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On the Isolation of the Cod Population in Flemish Cap (Division 3M)

by

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1. Introduction.

Cod population distributions in the North West Atlantic and their migratory schemes have been analyzed by different authors (Cross et al., 1978; Fleming, 1960; Jamieson, 1975; Konstantinov, 1967; 1970; Lear, 1982; 1984; Lear and Wells, 1980; Templeman, 1962; 1976; 1979; 1982...).

These studies were based on tagging experiments but also on parasitism infections, biological parameters (growth, maturity, vertebral number...) and genetic analysis (electrophoretic analysis of proteins and mitochondrial DNA). One conclusion was the existence of a separated cod stock on Flemish Cap (3M NAFO Division) (Fig. 1).

Nevertheless, over the years this population structure has shown a special shape, in comparison with other cod populations in neighbouring areas, its genitor components being a small proportion of the total biomass. This fact has been specially noticeable in recents years, and has been taken into account in the management of this cod stock.

An analysis of the history of the cod fishery in Flemish Cap (de Cárdenas and Pereiro, 1990) concluded by casting some doubt on the assumptions of isolation of this stock.

The purpose of this study is to analyse all arguments in favour of and against the isolation of this cod population.

2. Pro's for the isolation of the cod population.

2.1. Genetic studies.

Jamieson (1975) found highly significant differences in frequencies of transferine alleles in blood serum between Flemish Cap cod and those of the adjacent northwest Grand Bank area.

Cross and Payne (1978) repeated the study of the frequency of this allele, and concluded that it was possible to distinguish clearly between the population of Flemish Cap. They stated that, a distinct cod population may have been kept separate during the last glaciation, while the remaining populations in other areas in more coastal waters were forced to go South. These two groups have subsequently not been mixed.

2.2. Vertebrae.

Templeman (1962) indicated that the average number of vertebrae in cod on Flemish Cap was slightly lower than in cod on the northeast of Grand Bank.

Lear and Wells (1982) reported that the variances of the vertebral frequencies on Flemish Cap were less than those found on Grand Bank.

2.3. Biological markers.

The cod nematode Terranova (= Prorocaecum) decipiens cannot be found in fillets of cod caught in Flemish Cap waters (Templeman et al., 1957). The same is true for Lernaeocera branchialis (Templeman and Fleming, 1963).

2.4. Cod tagging.

Cod tagging experiments have been carried out by several countries over the last forty years. Konstantinov (1970) reported 15 recaptures on Flemish Cap from cod tagged in the area and no recoveries outside Division 3M. Also, there were no records of tagged cod migrating to Flemish Cap from 35.000 cod tagged by USSR in Subareas 2 and 3 during 1960-66 (Konstantinov, 1967). No recoveries were reported from Flemish Cap from Canadian cod tagging in 1954-55 mainly in Newfoundland coastal areas (Templeman, 1974). Also, from more recent Canadian results of cod tagged on Flemish Cap in 1962 and 1964 (Templeman, 1974), one from 98 recaptures in the tagging year was recovered outside the tagging area. In addition, six out of forty cod tagged in Flemish Cap were recaptured after the tagging year from that area (Templeman 1976, 1979).

3. Con's for the isolation of the cod population.

3.1. Origin of water on Flemish Cap.

Hayes et al. (1977) stated that water on Flemish Cap is essentially a mixture of water from the two currents - the Labrador current and the North Atlantic current. Akenhead (1986), using a model of salt flux in the upper 100 m on the bank demonstrated that Flemish Cap water with salinity over 35 does not derive from North Atlantic current waters, rather it is derived exclusively from Labrador Current water. About 50% of the surface water on Flemish Cap is replaced each month.

3.2. Spawning areas and larvae drift.

Templeman (1975) supports that, for some years, cold water from the Labrador current has reached Flemish Cap bringing larvae from the northeastern part of Grand Bank.

Fitzpatrick and Miller (1979) described the main spawning areas of cod in Newfoundland and Labrador waters. The northern cod (2J3KL NAFO Divisions) spawning areas are situated on the slope off the Labrador coast, where the Labrador current flows; most of these areas are less than 500 miles from Flemish Cap (Belle Isle Bank is more or less at 450 miles). On the other hand, considering the rate of flow of the Labrador current (10 miles/day) and egg development time (50 days at ~ 1°C for cod), Serebryakov (1967) concludes that cod eggs can be carried 500 miles south during incubation. Templeman (1982) agreed with this and also admitted that the larval drifts may reach 600 nautical miles or more. Egg density would of course decrease with distance from the spawning ground due to advective mixing and natural mortality. These spawning areas and the main currents are presented in Fig. 2.

Akhatarina (1987) found the main part of cod eggs in Flemish Pass, between Grand Bank and Flemish Cap. She stated, considering the Labrador current, that the probability of them coming from Grand Bank is high (Fig. 3).

Cod eggs and larvae (Serebryakov, 1965) were observed for different months in the Newfoundland area. Some of them were placed in the northwestern part of Flemish Cap and in the Flemish Pass over 1000 m dephts (Fig. 4).

3.3. Maturity of cod off the east coast of Newfoundland.

Fleming (1960) pointed out that on the basis of the 50% maturity point, there is no statistical significance at 5% level in the differences in the time of maturity of cod from the east coast of Newfoundland, northeast Grand Bank and Flemish Cap.

Xu et al. (1991) found the length at 50% of maturity to be around 50 cm in the last years for females of 2J3kL cod stock. De Cárdenas and Moguedet (1992) have estimated a similar value for female cod from Flemish Cap (Division 3M) for 1991.

3.4. Cod population structure on Flemish Cap.

A great abundance of large sized cod specimens has never been observed in Flemish Cap. In 1887, when the fishing effort on this bank could not have been very intense, Collins and Rathburn (1887) stated, on the basis of information from North American fishermen visiting the bank during spring and summer, the following "no trouble was ever observed -in Flemish Cap- in obtaining large quantities of medium-sized cod, below the standard sizes required in U.S. market. Large fishes were less common, although occasionally very successful trips for large cod have been made".

A comparison of growth of cod in the Newfoundland area (Fleming, 1960) pointed out the very different length and age distribution in Flemish Cap (Fig. 5 and 6). The age distribution from 3M is truncated from age 7, showing that there is practically no presence of 7+ age cod in the catches and looking at Fig. 6, we can also see that no year class reaches 100 % of maturity in Flemish Cap.

Length composition from Russian fishery (March and April of 1958) (Mankevich and Prokhovov, 1962), revealed that in the shallows (less than 350 m) the bulk of the catch measured 35-50 cm and the peak of the length frequency was at 40-45 cm, whereas in the deeper portions of the slope the catches consisted mostly of 50-65 cm and the peak of length frequency distribution was at 55-60 cm. Analysis of the otolith structure, particularly the spawning marks, shows that 84% of the specimens had spawned only once.

On Flemish Cap, strong year classes of cod decrease dramatically as they become five or six years old. Wells (1980) showed the truncation of the 1979 year-class at six years old (Fig. 7). Wells and Gavaris (1984) presented the age composition of longliner catches in April and October for 1983. Truncation of the 1977 and 1978 year classes (age 5 and 6) are shown (Fig. 8). The Stacfis report (1988) noted that "the 1981 year class was predominant in 1984 and 1985, and still strong in 1986. In 1987 this year class was no longer strong".

3.5. Exploration of the fishing pattern.

A simulation exercise (de Cárdenas and Pereiro, 1990) demonstrated that partial recruitments obtained by V.P.A. conducted by Wells et al. (1984) are consistent with the hypothesis of an emigration from Flemish Cap (ages 5-7), considering the selectivity of the gear used in Flemish Cap is the same as that found by Hodder (1964).

3.6. Cod tagging.

A cod tagging experiment was carried out on Flemish Cap by E.E.C. in April 1991 (de Cárdenas and Moguedet, 1992).

At the present moment the number of specimens tagged in Division 3M which have been recovered points out that there is a certain rate of emigration from Flemish Cap (2 from 9 recoveries) to the neighbouring areas.

4. Discussion.

The Labrador current continuously reaches Flemish Cap, and about 50% of the surface water is replaced each month (Akenhead, 1986). This current flows through the main cod spawning areas off the Labrador coast (Hawke Channel) (Fitzpatrick and Miller, 1979). Taking into account the distance between these spawning grounds and Flemish Cap of about 450 miles and the conclusions of Serebriakov (1967), it can be expected that every year a certain amount of larvae is reaching the bank.

Akhatarina (1987) and Serebryakov (1965) found eggs and larvae in Flemish Pass and to the northwest of Flemish Cap over depths greater than 1000 m. Observation of Fig. 2 demonstrates that, as the mentioned authors suggest, they probably come from the spawning areas to the north of Grand Bank, perhaps the areas situated off Labrador coast. These eggs and larvae are found in a position in which they are probably caught by the eddy from Flemish Cap.

Cod tagging experiments carried out during the last years have clearly indicated that there is no migration from neighboring areas to Flemish Cap (Konstantinov, 1970; Templeman, 1974; 1976; 1979). This is confirmed by biological markers, Flemish Cap being an area free from parasitic infection.

Collins and Rathburn (1887) indicated that in the last century the abundance of large sized cod was low. This is confirmed for the present century, also after a period of reduced fishing activity (World War II) by Fleming (1960), but from a small sample. Nevertheless, the same situation was observed in 1958 by Mankevitch and Prokhovov (1962) from a large sample. They also noted than 84% of the spawning stock was composed of specimens at first spawning and 12% at second spawning. This means that the apparent fishing mortality was greater than 1.5. This is in contradiction with Fleming (1960) and Templeman (1976), stating that the fishing effort displayed in this period in the area was at a low level.

All these facts and the drastic decrease noted in the good year classes (Wells, 1980; Wells and Gavaris, 1984; de Cárdenas and Pereiro, 1990) when they reach the approximate age at first maturity (5 and 6) cannot be explained only by the fishing activity.

Analyses of tagging experiments on Flemish Cap show a certain rate of migration, (Templeman, 1976). The low rate found during the tagging year (1 outside Flemish Cap from 98 recoveries), can be interpreted as due to the period when the cruise was conducted (July), because it is quite obvious it is late in the year, considering the migration related to spawning. Nevertheless, after this year, this rate increase (6 outside Flemish Cap from 40 recoveries). De Cárdenas and Moguedet (1992) tagging at the end of the spawning period (April), had also found a higher rate (2 outside Flemish from 9 recoveries), during the tagging year.

With respect to the Canadian tagging experiment (Templeman 1976), it is not known how the recaptures were distributed after the first year. This would help to interpret the results adequately.

The probability of catching a tagged fish arriving at Grand Bank, would be very much less than that of catching it in Flemish Cap, due to the difference between the cod population existing in Div. 2J3KL-3NO and that existing in Div. 3M , so the percentage obtained earlier may indicate an important migration rate (de Cárdenas and Pereiro, 1990).

This emigration could also explain the length distribution found in 3M and just described above.

Although the spawning stock biomass in Flemish Cap has reached a low level in recent years, the length of 50% maturity for females is close to that estimated for cod females in Divisions 2J3KL (de Cárdenas and Moguedet, 1992) as it was estimated in the past (Fleming, 1960).

The number of vertebrae is clearly a phenotypical fact related to the temperature encountered by the larvae during their growth.

The extreme results found by genetic studies require a careful interpretation and some checking that discrepancies are not found among different ontogenic phases on among samples coming from the same area. On the other hand, it seems that these genetic analyses (Cross & Payne, 1978; Jamieson, 1975) have found some differences on just one allelic series among a high number of those tried.

Moreover, a recent paper using mitochondrial DNA to discriminate cod stocks in the northern Atlantic (Smith et al. 1989), and another using electrophoretic analysis (Mork et al. 1985), have concluded that a great genetic similarity exists in the different cod populations, colliding with the previous works mentioned above.

Finally, it seems difficult to conclude that there is a complete isolation of the Flemish Cap cod population if consideration is given to the Flemish Cap area, and it is compared with the autonomy of cod and the distance to other neighbouring fishing grounds.

5. Conclusions.

This bank appears to be mainly as an area for distribution of immature cod.

Part of the larvae coming from the Labrador spawning area are recruited on Flemish Cap bank, being carried by the Labrador current drift, their number depending on the year's hydrological conditions.

This recruitment would complete the spawning from Flemish Cap cod population.

Later, when cod reaches maturity, a migration from Flemish Cap to Grand Bank would take place, its intensity varying from year to year. Nevertheless, it must be consequently affect the cod population structure drastically.

This migratory scheme is presented in Fig. 9.

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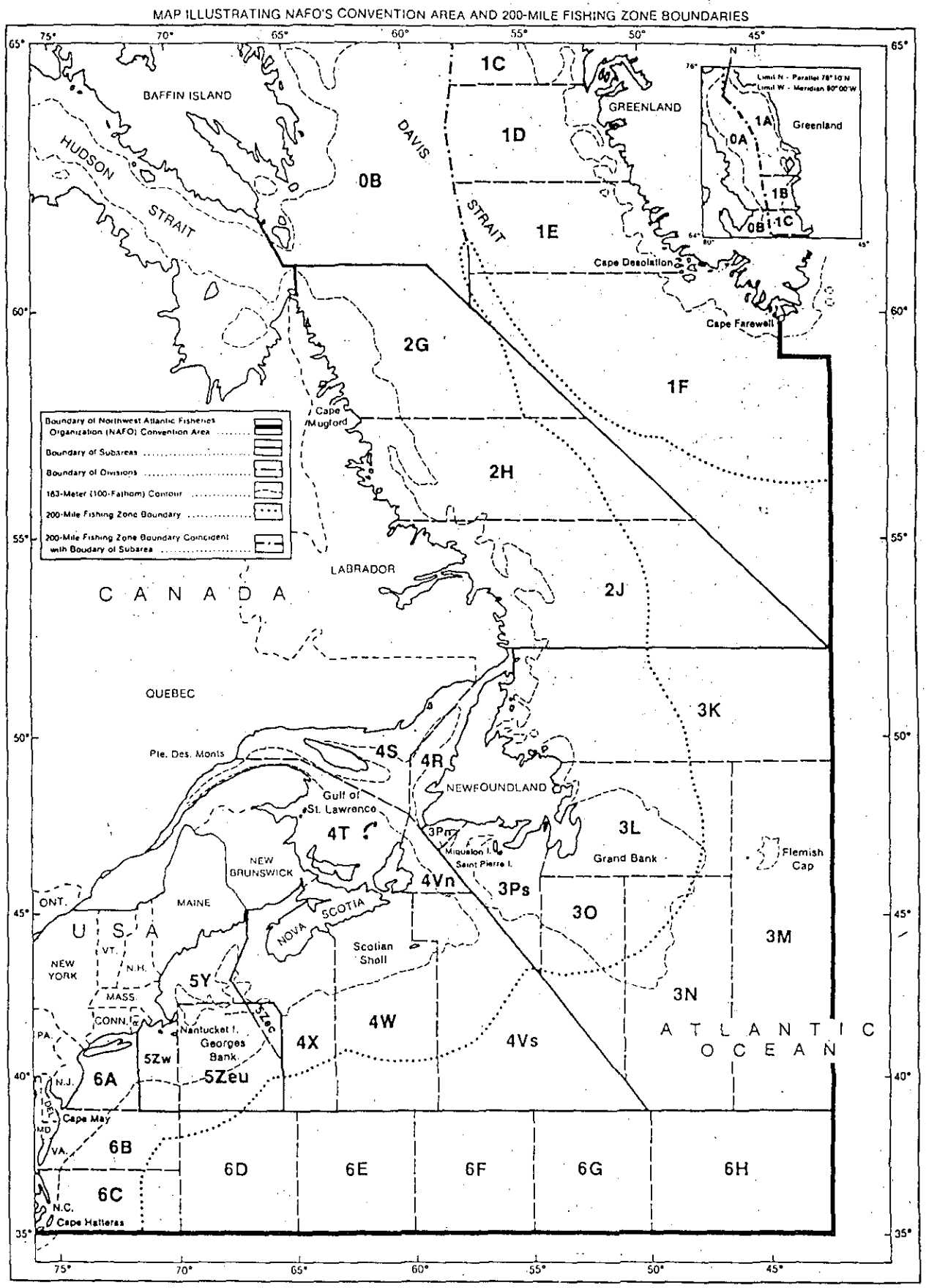


Fig. 1.- Map illustrating NAFO's convention area and 200 mile fishing zone boundaries.

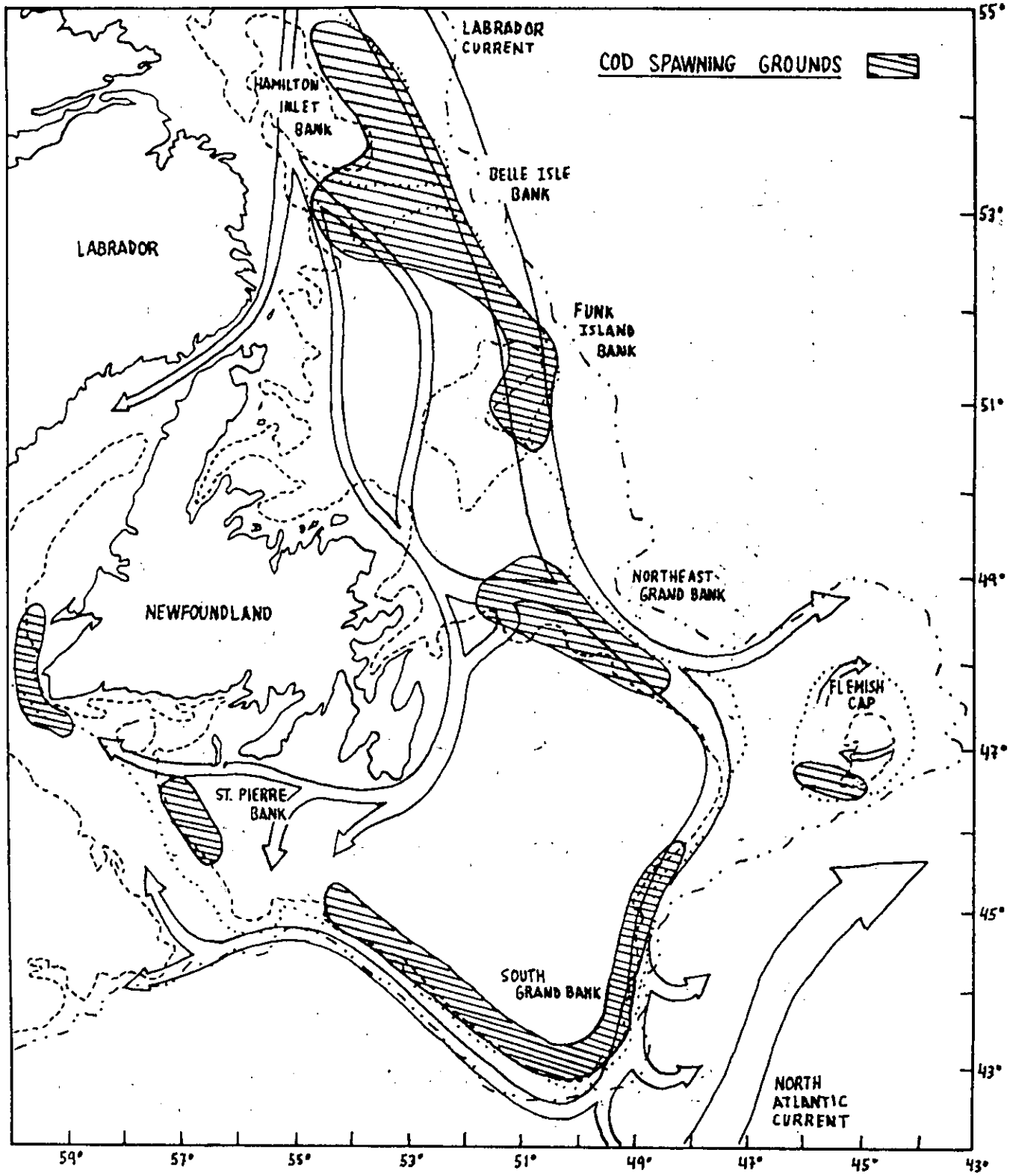


Figure 2.- Main cod spawning grounds and principal currents in Newfoundland area.

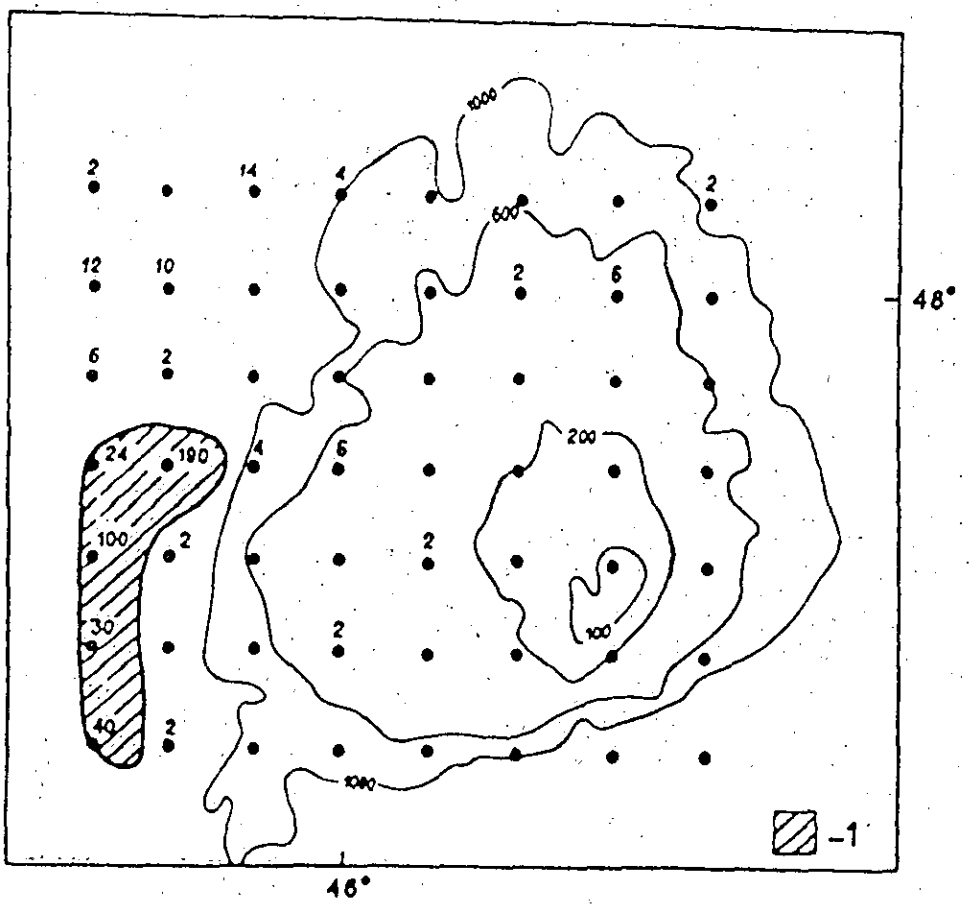
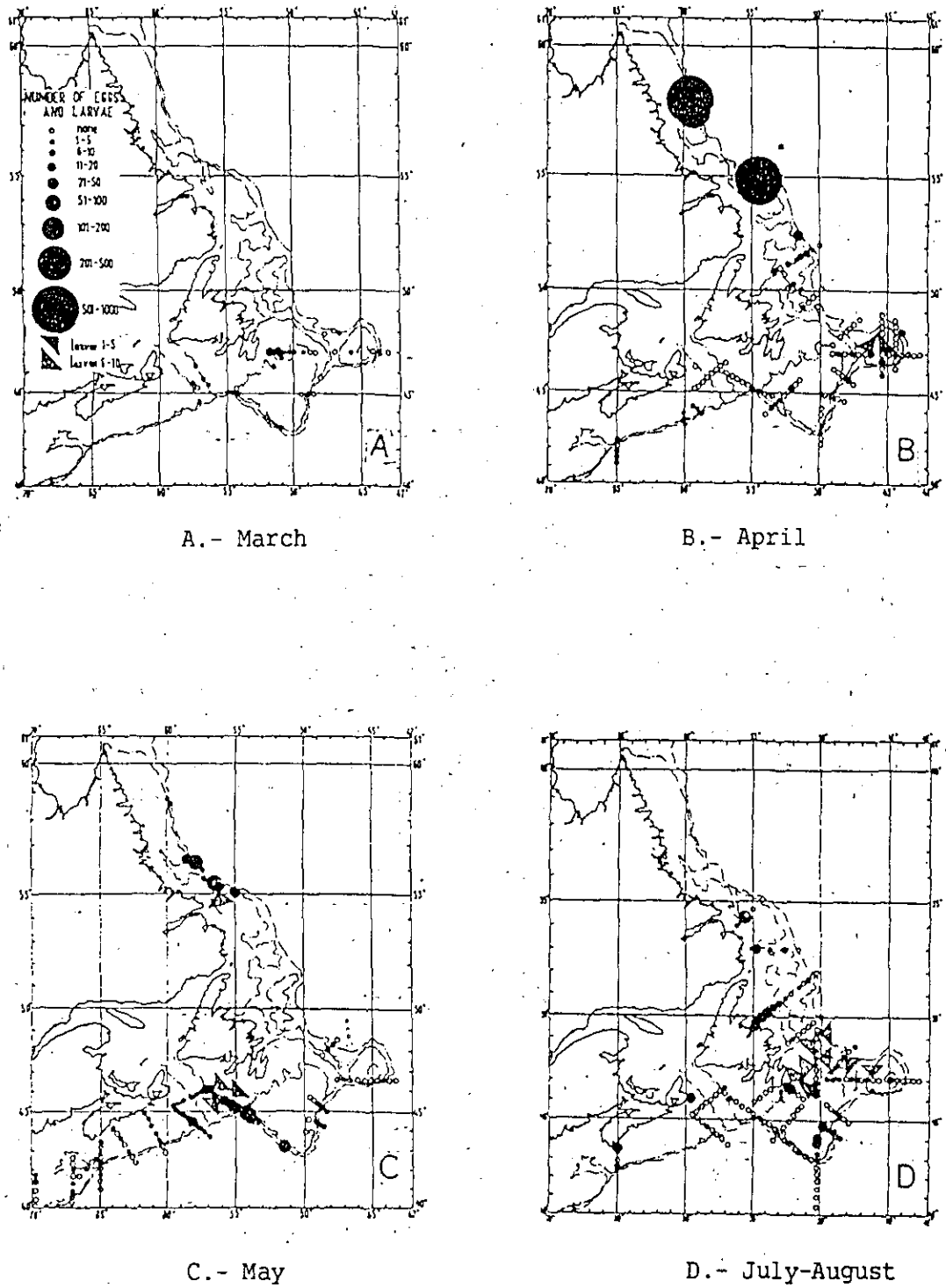


Figure 3.- Distribution of cod eggs in the Flemish Cap area in April/May 1986, according to Akhtarina (1987). 1=More than 20 eggs/m^2.



A.- March

B.- April

C.- May

D.- July-August

Fig. 4.- Distribution of eggs (circles) and larvae (triangles) of Cod (Serebryakov, 1965)

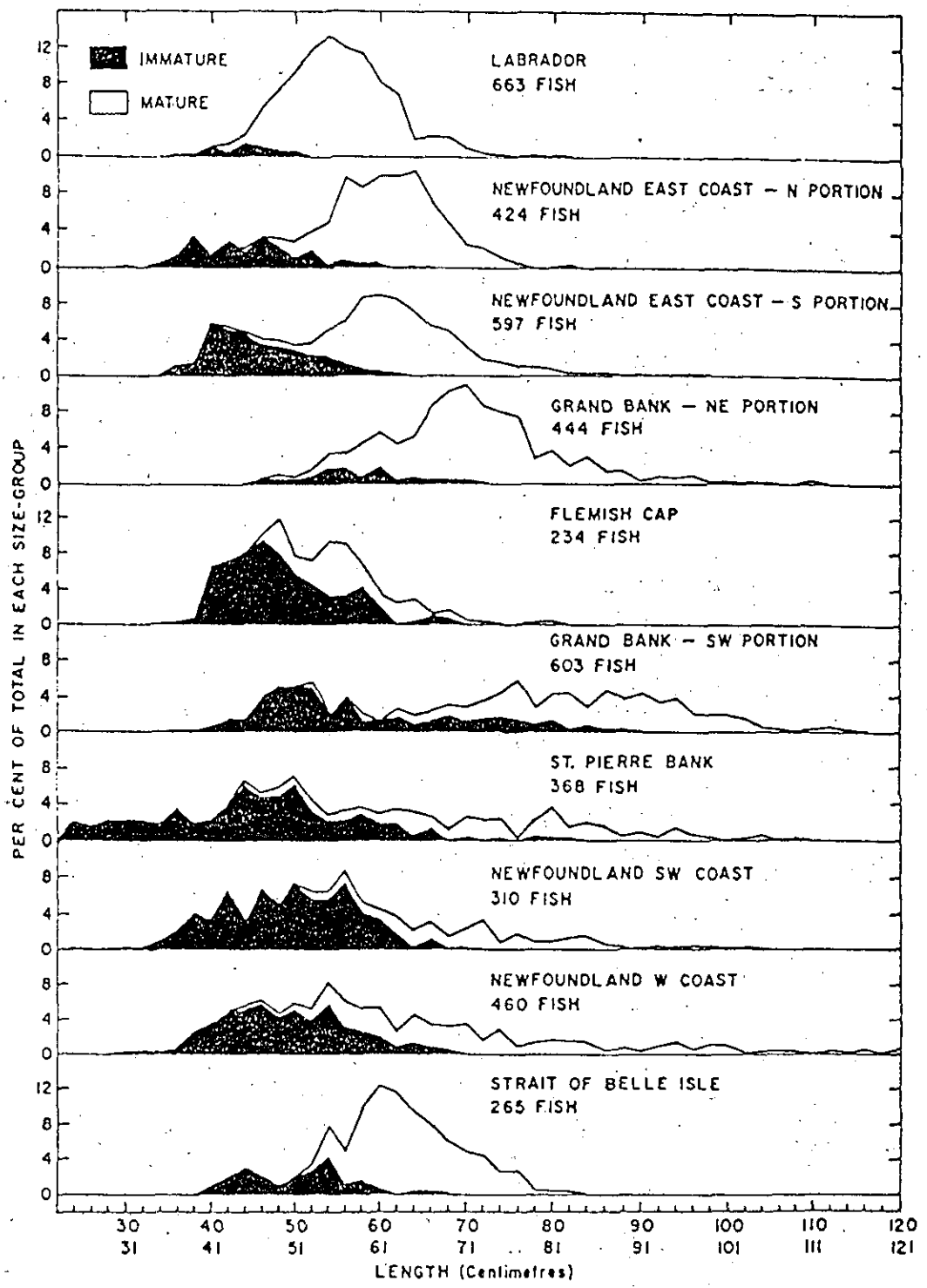


Figure 5.- Percentage of mature and immature cod for each length group for several locations in Labrador and Newfoundland, in the years 1947-50 (Fleming, 1960).

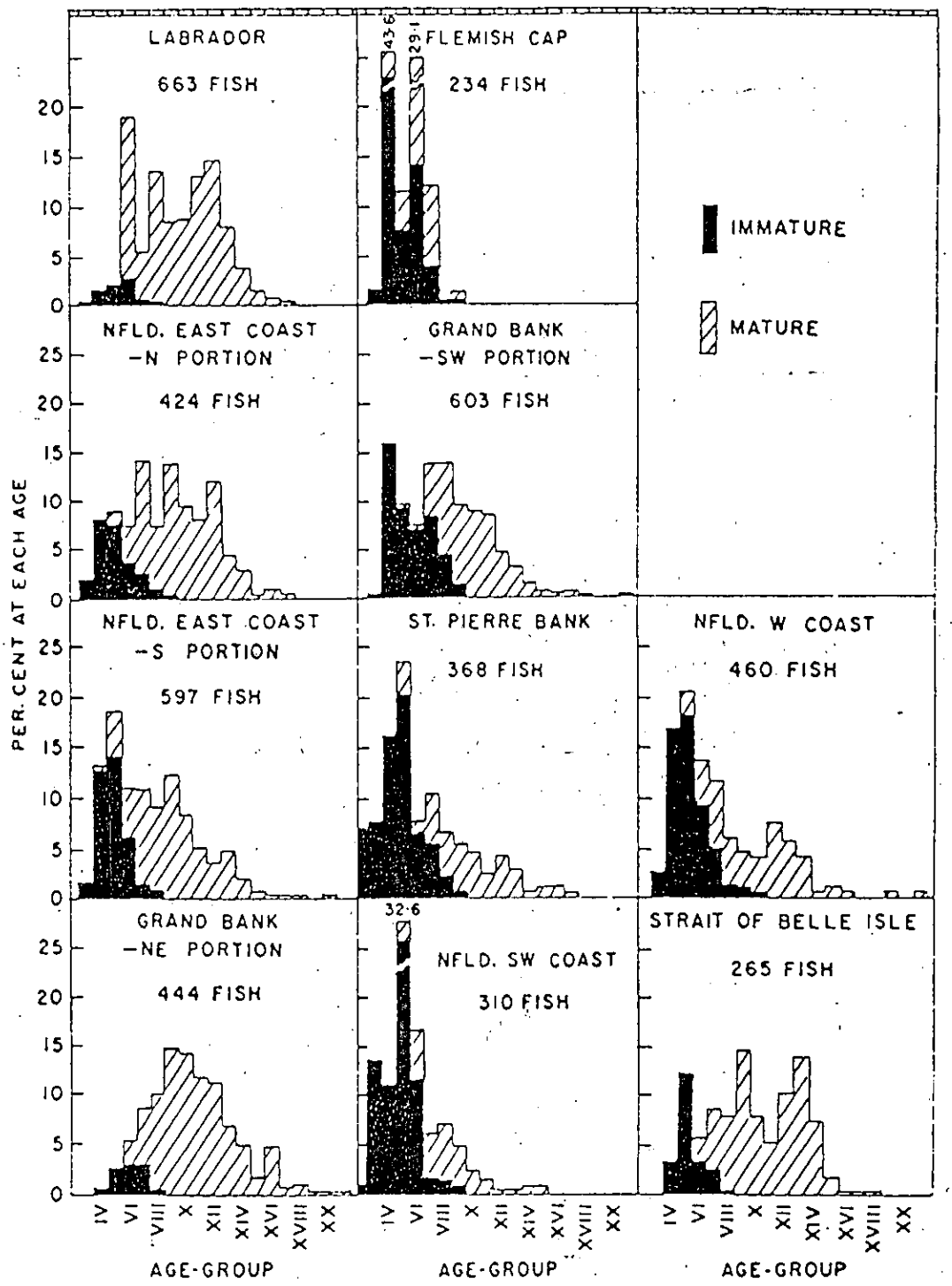


Figure 6.- Percentage of mature and immature cod by age-class, corresponding to several locations in Labrador and Newfoundland, 1947-1950. According to Fleming (1960).

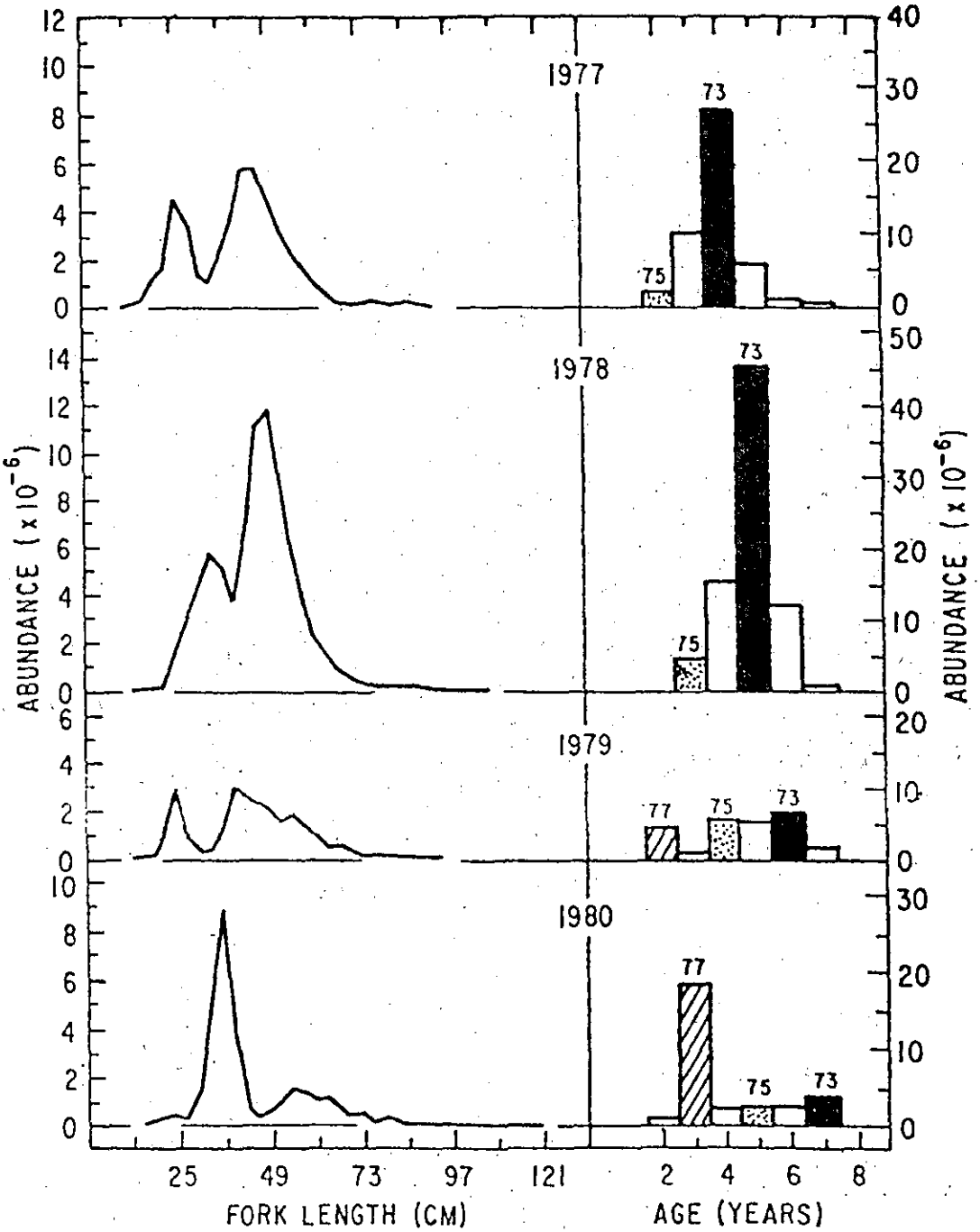


Figure 7.- Size and Age distribution of cod in Flemish Cap 1977-80, taken from survey data according to wells (1980).

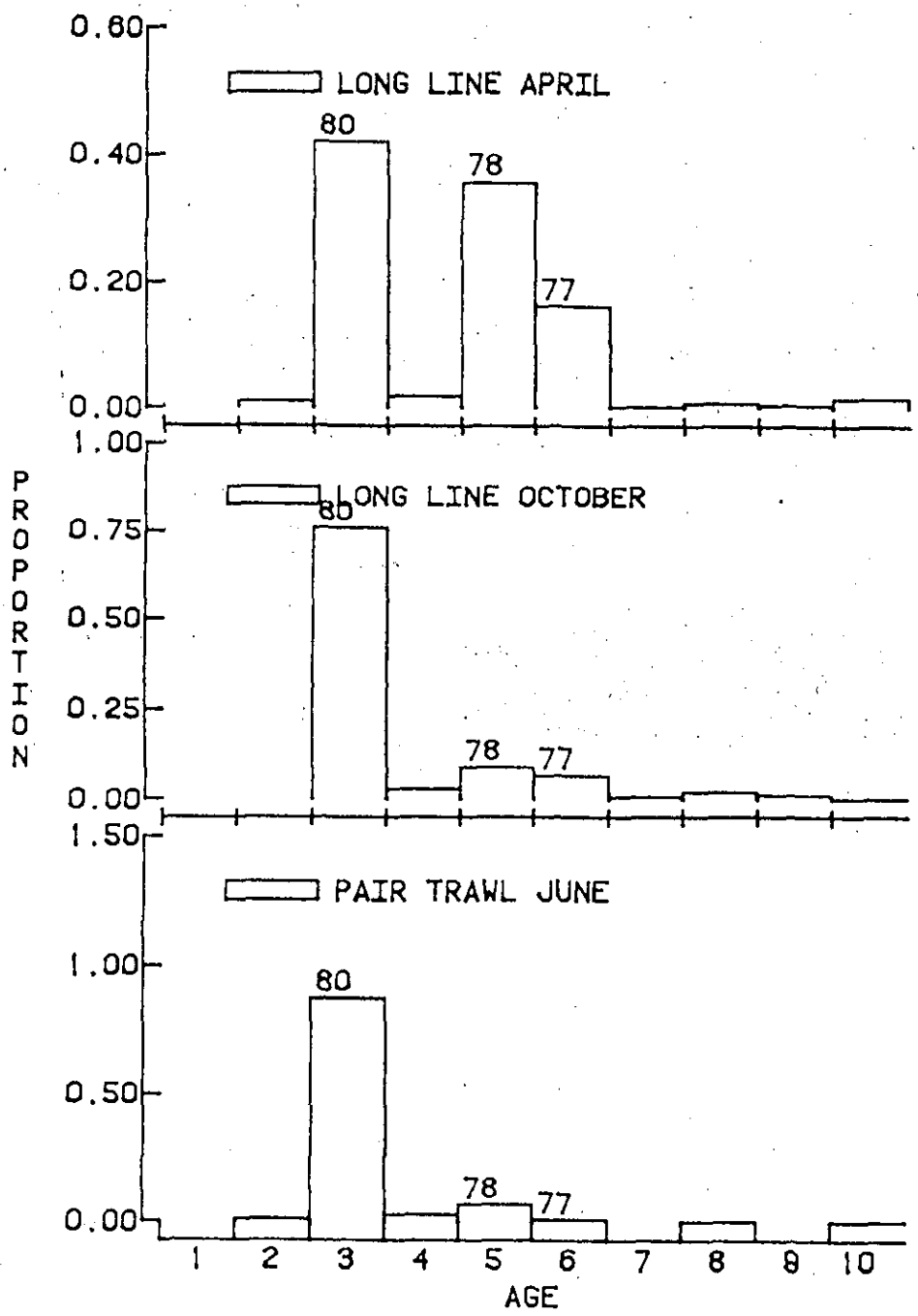


Figure 8.- Age composition of comercial capture for pair trawlers and long-liners in Division 3M, taken from data obtained by on-ship samplers during 1983 (Wells & Gavaris, 1984).

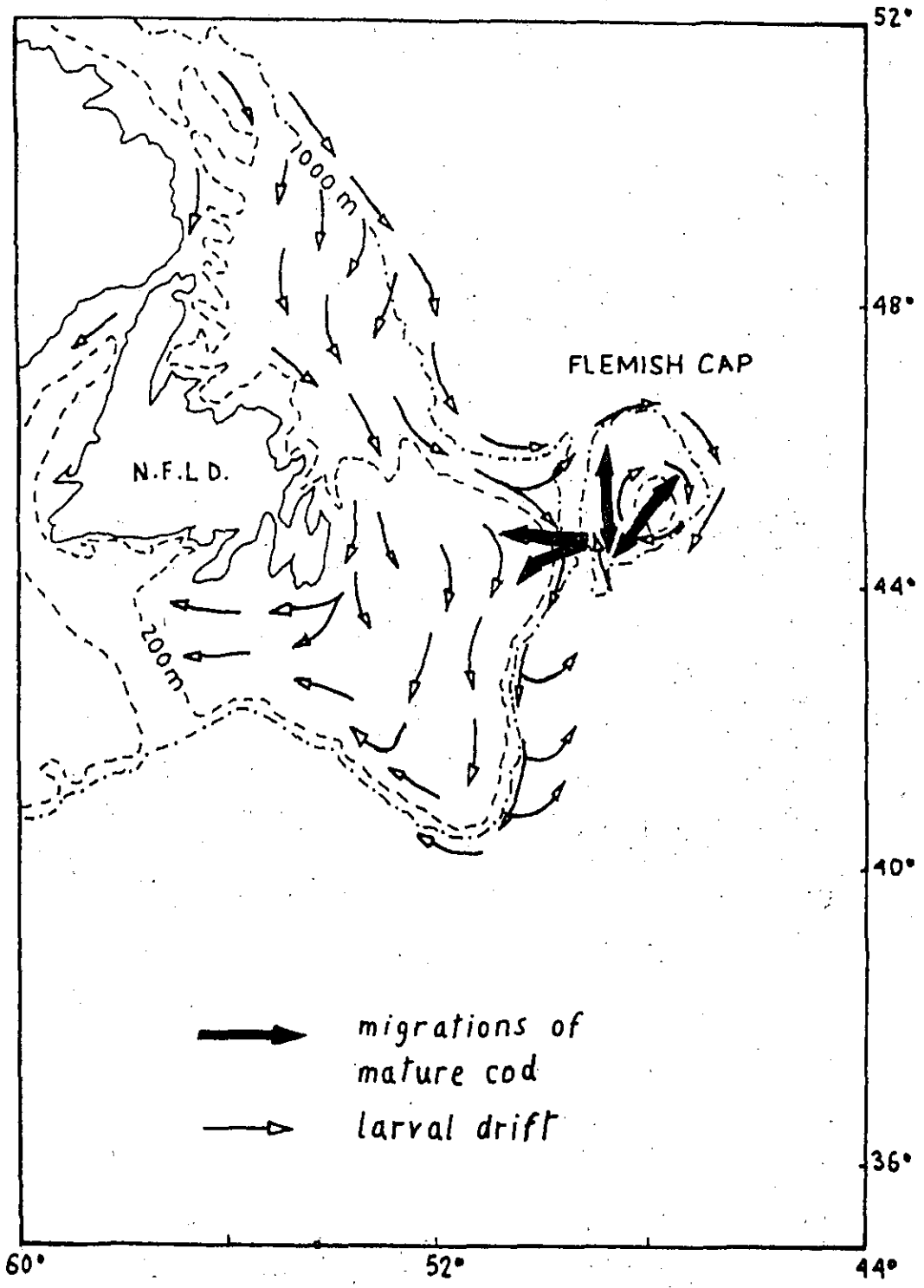


Figure 9.- Scheme representing larval drift in Newfoundland area and migration of mature cod in Flemish Cap.