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EXECUTIVE SUMMARY

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In JMA 1, species proportions were estimated for the purse-seine fishery from market sampling data collected during 2000–01 in Tauranga. The estimated proportions were 5% for *T. declivis*, 1% for *T. s. murphyi*, and 95% for *T. novaezelandiae*. Coefficients of variation on these estimates were 1% in all cases. Three further landings were taken off the Wairarapa coast and processed in Nelson. The estimated proportions were 62% for *T. declivis*, 9% for *T. s. murphyi*, and 29% for *T. novaezelandiae*.

In JMA 3, species proportions were estimated from MFish observer data collected on deepwater vessels during 2000–01 (17% for *T. declivis*, 83% for *T. s. murphyi*, and 0% for *T. novaezelandiae*), but observer coverage was not extensive enough to provide seasonal variations in species dominance. These estimates continue a time series of predominance of *T. s. murphyi* in the JMA 3 TCEPR (vessels recording catch on Trawl Catch Effort and Processing Returns) catch that has continued since 1987–88.

In JMA 7, species proportions were estimated for the purse-seine fishery from market sampling data collected during 2000–01 (23% for *T. declivis*, 76% for *T. s. murphyi*, and 10% for *T. novaezelandiae*), from MFish observer data for the large-vessel offshore trawling fleet (66% for *T. declivis*, 19% for *T. s. murphyi*, and 14% for *T. novaezelandiae*), and a time series from inshore trawl survey data. MFish observer data support an earlier observation that *T. s. murphyi* exhibit a winter peak, *T. novaezelandiae* a summer peak, and *T. declivis* a peak that lies between the two, but for the first year since 1990–91, *T. s. murphyi* was not the predominant species during the July–August "season" in 2000–01.

This observation adds another piece of evidence indicating a change in the availability of *T. s. murphyi* in both the purse-seine and TCEPR fisheries, although proportions remain largely unchanged in the JMA 3 TCEPR fishery, apart from an apparent reduction in *T. s. murphyi* in 1999–2000. Overall, there seems to be a reduction in abundance of this species, though it is difficult to provide definitive information given recent changes in the distribution of fishing effort and the possible effect of higher sea temperatures.

The continued estimation of species proportions from the catch is fundamental for stock assessment and other research initiatives on these species because landings of jack mackerel are recorded under the aggregate code JMA. Estimation of catch for each species can only be based on species proportions data. Recent work on age and growth of *T. s. murphyi* required annual catches to investigate year class strength, which provided a useful qualitative test of the ageing method developed during the study. Reliable age estimates are required for developing stock assessment and monitoring methods for these species.

1. INTRODUCTION

Because commercial catches of jack mackerel are recorded as an aggregate of the three species under the general code JMA, reliable estimates of the proportions of the three *Trachurus* species (*T. declivis*, *T. s. murphyi*, and *T. novaezelandiae*) from sources other than catch records are essential for assessment of their stocks individually. Because these species are aggregated in catch records, separate information for each is unavailable, either as stock indices using catch per unit effort (CPUE) or in catch histories from the jack mackerel quota management areas. Reliable estimates of species proportions can be used to apportion the aggregated catch histories to provide individual catch histories and CPUE series for each species, which can in turn be used in age-structured models (Taylor 1999a) or to scale size or age structures from the various fisheries.

Throughout this document *T. declivis* and *T. novaezelandiae* are referred to collectively as the "New Zealand species". This is based on their being endemic before the invasion by *T. s. murphyi* (see Section 1.2). The time frame for data collection referenced in both objectives is fishing year, which is defined as the 12 months between 1 October in any year and 30 September of the following year.

1.1 Overview

This report updates recent estimates of the relative proportions of the three *Trachurus* species in the commercial catch summarised by Taylor (1999b, 2002b). The proportions are based on market sampling data in JMA 1, 3, and 7, and MFish and industry observer data in JMA 3 and 7 (Fishstock boundaries are shown in Figure 1). A time series of changes in estimated species proportions based on MFish observer data is presented as a summary of the seasonal variability in species composition in the commercial catch in JMA 3 and 7.

This work was completed under the Ministry of Fisheries Research Project JMA2000/01, "Monitoring the species composition of the commercial catch of Jack Mackerel". Specific objectives were as follows.

1. To collect samples from fish processing sheds to determine the seasonality and species composition of the commercial catches of *Trachurus declivis*, *T. symmetricus murphyi*, and *T. novaezelandiae* in JMA 1, JMA 3, and JMA 7 in the 2000–01 fishing year;
2. To determine from the catch at sea, the seasonality and species composition of the commercial catches of *T. declivis*, *T. s. murphyi*, and *T. novaezelandiae* in JMA 3 and 7 in the 2000–01 fishing year.

The scope of this report goes beyond presenting the results of work completed under project JMA2000/01 only. Summaries of results by Taylor (1999b, 2002b) are presented, and are updated with the estimates for 2000–01 as defined in the objectives for JMA2000/01.

1.2 Distribution of jack mackerel

The three species have different geographical distributions, with some overlap in their ranges: *T. novaezelandiae* predominates in waters shallower than 150 m and warmer than 13 °C, and is uncommon south of latitude 42° S; *T. declivis* generally occurs north of 45° S in deeper waters than *T. novaezelandiae*, but shallower than 300 m and in temperatures less than 16 °C; and *T. s. murphyi* occurs to depths of at least 500 m over a wide latitudinal range (e.g., from 0° to 50° S off South America) (Annala et al. 2002).

Until recently, only *T. declivis* and *T. novaezelandiae* were known from New Zealand waters (Jones 1990). Murphy's mackerel, *T. s. murphyi*, was first described here by Kawahara *et al.* (1988), and has become abundant only since the late 1980s. It appears to have become established off the south and

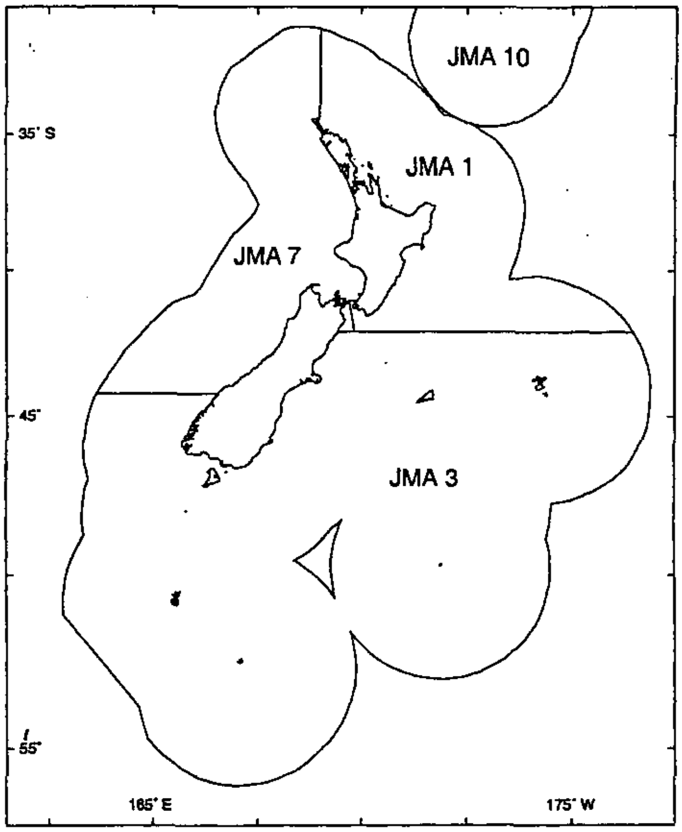


Figure 1: Jack mackerel Fishstocks

east coasts of the South Island on to the Chatham Rise in the mid 1980s, expanded to the west coast of the South Island and the North and South Taranaki Bights by the late 1980s, reached the Bay of Plenty in appreciable quantities by 1992, and had become common on the east coast of Northland by June 1994 (Taylor 2002a). Since then there has been a narrowing of its range within New Zealand waters to some extent (Taylor, unpublished data), but it is unknown whether this is only at the surface or whether it reflects any reduction in abundance.

The total range of *T. s. murphyi* extends along the entire west coast of South America, across the South Pacific, and through much of the New Zealand EEZ. It was also reported from waters off southeast Australia in the late 1989s (Pullen et al. 1989), although more recent sightings cannot be confirmed. Stepien & Rosenblatt (1996) have shown that *T. s. murphyi* is synonymous with *T. symmetricus*, which is distributed off the North American west coast.

The three jack mackerel species can all be caught by bottom trawl, midwater trawl, and by purse-seine targeting surface schools. Their vertical and horizontal movements are poorly understood, but they are presumed to generally be off the bottom at night, and surface schools can be common during the day.

1.3 Literature review

Relative proportions of the jack mackerel species were estimated by Horn (1991) for adjusting the aggregated catch history in JMA 7. Taylor (1998) used species proportions estimated from market sampling data collected from the JMA 1 purse-seine fleet between 1994 and 1996 to produce catch histories for the three species for use in a stock reduction model. Taylor (1999a) used the species proportions presented by Taylor (1999b) for JMA 7 to investigate the feasibility of developing CPUE stock indices and age-related stock assessment models. Taylor (2002a) used existing data to investigate the stock structure of *T. s. murphyi* in the South Pacific Ocean and examine the degree to which its population has become established in New Zealand waters. Taylor (2002b) updated species proportion estimates for 1999–2000.

1.4 Previous sampling of jack mackerel fisheries

The purse-seine fishery for jack mackerel accounts for 95% of the catch total in JMA 1 (7000–8000 t in 1994–95 and 1995–96), and for a relatively small fishery between Kaikoura and the Marlborough Sounds in JMA 3 and JMA 7. Most of the catch from the purse-seine fishery in both areas is taken and processed by Sanford Ltd, at factories in Tauranga and Nelson, with a smaller proportion of the JMA 1 catch landed into Pelco Ltd in Tauranga (formerly part of Mount Fish Ltd). The amount of catch landed into the Pelco Ltd factory has increased since 1997–98. Mostly, Pelco Ltd have targeted small fish, whereas Sanfords landings have varied between the small and large categories.

Market sampling by NIWA between 1994 and 1997 gathered information from the purse-seine catch of jack mackerels in Tauranga under MFish Projects PIJM01 and JMA9701. During the 1998–99 fishing year, NIWA began a collaborative approach with Sanford Ltd to reduce the costs of market sampling by using data collected by Sanford's staff since 1994–95 as part of the monitoring programme initiated with increased TACCs in JMA 1 and JMA 3. NIWA and Sanford's staff worked together to clarify data collection methods and features of species identification.

In JMA 3 and JMA 7, jack mackerel are also taken by large, deepwater trawlers recording their landings on Trawl, Catch, Effort and Processing Return forms (TCEPR), and small, inshore trawlers recording their landings on Catch, Effort and Landing Return forms (CELR); purse-seiners also use CELR forms. Large factory trawlers take catch throughout both Fishstocks. It is processed and packed at sea and is not able to be sampled on shore. The CELR inshore trawl fleet land unprocessed catch at Talley's Ltd in Motueka.

Catches in the TCEPR fleet have regularly been sampled for information on species composition by observers since the mid 1980s. Jack mackerel catch from the CELR inshore trawl fleet in JMA 7 was not sampled before the study described by Taylor (2002b).

2. METHODS

2.1 Seasonality and species composition from market sampling during 1999–2000

Market sampling data were collected from Sanford Ltd (Tauranga) (JMA 1), Pelco Ltd (Tauranga) (JMA 1), Sanford Ltd (Nelson) (JMA 3 and 7), and Talley's Ltd (Motueka) (JMA 7). Sampling in both Sanford factories was done by Sanford's staff, who were able to provide data for all purse-seine landings of jack mackerel; NIWA staff sampled at Pelco and Talleys.

Samples from the inshore trawl fishery were used to investigate Horn's (1991) hypothesis that the jack mackerel population of inshore JMA 7 is dominated by a high proportion of *T. novaezelandiae*. Observer data do not cover the CELR fleet, and an understanding of the relative proportions of jack mackerel species in both the inshore and deepwater fisheries in JMA 7 is required to determine a suitable method for assessment of this Fishstock (Taylor 1999a).

Sanford (Tauranga). It is standard practice in this fish shed to sort jack mackerel by weight into the following grades: 0–200 g, 201–400 g, 401–600 g, 601–1 kg, over 1 kg. These are referred to below as "grade-weights". The total weight of each species in a purse-seine landing of jack mackerel is estimated as follows.

1. Throughout the landing, which can take up to 3 days, samples of about 300 kg are taken at random from each grade. Samples are taken at a rate of up to two per day per grade, one each in the morning and afternoon during the landing.
2. Each sample is sorted by species, and the weight of each species in the sample is taken.
3. The sample-weight of each species is divided by the total weight of the sample to give estimates of the proportions of each species in the sample.
4. Means of the species proportions are estimated for each grade from all samples across the landing.
5. The total grade-weight for the landing is multiplied by the grade-species-proportions to give a grade-weight for the species.
6. The species weights from each grade are added to give a total weight of each species in the landing.

All landings of jack mackerel from four vessels were sampled by Sanford staff at Tauranga, from the beginning of 2000–01 until the end of December 2001. All were used in the analysis. This resulted in a between-landing variance of zero. Species proportions were estimated by month and for the year. This was done by taking the grade weights of each species in each landing (the output from step 5 above), adding the grade weights of each species over the time frame of interest to get an overall weight of each species in all grades, and dividing each of these species aggregates by the overall aggregate for all species to produce proportions of each of the species.

Sanford (Nelson). A similar method of estimating total weight of each species in a purse-seine landing was employed for data from this fish shed, but, because they do not grade their fish, the fine scale approach afforded by grade samples was not possible. Instead samples of about 700 kg were taken from each hold when it was about half emptied. Each sample was sorted by species, and the weight and number of specimens of each species in the sample was recorded.

Six landings from one vessel were sampled by Sanford staff at the Nelson factory during 1999–2000: one on 24 November 1999 from JMA 1, one on 13 January 2000 from JMA 7, and four between 14 November 1999 and 9 January 2000 from JMA 3. The nine from 1999 were used in the analysis.

Pelco Ltd, Tauranga. NIWA used a similar method to that employed at Sanford (Tauranga) to market sample purse-seine catch landed at this fish shed. Pelco also grade jack mackerel and 18 landings from two vessels were sampled from the beginning of 2000–01 (19 September 2000) until the end of August 2001. Pelco also provided tonnage totals by grade for all landings during the fishing year. However, there were difficulties compiling data from the period of interest because of changes in ownership of this company and transfer from one site to another. Consequently, there are discrepancies between sampling and landing dates that prevent assigning sample data to specific landings, which is necessary for correctly weighting sample data in the estimation procedure. As a result these data cannot be used until reliable assignment of samples to landings can be made.

Talley's Ltd, Motueka. Individual landings of jack mackerel at Talleys were not large. The adopted approach included all fish from a landing in a sample, except for landings of 500 kg or more. In this case, 500 kg of fish were chosen at random from the top of all containers used in the unloading. A second aspect of the approach was to maintain a sampling frequency of about 1–2 per week when possible to capture any seasonal changes that may occur throughout the year. Twenty-four landings from 12 vessels were sampled during 2000–01.

Estimation methods. Two methods of estimating species proportions were used. Where sampling covered all landings (i.e., Sanford data) the method was simple and required only that landing weights for each species be summed over all landings and divided by the total weight of all species in all landings. This provided species proportions for each species in all landings. Where only a subset of landings was sampled (i.e., at Talleys), the method was modified to scale proportions to the total number of landings in the stratum (Appendix A).

Estimating variability. Coefficients of variation (c.v.s) were estimated for all species proportions, although species proportions estimates from previous years do not have accompanying c.v.s (e.g., see Table 1). Where all landings were sampled (i.e., Sanford data), all variance was within-landing variance, variance was estimated for the sample species proportions and c.v.s for the annual species proportions using the equations in the "Estimating Variance" section of Appendix A.

Two methods were used to estimate number of fish, which was then used as input to variance estimation. For the Sanfords (Tauranga) data, mean fish weight was taken as the median value in the range for each grade, except for the grades "crayfish bait", "rejects", "mixed", and "ungraded", where an approximation was made to provide values that were towards the upper weight limit for *T. novaezelandiae* and were lower than the usual weight ranges for *T. declivis* and *T. s. murphyi* in this fishery. Bias from this source was low, given that only 11% of the catch was assigned to these grades, and would have little effect on the resulting low c.v. values (see Table 1). The following mean fish weights were used:

Grade	Mean fish weight (kg)	Grade	Mean fish weight (kg)
0–200 g	0.10	600 g–1 kg	0.80
0–400 g	0.20	700 g–1 kg	0.85
200–400 g	0.30	1 kg +	1.10
200–500 g	0.35	crayfish bait	0.50
400–500 g	0.45	rejects	0.50
400–600 g	0.50	mixed	0.50
500–700 g	0.60	ungraded	0.50

For the Sanfords (Nelson) data, the following approximate mean weights were assigned to each of the species: 0.85 kg for *T. declivis*, 1 kg for *T. s. murphyi*, and 0.45 kg for *T. novaezelandiae*.

In all other cases only a subset of landings was sampled. Variance in the species proportions is a combination of within-landing and between-landing variance, but because within-landing variance is a minor component of the total variance (Bull & Gilbert 2001) only the between-landing variance was estimated. This was done by bootstrapping (Efron & Tibshirani 1993) the species proportion estimates and calculating c.v.s using

$$\hat{c.v.} = \frac{\sqrt{\hat{var}(\text{bootstrapped species proportions})}}{\hat{mean}(\text{bootstrapped species proportions})}$$

Bootstrapping incorporated 1000 sets of species proportions based on data resampled from the original sample and landing weights, with replacement. The target value for c.v.s was 10%, based on arguments presented in Taylor (1999a).

A c.v. was estimated for the mean species proportion estimated from a time series of species proportions (for *T. s. murphyi* in the JMA 7 TCEPR fishery from observer data) using

$$\hat{c.v.}_{(mean(\hat{p}_i))} = \frac{\frac{1}{n}\sqrt{\sum(\hat{c}_i \hat{p}_i)}}{mean(\hat{p}_i)} \qquad (1)$$

where $\hat{p}_i$ is the ith species proportion in the series and $\hat{c}_i$ is its estimated c.v.

2.2 Species composition and seasonality for 2000–01

2.2.1 Observer data (JMA 3 and 7)

This work comprised data extracts from the observer database, estimation of species composition in the catch, and a characterisation of the variation in species composition over time. Appropriate data were extracted from the MFish observer database (*obs_lfs*) and loaded into an EMPRESS database table for use in the analysis. The method used was as follows.

1. Species composition data and total catch by tow and trip for 2000–01 were extracted from the database.
2. Species proportions were estimated by weight and number for each tow.
3. Species tow proportions were scaled to the tow tonnage to get species weights for the tow.
4. Means of the species tow weights for each trip were estimated.
5. These species trip estimates were scaled to the trip tonnage.
6. The species estimates were summed for all landings and proportions of the species in the catch were estimated for a given time frame. Two time frames were used: the first was based on fishing year; the second on month.
7. Species proportions were estimated, using the equations in Appendix B.
8. Coefficients of variation (c.v.s) were estimated by bootstrapping the sample data.

2.2.2 Industry observer data from the JMA 3 and 7 TCEPR fisheries

Fishing companies active in the jack mackerel TCEPR fishery (i.e., vessels using Trawl Catch Effort Processing Returns) were identified and contacted to discuss the possibility of their providing suitable data. Independent Fisheries Ltd operate joint venture vessels in JMA 3 and JMA 7 (Figure 1) and have their own observers on board, who were able to collect data for this work. Sealord Ltd also operate joint venture vessels in the TCEPR fishery, but do not employ industry observers. As an investigative approach to augment the low observer coverage in this fishery, NIWA collaborated with Sealord who organised collection of data coordinated by shift managers on board joint venture vessels operating primarily in the squid fishery, but who target jack mackerel from time to time.

For industry observers, NIWA undertook two instructive seminars at the premises of Independent Fisheries in Lyttelton. This included presentation of the sampling procedure used by MFish observers and identification of the three jack mackerel species using specimens provided by Sanford Ltd. Forms were designed by NIWA and provided with instructions on species identification, the sampling method, and data collection, similar to directions in the MFish Observer Programme (MOP) manual. Instigating sampling with Sealord joint-venture crews was more difficult and required translation with shift managers by the ship's husband. Species separation in this case was based on methods used on board these vessels, which, within the constraints of the language barrier, appeared to consistently identify the three species correctly.

These data provided information from some landings (Independent Fisheries, 44 landings; Sealord, 75 landings) of jack mackerel. However, no data were used in the present analysis: Independent Fisheries data were collected within 2000–01, but did not include information on position and were therefore unusable; Sealord data were collected during 2001–02 and were therefore not relevant in this analysis. They were held in reserve for future analyses for 2001–02.

3. RESULTS

3.1 Species composition from market sampling during 2000–01

3.1.1 The purse-seine catch (JMAs 1, 3, and 7)

The jack mackerel purse-seine fishing season in JMA 1 begins in about May or June each year and runs until about December (Figure 2). The main period of catch was between June–July and September–October. No seasonal pattern of species composition is evident. The proportion of *T. novaezelandiae* dominated the time series since June 1999.

Estimates of species proportions in JMA 1, 3, and 7 using market sampling data from 1997–98 to 2000–01 are summarised in Table 1. The relative proportion of *T. s. murphyi* has been consistently higher in JMAs 3 and 7 than in JMA 1. Proportions of *T. novaezelandiae* in the northern catch were much higher than in the south, with an increase in its proportion over *T. declivis* evident from 1997–98 to 1999–2000 that was sustained in 2000–01.

Table 1: Species composition of purse-seine catch of jack mackerel; North is Sanfords (Tauranga), South is Sanfords (Nelson); estimates for 1997–98 and 1998–99 are from Taylor (1999b, 2000) and have no accompanying coefficients of variation (c.v.s) (source: Sanford Ltd sampling data).

Shed	Fishstock	Fishing year	No of landings sampled	% of landings sampled	Species proportions and c.v.s where estimated (in parentheses) JMD	JMM	JMN
North	JMA 1	1997–98	14	25	0.23	0.35	0.42
		1998–99	50	100	0.14	0.29	0.57
		1999–00	65	100	0.03 (0.01)	0.02 (0.02)	0.95 (0.01)
		2000–01			0.05 (0.01)	0.01 (0.01)	0.93 (0.01)
South	JMA 1†	1999–00	1	100	0.92 (0.01)	0.07 (0.07)	0.01 (0.16)
		2000–01	3	100	0.62 (0.01)	0.09 (0.08)	0.29 (0.01)
	JMA 3	1997–98	1	100	0.29	0.69	0.02
		1999–00	4	100	0.23 (0.03)	0.77 (0.01)	0.00 (0.00)
		2000–01	0	–	–	–	–
	JMA 7	1998–99	9	100	0.51	0.49	<0.01
		1999–00	1*	100	0.34 (0.03)	0.66 (0.01)	0.00 (0.00)
		2000–01	5	100	0.23 (0.04)	0.76 (0.01)	0.1 (0.09)

*No of landings for JMA 7 in 1999–2000 is 1 plus a partial landing
†Wairarapa coast

3.1.2 Species composition from market sampling of the inshore trawl catch (JMA 7)

Estimates of species proportions in JMA 7 using market sampling data from August 1998 to August 2001 are summarised in Table 2 and presented, along with catch of the three species as time series plots, in Figure 3. There was no evidence for any regular seasonal patterns in species proportions, but there was evidence that species composition changes frequently, and that all three species were taken regularly in the CELR inshore trawl fishery.

The apparent breaks in catch of jack mackerel from this fishery reflect periods of sampling/no sampling. Bycatch of jack mackerels is continuous throughout the year (Taylor, unpublished data).

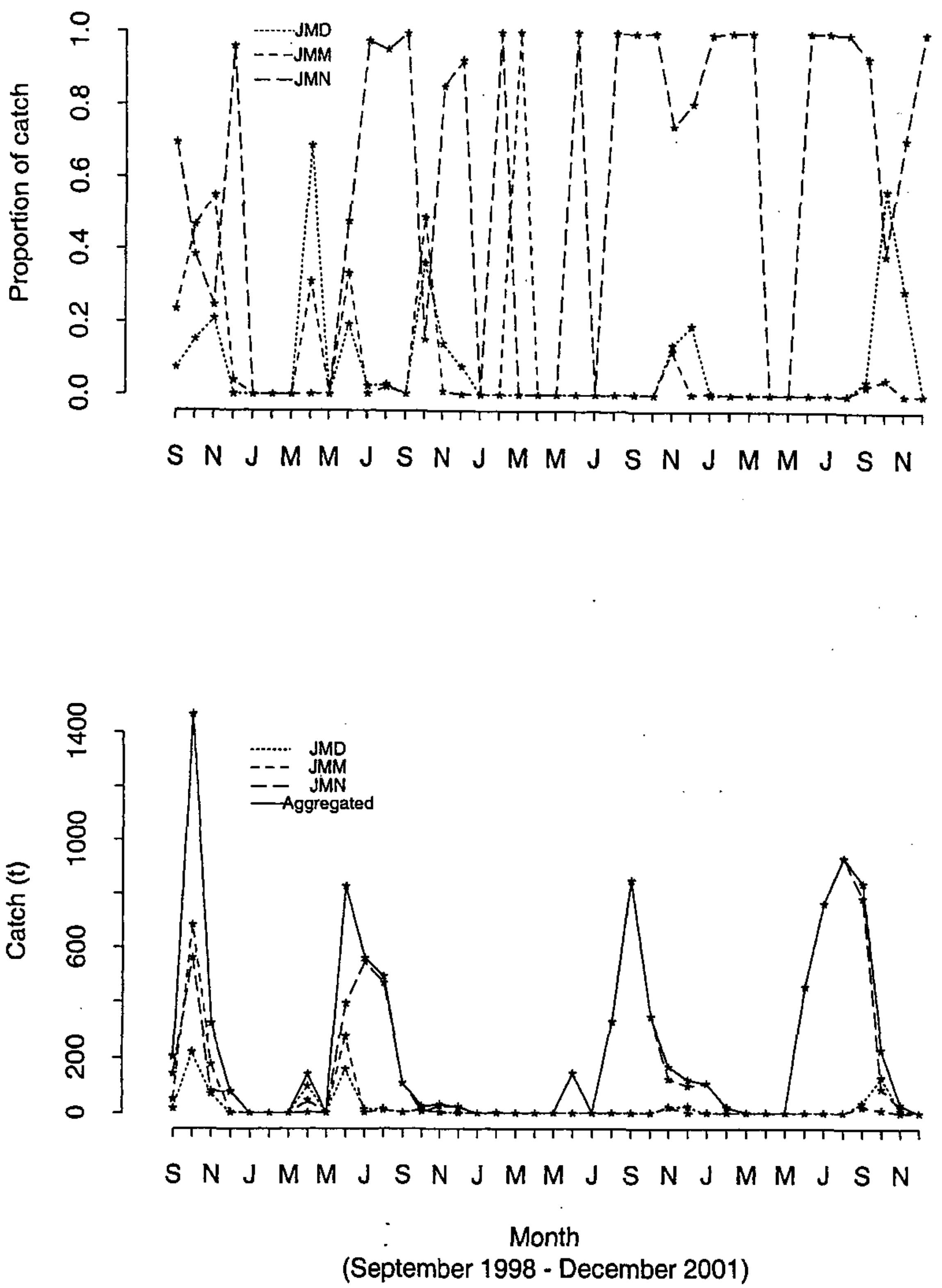
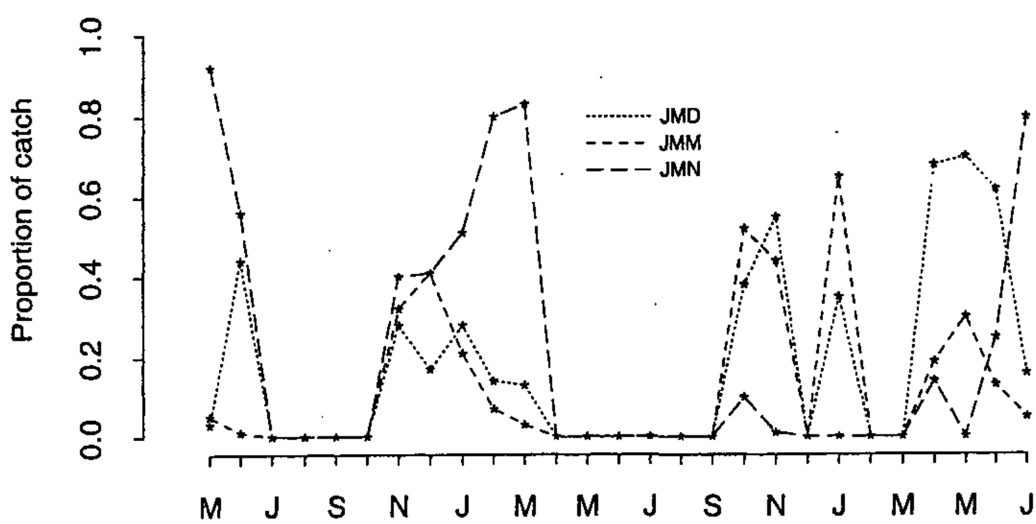


Figure 2: Time series of species proportions and catch of the three jack mackerel species in the JMA 1 purse-seine fishery between September 1998 and December 2001; JMD is *T. declivis*, JMM is *T. symmetricus murphyi*, and JMN is *T. novaezelandiae*; the aggregated catch for the three species is also shown (source MFish *market* database).



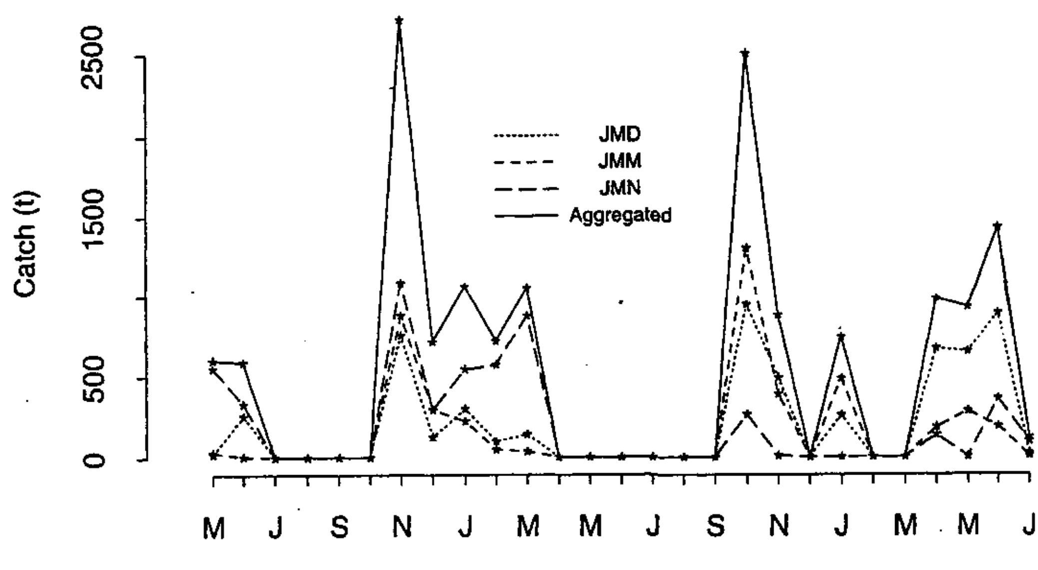


Figure 3: Time series of species proportions and catch of the three jack mackerel species in the JMA 7 inshore trawl catch (vessels using Catch Effort Landing Returns — CELR) between May 1999 and June 2001; JMD is *T. declivis*, JMM is *T. symmetricus murphyi*, and JMN is *T. novaezelandiae*; the aggregated catch for the three species is also shown (source MFish *market* database).

Table 2: Scaled species composition of inshore trawl catch of jack mackerel in JMA 7 by fishing year; JMD is *Trachurus declivis*, JMM is *T. symmetricus murphyi*, JMN is *T. novaezelandiae*, *N* is the number of tows sampled, c.v.s are coefficients of variation (source: MFish Market sampling database, *market*, Talley Ltd sampling data).

			Species proportions			c.v.		
Fishing year	Month	N	JMD	JMM	JMN	JMD	JMM	JMN
1998–99	August	2	0.03	0.05	0.92	2.14	0.91	0.22
	September	2	0.26	0.00	0.74	0.76	1.88	0.65
	Overall	4	0.17	0.02	0.81	0.85	0.71	0.32
1999–2000	November	5	0.31	0.40	0.30	0.41	0.63	0.43
	December	2	0.25	0.60	0.15	0.80	0.90	0.56
	January	3	0.33	0.23	0.44	0.68	0.65	0.38
	February	3	0.20	0.05	0.76	0.84	1.14	0.42
	March	3	0.12	0.03	0.85	0.66	1.04	0.71
	Overall	16	0.28	0.33	0.39	0.34	0.36	0.16
2000–01	November	6	0.38	0.57	0.05	0.28	0.28	1.50
	December	2	0.62	0.37	0.01	0.30	0.40	2.25
	February	1	0.35	0.65	0.00	0.35	0.66	1.82
	May	5	0.60	0.13	0.27	0.35	0.90	1.62
	June	2	0.67	0.33	0.00	0.61	1.19	1.00
	July	6	0.59	0.15	0.25	0.97	1.22	0.49
	August	2	0.16	0.08	0.76	1.24	1.47	0.37
	Overall	24	0.49	0.41	0.09	0.17	0.24	0.70

3.2 Species composition and seasonality for 2000–01

3.2.1 Observer data

The annual TCEPR catch in JMA 3 has been dominated by *T. s. murphyi* since 1987–88 (Table 3). In 1999–2000 *T. novaezelandiae* reappeared for the first time since 1987–88, but was again absent from samples in 2000–01. Coefficients of variation on the species proportions often met the target value of 5% or less for *T. s. murphyi*, although there were several instances where the variance was too high to be acceptable.

In JMA 7 the pattern was much more variable (Table 3). In most years the proportion of either *T. declivis* or *T. novaezelandiae* was the highest, with *T. declivis* having the highest proportion most often. The annual proportion of *T. s. murphyi* was highest only in 1995–96. The c.v.s for proportions of *T. declivis* and *T. novaezelandiae* were usually higher than 10%, although they were 5% or less in a number of cases for both species.

At a finer temporal scale (Appendix C), the predominance of *T. s. murphyi* in JMA 3 was striking, although there were some instances where *T. declivis* was the major component of the catch. By contrast, *T. novaezelandiae* was almost nonexistent in the time series, reappearing in seven tows during 1999–2000 after being absent from 1987–88. In most cases the c.v.s on species proportions for *T. s. murphyi* were lower than 5%, thus showing an acceptably low level of variance.

In JMA 7 the pattern of high proportions of *T. s. murphyi* was seasonal, occurring regularly around July–August from 1990–91, although this pattern was absent for the first time in 2000–01 with *T. s. murphyi* present in very few tows. Both *T. declivis* and *T. novaezelandiae* have been consistently predominant for some months, but neither have showed a clear seasonal pattern. In 2000–01, *T. declivis* dominated the catch. c.v.s of less than 5% were associated with the highest proportion in the species composition estimates in about 40% of cases, suggesting that these estimates were acceptable and could be used to examine patterns of seasonality.

Table 3: Scaled species composition by fishing year of the catch of jack mackerels in the TCEPR fleet (vessels using Trawl Catch Effort Processing Returns) in JMA 3 and 7; JMD is *Trachurus declivis*, JMM is *T. symmetricus murphyi*, JMN is *T. novaezelandiae*, *N* is the number of sampled tows that contained a particular species (source: MFish Market sampling database, *market*, Talley's Ltd sampling data).

	Fishing	Species proportions			c.v.			N		
Fishstock	year	JMD	JMM	JMN	JMD	JMM	JMN	JMD	JMM	JMN
JMA 3	1985–86	0	1	0	NA	0	NA	0	1	0
	1986–87	0.78	0	0.22	0.17	NA	0.54	7	0	4
	1987–88	0.19	0.79	0.02	0.98	0.73	0.75	2	1	1
	1988–89	0	1	0	NA	0	NA	0	1	0
	1989–90	0.3	0.7	0	0.24	0.12	NA	2	2	0
	1990–91	0	1	0	NA	0	NA	0	7	0
	1991–92	0	1	0	2.11	0	NA	3	14	0
	1992–93	0.14	0.86	0	0.27	0.04	3.51	18	119	1
	1993–94	0.24	0.76	0	0.68	0.21	NA	5	38	0
	1994–95	0.04	0.96	0	0.83	0.04	NA	2	15	0
	1995–96	0.02	0.98	0	0.27	0	NA	49	102	0
	1996–97	0	1	0	NA	0	NA	1	15	0
	1997–98	0.02	0.98	0	0.17	0	NA	31	60	0
	1998–99	0.15	0.85	0	0.33	0.06	NA	29	48	0
	1999–2000	0.29	0.65	0.06	0.31	0.16	0.5	20	27	7
	2000–01	0.17	0.83	0.00	0.33	0.06	NA	38	73	1
JMA 7	1985–86	0.68	0	0.32	0.02	NA	0.04	3	0	3
	1986–87	0.58	0	0.42	0.05	NA	0.07	186	0	170
	1987–88	0.58	0	0.42	0.25	NA	0.34	13	0	9
	1988–89	0.63	0.07	0.3	0.11	0.72	0.26	28	5	17
	1989–90	0.29	0.01	0.7	0.13	0.67	0.06	92	11	88
	1990–91	0.38	0.03	0.6	0.07	0.31	0.04	190	28	172
	1991–92	0.46	0.09	0.45	0.12	0.31	0.12	88	47	77
	1992–93	0.59	0.17	0.25	0.04	0.1	0.08	159	150	145
	1993–94	NA	NA	NA	NA	NA	NA	146	109	104
	1994–95	0.3	0.34	0.36	0.06	0.09	0.09	140	127	129
	1995–96	0.36	0.41	0.23	0.23	0.38	0.26	61	41	49
	1996–97	0.58	0.15	0.27	0.04	0.16	0.09	128	123	102
	1997–98	0.49	0.14	0.38	0.04	0.12	0.05	168	152	164
	1998–99	0.68	0.12	0.2	0.05	0.17	0.14	122	68	41
	1999–2000	0.66	0.19	0.14	0.07	0.25	0.29	61	48	31
	2000–01	0.66	0.19	0.14	0.05	0.10	0.21	77	65	57

4. DISCUSSION

Recently, two changes in the proportions of jack mackerels in commercial catches have been identified (Taylor 2002b). In JMA 1, the proportion of *T. novaezelandiae* has increased steadily to represent about 95% of the catch in 1999–2000 and 2000–01. This is probably the result of changes in targeting from large to small fish and is almost certainly market driven.

Since its proliferation in New Zealand during the early 1990s, *T. s. murphyi* has been the dominant carangid species in a number of areas at certain times. Its predominance in JMA 3 has been discussed previously by Taylor (2000) as has its seasonal predominance in the JMA 7 TCEPR catch. There is now evidence that this predominance may be waning. Taylor (2002b) discussed unpublished information from aerial sightings and anecdotal information from the purse-seine fishery, which suggest changes in its availability over the last few years. Declines in the proportion of "red-tail" (a synonym used in the TCEPR fishery for *T. s. murphyi*) in industry packing data provide evidence that this reduced availability also applies to the midwater TCEPR trawl fishery.

The present summary also provides some evidence of this change. Since 1990–91 a consistent feature of the fine scale time series (by month) from the JMA 7 TCEPR fishery has been the dominance of *T. s. murphyi* during the July–August "season". In 2000–01 however, this feature was absent. Although this is not compelling evidence on its own, particularly if one considers the number of tows from which the data are collected, overall this information tends to suggest a possible reduction in the abundance of *T. s. murphyi*. However, there is still some evidence from the JMA 3 TCEPR fishery that its presence remains high in that Fishstock.

5. IMPLICATIONS FOR STOCK ASSESSMENT

The continued estimation of species proportions from the catch is fundamental for stock assessments of these species. Results from the JMA 1 market sampling continue a series begun in 1994, and provide data that can be used in apportioning the total catch as catch histories for the three species.

Similarly, the results from JMA 3 and 7 can be used to provide catch histories, although there are complexities requiring the splitting of total catch between purse-seine and trawl landings. Furthermore, targeting can switch between Fishstocks from year to year, even though the actual geographical distance between areas where targeting occurs may not be great. Proportions from the inshore trawl survey in these areas could be used to apportion catch from inshore trawl vessels.

MFish observer data suggest an almost exclusive predominance of *T. s. murphyi* in JMA 3, which simplifies the approach necessary for that area, assuming there are no major seasonal variations. JMA 7 is more complicated and it is unlikely that stock indices based on species proportions and catch data from only the large-vessel offshore trawling fleet can be indicative of the JMA 7 jack mackerel population. Although they are highly variable, species proportions for the small-vessel inshore trawling fleet in JMA 7 are necessary for a complete picture of what is happening. Targeting in the JMA 7 large-vessel offshore trawling fishery is complex and undergoes geographical changes through the season. Work under the Ministry of Fisheries projects MOF1999/04E and MOF1999/04F has provided a strategy to improve species proportion estimates from this fishery, and this needs to be implemented.

Recent work on age and growth of *T. s. murphyi* required annual catches to investigate year class strength, which provided a useful qualitative test of the ageing method developed during the study (Taylor et al. unpublished results). Reliable ageing methods are important for developing stock assessment and monitoring methods. Therefore, the success of this ageing work relied partly on species proportions data collected by the MOP in the JMA 7 TCEPR fishery since 1990.

6. DATA STORAGE

Data used in this report are from the MFish observer database (*obs_lfs*), the MFish market sampling database (*market*), and the MFish catch and effort database (*MOBY*). Data collected by industry and NIWA staff will be stored in the market database.

7. ACKNOWLEDGMENTS

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Appendix A: Estimating species composition (proportions of the 3 jack mackerels) of the total annual purse-seine catch of *Trachurus* species in JMA 1

Definitions

w_{kl} is the weight of a sample of species l in sampled landing k.

$W_{k.}$ is the weight of landing k.

W_{kl} is the weight of species l in landing k.

1. Step a: to estimate proportions of species *l* in the sampled landings (*k*)

The proportion of species *l* in sampled landing *k* was based on its weight in the sample

$$\hat{p}_{kl} = \frac{w_{kl}}{\sum_{l} w_{kl}}$$

2. Step b: to estimate proportions of *Trachurus* species in the annual landings

Proportions of species in the total annual catch were estimated as the total annual weight of the species in the sampled landings divided by the total annual weight of the sampled landings

$$\hat{P}_{l} = \frac{\sum_{k}^{K} \hat{p}_{kl} W_{k.}}{\sum_{k}^{K} W_{k.}}$$

where *K* is the number of sampled landings.

3. Estimating variance

The estimated within landing variance is defined as

$$\hat{\text{var}}(\hat{p}_{l}) = \frac{\sum_{k} \hat{\text{var}}(\hat{p}_{kl}) W_{k.}^{2}}{\left(\sum_{k} W_{k}\right)^{2}}$$

where *K* is all landings (sampled and unsampled) and

$$\hat{\text{var}}(\hat{p}_{kl}) = \frac{\hat{p}_{kl}(1 - \hat{p}_{kl})}{N}.$$

N is the total number of fish (of all three species) in the sample and is given by

$$\hat{N} = \sum_{l'} w_{kl'} \Big/ \hat{t}_{k.}$$

where $\hat{t}$ is the estimated mean fish weight.

The c.v. for species proportions over a given time frame was estimated as

$$c\hat{v} = \frac{\sqrt{\hat{\text{var}}(\hat{p}_{.I})}}{\hat{p}_{.I}}.$$

Appendix B: Estimating species proportions in the JMA 7 trawl fishery from MFish Observer data

Definitions

i, j, k denotes species, tows, and trips respectively

S'_k is the set of all tows in trip k, sampled and unsampled

S_k is the set of sampled tows in trip k

w_{ijk} is the weight of a sample of species i in sampled tow j during trip k

w_{jk} is the total weight of jack mackerel (all species combined) in tow j during trip k

w'_{jk} is the total weight of jack mackerel (all species combined) in sampled tow j during trip k

w''_{jk} is the total weight of jack mackerel (all species combined) in the sample from sampled tow j during trip k

Estimating species proportions

The estimated proportion of species i in sampled tow j in trip k is

$$\hat{p}_{ijk} = w_{ijk} / w''_{jk}$$

The estimated weight of species i in trip k, is obtained by scaling up the total weight of catch

$$\hat{W}'''_{ik} = \sum_{j \in S_k} w'_{jk} \hat{p}_{ijk} \cdot \frac{\sum_{j \in S'_k} w_{jk}}{\sum_{j \in S_k} w'_{jk}}$$

The estimated proportion of species i in the total catch is obtained by summing over all trips

$$\hat{P}_i = \frac{\sum_k \hat{W}'''_{ik}}{\sum_i \sum_{j \in S'_k} w_{jk}}.$$

Appendix C: Species composition of the midwater trawl jack mackerel catch

Table C1: Scaled species composition by fishing year and month of the catch of jack mackerels in the TCEPR fleet (vessels using Trawl Catch Effort Processing Returns) in JMA 3 and 7; JMD is *Trachurus declivis*, JMM is *T. symmetricus murphyi*, JMN is *T. novaezelandiae*, c.v.s are coefficients of variation, *N* is the number of sampled tows that contained a particular species (source: MFish Market sampling database, *market*, Talley's Ltd sampling data).

	Fishing		Species proportions			c.v.			N		
Fishstock	Year	Month	JMD	JMM	JMN	JMD	JMM	JMN	JMD	JMM	JMN
JMA 3	1985–86	September	0	1	0	NA	0	NA	0	1	0
	1986–87	January	1	0	0	0	NA	NA	1	0	0
		March	0.77	0	0.23	0.33	NA	1.02	3	0	1
		June	0.78	0	0.22	0.22	NA	0.62	3	0	3
	1987–88	January	0.19	0.79	0.02	0.95	0.72	0.75	2	1	1
	1988–89	February	0	1	0	NA	0	NA	0	1	0
	1989–90	November	0.3	0.7	0	0.24	0.12	NA	2	2	0
	1990–91	October	0	1	0	NA	0	NA	0	2	0
		February	0	1	0	NA	0	NA	0	1	0
		March	0	1	0	NA	0	NA	0	4	0
	1991–92	October	0.01	0.99	0	0.87	0.01	NA	2	6	0
		November	0	1	0	1.48	0.02	NA	1	2	0
		January	0	1	0	NA	0	NA	0	1	0
		February	0	1	0	NA	0	NA	0	2	0
		March	0	1	0	NA	0	NA	0	2	0
		April	0	1	0	NA	0	NA	0	1	0
	1992–93	January	1	0	0	0	NA	NA	1	0	0
		February	0	1	0	NA	0	NA	0	40	0
		March	0	1	0	NA	0	NA	1	26	0
		April	0.19	0.8	0	0.27	0.06	1.91	16	51	1
		May	0	1	0	NA	0	NA	0	2	0
	1993–94	November	0	1	0	NA	0	NA	0	2	0
		February	0	1	0	NA	0	NA	0	9	0
		March	0.84	0.16	0	0.78	0.95	NA	2	16	0
		April	0.74	0.26	0	0.46	0.85	NA	2	3	0
		May	0	1	0	10.48	0	NA	1	6	0
		June	0	1	0	NA	0	NA	0	2	0
	1994–95	February	0	1	0	NA	0	NA	0	7	0
		March	0	1	0	NA	0	NA	0	4	0
		April	0.07	0.93	0	1.01	0.09	NA	1	3	0
		May	0.04	0.96	0	0	0	NA	1	1	0
	1995–96	December	0.03	0.97	0	0.17	0.01	NA	7	8	0
		January	0.02	0.98	0	0.32	0.01	NA	17	22	0
		February	0	1	0	NA	0	NA	0	6	0
		March	0.01	0.99	0	0.62	0.01	NA	6	15	0
		April	0.01	0.99	0	0.35	0	NA	19	49	0
		May	0	1	0	NA	0	NA	0	2	0
	1996–97	January	0	1	0	NA	0	NA	0	1	0
		February	0	1	0	NA	0	NA	0	3	0
		March	0	1	0	NA	0	NA	0	4	0
		April	0	1	0	NA	0	NA	0	5	0

Table C1 — *Continued*

	Fishing		Species proportions			c.v.			N		
Fishstock	Year	Month	JMD	JMM	JMN	JMD	JMM	JMN	JMD	JMM	JMN
		May	0.01	0.99	0	0.77	0	NA	1	2	0
	1997–98	December	0.02	0.98	0	0.23	0	NA	10	15	0
		January	0.03	0.97	0	0.19	0.01	NA	16	20	0
JMA 3	1997–98	February	0	1	0	NA	0	NA	0	17	0
		March	0.01	0.99	0	0.71	0.01	NA	2	4	0
		April	0.04	0.96	0	0.37	0.02	NA	3	4	0
	1998–99	February	0.15	0.85	0	0.57	0.1	NA	4	14	0
		March	0.15	0.85	0	0.48	0.09	NA	16	17	0
		April	0.16	0.84	0	0.74	0.13	NA	9	17	0
	1999–2000	February	0.05	0.95	0	0.75	0.04	NA	3	6	0
		March	0.4	0.51	0.1	0.28	0.22	0.44	16	17	7
		April	1	0	0	0	NA	NA	1	0	0
		May	0	1	0	NA	0	NA	0	3	0
		June	0	1	0	NA	0	NA	0	1	0
	2000–01	October	1	0	0	0.75	1.5	NA	1	1	0
		January	0	1	0	NA	0	NA	0	1	0
		February	0	1	0	NA	0	NA	0	22	0
		March	0.21	0.79	0	0.38	0.11	NA	17	25	0
		April	0.35	0.65	0	0.36	0.18	NA	20	17	1
		May	0	1	0	NA	0	NA	0	5	0
		September	0	1	0	NA	0	NA	0	1	0
JMA 7	1985–86	September	0.68	0	0.32	0.02	NA	0.04	3	0	3
	1986–87	November	0.65	0	0.35	0.09	NA	0.16	49	0	48
		December	0.57	0	0.43	0.07	NA	0.09	92	0	84
		January	0.54	0	0.46	0.11	NA	0.13	32	0	27
		April	0.08	0	0.92	0	NA	0	1	0	1
		May	0.31	0	0.69	0.35	NA	0.17	12	0	10
	1987–88	November	0.99	0	0.01	0	NA	0	1	0	1
		January	0.52	0	0.48	0.35	NA	0.4	6	0	4
		February	0.92	0	0.08	0.24	NA	1.55	3	0	1
		March	0.32	0	0.68	0.66	NA	0.35	3	0	3
	1988–89	December	0.53	0	0.47	0.14	NA	0.16	18	0	15
		August	0.97	0.03	0	0.19	1.2	NA	3	2	0
		September	0.74	0.18	0.08	0.18	0.71	0.95	7	3	2
	1989–90	October	0.48	0.2	0.32	0.16	0.44	0.32	13	4	9
		November	0.47	0	0.52	0.12	1.44	0.11	66	7	47
		December	0.13	0	0.87	0.06	NA	0.01	2	0	2
		March	0.03	0	0.97	0.47	NA	0.02	5	0	16
		April	0.1	0	0.9	0.48	NA	0.05	5	0	13
		June	0.68	0	0.32	0	NA	0	1	0	1
	1990–91	December	0.67	0	0.33	0.37	NA	0.7	4	0	3
		February	0.57	0.01	0.43	0.23	1.03	0.31	9	2	6
		March	0.47	0	0.52	0.09	9.95	0.09	51	5	52
		April	0.3	0	0.7	0.12	NA	0.05	89	2	89
		May	0.28	0	0.71	0.15	12.88	0.06	18	1	18
		July	0.66	0.34	0	0.54	0.69	NA	3	3	0
		August	0.17	0.83	0	0.63	0.14	NA	3	6	0

Table C1 — *Continued*

Fishstock	Fishing year	Month	Species proportions JMD	JMM	JMN	c.v. JMD	JMM	JMN	N JMD	JMM	JMN
		September	0.48	0.39	0.13	0.23	0.29	0.73	13	9	4
	1991–92	October	0.48	0.02	0.5	0.34	0.84	0.31	3	1	3
		November	0.51	0.04	0.45	0.14	0.25	0.18	33	24	28
		December	0.4	0.04	0.56	0.18	0.44	0.16	16	8	16
JMA 7		March	0.33	0.02	0.65	0.25	1.04	0.13	17	1	23
		May	0.86	0.07	0.07	0.16	1.14	1.14	8	2	1
		July	0.15	0.7	0.15	0.69	0.45	0.75	6	6	6
		August	0	1	0	NA	0	NA	0	2	0
		September	0.48	0.52	0	0.43	0.49	NA	5	3	0
	1992–93	October	0.84	0.16	0	0.4	1.12	NA	2	2	0
		December	0.67	0.11	0.22	0.06	0.16	0.19	51	42	45
		January	0.61	0.14	0.25	0.05	0.09	0.14	58	56	52
		February	0.5	0.21	0.3	0.05	0.09	0.08	47	47	47
		March	0.68	0.05	0.28	0	0	0	1	1	1
		June	0	1	0	NA	0	NA	0	1	0
	1992–93	August	0	1	0	NA	0	NA	0	1	0
	1993–94	October	0.18	0.16	0.65	0.67	0.67	0.24	2	2	7
		November	0.64	0	0.36	0.13	NA	0.23	25	0	18
		December	0.69	0.05	0.27	0.18	1.02	0.44	11	1	5
		January	0.54	0.07	0.39	0.1	0.26	0.14	20	14	17
		February	0.32	0.26	0.42	0.11	0.2	0.13	24	24	24
		May	0.33	0.24	0.43	0.21	0.33	0.28	17	13	15
		July	0.08	0.92	0	0.32	0.03	NA	14	20	0
		August	0	1	0	NA	0	NA	0	4	0
		September	0.65	0.35	0	0.33	0.53	NA	4	3	0
	1994–95	December	0.32	0.36	0.33	0.13	0.22	0.22	18	16	13
		January	0.31	0.22	0.47	0.08	0.18	0.11	98	84	92
		March	0.29	0.5	0.21	0.11	0.11	0.17	23	26	24
		July	0.06	0.94	0	0	0	NA	1	1	0
	1995–96	February	0.39	0.22	0.39	0.06	0.26	0.14	27	17	25
		March	0.56	0.21	0.23	0.08	0.23	0.22	31	19	24
		June	0	1	0	NA	0	NA	0	1	0
		August	0.05	0.95	0	0.57	0.03	NA	3	4	0
	1996–97	December	0.66	0.07	0.27	0.14	0.31	0.3	8	8	8
		January	0.59	0.07	0.34	0.05	0.15	0.1	53	49	53
		February	0.64	0.06	0.3	0.07	0.24	0.15	36	31	35
		March	0.51	0.22	0.26	0.13	0.29	0.19	6	6	6
		June	0.53	0.47	0	0.23	0.25	NA	9	9	0
		July	0.09	0.91	0	0.61	0.04	NA	1	2	0
		August	0.1	0.9	0	0.35	0.04	NA	3	3	0
		September	0.08	0.92	0	0.31	0.03	NA	12	15	0
	1997–98	November	0.44	0.19	0.37	0.1	0.09	0.12	45	45	43
		December	0.38	0.12	0.5	0.09	0.15	0.09	40	36	40
		January	0.61	0.09	0.3	0.04	0.15	0.07	64	53	63
		February	0.52	0.04	0.44	0.09	0.27	0.09	18	13	18
		July	0.17	0.83	0	1.13	0.22	NA	1	5	0
	1998–99	December	0.44	0.15	0.41	0.13	0.18	0.16	13	13	13
		January	0.47	0.13	0.41	0.03	0.14	0.05	20	19	20

Table C1 — ***Continued***

Fishstock	Fishing year	Month	Species proportions			c.v.			N		
			JMD	JMM	JMN	JMD	JMM	JMN	JMD	JMM	JMN
		April	0.87	0	0.13	0.1	NA	0.65	11	0	5
		June	0.98	0.02	0	0.01	0.45	NA	48	17	0
		July	0.79	0.21	0	0.09	0.34	NA	23	15	0
		August	0	1	0	NA	0	NA	0	1	0
JMA7		September	0.41	0.26	0.33	0.2	0.69	0.46	7	3	3
	1999–2000	October	0.78	0.14	0.08	0.06	0.26	0.45	42	32	20
		November	0.56	0.13	0.31	0.15	0.2	0.34	10	10	11
		June	1	0	0	0	NA	NA	1	0	0
		July	0.27	0.73	0	0.48	0.31	NA	5	3	0
		August	0.52	0.48	0	0.48	0.5	NA	3	3	0
	2000–01	October	0.84	0.08	0.08	0.05	0.37	0.45	10	7	5
		November	0.71	0.21	0.08	0.03	0.11	0.32	28	27	23
		December	0.54	0.24	0.23	0.12	0.16	0.30	28	27	26
		April	0.65	0.03	0.32	0.05	0.2	0.1	2	2	2
		July	0.99	0	0	0.01	3.16	3.16	6	1	6
		August	1	0	0	0	NA	NA	1	NA	NA
		September	0.67	0.33	0	0.15	NA	NA	2	1	NA