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Year-to-year and seasonal fluctuations in feeding and biological indices of the Flemish Cap Bank cod

> T. N. Turuk PINRO, Murmansk, USSR

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#### Abstract

Long-term observations on cod feeding on the Flemish Cap (1970-1980) are presented in the paper. The species composition of organisms consumed by cod by years and seasons as well as the influence of different food objects on the fish fattening are considered in detail. The annual and seasonal periodicity of cod biological indices fluctuation is shown.

#### Introduction

A local population of cod dwelling on the Flemish Cap Bank has a very peculiar pattern of feeding which differs greatly from cod feeding in other subareas of Labrador and Newfoundland.

There is little information in literature about feeding of the Flemish Cap cod. We find some data on the subject in papers by A.I.Postolaky and O.A.Popova (Postolaky, 1963; Popova, 1962) who concluded that in winter/spring cod feed on shrimps and different species of <u>Amphipoda</u>, and in summer/autumn - on plankton and deepsea fishes. The analysis of food of the Flemish Cap Bank cod made by G.K.Lilly (Lilly, 1979) showed that fishes (mostly redfish) and plankton <u>Crustacea</u> (<u>Hyperiidae</u>) were the predominant prey of adult cod in winter. The near-bottom <u>Crustacea</u>, mainly <u>Pandalus borealis</u>, were found more rarely and for the most part in small cod. Benthic organisms such as crabs, <u>Echinodermata</u>, <u>Polychaeta</u> and <u>Gastropoda</u> were of little importance in feeding of the Flemish Cap cod.

The aim of the present paper is to show on the materials of many years the significance of different food components in feeding of the Flemish Cap cod as they grow, and also year-to-year and seasonal differences in their feeding.

#### Material and methods

The material was collected during standard cruises of the PINRO research and scouting vessels carried out in 1970 to 1980. Two methods of investigations were used: a field analysis of cod feeding at sea and a quantitative-weight analysis of stomachs fixed in the 4% formalin solution in the laboratory of the Institute.

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The field analysis included the determination of occurrence frequency of food component in percentage of the number of cod stomachs with food and also definition of mean index of stomach fullness which was calculated as arithmetic mean of the fullness index of all the stomachs analysed.

The quantitative-weight analysis included the division of food objects into taxonomic categories. Objects in each taxonomic group were dried on paper and were weighed thereupon with an accuracy of 0.1 g. The relative significance of different components was estimated with the use of two indices:

1. Partial index of stomach fullness - ratio of a certain food organism weight to fish weight expressed in  $^{\circ}/_{\circ\circ\circ}$ ;

2. Total index of stomach fullness - ratio of all food components weight to fish weight expressed in  $^{\circ}/_{\circ\circ\circ}$ . Besides, fat content and condition factor were calculated for every fish analysed. The ratio of liver weight to fish weight in per cent was taken for an index of fat content and ratio of fish weight (g) to their length cubed (cm) multiplied by 100 - as an index of condition factor.

In all 11712 cod specimens were analysed; 830 specimens were investigated by the quantitative-weight method and 10882 specimens - by the method of field analysis.

<u>Common pattern of cod feeding on the Flemish Cap Bank</u> The species composition of cod food on the Flemish Cap Bank is rather a diverse one and differs much from that in other areas of Labrador and Newfoundland. When investigating cod stomachs the author distinguished between the observations made at sea (the qualitative analysis) and in the laboratory of the Institute (the quantitative analysis).

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# I. The qualitative analysis

The dissection of stomachs showed that the main food objects of cod on the Flemish Cap Bank were representatives of mesozooplankton (<u>Calanoida</u>, <u>Sagitta</u>, <u>Ctenophora</u>), macroplankton (<u>Euphausiacea</u>, <u>Themisto</u>) and also <u>Gammaridae</u>, shrimps, some benthic organisms, and fishes (<u>Myctophidae</u> and young redfish) (Fig.1 and 2).

<u>Calanoida</u> (mainly <u>Calanus finmarchicus</u>) were eaten almost at all depths by young cod of small sizes (up to 30 cm). <u>Calanus</u> occurred most frequently in spring at depths 250-300 m (49%) and in summer at depths 100-150 m (40%). Unlike <u>Calanus</u>, <u>Sagitta</u> were found most commonly in the stomachs of larger cod specimens (above 30 cm) caught at depths 200-300 m. Adult cod (40-60 cm) preferred <u>Ctenophora</u> of all plankton organisms which were distributed at small depths (100-200 m). No <u>Ctenophora</u> were practically found in cod above 72 cm.

Euphausiacea were observed constantly in cod stomachs but in small quantity. Their abundance increased slightly at depths 100-200 m (35%). Euphausiacea were found more often in the food of smaller cod than in that of larger specimens. But on the whole their occurrence frequency was not great and did not differ much by cod length groups.

Themisto were the most numerous food component of all cod length groups caught at the depths of 100 to 400 m. Rather often their occurrence frequency in cod stomachs reached 100%.

In contrast to <u>Themisto</u> (pelagic <u>Amphipoda</u>), <u>Gammaridae</u> (demersal <u>Amphipoda</u>) were found in cod stomachs singly and incidentally.

Shrimps were observed rather often in the food of adult cod. In fact it was the second after <u>Themisto</u> food object of cod. Their occurrence was, as a rule, higher in small and medium size specimens than that in large ones. The range of depths where shrimps occurred in cod stomachs was rather wide - to 600 m. Their occurrence frequency was the greatest in spring and summer at depths

### 250-300 m (58%) and 350-400 m (72%).

Bottom organisms such as <u>Crustacea</u>, <u>Ophiura</u>, <u>Polychaeta</u> and molluscs were found in cod stomachs singly, no connection with certain depths was observed. <u>Polychaeta</u> were registered most commonly while bottom <u>Crustacea</u> and <u>Ophiura</u> - more rarely but more often than other benthic organisms. Recently (since 1976) the occurrence of molluscs especially that of squids increased considerably. They were encountered singly earlier.

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The occurrence of fish in cod stomachs increased as the cod grew and with the greater fishing depth. As it was mentioned above, these were mainly <u>Myctophidae</u> and young redfish.

On the whole cod stomach fullness was not high on the Flemish Cap Bank. The mean index of stomach fullness ranged from 0.65 to 2.60 during the year (Fig.3).

### 2. The quantitative analysis

The field analysis was indicative of rather a wide spectrum of cod feeding on the Flemish Cap Bank. However, only some organisms were of great importance in their feeding by weight. As a result of investigations of stomachs fullness partial indices, only three species of food items (<u>Themisto</u>, shrimps and deep-sea fishes) could be stated to make up the bulk of the Flemish Cap cod diet (Figs 4 and 5). <u>Euphausiacea</u>, <u>Gammaridae</u>, <u>Polychaeta</u>, molluscs and other bottom organisms occurred often but their weight was not great. Cannibalism was also not cosiderable.

<u>Themisto</u> were the most numerous food item in cod stomachs of all length groups in all years. As regards seasons, the intensity of cod feeding on <u>Themisto</u> was the highest especially in summer months (June - 1991.3°/..., August - 2282.5°/...), much lower in winter and the lowest in spring (March -  $5.8^{\circ}/...$ , April - $9.2^{\circ}/...$ ).

Shrimps took the second after <u>Themisto</u> place in food ration of the Flemish Cap cod. In winter their weight was much less than that in summer (January -  $3.5^{\circ}/_{\circ\circ\circ}$ , July -  $272.9^{\circ}/_{\circ\circ\circ}$ ).

Young redfish were the third by significance in the Flemish

Cap cod feeding in general and the first among the fish food. The highest intensity of cod feeding on redfish was in February/March-2276.6°/....

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It is interesting to note that <u>Myctophidae</u> were the first in cod stomachs by occurrence frequency and young redfish - by weight. Cod feeding on young redfish was evidently of a localized pattern.

Unlike cod from other areas of Labrador and Newfoundland, the Flemish Cap young cod fed on plankton during a considerable part of the year. Both the occurrence frequency and weight of plankton consumed by them was great. Especially a great quantity of plankton was observed, as a rule, in cod food in spring (April -Flemish Cap Bank gave grounds to consider this area to be highly productive; the long-term mean plankton biomass made up here in May 323 mg/m<sup>3</sup>, in June - 552 mg/m<sup>2</sup> and in July - 248 mg/m<sup>3</sup> (Plekhanova, 1980). The stability of hydrological regime in this area resulted in a constant species composition of zooplankton and influenced its distribution by years. From February through June the abundance and biomass of zooplankton increased and in July they decreased. All the above-mentioned permitted to assume that in spring the Flemish Cap cod started feeding on developing plankton for lack of more nutritious food.

> Year-to-year and seasonal fluctuations in biological indices of the Flemish Cap Bank cod

According to the data of many years it was established that intensity of the Flemish Cap cod feeding was of a well-pronounced seasonal pattern. Cod fed more intensively in spring and summer which was corroborated by high indices of stomach fullness (Fig.6). In winter the feeding intensity decreased and reached the minimum in January. The quantitative-weight analysis showed that the increase in the Flemish Cap cod feeding was explained by the intensive consumption of developing plankton and <u>Themisto</u>. In winter the conditions for cod feeding on pelagic <u>Crustacea</u> were much worse. Shrimps, bottom organisms and young redfish made up the bulk of their ration. The latter were scattered and did not form dense concentrations till the age of 5 to 7 years. In winter separate cod specimens had rather high indices of stomach fullness due to feeding on fedfish but on the average the fish stomach fullness was not great in the whole area.

Mean indices of fat content and condition factor of the Flemish Cap cod were the highest in autumn and winter after the intensive feeding (fat content was 8% and condition factor - 1.0). In spring and summer they were minimum (Fig.6).

Due to isolation of the Flemish Cap Bank and localization of cod stock no considerable changes were observed by years in the species composition of organisms consumed by cod. One or another food object feeding on which influenced greatly cod fattening prevailed by occurrence frequency in fish food in separate years. The highest average annual fat content was registered in 1972 in large cod specimens (60-80 cm) owing to feeding on shrimps and in 1974 in medium size cod (40-60 cm) which prevailed in catches due to feeding on <u>Themisto</u> and <u>Myctophidae</u> (Fig.6). The minimum average annual fat content was observed in cod of all size groups in 1970, 1975 and 1979 when plankton organisms (with prevalence of <u>Ctenophora</u>) made up the bulk of their ration.

#### Conclusion

Conditions for cod feeding on the Flemish Cap Bank are rather limited due to isolation of the area and stability of hydrological regime. Average annual intensity of cod feeding is not great.

Despite a wide food spectrum, few organisms are of great importance in cod feeding: mesozooplankton (<u>Calanoidae</u>, <u>Sagitta</u>, <u>Cteno-</u> phora), <u>Themisto</u> and shrimps; among fishes - <u>Myctophidae</u> and young redfish.

Consumption of above-mentioned food items by cod is of a wellpronounced seasonal character. Cod feed on plankton in spring and summer (April to June) at depths 100-150 m and 251-300 m. <u>Themisto</u> is a mass food object found in cod stomachs all the year round within a wide range of depths - from 100 to 400 m. The greatest consumption of <u>Themisto</u> falls on summer months (June to August). Young redfish take the third place by significance in the Flemish Cap cod feeding and prevail in their food in late winter - early spring (February/March).

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Cod fat content and condition factor increase at the end of summer and in autumn. The highest indices of fat content and condition factor are observed in September to December, the lowest in April.

No marked difference is observed by years in the species composition of organisms eaten by cod. But consumption of great quantity of food rich in calories (shrimps, <u>Themisto</u>, <u>Myctophidae</u>) favours the increase in average annual fat content of cod (1972, 1974) while feeding on plankton leads to the decrease in fat content (1970, 1975, 1979).

The species composition of cod food on the Flemish Cap Bank

Aphroditidae Ansitides groenlandics Nereis Stylarioides plumosus Maldane sarsi Calanus finmarchicus Calanus hyperboreus Pseudocalanus Aetideus Undinopsis Pareuchaeta norvegica Centropages Metridia longa Metridia lucens Themisto libellula Themisto abyssorum Themisto compressa Anonyx nugax Ampelisca eschrichti Caprellidae Thysanoessa raschii

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Thysanoessa longicaudata Pandalus borealis Hetairus polaris Crangon Pantopoda Pagurus pubescens Clione limacina Limacina retroversa Pontaster Ophiura sarsi Ophiocanta Eidentata Chaetognatha Oikopleura Myctophum punctatum Notoscopelus elongatus Paralepis rissoi Gadus morhua Sebastes marinus Sebastes mentella Lumpenus Triglops murrayi

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Fig.1 Food composition for cod of different length groups:

--- 36-50 cm, ---- 51-71 cm, \_\_\_\_ above 71 cm.



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Fig.4 Quantitative-weight indices of cod feeding.



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Fig.6 Changes in cod biological indices by years and seasons:

- 1 total index of stomachs fullness,
- 2 fat content,

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3 - Fulton's condition factor (K).