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Comparison of the otolith length/width ratio of herring in ICNAF Subareas 4 and 5

J. J. Hunt
Fisheries and Marine Service,
Biological Station, St. Andrews, N. B.,
Canada.

Introduction

The significance of stock associations in assessing total fishing mortality and potential yields of the components of a stock complex has long been recognized as the key to a good management regime. To delineate stock boundaries and identify associations has proven a difficult task and many authors have attempted to use both biological and physical indices to separate stocks but with varying degrees of success. The use of otoliths for this purpose has proven beneficial in some fisheries but, in general, no conclusive evidence has been presented for the Northwest Atlantic herring stocks which allows separation on an individual basis.

Several otolith characteristics have been considered for herring, including general outline (Messieh 1972), nucleus type, and the ratio of otolith length to width (Konstantinov 1971). The promising results obtained by Konstantinov (1971) suggested a similar examination of Canadian-caught herring. This report, therefore, summarizes findings for the length and width of herring otoliths from Canadian catches in 1972 within ICNAF Subareas 4 and 5.

Materials and Methods

Five areas were selected for study on the basis of their geographical separation and on the probability of there being a distinct stock of herring within one or more of the areas. The areas examined were ICNAF Div. 5Y, 4X — Bay of Fundy, 4X — Scotian Shelf, 4W and 4Vn, and the otoliths of fish caught within these areas in 1972 have been used for measurements. Specific areas and sampling dates are summarized in Table 1.

Table 1. Sampling locations.

Area	Location	Date (1972)
5Y	Jeffrey Ledge	April-May
4X-Bay of Fundy	Nova Scotian Coast	June-October
4X-Scotian Shelf	Inshore Nova Scotian Coast	June-October
4W	Chedabucto Bay	January-March
4Vn	Cape Breton Coast	January-March

Individuals were selected at random from samples within these areas by taking five fish for each centimeter length group in the 15.0 to 38.0 cm range. Thus a possible total of 120 otoliths were measured for each area although some length groups were not represented in all areas.

Several methods for measuring length and width of otoliths were considered to determine the most accurate and efficient means. These included use of a micrometer eye-piece, image projection, and camera lucida. Little or no difference in accuracy was found in any of the methods but the camera lucida technique was judged to be the most efficient and was therefore used for all measurements. This method consisted of superimposing the image of a millimeter grid pattern through the camera lucida onto the image of the otolith to be measured. This provided a magnification of 30 diameters and permitted measurements to be made to an accuracy of ± 0.02 mm. To ensure consistent measurements, length was defined as the longest dimension taken along the axis of the rostrum-postrostrum and width defined as the widest dimension taken at right angles to the long axis. Broken or obviously deformed otoliths were rejected. Dimensions are summarized in Fig. 1.

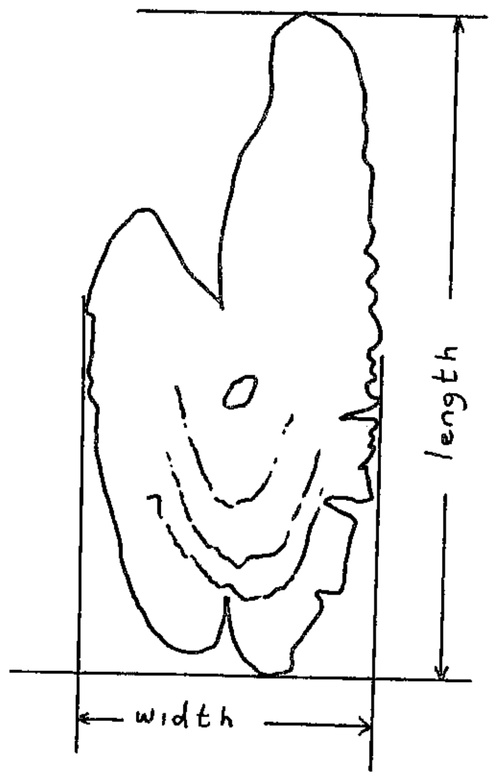

Fig. 1. Otolith dimensions and definition.

Measurements of the five individuals were averaged to obtain a mean otolith length and width for each centimeter interval and these mean values are summarized in Table 2. Regression parameters for fish length-otolith length and for otolith length-width were calculated from the data of Table 2 and are presented in Fig. 2 and 3 with the resultant regression lines. The otolith length/width ratio by length interval and area was calculated from Table 2 and results are presented in Table 3.

Results and Discussion

To assess differences in mean length and width of otoliths between areas, two relationships were considered from the data of Table 1. The first was the regression of fish length on otolith length. Messieh (1974) examined this relationship for small herring (< 120 mm) in the Bay of Fundy and found it to be best represented by a straight line although he does suggest some dependence on fish size and compares his data for two length ranges. Messieh (1972) also examined this relationship for adults in the Gulf of St. Lawrence and again suggested a straight line for the data. Lines were thus fitted to the data by the method of least squares for each area and the resultant value of the coefficient of regression (R) appears to support a straight-line relationship (Fig. 2). With the exception of area 4W, very little variation in the slope and intercept of these lines is evident and what divergence does exist may be attributed to the lack of data for small fish in areas 4W and 4Vn. Results therefore suggest a relatively constant relationship between fish and otolith length within the areas under discussion.

The second relationship examined was the regression of otolith length and width and a straight line was assumed to provide the best representation of data. High values of R were again achieved, suggesting good agreement with observed data (Fig. 3). Areas 4W and 4Vn appear divergent from the other three but the apparent shift in data for small fish and their absence in these two areas may account for the difference in slopes. While somewhat more generalized, the data tend to confirm that this relationship is constant throughout areas and what differences to exist are not significant for stock separation.

To test the significance of differences, the ratio of otolith length to width (Table 3) was examined for variation within and between areas. Since this ratio appeared to be less for small fish, standard deviations and means were calculated for both the entire length range and for the range from 21.0 to 37.0 cm. In both cases the deviation from the mean was small although the latter case did provide less variation from the mean value. These results confirm a constant relation between fish length and this ratio for fish above 21.0 cm, with a possible increase in variation in smaller fish. Konstantinov (1971) also found this ratio to be constant for fish length in Banquereau and Emerald Bank herring although he does not report the variation within each length group. Differences in the mean value of the ratio between areas did not appear significant, but to test differences the "multiple range test" described by Duncan (1955) was applied. This test provides a maximum range for differences in mean values based on the number of observations and on the standard error of the mean. At the 5% significance level it was found that differences were not significant and that areas could not be distinguished on the basis of this parameter. Konstantinov (1971) did find a significant difference between areas (2.4 for Emerald Bank vs 2.2 for Banquereau) but again he does not report the standard deviation in these values.

In summary, evidence presented suggests that the relationship between fish and otolith length and between otolith length and width is consistent within areas discussed. It further suggests that fish from each of the areas cannot be separated on the basis of an otolith length/width ratio. However, this does not imply that a homogenous stock exists within these areas, but rather that the one or more distinct unit stocks have similar otolith characteristics.

Literature Cited

Duncan, D. B. 1955. Multiple Range and F Test. Biometrics 11: 1-42.

Konstantinov, V. 1971. U.S.S.R. Research Report, 1970. Int. Comm. Northw. Atlant. Fish. Redbook Part II, 1971.

Messieh, S. N. 1972. Use of otoliths in identifying herring stocks in the southern Gulf of St. Lawrence and adjacent waters. J. Fish. Res. Bd. Canada 29: 1113-1118.

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TABLE 2. LENGTH AND WIDTH (MM) OF OTOLITHS BY AREA AND CENTIMETER LENGTH GROUP

Length Group	5Y		4X Bay of Fundy		4X Scotian Shelf		4W		4VN	
	Length	Width	Length	Width	Length	Width	Length	Width	Length	Width
15-15.9	2.60	1.36	2.60	1.36	-	-	-	-	-	-
16-16.9	2.64	1.44	2.72	1.40	-	-	-	-	-	-
17	2.92	1.48	2.70	1.40	3.02	1.48	-	-	-	-
18	2.80	1.48	2.90	1.48	2.96	1.56	-	-	-	-
19	3.14	1.58	2.98	1.50	3.16	1.54	-	-	-	-
20	3.26	1.58	3.26	1.62	3.08	1.56	-	-	-	-
21	3.40	1.66	3.26	1.58	3.32	1.64	-	-	3.24	1.62
22	3.38	1.66	3.38	1.66	3.44	1.66	3.82	1.74	3.66	1.70
23	3.50	1.72	3.46	1.70	3.58	1.66	3.84	1.80	3.84	1.78
24	3.54	1.74	3.90	1.86	3.52	1.72	3.86	1.94	3.84	1.80
25	3.82	1.90	4.14	1.92	3.94	1.86	4.10	1.90	3.92	1.84
26	4.32	1.86	4.28	1.96	4.04	1.92	4.12	1.88	4.18	1.94
27	4.30	1.88	4.28	2.02	4.20	1.96	4.20	1.96	4.36	2.02
28	-	-	4.32	2.00	4.16	1.98	4.30	2.04	4.42	1.92
29	4.60	2.12	4.46	2.08	4.44	2.10	4.46	2.06	4.56	2.10
30	4.62	2.20	4.56	2.16	4.40	2.10	4.50	2.08	4.60	2.18
31	4.72	2.28	4.72	2.18	4.54	2.04	4.70	2.10	4.78	2.24
32	4.82	2.34	4.96	2.28	4.90	2.22	4.62	2.24	4.78	2.24
33	5.18	2.42	4.98	2.28	4.82	2.26	4.78	2.30	5.04	2.32
34	5.26	2.48	5.16	2.40	4.76	2.34	5.38	2.48	5.22	2.40
35	5.34	2.58	5.34	2.50	5.18	2.40	5.14	2.42	5.32	2.46
36	5.46	2.38	5.26	2.58	5.18	2.50	5.34	2.58	5.38	2.52
37-37.9	5.20	2.56	5.50	2.56	5.24	2.54	5.44	2.52	5.52	2.64
38-38.9	-	-	4.98	2.50	5.60	2.62	-	-	5.42	2.62

TABLE 3. OTOLITH LENGTH/WIDTH RATIO BY AREA AND CENTIMETER LENGTH GROUP

Length Group	5Y	4X Bay of Fundy	Area 4X Scotian Shelf	4W	4VN	Combined
15-15.9	1.91	1.91	-	-	-	1.91
16	1.83	1.94	-	-	-	1.87
17	1.97	1.93	2.04	-	-	1.98
18	1.89	1.96	1.90	-	-	1.92
19	1.99	1.99	2.05	-	-	2.01
20	2.06	2.01	1.97	-	-	2.01
21	2.05	2.06	2.02	-	2.00	2.03
22	2.04	2.04	2.07	2.20	2.15	2.10
23	2.03	2.04	2.16	2.13	2.16	2.10
24	2.03	2.10	2.05	2.22	2.13	2.11
25	2.01	2.14	2.12	2.16	2.13	2.11
26	2.32	2.18	2.10	2.19	2.15	2.19
27	2.29	2.12	2.14	2.14	2.16	2.17
28	-	2.16	2.10	2.11	2.30	2.17
29	2.17	2.14	2.11	2.17	2.17	2.15
30	2.10	2.11	2.10	2.16	2.11	2.12
31	2.07	2.17	2.23	2.24	2.13	2.17
32	2.06	2.18	2.21	2.06	2.13	2.13
33	2.14	2.18	2.13	2.08	2.17	2.14
34	2.12	2.15	2.03	2.17	2.18	2.13
35	2.07	2.14	2.16	2.12	2.16	2.13
36	2.29	2.04	2.07	2.07	2.13	2.12
37	2.03	2.15	2.06	2.15	2.09	2.10
38-38.9	-	1.99	2.22	-	2.07	2.09
Mean	2.066	2.076	2.092	2.148	2.140	2.082
Standard Deviation	0.123	0.088	0.079	0.051	0.058	0.088
Mean(21.0 to 37.0)	2.128	2.127	2.115	2.148	2.153	2.133
Standard Deviation	0.109	0.049	0.055	0.051	0.045	0.028

Figure 2. Regression lines and parameters for fish length and otolith length.

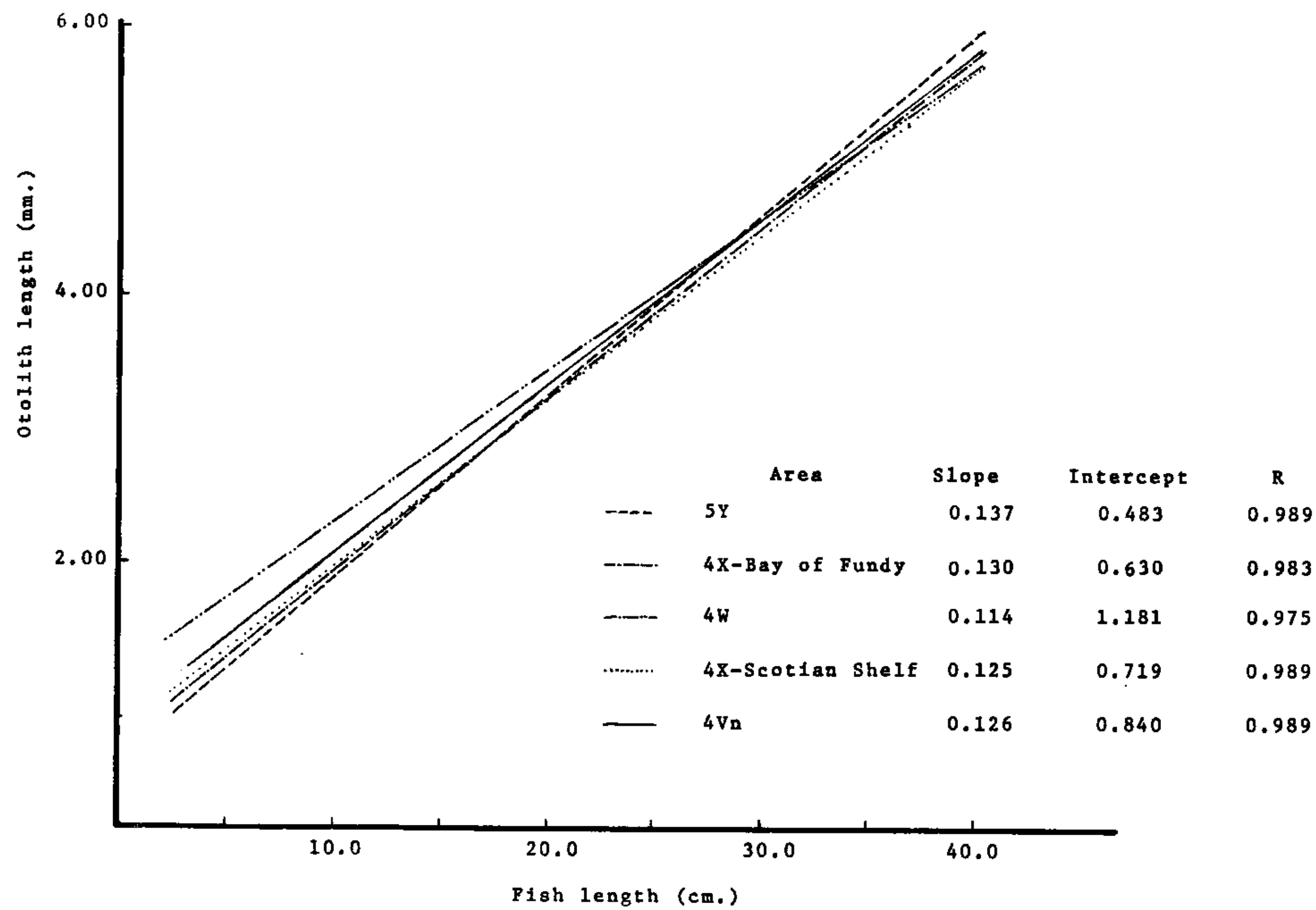
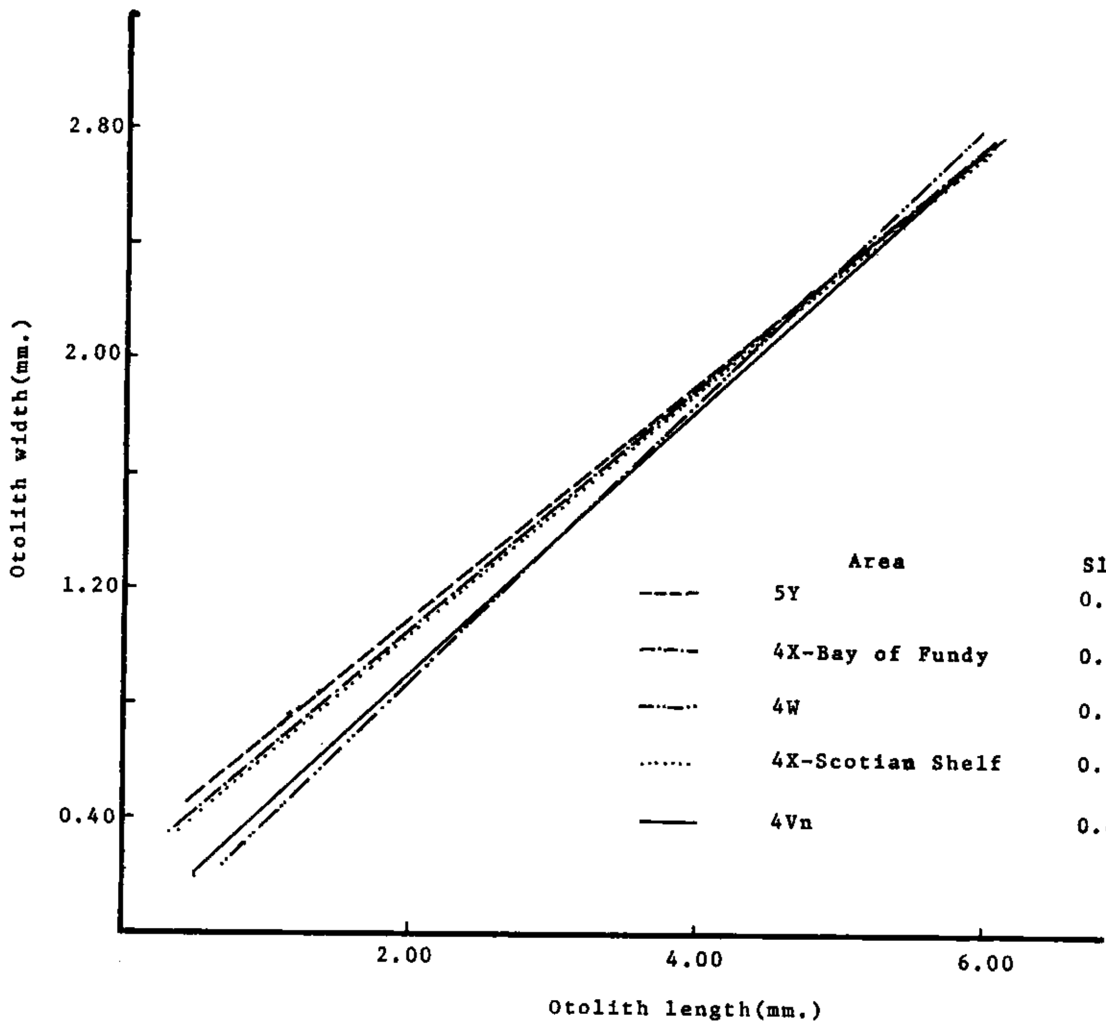


Figure 3. Regression lines and parameters of otolith length and width.



Area	Slope	Intercept	R
5Y	0.4122	0.1397	0.978
4X-Bay of Fundy	0.4226	0.1149	0.991
4W	0.4956	-0.0669	0.985
4X-Scotian Shelf	0.4201	0.1130	0.983
4Vn	0.4695	-0.0069	0.985