A Survey of the Atlantic Silverside Fishery of Prince Edward Island, 1979

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Department of Fisheries and Oceans
Halifax, Nova Scotia

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The growth and increasing value, since its inception in 1973, of the commercial fishery for Atlantic silversides in Prince Edward Island prompted a survey in 1979 to provide information on the fishery and on the biology of the species for use in its management. Daily catch and effort data were obtained from logbooks distributed to all trap-net fishermen in Queens and Kings counties, while life-history data were obtained by sampling at four representative fishing sites.

Both catch and fishing effort increased during 1979, to approximately 316 metric tons (t), caught in 23 licensed traps. In Queens and Kings counties, over 275 metric tons were caught in 3,620 net-days of effort, for a catch per unit effort of 0.076. The largest catches occurred in Fishery District 88 (Souris area), traditionally the largest producer, but catch-per-unit-effort values were similar between districts.

The age-structure, length- and weight-compositions, and sex ratios were generally similar between sampling locations, with the exception that fish from Colville Bay (Souris area) were significantly larger than elsewhere. Most silversides were age 0+, with approximately 2.6% being age 1+ or older. Female silversides were larger on average than males at age 0 but not at age 1. The sex ratio for age-0 fish was 1:1 male:female but at age 1, females outnumbered males by 3 to 1.

Silverside stocks do not presently appear to be overfished, but additional information on the life history of the species and continued monitoring of the fishery is necessary to ensure the maintenance of an economic fishery.

Key words: Atlantic silverside (*Menidia menidia*), commercial fishery, Prince Edward Island, life history.

RÉSUMÉ

Jessop, B.M. and D.L. Morantz. 1982. A survey of the Atlantic silverside fishery of Prince Edward Island, 1979. Can. Data Rep. Fish. Aquat. Sci. No. 1639. ix + 17 p.

Depuis ses débuts en 1973, la pêche commerciale des capucettes à l'Ile-du-Prince - Edouard à crû en volume et en valeur. Dans le but de se reseigner sur cette industrie et sur la biologie de l'espèce pour fins de gestion, on a entrepris en 1979 des releves de statistiques de pêche. Les carnets de bord des pêcheurs aux filets-trappes des comtés de Queens et de Kings nous on fourni les données sur les prises et l'effort quotidiens. Un programe d'échantillonnage à quatre lieux de pêche représentatifs a permit la collecte de données sur le cycle biologique des capucettes.

Les prises et l'effort de pêche augmentèrent tous deux en 1979, atteignant environ 316 tonnes métriques (t) dans 23 trappes munies de permis. Dans les comtés de Queens et de Kings, un effort de pêche de 3 620 jours-filets a donné plus de 275 t, les prises par unité d'effort étant de 0,076. Les prises les plus abondantes furent dans l'arrondissement de pêche n° 88 (région de Souris), traditionnellement le plus productif. La valeur des prises par unité d'effort fut toutefois la même dans tous les arrondissements.

La structure par âge, la répartition des longueurs et des poids, ainsi que la proportion des sexes sont généralement semblables d'un site d'échantillonnage à l'autre, sauf que les poissons de la baie Colville (région de Souris) sont nettement plus grands que les autres. L'âge de la plupart des capucettes est 0+, environ 2,6 % étant d'âge 1+ ou plus. Les femelles sont en moyenne plus grandes que les mâles à l'âge 0+ mais non à l'âge 1. La proportion des sexes des poissons d'âge 0+ est de 1:1, mais à l'âge 1, le rapport est de 3:1 en faveur des femelles.

Les stocks de capucettes ne semblent pas surexploités. Il faudra cependant recueillir des données supplémentaires sur le cycle biologique de l'espèce et continuer de surveiller la pêche afin d'assurer le maintien d'une exploitation rentable.

Mots clés: capucettes (*Menidia menidia*), pêche commerciale, Ile-du-Prince-Edouard, cycle biologique.

INTRODUCTION

The Prince Edward Island Atlantic silverside (*Menidia menidia*) commercial fishery has expanded in recent years due to the increasing Japanese demand for it as a food fish. The present study was implemented to provide catch and effort statistics and biological information needed to manage the stock effectively. Existing life-history data for the silverside originates almost exclusively from the Atlantic coast of the United States (Hildebrand 1924; Bayliff 1950; Bigelow and Schroeder 1953; Leim and Scott 1966; Austin et al. 1975; Barkman 1978) and cannot be assumed to fully describe populations in the Maritime Provinces of Canada.

Although Atlantic silversides were commercially caught on Prince Edward Island during the 1940s (McKenzie and Day 1949), the present silverside fishery began in 1973 as an experimental program in the Little Harbour and Cardigan areas of Kings County and has recently spread to all three counties (Fig. 1). It remains the only commercial exploitation of this species in the Maritime Provinces.

Silversides are reportedly abundant in the estuaries of eastern Prince Edward Island, from Wood Island to Tracadie Bay, becoming progressively scarcer to the west, with areas west of Malpeque (Prince County) being almost devoid of commercial quantities (Cavanagh 1981).[1] The commercial catch statistics reflect the natural distribution (Table 1). Between 1973 and 1979, total landings increased from 142 to 319 tonnes (t), worth $91,000 in 1979; but landings and fishing effort in 1980 were down sharply in almost all areas.

Seines were used in 1973 and 1974 but were later banned because the quality of catch suffered during contact with stirred up bottom sediments, and because seines were thought to be too efficient. Since 1975, only fish traps and dip-nets have been employed, the latter accounting for an insignificant proportion of the catch. In 1978, dip-nets were used more extensively than in other years and still accounted for a total of only about five tonnes (2% of total catch). In 1979, no dip-nets were used (D. Rix, Conservation and Protection Division, personal communication). Traps are generally set close to shore, in the mouths of rivers or at the heads of bays or harbours. Dip-nets are employed in similar areas, but mainly off wharves and in spillways. Originally, the silverside season ran from October 1 to December 10 but was extended to December 31 in 1979. In practice, the fishery lasts only as long as ice conditions permit. Traps fish continuously and are usually emptied daily, with the exception of Sundays, when the processing plants are closed. Quotas, typically about 23 tonnes (50,000 lb) per trap per season, are set on each net fished. Increases have been granted occasionally, particularly in the Souris area. Silverside traps vary in shape and size but all have a mesh size of about 6.35 mm (0.25 in.) and a maximum leader length of 30 m. Dip-nets vary in construction, ranging from hand-held units to large nets hooked to the end of a swivelling boom.

Following capture, the silversides are loaded into plastic trays and sold to buyers from several local seafood plants. The whole, round fish is then quick frozen in blocks of 5, 16.5, 25 and 50 lb and shipped to Japan and, less frequently, Korea. In 1973, prior to establishment of its desirability for human consumption, a quantity of fish was also converted to meal.

[1] Memorandum, Jan. 12, 1977, from C. Cavanagh, Prince Edward Island Dept. of Fisheries.

METHODS AND MATERIALS

BIOLOGICAL SAMPLING

Four silversides trap-net fishermen from different locations provided weekly samples from their catches during their 1979 fishing period. The traps sampled were located at: Colville Bay (Souris Harbour), Cardigan River (adjacent to causeway), Little Sands (mouth of Dan's Creek), and Hillsborough River (near bridge at Charlottetown)(Fig. 1). Samples were not necessarily available each week at every site, since occasionally the traps were not fished or were removed to be cleaned. Following removal of the trap, samples were collected by dip-net at Little Sands on November 20 and 27, and December 4. Similarly, a dip-net sample was taken at Cardigan on November 27.

A sample of 100-200 fish was non-selectively taken by each fisherman and was picked up for analysis within hours of being caught. Samples for immediate processing were refrigerated; those retained in excess of 24 hours were frozen. Generally, all samples were processed within 36 hours of capture. A subsample of 100 fish was chosen at random from each sample. All fish were measured (fork-length) to the nearest millimetre, weighed to the nearest 0.1 gram, and sexed by dissection and visual examination of the gonads. During the early part of the study, scales were collected from a sub-subsample of 50 of these fish to determine age and spawning history. Later (beginning Oct. 30), when it became apparent that all yearling (age 1+) silversides exceeded 100 mm fork length, only those fish 98 mm or larger were scale sampled. The scales were easily interpreted, so were aged once, jointly, by two persons. From October 30 onwards, all fish less than 98 mm in length were assigned age 0. Wherever age has been employed as a factor in analysis, only those fish aged by scale sample or collected from October 30 onwards have been used. The visual identification of ovary and testis was confirmed histologically for a group of 10 fish by Dr. C. Morrison, Department of Fisheries and Oceans, Halifax.

STATISTICAL ANALYSIS

The objective of the data analysis was to determine whether statistically significant ($P<0.05$) differences occurred in the mean lengths of Atlantic silversides caught by the commercial trap-net fishery in different geographic areas of Prince Edward Island as well as during the fishing season at a given location. The relations between age, sex and fish size were also examined. Only length data were analysed because of the close relationship between length and weight.

One-way analyses of variance tests (ANOVA) were made with the length data grouped: (a) by age and sample date for each site, (b) for each age-group and for ages combined, and (c) by age-sex group within sites, with linear contrasts used to compare age and sex groupings. The possible presence of linear trends in sample mean lengths over time was investigated by subdividing the "among dates of sum squares" into sums of squares due to regression and due to unexplained variability. Length was used as the dependent variable (Y) and sample date as the independent variable (X). One-way analyses of variance were used instead of the potentially more efficient multi-way analyses, because of the presence of cells with few and unequal or zero data values.

Tests were made for violations of certain of the assumptions underlying the use of the analysis of variance (Steele and Torrie 1960). The assumption that the residuals (observed, minus predicted values) are normally distributed with constant variance was tested by examination of the residuals versus the independent variable and plots of the cumulative percent distribution of sample lengths (Draper and Smith 1966; Sokal and Rohlf 1969). Normality of the sample data was also examined by calculating the Kolomogorov-Smirnov D statistic, while F-max tests were employed to check for homogeneity of variances in both total and age-grouped sample data. Independent distribution of the residuals was assumed.

The relationship between length and weight was calculated by geometric mean regression of the logarithmically transformed data (Ricker 1975), using up to 30 length-weight pairs, randomly selected from the total data set, per 5-mm length interval.

CATCH AND EFFORT DATA

Each licensed silverside trap-net fisherman (with the exception of two fishermen in Prince County) was provided with a booklet in which to record daily catches, fishing time (length of time the trap was actively fishing), and location for each trap fished. Each printed form in the booklet was capable of holding entries for a one-week period.

Monthly and catch-per-unit-effort statistics were compiled for each fishery district based upon the data from individual fishermen.

RESULTS

BIOLOGICAL DATA

The mean fork lengths and mean weights of the samples collected from each site between October 9 and December 4 are illustrated (Fig. 2) and summarized (Table 2). The large decline in length and weight of silversides collected by dip-net at Little Sands on November 20 and 27, and December 4, as compared with lengths and weights of previous trap-netted samples, may reflect gear selectively rather than actual fish distributions. The dip-net samples have thus been omitted from all analyses except the length-weight regressions.

Analyses of variance revealed no significant linear trends over time in mean lengths of silversides collected at any of the four locations sampled (Table 3). For Colville Bay, and Cardigan and Hillsborough rivers, the mean squares for deviations from regression were significant ($P<0.01$), due, in this case, primarily to the significant ($P<0.001$) differences in mean lengths between sampling dates.

The presence of two age groups in most samples contributed to a slight but non-significant deviation from normality of the sample length distributions according to the calculated Kolomogorov-Smirnov D statistic ($P<0.05$ for all but one sample from Colville Bay where n 100, $D=0.144$ and $0.05>P>0.02$). The combined age data for each site showed heterogeneous variances but residual plots suggested marked heterogneity only in the Colville Bay data, which was confirmed by F-max tests (Table 4). A chi-square test for equality of means with heterogeneous variances supported the ANOVA conclusion of significant differences in mean lengths between sampling dates for the Colville Bay data as well as for Cardigan and Hillsborough rivers (X^2 = 113.15, 19.21, 17.05; df = 5, 3, 2, respectively; $P<0.005$).

Division of the samples by age (ages 0 and 1) resulted in non-significant ($P>0.05$) values for F-max tests in all groupings except age-0 fish from Colville

Bay (Table 4). In this case, significant ($P<0.001$) heterogeneity of the group variances can be attributed to one sample with an unusually small variance. Testing of the group variances with this sample excluded resulted in a conclusion of homogeneous variances (variance ratio 1.69, df[4,40], $P>0.05$). The degree of heterogeneity of variances existing in these data is unlikely to seriously bias the conclusions reached by any of the ANOVA or regression procedures that follow (Glass et al. 1972; Green 1979).

Silverside juveniles (age 0) averaged 85.5 mm in length and 4.6 g in weight, while adults (age 1) averaged 113.9 mm and 11.2 g (Table 5). Size overlap was minimal between ages at all sites (Table 5 and Fig. 3) with the exception of one age-0 fish from the Hillsborough River, although it cannot be considered an outlier according to Grubb's test (T_n = 2.65, where $T_{26}[0.95]>2.66$). Age-0 fish differed significantly ($P<0.01$) in mean lengths between sample dates for three of four sites (exception was Little Sands), while age-1 fish (at Colville Bay and Hillsborough River, where numbers sufficient for testing were captured) did not (Table 3). For the Colville Bay site, exclusion of the sample with the anomalously low variance did not alter the conclusion of significant differences in mean lengths of age-0 fish between sample dates ($F_{[4,325]} = 4.52$, $P<0.01$).

Lengths varied significantly ($P<0.004$) between silversides caught at different sites, for fish of both age 0 and age 1 (Table 6). Age-0 silversides from Colville Bay were about 5% longer than those from elsewhere, a highly significant difference ($P<0.001$); while fish from the Hillsborough River were marginally smaller ($P = 0.04$) than those from Cardigan River (Table 7). At age 1, fish from the Hillsborough River were longer than those from Colville Bay and Cardigan River ($P<0.02$), with other differences marginal at best.

Significant differences ($P<0.001$) occurred in the mean lengths of different age-sex groups at each site (Table 8). Linear contrasts between groups divided by age and sex indicated that, at all sites, age-0 silversides were significantly ($P<0.001$) smaller than age-1 silversides (sexes combined) and males were significantly ($P<0.01$) smaller than females (ages combined) (Table 9). The usually significant interaction terms support the examination of individual age-sex-groups, which revealed at age 0, males were significantly ($P<0.01$) shorter than females at all sites, while at age 1, males and females did not differ significantly ($P>0.05$) in length (Table 10). Separation into age-sex groups further reduced the overlap of group length distributions.

Age 1 comprised 4.4% of the sample from Colville Bay, 2.3% from Cardigan River, 1.3% from Little Sands and 5.2% from the Hillsborough River (Table 5). The 46 age-1 fish represent 2.9% of the total sample of fish that were aged. Only one age-2 fish was caught.

Male:female sex ratios for age-0 silversides were similar at all sites and did not differ significantly ($P>0.01$) from 1:1; but at age 1, significantly more ($P<0.01$) females than males were observed (33 vs 11).

No significant differences existed between sexes in weight at a given length, as determined by regression analysis of the data combined by site (Table 11). Accordingly, the data were pooled by sex. The geometric mean regression equation (Ricker 1975) of the logarithmically transformed (base 10) data is: log weight $=-5.5001 + 3.1804$ (log length), where $n = 348$, $r^2 = 0.98$, $S^2_{y.x} = 0.0014$, and $P<0.001$ (Fig. 4).

DISTRIBUTION OF THE COMMERCIAL FISHERY

In 1979, silversides traps were distributed along the eastern and southern coasts of Prince Edward Island, with 11 and 10 traps being set in Kings and Queens counties, respectively (Fig. 1). The Colville Bay (Souris Harbour) and Little Harbour areas could be considered the center of the fishery. There were only two traps located in Prince County (see inset, Fig. 1), one each in Cascumpeque Bay and Darnley Basin.

COMMERCIAL CATCH DATA

Silversides catches and fishing effort were greatest in Statistical District 88, particularly in Colville Bay and Little Harbour (Table 1). Catches in other statistical districts were about 20% or less of those in District 88. The catch per unit of effort averaged 0.076 tonnes (t) per net-day for the total fishery but ranged from 0.099 t/net-day in District 87 to 0.056 t/net-day in District 85.

When only those areas included in the logbook survey are considered, the catches compiled by the Statistics Division of the Department of Fisheries and Oceans from sales slips differ by less than 1.6% from landings recorded by logbook (Table 12). Discrepancies in the statistical district totals, as in Districts 85 and 86, probably occur when sales slips reflect the location where fish were sold rather than caught. The catch grand totals do not agree, since logbooks were not distributed to the two fishermen in Prince County (Districts 92 and 93).

DISCUSSION

Silversides differed significantly in size at each age between sample sites representing the major fishing areas, with fish from Colville Bay being the largest and, as indicated by annual catches, the most abundant. Local fishermen recognize the Souris area (Colville Bay and Little Harbour regions of Statistical District 88) as the best silversides fishing grounds in the province, and it is apparent that conditions for fish growth and production are superior there. Such size at age differences imply the presence of local populations with, perhaps, limited coastal movement prior to offshore migration.

Lengths differed between sampling dates at three of four sites, although no trend over time was evident. This pattern may reflect sampling variability as well as local movement of schools of fish but does indicate that seasonal growth had ceased by mid-October when the first samples were collected. Growth cessation during winter has been reported for silversides from Chesapeake Bay (Bayliff 1950) and Massachusetts (Conover and Ross, in press).

The scarcity of age-1 or older silversides (<3% of total sample) implies a heavy mortality during the year following the first summer of growth. Severe winter mortality has been reported by Bayliff (1950) and Conover and Ross (in press), the latter concluding that differences in abundance of up to 99% may occur between fall juveniles and spring adults. The cause of winter mortality is unknown but could include exposure to cold temperatures, and predation and physiological stress resulting from offshore migration (Conover and Ross, in press).

Between 1973 and 1979, landings of silversides more than doubled, in response to increased fishing effort prompted by the ready marketability and increasing value to fishermen. In 1979, concern about possible over-harvesting and the concentration of fishing effort led to implementation of a limited entry and effort scheme, whereby fishing effort in heavily exploited areas is controlled at existing levels and new entrants or increased effort by existing fishermen are limited to new fishing areas. In 1980, the Japanese market for silversides collapsed and local fish processors restricted purchases. No nets were set in District 87 and only two in District 88, which resulted in sharply reduced landings.

Despite considerable fishing pressure in some years, there has been no clear evidence of overharvesting. Such evidence would include a sharp decrease in catch and catch/effort, followed by recovery 2-3 years after an appropriate reduction in quota and fishing effort. Given the present poor market for silversides and reduction in fishing effort, there is no need for change in existing regulatory measures. However, the continued collection of catch/effort data, particularly during any extended period of increasing fishing effort, is fundamental to the development of an effective management scheme for the fishery. In this case, effectiveness could be based upon supporting economic viability of the fishery for individual fishermen through an adequate catch/effort ratio. Heavy exploitation of the available inshore stock during autumn and early winter seems permissable, given a near complete annual migration of biomass to offshore areas and high overwinter mortality (Conover and Ross, in press), since the harvest potential of the stock is unlikely to be fully exploited by the quantity and type of gear presently used. However, although the proportion of silversides undergoing offshore migration during winter may be high, it is not total since they have been caught underneath the winter ice in Prince Edward Island (Needler 1940). Thus, in view of the uncertain proportion of silversides migrating offshore, their brief life span and the unknown extent of coastal movement and intermixing of populations, either in autumn when the fishery occurs or in spring when spawning occurs, caution should be used in the process of creating regulations for managing a fishery. It should also be realized that any significant exploitation creates uncertain effects upon the ecological relationships of the silversides with other forage fishes and with predators which may be of commercial importance (Bayliff 1950).

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TABLE 1. Reported landings of Atlantic silversides by the commercial fishery, Prince Edward Island, 1973-80.

	Commercial landings (tonnes), by statistical district											
	Prince Co.				Queens Co.				Kings Co.		Total	Value
Year	82	83	92	93	85	86	95	96	87	88	landings	($,000)
1973	–[1]	–	–	–	–	–	–	–	24	118	142	–[2]
1974	–	–	–	–	–	–	–	–	–[2]	–[2]	–[2]	–[2]
1975	–	–	–	–	–	–	–	–	21	48	69	7
1976	–	–	–	–	–	–	–	–	6	88	94	14
1977	–	–	–	–	–	–	–	–	28	125	153	30
1978	–	–	5	3	–	–	–	–	60	142	210	67
1979	–	–	32	12	6	21	–	0	42	206	319	91
1980	–	–	–	2	4	17	–	–	–	36	59	14

[1]Except where otherwise noted dashes indicate no commercial fishing.

[2]Fishing occurred, but statistics unavailable.

TABLE 2. Sample statistics for Atlantic silversides collected from four sites on Prince Edward Island, 1979 (n = 100 for all samples).

		Fork length (mm)			Weight (g)		
Site	Date	Mean	SD	Range	Mean	SD	Range
Colville Bay	Oct 9	92.4	8.80	77-119	6.17	2.013	3.2-14.4
	Oct 17	92.8	11.22	73-125	6.12	2.620	2.9-16.3
	Oct 23	92.7	7.95	74-116	5.85	1.551	2.9-11.6
	Oct 30	89.8	7.64	75-114	5.42	1.616	2.6-12.2
	Nov 7	95.4	3.52	86-103	6.44	0.653	5.3-8.6
	Nov 20	87.3	8.26	69-113	4.77	1.446	2.2-10.4
Cardigan River	Oct 16	90.1	12.50	66-123	5.96	2.757	2.0-15.7
	Oct 23	88.3	9.22	55-112	5.29	1.694	1.2-11.3
	Nov 20	84.3	9.03	58-105	4.33	1.406	1.3-9.5
	Nov 27	88.5	7.98	59-105	4.92	1.324	1.2-7.9
Little Sands	Oct 16	86.0	10.10	66-120	5.38	2.137	2.8-14.2
	Oct 23	84.7	10.53	52-115	4.88	1.951	1.0-12.7
	Oct 30	86.5	7.40	70-109	4.96	1.238	2.5-8.7
	Nov 7	84.7	8.03	66-102	4.53	1.284	2.1-7.4
	Nov 20	74.8	9.49	49-103	3.55	1.268	0.9-7.9
	Nov 27	78.6	8.91	61-122	3.61	1.495	1.6-13.4
	Dec 4	79.8	8.50	60-105	3.51	1.153	1.4-8.1
Hillsborough River	Oct 24	88.6	12.63	65-123	5.18	2.624	1.9-14.3
	Oct 31	82.9	9.03	50-105	4.15	1.325	0.7-7.9
	Nov 8	87.4	12.33	64-126	4.77	2.360	1.6-13.1

TABLE 3. Analysis of variance, by sample date, of the lengths (sexes combined) of Atlantic silverside of different ages, from four sites on Prince Edward Island, 1979.

Source	df	SS	MS	F	Probability
AGE 0					
Colville Bay					
Among dates	5	4,173.7	843.73	20.17	<0.001
Due to regression	1	50.6	50.61	1.22	>0.25
Unexplained	4	4,123.1	1,030.78	24.91	<0.001
Within dates	424	17,545.8	41.38		
Total	429	21,719.4			
Cardigan River					
Among dates	3	935.5	311.84	3.89	<0.01
Due to regression	1	99.8	99.78	1.24	>0.25
Unexplained	2	835.7	417.85	5.21	<0.01
Within dates	288	23,097.2	80.20		
Total	291	24,032.7			
Little Sands					
Among dates	3	254.0	84.65	1.35	>0.25
Due to regression	1	0.2	0.17	0.17	>0.50
Unexplained	2	253.8	126.90	2.02	>0.10
Within dates	292	11,335.5	62.79		
Total	295	18,589.4			
Hillsborough River					
Among dates	2	884.0	442.02	5.56	<0.005
Due to regression	1	142.3	142.33	1.79	>0.10
Unexplained	1	741.7	741.70	9.34	<0.001
Within dates	234	18,587.1	79.43		
Total	236	19,471.1			
AGE 1					
Colville Bay					
Among dates	4	64.1	16.02	0.60	>0.50
Due to regression	1	26.3	26.26	0.99	>0.25
Unexplained	3	37.8	12.60	0.48	>0.50
Within dates	15	397.7	26.51		
Total	19	461.8			
Hillsborough River					
Two sample t-test	11	-	-	0.08	>0.50

TABLE 4. Homogeneity of variance-test statistics for lengths of age-0, age-1 and combined-age groups of Atlantic silversides from four sites on Prince Edward Island, 1979.

Age-0				Age-1				Combined ages[1]			
Samples	F-max	df_1/df_2	Prob	Samples	F-max	df_1/df_2	Prob	Samples	F-max	df_1/df_2	Prob
Colville Bay											
6	5.31	43/100	<0.01	3	4.09	3/6	>0.05	6	10.15	100/100	<0.01
Cardigan River											
4	1.70	48/99	>0.05	-[2]	-	-	-	4	2.45	100/100	<0.01
Little Sands											
4	1.45	49/100	>0.05	-	-	-	-	4	2.02	100/100	<0.05
Hillsborough River											
3	1.08	45/92	>0.05	2	1.88[3]	8/5	>0.1	3	1.96	100/100	<0.05

[1] Includes unaged fish.
[2] Small sample size precludes test.
[3] Two-sample F-test.

TABLE 5. Sample statistics for Atlantic silversides, by age and sampling date, from four sites on Prince Edward Island, 1979.

	Age 0							Age 1						
		Fork length (mm)			Weight (g)				Fork length (mm)			Weight (g)		
Date	n	Mean	SD	Range	Mean	SD	Range	n	Mean	SD	Range	Mean	SD	Range
Colville Bay														
Oct 9	44	89.0	6.23	77–102	5.33	1.167	3.2–7.9	6	115.0	3.85	108–119	11.73	1.605	9.7–14.4
Oct 17	43	89.1	8.12	73–102	5.24	1.376	2.9–7.6	7	114.0	5.80	106–122	11.37	2.207	8.4–14.7
Oct 23	48	92.0	6.51	77–104	5.58	1.205	3.0–8.3	2	110.5	–	105–116	9.80	–	8.5–11.1
Oct 30	97	89.2	6.78	75–106	5.26	1.319	2.6–8.8	3	110.3	5.51	104–114	10.67	1.790	8.7–12.2
Nov 7	100	95.4	3.52	86–103	6.43	0.642	5.3–8.6	0	–	–	–	–	–	–
Nov 20	98	86.8	7.50	69–105	4.65	1.220	2.2–7.9	2	112.5	–	112–113	10.30	–	10.2–10.4
Total	430	90.4	7.12	69–106	5.43	1.300	2.2–8.8	20	113.3	4.93	104–122	11.11	1.778	8.4–14.7
Cardigan River														
Oct 16	46	85.2	9.82	66–105	4.72	1.702	2.0–8.1	3	111.3	5.86	107–118	11.43	2.250	9.8–14.0
Oct 23	48	86.1	10.30	55–106	4.83	1.640	1.2–9.4	2	110.5	–	109–112	11.00	–	10.7–11.3
Nov 20	99	84.1	8.83	58–104	4.28	1.312	1.3–8.4	1	105.0	–	–	9.50	–	–
Nov 27	99	88.3	7.91	59–105	4.89	1.296	1.2–7.8	1	102.0	–	–	7.90	–	–
Total	292	86.0	9.09	55–106	4.65	1.450	1.2–9.4	7	108.9	5.15	102–118	10.53	1.879	7.9–14.0
Little Sands														
Oct 16	47	85.3	7.69	72–100	5.02	1.363	2.8–8.0	3	115.0	5.57	109–120	12.50	1.997	10.3–14.0
Oct 23	49	84.1	8.90	65–102	4.75	1.543	2.0–8.5	1	115.0	–	–	12.70	–	–
Oct 30	100	86.5	7.40	70–109	4.96	1.238	2.5–8.7	0	–	–	–	–	–	–
Nov 7	100	84.7	8.03	66–102	4.53	1.284	2.1–7.4	0	–	–	–	–	–	–
Nov 20	99	78.1	9.21	49–100	3.51	1.196	0.9–7.2	1	103.0	–	–	7.90	–	–
Nov 27	99	78.2	7.80	61–98	3.51	1.127	1.6–6.7	1	122.0	–	–	13.40	–	–
Dec 4	100	79.8	8.51	60–105	3.51	1.153	1.4–8.1	0	–	–	–	–	–	–
Total	594	82.0	8.87	49–109	4.15	1.403	0.9–8.7	6	114.2	7.08	103–122	11.92	2.364	7.9–14.0
Hillsborough River														
Oct 24	45	88.2	9.05	71–115	4.96	1.754	2.2–11.9	5	117.4	3.78	111–120	11.80	1.616	9.8–14.3
Oct 31	100	82.9	9.03	50–105	4.15	1.325	0.7–7.9	0	–	–	–	–	–	–
Nov 8	92	84.7	8.71	64–102	4.21	1.342	1.6–7.5	8	117.6	5.18	109–126	11.29	1.618	8.0–13.1
Total	237	84.6	9.08	50–115	4.32	1.449	0.7–11.9	13	117.5	4.52	109–126	11.49	1.449	8.0–14.3
Grand Total														
	1,553	85.5	8.49	49–115	4.62	1.390	0.7–11.9	46	113.9	4.98	102–126	11.23	1.728	7.9–14.7

TABLE 6. Analysis of variance, by age group (sexes combined), between sites, of the lengths of Atlantic silversides from Prince Edward Island, 1979.

Source	df	SS	MS	F	Probability
Age 0					
Among sites	3	7,363.2	2,454.38	36.63	<0.001
Residual	1,251	83,812.7	67.00		
Total	1,254	91,175.8			
Age 1					
Among sites	3	363.1	121.05	5.22	<0.004
Residual	40	927.8	23.20		
Total	43	1,291.0			

TABLE 7. Matrix of t-values and probabilities, according to age-group (sexes combined), for comparisons among sites of mean lengths of Atlantic silversides from four sites on Prince Edward Island, 1979.

	Colville Bay		Cardigan River		Little Sands		Hillsborough River	
	t[1]	P	t	P	t	P	t	P
Age-0 df=1,251								
Colville Bay	-	-						
Cardigan River	-6.98	<0.001	-	-	-			
Little Sands	-8.20	<0.001	-1.09	0.28	-	-	-	
Hillsborough River	-8.71	<0.001	-2.01	0.04	-0.98	0.33	-	-
Mean length	90.4		86.0		85.3		84.6	
Sample size	430		292		296		237	
Age-1, df=40								
Colville Bay	-	-						
Cardigan River	-2.07	0.04	-	-				
Little Sands	0.66	0.51	2.03	<0.05	-	-		
Hillsborough River	2.50	0.02	3.84	<0.001	0.92	0.36	-	-
Mean length	113.3		108.9		115.0		117.5	
Sample size	20		7		4		13	

[1]Uses pooled error variance from ANOVA in two-sided t-test for age-group means.

TABLE 8. Analysis of variance, by age-sex group, of the lengths of Atlantic silversides from four sites on Prince Edward Island, 1979.

Source	df	SS	MS	F	Probability
Colville Bay					
Among age-sex groups	3	11,244.6	3,748.21	79.80	<0.001
Residual	446	20,947.4	46.97		
Total	449	32,192.0			
Cardigan River					
Among age-sex groups	3	4,098.2	1,366.08	17.04	<0.001
Residual	295	23,655.2	80.19		
Total	298	27,753.4			
Little Sands					
Among age-sex groups	2	4,361.5	2,180.76	36.36	<0.001
Residual	296	17,754.0	59.58		
Total	298	12,115.5			
Hillsborough River					
Among age-sex groups	3	14,226.5	4,742.18	61.84	<0.001
Residual	246	18,864.8	76.69		
Total	249	33,091.3			

TABLE 9. Linear contrasts between age-sex groups of Atlantic silverside from four sites on Prince Edward Island, 1979.

Contrast	t-value[1]	Probability
Colville Bay, df = 446		
Age 0 vs age 1[2]	-64.52	<0.001
Male vs female[3]	- 6.42	<0.001
Interaction	- 6.95	<0.001
Cardigan River, df = 295		
Age 0 vs age 1	-31.23	<0.001
Male vs female	- 2.44	0.015
Interaction	- 2.85	0.005
Little Sands, df = 297		
Male vs female[4]	- 2.05	0.042
Hillsborough River, df = 246		
Age 0 vs age 1	-33.60	<0.001
Male vs female	- 2.19	0.029
Interaction	- 1.96	0.051

[1] For contrasts in group means.
[2] Sexes combined.
[3] Ages combined.
[4] Numbers of age-1 fish insufficient for additional tests.

TABLE 10. Comparison of mean lengths, by age-sex group, of Atlantic silversides from four sites on Prince Edward Island, 1979.

	n	Fork length (mm) (male, age 0) Mean	SD	Range	n	Fork length (mm) (female, age 0) Mean	SD	Range	t-value[1]	P
Colville Bay	226	88.9	7.05	69–103	204	92.0	6.83	72–106	4.82	< 0.001
Cardigan River	152	84.7	9.13	58–106	140	87.4	8.85	55–105	2.59	0.01
Little Sands	139	83.3	7.54	65–100	157	87.0	7.90	68–109	2.82	< 0.001
Hillsborough River	116	82.6	8.62	50–102	121	86.5	9.13	64–115	3.33	< 0.001
		(male, age 1)				(female, age 1)				
Colville Bay	6	109.2	4.36	104–114	14	115.0	4.15	106–122	1.74	> 0.08
Cardigan River	3	109.2	8.19	102–118	4	108.7	2.87	105–112	−0.04	> 0.9
Little Sands	0	–	–	–	4	115.0	4.55	109–120	–	–
Hillsborough River	2	117.5	–	115–120	11	117.5	4.82	109–126	–	n.s.[2]

[1] Uses pooled error variance from ANOVA in t-test for age-sex group means.
[2] n.s. means non-significant.

TABLE 11. Tests of equality of slopes and adjusted means from the regressions of $\log_{10}$ weight with $\log_{10}$ length for male and female Atlantic silversides (pooled by site) from Prince Edward Island, 1979.[1]

Source	df	SS	MS	F	Probability
Equality of slopes	1	0.00012	0.00012	0.05	>0.75
Residual	1,996	2.49078	0.00249		
Equality of adj. means	1	0.00215	0.00215	1.72	>0.10
Residual	1,997	2.49090	0.00125		

[1] Residual variances were homogeneous; $F_{[1014,983]} = 1.02$, $P>0.05$.

TABLE 12. Commercial landings of Atlantic silversides on Prince Edward Island in 1979, as reported from sales slips and logbooks completed by individual fishermen.

Number of traps	Month	Catch reported from sales slips (t)	Fishermen's logbook catch data: Reported catch (t)	Effort (net-days)[1]	Catch/effort (t/net-day)
Statistical District 88					
8	Oct	107.00	105.43	1,336	0.079
	Nov	95.72	103.47	1,376	0.075
	Total	202.72	208.90	2,712	0.077
Statistical District 87					
4	Oct	26.89	26.76	280	0.096
	Nov	15.24	12.56	116	0.108
	Total	42.13	39.32	396	0.099
Statistical District 86					
4	Oct	-	16.52	172	0.096
	Nov	5.95	2.14	128	0.017
	Total	5.95	18.66	300	0.062
Statistical District 85					
3	Oct	20.58	8.04	87	0.092
	Nov	-	0.74	69	0.011
	Total	20.58	8.78	156	0.056
Statistical District 96					
2	Oct	0	0	34	0
	Nov	0	0	22	0
	Total	0	0	56	0
Statistical District 93[2]					
1	Oct	0.25	-	-	-
	Nov	-	-	-	-
	Total	0.25	-	-	-
Statistical District 92[2]					
1	Oct	0.12	-	-	-
	Nov	18.91	-	-	-
	Dec	13.39	-	-	-
	Total	32.42	-	-	-
Statistical District 83[2]					
0[3]	Oct	0.08	-	-	-
	Nov	11.92	-	-	-
	Total	12.00	-	-	-
Grand Total		316.05	275.66	3,620	0.076

[1]One net-day equals one net (trap) fishing for all or part of one day.

[2]Logbooks were not distributed to fishermen in these districts.

[3]There were no silverside traps set in this district; the catches recorded on sales slips were likely caught elsewhere but sold in the Summerside area.

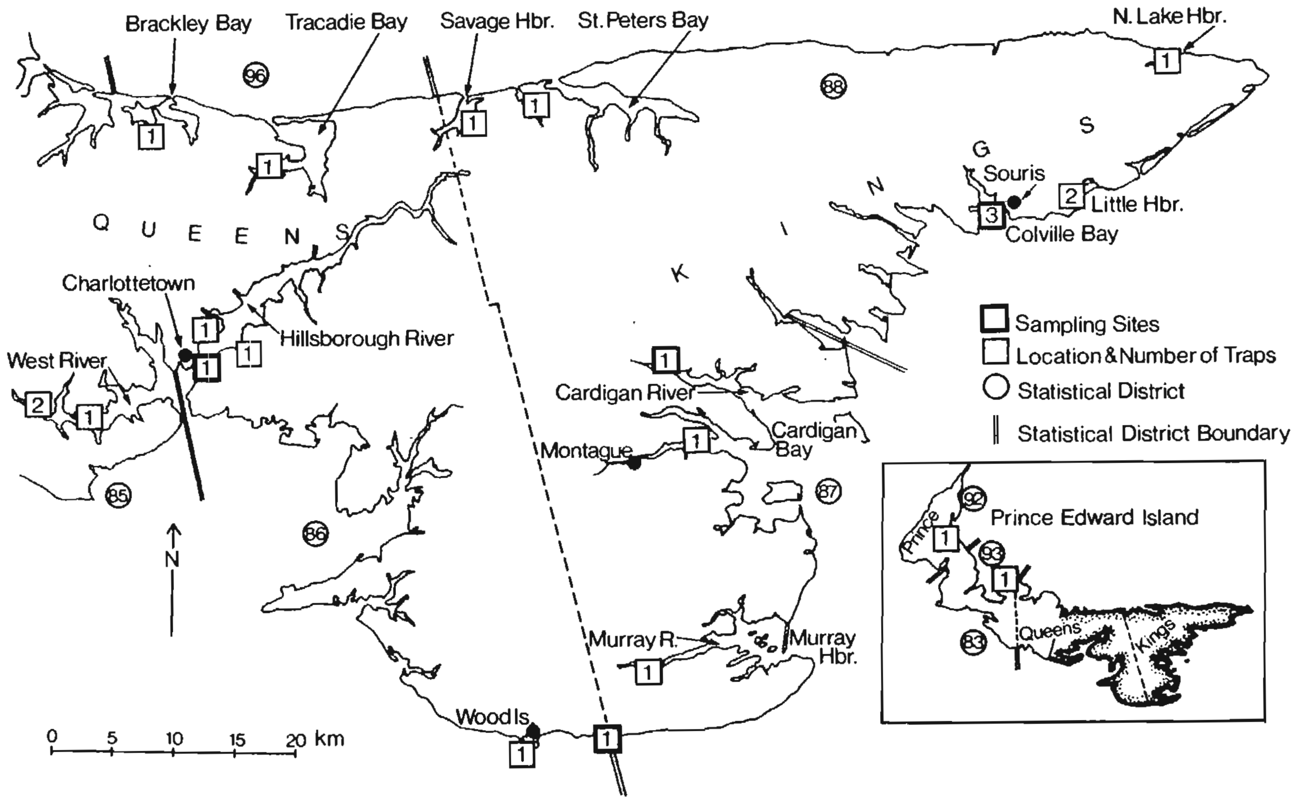

FIG. 1. Distribution of Atlantic silverside traps and locations of sampling sites on Prince Edward Island, 1979.

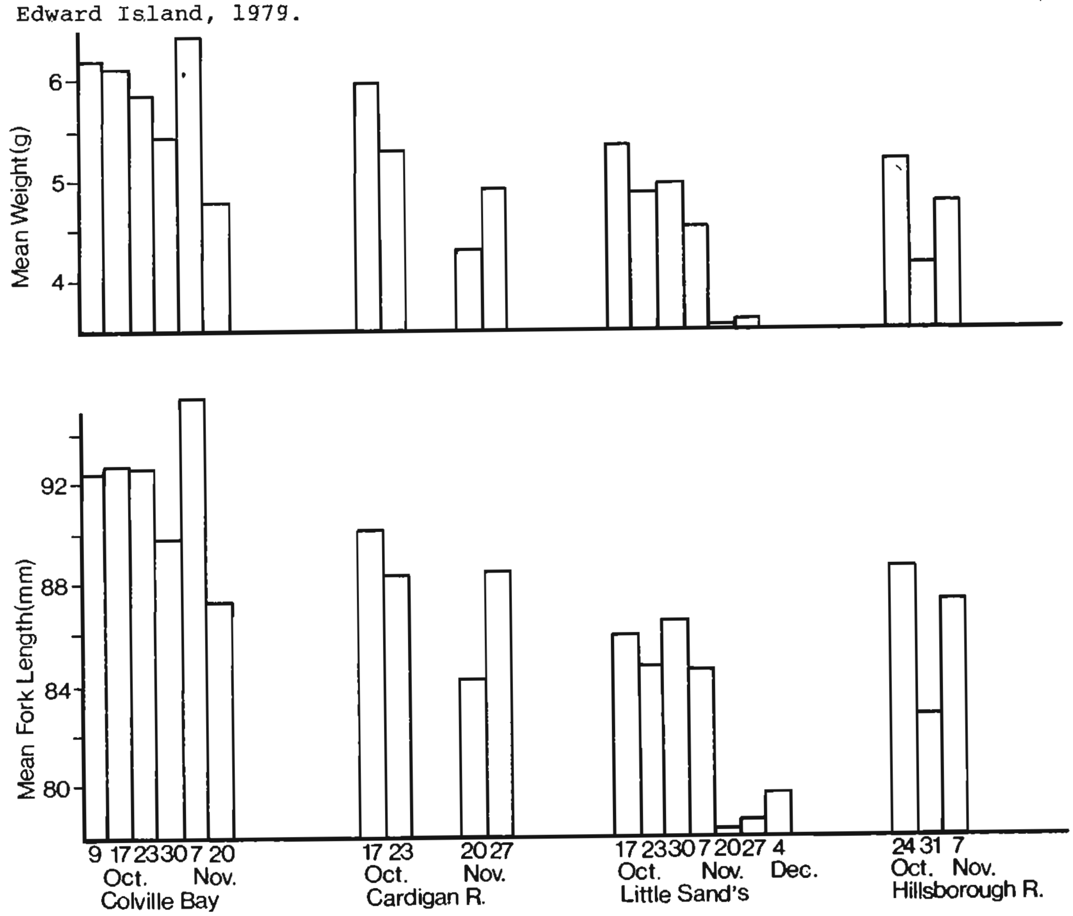

FIG. 2. Mean lengths and weights of Atlantic silversides sampled on different occasions at four sites on Prince Edward Island, 1979.

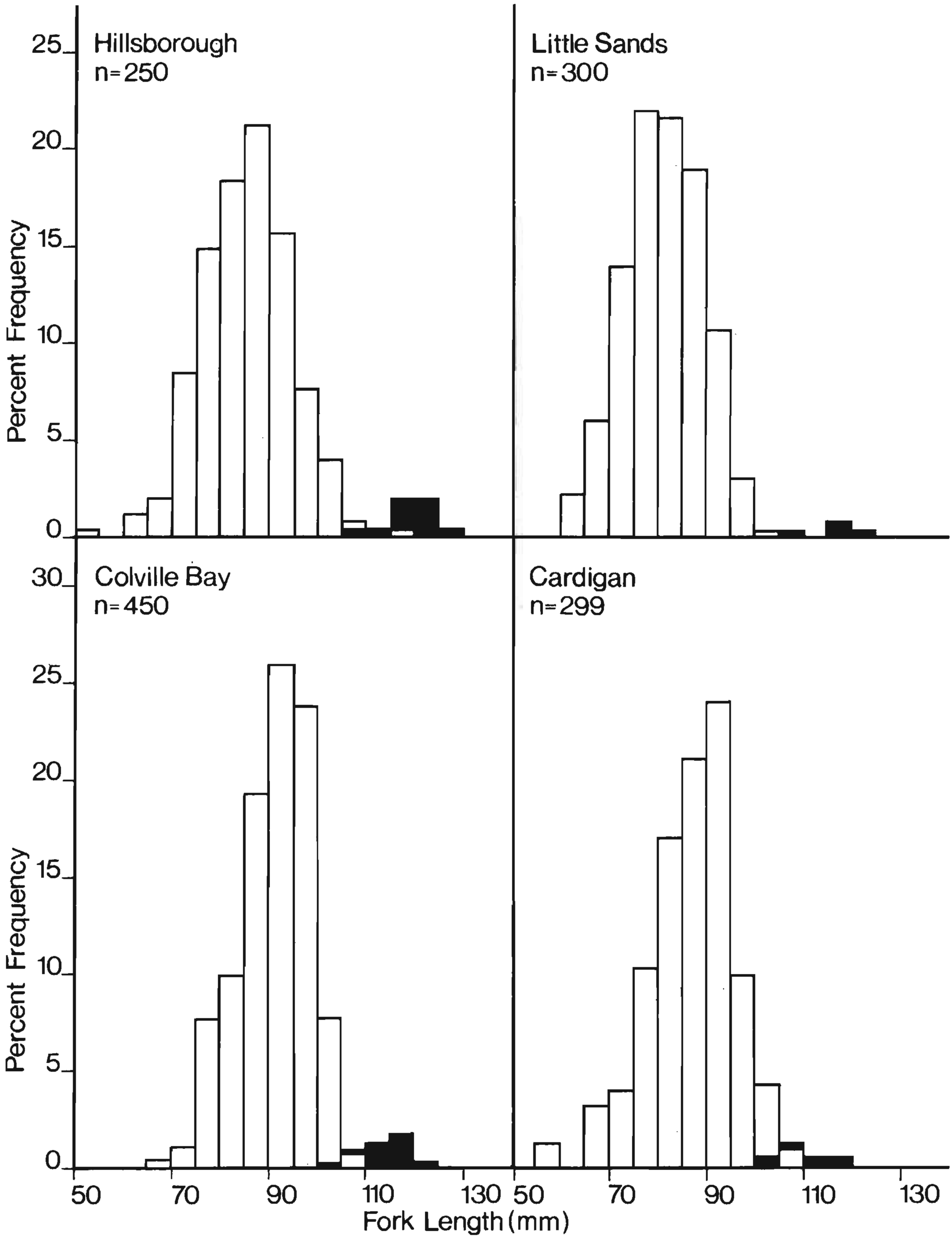

FIG. 3. Age-length frequency distributions of Atlantic silversides from four sites on Prince Edward Island, 1979.

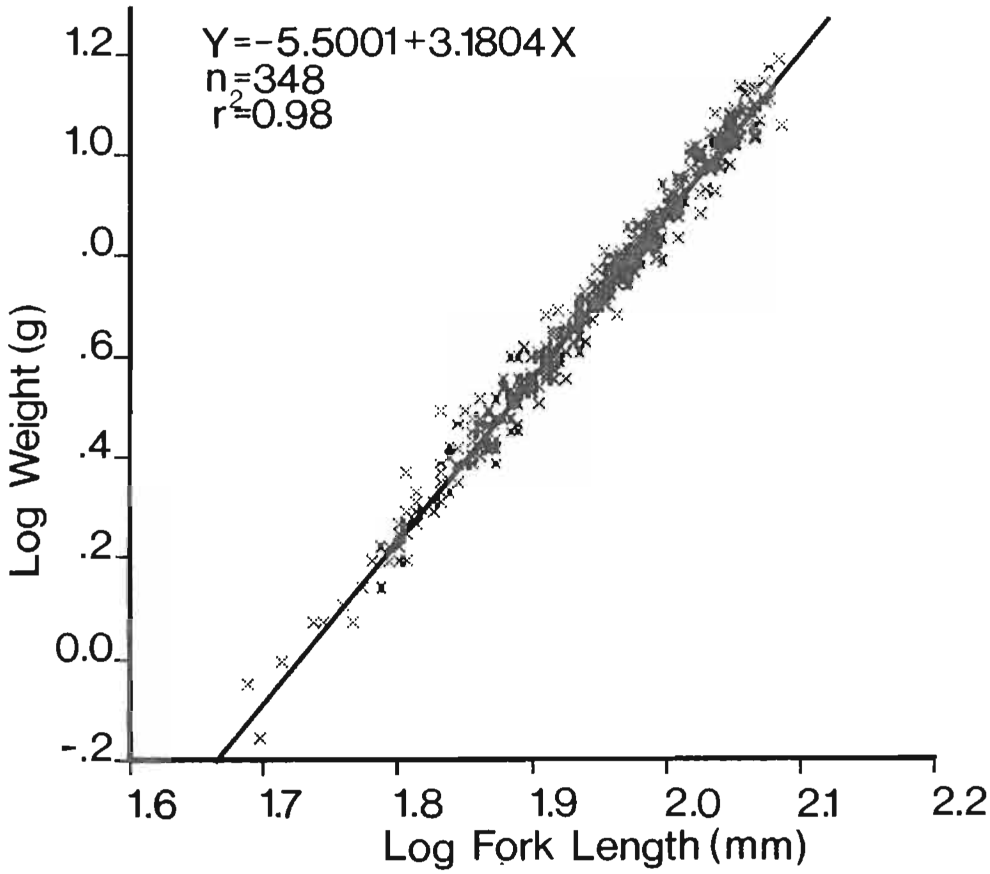

FIG. 4. Log-log geometric mean regression of weight vs length for Atlantic silversides from Prince Edward Island, 1979.

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