Fish bycatch in New Zealand tuna longline fisheries, 2000–01 and 2001–02.

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Abstract

Effort by domestic owner-operator and chartered Japanese tuna longline vessels in New Zealand waters continued to increase, with at least 9.3 million hooks set in 2000–01 and about 10.5 million in 2001–02. Observer coverage (as a percentage of the total effort) was greatest on chartered Japanese vessels in southern waters. The species most commonly recorded by observers in the tuna longline fishery were blue shark (*Prionace glauca*), albacore tuna (*Thunnus alalunga*), and Ray's bream (*Brama brama*). Dealfish (*Trachipterus trachypterus*), deepwater dogfish species, and Ray's bream clearly showed the opposite trend. Catch rates for school shark (*Galeorhinus galeus*), mako shark (*Isurus oxyrinchus*), porbeagle shark (*Lamna nasus*), and blue shark were fairly consistent throughout both regions.

1. Introduction

This paper is a condensed version of a larger report that exists as a preliminary draft and summarises the bycatch of non-target fish species during observed tuna longline fishing effort in New Zealand waters from 1988–89 to 2001–02. Thus, analysis of data for the fishing years (1 October-30 September) 2000–01 and 2001–02 are reported here and compared with data from earlier years. These data update those presented to ERSWG4 in 2001 (Francis et al. 2001).

2. Methods

2.1 Data sources

New Zealand tuna longline fishery data are available for 2000–01 and 2001–02 from two sources: observed fishing data and commercial fishing data. The most reliable fish bycatch data are collected by the Ministry of Fisheries Scientific Observers and stored in the scientific observer database (*l_line*) managed by NIWA for the Ministry of Fisheries. These observed data represent a proportion of the total fishing effort data. The commercial effort data are from the Tuna Longlining Catch Effort Returns (TLCER) and Catch Effort Landing Returns (CELR) that longline fishers are required to submit to the Ministry. These data are stored in a database (*tuna*), which is also maintained by NIWA. Analyses and descriptions given here for the entire tuna longlining fleet are based on these data.

2.2 Data treatment

For the purposes of these analyses, the tuna longline fleet operating in New Zealand waters has been separated into the domestic owner-operator vessels that fish primarily in waters north of about 40º S (*domestic*) and the chartered Japanese vessels that fish mainly in more southern waters during the southern bluefin tuna season (*charter*). One exception to this distinction is the addition of the effort of one large domestic owner-operator vessel that generally fishes the same waters as the chartered vessels and is consequently grouped with the chartered vessels, as described in Francis et al. (2001). Note that prior to 1995–96, foreign-licensed vessels fished in New Zealand waters and thus where data for earlier years are provided in this report, the *charter* vessel data also includes that from the foreign-licensed vessels (see Francis et al. 2001). Three distinct geographical regions are defined; North, South West, and South East. The north region was defined as being north of latitude 39º 30´ S on the west coast, and north of 43º 45´ S on the east coast. The south west region was defined as being below this boundary, and west of 169º E. The south east region definition follows.

One improvement in the current analysis over previous analyses is the inclusion of more accurate data on the number of observed hooks. Previously, analysis proceeded on the assumption that all hooks on an observed set were observed. This assumption had lead to estimates of catch rates and total catch that were biased. More refined data have been obtained to allow estimation of the actual number of hooks observed on each set. The number of hooks observed in each set is estimated from the proportion of the haul observed (based on the haul duration and time recorded as unobserved in the observer events logs) multiplied by the number of hooks set. The total catches and average catch rates (number of fish per 1000 hooks) are now estimated more accurately by the inclusion of this information. This correction has also been applied to the data from the fishing years 1988–89 to 1999–00 to remove the biases that were previously inherent in the estimates.

Exploratory analysis of the observer data for the two most recent fishing years indicated that there were problems with some length-weight data reported by one observer in 2001–02. The values recorded by this observer are considered unreliable. Thus, all the length-weight data reported by this observer from two *domestic* vessels (19 sets representing about 19 822 hooks) have been excluded from the length and weight analysis for 2001–02.

Identification of some species during the early years of the observer programme has been found to be unreliable (Francis et al. 2001). There do not appear to be any problems of this nature in the most recent two years' data. When data from earlier years are used the procedures identified in Francis et al. (2001) are followed.

There is also a geographical distinction made in the analysis. Initially, data were allocated to either a north (N) region, a South West (SW) region, or a South East (SE) region (Figure 1). No *domestic* vessels were observed in either of the southern regions, and only three trips by *charter* vessels were observed in the northern region (two of these consisted of only two sets at the end of a southern trip). This distribution of fishing effort is consistent with that in recent years, where *charter* vessels have fished primarily in the south. The spread of the data in the most recent fishing years showed similar patterns to that in previous years and indicated that we should continue to perform analyses on a single southern region, but also examine any differences between the east and west effort.

2.3 Catch per unit effort analysis

Catch per unit effort (CPUE) was defined as the number of fish caught per 1000 hooks set. The basic unit of sampling was an individual set; a set *i* has information on the number of fish caught (c_i) and the amount of effort expended (where u_i the number of hooks). As mentioned above, all hooks on a set may not be observed. In the calculation of CPUE we use the estimated number of observed hooks.

Although the aim of this report is to summarise the most recent two fishing years, it was necessary to re-calculate the CPUE for the previous 12 years as well. This was due to the use of a different methodology for calculation of the mean catch rates. The calculation of the mean catch rate used in this analysis differs from previous analyses, in that it uses a ratio of means estimator (1) rather than a mean of ratios estimator (2):

(1) $CPUE= =(\Sigma c_i /n) / (\Sigma u_i/n) = \Sigma c_i / \Sigma u_i$

(2) $CPUE=\Sigma (c_i / u_i) / n$

where n is the number of observed sets. The reasons for this change are discussed in Bradford (2002). The effect of this change is that the CPUE indices tend to have slightly smaller values than those reported in previous analyses, though the trends remain the same. Variances and confidence intervals are calculated by bootstrap.

3. Results and discussion

3.1 Fishing effort and observer coverage

Four chartered Japanese vessels and the one large domestic vessel comprised the *charter* fleet during 2000–01 and 2001–02. In 2000–01, these vessels set a total of 302 longlines (943 000 hooks). Of these, almost 819 000 hooks (approx. 87%) were observed on 272 sets (Figure 2). In 2001–02, these vessels set 322 longlines (983 000 hooks). Observer coverage was similar, with 275 sets observed, accounting for over 773 000 hooks (approx. 79%).

The *domestic* fleet operating in 2000–01 and 2001–02 consisted of 159 owner-operator vessels, of which 110 fished both fishing years. Over 7400 longlines were set in 2000–01, and 8133 were set in 2001–02. This equated to over 8.4 million and 9.5 million hooks being set in the two fishing years. Observer coverage in the *domestic* fishery remains sparse (Figure 2), despite an effort to increase coverage. Twenty-four vessels from the *domestic* fleet were observed during these fishing years. Only 202 sets (241 000 hooks) were observed in 2000–01. Coverage was even worse in 2001–02, with 123 sets observed (145 000 hooks). Total coverage of hooks for these two years is in the 2% range.

The two fleets differ in fishing practices (Murray et al. 1999, Francis et al. 2001). Over 95% of the *charter* fleet sets targeted southern bluefin tuna (the remainder targeted bigeye tuna). The *domestic* vessels targeted bigeye tuna predominantly (74% of sets). Southern bluefin tuna was targeted on 15% of the sets, and albacore tuna was targeted on 8% of the sets.

NB how was the % hooks observed estimated, this is not in the methods section. Also, Charter and domestic sets are combined in the following two paras, should be stated).

The number of hooks observed on any given set tends to be at or near the total number of hooks set. Of the 474 sets observed in the 2000–01 fishing year, all the hooks were observed on 304 sets (64.1%). When all hooks per set were not observed, the average percentage of hooks observed was 94%. The average for all sets is 97.8% of hooks observed.

The 2001–02 fishing year was slightly less well measured. Of the 398 observed sets, 180 had all the hooks observed (45.2%). The remaining sets averaged 89.0% of hooks observed. For all observed sets in 2001–02, the average was 94% hooks observed. In comparison with individual set data from previous years (1988–89 to 1999–00), in which an average of 95.8% hooks in each set were observed, the coverage per set for 2000–01 was above the average and that for 2001–02 was slightly below.

The majority of the fishing effort (and observational effort) occurs in the SW region (see Figure 1). In the past two years, only 75 000 hooks were observed in the SE region, in comparison with 1.4 million observed in the SW. The SE observations come from two observed trips, one in each year. In 2000–01, two *charter* vessels fished in the SE region, and a few domestic vessels also undertook short trips here. Only one *charter* vessel was observed. The 2001–02 fishing year was similar; one of the two *charter* vessels fishing in the SE area was observed. About five domestic vessels also made a few sets in this area.

Clearly, any trends observed in a combined southern region will be driven by the behaviour of the SW region. It is concluded that the analysis should retain only a single southern region, as trends observed in the SE are more likely to represent vessel/trip effects, more than regional effects.

Generally the c*harter* vessels fish during the autumn-winter months only, whereas the *domestic* vessels fish throughout the fishing year (Figure 2). The observer coverage is not uniform throughout the year on these *domestic* vessels. One interesting development is that the observations of *domestic* vessels include data from October and November of 2001. In previous fishing years, these months had no observer coverage. There are also observations in August, September, and December, for which historically there has been little coverage.

3.2 Species composition and CPUE of the observed catch

The main species observed as bycatch from the observed tuna longline sets in 2000–01 and 2001–02 were the same as those observed in previous years (Francis et al. 2001) (Table 1). The spatial distributions of the observed catches of these species are similar to those shown in Francis et al. (2000).

For each of the 18 major bycatch species, catch per unit effort values were calculated for each fleet (*domestic* and *charter*) and geographical region (northern and southern). The CPUE indices calculated using the method described earlier are presented for the fourteen-year period from 1988–89 to 2001–02 in Figure 3. Note that, in the years 1988–89 to 1994–95 inclusive, *charter* includes Japanese vessels that were fishing in New Zealand waters under a foreign licence agreement (Francis et al. 2001). The indices for the first twelve years are not identical to those presented in Francis et al. (2001) because of the use of the ratio of means estimator, rather than the mean of ratios estimator. Although the absolute values differ, the indices show almost identical trends.

For most species, the data suggest a continuation of the trends observed in the last analysis. The shark data (see Figure 3) show that all sharks, except deepwater dogfish, had their maximum CPUEs in the 1995–96 fishing year. Since that time the values have dropped. In the northern *charter* fleet, the estimated CPUE has increased in the final year for both blue sharks and mako sharks. Both blue and mako sharks have higher CPUEs in the northern region. Catch rates for porbeagle and school sharks on *charter* longlines had slightly higher catch rates in the southern region in 2000–01, but catch rates were similar in both northern and southern regions in the following year. The deepwater dogfish CPUE indices show that the species that form this group are caught primarily in the southern region by the *charter* fleet. The most recent CPUE values for these species are substantially lower than values since 1997-98 (roughly 25–33% of the size). The observed increase in the CPUE between 2000–01 and 2001–02 for all shark species for the northern *charter* vessels may be a result of the distribution of the observed fishing effort in those years.

The CPUEs of tuna species in the last two years do not show any great departures from previous trends. The *domestic* fleet shows a decline in CPUE for albacore and yellowfin tuna. These observations appear to be part of a longer decline, though the observer coverage of this fleet has been low in recent years and its distribution within the northern region has varied in spatially and temporally from year to year. It seems likely that these trends are influenced by observer location as much as by tuna abundance.NB check for interpretations here – reviewers do not agree, based on the plots alone – ALB was not in decline, SWO flat or not declining, and YFN is difficult to tell. Suggest stating that for some, there is a return to 1994/95 levels.

Note:
These are the data that we have. The two most recent years are substantially lower than the values from 96–98. As such, I think that we should note the decline in ALB and YFN. The issue that we should be discussing is *why* this decline appears. It is likely that the spatial distribution of observar coverage plays a role in this, but it’s effect is impossible to quantify. It seems that the years with lower CPUEs have more offshore observer coverage.

In addition, I’m hesitant to state that there is a *return* to 1994-95 levels. In doing this we are making the assumption that the 1994-95 levels represent some sort of ‘baseline’ level, or that the values from

96, 97, and 98 represent an anomalously high period. Neither of these assumptions can be substantiated from the data.

The CPUE trends for striped marlin are similar to those observed in the main shark and tuna species. There are no catches in the southern region, and the northern region shows an apparent decline in the last two years. A historic high catch rate appears in the mid to late 1990s.(NB, the latter may be due to a season/area effect not explored here.)

For other fish species there were some exceptions to the general trend in recent years. A large increase was seen in the catch rate of Ray’s bream by *charter* vessels in southern waters for 2001–02, back to the level observed in 1996–97. The catch rate for oilfish by northern *charter* effort in 2000–01 was more similar to that observed in 1996–97 and 1997–98, than in 1999–00 and 2001–02. Similarly, for the lancet fish from the northern *domestic* fleet, a substantial increase in catch rate was observed in 2001–02. However, generally the results given here for the most recent fishing years are consistent with previous analyses and as the work continues the reasons for some of these trends may become clearer.

3.3 Maturity data for sharks

Analysis of the maturity of sharks was carried out using length frequency data, combined with length at maturity information. This indicated that throughout the zone, female blue, porbeagle, and mako sharks were immature (96 – 97% immature). For male blue and porbeagle sharks, most were immature in southern New Zealand, while 65% of male mako sharks were mature in this region. However, in the north, significant proportions of males were mature with 39% of blue sharks, 27% of porbeagles, and 25% of makos being mature.

3.4 Status of fish on recovery, and subsequent treatment

Observers report that all striped marlin observed caught during the two most recent fishing years were discarded, with the exception of a few that were lost off the line. Most striped marlin were caught alive.

Most blue shark, mako shark, school shark, deepwater dogfish, Ray’s bream, moonfish, oilfish and rudderfish were alive when recovered. Most dealfish were dead in 2000–01, whereas nearly half were alive in 2001–02. About 50% of the porbeagle sharks and lancetfish, and 25% of the butterfly tuna were alive when recovered.

Most blue, mako, porbeagle and school sharks, butterfly tuna and moonfish were processed in some way. Almost all of the deepwater dogfish, dealfish, lancetfish, and most of the oilfish and rudderfish were discarded. About two thirds of Ray’s bream were discarded. Blue and porbeagle sharks that were processed were generally finned only, with the rest of the carcass discarded. A small proportion (1%) of school sharks were also finned and also processed for the flesh. Mako sharks were mainly retained for their flesh by the Japanese chartered vessels, whereas domestic owner-operator vessels mainly finned those processed, and discarded up to 50% of their observed catch of mako sharks.

4. Acknowledgements

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5. References

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Table 1: Number of fish for the main bycatch species recorded by observers from observed tuna longlines set by domestic and charter vessels during 2000–01 and 2001–02. [Species are listed in the order of greatest catch (number of fish) for all years (1988–89 to 2001–02).]

Species		2000–01	2001–02
Blue shark	*Prionace glauca*	8509	5901
Albacore	*Thunnus alalunga*	8549	1874
Ray's bream	*Brama brama*	1164	5725
Southern bluefin tuna	*Thunnus maccoyii*	3055	3077
Porbeagle shark	*Lamna nasus*	648	306
Dealfish	*Trachipterus trachypterus*	1075	650
Lancetfish	*Alepisaurus ferox* & *A. brevirostris*	1877	1775
Moonfish	*Lampris guttatus*	608	397
Oilfish	*Ruvettus pretisus*	600	105
Deepwater dogfish	Squaliformes	133	254
Swordfish	*Xiphias gladius*	785	309
Butterfly tuna	*Gasterochisma melampus*	254	88
Mako shark	*Isurus oxyrinchus*	375	194
Rudderfish	*Centrolophus niger*	289	495
School shark	*Galeorhinus galeus*	127	124
Bigeye tuna	*Thunnus obesus*	309	114
Yellowfin tuna	*Thunns albacares*	329	82
Striped marlin	*Tetrapturus audax*	81	11

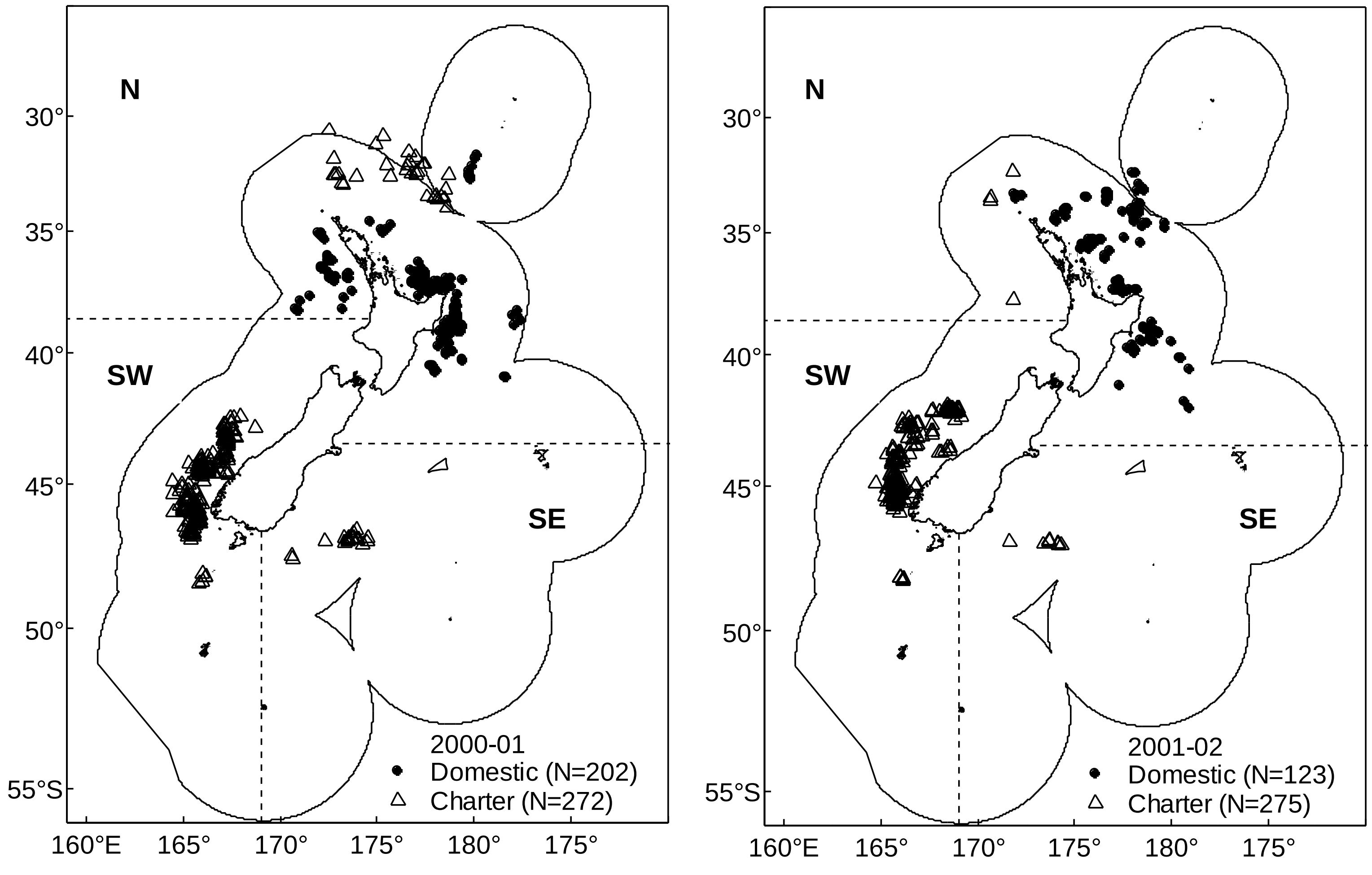

Figure 1: Start positions of observed tuna longline sets for domestic and charter vessels in the New Zealand tuna longline fishery, by area where N is north, SE is southeast and SW is southwest, for 2000–01 (left) and 2001–02 (right).

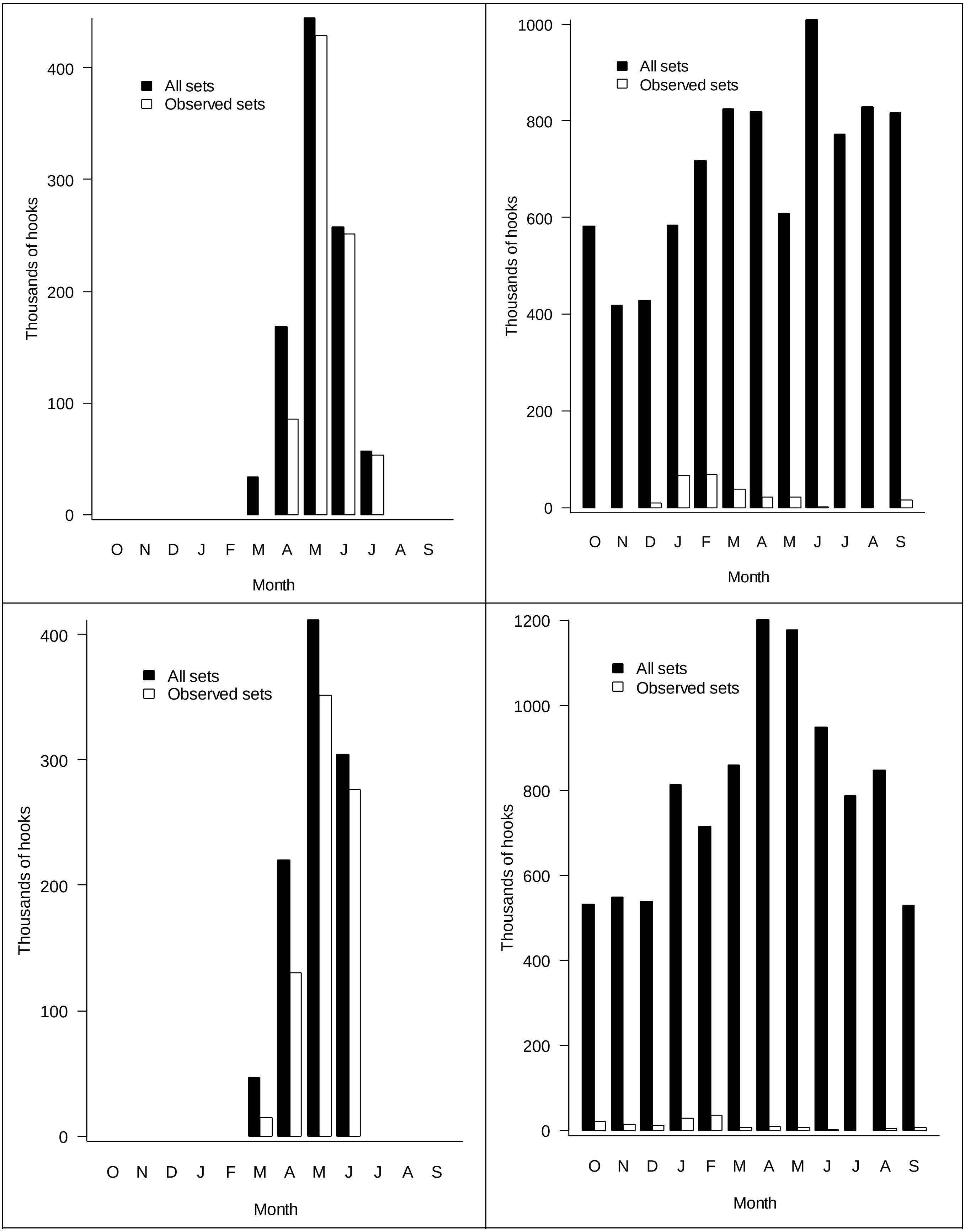

Figure 2: Number of total and observed hooks set by *charter* vessels (left) and *domestic* vessels (right) for 2000–01 (upper) and 2001–02 (lower).

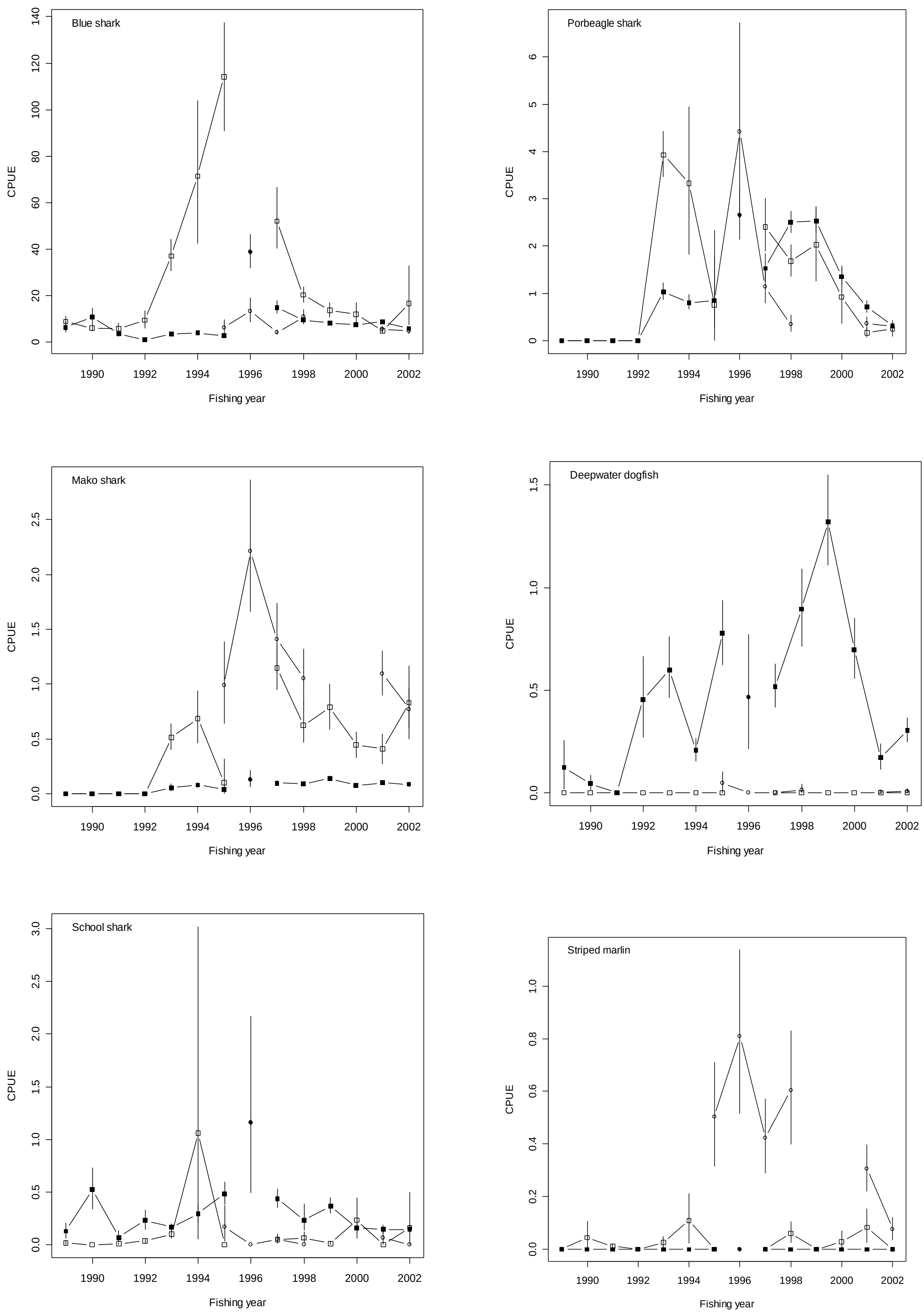

Figure 3: Annual variation in CPUE for the tuna longline *domestic* fleet fishing in northern waters (o) and the *charter* fleet in northern waters (□) and in southern waters (■), for 1988–89 to 2001–02. [Note: 1990 = fishing year 01 October 1989–30 September 1990. Identification of mako and porbeagle sharks in the early years up to 1992–93 is considered unreliable.]

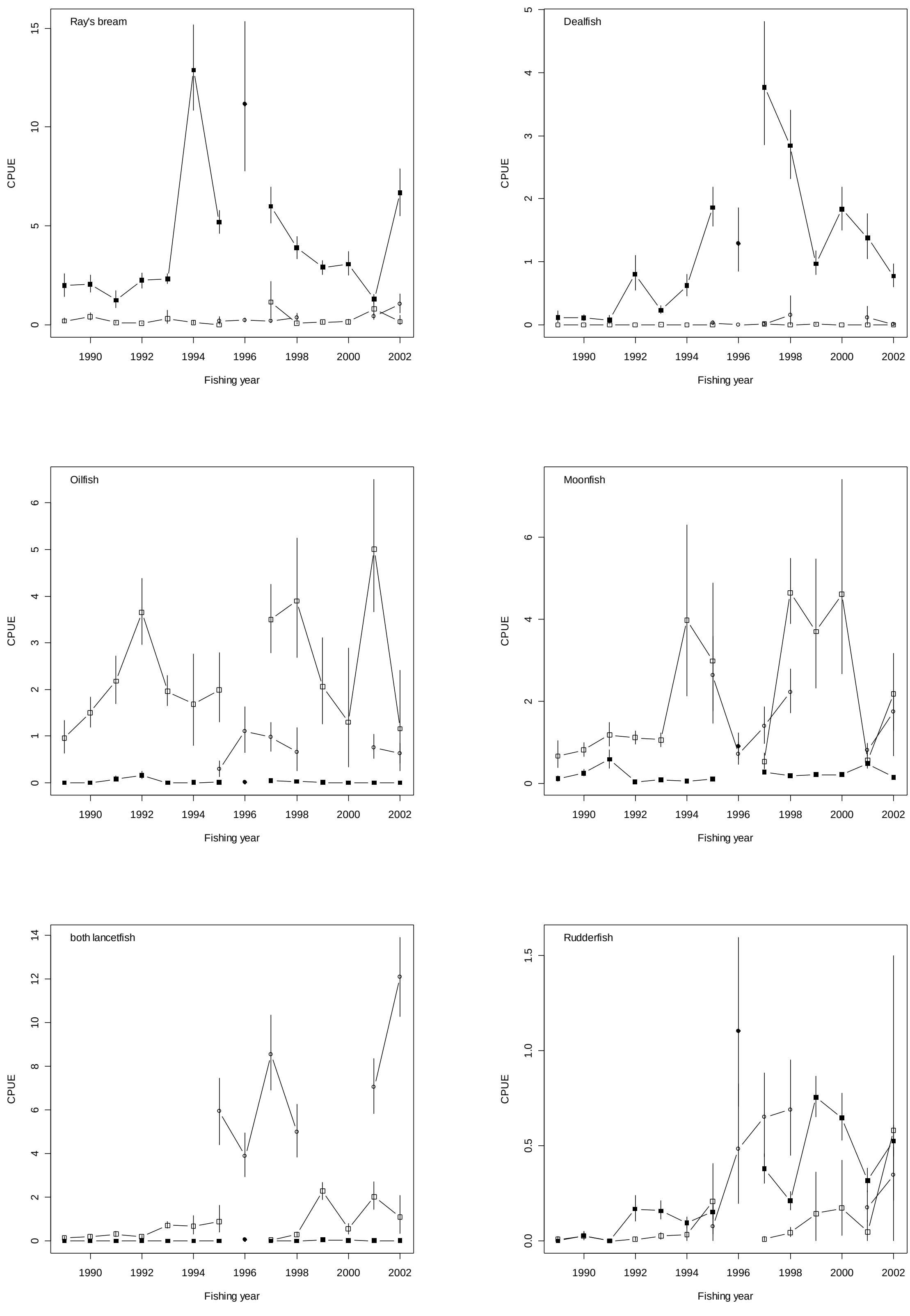

Figure 3 *continued*: Annual variation in CPUE for the tuna longline *domestic* fleet fishing in northern waters (o) and the *charter* fleet in northern waters (□) and in southern waters (■), for 1988–89 to 2001–02. [Note: 1990 = fishing year 01 October 1989–30 September 1990.]

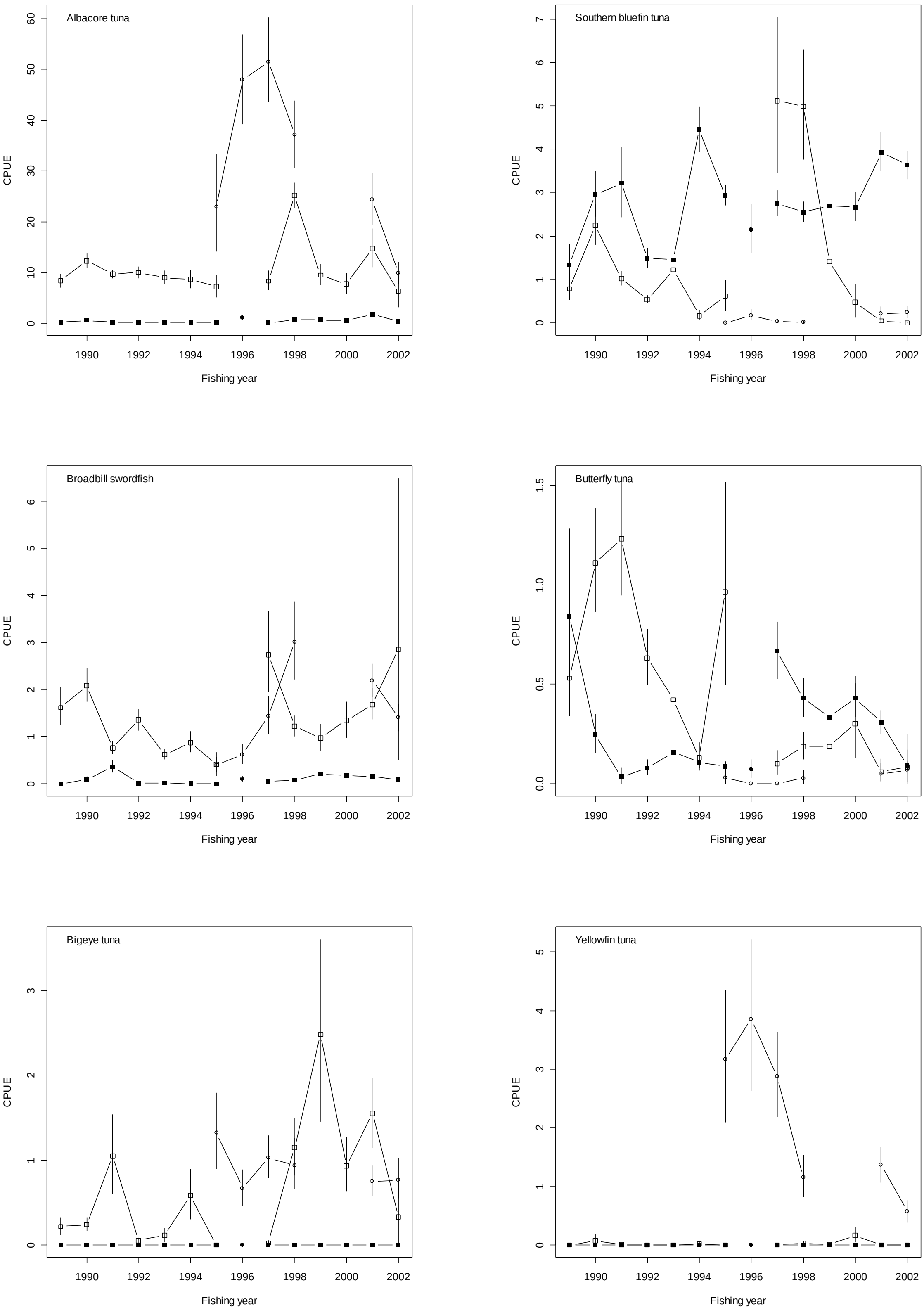

Figure 3 *continued*: Annual variation in CPUE for the tuna longline *domestic* fleet fishing in northern waters (o) and the *charter* fleet in northern waters (□) and in southern waters (■), for 1988–89 to 2001–02. [Note: 1990 = fishing year 01 October 1989–30 September 1990.]