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REPORT

## GUIDE TO THE BONY FISHES OTOLITHS OF THE WHITE SEA

by

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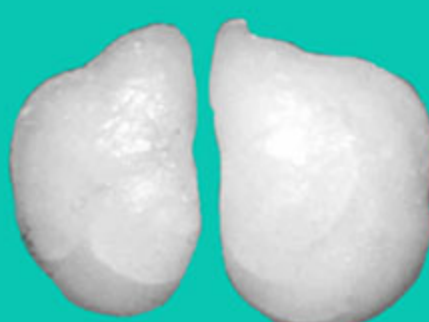
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GUIDE to the

# Otoliths of the Bony Fishes of the White Sea

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# GUIDE TO THE BONY FISHES OTOLITHS OF THE WHITE SEA

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## Introduction

The otoliths are firm formations of whitish color; placed pairwise in capsules of the webby labyrinth in fish skulls like balance bodies. Usually a webby labyrinth contains three otolith pairs. *Sagitta* otoliths are the largest; they are found in the sacculus capsule and have a constant form. The size of otoliths increases continuously as the fish grows older (Chugunova, 1959; Skalkin, 1963; Mina, 1965; Härkönen, 1986; Stevenson and Campana, 1992; Svetocheva and Stasenkova, 2003).

The otoliths are widely used in ichthyology for studying growth and fish age dynamics and also for species identification. In trophology the otoliths are used to determine the fish species in food of seals, whales and birds (Gurova and Pastuhov, 1974; Härkönen, 1986; Svetocheva et al., 2002). Otolith guides already exist for fishes in the northern seas, in the Far East Russian Seas, the Northeast Atlantic, the Baikal Lake and others (Skalkin, 1963; Schmidt, 1968; Agafonova, 1986; Härkönen, 1986; Sideleva and Zubova, 1990).

Chugunova (1959), for the first time among Russian ichthyologists gave the methodical instructions for otolith investigations. Then Pravdin (1966) proposed a description of otoliths for some fishes. The first guide of Far East Russian Seas fishes was made by Skalkin (1963).

Figures of otoliths from the three-spined stickleback, polar dab, capelin and herring from the White Sea are found in Muchomediarov (1966), Shubnikov et al. (1970) and Gosheva (1977). More recently published are a short guide and key to families of 19 bony fish species as well as a guide for juvenile fishes of the White Sea (Chrustaleva and Pavlov, 2000; Svetocheva et al., 2002).

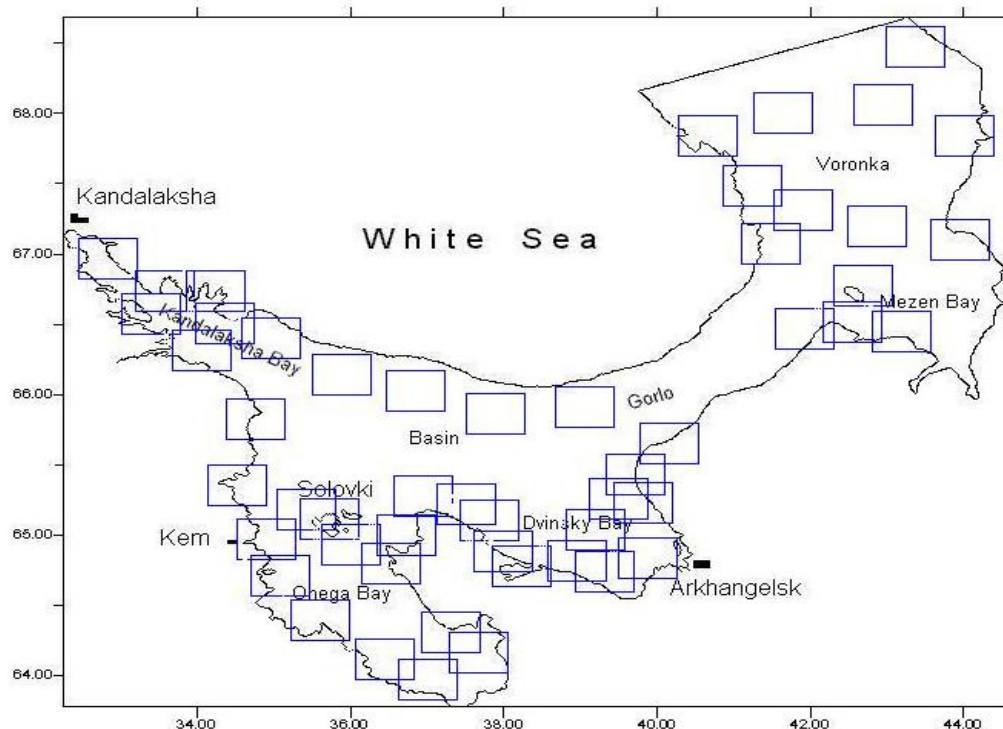


Fig. 1. Map of the White Sea. The areas of data collection are indicated.

The present Guide presents a collection of fish otolith samples from the White Sea vessel expeditions to Dvina, Onega and Mezen bays, the Gorlo and Voronka areas in 1981-1989 (the samples of the Sea Fishes Laboratory), and also from the coast of Kandalaksha, Onega and Mezen bays in June – October 1983-2005 (the samples of Marine Mammals Laboratory) (Fig. 1).

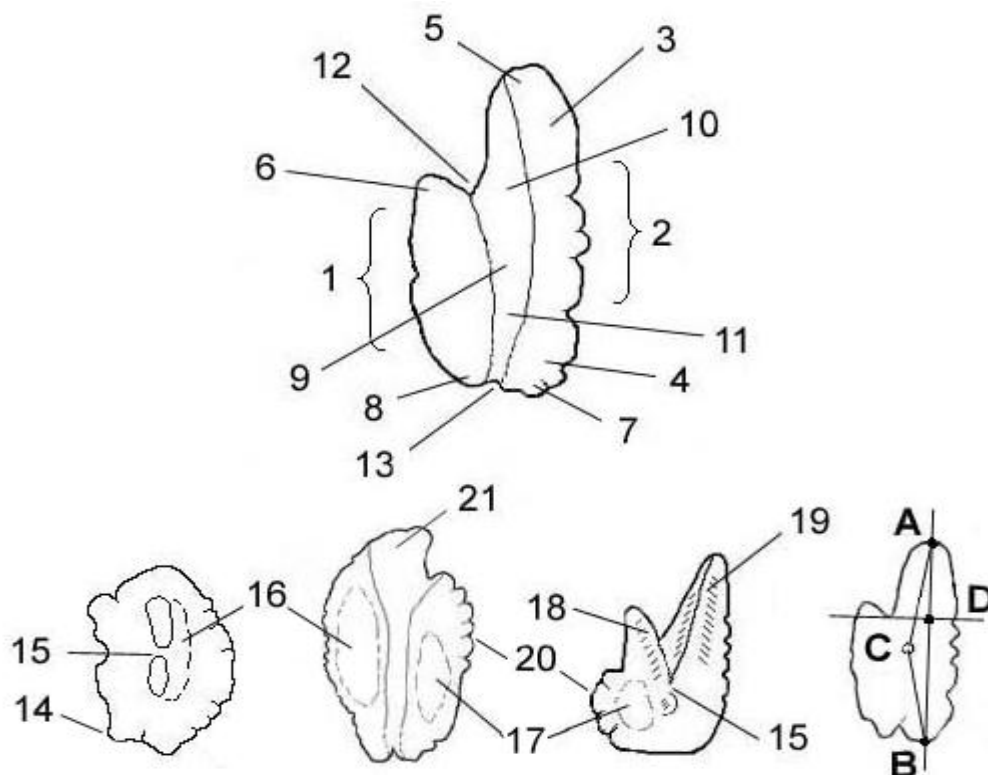


Fig. 2. The Basic terms for otolith description.

**Inside:** 1 – dorsal part, 2 – ventral part, 3 – anterior, 4 – posterior, 5 – rostrum, 6 – antirostrum, 7 – postrostrum, 8 – pararostrum, 9 – sulcus, 10 – ostium, 11 – cauda, 12 – big excision, 13 – small excision, 14 – papilla, 15 – sulcus arch (bulkhead), 16 – ventral area, 17 – dorsal area, 18 – dorsal crestae, 19 – ventral crestae, 20 – margin with lobules (lobed margin), 21 – hook (rostrum has a small curvature). **Outside:** AB – otolith length, AD – rostrum length (Rst), AC – rostral radius (R), CB – postrostral radius ( $Z_1$ ), C – nucleus

For examination of the otoliths we used a MBS – 9, 10, microscope with 8x eye-glasses with dioptric focus with scale and grid. The otoliths were looked at in reflected light on a dark background.

The main guidebook for the authors was the remarkable book of Tero Härkönen “Guide to the Otoliths of the Bony Fishes of the Northeast Atlantic” (1986).

Names of species and systematization of fishes in the present Guide are according to Andrijashev (1954) and Andrijashev and Chernova (1994). In total, almost 3500 otoliths from more than 2400 individuals of 39 species have been investigated.

The text and otolith figures have been made by Olga Svetocheva, Nina Stasenkov and Gennady Fooks. The photos of the otoliths have made by Alexander Choban and Gennady Fooks, and all White Sea fish photos have been presented by Gennady Fooks. The figures by illustrator Nikolai Kondakov (from book: “Commercial fishes of the USSR” (1956) and “The Fishes of the USSR Northern Seas” (1954)) have also been used in our Guide.

## Acknowledgements

We are very grateful to our colleagues on the Northern Branch of PINRO (SevPINRO): to Vladislav Svetochev for the help in the investigation organization and constant encouragement; to Vladimir Potelov, Vitaly Prischemichin, Vladimir Stasenkov, Gennady Ognetrov and Sergey Tarasov for the help during scientific expeditions and in otolith collection from the different areas of the White Sea; and to Alexander Choban - for remarkable otolith photos. We are especially grateful to colleagues at PINRO - Konstantin Drevetnyak and IMR - Kjell Harald Nedreaas, Elena Eriksen and Hildegunn Mjanger – for the help with publication of our Guide.










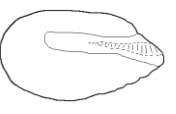

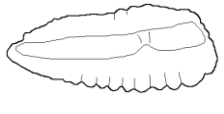
**KEY TO FAMILIES AND SPECIES  
FOR 39 SPECIES OF BONY FISHES FROM THE WHITE SEA**

- 1(10) Antirostrum pronounced, sulcus run open to the edges of the otolith.
- 2(9) Rostrum pronounced, long.
- 3(6) Otolith is equally wide in anterior and posterior parts.
- 4(5) Dorsal and ventral margins of the otolith are straight, almost parallel. Rostrum may be hooked (the ventral margin has a small curvature)  
..... *Clupea harengus*
- 5(4) Dorsal margin usually is rounded, ventral margin is almost straight. Rostrum may be hooked and visually less long, than at *Clupea harengus*  
..... *Clupea pallasii marisalbi*
- 6(3) Otolith is unequally wide in anterior and posterior parts.
- 7(8) Otolith wider in caudal part, otolith margins are rounded, sulcus is straight  
..... *Mallotus villosus villosus*
- 8(7) Otolith wider in caudal part, dorsal margin is rounded, ventral margin is straight. Otolith very extended in longitudinal section. Cauda curved to the ventral at posterior part ..... *Scomber scombrus*
- 9(2) Rostrum average, may be hooked, curved to the dorsal margin.  
Otolith oval. Otolith margins are rounded. Ostium funnel-shaped, cauda narrow  
..... *Osmerus mordax dentex*
- 10(25) Antirostrum pronounced, sulcus not open to the edges of the otolith.
- 11(14) Rostrum pronounced, long, robust, wide.
- 12(13) Rostrum length (Rst) less or equal to  $\frac{1}{3}$  of otolith length. Otolith is wide in cross section. Margins rounded, lobed. Inside slightly convex, outside flat  
..... *Gymnocanthus tricuspis*
- 13(12) Rostrum length (Rst) less to  $\frac{1}{3}$  of otolith length. Otolith slightly extended in longitudinal section. Margins rounded. Inside slightly convex, outside flat  
..... *Myoxocephalus scorpius scorpius*
- 14(17) Rostrum long, pointed.
- 15(16) Rostrum strongly extended. The length of the rostral radius (R) is about two lengths of the postrostral radius ( $Z_1$ ). Otoliths drop-shaped or pear-shaped. Dorsal and ventral crestae are big ..... *Anarhichas denticulatus*
- 16(15) The length of the rostral radius (R) is about one length of the postrostral radius ( $Z_1$ ) or little bit more. Otolith is wider in transverse section than at *Anarhichas denticulatus*. Dorsal and ventral crestae are small  
..... *Anarhichas lupus marisalbi*
- 17(20) Rostrum average.
- 18(19) Rostrum rounded. Ventral part of otolith is wider than dorsal part. Inside flat, outside rounded, convex, smooth. Otolith margins are straight. There is small ventral crestae on the sulcus margin ..... *Liparis liparis*
- 19(18) Rostrum pointed. The width of ventral part is same as width of dorsal part. Inside slightly convex, outside flat. There is dorsal smooth rounded area. Sulcus clearly parted into ostium and cauda by ventral crestae  
..... *Lumpenus fabricii*
- 20(11) Rostrum small.
- 21(24) The anterior width is same as posterior width.
- 22(23) Inside flat, outside – very convex in anterior and slightly convex in posterior. The otolith margins are rounded, smooth. There is small dorsal smooth area in anterior

- ..... *Liparis gibbus*
- 23(22) Inside flat, outside convex. Ventral margin of otolith straight, dorsal margin slightly rounded. There is small dorsal area in anterior  
..... *Liparis tunicatus*
- 24(21) Otolith wider in anterior part than posterior part.  
Otolith slightly extended in longitudinal section. Otolith margins are smooth, rounded. Sulcus clearly parted into ostium and cauda by small ventral crestae  
..... *Zoarces viviparus*
- 25(36) Antirostrum indistinct or small, sulcus run open to the edges of the otolith.
- 26(33) Rostrum pronounced, long, robust.
- 27(30) Posteroir part divided on postrostrum and pararostrum.
- 28(29) Inside convex, outside concave. The dorsal part of the otolith wider than ventral part. There is very shallow middle part of the sulcus. Cauda funnel-shaped. Otoliths of the large fish are strongly extended in longitudinal section  
..... *Coregonus lavaretus pidschian*
- 29(28) Inside flat, outside convex. The width of ventral part is same as width of dorsal part. Cauda narrow ..... *Salvelinus alpinus*
- 30(27) Posteroir part not divided on postrostrum and pararostrum.
- 31(32) Rostrum, straight, robust. Anterior and posterior ends visual equally, sharp-pointed. Ventral margin often rough, jagged. Sulcus deep. There is small ventral crestae on the sulcus margin ..... *Salmo salar*
- 32(31) Rostrum slightly hooked, curved to the dorsal margin of the otolith. Posterior end rounded. Otolith margins slightly rough, rounded. Central part of the sulcus shallower than ostium and cauda ..... *Salmo trutta*
- 33(26) Rostrum small, rounded.
- 34(35) Inside convex, outside flat. Posterior end rounded, its margin rough, jagged. Sulcus is shallow and the central part of sulcus is narrow. Ostium and cauda are widely open ..... *Oncorhynchus gorbuscha*
- 35(34) Inside and outside are slightly convex. Otolith margins are smooth. Posterior rounded or slightly concave. Sulcus narrow. Otoliths are very small  
..... *Pungitius pungitius*
- 36(1) Antirostrum indistinct or small, sulcus not run open to the edges of the otolith.
- 37(46) Rostrum long.
- 38(41) Rostrum straight, robust, pointed.
- 39(40) Inside convex, outside concave. Ventral part of the otolith thicker than dorsal part in the transverse section. Dorsal margin is slightly lobed. Posterior often rounded and seldom pointed. Ostium and cauda are deep  
..... *Triglops pingeli*
- 40(39) Inside and outside flat. Otolith is thin, similar to plate. Dorsal margin of the otolith very rounded. Otolith margins are rough. Posterior often pointed also is divided into postrostrum and pararostrum. Ostium deeper than cauda  
..... *Licodes polaris*
- 41(38) Rostrum straight, robust, rounded.
- 42(45) Sulcus straight.
- 43(44) Ventral part of the otolith is wider than dorsal part. Sulcus moderately deep. Ostium closed but often it is connect to the edge of the otolith by a narrow groove or may be open by a narrow groove. Cauda more narrow than ostium. Otoliths diamond-shaped ..... *Agonus cataphractus*





- 44(43) The width of ventral and dorsal parts is identical. Ostium open, funnel-shaped. Cauda deeper than ostium. There is dorsal area. Otolith oval ..... *Icelus bicornis* 
- 45(42) Sulcus curved to the ventral margin of the otolith. Ostium open, funnel-shaped, cauda deeper than ostium. There is ventral small crestae on the sulcus margin. Otolith very extended in longitudinal section. Otolith oval, its margins are smooth ..... *Triglops murrayi* 
- 46(54) Rostrum average.
- 47(51) There is ventral crestae on the sulcus margin.
- 48(49) The central part of sulcus is shallow. Ostium deep, funnel-shaped. There is wide massive ventral crestae. Ventral crestae stretched from the rostrum tip to the cauda. The crestae surface smooth and looks like a ventral area. Otoliths small, drop-shaped. Inside flat, outside convex, smooth ..... *Cyclopterus lumpus* 
- 49(50) Ostium deep, funnel-shaped. There is small ventral crestae. There is dorsal area. Otolith irregularly rounded. Inside flat, outside convex. Anterior and posterior ends visual equally. Posterior extended in longitudinal section, rounded ..... *Ulcina olriki* 
- 50(48) Ostium deep, funnel-shaped. Dorsal margin of the sulcus is curved. There is small ventral crestae. There is dorsal shallow area. Otolith oval, otolith margins are smooth. Inside and outside flat. Posterior rounded ..... *Pholis gunnelus* 
- 51(47) There is not ventral crestae on the sulcus margin.
- 52(53) Sulcus shallow, straight. Otolith oval, dorsal margin of the otolith is big lobed, ventral margin – rough or small lobed. Inside convex, outside concave. Posterior rounded, jagged or lobed ..... *Triglopsis quadricornis polaris* 
- 53(52) Sulcus deep, closed far to the edges of the otolith. There is sulcus arch between ostium and cauda. Ostium always longer than cauda. Ventral part wider than dorsal part. There is a big one dorsal papilla in the posterior part of the otolith usually. Otoliths irregularly rounded, otolith margins are lobed, rough or jagged ..... *Pleuronectidae* 
- 54(57) Rostrum small.
- 55(56) Sulcus shallow. There is small crestae (or fold) on the sulcus bottom. Inside convex, outside flat. Otolith oval, otolith margins are smooth. Sometimes posterior may be divided into pararostrum and postrostrum ..... *Ammodytes marinus* 
- 56(55) Sulcus deep, narrow, straight. Inside flat, outside convex. Otolith very small, rounded, otolith margins are smooth. Posterior rounded ..... *Gasterosteus aculeatus* 
- 57(37) Rostrum not protruded from otolith body. Sulcus straight, wide and filled with colliculum. There are an arch between ostium and cauda and a crestae on the ventral part of the sulcus. Ventral part wider than dorsal part and thicker it in the transverse section (looks like a bird wing). Anterior part always wider than posterior. Posterior often pointed. Otolith big, triangular or oval, otolith margins are lobed or jagged. In large specimens the general shape of the otolith is skewed ..... *Gadidae* 

**Clupeiformes**

**Clupeidae**

**Clupea** Linnaeus, 1758

*Clupea harengus* (Linnaeus, 1758).

Atlantic herring, common herring



Otoliths semicircular, bright, fragile, hooked. Inside (1) convex, outside (2) mostly flat. In the central part occasionally convex. Dorsal and ventral margins are almost straight, parallel. Dorsal margin smooth or slightly jagged, ventral margin strongly jagged. Rostrum pronounced, long, the rostrum tip rounded or pointed. Antirostrum distinct and rounded. The angle between the rostrum and the antirostrum (big excision) is acute. Pararostrum and postrostrum rounded, pararostrum shorter than postrostrum (other variants were not). The angle between the pararostrum and the postrostrum (small excision) is acute. Sulcus moderately deep, and run open to the edges of the otolith. Ostium wide, cauda narrow. Nucleus always distinct (Fig. 3,4).

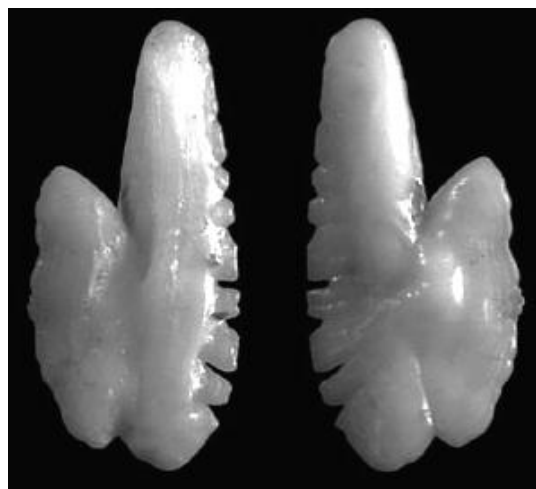
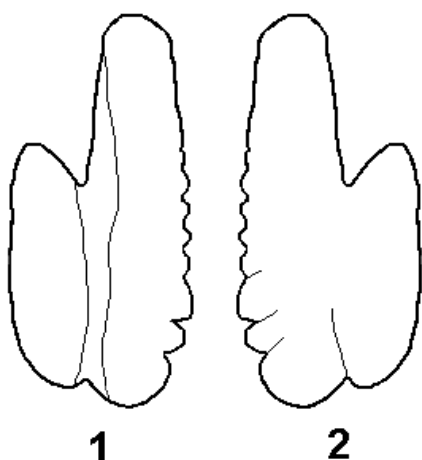


Fig. 3. Herring otolith, the length (OL) 5,0 mm

Atlantic herring, Konjuchova Bay, White Sea, 1991

Date	No	AB, mm	AD, mm	OL, mm
12.07	1	330	290	4,6
27.07	2	333	285	5,1



Fig. 4. Atlantic herring zoological length (FL) 210 mm, fish weight (FW) 54 g, White Sea

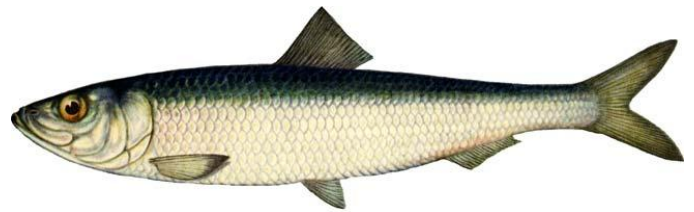
**Clupeiformes**

**Clupeidae**

**Clupea** Linnaeus, 1758

*Clupea pallasii marisalbi* (Berg, 1923).

White sea herring



Otoliths semicircular, bright, fragile, hooked. Inside (1) convex, outside (2) mostly flat but the central part of otolith occasionally convex. Dorsal and ventral margins slightly rounded or straight. Dorsal margin smoothly lobed, ventral margin slightly jagged. Rostrum pronounced, visually less long, than at *Clupea harengus*, the rostrum tip rounded or sharp-pointed, occasionally rostrum may be hooked (the ventral margin has a small curvature). Antirostrum distinct and rounded. The angle between the rostrum and the anterostrum (big excision) occasionally is right or obtuse but mostly acute. Pararostrum and postrostrum distinct and usually rounded. Pararostrum may be shorter, peer or longer postrostrum. The angle between the pararostrum and the postrostrum (small excision) is acute. Sulcus deep in the anterior part and run open to the edges of the otolith. Ostium wide, cauda narrow and shallow. Nucleus always distinct. The pararostrum size and the angle between the rostrum and the antirostrum (big excision) of the herring otolith are population marks (Fig. 5,6,7).

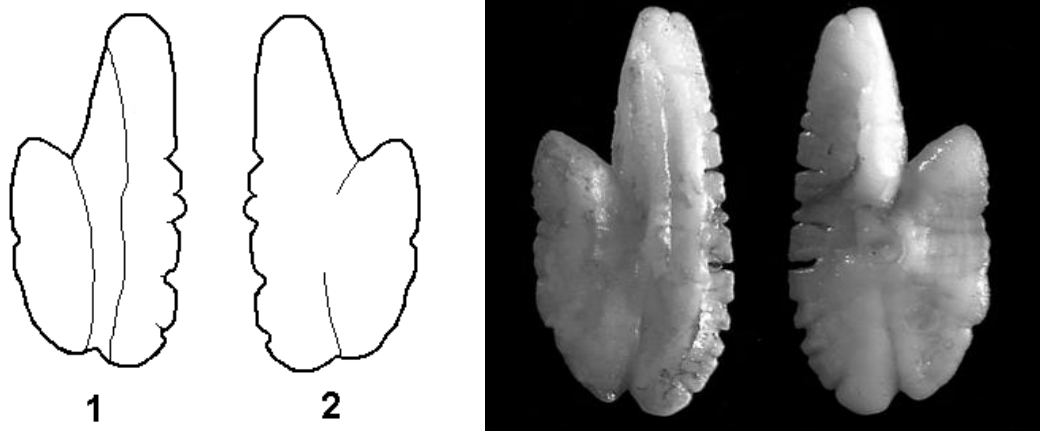


Fig. 5. White sea herring otolith, the length (OL) 5,5 mm

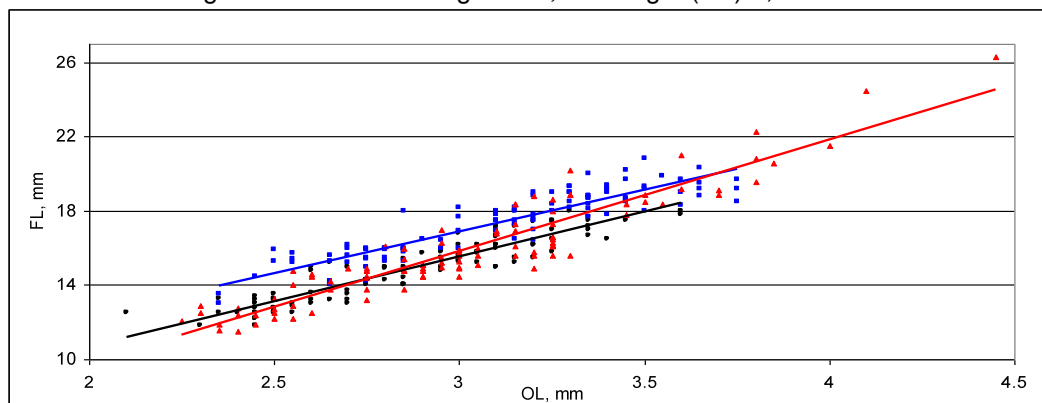


Fig. 6. Correlation between fish zoological length (FL) and otolith length (OL) at a herring. Chupa Bay (blue):  $R^2=0,9143$ ,  $Y=1,123+2,404*X$ ; Janda Bay (red):  $R^2=0,904$ ,  $Y=3,384+2,2509*X$ ; East Solovki Strait (black):  $R^2=0,938$ ,  $Y=-2,1732+6,0013*X$



Fig. 7. White sea herring zoological length (FL) 94 mm, Dvina Bay, White Sea

**Salmoniformes**

**Osmeridae**

**Mallotus** Cuvier, 1829

*Mallotus villosus* (Muller 1777).

Capelin



Otoliths semicircular, bright, fragile, hooked. Inside flat, outside mostly convex. Otoliths are wide in the posterior part. Dorsal and ventral margins rounded and lobed. Rostrum pronounced, sharp-pointed, mostly straight, occasionally with small hook on the tip. Antirostrum distinct and rounded, may be as lobule. Pararostrum and postrostrum distinct, usually rounded and lobed. The angles between the rostrum and the anterostrum (big excision) and between the pararostrum and the postrostrum (small excision) are acute or obtuse. Sulcus run open to the edges of the otolith. Ostium deep, funnel-shaped, cauda shallow and funnel-shaped too. There is distinct wide and deep area in dorsal part (Fig. 8,9,10).

There is a capelin otoliths, at which cauda is closed far to the edge of the otolith in the White Sea also.

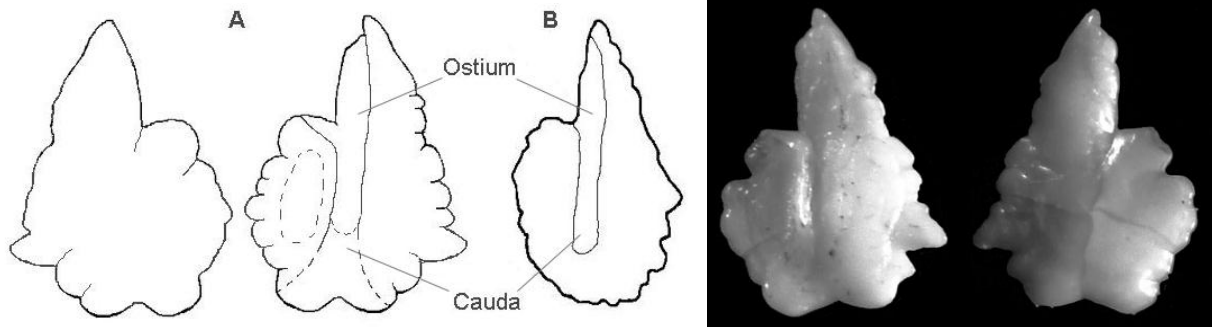


Fig. 8. Capelin otolith, the length (OL) 2.9 mm. A – from White Sea, B – from Northeast Atlantic (Harkonen, 1986)

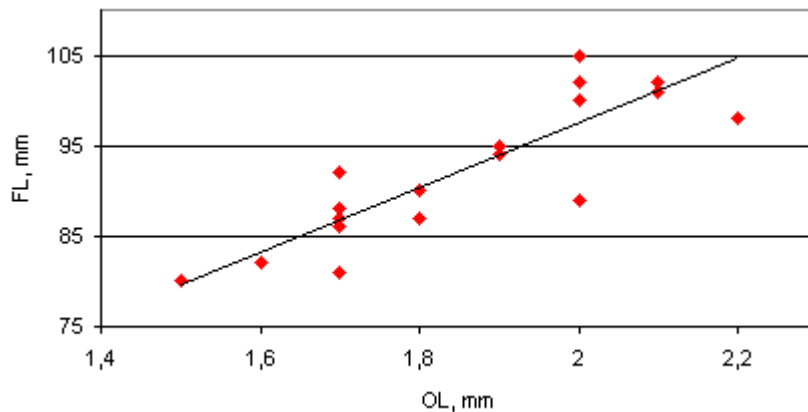


Fig. 9. Correlation between fish zoological length (FL) and otolith length (OL) at a capelin.  $R^2=0,775$ ,  $Y=26,34+35,58X$



Fig. 10. Capelin zoological length (FL) 200 mm (male), 180 mm (female), White Sea



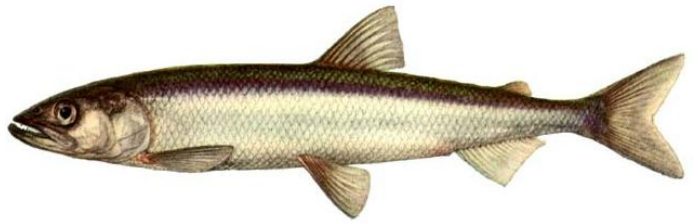
**Salmoniformes**

**Osmeridae**

**Osmerus** Linnaeus, 1758

*Osmerus mordax dentex* (Steindacher, 1870).

Rainbow smelt



A.P. Andrijashev (1954) determines the *Osmerus eperlanus dentex natio dvinensis* Smitt, 1882 (European smelt) for White Sea. Then A.P. Andrijashev and N.V. Chernova (1994) specify the *Osmerus mordax dentex* Steindacher, 1870 (Rainbow smelt) for White Sea. The rainbow smelt from White Sea is specified in the Guide to the fresh-water fish (2003) as subspecies *Osmerus mordax* (Mitchill, 1815) (Arctic smelt).

Otoliths white, bright, massive, oval. Otoliths are wide in the anterior part. Inside (1) flat, outside (2) convex. Dorsal and ventral margins are rounded, smoothly lobed, ventral margin occasionally may be smooth. Rostrum average, wide, rounded, may be hooked. Antirostrum distinct, wide, short. Posterior mostly rounded, lobed. Small excision looks like a deep rima. Sulcus run open to the edges of the otolith. Ostium funnel-shaped, wide, cauda looks like deep and narrow canal. There are distinct and flat areas on the dorsal and ventral parts (Fig. 11,12,13).

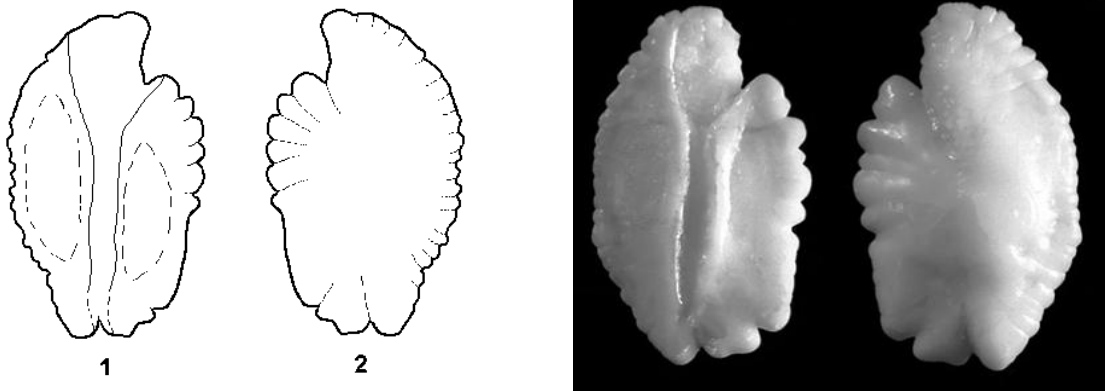


Fig. 11. Rainbow smelt otolith, the length (OL) 7,0 mm

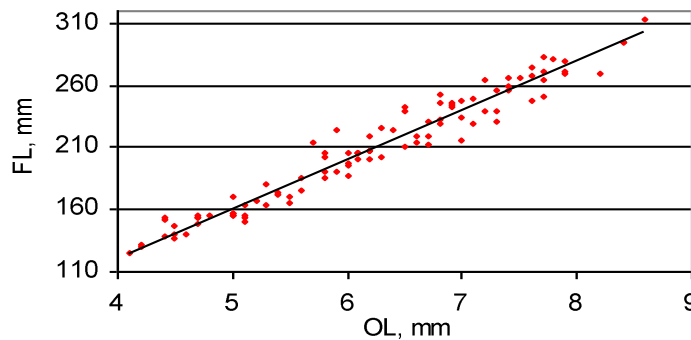


Fig. 12. Correlation between fish zoological length (FL) and otolith length (OL) at a rainbow smelt.  
 $R^2=0,9751, Y=-3,569+3,942*X$



Fig. 13. Rainbow smelt zoological length (FL) 180 mm, Onega Bay, White Sea

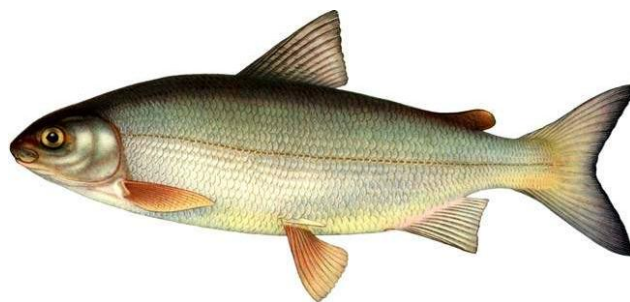
**Salmoniformes**

**Coregonidae**

**Coregonus** Linnaeus, 1758

*Coregonus lavaretus pidschian* (Pallas, 1776).

European white fish



Otoliths white, bright, drop-shaped. Inside (1) convex, outside (2) concave. Dorsal and ventral margins are straight, almost parallel and smooth at the big otoliths. Margins are slightly rounded at the small otoliths. Rostrum pronounced, long and wedge-shaped at the big otoliths. Rostrum conical and shorter at the small otoliths. Antirostrum distinct. Pararostrum and postrostrum distinct and may be rounded or the wrong form. Small excision with acute angle. Sulcus run open widely to the edges of the otolith. Sulcus shallow in middle part. Ostium and cauda deep, funnel-shaped (Fig. 14,15).

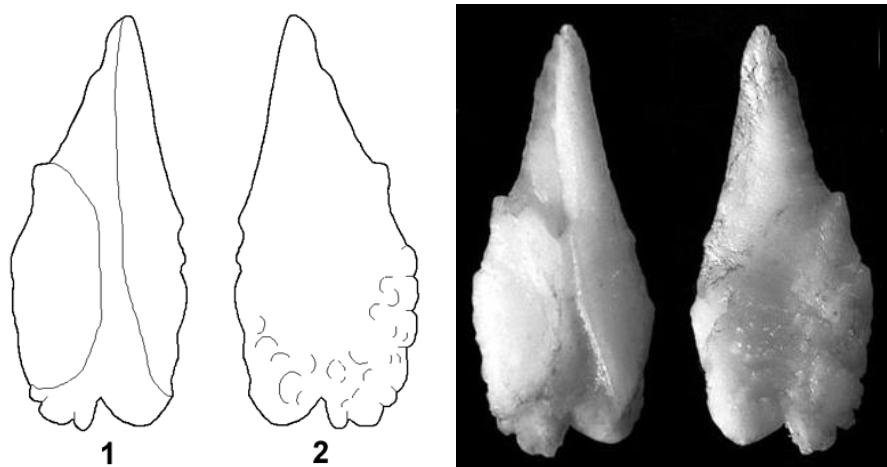


Fig. 14. European white fish otolith, the length (OL) 8,7 mm

European white fish, Konjuchova Bay, 2000, White Sea

Date	No	AB, mm	AC, mm	AD, mm	Sex	LO, mm
12.06	1	338	310	295	male	7,1
12.06	2	305	277	264	female	-
13.06	3	332	296	284	female	6,9
21.06	4	320	290	275	female	8,0
21.06	5	354	324	306	female	8,1
30.06	6	339	312	293	female	7,6
30.06	7	340	316	307	female	6,9



Fig. 15. European white fish zoological length (FL) 390 mm, White Sea



**Salmoniformes**

**Salmonidae**

**Oncorhynchus** Suckley, 1861

*Oncorhynchus gorbuscha* (Walbaum, 1792).

Pink salmon



Otoliths white, bright, oval. Otoliths are wide in the anterior part. Inside (1) convex, outside (2) flat, outside structure is flaky. Dorsal part shorter than ventral part and looks like a wide area. Dorsal and ventral margins are rounded. Dorsal margin slightly rough, ventral margin smooth. Rostrum straight, short, wide, rounded. Antirostrum distinct, short and wide. Posterior rounded, margin jagged. Sulcus run open widely to the edges of the otolith. Central part of sulcus is narrow and shallow. Ostium deep, wide, funnel-shaped, cauda more narrow than ostium (Fig. 16,17).

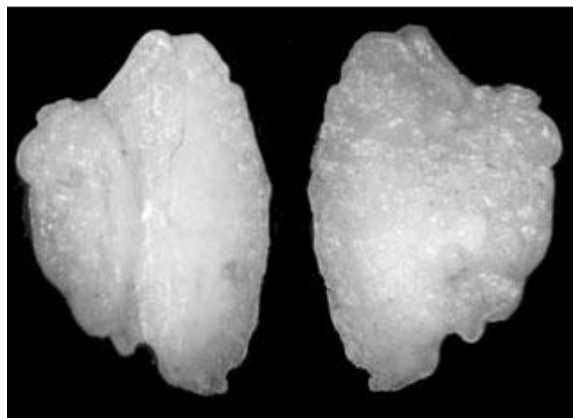
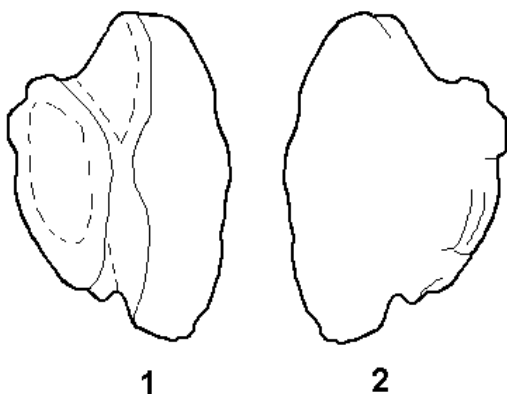


Fig. 16. Pink salmon otolith, the length (OL) 3.9 mm

Pink salmon, Konjuchova Bay, 2000, White Sea

Date	№	AB, mm	AC, mm	AD, mm	Sex	LO, mm
16.06	1	460	435	426	-	2,9
23.06	2	463	425	406	male	2,8
23.06	3	490	468	442	female	3,5
24.06	4	440	414	395	female	2,5
24.06	5	462	430	412	male	3,2
25.06	6	535	510	488	male	-
26.06	7	532	500	475	male	2,8
26.06	8	485	460	437	female	2,9
26.06	9	460	430	415	male	2,9
27.06	10	445	420	405	male	2,7
27.06	11	490	462	440	male	3,1
29.06	12	505	474	448	female	3,2
30.06	13	510	488	465	male	-
30.06	14	525	504	484	male	3,1
02.07	15	465	442	422	male	-



Fig. 17. Pink salmon zoological length (FL) 493 mm, fish weight (FW) 1460 g, Onega Bay, White Sea

**Salmoniformes**

**Salmonidae**

**Salmo** Linnaeus, 1758

*Salmo salar* (Linnaeus, 1758). Common Atlantic salmon



Otoliths white, bright, pear-shaped (somewhat triangular). Inside (1) convex, outside (2) flat, outside structure is flaky, its posterior part looks like granular. Dorsal part shorter than ventral part and looks like a wide area. Dorsal and ventral margins are rounded, dorsal margin almost smooth, ventral margin jagged. Rostrum robust, wide, straight, sharp-pointed. Antirostrum distinct, wide, rounded. Anterior and posterior ends visual equally, posterior end may be sharp-pointed too. Sulcus deep, run open widely to the edges of the otolith. Ostium funnel-shaped, cauda narrow than ostium. There is a small crestae on the ventral part of the sulcus (Fig. 18,19).

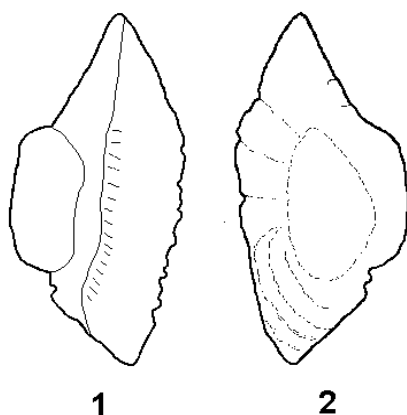


Fig. 18. Common salmon otolith, the length (OL) 5,1 mm

Common salmon, Konjuchova Bay, 2000, White Sea

Date	№	AB, mm	AC, mm	AD, mm	FW, g	Sex
12.06	1	690	658	628	-	female
	2	595	575	544	-	male
13.06	3	776	750	716	-	-
14.06	4	695	667	635	-	female
15.06	5	660	636	598	3000	female
15.06	6	664	640	605	2700	female
15.06	7	714	683	645	4000	female
15.06	8	770	742	700	4250	male
15.06	9	690	670	634	-	female
16.06	10	820	760	795	6250	male
16.06	11	752	720	680	3800	female
16.06	12	750	720	688	4000	female
16.06	13	744	715	672	3900	female
16.06	14	690	665	625	2500	female
18.06	15	695	666	630	2500	female
30.06	16	586	562	535	-	male



Fig. 19. Common salmon zoological length (FL) 550 mm, White Sea

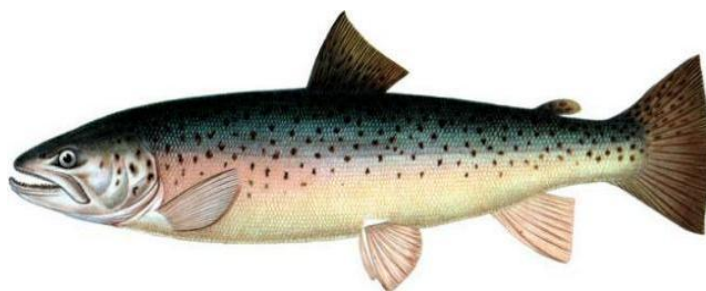
**Salmoniformes**

**Salmonidae**

**Salmo** Linnaeus, 1758

*Salmo trutta* (Linnaeus, 1758).

Brook trout



Otoliths white, bright, pear-shaped. Inside (1) convex, outside (2) flat, outside structure in the posterior part looks like granular. Dorsal part shorter than ventral part and looks like a smooth area. Dorsal and ventral margins are rounded, slightly rough. Rostrum robust, wide, hooked and slightly pointed on the tip. Antirostrum insignificantly distinct. Posterior part rounded, looks like an egg. Sulcus deep, narrow, run open to the edges of the otolith. Central part of sulcus is shallow. Ostium funnel-shaped, cauda narrower than ostium (Fig. 20, 21).

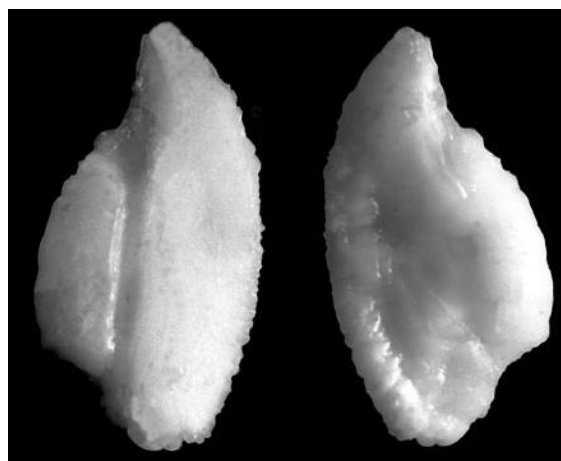
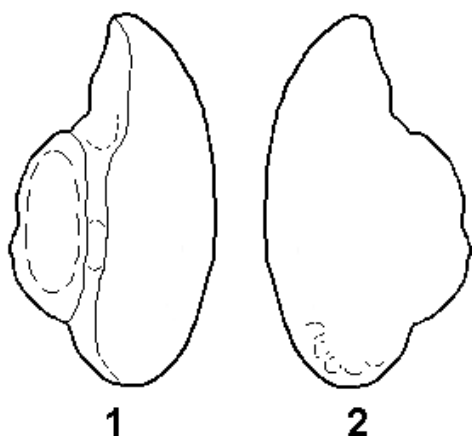


Fig. 20. Brook trout otolith, the length (OL) 4,8 mm

Brook trout, Konjuchova Bay, 2000, 2004, White Sea

Date	№	AB, mm	AC, mm	AD, mm	sex	LO, mm
9.06.2000	1	465	454	425	female	4,7
13.06.2000	2	387	376	355	-	4,5
18.06.2000	3	405	390	366	-	4,5
21.06.2000	4	472	450	425	-	4,3
29.06.2000	5	376	363	340	male	3,7
30.06.2000	6	423	410	384	female	4,3
30.06.2000	7	412	402	376	female	4,7
11.06.2004	1	408	396	372	female	4,5



Fig. 21. Brook trout zoological length (FL) 510 mm, White Sea

**Salmoniformes**

**Salmonidae**

**Salvelinus** Richardson (ex Nilsson), 1836

*Salvelinus alpinus* (Linnaeus, 1758).

Arctic char



Otoliths white, bright, drop-shaped. Inside (1) flat, outside (2) convex, outside structure in the posterior part slightly granular. Dorsal and ventral parts are equally wide. Dorsal part shorter than ventral part and looks like a wide area. Dorsal and ventral margins are rounded, slightly rough. Rostrum wide, straight and pointed on the tip. Antirostrum insignificantly distinct. Posterior part rounded, small excision may be distinct. Sulcus run open to the edges of the otolith. Ostium funnel-shaped, cauda narrow (Fig. 22,23).

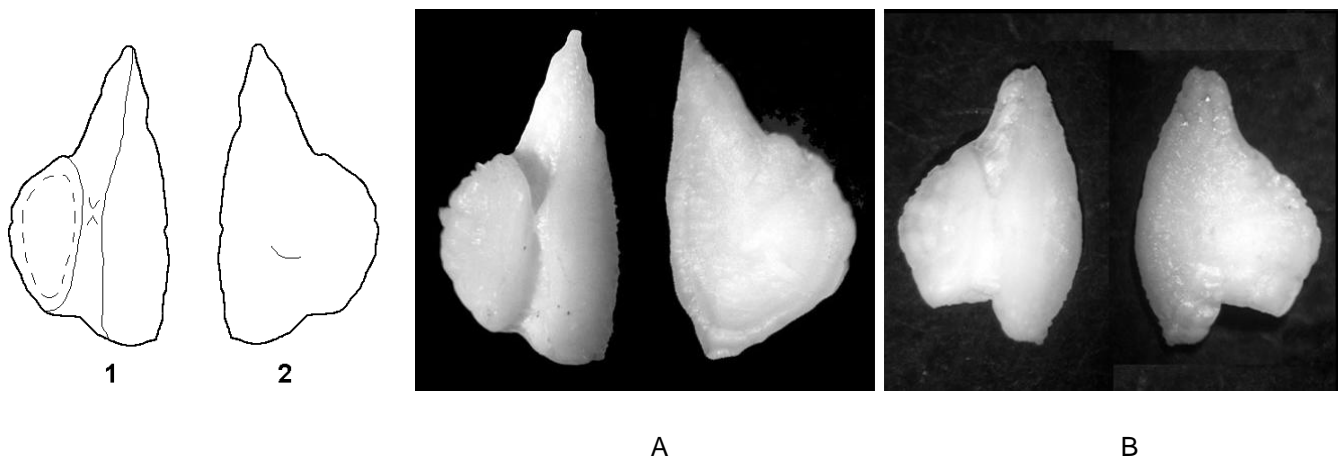


Fig. 22. Arctic char otolith, the length (OL) 4.7 mm (A), 4.2 mm (B)

Arctic char, 1989, 1991, 2005, White Sea

Date	No	AB, mm	Sex	LO,mm
July 1989	1	355	-	3,4
July 1989	2	440	-	3,7
July 1989	3	430	-	4,0
July 1989	4	415	-	3,8
July 1989	5	380	-	3,9
July 1989	6	405	-	3,7
July 1989	7	385	-	3,6
July 1989	8	385	-	3,6
July 1989	9	380	-	3,8
July 1989	10	355	-	3,4
June 1991	11	355	female	3,4
July 2005	12	430	female	4,2
July 2005	13	520	-	4,7



Fig. 23. Arctic char zoological length (FL) 430 mm, White Sea



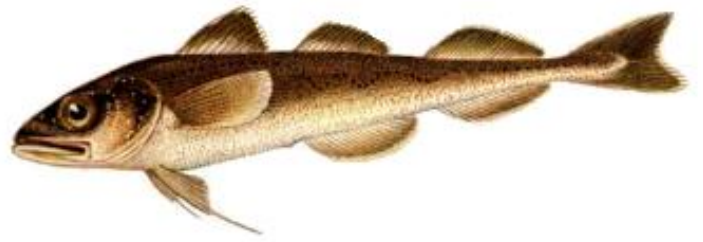
**Gadiformes**

**Gadidae**

**Boreogadus** Gunther, 1862

*Boreogadus saida* (Lepechin, 1774)

Polar cod



Otoliths white, chalk, frosted, oval. Inside (1) convex or flat. Outside (2) flat, lobed, in central part concave. Ventral part is thicker than dorsal part in the transverse section (looks like a bird wing). Anterior part lobed and always wider than posterior. Dorsal and ventral margins rounded and deeply lobed. Rostrum distinct, looks like a large lobule. Antirostrum distinct. Big excision always acute. Posterior part rounded or pointed and lobed. Sulcus filled with colliculum and closed far from the edges of the otolith. There are an arch between ostium and cauda and a crestae on the ventral part of sulcus. Ostium and cauda of about the same length. Nucleus always distinct on the outside (Fig. 24,25).

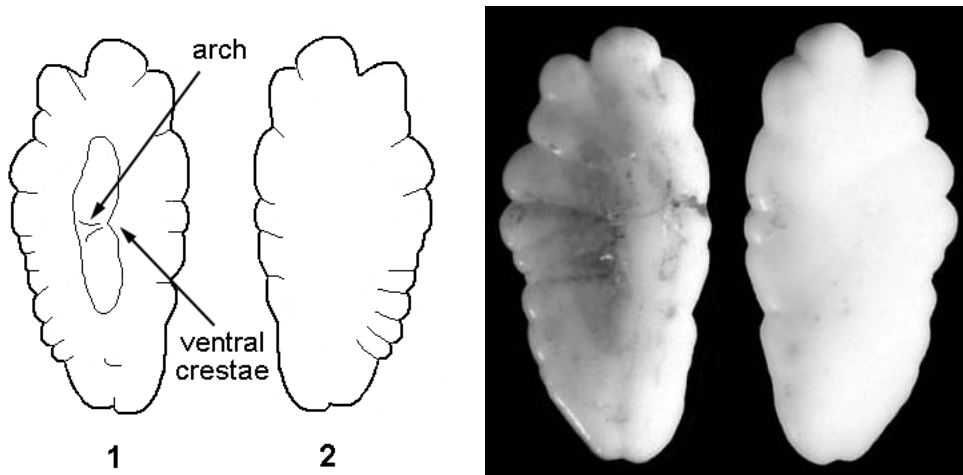


Fig. 25. Polar cod zoological length (FL) 107 mm, White Sea

Polar cod, 1993, 2005, White Sea

Date	№	AB, mm	FW, g	LO, mm
June 1993	1	107	21	4,5
June 1993	2	161	35	5,9
June 1993	3	182	42	6,8
June 1993	4	240	58	9,2
Sept. 2005	5	170	40	6,5



Fig. 25. Polar cod zoological length (FL) 107

**Gadiformes**

**Gadidae**

**Eleginus** Fischer von Waldheim, 1813

*Eleginus navaga* (Pallas, /1814/).

Navaga



Otoliths big, white, bright, triangular. Otoliths of very small specimens, are almost lanceolate. The big otoliths may be strongly bent. Inside (1) convex, outside (2) flat, lobed. Ventral part wider than dorsal part and thicker it in the transverse section (looks like a bird wing). Anterior part always wider than posterior. Dorsal and ventral margins rounded, small lobed. Rostrum lobate and not protruded from otolith body. Antirostrum lacking. Posterior rounded, lobed, may be slightly pointed. Sulcus straight, wide, filled with colliculum and closed near the edges of the otolith. There are an arch between ostium and cauda and a crestae on the ventral part of the sulcus. Cauda about twice the ostium length. Nucleus occasionally distinct on the outside (Fig. 26,27,28).

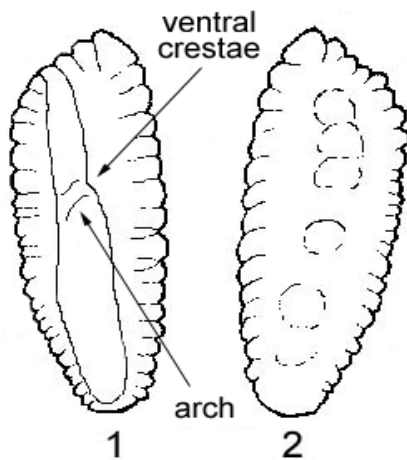


Fig. 26. Navaga otolith, the length (OL) 9,1 mm

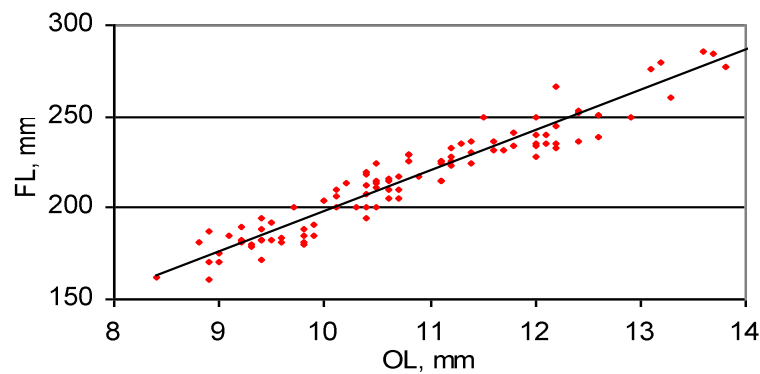


Fig. 27. Correlation between fish zoological length (FL) and otolith length (OL) at a navaga.  
 $R^2=0,9605$ ,  $Y=0,8608+0,0434*X$



Fig. 28. Navaga zoological length (FL) 191 mm, Dvina Bay, White Sea



**Gadiformes**

**Gadidae**

**Gadus** Linnaeus, 1758

*Gadus morhua marisalbi* Derjugin, 1920.

Cod



Otoliths big, white, bright, oval. In large specimens the general shape of the otolith is skewed and triangular. The otoliths strongly bent. Inside (1) very convex, outside (2) very concave, big lobed. Ventral part wider than dorsal part and thicker it in the transverse section (looks like a bird wing). Anterior part always wider than posterior. Dorsal and ventral margins rounded, lobed. Rostrum lobate and not protruded from otolith body. Antirostrum lacking. Posterior lobed, rounded or pointed. Sulcus straight, wide, filled with colliculum and closed near the edges of the otolith. There are an arch between ostium and cauda and a crestae on the ventral part of the sulcus. Cauda about twice the ostium length. Nucleus indistinct or lacking (Fig. 29,30,31).

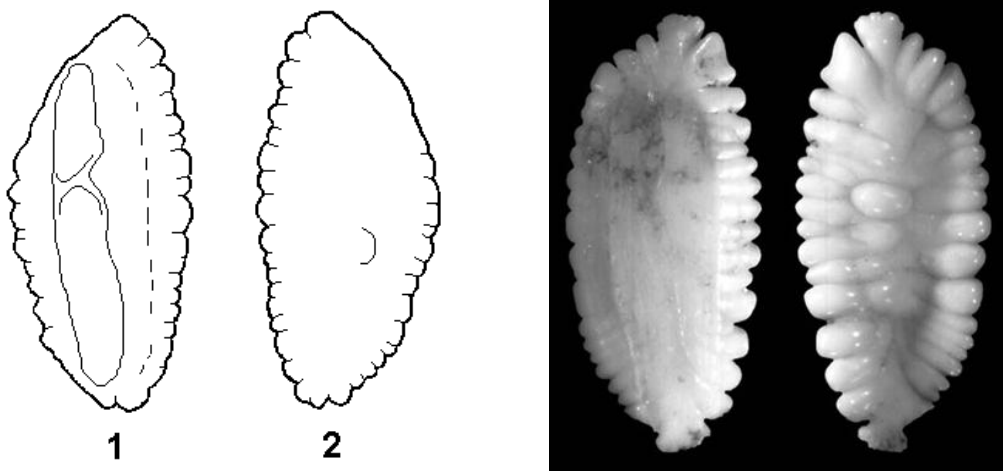


Fig. 29. Cod otolith, the length (OL) 9,8 mm

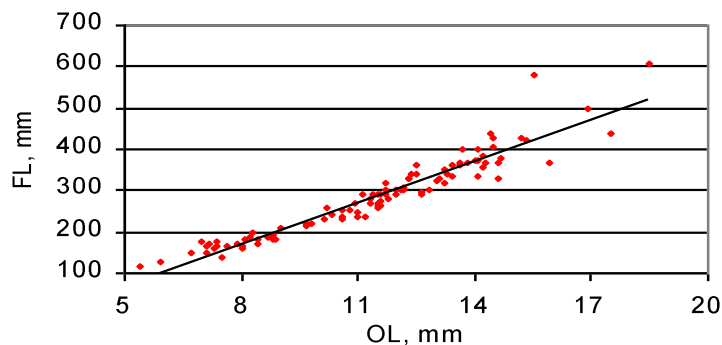


Fig. 30. Correlation between fish zoological length (FL) and otolith length (OL) at a cod.  $R^2=0,95$ ,  $Y=3,63+0,95*X$



Fig. 31. Cod zoological length (FL) 303 mm, White Sea

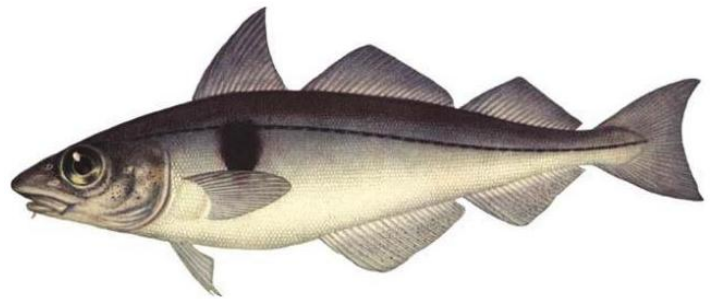
**Gadiformes**

**Gadidae**

**Melanogrammus** Gill, 1862

*Melanogrammus aeglefinus* (Linnaeus, 1758).

Haddock



Otoliths big, white, bright, triangular, extended in longitudinal section. The otoliths strongly bent. Inside (1) very convex, outside (2) very concave, big lobed. Ventral part wider than dorsal part and thicker in the transverse section (looks like a bird wing). Anterior part always wider than posterior. Dorsal and ventral margins are almost straight, parallel, small lobed. Rostrum not protruded from otolith body. Antirostrum lacking. Posterior pointed, margin small jagged. Sulcus straight, wide, filled with colliculum and closed near the edges of the otolith. There are an arch between ostium and cauda and a small crestae on the ventral part of the sulcus. Cauda about twice the ostium length (Fig. 32,33).

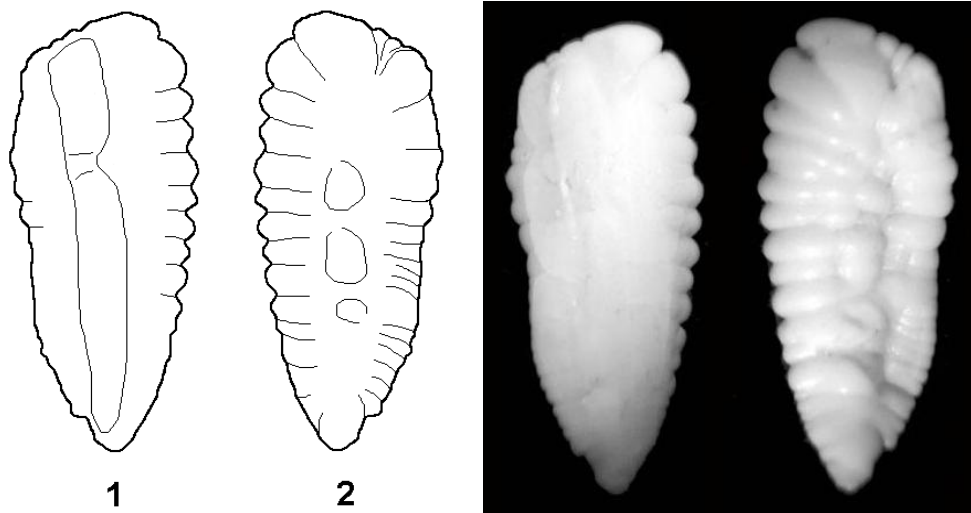


Fig. 32. Haddock otolith, the length (OL) 13,7 mm



Fig. 33. Haddock zoological length (FL) 430 mm, White Sea

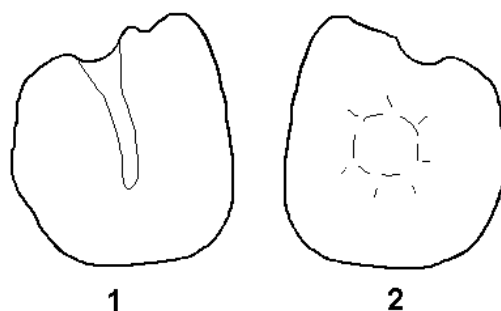
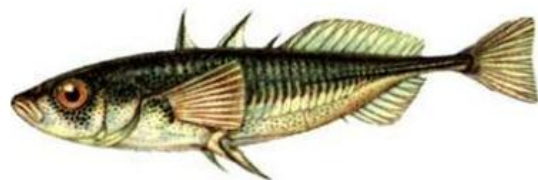
**Gasterosteiformes**

**Gasterosteidae**

**Gasterosteus** Linnaeus, 1758

*Gasterosteus aculeatus* (Linnaeus, 1758).

Three-spined stickleback



Otoliths white, chalk, rounded, very small. Inside (1) flat, outside (2) convex. Ventral and dorsal parts are same wide. Dorsal and ventral margins are rounded, smooth. Rostrum distinct, rounded. Antirostrum indistinct. Posterior wide, straight, margin of the posterior smooth. Sulcus deep, narrow. Ostium open, cauda closed far to the edge of the otolith. A crestae on the ventral part of sulcus distinct. Nucleus may be distinct on the outside (Fig. 34,35).

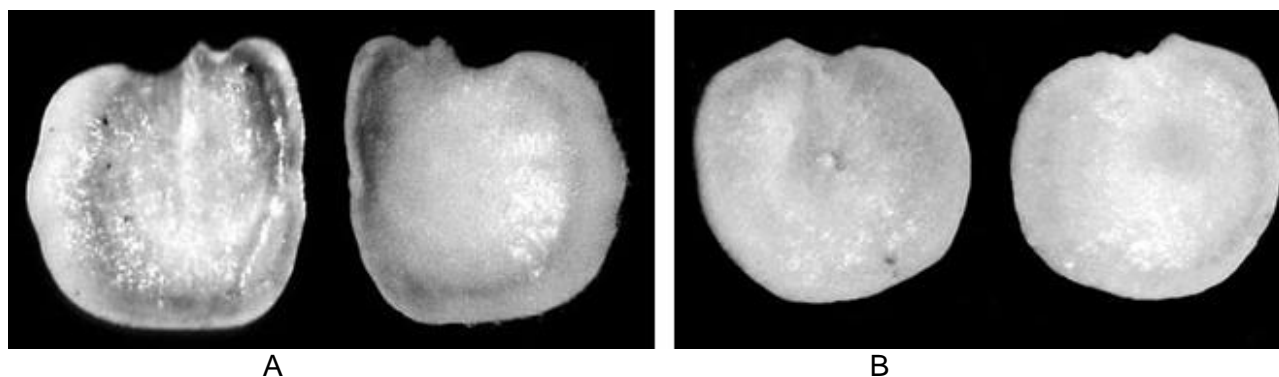


Fig. 34. Three-spined stickleback otolith, the length (OL) 1,2 mm (A), 0,7 mm (B)

Three-spined stickleback, Konjuchova Bay, 2000, 2004, White Sea

Date	№	AB, mm	Sex	OL,mm	Date	№	AB, mm	Sex	OL,mm
15.06.2000	1	62	female	0.6	23.06.2000	14	62	male	0,6
19.06.2000	2	60	female	0.5	23.06.2000	15	65	male	0,7
19.06.2000	3	69	female	1.0	23.06.2000	16	64	male	0,6
19.06.2000	4	74	female	1.2	23.06.2000	17	65	male	1,0
19.06.2000	5	68	female	0.6	23.06.2000	18	60	male	0,6
23.06.2000	6	58	female	0.5	23.06.2000	19	62	male	0,8
23.06.2000	7	75	female	0.9	23.06.2000	20	62	male	0,7
23.06.2000	8	67	female	0.6	29.06.2000	21	67	female	0,7
23.06.2000	9	66	female	0.6	21.06.2004	22	51	male	0,3
23.06.2000	10	75	female	0.7	25.06.2004	23	62	female	0,5
23.06.2000	11	62	female	0.4	25.06.2004	24	71	female	0,6
23.06.2000	12	62	male	0.7	25.06.2004	25	71	female	0,6
23.06.2000	13	65	male	0.8	-	-	-	-	-



Fig. 35. Three-spined stickleback zoological length (FL) 67 mm, White Sea

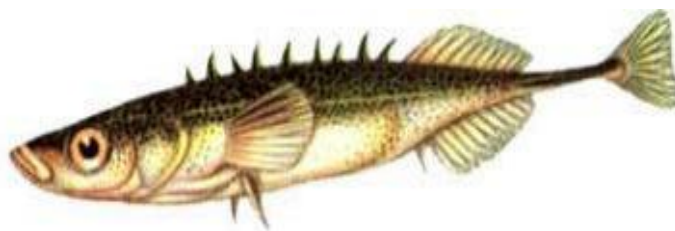
**Gasterosteiformes**

**Gasterosteidae**

**Pungitius** Coste, 1848

*Pungitius pungitius* (Linnaeus, 1758).

Nine-spined stickleback



Otoliths white and very small. They look as semicircular because of the small sizes. Inside (1) and outside (2) slightly convex. Ventral part is little bit less than dorsal part. Dorsal and ventral margins are rounded, smooth. Rostrum distinct, wide, rounded. Antirostrum indistinct. Posterior wide, margin of the posterior smooth or slightly concave. Sulcus narrow, run open to the edges of the otolith. Ostium deep, cauda shallow (Fig. 36,37).

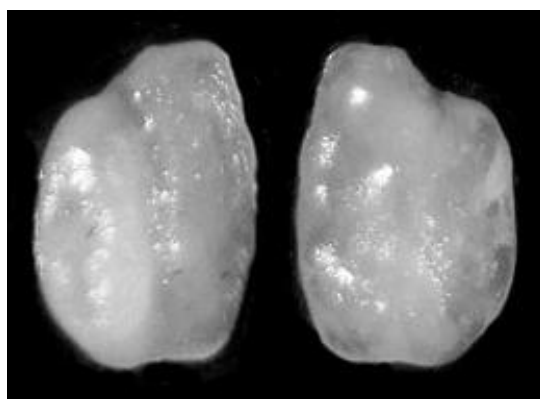
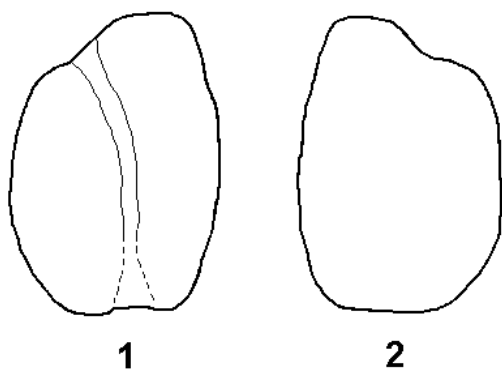


Fig. 37. Nine-spined stickleback zoological length (FL) 68 mm, White Sea

Nine-spined stickleback, Konjuchova Bay, 2000, White Sea

Date	№	AB, mm	AC, mm	AD, mm	sex	LO, mm
20.06	1	50	49	44	female	0,3
20.06	2	58	56	52	female	0,5
23.06	3	64	62	57	female	0,7
23.06	4	65	63	59	female	0,6



Fig. 37. Three-spined stickleback zoological length (FL) 68 mm, White Sea



**Scorpaeniformes**

**Cottidae**

**Gymnocanthus** Swainson, 1839

*Gymnocanthus tricuspis* (Reinhardt, 1831).

Arctic staghorn sculpin



Otoliths white, bright, massive, oval, wide. Inside (1) slightly convex, outside (2) flat. Dorsal and ventral margins are rounded, with big lobules or slightly rough. Rostrum pronounced, straight, robust, wide, rounded. Rostrum length less or equal to  $\frac{1}{3}$  of otolith length. Antirostrum distinct, wide, short. Posterior mostly rounded, posterior margin smooth. Sulcus deep, narrow. Ostium open, funnel-shaped, cauda closed far to the edge of the otolith. There are small flat area on the dorsal part of the otolith (Fig. 38,39).

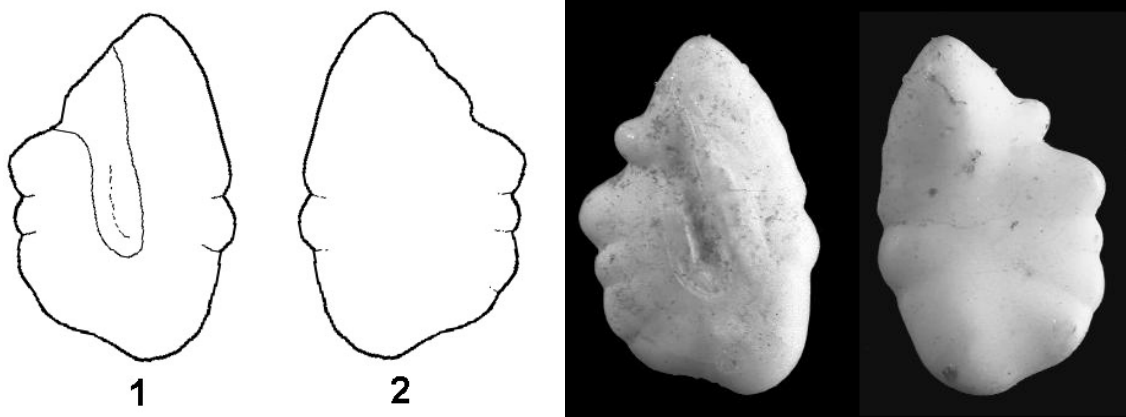


Fig. 38. Arctic staghorn sculpin otolith, the length (OL) 6,2 mm



Fig. 39. Arctic staghorn sculpin zoological length (FL) 180 mm, White Sea

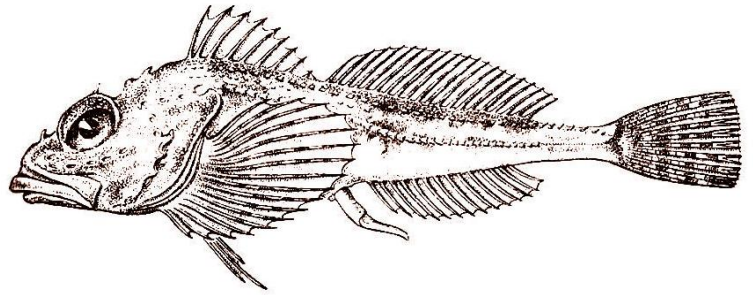
**Scorpaeniformes**

**Cottidae**

**Icelus** Krøyer, 1845

*Icelus bicornis* (Reinhardt, 1840).

Two-horned sculpin



Otoliths white, bright, oval, slightly extended in longitudinal section. Inside (1) slightly convex, outside (2) flat. Dorsal and ventral margins are rounded, dorsal margin mostly rough, ventral margin smooth. Rostrum pronounced, straight, robust, wide, rounded. Rostrum length always less to  $\frac{1}{3}$  of otolith length. Antirostrum distinct. Posterior mostly extended, slightly pointed, posterior margin smooth. Sulcus shallow. Ostium open, funnel-shaped, cauda narrow, closed far to the edge of the otolith. There is a big dorsal area (Fig. 40,41).

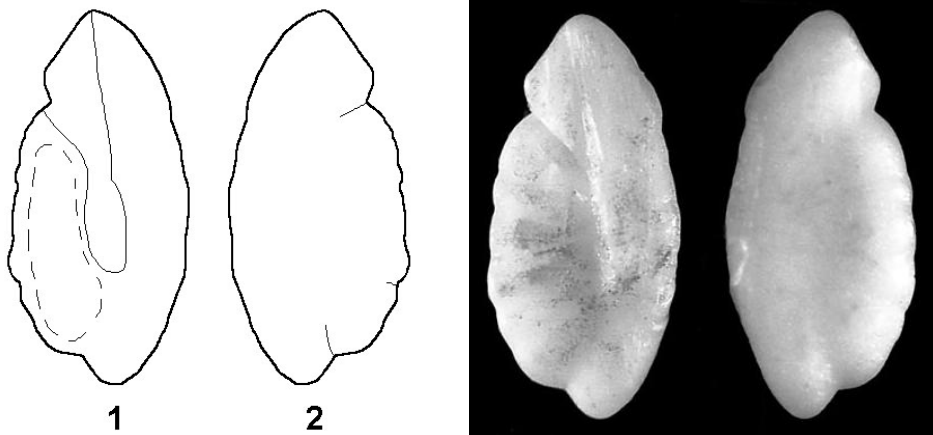


Fig. 40. Two-horned sculpin otolith, the length (OL) 4,5 mm



Fig. 41. Two-horned sculpin zoological length (FL) 134 mm, White Sea



**Scorpaeniformes**

**Cottidae**

**Myoxocephalus** Tilesius (ex Steller), 1811

*Myoxocephalus scorpius scorpius*  
(Linnaeus, 1758).

Bullrout, short-spined sea scorpion



Otoliths white, bright, massive, oval, extended in longitudinal section. Inside (1) convex, outside (2) concave. Ventral part wider, than dorsal part of the otolith. Dorsal and ventral margins are rounded, slightly lobed. Rostrum pronounced, straight, robust, wide, rounded. Rostrum length always less to  $\frac{1}{3}$  of otolith length. Antirostrum wide, short, rounded. Posterior mostly extended, slightly pointed, posterior margin smooth. Sulcus shallow. Ostium open, funnel-shaped, cauda narrow, closed far to the edge of the otolith (Fig. 42,43,44).

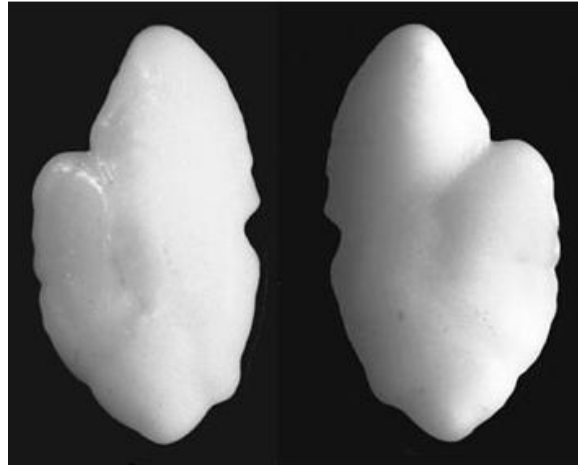
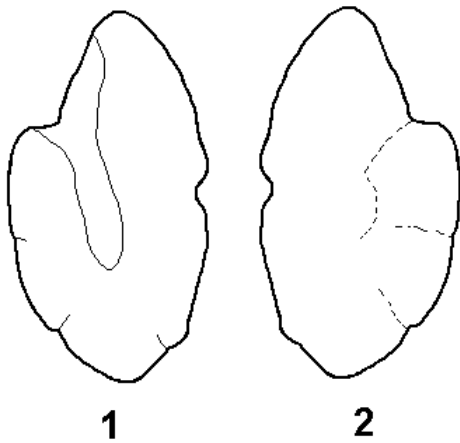


Fig. 42. Short-spined sea scorpion otolith, the length (OL) 5,1 mm

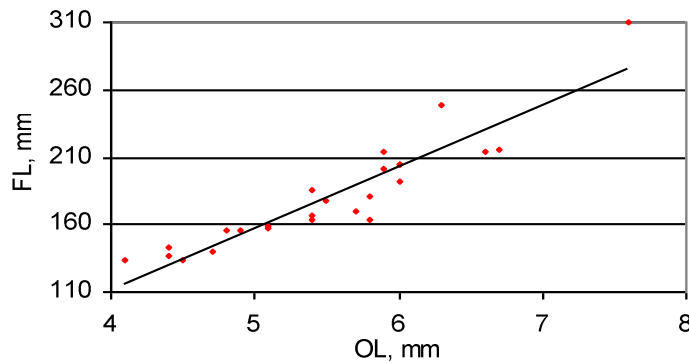


Fig. 43. Correlation between fish zoological length (FL) and otolith length (OL) at a short-spined sea scorpion.  
 $R^2=0,9257$ ,  $Y=-70,0275+4,5513*X$



Fig. 44. Short-spined sea scorpion zoological length (FL) 155 mm, White Sea

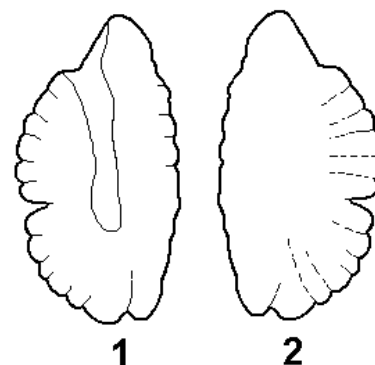
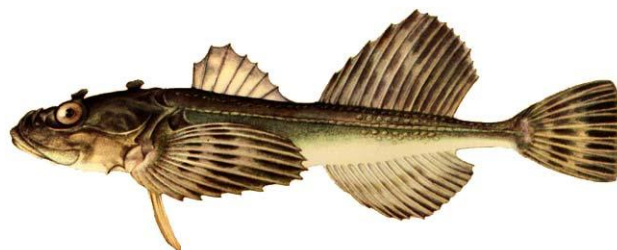
**Scorpaeniformes**

**Cottidae**

**Trigloopsis** Sabine, 1824

*Trigloopsis quadricornis polaris* (Sabine, 1824).

Four-horned sculpin



A.P. Andrijashev (1954) determines the *Myoxocephalus quadricornis labradoricus* (Girard) for White Sea.

Otoliths white, bright, oval. Inside (1) convex, outside (2) concave. Dorsal and ventral margins are rounded, lobed and jagged. Rostrum pronounced, straight, robust, wide, pointed. Rostrum length always less to  $\frac{1}{3}$  of otolith length. Antirostrum distinct or looks as a big lobule. Posterior rounded, jagged, lobed. Sulcus shallow. Ostium open, narrow, funnel-shaped, cauda closed far to the edge of the otolith (Fig. 45,46).

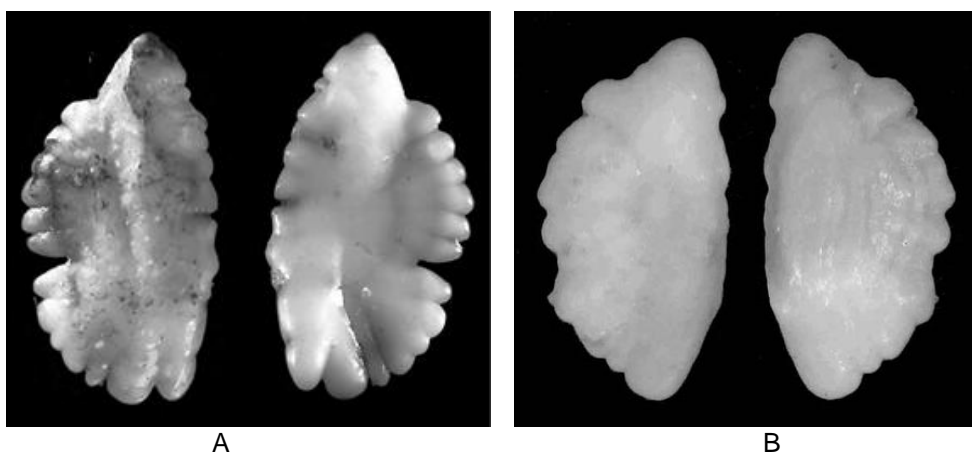


Fig. 45. Four-horned sculpin otolith, the length (OL) 8,1 mm (A), 6,0 mm (B)

Four-horned sculpin, 1989, 1991, White Sea

Date	№	AB, mm	OL, mm
July 1989	1	230	7,1
July 1989	2	191	6,7
July 1989	3	185	5,4
July 1989	4	210	7,0
July 1989	5	203	6,7
July 1989	6	175	6,0
July 1989	7	197	6,2
July 1989	8	155	5,3
July 1989	9	163	5,2
July 1989	10	222	7,3
July 1991	11	225	7,5



Fig. 46. Four-horned sculpin zoological length (FL) 190 mm, White Sea

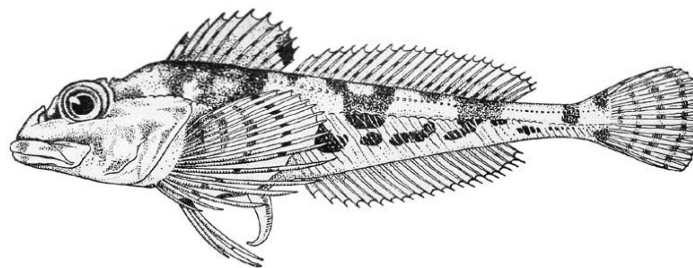
**Scorpaeniformes**

**Cottidae**

**Triglops** Reinhardt, 1831

*Triglops murrayi* (Gunther, 1888).

Mailed sculpin



Otoliths white, bright, oval, very extended in longitudinal section. Inside (1) convex, outside (2) concave. Dorsal and ventral margins are rounded, smooth. Rostrum pronounced, straight, robust, wide, rounded. Rostrum length always less to  $\frac{1}{3}$  of otolith length. Antirostrum indistinct. Posterior mostly extended, slightly pointed, posterior margin smooth. Sulcus shallow and curved to the ventral margin of the otolith. There is ventral small crestae on the sulcus margin. Ostium open, funnel-shaped, cauda is deeper than ostium and closed far to the edge of the otolith (Fig. 47,48).

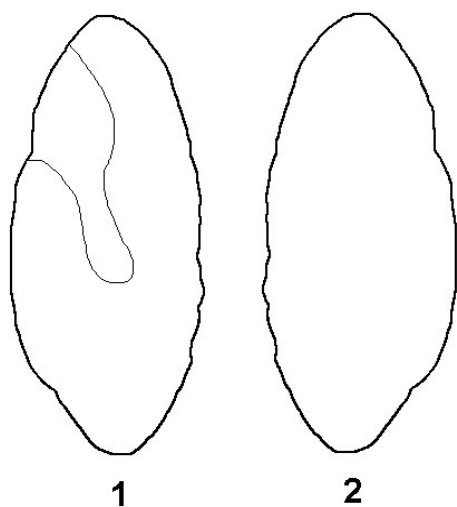


Fig. 47. Mailed sculpin otolith, the length (OL) 3,7 mm



Fig. 48. Mailed sculpin zoological length (FL) 94 mm, White Sea

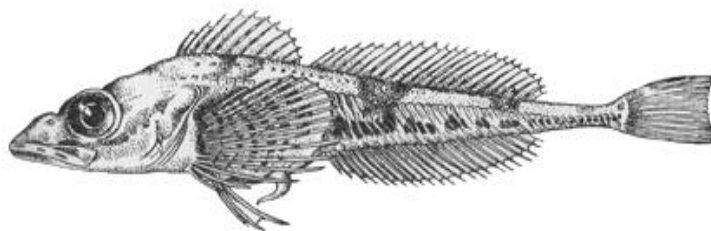
**Scorpaeniformes**

**Cottidae**

**Triglops** Reinhardt, 1831

*Triglops pingeli* (Reinhardt, 1831).

Ribbed sculpin



Otoliths white, bright, massive, oval, slightly extended in longitudinal section. Inside (1) convex, outside (2) concave and slightly lobed. Ventral part thicker than dorsal part in the transverse section. Dorsal and ventral margins are rounded, dorsal margin lobed. Rostrum pronounced, robust, wide, pointed. Rostrum length less or equal to  $\frac{1}{3}$  of otolith length. Antirostrum indistinct. Posterior and anterior equally pointed. Sulcus wide and moderate deep on all length of the otolith. Ostium open, funnel-shaped, cauda more narrow and closed far to the edge of the otolith. There is distinct small area in dorsal part (Fig. 49,50).

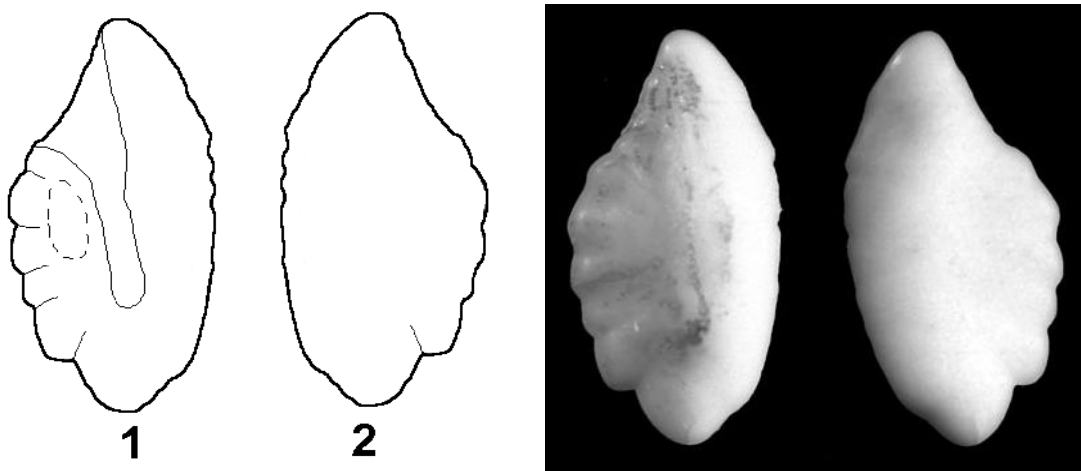


Fig. 49. Ribbed sculpin otolith, the length (OL) 4,1 mm



Pic. 50. Ribbed sculpin zoological length (FL) 132 mm, White Sea



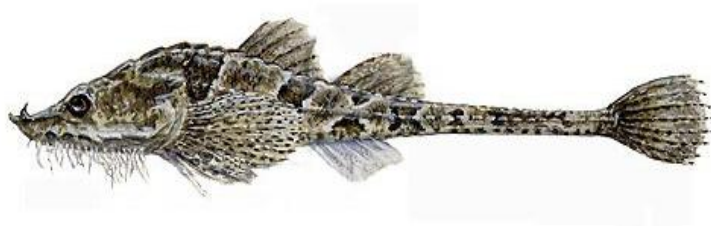
**Scorpaeniformes**

**Agonidae**

**Agonus** Bloch et Schneider, 1801

*Agonus cataphractus* (Linnaeus, 1758).

Armed bullhead, hooknose



Otoliths white, chalk, frosted, diamond-shaped. Inside (1) convex or flat, outside (2) concave and slightly lobed. Ventral part of the otolith is wider than dorsal part. Dorsal and ventral margins are equal rounded, dorsal margin lobed. Rostrum massive, straight, wide and rounded. Antirostrum small. Posterior extended in longitudinal section, pointed. Sulcus wide and moderate deep. Ostium closed but often it is connect to the edge of the otolith by a narrow groove or may be open by a narrow groove. Cauda more narrow than ostium and closed far to the edge of the otolith (Fig. 51,52).

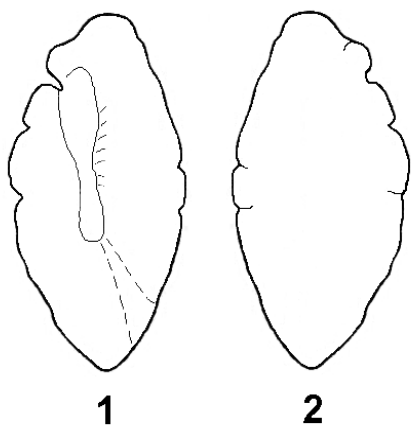


Fig. 51. Hooknose otolith, the length (OL) 4,7 mm



Fig. 52. Hooknose zoological length (FL) 135 mm, White Sea

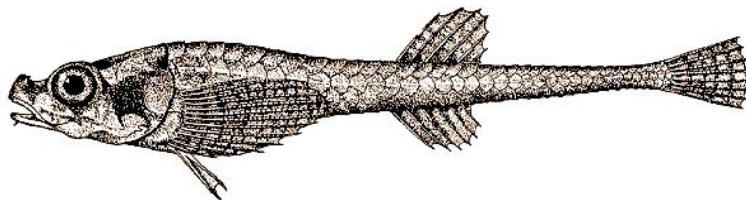
**Scorpaeniformes**

**Agonidae**

**Ulcina** Cramer, 1896

*Ulcina olriki* (Lutken, 1876).

Arctic alligator fish



Otoliths white, bright, irregularly rounded. Inside (1) flat, outside (2) convex. Ventral part is thicker than dorsal part in the transverse section (looks like a bird wing). Dorsal and ventral margins rounded, smooth. Rostrum average, rounded. Antirostrum distinct. Anterior and posterior ends visual equal. Posterior extended in longitudinal section, rounded. Sulcus deep in the anterior part. There is sulcus arch between ostium and cauda. Ostium open, funnel-shaped. Cauda closed far to the edge of the otolith. There is dorsal area (Fig. 53,54).

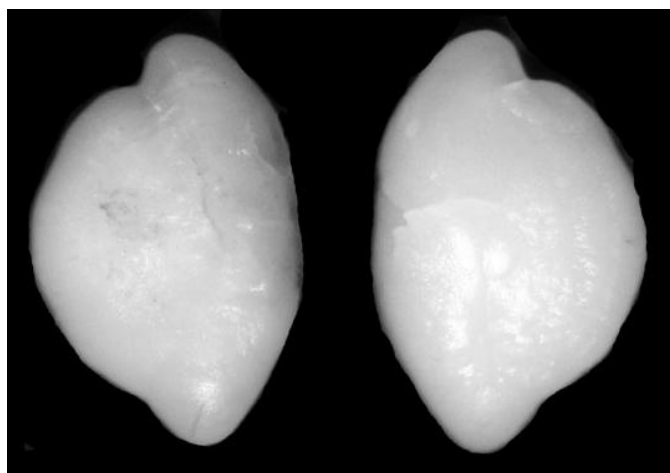
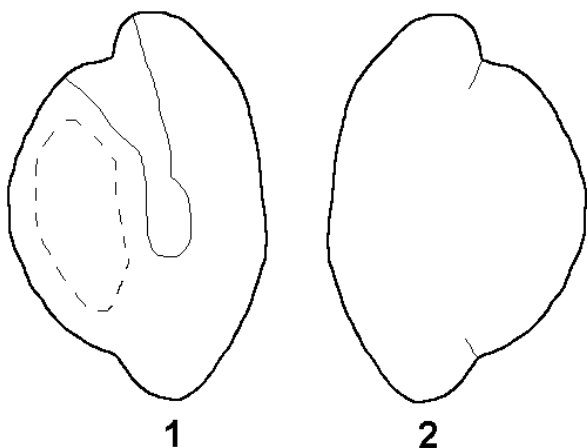


Fig. 53. Arctic alligator fish otolith, the length (OL) 2,2 mm



Fig. 54. Arctic alligator fish zoological length (FL) 68 mm, White Sea



**Scorpaeniformes**

**Cyclopteridae**

**Cyclopterus** Linnaeus, 1758

*Cyclopterus lumpus* (Linnaeus, 1758).

Lumpfish, sea hen, henfish



Otoliths white, bright, small, drop-shaped. Left and right otoliths often have the different sizes. Inside (1) flat, outside (2) slightly convex and smooth. Dorsal margin rounded and slightly lobed, ventral margin slightly concave, smooth. Rostrum average, wide in the basis and narrow on the tip. Rostrum tip hooked and slightly pointed. Antirostrum indistinct. Posterior rounded. Sulcus shallow in the middle part. Ostium deep, open, funnel-shaped. Cauda more shallow, rounded, closed far to the edge of the otolith. There is wide massive ventral crestae in ventral part of the otolith. Ventral crestae stretched from the rostrum tip to the cauda. The crestae surface smooth and looks like a ventral area (Fig. 55,56,57).

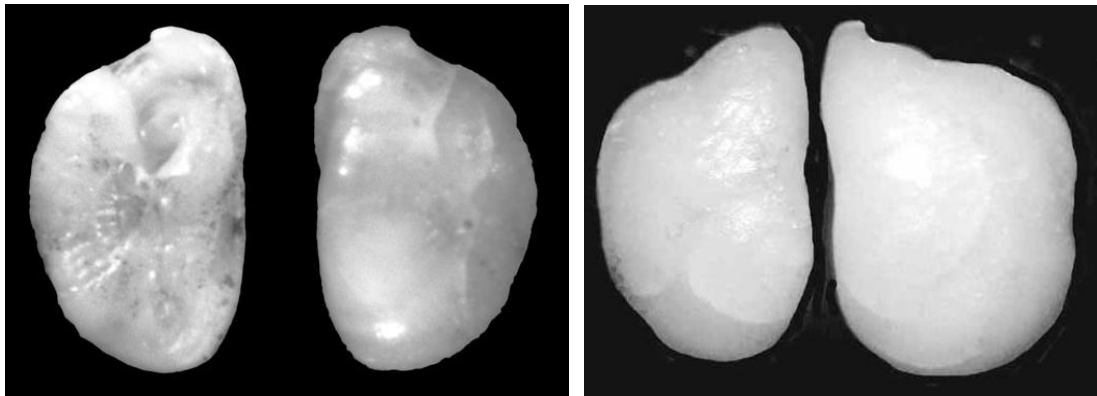
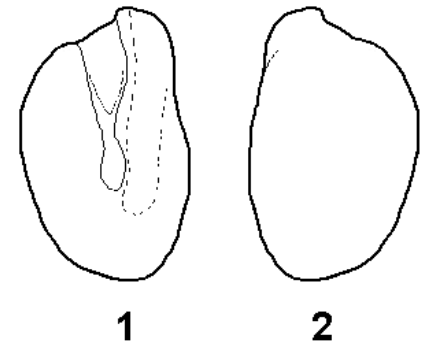


Fig. 55. Lumpfish otolith, the length (OL) 1,2 mm



Male

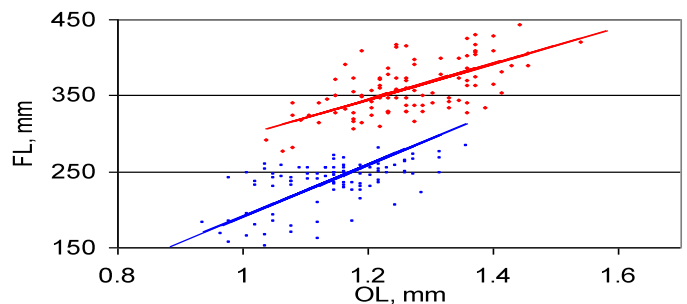


Fig. 56. Correlation between fish zoological length (FL) and otolith length (OL) at a lumpfish.

For males (blue):  $R^2=0,6824$ ,  $Y=-14,6574+4,7423 \cdot X$ , for females (red):  $R^2=0,6724$ ,  $Y=6,1871+3,3088 \cdot X$



Female

Fig. 57. Lumpfish zoological length (FL) 170 mm (male), 420 mm (female), White Sea

**Scorpaeniformes**

**Liparidae**

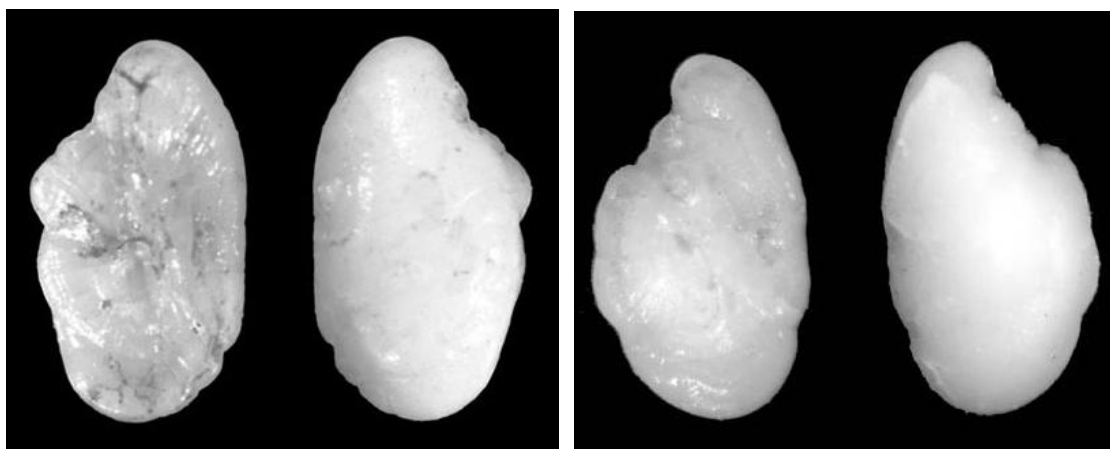
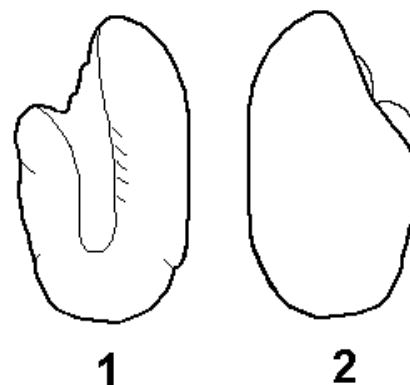
**Liparis** Scopoli (ex Artedi), 1777

*Liparis liparis* (Linnaeus, 1758).

Striped sea snail



Otoliths white, bright, small, drop-shaped. Inside (1) flat, outside (2) round-convex and smooth. Ventral part wider, than dorsal part of the otolith. Dorsal and ventral margins straight, smooth, parallel each other. Rostrum straight, massive, wide, rounded. Antirostrum distinct, rounded. Posterior rounded, posterior margin smooth. Sulcus shallow. Ostium open, funnel-shaped. Cauda closed far to the edge of the otolith. There is ventral small crestae on the sulcus margin (Fig. 58,59).



A B  
Fig. 58. Striped sea snail otolith, the length (OL) 2,1 mm (A), 2,05 mm (B)



Fig. 59. Striped sea snail zoological length (FL) 103 mm, White Sea

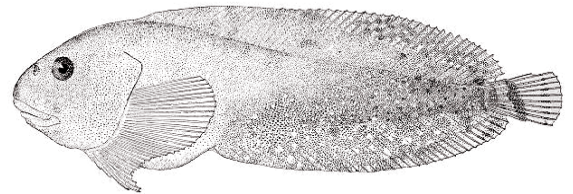
**Scorpaeniformes**

**Liparidae**

**Liparis** Scopoli (ex Artedi), 1777

*Liparis tunicatus* (Reinhardt, 1837).

Arctic sea snail



Otoliths white, bright, small, drop-shaped. Inside (1) flat, outside (2) convex and smooth. Ventral part wider, than dorsal part of the otolith. Dorsal margin rounded, rough, ventral margin smooth. Rostrum short, straight, massive, wide, rounded. Antirostrum distinct, rounded, lobed. Posterior rounded, posterior margin smooth. Sulcus shallow. Ostium open, funnel-shaped. Cauda closed far to the edge of the otolith. There is dorsal ribbed area in the anterior part (Fig. 60,61).

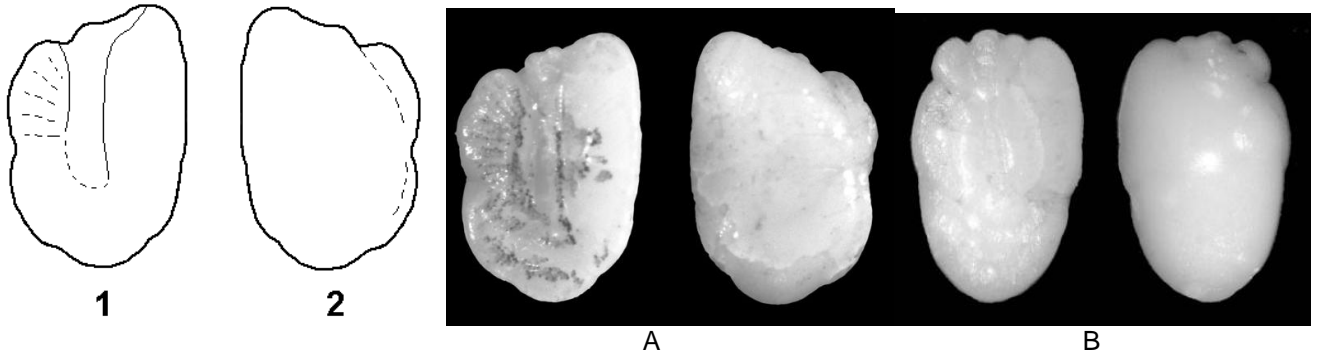


Fig. 60. Arctic sea snail otolith, the length (OL) 2,9 mm (A), 1,5 mm (B)



Fig. 61. Arctic sea snail zoological length (FL) 78 mm, White Sea

*Liparis gibbus* Bean, 1881.

Humpbacked sea snail

Otoliths white, bright, oval, small. Inside (1) flat, outside (2) smooth, very convex in anterior and moderate convex in posterior. Ventral part wider, then dorsal part of the otolith. Dorsal and ventral margins rounded, smooth. Rostrum average, straight, wide, rounded. Antirostrum distinct, small, rounded. Posterior rounded, posterior margin smooth. Sulcus shallow. Ostium open, funnel-shaped. Cauda closed far to the edge of the otolith. There is dorsal shallow oval area, which occupies all surface of the dorsal part of the otolith (Fig. 62).

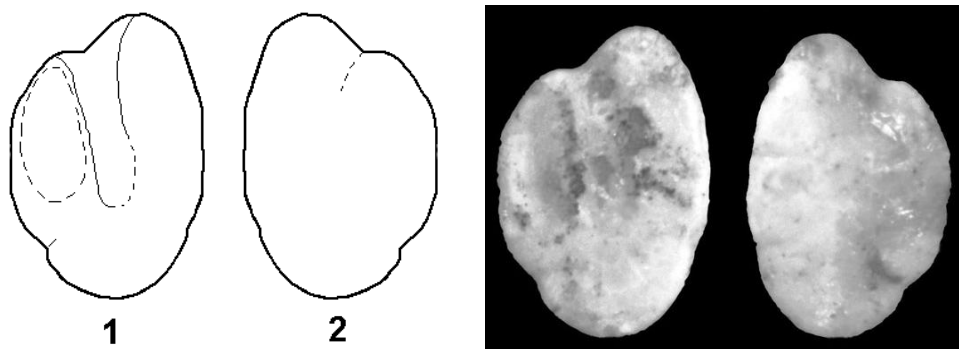


Fig. 62. Humpbacked sea snail otolith, the length (OL) 1,2 mm

**Perciformes**

**Zoarcidae**

**Lycodes** Reinhardt, 1831

*Lycodes polaris* (Sabine, 1824).

Polar eelpout



Otoliths white, bright, diamond-shaped. Inside (1) and outside (2) flat. Dorsal and ventral margins rounded, rough. Dorsal margin more rounded, than ventral margin. Rostrum straight, wide, pointed. Antirostrum indistinct. Posterior pointed, divided into postrostrum and parastrostrum. Sulcus deep in the anterior part of the otolith. Ostium open, wide, funnel-shaped. Cauda shallow, closed far to the edge of the otolith. There is dorsal shallow area (Fig. 63,64).

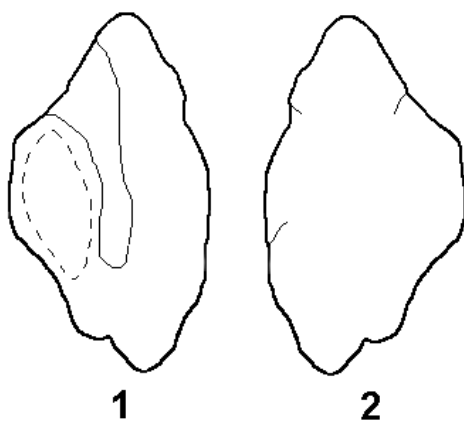


Fig. 63. Polar eelpout otolith, the length (OL) 5,9 mm



Fig. 64. Polar eelpout zoological length (FL) 210 mm, White Sea



**Perciformes**

**Zoarcidae**

**Zoarces** Cuvier, 1829

*Zoarces viviparus* (Linnaeus, 1758).

European ocean pout, eelpout



Otoliths white, bright, oval, extended in longitudinal section. Inside (1) flat, outside (2) convex. Dorsal and ventral margins rounded, smooth. Anterior wider, than posterior. Rostrum average, straight, wide, rounded. Antirostrum distinct, rounded. Posterior rounded, egg-shaped, posterior margin smooth. Sulcus shallow, clearly parted into ostium and cauda by small ventral crestae. Ostium open, wide, funnel-shaped. Cauda closed far to the edge of the otolith (Fig. 65, 66).

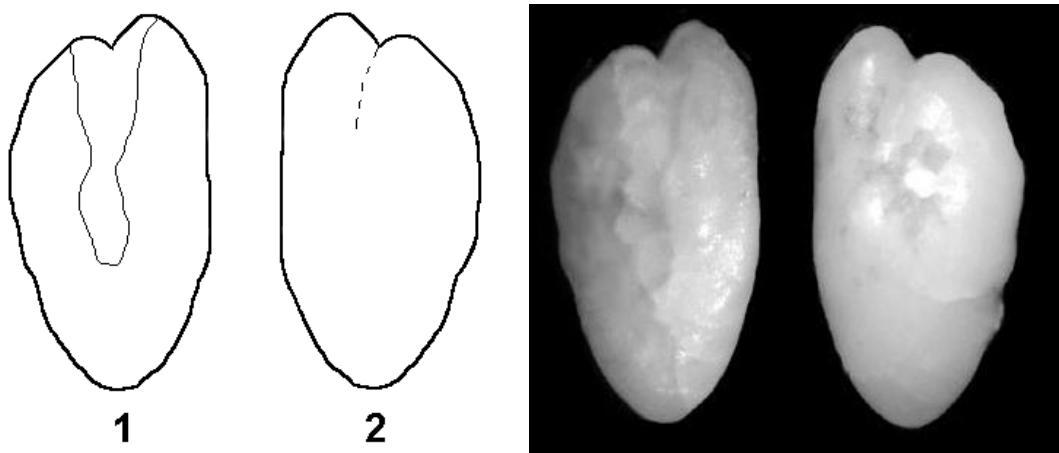


Fig. 65. European ocean pout otolith, the length (OL) 2,7 mm



Fig. 66. European ocean pout zoological length (FL) 230 mm, White Sea



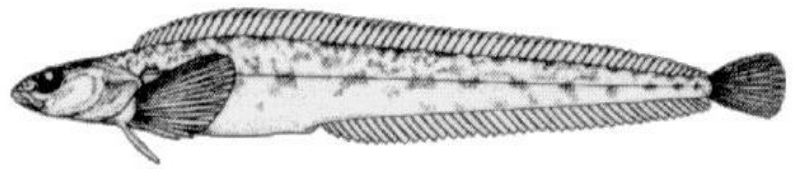
**Perciformes**

**Lumpenidae**

**Lumpenus** Reinhardt, 1837

*Lumpenus fabricii* (Valenciennes, 1836),

Slender eel blenny



Otoliths white, bright, oval. Inside (1) slightly convex, outside (2) flat. Dorsal margin rounded, occasionally lobed, ventral margin straight, rough. Rostrum average, straight, wide in the basis, pointed. Antirostrum distinct, rounded. Posterior rounded, posterior margin smooth. Sulcus deep in the anterior part of the otolith. Sulcus clearly parted into ostium and cauda by ventral crestae. Ostium open, funnel-shaped. Cauda shallow, closed far to the edge of the otolith. There is dorsal smooth shallow area (Fig. 67,68,69).

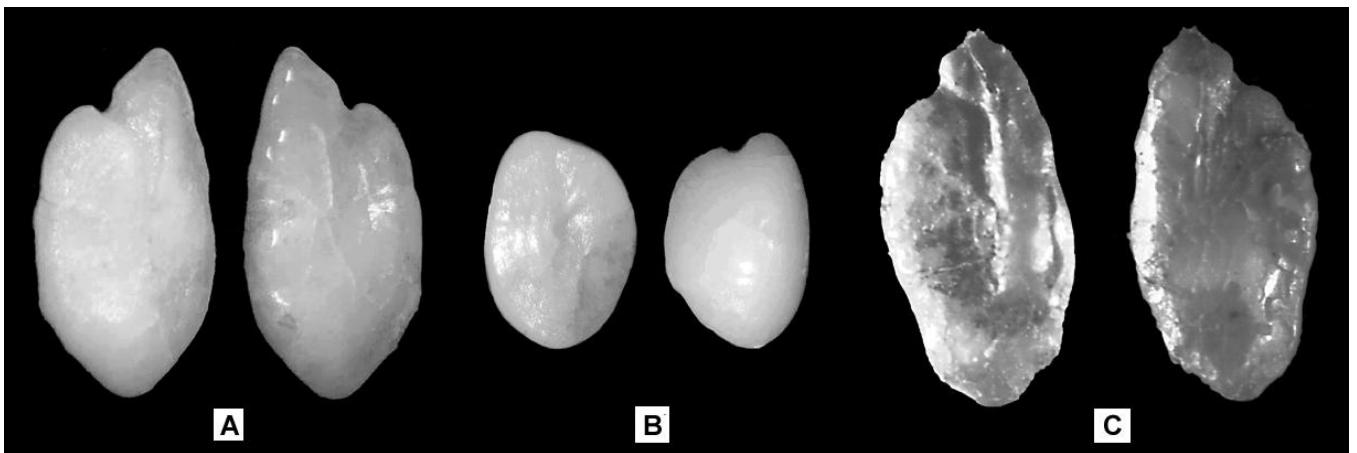
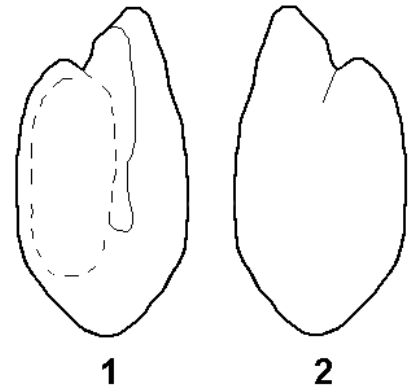


Fig. 67. Slender eel blenny otolith, the length (OL) 6,3 mm (A), 1,6 mm (B), 3,2 mm (C)

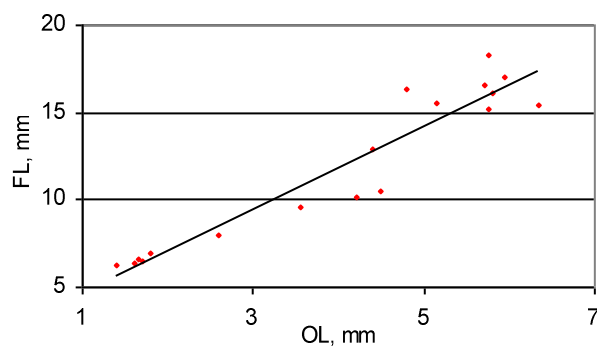


Fig. 68. Correlation between fish zoological length (FL) and otolith length (OL) at a slender eel blenny.  
 $R^2 = 0,9507$ ,  $Y = 2,4216 + 1,1748 * X$



Fig. 69. Slender eel blenny zoological length (FL) 170 mm, White Sea

**Perciformes**

**Pholidae**

**Pholis** Scopoli (ex Gronov), 1777

*Pholis gunnelus* (Linnaeus, 1758).

Rock eel, butterfish



Otoliths white, bright, diamond-shaped. Inside (1) and outside (2) flat. Dorsal margin rounded, smooth, ventral margin straight or rounded, margin rough. Rostrum average, straight, wide, rounded. Antirostrum indistinct. Posterior rounded. Sulcus deep in the anterior part of the otolith. Dorsal margin of the sulcus is curved. There is ventral small crestae on the sulcus margin. Ostium open, funnel-shaped. Cauda shallow, closed far to the edge of the otolith. There is dorsal shallow area (Fig. 70,71).

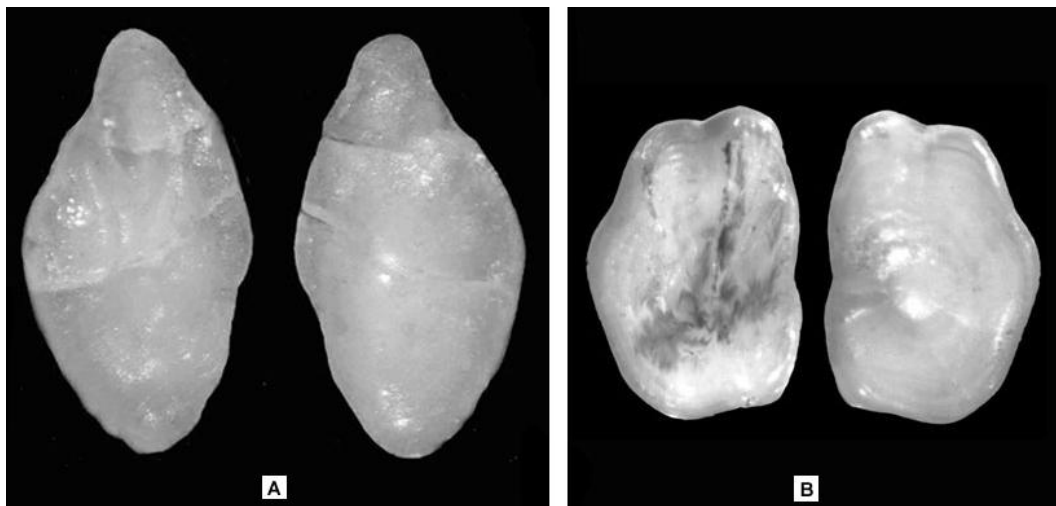
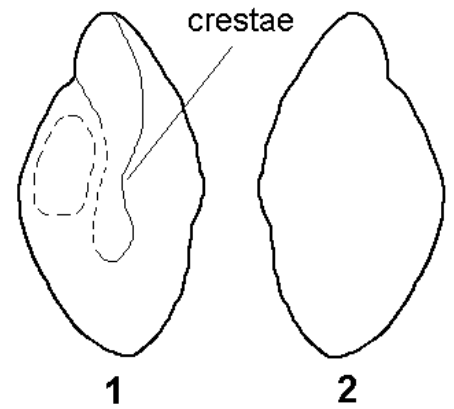


Fig. 70. Rock eel otolith, the length (OL) 1,5 mm (A), 1,85 mm (B)

Rock eel, Konjuchova Bay, 2000, Karelia, 2005, White Sea

Date	№	AB, mm	AD, mm	sex	LO, mm
27 June 2000	1	205	193	m	1,85
June 2005	2	178	-	-	1,5



Fig. 71. Rock eel zoological length (FL) 178 mm, White Sea

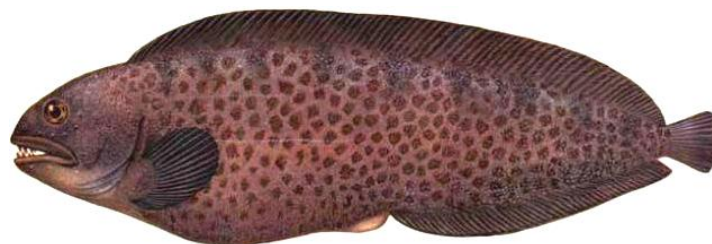
**Perciformes**

**Anarhichadidae**

**Anarhichas** Linnaeus, 1758

*Anarhichas denticulatus* (Krøyer, 1845).

Northern wolffish



Otoliths white, bright, drop-shaped or pear-shaped. Inside (1) flat, outside (2) convex. Dorsal part shorter than ventral part. Dorsal margin rounded, slightly lobed, ventral margin straight, jagged or rough. Rostrum straight, long, wide in the basis, pointed. The length of the rostral radius (R) is about two lengths of the postrostral radius ( $Z_1$ ). Antirostrum distinct, pointed. Posterior rounded or straight, margin smooth or slightly lobed. Sulcus deep in the anterior part of the otolith. There is sulcus arch between ostium and cauda. Ostium open, funnel-shaped. Cauda shallow, closed far to the edge of the otolith. There is a big ventral crestae run open from rostrum to sulcus arch. There is a big dorsal crestae run open from antirostrum to sulcus arch. There is deep dorsal area (Fig. 72,73).

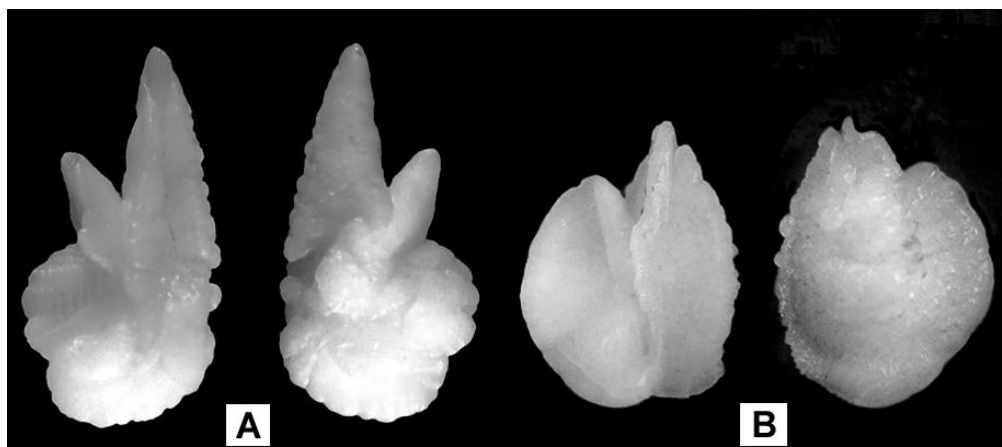
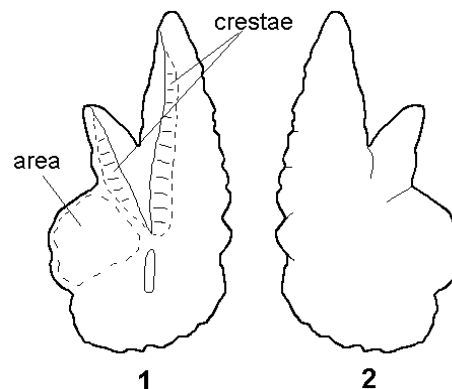


Fig. 72. Northern wolffish otolith, the length (OL) 4,4 mm (A), White Sea; 3,6 mm (B), Barents Sea

Northern wolffish, Konjuchova Bay, 2000, White Sea

Date	№	AB,mm	AD, mm	Sex	OL, mm
21.06	1	660	615	female	4,4



Fig. 73. Northern wolffish zoological length (FL) 590 mm, White Sea

**Perciformes**  
**Anarhichadidae**

**Anarhichas** Linnaeus, 1758

*Anarhichas lupus marisalbi*  
 (Barsukov, 1959).

White Sea catfish (wolffish)



Otoliths white, bright, drop-shaped or pear-shaped. Inside (1) flat, outside (2) convex. Dorsal part shorter than ventral part. Dorsal margin rounded, slightly lobed, ventral margin straight, jagged or rough. Rostrum straight, long, wide in the basis, pointed. The length of the rostral radius (R) is about one length of the postrostral radius (Z<sub>1</sub>) or little bit more. Antirostrum distinct, pointed. Posterior rounded or straight, margin smooth. Sulcus deep in the anterior part of the otolith. There is sulcus arch between ostium and cauda. Ostium open, funnel-shaped. Cauda shallow, closed far to the edge of the otolith. There is a small ventral crestae run open from rostrum to sulcus arch. There is a small dorsal crestae run open from antirostrum to sulcus arch. There is deep dorsal area (Fig. 74,75).

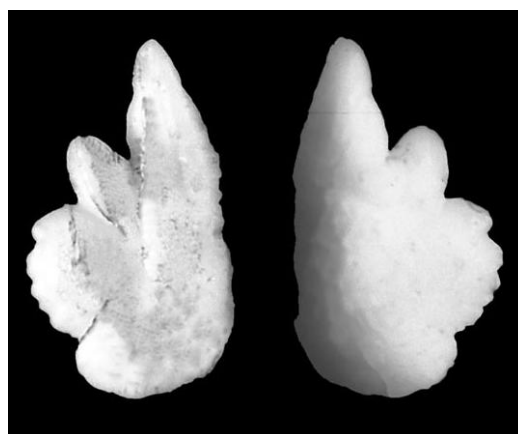
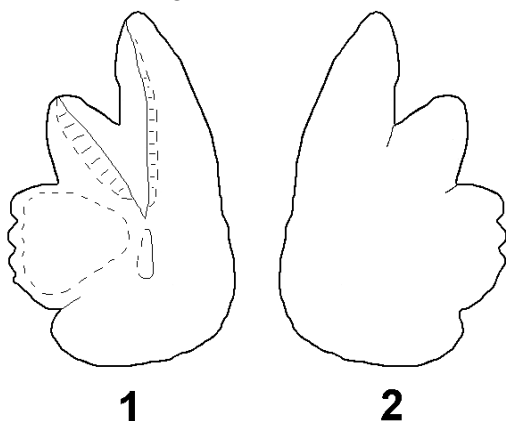


Fig. 74. White Sea catfish otolith, the length (OL) 3,9 mm

White Sea catfish , Konjuchova Bay, 2000, 2004, v. Lopshenga, 2002, White Sea

Date	№	AB, mm	AD, mm	Sex	OL, mm
9.06.2000	1	447	40,6	female	3,1
9.06.2000	2	413	37,7	male	3,1
11.06.2000	3	348	32,0	male	2,6
21.06.2000	5	486	45,7	male	3,1
24.06.2000	6	440	39,5	female	3,0
27.06.2000	8	420	38,5	female	3,3
18.06.2002	1	382	35,7	male	2,1
9.07.2002	2	335	30,2	male	2,5
11.06.2004	1	498	46,2	male	3,1
11.06.2004	2	468	42,8	male	3,4
20.06.2004	3	327	29,8	female	3,1



Fig. 75. White Sea catfish zoological length (FL) 480 mm, White Sea



**Perciformes**  
**Ammodytidae**  
**Ammodytes** Linnaeus, 1758  
*Ammodytes marinus* (Raitt, 1934).  
 Greater sand eel



Otoliths white, bright, oval. The otoliths are similar on the sunflower seeds. Inside (1) convex, outside (2) flat. Dorsal and ventral margins rounded, smooth. Rostrum straight, short, wide in the basis, pointed. Sometimes rostrum not protruded from otolith body (Fig. 76 B, C). Antirostrum indistinct. Posterior rounded, margin smooth (Fig. 76 A). Sometimes posterior may be divided into pararostrum and postrostrum (Pic. D). Sulcus shallow and straight. There is small crestae (or fold) on the sulcus bottom. Ostium open, wide. Cauda closed far to the edge of the otolith. There is convex nucleus in the outside (Fig. 76,77,78).

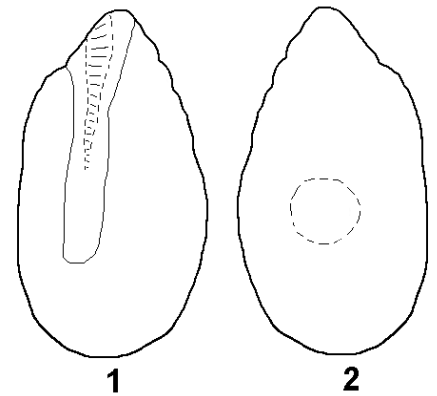


Fig. 76. Greater sand eel otolith, the length (OL) 2,0 mm (A), 2,2 mm (B), 2,4 mm (C), 2,3 mm (D)

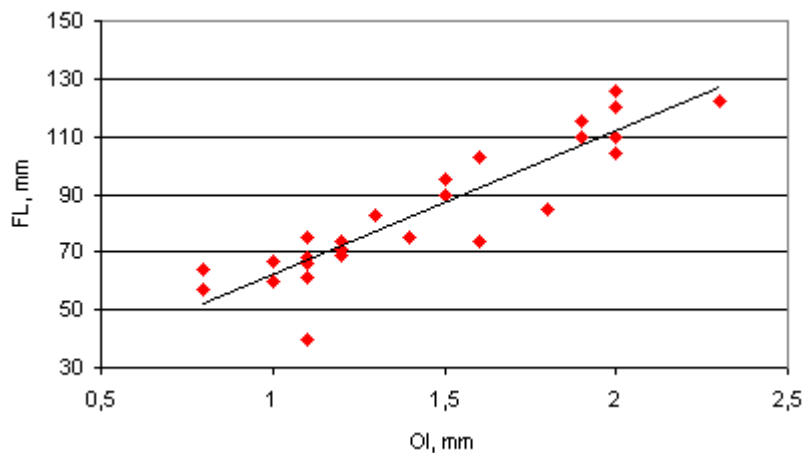


Fig. 77. Correlation between fish zoological length (FL) and otolith length (OL) at a greater sand eel.  
 $R^2=0,8372$ ,  $Y=11,95+50,207X$



Fig. 78. Greater sand eel zoological length (FL) 80 mm, White Sea



**Perciformes**

**Scombridae**

**Scomber** Linnaeus, 1758

*Scomber scombrus* (Linnaeus, 1758).

Atlantic mackerel



Otoliths white, bright, oval, very extended in longitudinal section. Inside (1) convex, outside (2) concave. Dorsal margin rounded, rough, ventral margin straight, smooth. Rostrum straight, long, wide, pointed. Antirostrum distinct, pointed but may be rounded too. Posterior rounded or pointed, margin rough, jagged, posterior shape is irregular. Sulcus deep, wide and open. Ostium clearly open, cauda longer and more narrow than ostium. Cauda open but may be closed near to the edge of the otolith. Cauda curved to the ventral at posterior part (Fig. 79,80).

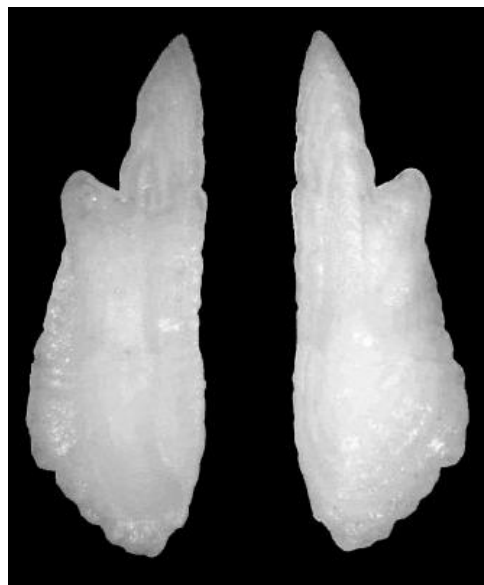
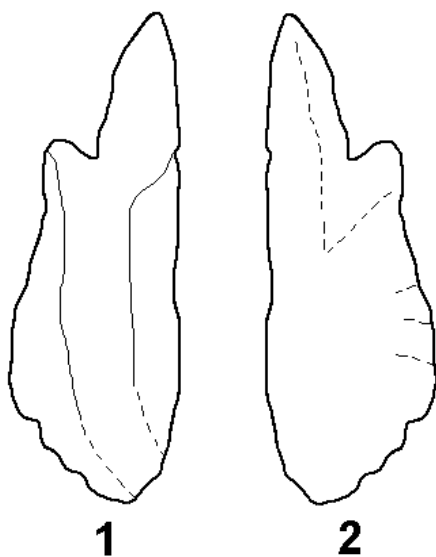


Fig. 79. Atlantic mackerel otolith, the length (OL) 5,1 mm



Fig. 80. Atlantic mackerel zoological length (FL) 440 mm, White Sea

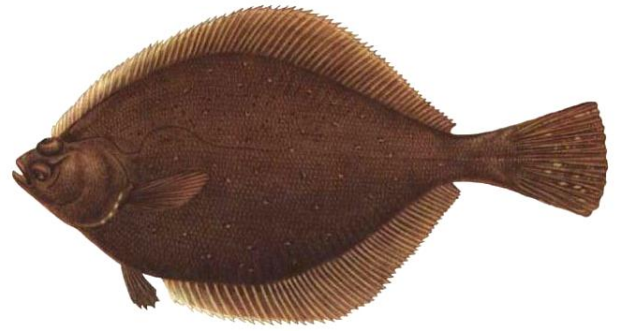
**Pleuronectiformes**

**Pleuronectidae**

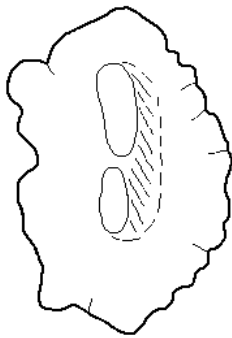
**Limanda** Gottsche, 1835

*Limanda limanda* (Linnaeus, 1758).

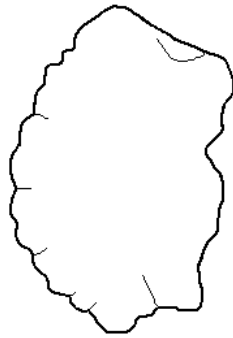
Common dab



Otoliths white, bright, irregularly rounded. Inside (1) convex, outside (2) flat, posterior margin lobed or rough. Ventral part wider than dorsal part. Dorsal margin straight, irregularly rough or jagged. Ventral margin rounded, lobed or jagged. Rostrum average, wide, rounded. Antirostrum indistinct or small. Big excision is similar to the small fold. Posterior rounded, margin rough. Sulcus deep, closed far to the edges of the otolith. There is sulcus arch between ostium and cauda. Ostium longer than cauda. There is oval deep ventral area near the sulcus. There is a big one dorsal papilla in the posterior part of the otolith usually (Fig. 81,82,83).



**1**



**2**

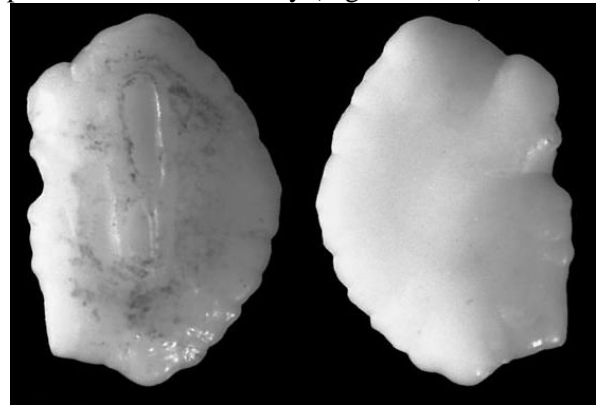


Fig. 81. Common dab otolith, the length (OL) 4,0 mm

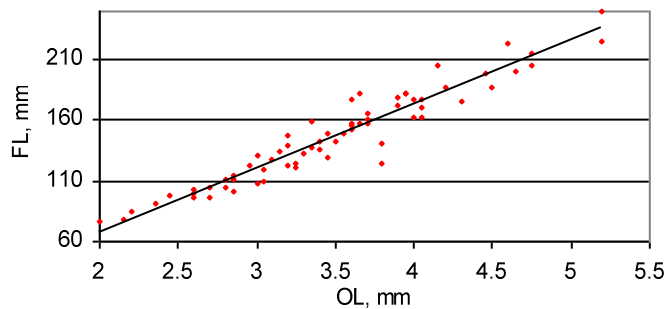


Fig. 82. Correlation between fish zoological length (FL) and otolith length (OL) at a common dab.  
 $R^2 = 0,9577$ ,  $Y = 1,8183 + 0,3515 * X$



Fig. 83. Common dab zoological length (FL) 210 mm, White Sea

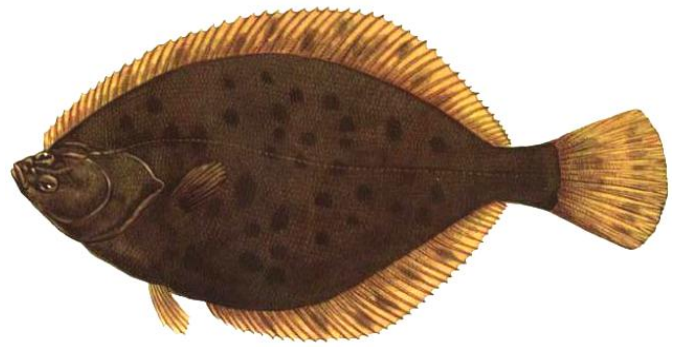
**Pleuronectiformes**

**Pleuronectidae**

**Liopsetta** Gill, 1864

*Liopsetta glacialis* (Pallas, 1776).

Polar flounder



Otoliths white, bright, oval. Inside (1) and outside (2) slightly convex. Ventral part wider than dorsal part. Dorsal margin slightly rounded, rough. Ventral margin rounded, slightly lobed. Rostrum average, straight, wide, rounded, margin smooth. Antirostrum distinct, small, rounded. The angle between the rostrum and the antirostrum (big excision) is obtuse. Posterior rounded or irregularly rounded, margin rough. Sulcus deep, closed far to the edges of the otolith. There is narrow sulcus arch between ostium and cauda. Ostium longer than cauda. Cauda more narrow than ostium. There is a big one dorsal rounded papilla in the posterior part of the otolith usually (Fig. 84,85,86).

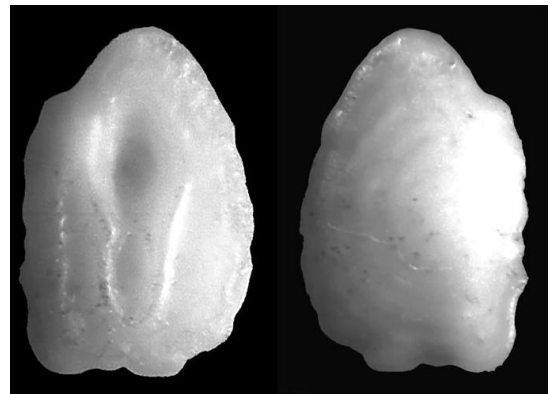
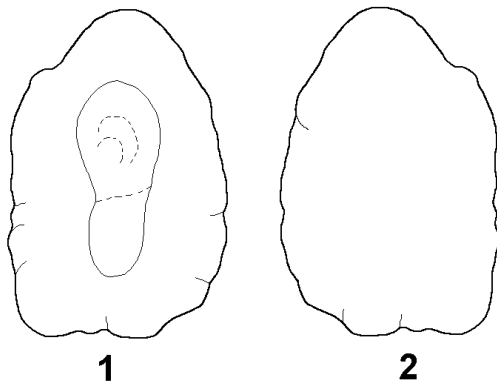


Fig. 84. Polar flounder otolith, the length (OL) 4,0 mm

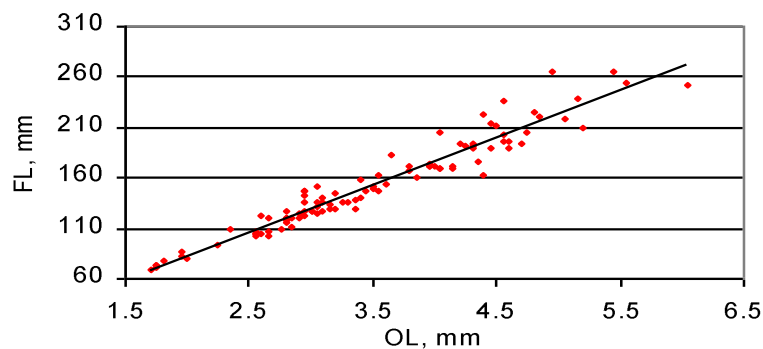


Fig. 85. Correlation between fish zoological length (FL) and otolith length (OL) at a polar flounder.  
 $R^2 = 0,97$ ,  $Y = -1,07 + 2,34 * X$



Fig. 86. Polar flounder zoological length (FL) 144 mm, White Sea

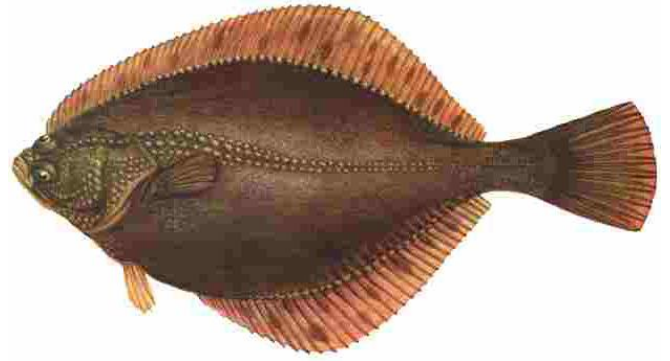
**Pleuronectiformes**

**Pleuronectidae**

**Platichthys** Girard, 1854

*Platichthys flesus* (Linnaeus, 1758).

European flounder, fluke



A.P. Andrijashev (1954) determines the White sea European flounder, *Pleuronectes (Platichthys) flesus bogdanovi* Sandeberg, 1878, for the White Sea.

Otoliths white, bright, oval. Inside (1) convex, outside (2) concave. Ventral part wider than dorsal part. Dorsal margin straight, rough. Ventral margin rounded, rough or jagged. Rostrum average, straight, wide, pointed. Antirostrum distinct, small. The angle between the rostrum and the antirostrum (big excision) is obtuse. Posterior rounded or irregularly rounded, margin rough or slightly jagged. Sulcus deep, closed far to the edges of the otolith. There is sulcus arch between ostium and cauda. The length of the ostium and the length of the cauda is equally or ostium longer than cauda. Cauda more narrow than ostium. There is a big one dorsal rounded papilla in the posterior part of the otolith usually (Fig. 87,88,89).

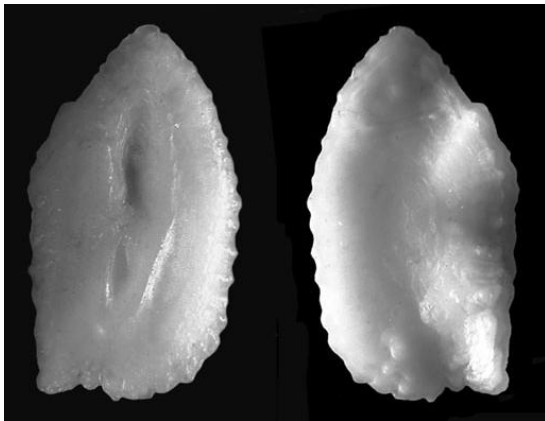
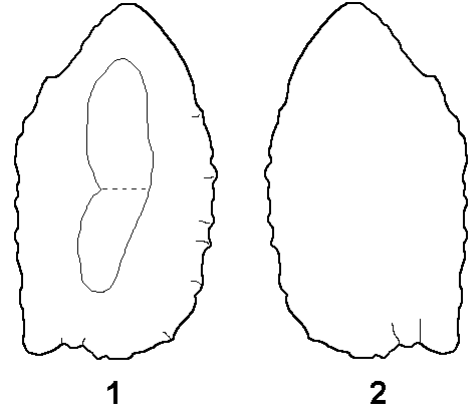


Fig. 87. European flounder otolith, the length otolith (OL) 7,8 mm

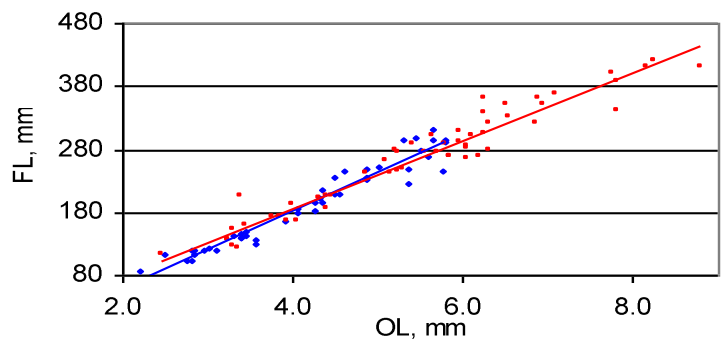


Fig. 88 . Correlation between fish zoological length (FL) and length (OL) at a European flounder. For males (blue):  $R^2=0,9702$ ,  $Y=-6,0623+3,041*X$ ; for females (red):  $R^2=0,968$ ,  $Y=-2,6573+2,647*X$



Fig. 89. European flounder zoological length (FL) 340 mm, White Sea



## Pleuronectiformes

### Pleuronectidae

#### *Pleuronectes* Linnaeus, 1758

*Pleuronectes platessa* (Linnaeus, 1758).

Plaice



Otoliths white, bright, irregularly rounded. Inside (1) convex, outside (2) concave. Ventral part wider than dorsal part. Dorsal margin straight, with big lobules. Ventral margin rounded, rough or jagged. Rostrum average, wide, rounded. Antirostrum distinct, small, rounded. Big excision is similar to the small fold. Posterior rounded, margin rough. Frequently posterior may be divided into pararostrum and postrostrum. Sulcus deep, closed far to the edges of the otolith. There is sulcus arch between ostium and cauda. Ostium longer than cauda. Cauda narrower than ostium. There is oval dorsal area. There is a big one dorsal rounded papilla in the posterior part of the otolith usually (Fig. 90,91).

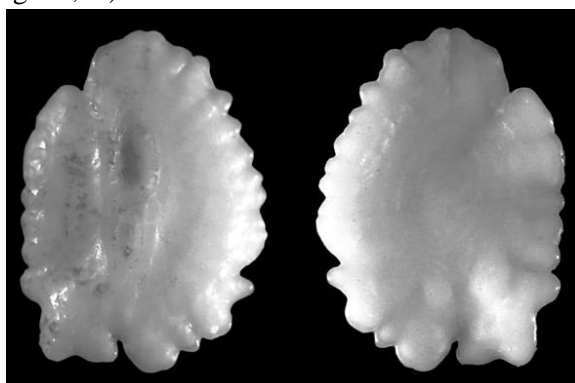
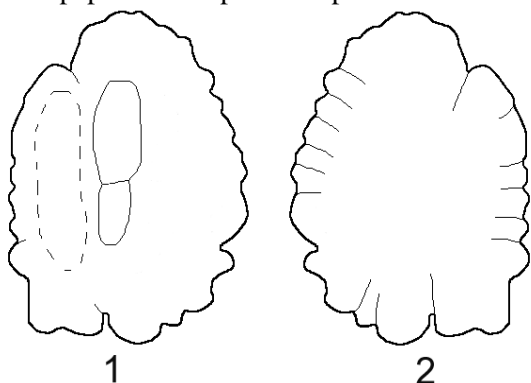


Fig. 90. Plaice otolith, the length (OL) 4,9 mm

Plaice, Konjuchova Bay, 2000, 2003, 2004, White Sea

Date	No	AB, mm	Sex	LO, mm
15.06.2000	1	282	female	5,7
21.06.2000	2	230	female	4,4
24.06.2000	3	330	female	6,1
24.06.2000	4	220	male	4,3
24.06.2000	5	217	male	4,4
24.06.2000	6	210	male	4,3
24.06.2000	7	185	female	3,7
25.06.2000	8	250	female	4,7
27.06.2000	9	233	female	4,5
30.06.2000	10	300	female	5,4
12.06.2003	11	200	female	4,0
13.06.2003	12	191	male	4,3
14.06.2003	13	217	female	4,0
14.06.2003	14	210	female	4,4
11.06.2004	15	198	female	4,1
12.06.2004	16	307	female	6,1



Fig. 91. Plaice zoological length (FL) 400 mm, White Sea



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