RESTRICTED

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No.1808
(D.c.2)

ICNAF Res.Doc.67/30

ANNUAL MEETING - JUNE 1967

MERISTIC COMPARISON OF ADULT HERRING FROM THE GULF OF MAINE

by
Vaughn C. Anthony and H.C. Boyar
U.S. Bureau of Commercial Fisheries
Biological Laboratory
Boothbay Harbor, Maine

The identification of stocks of herring in the Gulf of Maine is being studied by the U.S. Bureau of Commercial Fisheries. Serological methods, age, length and maturity data and parameters of growth have been investigated as indicators of racial differences. The increase in counts of meristic characters with a decrease in temperature has been documented by other scientists and is investigated in this paper. If herring remain in or return to their respective areas of spawning, they should exhibit meristics unique to that environment--in particular, greater counts should be found in colder waters. The mean temperature of surface water for September-October (Figure 1) is used as a basis for comparison, since nearly all spawning of herring occurs in the Gulf of Maine at this time. The differences in surface temperature were pronounced between areas with temperatures consistently lower in 1958 than in 1960 for all areas.

In 1962 sampling of herring (mostly spawning groups) was initiated in the Gulf of Maine. From 1962-1965, coastal samples were obtained from Stonington, Connecticut to Grand Manan, New Brunswick and from St. Mary's Bay to Port Mouton, Nova Scotia; samples from offshore were from Georges Bank. Counts of fin rays (right pectoral, dorsal and anal) and vertebrae were made from samples of 100 fish. The vertebral counts were made excluding the hypural plate. The 1958 and 1960 year classes of herring, considered to be the two most dominant year classes in recent years, were chosen for analysis (Table 1). The data were grouped on an arbitrary area basis, since little is known about the identity of stocks within the Gulf of Maine. Five areas were chosen for investigation; Western and Eastern Maine, Nova Scotia, Georges Bank and Cape Cod (Figure 1).

We examined the differences between years and sexes for each year class and each area before pooling the data. Since unequal numbers of fish were sampled from each area inequality of variances would badly invalidate analysis of variance procedures and individual area comparisons based on the t-distribution. The Bartlett test was therefore used to test for homogeneity of variance between meristic data sampled in different years for each sex, area and meristic character. Six of eighty comparisons were significant at the 5 percent level. Bartlett's test is sensitive to nonnormality and may falsely reject the hypothesis of equality of variance when the meristic frequency distribution is heavily concentrated around the mean such as occurs with herring vertebral data. Three of the significant values were with vertebral data and may have been due to nonnormality. The inferences associated with the t and the F distributions, however, are not seriously invalidated by such nonnormality.

Analysis of variance tests were conducted between years of sampling and sexes. No differences in meristic counts according to sexes were observed. There were several cases, however, in which the mean meristic counts varied significantly from year to year for the same year class in a given area. The areas chosen may have been too large and may have contained several stocks of herring, but probably the herring were not distributed equally in successive years. For example, on Georges Bank in 1964, the 1960 year class was sampled mainly in June and September-October. In June the herring were found primarily on the Southeast Part of the Banks while in September-October there was spawning on the northwest part of the Banks. The fish sampled in June had a significantly higher meristic count than all other herring obtained from Georges Bank. In the winter or spring herring apparently moved southward onto the Southeast Banks and as the season progressed were replaced with a different group of herring on the northwest portion. When a group of samples was significantly different from all other samples obtained in that area for all years the differences were clearly evident for several meristic characters in most cases. Such samples were discarded on the assumption that the herring belonged to other herring groups or stocks not normally indigenous to that area.

Fish excluded from the samples of Nova Scotia and Eastern Maine had unusually high meristic counts while those discarded from Georges Bank, Western Maine and the Cape Cod area (other than that mentioned above) had meristic counts that were unusually low. Such discarding of data will not create significant differences between areas since the meristic counts of fish from Nova Scotia and Eastern Maine are greater than those from Georges Bank and southern New England. The remaining data were combined over years of sampling and over sex. The area means and their variability are shown in Figure 2.

With the combined data, differences between areas were tested by the analysis of variance and adjusted t-tests which determined both the overall significance level among areas for each meristic count and the significance of all area comparisons (Table 2). Adult herring from Georges Bank and Cape Cod were similar as were fish from Eastern Maine, Western Maine and Nova Scotia. There is, however, some question whether the fish from Nova Scotia and Western Maine are similar in all respects. The total probability from the mean difference between Nova Scotia and the Western section was only 35 percent as compared to over 90 percent for Cape Cod-Georges Bank, Eastern-Western Maine, and Nova Scotia-Eastern Maine. The variability of meristic data in the Western section of Maine suggests that this area may be one where stocks frequently intermingle.

The counts of vertebrae and right pectoral fin rays of the two year classes, 1958 and 1960, showed statistical significance between Nova Scotia and both Georges Bank and Cape Cod, and between Western Maine and both Georges Bank and Cape Cod. The vertebral counts of the 1960 year class, and the right pectoral counts for both year classes indicated that Eastern Maine was also significantly different from both Georges Bank and Cape Cod. This strongly suggests that herring from coastal Maine and Nova Scotia comprise one complex of herring which is significantly different from the Georges Bank-Cape Cod complex.

While both year classes showed similar differences between areas, the meristic counts were not similar between the two year classes. As we had expected from the temperature data (Figure 1) the mean counts of the 1958 year class for the Maine-Nova Scotia complex were greater than the 1960 year class. The mean counts of the 1958 year class, however, for the Georges Bank-Cape Cod complex were consistently less than those of the 1960 year class. This difference may be due to a variation of spawning time from year to year irrespective of temperature. The relationship between the two year classes is generally consistent for each meristic character in both the Maine-Nova Scotia complex and the Georges Bank-Cape Cod complex and is additional evidence of the existence of two general groups of herring within the Gulf of Maine.

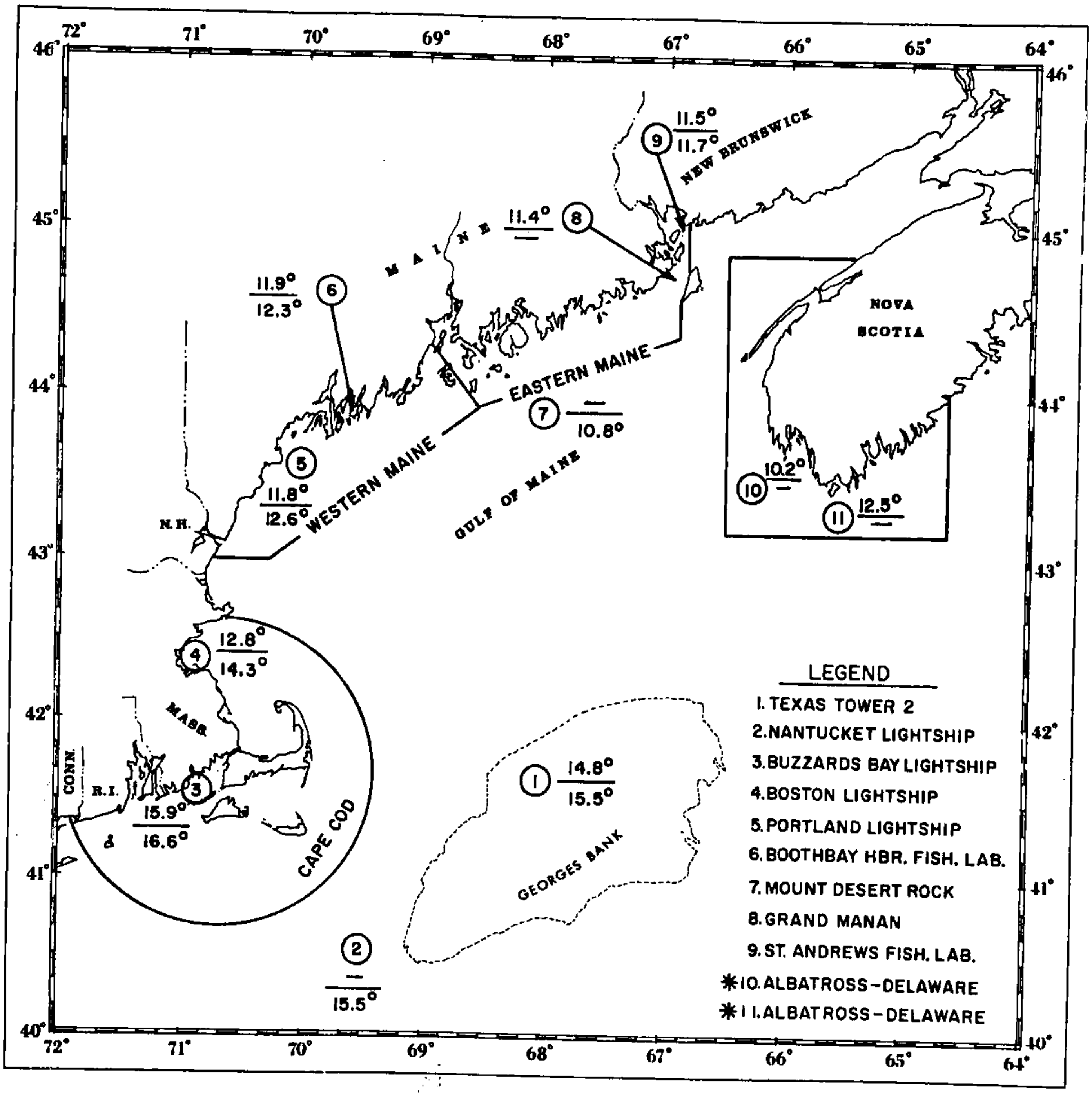

Figure 1. Areas of investigation of stocks of herring and the mean temperature (°C) of surface waters for September-October, 1958 (upper value) and 1960 (lower value) from selected sites in the Gulf of Maine. *Data available only from cruises of the R/V Albatross III and M/V Delaware.

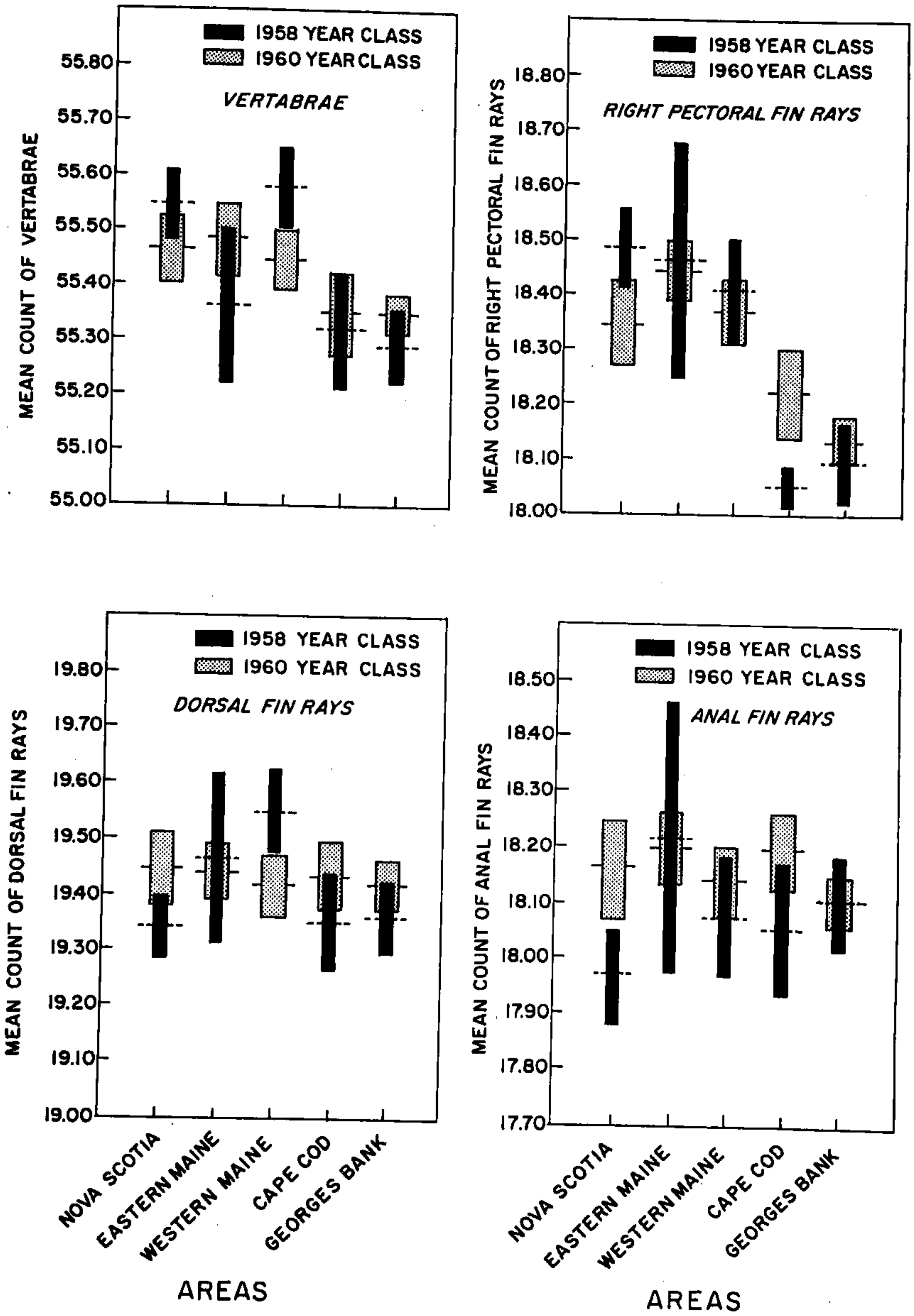

Figure 2. Mean counts of 4 meristics by area and year class (horizontal bars indicate means; vertical bars indicate 2 standard errors on each side of the mean).

Table 1. Mean Counts of Vertebrae and Right Pectoral fin rays of the 1958 and 1960 year classes from the Gulf of Maine.

AREA AND YEAR	NUMBER OF FISH				MERISTIC COUNT - MEAN NUMBER							
					Vertebrae				Right Pectoral			
	1958 Yr Class		1960 Yr Class		1958 Yr. Class		1960 Yr Class		1958 Yr Class		1960 Yr Class	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Nova Scotia												
1962	29	24	--	--	55.3793	55.7083	--	--	18.4828	18.4583	--	--
63	133	150	72	61	55.5940	55.5733	55.5417	55.2459	18.4211	18.5333	18.2361	18.2951
64	67	62	155	136	55.4179	55.5323	55.5355	55.4412	18.4776	18.5323	18.3548	18.4191
65	95	90	300	240	55.5474	55.6000	55.5133	55.6000	18.4737	18.3444	18.4967	18.4958
1962-65	324	326	527	437	55.5247	55.5828	55.5237	55.5011	18.4537	18.4755	18.4194	18.4439
Eastern Maine												
1963	49	48	--	--	55.5510	55.7500	--	--	18.6939	18.3750	--	--
64	17	21	92	93	55.3529	55.3333	55.4891	55.5376	18.2353	18.3333	18.4565	18.3441
65	12	19	321	320	55.3333	55.4211	55.4424	55.5125	18.6667	18.6842	18.4455	18.4688
1963-65	78	88	413	413	55.4744	55.5796	55.4455	55.5182	18.5897	18.4318	18.4479	18.4407
Western Maine												
1963	99	112	109	124	55.5960	55.5893	55.4587	55.4919	18.3939	18.4554	18.2752	18.1613
64	32	50	154	161	55.4375	55.3400	55.3377	55.4721	18.1563	18.4800	18.3831	18.2795
65	52	59	193	208	55.5769	55.5254	55.4871	55.4664	18.2885	18.4576	18.4145	18.3846
1963-65	183	221	456	493	55.5628	55.5158	55.4298	55.4746	18.3224	18.4615	18.3706	18.2941
Georges Bank												
1962	136	125	--	--	55.4338	55.3760	--	--	18.1691	18.1600	--	--
63	139	126	206	183	55.2878	55.2698	55.3010	55.3716	18.0072	18.0635	17.9903	18.0656
64	80	77	394	440	55.4625	55.2208	55.4264	55.3932	18.2500	18.1039	18.2031	18.2091
65	29	22	297	335	55.8966	55.5455	55.3569	55.3164	18.1036	18.2727	18.1145	18.0896
1962-65	384	350	897	958	55.3464	55.3143	55.3746	55.3622	18.1224	18.1200	18.1249	18.1399
Cape Cod												
1963	91	78	--	--	55.3846	55.3205	--	--	18.1648	18.1154	--	--
64	76	76	147	149	55.1974	55.2632	55.3265	55.3356	18.0263	18.0526	18.1565	18.2215
65	--	--	171	190	--	--	55.3743	55.3263	--	--	18.2398	18.1895
1963-65	167	154	318	339	55.2994	55.2922	55.3522	55.3304	18.1018	18.0844	18.2013	18.2035

Table 1a. Mean Counts of Dorsal and Anal fin rays of the 1958 and 1960 year classes from the Gulf of Maine.

AREA AND YEAR	NUMBER OF FISH				MERISTIC COUNT - MEAN NUMBER							
					Dorsal Fin				Anal Fin			
	1958 Yr Class		1960 Yr Class		1958 Yr Class		1960 Yr Class		1958 Yr Class		1960 Yr Class	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Nova Scotia												
1962	29	24	--	--	19.3448	19.4167	--	--	18.0690	17.7917	--	- --
63	133	150	72	61	19.3158	19.3133	19.4583	19.4590	17.8872	17.9400	18.1667	18.1475
64	67	62	155	136	19.3881	19.3871	19.3936	19.4927	18.1194	18.1290	18.0323	18.3088
65	95	90	300	240	19.5790	19.5222	19.4533	19.5458	18.1790	18.1000	18.1733	18.1917
1962-65	324	326	527	437	19.4105	19.3926	19.4364	19.5172	18.0370	18.0092	18.1309	18.2220
Eastern Maine												
1963	49	48	--	--	19.6122	19.5000	--	--	18.1429	18.2708	--	--
64	17	21	92	93	19.4118	19.5714	19.4674	19.3979	18.0000	18.3810	18.2283	18.2366
65	12	19	321	320	19.3333	19.4737	19.4143	19.4688	18.3333	18.1579	18.1807	18.2000
1963-65	78	88	413	413	19.5256	19.5114	19.4262	19.4528	18.1410	18.2727	18.1913	18.2082
Western Maine												
1963	99	112	109	124	19.4950	19.5714	19.4587	19.4274	17.8788	18.1518	17.9358	17.9436
64	32	50	154	161	19.3125	19.3400	19.3182	19.2547	18.1250	18.0800	18.0260	18.1739
65	52	59	193	208	19.5000	19.6271	19.5337	19.5000	18.3269	18.0339	18.1399	18.1923
1963-65	183	221	456	493	19.4645	19.5339	19.4430	19.4016	18.0492	18,1041	18.0526	18.1237
Georges Bank												
1962	136	125	--	--	19.1985	19.1840	--	--	18.0074	18.1120	--	--
63	139	126	206	183	19.4317	19.3333	19.4320	19.4481	18.1871	17.9841	17.9952	18.1202
64	80	77	394	440	19.2625	19.3377	19.4289	19.4409	18.0375	18.1429	18.1117	18.1636
65	29	22	297	335	19.3103	19.5455	19.4242	19.3851	18.2414	18.1818	18.1650	18.0716
1962-65	384	350	897	958	19.3047	19.2943	19.4281	19.4228	18.0964	18.0771	18.1026	18.1232
Cape Cod												
1963	91	78	--	--	19.2857	19.3590	--	--	17.9451	18.0385	--	--
64	76	76	147	149	19.2895	19.2895	19.3946	19.5034	18.1184	18.1184	18.1701	18.2349
65	--	--	171	190	--	--	19.3918	19.4053	--	--	18.2164	18.1105
1963-65	167	154	318	339	19.2874	19.3247	19.3931	19.4484	18.0240	18.0779	18.1950	18.1652

Table 2. Probabilities based on four meristic characters that herring from 2 areas do not differ; the total probabilities are listed in ascending order.

Area Comparisons by Year Class	Vertebrae	Right Pectoral fin	Dorsal fin	Anal fin	Total for each comparison
Nova Scotia vs. Georges Bank					<.005
1958	<.005	<.005	>.900	.120	
1960	.020	<.005	>.900	>.900	
Western Maine vs. Georges Bank					<.005
1958	<.005	<.005	<.005	>.900	
1960	.020	<.005	>.900	>.900	
Western Maine vs. Cape Cod					<.005
1958	<.005	<.001	<.001	>.900	
1960	.050	<.001	>.900	>.900	
Nova Scotia vs. Cape Cod					<.005
1958	<.005	<.005	>.900	>.900	
1960	.030	.015	>.900	>.900	
Eastern Maine vs. Georges Bank					<.005
1958	>.900	<.005	>.900	>.900	
1960	<.005	<.005	>.900	.050	
Eastern Maine vs. Cape Cod					<.005
1958	>.900	<.005	.325	.820	
1960	<.005	<.005	>.900	>.900	
Nova Scotia vs. Western Maine					.350
1958	>.900	<.005	<.005	.560	
1960	>.900	>.900	>.900	>.900	
Cape Cod vs. Georges Bank					>.900
1958	>.900	>.900	>.900	>.900	
1960	>.900	<.005	>.900	.330	
Eastern Maine vs. Western Maine					>.900
1958	.090	.150	>.900	>.900	
1960	>.900	.290	>.900	.830	
Nova Scotia vs. Eastern Maine					>.900
1958	.180	>.900	.730	.170	
1960	>.900	.190	>.900	>.900	