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SEASONAL CATCHES, SIZE AND MERISTIC DATA FOR SPRAT, *SPRATTUS SPRATTUS*, IN THE SEVERN ESTUARY

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(Figs. 1–2)

Samples collected at regular intervals from the intake screens of power stations have been used to provide data on various aspects of the biology of sprat in the Severn Estuary between November 1973 and June 1977. Young sprat took approximately 4 months to pass from spawning regions outside the central Bristol Channel to inshore areas in the inner Severn Estuary. The influx into this latter region of these new 0+ recruits (minimum standard length 26 mm) produced a pronounced peak in catches in either August or September, while a secondary peak between January and March was due to the immigration of larger and older fish (80–143 mm). 0+ sprat did not increase markedly in size between the autumn and following spring, with the result that the modal standard length was still only *ca.* 50 mm at the end of the first year of life. The copepod parasites, *Lernaeenicus sprattae* (Sowerby) and *Lernaeenicus encrasicola* (Turton), were found on the eyes of 3·2 % of sprat and on the dorsal surface of 0·3 % of sprat respectively. Meristic characters for the Severn Estuary population are compared with those recorded for sprat in other parts of Europe.

INTRODUCTION

While the sprat, *Sprattus sprattus* (L.), may live for up to a total of six years, at the end of which time the total length can exceed 150 mm, the fishery in British waters is based primarily on the second, third and fourth year classes (Robertson, 1936, 1938; De Silva, 1973). Historically, the sprat was a major contributor to the fishery of the Bristol Channel and Severn Estuary (Matthews, 1933; Lloyd, 1942). Although this fishery has declined during recent decades, the sprat has remained an important component of the teleost fauna of the region. This point is illustrated by the observation that *S. sprattus* was by far the most abundant of all teleosts in plankton samples taken throughout the Bristol Channel between the spring and autumn of 1974 (Russell, 1980). While length–frequency data were provided by Russell (1980) for these recently spawned sprat and there is comparable information for those sprat which form the basis of the commercial fishery in the Bristol Channel (Lloyd, 1942), no such data are available for those members of the population which are known sometimes to enter the Severn Estuary in considerable numbers (Lloyd, 1941). Indeed, the only relatively detailed studies of sprat in British estuaries are apparently those of Huddart & Arthur (1971) in the Thames and van den Broek (1979) in the Medway. Even in the former of these cases, however, the authors recognize that their sampling regime did not collect the smaller fish.

Large numbers of fish were collected from the intake screens of power stations in the Severn Estuary during the mid-1970s. An analysis of the resultant data on such features as size, numbers, gonadal condition and otolith annuli has yielded much useful information on seasonal movements and abundance, size and age composition, growth and breeding time of populations of such species as northern rockling, *Ciliata septentrionalis* (Collett); twaite shad, *Alosa fallax* (Lacépède); herring, *Clupea harengus* L.; river lamprey, *Lampetra fluviatilis* (L.); bass, *Dicentrarchus labrax* (L.) and also two mugilids and various gadoids (Claridge & Gardner, 1977, 1978; Titmus, Claridge & Potter, 1978; Abou-Seedo & Potter, 1979; Claridge & Potter, 1983, 1984, 1985).

The present study utilized samples of sprat taken from power stations in the Severn Estuary to provide data on the abundance and size composition of *S. sprattus* in this environment at different times of the year. These data have been related to those recorded for eggs, larvae and postlarvae by Russell (1980) and Williams (1984) to ascertain the timing of the movement of young fish from their spawning grounds in the outer Bristol Channel to nursery areas within the estuary. Comparisons have also been made between various aspects of the biology of sprat in the Severn Estuary with those described for this species in other estuaries (Huddart & Arthur, 1971; van den Broek, 1979) and in Scottish sea lochs (De Silva, 1973), and between the meristic characters of the Severn population and those recorded for sprat elsewhere in Europe (Molander, 1940; Bowers, 1949; Poulsen, 1950; Lindquist, 1968).

MATERIALS AND METHODS

Sprat were collected from the intake screens of power stations at Oldbury and Berkeley in the inner Severn Estuary and from Uskmouth, which is located on the River Usk 1 km from its confluence with the outer Severn Estuary. [N.B. Since the terms Severn Estuary and Bristol Channel have frequently been used inconsistently in the literature, the terms outer and inner Severn Estuary and outer, central and inner Bristol Channel used in this paper follow the delineation of these regions given by Radford & Joint (1980).] Samples of sprat were collected weekly from Oldbury (48 collections per year) between November 1973 and June 1977, weekly from Berkeley between September 1974 and June 1977 and monthly from Uskmouth between October 1975 and June 1977. Each weekly Oldbury sample represents the number of sprat collected over 24 h. A correction factor has been employed to adjust, where necessary, the fish numbers to correspond to a daily water intake of $2 \cdot 2 \times 10^9$ l, the volume that passed through the screens between the autumn and spring when the station was under maximum load and the largest collections of teleosts were taken. Because the trash baskets were emptied at irregular intervals at Berkeley and Uskmouth, the sprat samples for these stations represent collections over variable periods of time.

The standard length and wet weight of all sprat were recorded to the nearest 0·1 mm and 0·1 g. Randomly selected subsamples of these fish were used for measurements of total length and the following meristic characters: number of vertebrae (including the urostyle), number of keeled scutes between the throat and origin of pelvic fin (K1) and between the origin of the pelvic fin and vent (K2), and the number of both anal and dorsal fin rays.

RESULTS

Seasonal trends in catches

The numbers of *S. sprattus* collected from Oldbury during the mid-1970s showed a pronounced peak in either August or September, a feature which was particularly marked in 1974 and 1975 (Fig. 1). Thus monthly catches (expressed as mean catch per day) reached maximum values of 51 in August 1974, 37 in August 1975 and 8 in September 1976. Since these represent mean daily values, the corresponding total number of sprat in the above three months would have been approximately 1581, 1147 and 240 respectively. There was a marked tendency for a second but smaller peak in numbers to occur in January, February or March (Fig. 1). This feature was most evident in January 1975 and February 1976, when the mean daily catches were 17 and 27 respectively. The numbers of sprat at Oldbury were low in the late spring and early summer. This point is emphasized in the data for 1974 by the absence of sprat from each of the four samples collected in June (Fig. 1).

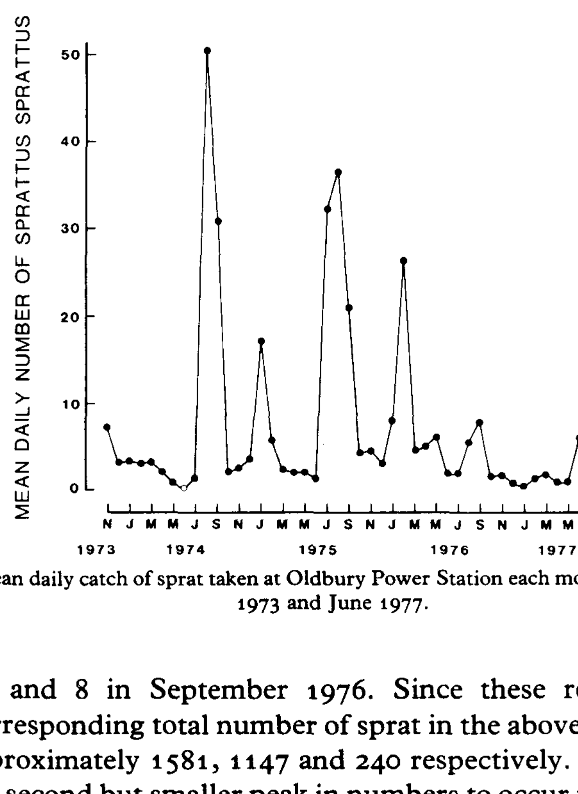

Fig. 1. The mean daily catch of sprat taken at Oldbury Power Station each month between November 1973 and June 1977.

The total numbers of sprat at Oldbury in the 48 samples collected between 1 July and the following 30 June were 484 in 1974/75, 614 in 1975/76 and 120 in 1976/77. These values would be equivalent to a total annual catch of approximately 3680, 4669 and 913 respectively.

Length–frequency data

The relatively large numbers of sprat which appeared in the Oldbury samples of August 1974, after a three-month period when very few had been taken (Fig. 1), produced a sharp modal length class at 40–44 mm (Fig. 2). An examination of the otoliths of a subsample of 60 sprat caught in the estuary in August demonstrated that most of the fish taken from this region at this time were in the first year of life. A pronounced modal length class at 40–44 mm was conspicuous in each of the following three histograms covering the period up to March 1975.

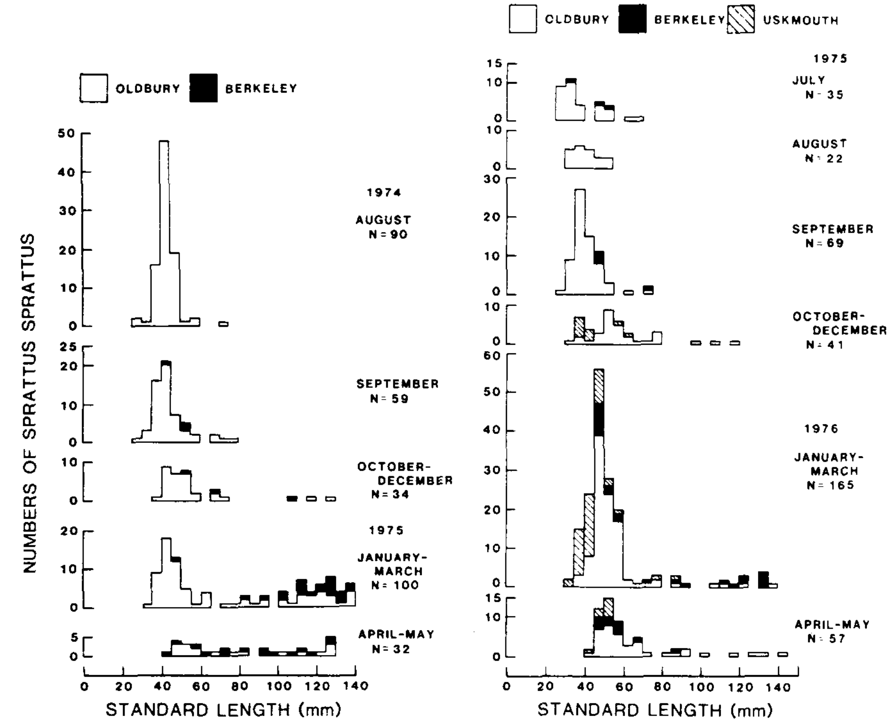

Fig. 2. Length–frequency histograms for sprat (*Sprattus sprattus*) collected from (left) Oldbury and Berkeley Power Stations between August 1974 and April/May 1975; (right) Oldbury, Berkeley and Uskmouth Power Stations between July 1975 and April/May 1976.

Sprat with standard lengths greater than 80 mm started appearing in October–December 1974 and increased in numbers between January and May 1975. Otoliths taken from a subsample of 30 such fish indicated that these larger sprat were more than one year old. While sprat as small at 26 mm were taken in August 1974, no fish less than 40 mm appeared in the samples between April and May 1975. In the first five months of 1975, the percentage of larger sprat (> 80 mm) was greater in samples from Berkeley than Oldbury (81·1 vs 34·7 %).

The trends shown by the length–frequency histograms for samples from Oldbury between July 1975 and May 1976 were similar to those just described for the corresponding months in the previous year (Fig. 2). The well-defined modal length class for the smaller fish did increase, however, in this year, rising from 30–34 mm in July 1975 to 50–54 mm in April/May 1976 (Fig. 2). While the proportion of sprat with lengths greater than 80 mm at Berkeley was less between

January and May 1976 than in the same months in 1975, it was still greater than at Oldbury (40·7 vs 10·6 %).

Although the samples between July 1976 and May 1977 were considerably smaller than during the same months in the two previous years (Fig. 1), the trends shown by the length–frequency histograms were comparable with those already described. Thus small sprat (< 30 mm) appeared in July and numbers of larger sprat (> 80 mm) became evident after September. As in 1976, the main modal length class in April–May 1977 was 50–54 mm.

The smallest and largest sprat caught in the estuary had standard lengths of 26 mm (≡ 0·08 g) and 143 mm (≡ 31·4 g) respectively.

Meristic data

The mean (±95 % confidence limits and range) for the number of keeled scutes between the throat and origin of pelvic fin (K1) and between the origin of the pelvic fin and vent (K2) of 60 sprat caught in the estuary was 21·7 (±0·20, 20–23) and 11·5 (±0·19, 10–13). The comparable values for anal and dorsal fin rays were 18·8 (±0·26, 17–20) and 16·4 (±0·25, 15–18), while for the number of vertebrae it was 48·2 (±0·21, 47–50).

The above mean for number of vertebrae is slightly greater than that for sprat from Manx waters (Bowers, 1949) and the west coast of Scotland (De Silva, 1973) but within the range of means provided for many localities off Scandinavia (Molander, 1940; Poulsen, 1950; Lindquist, 1968). While the above mean for the K2 of Severn sprat is similar to that given by De Silva (1973), the mean number of both anal and dorsal fin rays is slightly less than his minimum comparable means for sprat in Scottish waters. Although values for confidence limits were not given by De Silva (1973), it would appear from his figures that his means did not differ significantly from those recorded for the Severn population. The mean value for K2 in fish from the Severn is very similar to those recorded by Poulson (1950) for the Skagerrak and Kattegat, but much lower than the values given for this latter region by Lindquist (1968).

Incidence of parasites

The copepod parasite, *Lernaeenicus sprattae* (Sowerby), was present on the eyes of 3·2 % of 661 sprat examined. This incidence level lies within the range of 0·7–6·6 % recorded for sprat in the Tamar and Medway Estuaries (Leigh-Sharpe, 1935; Sproston & Hartley, 1941; van den Broek, 1979), but is much lower than the 30·7 and 74·2 % found respectively in the same species in the River Crouch (Harding & Wheeler, 1958) and at Leigh-on-Sea (Robertson, 1938). The closely related *Lernaeenicus encrasicola* (Turton) was present in the mid-dorsal region of only a small proportion of sprat (0·3 %) in the Severn Estuary, thereby paralleling the situation found by van den Broek (1979) in the Medway Estuary and Sproston & Hartley (1941) in the Tamar Estuary. A much higher infestation by *L. encrasicola* (6·4 %) was found by Harding & Wheeler (1958) in sprat from the River Crouch.

DISCUSSION

This study has shown that sprat are almost invariably present in the Severn Estuary throughout the year, as they also are in the Medway Estuary in south-eastern England (van den Broek, 1979; Wharfe, Wilson & Dines, 1984). Direct comparisons cannot be made with the seasonal abundance given by Hardisty & Huggins (1975) for Oldbury in the inner Severn Estuary between mid-1972 and mid-1973 because the samples used to obtain these data were later shown also to contain twaite shad and herring (R. J. Huggins, personal communication). Our data also demonstrate that the numbers in the inner Severn Estuary show consistent seasonal variations. The marked increase in the numbers of small sprat between July and September represents the influx of the new young of the year, a situation paralleling quite closely that recorded for the estuaries of both the Medway (van den Broek, 1979) and the Thames (Robertson, 1936, 1938; Huddart & Arthur, 1971). This is also the period when in 1970 and 1971 the new 0+ sprat accumulated in Scottish sea lochs and associated inshore marine waters (De Silva, 1973). The 0+ sprat from these lochs in August and September had mean total lengths ranging from approximately 45 to 70 mm (De Silva, 1973). The standard lengths corresponding to the bottom end of this range are similar to the modal classes for the standard length of sprat caught at Oldbury in August and September of 1974 (40–44 mm) and 1975 (35–39 mm). The maximum length of the sprat at Oldbury in these months never exceeded those of samples of 0+ sprat taken in Scottish sea lochs in the same months.

Estimates of time taken for sprat to reach the shallows at Oldbury in the estuary depend on ascertaining the breeding season. Data on plankton haul catches recorded by Russell (1980) suggest that spawning in 1974 was initiated in April. This view is based on the absence of young sprat in samples from early April and the observation that all the large numbers of small sprat taken from several localities in mid-April were either larvae or very early postlarvae. The presence of similar stages amongst the large samples of young sprat in the following two months and of sprat eggs in samples as late as June (Williams, 1984) suggests, however, that the spawning season may be relatively protracted. Such a view is consistent with the situation in the North Sea and English Channel (Robertson, 1936). Our estimate of an April–June spawning period agrees with that recorded for this species by Wheeler (1969).

From the pattern of distribution shown by Russell (1980) and Williams (1984) for larval fish in mid-April and by Russell (1980) for young fish in mid-May and mid-June, it can be concluded that in 1974 sprat spawned predominantly in waters outside the central Bristol Channel and that the resultant progeny then gradually dispersed towards inshore and estuarine habitats. Russell's data showed that some young fish appeared near the Holm Islands at the junction of the inner Bristol Channel and outer Severn Estuary in mid-June 1974, and our results demonstrate that the shallow waters at Oldbury started to be colonized by small sprat in early August of the same year. Assuming that these first arrivals at the above locations were the products of the first part of the spawning period, they had taken just over two months to each the Holm Islands and a further seven weeks to enter the shallow waters of the inner Severn Estuary, a further 45 km upstream.

While the majority of the postlarvae in the 1974 plankton hauls in the Bristol Channel measured 10–15 mm in mid-May and 14–21 mm in mid-June, a few slightly larger fish with total lengths of 27–34 mm were taken in the latter period (Russell, 1980). These larger fish, which are probably of the size at which a movement towards inshore or estuarine regions commences (Russell, 1980), are only slightly shorter than those fish whose lengths are shown at the bottom end of the standard length–frequency histograms for sprat from Oldbury.

The absence of a marked shift in the modal length of the 0+ year class of sprat taken at Oldbury between the autumn and following spring is similar to the situation recorded by Robertson (1936) for the Thames Estuary and by De Silva (1973) for Scottish sea lochs. The modal total length (obtained from the relationship between total length and standard length) for sprat in the inner Severn Estuary in April after approximately 12 months growth was *ca.* 55 mm. This value is slightly less than that recorded by van den Broek (1979) for sprat in the Medway Estuary and below the lower end of the mean total lengths (*ca.* 60–80 mm) found in Scottish sea lochs at the same time of the year (De Silva, 1973).

The influx of considerable numbers of sprat with standard lengths > 80 mm into the inner Severn Estuary between January and May, which results in the production of the second peak in numbers each year, contrasts with the relatively few such larger sprat collected from the Medway Estuary by van den Broek (1979) at this or at any other time of the year. However, it does parallel the situation found in Scottish sea lochs during the winter and early spring (De Silva, 1973). Most of the larger sprat in this latter environment at this time were approaching the end of their second, or less commonly, their third year of life, as is also the case in the Severn. The marked decline in the abundance of the older fish in the Severn during the spring presumably reflects their migration towards marine spawning grounds. Comparable movements away from inshore areas have been observed by Robertson (1936) and De Silva (1973). These latter studies also demonstrated that sprat do not mature until they are at least 70 mm in total length and are more than one year old. Since small fish also declined in numbers in the Severn Estuary during the spring and summer, they apparently show a tendency to mimic the spawning movements of older fish. The presence of a greater relative number of larger fish (> 80 mm standard length) in samples from Berkeley, where the water is drawn from the deep mid-water channel, than from the nearby Oldbury station, where the water comes from more inshore and shallow regions, presumably reflects the tendency for clupeids to move into deeper water with increasing size and age (Parrish & Saville, 1965; Dragesund, 1970; De Silva, 1973).

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