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Report 189

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# Stock Separation of Jack Mackerel *Trachurus declivis* (Jenyns, 1841) and Yellowtail *T. novaezealandiae* (Richardson 1843) in Southern Australian Waters, using Principal Component Analysis

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**Abstract** To determine the stock structure of *Trachurus declivis* and *Trachurus novaezealandiae* in the Great Australian Bight, off New South Wales and off Tasmania, principal component analysis was carried out on their morphometric and meristic characters. The analysis of *T. declivis* indicates that each of the three areas has a separate subpopulation. Two subpopulations are suggested for *T. novaezealandiae*: one in the Great Australian Bight, and the other in south-eastern Australia. A separation within the south-eastern group is also identified for *T. novaezealandiae*, which could indicate the presence of two species or subspecies.

# Introduction

The genus *Trachurus* is of commercial importance in many temperate areas of the world. The world catch in 1982 was about three million tonnes (FAO 1983). In Australia the jack mackerel, *Trachurus declivis*, occurs throughout southern waters from mid-New South Wales to Shark Bay in Western Australia (Last *et al.* 1983). Fish available for commercial exploitation off the south-east coast have been estimated to be at least 250 000 t (Webb, personal communication). This tonnage would include an unknown proportion of yellowtail, *T. novaezealandiae*. The two species co-occur in inshore catches and are difficult to distinguish from each other. Yellowtail are, therefore, frequently included in the jack mackerel catch.

Surface schools of jack mackerel have been reported appearing progressively down the coast from New South Wales towards Tasmania with the approach of summer (Shuntov 1969, Maxwell 1979, Stevens and Hausfeld 1982). On the basis of these observations, Maxwell (1979) suggested a southern or an offshore spawning migration following the 17° C isotherm as it moves to the south. However, acoustic surveys carried out by Wolfe (1970, 1971, 1976) indicated that jack mackerel were present all year round, which implies that only the surface schooling is a seasonal occurrence.

Richardson's (1982) electrophoretic study distinguished jack mackerel of the western Great Australian Bight from those of western Bass Strait and south-eastern Australia. He also found a decrease in the frequency of one of the alleles from north to south which, although not statistically significant, he interpreted as between-sample variation.

The present study was initiated to determine whether the jack mackerel and yellowtail populations consisted of different stocks and, if so, how they were delineated. For this, a principal component analysis (PCA) was used.

The word "stock" has been used by different authors to describe different concepts. For this study we used the definition derived by the 1960 Joint Scientific Meeting of ICNAF, ICES and FAO: "a relatively homogenous and self-contained population whose losses by emigration and accessions by immigration, if any, are negligible in relation to the rates of growth and mortality" (ICNAF 1960).

# Methods

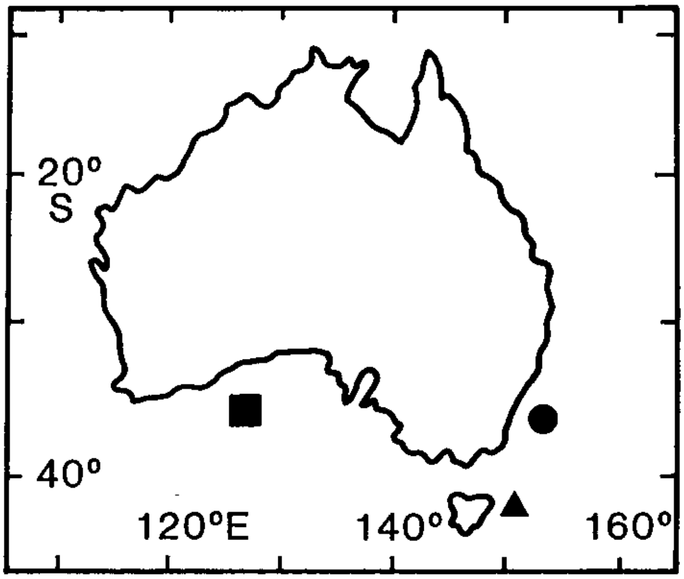
Between 1978 and 1981, 91 jack mackerel and 51 yellowtail were collected from trawled samples by the FRV *Courageous* and FRV *Soela*. Of these, 27 jack mackerel and 10 yellowtail were from the western Great Australian Bight, 55 jack mackerel and 21 yellowtail from eastern and northern Tasmania, and 9 jack mackerel and 20 yellowtail from the waters off New South Wales (Fig. 1). The jack mackerel ranged in size from 14 to 35 cm FL, and the yellowtail from 15 to 25 cm FL

The fish were frozen on board to -20° C and brought back to be measured in the laboratory. All fish were measured within six months of capture.

Twenty-one morphometric characters were measured to the nearest millimetre and four meristic counts were recorded (see Fig. 2). To standardise the data, all morphometric measurements were expressed as a percentage of the standard length. The data were analysed by principal component analysis using a correlation matrix.

Fig. 1 The areas from which samples of *T. declivis* and *T. novaezealandiae* were collected for this study.

▲ Tasmania
● New South Wales
■ Great Aust. Bight



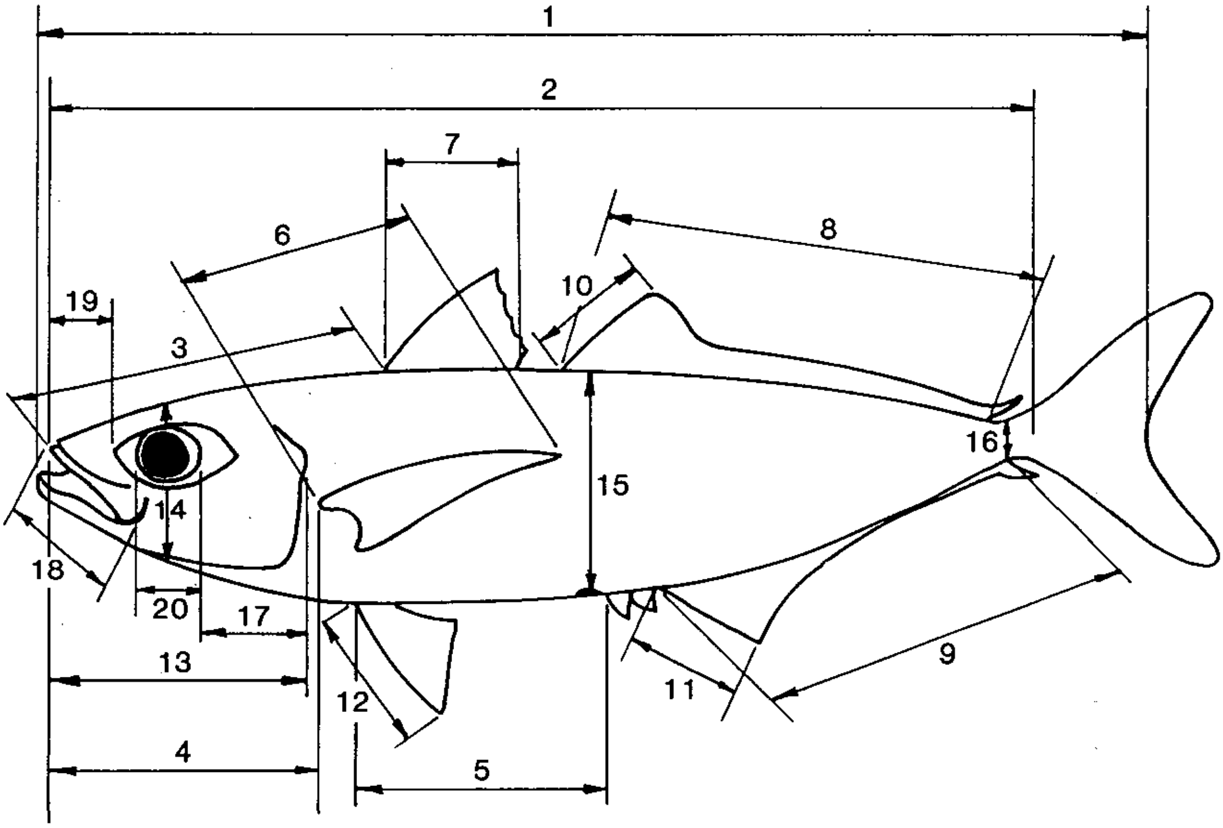


Fig. 2 Morphometric (1 to 21) and meristic (22 to 25) characters examined.

1 caudal fork length
2 standard length
3 snout to origin of first dorsal
4 snout to origin of pectoral fin
5 ventral fin origin to anal fin origin
6 pectoral fin length
7 1st dorsal fin base length
8 2nd dorsal fin base length
9 anal fin base length
10 height, 2nd dorsal fin
11 height, anal fin
12 height, ventral fin
13 head length
14 head depth
15 body depth
16 caudal peduncle depth
17 post-orbital length of head
18 upper jaw length
19 snout length
20 orbital length
21 interorbital width
22 pectoral fin rays
23 lateral line scales (to caudal inflexion)
24 lateral line scales (to split)
25 gill rakers (upper)

# 3
# Results

The first and second principal components for both jack mackerel and yellowtail were plotted against each other. Each point was highlighted to identify the geographical origin of the sample (Fig. 3), the sex, season, year and method of capture (i.e. demersal or pelagic trawl). The other components were plotted against each other but showed little of significance.

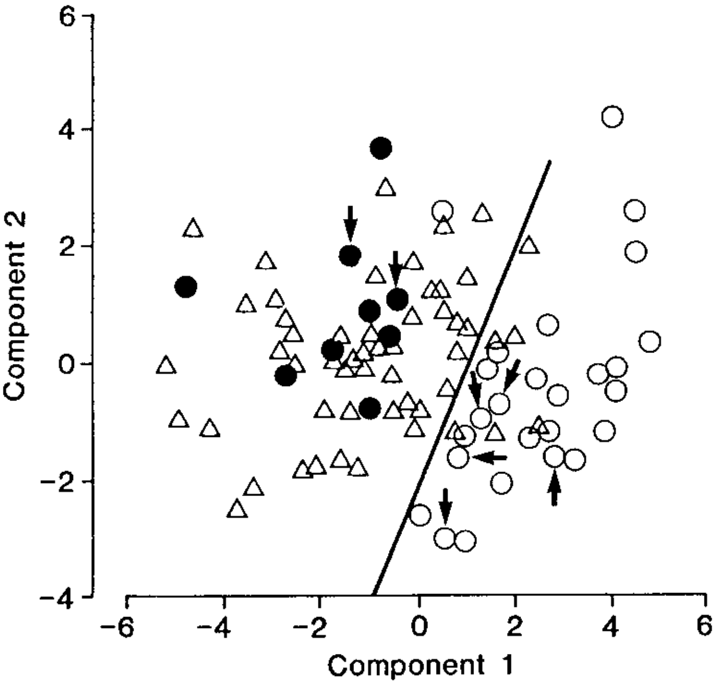


Fig. 3 Principal component plots for *T. declivis*. The plots from each area have a different symbol. The arrows mark the points representing fish of overlapping sizes.

## Jack mackerel

The first principal component shows a clear separation between the samples from the Great Australian Bight and those from the waters off New South Wales (Fig. 3). The plots representing the fish from the Tasmanian area overlap those from off New South Wales and partially overlap those of the Great Australian Bight.

When sex, season, year and method of capture were highlighted, no separation was evident in the first, second or third component. However, each sample tends to group together (Fig. 4), even though some of the groups overlap considerably and some of the groups have very small numbers.

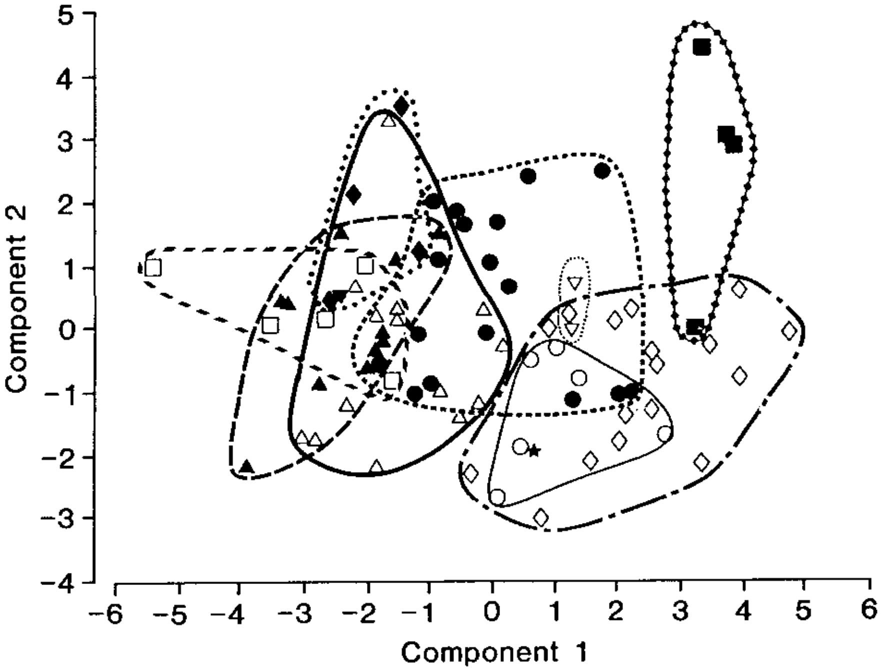


Fig. 4 Principal component plots for *T. declivis* highlighted for each tow. Fish caught in the same tow have been given the same symbol and grouped with a surrounding line.

The first three components explain 23.6, 9.0 and 7.6% of the variance. The separation in figure 3 between the samples from off New South Wales and those from the Bight can be accounted for by the first component alone. To determine the morphological characters that separate the fish between the two areas, the variables that exhibited the greatest loading in the first component were identified. These were plotted against each other (Fig. 5). In this manner, snout length, head length and snout origin to pectoral fin (all relative to post-orbital length of the head) were identified. This means that, in general, the pectoral fin and the eyes are situated slightly further forward in the fish off New South Wales than in those from the Bight.

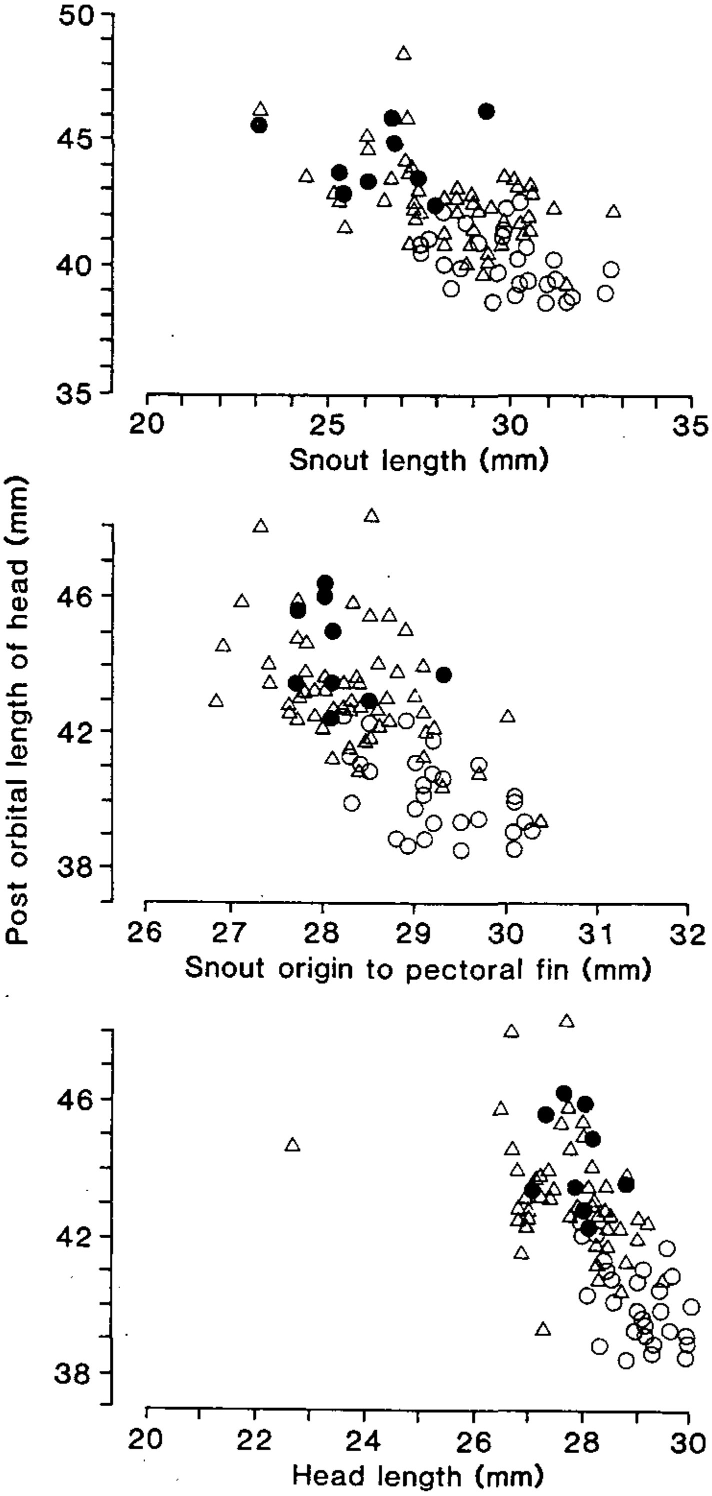


Fig. 5 Morphometric characters of *T. declivis* that contributed the most variance to the separation of the principal components.

### Yellowtail

When the principal components were plotted for yellowtail, the first component showed a clear separation between the fish from the Great Australian Bight and those from south-eastern Australian waters (Fig. 6). As with the jack mackerel, no separation was apparent when sex, season, year or method of capture was highlighted.

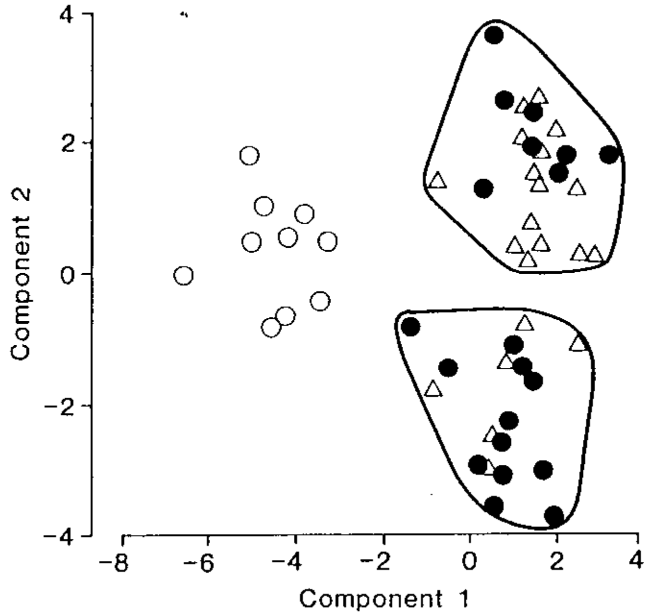


**Fig. 6** Principal component plots for *T. novaezealandiae,* where the plots from each area has been given a different symbol. Two groups separated by the second component have been circled.

The second component also showed a distinct separation within the south-eastern sample (Fig. 6). This separation cannot be explained by sex, size, area, year, season or method of capture. In fact, individuals from both groups were caught in the same tow.

## Discussion

### Jack mackerel

The total separation of the samples from the Great Australian Bight and from off New South Wales indicates that these are two distinct subpopulations. As most of the fish sampled in the Great Australian Bight were smaller than those from off New South Wales, allometric growth cannot be completely disregarded as the reason for the separation. However, three fish from off New South Wales and five from the Bight overlapped in size. These eight fish were clearly within their respective groups (Fig. 3), which would suggest that allometric growth is not causing the separation. That the separation is induced by different environmental factors is unlikely, as Richardson's (1982) electrophoretic study shows that the populations from the Great Australian Bight and south-eastern Australia are also genetically discrete.

Our data show no significant separation between the jack mackerel off New South Wales and Tasmania. However, the following observations make it likely that fish from these areas form separate subpopulations.

- Allele frequency decreased from north to south in Richardson's (1982) samples, which suggests his south-east Australian and southern samples were genetically different .

- Reports of surface schooling of jack mackerel in the Great Australian Bight (Shuntov 1969) give no indication of a movement towards Tasmania, unlike the schools in south-eastern Australia. Maxwell (1979) related the southward progression of observations of surface-schooling jack mackerel to the southward movement of the 17°C isotherm. As the fish are present all the year (Wolfe 1970, 1971, 1976) and schools have not been observed moving towards Tasmania in the Bight, it seems more likely that surface schooling is a behaviour related to the movement of the 17°C isotherm, rather than a southern migration.

- As jack mackerel is a schooling species (Stevens and Hausfeld 1982), it is reasonable to assume that one tow of the net generally samples one school. The principal component plots from each sample seem to group together (Fig. 4), which implies that each school is a relatively discrete unit. This interpretation is supported by Stevens and Hausfeld's (1982) observation that jack mackerel school by size. It is also supported by Richardson's (1982) observations, if we assume each of his "stations", like our tows, probably sampled one school. He found that the decrease in allele frequency from north to south was not due to a population cline, but to between-station differences. Kijima et al. (1985) reached a similar conclusion about *T. japonicus* in the coastal waters of Japan. On the basis of electrophoresis, they postulated many breeding units within one large population.

For fish from separate schools to remain morphologically and genetically discrete, there can be only very limited reproductive interaction between schools throughout the fishes' life cycle. Each school would have to spawn as a group, and their offspring would create a new group that, in turn, would remain largely intact throughout its life cycle. Should this be the case with the jack mackerel, a purse-seine fishery could have serious effects on the gene-pool diversity of the species, as each seining operation tends to capture the entire school.

In summary, the jack mackerel off New South Wales, Tasmania and the Great Australian Bight are probably separate stocks. Whether the three areas represent separate populations, or three clines of one population, would require further morphological and genetic studies, as would confirmation of the hypothesis of discrete schools. However, from a management point of view, the three areas can be treated separately.

## Yellowtail

The principal component plots (Fig. 4) indicate that two subpopulations of yellowtail exist: one in the Bight and one in south-eastern Australia. However, allometric growth cannot be eliminated as a possible cause for the separation in the principal component plots, since all of the fish sampled from the Bight were smaller than those from south-eastern Australia.

The separation on the second component in Fig. 6 is more intriguing. Fish from both groups were caught in the same tow, which indicates that they co-exist. The obvious explanation for this separation is that the groups represent two subspecies or even species. Further taxonomic studies would be needed to resolve this issue.

# 7
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