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J. Northw. Atl. Fish. Sci., Vol. 5: 213-217

NOTE

Vertebral Numbers in Larval and Juvenile Haddock of the Scotian Shelf and Implications for Stock Discrimination

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Abstract

Analysis of vertebral number in larval and juvenile haddock (*Melanogrammus aeglefinus*) from different parts of the Scotian Shelf indicated that juveniles from the northeastern area (Div. 4V) had significantly fewer vertebrae than those from the central and southwestern areas (Div. 4W and 4X). This is in contrast to previous studies of vertebral number in adults. Complex segmentation in the caudal region of the vertebral column occurred in about 25% of the specimens in the length range of 15-220 mm.

Introduction

Most of the studies on stock structure of haddock on the Scotian Shelf can be considered in the light of Booke's (1981) definition of a stock, i.e. a species group or population of fish that maintains and sustains itself over time in a definable area. Such studies since the mid-1920's have involved the analysis of commercial fishery statistics (Needler, 1930; Hennemuth *et al.*, 1964; Halliday, 1971), migrations (Needler, 1930; McKenzie, 1940; Schroeder, 1942; McCracken, 1956, 1960, 1963; Halliday and McCracken, 1970), parasites (Scott, 1981), and egg and larval surveys (O'Boyle *et al.*, 1984). The first analysis of meristic characters was by Vladykov (1935) who used vertebral counts of adult haddock to differentiate the New England, Nova Scotia and Newfoundland stocks. Clark and Vladykov (1960) updated the earlier meristic analysis and proposed the existence of three haddock stocks on the Scotian Shelf, occupying the northeastern, central and southwestern parts of the shelf. Although Martin (1953) recognized the existence of several populations of haddock on the shelf, comprehensive analysis of all available data by the Research and Statistics Committee of the International Commission for the Northwest Atlantic Fisheries (ICNAF) resulted in the delineation of two stocks (McCracken, 1956; Grosslein, 1962), one occupying the northeastern and central area (Div. 4V and 4W) and the other occupying the southeastern area (Div. 4X).

Any differences which exist between the stocks should be maximal during the first year of life before any significant mixing of the adjoining stocks occurs. In this paper, the variation in vertebral numbers and the frequency of vertebral abnormalities are described from observations of larval and juvenile haddock caught on different parts of the Scotian Shelf.

Materials and Methods

The analysis involved 271 larval and juvenile haddock (8-41 mm long) which were collected during an ichthyoplankton survey of the Scotian Shelf in May-June 1980, and 282 juveniles (45-200 mm) which were obtained during a bottom-trawl survey in July 1981 (Fig. 1). The specimens were measured to the nearest millimeter from the tip of the snout to the tip of the notochord or hypural plate, whichever was most posterior.

Examination of the vertebrae in the planktonic specimens was facilitiated by enzyme clearing and staining with Alizarin Red S for bone. This permitted the counting of neural and haemal spines in larvae as small as 8 mm. Specimens smaller than 8 mm were not examined, because attempts to stain cartilage with Alcian Blue (Dingerkus and Uhler, 1977) were unsuccessful. The vertebrae of trawl-caught specimens were examined on X-ray generated photographs.

Most intraspecific variation in vertebral number of gadoids appears to occur in the abdominal region of the vertebral column (Ford, 1937; Markle, 1982). For this reason, the vertebral elements (spines and centra) were enumerated separately for the abdominal and caudal regions, and the following vertebral counts

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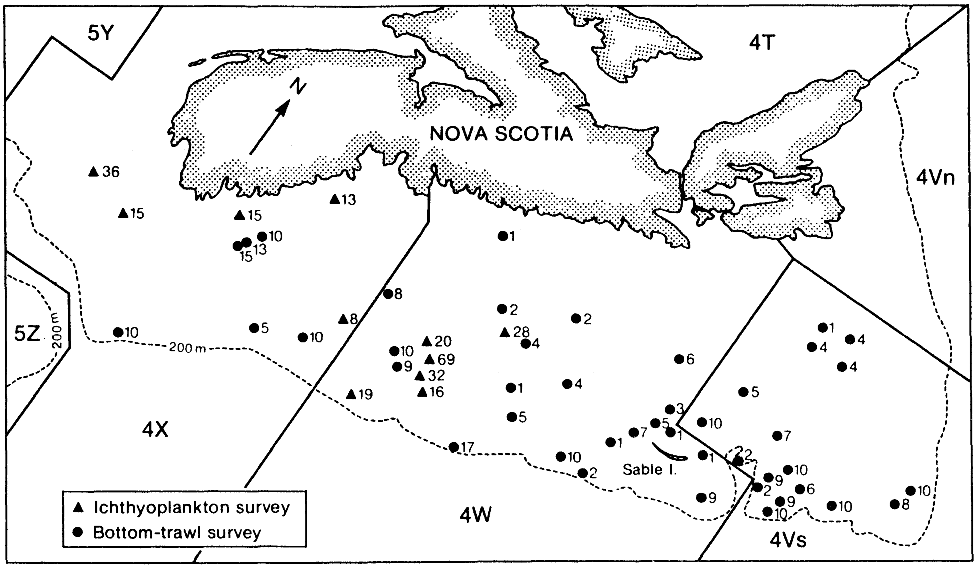

Fig. 1. Ichthyoplankton and bottom-trawl sampling locations on the Scotian Shelf, with numbers of haddock specimens and the boundaries of the relevant NAFO divisions.

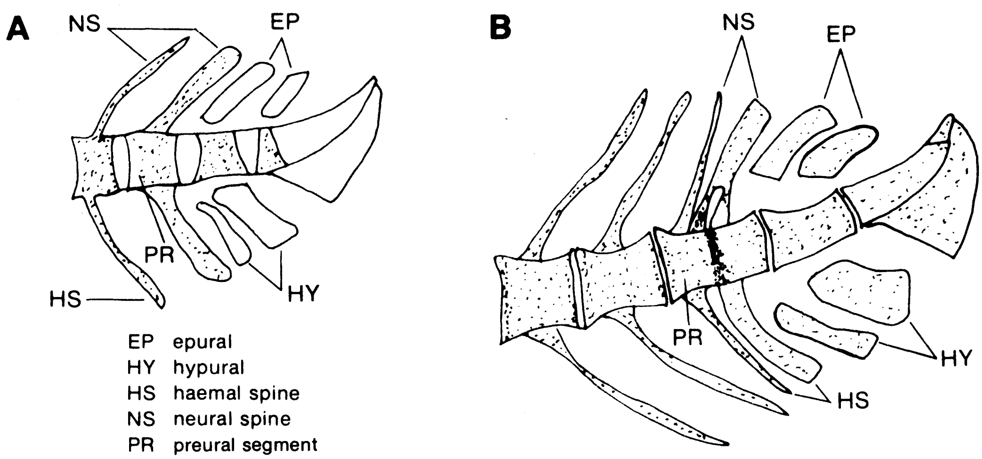

Fig. 2. Caudal region of representative juvenile haddock specimens: (**A**) 17 mm specimen showing normal caudal development and (**B**) 21 mm specimen showing duplicate neural and haemal spines on the first preural vertebra. (Stippling indicates intensity of Alizarin Red S stain.)

were made: abdominal vertebrae utilizing spines or centra as convenient, caudal neural spines, haemal spines, caudal centra, total neural spines, and total centra. Following the practice of Templeman (1981), the urostylar half-vertebra was included in the total centra count. Incomplete ossification and caudal development in specimens smaller than 15-20 mm prevented counting the last two vertebrae which follow the first preural vertebra with thickened neural and haemal spines (Fig. 2), and these were accounted for by adding two to the vertebral counts which ended at the first preural vertebra. The sample sizes differ slightly for the various counts, because all elements could not be resolved in every specimen.

Analysis initially involved examination of complex segmentation characteristics as a function of fish size by the chi-square test. This was followed by analysis of the vertebral number of small and large specimens by NAFO divisions through the use of the Mann-Whitney U test (Conover, 1971). Interdivision comparisions of vertebral counts in 8-41 cm fish were restricted to Div. 4W and 4X, because no specimens in this length range were available from Div. 4V.

Results

Complex segmentation, involving duplication of neural and/or haemal spines (Fig. 2) or bifurcation of spines, was evident in a substantial number of the specimens examined (Table 1). The former condition occurred in about 25% of the specimens greater than 15 mm long and was associated almost exclusively

TABLE 1. Frequency of complex segmentation type involving additional processes by size-group of haddock from the Scotian Shelf. (Significance of chi-square pertains to the probability that size and frequency are independent based on contingency table analysis, where NS = not significant, * = P <0.05, and ** = P <0.01.)

Abnormalities	Frequency by size-group (mm)			Chi-square test
	<15	15–41	45–220	
Preural segments one and/or two with				
— additional neural spine (%)	9 (6.0)	9 (7.8)	18 (6.7)	NS
— additional haemal spine (%)	8 (5.3)	11 (9.5)	7 (2.6)	*
— additional neural and haemal spine (%)	0 (0.0)	7 (6.0)	44 (16.4)	**
Total additional elements (%)	17 (11.3)	27 (23.3)	69 (25.7)	**
Other segments — extra elements (%)	0 (0.0)	1 (0.9)	4 (1.5)	NS
Number of specimens examined	151	116	269	

TABLE 2. Vertebral counts by size-group of haddock from the three divisions of the Scotian Shelf. (Mann-Whitney U test pertains to the probability that element numbers for two divisions are equal, based on mean ranks, where NS = not significant, * = P <0.05, and ** = P <0.01.)

Vertebral region and elements counted	Div. 4V		Div. 4W		Div. 4X		Mann-Whitney U test		
	Mean	No.	Mean	No.	Mean	No.	4V-4W	4V-4X	4W-4X
			Haddock 8-41 mm						
Abdominal vertebrae	—	—	20.17	181	20.12	86	—	—	NS
Caudal neural spines	—	—	32.79	178	32.98	84	—	—	*
Haemal spines	—	—	32.80	178	32.98	84	—	—	NS
Caudal centra	—	—	34.68	177	34.88	84	—	—	*
Total neural spines	—	—	52.96	181	53.09	86	—	—	NS
Total centra	—	—	54.86	180	55.01	86	—	—	NS
			Haddock 45-220 mm						
Abdominal vertebrae	20.11	107	20.25	107	20.27	52	NS	NS	NS
Caudal neural spines	32.37	105	32.74	105	32.62	58	**	NS	NS
Haemal spines	32.31	105	32.73	105	32.53	58	**	NS	NS
Caudal centra	34.11	105	34.51	105	34.41	58	**	*	NS
Total neural spines	52.46	105	52.99	106	52.88	49	**	**	NS
Total centra	54.19	105	54.76	106	54.69	49	**	**	NS

with the first and second preural segments. When both haemal and neural spines were duplicated, the condition appeared to be associated with fusion of the centra (Fig. 2B). There was considerable variation in frequency of complex segmentation with size of fish (Table 1). Additional haemal spines were significantly more prevalent in specimens ≤41 mm long than in the larger juveniles, but duplication of both haemal and neural spines was significantly more frequent in the larger fish (45-210 mm). This latter observation may have been due to the difficulty of distinguishing discrete centra (and hence duplication of spines) in fish less than 15-20 mm in length.

In the small haddock (8-41 mm) from the ichthyoplankton survey in Div. 4W and 4X, significant differences were evident in the numbers of caudal neural spines and caudal centra, with the values being higher in Div. 4X than in Div. 4W (Table 2). However, there was no difference between divisions for counts of total neural spines or total centra. In the larger haddock (45-220 mm) from the groundfish survey of all three divisions, no significant differences were evident in the vertebral counts between Div. 4W and 4X. However, except for abdominal vertebrae, the differences were highly significant between Div. 4V and 4W for all other counts and between Div. 4V and 4X for total neural spines and total centra.

Discussion

The high occurrence of complex segmentation associated with the preural centra (Table 1) is consistent with the findings of Ford (1937) and Markle (1982) who reported on gadoids in general. However, Clark and Vladykov (1960) reported that only 1% of their adult haddock specimens had vertebral abnormalities.

As that value is similar to the low frequency of abnormalities in segments of the vertebral column other than the preural segments in the present study (Table 1), it is possible that Clark and Vladykov (1960) were not concerned with the complex segmentation of the preural region.

Clark and Vladykov (1960) reported that the mean vertebral counts (increased by one to account for the urostylar half-vertebra) for haddock increased gradually from 54.50–54.58 in the Browns Bank-LaHave Bank area (Div. 4X) to 55.16–55.19 on the northeastern part of the Scotian Shelf (Div. 4V). The range of mean vertebral elements (centra) in the present study was somewhat lower (54.19–55.01), with the lowest value for juveniles from Div. 4V and higher values (54.86 and 55.01) for larvae and juveniles from Div. 4W and 4X.

The south to north increase in vertebral numbers, reported for haddock of the Scotian Shelf by Clark and Vladykov (1960), was also noted for cod of the Scotian Shelf and Newfoundland-Labrador regions by Templeman (1981), who attributed the trend to increasingly lower temperatures at the time of egg and early larval development from south to north. An inverse relationship between vertebral number and temperature was shown also for juvenile cod of eastern Newfoundland by Lear and Wells (1984) and has been demonstrated for many other species of fish (Dannevig, 1950; Blaxter, 1957; see references in Clark and Vladykov, 1960, and in Templeman, 1981). The trend in vertebral numbers of juvenile haddock on the Scotian Shelf from the present study contradicts this inverse relationship because temperatures in a given period on the northeastern part of the shelf (Div. 4V) are lower than those prevailing in the southwestern areas (Div. 4W and 4X) (McLellan, 1954; Houghton *et al.*, 1978). Although the eggs and larvae of haddock in Div. 4V may develop in temperatures quite different from the average conditions in the area, data are insufficient to investigate this possibility.

Another possibility is that the juveniles taken in Div. 4V originated on St. Pierre Bank, which is just across the Laurentian Channel in Div. 3P. Clark and Vladykov (1960) and Grosslein (1962) reported that haddock of that area have lower vertebral counts (53.6–54.1) than haddock of the Scotian Shelf. In the present study, the mean number for juvenile haddock in Div. 4V (54.2) is close to the upper limit of the range given by Grosslein (1965) for St. Pierre Bank.

Whatever the reason for the lower vertebral counts in juveniles of Div. 4V, this observation provides evidence for the separation of haddock in Div. 4V and 4W into two components, in contrast to the present management regime where haddock of both divisions are considered as a single stock.

Acknowledgements

We thank D. Markle and L. Van Guelpen of the Huntsman Marine Laboratory and M. White of the University of Guelph for helpful discussion of staining techniques, K. Howes of the St. Andrews Biological Station for X-ray photographs, G. Paul of the Marine Fish Division, BIO, Dartmouth, for the illustrations, and D. Markle and J. McGlade for comments on an earlier draft of the manuscript. Samples of planktonic haddock were provided by the Huntsman Marine Laboratory, St. Andrews, New Brunswick.

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