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Flemish Cap - A Review on Research Activities Concerning Environmental and Biotic Conditions

by

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Introduction

During the NAFO Scientific Council Meeting in September 1994, STACPUB discussed the potential submission of an overview paper on Flemish Cap Oceanography. The incoming STACFEN Chairman (M. Stein, EU-Germany) indicated that he will present an overview paper, provided the database permits such an overview. In the meantime a literature recherche has been done on the **ASFA** database. As a first step, the present paper gives a historic overview on summarized results of this recherche (Abstracts).

Methods

A recherche on the **ASFA** database was done on the most recent version of the database (May 1995). For keywords Flemish Cap, temperature, environment were taken and a total of **26** hits retrieved from the database. The resulting abstracts are composed and the references are given in the last chapter.

Results

Kamotskaya and Plekhanova (1975) report on the distribution of zooplankton on the Grand and Flemish Cap Banks in relation to thermal conditions. **Kudlo and Boytsov (1979)** describe by means of geostrophic circulation charts based on hydrological data from surveys by USSR research vessels and the international Ice Patrol from 1955 to 1974 the existence of quasi-steady water circulation with **anticyclonic motion** over the **central part** of the **Flemish Cap**. The intensity of the horizontal and vertical water circulation over the central part of the bank during the period of development of cod (Gadus morhua) eggs and larvae was found to be one of the main abiotic factors affecting the abundance of year-classes. It is suggested that these dynamic indices can be used to predict the relative abundance of cod year-classes well in advance of their recruitment to the commercial fishery. According to **Borovkov et al. (1978)** a characteristic feature of the water circulation over the Flemish Cap Bay is the **quasi-stationary anticyclonic circulation dependent on** the **intensity** of the **Labrador Current**. The intensification of the circulation is usually accompanied by a temperature decline in the water column caused by the intrusion of Arctic water. The dynamic state of the anticyclonic circulation during the period of

ichthyoplankton development is a major factor determining the year-class strength of the Flemish Cap cod. The intensification of the circulatin contributes to the accumulation of plankton and cod eggs and larvae above the Bank increasing the food supply to the larvae and the survival of young fish when they go over to the demersal mode of life. The close correlation between the indices of the circulation intensity and the abundance of cod year-classes characterized by the average catches of 2-year-olds may serve as a basis for predicting the relative abundance of young cod two years in advance. By means of geostrophic circulation charts based on hydrological data from seven surveys by USSR research vessels from December 1977 to July 1978, **Borovkov and Kudlo (1980)** confirmed the existence of a quasi-stationary water circulation system in the Flemish Cap area, the main element of which is the anticyclonic gyre over the central part of the bank, composed predominantly of mixed water from the Flemish Cap Current. Variation in the intensity, or horizontal and vertical water movements within the gyre was observed, and the most probable factors causing this variability are discussed by the authors with particular reference to its influence on the ichthyofauna of the area. **Keeley (1981)** reports on analyses of all observations of potential temperature and salinity along the Flemish Cap section held by the Marine Environmental Data Service. Computations of mean conditions were made using some of the ideas of optimum interpolation. It was found that the variability in the observations was larger between the same months in different years than within the month. This resulted in a simplification of the procedure to calculate means. The values of potential temperature, salinity, and sigma theta are presented for each month. A volumetric analysis of the potential temperature and salinity by month has also been performed and is presented. A technical report was presented by **Kendaris (1981a)** which gives data results from three oceanographic research cruises to the Flemish Cap, carried out in March, April and May 1979. Vertical CTD Profiles were obtained from "Flemish Cap Plankton Grid" stations. Fully calibrated and processed data were interpolated to standard hydrographic depths and tabulated in Appendices. Computer generated contour diagrams from each horizontal distribution of temperature, salinity and density have been provided. Observations performed in the Flemish Cap area in April, May and July 1980 were published by the same author **(Kendaris, 1981b)**. Vertical CTD profiles from 'Flemish Cap Plankton Grid' stations were obtained. Fully calibrated and processed data were interpolated to standard hydrographic depths and tabulated in Appendices. Computer generated contour diagrams from each horizontal distribution of temperature, salinity and density have been provided. **Keeley (1982)** provides an analysis of water temperature and salinity anomalies at selected stations on the Flemish Cap section across the northern Grand Bank and Flemish Cap for the 1970-79 decade. Relative to the long-term mean conditions, the analysis indicated that the water flowing through the section was colder and fresher during the early part of the decade, followed by a return to warmer and saltier water during the later years of the decade. The change seems to have occurred sometime in 1976 or 1977. **Georgi and Schmitt (1983)** investigate the spatial distribution of fine and microstructure between the Azores and Flemish Cap. The CTD data are used to calculate a conductivity-microstructure Cox number. This indicator summarizes microstructure variance from the 0.08-2 m vertical wavelength range. The CTD data are also

used to calculate the finestructure-temperature Cox number. Finally, the fine and microstructure data are combined to calculate lateral flux and flux divergence for the waters east of the North Atlantic Current. **Holdway (1983)** analyses the effect of growth rate on the proximate composition, energy content, ovarian development maturation of Atlantic cod, Gadus morhua, in relation to ration size, season, temperature, age maturity, sex, and body weight for fish reared for 10 months in the laboratory over two consecutive years, 1978-80. The effect of growth rate on ovarian development and maturity was also studied for cod collected from the Gulf of St. Lawrence, the Scotian Shelf, Georges Bank, the Flemish Cap, and the N.E. Newfoundland Shelf. Relative energy and lipid content of whole cod increased with specific growth rate for all three sampling periods (November, January, March), each at 5 and 8 degree C. Energy, lipid, and water content were highly correlated to each other, and regressions are provided to allow for their prediction, given one of the components. Relative protein content was positively correlated with specific growth rate. **Mitenev (1984)** in a publication on "Fishery oceanography of the northern seas" reports on the results of Soviet oceanographic research within the "Flemish Cap" project in 1977-1982. **Kudlo et al. (1984)** confirm with an analysis of geostrophic circulation charts, based on oceanographic data from 26 surveys of Flemish Cap by USSR research vessels from December 1977 to April 1982 and a Canadian survey in January 1979, that the anticyclonic gyre is the prevailing form of water circulation, which favor the retention of ichthyoplankton, mainly eggs and larvae of cod (Gadus morhua) and redfish (Sebastes spp) on the bank. Destruction of the gyre by the passage of frequent storms results in a meandering flow across the bank, providing conditions which favor the transport of eggs and larvae away from the bank and their loss from the Flemish Cap ecosystem. Therefore, the relative stability of the anticyclonic gyre during the period from spawning until the larvae are able to avoid massive transport by currents, is an important element in determining the success or failure of year-classes of Atlantic cod and Atlantic redfish in the area. Studies were carried out on Flemish Cap, 1978-82 by **Anderson (1984)** to assess fish spawning cycles, the distribution, abundance, and growth of early life stages, and their relationship to environmental factors. Redfish larvae (Sebastes spp.) were the most abundant fish larvae found on Flemish Cap. Redfish began releasing larvae during March, reaching an abrupt peak in late April. Larval abundance for the study area being 6.8×10^{12} larvae. Redfish larvae first appeared in the southwest corner of Flemish Cap and within 3 week were found in waters throughout the area over depths > 200 m. In July the survivors were concentrated over the Cap supporting the concept that Flemish Cap redfish constitute a distinct group. Based on water temperature measurements along the 4-A hydrological section in the vicinity of the south-western slope of the Flemish Cap Bank, **Konstantinov (1984)** correlates water temperature with the year class strength of Cod (Gadus morhua) derived from the results of regular surveys of one and two-year-olds. An inverse relationship between water temperature and year class strength has been revealed. The Flemish Cap Bank is located in the southern part of cod fishing ground, where due to negative temperature anomalies favourable conditions for survival of developing eggs and larvae seem to be constructed. Similar relationships have been established in the Northeast Atlantic. Analyses of mesoscale horizontal distributions of temperature and attenuation were performed using data from the AVHRR and the CZCS

Viehoff (1987). Primarily the situations during summer 1981 and 1983 in the area of the North Atlantic Current were investigated. Sea surface temperature distributions at strong thermal fronts are comparable with the temperature of the diurnal mixed layer. For synoptic measurements the absolute accuracy is better than 0.4 K, for time lags of plus or minus 2 days between radiometric and in-situ measurements the accuracy is about plus or minus 0.5 K. At the polar front the thermal pattern is moving eastward with velocities of 4.0 and 6.5 cm/s respectively, with a relative persistence of mesocale pattern 14 days. The sea surface temperature distributions have considerable time variability, especially east of Flemish Cap and at the Mid-Atlantic Ridge south of 50 degree N. Based on midwater-trawl catches of glacier lanternfish (Benthosema glaciale) over the slopes of Flemish Cap and eastern Grand Bank in the Northwest Atlantic **Albikovskaya (1988)** reports that these catches consisted mainly of age-groups 3 and 4, most of which were in the 45-60 mm SL range. The smallest and largest specimens were 27 and 72 mm SL, and males were somewhat more numerous than females. The pattern of gonad development in females indicated that spawning probably occurs intermittently in early autumn and winter, with the subsequent occurrence of larvae being coincident with the period of high zooplankton abundance (April-May). Growth is evidently rapid during the first 2-3 years of life and decelerates markedly thereafter, with the lifetime being at least 5 years. The sonic-scattering layer (mainly B. glaciale and other myctophids) remained at 300-400 m (3.5 degree C) with little daily vertical movement, due presumably to the overlying very sharp temperature gradient. **Anderson (1989)** compares the timing of primary and secondary production cycles and their effect on larval fish feeding, growth, and survival between two years on Flemish Cap (47'N, 45'W). **Colbourne (1993a)** examined oceanographic data around the Flemish Cap area to compare conditions during the last few years to the long-term average. The results indicate that the large oceanographic anomalies experienced over the continental shelf in Atlantic Canada also existed around the Flemish Cap area during the same time periods. In particular, temperatures have been up to 2.0 °C below normal in the upper 100 m of the water column since the late 1980s and about normal in water depths below 300 m. These anomalies are generally associated with strong winter northwesterly circulation, colder than normal air temperatures and heavy ice years in the Northwest Atlantic. In addition, the presence of a general anticyclonic circulation around the Flemish Cap was confirmed on a July 1993 cruise, using an acoustic doppler current profiler. In a report **Colbourne (1993b)** describes the state-of-the-ocean over the Grand Banks of Newfoundland during mid-spring 1993 with a comparison to the mean conditions based on all available historical data. The report presents a subset of the data collected on the first oceanographic cruise of the 1993 field season funded by the Northern Cod Science Program (NCSP) aboard the CSS PARIZEAU. This study is intended to provide information on oceanographic conditions during the inshore migration of northern Atlantic cod (Gadus morhua) to the bays along the east coast of Newfoundland at approximately one month intervals prior to, during, and after the peak cod migration. It was intended to make oceanographic measurements along transects running from the inshore areas of Conception Bay, Trinity Bay and Bonavista Bay and offshore to the shelf edge, however ice conditions prevented working north of Cape St. Francis. Instead the survey was conducted from the inshore areas

along the Avalon Peninsula from Station 27 south to Cape Race and offshore to the shelf edge along the standard NAFO Flemish Cap transect. The survey then proceeded southwest along the shelf edge to Carson Canyon and shoreward to Cape Race. A final transect running from Cape Race across the northern Grand Banks in a northeasterly direction to the ice edge was conducted. Measurements along the transects included vertical profiles of current, temperature, salinity, chlorophyll and dissolved oxygen. In addition water samples were collected at each station for salinity, chlorophyll, oxygen and biological analysis. **Anderson (1994)** reveals that eggs and nauplii of Calanus finmarchicus were the preferred prey types of redfish Sebastes larvae whereas Oithona copepodites were not, even though they were within the preferred size range. Significant seasonal and annual differences in larval diet of redfish resulted from differences in the availability of preferred prey. Seasonally, feeding was related to the succession of the spring dominance of C. finmarchicus to summer dominance of Oithona spp. Interannually, feeding was related to differences in the timing of spring spawning and temperature-dependent development of C. finmarchicus. Earlier spawning and faster development of C. finmarchicus, dependent on warmer water temperatures, resulted in poorer feeding conditions for redfish larvae. Under these conditions redfish larvae; (1) ate predominantly nauplii and copepodites of Oithona spp.; (2) ate less food by weight; (3) had lower relative body condition; and (4) there was a delayed size at metamorphosis from larvae to pelagic juveniles. Total prey concentrations between years did not determine better feeding and condition of redfish larvae, whereas the availability of preferred prey types did. Specifically, a lower abundance of C. finmarchicus nauplii resulted in better feeding conditions than a higher abundance of Oithona spp. copepodites. These results emphasize that measuring total prey biomass within preferred prey sizes is not sufficient when evaluating larval redfish feeding conditions. There was a switch in diet for pelagic juveniles to include Oithona spp. copepodites as preferred prey, in addition to copepod eggs and nauplii. This switch in diet coincided with changing prey availability due to the seasonal succession of zooplankton on Flemish Cap, Canada. Metamorphosis from larvae to juveniles at smaller sizes and younger ages is hypothesized to be advantageous to annual survival of redfish due to an increased foraging ability. **Frank et al. (1994)** demonstrate that we are now witnessing a concurrent southward and eastward extension of capelin (Mallotus villosus) distribution, particularly on the eastern Scotian Shelf and Flemish Cap. These latest events coincide with the occurrence of atmospheric and oceanic extremes in the Labrador Sea/Newfoundland Shelf region and the Gulf of St. Lawrence. In general, cold air temperatures, heavy sea ice and cold water temperatures have prevailed in these regions during the past 3-5 years. They document these recent unusual occurrences of capelin on the eastern Scotian Shelf and Flemish Cap in the context of their historical occurrences in these areas and in relation to recent hydrographic events. **Myers and Pepin (1994)** examine the hypothesis that recruitment is more variable in populations on isolated offshore banks than nearby shelf populations. Recruitment of cod (Gadus morhua) and American plaice (Hippoglossoides platessoides) on Flemish Cap is more variable than in any comparable population. **Perez-Gandaras and Casas (1994)** study the otoliths of different Flemish Cap Atlantic cod (Gadus morhua) cohorts for the period 1980 to 1989. It is shown that the annual classes of Flemish Cap cod from 1979 to 1989 provide no evidence of migration. This conclusion is

based on a study of their otoliths following the characterization of the rings applied to Greenland cod. **Bowering and Brodie (1994)** determine distribution, age and growth, and sexual maturity of American plaice (Hippoglossoides platessoides) on the Flemish Cap from 1978 to 1985. American plaice were distributed mainly in the shallower areas, generally in the central, southern and southwestern areas of Flemish Cap. Densities were much lower on average than in the adjacent Grand Bank area. There was no size selective distribution by depth or temperature. Examination of otoliths revealed that females grew at a faster rate than males after age 3. The maximum age recorded was 15 years, which was considerably lower than the value for adjacent stocks of American plaice. In many years the population was dominated by no year-class, which comprised up to 68% of the catch numbers.

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