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Supplementary data on meristic characteristics of herring (*Clupea harengus harengus* L.) stocks of the southern part of the Gulf of St. Lawrence, the southern coast of Newfoundland and Banquereau Bank

by

A. Forest and D. Briand
CRIP, ISTPM
St. Pierre et Miquelon

I. Introduction

The development of an intensive herring fishery in the Gulf of St. Lawrence-Nova Scotia Shelf-southern coast of Newfoundland has brought many authors to investigate the possible existance of a number of stocks in this region and the relationships that could exist between them.

Actually, if one is familiar with the migratory patterns of the Gulf of St. Lawrence herring, its relationships with nearby stocks, particularly those of Nova Scotia and Banquereau Bank, controvercies arise which necessitate a more thorough study.

The techniques used in the course of this study are numerous: length composition and age of the fish caught, tagging, nematode infestation, meristic characteristics, etc. Thus, since 1970, CRIP at St. Pierre and Miquelon has conducted a systematic study of the herring stocks in Div. 4R, 4T, 4Vn, 4Vs, 4W and 3Pn where the collection of diverse biological data are gathered (length, weight, age, sex and maturity stages, gonadal-somatic condition, fat content) and certain meristic characteristics studied (number of keeled scales, of rays in the dorsal, anal and pectoral fins, of vertebrae, of gill rakers). This work has already been the subject of some publications (Decamps, 1971 and 1972; Decamps and Briand, 1973 and 1974).

In this paper we have concentrated on meristic characteristics in order to effer more supplementary data to the study of the inter-relationship between the stocks from the Gulf of St. Lawrence, southwest coast of Newfoundland, Nova Scotia Shelf and Banquereau Bank.

II. Methods

Station distribution as well as the sampling year are shown in Fig. 1. All of these samples were taken from the end of winter to the beginning of spring (March to May) except for numbers 5 (July 1972) and 6 (November 1972). The R/V *Cryos* completed all sampling with either a bottom or mid-water trawl. The study technique of these samples has been described by Decamps (1971). The herring were separated into an autumn and a spring population and into juveniles depending on their gonadal-somatic condition. Juvenile herring were not used in this study.

For the spring and autumn herring populations Tables 1 to 5 show for each characteristic and by station, the number of individuals studied, the mean and the variance.

In order to compare the means of each characteristic between stations, we have used the analysis of variance technique (Fisher F test), and tested the null hypothesis for the probability $p = 0.01$. Re-grouping samples, we have been able to compare different means. Calculation of chi-square shows that certain tested distributions did not perfectly fit the normal curve, but this is of not much consequence for the technique used, as the divergence around the norm was in general weak. However, it was necessary in one case to make a correction: the gill raker distribution for station 6 (Cape Dolphin) shows two modes which the Cassie (1954) method permits to isolate; one corresponds to a mean of 46.20, the other to 49.50. Indeed the young were represented in this sample, and as it was shown by Krefft (1958) the number of gill rakers is a function of size for the youngest individuals. It is this corrected value (49.50) which was used in the calculations.

III. Meristic Characteristics Study

1) Autumn herring

a) Number of keeled scales (K-2). In 1972, the difference between the stations is significant, and two groups can be distinguished. The test did not show any obvious differences between the inshore stations, but there was a difference between the inshore and offshore stations.

- Cape St. Georges, Table Point, St. Paul Island, Cape Dolphin (stations 1-6): the K-2 varied from 13.812 (Cape St. Georges) to 13.926 (Table Point).

- Banquereau and Sable Island Banks (stations 7-10), with a K-2 variation from 14.129 to 14.202.

In 1973 the difference between stations 11-20 is not significant. However, it must be noted that the K-2 frequency distribution for station 20 (Sable Island) is distinctly asymmetrical, so that the Cassie method does not allow us to isolate two populations. The highest K-2 values are found in the Sable Island area, but they are lower than those of 1972.

For the 1974 samples (21-24) the values vary from 13.853 to 14.029 and the test shows no significant difference.

b) Number of dorsal fin rays. Counting these rays presents a problem as the first dorsal fin ray is not always well developed; also there is some differences of opinion between authors (Parsons, 1973).

We cannot bring forth any evidence of differentiation between stations 1-20 and the values are between 19.348 (Bonne Bay) and 19.552 (St. Paul Island).

In 1974, the values are higher (19.560-19.759) but the test shows no difference between them.

For the description of these characteristics, Messieh (1974), finds a difference between all of the spring herring and autumn herring between Ste. Anne Bay and Chedabucto Bay.

c) Number of pectoral fin rays. In 1972 the difference between stations is significant, but it is difficult to show a clear trend: three stations different from each other, but apparently homogeneous between them, St. Georges Bay (station 1: 18.305), Dead Island (station 3: 18.290), Cape Dolphin (station 6: 18.312). For the other samples, the mean number of pectoral rays varies from 18.489 (Banquereau Bank) to 18.621 (Table Point) without showing and difference between them.

In 1973, two stations different from one another show distinctly high values: Bay of Islands (station 13: 18.820) and Bird Rock (18.767). For these samples, there are fewer individuals than for the others (61 and 43 respectively). The mean number of pectoral rays varied from 18.457 (station 15, Martin Point) to 18.604 (station 12, St. Georges Bay) for the rest of the stations.

In 1974, the four stations did not show a difference and the values were between 18.538 and 18.611.

If one compares all of the samples together (1-24) with the exception of stations 1 (St. Georges Bay), 3 (Dead Island), 6 (Cape Dolphin), 13 (Bay of Islands) and 18 (Bird Rock), the test shows no significant difference.

In order to be able to compare our values with those of other areas, we have used Parsons (1973) data for Gabarous Bay (18.474), Magdalen Islands (18.489) and the southwest coast of Newfoundland (18.579); no significant difference was shown.

d) Number of anal fin rays. Counting the number of anal fin rays did not begin until 1973. For this year, it is not possible to show evidence between the mean values which varied from 18.094 (station 16, St. Paul Island) to 18.377 (station 13, Bay of Islands).

Similarly, the 1974 values do not seem different and are between 17.999 (station 22) and 18.278 (station 24). They are not different from all of the 1973 samples.

We note that Parsons (1973) demonstrated a significant difference between Gabarous Bay (18.080) and the Magdalen Islands (18.300).

e) Number of vertebrae. Analysis of variance does not show any difference between the 1972 samples: the mean vertebral variation is from 55,544 (Cape Dolphin, station 6) to 55.710 (Dead Island).

Similarly, in 1973, there is a mean vertebral variation of 55.393 (Sable Island, station 20) and 55.643 (Bird Rock, station 18) and shows no significant difference.

In 1974, they varied between 55.447 to 55.510, the differences being not significant.

Briefly, the test used showed no significant difference between all of the stations. We note that the values given by Parsons (1973) for Gabarous Bay (55.497), Magdalen Islands (55.617) and the southern coast of Nova Scotia (55.610) are not significantly different from ours.

On one hand there is a positive correlation between the mean number of vertebrae of stations 11-20 and the stations' latitude (Fig. 2). The coefficient correlation is significantly different from zero ($r = 0.75$; $p \simeq 0.01$). This corresponds to the principle of a decrease in the number of vertebrae with latitude. On the other hand the coefficient correlation is not significant for stations 1-10 ($r = 0.39$; $p \simeq 0.10$).

f) Number of gill rakers. As we have seen, the mean of station 6 (Cape Dolphin) was corrected by the Cassie method.

In 1972, the difference between stations is significant but interpretation is difficult: there appears to be no clear tendency; we can indeed show three different groups:

- station 4 (St. Paul Island, 48.783)
- station 8 (Sable Island, 49.825 and 50.179)

These in particular are different than those of Banquereau Bank (49.489 and 49.593).

For all other stations, the mean varied between 49.261 (St. Georges Bay, station 1) to 49.593 (Banquereau, station 9).

For the 1973 samples, interpretation is not any easier since two stations are different (Bird Rock, station 18: 48.256 and Sable Island, station 19: 49.658) while the other stations do not show a significant difference and vary between 49.115 to 49.532.

Finally, in Parsons (1973) description he finds a significant difference between Gabarous (49.655), Magdalen Island (48.997) and the southwest coast of Newfoundland (49.166).

2) Spring herring

a) Number of keeled scales. In 1972 the difference between all stations is significant and three groups can be distinguished:

- St. Georges Bay (stations 1 and 2), Dead Island (station 3): the K-2 between 13.622 to 13.830.

- St. Paul Island (station 4) and Cape Dolphin (station 6): 13.447 and 13.370.

- Sable Island (station 10): 14.214.

In 1973, all of the means are heterogenous and the three following groups are found:

- St. Georges Bay (stations 11 and 12), Bay of Islands (station 19), Bonne Bay (station 14) and Martin Point (station 15): the K-2 values between 13.718 to 13.825.

- St. Paul Island (stations 16 and 17) and Bird Rock (station 18) with a K-2 variation of 13.214 to 13.520.

- Sable Island (stations 19 and 20): 14.075 and 13.900.

The test does not establish any significant difference between the 1972 and 1973 stations for the same group.

b) Number of dorsal fin rays. In 1972, no significant difference was established and the means varied from 19.145 (st. Georges Bay, station 1) to 19.536 (Sable Island, station 10).

In 1973, two stations, different from the others, showed no significant difference between them: this concerns stations 17 (St. Paul Island, 19.515) and 19 (Sable Island, 19.487). This difference is possibly due to the small number of individuals in each sample (64 and 39 respectively). The test does not establish a significant difference between the other stations, and the mean variation of 19.121 (St. Paul Island, station 16) to 19.268 (St. Georges Bay, station 12). Finally, the difference between stations 1 to 20, except 17 and 19, is not significant.

c) Number of pectoral fin rays. Analysis of variance shows a significant difference between the 1972 stations: the mean number of pectoral fin rays for Sable Island (station 10: 18.464) gives a higher value than all of the others. For the other stations, the mean varied from 17.289 (station 6, Cape Dolphin) to 17.579 (station 5, Table Point).

In 1973, the situation is identical: the means for stations 19 and 20 (Sable Island) are higher than the others (18.000 and 18.100), but no difference between them. Analysis of variance does not show a difference between stations 11 to 18 and the means varying from 17.222 (St. Paul Island, station 16) to 18.379 (station 17).

d) Number of anal fin rays. Analysis of variance shows no significant difference between the stations 11 to 20 with a mean variation of 17.690 to 17.985. Similarly, Parsons (1973) did not establish a difference between the Magdalen Islands (17.691) and the southwest coast of Newfoundland (17.598).

e) Number of vertebrae. In 1972, two stations different from the others but not different between themselves: this concerns samples 4 (St. Paul Island, 55.400) and 6 (Cape Dolphin, 55.133). For the other samples, there is a mean vertebral variation of 55.592 to 55.808.

In 1973, stations 13 (Bay of Islands, 55.918) and 20 (Sable Island, 55.333) are different and different from the others. For all the other stations, no difference was established and the values are between 55.428 (St. Paul Island, station 17) and 55.701 (St. Georges Bay, station 12). We can also note that there exists a positive correlation between the vertebral mean and latitide for stations 11 to 20 ($r = 0.75$; $p \simeq 0.01$, Fig. 3). This correlation did not exist for the preceeding stations (1 to 10: $r = 0.39$; $p \simeq 0.20$).

f) Number of gill rakers. The means of stations 1-10 are heterogeneous and three groups can be established:

- St. Georges Bay (stations 1 and 2), Dead Island (station 3) and Table Point (station 5): the mean number of gill rakers varied from 48.405 (Table Point) to 48.581 (St. Georges Cape).

- St. Paul Island (station 4) and Cape Dolphin (station 6) with 46.652 and 46.196, respectively as their mean values.

- Sable Island (station 10): 50.357.

The situation is similar in 1973:

- St. Georges Bay (stations 11 and 12), Bay of Islands (station 13), Bonne Bay (station 14) and Point Martin (station 15), the values fluctuated from 48.311 (St. Georges Bay) to 48.662 (Bay of Islands). Analysis of variance does not show a difference with the preceeding group.

- St. Paul Island (stations 16 and 17) and Bird Rock (station 18): a mean variation from 46.526 (Bird Rock) to 46.965 (St. Paul Island, station 16). There was no evidence of a difference with the samples from the same areas in 1972.

- Sable Island (stations 19 and 20): 49.000 and 48.974. These two values did not differ between them, but differed from those of 1972; this is possibly due to the small number of individuals studied in 1972 ($m = 28$).

IV. Conclusion

For all of our samples, three characteristics do now show a significant difference: these are the number of dorsal and anal rays and the number of vertebrae.

The other characteristics show variations which do not always show a distinct tendency. For the autumn herring in 1972, the K-2 allowed two complexes to be distinguished: St. Paul Island, western coast of Nova Scotia on one side, Banquereau and Sable Island Bank on the other. As we have seen, the differences between the number of pectoral rays and the number of gill rakers are more difficult to interpret: Banquereau and Sable Island show no significant difference, but between the other stations some are closely related and others are different. The same problem exists with the gill rakers. In 1973 and 1974, the K-2 of the autumn herring regularly varied from 13.836 to 14.079, and it becomes difficult to differentiate the populations; however, the highest values correspond to the Banquereau-Sable Island area. The same problem is found with the other characteristics, suggesting a mixture of populations especially between Subdiv. 4Vs and 4Vn, as it was suggested by Stobo *et al* (1973) from the analysis of the catches. Meanwhile we note that for Hodder and Parsons (1971), these exchanges are not important.

For the spring herring, three complexes can be distinguished:

- west and southwest coast of Newfoundland with: mean K-2 values about 13.8; mean number of gill rakers about 48.5 and the mean number of pectoral rays approximately 17.5.

- St. Paul Island, Bird Rock, Cape Breton: K-2: 13.3; gill rakers: 46.5; pectoral: 17.5.

- Sable Island: K-2: 14; gill rakers: 49; Pectoral: 18.

These three groups are found each year. The presence of a complex of spring herring along the western coast of Newfoundland seems to correspond with Winters and Parsons (1972) work. These authors have indeed shown that there probably exists a local population at least in the northern part of Div. 4R. To this population which does not migrate to the south, we can possibly connect our Dead Island sample which does show a significant difference with the spring herring of the St. Paul Island and Bird Rock areas.

Finally, the relationships between the spring herring of Subdiv. 4Vn and 4Vs, if they exist, must be weak, as the two groups are well separated.

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Table 1 : Numbers of examined fishes (N), means (m) and standard deviations (S.D.) for meristic characters of autumn spawning herring from various areas, in 1972.

date		April	April	April	April	July	November	March	April	April	May
Locality		Cape StGeorges	Cape St Georges	Isle aux Morts	St Paul's Is.	Table Point	Cape Dauphin	Banquereau	Gully of Sable Is.	Banquereau	Gully of Sable Is.
N°		1	2	3	4	5	6	7	8	9	10
K_2	N	307	138	145	431	162	171	88	292	194	183
	m	13.883	13.812	13.924	13.909	13.926	13.836	14.182	14.191	14.129	14.202
	S.D.	0.607	0.665	0.557	0.603	0.603	0.550	1.093	0.802	0.693	0.789
D	N	308	137	145	431	160	169	87	288	193	184
	m	19.497	19.547	19.448	19.552	19.525	19.450	19.402	19.476	19.503	19.391
	S.D.	0.479	0.455	0.499	0.453	0.452	0.559	0.383	0.445	0.501	0.414
P	N	308	138	145	429	161	170	88	292	193	184
	m	18.305	18.522	18.290	18.548	18.621	18.312	18.489	18.548	18.570	18.603
	S.D.	0.812	0.850	0.805	0.697	0.612	0.926	0.483	0.544	0.684	0.601
V	N	308	137	145	430	161	171	88	272	194	183
	m	55.620	55.657	55.710	55.577	55.696	55.544	55.614	55.643	55.582	55.623
	S.D.	0.498	0.507	0.610	0.613	0.563	0.674	0.677	0.467	0.556	0.599
G	N	307	138	145	430	161	85*	88	292	194	184
	m	49.261	49.500	49.296	48.783	49.311	49.50*	49.489	49.825	49.593	50.179
	S.D.	2.946	3.113	2.835	3.750	2.816	1.275*	3.173	2.660	2.274	2.750

K_2 : Keeled Scales D : Dorsal fin ray P : Pectoral fin ray V: Vertebral G : Gillraker

* Estimated by CASSIE'S method

Table 2 : Numbers of examined fishes (N), means (m) and standard deviations (S.D.) for meristic characters of autumn spawning herring from various areas, in 1973.

Date		April	April	April	April	April	April	April	May	March	April
Locality		St Georges Bay	St Georges Bay	Bay of Islands	Bonne Bay	Martin Pte	N.W. St Paul's I.	N.W. St Paul's I.	Bird Rocks	N.W. Sable Is.	N.W. Sable Is.
N°		11	12	13	14	15	16	17	18	19	20
K_2	N	116	145	61	91	94	181	224	43	302	218
	m	13.889	13.903	13.836	13.912	13.872	13.873	14.004	13.953	14.079	13.982
	S.D.	0.518	0.616	0.406	0.503	0.607	0.545	0.767	0.855	0.665	0.672
D	N	116	144	61	92	94	181	225	43	301	219
	m	19.483	19.507	19.508	19.348	19.574	19.436	19.547	19.581	19.482	19.498
	S.D.	0.513	0.532	0.521	0.405	0.441	0.425	0.356	0.487	0.497	0.426
P	N	116	144	61		94	180	225	43	302	219
	m	18.500	18.604	18.820		18.457	18.517	18.542	18.767	18.506	18.521
	S.D.	0.687	0.647	0.617		0.767	0.721	0.723	0.611	0.656	0.728
A	N	115	144	61	92	94	181	223	41	300	216
	m	18.252	18.243	18.377	18.130	18.361	18.094	18.175	18.171	18.120	18.162
	S.D.	0.787	0.954	1.039	0.990	0.792	0.830	0.731	0.895	0.822	0.620
V	N	115	145	61	92	93	181	222	42	301	216
	m	55.583	55.593	55.623	55.598	55.527	55.585	55.531	55.643	55.488	55.393
	S.D.	0.439	0.646	0.438	0.529	0.339	0.500	0.558	0.479	0.677	0.547
G	N	116	144	59	92	93	174	222	43	298	218
	m	49.422	49.305	49.051	48.978	49.215	49.091	48.950	48.256	49.658	49.041
	S.D.	4.194	3.053	3.153	2.791	3.041	3.645	3.414	1.481	2.577	3.312

K_2 : Keeled scales D : Dorsal fin ray P : Pectoral fin ray A : Anal fin ray V : Vertebral

G : Gillraker

Table 3 : Numbers of examined fishes (N), means (m) and standard deviations (S.D.) for meristic characters of autumn spawning herring from various areas, in 1974.

Date		March	March	March	March
Locality		Misaine B.	Misaine B.	Misaine B.	Misaine B.
N°		21	22	23	24
K_2	N	156	102	242	258
	m	13.853	14.020	14.029	13.930
	S.D.	0.514	0.752	0.800	0.672
D	N	197	140	295	132
	m	19.665	19.693	19.759	19.560
	S.D.	0.546	0.513	0.528	0.532
P	N	157	104	244	253
	m	18.548	18.538	18.611	18.565
	S.D.	0.762	0.758	0.749	0.636
A	N	150	116	238	248
	m	18.127	17.999	18.277	18.278
	S.D.	0.804	0.845	0.807	0.772
V	N	155	104	243	253
	m	55.510	55.471	55.465	55.447
	S.D.	0.551	0.407	0.655	0.589
G	N	156	104	243	250
	m	49.115	49.308	49.152	49.532
	S.D.	3.019	3.244	2.221	2.958

K_2 : Keeled scales D : Dorsal fin ray P : Pectoral fin ray

A : Anal fin ray V : Vertebral G : Gillraker

Table 4 : Numbers of examined fishes (N), means (m) and standard deviations (S.D.) for meristic characters of spring spawning herring from various areas, in 1972.

Date		April	April	April	April	July	November	May
Locality		Cape St Georges	Cape St Georges	Isle aux Morts	StPaul's Is.	Table Point	Cape Dauphin	Gully of Sable Is.
N°		1	2	3	4	5	6	10
K_2	N	185	62	47	114	37	46	28
	m	13.816	13.822	13.830	13.447	13.622	13.370	14.214
	S.D.	0.499	0.509	0.666	0.621	0.742	0.327	0.915
D	N	183	62	47	114	38	46	28
	m	19.180	19.145	19.319	19.263	19.316	19.261	19.536
	S.D.	0.501	0.487	0.527	0.497	0.438	0.331	0.332
P	N	185	62	47	115	38	45	28
	m	17.368	17.290	17.297	17.565	17.579	17.289	18.464
	S.D.	0.440	0.504	0.518	0.599	0.521	0.483	0.999
V	N	185	62	47	115	38	45	27
	m	55.622	55.806	55.808	55.400	55.684	55.133	55.592
	S.D.	0.508	0.421	0.463	0.768	0.762	0.346	0.328
G	N	185	62	47	115	37	46	28
	m	48.530	48.581	48.574	46.652	48.405	46.196	50.357
	S.D.	2.588	3.002	2.294	3.264	2.026	1.805	0.332

K_2 : Keeled scales D : Dorsal fin ray P : Pectoral fin ray V : Vertebral
G : Gillraker

Table 5 : Numbers of examined fishes (N), means (m) and standard deviations (S.D.) for meristic characters of spring spawning herring from various areas, in 1973.

Date		April	April	April	April	April	April	April	May	March	April
Locality		St Georges Bay	St Georges Bay	Bay of Islands	Bonne Bay	Martin Pte	N.W. St Paul's I.	N.W. St Paul's Is.	Bird Rocks	N.W. Sable Is.	N.W. Sable Is.
N°		11	12	13	14	15	16	17	18	19	20
K_2	N	149	134	137	191	173	117	66	253	40	40
	m	13.178	13.761	13.825	13.785	13.809	13.214	13.530	13.277	14.075	13.900
	S.D.	0.555	0.408	0.439	0.475	0.528	0.583	0.684	0.447	0.892	0.400
D	N	147	134	137	190	171	116	64	249	39	40
	m	19.122	19.268	19.357	19.168	19.134	19.121	19.515	19.193	19.487	19.250
	S.D.	0.465	0.408	0.408	0.405	0.494	0.438	0.476	0.471	0.415	0.448
P	N	149	134	137		173	117	66	254	40	40
	m	17.335	17.373	17.277		17.266	17.222	17.379	17.224	18.000	18.100
	S.D.	0.481	0.401	0/599		0.592	0.485	0.639	0.499	0.513	0.708
A	N	147	134	136	189	167	116	64	243	39	40
	m	17.837	17.985	17.772	17.815	17.862	17.690	17.891	17.728	17.950	17.950
	S.D.	0.727	0.692	0.755	0.673	0.710	0.651	0.893	0.628	0.840	0.407
V	N	148	134	136	190	170	115	63	250	40	39
	m	55.689	55.701	55.918	55.677	55.676	55.478	55.428	55.600	55.475	55.333
	S.D.	0.570	0.617	0.539	0.614	0.563	0.567	0.475	0.385	0.409	0.544
G	N	148	131	136	188	170	114	65	251	40	39
	m	48.311	48.527	48.662	48.452	48.659	46.965	46.692	46.526	49.000	48.974
	S.D.	2.651	2.252	2.255	2.636	2.238	2.972	2.467	2.203	4.718	3.711

K_2 : Keeled scales D : Dorsal fin ray P : Pectoral fin ray A : Anal fin ray V : Vertebral

G : Gillraker

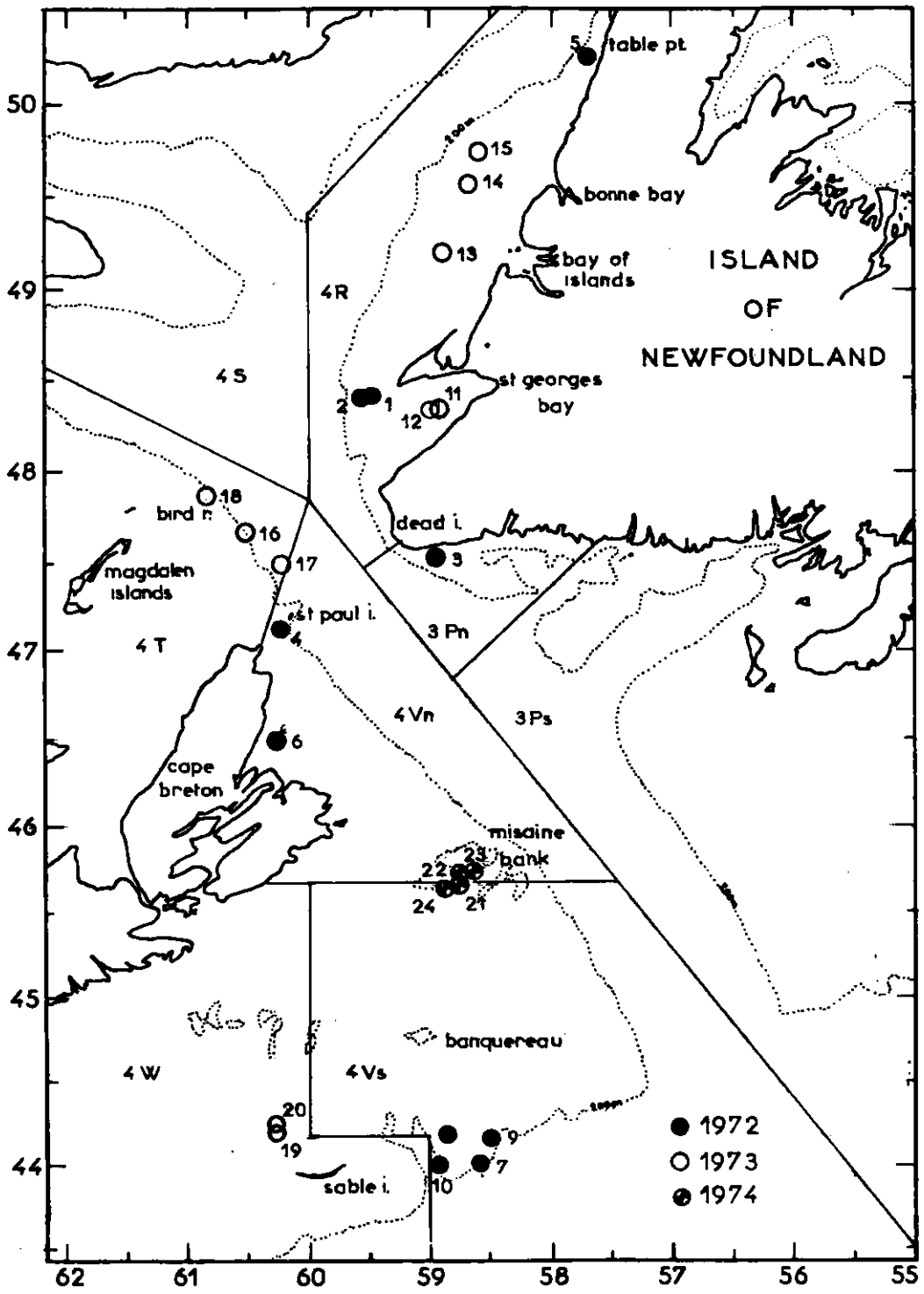

Fig. 1. Chart showing location of stations and year of sampling.

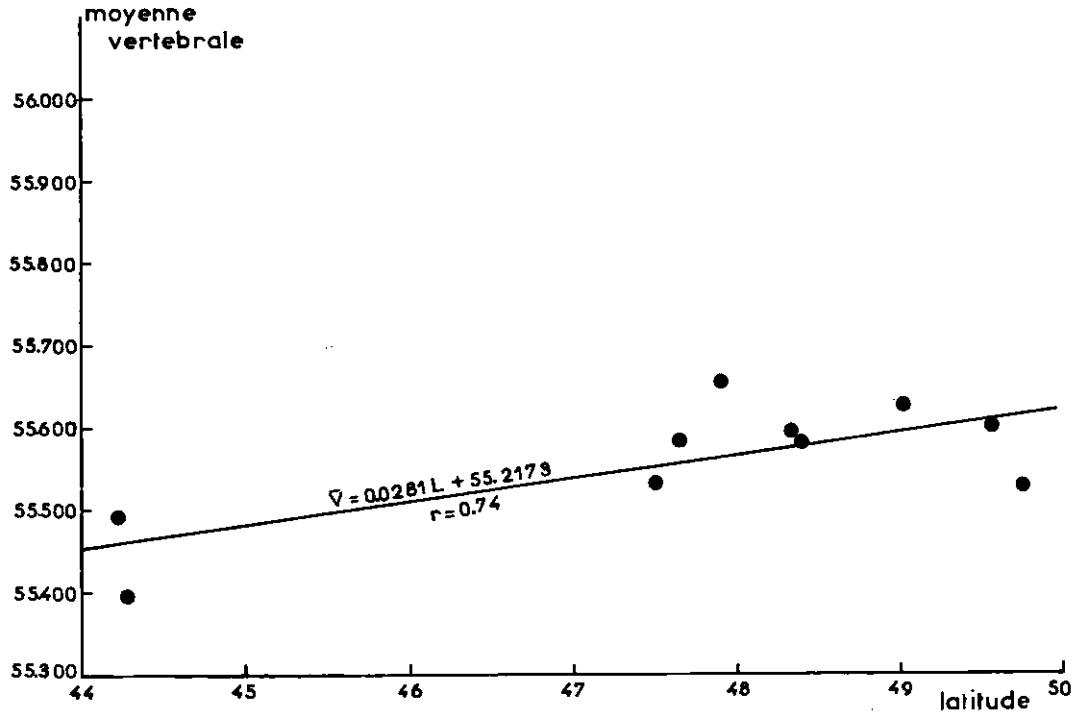

Fig. 2. Relation between average vertebral count and degrees of latitude for autumn herring in 1973.

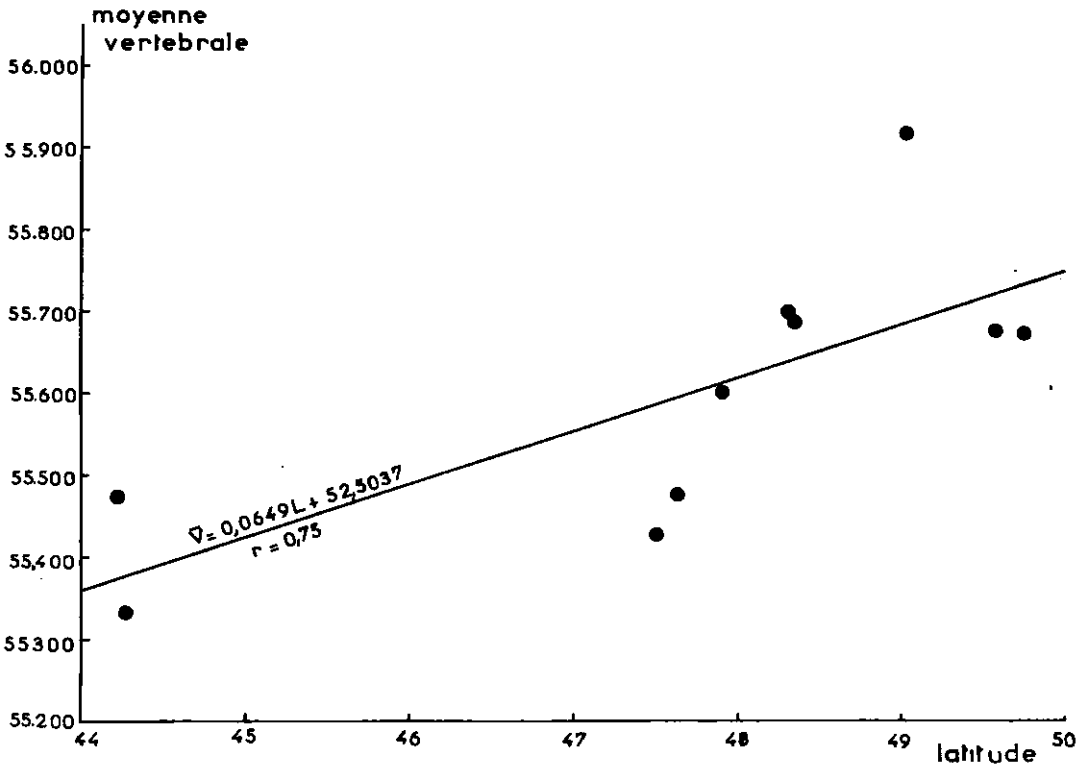

Fig. 3. Relation between average vertebral count and degrees of latitude for spring herring in 1973.