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DEFINITION OF HADDOCK STOCKS OF THE NORTHWESTERN ATLANTIC

BY JOHN R. CLARK AND VADIM D. VLADYKOV

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ABSTRACT

Differences in average vertebral number, related to temperature on the spawning grounds, have been used to separate northwestern Atlantic haddock into five major stocks: Newfoundland, eastern Nova Scotian, central Nova Scotian, western Nova Scotian, and New England.

DEFINITION OF HADDOCK STOCKS OF THE NORTHWESTERN ATLANTIC

By JOHN R. CLARK, *Fishery Research Biologist*, and VADIM D. VLADYKOV, *Fishery Biologist*

Haddock are distributed over the continental shelves of the North Atlantic Ocean and in no other waters. They are not distributed continuously over this vast range, but reside in certain areas delimited by topographic and hydrographic boundaries. Nor are they evenly distributed within any area. Haddock generally prefer depths of less than 110 fathoms. They are presently considered to belong to a single species, *Melanogrammus aeglefinus* (L.).

In the northwestern Atlantic, haddock appear on certain fishing grounds only during the winter or spring for spawning. Some grounds support fisheries for haddock only during the summer and autumn while others are fished throughout the year. The character of populations sustaining year-round fisheries often varies from season to season, with older fish appearing for spawning and younger fish replacing them during the remainder of the year.

Age composition, growth rate, and other characteristics of haddock population units differ from place to place, causing us to believe that the species consists of many more-or-less separate units. This idea is strengthened by tagging experiments in the western Atlantic which have shown that haddock, although migrating over rather definite routes, infrequently cross the deep-water channels separating the New England, Nova Scotian, and Newfoundland Banks (fig. 1). On the basis of such evidence, Needler (1930) suggested a subdivision of northwestern Atlantic haddock into three major units: the New England, Nova Scotian, and Newfoundland stocks. Further research has, in general, substantiated this division (Schroeder 1942; Schuck and Arnold, 1951; Vladykov 1935). Each of the three regions encompasses a number of distinct grounds which support important fisheries at various times of the year.

Properties of the environment, notably temperature, differ from one fishing ground to another. These properties may be expected to significantly modify the meristic characters of haddock as they do of other species. Notwithstanding the effect of genetic influences, the differences in these characters should permit identification of broods originating in different localities. It is the purpose of this paper to demonstrate that one meristic character, the number of vertebrae, can be used to identify haddock stocks.

COLLECTION OF DATA

Our collection of vertebral counts was begun in 1932, and a preliminary study was published (Vladykov 1935) which demonstrated recognizable differences for the haddock of various western Atlantic fishing grounds. Since then the Fisheries Research Board of Canada and the U.S. Fish and Wildlife Service have added many thousands of counts to the collection, representing altogether the haddock of 16 major fishing grounds from New England to Newfoundland. The samples have come from the catches of commercial fishermen and research vessels using otter trawl and hook-and-line gear.

The entire collection of data is detailed in table A–1 of the Appendix, p. 294. In counting the vertebrae, all of them from the first vertebra, found immediately behind the basi-occipital bone, to the penultimate one, which has a normal centrum and a hypural plate, are included. The last vertebra with its modified centrum and terminal hypural plate is not included in our counts. Fish having vertebral abnormalities, such as fused centra, amounted to slightly more than 1 percent of the total number of specimens and were not used.

NOTE.—John R. Clark, North Atlantic Fishery Investigations, U.S. Bureau of Commercial Fisheries; Vadim D. Vladykov, Department of Biology, University of Ottawa, Ottawa, Ontario.
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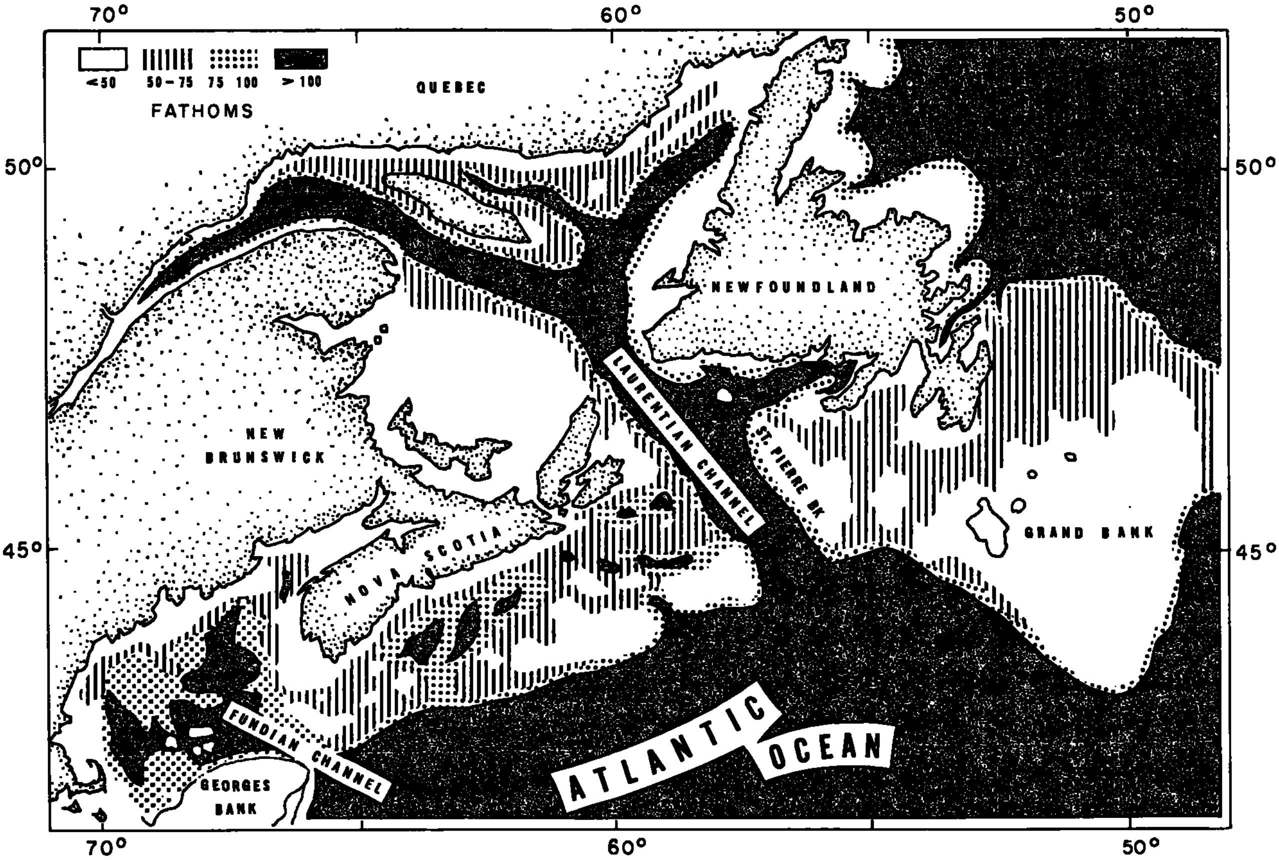

FIGURE 1.—The submarine physiography of the Continental Shelf from Labrador to Cape Cod. (Adapted from Hachey, Hermann, and Bailey, 1954.)

GEOGRAPHICAL VARIATION IN VERTEBRAL NUMBERS

In studies of many species, the number of vertebrae has been shown to differ significantly among geographically separated units of the population. The number of vertebrae typically increases with latitude, suggesting an inverse relation with water temperature.[1]

To investigate the possibility of such a relation between number of vertebrae and water temperature for haddock, we grouped our samples by fishing ground and calculated the average number of vertebrae for each (appendix table A–2). A difference of nearly 1.3 vertebrae is shown between the highest and lowest averages. Analysis-of-variance treatment of the data (see appendix) showed these differences between the grounds to be highly significant ($F = 182$).

As shown in figure 2, the number of vertebrae tends to increase from Georges Bank northeasterly along the Scotian Shelf. The average for St. Pierre Bank, however, is lower than even the one for Georges Bank.

Another presentation of these data is given in figure 3 where we have plotted, after the method of Hubbs and Perlmutter (1942), the main statistical values for the data from each fishing ground: total range of items, standard deviation, mean, and two standard errors either side of the mean. Here we see that numbers of vertebrae increase regularly from Georges Bank to Emerald Bank, hold relatively constant from Emerald Bank to the Gulf of St. Lawrence, then drop sharply to St. Pierre Bank. The significance of these differences is shown by comparison of the standard errors of the various distributions.

[1] See, for example, Schmidt 1930, Thompson 1943, Hansen 1949, for cod; Bertelsen 1942, for coalfish; Tåning 1929, Devold 1942, for plaice; Runnström 1941, Tester 1949, McHugh 1954, for herring; Hansen 1943, Templeman 1948, for capelin; Clark 1947, for sardine; Hubbs and Perlmutter, 1942, McHugh 1951, for anchovy; Vladykov 1934, for summary of earlier information.

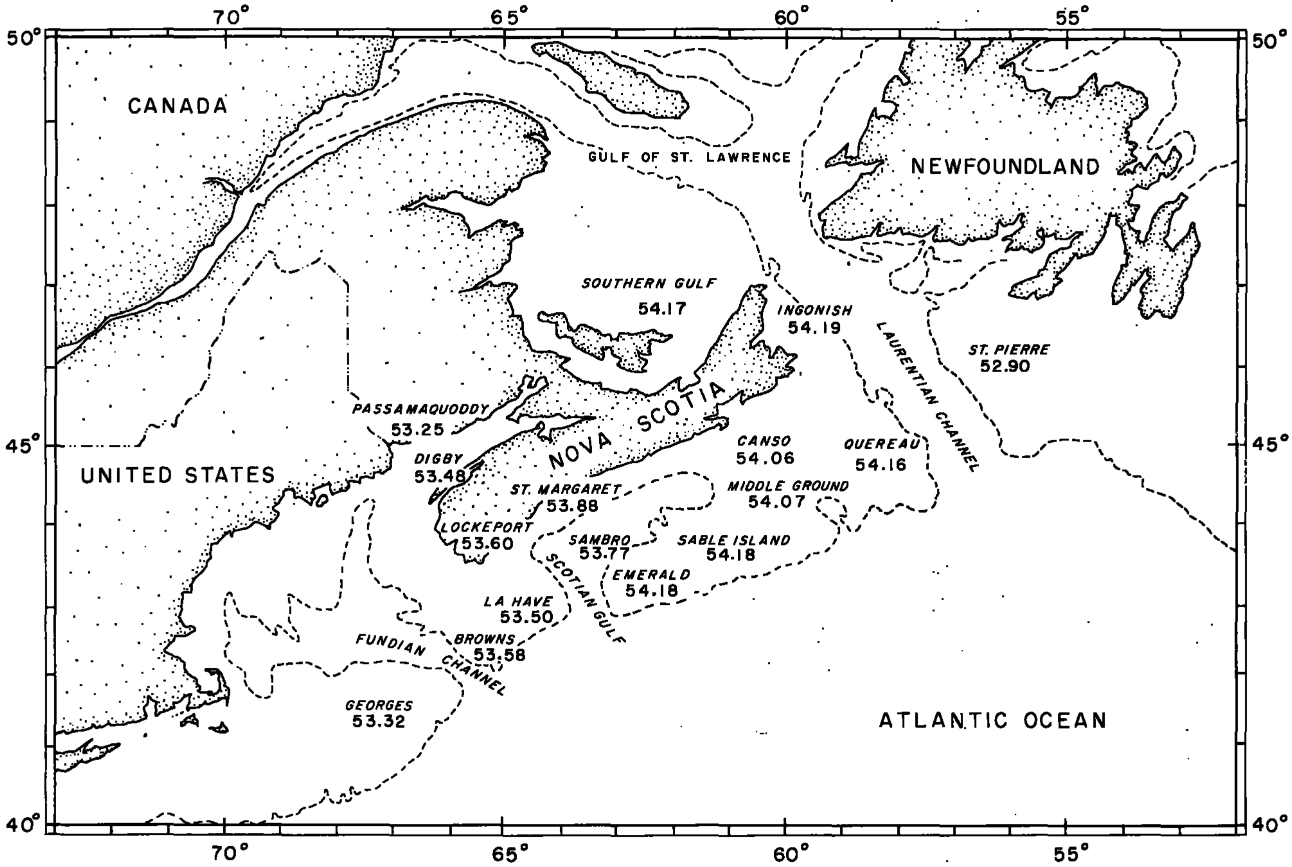

FIGURE 2.—Haddock fishing grounds of the northwestern Atlantic and the mean number of vertebrae of haddock from each.

VERTEBRAL NUMBERS AND WATER TEMPERATURE

Since water temperatures decrease from Georges Bank northeasterly along the coast, we see that haddock conform in general to the typical negative relation of meristic characters and temperatures. To discover how close this correspondence is, we must examine the temperature regime on each fishing ground during the time when the number of vertebrae is actually established.

It is probable that vertebral numbers are established within the first week or so following fertilization of the eggs. We do know for certain that all myomeres are formed by the time the fish reaches 13 mm. in length, which requires 5 or 6 weeks. Although haddock spawn on or near the bottom, their eggs are buoyant and rise toward the surface following fertilization.[2] Since the eggs tend to be concentrated near the surface, the temperatures of the surface layer are most appropriate. We have, therefore, gathered such information as is available on surface water temperatures during the spawning period of northwestern Atlantic haddock to compare with their average numbers of vertebrae.

Haddock spawn in greatest numbers in mid-March in the New England area, in late March and early April in the Nova Scotian area, and in late May and June in the Newfoundland area.[3] Unpublished surface temperature records representing all available observations during these spawning times were obtained from the Woods Hole Oceanographic Institution. These data are plotted as isothermic lines in figure 4. The temperature for each fishing ground has been estimated from the chart and listed along with the

[2] See Walford (1938) for a discussion of the distribution and development of the early stages of northwestern Atlantic haddock.

[3] Needler 1930; Vladykov and Homans, 1935; Bigelow and Schroeder, 1953; Thompson 1939; and unpublished records of the U.S. Fish and Wildlife Service.

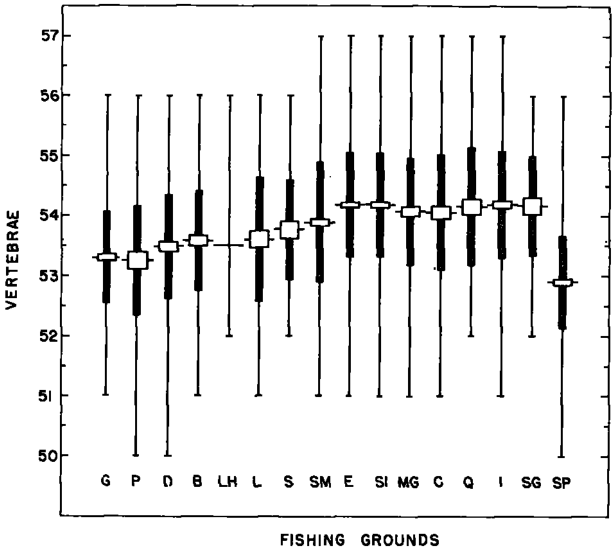

FIGURE 3.—Numbers of vertebrae of haddock from fishing grounds of the northwestern Atlantic. The vertical line represents the range; the solid bar, one standard deviation on each side of the mean; the hollow rectangle, two standard errors on each side of the mean; and the crossbar, the mean. The fishing grounds shown are Georges Bank (G); Passamaquoddy Bay (P); Digby (D); Browns Bank (B); La Have Bank (LH); Lockeport (L); Sambro Bank (S); St. Margaret's Bay (SM); Emerald Bank (E); Sable Island Bank (SI); Middle Ground (MG); Canso Bank (C); Quereau Bank (Q); Ingonish (I); Southern Gulf of St. Lawrence (SG); St. Pierre Bank (SP).

appropriate spawning time in table 1. A negative relation between temperature and vertebral number is demonstrated by the data. The apparent anomaly for St. Pierre Bank is now easily explained by the high water temperature obtaining there during the spawning time (May–June).

TABLE 1.—*Mean number of vertebrae and average surface water temperature during spawning time for haddock of the northwestern Atlantic*

Fishing ground	Temperature (° F.)	Mean number of vertebrae
St. Pierre Bank	43.5	52.90
Georges Bank	38.0	53.32
Digby	37.0	53.48
Passamaquoddy Bay	36.5	53.25
Browns Bank	36.5	53.58
La Have Bank	36.0	53.50
Emerald Bank	36.0	54.18
Lockeport	35.5	53.60
Sambro Bank	35.0	53.77
Sable Island Bank	34.5	54.18
St. Margaret's Bay	34.0	53.88
Middle Ground	34.0	54.07
Canso Bank	33.5	54.06
Quereau Bank	33.0	54.16
Ingonish	32.0	54.19
Southern Gulf of St. Lawrence	32.0	54.17

Some data are available for the northeastern Atlantic for comparison with northwestern Atlantic data. Tåning (1935) listed average numbers of vertebrae that show little relation to latitude in the North Sea, Ireland, Iceland, Faroes, and Norway. Nor could Saetersdal (1952) find a relation in his data between latitude and vertebral numbers along the Norwegian coast. However, upon treating spawning-time temperatures and vertebral averages for these northeastern Atlantic data in the manner described previously for our data,[4] we find evidences of a relation between the two (table 2 and fig. 5).

TABLE 2.—*Mean number of vertebrae and average water temperature during spawning time for haddock of the northeastern Atlantic*

Area [1]	Temperature (° F.)	Mean number of vertebrae [2]
Ireland	47.5	52.84
Faroe Islands	45.0	52.88
Iceland	44.0	52.96
North Sea	43.0	53.04
Norway	41.0	53.12
Norway [3]	41.0	53.03

[1] From Tåning (1935).
[2] A single average was calculated where ranges were given or more than one mean was presented in the original publication.
[3] From Saetersdal (1952).

The average vertebral numbers for haddock from both sides of the Atlantic have been plotted against surface water temperatures at spawning time and a curve has been fitted to them (fig. 6). The data thus assembled include the entire known range of spawning-time temperatures of haddock.

A similar relation between average number of vertebrae and temperatures at spawning time is shown for both sides of the Atlantic. This, together with the overlapping range in vertebral numbers of the Newfoundland and northeastern Atlantic samples, suggests that a single vertebral number-temperature relationship applies to the species throughout its range. Temperature would then appear to be an important factor in the variation in number of vertebrae of haddock.

[4] Data on spawning times of northeastern Atlantic haddock have come from Schmidt 1909, Wiborg 1950, Thompson 1928, and Raitt 1948. These data indicate that haddock spawn in greatest numbers off Norway and in the North Sea in late March, off Iceland and Ireland in mid-April, and off the Faroe Islands in early May. Temperature data are from Conseil Permanent International pour l'Exploration de la Mer, (1933) and U.S. Hydrographic office (1944).

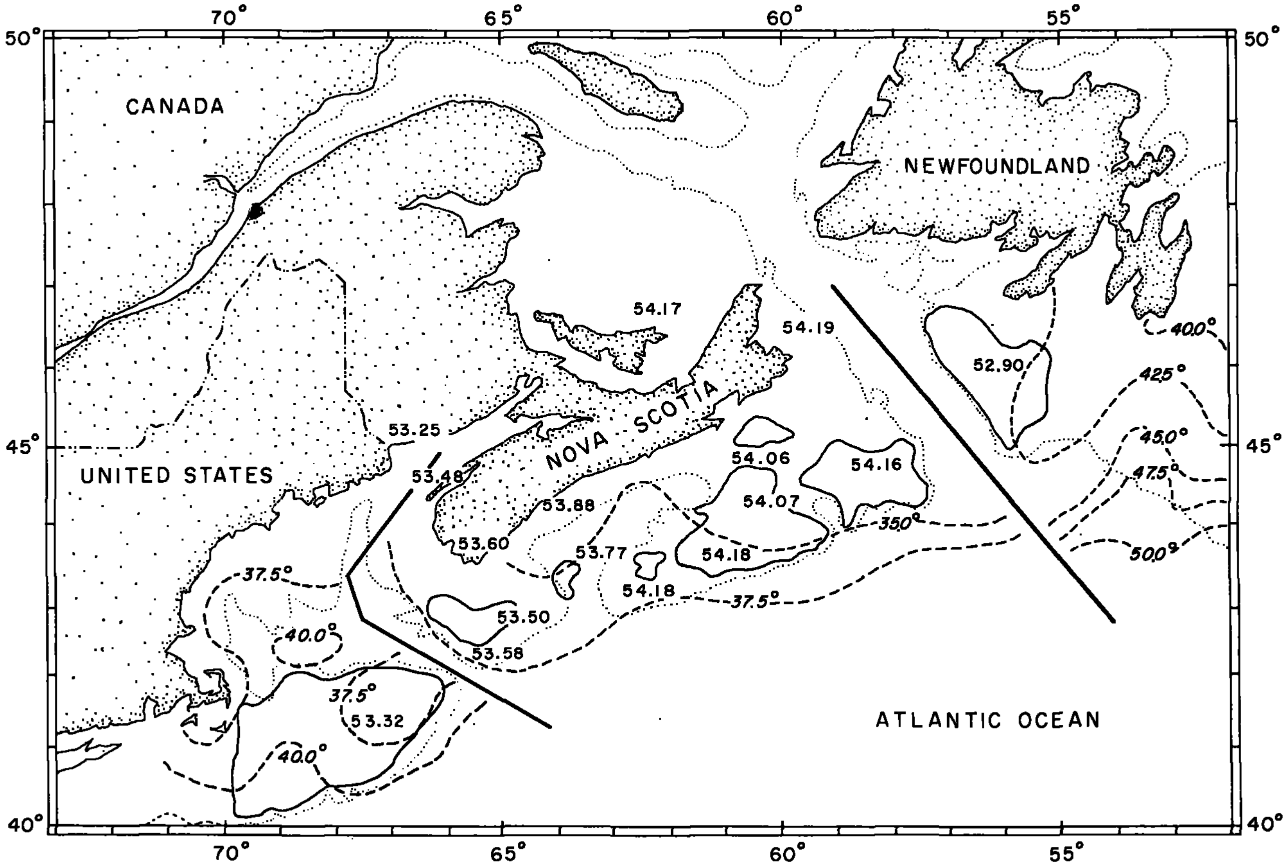

FIGURE 4.—Mean numbers of vertebrae of haddock from fishing grounds of the northwestern Atlantic and surface water temperatures (°F.) during spawning time.

VERTEBRAL NUMBERS AND YEARLY VARIATIONS IN WATER TEMPERATURE

The evidence presented suggests that annual variations in water temperature in any particular locality would cause haddock originating in that locality to have varying numbers of vertebrae. Temperature at time of spawning and average number of vertebrae for individual year classes have been successfully correlated for herring by McHugh (1942), Rounsefell and Dahlgren (1932), and Tester (1937, 1938, and 1949).

Data are not available with which to assign ages to most of our specimens, and the year classes must for the most part be treated together. Some material, however, was available to evaluate differences among certain year classes on Georges and Browns Banks. This material was collected during two trips of the *Albatross III* in the spring and autumn of 1950. We obtained 369 specimens from Browns Bank and 974 specimens from Georges Bank which were taken over widely separated areas of each bank and so adequately represented the population present at the time. The ages of the fish were determined from their scales. The vertebral numbers are given in table 3 for each year class. Since the reliability of age determination from scales is uncertain for haddock over 8 years of age, we have grouped the older fish into a single category (9+) and have not assigned them to year classes.

Analysis-of-variance treatment of the data showed the difference between average vertebral numbers from the two banks to be highly significant ($F=10.51$).

The difference between year classes is highly significant only for Georges Bank ($F=4.63$). Although the Browns Bank year classes are not shown by analysis of variance to differ significantly ($F=1.82$), we have used them since the magnitude of the differences was even greater than for Georges Bank.

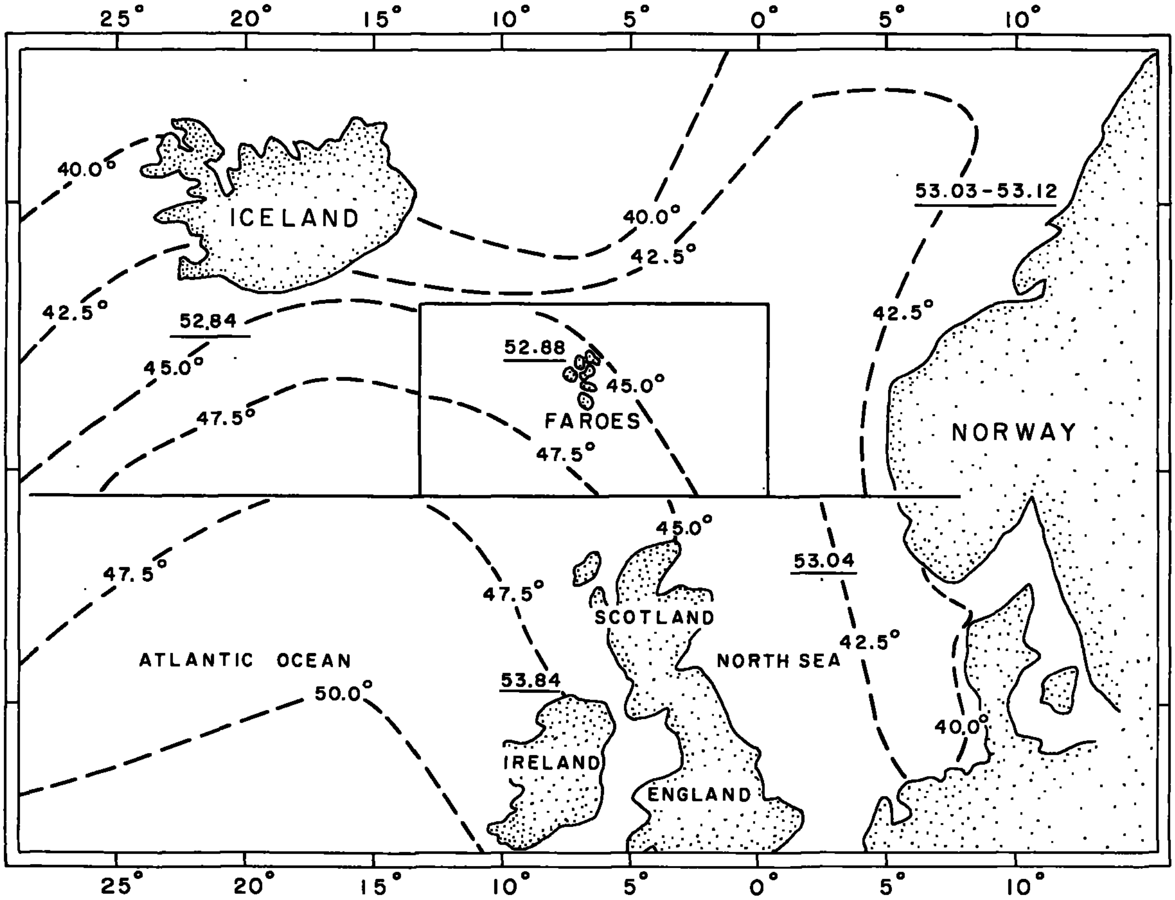

FIGURE 5.—Mean numbers of vertebrae of haddock from the northeastern Atlantic and temperatures (°F.) during spawning time.

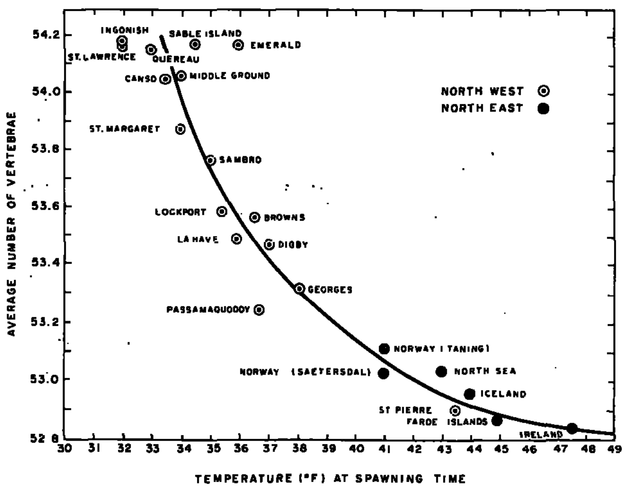

FIGURE 6.—The relation between water temperature during spawning time and numbers of vertebrae of haddock.

No series of temperature observations is available directly from Browns and Georges Banks for the period 1942–49 to use in correlating with vertebral averages of the year classes. A continuous series of records is available (U.S. Coast and Geodetic Survey, 1947), however, for surface water temperatures at Eastport, Maine, in Passamaquoddy Bay, near the entrance to the Bay of Fundy. Hachey and McLellan (1948) have demonstrated that temperatures for Passamaquoddy Bay give a reliable measure of annual temperature variation along the northwestern Atlantic coast.

To utilize these data from Eastport, Maine, we found it necessary to relate them to the temperatures on the two banks for individual years. The average surface water temperature over Browns Bank during the time of haddock spawning is shown in table 1 to be about 36.5° F., and the average water temperatures at Eastport for the same period of the year are shown in table 4 to be the same. The average surface temperature during the spawning time on Georges Bank, how-

TABLE 3.—*Vertebral-number frequencies for each age of haddock from Georges and Browns Banks*

Age (years)	Year class	Georges Bank									Browns Bank								
		Number of fish	Occurrence of vertebrae numbering—							Mean	Number of fish	Occurrence of vertebrae numbering—							Mean
			50	51	52	53	54	55	56			50	51	52	53	54	55	56	
1	1949	32			5	17	8	2		53.22	1					1			
2	1948	381		1	24	153	173	30		53.54	41			3	18	19	1		53.44
3	1947	76	1		10	42	22	1		53.14	76		1	6	31	32	6		53.47
4	1946	137	1	1	19	59	44	13		53.34	100		1	6	35	48	9	1	53.61
5	1945	194		5	25	95	60	9		53.22	60		1	5	29	19	6		53.40
6	1944	82		2	6	40	26	7	1	53.40	50			4	15	24	7		53.68
7	1943	39			3	19	13	3	1	53.49	30			1	11	11	6	1	53.83
8	1942	15			1	10	3	1		53.27	4				3				
9+		18			2	5	10	1			7		1		3	1	2		
All ages		974	2	9	95	440	359	67	2	53.39	369		4	25	145	156	37	2	53.55

ever, approximates 38° F. while temperatures at Eastport for the same period average 35.6° F. Temperatures on Browns Bank can therefore be estimated directly from readings at Eastport, but estimates for Georges Bank require an adjustment of about 2.5° F.

An average of the April readings for Eastport was, therefore, used to approximate spawning time temperatures on Browns Bank. The March–April average for Eastport was increased by 2.5° F. to estimate spawning time temperatures for Georges Bank.

The temperature estimates thus obtained are listed for the years 1942 to 1949 in table 4, along with the average number of vertebrae for the haddock spawned in those years. The 1942 and 1949 year classes for Browns Bank are represented by too few specimens to give meaningful results and have not been included. These data indicate a close correlation between water temperature and number of vertebrae of the year

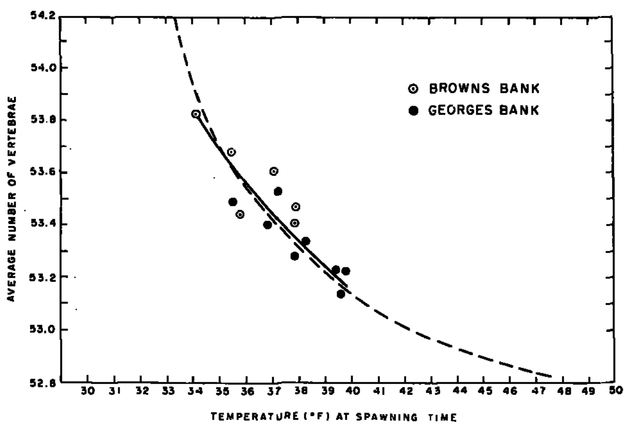

FIGURE 7.—The vertebrae–temperature relation for individual year classes from Georges and Browns Banks. (Dashed line from fig. 6.)

classes. How this compares with the previous relationship (fig. 6) can be seen in figure 7, where we have imposed the temperature-vertebrae data for our year classes from Browns and Georges Banks over the curve from figure 6. The curve fitted to the data from the Georges and Browns year classes deviates very little from the curve representing all the fishing grounds.

TABLE 4.—*Estimated surface water temperature at spawning time and mean number of vertebrae for certain year classes of haddock from Georges and Browns Banks*

Year class	Georges Bank			Browns Bank	
	March–April mean temperature at Eastport (°F.)	Adjusted mean temperature (°F.)[1]	Average number of vertebrae	April mean temperature at Eastport (°F.)	Average number of vertebrae
1949	37.4	39.9	53.22		
1947	37.2	39.7	53.14	38.0	53.47
1945	37.0	39.5	53.22	37.9	53.40
1946	35.8	38.3	53.34	37.2	53.61
1942	35.4	37.9	53.27		
1948	34.8	37.3	53.54	35.8	53.44
1944	34.4	36.9	53.40	35.6	53.68
1943	33.0	35.5	53.49	34.3	53.83
Mean	35.6			35.5	

[1] See text for explanation.

IDENTIFICATION OF POPULATION UNITS

It appears from the consistency of the vertebral number-temperature relation that we should be able to predict, within limits, the average number of vertebrae of haddock from any area if we know the temperature at spawning time. The deviations from the curve in figure 6 may represent fish not spawned on the grounds where they were captured. In like manner, the points falling near the line may represent stocks which were spawned on the grounds where captured or on grounds having similar temperatures at spawning. Some interesting points may be brought forth by considering the data for each fishing ground with these suggestions as an hypothesis:

St. Pierre Bank.—The data fit closely to the curve, indicating negligible movement of other haddock to this area.

Georges Bank.—Following the same reasoning as for St. Pierre, Georges Bank haddock appear to reside in the area of their origin with no significant immigration.

Passamaquoddy Bay.—Haddock are known to be summer visitants only to this area, with spawning taking place elsewhere. Their average vertebral number indicates that they are probably hatched in waters having temperatures higher than 38° F. As water of this temperature is usually found in the western Atlantic only in the vicinity of Georges Bank during the spawning time of haddock (see fig. 4), we may assume that the Passamaquoddy haddock were spawned in the George Bank area, perhaps slightly north of the western part of the bank proper. Needler's study (1930) of age and length composition and growth rates showed Passamaquoddy and Georges Bank haddock to be closely related. Needler's tag-return data, as well as recent unpublished United States and Canadian tag-return data, further show that Passamaquoddy haddock generally move south in the winter.

Browns Bank, Digby, Lockeport, LaHave and Sambro Banks, St. Margarets Bay, Canso Bank, Middle Ground, and Quereau Bank.—Average vertebral numbers fit well to the curve for haddock of these grounds indicating that they reside as adults near their original birthplace. In a study of greatly increased haddock catches in the western Nova Scotian area in 1938, McKenzie and Homans (1939) found subnormal numbers of vertebrae, indicating recruitment from New England stocks. Thus, occasional movement of New England haddock via the shoal water of the Bay of Fundy to Nova Scotian waters has been shown to be a possibility. But this is the only instance of such a population shift that has been brought to our attention.

Emerald and Sable Island Banks, Ingonish, and Southern Gulf of St. Lawrence.—Averages do not fit the curve well for haddock of these haddock grounds indicating that they have been hatched in an area where spawning temperatures would average about 33.5° F. rather than in the areas where they were caught. Waters of this temperature may be found over certain of the eastern Nova Scotian Banks. Our method would indicate therefore that these four groups of haddock have a common birthplace on the eastern part of the Scotian Shelf where temperatures from 33° to 34° F. are to be expected during the spawning period. This conclusion is partially substantiated by the tag studies of Needler (1930), who discovered that haddock appearing on the eastern Nova Scotian Banks during the Spring spawning period migrated in summer and fall to the Ingonish area and into the Gulf of St. Lawrence.

We now have sufficient evidence to reexamine the problem of grouping northwestern Atlantic haddock into major subdivisions. The discussion of individual fishing grounds suggests that more than three independent units (New England stock, Nova Scotian stock, and Newfoundland stock) may be recognized. If we group the grounds on the basis of vertebral averages, a redefinition of the major units is suggested.

The choice of words to be used in defining population units is always difficult, and we chose not to concern ourselves too greatly with the semantics of such terminology. We shall follow the nomenclature suggested by Marr (1957), and describe our subdivisions as "stocks."

The five major units of the northwestern Atlantic haddock population which may at present be identified are as follows:

1. The Newfoundland stock, which can be clearly separated from all others on the basis of the very low number of vertebrae of haddock from St. Pierre Bank and vicinity. As samples from Grand Bank proper are not available, the status of these fish must still remain in question.

2. The eastern Nova Scotian stock, which extends east to the Laurentian Channel and west to the Scotian Gulf. An inshore group on Canso Bank and Middle Ground may be distinguished from the offshore group on Emerald, Sable Island, and Quereau Banks, and in the Gulf of St. Lawrence. The differences appear too slight, however, to justify further subdivision at present.

3. The central Nova Scotian stock, which is represented in this study by the St. Margaret's Bay and Sambro Bank groups, and resides in the vicinity of the Scotian Gulf.

4. The western Nova Scotian stock, which resides in the area bounded on the east by the Scotian Gulf and on the west by the Fundian Channel. This stock includes fish from Lockeport and Digby, LaHave, and Browns Banks.

5. The New England stock, which includes fish inhabiting grounds west of the Fundian Channel and along the New England coast and is represented in this study by the Georges Bank and Passamaquoddy Bay samples.

DISCUSSION

Our data do not permit us to go beyond the point of suggesting the general arrangement of stocks. The actual degree of mixing between such units of the population as we have suggested cannot be estimated from the average numbers of vertebrae and such considerations are not within the scope of this analysis. A gradual mixing of substantial proportions of adjoining stocks of postplanktonic stages, however, should cause the vertebral numbers of the older ages to differ less than those of the younger ages. An increase in vertebral averages would be shown for the more southerly stock, and the reverse would be shown for the more northerly stock. This was not true for our year-class samples from Georges or Browns Banks, however, and the relation between temperature and vertebrae remained constant through the range of ages.

Whether refinement of our method will permit more precise identification of components of the major stocks must await the results of further research that is now in progress. Recent success in tagging haddock offshore should provide direct evidence on the question of intermixture of units.

Direct confirmation of our vertebral number-temperature relationship must await experimental hatching and rearing. Haddock eggs are known to develop in water as cold as 30° F. and as warm as 60° F. (personal communication, John B. Colton, Jr.). We could thus experimentally extend the relation past the range of our present observations which are based on natural spawning conditions.

SUMMARY

Vertebrae of haddock from 16 fishing grounds in the northwestern Atlantic were counted to determine whether such counts could be used to identify population units.

Comparison of average numbers of vertebrae from the different areas showed significant differences, which could be related to surface water temperatures on the grounds during the spawning time. The relationship is consistent with that developed for northeastern Atlantic haddock from published European data.

Age data which were available for the samples from Georges and Browns Banks demonstrated that the differences in average vertebral numbers among the individual year classes on each bank could be attributed to differences in temperatures in the spawning period in different years.

Consideration of average vertebral numbers of the various population units suggests the following as major haddock stocks of the northwestern Atlantic: Newfoundland, eastern Nova Scotian, central Nova Scotian, western Nova Scotian, and New England.

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APPENDIX

The entire collection of vertebral counts used in this study is given by fishing ground and date in table A–1. A summary of the frequency distributions of the vertebral counts for the various fishing grounds and related statistical values is given in table A–2.

Analysis of variance was used to test differences among grounds and among samples of the same grounds. The original total of 9,985 vertebral counts composed of 108 samples from 16 grounds were used in the analysis. The results are as follows:

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Total	9,984	9822.30		
Between grounds	15	2112.30	140.8200	182.08
Within grounds	9,969	7110.00	0.7734	
Between samples	107	145.02	1.3553	1.77
Within samples	9,862	7564.98	0.7671	

The F value of 182.08 shows that differences among the grounds are highly significant (probability of occurrence by chance less than 0.01).

Individual tests, comparing differences between pairs of grounds, can be made with the analysis of variance, but to make all possible comparisons between the 16 grounds is not practicable. Individual comparisons were made between units of different major stocks which are adjacent to each other but separated by the channels because these are of particular importance.

Highly significant differences were found between Georges and Browns Banks (F=15.52), between Sambro and Emerald Banks (F=26.80), and between St. Pierre and Quereau (F=486.87). These results indicate that population units representing different stocks but adjacent to each other and bordering on the channels are clearly distinct from each other.

The highly significant F value of 1.77 for the between-samples treatment indicates that the variation among samples for particular grounds is real, and the samples have been drawn from different populations.

Such real differences as do exist may be explained partially by seasonal and annual changes in year-class composition on the grounds. The only data available to test this hypothesis are those for which age data are available; namely, the 1950 collection for Georges and Browns Banks. These data are shown in text table 3. Analysis-of-variance treatments showed that the differences between individual year classes on Georges Bank were highly significant (F=4.63). The year classes on Browns Bank did not differ significantly (F=1.82), although the magnitude of difference was even greater for Browns than for Georges year classes. We would expect such differences to occur on other grounds as well.

Year-class composition on any ground will change with time. The mean vertebral number can also be expected to change since it depends on the proportion of various year classes represented. This is the most probable explanation for the significant difference between samples.

TABLE A-1.—*Vertebral-number frequencies of haddock, by fishing ground and date of collection*

Fishing ground and date of collection	Number of fish with vertebrae totaling—								Total
	50	51[a]	52	53	54	55	56	57	
Georges Bank:									
November 1932		1	19	55	32	2			109
June 1935			8	36	18	1			63
Do			1	10	10	1			22
Do			9	27	14	1			51
Do			3	20	15	5			43
February 1939		4	50	172	110	10	1		347
March 1949				4	2				6
April 1950		2	23	113	105	18	1		262
August 1950	2	7	72	327	254	49	1		712
Total	2	14	185	764	560	87	3		1,615
Passamaquoddy Bay:									
July–August 1933			6	14	13	2			35
September 1933	1	2	19	55	39	5	2		123
Total	1	2	25	69	52	7	2		158
Digby:									
December 1933			7	14	24	5			50
October 1934		2	13	46	50	20			131
December 1935	1	1	13	65	37	6	1		124
May 1936			9	44	48	14	1		116
Total	1	3	42	169	159	45	2		421
Browns Bank:									
April 1935		1	17	72	64	18	1		173
July 1936			2	12	6				20
March 1939		1	16	67	54	10	1		149
March 1949			2	2	3	1			8
May 1950		3	5	69	64	22	2		165
August 1950		1	20	76	92	15			204
Total		6	62	298	283	66	4		719
La Have:									
June 1936			4	5	9	1	1		20
Lockeport:									
December 1930		3	9	34	25	19	5		95
November 1934		1	10	39	40	13	1		104
Total		4	19	73	65	32	6		199
Sambro:									
July 1933			2	10	10	3			25
October 1934			5	30	50	17	2		104
Total			7	40	60	20	2		129
Halifax and St. Margaret's Bay:									
July–August 1932			2	10	7	10	3		32
July–October 1932		1	4	48	64	45	9		171
June–September 1933			3	17	24	11	3		58
July 1933			5	23	26	18	3		75
August 1933		1	8	29	34	10	1		83
November 1934		1	5	16	18	8	3		51
Do		1	5	28	19	3	1		57
Do		1	5	11	18	12	2		49
Do			1	18	20	9	1		49
December 1934			9	27	32	17	6		91
May 1935		2	8	39	65	37	6		157
Do			4	30	60	21	5	1	121
Do			7	30	38	30	2	2	109
Do			6	19	43	29	4	1	102
Total		7	72	345	468	260	49	4	1,205
Emerald Bank:									
September 1934			1	10	7	5	1		24
January 1935			2	7	23	20	4		56
Do			2	17	64	36	4		123
February 1935			3	12	47	30	5		97
Do			5	24	65	47	7		148
Do			3	16	46	38	3		106
Do			3	18	39	23	5		88
March 1935			3	16	43	28	10		100
Do			3	12	45	31	5		96
Do			2	14	50	32	4		102
April 1935			3	28	73	60	10		174
Do			1	10	40	36	6		93
May 1935		2	1	8	36	25	2		74
Do			1	15	51	29	4		100
Do				19	40	34	6		99
June 1935			5	20	46	22	2		95
March 1936		1	4	20	39	32	2		98
Do			5	31	63	39	4		142
April 1936			5	21	38	21	4		89
Total		3	52	318	855	588	88		1,904
Sable Island:									
August 1933			1	12	44	42	2		101
September 1934			3	30	74	64	9		180
Do		1	2	32	65	39	8	2	149
Do			4	17	37	39	1	1	99

TABLE A-1.—*Vertebral-number frequencies of haddock, by fishing ground and date of collection*—Continued

Fishing ground and date of collection	Number of fish with vertebrae totaling—								Total
	50	51	52	53	54	55	56	57	
Sable Island—Continued									
October 1934		1	1	35	65	52	8		162
Do			2	17	44	26	4		93
Do			1	10	32	31	6		80
Do			3	19	28	23	6		79
November 1934			1	10	14	12	2		39
Do				6	20	8	1		35
Do			1	6	28	22			57
Do			6	16	22	21	3		68
Do				5	20	12			37
Do			2	8	14	11			35
July 1935		1	1	10	28	21	5		66
Do		1	2	19	63	15	7	1	108
Do				23	43	26	4		96
February 1936			2	17	74	40	4	1	138
Total		4	32	292	715	504	70	5	1,622
Middle Ground:									
October 1934			2	17	65	37	1		122
August 1935		4	17	52	106	69	4	1	253
April 1936			1	12	40	45	1		99
Total		4	20	81	211	151	6	1	474
Canso Bank and Petit Degrat:									
July 1934			2	7	10	4	3		26
November 1934			1	2	8	5			16
Nov.-Dec. 1934		1	5	27	35	23	1	1	93
June 1935		1	1	11	25	12	3		53
November 1935		1	2	14	42	31	1	1	92
June 1936			3	5	29	15	4	1	57
Total		3	14	66	149	90	12	3	337
Quereau Bank:									
November 1934			1	10	14	8	2		35
December 1934			4	18	45	26	6		99
Do			6	14	40	30	8	2	100
Do			6	29	65	37	5		142
Total			17	71	164	101	21	2	376
Ingonish:									
June 1935		2	5	24	77	37	8	1	154
Do			6	24	59	38	11		138
May 1936			4	14	39	36	6		99
Do		1	1	17	65	53	6	1	144
Do			2	20	59	50	8		139
Do			5	13	45	30	5		98
Total		3	23	112	344	244	44	2	772
Southern Gulf of St. Lawrence:									
November 1934				3	12	4			19
November 1935			3	14	39	33	3		92
Do				10	10	15			35
Total			3	27	61	52	3		146
St. Pierre Bank and vicinity:									
June 1934		2	4	7	1				14
November 1934		3	24	48	21	4			100
Do	1	2	28	37	29	3			100
Do		13	37	28	17	2			97
Do	1	2	21	57	15	1			97
Do		2	15	19	9				45
December 1934		5	28	45	26				104
June 1935		3	21	35	17		1		77
July 1935				125					125
Do				156					156
July 1936		3	21	59	12	1			96
Do		2	28	44	19	2	2		97
Do		7	32	61	18	4			122
Total	2	44	259	721	184	17	3		1,230

TABLE A-2.—*Vertebral-number frequencies of haddock from fishing grounds of the northwestern Atlantic and related statistical values*

Area	Number of fish with vertebrae totaling—								n	$\bar{x}$	S	$S_{\bar{x}}$
	50	51	52	53	54	55	56	57				
NEW ENGLAND:												
Georges Bank	2	14	185	764	560	87	3	--------	1,615	53.32	0.7965	0.0198
Passamaquoddy Bay	1	2	25	69	52	7	2	--------	158	53.25	.9099	.0724
WESTERN NOVA SCOTIA:												
Digby	1	3	42	169	159	45	2	--------	421	53.48	.8742	.0427
Browns Bank	0	6	62	298	283	66	4	--------	719	53.58	.8477	.0316
LaHave Bank [1]	--------	--------	4	5	9	1	1	--------	20	53.50	--------	--------
Lockeport	--------	4	19	73	65	32	6	--------	199	53.60	1.0298	.0730
CENTRAL NOVA SCOTIA:												
Sambro Bank	--------	--------	7	40	60	20	2	--------	129	53.77	.8338	.0734
St. Margaret's Bay	--------	7	72	345	468	260	49	4	1,205	53.88	.9866	.0284
EASTERN NOVA SCOTIA:												
Emerald Bank	--------	3	52	318	855	588	88	1	1,905	54.18	.8706	.0199
Sable Island Bank	--------	4	32	292	715	504	70	5	1,622	54.18	.8721	.0216
Middle Ground	--------	4	20	81	211	151	6	1	474	54.07	.8952	.0411
Canso Bank	--------	3	14	66	149	90	12	3	337	54.06	.9651	.0525
Quereau Bank	--------	--------	11	42	99	64	16	2	234	54.16	.9849	.0644
Ingonish	--------	3	29	141	409	281	49	2	914	54.19	.9033	.0299
So. Gulf of St. Lawrence	--------	--------	3	27	61	52	3	--------	146	54.17	.8263	.0684
NEWFOUNDLAND:												
St. Pierre Bank and vicinity	2	44	259	721	184	17	3	--------	1,230	52.90	.7648	.0224

[1] Statistical values not computed for this small sample.

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