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Species composition and seasonal variability of jack mackerel, *Trachurus declivis*, *T. symmetricus murphyi*, and *T. novaezelandiae*, in JMA 1, JMA 3, and JMA 7

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1. EXECUTIVE SUMMARY

This report provides estimates of relative species proportions and information on the seasonal variability of the three jack mackerel species, *T. declivis*, *T. s. murphyi*, and *T. novaezelandiae*, in Quota Management Areas JMA 1, JMA 3, and JMA 7.

In JMA 1, species proportions were estimated for the purse-seine fishery from market sampling data collected during 1997–98. The estimated proportions are 0.23 for *T. declivis*, 0.35 for *T. s. murphyi*, and 0.42 for *T. novaezelandiae*. Inshore trawl survey data also provided a time series of species proportions.

Aerial sightings data summaries for JMA 1 indicate that the abundance of all jack mackerel species usually peaks during spring. Mean monthly sightings of *T. s. murphyi* appear to be greater than for the combination of *T. declivis* and *T. novaezelandiae* in East Northland, but this is probably a result of few sightings of the former in the early to mid 1990s. In the Bay of Plenty, mean sightings of *T. s. murphyi* are about half those of the other two species.

In JMA 3, species proportions were estimated from scientific observer data collected on deepwater vessels recording their catch on Trawl, Catch, Effort, Processing Return forms (the TCEPR fleet) from market sampling data of the purse-seine fleet collected during 1997–98, and from inshore trawl survey data. Generally, these proportions indicate a predominance of *T. s. murphyi* in JMA 3. Coverage was not extensive enough to provide seasonal variations in species dominance.

In JMA 7, species proportions were estimated from scientific observer data for the TCEPR fleet, and from inshore trawl survey data. The former were used in a feasibility study for developing CPUE based stock indices and age-structured stock assessment models and it was concluded that such indices could not be based on catches of the TCEPR alone. The scientific observer data indicate a winter peak of *T. s. murphyi*, a summer peak of *T. novaezelandiae*, and a peak in *T. declivis* which shifts between the two.

2. INTRODUCTION

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. Because these species are aggregated in catch records under "JMA" (jack mackerel), separate information for each is unavailable, either as stock indices using 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 catch histories and CPUE series for each species.

2.1 Overview

This report summarises recent estimates of the relative proportions of the three *Trachurus* species in the commercial catch (from market sampling data in JMA 1 and 3 and scientific observer data in JMA 3 and 7) and trawl survey data in JMA 1, 3, and 7 (Figure 1). A time series of changes in the species proportions based on the scientific observer data information is presented as a summary of the seasonal variability of these species in the commercial catch in JMA 3 and 7. The seasonality of their occurrence at the surface in JMA 1 is summarised from the aerial sightings data.

This work was completed under Objective 1 in the MFish Research Project JMA9701, "Stock Assessment of Jack Mackerel":

- *To determine the seasonality and species composition of the three species in the commercial catch in JMA 1, 3, and 7 from samples taken in fish sheds during the 1997–98 fishing year and data collected at sea by scientific observers and other sources during the 1996–97 year.*

2.2 Distribution of jack mackerel

According to Annala *et al.* (1998), 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 in deeper waters, but shallower than 300 m and in temperatures less than 16 °C north of 45 °S; and *T. s. murphyi* occurs to depths of least 500 m over a wide latitudinal range (e.g., from 0 °S to 50 °S off South America).

Until recently, only *T. declivis* and *T. novaezelandiae* were known from New Zealand waters (Jones 1990). The Chilean jack mackerel, *T. s. murphyi*, was first described in New Zealand waters by Kawhara *et al.* (1988), and has become abundant here only since the late 1980s. It appears to have become established off the south and 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, by June 1994, had become common on the east coast of Northland. The total range of *T. s. murphyi* now extends along the entire west coast of South America, across the South Pacific, through much of the New Zealand EEZ, and into waters off southeast Australia.

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

2.3 Literature Review

Relative proportions of the jack mackerel species have been 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 (in press) used the species proportions presented in this report for JMA 7 to investigate the feasibility of developing CPUE stock indices and age-related stock assessment models.

3. METHODS

3.1. Species composition in JMA 1 & 3 from market sampling during 1997–98

Obtaining representative samples of jack mackerel purse-seine landings is hampered by the way that skippers often split their catch between holds to maintain balance of the vessel at sea. Given that inter-school variability in fish size may be high, sampling should include all landed schools to ensure that all sources of variability are included in the data. Defining a strategy to ensure precise sampling from all schools is difficult, however, because of mixing that occurs in the hold during unloading.

Sampling by grade provides a set of sampling strata that are reasonably homogeneous with respect to fish size and species composition. For example, at the Sanford factory in Tauranga, jack mackerel grades are based on size class (200–400 g, 400–600 g, 600 g–1 kg, over 1 kg), and generally the species composition of each is consistent, although there are some variations. Each sampled landing is characterised by its grade weights which are available from the weighbridge operator.

Sampling by grade produces data that can be summarised in a consistent way, thus providing more precise estimates than can be derived from the ungraded catch. Mean species proportions for each grade, estimated using data from all sampled landings, can then be applied to the annual total tonnage for each grade.

This method was developed during sampling of jack mackerel landings at Sanford Limited, Tauranga, between 1994 and 1996, and the procedure was summarised by Taylor (1998). In the present context, it was used for sampling Tauranga landings, but could not be applied in Nelson where jack mackerel are not graded.

3.1.1. Sampling at Sanford Ltd, Tauranga (JMA 1)

Graded fish were selected at random from the top of up to about a dozen alloys after they had been placed on the factory floor for emptying onto the packing line belt. These graded fish had not been sorted into species. Fish so selected are referred to as the sample.

Because the sampling was random, no bias arises from this approach. The sample size varied somewhat, depending on the grade being sampled, the apparent proportions of the species in the landing, or the sample itself (e.g., a larger sample would be taken where a species was poorly represented), or the availability of fish in a grade (certain grades were poorly represented in some landings). Generally, the objective was to include about 300 fish in the sample.

Once selected, the sample was sorted by species. These species samples were then weighed at the weighbridge, counted to determine the number of fish in each, and the data recorded. Species were distinguished according to known external features (Stephenson & Robertson 1977, Paulin *et al.* 1989).

A series of equations (Appendix 1) was used to estimate the species composition of all landings in a year, based on the following steps:

a. estimate grade proportions and weight of species l in the sampled landings (k);
b. estimate average species proportions in the grades of the sampled landings;
c. apply averages to grade totals of the annual catch;
d. estimate proportions of *Trachurus* species in the annual landings.

Between 21 October 1997 and 25 September 1998, 18 landings were sampled: This represents 30% of the 59 landings for the fishing year. Data from 14 of the sampled landings were included in estimating species proportions.

3.1.2. Sampling at Sanford Ltd, Nelson (JMA 3)

A sample of about 200 kg of ungraded jack mackerel was taken from each hold. The sample weight was recorded and the sample was then sorted into species. The weights of these species samples were recorded. A series of equations (Appendix 2) was used to estimate the species proportions in the catch.

Activity in the Nelson fishery was minimal during 1997–98, and only four landings were sampled (between 15 April 1998 and 18 May 1998) before fishing was discontinued for the year. To produce estimates closely representative of the landing, samples were taken from as many holds as possible.

3.2. Species composition and seasonality from observer data (JMA 3)

Data were extracted from the MFish Observer Database to provide estimates of species proportions for 1990 to 1997. The method used was as follows.

- Species composition data and total catch by tow were extracted from the database.
- Species proportions were estimated by weight and number for each tow.
- Species tow proportions were scaled to the tow tonnage.
- Means of the species tow weights for each trip were estimated.
- These species trip estimates were scaled to the trip tonnage.
- The species estimates were summed for all landings and proportions of the species in the catch were estimated for a given time frame.

3.3. Seasonality from aerial sightings data (JMA 1, East Northland and Bay of Plenty)

The aerial sightings database (*aer_sight*) contains information on the surface abundance of schooling pelagic fish species recorded by pilots assisting with the operation of purse-seine vessels. Pilots can identify the species composition of schools from colour and swimming behaviour. They summarise school species composition and tonnage, and record the data as aggregated sightings of all schools of a particular species composition observed at a certain time in a particular area. This database is administered by NIWA under the MFish Project DMAN04.

The number of sightings by year and month, and the total flying hours as a measure of search effort, were extracted from the aerial sightings database, for all months from June 1976 to December 1997. The number of sightings for each month was normalised by dividing by the number of flying hours for the month, and the normalised sightings were plotted as a time series by month since May 1976. The month of greatest availability of jack mackerel to the JMA 1 fishery in each year was defined as the month where the major peak occurred in the normalised sighting plot.

To examine the seasonality of *T.s. murphyi* and compare it with that of the two "New Zealand species" combined, a simpler approach was taken. Here, the numbers of sightings were pooled for all years (1976–97) and monthly means were estimated to provide a time series of the mean number of sightings by month throughout the year, and series so defined are sometimes referred to in the text as the long-term mean. This method was used to produce time series of mean monthly values for sightings of jack mackerel (i.e., the two New Zealand species) and for sightings of *T.s. murphyi.*

To compare data from the most recent fishing year (1996–97) with the long term means, total monthly sightings of "jack mackerel" and *T. s. murphyi* were plotted as annual time series. To provide a good spatial coverage, these plots were produced for JMA 1, East Northland, and the Bay of Plenty. No sightings records distinguishing *T. s. murphyi* were available for JMA 3 or JMA 7, and no seasonal plots have been produced for those areas.

3.4. Species composition from the trawl database (JMA 1, JMA 3, JMA 7)

Catch weights of each of the three *Trachurus* species were extracted from the trawl survey database and voyage reports for inshore trawl surveys by *R.V. Kaharoa*. The following trawl series were analysed: ECNI for all years between 1993 and 1996, inclusive; WCSI in 1992, 1994, 1995, and 1997; ECSI in all years between 1993 and 1998, inclusive, except 1995 when there was no survey. Proportions of the three species were estimated as the proportion of the total catch weight of jack mackerel during the survey. Where some of the jack mackerel catch was recorded as species code *JMA* (jack mackerel) (e.g., ECSI in 1991 and 1992) the data were difficult to separate and species proportions were not estimated.

4. RESULTS

4.1. Species composition from market sampling during 1997–98 (JMA 1 & JMA 3)

The relative proportion of *T. s. murphyi* is higher in the south and represents more than twice the catch of *T. declivis*. The catch of *T. novaezelandiae* is negligible in the south, contrasting dramatically with its predominance in the north. Relative proportions of *T. declivis* are similar in each area:

	T. declivis	*T. s. murphyi*	*T. novaezelandiae*
JMA 1	0.23	0.35	0.42
JMA 3	0.29	0.69	0.02

4.2. Species composition and seasonality from scientific observer data (JMA 3 & 7)

Species composition from JMA 3 for months when observer records are available are shown in Table 1. Since 1988 a predominance of *T. s. murphyi* is evident in most records, although there are two months in 1994 (March & April) when the percentage of *T. declivis* exceeded 70% with a corresponding drop in the proportion of *T. s. murphyi*. Since 1996, *T. declivis* has been about 1% of the sample, but sample sizes for 1996–97 in JMA 3 were very small (mean = 4). Since 1989 there have been no records of *T. novaezelandiae*.

The data series in JMA 3 is too patchy to provide any information on seasonal variations in species composition.

Species composition from JMA 7 for those months where observer records are available are shown in Table 2. Before September 1989, there are no records of *T. s. murphyi* in the data, although this is unlikely to be a true representation of what occurred because misidentifications were probably frequent before this species became commonly known. From 1991, *T. s. murphyi* is predominant in the JMA 7 catch somewhere between July and September each year.

Patterns in *T. declivis* and *T. novaezelandiae* are difficult to summarise and there is no evidence for any seasonal or monthly structure in their data. However, there is evidence for an inverse relationship between the peaks and troughs of *T. novaezelandiae* with the other two species — before 1991 the relationship is with *T. declivis*, but since then it occurs more often with *T. s. murphyi*.

4.3. Seasonality from aerial sightings data (JMA 1, East Northland and Bay of Plenty)

The time series plot of normalised numbers of sightings by month (Figure 2) shows that in most years the peak of availability of jack mackerel to the JMA 1 fishery occurs in spring (September–October), but in 1987, 1990, and 1997 it occurred earlier.

In JMA 1 (Figure 3) both the "New Zealand species" and *T. s. murphyi* series follow a similar pattern and amplitude, with fewer sightings in the first half of the year, and the mean number of sightings ranging between 25 to 30 from August to November. The variability of *T. s. murphyi* is greater, probably as a result of fewer data points, with sightings recorded only since the early 1990s.

In East Northland (Figure 4), sightings of the "New Zealand species" are fairly flat throughout most of the year, although there is a gradual rise and fall between July and December, with a peak of mean sightings in September. The sightings trend of *T. s. murphyi* in this area is about double the sightings of the "New Zealand species" during the second half of the year when most sightings are recorded.

Patterns in the Bay of Plenty (Figure 5) are different from those in East Northland. Generally, there are more sightings of the "New Zealand species" than of *T. s. murphyi*, and they increase gradually throughout the year to a peak around September. The seasonal pattern of *T. s. murphyi* in the Bay of Plenty is similar to that in East Northland, although the amplitude of peak sightings is lower.

Sightings of the New Zealand species in JMA 1 during 1996–97 (*see* Figure 3) suggest a similar overall pattern to the long-term mean, although sightings between January and April are low, and the peak in May is unusually large. The 1996–97 series for *T s. murphyi* sightings is similar to the overall pattern, with most sightings recorded in the second half of the year, although its peak is lower.

Sightings of the "New Zealand species in East Northland during 1996–97 (*see* Figure 4) appear flat, and therefore similar to the long-term mean series. The "total sightings" series for *T. s. murphyi* in 1996–97 is consistent with the pattern in the series of mean sightings, although the peak is low.

Sightings of the New Zealand species in the Bay of Plenty during 1996–97 (*see* Figure 5) shows an earlier and higher peak than for the long-term mean, and a more gradual decline in sightings through the second half of the year. A number of months are missing sightings of *T. s. murphyi* in 1996–97, but the pattern is consistent with the long-term mean with a similar peak.

4.4. Species composition from the trawl database

Percentages of the three jack mackerel species in the total jack mackerel catch are shown in Table 3 for individual surveys in each *R.V. Kaharoa* inshore trawl survey series.

Trawl surveys on the east coast North Island indicate a predominance of *T. novaezelandiae* from 1993 to 1995 with a percentage ranging between 69.5 and 74.6%. In 1996 this dropped to 33.2% with relative increases in both *T. declivis* and *T. s. murphyi.*

Data from west coast South Island trawl surveys show similar proportions of *T. declivis* for all years, except for 1995 when a decline is evident. A high proportion of *T. novaezelandiae* in

1992 was followed by a declining trend to 1995, with a major increase for the final year. The inverse of this trend is evident for the proportions of *T. s. murphyi*, although simple replacement of one for the other is not evident.

The east coast South Island data show an increasing trend in *T. s. murphyi* to a maximum of 99% in 1998. Declining trends are evident for both *T. declivis* and *T. novaezelandiae*. This result is potentially invalidated by a change in the timing of this survey, resulting in the data comprising three years of winter surveys (1993, 1994, 1996), and two of summer surveys (1997, 1998). However, it appears to remain largely unaffected, except that the 1998 figures may not be particularly reliable because of the small sample size. Catch rates of jack mackerel were higher on winter surveys, but the species composition did not change much for the first year of summer surveys, although the percentage of *T. novaezelandiae* was reduced to about 30% of its proportion on the previous survey. This last point could be interpreted as natural succession in the declining trend throughout the series.

During 1998, the year of the second summer survey, there appears to have been a change in species composition: there was an 11% reduction in the proportion of *T. declivis* that was apparently replaced by *T. s. murphyi*. However, the catch weight was very low this year (26.2 kg) at only about 10% of that for the previous survey and 1% of that in 1996. It is therefore reasonable to conclude that the result in 1998 is less reliable than in other years because of the small sample size.

In summary, it is unlikely that the variation in species composition between the two summer surveys can be accounted for by the 2 weeks difference in their timing, but it is reasonable to expect some seasonally driven differences between summer and winter surveys. However, certain similarities between the winter surveys and the first summer survey suggest that seasonality has little influence. The sample size of the second summer survey make its results too unreliable to include in the interpretation.

5. CONCLUSIONS

The contrast in species proportions between Tauranga and Nelson results from a combination of variations in species distribution and size-targeting by the purse-seine fleet. The preference by *T. novaezelandiae* for warmer, shallower water and its low occurrence south of 42° S dictates its low proportion in the Nelson data which are mainly landings from the Kaikoura area. Comparison with previous years (Taylor 1998) suggests that its high proportion in the Tauranga data during 1997–98 is indicative of a target preference for small fish by the purse-seine fleet in JMA 1.

Results from scientific observer data indicating a high proportion of *T. s. murphyi* in JMA 3 since 1988 is reinforced by the trawl survey data for the ECSI. The predominance of *T. novaezelandiae* in the ECNI trawl survey data agrees with knowledge of its distribution, but its high proportion in the WCSI data appears more contradictory. However, these surveys include Golden and Tasman Bays and the area to Cape Foulwind, which are all north of 42° S and include extensive areas of shallow water.

The predominance of *T. s. murphyi* in the JMA 7 scientific observer data somewhere between July and September each year has been discussed by Taylor (in press). There the data were aggregated by annual quarter, and examination of CPUE based on this time series, in conjunction with the distribution of tow positions in time and space, suggested the possibility of two separate fisheries with different species compositions. One operates during November to April in a more northerly (North and South Taranaki Bight to Cook Strait) area with a peak CPUE during January–February. The other operates from May to October over the full geographical range from the North Taranaki Bight to the central west coast (South Island), probably in conjunction with the hoki fishery, with a CPUE peak usually in June or July.

The high proportion of *T. s. murphyi* occurs in what is defined there as "the winter fishery", which agrees, both in time and space, with its preference for cooler water. High proportions of *T. novaezelandiae* occur during the period of the "summer fishery", which agrees with its preference for warmer water. Peaks of high proportion of *T. declivis* occur during either the winter fishery (1991, 1992) or the summer fishery (1992, 1993).

Aerial Sightings data summaries for JMA 1 indicate the peak presence of jack mackerel during spring, and, in some years, in winter. The comparison of the "New Zealand species" with *T. s. murphyi*, suggests similarities between the two groups in JMA 1 as a whole, but differences emerge when the Fishstock is broken down into subareas. Sightings of *T. s. murphyi* appear to be greater than those of the other species in East Northland, but while it is true that large schools can be seen, particularly during cooler years (P. Taylor, unpublished data), this pattern is probably the result of several years of high abundance, and is unlikely to be consistent in the long term.

Aerial sightings indicate that distribution patterns of jack mackerel were different in 1996–97 from the status quo represented by the long-term mean.

6. 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 can be used to provide catch histories, although there are complexities requiring the splitting of total catch between purse-seine and trawl landings. Proportions from the inshore trawl survey in this area could be used to apportion catch from inshore trawl vessels. Whether there are any seasonal variations is unknown.

Scientific 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 seasonal variations. JMA 7 is more complicated and it is unlikely that stock indices based on species proportions and catch data from only the TCEPR fishery can be indicative of the JMA 7 jack mackerel population.

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

Definitions

w_{jkl} is the weight of a sample of species l in grade j and sampled landing k.

$W_{jk.}$ is the weight of size group j, in landing k.

W_{jkl} is the weight of species l in grade j and landing k.

p_{jkl} is the grade proportion of species l.

Step a, to estimate grade proportions and weight of species l in the sampled landings (k)

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

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

The proportion was applied to the total weight of grade j in landing k to determine its species composition by weight, using

$$W_{jkl} = \hat{p}_{jkl} \cdot W_{jk}$$

An estimate of the weight of species l, in the sampled landing k is given by $\sum_{j} W_{jkl}$. This measure is useful in summarising individual landings.

Step b, to estimate average species proportions in the grades of the sampled landings

The mean grade proportion of species l was estimated using sum of the estimated weights in sampled landings over the total weight

$$\hat{p}_{j.l} = \frac{\sum_{sampledk} \hat{p}_{jkl} \cdot W_{jk}}{\sum_{sampledk} W_{jk}}$$

where n is the number of landings that were sampled.

Step c, to apply averages to grade totals of the annual catch

The mean species proportions were used to estimate the tonnage of species l in grade j of the

k'th landing of all landings for the year (sampled and unsampled)

$$\hat{W}_{j.l} = \hat{p}_{j.l} \sum_{k} W_{jk.}$$

Step d, to estimate proportions of Trachurus species in the annual landings

The species were summed across each grade to get the totals for each species and these were divided by the grand total (of all species) to estimate the species proportions in the annual catch

$$\hat{p}_{..l} = \frac{\sum \hat{W}_{j.l}}{\sum_{jkl} W_{jkl}}$$

Appendix 2: Estimating species composition (proportions of the three jack mackerel species) of the total annual purse-seine catch of *Trachurus* species in JMA 3

Definitions

w_{jk} is the weight of a sample of species *j* from hold *k*.

$W_{k.}$ is the total weight of the sample (all species) from hold *k*.

$\hat{p}_{jk}$ is the estimated proportion of species *j* in the sample from hold *k*.

$\hat{P}_j$ is the estimated proportion of species *j* in the catch.

The estimated proportion of species *j* in the sample from hold *k* is given by

$$\hat{p}_{jk} = {w_{jk}}/{W_k}$$

and the estimated proportion of species *j* in the catch is given as the mean of the estimated hold proportions of species *j*

$$\hat{P}_j = \frac{\sum_{k=1}^{n} \hat{p}_{jk}}{n}$$

where *n* is the overall number of holds sampled.

Table 1: Species proportions estimated from scientific observer data for the three *Trachurus* species in JMA 3, by year and month

Year	Month	*T. declivis*	*T. s. murphyi*	*T. novaezelandiae*
1986	9	0	1	0
1987	1	1	0	0
1987	3	0.77	0	0.23
1987	6	0.78	0	0.22
1988	1	0.19	0.79	0.02
1989	2	0	1	0
1989	11	0.3	0.7	0
1990	10	0	1	0
1991	2	0	1	0
1991	3	0	1	0
1991	10	0.01	0.99	0
1991	11	0	1	0
1992	1	0	1	0
1992	2	0	1	0
1992	3	0	1	0
1992	4	0	1	0
1993	1	1	0	0
1993	2	0	1	0
1993	3	0	1	0
1993	4	0.19	0.8	0
1993	5	0	1	0
1993	11	0	1	0
1994	2	0	1	0
1994	3	0.84	0.16	0
1994	4	0.74	0.26	0
1994	5	0	1	0
1994	6	0	1	0
1995	2	0	1	0
1995	3	0	1	0
1995	4	0.07	0.93	0
1995	5	0.04	0.96	0
1995	12	0.03	0.97	0
1996	1	0.02	0.98	0
1996	2	0	1	0
1996	3	0.01	0.99	0
1996	4	0.01	0.99	0
1996	5	0	1	0
1997	1	0	1	0
1997	2	0	1	0
1997	3	0	1	0
1997	4	0	1	0
1997	5	0.01	0.99	0

Table 2: Species proportions estimated from scientific observer data for the three *Trachurus* species in JMA 7, by year and month

Year	Month	*T. declivis*	*T. s. murphyi*	*T. novaezelandiae*
1986	9	0.68	0	0.32
1986	11	0.65	0	0.35
1986	12	0.57	0	0.43
1987	01	0.54	0	0.46
1987	04	0.08	0	0.92
1987	05	0.31	0	0.69
1987	11	0.99	0	0.01
1988	1	0.52	0	0.48
1988	2	0.92	0	0.08
1988	3	0.32	0	0.68
1988	12	0.53	0	0.47
1989	8	0.97	0.03	0
1989	9	0.74	0.18	0.08
1989	10	0.48	0.2	0.32
1989	11	0.47	0	0.52
1989	12	0.13	0	0.87
1990	3	0.03	0	0.97
1990	4	0.1	0	0.9
1990	6	0.68	0	0.32
1990	12	0.67	0	0.33
1991	2	0.57	0.01	0.43
1991	3	0.47	0	0.52
1991	4	0.3	0	0.7
1991	5	0.28	0	0.71
1991	7	0.66	0.34	0
1991	8	0.17	0.83	0
1991	9	0.48	0.39	0.13
1991	10	0.48	0.02	0.5
1991	11	0.51	0.04	0.45
1991	12	0.4	0.04	0.56
1992	3	0.33	0.02	0.65
1992	4	NA	NA	NA
1992	5	0.86	0.07	0.07
1992	7	0.15	0.7	0.15
1992	8	0	1	0
1992	9	0.48	0.52	0
1992	10	0.84	0.16	0
1992	12	0.67	0.11	0.22
1993	1	0.61	0.14	0.25
1993	2	0.5	0.21	0.3
1993	3	0.68	0.05	0.28
1993	6	0	1	0
1993	8	0	1	0
1993	10	0.18	0.16	0.65
1993	11	0.64	0	0.36
1993	12	0.69	0.05	0.27
1994	1	0.54	0.07	0.39

Table 2 — *Continued*

Year	Month	*T. declivis*	*T. s. murphyi*	*T. novaezelandiae*
1994	2	0.32	0.26	0.42
1994	5	0.33	0.24	0.43
1994	6	0.11	0.89	0
1994	7	0.08	0.92	0
1994	8	0	1	0
1994	9	0.65	0.35	0
1994	12	0.32	0.36	0.33
1995	1	0.31	0.22	0.47
1995	3	0.29	0.5	0.21
1995	7	0.06	0.94	0
1996	2	0.39	0.22	0.39
1996	3	0.56	0.21	0.23
1996	6	0	1	0
1996	8	0.05	0.95	0
1996	12	0.66	0.07	0.27
1997	1	0.59	0.07	0.34
1997	2	0.64	0.06	0.3
1997	3	0.51	0.22	0.26
1997	6	0.53	0.47	0
1997	7	0.09	0.91	0
1997	8	0.1	0.9	0
1997	9	0.08	0.92	0

Table 3: Percentages of each jack mackerel (*Trachurus*) species in the total jack mackerel catch for individual surveys in each *R.V. Kaharoa* inshore trawl survey series; catch weights are in kg. *Source:* Trawl survey database and voyage reports

	All *Trachurus* spp	*T. novaezelandiae*		*T. declivis*		*T s murphyi*	
Year	Catch	Catch	% of total	Catch	% of total	Catch	% of total
East Coast North Island							
1993	944.5	656.8	69.5	99.5	10.5	188.2	19.9
1994	2 275.7	1586.9	69.7	179.7	7.9	509.1	22.4
1995	2 319.6	1731.5	74.6	193.8	8.4	394.3	17.0
1996	10 579.5	3 512.3	33.2	1 909.7	18.1	5 157.5	48.7
West Coast South Island							
1992	1 053.2	502.8	47.7	242.7	23.0	307.7	29.2
1994	836.8	173.3	20.7	248.4	29.7	415.1	49.6
1995	1 697.3	98.8	5.8	238.7	14.1	1 359.8	80.1
1997	1 140.2	727.7	63.8	303.0	26.6	109.5	9.6
East Coast South Island							
1993	817.3	58.1	7.1	404.2	49.5	355.0	43.4
1994	430.0	18.0	4.2	56.0	13.0	356.0	82.8
1996	2 966.8	54.3	1.8	303.1	10.2	2609.4	88.0
1997	227.8	1.2	0.5	26.7	11.7	199.9	87.8
1998	26.2	0.1	0.4	0.1	0.4	26.0	99.2

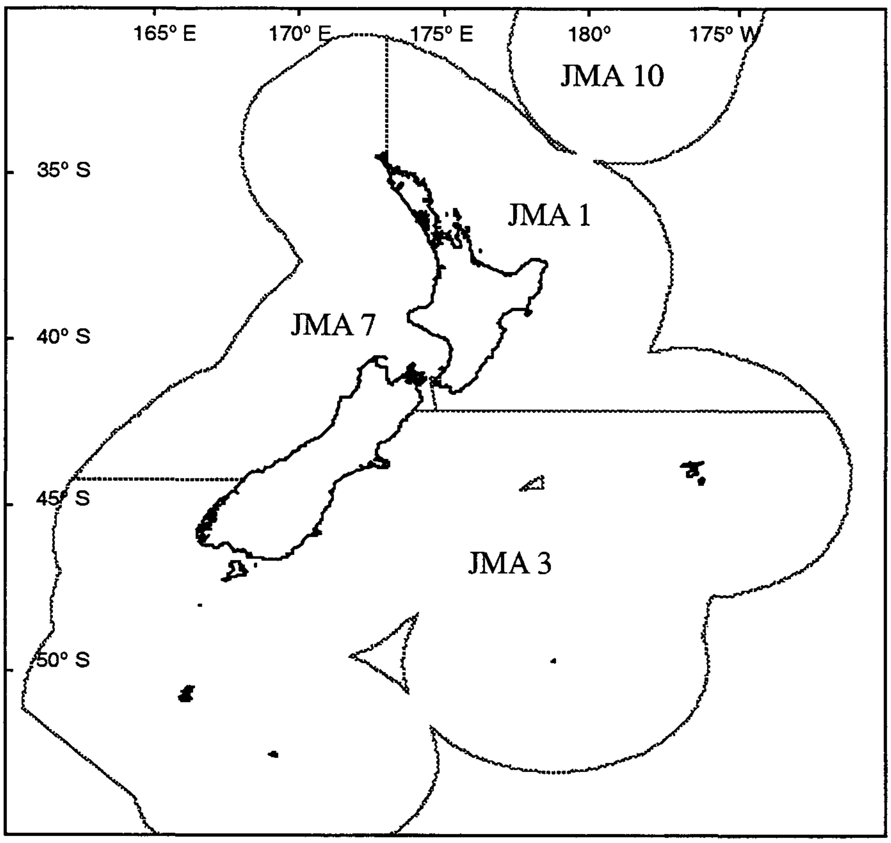

Figure 1: Jack mackerel Fishstocks

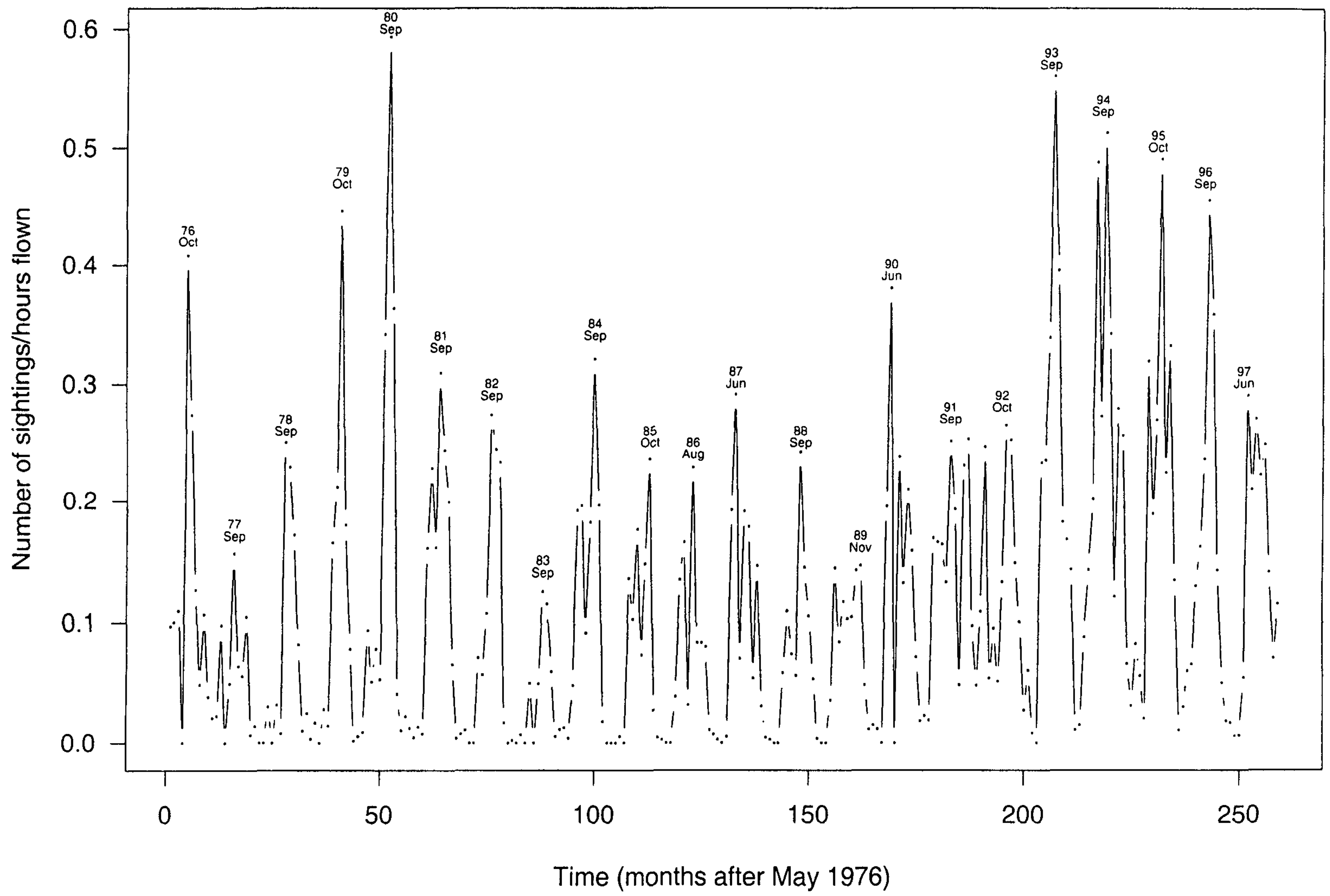

Figure 2: Long-term summary of the seasonality of jack mackerel (all species combined) in JMA 1, from aerial sightings data.

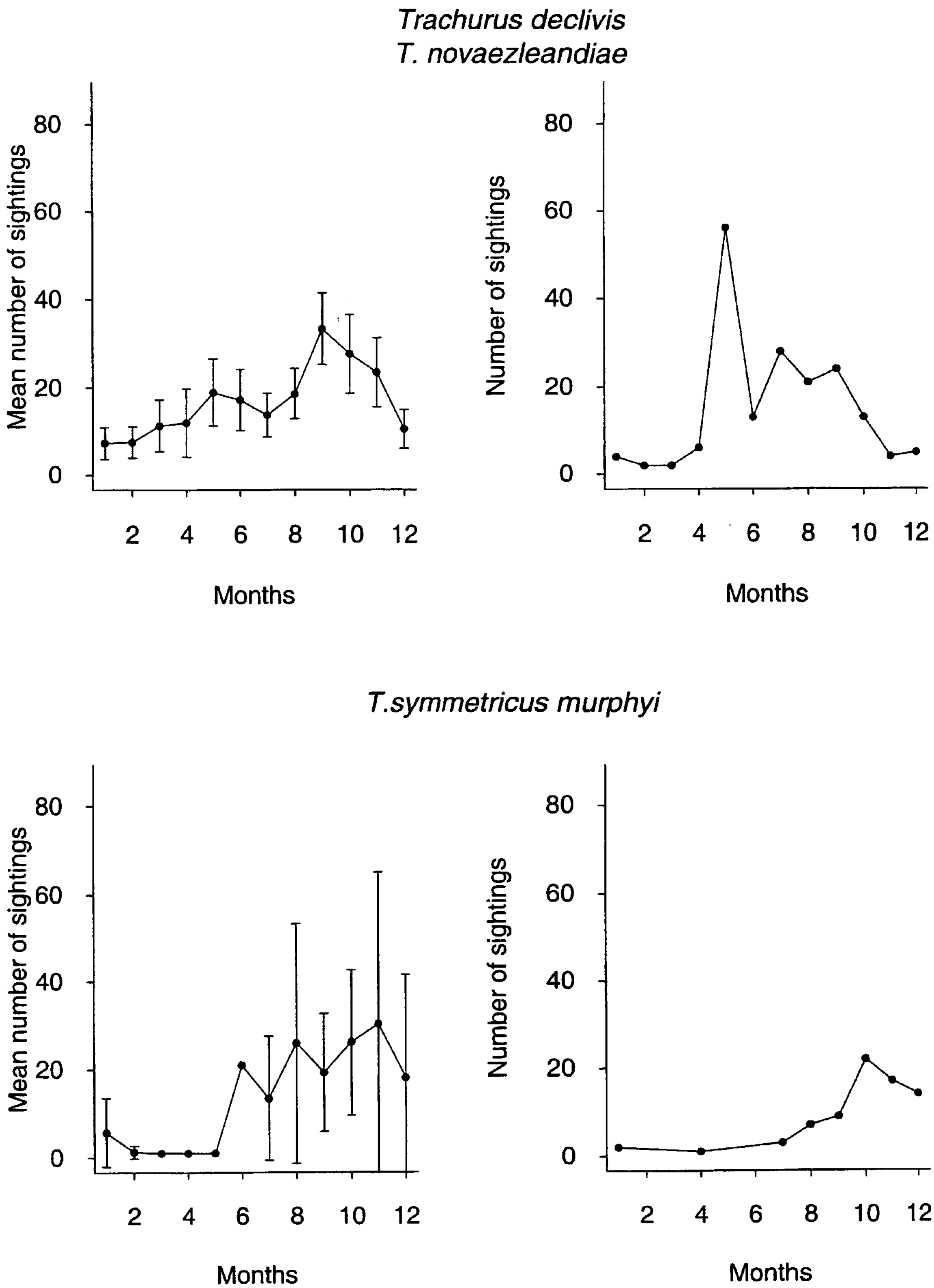

Figure 3: Aerial sightings of jack mackerel in JMA 1. The left hand plots are of monthly means using data pooled for all years; the right hand plots show monthly totals for 1997.

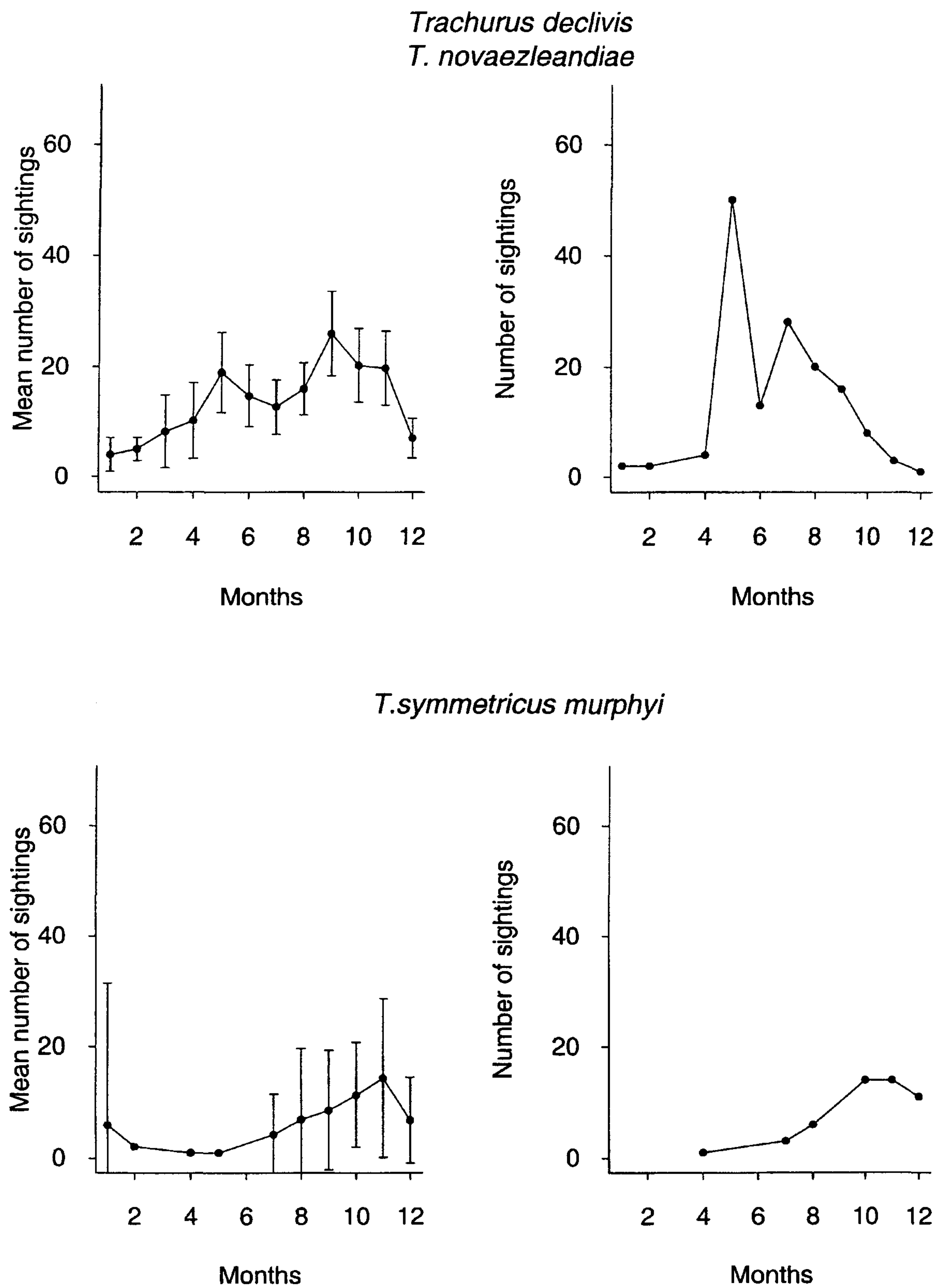

Figure 4: Aerial sightings of jack mackerel in East Northland. The left hand plots are of monthly means using data pooled for all years; the right hand plots show monthly totals for 1997.

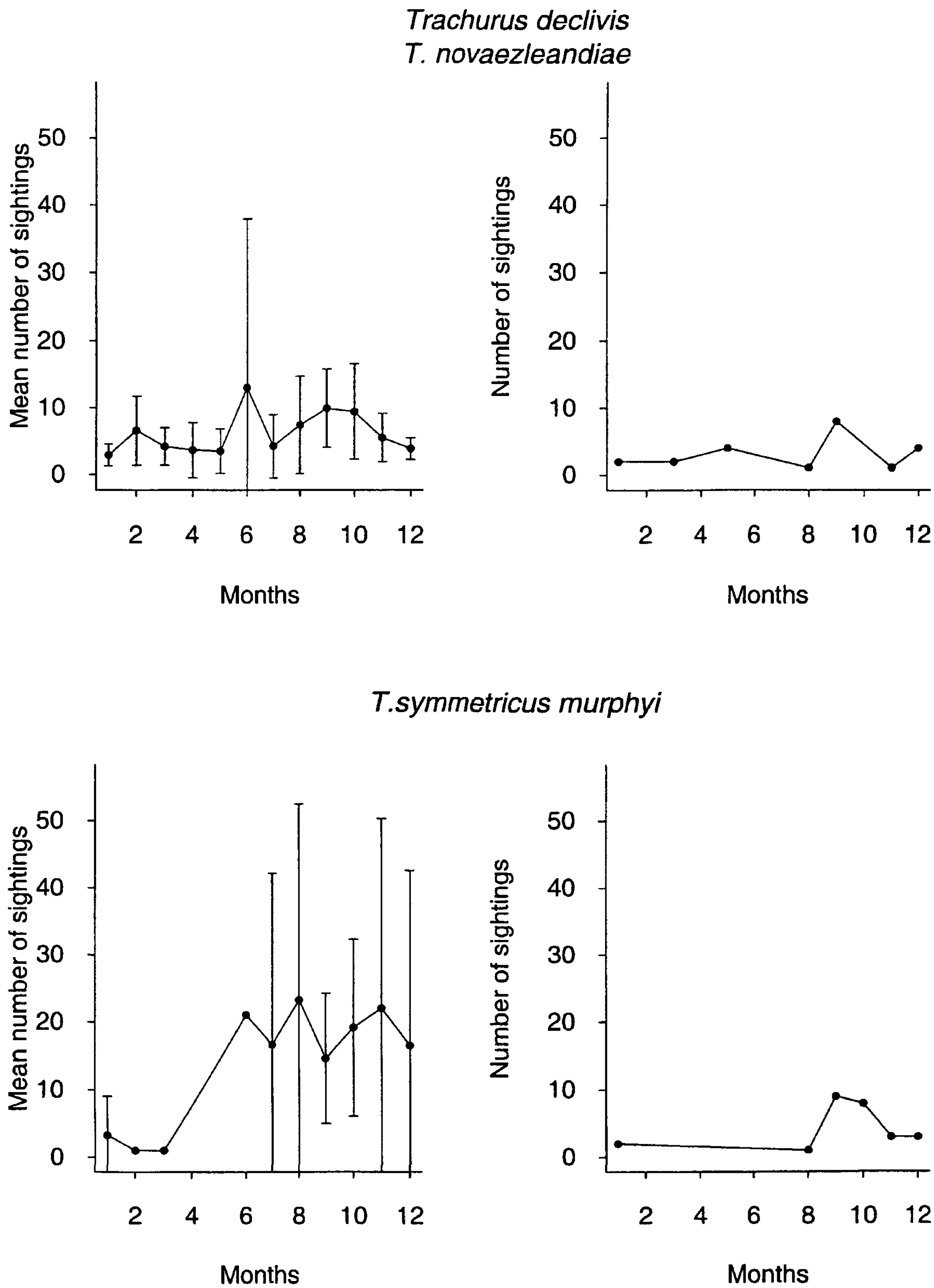

Figure 5: Aerial sightings of jack mackerel in the Bay of Plenty. The left hand plots are of monthly means, using data pooled for all years; the right hand plots show monthly totals for 1997.