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The Validity of Otolith Ages of Southern Grand Bank Cod

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Abstract

Length frequency distributions of research vessel catches of cod from the southern Grand Bank (Divisions 3N and 30) are typically polymodal. Petersen's method, and progression of dominant year-classes, are used as evidence of the validity of otolith ages. Rather large fluctuations in year-class survival apparently occur, and during the 1946-1960 period, best survival of new year-classes occurred in 1946, 1949, 1953, 1955, 1958 and 1959.

Introduction

Age determination of fish from skeletal structures was brought to fruition during the early years of the present century. Validity studies, confirming the accuracy of the method for a number of species, are reviewed by Graham (1929). In recent years the tendency has been to accept the validity of a particular structure for a particular species, and to use it to determine age of fish from widely separated areas without further tests of validity. The importance of a critical approach to the ageing problem, in order that results of different workers and from different areas be comparable, has been pointed out by Dannevig (1933) and Saetersdal (1953). More recently, variable results from otolith exchange programmes have led to the recommendation by the Research and Statistics Committee of ICNAF (1963 Redbook, Part 1, p. 48) "that studies of validation of cod otolith age reading methods be vigorously pursued by member countries."

Evidence on the validity of otolith ages for various localities in the Newfoundland area, through examination of seasonal changes in the otolith edge, is presented by Fleming (1960). The present study gives further evidence of the reliability of otoliths to determine age of cod from the southern Grand Bank (Divisions 3N and 30), through agreement with Petersen's method, and observations on dominant year-classes.

Material and Methods

The length and age data were obtained from annual survey cruises on the southern Grand Bank from 1950 to 1962, by research vessels of the St. John's Biological Station. These were carried out during the months of April-June of each year, with additional cruises in March, 1961 and February, 1962. Depths fished ranged from about 25 fathoms (45 m) on the Southeast Shoal to 150 fathoms (275 m) on the southwest slope of the Grand Bank (Fig. 1). The fishing was carried out along a regular pattern of stations, mainly along lines B, D, F and H of Fig. 1. The otter-trawl codends were either lined or covered with 1 3/4-inch manila netting from 1950 to 1957, and lined with 1 1/8-inch nylon netting from 1958 to 1962.

The primary purpose of these cruises was to study the distribution and abundance, and to collect samples, of the haddock population of this area. Thus cod were not always measured, or otolith samples taken, from each set in which they occurred. Where length measurements were obtained, they were either of the entire catch of cod, or of random samples of the catch. In the latter case the length frequencies were adjusted to catch on a set by set basis. Otolith collections were generally made from random sub-samples of the fish selected for measurements. These were used to construct yearly age-length keys, by means of which the adjusted length frequencies were broken down by age. Otolith collections in 1950, 1954, 1955 and 1957 were insufficient for this purpose, and the length frequencies for the former 2 years were broken down by means of an age-length key based on combined collections during 1950-54, while those for the latter 2 years were broken down by means of a key based on 1955-59 data.

The ages were read from otoliths by Mr. G. R. Williamson, a former member of the staff of the St. John's Biological Station, in consultation with the author. The age reading technique is described in the summary by Keir (MS, 1960). The fish length measurements were invariably from tip of the snout to mid-fork of the caudal fin (fork length).

Validity of Otolith Ages

Parrish (1956) summarizes the principles underlying Petersen's method as follows:

(1) If a fish population has a single restricted spawning season, the lengths of the individuals of an age-group are normally distributed.

(2) Growth of each age-group is such that the modes of the length distributions of successive age-groups are sufficiently separated along the length axis as to make them readily distinguishable.

(3) The separate modes of the polymodal length distribution represent the approximate mean sizes of the age-groups present.

Since the method cannot be used to determine age of individuals, it is generally employed only as a last resort, but remains very useful as a check on the reliability of other methods (Kohler, 1958, 1964; Sandeman, 1961). It is particularly applicable to the southern Grand Bank where a restricted annual spawning season occurs (Thompson, 1943), and where annual growth at most ages is greater than in any other part of the Newfoundland area (Thompson, 1943; Fleming, 1960; May _et al._, MS, 1964).

The adjusted length and age distributions for each year are shown in Fig. 2. Fish greater than 101 cm in length and 12 years of age were generally not very abundant, and are included together for present purposes. The length distributions (percent in each 3-cm length group) are seen to be typically polymodal up to about 70 cm. The smallest size at which a peak in the length distributions occurs is 13-16 cm. Otoliths of these fish typically show an opaque central area, surrounded by a well-defined translucent zone, with sometimes a small amount of opaque material on the otolith edge. These are regarded as having completed one year of growth, with any opaque edge material representing the beginning of the next growing year. Some otoliths also exhibit a very narrow translucent zone close to the centre, and this is regarded as a "settling check", its formation probably related to the attainment of a bottom or near-bottom dwelling existence.

The next largest size at which a well-defined mode occurs is 22-25 cm, and after that at 31-37 cm, 40-46 cm and 52-55 cm. Thus it would be expected that these represent ages 2-5 respectively. This assumption is quite justified by the progression of modes through each of these length ranges from year to year. This is particularly evident for fish of the 1955 year-class in the length distributions of 1956 to 1960, and the presence of this year-class can even be discerned in the length distributions of 1960 and 1961. On this basis, ages can be assigned to the most prominent modes in the length distributions (Fig. 2), and show that the most abundant year-classes in this period were those of 1946, 1949, 1953, 1955, 1958 and 1959. The modes tend to become indistinct beyond age 5.

Figure 2 also shows the adjusted age distributions for each year and the calculated length distributions of the dominant age-groups. These have been determined from yearly age-length keys (except as noted earlier) constructed on the basis of otolith ages. The very close correspondence of the calculated length distributions for dominant ages to the modes of the overall length distribution, and the progression of dominant year-classes through the yearly age distributions, provide very convincing evidence of the validity of otolith ages in the area under consideration.

Discussion and Conclusions

The importance of validity studies to determine the reliability of a particular method of age determination should not be underestimated. Aside from the need to establish the reliability of an ageing method for a particular species or area, determination of age from skeletal structures usually involves interpretation of zone patterns rather than straightforward counting. Validity studies provide criteria for such interpretation. Thus Sandeman (1961) uses Petersen's method to support evidence from scales and otoliths of slow growth rate for Hermitage Bay (Newfoundland South Coast) redfish, and Kohler (1964) uses it to establish a basis for identification of the first annulus on otoliths of cod from the Western Gulf of St. Lawrence (Division 4T).

In the present study the following of dominant year-classes, and the comparing of their length distributions with the various sections of the overall length distributions, are facilitated by the obvious variability in year-class survival. While there are no complete failures of year-class, such as occur in the haddock population of this area (Templeman, MS, 1964), some year-classes are consistently poorly represented (1950 and 1956), while others (1949 and 1955) dominate the age distributions for several years and continue to stand out even at ages up to 7-9. It is of interest to note that the two apparently largest year-classes (1949 and 1955) are followed by two of the smallest.

Also worthy of note is the correspondence between the relative survival of cod year-classes and those of haddock in the same area. Templeman (MS, 1964) describes haddock survival as very successful in 1949 and 1955, years of very successful cod survival as well. Haddock survival is described as moderate in 1946 and 1952, and modest in 1947, 1953, and 1956. Of these years, particularly significant survival of cod year-classes occurred in 1946 and 1953. Thus with the exception of 1958 and 1959, best survival of cod occurred in years in which haddock were particularly abundant. This would appear to point to some physical factor or factors, operating simultaneously on both species as having the controlling influence on survival, The adverse effect on cod should not be as great as on haddock, since fluctuations in survival of cod year-classes might be evened out by replenishment at the larval and later stages from areas to the north, while no northerly haddock populations are present in the area.

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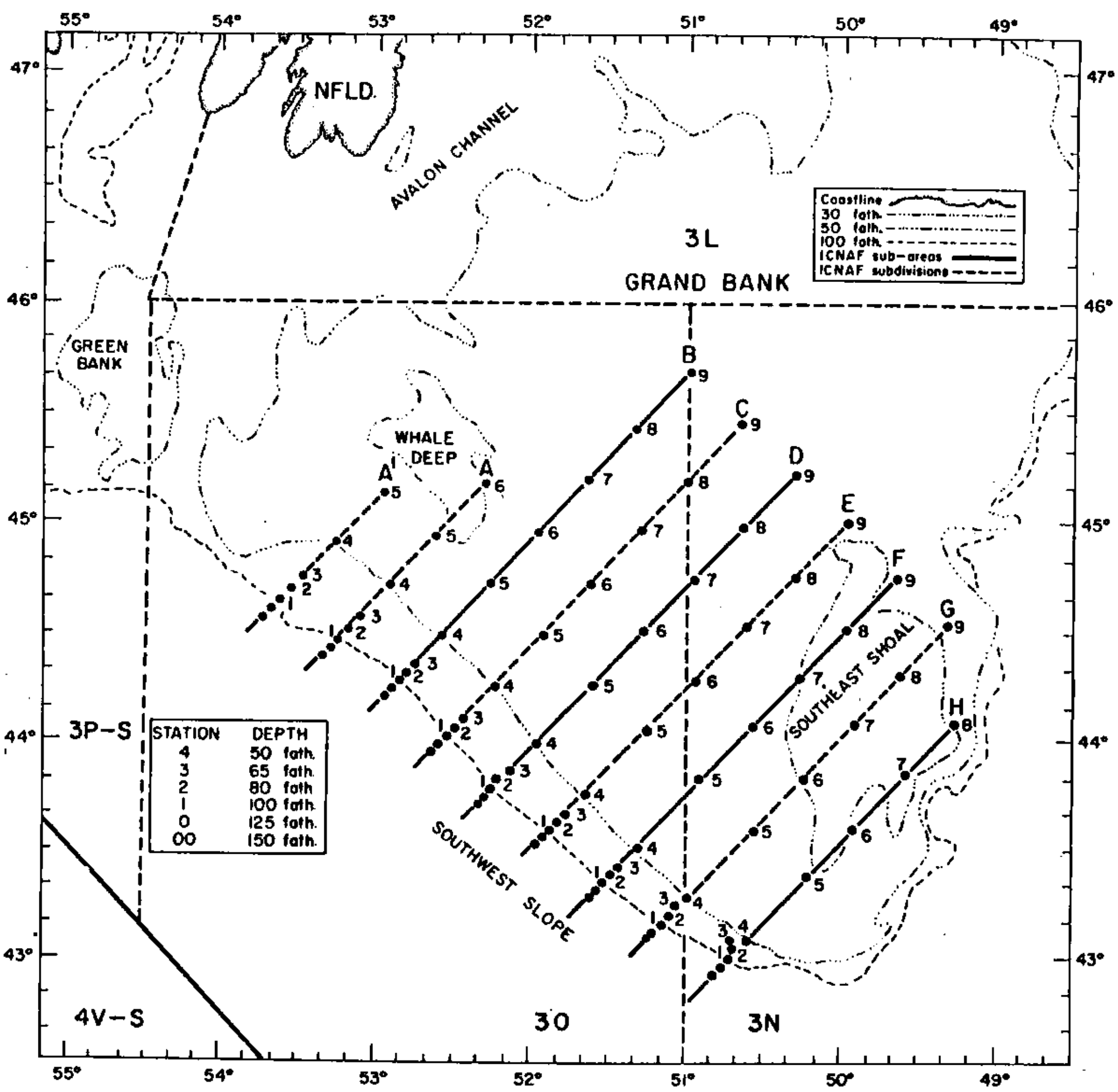

Fig. 1. Map of the southern Grand Bank showing lines of stations fished in surveys by research vessels of the St. John's Biological Station.

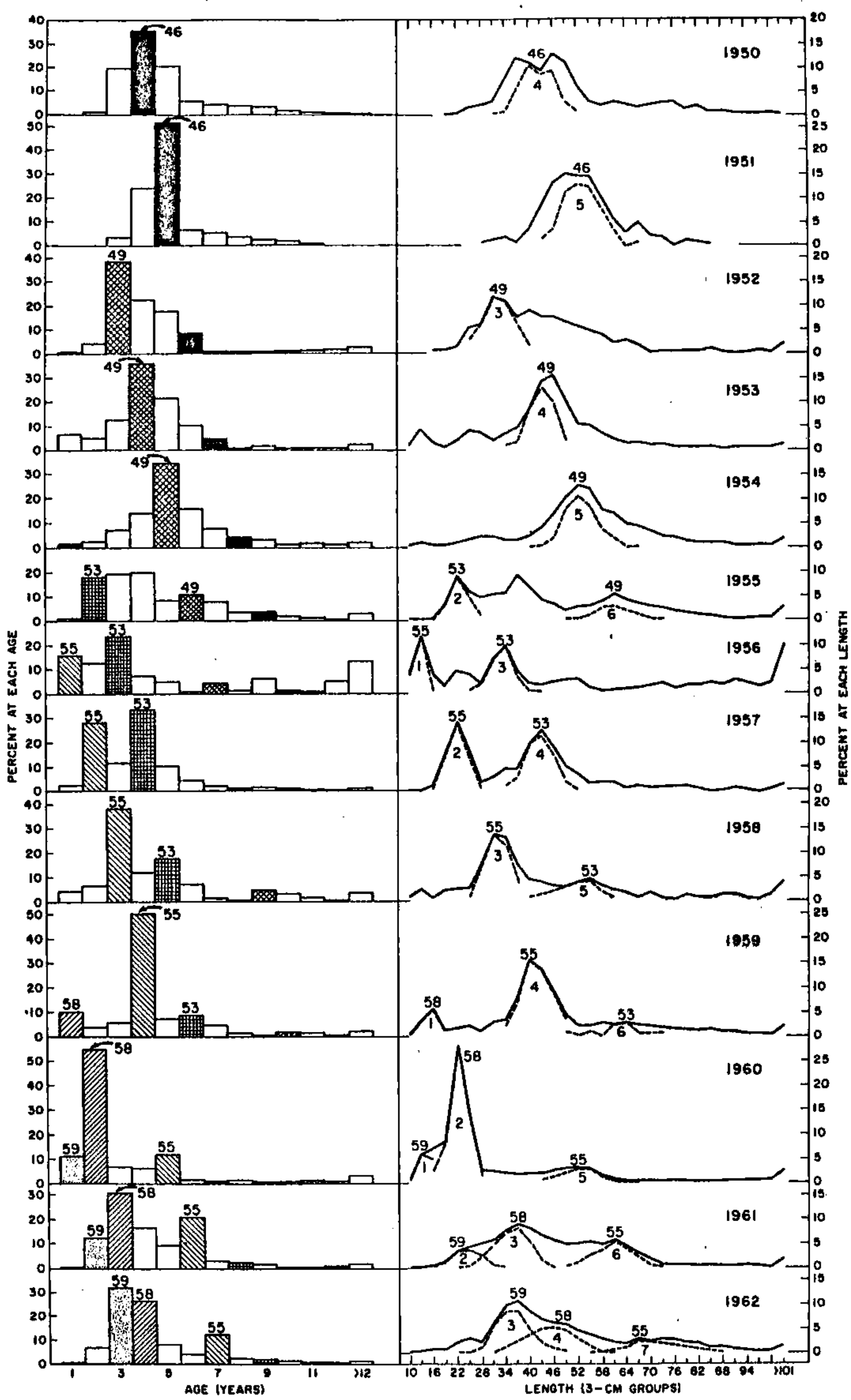

Fig. 2. Adjusted age and length distributions of research vessel catches of cod from spring surveys on the southern Grand Bank, 1950-1962.