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Vertebral and Dorsal Fin-ray Numbers in Atlantic Wolffish (*Anarhichas lupus*) of the Northwest Atlantic

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Abstract

From collections of Atlantic wolffish in the Northwest Atlantic (West Greenland to the Scotian Shelf) during 1950–67, mean vertebral counts increased gradually from the colder northern to the warmer southern areas (74.19 off Labrador to 75.29 on the southern Scotian Shelf). This is the reverse of the usual pattern in other fishes of the region with pelagic eggs. The pattern for mean dorsal fin-ray counts was similar, but the area coverage and sample sizes were less extensive and the differences were less significant than in the vertebral data. The overall ranges in counts were 72–78 for vertebrae and 71–77 for dorsal fin-rays. Dorsal fin-ray and vertebral numbers were moderately well correlated in a limited number of specimens.

Introduction

Atlantic wolffish (*Anarhichas lupus*) and spotted wolffish (*A. minor*) are the two commercial species of wolffish in the Northwest Atlantic. Catches of the third species (*A. denticulatus*) are not retained by fishermen because of the jellied condition of the flesh. Distribution and abundance of these species in the Newfoundland area have been described by Albikovskaya (1982), feeding characteristics by Albikovskaya (1983), and migration patterns by Templeman (1984). Some data on the stomach contents of Atlantic wolffish from the Northwest Atlantic were reported by Templeman (1985).

Nominal catches of Atlantic and spotted wolffishes in the Northwest Atlantic in 1981 were about 10,200 tons (metric), of which 3,720 tons were taken off West Greenland (NAFO Subarea 1), 5,640 tons off eastern Canada (Subareas 2, 3 and 4), and 840 tons off northeastern United States (Subareas 5 and 6). The wolffish species are not separated in these published statistics (NAFO, 1983). However, almost all of the wolffish taken in Subareas 4 and 5 are Atlantic wolffish (Bigelow and Schroeder, 1953; Scott, 1982), whereas both Atlantic and spotted wolffishes are important in Subareas 1, 2 and 3 (Templeman and Fleming, 1956; Hansen, 1958; Barsukov, 1959; Beese and Kändler, 1969; Albikovskaya, 1982).

In this paper, numbers of vertebrae and dorsal fin-rays in Atlantic wolffish of the Northwest Atlantic were examined for comparison with studies by Luhmann (1954), Barsukov (1959), and Beese and Kändler (1969) in the Northeastern Atlantic, and for possible differences in these meristic counts between areas, providing information that may be useful for stock and species separation.

Materials and Methods

All wolffish, used for dorsal fin-ray and vertebral counts, were 20 cm or more in total length and were usually random samples of catches by research vessels during 1950–67, typically with bottom otter trawls but occasionally with bottom longlines. Vertebral columns with fused vertebrae were not used. For consistency with studies by European researchers, the urostylar half-vertebra was included in the counts. Direct vertebral counts were made on oven-dried vertebral columns, from which the flesh had been removed by steam-cooking and cleaning with a water pressure hose. About 87% of the specimens were treated in this way, and counts for the remaining specimens were made from radiographs of fish which had been preserved in formalin. Dorsal fin-ray counts were made directly from the fish with the skin peeled from one side of the fin.

Within-area comparisons of direct and radiograph counts of vertebrae (from different specimens) showed no consistent differences, the effect of including the data from radiographs being to increase the final means by 0.014, 0.072 and 0.110 respectively for three areas (2HJn, 4VW and 2Js+3K) of Table 1 and to decrease the means by 0.006, 0.012 and 0.048 respectively for three others (3P, 3N and 4R), all being non-significant differences. The differences were so small that the direct and radiograph counts were combined for the analyses.

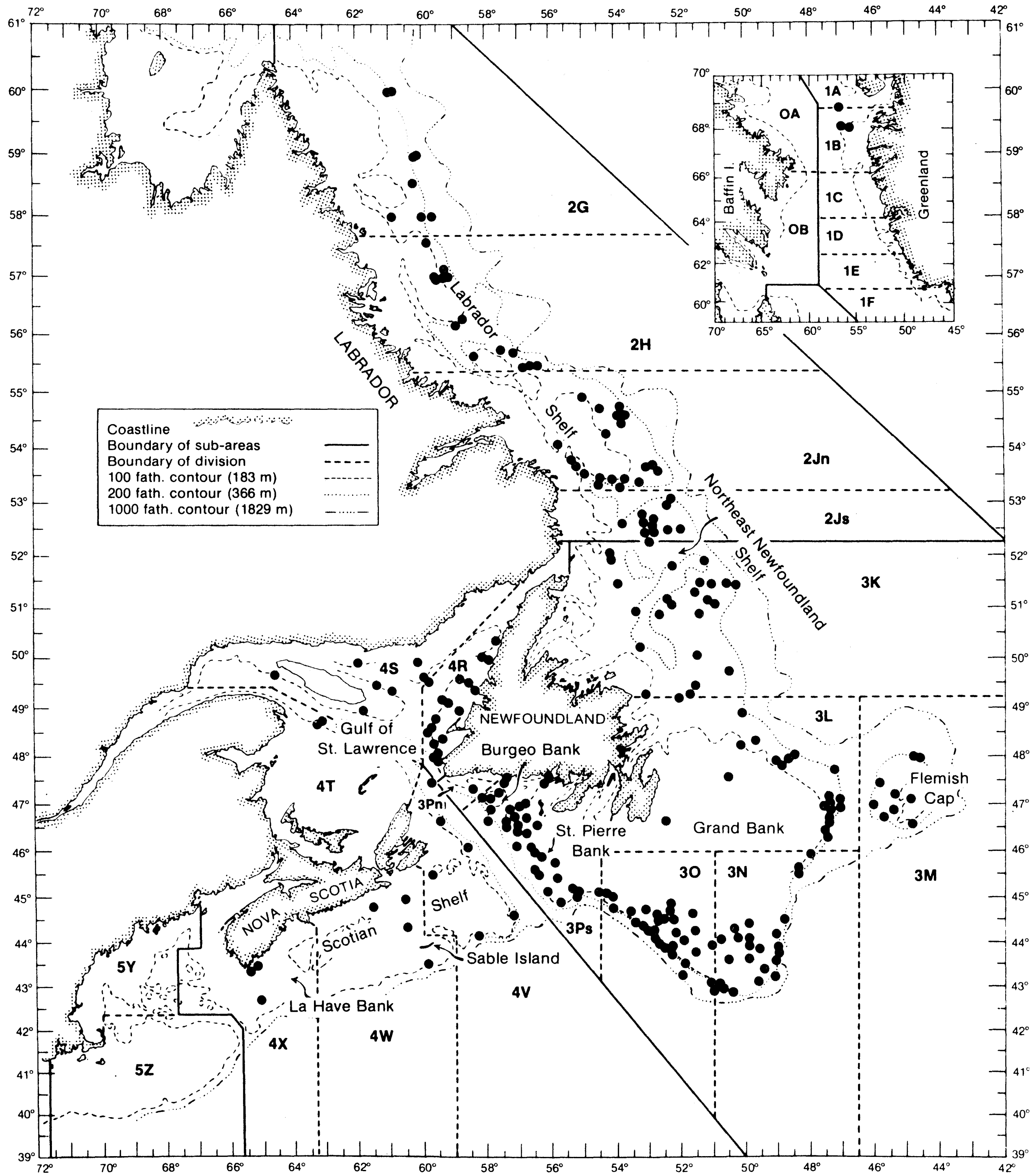

Fig. 1. Place names, NAFO divisions and locations of Atlantic wolffish samples in the Northwest Atlantic.

The distribution of wolffish samples is shown in Fig. 1. The samples were generally too small in relation to the long period of sampling and the size of the areas, with the possibility of within-area differences, to apply period, fish size and sex comparisons within and between areas. For the analysis of vertebral counts, Div. 2J was divided into 2Jn and 2Js at 53° 10'N. This division allowed data from 2Js to be included with data from the Northeast Newfoundland Shelf (Div. 3K) of which it (2Js) forms a natural part.

Results and Discussion

Vertebral numbers (Table 1, Fig. 2)

Mean vertebral counts in Atlantic wolffish increased gradually in a southerly direction from the lowest value (74.19) on the Labrador Shelf (Div. 2HJn)

TABLE 1. Sample information by area relevant to numbers of vertebrae in Atlantic wolffish from the Northwest Atlantic, 1950-67 (Fig. 2).

NAFO Div.	Years of sampling	Length range (cm)	No. of wolffish	Number of vertebrae		
				Mean	SE	Range
1AB	1965	20-69	12	74.833	0.241	74-76
2HJn	1950-67	20-69	72	74.194	0.085	73-76
2Js+3K	1950-64	20-79	120	74.308	0.076	72-77
3L	1950-67	20-119	198	74.455	0.051	73-76
3M	1950-64	20-89	46	75.087	0.120	73-77
3N	1950-67	20-129	123	74.610	0.081	72-78
3O	1950-64	20-109	207	74.860	0.056	73-78
3Ps	1950-67	20-119	304	74.816	0.044	73-77
4R	1950-67	20-89	167	74.844	0.056	73-78
4VW	1950-67	20-99	46	74.739	0.118	73-76
4X	1954-55	20-109	194	75.289	0.057	73-77

to the highest value (75.29) on the southern part of the Scotian Shelf (Div. 4X). In the Labrador-Newfoundland region, the mean counts for the three northern areas (Div. 2HJn to 3L) were significantly lower ($P < 0.01$) than those for Flemish Cap (Div. 3M), southwestern Grand Bank (Div. 3O), St. Pierre Bank and vicinity (Div. 3Ps), and eastern Gulf of St. Lawrence (Div. 4R). The mean count for southern Scotian Shelf (Div. 4X) was significantly higher ($P < 0.01$) than all other means except those for Flemish Cap (Div. 3M) and West Greenland (Div. 1AB). The latter mean, although considerably higher than those for areas off Labrador and eastern Newfoundland (Div. 2HJn to 3L) and lower than those for Flemish Cap and southern Scotian Shelf, did not differ significantly ($P > 0.05$) from any of them because of the small number of fish in the West Greenland sample.

The overall vertebral distribution for 1,491 Atlantic wolffish from the Northwest Atlantic was 72(3), 73(74), 74(472), 75(706), 76(209), 77(24) and 78(3). This range (72–78) compares with 74–77 (40 specimens) for Atlantic wolffish from southwestern Iceland (Luhmann, 1954), 72–76(33) for the White Sea (Barsukov, 1959), and 73–77(124) for the Barents Sea, northern North Sea–Norwegian coastal waters, and Iceland (Beese and Kändler, 1969).

The mean vertebral counts in this paper, ranging from 74.19 to 75.29 (Table 1) with overall mean of 74.76 ± 0.02, compare with means of 74.5(33) for Atlantic wolffish from the White Sea (Barsukov, 1959), 74.88(40) for southwestern Iceland (Luhmann, 1954), and, as reported by Beese and Kändler (1969), 74.76 ± 0.10(54) for Barents Sea, 75.15 ± 0.12(47) for Iceland and 75.39 ± 0.18(23) for northern North Sea-Norwegian coastal waters. Presumably, these vertebral means for Northeast Atlantic areas included the urostylar half-vertebra as a vertebra. The range of means for the Northeast Atlantic (74.19–75.39) was slightly higher than that for the Northwest Atlantic but the patterns appear to be similar, with a tendency toward lower vertebral numbers in the colder and higher numbers in the warmer regions. This was noted also by Beese and Kändler (1969).

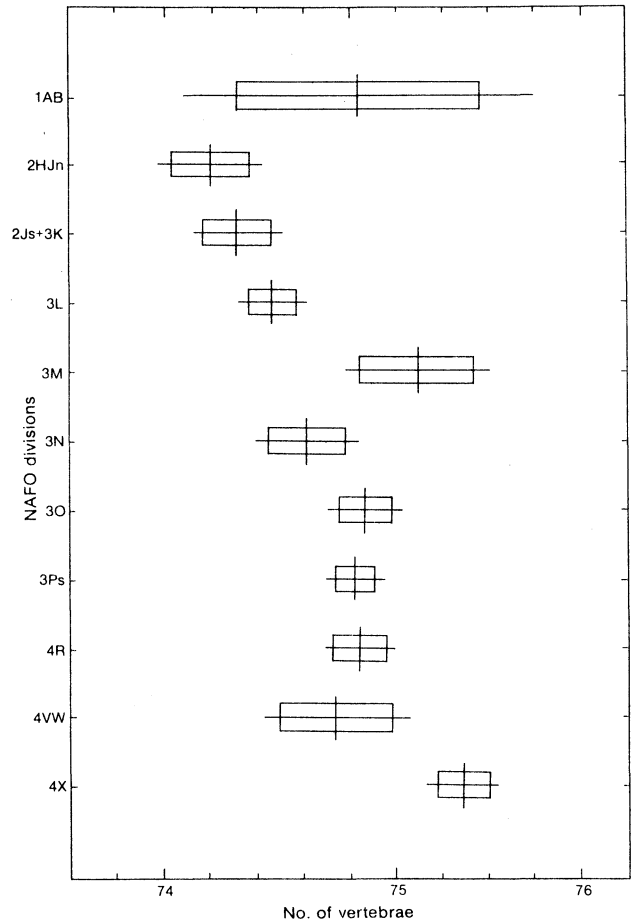

Fig. 2. Mean (median vertical line), 95% confidence interval (horizontal bar) and 99% confidence interval (median horizontal line) for vertebral numbers of Atlantic wolffish (20 cm and larger in total length) from various parts of the Northwest Atlantic.

Many researchers have studied the effects of temperature and other factors on the number of vertebrae and dorsal fin-rays in fishes. Tåning (1952), for sea trout, and Seymour (1959), for chinook salmon, found that vertebral number was lowest at intermediate rearing temperatures and increased at both lower and higher temperatures. Also, Tåning (1952) demonstrated experimentally that both lower oxygen tension and higher carbon dioxide tension during early development increased the number of vertebrae in sea trout. In nature, there is typically an inverse relationship between vertebral number and temperature of the water in which the eggs and larvae have developed, as reported by Schmidt (1930) and Templeman (1981) for cod and by Clark and Vladykov (1960) for haddock. For Atlantic wolffish, on the other hand, the pattern of higher vertebral numbers in warmer regions and lower numbers in colder regions is opposite the usual pattern for many North Atlantic fishes with pelagic eggs and larvae. With mainly autumn spawning and over-winter development of eggs and larvae (Jonsson 1982, for Icelandic waters; W. Templeman, unpubl. data for the Newfoundland area), it is likely that the critical time (Tåning, 1952) for determining the vertebral number in Atlantic wolffish occurs in late autumn, winter or spring, depending on the temperatures during development. Under the hypothesis that an inverse relationship between vertebral number and temperature during early development exists for Atlantic wolffish, as for other fishes, an explanation of the apparent reversal of pattern in wolffish is that spawning and egg development, during autumn-winter-spring in the northern areas, occurred at times, places and depths where temperatures were higher than those encountered during egg development farther south where vertebral numbers were higher. However, information on spawning times and areas is too sparse to allow more than speculation on the actual conditions for egg development other than that the hypothesis would require earlier or deeper spawning in the northern than in the southern areas. Another possibility is that, in the southern areas, egg clutches are laid on muddier bottom with lower oxygen and higher carbon dioxide levels than in northern areas.

Dorsal fin-rays (Table 2, Fig. 3)

Dorsal fin-ray numbers in Atlantic wolffish of the Northwest Atlantic were usually between 72 and 75 with extremes of 71 and 77. Like the mean vertebral counts, the mean fin-ray counts usually increased from north to south, the values being 73.23 in the Labrador-Northeast Newfoundland Shelf region (Div. 2H–3K), 73.55 on St. Pierre Bank (Div. 3Ps) and 73.88 on the northern Scotian Shelf (Div. 4VW). The mean fin-ray count for West Greenland (Div. 1A) was somewhat higher than that for the adjacent area to the south and the mean for Flemish Cap (Div. 3M) was only slightly lower than that for the northern Scotian Shelf (Div. 4VW). However, the small sample sizes make the 95% confidence intervals so great that the differences among means were not significant ($P > 0.05$) except that the mean for Div. 3NO was barely significantly lower than that for Div. 3M.

TABLE 2. Sample information by area relevant to numbers of fin-rays in Atlantic wolffish from the Northwest Atlantic, 1950–67 (Fig. 3).

NAFO Div.	Years of sampling	Length range (cm)	No. of wolffish	Number of fin-rays Mean	SE	Range
1AB	1965	20-67	13	73.385	0.213	72-75
2H-3K	1951-67	30-54	30	73.233	0.149	72-75
3M	1951-64	21-66	33	73.788	0.136	72-76
3NO	1951-67	22-77	37	73.216	0.140	71-75
3Ps	1951-59	20-108	62	73.548	0.120	71-75
4R	1951-67	20-80	83	73.482	0.099	72-77
4VW	1951-67	25-101	25	73.880	0.185	72-76

The overall distribution of fin-ray counts for 303 Atlantic wolffish from the Northwest Atlantic was 71(2), 72(32), 73(120), 74(122), 75(23), 76(3) and 77(1). This range (71–77) compares with 70–75(40) for Atlantic wolffish from southwestern Iceland (Luhmann, 1954), 71–75(32) for the White Sea and 72–76(42) for the Barents Sea (Barsukov, 1959), and 71–77(124) for fish from the Barents Sea, northern North Sea, Norwegian coastal waters and Iceland combined (Beese and Kändler, 1969).

The mean fin-ray counts in this paper, ranging from 73.23 to 73.88 (Table 2) with overall mean of 73.48 $\pm$ 0.05, compare with means of 73.0(32) for Atlantic wolffish from the White Sea and 73.98 $\pm$ 0.14(42) for the Barents Sea (Barsukov, 1959), 72.83(40) for southwestern Iceland (Luhmann, 1954), 73.54 $\pm$ 0.14(54) for the Barents Sea, 73.74 $\pm$ 0.12(47) for Iceland and 74.82 $\pm$ 0.17(23) for the northern North Sea-Norwegian coastal waters (Beese and Kändler, 1969). In the latter data,

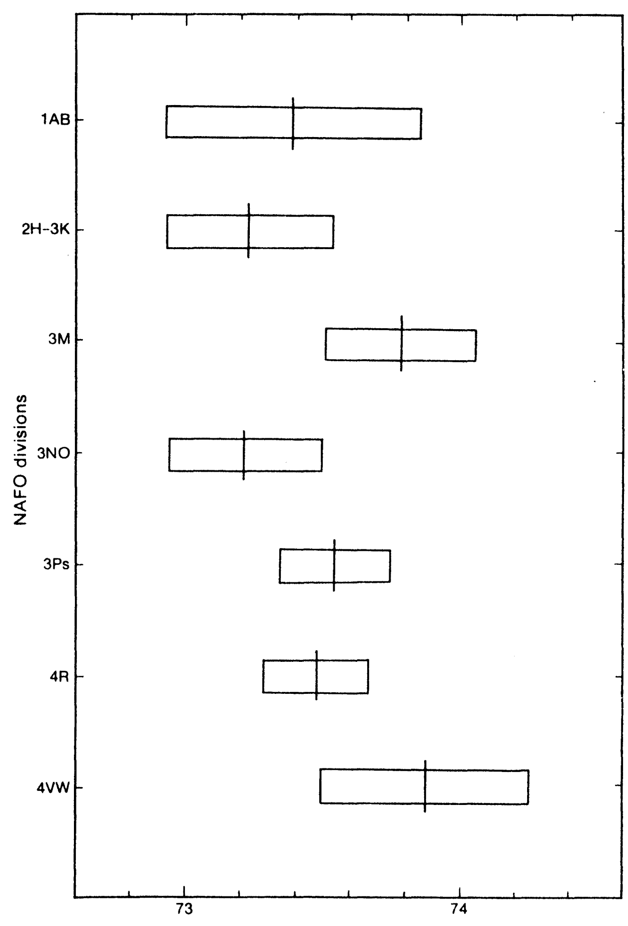

Fig. 3. Mean (median vertical line) and 95% confidence interval (horizontal bar) for dorsal fin-ray numbers of Atlantic wolffish (20 cm and larger in total length) from various parts of the Northwest Atlantic.

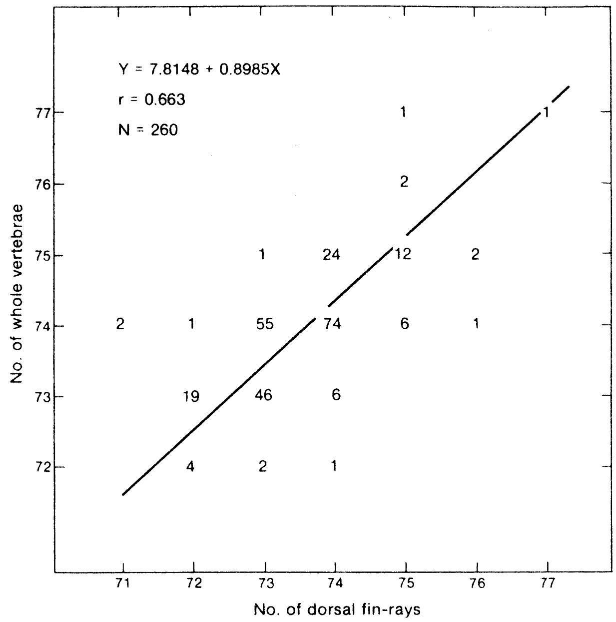

Fig. 4. Correlation of numbers of dorsal fin-rays and whole vertebrae of Atlantic wolffish (20 cm and larger in total length) from the Northwest Atlantic. (GM functional regression line is illustrated.)

as in those for the Northwest Atlantic, the mean fin-ray count increased from the colder to the warmer regions. However, the Northwest Atlantic fin-ray data in this paper, from lack of area coverage to the south and small sample sizes, are less extensive and of lesser significance than the vertebral data.

In the rearing experiments noted above (Tåning, 1952; Seymour, 1959), variation in dorsal fin-ray numbers with temperature was opposite to that for vertebral numbers, with fin-ray numbers being highest at intermediate temperatures and lower at both higher and lower temperatures. However, in nature, the trend in counts of second dorsal fin rays in Atlantic cod was similar to that for vertebral counts, with the counts being generally higher at lower temperatures than at higher temperatures (Schmidt, 1930). According to Tåning (1952), fin-ray numbers in sea trout are determined considerably later in development than vertebral numbers. In such cases, the larvae could be subjected to different temperatures during the period when fin-ray numbers are determined than those prevailing during the period of vertebral formation. However, for Atlantic wolffish, from the similarity of variations in dorsal fin-ray and vertebral numbers by area and from the drawing of a larva from an egg clutch in the eastern Barents Sea (Barsukov, 1959), it is likely that both the vertebral and dorsal fin-ray numbers are determined before the larvae leave the egg clutches on the seabed and thus are related to near-bottom temperatures and other environmental conditions.

Correlation of dorsal fin-ray and whole vertebral numbers

Because vertebral number (Y) and fin-ray number (X) are both subject to natural variability, the GM functional regression (Ricker, 1973, 1975) seemed appropriate to describe the relationships between these variables (Fig. 4). The averages for 260 specimens were 73.86 whole vertebrae (excluding urostylar half-vertebra) and 73.51 fin-rays. With a correlation coefficient (r) of 0.66 (highly significant), the approximate correspondence of fin-ray and vertebral numbers indicate that these meristic characters may be determined during early development by similar environmental and genetic influences.

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