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## EXECUTIVE SUMMARY

**Taylor, P.R; Julian, K.A. (2008). Species composition and seasonal variability in commercial catches of jack mackerel (*Trachurus declivis*, *T. murphyi*, and *T. novaezelandiae*) in JMA 1, 3, and 7 during 2004–05.**

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In JMA 1, species proportions were estimated for the purse-seine fishery from market sampling data collected during 2004–05 in Tauranga. The estimated proportions were 12% for *Trachurus declivis*, 7% for *T. murphyi*, and 81% for *T. novaezelandiae*. In JMA 3, species proportions were estimated from MFish observer data collected on TCEPR vessels (vessels recording catch information on Trawl Catch Effort and Processing Returns) during 2004–05 (24% for *T. declivis*, 76% for *T. murphyi*, and 0% for *T. novaezelandiae*.

In JMA 7, species proportions were estimated from MFish observer data for the TCEPR fleet in 2004–05 (49% for *T. declivis*, 7% for *T. murphyi*, and 44% for *T. novaezelandiae*). In previous years, MFish observer data supported the observation that *T. murphyi* exhibits a winter peak, *T. novaezelandiae* a summer peak, and *T. declivis* a peak somewhere between the two, although the number of tows containing jack mackerel, and consequently the sample size, has been quite low during June–August. In 1998–99, for the first year since 1990–91, *T. declivis* replaced *T. murphyi* as the predominant species during the July–August "season". This result was also evident in 2001–02, but was inconclusive during 2002–03 and 2003–04 when sampling was not extensive enough to provide sufficient data. Coverage was increased in 2004–05 and the predominance of *T. declivis* during July–September is evident.

This reappearance of *T. declivis* adds another piece of evidence indicating a change in the availability of *T. murphyi* in both the purse-seine and TCEPR fisheries. Although *T. murphyi* still appears to be the most abundant species in the JMA 3 TCEPR fishery, there has been a shift in the overall species composition since 1998–99, with annual and monthly proportions of *T. declivis* showing an increase and monthly proportions often being higher than for *T. murphyi*. One confounding factor here is the coincidental reduction in sample size in recent years, although this was reversed with increased observer coverage in 2004–05. Overall, there seems to be a reduction in abundance of *T. murphyi*, 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. Reliable age estimates are required for developing stock assessment and monitoring methods for these species.

# 1. INTRODUCTION

Commercial catches of jack mackerel are recorded as an aggregate of the three species (*Trachurus declivis*, *T. murphyi*, and *T. novaezelandiae*) under the general code JMA. 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 (Figure 1). Consequently, reliable estimates of proportions of the three *Trachurus* species from sources other than catch records are essential for assessment of their stocks individually. 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 at least back to when sampling began, which can in turn be used in age-structured models (Taylor 1999a) or to scale size or age structures from the various fisheries.

The time frame for data collection is fishing year (the 12 months between 1 October in any year and 30 September of the following year). A recent mitochondrial DNA study by Poulin et al. (2004) has shown that the lineages between *T. murphyi* and *T. symmetricus* separated about 250 000 years ago. Thus, the specific name *Trachurus symmetricus murphyi* has now been revised to *Trachurus murphyi*; the revised name is used in this report.

## 1.1 Overview

This report updates estimates of relative proportions of the three *Trachurus* species in the commercial catch summarised by Taylor (1999b, 2000, 2002b, 2004) and several other years that have not been published previously but are included here. The proportions are based on market sampling data in JMA 1, 3, and 7 (Figure 1), and MFish observer data in JMA 3 and 7. A timeseries 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 JMA2004/01, "Monitoring the species composition of the commercial catch of jack mackerel". Specific objectives were as follows, although the present work includes only the components for 2004–05.

1. To collect samples from fish processing sheds to determine the seasonality and species composition of the commercial catches of *T. declivis*, *T. murphyi*, and *T. novaezelandiae* in JMA 1 in the 2004/2005 fishing year and in the 2005/2006 fishing year.
2. To collect samples from fish processing sheds to determine the seasonality and species composition of the commercial catches of *T. declivis*, *T. murphyi*, and *T. novaezelandiae* in JMA 3 in the 2004/2005 fishing year and in the 2005/2006 fishing year.
3. To collect samples from fish processing sheds to determine the seasonality and species composition of the commercial catches of *T. declivis*, *T. murphyi*, and *T. novaezelandiae* in JMA 7 in the 2004/2005 fishing year and in the 2005/2006 fishing year.
4. To determine from the catch at sea, the seasonality and species composition of the commercial catches of *T. declivis*, *T. murphyi*, and *T. novaezelandiae* in JMA 3 in the 2004/2005 fishing year and in the 2005/2006 fishing year.
5. To determine from the catch at sea, the seasonality and species composition of the commercial catches of *T. declivis*, *T. murphyi*, and *T. novaezelandiae* in JMA 7 in the 2004/2005 fishing year and in the 2005/2006 fishing year.
6. To document relevant market variables for the JMA 1, 3 & 7 fisheries in the 2004/05 fishing year and in the 2005/2006 fishing year.

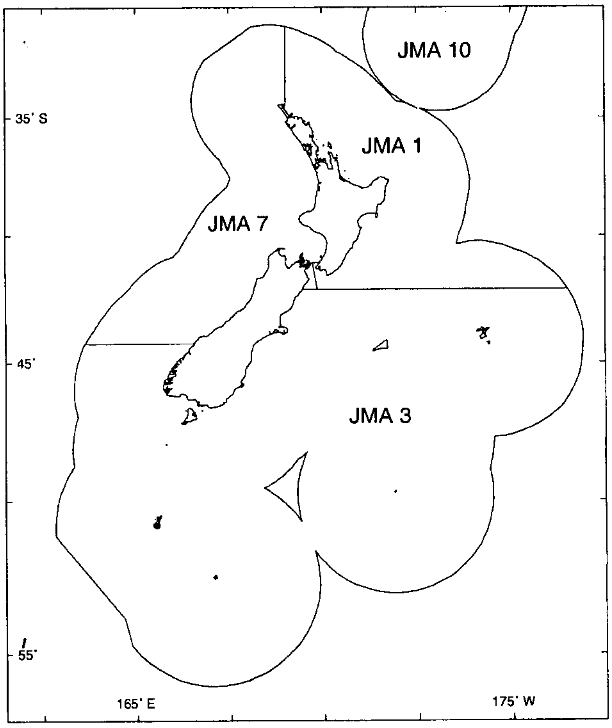


**Figure 1: Jack mackerel Fishstocks.**

The scope of this report goes beyond presenting only the results of work completed under project JMA2004/01. Summaries of results by Taylor (1999b, 2000, 2002b, 2004) are presented as well as estimates for 2001–02, 2002–03, and 2003–04, which were produced under MFish Projects JMA2001/01 and JMA200302 but have not been published previously. These are updated with the estimates for 2004–05, as defined in the objectives for JMA2004/01 (see above).

## 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. murphyi* occurs to depths of at least 500 m over a wide latitudinal range (e.g., from 0° to 50° S off South America) (Ministry of Fisheries, Science Group, 2006).

Until the mid 1980s, only *T. declivis* and *T. novaezelandiae* were known from New Zealand waters (Jones 1990). Murphy's mackerel, *T. murphyi*, was first described here by Kawahara et al. (1988), and has become abundant only since the late 1980s. It first appeared on the Chatham Rise and the south and east coasts of the South Island 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 its range within New Zealand waters seems reduced (Taylor 2004), but it is unknown whether this is only its presence at the surface or whether it reflects reduced abundance.

The total range of *T. murphyi* extends along the west coast of South America from the Galapagos Islands and Ecuador in the north to the southern coast of Chile, across the South Pacific, and through much of the New Zealand EEZ. It was reported from waters off southeast Australia in the late 1980s

(Pullen et al. 1989), and sightings in 2 003 have also been confirmed (Jeremy Lyle, Tasmanian Aquaculture & Fisheries Institute, University of Tasmania, pers. comm.). 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 the popular perception is that they are generally 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 (2002a) used existing data to investigate the stock structure of *T. murphyi* in the South Pacific Ocean and examine the degree to which it has become established in New Zealand waters. Taylor (2002b) updated species proportion estimates for 1999–2000; similar estimates for 2000–01, 2001–02, 2002–03, and 2003–04 have also been produced (see Taylor 2004) though not all have been published.

### 1.4 Previous sampling of jack mackerel fisheries

The purse-seine fishery for jack mackerel accounts for 95% of the total catch in JMA 1 (7000–8000 t in 1994–95 and 1995–96) and for a relatively small fishery in JMA 3 and 7 between Kaikoura and the Marlborough Sounds. Most of the purse-seine catch in both areas is taken and processed by Sanford Ltd at their factory in Tauranga, with a smaller component processed in Nelson until November 2002 when the Sanford factory there closed. A smaller proportion of the JMA 1 catch is landed by Pelco Ltd in Tauranga, although the amount of catch landed into the Pelco Ltd factory has increased since 1997–98. Mostly, Pelco Ltd have targeted small fish, whereas Sanford's landings have varied between small and large fish.

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 working collaboratively with Sanford Ltd to reduce the costs of market sampling by using species-composition data collected by Sanford's staff as part of the monitoring programme initiated in 1994–95 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 7, jack mackerel are taken by large, deepwater TCEPR trawlers and small, inshore trawlers recording their landings on Catch, Effort and Landing Return (CELR) forms. In both Fishstocks, large factory trawlers take catch which is processed and packed at sea and thus not available for sampling on shore. The CELR inshore trawl fleet land unprocessed catch at Talley's Ltd, Motueka. Sampling from these landings began in 2000–01, but was not carried out after December during 2001 until being resumed in 2003–04.

Catches in the TCEPR fleet have been sampled regularly since the mid 1980s by observers for data on species composition, although inadequacies in the sampling have been identified (Taylor 1999a) and improvements suggested by Taylor & Richardson (2001a, 2001b). Reductions in observer coverage led to decreased sampling between 2002–03 and 2003–04, but increased coverage in 2004–05 returned sampling to earlier levels. 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

Market sampling data were collected from Sanford Ltd (Tauranga) (JMA 1), Pelco Ltd (Tauranga) (JMA 1), and Talley's Ltd (Nelson & Motueka) (JMA 7). Sampling in 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 Talley's.

**Sanford (Tauranga).** During previous years data have been collected by grade, which simplifies the sampling approach and provides more reliable species proportion estimates (Taylor 1999b). During 2003 an automatic grader was installed which had the potential to cause bias in the sample data. To avoid this possibility until the issue could be examined, sampling for the present analysis was of ungraded fish. Consequently, the fine scale approach afforded by grade samples was not possible during the present analysis. Instead a sample of about 700 kg was 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. All landings of jack mackerel from four vessels were sampled and data from all landings were used in the analysis, which resulted in a between-landing variance of zero. The data have been provided as estimated proportions. During 2006, early estimates for 1994–95 to 1996–97 were discovered and have been included here.

**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. Summaries published in earlier reports have not included data from Pelco because tonnage totals of the landed catch, which are necessary for correctly weighting sample data in the estimation procedure, were not available. Pelco provided access to these data during 2006–07 and summaries for JMA 1 have been updated to include them. Consequently, proportions presented here differ from previous years.

**Talley's Ltd, Motueka.** Individual landings of jack mackerel at Talley's were not large. The 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 feature of the approach was the aim to maintain a sampling frequency of about 1–2 per week, when possible, to capture any seasonal changes that may occur. During 2004–05, there were 382 landings containing jack mackerel from JMA 7 by 38 vessels, and 105 landings from JMA 3 by 7 vessels; 42 landings by 19 vessels from JMA 7 were sampled.

**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 Pelco), the method was modified and proportions scaled 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. Where all landings were sampled, i.e., 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. The following approximate mean weights were assigned to each of the species for estimations of number of fish: 0.85 kg for *T. declivis*, 1 kg for *T. murphyi*, and 0.45 kg for *T. novaezelandiae*.

In all other cases only a subset of landings was sampled. Variance in 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

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

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

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

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

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

## 2.2 Species composition and seasonality in JMA 3 and 7 using observer data

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

1. Species composition and total catch by tow and trip for 2004–05 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. Species estimates were summed for all landings, and proportions of the species in the catch were estimated based on the two time frames, fishing year and 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.

# 3. RESULTS

## 3.1 Species composition and seasonality during 2004–05

### 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). For 2004–05 the main period of catch was between June and September. As with previous years, no seasonal pattern of species composition was evident. The proportion of *T. novaezelandiae* has dominated throughout the time series since sampling began, although this was interspersed with occasional high proportions of *T. murphyi* until March 2000, after which catches of the latter species became a rare event (Table 1).

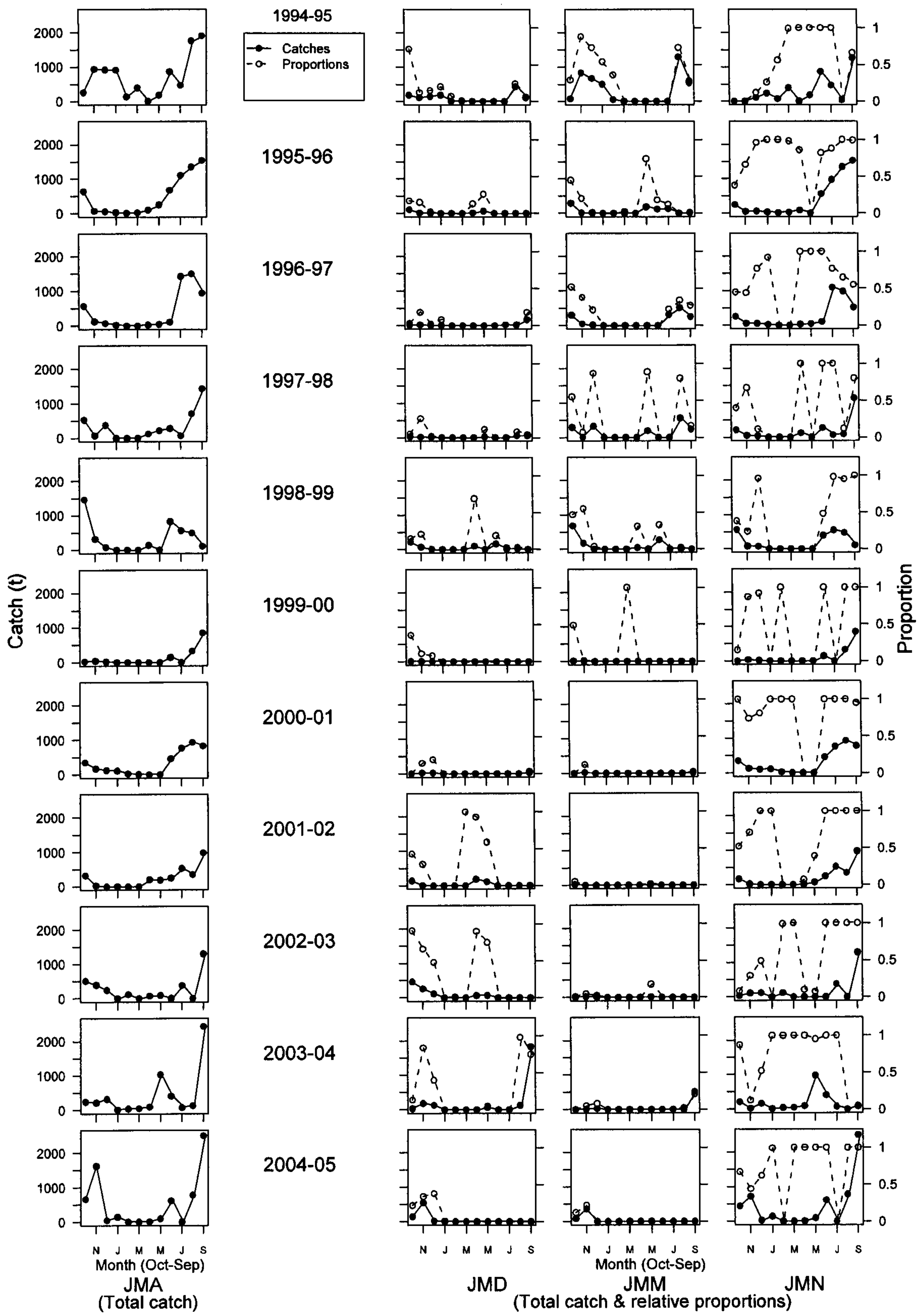


**Figure 2: Time series of catch and species proportions in the JMA 1 purse-seine fishery between October 1994 and September 2005; JMA is the total jack mackerel catch, JMD is *T. declivis*, JMM is *T. murphyi*, and JMN is *T. novaezelandiae*; individual species catches were generated as scaled portions of the sampled catch using estimated species proportions (source MFish *market* database).**

Because of the closure of Sanford's Nelson shed and poor information on area of catch, there have been no data to extend estimates for the southern area beyond 2000–01 (Table 1). In earlier years, the relative proportion of *T. murphyi* was consistently higher in JMAs 3 and 7 than in JMA 1 and proportions of *T. novaezelandiae* in the northern catch were much higher than in the south. In JMA 1, the proportion of *T. declivis* increased from about 0.18 in 2001–02 to 0.54 in 2003–04, but decreased in 2004–05 to 0.12.

**Table 1: Species composition of purse-seine catch of jack mackerel; North is Sanfords (Tauranga), South is Sanfords (Nelson); JMD is *Trachurus declivis*, JMM is *T. murphyi*, JMN is *T. novaezelandiae* (source: Sanford Ltd sampling data).**

| | | | No of | % of | | | |
|---|---|---|---|---|---|---|---|
| | | Fishing | landings | landings | Species proportions | | |
| Shed | Fishstock | year | sampled | sampled | JMD | JMM | JMN |
| North | JMA 1 | 1994–95 | 81 | 100 | 0.13 | 0.45 | 0.42 |
| | | 1995–96 | 73 | 100 | 0.03 | 0.13 | 0.84 |
| | | 1996–97 | 79 | 100 | 0.05 | 0.30 | 0.65 |
| | | 1997–98 | 44 | 25 | 0.05 | 0.42 | 0.53 |
| | | 1998–99 | 49 | 100 | 0.14 | 0.30 | 0.56 |
| | | 1999–00 | 42 | 100 | 0.01 | 0.01 | 0.98 |
| | | 2000–01 | 74 | 100 | 0.02 | 0.01 | 0.97 |
| | | 2001–02 | 53 | 100 | 0.18 | 0.01 | 0.81 |
| | | 2002–03 | 59 | 100 | 0.25 | 0.02 | 0.73 |
| | | 2003–04 | 63 | 100 | 0.54 | 0.09 | 0.46 |
| | | 2004-05 | 63 | 100 | 0.12 | 0.07 | 0.81 |
| South‡ | JMA 1† | 1999–00 | 1 | 100 | 0.92 | 0.07 | 0.01 |
| | | 2000–01 | 3 | 100 | 0.62 | 0.09 | 0.29 |
| | JMA 3 | 1997–98 | 1 | 100 | 0.29 | 0.69 | 0.02 |
| | | 1999–00 | 4 | 100 | 0.23 | 0.77 | 0.00 |
| | JMA 7 | 1998–99 | 9 | 100 | 0.51 | 0.49 | <0.01 |
| | | 1999–00 | 1* | 100 | 0.34 | 0.66 | 0.00 |
| | | 2000–01 | 5 | 100 | 0.23 | 0.76 | 0.1 |

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

†Wairarapa coast

‡Sanfords (Nelson) closed in November 2002; data collected during 2001–02 were from landings taken in an unspecified part of JMA 1 or mixed landings taken in JMA 1 and JMA 7; none were used in the analysis.

### 3.1.2 Species composition in the inshore trawl catch (JMA 7)

Bycatch of jack mackerels in the JMA 7 inshore trawl fishery is continuous throughout the year (Table 2 & Figure 3), although a declining trend is evident in all years for the total monthly catches in this fishery. Estimates of species proportions using market sampling data from October 1999 to September 2005 are summarised in Table 2 and presented, along with catches of the three species as time series plots, in Figure 3. No sampling data were available for 2002–03. 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. In 2003–04, *T. novaezelandiae* was often the most highly represented of the three species in the fishery, but for 2004–05 this was true for late in the year. Earlier in 2004–05, *T. declivis* was usually the predominant species in the catch. The apparent breaks in catch of jack mackerel from this fishery reflect periods of sampling/no sampling.

**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. murphyi*, JMN is *T. novaezelandiae*, *N* is the number of landings sampled, c.v.s are coefficients of variation (source: MFish Market sampling database, *market*, Talley's 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 | 0.17 | 0.14 | 0.01 |
| | September | *2* | 0.26 | 0.00 | 0.74 | 0.02 | 0.50 | 0.01 |
| | Overall | 4 | 0.17 | 0.02 | 0.81 | 0.02 | 0.14 | 0.01 |
| 1999–2000 | November | 5 | 0.31 | 0.40 | 0.30 | 0.30 | 0.02 | 0.02 |
| | December | 2 | 0.25 | 0.60 | 0.15 | 0.08 | 0.03 | 0.04 |
| | January | 3 | 0.33 | 0.23 | 0.44 | 0.04 | 0.06 | 0.03 |
| | February | 3 | 0.20 | 0.05 | 0.76 | 0.07 | 0.13 | 0.02 |
| | March | 3 | 0.12 | 0.03 | 0.85 | 0.06 | 0.13 | 0.01 |
| | Overall | 16 | 0.28 | 0.33 | 0.39 | 0.02 | 0.02 | 0.01 |
| 2000–01 | November | 6 | 0.38 | 0.57 | 0.05 | 0.03 | 0.02 | 0.02 |
| | December | 2 | 0.62 | 0.37 | 0.01 | 0.03 | 0.05 | 0.39 |
| | February | 1 | 0.35 | 0.65 | 0.00 | 0.05 | 0.03 | 0.00 |
| | May | 5 | 0.60 | 0.13 | 0.27 | 0.03 | 0.07 | 0.06 |
| | June | 2 | 0.67 | 0.33 | 0.00 | 0.02 | 0.04 | 0.00 |
| | July | 6 | 0.59 | 0.15 | 0.25 | 0.01 | 0.05 | 0.03 |
| | August | 2 | 0.16 | 0.08 | 0.76 | 0.19 | 0.32 | 0.05 |
| | September | 3 | 0.29 | 0.21 | 0.50 | 0.04 | 0.04 | 0.02 |
| | Overall | 27 | 0.48 | 0.40 | 0.12 | 0.01 | 0.02 | 0.02 |
| 2001-02 | October | 10 | 0.47 | 0.22 | 0.31 | 0.01 | 0.03 | 0.02 |
| | November | 7 | 0.32 | 0.42 | 0.27 | 0.02 | 0.02 | 0.02 |
| | December | 5 | 0.38 | 0.38 | 0.23 | 0.03 | 0.03 | 0.02 |
| | Overall | 22 | 0.40 | 0.33 | 0.28 | 0.01 | 0.01 | 0.01 |
| 2003–04 | October | 2 | 0.39 | 0.05 | 0.57 | 0.03 | 0.13 | 0.02 |
| | November | 8 | 0.37 | 0.29 | 0.34 | 0.04 | 0.04 | 0.02 |
| | December | 6 | 0.25 | 0.27 | 0.48 | 0.04 | 0.04 | 0.01 |
| | January | 5 | 0.23 | 0.12 | 0.65 | 0.04 | 0.06 | 0.01 |
| | February | 7 | 0.41 | 0.34 | 0.25 | 0.03 | 0.03 | 0.02 |
| | March | 9 | 0.56 | 0.27 | 0.17 | 0.02 | 0.05 | 0.02 |
| | April | 3 | 0.15 | 0.01 | 0.84 | 0.05 | 0.28 | 0.01 |
| | May | 3 | 0.51 | 0.15 | 0.34 | 0.03 | 0.11 | 0.02 |
| | June | 7 | 0.24 | 0.02 | 0.74 | 0.03 | 0.08 | 0.02 |
| | July | 5 | 0.38 | 0.07 | 0.54 | 0.03 | 0.10 | 0.02 |
| | August | 1 | 0.69 | 0.31 | 0.00 | 0.03 | 0.07 | 0.00 |
| | September | 7 | 0.26 | 0.22 | 0.52 | 0.07 | 0.11 | 0.05 |
| | Overall | 61 | 0.35 | 0.22 | 0.43 | 0.02 | 0.04 | 0.01 |
| 2004–05 | October | 2 | 0.82 | 0.02 | 0.17 | 0.02 | 0.37 | 0.07 |
| | December | 4 | 0.75 | 0.12 | 0.13 | 0.02 | 0.09 | 0.04 |
| | January | 1 | 0.13 | 0.87 | 0.00 | 0.17 | 0.02 | 0.00 |
| | February | 1 | 0.69 | 0.31 | 0.00 | 0.05 | 0.10 | 0.00 |
| | March | 5 | 0.55 | 0.08 | 0.37 | 0.03 | 0.09 | 0.05 |
| | April | 2 | 0.70 | 0.30 | 0.00 | 0.04 | 0.09 | 0.00 |
| | May | 4 | 0.62 | 0.36 | 0.01 | 0.04 | 0.06 | 0.01 |
| | June | 8 | 0.69 | 0.26 | 0.04 | 0.02 | 0.04 | 0.02 |
| | July | 2 | 0.03 | 0.00 | 0.96 | 0.13 | 0.38 | 0.00 |
| | August | 1 | 0.23 | 0.04 | 0.73 | 0.11 | 0.31 | 0.04 |
| | September | 7 | 0.22 | 0.14 | 0.64 | 0.04 | 0.04 | 0.01 |
| | Overall | 37 | 0.49 | 0.23 | 0.28 | 0.03 | 0.05 | 0.02 |

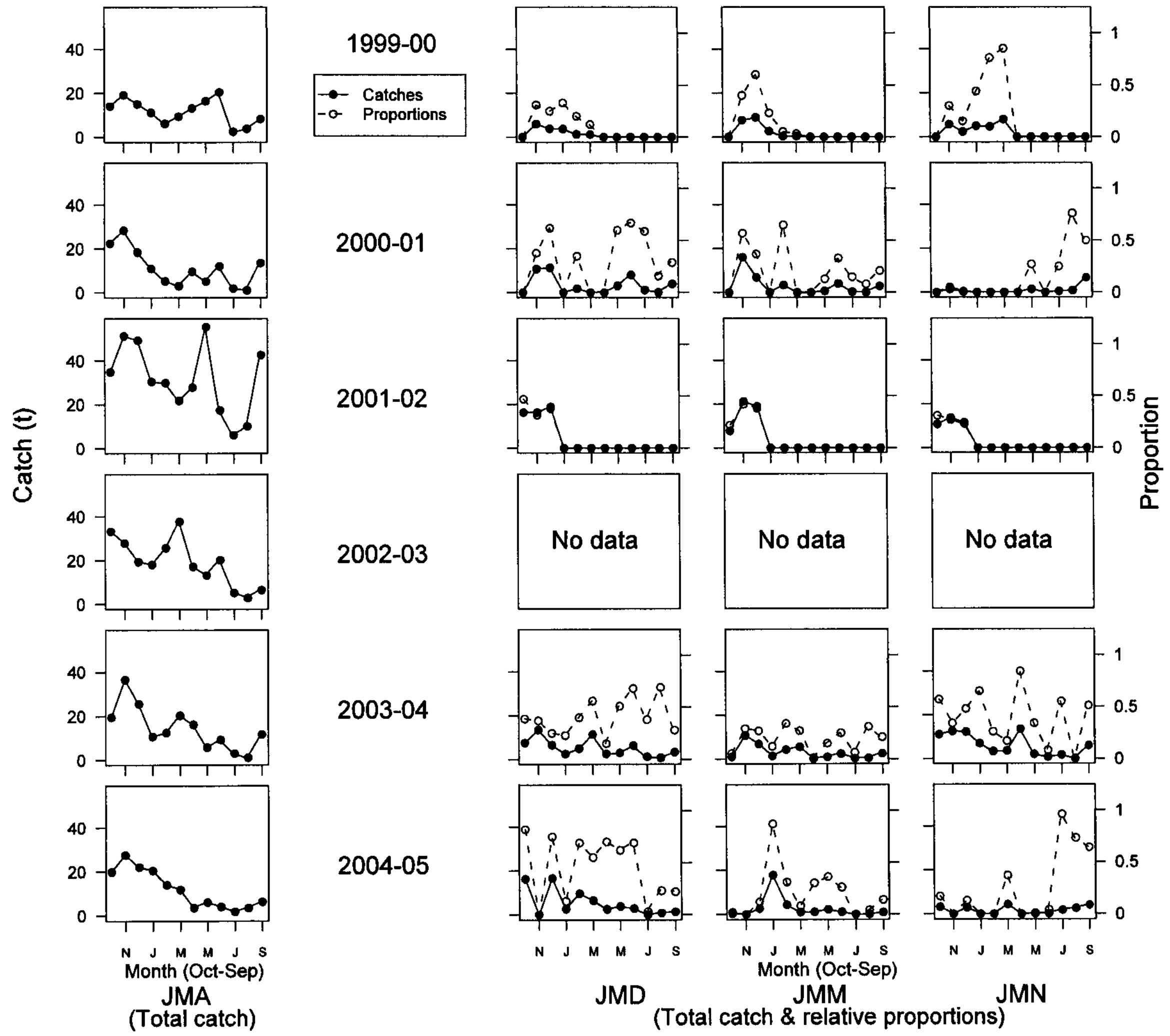


**Figure 3: Time series of catch and species proportions and catch of the three jack mackerel species in the JMA 7 inshore trawl catch (vessels using Catch Effort Landing Returns — CELR) between October 1999 and September 2005; JMA is the total jack mackerel catch, JMD is *T. declivis*, JMM is *T. murphyi*, and JMN is *T. novaezelandiae*; individual species catches were generated as scaled portions of the sampled catch using estimated species proportions; sampling data were unavailable as follows — October & April–September in 1999–00, October, January, March, April in 2000–01, January–September in 2001–02, all months in 2002–03, November in 2004–05 (source MFish *market* database).**

### 3.1.3 Observer data (JMA 3 and 7)

The annual TCEPR catch in JMA 3 was dominated by *T. murphyi* in all years since 1987–88 except 2002–03, when its proportion declined to 0.32, less than half its previous lowest value (Table 3) although few tows were sampled before 1992–93. The apparent increase to 0.81 in 2003–04 suggests a return to previous levels, but it is estimated from only 7 samples (tows). In 1999–2000 *T. novaezelandiae* reappeared for the first time since 1987–88, but has been absent from samples since. Coefficients of variation on the species proportions often met the target value of 5% or less for *T. murphyi*, although there were several instances where the variance was too high to be acceptable.

**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. murphyi*, JMN is *T. novaezelandiae*, *N* is the number of sampled tows that contained a particular species (source: MFish Market sampling database, *market*).**

| | Fishing | Species proportions | | | c.v. | | | *N* | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fishstock | year | JMD | JMM | JMN | JMD | JMM | JMN | JMD | JMM | JMN |
| JMA 3 | 1985–86 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 1986–87 | 0.78 | 0 | 0.22 | 0.17 | 0 | 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 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 1989–90 | 0.3 | 0.7 | 0 | 0.24 | 0.12 | 0 | 2 | 2 | 0 |
| | 1990–91 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 7 | 0 |
| | 1991–92 | 0 | 1 | 0 | 2.11 | 0 | 0 | 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 | 0 | 5 | 38 | 0 |
| | 1994–95 | 0.04 | 0.96 | 0 | 0.83 | 0.04 | 0 | 2 | 15 | 0 |
| | 1995–96 | 0.02 | 0.98 | 0 | 0.27 | 0 | 0 | 49 | 102 | 0 |
| | 1996–97 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 15 | 0 |
| | 1997–98 | 0.02 | 0.98 | 0 | 0.17 | 0 | 0 | 31 | 60 | 0 |
| | 1998–99 | 0.15 | 0.85 | 0 | 0.33 | 0.06 | 0 | 29 | 48 | 0 |
| | 1999–00 | 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 | 0 | 38 | 73 | 1 |
| | 2001–02 | 0.33 | 0.66 | *0.00 | 0.25 | 0.14 | 1.57 | 48 | 70 | 1 |
| | 2002–03 | 0.68 | 0.32 | 0 | 0.37 | 0.59 | 0 | 6 | 16 | 0 |
| | 2003–04 | 0.03 | 0.97 | 0 | 1.64 | 0.11 | 0 | 1 | 7 | 0 |
| | 2004–05 | 0.24 | 0.76 | 0 | 0.86 | 0.27 | 0 | 2 | 27 | 0 |
| JMA 7 | 1985–86 | 0.68 | 0 | 0.32 | 0.02 | 0 | 0.04 | 3 | 0 | 3 |
| | 1986–87 | 0.58 | 0 | 0.42 | 0.05 | 0 | 0.07 | 186 | 0 | 170 |
| | 1987–88 | 0.58 | 0 | 0.42 | 0.25 | 0 | 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 | 0.37 | 0.35 | 0.28 | 0.08 | 0.11 | 0.11 | 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 |
| | 1999–00 | 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 |
| | 2001–02 | 0.64 | 0.05 | 0.32 | 0.07 | 0.37 | 0.14 | 67 | 23 | 42 |
| | 2002–03 | 0.62 | 0.06 | 0.32 | 0.08 | 0.17 | 0.17 | 102 | 67 | 74 |
| | 2003–04 | 0.73 | 0.06 | 0.21 | 0.04 | 0.17 | 0.15 | 60 | 46 | 42 |
| | 2004–05 | 0.49 | 0.07 | 0.44 | 0.05 | 0.13 | 0.06 | 273 | 176 | 223 |

**T. novaezelandiae* appeared in 1 tow in each of these years, but at very low levels.

In JMA 7 the pattern has been 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. murphyi* was highest only in 1995–96. Between 1996–97 and 2000–

01 its proportion varied between 0.12 and 0.19, but in 2001–02 it fell markedly to 0.05 where it has remained. This most recent level is similar to that estimated for its early years of the invasion of New Zealand waters. The proportion of *T. novaezelandiae* in JMA 7 was highest in 1989–90 and 1990–91. In contrast to *T. murphyi*, the proportion of *T. novaezelandiae* rose to 0.32 in 2001–02 and 2002–03, decreased slightly to 0.21 in 2003–03, and rose to 0.44 in 2004–05. 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. murphyi* in the monthly catch from JMA 3 has been striking, although there have been recent instances during 2001–02 and 2002–03 when *T. declivis* was the major component, an event that had been absent since 1993–94. By contrast, *T. novaezelandiae* has been almost nonexistent in the time series, reappearing in seven tows during 1999–2000 and two single tows in 2000–01 and 2001–02, after being absent since 1987–88.

In JMA 7 the pattern of high proportions of *T. murphyi* has been seasonal, occurring regularly around July–August from 1990–91. However, this pattern was absent for the first time in 2000–01, with *T. murphyi* present in very few tows. Observer coverage was low in 2002–03 and 2003–04, resulting in reduced sampling and unreliable estimates, but in 2004–05 increased sampling provided estimates showing a very low rate of representation of *T. murphyi* from the fishery, and a switching predominance between the other two species. High proportions of *T. novaezelandiae* in April–June probably reflect increased fishing north of the North Taranaki Bight. For both *T. declivis* and *T. novaezelandiae,* species proportions are highly variable, with neither showing a clear seasonal pattern. In 2000–01, *T. declivis* dominated the catch and this continued throughout most of 2001–02, 2002–03, and 2003–04, except in April–May 2002–03 when *T. novaezelandiae* represented the highest proportion. Coefficients of variation 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.

## 4. DISCUSSION

Recently, two changes in the proportions of jack mackerels in commercial catches have been identified by Taylor (2002b, 2004, unpublished data). In JMA 1, the proportion of *T. novaezelandiae* increased steadily to represent about 98% of the catch in 1999–2000 and 2000–01, declined to 46% by 2003–04, and returned to higher levels in 2004–05 (81%). 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. murphyi* has been the dominant carangid species in a number of areas at certain times. Its predominance in JMA 3 has been discussed by Taylor (2000, 2004) 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. murphyi*) in industry packing data have provided evidence that this reduced availability has also applied to the midwater TCEPR trawl fishery between 1997 and 1999 (Taylor 2002b).

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. murphyi* during the July–August "season". In 2000–01 however, this feature was absent and, perhaps most significantly, it remained absent during 2001–02. No sampling occurred during these months in 2002–03 and 2003–04, but sampling from 2004–05 showed almost total absence of the species during this most recent year. Estimates from the JMA 3 TCEPR fishery suggest that the presence of *T. murphyi* remains high although there was some indication of a possible change, with proportions of *T. declivis* higher than those of *T. murphyi* in March 2001–02 and April 2002–03. This may have, however, been the result of a change in the distribution of *T. declivis* rather than a reduction in the abundance of *T. murphyi*. The predominance of *T. murphyi* was again evident during 2004–05.

## 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 physical distance between areas where targeting occurs may not be great. Proportions from the inshore trawl surveys in these areas could be used to apportion catch from inshore trawl vessels.

MFish observer data suggest a change in the almost exclusive predominance of *T. murphyi* in JMA 3. Although this species still appears to be the most abundant jack mackerel in the JMA 3 TCEPR fishery, there has been a shift in the overall species composition since 1998–99, with annual and monthly proportions of *T. declivis* showing an increase and monthly proportions sometimes being higher than *T. murphyi*. However, this was not evident during 2004–05.

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 species proportions for the small-vessel inshore trawling fleet in JMA 7 are highly variable (Taylor 2004) they are necessary for a complete picture of what is happening. Targeting in the JMA 7 large-vessel offshore trawl fishery is complex and undergoes geographical changes through the season. Work under MFish projects MOF1999/04E and MOF1999/04F has provided a strategy to improve species proportion estimates from this fishery. Increased observer coverage during 2004–05 is a first step in implementing this strategy. Results from a Bayesian analysis of the species proportions will provide useful insights into the geographical distribution of the sampling data.

Unpublished work on age and growth of *T. murphyi* under JMA1999/02 required annual catch estimates to investigate year class strength, which provided a qualitative test of the ageing method developed during the study. Reliable ageing methods are important for stock assessment and monitoring methods. Success of this ageing work relied partly on species proportions data collected by MFish observers in the JMA 7 TCEPR fishery since 1990. Current work under JMA2005/01 aims to validate the ageing method using marginal state analysis and bomb radiocarbon techniques.

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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

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

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

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

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

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

### Definitions

$i, j, k$ denote 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. 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, catch & effort database, MOBY).**

| | 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 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 1986–87 | January | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | | March | 0.77 | 0 | 0.23 | 0.33 | 0 | 1.02 | 3 | 0 | 1 |
| | | June | 0.78 | 0 | 0.22 | 0.22 | 0 | 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 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 1989–90 | November | 0.3 | 0.7 | 0 | 0.24 | 0.12 | 0 | 2 | 2 | 0 |
| | 1990–91 | October | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| | | February | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | | March | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| | 1991–92 | October | 0.01 | 0.99 | 0 | 0.87 | 0.01 | 0 | 2 | 6 | 0 |
| | | November | 0 | 1 | 0 | 1.48 | 0.02 | 0 | 1 | 2 | 0 |
| | | January | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | | February | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| | | March | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| | | April | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 1992–93 | January | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | | February | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 40 | 0 |
| | | March | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 26 | 0 |
| | | April | 0.19 | 0.8 | 0 | 0.27 | 0.06 | 1.91 | 16 | 51 | 1 |
| | | May | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| | 1993–94 | November | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| | | February | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 9 | 0 |
| | | March | 0.84 | 0.16 | 0 | 0.78 | 0.95 | 0 | 2 | 16 | 0 |
| | | April | 0.74 | 0.26 | 0 | 0.46 | 0.85 | 0 | 2 | 3 | 0 |
| | | May | 0 | 1 | 0 | 10.48 | 0 | 0 | 1 | 6 | 0 |
| | | June | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| | 1994–95 | February | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 7 | 0 |
| | | March | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| | | April | 0.07 | 0.93 | 0 | 1.01 | 0.09 | 0 | 1 | 3 | 0 |
| | | May | 0.04 | 0.96 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| | 1995–96 | December | 0.03 | 0.97 | 0 | 0.17 | 0.01 | 0 | 7 | 8 | 0 |
| | | January | 0.02 | 0.98 | 0 | 0.32 | 0.01 | 0 | 17 | 22 | 0 |
| | | February | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 6 | 0 |
| | | March | 0.01 | 0.99 | 0 | 0.62 | 0.01 | 0 | 6 | 15 | 0 |
| | | April | 0.01 | 0.99 | 0 | 0.35 | 0 | 0 | 19 | 49 | 0 |
| | | May | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| | 1996–97 | January | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | | February | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| | | March | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| | | April | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 5 | 0 |

**Table C1 — *Continued***

| Fishstock | Fishing Year | Month | Species proportions JMD | JMM | JMN | c.v. JMD | JMM | JMN | *N* JMD | JMM | JMN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JMA 3 | | 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 |
| | 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 |
| | 1999–00 | 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 |
| | 2001–02 | October | 0.42 | 0.58 | 0 | 0.62 | 0.26 | 0 | 4 | 8 | 0 |
| | | February | 0.32 | 0.65 | 0.04 | 0.22 | 0.1 | 0.99 | 18 | 25 | 1 |
| | | March | 0.53 | 0.47 | 0 | 0.18 | 0.19 | 0 | 20 | 20 | 0 |
| | | April | 0.25 | 0.75 | 0 | 0.6 | 0.22 | 0 | 6 | 15 | 0 |
| | | May | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| | 2002–03 | December | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | | January | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| | | February | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| | | March | 0.03 | 0.97 | 0 | 1.11 | 0.07 | 0 | 2 | 5 | 0 |
| | | April | 0.86 | 0.14 | 0 | 0.11 | 0.49 | 0 | 4 | 3 | 0 |
| | | September | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 2003–04 | February | 0.19 | 0.81 | 0 | 0.98 | 0.20 | 0 | 1 | 5 | 0 |
| | 2004–05 | February | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 9 | 0 |
| | | March | 0.49 | 0.51 | 0 | 0 | 0 | 0 | 2 | 10 | 0 |
| | | April | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 7 | 0 |
| | | May | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| JMA 7 | 1985–86 | September | 0.68 | 0 | 0.32 | 0.02 | 0 | 0.04 | 3 | 0 | 3 |
| | 1986–87 | November | 0.65 | 0 | 0.35 | 0.09 | 0 | 0.16 | 49 | 0 | 48 |
| | | December | 0.57 | 0 | 0.43 | 0.07 | 0 | 0.09 | 92 | 0 | 84 |
| | | January | 0.54 | 0 | 0.46 | 0.11 | 0 | 0.13 | 32 | 0 | 27 |
| | | April | 0.08 | 0 | 0.92 | 0 | 0 | 0 | 1 | 0 | 1 |
| | | May | 0.31 | 0 | 0.69 | 0.35 | 0 | 0.17 | 12 | 0 | 10 |
| | 1987–88 | November | 0.99 | 0 | 0.01 | 0 | 0 | 0 | 1 | 0 | 1 |
| | | January | 0.52 | 0 | 0.48 | 0.35 | 0 | 0.4 | 6 | 0 | 4 |
| | | February | 0.92 | 0 | 0.08 | 0.24 | 0 | 1.55 | 3 | 0 | 1 |
| | | March | 0.32 | 0 | 0.68 | 0.66 | 0 | 0.35 | 3 | 0 | 3 |
| | 1988–89 | December | 0.53 | 0 | 0.47 | 0.14 | 0 | 0.16 | 18 | 0 | 15 |

**Table C1 — *Continued***

| | Fishing | | Species proportions | | | c.v. | | | *N* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fishstock | year | Month | JMD | JMM | JMN | JMD | JMM | JMN | JMD | JMM | JMN |
| JMA7 | | August | 0.97 | 0.03 | 0 | 0.19 | 1.2 | 0 | 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 |
| JMA 7 | | December | 0.13 | 0 | 0.87 | 0.06 | 0 | 0.01 | 2 | 0 | 2 |
| | | March | 0.03 | 0 | 0.97 | 0.47 | 0 | 0.02 | 5 | 0 | 16 |
| | | April | 0.1 | 0 | 0.9 | 0.48 | 0 | 0.05 | 5 | 0 | 13 |
| | | June | 0.68 | 0 | 0.32 | 0 | 0 | 0 | 1 | 0 | 1 |
| | 1990–91 | December | 0.67 | 0 | 0.33 | 0.37 | 0 | 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 | 0 | 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 | 0 | 3 | 3 | 0 |
| | | August | 0.17 | 0.83 | 0 | 0.63 | 0.14 | 0 | 3 | 6 | 0 |
| | | 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 |
| | | 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 | 0 | 0 | 0 | 0 | 2 | 0 |
| | | September | 0.48 | 0.52 | 0 | 0.43 | 0.49 | 0 | 5 | 3 | 0 |
| | 1992–93 | October | 0.84 | 0.16 | 0 | 0.4 | 1.12 | 0 | 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 | 0 | 0 | 0 | 0 | 1 | 0 |
| | | August | 0 | 1 | 0 | 0 | 0 | 0 | 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 | 0 | 14 | 20 | 0 |
| | | August | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| | | September | 0.65 | 0.35 | 0 | 0.33 | 0.53 | 0 | 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 | 0 | 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 | 0 | 0 | 0 | 0 | 1 | 0 |
| | | August | 0.05 | 0.95 | 0 | 0.57 | 0.03 | 0 | 3 | 4 | 0 |

**Table C1** — ***Continued***

| Fishstock | Fishing year | Month | Species proportions JMD | JMM | JMN | c.v. JMD | JMM | JMN | *N* JMD | JMM | JMN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JMA7 | 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 | 0 | 9 | 9 | 0 |
| | | July | 0.09 | 0.91 | 0 | 0.61 | 0.04 | 0 | 1 | 2 | 0 |
| | | August | 0.1 | 0.9 | 0 | 0.35 | 0.04 | 0 | 3 | 3 | 0 |
| | | September | 0.08 | 0.92 | 0 | 0.31 | 0.03 | 0 | 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 | 0 | 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 |
| | | April | 0.87 | 0 | 0.13 | 0.1 | 0 | 0.65 | 11 | 0 | 5 |
| | | June | 0.98 | 0.02 | 0 | 0.01 | 0.45 | 0 | 48 | 17 | 0 |
| | | July | 0.79 | 0.21 | 0 | 0.09 | 0.34 | 0 | 23 | 15 | 0 |
| | | August | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | | September | 0.41 | 0.26 | 0.33 | 0.2 | 0.69 | 0.46 | 7 | 3 | 3 |
| | 1999–00 | 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 | 0 | 0 | 1 | 0 | 0 |
| | | July | 0.27 | 0.73 | 0 | 0.48 | 0.31 | 0 | 5 | 3 | 0 |
| | | August | 0.52 | 0.48 | 0 | 0.48 | 0.5 | 0 | 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 | 0 | 0 | 1 | 0 | 0 |
| | | September | 0.67 | 0.33 | 0 | 0.15 | 0 | 0 | 2 | 1 | 0 |
| | 2001–02 | October | 0.59 | 0.03 | 0.38 | 0.07 | 0.43 | 0.08 | 52 | 13 | 39 |
| | | July | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | | August | 0.68 | 0.18 | 0.13 | 0.19 | 0.56 | 0.56 | 2 | 1 | 1 |
| | | September | 0.8 | 0.1 | 0.09 | 0.07 | 0.31 | 1.13 | 12 | 9 | 2 |
| | 2002–03 | October | 0.76 | 0.06 | 0.17 | 0.05 | 0.12 | 0.2 | 78 | 55 | 48 |
| | | November | 0.56 | 0.31 | 0.12 | 0.09 | 0.14 | 0.51 | 10 | 10 | 10 |
| | | April | 0.38 | 0 | 0.61 | 0.2 | 2.24 | 0.09 | 10 | 2 | 12 |
| | | May | 0.24 | 0 | 0.76 | 0.72 | 0 | 0.23 | 4 | 0 | 4 |
| | 2003–04 | October | 0.60 | 0 | 0.39 | 0.21 | 3.20 | 0.44 | 6 | 0 | 3 |
| | | December | 0.74 | 0.06 | 0.20 | 0.04 | 0.20 | 0.17 | 46 | 36 | 32 |
| | | January | 0.75 | 0.05 | 0.20 | 0.05 | 0.30 | 0.16 | 8 | 8 | 7 |
| | 2004–05 | October | 0.6 | 0 | 0.39 | 0.12 | 0 | 0.23 | 6 | 2 | 3 |
| | | December | 0.74 | 0.06 | 0.2 | 0.02 | 0 | 0.06 | 46 | 36 | 32 |
| | | April | 0.37 | 0 | 0.63 | 0.19 | 0 | 0.03 | 4 | 1 | 4 |
| | | May | 0.2 | 0 | 0.8 | 0 | 0 | 0 | 1 | 0 | 1 |
| | | June | 0.39 | 0 | 0.61 | 0.1 | 0 | 0.04 | 9 | 1 | 8 |

**Table C1 — *Continued***

| | Fishing | | Species proportions | | | c.v. | | | *N* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fishstock | year | Month | JMD | JMM | JMN | JMD | JMM | JMN | JMD | JMM | JMN |
| JMA 7 | 2004–05 | July | 0.97 | 0.03 | 0 | 0.04 | 1.41 | 0 | 32 | 5 | 0 |
| | | August | 0.97 | 0.03 | 0 | 0.08 | 0.06 | 0 | 4 | 3 | 0 |
| | | September | 0.6 | 0.17 | 0.23 | 0.01 | 0.08 | 0.1 | 2 | 2 | 1 |