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Blue whiting (*Micromesistius poutassou*) stock components in samples from the northern Norwegian Sea and Barents Sea, winter 2002.

Rebekka Varne and Jarle Mork

Abstract

Blue whiting from the eastern parts of the Barents Sea are genetically different from other parts of the northeast East Atlantic, indicating the existence of a self-sustaining and reproductively isolated or semi-isolated stock there. In mid- and western Barents Sea, its geographic distribution may overlap with Hebrido-Norwegian blue whiting on summer feeding migration. Circumstantial evidence from egg- and larvae distributions supports such a stock structure. Based on observation of unusually large amounts of young blue whiting in the northwest Barents Sea in 2000 and 2001, a sampling scheme encompassing the entire Barents Sea was designed and carried out in winter 2002 to explore the stock origin of these. The polymorphic isozyme loci *PGM-1** and *IDHP-2**, which showed discriminatory power in earlier blue whiting studies, were employed. The genetic analyses did not reveal overall genetic heterogeneity among geographic samples, but more detailed analysis revealed a statistical significant heterogeneity between age groups. At both loci, allele frequencies in Blue whiting four years and older were different from those in younger age groups, which in turn showed allele frequencies similar to those in the Hebrido-Norwegian stock. Hence, the younger specimens in the blue whiting occurrences in the northwest parts of the Barents Sea in 2001-2002 appear to origin with the Hebrido-Norwegian stock, while the older ones showed genetic characteristics like those of the previously reported Barents Sea stock. The possibility of physical population mixtures by different age groups is a novel feature which must be considered in genetic analyses of blue whiting.

Keywords: Blue whiting; *Micromesistius poutassou*; isozymes; population genetics

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Introduction

The blue whiting is distributed along the continental shelf from the Canary Island to the Barents Sea in the East Atlantic. In the West Atlantic its occurrence is sparse and details of its distribution are not known.

Blue whiting lives mesopelagic between 200 and 700 m of depth with daily vertical migrations (Stensholt *et al* 2002). Large schools of blue whiting perform seasonal migrations between spawning and feeding areas (Bailey 1982, Monstad 1990). The main east Atlantic spawning grounds are found on the European continental edge. The huge Hebrido-Norwegian stock which spawns west of the British Isles is subject to a large commercial fishery, exceeding 2.3 million tons in 2003 (ICES 2003).

The eggs and larvae are pelagic. Newly spawned eggs are found between 250 and 450 m, at later development stages closer to the surface. The juvenile blue whiting are mainly non-migratory and are found in the fringes of the area occupied by mature fish. Blue whiting reach maturation at 2-7 years of age and an average length of 18-20 cm. There is a distinct size difference between the sexes; the females grow faster and get bigger than the males (Bailey, 1982).

Blue whiting are not suitable for tagging-recapture experiments. Being a deepwater fish with closed swimbladder it will die if brought to the surface. Also, the specimens are usually completely deshelled when caught by trawl. In the East-Atlantic the knowledge of the stock structure is thus mostly achieved by echo-surveys, reports from commercial fisheries, and parasitological studies (see Mork and Giæver 1993 for a review). More recently, stock structure studies have utilized isozyme and DNA markers (Mork and Giæver 1993, 1995; Giæver and Mork 1995; Giæver and Stien 1998). Evidence from the genetic studies suggests the existence of a reproductively isolated stock in the Barents Sea (Mork and Giæver, 1993). This stock is comparatively small compared to the Hebrido-Norwegian stock. It has been suggested to spawn on the northern Norwegian continental slope (Zilanov 1968).

The geographic distribution and interface of the Hebrido-Norwegian and the Barents Sea stock seems to vary by season and fish age. In some years, the Hebrido-Norwegian stock may penetrate far (north to Spitsbergen and east to 30°E) into the Barents Sea during its summer feeding migrations, and hence overlap with the local Barents Sea stock. In 2000 and 2001, unusually large occurrences of young blue whiting were reported in the Barents Sea. It was unclear, however, whether this fish belonged to a local stock or to the Hebrido-Norwegian stock.

Sexually maturing specimens of the Hebrido-Norwegian stock in the Barents Sea will expectedly migrate towards their spawning grounds west of the British Isles in winter, leaving behind their own juveniles and a more pure local Barents Sea stock as well. An exploration of the validity of this hypothesis would thus best be performed in materials which include non-juveniles caught in the winter season. Here, we report results from a population genetic study performed in late winter 2002, with a sampling net that included large parts of the Barents Sea.

Materials and methods

Blue whiting were collected by bottom trawl (20 mm mesh in the cod end) at 15 locations ranging from the northern Norwegian Sea (11º35'E) to the Eastern Barents Sea (38º58'E) (Fig.1 and Table 1), according to IMR (Institute of Marine Research, Bergen, Norway) procedures for sampling of tissues for genetic studies (Mjanger *et al* 2002). Fresh tissue samples were put in sealed plastic bags and immediately frozen at -20 ºC. Upon arrival at TBS (Trondheim Biological Station, the Norwegian University of Science and Technology, Trondheim, Norway) they were stored at -80 ºC until analyses. Isozyme electrophoretic conditions were as described by Allendorf *et al.* (1997) using the Ridgway buffer system (Ridgway *et al*. 1970). Two highly polymorphic tissue enzyme loci were used; Phosphoglukomutase (*PGM-1**) and Isocitrate dehydrogenase (*IDHP-2**) (Mork and Giæver 1993). Data analyses were done with Genepop v. 2.1 (Raymond and Rosset 1995), Statgraphics 5.0 (STSC, Inc) and the Monte Carlo based significance tests of Zaykin and Pudovkin (1993).

Results

There were no significant deviations from a 1:1 sex-ratio in any sample (Table 1). The age distribution and the percent of fish 4 years and older in each location are shown in Table 2. Also, there was no significant deviation from Hardy-Weinberg genotypic proportions in individual samples or in total materials at any locus. Geographically, no significant heterogeneity of genotypic or allelic frequencies (Table 3) was detected at individual loci or when combining locus P-values by Fisher's omnibus test.

Further analyses were performed on age groups within the total materials (<4 and >3 years). Internally, these age groups showed Hardy-Weinberg equilibrium genotypic proportions. A considerable but not significant excess of heterozygotes at *IDHP-2** for females >3 years was noted; most specimens in this category were taken at the northernmost sampling location (Ba3 near the Bear Island).
In pooled sexes the genotypic proportions among age groups <4 and >3 were significantly different at *IDHP-2** (P=0.0037), and the allelic proportions were significantly different at both *IDHP-2** and *PGM-1** (Tables 4 and 5). Combining the P-values for both loci (Fisher's omnibus test), the overall P-value for the observed differences was hence 0.001, which points very strongly to different population origins for the various age groups.

Discussion

The sampling net which was initially designed for this study included several locations in the northern and eastern Barents Sea, which were especially interesting as habitats for a potentially unmixed Barents Sea blue whiting stock. Unfortunately, sampling in these areas was prohibited because of ice and weather conditions. The exclusion of these important areas from the materials may explain the lack of a northeast-southwest geographic heterogeneity in genetic characteristics which was demonstrated in previous studies (Mork and Giæver 1993; Giæver and Stien 1998).

The blue whiting is known as a notoriously difficult species to obtain representative population samples from (Bailey 1982). It is a schooling fish, and the schools are usually composed of individuals of similar size. Size is dependent on both age and sex, hence samples are often dominated by one year class and/or one sex. The present samples, however, showed a rather equal representation of the sexes.

The present materials and genetic results, with an overweight of juvenile fish with genetics characteristics like those in the central blue whiting distribution areas, may reflect the influence of the large 2001 Hebrido-Norwegian yearclass, and maybe also the large influx of warm Atlantic water into the Barents Sea in recent years (Heino et al. 2003). Possibly, juvenile stages of a local Barents Sea stock are pushed to the north and east under such circumstances, which were not in force during the study by Mork and Giæver (1993). Older fish (> 3 years) in the present materials, however, actually showed the same genetic signature as those classified as Barents Sea blue whiting in previous studies (Mork and Giæver 1993; Giæver and Stien 1998).
It is desirable, however, to obtain additional samples, especially from the eastern and northern parts of the Barents Sea, in order to explore in more detail the genetic characteristics, geographic structure and temporal dynamics of the blue whiting occurrences in these areas.

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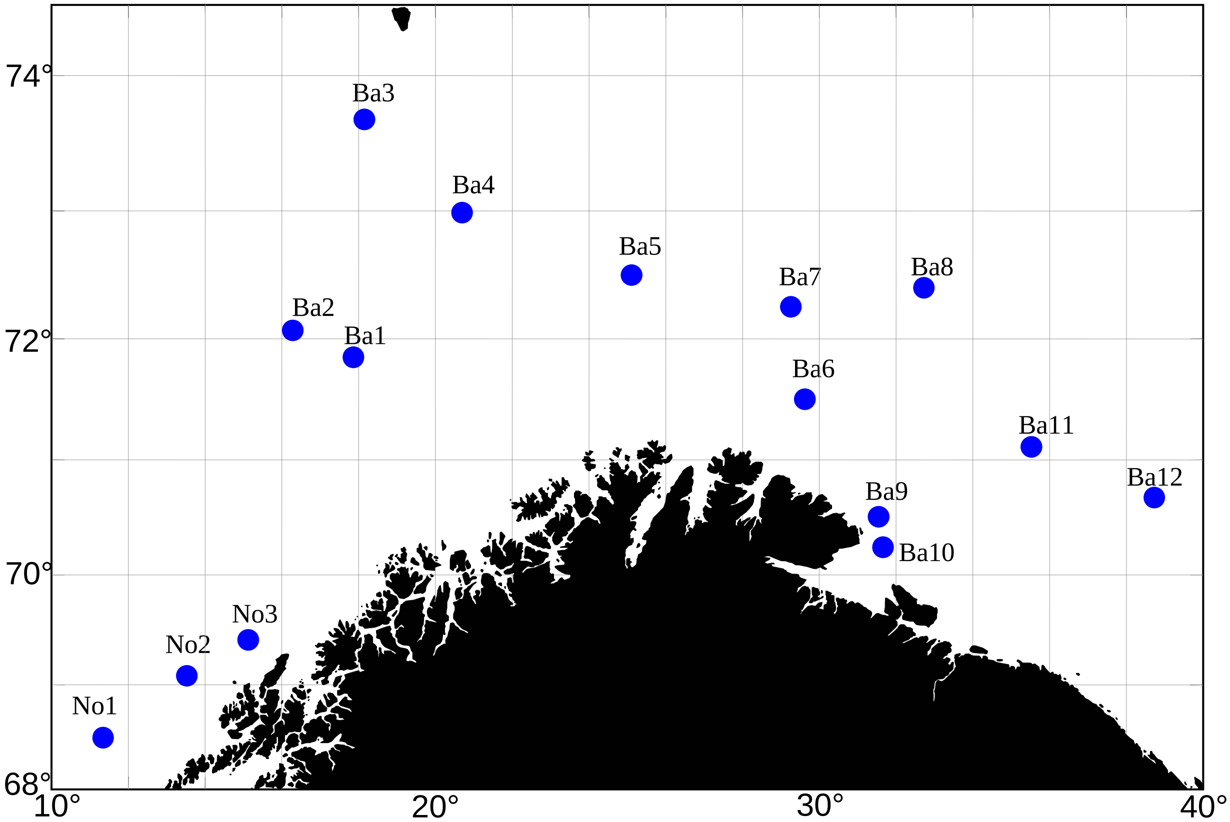

Fig. 1. Map of the sampling stations in the Barents Sea (Ba) and the Norwegian Sea (No).

Table 1. Station names, ship, date, trawl, position, % females and total number of fish.

Location	Date	Research Vessel	Gear	Position	% females	No. of Fish
Ba1	31 Feb 2002	"G.O. Sars"	Bottom trawl[1]	N 71°51' E 17°52'	57	30
Ba2	09 Feb 2002	"G.O. Sars"	Bottom trawl[2]	N 72°04' E 16°17'	44	70
Ba3	08 Feb 2002	"G.O. Sars"	Bottom trawl[1]	N 73°41' E 18°09'	56	18
Ba4	01 Feb 2002	"G.O. Sars"	Bottom trawl[2]	N 72°56' E 20°56'	58	100
Ba5	24 Feb 2002	"G.O. Sars"	Bottom trawl[2]	N 72°21' E 25°21'	50	16
Ba6	16 Feb 2002	"G.O. Sars"	Bottom trawl[1]	N 71°27' E 29°52'	58	38
Ba7	20 Feb 2002	"G.O. Sars"	Bottom trawl[2]	N 72°12' E 29°30'	51	74
Ba8	24 Feb 2002	"G.O. Sars"	Bottom trawl[2]	N 72°21' E 32°58'	40	50
Ba9	15 Feb 2002	"Johan Hjort"	Bottom trawl[2]	N 70°27' E 31°47'	46	50
Ba10	30 Jan 2002	"Johan Hjort"	Bottom trawl[2]	N 70°11' E 31°54'	41	80
Ba11	31 Jan 2002	"Johan Hjort"	Bottom trawl[2]	N 71°03' E 35°46'	56	41
Ba12	01 Jan 2002	"Johan Hjort"	Bottom trawl[2]	N 70°32' E 38°58'	62	26
No1	22 Mar 2002	"G.O. Sars"	na	N 68°26' E 11°35'	na	50
No2	18 Mar 2002	"G.O. Sars"	Bottom trawl[1]	N 69°01' E 13°46'	na	20
No3	18 Mar 2002	"G.O. Sars"	na	N 69°21' E 15°22'	na	30
		Total				693

1) Campelen 1800ma 20mm m/40m. Sveiper, Rockhopper gear strapping.
2) Campelen 1800ma 20mm m/40m. Sveiper, Rockhopper gear.

Table 2. Age distribution and the percent of fish more than 3 years of age in each location

Location	Age											SUM	**% ≥ 4 years**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**		
Ba1	25	1	3	1								30	3.3
Ba2	61	4	4	1								70	1.4
Ba3	5			3	4	1	3	1	1			18	72.2
Ba4	77	15	8									100	0.0
Ba5	15	1										16	0.0
Ba6	34	1	1		2							38	5.3
Ba7	67	2	2	2	1							74	4.1
Ba8	47	3										50	0.0
Ba9	38	7	3	3						2	1	54	12.0
Ba10	66	9	2	1	1				1			80	3.8
Ba11	31	2	5	1	2							41	7.3
Ba12	23	1	1	1								26	3.8
No1												50	na
No2												20	na
No3												30	na
TOTAL	**489**	**46**	**29**	**13**	**10**	**1**	**3**	**1**	**2**	**2**	**1**	**693**	

Table 3 Allele frequencies in geographic samples

Location	Locus						
	*PGM-1**				*IDHP-2**		
	100	**110**	**88**	**78**	**100**	**78**	**44**
Ba1	0.876	0.117	0.017	0.000	0.833	0.167	0.000
Ba2	0.814	0.157	0.021	0.007	0.793	0.207	0.000
Ba3	0.806	0.194	0.000	0.000	0.833	0.167	0.000
Ba4	0.780	0.205	0.015	0.000	0.005	0.200	0.050
Ba5	0.875	0.094	0.031	0.000	0.844	0.156	0.000
Ba6	0.829	0.158	0.013	0.000	0.789	0.211	0.000
Ba7	0.845	0.142	0.014	0.000	0.884	0.116	0.000
Ba8	0.870	0.130	0.014	0.000	0.770	0.230	0.000
Ba9	0.910	0.080	0.010	0.000	0.776	0.224	0.000
Ba10	0.778	0.203	0.013	0.006	0.865	0.135	0.000
Ba11	0.854	0.146	0.000	0.000	0.841	0.156	0.000
Ba12	0.923	0.077	0.000	0.000	0.806	0.180	0.000
Average	***0.847***	***0.142***	***0.012***	***0.001***	***0.753***	***0.179***	***0.004***
No1	0.850	0.140	0.010	0.000	0.806	0.194	0.000
No2	0.875	0.100	0.025	0.000	0.750	0.205	0.000
No3	0.917	0.067	0.017	0.000	0.776	0.224	0.000
Average	***0.881***	***0.102***	***0.017***	***0.000***	***0.777***	***0.208***	***0.000***

Table 4. Test of *IDHP-2** allelic homogeneity of age groups.

Age group	**Allele**		**2N**
	78	**100**	
Age<4	190	918	1108
Age>3	20	46	66
Sum	210	964	1174

Chi-square=7.339, DF=1, P=0.007

Table 5. Test of *PGM-1** allelic homogeneity of age groups.

Age group	**Allele**			**2N**
	88	**100**	**110**	
Age >4	15	937	166	1118
Age 4+5	1	31	14	46
Sum	16	968	180	1164

Chi-square= 8.596, DF=2, P= 0.016