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Stock identification of *S. marinus* L. and *S. mentella* Travin in the Northeast-Atlantic based on meristic counts and morphometric measurements

by

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Abstract

Meristic counts and morphometric measurements have been performed on redfish sampled in Icelandic, Faroese, Norwegian and international waters in the Irminger Sea. The results are presented in this paper together with a statistical analysis of the morphometric measurements in order to elucidate the stock distribution of *S. marinus* and *S. mentella* in the Northeast Atlantic. Significant differences were found between all areas for both species, and for *S. mentella* a large degree of heterogeneity was found between stations in the Faroe waters; this heterogeneity between stations was not observed in the Irminger Sea. The consequences of this are briefly discussed and tentatively a rewised stock distribution scheme is proposed for both species.

Introduction

The two redfish species, *Sebastes marinus* L. and *Sebastes mentella* Travin have a very wide distribution in the Central and Northeast Atlantic as can be seen in Templeman 1959 (Fig. 1). At that time it was usual to deal with only one species, *S. marinus*, divided into two subspecies, *S. marinus marinus* and *S. marinus mentella*. Later the existence of two "good species" was accepted based on morphological, morphometric and meristic characters. Recently this has been verified by biochemical analysis (Nedreaas and Nævdal 1989, 1991) using haemoglobin patterns and enzymes (liver IDH, muscle ME) although they state, that generally the two species are very similar in most enzyme patterns. The calculated genetic differences were very small.

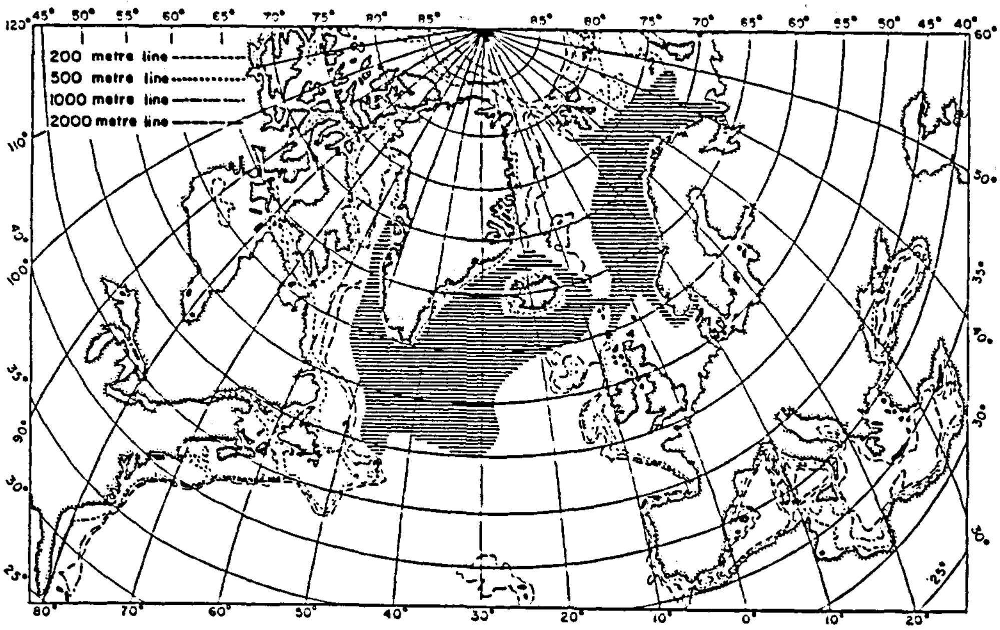

Figure 1. The distribution of S. marinus and S. mentella in the Northeast Atlantic according to Templeman(1959).

The distribution area shown in Figure 1 could today be refined somewhat based on new information but generally it is still valid for the two species taken together. The depth distribution is different for the two species, *S. marinus* being the shallower one. The depth range is somewhat different in different regions, but the main distribution of *S. marinus* is 150-450 m and that of *S. mentella* 300-750 m (Jónsson 1983, Reinert 1990). Due to the overlap in depth distribution there have been many practical problems connected with the split of the commercial catches of redfish into *S. mentella* and *S. marinus* with consequences for a separate management of them.

Even more important for management purposes is the division of each of the species into stock units. This has been very difficult due to lack of supporting data and has been done more on a geographical than on a biological basis. In the ICES area *S. marinus* and *S mentella* are both divided into two stock complexes; one in the Northeast·Arctic (Sub-areas I and II) with main areas of adult distribution, reproduction and nursery within the Norwegian Economic Zone and the Fishery Zone at Svalbard, and the other in the Faroe, Iceland and East Greenland region (Sub-areas V, VI, XII and XIV). In addition to this a pelagic stock of *S. mentella* with main distribution in the open Irminger Sea has been defined by the ICES Study Group on Redfish Stocks and named oceanic *S. mentella* compared with the ordinary bottom living *S. mentella* which now is named deep-sea *S. mentella* (Anon. 1992).

The term "Irminger Sea stock complex" has been applied to the redfish stocks in Sub-areas V, VI, XII and XIV pointing to the very central role of the areas SW of Iceland as common spawning (i.e. extrusion of larvae) places for the redfish from these areas (Anon. 1983). Nursery areas for the juveniles are found at Iceland (*S. marinus*), East Greenland (*S. marinus* and deep-sea *S. mentella*) and East/West Greenland (most probably oceanic *S. mentella*). Feeding and copulation areas of the adults of this stock complex are assumed to be along the coast of East Greenland, around Iceland and the Faroe Islands. This implies extensive migrations between feeding and spawning areas of the females and between nursery and feeding areas of the young fish.

Observations of the sex composition of the demersal redfish catches in the spring/summer time in all 3 areas have supported spawning migrations of the females, most of the redfish caught in the spring/summer time being males (Reinert 1990). Several O-group surveys have revealed the drift of larvae/fry to the mentioned nursery ground (Anon. several years) and young fish surveys have shown the nursery grounds at Iceland and East Greenland (Magnússon et al. 1975, 1988).

Spawning has also been observed at the Faroes in some years for both *S. marinus* and *S. mentella*, as well as larvae, but juveniles and young fish have never been recorded in this region, so the fate of this offspring is unsure. The smallest specimen caught in the trawl surveys (40 mm mesh size in the codend) have been 28 cm for *S. marinus* and 22 cm for *S. mentella*; in the commercial catches of *S. marinus* lengths of 40-60 cm are prevailing, whereas those of *S. mentella* are 37-50 cm.

These observations indicate that the adult redfish in Faroese waters is spawned or at least spends its younger years somewhere else and that would support the traditional view that Faroese redfish derives from the Irminger Sea stock complex. Recent studies of redfish from the mentioned areas using biochemical genetic analysis have, however, raised some doubts about this stock division, pointing to a closer relationship between Faroese and Norwegian Waters (Nedreaas & Nævdal 1991). From Figure 1 it should be obvious, that the redfish at the Faroes could derive from both of the stock complexes as the Faroes are situated on the submerged ridge between Scotland and Greenland via Iceland which separates the two main "redfish regions".

Realizing the problems regarding the stock identification a lot of international work have been made on this matter in recent years. In 1989 an ICES "Study Group on Oceanic-Type *Sebastes mentella*" was established which in 1990 was renamed "Study Group on Redfish Stocks"; stock distribution of redfish has been one of the main matter dealt with in this study group. In 1990 a redfish workshop was held in Iceland sponsored by the Committee for West Nordic Projects. The main topic of the meeting was stock distribution, and several possibilities were discussed for finding some ways to distinguish between stocks. As a result of this meeting two projects, founded by the same Committee, were started, both aiming at *S. marinus*. The one project was biochemical analysis of *S. marinus* from Icelandic, Faroese and Norwegian waters, carried out by the Marine Research Institute in Bergen, Norway. The other was a pilot project analysing the content of the radioactive isotope Cs-137 in *S. marinus* from the same areas, carried out by the Fisheries Laboratory of the Faroes. Results of this pilot project are presented in Reinert et al. 1992.

Also local institutes have worked on this matter. In 1988 the Fisheries Laboratory of the Faroes started sampling of redfish from different areas for analysis of selected meristic counts and morphometric measurements. This paper presents preliminary results of this analysis.

Material and methods

Material for the analysis of meristic counts and morphometric measurements was collected at the locations shown in Figure 2; Table 1 gives more information about the sampling stations. *S. marinus* was sampled in Icelandic, Norwegian and Faroese waters while *S. mentella* samples were from Norwegian, Faroese and international waters in the open part of the Irminger Sea.

Table 1. Data for the redfish samples for meristic and morphometric analysis. The sampling stations are denoted by codes shown in Figure 2 and in the column termed location in the table. Position and depth refer to start of haul; the depth values are bottom depts except for the stations in the Irminger Sea, where they refer to the depth of the head line of the pelagic trawl. Number of fish preserved for analysis is split into males (M) and females (F).

Location	Position	Depth (m)	Time of catch	Number of redfish sampled S. marinus	S. mentella
I1	63°27'N 24°40'W	257	March 1991	11F + 14M	0
IRM1	58°47'N 31°10'W	160	April 1988	0	10F + 0M
IRM2	58°35'N 31°23'W	500	April 1988	0	17F + 5M
IRM3	60°40'N 29°11'W	380	April 1988	0	21F + 20M
F1	60°24'N 06°04'W	419	Oct. 1988	0	21F + 33M
F2	60°59'N 05°25'W	386	Oct. 1988	25F + 20M	0
F3	61°14'N 05°05'W	446	Oct. 1988	0	18F + 13M
F4	62°50'N 11°13'W	523	Nov. 1988	0	17F + 27M
F5	60°33'N 09°34'W	510	Nov. 1988	0	20F + 21M
N1	72°27'N 27°40'E	145	Febr. 1991	12F + 0M	0
N2	71°40'N 31°23'E	330	Febr. 1991		21F + 19M

The redfish from Iceland (Station I) were collected on board a commercial Icelandic trawler and sent in a frozen state to Tórshavn, Faroe Islands, by a freezer ship. The redfish from Norwegian Waters (Stations N1 and N2) were collected during a trawl survey with the trawler "M/T Anny Kramer" in February 1991 and sent in a frozen state to Tórshavn, Faroe Islands by a freezer ship. The redfish from Faroese Waters (Stations F1-F5) were collected on board the Faroese "R/V Magnus Heinason" on a redfish survey in October/November 1988. The fish were frozen whole on board the vessel immediately after being caught and then kept frozen to the embarking at Tórshavn, Faroe Islands. The redfish from the Irminger Sea (Stations IRM1-IRM3) were collected on board the Faroese R/V Magnus Heinason during a survey in April 1988 and treated in same way as the Faroese samples. The sampling stations for *S. mentella* in the Irminger Sea and around the Faroes were chosen to investigate the heterogeneity inside the areas.

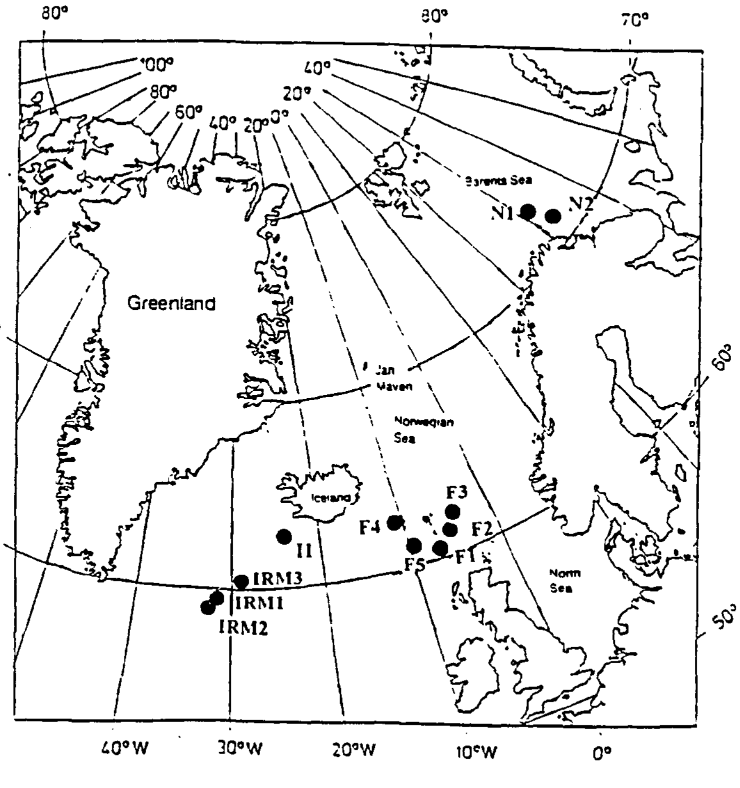

Figure 2. Locations where redfish were sampled for meristic and morphometric analysis.

Unfortunately, no males of *S. marinus* were in the sample from Norwegian waters. For *S. mentella* no sample were from Icelandic waters, and for one of the stations in the Irminger Sea only one sex was present in the sample (Table 1).

The meristic counts and morphological measurements (to the nearest mm below) were made on newly thawn up specimen at the Fisheries Laboratory of the Faroes by trained assistants; in the counting of vertebra the urostyla was included. The parameters counted/measured were adapted from Gall 1952 and are shown in Appendix 1 together with explanations of the abbreviations used in this paper.

For the meristic countings only mean values and total ranges have been calculated for each sampling station. The calculations were made for both sexes combined and split into females and males to allow for possible differences between the two sexes.

Statistical analyses on the morphometric measurements were performed using the SYSTAT software (SYSTAT, Inc.)

Because multivariate normality is usualy more closely approximated by logarithms of the values, logarithmic transformation was applied to the data before statistical analyses were performed.

F-statistic was used to test the assumption of common variance between the characters. Discriminant analyses were then applied to deduce differences in characters, using the length of the head Lcpl as covariate for the measurements in the head region, and the total length as covariate for the other measurements (le Gall, 1952). Variables was thereby generated which had been removed by the effect of length, which in Tables 2 and 3 is shown to vary between stations and especially between areas.

Analysis of covariance (ANCOVA) and multivariate analysis of variance (MANOVA) were used to investigate diffrences in the morphometri within and between areas and Hotellings T^2 test and Wilks' λ (likelihood ratio criterion) were used to test the statistic.

Results

Meristic counts

S. marinus and *S. mentella*

The results of the meristic counts are presented in Table 2 (*S. marinus*) and Table 3 (*S. mentella*) together with information on number of fish in the sample, sex, weight and size of the fish. 14 different characters have been counted; very few counts were made of the total number of rays in the caudal fin (RT) due to difficulties in the counting. No statistical analysis have so far been applied to the meristic counts and the results will only briefly be mentioned here.

The close relationship between *S. marinus* and *S. mentella* is demonstrated by the fact, that 5 of the counts (RV, RVh, RVs, RAnh, Opsp) being exactly the same for all specimen examined and other 5 counts (RD, RDh, RDs, RPec, Br) have the same mean and total range. Left are 3 characters, which could be diagnostic for the two species, although there are big overlaps between the counts. Total number of fin rays in the anal fin (RAn) seem to have a tendency to be higher in *S. mentella* than in *S. marinus*. The number of vertebra (Vert) also seem to be slightly higher in *S. mentella*. The number of rays in the caudal fin (RT) could seem to be a good diagnostic character separating the two species, but the number of counts in this analysis is to small.

There seem neither to be any pronounced difference between sexes nor between areas; however, the number of spines on the first branchial arch seems to vary between areas, and this and some other character could be of value in a statistical analysis.

Morphometric measurements

S. marinus

Stations F2, N1 and I1 were used to represent the Faroese, Norwegian and Icelandic waters, despite the fact that samples of males were missing at the Norwegian station (Table 1).

Before a discriminant analysis was performed (to deduce differences between the three areas) the morfometric data were submitted to an F-test to test the assumption of common variance between the characters. All characters except A (length to the beginning of the anal fin) showed common variance, implying that equality of the covariance matrices in all three areas may not be violated. A possible existence of sexual dimorphism was analysed by ANOVA and no significant difference was found (Wilk's $\lambda=0.55$, $p>0.001$).

In Table 4 means and standard deviations of the morfometric measurements from the three areas are shown together with the results of the T-test of the discriminant analysis. The discriminant analysis was performed after adjustment of the characters measured in the head (Po, Op, Od, Max and T) with the covariate Lcpl and the rest of the characters with LT to take the differences in these two lengths (Table 4) into account.

Table 4 shows differences in the characters Po (length to the front of the eye), Od (diameter of the eye), T (length of the protuberance of the lower jaw), Dp (length to the end of the dorsal fin) and V_1 (length to the beginning of the pelvic fin) at significance level $p < 0.001$. The statistic test of differences between the areas was found significant connected with a value of Wilk's λ of 0.101 ($p < 0.001$).

Analysis to deduce differences between each area seperately was then performed and the results are shown in Table 5, where the results of the analysis of covariance (ANCOVA) are presented as F values with corresponding significant p values.

The analysis of differences between Icelandic and Norwegian waters showed rejection of zero variance between the areas connected with Wilk's $\lambda=0.111$ ($p < 0.001$). Samples from Icelandic and Faroese waters were compared and variations were shown to derive from the characters T, Dp and V_1 (Wilk's $\lambda=0.155$, $p < 0.001$). The analysis of differences between Faroese and Norwegian waters was not significant ($p \ngtr 0.001$) corresponding to a Wilk's $\lambda=0.273$, which is more than double of that obtained in the two other comparisons.

S. mentella.

Table 6 shows mean values and standard deviations in the Irminger sea, Faroese and Norwegian waters, respectively. The stations in the areas (Fig. 2 and Table 1) were pooled to represent the specific area and mean values and standard deviations were then computed for the entire area except for the Norwegian waters, where there was only one station. As in the case of the analysis of *S. marinus* the characters of the samples of *S. mentella* were adjusted by the lengths LT and Lcpl before a discriminant analysis was performed to deduce differences in the morphometri between the three areas. The results of the analysis are presented in Table 6 as significance of the applied T- test of the analysis and showed high significance for several characters. The analysis of difference between areas was found significant, connected with a Wilk's λ value of 0.209 ($p < 0.001$).

To deduce exsistence of heterogenity within areas, a discriminant analysis was performed on the stations occupied in each of the waters. The results are displayed in Tables 7.a and 7.b together with mean and standard deviations for each of the stations analysed. From Table 7.a it can be seen, that the stations representing the Irminger Sea (IRM1,IRM2 and IRM3) only showed differences in two of the characters analysed, and the zero hypothesis of no difference between the stations could not be rejected ($p > 0.05$).

The results of the analysis of difference in the morphometri within the stations representing the Faroese water (F1-F5) are presented in Table 7.b together with mean values and corresponding standard deviations for each station. Discriminant analysis was performed as in the analysis of *S. marinus* and the results displayed as significant p values of each of the characters. Table 7.b shows differences for several characters and differences between the stations in the area was connected with significance, represented by a Wilk's λ value of 0.217 ($p < 0.001$). This difference between the stations might be explained by the lower mean values obtained at station F3 compared with the other stations analysed.

To deduce whether the the observed differences between stations could be explained by sexual dimorphism a multivariate variance analysis (MANOVA) was performed. The zero hypothesis of no difference could not be rejected (Wilk's λ=0.54, $p > 0.001$). The same analysis was performed on the stations in the Irminger Sea and in the Faroese waters, and neither showed existence of significant differences between the sexes (Wilk's λ=0.753, $p > 0.001$ and Wilk's λ=0.745, $p > 0.001$, respectively).

With the purpose to analyse possible relationship between the stations in the Faroese waters, a multivariate variance analysis was run. Table 8 presents the results from this analysis, expressed as F values and p values from the test, and the corresponding test of significance between the stations is presented by Wilk's λ and p values together with Hotellings T^2 and p values below each row in the table. Table 8 shows, that combinations of stations where F1 was included, showed small differences in the morphometrithe between the stations (relatively high Wilk's λ values and corresponding low Hotellings T^2 values). The observed differences are all between the most distant stations (F3, F4 and F5).

To investigate the heterogeneity in the Faroese waters further, multivariate variance analysis (MANOVA) was applied to deduce the variance between each station in the Faroese waters and the pooled data from the Irminger Sea and the one station in the Norwegian Waters, respectively. The results are shown in Table 9 together with tests of the statistic used (Wilk's λ, Hotellings T^2). From the table it is evident, that significant differences exist between each of the Faroese stations and the one in the Norwegian waters. Further it can be seen, that the most westerly stations F4 and F5 showed greater significance than F1 and F3 situated to the south and east, respectively. Also evident from the test of significance is, that a closer relationship seems to be between the Faroese waters and the Irminger Sea than between Faroese and Norwegian waters. Very spectacular is the finding of least difference being between the Irminger Sea and the most easterly Faroese station (F3). Also it should be mentioned, that the significant differences between the Faroese and the Norwegian waters were found in the measurements of the dorsal and anal fins, whereas the difference between the Faroese waters and the Irminger Sea were found in the head region (Po, Od) and in the pectoral fin.

Discussion

Meristic counts and morphometric measurements have been widely used to separate different species and subspecies/races, although meristic differences can be related to both environmental factors, especially temperature, and genetic effects (Templeman 1981). The traditional way to present the results of these investigations have been as mean values and total range. This is also the case in this paper with regard to the meristic counts, and generally they fit well with the species criteria given in f.ex. Hureau et al. 1986; however, the total range in this investigation is in many cases larger.

Application of refined statistic analysis in recent years have revealed the usefullness of meristics and morphometrics in separating a species into stock units (f.ex. Andersen et al. 1979, Jover 1991), and the results of this paper, using multivariate analysis, shows, that it also can be useful for redfish in the Northeast Atlantic.

S. marinus. The results of the analysis of the morphometric measurements reveal three separate groups, one in each of the areas. This is contradictionary to the traditional view of two stock complexes (Anon. 1983), to the recent results pointing to the Faroese *S. marinus* being more linked to the Norwegian than to the Icelandic *S. marinus* (Nedreaas et al. 1991, Reinert et al. 1992) and to the point of view, that Icelandic, Faroese and Norwegian *S. marinus* should be separated from the ones in East- and West Greenland waters (Nedreaas et al. 1992). However, when comparing the three areas there was found a greater difference between Norway and Iceland and between Faroes and Iceland than for Faroes and Norway thus supporting the results obtained from measurements of the Cs-137 content in the fish (Reinert et al. 1992).

The preliminary statistical analysis of *S. marinus* presented in this paper should of course be taken with care as only one sample from each of the three areas (Icelandic, Faroese and Norwegian waters) was available and only females were in the Norwegian sample. Further, the samples were taken at different times of the year, but this should not affect the result, because the times of the sampling were outside the time of possible spawning migrations (Table 1).

Given the differences in morphometric characters between the stations inside the Faroe area for *S. mentella* (see later), the situation could be the same for *S. marinus* (and eventually in other areas as well). Combining the various sources of information one might end up with a rewised stock distribution for *S. marinus* in the Northeast Atlantic: One stock unit in waters off each of the areas Greenland, Iceland, Faroes and Norway with two areas of overlap, East Greenland and Faroese waters, respectively, with elements from the neighbouring areas in addition to the local component.

However, more research involving different methods is needed in this matter before a conclusion can be made about this; this research should include fish from spawning, nursery and feeding areas, as well as account for variation through the year.

S. mentella.

The usefullness of the results of the present analysis is hampered by the fact, that no sample of *S. mentella* were from Icelandic waters, and only one sample from Norwegian waters.

However, the analysis deduces significant differences between *S. mentella* from the Irminger Sea, the Faroese and Norwegian waters. The finding of no significant differences between stations in the Irminger Sea supports the existing view, that the pelagic *S. mentella* in the Irminger Sea is a separate stock unit. The same could be applied to the Norwegian *S. mentella*, although the fact, that only one station were sampled must imply, that there exists at least one stock of *S. mentella* in Norwegian waters.

With regard to the Faroese waters the situation is more complicated. The difference between areas implies the existence of a lokal stock, but the variation between the stations in the Faroe area could be explained by migration between the Faroese waters and the neighbouring areas. Thus it might be concluded, that this preliminary multivariate variance analysis of morphometric measurements reveals the existence of a separate stock of *S. mentella* in the Faroese waters together with a component from the Icelandic waters (F4) and the Irminger Sea. This could also be explained by the location of the Faroes on the submerge ridge between Scotland via Iceland to East Greenland and the prevailing currents in the area (Fig. 3).

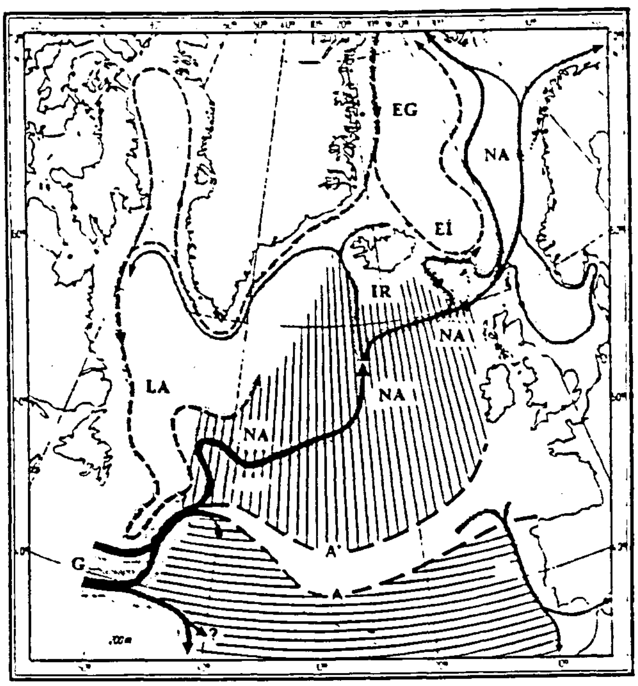

Figure 3. Surface currents in the North Atlantic.
G: Golf current, NA: North Atlantic Current, LA: Labrador Current,
IR: Irminger Current, EG: East Greenlandic Current,
EI: East Icelandic Current.

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Table 2. Meristic counts of S. marinus - mean values and total range (in brackets). The sampling stations are denoted by codes and shown in Figure 2.
I1 = Icelandic waters; F2 = Faroese waters; N1 = Norwegian waters.

Station	No. of fish in sample	Sex	N.weight	LT	RD	RDh	RDs	RV	RVh	RVs	RAn	RAnh	RAns	RPec	RT	Opsp	Vert	Br
I1	25	F+M	575 (315-747)	350 (307-394)	29 (29-31)	15 (14-16)	15 (14-16)	6 (6-6)	1 (1-1)	5 (5-5)	11 (10-12)	3 (3-3)	8 (7-9)	18 (17-19)		5 (5-5)	30 (29-30)	34 (32-36)
I1	11	F	583 (476-747)	343 (318-360)	29 (29-31)	15 (15-16)	15 (14-16)	6 (6-6)	1 (1-1)	5 (5-5)	11 (10-12)	3 (3-3)	8 (7-9)	18 (17-19)		5 (5-5)	30 (29-30)	34 (33-36)
I1	14	M	571 (315-738)	356 (307-394)	30 (29-31)	15 (14-16)	15 (14-16)	6 (6-6)	1 (1-1)	5 (5-5)	11 (11-12)	3 (3-3)	8 (8-9)	18 (17-19)		5 (5-5)	30 (29-30)	34 (32-36)
F2	45	F+M	1625 (739-3059)	474 (382-580)	30 (28-31)	15 (14-15)	15 (14-16)	6 (6-6)	1 (1-1)	5 (5-5)	11 (10-12)	3 (3-3)	8 (7-9)	18 (17-19)	15 (13-18)	5 (5-5)	30 (29-32)	35 (32-37)
F2	25	F	1906 (1069-3059)	501 (422-580)	30 (28-31)	15 (14-15)	15 (14-16)	6 (6-6)	1 (1-1)	5 (5-5)	11 (11-12)	3 (3-3)	8 (8-9)	18 (17-19)	15 (13-17)	5 (5-5)	30 (29-32)	35 (33-36)
F2	20	M	1274 (739-2124)	441 (382-531)	30 (29-31)	15 (15-15)	15 (14-16)	6 (6-6)	1 (1-1)	5 (5-5)	11 (10-12)	3 (3-3)	8 (7-9)	18 (17-19)	15 (14-18)	5 (5-5)	30 (29-31)	35 (32-38)
N1	12	F	1149 (374-1770)	421 (302-484)	30 (29-30)	15 (14-15)	15 (14-15)	6 (6-6)	1 (1-1)	5 (5-5)	11 (11-12)	3 (3-3)	8 (8-9)	18 (17-19)		5 (5-5)	30 (29-32)	33 (30-36)

Table 3. Meristic counts of S. mentella - mean values and total range (in brackets). The sampling stations are denoted by codes and shown in Figure 2.
IRM1-3 = Irminger Sea; F1, F3-F5 = Faroese waters; N2 = Norwegian waters.

Station	No. of fish in sample	Sex	N.weight	LT	RD	RDh	RDs	RV	RVh	RVs	RAn	RAnh	RAns	RPec	RT	Opsp	Vert	Br
IRM1	10	F	698 (527-939)	370 (343-390)	30 (28-31)	15 (15-15)	15 (13-16)	6 (6-6)	1 (1-1)	5 (5-5)	12 (11-13)	3 (3-3)	9 (8-10)	18 (17-19)		5 (5-5)	30 (30-30)	33 (32-34)
IRM2	22	F+M	683 (417-1352)	377 (300-456)	29 (28-31)	15 (14-18)	14 (12-16)	6 (6-6)	1 (1-1)	5 (5-5)	11 (11-12)	3 (3-3)	8 (8-9)	18 (16-20)	17 (15-18)	5 (5-5)	30 (30-31)	34 (32-36)
IRM2	17	F	677 (437-1332)	374 (300-456)	29 (28-31)	15 (14-18)	14 (12-16)	6 (6-6)	1 81-1)	5 (5-5)	11 (11-12)	3 (3-3)	8 (8-9)	18 (16-20)	17 (15-18)	5 (5-5)	30 (30-30)	34 (32-36)
IRM2	5	M	703 (446-971)	384 (320-439)	29 (29-30)	15 (15-15)	14 (14-15)	6 (6-6)	1 (1-1)	5 (5-5)	11 (11-12)	3 (3-3)	8 (8-9)	18 (18-19)	18	5 (5-5)	30 (30-31)	34 (32-35)
IRM3	41	F+M	581 (341-1055)	358 (304-439)	29 (28-31)	15 (14-16)	14 (13-16)	6 (6-6)	1 (1-1)	5 (5-5)	11 (11-12)	3 (3-3)	8 (8-9)	18 (17-20)	20 (19-20)	5 (5-5)	30 (29-31)	33 (31-36)
IRM3	21	F	634 (348-991)	366 (308-410)	29 (28-31)	15 (14-16)	14 (13-15)	6 (6-6)	1 (1-1)	5 (5-5)	11 (11-12)	3 (3-3)	8 (8-9)	18 (17-19)		5 (5-5)	30 (30-31)	33 (31-35)
IRM3	20	M	525 (341-1055)	349 (304-439)	30 (28-31)	15 (14-16)	15 (14-16)	6 (6-6)	1 (1-1)	5 (5-5)	12 (11-12)	3 (3-3)	9 (8-9)	19 (17-20)	20 (19-20)	5 (5-5)	30 (29-30)	33 (32-36)

Table 3 (continued). Meristic counts of S. mentella - mean values and total range (in brackets). The sampling stations are denoted by codes and shown in Figure 2. IRM1-3 = Irminger Sea; F1, F3-F5 = Faroese waters; N2 = Norwegian waters.

Station	No. of fish in sample	Sex	N.weight	LT	RD	RDh	RDs	RV	RVh	RVs	RAn	RAnh	RAns	RPec	RT	Opsp	Vert	Br
F1	54	F+M	1092 (533-1845)	422 (353-494)	30 (28-31)	15 (14-16)	15 (14-16)	6 (6-6)	1 (1-1)	5 (5-5)	12 (11-13)	3 (3-3)	9 (8-10)	18 (18-19)		5 (5-5)	31 (30-32)	34 (32-36)
F1	21	F	1143 (661-1845)	429 (368-494)	30 (28-31)	15 (14-16)	15 (14-15)	6 (6-6)	1 (1-1)	5 (5-5)	12 (11-13)	3 (3-3)	9 (8-10)	18 (18-18)		5 (5-5)	31 (30-32)	34 (32-36)
F1	33	M	1051 (533-1635)	418 (353-481)	30 (28-31)	15 (14-16)	15 (14-16)	6 (6-6)	1 (1-1)	5 (5-5)	12 (11-13)	3 (3-3)	9 (8-10)	18 (18-19)		5 (5-5)	32 (30-32)	34 (32-36)
F3	31	F+M	757 (432-1047)	384 (334-420)	29 (28-31)	15 (14-15)	15 (13-16)	6 (6-6)	1 (1-1)	5 (5-5)	12 (11-12)	3 (3-3)	9 (8-9)	18 (17-18)		5 (5-5)	31 (30-31)	34 (33-36)
F3	18	F	827 (628-1047)	393 (362-427)	29 (28-31)	15 (14-15)	14 (13-16)	6 (6-6)	1 (1-1)	5 (5-5)	12 (11-12)	3 (3-3)	9 (8-9)	18 (17-18)		5 (5-5)	30 (30-31)	34 (33-36)
F3	13	M	661 (533-840)	372 (334-421)	30 (29-31)	15 (15-15)	15 (14-16)	6 (6-6)	1 (1-1)	5 (5-5)	11 (11-12)	3 (3-3)	8 (8-9)	18 (17-18)		5 (5-5)	31 (30-31)	34 (33-35)
F4	44	F+M	1147 (686-1901)	425 (368-498)	30 (29-31)	15 (14-16)	15 (14-16)	6 (6-6)	1 (1-1)	5 (5-5)	12 (11-13)	3 (3-3)	9 (8-10)	18 (17-19)		5 (5-5)	32 (31-32)	34 (32-37)
F4	17	F	1139 (686-1349)	424 (368-463)	30 (29-31)	15 (15-16)	15 (14-16)	6 (6-6)	1 (1-1)	5 (5-5)	12 (11-13)	3 (3-3)	9 (8-10)	18 (17-19)		5 (5-5)	32 (31-32)	35 (32-37)
F4	27	M	1152 (785-1901)	425 (374-498)	30 (29-31)	15 (14-16)	15 (14-15)	6 (6-6)	1 (1-1)	5 (5-5)	12 (11-13)	3 (3-3)	9 (8-10)	18 (17-19)		5 (5-5)	32 (31-32)	34 (33-36)
F5	41	F+M	1205 (797-1965)	439 (396-490)	30 (28-31)	15 (14-16)	15 (14-16)	6 (6-7)	1 (1-1)	5 (5-6)	12 (11-13)	3 (3-3)	9 (8-10)	18 (17-19)		5 (5-5)	31 (30-32)	33 (32-36)
F5	20	F	1341 (797-1965)	452 (396-490)	30 (29-30)	15 (14-16)	15 (14-15)	6 (6-6)	1 (1-1)	5 (5-5)	12 (11-12)	3 (3-3)	9 (8-9)	18 (17-19)		5 (5-5)	31 (30-32)	34 (32-36)
F5	21	M	1054 (856-1303)	424 (400-469)	30 (28-31)	15 (14-15)	15 (14-16)	6 (6-7)	1 (1-1)	5 (5-5)	12 (11-13)	3 (3-3)	9 (8-10)	18 (17-19)		5 (5-5)	31 (30-31)	33 (32-35)
N2	40	F+M	328 (249-461)	300 (281-345)	30 (28-31)	15 (14-15)	15 (13-16)	6 (6-6)	1 (1-1)	5 (5-5)	12 (11-13)	3 (3-3)	9 (8-10)	18 (17-19)		5 (5-5)	31 (30-32)	34 (32-37)
N2	21	F	328 (257-461)	301 (285-345)	30 (28-31)	15 (14-15)	15 (13-16)	6 (6-6)	1 (1-1)	5 (5-5)	12 (11-13)	3 (3-3)	9 (8-10)	18 (18-19)		5 (5-5)	31 ('(31-32)	34 (32-36)
N2	19	M	333 (249-452)	301 (281-337)	29 (28 30)	15 (14-15)	14 (13 15)	6 (6-6)	1 (1-1)	5 (5-5)	12 (11-13)	3 (3-3)	9 (8-10)	18 (17-19)		5 (5-5)	31 (30-32)	33 (32-37)

Table 4. S. marinus Mean, standard deviation (std) and results of results of comparasion of adjusted means of log-transformed variables by use of multivariate discriminant analysis.

	Icelandic water	Faroese water	Norwegian water	
Character	mean (std) mm	mean (std) mm	mean (std) mm	
LT	350 (23)	473 (78)	421 (63)	**
OP	62 (13)	105 (25)	91 (24)	
PO	30 (9)	57 (16)	49 (14)	**
OD	31 (5)	53 (11)	42 (10)	**
MAX	48 (7)	83 (17)	73 (23)	
T	8 (2)	16 (4)	12 (3)	**
LCPL	106 (10)	139 (16)	129 (20)	
LC	298 (22)	401 (43)	360 (52)	
DP	252 (18)	348 (38)	303 (47)	**
DN	163 (15)	230 (26)	197 (32)	
DS	57 (8)	80 (8)	66 (9)	*
DH	110 (11)	153 (18)	134 (22)	*
HS	26 (4)	35 (4)	28 (3)	
D	92 (9)	127 (15)	112 (17)	
P1	99 (8)	132 (16)	122 (18)	
P2	75 (7)	103 (9)	85 (10)	
P1P2	170 (13)	230 (23)	208 (29)	
V1	104 (9)	147 (17)	131 (16)	**
V2	59 (8)	76 (7)	69 (9)	
A	206 (15)	277 (34)	253 (42)	
AN	43 (4)	58 (6)	50 (8)	**
AP	240 (17)	328 (38)	288 (46)	

Table 5. S. marinus Results of covariance analysis (ANOVA) between samples obtained in Icelandic, Norwegian and Faroese waters, displayed as F values and corresponding significant p values

	I1 - N1	F2 - N1	F2 - I1
Character	F	F	F
LT	26.23 **	9.57 *	149.28 **
OP	0.22	0.62	2.70
PO	8.98 *	0.68	15.82 **
OD	21.78 **	12.09 *	3.55
MAX	0.02	0.23	0.22
T	0.01	11.04	16.02 **
LCPL	0.36	6.27	5.40
LC	0.56	2.22	0.72
DP	0.05	18.30 **	20.38 **
DN	0.02	10.86 *	12.20 *
DS	0.89	9.14 *	2.53
DH	0.41	0.73	3.79
HS	1.97	7.05	0.04
D	0.41	0.20	0.11
P1	2.96	9.70 *	0.79
P2	5.81	12.42 *	1.08
P1P2	2.03	2.89 *	0.13
V1	6.41	0.27	15.11 **
V2	0.23	0.47	2.33
A	2.05	3.54	0.47
AN	0.68	2.36	0.86
AP	0.01	1.27	2.31

* $0.001 < p < 0.01$ ** $p < 0.001$

Table 6. S. mentella Mean, standard deviation (std) and results of comparasion of adjusted means of log-transformed variables by use of multivariate discriminant analysis.

	Irminger Sea	Faroese water	Norwegian water	
Character	mean (std) mm	mean (std) mm	mean (std) mm	
LT	365 (36)	419 (35)	339 (68)	**
OP	65 (9)	75 (10)	57 (9)	
PO	30 (5)	37 (6)	28 (5)	
OD	37 (4)	40 (5)	30 (4)	**
MAX	49 (5)	55 (5)	44 (8)	
T	8 (2)	10 (2)	7 (2)	*
LCPL	116 (13)	131 (15)	102 (20)	**
LC	306 (30)	352 (31)	283 (60)	
DP	263 (27)	302 (29)	241 (51)	**
DN	164 (17)	194 (20)	152 (35)	**
DS	16 (1)	16 (1)	16 (1)	
DH	109 (12)	131 (14)	103 (26)	**
HS	6 (1)	6 (1)	6 (1)	
D	29 (2)	28 (2)	28 (1)	**
P1	107 (2)	123 (13)	98 (2)	
P2	81 (8)	88 (8)	73 (13)	
P1P2	188 (19)	213 (22)	171 (30)	
V1	111 (14)	128 (12)	103 (23)	
V2	57 (5)	66 (7)	53 (12)	
A	208 (26)	237 (24)	191 (47)	
AN	45 (4)	53 (5)	44 (6)	**

* $0.001 < p < 0.01$ ** $p < 0.001$

Table 7.a. S. mentella Mean, standard deviation (std) and levels of significance obtained from discriminant analysis evaluated to deduce heterogenity within stations occupied in Irminger Sea.

	IRM1	IRM2	IRM3	
Character	mean (std) mm	mean (std) mm	mean (std) mm	
LT	370 (18)	378 (27)	358 (32)	
OP	62 (6)	69 (10)	64 (8)	
PO	30 (3)	32 (6)	30 (4)	
OD	36 (2)	39 (5)	37 (4)	
MAX	49 (2)	50 (7)	49 (5)	
T	7 (2)	10 (3)	7 (2)	
LCPL	117 (6)	120 (16)	113 (12)	*
LC	309 (15)	318 (36)	299 (29)	*
DP	266 (14)	274 (34)	256 (24)	**
DN	165 (12)	170 (21)	160 (14)	
DS	16 (1)	16 (2)	17 (1)	
DH	110 (10)	112 (15)	106 (10)	
HS	6 (1)	9 (1)	6 (1)	
D	29 (1)	29 (1)	29 (2)	
P1	103 (7)	111 (17)	105 (10)	
P2	79 (5)	84 (9)	79 (7)	
P1P2	185 (8)	194 (27)	185 (16)	
V1	105 (9)	113 (21)	111 (11)	
V2	55 (3)	59 (6)	55 (5)	
A	207 (30)	220 (27)	202 (23)	
AN	46 (3)	47 (5)	45 (4)	
AP	253 (15)	260 (30)	240 (24)	

* $0.001 < p < 0.01$ ** $p < 0.001$

Table 7.b S. mentella Mean, standard deviation (std) and levels of significanse obtained from discriminant analysis, evaluated to deduce heterogenity within stations occupied in Faroese waters.

	F1	F3	F4	F5	
Character	mean (std) mm	mean (std) mm	mean (std) mm	mean (std) mm	
LT	421 (41)	386 (32)	425 (27)	437 (26)	**
OP	74 (11)	70 (8)	74 (8)	82 (7)	*
PO	36 (7)	35 (5)	36 (6)	42 (4)	**
OD	41 (6)	38 (3)	40 (4)	43 (5)	*
MAX	55 (5)	51 (4)	55 (4)	60 (4)	
T	10 (2)	9 (2)	9 (2)	10 (2)	
LCPL	131 (17)	120 (11)	131 (11)	141 (11)	**
LC	352 (36)	324 (20)	357 (25)	367 (22)	*
DP	302 (31)	278 (17)	305 (24)	317 (22)	*
DN	194 (22)	176 (13)	199 (15)	204 (17)	
DS	16 (1)	16 (1)	16 (1)	16 (1)	
DH	130 (14)	120 (10)	134 (11)	139 (12)	*
HS	6 (1)	6 (1)	7 (1)	7 (1)	
D	27 (1)	28 (2)	27 (1)	29 (1)	
P1	123 (13)	112 (9)	122 (11)	132 (9)	
P2	89 (8)	83 (5)	87 (6)	93 (8)	*
P1P2	212 (30)	199 (12)	212 (15)	226 (14)	
V1	127 (12)	121 (8)	128 (9)	137 (10)	**
V2	66 (8)	60 (3)	66 (4)	70 (5)	*
A	238 (28)	218 (13)	241 (20)	248 (19)	
AN	53 (6)	48 (4)	54 (3)	54 (5)	
AP	284 (31)	260 (16)	285 (20)	296 (21)	

* $0.001 < p < 0.01$ ** $p < 0.001$

Table 8. S. mentella Multivariate variance analysis of stations occupied in the Faroese water where samples of S. mentella were obtained. The results displayed as F-values with corresponding significance levels, with results of Wilk's λ and Hotellins T^2 test included.

	F1 - F3	F1 - F4	F1 - F5	F3 - F4	F3 - F5	F4 - F5
Character	F	F	F	F	F	F
OP	7.05	0.64	3.53	9.31 **	0.61	5.76
PO	3.09	0.01	20.56 **	2.70	5.83	19.10 **
OD	0.18	2.91	1.09	3.48	1.09	0.00
MAX	0.83	0.75	0.02	2.71	0.60	1.00
T	5.52	3.90	10.41 *	0.04	0.53	0.84
LCPL	0.19	0.06	15.82 **	0.48	9.53 *	21.31 **
LC	5.04	3.03	0.97	0.63	1.84	0.51
DP	3.46	0.00	9.02 *	1.44	1.06	4.43
DN	0.25	3.83	2.53	5.31	3.49	0.03
DS	4.09	0.78	0.90	1.92	8.20 *	3.58
DH	0.32	3.60	7.13 *	0.83	2.41	0.81
HS	1.41	15.60 **	1.21	33.27 **	6.72	10.04 *
D	3.50	0.39	13.04 **	5.86	1.47	18.18 **
P1	0.01	4.19	20.32 **	2.38	13.57 **	34.51 **
P2	2.44	7.72 *	0.29	12.30 *	0.77	7.93 *
P1P2	1.11	0.32	2.00	25.88 **	0.41	34.03 **
V1	13.71 **	1.69	14.06 **	18.92 **	0.05	20.11 **
V2	0.41	0.00	6.43	0.48	12.32 *	8.07 *
A	0.42	0.71	0.44	0.01	0.00	0.03
AN	0.58	2.05	0.98	5.89	0.04	7.02
AP	0.72	0.52	1.26	1.73	0.38	4.00
Wilk's λ	0.444	0.534	0.410	0.230	0.263	0.213
	p<0.001	p>0.001	p<0.001	p<0.001	p<0.001	p<0.001
Hot. T^2	1.25	0.87	1.44	3.35	2.80	3.69
	p<0.001	p>0.001	p<0.001	p<0.001	p<0.001	p<0.001

* 0.001 < p < 0.01 ** p < 0.001

Table 9. *S. mentella* Multivariate variance analysis of stations occupied in the three areas where samples of *S. mentella* were obtained. The results displayed as F-values, with corresponding significance levels, with results of Wilk's λ and Hotellins T^2 test included.

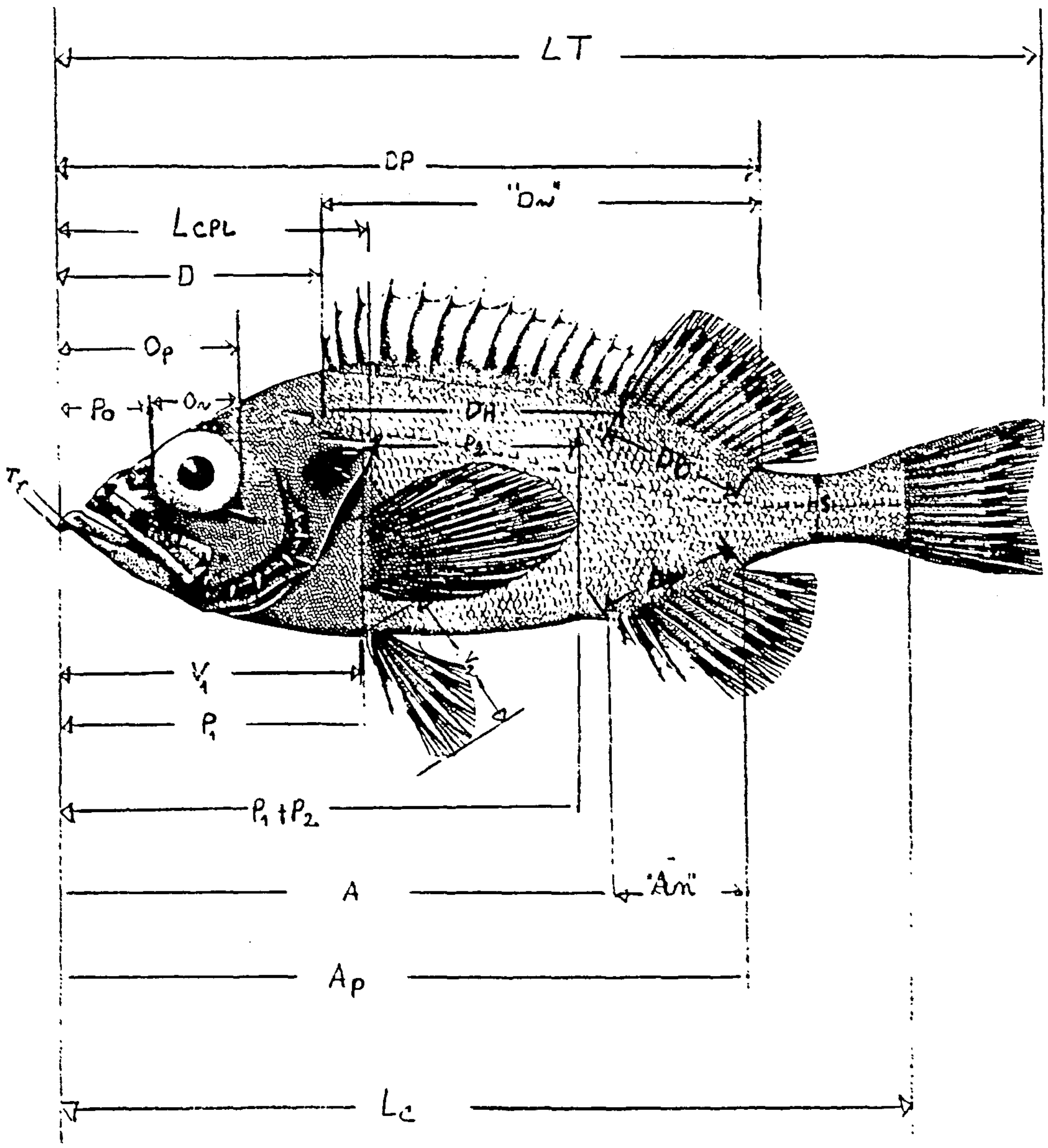
	N2 - F1	N2 - F3	N2 - F4	N2 - F5	IRM - F1	IRM - F3	IRM - F4	IRM - F5
Character	F	F	F	F	F	F	F	F
OP	7.75 *	0.00	10.33 *	0.65	0.01	9.28 *	0.62	4.76
PO	0.00	3.16	0.00	21.80 **	7.15 *	21.50 **	7.28	77.69 **
OD	0.39	0.78	0.74	0.30	10.71 *	5.89	22.16 **	8.48 *
MAX	1.55	0.02	4.49	1.20	0.11	0.49	1.56	0.03
T	6.11	0.00	0.08	0.46	8.32 *	0.58	1.03	0.04
LCPL	4.46	5.44	4.21	40.71 **	7.71 *	3.59	10.76 *	4.16
LC	6.65	12.26 *	12.79 *	9.07 *	0.10	2.24	1.03	0.04
DP	33.75 **	43.54 **	17.15 **	55.36 **	0.06	1.83	0.02	6.03
DN	22.44 **	14.06 **	43.85 **	33.06 **	10.13 *	5.05	28.43 **	21.21 **
DS	0.17	5.46	1.68	0.26	4.98	0.09	1.79	10.35 *
DH	10.48 *	7.91 *	17.23 **	19.76 **	8.24 *	7.01	17.53 **	21.68 **
HS	7.79 *	2.64	51.82 **	17.22 **	0.91	4.69	10.16 *	0.04
D	2.39	0.36	5.01	4.69	22.57 **	3.86	28.11 **	0.59
P1	0.89	0.55	2.14	0.08	0.89	0.65	7.58 *	9.37 *
P2	10.47 *	1.80	25.65 **	5.13	25.23 **	7.77 *	45.75 **	14.70 **
P1P2	0.93	0.21	14.77 **	1.06	2.46	0.07	27.66 **	0.12
V1	1.52	12.16 *	0.05	13.40 **	1.03	1.94	2.85	1.94
V2	0.55	0.01	0.59	11.80 *	0.01	0.20	0.01	5.37
A	3.64	3.33	4.84	4.14	3.84	1.16	1.30	1.55
AN	25.73 **	41.80 **	17.69 **	43.89 **	0.16	0.24	4.28	0.53
AP	3.98	5.52	2.46	8.78 *	1.38	0.32	4.21	0.01
Wilk's λ	0.089 $p<0.001$	0.080 $p<0.001$	0.070 $p<0.001$	0.049 $p<0.001$	0.295 $p<0.001$	0.450 $p<0.001$	0.197 $p<0.001$	0.161 $p<0.001$
Hot. T^2	10.28 $p<0.001$	11.47 $p<0.001$	13.30 $p<0.001$	19.29 $p<0.001$	2.39 $p<0.001$	1.22 $p<0.001$	4.08 $p<0.001$	5.20 $p<0.001$

* $0.001 < p < 0.01$ ** $p < 0.001$

APPENDIX 1.

Sample sheet for REDFISH

MORPHOMETRICS - MERISTICS



Station nr.: ____________ Position: ____________ Depth(m): __

Vessel: ____________ Date: ____________ Gear: ______

Species: ____________ Individual nr.: ________

Sex: ______ Maturity-stage: _______ Scales (+/-): __ Age: __

Total length (cm): ____________ Nom. weight (g): ____________

Stomach (+/-): _______ Stomach weight (g): ____________

Gonad-weight (g): ____________ "Gonad-width" (mm): ____________

Morphometric measurements (to the nearest mm below)

LT (Total length): ____________
Lc (Caudal length): ____________
D (Length to the beginning of the dorsal fin) ____________
Dp (Length to the end of the dorsal fin) ____________
Dn (Length of the dorsal fin) ____________
Dh (Length of the spiny-part of the dorsal fin): ____________
Ds (Length of the soft part of the dorsal fin): ____________
Lcpl (Maximum length to the end of operculare): ____________
Po (Length to the front of the eye): ____________
Op (Length to the posterior of the eye): ____________
Od (Diameter og the eye): ____________
Max (Length of the maxilla): ____________
T (Length of "protuberance" of the lower jaw): ____________
V_1 (Length to the beginning of the pelvic fin): ____________
V_2 (Length of the pelvic fin): ____________
P_1 (Length to the beginning of the pectoral fin): ____________
P_2 (Length of the pectoral fin): ____________
$P_1 +_2$ (Length to the end of the pectoral fin): ____________
A (Length to the beginning of the anal fin): ____________
Ap (Length to the end of the anal fin): ____________
An (Length of the anal fin): ____________
Hs (Heigth og the thinnest part of the tail): ____________

Meristic counts

RD (Total number of fin rays in the dorsal fin): ____________
RDh (Number of spiny rays in the dorsal fin): ____________
RDs (Number of soft rays in the dorsal fin): ____________
RV (Total number of fin rays in the pelvic fin): ____________
RVh (Number of spiny rays in the pelvic fin): ____________
RVs (Number of soft rays in the pelvic fin): ____________
RAn (Total number of fin rays in the anal fin): ____________
RAnh (Number of spiny rays in the anal fin): ____________
RAns (Number of soft rays in the anal fin): ____________
RPec (Total number of fin rays in the pectoral fin): ____________
RT (Total number of rays in the caudal fin): ____________
Opsp (Number of preopercular spines): ____________
Vert (Number of vertebrae): ____________
Br (Number of branchial spines): ____________