Res. Doc. 77/1

This report not to be cited without prior reference to the author.

THE GROUPING OF HERRING POPULATIONS IN THE SOUTHERN GULF OF ST. LAWRENCE

by
D.M. Ware
Marine Ecology Laboratory, Bedford Institute of Oceanography, Dartmouth, N.S.

INTRODUCTION

In the course of analysing the growth of herring larvae in St. Georges Bay, Nova Scotia, I was puzzled by the fact that the observed growth rates, which agreed favourably with other estimates, seemed to be inconsistent with the back-calculated lengths-at-age 1. This report summarizes the problem, as I see it, that might exist with our current age determination and grouping of herring populations in the southern Gulf of St. Lawrence. Although the interpretation I suggest reconciles the larval growth rates with the back-calculated lengths-at-age 1, several points are quite speculative and require verification, or revision, on the basis of new evidence. However (from a management point of view), the implications of the existing data are important enough that I am willing to stick my neck out somewhat prematurely and tender the following observations.

HERRING SPAWNING GROUPS

According to the temporal variation in the proportion of mature fish in the catch in different areas (Day, 1957a; Tibbo, 1957), the herring in the southern Gulf of St. Lawrence can be separated into four spawning groups (Table 1).

Instead of calling all the fish caught in May and June "spring" herring, as we have traditionally done, there seems to be sufficient evidence to distinguish a spring (Group A) and early summer (Group B) spawning population. Similarly, the herring caught in the "autumn" can be divided into a late summer (Group C) and autumn (Group D) spawning group.

Since the existing information is quite sketchy for several of the spring and early summer fisheries, I have assumed that the first spawning of the year occurs in the northern half of the Magdalen shallows. The water temperature is usually several degrees higher in the north at that time than it is in the waters around the Magdalen Islands and the southwestern half of the Magdalen shallows. Again, the lack of information for some of the late summer and autumn fisheries makes it impossible to be very comprehensive at this time. So I have only attempted to group the fisheries where the spawning times are reasonably well known (Table 1).

THE GROWTH OF HERRING LARVAE

Fig. 1 summarizes all the published data, of which I am aware, on the seasonal length-frequency distribution of herring larvae in the southern Gulf. Each point indicates the mean length of a distinct size group. The figure clearly shows that the points fall into four separate groups, each of which hatches at a different time and grows at a somewhat different rate.

Although it might be argued that the proposed grouping is too arbitrary, I was unable to devise another scheme which fit the data as well. In addition, I found it most interesting that the average date of peak hatching for each group (the point of intersection on the X axis) agreed quite favourably with the estimated time of peak egg production of the four spawning groups (allowing for a 10 to 15 day incubation period).

GROWTH OF JUVENILE AND ADULT HERRING

Unfortunately our information on the growth of juvenile herring is truly fragmentary. We do know, however, that after metamorphosis (around 40 mm) the growing season in our waters lasts from about May 24 to October 1 (Lea, 1919; Huntsman, 1919).

Fig. 2 shows the relationship between the length of herring at the beginning of the growing season in late May, and the average growth rate over the next 130 days (Lea, 1919; Huntsman, 1919; Messieh and Tibbo 1971). For some reason that we do not understand, "autumn" herring grow faster than "spring" herring. I have assumed that this difference also exists between the juveniles (fish less than 160 mm).

The results of Huntsman's and Lea's work were included in Fig. 2 largely for comparison, but perhaps their findings also give us some indication of what the growth rates used to be in the Bay of Fundy and southern Gulf when the herring stocks were less heavily exploited.

PROBABLE LENGTHS OF IMMATURE HERRING

Using the growth rates of the four groups of larvae (Fig. 1), and postlarvae (Fig. 2), I have estimated the lengths from hatching up to age 3 (Fig. 3). The reconstructed growth "curves" are based on three assumptions:

1) The apparent growth rate of spring spawned larvae ($\sim$ 0.5 mm/day) is low. The real rate is probably

closer to 0.7 mm/day; or, alternatively, the first growing season lasts about 190 days.

2) After metamorphosis the normal growing season lasts about 130 days (May 24 to Oct. 1).

3) The winter growth rate of both juveniles and adults is about 1/10th the summer growth rate.

Strictly speaking, the last two points are not really assumptions, since they follow from the growth measurements made by Lea (1919) and Huntsman (1919).

The most striking feature of Fig. 3 is the unusually slow growth of the fish born early in the summer (Group B). They hatch no more than a month after Group A, and yet do not reach metamorphosis until the end of the first winter. The growing season is so short in our waters that a delay in hatching, evidently, has a major impact on the ability of the larvae to reach metamorphosis during the first summer.

INTERPRETATION OF THE BACK-CALCULATED ℓ_1 DISTRIBUTION OF "SPRING" AND "AUTUMN" HERRING

Messieh (1969) pointed out that the ℓ_1-frequency distribution of "spring" herring can be separated into two groups: one with a wide area in the centre of the scale, and one with a narrow central zone. I suggest that a statistical examination of the ℓ_1 distribution of "autumn" herring will also reveal two distinct groups (see Messieh and Tibbo, 1971; Fig. 6). Accordingly

I have divided the ℓ_1 frequency distribution of "spring" and "autumn" herring into four groups (Fig. 4).

So far as the interpretation of the scales of "spring" herring is concerned, the probable growth patterns shown in Fig. 3 suggest that the group with the narrow central area consists of fish which originate from spawning Group A. These fish form a distinct annulus during the first winter, at which time they should average about 115 mm (Fig. 3).

The second group of "spring" herring vary from about 110 to 170 mm in size ($\bar{X} \sim 140$ mm). These individuals are probably the progeny of spawning Group B. Since they form the first annulus during the second winter the back-calculated ℓ_1's of this group should average about 144 mm.

Again, according to Fig. 3, I suggest that the "autumn" herring with ℓ_1's which range from 110 to 170 mm probably hatched in the autumn (Group D). The length at the formation of the first annulus (during the second winter) in this group should average about 144 mm.

The back-calculated ℓ_1's of the second group of "autumn" herring vary from 140 to 210 mm ($\bar{X} \sim 175$ mm). Presumably these fish originated from the late summer spawning group (C), so they would be about 155 to 177 mm during the second winter of life when the first annulus is formed.

If this interpretation is correct, then it confirms that mature herring eventually spawn in the same season in which they were born.

AGE DETERMINATION

Over the years, two methods of age determination have been used by different workers. Lea (1919) recommended an aging scheme based on the number of summer growth zones. According to his method, a herring caught in the spring with 10 summer zones is 10 years old, whereas one caught in the same area in autumn with 10 summer belts (including the current one) is approaching its 10th birthday. Other workers have estimated the age of herring by counting the number of complete winter growth zones.

According to the probable time of formation of the first annulus by the different spawning groups (Fig. 3), it can be seen that Lea's method will give the right age for all but Group B. On the other hand, an aging scheme based solely upon the number of complete winter rings will underage everything, except Group A, by one year. Thus, although Lea's method is clearly the preferred one, the unusually slow growth of Group B fish during the larval stage seems to fool everyone.

CONCLUSIONS.

1. The available information on the approximate time of peak spawning of herring in different parts of the southern Gulf of St. Lawrence suggests that there are four discrete spawning groups.

2. The length-frequency distributions of herring larvae also fall into four modes, which roughly correspond in time to the four spawning groups.

3. The spring spawning group (A) probably consists of herring which reproduce in the northern half of the Magdalen Shallows, in Chaleur Bay and off the shores of Northumberland, Westmorland and Kent Counties. The larvae of this group seem to grow at an average rate of 0.5 to 0.7 mm/day throughout the first summer, and form an annulus during the first winter.

4. The early summer spawning group (B) probably consists of herring from the southern half of the Magdalen Shallows, including the Magdalen Islands. The larvae produced by this group seem to grow at an unusually slow rate ($\sim$ 0.16 mm/day), and presumably do not form the first annulus until the second winter.

5. The late summer group (C) spawns largely off the shores of Pictou, Gloucester and Northumberland Counties from late July to mid-August. Their larvae grow at about the same rate as the early summer group.

6. A much smaller body of fish (Group D) spawns off the shores of Inverness, Antigonish, and Westmorland Counties from late August to late September. Their larvae grow at the same rate as the autumn larvae in the Bay of Fundy (about 0.12 mm/day).

7. It can be shown from the available estimates of the larval and juvenile growth rates that four distinct ℓ_1-frequency distributions should result due to the variation in the time of hatching, and subsequent growth of the young fish, from the different spawning groups.

8. There is some evidence that these different growth patterns match the back-calculated ℓ_1 distributions of "spring" and "autumn" spawners.

9. The problem of determining the age composition of the different spawning groups is discussed. Although Lea's method is the most suitable, it is concluded that even it might lead to a consistent under-estimate of the age of Group B fish by 1 year.

10. Clearly, the evidence supporting the interpretation suggested above is far from being complete, and may require major revision in the light of new information. On the other hand, the suggested grouping of herring agrees with the known spawning times, the empirical growth rates, and the back-calculated ℓ_1-frequency distribution of "spring" and "autumn" spawners. I find it difficult to believe that the agreement on all these points is purely coincidental.

REFERENCES

Day, L.R. 1957a. Populations of herring in the southern Gulf of St. Lawrence. Bull. Fish. Res. Board Can. 111: 121-137.

Day, L.R. 1957b. Vertebral numbers and first-year growth of Canadian Atlantic herring (*Clupea Harengus L.*) in relation to water temperature. Bull. Fish. Res. Board Can. 111: 165-176.

Hodder, V.M. and G.H. Winters. 1972. Distribution and size of larval herring and capelin, southern Gulf of St. Lawrence and southwestern Newfoundland, November 1969 and 1970. Fish. Res. Board Can. Tech. Rept. 315, 25 p.

Huntsman, A.G. 1919. Growth of the young herring (so-called sardines) of the Bay of Fundy. Canadian Fisheries Expedition, 1914-15, pp. 165-171, Dept. of Naval Service, Ottawa.

Lea, E. 1919. Age and growth of herring in Canadian waters. Canadian Fisheries Expedition, 1914-15, pp. 77-164.

Messieh, S.N. 1969. Similarity of otolith nuclei in spring - and autumn - spawning Atlantic herring in the southern Gulf of St. Lawrence. J. Fish. Res. Bd. Canada 26: 1889-1898.

Messieh, S.N. and S.N. Tibbo. 1971. Discreteness of Atlantic herring (*Clupea harengus harengus*) population in spring and autumn fisheries in the southern Gulf of St. Lawrence. J. Fish. Res. Bd. Canada 28: 1009-1014.

Messieh, S.N. and A.C. Kohler. 1972. Distribution, relative abundance and growth of larval herring (*Clupea harengus L.*) in the southern Gulf of St. Lawrence. Fish. Res. Board Can. Tech. Rept. 318, 31 p.

Tibbo, S.N. 1957. Herring of the Chaleur Bay area. Bull. Fish. Res. Board Can. 111: 85-102.

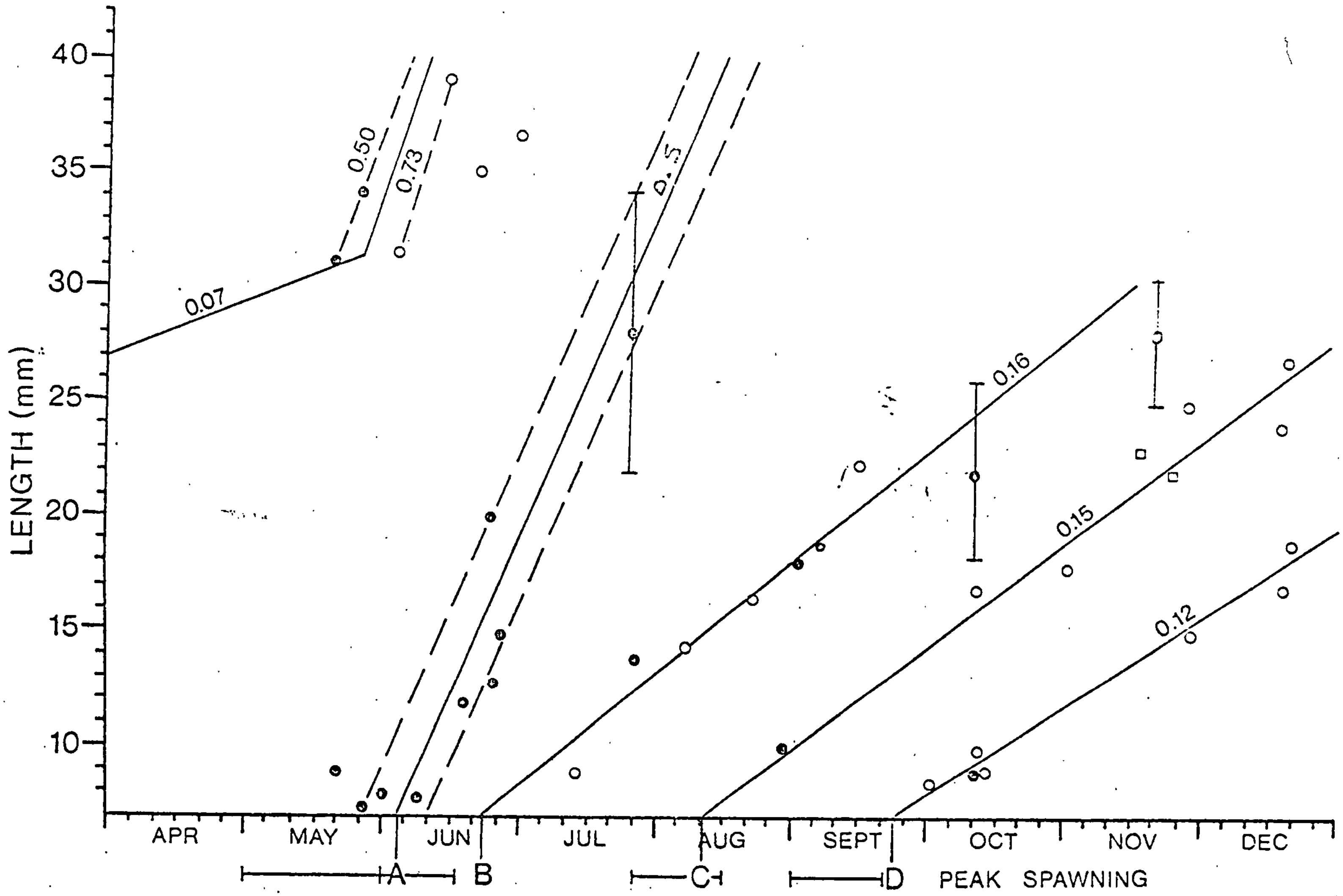

Fig. 1. Growth rates of herring larvae in the southern Gulf. The figures associated with each line indicate the growth rates (mm/day) of the four larval groups. The horizontal lines below the time axis indicate the estimated time of peak spawning for the four spawning groups. Data sources: (⊙) Messieh and Kohler (1972); (o) Ware, unpublished data from St. Georges Bay; (□) Hodder and Winters (1972).

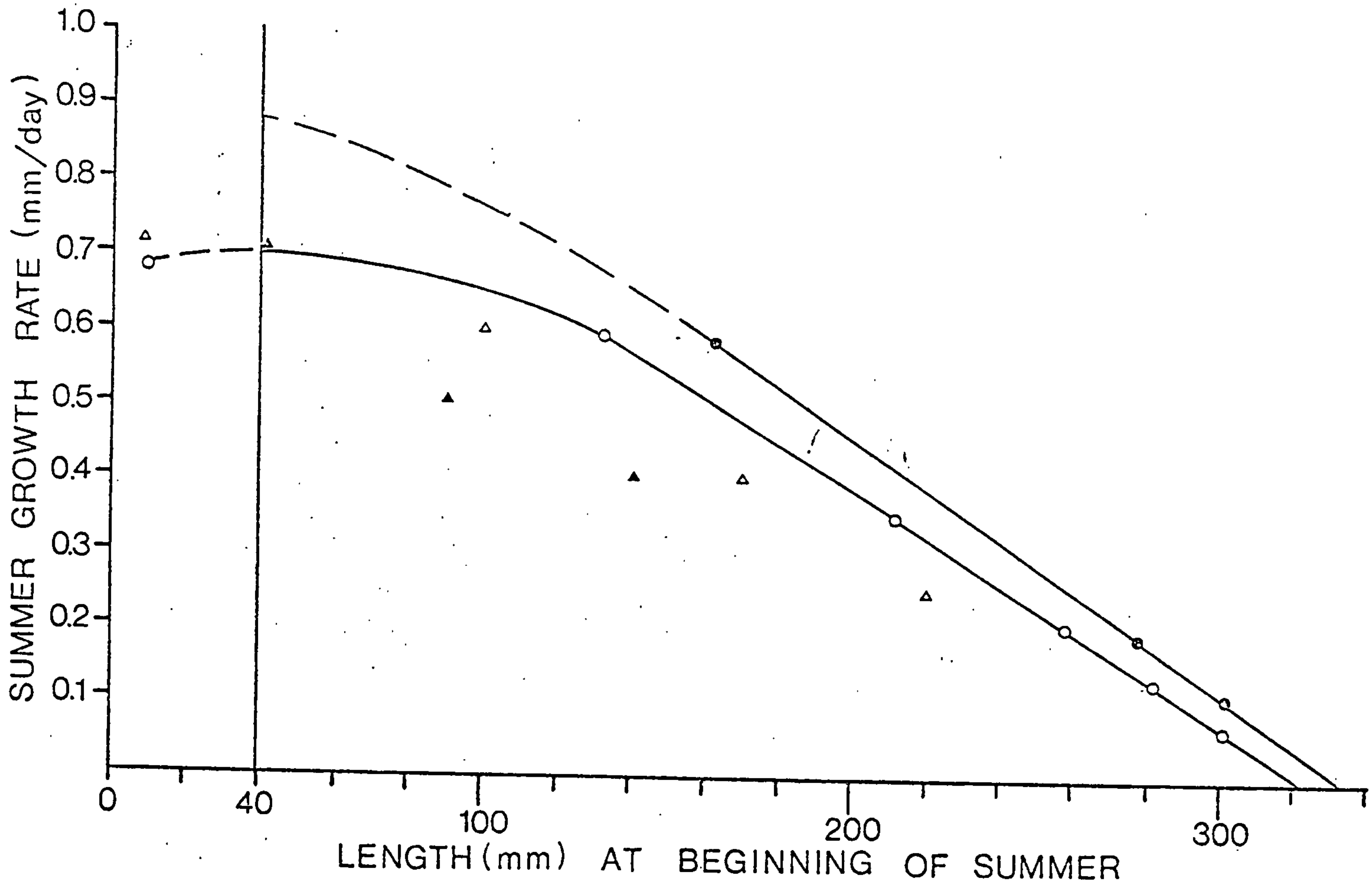

Fig. 2. Summer growth rate of juvenile and adult herring in relation to their length at the beginning of the growing season. Data sources: (Δ) Lea (1919); (▲) Huntsman (1919); (o) "spring" herring; (●) "autumn" herring.

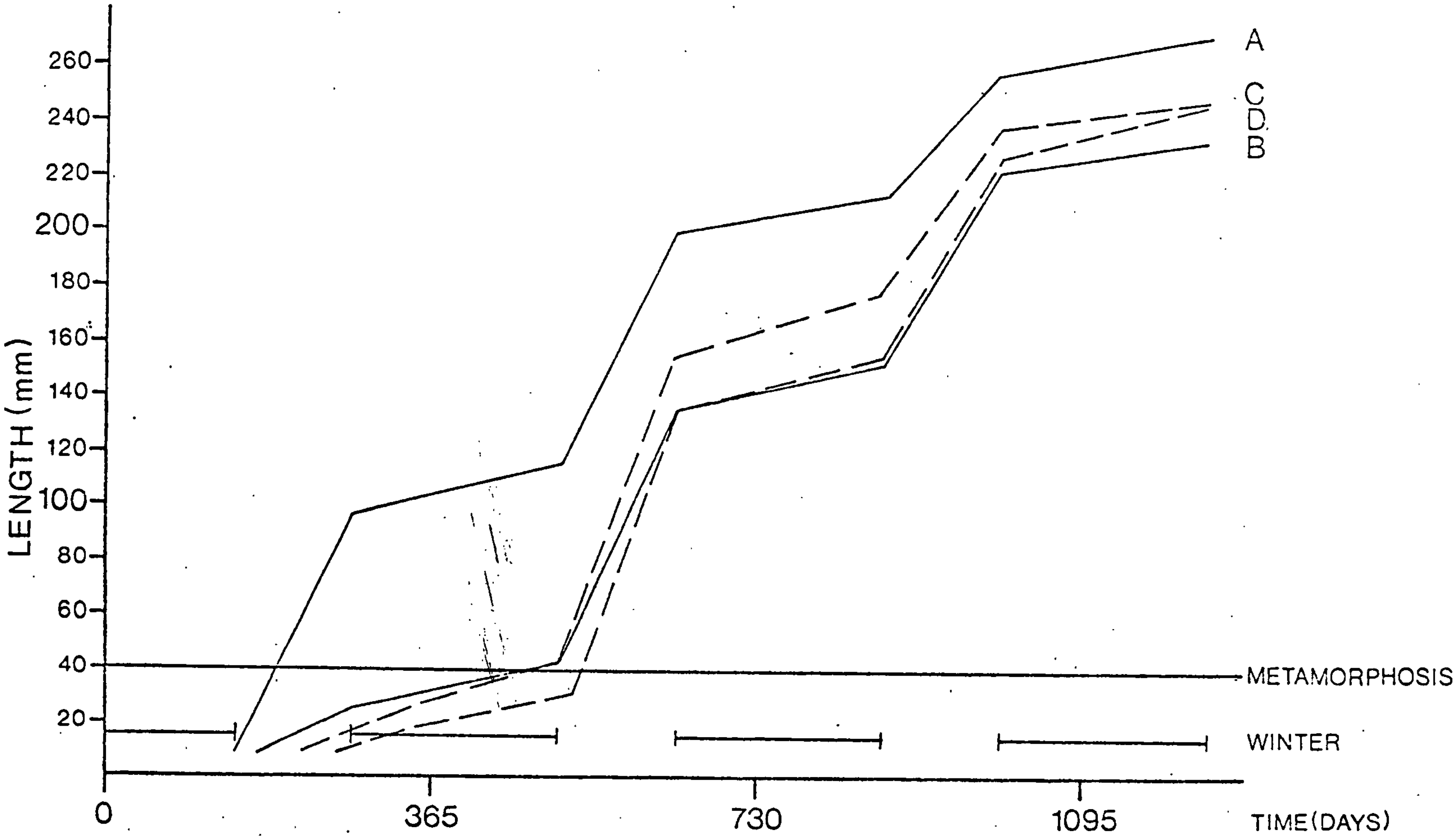

Fig. 3. Estimated growth "curves" of the four spawning groups.

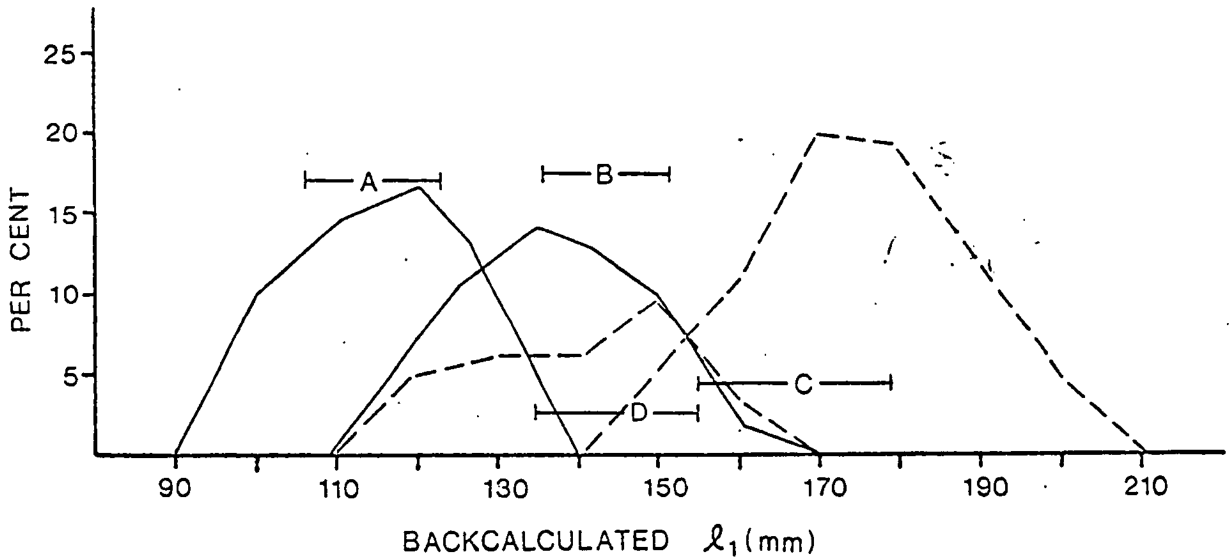

Fig. 4. Estimated lengths of the four spawning groups at the formation of the first annulus (horizontal lines) in relation to the back-calculated ℓ_1 distributions reported by Messieh (1969), and Messieh and Tibbo (1971). The "autumn" distribution reported by Messieh and Tibbo (1971, Fig. 6) has been split into two groups (dashed curves).

TABLE 1. HERRING SPAWNING GROUPS IN THE SOUTHERN GULF OF ST. LAWRENCE

FISHERY	APPROXIMATE TIME [a] OF PEAK SPAWNING	MAXIMUM CATCH	VERTEBRAL COUNT	SEASON	SPAWNING GROUP	SOURCE
Gloucester/ Northumberland	Early May (May 11)	Mid-May	55.64	Spring	A	(Messieh & Tibbo, 1971; Day, 1957)
Gaspé	Mid-May (May 19)	Mid-May	55.69	Spring	A	(Tibbo, 1957)
Westmorland/ Kent	Mid-May (May 21)	Mid-May	55.50	Spring	A	(Day, 1957)
Queens/Kings	Late May (May 28)	Mid-May	55.55	Spring	A/B(?)	(Day, 1957)
Bonaventure	Late May (May 29)	Mid-May	55.58	Spring	A	(Tibbo, 1957)
Antigonish/ Pictou	Late May - Early June (May 29)	Late May	?	Summer	B	(Ware, unpublished data)
Magdalen Is.	Early June (June 9)	Late May	55.66	Summer	B	(Day, 1957)
Inverness	Mid-June (June 13)	Late May	55.60	Summer	B	(Day, 1957)
Pictou/Kings	Late July - Early Aug. (?)	August	?	Summer	C	(Ware, Pers. Comm. local fishermen)
Gloucester/ Northumberland	Mid-Aug. (Aug. 16)	Late Aug.	?	Summer	C	(Day, 1957)
Inverness	Early Sept. (Sept. 9)	September	?	Autumn	D	(Day, 1957)
Antigonish/ Pictou	Early Sept. (Sept. 3)	Late Sept.	?	Autumn	D	(Ware, unpublished data)
Westmorland/ Kent	Mid-Sept. (Sept. 15)	Mid-Sept.	?	Autumn	D	(Ware, Pers. Comm. local fishermen)

[a] The dates in parentheses are the best, current estimates of the time of peak spawning. They are probably no more accurate than ± 1 week.