INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No. 2962
(D.c. 5)

ICNAF Res.Doc. 73/29

ANNUAL MEETING - JUNE 1973

Biological characteristics of southwest Newfoundland herring, 1965-71

by

L. S. Parsons and V. M. Hodder[1]
Fisheries Research Board of Canada
Biological Station, St. John's, Newfoundland

Introduction

Since its inception during the winter of 1965 the Newfoundland purse seine fishery for herring has been primarily concentrated along southwest Newfoundland in areas J1 and J2 (Fig. 1) with lesser quantities being caught in Fortune, Placentia and St. Mary's bays and along western Newfoundland (Hodder, 1971). In southwest Newfoundland coastal waters the seasonal catches increased from less than 5,000 tons in 1964-65 to nearly 140,000 tons in 1968-69 and 1969-70, accompanied by a rapid increase in the seiner fleet to more than 50 vessels during the 1969-70 and 1970-71 fishing seasons (July - June). Recently there has been a substantial decrease in southwest Newfoundland herring catches to 103,000 tons in 1970-71 and less than 40,000 tons in 1971-72 (Winters and Parsons, MS, 1972). Information on the fishery and distribution of catches is given by Hodder (1969, 1970, 1971).

The herring concentrations which appear in southwest Newfoundland fjords in late November - early December have recently been shown by meristic studies (Hodder and Parsons, 1971a,b; Parsons, 1973) and tagging recaptures (Winters, 1970; MS 1971a,b) to migrate there from the southwestern Gulf of St. Lawrence where a substantial fishery occurs during June to September. The eastward migration apparently commences in October and, for a brief period in November just prior to the start of the southwest Newfoundland fishery, the herring schools are exploited as they move eastward past the Magdalen Islands. In late April, as the westward migration of herring into the Gulf of St. Lawrence is in progress, a brief fishery occurs in the area between St. Paul Island and the Magdalen Islands.

This paper presents data on the size and year-class compositions, growth and selected biological characteristics of herring from the southwest Newfoundland area during the recent period of increased exploitation (1965-71) and analyzes these in relation to recent changes in the fishery.

Materials and Methods

Random samples of 50 fish each were obtained from the catches of seiners as they were being discharged at the processing plants. Information on the time and place of capture was obtained from logbook records or from port interviews with officers of the fishing vessels. Emphasis was placed on sampling the southwest Newfoundland fishery but catches from other areas were sampled when opportunities arose. The sampling program was designed to obtain as broad a coverage of the fleet as possible during each fishing season. In addition to the samples collected for age and growth studies, special collections of herring for fat and water analyses were begun in 1966 and continued during 1969-71 (Table 1). Details of sample collection and processing are given by Hodder et al. (MS 1972; MS 1973).

Some of the samples were examined in the fresh condition immediately after capture but many were examined after being kept in frozen storage for several weeks. Routine examination for each specimen involved the recording of total length, whole weight, gonad weight, maturity condition of gonads, estimation of the degree of stomach fullness, and the removal of otoliths for subsequent age determination. The length used is the greatest total length (to the nearest millimetre) measured from the tip of the lower jaw to the end of the longest lobe of the caudal fin with the lobe extending posteriorly in line with the body. Thawed lengths were adjusted to the fresh condition by applying a conversion factor of 1.02 (Hodder et al., MS, 1972). In tables and figures where length measurements are given in cm, the cm-interval is given such that 30 cm = 300 to 309 mm. Whole weights of fish and weights of gonads were determined to the nearest gram. No weight adjustments were required since the change in weight between fresh herring and herring examined after frozen storage was insignificant.

[1] Present address: ICNAF, P.O. Box 638, Dartmouth, N.S., Canada

Published in ICNAF RES. BULL. NO. 11: 145-160

The stage of maturity was determined by gross examination of gonads using the numerical scale of gonadal development stages adopted by ICNAF (ICNAF, 1964). The absence of stages V to VII in the samples facilitated the classification of the adult specimens as spring- or autumn-type spawners; those classed as stages III and IV (mostly IV) were designated as spring spawners and stage VIII as autumn spawners. Immature herring were generally scarce in the samples but those present were assigned as spring- or autumn-type on the basis of otolith characteristics. The necessity of treating autumn- and spring-spawning types separately was demonstrated by Parsons and Hodder (1971) and Parsons (1972) who showed that they differed significantly in mean numbers of fin rays and gill rakers and suggested that these spawning components constitute distinct breeding populations.

Feeding intensity was estimated by the degree of fullness of the stomachs based on the following scale: 0 = empty, 1 = 1/4 full, 2 = 1/2 full, 3 = 3/4 full, 4 = full.

Age determinations were made from whole otoliths premounted in small circular depressions of otolith trays of black plexiglass according to the technique developed by Watson (1965). The otoliths were immersed in ethyl alcohol and viewed under reflected light. Age estimates were initially made independently by two experienced readers with about 60-80% agreement on a sample-by-sample basis. Disagreements were resolved either mutually after further checking or by majority decision after the disputed otoliths were examined by a third reader.

The age was recorded as the number of completed summer (opaque) growth zones on the otolith. A fish is considered to be age 1 following completion of the first summer's growth. Ages were recorded individually for specimens up to 10 years and those obviously greater than 10 years old were grouped into a 11+ category. The age compositions reported in this paper are based upon monthly data for the six seasons from 1965-66 to 1970-71 presented by Hodder et al. (MS, 1972).

In nearly all cases specimens for fat and moisture analyses were measured and weighed while in the fresh condition, placed in individual polyethylene bags and frozen for subsequent sampling at the laboratory, where the entire fish was chopped into small pieces and blended into a paste. For determination of moisture content the paste samples were mixed, 10-15 g of the paste weighed to the nearest mg and then dried to a constant weight at 100°C in an oven. Loss in weight was reported as percent moisture. Fat content was determined by ethyl-ether extraction in a Soxhlet apparatus, and the fat content was calculated as the percent of the wet weight of the whole fish. All analyses were performed in duplicate with a precision of ±0.5% for moisture and ±0.1% for fat.

Results

Size, Maturity and Age Composition

a) Southwest Newfoundland

There has been a gradual increase in the average size of herring taken along southwest Newfoundland since the purse seine fishery began in 1965 (Fig. 2). The modal size increased from 32 cm during the 1965-66 season to 35 cm during 1970-71 and the average length from 32.7 to 34.5 cm. The increase in size over the six seasons was steady at a rate of about 0.4 cm per year. The relatively narrow size range with more than 95% of the herring between 30 and 36 cm and the gradual increase in size suggests that a narrow range of year-classes was represented in the fishery.

The composition of the samples by maturity stages indicates a mixture of two spawning groups - spring and autumn, with the latter type comprising about 70% of the specimens in the samples. The relative abundance of the two types fluctuated from month to month within a season (Fig. 3) but no consistent trend is evident.

The high degree of similarity among the monthly length frequency distributions within each spawning type and season (Fig. 4) indicates that very little change in the stock structure occurred on a month by month basis during each of the six seasons, the only exception being for spring spawners in April 1971, when 3 of the 15 samples examined consisted almost entirely of juveniles taken after the adults had disappeared from the area. These juveniles are probably the progeny of "local" spring-spawning stocks which frequent the coastal waters of western Newfoundland. The length distributions in Fig. 4 also show the consistency of the difference in modal size between spring- and autumn-type spawners over the six seasons during which each type gradually increased in size at about the same rate, as indicated by the vertical lines through the modes. The obvious difference in average size of spring and autumn spawners necessitated separate treatment of the two types in analyses of the data.

The seasonal length and age compositions of the two types in the seiner catches during the 1965-66 to 1970-71 seasons are shown in Fig. 5. The trend in length composition of both types is indicative of the progression of one or two good year-classes through the fishery, and this is confirmed by the age composition data. Since its inception this winter fishery has been largely dependent on the very abundant 1958 year-class of autumn-spawned herring, exploited in the 1965-66 season as 7-year-olds and just as dominant during the 1970-71 season (over 40% by number) as 12-year-olds. Spring spawners, which on the average constituted about

30% of the herring sampled, were dominated by a reasonable good 1959 year-class which persisted as the most important one throughout the six seasons of sampling. Clearly evident is the absence of any significant recruitment of recent good year-classes to the exploited stock.

b) Southern Gulf of St. Lawrence

Herring taken at Magdalen Islands in November 1969, just before the start of the southwest Newfoundland winter fishery, and those taken near St. Paul Island in April of the years 1970 and 1971, after the cessation of the winter fishery, were very different in both length and age composition (Fig. 6). However, those from Magdalen Islands are very similar to herring from southwest Newfoundland for the 1969-70 season in both length and age composition and the relative proportions of spring- and autumn-spawning types. The April samples, on the other hand, consisted largely of spring spawners whose year-class compositions bear little resemblance either to those from Magdalen Islands or to those from southwest Newfoundland. Reports from seiner captains indicate that the herring concentrations found in the vicinity of St. Paul Island in April gradually move towards the Magdalen Islands where they spawn in early May.

Age-length Relationships

The length-at-age data, given on a monthly basis by Hodder et al. (MS, 1972), are summarized by spawning type and season in Table 2 for the southwest Newfoundland data and in Table 3 for the data available from the southern Gulf of St. Lawrence. Except for age group 2 whose average lengths are based on very small numbers of specimens, the seasonal variability in the length-at-age values is very small for both areas.

The unweighted mean values, given in the last column of Tables 2 and 3, are shown separately for spring and autumn spawners in Fig. 7. In the upper part of the figure are shown the Bertalanffy growth curves for southwest Newfoundland herring based on the parameters given under S and A for ages 3-10. These same curves are superimposed on the plotted length-at-age values for the Magdalen and St. Paul Islands area in the lower part of the figure.

The difference in growth between spring and autumn spawners, the latter having slightly higher length-at-age values, is probably due to the fact that in the first full year of growth after metamorphosis the progeny of autumn spawners have a longer growing period than those of spring spawners. At age 2 the values on the curves are higher than the data points and probably do not realistically reflect the growth pattern for this age. For some fish species the rather rapid rate of growth for juveniles followed by the inhibition of growth with the onset of sexual maturity usually produces length-at-age values to which the fit of the Bertalanffy growth equation is not strictly applicable. This may be to a certain degree true for herring, whose growth rate seems to decrease rapidly after they reach sexual maturity at about ages 4 and 5.

Length-weight Relationships

Length-weight data for southwest Newfoundland herring during the 1966-67 to 1970-71 seasons are summarized in Table 4. On the average the mean weight values over the 28-37 cm range decreased between November and April by about 6% for spring spawners and 4% for autumn spawners. A similar decrease in weight-at-length is also evident in the limited data from the southern Gulf of St. Lawrence (Hodder et al., MS, 1972).

Length-weight curves (Fig. 8) for spring and autumn spawners separately were derived from the least squares regression $\log_e W = b.\log_e L + C$, where W = whole weight, L = total length and C = constant. The curves begin to diverge at about 26-27 cm, the size at which spring spawners reach sexual maturity. At each 1-cm length group spring spawners are heavier than autumn spawners by an amount approximately equal to the difference between the weight of gonads of spring and autumn spawners.

Relationship between Gonad Weight and Maturity Condition

Almost from the start of the most recent period of herring investigations at the St. John's Biological Station, the maturity condition of the gonads was used for separating adult spring- and autumn-spawning herring in the samples. Adult herring taken in autumn and winter were classed mostly as maturity stages IV and VIII. The absence of intermediate stages (the observations are based largely on the examination of fresh herring) indicate that spawning is restricted to the spring and autumn periods.

The percentage composition of the monthly samples by maturity stage during the 1970-71 season was as follows:

Area	Month	I,II	VIII	III	IV
Southwest Nfld	Nov 1970	-	82.8	4.4	12.8
" "	Dec 1970	0.3	76.3	2.4	21.0
" "	Jan 1971	1.2	75.5	1.1	22.2
" "	Feb 1971	1.7	73.6	1.2	23.5
" "	Mar 1971	2.3	74.3	1.7	21.7
" "	Apr 1971	30.2	57.7	3.4	8.7
St. Paul Island	Apr 1971	4.0	15.6	2.8	77.6

Herring of maturity stage VIII (autumn spawners) constituted about 75% of the fish in the November - March samples; gonads of practically all of these were in the weight interval 0-9 g, with females weighing slightly more than males (Fig. 9). The gonads of spring spawners (stage IV), on the other hand, were generally greater than 20 g in weight. During November - March juveniles (stages I and II) and adults classed as stage III were infrequent. The latter type, whose gonad development was intermediate between that of autumn spawners (stage VIII) and spring spawners (stage IV), may have been summer spawners which had a somewhat longer period for growth and gonad development than autumn spawners prior to the onset of winter. The April samples from southwest Newfoundland, taken at a time when the adults are moving westward into the Gulf of St. Lawrence, contained an unusually large proportion of juveniles in 1971. The St. Paul Island samples were taken at a time when herring were migrating towards Magdalen Islands for spawning in early May, and a high proportion of spring spawners (stage IV) would be expected.

Plots of average gonad weight against fish length separately by sex for the various maturity stages for December 1970 to March 1971 (Fig. 9) revealed an obvious increase in gonad weight with fish size for maturity stages III and IV but little or no increase during this period for maturity stage VIII. This relationship was more pronounced for males of maturity stages III and IV than for females. Stage III-IV female herring exhibited a definite increase in average gonad weight during the December - March period but there was no discernible weight increase for males of the same maturity category. Stage III-IV male gonads were, on the average, 24 g heavier than females of the same maturity stage in December but by March male and female gonads were equivalent in weight. The average weight of stage III-IV female gonads increased from 29.9 g in December to 45.2 g in March whereas the male gonads were almost fully developed in December.

Feeding Intensity

During the overwintering period from late November to early April virtually all of the herring examined had empty stomachs (Fig. 10). By early May 1971, however, approximately 90% of the stomachs examined contained food, indicating that the feeding intensity was very high at that time. These stomach samples were taken from catches off St. George's Bay which consisted almost entirely of autumn-type spawners. Apparently the autumn-spawning component of the herring concentrations which overwinter along southwest Newfoundland resumes feeding during its westward migration into the Gulf of St. Lawrence in the spring. A cusory examination of the stomach contents of there herring revealed that euphausiids were by far the predominant food item (J.A. Moores, personal communication).

Fat and Water Content

A summary of the fat content analyses by months (Table 5) indicates that during December to April spring spawners have a consistently higher fat content than autumn spawners, the average of the differences being nearly 5% in absolute terms. Also some evidence of an increasing trend in the fat content of both spring and autumn spawners is indicated in the data, with the values for 1970 and 1971 being generally higher than those in 1966 and 1969. Although there has been a gradual increase in the average size and age of herring sampled between 1965 and 1971 (Fig. 5), an analysis of the fat content data by length of fish for each spawning type separately and for each month and year revealed no consistent trend in fat content with length. Consequently the apparent trend from 1966 to 1971 cannot be attributed to variation in the length and age composition of the samples over that period.

In Fig. 11 the average fat content values of the individual samples for spring and autumn spawners separately (for details, see Hodder et al., MS, 1973) are plotted against the dates when the samples were collected. For spring spawners the fat content decreases rapidly from about 15% in December and January to a low of 10% in April. Autumn spawners, which have an average of about 12% fat in December, exhibit a similar rapid decrease to a low level of about 6% in April. The variation about an imaginary trend line through the points is associated with the annual variation mentioned in the preceding paragraph.

Perusal of the percentage fat and water values for individual fish suggest that fat and water together make up a constant percentage of about 80% of the wet weight of the fish, indicating that as the fat is utilized as a source of energy the fish takes in water in the same proportion, and vice versa. This aspect was examined by analyzing the trend in total fat plus water content with increasing fat content values grouped in 5% intervals (Table 6). There appears to ba a gradual increase in the total fat plus water content with increasing fat content; fish with fat content values less than 5% have on the average a total fat plus water content of just under 80%, and those with more than 20% fat have a total fat plus water content of about 81.5%. The fat/water relationship is, therefore, not strictly linear.

Polynomial regression, with percent water as the dependent variable, was used to determine the fat/water relationship. The resulting curve and quadratic equation are shown in Fig. 12, together with the curve for total fat plus water content plotted against the water content. The very high degree of correlation (0.98) between the percent fat and percent water values indicates that a reliable estimate of the percent fat may be computed from the equation, given an estimate of the percent water content.

Discussion and Conclusions

The rapid upsurge in the Newfoundland herring fishery during the mid- to late-1960's was due almost entirely to the development of a substantial late autumn and winter purse seine fishery in the fjords along the western part of the south coast on herring concentrations which migrate there from the southern part of the Gulf of St. Lawrence in November and move westward into the Gulf in late April. Whether or not the migratory pattern of these herring has been a traditional one is uncertain, for prior to the initial explorations in the fjords of southwest Newfoundland by a large purse seiner in 1964-65, there are no records of a signigicant inshore fishery along that part of the coast in winter.

Past periods of intensive herring fisheries in Newfoundland waters have occurred in areas where the local stocks being fished were known to move inshore for spawning in May and June (Tibbo, 1956; 1957), whereas the stocks exploited along southwest Newfoundland disappear from the fjords in April. During the overwintering period the fjord schools of herring consist of a mixture of nonfeeding spring- and autumn-type spawners, with the latter being generally more than twice as abundant as spring spawners. Just before the herring leave the fjords in the spring some separation of spring- and autumn-spawning herring is evident from samples of seiner catches near the end of the season in April. Catches during the short fishery in the area between St. Paul Island and Magdalen Islands in late April consist mostly of spring spawners heading for shallow water at Magdalen Islands to spawn. Catches made at this time off the southwest tip of Newfoundland and off St. George's Bay consist almost entirely of autumn-type spawners. These latter schools ultimately move westward to the southwestern part of the Gulf of St. Lawrence where they feed during the summer and spawn in late summer and early autumn. While the movement of spring spawners toward the Magdalen Islands area and autumn spawners to the Gaspé area has been confirmed by tagging experiments (Winters, 1971a), this does not preclude the possibility of some spring spawners moving westward past the Magdalen Islands to spawn in the Chaleur Bay - Gaspé area in May.

The average size and age of the two spawning groups of herring which overwinter in southwest Newfoundland fjords gradually increased during the 6-year-period from 1965-66 to 1970-71. The southwest Newfoundland purse seine fishery has, since its inception, been based largely on two dominant year-classes of herring, the 1958 year-class of autumn spawners and the 1959 year-class of spring spawners. The scarcity of immature herring suggests that juveniles do not migrate with the adults, and the general scarcity of adult herring in the younger age groups indicates that recruitment has been very poor since the appearance of the 1958 and 1959 year-classes.

It has been traditional for most herring fisheries to fluctuate greatly according to great variations in year-class strength, with the consequence that stock recruitment relationships are unpredictable. This is especially true for the southern Gulf of St. Lawrence - southwest Newfoundland spring- and autumn-spawning stocks, which, despite the great abundance of sexually mature adults of the 1958 and 1959 year-classes from about 1962 or 1963 until recently, has exhibited relatively poor recruitment to the exploited stocks in recent years. There is no evidence to show that the series of poor year-classes has been caused by consistently unfavourable environmental conditions. The extremely high yields from these stocks in recent years may be somewhat anomalous for the fishery has been based almost entirely on two very large year-classes of herring which are now passing out of the fishery leading to a dramatic decline in landings to less than 40,000 tons in 1971-72 and an even further decrease in 1972-73. There has been no significant recruitment of young fish to replace these dominant year-classes. It is likely that the fishery along southwest Newfoundland in the future will be very sporadic.

In the past the Gulf of St. Lawrence herring stocks have periodically been stricken by epidemics of fungus disease (*Ichthyosporidium hoferi*), particularly during periods when the demand for herring was low and the fishery practically nonexistent. The most recent period of widespread natural mortality occurred during an epidemic of fungus disease in 1953-57 (Leim, 1955; Sindermann, 1958). It has been estimated that at least half of the mature herring in the western Gulf of St. Lawrence were destroyed by this disease, with the spring-spawning stocks reduced to a greater extent than the autumn-spawning stocks (Tibbo and Graham, 1963). The resulting reduction in predation and in competition for food undoubtedly provided conditions favourable to the production of good year-classes during the late 1950's. It is our opinion that the abundant 1958 and 1959

year-classes thus experienced favourable conditions for survival, and that their consequent great abundance both as juveniles during 1959-62 and subsequently as adults inhibited opportunities for the good survival of young for several years.

The difference in percentage fat content between spring and autumn spawners in the late autumn when they migrate to southwest Newfoundland, *i.e.* 15% and 12% respectively, is undoubtedly due to the fact that the accumulation of fat in body tissues of autumn spawners is interrupted in the middle of the main feeding and growing period (September, when spawning occurs). A consequence of this is that during the winter non-feeding period, when fat is utilized by the fish as a source of energy, autumn spawners have an average fat content ocnsistently lower than that of spring spawners by a factor of about one-third. The seasonal trend in fat content between December and April is in general agreement with observations on herring taken in western and southern Newfoundland waters during 1945-50, for which data the maximum values were recorded in November and December and the lowest values in April and May (Liem, 1957). Also the apparent decrease in mean weight-at-length between December and April (Table 4) is probably associated with the rapid decline in fat content during the same period.

The evidence of an increasing trend in fat content between 1966 and 1971 may be indicative of the operation of a density-dependent factor, *e.g.* food supply during the feeding season in the southern Gulf of St. Lawrence. Information obtained from acoustic surveys, tagging experiments, trends in catch per unit effort and quantitative estimates of stock sizes (Winters and Hodder, MS, 1973) indicates that the herring stocks in 1971 were less than one-fifth the size of the stocks present in 1966. A consequence of this would be more favourable feeding conditions in the most recent years due to reduced competition for food.

References

Hodder, V.M. 1969. Herring landings and distribution of catches in Newfoundland, 1967-68. Fish. Can 22(4): 3-6.

1970. Recent developments in the Newfoundland herring fishery. Fish. Res. Bd. Canada, St. John's Biol. Stat. Circ. 18: 1-19.

1971. Status of the southwest Newfoundland herring stocks, 1965-70. Int. Comm. Northw. Atlant. Fish. Redbook 1971, Part III: 105-114.

Hodder, V.M. and L.S. Parsons. 1971a. Comparison of certain biological characteristics of herring from Magdalen Islands and southwestern Newfoundland. Int. Comm. Northw. Atlant. Fish. Res. Bull. 8: 59-65.

1971b. Some biological features of southwest Newfoundland and northern Scotian Shelf herring stocks. Int. Comm. Northw. Atlant. Fish. Res. Bull. 8: 67-73.

Hodder, V.M., L.S. Parsons, C.I. Barbour and R. Chaulk. 1972. Length, age and weight of herring in the southwest Newfoundland winter fishery from 1965-66 to 1970-71. Fish. Res. Bd. Canada, Tech. Rept. 339, 113 p.

Hodder, V.M., L.S. Parsons, G.H. Winters and K. Spencer. 1973. Fat and water content of herring in Newfoundland and adjacent waters, 1966-71. Fish. Res. Bd. Canada, Tech. Rept. 365, 49 p.

ICNAF. 1964. Report of Standing Committee on Research and Statistics. App. 1. Report of *ad hoc* group on herring and other pelagic fish. Int. Comm. Northw. Atlant. Fish. Redbook 1964, Part I: 23-30.

Leim, A.H. 1955. Herring mortalities in the Bay of Chaleur in 1955. Fish. Res. Bd. Canada, Prog. Rept. Atlantic Coast Stat. 62: 32.

Parsons, L.S. 1972. Use of meristic characters and a discriminant function for classifying spring- and autumn-spawning Atlantic herring. Int. Comm. Northw. Atlant. Fish. Res. Bull. 9: 5-9.

1973. Meristic characteristics of Atlantic herring (*Clupea harengus harengus* L.) stocks in Newfoundland and adjacent waters. Int. Comm. Northw. Atlant. Fish. Res. Bull. 10 (in press).

Parsons, L.S. and V.M. Hodder. 1971. Meristic differences between spring- and autumn-spawning Atlantic herring (*Clupea harengus harengus* L.) from southwestern Newfoundland. J. Fish. Res. Bd. Canada 28: 553-558.

Sindermann, C.J. 1958. An epizootic in Gulf of St. Lawrence fishes. Trans. 23rd N. Am. Wildl. Conf. 1958, Part II: 349-360.

Tibbo, S.N. 1956. Populations of herring (*Clupea harengus* L.) in Newfoundland waters. J. Fish. Res. Bd. Canada 13(4): 449-466.

1957. Herring populations on the south and west coast of Newfoundland. Fish. Res. Bd. Canada Bull. 111: 153-164.

Tibbo, S.N. and T.R. Graham. 1963. Biological changes in herring stocks following an epizootic. J. Fish. Res. Bd. Canada 20: 435-449.

Watson, J.E. 1965. A technique for mounting and storing herring otoliths. Trans. Amer. Fish. Soc. 95(3): 267-268.

Winters, G.H. 1970. Preliminary results of herring tagging in southwest Newfoundland coastal waters. Fish. Res. Bd. Canada, St. John's Biol. Stat. Circ. 18:20-24.

MS, 1971a. Migrations of the southwest Newfoundland stock of herring as indicated by tag recaptures. Annu. Meet. Int. Comm. Northw. Atlant. Fish. 1971, Res.Doc. 108, Serial No. 2591, 6 p.

MS, 1971b. Population estimates of the southwestern Newfoundland stock of herring from tag recaptures. Annu. Meet. Int. Comm. Northw. Atlant. Fish. 1971, Res.Doc. 109, Serial No. 2592, 7 p.

Winters, G.H. and L.S. Parsons. MS, 1972. Present status of the southwest Newfoundland herring stocks. Annu. Meet. Int. Comm. Northw. Atlant. Fish. 1972, Res.Doc. 88, Serial No. 2791, 7 p.

Winters, G.H. and V.M. Hodder. MS, 1973. Assessment of the southern Gulf of St. Lawrence herring stocks and implications concerning the management of the resource. (In preparation)

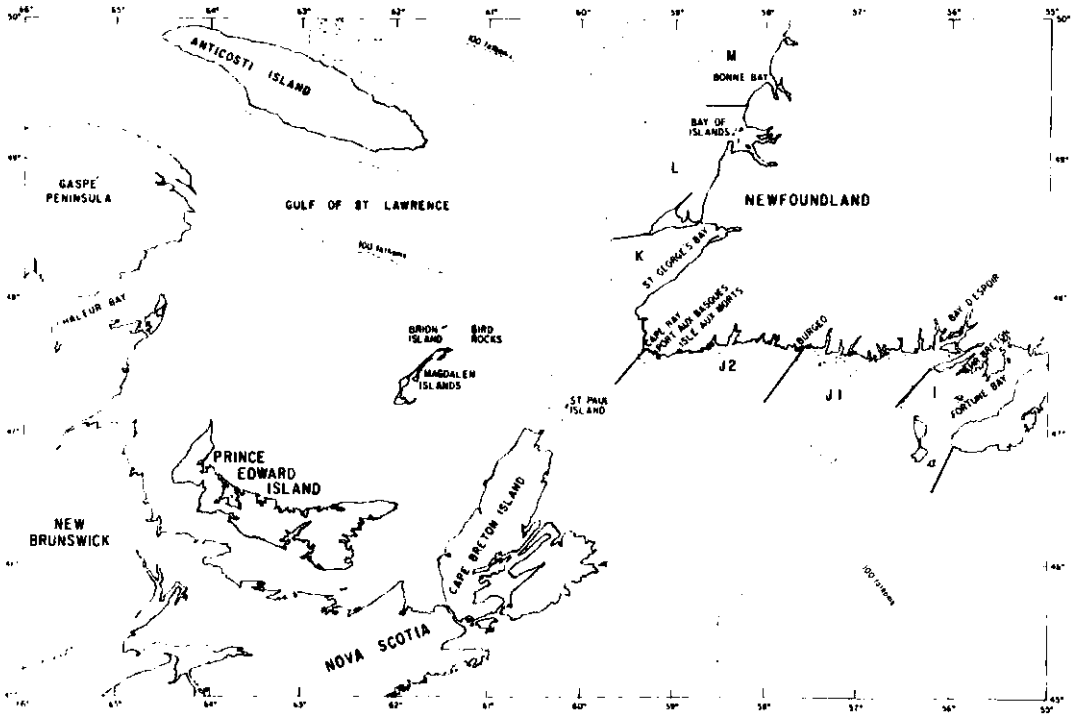


Fig. 1. Map of Gulf of St. Lawrence and Newfoundland showing the location of place names and statistical areas mentioned in the text.

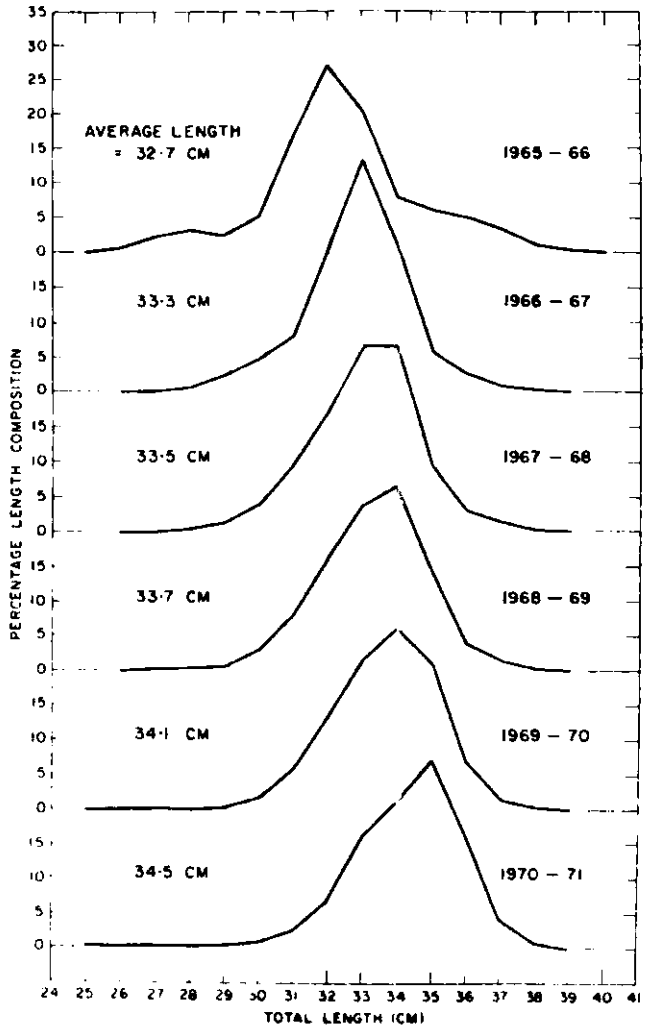
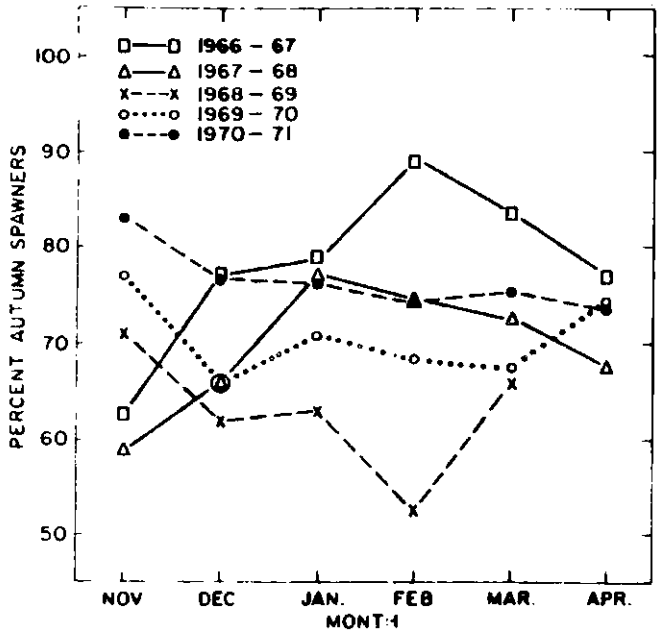


Fig. 2. Length composition of herring from seiner catches in southwest Newfoundland coastal waters during the 1965-66 to 1970-71 seasons



B 9

Fig. 3. Percentage of autumn spawners by month along southwest Newfoundland during the 1966-67 to 1970-71 seasons.

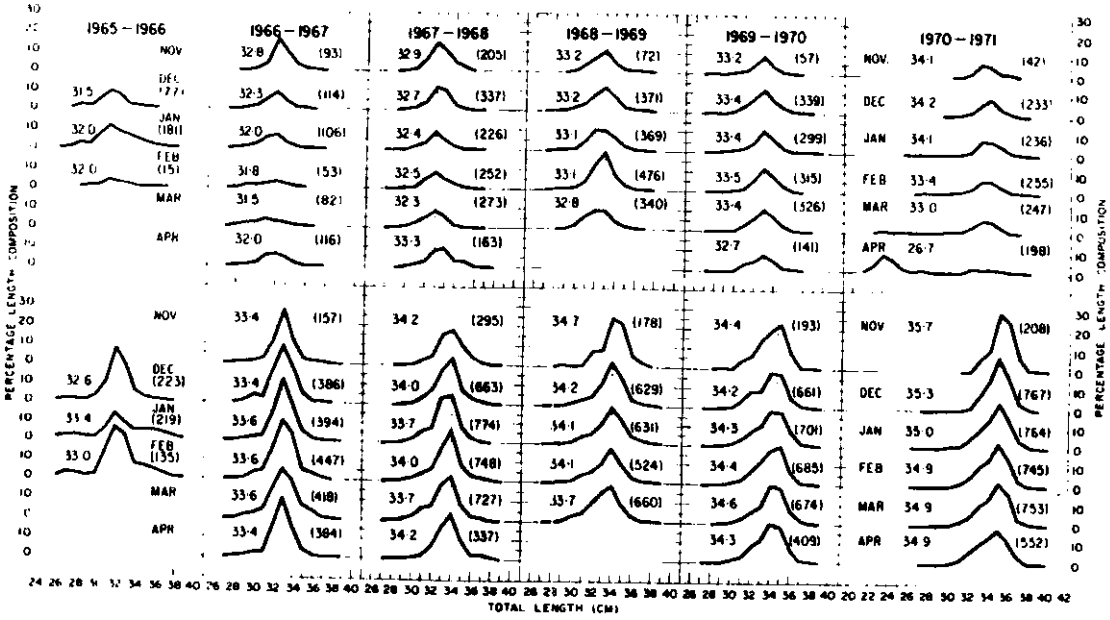


Fig. 4. Length composition and average length (cm) of southwest Newfoundland herring by month for spring spawners (upper) and autumn spawners (lower) during the 1965-66 to 1970-71 seasons.

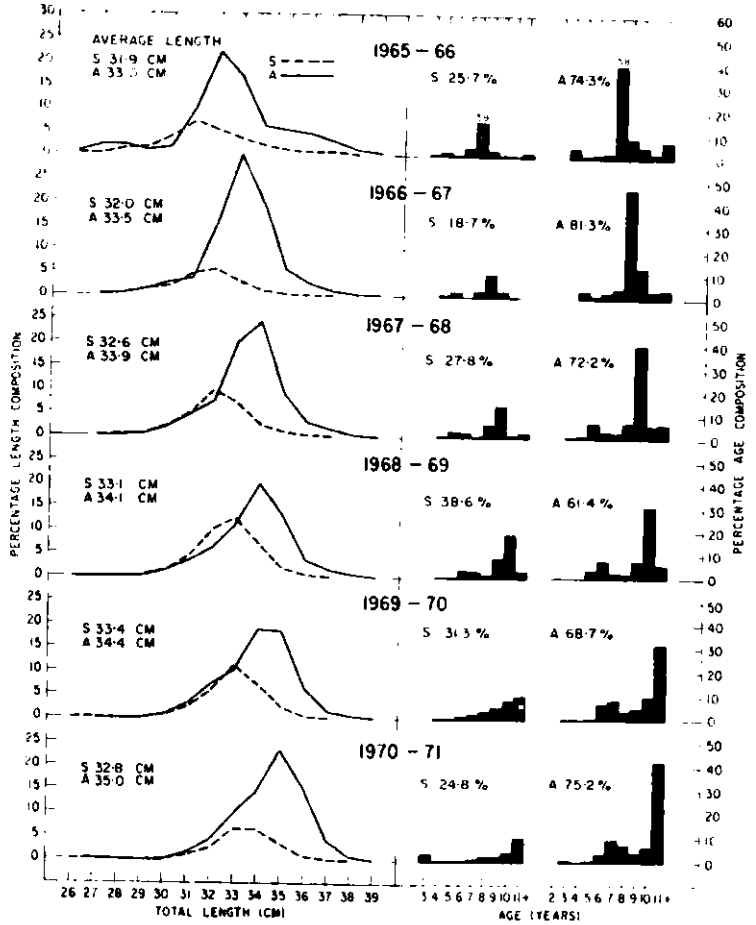


Fig. 5. Length and age composition of spring (S) and autumn (A) spawners in the southwest Newfoundland herring fishery during the 1965-66 to 1970-71 seasons.

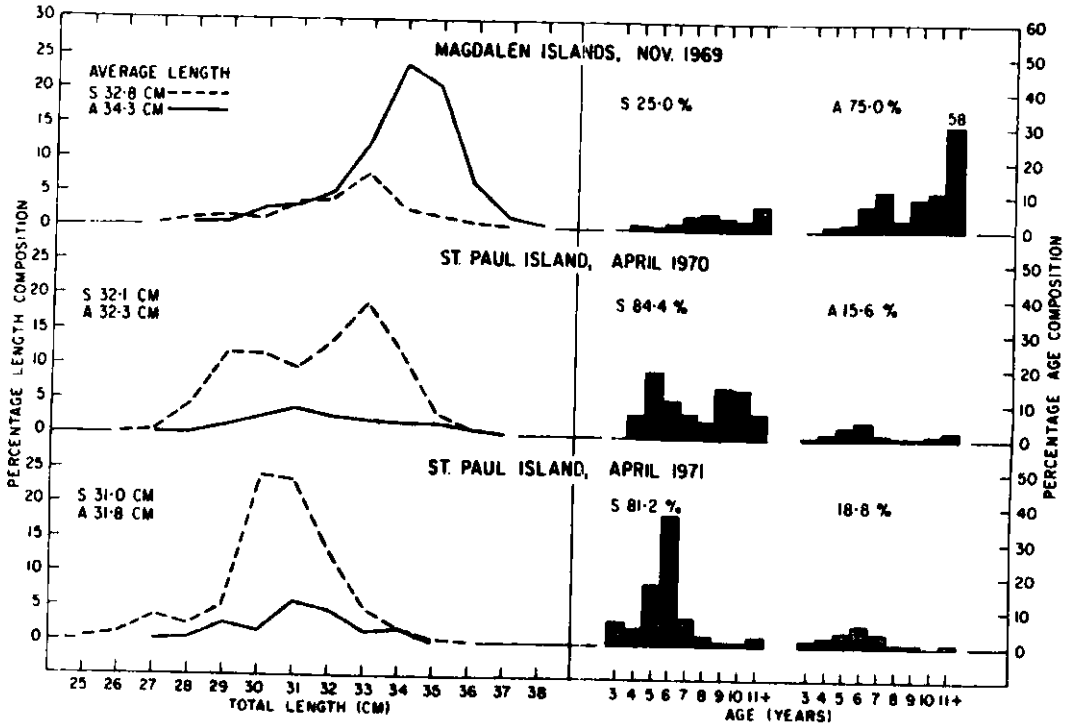


Fig. 6. Length and age composition of spring (S) and autumn (A) spawners from Magdalen Islands in November 1969 and St. Paul Island in April 1970 and 1971.

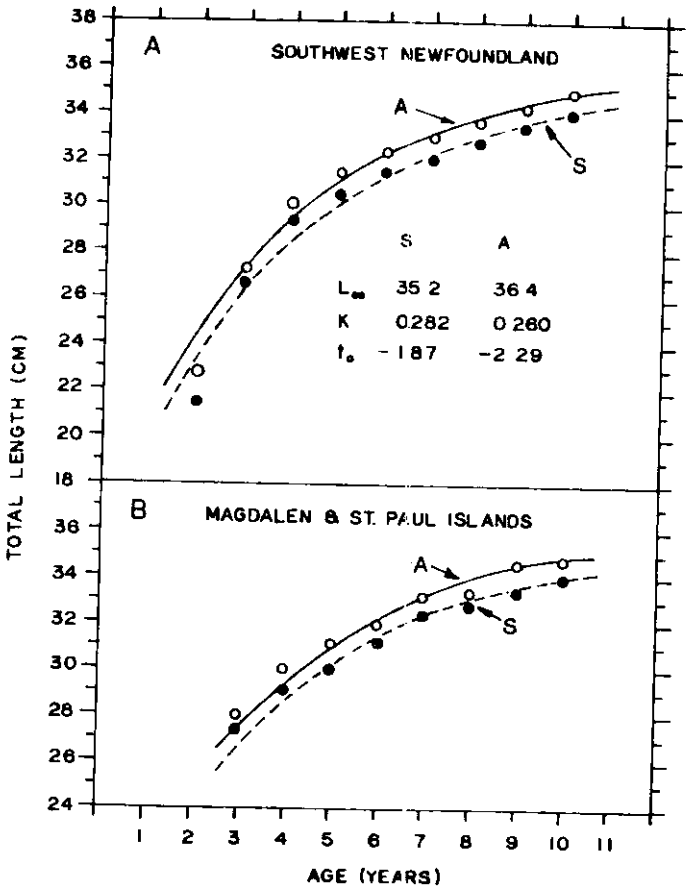


Fig. 7. A. Bertalanffy growth curves fitted to age-at-length data for southwest Newfoundland herring. B. Age-at-length data for herring from Magdalen and St. Paul Islands with the growth curves for southwest Newfoundland herring superimposed.

B 11

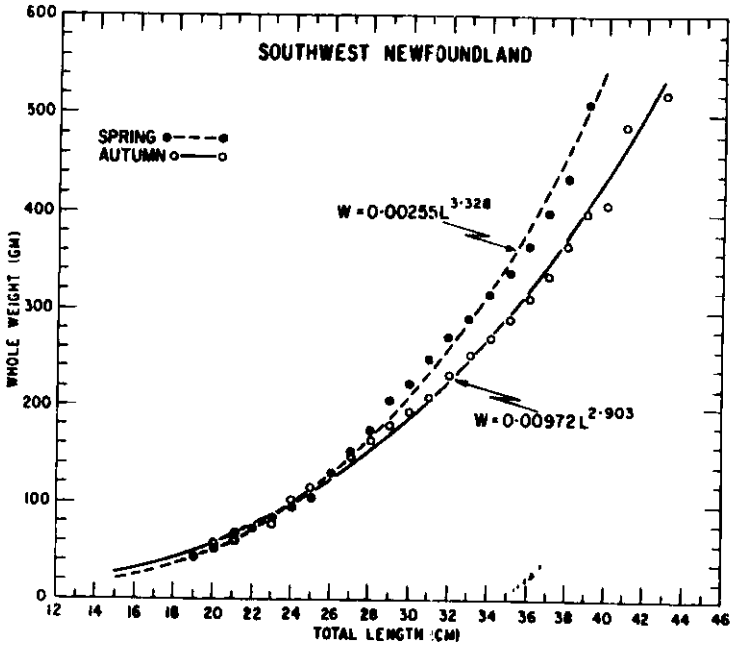


Fig. 8. Length-weight relationships for southwest Newfoundland herring based on data for the 1966-67 to 1970-71 seasons.

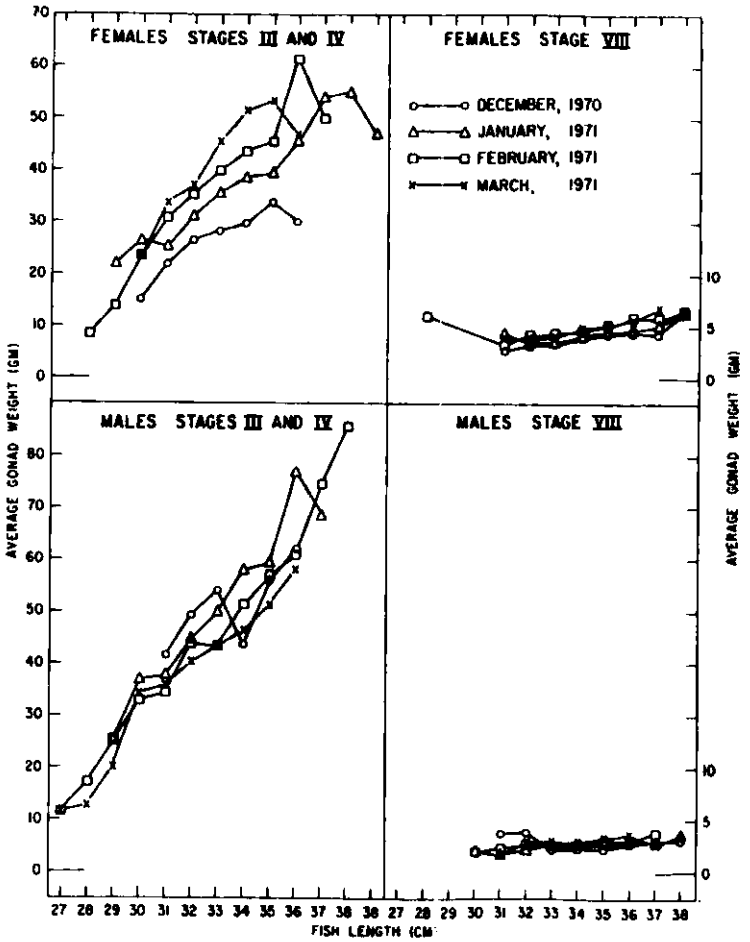


Fig. 9. Average gonad weight (gm) against fish length (cm) by sex and maturity stage from December 1970 to March 1971.

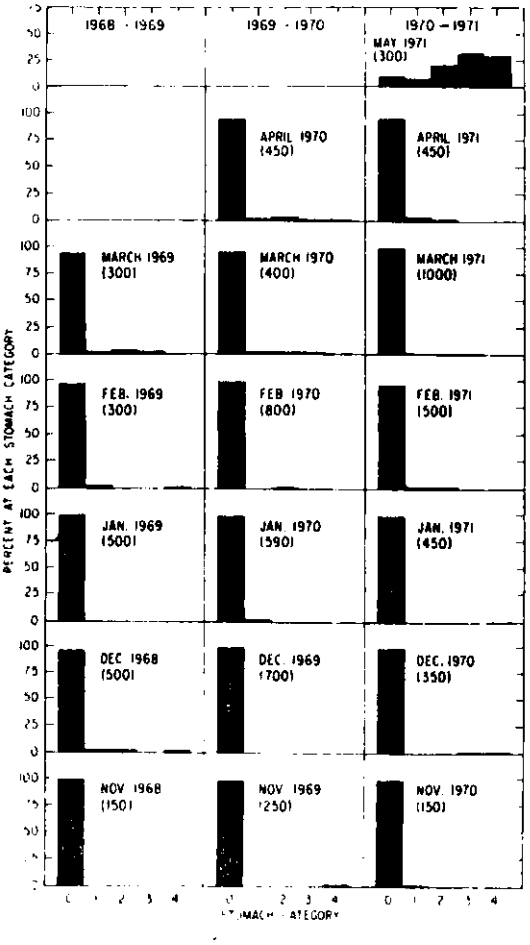


Fig. 10. Feeding intensity of southwest Newfoundland herring by month during the 1968-69 to 1970-71 seasons.

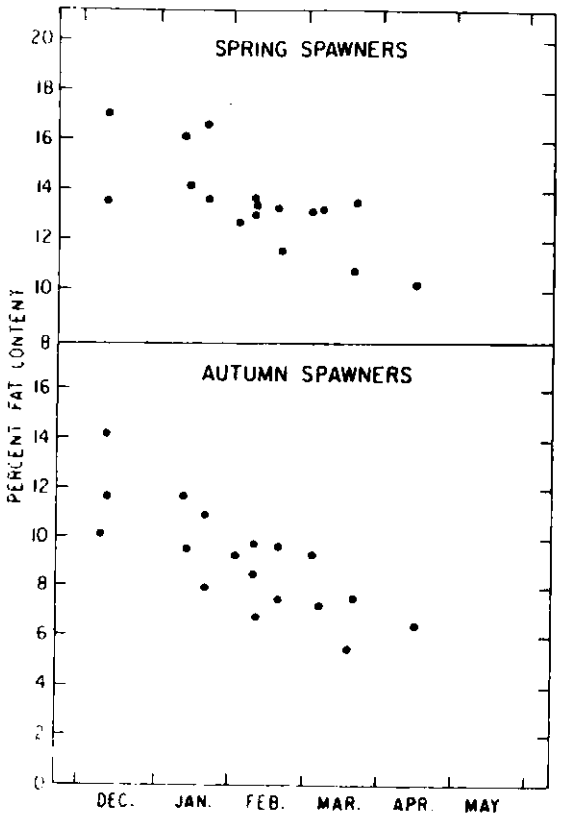


Fig. 11. Seasonal variation in fat content for spring and autumn spawners from southwest Newfoundland.

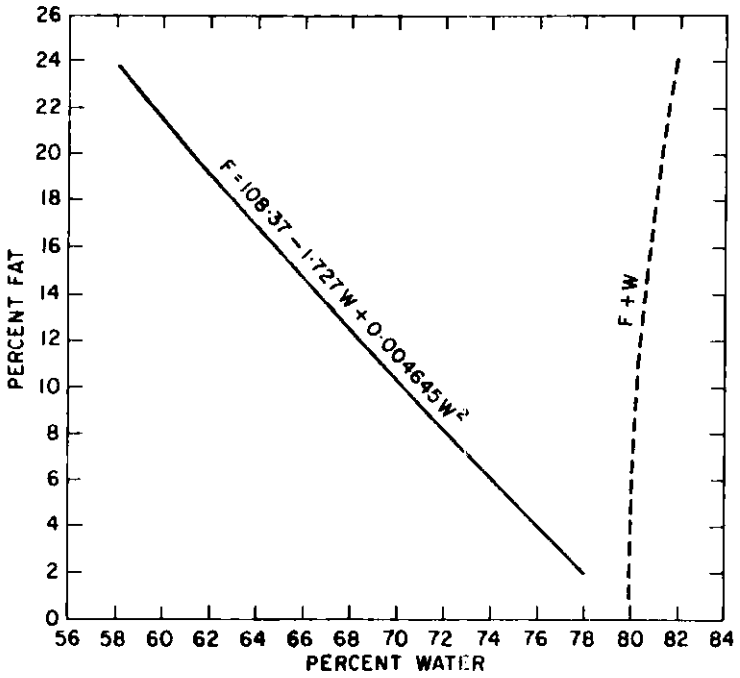


Fig. 12. The fat-water relationship in southwest Newfoundland herring.

Table 1. Numbers of herring specimens sampled (A) for age and growth studies and (B) for fat and moisture analyses, from southwest Newfoundland and the southern Gulf of St. Lawrence during the 1965-66 to 1970-71 seasons.

	Area	Month	1965-66	1966-67	1967-68	1968-69	1969-70	1970-71
A.	Southwest Newfoundland	Nov	-	250	500	250	250	250
		Dec	300	500	1000	1000	1000	1000
		Jan	400	500	1000	1000	1000	1000
		Feb	150	500	1000	1000	1000	1000
		Mar	-	500	1000	1000	1000	1000
		Apr	-	500	500	-	550	450
		May	-	-	-	-	-	300
	South Gulf of St. Lawrence	Nov	-	-	-	-	500	-
		Apr	-	-	-	-	500	250
B.	Southwest Newfoundland	Dec	-	10	-	-	-	48
		Jan	32	-	-	40	-	60
		Feb	30	-	-	60	72	60
		Mar	-	-	-	42	60	72
		Apr	-	-	-	-	40	-

Table 2. Mean length at age by spawning type and season for southwest Newfoundland herring.

Type	Age	Average length (cm)						Unweighted mean (cm)
		1965-66	1966-67	1967-68	1968-69	1969-70	1970-71	
Spring	2	-	-	-	-	21.5	-	21.5
	3	25.7	27.5	28.2	26.8	27.3	24.6	26.7
	4	28.8	29.4	29.8	29.3	29.2	29.7	29.4
	5	30.1	29.9	30.8	30.3	30.6	31.3	30.5
	6	31.5	31.4	31.2	31.4	31.6	32.0	31.5
	7	31.8	31.8	32.2	32.0	32.2	32.7	32.1
	8	33.2	32.3	32.5	32.6	32.7	33.3	32.8
	9	34.3	33.3	33.0	32.8	33.2	33.6	33.4
	10	34.8	34.5	34.1	33.5	33.7	34.0	34.1
	11+	36.1	35.7	35.1	35.2	34.5	34.9	35.2
Autumn	2	-	-	-	21.5	23.2	23.8	22.8
	3	27.6	25.7	28.2	27.1	27.1	27.4	27.2
	4	29.8	30.2	30.0	29.6	29.8	30.9	30.1
	5	31.5	31.3	31.6	31.1	31.3	32.0	31.5
	6	32.1	32.1	32.5	32.5	32.2	32.9	32.4
	7	32.6	32.7	33.0	33.1	33.1	33.6	33.0
	8	33.5	33.4	33.5	33.6	33.8	34.3	33.7
	9	35.1	34.2	34.1	33.9	34.1	34.6	34.3
	10	35.8	35.3	35.0	34.8	34.5	35.0	35.0
	11+	37.0	36.8	36.4	36.5	35.5	36.0	36.4

Table 3. Mean length at age by spawning type for herring samples from Magdalen Islands and St. Paul Island.

Type	Age	Average length (cm)			Unweighted mean (cm)
		Nov 1969	Apr 1970	Apr 1971	
Spring	3	-	-	27.4	27.4
	4	28.9	28.8	29.5	29.1
	5	29.4	30.0	30.7	30.0
	6	31.1	31.2	31.3	31.2
	7	32.2	32.4	32.6	32.4
	8	32.9	32.9	32.4	32.7
	9	33.1	33.4	33.6	33.4
	10	33.7	33.8	34.4	34.0
	11+	34.4	34.9	33.9	34.4
Autumn	3	-	26.8	29.3	28.0
	4	29.7	30.2	30.3	30.1
	5	31.1	30.9	31.4	31.1
	6	32.1	31.9	32.0	32.0
	7	33.4	32.9	33.2	33.2
	8	33.9	33.0	32.8	33.3
	9	34.3	34.7	34.8	34.6
	10	34.7	34.7	-	34.7
	11+	35.5	35.5	34.7	35.2

Table 4. Length-weight relationships for southwest Newfoundland herring by spawning type and month for the 1966-67 to 1970-71 seasons combined.

Total length (cm)	Average weight (grams)													
	Spring Type							Autumn Type						
	Nov	Dec	Jan	Feb	Mar	Apr	Average	Nov	Dec	Jan	Feb	Mar	Apr	Average
19	-	-	-	-	-	43	43	-	-	-	-	-	-	-
20	-	-	-	-	-	56	56	-	-	59	-	-	-	59
21	-	-	-	-	-	68	68	-	-	62	-	-	-	62
22	-	-	-	-	71	75	73	-	-	66	77	-	-	71
23	-	-	-	-	84	84	84	-	-	77	79	72	86	79
24	-	-	95	-	97	94	95	-	118	-	100	89	100	102
25	-	-	-	-	-	106	106	-	-	136	98	107	114	114
26	-	-	150	132	109	133	131	-	127	137	138	124	-	132
27	-	157	151	151	149	150	152	-	150	155	152	152	134	149
28	178	174	182	163	169	175	174	172	180	167	160	159	160	166
29	222	215	205	196	195	204	206	183	186	182	175	178	169	179
30	235	234	224	216	219	214	224	197	199	195	191	190	192	194
31	258	258	249	245	242	241	249	214	218	212	209	210	216	213
32	280	283	275	270	267	262	273	233	238	231	229	232	234	233
33	301	301	295	290	287	281	292	253	257	252	249	249	251	252
34	323	327	318	312	308	306	316	274	275	270	268	269	269	271
35	352	347	334	335	327	325	337	298	295	290	286	288	290	291
36	384	362	375	364	357	360	367	317	315	312	310	307	316	313
37	399	390	416	398	390	406	400	334	335	343	335	331	337	336
38	-	-	440	440	429	-	436	365	371	374	370	349	371	367
39	532	-	493	-	-	-	512	404	403	429	389	378	401	400
40	-	-	-	-	-	-	-	-	383	-	390	422	424	405
41	-	-	-	-	-	-	-	-	-	506	472	486	-	488
43	-	-	-	-	-	-	-	520	-	-	-	-	-	520

Table 5. Average fat content by month and year for spring- and autumn-type herring taken in southwest Newfoundland waters, 1966-71.

Month	Year	Spring			Autumn			Difference in fat content
		No. of fish	Percent fat	Range	No. of fish	Percent fat	Range	
Dec	1966	-	-	-	10	10.08	(5.3-14.3)	-
	1970	20	15.56	(6.3-21.1)	27	12.80	(8.2-17.2)	2.76
Jan	1966	14	13.85	(11.6-16.2)	12	8.18	(3.9-12.0)	5.67
	1969	11	14.08	(11.8-16.8)	29	9.67	(4.9-14.6)	4.41
	1971	23	16.33	(12.5-22.8)	37	11.34	(5.7-17.0)	4.99
Feb	1966	12	13.67	(9.9-16.5)	13	9.81	(6.3-12.3)	3.86
	1969	36	12.57	(4.9-16.7)	24	6.98	(1.3-12.6)	5.59
	1970	36	13.52	(9.0-18.1)	36	8.55	(2.5-12.8)	4.97
	1971	16	13.35	(7.2-17.1)	39	9.52	(5.1-17.3)	3.83
Mar	1969	20	10.77	(8.1-16.6)	22	5.52	(2.1-11.9)	5.25
	1970	30	13.37	(9.0-18.8)	21	7.24	(2.0-11.2)	6.13
	1971	25	13.47	(7.5-18.5)	43	8.50	(2.5-14.5)	4.97
Apr	1970	11	10.36	(6.3-15.8)	17	6.43	(3.3-11.2)	3.93

Table 6. Comparison of average fat, water and total fat plus water content by 5% fat content intervals for southwest Newfoundland herring.

Range of fat (%)	Number of fish	Percentage		
0.0-4.9	48	3.70	76.00	79.70
5.0-9.9	220	7.88	72.24	80.12
10.0-14.9	266	12.30	68.13	80.43
15.0-19.9	88	16.56	64.34	80.90
20.0-24.9	4	21.07	60.43	81.50