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Problems of ageing Atlantic herring (*Clupea harengus harengus* L.) in the ICNAF Area

by

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Valid ageing of fish is essential in estimating the population parameters. Since the formation of ICNAF, age validation studies have been recognized as important in the ICNAF area. This led to the formation of the "Ageing Technique Subcommittee" to organize age validation studies. Progress has been made in these studies mainly for groundfish species, but it was not until 1966 that herring ageing problems attracted the attention of member countries, and a Herring Otolith Exchange Program to resolve the discrepancies in age determinations between these countries was proposed.

Review of the Herring Otolith Exchange Program

In 1966 a herring otolith exchange program was initiated following a recommendation of the Standing Committee on Research and Statistics (R & S) which reported the following:

> "Comparison of data on the age compositions of samples taken by different countries revealed differences in the relative contributions of the different year-classes in the catch taken by Canada and other countries. To determine whether this is attributable to differences in age reading, R & S recommends:
>
> > that Canada, Poland, and U.S.A. exchange herring otoliths to compare ageing techniques. Canada will initiate this exchange and report on the results next year." (Anon. 1966).

In accordance with this recommendation, herring otoliths were exchanged among Canada, Poland and U.S.A., and the results were reported to ICNAF (Tibbo 1968). The results indicated discrepancies in age estimates and pointed to the need for continuation of studies of ageing techniques. It was agreed then that the exchanges should continue and be arranged through the Secretariat. (Anon. 1967). The program continued from 1967 through 1970 (Tibbo 1969, 1970). The completed results supported the view expressed in the previous reports that there was a lack of uniformity in age estimates between countries, and further study would appear to be necessary to resolve these differences (Tibbo 1970).

In 1971, a selection of otoliths representing herring stocks from Georges Bank to southwest Newfoundland was circulated and participants were requested to provide, in addition to age and year-class estimates, a description of age definition, conventions, and techniques (Parsons and

Winters 1972). The overall results again revealed considerable discrepancies in age and year-class estimates among participating countries. In their report, Parsons and Winters (op. cit.) concluded that "this and previous exchange have delineated the nature and extent of the problem and it is doubtful that future exchange of the same type will suffice to resolve these differences." They suggested that many major discrepancies might best be resolved through a special Herring Ageing Workshop to bring together ageing experts from all countries having an interest in herring of the ICNAF area. These results led the Herring Working Group, in its 1972 meeting, to recommend:

> "that a special herring ageing workshop be set up to concentrate on the study of objective criteria for herring age determination and on standardizing methods and conventions. Such a workshop would also consider the usefulness of otolith characteristics and otolith morphometry as a means of stock identification" (Anon. 1972).

The Herring Ageing Workshop was scheduled for Hamburg, Germany early in 1973, but was subsequently cancelled. Instead, a small study group on herring ageing, including scientists from Canada and U.S.A., met in December 1972 at St. Andrews, N.B. (Hunt et al. 1973). In their report they recommended some conventions to resolve the existing discrepancies, and concluded that further exchanges among member laboratories to correct differences in estimation of zone counts might be fruitful but would prove so massive and time-consuming as to be impractical. They further suggested that consultation between investigators on specific problems should be encouraged.

Herring Ageing Problems

These can be classified into two categories:

A. Annuli misinterpretation

Misinterpretation of the annuli in younger fish does not constitute a problem at present. This appears from the results of the otolith exchange program, and other studies (e.g. Messieh and Tibbo 1970). For older fish, however, there is a considerable amount of variation between different age estimates, and the level of agreement for age gets progressively worse with the increase in age of the fish (Tibbo 1969).

Messieh and Tibbo (op. cit.), in their study on herring otolith and scale ageing, found that, for older herring, the margins of the otoliths showed little contrast between hyaline (winter) and opaque (summer growth) zones. This resulted in lower values of age estimates from otoliths than from scales. In a later study (unpublished data), with the improvement of otolith ageing techniques by the use of reflected polarized light and immersing the otoliths in alcohol, the level of agreement increased up to age 9. The considerable amount of variation and difficulties in ageing old herring was reported by Tibbo (1969). For fish of 30-40 cm, for example, there were differences of as much as 4 years.

Parsons and Winters (1972) found similar discrepancies. They reported that the level of agreement for relatively small fish (12-23 cm in length) in the Bay of Fundy sample was higher (greater than 90% between all pairs of laboratories with the exception of Germany). However, the degree of agreement decreases markedly with increase in fish size. Valid comparisons could not be made for the southern Gulf of St. Lawrence and southwest Newfoundland samples because of the high proportion of relatively old fish (greater than age 8) in these samples and differences in the grouping categories employed by the various laboratories.

The problem of whether or not to count the nucleus as the first winter zone arises from the difficulty in identifying the spring- and autumn-spawned fish. It is assumed that the otolith of an autumn-spawned fish has a nucleus which represents growth from the time of hatching until the first winter of its life. A spring-spawned fish would have enough time (being hatched in the peak of the spring bloom at the beginning of the summer growth period) to form an opaque zone large enough to contrast with the first hyaline winter zone. There is, however, a problem in identifying the nucleus of the otolith in relation to the hatching season. Messieh (1969) suggested that due to the changes in the hydrographic conditions within the season, and the overgrowth of opaque material in the central areas of the otoliths resulting from subsequent growth, the optic appearance of the nucleus could be misleading.

The problem of identifying the otolith nuclei, their relative sizes, and their possible use in identifying the spawning seasons needs further research. The sporadic nature of herring spawnings, and the possibility of overlap between different progenies make the problem more difficult. An earlier study (Messieh 1970) showed that in an area such as the Bay of Fundy where there are herring nursery grounds inhabited by fish of different spawning groups, part of the autumn spawned population metamorphoses before the winter, leading to a different size group which could overlap with the spring-spawned group.

Studies on developing and improving the techniques of fish stock identification are important. Criteria of separating the stocks should preferably be independent. Different characteristics have been used with various degrees of success in separating herring stocks in the ICNAF area. The characteristics used are times of spawning and maturation stages (Messieh and Tibbo 1971), otolith types (Messieh 1972), meristic characters (Antony and Boyar 1968), discriminant analysis on meristic characters (Parsons 1972; Messieh 1973), infestation with larval nematodes (Parsons and Hodder 1971; Lubieniecki 1973), and biochemical and serological methods (Sinderman 1962; Ridgway et al. 1971; Odense and Allen 1971; Zenkin 1971). Overlapping between the morphological characters creates difficulties in stock separation and more research to resolve stock identification problems is needed.

B. Age definition differences

All reports on the herring otolith exchange program indicated that some of the differences among otolith readers were due to differing definitions, conceptions or interpretations of ages and year-classes. In a questionnaire circulated to laboratories engaged in herring research in Canada (St. Andrews and St. John's), France, Germany, UK, USA, and USSR, information was solicited on several points about definitions used in herring ageing (Parsons and Winters 1972). The responses to these queries indicated differences in criteria and conventions for age and year-class determination. One criterion on which all responden's agreed was the consideration of January first as an arbitrary birth date.

The adoption of January first as an arbitrary birth date for herring was recommended previously (Messieh et al. 1968). In their report on length-age distribution of Bay of Fundy herring, they considered a fish to be age one on January first following hatching, regardless of the hatching season. They further added that "spring-spawned herring will be obviously several (3 to 5) months older than autumn-spawned herring of the same age and year-class, but this method avoids many difficulties of other techniques that are used".

The Herring Ageing Workshop report (Hunt et al. 1973), recommended four conventions aimed at resolving the discrepancies among member countries. These recommendations are: the adoption of January first as the arbitrary birth date; the use of age-group instead of age; and the definitions of the age and year-class. They defined an age-group as:

When opaque zones are counted:

(a) For spring spawners - the number of completed opaque zones prior to January first of the sampling year;

(b) For autumn spawners - the number of completed opaque zones prior to January first of the sampling year plus one.

When hyaline zones are counted:

(a) For spring spawners - the number of completed hyaline zones prior to January first of the sampling year plus one.

(b) For autumn spawners - the number of completed hyaline zones prior to January first of the sampling year including the nucleus as the first zone.

The inclusion of opaque zone counts in age-group definitions (as reported above) could lead to some confusion. This can be seen in Fig. 1 which shows that the completion of the opaque (summer growth) zones occurs prior to January first. Studies on herring otolith growth (Messieh, this meeting) indicate that the hyaline zone is formed in October, and the subsequent opaque zone does not start before April. Thus, while the January first date coincides with the middle of the formation of the hyaline zone, the completion of the opaque zone occurs after the period of summer growth. Hence, it is more appropriate to use the hyaline zones in age conception if the January first date is accepted as an arbitrary birth date. Hyaline margins should be excluded from the counts when they appear in the fall of the year.

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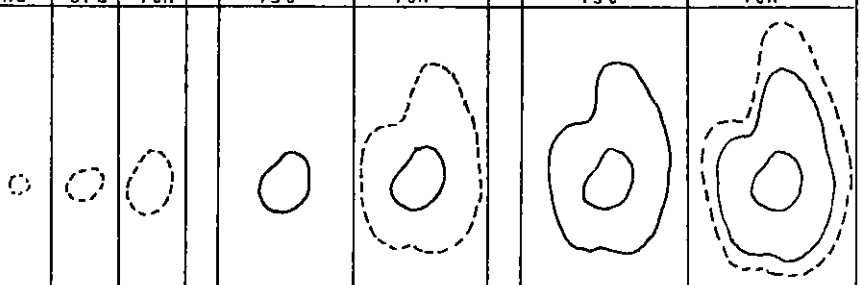
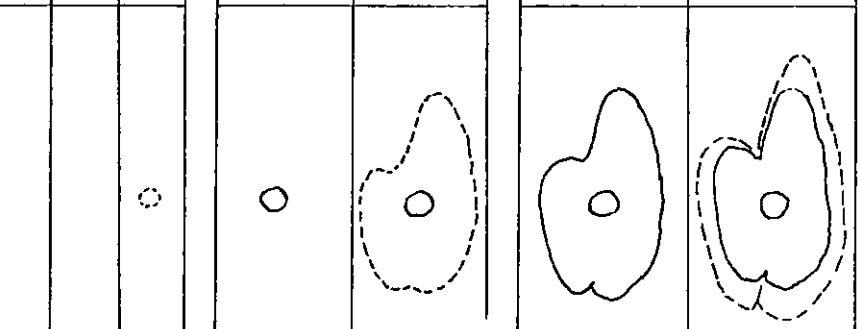
Fig. 1. Diagram of herring otolith of a hypothetical year-class (1971) sampled in three successive years, showing number of hyaline and opaque zones, and age-groups. (Completed hyaline zone ——; Uncompleted hyaline zone- - - -)

Sampling year	1971			1972		1973	
Quarter	2nd	3rd	4th	1st	4th	1st	4th
Spring-spawned							
Autumn-spawned							
Age*	0			1		2	
Number of opaque zones	0-1			0-2		1-3	
Number of hyaline zones	0			1		2	

* Adopted by Herring Ageing Workshop (1973).