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## Morphometric variation in Atlantic herring from Newfoundland and adjacent waters

by

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## Abstract

The relative sizes of various body parts (orbit diameter, head, snout, postorbital and predorsal length) of herring from Newfoundland and adjacent waters were examined to ascertain the value of these characters for the differentiation of herring stocks in the Newfoundland area. In most areas autumn spawners have relatively larger heads, snouts, orbit diameters, postorbital and predorsal lengths than spring spawners. Sexual dimorphism in morphometric characteristics is negligible. Covariance comparisons of the log-log regressions of body parts on standard length revealed considerable heterogeneity in morphometric characteristics. Between-area differences were evident for all characters and all pairs of areas compared. Significant differences were found even between closely related stocks. It is concluded that morphometric characters are of limited value for stock differentiation.

## Introduction

Although morphometric characters have been frequently used in population studies of scombroid fishes, particularly the tunas (Godsil, 1948; Schaefer, 1948; Schaefer and Walford, 1950; Roedel, 1952; Royce, 1953, 1964; Yang, Nose and Hiyama, 1969), there have been very few attempts to characterize different biological groups of herring on the basis of the relative dimensions of various body parts. Apart from a few scattered observations by early European investigators, Popiel (1955), who examined the head lengths of certain groups of Baltic herring, was one of the first to utilize morphometric characters in European herring racial investigations. Muzinic and Parrish (1960) compared the head length-total length relationships among herring spawning in the northern and southern regions of the North Sea and found a significant difference between the body proportions of the two spawning groups studied. More recently, Burd (MS 1969) applied principal component or cluster analysis to eight morphometric characters - preorbital, postorbital, caput, pectoral, predorsal, pelvic, preanal and cranial lengths. He reported that multiple morphometric measurements did not satisfactorily discriminate between three samples of spawning herring from the Dogger, Sandettie and Flamborough fisheries. However, Pope and Hall (MS 1970) concluded from a preliminary discriminant function analysis that these same characters, although of little value singly, were useful when combined to construct a linear discriminant function for separating the Buchan and Kobbergrund herring stocks.

Jean (1967) compared herring from different regions in the Gulf of St. Lawrence on the basis of four morphometric characters - head length, snout length, orbit diameter and postorbital length. He reported that herring from the relatively cold waters of Ile Verte had a slower growth rate and smaller snouts and heads than those from the warmer waters of Anse au Gascon.

The present study was undertaken to examine the variation in morphometric characters of herring inhabiting Newfoundland and adjacent waters and to ascertain the value of such characters for stock delineation.

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## Materials and Methods

Herring populations ranging from Gabarus Bay, Nova Scotia, in the south to the Strait of Belle Isle in the north including most coastal areas of Newfoundland (Fig. 1) were sampled during the period from January 1969 to June 1970. Herring samples, usually of 50 specimens but sometimes in multiples of 50, were collected from catches of purse seines, midwater trawls, gillnets and codtraps.

The numbers of herring in each area from which body measurements were obtained are listed in Table 1.

Various body measurements were made on thawed specimens using a measuring board similar to that described and illustrated by Rounsefell (1930) and employed by Tester (1937) and Jean (1967). All distances were measured in millimetres from the tip of the closed lower jaw to the various end points. These measurements were not of actual distances but rather of distances as projected on the millimetre scale of the board. All measurements were made by the author to eliminate between-individuals variation in methods of measuring. No corrections were made for shrinkage due to freezing.

The following body measurements were taken (Fig. 2):

Total length: distance from the tip of the closed lower jaw to the end of the longest lobe of the caudal fin with the lobe extending posteriorly in line with the body (greatest total length).

Standard length: distance from the tip of the closed lower jaw to the end of the silvery area on the caudal peduncle after the scales have been removed from that region.

Head length: distance from the tip of the closed lower jaw to the posterior margin of the operculum.

Snout length: distance from the tip of the closed lower jaw to the anterior margin of the orbit.

Orbit diameter: horizontal distance from the anterior to the posterior margin of the orbit.

Postorbital length: distance from the posterior margin of the orbit to the posterior margin of the operculum.

Predorsal length: distance from the tip of the closed lower jaw to the base of the most anterior ray of the dorsal fin.

Individual adult fish were assigned to spawning groups on the basis of gonad development in relation to time of capture, as described by Parsons (MS 1972).

The relative growth method of analysis described by Huxley (1924, 1932) was utilized for analyses of the morphometric data.

Graphical plots of the raw data indicated straight line relationships between standard length and all body parts examined; there were no obvious departures from linearity. It has been demonstrated for many species that the major growth inflection is related to the onset of sexual maturity after which the rate of relative growth is relatively constant (Desbrosse, 1936; Mottley, 1936; Hamai, 1941; Wilder, 1952; Martin, 1949). Therefore, to avoid difficulties introduced by allometric growth, immature specimens were excluded from the data analyses. To ensure linearity and homogeneity of variance the data were converted to common logarithms and log-log regressions of the various body parts on standard length were calculated. Differences in the regression coefficient (slopes) and adjusted means of the regression lines were compared by analysis of covariance as described by Snedecor (1961). If the differences in slopes are significant, in which case the regression lines are not parallel, differences in adjusted means have little meaning. Because of the relatively small size and irregular length distribution of the samples, a significance level of 0.01 was used.

## Results

### Variation among samples

Log-log regressions of body parts on standard length were calculated separately for each sample for both spawning groups within each area. Between-sample differences were tested by analysis of covariance (Table 2). Differences in slopes were generally not significant (only 2 instances out of a

possible 105). However, there were numerous instances of between-sample differences in adjusted means for all morphometric characters examined. Despite between-sample differences within areas valid area comparisons can be made if the mean square difference among the samples is smaller than that between areas. Therefore, the variation between samples within areas was used to test the differences between the areas. For both spawning groups and all morphometric characters the mean square difference between areas exceeded the mean square difference between samples and in each instance the F value thus derived was statistically significant. Therefore, all samples within each area were pooled and regression lines computed for both spawning groups and both sexes within each area.

## Variation between spawning groups

Log-log regressions of body parts on standard length were calculated for spring and autumn spawners within each of the eight areas where both spawning groups were represented (Tables 3-7). In seven of the eight areas autumn spawners had relatively larger heads at any particular standard length than spring spawners (Fig. 3 and 4). However, Conche spring spawners had relatively larger heads than autumn spawners. Covariance analysis to test the hypothesis that a common line can be utilized to express the head length-standard length relationship yielded significant F values for six of the eight areas (Table 3). Differences in slopes of the regression lines were significant between spring and autumn spawners from southwestern Newfoundland and Hawke's Bay. Adjusted means accounted for the significant differences between spring and autumn spawners from Magdalen Islands, Trinity Bay, Bonavista Bay and Conche.

Snout length-standard length regression lines for spring and autumn spawners in each area are illustrated in Fig. 5. In six of the eight areas autumn spawners had relatively larger snouts than spring spawners but Conche spring spawners had relatively larger snouts than autumn spawners. The regression lines for Bonavista Bay spring- and autumn-spawning herring overlap. F values comparing spring and autumn spawners were significant for three areas (Table 4). Differences in adjusted means were significant between spring and autumn spawners from Magdalen Islands, southwest Newfoundland and Quirpon. In all three instances autumn spawners had relatively larger snouts than spring spawners.

In six areas autumn spawners had relatively larger orbit diameters than spring spawners (Fig. 6) but F values were significant (in adjusted means) for only three areas (Table 5). Spring spawners at Conche and Quirpon had relatively larger orbit diameters than autumn spawners but the differences were not statistically significant.

Autumn spawners had relatively larger postorbital lengths than spring spawners in five areas (Fig. 7). F values were significant in four of the five instances. Adjusted means accounted for the differences between spawning groups at Magdalen Islands, along southwest Newfoundland and in Bonavista Bay. Hawke's Bay spring and autumn spawners differed significantly in slope. Conche spring spawners had relatively larger postorbital lengths than autumn spawners but the difference was not significant. The regression lines for spring and autumn spawners from Quirpon and Placentia Bay overlap.

In four areas autumn spawners had relatively larger predorsal lengths than spring spawners throughout the adult size range (Fig. 8 and 9). Spring spawners from Hawke's Bay appeared to have slightly larger predorsal lengths than autumn spawners. The regression lines for spring and autumn spawners in the other three areas overlap. In these instances the predorsal lengths of spring spawners were relatively larger than those of autumn spawners in smaller fish and relatively smaller in larger fish. F values were significant for only two of the eight areas (Table 7).

In general there was a tendency for autumn spawners to possess relatively larger body parts (in relation to standard length) than spring spawners.

## Variation between sexes

Log-log regressions of body parts on standard length were computed for the sexes within each spawning group for each area (Table 6). There was no evidence of sexual dimorphism in snout length and orbit diameter. Significant sex differences were evident in only 1 of 21 possibles for each of head length, postorbital length and predorsal length. It was concluded that sexual dimorphism is negligible.

## Variation among areas

Head length-standard length regression lines for all areas are shown in Fig. 10 and 11 for spring and autumn spawners respectively. Spring-spawning herring from Placentia, Bonavista and Trinity bays have the largest heads. Hawke's Bay spring spawners have the smallest heads followed in order of increasing size by Magdalen Islands and southwest Newfoundland spring spawners. Regression lines for spring spawners from the other areas overlap considerably. Among autumn spawners Strait of Belle Isle herring have the

smallest heads followed in order of increasing size by Conche, Hawke's Bay and Quirpon herring. Autumn spawners from Magdalen Islands, Bonavista Bay, Placentia Bay, Gabarus Bay and southwest Newfoundland have relatively larger heads. Regression lines for these latter areas exhibit considerable overlap but there is a fair amount of spread between the lines for Strait of Belle Isle, Conche, Hawke's Bay and Quirpon.

Spring-spawning herring from Bonavista and Placentia bays have the largest snouts and Hawke's Bay spring spawners the smallest followed in order of increasing size by Magdalen Islands and southwest Newfoundland spring spawners (Fig. 12 and 13). Among autumn spawners herring from Quirpon, Placentia Bay, Trinity Bay and Bonavista Bay have the largest snouts. Conche autumn spawners have the smallest snouts followed in order of increasing size by Hawke's Bay and Strait of Belle Isle autumn spawners. Snout length is intermediate in autumn spawners from Gabarus Bay, southwest Newfoundland and Magdalen Islands.

There is considerable overlap of the orbit diameter-standard length regression lines for both spring and autumn spawners and no clearcut geographic trends are evident (Fig. 14 and 15). Notre Dame Bay herring have the largest orbit diameters among spring spawners and Placentia Bay herring the smallest. Spring spawners from southwest Newfoundland and Magdalen Islands appear to have similar relatively large orbit diameters exceeded only by Notre Dame Bay spring spawners. Herring from Quirpon and Conche have the smallest orbit diameters among autumn spawners. Regression lines for several areas including southwest Newfoundland and Magdalen Islands overlap near the top of the scale for autumn spawners.

No geographic trend in postorbital length is evident among spring spawners (Fig. 16). Throughout most of the adult size range Placentia Bay spring spawners have the largest postorbital lengths and Hawke's Bay spring spawners the smallest. St. Mary's Bay, Notre Dame Bay and southwest Newfoundland spring spawners have relatively small postorbital lengths. Regression lines for spring spawners from other areas overlap considerably. Among autumn spawners there appears to be a tendency for herring from the more northerly areas to possess relatively small postorbital lengths (Fig. 17). Strait of Belle Isle autumn spawners have the smallest postorbital lengths followed in order of increasing size by autumn spawners from Quirpon, Conche and Hawke's Bay which exhibit considerable overlap. Magdalen Islands autumn spawners have the largest postorbital lengths and autumn spawners from southwest Newfoundland also possess relatively large postorbital lengths. Autumn spawners from Gabarus Bay, the most southerly area, possess intermediate postorbital lengths.

No geographic trend in predorsal length is evident among either spawning group (Fig. 18 and 19). Notre Dame Bay and Conche herring have the largest predorsal lengths among spring spawners and Fortune Bay herring the smallest over most of the adult size range. Placentia Bay and southwest Newfoundland spring spawners also have relatively small predorsal lengths. Gabarus Bay herring have the largest predorsal lengths among autumn spawners and Hawke's Bay herring the smallest. Autumn spawners from the Strait of Belle Isle have relatively large predorsal lengths exceeded only by those from Gabarus Bay.

There were highly significant differences among areas for both spring and autumn spawners in both slopes and adjusted means (Table 8) for all characters examined in this study. To test the significance of apparent differences between areas, regression lines for pairs of geographically adjacent areas were compared for spring and autumn spawners separately (Tables 9 and 10). The results of these area comparisons are summarized below.

## Spring spawners

Spring spawners from Trinity Bay differed only in snout length from Bonavista Bay spring spawners but differed significantly in orbit diameter, head, postorbital and predorsal length from St. Mary's Bay spring spawners, in head, snout and postorbital length from Placentia Bay spring spawners and in head, snout and predorsal length from Fortune Bay spring spawners. Bonavista Bay spring spawners differed significantly in head, snout and predorsal length from both Fortune Bay and Conche spring spawners and in head, snout, postorbital and predorsal length from St. Mary's Bay spring spawners. Spring spawners from Notre Dame Bay differed in all five characters from both Bonavista Bay and Trinity Bay spring spawners; they also differed in orbit diameter, head, snout and postorbital length from Conche spring spawners and in orbit diameter, snout, postorbital and predorsal length from Quirpon spring spawners. Conche and Quirpon spring spawners differed only in snout and postorbital length but Conche spring spawners differed in head, snout and postorbital length from Hawke's Bay spring spawners while Quirpon and Hawke's Bay spring spawners differed in orbit diameter, head, snout and postorbital length. Spring spawners from Hawke's Bay also differed in head, postorbital and predorsal length from Magdalen Islands spring spawners and in head, snout and postorbital length from southwest Newfoundland spring spawners. The latter differed only in postorbital length from Magdalen Islands and in orbit diameter and postorbital length from Fortune Bay spring spawners. Spring spawners from Fortune Bay in turn differed in head, snout, postorbital and predorsal length from Placentia Bay spring spawners and in snout, postorbital and predorsal length from St. Mary's Bay spring spawners. Placentia Bay and St. Mary's Bay spring spawners differed in all five characters.

Autumn spawners

        Autumn-spawning herring from Trinity Bay differed only in predorsal length from Placentia Bay and
in head and postorbital length from Bonavista Bay autumn spawners. They also differed in orbit diameter,
head and snout length from Conche and in orbit diameter, head and postorbital length from southwest
Newfoundland autumn spawners. Bonavista Bay autumn spawners differed only in orbit diameter and
predorsal length from Placentia Bay autumn spawners but differed in orbit diameter, head, snout and
postorbital length from both Conche and Quirpon autumn spawners. They also differed in head, snout and
postorbital length from Strait of Belle Isle autumn spawners and in orbit diameter, snout and predorsal
length from southwest Newfoundland autumn spawners. Conche autumn spawners differed from Strait of Belle
Isle autumn spawners only in orbit diameter and postorbital length but differed from Quirpon autumn
spawners in head, snout and postorbital length. Autumn spawners from Quirpon differed from both Strait
of Belle Isle and Hawke's Bay autumn spawners in orbit diameter, head, snout and postorbital length.
Strait of Belle Isle autumn spawners differed in head, postorbital and predorsal length from Hawke's Bay
autumn spawners, in orbit diameter, head, snout and postorbital length from Magdalen Islands autumn
spawners, in head, snout and postorbital length from Gabarus Bay autumn spawners and in all five characters
from southwest Newfoundland autumn spawners. Hawke's Bay autumn spawners differed from Magdalen Islands,
southwest Newfoundland and Gabarus Bay autumn spawners in all five characters. Magdalen Islands autumn
spawners differed only in head and postorbital length from southwest Newfoundland autumn spawners but
differed in orbit diameter, head, postorbital and predorsal length from Gabarus Bay autumn spawners. The
latter differed in orbit diameter, head and predorsal length from southwest Newfoundland autumn spawners
which in turn differed in orbit diameter, head and postorbital length from Trinity Bay autumn spawners
and in all five characters from Placentia Bay autumn spawners.


                                    Discussion and Conclusions


        The present study provides evidence that spring- and autumn-spawning herring from the same area
differ in morphometric as well as meristic characteristics as described by Parsons (MS 1972). In most
areas autumn spawners have relatively larger heads and snouts and relatively larger orbit diameters and
postorbital and predorsal lengths in relation to standard length than spring spawners.

        Martin (1949) demonstrated that early development is important in the determination of the
relative size of the body parts of fish and that temperature and diet during the early growth period
result in differences in body form. Since data on the influence of these environmental factors on body
form in herring are lacking, it is not possible to relate these factors to the observed morphometric
differences between spring- and autumn-spawning herring. However, it is possible that these differences
are due to differences in the size at which these herring attain sexual maturity and spawn for the first
time. If spring spawners mature earlier than autumn spawners, as is suggested by available data,
differences in the size at growth inflection would account for the tendency for adult autumn spawners to
possess relatively larger body parts than adult spring spawners.

        In view of the significant morphometric differences between spawning groups within areas, it is
necessary to consider spring and autumn spawners separately for between-area comparisons of all
morphometric characters. Herring from Newfoundland and adjacent waters exhibit considerable heterogeneity
in morphometric as well as meristic characteristics. Between-area differences are evident for all
morphometric characters and all pairs of areas compared for at least one character. Some areas differ
in all morphometric characters but for other paired area comparisons the results are much more complex.

        Mayr, Linsley and Usinger (1953), Royce (1953, 1957, 1964) and Ahlstrom (1957) have shown that
statistically significant morphometric differences can be found commonly even between closely related
natural populations. Such statistical differences have been found so consistently that Royce (1953)
concluded that, even with samples from closely related stocks, highly significant statistical differences
could always be found by increasing the size of the sample or by considering enough characters.
Groups considered to be distinct on the basis of morphometric studies have been found to exhibit considerable
intermixture when tagging experiments were performed.

        In this study differences in two morphometric characters - head length and postorbital length -
were found between autumn-spawning herring from the Magdalen Islands and southwest Newfoundland and spring
spawners from these areas also differ in postorbital length. However, tagging results have demonstrated
that herring which overwinter along southwest Newfoundland merely represent the overwintering phase of a
stock complex which spawns and feeds in the southern Gulf of St. Lawrence (Winters, MS 1971; Beckett,
MS 1971). Therefore, it is apparent that statistically significant differences in head length and
postorbital length cannot be considered valid indicators of stock discreteness. Although the highly
significant morphometric differences between herring stocks in Newfoundland and adjacent waters confirm
that the herring from these various areas do not belong to a single completely mixed population, it is

difficult to determine from these differences which stocks are distinct and which intermingle freely. The author has not yet attempted to apply cluster analysis using the technique of principal components to these morphometric data but it appears unlikely that further analyses along these lines will shed much more additional light on the degree of intermixture between stocks.

Fish inhabiting colder waters tend to have relatively smaller heads and other body parts than fish from warmer waters (Rounsefell, 1930; Hubbs, 1940; Martin, 1949). These smaller body parts are usually correlated with higher meristic counts for these populations. Jean (1967) from investigations in 1943-44 found that herring from the relatively cold waters of Ile Verte in the Estuary of the Gulf of St. Lawrence had a slower growth rate and smaller snouts and heads than those from the warmer waters of Anse au Gascon. In the present study no clearcut geographic trend in either of the morphometric characters is evident among spring spawners. No geographic trend in snout or predorsal length is evident among autumn spawners, but autumn spawners from more northerly areas, e.g. Strait of Belle Isle, Quirpon, Conche and Hawke's Bay, tend to have smaller heads, orbit diameters and postorbital lengths than those from more southerly areas, e.g. Magdalen Islands and southwest Newfoundland. Herring in these northern regions inhabit generally colder water than those along southwest Newfoundland and in the southern Gulf of St. Lawrence.

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Table 1. Numbers of herring in each area from which body measurements were obtained (S = Spring spawners; A = Autumn spawners).

| Area code | Locality and spawning group | | Number of specimens |
|:---:|:---|:---:|:---:|
| 1 | Gabarus Bay, N.S. | (A) | 146 |
| 2 | Magdalen Islands<br>   "      " | (S)<br>(A) | 107<br>373 |
| 3 | Southwest Nfld.<br>   "     " | (S)<br>(A) | 141<br>348 |
| 4 | Fortune Bay | (S) | 219 |
| 5 | Placentia Bay<br>   "     " | (S)<br>(A) | 76<br>49 |
| 6 | St. Mary's Bay<br>  "   "   " | (S)<br>(A) | 244<br>- |
| 7 | Trinity Bay<br>  "   " | (S)<br>(A) | 322<br>105 |
| 8 | Bonavista Bay<br>  "    " | (S)<br>(A) | 334<br>150 |
| 9 | Notre Dame Bay | (S) | 431 |
| 10 | Conche<br>  " | (S)<br>(A) | 73<br>74 |
| 11 | Quirpon<br>  " | (S)<br>(A) | 82<br>133 |
| 12 | Strait of Belle Isle | (A) | 195 |
| 13 | Hawke's Bay<br>  "    " | (S)<br>(A) | 243<br>141 |
| | | | 3986 |

Table 2. Covariance comparisons of the log-log regressions of various body parts on standard length between samples within each area for spring and autumn spawners separately. (A double asterisk indicates significance at the 1% level.)

| Area | d.f. Slopes F | d.f. Adj Means F | Head length Slopes F | Head length Adj Means F | Snout length Slopes F | Snout length Adj Means F | Orbit diameter Slopes F | Orbit diameter Adj Means F | Postorbital length Slopes F | Postorbital length Adj Means F | Predorsal length Slopes F | Predorsal length Adj Means F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Spring spawners | | | | | | | |
| Magdalen Islands | 8,89 | 8,97 | 0.57 | 0.38 | 0.49 | 1.79 | 0.78 | 1.40 | 0.91 | 0.74 | 0.64 | 1.69 |
| Southwest Nfld. | 9,121 | 9,130 | 1.54 | 1.63 | 0.30 | 3.70** | 1.32 | 1.60 | 1.07 | 1.38 | 0.72 | 1.19 |
| Fortune Bay | 3,207 | 3,211 | 0.70 | 20.47** | 3.19 | 21.91** | 0.95 | 4.24** | 1.92 | 8.72** | 1.75 | 1.01 |
| Placentia Bay | 1,72 | 1,73 | 0.00 | 0.40 | 0.11 | 2.68 | 0.01 | 0.00 | 0.11 | 4.18 | 0.00 | 0.10 |
| St. Mary's Bay | 2,240 | 2,241 | 3.92 | 0.84 | 0.25 | 1.18 | 0.02 | 4.18 | 4.68 | 8.81** | 6.72** | 13.54** |
| Trinity Bay | 6,303 | 6,309 | 0.90 | 3.99** | 1.05 | 5.21** | 1.12 | 1.42 | 0.45 | 4.59** | 1.14 | 4.52** |
| Bonavista Bay | 9,310 | 9,319 | 1.01 | 6.76** | 0.70 | 10.41** | 0.55 | 2.51 | 1.48 | 10.76** | 0.98 | 1.63 |
| Notre Dame Bay | 4,421 | 4,425 | 0.63 | 5.51** | 0.87 | 4.40** | 1.93 | 4.78** | 1.57 | 9.59** | 0.95 | 3.78** |
| Conche | 3,65 | 3,68 | 1.10 | 1.24 | 0.41 | 0.17 | 0.62 | 3.39 | 1.00 | 2.89 | 2.76 | 0.14 |
| Quirpon | 3,71 | 3,74 | 4.67** | 1.58 | 0.80 | 24.43** | 1.55 | 2.26 | 2.87 | 15.88** | 1.96 | 2.54 |
| Hawke's Bay | 8,225 | 8,233 | 1.47 | 5.77** | 2.39 | 2.66** | 0.60 | 3.28** | 0.63 | 2.54 | 1.01 | 3.36** |
| | | | | | Autumn spawners | | | | | | | |
| Gabarus Bay, N.S. | 1,142 | 1,143 | 1.00 | 0.06 | 0.93 | 0.08 | 0.00 | 1.17 | 0.33 | 0.65 | 1.22 | 0.29 |
| Magdalen Islands | 8,355 | 8,363 | 0.60 | 3.67** | 0.61 | 9.53** | 0.20 | 2.73** | 0.50 | 1.03 | 0.64 | 1.26 |
| Southwest Nfld. | 9,328 | 9,337 | 0.94 | 4.67** | 1.07 | 3.59** | 1.34 | 2.59 | 1.23 | 3.63** | 0.93 | 1.16 |
| Placentia Bay | 1,45 | 1,46 | 0.48 | 0.01 | 2.42 | 0.98 | 0.11 | 2.40 | 0.05 | 2.27 | 0.88 | 0.32 |
| Trinity Bay | 4,90 | 4,94 | 0.57 | 0.16 | 2.91 | 0.62 | 1.48 | 0.76 | 2.41 | 0.76 | 1.00 | 0.56 |
| Bonavista Bay | 7,132 | 7,139 | 2.31 | 3.25** | 0.48 | 7.97** | 1.57 | 3.52** | 1.56 | 0.93 | 0.95 | 0.83 |
| Conche | 4,64 | 4,68 | 2.32 | 2.17 | 0.49 | 4.87** | 2.90 | 0.67 | 1.19 | 1.21 | 1.79 | 2.00 |
| Quirpon | 5,121 | 5,126 | 2.38 | 1.75 | 0.67 | 21.55** | 1.16 | 5.74** | 1.99 | 7.00** | 0.92 | 3.92** |
| Strait of Belle Isle | 3,187 | 3,190 | 1.70 | 2.15 | 4.36** | 6.15** | 0.19 | 1.68 | 0.39 | 0.22 | 0.15 | 3.03 |
| Hawke's Bay | 8,123 | 8,131 | 0.80 | 0.95 | 0.28 | 1.91 | 1.66 | 1.57 | 0.70 | 0.58 | 1.72 | 0.66 |

Table 3. Covariance statistics comparing the log-log regressions of head length on standard length for spring and autumn spawners within each area. (The double asterisk indicates significance at the 1% level.)

| Area and spawning group | | No. of specimens | Regression coef., n | Intercept log k | Correlation coef., r | St. error of estimate | Covariance analysis Slopes F | Adjusted means F |
|---|---|---|---|---|---|---|---|---|
| Magdalen Islands | (S) | 107 | 0.9847 | -0.6458 | 0.850 | 0.013} | 0.15 | 107.70** |
| " | (A) | 373 | 0.9593 | -0.5688 | 0.832 | 0.012} | | |
| Southwest Nfld. | (S) | 141 | 0.8479 | -0.3159 | 0.698 | 0.012} | 7.79** | 143.66** |
| " | (A) | 348 | 1.0764 | -0.8591 | 0.832 | 0.012} | | |
| Placentia Bay | (S) | 76 | 0.8583 | -0.3297 | 0.956 | 0.013} | 0.07 | 2.70 |
| " | (A) | 49 | 0.8393 | -0.2779 | 0.870 | 0.015} | | |
| Trinity Bay | (S) | 322 | 0.8503 | -0.3132 | 0.933 | 0.012} | 0.32 | 10.05** |
| " | (A) | 105 | 0.8131 | -0.2162 | 0.844 | 0.009} | | |
| Bonavista Bay | (S) | 330 | 0.8316 | -0.2656 | 0.892 | 0.013} | 1.46 | 34.84** |
| " | (A) | 150 | 0.9058 | -0.4394 | 0.789 | 0.013} | | |
| Conche | (S) | 73 | 0.9026 | -0.4435 | 0.933 | 0.013} | 0.51 | 14.39** |
| " | (A) | 74 | 0.9421 | -0.5487 | 0.949 | 0.012} | | |
| Quirpon | (S) | 82 | 0.8607 | -0.3425 | 0.903 | 0.012} | 0.01 | 2.96 |
| " | (A) | 133 | 0.8671 | -0.3547 | 0.843 | 0.014} | | |
| Hawke's Bay | (S) | 243 | 0.9275 | -0.5184 | 0.920 | 0.014} | 7.29** | 39.01** |
| " | (A) | 141 | 1.0377 | -0.7786 | 0.943 | 0.013} | | |
| Fortune Bay | (S) | 217 | 0.7806 | -0.1484 | 0.921 | 0.015 | | |
| St. Mary's Bay | (S) | 244 | 0.8139 | -0.2308 | 0.934 | 0.010 | | |
| Notre Dame Bay | (S) | 431 | 0.7914 | -0.1730 | 0.896 | 0.010 | | |
| Gabarus Bay, N.S. | (A) | 146 | 0.8719 | -0.3600 | 0.940 | 0.010 | | |
| Strait of Belle Isle | (A) | 195 | 0.9962 | -0.6860 | 0.868 | 0.011 | | |

A = Autumn; S = Spring

Table 4. Covariance statistics comparing the log-log regressions of snout length on standard length for spring and autumn spawners within each area. (The double asterisk indicates significance at the 1% level.)

| Area and spawning group | | No. of specimens | Regression coef., n | Intercept log k | Correlation coef., r | St. error of estimate | Covariance analysis | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Slopes F | Adjusted means F |
| Magdalen Islands | (S) (A) | 107 373 | 0.8148 0.9576 | -0.7769 -1.1064 | 0.532 0.607 | 0.027} 0.024} | 1.14 | 43.52** |
| Southwest Nfld. | (S) (A) | 141 348 | 0.7155 1.0094 | -0.5277 -1.2312 | 0.370 0.587 | 0.026} 0.023} | 3.29 | 34.53** |
| Placentia Bay | (S) (A) | 76 49 | 0.7632 0.8547 | -0.6181 -0.8356 | 0.868 0.765 | 0.022} 0.022} | 0.63 | 1.70 |
| Trinity Bay | (S) (A) | 321 105 | 0.7711 0.7183 | -0.6433 -0.5054 | 0.785 0.546 | 0.023} 0.020} | 0.18 | 5.79 |
| Bonavista Bay | (S) (A) | 332 150 | 0.7000 0.9314 | -0.4629 -1.0296 | 0.653 0.570 | 0.025} 0.025} | 3.88 | 3.50 |
| Conche | (S) (A) | 73 74 | 0.8481 1.0101 | -0.8463 -1.2950 | 0.781 0.828 | 0.025} 0.026} | 2.02 | 5.69 |
| Quirpon | (S) (A) | 82 133 | 1.3238 1.1809 | -1.9956 -1.6280 | 0.806 0.698 | 0.028} 0.030} | 0.87 | 11.60** |
| Hawke's Bay | (S) (A) | 243 141 | 0.7999 0.9080 | -0.7458 -1.0026 | 0.698 0.759 | 0.028} 0.027} | 1.59 | 5.51 |
| Fortune Bay | (S) | 217 | 0.6503 | -0.3643 | 0.668 | 0.033 | | |
| St. Mary's Bay | (S) | 243 | 0.6416 | -0.3327 | 0.736 | 0.020 | | |
| Notre Dame Bay | (S) | 431 | 0.6416 | -0.3327 | 0.736 | 0.017 | | |
| Gabarus Bay, N.S. | (A) | 146 | 0.7830 | -0.6740 | 0.777 | 0.021 | | |
| Strait of Belle Isle | (A) | 195 | 0.9272 | -1.0432 | 0.653 | 0.022 | | |

A = Autumn; S = Spring

Table 5. Covariance statistics comparing the log-log regressions of orbit diameter on standard length for spring and autumn spawners within each area. (The double asterisk indicates significance at the 1% level.)

| Area and spawning group | | No. of specimens | Regression coef., n | Intercept log k | Correlation coef., r | St. error of estimate | Covariance analysis Slopes F | Adjusted means F |
|---|---|---|---|---|---|---|---|---|
| Magdalen Islands | (S) | 107 | 0.9436 | -1.1772 | 0.597 | 0.027 | 0.23 | 7.39** |
| " | (A) | 373 | 0.8762 | -1.0044 | 0.544 | 0.026 | | |
| Southwest Nfld. | (S) | 141 | 0.9341 | -1.1520 | 0.454 | 0.026 | 0.43 | 2.10 |
| " | (A) | 348 | 1.0412 | -1.4102 | 0.597 | 0.024 | | |
| Placentia Bay | (S) | 76 | 0.7609 | -0.7489 | 0.821 | 0.026 | 0.80 | 3.16 |
| " | (A) | 49 | 0.8917 | -1.0579 | 0.679 | 0.030 | | |
| Trinity Bay | (S) | 321 | 0.8248 | -0.8963 | 0.796 | 0.024 | 0.40 | 10.11** |
| " | (A) | 105 | 0.9055 | -1.0880 | 0.635 | 0.020 | | |
| Bonavista Bay | (S) | 332 | 0.8052 | -0.8466 | 0.690 | 0.026 | 0.88 | 7.76** |
| " | (A) | 150 | 0.6890 | -0.5496 | 0.426 | 0.028 | | |
| Conche | (S) | 73 | 0.8231 | -0.8885 | 0.752 | 0.027 | 0.80 | 5.68 |
| " | (A) | 74 | 0.9338 | -1.1720 | 0.778 | 0.029 | | |
| Quirpon | (S) | 82 | 0.6533 | -0.4796 | 0.574 | 0.027 | 0.06 | 2.16 |
| " | (A) | 133 | 0.6172 | -0.3971 | 0.452 | 0.030 | | |
| Hawke's Bay | (S) | 243 | 1.0285 | -1.3898 | 0.798 | 0.027 | 0.04 | 1.72 |
| " | (A) | 141 | 1.0116 | -1.3445 | 0.783 | 0.028 | | |
| Fortune Bay | (S) | 217 | 0.7540 | -0.7235 | 0.799 | 0.025 | | |
| St. Mary's Bay | (S) | 243 | 0.8845 | -1.0342 | 0.852 | 0.018 | | |
| Notre Dame Bay | (S) | 431 | 0.7747 | -0.7584 | 0.691 | 0.021 | | |
| Gabarus Bay, N.S. | (A) | 146 | 0.6306 | -0.4084 | 0.675 | 0.022 | | |
| Strait of Belle Isle | (A) | 195 | 0.7424 | -0.6816 | 0.565 | 0.022 | | |

A = Autumn; S = Spring

Table 6. Covariance statistics comparing the log-log regressions of postorbital length on standard length for spring and autumn spawners within each area. (The double asterisk indicates significance at the 1% level.)

| Area and spawning group | | No. of specimens | Regression coef., n | Intercept log k | Correlation coef., r | St. error of estimate | Covariance analysis Slopes F | Adjusted means F |
|---|---|---|---|---|---|---|---|---|
| Magdalen Islands | (S) | 107 | 1.1041 | -1.2549 | 0.789 | 0.018 | 1.22 | 60.36** |
| " | (A) | 373 | 1.0000 | -0.9848 | 0.741 | 0.018 | | |
| Southwest Nfld. | (S) | 141 | 0.9421 | -0.8724 | 0.578 | 0.019 | 2.78 | 128.23** |
| " | (A) | 348 | 1.1368 | -1.3274 | 0.754 | 0.017 | | |
| Placentia Bay | (S) | 76 | 0.9653 | -0.9119 | 0.924 | 0.020 | 2.28 | 0.10 |
| " | (A) | 49 | 0.8017 | -0.5096 | 0.752 | 0.022 | | |
| Trinity Bay | (S) | 321 | 0.9134 | -0.7921 | 0.872 | 0.019 | 0.59 | 0.34 |
| " | (A) | 105 | 0.8346 | -0.5948 | 0.710 | 0.015 | | |
| Bonavista Bay | (S) | 329 | 0.9310 | -0.8361 | 0.802 | 0.021 | 0.40 | 21.53** |
| " | (A) | 150 | 0.9924 | -0.9757 | 0.699 | 0.019 | | |
| Conche | (S) | 73 | 1.0023 | -1.0062 | 0.905 | 0.018 | 1.60 | 5.09 |
| " | (A) | 74 | 0.9114 | -0.7895 | 0.920 | 0.015 | | |
| Quirpon | (S) | 82 | 0.6458 | -0.1448 | 0.647 | 0.022 | 1.14 | 0.00 |
| " | (A) | 133 | 0.7792 | -0.4735 | 0.611 | 0.025 | | |
| Hawke's Bay | (S) | 243 | 0.9578 | -0.9181 | 0.859 | 0.020 | 7.67** | 33.92** |
| " | (A) | 141 | 1.1282 | -1.3214 | 0.885 | 0.021 | | |
| Fortune Bay | (S) | 215 | 0.8666 | -0.6801 | 0.883 | 0.021 | | |
| St. Mary's Bay | (S) | 243 | 0.8875 | -0.7429 | 0.852 | 0.018 | | |
| Notre Dame Bay | (S) | 431 | 0.9363 | -0.8610 | 0.824 | 0.017 | | |
| Gabarus Bay, N.S. | (A) | 146 | 1.0506 | -1.1204 | 0.899 | 0.017 | | |
| Strait of Belle Isle | (A) | 195 | 1.1684 | -1.4444 | 0.831 | 0.016 | | |

A = Autumn; S = Spring

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Table 7. Covariance statistics comparing the log-log regressions of predorsal length on standard length for spring and autumn spawners within each area. (The double asterisk indicates significance at the 1% level.)

| Area and spawning group | | No. of specimens | Regression coef., n | Intercept log k | Correlation coef., r | St. error of estimate | Covariance analysis | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Slopes F | Adjusted means F |
| Magdalen Islands | (S) | 107 | 1.0879 | -0.5116 | 0.947 | 0.008 | 1.16 | 16.93** |
| " | (A) | 373 | 1.0418 | -0.3951 | 0.928 | 0.008 | | |
| Southwest Nfld. | (S) | 141 | 1.0757 | -0.4808 | 0.890 | 0.008 | 0.46 | 7.63** |
| " | (A) | 348 | 1.1099 | -0.5621 | 0.932 | 0.007 | | |
| Placentia Bay | (S) | 76 | 1.0179 | -0.3405 | 0.986 | 0.009 | 1.34 | 1.33 |
| " | (A) | 49 | 0.9661 | -0.2112 | 0.964 | 0.008 | | |
| Trinity Bay | (S) | 322 | 1.0498 | -0.4169 | 0.977 | 0.009 | 1.20 | 6.78 |
| " | (A) | 105 | 1.1017 | -0.5432 | 0.926 | 0.008 | | |
| Bonavista Bay | (S) | 334 | 1.0227 | -0.3504 | 0.970 | 0.008 | 0.43 | 3.89 |
| " | (A) | 149 | 0.9984 | -0.2883 | 0.925 | 0.008 | | |
| Conche | (S) | 73 | 1.0234 | -0.3494 | 0.980 | 0.008 | 0.10 | 1.31 |
| " | (A) | 74 | 1.0347 | -0.3787 | 0.979 | 0.008 | | |
| Quirpon | (S) | 82 | 0.9618 | -0.1998 | 0.969 | 0.007 | 5.76 | 0.72 |
| " | (A) | 133 | 1.0652 | -0.4534 | 0.948 | 0.009 | | |
| Hawke's Bay | (S) | 243 | 1.0336 | -0.3765 | 0.974 | 0.008 | 1.81 | 4.69 |
| " | (A) | 141 | 1.0674 | -0.4614 | 0.978 | 0.008 | | |
| Fortune Bay | (S) | 219 | 1.0427 | -0.4023 | 0.986 | 0.008 | | |
| St. Mary's Bay | (S) | 244 | 0.9807 | -0.2441 | 0.977 | 0.007 | | |
| Notre Dame Bay | (S) | 431 | 1.0230 | -0.3467 | 0.970 | 0.007 | | |
| Gabarus Bay, N.S. | (A) | 146 | 1.0085 | -0.3087 | 0.975 | 0.007 | | |
| Strait of Belle Isle | (A) | 195 | 1.0084 | -0.3114 | 0.936 | 0.008 | | |

A = Autumn; S = Spring

Table 8. Covariance comparisons of the log-log regressions of head length on standard length among all areas for spring and autumn spawners separately. (The double asterisk indicates significance at the 1% level.)

| Test | Source of variation | Degrees of freedom | Sum of squares | Mean square | F |
|---|---|---|---|---|---|
| Among areas spring spawners | Within Samples | 2244 | $3.4448 \times 10^{-1}$ | $1.5351 \times 10^{-4}$ | |
| | Reg. Coefficients | 10 | $6.1829 \times 10^{-3}$ | $6.1829 \times 10^{-4}$ | 4.03** |
| | Common Regression | 2254 | $3.5067 \times 10^{-1}$ | $1.5557 \times 10^{-4}$ | |
| | Adjusted Means | 10 | $7.1728 \times 10^{-2}$ | $7.1728 \times 10^{-3}$ | 46.11** |
| | Total | 2264 | $4.2239 \times 10^{-1}$ | | |

At df 10 and ∞ : F(.01) = 2.32

| Test | Source of variation | Degrees of freedom | Sum of squares | Mean square | F |
|---|---|---|---|---|---|
| Among areas autumn spawners | Within Samples | 1694 | $2.5208 \times 10^{-1}$ | $1.4881 \times 10^{-4}$ | |
| | Reg. Coefficients | 9 | $5.8523 \times 10^{-3}$ | $6.5025 \times 10^{-4}$ | 4.37** |
| | Common Regression | 1703 | $2.5793 \times 10^{-1}$ | $1.5146 \times 10^{-4}$ | |
| | Adjusted Means | 9 | $1.1295 \times 10^{-1}$ | $1.2549 \times 10^{-2}$ | 82.86** |
| | Total | 1712 | $3.7088 \times 10^{-1}$ | | |

At df 9 and ∞ : F(.01) = 2.41

Table 9. Covariance comparisons of the log-log regressions of various body parts on standard length between pairs of areas for spring spawners. (The double asterisk indicates significance at the 1% level.)

| Area comparisons (spring spawners) | Head length | | Snout length | | Orbit diameter | | Postorbital length | | Predorsal length | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Slopes F | Adj Means F | Slopes F | Adj Means F | Slopes F | Adj Means F | Slopes F | Adj Means F | Slopes F | Adj Means F |
| Bonavista Bay vs Trinity Bay | 0.40 | 3.76 | 1.63 | 12.12** | 0.11 | 1.09 | 0.14 | 0.48 | 1.99 | 0.47 |
| Bonavista Bay vs Notre Dame Bay | 1.84 | 39.33** | 4.66 | 36.57** | 0.26 | 66.57** | 0.01 | 76.24** | 0.00 | 73.61** |
| Bonavista Bay vs St. Mary's Bay | 0.32 | 60.43** | 0.94 | 31.01** | 1.73 | 4.91 | 0.68 | 48.61** | 4.42 | 48.19** |
| Bonavista Bay vs Conche | 2.24 | 7.60** | 2.63 | 45.81** | 0.04 | 0.26 | 0.88 | 2.00 | 0.00 | 8.06** |
| Bonavista Bay vs Fortune Bay | 2.49 | 26.56** | 0.56 | 71.29** | 0.72 | 0.23 | 1.68 | 0.00 | 1.18 | 21.99** |
| Notre Dame Bay vs Conche | 7.92** | 0.42 | 14.67** | 23.92** | 0.35 | 17.90** | 1.11 | 52.74** | 0.00 | 3.52 |
| Notre Dame Bay vs Quirpon | 2.38 | 0.03 | 79.62** | 4.35 | 1.64 | 42.19** | 14.73** | 5.30 | 4.55 | 11.25** |
| Notre Dame Bay vs Trinity Bay | 4.93 | 16.49** | 15.86** | 4.22 | 0.90 | 84.56** | 0.29 | 91.04** | 2.25 | 74.76** |
| Conche vs Quirpon | 0.46 | 0.67 | 12.53** | 11.03** | 1.59 | 2.34 | 12.57** | 10.76** | 2.77 | 1.04 |
| Conche vs Hawke's Bay | 0.25 | 61.77** | 0.22 | 20.51** | 4.27 | 0.02 | 0.39 | 61.35** | 0.11 | 4.97 |
| Quirpon vs Hawke's Bay | 1.40 | 49.42** | 18.87** | 68.92** | 10.76** | 4.78 | 12.96** | 12.24** | 4.33 | 1.15 |
| Hawke's Bay vs Magdalen Islands | 0.74 | 59.52** | 0.01 | 2.47 | 0.40 | 3.49 | 2.33 | 74.15** | 1.78 | 7.46** |
| Hawke's Bay vs Southwest Nfld. | 0.94 | 33.54** | 0.25 | 16.31** | 0.33 | 6.68 | 0.02 | 12.14** | 0.69 | 2.22 |
| Magdalen Islands vs Southwest Nfld. | 2.08 | 5.87 | 0.25 | 4.00 | 0.00 | 0.35 | 1.33 | 27.48** | 0.04 | 1.02 |

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Table 9. Cont'd.

| Area comparisons (spring spawners) | Head length | | Snout length | | Orbit diameter | | Postorbital length | | Predorsal length | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Slopes F | Adj Means F | Slopes F | Adj Means F | Slopes F | Adj Means F | Slopes F | Adj Means F | Slopes F | Adj Means F |
| Southwest Nfld. vs Fortune Bay | 0.62 | 3.50 | 0.13 | 1.40 | 1.31 | 13.18** | 0.38 | 11.41** | 0.47 | 5.05 |
| Fortune Bay vs Placentia Bay | 10.13 | 25.29** | 6.63 | 42.90** | 2.65 | 1.77 | 2.60 | 7.35** | 1.53 | 6.96** |
| Fortune Bay vs St. Mary's Bay | 1.15 | 2.76 | 0.02 | 18.36** | 5.92 | 4.17 | 0.19 | 46.48** | 11.49** | 149.63** |
| Fortune Bay vs Trinity Bay | 5.99 | 12.31** | 4.37 | 29.72** | 1.87 | 0.12 | 1.23 | 0.82 | 0.16 | 9.58** |
| Placentia Bay vs St. Mary's Bay | 5.58 | 63.59** | 11.54** | 24.67** | 0.38 | 12.86** | 1.25 | 79.61** | 4.21 | 49.13** |
| Placentia Bay vs Trinity Bay | 1.40 | 14.28** | 0.88 | 15.25** | 0.21 | 0.41 | 0.41 | 7.13** | 2.41 | 0.33 |
| St. Mary's Bay vs Trinity Bay | 1.68 | 30.33** | 6.11 | 3.59 | 1.32 | 12.45** | 0.32 | 60.36** | 12.69** | 46.63** |

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Table 10. Covariance comparisons of the log-log regressions of various body parts on standard length between pairs of areas for autumn spawners. (The double asterisk indicates significance at the 1% level.)

| Area comparisons (autumn spawners) | Head length | | Snout length | | Orbit diameter | | Postorbital length | | Predorsal length | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Slopes F | Adj Means F | Slopes F | Adj Means F | Slopes F | Adj Means F | Slopes F | Adj Means F | Slopes F | Adj Means F |
| Bonavista Bay vs Trinity Bay | 1.26 | 21.55** | 1.73 | 3.11 | 1.58 | 0.01 | 1.67 | 24.25** | 3.50 | 3.10 |
| Bonavista Bay vs Conche | 0.28 | 107.92** | 0.33 | 66.50** | 2.68 | 14.97** | 0.72 | 30.81** | 0.73 | 0.08 |
| Bonavista Bay vs Quirpon | 0.26 | 49.25** | 2.59 | 36.73** | 0.20 | 54.79** | 2.95 | 96.97** | 2.06 | 0.45 |
| Bonavista Bay vs Strait of Belle Isle | 1.70 | 250.47** | 0.00 | 85.29** | 0.15 | 0.07 | 3.26 | 256.55** | 0.05 | 4.11 |
| Bonavista Bay vs Placentia Bay | 0.12 | 4.76 | 1.04 | 0.14 | 1.55 | 7.50** | 0.30 | 2.53 | 0.34 | 6.75** |
| Bonavista Bay vs Southwest Nfld. | 6.44 | 2.07 | 0.36 | 9.50** | 6.91** | 11.93** | 2.35 | 6.41 | 7.73** | 4.38 |
| Conche vs Trinity Bay | 3.86 | 52.71** | 4.22 | 46.25** | 0.04 | 12.93** | 0.68 | 2.74 | 1.70 | 1.76 |
| Conche vs Quirpon | 1.49 | 18.91** | 1.61 | 136.20** | 5.19 | 3.70 | 1.66 | 11.50** | 0.57 | 0.35 |
| Conche vs Strait of Belle Isle | 0.99 | 2.80 | 0.59 | 3.16 | 2.87 | 19.00** | 12.43** | 53.96** | 0.51 | 2.71 |
| Quirpon vs Strait of Belle Isle | 4.28 | 48.85** | 3.96 | 226.78** | 0.95 | 77.87** | 14.95** | 2.72 | 1.93 | 0.60 |
| Quirpon vs Hawke's Bay | 9.10** | 1.86 | 4.97 | 169.05** | 10.07** | 48.84** | 12.72** | 21.11** | 0.00 | 5.33 |
| Strait of Belle Isle vs Hawke's Bay | 0.64 | 41.75** | 0.03 | 4.78 | 6.39 | 2.00 | 0.27 | 95.16** | 3.09 | 11.36** |
| Strait of Belle Isle vs Magdalen Islands | 0.47 | 316.02** | 0.08 | 19.09** | 1.45 | 8.78** | 4.93 | 426.61** | 0.89 | 0.93 |
| Strait of Belle Isle vs Southwest Nfld. | 1.99 | 298.55** | 0.56 | 30.06** | 7.37** | 15.30** | 0.16 | 364.02** | 8.17** | 0.37 |
| Strait of Belle Isle vs Gabarus Bay, N.S. | 6.62 | 110.22** | 2.39 | 14.17** | 1.32 | 0.89 | 2.75 | 164.07** | 0.00 | 5.82 |

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Table 10. Cont'd.

| Area comparisons (autumn spawners) | Head length | | Snout length | | Orbit diameter | | Postorbital length | | Predorsal length | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Slopes F | Adj Means F | Slopes F | Adj Means F | Slopes F | Adj Means F | Slopes F | Adj Means F | Slopes F | Adj Means F |
| Hawke's Bay vs Magdalen Islands | 3.01 | 198.79** | 0.30 | 52.83** | 1.96 | 9.01** | 3.69 | 143.98** | 0.78 | 17.20** |
| Hawke's Bay vs Southwest Nfld. | 0.62 | 141.06** | 1.06 | 68.97** | 0.09 | 8.19** | 0.01 | 71.00** | 2.00 | 21.32** |
| Hawke's Bay vs Gaberus Bay, N.S. | 16.47** | 79.51** | 2.16 | 60.69** | 18.14** | 1.99 | 1.37 | 24.51** | 4.72 | 78.99** |
| Magdalen Islands vs Gaberus Bay, N.S. | 3.97 | 18.30** | 4.07 | 4.85 | 6.91** | 3.26 | 0.62 | 43.63** | 1.30 | 36.10** |
| Magdalen Islands vs Southwest Nfld. | 5.27 | 9.96** | 0.27 | 1.52 | 2.51 | 0.17 | 3.67 | 28.64** | 4.50 | 0.06 |
| Gaberus Bay, N.S. vs Southwest Nfld. | 18.62** | 2.06 | 5.97 | 1.54 | 18.66** | 1.96 | 1.60 | 4.79 | 11.48** | 42.72** |
| Southwest Nfld. vs Placentia Bay | 11.26** | 1.49 | 1.36 | 17.03** | 1.16 | 17.61** | 11.54** | 6.40 | 11.73** | 7.20** |
| Southwest Nfld. vs Trinity Bay | 13.34** | 35.50** | 4.19 | 1.68 | 0.90 | 19.32** | 8.76** | 49.89** | 0.03 | 1.75 |
| Placentia Bay vs Trinity Bay | 1.08 | 1.15 | 0.70 | 2.07 | 0.16 | 5.08 | 1.07 | 3.23 | 2.95 | 10.21** |

Fig. 1. Area map showing the localities and place names mentioned in the text.



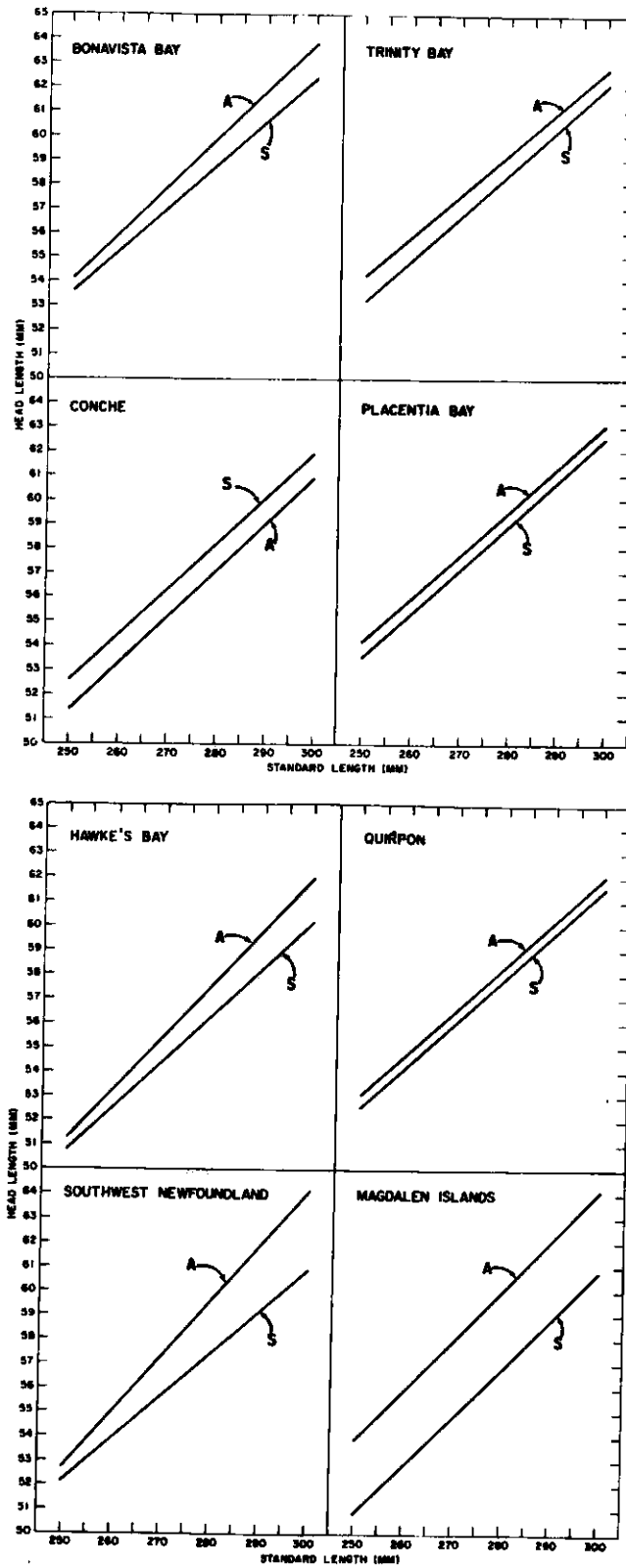Fig. 2. Sketch of a herring showing the body measurements taken.

Fig. 3. Relation of head length to standard length for spring and autumn spawners in each area.
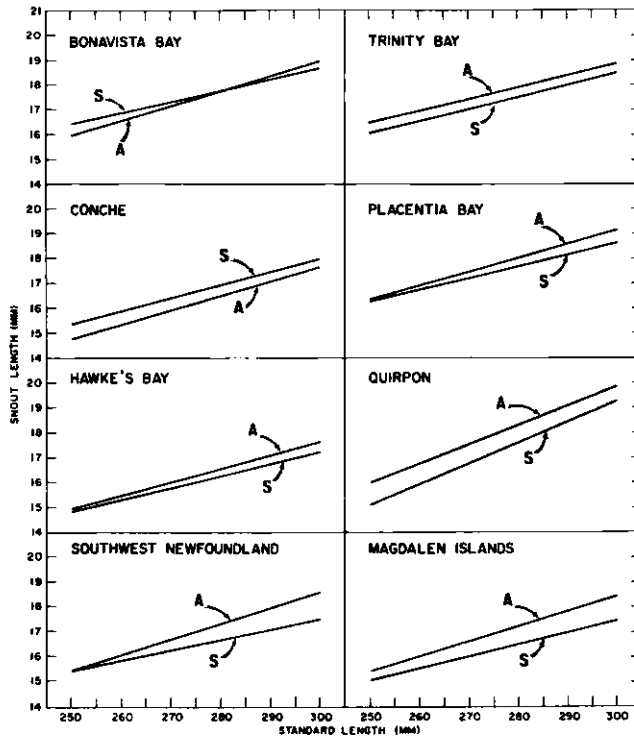
Fig. 4. Relation of snout length to standard length for spring and autumn spawners in each area.
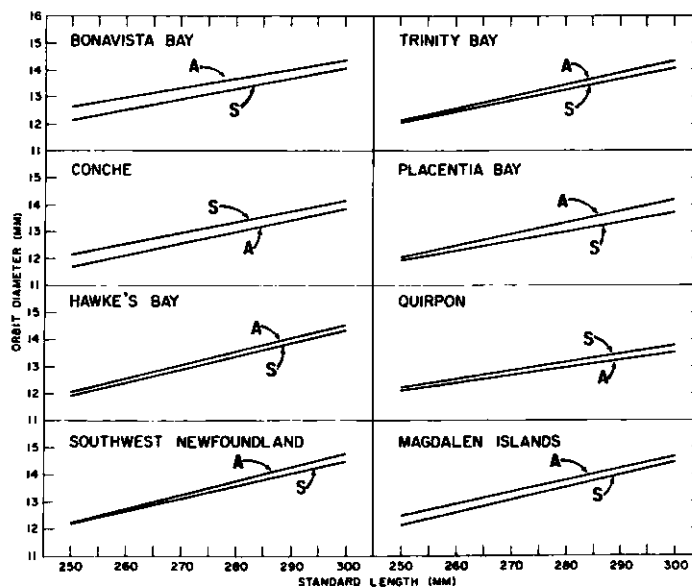


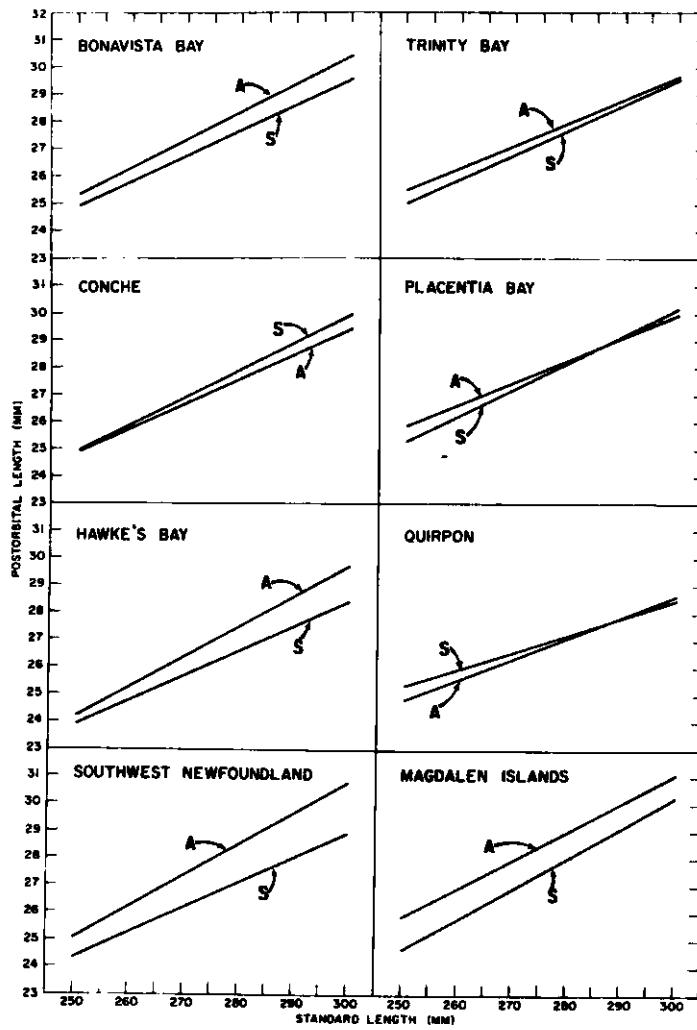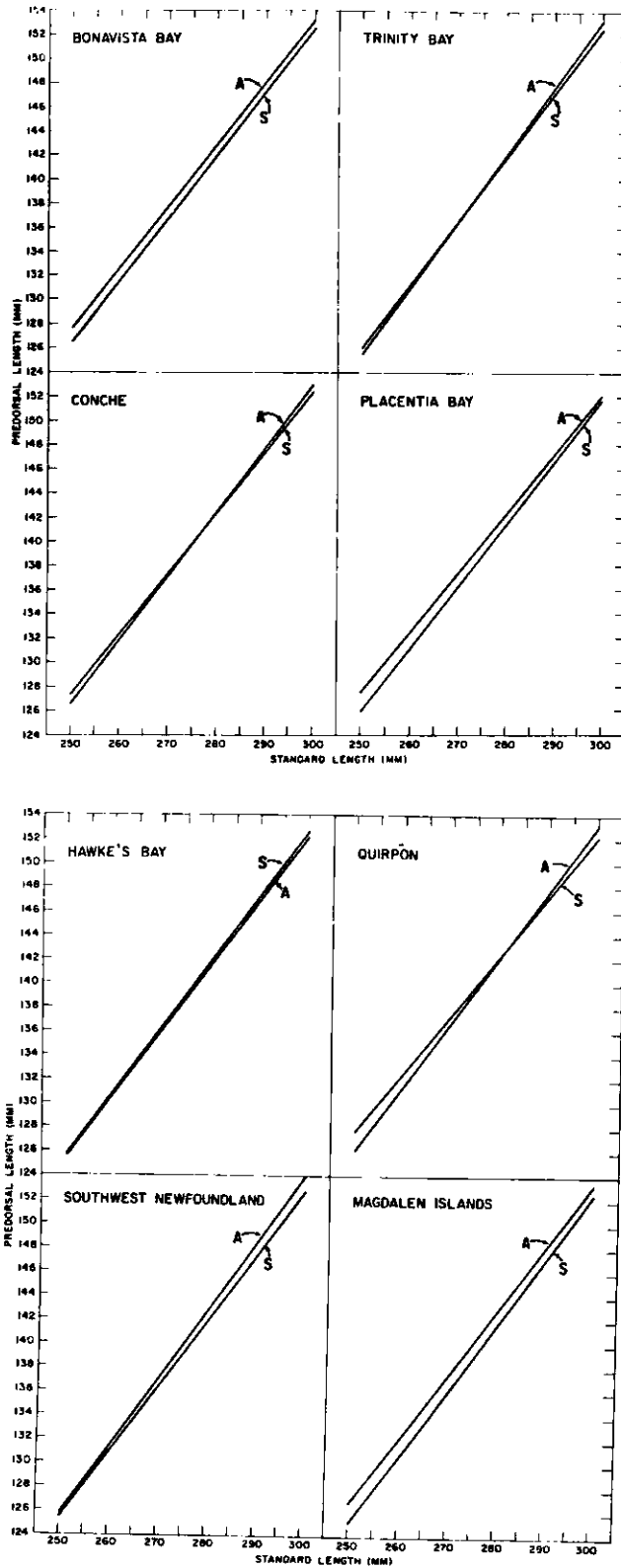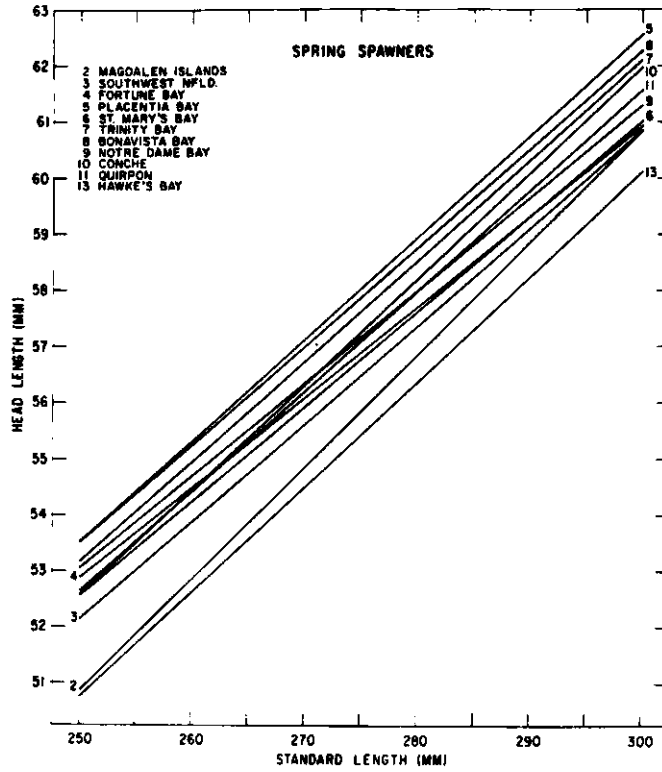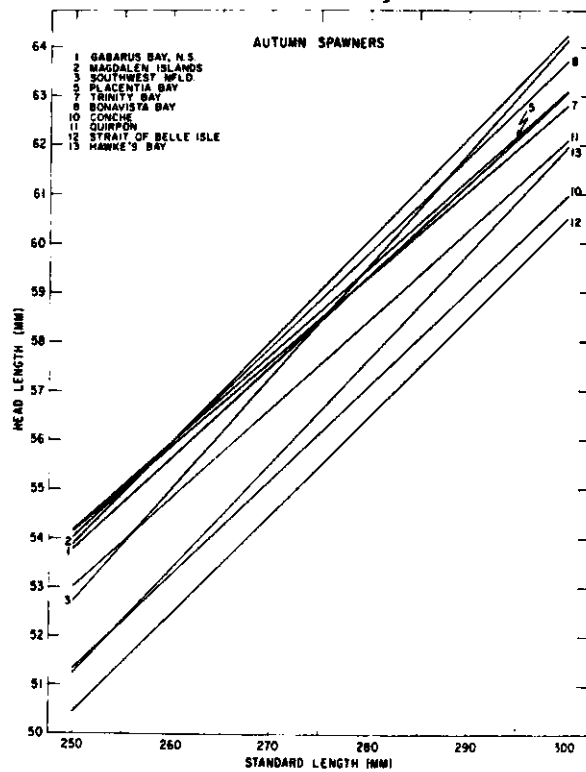Fig. 5. Relation of orbit diameter to standard length for spring and autumn spawners in each area.

**F 9**

Fig. 6. Relation of postorbital length to standard length for spring and autumn spawners in each area.

Fig. 7. Relation of predorsal length to standard length for spring and autumn spawners in each area.

F 11

Fig. 8. Relation of head length to standard length for spring spawners in all areas.



Fig. 9. Relation of head length to standard length for autumn spawners in all areas.
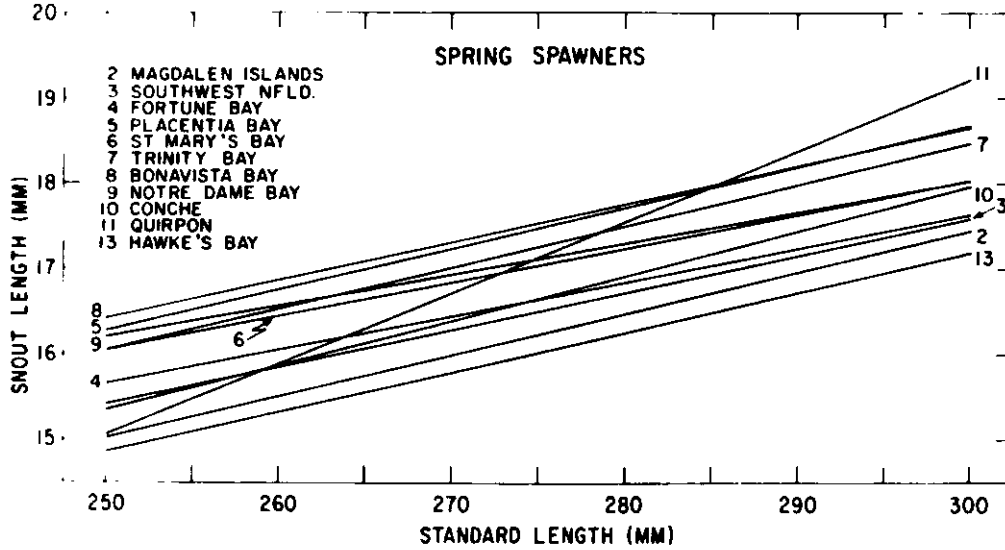
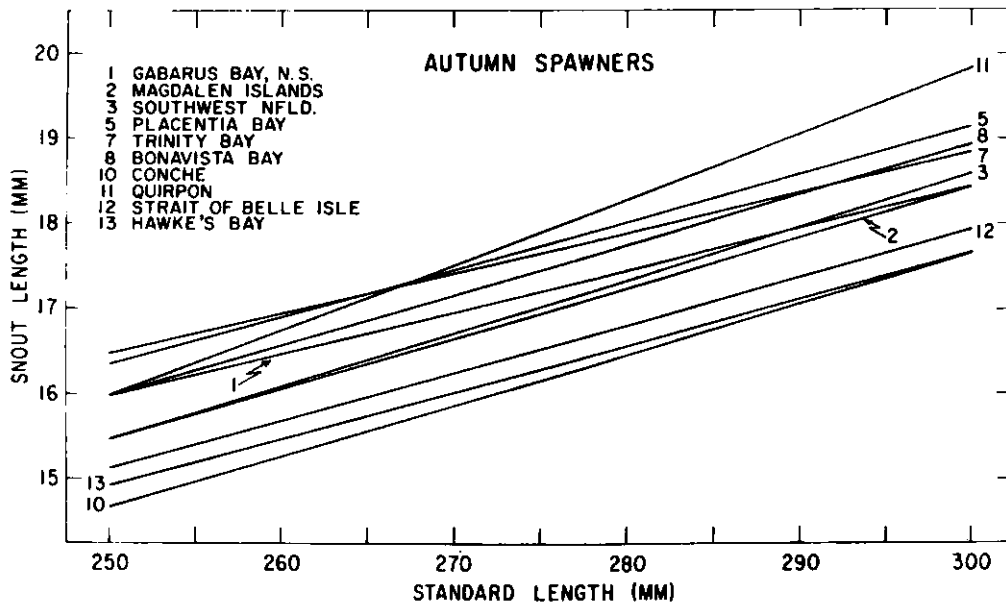Fig. 10. Relation of snout length to standard length for spring spawners in all areas.



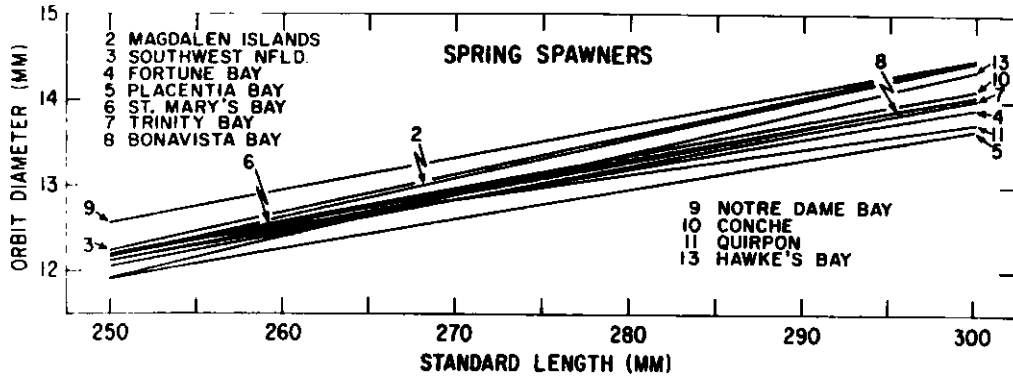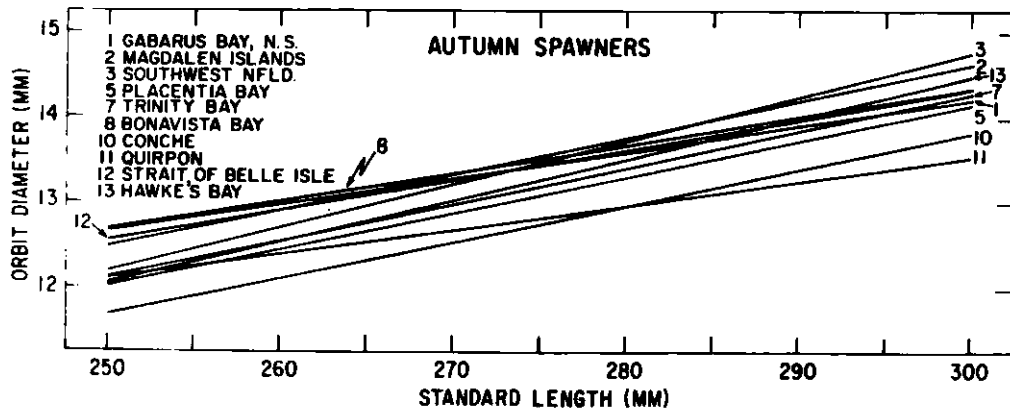Fig. 11. Relation of snout length to standard length for autumn spawners in all areas.

**SPRING SPAWNERS**

1 
2 MAGDALEN ISLANDS
3 SOUTHWEST NFLD.
4 FORTUNE BAY
5 PLACENTIA BAY
6 ST. MARY'S BAY
7 TRINITY BAY
8 BONAVISTA BAY

9 NOTRE DAME BAY
10 CONCHE
11 QUIRPON
13 HAWKE'S BAY

ORBIT DIAMETER (MM)

STANDARD LENGTH (MM)

Fig. 12. Relation of orbit diameter to standard length for spring spawners in all areas.



**AUTUMN SPAWNERS**

1 GABARUS BAY, N.S.
2 MAGDALEN ISLANDS
3 SOUTHWEST NFLD.
5 PLACENTIA BAY
7 TRINITY BAY
8 BONAVISTA BAY
10 CONCHE
11 QUIRPON
12 STRAIT OF BELLE ISLE
13 HAWKE'S BAY

ORBIT DIAMETER (MM)

STANDARD LENGTH (MM)

Fig. 13. Relation of orbit diameter to standard length for autumn spawners in all areas.
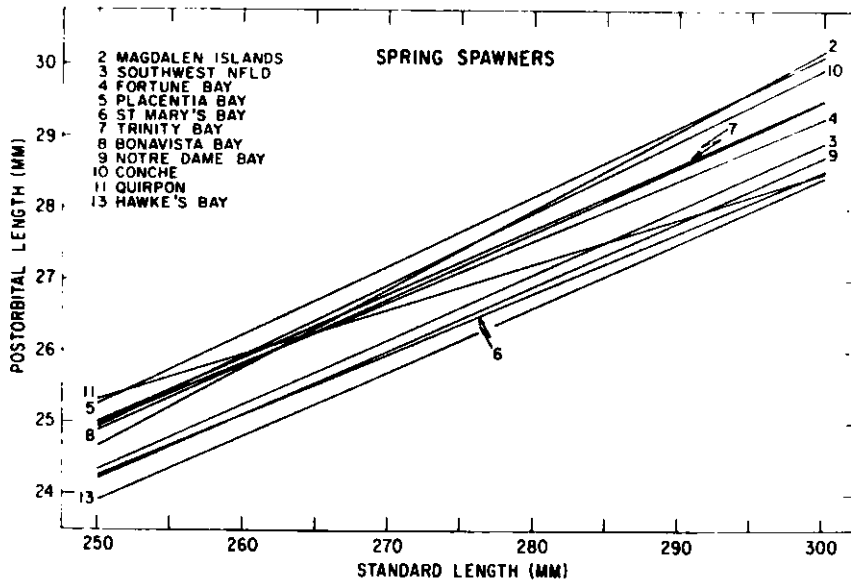
F 14

Fig. 14.   Relation of postorbital length to standard length for spring spawners in all areas.
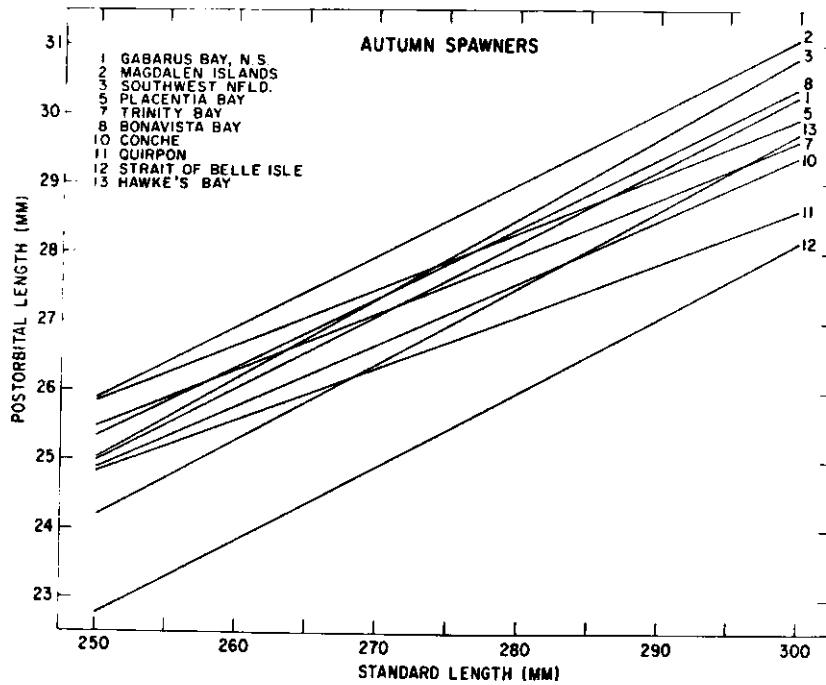


Fig. 15.   Relation of postorbital length to standard length for autumn spawners in all areas.
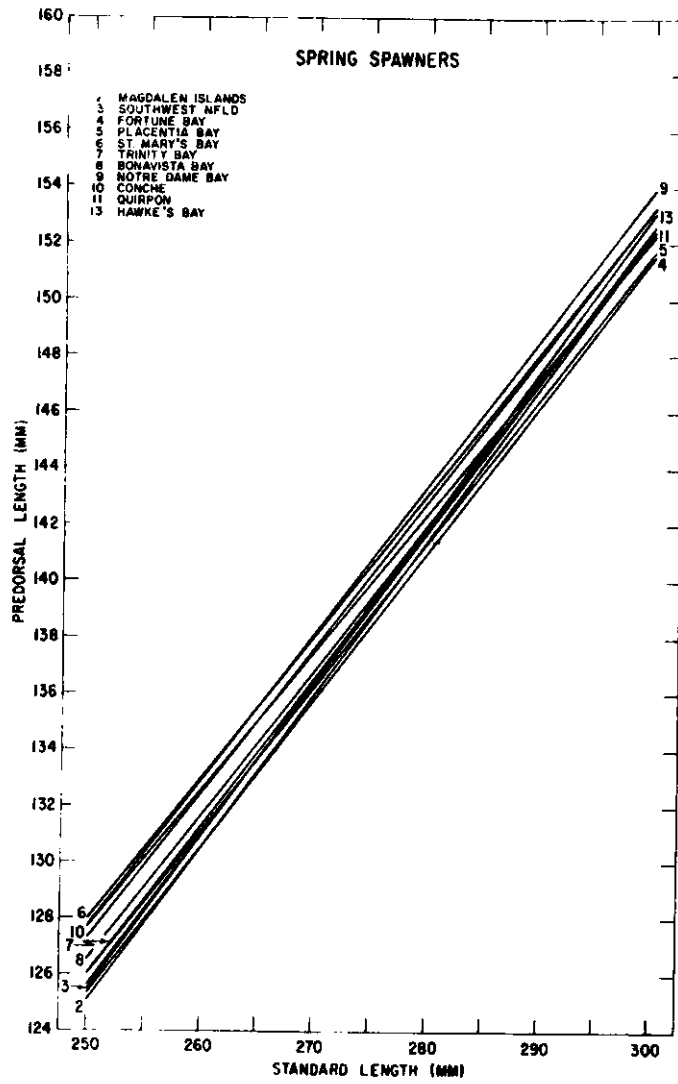
G 1

Fig. 16. Relation of predorsal length to standard length for spring spawners in all areas.
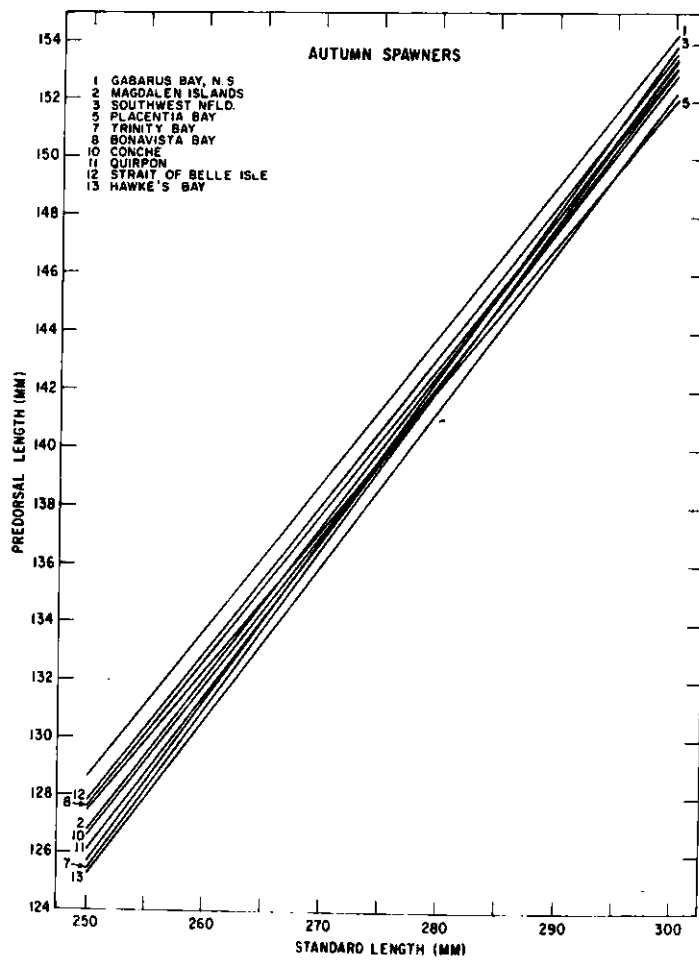
Fig. 17.   Relation of predorsal length to standard length for autumn spawners in all areas.