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SPAWNING AND DEVELOPMENT OF THE NEW ZEALAND SPRAT, *SPRATTUS ANTIPODUM* (HECTOR)

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ABSTRACT

In the Marlborough Sounds region the New Zealand sprat spawns from July to January. Females of 86mm body length are mature and contain up to 4,000 ripe eggs. Fertilised eggs are free-floating and measure between 0.81 and 1.10mm in diameter. They are spherical, with a small perivitelline space and a segmented yolk with no oil globule. Eggs hatch after about four days in water of temperatures between 11° and 13°C. Larvae are sparsely pigmented, with a convoluted intestine and posteriorly placed anus. Metamorphosis to juvenile sprats involves a marked increase in pigmentation and deepening of the body.

INTRODUCTION

While investigating the biology of the New Zealand pilchard, *Sardinops neopilchardus* (Steindachner), in the Marlborough Sounds during 1966, I obtained samples of adult specimens of the sprat, *Sprattus antipodum* (Hector), which were in ripe breeding condition. Eggs stripped from these fishes were identical to some containing developing embryos which had been collected shortly before from a plankton tow.

Confirmation that the eggs from the plankton tow were those of *Sprattus* was provided by rearing them through hatching to an early larval stage, and comparing the larvae with a series through to adults built up from other plankton samples.

Species of the clupeoid genus *Sprattus* are coastal and estuarine fishes found in the north-eastern and south-western Atlantic Ocean, and in the waters of southern Australia, Tasmania, and New Zealand (Svetovidov, 1952). They are fished commercially only in the waters close to Europe. Although the spawning and development of the European species have been extensively studied (see Fage, 1920; Lebour, 1921; and Russian references in Svetovidov, 1952), little is known about the breeding of the southern hemisphere species.

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Two species, *S. antipodum* (Hector) and *S. muelleri* (Klunzinger), have been described from New Zealand, but the identity of the latter species is uncertain and it may be a synonym of *S. antipodum* according to Svetovidov (1952). Most New Zealand records of the sprat are from the east coast, and indicate that it ranges at least from the Bay of Islands in the north (my collection) to Foveaux Strait in the south (Young and Thomson, 1926). It also occurs at the Auckland Islands (Baker, 1972). In the Marlborough Sounds region the sprat occurs throughout the year in small schools, either homogeneous or mixed with anchovies (*Engraulis australis* (White)) and/or pilchards of similar size.

MATERIALS AND METHODS

The plankton sample containing developing sprat eggs was obtained near the southern end of Tory Channel, Queen Charlotte Sound, at 1545 hrs on July 27, 1966. A 1m diameter nylon plankton net of 0.6mm mesh size was towed for 15 minutes between 0 and 30m in water with a surface temperature of 11°C. Amongst the catch were 118 clupeoid-type eggs which were transferred to jars of fresh sea-water and kept under observation (the water temperature varied between 11°C and 13°C during observations). A few were fixed in formalin at intervals of about 12 hrs, so that a series of developmental stages through to hatching was obtained.

Sixteen adult specimens of *S. antipodum* measuring between 86mm and 112mm body length (= standard length) were collected from a 1in mesh nylon gill net set near the surface in the Bay of Many Coves, Queen Charlotte Sound, at 2000 hrs on the same day as the plankton tow was made. Twelve specimens were females and four were males; some of the females exuded small quantities of colourless eggs when lightly stripped, but no sperm emerged from the males when similarly treated. The eggs were observed fresh and then fixed in 5% formalin as were the fishes.

RESULTS

I. Eggs from the adult females.

Eggs stripped from the sprat ovaries were spherical and between 0.90 and 1.00mm in diameter. They were almost completely filled with translucent, closely packed yolk globules, giving the whole yolk a coarsely granular or segmented appearance. No oil globule was present. Samples dissected from the ovaries consisted of two kinds of cells: small (0.1 - 0.3mm), irregularly shaped, translucent cells, and large (0.5 - 1.0mm), rounded, yellowish cells. The small cells were very numerous and formed interstitial packing between the larger cells. The large cells contained yolk, and some were translucent like those stripped from the fish at sea (Fig. 2). Evidently the largest cells were eggs about to be spawned, for their diameters were almost the same as the fertilised eggs collected from the plankton. Ovary samples of the large eggs showed a progression of egg diameter modes for sprats at slightly different stages of maturity—samples from three fish are plotted in Fig. 1 for comparison with the diameters of the planktonic eggs.

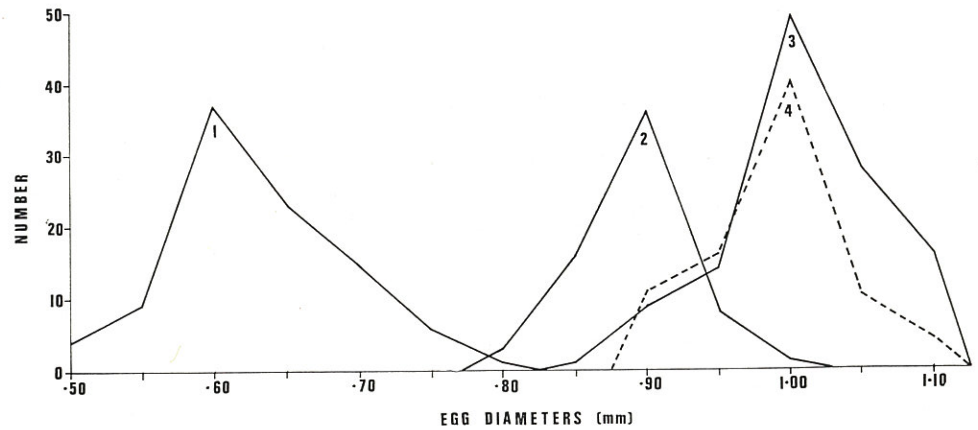


Fig. 1: Frequency of diameters for samples of **Sprattus antipodum** eggs from ovaries of three specimens (solid-line polygons, 1-3), and from plankton tow (broken-line polygon, 4).

Counts of large eggs indicated that between 3,000 and 4,000 were present in each pair of ovaries.

Following the July catch, sprats with well developed ovaries and testes (stages 4-5, see Baker, 1972, p.19) were taken in the Sounds again in August, September, and October of 1966; and in January, 1967, one ripe/running female sprat was caught in Pelorus Sound. This indicates that the spawning season is a lengthy one, extending over seven months. Fishes with long spawning seasons are often fractional spawners, releasing their eggs intermittently throughout the season. Many clupeids spawn in this way (see Ivanova, 1949 and Naumov, 1956) and their ovaries are characterised by the presence of very small, non-developing eggs, and eggs in several different phases of development. Measured samples from such ovaries show multimodal egg diameter frequencies.

The New Zealand sprat, however, has only two size-groups of eggs in the ovaries—usually a characteristic of total spawning over a short period. While it is possible that the small size-group of eggs may develop to maturity after the large size-group and be released later in the spawning season, it is more likely that the long spawning season is due to different individuals, or broods of individuals, becoming mature at different times. The New Zealand sprat is, therefore, probably not an extended fractional spawner (nevertheless, the fishes could spawn intermittently over a short period of perhaps several days).

II. Eggs from the plankton.

The developing eggs collected from the plankton tow ranged in size from 0.81 to 1.10mm, with a mean diameter of 0.98mm. They were spherical with a smooth transparent vitelline membrane, and (initially)

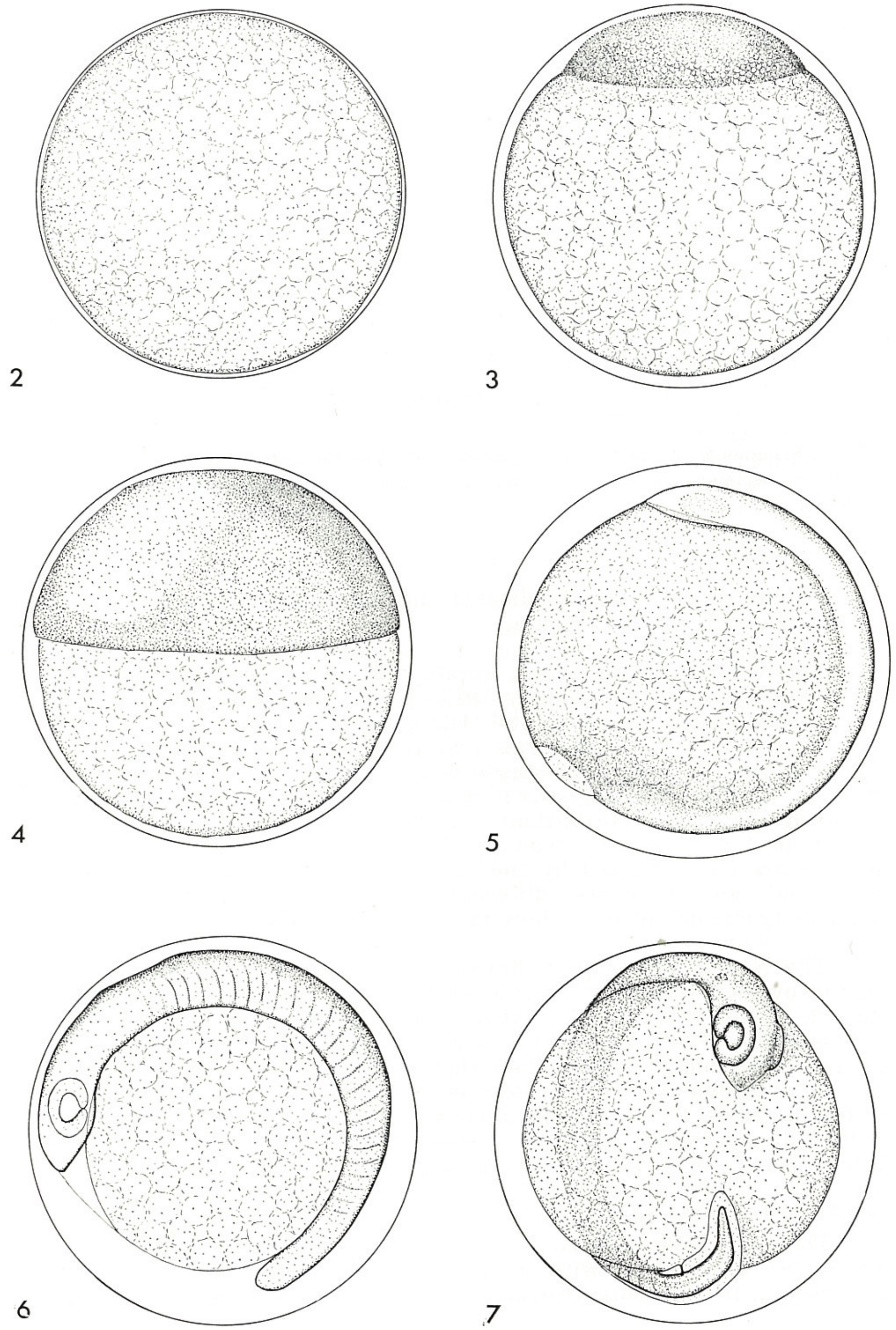


Fig. 2: Unfertilised egg from **Sprattus antipodum.** Figs. 3-7: Stages in the development of sprat eggs—3, at capture, blastodermal cap stage; 4, 12-14 hrs after capture, blastula formation; 5, 45-48 hrs, blastopore closure; 6, 55-60 hrs, somites developing; 7, 72 hrs, tail separation.

a small (0.005 - 0.01mm) perivitelline space. The yolk was large, segmented, and there was no oil globule.

During development the yolk decreased in size and the perivitelline space widened. The living eggs sank to the bottom of the containers, indicating a high specific gravity.

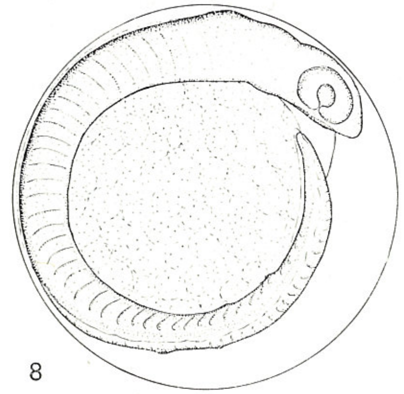
Stages in the development of the eggs are illustrated in Figs. 3 - 9. The earliest stage present in the plankton sample already possesses a many-celled blastodermal cap which forms a prominent dome on the yolk (Fig. 3). Other stages present show the eccentric development of the blastocoele and the surrounding of the blastoderm by the germ ring (Fig. 4), culminating in the formation of the embryonic keel and closure of the blastopore (Fig. 5). Figures 6 and 7 show that as the embryo lengthens and thickens, somites develop in the middle part of the body, and the optic vesicles become prominent. As the tail begins to separate from the yolk the dorsal and ventral fin folds form. A characteristic clupeoid feature appears with the formation of the intestine—a posteriorly placed anus, which can be seen as a small indentation in the ventral fin fold near the tail. With the increasing size of the embryo the diphycercal tail lengthens and begins to curl around the yolk (Figs. 7 and 8), and by the time hatching is imminent, it has curled beyond the head parallel to the body axis (Fig. 9). In the late embryonic stages somites develop posterior to the anus, and sensory neuromast organs appear as slight protruberances along the flanks towards the tail. At hatching the egg capsule is ruptured by the flexing embryo, which then escapes headfirst (Fig. 9).

Eggs at the blastodermal cap stage were separated from the rest of the sample immediately they were recognised, and their development monitored. Twenty-four hours after capture the blastoderm had covered about two-thirds of the yolk and the embryonic shield was just visible. At 48 hrs the blastopore had closed, and the head and tail regions of the embryo had become differentiated from the surrounding tissue. After 72 hrs the embryo was well formed, with somites present in the middle of the body, and the tail had separated from the yolk and begun to curl towards the head. The embryos began hatching at about 90 hrs, and by 98 hrs all had hatched.

Assuming that the blastodermal cap-stage eggs were only a few hours old, it then appears that the sprat takes about 4 days to hatch at temperatures between 11° and 13°C.

III. **Development of the larvae.**

At hatching, the yolk-sac larvae measure between 2.5mm and 3.2mm body length. They show the typical clupeoid characteristics of a slender, sparsely pigmented body, a posteriorly placed anus, and coarsely granular yolk. The head of the young larva is still curved over the yolk, and the mouth is not yet developed. The fin folds are smooth-outlined and erect, with a slight constriction at the anus. Dendritic melanophores develop along the dorsum either side of the fin fold, and as the larva grows they



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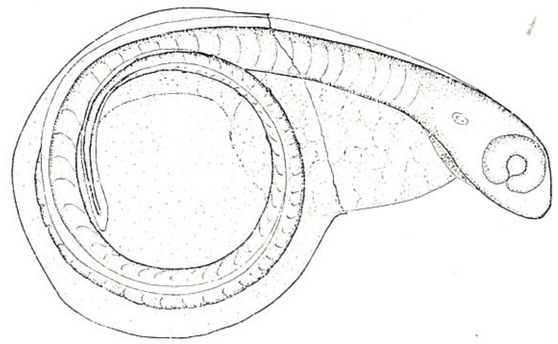

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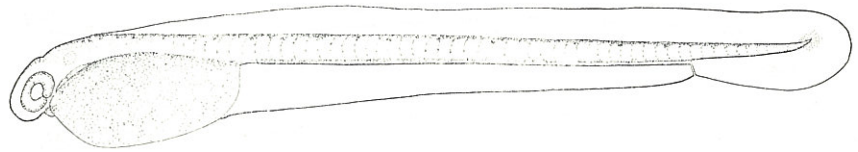

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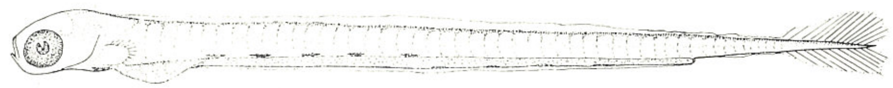

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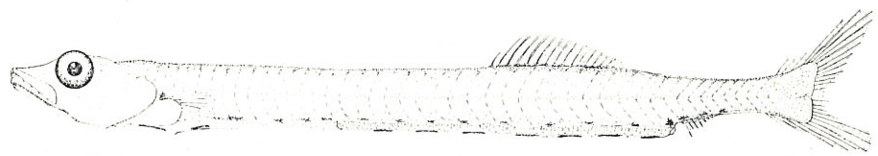

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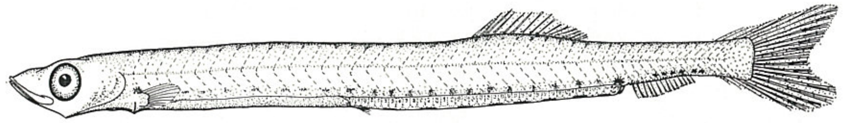
Figs. 8-9: Final stages of development and hatching of the sprat embryo—8, 80-86 hrs, tail lengthening; 9, 90-98 hrs, hatching. Fig. 10: Sprat yolk-sac larva measuring 4.0mm b.l. Figs 11-13: Sprat larva measuring 4.7mm, 8.5mm, and 12.0mm b.l., respectively.

migrate down the flanks to a position level with the dorsal side of the abdomen anterior to the pylorus, and along the ventral edge of the intestine posteriorly (Figs. 10 and 11). At about 4.7 - 5.0mm body length the yolk sac is very reduced, the mouth forms terminally, and the caudal and pectoral fin lepidotrichia develop. The slenderness of the body is



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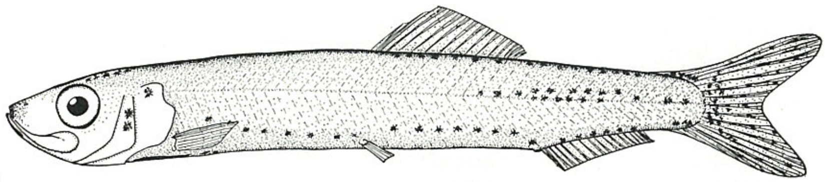

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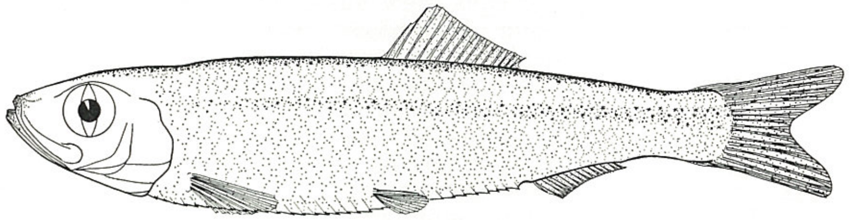

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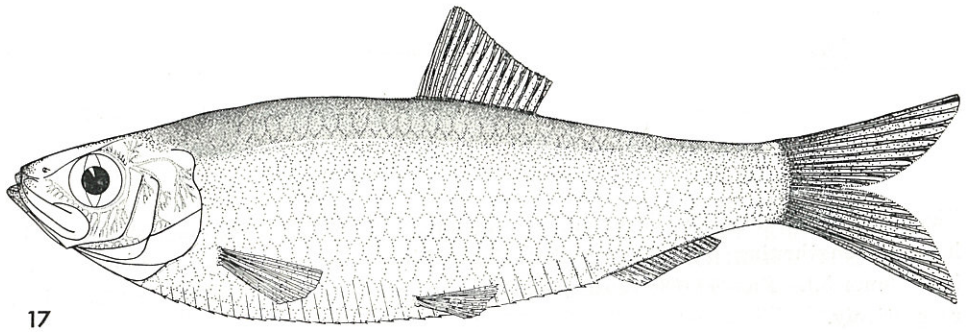

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Fig. 14: Post-larval sprat measuring 19.5mm b.l. Fig. 15: Late post-larval sprat of 31.0mm b.l. at beginning of metamorphosis. Fig. 16: Juvenile sprat of 43.0mm b.l. in advanced metamorphosis. Fig. 17: Adult sprat measuring 125.0mm b.l.

accentuated by a decrease in height of the fin folds relative to the body depth (Fig. 11).

By 7.0 - 9.0mm body length (Fig. 12) the yolk sac has been completely absorbed and the mouth has assumed its functional shape. The dorsal fin is prominent by 8.0mm, and the intestine is tightly convoluted, with a row of superficial melanophores above its dorsal side. There is also a single melanophore just above the origin of the pectoral fin. The notochord turns dorsally and the hypurals develop at about 12mm. The anal fin also appears at this length, and the tail assumes a slightly heterocercal shape (Fig. 13). At 19.0mm pelvic fins arise alongside the pyloric region of the gut (Fig. 14), and the full complement of vertebrae (44 - 46) are evident in stained specimens. The tail is now homocercal.

Changes in pigmentation and body form take place when the sprat metamorphoses from post-larva to juvenile at body lengths between 30 and 50mm (Figs 15-18). The colour change begins with silver pigment developing on the sides of the head and the opercula, and spreading along the flanks. The whitish-silver colour covers all but the dorsal one-quarter or one-fifth of the flanks before the dark pigment becomes fully developed along the dorsum. As the silver spreads, a multiple row of melanophores extends from the caudal peduncle along the middle of the flanks to the top corner of the opercula; melanophores also appear along the dorsum, in the caudal rays, and around the tip of the snout (Fig. 16). As the lateral melanophores are over-coloured by silver pigment, the dorsal strip

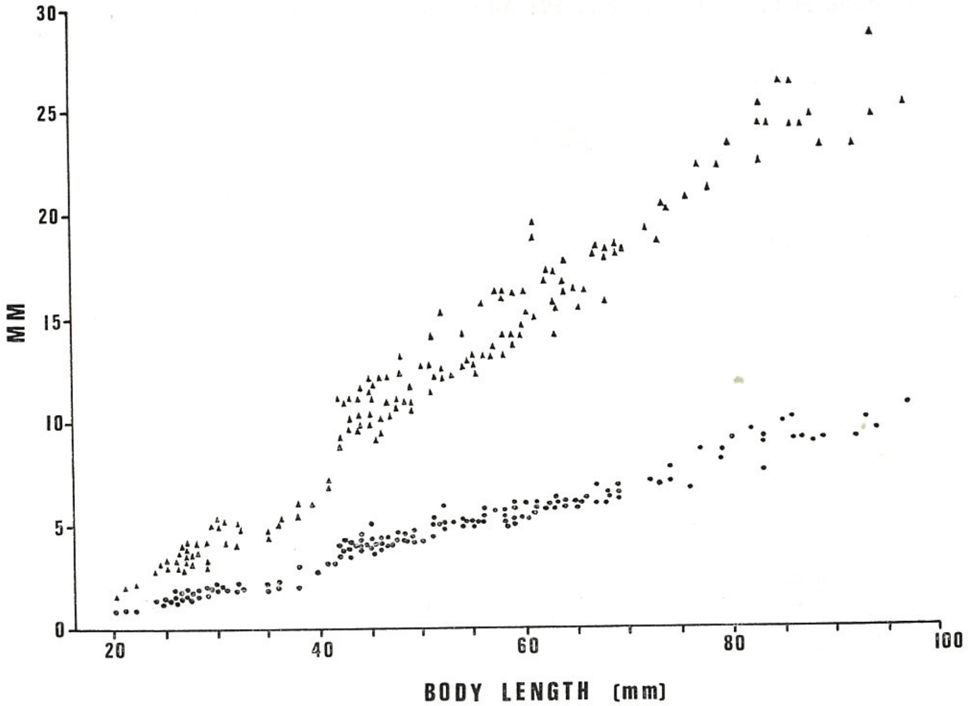

Fig. 18: The changing proportions of the sprat body during metamorphosis 30-50mm b.l.) and subsequent growth. Triangles represent greatest depth of body, dots represent greatest thickness of body (n = 134).

gradually becomes darker until it reaches the adult bluish-grey. The flanks and belly remain whitish-silver.

During the colour change the body deepens markedly, becomes laterally compressed (Fig. 18), and the ventral edge of the belly becomes noticeably curved and armed with enlarged, pointed scales which give it a serrated appearance (Fig. 17). There is also considerable migration of fins and the anus along the long axis of the body during late post-larval life; the pelvic fins migrate backward over two myotomes (17th - 18th), the dorsal fin migrates forward over seven myotomes (25th - 18th), and the anus migrates forward over four myotomes (35th - 31st).

DISCUSSION

The eggs of *Sprattus antipodum* can be distinguished from all other non-clupeoid eggs in New Zealand waters by a combination of their size, segmented yolk, small perivitelline space, and absence of an oil globule. Although the eggs of the other two New Zealand clupeoids have segmented yolks, they are very distinctive and cannot be confused with those of the sprat: anchovy eggs are elongate-oval and measure 1.06 - 1.20mm by 0.48 - 0.56mm (Marlborough Sounds collection); they have no oil globule. Pilchard eggs are spherical with a diameter range of 1.32 - 1.70mm (Baker, 1972). They have a wide (0.65 - 0.85mm) perivitelline space and the yolk contains a single oil globule.

The sprat and anchovy yolk-sac larvae are almost impossible to separate: their yolks lack oil globules and their body form is practically identical. The sprat larva appears to be slightly longer, and to have more pigment, than the anchovy larva at hatching, but I have insufficient material of the anchovy to support these apparent differences. Identification of the post-larvae of New Zealand clupeoid fishes has been dealt with in an earlier publication (Baker, 1972).

The eggs and larvae of the New Zealand sprat closely resemble those of the North Sea sprat, *Sprattus sprattus* L., in both morphology and development (see Fage, 1920 and Lebour, 1921).

The discovery of a long breeding season for *S. antipodum* confirms a suggestion to this effect by Morgans (1966), who made a detailed statistical study of the size distribution in a shoal of over 2,000 sprats stranded near Kaikoura. His results showed non-normal length distribution within year-classes, indicating that the sample consisted of mixed broods of sprats which were the result of a prolonged breeding season.

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LITERATURE CITED

BAKER, ALAN N., 1972. Reproduction, early life history, and age-growth relationships of the New Zealand pilchard, **Sardinops neopilchardus** (Steindachner). **N.Z. Marine Department Fisheries Research Bulletin,** No. 5, 64pp.

FAGE, L., 1920. Engraulidae. Clupeidae. **Report of the Danish Oceanographic Expedition to the Mediterranean, 2, Biology,** (9), 140pp.

IVANOVA, S. A., 1949. The change of the gonads of the Brazhnikov herring in connection with the ripening of the sexual products. **Vestnik Moskovskogo gosudarstvenogo universiteta,** 9 (in Russian).

LEBOUR, M. V., 1921. The larval and post-larval stages of the pilchard, sprat and herring from Plymouth district. **Journal of the Marine Biological Association United Kingdom,** 12: 427-57.

MORGANS, J. F. C., 1966. Possibilities raised by a study of the size distribution in a sample of sprats, **Sprattus anipodum** (Hector). **Transactions of the Royal Society of New Zealand (Zoology),** 8 (13): 141-7.

NAUMOV, V. M., 1956. The ovogenesis and ecology of the sexual cycle of the Murmansk herring **(Clupea harengus harengus** L.). **Special Scientific Report, Fisheries** No. 327, U.S. Fish and Wildlife Service, 1959: 203-61. (Translation from Russian.)

SVETOVIDOV, A. N., 1952. Clupeidae. In **Fauna of U.S.S.R.,** Vol. 2 (1). Zoological Institute of the Academy of Sciences of the U.S.S.R. Moscow. (Translated from the Russian and published by Israel Program for Scientific Translations, Jerusalem, 1963, 428pp.)

YOUNG, M. and THOMSON, G. M., 1926. Occurrence of pilchards and sprats in New Zealand seas. **Transactions of the New Zealand Institute,** 57: 314-9.