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Plankton Research in the ICNAF Area

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1. Introduction

As a result of discussions in the Committee on Research and Statistics at the last Annual Meeting I was asked to make a "review" of the Commission's plankton requirements. I feel that I have not the special knowledge of the work being done in the area nor the time to do this adequately, and this paper is only intended as a basis for discussion, either by the Committee on Research and Statistics or, better still, by a sub-committee of plankton experts who are working in the area. The first part is a general discussion on plankton programmes in fishery research in the ICNAF area and the second is notes about the separate subareas. One difficulty has been finding what plankton work has been done in the area in recent years, and there seems to be a need for a collecting together and writing up of the data to see where the gaps are - something like the paper by Hachey, Hermann and Bailey on "The Waters of the ICNAF Convention Area", (Annual Proceedings, Vol. 4). Although I have not considered hydrography specially, references to hydrographic work are inevitably included in several places.

2. General

In the Commission's Research Programme (Annual Proceedings, Vol. 3) the third question to be answered is "How are the stocks of fish affected by natural factors?", and to answer it "The Commission needs to know climatic and hydrographic conditions and their variations in order to relate these changes in the fishery and so distinguish between natural factors influencing the abundance and distribution of the commercial species and the effects of the fishery itself. Ultimately it is hoped to understand the changes in hydrographic conditions well enough to predict them". To hydrography should be added plankton; and the aim of the research should be the early prediction of abundance, or stock size, from the year class strengths, and of distribution, or availability to the fisherman. It should be stressed that the plankton research needs to be quantitative and all the year round - much qualitative work in summer has already been done in the area. The needs will be considered under three headings, "Fish eggs and larvae", "zooplankton" and "phytoplankton", with some comments on plankton gear.

A. Fish eggs and larvae. It is generally agreed that the strength of a year class entering a fishery is determined during the first few weeks or months of its life. Larval survival depends on different factors in different species of fish, and also in the same species of fish in different areas, and those concerned need to be determined for each stock. Two of the most important factors are:-

(i) the availability of the right type of planktonic food for the larvae at the time of hatching (e.g. North Sea plaice-Shelbourne) and during the first few months of life (e.g. Barents Sea cod - Corlett), and

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(ii) that the larvae should be carried to the nursery grounds by currents of the right direction and strength (e.g. Georges Bank haddock - Walford, Colton). These imply research on:-

(a) the food of larval fish of different species and ages,
(b) the timing of plankton production in relation to times of spawning and hatching,
(c) the distribution and quantity of plankton in relation to the distribution and numbers of larvae for several months after spawning,
(d) the deliniation of spawning places of different stocks of fish and any variations there may be from year to year depending on hydrographic factors,
(e) the distribution of eggs and larvae and their movement by water currents, as shown by several successive surveys close together in time,
(f) the relationship between larval survival and water temperature, i.e. "warm" and "cold" years. There may be a direct effect of temperature, but usually it will act through the factors of food and currents,
(g) the relation between currents and wind direction and strength.

B. Zooplankton. The need for research on zooplankton in relation to larval feeding has been mentioned above. The type of food available at hatching may be critical (e.g. Oikopleura for North Sea plaice - Shelbourne. Copepod nauplii for Arcto-Norwegian cod - Wiborg), and when the important species have been found their biology and distribution should be investigated. After the first few weeks, as the larvae grow larger, the type of food may not be so important as its quantity, and there may be a relationship between the size of year class and some index of abundance of total zooplankton, such as the average dry weight under a square metre over the dispersal area (e.g. Barents Sea cod - Corlett). Zooplankton may also serve as food for some adult fish such as cod and redfish which are pelagic or bathypelagic feeders. In the ICNAF area planktonic species such as euphausiids and hyperid amphipods do not seem to be so important as food for cod as they are in other areas (e.g. Barents Sea), but they are the food of redfish (e.g. Gulf of St. Lawrence - Steele). Where plankton is found to be a main food then the distribution and biology of the food animal should be investigated for its importance in influencing the distribution of shoals of feeding fish. For many more fish the planktonic food is important at the secondary level where they feed on pelagic fish, such as capelin and herring, which in turn feed on copepods, euphausiids, etc. In this case the rich areas or patches of zooplankton attract the shoals of pelagic fish which in turn attract the larger fish. One ultimate aim of plankton research should be to work out quantitatively the food chains from phytoplankton to commercial fish.

Apart from research mentioned in the section on larvae that implied here is:-

(i) The production of an index of abundance of zooplankton for the larval dispersal area for several months after spawning. After preliminary surveys it may be found that one or two lines of stations worked regularly as frequently as possible will suffice.
(ii) Study of the abundance and biology of any species found to be important as food for adult fish (e.g. euphausiids).
(iii) Study of the food of pelagic fish which form the food of commercial species, and of its distribution. It may be that the distribution of total zooplankton only will be necessary to deliniate the feeding area. Surveys should be made regularly over the feeding season to find the movement of centres of abundance, and of the fish (e.g. North Sea herring - Cushing).

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C. Phytoplankton. The amount of fish that an area will produce depends ultimately on the primary production of organic matter by the phytoplankton, and so a knowledge of the size of this basic production is necessary for the full understanding of fish production. Direct measurements of primary production can now be made relatively simply using the C_{14} technique. While "spot" observations and one season surveys are of some value, regular observations throughout a year at a fixed point such as a light-vessel, or regular surveys throughout several years over a wider area are much more valuable. A single survey made for instance in high summer (e.g. Greenland waters and Labrador Sea - Steemann Nielsen) may be misleading if it is interpreted as showing which are the general areas of high and low production, because the timing of the peak production may vary in nearby areas, (e.g. Barents Sea - Marshall). The timing of the phytoplankton production is often important in relation to the hatching of fish larvae, for instance the spawning of copepods, and so the production of nauplii on which some larvae feed, is governed by the diatom production: (and the success of southern North Sea plaice broods depends on phytoplankton producing food for Oikopleura on which the larvae feed - Shelbourne). The timing of the phytoplankton outburst and so of the zooplankton production is often important for the distribution of pelagic fish and so of their predators (e.g. Barents Sea - Manteufel, Marshall, Corlett).

The research implied here is:-

(i) Study of the timing of the spring (and autumn) phytoplankton outbursts in spawning and feeding areas.
(ii) Study of the basic productivity of the area by regular surveys and/or regular observations at fixed points.
(iii) Theoretical studies of the organic production based on hydrographic and meteorological data, showing the reasons for areas of high and low production.

D. Gear. It is necessary that plankton should be quantitative and that the gear should be standardized as much as possible throughout the area - or at least that the results should be reported in standard units. Nets should have flowmeters, and depth recorders should be used for horizontal or oblique hauls. Standard conversion factors for reporting plankton have been recommended by the ICES Symposium on "Measurements of Primary Production in the Sea" of October, 1957, and by FAO (Laevastu). Suggestions for standard gear are:-

(i) Fish eggs and larvae. Large larvae - Isaacs-Kidd net: small larvae - high speed tow net or, second best, 1 M. or 2 M. silk tow nets: eggs and earliest larvae - vertical hauls with 50 cm. or 1 M. silk net.
(ii) Zooplankton. Euphausiids, etc. - as "small" larvae (see above): Copepods, etc. - vertical hauls, bottom to surface (or divided) with net of No. 3 silk with conical top-piece (Hensen type). Gross zooplankton to be reported as dry weight under 1 M^2; half of catch may be dried or two nets used in parallel, or a standard technique for measuring volume converted to dry weight.
(iii) Phytoplankton. At the ICES Symposium in October, 1957, the estimation of the standing crop of phytoplankton was discussed and it was recommended that sedimentation and filtration methods should be used and that net methods should not be used. In using the standard Utermöhl sedimentation technique the initial sample should be a least 200 cc. for an adequate count of the larger diatoms and dinoflagellates. Hentschel, for his filtration method, recommends using between 1 and 25 litres according to area and season. Whichever of these methods is used it is

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necessary to take samples from several depths. In spite of the recommendations of the symposium it is possible to use vertical hauls with fine nets to study the timing of the diatom outburst in northern waters.

3. Notes on Subareas

Subarea 1. The main need seems to be for co-operation between the nations working in the area to see that observations are taken to the best advantage, spread out over the year.

Some other suggestions are:-

(i) Winter observations of hydrographic conditions, particularly volume transport, as availability of cod in summer may depend on previous winter conditions (cf. Western Barents Sea). Also the good broods in "warm" years may be related to transport and/or food.
(ii) Serial observations of distribution of cod eggs and larvae, March to August, Cape Farewell northwards, to show importance of different spawning areas (fjords and banks), drift of larvae to nursery grounds, drift of larvae over deep water westwards - are these lost or carried to Labrador?, and the relation of the stocks with those of Iceland and East Greenland
(iii) Report of dry weight or volumes of plankton already collected to see if there is any relation with year class strengths.
(iv) Systematic collection of data on zooplankton quantities spread out in area and time.
(v) Study of capelin feeding and relation to cod.
(vi) Study of timing of spring diatom production, copepod spawning, cod spawning and capelin feeding.
(vii) Measurements of primary production spring and autumn in feeding areas.

Subarea 2. In this area there seems to be scope for work on most of the general lines mentioned above. As a beginning one might suggest surveys of the drift of cod eggs and larvae from the spawning near Hamilton Inlet bank: a survey for redfish larvae over the south-eastern Labrador Sea: a study of the relation between the strength of the Labrador Current and the phytoplankton and zooplankton production - perhaps beginning with two or three lines of stations out from the coast over the shelf and banks to deep water, worked several times a year.

Subarea 3. As in Subarea 2 surveys for the drift of cod larvae on the banks and for redfish larvae to the east of the banks would be valuable. Particularly important would be an examination of the drift of haddock eggs and larvae from spawning areas south of Newfoundland, as the direction of this drift may be the deciding factor of good and bad year classes.

Work on zooplankton abundance is needed all the year round (similar to that reported for the autumns of 1955 and 1956), with studies of capelin feeding. A study of phytoplankton production in different water masses would be valuable. These studies could well be related to the variations in the strength of the Labrador Current from year to year, with observations of transport needed before and after the Ice Patrol cruises.

Subarea 4. The collections of fish eggs and larvae and zooplankton volumes made in 1954-5 show the value of such work in the area and the advisability of their continuance, with surveys beginning earlier in the year and possibly extending off the shelf for redfish larvae. These and other studies on lines outlined above would help to answer questions 3(b), 4(a), 8 and 9 posed by Martin in his paper on cod to the 1957 Annual Meeting (Document No. 31, Serial No. 476).

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Subarea 5. Much valuable plankton work has been done in the past in this subarea and it is not proposed to review it here. Knowledge of the migrations of redfish might be increased by an examination of the distribution of redfish larvae (possibly off the shelf), and of the food of redfish and the distribution of the food organisms.

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