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Growth and Age of the Roughhead Grenadier *Macrourus berglax* in Waters off Southwest Greenland

A. M. Orlov[a, b, c, d, *], E. V. Vedishcheva[a], A. O. Trofimova[a], and S. Yu. Orlova[a]

[a] *Russian Research Institute of Fisheries and Oceanography (VNIRO), Moscow, 107140 Russia*
[b] *Severtsov Institute of Ecology and Evolution (IEE), Russian Academy of Sciences, Moscow, 119071 Russia*
[c] *Dagestan State University, Makhachkala, the Republic of Dagestan, 367000 Russia*
[d] *Tomsk State University, Tomsk, 634050 Russia*
**e-mail: orlov@vniro.ru*

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Abstract—Data on the age and growth of the roughhead grenadier *Macrourus berglax* from waters off Southwest Greenland have been obtained based on the analysis of otoliths. Specimens with a preanal length of 5–39 cm, a weight of 7–5275 g, and age from 2 to 22 years are recorded in trawl catches. Roughhead grenadier exhibits a similar rate of linear growth in waters off Southwest Greenland and other parts of the range in the Northwest Atlantic. No considerable differences from the rate of the linear growth calculated earlier from scales for the species in waters off West Greenland have been found. In the recent period, the rate of weight gain in roughhead grenadier in waters off Southwest Greenland has been lower than in the Northwest Atlantic in the first half of the 1980s. The age of mass maturation in males (7–9 years) and females (16–17 years) in waters off West and East Greenland is somewhat higher than in coastal waters of Norway and the Northwest Atlantic.

Keywords: roughhead grenadier *Macrourus berglax*, otoliths, size, age, growth, Southwest Greenland, North Atlantic

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The roughhead grenadier *Macrourus berglax* is one of the most abundant representatives of the family Macrouridae in the North Atlantic, where it is widespread from temperate (37°N near the coast of the United States) to high Arctic (Spitsbergen and both coasts of Greenland) latitudes, including the area of the Mid-Atlantic Ridge, semounts to the west of the British Isles, and waters off the coasts of Iceland and Norway (Savvatimsky, 1989; Cohen et al., 1990). The species is rare in waters of Russia; it is reported in the Barents Sea off the Murmansk coast (Parin et al., 2014), as a rule, in research survey catches (Dolgov et al., 2008). Roughhead grenadier forms the maximum concentrations on the eastern slope of the Grand Banks off Newfoundland, between Southeast Greenland and Iceland and in the central part of the Norwegian coast near the Lofoten Islands (Savvatimsky, 1989; Cohen et al., 1990). Roughhead grenadier is of some commercial importance as the main species of the by-catch in the Greenland halibut *Reinhardtius hippoglossoides* fishery in the northwestern Atlantic Ocean with annual catches from several hundreds to 7000 t (Alpoim, 1997; Murua et al., 2005; Gonzalez-Costas and Murua, 2008). The species has low productivity due to long lifespan, slow growth, and late maturation (Devine et al., 2012), which was one of the main reasons for the decrease in its abundance in Canadian waters of the Northwest Atlantic under impact of fishery in 1975–2005 (Devine and Headrich, 2008).

The age of roughhead grenadier has been well studied by otoliths in the area of the Great Banks off Newfoundland with adjacent waters of the Flemish Cap and Flemish Pass (Murua et al., 1999; Rodriguez-Marin et al., 2002; Murua, 2003; Murua, Gonzalez, 2006) and by scales (Savvatimsky, 1984, 1994). It is difficult to use the results of the latter works for the comparison with the modern data, because they are based on measurements of the total length instead of preanal length. The results of the age determination of roughhead grenadier in waters off West Greenland are presented in the only published work (Jørgensen, 1996) and are also based on the analysis of scales. Meanwhile, since the beginning of the 1990s, Greanland halibut fishery has intensified in West Greenland (Bowering and Nedreaas, 2000), including Russian fishing vessels within the framework of an agreement between the Russian Federation and Greenland on mutual fishery relations concerning quotas exchange (Glubokovskii et al., 2013) that may result in changes

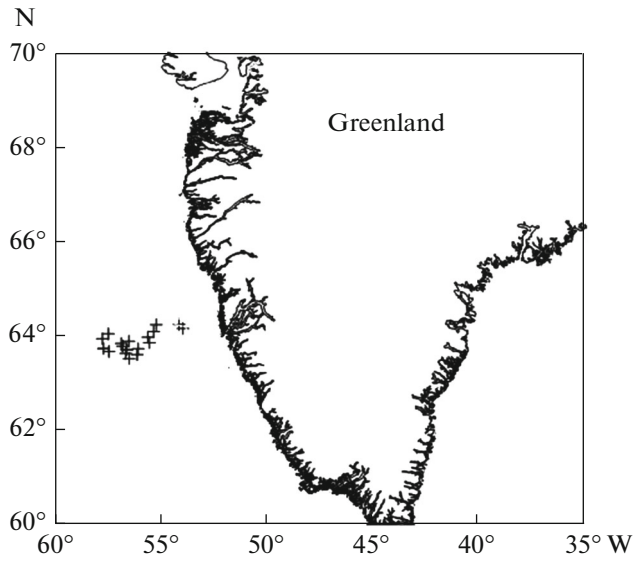

Fig. 1. Sites of sampling (+) of otoliths of the roughhead grenadier *Macrourus berglax* in waters off Southwest Greenland in September 2013.

of the growth rates of roughhead grenadier as one of the main species of the by-catch. The aim of this work is to study the age and growth of roughhead grenadier from waters off Southwest Greenland based on the analysis of otholiths and compare our results with the published data.

MATERIALS AND METHODS

The material was collected in the course of the research trawl surveys of the stock of Greenland halibut onboard the RV *Paamiut* (Greenland Institute of Natural Resources, Nuuk, Greenland) in the waters off Southwest Greenland (the Northwest Atlantic) in September 2013 (Fig. 1). A complete biological analysis of 168 specimens of roughhead grenadier captured at a depth range from 912 to 1501 m was performed according to the standard method (Laevastu, 1965; Pravdin, 1966). Because of the problem of tail tip breakage in the trawl and during the process of fishing and the presence of fish with tails lost in the past, the preanal length (*PAL*) from the tip of the snout to the beginning of the anal fin was measured to the nearest half-centimeter. The total length (*TL*) was determined using the formula proposed by Atkinson (1991): $TL = 5.232 + 2.3455 \times PAL$.

Otoliths were extracted from freshly caught fish during the biological analysis aboard the vessel and placed into paper bags. The age was determined under laboratory conditions. Since the beginning of the 1980s, the technique of counting of annuli using burned cross sections of otoliths was well validated for bottom (including deepwater) fish off the western coast of the United States and Canada (Beamish and McFarlane, 1987). Taking into account that roughhead greanadier is a long-lived species like many deepwater fishes (Devine et al., 2006), its age was determined according the methods specially developed for some long-lived deepwater fish species (Beamish and Chilton, 1982; Rodríguez Mendoza, 2006).

An otolith fixed with clips was broken in the middle part using forceps. If necessary, the surface of a broken otolith was polished and burned over a flame of an alcohol burner. For grinding of otolith sections, discs coated with aluminium oxide or silicon carbide abrasives of 0.1–0.9 μm were used (Buehler, United States). Sections were examined at a magnification of 10 × 4, 10 × 10, or 10 × 20 under a stereomicroscope (Leica DMLS). Otoliths were examined in glycerol using either reflected or transmitted light (Fig. 2).

RESULTS

Roughhed grenadier in catches of a bottom trawl was represented by specimens *PAL* 5–39 (that corresponds to *TL* 17.0–96.7) cm, a weight of 7–5275 g, and aged 2–22 years. Males in catches constituted 54.7%, females 28.5%, and juvenile specimens 16.8%.

According to our data from the waters off Southwest Greenland, roughhead grenadier of 5 years of age reaches *PAL* 11.5 (*TL* 32.2) cm and a weight of 130 g, 19.0 (49.8) cm and 573 g at the age of 10 years, 23.5 (60.4) cm and 1058 g at the age of 15 years, and 29.5 (74.4) cm and 2533 g at the age of 20 years (Table 1). Juvenile specimens were recorded among fish 2–9 years old, *PAL* 5.0–15.0 (*TL* 17.0–40.4) cm.

The minimum age of females in catches is smaller than that of males (5 years old at *PAL* 11.0 (*TL* 31.0) cm and a weight of 119 g vs. the age of 6 years at 13.5 (36.9) cm and a weight of 190 g). Until the age of 9 years, males have higher linear and weight growth compared to females; at the age of 9 years, average values of length and weight in males and females are practically equal, and females demonstrate higher values of both parameters from the age of 10 years. In our catches, the maximum age was 15 years of males and 22 years of females.

Gonads of most males and females of roughhead grenadier were at maturity stages I and II. All males in catches had gonads at maturity stages I and II. It is difficult to determine the portion of immature males in the state of postspawn recovery without histological analysis of gonads. The age of immature females was 4–15 years at *PAL* 11.0–26.0 (*TL* 31.0–66.2) cm. Mature females with ovaries at stage III *PAL* > 30 (*TL* > 75.6) cm were 20–22 years of age. Postspawn females with gonads at stages VI–II and VI–III had *PAL* 26.0–35.0 (*TL* 66.2–87.3) cm and were at the age of 14–20 years.

Roughhead grenadier grows extremely unevenly during its life if we judge by annual linear growth and weight increments. Several periods with different

growth rates may be distinguished during the life cycle of females. The first period of an intensive growth lasts until the age of 8–9 years when the annual increase in a preanal length is 1–2 cm, and the weight increase is 11–180 g. Then the growth rates decrease to the age of 12–13 years: the increase in the length even reaches negative values (*PAL* –0.37–1.25 cm) and the weight increases within 18–95 g per year. From the age of 13 years, the rates of linear and weight growth of females increase (*PAL* 2–3 cm and 295–828 g per year) reaching the maximum at 16–17 years of age; then the growth begins to decelerate. Males demonstrate the highest rate of linear growth and weight gain at the age of 6–7 years (*PAL* 1.5–1.7 cm and 77–102 g per year; the growth slows down (*PAL* 0.4–0.8 cm and 4–78 g) at the age of 7–11 years and accelerates (*PAL* 1.6 cm and 222 g) in males aged 12 years, then the growth rate decelerates again.

DISCUSSION

The comparison of our results and published data demonstrates that the age structure of roughhead grenadier is not only characterized by regional features but may change with time (Table 2). This is, probably, due to the features of the population reproduction in different parts of the range and the impact of fishing. On the eastern slope of the Grand Banks of Newfoundland, males and females of roughhead grenadier aged 7–13 and 6–23 years, respectively, were recorded in catches in 1982 (Savvatimsky, 1984); in waters of the Northhwest Atlantic, males and females aged 3–13 and 3–22 years were recorded in 1985 (Savvatimsky, 1994). Males aged 1–14 years and females aged 1–18 years were found in trawl catches in the Flemish Cap area in the 1990s (Casas, 1994; Sainza, 1996; Alpoim, 1997; Murua et al., 1999) and males and females aged 1–18 and 1–23 years, respectively, in 2005–2007 (Murua and Gonzalez, 2006; Gonzalez and Murua, 2008). According to Jørgensen (1996), males of roughhead grenadier at ages of 4–13 years and females at ages of 3–19 years were recorded in trawl catches in waters off West Greenland in 1987–1994. According to our data, this species was represented 20 years later in this area by specimens aged from 2 to 22 years (males 6–15 years old and females 5–22 years old), i.e., practically by the same age groups despite an intensive fishing of Greenland halibut. This fact may be due to the increase in the abundance and biomass of roughhead grenadier in waters off West Greenland from 2259 t and 4.6×10^6 ind. in 1997 to 6303 t and 8.4×10^6 ind. in 2012 (Jørgensen, 2013).

Specimens of age 1+ of roughhead grenadier were absent in our catches, which may be caused by performing of trawl hauls beyond the depths and areas inhabited by juveniles and the absence of the yield generation during the year preceding our studies. Values of average length of males of different age in the area of our surveys do not differ from the values in

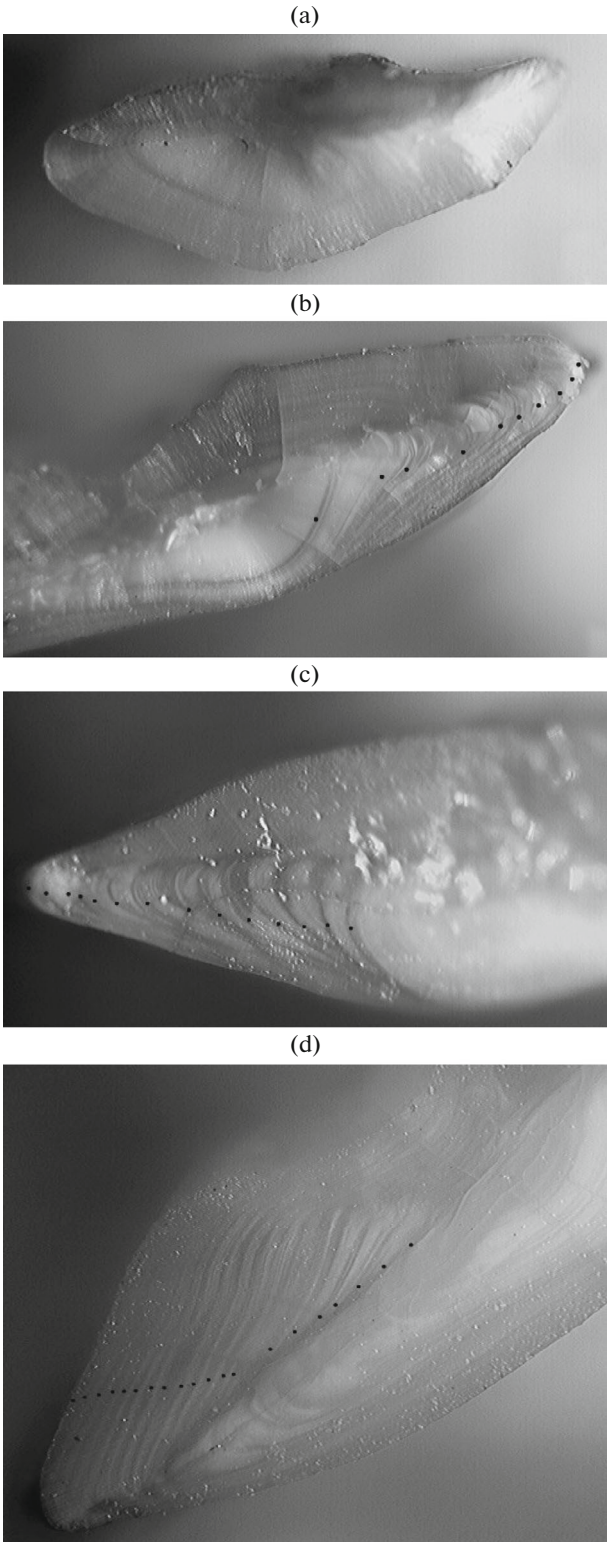

Fig. 2. Sections of otoliths of the the roughhead grenadier *Macrourus berglax* from waters off Southwest Greenland: (a) *PAL* 5 cm, weight of 7 g, age of 2 years; (b) *PAL* 18.5 cm, weight 485 g, age of 10 years; (c) *PAL* 23 cm, weight 974 g, age of 14 years; (d) *PAL* 26 cm, weight 1169 g, age of 20 years; (·) annual growth zones.

Table 1. Preanal length (*PAL*) and weight of the roughhead grenadier *Macrourus berglax* of different age in waters of Southwest Greenland

Age, years	Males			Females			Both sexes and juvenile specimens		
	PAL, cm	Weight, kg	*n*, ind.	*PAL*, cm	Weight, kg	*n*, ind.	*PAL*, cm	Weight, kg	*n*, ind.
2							5.0–5.5 5.25 ± 0.35	0.007–0.013 0.010 ± 0.004	2
3							5.5–7.5 6.50 ± 1.00	0.014–0.036 0.028 ± 0.012	3
4							7.0–18.0 10.05 ± 3.03	0.030–0.147 0.076 ± 0.042	11
5				11.0–13.5 12.33 ± 1.26	0.119–0.200 0.160 ± 0.041	3	10.0–13.5 11.45 ± 1.21	0.090–0.200 0.130 ± 0.041	10
6	13.5–15.5 14.25 ± 0.88	0.190–0.331 0.264 ± 0.058	6	12.0–14.5 13.33 ± 1.26	0.200–0.235 0.233 ± 0.003	3	9.5–15.5 13.08 ± 1.69	0.095–0.331 0.250 ± 0.080	13
7	14.0–18.0 15.79 ± 1.05	0.242–0.448 0.341 ± 0.063	12	11.5–17.0 14.70 ± 2.02	0.129–0.369 0.244 ± 0.106	5	11.5–18.0 15.47 ± 1.39	0.138–0.448 0.312 ± 0.085	17
8	15.5–19.0 17.50 ± 1.08	0.286–0.656 0.443 ± 0.087	22	14.5–19.0 16.69 ± 1.31	0.234–0.639 0.407 ± 0.113	8	14.5–19.0 17.28 ± 1.18	0.234–0.639 0.433 ± 0.094	30
9	16.5–19.0 17.92 ± 0.95	0.383–0.583 0.486 ± 0.081	12	16.0–18.5 17.75 ± 0.88	0.418–0.514 0.483 ± 0.084	6	15.0–19.0 17.71 ± 1.07	0.252–0.583 0.472 ± 0.091	19
10	17.5–21.0 18.75 ± 0.93	0.435–0.764 0.550 ± 0.104	16	18.5–23.0 19.75 ± 2.18	0.475–1.147 0.663 ± 0.324	4	17.5–23.0 18.95 ± 1.27	0.435–1.147 0.573 ± 0.165	20
11	18.0–21.0 19.33 ± 1.03	0.519–0.685 0.628 ± 0.062	6	21.0	0.681	1	18.0–21.0 19.57 ± 1.05	0.519–0.685 0.635 ± 0.056	7
12	18.0–21.0 19.77 ± 1.06	0.505–0.805 0.632 ± 0.078	11	19.0–23.02 0.63 ± 1.97	0.494–1.033 0.770 ± 0.276	4	18.0–23.0 20.00 ± 1.34	0.494–1.033 0.670 ± 0.157	15
13	19.5–26.0 21.38 ± 3.09	0.575–1.480 0.854 ± 0.427	4				19.5–26.0 21.38 ± 3.09	0.575–1.480 0.854 ± 0.427	4
14	20.0–20.5 20.25 ± 0.35	0.583–0.675 0.629 ± 0.065	2	23.0–27.0 24.33 ± 2.31	0.948–1.342 1.088 ± 0.220	3	20.0–27.0 22.70 ± 2.77	0.583–1.3428 0.904 ± 0.29	5
15	20	0.682	1	23.0–26.0 24.76 ± 1.183	1.031–1.325 1.183 ± 0.147	3	20.0–26.0 23.50 ± 2.65	0.682–1.325 1.058 ± 0.278	4
16				27.0	1.487	1	27.0	1.487	1
18				30.0	1.782	1	30.0	1.782	1
19				32.0	2.610	1	32.0	2.610	1
20				26.0–35.0 29.50 ± 4.04	1.169–4.781 2.533 ± 1.578	4	26.0–35.0 29.50 ± 4.04	1.169–4.781 2.533 ± 1.578	4
22				39.0	5.275	1	39.0	5.275	1

Ranges of variation of the parameter are above the line; the mean and standard deviation are under the line; *n* is the number of fishes.

other parts of the range (Savvatimsky, 1984, 1994; Murua et al., 1999; Rodriguez-Marin et al., 2002; Murua, 2003) and in waters off West Greenland calculated by scales (Jørgensen, 1996). Whereas the rate of linear growth of females in the area of our surveys is similar to that in other areas only to the age of 11 years, females then grow slower than in the other parts of the range, which cannot be explained reasonably.

The published data on the body weight of roughhead grenadier of various age are scanty. The comparison of our data with the data obtained in other areas of the Northwest Atlantic in the first half of the 1980s (Savvatimsky, 1984, 1994) demonstrates that the average weight of specimens from different areas is similar only in fish aged 6 years (Table 3). In other age groups, the average weight of roughhead grenadier in the

Table 2. Mean preanal length (*PAL*, cm) of males and females of the roughhead grenadier *Macrourus berglax* of different age in different areas of the Northwest Atlantic

Age, years	Eastern slope of the Great Banks of Newfoundland, 1982 (Savvatimsky, 1984)*		Northwest Atlantic, 1985 (Savvatimsky, 1994)*		Flemish Cap						West Greenland, 1987–1994 (Jørgensen, 1996)		Southwest Greenland, 2013 (our data)	
					1991–1998 (Murua et al., 1999)		1994–2001 (Murua, 2003)		1995–1997 (Rodriguez-Marin, et al., 2002)					
	males	females	males	females	males	females	males	females	males	females	males	females	males	females
1	–	–	–	–	3.3	3.0	3.2	3.0	–	–	–	–	–	–
2	–	–	–	–	5.5	5.6	5.6	5.6	4.7	5.1	–	–	–	–
3	–	–	9.0	8.0	8.3	7.9	8.1	7.9	7.5	7.3	–	7.2	–	–
4	–	–	9.6	9.4	10.0	10.0	10.1	10.1	9.8	9.8	8.1	7.8	–	–
5	–	–	11.5	11.8	12.4	12.3	12.2	12.2	12.5	12.1	9.7	10.2	–	12.3
6	–	–	13.2	13.3	14.1	14.1	14.1	14.0	13.7	13.9	11.9	12.4	14.3	13.3
7	16.0	16.5	14.8	14.7	15.7	15.9	15.4	15.7	15.0	15.2	14.4	14.3	15.8	14.7
8	17.6	18.1	17.1	16.9	17.1	17.3	16.7	17.1	16.7	16.7	16.0	16.4	17.5	16.7
9	18.5	18.9	18.2	18.2	18.4	19.1	17.9	18.7	18.4	18.7	17.7	17.6	17.9	17.8
10	19.5	20.8	18.7	18.9	18.8	20.8	18.5	20.2	18.9	20.8	18.7	18.8	18.8	19.8
11	19.2	22.1	19.5	20.7	19.3	22.5	19.3	22.0	19.8	21.7	20.3	21.0	19.3	21.0
12	20.2	23.4	20.3	22.3	20.1	23.4	20.1	23.4	20.2	23.2	20.1	23.3	19.8	20.6
13	22.5	25.6	22.9	23.9	20.3	24.7	20.2	24.4	21.2	25.3	22.0	23.9	21.4	–
14	–	–	–	25.0	21.2	26.0	21.3	26.1	22.0	27.3	–	27.2	20.3	24.3
15	–	–	–	26.3	–	27.2	19.3	27.4	22.0	28.7	–	28.5	20.0	24.8
16	–	–	–	28.0	–	29.4	21.0	28.5	–	29.7	–	29.7	–	27.0
17	–	–	–	29.1	–	28.5	–	29.6	–	30.3	–	28.5	–	–
18	–	–	–	30.6	–	31.0	23.0	31.3	–	30.9	–	31.5	–	30.0
19	–	–	–	34.2	–	–	–	35.0	–	33.5	–	35.0	–	32.0
20	–	–	–	34.1	–	–	23.0	31.0	–	32.5	–	–	–	29.5
21	–	–	–		–	–	–	–	–	34.9	–	–	–	–
22	–	–	–	37.4	–	–	–	–	–	34.0	–	–	–	39.0
23	–	–	–	–	–	–	–	–	–	34.0	–	–	–	–
24	–	–	–	–	–	–	–	–	–	40.0	–	–	–	–
25	–	–	–	–	–	–	–	–	–	35.3	–	–	–	–
26	–	–	–	–	–	–	–	–	–	35.0	–	–	–	–

* *PAL* is calculated from *TL* using the formula presented in Atkinson (1991).

Table 3. Average weight of the roughhead grenadier *Macrourus berglax* of various ages in different areas of Northwest Atlantic, g

Age, years	Eastern slope of Grand Bank, May–July 1982 (Savvatimsky, 1984)		Northwest Atlantic, October–December 1985 (Savvatimsky, 1994)			Southwest Greenland, September 2013 (our data)		
	males	females	males	females	both sexes	males	females	all specimens
2	–	–	–	–	–	–	–	10
3	–	–	114	79	97	–	–	28
4	–	–	124	111	118	–	–	76
5	–	–	171	183	177	–	160	130
6	–	–	241	251	246	264	233	250
7	420	460	326	322	324	341	244	312
8	470	550	484	491	487	443	407	433
9	580	670	585	622	601	486	483	472
10	670	820	630	694	662	550	663	573
11	720	990	703	894	840	628	681	635
12	870	1200	783	1111	1073	632	770	670
13	1120	1510	1162	1351	1343	854	–	854
14	–	–	–	1583	1583	629	1088	904
15	–	–	–	1831	1831	682	1183	1058
16	–	–	–	2203	2203	–	1487	1487
17	–	–	–	2460	2460	–	–	–
18	–	–	–	2772	2772	–	1782	1782
19	–	–	–	3771	3771	–	2610	2610
20	–	–	–	3911	3911	–	2533	2533
21	–	–	–	–	–	–	–	–
22	–	–	–	5739	5739	–	5275	5275

region of our surveys is notably smaller than in other parts of the range, especially in older age groups. One of the possible reasons for such differences may be a factor of density as a result of a considerable increase in the abundance of the species in the surveyed region in the recent past (Jørgensen, 2013).

The published data on the length and age of maturity of roughhead grenadier are contradictory. In waters of Norway, 50% of females reach sexual maturity at age of 15 years and all females mature by the age of 18 years (Eliassen and Falk-Petersen, 1985). In waters off East Greenland, 50% of females and males reach maturity at *PAL* 29.5–29.7 and 15.6–16.4 cm, respectively (Fossen et al., 2003), that corresponds to ages of 16–18 years in females and 7–8 years in males. In waters of the Northwest Atlantic, 50% of females mature at *TL* 66.7 (*PAL* 26.2) cm and the age of 13–14 years (Murua and Motos, 2000).

In our catches, immature females were visually observed at *PAL* < 26 cm (age to 15 years) and mature at *PAL* > 26 cm (14 years old). The growth deceleration terminates by 16–17 years old, when all females most likely become mature. Thus, females in waters off West Greenland mature somewhat later compared to waters off the Northwest Atlantic (Murua and Motos, 2000) and Norway (Eliassen and Falk-Petersen, 1985) and at approximately the same age as in waters off the coast of East Greenland (Fossen et al., 2003). We found the most notable deceleration of growth of males at ages 7–9 years, which is probably associated with their maturation. Thus, the age of maturation of males in the region of our surveys is similar to that in waters off East Greenland (Fossen et al., 2003).

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REFERENCES

Alpoim, R., *Age Structure of Roughhead Grenadier (Macrourus berglax) on Flemish Cap, 1996, NAFO SCR Doc. 97/58,*

Ser. no. N2892, Dartmouth: Northw. Atlant. Fish. Org., 1997.

Atkinson, D.B., Relationships between pre-anal fin length and total length of roughhead grenadier (*Macrourus berglax* Lacepede) in the Northwest Atlantic, *J. Northw. Atlant. Fish. Sci.*, 1991, vol. 11, pp. 7–9.

Beamish, R.J. and Chilton, D.E., Preliminary evaluation of a method to determine the age of sablefish (*Anoplopoma fimbria*), *Can. J. Fish. Aquat. Sci.*, 1982, vol. 39, pp. 277–287.

Beamish, R.J. and McFarlane, G.A., Current trends in age determination methodology, in *Age and Growth of Fish*, Summerfelt, R.C. and Hall, G.E., Eds., Ames: Iowa St. Univ. Press, 1987, pp. 15–42.

Bowering, W.R. and Nedreaas, K.H., A comparison of Greenland halibut (*Reinhardtius hippoglossoides* (Walbaum)) fisheries and distribution in the Northwest and Northeast Atlantic, *Sarsia*, 2000, vol. 85, pp. 61–76.

Casas, J.M., *Age Structure of Roughhead Grenadier (Macrourus berglax) on Flemish Cap, 1994, NAFO SCR Doc. 94/80, Ser. No. N2459*, Dartmouth: Northw. Atlant. Fish. Org., 1994.

Cohen, D.M., Inada, T., Iwamoto, T., and Scialabba, N., Gadiform fishes of the world (order Gadiformes). An annotated and illustrated catalogue of cods, hakes, grenadiers and other gadiform fishes known to date, in *FAO Fisheries Synopses No. 125*, Rome: Food Agric. Org., 1990, vol. 10.

Devine, J.A. and Haedrich, R.L., Population trends and status of two exploited Northwest Atlantic grenadiers, *Coryphaenoides rupestris* and *Macrourus berglax*, in *Grenadiers of the World Oceans: Biology, Stock Assessment, and Fisheries*, Orlov, A.M. and Iwamoto, T., Eds., Bethesda: Am. Fish. Soc., 2008, pp. 463–484

Devine, J.A., Baker, K.D., and Haedrich, R.L., Deep-sea fishes qualify as endangered, *Nature*, 2006, vol. 439, no. 5, p. 29.

Devine, J.A., Watling, L., Cailliet, G., et al., Evaluation of potential sustainability of deep-sea fisheries for grenadiers (Macrouridae), *J. Ichthyol.*, 2012, vol. 52, no. 10, pp. 709–721.

Dolgov, A.V., Drevetnyak, K.V., Sokolov, K.M., et al., Biology and fisheries of roughhead grenadier in the Barents Sea, in *Grenadiers of the World Oceans: Biology, Stock Assessment, and Fisheries*, Orlov, A.M. and Iwamoto, T., Eds., Bethesda: Am. Fish. Soc., 2008, pp. 343–363.

Eliassen, J.-E. and Falk-Petersen, I.-B., Reproductive biology of the roughhead grenadier (*Macrourus berglax* Lacepede) (Pisces, Gadiformes) from the continental slope of the northern Norway, *Sarsia*, 1985, vol. 70, pp. 59–67.

Fossen, I., Jørgensen, O.A., and Gundersen, A.C., Roughhead grenadier (*Macrourus berglax*) in the waters off East Greenland: distribution and biology, *J. Northw. Atlant. Fish. Sci.*, 2003, vol. 31, pp. 285–298.

Glubokovsky, M.K., Glubokov, A.I., Orlov, A.M., et al., *Mezhdunarodnoe rybolovstvo-interesy Rossii* (International Fishery: Russian Interests), Moscow: VNIRO, 2013.

Gonzalez, F. and Murua, H., *A Review on Roughhead Grenadier (Macrourus berglax) Biology and Population Structure on Flemish Cap (NAFO Division 3M) 1991–2007 Based upon EU Flemish Cap Bottom Survey Data, NAFO SCR Doc. 08/27, Ser. No. N5527*, Dartmouth: Northw. Atlant. Fish. Org., 2008.

Gonzalez-Costas, F. and Murua, H., An analytical assessment of the roughhead grenadier stock in NAFO subareas 2 and 3, in *Grenadiers of the World Oceans: Biology, Stock Assessment, and Fisheries*, Orlov, A.M. and Iwamoto, T., Eds., Bethesda: Am. Fish. Soc., 2008, pp. 319–342.

Jørgensen, O.A., Distribution and biology of grenadiers in west Greenland waters, *J. Northw. Atlant. Fish. Sci.*, 1996, vol. 18, pp. 7–29.

Jørgensen, O.A., *Survey for Greenland halibut in NAFO Divisions 1C-1D, 2012, NAFO SCR Doc. 13/006, Ser. No. 6155*, Dartmouth: Northw. Atlant. Fish. Org., 2013.

Laevastu, T., *Manual of Methods in Fisheries Biology*, Rome: Food Agric. Org., 1965.

Murua, H., Population structure, growth and reproduction of roughhead grenadier on the Flemish Cap and Flemish Pass, *J. Fish. Biol.*, 2003, vol. 63, pp. 356–373.

Murua, H. and Gonzalez, F., *A Review on Roughhead Grenadier (Macrourus berglax) Biology and Population Structure on Flemish Cap (NAFO Division 3M) 1991–2005 Based upon EU Flemish Cap Bottom Survey Data, NAFO SCR Doc. 06/7, Ser. No. N5219*, Dartmouth: Northw. Atlant. Fish. Org., 2006.

Murua, H. and Motos, L., Reproductive biology of roughhead grenadier (*Macrourus berglax* Lacepède, 1801) (Pisces, Macrouridae), in Northwest Atlantic waters, *Sarsia*, 2000, vol. 85, pp. 393–402.

Murua, H., Sarasua, A., and Rodriguez-Marin, E., *A Review on Roughhead Grenadier (Macrourus berglax) Population Structure on Flemish Cap (NAFO Division 3M) 1991–1998, NAFO SCR, Doc. 99/18, Ser. No. N4068*, Dartmouth: Northw. Atlant. Fish. Org., 1999.

Murua, H., Gonzalez, F., and Power, D., A review of the fishery and the investigations of roughhead grenadier (*Macrourus berglax*) in Flemish Cap and Flemish Pass, *J. Northw. Atlant. Fish. Sci.*, 2005, vol. 37, pp. 13–27.

Parin, N.V., Evseenko, S.A., and Vasil'eva, E.D., *Ryby morei Rossii* (Fishes of Russian Seas), Moscow: KMK, 2014.

Pravdin, I.F., *Rukovodstvo po izucheniyu ryb* (Manual for Fish Analysis), Moscow: Pishchevaya Prom-st, 1966.

Rodriguez-Marin, E., Ruiz, M., and Sarasua, A., Validation of roughhead grenadier (*Macrourus berglax*) otolith reading, *J. Appl. Ichthyol.*, 2002, vol. 18, pp. 70–80.

Rodríguez Mendoza, R.P., Otoliths and their applications in fishery science, *Ribarstvo*, 2006, vol. 64, no. 3, pp. 89–102.

Sainza, C., *Age Structure of Roughhead Grenadier (Macrourus berglax) on Flemish Cap, 1995, NAFO SCR. Doc. 96/58, Ser. No. N2734*, Dartmouth: Northw. Atlant. Fish. Org., 1996.

Savvatimsky, P.I., Biological aspects of roughhead grenadier (*Macrourus berglax*) from long-line catches in the eastern Grand Bank area, 1982, *NAFO Sci. Counc. Stud.*, 1984, vol. 7, pp. 45–51.

Savvatimsky, P.I., Investigations of roughhead grenadier (*Macrourus berglax* L) in the Northwest Atlantic, 1967–1983, *NAFO Sci. Counc. Stud.*, 1989, vol. 13, pp. 59–75.

Savvatimsky, P.I., Age structure of roughhead grenadier (*Macrourus berglax*) in the Northwest Atlantic, 1985, *NAFO Sci. Counc. Stud.*, 1994, vol. 20, pp. 53–64.

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