: Parasitic isopods of the genus Meinertia from the Australia — New Zealand region [in Russian]. *Biologiya morya 2*: 48–54.

Bailey, K. 1983: Food and feeding habits of fish associated with skipjack tuna in New Zealand. (Unpublished MSc thesis, lodged in the Victoria University of Wellington library.)

Bailey, K. 1989: Description and surface distribution of juvenile Peruvian jack mackerel, *Trachurus murphyi*, Nichols from the Subtropical Convergence Zone of the central South Pacific. *Fishery Bulletin 87 (2)*: 273–278.

Bailey, K. and Habib, G. 1982: Food of incidental fish species taken in the purse-seine skipjack fishery, 1976–1981. *Fisheries Research Division Occasional Publication Data Series No. 6*. 24 p.

Brunsdon, R. V. 1956: Studies on nematode parasites of New Zealand fishes. 2 vols. (Unpublished PhD thesis, lodged in the Victoria University of Wellington library.)

Carrera, P. P. and Collantes, E. S. 1978: Determinacion de edad y crecimiento del jurel *Trachurus murphyi* Nichols, 1920. *Investigaciones Marinas 6 (6)*: 89–100.

Chilton, C. 1911: The Crustacea of the Kermadec Islands. *Transactions of the N.Z. Institute 43*: 544–573.

Clement, I. T. 1978: School fish sightings around New Zealand 1976–1977. *In* Habib, G. and Roberts, P. E. (Eds), Proceedings of the pelagic fisheries conference July 1977, pp. 35–42. *Fisheries Research Division Occasional Publication Series No. 15*.

Crossland, J. 1981: Fish eggs and larvae of the Hauraki Gulf, New Zealand. *Fisheries Research Bulletin No. 23*. 61 p.

Crossland, J. 1982: Distribution and abundance of fish eggs and larvae from the spring and summer plankton of north east New Zealand, 1976–78. *Fisheries Research Bulletin No. 24*. 59 p.

Dillon, W. A. and Hargis, W. J. 1965: Monogenetic trematodes from the Southern Pacific Ocean. 2. Polyopisthocotyleids from New Zealand fishes. The families Mazocraeidae, Diclidophoridae and Hexabothriidae. *Proceedings of the Biological Society of Washington 81*: 351–366.

Evseenko, S. A. 1988: Reproduction of Peruvian jack mackerel, *Trachurus symmetricus murphyi*, in the southern Pacific. *Journal of Ichthyology 27(3)*: 151–160.

Gasior, W. and Kompowski, A. 1982: Biological and fishery related observations on jack mackerel, *Trachurus declivis* (Jenyns, 1841), stock during spawning off south-east Australia. *Acta Ichthyologica et Piscatoria 12*: 3–20.

Gauldie, R. W., Purnell, D., and Robertson, D. A. 1977: Some biochemical similarities and differences between two jack mackerel species, *Trachurus declivis* and *T. novaezelandiae*. *Comparative Biochemistry and Physiology 58B*: 389–391.

Godfriaux, B. L. 1974: Food of snapper in western Bay of Plenty, New Zealand. *N.Z. Journal of Marine and Freshwater Research 8*: 473–504.

Graham, D. H. 1956: "A treasury of New Zealand fishes." 2nd edition. Reed, Wellington. 424 p.

Gutiérrez, A. T. 1986: Migraciones de *Trachurus murphyi* en el norte de Chile. *Investigacíon Pesquera (Chile) 33*: 99–103.

Habib, G., Clement, I. T., and Fisher, K. A. 1981: School fish sightings around New Zealand June 1976 to December 1980: 2. Blue mackerel, Jack mackerels, and mixed schools. *Fisheries Research Division Occasional Publication Data Series No. 3*. 76 p.

Hector, J. 1872: Notes on the edible fishes. In Hutton, J. H. "Fishes of New Zealand." pp. 95–133. Hughes, Wellington, 133 p, XII plates.

Hine, P. M., Wain, J. M., and Boustead, N. C. 1987: The leucocyte enzyme cytochemistry of fish. *N.Z. Fisheries Research Bulletin 28*. 74 p.

Hogg, M. G., Scott, D. N., and Triggs, C. M. 1984: An evaluation of smoked New Zealand jack mackerel. *Fish Processing Bulletin DSIR (N.Z.) No 2*. 101 p.

Hurley, D. E. 1961: A checklist and key to the Crustacea Isopoda of New Zealand and the Subantarctic Islands. *Transactions of the Royal Society of N.Z., Zoology 1*: 259–292.

Hurst, R. J. 1984: Identification and description of larval *Anisakis simplex* and *Pseudoterranova decipiens* (Anisakidae: Nematoda) from New Zealand waters. *N.Z. Journal of Marine and Freshwater Research 18*: 177–186.

Hurst, R. J. and Bagley, N. W. 1986: By-catch summaries of 5 major deepwater target fisheries 1981/82, 1982/83 and 1983/84. Fisheries Research Division Internal Report No. 49. 45 p. (Unpublished report, held in MAF Fisheries Greta Point library, Wellington).

Hurst, R. J. and Bagley, N. W. 1987: Results of a trawl survey of barracouta and associated finfish near the Chatham Islands, New Zealand, December 1984. *N.Z. Fisheries Technical Report No. 3.* 44 p.

Hurst, R. J. and Fenaughty, J. M. 1985: Report on biomass surveys 1980–84: summaries and additional information. Fisheries Research Division Internal Report No. 21. 53 p. (Unpublished report, held in MAF Fisheries Greta Point library, Wellington).

James, G. D. 1975: Size composition of jack mackerel catches from the west coast of New Zealand. *N.Z. Journal of Marine and Freshwater Research 9*: 45–52.

Johnston, A. D. 1983: The southern Cook Strait groper fishery. *Fisheries Technical Report 159.* 33 p.

Jones, J. B. 1988: Jack mackerel. *In* Baird, G. G., and McKoy, J. L. 1988: Papers from the workshop to review fish stock assessment for the 1987–88 New Zealand fishing year. 300 p. (Preliminary discussion paper, held in MAF Fisheries Greta Point library, Wellington).

Kawahara, S., Uozumi, Y., and Yamada, H. 1988: First record of a carangid fish *Trachurus murphyi* from New Zealand. *Japanese Journal of Ichthyology 35*: 212–214.

Kerstan, M. and Sahrhage, D. 1980: Biological investigations on fish stocks in the waters off New Zealand. *Mitteilungen aus dem Institut fur Seefischerei der Bundesforschungsanstalt fur Fischerei No. 29.* 181 p.

Kijima, A., Tanaguchi, N., and Ochiai, A. 1988: Genetic divergence and relationship among fifteen species of genera *Trachurus, Decapterus, Selar,* and *Selaroides. Japanese Journal of Ichthyology 35 (2)*: 167–176.

Lebedev, B. I. 1967: Australorhynchus tetramorphacanthus gen. et sp. n. — found in fish of the New Zealand — Australian shelf (Acanthocephala, Rhadinorhynchidae, Travassos 1923). *Zoologich. zhurnal 46(2)*: 279–282. [in Russian, English summary].

Lebedev, B. I. 1968: New trematodes from pelagic fishes of the order Perciformes from the Pacific Ocean basin. *In* Skryabin, K. I. and Mamaev, Yu. C. (Eds). "Helminths of animals of the Pacific Ocean", pp. 56–64. Izdat. Nauk. Moscow. [in Russian].

Maxwell, J. G. H. 1982: Infestation of the jack mackerel, *Trachurus declivis* (Jenyns), with the cymothoid isopod, *Ceratothoa imbricatus* (Fabricus), in south eastern Australian waters. *Journal of Fish Biology 20*: 341–349.

Mendez, Z. R. and Yany, G. G. 1978: La pesqueria del jurel (*Trachurus murphyi* Nichols, 1920) en Chile. *Investigaciones Marinas 6 (6)*: 101–124.

Meglitsch, P. A. 1960: Some coelozoic Myxosporida from New Zealand fishes. Part 1 — General, and family Ceratomyxidae. *Transactions of the Royal Society of N.Z. 88*: 265–356.

Miezitis, O. and Wright, A. D. 1979: Variations in the chemical composition of jack mackerel *Trachurus declivis* (Jenyns) from commercial fishing for FPC production 1973–1974. *Tasmanian Fisheries Research 22*: 30–39.

Muck, P., Sandoval de Castillo, O., and Carrasco, S. 1987: Abundance of sardine, mackerel and horse mackerel eggs and larvae and their relationship to temperature, turbulence and anchovetta biomass off Peru. *ICLARM Studies and Reviews No. 15*: 268–275.

Nosov, E. V. 1975a: The influence of hydrometeorlogical conditions on the distribution and features of the vertical migrations of the scad — (*Trachurus declivis* Jenyns). Translation No. 31 held in MAF Fisheries Greta Point library. Originally published in *Izvestiya TINRO, Transactions of the Pacific Ocean Scientific Research Institute for Fisheries and Oceanography 96*: 197–208. [in Russian].

Nosov, E. V. 1975b: Determining natural mortality and number using the example of the New Zealand jack mackerel (*Trachurus declivis* Jenyns). Translation No. 6 held in MAF Fisheries Greta Point library. Originally published in *Izvestiya TINRO, Transactions of the Pacific Ocean Scientific Research Institute for Fisheries and Oceanography 98*: 55–66. [in Russian].

Nosov, E. V. and Platoshina, L. K. 1975: The reproduction of New Zealand jack mackerel (*Trachurus declivis* Jenyns) on the New Zealand plateau. Translation No. 4 held in MAF Fisheries Greta Point library. Originally published in *Izvestiya TINRO, Transactions of the Pacific Ocean Scientific Research Institute for Fisheries and Oceanography 98*: 67–79. [in Russian].

Nosov, E. V. and Shurunov, N. A. 1975: Some features of seasonal and year to year variation in the distribution of the jack mackerel (*Trachurus declivis* Jenyns). Translation No. 28 held in MAF Fisheries Greta Point library. Originally published in *Research into the biology of fish and commercial oceanography, Pacific Ocean Scientific Research Institute for Fisheries and Oceanography No. 6*: 91–104. [in Russian].

Parrish, R. H. (in press): The South Pacific oceanic horse mackerel (*Trachurus picturatus murphyi*) fishery. *In* Pauly, D., Muck, P., Mendo, J. and Tsukayama, L. (Eds). The Peruvian upwelling ecosystem: dynamics and interactions, pp. 321–331. *ICLARM Conference Proceedings 18.*

Pullen, G., Williams, H. and Last, P. 1989: South American fish found off Tasmania. *Australian Fisheries, June 1989*: 35.

Richardson, B. J. 1982: Geographical distribution of electrophoretically detected protein variation in Australian commercial fishes. I. Jack mackerel, *Trachurus declivis* Jenyns. *Australian Journal of Marine and Freshwater Research 33*: 917–926.

Robertson, D. A. 1975: A key to the planktonic eggs of some New Zealand marine teleosts. *Fisheries Research Division Occasional Publication No. 9.* 19 p.

Robertson, D. A. 1977: NZ jack mackerel fishery. *Catch '77 4(4)*: 10–11.

Robertson, D. A. 1978: The New Zealand jack mackerel fishery. *In* Habib, G. and Roberts, P. E. (Eds). Proceedings of the Pelagic Fisheries Conference, July 1977, pp. 43–47. *Fisheries Research Division Occasional Publication No. 15.*

Robertson, D. A., and Eggleston, D. 1979: Shelf resources: jack mackerel and barracuda. *In* Elder, R. D., and Taylor J. L. (Eds). Prospects and problems for New Zealand's demersal fisheries. Proceedings of the Demersal Fisheries Conference, October 1978, pp. 30–34. *Fisheries Research Division Occasional Publication No. 19.*

Robertson, D. A., Grimes, P. J., and Francis, R. I. C. C. 1981: Central west coast fish biomass survey. October — November 1981. Fisheries Research Centre Internal Report No. 120. 35 p. (Draft report held in MAF Fisheries Greta Point library, Wellington.)

Robins, J. P. 1963: Synopsis of biological data on bluefin tuna *Thunnus thunnus maccoyii* (Castlenau). *Proceedings of the World Scientific Meeting on the Biology of Tuna and Related Species, Rome (FAO) 2*: 562–587.

Robinson, E. S. 1959: Records of cestodes from marine fishes of New Zealand. *Transactions of the Royal Society of N.Z. 86*: 143–153.

Robinson, M. 1988: Summary of scientific observer programme data: 1987–88 Taranaki Bight jack mackerel fishery. Fisheries Research Centre Internal Report No. 98. 20 p. (Draft report held in the MAF Fisheries Greta Point library, Wellington.)

Robinson, M. and Shearer, P. 1988: Summary of scientific observer programme data: the 1986–87 Taranaki Bight jack mackerel fishery. Fisheries Research Centre Internal Report No. 104. 67 p. (Draft report held in the MAF Fisheries Greta Point library, Wellington.)

Scott, D. N., Fletcher, G. C., Temple, S. M., Hogg, M. G., and Buisson, D. H. 1986: The processing and storage of smoked New Zealand jack mackerel. *Fish Processing Bulletin DSIR (N.Z.) No. 8.* 43 p.

Seafood International 1987: Thumbs up for mackerel. *Seafood International 2 (3) March*: 9.

Serra, J. R. 1983: Changes in the abundance of pelagic resources along the Chilean coast. *FAO Fisheries Report 291 vol. 2*: 255–284.

Shaboneyev, I. Ye. 1980: Systematics, morpho-ecological characteristics and origin of carangids of the genus *Trachurus*. *Journal of Ichthyology 20 (6)*: 15–24.

Shuntov, V. P. 1979: Ikhtiofauna Yugo-Zapadnoi Casti Tikhogo Okeana. Pishchevaya Promyshlennost, Moscow. (Held in MAF Fisheries Greta Point library, as USSR odd publication No. 55). 192 p. [in Russian].

Shuntov, V. P., Gavrilov, G. M., Pashkin, V. N., Shpak, V. M., Blagoderov, A. I., and Kirlan, D. F. 1979: Some tendancies in dynamics of fish abundance of New Zealand plateau. Translation No. 117 held in MAF Fisheries Greta Point library. Originally published in *Biologiya Morya 2*: 11–19.

Shuntov, V. P., Shurunov, N. A. and Vasil'kov, V. P. 1981: Periodicity in the reproduction of fish from the New Zealand plateau based on data from commercial statistics. *Journal of Ichthyology 20 (1)*: 32–43.

Stephenson, A. B. 1976: Gill damage in fish produced by buccal parasites. *Records of the Auckland Institute and Museum 13*: 167–173.

Stephenson, A. B. and Robertson, D. A. 1977: The New Zealand species of *Trachurus (Pisces: Carangidae)*. *Journal of the Royal Society of N.Z. 7 (2)*: 243–253.

Vlieg, P. 1982a: The proximate and fatty acid composition of the flesh of the New Zealand red cod, hoki, and jack mackerel. *N.Z. Journal of Science 25*: 155–158.

Vlieg, P. 1982b: Compositional analysis of jack mackerel and blue mackerel. *N.Z. Journal of Science 25*: 229–232.

Webb, B. F. 1976: Aspects of the biology of jack mackerel *Trachurus declivis* (Jenyns) from south east Australian waters. *Tasmanian Fisheries Research 10 (1)*: 1–14.

Whitley, G. P. 1946: Aerial observations on fish schools. *Proceedings of the Royal Zoological Society of New South Wales 1945#1946*: 17–27.

Williams, H. and Pullen, G. 1986: A synopsis of biological data on the jack mackerel *Trachurus declivis* Jenyns. *Department of Sea Fisheries, Tasmania, Technical Report 10*. 34 p.

Williams, H., Kirkwood, R., Pullen, G., and Kucerans, G. 1986: The jack mackerel purse-seine fishery in Tasmania 1985–86. *Department of Sea Fisheries, Tasmania, Technical Report 13*. 43 p.

Printed by Madison Printing Company Ltd