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Possible causes of growth variations in Subarea 2 cod

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Introduction

Variations in growth of Subarea 2 cod, based mainly on data from the summer inshore fishery, were described by May (MS, 1966). The present study extends the data series by two years, and examines trends in annual catch and mean annual air temperatures in a search for causative factors.

Material and Method

Inshore material from 1948 and 1950 was available from studies by Fleming (1960) and May (1959) respectively. Further collections from the July-August fishery by trap and jigger were made in 1959-60 and 1962-66. Random otolith samples were used to determine average length at age to 1964. In 1965 and 1966 20 to 25 otoliths were collected from each 3-cm length group in random samples of measured fish. Average lengths at each age were determined from age-length keys adjusted to the number measured. Validity of the otolith method of age determination was established by May (1967a). Length measurements were of fork length.

Growth Variations

Average lengths at selected ages for each year of sampling in Divisions 2J, 2K and 2J separately are plotted in Figures 1-3. From 1950-59 there are no consistent trends in either of the areas; some age-groups showing an increase in average size while others show a decrease.

In Division 2G there is little variation in size at age from 1959-64. Ages 7, 9 and 14 exhibit slight upward trends over this period, while ages 8, 10 and 12 show relatively stable or slightly declining average sizes. For the data as a whole there are no pronounced changes over the period. All ages, however, show increased average sizes in 1965 and 1966.

In Division 2H most age-groups exhibit a tendency toward increased average size from 1959-66. The only notable exception is age 12, in which average sizes decline to 1963, but increase from 1963-66. The averages for the youngest ages (6 and 7) are generally more variable from year to year than those for ages above 7.

In Division 2J from 1959-66 there is a very pronounced upward trend in average size for ages 8 and above; a less pronounced upward trend for ages 6 and 7. Ages 4 and 5 exhibit a decline in average size from 1960-64, followed by an increase to 1966.

Possible Causes of Growth Variations

Two factors have been considered for their possible effect on cod growth: temperature and amount of fishing. Of the two, temperature is most difficult to relate to growth because of the lack of synoptic sea temperature data and the extensive seasonal movements north-south, east-west and from surface to 350 metres or deeper which cod in this area undertake. While trends in amount of fishing and annual catches are well-established, any relation these may have to cod growth may be obscured by the fact that the cod populations of Subarea 2 are not "closed". Mixing does occur between the whole area from Divisions 2G to 2J though this is by no means complete. The area as a whole appears to be inhabited by a series of interbreeding or overlapping populations whose boundaries in area and time are not well-defined. In spite of these limitations, correlations between growth and temperature on the one hand, and amount of fishing on the other, are evident as will be seen below.

Lacking relevant sea temperatures, air temperatures have been used as an index of conditions in the sea. Templeman (MS, 1967) has shown that mean annual air temperatures and mean annual sea temperatures from

surface to 175 metres near St. John's (Division 3L) exhibit similar trends. Year to year changes in sea temperatures are generally in the same direction as those in the air, though of reduced magnitude.

Mean annual air temperatures were derived for the following 5 meteorological stations of the Meteorological Branch, Canada Department of Transport, covering the possible geographical range of the Labrador-Newfoundland cod stock from north to south:

Resolution Island	-	Lat. 61°35'N, Long. 64°39'W,
Hopedale	-	Lat. 55°27'N, Long. 60°14'W,
Belle Isle	-	Lat. 51°53'N, Long. 55°23'W,
Twillingate	-	Lat. 49°41'N, Long. 54°49'W,
St. John's	-	Lat. 47°35'N, Long. 52°44'W.

The mean annual temperatures were obtained by averaging mean monthly temperatures, given as the mid-point of mean minimum and maximum temperatures for the month.

Year to year variations and long-term trends are generally similar at each of the 5 stations (Fig. 4). All stations show unusually warm years in 1951, 1952, 1958, 1960 and 1966; unusually cold years in 1950, 1957, 1959 and 1964. Over the whole period there is a slight downward trend in temperatures to 1964, followed by an increase in 1965 and 1966.

Returning to the data on average size at age in each year, there is some correspondence between the direction of variations in mean annual temperature and variations in average size. Thus in the warm years of 1960 and 1966 average sizes of most age groups in all areas (Fig. 1-3) show an increase from the previous year. In the cold years of 1950 and 1959 average sizes of many age-groups are at or near the minimum sizes for the period considered. In the cold year of 1964 this relation does not hold for the older age-groups, but is evident for age-group 6 in Division 2H (Fig. 2) and age-groups 4 and 5 in Division 2J. There is no correspondence in long term trends since those in temperature are downward and those in growth upward.

Cod catches in Subarea 2 were at a low level to 1959. The fishery as a whole rapidly increased from 1960 so that the 1965 catch was more than 10 times that in 1950-51 (Table 1). Virtually all this increase has occurred in Division 2J, though in 1965 catches rose significantly in Divisions 2G and 2H as well. Annual catch per unit effort in the offshore fishery increased to 1963, coincident with increased knowledge of seasonal distribution of cod. Catch per man in the inshore fishery was reduced by 1965 to about half the level in 1959, coincident with increased fishing offshore (May, 1967b). There is thus some evidence of decline in stock abundance, at least for those age-groups taken in the fishery. Since most of the fishing occurs in Division 2J, the marked increase in average size of the older age-groups in this area since 1960 is consistent with the greatly increased fishing which has occurred over the same period. The effect is less pronounced in Division 2H and hardly noticeable at all in Division 2G because of lesser fishing in these areas and incomplete mixing of the cod populations.

Summary and Conclusions

Variations in growth of Subarea 2 cod may be traced to effects of environmental (temperature) variations and variations in amount of fishing. Over the 1948-66 period the former is responsible for short-term variations in average size; the latter for long-term trends.

Any effect of temperature on growth would be expected to be general for all age-groups and for the whole area considered. Effects of increased fishing should be most pronounced only for those areas and age-groups heavily fished. If both factors influence growth it is evident that either one may mask the effect of the other. Variations in temperature and amount of fishing must be considered together in explaining growth changes over the period.

In Division 2G (Fig. 1) variations in average size due to fishing are minimal because of the small amount of fishing in this Division and incomplete mixing with the area of heavy fishing (Division 2J) to the

south. Most age-groups exhibit relatively low or declining average sizes in the cold years 1950, 1959 and 1964; increased average size in the warm years 1960 and 1966. Trends in average size from 1960-66 follow the trends in air temperatures (Fig. 4) fairly closely.

In Division 2H (Fig. 2) there is again a fairly good relation between trends in average size and air temperatures, but the influence of increased fishing in the neighbouring area (Division 2J) is also evident. Thus average sizes are low in the cold year 1959; increasing in the warm years 1960 and 1966. There is however an overriding upward trend in the period as a whole so that the cold year of 1964 produced a low average size only for age-group 6. These young fish would not have been fully recruited to the fishery.

The effect of the fishery is most obvious in Division 2J where age-groups 8 and above show much increased average size since 1959 (Fig. 3). The effect is not as obvious for age-groups 6 and 7, and there is no effect at all on age-groups 4 and 5. These age-groups are partly or fully below the selection range of the gear and are thus not subjected to the full fishing pressure. The trends in average length of age-groups 4 and 5, in particular, follow closely the trends in mean annual temperature.

Increased growth over the 1950-66 period is thus evident only for those ages and areas where fishing has increased. For the remainder there is general correspondence between average sizes and mean annual air temperatures. A similar relation between temperature and average size in a lightly fished area is described by May (MS, 1967).

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Table 1. Subarea 2 cod catch, 1950-65, thousands of metric tons.

	2G	2H	2J	2HK	Total
1950				29.7	29.7
1951				29.5	29.5
1952				49.4	49.4
1953	2.0	45.4	11.9	51.4	128.5
1954		1.7	20.0		21.7
1955		.7	25.1		25.8
1956		.2	34.1		34.3
1957		1.0	31.2		32.2
1958		2.5	37.7	.4	40.6
1959		3.0	57.0		60.0
1960	.3	8.1	179.6	.2	188.2
1961		4.3	260.7		265.0
1962	.1	4.8	250.3		255.2
1963	1.3	2.7	211.7		215.7
1964	.4	8.4	195.0	8.9	212.7
1965	8.4	41.4	252.3	30.6	332.7

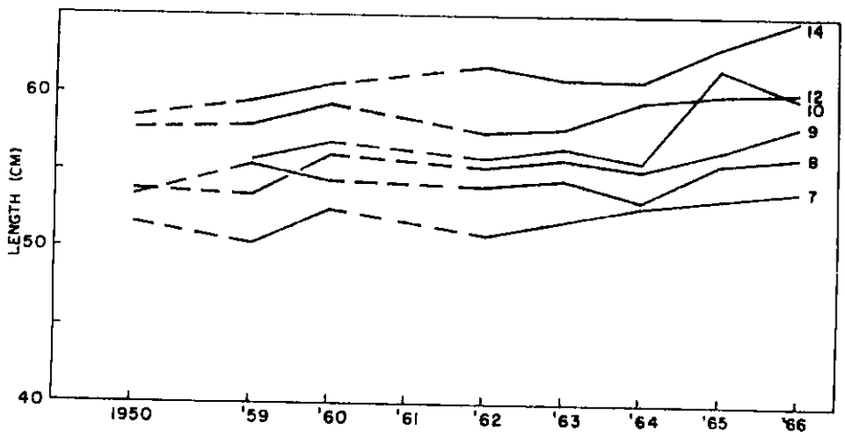

Fig. 1. Trends in average length at age, Division 2G.

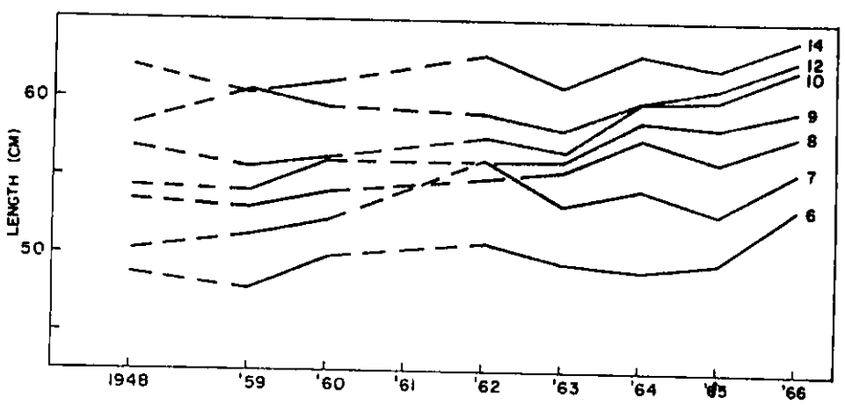

Fig. 2. Trends in average length at age, Division 2H.

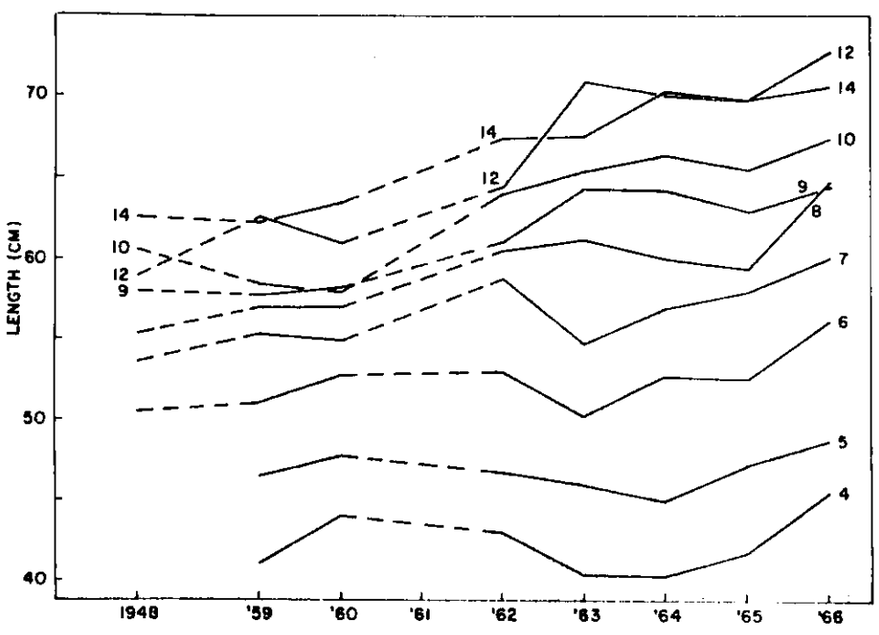

Fig. 3. Trends in average length at age, Division 2J.

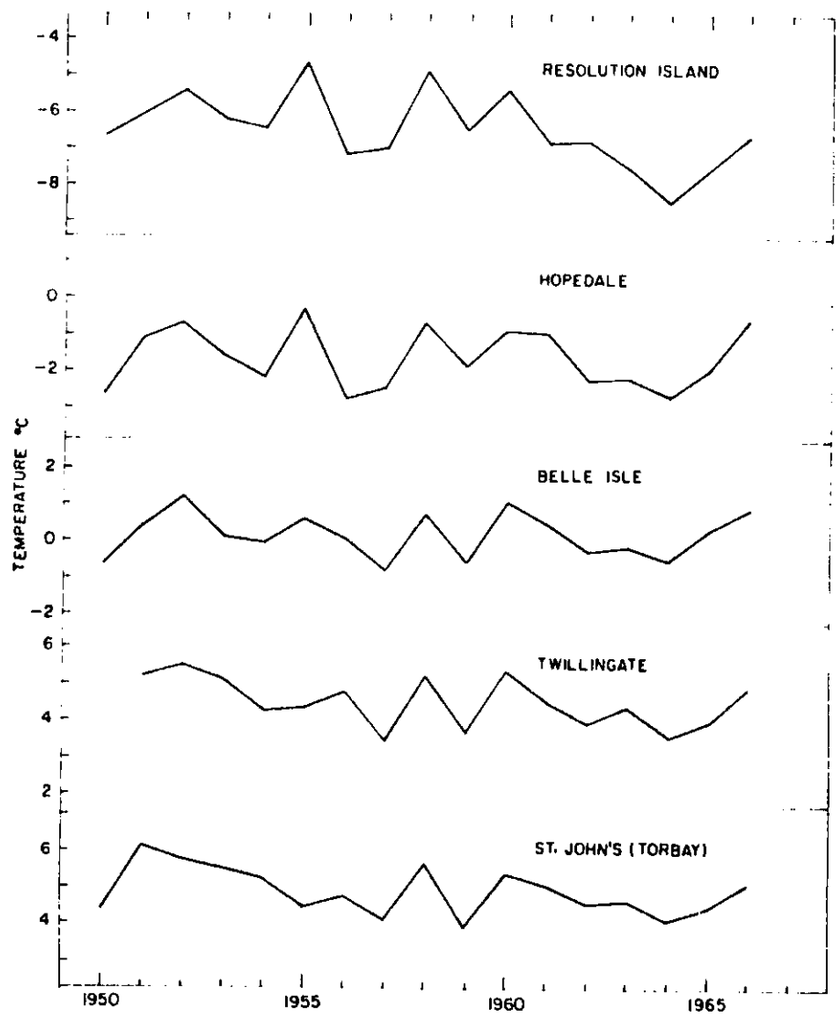

Fig. 4. Mean annual air temperatures at selected stations, 1950-66.