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Ecological and biological characteristics of redfish *Sebastes mentella* in Va and XIVb Divisions of ICES

by

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Abstract

A possibility of interrelation between deep-sea redfish of the southwestern slope of Iceland and adjacent area of the pelagial of the Irminger Sea by means of different methods is discussed. It is important for development of measures on conservation and rational exploitation of this species stocks.

Differences in the length-age composition of fish in both surveyed areas were revealed. It was established that redfish from the slope have lower rate of maturation than fish in the pelagic sea. Maturation of fish (50 and 100 %) inhabiting the slope happens at the larger length and in the later period. At the similar rate of linear growth, higher rate of weight growth is observed in redfish from the slope. Differences in food base of redfish in the surveyed areas were established.

Big differences in the parasite fauna of redfish from the surveyed areas were observed. The reliable differences in infestation with copepod *Sphyrion lumpi*, nematode *Anisakis simplex* l. and occurrence of pigment spots on the skin of redfish were established. They are expressed both in the heavier affection of redfish from the pelagic waters and in the heavier affection of redfish females (that is peculiar for any area of the pelagic Irminger and Labrador Seas) compared to poor or equal affection level of redfish males and females on the slope of Iceland.

Close ratio of specimens with a rare allele 20 of MDH locus justifies, probably, on the genetic uniformity of redfish stock of two investigated areas; but one can also assume some isolation of deep-sea redfish from the southwestern slope of Iceland caused by specific hydrological conditions of the area.

No big exchange between redfish stocks distributed on the southwestern slope of Iceland and in the pelagic Irminger Sea was established in the result of the investigations carried out.

Introduction

Sebastes mentella is the most important object for fishery of three species of redfish dwelling in the North-East Atlantic. Bottom fishery for deep-sea redfish *S. mentella* (shelf redfish) is carried

out on the shelf and slope of Iceland, Faroe Isls and East Greenland (ICES Subareas V, VI, XIV). Pelagic fishery of redfish is performed in the Irminger Sea and adjacent areas of the Labrador Sea (ICES Divisions Va, XII, XIVb, NAFO Divisions 1F and 2HJ). In the early 1990's Magnusson (Magnusson, 1991; Magnusson et al., 1995) set up a hypothesis of existence in the pelagial of the Irminger Sea of two types of redfish – "oceanic *S. mentella*" and "pelagic deep-sea *S. mentella*". To his opinion, redfish of the first type are distributed at depths less than 500 m, whereas those of the second type – deeper than 500 m. Recent two decades, the Russian scientists carried out investigations on studying of a populational structure of redfish of the pelagic Irminger Sea (Pavlov and Shibanov, 1984; Pavlov, 1992; Shibanov et al., 1996; Melnikov, 1998; Bakay and Melnikov, 2001 and 2002; Melnikov et al., 2001; Melnikov and Bakay, 2002; Novikov et al., 2002). The identity of origin and uniformity of the stock of pelagic deep-sea *S. mentella* in the area of the Irminger Sea and adjacent area of the Labrador Sea over the entire range of the vertical distribution of concentrations were revealed.

In recent decades the positive experience of the use of parasitological data was accumulated in the process of studying of ecology and intra-species structure of marine fishes. Such data and other natural marks (pigment spots on the skin) were used for determination of local groups of marine redfish of genus *Sebastes* in the North-West Atlantic (Herrington, 1939; Sinderman, 1961; Yanulov, 1962; Kabata, 1963; MacKenzie, 1983; Bakay and Bakay, 2002) and intra-species differentiation of *S. mentella* of the Irminger Sea and other areas of its habitat (Bakay, 1988, 1989, 1999, 2000, 2001; Sigurdsson et al., 1999 and 2001; Bakay and Melnikov, 2001, 2002; Melnikov and Bakay, 2002). Therefore, we used parasites and pigment neoplasms of redfish for studying of specific features of invasion by them of concentrations of *S. mentella* distributed southwestwards of Iceland as a criterion of investigations of ecological peculiarities and intra-species structure of redfish.

A possible interrelation between redfish of the pelagial and redfish of close areas of the slope and shelf is not studied to completion. In the recent years, the intensive fishery for pelagic redfish was carried out at depths more than 500 m in the north of the Reykjanes Ridge close to areas of the bottom fishery for redfish. In connection with that, the discussion of a possibility of interrelation between redfish from the slope of Iceland and redfish of the adjacent area of the pelagial of the Irminger Sea has a great importance for development of measures on conservation and rational exploitation of this species stock.

Material and methods

Results of investigations of redfish *Sebastes mentella* caught in two areas are presented. The first area is a part of the southwestern slope of Iceland (the Reykjanes Ridge, 63°00'-63°10'N 25°10'-25°30'W) where samples were selected from catches taken by a bottom trawl at the depth of 430-760 m. The second area is the adjacent to the first one part of the pelagial above the Reykjanes Ridge and its western slope over the square of 60°30'-63°00'N 27°00'-33°00'W where samples of redfish were separated from the catches taken by a pelagic trawl at the depth of 500-900 m.

Ichthyological material on redfish was collected in accordance with methods accepted at PINRO. Data used are those obtained during one scientific-research and four scientific-fishing cruises in June-August 2001. To study the biological status of fish, the length-age composition, linear and weight growth, maturation rate and range of feeding of redfish from two surveyed areas were analyzed. The volume of the examined ichthyological material is in Table 1.

Parasitological investigations were carried out in the period from 23 June to 16 July 2001 on board R/V "AtlantNIRO" (Russia) and R/V "Arni Fridriksson" (Iceland). To study all parasite fauna of redfish, 108 and 55 individuals of fish, correspondingly to the mentioned areas, were examined by a method of complete parasitological dissection (Dogiel, 1933; Bykhovskaya-Pavlovskaya, 1985). A number of fish examined by the method of a partial parasitological dissection was as follows: aimed at studying of peculiarities of infestation with a copepod *Sphyrion lumpi* – 543 and 361 individuals, and aimed at determination of a level and length-age dynamics of invasion with a nematode *Anisakis simplex* l. – 108 and 230 individuals, correspondingly.

Reliability of differences in rates of maturation of redfish from different areas, prevalence of infection with parasites, and occurrence of fish with pigment spots on the skin were tested by a statistical significance (P) with the use of "chi-square test" (criterion χ^2, probability 0.95). A measure of similarity of compositions of parasite fauna was calculated on the basis of Serensen-Chekanovsky's coefficient by the "weighed pair-group method". Prevalence (percentage of fish infected with a particular parasite species of total number of fish examined) and abundance index (number of parasites of a particular species per one fish individual examined) were used as indices of a level of infection with parasites.

Genetic investigations were carried out by a method of electrophoresis in the starch gel. The unified enzyme systems used for population/genetic investigations of redfish both in Russia and abroad were studied: NADH-dependent malate dehydrogenase (malic enzyme) (MER-2), NAD-dependent malate dehydrogenase (MDH), glucose phosphate isomerase (GPI), isocitrate dehydrogenase (IDH), lactate dehydrogenase (LDG), phosphoglucomutase (PGM), superoxide dismutase (SOD), fluorescent esterase (ESTD). The works were carried out in accordance with the accepted methods (Dushchenko, 1986; Johansen et al., 1996, 1997). Samples were taken in the areas mentioned above. Preliminary attribution of specimens to the "oceanic" or "deep-water" types by morphological signs was not conducted. Volume of processed samples is pointed out in the corresponding tables.

Results

Comparative biological characteristics of redfish from the pelagial of the Irminger Sea and southwestern slope of Iceland

Length-age composition. In 2001 in the pelagial of the Irminger Sea at the depth more than 500 m the length of redfish males and females varied from 27 to 49 cm. The basis of catches was males 39-44 cm and females 42-45 cm. A portion of males in catches constituted 53.1 %. Length of redfish on the slope of Iceland fluctuated within the same range like in the pelagial, however, fish of less length predominated in catches: males were 36-41 cm long, females – 35-43 cm long. Sex ratio was approximately equal. A portion of redfish less than 35 cm on the slope was 2.5-3 times higher than in fish in the pelagic sea (Fig. 1).

Redfish age in the pelagial of the Irminger Sea and on the slope of Iceland varied from 8 to 24. The basis of catches in the pelagial consisted of individuals at the age of 17-20, whereas on the slope – 14-19. The age compositions of redfish in both areas in the age range of 16-24 were similar. However, a portion of fish at the age of 16 on the slope was larger than in the pelagial (Fig. 2).

The result of analysis of length-age composition of redfish has shown the absence of young fish in both areas in the investigated range of depths. It is evident that redfish stocks in the pelagial of the Irminger Sea and on the slope of Iceland are recruited from other areas.

Rate of maturation. In the pelagial the mature males were found first at the length of 28 cm, and females – 29 cm. Level of 50 % of maturation of fish was registered in males at the length of 32 cm and age of 10, and in females – 33 cm and age of 10. Full maturation (100 %) of males happened at the length of 38 cm and age of 16, and in females – 41 cm and age of 17 (Fig. 3A, 4A).

On the slope the mature males were registered first at the length of 34 cm and females – 38 cm. A level of 50-% maturation males reached at the length of 37 cm and age of 15, and females – 41 cm and age of 17, correspondingly. All males became mature at the length of 43 cm and age of 20, and females – 47 cm and age of 22, correspondingly (Fig. 3B, 4B).

Statistically highly significant differences between rates of maturation of redfish in the pelagial of the Irminger Sea and on the slope of Iceland were revealed during the statistical analysis.

A comparative analysis of data on maturity corroborated the earlier revealed character of lower rate of maturation of redfish on the slope than in the pelagial of the Irminger Sea (Zakharov, 1969; Melnikov, 1998). Maturation of fish dwelling on the slope takes place at larger length and at later time. It was established that in the pelagial a portion of mature redfish constituted 59 % for males under 33 cm and 82 % for females under 37 cm. No mature fish of these length groups were registered on the slope. At the same time in the pelagial, the immature males longer than 38 cm and females longer than 41 cm were completely absent. On the slope, a portion of immature fish of these linear sizes constituted 15 % in males and 27 % in females. Results of analysis of maturation rate by age groups corroborate the natural features revealed during investigation of ratio between mature and immature individuals by length groups (Fig. 4). Consequently, the analysis of maturation rate of redfish did not reveal an interrelation and exchange between fish stocks in the pelagial of the Irminger Sea and on the slope of Iceland.

Linear and weight growth. The comparative analysis of the same age fish of mean length revealed the similarity of linear growth of redfish males and females in the pelagial of the Irminger Sea and on the slope of Iceland (Table 3). However, at the similar linear growth the mean weight of the same age redfish males and females on the slope was 1.8-19.4 % higher than in fish dwelling in the pelagial. The largest deviation in weight (7.0-19.4 %) was registered in redfish at the age of 15. As the analysis of maturation rate has shown (Fig. 4), all redfish at this age were mature in the pelagial, whereas on the slope a portion of immature fish exceeded 50 %. It is known that immature fish of many species have higher rate of weight growth than mature ones, since a big part of assimilated food is used for the increment of the body weight but not for the generative exchange (Shatunovsky et al., 1975; Shatunovsky, 1980). Therefore, higher rate of weight growth of redfish on the slope compared to fish in the pelagial is explained by greater part of immature fish at the age of less than 15.

Feeding. The main place in the food range of redfish in the pelagial of the Irminger Sea was occupied by mesopelagic fish (*Myctophidae, Paralepidae*), shrimp, and cephalopods (*Gonatus fabricii*). In feeding of redfish on the slope of Iceland a portion of fish and young squids was 2-3 times less than in the pelagic sea. However, a portion of *Euphausiacea* in the food range of redfish reached 50 % (Table 2). Mean fullness of stomach of fish in the pelagial constituted 0.2 and on the slope – 0.8.

In summer, there are peculiarities in distribution of food plankton in two investigated areas. In the pelagial of the Irminger Sea, zonal distribution of food organisms by depths is clearly observed. Plankton crustaceans are concentrated predominantly in the upper 500-meter layer. In the lower 500-meter layer of the pelagial, where the main fishery concentrations of redfish are distributed, a food base is predominantly presented by mesopelagic fish species and macroplankton (Pavlov, 1992). In the area of the continental slope of Iceland the dominating food organisms are euphausids and shrimp (Zakharov, 1969). One of the reasons of differences in distribution of food plankton is a peculiarity of the hydrological regime in the pelagial of the Irminger Sea and on the slope of Iceland. The carried out analysis of feeding justifies on the ecological and trophic plasticity of redfish promoting the decrease of food competition inside of a species, the effective usage of the food base and widening of the habitat.

Parasitological investigations

A list of parasites of redfish caught on the southwestern slope of Iceland and adjacent area of the pelagic Irminger Sea consists of 22 parasite species attributed to 7 taxonomic groups (classes) (Tables 5 and 6). Big differences in composition of parasite fauna of redfish from those areas were registered. In redfish from the pelagial the following parasites were absent: *Microcotyle caudata* (*Monogenea*) – the usual parasite for redfish from the slope of Iceland, as well as nematodes of two species (*Spinitectus* sp., *Nematoda* gen. sp.) and *Acanthocephala* sp. On the contrary, in redfish from the slope the following parasites were not registered: larvae of *Cestoda* of five species (*Hepatoxylon trihiuri* pl., *Grillotia erinaceus* pl.) peculiar for fish of the open ocean, as well as *Scolex pleuronectis* pl., *Pelichnibothrium speciosum* pl., *Diphyllobothrium* sp. pl. The statistically significant differences ($P<0.05$) of degree of invasion by 9 items of 25 (36 %) including the occurrence of fish with pigment spots on the skin (Table 5) were established.

In general, coincidence of compositions of parasite fauna of the specified areas is 74.3 %, this points to big differences between them. For example, high similarity (92-100 %) is peculiar for parasite fauna of redfish from different and even hundred miles distant from each other parts of the pelagial of the Irminger and Labrador Seas. Of 22 items composing parasite fauna and other biological marks, the number of items with the statistically significant differences does not exceed 1 (4.5 %) (Melnikov and Bakay, 2002).

According to the accepted method (Bakay and Karasev, 2001), reliable differences were established between various kinds of lesions of redfish (separately by sex), caused by copepod *Sphyrion lumpi* (live parasites, ulcers and old lesions) (Table 7). They lie in higher level of invasion by all kinds of lesions of redfish of both sexes dwelling in the pelagial. The statistically significant differences were registered in 11 of 12 discussed items (Table 7). Compared to redfish from the slope of Iceland, in which a degree of invasion by this parasite of males and females is equal, invasion of redfish females in the pelagial exceeded that of males (prevalence – 1.5-4.5 times, abundance index – 1.7-5.0 times). Such a feature is typical for redfish from any area of the pelagial of the Irminger and Labrador Seas (Bakay, 1988, 1989 and 2000; Sigurdsson et al., 1999 and 2001; Bakay and Melnikov, 2001 and 2002; Melnikov and Bakay, 2002).

Such a situation is observed during the analysis of occurrence of redfish individuals with pigment spots on the skin (Table 8). This index was much higher both in males and females of redfish from the pelagial (by 8 items of 9). On the slope of Iceland the occurrence of redfish with pigment spots on the skin did not differ much between males and females, whereas in the pelagial it was 1.6-1.8 times higher in females than in males. Such a sign is typical for redfish from the pelagial of all areas of the Irminger and Labrador Seas.

Compared to redfish from the pelagial, in redfish from the slope of Iceland the major part of lesions (78.3 %) of total number of affected fish with copepod *S. lumpi* was located in the dorsal part of a fish (zone of examination I) and diminished in the area of the anus (zone IV) and on the head (zone III). Such a specific invasion can be caused by a possibility of redfish on the slope to remove partly a parasite from the mentioned parts of the body by scraping it against the ground (Table 9).

Data of Table 10 justifies that in the discussed areas the mentioned peculiarities of redfish invasion with copepod *S. lumpi* and of occurrence of fish with pigment spots on the skin revealed in 2001 are not occasional (Tables 7 and 8). We registered the similar facts yet in the1980's.

Peculiarities of redfish invasion by a parasite of one more species – *Anisakis simplex l.* – are discussed. Larvae of this parasite have a specific locality and the largest (compared to other parasites) degree of invasion of redfish, but similar to *S. lumpi,* they correspond in a great measure to the requirements established for parasites-indicators. In accordance with Table 5, both total invasion and invasion of muscles by this parasite is more reliable in redfish in the pelagial. Such dependence was discovered in all length (age) groups of redfish (Fig. 5). Maximal (100 %) prevalence of invasion is observed in fish more than 37 cm long in the pelagial and more than 43 cm on the slope.

Thus, the results of analysis of the parasite fauna of *S. mentella* and peculiarities of redfish lesion with some described biological signs (copepod *S. lumpi*, pigment spots on the skin, nematode *A. simplex* etc.) indicate to the sufficient isolation of the studied redfish stocks. To our opinion, only insufficient exchange between them is possible, and its predominant direction is from the pelagial to the slope. The following facts prove this idea:

- absence of *Microcotyle caudata* in redfish from the pelagial which is typical for redfish of the slope of Iceland;
- a single find of "live" *S. lumpi* and very rare occurrence of ulcers caused by them in redfish on the slope;
- the outlined on the slope tendency of bigger infestation with *S. lumpi* and of pigment spots in females compared to males of redfish.

Peculiarities of distribution of redfish in the pelagic Irminger Sea and on the southwestern slope of Iceland (by protein marks)

Distribution of frequencies of alleles of locus MER-2* in the studied samples reflects the mosaic distribution of samples with different frequencies at different horizons and in different areas (Tables 1 and 2). Frequency of allele "100" of locus MER-2* in redfish from samples taken at horizons 300-500 m varies from 0,378 to 0,680 and in samples from horizons 500-800 m – from 0.357 to 0.950. Such amplitude proves a conclusion made before on the unity of redfish stock from the pelagic Irminger Sea along its entire vertical distribution (Bakay and Melnikov, 2002). Thus, such a big range of frequencies can justify on both occasional change of a part of various alleles inside of samples and specific movements of different single groups within both yearly migration circle (feeding period – fertilization – larvae extrusion) and in the process of ontogenesis of specimens of the given species.

The analysis of peculiarities of distribution of frequencies of allele MER-2*100 separately by two areas of sampling (pelagic trawlings in the Irminger Sea; bottom trawlings on the

southwestern slope of Iceland) has shown the similar character of distribution of frequencies in all variants, i.e. the frequency of allele MER-2*100 varied within the wide range in samples of each pointed out area independently on the year of sampling. To our opinion, high level of polymorphism of locus MER-2* made difficult, on the one hand, the characteristics of redfish dwelling on the southwestern slope of Iceland and in the pelagial of the Irminger Sea, and on the other hand, it could characterize the given population of fish as the common one.

The other investigated loci were monomorphic ones or demonstrated very low measure of polymorphism. An attempt is made to reveal some differences observing the distribution of a rare allele 20 of the locus MDH. A picture of distribution in some areas of alleles of the locus MDH* was characterized by some peculiarity connected with low level of polymorphism (Tables 3 and 4). It was shown that the presence of a rare allele MDH*20 could change in samples of different years and differed in some measure in the pelagial of the Irminger sea and on the southwestern slope of Iceland (percentage of individuals-carriers of a rare allele in the united samples was determined). Allele MDH*20 was found in 5 % of individuals from the pelagial of the Irminger Sea in the year of 2000, and in 2001 only 2.8 % of such fish were registered. In samples from the bottom trawlings on the southwestern slope of Iceland a portion of individuals of redfish with allele MDH*20 constituted 1.7 %.

A close ratio between individuals with rare allele 20 of locus MDH indicates, probably, to the genetic unity of redfish stock of two investigated areas, but one can also assume some isolation of redfish from the southwestern slope of Iceland caused by specific hydrological conditions of the area. In connection with higher percentage of individuals with rare allele in the pelagial of the Irminger Sea, one can expect the migration of genetic material from more dense concentrations of redfish from the pelagial of the Irminger Sea to the southwestern slope of Iceland.

Conclusion

During investigations the following facts were established.

1. Analysis of length-age composition of redfish has shown that mean length and mean age of fish on the southwestern slope of Iceland were 2.3 cm and 1.5 years less than those in the pelagial of the Irminger Sea. No young fish less than 27 cm were registered in both surveyed areas.

2. Statistically significant differences in the maturation rate of redfish in the pelagial of the Irminger Sea and on the slope of Iceland were established. Analysis of data on maturity indicated lower rate of maturation of redfish on the slope than in fish in the pelagic sea. Fish dwelling on the slope become mature (50 % and 100%) at larger length and at later time. Analysis of maturation rate of redfish by length and age groups did not reveal an interrelation and exchange between fish stocks in the pelagic sea and on the slope.

3. A comparative analysis of mean lengths of the same age fish has shown the similarity of linear growth of redfish males and females in the pelagic Irminger Sea and on the slope of Iceland. Higher rate of weight growth of redfish on the slope compared to fish in the pelagial is explained by larger portion of immature fish at the age of 15.

4. Analysis of fish feeding showed the difference in the food base of redfish in the surveyed areas. In the food range of redfish in the pelagial of the Irminger Sea, the main part

consisted of fish of the mesopelagic complex, as well as of shrimp and cephalopods. A portion of fish and young squid in the feeding of redfish was 2-3 times less than in the pelagial. And a portion of euphausids in the food range of redfish reached 50 %.

5. In spite of the closeness on the discussed areas of redfish dwelling, the significant differences in the composition of their relatively poor parasite fauna. Only 13 of 22 revealed parasite species were common for redfish of both areas (degree of similarity of the parasite fauna composition constituted 74.3 %). Statistically significant differences in the degree of invasion were registered either for some common parasite species.

6. The reliable differences were established in the infestation with copepod *Sphyrion lumpi* and nematode *Anisakis simplex* l. and in the occurrence of pigment spots on the redfish skin. They are expressed not only in the higher invasion of redfish from the pelagial, but in the higher invasion of redfish females (1.8-2 times higher on average), typical for any area of the pelagic Irminger and Labrador Seas and compared to poor and equal invasion of redfish males and females on the slope of Iceland. The analyzed results of parasitological investigations obtained in the discussed areas in 2001 during short-term period (three weeks) were not occasional. We registered similar facts in the 1980's.

7. Analysis of the composition of parasite fauna of *S. mentella* and the established peculiarities of redfish lesion with some of the discussed biological signs (copepod *S. lumpi*, pigment spots on the skin, nematode *A. simplex* etc.) justifies on the noticeable isolation of studied redfish stocks. To our opinion, only insufficient exchange between them is possible, and its predominant direction is from the pelagial to the slope.

8. A close ratio between individuals with rare allele 20 of locus MDH indicates, probably, to the genetic unity of redfish stock of two investigated areas, but one can also assume some isolation of redfish from the southwestern slope of Iceland caused by specific hydrological conditions of the area. In connection with higher percentage of individuals with rare allele in the pelagial of the Irminger Sea, one can expect the migration of genetic material from more dense concentrations of redfish from the pelagial of the Irminger Sea to the southwestern slope of Iceland.

In the result of the carried out biological, parasitological and genetic investigations against the background of the genetic unity, no significant exchange was established between redfish stocks distributed on the southwestern slope of Iceland and in the pelagial of the closest area of the Irminger Sea.

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Table 1. Volume of the analyzed ichthyological material

Volume of measurements	No., ind.
Ind. measured	23358
Maturation analysis, ind.	13895
Feeding analysis, ind.	9054
Age, ind.	1184

Table 2. Diet (%) of *Sebastes mentella* in the pelagial of the Irminger Sea and on the southwestern slope of Iceland in 2001

Food composition	Pelagial of the Irminger Sea	S.-W. slope of Iceland
Calanus	0,2	3,5
Euphausiids	5,1	50,0
Shrimp	22,0	23,3
Squid	18,3	9,3
Fish	38,0	8,1
Other species	16,4	5,8

Table 3. Mean length of the *Sebastes mentella* by age groups in the pelagial of the Irminger Sea and on the southwestern slope of Iceland in 2001

Age, years	Pelagial of the Irminger Sea		S.-W. slope of Iceland	
	Males	Females	Males	Females
6	-	22,0	-	-
7	24,8	25,5	-	-
8	27,2	27,5	-	-
9	28,0	28,8	28,0	-
10	29,0	29,4	31,0	30,0
11	30,5	30,5	31,2	31,2
12	33,0	32,3	33,3	32,7
13	34,0	34,0	34,2	34,2
14	35,0	35,3	35,7	35,5
15	36,8	37,1	36,9	36,9
16	39,2	38,3	38,4	38,5
17	40,2	39,8	40,0	40,4
18	41,8	42,0	41,8	42,2
19	43,0	43,0	43,2	43,0
20	44,4	44,4	44,2	45,0
21	45,7	45,7	45,3	46,0
22	46,6	46,6	46,5	46,6
23	47,2	47,8	-	48,0
24	48,0	48,5	-	-
25	49,0	49,4	-	-
26	-	50,5	-	-

Table 4. Mean weight of the *Sebastes mentella* by age groups in the pelagial of the Irminger Sea and on the southwestern slope of Iceland in 2001

Age, years	Pelagial of the Irminger Sea		S.-W. slope of Iceland	
	Males	Females	Males	Females
6	-	136,0	-	-
7	180,0	211,5	-	-
8	235,2	249,0	-	-
9	257,7	307,5	300,0	-
10	298,5	360,6	319,0	386,0
11	360,0	385,0	429,9	433,9
12	433,3	422,3	497,6	499,8
13	476,6	473,4	542,7	556,1
14	520,0	539,0	593,2	627,4
15	616,0	673,6	704,3	670,4
16	785,7	762,7	799,0	750,0
17	819,9	828,6	862,2	863,1
18	928,7	944,7	961,4	987,4
19	1030,7	1031,7	1046,5	1043,9
20	1075,7	1101,8	1076,7	1203,1
21	1150,9	1132,5	1120,8	1159,2
22	1203,1	1233,2	1262,5	1308,3
23	1292,9	1285,9	-	1230,0
24	1304,7	1348,2	-	-
25	1585,0	1494,8	-	-
26	-	1585,0	-	-

Table 5. Degree of invasion of parasites into *Sebastes mentella* in various areas of investigations (June-July, 2001).

Parasites	S.-W. slope of Iceland Depth 430-760 m	Pelagial Depth 500-900 m	Significance of differences (P)
Myxidium incurvatum	22,2	5,5	**< 0,05**
M. obliquelineolatum	11,1	3,6	> 0,05
Leptotheca macroformis	1,9	1,8	> 0,05
L. adeli	0,9	5,5	> 0,05
Pseudalataspora sebastei	8,3	9,1	> 0,05
Microcotyle caudata	25,0 / 0,7	-	**< 0,05**
Bothriocephalus scorpii	7,4 / 0,07	5,5 / 0,05	> 0,05
Hepatoxylon trichiuri pl.	-	5,5 / 0,05	**< 0,05**
Grillotia erinaceus pl.	-	1,8 / 0,02	> 0,05
Phyllobothrium sp pl.	0,9 / 0,01	1,8 / 0,02	> 0,05
Scolex pleuronectis pl.	-	9,1 / 0,09	**< 0,05**
Pelichnibothrium speciosum pl.	-	1,8 / 0,04	> 0,05
Diphyllobothrium sp. pl.	-	1,8 / 0,02	> 0,05
Lecithophyllum bothriophoron	0,9 / 0,02	1,8 / 0,02	> 0,05
Podocotyle reflexa	6,5 / 0,07	3,6 / 0,04	> 0,05
Anomalotrema koiae	4,5 / 0,05	1,8 / 0,02	> 0,05
Anisakis simplex l. (total invasion)	70,4 / 3,0	90,9 / 7,4	**< 0,05**
A. simplex l. (invasion of muscles)	13,0 / 0,4	38,2 / 1,2	**< 0,05**
Hysterothylacium aduncum	13,9 / 0,3	5,5 / 0,07	> 0,05
Spinitectus sp.	0,9 / 0,02	-	> 0,05
Nematoda sp.	1,9 / 0,03	-	> 0,05
Acanthocephala sp. l.	1,9 / 0,04	-	> 0,05
Sphyrion lumpi (total invasion)	17,9 / 0,28 *	48,8 / 0,96 **	**< 0,05**
S. lumpi (invasion by live parasites only)	0,4 / 0,02 *	6,6 / 0,09 **	**< 0,05**
Pigment spots (occurrence, %)	2,8 *	17,7 **	**< 0,05**

Note**:** in front of slash – prevalence (%) of invasion, behind a slash – abundance index; * - n = 543; ** - n = 361

Table 6. Number of species of main systematic groups (classes) composing parasite fauna of *Sebastes mentella* in the surveyed areas.

Systematic groups of parasites	S.-W. slope of Iceland	Pelagial
Myxosporea	5	5
Monogenea	1	-
Cestoda	2	7
Trematoda	3	3
Nematoda	4	2
Acanthocephala	1	-
Crustacea	1	1

Note: similarity between compositions of parasite fauna constituted 74,3 %.

Table 7. Degree of invasion of males and females of *Sebastes mentella* with copepod *Sphyrion lumpi* (taking into account remnants of parasitizing of the copepod) in various areas in June-July, 2001.

Kind of lesioning with *S. lumpi*	Fish sex	Prevalence, %		Abundance index		Significance of differences (P)
		S.-W. slope of Iceland (n=543)	Pelagial (n=361)	S.-W. slope of Iceland	Pelagial	
Live	M	0,8	2,3	0,02	0,03	> 0,05
	F	-	10,5	0,02	0,15	**< 0,05**
	M+F	0,4	6,6	0,02	0,09	**< 0,05**
Ulcers	M	0,8	9,4	0,02	0,11	**< 0,05**
	F	2,2	20,0	0,03	0,32	**< 0,05**
	M+F	1,5	15,0	0,02	0,22	**< 0,05**
Old	M	15,5	32,7	0,26	0,47	**< 0,05**
	F	17,9	46,8	0,26	0,81	**< 0,05**
	M+F	16,8	40,2	0,26	0,65	**< 0,05**
Sum of lesions with *S. lumpi*	M	16,7	38,0	0,27	0,61	**< 0,05**
	F	19,0	58,4	0,29	1,28	**< 0,05**
	M+F	17,9	48,8	0,28	0,96	**< 0,05**

Table 8. Occurrence (%) of males and females of *Sebastes mentella* with pigment spots on the skin in various areas in June-July, 2001.

Colour of pigment spots	Fish sex	Areas of investigations		Significance of differences (P)
		S.-W. slope of Iceland (n=543)	Pelagial (n=361)	
Red	M	1,5	11,7	**< 0,05**
	F	2,2	18,4	**< 0,05**
	M+F	1,8	15,2	**< 0,05**
Black	M	0,8	1,8	> 0,05
	F	0,7	3,2	**< 0,05**
	M+F	0,7	2,5	**< 0,05**
All spots	M	2,3	13,4	**< 0,05**
	F	3,2	21,6	**< 0,05**
	M+F	2,8	17,7	**< 0,05**

Table 9. Distributions of lesions with copepod *Sphyrion lumpi* by zones of investigation on redfish body.

Zones of redfish investigation	S.-W. slope of Iceland	Pelagial
I	78,8	68,8
II	15,3	14,7
III	-	1,8
IV	5,9	14,7
Sum, %	100,0	100,0

Note: I – dorsal (“fillet”) and caudal part, II – ventral part, III – head, IV – anal part.

Table 10. Degree of invasion of redfish with copepod *Sphyrion lumpi* and occurrence (%) of fish with pigment spots on the skin in different areas.

Year, month	S.-W. slope of Iceland						Pelagial					
	Copepod *Sphyrion lumpi*			Pigment spots, %			Copepod *Sphyrion lumpi*			Pigment spots, %		
	males	females	males, females	males	females	males, females	males	females	males, females	males	females	males, females
2001 (June-July)	16,7 / 0,3	19,0 / 0,3	17,9 / 0,3	2,3	3,2	2,8	38,0 / 0,6	58,4 / 1,3	48,8 / 1,0	13,4	21,6	17,7
1989 (May)	20,0 / 0,3	24,4 / 0,3	21,0 / 0,3	2,7	4,0	3,0	33,3 / 0,5	55,1 / 1,4	49,2 / 1,1	11,6	22,0	16,0
1986 (May)	14,2 / 0,2	14,9 / 0,2	14,6 / 0,2	4,1	6,5	5,5	29,6 / 0,5	44,2 / 1,2	41,8 / 1,0	12,9	23,9	17,9

Note: above a slash – prevalence (%) of invasion, under a slash – abundance index.

Table 11. Frequencies of alleles of MER-2 locus in samples of *Sebastes mentella* in the pelagial of the Irminger Sea in 2000

Characteristics of samples							
No. of sample	Latitude (N)	Longitude (W)	Trawling depth range, m		Volume of a sample	Alleles of the MER-2 locus	
			min	max		60	100
1	61,30	28,10	740	835	10	0,200	0,800
2	61,20	28,10	705	770	10	0,350	0,650
3	61,30	28,20	640	740	10	0,300	0,700
4	61,20	28,10	760	780	10	0,100	0,900
5	61,20	28,10	740	760	10	0,300	0,700
6	61,30	28,10	760	770	10	0,200	0,800
7	61,20	28,10	760	760	10	0,300	0,700
8	61,40	29,10	780	800	10		1,000
9	61,20	28,10	650	720	10	0,150	0,850
10	61,30	28,20	720	750	10	0,150	0,850
11	61,14	28,10	580	600	10	0,300	0,700
12	61,10	28,10	540	700	10	0,100	0,900

Table 12. Frequencies of alleles of MER-2 locus in samples of *Sebastes mentella* in 2001

Characteristics of samples								
No. of trawl	Latitude (N)	Longitude (W)	Trawling depth range, m			Volume of a sample	Alleles of the MER-2 locus	
			min	max	mean		60	100
Pelagial of the Irminger Sea, R/V 'AtlantNIRO'								
62	60,65	31,53	640	691	666	17	0,412	0,588
63	60,60	31,53	277	307	292	63	0,421	0,579
64	61,87	28,92	660	740	700	18	0,500	0,500
65	62,05	27,28	788	853	821	35	0,200	0,800
66	62,55	27,20	710	790	750	18	0,333	0,667
68	63,12	25,73	695	915	805	25	0,120	0,880
Bottom trawlings, southwestern slope of Iceland, R/V 'AtlantNIRO'								
69	63,00	25,15	639	639	639	50	0,380	0,620
70	63,03	25,42	755	755	755	28	0,250	0,750
71	63,17	25,57	824	824	824	11	0,409	0,591
72	63,15	25,17	430	430	430	37	0,622	0,378
73	63,12	25,18	509	509	509	50	0,450	0,550
74	63,10	25,20	597	597	597	50	0,490	0,510
76	62,97	24,12	597	597	597	29	0,241	0,759
77	62,85	24,02	688	688	688	50	0,300	0,700
78	63,07	23,80	525	525	525	50	0,320	0,680
Pelagial of the Irminger Sea, R/V 'A.Fridriksson'								
275	62,25	28,10			560	50	0,360	0,640
287	61,30	21,02			680	7	0,643	0,357
290	61,30	26,54			490	4	0,250	0,750
291	61,30	28,37			670	13	0,346	0,654
293	60,31	30,25			650	23	0,326	0,674

Table 13. Frequencies of alleles of MDH locus in samples of *Sebastes mentella* in the pelagial of the Irminger Sea in 2000

Characteristics of samples							
No. of sample	Latitude (N)	Longitude (W)	Trawling depth range, m		Volume of a sample	Alleles of the MDH locus	
			min	max		20	100
1	61,30	28,10	740	835	10		1,000
2	61,20	28,10	705	770	10	0,050	0,950
3	61,30	28,20	640	740	10		1,000
4	61,20	28,10	760	780	10		1,000
5	61,20	28,10	740	760	10	0,050	0,950
6	61,30	28,10	760	770	10		1,000
7	61,20	28,10	760	760	10	0,050	0,950
8	61,40	29,10	780	800	10		1,000
9	61,20	28,10	650	720	10	0,050	0,950
10	61,30	8,20	720	750	10	0,100	0,900
11	61,14	28,10	580	600	10		1,000
12	61,10	28,10	540	700	10		1,000

Table 14. Frequencies of alleles of MDH locus in samples of *Sebastes mentella* in 2001

Characteristics of samples							
No. of sample	Latitude (N)	Longitude (W)	Trawling depth range, m		Volume of a sample	Alleles of the MDH locus	
			min	max		20	100
Pelagial of the Irminger Sea, R/V 'AtlantNIRO'							
62	60,65	31,53	640	691	17	0,059	0,941
63	60,60	31,53	277	307	63		1,000
64	61,87	28,92	660	740	18	0,056	0,944
65	62,05	27,28	788	853	35	0,057	0,943
66	62,55	27,20	710	790	18		1,000
68	63,12	25,73	695	915	25		1,000
Bottom trawlings, southwestern slope of Iceland, R/V 'AtlantNIRO'							
69	63,00	25,15	639	639	50	0,040	0,960
70	63,03	25,42	755	755	28		1,000
71	63,17	25,57	824	824	11		1,000
72	63,15	25,17	430	430	37		1,000
73	63,12	25,18	509	509	50		1,000
74	63,10	25,20	597	597	50	0,040	0,960
76	62,97	24,12	597	597	29		1,000
77	62,85	24,02	688	688	50	0,020	0,980
78	63,07	23,80	525	525	50	0,020	0,980
Pelagial of the Irminger Sea, R/V 'A.Fridriksson'							
275	62,25	28,10	560		50	0,020	0,980
287	61,30	21,02	680		7		1,000
290	61,30	26,54	490		4		1,000
291	61,30	28,37	670		13	0,076	0,924
293	60,31	30,25	650		23		1,000

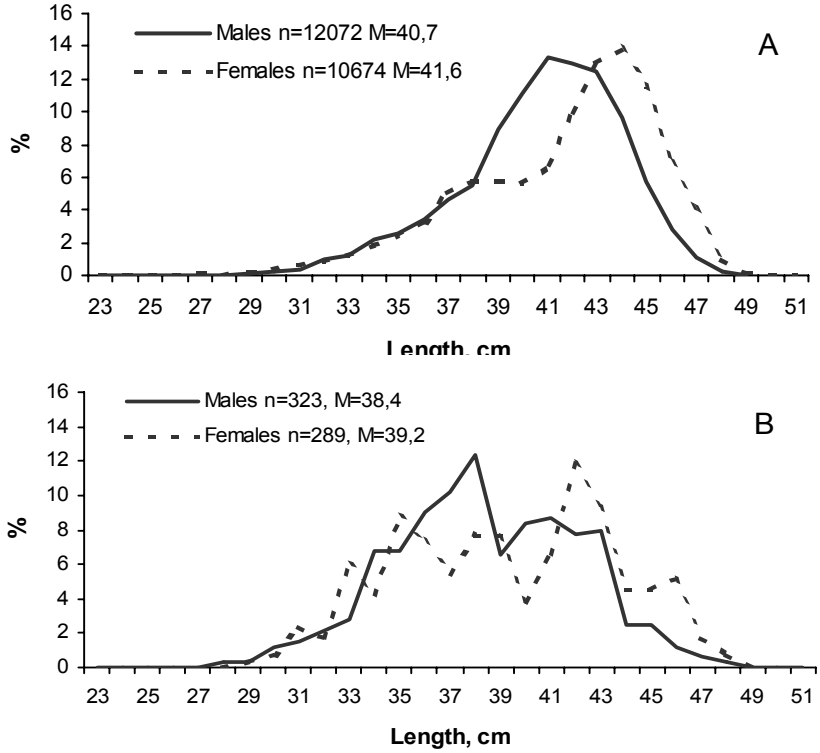

Fig. 1. Length composition of redfish in pelagial of the Irminger Sea (A) and on the southwestern slope of Iceland (B).

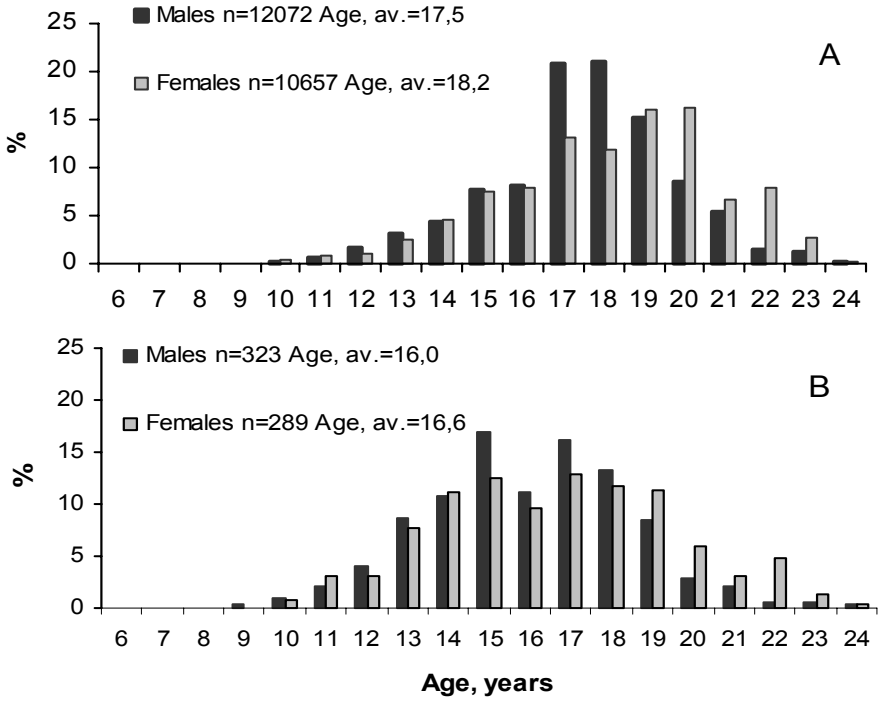

Fig. 2. Age composition of redfish in pelagial of the Irminger Sea (A) and on the southwestern slope of Iceland (B).

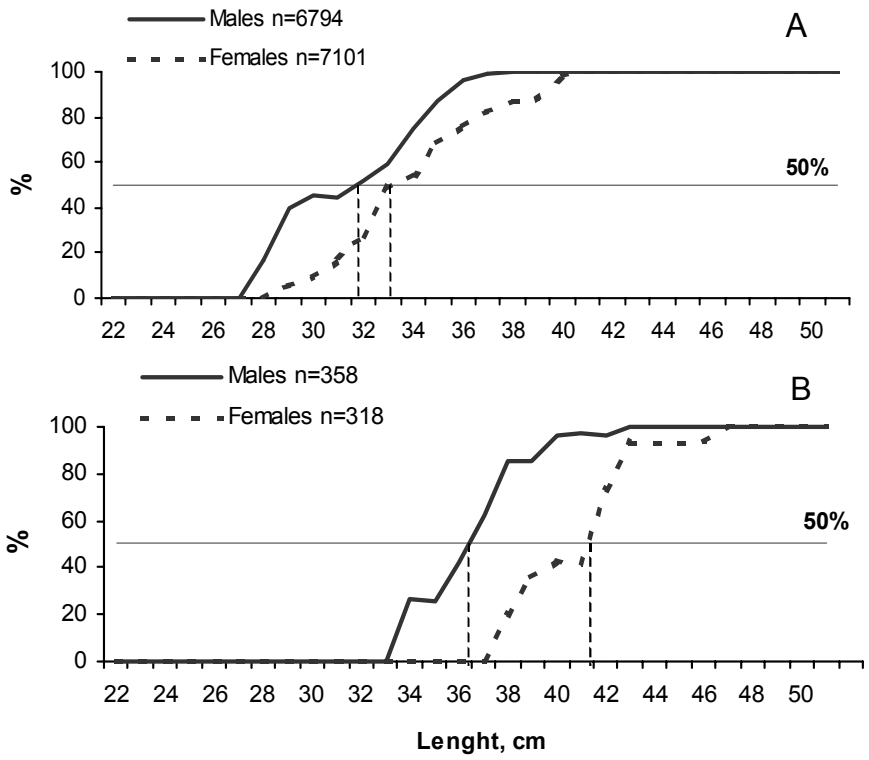

Fig. 3. Maturation of males and females of redfish of different length groups in pelagial of the Irminger Sea (A) and on the southwestern slope of Iceland (B).

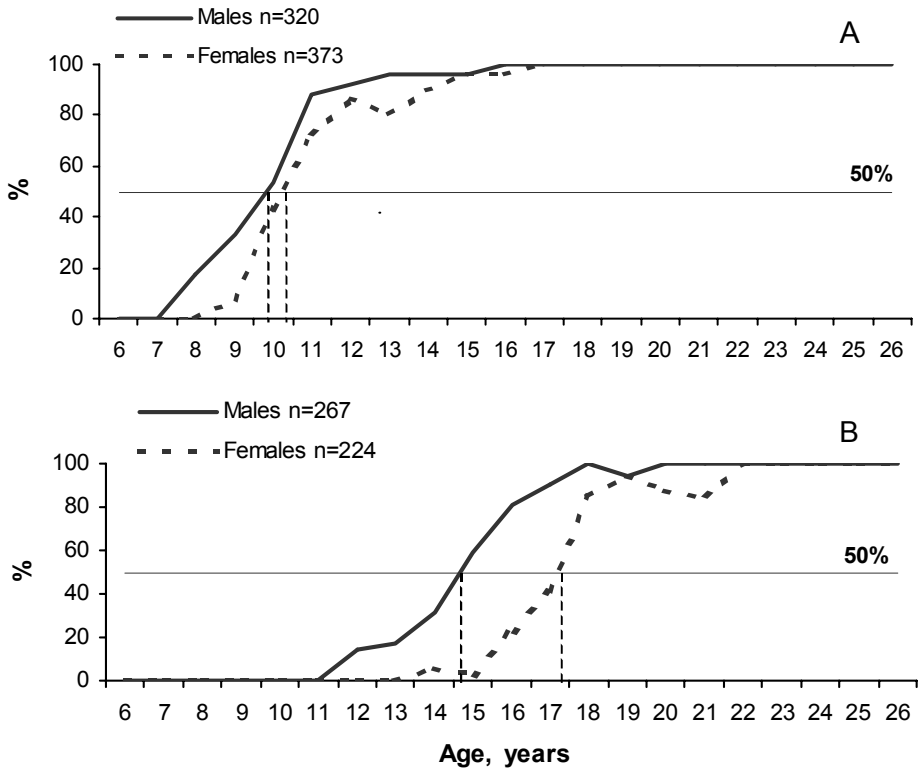

Fig. 4. Maturation of males and females of redfish of different age groups in pelagial of the Irminger Sea (A) and on the southwestern slope of Iceland (B).

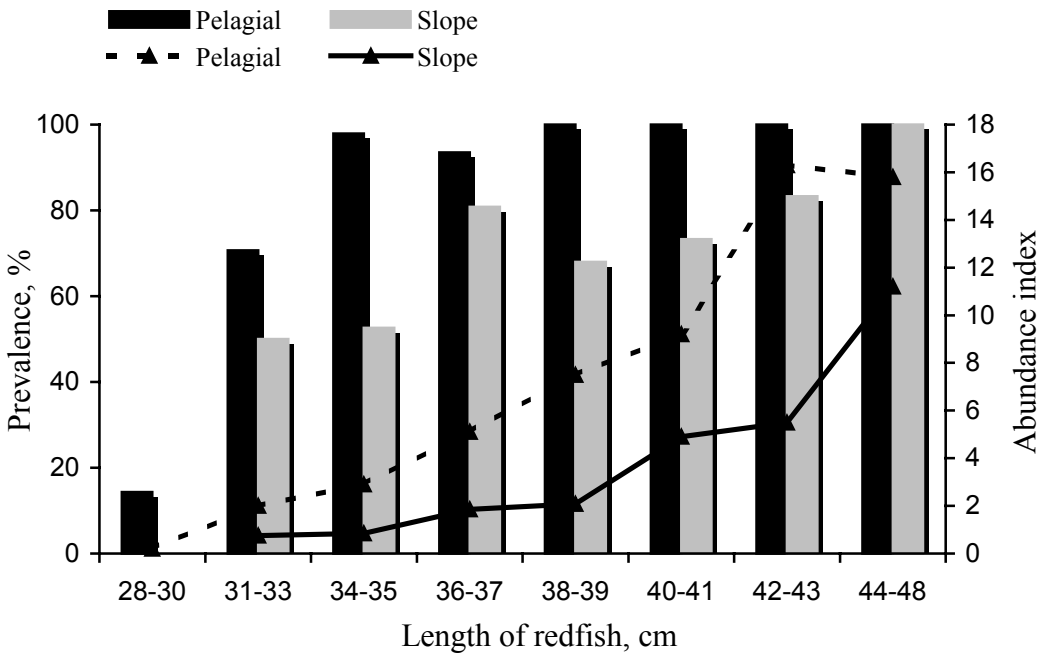

Fig. 5. Dynamics of prevalence (bars) and abundance index (lines) of invasion by nematode *Anisakis simplex* l. of redfish of the slope of Iceland and pelagial.