Seasonal variation in fat content of mackerel (*Scomber scombrus* L.) caught in the western English Channel

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CONTENTS

1. INTRODUCTION

Oil-rich fish which accumulate fat reserves when actively feeding during the summer generally deplete them during sexual maturation, and this is often enhanced by the energy requirements of the migrations that commonly precede or accompany sexual maturation and spawning. Henderson *et al.* (1984) established that, in the period of sexual maturation and spawning of capelin (*Mallotus villosus*), both male and female fish show decreases in muscle fat, amounting to approximately 70% of the amount of fat originally present in January. Ackman and Eaton (1976) show that certain aspects of fat biochemistry in Newfoundland winter herring (*Clupea harengus harengus*) are influenced by the reproductive cycle, in common with other herring from the Atlantic and Pacific Oceans. Thus, these variations are a common feature among pelagic fish and are known by those working in the field also to be true for mackerel. This knowledge has not been published previously in the literature, other than in a very generalised form (Hardy and Keay, 1972; Wallace and Hulme, 1977).

Western mackerel feed little in the winter months, but start feeding intensively in May/June when the main diet consists of copepods. The diet changes towards the end of June when young pelagic stages of fish, augmented with large crustaceans, are eaten. These organisms form the staple food of mackerel until the end of November (Steven, 1949; Walsh and Rankine, 1979). This pattern of feeding behaviour over the year is associated with fat values present in mackerel muscle, and this paper describes how the values can vary with the length, weight and maturity stage of mackerel throughout the year.

2. MATERIALS AND METHODS

Throughout 1973 and 1974, samples of mackerel were taken regularly from commercial landings by boats working out of ports in South Devon and Cornwall. Immediately after landing, they were despatched in ice, in insulated containers, to the Fisheries Laboratory at Lowestoft. The main fishing areas from which the samples came are shown in Figure 1. Samples of mackerel were also collected by MAFF research vessels working in these areas. On arrival at the laboratory, length, sex, maturity stages and weight of each fish were recorded and its age was determined from the otoliths. The maturity stage was assessed by comparison with the scale described by Steven (1952); some fish were also analysed for fat content.

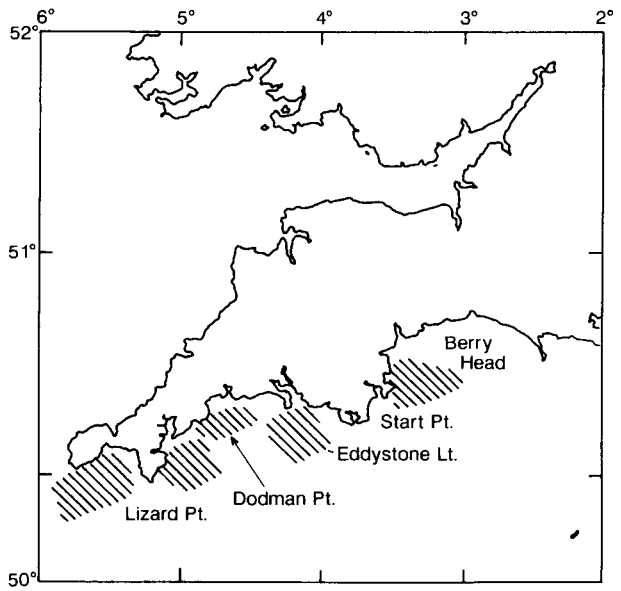

Figure 1. The fishing areas (shaded) from which samples of mackerel were obtained.

For fat analysis, a complete fillet was cut from each side of the fish and resulting fillets, comprising all of the swimming muscles, their covering skin, connective tissue and any adipose tissue present, were cut into pieces before being homogenised in a high-speed blender. After homogenisation, a portion of approximately 12 g of tissue was weighed and then dried to constant weight under an infra-red lamp. The dried tissue was broken into small pieces and placed in a Soxhelet apparatus for 8 h to obtain a fat content. The solvent used was Analar petroleum ether, with a 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.

3. RESULTS

3.1 Fat content by length group

A total of 304 mackerel were examined for fat content. The lengths were grouped as follows: ≤30 cm, 31–35 cm, 36–40 cm and >40 cm. The monthly mean percentage of fat content by length category is shown in Figure 2. The lowest monthly mean value of around 3% was recorded in the smaller fish (≤30 cm) in May. In June/July, a gradual increase in fat values took place, until a peak of 19% was reached in October. Following this peak, a gradual decline in fat values occurred throughout the first four months of the year, with the exception of one fish examined in February. A similar pattern was found in the other three length

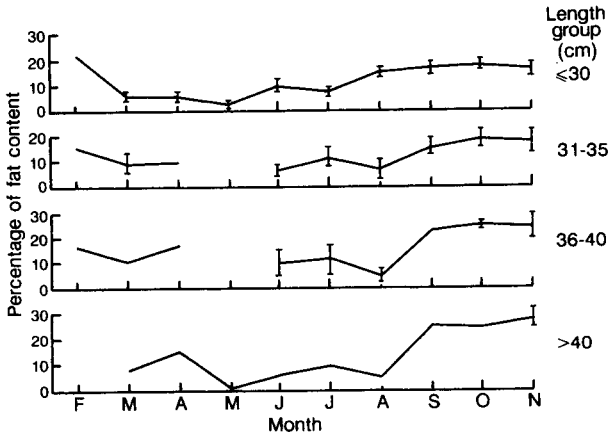

Figure 2. Mean monthly percentage of fat content (± 2 s.e.) of mackerel by length group.

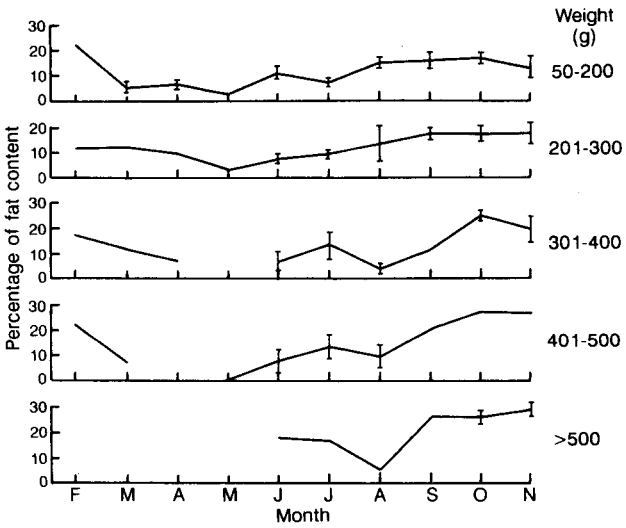

Figure 3. Mean monthly percentage of fat content (± 2 s.e.) of mackerel by weight category.

groups, with the higher fat values being recorded in the larger fish throughout the autumn and winter. Mackerel of 36 cm and above had mean fat values of over 23% from September to November, while mean values of 25% and over were recorded in October and November.

3.2 Fat content by weight

The mean monthly percentage of fat content by weight category is shown in Figure 3. The weights were grouped as follows: 50–200 g, 201–300 g, 301–400 g, 401–500 g and >500 g. The fat values for the lighter fish were low in the early part of the year, ranging from 4% in March to 2.5% in May; after May, there was a gradual increase throughout the rest of the year, with a peak of 17% in October. Similar annual cycles were recorded for fish heavier than 200 g, with the main difference being a sharper rise and fall between the trough (<1–3%) and peak (25–28%) values of the heavier fish. As might be expected from the analyses by length group, the higher fat content was recorded in the heavier fish during the autumn and early winter.

3.3 Fat content by maturity stage

This assessment of the seasonal fat cycle was made independently of size.

The mean monthly percentage of fat content by maturity stage for both sexes combined is shown in Figure 4. The lower fat values for virgin fish were recorded in March/April, while later in the year a gradual rise to 17% was observed in October.

Low mean fat values of 4% were recorded for maturing fish (Stage III) in May and July. Mackerel at this stage of maturation were rarely found in samples between August and December, but they were present in February and March with a mean fat content of 11% and 7%, respectively.

Fish approaching sexual maturity (Stages IV and V) were not present in the samples from August to the end of the year. The highest fat value for these fish

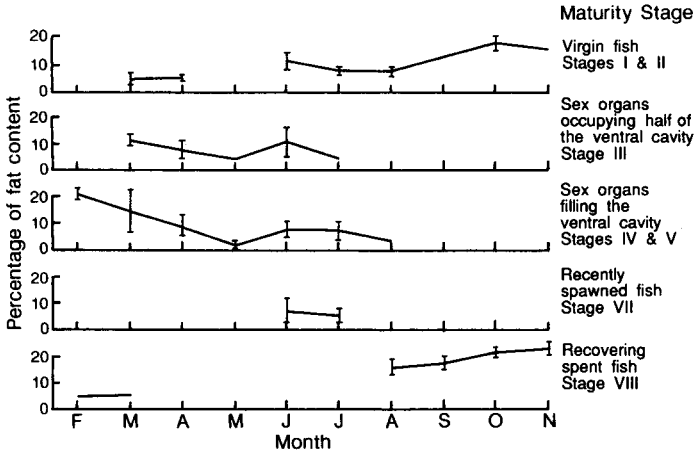

Figure 4. Mean monthly percentage of fat content (± 2 s.e.) of mackerel by maturity stage. Note: There were no samples for Stage VI.

occurred in February, after which time a gradual fall in values, to less than 10%, took place from April to August.

Most of the recently spent fish (Stage VII) were found in the samples from June to August; in June the mean fat content was 6% and in July it was 5%.

The majority of recovering spent mackerel (Stage VIII) were present in the samples from September to November, when the mean fat content was 20%. The few fish found from March to June had a low fat content at this stage of sexual maturity.

4. DISCUSSION

In this investigation, the emphasis was on the fat content of muscle. However, when Hardy and Keay (1972) were studying the chemical composition of Cornish mackerel they recorded the fat content of male and female gonads in winter and early summer (Table 1). Although they did not allot maturity stages to these fish and the number sampled was very small, they nevertheless showed that relatively low fat values occurred in the gonads of both sexes at these times. Their muscle fat values are in broad agreement with those shown in Figure 2 for comparable times of the year.

Table 1. Fat analysis of Cornish mackerel, as a percentage of the weight of tissue (from Hardy and Keay, 1972)

Winter				Summer			
Male 4 fish		Female 2 fish		Male 3 fish		Female 1 fish	
Flesh	Gonad	Flesh	Gonad	Flesh	Gonad	Flesh	Gonad
24.1	4.3	21.6	2.1	9.1	2.1	3.9	4.8

The results in Figure 2 show that the lowest mean fat content for mackerel occurs in May. Feeding resumes in May/June and throughout the summer the fish build up fat reserves, culminating in high mean fat values at the end of the year for fish at each length and weight category. Throughout the winter the fat levels gradually fall, because the mackerel do not feed and are using the fat as an energy store. Moreover, the maturing mackerel begin to move from their wintering areas towards the spawning grounds and, at the same time, the gonads are enlarging in preparation for spawning.

Western mackerel commence spawning in the Celtic Sea and Biscay in March. Spawning continues until July with a peak in May/June (Lockwood *et al.*, 1981). In the southern North Sea and English Channel, spawning starts about mid-May and extends through to August with a peak in June–July (Wallace and Pleasants, 1972; Bainbridge *et al.*, 1974; Iversen, 1977). However, during the period of sampling, some of the mackerel found off Cornwall in the spring were probably destined to spawn in the English Channel and the southern North Sea. These fish were thought to mature to Stages IV and V two to three months later. Consequently, fish which were in maturity Stages IV and V were present from January to July in Cornish waters; some had relatively high fat values throughout the early part of the year, when the mean fat content was 16%. Mackerel in the same maturity stages during the period May–July had a mean fat content of 7%.

Clearly, mackerel which matured to Stages IV and V in winter had a higher mean fat content than those fish at the same maturity stages later in the annual cycle. The latter had lived on their fat reserves throughout the winter and had attained sexual maturity before feeding commenced in earnest. It was likely that those mackerel in maturity Stages IV and V during the period January–March would have spawned in the Celtic Sea, while those fish at similar stages in May–July would probably have spawned in the English Channel and the southern North Sea. Bolster (1971) concluded that there were two groups of maturing mackerel present in the southwest fishery in most years during the period 1960–1968 – an early group between March and July and a later one in August and September. He interpreted this as being two groups of fish, each of which had spawned a month or so before entering the fishery – one in April and the other in August. He further suggested that the April group spawned in the Celtic Sea in March and the August group in the southern North Sea and, to a lesser extent, the English Channel before returning to Cornish waters in August/September.

From August to September, most of the mackerel in the southwest fishery were either virgin Stage I or Stage II fish, with the fat content being relatively high in both groups throughout this period. The fat cycle of the virgin fish was very similar to that of the smaller fish, as might be expected. The larger, heavier fish, which comprise the most mature individuals, had the highest fat content (it is possible that they use this for reproductive development). However, it is clear that the seasonal fat cycle of mackerel is not simply tied to the maturation cycle, as fish at all stages of maturity follow virtually the same seasonal pattern.

Mackerel have undergone considerable changes in their migration and distribution since the work presented here was originally undertaken. During the late 1960s and early 1970s, the North Sea stock was very healthy and supported a large commercial fishery. The North Sea stock was interacting with

the Western stock in the English Channel during the summer months, before spawning commenced on their respective spawning grounds. Their behaviour pattern is now quite different. During the early 1980s, a northwestward shift in the overwintering grounds took place (Walsh and Martin, 1986), and mackerel now overwinter to the north and northeast of Scotland, with just a juvenile component of the stock resident off Cornwall in the winter months. Any mixing of the North Sea stock with the Western stock on the main feeding and overwintering grounds off Scotland is now insignificant, as the spawning stock was last estimated to be only 78,000 tonnes (in 1990) compared to 2 million tonnes of the Western stock (Anon., 1991).

5. REFERENCES

ACKMAN, R. G. and EATON, A., 1976. Variations in fillet lipid content and some percent lipid iodine value relationships for large winter Atlantic herring (*Clupea harengus harengus*) from south eastern Newfoundland. J. Fish Res. Bd Can., ***33***: 1634–1638.

ANON., 1991. Report of the Mackerel Working Group. ICES CM 1991 Assess: 19, 90 pp. (mimeo).

BAINBRIDGE, V., COOPER, G. A. and HART, P. J. B., 1974. Seasonal fluctuations in the abundance of the larvae of mackerel and herring in the north eastern Atlantic and North Sea. pp. 159–169. *In* J. H. S. Blaxter (ed.), The Early Life History of Fish. Springer-Verlag, Berlin, Heidelberg and New York, 765 pp.

BOLSTER, G. C., 1971. Mackerel of the south-west. Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft, (23): 1–18.

HARDY, R. and KEAY, J. N., 1972. Seasonal variations in the chemical composition of Cornish mackerel, *Scomber scombrus* (L.), with detailed reference to lipids. J. Fd Technol., ***1***: 125–137.

HENDERSON, R. J., SARGENT, J. R. and HOPKINS, C. C. E., 1984. Changes in the content and fatty acid composition of lipids in an isolated population of the capelin *Mallotus villosus* during sexual maturation and spawning. Mar. Biol., ***78***: 255–267.

IVERSEN, S. A., 1977. Spawning, egg production and stock size of mackerel (*Scomber scombrus* L.) in the North Sea 1968–1975. ICES CM 1977/H: 17, 19 pp. (mimeo).

LOCKWOOD, S. J., NICHOLS, J. H. and DAWSON, WENDY, A., 1981. The estimation of a mackerel (*Scomber scombrus* L.) spawning stock size by plankton survey. J. Plankt. Res., ***3***: 217–233.

STEVEN, G. A., 1949. Contributions to the biology of the mackerel, *Scomber scombrus* L. II. A study of the fishery in the south-west of England, with special reference to spawning, feeding and fishermen's signs. J. mar. biol. Ass., UK, ***28***: 555–581.

STEVEN, G. A., 1952. Contributions to the biology of the mackerel *Scomber scombrus* L. III. Age and growth. J. mar. biol. Ass. UK, ***30***: 561.

WALLACE, P. D. and HULME, T. J., 1977. 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. Fish. Res. Tech. Rep., MAFF Direct. Fish. Res., Lowestoft, (35): 1–10.

WALLACE, P. D. and PLEASANTS, C. A., 1972. The distribution of eggs and larvae of some pelagic fish species in the English Channel and adjacent waters in 1967 and 1968. ICES CM 1972/J: 8, 4 pp. (mimeo).

WALSH, M. and MARTIN, J. H. A., 1986. Recent changes in the distribution and migrations of the Western mackerel stock in relation to hydrographic changes. ICES CM 1986/H: 17, 19 pp. (mimeo).

WALSH, M. and RANKINE, P., 1979. Observations on the diet of mackerel in the North Sea and the west of Britain. ICES CM 1979/H: 45, 8 pp. (mimeo).