NIWA

Taihoro Nukurangi

New Zealand Domestic Tuna Fisheries 1989–90 to 1998–99

Talbot Murray, Lynda Griggs, & Hudson Dean

Final Research Report for Ministry of Fisheries Research Project TUN1999/01 Objective 1

National Institute of Water and Atmospheric Research

March 2001

Final Research Report

Report Title: New Zealand Tuna Fisheries

Authors: Talbot Murray, Lynda Griggs, & Hudson Dean

1. **Date:** 30 October 2000

2. **Contractor:** NIWA

3. **Project Title:** Monitoring albacore, bigeye, skipjack and yellowfin tuna and swordfish in support of New Zealand's international fisheries agreements

4. **Project Code:** TUN1999/01

5. **Project Leader:** Talbot Murray

6. **Duration of Project:**

   Start date: 1 October 1999
   Completion date: 30 September 2001

7. Executive Summary

The New Zealand tuna industry now lands tuna year round with peak summer activity by a large troll fleet (usually over 200 vessels) targeting albacore, a small purse seine fleet (six vessels) targeting skipjack, and longliners (about 80 vessels) targeting southern bluefin in winter and bigeye throughout the year. The value of this industry exceeds $ 20 million per year with potential to expand further.

New Zealand tuna fishing began in 1968 when the F/V *Sea Bee* began landing large catches of albacore into North Island ports (Slack 1970). This interest expanded following the successful purse seine surveys in 1974 and 1975 by the F/V *Paramount* targeting skipjack (Eggleston 1976). Interest in other tunas followed with commercial catches of southern bluefin tuna off the West Coast of the South Island in 1980 by handline (Paul 1980). In more recent years (since 1991–92), tuna fishing has expanded into a year round industry due in large part to the development of longline fisheries for southern bluefin and bigeye tunas. The expansion of domestic capacity occurred as foreign licensed interest in fishing the EEZ declined during the 1980s and 1990s. The foreign fleets that dominated the New Zealand area tuna catches from the 1960s have not fished in the EEZ since 1994–95 with the exception of occasional purse seine sets by USA vessels.

Annual domestic tuna landings are now expected to be on the order of 3700–6500 t for albacore, 100–400 t for bigeye, 1000–7500 t for skipjack, 420 t (±) for southern bluefin, and 100–200 t for yellowfin tuna. Swordfish catch, regarded as an incidental longline catch, has nearly doubled in each of the past five years and may continue to increase, the catch is now nearing 1000 t.

Most increases in catch can be attributed to the trend in increasing longline fishing effort which began in 1991–92. In 1998–99 albacore and skipjack catches declined, probably due to low market demand. In both instances effort in 1998–99 was significantly lower than the previous year, despite albacore CPUE being the highest in the past nine years, there is no trend in skipjack CPUE. Longline CPUE trends differ for each species from a slight declining trend since 1990–91 for albacore, to no appreciable trend for bigeye over the same period. Southern bluefin tuna CPUE increased during the first 2–3 years of domestic longlining but has been stable since 1992–93. Swordfish CPUE appeared to decline from 1991–92 (few sets) but showed a slight increasing trend since 1994–95.

The apparent relationship between swordfish CPUE and total longline effort suggests that there may be some targeting of swordfish.

Catches of tunas and swordfish by domestic owned and operated vessels is estimated by gear type from an analysis of CPUE converted to weight and scaled to landings data. This includes estimates of Pacific bluefin tuna catches (formerly known as northern bluefin tuna). Because of difficulty in clearly separating these species in catch and landings statistics the estimates provided are likely to under-estimate Pacific bluefin catches and over-estimate southern bluefin catches. Because the frequency of misidentification is unknown, the extent of this problem is also unknown at present.

The tunas and swordfish caught within the EEZ are part of broadly distributed stocks that are subject to fishing by many fleets and gear types at different stages of their lives. A review of available information indicates that stocks of South Pacific albacore, skipjack and yellowfin tunas are probably sustainable at current fishing levels. Stocks of bigeye and northern (Pacific) bluefin tuna and swordfish are uncertain. Of these, recent concern has been raised about incidental mortality rates on juvenile bigeye in the purse seine fishery in the eastern and western tropical Pacific Ocean. The southern bluefin tuna stock continues to be of concern and can be regarded as over-fished. It is unclear whether current fishing levels will achieve the management target of recovery of the parental stock to 1980 levels by 2020.

8. Objectives

To produce a report on the status of New Zealand fisheries for albacore, bigeye, skipjack, southern bluefin and yellowfin tuna and swordfish for 1998–99 fishing year.

9. Methods

See attached report.

10. Results

See attached report.

11. Conclusions

See attached report.

12. Publications

Nil.

13. Data Storage

All data used in this report are stored in relational research databases at NIWA, Greta Point.

New Zealand Domestic Tuna Fisheries 1989–90 to 1998–99

Talbot Murray, Lynda Griggs, & Hudson Dean

Contents

Abstract

This report summarises the tuna and swordfish catches by the domestic troll, purse seine and longline fisheries for the last 10 fishing years in the New Zealand EEZ. The species covered are albacore, bigeye, skipjack, Pacific bluefin (formerly northern bluefin), southern bluefin and yellowfin tunas and swordfish. Domestic landings (including chartered longliners) and estimates of the total catch by all fleets operating in the EEZ are summarised. Catch per unit of fishing effort (CPUE) for domestic owned and operated vessels is used to estimate catch by this fleet by gear type for the period 1989–90 to 1998–99 for each species. CPUE trends from tuna fisheries operating in the EEZ are reviewed as is recent information on the status of stocks.

Introduction

New Zealand tuna fisheries are based on stocks distributed largely outside of the 200 nautical mile Exclusive Economic Zone (EEZ). In New Zealand waters tuna represent important and valuable seasonal fisheries (worth over $NZ 20 million per year). No tuna species are included in the Quota Management System and only southern bluefin tuna (*Thunnus maccoyii*), managed by the *Commission for the Conservation of Southern Bluefin Tuna* (CCSBT), is subject to catch restrictions. New Zealand's competitive national catch limit of 420 t has been in place sine 1989. Other commercially important tuna species are albacore (*T. alalunga*), bigeye (*T. obesus*), Pacific or northern bluefin (formerly *T. thynnus* recently renamed *T. orientalis* by Collette (1999), skipjack (*Katsuwonus pelamis*) and yellowfin tuna (*T. albacares*). While billfish, especially marlins (*Tetrapturus sp.* and *Makaira sp.*) are of commercial interest and regularly caught on tuna longlines, all billfish except swordfish (*Xiphias gladius*) must be released if caught. Swordfish may not be targeted but can be landed by domestic fishers. Swordfish has become increasingly important in the domestic tuna longline fishery as a valuable bycatch species and landings in the last few years have rapidly increased.

In New Zealand, albacore form the basis of a summer troll fishery, primarily on the west coasts of the North and South Island, with annual landings over the past 10 years averaging 4414 tonnes (maximum landing 6524 t). Albacore are also caught throughout the year by longline (usually ≤ 1000 t per year). Bigeye, the second most valuable tuna (per kg), are caught by longline around the northern half of the North Island throughout the spring–autumn period with landings averaging 121 t per year over the past 10 years (maximum landing 390 t). Skipjack are caught in small numbers by trolling with most of the catch by purse seine during summer months. Skipjack landings have averaged 3893 t per year over the past 10 years (maximum landing 7308 t). Southern bluefin tuna traditionally have been caught by handline and trolling during winter months off the West Coast of the South Island from small vessels. These methods are still occasionally used. Most southern bluefin tuna, however, are caught by medium to large (20–50 m) longline vessels in autumn–winter months. Southern bluefin catches, restricted to a national competitive catch limit of 420 t since 1989, have usually been below this limit with landings averaging 295 t per year over the past 10 years (maximum landing = 529 t in 1989–90).

Yellowfin tuna, caught in small numbers in the troll and purse seine fisheries, are generally a bycatch of longline sets targeting bigeye in summer months. Landings of yellowfin tuna have averaged 87 t per year over the past 10 years (maximum landing 193 t). Although it is possible to target swordfish with longline gear, swordfish are reported as a bycatch of longline sets targeting bigeye and southern bluefin tunas around both the North and South Islands. Swordfish landings have averaged 240 t per year over the past 10 years but have risen dramatically, with increased longline effort, especially over the last few years (maximum landing = 965 t in 1998–99).

In addition to the tuna target species and billfish, several commonly caught species of little or no value also contribute to the longline bycatch (see Francis *et al.* (1999 & 2000)). The number of species in the longline bycatch has raised some concern about the potential effects of longline fishing on dependent and associated species, particularly those that are rare, have low fecundity or about which little is known. Longline bycatch diversity is similar to purse seine fishing for skipjack tuna where many fish taxa (>60 species) occur as bycatch (Habib *et al.* 1982). Trolling and other tuna fishing methods do not have an appreciable bycatch.

Foreign licensed tuna fishing, primarily for southern bluefin tuna, has been declining since the late 1980s and no foreign licensed vessels have operated in the New Zealand EEZ since 1995–96. At the same time domestic tuna fishing has expanded through the increased use of longline for both southern bluefin and bigeye tunas. Most vessels are New Zealand owned and operated although a few (usually 5 vessels) chartered Japanese longliners have fished the EEZ each year since 1988–89 except 1990–91 (3 vessels) and 1995–96 (no vessels).

This report focuses on the six tuna species and swordfish caught by New Zealand owned and operated tuna vessels. The species covered in this report, their full scientific name and codes used for them are given in Appendix 1. While handline and pole-and-line fishing are occasionally used, this report focuses on catches by longline, purse seine and troll.

Methods

The data used in this report were collected and compiled by the Ministry of Fisheries (MFish) from forms supplied by the commercial fishing sector. These data are supplied by fishers on each operation catching tuna, by licensed fish receivers and by MFish observers. Data are provided to NIWA through "views" of the MFish Catch and Effort database. Most data on tuna longlining comes from the Tuna Longlining Catch, Effort Returns (TLCER) while data on trolling, purse seining, and some longlining comes from the Catch, Effort and Landing Returns (CELR). A description and examples of these forms and the requirements for filling them out are specified in the Fisheries (Reporting) Regulations of 1990. Both the CELR and TLCER forms enable fishers to provide information on their catch (in number and estimated weight) by species for each operation with information on the type and amount of gear used, area fished, and on environmental factors which might affect fishing success.

The TLCER form has been used in nearly the same format since its introduction in 1980 for foreign licensed vessels. The CELR, however, has varied over time. Fishers are required to fill out the catch on the "Trip Data" portion of the CELR form as number of fish caught for all tunas (for both the Lining Methods and Other Lining Methods templates). This was not so for the first few years after the form was introduced. Prior to the introduction of the CELR form (1988–89), tuna catch and effort were reported through the MAF Fisheries Statistics Unit in method-specific catch and effort logbooks, where catch was recorded as number of fish. However, for the two years following the introduction of the CELR form, the requirement was for catch to be recorded as estimated weight. Not only did this nullify the use of tuna data for CPUE analyses but also interrupted a valuable time series of data. A further unfortunate consequence of the redesign of the MAF catch and effort data at this time was the corruption of data from 1976 to 1988. From 1990–91 fishers were instructed to fill out the catch portion of the CELR as catch in number and since that time many fishers have complied. Some fishers, however, (about 20%) still report their tuna catch as estimated weights. Purse seine and swordfish catches are reported in weight.

Another source of error in these data arises from some fishers reporting tuna catches using method codes not associated with tuna fishing. In part this may be due to fishers confusing the codes for trawling, trot lining, and other lining methods. A number of unusual method codes also exist in the MFish data (e.g., bottom longlining, set netting), it also appears that fishers catching tuna for rock lobster bait often record the method used as "Rock Lobster Potting". Tuna catches reported by methods other than handline, pole-and-line, troll, purse seine or surface longline are not included in this report.

In grooming data for this project we used a number of criteria to identify errors in catch and effort in a "research" version of the official MFish catch effort data. A number of range checks were done and probable errors were either checked individually against the original form or, more usually, against fishing operations by a vessel preceding and following the operation in question. Where there was clear evidence of an error (e.g., numbers transposed, longitude recorded as W instead of E, decimal point misplaced, etc), these were replaced with the value used elsewhere in the trip (if constant) or by the mean of adjacent values.

Trips where the estimated catch in number to landed weight ratio was near 1 (± 20%) were excluded. We have also applied range checks on average fish size so that data used for CPUE analyses do not include fish that on average are unrealistically small or large to have been caught by a given method. Limits imposed to restrict troll caught albacore size were taken from Labelle & Murray (1992). Maximum sizes of longline caught tunas and swordfish were taken from Collette & Nauen (1983) and Nakamura (1985). Minimum fish size restrictions were derived from MFish observer data for longline caught fish. Maximum catch per trip and duration of each trip limits were provided by industry experts (Peter Reid for skipjack purse seining and Roger Burgess for albacore trolling). All error corrections were applied to a "research version" of the MFish data held by NIWA in a relational database (Dean 1998). The constraints applied to MFish data used in this report are summarised in Table 1.

Errors identified during analysis (i.e. those that passed the first order detection and error correction) include wrongly assigned fishing method codes, target species as well as catch that appears to be wrongly assigned to species. It is not known how often this happens but an obvious example is striped marlin (STM) where this species does not occur but southern bluefin tuna (STN) are caught. These errors exist in both the TLCER and in the CELR data.

***Table 1*:** **Constraints applied to Ministry of Fisheries catch and effort data**

Fishing method	Species	Constraint applied
purse seine	skipjack tuna	catch per set ≤ 160 t sets per day ≤ 7
Trolling	albacore	no. fish per trip ≤ 2000 and weight of catch per trip ≤ 10 t 2.0 kg ≤ average fish weight in landing ≤ 20.0 kg 5 ≤ no. hooks ≤ 20 4 ≤ hours fished ≤ 17 USA trollers excluded
Longline	all targets	1 ≤ sets per day ≤ 2 and 50 ≤ hooks per set ≤ 4000 2 kg ≤ average albacore weight ≤ 40 kg (CELR data only) 14 kg ≤ average yellowfin weight ≤ 176 kg (CELR data only) 16 kg ≤ average swordfish weight ≤ 540 kg (CELR data only)
Longline	bigeye tuna	19 kg ≤ average fish weight ≤ 197 kg (CELR data only)
Longline	southern bluefin tuna	19 kg ≤ average fish weight ≤ 225 kg (CELR data only)
Longline	northern bluefin tuna	19 kg ≤ average fish weight ≤ 350 kg (CELR data only)

New Zealand tuna fishers are required to report tuna catches as number of fish for each operation (except for purse seine), with weight reported for each landing. The catch in weight is provided to fishers when landed to a licensed fish receiver. Since a mixture of fishing methods can be used on a fishing trip, except for purse seine vessels, this landed weight does not distinguish catch in weight by gear type unless the weight can be related to the CPUE. For this reason tuna catch by gear type was estimated as follows:

1. CPUE was estimated from the catch in number of fish per individual fishing operation for tuna other than skipjack and in weight for swordfish for each target species–gear combination using groomed catch and effort data;

2. total catch in number was estimated by multiplying CPUE by the total number of fishing operations from the original data for each species by gear type;
3. total catch in weight was estimated by multiplying the average weight of each species by gear type by the total catch in number; and
4. catch in weight by gear type was proportionally scaled to the LFRR landings data.

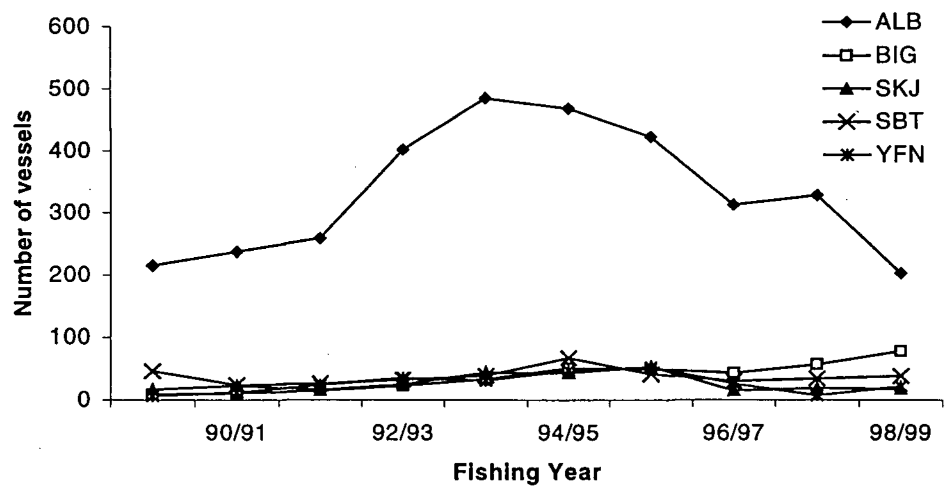
In this report, catch estimates for domestic owned and operated vessels were obtained by first subtracting the catch by charter vessels from the LFRR data before scaling. Summaries of groomed catch and effort data from domestic owned and operated vessels used in this report by gear type, target species, and fishing year are given in Appendix 2 for surface fisheries and in Appendix 3 for longline fisheries.

Average weights were based on observer data for the longline fishery, catch sampling of troll caught albacore and logsheet data for other lining methods. No conversion from number to weight was required for the purse seine fishery for skipjack or for swordfish since catches are reported in weight rather than number.

The New Zealand tuna fleet

A wide range of vessel types fish for tuna in the EEZ with many vessels also operating in other fisheries during the year. Of these, only those engaged in purse seining and a few longline vessels are purpose built tuna vessels. Trolling, purse seining and longlining are the main tuna fishing methods used in New Zealand although handline and pole-and-line are also occasionally used. Appendix 4 summarises the number of tuna vessels by target species, gear type and fishing year (1 October to 30 September).

Figure 1: **Total number of New Zealand tuna vessels (including chartered vessels) by target species fishing since 1989–90.**

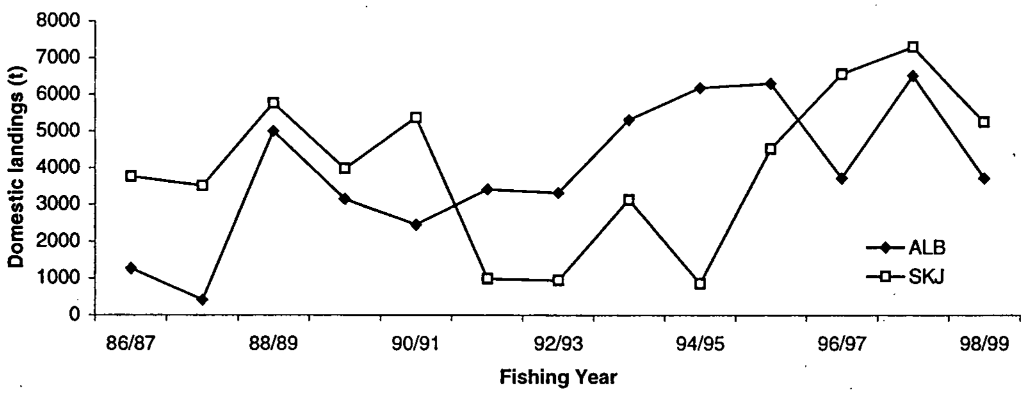


The largest number of vessels target albacore although the number doing so has declined from the peak of nearly 500 vessels in 1993–94 to around 200 in 1998–99 (Figure 1). Fewer than 50 vessels report targeting southern bluefin or yellowfin tunas and, while the number of vessels varies each year, there is no trend evident in vessel number for these target species. In contrast, the number of vessels targeting bigeye tuna has increased in each of the past two years to nearly 80 vessels. Skipjack tuna, primarily caught by 6 purse seine vessels, are also caught by up to 11 boats using pole-and-line and up to 44 troll vessels. Most vessels targeting albacore (93% over the past five years) are trollers while those targeting bigeye and southern bluefin tunas (98% and 74% respectively over the past five years) use longline.

Total tuna and swordfish landings

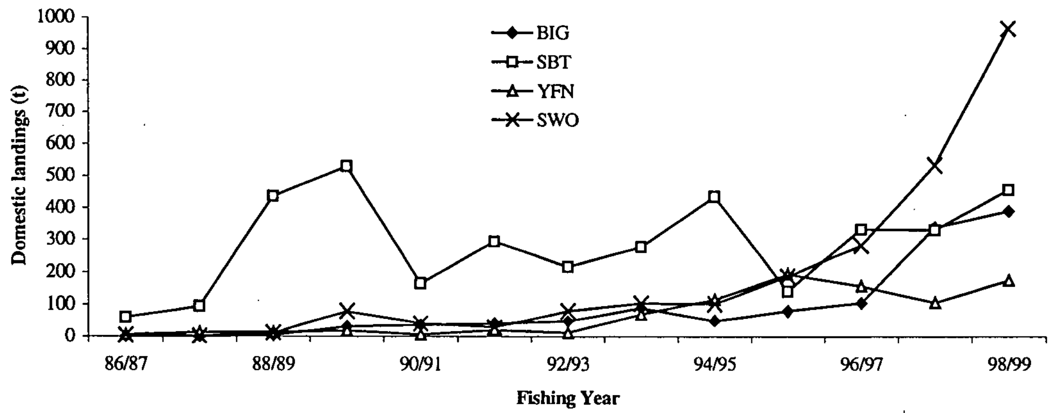
The largest annual landings in the EEZ are from the summer surface fisheries for albacore and skipjack tuna. Figure 2 indicates that skipjack landings have been more variable than landings of albacore. With the exception of the period 1991–92 to 1994–95 annual landings of skipjack have been more than 4000 t. Albacore landings have tended to increase since 1986–87. In the context of the entire Pacific stock, New Zealand skipjack landings represent a small fraction of the more than 1,100,000 t annual landings. New Zealand caught albacore represent roughly half of all surface fishery landings from the South Pacific stock in some years.

Figure 2: **Domestic landings (tonnes) of albacore and skipjack tuna by fishing year from Licensed Fish Receiver reports.**



The annual landings of species caught primarily by longline are shown in Figure 3. Between 1986–87 and 1990–91 most tuna longlining was by 3–5 Japanese vessels operating under charter, primarily targeting southern bluefin tuna, with catches of bigeye, yellowfin and swordfish mostly at the end of the season. Of particular note is the increase in the landings for these species (except yellowfin tuna) starting in 1990–91 as the domestic longline fishery expanded.

Figure 3: **Domestic landings (tonnes) of bigeye, southern bluefin and yellowfin tunas and swordfish by fishing year from Licensed Fish Receiver reports.**



While landings of southern bluefin tuna appear quite variable, the fluctuation seen in Figure 3 are exaggerated by charter vessels reporting their catch on Licensed Fish Receiver Reports LFRR) in all years except 1991–92. Similarly the low landings in 1995–96 are due to no charter vessels operating in the EEZ in that year. The four years since 1982 in which New Zealand exceeded its southern bluefin tuna catch allocation can also be seen (i.e., 1988–89, 1989–90, 1994–95 and 1998–99).

Estimates of total tuna and swordfish catches for domestic and foreign licensed vessels are summarised in Table 2 for the period 1986–87 to 1998–99. It is clear that foreign licensed catches which dominated catches in the 1980s, declined after 1991–92 for most species and ended in 1994–95 except for occasional skipjack catches by USA vessels operating under the "*US-Pacific States Treaty*". The maximum catch of each species during this period was 6524 t for albacore, 649 t for bigeye, 7820 t for skipjack, 1927 t for southern bluefin, 175 t for yellowfin, and 965 t for swordfish.

Table 2: **Domestic and foreign licensed catches (t) from the New Zealand EEZ by fishing year**

Fishing	Albacore			Bigeye			Skipjack		
Year	Domestic	Foreign	Total	Domestic	Foreign	Total	Domestic	Foreign[1]	Total
1986–87	1 265.2	668.8	1 934.0	0.1	648.7	648.9	3 762.6	0.0	3 762.6
1987–88	409.6	562.1	971.7	0.0	247.2	247.2	3 509.4	0.0	3 509.4
1988–89	4 999.8	280.4	5 280.1	4.0	176.1	180.1	5 768.8	2 051.0	7 819.8
1989–90	3 144.3	385.1	3 529.4	30.7	344.0	374.7	3 971.7	2 270.0	6 241.7
1990–91	2 451.3	404.0	2 855.3	36.0	158.9	194.9	5 371.1	192.0	5 563.1
1991–92	3 417.5	296.8	3 714.2	41.1	83.7	124.8	988.2	0.0	988.2
1992–93	3 322.7	66.8	3 389.5	48.8	3.3	52.1	945.6	0.0	945.6
1993–94	5 315.2	5.3	5 320.5	89.3	0.1	89.3	3 136.4	0.0	3 136.4
1994–95	6 194.8	1.6	6 196.4	49.8	0.0	49.8	860.5	0.0	860.5
1995–96	6 315.8	0.0	6 315.8	79.3	0.0	79.3	4 519.5	0.0	4 519.5
1996–97	3 726.2	0.0	3 726.2	104.9	0.0	104.9	6 570.8	0.0	6 570.8
1997–98	6 524.0	0.0	6 524.0	339.7	0.0	339.7	7 307.6	317.0	7 624.6
1998–99	3 727.3	0.0	3 727.3	391.2	0.0	391.2	5 261.4	728.7	5 990.1

Fishing	Southern bluefin			Yellowfin			Swordfish		
Year	Domestic	Foreign	Total	Domestic	Foreign	Total	Domestic	Foreign	Total
1986–87	59.9	1867.4	1 927.3	5.7	139.6	145.3	4.7	496.3	501.0
1987–88	94.0	1059.3	1 153.3	12.4	39.8	52.2	0.9	235.6	236.6
1988–89	437.0	760.7	1 197.8	13.8	13.8	27.6	11.4	149.9	161.3
1989–90	529.3	880.8	1 410.1	17.6	33.1	50.7	78.8	161.9	240.7
1990–91	164.6	905.6	1 070.1	6.3	16.1	22.4	40.7	184.9	225.6
1991–92	294.6	585.3	879.9	19.8	0.2	20.0	28.5	160.8	189.2
1992–93	216.4	250.8	467.1	11.8	0.0	11.8	79.0	25.6	104.6
1993–94	277.0	26.2	303.2	69.7	0.0	69.7	102.3	2.3	104.6
1994–95	435.3	37.3	472.5	114.5	0.0	114.5	101.9	0.0	101.9
1995–96	140.5	0.0	140.5	193.4	0.0	193.4	186.8	0.0	186.8
1996–97	333.5	0.0	333.5	156.7	0.0	156.7	282.8	0.0	282.8
1997–98	331.5	0.0	331.5	105.3	0.0	105.3	534.3	0.0	534.3
1998–99	457.7	0.0	457.7	174.7	0.0	174.7	965.2	0.0	965.2

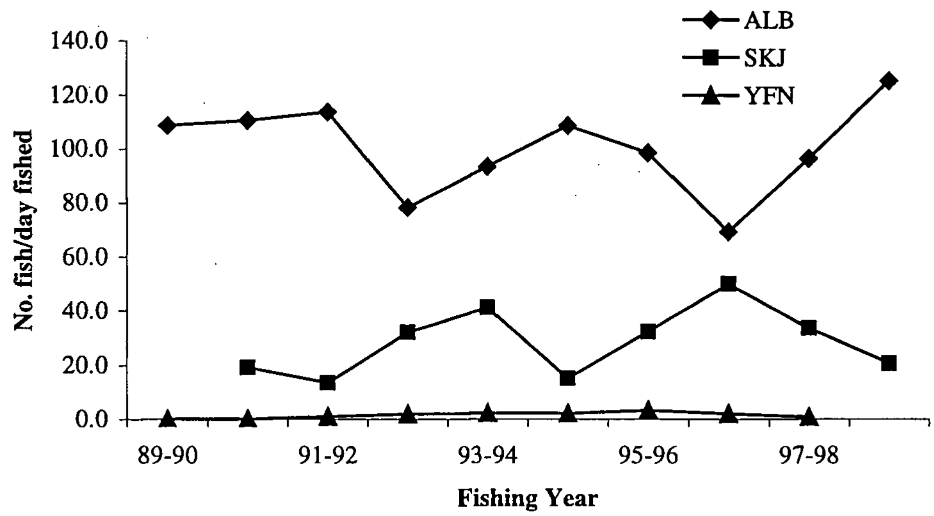
1 Estimates provided by SPC from logsheet data collected under the US–Pacific States Multilateral Treaty.

CPUE trends by gear type

Troll fishery

Most trolling in the New Zealand EEZ is for albacore (>80% of all albacore catches on average) with small but regular catches of skipjack and yellowfin tunas. Trolling is also done for southern bluefin tuna in most years but catches are usually small. Some trolling for yellowfin and skipjack tuna has been done each year since 1990–91, but catch rates are substantially lower than for albacore (Figure 4). Yellowfin CPUE is very low, typically 1–3 fish per day (mean = 2.2 fish per day) while skipjack tuna CPUE is 20–50 fish per day (mean = 33.3 fish per day). Albacore CPUE, in contrast, is typically 70–125 fish per day (mean = 97.2 fish per day) and is comparable with albacore troll CPUE elsewhere in the South Pacific (Anon 1998b). There is no evidence of trends in CPUE for any of the species targeted by trolling, although there may be a tendency for albacore CPUE to be higher when skipjack CPUE is low and vice versa. This may be a climatic effect since it is known that albacore are predominately caught in slightly colder water than skipjack tuna (Murray 1994).

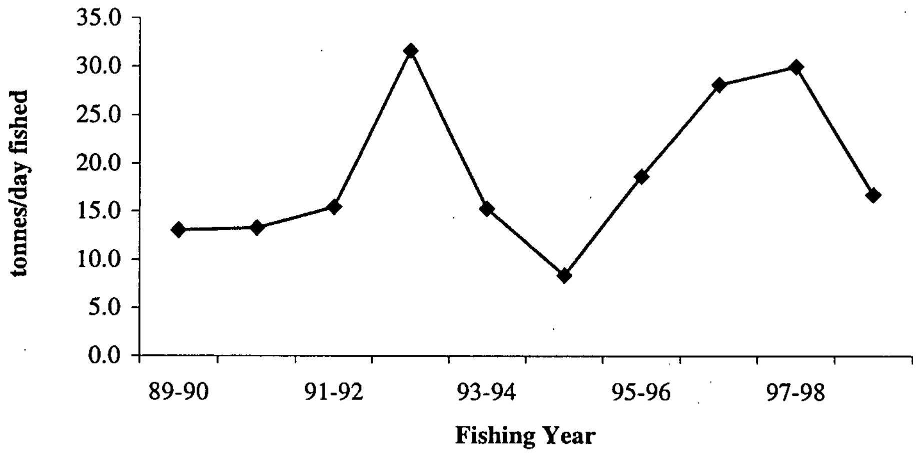
Figure 4: **Troll fishery CPUE (number caught per day fished) for domestic owned and operated tuna vessels targeting albacore, skipjack and yellowfin tunas.**



Purse seine fishery

The only tuna targeted by purse seine in the EEZ is skipjack, although occasional small catches of albacore and yellowfin tuna have been reported as bycatch (Murray, *et al.* 1999). CPUE ranged from 8–30 t per day with the highest catch rates in 1992–93 and the 1996–97 to 1997–98 fishing years (Figure 5). The low in 1994–95 for purse seine CPUE coincided with the low CPUE for skipjack caught by trolling. This low CPUE in the purse seine fishery in 1994–95 was not generally seen in purse seine fisheries elsewhere in the equatorial or sub-equatorial Pacific Ocean in that year (Anon 1998b).

Figure 5. **Purse seine fishery CPUE (tonnes per day fished) for domestic owned and operated tuna vessels targeting skipjack tuna.**



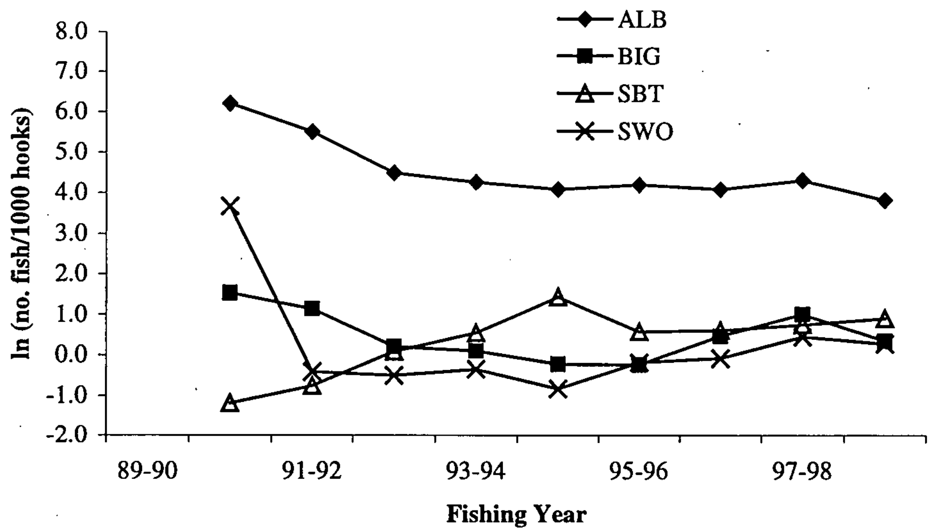
Longline fisheries

The longline CPUE in Figure 6 has been shown as the natural log of CPUE for two reasons. First albacore CPUE (number of fish per 1000 hooks) is a factor of 10 higher than any other CPUE and second, catch rates in the first few years may be uncharacteristically high since they are likely to be based on relatively few sets when fishing was good.

Albacore CPUE exhibits a log-linear decline from a peak in 1989–90 of nearly 500 fish per 1000 hooks to 46 fish per 1000 hooks in 1998–99. Similar trends in CPUE are not evident in the longline statistics of other fleets operating in the South Pacific and certainly not in the only fleet (Taiwanese distant water vessels) which regularly targets albacore (Anon 1998b). Bigeye CPUE declines from a peak of 4.6 fish per 1000 hooks in 1989–90 to 0.8 fish per 1000 hooks 1994–1996 followed by an increase to 1.4–2.7 fish per 1000 hooks in the last two years. Southern bluefin tuna CPUE increased from 0.3 to 4.2 fish per 1000 hooks from 1989–90 to 1994–95, and since 1994–95 has varied from 1.8 to 2.5.

Swordfish is not allowed to be targeted but can be retained as a bycatch species by domestic fishers. Given this prohibition, fishers do not report swordfish as a target species, although there is speculation that some targeting occurs. Ward & Elscot (2000) present CPUE data (number of fish per 1000 hooks) for two swordfish target fisheries in the Pacific Ocean. They indicate that swordfish CPUE ranges from about 12 to 16 fish per 1000 hooks for trips targeting swordfish over the period 1991–98 for the Hawaii based longline fleet while the Australian fleet operating from Brisbane caught 3–10 swordfish per 1000 hooks since 1995. For New Zealand CPUE declined from 39.2 swordfish per 1000 hooks in 1990–91 (about 60 sets fished) to a slightly increasing trend in CPUE that ranges from 0.6 to 1.6 swordfish per 1000 hooks over the period 1991–92 to 1998–99 (Figure 6). The effort since 1994–95 increased and may still be rising (from 1500 to > 4000 days fished).

Figure 6: **Longline fishery CPUE (natural log of the number caught per 1000 hooks) for domestic owned and operated tuna vessels targeting and catching albacore, bigeye and southern bluefin tunas, swordfish CPUE is for all sets regardless of target.**



While swordfish CPUE is much lower in the EEZ than that for target fisheries elsewhere (Ward & Elscot 2000) suggesting that swordfish are not usually targeted, CPUE is positively correlated with days fished in the domestic longline fishery (r = 0.67) over the period 1991–92 to 1998–99. The increasing trend in domestic longline effort and the positive correlation between effort and swordfish CPUE at least partially explains the increase in swordfish catch by domestic fishers.

Domestic catch by gear type

The domestic catch of commercial tuna species and swordfish by each gear type has been estimated from CPUE and scaled to the reported landings at Licensed Fish Receivers (Total in the following tables). Catch estimates exclude the catch by the small fleet of chartered Japanese longliners and are therefore, the first estimates of catch by gear type for New Zealand owned and operated tuna vessels. These estimates, have two sources of potential bias (i) discarded catch at sea which is not included but is considered to be negligible and (ii) bias resulting from the error grooming of CELR data for minor gear types.

The CELR data has been found to contain many errors which had to be removed before estimating CPUE, these error types are described by Murray *et al.* (1999). In the case of infrequently used fishing methods (e.g., handline and pole-and-line) Murray *et al.* (1999) reported that nearly all (> 90%) of the data for these methods failed the error checks established. The accuracy of catch estimates by these methods therefore depends on how representative the CPUE is from the few CELR forms that were filled out correctly. However, for the main tuna fishing methods (purse seine, longline, and troll) considerably more data is retained after grooming (about 80% in most years).

Albacore

Total albacore catches by domestic owned and operated vessels have ranged from 2431 t to 6440 t since 1989–90. Table 3 summarises the catch of albacore in the EEZ by domestic owned and operated vessels. Small catches are made by handline in some years (< 1% of all catches on average), mostly as bycatch in the southern bluefin tuna fishery off the West Coast of the South Island during winter months. By far the most important fishing method for albacore is trolling, which on average accounts for 83% of all catches. Albacore catches by trolling range from 2000 t to over 5000 t per year, mostly during the January–March period (Murray *et al.* 1999). The low troll catch in 1998–99 was attributed by fishers to low market demand, CPUE was actually higher in 1998–99 than in 1997–98 but the days fished were half those fished. Longline catches of albacore result from both target and non-target catches throughout most of the year. While on average the longline catches of albacore have only accounted for 17% of all catches, they have been increasing since the early 1990s coincident with the increase in domestic longline effort, especially in the bigeye target fishery.

Table 3: **Albacore catch (greenweight, t) by New Zealand owned and operated vessels by gear type and fishing year (HL = handline, LL = longline)**

Fish Year	HL	LL	Troll	Total
1989–90	0.0	42.0	3 062.0	3 104
1990–91	10.9	115.0	2 304.8	2 431
1991–92	0.0	108.9	3 308.6	3 417
1992–93	5.8	330.2	2 972.6	3 309
1993–94	0.1	606.6	4 704.5	5 311
1994–95	2.1	706.9	5 477.9	6 187
1995–96	0.0	1 165.4	5 150.4	6 316
1996–97	0.0	878.0	2 831.0	3 709
1997–98	0.0	1 945.4	4 494.9	6 440
1998–99	0.0	1 674.8	2 032.6	3 707
Average %	0	17	83	

Bigeye tuna

Bigeye tuna are caught almost exclusively by longline, primarily north of 40° S on the East Coast and north of 38° S on the West Coast of the North Island. Small catches (< 1% of all catches on average) are also reported by trolling. Prior to 1996–97 total bigeye catches were less than 100 t (Table 4) but with the increase in domestic longline effort, catches rose to 382 t in 1998–99.

Table 4: **Bigeye tuna catch (greenweight, t) by New Zealand owned and operated vessels by gear type and fishing year (LL = longline)**

Fish Year	LL	Troll	Total
1989–90	18.0	0.0	18
1990–91	27.2	0.1	27
1991–92	41.1	0.1	41
1992–93	48.8	0.0	49
1993–94	85.3	1.4	87
1994–95	49.4	0.3	50
1995–96	79.3	0.0	79
1996–97	104.6	0.1	105
1997–98	325.6	0.1	326
1998–99	381.6	0.0	382
average %	100	0	

Skipjack tuna

Total skipjack catches by domestic owned and operated vessels range from 860 t to more than 7300 t per year. Skipjack tuna are caught by handline (occasionally), longline, troll and purse seine. Of these, only troll and purse seine are substantial and the latter so dominates landings that it accounts for nearly all of the landings in any year. Purse seine catches, summarised in Table 5, have ranged from 831 t (1994–95) to 7293 t (1997–98). The decline in 1998–99 is due to a slight decrease in the number of days fished combined with a decline in catch rate (about 50% of that in 1997–98).

Table 5: **Skipjack tuna catch (greenweight, t) by New Zealand owned and operated vessels by gear type and fishing year (HL = handline, LL = longline, PS = purse seine)**

Fish Year	HL	LL	PS	Troll	Total
1989–90	0.0	0.0	3 926.3	45.4	3 972
1990–91	0.3	0.1	5 360.7	10.0	5 371
1991–92	0.0	0.0	987.0	1.2	988
1992–93	0.0	0.0	939.2	6.4	946
1993–94	0.0	0.3	3 108.0	28.1	3 136
1994–95	5.5	3.0	830.7	21.3	861
1995–96	0.0	2.8	4 492.3	24.4	4 520
1996–97	0.0	0.2	6 564.2	6.4	6 571
1997–98	0.0	2.2	7 292.9	12.5	7 308
1998–99	0.0	1.1	5 247.3	13.1	5 261
average %	0	0	100	0	

Southern and Pacific bluefin tunas

Southern bluefin tuna catches in the EEZ contain small amounts of a second species (Smith *et al.* 1994) that until recently was regarded as northern bluefin tuna. Recently this second species, now called Pacific bluefin tuna (Collette 1999), has been recognised as distinct from the northern bluefin tuna found in the Atlantic and Indian Oceans and Mediterranean Sea. This second species is not routinely identified in longline catches although some fishers have done so. Table 6 is the first attempt to estimate the catch of the two bluefin tuna species separately and is based on the species identification by fishers on logsheets and at landing. While it is clear that there are two bluefin species in domestic longline catches from the EEZ (Smith & Griggs, in press), it is likely that some Pacific bluefin have been recorded as southern bluefin tuna. The totals in Table 6 therefore probably under-estimate the catch of Pacific bluefin while over-estimating the catch of southern bluefin tuna. This inference is drawn because the species are morphologically similar and it appears that Pacific bluefin can be readily confused with southern bluefin tuna by fishers. However, because the differences that appear to be recognised by fishers are size related, the opposite (southern bluefin identified as Pacific bluefin tuna) seems unlikely.

Catches of both bluefin species are primarily by longline (67–100% of all catches on average) with small amounts of southern bluefin tuna caught in some years by handline and trolling. Since these species have not been readily identifiable until recently (Smith & Griggs, in press), catches of both species have counted against New Zealand's national allocation of southern bluefin tuna under domestic fisheries regulations. The national allocation has been 420 t since 1989. In most years less than half of the national catch limit has been caught by domestic owned and operated vessels. Years when domestic vessels caught more than 50% were 1989–90 (54%), 1994–95 (53%), 1995–96 (100%), and 1998–99 (56%).

Table 6: **Southern and Pacific bluefin tuna catch (greenweight, t) by New Zealand owned and operated vessels by gear type and fishing year (HL = handline, LL = longline)**

	Southern bluefin				Pacific bluefin	
Fish Year	HL	LL	Troll	Total	LL	Total
1989–90	233.3	0.0	54.3	288	0.0	0
1990–91	46.2	3.0	1.4	51	0.4	0
1991–92	0.0	59.8	0.0	60	0.1	0
1992–93	23.6	23.7	0.4	48	5.1	5
1993–94	0.0	42.6	0.3	43	1.7	2
1994–95	0.0	223.4	5.5	229	1.8	2
1995–96	0.0	140.3	0.2	140	4.0	4
1996–97	0.0	95.3	0.0	95	12.0	12
1997–98	0.0	50.9	79.4	130	18.0	18
1998–99	0.0	254.4	0.0	254	17.3	17
average %	23	67	11		100	

Yellowfin tuna

Yellowfin tuna are caught primarily north of 40° S by longline (93% of all catches on average) with lesser amounts by trolling (5%), handline (1%) and purse seine (1%). Catches have increased since 1993–94 to 105–193 t per year (Table 7). These relatively low catches are due to this species only being available seasonally and primarily in northern waters as bycatch in the bigeye target fishery. Increased catches over the last five years are most likely to be related to increased fishing effort by domestic vessels in this fishery.

Table 7: **Yellowfin tuna catch (greenweight, t) by New Zealand owned and operated vessels by gear type and fishing year (HL = handline, LL = longline, PS = purse seine).**

Fish Year	HL	LL	PS	Troll	Total
1989–90	0.2	16.4	0.2	0.9	18
1990–91	0.1	6.2	0.0	0.0	6
1991–92	0.0	16.7	0.0	3.1	20
1992–93	1.3	6.1	0.0	4.3	12
1993–94	4.5	58.9	0.0	6.3	70
1994–95	2.0	105.1	0.0	6.9	114
1995–96	0.0	169.1	11.0	13.2	193
1996–97	0.0	151.8	0.0	4.9	157
1997–98	0.0	103.3	0.0	1.8	105
1998–99	0.0	174.6	0.0	0.1	175
average %	1	93	1	5	

Swordfish

Estimates of swordfish catches by domestic owned and operated longline vessels are given in Table 8. Swordfish catches have risen dramatically since 1993–94 due, in part, to increased longline effort, the only tuna fishing method regularly catching swordfish. As we noted in discussing swordfish CPUE there appears to be a positive linear relationship between longline effort and swordfish CPUE (r = 0.67). It is difficult to determine why this might be the case.

Table 8: **Swordfish catch (greenweight, t) by New Zealand owned and operated vessels by gear type and fishing year (LL = longline)**

Fish Year	LL	Total
1989–90	56.2	56
1990–91	31.9	32
1991–92	28.5	28
1992–93	71.5	72
1993–94	100.3	100
1994–95	100.0	100
1995–96	186.8	187
1996–97	257.8	258
1997–98	510.0	510
1998–99	937.2	937
average %	100	

Status of stocks

The New Zealand EEZ represents a small part of the geographic distribution of the highly migratory fish stocks found there. Although catches from the EEZ generally represent a small proportion of the total catches from these stocks, they can be significant when considering issues of sustainability. The following paragraphs seek to place New Zealand catches in perspective to catches from the stock and review what is currently known of stock status. Information on the status of stocks is drawn primarily from Hampton *et al.* (1999) who summarises the work of the SPC Standing Committee on Tuna and Billfish and Anon (1999a) summarising information from the eastern Pacific Ocean.

Albacore are part of a single South Pacific Ocean stock found from about 5°–50° S from the Australian coast eastwards to South America. Total catches, mostly by longline, have generally been 30 000–40 000 t per year since 1960. During the 1990s catches by longline have been 23 000–30 000 t while those by trolling have been 4000–8000 t. Recent catches by longline in the stock have increased over the years probably as a result of increased longline fishing by South Pacific States, including New Zealand (currently < 2000 t per year by longline). Troll catches of juvenile albacore are primarily by USA and New Zealand fleets. Of these the New Zealand fleet is probably of greater significance (currently 2000–5000 t per year) and given a higher economic return, more likely to expand. Analysis of CPUE and preliminary size-structured stock assessment model results indicate a declining biomass from the mid-1970s to early 1990s that is postulated to be recruitment/climate driven. Nominal CPUE from the EEZ show no clear trend for the troll fishery but a marked decline in longline CPUE from 1990–91. Increased exploitation rates during the late 1980s and early 1990s that coincided with the rapid expansion of driftnet fishing declined to moderate rates following the prohibition of this fishing method in the Pacific Ocean. While model results should be regarded as preliminary, current catches are regarded as sustainable.

Bigeye tuna are considered to form a single stock in the Pacific Ocean that is found from about 45° S to 45° N latitude. Catches are primarily by longline although there have been very large increases in the bycatch of small bigeye tuna by purse seine sets on floating objects (FADs) in both the eastern and western tropical Pacific Ocean that have raised concern over stock status. Total catches during the 1990s have been 150 000–190 000 t per year, about 80% of which has been caught by Japanese longliners. Since the mid-1990s purse seine catches of juveniles have increased in the eastern tropical Pacific Ocean to over 30 000 t per year (maximum in 1996 of 52 000 t), and in the western tropical Pacific Ocean to nearly the same level (about 20 000–30 000 t per year). Catches in the EEZ, while steadily increasing, are small in comparison. New Zealand catches are predominantly by longline (usually < 1 t per year by trolling). Bigeye catches in the EEZ have increased over the past four years from < 100 t to 382 t per year in 1998–99. Standardised CPUE analysis of bigeye indicate a declining trend since the 1970s for the western Pacific and since 1990 for the eastern Pacific. Nominal CPUE in the EEZ show a slight decline since the start of domestic longlining in 1991–92. Concern over stock status has arisen because this species is relatively slow growing, longline CPUE appears to have been declining and juveniles may be subject to moderate to high exploitation rates. No stock assessment modelling has yet been done for this stock and stock status is uncertain but of possible concern.

Skipjack tuna are a widely distributed (40° S–50° N), fast growing species comprising a single Pacific Ocean stock. Catches are by a range of surface gears with purse seine accounting for most catches. In the western Pacific Ocean annual catches have been greater than 1 000 000 t since 1991 and are likely to continue to increase as regulations on FAD setting in the eastern tropical Pacific Ocean constrain effort. Skipjack catches in the eastern Pacific are smaller (typically 60 000 – 160 000 t since 1980) than in the western Pacific. New Zealand catches of skipjack are small in comparison with catches ranging from < 1000 t to over 7300 t. There appears to be no clear trend in standardised or nominal CPUE for several important fisheries in the western Pacific Ocean. Similarly for the New Zealand purse seine fishery there appears to be no trend in CPUE since 1989–90. Skipjack CPUE and size data together with tag analyses from the early 1990s suggest that current fishing is sustainable.

Southern bluefin tuna comprise a single stock occurring primarily from 30°–55° S in the South Atlantic, Indian and south-west Pacific Oceans. Catches are regulated by the CCSBT through catch allocations to members (Australia – 5265 t, Japan – 6065 t, and New Zealand – 420 t), although non-Parties to this convention account for several thousand tonnes (Korea – 2000 t, Indonesia – 2000 t and Taiwan – 1450 t). Total catches from the stock are now likely to regularly exceed 17 000 t per year. Interpreting results of the most recent stock assessment (Anon 1998a) scientists agree that "the continued low abundance of the SBT parental biomass is cause for serious concern" and "parental biomass in 1997 remains at historically low levels". They further agreed that the "recent increase in the fishing mortality rates on juvenile fish (age 5 and younger) will lead to lower recruitment from these cohorts to the parental biomass". While scientists agree on current stock status, there are a range of views as to the likelihood of the recovery of the parental biomass under current catch restrictions. The differences arise as to which of several alternative assumptions about population growth are most reasonable and what the parental stock size will be in 2020 if fishing effort stays the same. Regardless of what happens in future, current stock status is clearly cause for concern. The degree of concern over the stock is reflected in the work of Matsuda *et al.* (1998) in modelling extinction probability concluded that: "the southern bluefin tuna population will be below 500 mature individuals within the next 100 years". The World Conservation Union listed southern bluefin tuna s critically endangered in 1996 (Matsuda *et al.* 1998).

Pacific (or northern) bluefin tuna also occur in the EEZ and are caught in relatively small quantities (< 20 t per year). These fish are part of a single stock distributed primarily in the North Pacific Ocean (0°–50° N) with most caught off Japan in the west and off California. Occurrences as far south as 45° S off Australia and 35° S off Chile are also reported. Total catches from the stock appear to be on the order of 10 000–20 000 t per year (about 10 000 t in the north-west Pacific (Bayliff 1994) and up to 8300 t in the eastern Pacific in recent years (Anon 1999a). Stock status is unknown.

Yellowfin tuna in the EEZ are part of a central and western Pacific Ocean stock that is separate from the yellowfin tuna stock in the eastern Pacific Ocean. Total catches from the central and western Pacific stock have risen in recent years to over 400 000 t, mostly by purse seine in equatorial waters. Catches of yellowfin tuna in the EEZ are small, < 200 t per year, and are primarily by longline (93% on average) with trolling about 5% of catches on average. Analyses of CPUE and preliminary length-based modelling show no evidence of current fishing levels having an impact on the stock and therefore current fishing is regarded as sustainable.

Swordfish stock structure is uncertain but has generally been considered to comprise a single stock in the Pacific Ocean. This view has recently been contested by Reeb *et al.* (2000) who suggest genetic structuring between the North and South Pacific Oceans based on the analysis of a large number of swordfish from several locations around the Pacific basin. This analysis, however, was only able to detect a significant difference between Australian and Japanese samples and not elsewhere within the basin (after applying the Bonferroni correction for multiple samples). Unfortunately the Australian sample appears to have pooled fish from the west and east coasts of Australia (footnote to their Table 1) and hence may reflect a difference between, rather than within ocean basins. At present while there appears to be greater genetic variability than formerly thought, there is little evidence supporting the view advanced by Reeb *et al.* (2000). Catches in the Pacific Ocean averaged about 30 000 t per year in the late 1980s and 1990s (Anon 1999b). Catches are primarily by longline (both as a target species and as bycatch), with significant Japanese and USA harpoon and driftnet fisheries targeting swordfish. Coincident with the recent increase of tuna longlining by domestic fishers in New Zealand there has been a dramatic increase in catch of swordfish. While targeting of swordfish is not permitted, incidental catches can be landed and these have nearly doubled in each of the past three years to nearly 1000 t. Despite the high catches, CPUE is an order of magnitude lower than in longline fisheries targeting swordfish in Hawaii and Australia. Increasing catches of swordfish in New Zealand and Australia, the potential for local depletion (Ward & Elscot 2000), and the scarcity of information on which to base a stock assessment all contribute to the concern over swordfish in the western South Pacific. Despite these concerns Ward & Elscot (2000) state in their global review of swordfish fisheries that " there is no clear evidence of swordfish stocks or their fisheries collapsing from over-fishing" and note "the apparent resilience of swordfish stocks to intensive harvesting". Recent attempts to assess stock status (Anon 1999b) were inconclusive. However, given increasing catches of swordfish in the south-west Pacific Ocean, the apparent potential for local depletion and the limited information on this species, concern over the status of the stock is likely to remain. Stock status is uncertain.

Summary

The New Zealand tuna industry now lands tuna year round with peak summer activity by a large troll fleet (usually over 200 vessels) targeting albacore, a small purse seine fleet (six vessels) targeting skipjack, and longliners (about 80 vessels) targeting southern bluefin in winter and bigeye throughout the year. The value of this industry exceeds $20 million per year with potential to expand further.

New Zealand tuna fishing began in 1968 when the F/V *Sea Bee* began landing large catches of albacore into North Island ports (Slack 1972). This interest expanded following the successful purse seine surveys in 1974 and 1975 by the F/V *Paramount* targeting skipjack (Eggleston 1976). Interest in other tunas followed with commercial catches of southern bluefin tuna off the West Coast of the South Island in 1980 by handline (Paul 2000). In more recent years (since 1991–92), tuna fishing has expanded into a year round industry due in large part to the development of longline fisheries for southern bluefin and bigeye tunas. The expansion of domestic capacity occurred as foreign licensed interest in fishing the EEZ declined during the 1980s and 1990s. The foreign fleets that dominated the New Zealand area tuna catches from the 1960s have not fished in the EEZ since 1994–95 with the exception of occasional purse seine sets by USA vessels.

Annual domestic tuna landings are now expected to be on the order of 3700–6500 t for albacore, 100–400 t for bigeye, 1000–7500 t for skipjack, 420 t (±) for southern bluefin, and 100–200 t for yellowfin tuna. Swordfish catch, regarded as an incidental longline catch, has nearly doubled in each of the past five years and may continue to increase, the catch is now nearing 1000 t.

Most increases in catch can be attributed to the trend in increasing longline fishing effort which began in 1991–92. In 1998–99 albacore and skipjack catches declined, probably due to low market demand. In both instances effort in 1998–99 was significantly lower than the previous year, despite albacore CPUE being the highest in the past nine years, there is no trend in skipjack CPUE. Longline CPUE trends differ for each species from a slight declining trend since 1990–91 for albacore, to no appreciable trend for bigeye over the same period. Southern bluefin tuna CPUE increased during the first 2–3 years of domestic longlining but has been stable since 1992–93. Swordfish CPUE appeared to decline from 1991–92 (few sets) but showed a slight increasing trend since 1994–95.

The apparent relationship between swordfish CPUE and total longline effort suggests that there may be some targeting of swordfish.

Catches of tunas and swordfish by domestic owned and operated vessels is estimated by gear type from an analysis of CPUE converted to weight and scaled to landings data. This includes estimates of Pacific bluefin tuna catches (formerly known as northern bluefin tuna). Because of difficulty in clearly separating bluefin tuna species in catch and landings statistics the estimates provided are likely to under-estimate Pacific bluefin catches and over-estimate southern bluefin catches. Because the frequency of misidentification is unknown, the extent of this problem is also unknown at present.

The tunas and swordfish caught within the EEZ are part of broadly distributed stocks that are subject to fishing by many fleets and gear types at different stages of their lives. A review of available information indicates that stocks of South Pacific albacore, skipjack and yellowfin tunas are probably sustainable at current fishing levels. The status of stocks of bigeye and northern (Pacific) bluefin tuna and swordfish are uncertain. Of these recent concern has been raised about incidental mortality rates on juvenile bigeye tuna in the purse seine fishery in the eastern and western tropical Pacific Ocean. The southern bluefin tuna stock continues to be of concern and can be regarded as over-fished. It is unclear whether current fishing levels will achieve the management target of recovery of the parental stock to 1980 levels by 2020.

Acknowledgements

This report is based on work done under Ministry of Fisheries projects TUN98(01), TUN1999(01) and TUN1999(02), the support of the Ministry of Fisheries and the tuna fishing industry is gratefully acknowledged.

References

Anon. (1998a). *Report of the scientific committee, 1998.* 3–6 August 1998, Tokyo, Japan.

Anon. (1998b). Tuna fishery yearbook 1997. vi + 132 pp, Secretariat of the Pacific Community, Noumea, New Caledonia.

Anon. (1999a). Annual report of the Inter-American Tropical Tuna Commission, 1997. Inter-American Tropical Tuna Commission, San Diego, California.

Anon. (1999b). Report of the swordfish working group meeting, 15–16 January 1999. The 2nd Meeting of the Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean. 15–23 January 1999, Honolulu, Hawaii.

Bayliff, W. (1994). A review of the biology and fisheries for northern bluefin tuna, *Thunnus thynnus*, in the Pacific Ocean. FAO Fish. Tech. Paper 336/2: 244–295.

Collette, B.B. (1999). Mackerels, molecules, and morphology. Proc. 5th Indo–Pacific Fish Conference. In: B. Seret & J.-Y. Sire (eds). Soc. Fr. Ichtyol., 1999: 149–164.

Collette, B.B.; Nauen, C.E. (1983). FAO species catalogue, Volume 2 Scombrids of the world. FAO Fish. Synop. 125, vol. 2, vii + 137 pp.

Eggleston, D. (1976). The Paramount project: a purse seine survey of New Zealand's skipjack resource. Fish. Res. Div. Occ. Pub. 11: 31–35.

Francis, M.P.; Griggs, L.H.; Baird, S.J.; Murray, T.E.; Dean, H.A. (1999). Fish bycatch in New Zealand tuna longline fisheries. NIWA Tech. Rept. 55. 70 pp.

Francis, M.P.; Griggs, L.H.; Baird, S.J.; Murray, T.E.; Dean, H.A. (2000). Fish bycatch in New Zealand tuna longline fisheries, 1988–89 to 1997–98. NIWA Tech. Rept. 76. 79 pp.

Griggs, L.; Murray, T. (2000). Determination of size composition, sex ratio and length:weight relationships of albacore tuna during the 1998–99 fishing year from samples collected in fish sheds. Final Res. Rept. for Ministry of Fisheries research project TUN9801. 7 pp.

Habib, G.; Clement, I.T.; Bailey, K.N.; Carey, C.L.; Swanson, P.M.; Voss, G.J. (1982). Incidental fish species taken in the purse-seine skipjack fishery, 1975–81. Fisheries Research Division Occ. Pub.: Data Ser. No. 5. 49 pp.

Labelle, M.; Murray, T. (1992). South Pacific albacore observer programme summary report, 1988–1991. SPC Tuna and Billfish Assessment Programme Tech. Rept. 26, vii + 23 pp, Noumea.

Matsuda, H.; Takenaka, Y.; Yahara, T.; Uozumi, Y. (1998). Extinction risk assessment of declining wild populations: the case of southern bluefin tuna. Res. in Pop. Ecol. 40: 271–278.

Murray, T. (1994). A review of the biology and fisheries for albacore, *Thunnus alalunga*, in the South Pacific Ocean. FAO Fish. Tech. Paper 336/2:188–206.

Murray, T.; Richardson, K.; Dean, H.; Griggs, L. (1999). New Zealand tuna fisheries with reference to stock status and swordfish bycatch. Unnumbered Client Report published by NIWA and the Ministry of Fisheries. 126 pp.

Nakamura, I. (1985). FAO species catalogue, Volume 2 Billfishes of the world. FAO Fish. Synop. 125, vol. 5, iv + 65 pp.

Paul, L. (2000). New Zealand fishes, identification, natural history & fisheries. viii + 253 pp. Reed Books, Auckland.

Reeb, C.A.; Arcangeli, L.; Block, B.A. (2000). Structure and migration corridors in Pacific populations of the swordfish, *Xiphias gladius*, as inferred through analysis of Mitochondrial DNA. SPC Standing Committee on Tuan and Billfish SCTB-13 Working Paper BBRG-13. 29 pp.

Slack, E.B. (1972). The albacore (*Thunnus alalunga* (Bonaterre)) fishery in New Zealand, commercial catches at New Plymouth 1970. NZ Mar. Dept. Fish. Tech. Rept. 80: 1–23.

Smith, P.J.; Conroy, A.M.; Taylor, P.R. (1994). Biochemical-genetic identification of northern bluefin tuna Thunnus thynnus in the New Zealand fishery. NZ J. Mar. & Freshw. Res. 28: 113–118.

Smith, P.; Griggs, L.. (in press). Identification of northern bluefin tuna in the New Zealand EEZ. NIWA Final Res. Rept. For MFish Res. Proj. MOF2000/02B Objective 1.

Ward, P.; Elscot, S. (2000). Broadbill swordfish, status of world fisheries. xiv + 208 pp. Unnumbered report by the Bureau of Rural Sciences, Canberra, Australia.

Appendix 1: Species names and codes used in this report.

Common name	Scientific name	Code
Albacore	*Thunnus alalunga* (Bonnaterre, 1788)	ALB
Bigeye tuna	*Thunnus obesus* (Lowe, 1839)	BIG
Northern bluefin tuna	*Thunnus orientalis* (Temminck & Schlegel, 1844)	NTU
Skipjack	*Katsuwonus pelamis* (Linnaeus, 1758)	SKJ
Southern bluefin tuna	*Thunnus mccoyii* (Castlenau, 1872)	STN
Yellowfin tuna	*Thunnus albacares* (Bonnaterre, 1788)	YFN
Swordfish	*Xiphias gladius* (Linnaeus, 1758)	SWO
Other target species		OTH

Appendix 2: Summary of groomed purse seine (PS) and troll fishery catch and effort data from New Zealand tuna vessels by target and fishing year.

Gear	Target	Fish Yr	No. days	No. sets	SKJ (t)	YFN (t)
PS	SKJ	1989–90	69	99	901.8	0
PS	SKJ	1990–91	81	119	1 075.0	0
PS	SKJ	1991–92	40	61	617.0	0
PS	SKJ	1992–93	16	25	505.5	0
PS	SKJ	1993–94	71	109	1 083.0	0
PS	SKJ	1994–95	30	51	252.0	0
PS	SKJ	1995–96	92	161	1 714.2	3.3
PS	SKJ	1996–97	82	135	2 303.1	0
PS	SKJ	1997–98	96	174	2 876.5	0
PS	SKJ	1998–99	88	159	1 470.0	0

Gear	Target	Fish Yr	No. days	Hook hr	No ALB	No BIG	No SKJ	No SBT	No YFN
Troll	ALB	1989–90	195	27 646	21 193	0	195	0	0
Troll	ALB	1990–91	2 796	413 594	308 937	1	815	0	3
Troll	ALB	1991–92	3 602	542 929	409 255	1	177	0	6
Troll	ALB	1992–93	4 717	711 207	368 502	0	1 287	0	29
Troll	ALB	1993–94	6 651	1 029 348	622 193	14	4 309	3	385
Troll	ALB	1994–95	5 850	874 075	634 695	4	2 734	48	515
Troll	ALB	1995–96	4 590	705 882	451 672	0	3 863	1	1 228
Troll	ALB	1996–97	3 890	613 545	268 884	2	1 426	0	463
Troll	ALB	1997–98	4 014	607 590	387 212	1	3 645	0	148
Troll	ALB	1998–99	2 009	309 390	251 346	0	3 151	0	9
Troll	SKJ	1988–89	4	100	30	0	110	0	0
Troll	SKJ	1989–90	3	340	0	0	810	0	0
Troll	SKJ	1990–91	17	620	15	0	327	0	1
Troll	SKJ	1991–92	2	239	9	0	27	0	0
Troll	SKJ	1992–93	5	238	62	0	160	0	0
Troll	SKJ	1993–94	61	4 026	73	0	2 509	0	7
Troll	SKJ	1994–95	43	3 848	142	0	650	0	18
Troll	SKJ	1995–96	34	2 254	83	0	1 098	0	5
Troll	SKJ	1996–97	1	45	0	0	50	0	0
Troll	SKJ	1997–98	8	333	2	0	268	0	0
Troll	SKJ	1998–99	9	880	32	0	186	0	0
Troll	SBT	1989–90	16	868	0	0	0	1 927	0
Troll	SBT	1990–91	9	632	0	0	0	1	0
Troll	SBT	1992–93	26	1 051	0	0	0	1	0
Troll	SBT	1994–95	4	170	0	0	0	3	0
Troll	SBT	1997–98	13	590	0	0	0	435	0
Troll	YFN	1989–90	2	220	0	0	0	0	0
Troll	YFN	1990–91	4	256	3	0	4	0	0
Troll	YFN	1991–92	21	1 016	50	0	2	0	18
Troll	YFN	1992–93	53	2 881	55	0	0	0	97
Troll	YFN	1993–94	95	4 975	555	0	796	0	211
Troll	YFN	1994–95	117	8 205	611	0	238	0	247
Troll	YFN	1995–96	58	3 884	287	0	276	0	191
Troll	YFN	1996–97	25	1 972	33	0	10	0	50
Troll	YFN	1997–98	4	366	0	0	0	0	3

Appendix 3: Summary of groomed longline fishery catch (number of fish) and effort data from New Zealand tuna vessels by target and fishing year.

Target	Fish Yr	No. days	No hooks	ALB	BIG	NTU	SKJ	STN	YFN	SWO
ALB	1990–91	13	3 140	1 551	0	0	0	0	0	0
ALB	1991–92	4	1 200	296	0	0	0	0	0	0
ALB	1992–93	20	13 910	1 237	5	1	0	2	0	4
ALB	1993–94	101	57 145	4 044	13	0	0	12	56	16
ALB	1994–95	253	159 590	9 496	45	0	60	18	137	52
ALB	1995–96	215	158 874	10 608	69	3	54	30	286	111
ALB	1996–97	145	112 135	6 695	79	6	3	36	100	124
ALB	1997–98	459	383 046	28 577	799	42	98	184	199	789
ALB	1998–99	373	355 970	16 359	479	20	20	206	153	729
BIG	1990–91	39	23 400	1 183	108	0	1	4	131	1 297
BIG	1991–92	397	281 208	5 282	871	6	0	18	70	190
BIG	1992–93	754	636 171	21 061	782	22	0	84	66	448
BIG	1993–94	1 102	941 166	37 531	1 039	23	36	43	1 013	850
BIG	1994–95	1 246	1 047 708	28 946	835	7	207	34	2 165	716
BIG	1995–96	1 337	1 134 804	41 865	887	25	325	74	3 665	1 194
BIG	1996–97	1 265	1 052 317	38 533	1 669	43	35	147	3 123	1 218
BIG	1997–98	2 142	1 913 645	89 687	5 238	96	336	429	1 947	3 112
BIG	1998–99	3 440	3 419 336	105 123	4 822	107	126	909	2 510	4 447
NTU	1993–94	4	2 450	20	0	0	0	0	0	1
NTU	1994–95	7	4 000	133	1	0	0	0	1	0
NTU	1995–96	5	4 000	503	3	3	2	0	2	5
NTU	1996–97	7	6 950	456	4	5	5	3	14	5
NTU	1997–98	11	11 800	936	0	3	0	2	0	34
NTU	1998–99	15	16 050	560	1	8	0	2	0	59
STN	1989–90	6	2 250	240	0	0	0	0	0	0
STN	1990–91	7	6 560	24	0	0	0	2	0	0
STN	1991–92	17	12 780	209	5	1	0	6	0	5
STN	1992–93	133	163 552	3 322	25	9	0	178	0	41
STN	1993–94	345	309 925	6 683	83	2	11	534	93	59
STN	1994–95	807	778 905	11 244	22	2	9	3 272	66	98
STN	1995–96	543	572 333	13 881	43	13	19	1 015	31	241
STN	1996–97	252	381 782	5 935	70	10	0	700	34	75
STN	1997–98	275	482 712	10 269	186	21	20	1 020	7	438
STN	1998–99	476	737 290	12 576	373	36	1	1 830	44	720
OTH	1989–90	1	400	0	0	0	0	0	0	0
OTH	1990–91	8	3 860	0	0	0	0	0	10	0
OTH	1991–92	10	4 250	8	7	0	0	4	1	1
OTH	1992–93	24	12 200	521	1	0	0	4	10	3
OTH	1993–94	13	9 920	961	1	1	0	0	7	6
OTH	1994–95	57	30 960	875	9	0	0	12	140	4
OTH	1995–96	72	55 765	2901	12	0	112	19	351	31
OTH	1996–97	146	104 705	3276	109	0	13	5	338	354
OTH	1997–98	48	39 440	2776	83	1	38	11	27	42
OTH	1998–99	174	179 814	1 839	131	2	0	20	293	276

Appendix 4: Number of New Zealand tuna vessels (including chartered vessels) by target species, fishing year and method (HL = handline, P&L = pole-and-line, PS = purse seine, LL = longline and T = troll).

Target	Fish. Yr.	HL	P & L	PS	LL	T	Total
Albacore	1989–90	3	3	0	4	212	215
	1990–91	6	3	0	5	230	237
	1991–92	2	1	0	6	255	259
	1992–93	4	7	0	9	393	402
	1993–94	1	11	0	15	473	485
	1994–95	2	9	0	31	452	468
	1995–96	0	6	0	23	410	422
	1996–97	1	1	0	20	299	313
	1997–98	1	1	0	29	300	328
	1998–99	0	1	0	25	180	203
Bigeye	1989–90	0	0	0	9	0	9
	1990–91	0	0	0	11	0	11
	1991–92	0	0	0	15	0	15
	1992–93	0	0	0	22	1	23
	1993–94	0	0	0	33	0	33
	1994–95	0	0	0	50	1	51
	1995–96	0	0	0	49	0	49
	1996–97	0	0	0	42	2	43
	1997–98	0	0	0	56	3	57
	1998–99	0	0	0	77	1	78
Skipjack	1989–90	0	0	5	2	10	17
	1990–91	0	0	5	0	18	23
	1991–92	0	0	7	0	9	16
	1992–93	0	2	5	0	19	25
	1993–94	0	3	7	0	35	44
	1994–95	1	11	5	0	32	43
	1995–96	0	5	6	1	44	53
	1996–97	0	2	7	0	8	15
	1997–98	0	1	6	1	13	19
	1998–99	0	3	6	0	10	18
Southern bluefin	1989–90	29	0	0	12	17	46
	1990–91	15	0	0	8	9	24
	1991–92	16	0	0	9	6	26
	1992–93	12	0	0	20	6	32
	1993–94	10	0	0	28	5	39
	1994–95	14	0	0	51	7	67
	1995–96	5	0	0	38	4	41
	1996–97	3	0	0	22	7	30
	1997–98	3	0	0	24	10	34
	1998–99	3	0	0	36	4	38
Yellowfin	1989–90	1	0	0	2	5	6
	1990–91	2	0	0	3	9	12
	1991–92	1	0	0	4	19	24
	1992–93	1	0	0	5	32	35
	1993–94	2	0	0	1	29	31
	1994–95	5	3	0	13	34	47
	1995–96	2	1	0	16	36	52
	1996–97	0	1	0	6	20	26
	1997–98	0	0	0	2	5	7
	1998–99	0	0	0	19	3	22