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Geographic variation of *Sebastes mentella* in the Northeast Arctic derived from a morphometric approach

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At present there is considered to be only one management unit of *Sebastes mentella* in the Northeast Arctic. A morphometric analysis was conducted to compare specimens from different locations and different times of the year. Residuals of the regression between each morphometric variable and standard length were used as input in a stepwise discriminant analysis, which revealed morphometric differences between three main regions: Svalbard, the Barents Sea and the Norwegian Sea, with the Lofoten area being an intermediate area where fish from the other three areas are present during some of the year. A previously described spawning migration pattern can also be derived from this analysis; the implications on survey design in this region are discussed.

Key words: *Sebastes mentella*, redfish, Northeast Arctic, population structure, stock discrimination, morphometrics, discriminant analysis.

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Introduction

An outline of the geographical distribution of the Northeast Arctic stock of *Sebastes mentella* is shown in Figure 1. The outline is based on literature (e.g. Travin, 1952; Sorokin, 1961; Drevetnyak, 1993, 1995; Nedreaas, 1995) and data from surveys and fisheries collected and analyzed by the authors. The southwestern Barents Sea and the Spitsbergen areas are primarily nursery areas. Although some adult fish may be found in smaller areas within these main areas, the main behaviour of these fish is to migrate westwards and southwestwards towards the continental slope as they grow and become adults. *S. mentella* in the Northeast Arctic start maturing at age 7–8 (25–29 cm), and at age 12–13 (30–34 cm) about 50% of the specimens are considered to be mature (ICES, 2000). South of 70°N only a few specimens less than 28 cm have been observed, and here *S. mentella* are only found along the slope from about 450 m down to about 650 m. The southern limit of the *S. mentella* distribution is not well defined but it is believed to be somewhere on the slope west of Shetland. The larval extrusion grounds are along the slope from north of Shetland to west of Bear Island, but it is not known whether some extrusion grounds are more important than others within this area. The peak in larval extrusion takes place during the first half of April (Sorokin, 1961, authors' observations). Low isozyme genetic variation has so far been found in *S. mentella* in the Northeast Arctic (e.g. Nedreaas and Nævdal, 1989), and there are to date no genetic results which support any splitting of the present single management unit. However, the main aim and purpose of the genetic work so far has been species and not stock or population discrimination.

Morphometric studies have proved useful for identifying marine fish stocks and describing their spatial distribution (Ihssen *et al*., 1981). These have been previously used to distinguish *Sebastes* species and populations on both sides of the North Atlantic (Misra and Ni, 1983; Power and Ni, 1985; Kenchington, 1986; Saborido-Rey, 1994). Saborido-Rey (1994) studied different populations of *Sebastes* in the North Atlantic, including the Northeast Arctic *S. mentella* management unit, Flemish Cap, Grand Bank of Newfoundland and Saint Pierre Bank. He noted a significant variation in morphometric characters within the Northeast Arctic management unit with the occurrence of two groups of *S. mentella*, one around Norway and another at Svalbard.

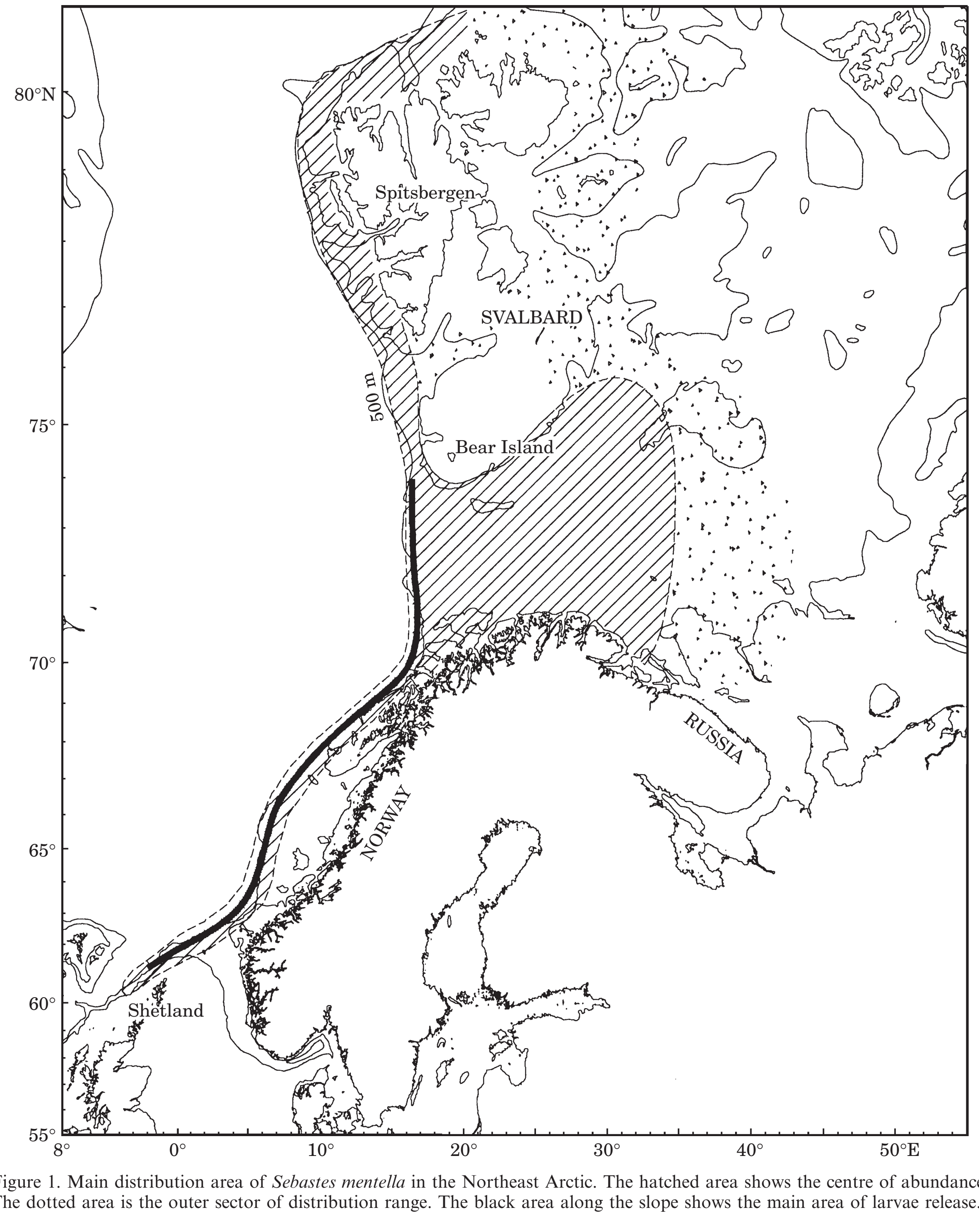

Figure 1. Main distribution area of *Sebastes mentella* in the Northeast Arctic. The hatched area shows the centre of abundance. The dotted area is the outer sector of distribution range. The black area along the slope shows the main area of larvae release.

Nevertheless, the question of whether there is a single stock or multiple stocks of *S. mentella* in the Northeast Arctic remains unresolved since Norwegian surveys show a continuous distribution of the resource with a clear pattern of distribution of juveniles and adults, as stated above (Fig. 1), and the genetic results have not shown any sub-structuring of the stocks. Our objectives were: (i) to assess and describe the geographic variation in morphological characters of *S. mentella* in the Northeast Arctic; (ii) to elucidate the distribution

Table 1. Description of the sampling location. Lofoten samples are split into autumn and spring and Svalbard samples into Spitsbergen and Bear Island. Sex ratio = number of females/number of males.

Location	Date	N	Size range (mm)	Sex ratio	Source
Norwegian Sea (excluding Lofoten)	October 1990	48	240–390	1.00	R/V "G. O. Sars"
Lofoten					
Autumn	October 1990	8	245–340	1.00	R/V "G. O. Sars"
Spring	March 1993	43	253–366	1.00	R/V "Michael Sars"
Barents Sea	October 1996	87	201–342	0.92	R/V "Johan Hjort"
Svalbard					
Spitsbergen	August 1992	38	154–324	1.11	Spanish cod pair trawler
Bear Island		95	212–379	1.11	

pattern of the resource in the area; and (iii) to investigate their implications for survey design.

Material and methods

A total of 319 specimens of *S. mentella* were sampled (Table 1, Fig. 2). In the Northeast Arctic some specimens of *S. mentella* and *S. marinus* are not easily distinguished. For that reason specimens were identified using the gasbladder musculature (Ni, 1981; Power and Ni, 1982) which is a more precise attribute than external characteristics.

A total of 21 morphometric variables were measured, including standard length. Figure 3 shows the landmarks used, the measurements taken and the acronyms for each varible as used in the Results and Discussion. Variables were chosen following a truss network method (Humphries *et al.*, 1981) and variables describing the head and fins were also incorporated. All measurements were taken with a digital caliper (MITUTOYO 500-301) at ± 0.01 mm.

Outliers were detected by regression analysis of morphometric measurements against standard length, and by scatter plots of residuals *versus* predicted values (Cook and Weinsberg, 1982). When an outlier was found, all morphometric data for that fish were withdrawn. This procedure resulted in the elimination of morphometric data for three fish from the Svalbard group.

In order to remove the size-dependence of the morphometric variables and compare the shape of the fish of different sizes, morphometric data were statistically adjusted to permit comparative analysis in terms of shape, independent of size (Thorpe, 1983). There are several methods to achieve a separation between size and shape (see review in Reist, 1986); we prefer to use the residuals of the regression between each variable and standard length as input in the subsequent analysis. This technique was shown to achieve the best separation between size and shape variation in *Sebastes* (Saborido-Rey, 1994). The data from all groups were pooled, and the 20 morphometric variables regressed against standard length. The residuals thus obtained (adjusted morphometric characters) were used in the stepwise discriminant analysis. The discriminant analysis was applied to adjusted morphometric characters with variables entered in a forward manner using $F=1.0$ for entering, and $F=0.99$ for removal. To assess the discriminatory effectiveness of the analysis, Wilks' λ was used (Wilks, 1932). This is a multivariate analysis of variance statistic that tests the equality of group means for the variable(s) in the discriminant function. The smaller the λ, the bigger the difference among groups, ranging from zero to one. The discrimination between groups can also be assessed by the proportion of correct classification of the individuals within their own group.

Differences by sex within groups were tested prior to the final analysis. Differences were tested both with principal component analysis (PCA) and stepwise discriminant analysis (SDA). Differences between fish from different hauls within each group were tested using the same methodology. As a result of this analysis, a pattern in the data was observed for fish collected in the Lofoten area. Therefore it was decided to run the analysis as follows:

Step 1: including in the analysis the three most distant groups, i.e. Norwegian Sea, Barents Sea and Spitsbergen (Fig. 2).
Step 2: Bear Island, which is situated between Spitsbergen and Barents Sea, is incorporated in the analysis.
Step 3: Bear Island and Spitsbergen were pooled in the same group (Svalbard) and compared with Norwegian Sea and Barents Sea.
Step 4: Fish collected from Lofoten in both surveys (autumn and spring) were combined and incorporated in the analysis together with Svalbard, Norwegian Sea and Barents Sea.

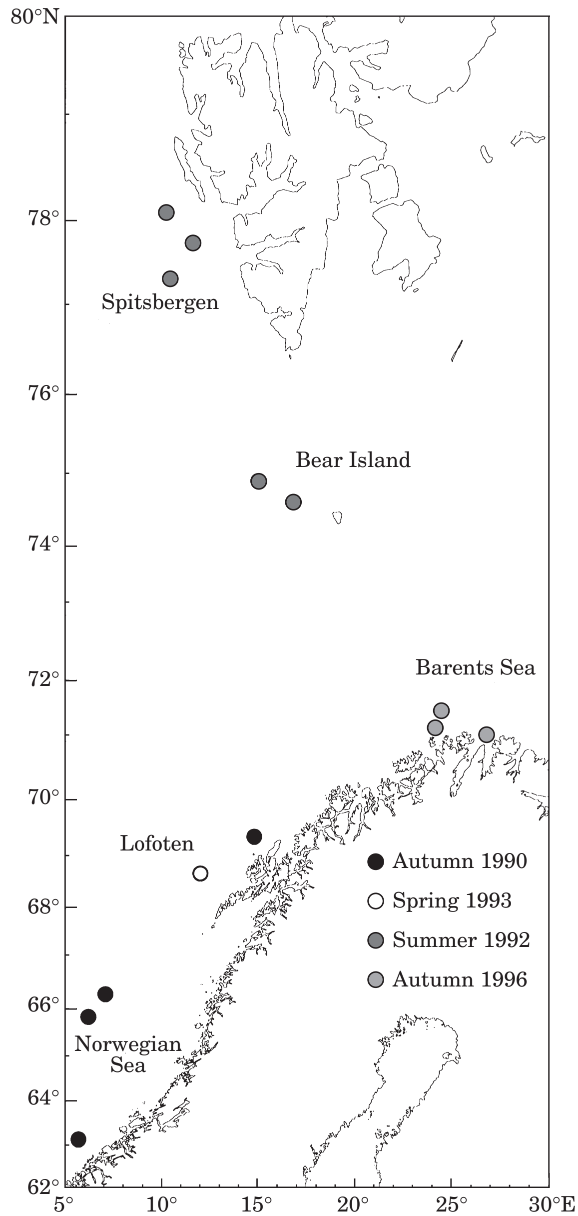

Figure 2. Sampling locations and dates of the five groups of *S. mentella* collected in the Northeast Arctic.

Statistica for Windows 5.0 (StatSoft Inc., 1995) was used to perform principal component analysis, stepwise discriminant analysis and screening of data.

Results

There were no differences between sexes within each region except for the spring Lofoten samples. The PCA from Lofoten spring samples reveal a clear pattern of two groups that can be considered as males and females (Fig. 4). The SDA shows that the differences between sexes are relatively large, with a final correct classification rate of 92.86%, although Wilks' λ is not particularly low (0.30). For each region, i.e. Spitsbergen, Bear Island, Barents Sea, Norwegian Sea and Lofoten, the within area variation was tested by analyzing differences between stations. There was significant variation within the Lofoten area, which was related to differences between the spring and autumn stations. Lofoten was the only area where samples from different seasons were available. Therefore, as explained above, it was decided to run the analysis step-by-step, progressively incorporating different groups in the analysis.

Step 1: most distant groups (Norwegian Sea, Barents Sea and Spitsbergen)

The plot of the two canonical variables shows a complete separation between the three groups (Fig. 5). The first canonical variable accounts for 83% of the total variation. The total correct classification rate was 94.8%, which may be considered as very good discrimination. All of the specimens from the Norwegian Sea were correctly classified. Although there is some overlap of individuals between Spitsbergen and Barents Sea the discrimination between them is high with a correct classification of 89.5% and 94.2%, respectively (Table 2). When 16 morphometric variables had been entered Wilks' λ drops to 0.08 with an approximate F-statistic indicating a significant difference among the three groups ($F=23.58$; df, 32,310; $p<0.001$). The other four variables did not contribute significantly to the multivariate discrimination.

Step 2: including Bear Island

Bear Island samples were collected from two stations between the Spitsbergen and Barents Sea locations. Therefore in this step, fish sampled at Bear Island were considered as a different group and analyzed with the groups described in the previous step. Figure 6 shows the plot of the first two canonical variables, which account for 79% and 19% of the total variation. There is a noticeable overlap of individuals from Bear Island and Spitsbergen and less overlap with the Barents Sea. The Norwegian Sea is still 100% discriminated. The total correct classification rate is only 75.75%, which is a poor discrimination rate (Table 3). This low rate is due to the low classification rates of fish from Spitsbergen and Bear Island. Note that the Barents Sea specimens are classified mainly within their group (86.2%) and the rest are mainly classified in the Bear Island group. However 55.3% of the Spitsbergen specimens are classified in the Bear Island group. The stepwise analysis revealed that 16 of the 20 adjusted morphometric characters contributed significantly to the multivariate discrimination of

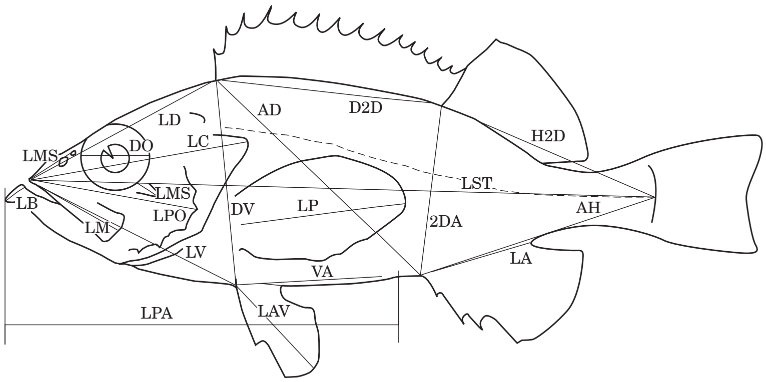

Figure 3. Morphometric variables measured acronyms used for analysis of population structure of Northeast Arctic *S. mentella*. Width (AN) is not shown; it was taken as the width between the opercula.

the four groups of fish (Table 3). The approximate F-statistic indicates a significant difference among groups (F=18.25; df, 48,741; p<0.001) and Wilks' λ is low, 0.098. It seems clear that fish from Bear Island are mainly the same as those from Spitsbergen, so it was decided to run a new analysis combining both groups as one Svalbard group.

Step 3: Spitsbergen and Bear Island combined as Svalbard

The two canonical variates from the discriminant analysis were plotted and are shown in Figure 7. As expected, there is an overlap between Barents Sea and Svalbard but the classification rate is high for both groups, 86.2% and 88%, respectively (Table 4). All Norwegian Sea specimens are correctly classified. The total classification rate is 89.55%. Some 17 morphometric variables were entered in the analysis and the final statistics show a significant multivariate discrimination of the three groups, Wilks' λ was 0.11 and approximate F-statistic was 29.54 (df, 34,498; p<0.001). These results can be considered as a good discrimination and the combination of the Bear Island and Spitsbergen specimens into a Svalbard group a correct step.

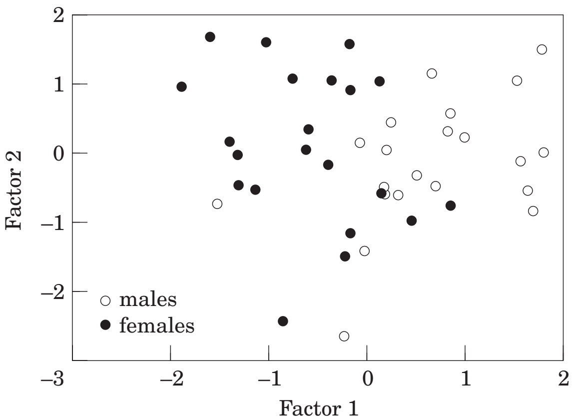

Figure 4. Factorial scores of principal component analysis made with morphometric characters of the spring Lofoten samples.

Step 4: including Lofoten samples

As a final step, the Lofoten samples were included in a new analysis, together with the three other groups, Norwegian Sea, Svalbard and Barents Sea. As shown in Figure 8 there is considerable overlap between the Lofoten individuals and the other three groups, mainly with Svalbard and Barents Sea. The low total correct classification rate, 77.74% (Table 5) is due to the large percentage of Lofoten specimens that are classified in other groups (25.49% into Svalbard, 13.73% into Barents Sea and 7.84% into Norwegian Sea). In this analysis it was necessary to enter all 20 morphometric variables; Wilks' λ (0.16) was the highest of the four analyses, but was still significant (the approximate F-statistic was 12.57; df, 60,884, p<0.001). These significant values are the result of good discrimination of the Norwegian Sea individuals. As explained above, there were significant differences between the sexes in the Lofoten samples, and the samples from Lofoten were collected in two seasons (autumn and spring). Therefore a new plot was produced with the same discriminant scores but with different symbols for spring and autumn Lofoten samples, and for males and females from the Lofoten spring samples (Fig. 9). It can be observed that the Lofoten specimens classified as Norwegian Sea are those collected in autumn. Females and males of Lofoten spring samples are clearly divided into two groups, the males being more linked with the Svalbard samples, whereas the females show an overlap with both Svalbard and Barents Sea.

Table 2. Summary of stepwise discriminant analysis for Step 1. Variable acronyms are defined in Figure 3.

Step number	Variable entered	Wilks' λ	F-value to enter	Approximate F-statistic	Degrees of freedom	
1	AN	0.350489	157.52	157.52	2	170
2	LPO	0.208633	57.45	100.50	4	338
3	2DA	0.179283	13.75	76.26	6	336
4	LM	0.158222	11.11	63.21	8	334
5	DO	0.142430	9.20	54.77	10	332
6	DV	0.128663	8.83	49.17	12	330
7	H2D	0.118660	6.91	44.58	14	328
8	LD	0.110846	5.75	40.82	16	326
9	LA	0.104682	4.77	37.63	18	324
10	LP	0.099219	4.43	35.01	20	322
11	LAV	0.095934	2.74	32.42	22	320
12	LMS	0.093424	2.14	30.10	24	318
13	AD	0.090719	2.36	28.20	26	316
14	LC	0.088290	2.16	26.53	28	314
15	VA	0.086740	1.39	24.91	30	312
16	LV	0.084777	1.79	23.58	32	310

Classification matrix

Group	Percentage correct	Number of fish classified into group		
		Norwegian Sea	Spitsbergen	Barents Sea
Norwegian Sea	100.00	48	0	0
Spitsbergen	89.47	0	34	4
Barents Sea	94.25	0	5	82
Total	94.80	48	39	86

Discussion

The results of these analyses of morphometric characters suggest that there are at least three discrete morphometric groups of *S. mentella* in the Northeast Arctic: Svalbard, Barents Sea and the Norwegian Sea. These three groups correspond to the more distant samples collected in this study and the overlap between them is low. However, the Svalbard group is formed by specimens from Bear Island and Spitsbergen. Bear Island is in the central part of the studied area, between the locations where the Spitsbergen and Barents Sea samples were collected, and shows a high degree of overlap with both groups, although Bear Island specimens are mostly associated with Spitsbergen specimens. Thus, the Svalbard group was defined by the specimens from Spitsbergen and Bear Island.

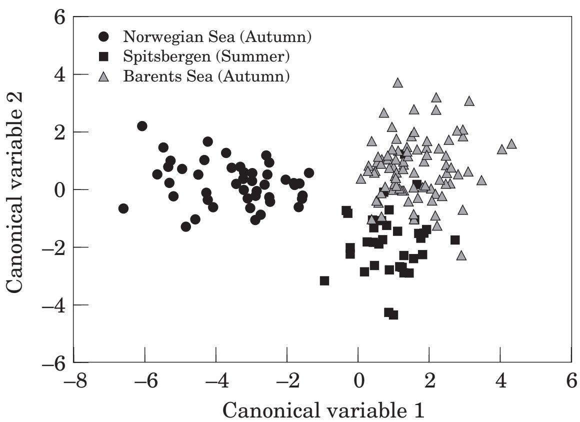

Figure 5. Plot of canonical scores for the three groups considered in step 1 (Norwegian Sea, Spitsbergen and Barents Sea).

In the case of Lofoten, it should be taken into account that most of the samples were taken in spring, during the spawning season of *S. mentella*. The autumn samples from Lofoten were classified mainly into the Norwegian Sea group. The Svalbard and Barents Sea samples were collected in autumn and summer and classified as distinct groups. These results suggest that in summer–autumn (feeding season) there is a clearly separate distribution pattern for the three groups. Nevertheless, more specimens should be collected in autumn from Lofoten to clarify the distribution range of the Norwegian Sea group.

Table 3. Summary of stepwise discriminant analysis for Step 2. Variable acronyms are defined in Figure 3.

Step number	Variable entered	Wilks' λ	F-value to enter	Approximate F-statistic	Degrees of freedom	
1	AN	0.463096	102.03	102.03	3	264
2	LPO	0.264574	65.78	82.73	6	526
3	DO	0.214134	20.57	62.62	9	638
4	DV	0.173642	20.29	54.01	12	691
5	LM	0.153065	11.65	46.62	15	718
6	LD	0.138388	9.16	41.22	18	733
7	LMS	0.130901	4.92	36.37	21	741
8	LC	0.124943	4.09	32.59	24	746
9	2DA	0.120420	3.20	29.50	27	748
10	LA	0.115712	3.46	27.09	30	749
11	LV	0.112028	2.78	25.02	33	749
12	LP	0.108062	3.10	23.35	36	748
13	LAV	0.104452	2.90	21.92	39	747
14	AD	0.102043	1.98	20.56	42	745
15	H2D	0.099557	2.08	19.40	45	743
16	VA	0.098251	1.10	18.25	48	741

Classification matrix

Group	Percentage correct	Number of fish classified into group			
		Norwegian Sea	Bear Island	Spitsbergen	Barents Sea
Norwegian Sea	100.00	48	0	0	0
Bear Island	69.47	0	66	11	18
Spitsbergen	36.84	0	21	14	3
Barents Sea	86.20	0	10	2	75
Total	75.75	48	97	27	96

While in summer–autumn the groups are disaggregated, the spring Lofoten samples show a considerable mixture of specimens belonging to the Svalbard and Barents Sea groups, suggesting that during this time of the year specimens from both areas inhabit the Lofoten area. In this context it is interesting to observe that the spring Lofoten group was the only one showing differences between sexes. The four-step analysis strongly suggest that this group is formed of fish migrating from different areas, probably males from Svalbard and females mainly from the Barents Sea, but also from Svalbard. This means that there is a seasonal migration pattern, probably related to spawning, from Svalbard and the Barents Sea to the areas outside Lofoten. *Sebastes* is viviparous, with copulation occurring in autumn and parturition of larvae in February–July, depending on species and stock/geographical area (Sorokin, 1961; Saborido-Rey, 1994). The peak parturition period of *S. mentella* in the Northeast Arctic is at the end of March and in April (Sorokin, 1961).

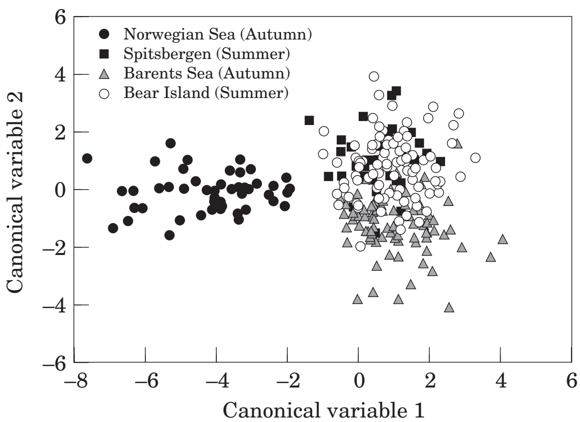

Figure 6. Plot of canonical scores for the four groups considered in step 2 (Norwegian Sea, Spitsbergen, Barents Sea and Bear Island).

Smaller aggregations of mature *S. mentella* within the Barents Sea and at Svalbard have been shown to migrate southwestwards to the slope area for extrusion of larvae in April (Sorokin, 1961). This matches the observed mixture of Barents Sea and Svalbard *S. mentella* groups outside Lofoten at this time of the year. Despite the fact that both groups were caught in the same area (i.e.

Table 4. Summary of stepwise discriminant analysis for Step 3. Variable acronyms are defined in Figure 3.

Step number	Variable entered	Wilks' λ	F-value to enter	Approximate F-statistic	Degrees of freedom	
1	AN	0.466454	151.56	151.56	2	265
2	LPO	0.266528	99.01	123.68	4	528
3	DO	0.216088	30.69	100.92	6	526
4	DV	0.176231	29.63	90.53	8	524
5	LM	0.156899	16.08	79.58	10	522
6	LD	0.147214	8.55	69.61	12	520
7	LC	0.140817	5.88	61.60	14	518
8	2DA	0.134979	5.58	55.53	16	516
9	LA	0.130692	4.22	50.43	18	514
10	LP	0.127091	3.63	46.21	20	512
11	LV	0.122221	5.08	43.13	22	510
12	LMS	0.119053	3.38	40.18	24	508
13	H2D	0.116127	3.19	37.65	26	506
14	AD	0.113475	2.94	35.43	28	504
15	LAV	0.112021	1.63	33.26	30	502
16	VA	0.110821	1.35	31.31	32	500
17	LMO	0.109861	1.09	29.54	34	498

Classification matrix

Group	Percentage correct	Number of fish classified into group		
		Norwegian Sea	Svalbard	Barents Sea
Norwegian Sea	100.00	48	0	0
Svalbard	87.97	0	117	16
Barents Sea	86.21	0	12	75
Total	89.55	48	129	91

outside Lofoten) during extrusion time in spring, Svalbard and Barents Sea specimens seem to a great extent to live on separate nursery grounds. A possible explanation for this may be that the release of larvae outside Lofoten occurs at different depths and times, and the larvae are thus transported in different directions.

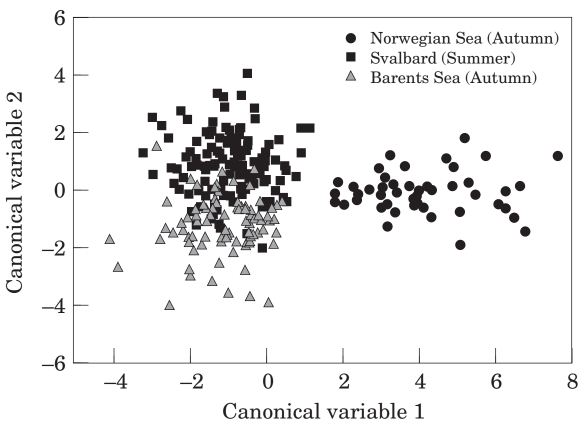

Figure 7. Plot of canonical scores for the three groups considered in step 3 (Norwegian Sea, Svalbard and Barents Sea).

Investigations by the Institute of Marine Research in Bergen, Norway, show that most of the mature stock of Northeast Arctic *S. mentella* live year-round along the continental slope at 450–650 m from west of Shetland and northwards towards Bear Island. It is known that extrusion of larvae in spring occurs here as does, most probably, copulation in autumn. According to our data and analysis, no fish from the Norwegian Sea group were present in the Lofoten spring samples which may, although data are scarce, suggest that Norwegian Sea *S. mentella* release their larvae elsewhere along the slope. Larvae from the Norwegian Sea group are transported northwards to the Barents Sea and/or Svalbard (Bjørke *et al.*, 1989, 1991) but poor sampling and/or the fact that these specimens may have migrated out of these areas at a smaller size may have prevented us from observing the Norwegian Sea group within the Barents Sea or Svalbard areas.

A denser grid of sampling stations along the slope during the larvae extrusion time in spring is necessary

Table 5. Summary of stepwise discriminant analysis for Step 4. Variable acronyms are defined in Figure 3.

Step number	Variable entered	Wilks' λ	F-value to enter	Approximate F-statistic	Degrees of freedom	
1	AN	0.534539	91.43	91.43	3	315
2	LPO	0.388847	39.22	63.18	6	628
3	DO	0.307460	27.62	52.79	9	762
4	DV	0.270718	14.11	43.95	12	826
5	AH	0.251413	7.96	37.16	15	859
6	LM	0.235714	6.88	32.50	18	877
7	2DA	0.220017	7.35	29.35	21	888
8	LD	0.209030	5.40	26.65	24	894
9	LB	0.202757	3.17	24.16	27	897
10	LP	0.196173	3.42	22.22	30	899
11	LV	0.189043	3.83	20.72	33	899
12	LMS	0.184049	2.75	19.31	36	899
13	LC	0.179729	2.43	18.08	39	898
14	H2D	0.176080	2.09	16.99	42	897
15	LMO	0.173086	1.74	16.00	45	895
16	LAV	0.170183	1.71	15.14	48	893
17	LA	0.167768	1.43	14.35	51	891
18	VA	0.165463	1.38	13.64	54	889
19	D2D	0.162155	2.02	13.07	57	886
20	AD	0.158706	2.14	12.57	60	884

Classification matrix

Group	Percentage correct	Number of fish classified into group			
		Norwegian Sea	Lofoten	Svalbard	Barents Sea
Norwegian Sea	95.84	46	0	2	0
Lofoten	52.94	4	27	13	7
Svalbard	83.46	0	10	111	12
Barents Sea	73.56	0	7	16	64
Total	77.74	50	44	142	83

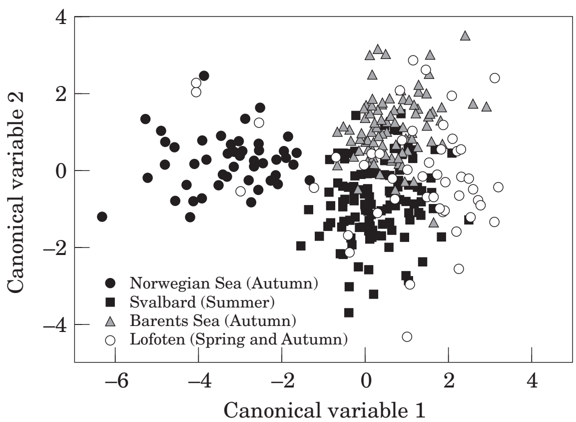

Figure 8. Plot of canonical scores for the four groups considered in step 4 (Norwegian Sea, Svalbard, Barents Sea and Lofoten).

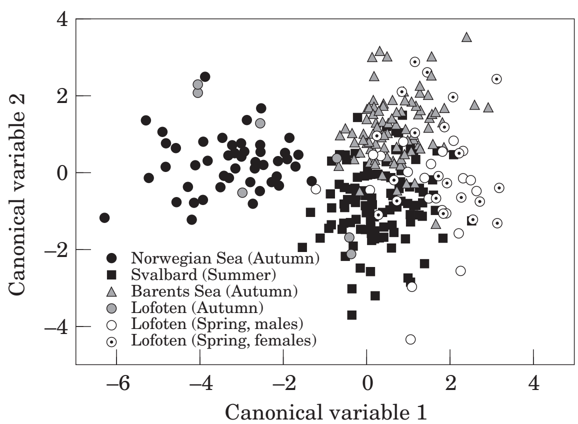

Figure 9. Plot of canonical scores as in step 4 but with different symbols for the Lofoten samples from autumn and spring (males and females separated).

before any conclusions can be drawn about the structure of the stock(s) in question. It may well be that fish from different nursery/feeding areas recruit to different spawning grounds and/or at different times, which may have implications for the subsequent larval drift routes. Year-to-year variations should also be investigated. Given the incomplete sampling, especially in spring, it is difficult to be more conclusive about the interaction among the three main groups and the mixing during spring. Hence further sampling should be conducted.

Our results suggest that data from surveys conducted in different areas at different seasons should be interpreted with caution. No surveys for *S. mentella* are being conducted south of Lofoten; this should be done to incorporate the Norwegian Sea group. Our findings also suggest that the current Russian survey in the Kopytov area southwest of Bear Island during the spawning season may cover part of the mixed Svalbard/Barents Sea spawning fish, but most likely none of the fish classified as the Norwegian Sea group. The Norwegian surveys along the continental slope from Lofoten (68°N) to Spitsbergen (80°N) and within the shallower parts of the Svalbard/Barents Sea areas in August will mainly cover the Svalbard/Barents Sea groups, but will only partially cover the Norwegian Sea group.

The question arises whether the scientific surveys should be conducted while the three morphometric components are furthest apart or during the time of maximum mixing, i.e. during larval extrusion. Until further morphometric (and/or genetic) analyses have been conducted, and as long as the stock is in bad shape, the total spawning stock biomass should be surveyed in spring. The Russian survey of the northern part of the spawning grounds seems insufficient, and the spawning areas of the Norwegian Sea morphometric component should also be covered. It has previously been described how the new fishery in the late 1980s, mainly on the Norwegian Sea component, was the ultimate cause of the drastic reduction of juveniles seen since 1991 (Nedreaas, 1995). The main cause for the present low stock level was most probably, however, the decades of heavy fishing in the western parts of Svalbard and the Barents Sea on stock components which, according to the present results, must have been the Barents Sea and Svalbard groups.

A time series of surveys covering the three morphometric components during late summer-early autumn, when the separation is at its maximum, could also provide useful information both on recruitment and on which components are most heavily fished and thus need to be protected if we want to maintain the present morphometric stock structure. The consequences of altering the present morphometric stock structure will, however, be a subject of further research.

Morphometric analysis is a useful tool not only for stock discrimination, but also for identifying possible temporal changes in the aggregation of fishes from different areas, and migration routes. If we assume that there are different *S. mentella* groups in the Northeast Arctic, we also have to consider that these groups are separated during the feeding time (summer) and, to a large extent, during copulation time (autumn), but are mixed during spawning time (spring). A single stock-discrimination method may not be sufficient to split a stock into a number of management units. However, significant morphometric differences, especially when related to geography, shed light on important fish behaviour and/or hydrographical processes that improve our perception of the stock dynamics. The results here cannot determine whether the current single management unit is appropriate. The degree and extent of this mixing should be further investigated. Further work on morphometric analysis and more genetic work is also needed before this question can be properly answered.

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