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2. Distribution, age and growth

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(312)*

Young flatfishes (Pleuronectidae) of the Far Eastern seas

by L.N. Musienko

2. DISTRIBUTION, AGE AND GROWTH[1]

Distribution of the young

The areas of distribution of the young and of the adult fish of the species studied by us are shown in Figs. 1-4. A list of the areas in which the young are found is given in Appendix I. The distribution of young flatfishes in relation to depth, temperature and the salinity of the near-bottom layer, as well as the substrate, is shown in Table 1.

From this table, we see that the young of the flatfishes studied by us were caught on various types of substrate, ranging from sand with gravel and pebbles to silty mud, at depths of 1-268 m (predominantly less than 100 m), at near-bottom temperatures of -1.56° to +9.06°C and a salinity of 22.59-34.33‰.

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*The numbers in the right-hand margin are the pages of the Russian text - translator

[1]Part 1 (Systematics) published in the Proceedings of the Institute of Oceanology, vol. XI, 1954.

The type of bottom selected by the young of different species of flatfishes is shown in Table 2[2].

The young of the majority of species of flatfishes live predominantly on sand. The young of the Kamchatka flounder, the Pacific halibut and the eel-back flounder have been encountered only on sand. The young of the rock sole prefer sand and a gravelly-pebbly bottom, and only sometimes are encountered on silty sand. The young of the Pacific black halibut, the Alaska plaice and the yellowfin sole also forage on silty sand. On the other hand, the young of the flathead sole, Nadezhny's flounder, the northern longsnout flounder and Steller's flounder may forage both on silty sand and on silty mud.

The fluctuations in the hear-bottom temperature at which the young flatfishes were caught are shown in Table 3.

The temperature of the near-bottom layer in the areas inhabited by young flatfishes is usually 0-2°C, but it may vary from -1.56 to 0.06°C. The young of the Alaska plaice are apparently the most heat-loving of all. The young of this species were caught only at above-zero temperatures. Only the young of the flathead sole and Steller's flounder were caught at temperatures below -1°C.

The fluctuations in the salinity of the near-bottom layer in the areas of distribution of young flatfishes are shown in Table 4.

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[2]Tables 2, 3 and 4 were compiled without taking the size of the young into consideration, for we observed no relationship between the size of the young and their distribution according to depth and type of substrate at various salinities and temperatures of the near-bottom layer.

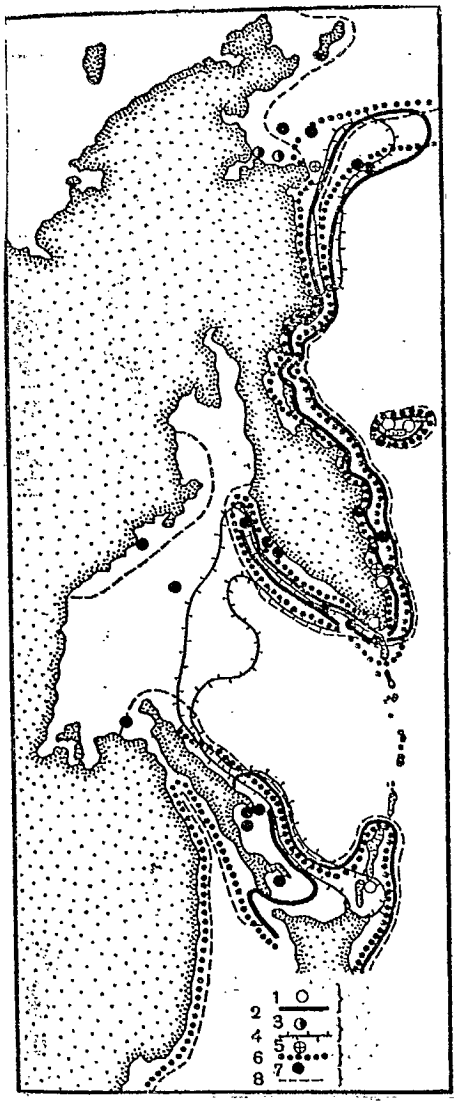

Fig. 1. Points of occurrence of young flatfishes and the boundaries of distribution of the adults (the latter given after P.A. Moiseyev, 1953)

1 - points of occurrence of young Kamchatka flounder; 2 - boundary of distribution of its adults; 3 - points of occurrence of young Pacific black halibut; 4 - boundary of distribution of its adults; 5 - points of occurrence of young Pacific halibuts; 6 - boundary of distribution of its adults; 7 - points of occurrence of young flathead sole; 8 - boundary of distribution of its adults

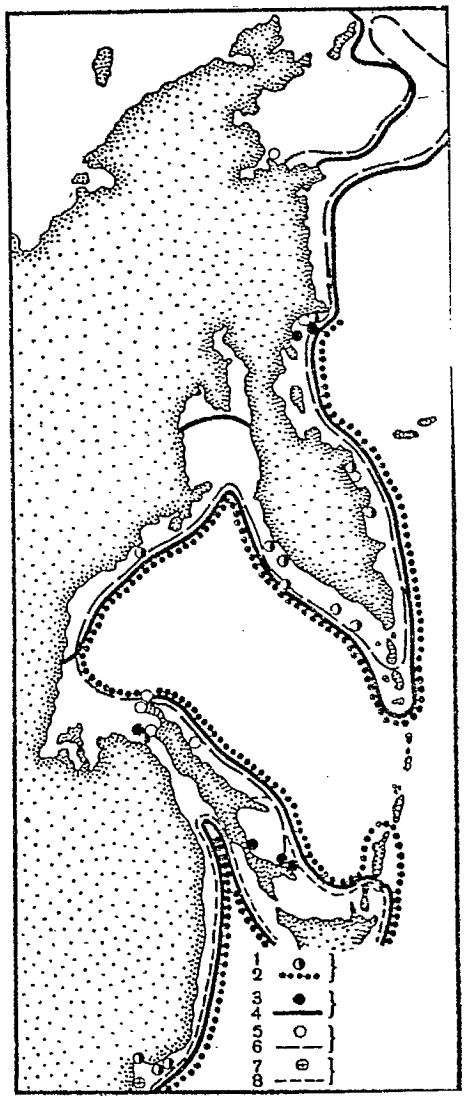

Fig. 2. Points of occurrence of young flatfishes and the boundaries of distribution of the adults

1 - points of occurrence of young Nadezhny's flounder; 2 - boundary of distribution of its adults; 3 - points of occurrence of young yellowfin sole; 4 - boundary of distribution of its adults; 5 - points of occurrence of young northern longsnout flounder; 6 - boundary of distribution of its adults; 7 - points of occurrence of young southern longsnout flounder; 8 - boundary of distribution of its adults

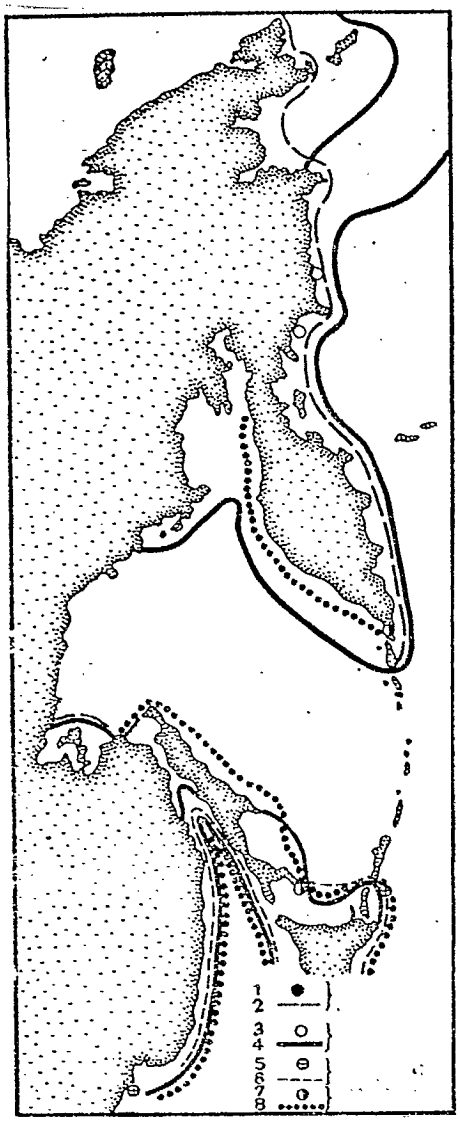

Fig. 3. Points of occurrence of young flatfishes and the boundaries of distribution of the adults

1 - points of occurrence of young eel-back flounder; 2 - boundary of distribution of its adults; 3 - points of occurrence of young Alaska plaice; 4 - boundary of distribution of its adults; 5 - points of occurrence of young Yokohama flounder; 6 - boundary of distribution of its adults; 7 - points of occurrence of young Steller's flounder; 8 - boundary of distribution of its adults

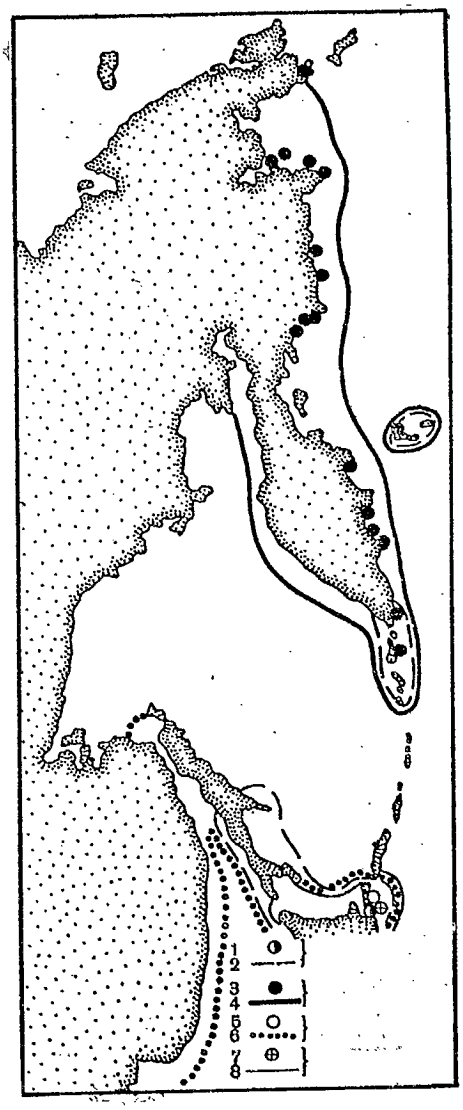

Fig. 4. Points of occurrence of young flatfishes and the boundaries of distribution of the adults

1 - points of occurrence of young rough-scale sole; 2 - boundary of distribution of its adults; 3 - points of occurrence of young rock sole; 4 - boundary of distribution of its adults; 5 - points of occurrence of young mochi-gar flounder ; 6 - boundary of distribu-tion of its adults; 7 - points of occur-rence of young slime flounder; 8 - boundary of distribution of its adults

Table 1. Conditions of distribution of young flatfishes

Species	Depth (m)	t°	S‰	Bottom	n
Kamchatka flounder	41–116	(–0.68)–(+3.36)	32.78–33.62	Sand	10
Pacific black halibut	18–40	(–0.14)–(+9.06)	22.59–33.50	Sand with pebbles, silty sand	4
Pacific halibut	7–43	(–0.91)–(+3.6)	30.98–32.78	Sand	3
Flathead sole	22–268	(–1.56)–(+5.0)	32.60–34.33	Gravel and pebbles, sand, silty mud	180
Nadezhny's flounder	22–82	(–0.63)–(+3.36)	32.63–33.20	Sand with gravel and pebbles, silty sand	67
Roughscale sole	30	–	–	–	4
Rock sole	10–90	(–0.4)–(+8.2)	27.11–33.50	Gravel and pebbles, sand, silty sand	128
Mochigar flounder	30	–	–		10
Yellowfin sole	20–33	(+0.04)–(+3.5)	32.63–32.99	Sand, silty sand	38
Northern longsnout flounder	9–67	(–0.58)–(+8.48)	27.11–33.25	Sand, silty mud	15
Alaska plaice	9–10	–	–	Sand, silty sand	2
Slime flounder	30	–	–	–	1
Steller's flounder	48–207	(–1.04)–(+5.0)	32.78–33.08	Sand, silty mud	6
Eel-back flounder	1–2	–	–	Sand	4

The young of the flatfishes studied are mostly encountered at a salinity of 32–34‰. The young of the Pacific black halibut, the rock sole and northern longsnout flounder have been caught in freshened areas (with a salinity of 22.59–27.11‰). Only young flathead sole have been caught at a fairly high salinity (34.33‰).

On the basis of the above information, we can say that the young of the majority of flatfishes are encountered predominantly at depths of less than 100 m, on sandy bottoms, at near-bottom temperatures of 0–2°C and salinities of 32.0–34.0‰.

Age and growth of the young

On the whole, the growth of young flatfishes is far from being well-researched. Special research has been done only on the growth of young fluke (Pleuronectes flesus) in a fertilized sea loch (Loch Craiglin) (Gross, 1947). In the Far Eastern seas, the growth of young flatfishes has been studied only to a small degree by Japanese scientists (Ishida, Kitakata and Ishigaki, 1952; Ishida and Kitaka-
(316)
ta, 1953). The growth of young flatfishes off the Soviet shores of the Far Eastern seas has not been studied at all; we have information only on the size of yearlings, obtained by inverse calculation on the basis of otoliths from adult commercial flatfishes (Vernidub and Panin, 1937; Vernidub, 1936, 1938; Schmidt, 1949, 1949a; Moiseyev, 1946, 1953; Yesipov, 1949b).

The diversity of the flatfish fauna and the significant differences in the biology of the different species make it particularly interesting to study the growth of young Far Eastern flatfishes. The Far Eastern flatfishes studied by us are divided into the following three groups according to spawning time:

1) autumn-winter spawning[1] (October-February) - Atheresthes evermanni, Reinhardtius hippoglossoides matsuurae, Hippoglossus hippoglossus stenolepis, Liopsetta glacialis glacialis; 2) spring-summer spawning (May-June) - Hippoglossoides elassodon, Lepidopsetta bilineata bilineata, Limanda punctatissima punctatissima, Platessa quadrituberculata, Glyptocephalus stelleri; 3) summer-autumn spawn-
(317)
ing (May-August) - Acanthopsetta nadeshnyi, Limanda aspera.

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[1]P.A. Moiseyev (1953) notes that the Kamchatka flounder and Pacific halibut spawn in August; however, first-hand discoveries of eggs and larvae by expeditions of the Institute of Oceanology indicate that these species spawn not earlier than late autumn.

Because of different spawning periods, the development and feeding of the young takes place at different times of the year; by the end of the first year, the young flatfishes of these three groups have different dimensions due to differences in the length of the vegetative season.

Table 2. Distribution of young flatfishes depending on the type of substrate

1 Вид	2 Гравий с галькой	3 Гравий и галька с примесью песка	4 Песок с гравием и галькой	5 Песок	6 Илистый песок	7 Ил алевритовый	8 Ил глинистый
Atheresthes evermanni	—	—	—	6 100,0	—	—	—
Reinhardtius hippoglossoides matsuurae	—	—	—	1 50,0	1 50,0		
Hippoglossus hippoglossus stenolepis	—	—	—	2 100,0	—	—	—
Hippoglossoides elassodon	2 7,7	—	5 19,2	10 38,4	6 23,1	2 7,7	1 3,9
Acanthopsetta nadeshnyi	—	—	1 6,7	8 53,2	5 33,4	1 6,7	—
Lepidopsetta bilineata bilineata	4 21,1	2 10,5	3 15,8	7 36,8	3 15,8	—	—
Limanda aspera	—	1 14,2	—	3 42,9	3 42,9	—	—
Limanda punctatissima proboscidea	—	—	1 20,0	2 40,0	1 20,0	1 20,0	—
Platessa quadrituberculata	—	—	—	1 50,0	1 50,0	—	—
Glyptocephalus stelleri	—	—	—	2 66,7	—	1 33,3	—
Liopsetta glacialis glacialis	—	—	—	1 100,0	—	—	—

Key to table 2: 1 - Species; 2 - Gravel with pebbles; 3 - Gravel and pebbles with the mixture of sand; 4 - Sand with gravel and pebbles; 5 - Sand; 6 - Silty sand; 7 - Silty mud; 8 - Clayey silt

N o t e : Numerator - frequency of occurrence of young flatfish, denominator - their distribution according to the different types of substrate (in %)

Material and Method

The age of young flatfishes is determined on the basis of otoliths. The otoliths of only some of the young fish collected could be

used, as the otoliths in many of the sample fish kept in Formalin for a relatively long time were damaged and found unsuitable for age determination. First, the fat was extracted from the otoliths in ammonium hydroxide (2-3 hours), and then the otoliths were washed with hot water, placed in a drop of glycerin and examined under a microscope. Due to the fact that the form of the otoliths of young flatfishes varies and it is often difficult to distinguish the anterior margin of an otolith from the posterior margin, we measured the diameter of the annuli along the greatest axis when calculating the rate of growth. This was carried out under a microscope with the help of an ocular micrometer.

Table 3. Distribution of young flatfish depending on the near-bottom temperature

Species	(—2)—(—1)°	(—1)—0°	0—(+1)°	1—2°	2—3°	3—4°	4—5°	5—6°	6—7°	7—8°	8—9°	9—10°
Atheresthes evermanni		1 16,7	1 16,7	3 49,9	—	1 16,7	—	—	—	—	—	—
Reinhardtius hippoglossoides matsuurae		1 50,0	—	—	—	—	—	—	—	—	—	1 50,0
Hippoglossus hippoglossus stenolepis		—	1 50,0	—	—	1 50,0	—	—	—	—	—	—
Hippoglossoides elassodon	3 12,0	3 12,0	11 44,0	5 20,0	1 4,0	1 4,0	1 4,0	—	—	—	—	—
Acanthopsetta nadeshnyi	—	2 16,7	4 33,3	3 25,0	1 8,3	2 16,7	—	—	—	—	—	—
Lepidopsetta bilineata bilineata	—	2 14,3	3 21,5	2 14,3	1 7,1	4 28,6	—	—	—	1 7,1	1 7,1	—
Limanda aspera	—	—	2 50,0	1 25,0	—	1 25,0	—	—	—	—	—	—
Limanda punctatissima proboscidea	—	2 40,0	—	1 20,0	—	—	—	—	—	—	2 40,0	—
Glyptocephalus stelleri	1 33,3	—	—	1 33,3	—	—	—	1 33,4	—	—	—	—

N o t e : Numerator - frequency of occurrence of young fish, denominator - their distribution at various temperatures (in %)

Table 4. Distribution of young flatfish depending on the salinity of the near-bottom layer of water

Species	22—23‰	23—27‰	27—28‰	28—30‰	30—31‰	31—32‰	32—33‰	33—34‰	34—35‰
Atheresthes evermanni	—	—	—	—	—	—	2 / 40,0	3 / 60,0	—
Reinhardtius hippoglossoides natsuurae	1 / 50,0	—	—	—	—	—	—	1 / 50,0	—
Hippoglossus hippoglossus stenolepis	—	—	—	—	1 / 50,0	—	1 / 50,0	—	—
Hippoglossoides elassodon	—	—	—	—	—	—	7 / 24,2	21 / 72,3	1 / 3,5
Acanthopsetta nadeshnyi	—	—	—	—	—	—	8 / 66,7	4 / 33,3	—
Lepidopsetta bilineata bilineata	—	—	1 / 7,1	—	1 / 7,1	—	7 / 50,0	5 / 35,8	—
Limanda aspera	—	—	—	—	—	—	4 / 100,0	—	—
Limanda punctatissima proboscidea	—	—	1 / 25,0	—	1 / 25,0	—	1 / 25,0	1 / 25,0	—
Glyptocephalus stelleri	—	—	—	—	—	—	1 / 33,4	2 / 66,6	—

N o t e : Nominator - frequency of occurrence of young fish, denominator - their distribution at different salinities (in %)

Inverse calculation of the growth rate of young flatfishes was carried out by the formula of proportionality. In all, we obtained information about the age and growth rate of eleven species of flatfishes. The volume and composition of the material used for age determination are shown in Appendix II. A total of 905 specimens of young flatfishes was studied.

SPECIAL SECTION

Kamchatka flounder - Atheresthes evermanni (Jordan and Gilbert)

In all, we collected and measured 15 young fish from the waters of Kamchatka (Kambal'ny Bay, Kronotski Gulf), the Commander Islands and the southern Kurile Islands. Age was determined in three young fish 70.5-84.2 mm in length from Kambal'ny Bay of

southeastern Kamchatka, in one 95.8 mm fish from Kronotski Gulf and in three young 48.7-63.9 mm fish caught off the shores of Bering Is. If we take our specimens (5 catches of young fish, see Appendix II) according to size, we get the following picture:

December	48.7; 60.2-63.9 and 75.6 mm
April	70.5-84.2 mm
May	73.2 and 95.8 mm
June	70.1-75.5 mm

(319)

The otoliths of the young caught in December and April showed a large light-coloured nucleus and a dark ring along the margin. The otoliths of the young 95.8 mm fish caught in May showed a large light nucleus, a dark ring, and also a light ring along the margin (Fig. 5).

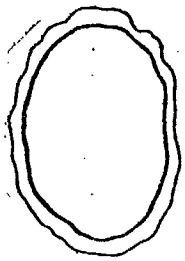

Fig. 5. Diagram of otolith from Atherestes evermanni

Age - 1+, length of young fish (L) - 95.8 mm, L_1=86.7 mm

Kamchatka flounders spawn in late autumn and winter (Vernidub, 1938). On the basis of our examination of otoliths from our study specimens and the available data on the spawning of the Kamchatka flounder in winter, we can say that the young fish caught in December and April (measuring from 48.7 to 84.2 mm in length) were yearlings (1), and the ones caught in May and June (70.1-95.8 mm in length) second-year fish (1+). By calculating the growth rate of the second-year 95.8 mm fish on the basis of its otoliths, we find that its first dark ring formed at a length of 86.7 mm. By combining our results of inverse growth calculation using otoliths with

direct measurements of length, we learn that in the study areas (Kambal'ny Bay, Kronotski Gulf and the waters of Bering Is.), yearlings of the Kamchatka flounder reach a length of 48.7-86.7 mm, and second-year fish 70.1-95.8 mm.

The length of yearlings is 7-11 cm when calculated from the growth rate of an adult Kamchatka flounder (Vernidub, 1938).

Pacific black halibut - Reinhardtius hippoglossoides matsuurae (Jordan and Snyder)

In all, we measured five young 59-64 mm fish caught in Anadyr Gulf in September 1950. Otoliths were taken from one 61.4 mm specimen. No dark rings were observed on the otoliths of this fish. We have no accurate data on the spawning time of the black halibut. Females with ripening eggs at the 4th stage were caught in the Bering Sea in September (Vernidub and Panin, 1937; Andriyashev, 1937); this species apparently spawns in October-December. On the basis of these data and the fact that there was no dark ring on the otoliths of a young 61.4 mm fish, we can say that our 59.0-64.0 mm specimens had lived only one winter, spring and summer, i.e. slightly less than a year.

According to the data of inverse calculation , black halibut yearlings measure 9.4-16.8 cm in the Sea of Okhotsk, and 9.3-13.5 cm in the Bering Sea (Vernidub and Panin, 1937).

Pacific halibut - Hippoglossus hippoglossus stenolepis (Schmidt)

In all, we measured five young fish collected in May and September off the eastern coast of Kamchatka and in October near the entrance to Anadyr Gulf, off Cape Navarin. The fish caught

in autumn (September-October) measured from 34+ to 42 mm in length; one caught in May measured 56 mm. Otoliths for age determination were taken from a young 35+ mm fish caught in October and from a 56 mm one caught in May in Kronotski Gulf. We could not find any distinct dark rings on the otoliths of these fish. Accurate data on the time and place of spawning of the Pacific halibut off the Soviet coast were obtained only recently. The spawning of this species was detected by the USSR Academy of Sciences Institute of Oceanology in December-January in areas southeast of Cape Navarin and south of Cape Goven. An abundance of larvae of the Pacific halibut was encountered in June in Anadyr Gulf, off the Koryak coast and in Olyutorski Gulf. Considering the spawning period of the Pacific halibut, the size of the young specimens and the time at which they were caught, we can say that the 34+ – 42 mm fish caught in September-October were slightly less than a year old, while the 56 mm fish caught in May was slightly older than a year. (321)

Data on the growth of the Pacific halibut are scarce in the literature. According to the data of inverse calculation (Vernidub, 1936), the yearlings of this species reach a length of 8.0-16.0 cm in Olyutorski Gulf, and an average 12.4 cm in the Sea of Okhotsk, off southern Kamchatka (Yesipov, 1949). As we can see from the above data, the growth rate of our specimens was lower than indicated in the literature.

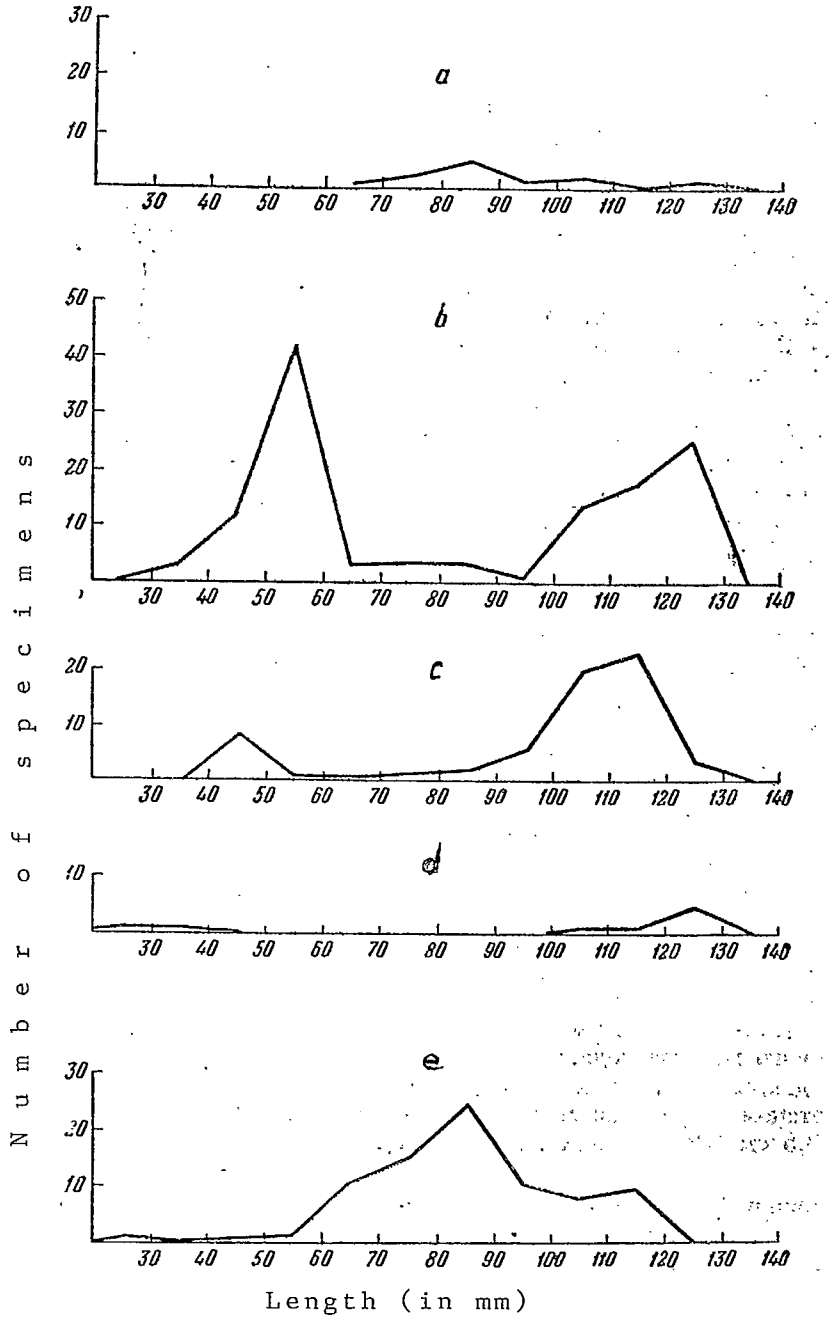

Fig. 6. Size of H. elassodon during different months

a - in April, b - in May, c - in June, d - in August, d - in September. Two specimens measuring 31.0 and 35.3 mm in length were caught in October

Flathead sole - Hippoglossoides elassodon (Jordan and Gilbert)

We measured a total of 244 young specimens of this species, which varied from 25.8 to 129.2 mm in length.

Age was determined in 42 28.3-124.9 mm specimens from the Sea of Okhotsk, in 13 31.0-125.5 mm specimens from the Bering Sea, and in 38 25.8-63.2 mm specimens caught off the eastern coast of Kamchatka.

The largest number of young flathead sole was caught in May, June and September (fig. 6, b, c, e). The size curve for the young fish caught in May (Fig. 6, b) has two well-defined peaks which reflect a predominance of 40-60 mm and 100-130 mm individuals in the catches. The size curve for the fish caught in June (Fig. 6, c) has one well-defined peak which indicates that 100-120 mm individuals predominate in the catches. The size curve for the fish caught in September (fig. 6, e) has only one clearly defined peak which shows that 60-100 mm individuals predominate in the catches; this is definitely the result of the growth of the May 40-60 mm size group of young fish.

The flathead sole spawns in April-May (June) (Rass, 1949). The 20-40 mm size group which appeared in the catches in August-October undoubtedly consisted of fingerlings.

The results of our analysis of otoliths from young fish of this species caught in different fishing areas are given in table 5.

The second-year (1+) fish caught at the end of May also included fairly small individuals measuring 36.8-37.1 mm in length.

Table 5. Length of various age groups of H. elassodon from different fishing areas

Fishing area	Depth (m)	Time of catch	Length (in mm)				n
			fingerlings	1+	2+	3+	
Kambal'ny Bay, SW coast of Kamchatka	73	IV/1951	–	–	82.9	122.7	2
Aniva Gulf (S Sakhalin)	60	V/1952	–	48.7–60.0	72.6–70.0	100.2–118.0	20
Off southeastern coast of Kamchatka, near Cape Lopatka	103–107	V/1952	–	45.7	–	–	1
Avacha Bay	61	V/1952	–	63.2	–	–	1
Kronotski Gulf	41–163	V/1952	–	37.1–58.1	–	–	23
Kamchatka Gulf	33–143	V/1952	–	36.8–57.9	–	110.0	12
Olyutorski Gulf	124–118	VI/1952	–	42.5–48.8	–	–	7
Anadyr Gulf	90	VI/1952	–	42.1	77.3–82.5	–	3
Off western coast of Bering Is.	126	VIII/1950	–	–	–	125.5	1
Off western coast of Kamchatka, between the Moroshechnaya and Icha rivers	80	VIII/1949	–	–	104.1	119.4–124.9	3
Opposite Khmitevsky Peninsula, near 67° N lat	175	VIII/1949	28.3–30.9	–	–	–	2
Near Khmitevsky Peninsula	70	IX/1949	–	58.3	–	95.6–111.2	4
Off western coast of Kamchatka, near Bol'shaya R.	82	IX/1949		75.0	92.9	–	2
Kambal'ny Bay	48	IX/1949	–	67.8–72.0	99.6–115.4	–	9
Near Avacha Bay	120–137	IX/1951	25.8	–	–	–	1
Southeast of Cape Navarin, near 61° N lat	294–268	X/1951	31.0	–	–	–	1
Anadyr Gulf	88–89	X/1951	35.3	–	–	–	1
Variation range	–	–	25.8–35.3	36.8–75.0	72.6–115.4	95.6–125.5	
Total	–	–	–	–	–		93

The otoliths of these fish had one dark ring which was formed (according to Gross, 1947) during their first autumn-winter. Since the flathead sole spawns in April-May (June), the fish measuring 36.8-37.1 mm were apparently exactly a year old from the moment of hatching.

The fingerlings of this species reach a length of 25-35 mm by autumn, as indicated by the three 25.8-35.3 mm fry caught at the end of September and first half of October near the shores of eastern Kamchatka.

The establishment of the first annulus on the otoliths of this species apparently takes place in wintering 30-40 mm fish.

The data presented in table 5 on the length of different age groups of flathead sole and its size curves (Fig. 6, a, b, c, d) bring us to the conclusion that second-year (1+) and fourth-year (3+) fish predominated in our catches in May, fourth-year fish (3+) in June, and second-year fish (1+) in September.

Inverse calculation of the growth rate of flathead sole by the otolith method (Fig. 7) was carried out only for 11 specimens. The results of this calculation are given in table 6.

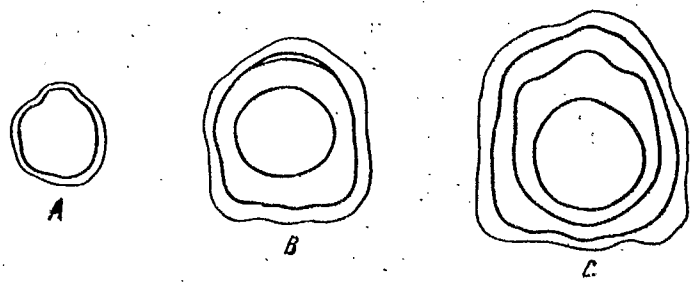

Fig. 7. Diagram of H. elassodon otoliths
A - age - 1+, length of fish (L)=48.7 mm, L_1=44.1 mm; B - age - 2+, length of fish (L)=82.9 mm, L_1=44.0 mm, L_2=73.8 mm; C - age - 3+, length of fish (L)=100.2 mm, L_1=47.7 mm, L_2=78.7 mm, L_3=93.0 mm

(323)

Table 6. Growth rate of young flathead sole (based on data of inverse calculation by otoliths, Fig. 7)

Fishing area	Depth (m)	Time of catch (m, yr)	Length L (mm)	Results of inverse calculation		
				L_1	L_2	L_3
Kambal'ny Bay, south-western coast of Kamchatka	73	IV/1951	82.9	44.0	73.8	–
Aniva Gulf (off S Sakhalin)	60	V/1952	57.7	44.1		–
			72.6	51.8	69.5	–
			100.2	47.7	78.7	93.0
			118.0	52.1	75.4	105.6
			48.7	44.1		
Kronotski Gulf	160–163	V/1952	40.4	34.2	–	–
			48.6	27.6	–	–
Kamchatka Gulf	112–143	V/1952	53.0	41.5	–	–
			57.0	45.1	–	–
Anadyr Gulf	90	VI/1952	77.3	36.2	72.5	–
Variation range	–	–	–	27.6–52.1	69.5–78.7	93.0–105.6

Thus, according to the data of inverse calculation, year-old flathead sole measure from (27.6) 34.2 to 52.1 mm in length, two-year-olds from 69.5 to 78.7 mm, and three-year-olds from 93.0 to 105.6 mm.

Unfortunately, we have no first-hand data on the size of wintering young fish to compare with the data of inverse calculation. We have only the measurements of fingerlings (25.8–35.3 mm), second-year fish (36.8–75.0 mm), third-year fish (72.6–115.4 mm) and fourth-year fish (95.6–125.5 mm).

Due to a lack of material on the age of fish from some of the areas, it is difficult to establish the differences in the growth rate of young flathead sole in the different areas and during

different years; we can only get a rough idea of this. For instance, the young flathead sole in the northern part of the Sea of Okhotsk (Khmitevsky Peninsula) and Bering Sea (Anadyr and Olyutorski gulfs) apparently grow more slowly than those off the coast of southern Sakhalin and Kamchatka, for the June second-year fish (1+) measured42.1-48.8 mm and the September ones 58.3 mm in the first group of areas as compared with 36.8-60.0 mm and 67.8-75.0 mm respectively in the second group of areas (see table 5).

Nadezhny's flounder - Acanthopsetta nadeshnyi (Schmidt)

We measured a total of 137 young specimens of this species, ranging from 23.8 to 128.3 mm in length. Age was determined in 13 77.1-128.3 mm fish from the Sea of Okhotsk, 8 71.6-112.2 mm fish from the Bering Sea, 35 71.5-111.9 mm fish caught off the Pacific coast of eastern Kamchatka, and in two 23.8-30.5 mm fish from Peter the Great Gulf in the Sea of Japan. (324)

Size curves were plotted on the basis of these measurements (Fig. 8). Young fish measuring 70-90 mm predominated in the catches in May, and 80-100 mm fish predominated in April and September.

According to the observations of T.A. Ostroumova, Nadezhny's flounder spawns in June-July.

Data on the age of young Nadezhny's flounder from different fishing areas are presented in Table 7. As we can see from this table and Fig. 8, third-year fish (2+) predominated in our catches in April, May and September.

The growth rate was calculated by means of otoliths in 15 specimens of this species. The results of inverse calculation of the

growth rate by otoliths (Fig. 9) are presented in table 8.

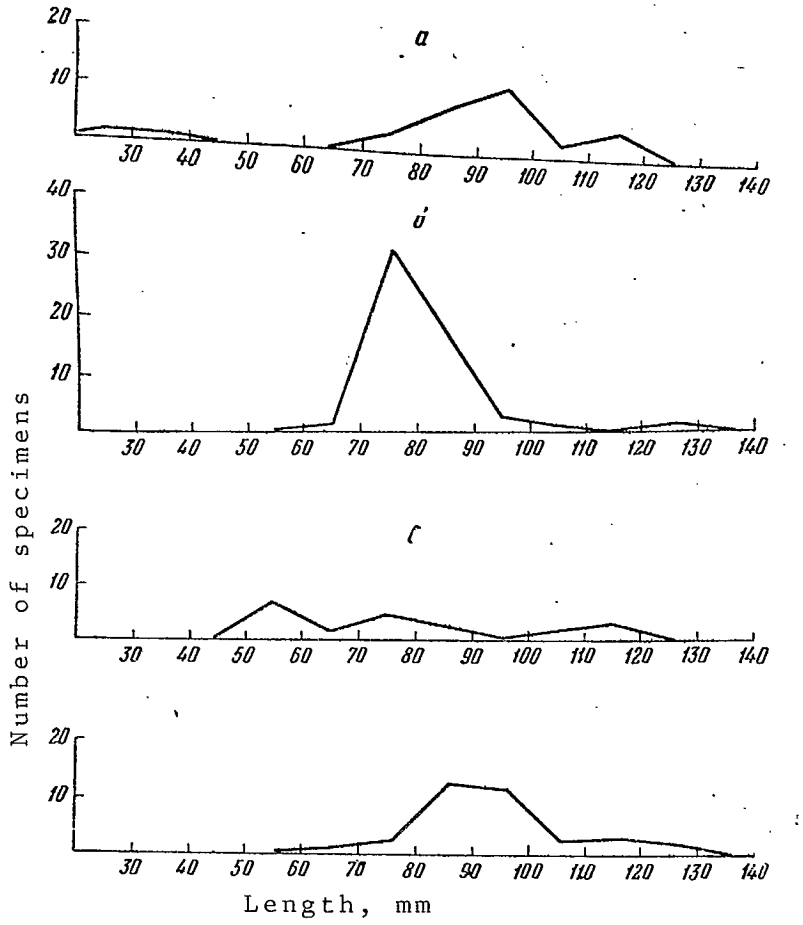

Fig. 8. Size of young Ac. nadeshnyi during different months
a - in April, b - in May, c - in June, d - in September

According to the data of inverse calculation, year-old Nadezhny's flounder measure from 28.4 to 39.6 mm in length, two-year-old fish from 67.3 to 79.0 mm, and three-year-old fish from 95.4 to 110.3 mm. The landing of two 23.8 and 30.5 mm fish in Peter the (326)
Great Gulf in April, i.e. long before the spawning time of this species, indicates that young Nadezhny's flounder may still be very small during their first winter. On the other hand, third-year

fish measured from 71.5 to 99.8 mm, and fourth-year fish from 77.1 to 128.3 mm.

Table 7. Length of different age groups of Ac. nadeshnyi from various fishing area

Fishing area	Depth (m)	Time of catch (m, yr)	Length, mm			n
			1+	2+	3+	
Peter the Great Gulf	–	IV/1950	23.8–30.5	–	–	2
Off western coast of Kamchatka, slightly north of 52° N lat	70	IV/1951	–	–	77.1–119.5	9
Kronotski Gulf	55	IV/1951	–	78.9	111.9	2
Kronotski Gulf	41–73	V/1952	–	71.5–92.2	–	21
Kamchatka Gulf	33	V/1952	–	71.9–93.1	–	12
Olyutorski Gulf	29–48	VI/1952	–	71.6–76.7	98.2–112.2	8
Off western coast of Kamchatka, near Bryumka R.	386	IX/1949	–	–	117.6	1
Off western coast of Kamcnatka, near Bol'shaya R.	82	IX/1949	–	99.8	–	1
Off Khmitevsky Peninsula	70	IX/1949	–	–	115.3–128.3	2
Variation range	–	–	23.8–30.5	71.5–99.8	77.1–128.3	
T o t a l	–	–	–	–	–	58

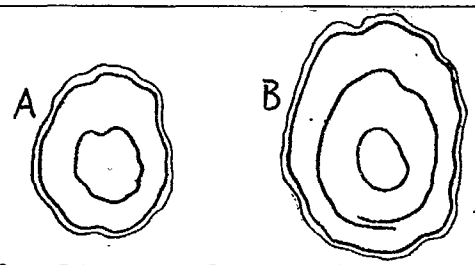

Fig. 9. Diagram of Ac. nadeshnyi otoliths

A – age – 2+, length of young fish (L)=76.7 mm, L_1=34.6 mm, L_2=72.9 mm,
B – age – 3+, length of young fish (L)=112.2 mm, L_1=29.3 mm, L_2=73.9 mm, L_3=108.8 mm

Table 8. Growth rate of young Nadezhny's flounder (based on the data of inverse calculation, Fig. 9)

Fishing area	Depth (m)	Time of catch (m, yr)	Length L (mm)	Results of inverse calculation		
				L_1	L_2	L_3
Kronotski Gulf	55	IV/1951	111.9	37.3	71.7	101.8
Kronotski Gulf	41–73	V/1952	76.1	28.8	68.8	–
			77.6	31.0	72.6	–
			79.6	29.2	76.4	–
Kamchatka Gulf	33	V/1952	71.9	30.1	68.5	–
			80.8	33.9	77.1	–
			82.2	29.6	78.3	–
Olyutorski Gulf	29–48	VI/1952	71.6	36.4	69.6	–
			72.7	39.6	71.1	–
			76.7	34.6	72.9	–
			98.2	36.4	67.3	95.4
			100.3	28.4	73.2	98.1
			107.4	32.2	72.5	102.0
			111.7	32.7	79.0	110.3
			112.2	29.3	73.9	108.8
Variation range	–	–	–	28.4–39.6	67.3–79.0	95.4–110.3

Roughscale sole - Clioderma asperrimum (Schlegel)

We only measured the length of the four young roughscale sole caught in September near Shibotsu Is. (Nemuro Strait), as their otoliths were found to be unsuitable for age determination. These fish measured 41.2–56.6 mm in length, and were apparently fingerlings. The roughscale sole yearlings (1) studied by Japanese scientists (Ishida,Kitakata and Ishigaki, 1952) measured from 60.03 to 76.29 mm.

Northern whitebelly or rock sole - Lepidopsetta bilineata bilineata (Ayres)

In all, we measured 339 young specimens ranging from 24.5 to 129.7 mm in length. Age was determined in 77 young 44.1–127.8 mm fish caught near Paramushir Is. and off the Pacific coast of eastern Kamchatka, as well as in sixty-two 24.5–126.9 mm fish from the

Bering Sea. On the basis of these measurements of young Lep. bilineata bilineata, we plotted size curves (Fig. 10) which show that our catches consisted predominantly of 40-60 and 80-100 mm fish in May, 30-50 and 60-90 mm fish in June, 20-30 and 40-50 mm fish in September, and 40-70 mm fish in December.

According to the literature (Schmidt, 1949), Lep. bilineata bilineata spawns in April-June.

The results of age determination in young fish of this species from various fishing areas are presented in table 9. The fingerlings of this species in Anadyr Gulf reach a length of 25-30 mm by autumn.

The data on the length of various age groups (Table 9) and the size curves (Fig. 10) bring us to the following conclusions:

1) the young fish caught in April are predominantly third-year fish (age group 2+);

2) the young fish caught in May and June belong mainly to age groups 1+ and 2+ (second-year and third-year fish);

3) in September, the young fish consist predominantly of fingerlings and second-year fish (0 and 1+);

4) the young fish caught in December are predominantly two-year-olds (2).

The growth rate (Fig. 11) has been calculated from the otoliths of 60 young specimens of this species (Table 10).

(328)

Therefore, according to the data of inverse calculation, year-old rock sole measure from 26.3 to 53.3 mm in length, two-year-olds from 49.8 to 88.2 mm, three-year-olds from 77.3 to 118.2 mm, and four-year-olds from 97.1 to 123.2 mm.

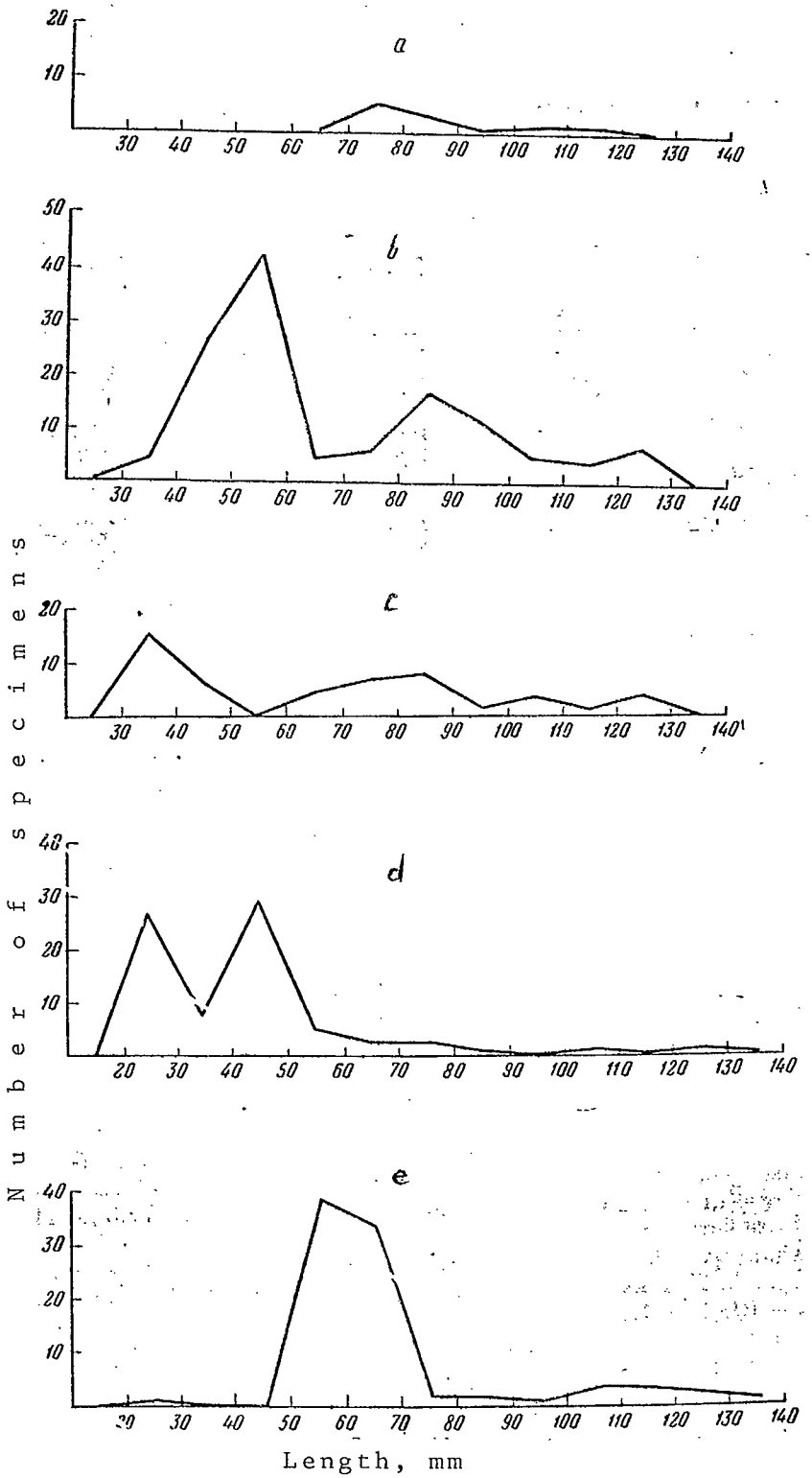

Fig. 10. Size of young Lep. bilineata bilineata during different months: a - in April, b - in May, c - in June, d - in September, e - in December

Table 9. Length of different age groups of young Lep. bilineata bilineata from various fishing areas

Fishing area	Depth (m)	Time of catch (m, yr)	Length (in mm)							n
			fingerlings	1+	2	2+	3	3+	4+	
Kronotski Gulf	55	IV/1951	–	–	–	71.6–86.4	–	99.9–109.7	–	10
Kronotski Gulf	32–90	V/1952	–	44.1–52.8	–	67.1–93.2	–	125.4–129.6	–	25
Kamchatka Gulf	33	V/1952	–	48.6–61.4	–	80.8–105.3	–	124.3	–	30
Near Paramushir Is.	52	V/1952	–	50.5	–	80.3–91.1	–	–	–	4
Off SE coast of Kamchatka, slightly north of Cape Lopatka	70	V/1952	–	–	–	72.1–101.9	–	–	–	8
Olyutorski Gulf	30–48	VI/1952	–	–	–	61.7–84.6	–	86.6–122.6	119.1–126.9	15
Glubokaya Bay, Koryak coast	10	VI/1952	–	35.0–48.8	–	60.5–77.8	–	–	–	21
Off Koryak coast, slightly north of 61° N lat	55	IX/1950	–	47.6	–	68.7–81.1	–	106.0	–	5
Anadyr Gulf	15	IX/1950	24.5–29.1	45.0–45.8	–	55.1	–	–	–	7
Near Bering Is.	64	XII/1952	–	–	50.5–83.2	–	108.1–121.0	–	–	14
Variation range	–	–	24.5–29.1	35.0–61.4	50.5–83.2	55.1–105.3	108.1–121.0	86.6–129.6	119.1–126.9	
Total										139

According to our December measurements of the young, yearlings measured 28.1 mm, two-year-olds 50.5-83.2 mm, and three-year-olds 108.1-121.0 mm. These data more or less coincide.

Judging by Table 10, young rock sole near Paramushir Is. and off the eastern coast of Kamchatka apparently have a more or less similar growth rate (yearlings 33.2-50.1 mm, two-year-olds 64.3-88.2 mm); a somewhat slower growth rate is observed in the young

from Glubokaya Bay (yearlings 30.2-45.4 mm, two-year-olds 54.6-75.7 mm) and Anadyr Gulf (yearlings 35.4-37.9 mm, two-year-olds 49.8 mm).

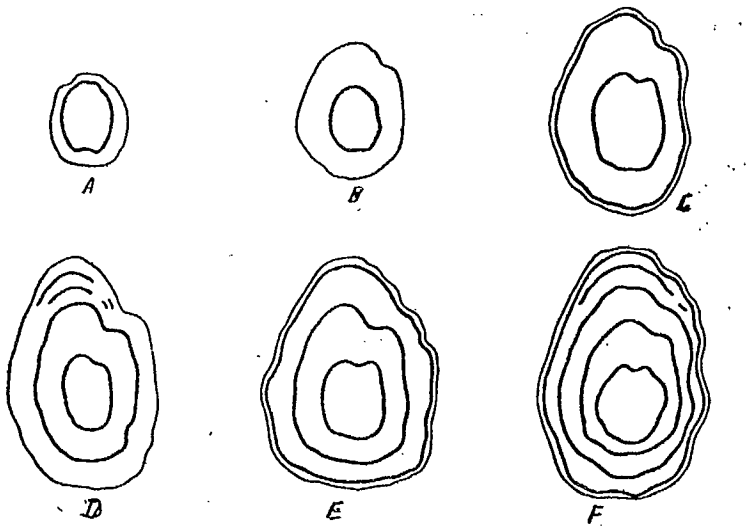

Fig. 11. Diagram of Lep. bilineata bilineata otoliths
A - age - 1+, length of young fish (L)=45.0 mm, L_1=37.9 mm; B - age - 2, length of young fish (L)=62.3 mm, L_1=33.7 mm; C - age - 2+, length of young fish (L)=93.2 mm, L_1=47.8 mm, L_2=88.2 mm; D - age - 3,length of young fish (L)=121.0 mm, L_1=43.2 mm, L_2=86.4 mm; E - age - 3+, length of young fish (L)=122.6 mm, L_1=45.2 mm, L_2=87.6 mm, L_3=118.2 mm; F - age - 4+, length of young fish (L)=126.9 mm, L_1=42.3 mm, L_2=70.5 mm, L_3=101.5 mm, L_4=123.2 mm

(331)

Mochigar flounder or southern whitebelly sole - Lepidopsetta bilineata mochigarei (Snyder)

Our material includes only ten 62.3-68.4 mm specimens of this species, caught in September near Shibotsu Is. (Nemuro Strait). We were unable to determine the age of the young fish due to the fact that the otoliths were damaged. The specimens studied were probably two-year-olds.

Table 10. Growth rate of young Lepidopsetta bilineata bilineata (based on the data of inverse calculation by means of otoliths, Fig. 11)

Fishing area	Depth (m)	Time of catch (m, yr)	L (mm)	Results of calculations			
				L_1	L_2	L_3	L_4
Kronotski Gulf	55	IV 1951	71,6	38,2	66,8	—	—
			75,5	46,8	70,3	—	—
			79,6	43,6	69,3	—	—
			80,5	45,3	75,5	—	—
			81,3	48,8	75,5	—	—
			86,4	48,9	74,8	—	—
			99,9	37,4	69,3	94,3	—
Near Paramushir Is.	52	V 1952	81,7	33,2	70,2	—	—
Off SE coast of Kamchatka, slightly north of Cape Lopatka	70	V 1952	86,5	37,8	67,6	—	—
			90,8	38,3	68,1	—	—
			98,3	39,8	81,0	—	—
Kronotski Gulf	32—90	V 1952	92,3	44,8	87,2	—	—
			78,7	42,4	76,3	—	—
			81,2	45,4	78,8	—	—
			90,6	46,6	88,0	—	—
			93,2	47,8	88,2	—	—
			125,4	47,4	80,8	114,2	—
			126,8	49,1	85,5	115,0	—
			127,8	46,2	84,3	108,8	—
			129,6	50,1	76,6	111,9	—
Kamchatka Gulf	33	V 1952	80,8	41,1	64,3	—	—
			86,9	39,2	67,2	—	—
			95,2	44,9	73,4	—	—
			102,0	47,5	81,0	—	—
			124,3	49,1	87,5	109,8	—
Olyutorski Gulf	29—48	VI 1952	68,7	40,6	64,4	—	—
			61,7	37,0	57,9	—	—
			72,8	40,7	69,1	—	—
			77,9	44,1	74,0	—	—
			80,8	48,5	76,7	—	—
			83,0	44,2	80,0	—	—
			84,6	48,6	80,6	—	—
			86,6	37,3	69,3	81,7	—
			97,6	35,2	67,8	93,5	—
			103,3	43,0	77,4	99,6	—
			111,5	38,6	70,7	106,6	—
			112,0	42,0	81,2	107,8	—
			119,1	40,6	63,6	97,4	113,7
			122,6	45,2	87,6	118,2	
			126,9	42,3	70,5	101,5	123,2
Glubokaya Bay, Koryak coast	10	VI 1952	60,5	30,2	55,8	—	—
			69,5	43,7	65,6	—	—
			77,8	45,4	75,7	—	—
			100,1	34,2	54,6	77,3	97,1

(Table 10 continued)

Fishing area	Depth (m)	Time of catch (m, yr)	L (mm)	Results of calculations L_1	L_2	L_3	L_4
Anadyr Gulf	15	IX 1950	45,0	37,9	—	—	—
			55,1	35,4	49,8	—	—
Near Bering Is.	64	XII 1952	50,5	26,3	—	—	—
			52,8	27,6	—	—	—
			55,1	29,9	—	—	—
			58,2	31,5	—	—	—
			60,1	36,6	—	—	—
			62,3	33,7	—	—	—
			67,8	38,9	—	—	—
			69,8	44,8	—	—	—
			72,4	44,7	—	—	—
			83,2	48,9	—	—	—
			108,1	45,9	78,3	—	—
			114,1	53,3	82,9	—	—
			116,8	50,0	86,2	—	—
			121,0	43,2	86,4	—	—
Variation range	—	—	—	26,3— 53,3	49,8— 88,2	77,3— 118,2	97,1— 123,2

Yellowfin sole - Limanda aspera (Pallas)

We measured a total of 55 specimens from 35.6 to 119.5 mm in length. Age was determined in six 47.0-100.7 mm specimens caught in May in Kamchatka Gulf, and in six 90.8-119.5 mm fry caught in June in Olyutorski Gulf.

Size curves were plotted on the basis of these measurements (Fig. 12). Our catches consisted predominantly of large 100-120 mm fingerlings of this species in June, and of small 30-50 mm ones in September.

According to the literature (Schmidt, 1949a), the yellowfin sole spawns in (May) June—July (August). The results of age determination in young fish are presented in Table 11.

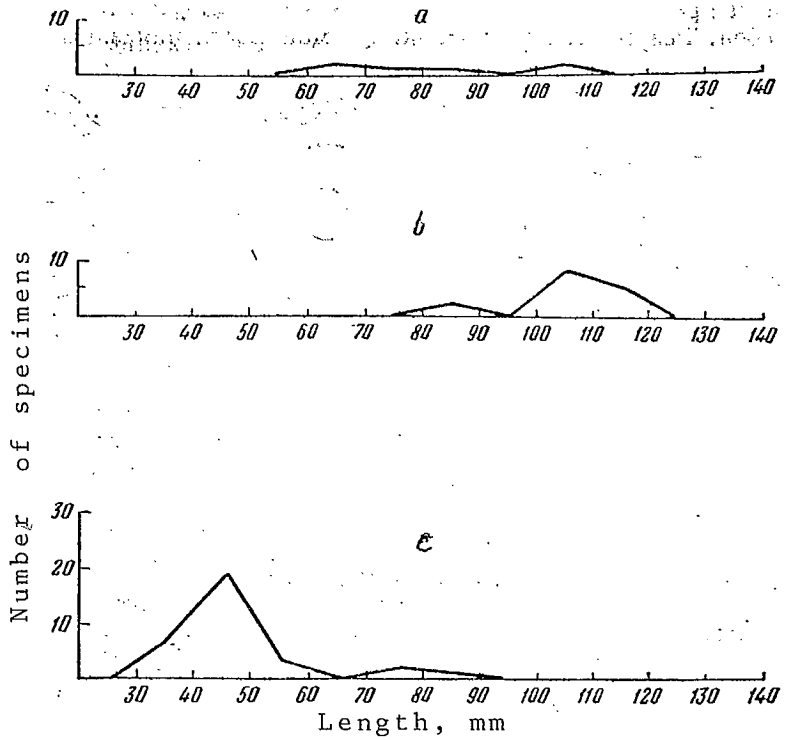

Fig. 12. Size of young L. aspera
a - in May, b - in June, c - in September

Table 11. Length of young Limanda aspera of different age groups

Fishing area	Depth (m)	Time of catch (m, yr)	Length, mm				n
			1+	2+	3+	4+	
Kamchatka Gulf	33	V/1952	47.0	69.1-82.1	100.7	-	6
Olyutorski Gulf	29	VI/1952	-	-	-	90.8-119.5	6
Variation range	-	-	47.0	69.1-82.1	100.7	90.8-119.5	
T o t a l	-	-	-	-	-	-	12

The data in Table 11 permit us to conclude that fifth-year fish (4+) predominated in the catch in June, and fingerlings with a mixture of second-year fish (1+) in September.

Inverse calculation of the growth rate by means of otoliths (Fig. 13) was carried out in 11 specimens. The results of this calculation are given in Table 12.

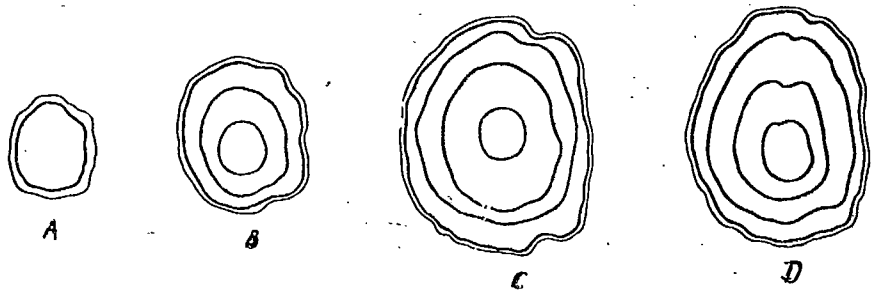

Fig. 13. Diagram of L. aspera otoliths

A - age - 1+, length of young fish (L)=47.0 mm, L_1=41.9 mm; B - age - 2+, length of fish (L) =69.1 mm, L_1=26.1 mm, L_2=66.5 mm; C - age - 3+, length of fish (L)=100.7 mm, L_1=24.0 mm, L_2=66.3 mm, L_3=95.5 mm; D - age - 4+, length of fish (L)=114.2 mm, L_1=31.5 mm, L_2=60.4 mm, L_3=91.9 mm, L_4=110.8 mm

Table 12. Growth rate of young L. aspera (based on the data of inverse calculation by means of otoliths, Fig. 13)

Fishing area	Depth (m)	Time of catch (m, yr)	Length L (mm)	Results of calculation			
				L_1	L_2	L_3	L_4
Kamchatka Gulf	33	V/1952	47.0	41.9	–	–	–
			69.1	26.1	66.5	–	–
			71.4	30.9	69.1	–	–
			82.1	38.9	80.7	–	–
			100.7	24.0	66.3	99.5	–
Olyutorski Gulf	29	VI/1952	90.8	20.7	41.5	75.2	88.2
			108.6	27.8	60.9	84.7	105.1
			110.1	28.1	58.7	90.5	108.1
			110.2	21.5	48.4	94.1	106.1
			114.2	31.5	60.4	91.9	110.8
			119.5	29.8	54.8	87.1	115.6
Variation range	–	–	–	20.7–41.9	41.5–80.7	75.2–99.5	88.2–115.6

(333)

Thus, according to the data of inverse calculation, a one-year-old yellowfin sole measures from 20.7 to 41.9 mm in length, a two-year-old from 41.5 to 80.7 mm, a three-year-old from 75.2 to 99.5 mm, and a four-year-old from 88.2 to 115.6 mm.

Judging by Table 12, the young of the yellowfin sole in Kamchatka Gulf most likely grow better than in Olyutorski Gulf, for the yearlings in Kamchatka Gulf reach a length of 24.0-41.9 mm, while those in Olyutorski Gulf grow to 20.1-31.5 mm. According to the data of P.A Moiseyev (1946), the young of L. aspera from Peter the Great Gulf grow as follows (based on inverse calculation):

Age (years)	1	2	3	4
Size of males (cm)	6.3	12.2	18.3	22.3
Size of females (cm)	6.9	12.6	18.4	23.5

The growth of young L. aspera from different areas of the Far Eastern seas is shown in Table 13 (based on the literature).

Table 13. Size of different age groups of Limanda aspera from various areas of the Far Eastern seas (in cm)*

Age (years)	Peter the Great Gulf (after Demidova)		Tatar Strait (after Somova)		Western Kamchatka (after Krivobok)	
	♂	♀	♂	♀	♂	♀
2	24.98	17.00	13.0	-	8.0	8.0
3	20.18	22.26	15.0	-	12.7	13.5
4	23.38	24.92	17.02	-	17.0	17.6

*Table taken from Moiseyev's paper (1946)

From all the data presented here, we can see that the young of the yellowfin sole off the Pacific coast of eastern Kamchatka, and especially along the Bering Sea coast, grow at a much slower rate than in Peter the Great Gulf, the Tatar Strait and off the coast of W Kamchatka. This is most likely due to less favourable feeding and hydrologic conditions. This decrease in the growth rate of the yellowfin sole as we move northward is also noted by P.A. Moiseyev (1946) who writes, "It appears that the growth rate of the yellowfin sole diminishes towards the north, in the region of more severe hydrologic conditions".

Northern longsnout flounder - Limanda punctatissima proboscidea (Gilbert)

We measured a total of 15 young fish of this species, which varied from 35.9 to 125.7 mm in length; they were caught in Olyutorski Gulf in June (one fingerling measuring 53.3 mm in length), and off the coast of Sakhalin (13 35.9-66.0 mm fish) and in Anadyr Gulf (one 125.7 mm specimen) in September. Age was determined in the 125.7 mm specimen. The size curve for the September young of L. p. proboscidea is given in Fig. 14. Our September specimens consisted mainly of 30-40 mm fry.

The literature contains no data on the spawning time of L. p. proboscidea However, this information is available on a similar (334)
subspecies, Limanda punctatissima punctatissima. In Peter the Great Gulf, this subspecies spawns in May or the beginning of June (Schmidt, 1949b). In all probability, L. p. proboscidea spawns at approximately the same time. Analysis of otoliths from the 125.7 mm specimen placed its age at 3+. The fish caught in June (53.3 mm) was apparently a second-year fish (1+), and the September specimens were predominantly underyearlings.

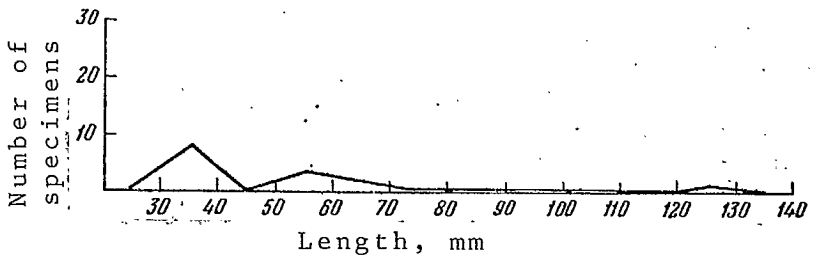

Fig. 14. Size of young L. punctatissima proboscidea in September

Southern longsnout flounder - Limanda punctatissima punctatissima (Steindachner)

We studied three 45.9-54.0 mm specimens of this species, caught in October in Posyet Bay of the Sea of Japan. The age of these fry was not determined due to damaged otoliths. Judging by their length and the spawning time of this flounder (May-June), these specimens were yearlings.

Yokohama flounder - Pseudopleuronectes yokohamae (Cünther)

We could only measure the length of the five young Yokohama flounder caught near Shikotan Island in September and in Posyet Bay in October, as the otoliths were found to be unsuitable for age determination. The young fish caught in September varied from 53.1 to 67.4 mm, while those caught in October measured 43.4-62.0 mm. These specimens were apparently yearlings. According to the Japanese scientist S. Okubo (1952), yearlings of the Yokohama flounder reach a length of 57.4-99.7 mm in Lake Notoro.

Alaska plaice - Platessa quadrituberculata (Pallas)

We measured only two 58.0 and 87.2 mm fry caught in June in Olyutorski Gulf and Glubokaya Bay on the Koryak coast. Age was determined in the 87.2 mm specimen from Glubokaya Bay on the Koryak coast. According to the literature (Schmidt, 1949c), this species spawns in March-April (May). The age of the 87.2 mm specimen was determined as 2+, and that of the 58 mm one as probably 1+.

Slime flounder - Microstomus achne (Iordan et Srarks)

Our material includes only one 79.8 mm specimen of this species, caught in September near Shibotsu Isand (Nemuro Strait).

The age of this specimen was not determined, as its otoliths were found to be damaged. This specimen was apparently a second-year fish.

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Steller's smallmouth flounder - Glyptocephalus stelleri (Schmidt)

In all, we measured six 50.1-97.8 mm fry caught in May and September in Kambal'ny Bay and off the southern point of Sakhalin. Age was determined in three 72.4-97.8 mm specimens caught in May off the southern shore of Sakhalin (Aniva Gulf).

According to the literature (Rass, 1949a), Glyptocephalus stelleri spawns in May. The fry in which otoliths had been taken for age determination proved to be second-year fish (1+). Apparently, the specimens caught in September (50.1-64.2 mm in length) were underyearlings, and the one caught in May (93.6 mm) was a second-year fish.

The otoliths (Fig. 15) taken for age determination were also used to calculate the rate of growth (Table 14).

According to Japanese data (Inshida, Kitakata, 1953), the second-year specimens caught in June-July measured 63.0-76.0 mm in length.

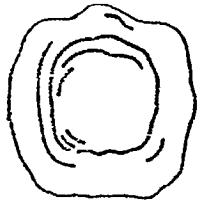

Fig. 15. Diagram of Gl. stelleri otolith
Age - 1+, length of fish (L)=97.8 mm, L_1=63.3 mm

Table 14. Growth rate of young Glyptocephalus stelleri (based on the data of inverse calculation by means of otoliths, Fig. 15)

Fishing area	Time of catch (m, yr)	Length L (mm)	Results of calculations
Aniva Gulf (off S Sakhalin)	V/1952	72.4 93.1 97.8	40.5 69.8 63.3

Eel-back flounder - Liopsetta glacialis glacialis (Pallas)

In all, we measured four 116.6-121.9 mm specimens caught in September in the Anadyr Estuary. Age was determined in three of the specimens (116.6-121.9 mm in length). According to the literature (Yesipov, 1949b), this subspecies spawns in January-February.

A study of otoliths from these specimens showed that the two measuring 116.6-118.2 mm in length were fourth-year fish (3+), and the 121.9 mm specimen was a fifth-year fish (4+).

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The results of inverse calculation of growth rate by the otolith method (Fig. 16) for the two young eel-back flounder measuring 116.6 and 118.2 mm in length are given in Table 15.

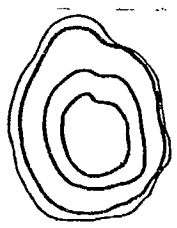

Fig. 16. Diagram of otolith from Liopsetta glacialis glacialis

Age - 3+, length of fish (L)=118.8 mm, L_1=52.5 mm, L_2=75.5 mm, L_3=118.(?) mm

Other published data on the growth of young eel-back flounder from other areas (Yesipov, 1949b) are given in Table 16.

As we can see from tables 15 and 16, the eel-back flounder in the Anadyr Estuary grows much more slowly than in the White and Barents seas.

Table 15. Growth rate of young Liopsetta glacialis glacialis (based on data of inverse calculation by means of otoliths, Fig. 16)

Fishing area	Time of catch (m, yr)	Length L (mm)	Results of calculations		
			L_1	L_2	L_3
Anadyr Estuary, near the shore	IX/1950	116.6	84.9	56.1	109.4
		118.8	52.5	75.5	110.0

Table 16. Growth rate of young Liopsetta glacialis glacialis according to the literature (Yesipov, 1949b) (Average absolute length, in cm)

Age (years)	White Sea, Dvina Bay	Chesha Bay	Kolguyev Is.
1	10.2-10.5	6.5	-
2	12.1-12.9	10.1	-
3	13.8-15.4	14.2	15.6

COMPARATIVE NOTES

Comparison of growth in the young of different species of flatfishes

The growth rate in the young of the species studied by us is compared in Table 17.

As we can see from this table, the largest yearlings are found in the flatfishes that spawn in autumn-winter (Atheresthes evermanni, Liopsetta glacialis glacialis), and the small yearlings in those that spawn in summer-autumn (Ac. nadeshnyi, L. aspera); an intermediate position regarding size is occupied by the yearlings of flatfishes that spawn in spring-summer (H. elassodon, L. bilineata

bilineata[1]. From the second year, the young of the species studied grow at a more or less equal rate.

Only L. aspera has a slightly lower growth rate in comparison with the other species. Its slower rate of growth is apparently due to the fact that the bulk of the material on this species was obtained from areas with unfavourable hydrologic conditions.

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Comparison of the growth rate in the young of the studed species of flatfishes with that of the young of similar species from other bodies of water

The literature contains almost no data on the growth rate in the young of similar species of flatfishes from other water bodies. We have only some data (Yesipov, 1949a) on the growth of Hippoglossoides plattessoides limandoides which is similar to Hippoglossoides elassodon (Table 18).

Table 18. Growth of Hippoglossoides plattessoides limandoides in the Barents Sea

Age (years)	Absolute average length (in cm)	
	♂	♀
1	9.0	13.0
2	14.6	14.7
4	20.0	20.4

As we can see from tables 17 and 18, the young of H. elassodon have a lower growth rate than the young of H. plattessoides limandoides.

[1] The large dimensions of the yearlings of Gl. stelleri, which spawns in May, are apparently due to the more favourable conditions in the areas where they were caught (Aniva Gulf).

Table 17. Growth rate of various species of flatfishes

Species	L_1		L_2		L_3		L_4	
	average	variation	average	variation	average	variation	average	variation
Atheresthes evermanni	71,3 (o) 86,7 (c) *	48,7—84,2 (o) 70,0— —110,0(l) **	—	—	—	—	—	—
Hippoglossoides elassodon	42,6 (c)	(27,6) 34,2— 52,1 (c)	74,0 (c)	69,5—78,7 (c)	99,3 (c)	93,0—105,6 (c)	—	—
Acanthopsetta nadeshnyi	32,6 (c)	28,4—39,6 (c)	72,8 (c)	67,3—79,0 (c)	102,7 (c)	95,4—110,3 (c)	—	—
Lepidopsetta bilineata bilineata	28,1 (o) * 41,7 (c)	26,3—53,3 (c)	63,2 (o) 72,9 (c)	50,5—83,2 (o) 49,8—88,2 (c)	115,0 (o) 102,5 (c)	108,1—121,0 (o) 77,3—118,2 (c)	111,3 (c)	97,1—123,2 (c)
Limanda aspera	29,2 (c) 63,0—69,0 (l) ***	20,7—38,9 (c)	60,7 (c) 80,0—249,8 (l) ***	41,5—80,7 (c)	89,0 (c) 127—0— —222,6 (l) ***	75,2—99,5 (c)	105,6 (c) 170,0—249,2 (l) ***	88,2—115,6 (c)
Glyptocephalus stelleri	57,8 (c)	40,5—69,8 (c) 63,0—76,0 (l) **	—	—	—	—	—	—
Liopsetta glacialis glacialis	54,3 (c) 65,0—105,0 (l) ***	52,5—56,1 (c)	80,2 (c) 101,0—129,0 (l) ***	75,5—84,9 (c)	109,7 (c) 138,0—156,0 (l) ***	109,4—110,0 (c)	—	—

*One specimen studied

**Combined data of various authors without an indication of the mean value.

***Range of mean values according to to different authors.

Note: Letters in brackets denote data of inverse calculation (c), observation data (o) and data from the literature (l)

Growth rate of young flatfishes in different areas

The material available on the age and growth of young A. evermanni, R. hippoglossoides matsuurae, H. hippoglossus stenolepis, L. punctatissima proboscidea, Pl. quadrituberculata, Gl. stelleri and L. glacialis glacialis is very insignificant, and so tables 19-22 contain comparative data on the growth rate of only young H. elassodon, Ac. nadeshnyi, L. bilineata bilineata and L. aspera in different areas.

Table 19. Growth rate of young H. elassodon from different fishing areas (in mm)

Fishing area	L_1		L_2		L_3		n
	mean	variation	mean	variation	mean	variation	
Sea of Okhotsk							
Aniva Gulf (off S Sakhalin)	47.9	44.1-51.8	74.5	69.5-78.7	99.3	99.0-105.6	5
Pacific Ocean off eastern coast of Kamchatka							
Kronotski and Kamchatka gulfs	37.1	27.6-45.1	-	-	-	-	4

Table 19 indicates that the young of the flathead sole off the coast of eastern Kamchatka most likely have a lower growth rate than those found off the coast of S Sakhalin.

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As we can see from Table 20, the growth rate of young Ac. nadeshnyi off the eastern coast of Kamchatka (From Kronotski Gulf to Olyutorski Gulf) is almost the same.

Table 21 indicates that there are no marked differences in the growth rate of young L. bilineata bilineata off the coast of eastern Kamchatka and near Bering Is.; the growth of the young of this species apparently slows down as we move northward (in Glubokaya Bay on the Koryak coast, and in Anadyr Gulf).

Table 20. Growth rate of young Ac. nadeshnyi from different fishing areas (in mm)

Fishing area	L_1		L_2		L_3		n
	mean	variation	mean	variation	mean	variation	
Pacific Ocean off eastern coast of Kamchatka							
Kronotski and Kamchatka gulfs	31.4	28.8–37.3	73.3	68.5–78.3	–	101.8	7
Bering Sea							
Olyutorski Gulf	33.7	28.4–39.6	72.4	67.3–79.0	102.9	95.4–110.3	8

Table 21. Growth rate of young Lepidopsetta bilineata from different fishing areas (in mm)

Fishing area	L_1		L_2		L_3		L_4		n
	mean	variation	mean	variation	mean	variation	mean	variation	
Pacific Ocean off eastern coast of Kamchatka									
Kronotski Gulf	45.5	37.4–50.1	77.9	66.8–88.2	109.0	94.3–115.0	–	–	16
Kamchatka Gulf	44.4	39.2–49.1	74.7	64.3–87.5	–	109.8	–	–	5
Bering Sea									
Near Bering Is.	39.7	26.3–53.3	83.4	78.3–86.4	–	–	–	–	14
Olyutorski Gulf	41.9	35.2–48.6	72.7	57.9–87.6	98.5	81.7–118.2	118.3	113.7–123.2	15
Glubokaya Bay of the Koryak coast	38.4	30.2–45.4	62.9	55.8–75.7	–	77.3	–	97.1	4
Anadyr Gulf	36.6	35.4–37.9	–	49.8–	–	–	–	–	2

Judging by Table 22, the young of L. aspera in Olyutorski Gulf have a lower growth rate than in Kamchatka Gulf.

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Table 22. Growth rate of young Limanda aspera from different fishing areas (in mm)

Fishing area	L_1		L_2		L_3		L_4		n
	mean	variation	mean	variation	mean	variation	mean	variation	
				Pacific Ocean					
Kamchatka Gulf	32.9	24.0–41.9	70.7	66.3–80.7	–	99.5	–	–	5
				Bering Sea					
Olyutorski Gulf	26.6	20.7–31.5	54.1	41.5–60.9	87.2	75.2–91.9	105.6	88.2–115.6	6

CONCLUSIONS

1. The young of the majority of species of flatfishes are encountered predominantly at depths of less than 100 m, on sandy bottoms, at a near-bottom temperature of 0-2°C and salinity of 32.0-34.0‰.

2. The young of the flathead sole (H. elassodon) off the coast of eastern Kamchatka have a lower growth rate than those off the shores of southern Sakhalin.

3. The growth rate of young Ac. nadeshnyi in different areas along the eastern coast of Kamchatka hardly differs.

4. The young of the rock sole (Lep. bilineata bilineata) off the coast of eastern Kamchatka and near Bering Is. have the same growth rate, whereas the young of this species in the north (in Glubokaya Bay on the Koryak coast and in Anadyr Gulf) apparently grow more slowly.

5. The young of the yellowfin sole (L. aspera) in Olyutorski Gulf have a lower growth rate than in Kamchatka Gulf. Perhaps this is due to the greater intensity of fishing in Kamchatka Gulf.

6. The dimensions of flatfish yearlings depend (mainly) on the hatching time of this or that species. The yearlings of autumn-winter spawning flatfishes are larger than those of summer-autumn spawning ones. The growth rate of the young of the species studied becomes more or less similar beginning with the second year.

Appendix I. Feeding areas of young Far Eastern flatfishes

Species	Feeding areas of the young
Kamchatka flounder (*Atheresthes evermanni*)	Kambal'ny Bay Kronotski Gulf Waters around Bering Is. Nemuro Strait
Pacific black halibut (*Reinhardtius hippoglossoides matsuurae*)	Anadyr Gulf
Pacific halibut (*Hippoglossus hippoglossus stenolepis*)	Kronotski Gulf Avacha Bay Gavriil Bay
Flathead sole (*Hippoglossoides elassodon*)	Sakhalin Gulf Terpeniye Gulf Aniva Gulf Off Khmitevsky Peninsula Off western coast of Kamchatka (from Cape Lopatka to Moroshechnaya R.) Off eastern coast of Kamchatka (from Avacha Bay to Olyutorski Gulf) Off northwestern coast of Bering Is. near Cape Navarin Anadyr Gulf
Nadezhny's flounder (*Acanthopsetta nadeshnyi*)	Peter the Great Gulf Sakhalin Gulf Off eastern coast of S Sakhalin Nemuro Strait Off Khmitevsky Peninsula Off western coast of Kamchatka (from Bol'shaya R. to Moroshechnaya R.) Off estern coast of Kamchatka (from Kronotski Gulf to Olyutorski Gulf)

(continuation of Appendix I)

Species	Feeding areas of the young
Roughscale sole (*Clioderma asperrimum*)	Nemuro Strait
Rock sole (*Lepidopsetta bilineata bilineata*)	Off Paramushir Is. Off northwestern tip of Bering Is. Off eastern coast of Kamchatka Off Koryak coast Gavriil Bay Anadyr Gulf
Mochigar flounder (*Lepidopsetta bilineata mochigarei*)	Nemuro Strait
Yellowfin sole (*Limanda aspera*)	Sakhalin Gulf Off eastern coast of S Sakhalin Kamchatka Gulf Olyutorski Gulf
Northern longsnout flounder (*Limanda punctatissima proboscidea*)	Sakhalin Gulf Off northern tip of Sakhalin Off eastern coast of N Sakhalin Olyutorski Gulf Anadyr Gulf
Southern longsnout flounder (*Limanda punctatissima punctatissima*)	Posyet Bay
Yokohama flounder (*Pseudopleuronectes yokohamae*)	Posyet Bay Off Shibotsu Is. (Nemuro Strait)
Alaska plaice (*Platessa quadrituberculata*)	Glubokaya Bay (Koryak coast) Olyutorski Gulf Off Cape Grozny
Slime flounder (*Microstomus achne*)	Off Shibotsu Is.
Steller's smallmouth flounder (*Glyptocephalus stelleri*)	Aniva Gulf Off Cape Aniva Kambal'ny Bay
Eel-back flounder (*Liopsetta glacialis glacialis*)	Anadyr Estuary

Appendix II. Number of young flatfishes used for determining age and growth rate

Time of sampling	Area of sampling	Size of specimens (in mm)	No. of specimens in which age was determined	No. of specimens in which growth rate was calculated	No. of specimens in which length was measured
		Atheresthes evermanni			
April	Kambal'ny Bay, southwestern Kamchatka	70.5–84.2	3	1	6
May	Same location	73.2	–	–	1
"	Kronotski Gulf	95.8	1	1	1
June	Nemuro Strait	70.1–75.5	–	–	2
December	Off northern tip of Bering Is.	48.7–63.9	3	–	4
"	Off southern tip of Bering Is.	75.6	–	–	1
		Reinhardtius hippoglossoides matsuurae			
September	Anadyr Gulf	59.0–64.0	1	–	5
		Hippoglossus hippoglossus stenolepis			
May	Kronotski Gulf	56.0	1	–	1
September	Near Avacha Bay	41.9	–	–	1
October	Gavriil Bay (near Cape Navarin)	34.0+–42.0	1	–	3
		Hippoglossoides elassodon			
January	Southeast of Cape Navarin, near 61°N lat	125.0	–	–	1
April	Kambal'ny Bay	76.7–125.3	2	1	12
May	" "	59.8–127.4	–	–	51
"	Off southern Sakhalin (Aniva Gulf)	48.7–120.0	20	5	26
"	Off southwestern coast of Kamchatka near 155°E long	119.7–129.2	–	–	9
"	Off western coast of Kamchatka hear Bol'shaya River	48.5–125.9	–	–	2
"	Off southeastern Kamchatka	45.7–65.2	1	–	2
"	Avacha Bay	63.2	1	–	1
"	Kronotski Gulf	37.1–58.1	23	2	24
"	Kamchatka Gulf	36.8–110.0	12	2	14

(continuation of Appendix II)

Time of sampling	Area of sampling	Size of specimens (in mm)	No of specimens in which		
			age was determined	growth rate was calculated	length was measured
June	Anadyr Gulf	42.1-82.5	3	1	3
"	Olyutorski Gulf	42.5-48.8	7	-	7
"	Kronotski Gulf	83.8-129.0	-	-	54
August	Off western coast of Kamchatka between Moroshechnaya and Icha rivers	104.1-126.6	3	-	6
"	Opposite Khmitevsky Peninsula near 67°N lat	28.3-30.9	-	-	2
"	Off northwestern coast of Bering Is.	125.5	1	-	1
September	Terpeniye Gulf, southern Sakhalin	63.0-96.2	-	-	39
"	Sakhalin Gulf	56.3	-	-	1
"	Off Khmitevsky Peninsula	49.0-111.2	4	-	15
"	Off western coast of Kamchatka near Bryumka R.	96.7	-	-	1
"	Off western coast of Kamchatka near Bol'shaya R.	67.1-92.9	2	-	3
"	Kambal'ny Bay	67.8-120.0	9	-	21
"	Near Avacha Bay	25.8	-	-	1
October	Southeast of Cape Navarin, near 61°N lat	31.0	-	-	1
"	Anadyr Gulf	35.3	-	-	1
		Acanthopsetta nadeshnyi			
April	Off western coast of Kamchatka, slightly north of 52°N lat	77.1-120.2	9	-	28
"	Kronotski Gulf	78.9-111.9	2	1	2
"	Peter the Great Gulf	23.8-30.5	-	-	2
May	Kronotski Gulf	71.2-92.2	21	3	40
"	Off western coast of Kamchatka near Bol'shaya R.	99.8-122.1	1	-	2
"	Kamchatka Gulf	71.9-93.1	12	3	12
June	Nemuro Strait	51.7-62.5	-	-	7
"	Olyutorski Gulf	71.6-113.3	8	8	10

(continuation of Appendix II)

Time of sampling	Area of sampling	Size of specimens (in mm)	No. of specimens in which age was determined	growth rate was calculated	length was measured
August	Off western coast of Kamchatka between Moroshechnaya and Icha rivers	125.1	-	-	1
September	Off Khmitevsky Peninsula	105.2-128.3	2	-	5
"	Sakhalin Gulf	65.8-86.6	-	-	4
"	Off western coast of Kamchatka between Krutogorova and Icha rivers	95.4-101.8	-	-	2
"	Off western coast of Kamchatka near Bol'shaya R.	99.8	1	-	1
"	Off western coast of Kamchatka near Bryumka R.	117.6	-	-	1
"	Off eastern coast of S Sakhalin	73.9-98.6	-	-	20
	Clioderma asperrimum				
September	Off Shibotsu Is. (Nemuro Strait)	41.2-56.6	-	-	4
	Lepidopsetta bilineata bilineata				
April	Kronotski Gulf	71.6-117.6	10	7	11
May	Off Paramushir Is.	50.5-91.1	4	1	4
"	Off southeastern coast of Kamchatka	72.1-101.9	8	3	8
"	Kronotski Gulf	33.8-129.6	25	9	32
"	Kamchatka Gulf	46.4-124.3	30	5	61
June	Glubokaya Bay, Koryak coast	34.7-100.8	21	4	25
"	Olyutorski Gulf	40.4-127.6	15	15	27
September	Olyutorski Gulf	129.7	-	-	1
"	Off Koryak coast, slightly north of 61°N lat	38.0-106.0	5	-	23
"	Anadyr Gulf	24.5-72.3	7	2	59
October	Gavriil Bay (off Cape Navarin)	24.3-44.5	-	-	10
December	Off northwestern tip of Bering Is.	28.1-121.0	14	14	78
	Lepidopsetta bilineata mochigarei				
September	Off Shibotsu Is. (Nemuro Strait)	62.3-68.4	-	-	10

(continuation of Appendix II)

Time of sampling	Area of sampling	Size of specimens (in mm)	No. of specimens in which age was determined	growth rate was calculated	length was measured
		Limanda aspera			
May	Kamchatka Gulf	47.0-110.1	6	5	10
June	Olyutorski Gulf	85.4-119.5	6	6	15
September	Sakhalin Gulf	39.2-46.3	-	-	11
"	Off eastern coast of S Sakhalin	35.6-80.1	-	-	22
		Limanda punctatissima proboscidea			
June	Olyutorski Gulf	53.3	-	-	1
September	Sakhalin Gulf	35.9-36.8	-	-	10
"	Off northern tip of Sakhalin	38.1-39.5	-	-	2
"	Off eastern coast of N Sakhalin	66.0	-	-	1
"	Anadyr Gulf	125.7	1	-	1
		Limanda punctatissima punctatissima			
October	Posyet Bay of the Sea of Japan	45.9-54.0	-	-	3
		Pseudopleuronectes yokohamae			
September	Off Shikotan Is. (Nemuro Strait	53.1-67.4	-	-	3
October	Posyet Bay of the Sea of Japan	43.4-62.0	-	-	3
		Platessa quadrituberculata			
June	Glubokaya Bay , Koryak coast	87.2	1	-	1
"	Olyutorski Gulf	58.0	-	-	1
		Microstomus achne			
September	Off Shibotsu Is. (Nemuro Strait)	79.8	-	-	1
		Glyptocephalus stelleri			
May	Off S Sakhalin (Aniva Gulf)	73.0-97.8	3	3	3
"	Kambal'ny Bay	93.6	-	-	1
September	Kambal'ny Bay	64.2	-	-	1
"	Off southern tip of Sakhalin, near Cape Aniva	50.1	-	-	1

(continuation of Appendix II)

Time of sampling	Area of sampling	Size of specimens (in mm)	No. of specimens in which		
			age was determined	growth rate was calculated	length was measured
		Liopsetta glacialis glacialis			
September	Anadyr Estuary	116.6-129.9	3	2	4
	T o t a l	-	313	104	905

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