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# Life History Characteristics of Alewives and Blueback Herring from Five Nova Scotia Rivers, 1985

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# LIFE HISTORY CHARACTERISTICS OF ALEWIVES AND BLUEBACK HERRING FROM FIVE NOVA SCOTIA RIVERS, 1985

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Life history characteristics, run composition and stock status of commercially exploited alewives (Alosa pseudoharengus) and blueback herring (A. aestivalis) are examined from the 1985 spawning runs to the Tusket, Medway, Ship Harbour, Little West and Salmon rivers. Alewives dominated catches on all five rivers; blueback herring occurred in the Tusket, Ship Harbour and Salmon rivers but were absent from the Medway River. The earliest runs of both species occurred on the Tusket River. Male and female alewives and blueback herring from the Tusket River had the greatest weight at a common length. Alewives of both sexes progressively decreased in length, age and length at age throughout the spawning runs on all five rivers. Within rivers, male alewives outnumbered females but not sufficiently to be statistically significant. Blueback herring males outnumbered females on the Salmon River and females outnumbered males on the Tusket River. Ovary weights of female alewives increased allometrically with length at similar rates among rivers. Recruitment to the spawning stock was complete at ages 5 to 6 for alewife and age 5 for blueback herring. Age 4 fish dominated the composition of virgin spawners in all rivers. Previous spawners composed 41% to 56% of alewife and 66% to 71% of blueback herring stock abundance. Fishing pressure is likely moderate for alewives and low for blueback herring on all five rivers.

## RÉSUMÉ

Stone, H.H., B.M. Jessop, and H.A. Parker. 1992. Life history characteristics of alewives and blueback herring from five Nova Scotia rivers, 1985. Canadian MS Rep. Fish. Aquat. Sci. No. 2136: 34 p.

On a étudié les caractéristiques du cycle vital et la composition des montaisons de gaspareau (Alosa pseudoharengus) et d'alose d'été (A. aestivalis) ainsi que l'état des stocks de ces espèces qui font l'objet d'une exploitation commerciale, en se fondant sur les montaisons de 1985 dans les rivières Tusket, Medway, Ship Harbour, Little West et Salmon. Les gaspareaux dominaient dans les prises capturées dans ces cinq rivières. Il y avait de l'alose d'été dans les prises des rivières Tusket, Ship Harbour et Salmon, mais non dans celles de la rivière Medway. C'est dans la rivière Tusket que se sont produites les premières montaisons des deux espèces. C'est aussi dans cette rivière que le gaspareau et l'alose d'été, mâles et femelles, atteignaient le poids le plus fort à une longueur courante. La longueur, l'âge et la longueur selon l'âge du gaspareau des deux sexes décroissaient progressivement dans les montaisons, et cela dans les cinq rivières considérées. Dans la totalité de ces rivières, les gaspareaux mâles était plus nombreux que les femelles, mais dans une proportion négligeable d'un point de vue statistique. En ce qui concerne l'alose d'été, les mâles étaient plus nombreux que les femelles dans la rivière Salmon et les femelles plus abondantes que les mâles dans la rivière Tusket. On a constaté une croissance allométrique du poids des ovaires des gaspareaux femelles par rapport à la longueur de ces derniers, cela dans des proportions similaires dans toutes les rivières considérées. Le recrutement dans le stock de reproducteurs était terminé à l'âge de 5 ou 6 ans pour le gaspareau et de 5 ans pour l'alose d'été. Les poissons de 4 ans dominaient le lot de reproducteurs vierges dans toutes les rivières, tandis que les géniteurs à ponte antérieure représentaient respectivement de 41 % à 56 % et de 66 % à 71 % de l'abondance des stocks de gaspareau et d'alose d'été. Dans les cinq rivières en question, la pression de pêche exercée est vraisemblablement modérée en ce qui concerne le gaspareau et faible pour ce qui est de l'alose d'été.

## INTRODUCTION

Alewives (Alosa pseudoharengus) and blueback herring (A. aestivalis) are closely related anadromous clupeids native to the Atlantic coast of North America, including Nova Scotia. Collectively referred to as "gaspereau" in the Maritime Provinces, they have been fished commercially during their upstream spawning migrations for well over a century (Perley 1852; Knight 1867). Commercial landings of both species are usually reported as alewife because of similarities in appearance, time of spawning and methods of capture.

The onset of the spring spawning migration from the sea is related to water temperature and can vary annually by two to three weeks in a given location. In rivers tributary to the Bay of Fundy, alewife spawning runs begin in late April, extend for up to six weeks and generally precede the blueback herring run by two to three weeks (Leim and Scott 1966). On the Saint John River, New Brunswick, blueback herring spawning migrations commence in late May-early June and extend for about four weeks (Jessop 1990). Alewife spawning generally begins at water temperatures between 5°C and 10°C with blueback herring spawning between 10°C and 15°C (Loesch 1987), although there is considerable overlap in the spawning seasons of the two species. Both species typically home to their natal rivers to spawn (Messieh 1977; Jessop 1990) and return to sea shortly after spawning.

In rivers where alewives and blueback herring are sympatric, the spawning habitat of each species tends to be spatially isolated. Alewives generally spawn in slow-flowing sections of streams or enter ponds and lakes while blueback herring prefer relatively swift flows (Leim and Scott 1966; Loesch 1987). Alewives are the dominant species in many of the moderately small Maritime rivers because they spawn in headwater ponds and lakes.

Commercially exploited populations of alewives and blueback herring have been studied by the Department of Fisheries and Oceans (DFO) for stocks which support major fisheries, i.e., the Miramichi (Chaput and LeBlanc 1988a), Margaree (Chaput and LeBlanc 1988b), Gaspereau (Jessop and Parker 1988) and Saint John (Jessop 1986; 1990) rivers. Many rivers along the Atlantic coast of Nova Scotia support small, locally important fisheries for gaspereau for which relatively little biological information is available. This report presents the results of a 1985 study to determine the run composition, life history characteristics and status of commercially exploited stocks of gaspereau from the Tusket, Medway, Ship Harbour, Little West, and Salmon (Guysborough Co.) rivers.

**STUDY AREA**

The five rivers selected are widely separated along the Atlantic coast of Nova Scotia (Fig. 1). The Tusket River, in southwestern Nova Scotia, is a relatively large system with a stream length (i.e., longest continuous length of river) of 99.4 km, a total drainage area of 1460 $km^2$, and many lakes, not all of which are accessible to fish. Vaughan and Carleton lakes are large lakes near the river mouth and are believed to be productive spawning and nursery areas. The Medway River, also in southwestern Nova Scotia, is similar in size to the Tusket (stream length = 92.7 km, total drainage area = 1507 $km^2$) and has many lakes, the two largest being Molega and Ponhook. The Ship Harbour, Little West, and Salmon rivers, all located along the eastern shore, are much smaller systems than the Tusket and the Medway (stream lengths = 56.9, 22.9 and 42.5 km; total drainage areas = 357, 60 and 296 $km^2$, respectively) and contain fewer and smaller lakes to be used as spawning and nursery areas. It is assumed that the physical characteristics of the home river may influence some of the life history attributes of each population.

**COMMERCIAL FISHERIES**

Within each river, a variety of gear is used to harvest alewives and blueback herring during their spring spawning migrations. Dip-netting from platforms or anchored boats occurs in the lower reaches of the Tusket and Medway rivers, while gillnets are used in the estuaries. Various types of wooden traps with wings extending into the river channel are used on the Ship Harbour, Little West and Salmon rivers. Fish are dipped out of the trap with large, hand-held nets.

Gaspereau landings are reported by Fisheries Statistical District (FSD) rather than by river system. For the five rivers studied, annual catches (1976 to 1985; Table 1) by FSD are representative because most of the catch occurs in those rivers. Landings prior to 1982, when a license for dip-netting was first required, are likely much higher than indicated. Between 1976 and 1985, the annual gaspereau harvest in FSD 33 (mainly Tusket River) averaged 227 t/year (range: 25-549 t). Catches were highest in the late 1970's but declined thereafter and remained low during the 1980's. The commercial fishery on the Tusket River involved up to 100 licenced dip-net fishermen and 40 to 50 gill-net fishermen. On the Medway River, the gaspereau fishery supported 20 to 30 licensed dip-net and 20 gill-net fishermen in 1985, with the commercial harvest for FSD 28 averaging 217 t/year from 1976 to 1985 (range: 63-421 t). Catches peaked in 1978, then declined until 1984 when they again increased. In 1985, three licensed dip-net fishermen were on the Ship Harbour River (FSD 20), one on the Little West River (FSD 19) and five on the Salmon River (FSD 14). No licenced gill-net fishermen were present on any of these rivers. Landings from 1976 to 1985 averaged 164 t/year for FSD 20 (range: 103-365 t), 44 t/year for FSD 19 (range: 8-113 t) and < 1 t/year for FSD 14. Catches in FSD 20 (Ship Harbour) and FSD 19 (Little West River) have also declined since the late 1970's and recently have remained relatively constant. Landings from FSD 14 (Salmon River) are frequently less than 1 t/year and therefore often unreported. Gaspereau from the Tusket and Little West rivers are used primarily for lobster bait, while those from the Medway, Ship Harbour, and Salmon rivers are destined for human consumption.

# METHODS

## DATA COLLECTION

At the start of the spawning migration in May, samples of 100 fish per river were obtained weekly from licensed commercial fishermen. Samples were dip-netted either from a box trap or directly from the river. Capture methods were not considered to be selective for size, sex or age and were presumed to be representative of the true composition of the migratory stock. River surface water temperature (°C) at the time of fish capture was taken with a hand-held thermometer. Unusually high water levels in June and the closure of the commercial fishery on June 15 prevented sample collection during the mid to late portion of the runs on the Medway, Ship Harbour, Little West and Salmon rivers. After the commercial season ended, sampling was completed for the entire run on the Tusket River with an additional six samples obtained from two fishways.

All specimens were transferred in insulated containers to a laboratory in Halifax for refrigeration and processing within 24 hours of collection. Total length (mm), weight (g), sex (by inspection of gonads), stage of maturity (after Nikolsky (1963)) and species (distinguished by colour of the peritoneal lining (Leim and Scott 1966)) were recorded for each fish. Ovaries were removed and weighed to the nearest 0.01 g. Scales (6-10) obtained from the mid body between the dorsal fin posterior insertion and the lateral line were aged by counting the number of annuli and spawning marks and adding a year for the scale edge in accordance with methods described by Cating (1953) and Marcy (1969). Each scale sample was aged independently by two people, and, when readings differed, a third reading was made and an age assigned on the basis of majority agreement.

## DATA ANALYSIS

Weight-length (variables $\log_{10}$ transformed) relationships for separate sexes of both species were compared within and between rivers by analysis of covariance (ANCOVA) (Cone 1989;

Trippel and Hubert 1990). ANCOVA was also used to examine fork length-sample date and age-sample date relations for male and female alewives (within and between rivers), fork length-sample date regressions (between rivers) for combined sexes of age five alewives (the most abundant year-class), and ovary weight-fork length regressions (variables $\log_{10}$ transformed) between rivers for female alewives. For the latter comparison, female alewives collected during the first three to four weeks of the run were used because a continuous time series of weekly samples was available from each river. Most analyses made for alewives could not be made for blueback herring due to small sample sizes and short time series.

Linear contrasts with a Bonferroni significance level ($\alpha$ = 0.05, divided by the number of dependent comparisons; Day and Quinn 1989) were used to test pairwise differences in the multiple comparisons of adjusted means. The adjusted $r^2$ (coefficient of determination) was used to assesss and compare the goodness of fit of each regression. Tests of normality of distribution and homogeneity of variance ($F_{max}$) were made to evaluate compliance with assumptions underlying regression and ANCOVA (Sokal and Rohlf 1981). The consequences of slight heterogeneity were not considered too serious for the overall test of significance. Partial probability plots of each variable and residual plots helped to evaluate each regression.

Sex ratios were tested by chi-square with 1:1 as the expected ratio. Differences between sexes in the percentage of virgin spawners were tested within rivers with the proportions test (Snedecor and Cochran 1989), while a paired t-test determined differences between sexes in the mean length, weight, age and age at first spawning.

## RESULTS

### RUN COMPOSITION AND TIMING

Sampling of commercial catches between May 2 and July 8, 1985, yielded 2,453 alewives (range = 225 to 364 mm FL; mean = 268.6±0.34 mm FL) and 301 blueback herring (range = 182 to 309 mm FL; mean = 247.5±1.28 mm FL). Temporal coverage of spawning runs was most extensive for the Tusket River (May 2-July 8, 11 samples), followed by the Medway (May 21-June 17, 6 samples), Ship Harbour (May 14-June 3, 4 samples), Salmon (May 21-June 10, 4 samples) and Little West rivers (May 23-June 3, 3 samples). Alewives dominated catches on all five rivers (Tusket: 81%, Medway: 100%, Ship Harbour: 99%, Little West: 100%, Salmon: 75%); blueback herring were less common, occurring mainly in catches from the Tusket (19%) and Salmon (25%) rivers. The three blueback herring caught in the Ship Harbour River were excluded from subsequent analysis because of small sample size. No blueback herring were present in collections from the Medway or Little West rivers.

Blueback herring first appeared in catches during the latter half of the sampling periods (i.e., May 27 for Tusket River, June 3 for Ship Harbour River, June 6 for Salmon River) and arrived later in the season in a west-to-east progression along the coast. A similar trend was not apparent for alewives, although the spawning run on the Tusket River commenced earliest (May 2) compared to the other four rivers (May 14-21). During the early stages of the runs, surface water temperatures were lowest for the Tusket and Ship Harbour rivers (10°C and 11$^{oc}$), similar for the Medway and Little West rivers (14°C) and highest for the Salmon River (16°C) (Fig. 2). Compared to other rivers, Tusket River temperatures were generally the lowest thoughout the sampling period, although water temperatures for the Salmon River declined quite dramatically in June.

**LENGTH, WEIGHT AND AGE COMPOSITION**

Length-, weight- and age- frequency distributions of both species (sexes combined) overlapped considerably among rivers and were approximately normally distributed for alewives (Fig. 3) and slightly positively skewed for blueback herring (Fig. 4). Ages ranged from 3 to 11 years for alewives and 3 to 10 years for blueback herring, with 4- to 6-year-olds being most abundant for both species. Smaller, younger alewives occurred more frequently in the Tusket and Salmon rivers than in other rivers, while blueback herring from the Tusket River were smaller but not younger than those from the Salmon River. Alewife age frequencies were similar for Medway, Ship Harbour and Little West River catches, with 5-year-olds being the modal (58% to 69%) age group. Age-4 and -5 alewives were about equally abundant (34% to 43%) in the Tusket and Salmon rivers. Five-year-old blueback herring dominated Tusket River samples (34%); 4-year-olds were most abundant in the Salmon River (42%). Few alewives or blueback herring exceeded eight years of age in any river.

Seasonal (pooled sample) variances for length, weight and age varied significantly for alewives ($F_{max}$ test, $\underline{P} < 0.01$, all variables) but not for blueback herring ($F_{max}$ test, $\underline{P} > 0.05$, all variables). Much of the among-river variability of alewife data can be attributed to the Tusket River samples, which, due to an extended sampling period, had the greatest range in size, weight, and age of fish collected (Table 2). Excluding Tusket River collections, seasonal among-river sample variances were barely significant for length and age ($F_{max}$ test, $0.01 \leq \underline{P} \leq 0.05$, each variable) and non-significant for weight ($F_{max}$ test, $\underline{P} > 0.05$).

Seasonal variances for length, weight and age (individual samples) within rivers were not significant for male or female blueback herring ($F_{max}$ test, $P > 0.05$, all variables, each river, each sex). Male alewives showed no seasonal variability in length within rivers, however, male sample variances for weight and age differed for Little West River collections ($F_{max}$ test; $P < 0.01$, each variable). For female alewives, seasonal within-river variability occurred in length ($F_{max}$ test, $P < 0.01$, Medway and Salmon rivers), weight ($F_{max}$ test, $P < 0.01$, Little West River) and age ($F_{max}$ test, $P < 0.05$, Tusket, Little West and Salmon rivers). Variability among individual samples within rivers was attributed to small sample sizes and limited run coverage (i.e., Little West and Salmon rivers) and is not considered to seriously affect subsequent analyses.

For each river, the mean lengths, weights and ages of female alewives and blueback herring were significantly greater than for males (Table 2). Length and weight increased with age for each sex of both species (Tables 3 to 5). Alewives of each sex were substantially longer and heavier than were blueback herring of similar age.

**WEIGHT-LENGTH RELATIONSHIPS**

For both alewives and blueback herring from all rivers, weight increased with length for each sex, with fork length accounting for 83% to 94% of the variation ($r^2_{adj}$) in weight (Table 6). For each river, the weight-length relation regression coefficients (slopes) were similar ($P > 0.06$) for each sex of a given species, but y-intercept values (adjusted mean weights) were significantly higher for females than for males (alewife: $P < 0.001$; blueback herring: $P < 0.05$, for each river). Comparisons of weight-length relations among rivers were made for each sex because females are heavier at a given length than males.

The slopes of the weight-length regressions for male alewives differed among rivers ($F_{4,1228} = 4.79$, $P = 0.001$). Removal of the Medway River data resulted in similar regression coefficients for the remaining four rivers ($F_{3,973} = 2.34$, $P = 0.072$) (Table 6). Mean weights, adjusted to a common length, show that Tusket River male alewives are significantly heavier than males from the Ship Harbour, Little West and Salmon rivers. Weight-length regression coefficients for female alewives were homogeneous ($F_{4,1145} = 2.02$, $P = 0.089$); adjusted weights for Tusket River females were significantly heavier than those from other rivers. Slopes of weight-length regressions were homogeneous for both sexes of blueback herring (males: $F_{1,119} = 0.02$, $P = 0.881$; females: $F_{1,171} = 0.40$, $P = 0.529$); adjusted mean weights were significantly higher for fish of both sexes from the Salmon River than from the Tusket River.

## CHANGES IN FORK LENGTH DURING THE SPAWNING RUN

Mean fork lengths of male and female alewives and blueback herring decreased with time during the upstream migration on each river (Tables 7 and 8). Capture date accounted for 4% to 31% (for males) and 17% to 25% (for females) of the decrease in alewife length as indicated by the coefficient of determination ($r^2_{adj}$). Regression coefficients for the length-date relations differed significantly between sexes for the Tusket ($F_{1,864}$ = 10.39, $P$ = 0.001) and Ship Harbour ($F_{1,387}$ = 5.50, $P$ = 0.020) rivers, indicating that the size of male and female alewives decreased at different rates during the sampling period. Length-date regression coefficients were similar among sexes for the Medway, Little West and Salmon rivers but adjusted means (y-intercepts) differed ($P$ < 0.001, each river). Sexes were therefore treated separately for comparisons among rivers.

For male alewives, regression coefficients of fork length on capture date differed, barely, among rivers ($F_{4,1228}$ = 2.54, $P$ = 0.049). Fork lengths for male alewives were therefore assumed to decline at a similar rate for all rivers. Adjusted mean lengths of male alewives differed among all rivers except the Ship Harbour and Little West rivers, being highest for the Medway River and lowest for Tusket River (Table 8). For female alewives, slopes differed among all rivers ($F_{4,1145}$ = 9.21, $P$ < 0.001), but sequential removal of Little West and Tusket river fish yielded similar slopes for Medway, Ship Harbour and Salmon rivers ($F_{2,595}$ = 1.52, $P$ = 0.221). The rate of decline in length of female alewives also differed with time between Little West and Tusket rivers ($F_{1,550}$ = 18.56, $P$ < 0.001). Mean lengths, adjusted for sample date, were highest for the Medway River and similar for the Little West and Salmon rivers.

Regressions of fork length on sample date for age-5 alewives (the most abundant age group) decreased in length during the spawning migration on each river ($P \leq$ 0.005; Table 8). Slopes differed significantly among rivers ($F_{4,1226}$ = 4.22, $P$ = 0.002), although, within two groups of rivers, slopes did not differ significantly for: 1) all rivers excluding Tusket, and 2) Tusket, Ship Harbour and Salmon rivers. Within the first group, adjusted mean lengths did not differ between Ship Harbour and Little West rivers, while in the second, Tusket and Ship Harbour river fish did not differ.

## CHANGES IN AGE DURING THE SPAWNING RUN

Mean ages of both species declined as the runs progressed on all rivers (Table 9). This trend was most apparent for Tusket River male alewives which averaged 5-years-old at the beginning of the run and 3.7-years-old at the end. Regressions of alewife age on sample date for each sex and river were all negatively sloped and significant ($\underline{P} < 0.005$; Table 10). Run progression accounted for a 5% to 13% decrease in age for male alewives and a 3% to 14% decrease for females, based on $r^2_{adj}$ values. The rate of decline in age with time (slope) was similar for both sexes on all rivers except the Tusket ($\underline{F}_{1,843} = 5.83$, $\underline{P} = 0.016$), where males declined more rapidly in age than females. For rivers which had similar slopes, adjusted mean ages differed between male and female alewives ($\underline{P} < 0.05$, each river), with females being older at a given date than males. Sexes were treated separately for comparisons among rivers.

Slopes of the age-time regressions for male alewives did not differ when Little West River fish were excluded from the analysis ($\underline{F}_{3,1109} = 2.07$, $\underline{P} = 0.103$). Further examination revealed common slopes for Salmon and Little West River male alewife ($\underline{F}_{1,310} = 1.88$, $\underline{P} = 0.172$), indicating the existence of two groups with different rates of decline in age over time. Mean ages of alewife adjusted for a common sampling date differed among rivers and were highest for Medway and lowest for Tusket River males. Regression coefficients of age on sample date for female alewives were similar only after Tusket River and Little West River samples were removed from the analysis ($\underline{F}_{2,585} = 1.39$, $\underline{P} = 0.250$). In comparison with other rivers, the age trend was flatter for Tusket River female alewives and steeper for Little West River fish. Adjusted mean ages were highest for female alewives from the Medway River, followed by Ship Harbour and Salmon rivers.

## SEX RATIOS

Within rivers, male:female sex ratios for alewives were basically 1:1 (Chi-square, $\underline{P} > 0.05$) in most samples, with the exception of two collections each for the Tusket and Medway rivers (Table 11). Male alewives were more abundant than females only in combined samples from the Salmon River (Chi-square = 4.87, $\underline{P} < 0.05$). Sample sizes for Tusket River blueback herring were too small to allow comparison of sex ratios during the first half of the run, but during the last half, females outnumbered males. No differences in sex ratios were apparent for blueback herring from the Salmon River.

## SPAWNING HISTORY

All alewives and blueback herring were adult and sexually mature (i.e., gonad maturation stages IV and V; Nikolsky 1963). The proportion of virgin alewives did not differ between sexes (two-sample test for proportions; $\underline{P} > 0.10$, each river) and was highest in catches from the Medway River (59%), followed by Ship Harbour (57%), Salmon (52%), Little West (50%) and Tusket (44%) rivers. Alewives from the Tusket and Salmon rivers generally spawned first at age 3 or 4, and in all other rivers at age 4 or

5 (Table 12). Male alewives averaged younger at first spawning than females, although the difference was significant (t-test, $P < 0.005$) only for Tusket and Ship Harbour river samples.

The percentage of the return composed of virgin blueback herring was 29% in the Tusket River and 34% in the Salmon River, a lower percentage than was observed for alewives. No differences occurred between sexes in the proportion of virgin spawners (two-sample test for proportions, $P > 0.20$, each river), but blueback herring males averaged younger at first spawning than females (t-test, $P < 0.01$, each river). Both sexes spawned first at ages 3 or 4 although a few (mainly females) spawned first at age 5.

Previous spawners (sexes combined) composed 41% to 56% of alewives and 66% to 71% of blueback herring sampled on all rivers (Table 13). The proportion of previous spawning females was not significantly higher than males for both species (two-sample test for proportions, $P > 0.05$, each river and species). For alewives, the proportion of previous spawners declined in the following order: Tusket (56.5%), Little West (49.6%), Salmon (47.6%), Ship Harbour (42.6%) and Medway (41.2%) rivers. For blueback herring, previous spawners were more abundant in the Tusket River (71.4%) than in the Salmon River (65.6%). Alewives with one and two previous spawnings represented 29% to 37% and 10% to 14% of the catch. Alewives with three or more previous spawnings occurred mainly in catches from the Tusket (5%) and Little West rivers (6%). Blueback herring with one and two previous spawnings represented 23% to 26% and 19% to 23% of the catch. Blueback herring with three or more previous spawnings composed 22% of Tusket River and 24% of Salmon River catches.

## REPRODUCTIVE CONDITION

Sample variances for the ovary weights ($\log_{10}$ transformed) of female alewives were slightly heterogenous among rivers ($F_{max} = 3.65$, $P < 0.05$) primarily because of high variability for the smaller (n=129) Salmon River sample ($F_{max}$ excluding Salmon R. = 1.53, $P > 0.05$). Ovary weight increased allometrically with increasing fork length for female alewives from all rivers ($P < 0.001$, each river; $r^2_{adj}$ range: 0.33 to 0.68; Table 14). Regression coefficients of ovary weight on fork length (both variables $\log_{10}$ transformed) were not significantly different among rivers ($F_{4,812} = 1.77$, $P = 0.133$). Length-adjusted mean ovary weights were highest for Salmon River, lowest for Ship Harbour River and similar for Medway/Ship Harbour and Medway/Little West River pairs (Table 14).

## DISCUSSION

Differences in the duration of sampling of spawning migrations among rivers likely influenced length, weight and age composition sufficiently to make it difficult to separate population differences from bias due to sampling. Complete coverage of the run makes comparisons among rivers more reliable because the spawning migration of anadromous alewives (and probably blueback herring) is characterized by a decrease in size, age and size-at-age as the run progresses (Kissil 1974; Libby 1981, 1982; this study). Despite the limited temporal coverage of the spawning runs for three of the five rivers, several common trends were apparent in the life history characteristics of their alewife and blueback herring populations.

Blueback herring occurred with alewife on the Tusket, Ship Harbour and Salmon rivers but were absent from the Medway River. A conclusion that blueback herring are absent from the Medway River is considered reliable because the May 21 to June 17 sampling period substantially covers the known migration period in Nova Scotian rivers. It is unclear whether blueback herring occur in the Little West River because all sampling was curtailed by June 3.

Although water temperature influences the migration run timing of alewives and blueback herring (Loesch 1987), the earliest runs of both species occurred on the Tusket River (alewife: May 2; blueback herring: May 27) despite surface water temperatures that remained lower than in the other rivers throughout the sampling period. By comparison, where water temperatures in the Salmon River were highest at the start of migration, the run did not commence until two to three weeks later (alewife: May 21, blueback herring: June 6). Water temperature is believed to act as a "gating factor" by controlling whether fish present in the estuary will enter and move upstream (Kissil 1974).

Nearshore marine temperatures may be an earlier influence on the timing of run arrival to the estuary. Cold ocean water known as the Nova Scotia Current originates from the Labrador Current, flows southwesterly parallel to the Atlantic coast of Nova Scotia (Sutcliffe *et al*. 1976), and results in cooler water temperatures along the eastern shore and warmer water temperatures off southwestern Nova Scotia. Coastal water temperatures (April to June, 1985, from moored thermographs at 5 to 10 m depth) decreased among stations from east to west along the Atlantic coast of Nova Scotia (Walker *et al*. 1986). Cold sea temperatures along the eastern shore in spring may delay the onset of fish migration from coastal waters into the estuaries.

Females of both species were generally larger and older than males, and alewives were larger than blueback herring, as is typical of these species (Loesch 1987). Male age composition is typically younger than females because females spawn first at an older age (Marcy 1969; Jessop and Parker 1988; this study) and often live longer than males (Richkus and DiNardo 1984). The modal abundance of 4- and 5-year-old alewives and blueback herring has also been observed in populations from various rivers along the Atlantic coast of North America (Richkus and DiNardo 1984). Although direct comparison of mean length and weight among rivers was complicated by differences in sampling periods, the weight-length relations show that males and females of both species from the Tusket River were heaviest at a common length. This phenomenon may be related to genetic differences among stocks or to warmer sea conditions off southwestern Nova Scotia, which accelerate somatic and gonadal rates of development prior to the spawning migration.

Alewives of both sexes exhibited a progressive decrease in length, age and length-at-age throughout the spawning runs on all rivers, consistent with results from other studies (Kissil 1974; Libby 1982). Fish which arrive earliest are not only the largest and oldest of the migratory stock, but also of the age group. The decreasing trend in size and age composition may reflect the earlier arrival of faster swimming, larger, older individuals, than smaller, younger fish. Compared to other rivers, the low mean length and age (adjusted for sample date) of male and female alewives from the Tusket River reflects differences in the extent of sampling and the younger, smaller size composition of the run. In the other rivers, high rates of decline in length, age and length-at-age occurred during the first half of the run (i.e., the first three to four weeks).

In each river, male alewives generally outnumbered females throughout the run, but not sufficiently to be statistically significant, except in the Salmon River. Early male dominance during spawning migrations observed in other alewife populations (Kissil 1974; Libby 1981; Jessop and Parker 1988), has been attributed to males maturing a year earlier and ripening earlier in the season than females (Kissil 1974). The higher proportion of males in the Salmon River may have resulted from the short sampling period. Blueback herring males outnumbered females on the Salmon River (1.2:1), but females outnumbered males on the Tusket River (0.5:1). Loesch and Lund (1977) found a 2:1 ratio of males to females in Connecticut rivers; Jessop et al. (1982) found 1:1 ratios in five of seven years and no trend within years when the ratio differed.

Recruitment to the spawning stock for all rivers was essentially complete at ages 5 to 6 for alewife and age 5 for blueback herring. In both species, recruitment to the spawning stock was by platoon (i.e., only part of a year-class was recruited in a given year; Ricker 1975), occurring over four years for alewife and three years for blueback herring. Age-4 fish dominated the composition of virgin spawners in all rivers, which appears to be the case for most populations (Loesch 1987). Six-year-old virgin spawning alewives occurred in collections from the Tusket, Medway and Ship Harbour rivers and have also been observed in runs on the Gaspereau and Saint John rivers (Jessop et al. 1982; Jessop and Parker 1988).

Differences in the age composition and proportion of repeat spawners among rivers could imply differences in commercial exploitation rates, although variation in newly recruited year-class size could also be a factor (i.e., recruitment of a strong year-class of virgin spawning fish to the population would depress the percentage of repeat spawners). Furthermore, a greater distance to the spawning ground combined with rising water temperature may reduce post-spawning adult survival (Carscadden and Leggett 1975). The presence of adequate proportions of repeat-spawning fish in a population acts as insurance against population fluctuations in an unfavourable environment (Carscadden and Leggett 1975). Alewife stocks from the Tusket, Little West and Salmon rivers may have lower fishing mortality rates than stocks from the Medway and Ship Harbour rivers since more older fish are present (i.e., percentages of fish $\geq$ age 7 are 4.4% to 6.3% vs 0.5% to 1.0%), and the proportion of repeat spawners is higher (48% to 56% vs 41% to 42%). For blueback herring, proportions of older fish and repeat-spawning fish were similar for the Tusket and Salmon rivers (i.e., percentages of fish $\geq$ age 7 are 15.6% and 16.1%, proportions of repeat spawners are 71% and 66%, respectively). Blueback herring may live longer and spawn more years than alewives due to lower exploitation rates. Alewife runs were composed of 30% to 40% previous spawners in American streams with moderate to heavy fishing pressure (Richkus and DiNardo 1984). The Gaspereau River alewife run in Nova Scotia, which is heavily exploited, averaged 14% previous spawners (Jessop and Parker 1988), while the alewife run to the Mactaquac Dam in New Brunswick averaged 67% previous spawners during an 11-year period when the exploitation rate was greater than 70% (Jessop 1990). Fishing pressure seems moderate for alewife and low for blueback herring on all five rivers. Annual fishing pressure on stocks varies inversely with the availabilty of other preferred types of bait (i.e., mackerel) used in the commercial lobster fishery (Duggan 1982).

Ovary weights of female alewives increased allometrically with length at similar rates for all five populations, indicating that the energy allocated to reproduction was similar among stocks. Differences in length-adjusted mean ovary weights may reflect variation in ambient water temperature, distance from spawning habitat and differences in sampling time within the run. High length-adjusted mean ovary weights of Salmon River fish are coincident with high ambient surface water temperatures recorded at the time of sampling (16.5 °C). Although development of ovaries may be essentially complete prior to river entry, instream maturation by water absorption likely continues, as has been observed in the closely related American shad, Alosa sapidissima (Glebe and Leggett 1981). Ovary development rate may increase with increasing water temperature, which was highest on the Salmon River.

Life history characterictics of anadromous alewife and blueback herring populations in Nova Scotia were similar to those of populations along the U.S. seaboard (Richkus and DiNardo 1984). Both Canadian and U.S. gaspereau populations experience similar environmental conditions during the marine phase of their life history (Stone and Jessop, in press) but experience different freshwater conditions (i.e., during the adult spawning migration and early juvenile life). For anadromous alewives and blueback herring, factors operating to select for adaptive differences among geographically dispersed populations and generate optimum life history strategies are probably most important during the freshwater phase.

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Table 1. Annual gaspereau landings (1976 to 1985) for five Fishery Statistical Districts located along the Atlantic coast of Nova Scotia. The rivers from which most of the fish were harvested are given in parentheses. Years for which no landings reported are indicated by a "+". S.E. = standard error of the mean.

| Fisheries Statistical District (river) | Gaspereau landings by year (t) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | Mean ± S.E. |
| 33 (Tusket) | 485 | 502 | 549 | + | 36 | 135 | 86 | 30 | 198 | 25 | 227 ± 73.7 |
| 28 (Medway) | 256 | 94 | 421 | 333 | 196 | 287 | 120 | 63 | 164 | 231 | 217 ± 35.4 |
| 20 (Ship Harbour) | 143 | 365 | 222 | 149 | 141 | 188 | 111 | 115 | 103 | 106 | 164 ± 25.4 |
| 19 (Little West) | 51 | 93 | 113 | 35 | 42 | 27 | 8 | + | 12 | 13 | 44 ± 12.3 |
| 14 (Salmon) | 7 | + | + | 1 | + | + | + | + | + | + | <1 - |

Table 2. Mean fork length, weight and age of alewives and blueback herring from five Nova Scotia rivers, 1985. T-test comparisons of means between sexes within rivers were significant for all variables (i.e., $P < 0.001$ for length and weight; $P < 0.05$ for age). S.E. = standard error of the mean.

| River | Sex | n | Fork length (mm) Mean ± S.E. | Fork length (mm) Range | Weight (g) Mean ± S.E. | Weight (g) Range | Age (years) Mean ± S.E. | Age (years) Range |
|---|---|---|---|---|---|---|---|---|
| **Alewife** | | | | | | | | |
| Tusket | Male | 457 | 256.4 ± 1.00 | 300-312 | 242.3 ± 1.00 | 110-429 | 4.5 ± 0.05 | 3-10 |
| | Female | 411 | 271.4 ± 0.88 | 217-316 | 297.5 ± 3.05 | 140-483 | 4.8 ± 0.04 | 3-9 |
| | Combined | 868 | 263.5 ± 2.80 | 200-316 | 268.4 ± 2.29 | 110-483 | 4.6 ± 0.03 | 3-10 |
| Medway | Male | 317 | 269.2 ± 0.69 | 240-307 | 263.6 ± 2.02 | 185-390 | 4.8 ± 0.03 | 3-7 |
| | Female | 281 | 276.9 ± 0.81 | 248-328 | 298.9 ± 2.53 | 201-452 | 4.9 ± 0.04 | 3-7 |
| | Combined | 598 | 272.8 ± 0.55 | 240-328 | 280.2 ± 1.88 | 185-452 | 4.8 ± 0.03 | 3-7 |
| Ship Harbour | Male | 200 | 268.3 ± 0.81 | 225-298 | 262.2 ± 2.46 | 155-346 | 4.8 ± 0.04 | 3-6 |
| | Female | 191 | 278.1 ± 0.76 | 253-301 | 302.9 ± 2.82 | 214-410 | 5.1 ± 0.04 | 4-7 |
| | Combined | 391 | 273.1 ± 0.61 | 225-301 | 282.1 ± 2.13 | 155-410 | 5.0 ± 0.03 | 3-7 |
| Little West | Male | 157 | 267.5 ± 0.96 | 238-308 | 260.5 ± 3.37 | 176-413 | 5.0 ± 0.07 | 4-9 |
| | Female | 143 | 280.1 ± 1.20 | 247-336 | 312.6 ± 4.79 | 200-503 | 5.2 ± 0.09 | 4-11 |
| | Combined | 300 | 273.5 ± 0.84 | 238-336 | 285.3 ± 3.25 | 176 503 | 5.1 ± 0.06 | 4-11 |
| Salmon | Male | 167 | 261.8 ± 1.26 | 227-364 | 237.5 ± 2.96 | 165-373 | 4.6 ± 0.06 | 3-8 |
| | Female | 129 | 272.9 ± 1.47 | 243-320 | 291.1 ± 5.44 | 186-483 | 4.8 ± 0.10 | 3-8 |
| | Combined | 296 | 266.7 ± 1.02 | 277-364 | 260.8 ± 3.28 | 168-483 | 4.7 ± 0.05 | 3-8 |
| **Blueback herring** | | | | | | | | |
| Tusket | Male | 70 | 235.5 ± 2.46 | 182-277 | 163.9 ± 5.18 | 66-275 | 4.9 ± 0.15 | 3-8 |
| | Female | 129 | 248.5 ± 1.88 | 200-293 | 201.2 ± 5.04 | 95-344 | 5.3 ± 0.14 | 3-10 |
| | Combined | 199 | 243.9 ± 1.56 | 182-293 | 188.1 ± 3.94 | 66-334 | 5.1 ± 0.10 | 3-10 |
| Ship Harbour | Male | 2 | 230.0 ± 0.00 | 230-230 | 152.0 ± 4.00 | 146-156 | 3.5 ± 0.50 | 3-4 |
| | Female | 1 | 236.0 - | - | 158.0 - | - | 3.0 - | - |
| | Combined | 3 | 232.0 ± 2.00 | 230-326 | 154.0 ± 3.05 | 148-158 | 3.4 ± 0.32 | 3-4 |
| Salmon | Male | 53 | 247.5 ± 2.37 | 218-290 | 200.4 ± 6.32 | 129-304 | 4.7 ± 0.17 | 3-8 |
| | Female | 46 | 264.2 ± 3.17 | 229-309 | 253.3 ± 9.99 | 143-399 | 5.4 ± 0.20 | 3-8 |
| | Combined | 99 | 255.3 ± 2.11 | 218-307 | 244.9 ± 6.31 | 129-399 | 5.1 ± 0.13 | 3-8 |

Table 3. Mean fork length (mm) by age and sex of alewives from five Nova Scotia rivers, 1985. S.D. = sample standard deviation.

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| Age | n | Mean | S.D. | Range | n | Mean | S.D. | Range |
| **Tusket** | | | | | | | | |
| 3 | 70 | 224.8 | 10.47 | 205-248 | 9 | 229.3 | 8.14 | 217-243 |
| 4 | 188 | 250.3 | 12.59 | 220-288 | 152 | 257.8 | 12.44 | 227-300 |
| 5 | 130 | 269.3 | 10.48 | 237-295 | 163 | 277.2 | 10.24 | 251-305 |
| 6 | 42 | 279.8 | 8.79 | 265-296 | 60 | 288.5 | 8.61 | 270-316 |
| 7 | 12 | 281.8 | 11.97 | 264-302 | 12 | 299.4 | 9.77 | 281-315 |
| 8 | 3 | 282.0 | 17.78 | 262-296 | 1 | 295.0 | - | - |
| 9 | 3 | 302.7 | 7.37 | 297-311 | 1 | 295.0 | - | - |
| 10 | 1 | 305.0 | - | - | - | - | - | - |
| **Medway** | | | | | | | | |
| 3 | 1 | 246.0 | - | - | 1 | 250.0 | - | - |
| 4 | 96 | 258.3 | 7.56 | 240-283 | 56 | 264.7 | 8.89 | 248-285 |
| 5 | 188 | 271.9 | 9.42 | 245-295 | 184 | 277.4 | 10.08 | 248-304 |
| 6 | 23 | 289.2 | 6.34 | 280-303 | 30 | 294.5 | 11.79 | 270-314 |
| 7 | 2 | 303.0 | 5.66 | 299-307 | 4 | 307.8 | 15.84 | 290-328 |
| **Ship Harbour** | | | | | | | | |
| 3 | 1 | 225.0 | - | - | 1 | 225.0 | - | - |
| 4 | 43 | 256.2 | 8.54 | 240-274 | 21 | 265.1 | 8.28 | 253-281 |
| 5 | 135 | 270.8 | 8.57 | 244-298 | 135 | 277.4 | 8.61 | 258-298 |
| 6 | 15 | 281.5 | 5.69 | 270-290 | 30 | 289.7 | 5.97 | 281-301 |
| 7 | - | - | - | - | 2 | 294.5 | 9.19 | 288-301 |
| **Little West** | | | | | | | | |
| 4 | 34 | 256.2 | 9.94 | 238-276 | 24 | 265.3 | 9.22 | 247-279 |
| 5 | 91 | 267.7 | 7.84 | 251-295 | 83 | 277.8 | 8.66 | 261-305 |
| 6 | 20 | 279.4 | 8.06 | 265-292 | 19 | 289.4 | 9.63 | 272-309 |
| 7 | 3 | 289.3 | 5.86 | 285-296 | 8 | 300.3 | 6.94 | 292-309 |
| 8 | - | - | - | - | 3 | 315.3 | 3.32 | 314-318 |
| 9 | 3 | 289.3 | 5.86 | 285-296 | 1 | 312.0 | - | - |
| 10 | - | - | - | - | - | - | - | - |
| 11 | - | - | - | - | 1 | 336.0 | - | - |
| **Salmon** | | | | | | | | |
| 3 | 8 | 240.0 | 5.81 | 227-245 | 2 | 245.5 | 3.54 | 243-248 |
| 4 | 68 | 253.9 | 8.67 | 231-273 | 55 | 264.0 | 12.13 | 243-295 |
| 5 | 74 | 264.7 | 9.32 | 242-292 | 53 | 273.2 | 10.05 | 251-300 |
| 6 | 9 | 281.4 | 8.83 | 266-295 | 7 | 293.0 | 5.32 | 285-299 |
| 7 | 3 | 288.3 | 3.06 | 285-291 | 5 | 301.6 | 4.56 | 297-309 |
| 8 | 1 | 291.0 | - | - | 7 | 308.6 | 8.27 | 298-320 |

Table 4. Mean weight (g) by age and sex of alewives from five Nova Scotia rivers, 1985. S.D. = sample standard deviation.

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| Age | n | Mean | S.D. | Range | n | Mean | S.D. | Range |
| **Tusket** | | | | | | | | |
| 3 | 70 | 157.1 | 22.52 | 110-208 | 9 | 168.6 | 17.81 | 140-192 |
| 4 | 188 | 221.5 | 33.74 | 142-297 | 152 | 249.9 | 42.50 | 164-457 |
| 5 | 130 | 278.8 | 31.76 | 196-347 | 163 | 315.3 | 36.09 | 231-434 |
| 6 | 42 | 314.4 | 36.89 | 240-403 | 60 | 357.1 | 39.37 | 277-444 |
| 7 | 12 | 317.2 | 45.69 | 224-377 | 12 | 405.4 | 40.87 | 338-483 |
| 8 | 3 | 320.3 | 68.24 | 245-378 | 1 | 376.0 | - | - |
| 9 | 3 | 399.3 | 17.04 | 383-417 | 1 | 389.0 | - | - |
| 10 | 1 | 379.0 | - | - | - | - | - | - |
| **Medway** | | | | | | | | |
| 3 | 1 | 188.0 | - | - | 1 | 226.0 | - | - |
| 4 | 96 | 233.2 | 22.63 | 185-307 | 56 | 260.5 | 26.82 | 201-316 |
| 5 | 188 | 271.0 | 28.95 | 202-372 | 184 | 298.6 | 36.97 | 209-427 |
| 6 | 23 | 320.1 | 27.72 | 270-377 | 53 | 343.6 | 47.56 | 270-449 |
| 7 | 2 | 383.5 | 9.19 | 377-390 | 4 | 400.8 | 48.71 | 342-452 |
| **Ship Harbour** | | | | | | | | |
| 3 | 1 | 155.0 | - | - | 1 | 155.0 | - | - |
| 4 | 43 | 227.0 | 22.71 | 186-286 | 64 | 238.7 | 29.68 | 186-306 |
| 5 | 135 | 269.1 | 27.58 | 193-344 | 270 | 283.8 | 33.10 | 193-401 |
| 6 | 15 | 304.9 | 25.50 | 248-346 | 45 | 334.2 | 33.95 | 248-410 |
| 7 | - | - | - | - | 2 | 282.1 | 42.02 | 155-410 |
| **Little West** | | | | | | | | |
| 4 | 34 | 222.3 | 26.21 | 176-262 | 58 | 235.5 | 30.38 | 176-303 |
| 5 | 91 | 259.4 | 27.82 | 202-361 | 174 | 279.4 | 37.67 | 202-440 |
| 6 | 20 | 305.2 | 32.02 | 245-348 | 39 | 328.8 | 40.15 | 245-410 |
| 7 | 3 | 345.3 | 25.78 | 322-373 | 11 | 382.7 | 34.18 | 322-447 |
| 8 | - | - | - | - | 3 | 468.7 | 10.69 | 462-481 |
| 9 | 3 | 352.7 | 84.57 | 256-413 | 4 | 382.5 | 91.26 | 256-472 |
| 10 | - | - | - | - | - | - | - | - |
| 11 | - | - | - | - | 1 | 503.0 | - | - |
| **Salmon** | | | | | | | | |
| 3 | 8 | 183.4 | 15.50 | 165-202 | 2 | 205.5 | 21.92 | 190-221 |
| 4 | 68 | 218.6 | 25.11 | 170-292 | 55 | 259.7 | 39.98 | 185-355 |
| 5 | 74 | 247.5 | 28.24 | 188-325 | 53 | 288.0 | 38.23 | 190-399 |
| 6 | 9 | 300.7 | 31.08 | 246-345 | 7 | 368.0 | 36.72 | 312-409 |
| 7 | 3 | 329.0 | 38.16 | 305-373 | 5 | 400.8 | 18.58 | 381-421 |
| 8 | 1 | 318.0 | - | - | 7 | 430.3 | 41.84 | 377-483 |

Table 5. Mean fork length (mm) and weight (g) by age and sex of blueback herring sampled from the Tusket River and the Salmon River, 1985. S.D. = sample standard deviation.

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| Age | n | Mean | S.D. | Range | n | Mean | S.D. | Range |
| | | | | **Tusket** | | | | |
| Fork Length | | | | | | | | |
| 3 | 10 | 207.3 | 15.72 | 182-230 | 8 | 212.6 | 10.34 | 200-229 |
| 4 | 17 | 223.9 | 10.97 | 196-244 | 30 | 230.6 | 8.52 | 215-247 |
| 5 | 24 | 238.3 | 10.52 | 224-263 | 43 | 244.1 | 8.29 | 227-271 |
| 6 | 9 | 249.0 | 10.87 | 229-267 | 17 | 258.8 | 13.35 | 239-280 |
| 7 | 8 | 263.8 | 12.10 | 244-277 | 6 | 274.7 | 8.94 | 260-285 |
| 8 | 1 | 265.0 | - | - | 12 | 278.3 | 9.40 | 266-293 |
| 9 | - | - | - | - | 2 | 284.0 | 1.41 | 283-285 |
| 10 | - | - | - | - | 2 | 286.0 | 4.24 | 283-289 |
| Weight | | | | | | | | |
| 3 | 10 | 109.1 | 29.46 | 66-152 | 8 | 133.6 | 52.57 | 95-255 |
| 4 | 17 | 141.0 | 23.78 | 89-197 | 30 | 155.6 | 28.46 | 112-218 |
| 5 | 24 | 164.7 | 22.67 | 138-216 | 43 | 183.8 | 25.11 | 129-261 |
| 6 | 9 | 196.0 | 24.11 | 158-241 | 17 | 225.1 | 37.03 | 150-303 |
| 7 | 8 | 221.9 | 29.60 | 167-265 | 6 | 271.7 | 37.55 | 230-331 |
| 8 | 1 | 275.0 | - | - | 12 | 283.3 | 28.87 | 239-334 |
| 9 | - | - | - | - | 2 | 281.5 | 4.95 | 278-285 |
| 10 | - | - | - | - | 2 | 318.0 | 1.41 | 317-319 |
| | | | | **Salmon** | | | | |
| Fork Length | | | | | | | | |
| 3 | 4 | 237.8 | 10.56 | 223-248 | 1 | 229.0 | - | - |
| 4 | 27 | 236.7 | 9.04 | 218-259 | 14 | 244.3 | 10.17 | 232-265 |
| 5 | 4 | 253.3 | 12.04 | 240-269 | 8 | 254.4 | 10.11 | 241-271 |
| 6 | 11 | 261.9 | 13.82 | 249-290 | 11 | 273.6 | 12.99 | 253-294 |
| 7 | 4 | 273.5 | 9.15 | 261-283 | 8 | 287.0 | 11.01 | 277-309 |
| 8 | 1 | 285.0 | - | - | 3 | 287.0 | 17.69 | 268-303 |
| Weight | | | | | | | | |
| 3 | 4 | 172.0 | 17.30 | 150-189 | 1 | 161.0 | - | - |
| 4 | 27 | 171.3 | 28.03 | 129-221 | 14 | 186.4 | 28.76 | 143-251 |
| 5 | 4 | 211.3 | 30.60 | 187-256 | 8 | 220.0 | 34.77 | 177-275 |
| 6 | 11 | 241.1 | 40.25 | 188-299 | 11 | 286.6 | 36.80 | 223-352 |
| 7 | 4 | 273.3 | 25.34 | 242-304 | 8 | 331.5 | 32.50 | 294-399 |
| 8 | 1 | 301.0 | - | - | 3 | 321.0 | 31.61 | 288-351 |

Table 6. Intercepts (A) and slopes (B) of the weight (Y) - length (X) regression, $\log_{10} Y = A + \log_{10} X$, for male and female alewives and blueback herring from five Nova Scotia rivers, 1985. All regressions were significant at $P < 0.001$. For each sex, slopes without a letter in common are significantly different from each other (ANCOVA, $P < 0.05$). Adjusted mean weights without a letter in common are significant at the adjusted Bonferroni significance level of $P < 0.013$ (male alewife), $P < 0.01$ (female alewife) and $P < 0.025$ (blueback herring). S.E. = standard error of the coefficient (coef.).

| | Weight(g) - length(mm) regression | | | | | | |
|---|---|---|---|---|---|---|---|
| | Intercept | | Slope | | | | Adjusted mean weight (g) |
| River | Coef. | S.E. | Coef. | S.E. | n | $r^2_{adj}$ | |
| | | | **Male Alewife** | | | | |
| Tusket | -4.973 | 0.086 | 3.050 y | 0.036 | 457 | 0.94 | 248.9 y |
| Medway | -4.303 | 0.172 | 2.766 z | 0.071 | 317 | 0.83 | - |
| Ship Harbour | -4.612 | 0.207 | 2.894 y | 0.085 | 200 | 0.85 | 238.8 z |
| Little West | -5.464 | 0.262 | 3.036 y | 0.108 | 157 | 0.85 | 238.2 z |
| Salmon | -4.718 | 0.226 | 3.244 y | 0.094 | 167 | 0.86 | 235.5 z |
| | | | **Female Alewife** | | | | |
| Tusket | -5.132 | 0.120 | 3.123 z | 0.049 | 411 | 0.91 | 303.7 y |
| Medway | -4.750 | 0.170 | 2.957 z | 0.070 | 281 | 0.86 | 288.9 z |
| Ship Harbour | -4.942 | 0.275 | 3.036 z | 0.112 | 191 | 0.79 | 289.7 z |
| Little West | -5.614 | 0.200 | 3.311 z | 0.082 | 143 | 0.92 | 290.7 z |
| Salmon | -5.136 | 0.280 | 3.177 z | 0.117 | 129 | 0.85 | 292.2 z |
| | | | **Male Blueback** | | | | |
| Tusket | -4.993 | 0.252 | 3.034 z | 0.106 | 70 | 0.92 | 169.0 z |
| Salmon | -4.930 | 0.299 | 3.018 z | 0.144 | 53 | 0.92 | 179.1 y |
| | | | **Female Blueback** | | | | |
| Tusket | -5.213 | 0.255 | 3.133 z | 0.107 | 129 | 0.87 | 203.2 z |
| Salmon | -5.526 | 0.348 | 3.270 z | 0.144 | 46 | 0.92 | 211.1 y |

Table 7. Fork length statistics for alewives and blueback herring (sexes separate) by collection date for five Nova Scotia rivers, 1985. S.E. = standard error of the mean.

| | | Fork length (mm) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Males | | | Females | | |
| River | Date | n | Mean ± S.E. | Range | n | Mean ± S.E. | Range |
| | | | **Alewife** | | | | |
| Tusket | May 2 | 57 | 266.2 ± 1.74 | 231-300 | 43 | 276.0 ± 1.91 | 243-300 |
| | May 9 | 54 | 267.9 ± 1.81 | 245-287 | 46 | 284.2 ± 2.08 | 252-315 |
| | May 13 | 61 | 271.0 ± 2.00 | 227-312 | 39 | 279.4 ± 2.58 | 244-316 |
| | May 21 | 49 | 260.7 ± 2.71 | 227-302 | 51 | 274.1 ± 1.96 | 233-305 |
| | May 27 | 39 | 257.5 ± 3.39 | 207-296 | 59 | 274.9 ± 1.78 | 241-301 |
| | June 3 | 55 | 255.5 ± 2.44 | 220-297 | 43 | 270.7 ± 2.52 | 226-300 |
| | June 10 | 48 | 244.8 ± 2.61 | 208-285 | 43 | 264.1 ± 2.68 | 227-309 |
| | June 17 | 41 | 249.7 ± 3.43 | 212-309 | 50 | 259.9 ± 2.88 | 221-309 |
| | June 24 | 15 | 228.0 ± 3.95 | 208-260 | 12 | 254.8 ± 3.54 | 232-276 |
| | July 2 | 26 | 229.0 ± 3.62 | 200-273 | 17 | 257.9 ± 4.72 | 217-287 |
| | July 8 | 12 | 229.8 ± 3.71 | 200-273 | 8 | 260.9 ± 6.95 | 225-295 |
| Medway | May 21 | 48 | 282.4 ± 1.67 | 257-303 | 52 | 290.1 ± 2.96 | 269-328 |
| | May 27 | 49 | 272.0 ± 1.62 | 245-296 | 51 | 279.2 ± 1.69 | 259-314 |
| | June 3 | 59 | 268.2 ± 1.28 | 245-307 | 39 | 276.7 ± 0.18 | 258-299 |
| | June 10 | 61 | 266.5 ± 1.52 | 245-297 | 39 | 275.2 ± 1.87 | 249-306 |
| | June 13 | 50 | 262.6 ± 1.33 | 245-285 | 50 | 269.9 ± 1.73 | 248-300 |
| | June 17 | 49 | 264.6 ± 1.43 | 240-281 | 51 | 269.5 ± 1.48 | 248-295 |
| Ship H. | May 14 | 51 | 270.2 ± 1.43 | 244-290 | 43 | 281.6 ± 1.36 | 258-300 |
| | May 21 | 42 | 270.3 ± 1.92 | 245-298 | 58 | 282.5 ± 1.33 | 256-301 |
| | May 27 | 57 | 269.2 ± 1.49 | 243-298 | 43 | 278.2 ± 1.35 | 258-298 |
| | June 3 | 50 | 263.6 ± 1.55 | 225-295 | 47 | 269.2 ± 1.21 | 253-289 |
| Little W. | May 23 | 46 | 274.0 ± 1.70 | 253-308 | 54 | 288.8 ± 2.05 | 258-336 |
| | May 27 | 55 | 267.5 ± 1.71 | 238-296 | 45 | 278.6 ± 1.70 | 255-318 |
| | June 3 | 56 | 262.3 ± 1.23 | 238-283 | 44 | 270.9 ± 1.39 | 247-290 |
| Salmon | May 21 | 55 | 270.4 ± 1.67 | 242-295 | 44 | 283.9 ± 2.33 | 255-320 |
| | May 27 | 54 | 257.6 ± 1.28 | 240-276 | 46 | 268.9 ± 2.36 | 245-317 |
| | June 6 | 34 | 255.6 ± 1.94 | 231-286 | 21 | 266.3 ± 1.42 | 256-280 |
| | June 10 | 24 | 252.3 ± 2.11 | 227-266 | 18 | 264.0 ± 3.87 | 243-295 |
| | | | **Blueback herring** | | | | |
| Tusket | May 27 | 0 | - - | - | 2 | 260.0 ±20.80 | 240-280 |
| | June 3 | 1 | 252.0 - | - | 1 | 240.0 - | - |
| | June 10 | 4 | 240.3 ± 9.51 | 224-267 | 4 | 275.0 ± 6.91 | 255-285 |
| | June 17 | 8 | 237.1 ± 7.16 | 213-265 | 0 | - - | - |
| | June 24 | 33 | 236.6 ± 3.05 | 191-270 | 40 | 251.1 ± 3.32 | 213-293 |
| | July 2 | 17 | 232.3 ± 4.57 | 196-276 | 40 | 243.7 ± 3.01 | 200-283 |
| | July 8 | 7 | 231.0 ±14.62 | 182-277 | 41 | 247.7 ± 3.61 | 203-287 |
| Salmon | June 6 | 21 | 250.5 ± 4.38 | 223-290 | 20 | 272.2 ± 4.03 | 240-301 |
| | June 10 | 32 | 245.6 ± 2.68 | 218-283 | 26 | 258.0 ± 4.37 | 229-309 |

Table 8. Intercepts (A) and slopes (B) of the fork length (Y) - capture date (X) regression, Y = A + BX, for male and female alewives from five Nova Scotia rivers, 1985. All regressions were significant at $\underline{P} < 0.005$. For each sex and combined sexes, slopes without a letter in common are significantly different from each other (ANCOVA, $\underline{P} < 0.05$). Adjusted mean lengths without a letter in common are significant at the adjusted Bonferroni significance level of $\underline{P} < 0.01$ (male alewife), $\underline{P} < 0.017$ (female alewife) and $\underline{P} < 0.013$ (combined sexes, age 5). S.E. = standard error of the coefficient (coef.).

| | Fork length(mm) - capture date regression | | | | | | |
|---|---|---|---|---|---|---|---|
| | Intercept | | Slope | | | | Adjusted mean length (mm) |
| River | Coeff. | S.E. | Coeff. | S.E. | n | $r^2_{adj}$ | |
| | | | **Male Alewife** | | | | |
| Tusket | 349.3 | 6.52 | -0.630 z | 0.044 | 457 | 0.31 | 255.2 z |
| Medway | 366.5 | 10.44 | -0.624 z | 0.067 | 317 | 0.21 | 273.4 w |
| Ship Harbour | 312.9 | 15.46 | -0.310 z | 0.107 | 200 | 0.04 | 265.0 x |
| Little West | 417.5 | 29.41 | -1.011 z | 0.198 | 157 | 0.14 | 266.9 x |
| Salmon | 383.5 | 17.62 | -0.824 z | 0.118 | 167 | 0.22 | 260.4 y |
| | | | **Female Alewife** | | | | |
| Tusket | 334.5 | 6.70 | -0.426 x | 0.045 | 411 | 0.18 | - |
| Medway | 384.6 | 11.05 | -0.692 y | 0.071 | 281 | 0.25 | 280.7 x |
| Ship Harbour | 371.2 | 13.64 | -0.647 y | 0.095 | 191 | 0.19 | 273.4 z |
| Little West | 515.0 | 33.81 | -1.591 z | 0.229 | 143 | 0.25 | - |
| Salmon | 413.6 | 27.22 | -0.947 y | 0.183 | 129 | 0.17 | 271.6 z |
| | | | **Combined Sexes Age 5** | | | | (1)* (2) |
| Tusket | 298.7 | 5.48 | -0.177 y | 0.038 | 293 | 0.07 | - v |
| Medway | 337.1 | 8.04 | -0.402 z | 0.035 | 372 | 0.14 | 276.6 x |
| Ship Harbour | 306.9 | 10.61 | -0.228 yz | 0.074 | 270 | 0.03 | 272.0 y v |
| Little West | 356.9 | 23.02 | -0.569 z | 0.156 | 174 | 0.07 | 272.0 y |
| Salmon | 316.2 | 17.71 | -0.325 yz | 0.120 | 127 | 0.01 | 267.5 z w |

* (See Results for explanation of comparisons between adjusted cell means for groups 1 and 2).

Table 9. Mean age of alewives and blueback herring (sexes separate) by collection date from five Nova Scotia rivers, 1985. S.E. = standard error of the mean.

| | | Age (years) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Males | | | Females | | |
| River | Date | n | Mean ± S.E. | Range | n | Mean ± S.E. | Range |
| | | **Alewife** | | | | | |
| Tusket | May 2 | 57 | 5.0 ± 0.14 | 3-9 | 41 | 5.1 ± 0.12 | 4-7 |
| | May 9 | 51 | 4.7 ± 0.12 | 4-8 | 45 | 5.1 ± 0.11 | 4-7 |
| | May 13 | 60 | 4.6 ± 0.13 | 3-9 | 37 | 4.8 ± 0.22 | 4-7 |
| | May 21 | 48 | 4.6 ± 0.14 | 3-7 | 48 | 4.8 ± 0.12 | 3-7 |
| | May 27 | 39 | 4.5 ± 0.19 | 3-8 | 56 | 4.8 ± 0.11 | 3-7 |
| | June 3 | 55 | 4.7 ± 0.16 | 3-9 | 43 | 4.8 ± 0.13 | 3-7 |
| | June 10 | 47 | 4.1 ± 0.11 | 3-6 | 42 | 4.6 ± 0.12 | 3-6 |
| | June 17 | 40 | 4.5 ± 0.23 | 3-10 | 49 | 4.6 ± 0.16 | 3-8 |
| | June 24 | 15 | 3.6 ± 0.19 | 3-5 | 12 | 4.3 ± 0.13 | 4-5 |
| | July 2 | 25 | 3.6 ± 0.19 | 3-7 | 17 | 4.6 ± 0.23 | 3-6 |
| | July 8 | 12 | 3.7 ± 0.23 | 3-5 | 8 | 4.8 ± 0.65 | 3-9 |
| Medway | May 21 | 48 | 5.2 ± 0.10 | 4-7 | 51 | 5.4 ± 0.08 | 4-7 |
| | May 27 | 49 | 4.9 ± 0.08 | 4-6 | 50 | 5.0 ± 0.09 | 4-7 |
| | June 3 | 58 | 4.7 ± 0.08 | 4-7 | 38 | 4.8 ± 0.08 | 4-6 |
| | June 10 | 60 | 4.6 ± 0.07 | 4-6 | 39 | 4.8 ± 0.10 | 4-6 |
| | June 13 | 51 | 4.6 ± 0.07 | 4-6 | 45 | 4.8 ± 0.07 | 4-6 |
| | June 17 | 45 | 4.6 ± 0.09 | 3-6 | 51 | 4.6 ± 0.08 | 3-6 |
| Ship H. | May 14 | 50 | 5.0 ± 0.06 | 4-6 | 43 | 5.3 ± 0.08 | 4-7 |
| | May 21 | 40 | 4.9 ± 0.10 | 4-6 | 58 | 5.2 ± 0.08 | 4-7 |
| | May 27 | 56 | 4.8 ± 0.07 | 4-6 | 43 | 4.9 ± 0.07 | 4-6 |
| | June 3 | 48 | 4.7 ± 0.08 | 3-6 | 44 | 4.8 ± 0.06 | 4-6 |
| Little W. | May 23 | 46 | 5.4 ± 0.20 | 4-9 | 53 | 5.8 ± 0.17 | 4-11 |
| | May 27 | 52 | 5.0 ± 0.10 | 4-7 | 44 | 5.0 ± 0.11 | 4-8 |
| | June 3 | 53 | 4.7 ± 0.07 | 4-6 | 42 | 4.8 ± 0.08 | 4-6 |
| Salmon | May 21 | 54 | 5.2 ± 0.10 | 4-8 | 44 | 5.4 ± 0.19 | 4-8 |
| | May 27 | 53 | 4.3 ± 0.09 | 3-6 | 46 | 4.5 ± 0.15 | 3-8 |
| | June 6 | 33 | 4.5 ± 0.12 | 3-6 | 21 | 4.7 ± 0.11 | 4-5 |
| | June 10 | 23 | 4.2 ± 0.13 | 3-6 | 18 | 4.5 ± 0.17 | 3-6 |
| | | **Blueback herring** | | | | | |
| Tusket | May 27 | - | - - | - | 2 | 5.0 ± 3.25 | 4-6 |
| | June 3 | 1 | 5.0 - | - | 1 | 5.0 - | - |
| | June 10 | 4 | 5.0 ± 0.82 | 3-7 | 3 | 6.7 ± 0.88 | 5-8 |
| | June 17 | 8 | 5.1 ± 0.61 | 3-8 | 1 | 5.0 - | - |
| | June 24 | 32 | 4.9 ± 0.19 | 3-7 | 40 | 5.4 ± 0.25 | 3-10 |
| | July 2 | 17 | 4.8 ± 0.26 | 3-7 | 39 | 5.2 ± 0.27 | 3-10 |
| | July 8 | 7 | 4.7 ± 0.68 | 3-7 | 34 | 5.2 ± 0.29 | 3-9 |
| Salmon | June 6 | 20 | 5.1 ± 0.29 | 3-8 | 19 | 6.1 ± 0.28 | 4-8 |
| | June 10 | 31 | 4.5 ± 0.21 | 3-7 | 26 | 5.0 ± 0.25 | 3-8 |

Table 10. Intercepts (A) and slopes (B) of the age (Y) - capture date (X) regression, Y = A + BX, for male and female alewives from five Nova Scotia rivers, 1985. All regressions were significant at $\underline{P} < 0.005$. Separate analyses were carried out between rivers for each sex. Slopes without a letter in common are significantly different from each other (ANCOVA, $\underline{P} < 0.001$). Adjusted mean ages without a letter in common are significant at the adjusted Bonferroni significance level of $\underline{P} < 0.013$ (male alewife), $\underline{P} < 0.017$ (female alewife). S.E. = standard error of the coefficient (coef.).

| | Age(years) - capture date regression | | | | | | |
|---|---|---|---|---|---|---|---|
| | Intercept | | Slope | | | | Adjusted mean age |
| River | Coef. | S.E. | Coef. | S.E. | n | $r^2_{adj}$ | (years) |
| **Male Alewife** | | | | | | | |
| Tusket | 7.09 | 0.386 | -0.018 y | 0.003 | 449 | 0.09 | 4.4 z |
| Medway | 8.17 | 0.555 | -0.022 y | 0.004 | 311 | 0.11 | 4.9 x |
| Ship Harbour | 7.36 | 0.742 | -0.017 y | 0.005 | 194 | 0.05 | 4.7 xy |
| Little West | 14.11 | 2.206 | -0.061 z | 0.015 | 151 | 0.10 | - |
| Salmon | 10.38 | 1.167 | -0.039 yz | 0.008 | 163 | 0.13 | 4.6 yz |
| **Female Alewife** | | | | | | | |
| Tusket | 6.13 | 0.364 | -0.009 x | 0.002 | 398 | 0.03 | - |
| Medway | 8.55 | 0.574 | -0.023 y | 0.004 | 274 | 0.14 | 5.1 y |
| Ship Harbour | 8.40 | 0.005 | -0.023 y | 0.005 | 188 | 0.08 | 4.9 yz |
| Little West | 18.22 | 2.642 | -0.088 z | 0.018 | 139 | 0.14 | - |
| Salmon | 10.55 | 1.874 | -0.039 yz | 0.013 | 129 | 0.06 | 4.8 z |

Table 11. Male:female sex ratios by sample date for alewife and blueback herring from five Nova Scotia rivers, 1985. Ratios with an asterisk are significantly different from 1:1 at $\underline{P} < 0.05$ (Chi-square statistic). Sample sizes $\leq$ 10 were considered too small to test.

| Tusket R. | | | Medway R. | | | Ship Harbour R. | | | Little West R. | | | Salmon R. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | n | Ratio | Date | n | Ratio | Date | n | Ratio | Date | n | Ratio | Date | n | Ratio |
| **Alewife** | | | | | | | | | | | | | | |
| 2/5 | 100 | 1.3:1 | | | | | | | | | | | | |
| 9/5 | 100 | 1.2:1 | | | | | | | | | | | | |
| 13/5 | 100 | 1.6:1* | | | | 14/5 | 94 | 1.2:1 | | | | | | |
| 21/5 | 100 | 1:1 | 21/5 | 100 | 0.9:1 | 21/5 | 100 | 0.7:1 | 23/5 | 100 | 0.9:1 | 21/5 | 99 | 1.3:1 |
| 27/5 | 98 | 0.7:1* | 27/5 | 100 | 1:1 | 27/5 | 100 | 1.3:1 | 27/5 | 100 | 1.2:1 | 27/5 | 100 | 1.2:1 |
| 3/6 | 98 | 1.3:1 | 3/6 | 98 | 1.5:1* | 3/6 | 97 | 1.1:1 | 3/6 | 100 | 1.3:1 | 6/6 | 55 | 1.6:1 |
| 10/6 | 91 | 1.1:1 | 10/6 | 100 | 1.6:1* | | | | | | | 10/6 | 42 | 1.3:1 |
| 17/6 | 91 | 1.1:1 | 13/6 | 100 | 1:1 | | | | | | | | | |
| 24/6 | 27 | 1.3:1 | 17/6 | 100 | 1:1 | | | | | | | | | |
| 2/7 | 43 | 1.5:1 | | | | | | | | | | | | |
| 8/7 | 20 | 1.5:1 | | | | | | | | | | | | |
| all | 868 | 1.1:1 | | 598 | 1.1:1 | | 391 | 1:1 | | 300 | 1.1:1 | | 296 | 1.3:1* |
| **Blueback herring** | | | | | | | | | | | | | | |
| 27/5 | 2 | 0:2 | | | | | | | | | | | | |
| 3/6 | 2 | 1:1 | | | | | | | | | | 6/6 | 41 | 1:1 |
| 10/6 | 8 | 1:1 | | | | | | | | | | 10/6 | 58 | 1.2:1 |
| 17/6 | 9 | 8:1 | | | | | | | | | | | | |
| 24/6 | 73 | 0.8:1 | | | | | | | | | | | | |
| 2/7 | 57 | 0.4:1* | | | | | | | | | | | | |
| 8/7 | 48 | 0.2:1* | | | | | | | | | | | | |
| all | 199 | 0.5:1* | | | | | | | | | | | 99 | 1.2:1 |

Table 12. Age at first spawning and percentage of virgin spawners by age group for alewives and blueback herring (sexes separate) from five Nova Scotia Rivers, 1985. S.E. = standard error of the mean.

| | | Age at first spawning | | Percent by age group | | | |
|---|---|---|---|---|---|---|---|
| River | Sex | Mean ± S.D. | n | 3 | 4 | 5 | 6 |
| | | **Alewife** | | | | | |
| Tusket | male | 3.7 ± 0.04 | 205 | 41.9 | 50.6 | 7.6 | - |
| | female | 3.9 ± 0.05 | 164 | 26.7 | 52.8 | 19.9 | 0.5 |
| Medway | male | 4.3 ± 0.05 | 186 | 16.1 | 42.9 | 39.7 | 1.3 |
| | female | 4.4 ± 0.06 | 158 | 13.8 | 39.6 | 44.7 | 1.8 |
| Ship H. | male | 4.3 ± 0.07 | 112 | 15.0 | 41.2 | 42.3 | 1.6 |
| | female | 4.5 ± 0.07 | 107 | 12.2 | 29.8 | 54.8 | 3.2 |
| Little W. | male | 4.3 ± 0.08 | 77 | 13.9 | 46.4 | 39.7 | - |
| | female | 4.4 ± 0.08 | 69 | 10.1 | 43.9 | 46.0 | - |
| Salmon | male | 3.9 ± 0.07 | 86 | 21.5 | 63.2 | 15.3 | - |
| | female | 4.0 ± 0.08 | 67 | 20.2 | 55.8 | 24.0 | - |
| | | **Blueback herring** | | | | | |
| Tusket | male | 3.4 ± 0.13 | 18 | 66.7 | 29.0 | 4.4 | - |
| | female | 3.7 ± 0.11 | 36 | 45.0 | 45.0 | 10.0 | - |
| Salmon | male | 3.5 ± 0.12 | 19 | 49.0 | 51.0 | - | - |
| | female | 3.8 ± 0.16 | 14 | 28.9 | 62.2 | 8.9 | - |

Table 13. Percentage of previous spawners by sex in the returns (pooled samples) of alewives and blueback herring (sexes separate) from five Nova Scotia Rivers, 1985.

| | | Number of previous spawnings | | | | | | |
|---|---|---|---|---|---|---|---|---|
| River | Sex | 0 | 1 | 2 | 3 | 4 | 5 | 6+ |
| | | | | **Alewife** | | | | |
| Tusket | male | 45.7 | 35.9 | 12.9 | 3.7 | 0.9 | 0.6 | 0.2 |
| | female | 41.2 | 39.0 | 14.5 | 3.8 | 1.6 | 0.3 | - |
| | combined | 43.5 | 37.3 | 13.6 | 3.8 | 1.1 | 0.4 | 0.1 |
| Medway | male | 60.0 | 31.0 | 8.7 | 0.3 | - | - | - |
| | female | 57.5 | 30.2 | 11.4 | 1.1 | - | - | - |
| | combined | 58.8 | 30.6 | 9.9 | 0.7 | - | - | - |
| Ship Harbour | male | 57.8 | 30.5 | 10.3 | 0.5 | - | - | - |
| | female | 56.9 | 29.3 | 12.7 | 1.0 | - | - | - |
| | combined | 57.4 | 29.9 | 11.6 | 0.8 | - | - | - |
| Little West | male | 51.0 | 29.2 | 16.0 | 1.4 | 2.0 | 0.7 | - |
| | female | 49.8 | 28.8 | 13.7 | 4.3 | 2.1 | 0.7 | 0.7 |
| | combined | 50.4 | 29.1 | 14.8 | 2.7 | 2.1 | 0.7 | 0.3 |
| Salmon | male | 52.8 | 31.9 | 13.5 | 0.6 | 1.2 | - | - |
| | female | 52.0 | 31.8 | 7.9 | 2.3 | 6.2 | - | - |
| | combined | 52.4 | 31.9 | 10.9 | 1.3 | 3.4 | - | - |
| | | | | **Blueback herring** | | | | |
| Tusket | male | 26.2 | 27.5 | 27.4 | 16.0 | 4.4 | 1.5 | - |
| | female | 30.0 | 25.8 | 22.5 | 5.0 | 6.6 | 7.5 | 2.4 |
| | combined | 28.6 | 26.4 | 23.2 | 9.0 | 5.8 | 5.3 | 1.5 |
| Salmon | male | 37.2 | 27.4 | 15.7 | 15.2 | 2.0 | 2.0 | - |
| | female | 31.0 | 17.8 | 22.3 | 15.5 | 11.1 | 2.2 | - |
| | combined | 34.4 | 22.9 | 18.7 | 15.6 | 6.3 | 2.1 | - |

Table 14. Intercepts (A) and slopes (B) of the ovary weight (Y) - fork length (X) regression, $\log_{10} Y = A + \log_{10} X$, for female alewives from five Nova Scotia rivers, 1985. All regressions were significant at $\underline{P} < 0.001$. Slopes are not significantly different from each other (ANCOVA, $\underline{P} = 0.1333$). Adjusted mean ovary weights without a letter in common are significant at the adjusted Bonferroni significance level of $\underline{P} < 0.010$. S.E. = standard error of the coefficient (coef.).

| | Ovary weight(g) - fork length(mm) regression | | | | | | |
|---|---|---|---|---|---|---|---|
| | Intercept | | Slope | | | | Adjusted mean ovary weight |
| River | Coef. | S.E. | Coef. | S.E. | n | $r^2_{adj}$ | (g) |
| Tusket | -8.764 | 0.634 | 4.229 | 0.259 | 179 | 0.60 | 37.22 x |
| Medway | -7.907 | 0.609 | 3.843 | 0.249 | 181 | 0.57 | 31.29 yz |
| Ship Harbour | -8.197 | 0.991 | 3.957 | 0.406 | 190 | 0.33 | 29.83 z |
| Little West | -9.066 | 0.611 | 4.331 | 0.250 | 143 | 0.68 | 32.85 y |
| Salmon | -10.476 | 1.179 | 4.591 | 0.484 | 129 | 0.45 | 41.48 w |

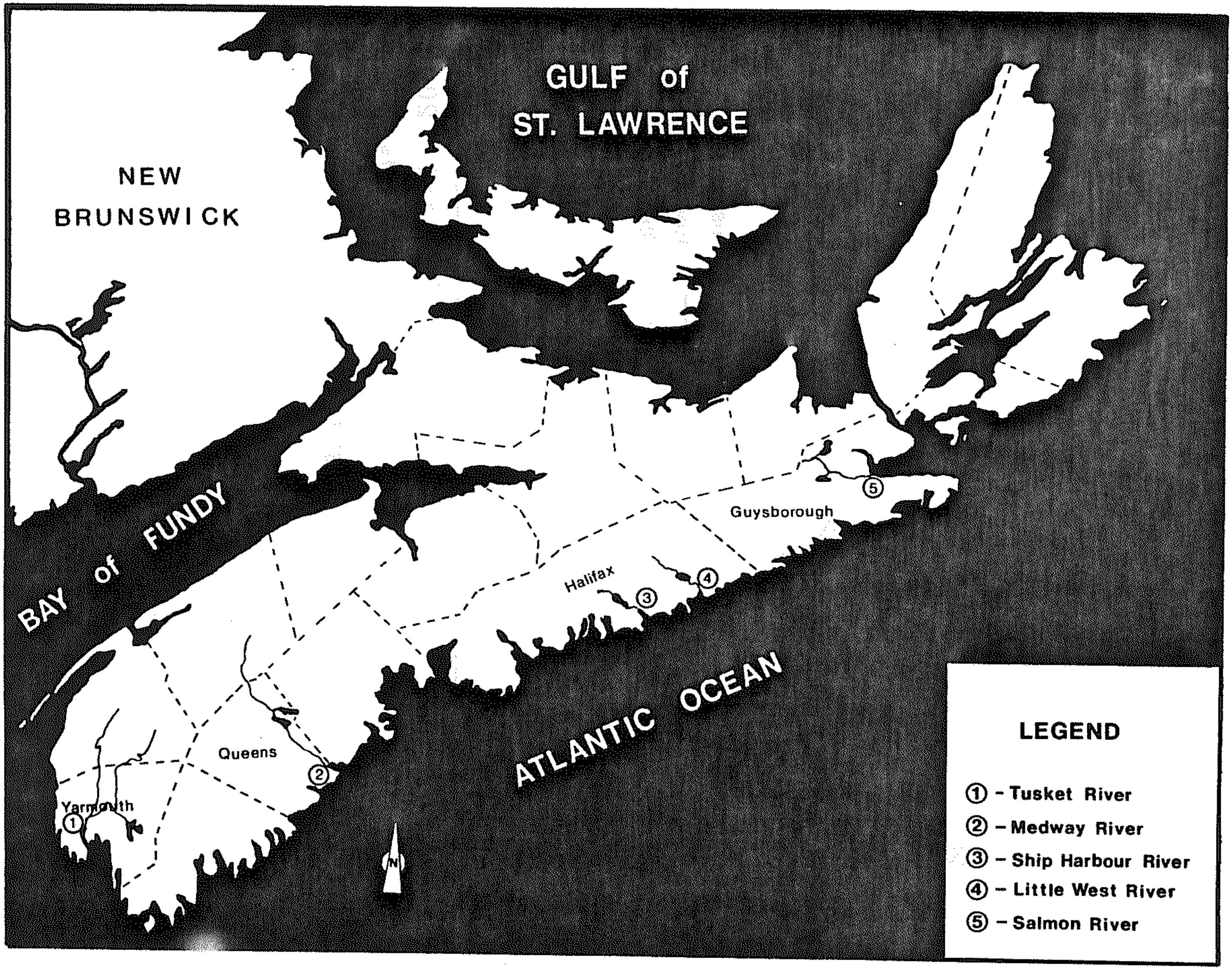


FIG. 1. Location of five Nova Scotia rivers where alewives and blueback herring were collected from May to July, 1985.

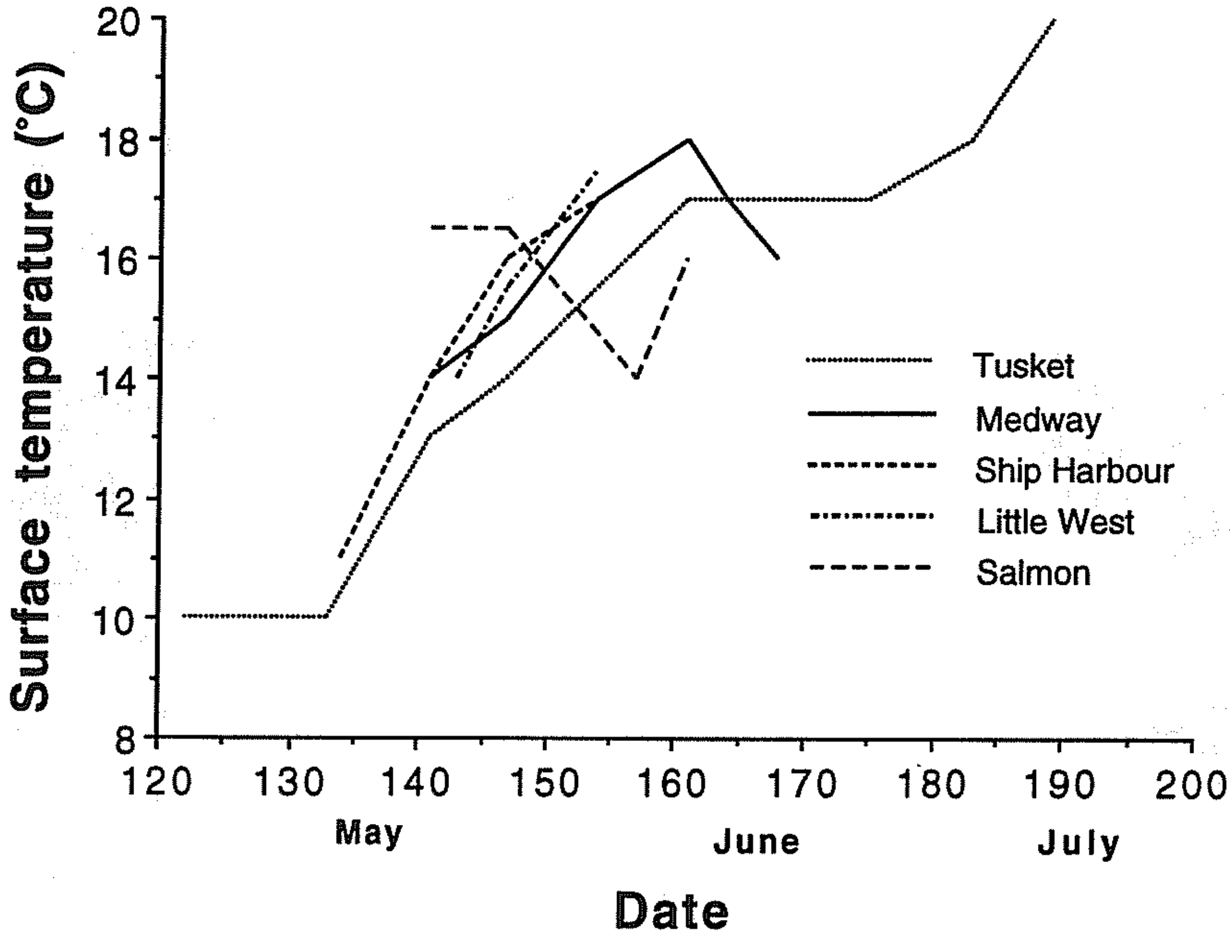


FIG. 2. Surface water temperatures (°C) obtained concurrently with alewife and blueback herring collections from five Nova Scotia rivers, 1985.

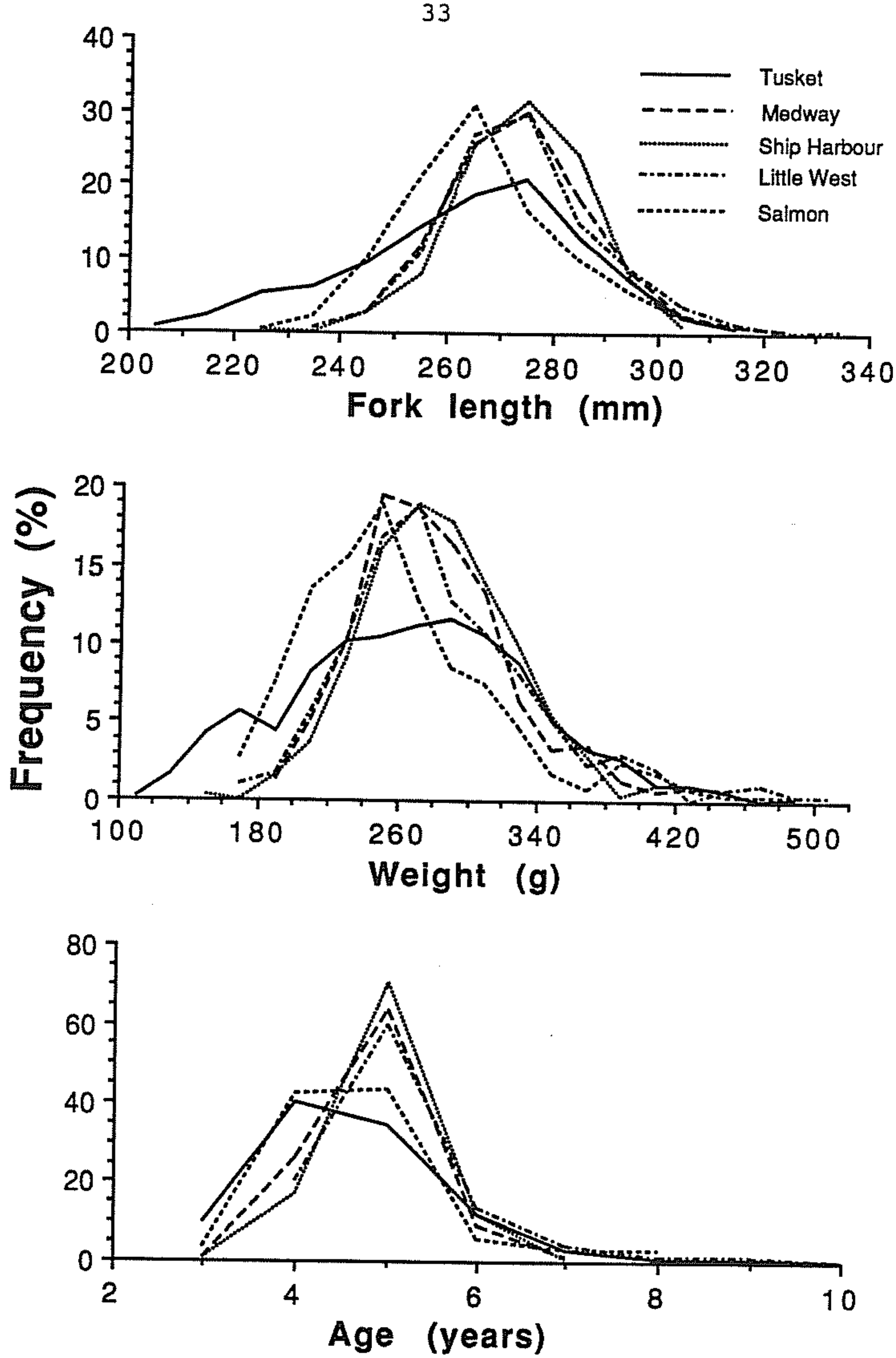


FIG. 3. Percent frequency of fork length, weight and age distribution of alewives from five Nova Scotia rivers, 1985.

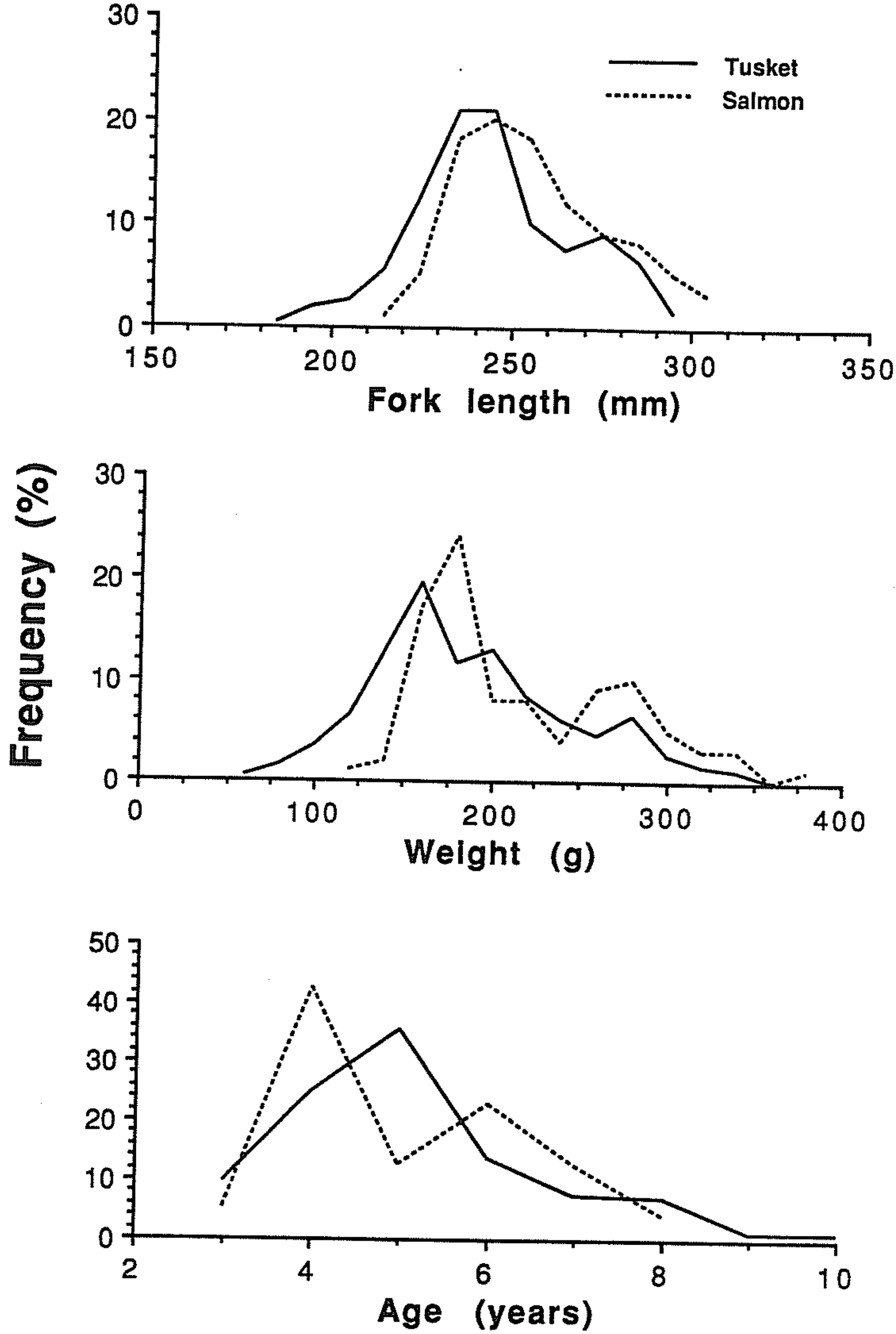


FIG. 4. Percent frequency of fork length, weight and age distribution of blueback herring from the Tusket and Salmon rivers, 1985.