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SPRAT IN NORWEGIAN WATERS, A SHORT REVIEW OF BIOLOGY, FISHERY AND CURRENT RESEARCH

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INTRODUCTION

Comprehensive accounts of sprat (Clupea sprattus) and sprat fishery in Norway are lacking. This shortcoming has been noticed by fisheries scientists undertaking studies of sprat in the North Sea area.

Published literature on sprat, including reports from Norwegian waters, are listed in the useful bibliography by LINDQUIST (1966). Reviews and summaries were given at the symposium on sprat in 1968 (LINDQUIST 1969, 1970a).

In the absence of a more complete report a short, general outline of biology, fishery, catch and current biological research on sprat in Norwegian fjords is presented in the following.

BIOLOGY

The sprat is common in the fjords of southern Norway from Oslo to Trondheim. Further north, it is much less numerous, but has been taken northward to Narvik (68° N). The distribution is restricted to the coastal waters only.

Spawning takes place over wide areas and extends through several months. A series of investigations in Norwegian waters (SUND 1911, GUNDERSEN 1954 and DANNEVIG 1954, 1956) have shown that the sprat spawn in the Oslofjord, the fjords of western Norway south of Stad and in the Trondheimsfjord. These fjord areas are, however, of less importance compared to the extensive spawning in the inner Skagerakk (HØGLUND 1938 and LINDQUIST 1961, 1970b). Generally, the number of sprat eggs per unit volume of water is 20 - 60 times greater in the Skagerrak - Kattegat area than in the fjords of western Norway. Sprat eggs have been found in the fjords from April to July, but the major spawning takes place in June.

Several studies indicate that the main part of the sprat stock in the fjords originates from the spawning areas in the inner Skagerrak (SUND 1911, BJERKAN 1950, LJØEN 1962 and BAKKEN 1966). The sprat larvae are transported, in water of Baltic origin, by the coastal current to the Oslofjord area and to the fjords of western Norway. Spawning locally seems to be important for the recruitment only in the inner Oslofjord, certain fjord branches in western Norway and the Trondheimsfjord.

During July sprat larvae 20-25 mm in length are caught in the upper 25 m along the southwest and west coast of Norway. In August-September the length has increased to 4-5 cm and young sprat are found in the outer parts of the fjords. During autumn these O-group sprat penetrate further into the fjords and are often noticed in small school in the upper water layers near the shore. The growth ceases in November-December at a length of 6-9 cm, and the sprat remain at intermediate depths in the fjords during winter. The acivity and feeding increases again in April-May. In June, then one year old, the sprat is on an average 10 cm in length. At the same time the two-year-olds are about 11.5 cm.

The sprat stock in Norwegian waters is in summer dominated by the one-year-olds. Older sprat normally constitute less than 20% of the stock in the fjords of western Norway, somewhat more on the Skagerrak coast and in the Oslofjord. Sprat older than three years are scarce and usually found only in enclosed bays and fjord branches.

The sprat becomes mature at two years of age, but mature one-year-olds are occationally observed. The fat content of the sprat undergo seasonal variations with a minimum in March and a maximum about September. Typical values are: March 5.0 %, June 7.5 %, September 14.0 %, December 9.0 %.

The long period of spawning and differences within and among the fjords in available zooplankton as food results in great variations in size and condition of the sprat, even within the same age group and geographical area. Variations from year to year in stock size and in the distribution of the sprat along the coast are also observed. This is linked with the age structure dominated by a single year class, and very likely also with abiotic factors, especially variations in direction, speed and strength of the coastal current.

Migrations of sprat within fjord systems have been studied by tagging (GUNDERSEN 1959, 1960, 1961, 1962, 1963). During summer the sprat remained within a limited area or migrated to the inner parts of the larger fjords. Tagging of mature sprat in order to detect a possible spawning migration from western Norway to the North Sea or Skagerrak have failed to yield any results. Echo surveys in the fjords during winter have shown that O-group sprat entering the larger fjords during autumn migrate very little in winter (BAKKEN 1971). Diurnal, vertical migrations associated with formation of schools in daytime and dispersion at night are typical of the summer half of the year.

The sprat in Norwegian waters belong to more than one population unit, but the relative proportion of these units is not known. Morphometric methods have proved to be doubtful for identification of seperate units of sprat (DANNEVIG 1951 and LINDQUIST 1968). Serological studies

(NÆVDAL 1968, 1969, 1970) have shown that the sprat in Norwegian coastal waters demonstrate great variations in sample composition, and only part of the coastal samples coincide with samples from the inner Skagerrak.

FISHERY

The stock of one year old sprat forms the basis of the fishery. In some years and some areas, e.g. the Oslofjord, the two-year-olds add to the catches, and under favourable conditions the sprat can be utilized in the O-group stage in autumn.

The fishing season usually starts June 1 and goes on until October-November. Best catches are obtained in June and August. About 80% of the total catch is taken on the west coast and the rest in the Oslofjord area. Nearly all is now taken by purse seine, and about 100 larger seiners participate. Typically, these seiners are 60 ft overall length, has a crew of 7 and operates a seine of knotless netting 200 fms in length and 40 fms in depth. The net is set from the aft part of the seiner and hauled back by help of a hydraulic power block. Both the seiner and a small, 20 ft, scouting and towing boat are equipped with echo-sounders or sonar.

Individual catches vary from about 5 to 60 tons and the sprat is transferred alive from the seine to holding nets anchored near shore. From August on artificial light is used to attract the sprat. A small boat with an electric generator and up to 15 halogen lamps of 1 kW each is used. Usually the light is on all night and the seine set around the boat in early morning.

The sprat is taken from the holding nets to transport vessels; being shipped either fresh in boxes with ice for immediate production or frozen in blocks onboard refrigerated vessels at the fishing locality for storage and later production. In the last years about 80% of the catch has been frozen onboard the 6 specially constructed vessels.

CATCH

Since the fishery is based mainly on a single year class, the yield is to a large extent determined by the strength of this year class. Other factors seem to have minor influence on the total yield. The weather does not effect the fishery much because it takes place in sheltered areas, the market conditions fluctuate very little as there is a steady demand for sprat and the number of vessels participating has been rather constant over a long period. Consequently, a direct relationship probably exist between the amount of available one-year-old sprat and the total annual catch.

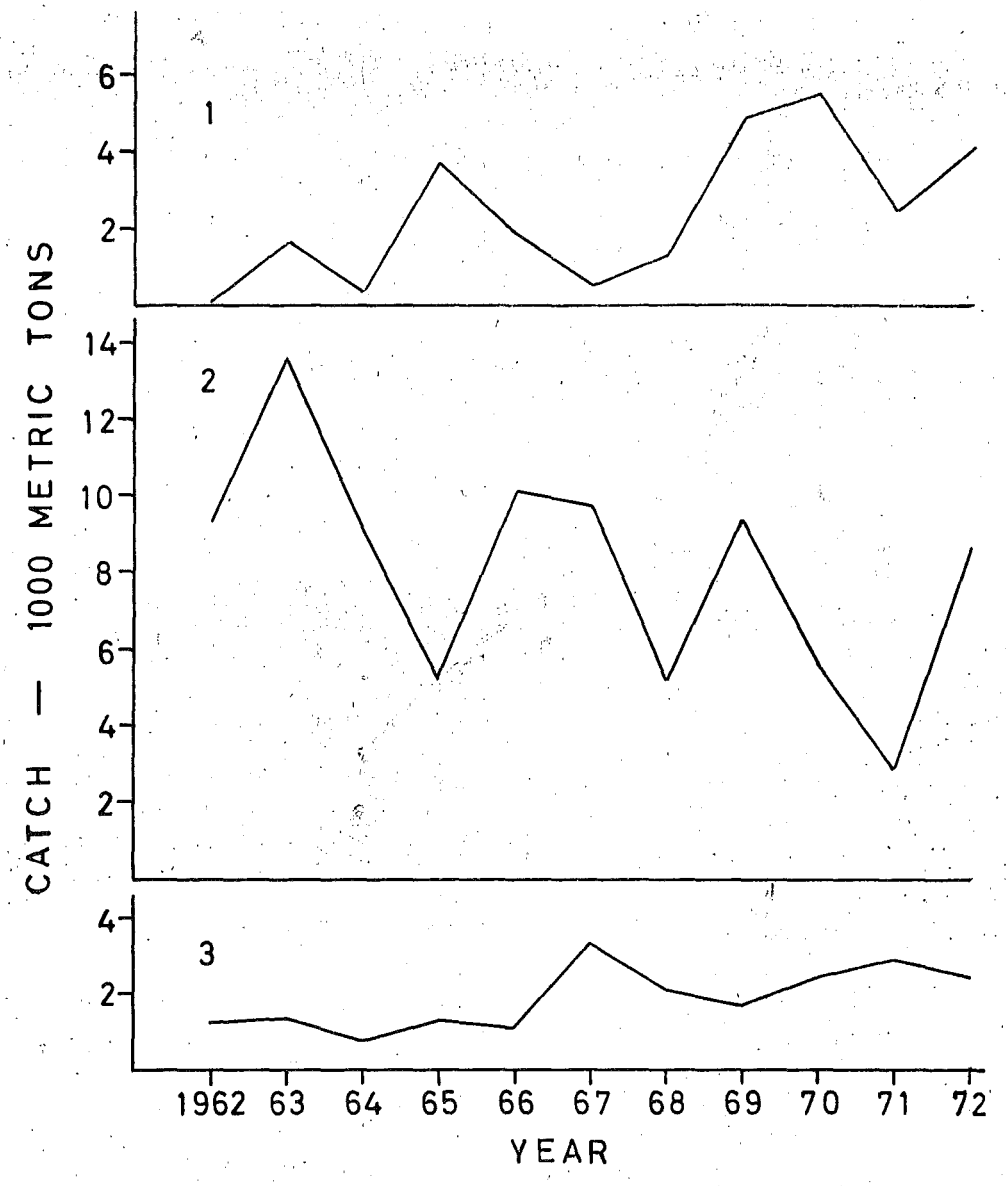

Fig. 1. Catch of sprat. 1) The area north of Stad, 2) Western Norway south of Stad, 3) The Skagerrak coast and Oslofjord.

In Fig. 1 is given the Norwegian catch statistics of sprat for the last decade. The figure is based on records from the fishermens' salesorganization being very reliable as regards quantity and area. The catch vary greatly from year to year reflecting the availability. Shifts in fishing areas are also observed, as e.g. the catches during the last 10 years have increased north of Stad and in the Oslofjord area, while the catch in western Norway south of Stad has diminished.

The average annual catch within 10 year periods has not changed much until recently. For the last four decades the average catch has been:

1932 - 1940	8 200 m.tons
1941 - 1950	8 300
1951 - 1960	8 400
1961 - 1970	12 100

Detailed catch statistics are published annually (ANON. 1930-1962, 1963 -).

The Norwegian sprat fishery is regulated in different ways, mainly to secure raw material of high quality for the canning industry. A minimum content of 7% fat is required, and maximum 40% of sprat less than 9 cm in length is allowed in each catch. The opening date for the fishery has been set to June 1, but the opening of the season can be postponed in the whole area or part of it if the quality requirements are not fulfilled. On biological grounds the fishery in the autumn is some times prohibited to protect the young of the year.

About N kr. 1.80 per kg is paid for sprat used by the canners, and the value of the sprat catch on first hand has the last years been about 20 mill N kr., equivalent to roughly 1.5 mill £. This, however, accounts for only 1-2 % of the total value of the Norwegian fisheries.

Due to the shortage of O-group herring for canning purposes sprat have been imported mainly from Scotland and the German Democratic Republic. This import has in the latest years partly been compensated by a Nor-

wegian fishery for sprat in the North Sea. During the winter 1971-72 5 600 tons were taken off the coast of Scotland and North-England, and in the season 1972-73 4 200 tons from the same area. The Norwegian sprat fishery in the North Sea is likely to expand, although there have been problems in meeting the quality requirements.

PRODUCTS

The Norwegian sprat fishery have developed together with the fish canning industry which started the production of canned sprat 100 years ago. Today some 35 factories are found along the coast, and due to the system of deep freezing most of them operate all year round.

About 80% of the sprat catch is utilized by the canning industry. The rest is used for salt and spice cured "anchovies", salmon bait, food for rearing of trout and a small portion for meal and oil.

In the canning factories the sprat pass through a brine solution and sorting system and are then automatically threaded on to metal rods suspended on frames which are drawn through smoking ovens. Afterwards the fish are decapitated and by hand laid in the cans. Olive oil, other edible oil or tomato puree is added and the cans are sealed before being autoclaved, washed and labelled.

About 85% of the canned sprat is exported. USA, Britain and Canada accounts for 90% of the market and the export value was in 1972 60 mill N kr., equivalent to about 4.3 mill £. The total value of the sprat products is 3-4 times higher than the first hand price, which is a much greater increase than the average of the fishing industry.

CURRENT RESEARCH

During the last five years the biological research on sprat in Norway has been consentrated on O-group surveys. Earlier investigations (DANNEVIG 1956 and BAKKEN 1966) had shown no relationship between the abundance of larvae and the strength of the year class as deter-

mined by the catch the following year. However, it was felt that an estimation of recruiting sprat at a somewhat later stage would give a basis for a catch prognosis, and that the acoustic technique then being developed could be applied.

Echo surveys of O-group sprat in the fjords of western Norway have therefore been carried out each autumn since 1968, with the purpose of determining distribution and abundance. Results of the surveys have been published in Norwegian with abstracts in English (DAHL and SANGOLT 1969 and BAKKEN 1970, 1971, 1972, 1973).

The surveys cover the important sprat districts in western Norway between Stavanger and Trondheim during 8-10 days in October-November. The distribution of the sprat is mapped on the basis of echo recordings. A 50 KHz sounder is used and this is connected to an echo integrator which gives a quantitative measure of the recorded echoes per nauticle mile sailed (FORBES and NAKKEN 1972, p. 84). The recordings are sampled by pelagic trawl for identification and for determinations of sprat size. When the sprat dominate, or occur seperated from other fish and pelagic organisms, the echo integrator gives a good estimate of relative abundance. A reliable estimate is difficult to obtain when the sprat is mixed with euphausides, medusas and smaller fish:O- group herring, Benthosema glaciale, Maurolicus mülleri, young gadoids etc. The proportion of sprat must then be estimated on the basis of catches, previous readings of similar composition or evaluation of echograms.

The use of echo integrator in the fjords in late autumn is, however, favoured since there generally are few other abundant pelagic fish. The integrator provides relative estimates of total abundance and density of the O-group sprat. The estimates are used for comparisons of abundance among fjord areas and among the different years, and give a basis for a catch prognosis about half a year before the fishing season starts.

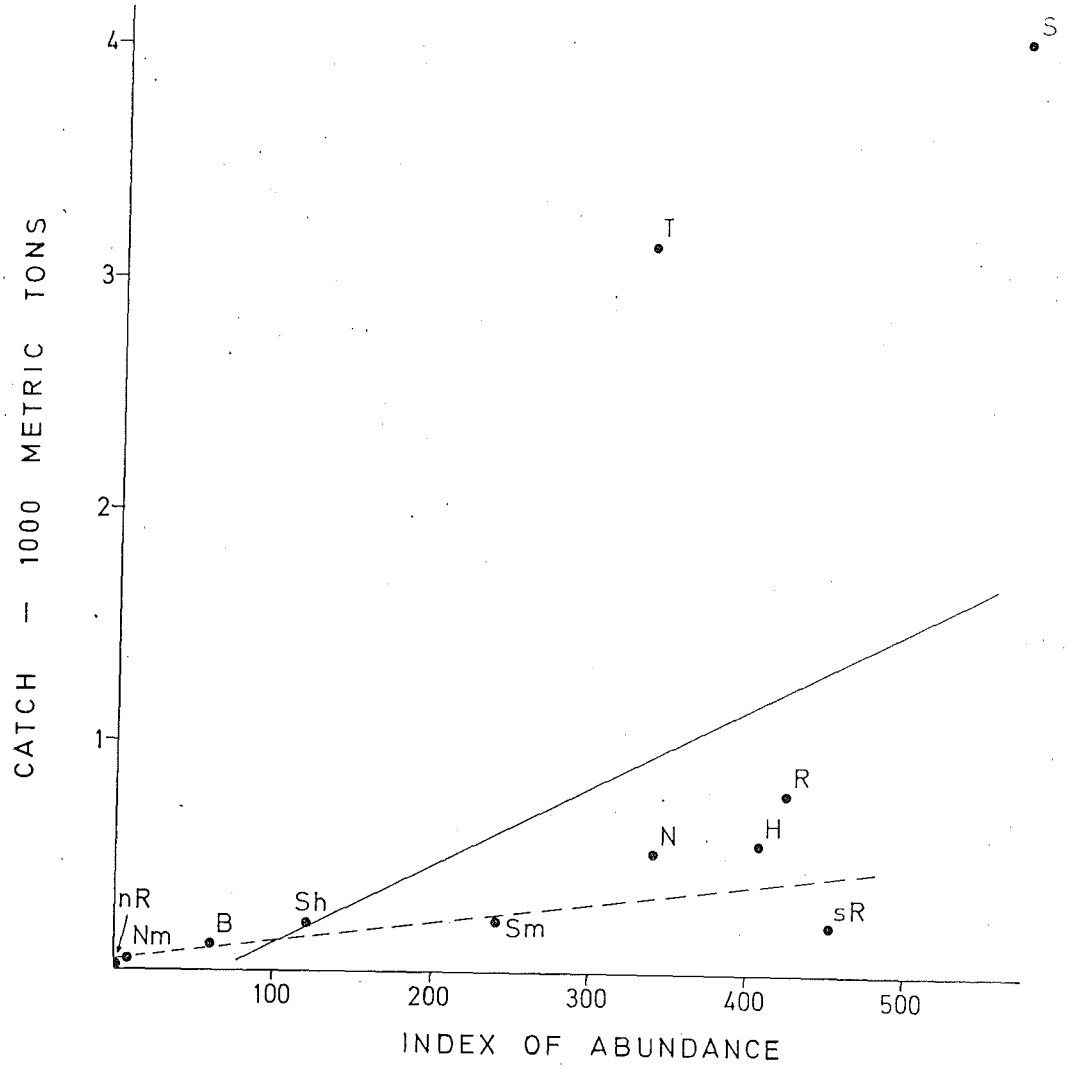

Fig. 2 Relationship between abundance index of sprat as obtained by echo integrator in autumn 1971 and catch the following year. (Modified from Bakken 1973).

The predictive value of such estimates can to a certain extent be evaluated by a comparison of the echo integrator values of the autumn and the actual catch in different areas the following summer. This is illustrated in Fig. 2. Abundance indeces were calculated for 11 topographically separated fjord systems as the product of mean integrator reading per nauticle mile and area. The linear correlation coefficient is low, 0.58 ($p \sim 0.05$), while e.g. the Spearman rank correlation coefficient is 0.81 ($p < 0.01$). The relationship holds well for the smaller fjord systems which are sampled with about equal intensity. Larger fjords, as e.g. those indicated by T and S in Fig. 2, are poorly covered, and this seems to introduce a serious bias. The principle is, however,

illustrated by the figure, although a straight line relationship can only be expected under a series of assumtions, particularly that equal fishing effort applies.

The survey work will continue, but plans are also made to carry out detailed work of methodological character: via target strength measurements obtain absolute estimates, relate integrator readings of sprat schools to catches directly, compare day and night readings, test survey patterns and improve the sampling of the echo recordings.

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