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THE FAT/WATER RELATIONSHIP IN THE MACKEREL,
Scomber scombrus L., PILCHARD, Sardina pilchardus
(Walbaum), AND SPRAT, Sprattus sprattus (L.), AND
THE SEASONAL VARIATION IN FAT CONTENT BY
SIZE AND MATURITY

P. D. Wallace and T. J. Hulme

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INTRODUCTION

Mackerel, pilchard and sprat have the ability to store fat in their body tissues. During the spring and summer, when their main source of food, zooplankton, is abundant, fat reserves are accumulated. These reserves are utilized in the autumn and winter when zooplankton is scarce. Consequently, wide variations in fat content occur throughout a single year of life of these species. This report describes the relationship that exists between fat and water in these species and describes how the fat content varies with size, maturity stage and season.

METHODS

Samples of mackerel, pilchards and sprats were regularly despatched in insulated containers to the Fisheries Laboratory, Lowestoft from commercial boats working out of ports in Devon and Cornwall; the main fishing areas from which the samples came are shown in Figure 1A. Samples of sprats from the north-east coast of England (see Figure 1B) and other fisheries were also used, as were samples collected by research vessels working in the sea area off south-west England.

Mackerel samples were split into the length groups 20-30 cm (small), 31-35 cm (medium) and over 35 cm (large). Pilchard samples were split into the groups 20-22 cm (small), 23-25 cm (medium) and 26-28 cm (large). Sprat samples were split into 1 cm length groups.

To obtain a sample of fish tissue for fat analysis the fish were homogenized in a high-speed blender. The preparation of the fish prior to homogenization varied slightly for each species, mainly because the blender could not cope with a whole mackerel, on the one hand, and an individual sprat, on the other. For mackerel, one full fillet was cut from each side and sliced before being put into the blender; for pilchard the whole fish, minus the gut and gonads, was used; and for sprat several whole fish.

After homogenization a weighed portion of approximately 12 g was heated for 1.5 h under an infra-red lamp to constant weight. The resulting dried tissue was weighed, thus allowing the water content of the sample to be determined, and then broken into small pieces and extracted for 8 h in a Soxhlet apparatus to obtain the fat content. The solvent used was Analar Petroleum Ether with a

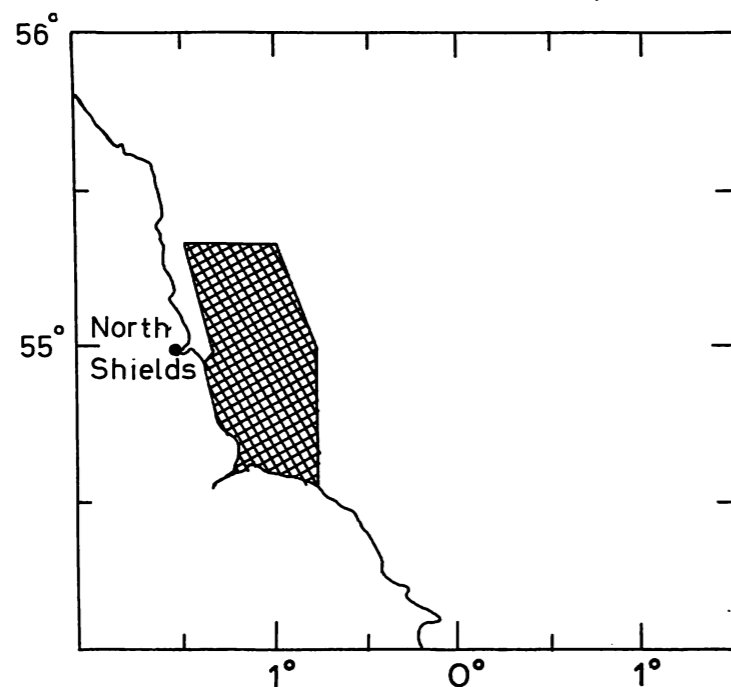
File graded for fat content

Moisture noted

The authors:

P. D. Wallace and T. J. Hulme are Higher Scientific Officers in the Fish Stock Management Group of the Directorate of Fisheries Research. Both are stationed at the Fisheries Laboratory, Lowestoft.

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THE RELATIONSHIP BETWEEN THE PERCENTAGES OF FAT AND WATER

The relationship between the percentages of fat and water was determined from 83 analyses for mackerel, 74 for pilchard and 182 for sprat. In each case there was a highly significant linear correlation (Table 1).

Table 1 Fat/water relationships for each species (F = % fat, W = % water)

Species	Equation	Correlation coefficient	P
Mackerel	$F = -1.074W + 87.154$	-0.987	< 0.001
Pilchard	$F = -1.087W + 87.607$	-0.981	< 0.001
Sprat	$F = -1.059W + 86.556$	-0.981	< 0.001

The fat/water regressions for mackerel, pilchard and sprat are shown in Figures 2-4. 96% of the variance in the observations is accounted for by the regressions; the confidence limits about the regression lines are therefore so close to the line that they cannot be shown on the graphs.

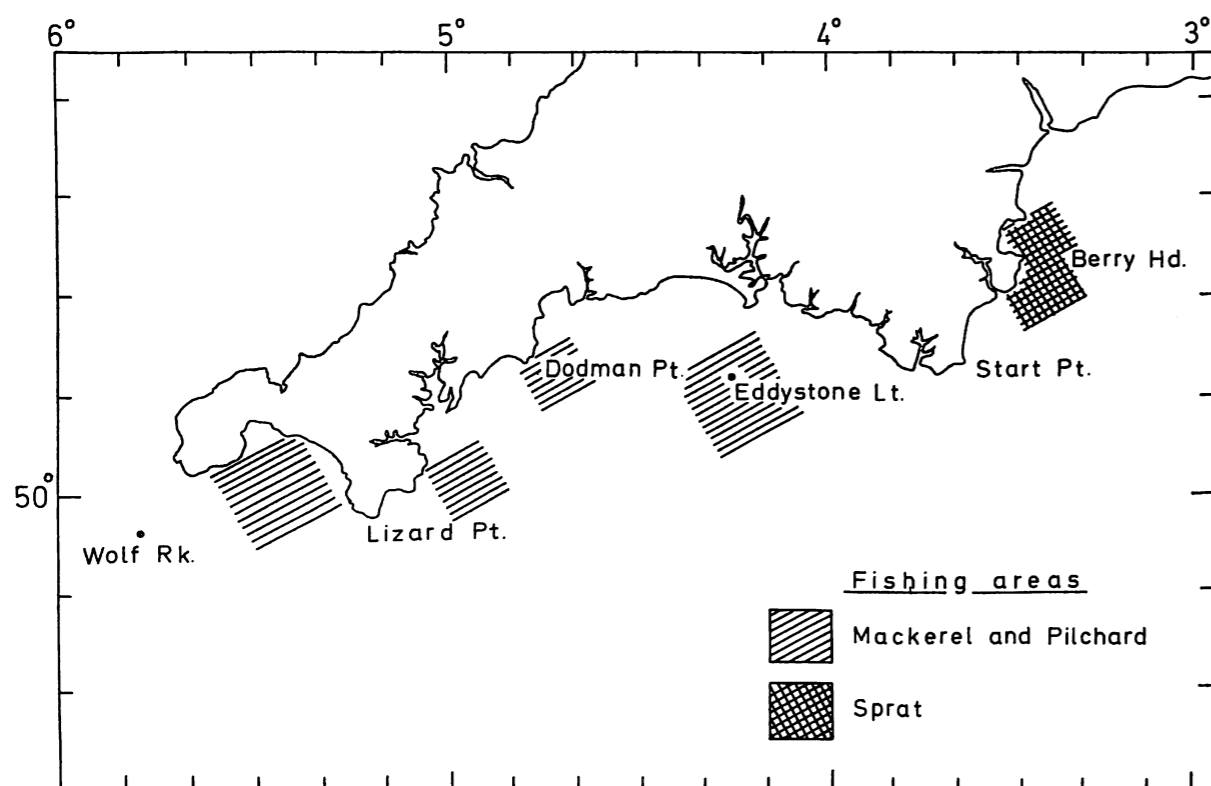


Figure 1 The fishing areas from which samples of fish were obtained.

boiling point below 40°C. After extraction the residue was dried under an infra-red lamp and weighed again. The loss of weight during extraction, i. e. the weight of fat, was expressed as a percentage of the original wet weight.

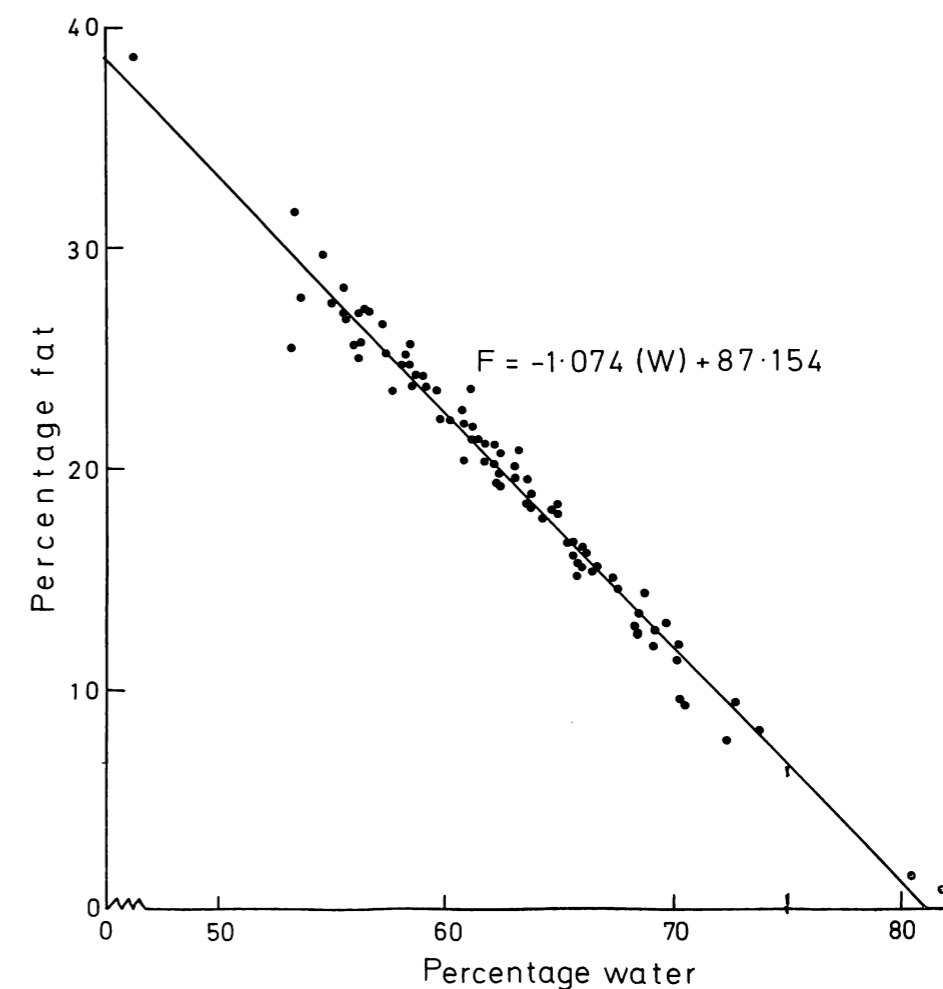


Figure 2 The regression of percentage fat:percentage water for mackerel.

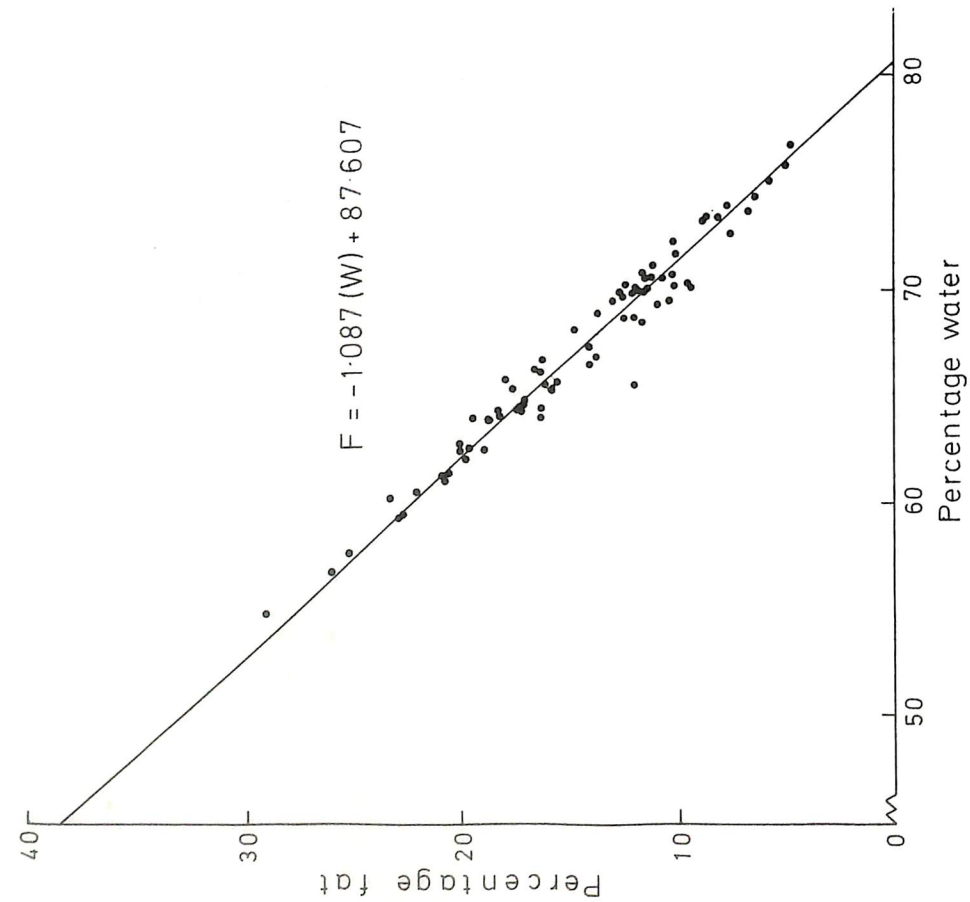


Figure 3 The regression of percentage fat:percentage water for pilchard.

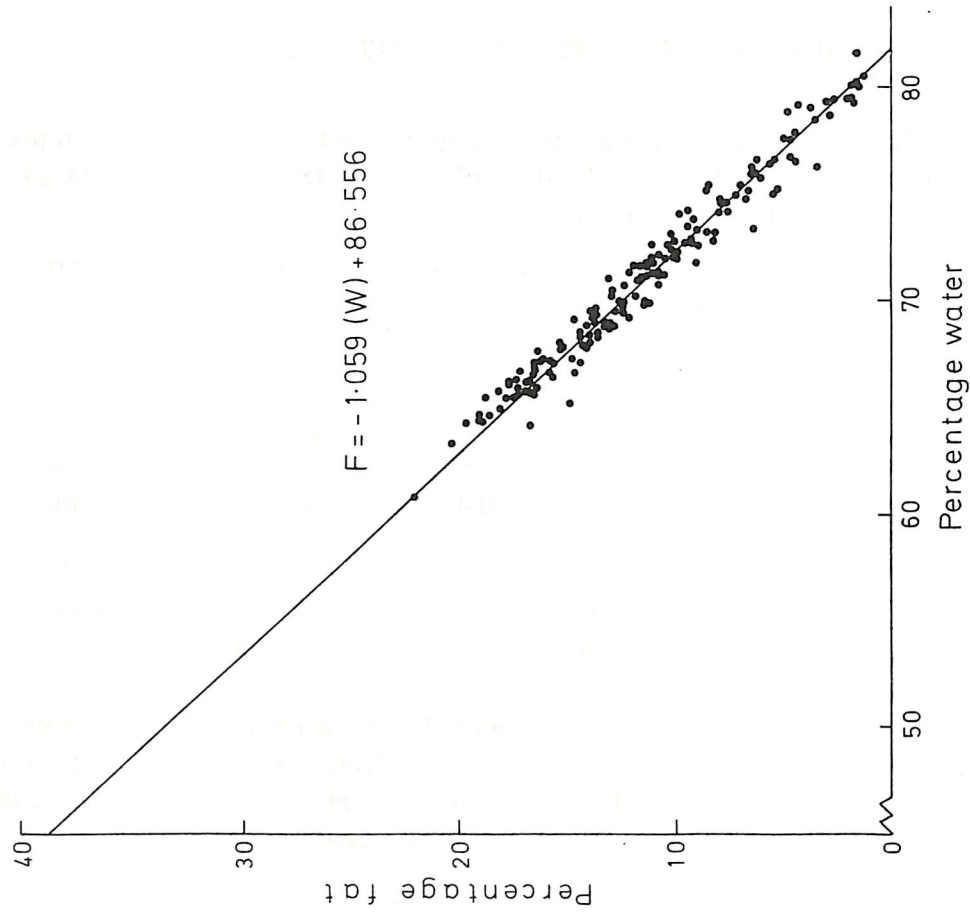


Figure 4 The regression of percentage fat:percentage water for sprat.

An analysis of variance of the three slopes showed that all three regressions can be represented by a common line expressed by the equation

$$F = -1.049(W) + 85.58,$$

in which F = percentage fat and W = percentage water. The percentage fat content of individual mackerel and pilchard and in the case of sprats that of a 10 g sample of several fish of the same length group can therefore be found when only the percentage moisture is known (see Table 2). Hardy and Keay (1972) examined the fat content of Cornish mackerel throughout one year and observed a similar relationship between fat and water content.

Table 2 Percentage fat (with 95% confidence limits) corresponding to different percentage water contents of mackerel, pilchard and sprat

Percentage water	Percentage fat	\leq
50	33.1 ± 0.3	83.1
55	27.8 ± 0.2	82.8
60	22.6 ± 0.1	82.6
65	17.4 ± 0.1	82.4
70	12.1 ± 0.1	82.1
75	6.9 ± 0.1	81.9
80	1.6 ± 0.1	81.6

Higher H₂O
Lower fat

SEASONAL VARIATION IN FAT CONTENT BY SIZE AND MATURITY

Mackerel

The analyses showed that the moisture content and therefore the fat content of mackerel varies with both length and stage of maturity over the year. Average fat contents, with 95% confidence limits, by size category/maturity group of mackerel for each quarter are shown in Figure 5. No data are available for immature medium and large mackerel. The main features are:

1. The fat content of mature and spent fish increases with size within a quarterly period, except in the case of mature fish ¹/₃ qtr. year in the third quarter of the year.
2. The highest fat content is found in spent large fish in the fourth quarter and the next highest in mature large fish in the first and fourth quarters.
3. In general the lowest fat content is found in fish caught in the second quarter of the year, but a notable exception is the case of medium and large mature fish in the third quarter.

There is no minimum fat level for canning mackerel but one of 10% or more is desirable before they are smoked. It is mainly fish which are caught

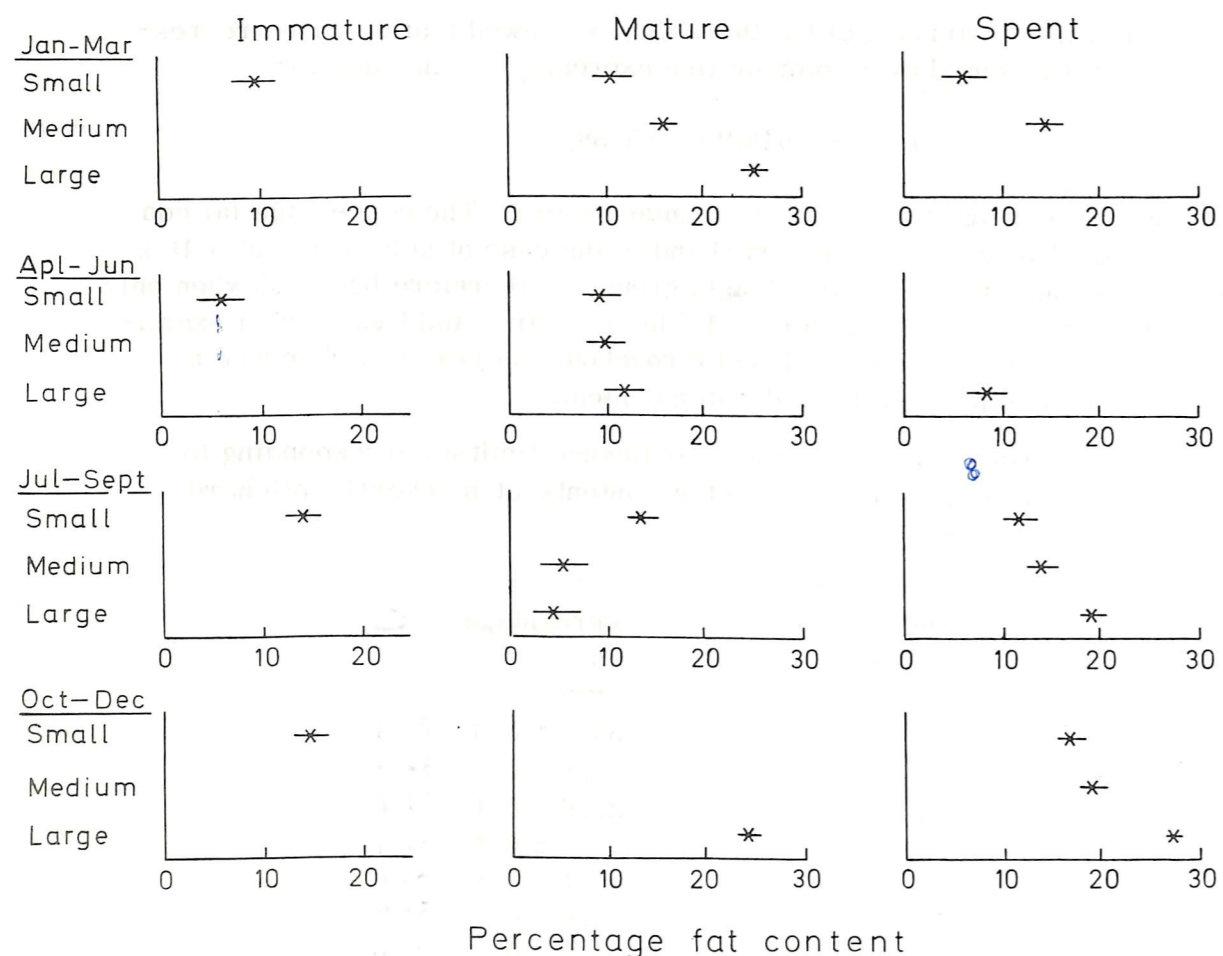


Figure 5 The average percentage fat content of mackerel (with 95% confidence limits) by size and maturity stage.

in the second quarter of the year and medium and large mature fish in the third quarter that are unlikely to meet this requirement.

Pilchard

The fat content of pilchards also varies with both length and stage of maturity over the year. Average fat contents with 95% confidence limits for each size group of mature and spent pilchards for each quarter are shown in Figure 6. The results for immature pilchards are not shown because very few were caught during the period sampled. The main features shown in Figure 6 are:

1. Within any quarter and maturity group fat content decreases with size (the opposite to mackerel) with the exception of the spent fish in the fourth quarter and the mature fish in the first quarter.
2. Within any size/maturity group the highest fat content was found in the third quarter of the year and the lowest in the second quarter, except in the case of large mature fish where the fat content in the first quarter slightly exceeded that in the third.

During a routine examination of fat content of pilchards in May 1974 five large immature pilchards were found with fat contents in the range from 18 to

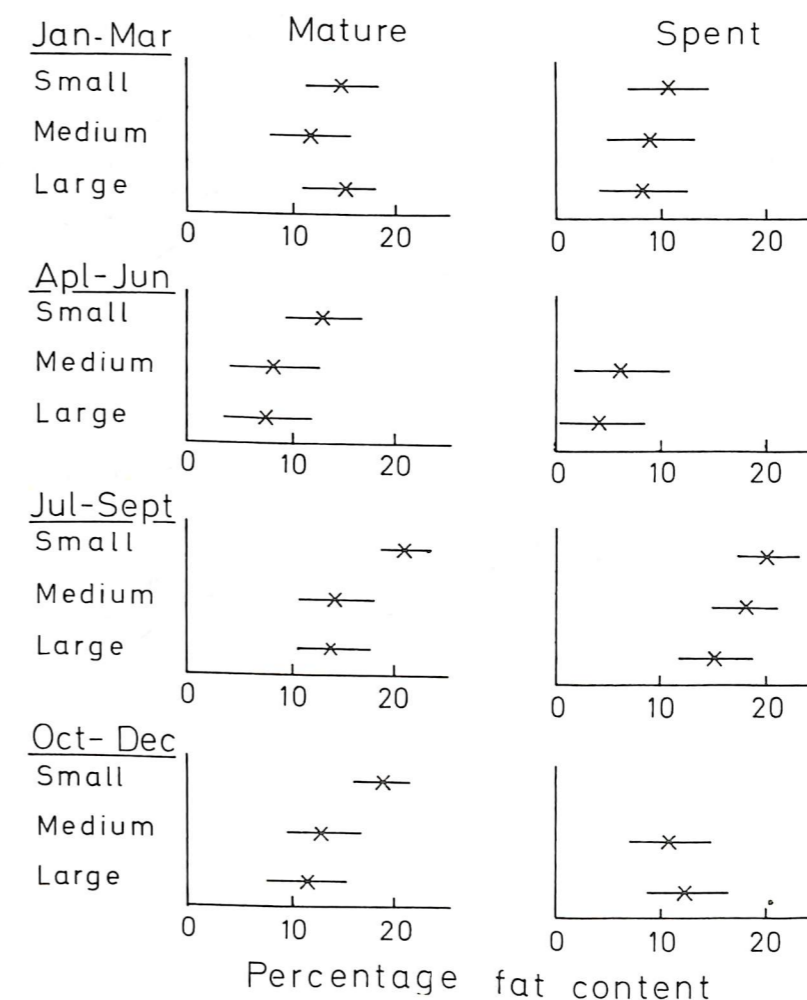


Figure 6 The average percentage fat content of pilchards (with 95% confidence limits) by size and maturity stage.

32%, with an average value of 25%. These pilchards were probably the 'capon' fish noted by Hickling (1945). He described these fish as sterile pilchards in which the gonads had degenerated or even disappeared entirely. It is possible that such fish could be present in the pilchard shoals during May.

Knowledge of the fat content of pilchards is most important for canning for which the minimum requirement is 6%. This requirement is unlikely to be met by medium and large spent fish caught in the second quarter of the year (Figure 6).

Sprat

Torbay fishery

The samples of Torbay sprats analysed for fat content were taken only during the winter months when sprats were being fished commercially. Consequently, only the non-feeding winter phase of their annual fat cycle has been examined, and the results for the 11-15 cm fish in the 1969-70, 1971-72, 1972-73 and 1973-74 seasons are given in Figure 7. They show that within the same shoals the fat content of large fish is higher than that of small fish. Furthermore, the fat content of fish of the same length normally decreases between September and February, but this does not always occur. A sudden

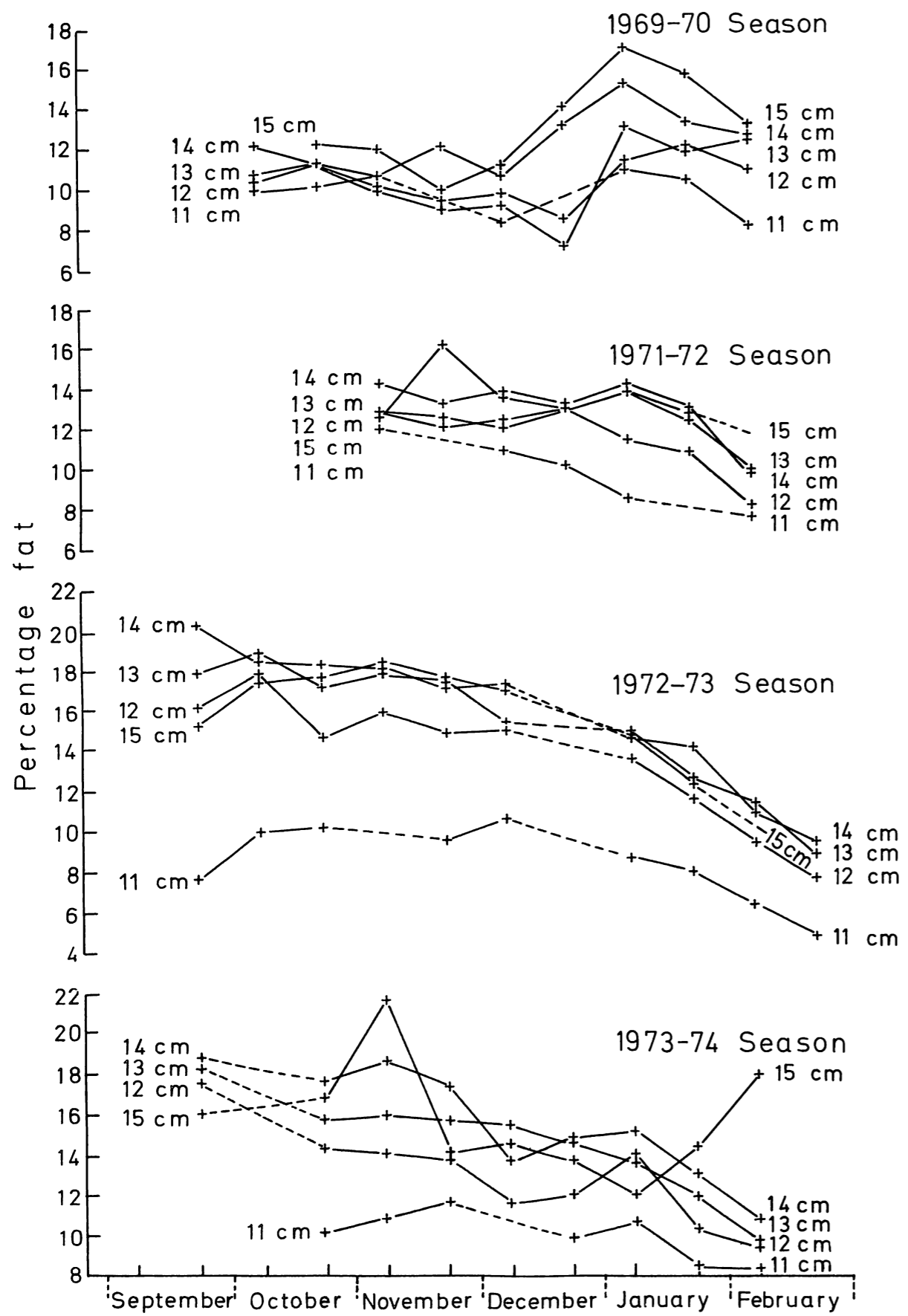


Figure 7 Torbay sprats: the mean percentage fat content of the 11-15 cm fish for 15-day periods over four different seasons.

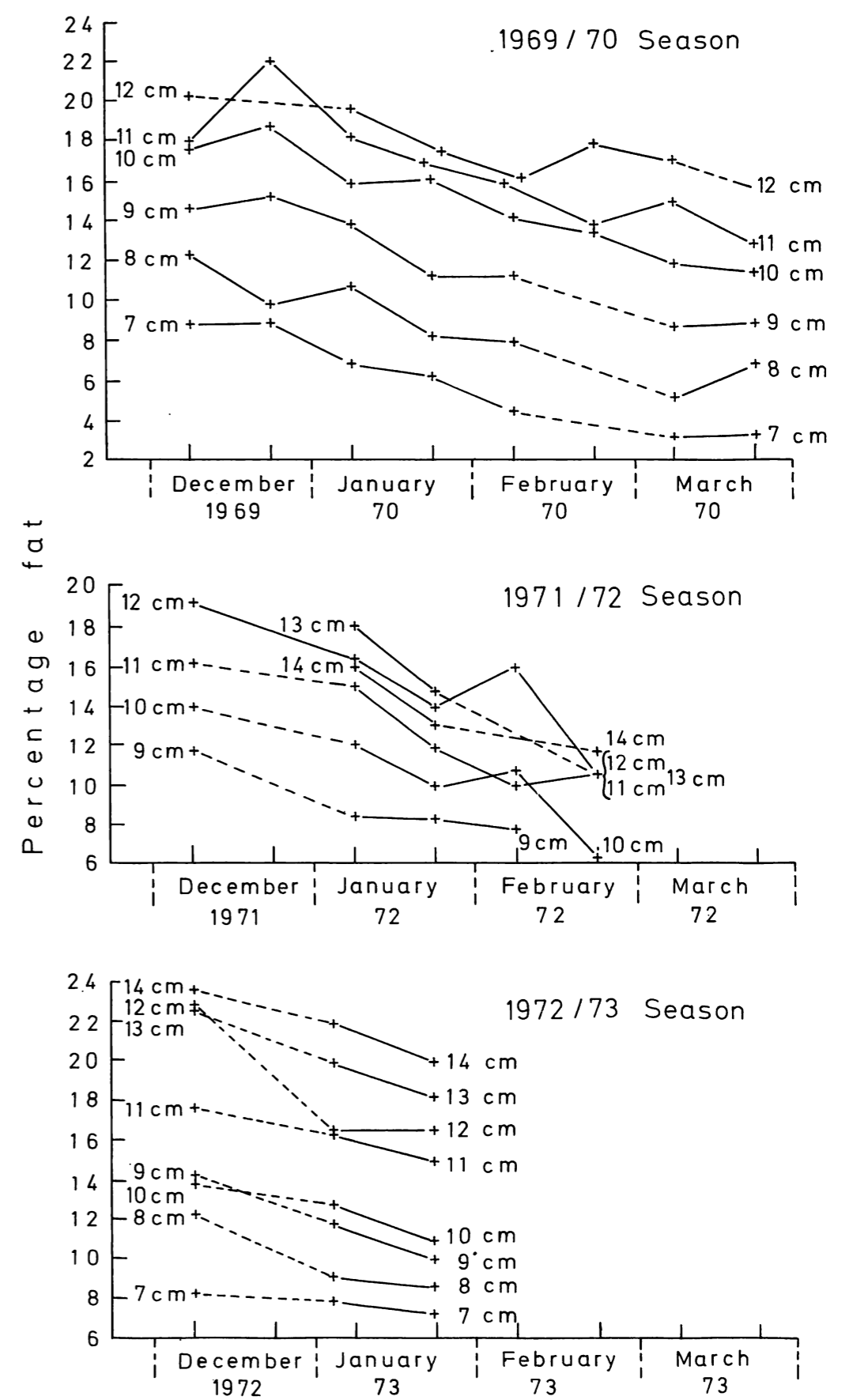


Figure 8 North Shields sprats: the mean percentage fat content of the 7-14 cm fish for 15-day periods over three different seasons.

rise in the fat levels of all length groups occurred between December 1969 and January 1970. This was caused by the entry into the fishery of fish which originated from a different stock. This entry was not evident from visual inspection because they were the same size as those already present in the fishery. A similar rise in the fat levels was observed during the 1966-67 season.

The usual requirements of the processors in the south-west of England are for sprats larger than 10 cm having a fat content higher than 10%. The Torbay sprat fishery normally produces a 'run' of sprats ranging from 10 to 16 cm, with an average length of 13 cm, so this fishery produces sprats that meet the processors requirements over almost the entire period of the fishery.

North Shields fishery

The sprat samples from this fishery analysed for fat content were taken only during the commercial fishery in the winter months of 1969-70, 1971-72 and 1972-73. Thus only the non-feeding phase of their annual fat cycle has been examined and the results for fish between 7 and 14 cm are given in Figure 8. They show that the fat content of large fish is higher than that of small fish and that the fat content of each 1 cm group decreases between December and March.

Some of the sprats caught in this fishery are bought as fresh fish for export to Norway. The requirements of the merchants are similar to those of the processors taking fish from the Torbay fishery, but the 'run' of sprats is usually much smaller ranging from 5 to 16 cm with an average length that varies seasonally from 7 to 12 cm. A large proportion of the catch goes for conversion to meal and oil. Compared with sprats from Torbay, these fish have a lower fat content because most of the fish are smaller. However, sprats with the minimum required fat content of 10% are present throughout the fishery but the fat content of the smallest fish falls below this minimum at the end of the fishery.

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