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M. P. Francis
L. H. Griggs
S. J. Baird

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M. P. Francis
L. H. Griggs
S. J. Baird

NIWA
Private Bag 14901
Wellington

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EXECUTIVE SUMMARY

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We used scientific observer data to determine which fish species were caught on tuna longlines, and to estimate the catch per unit effort (CPUE) and the number of fish caught by observed foreign and charter vessels in 1998–99 and 1999–2000. These catch estimates were scaled up to provide estimates for the foreign and charter longline fleet. Observer coverage of the domestic fleet was too low to allow comparable scaling for that sector. For the main non-target species, we used observer data to estimate the proportion of fish that were alive on recovery, and the proportion that were discarded or lost since 1992–93. The size, sex, maturity composition, and catch weight of blue, porbeagle, and mako sharks and Ray's bream were also estimated.

The number of hooks set by tuna longline vessels in the New Zealand Exclusive Economic Zone (EEZ) declined from a maximum of 24–27 million hooks per year (mean 25.3 million) in 1979–82 to 2–4 million hooks in 1993–98 (mean 3.2 million). This decline of 87% in fishing effort resulted from a reduction in licensed foreign vessels fishing in New Zealand. Since then, the number of hooks has increased rapidly, reaching 6.7 million hooks in 1998–99 and 8.1 million hooks in 1999–2000. The effort of chartered foreign vessels has remained steady, and the increase is a result of domestic effort expansion. Overall observer coverage has been low, with only 8.2% of hooks being observed. Recent coverage has been high for chartered foreign vessels (72.9% and 59.2% for 1998–99 and 1999–2000 respectively), but very low for domestic vessels (0.7% and 0.6% respectively). Observer coverage of domestic vessels was considered too low in 1998–99 and 1999–2000 to be representative of the catch.

Between 1988–89 and 1999–2000, 254 511 fish and invertebrates from at least 72 species were observed. Most species were rarely observed, with only 31 species or species groups exceeding 100 observations. Only 267 striped marlin were observed, 43 of them in 1998–99 and 14 in 1999–2000. Other marlin species were rare (48 shortbill spearfish and 6 blue marlin). The most commonly observed species over all years were blue shark, albacore tuna, and Ray's bream. The next most important non-target species were porbeagle and mako sharks, followed by smaller numbers of dealfish, moonfish, oilfish, deepwater dogfish, swordfish, lancetfish, butterfly tuna, rudderfish, school shark, and escolar.

For most species, there were large differences in CPUE between the domestic and foreign and charter fleets, and between northern and southern New Zealand. Differences were also observed between the east and west coasts of the South Island, and we recommend that the south region be subdivided into east and west strata in future. We also recommend that the southern boundary of north region be moved south to 40° S on the west coast North Island.

During the last 2–3 years reported catches reached their highest levels (since the fishery began) for porbeagle shark, mako shark, albacore, broadbill swordfish, bigeye tuna, Ray's bream, dealfish, oilfish, moonfish, and rudderfish. Much of this increase is attributable to the increases in domestic effort, but better reporting of shark species may also be a factor. For commercially important species (mako shark, school shark, albacore, southern bluefin tuna, broadbill swordfish, bigeye tuna, yellowfin tuna, and moonfish), the Tuna Longlining Catch Effort Return (TLCER) data provide the best indication of catches in 1998–2000. For non-commercial species that occur mainly in south region (deepwater dogfish, dealfish), observer-based estimates are probably reasonable. For other non-commercial or low value species (blue shark, porbeagle shark, butterfly tuna, Ray's bream, oilfish, lancetfish, rudderfish), neither the estimates nor the reported catches are considered reliable. The numbers of striped marlin reported on TLCERs were 1651 in 1998–99 and 806 in 1999–2000.

Length-frequency data combined with length at maturity information indicated that 94–98% of female blue, porbeagle, and mako sharks were immature. Most male sharks were also immature, with significant proportions of mature males found only for blue, porbeagle, and mako sharks in northern New Zealand (29, 27, and 32% respectively) and mako sharks in southern New Zealand (76%).

Most blue shark, mako shark, deepwater dogfish, school shark, Ray's bream, oilfish, moonfish, and rudderfish were alive when recovered. Most dealfish were dead, and about half of the porbeagle sharks and lancetfish, and one-third of the butterfly tuna, were alive when recovered. Since 1992–93, 72% of 249 observed striped marlin have been alive. Most blue, porbeagle, mako and school sharks, and moonfish and butterfly tuna were processed in some way. Most deepwater dogfish, dealfish, and lancetfish were discarded or lost. Most of the blue and porbeagle sharks that were processed were finned only, and the rest of the carcass was discarded, whereas school sharks were mainly processed for their flesh. Mako sharks were mainly processed for their flesh by foreign and charter vessels, but mainly finned by domestic vessels.

Considering the dramatic decline in fishing effort around New Zealand during the last 20 years, the low New Zealand shark catches compared with those elsewhere in the Pacific Ocean, and the stock and productivity characteristics of the species, it is unlikely that New Zealand's tuna longline fishery is seriously affecting the stocks of blue, porbeagle, and mako sharks. However, an adequate stock assessment is not feasible using currently available data. Catches of oceanic sharks throughout the Pacific are poorly known, so accurate monitoring of levels of fishing mortality throughout the stock ranges is an important first step towards ensuring sustainability of their populations.

The effect of the recent rapid increase in domestic fishing effort on bycatch should be monitored closely. Recent observer coverage of the large domestic fleet, which accounted for 77% and 86% of fishing effort in 1998–99 and 1999–2000 respectively, has been inadequate for this purpose. We strongly recommend that the observer coverage of the domestic fleet be increased in future, and that efforts are made to ensure that the spatial and temporal extent of that coverage is representative of the fishery and therefore the catch.

1. INTRODUCTION

The Ministry of Fisheries is responsible for determining the impacts of fishing on associated or dependent species, including non-target fish species, taken as bycatch during normal fishing operations. New Zealand also has an obligation to provide estimates of the numbers of non-target fish species taken in the tuna longline fishery as part of its contribution to the Ecologically Related Species Working Group under the Convention for the Conservation of Southern Bluefin Tuna. The New Zealand tuna longline fishery targets mainly bigeye tuna (*Thunnus obesus*) and southern bluefin tuna (*T. maccoyii*). The main bycatch[1] species are blue shark (*Prionace glauca*), Ray's bream (*Brama brama*), porbeagle shark (*Lamna nasus*), dealfish (*Trachipterus trachypterus*), oilfish (*Ruvettus pretiosus*), and moonfish (*Lampris guttatus*) (Francis et al. 2000).

Oceanic sharks are important non-target species in longline fisheries throughout the Pacific Ocean (Stevens 1992, Bailey et al. 1996, He & Laurs 1998, Stevens & Wayte 1999, Francis et al. 2000, 2001), and the demand for shark fins in Asia has led to increased catches over the last few decades (Bonfil 1994, Hayes 1996). Some oceanic sharks have low reproductive rates, long life spans, and possibly slow growth, and they segregate by size and sex. These features make them vulnerable to overfishing (Compagno 1990, Hoenig & Gruber 1990, Castro et al. 1999).

Billfish species are also caught in tuna longline fisheries (Bailey et al. 1996, Government of Australia 1998). In New Zealand, broadbill swordfish are commonly caught, and striped, blue, and black marlin are occasionally taken (Ross & Bailey 1986, Francis et al. 1999, 2000). These species are targeted by recreational big game fishers during summer with much of the catch being tagged and released (Saul & Holdsworth 1992, Davies & Hartill 1998, Hartill & Davies 1999). The only commercial fishery with a regular catch of marlins is the tuna longline fishery.

Since October 1987, foreign licensed vessels have been required to release all billfish caught in the New Zealand Exclusive Economic Zone (EEZ). Domestic fishers may retain broadbill swordfish but must return other billfish species to the water alive or dead. Commercial fishers view the practice of discarding dead marlins as a waste of a valuable resource, and sought a change in regulations to allow them to retain dead marlins, especially striped marlin which have high commercial value overseas. Recreational fishers, on the other hand, are concerned about any potential impact on the recreational fishery from increased domestic tuna longline activity, especially fishing effort which might target striped marlin. This longline effort was perceived by recreational fishers as the cause of low abundance of striped marlin off east Northland from 1983 to 1987. Both commercial and recreational sector groups have requested information on the numbers of marlin caught and on the discard rate before changes to the current regulations are considered.

Studies of tuna longline bycatch in the temperate Pacific Ocean are limited. Preliminary assessments of bycatch composition and quantity are available for tuna longlines in Australian waters (Stevens 1992, Government of Australia 1998). Vessel logbook data and limited scientific observer data on catches in the New Zealand EEZ were presented by Ross & Bailey (1986), Stevens (1992), and Bailey et al. (1996). Michael et al. (1987, 1989) reported on the catches of five Japanese tuna longliners off the east coast of North Island in 1987 and 1988. NIWA has recently reported the results of two Ministry of Fisheries research projects that investigated the bycatch of the New Zealand tuna longline fleet (Francis et al. 1999, 2000). The present study, funded by the Ministry of Fisheries under project ENV2000/03, updates and extends those previous analyses. It addresses the following objective:

1. To estimate the catch rates, quantity and discards of non-target fish, particularly oceanic shark species, broadbill swordfish and marlin species, caught in the longline fisheries for tuna, using data from Scientific Observers and commercial fishing returns for the 98/99 and 99/2000 fishing years.

Only a small proportion of the tuna longline fishing effort in the New Zealand EEZ has been observed, but this is the only independent source of information on the scale of bycatch and discarding in the fishery.

[1] The term "bycatch" is defined in this report as the catch of non-target fish species.

2. METHODS

2.1 Fishing effort, catch per unit effort and numbers caught

Tuna longline vessels submit information on their fish bycatch to the Ministry of Fisheries on Tuna Longlining Catch Effort Returns (TLCERs) and Catch Effort Landing Returns (CELRs). However, these returns underestimate bycatch because much of it is discarded at sea (Michael et al. 1987, 1989, Stevens 1992, Francis et al. 2000). More reliable data on the amount of fish bycatch are available from the Ministry's Scientific Observer Programme, in which observers aboard commercial vessels identify, count, and sometimes weigh, measure, and sex the bycatch. We used scientific observer data to determine which non-target fish species are caught, and to estimate CPUE, the number of fish caught, the proportion of the catch alive and dead on recovery, and the proportion of fish processed and discarded. We present results from the 1998–99 and 1999–2000 fishing years in detail, and compare them with results obtained for previous years (1988–89 to 1997–98) so that the full time series is available.

The New Zealand tuna longline fishery comprises three separate sectors: foreign licensed, foreign chartered, and domestic vessels. The fishery was initiated by foreign licensed vessels (mainly Japanese, but also Taiwanese and Korean) in the early 1950s, and licensing of this fishery began in 1979. One New Zealand fishing company has chartered foreign vessels, beginning in the 1988–89 fishing year (1 October 1988–30 September 1989), and domestic vessels also entered the fishery in 1988–89. Foreign licensed vessels ceased fishing in New Zealand at the end of 1994–95. We combined the data for foreign licensed and chartered vessels in this report, because both fleets generally fished the same areas and used the same fishing gear and methods. Another reason for combining the two fleets was that observer coverage rates were low in some years and some geographical strata (see below), resulting in some unobserved strata; combining the fleets overcame this difficulty. In the rest of this report, we refer to the foreign licensed and foreign charter vessels as the "foreign and charter" fleet, and New Zealand owned and operated vessels as the "domestic" fleet. However, one large domestic vessel that fished with and used the same methods as the chartered vessels was grouped with the foreign and charter fleet for analysis.

In 1998–99 and 1999–2000, bigeye was the main target species (75% of sets recorded on TLCERs), with southern bluefin tuna second (15%). Albacore tuna, which is the tuna species caught most frequently, was listed as the target for only 9% of sets. Northern bluefin tuna, broadbill swordfish, and yellowfin tuna were rarely targeted. In this study, we defined non-target species to be all other fish species caught on the longlines. Nevertheless, we also included information and analyses for the six target species where relevant.

Data on the number of hooks set and observed, and the numbers of each species caught, were extracted from the scientific observer database (*l_line*) managed by NIWA for the Ministry of Fisheries for all observed tuna longline sets. The numbers of hooks set by all vessels in the fishery, and their reported catches, were extracted from the groomed version of the TLCER database maintained by NIWA (*tuna*), and a groomed extract of surface longline records from the CELR database (to 1997–98 only).

Some species identifications during the early years of the observer programme were unreliable. Some observers did not differentiate between porbeagle and mako sharks, so we report data for both species combined since 1988–89, and for the two species separately since 1992–93 (inclusive). One observer in 1994–95 was also uncertain about distinguishing the species, so data for the two species collected on those two trips were combined. The two lancetfish species (*Alepisaurus ferox* and *A. brevirostris*) were not routinely distinguished until 1997–98 and were combined here. Other groups of closely related or difficult to identify species were also combined (e.g., deepwater dogfishes of the Order Squaliformes). Unidentified fishes were classified as teleosts, sharks, or rays. Records of uncommon species were checked for accuracy where possible by examining photographs taken by observers. Species reported by only one observer were regarded as misidentifications (unless the number of records was very low, or they could be verified from photographs) and were treated as unidentified.

Inspection of CPUE by trip revealed that one observer consistently under-reported non-target species The five trips completed by that observer were deleted from the data set.

CPUE was expressed as the number of fish caught per 1000 hooks set. CPUE varies significantly between the domestic and foreign and charter fleets, and also among different parts of the EEZ (Francis et al. 2000). To provide precise estimates of the numbers of fish caught, it was necessary to stratify the data to reduce the within-stratum variation. We therefore stratified the longline sets into four strata: two fleets and two regions (north and south) which were separated at 38° S on the west coast and 43° 50' S on the east coast (see Figures 3 and 4) following Francis et al. (2000).

Catch rates of some oceanic pelagic species are strongly seasonal, so temporal stratification of the data would be desirable. Foreign and charter vessels fished only a short season, mainly between April and July. Domestic effort and observer coverage were greatest in January–June, but the coverage rate was low (see Results). This made seasonal stratification of the data impractical.

Mean CPUE was calculated (as an unweighted arithmetic mean over all sets) for each stratum and fishing year for 18 of the commonest species (or species groups, see Table 8), and for porbeagle and mako sharks combined (this is the same set of species that was analysed previously by Francis et al. (2000)). The total numbers of each species caught in each stratum and fishing year were estimated by multiplying the mean CPUE by the total number of hooks set; these numbers were then summed across the four strata to give an annual catch estimate. Estimates of the 95% confidence limits of CPUE and annual catch were derived by taking 1000 bootstrap samples from the original data by randomly sampling sets with replacement (Efron & Tibshirani 1993). CPUE estimates were plotted against fishing year to determine whether there were any trends over the 12-year period, or differences among strata.

An attempt was made to validate observer-based estimates of bycatch by comparing them with numbers of fish reported in TLCERs. On CELRs, non-tuna species are reported as weight, not numbers, so we were unable to include CELR catches in this comparison. Reported catches are likely to be most reliable for the highly valued commercial species (especially southern bluefin tuna, bigeye tuna, and albacore), so we also estimated the numbers of target species caught. Poor correspondence might indicate biased observer coverage, biased reporting by vessel skippers, or both.

2.2 Catch weights of oceanic sharks and Ray's bream

For the 1996–97 and 1997–98 fishing years, we estimated the catch weights of three oceanic shark species (blue, porbeagle, and mako sharks) from the estimated numbers caught (Francis et al. 2000). In 1998–99 and 1999–2000, observer coverage of the domestic fleet was too low to provide reasonable estimates of the numbers caught, or of the length-frequency distributions. We therefore restricted the estimation of catch weights to the foreign and charter fleet in those two years. Length-frequency distributions were plotted by region, year, and sex using 5 cm length intervals. Most shark measurements were fork lengths (FL), but often a second measurement (either precaudal (PCL) or total length (TL)) was also taken. For blue sharks, missing fork lengths were estimated from precaudal lengths where available using the regression developed from observer data by Francis et al. (2000):

$$\mathrm{FL} = 1.076 + 1.088\,\mathrm{PCL} \qquad N = 5259, R^2 = 0.998$$

Catch weight was estimated separately by region, and also by sex for blue and porbeagle sharks. We assumed that the size composition and sex ratio of the samples were representative of the catch within each region. The length frequencies were converted to proportions of the measured (and sexed) sample, and the number caught in each length class was calculated as the proportion multiplied by the estimated total numbers caught in each region. These numbers were converted to weights by multiplying by the mean weight for the length class. The latter was calculated using length-weight regressions obtained from all the data in the observer database up to September 1998 (Francis et al. 2000):

Blue sharks, males:	$\log_{10}\text{Weight} = -5.866 + 3.322 \log_{10}\text{FL}$	$N = 1250, R^2 = 0.939$
Blue sharks, females:	$\log_{10}\text{Weight} = -6.225 + 3.504 \log_{10}\text{FL}$	$N = 2001, R^2 = 0.966$
Porbeagles, both sexes:	$\log_{10}\text{Weight} = -4.929 + 3.060 \log_{10}\text{FL}$	$N = 1049, R^2 = 0.953$
Makos, both sexes:	$\log_{10}\text{Weight} = -4.672 + 2.868 \log_{10}\text{FL}$	$N = 428, R^2 = 0.968$

where weight is measured in kilograms and length in centimetres. The estimated weights were then summed across all length classes and both regions to provide an estimated total weight for the fishing year.

A similar procedure was used for Ray's bream except that 1 cm length intervals were used, and because the measured samples from the north region were small, the length distributions from the south region were applied to both regions. The weights of Ray's bream measured by observers aboard tuna longliners were imprecise (to the nearest 1 kg) and were therefore unsuitable for deriving a length-weight relationship. Instead, length and weight data for a sample of 122 Ray's bream were extracted from the research trawl database *trawl*. The small sample size and the fact that most of the data came from only four trawl stations mean that the data may be unrepresentative, and that any relationship derived from them is approximate only (Francis et al. 2000):

Ray's bream, both sexes: $\log_{10}\text{Weight} = -4.956 + 3.132 \log_{10}\text{FL}$ $N = 122, R^2 = 0.974$

2.3 Status of fish on recovery, and subsequent treatment

The status of fish at the time of recovery (i.e., retrieval to the side of the vessel), and the subsequent treatment of the catch, were analysed from scientific observer data from 1992–93 to 1999–2000 for the main non-target fish species and striped marlin. Fish status was recorded as alive, dead, killed by crew, or unobserved. Fish recorded as killed by crew were treated as alive on recovery. Fish treatment was recorded as retained, finned, discarded, lost, or unobserved. The first two categories were combined to reflect the fish that were processed in some way, and the discarded and lost categories were combined to reflect fish that were not processed.

3. RESULTS

3.1 Fishing effort and observer coverage

The number of hooks set by tuna longline vessels in the New Zealand EEZ declined from a maximum of 24–27 million hooks per year (mean 25.3 million) in 1979–82 to 2–4 million hooks in 1993–98 (mean 3.2 million) (Figure 1, Table 1). This decline of 87% in fishing effort resulted from a reduction in foreign licensed vessels fishing in New Zealand. Since then, the number of hooks has increased rapidly, reaching 6.7 million hooks in 1998–99 and 8.1 million hooks in 1999–2000 (provisional values, excluding effort reported on CELRS). The effort of foreign chartered vessels has remained steady, and the increase is a result of domestic effort expansion.

Fishing effort by fleet and fishing year (1 October–30 September) is shown in Figure 2 and Table 2. Foreign and charter vessels have always filled out TLCERs, whereas domestic vessels have provided both TLCERs and CELRs. Most fishing effort has been reported on TLCERs, though in 1995–96 almost 17% of effort was reported on CELRs (Table 2). CELR totals for 1998–99 and 1999–2000 are not yet available.

The first observer trips on tuna longliners were in June–July 1987 (Michael et al. 1987). Two trips were completed, but only one trip collected sufficient data to warrant inclusion in the database. Overall observer coverage since then has been low, with only 8.2% of total hooks being observed (Tables 2 and 3, Figure 2). The coverage was higher for foreign and charter than domestic fleets (9.9% and 2.0% respectively). Up to the end of 1999–2000, observers had completed 121 trips and observed 3280 sets. Recent observer coverage has been high for foreign and charter vessels (72.9% and 59.2% for 1998–99 and 1999–2000 respectively), but very low for domestic vessels (0.7% and 0.6% respectively). Observer coverage of domestic vessels was considered too low in 1998–99 and 1999–

2000 to be representative of the catch. We therefore restricted our analyses for those years to foreign and charter vessels.

In 1998–99 and 1999–2000, all hooks set by domestic vessels when observers were aboard were actually observed (Table 4). However, not all hooks were observed on foreign and charter vessels, for a variety of reasons. In 1998–99, 90% of sets were fully observed, and the lowest observation percentage was 77%. In 1999–2000, 86% of sets were fully observed; of the 14% of sets that were incompletely observed, 11% were from one trip, in which the number of hooks observed averaged 53% (range 26–90%).

The numbers of observed and set hooks used in our analyses are given in Tables 5 and 6. Five strata that contained fishing effort had no observer coverage (Table 6), so we combined the effort from each stratum with that of the other fleet in the same fishing year and region. For three of the strata, the numbers of hooks involved were trivial, but for the other two strata (domestic south in 1994–95 and foreign and charter south in 1995–96) substantial numbers of hooks were reassigned.

In both 1998–99 and 1999–2000, the domestic fleet fished mainly in the north region, and the foreign and charter fleet fished mainly in the south region (Figures 3 and 4). Domestic effort was concentrated along the east coast of North Island, and the northwest coast of North Island. Foreign and charter effort was concentrated off the west coast South Island, with smaller amounts of effort off the east coast South Island and northeast coast North Island. In both years, some of the domestic fishing effort off the west coast North Island "spilled over" the boundary between north and south regions (38° S). In future years, the stratum boundary should be shifted southwards to 40° S so that this domestic effort is captured in north region.

Observer coverage was representative of the foreign and charter fleet effort in both years (Figures 5 and 6). However, observer coverage of the domestic effort was limited to the Bay of Plenty and East Cape – Hawke Bay regions, and clearly did not represent the geographical range of the fishery.

Our estimates of the numbers of fish caught by the tuna longline fishery represent the catches of the foreign and charter fleet from 1988–89 to 1999–2000, and domestic vessels from 1994–95 to 1997–98. Korean vessels fished for albacore tuna north of 35° S in 1988–89: six vessels made 108 sets. No observers were placed on Korean vessels, and their fishing methods differed significantly from those of the Japanese vessels, so the observer coverage of Japanese vessels is unlikely to be representative of the catches of Korean vessels. All tables and estimates in this report exclude Korean effort and catch except for Table 1.

Most fishing by the foreign and charter fleet occurred between April and July (Figure 7). Observer coverage of this fleet shows the same seasonal pattern (Figure 7, Table 7). Domestic vessels operated during a longer season (mainly January–June), and observer coverage had a similar pattern.

3.2 Species composition and distribution

Between 1988–89 and 1999–2000, 254 511 fish and invertebrates from at least 72 species were observed (Table 8). Most species were rarely observed, with only 31 species or species groups exceeding 100 observations (treating porbeagle and mako sharks, and the two *Alepisaurus* species, separately, and ignoring unidentified fish categories). Only 267 striped marlin were observed, 43 of them in 1998–99 and 14 in 1999–2000. Other marlin species were rare (48 shortbill spearfish and 6 blue marlin).

The most commonly observed species over all years were blue shark, albacore tuna, and Ray's bream (Table 8, Figure 8). The next most important non-target species were porbeagle and mako sharks, followed by smaller numbers of dealfish, moonfish, oilfish, deepwater dogfish, swordfish, lancetfish, butterfly tuna, rudderfish, school shark, and escolar. Deepwater dogfish consists of a number of squaloid dogfish species including *Centroscymnus squamosus, C. owstoni, Dalatias licha,* and *Zameus squamulosus*. The species proportions are biased towards those of the foreign and charter fleet, because of the low observer coverage of the domestic fleet. In 1998–2000, southern bluefin tuna, porbeagle and mako sharks, deepwater dogfish, rudderfish, and escolar were more common than in the entire dataset, and albacore tuna and oilfish were less common (Figure 8).

Blue shark, Ray's bream, porbeagle shark, moonfish, butterfly tuna, mako shark, and rudderfish occurred throughout the area covered by observers (Francis et al. 1999, Bagley et al. 2000). Dealfish, deepwater dogfish, and school shark were mainly recorded around the South Island, and oilfish and lancetfish were mainly recorded around the North Island.

3.3 Catch per unit effort

Estimates of mean CPUE for the target and main non-target species are shown by stratum and fishing year in Figure 9 and Appendix 1. For most species, there were large differences in CPUE between the two fleets and/or between the two regions. This suggests that the stratification scheme was effective in reducing within-stratum variation relative to between-stratum variation. The 95% confidence limits were mostly reasonable, apart from two estimates of school shark mean CPUE, where one unusually large CPUE in each stratum resulted in broad limits.

Notable features of the foreign and charter CPUE for 1998–99 and 1999–2000 include:

- continued low catch rate of blue sharks in the north region;
- continued high catch rate of deepwater dogfish in the south region;
- return to previous levels of albacore CPUE in the north region, following an anomalously high value in 1997–98;
- large decline in southern bluefin tuna CPUE in the north region following the two highest values ever recorded;
- continued high CPUE of butterfly tuna in the south region, and low CPUE in the north region;
- high bigeye tuna catch rate in the north region;
- continued high catch rate of moonfish in the north region;
- highest ever recorded foreign and charter CPUE for lancetfish in the north region in 1998–99, followed by a return to previous levels in 1999–2000;
- highest ever CPUE for rudderfish in the south region.

Over the full time series, the following patterns were apparent.

- In some years, blue shark CPUE was much higher for the foreign and charter fleet in the north region than for the same fleet in the south region, but in other years the two regions had similar, low CPUE. Domestic north CPUE was lower than foreign and charter north CPUE.
- CPUE of mako sharks was higher in the north region than the south region, but CPUE of porbeagle sharks has been similar in both regions in recent years.
- Deepwater dogfish CPUE was higher in the south region than in the north region.
- Greatest catch rates of albacore, yellowfin tuna, and lancetfish were usually made by the domestic fleet in the north region. Catch rates were higher in the north region than in the south region. The foreign and charter fleet had very low catch rates of yellowfin tuna because most of their fishing was during winter months when yellowfin are rare or absent in New Zealand waters.
- CPUE of southern bluefin tuna was higher in the south region than in the north region except for the foreign and charter fleet in 1996–98.
- Broadbill swordfish, bigeye, oilfish, and moonfish catch rates were highest in the north region. Oilfish CPUE in the north region was greater for the foreign and charter fleet than for the domestic fleet.
- CPUEs of Ray's bream and dealfish were greatest in the south region.

In 1998–99 and 1999–2000, observers were deployed on foreign and charter vessels fishing off both east and west coasts South Island (ECSI and WCSI) (see Figures 5 and 6). For two vessels that fished both coasts, we compared ECSI and WCSI CPUEs for the main species caught. The number of sets observed off ECSI was low in both years (Table 9), but there were some clear differences between coasts. For both vessels and both years, CPUE was greater on WCSI than ECSI for blue shark, school shark, albacore, southern bluefin tuna, broadbill swordfish, dealfish, moonfish, and rudderfish. Conversely, CPUE was greater on ECSI for butterfly tuna. CPUE patterns for the remaining species were not consistent across years and vessels.

The differences in CPUE between east and west coast South Island may not be due solely to spatial variation. All ECSI sets in both years were made in April, whereas WCSI sets were made in April–July (84% in May–June). Thus the differences may have been partly due to seasonal variation. Nevertheless, it is important to account for this CPUE heterogeneity in future analyses, though this will only be possible if there is adequate observer coverage of the fishing effort on both coasts.

3.4 Numbers of fish caught

Insufficient observer coverage prevented the estimation of the numbers of fish caught by domestic vessels in 1998–99 and 1999–2000. Figure 10 shows the estimated numbers of fish caught by foreign and charter vessels, and also the numbers of fish reported caught by both domestic and foreign and charter vessels on TLCERs, and historical data for the previous 10 years (Francis et al. 2000) for comparison. Note that the following fishing effort was not included in the estimates in Figure 10.

- Korean vessels in 1988–89; they set 340 685 hooks, or 3.5% of the total effort for that year.
- Domestic effort before 1994–95 (because of low observer coverage). In 1991–92, 1992–93, and 1993–94, domestic effort constituted 4%, 16%, and 57% respectively of the total reported effort (see Table 2). Therefore, the observer estimates of the numbers of fish caught in 1991–92 and 1992–93 will be slightly underestimated and those in 1993–94 will be grossly underestimated.
- Domestic effort in 1998–2000. That effort constituted 77% and 86% of the effort in 1998–99 and 1999–2000 respectively, so estimates for those two years are grossly underestimated.

Furthermore, CELR data are not included in the reported catches. This will cause a negative bias, especially for 1993–94 to 1995–96 when 7–17% of hooks were reported on CELRs (see Table 2).

Reported catches reached their highest levels ever during the last 2–3 years for porbeagle shark, mako shark, albacore, broadbill swordfish, bigeye tuna, Ray's bream, dealfish, oilfish, moonfish, and rudderfish. Much of this increase is attributable to the increases in domestic effort, but better reporting of shark species that are finned, and increased retention of previously discarded species, may also be factors.

For commercially important species (mako shark, school shark, albacore, southern bluefin tuna, broadbill swordfish, bigeye tuna, yellowfin tuna and moonfish), the TLCER data provide the best indication of the magnitude of catches in 1998–2000 (Figure 10). However, caution is required in interpreting these results, because some of these species (especially porbeagle and mako sharks and possible swordfish) have been under-reported previously.

For non-commercial species that occur mainly in south region (deepwater dogfish, dealfish), observer-based estimates are probably reasonable. For other non-commercial or low value species (blue shark, porbeagle shark, butterfly tuna, Ray's bream, oilfish, lancetfish, rudderfish), neither the estimates nor the reported catches are considered reliable.

3.5 Length-frequency and catch weight of oceanic sharks

Length-frequency distributions of blue shark by region and year showed differences in size composition between the north and south regions (Appendix 2). In the north region, the catch was often dominated by a single broad mode at 75–150 cm FL, and in some years, including 1998–99 and 1999–2000, had a long tail of larger sharks over 200 cm. In the south region, there were two strong modes at 75–100 cm and 140–180 cm, with few sharks over 200 cm. During the last three years, sharks in the larger mode were dominant. Pooling data across all years and examining the two sexes separately revealed strong differences. In the north region, males had a broad length distribution with a significant proportion of sharks over 200 cm, whereas females had a much narrower distribution with few sharks over 170 cm (Figure 11). In the south region, males and females both displayed a strong juvenile mode at 75–100 cm, but females had a stronger mode at 140–180 cm than males. Based on the length-frequency distributions, and an approximate mean length at maturity for both sexes in the Pacific Ocean of about 185 cm FL (Stevens 1984, Stevens & McLoughlin 1991, Nakano 1994), most blue sharks were immature, though in the north region 29% of males were mature (Figure 11, Table 10). The strong mode of 140–180 cm females approaching the length at maturity (subadults) in the south region was responsible for a highly skewed sex ratio of 2.8 females per male. In the north region, males slightly outnumbered females by 1.2:1.

The estimated weights of blue sharks caught by foreign and charter vessels in 1998–99 and 1999–2000 were 373 t and 275 t respectively (Table 11).

Measured samples of porbeagle and mako shark before 1996–97 were few because of identification problems in some years, and lower priority given to these species by observers (Appendix 2). Too few length measurements were available for the north region in 1999–2000 to estimate length-frequency. In the north region, porbeagle distributions had clear juvenile modes at 70–90 cm FL, with variable amounts of larger fish. In the south region, the distributions varied among years, with juvenile modes at 75–100 cm in some years and larger modes at 110–140 cm in other years; the latter mode has dominated during the last four years. Pooling data across years showed a distinct juvenile mode at 70–100 cm for both sexes in both regions, but there were differences in the distributions of larger animals between regions, and in the north region between sexes (Figure 12). Based on the length-frequency distributions, and approximate mean lengths at maturity of 153 cm FL for males and 172 cm FL for females (Francis & Stevens 2000), most porbeagles were immature, though in the north region 27% of males were mature (Figure 12, Table 12). The presence of mature and adolescent males in the north region skewed the sex ratio in favour of males to 1.9:1. In the south region the sex ratio was close to one.

The estimated weights of porbeagle sharks caught by foreign and charter vessels in 1998–99 and 1999–2000 were 145 t and 62 t respectively (see Table 11).

In the north region, mako length-frequency distributions were very broad for both sexes (60–250 cm FL) (Appendix 2, Figure 13). In the south region, small sharks less than about 140 cm were rare, and the catch was dominated by males of 140–230 cm FL with a sex ratio of 6.5:1 (Figure 13). Based on the length-frequency distributions, and approximate mean lengths at maturity of 175 cm FL for males and 265 cm FL for females (M. Francis and C. Duffy, unpublished data), nearly all female makos were immature, but there was a significant proportion of mature males (32% in the north region and 76% in the south region) (Figure 13, Table 13).

The estimated weights of mako sharks caught by foreign and charter vessels in 1998–99 and 1999–2000 were 24 t and 13 t respectively (Table 11).

3.6 Length-frequency and catch weight of Ray's bream

The length-frequency distributions for Ray's bream from the south region typically consisted of a single prominent mode centred around 45–55 cm FL (Appendix 2). Fish sampled in 1998–99 and 1999–2000 were consistent with the pattern from previous years. Fewer than 20 Ray's bream were observed in the north region in each of the two fishing years. Length-frequency distributions pooled across all years are shown in Figure 14. In the south region, males and females had similar size distributions, but only about 40% of the Ray's bream were sexed. Females mature at about 43 cm (unpublished observer data from trawl-caught Ray's bream), suggesting that most fish caught by tuna longlines are mature.

The estimated weight of Ray's bream caught by foreign and charter vessels in 1998–99 and 1999–2000 were 8 t and 7 t respectively (north and south regions combined), and the mean estimated fish weight in both years was 2.0 kg.

3.7 Striped marlin

The annual numbers of marlins reported on TLCERs during the last 10 years are shown in Table 14. These values are for fishing years, and are therefore not directly comparable with the calendar year values reported previously (Francis et al. 1999, table 7; Francis et al. 2000, table 12). However, it is clear that the present striped marlin values are much greater than those reported in the latter study and similar to those reported in the former. We believe the values reported by Francis et al. (2000) were in error, possibly as a result of using an incorrect extract procedure.

Most marlins reported on TLCERs were striped marlin; only a few black marlin, sailfish, and shortbill spearfish were recorded. The numbers of striped marlin reported by fishers have increased dramatically in the last two years, reaching a peak of 1651 fish in 1998–99 and dropping back to 806 fish in 1999–2000. Striped marlin were reported caught around the northern North Island north of 40° S (Figures 15 and 16).

In 1998–99, 43 striped marlin were recorded by observers, 41 on domestic vessels and 2 on foreign and charter vessels (Figure 17). Thirty-two (78%) of the striped marlin observed on domestic vessels came from just 10 sets made by one of four observed vessels over 16 days in January 1999. In 1999–2000, 14 striped marlin were recorded by observers, 12 on domestic vessels and 2 on foreign and charter vessels. Striped marlin observed on domestic vessels came from outside the 1000 m depth contour in the Bay of Plenty and between East Cape and Hawke Bay. The four striped marlin observed aboard foreign and charter vessels were all caught in the Kermadec Fisheries Management Area.

As in previous years, observed domestic catches of striped marlin in 1998–2000 were limited spatially to the area 33–40° S and 171–180° E (Figure 17). Domestic observer effort in this "marlin box" was low, and limited temporally to December–February in 1998–99, and December–March and June in 1999–2000 (Tables 15 and 16). Observer coverage rates for the domestic fleet in the observed months were 1–5% and 1–3% for the two years respectively. These rates were too low to provide reliable estimates of the striped marlin CPUE across the whole fleet.

3.8 Status of fish on recovery, and subsequent treatment

The percentages of each of the main non-target species recorded as alive or dead between 1992–93 and 1999–2000 are shown in Table 17. The data are presented separately by stratum. The percentage of fish alive on recovery was usually greater in the south region than in the north region. Exceptions to this pattern were domestic blue sharks (equal proportions alive in north and south regions), and foreign and charter oilfish and domestic rudderfish (higher proportion alive in north region); however, sample sizes for the last two comparisons were small in at least one of the two regions. Similarly, the percentage alive tended to be greater for domestic vessels than for foreign and charter vessels, but there were a number of exceptions and some comparisons were based on small samples. Because of these differences among strata, the overall species totals in Table 17 should be interpreted cautiously, as they depend on the number of hooks observed in each stratum (no weighting has been applied). However, it is clear that most blue shark, mako shark, deepwater dogfish, school shark, Ray's bream, oilfish, moonfish, and rudderfish were alive when recovered. Most dealfish were dead, and about half of the porbeagle sharks and lancetfish, and one-third of the butterfly tuna, were alive when recovered.

Since 1992–93, 72% of 249 observed striped marlin have been alive (Table 18). There was no significant difference in the proportion recovered alive by domestic or foreign and charter vessels (G-test, $G = 0.93, P > 0.5$).

The treatment of the main non-target species between 1992–93 and 1999–2000 is shown in Table 19. The data are presented by stratum for sample sizes greater than 50. Most blue, porbeagle, mako and school sharks, and moonfish and butterfly tuna were processed in some way. Domestic vessels processed a higher proportion of blue, porbeagle, and school sharks, and Ray's bream, oilfish, moonfish, and rudderfish than did foreign and charter vessels. The reverse was true for mako sharks. The biggest differences were for Ray's bream and oilfish, which were mainly processed by domestic vessels, but mainly discarded or lost by foreign and charter vessels. Most deepwater dogfish, dealfish, and lancetfish were discarded or lost.

Most of the blue and porbeagle sharks that were processed were finned only, and the rest of the carcass was discarded, whereas school sharks were mainly processed for their flesh (Table 20). Mako sharks were mainly processed for their flesh by foreign and charter vessels, but mainly finned by domestic vessels.

4. DISCUSSION

Observer data showed that a wide range of fish species was taken as incidental bycatch in the tuna longline fishery in 1998–2000, but few were caught in large numbers. The main non-target species are similar to those reported previously in the New Zealand fishery (Francis et al. 1999, 2000), and many are also taken by longliners in Australia (Stevens 1992, Government of Australia 1998) and the subtropical western Pacific (Bailey et al. 1996).

Observer coverage of the large domestic fleet in 1998–2000 was inadequate for estimating their bycatch, and we were able to estimate the bycatch of only the foreign and charter fleet. Species proportions in the catch could not be estimated because observer coverage was largely restricted to the foreign and charter fleet, which takes a different species mix from the domestic fleet. Nevertheless, it was clear that blue shark contributed the largest proportion of the catch, followed by albacore tuna, Ray's bream, southern bluefin tuna, and porbeagle shark. Previous work (Francis et al. 2000) has shown that the change from a foreign and charter dominated fishery up to 1992–93 to a domestic dominated fishery in recent years has resulted in a shift in the overall species mix towards a higher proportion of albacore and lower proportion of blue sharks.

Francis et al. (2000) discussed the differences in CPUE between the foreign and charter and domestic fleets, and between the north and south regions. The lack of adequate observer coverage for the domestic fleet during 1998–2000 has prevented us from extending those comparisons. In this and our previous study, the four strata (two geographical regions and two fleets) were identified as significant sources of variation in CPUE. Ongoing observer coverage of all the identified strata is therefore necessary in order to obtain unbiased estimates of the numbers of fish caught.

Two revisions to the stratification scheme are proposed for future analyses. If observer data are adequate, the south region should be split into southeast and southwest regions, to allow for the large differences in CPUE noted between the east and west coasts of South Island. Also, the boundary between north and south (or southwest) regions on the west coast should be moved south to 40° S so that all domestic fishing effort in the "northern" fishery is retained in the north region.

The numbers of many bycatch (and target) species caught have undoubtedly increased during the last two years as a result of large increases in domestic fishing effort (foreign and charter effort has remained stable). We have been unable to quantify the increases in catch from observer data because of the low coverage rate for domestic vessels, which contributed most of the effort. Nevertheless, TLCER data for those species that are well reported (high value, target species) confirms that catches have increased over the last 2–3 years.

Reported catches of striped marlin have also increased dramatically in the last two years. The three-fold increase between 1997–98 and 1998–99 (see Table 14) cannot be completely explained by an increase in effort; domestic effort, which accounts for most of the effort in the north region where striped marlin are caught, approximately doubled between the two years. Other possible reasons for the increase include improved reporting of striped marlin (Francis et al. (2000) presented evidence of under-reporting in previous years), and an increase in the abundance of striped marlin resulting from the above-average water temperatures in northern New Zealand during summer 1998–99. The decline in reported striped marlin landings in 1999–2000 accompanied a return to cooler, but still above average, water temperatures. The numbers of striped marlin tagged and released by recreational fishers peaked at 1544 in 1998–99, and then declined to 790 in 1999–2000; a similar trend occurred in the number of striped marlin caught by gamefish clubs (Hartill & Davies 2001). In combination, these observations suggest that striped marlin were more abundant than usual during 1998–99.

The life status on recovery, and subsequent treatment, of the main bycatch species were determined for data pooled from 1992–93 to 1999–2000. Most non-target fish species were alive on recovery. The main exceptions were dealfish, lancetfish, and butterfly tuna. Survival rates tend to be higher in the south region than in the north region, perhaps because of the reduced metabolic rates and lower oxygen demands of fish at lower temperatures. Survival rates tended to be greater on domestic vessels than on foreign and charter vessels, probably because domestic longlines are shorter, so their haul times and therefore maximum soak times are shorter. Most striped marlin (72%) were alive on recovery, and most were released alive. Survival rates of striped marlin were similar on domestic and foreign and charter vessels.

Blue, porbeagle, mako, and school sharks were mostly processed when caught, although most blue and porbeagle sharks were finned only, with the carcass being discarded. Foreign and charter vessels mainly processed mako sharks for their flesh, whereas domestic vessels mainly finned them. Moonfish and butterfly tuna were mainly processed. Deepwater dogfish, dealfish, and lancetfish were nearly all discarded. Ray's bream, oilfish, and rudderfish were more likely to be processed by domestic vessels than foreign and charter vessels.

Based on tagging studies in New Zealand and overseas (reviewed by Francis et al. (2000)), and limited genetic work on the mako shark (Heist et al. 1996), stock ranges of the three oceanic shark species are large, and individual sharks are highly mobile, suggesting that population turnover in the EEZ is high. The porbeagle shark stock probably encompasses at least the Tasman Sea and temperate and subantarctic waters of the Southwest Pacific. The mako shark stock may span the whole South Pacific (and possibly also the North Pacific), and the blue shark stock may encompass the entire Pacific, with some links into the Indian Ocean as well. The New Zealand tuna longline fishery therefore exploits only a small part of each stock. This is supported by evidence that most of the blue and porbeagle sharks, and nearly all of the female mako sharks, caught around New Zealand are immature. Stocks of these oceanic sharks need to be assessed and managed internationally.

We derived stratified mean CPUE indices for a 12-year period for blue shark, and an 8-year period for porbeagle and mako sharks, using scientific observer data, though the time series were incomplete in all strata. We believe that these indices do not monitor stock abundance, but at best index the degree to which each species either migrates into the New Zealand EEZ, or migrates towards the continental shelf edge from the open ocean.

The impact of New Zealand tuna longline catches on the stocks of the three shark species is probably minor. Our estimates (Francis et al. 2000) of the 1996–97 and 1997–98 catches of blue sharks (800–1400 t) are trivial compared with a Pacific-wide estimate of 140 000 t caught in 1994 (Bonfil 1994, J. D. Stevens, CSIRO, unpubl. data). Furthermore, New Zealand fishing effort declined by 87% between the early 1980s and the late 1990s, and driftnet fishing in the South Pacific has ceased. However there has been a strong increase in domestic fishing effort in the last two years, and fishing effort elsewhere in the stock range is probably still high. Blue sharks are moderately productive (Smith et al. 1998), and most of the mature part of the stock is not vulnerable to New Zealand longliners. Similarly, porbeagle and mako shark catches in New Zealand were low in 1996–97 and 1997–98 (about 150 t and 100–200 t respectively (Francis et al. 2000)), but have probably increased in the last two years. Both species are moderately productive (though North Atlantic porbeagles have proven very vulnerable to overfishing), and the mature part of each stock appears to be unavailable to the fishery.

It is unlikely that New Zealand's tuna longline fishery is seriously affecting the stocks of blue, porbeagle, and mako sharks. However, an adequate stock assessment is not feasible using currently available data. Catches of oceanic sharks throughout the Pacific are poorly known, so accurate monitoring of levels of fishing mortality throughout the stock ranges is an important first step towards ensuring sustainability of their populations.

The effect of the recent rapid increase in domestic fishing effort on bycatch should be monitored closely. Recent observer coverage of the large domestic fleet, which accounted for 77% and 86% of fishing effort in 1998–99 and 1999–2000 respectively, has been inadequate for this purpose. We strongly recommend that the observer coverage of the domestic fleet be increased in future, and that efforts are made to ensure that the spatial and temporal extent of that coverage is representative of the fishery and therefore the catch.

5. ACKNOWLEDGMENTS

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6. REFERENCES

Bagley, N.W.; Anderson, O.F.; Hurst, R.J.; Francis, M.P.; Taylor, P.R.; Clark, M.R.; Paul, L.J. (2000). Atlas of New Zealand fish and squid distributions from midwater trawls, tuna longline sets, and aerial sightings. *NIWA Technical Report 72.* 171 p.

Bailey, K.; Williams, P.G.; Itano, D. (1996). By-catch and discards in Western Pacific tuna fisheries: a review of SPC data holdings and literature. *Oceanic Fisheries Programme Technical Report 34.* 171 p.

Bonfil, R. (1994). Overview of world elasmobranch fisheries. *FAO Fisheries Technical Paper 341.* 119 p.

Castro, J.I.; Woodley, C.M.; Brudek, R.L. (1999). A preliminary evaluation of the status of shark species. *FAO Fisheries Technical Paper 380.* 72 p.

Compagno, L.J.V. (1990). Shark exploitation and conservation. *NOAA Technical Report NMFS 90*: 391–414.

Davies, N.M.; Hartill, B. (1998). New Zealand billfish and gamefish tagging, 1996–97. *NIWA Technical Report 35.* 33 p.

Efron, B.; Tibshirani, R. (1993). An introduction to the bootstrap. Chapman and Hall, New York. 436 p.

Francis, M.P.; Griggs, L.H.; Baird, S.J. (2001). Pelagic shark bycatch in the New Zealand tuna longline fishery. *Marine and Freshwater Research 52*: 165–178.

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 Technical Report 55.* 70 p.

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 Technical Report 76.* 79 p.

Francis, M.P.; Stevens, J.D. (2000). Reproduction, embryonic development and growth of the porbeagle shark, *Lamna nasus*, in the south-west Pacific Ocean. *Fishery Bulletin 98*: 41–63.

Government of Australia (1998). Annual review of bycatch in Australian SBT and related tuna longline fisheries. *CCSBT Ecologically Related Species 9806/23.* 21 p.

Hartill, B.; Davies, N.M. (1999). New Zealand billfish and gamefish tagging, 1997–98. *NIWA Technical Report 57.* 39 p.

Hartill, B.; Davies, N.M. (2001). New Zealand billfish and gamefish tagging, 1999–2000. *NIWA Technical Report 106.* 29 p.

Hayes, E. (1996). New Zealand overview. *In*: The world trade in sharks: a compendium of TRAFFIC's regional studies, pp. 751–790. TRAFFIC International, Cambridge, United Kingdom.

He, X.; Laurs, M. (1998). Bycatch, discards, finning, and economic value of blue shark in the Hawaii based longline fishery. *In*: Gribble, N.A.; McPherson, G.; Lane, B. (Eds). Shark Management and Conservation. Proceedings from the Sharks and Man Workshop of the Second World Fisheries Congress, pp. 88–91. Department of Primary Industries, Queensland, Brisbane.

Heist, E.J.; Musick, J.A.; Graves, J.E. (1996). Genetic population structure of the shortfin mako (*Isurus oxyrinchus*) inferred from restriction fragment length polymorphism analysis of mitochondrial DNA. *Canadian Journal of Fisheries and Aquatic Sciences 53*: 583–588.

Hoenig, J.M.; Gruber, S.H. (1990). Life-history patterns in the elasmobranchs: implications for fisheries management. *NOAA Technical Report NMFS 90*: 1–16.

Michael, K.P.; Bailey, K.N.; Taylor, P.R.; Sharples, P.B. (1989). Report of observer trips on Japanese southern bluefin tuna longliners off East Cape, June–July 1988. Fisheries Research Centre Internal Report 111. 35 p. (Unpublished report held in NIWA library, Wellington.)

Michael, K.P.; Jones, J.B.; Bailey, K.N. (1987). Report of observer trips on Japanese southern bluefin tuna longliners off East Cape, June–July 1987. Fisheries Research Centre Internal Report 80. 54 p. (Unpublished report held in NIWA library, Wellington.)

Nakano, H. (1994). Age, reproduction and migration of blue shark in the North Pacific Ocean. *Bulletin of the National Research Institute of Far Seas Fisheries 31*: 141–256.

Ross, A.; Bailey, K. (1986). The foreign longline catch of marlins, swordfish, and mako shark in the New Zealand EEZ for 1984. *Catch 13 (4–5)*: 12–16.

Saul, P.; Holdsworth, J. (1992). Cooperative gamefish tagging in New Zealand waters, 1975–90. *New Zealand Fisheries Technical Report 33.* 24 p.

Smith, S.E.; Au, D.W.; Show, C. (1998). Intrinsic rebound potentials of 26 species of Pacific sharks. *Marine and Freshwater Research 49*: 663–678.

Stevens, J.D. (1984). Biological observations on sharks caught by sport fishermen off New South Wales. *Australian Journal of Marine and Freshwater Research 35*: 573–590.

Stevens, J.D. (1992). Blue and mako shark by-catch in the Japanese longline fishery off South-eastern Australia. *Australian Journal of Marine and Freshwater Research 43*: 227–236.

Stevens, J.D.; McLoughlin, K.J. (1991). Distribution, size and sex composition, reproductive biology and diet of sharks from Northern Australia. *Australian Journal of Marine and Freshwater Research 42*: 151–199.

Stevens, J.D.; Wayte, S.E. (1999). A review of Australia's pelagic shark resources. *FRDC Project 98/107.* 64 p. (Unpublished report held in CSIRO library, Hobart.)

Table 1: Numbers of hooks reported on TLCERs and CELRs by tuna longline vessels in the New Zealand EEZ, classified by fleet. Includes Korean effort. One large domestic vessel was grouped with the foreign and charter vessels.

Fishing year	Domestic	Foreign + charter	Total
1979–80	0	25 908 413	25 908 413
1980–81	0	26 190 714	26 190 714
1981–82	0	23 651 052	23 651 052
1982–83	0	15 693 677	15 693 677
1983–84	0	12 826 582	12 826 582
1984–85	0	11 778 610	11 778 610
1985–86	0	12 881 145	12 881 145
1986–87	0	16 904 312	16 904 312
1987–88	0	12 942 901	12 942 901
1988–89	400	9 618 860	9 619 260
1989–90	91 232	8 553 288	8 644 520
1990–91	195 645	13 129 251	13 324 896
1991–92	396 253	9 177 019	9 573 272
1992–93	869 013	4 589 581	5 458 594
1993–94	1 467 890	1 096 767	2 564 657
1994–95	2 197 548	1 685 821	3 883 369
1995–96	2 131 459	208 988	2 340 447
1996–97	1 709 417	1 465 302	3 174 719
1997–98	2 648 811	1 255 786	3 904 597
1998–99[1]	5 191 438	1 515 915	6 707 353
1999–00[1]	6 912 104	1 152 892	8 064 996

[1] Provisional TLCER total; excludes CELR data.

Table 2: Numbers of trips, sets, and hooks observed by scientific observers, and numbers of hooks set by tuna longline vessels, classified by fleet. Data exclude five trips made by an unreliable observer in 1991–92 and 1992–93, and one trip which was dedicated to observations of longline sinking rates in 1998–99. One large domestic vessel was grouped with the foreign and charter vessels. Sources: Scientific observer database, TLCERs, and CELRs (excluding Korean effort).

Fishing year	Observed Trips	Observed Sets	Observed hooks Domestic	Observed hooks Foreign +charter	Observed hooks Total	Set hooks Domestic	Set hooks Foreign +charter	Set hooks Total	Set hooks % on CELRs
1986–87	1	13	0	38 244	38 244	0	16 904 312	16 904 312	0.0
1987–88	3	41	0	116 880	116 880	0	12 942 901	12 942 901	0.0
1988–89	5	86	0	243 582	243 582	400	9 618 860	9 619 260	0.0
1989–90	6	154	0	447 454	447 454	91 232	8 553 288	8 644 520	1.1
1990–91	3	150	0	439 144	439 144	195 645	13 129 251	13 324 896	1.4
1991–92	8	193	19 525	518 849	538 374	396 253	9 177 019	9 573 272	1.1
1992–93	17	373	0	1 106 022	1 106 022	869 013	4 589 581	5 458 594	0.5
1993–94	9	246	2 418	739 146	741 564	1 467 890	1 096 767	2 564 657	6.7
1994–95	12	339	65 750	867 003	932 753	2 197 548	1 685 821	3 883 369	12.1
1995–96	5	147	162 953	0	162 953	2 131 459	208 988	2 340 447	16.8
1996–97	15	424	79 991	936 093	1 016 084	1 709 417	1 465 302	3 174 719	3.1
1997–98	15	438	71 195	1 030 859	1 102 054	2 648 811	1 255 786	3 904 597	1.8
1998–99[1]	9	402	35 264	1 105 179	1 140 443	5 191 438	1 515 915	6 707 353	–
1999–00[1]	13	274	38 458	682 000	720 458	6 912 104	1 152 892	8 064 996	–
Total	121	3 280	475 554	8 270 455	8 746 009	23 811 210	83 296 683	107 107 893	1.7

[1] Provisional TLCER total; excludes CELR data.

Table 3: Percentage of hooks observed by scientific observers, based on the data in Table 2.

Fishing year	Domestic	Foreign +charter	Total
1986–87	–	0.2	0.2
1987–88	–	0.9	0.9
1988–89	0.0	2.5	2.5
1989–90	0.0	5.2	5.2
1990–91	0.0	3.3	3.3
1991–92	4.9	5.7	5.6
1992–93	0.0	24.1	20.3
1993–94	0.2	67.4	28.9
1994–95	3.0	51.4	24.0
1995–96	7.6	0.0	7.0
1996–97	4.7	63.9	32.0
1997–98	2.7	82.1	28.1
1998–99[1]	0.7	72.9	17.0
1999–00[1]	0.6	59.2	8.9
Total	2.0	9.9	8.2

[1] Provisional TLCER total; excludes CELR data.

Table 4: Percentages of hooks observed on observed sets.

		Number of sets		
Fishing year	Percentage hooks obs.	Domestic	Foreign +charter	Total
1998–99	70–79		2	2
	80–89		11	11
	90–99		22	22
	100	37	330	367
	Total	**37**	**365**	**402**
1999–00	20–29		2	2
	40–49		6	6
	50–59		12	12
	60–69		5	5
	80–89		2	2
	90–99		6	6
	100	36	205	241
	Total	**36**	**238**	**274**

Table 5: Numbers of observed hooks used in estimates of CPUE and numbers of fish caught, classified by fleet and region. One large domestic vessel was grouped with the foreign and charter vessels. Source: Scientific observer database.

Fishing year	Domestic			Foreign + charter			Total
	North	South	Total	North	South	Total	
1988–89	0	0	0	129 294	114 288	243 582	243 582
1989–90	0	0	0	226 010	221 444	447 454	447 454
1990–91	0	0	0	353 146	85 998	439 144	439 144
1991–92	0	0	0	243 646	275 203	518 849	518 849
1992–93	0	0	0	350 215	755 807	1 106 022	1 106 022
1993–94	0	0	0	91 452	647 694	739 146	739 146
1994–95	65 750	0	65 750	29 207	837 796	867 003	932 753
1995–96	64 512	98 441	162 953	0	0	0	162 953
1996–97	79 991	0	79 991	127 000	809 093	936 093	1 016 084
1997–98	71 195	0	71 195	250 636	780 223	1 030 859	1 102 054
1998–99	0	0	0	88 360	1 016 819	1 105 179	1 105 179
1999–00	0	0	0	69 500	612 500	682 000	682 000
Total	281 448	98 441	379 889	1 958 466	6 156 865	8 115 331	8 495 220

Table 6: Numbers of set hooks used in estimating CPUE and numbers of fish caught, classified by fleet and region. One large domestic vessel was grouped with the foreign and charter vessels. Bold values indicate effort that was not represented by observer coverage (see Table 5) and was pooled with the effort of the other fleet in the same region and fishing year for estimating numbers caught.

Fishing year	Domestic			Foreign + charter			Total
	North	South	Total	North	South	Total	
1988–89	0	0	0	3 360 424	6 258 436	9 618 860	9 618 860
1989–90	0	0	0	3 758 120	4 795 168	8 553 288	8 553 288
1990–91	0	0	0	5 218 821	7 910 430	13 129 251	13 129 251
1991–92	0	0	0	3 983 289	5 193 730	9 177 019	9 177 019
1992–93	0	0	0	815 391	3 774 190	4 589 581	4 589 581
1993–94	0	0	0	91 308	1 005 459	1 096 767	1 096 767
1994–95	1 511 018	**686 530**	2 197 548	45 187	1 640 634	1 685 821	3 883 369
1995–96	1 846 196	285 263	2 131 459	**5 400**	**203 588**	208 988	2 340 447
1996–97	1 701 757	**7 660**	1 709 417	135 820	1 329 482	1 465 302	3 174 719
1997–98	2 647 311	**1 500**	2 648 811	326 224	929 562	1 255 786	3 904 597
1998–99	0	0	0	174 930	1 340 985	1 515 915	1 515 915
1999–00	0	0	0	134 400	1 018 492	1 152 892	1 152 892
Total	7 706 282	980 953	8 687 235	18 049 314	35 400 156	53 449 470	62 136 705

Table 7: Monthly distribution of observed hooks (percentages of fishing year totals) by fleet, region, and fishing year. One large domestic vessel was grouped with the foreign and charter vessels. No hooks were observed in October or November. Source: Scientific observer database.

Fleet	Region	Fishing year	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Domestic	North	1994–95	24	36	11						21	7
		1995–96	4	17	17			26	36	1		
		1996–97		18	35	11	11	15	9			
		1997–98			50	18	13		20			
		1998–99	44	39	17							
		1999–00	12	19	43	16	2		9			
		Total	11	20	29	8	5	8	13		4	1
	South	1995–96					42	44	7	7		
		Total					42	44	7	7		
	Total		9	15	23	6	13	16	12	2	3	1
Foreign and charter	North	1988–89							100			
		1989–90							18	63	19	
		1990–91							20	56	25	
		1991–92						19	69	13		
		1992–93							52	47	1	
		1993–94							100			
		1994–95							7	55	38	
		1996–97							42	58		
		1997–98							36	54	10	
		1998–99								53	47	
		1999–00							61	39		
		Total						2	44	43	11	
	South	1988–89						71	3			
		1989–90					32	42	26			
		1990–91							49	51		
		1991–92					35	57		8		
		1992–93					39	42	12	8		
		1993–94					23	53	20	0		
		1994–95					19	37	30	13		
		1996–97				4	21	43	32			
		1997–98				6	12	47	35			
		1998–99					17	35	41	6		
		1999–00					18	43	35	4		
		Total				2	22	43	28	5		
	Total					1	17	33	32	14	3	
Total			0	1	1	2	17	32	31	14	3	0

Table 8: Species and numbers of fish recorded by scientific observers aboard tuna longline vessels for the 1998–99 and 1999–2000 fishing years, and the combined total for 1 October 1988 – 30 September 2000. Species are listed in descending order of total number observed. Source: Scientific observer database (includes all trips except those for one observer who did not record non-target fish species accurately).

		Number observed		
Common name	Scientific name	1998–99	1999–00	Total 1988–00
Blue shark	*Prionace glauca*	9 806	5 994	95 505
Albacore tuna	*Thunnus alalunga*	2 456	1 651	38 830
Ray's bream	*Brama brama*	2 998	2 020	30 448
Southern bluefin tuna	*Thunnus maccoyii*	2 887	1 801	20 540
Porbeagle and mako shark	*Lamna nasus & Isurus oxyrinchus*	–	–	16 662
Porbeagle shark	*Lamna nasus*	2 788	961	–
Mako shark	*Isurus oxyrinchus*	258	133	–
Dealfish	*Trachipterus trachypterus*	996	1 202	10 019
Moonfish	*Lampris guttatus*	563	476	5 319
Oilfish	*Ruvettus pretiosus*	221	102	5 116
Deepwater dogfish	Squaliformes	1 357	456	4 371
Broadbill swordfish	*Xiphias gladius*	344	310	3 478
Lancetfish	*Alepisaurus ferox & A. brevirostris*	–	–	3 358
Shortnose lancetfish	*Alepisaurus brevirostris*	44	4	–
Longnose lancetfish	*Alepisaurus ferox*	564	402	–
Butterfly tuna	*Gasterochisma melampus*	360	305	3 149
Teleosts, unidentified	Teleostei	567	629	3 141
Rudderfish	*Centrolophus niger*	798	439	2 356
School shark	*Galeorhinus galeus*	379	119	2 253
Bigeye tuna	*Thunnus obesus*	262	100	1 559
Escolar	*Lepidocybium flavobrunneum*	201	521	1 502
Hoki	*Macruronus novaezelandiae*	271	106	907
Yellowfin tuna	*Thunnus albacares*	69	42	906
Sunfish	*Mola mola*	54	100	822
Big scale pomfret	*Taractichthys longipinnis*	165	94	796
Pelagic stingray	*Pteroplatytrygon violacea*	46	58	677
Thresher shark	*Alopias vulpinus*	110	75	565
Barracouta	*Thyrsites atun*	70	68	330
Striped marlin	*Tetrapturus audax*	43	14	267
Black barracouta	*Nesiarchus nasutus*	62	130	232
Skipjack tuna	*Katsuwonus pelamis*	3	8	188
Spiny dogfish	*Squalus acanthias*	6	1	161
Shark, unidentified	Selachii	0	1	150
Slender tuna	*Allothunnus fallai*	7	7	138
Northern bluefin tuna	*Thunnus orientalis*	5	4	134
Taractes asper	*Taractes asper*	25	13	89
Ray, unidentified	Myliobatiformes	0	0	79
Hapuku bass	*Polyprion oxygeneios & P. americanus*	10	12	59
Kingfish	*Seriola lalandi*	33	1	53
Shortbill spearfish	*Tetrapturus angustirostris*	36	2	48
Opah	*Lampris immaculatus*	19	6	45
Snipe eel	Nemichthyidae	10	12	40
Bronze whaler shark	*Carcharhinus brachyurus*	2	1	37
Dolphinfish	*Coryphaena hippurus*	19	0	31

(continued)

Table 8 (continued):

Common name	Scientific name	Number observed 1998–99	1999–00	Total 1988–00
Wingfish	*Pteraclis velifera*	3	1	19
Hake	*Merluccius australis*	8	2	17
Bigeye thresher	*Alopias superciliosus*	0	1	16
Gemfish	*Rexea solandri*	2	2	10
Pilotfish	*Naucrates ductor*	0	0	8
Hammerhead shark	*Sphyrna zygaena*	0	1	7
Oceanic whitetip shark	*Carcharhinus longimanus*	0	1	7
Ragfish	*Icichthys australis*	0	0	7
Blue marlin	*Makaira mazara*	0	0	6
Remora	Echeneidae	0	0	6
Frostfish	*Lepidopus caudatus*	2	0	5
Unicornfish	*Lophotus capellei*	0	0	5
Ribaldo	*Mora moro*	0	0	5
Squid	Cephalopoda	0	1	4
Bluenose	*Hyperoglyphe antarctica*	0	0	4
False frostfish	*Paradiplospinus gracilis*	0	0	4
Great white shark	*Carcharodon carcharias*	0	0	3
Octopus	Cephalopoda	1	0	2
Carpet shark	*Cephaloscyllium isabellum*	0	0	2
Broadnose seven gill shark	*Notorynchus cepedianus*	0	0	2
Wahoo	*Acanthocybium solandri*	1	0	1
Cubehead	*Cubiceps baxteri*	0	0	1
Manefish	*Caristius* spp.	0	0	1
Blue mackerel	*Scomber australasicus*	0	0	1
Frigate tuna	*Auxis thazard*	0	0	1
Sharpnose seven gill shark	*Heptranchias perlo*	0	0	1
Cookiecutter shark	*Isistius brasiliensis*	0	0	1
Red cod	*Pseudophycis bachus*	0	0	1
Seahorse	*Hippocampus abdominalis*	0	0	1
Tiger shark	*Galeocerdo cuvier*	0	0	1
Tubbia	*Tubbia tasmanica*	0	0	1
White warehou	*Seriolella caerulea*	0	0	1
All species		28 931	18 389	254 511

Table 9: Comparison of observed catch per unit effort (number per 1000 hooks) by two foreign and charter vessels operating on the east coast South Island (ECSI) and west coast South Island (WCSI) in 1998–99 and 1999–2000.

Fishing		Vessel 1		Vessel 2	
Year	Species	ECSI	WCSI	ECSI	WCSI
1998–99		17 sets	58 sets	19 sets	64 sets
	Blue shark	3.17	10.00	3.06	4.93
	Porbeagle shark	2.23	2.95	1.82	1.84
	Mako shark	0.00	0.16	0.09	0.10
	Deepwater dogfish	0.42	1.37	0.25	0.87
	School shark	0.00	0.48	0.00	0.29
	Albacore	0.00	0.73	0.00	0.27
	Southern bluefin tuna	1.37	2.81	1.42	2.00
	Broadbill swordfish	0.00	0.20	0.00	0.18
	Butterfly tuna	1.41	0.23	1.07	0.20
	Ray's bream	3.87	2.26	0.74	0.46
	Dealfish	0.00	1.48	0.07	0.45
	Moonfish	0.02	0.22	0.02	0.18
	Rudderfish	0.00	0.94	0.00	0.18
1999–00		6 sets	56 sets	15 sets	51 sets
	Blue shark	2.94	11.03	4.14	8.52
	Porbeagle shark	1.67	1.92	1.56	1.27
	Mako shark	0.06	0.09	0.02	0.04
	Deepwater dogfish	0.50	1.14	0.35	0.28
	School shark	0.00	0.25	0.00	0.10
	Albacore	0.00	0.50	0.00	0.25
	Southern bluefin tuna	0.33	3.47	0.75	1.92
	Broadbill swordfish	0.00	0.24	0.00	0.14
	Butterfly tuna	2.00	0.31	2.12	0.16
	Ray's bream	2.00	5.52	0.85	1.11
	Dealfish	0.17	1.98	0.06	1.70
	Moonfish	0.06	0.16	0.13	0.19
	Rudderfish	0.00	0.92	0.00	0.18

Table 10: Percentage maturity of blue sharks by region, sex, and fishing year. Maturity was determined from shark length (see text). Sample sizes less than 50 not shown. Totals are for 1991–92 to 1999–2000.

Region	Sex	Fishing year	Percentage immature	Percentage mature	Sample size
North	Male	1991–92	95	5	186
		1992–93	87	13	550
		1993–94	49	51	125
		1994–95	43	57	142
		1995–96	83	17	318
		1996–97	81	19	103
		1997–98	61	39	352
		1998–99	44	56	145
		1999–00	39	61	148
		Total	**71**	**29**	**2 069**
	Female	1991–92	97	3	152
		1992–93	99	1	626
		1993–94	100	0	54
		1994–95	86	14	204
		1995–96	94	6	86
		1996–97	100	0	54
		1997–98	96	4	324
		1998–99	78	22	155
		Total	**94**	**6**	**1 675**
South	Male	1992–93	99	1	614
		1993–94	99	1	151
		1994–95	83	18	120
		1995–96	98	2	763
		1996–97	99	1	375
		1997–98	96	4	360
		1998–99	98	2	971
		1999–00	96	4	262
		Total	**97**	**3**	**3 629**
	Female	1992–93	96	4	1 131
		1993–94	84	16	599
		1994–95	85	15	254
		1995–96	96	4	1 852
		1996–97	94	6	974
		1997–98	99	1	1 173
		1998–99	97	3	2 833
		1999–00	99	1	1 283
		Total	**96**	**4**	**10 145**

Table 11: Estimated total weights and mean fish weights of blue, porbeagle, and mako sharks caught by tuna longliners. Values in parentheses are for the foreign and charter fleet (including one large domestic vessel) only, because observer coverage of the domestic fleet was inadequate for estimating their catch. Total New Zealand landings reported on Licensed Fish Receiver Returns (LFRR) are also shown.

	Fishing	Total weight (t)			LFRR	Mean shark weight (kg)	
Species	year	North	South	Total	landings (t)	North	South
Blue shark	1996–97	386	414	800	303	27	20
	1997–98	1 146	223	1 369	537	32	25
	1998–99	(100)	(273)	(373)	525	(41)	(24)
	1999–00	(94)	(181)	(275)	841	(59)	(22)
Porbeagle shark	1996–97	76	69	145	52	35	34
	1997–98	61	85	146	162	42	36
	1998–99	(14)	(131)	(145)	240	(40)	(38)
	1999–00	(4[1])	(58)	(62)	180	–	(38)
Mako shark	1996–97	104	9	113	55	42	71
	1997–98	181	7	188	76	62	80
	1998–99	(9)	(15)	(24)	98	(63)	(82)
	1999–00	(4)	(8)	(13)	179	(77)	(86)

[1] Estimate based on length-frequency distribution from South region.

Table 12: Percentage maturity of porbeagle sharks by region, sex, and fishing year. Maturity was determined from shark length (see text). Sample sizes less than 50 not shown. Totals are for 1992–93 to 1999–2000.

Region	Sex	Fishing year	Percentage immature	Percentage mature	Sample size
North	Male	1992–93	96	4	74
		1996–97	64	36	159
		1997–98	67	33	214
		1998–99	78	22	97
		Total	**73**	**27**	**579**
	Female	1992–93	100	0	58
		1996–97	99	1	84
		1997–98	92	8	91
		Total	**97**	**3**	**305**
South	Male	1992–93	97	3	159
		1993–94	96	4	111
		1996–97	90	10	335
		1997–98	89	11	483
		1998–99	85	15	1 078
		1999-00	83	17	245
		Total	**88**	**12**	**2 425**
	Female	1992–93	99	1	176
		1993–94	99	1	97
		1996–97	97	3	403
		1997–98	94	6	441
		1998–99	97	3	792
		1999-00	97	3	214
		Total	**97**	**3**	**2 132**

Table 13: Percentage maturity of mako sharks by region, sex and fishing year. Maturity was determined from shark length (see text). Sample sizes less than 50 not shown. Totals are for 1992–93 to 1999–2000.

Region	Sex	Fishing year	Percentage immature	Percentage mature	Sample size
North	Male	1996–97	77	23	109
		1997–98	55	45	67
		Total	**68**	**32**	**317**
	Female	1996–97	99	1	85
		1997–98	98	2	95
		Total	**98**	**2**	**286**
South	Male	1997–98	22	78	51
		1998–99	19	81	104
		Total	**24**	**76**	**280**

Table 14: Numbers of marlin reported by tuna longline vessels on TLCERs. No blue marlin were reported.

Fishing year	Striped marlin	Black marlin	Sailfish	Shortbill spearfish
1990–91	21	3	0	3
1991–92	17	0	0	0
1992–93	7	0	0	1
1993–94	63	0	0	4
1994–95	150	1	0	2
1995–96	422	0	6	10
1996–97	355	1	0	0
1997–98	467	5	0	0
1998–99	1 651	7	2	17
1999–00	806	1	0	7

Table 15: Numbers and percentages of domestic hooks set and observed by month in 1998–99 in the area 33–40° S and 171–180° E, and number of striped marlin observed. Sources: Scientific observer and TLCER databases (CELR data not available).

Month	Hooks set	Hooks observed	Percentage of hooks observed	Number of marlin observed
October 1998	145 485	0	0.0	
November	219 530	0	0.0	
December	297 051	15 662	5.3	6
January 1999	433 706	13 632	3.1	33
February	423 430	5 970	1.4	2
March	613 312	0	0.0	
April	416 715	0	0.0	
May	541 920	0	0.0	
June	537 110	0	0.0	
July	435 940	0	0.0	
August	478 934	0	0.0	
September	438 315	0	0.0	
Total	4 981 448	35 264	0.7	41

Table 16: Numbers and percentages of domestic hooks set and observed by month in 1999–2000 in the area 33–40° S and 171–180° E, and number of striped marlin observed. Sources: Scientific observer and TLCER databases (CELR data not available).

Month	Hooks set	Hooks observed	Percentage of hooks observed	Number of marlin observed
October 1999	451 670	0	0.0	
November	488 867	0	0.0	
December	494 243	4 520	0.9	0
January 2000	542 574	7 140	1.3	6
February	585 417	15 335	2.6	5
March	572 755	5 974	1.0	1
April	525 685	0	0.0	
May	713 431	0	0.0	
June	568 297	3 400	0.6	0
July	347 880	0	0.0	
August	488 860	0	0.0	
September	401 970	0	0.0	
Total	6 181 649	36 369	0.6	12

Table 17: Percentages of main non-target species that were alive or dead when observed, 1992–93 to 1999–2000. Sharks. Strata with sample sizes less than 50 fish not shown.

Species	Fleet	Region	Percentage alive	Percentage dead	Number observed
Blue shark	Domestic	North	90.36	9.64	2 095
		South	89.73	10.27	3 397
		Total	89.97	10.03	5 492
	Foreign + charter	North	82.43	17.57	7 388
		South	87.17	12.83	26 602
		Total	86.14	13.86	33 990
	Total		**86.67**	**13.33**	**39 482**
Porbeagle shark	Domestic	North	49.01	50.99	404
		South	54.58	45.42	273
		Total	51.26	48.74	677
	Foreign + charter	North	51.31	48.69	1 978
		South	62.32	37.68	8 319
		Total	60.20	39.80	10 297
	Total		**59.65**	**40.35**	**10 974**
Mako shark	Domestic	North	76.53	23.47	473
		Total	76.75	23.25	486
	Foreign + charter	North	76.27	23.73	632
		South	79.74	20.26	543
		Total	77.87	22.13	1 175
	Total		**77.54**	**22.46**	**1 661**
Deepwater dogfish	Foreign + charter	South	81.32	18.68	4 063
		Total	81.32	18.68	4 063
	Total		**81.22**	**18.78**	**4 100**
School shark	Domestic	South	79.13	20.87	115
		Total	73.28	26.72	131
	Foreign + charter	North	52.63	47.37	95
		South	71.85	28.15	1 755
		Total	70.86	29.14	1 850
	Total		**71.02**	**28.98**	**1 981**

(continued)

Table 17 (continued): Teleosts.

Species	Fleet	Region	Percentage alive	Percentage dead	Number observed
Ray's bream	Domestic	North	73.42	26.58	79
		South	88.53	11.47	828
		Total	87.21	12.79	907
	Foreign + charter	North	69.23	30.77	91
		South	82.78	17.22	9 734
		Total	82.66	17.34	9 825
	Total		**83.04**	**16.96**	**10 732**
Dealfish	Domestic	South	17.39	82.61	69
		Total	21.69	78.31	83
	Foreign + charter	South	13.29	86.71	5 777
		Total	13.30	86.70	5 781
	Total		**13.42**	**86.58**	**5 864**
Oilfish	Domestic	North	84.08	15.92	245
		Total	84.15	15.85	246
	Foreign + charter	North	63.66	36.34	974
		South	42.67	57.33	75
		Total	62.15	37.85	1049
	Total		**66.33**	**33.67**	**1295**
Moonfish	Domestic	North	68.24	31.76	551
		South	75.00	25.00	84
		Total	69.13	30.87	635
	Foreign + charter	North	69.91	30.09	2 446
		South	82.33	17.67	832
		Total	73.06	26.94	3 278
	Total		**72.43**	**27.57**	**3 913**
Lancetfish	Domestic	North	45.30	54.70	2 137
		Total	45.22	54.78	2 143
	Foreign + charter	North	44.70	55.30	472
		South	77.03	22.97	74
		Total	49.08	50.92	546
	Total		**46.00**	**54.00**	**2 689**
Rudderfish	Domestic	North	94.16	5.84	137
		South	89.91	10.09	109
		Total	92.28	7.72	246
	Foreign + charter	North	79.25	20.75	53
		South	83.14	16.86	1 862
		Total	83.03	16.97	1 915
	Total		**84.08**	**15.92**	**2 161**
Butterfly tuna	Foreign + charter	North	23.87	76.13	419
		South	33.81	66.19	1 760
		Total	31.90	68.10	2 179
	Total		**31.79**	**68.21**	**2 196**

Table 18: Numbers of striped marlin landed alive and dead by observed foreign and charter and domestic vessels. Totals are for 1992–93 to 1999–2000.

Fleet	Fishing year	Alive	Dead	Total	Percent alive
Domestic	1998–99	36	5	41	87.8
	1999–00	7	5	12	58.3
	Total	**157**	**58**	**215**	**73.0**
Foreign + charter	1998–99	2	0	2	100.0
	1999–00	2	0	2	100.0
	Total	**22**	**12**	**34**	**64.7**
Total		**179**	**70**	**249**	**71.9**

Table 19: Percentages of main non-target species that were discarded or lost, and retained or finned from 1992–93 to 1999–2000. Sharks. Strata with sample sizes less than 50 fish not shown.

Species	Fleet	Region	Percentage discarded or lost	Percentage retained or finned	Number observed
Blue shark	Domestic	North	38.87	61.13	2 097
		South	15.11	84.89	3 395
		Total	24.18	75.82	5 492
	Foreign + charter	North	41.20	58.80	7 423
		South	32.78	67.22	26 791
		Total	34.60	65.40	34 214
	Total		**33.16**	**66.84**	**39 706**
Porbeagle shark	Domestic	North	19.06	80.94	404
		South	8.06	91.94	273
		Total	14.62	85.38	677
	Foreign + charter	North	41.33	58.67	1 996
		South	21.22	78.78	8 413
		Total	25.07	74.93	10 409
	Total		**24.44**	**75.56**	**11 086**
Mako shark	Domestic	North	40.17	59.83	473
		Total	39.92	60.08	486
	Foreign + charter	North	10.11	89.89	643
		South	27.45	72.55	550
		Total	18.11	81.89	1 193
	Total		**24.42**	**75.58**	**1 679**
Deepwater dogfish	Foreign + charter	South	99.78	0.22	4 082
		Total	99.78	0.22	4 082
	Total		**99.71**	**0.29**	**4 119**
School shark	Domestic	South	1.74	98.26	115
		Total	4.58	95.42	131
	Foreign + charter	North	56.25	43.75	96
		South	38.42	61.58	1 770
		Total	39.34	60.66	1 866
	Total		**37.06**	**62.94**	**1 997**

(continued)

Table 19 (continued): Teleosts.

Species	Fleet	Region	Percentage discarded or lost	Percentage retained	Number observed
Ray's bream	Domestic	North	6.33	93.67	79
		South	4.50	95.50	822
		Total	4.66	95.34	901
	Foreign + charter	North	89.01	10.99	91
		South	90.86	9.14	9 752
		Total	90.85	9.15	9 843
	Total		**83.62**	**16.38**	**10 744**
Dealfish	Domestic	South	100.00	0.00	69
		Total	100.00	0.00	83
	Foreign + charter	South	99.93	0.07	5 868
		Total	99.93	0.07	5 872
	Total		**99.93**	**0.07**	**5 955**
Oilfish	Domestic	North	30.20	69.80	245
		Total	30.49	69.51	246
	Foreign + charter	North	99.71	0.29	1 026
		South	100.00	0.00	75
		Total	99.73	0.27	1 101
	Total		**87.08**	**12.92**	**1 347**
Moonfish	Domestic	North	5.82	94.18	550
		South	8.43	91.57	83
		Total	6.16	93.84	633
	Foreign + charter	North	7.11	92.89	2 530
		South	28.35	71.65	843
		Total	12.42	87.58	3 373
	Total		**11.43**	**88.57**	**4 006**
Lancetfish	Domestic	North	99.44	0.56	2 141
		Total	99.44	0.56	2 147
	Foreign + charter	North	99.58	0.42	473
		South	98.72	1.28	78
		Total	99.46	0.54	551
	Total		**99.44**	**0.56**	**2 698**
Rudderfish	Domestic	North	29.20	70.80	137
		South	97.25	2.75	109
		Total	59.35	40.65	246
	Foreign + charter	North	100.00	0.00	53
		South	99.63	0.37	1 897
		Total	99.64	0.36	1 950
	Total		**95.13**	**4.87**	**2 196**
Butterfly tuna	Foreign + charter	North	2.51	97.49	438
		South	4.10	95.90	1 782
		Total	3.78	96.22	2 220
	Total		**3.76**	**96.24**	**2 237**

Table 20: Processing method applied to sharks, 1992–93 to 1999–2000.

Species	Fleet	Percentage finned	Percentage processed for flesh	Number observed
Blue shark	Domestic	97.6	2.4	4 164
	Foreign + charter	99.2	0.8	22 341
	Total	**98.9**	**1.1**	**26 505**
Porbeagle shark	Domestic	95.9	4.1	578
	Foreign + charter	80.3	19.7	7 612
	Total	**81.4**	**18.6**	**8 190**
Mako shark	Domestic	88.7	11.3	292
	Foreign + charter	10.7	89.3	939
	Total	**29.2**	**70.8**	**1 231**
School shark	Domestic	11.2	88.8	196
	Foreign + charter	9.3	90.7	1 061
	Total	**9.6**	**90.4**	**1 257**

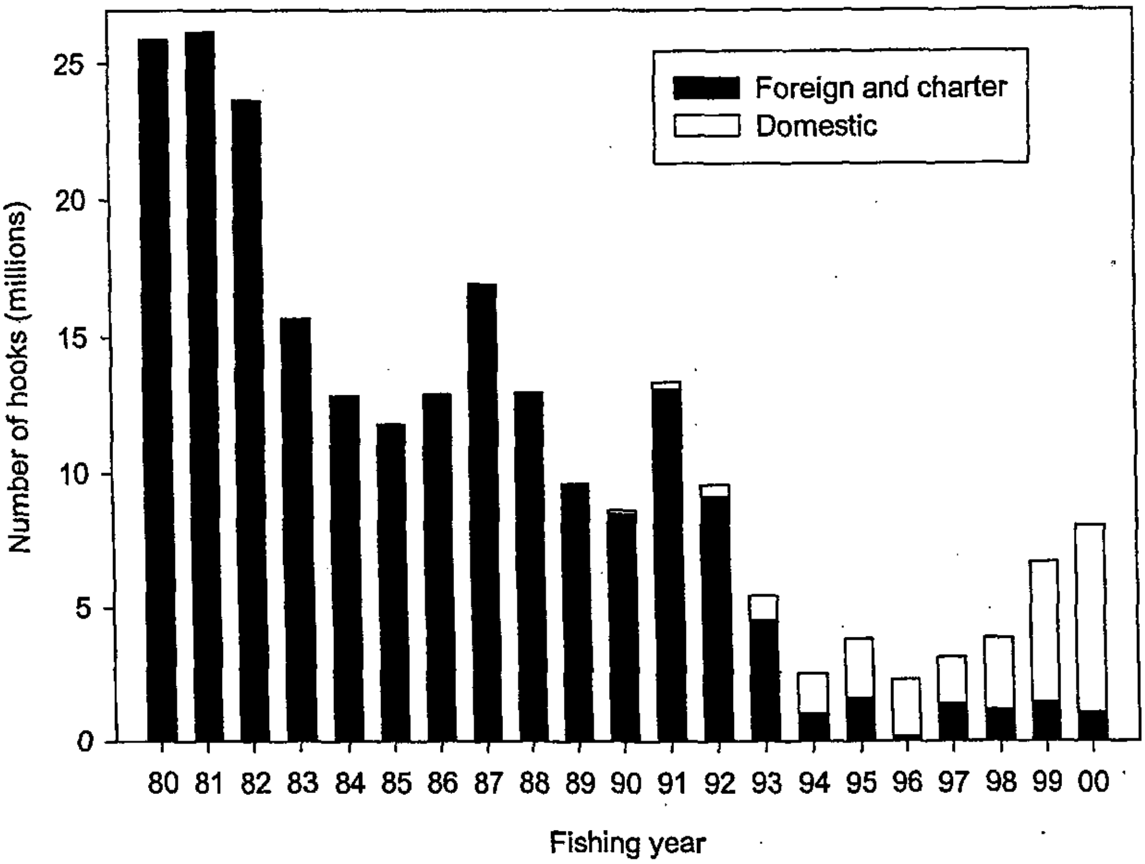


Figure 1: Reported number of hooks set in the tuna longline fishery by fleet and fishing year. One large domestic vessel was grouped with the foreign and charter fleet. Fishing year 80 = October 1979 to September 1980.

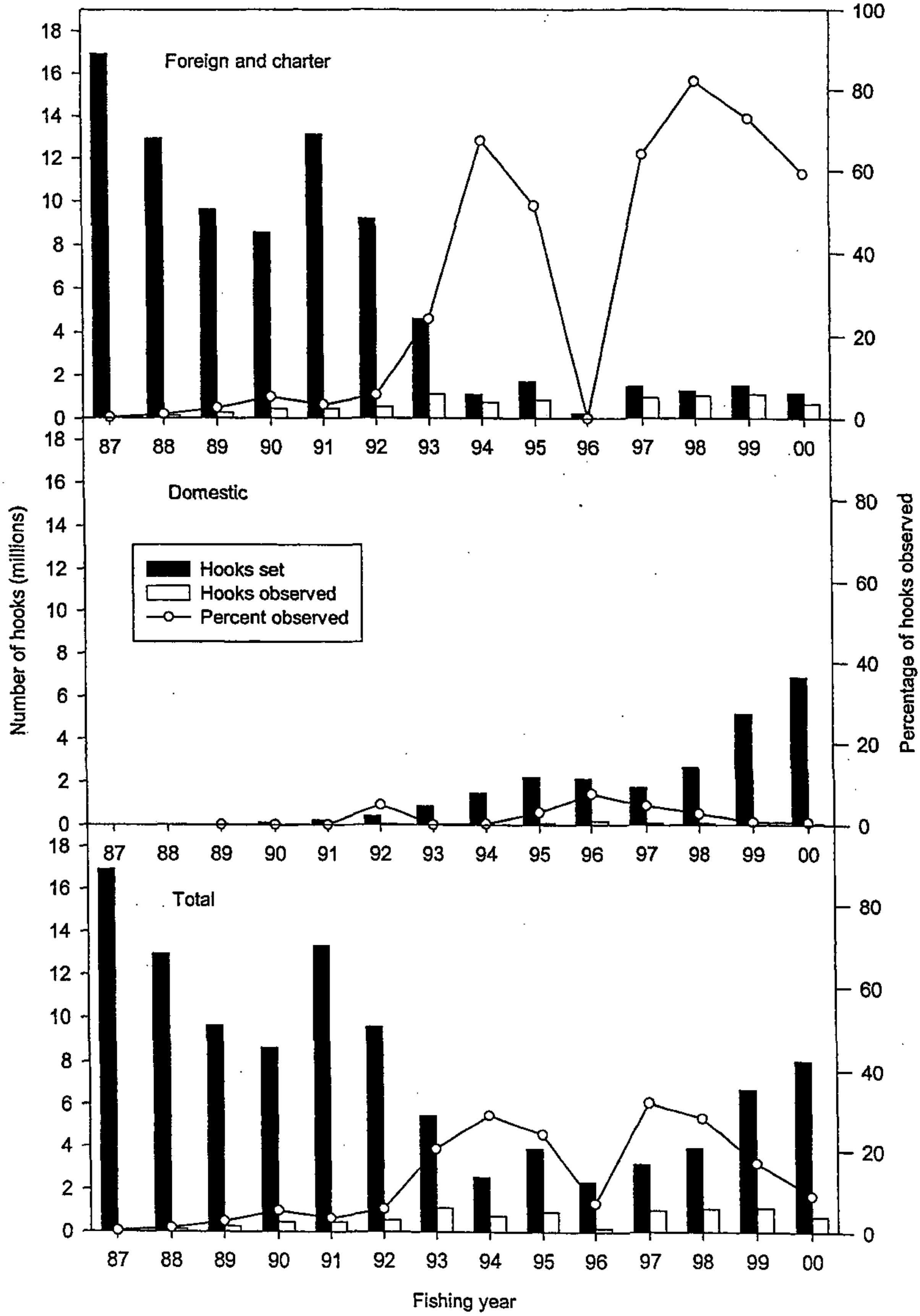


Figure 2: Numbers of hooks set and observed, and percentage of hooks observed, by fleet and fishing year. One large domestic vessel was grouped with the foreign and charter vessels. Fishing year 87 = October 1986 to September 1987.

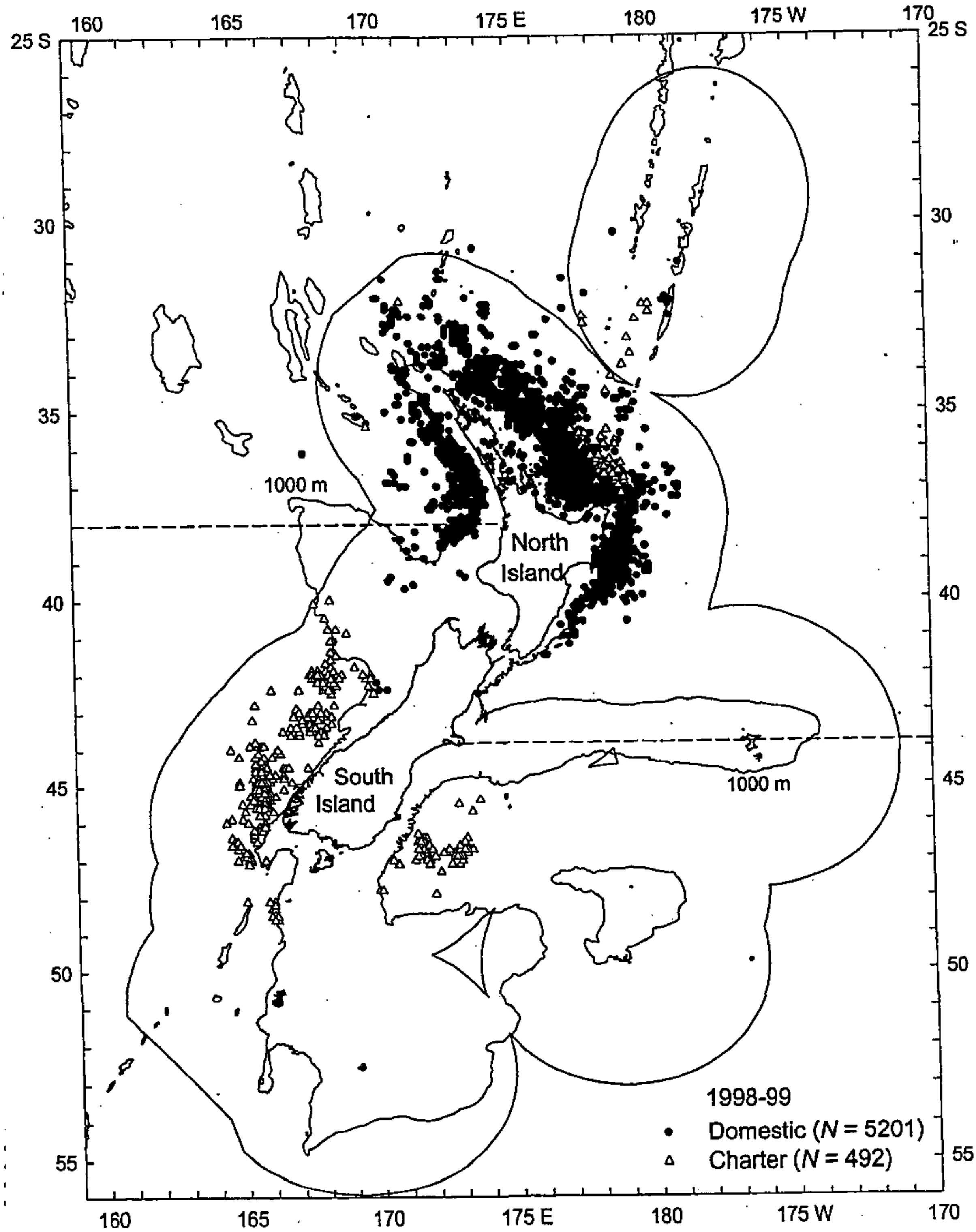


Figure 3: Start positions for tuna longline sets reported on TLCERs in 1998–99. One large domestic vessel was grouped with the foreign and charter fleet.

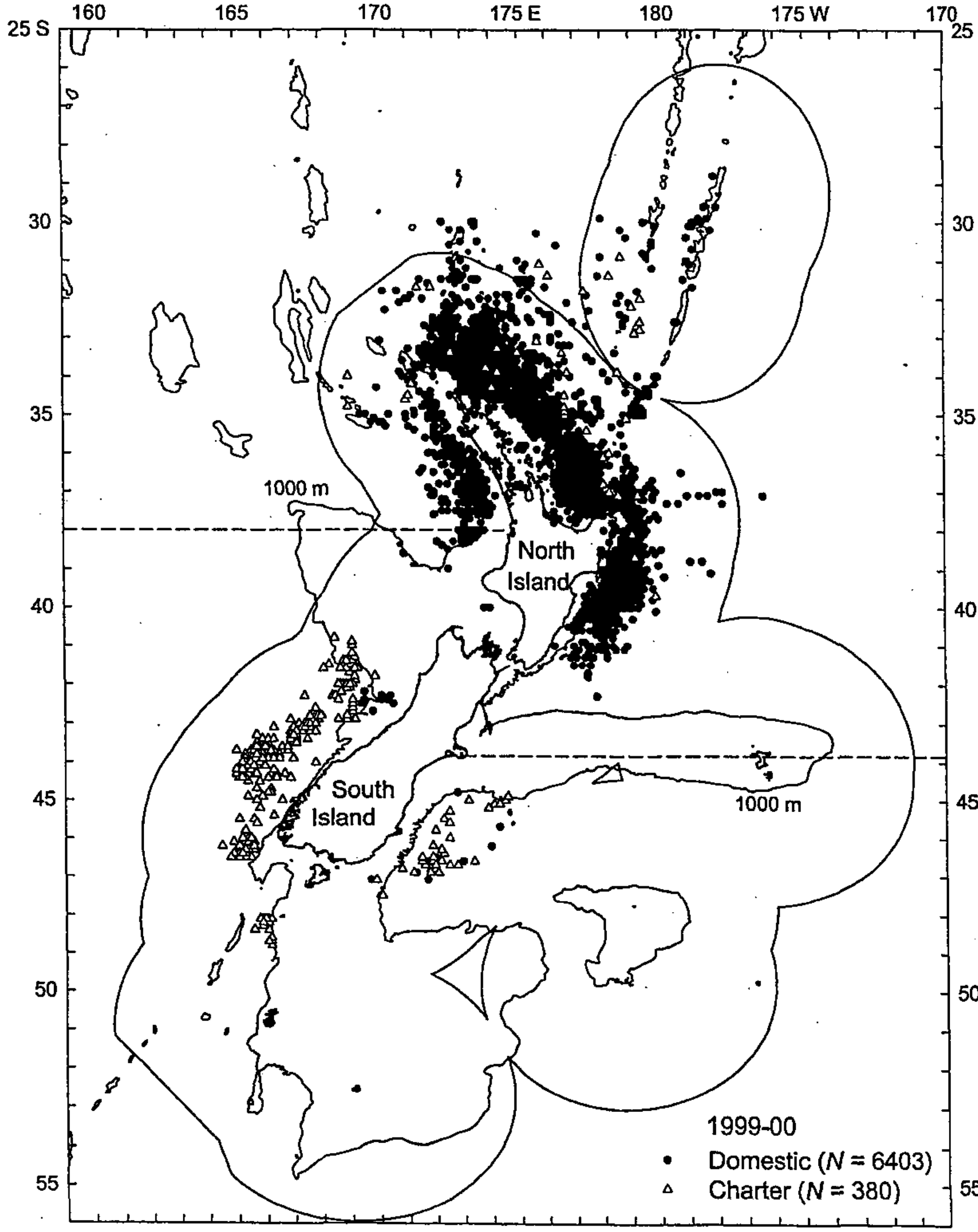


Figure 4: Start positions for tuna longline sets reported on TLCERs in 1999–2000. One large domestic vessel was grouped with the foreign and charter fleet.

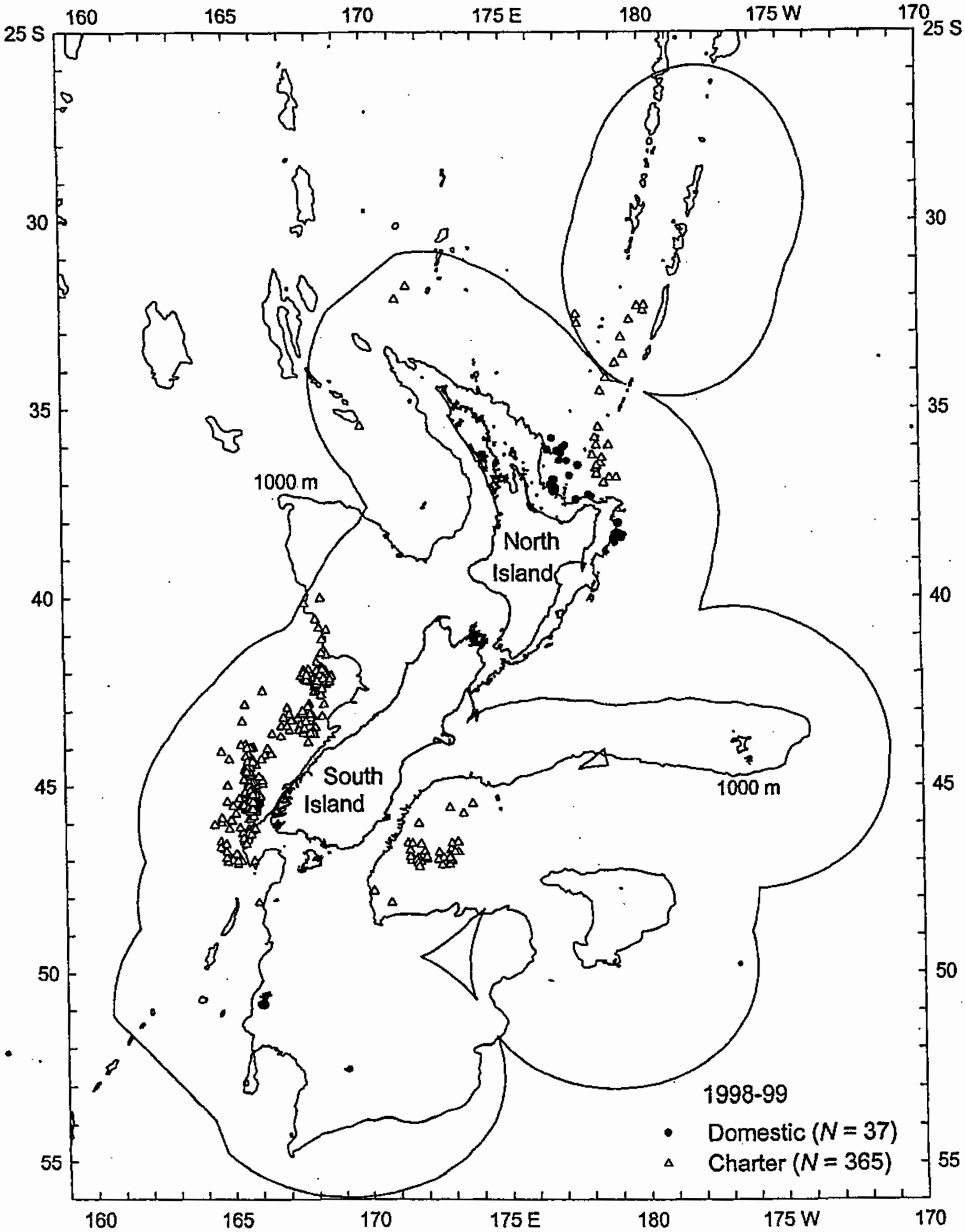


Figure 5: Start positions of observed tuna longline sets 1998–99.

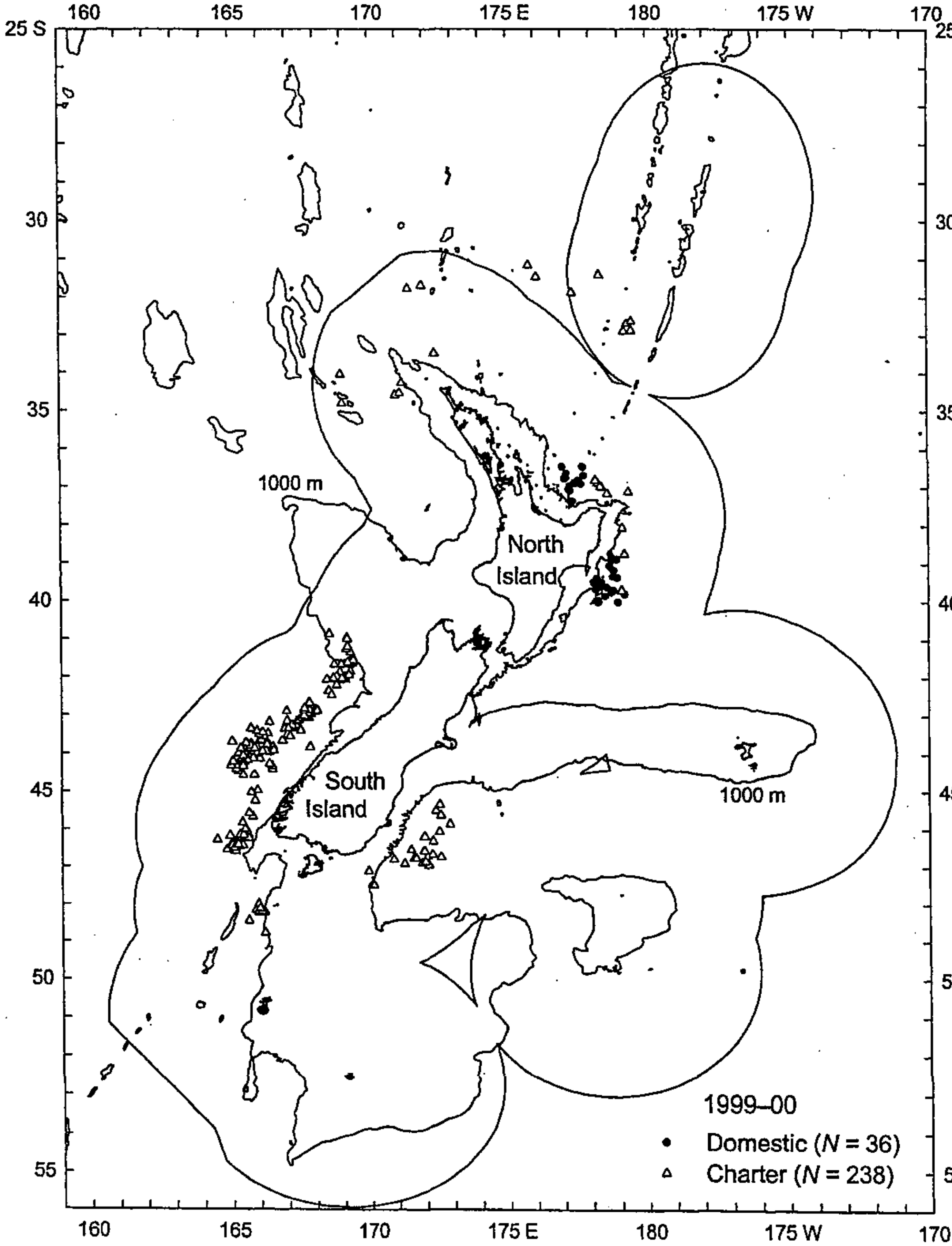


Figure 6: Start positions of observed tuna longline sets 1999–2000.

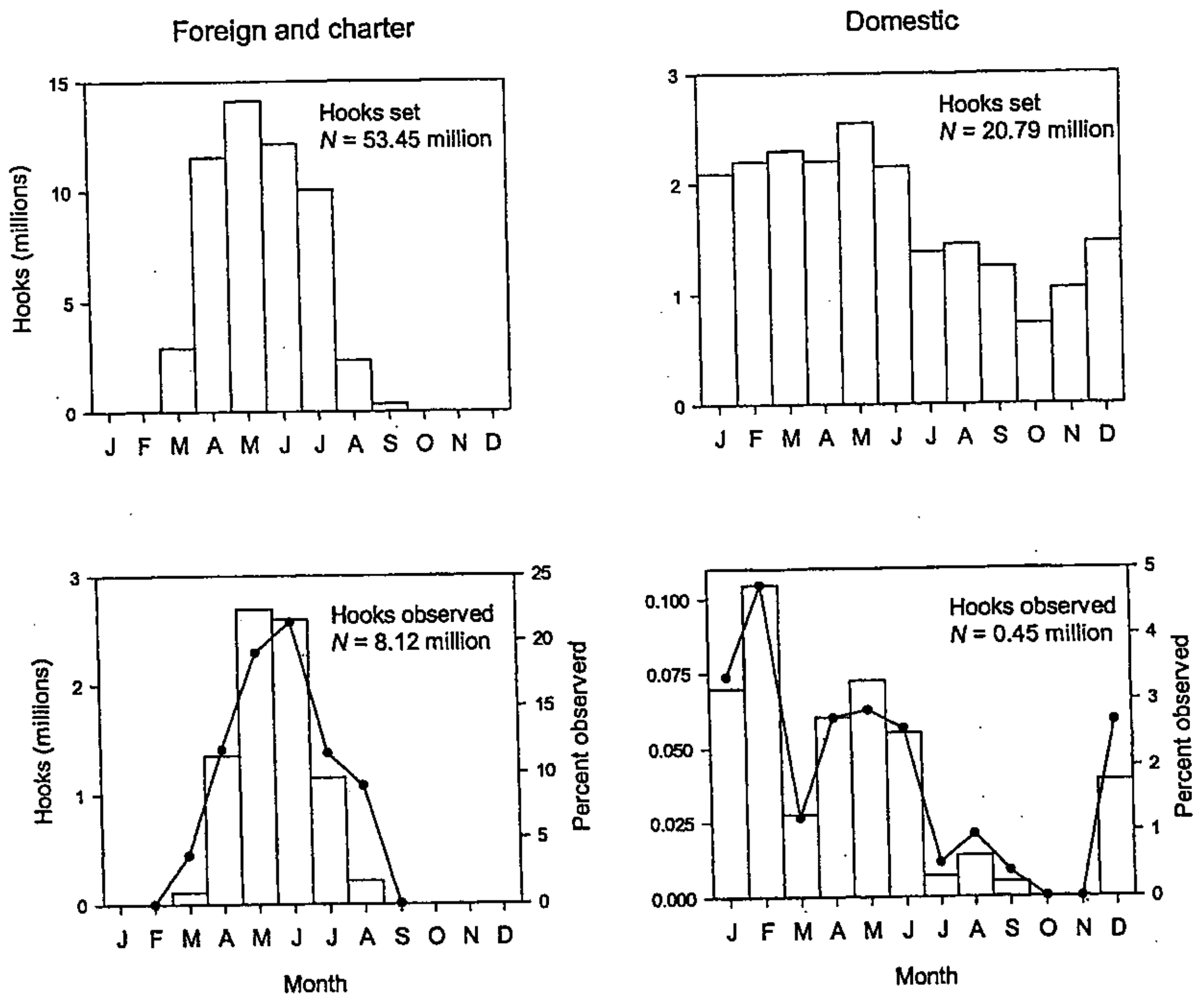


Figure 7: Seasonal distribution of set and observed hooks (histograms) and percentage of hooks observed (lines), October 1988 to September 2000. One large domestic vessel was grouped with the foreign and charter vessels. N, sample size.

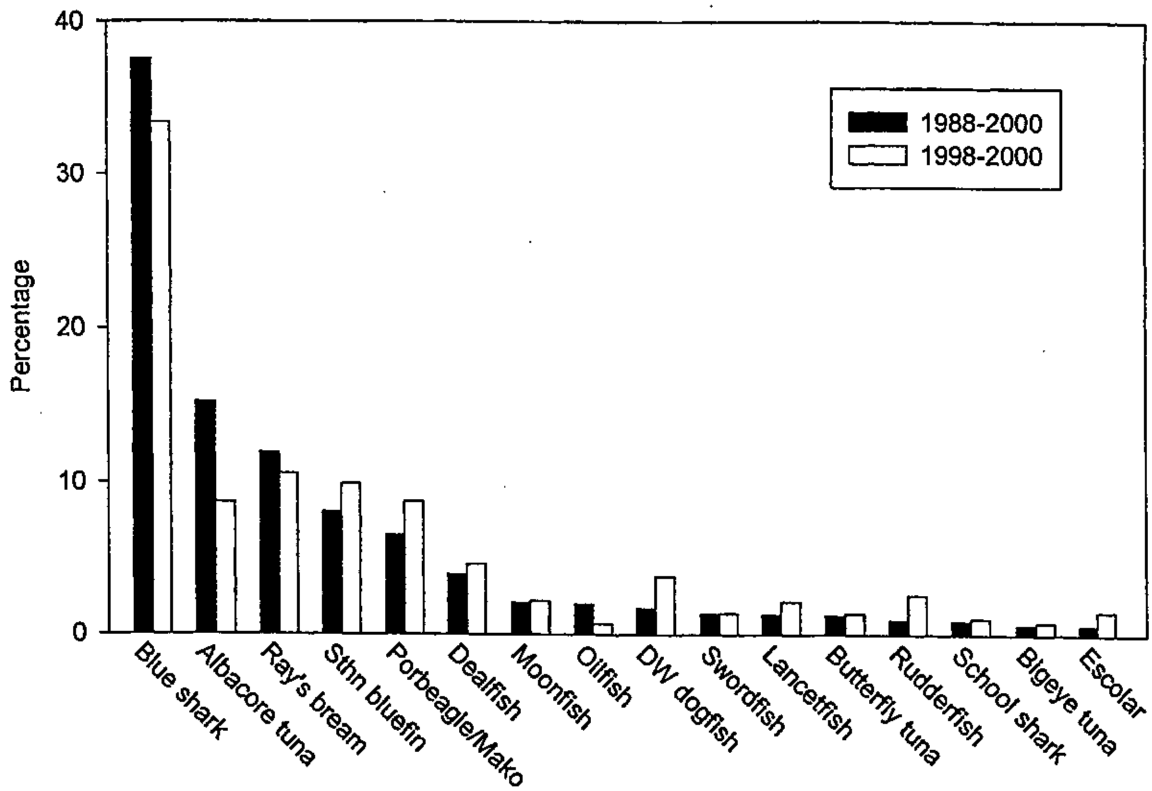


Figure 8: Percentage of each species observed in the tuna longline fishery, 1988–2000 and 1998–2000.

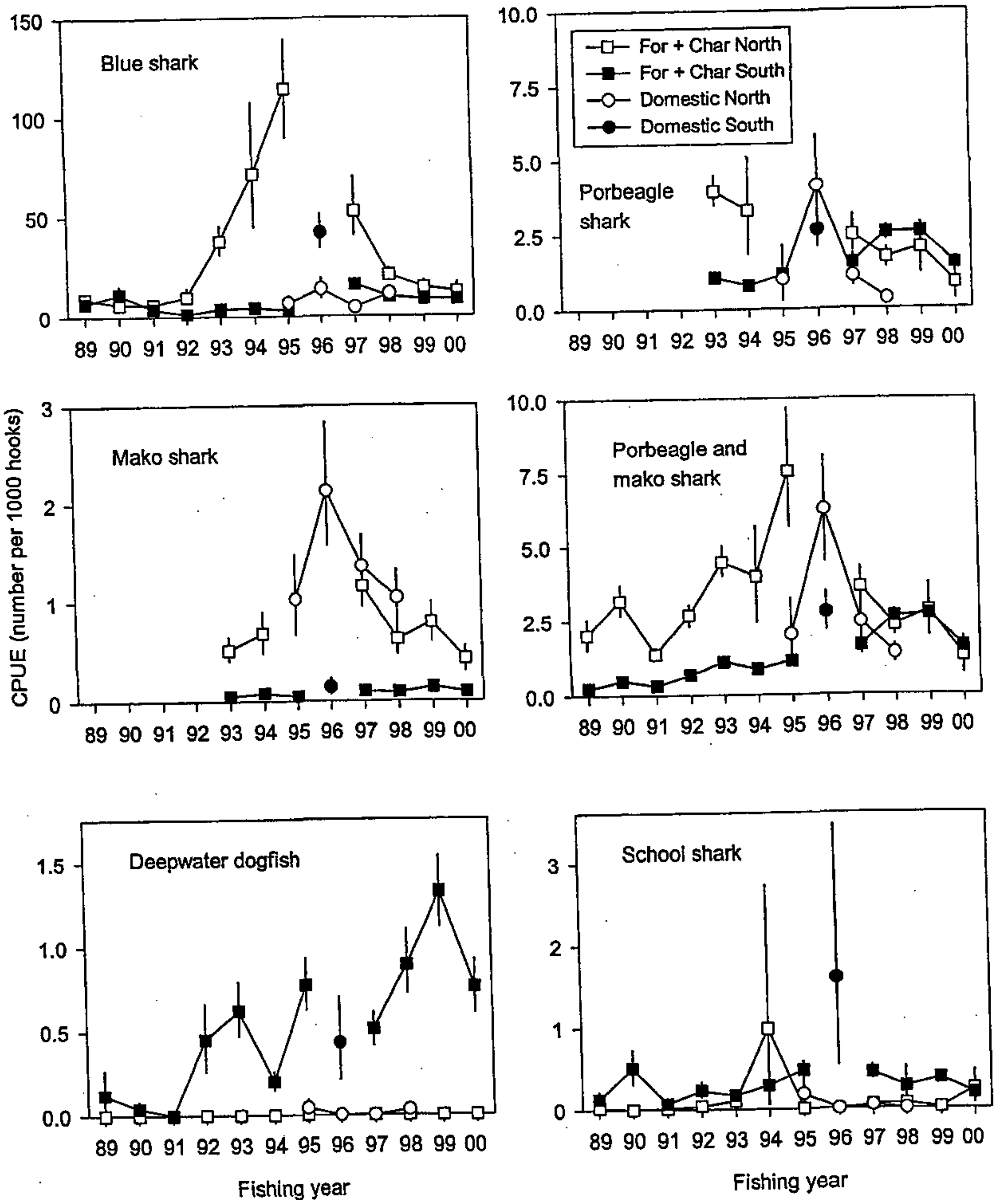


Figure 9: Annual variation in catch per unit effort (CPUE) for the foreign and charter (For + Char), and domestic fleets fishing in the north and south regions – Sharks. Plotted values are the mean estimates with bootstrap 95% confidence limits. Fishing year 89 = October 1988 to September 1989.

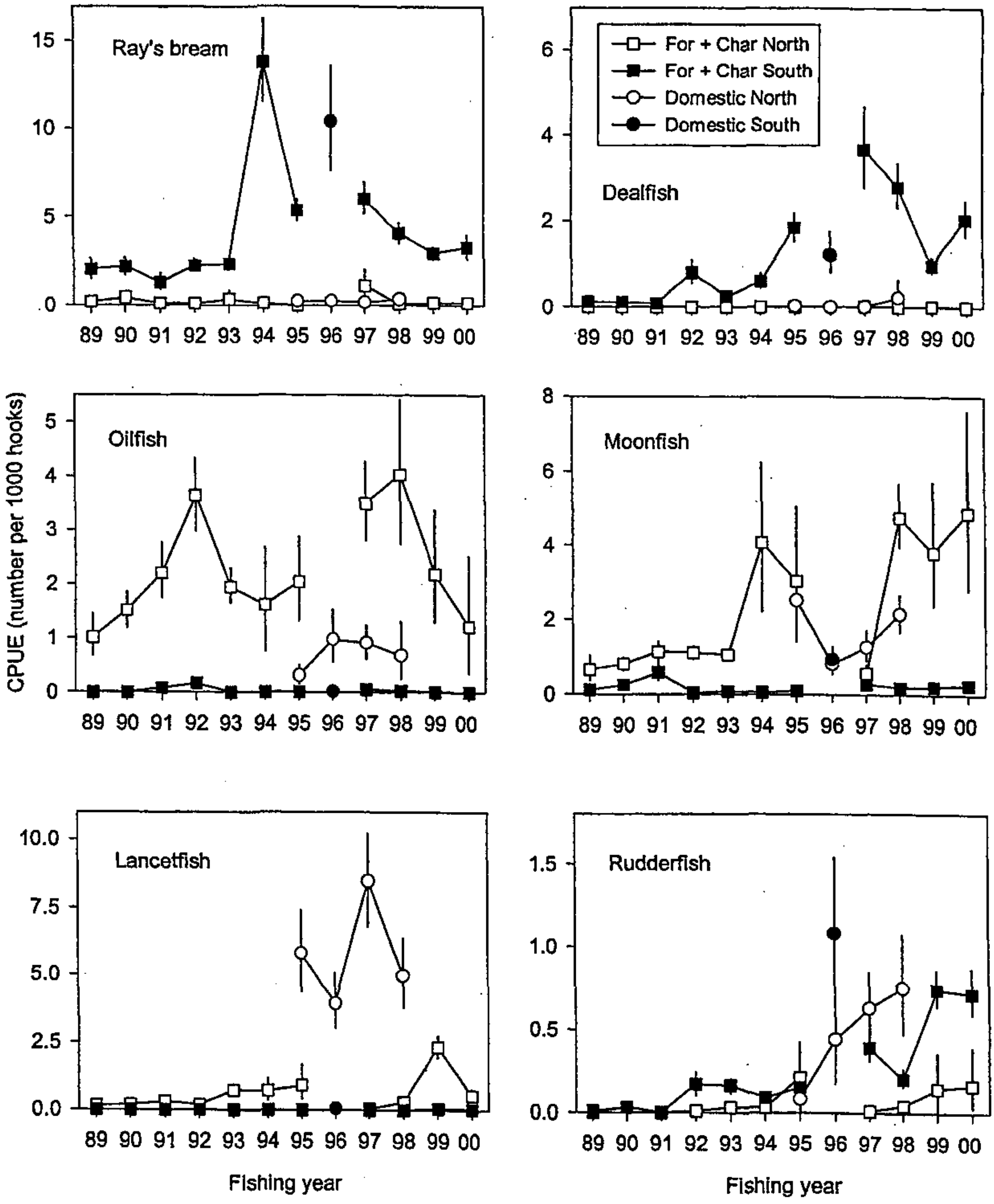


Figure 9 (continued): Annual variation in catch per unit effort (CPUE) for the foreign and charter (For + Char), and domestic fleets fishing in the north and south regions – Other species. Plotted values are the mean estimates with bootstrap 95% confidence limits. Fishing year 89 = October 1988 to September 1989.

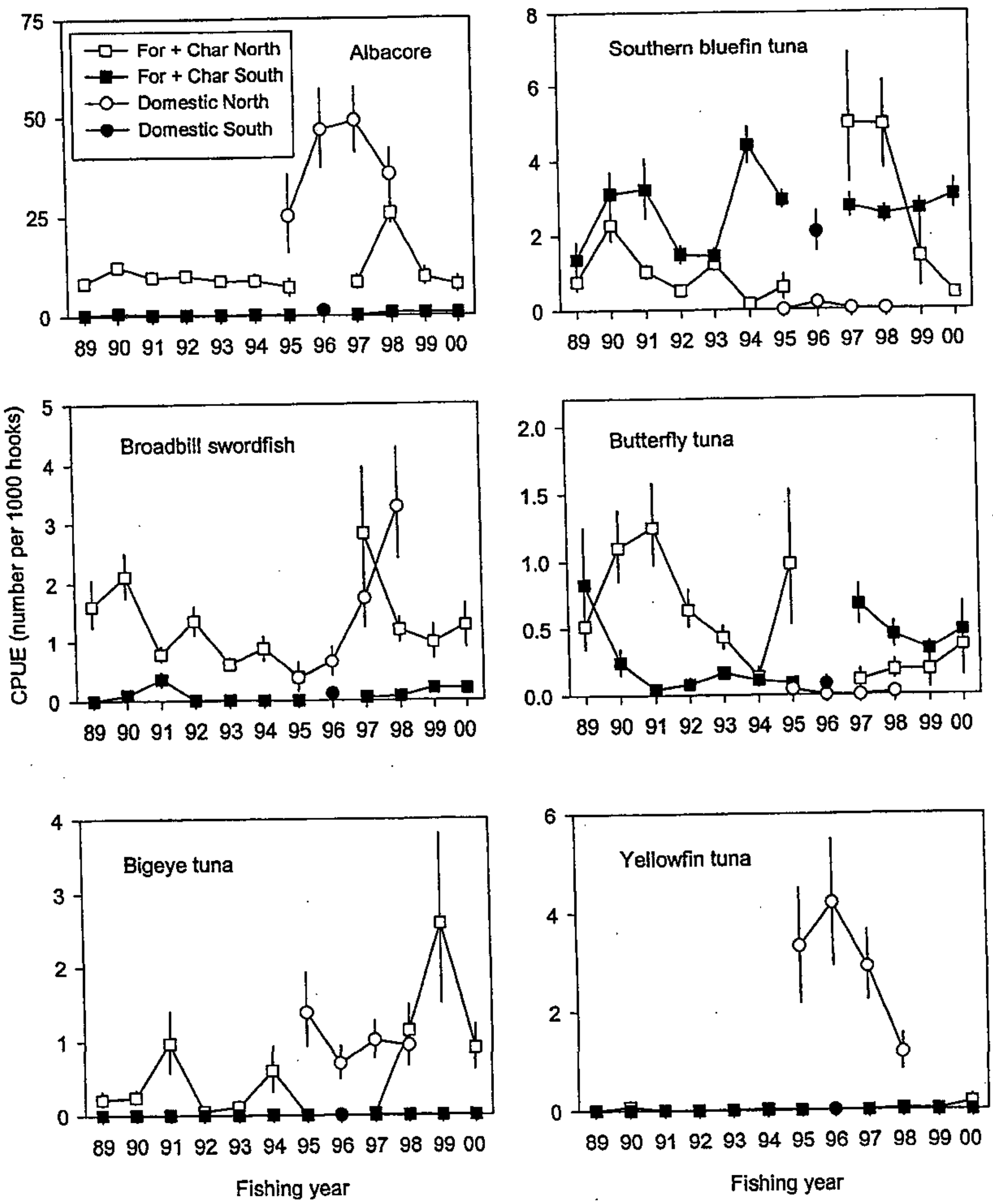


Figure 9 (continued): Annual variation in catch per unit effort (CPUE) for the foreign and charter (For + Char), and domestic fleets fishing in the north and south regions – Tunas and broadbill swordfish. Plotted values are the mean estimates with bootstrap 95% confidence limits. Fishing year 89 = October 1988 to September 1989.

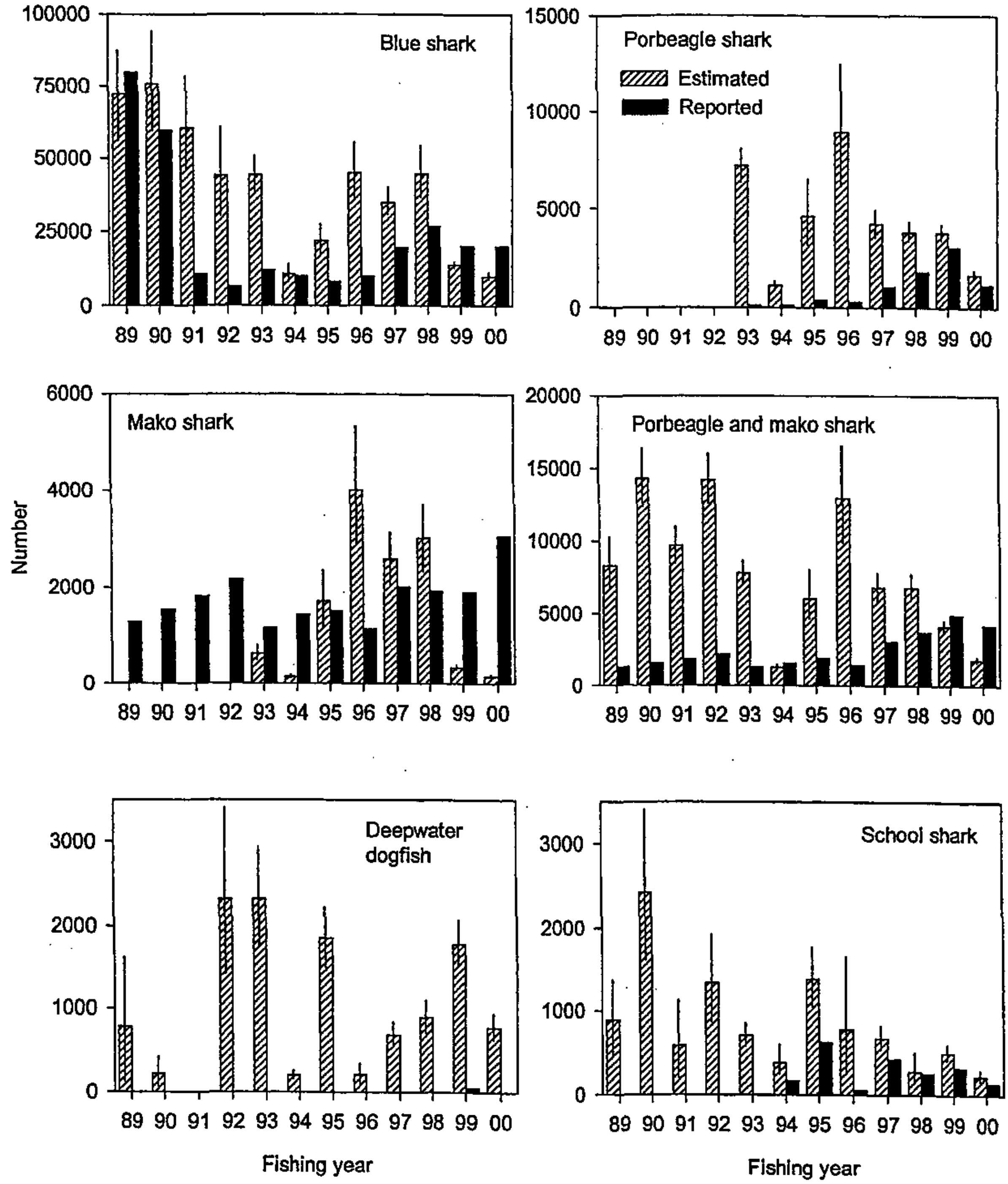


Figure 10: Estimates of scaled total numbers of fish caught (with 95% confidence limits) and numbers reported by vessel skippers on TLCERs – Sharks. The estimated values underestimate actual catches in 1992–93 and 1993–94 because some domestic vessels were not included, and in 1998–99 and 1999–2000 because all domestic vessels were omitted. Fishing year 89 = October 1988 to September 1989. See text for further details.

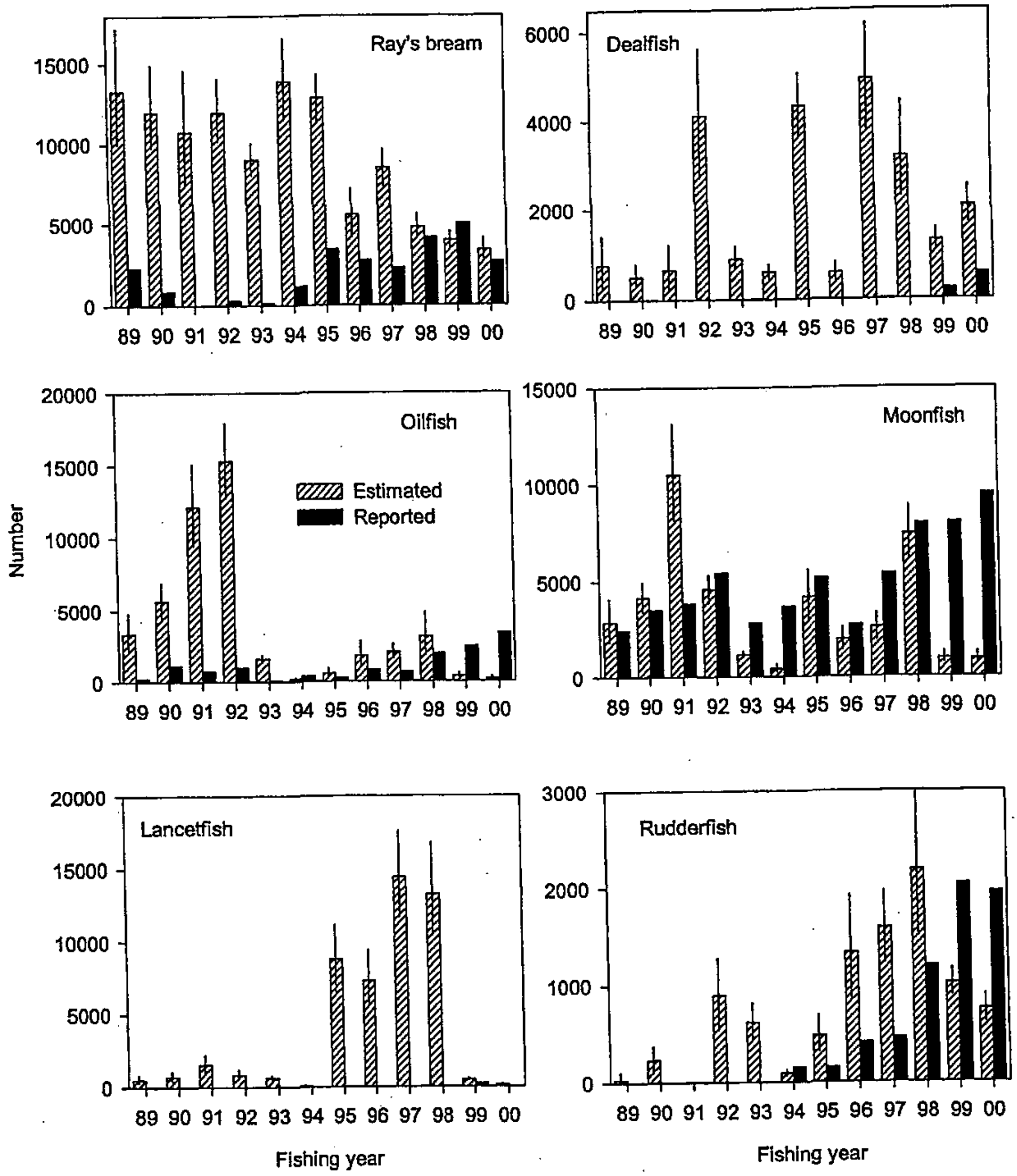


Figure 10 (continued): Estimates of scaled total numbers of fish caught (with 95% confidence limits) and numbers reported by vessel skippers on TLCERs – Other species. The estimated values under-estimate actual catches in 1992–93 and 1993–94 because some domestic vessels were not included, and in 1998–99 and 1999–2000 because all domestic vessels were omitted. Fishing year 89 = October 1988 to September 1989. See text for further details.

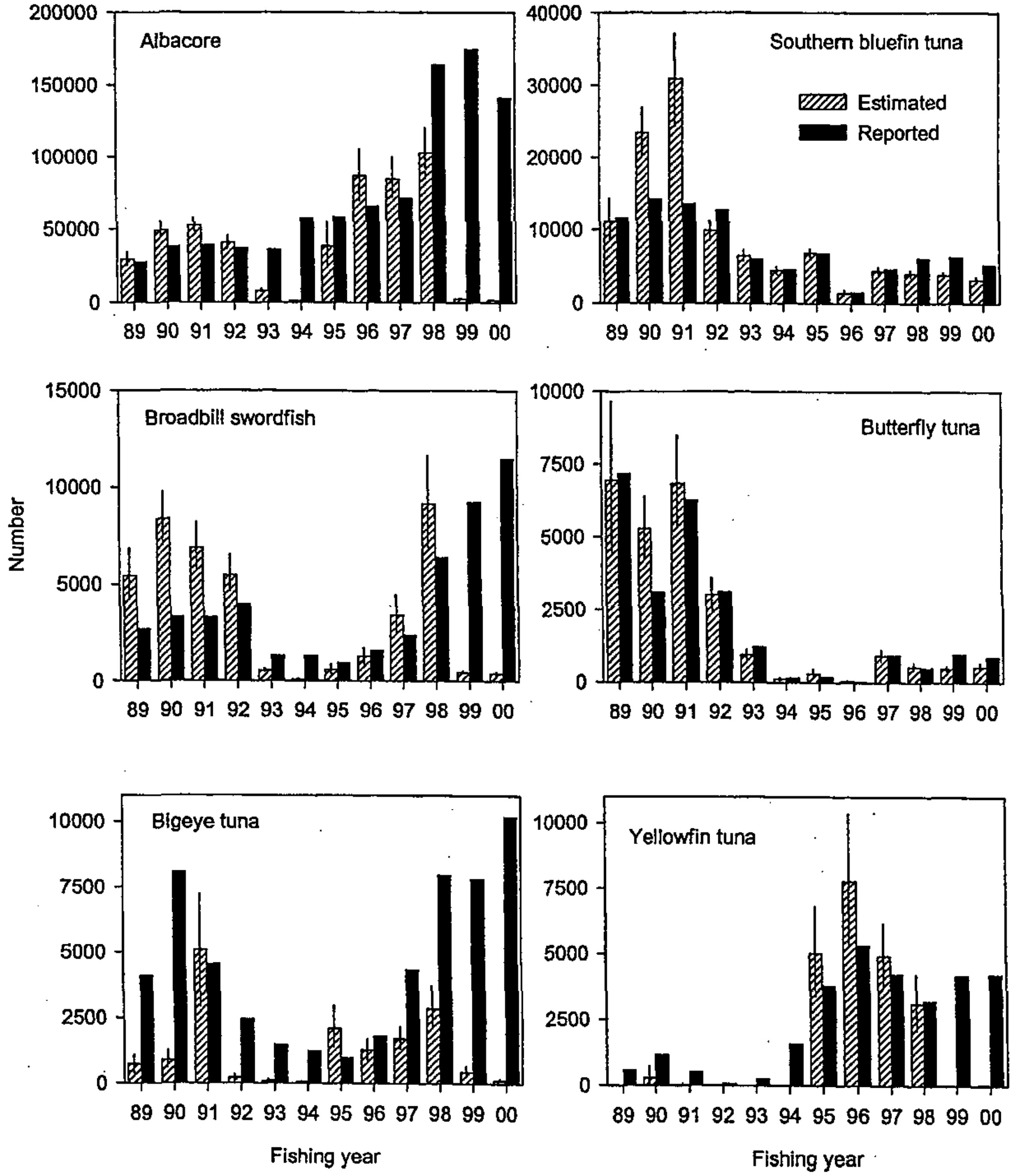


Figure 10 (continued): Estimates of scaled total numbers of fish caught (with 95% confidence limits) and numbers reported by vessel skippers on TLCERs – Tunas and broadbill swordfish. The estimated values under-estimate actual catches in 1992–93 and 1993–94 because some domestic vessels were not included, and in 1998–99 and 1999–2000 because all domestic vessels were omitted. Fishing year 89 = October 1988 to September 1989. See text for further details.

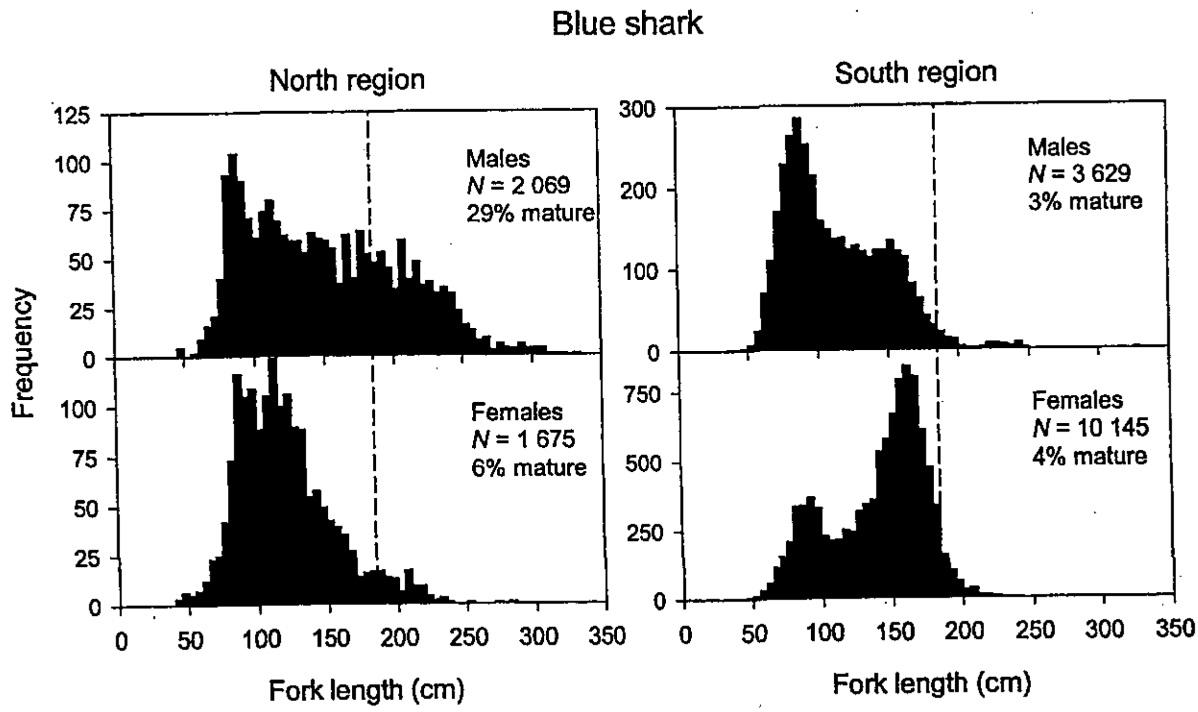


Figure 11: Blue shark length-frequency distributions by region and sex, pooled data from 1991–92 to 1999–2000. Dashed lines indicate approximate length at 50% maturity (185 cm for both sexes). N, sample size.

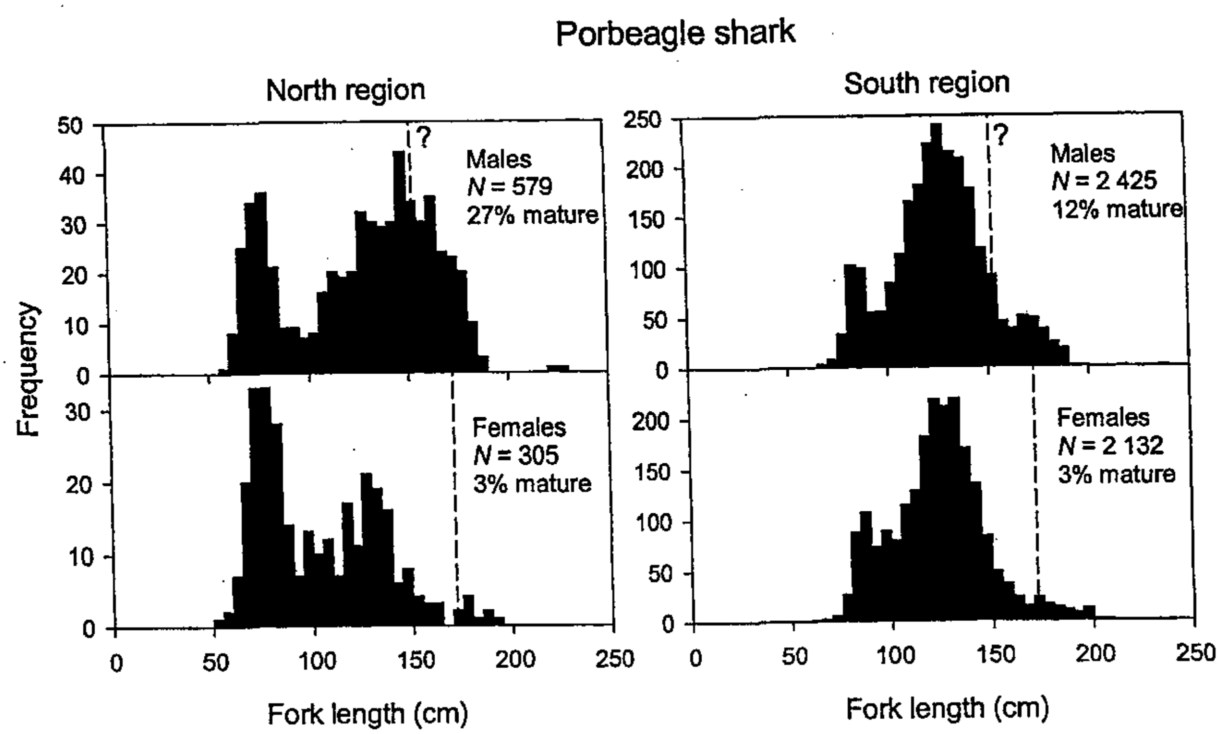


Figure 12: Porbeagle shark length-frequency distributions by region and sex, pooled data from 1992–93 to 1999–2000. Dashed lines indicate approximate length at 50% maturity (153 cm for males and 172 cm for females). N, sample size.

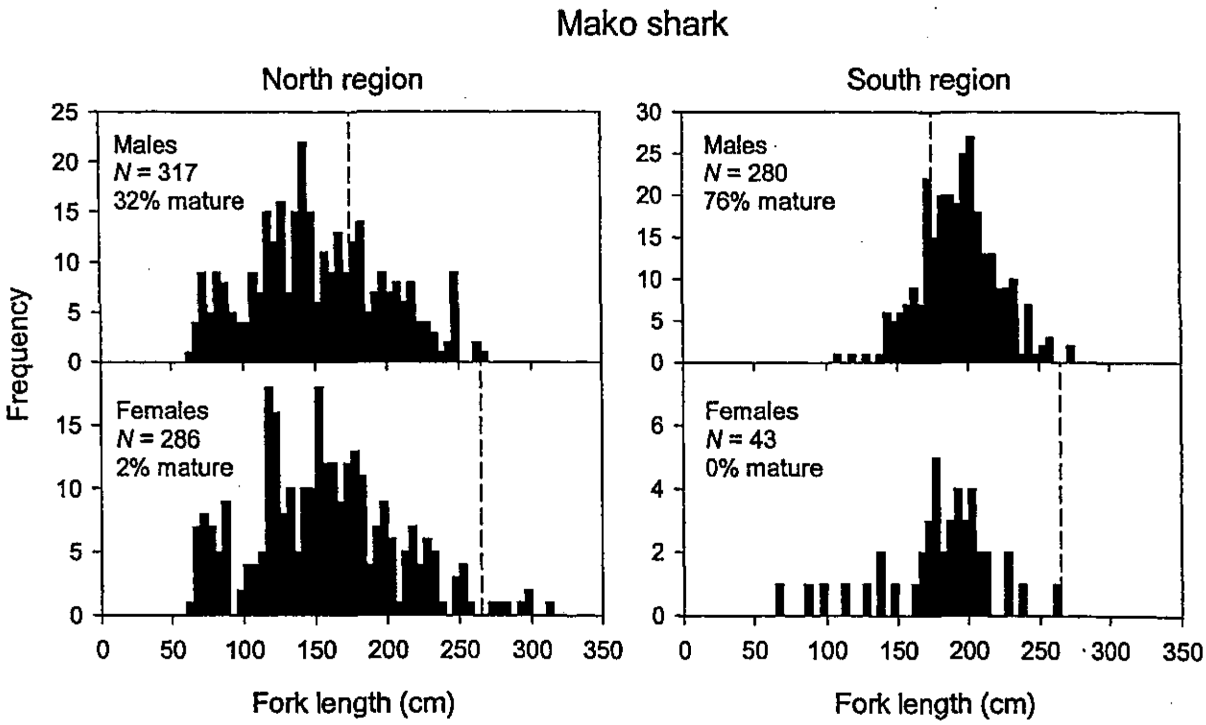


Figure 13: Mako shark length-frequency distributions by region and sex, pooled data from 1992–93 to 1999–2000. Dashed lines indicate approximate length at 50% maturity (175 cm for males and 265 cm for females). N, sample size.

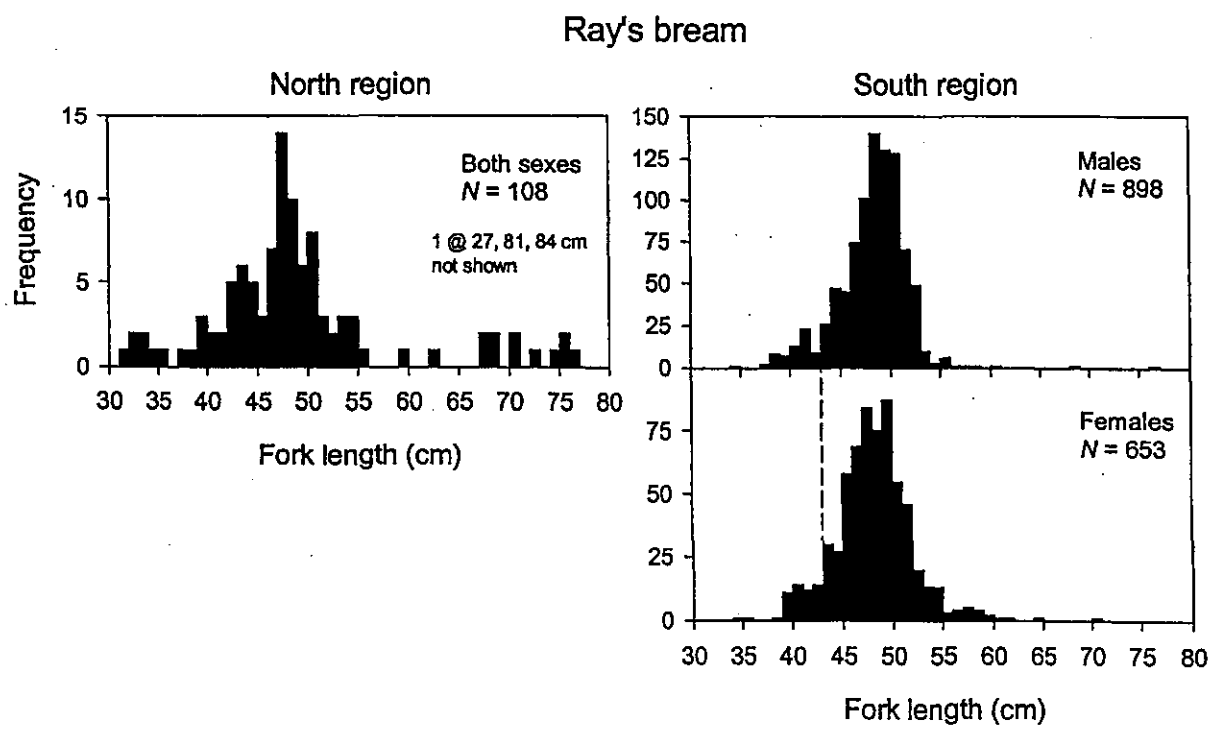


Figure 14: Ray's bream length-frequency distributions by region and sex, pooled data from 1991–92 to 1999–2000. Dashed line indicates approximate female length at maturity (43 cm). N, sample size.

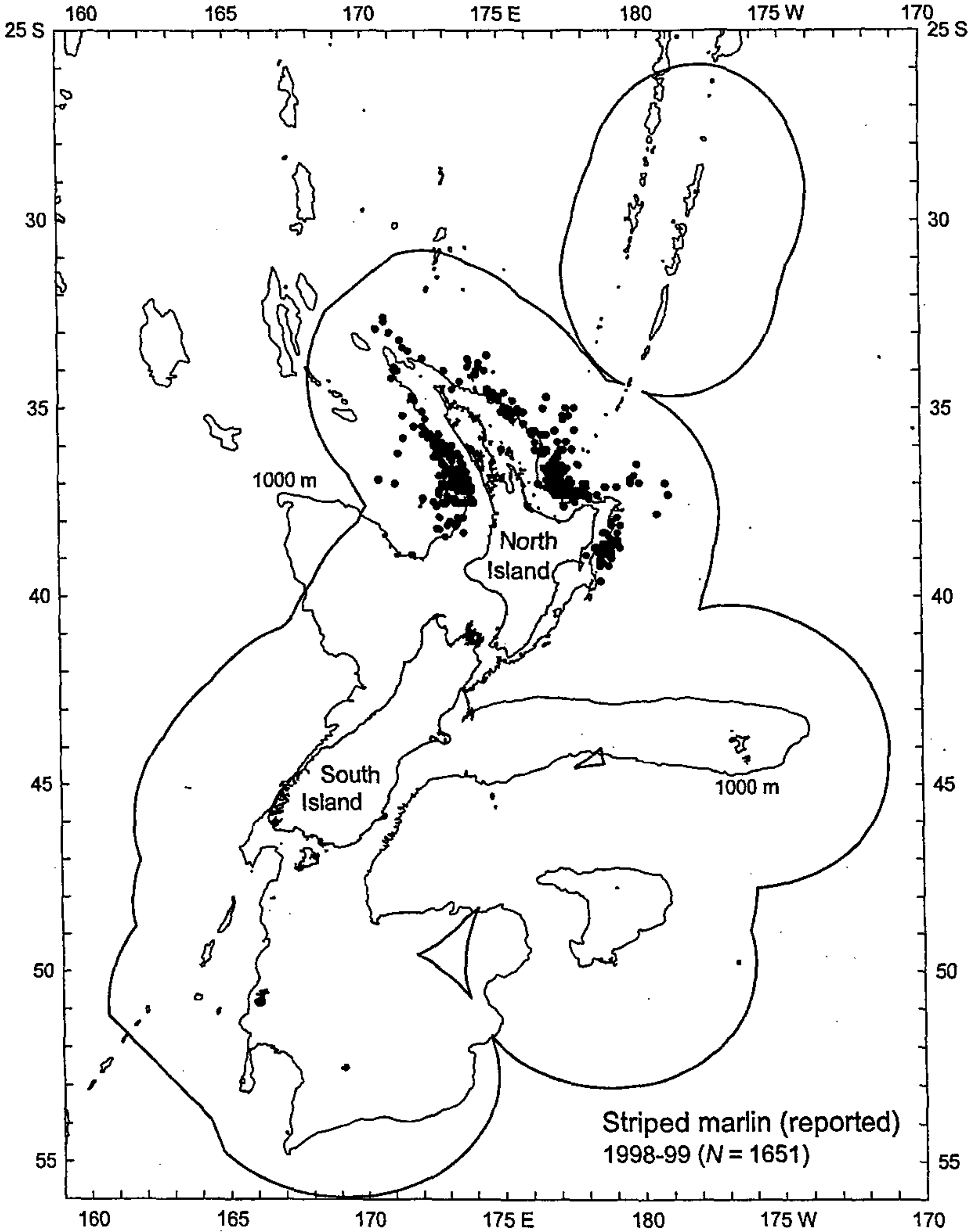


Figure 15: Start positions for domestic tuna longline sets catching striped marlin (TLCER), October 1998 to September 1999 (N = 1651). Some points represent multiple captures.

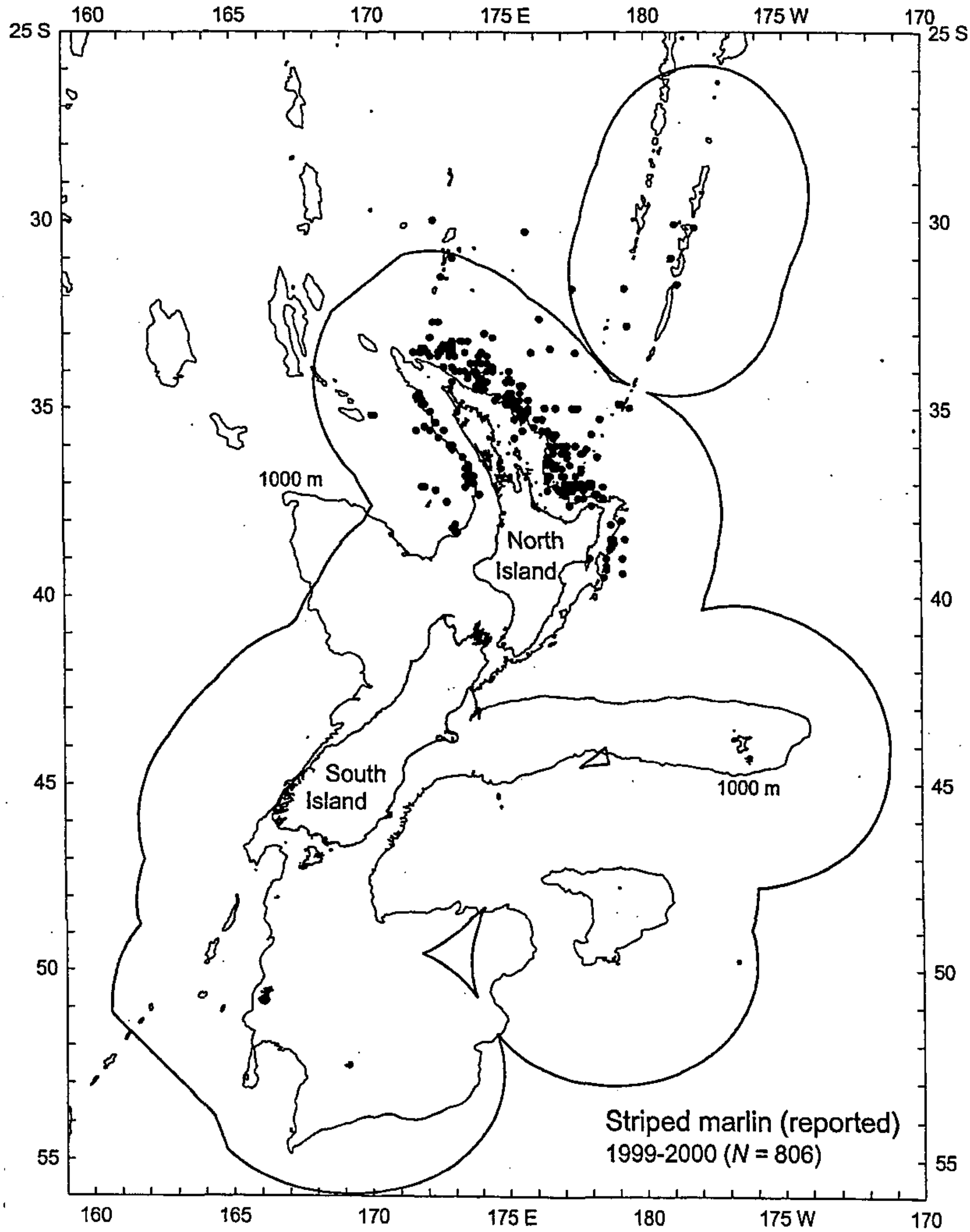


Figure 16: Start positions for domestic tuna longline sets catching striped marlin (TLCER), October 1999 to September 2000 (N = 806). Some points represent multiple captures.

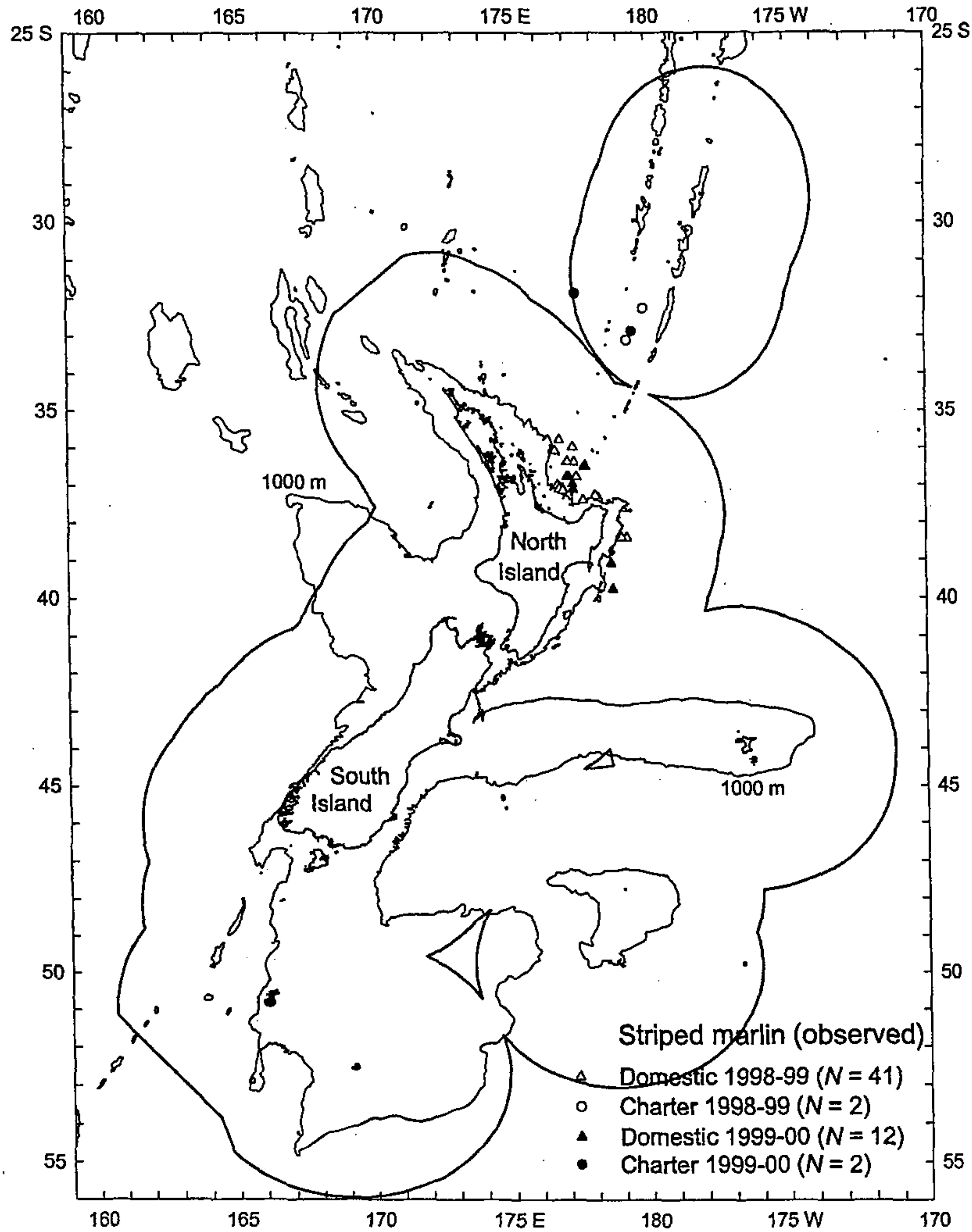


Figure 17: Start positions for observed tuna longline sets catching striped marlin, October 1998 to September 2000 (N = 57). Some points represent multiple captures.

Appendix 1: Estimates of CPUE (numbers per 1000 hooks) for sharks. The three columns under each species are (from left to right) mean CPUE, and bootstrap lower and upper 95% confidence limits.

Fleet	Region	Fish. year	No. sets	Blue shark			Porbeagle shark			Mako shark			Porbeagle & mako			Deepwater dogfish			School shark		
Foreign +charter	North	1988–89	47	9.06	7.06	11.56	–	–	–	–	–	–	2.02	1.53	2.54	0.00	0.00	0.00	0.02	0.00	0.04
		1989–90	77	5.99	4.82	7.32	–	–	–	–	–	–	3.18	2.69	3.70	0.00	0.00	0.00	0.00	0.00	0.00
		1990–91	122	5.99	4.11	8.84	–	–	–	–	–	–	1.37	1.21	1.57	0.00	0.00	0.00	0.01	0.00	0.02
		1991–92	83	9.57	6.26	13.94	–	–	–	–	–	–	2.68	2.30	3.04	0.00	0.00	0.00	0.04	0.02	0.06
		1992–93	127	37.59	30.94	45.13	3.96	3.46	4.48	0.51	0.40	0.64	4.47	4.01	5.01	0.00	0.00	0.00	0.10	0.06	0.15
		1993–94	32	71.60	44.53	107.23	3.30	1.84	5.09	0.68	0.48	0.90	3.98	2.43	5.70	0.00	0.00	0.00	0.98	0.05	2.73
		1994–95	13[2]	114.16	89.60	139.14	–	–	–	–	–	–	7.56	5.65	9.69	0.00	0.00	0.00	0.00	0.00	0.00
		1996–97	44	52.54	40.43	69.82	2.46	1.92	3.13	1.16	0.95	1.37	3.62	3.01	4.29	0.00	0.00	0.00	0.05	0.01	0.08
		1997–98	94	20.39	17.16	23.71	1.70	1.37	2.02	0.62	0.47	0.80	2.32	1.99	2.69	0.00	0.00	0.00	0.06	0.02	0.11
		1998–99	29	14.10	10.74	17.66	2.02	1.17	2.87	0.79	0.59	1.00	2.82	1.95	3.75	0.00	0.00	0.00	0.01	0.00	0.03
		1999–00	25	11.88	7.87	16.58	0.85	0.32	1.54	0.43	0.30	0.55	1.27	0.70	1.91	0.00	0.00	0.00	0.24	0.06	0.46
	South	1988–89	39	6.67	4.45	8.98	–	–	–	–	–	–	0.24	0.16	0.34	0.12	0.02	0.27	0.13	0.06	0.22
		1989–90	77	11.09	7.97	14.92	–	–	–	–	–	–	0.49	0.35	0.64	0.04	0.01	0.08	0.51	0.31	0.73
		1990–91	28	3.68	2.60	4.91	–	–	–	–	–	–	0.32	0.22	0.43	0.00	0.00	0.00	0.07	0.02	0.13
		1991–92	93	1.15	0.69	1.73	–	–	–	–	–	–	0.68	0.52	0.87	0.45	0.26	0.66	0.23	0.14	0.33
		1992–93	246	3.64	3.15	4.19	1.05	0.88	1.26	0.05	0.03	0.09	1.11	0.92	1.32	0.62	0.47	0.79	0.17	0.13	0.21
		1993–94	211	4.12	3.56	4.66	0.78	0.65	0.94	0.08	0.06	0.10	0.86	0.72	1.03	0.20	0.15	0.26	0.29	0.22	0.38
		1994–95	276[3]	2.97	2.50	3.50	1.14	0.94	1.35	0.05	0.03	0.07	1.14	0.98	1.35	0.77	0.62	0.93	0.47	0.38	0.58
		1996–97	279	15.54	12.73	18.68	1.54	1.26	1.84	0.10	0.08	0.13	1.64	1.35	1.96	0.51	0.41	0.61	0.44	0.36	0.53
		1997–98	263	9.58	8.54	10.71	2.53	2.29	2.77	0.09	0.07	0.11	2.62	2.40	2.84	0.89	0.72	1.10	0.27	0.13	0.51
		1998–99	336	8.34	7.63	9.10	2.55	2.31	2.82	0.14	0.12	0.17	2.70	2.44	2.97	1.33	1.12	1.53	0.37	0.30	0.44
		1999–00	213	8.16	7.20	9.23	1.50	1.33	1.71	0.09	0.06	0.12	1.60	1.40	1.81	0.76	0.60	0.92	0.19	0.13	0.25
Domestic	North	1994–95	50	6.56	3.41	10.19	0.99	0.28	2.12	1.03	0.67	1.48	2.02	1.17	3.24	0.04	0.00	0.09	0.18	0.03	0.40
		1995–96	66	13.34	8.94	18.88	4.12	2.72	5.81	2.13	1.57	2.83	6.26	4.47	8.05	0.00	0.00	0.00	0.00	0.00	0.00
		1996–97	101	4.15	3.31	5.20	1.08	0.76	1.44	1.36	1.04	1.68	2.43	1.86	2.99	0.00	0.00	0.00	0.04	0.01	0.09
		1997–98	81	11.03	7.81	14.55	0.33	0.18	0.52	1.04	0.79	1.32	1.37	1.07	1.67	0.03	0.00	0.07	0.00	0.00	0.00
	South	1995–96	81	41.70	33.73	51.09	2.63	2.08	3.31	0.14	0.07	0.23	2.77	2.16	3.46	0.43	0.21	0.70	1.59	0.53	3.45

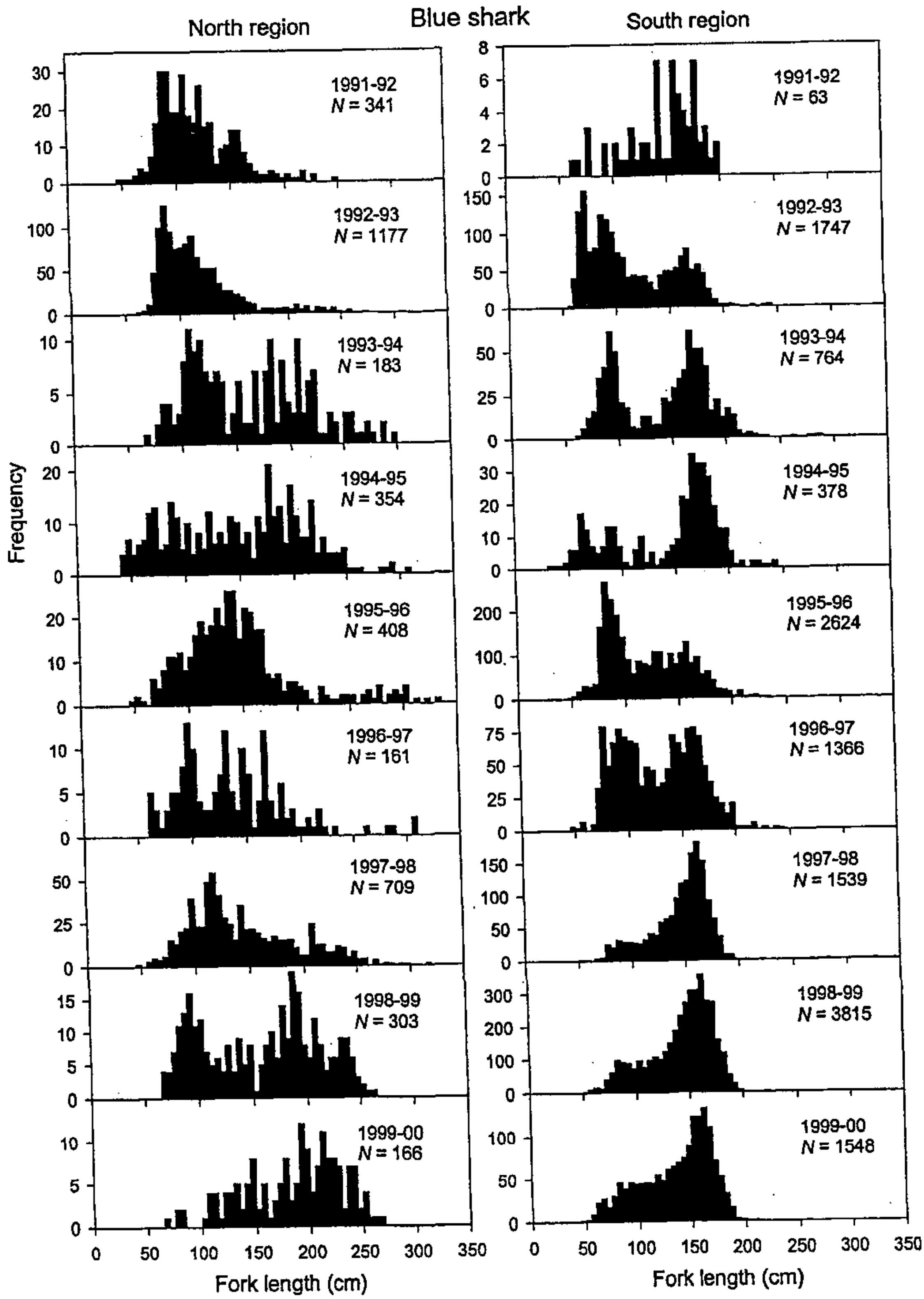
[2] Porbeagle and mako sharks were correctly identified by the observer in only 1 set, so CPUE is not reported for the two species separately.
[3] Porbeagle and mako sharks were correctly identified by the observer in 212 sets.

Appendix 1 (continued): Estimates of CPUE (numbers per 1000 hooks) for tunas and broadbill swordfish. The three columns under each species are (from left to right) mean CPUE, and bootstrap lower and upper 95% confidence limits.

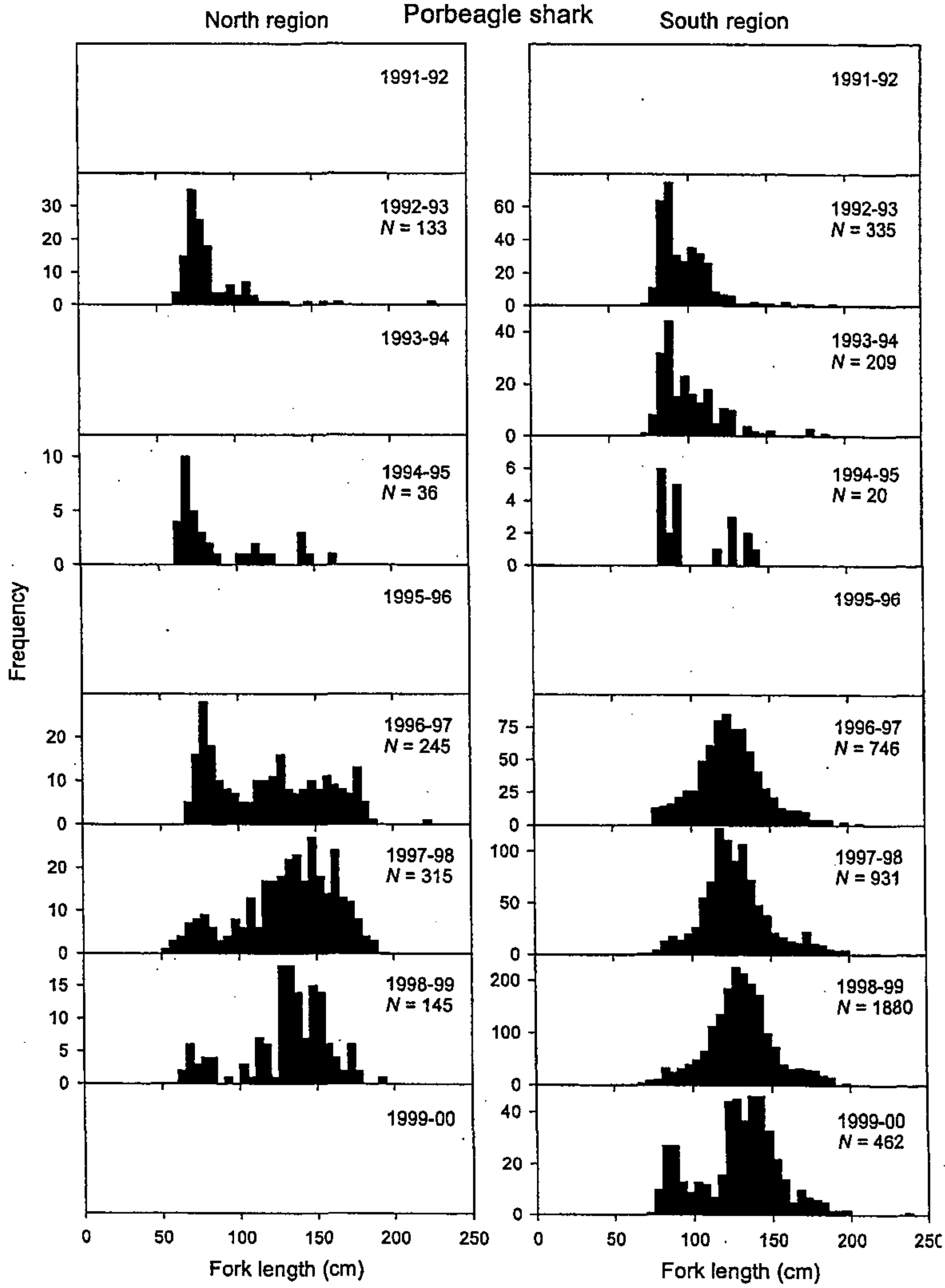
Fleet	Region	Fish. year	No. sets	Albacore			Southern bluefin tuna			Broadbill swordfish			Butterfly tuna			Bigeye tuna			Yellowfin tuna		
Foreign +charter	North	1988–89	47	8.34	7.00	9.66	0.76	0.53	1.07	1.61	1.24	2.05	0.52	0.34	0.69	0.21	0.12	0.32	0.00	0.00	0.00
		1989–90	77	12.24	10.91	13.77	2.27	1.84	2.73	2.11	1.75	2.50	1.10	0.85	1.38	0.24	0.16	0.34	0.07	0.00	0.19
		1990–91	122	9.67	8.84	10.57	1.03	0.86	1.20	0.78	0.65	0.92	1.25	0.97	1.58	0.97	0.57	1.40	0.00	0.00	0.01
		1991–92	83	10.02	8.85	11.14	0.53	0.45	0.63	1.36	1.12	1.60	0.64	0.51	0.79	0.05	0.02	0.09	0.00	0.00	0.00
		1992–93	127	8.78	7.46	10.14	1.22	1.05	1.38	0.61	0.50	0.73	0.43	0.34	0.52	0.11	0.03	0.20	0.00	0.00	0.00
		1993–94	32	8.78	7.10	10.47	0.16	0.06	0.28	0.88	0.66	1.09	0.13	0.06	0.20	0.60	0.31	0.93	0.02	0.00	0.06
		1994–95	13	7.19	4.96	9.51	0.60	0.28	0.96	0.39	0.15	0.64	0.98	0.53	1.53	0.00	0.00	0.00	0.00	0.00	0.00
		1996–97	44	8.40	6.59	10.34	4.98	3.40	6.88	2.83	1.95	3.95	0.11	0.05	0.19	0.02	0.00	0.05	0.00	0.00	0.00
		1997–98	94	25.63	23.20	28.50	4.93	3.75	6.10	1.20	0.99	1.42	0.18	0.12	0.26	1.14	0.82	1.49	0.03	0.01	0.06
		1998–99	29	9.63	7.60	12.02	1.40	0.59	2.42	0.98	0.70	1.29	0.18	0.05	0.36	2.59	1.51	3.79	0.01	0.00	0.03
		1999–00	25	7.74	5.76	9.92	0.42	0.12	0.76	1.28	0.89	1.65	0.37	0.14	0.70	0.90	0.62	1.22	0.16	0.04	0.30
	South	1988–89	39	0.25	0.10	0.41	1.36	0.94	1.81	0.00	0.00	0.00	0.83	0.48	1.25	0.00	0.00	0.00	0.00	0.00	0.00
		1989–90	77	0.61	0.42	0.86	3.11	2.59	3.68	0.09	0.04	0.16	0.24	0.15	0.34	0.00	0.00	0.00	0.00	0.00	0.00
		1990–91	28	0.25	0.12	0.42	3.23	2.45	4.06	0.36	0.23	0.48	0.04	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
		1991–92	93	0.16	0.10	0.24	1.49	1.25	1.72	0.01	0.00	0.03	0.08	0.05	0.13	0.00	0.00	0.00	0.00	0.00	0.00
		1992–93	246	0.22	0.16	0.29	1.44	1.25	1.64	0.01	0.01	0.03	0.16	0.12	0.20	0.00	0.00	0.00	0.00	0.00	0.00
		1993–94	211	0.22	0.17	0.27	4.40	3.92	4.89	0.00	0.00	0.01	0.11	0.08	0.13	0.00	0.00	0.00	0.00	0.00	0.00
		1994–95	276	0.18	0.13	0.23	2.93	2.70	3.17	0.00	0.00	0.00	0.09	0.06	0.11	0.00	0.00	0.00	0.00	0.00	0.00
		1996–97	279	0.15	0.12	0.19	2.75	2.46	3.07	0.05	0.03	0.06	0.68	0.53	0.83	0.00	0.00	0.00	0.00	0.00	0.00
		1997–98	263	0.75	0.61	0.90	2.52	2.30	2.77	0.07	0.05	0.09	0.45	0.35	0.55	0.00	0.00	0.00	0.00	0.00	0.00
		1998–99	336	0.71	0.62	0.81	2.68	2.41	2.94	0.21	0.17	0.24	0.34	0.28	0.39	0.00	0.00	0.00	0.00	0.00	0.00
		1999–00	213	0.66	0.53	0.82	3.05	2.65	3.47	0.20	0.15	0.25	0.48	0.38	0.60	0.00	0.00	0.00	0.00	0.00	0.00
Domestic	North	1994–95	50	24.95	15.84	35.55	0.00	0.00	0.00	0.38	0.23	0.57	0.04	0.00	0.12	1.38	0.93	1.92	3.31	2.16	4.49
		1995–96	66	46.61	37.01	56.77	0.19	0.06	0.38	0.65	0.42	0.90	0.00	0.00	0.00	0.70	0.49	0.94	4.20	2.91	5.49
		1996–97	101	48.87	40.73	57.28	0.03	0.00	0.07	1.74	1.24	2.32	0.00	0.00	0.00	1.01	0.77	1.27	2.89	2.22	3.65
		1997–98	81	35.43	29.07	41.96	0.01	0.00	0.04	3.28	2.41	4.28	0.02	0.00	0.06	0.94	0.66	1.24	1.16	0.81	1.55
	South	1995–96	81	1.22	0.77	1.74	2.07	1.56	2.62	0.11	0.04	0.18	0.08	0.02	0.14	0.00	0.00	0.00	0.00	0.00	0.00

Appendix 1 (continued): Estimates of CPUE (numbers per 1000 hooks) for other fish species. The three columns under each species are (from left to right) mean CPUE, and bootstrap lower and upper 95% confidence limits.

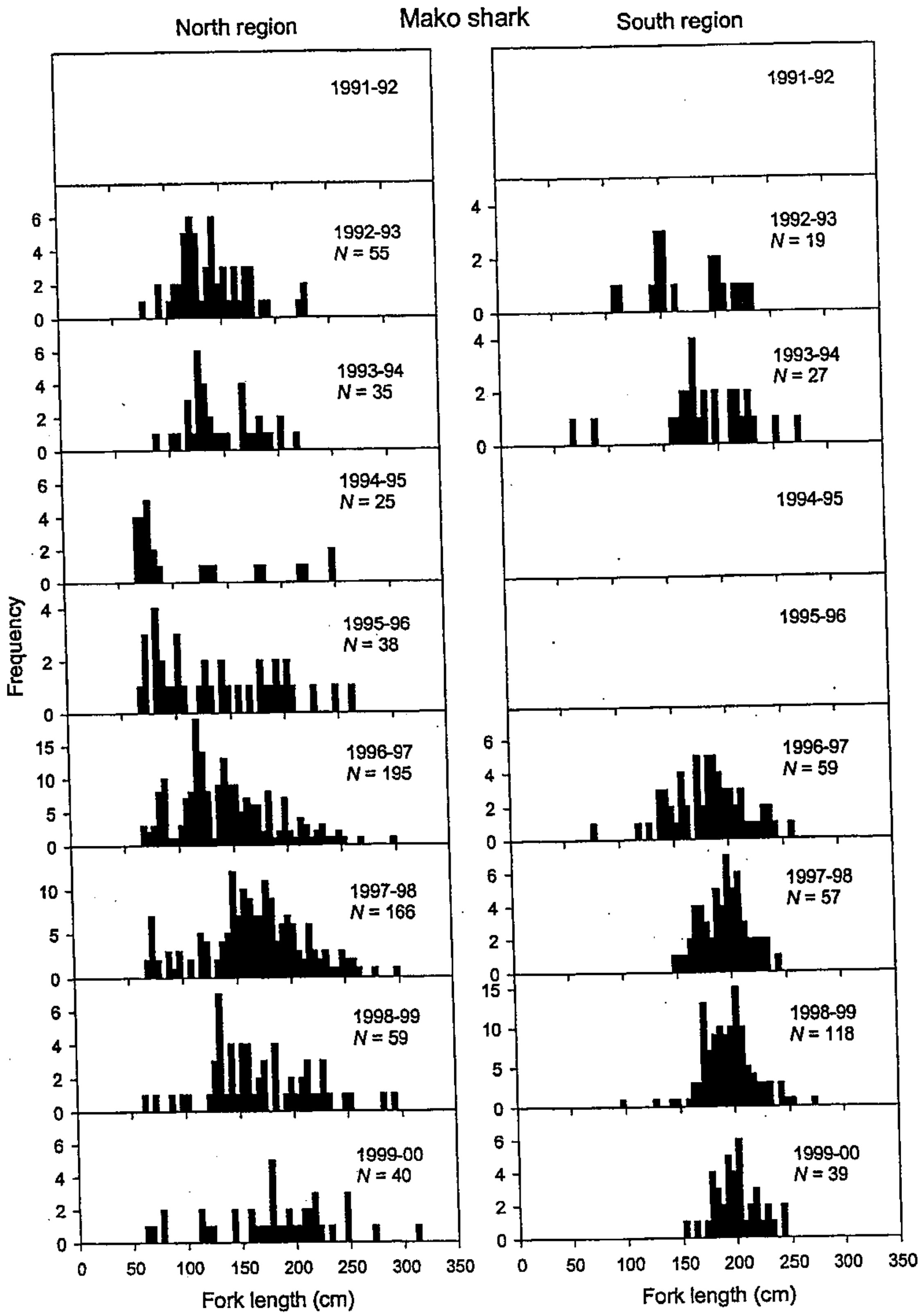
Fleet	Region	Fish. year	No. sets	Ray's bream			Dealfish			Oilfish			Moonfish			Lancetfish			Rudderfish		
Foreign +charter	North	1988–89	47	0.19	0.08	0.32	0.00	0.00	0.00	1.01	0.67	1.44	0.65	0.36	1.02	0.15	0.08	0.22	0.01	0.00	0.02
		1989–90	77	0.42	0.25	0.63	0.00	0.00	0.00	1.51	1.18	1.85	0.80	0.62	0.97	0.19	0.11	0.28	0.03	0.00	0.05
		1990–91	122	0.12	0.06	0.18	0.00	0.00	0.00	2.20	1.74	2.76	1.14	0.87	1.42	0.30	0.18	0.43	0.00	0.00	0.00
		1991–92	83	0.09	0.05	0.14	0.00	0.00	0.00	3.64	2.97	4.33	1.11	0.93	1.28	0.19	0.12	0.27	0.01	0.00	0.02
		1992–93	127	0.33	0.08	0.80	0.00	0.00	0.01	1.94	1.65	2.30	1.05	0.88	1.21	0.72	0.54	0.93	0.03	0.01	0.05
		1993–94	32	0.11	0.02	0.23	0.00	0.00	0.00	1.61	0.75	2.67	4.08	2.21	6.23	0.70	0.33	1.16	0.03	0.00	0.08
		1994–95	13	0.00	0.00	0.00	0.00	0.00	0.00	2.04	1.32	2.87	3.03	1.41	5.04	0.90	0.41	1.69	0.21	0.03	0.42
		1996–97	44	1.09	0.33	2.01	0.02	0.00	0.04	3.49	2.80	4.27	0.56	0.37	0.79	0.05	0.01	0.09	0.01	0.00	0.03
		1997–98	94	0.09	0.05	0.16	0.00	0.00	0.00	4.03	2.75	5.41	4.76	3.96	5.67	0.29	0.19	0.40	0.04	0.02	0.07
		1998–99	29	0.14	0.08	0.22	0.01	0.00	0.03	2.18	1.29	3.37	3.81	2.38	5.72	2.33	1.92	2.73	0.14	0.00	0.36
		1999–00	25	0.16	0.05	0.31	0.00	0.00	0.00	1.22	0.35	2.52	4.89	2.80	7.62	0.53	0.31	0.77	0.16	0.03	0.39
	South	1988–89	39	2.02	1.47	2.63	0.12	0.04	0.22	0.00	0.00	0.00	0.11	0.05	0.19	0.00	0.00	0.00	0.00	0.00	0.00
		1989–90	77	2.17	1.68	2.66	0.11	0.06	0.16	0.00	0.00	0.00	0.24	0.17	0.34	0.00	0.00	0.00	0.03	0.01	0.05
		1990–91	28	1.28	0.85	1.78	0.08	0.02	0.14	0.08	0.02	0.15	0.58	0.36	0.84	0.00	0.00	0.00	0.00	0.00	0.00
		1991–92	93	2.23	1.86	2.64	0.79	0.54	1.08	0.16	0.09	0.26	0.04	0.01	0.08	0.01	0.00	0.02	0.17	0.10	0.24
		1992–93	246	2.31	2.08	2.54	0.24	0.17	0.31	0.00	0.00	0.00	0.08	0.06	0.11	0.00	0.00	0.00	0.16	0.11	0.20
		1993–94	211	13.79	11.52	16.27	0.59	0.43	0.78	0.00	0.00	0.01	0.05	0.03	0.07	0.00	0.00	0.01	0.09	0.06	0.12
		1994–95	276	5.37	4.77	6.00	1.84	1.51	2.17	0.01	0.00	0.02	0.09	0.07	0.12	0.00	0.00	0.01	0.15	0.11	0.19
		1996–97	279	6.01	5.14	7.00	3.67	2.77	4.67	0.05	0.02	0.07	0.27	0.22	0.32	0.00	0.00	0.00	0.39	0.31	0.46
		1997–98	263	4.08	3.48	4.66	2.80	2.30	3.36	0.03	0.01	0.04	0.18	0.14	0.22	0.00	0.00	0.01	0.20	0.15	0.26
		1998–99	336	2.92	2.57	3.28	0.96	0.80	1.15	0.01	0.00	0.01	0.20	0.17	0.24	0.05	0.02	0.08	0.74	0.64	0.85
		1999–00	213	3.28	2.63	3.97	2.03	1.64	2.48	0.00	0.00	0.00	0.24	0.18	0.31	0.04	0.02	0.06	0.71	0.59	0.86
Domestic	North	1994–95	50	0.23	0.05	0.51	0.02	0.00	0.06	0.31	0.15	0.50	2.52	1.69	3.43	5.78	4.37	7.41	0.08	0.00	0.21
		1995–96	66	0.24	0.13	0.37	0.00	0.00	0.00	0.97	0.55	1.52	0.81	0.53	1.12	3.93	3.03	5.04	0.44	0.17	0.75
		1996–97	101	0.17	0.09	0.27	0.01	0.00	0.03	0.91	0.61	1.24	1.27	0.89	1.71	8.47	6.76	10.21	0.63	0.42	0.84
		1997–98	81	0.35	0.17	0.57	0.22	0.00	0.63	0.68	0.25	1.31	2.16	1.67	2.67	4.95	3.79	6.34	0.75	0.47	1.07
	South	1995–96	81	10.41	7.61	13.60	1.20	0.80	1.74	0.01	0.00	0.03	0.93	0.62	1.27	0.05	0.01	0.10	1.08	0.70	1.54



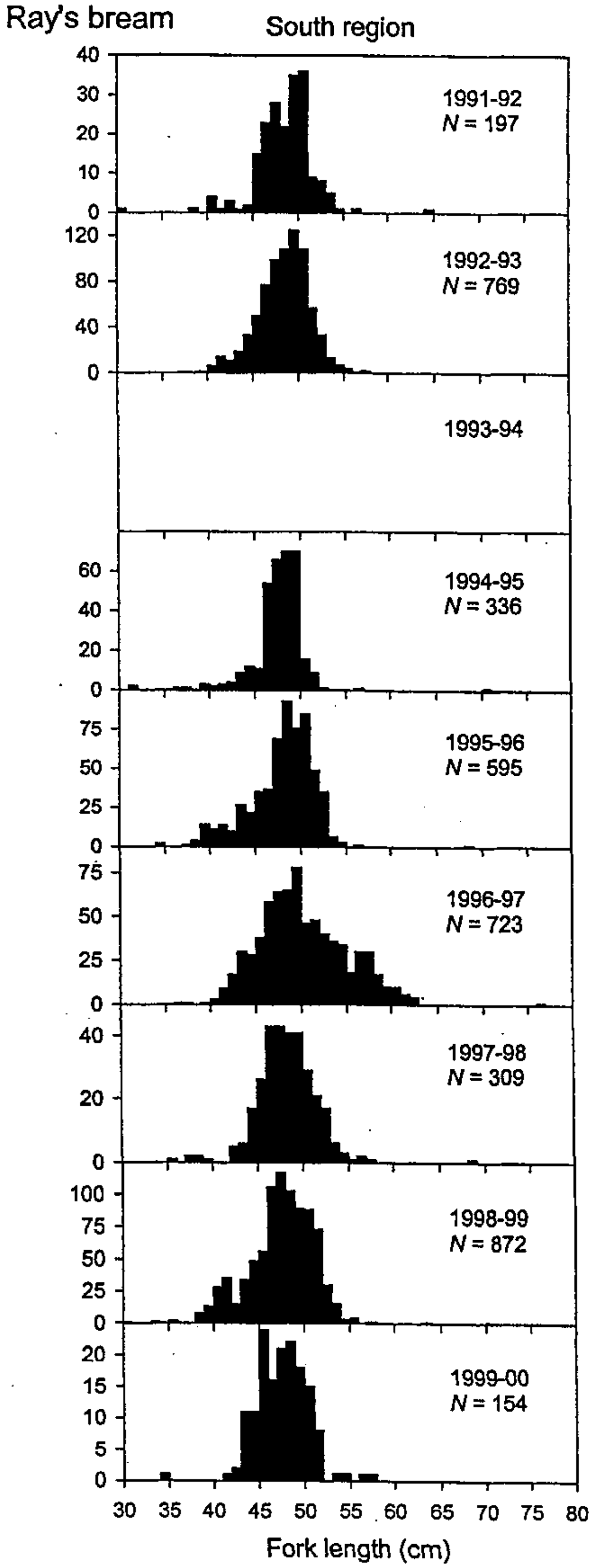
Appendix 2: Blue shark length-frequency distributions by region and fishing year. N, sample size.



Appendix 2 (cont.): Porbeagle shark length-frequency distributions by region and fishing year. N, sample size.



Appendix 2 (cont.): Mako shark length-frequency distributions by region and fishing year. N, sample size.



Appendix 2 (cont.): Ray's bream length-frequency distributions by region and fishing year. N, sample size.