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## EXECUTIVE SUMMARY

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The correct definition of the spatial extent of fish stocks is important for their monitoring and management. This study examined the relationship between barracouta fisheries around the South Island of New Zealand. The spatial distribution of the barracouta catches was examined for each fishing year from 1989–90 to 1999–2000 to identify distinct and consistent fishery areas. Six fishery areas were defined using Ministry of Fisheries statistical areas: west coast South Island, Cook Strait, east coast South Island, Stewart Island, Snares shelf, Auckland Islands. The characteristics of the fishery in each of these areas was examined using three sources of data: (1) catch and effort data from the commercial fishery; (2) length frequency data from the commercial fishery; (3) indices of relative abundance and length composition from trawl surveys. We examined whether there were consistent trends in these sets of data among fishery areas.

On the basis of the information available, the level of affinity of barracouta between fishery areas was qualitatively assessed with consideration of the following aspects.

1. Seasonal trends in catch and catch rates of barracouta relative to the adjacent areas.
2. Similarity in annual trends in catch, CPUE, and trawl survey indices.
3. Similarity in the strength of cohorts and the persistence of strong year classes into the length composition of the commercial catch from each fishery area.
4. Existing information from the literature of relevance to the definition of barracouta stocks around New Zealand, including the results of a tagging study, parasitology, and the distribution of spawning and juvenile barracouta.

The review of the available data from the barracouta fishery does not lead to definitive conclusions regarding the stock boundaries around mainland New Zealand. However, the qualitative appraisal of these data suggested a distinction between the western (BAR 7) and eastern (BAR 1) stocks of barracouta, while the Southland (BAR 5) population appears more closely aligned to the eastern stock.

There may be at least some mixing of barracouta between these areas due to the movement of fish from the east coast South Island to the west coast North Island associated with spawning (as evident from tagging studies).

Barracouta are known to spawn in the Southland area and this area may support a discrete stock. Some strong similarities were identified between barracouta from BAR 1 and BAR 5. It has been proposed that fish from BAR 1 migrate to southern feeding grounds during the summer. The similarity between the two fishstock areas may be attributable to a high level of stock mixing during this period.

The present review of available data suggests a closer linkage between BAR 5 and the east coast South Island fisheries. However, the conclusions regarding the stock structure of barracouta should be considered tentative given the paucity of the data and some apparent inconsistencies in the observed trends between fishery areas. Further analysis of these data is currently being undertaken to attempt to quantify the relative strength of the various alternative stock scenarios for the species.

# 1. INTRODUCTION

Barracouta are found in continental shelf waters around the North Island, South Island, and Chatham Islands (Hurst & Bagley 1989), but the stock structure is not well understood (Annala et al. 2001). There appears to be some overlap between the mainland fishstock areas. In particular, it has been concluded that there is considerable overlap of the Southland fish with other areas, probably the west coast of the South Island and possibly the east coast as well (Annala et al. 2001). Barracouta around the Chatham Islands are considered distinct from the mainland stock(s).

Harley et al. (1999) conducted a stock assessment of the Southland (BAR 5) fishery. The assessment assumed that BAR 5 represented a single unit stock. The validity of this assumption was unknown, but required further investigation before the stock assessment could be updated. The purpose of the present study was to investigate the relationship between barracouta in the BAR 5 fishstock and barracouta off the eastern and the western coasts of the South Island (BAR 1 and BAR 7 respectively, Figure 1). It was intended that these results would address the outstanding issues of the BAR 5 stock assessment and potentially resolve wider stock relationships for barracouta around southern New Zealand.

Previous examinations of stock boundaries have principally been based on analyses of commercial fishing patterns, genetics, a tagging programme, and analysis of parasite infection rates. The analysis of seasonal trends in commercial catch and effort data indicated spawning occurs from August to December around the North Island and off the northeast and west coast of the South Island (Hurst 1988). Spawning also occurs in the Solander Corridor during late spring (Bagley & Hurst 1987). The fishing patterns further suggest a southward movement of significant quantities of barracouta in early summer to feeding grounds off the east and south of the South Island (Hurst 1988).

The seasonal trend in commercial catch is consistent with the results of a series of seasonal trawl surveys conducted in the Canterbury Bight (Hurst & Fenaughty 1985). These surveys indicated that the abundance of barracouta was high during December–May and low in September. However, no surveys were conducted during June–August and October–November. The seasonal decline in the abundance of barracouta off the east coast of the South Island during winter is consistent with the results of a standardised CPUE analysis of the target barracouta fishery and the barracouta bycatch from the red cod trawl fishery (Langley & Walker 2002). Both CPUE analyses revealed a seasonal minimum in the catch rates of barracouta during August–September and a recovery in catch rates during the following months.

Seasonal trends in the distribution and relative abundance of barracouta in the Southland area were investigated from the results of a series of trawl surveys conducted during 1981 to 1986 (Hurst & Fenaughty 1985, Hurst et al. 1990, Hurst & Bagley 1997a). Five trawl surveys were conducted by *Shinkai Maru* during this period with surveys during February–June yielding broadly comparable biomass estimates for barracouta. The highest biomass estimate was from a survey in June 1986.

The biomass estimate for barracouta was very low from the survey in October–November 1983, suggesting a movement of barracouta out of the survey area or much reduced availability to bottom trawls during late winter–spring (Hurst et al. 1990). It was concluded that the low biomass was due to the movement of fish to the spawning grounds, including the Solander Corridor area (Hurst et al. 1990). The shallower area of the Solander Corridor was not included in the survey area.

A comparison of the results from trawl surveys in July and November 1986 revealed that barracouta were distributed over the Stewart–Snares shelf during July but were limited to the shallower areas (less than 100 m) around the west and east of Stewart Island in November (Hurst et al. 1990 and Hurst & Bagley 1997a). Subsequent surveys conducted annually in February from 1993 to 1996 revealed most of the barracouta biomass was along the western side of the Stewart–Snares shelf and off the Catlins coast, although the distribution of barracouta varied between years (Hurst & Bagley 1997b).

Tagging has confirmed that New Zealand barracouta are capable of travelling long distances (Hurst & Bagley 1989). A tagging study was undertaken in 1984–87 with barracouta tagged in spring/summer off the east and northwest coast of the South Island, Bay of Plenty, and Stewart Island. Most of tag releases were off Kaikoura and Dunedin. The recapture rate of tagged fish was low (1%) with only 42 tags recovered (Hurst & Bagley 1989).

Most of the recoveries were from fish tagged off the east coast of the South Island. These fish exhibited a predominantly northward movement. Ten fish moved from off the South Island to the North Island with two crossing from the east coast to the west coast. All these fish were recaptured between July and September, consistent with a northern migration of fish during the spawning season (Hurst & Bagley 1989).

No tagged fish were recaptured off the west coast of the South Island and only one tag was recovered from the Southland area. The lack of tag recoveries in these areas was partly attributed to a low level of reporting of tagged fish by foreign crewed trawlers that accounted for most of the catch (Hurst & Bagley 1989). The lack of tag recoveries prevented any conclusions regarding the stock relationships of barracouta from these two areas. The tagging study was also unable to determine the extent of the interaction between fish off the west coast North Island and barracouta from either the east or west coast of the South Island (Hurst & Bagley 1989).

Examination of enzyme polymorphisms suggested that there were genetic differences in barracouta among areas. However, this may have represented selective clines rather than genetically isolated stocks (Gauldie & Johnston 1980). Barracouta from the west coast of the South Island have higher rates of infection by anisakid nemadotes than those from the east coast of the South Island (Hurst 1980, unpublished data cited by Hurst & Bagley 1989).

A recent study summarised data from research and commercial fisheries to define the distribution of juvenile and spawning barracouta (Hurst et al. 2000, Hurst et al. in press). Juvenile barracouta (age 0+ and 1+ years) were distributed throughout the mainland continental shelf in depths less than 200 m. The highest incidence of capture of juvenile barracouta was in Tasman Bay, off the west coast of the South Island, Canterbury Bight, and Hauraki Gulf, while few 0+ barracouta were caught in the Southland area.

The distribution of juvenile fish is consistent with the observed distribution of spawning and spent barracouta. Fish in these stages of gonad development were sampled from around mainland New Zealand and were most prevalent in areas adjacent to the location of juvenile barracouta (Hurst et al. in press). Information on the location and timing of the spawning of barracouta is summarised in more detail later in this report.

This study further investigates the stock structure of barracouta around mainland New Zealand (BAR 1 and BAR 7) and within the Southland area (BAR 5). The study was principally based on an examination of trends in the abundance and length composition from the commercial fisheries and from research trawl surveys.

## 2. METHODS

### 2.1 Overview

The scope of the analysis included three main sources of data from the barracouta fisheries around mainland New Zealand and the sub-Antarctic islands. These data sources are as follows.

1. Catch and effort data from the commercial fisheries from 1989–90 to 1999–2000.
2. Relative abundance indices and length frequency data from inshore trawl surveys conducted off the east and west coasts of the South Island and from the Southland area.

3. Length frequency data collected by the Ministry of Fisheries Scientific Observer Programme.

The catch and effort data were initially used to define the main fishery areas for barracouta around the South Island and within BAR 5. The distribution of catch from each area was examined with respect to season, target species, and vessel capacity to identify the main fisheries operating for barracouta in each area. Annual trends in the catch rate of barracouta were then determined for each of the main fisheries operating in a specific area. The trends in catch rate were also compared with trends in the relative abundance of barracouta determined from trawl surveys conducted in the specific area.

Seasonal trends in the commercial catch of barracouta were compared between adjacent fishing areas and, at a finer scale, between statistical areas. Barracouta are known to move long distances (Hurst & Bagley 1989) and it was considered that an examination of seasonal trends in catch (and catch rate) could reveal trends in the movement of fish between areas.

Length frequency data collected from trawl surveys were examined to investigate the extent of variation in recruitment strength of individual year classes between areas. The cohort strengths were also compared with the length composition of the recruited population sampled from the commercial fishery. The annual length compositions of the commercial catch were also compared to assess the similarity of the length structure of the catch between adjacent fishery areas.

On the basis of the information available, the level of affinity of barracouta between fishery areas was qualitatively assessed with consideration of the following aspects.

1. Seasonal trends in catch and catch rates of barracouta relative to the adjacent areas.
2. Similarity in annual trends in catch, CPUE, and trawl survey indices.
3. Similarity in the strength of cohorts and the persistence of strong year classes into the length composition of the commercial catch from each fishery area.
4. Existing information from the literature of relevance to the definition of barracouta stocks around New Zealand, including the results of a tagging study, parasitology, and the distribution of spawning and juvenile barracouta.

These elements were then considered in conjunction with broader scale seasonal trends in the distribution of barracouta to propose stock hypotheses for the barracouta within BAR 1, BAR 5, and BAR 7.

## 2.2 Commercial catch and effort data

The Ministry of Fisheries Information Management Group provided a summary of all catch and effort data from the barracouta fishery from 1989–90 to 1999–2000. The data set included all records where barracouta were caught and all records where barracouta were targeted.

The catch and effort data from the period studied were collected in two data formats; Trawl, Catch, Effort, and Processing Returns (TCEPRs) and Catch, Effort and Landing Returns (CELRs). TCEPR data were specific to trawl vessels and generally larger vessels (longer than 35 m), while CELR recorded the catch and effort from smaller vessels. The CELR format summarises catch and effort data for each day of fishing by an individual vessel and records fishing location based on the broad Ministry of Fisheries General Statistical Areas. TCEPRs record the position and associated catch and effort data for each individual trawl.

Error checking was performed on the TCEPR and CELR data separately as the different data required different constraints. For the TCEPR dataset, records were excluded if *catch* was null, less than zero or greater than 50 000 kg or the *duration* of the trawl was less than 0.5 hour. For the CELR dataset, records were excluded if, (a) the *catch_weight* from the related record in the table estimated_subcatch, where *species_code* was BAR, was null, less than 40 or greater than 50 000 kg, (b) the *fishing_duration* was null, less than 1 or greater than 17 hours, (c) the *effort_num* field was null or less than 1 or greater than 7 trawls (for trawl records), or (c) the average trawl duration (*fishing_duration/effort_num*) was less than 0.5 or greater than 6 hours (where *effort_num* was not zero).

Most of the analyses of catch and effort data were based on an amalgamated dataset of CELR and TCEPR data. The format of the amalgamated data was dictated by the level of definition of the CELR data. Consequently, all TCEPR data were aggregated to summarise the catch and effort associated with each day of fishing by a vessel in a statistical area.

### 2.2.1 Definition of fishery areas

The spatial distribution of catch and effort data from the target barracouta fishery was examined using TCEPR data for each year from 1989–90 to 1999–2000. The spatial distribution of the catch identifies six main target fisheries; west coast South Island, Cook Strait, east coast South Island, Stewart shelf, Snares shelf, and Auckland Islands (Figure 2).

These six fishery areas were defined based on the Ministry of Fisheries Statistical Areas (Table 1). Catch and effort records were assigned to each of these fishery areas based on the trawl position (TCEPR) or statistical area fished (CELR).

### 2.2.2 Seasonal trends in commercial catch

Seasonal trends in barracouta catch were examined for each of the inshore statistical areas around mainland New Zealand and the sub-Antarctic Islands (statistical areas 001 to 048 and 602). For each fishing year, the monthly catch of barracouta from each statistical area was determined for all fisheries combined. In some instances, statistical areas with small catches (a combined catch of less than 750 t from 1989–90 to 1999–2000) were amalgamated with data from adjacent statistical areas. For clarity of presentation these areas are referenced by geographic region (Table 2).

Monthly trends in the catch of barracouta from each statistical area were compared between fishing years. For most areas, the seasonal trends in catch were comparable throughout the study period and annual catches were amalgamated to determine the overall seasonal trend in catch.

For each area, the seasonal trends in catch were also compared to the trends in monthly landings described by Hurst (1988).

### 2.2.3 CPUE trends

For each of the six fishery areas (as defined in Section 2.2.1), catch and effort data from 1989–90 to 1999–2000 were summarised by target species, fishing method, vessel size class and month. This analysis identified the specific fisheries in each area that accounted for a substantial proportion of the total barracouta catch and/or persisted over the entire study period (Table 3).

For each of the main fisheries in the fishery area, unstandardised indices of CPUE were calculated as the mean catch of barracouta per trawl. Trawl records with a zero catch of barracouta were not included in the analysis.

For each fishery area, a single preferred CPUE time series was selected from the alternative indices derived for each fishery. In general, the preferred index was selected on the basis of the following criteria.

1. The index included the largest number of records from the fishery.

2. The index included the longest time series for the fishery.
3. The annual trend in the CPUE index was comparable between the individual statistical areas comprising the fishery.
4. Trends in the CPUE time-series were generally comparable to the annual trend in the total catch from the fishery.
5. Trends in the CPUE time-series were generally comparable to the time series of trawl survey indices from the fishery, where available.

On this basis, the preferred CPUE index was selected for each of the six fisheries; Auckland Islands (CPUE1), Cook Strait (CPUE1), east coast South Island (CPUE3), Snares (CPUE2), Stewart (CPUE1), and west coast South Island (CPUE1) (Table 3).

Correlations among the preferred CPUE indices for each of the six fishery areas were examined. The preferred CPUE indices were all derived from fishing effort during October to May, with the exception of the west coast South Island. The latter index was determined from fishing during August–September, at the end of the fishing year. Due to the seasonality of the west coast South Island fishery, it was more appropriate to compare the index with the indices derived from the other fisheries in the subsequent fishing year.

## 2.3 Trawl survey abundance and length frequency data

Barracouta data from trawls surveys off the east coast South Island, west coast South Island (and including Tasman/Golden Bay), and Southland were provided by the Ministry of Fisheries from the *trawl survey* database. The individual surveys included in the analysis are summarised in Table 4. The details of the individual surveys are documented in the associated publications.

For each trawl survey, relative biomass estimates and scaled length frequency distributions were calculated using the methods described by Vignaux (1994).

The east coast South Island and west coast South Island trawl surveys maintained a relatively constant survey area throughout the time series. Similarly, the survey area of the time series of *Tangaroa* trawl surveys of the Southland area was consistent throughout the series. However, the survey area encompassed by the *Shinkai Maru* surveys was variable over the four surveys and differed from the area of the *Tangaroa* surveys.

To establish a comparable time series of survey biomass estimates and length compositions between the two series of Southland surveys it was necessary to define a core survey area that was included in all surveys. This area encompassed the area of the continental shelf south and east of Stewart Island in the 100–600 m depth range. The survey strata that make up this section of the total survey area are defined in Table 5.

A time series of separate biomass estimates was also derived for two sub-areas of the *Tangaroa* Southland survey area; Snares shelf (strata 7, 8, 9, 10) and Stewart shelf (strata 4, 5, and 6).

The timing of the east coast South Island trawl survey was changed during the middle of the time series. Trawl surveys were conducted during May–June (winter) from 1991 to 1996 and during December–January (summer) in subsequent years. There was also a change in the trawl gear used between the winter and summer trawl surveys and the depth range of the summer survey was extended to include the shallower area of the Pegasus Bay and Canterbury Bight (10–30 m).

At the time of the analysis, a biomass estimate was available from the 2000 trawl survey of the west coast South Island. However, the associated length frequency data were unavailable.

The biomass estimates derived from each series of trawl surveys are presented in Tables 6–9.

## 2.4 Scientific observer length frequency data

Length frequency data from barracouta catches sampled by the scientific observer programme were obtained from the Ministry of Fisheries Observer database. From 1986–87 to 1999–2000, catches were sampled from throughout the six fishery areas (Figure 3). However, sampling intensity and number of fish measured varied considerably among years and fishery areas (see Table 10, Table 11).

Preliminary examination of the data by target fishery revealed no significant differences between the length compositions from the different target fisheries within a year and area. Therefore data were amalgamated from all sampled trawls regardless of target species. Length frequencies were derived for years and areas where at least 200 fish were measured.

For the comparison of the length composition of the catches between areas, length data from the west coast South Island fishery were directly compared with data collected from the other fishery areas in the subsequent fishing year. This was due to the seasonal distribution of the individual fisheries with catches from the west coast South Island fishery being sampled during August–September and catches from the other areas were generally sampled from October to May.

## 2.5 Identification of year classes

Many of the length frequency samples, particularly from inshore trawl surveys, exhibited clear length modes. These modes were assigned to year classes based on their length and the date of sampling. For all areas, an assumed age-length key was applied based on ageing of fish from the Southland trawl survey (Harley et al. 1999). We classified any clear length mode up to 65 cm fork length according to the year of birth assuming a 1 October birth date (Harley et al. 1999) (see Table 12).

# 3. SEASONAL TRENDS IN CATCHES

## 3.1 East coast

A strong seasonal trend is apparent in the seasonal distribution of barracouta catch along the eastern coast of mainland New Zealand. During October–April, catches off the east coast of the North Island are very low, while a high proportion of the catch taken from off the east coast of the South Island is taken during this period (Figure 4).

From September to December, there was an increase in the monthly proportion of the annual catch taken in Pegasus Bay, followed by a drop in the proportion in January and February. In Canterbury Bight, catches also increased from September to December and were maintained until April, while off the Otago coast barracouta catches were low until December and increased to a peak in April (Figure 4).

The level of catch from the Otago area declined markedly between April and June and catches were negligible between June and October (Figure 4). There was also a decline in the monthly catch from the Canterbury Bight from April to a low level in July. Further north, in Pegasus Bay and off Kaikoura, the monthly catches declined from May to a low level in July, while off the east coast of the North Island the inverse trend was evident, with monthly catches increasing from June to reach a peak in August–September.

During September–October, catches off the east coast of the North Island declined, while monthly catches from northern Cook Strait and Kaikoura increased. During the subsequent months, the catches from these two areas declined, while catches increased in Pegasus Bay (Figure 4).

These monthly trends in the distribution of barracouta catch suggest a seasonal movement of barracouta along the eastern coast of mainland New Zealand. Barracouta are most abundant off Canterbury Bight during October–May. A strong northern migration of fish appears to occur from April to June, with fish migrating into the Wairarapa coast and Bay of Plenty during winter (August–September). There is an apparent reversal of this movement between September and November as fish return to Pegasus Bay and Canterbury Bight.

These observations are broadly consistent with trends in the domestic catch of barracouta from 1978 to 1984 (Hurst 1988). Catches from Cape Campbell to Pegasus Bay peaked in spring (September–November) and again in late summer (February) while the fishery south of Banks Peninsula peaked in summer (December–February) but extended until early winter (June) (Hurst 1988). In the Bay of Plenty, the main fishing season during 1978–84 was July–October, with the peak season during August–September. A similar seasonal trend in catch was also evident from Hawke Bay and the Wairarapa coast in 1983 and 1984 (Hurst 1988).

The seasonal trend in catch is also consistent with the results of a series of nine seasonal trawl surveys off the east coast of the South Island between March 1980 and December 1982 (Hurst & Fenaughty 1985). The surveys indicated the abundance of barracouta was higher during January–March and low in September. The length composition of the catch from the September trawl survey was characterised by virtual absence of larger barracouta (greater than 70 cm F.L.) (R. Hurst, pers. comm.).

## 3.2 Southland

The seasonal trend in catches from southeast of Stewart Island and southern Snares was similar to the trend in catch from the Otago area. Catches increased from November to reach a peak in February–April before declining to a low level in May (Figure 4). Catches were low throughout May–October. A similar trend was also apparent for the distribution in catch from the Auckland Islands fishery, although the seasonal peak in catch was limited to March–April.

For the Foveaux Strait and eastern Stewart Island areas, catches tended to increase from October to peak in November–January (Figure 4). This period of higher catch coincides with the occurrence of spawning of barracouta in late spring (November–December) in Southland (Annala et al. 2001). Catches in these areas declined in February, although the monthly catch from the eastern Stewart Island area increased to reach a secondary peak in April. The level of catch from the area declined between April and June and was low throughout June to October (Figure 4).

The seasonal trend in the distribution of catches from the Southland area suggests that barracouta may aggregate to spawn in the Foveaux Strait and eastern Stewart Island regions during November–December (Figure 4). Catches in these areas decline in the subsequent months, corresponding to an increase in the level of catch south of Stewart Island during December–March. This trend in monthly catch suggests a southern migration of barracouta to summer feeding grounds around the Stewart–Snares shelf and the Auckland Islands. Catches in these areas decline in April. However, there is no strong increase in the catch of barracouta in the adjacent areas in the subsequent months that would indicate the associated immigration of barracouta during this period.

Catches of barracouta in the Southland area were generally low throughout June to October and it is possible that the barracouta move north from the area during this period. Monthly catches of barracouta east of Stewart Island, off Otago, and in the Canterbury Bight persist in May before declining to a low level in June (Figure 4). This may correspond to a northern migration of fish from the Stewart–Snares shelf during April–May. Similarly, the seasonality of catches in the Foveaux Strait and eastern Stewart Island regions during November–December is consistent with a continued southern migration of fish from Pegasus Bay/Canterbury Bay. However, the lack of a strong seasonal trend in catches off Otago during September–December weakens this argument.

Seasonal trends in barracouta catch by the foreign licensed vessels from 1978 to 1984 were summarised by Hurst (1988). There was a general seasonal trend in both catch and catch rates peaking in the regions west and east of Stewart Island during October–December. Fishing effort moved to the southern side of the Snares Islands from December and monthly catches in this area peaked in February–March. High catch rates were also recorded from the Puysegur area during August. Catches were generally low from the Southland area from May to September. However, in 1981–82 and 1982–83 large catches and relatively high catch rates were recorded in the Solander Corridor and around the Snares Islands during May–June.

The seasonal trend in catch from the Southland area is consistent with seasonal trends in barracouta biomass estimates derived from the four *Shinkai Maru* trawl surveys during 1981–83. Three of these surveys were conducted during February–April and a survey conducted during February–March and yielded high biomass estimates compared to a very low biomass estimate derived from a single survey conducted in October–November 1983 (Hurst & Fenaughty 1985). However, the surveys did not include the area included within the 12 n. mile Territorial Sea or the Puysegur Bank/Solander Corridor region.

It is proposed that barracouta migrate to the Solander Corridor region in spring and, consequently, were not available to the trawl survey conducted during this period (Hurst & Fenaughty 1985). This is consistent with the comparison of the areal distribution of barracouta catches from a further *Shinkai Maru* survey conducted in June 1986 and a trawl survey conducted by *Akebono Maru* in the following November. The former survey revealed the catches of barracouta to be distributed over the Stewart-Snares shelf (Hurst et al. 1990), although catches of barracouta in this area were negligible from the subsequent survey, with most of the catches taken in the shallower areas (50–100 m) off eastern Stewart Island and the western approach to Foveaux Strait (Hurst & Bagley 1997a).

## 3.3 West coast South Island

Monthly trends in the distribution of catch from the northwestern coast of the North Island reveal a seasonal peak in catches during July–August and a declining catch in September–October (Figure 5). Catches were low through the remainder of the year. However, the overall level of catch was low and the distribution of catch will be influenced by the seasonal operation of the inshore trawl fisheries off the west coast of the North Island, principally snapper (October–February), trevally (December–March), gemfish (May–August), and tarakihi (May–August).

There was also a strong seasonal peak in barracouta catches off the west coast of the South Island during August–September (Figure 5). Catches within the three sub-areas of the west coast South Island declined sharply in October and catches remained low throughout October to June. The decline in catch in September corresponded to an increase in the monthly catch in both the Tasman Bay and Taranaki areas. Monthly catches in these areas continued to increase to reach a peak through December to January, before declining over the subsequent months (Figure 5).

Catches of barracouta off Cape Farewell were low through December–April, but increased in May and June before subsequently declining in July (Figure 5). This peak in catch occurred immediately before the increase in catch off the west coast South Island in August and may indicate that fish are moving through the area before spawning on the west coast. There is a second peak in the monthly catch from the area during September–November immediately following the large peak in catches to the south which may coincide with a northern movement of fish after spawning.

The seasonal distribution of catches from the Tasman Bay and Taranaki areas is consistent with the dispersal of the fish from the west coast South Island following spawning. However, for the latter area the seasonal timing of barracouta catches would also be influenced by the operation of the target jack mackerel fishery in the area during the summer period.

Further, the seasonal distribution of catches in the two areas was low during February–June and there is no corresponding strong increase in monthly catch of barracouta in the adjacent areas. Monthly catches from off the Kapiti coast increased markedly in April and remained high until June. However, this seasonal trend is largely driven by barracouta catches taken from this area in only a few years. Eastwards, in the area of southern Cook Strait, catches of barracouta increased between December and February and remained relatively constant between February and June (Figure 5). However, the exact location of the catch within this area is unknown and the affinity of fish in the area to either BAR 1 or BAR 7 remains unclear.

The extent of any movement of barracouta between the Taranaki coast and the northwest coast of the North Island during August–September is unknown. However, the seasonal trend in catch catch from the Taranaki and Tasman Bay areas could be related to a southern dispersal of barracouta following the spawning period.

Catches of barracouta from Puysegur and off the Fiordland coast are very low and there is insufficient information to reliably define a strong seasonal trend in the catch that may indicate the direct movement of barracouta between BAR 5 and BAR 7.

The strong seasonal trend in catch off the west coast of the South Island is consistent with eight seasonal trawl surveys conducted by *Tomi Maru, Shinkai Maru,* and *W.J. Scott* between December 1980 and April 1983 (Hurst & Fenaughty 1985). In general, the three surveys conducted during July–October yielded higher biomass estimates for barracouta than surveys at other times.

Monthly trends in the domestic catch from 1978 to 1984 revealed that catches off the west coast of the North and South Islands peaked during July–September, but catches from the small Tasman Bay fishery peaked in November–February (Hurst 1988). Most of the barracouta catch by foreign licensed vessels operating off the west coast of the South Island was taken immediately after the hake and hoki fishing seasons, with peak catches in August–September. Foreign licensed vessels also caught barracouta off the west coast of the North Island as a bycatch of the jack mackerel fishery between August and February (Hurst 1988).

## 3.4 Summary

In all areas, monthly trends in barracouta will be influenced, at least to some extent, by the distribution of the main target fisheries. However, in most areas the persistent seasonal trends in the monthly distribution of catch and the consistency in the trends with the adjacent statistical areas gives credence to the assumption that the monthly changes in catch are due to changes in the abundance of barracouta in the area. Nevertheless, this may not be the case for all areas, in particular the trends in monthly catch in the Southland area are likely to be more sensitive to the seasonal distribution of the other main target fisheries. The monthly distribution of catch is likely to be strongly influenced by the seasonal trends in the target squid fishery which barracouta represents a significant bycatch. More importantly, the absence of barracouta catch during June–October may be more attributable to the vessels involved in the fishery being present in the west coast South Island hoki fishery during that period.

Nevertheless, despite the limitations of the data, some general conclusions are proposed based on the monthly trends in barracouta catch by area.

1. There is a northward movement of fish up the east coast of mainland New Zealand during April to July from Canterbury Bight/Pegasus Bay. The extent of this movement is unclear, but appears to extend along the Wairarapa coast and possibly into the Bay of Plenty. There is a corresponding southern movement during September to December with fish resident in the Canterbury Bight during December–May.

2. In the Southland area, barracouta are abundant in the Foveaux Strait and eastern Stewart Island regions during November–December. These fish appear to move south to the Stewart–Snares shelf

and Auckland Islands in December–March and remain in these areas until April. The catch of barracouta in the Southland area is negligible during May–October.

3. Barracouta in BAR 7 appear to move down the west coast of the South Island during April–July to spawn in August–September. There is a corresponding northern movement during September–November. During October–February these fish may reside in Tasman/Golden Bay, western Cook Strait, and North and South Taranaki Bight.

# 4. ANNUAL TRENDS IN ABUNDANCE

## 4.1 West coast South Island

Most of the barracouta catch from the west coast South Island fishery is taken by the target trawl fishery during August and September (Figure 6). Total catch from this fishery increased from about 3000–4000 t during the 1989–90 and 1990–91 fishing years, dropped in 1991–92, increased in 1992–93 to about 5000 t, and steadily declined over the subsequent years to a low level in 1999–2000 (Figure 7).

The trend in catch is consistent with the trend in relative abundance from the *Kaharoa* trawl survey time series. The biomass estimates from the survey increased from 1991–92 to a high level in 1993–94 and 1994–95 and declined in 1996–97 and 1999–2000 (Figure 7). The trawl survey was conducted outside the main barracouta fishing season and, therefore, it was unlikely to monitor the abundance of the proportion of the stock that immigrates to spawn. The survey catch is also dominated numerically by a high proportion of prerecruit barracouta (less than 50 cm F.L.) and the resulting biomass estimates will be influenced by the relative strength of the prerecruit year classes. The main inshore target barracouta trawl fishery (CPUE 1, see Table 3) achieved high catch rates in 1989–90 and 1990–91. However, average catch per trawl dropped markedly in 1991–92 and recovered in the subsequent year, although not to the level of the earlier years. Since 1993–94, there has been an increase in the level of fishing effort, while catch rates have been variable between years. Catch rates have been low in the most recent years. In general, the observed trends in catch rate have been comparable in both statistical areas 033 and 034 (Figure 7).

CPUE from the larger vessels (45–75 m length) targeting barracouta during August–September was variable during 1989–90 to 1995–96, with high catch rates in 1990–91 and 1992–93 and lowest catch rates in 1991–92 (Figure 7). The level of target fishing has declined since 1995–96 and insufficient data are available from these years to determine the CPUE indices for the fishery. Most of the fishing effort for the fishery is from statistical area 035 (Figure 7).

Limited data were available from the barracouta bycatch from the target jack mackerel midwater trawl fishery on the west coast of the South Island. Catch rates from the fishery were variable over the study period, with relatively high catch rates achieved in 1996–97 and 1997–98 (Figure 7).

Overall, the trend in the level of catch from the west coast South Island fishery may indicate an increase in abundance of barracouta during the early 1990s to reach a peak around 1992–93 to 1996–97 followed by a decline. This is consistent with the trend in the trawl survey biomass estimates, with higher abundance in 1993–94 and 1994–95 and a subsequent decline in survey biomass. However, the trends in catch rate from three CPUE series are variable and inconsistent with the trend in the total catch. The preferred CPUE index was highest in 1989–90 and 1990–91 and low in 1994–95 when both the catch and trawl survey index were high. The decline in total catch may be attributable to the decline in fishing effort from the larger vessels (CPUE 2 and CPUE 3) since 1995–96.

## 4.2 Cook Strait

The total barracouta catch from the Cook Strait fishery increased from 1989–90 to 1991–92 and remained relatively constant between 1991–92 and 1997–98 at about 3000 t. The catch declined from 1997–98 to a low level in 1999–2000. A significant proportion of the catch was taken by the target barracouta fishery, although the level of target catch declined steadily from 1991–92 to 1999–2000 (Figure 8).

The inshore target barracouta fishery in the Cook Strait area operates primarily in statistical areas 037 and 038. Trends in the level of fishing effort and catch rate were comparable between 1989–90 and 1999–2000, with effort and CPUE generally increasing from 1989–90 to 1993–94 and then steadily declining over the remainder of the study period. The CPUE trends were generally consistent between the two statistical areas although the magnitude of the trend was greater in 037 than 038 (Figure 8).

The target jack mackerel trawl bottom trawl fishery accounts for a significant catch of barracouta within the Cook Strait area. The number of trawls from this fishery that caught barracouta increased between 1989–90 to 1992–93 and subsequently declined to a low level at the end of the time series. In contrast, the average catch rate of barracouta from these trawls increased during the same period in both statistical areas 037 and 040 (Figure 8).

The total and target barracouta catch from the Cook Strait fishery increased from 1989–90 to 1991–92, remained relatively stable until the mid 1990s, and subsequently declined. This trend was also evident in the preferred CPUE series with catch rates declining from 1993–94 in the two main areas fished. However, the converse trend was evident in the CPUE series from the bycatch of the jack mackerel fishery as catch rates increased from 1993–94 to 1997–98. The two fisheries operate in different areas and the conflicting trends in catch rate could be influenced by a change in the areal distribution of barracouta.

## 4.3 East coast South Island

The total annual barracouta catch from the east coast South Island fishery remained relatively constant from 1989–90 to 1993–94 at about 7000 t. In the subsequent years, annual catches steadily increased to a maximum of about 10 000 t in 1996–97 before declining slightly. A high proportion of the barracouta catch taken between 1989–90 and 1992–93 was from the target trawl fisheries. However, the proportion of the total catch taken by the barracouta target fishery declined considerably in 1993–94 and, while the level of target catch remained relatively stable, the proportion of the catch targeted declined with the increase in total catch to 1996–97 (Figure 9).

The total BAR 1 catch substantially exceeded the TACC for the first time in 1995–96 and remained at this higher level until 1997–98, largely due to the increase in the level of barracouta bycatch taken in the associated trawl fisheries (Annala et al. 2001).

There was a general decline in the level of fishing effort by the inshore target barracouta trawl fishery (CPUE 1) between 1990–91 and 1993–94, although the fishery remained relatively stable for the remainder of the study period. Annual catch rates from the fishery varied between years, but there was a slight increase in CPUE over the period (Figure 9).

However, the trend in catch rate was variable between statistical areas encompassing the east coast South Island fishery. Catch rates from 018 and 020 generally declined between 1989–90 and 1995–96 and subsequently increased to a peak in 1998–99 before declining in 1999–2000 (Figure 9). In contrast, catch rates in 022 were stable between 1989–90 and 1993–94, increased substantially in 1994–95 and declined gradually over the remaining period. Catch rates from 024 increased markedly between 1989–90 and 1991–92 and remained higher during subsequent years.

The offshore target barracouta fishery (CPUE 2) accounts for a relatively small proportion of the total east coast South Island barracouta catch (see Figure 6). There has also been a decline in the level of target fishing throughout the study period. The catch rate from the fishery was variable between years and, overall, reveals no strong trend in CPUE from the fishery over the entire study period (Figure 9). Nevertheless, there was an apparent decline in catch rates from both statistical areas 020 and 022 between 1989–90 and 1991–92. CPUE indices recovered in the subsequent years and, for statistical area 020, were maintained at a high level between 1993–94 and 1996–97. Catch rates from this area dropped in 1997–98, following a drop in catch rates from 022 during the previous year (Figure 9).

Between 1989–90 and 1999–2000, many trawls conducted by inshore trawl vessels targeting red cod yielded a bycatch of barracouta (Figure 9). The number of trawls increased annually from 1989–90 to 1997–98 before dropping in the two subsequent years. The increase in the number of red cod trawls with a bycatch of barracouta is consistent with an increase in the catch and level of fishing effort in the red cod fishery during the period (Beentjes & Renwick, NIWA, unpubl. results). Catch rates of barracouta from the target red cod trawls declined slightly between 1989–90 and 1992–93 and then steadily increased to a high level in 1996–97. The CPUE declined between 1996–97 and 1998–99 to 1999–2000 (Figure 9).

The trends in catch rate of barracouta from the red cod fishery varied between statistical areas. Catch rates from statistical areas 020 and 022 were comparable from 19989–90 to 1993–94 before increasing to reach a high level between 1995–96 and 1997–98 (Figure 9). CPUE from trawls in statistical area 020 declined during the two following years, while catch rates in 022 were maintained at a higher level.

There was a general increase in the bycatch of barracouta from red cod target trawls in statistical area 024 from 1989–90 to a peak in 1995–96 (Figure 9). Catch rates from this area declined in the two subsequent years, but recovered in both 1998–99 and 1999–2000. Limited data were available from statistical area 018, although catch rates between 1996–97 and 1998–99 were generally higher than in the preceding years.

There was a general increase in the barracouta bycatch from the fishery from 1992–93 to 1996–97. This was largely due to an increase in the bycatch from the red cod target trawl fishery driven partly by an increase in the catch rate of barracouta from the fishery. The increase in catch rate during this period was evident in each of the main statistical areas fished. The increasing trend in catch rate was also evident from the CPUE of the inshore target barracouta fishery operating in statistical area 022 and the target catch from larger vessels fishing in 020 and 022. However, this trend is not consistent with the high catch rates of the inshore target fishery in statistical area 024 in 1991–92 and 1992–93 or the decline in catch rate from the inshore fishery in 018 and 020 between 1991–92 and 1995–96 (Figure 9).

Catch rates of barracouta from the red cod target fishery declined from 1996–97 to 1998–99, largely due to a decline in catch rates from the 020 fishery, while catch rates from the other areas were generally maintained at the higher level. There was also a gradual decline in catch rates from the inshore target fishery in statistical area 022, although this was contrary to an increase in catch rates for areas 018 and 020 between 1995–96 and 1998–99 (Figure 9).

Two separate series of inshore trawl surveys off the east coast South Island were conducted during the study period. The winter survey was annual from 1990–91 to 1993–94 and in 1995–96, while the summer survey was conducted annually from 1996–97 to 1999–2000. The summer series used a finer mesh codend and was extended to include the 10–30 m depth range. However, consecutive winter (May 1996) and summer (December 1996) trawl surveys yielded comparable biomass estimates and similar length frequency distribution (see Figure 19).

This may indicate that the catchability of barracouta was comparable in the two survey series and, consequently, it may be valid to compare the entire series of east coast South Island surveys. These surveys indicated the abundance of barracouta was higher in 1995–96 to 1999–2000 compared to 1990–91 to 1993–94. This result is consistent with the increase in the catch rate of barracouta from the preferred CPUE index.

## 4.4 Stewart shelf

Annual catches of barracouta from the Stewart shelf area remained relatively constant between 1989–90 and 1996–97 at about 500–1000 t. Catches increased in 1997–98 to about 2000 t, before declining to the earlier level over the two subsequent years. Before 1997–98, most of the catch was taken by the target trawl fishery, although in subsequent years a higher proportion of the catch has been taken as a bycatch of other trawl fisheries, primarily the squid fishery (Figure 10).

Biomass estimates of barracouta for the Stewart shelf area derived from the time series of Southland trawl surveys were generally comparable between 1992–93 and 1995–96. There was a high coefficient of variation associated with most the indices with the exception of the 1994–95 index (Figure 10).

Limited catch and effort data are available from the main Stewart shelf barracouta target and bycatch fisheries. Catch rates from the target fishery were relatively stable between 1989–90 and 1991–92, but increased in the two subsequent years to reach a peak in 1993–94. CPUE indices declined in 1994–95 and remained at a relatively low level for the remainder of the study period (Figure 10).

## 4.5 Snares

Catches of barracouta from the Snares fishery were high between 1989–90 and 1992–93, dropped markedly in 1993–94, and remained at the lower level from 1993–94 to 1996–97. Total catch increased in 1997–98 and 1998–99 and remained high in 1999–2000. Most of the barracouta catch from the Snares fishery between 1989–90 and 1999–2000 was taken as a bycatch of other target trawl fisheries, primarily the squid fishery (Figure 11).

Trawl survey indices derived for the Snares area from the time series of *Tangaroa* Southland surveys reveal a large decline in barracouta abundance in the area between 1992–93 and 1993–94. The trawl survey indices from the two subsequent surveys remained at about the level of the 1993–94 index (Figure 11).

Limited catch and effort data are available from the small target barracouta trawl fishery operating in the Snares area (CPUE 1). Consequently, the time series of data has limited application in monitoring trends in relative abundance from the fishery. Nevertheless, the time series indicates catch rates were moderate in 1991–92 to 1992–93, lower in 1994–95 and 1995–96, and high from 1997–98 to 1999–2000 (Figure 11).

Catch rates of barracouta from the target squid midwater trawl (CPUE 2) and bottom trawl (CPUE 3) fisheries reveal a similar general trend from 1989–90 to 1999–2000. There was a general decline in barracouta bycatch from both fisheries from 1989–90 to 1996–97 followed by an increase in catch rate in the subsequent years (Figure 11). The trend was more evident in the midwater trawl fishery dataset which includes a higher number of trawl records than from the bottom trawl fishery. The anomalously high index of CPUE from the bottom trawl fishery for the 1995–96 fishing year is derived from a small number of trawl records. The trend in CPUE from both the midwater and bottom trawl fisheries is largely driven by the catch rates from the main area of the fishery, statistical area 028 (Figure 11).

The decline in catch rate from the target squid bottom trawl (CPUE 2) is consistent with the standardised CPUE indices from 1989–90 to 1997–98 (Harley et al. 1999) (Figure 11).

The trend in the preferred CPUE index (target squid midwater fishery) is broadly consistent with the trend in annual total catch and trawl survey indices. Overall, the indices suggest abundance was high in the early 1990s and declined sharply between 1992–93 and 1993–94. Abundance remained low from 1993–94 to 1996–97 then increased during the subsequent three years. However, the high CPUE index for 1993–94 was inconsistent with this overall trend.

## 4.6 Auckland Islands

In most years, the catch of barracouta from the Auckland Islands fishery has been less than 200 t (Figure 12). This catch was virtually exclusively taken by the target squid fishery and the level of barracouta bycatch will be highly dependent on the level of effort expended in the squid fishery. In 1995–96, the fishery yielded an exceptionally high catch of barracouta, although the total number of trawls conducted annually in the SQU 6T fishery was relatively stable from 1993–94 to 1996–97 (Langley 2001).

Limited barracouta catch and effort data are available from the target squid midwater fishery due to the small number of trawls catching barracouta in most years (Figure 12), except the 1995–96 year, when barracouta was caught in a large number of trawls. The average catch rate of barracouta was determined for those years where sufficient records were available (at least 50 trawls catching barracouta) (CPUE 1). These data suggest catch rates were comparable in 1990–91, 1992–93 to 1993–94, and 1995–96, but low in 1996–97 (Figure 12).

## 4.7 Correlations

The trends in relative abundance between fishery areas were compared to investigate potential relationships between the main barracouta fisheries. A strong trend in stock abundance, as indicated by the CPUE from some of the barracouta fisheries, may be expressed as a corresponding trend in abundance in another related fishery providing evidence of the stock relationship between the two fisheries. For example, a similar trend in abundance from spawning and non-spawning areas may indicate that both fisheries operate on the same population. Similarly persistent differences in the abundance between areas may indicate the fishery exploits a different population or that the distribution of the population is variable between years.

For each of the six fishery areas, the annual CPUE indices from the preferred CPUE time series were compared (Figure 13). This comparison assumes that the preferred CPUE index reflected trends in the abundance of barracouta in each area.

In most cases, correlations between corresponding annual CPUE indices were insignificant due, in part, to the low sample size (between 3 and 9 degrees of freedom) (Table 13). A significant positive correlation ($p < 10\%$) was identified between the CPUE indices from the Stewart shelf and Cook Strait fisheries, while CPUE indices from the Snares shelf and east coast South Island fisheries are negatively correlated. There are also negative correlations between the CPUE indices from the east coast South Island fishery and the Stewart shelf, Auckland Islands, and west coast South Island fisheries, although the correlation coefficients are not significant (Figure 13). CPUE indices from the west coast South Island and Cook Strait fisheries are correlated, although the correlation is not significant at the 10% level.

Negative correlations were identified between the east coast South Island fishery and the Stewart shelf and Snares shelf fisheries and, to a lesser extent, the Auckland Islands fishery. The east coast South Island CPUE indices are derived from fishing during October–May, while remaining indices were derived from January–May. The comparison between the indices shows that when abundance is high in the east coast South Island fishery it is generally low in both the Snares shelf and Stewart shelf fisheries. Conversely, when abundance is low in the east coast South Island fishery abundance is high in either the Snares shelf and Stewart shelf fisheries. Differences in the catch rate of barracouta do appear between the two latter fisheries with relatively higher catch rates observed in the Stewart shelf fishery in 1993–94 and lower catch rates in the Stewart shelf fishery in both 1998–99 and 1999–2000.

Most of the contrast in catch rates between the east coast South Island fishery and the Snares shelf and Stewart shelf fisheries is due to differences in catch rates during two periods; between 1990–91 and 1993–94 when catch rates were low for the east coast South Island fishery and generally high for Snares shelf and Stewart shelf fisheries and between 1995–96 and 1997–98 when the trend was reversed. In the intervening years, catch rates for the east coast South Island and the Snares shelf and Stewart shelf fisheries were moderate. During 1998–99 and 1999–2000, catch rates for the east coast South Island and the Snares shelf fisheries were moderate, while catch rates remained low in the Stewart shelf fishery.

Catch rates from the west coast South Island fishery (August–September) were positively correlated with catch rates from the Cook Strait fishery during the subsequent period (October–February). Both sets of indices are generally characterised by high catch rates in the early 1990s and low catch rates in the late 1990s (Figure 13), although there is deviation from this correlation in 1992–93 and 1994–95.

CPUE indices from the Cook Strait fishery are also positively correlated with the indices from the Stewart shelf fishery. Both sets of CPUE indices are derived from fishing effort during the same period (October to February or March) and given the distance between the two areas it is unlikely that the two sets of indices are monitoring the same barracouta stock. A more probable explanation is that the two populations have both exhibited similar trends in relative abundance due to corresponding trends in recruitment strength or some other perturbation.

Trends in CPUE from the west coast South Island were positively correlated with catch rates from the Snares shelf and, to a lesser extent, with the Stewart shelf. However, the correlations were not significant at the 10% acceptance level.

## 5. PATTERNS IN LENGTH FREQUENCIES

### 5.1 Year class strengths

Juvenile fish were sampled in significant quantities from the inshore *Kaharoa* surveys from the west coast of the South Island. Overall, larger (over 60 cm F.L.) barracouta accounted for a smaller proportion of the catch (by number) from the west coast South Island survey than from the eastern survey. This is consistent with the low level of commercial catch taken during March–April when the west coast South Island surveys were conducted (see Figure 6). Analysis of length frequency modes suggests strong 1991, 1992, and 1996 year classes, while the 1993–1995 year classes appear weak (Figure 14).

Commercial catch length frequencies from the west coast South Island fishery are generally dominated by larger fish (over 60 cm F.L.) and strong length modes are not evident in most of the annual length compositions. Nevertheless, there is an indication of the presence of a strong 3 year age class (55–65 cm F.L.) in the 1998–99 length composition (Figure 15). This age class corresponds to the 1996 year class which is also apparent as a strong year class in the length composition of the commercial catch sampled from the Cook Strait, Snares, and east coast South Island fishery areas (Figure 16, Figure 17, and Figure 18).

Length frequency distributions from winter and summer east coast South Island trawl surveys are dominated by length modes of the juvenile length classes occupying the 20–65 cm (F.L.) length range. In addition, the trawl surveys during 1995–96 and 1996–97 indicated a relatively high abundance of barracouta in the larger length classes (over 65 cm F.L.). The relative abundance of fish in these length classes declined in subsequent years.

For the time-series of winter and summer surveys, the 20–65 cm length range generally comprised 2–3 distinct length modes: about 20–40 cm, 40–53 cm, and 53–65 cm. A comparison of the magnitude of these modes suggests strong 1989, 1990, 1995, and 1996 year classes (Figure 19). The 1989 and 1990 year classes are evident as 1 year olds in the KAH9105 and KAH9205 survey, as 2 and 3 year olds in

1992–93, and were likely to contribute to a significant proportion of the dominant 55–65 length class in KAH9406. These strong year classes are also likely to have represented a significant proportion of the fish in the larger (70+ cm) length classes in subsequent years. These year classes also dominated the length composition of commercial catches sampled from the east coast South Island fishery in 1992–93 (Figure 19).

The strong 1996 year class was evident recruiting to the commercial fishery in east coast South Island and Snares area in 1999–2000, although the year class was more dominant in the length composition of the catch from the latter area (Figure 18 and Figure 20).

Conversely, the age 1+ year classes sampled by the KAH9306 (1991 year class), KAH9406 (1992 year class), and KAH9606 (1994 year class) surveys appear to be relatively weak. This period of low recruitment is evident from the small proportion of fish less than 65 cm (F.L.) in the KAH9606 survey and persists in the subsequent survey length compositions. More recent year classes, sampled as age 1 fish in 1997–98 to 1999–2000, appear to be of moderate strength. However, there may be some differences in the catchability of small barracouta between the winter and summer surveys due to the changes in the codend mesh size and the depth range fished. Commercial catch length frequency distributions from the east coast South Island for the 1998–99 fishing year have higher proportions of 2 year olds, supporting the suggestion of a strong 1996 year class (see Figure 17).

The Southland trawl survey conducted by *Shinkai Maru* during the 1980s indicated the presence of strong 1984 and 1985 year classes (Figure 20). The *Tangaroa* surveys sampled a few small (less than 60 cm) barracouta (Figure 20). The age compositions derived from these surveys revealed the presence of strong 1986 and 1989 year classes followed by weak year classes from 1990 to 1994 (Harley et al. 1999). The length composition of the commercial catch from the Snares fishery indicates the presence of the strong 1996 year class in 1999–2000 and possibly strong 1988 and 1989 year classes in 1990–91 and 1992–93, respectively (Figure 18).

For comparability, the Southland trawl survey length compositions did not incorporate catches from the shallow areas (less than 100 m) surveyed by *Tangaroa*. However, these surveys did not catch large numbers of small barracouta in the shallow areas and the total survey length compositions are comparable to those presented in Figure 20 (Hurst & Bagley 1997b).

For the years when both trawl survey and commercial catch sampling data from the Snares fishery are available (1992–1993 to 1995–1996) the length frequency distributions derived from each data set are comparable (Figure 20, Figure 18, Hurst & Bagley 1997a). Commercial catch length frequencies from the Snares suggest relatively fewer small fish from 1992–93 to 1995–96 corresponding to the weak 1990–1994 year classes. (Figure 18). No small barracouta were sampled from the commercial catch from the Auckland Island area, while sampling from the Stewart shelf fishery was limited (Table 10, Figure 21, Figure 22).

The 1997 year class was present as a strong cohort in the commercial catch from the Stewart shelf commercial catch in 1998–99 (Figure 21).

The assignment of year classes to the length modes of the length frequency distributions requires assumptions regarding the timing of spawning and growth rate. Growth rates may vary between years and fishery areas making the accurate assignment of the year class problematic. This is evident when comparing the length range occupied by the cohorts making up the length composition of the barracouta catch from corresponding west coast and east coast South Island trawl surveys (Figure 23). For example, in 1992 the length mode assumed to represent the 1990 cohort was considerably smaller in the length composition from the east coast South Island survey conducted in May than in the west coast South Island in the preceding February. Similar differences are also evident between the corresponding surveys in 1994 and 1997. Consequently, in the absence of reliable ageing data, the assignment of year class strengths based on the length range of individual modes should be considered approximate only.

In summary, the length compositions from all areas indicate strong recruitment of the 1995 and 1996 year classes, while the 1993 and 1994 year classes are weak. The east coast South Island and the Stewart/Snares/Auckland areas also had weak recruitment from the 1991 and 1992 year classes, although the west coast South Island trawl survey indicated that these cohorts were strong. There is no evidence of strong recruitment of these cohorts in the recruited population sampled by the SOP. However, it is difficult to resolve individual year classes as the 3+ age class is only partially recruited and individual length modes merge in the adult. Ageing data would be required to clearly resolve the relative year class strength of the cohorts comprising the adult mode.

The 1989 year class was strong in both the east coast South Island and the Stewart/Snares/Auckland fishery areas but weak from the west coast South Island trawl survey. The 1990 year class appeared to be strong in the east coast South Island fishery and weak in the Stewart/Snares/Auckland areas and from the west coast South Island trawl survey.

Overall, the relative year class strengths of individual cohorts appear comparable between the east coast South Island and the Stewart/Snares/Auckland areas, but frequently differ from the west coast South Island trawl survey. Limited information is available to resolve year class strengths from the recruited component of the west coast South Island fishery. However, there appear to be some differences between the year class strength of trawl survey and commercial catch from the west coast South Island that may indicate that recruitment to the adult component of the stock is not restricted to the localised recruitment monitored by the survey.

## 5.2 Length frequency distributions of commercial catch

Barracouta are relatively fast growing and have a high degree of variability in recruitment strength. On this basis, it was considered that populations subject to differences in recruitment strength and exploitation rate may exhibit considerable differences in the length composition of the catch. A comparison of the length composition of catches from the main fisheries over time may indicate the extent of stock separation between different areas. Unfortunately, the areal distribution of barracouta length frequency data collected by the SOP varied over the study period and there were insufficient data available to determine the length composition of the recruited barracouta for each of the main fishing areas in each year. In most years, sufficient data were available to determine only the length composition of the catch in only two or three of the six defined fishing areas.

Sufficient samples were available to determine the length composition of barracouta from the Snares in each of the 11 years that SOP length frequency data were available (19986–87 to 1999–2000). Annual sampling was relatively limited in the other areas; west coast South Island (8 years), Auckland Islands (6 years), east coast South Island (6 years), Cook Strait (4 years), and Stewart shelf (3 years) (Figure 24). The limited sampling prevented the comparison of length compositions from an individual fishery area over successive years and prevented a direct comparison of the length compositions between each of the areas in most years.

For many of the years, the length composition of the barracouta catch was derived from relatively few fish, measured from a limited number of samples. Consequently, it is unknown how representative the resulting length composition is of the total barracouta catch from the area. The length compositions from separate areas were generally collected during the peak fishing period in each area. However, due to seasonal differences between some fisheries, differences in the length compositions between areas could be partially due to growth and/or the recruitment of a new cohort to the fishery.

There were similarities between the length compositions from the west coast South Island and Cook Strait areas in 1993–94, 1994–95, and 1999–2000. In 1999–2000, the strong 1995 age class was present in the length compositions from both areas, occupying the 55–65 cm length range (Figure 24). The length structure sampled in 1987–88 differed between the two areas. The 1994–95 and 1997–98 length compositions from the west coast South Island were comparable to the length structure of the

Snares shelf catch in the corresponding years, although the length frequency data were divergent in the other years where data were available (1987–88, 1993–94, 1995–96, and 1999–2000) (Figure 24). The length compositions from the west coast South Island and Stewart shelf fisheries were comparable in 1990–91, but differed in 1987–88.

Only four annual length frequency distributions were available for the Cook Strait fishery. For the 1987–88 fishing year, the length frequency data were comparable to the length compositions sampled from both the east coast South Island and Snares shelf fisheries. However, in the remaining years (1993–94, 1994–95, and 1999–2000) the length structure from the Cook Strait fishery was not comparable with the corresponding data from either area.

Length compositions derived for the Snares shelf and east coast South Island fisheries were very similar in 1987–88, 1994–95, 1996–97, and 1998–99, but were dissimilar in 1986–87, 1992–93, and 1999–2000 (Figure 24). Length frequency data were available for the Stewart shelf area in 1987–88 and 1998–99. In 1987–88, the length composition from this area was dissimilar from the other two areas. In the latter year, the length composition was dominated by a strong juvenile mode (1997 year class), although the length composition of the adult mode was comparable to the length compositions from both the Snares shelf and east coast South Island fisheries (Figure 24).

Length frequency data from the Auckland Islands fishery revealed the barracouta catch generally comprised larger fish compared to the other areas sampled. The length composition of the Auckland Islands catch was different from the other areas sampled, except in the 1995–96 and 1996–97. In 1995–96, the length composition was similar to the distribution of the catch sampled from the west coast South Island fishery and in 1996–97 the length composition was comparable to data from both the Snares shelf and east coast South Island areas (Figure 24).

In summary, the examination of length frequency data from the commercial catch does not reveal strong similarities in length structure of the catch sampled from each of the main fisheries. This may, in part, be attributable to the deficiencies of the available data, in particular the limited quantity of data available from many of the areas over the study period. However, for areas where sufficient data are available, it is apparent that there is considerable annual variation in the length composition from successive years that are likely to be attributable to growth and variation in year class strength.

Given the extent of the observed annual variation within an area, the high level of similarity between length compositions derived from different areas in corresponding years suggests a high level of mixing between some areas in some years. In most years, there is a relatively high affinity in the length compositions from east coast South Island and the Snares shelf fisheries and between the west coast South Island and Cook Strait fisheries. These areas are broadly adjacent to each other and the similarities in length composition may be attributable to the seasonal movement of barracouta between areas and/or due to similarities in recruitment strength and growth in the adjacent areas.

## 6. SPAWNING LOCATIONS

The information available concerning the distribution of spawning barracouta and the location of juvenile fish is presented in Hurst et al. (2000) and Hurst et al. (in press). These data reveal that barracouta possessing gonads in the ripe and running ripe stages of development are present in each of the main fishery areas, although the prevalence of spawning fish off the east coast of the South Island is low. Within the Southland area, most of the samples including spawning fish were from catches of barracouta in the shallower areas to the east and west of Stewart Island. These samples were collected during October–November when spawning fish made up a relatively high proportion of the fish sampled. However, no sampling was conducted during the three preceding months so the duration of the spawning period in the Southland area is unknown.

There is a well defined spawning season for barracouta off the west coast of the South Island with spawning fish constituting a significant proportion of sampled catches during August–October (Hurst et al. in press). Very limited sampling of the barracouta catches off the east coast of the South Island was conducted during August–October, although the low number of fish sampled is consistent with the apparent low seasonal abundance of barracouta in the area. A few ripe and running ripe fish were sampled from the catch in November, while a relatively high proportion of spent fish were present in the catch during December–February (Hurst et al. in press). In contrast, virtually all sampling from the fisheries off the east coast of the North Island was restricted to August–September and sampled catches were dominated by spawning fish. No sampling data are available from the west coast of the North Island. However, anecdotal information suggests barracouta may also spawn in this area (R. Hurst, pers.comm.).

Juvenile barracouta (0+ and 1+ age classes) are widespread throughout the coastal waters of New Zealand (Hurst et al. 2000, Hurst et al. in press). However, the abundance of juvenile barracouta appears to be higher in Tasman Bay, Hauraki Gulf, and off the east and west coasts of the South Island, while the occurrence of juvenile barracouta in the Southland area was relatively low (Hurst et al. in press). However, the number of records of juvenile barracouta in each area is largely determined by the number of surveys conducted in each area, the trawl gear used, and the depth range surveyed. Consequently, few conclusions can be drawn concerning the relative abundance of juvenile barracouta between areas.

The distributions of juvenile barracouta do not provide a strong indication of the location of the main spawning areas for barracouta and there may be considerable movement of barracouta in both the larval and juvenile phases of the life history.

## 7. DISCUSSION

Barracouta are a highly mobile species capable of large-scale movements between fishstock areas. Potential stock scenarios for barracouta around southern New Zealand were qualitatively assessed based on a review of existing data from the fishery. Most of the data were not collected specifically to address and objective of this project and, consequently, there are considerable limitations in the application of these data to resolve potential stock boundaries.

A number of potential stock hypotheses for barracouta are plausible, including the separation of the stocks by the three administrative fishstock areas or the amalgamation of the two or all of the fishstock areas. Five potential stock scenarios were initially considered:

1. three discrete stocks: BAR 1, BAR 5, and BAR 7.
2. a single western and southern stock (BAR 7 and BAR 5 combined) and a separate eastern stock (BAR 1).
3. a single western stock (BAR 7) and a separate eastern and southern stock (BAR 1 and BAR 5 combined).
4. a combined eastern and western stock (BAR 1 and BAR 7) and a separate southern stock (BAR 5).
5. a more complex stock relationship with a high level of mixing between all areas and essentially a single mainland New Zealand stock (BAR 1, BAR 5, and BAR 7 combined).

The review of the available data from the barracouta fishery does not enable definitive conclusions regarding the stock boundaries around mainland New Zealand. However, the qualitative appraisal of these data suggested a distinction between the western (BAR 7) and eastern (BAR 1) stocks of barracouta, while the Southland (BAR 5) population appears more closely aligned to the eastern stock.

There may be at least some mixing of barracouta between these areas due to the movement of fish from the east coast South Island to the west coast North Island associated with spawning (as evident from tagging studies).

Spawning of barracouta is also known to occur in the Southland area and this area may support a discrete stock. Some strong similarities were identified between barracouta from BAR 1 and BAR 5. It has been proposed that fish from BAR 1 migrate to southern feeding grounds during the summer (Hurst 1988). The similarity between the two fishstock areas may be attributable to a high level of stock mixing during this period.

This stock hypothesis is based on relatively limited information and other stock hypotheses may also be plausible. The data are available for a relatively short period (10–15 years) and it is unknown whether these recent observations persist over the longer term or whether the observations are attributable to recent trends in the distribution of barracouta between areas. A more comprehensive study of barracouta stock boundaries would also include additional information from the barracouta fisheries off the northern North Island. However, this was beyond the scope of the present study.

The rationale for the proposed stock hypothesis is outlined below.

**Western stock (BAR 7)**

The proposed western stock includes the barracouta fisheries off the west coast South Island, Tasman Bay, western Cook Strait, and off the Taranaki coast. The west coast South Island area represents the principal spawning ground for the stock with spawning occurring during winter (August–September). It is proposed that barracouta migrate to spawn in this area from the Taranaki Bight and Tasman Bay areas. The affinity of barracouta between these areas is supported by several observations.

- Trends in the seasonal distribution of catch suggest movement of fish from the west coast South Island in winter (August–September) to the Taranaki Bight and Tasman Bay during summer (November–February).

- A correlation between CPUE indices from inshore west coast South Island fishery and the Cook Strait fisheries with both indices indicating a general decline in abundance of barracouta during the late 1990s. However, there are some conflicting signals in the other abundance indices from both fishery areas.

- The apparent decline in abundance of barracouta in these areas is consistent with a recent decline in the level of recruitment to the fishery. The time-series of west coast South Island trawl surveys indicated that the recruitment strength of the 1993–1995 year classes was low. However, it is unknown whether recruitment of the stock is dependent solely on localised recruitment or the recruitment of barracouta from other areas. For example, while the 1995 year class was weak in the trawl survey it appeared to be relatively strong in the length composition of the commercial catch from the west coast South Island.

- The length compositions of the commercial catch from the Cook Strait and west coast South Island fisheries were comparable in most years where corresponding samples were available.

**Eastern (BAR 1) and Southland (BAR 5) stocks**

Barracouta off the eastern coast of Mainland New Zealand (BAR 1) appear to make substantial movements along the eastern coast, migrating north in winter (August–September) associated with spawning and returning south during the following months. These fish may also migrate southward from BAR 1 to feeding grounds within the Southland area during the summer (November–April). The extent of the interaction between the barracouta populations resident in the east coast South Island and Southland area is unknown.

Recruitment appears to occur from spawning within the BAR 5 during late spring. However, there appears to be an overlap in the distribution of fish from BAR 1 and BAR 5 through the summer. Full or partial mixing of the barracouta populations may occur during this period. The extent of the interaction between BAR 1 and BAR 5 may also vary between years, potentially influenced by variation in the prevailing environmental conditions.

The following observations are available from the BAR 1 and BAR 5 fisheries that support the proposed stock hypothesis and the interrelationship between fish from these two areas.

- A strong seasonal trend in catch indicates that barracouta migrate north from southern BAR 1 during winter and return in spring. These trends are broadly consistent with the trends described for the 1978–1984 period (Hurst 1988) and the movement of the tagged barracouta (Hurst & Bagley 1989). It is also suggested that a component of the catches of barracouta taken from BAR 5 during the summer months are from fish migrating south from BAR 1 to feeding grounds in the Southland area.

- The absence of significant catches in BAR 5 during June–October suggests a decline in availability of barracouta in the Southland area. This may relate to an emigration of fish from the area in April–May, although the magnitude and extent of any northern migration is unknown. During June–October, the distribution of the resident BAR 5 population may be restricted to the shallower areas of the Stewart–Snares shelf, Foveaux Strait, and eastern Stewart Island. Spawning is known to occur in these areas in late spring (October–November).

- The northern migration of barracouta is consistent with the movement of tagged fish from off the east coast of the South Island to the eastern North Island and, to a lesser extent, to the western North Island from July to September. The tagging results do not provide any conclusions regarding the relationship between fish in the Southland (BAR 5) and east coast South Island (BAR 1) areas. A few fish were tagged around Stewart Island but none were recovered. One fish tagged off Dunedin was recovered to the southeast of Stewart Island (Hurst & Bagley 1989).

- The strong negative correlation between the CPUE indices from the east coast South Island and Snares/Stewart shelf fisheries. These two sets of CPUE indices were derived from a corresponding period (January–May). The indices revealed an increase in catch rates from the east coast South Island fishery during 1993–94 to 1996–97 and a corresponding decline in catch rate from the Snares shelf fishery during the same period. Conversely, catch rates declined from the east coast South Island fishery between 1996–97 and 1999–2000, while CPUE increased in the Snares fishery. The magnitude of the annual variation in CPUE indices in each of the areas appears too great to be solely driven by variation in recruitment. Recruitment in BAR 5 appeared to be low during the mid 1990s and does not account for the recent increase in CPUE in the area. It is proposed that the large changes in annual abundance between areas are due to changes in the distribution of barracouta between years, in particular the extent of the southern migration of fish during the summer period. This hypothesis is consistent with the high proportion of recruited barracouta sampled by the east coast South Island trawl survey length composition in 1995–96 and 1996–97 and the subsequent decline in the abundance of recruited barracouta in the survey biomass in subsequent years.

- General similarity in the year class strength of barracouta between the east coast South Island and Southland areas inferred from the trawl surveys and length composition from the commercial catch. However, there are some apparent exceptions to this trend with the strong 1990 year class present in the east coast South Island fishery while the year class was weak in Southland.

- General similarity in recruited length composition between the east coast South Island and Snares shelf fishery. This is despite some indication of differences in year class strength of prerecruit fish between areas, suggesting that stock mixing occurs as adults conduct broader movements, possibly associated with spawning. Length compositions of recruited barracouta between the east coast South Island and Snares shelf fishery were very similar after the initial decline in CPUE from the Snares fishery in 1994–95 and the corresponding increase in CPUE in east coast South Island. Length compositions from the two areas are virtually identical for the three years when samples were collected from both areas during this period (1994–95, 1996–97, and 1998–99) but were divergent in 1999–2000. Before 1994–95, there was considerable difference in the length compositions between the two areas in 1986–87 and 1992–93, but length compositions were comparable in 1987–88.

- The length composition of fish from the Auckland Islands fishery generally containes larger fish than for all other areas. The length composition of the catch was comparable to both the east coast South Island and Snares fishery in 1996–97. However, in the remainder of the study period the length composition of the Auckland Islands catch differed from all other fishery areas sampled. These differences are not consistent with the current stock hypothesis that would suggest a high affinity between the Auckland Islands and Snares and east coast South Island fisheries.

The separation of the west coast South Island stock from the east coast South Island and southern stock unit(s) is supported by the following.

- *Different patterns in year class strength were discernible in trawl survey length frequency data* from the west coast and east coast South Island. The west coast South Island trawl survey revealed low recruitment for the 1989, 1990, and 1995 year classes, although these year classes were strong on the east coast South Island. However, as noted above, it is uncertain whether recruitment to the western stock is dependent entirely on the cohorts monitored by the trawl survey. There are also difficulties in identifying the individual year classes from the two sets of length frequency data that undermine the strength of such a comparison.

- Differences in the length composition of the recruited component of the population between areas. Corresponding length frequency data are available from the east and west coast South Island commercial fisheries from 1987–88, 1994–95, 1996–97, and 1999–2000. For each year, there were considerable differences in the length composition from the two areas. There is less of a consistent pattern in the length compositions from the east coast South Island and Cook Strait fisheries; the length structure was comparable in 1987–88 but differed in 1994–95 and 1999–2000. The length compositions of the west coast South Island catch differed from the Snares fishery area in 1987–88, 1993–94, 1995–96, 1996–97, and 1999–2000 but was comparable in 1994–95.

- A higher rate of parasite infection of barracouta from the west coast South Island compared to the east coast South Island infers a degree of stock separation (Hurst 1980, unpublished data cited by Hurst & Bagley 1989).

Several of the other alternative stock hypotheses for barracouta may explain the recent observations from barracouta fisheries. Uncertainty remains concerning the extent and duration of spawning within BAR 5. There is considerable evidence to indicate that barracouta spawn within the Solander Corridor area and east of Stewart Island during October–November. This is supported by the seasonal change in the distribution of barracouta observed from trawl surveys that indicate a northern movement of barracouta into this area from the Stewart–Snares shelf. Similarly, there is a strong seasonal increase in barracouta catch in the Foveaux Strait and eastern Stewart Island areas during November–January that is consistent with an increase in the abundance of barracouta associated with spawning.

However, catches from the entire BAR 5 area are very low throughout May to October. This may be partly attributable to a change in fishing patterns and/or a change in the availability of barracouta to the fishery during this period. Nevertheless, the magnitude of catch during May–October suggests a large decline in the abundance of barracouta in BAR 5 that may be attributable to the migration of fish from the area during this period.

It has previously been suggested that barracouta may migrate from BAR 5 to the west coast of the South Island during winter as well as to the east coast of mainland New Zealand (Annala et al. 2001). A number of other species undergo spawning migrations from the Southland area to the west coast South Island during winter (principally hoki and gemfish) and barracouta may undertake similar migrations. The present review suggests a closer linkage between BAR 5 and the east coast South Island fisheries. However, these conclusions regarding the stock structure of barracouta should be considered tentative given the paucity of the data and some apparent inconsistencies in the observed trends between fishery areas. These data are currently being for analysed undertaken to attempt to quantify the relative strength of the various alternative stock scenarios for the species.

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**Table 1: Definitions of barracouta fishery areas based on Ministry of Fisheries statistical areas.**

| Fishery area | Statistical area |
|---|---|
| West coast South Island | 034, 035,036 |
| Cook Strait | 037, 038, 039, 040 |
| East coast South Island | 018, 020, 021, 022, 023, 024, 026 |
| Stewart shelf | 025, 027 |
| Snares shelf | 028, 029, 504 |
| Auckland Islands | 602 |

**Table 2: Regions defined for summarising seasonality in catches.**

| Region | Statistical Areas | Region | Statistical Areas |
|---|---|---|---|
| East Northland | 002, 003, 004, 008 | Southern Snares | 028 |
| Bay of Plenty | 009 | Northern Snares | 029 |
| East Cape | 010, 011, 012 | Auckland Is. | 602 |
| Gisborne | 013 | Southeast Stewart I. | 504 |
| North Wairarapa | 014 | Puysegur | 032 |
| South Wairarapa | 015 | Fiordland | 030, 031 |
| North Cook Strait | 016 | South Westland | 033 |
| South Cook Strait | 017 | Mid Westland | 034 |
| Kaikoura | 018 | North Westland | 035 |
| Pegasus Bay | 020, 021 | Cape Farewell | 036 |
| Canterbury Bight | 022, 023 | Tasman Bay | 037, 038 |
| Otago | 024 | Kapiti | 039 |
| Foveaux Strait | 025, 026 | Taranaki | 040, 041 |
| East Stewart I. | 027 | West Northland | 042, 045, 046 |
| | | Cape Reinga | 047 |

**Table 3: Definition of catch per unit effort data sets for each fishery area. The asterix denotes the preferred index for the fishery area.**

| Area | Dataset | Target species | Method | Vessel class (m) | Period | Total no. trawls |
|---|---|---|---|---|---|---|
| East coast South Island | CPUE 1 | BAR | BT | 15–35 | Oct–May | 14 652 |
| | CPUE 2 | BAR | BT | 45–65 | Oct–May | 1 804 |
| | CPUE 3* | RCO | BT | 15–35 | Oct–May | 36 988 |
| Stewart shelf | CPUE 1* | BAR | BT | 45–65 | Oct–Mar | 1 023 |
| | CPUE 2 | SQU | BT | 55–85 | Jan–May | 325 |
| Snares shelf | CPUE 1 | BAR | MW | 75–105 | Oct–Mar | 834 |
| | CPUE 2* | SQU | MW | 55–85 | Jan–May | 8 403 |
| | CPUE 3 | SQU | BT | 55–85 | Jan–May | 3 154 |
| Auckland Islands | CPUE 1* | SQU | MW | 55–85 | Jan–May | 2 052 |
| Cook Strait | CPUE 1* | BAR | BT | 15–25 | Oct–Feb | 5 668 |
| | CPUE 2 | JMA | BT | 75–95 | Dec–May | 2 528 |
| West coast South Island | CPUE 1* | BAR | BT | 15–35 | Aug–Sept | 2 356 |
| | CPUE 2 | BAR | BT | 45–75 | Aug–Sept | 1 362 |
| | CPUE 3 | JMA | MW | 75–95 | Jun–Oct | 709 |

**Table 4: Summary of trawl survey data by fishery area.**

| Fishery area | Vessel | Date | Survey code | Depth range (m) | Reference |
|---|---|---|---|---|---|
| West coast South Island | *Kaharoa* | Mar–Apr 1992 | KAH9204 | 20–400 | Stevenson & Hanchet 2000 |
| | | Mar–Apr 1994 | KAH9404 | 20–400 | Stevenson & Hanchet 2000 |
| | | Mar–Apr 1995 | KAH9504 | 20–400 | Stevenson & Hanchet 2000 |
| | | Mar–Apr 1997 | KAH9701 | 20–400 | Stevenson & Hanchet 2000 |
| | | Mar–Apr 2000 | KAH0004 | 20–400 | |
| East coast South Island | *Kaharoa* | May–Jun 1991 | KAH9105 | 30–400 | Beentjes & Stevenson 2000 |
| | | May–Jun 1992 | KAH9205 | 30–400 | Beentjes & Stevenson 2000 |
| | | May–Jun 1993 | KAH9306 | 30–400 | Beentjes & Stevenson 2000 |
| | | May–Jun 1994 | KAH9406 | 30–400 | Beentjes & Stevenson 2000 |
| | | May–Jun 1996 | KAH9606 | 30–400 | Beentjes & Stevenson 2000 |
| | | Dec–Jan 1996–97 | KAH9618 | 10–400 | Beentjes & Stevenson 2001 |
| | | Dec–Jan 1997–98 | KAH9704 | 10–400 | Beentjes & Stevenson 2001 |
| | | Dec–Jan 1998–99 | KAH9809 | 10–400 | Beentjes & Stevenson 2001 |
| | | Dec–Jan 1999–2000 | KAH9917 | 10–400 | Beentjes & Stevenson 2001 |
| Stewart shelf and Snares shelf | *Tangaroa* | Feb–Mar 1993 | TAN9301 | 30–600 | Hurst & Bagley 1994 |
| | | Feb–Mar 1994 | TAN9402 | 30–600 | Bagley & Hurst 1995 |
| | | Feb–Mar 1995 | TAN9502 | 30–600 | Bagley & Hurst 1996a |
| | | Feb–Mar 1996 | TAN9604 | 30–600 | Bagley & Hurst 1996b |
| | *Shinkai Maru* | Feb 1981 | SHI8101 | 100–600 | Kawahara & Tokusa 1981 |
| | | Mar–Apr 1982 | SHI8201* | 100–600 | Van der Broek et al. 1984 |
| | | Apr 1983 | SHI8302 | 100–600 | Uozumi et al. 1987 |
| | | Jun 1986 | SHI8601 | 100–600 | Hurst et al. 1990 |

*No barracouta measured during survey.

**Table 5: Summary of survey strata included in the analysis of length frequency data from the time series of Southland trawl surveys.**

| Trawl survey | Strata | Survey area (km²) | | | No. stations |
|---|---|---|---|---|---|
| | | <200 m | 200–600 m | Total | |
| SHI8101 | 1, 2, 3, 4, 5 | 22 344 | 7 754 | 30 098 | 97 |
| SHI8201 | 1, 2, 3 | 25 968 | 7 909 | 33 877 | 58 |
| SHI8302 | 1, 2, 3,4, 5 | 25 351 | 8 231 | 33 582 | 66 |
| SHI8601 | 1, 3, 4, 5, 6, 7, 8, 10 | 24 116 | 4 027 | 28 143 | 41 |
| TAN9301 | 4, 5, 6, 7, 8, 9, 10, 13, 14, 15, 17, 18 | 30 351 | 5 943 | 36 294 | 69 |
| TAN9402 | 4A, 4B, 5A, 5B, 6A, 6B, 7A, 7B, 8A, 8B, 10A, 10B, 9, 13, 17, 18 | 30 404 | 4 446 | 34 850 | 88 |
| TAN9502 | 4A, 4B, 5A, 5B, 6A, 6B, 8A, 8B, 10A, 10B, 7, 9, 13, 17, 18 | 30 404 | 4 446 | 34 850 | 100 |
| TAN9604 | 4A, 4B, 5A, 5B, 6A, 6B, 8A, 8B, 10A, 10B, 7, 9, 13, 17, 18 | 30 404 | 4 446 | 34 850 | 82 |

**Table 6: Relative biomass estimates (t) and associated c.v.s (%) derived for the core survey area of the Southland area from the *Shinkai Maru* trawl surveys.**

| Survey | Biomass estimate | c.v. |
|---|---|---|
| SHI8101 | 15 567 | 25.0 |
| SHI8201 | 32 097 | 39.7 |
| SHI8302 | 53 244 | 25.8 |
| SHI8601 | 54 485 | 20.6 |

**Table 7: Relative biomass estimates (t) and associated c.v.s (%) derived for the core survey area of the Southland area from the *Tangaroa* trawl surveys and the separate biomass estimates for the Stewart shelf and Snares shelf sub-areas.**

| Survey | Total | | Stewart shelf | | Snares shelf | |
|---|---|---|---|---|---|---|
| | Biomass | c.v. | Biomass | c.v. | Biomass | c.v. |
| TAN9301 | 8 503 | 23.5 | 837 | 40.1 | 7 385 | 26.6 |
| TAN9402 | 4 062 | 26.6 | 1 191 | 43.0 | 2 871 | 33.2 |
| TAN9502 | 2 567 | 22.2 | 540 | 28.8 | 2 025 | 27.1 |
| TAN9604 | 4 428 | 30.3 | 1 481 | 54.4 | 2 919 | 36.7 |

**Table 8: Relative biomass estimates (t) and associated c.v.s (%) derived for the time-series of west coast South Island trawl surveys.**

| Survey | Biomass estimate | c.v. |
|---|---|---|
| KAH9204 | 2 478 | 14 |
| KAH9404 | 5 298 | 16 |
| KAH9504 | 4 480 | 13 |
| KAH9701 | 2 993 | 19 |
| KAH0004 | 1 787 | 11 |

**Table 9: Relative biomass estimates (t) and associated c.v.s (%) derived for the time-series of east coast South Island trawl surveys.**

| Survey | Biomass estimate | c.v. |
|---|---|---|
| KAH9105 | 12 936 | 29 |
| KAH9205 | 11 672 | 23 |
| KAH9306 | 18 197 | 22 |
| KAH9406 | 7 451 | 32 |
| KAH9606 | 16 845 | 19 |
| HAH9618 | 21 513 | 34 |
| KAH9704 | 11 843 | 25 |
| KAH9809 | 21 877 | 14 |
| KAH9917 | 21 476 | 14 |

**Table 10: Number of barracouta length samples collected by the MFish Scientific Observer Programme by fishery area, target species and fishing year. Target species codes BAR, HOK, JMA, SQU denote barracota, hoki, jack mackerel and squid, respectively. Other species include red cod, spikey dogfish, silver warehou and white warehou.**

| | West coast South Island | | | | | Stewart shelf | | | | | Snares shelf | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fishing year | BAR | HOK | JMA | Other | Total | BAR | JMA | SQU | Other | Total | BAR | JMA | SQU | Other | Total |
| 1986–87 | | 6 | | | 6 | 2 | | | | 2 | 12 | | 9 | 1 | 22 |
| 1987–88 | | | | | | 4 | | | | 4 | 12 | | 15 | | 27 |
| 1988–89 | | 1 | 1 | | 2 | | | | | | | | | | |
| 1989–90 | | | | | | 1 | | | | 1 | | | | | |
| 1990–91 | 27 | | | | 27 | | | | | | 4 | | 18 | | 22 |
| 1991–92 | | 1 | | | 1 | 20 | | | 1 | 21 | 1 | | | | 1 |
| 1992–93 | 5 | 2 | | 2 | 9 | | | | | | 1 | 3 | 88 | 1 | 93 |
| 1993–94 | 13 | 11 | 6 | | 30 | | | 2 | | 2 | 3 | | 90 | | 93 |
| 1994–95 | 4 | 8 | | | 12 | | | | | | 2 | 1 | 64 | | 67 |
| 1995–96 | 18 | 22 | | | 40 | | | | | | 1 | | 25 | | 26 |
| 1996–97 | 12 | 2 | 10 | | 24 | | | | | | | 2 | 14 | | 16 |
| 1997–98 | | | 3 | | 3 | 1 | | | | 1 | 3 | 5 | 31 | | 39 |
| 1998–99 | 5 | 13 | 10 | | 28 | 1 | 4 | | | 5 | 15 | 4 | 82 | 1 | 102 |
| 1999–2000 | | 19 | 6 | | 25 | | | | | | 6 | 38 | 85 | 3 | 132 |
| Total | 84 | 85 | 41 | 2 | 212 | 29 | 4 | 2 | 1 | 36 | 60 | 53 | 521 | 6 | 640 |

| | Auckland Islands | | | | East coast South Island | | | | | | Cook Strait | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fishing year | BAR | SQU | Other | Total | BAR | HOK | JMA | SQU | Other | Total | BAR | JMA | SQU | Other | Total |
| 1986–87 | | | | | 3 | | 1 | | 3 | 7 | | 1 | | | 1 |
| 1987–88 | | | | | 6 | | | | | 6 | | 8 | | | 8 |
| 1988–89 | | | | | | | | | | | | | | | |
| 1989–90 | | | | | | | | | | | | | | | |
| 1990–91 | | 1 | | 1 | 1 | | | | | 1 | | | | | |
| 1991–92 | | | | | 1 | | | | | 1 | | | | | |
| 1992–93 | | 8 | | 8 | 6 | | 6 | | 2 | 14 | | | | | |
| 1993–94 | | 62 | | 62 | | | | 11 | | 11 | | 12 | | | 12 |
| 1994–95 | | 44 | | 44 | 7 | | | | | 7 | | 22 | | | 22 |
| 1995–96 | | 44 | | 44 | | 1 | 3 | | | 4 | | | | | |
| 1996–97 | | 18 | | 18 | 2 | 1 | | | | 3 | | 1 | | | 1 |
| 1997–98 | | | | | | 2 | | | | 2 | | 2 | | | 2 |
| 1998–99 | | 7 | | 7 | 8 | 7 | 1 | 2 | 1 | 19 | | 1 | | | 1 |
| 1999–2000 | | 53 | | 53 | 13 | 1 | 2 | 11 | | 27 | | 14 | | | 14 |
| Total | | 237 | | 237 | 47 | 13 | 13 | 24 | 6 | 103 | | 63 | | | 63 |

**Table 11: Number of barracouta measured by the Scientific Observer Programme by fishery area and fishing year.**

| Fishing year | West coast South Island | Stewart shelf | Snares shelf | Auckland Islands | East coast South Island | Cook Strait | Fishery area Total |
|---|---|---|---|---|---|---|---|
| 1986–87 | 253 | 151 | 2 762 | | 688 | 134 | 3 988 |
| 1987–88 | | 730 | 2 912 | | 1 108 | 496 | 5 246 |
| 1988–89 | 142 | | | | | | 142 |
| 1989–90 | | 102 | | | | | 102 |
| 1990–91 | 2 650 | | 2 161 | 42 | 77 | | 4 930 |
| 1991–92 | 49 | 1 747 | 150 | | 102 | | 2 048 |
| 1992–93 | 547 | | 3 326 | 300 | 497 | | 4 670 |
| 1993–94 | 624 | 26 | 4 581 | 813 | 199 | 268 | 6 511 |
| 1994–95 | 323 | | 1 570 | 401 | 757 | 1 008 | 4 059 |
| 1995–96 | 1 776 | | 1 139 | 2 132 | 22 | | 5 069 |
| 1996–97 | 1 068 | | 919 | 233 | 326 | 40 | 2 586 |
| 1997–98 | 100 | 26 | 1 557 | | 22 | 50 | 1 755 |
| 1998–99 | 1 452 | 250 | 4 433 | 181 | 1 101 | 117 | 7 534 |
| 1999–2000 | 355 | | 7 729 | 631 | 1 173 | 354 | 10 242 |
| Total | 9 339 | 3 032 | 33 239 | 4 733 | 6 072 | 2 467 | 58 882 |

**Table 12: Ages inferred from length frequency modes in various length ranges.**

| Length range | Inferred age |
|---|---|
| 11–25 | 0+ |
| 26–45 | 1+ |
| 46–55 | 2+ |
| 56–65 | 3+ |

**Table 13: Correlation coefficients between the preferred CPUE indices for each of the fishery areas. *, significant at < 0.10 level.**

| Fishery area | Cook Strait | East coast South Island | Snares shelf | Stewart shelf | Auckland Islands |
|---|---|---|---|---|---|
| West coast South Island | 0.444 | -0.473 | 0.557 | 0.255 | -0.242 |
| Cook Strait | | -0.284 | -0.096 | 0.531* | 0.385 |
| East coast South Island | | | -0.586* | -0.526 | -0.556 |
| Snares | | | | 0.529 | 0.014 |
| Stewart | | | | | 0.329 |

**Table 14: Comparative year class strengths inferred from trawl survey (TS) and commercial (SOP) length frequency data. ?, insufficient data; - moderate or weak year class; + strong year class.**

| Area | West coast | | Cook Strait | | East coast | | Stewart/Snares/ Auckland | |
|---|---|---|---|---|---|---|---|---|
| | TS | SOP | TS | SOP | TS | SOP | TS | SOP |
| 1984 | | | | | | | + | + |
| 1985 | | | | | | | + | + |
| 1986 | | | | | | | + | |
| 1987 | | | | | | | | |
| 1988 | | | | | | | | + |
| 1989 | - | | | | + | + | + | + |
| 1990 | - | | | | + | + | - | - |
| 1991 | + | - | | | - | - | - | - |
| 1992 | + | - | | | - | | - | - |
| 1993 | - | - | | | - | - | - | - |
| 1994 | - | | | | - | | | - |
| 1995 | - | + | | | + | + | | ? |
| 1996 | + | + | | + | + | + | | + |
| 1997 | | | | | + | | | |

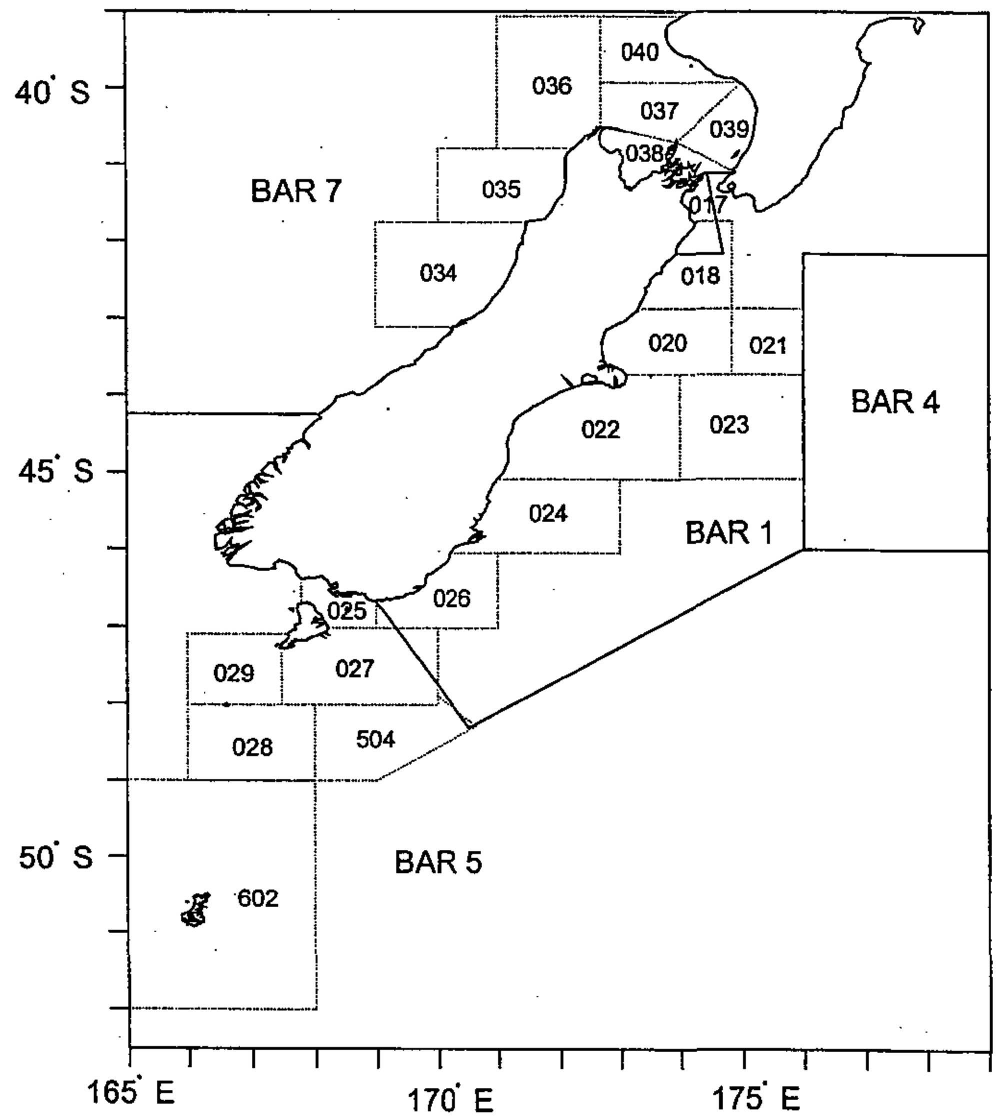


**Figure 1: Map of the South Island of New Zealand showing the boundaries of general statistical areas (dotted lines) and Fishstocks (solid lines).**

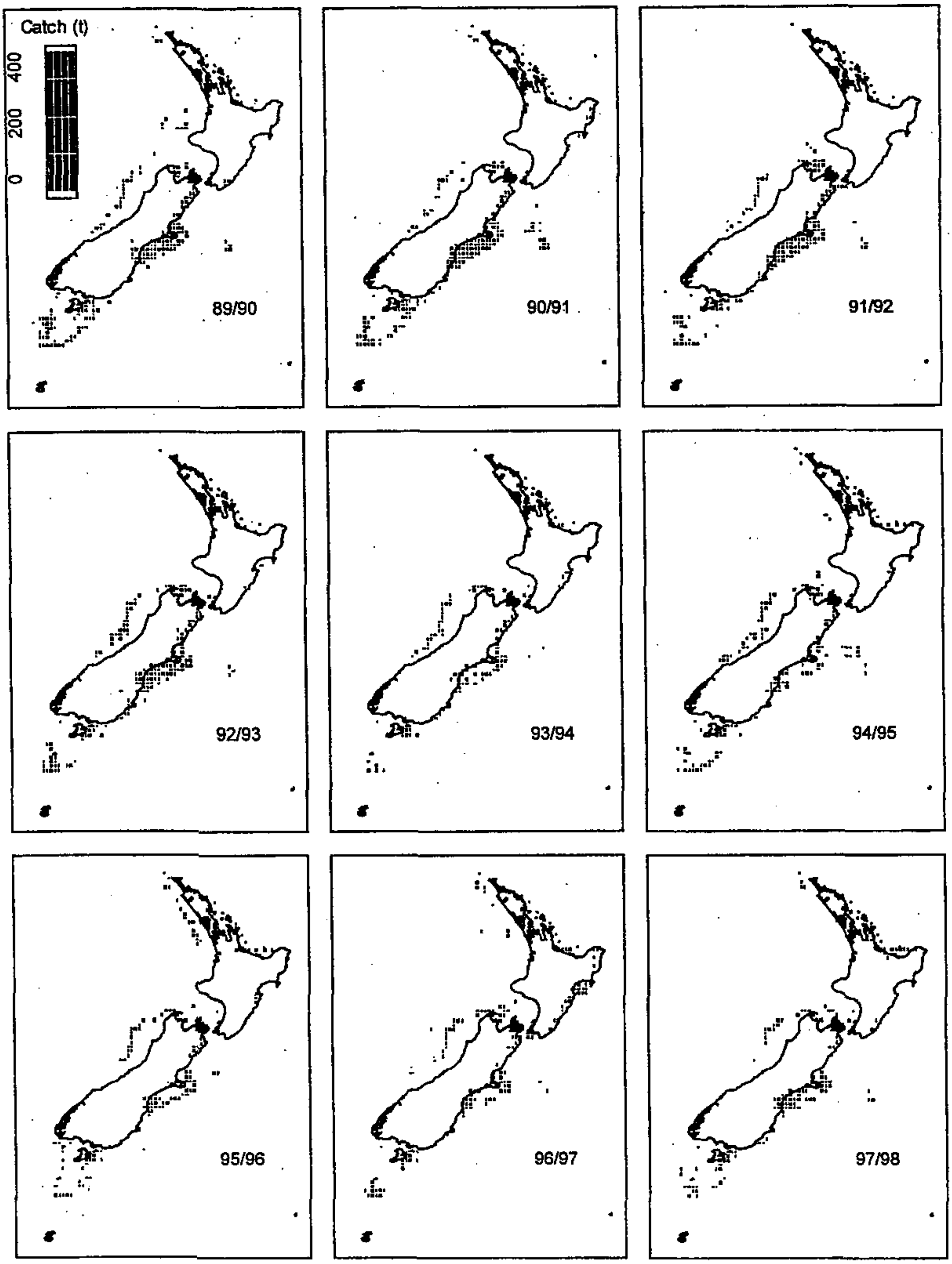


**Figure 2: Annual target barracouta catch by fishing year for 0.2 degree of latitude and longitude for the period 1989–90 to 1999–2000. Source: Ministry of Fisheries TCEPR data.**

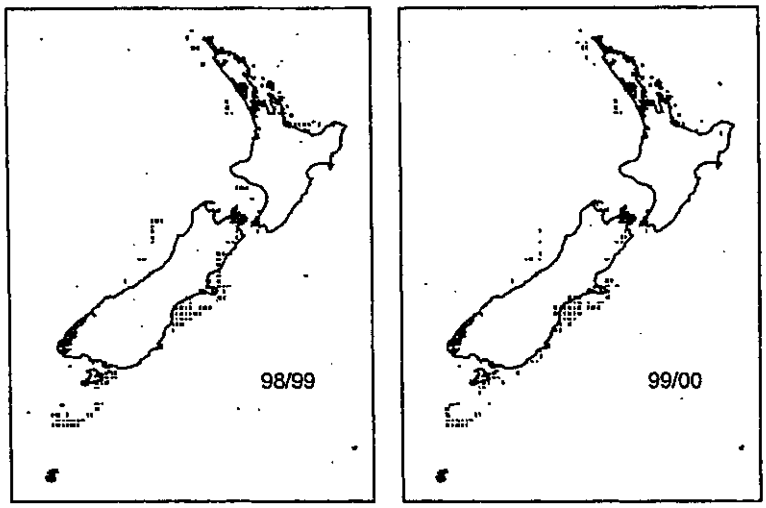


**Figure 2. continued.**

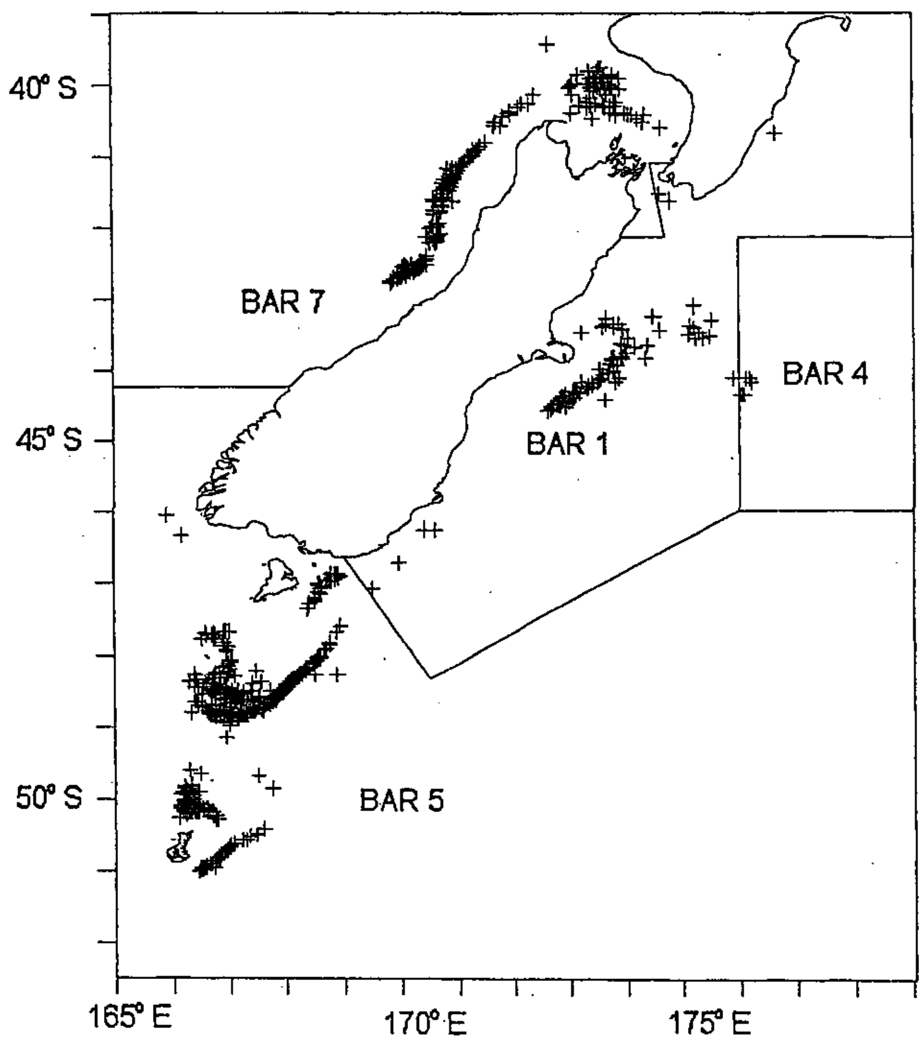


**Figure 3: Positions where barracouta catches were sampled by the MFish Scientific Observer Programme from 1986–87 to 1999–2000.**

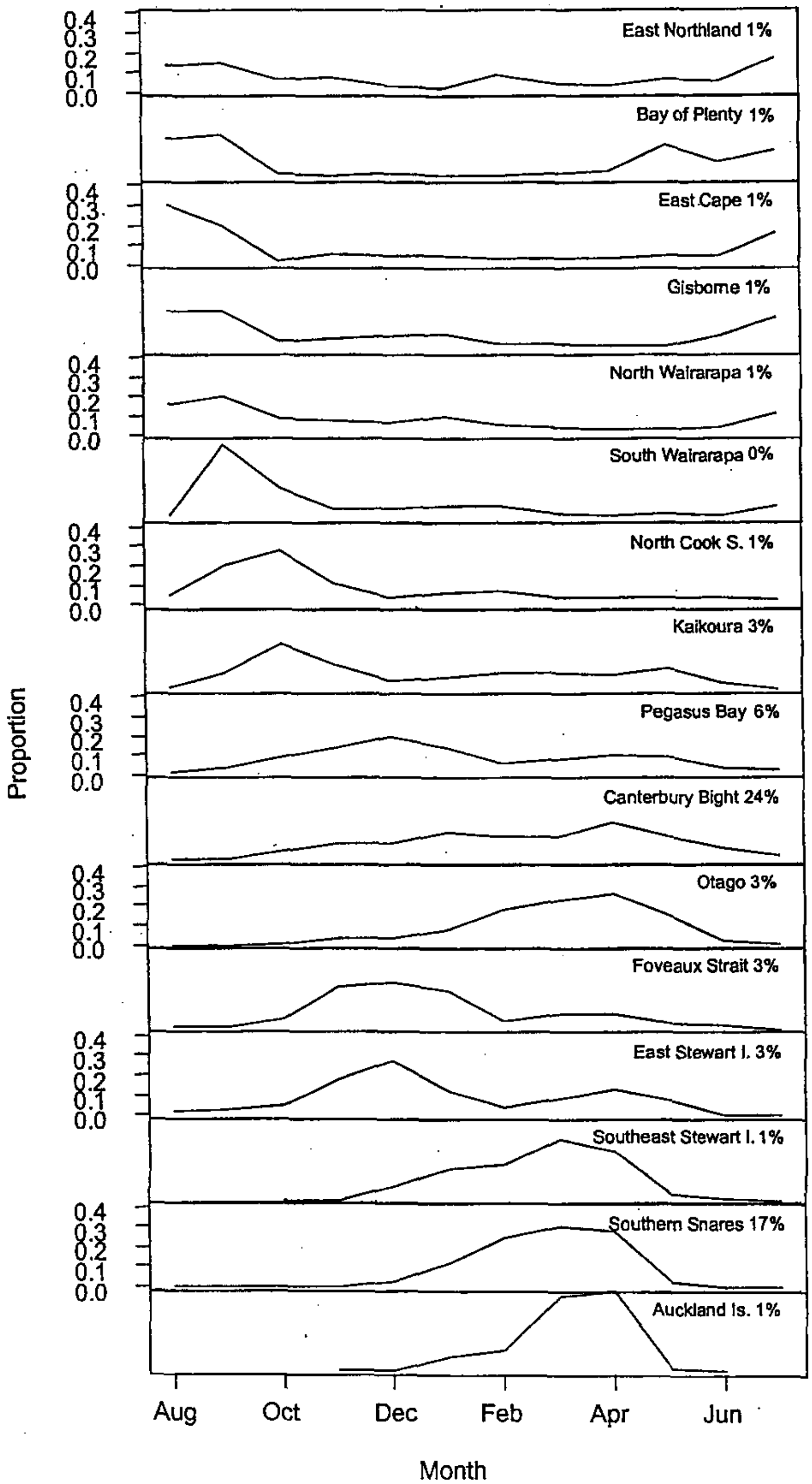


**Figure 4: Differences between regions on the east coast in the seasonality of barracouta catches. Proportion of catch taken in each month in each area, 1989–90 to 1999–2000. The percentage of the total barracouta catch taken over the period in each region is given.**

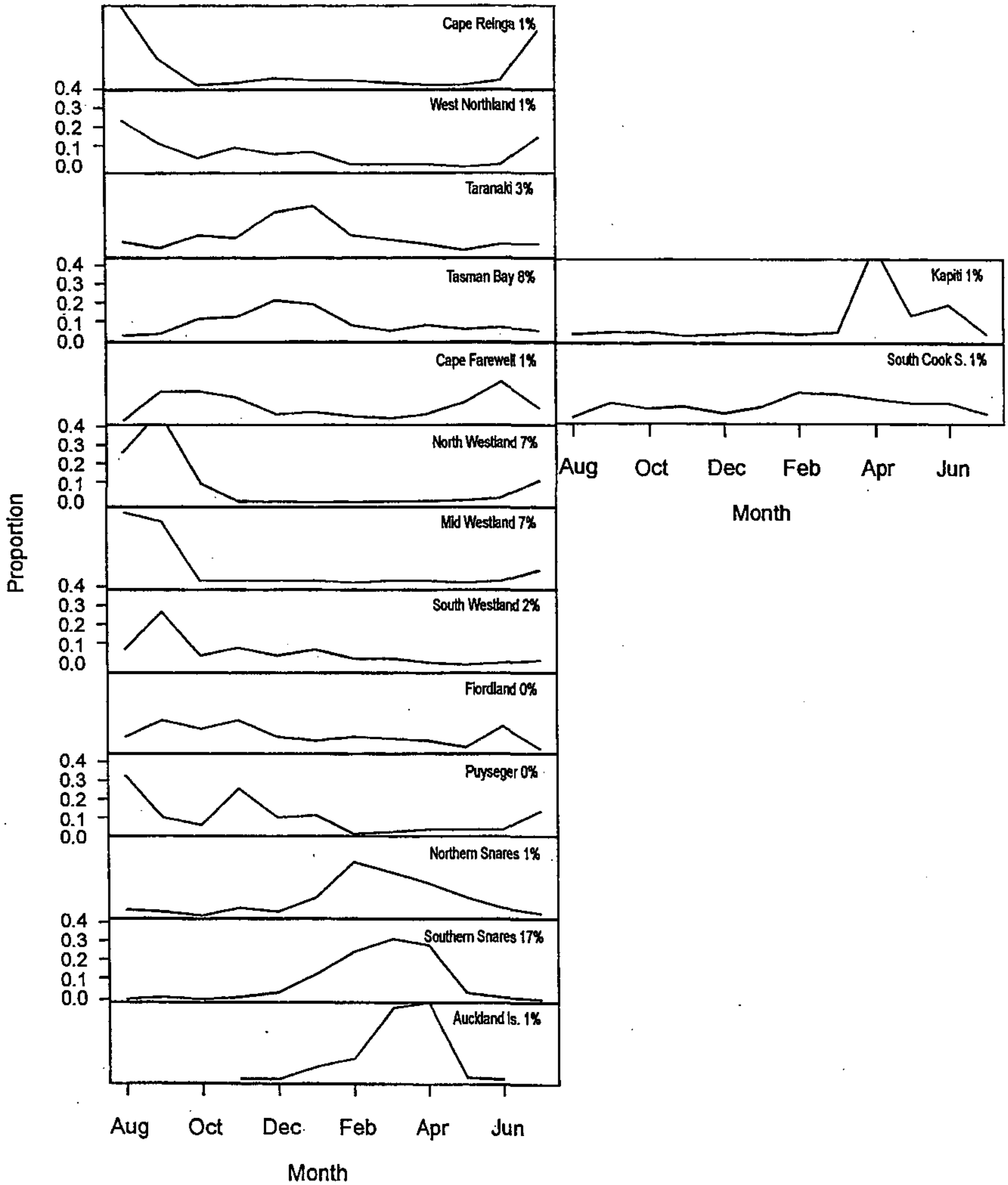


**Figure 5: Differences between regions on the west coast in the seasonality of barracouta catches. Proportion of catch taken in each month in each area, 1989–90 to 1999–2000. The percentage of the total barracouta catch taken over the period in each region is given.**

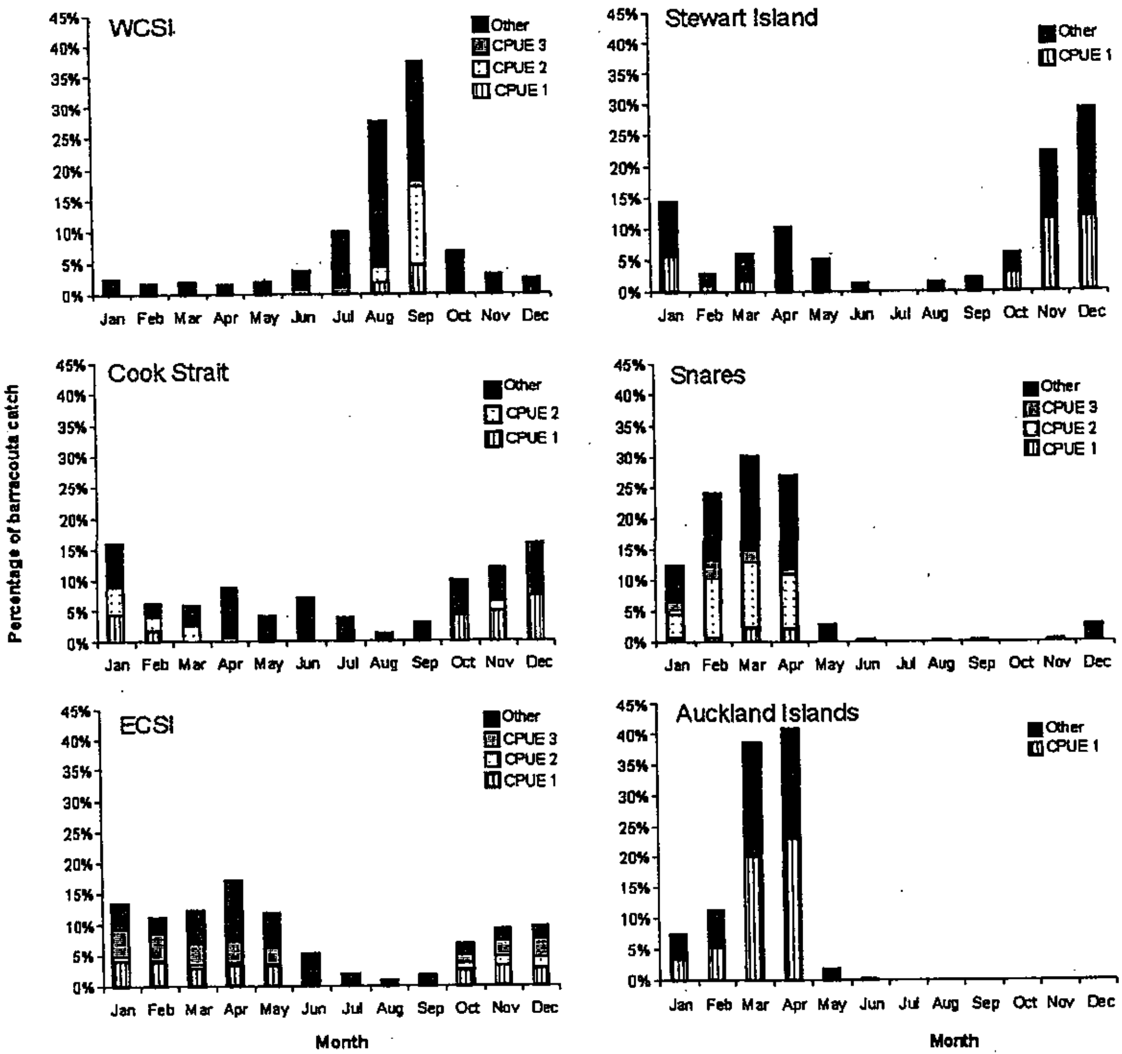


**Figure 6: Distribution of barracouta catch by fishery area, month and CPUE data set (see Table 3 for details) over all years, 1989–90 to 1999–2000.**

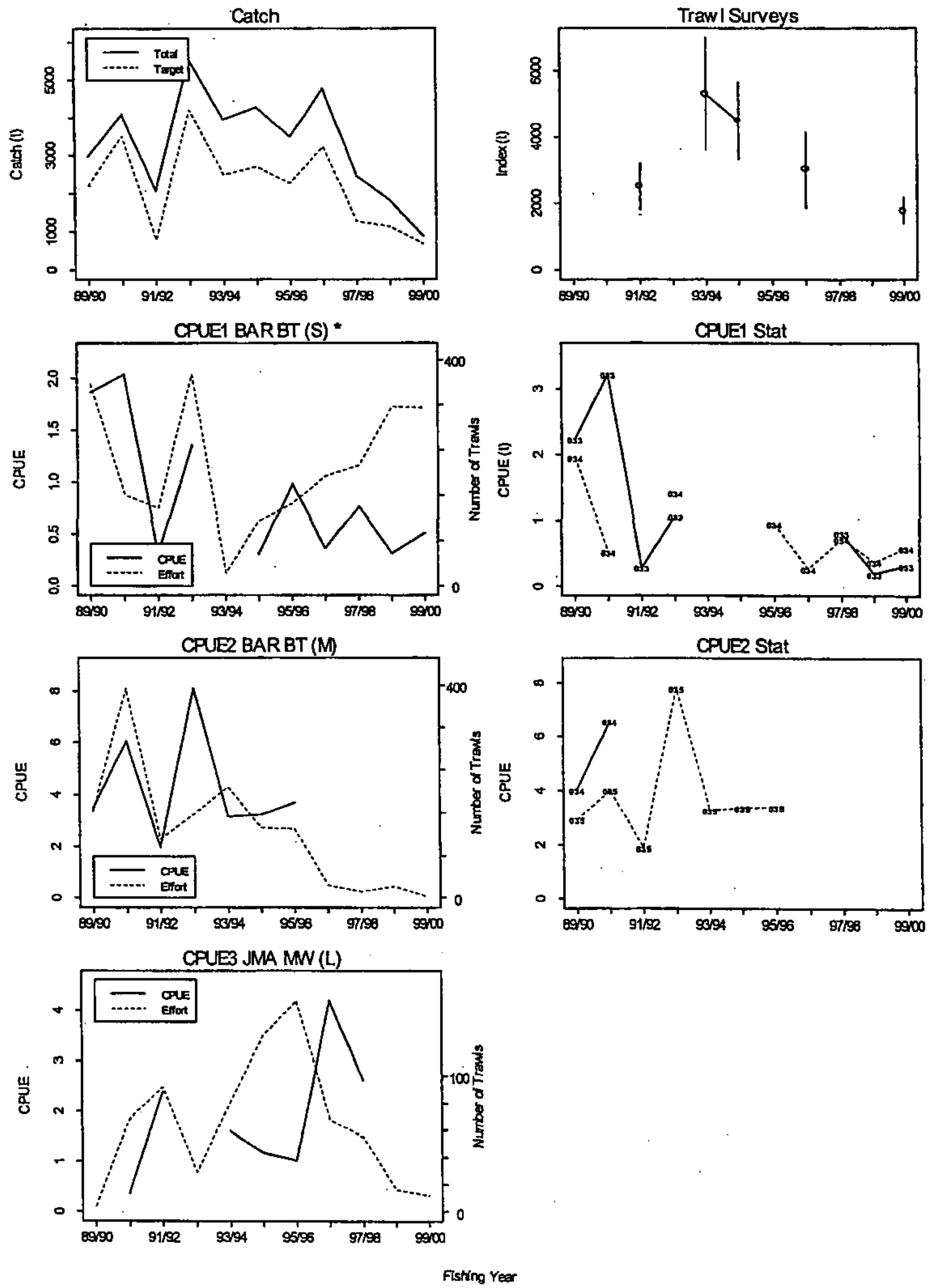


Figure 7: Summary of fishery indicators from the west coast South Island barracouta fishery. The asterix denotes the preferred CPUE index.

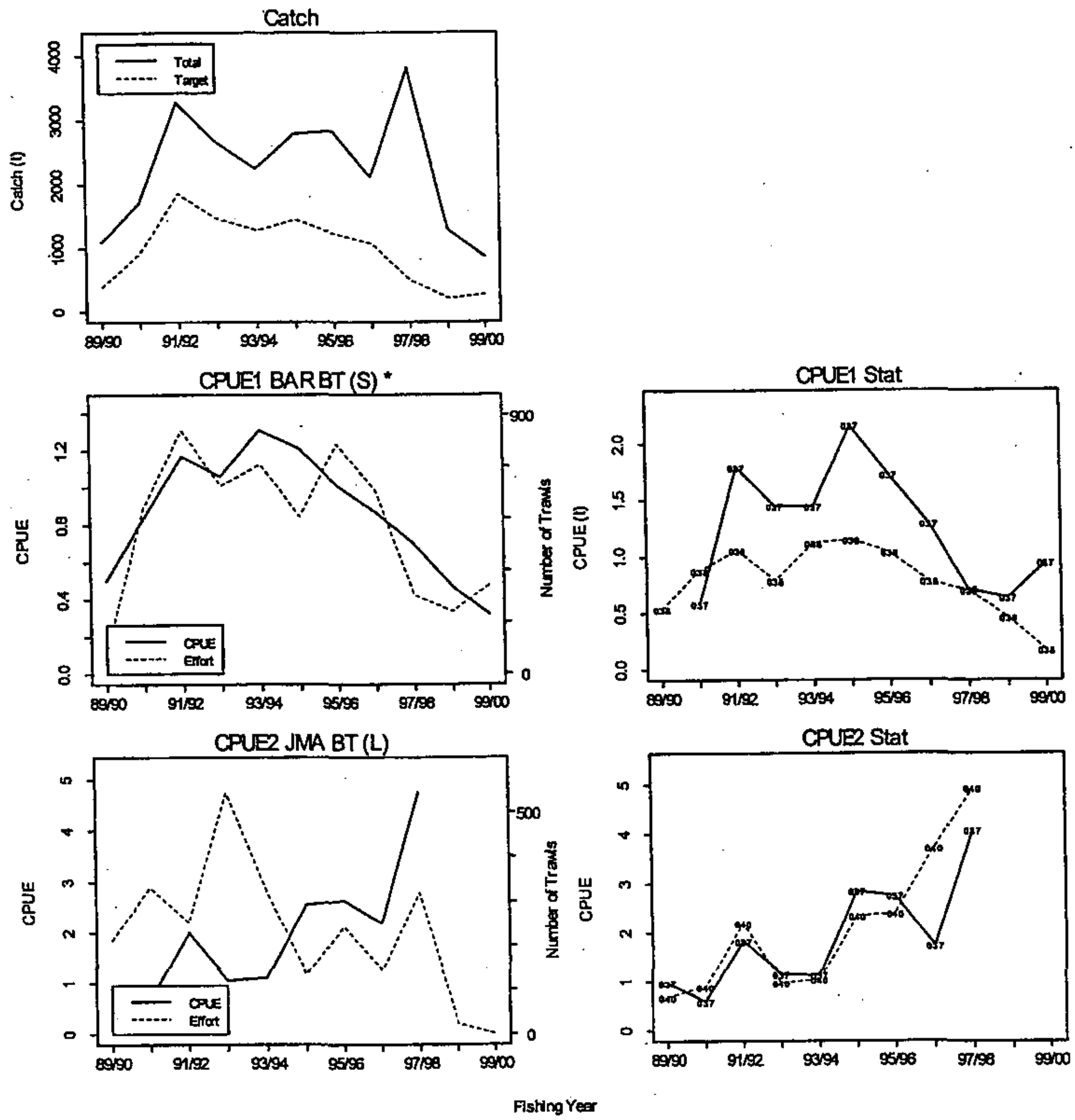


**Figure 8: Summary of fishery indicators from the Cook Strait barracouta fishery. The asterix denotes the preferred CPUE index.**

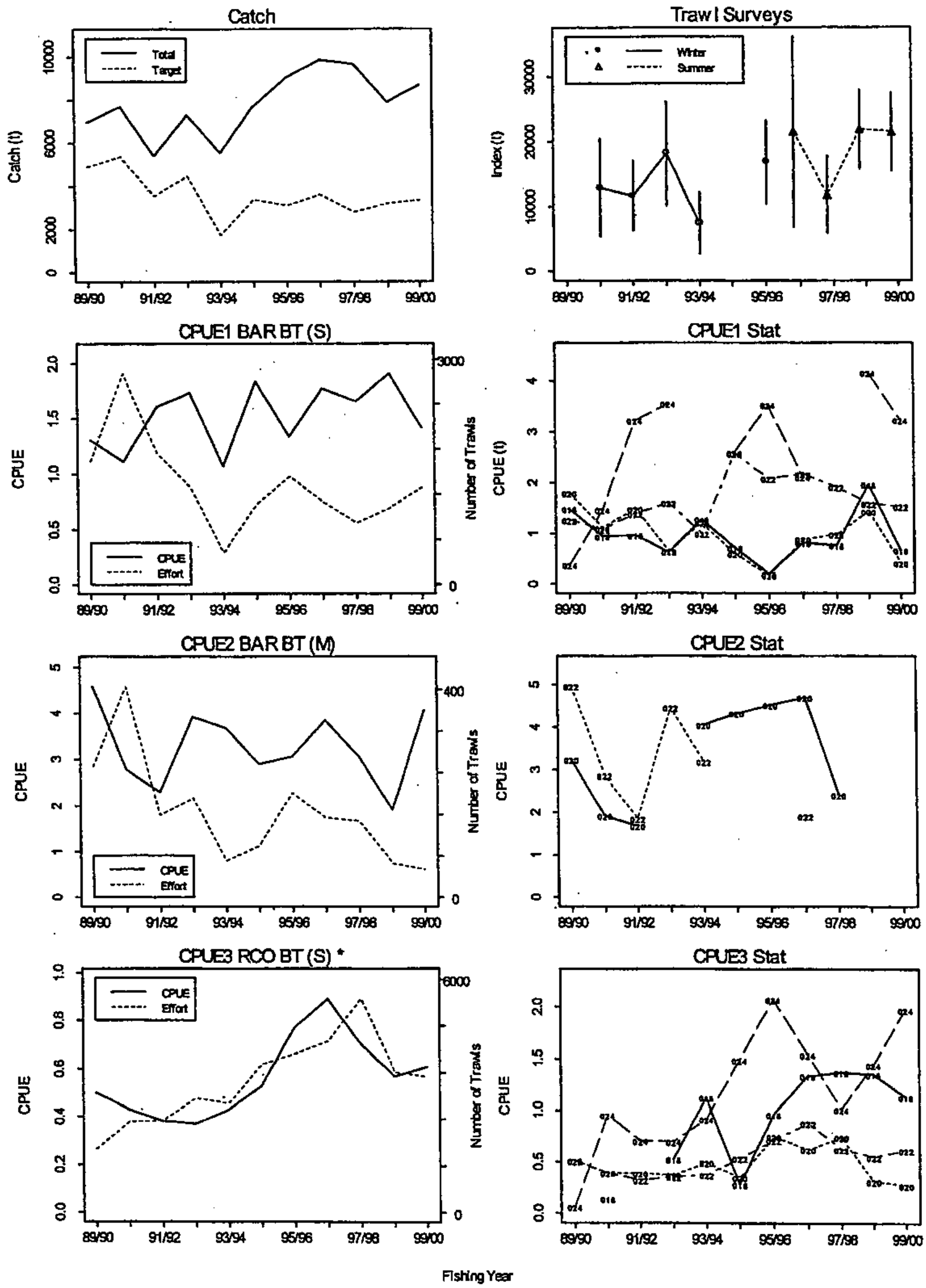


**Figure 9: Summary of fishery indicators from the east coast South Island barracouta fishery. The asterix denotes the preferred CPUE index.**

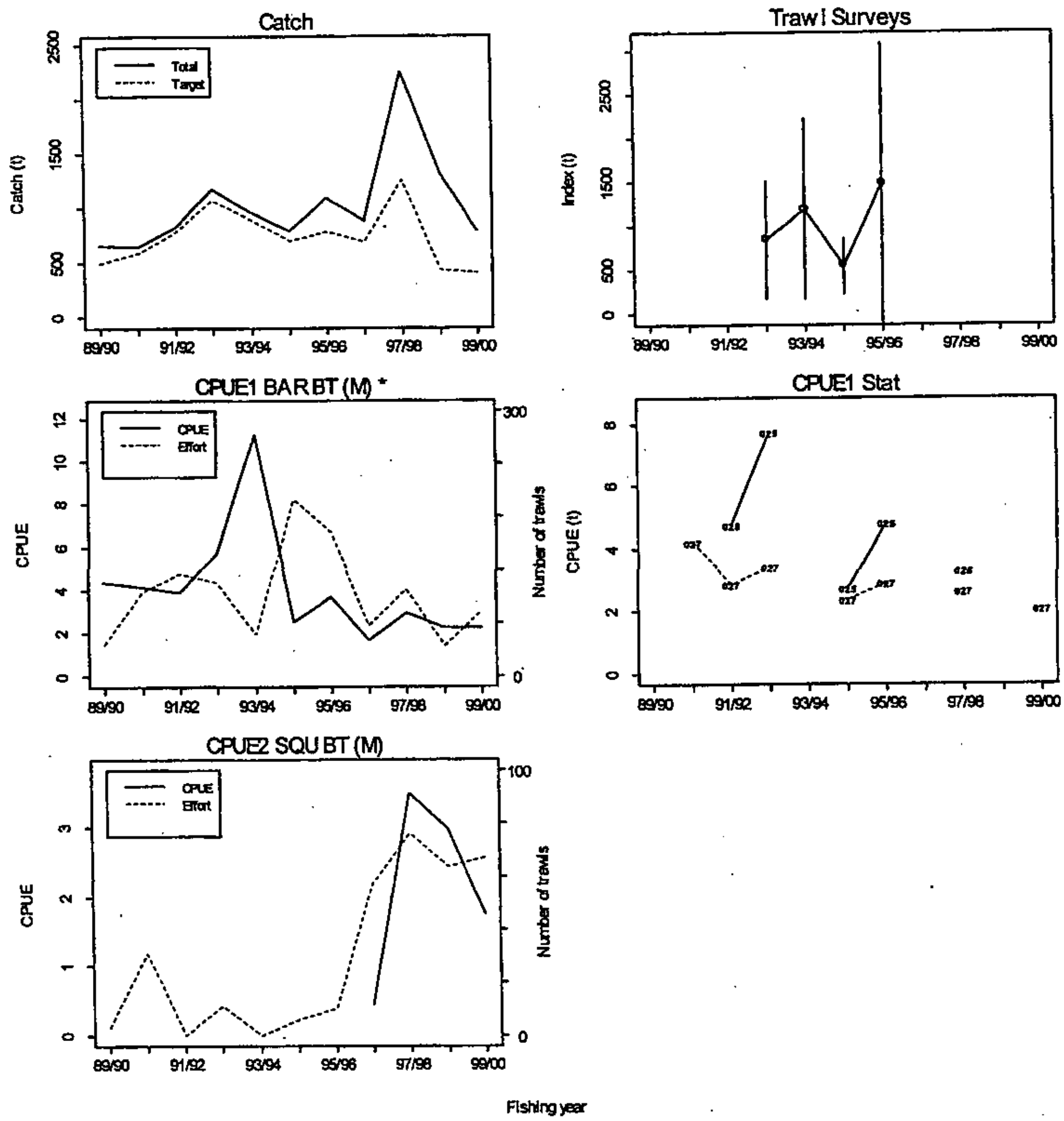


**Figure 10: Summary of fishery indicators from the Stewart shelf barracouta fishery. The asterix denotes the preferred CPUE index.**

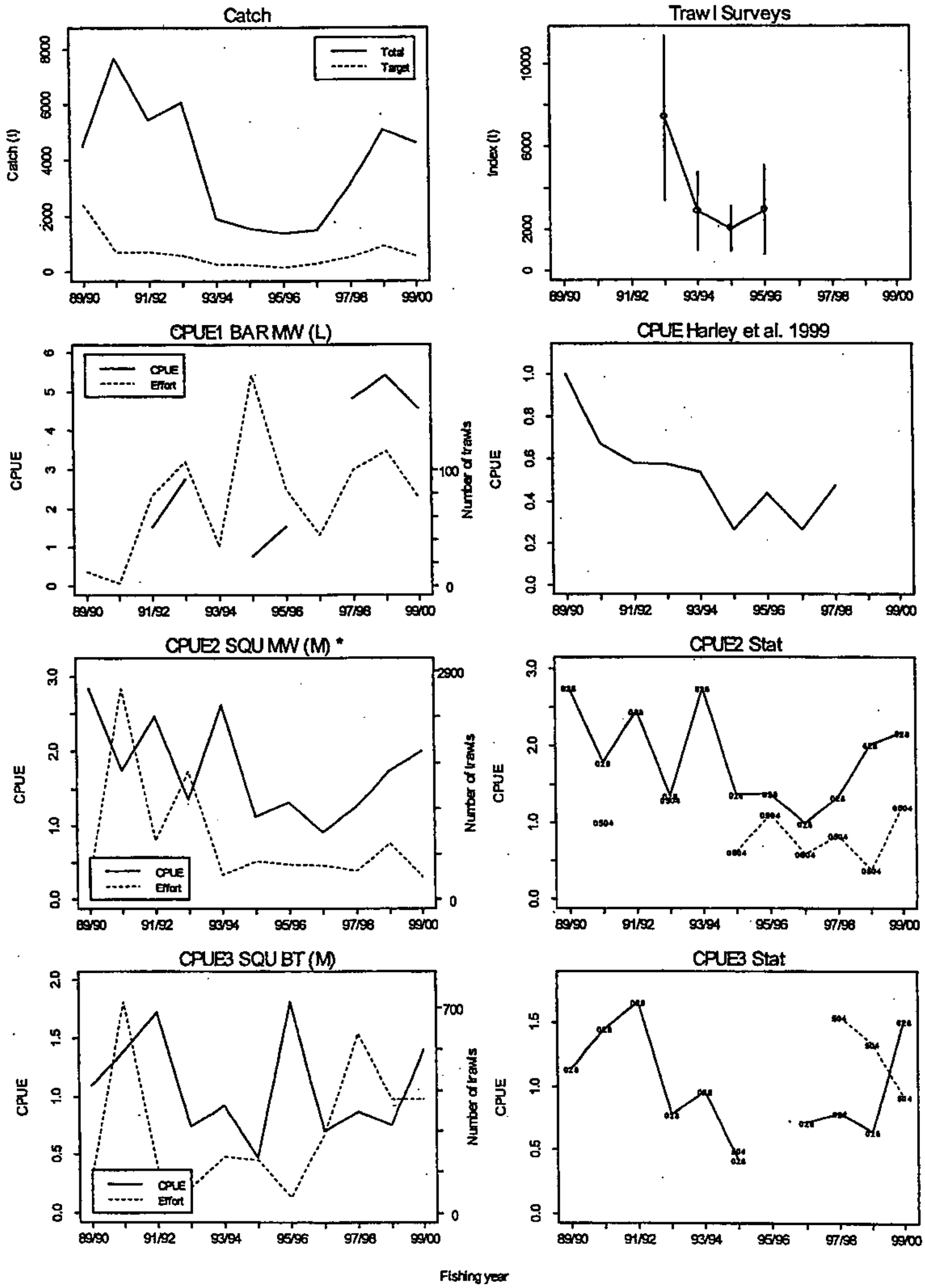


**Figure 11: Summary of fishery indicators from the Snares shelf barracouta fishery. The asterix denotes the preferred CPUE index.**

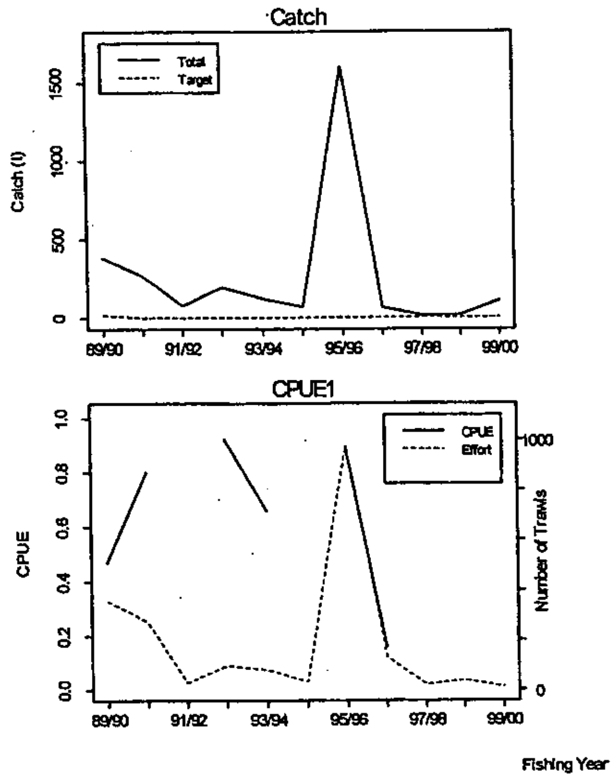


**Figure 12: Summary of fishery indicators from the Auckland Islands barracouta fishery.**

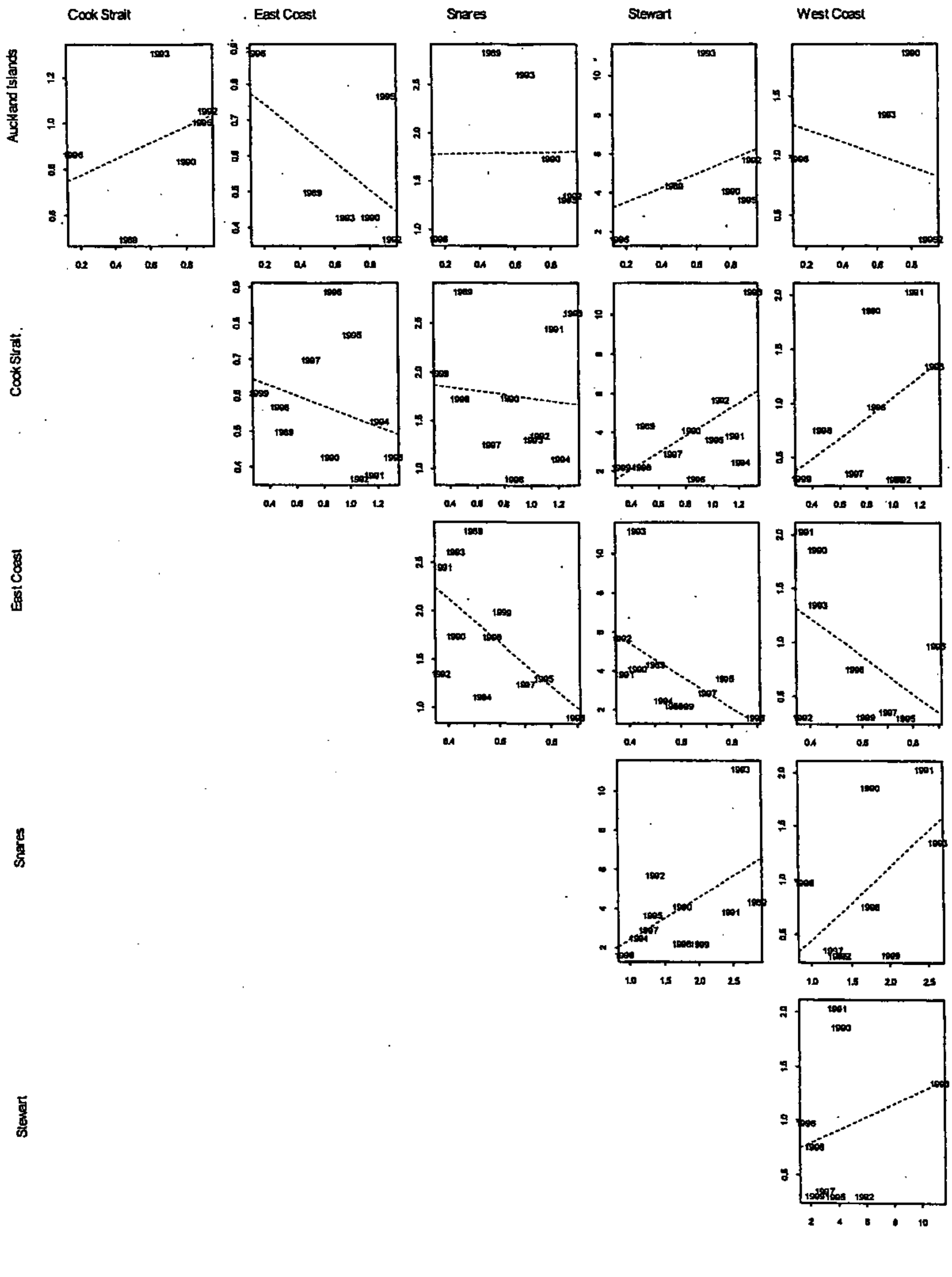


Figure 13: Correlations between the preferred CPUE indices for each of the fishery areas. The dashed lines represent the least squares fit to the data. The points are labelled with the first year of the fishing year (for example, label 1992 corresponds to the 1992–93 fishing year). CPUE indices derived from the west coast South Island fishery are compared with indices for the other areas from the subsequent year (see text).

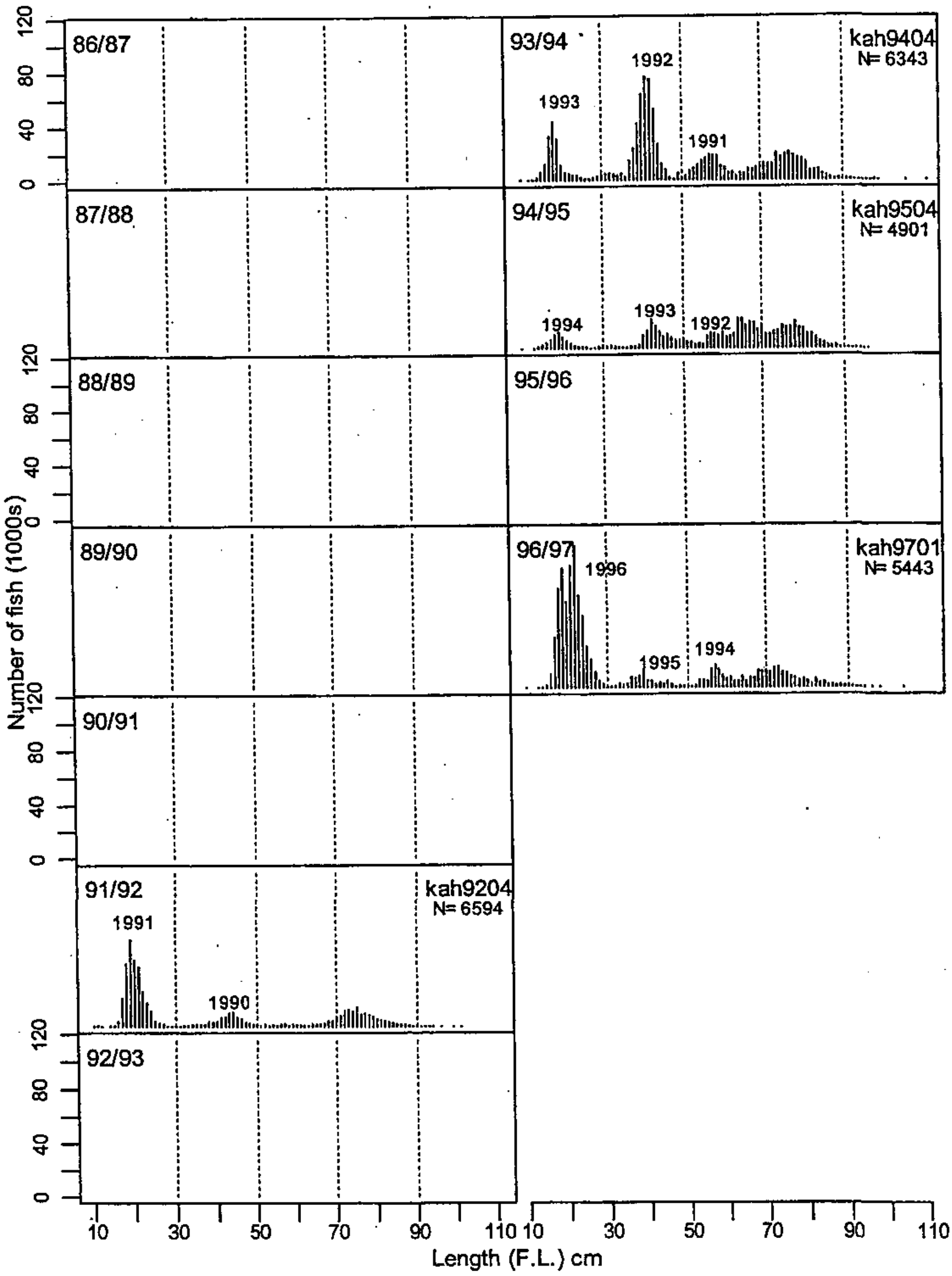


Figure 14. Length composition of barracouta from the time series of west coast South Island trawl surveys (March/April) by fishing year. N represents the number of fish measured.

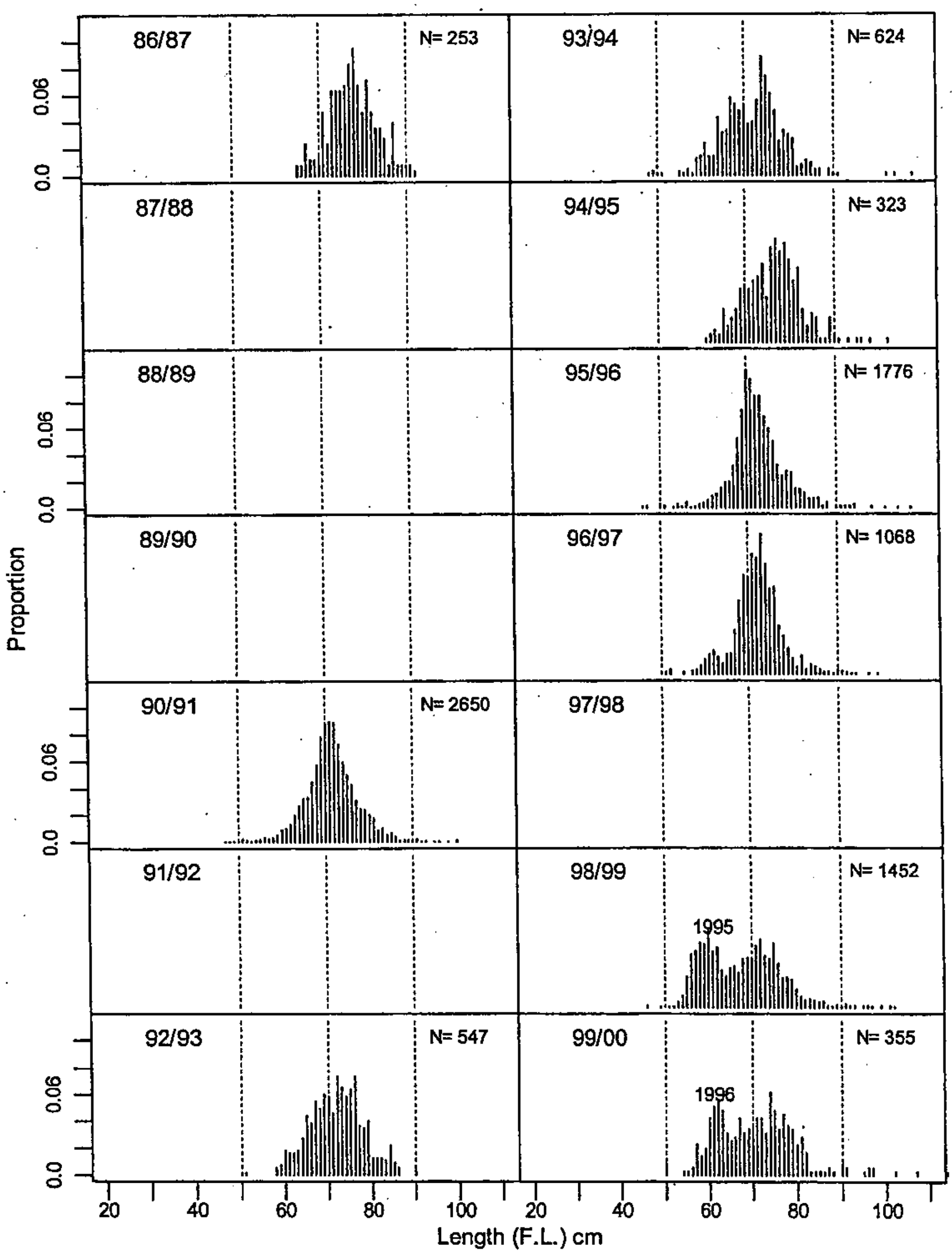


**Figure 15: Length composition of the barracouta catch sampled from the west coast South Island fishery (July-September) by the Scientific Observer Programme by fishing year. N represents the number of fish measured.**

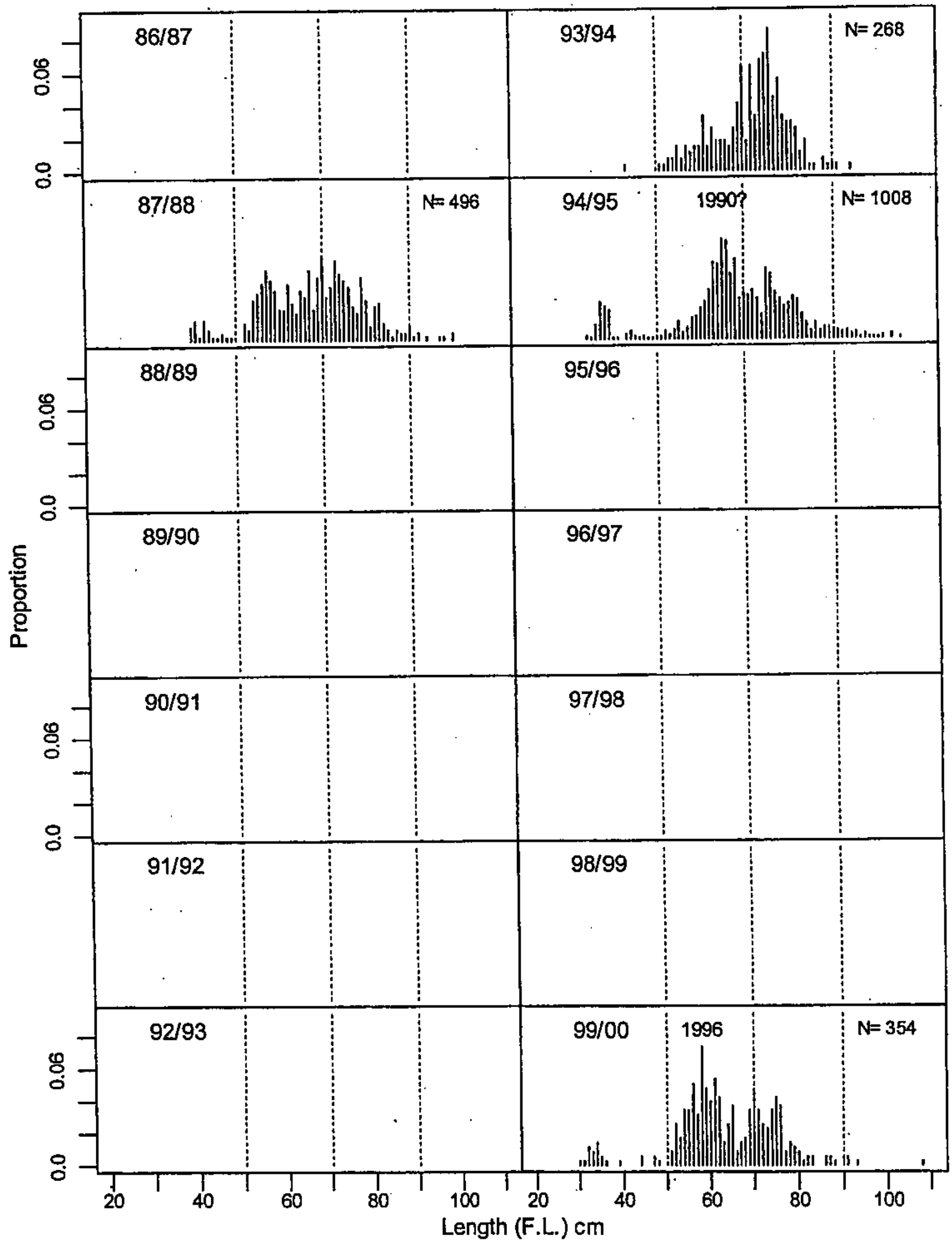


**Figure 16: Length composition of the barracouta catch sampled from the Cook Strait fishery by the Scientific Observer Programme by fishing year. Most of the samples were collected during the November–March period. N represents the number of fish measured.**

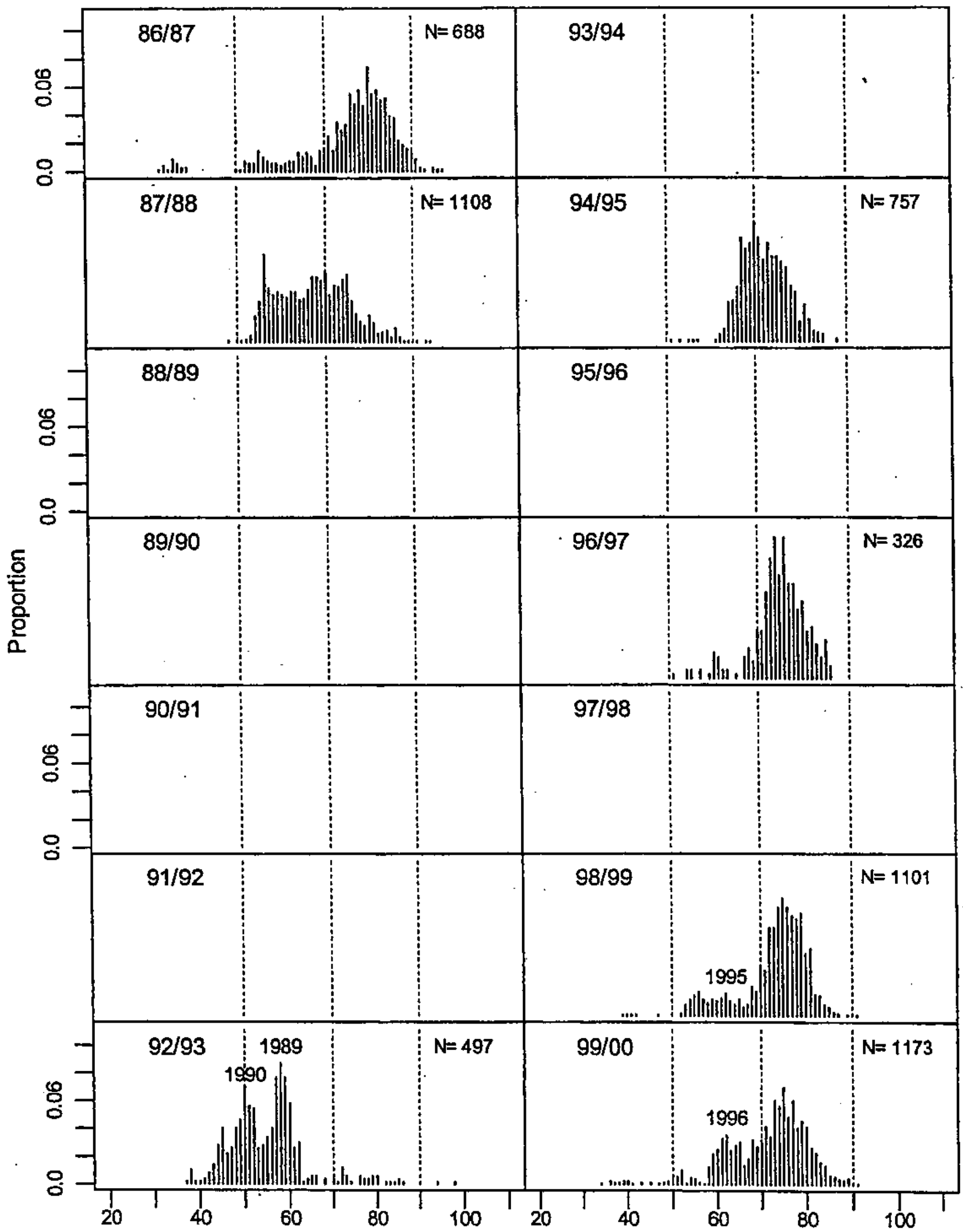


**Figure 17: Length composition of the barracouta catch sampled from the east coast South Island fishery by the Scientific Observer Programme by fishing year. N represents the number of fish measured.**

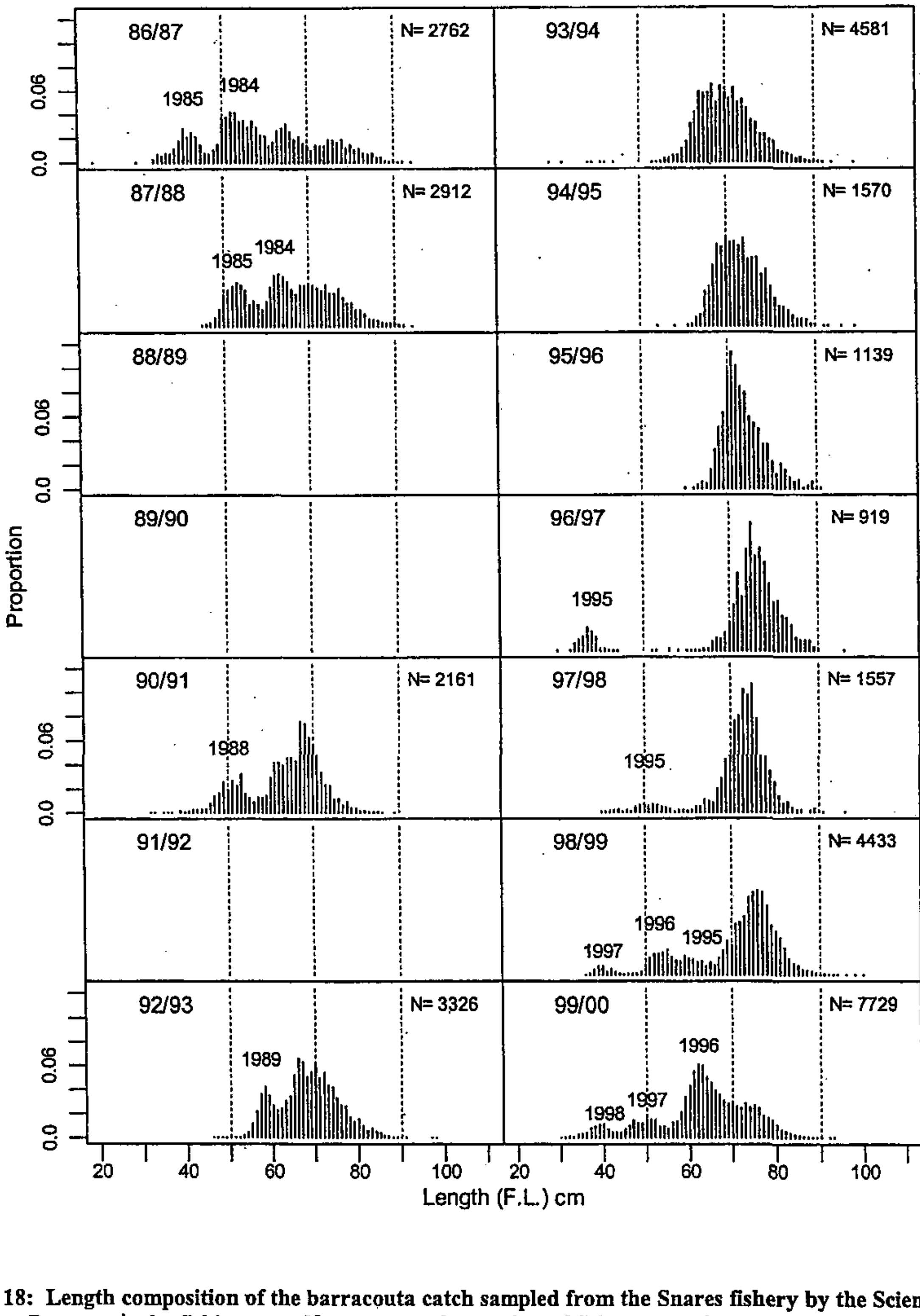


**Figure 18: Length composition of the barracouta catch sampled from the Snares fishery by the Scientific Observer Programme by fishing year. N represents the number of fish measured.**

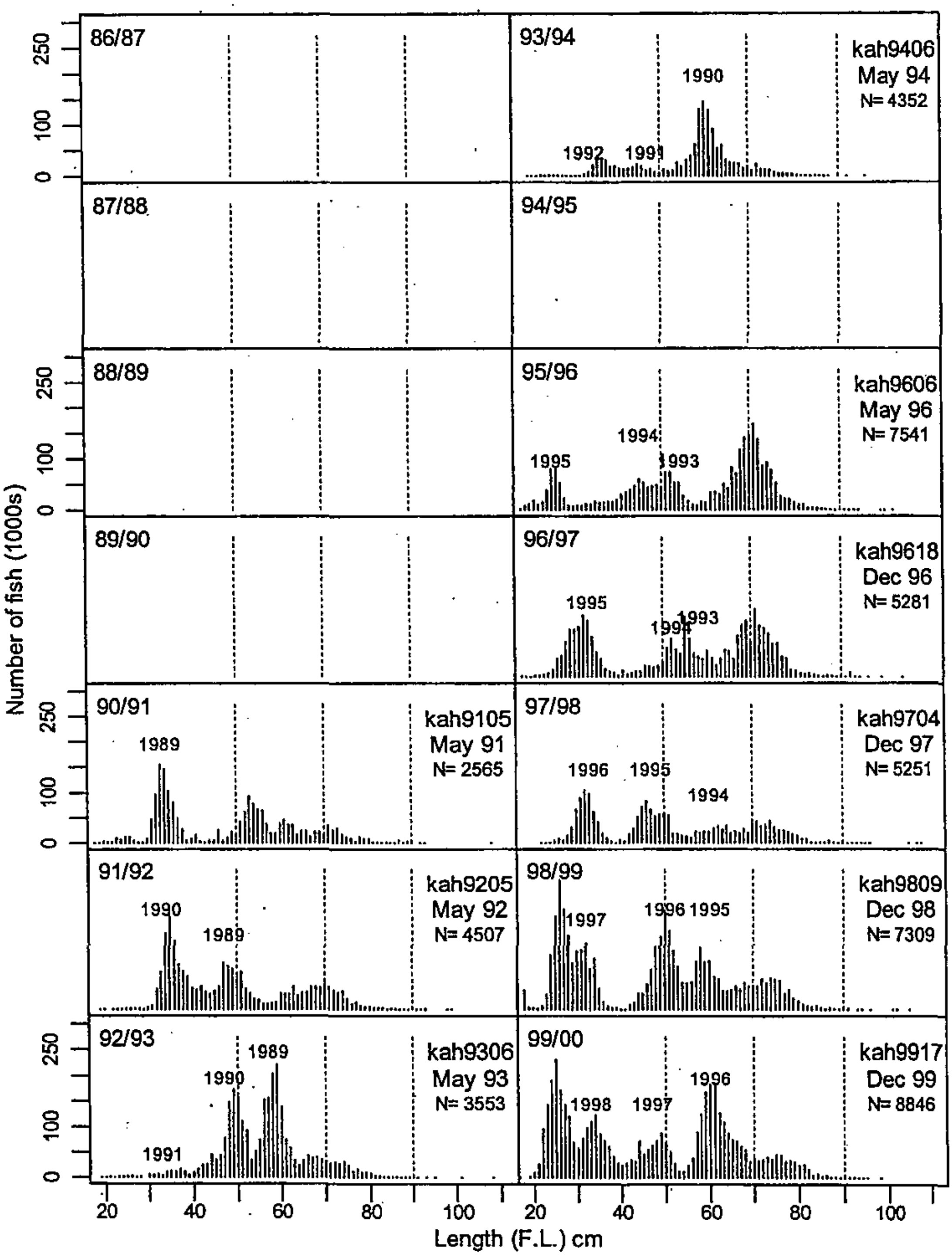


**Figure 19: Length composition of barracouta from the time series of east coast South Island trawl surveys (winter and summer). N represents the number of fish measured.**

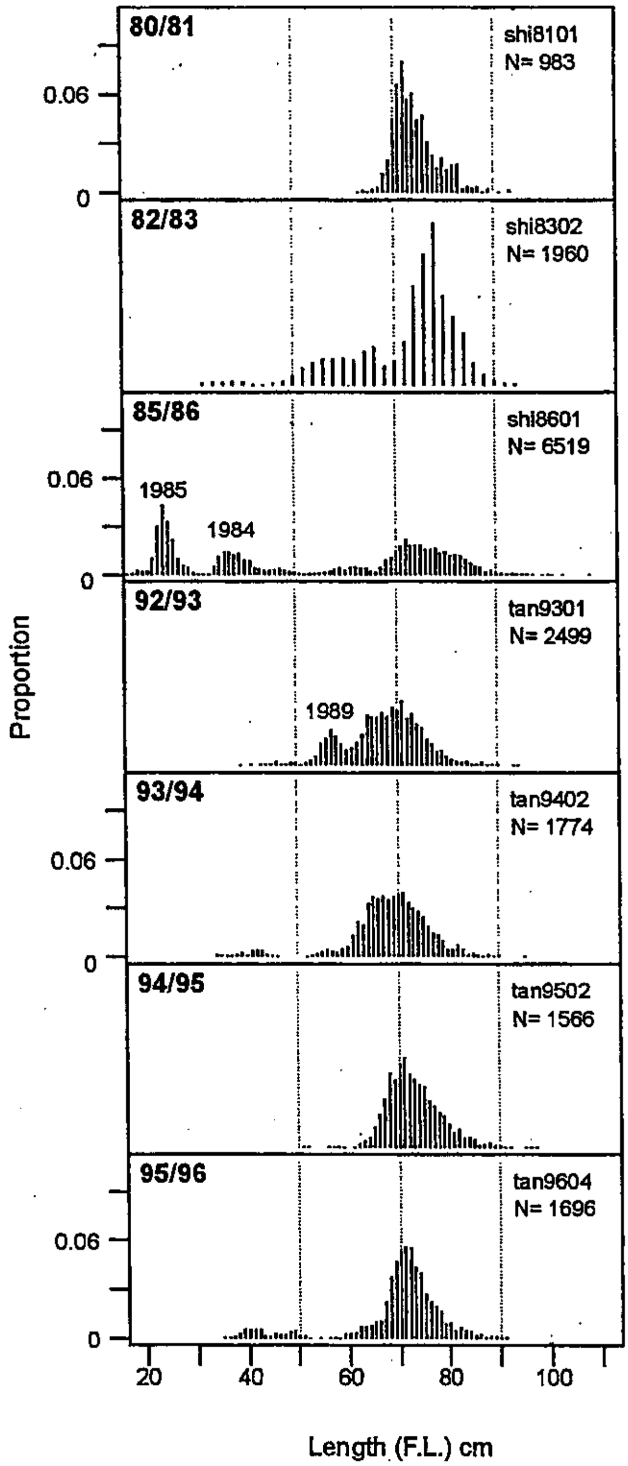


**Figure 20: Length composition of barracouta from the time series of Southland trawl surveys. N represents the number of fish measured.**

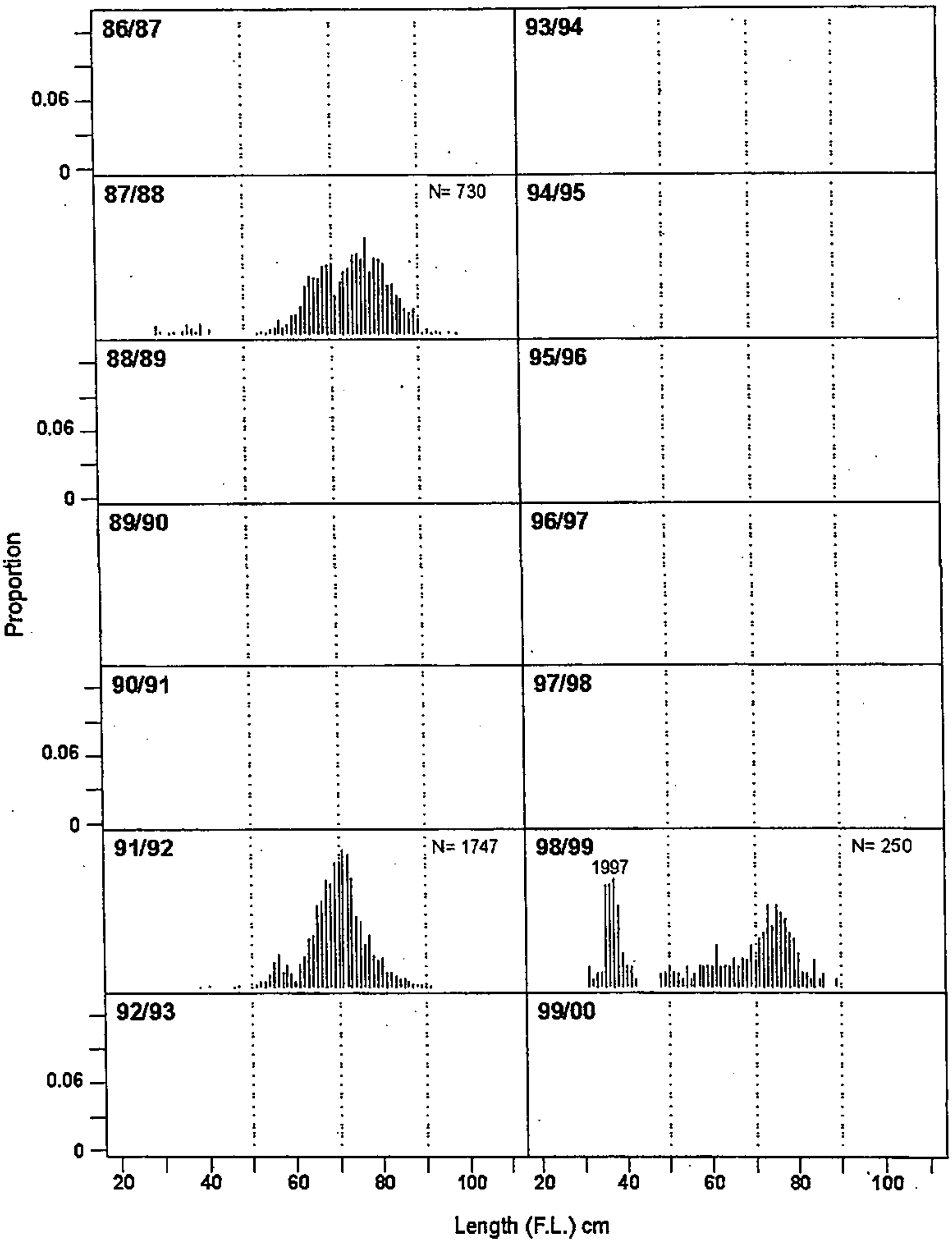


**Figure 21: Length composition of the barracouta catch sampled from the Stewart fishery by the Scientific Observer Programme by fishing year. N represents the number of fish measured.**

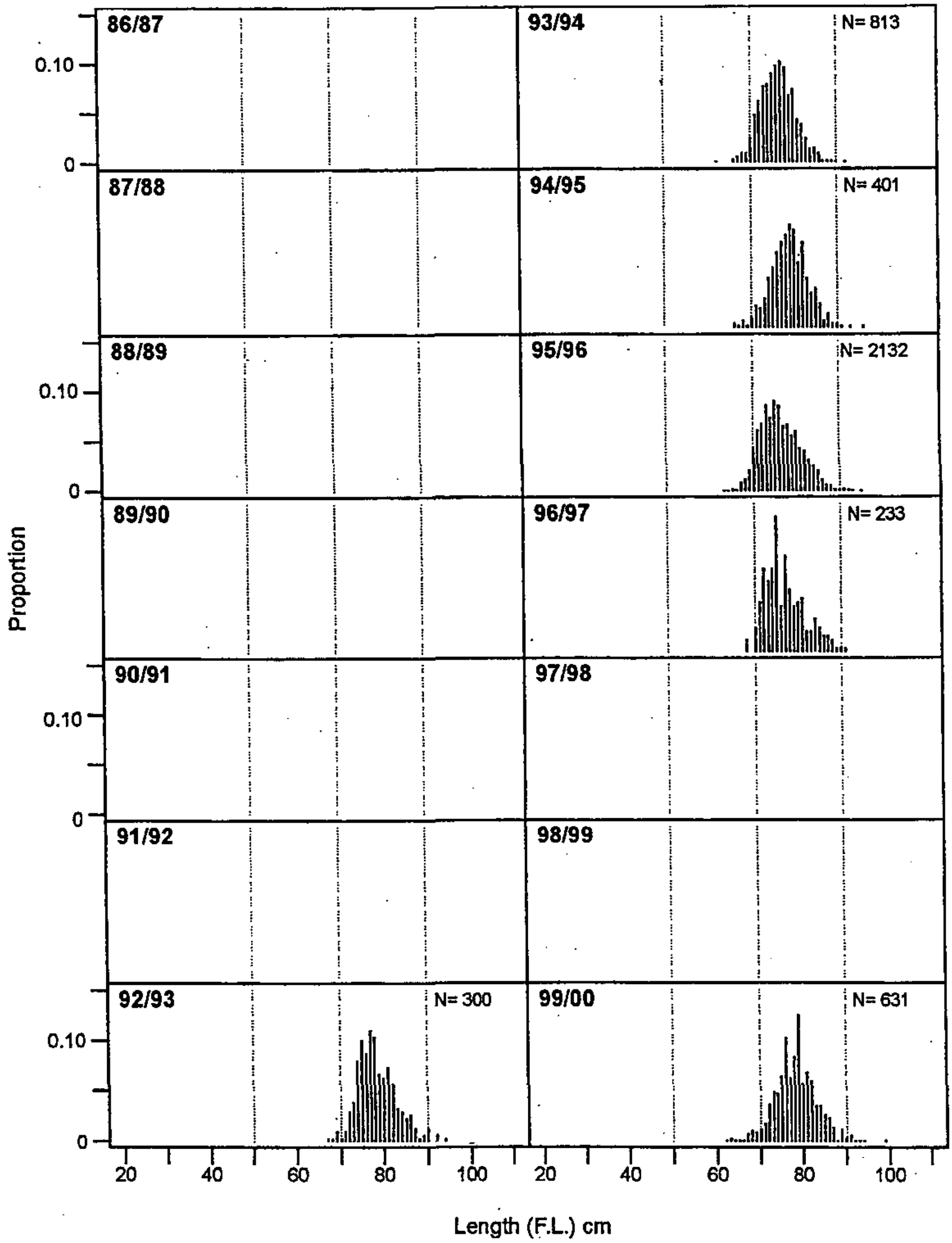


**Figure 22:** Length composition of the barracouta catch sampled from the Auckland Islands fishery by the Scientific Observer Programme by fishing year. N represents the number of fish measured.

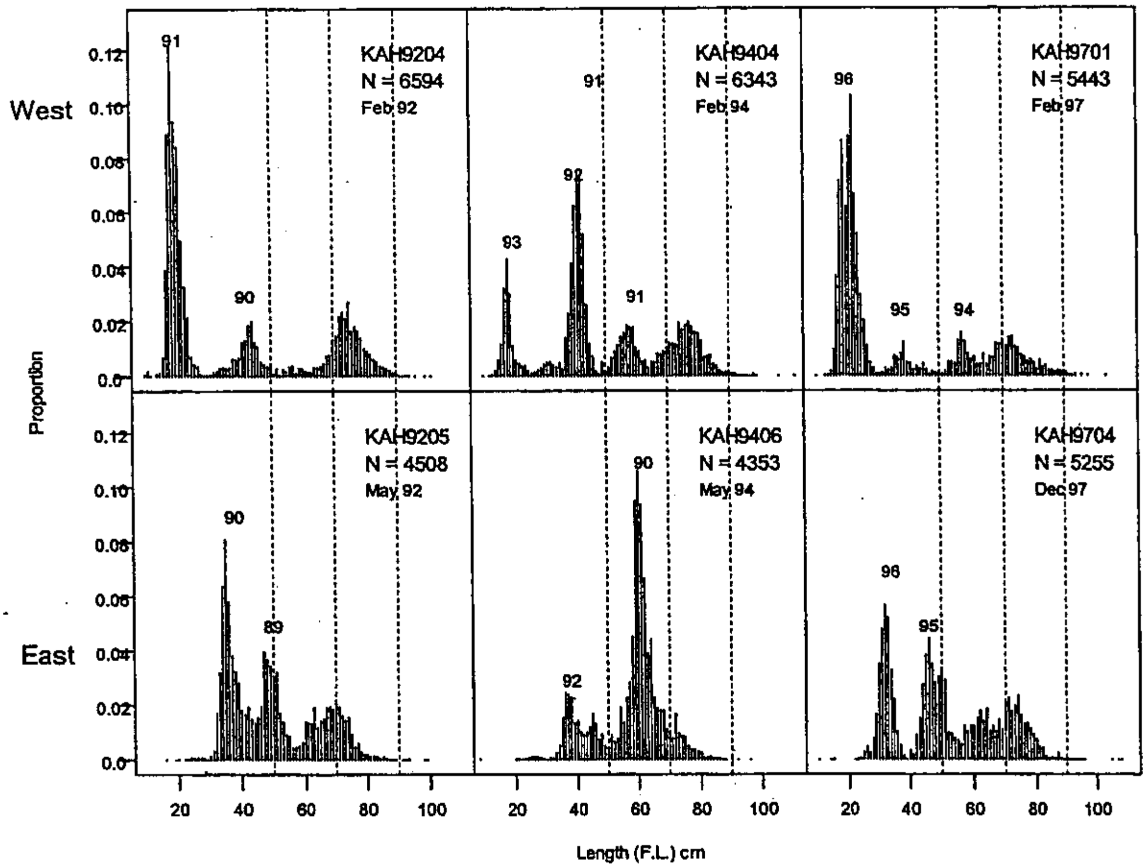


**Figure 23: Comparison of length frequencies done within the same year by the *Kaharoa* off the west (top) and east (bottom) coasts of the South Island.**

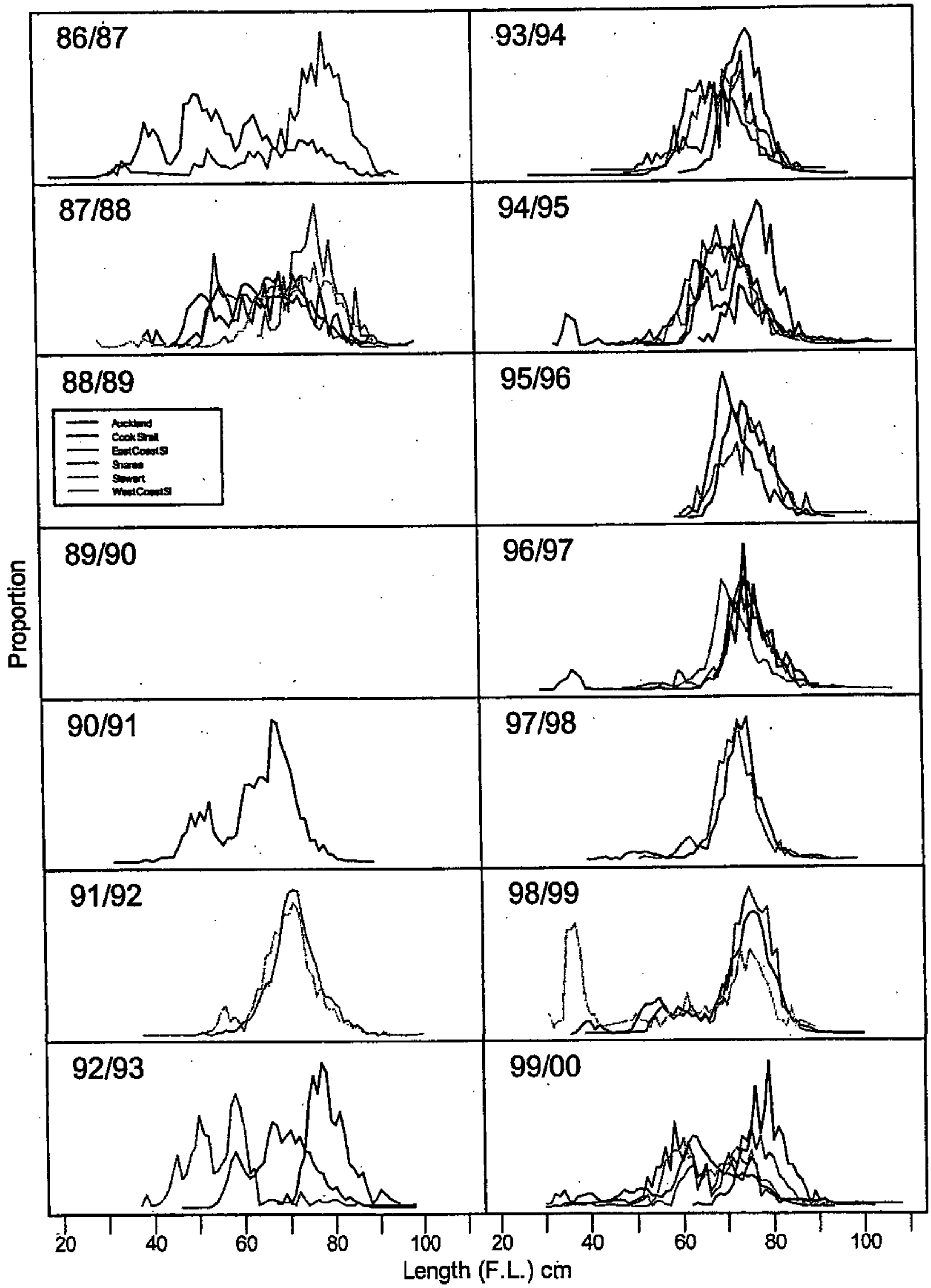


**Figure 24: Length composition of the barracouta catch sampled from the six fisheries by the Scientific Observer Programme by fishing year. Only area/years are presented where at least 200 fish were measured. Length samples from the west coast South Island fishery are plotted in the subsequent year consistent with the seasonal timing of the fishery to enable a more direct comparison of the length compositions.**