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On the Use of Vertebral Numbers to Discriminate Populations of Greenland Halibut (*Reinhardtius hippoglossoides*, Walbaum)) at West Greenland

by

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Abstract

Vertebral counts from samples of Greenland halibut in 1995 and 1989 were compared to previous samples in the period 1987-89 for similar areas at West Greenland. The 1995 samples obtained in Davis Strait, Baffin Bay and two West Greenland fjords showed no significant differences in mean vertebral numbers. Previous studies in 1987-89, however, showed significant differences in mean vertebral count between areas. Interannual variation in counts is thus higher than variation between areas sampled. Based on hydrographic conditions for recruitment, adults in the northernmost fjords of West Greenland is assumed to originate from other spawning grounds than are the adults in Davis Strait. The present study therefore indicates that vertebral number is not a suitable character for revealing the population structures of Greenland halibut at West Greenland.

Introduction

Greenland halibut are widely distributed in the Northwest Atlantic from Nova Scotia in south to Smith Sound in the north. An offshore fishery for Greenland halibut takes place east of Newfoundland (Div. 3K, 3L, 3M and 3N) and into Davis Strait (Div. 0B, 1C and 1D) (NAFO, MS 1995). Along the west coast of Greenland (subarea 1) an inshore fishery takes place from Nanortalik to Upernavik and also further north in Qaanaaq Fjord; most of the catches are taken in Div. 1A (NAFO, MS 1995).

Sporadic spawning are assumed to take place in the fjords of West Greenland as only few mature or spent fish have been found (Smidt, 1969; Riget and Boje, 1989). Hitherto recruitment of young fish to the fjords has therefore been supposed to be mediated by larval drift from offshore spawning areas. Major spawning areas of importance are assumed to be found in Davis Strait south of 67°N (Jensen, 1935; Smidt, 1969) more or less continously to Flemish Pass (Junquera et al. (1994). This spawning stock complex probably acts as the major source to the fjords north of Nuuk at West Greenland (Riget et al., 1992).

West of Iceland is a well determined spawning ground, which probably give rise to adult components in the fjords of Southwest Greenland. This assumption is based on the occurrence of drifting eggs and larvae towards Greenland from the Icelandic spawning grounds (Sigurdsson, 1979; Sigurdsson and Magnusson, MS 1980) and also on recaptures of adult fish off Iceland from tagging experiments in the Southwest Greenland fjords (Boje,1994).

It seems however unlikely that Greenland halibut in the fjords north of Ilulissat (Div.1A) could be recruited from Davis Strait because no larvae have previously been found off these areas (Riget and Boje, 1989). A simple calculation based on an assumption of passive drift in the upper layer of the West Greenland water current from the assumed spawning grounds, does either not explain such a northern distribution.

Tagging experiments indicate that adult Greenland halibut in the northern part of Greenland are resident (Riget and Boje, 1989; Boje 1994). Due to little or no fishing effort in the offshore areas of Div.1A, these results cannot be taken conclusive. Furthermore the length distributions in the catches off West Greenland does not imply any northward migrations of the young fish.

So the major questions are how the recruitment to Baffin Bay and to the fjords in Div 1A takes place and how the relationship is between these stocks and the known spawning stock in Davis Strait.

Several stock discrimination studies have been carried out on Greenland halibut in the Northwest Atlantic. Templeman (1970), Misra and Bowering (1984) and Riget et al. (1992) have analysed meristic characters, Bowering (1988) used morphometric characters, Fairbairn (1981) and Riget et al. (1992) has investigated frequencies of electrophoretic protein loci, Khan et al. (1982), Arthur and Albert (1993) and Boje et al. (1996) have dealt with parasites as biological tags.

In this study the vertebral counts were examined as a method for describing the relationship between inshore populations in West Greenland fjords and populations in Baffin Bay and Davis Strait.

In order to compare with a previous study by Riget et al. (1992), samples from three areas covered by them were obtained. In addition a sample from Baffin Bay was obtained in order to investigate the relationship between the Baffin Bay component and the components in the northern fjords.

Materials and Methods

Greenland halibut in the length range 29-87 cm were collected from four localities in the period July to August 1995 (Fig.1). Although the number sampled at each locality was predetermined to 100, the actual sampled number varied (Table 1). The samples from Upernavik and Uummannaq were collected during an annual longline survey. The Baffin Bay samples were collected by the use of both longline and gillnets. In Davis Strait the samples were collected by the Japanese research trawler "Shinkai Maru" during August 1995. All fish were weighed, total length were measured, and age and sex of each specimen was determined (Table 1).

Results from Boje (1989 unpublished data) (Table 1) and previous data from the study by Riget et al. (1992) are included in present analysis.

The vertebral columns were exposed by filleting the fish. Fish from site no. 1 and 4 were frozen and thawed before vertebral counting. Fish from site no. 2 and 3 had their vertebrae counted in fresh condition. All vertebrae including the urostylar half were counted. Fish with fused vertebrae were excluded.

As vertebral data consist of counts, non-continous data, all statistical tests performed were non-parametric.

Results

In order to analyse if length of the fish was correlated with vertebral number a Spearman correlation analysis was carried out for each sample (SAS, 1985). A highly significant correlation between length and vertebral counts was found for Uummannaq sampled in 1987. In none of the other samples any significant correlation between vertebral number and length were observed (Table 2). There is both negative and positive correlation coefficients so it seems unlikely that significant bias in meristic average are occuring, due to differences in length groups between samples.

There was no significant difference in the vertebral number between sexes in any of the samples (Wilcoxon two-sample test, $p>0.05$; SAS, 1985). Males and females were therefore combined for subsequent comparisons.

The sample obtained in Uummannaq 1995 include sufficient numbers of individuals to perform a yearclass analysis on vertebral number. The analysis showed no differences between the nine yearclasses born in 1981 to 1989 (Kruskall Wallis, $p=0.673$, $n=157$ (11-30 individuals in each yearclass); SAS, 1985).

The vertebral number ranged from 60 to 64 in the 1995 survey. In the 1987 to 1989 surveys the vertebral number ranged from 58 to 63. The mean value of counts obtained in 1995 were higher for all areas compared to 1987-89 (Table 3).

There was no significant difference in vertebral counts between areas sampled in 1995. (Kruskal Wallis $p=0.405$; SAS, 1989). The results obtained in the three areas from 1987 to 1989 all differed significantly from each other (Wilcoxon two-sample test $p<0.001$; SAS, 1989).

A comparison of vertebral number from 1995 with vertebral number from 1987 to 1989 shows highly significant differences between the two periods for each of the three areas, Davis Strait, Uummannaq and Upernavik (Wilcoxon two-sample test $p<0.001$; SAS, 1985). (Table 4).

Discussion

Based on available biological information on water current speeds, egg and larval drift, and migration pattern, it is assumed that adult fish in the northernmost fjords of West Greenland (Upernavik), are not recruited from the same spawning grounds as adult fish are in Davis Strait.

The presence of various frequency distributions in vertebral numbers within the same species was for the first time ascribed to the presence of different spawning populations in the 19'th century, when Heincke (1898) described herring races by means of meristic characters. Since then a more comprehensive understanding of the formation of the vertebrae has been obtained. For other species of fish the number of vertebrae are determined during the development of the embryo, before the eyed egg stage (Tåning, 1946; Fahy, 1976). Vertebral number is inherited (Christiansen et al., 1988), but the major difference in vertebral number observed between fish stocks are probably determined by differences in environmental factors, among which temperature is especially well-documented. (Tåning, 1946; Fahy, 1972; Brander, 1978; Hulme, 1995).

Two studies using vertebral counts performed by Templeman from 1950 to 1968 and Riget et al. from 1987 to 1988 give conflicting results (Templeman, 1970 and Riget et al., 1992). Templeman finds no significant difference between vertebral counts throughout a sampling area ranging from Baffin Bay to Southern Grand Bank except from one sample in Gulf of St. Lawrence. Riget et al. (1992) found on the other hand significant difference between samples from Davis Strait and three West Greenland fjords - Uummannaq Fjord (Div.1A), Godthaab Fjord (Div.1D) and Julianehaab Fjord (Div.1F). The three fjords also differed significantly from each other in vertebral counts.

The present study (1995) showed no significant differences between areas and a significant difference of mean vertebral counts compared to 1987-1989.

If numbers of vertebrae is determined by temperature or other environmental factors in the water currents where the eggs are drifting, it can be concluded that all sampled populations in 1995 derive from either one spawning area or from spawning areas with similar environmental conditions. Greenland halibut is known to be a bathypelagic spawner, and environmental conditions in these depths (approximately 1.000 to 2.000 m) are assumed very stable and homogenous throughout the Northern Atlantic.

Despite the result of the yearclass analysis on the Uummannaq sample from 1995, the observed inconsistency between the two sampling periods (1987-1989 and 1995) indicates that there is a pronounced effect of sampling year on the vertebral number. Following the assumption that Greenland halibut in the northern fjords of West Greenland does not originate from the same spawning areas as the stock complex in Davis Strait, the effect of sampling year is obviously larger than any geographic effect of spawning areas.

Our results emphasize the importance of relying on data based on more than point estimates. Our data suggest that counts of vertebral number may not be an conclusive method used solely to determine stock affinities for Greenland halibut at West Greenland.

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Table 1. Data on vertebral samplings with mean length, mean weight and mean age of specimens and standard deviation of the mean values.

Site No.	Locality	NAFO Div.	Sampling Month and Year	Depth Interval (m)	Number of fish	Length (cm) Mean	Length (cm) S.D.	Weight (g) Mean	Weight (g) S.D.	Age (years) Mean	Age (years) S.D.
1	Upernavik	1A	Jul 1995	240-820	99	62	8,43	2645	1325	9,95	2,04
2	Uummannaq	1A	Aug 1995	200-960	170	60	10,67	2130	1225	9,56	2,60
3	Baffin Bay	1A	Aug 1995	450-745	61	53	8,71	1400	715	7,69	1,68
4	Davis Strait	1D	Aug 1995	1103-1410	97	58	5,54	1680	557	8,77	1,42
1	Upernavik	1A	Aug-Sep 1989[1]	100-1300	96	56	5,76	[2]		9,17	1,10

Abbreviations (summary statistics): S.D. standard deviation of the mean.
[1] Data from Boje (1989 unpublished data)
[2] The fish were not weighed

Table 2. Spearman correlations coefficients, based on rank scores, of vertebral counts with length in different areas in 1995 and 1987-1989.

Location	Correlation coefficient	Probability of H_0 (p)	Number of fish
Davis Strait 1995	-0,092	0,374	95
Uummannaq 1995	0,063	0,422	165
Upernavik 1995	-0,052	0,606	98
Baffin Bay 1995	-0,102	0,439	59
Davis Strait 1988	-0,023	0,820	100
Uummannaq 1987	0,316**	0,003	90
Upernavik 1989	0,046	0,655	96

** Significance at the 99% level

Table 3. Frequency distribution of vertebral counts of Greenland halibut in different areas in 1995 and 1987-1989.

	Vertebral counts									
Location	58	59	60	61	62	63	64	n	Mean	S.D.
Davis Strait 1995	0	0	2	28	51	14	0	95	61,811	0,704
Uummannaq 1995	0	0	4	57	78	26	0	165	61,764	0,740
Upernavik 1995	0	0	2	41	44	10	1	98	61,663	0,731
Baffin Bay 1995	0	0	1	18	37	3	0	59	61,712	0,589
Davis Strait 1988	0	0	6	48	40	6	0	100	61,460	0,702
Uummannaq 1987	1	3	28	37	18	3	0	90	60,856	0,931
Upernavik 1989	2	17	33	41	2	1	0	96	60,281	0,891

Abbreviations (summary statistics): n: number of fish sampled
S.D.: standard deviation

Table 4. Wilcoxon two-sample test for difference between the sampling periods, 1995 and 1987 to 1989.

Comparison areas	Probability of H_0 (p)
Davis Strait 1995 - Davis Strait 1988	0,0007***
Uummannaq 1995 - Uummannaq 1987	0,0001***
Upernavik 1995 - Upernavik 1989	0,0001***

*** Significance at the 99,9% level

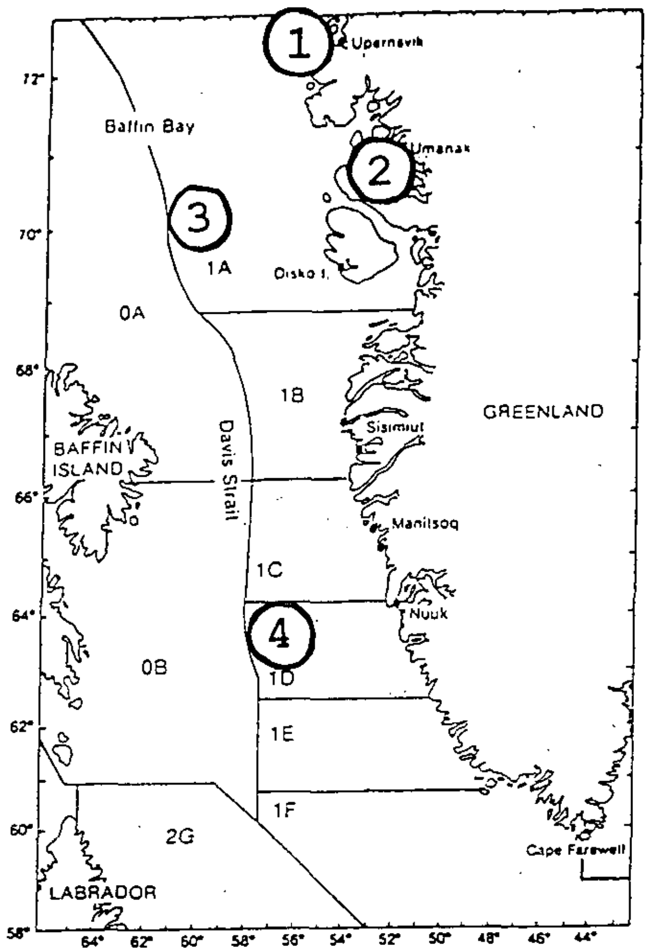

Fig.1. West Greenland and Davis Strait region, showing the NAFO divisions and the four areas sampled in 1995.