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Fecundity of Greenland Halibut, *Reinhardtius hippoglossoides* (Walbaum), from Southern Labrador and Southeastern Gulf of St. Lawrence

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Abstract

The fecundity of Greenland halibut from the southern Labrador and southeastern Gulf of St. Lawrence areas in 1976–78 was found to be highly correlated with length and to a lesser extent with age, the relationships being best described in terms of log-log regressions. The fecundity-length relationship for the southern Labrador area differed significantly from that for the southeastern Gulf of St. Lawrence both in the rate of egg production and the number of eggs produced, but no differences were found in the fecundity-age relationships. The higher fecundity of fish in the southeastern Gulf of St. Lawrence may be due to their becoming mature at considerably smaller sizes than in the southern Labrador area. Annual variation in fecundity was not evident in the data for 2 years from southern Labrador.

Introduction

The Greenland halibut is a deepwater flatfish, usually found in areas where the bottom temperature ranges from -0.5 to 3.0°C. Its distribution in the Northwest Atlantic extends from Arctic regions southward to the Grand Bank and into the Gulf of St. Lawrence, with small concentrations in various bays along the south coast of Newfoundland (Templeman, 1973; Bowering, MS 1978). Little work has been done on fecundity of Greenland halibut, due largely to the scarcity of mature individuals in the samples from the various areas. Jensen (1935) estimated that large females could produce up to 300,000 eggs, based on a specimen (101 cm long) taken at West Greenland in 1908. Milinskii (1944) counted 28,000 and 33,000 eggs in two specimens from the Barents Sea. The most recent information on fecundity of Greenland halibut in the Northwest Atlantic is that of Lear (1970), who examined 45 mature females collected during 1967–69 over an expanse of 500–700 nautical miles in the Labrador-eastern Newfoundland area.

This paper presents the results of fecundity studies on Greenland halibut in the southern Labrador and southeastern Gulf of St. Lawrence areas in relation to length and age, and compares the fecundity-length relationship for the southern Labrador area with that of Lear (1970) for the Labrador-eastern Newfoundland area.

Materials and Methods

The ovaries used for fecundity estimation were collected from maturing Greenland halibut taken by bottom otter trawl during random-stratified groundfish surveys of Canadian research vessels as follows: 47 specimens were collected in October–November 1976 and 66 in November 1977 from the southern Labrador area (ICNAF Div. 2J and 3K), and 40 specimens were obtained in January 1978 from the southeastern Gulf of St. Lawrence area (Div. 4R and Subdiv. 3Pn). Fork length measurements to the nearest cm and otoliths were obtained from all fish sampled for fecundity studies.

The ovaries were collected during periods when all eggs were still opaque. They were cut longitudinally, placed in Gilson's fluid (Simpson, 1951), and stored in jars for 1–3 months. The ovaries were then treated, as described by Bowering (1978a) for witch flounder, to separate the eggs from the connective tissue remnants, and the eggs were stored for several weeks in ethanol to allow them to harden. Preparatory to counting, the eggs were strained on to blotter paper for drying, with care being taken to avoid clustering. The egg counts were made with an electronic device as described by Boyar and Clifford (1967). All samples were counted twice to check for variation, which was less than 1% in all cases.

For analysis, the data were grouped by geographical area (i.e. southern Labrador and southeastern Gulf of St. Lawrence) and fitted by least squares regressions using log-log (base 10) transformations which gave higher correlations than arithmetic and semi-log plots. Analysis of covariance (Zar, 1974) was used to test the significance of the differences between regression coefficients and between the logarithms of the adjusted means. The areas of investigation and the place names mentioned in the text are shown in Fig. 1.

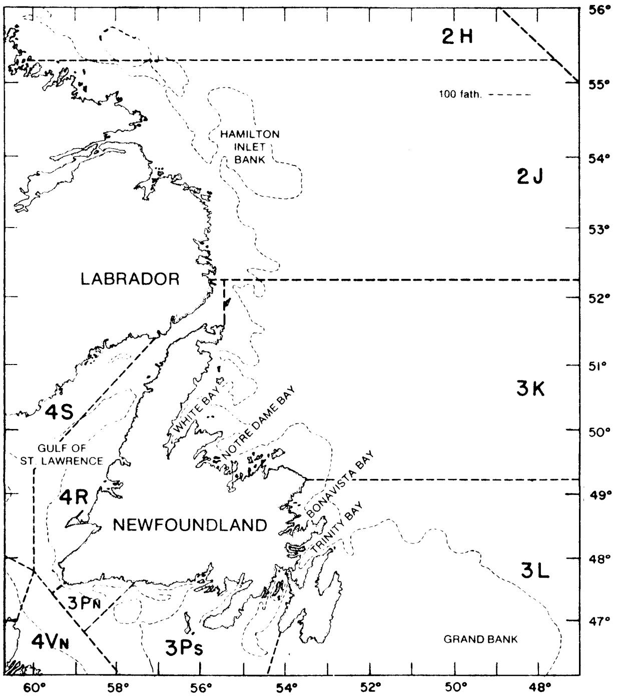

Fig. 1. Map of place names and areas mentioned in the text.

Results

Fecundity related to fish length

For the southern Labrador area, analysis of the combined data for 1976 and 1977 indicated that fecundity is related to length by the relationship

$$\log F = 3.082 \log L - 1.205$$

where F is fecundity (number of eggs) and L is fish length (cm). For the southeastern Gulf of St. Lawrence area, the relationship between fecundity and length is indicated by the equation

$$\log F = 4.264 \log L - 3.152 \ .$$

Plots of the fecundity-length data and the arithmetic forms of the relationships are shown in Fig. 2 and 3 respectively. In both cases the correlation coefficients (r) are significantly different from zero ($P < 0.01$) (Table 1).

An analysis of covariance of the fecundity-length data for southern Labrador in 1976 and 1977 (Table 2) indicated no significance in either the regression coefficients (rate of egg production) or the adjusted means (quantity of eggs produced) between the two years. However, a similar analysis of the fecundity-length relationships for southern Labrador in 1976–77 and southeastern Gulf of St. Lawrence in 1978 (Table

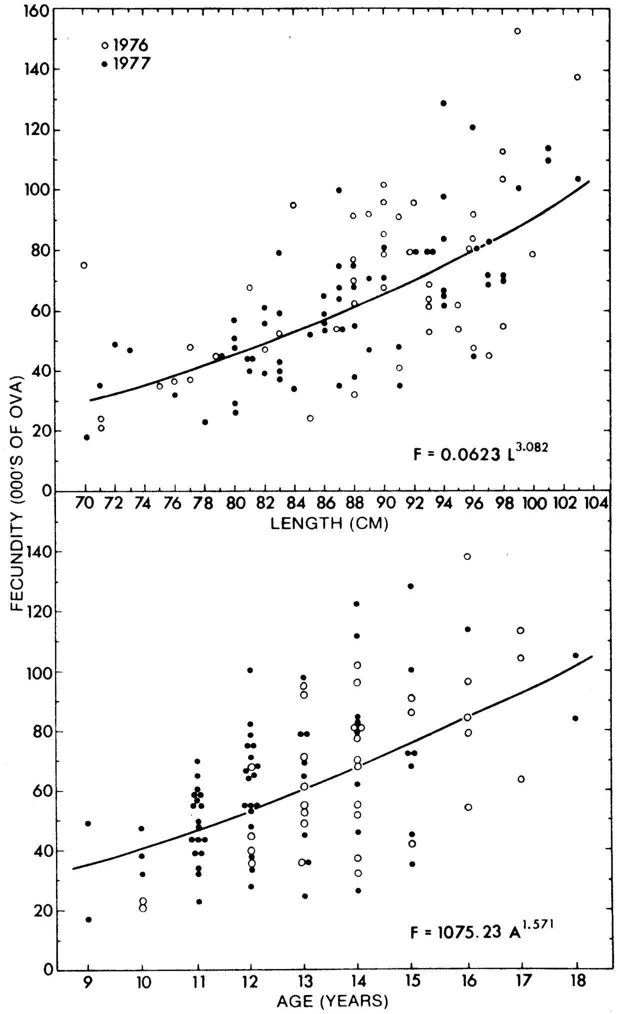

Fig. 2. Relationships of fecundity to length and age for Greenland halibut from southern Labrador, 1976–77.

2) indicated that the difference in the regression coefficients is significant with $P < 0.05$ and the difference in the adjusted means is highly significant with $P < 0.01$.

Fecundity related to fish age

The fecundity-age relationship for the southern Labrador area is indicated by the expression

$$\log F = 1.571 \log A + 3.032$$

and that for the southeastern Gulf of St. Lawrence area by

$$\log F = 1.989 \log A + 2.629$$

where A is fish age (years). Plots of the data and the arithmetic forms of the equations are shown in Fig. 2 and 3 respectively. The correlation coefficients (r) for

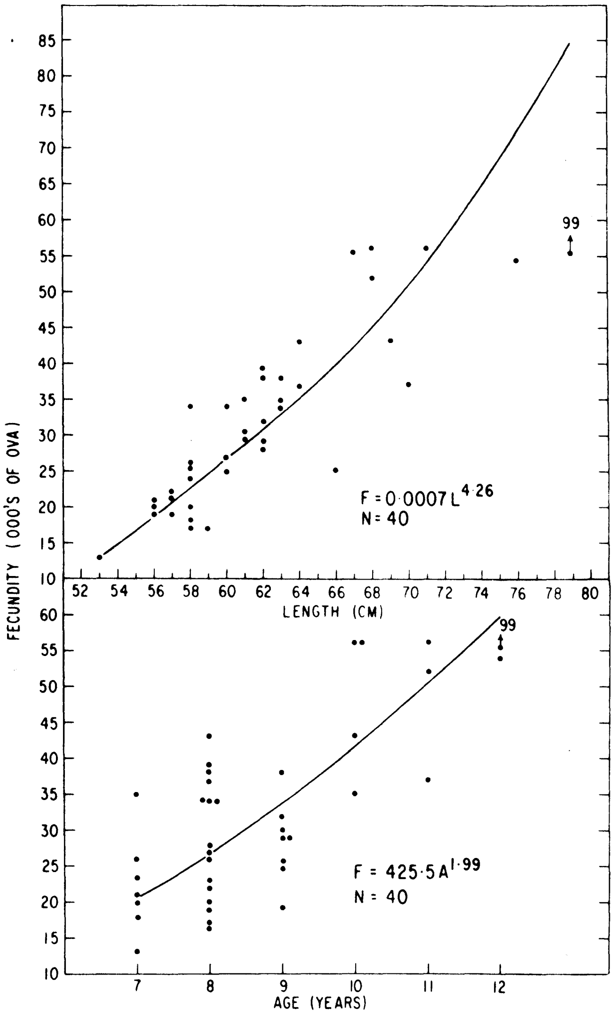

Fig. 3. Relationships of fecundity to length and age for Greenland halibut from southeastern Gulf of St. Lawrence, 1978.

both relationships are lower than those for the respective fecundity-length relationships (Table 1) but are still highly significant ($P < 0.01$).

Analysis of covariance of the 1976 and 1977 fecundity-age data for southern Labrador indicated no significant difference between the regression coefficients or between the adjusted means, nor were there significant differences in these parameters for the southern Labrador and southeastern Gulf of St. Lawrence relationships (Table 2).

Fecundity related to length and age

On the basis of the analyses presented above, fecundity in Greenland halibut appears to be related to both fish length and age. However, the lesser variation and the higher correlation of the fecundity-length data (Table 1) indicate that fecundity is more related to length than to age. A multiple correlation analysis was therefore performed in order to determine the relative contributions of length and age to variation in fecundity (Table 3).

For the fecundity data from both of the geographical areas, the coefficients of determination for log-fecundity and log-length (r^2_{12}) are considerably greater than those for log-fecundity and log-age (r^2_{13}) (Table 3). However, when log-length and log-age are considered together in relation to log-fecundity, the coefficients of multiple determination ($r^2_{1.23}$) for both areas are only slightly greater than the simple coefficients for log-fecundity and log-length (r^2_{12}). To determine whether these slight increases were significant, t-tests were applied to the coefficients of partial determination ($r_{13.2}$), which in both cases were found not to differ significantly from zero (Table 3). It

TABLE 1. Regression constants and tests of significance of correlations of fecundity with length and age for Greenland halibut from the southern Labrador and southeastern Gulf of St. Lawrence areas, 1976–78. (** indicates significance with $P<0.01$.)

Area	No. of fish	Slope (m)	Intercept (log k)	r	t
		Fecundity-length			
South Labrador, 1976	47	2.667	-0.380	0.59	4.95**
South Labrador, 1977	66	3.398	-1.833	0.73	8.61**
South Labrador, 1976-77	113	3.082	-1.205	0.67	9.51**
Southeast Gulf, 1978	40	4.264	-3.152	0.89	11.90**
		Fecundity-age			
South Labrador, 1976	38	2.010	2.506	0.58	4.26**
South Labrador, 1977	66	1.548	3.072	0.54	5.19**
South Labrador, 1976-77	104	1.571	3.032	0.55	6.60**
Southeast Gulf, 1978	40	1.989	2.629	0.72	6.42**

TABLE 2. Summary of covariance analyses for regressions of fecundity against length and age for Greenland halibut from southern Labrador and southeastern Gulf of St. Lawrence. (* indicates significance with $P < 0.05$, and ** with $P < 0.01$.)

Area	Mean squares			Mean squares		
	Within samples	Regression coefficients	F	Common regression	Adjusted means	F
Fecundity-length						
South Labrador, 1976						
South Labrador, 1977	0.019	0.024	1.27	0.019	0.029	1.55
South Labrador, 1976-77						
Southeast Gulf, 1978	0.016	0.059	3.72*	0.016	0.342	21.15**
Fecundity-age						
South Labrador, 1976						
South Labrador, 1977	0.024	0.017	0.72	0.024	0.046	1.94
South Labrador, 1976-77						
Southeast Gulf, 1978	0.022	0.021	0.96	0.022	0.007	0.03

TABLE 3. Summary of statistics for multiple correlation of fecundity length and age for Greenland halibut. (X_1 = log fecundity, X_2 = log length and X_3 = log age in the estimating equation $X_1 = a_{1.23} + b_{12.3}X_2 + b_{13.2}X_3$.

Parameters		Southern Labrador 1976-77	Southeast Gulf 1978
Number of specimens	N	104	40
Coef. of determination for X_1 and X_2	r^2_{12}	0.522	0.789
Coef. of determination for X_1 and X_3	r^2_{13}	0.299	0.520
Coefficient of multiple determination	$r^2_{1.23}$	0.523	0.791
Coefficient of partial determination	$r^2_{13.2}$	0.002	0.009
t for $r^2_{13.2}$		0.450	0.580
P for $r^2_{13.2}$		0.60-0.70	0.50-0.60

may be concluded therefore that variation in fecundity is adequately explained in terms of length alone.

Discussion

Fecundity in Greenland halibut from southern Labrador and southeastern Gulf of St. Lawrence was found to be related more to body length than to age. This conforms with results from earlier studies in the Northwest Atlantic on such species as American plaice, *Hippoglossoides platessoides* (Pitt, 1964), Atlantic cod, *Gadus morhua* (May, 1967) and witch flounder, *Glyptocephalus cynoglossus* (Bowering, 1978a).

Fecundity in fish of the same species has been reported to vary from one geographical area to another. Simpson (1951) found for North Sea plaice (*Pleuronectes platessa*) of the same body length that the faster-growing fish in the Slamborough area had a higher fecundity than the slower-growing fish from the Southern Bight. Bowering (1978a) also found significant variation in fecundity of witch flounder from three adjacent areas in the Northwest Atlantic (i.e. northern Grand Bank, southern Grand Bank, and St. Pierre Bank). The present study shows that the fecundity-length relationship for Greenland halibut from southern Labrador is significantly different from that for southeastern Gulf of St. Lawrence fish both in terms of the rate of egg production and the number of eggs produced. This may be due to variation in size at maturity. No maturity data are available to confirm this view, but, since the fecundity samples from both areas were collected over the entire size range of the mature females in the catches, it is apparent from Fig. 4 that

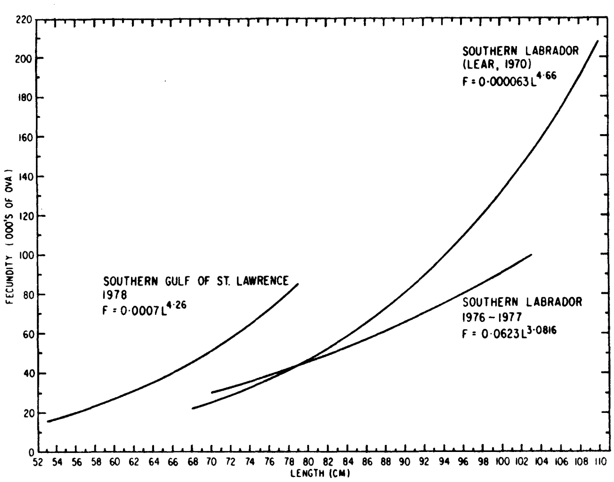

Fig. 4. Comparison of fecundity-length relationships for Greenland halibut from southern Labrador and southeastern Gulf of St. Lawrence.

Greenland halibut in the southeastern Gulf of St. Lawrence area mature at considerably smaller sizes than those in the southern Labrador area. Bowering (1978b) indicated that growth of Greenland halibut in the Gulf of St. Lawrence is essentially the same as, or only slightly faster than, in the Labrador area. Thus, in two populations of the same species with similar growth rates, it is considered unusual to find such a difference in size at maturity. Hodder (1963) showed for haddock, *Melanogrammus aeglefinus*, of the Grand Bank that fecundity increased with the frequency of spawning. This phenomenon was also found to exist for cod (May, 1967) and for witch flounder (Bowering 1978a). If it is assumed that Greenland halibut in the Gulf of St. Lawrence mature at an earlier age than those off Labrador, it would be expected that, within the length range common to the samples from both areas, i.e. 70–78 cm (Fig. 4), the southeastern Gulf of St. Lawrence fish would be more fecund than the southern Labrador fish because the former would have spawned more often.

No statistical difference was found between the fecundity-age relationships of Greenland halibut in the two areas. Fecundity was found to be related more to length than to age, and consequently the greater variation within samples resulted in considerably more overlap of the fecundity-at-age data for both areas than was apparent in the fecundity-at-length data.

Annual fluctuation in fecundity of Greenland halibut was not apparent in this study of fecundity-length and fecundity-age relationships for the southern Labrador area in 1976 and 1977. However, such variation has been reported in many studies of this nature, e.g. by Hodder (1963) for Grand Bank haddock, by Pitt (1964) for American plaice from Grand Bank and other Newfoundland areas, and by Bowering (1978a) for witch flounder from St. Pierre Bank and Grand Bank. Bagenal (1963), from a study of witch flounder in the Firth of Clyde, attributed annual fluctuation in fecundity to changes in fishing intensity, which in turn affects fecundity through variation in the food supply. He also indicated that the pattern of fluctuating fecundity for witch flounder was different from that of European plaice of the same area, and concluded that the variation in fecundity was not related to changes in hydrographic conditions.

Lear (1970) studied fecundity in Greenland halibut off Labrador and eastern Newfoundland from 45 specimens collected in an area extending from the banks off northern Labrador southward to Notre Dame Bay, Bonavista Bay and Trinity Bay. A comparison of the fecundity-length relationship for the southern Labrador area from the present study with that of Lear (1970) indicates that fecundity in fish greater than 80 cm during 1967–69 was higher than in 1976–78, the exponents of the relationships being 4.66 and 3.08 respectively. Since Lear's (1970) sample included specimens beyond the length range of those used in the present study, it was thought that high fecundity estimates of the very large fish may have been the reason for the higher value of the exponent in the 1967–69 fecundity-length relationship. However, an analysis of the 1967–69 data, excluding values for lengths beyond the range of the 1976–77 data, resulted in a higher exponent (5.36). These differences in the 1967–69 and 1976–77 fecundity-length relationships are difficult to explain biologically, but may be due to the fact that Lear's (1970) data, consisting of only 45 specimens, were collected over a period of 3 years and a geographical expanse of about 600 nautical miles.

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