ISSN 0032-9452, Journal of Ichthyology, 2016, Vol. 56, No. 6, pp. 868–889. © Pleiades Publishing, Ltd., 2016.
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Biological features of the Common Fish Species in Olyutorsky-Navarin Region and the Adjacent Waters of the Bering Sea: 1. Gadidae (Cods) Family

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Received January 29, 2016

Abstract—Biological features of the three common fish species, pollock *Theragra chalcogramma,* Pacific cod *Gadus macrocephalus*, and saffron cod *Eleginus gracilis* (Gadidae), have been studied using a 20-year dataset (1995–2015). These species inhabit the northwestern Bering Sea in the summer–autumn period and form the schoolings in Olyutorsky-Navarin region. The size–age parameters, as well as the peculiarities of the body length and body weight dynamics, spawning periods, spawning range, and conditions, of the fish caught by different sampling gear have been analyzed. Due to the construction peculiarities and catch efficiency of the different catching gear, the largest specimens are found in the setlines and snurrevads; the fish caught by the trawls are characterized by the smallest size. The body length and body weight of pollock is greater in the pelagic trawl catches compared to the bottom trawl catches. The abundant brood of Gadidae may well be tracked on the multiyear dynamics graphs reflecting the size distribution, as well as by the decrease of biological parameters of the fish. The studied species inhabit the vast growth areas, so smaller body size of them in the coastal waters may be a result of a high ratio of the young specimens there.

Keywords: Gadidae, pollock *Theragra chalcogramma*, Pacific cod *Gadus macrocephalus*, saffron cod *Eleginus gracilis*, biology, Olyutorsky-Navarin region, the Bering Sea

DOI: 10.1134/S0032945216050039

INTRODUCTION

The northwestern Bering Sea is characterized by less knowledge about its marine hydrobionts compared to the southern areas due to its farness from the industrial centers of the Far East region of Russia. In addition, harsh climate conditions and the absence of the bays convenient for the fleet location also decreased the interest paid to this area by the fishermen in the past, and so the exploitation of the fish resources was weak. Analyzing a significant number of publications (Andriashev, 1937, 1939, 1954; Moiseev, 1953; Fadeev, 1971, 1987; Novikov, 1974; Shuntov et al., 1993; Borets, 1997), it is clearly seen that large-scale fishing was performed mostly in the eastern Bering Sea and along the coasts of Kamchatka up to Olyutorsky Cape. Before the 1970s, in the northern Bering Sea, fishing was performed from time to time along Koryak coast and in the southern Gulf of Anadyr in the areas with the depths of 100 m and more. The major commercial species in that period were the Pacific cod *Gadus macrocephalus,* Pacific halibut *Hippoglossus stenolepis*, Greenland halibut *Reinhardtius hippoglossoides*, rock perches (Sebastidae), and sablefish *Anoplopoma fimbria*. The coastal fishing activities in the northern Bering Sea also included the harvesting of the Pacific salmonids of *Oncorhynchus* genus by the locals and by commercial fishing, large-scale in some years (Agapov, 1941; Andriashev, 1954; Barsukov, 1958). For example, the catch of the Anadyr chum salmon *Oncorhynchus keta* (the largest school of the northeastern Russia) reached 7000 tons in the 1940s (Makoedov et al., 1999; Korotaev et al., 2002). The other commercial species, such as sockeye salmon *O. nerka*, pink salmon *O. gorbuscha*, Pacific cod, Pacific saffron cod *Eleginus gracilis,* polar cod *Boreogadus saida*, Pacific capelin *Mallotus villosus catervarius*, and Pacific rainbow smelt *Osmerus mordax dentex*, were harvested in small amounts. The marine mammals were the commercial species also harvested by the locals living in the coastal settlements of Chukotka Peninsula (Makoedov et al., 1999).

In the 1960–1970s, the development of the modern lines of the fleet and the enhancement of the field equipment preconditioned active marine commercial fishery. The number of the commercial fishing vessels in the northern Bering Sea has increased, but much effort was targeted to the open sea, far from the shores. For example, up to 1991, in the northern Bering Sea and in the Chukchi Sea, vessel-based fishery was performed together with the coastal hunting on the

Pacific walrus *Odobenus rosmarus divergens* and true seals (Phocidae); these species contributed to 45% of the total catch (Makoedov et al., 1999). The trawl harvesting pollock *Theragra chalcogramma* became active in the areas of the lower shelf and the upper continental slope, as well as above the deep hollows of the sea (Shuntov et al., 1993). In the 1990s, the setline catches of large cod, halibuts, and rock perches preferring mostly the bottom areas outside the shelf have increased. Coastal harvesting was also developing during that period, but small- and medium-capacity fleet from the vessel's home ports on Kamchatka, Sakhalin, and Primorye regions brought the catches to the factory ships (fish processing vessels) located in the fishery areas; this was due to the weakly developed infrastructure along the coast of Chukotka. Currently, similar scheme of the fishery in the northwestern Bering Sea exists (Datsky and Andronov, 2007).

In the Russian sector of the Bering Sea, the Koryak shelf and the adjacent areas of the continental slope (between Navarin Cape and Olyutorsky Cape, here and further on Olyutorsky-Navarin region) play a significant role in forming the commercial schooling of the marine fish. This area is characterized by the high biomass of many of the commercial species, by the presence of a large number of different fishing vessels equipped by various fishing gear and harvesting many species of hydrobionts all the year round, and by a significant volume of the catches of aquatic bioresources. The review of the existing data on the distribution and the biology of the key species and, especially, the commercial species, in this productive area of the Bering Sea has a great value for the elaboration of the strategy of the developing of the coastal and open-sea fishery activities as well as for the understanding the role of these species in the forming of the fish communities.

Recently, in the northwestern Bering Sea, 276 species of Pisces and Ichthyoids species belonging to more than 53 families were registered (Datsky, 2015). In the meantime, more than 98% of the allowable catches belong to 21 abundant marine fish species: pollock, Pacific herring *Clupea pallasii*, Pacific cod, saffron cod, giant grenadier *Albatrossia pectoralis*, Pacific halibut, Greenland halibut, Alaska plaice *Pleuronectes quadrituberculatus*, northern rock sole *Lepidopsetta polyxystra,* yellowfin sole *Limanda aspera*, Bering flounder *Hippoglossoides robustus,* flathead sole *H. elassodon*, great sculpin *Myoxocephalus polyacanthocephalus,* warty sculpin *M. verrucosus*, butterfly sculpin *Hemilepidotus papilio*, armorhead sculpin *Gymnocanthus galeatus,* purplegray sculpin *G. detrisus*, yellow Irish lord *Hemilepidotus jordani,* Gilberts Irish lord *H. gilberti*, Pacific capelin, and Pacific rainbow smelt. Such a great role of the species listed above, especially belonging to true cods (Gadidae) and righteye flounders (Pleuronectidae), cannot be underestimated when talking about the ecosystem links and the fishery activities.

The knowledge about the biology of the keystone species is necessary for studying the structure of the fish communities and the mechanisms of their functioning. Alongside with that, lack of data on the biology and ecology, body length and weight growth dynamics, sex ratio and age structure, and some other important characteristics makes the effective long-term management and sustainable use impossible. These data for the northwestern Bering Sea were presented quite well in the recent publications (Naumenko, 2001; Glubokov, 2005; Balykin, 2006; Datsky and Andronov, 2007; Datsky and Batanov, 2013; Datsky et al., 2014; Datsky and Andronov, 2014; Maznikova et al., 2015). However, the data for Olyutorsky-Navarin region of the Bering Sea, especially in the coastal areas of its shelf, are presented randomly, and the fish ecology here is studied scantily.

The study aims to analyze and to compare the data on the peculiarities of the biology of the common and commercial species of the families of cods (Gadidae), grenadiers (Macrouridae), herrings (Clupeidae), smelts (Osmeridae), righteye flounders (Pleuronectidae), and sculpins (Cottidae) harvested by different fishing gear in Olyutorsky-Navarin region and adjacent waters of the Bering Sea. This publication presents the data on the biology of the species belonging to the cods.

MATERIALS AND METHODS

The present and coming publications cover the materials collected in 1995–2015 during the studies of the fish communities of the western Bering Sea from Olyutorsky Cape to Bering Strait; this area covers more than 200000 km^2. The studies were carried out onboard the research vessels and the commercial fishery fleet as well at the coastal observation stations. Different fishing and sampling gear were used: bottom trawls, allopelagic trawls, setlines, gill nets, and snurrevads; tackles and gill nets were used in the shallow areas of the shelf. The data referred to the depths of 2–800 m (mostly, 50–300 m) mostly in the warm period of the year (July–September), in some years, in April–June and October–February. In total, the data obtained in 32 expeditions were taken into analysis; this dataset covers more than 3500 of the control catches by different gear[1].

The description of the fish biology is based on the 215400 measurements of the body length and 51900 biological analyses (detailed analysis, or with dissec-

[1] The list of the cruises and the coastal observations, the parameters of the sampling gear, and the methods of the data collecting are described in detail in earlier publications (Pravdin, 1966; Pal'm et al., 1999; Chikilev and Pal'm, 2000; Buslov, 2005, 2009; *Atlas*..., 2006; Datsky and Andronov, 2007; Sergeeva et al., 2011; Golub' et al., 2012; *Makrofauna*..., 2012, 2014; Datsky and Batanov, 2013; Andronov and Datsky, 2014a; Andronov and Datsky, 2014b; Datsky et al., 2014; Datsky, 2015; Maznikova et al., 2015).

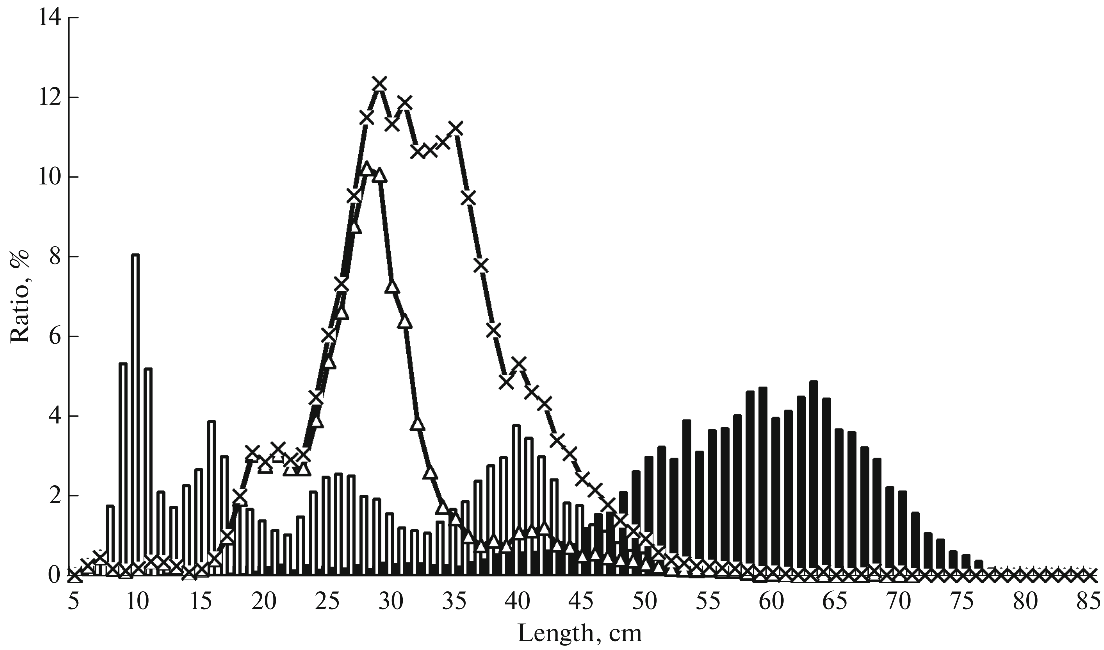

Fig. 1. Size structure (*FL*) of pollock *Theragra chalcogramma* in the catches of different fishing gear in Olyutorsky-Navarin region of the Bering Sea in 1995–2015: (□) bottom trawl with 10-mm mesh size in the cod end (*M* = 26.5 cm, *n* = 106566 ind.), (■) snurrevad with 35–60-mm mesh size (*M* = 57.1 cm, *n* = 14979 ind.), (–×–) allopelagic trawl with 30-mm mesh size in the cod end (*M* = 36.3 cm, *n* = 84744 ind.), (–Δ–) allopelagic trawl with 10-mm mesh size in the cod end (*M* = 28.6 cm, *n* = 13710 ind.).

tion only). The body length by Smith (*FL*) was measured for all the fish, except grenadiers, with 1-cm accuracy as well the total body weight (for all the fish). For giant grenadier, the total length (*TL*) was measured; this was the distance from the snout tip to the end of the longest rays in the caudal fin. The detailed biological analysis included the measurements of the largest and the smallest specimens of both sexes alongside with the fish of the most abundant size groups in the catches. For that purpose, 5–10 males and a similar number of females were sampled for each 1 cm of the size range. In most cruises, the representatives of ichthyofauna were weighed with 0.1-g accuracy using the balances adjusted especially for the work in the rocking. The fish age was defined under the scale and otolith analysis developed for each species. The sex ratio, size–age structure, and the gonad developmental stage distribution were calculated as the yearly mean.

RESULTS AND DISCUSSION

Pollock. In the northwestern Bering Sea, pollock reaches *FL* 87 cm and body weight of 5.20 kg. In the shelf areas, mostly large specimens are found, they are benthic similar to the cod (Shuntov et al., 1993). Frequently, fish of *FL* > 50 cm form the commercial schoolings in the shelf areas; they are the objects of the directed fishing (Serobaba, 1977; Fadeev, 1986, 1991; Balykin and Maksimenko, 1990; Shuntov, 1991; Shuntov et al., 1993; Datsky et al., 1999a, 1999b, 2000, 2002a, 2002b; Datsky, 2004a).

In the bottom trawl catches in this part of the sea, the pollock *FL* is 3–85 cm and the body weight is 0.006–4.800 kg. Less variability of these parameters is observed for the pelagic trawl catches: 4–79 cm and 0.01–4.10 kg, respectively. Such a great ratio of the young specimens is preconditioned by the use of the fine mesh in the cod end. For example, when using the allopelagic trawl equipped by the 30-mm and 100–110-mm mesh in the areas of traditional fishery activities, the variability range of the body length and body weight is smaller due to the absence of the young and the large fish in the gear; particularly, these parameters vary as 14–67 cm and 0.02–2.40 kg at bottom trawling and 22–59 cm and 0.05–1.30 kg at allopelagic trawling. Snurrevad, the bottom gear, is used in the coastal waters, where large specimens of pollock form their schoolings. That is why the size spectra of the fish caught by snurrevads is different from that in the trawl: *FL* 27–87 cm, body weight 0.15–5.20 kg (Datsky, 2004a; Datsky and Andronov, 2007). Large-size pollock is caught in a small amount also by the setline and the gill nets that are used for the harvesting of the cod and halibuts (Datsky and Ikonnikova, 1998; Datsky et al., 1999a).

In Olyutorsky-Navarin region of the Bering Sea, in the summer–autumn period, body length of pollock that is caught by the trawl-snurrevads is 5–85 cm and that by snurrevads is 12–84 cm (Figs. 1 and 2). Despite

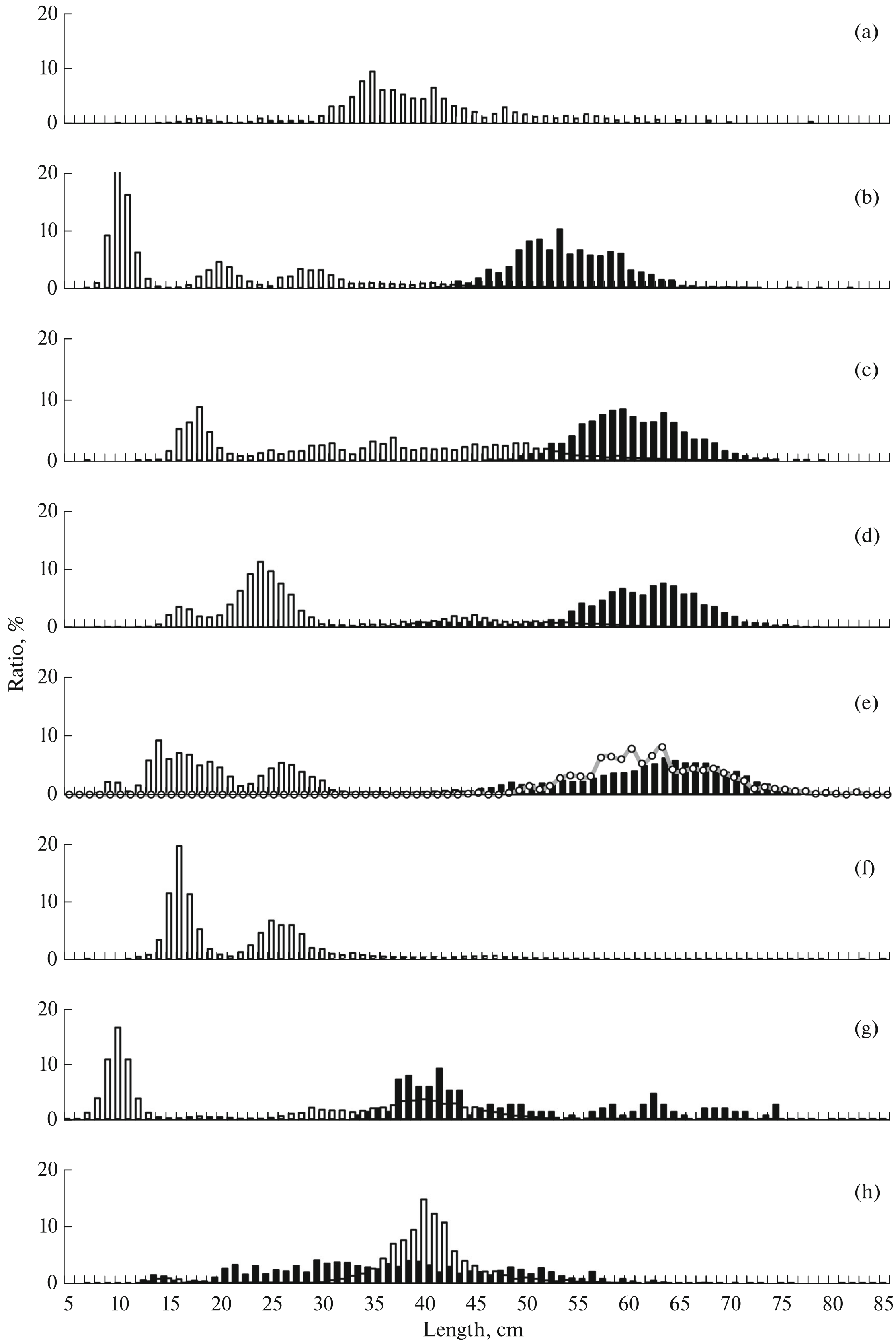

Fig. 2. Size structure (*FL*) of pollock *Theragra chalcogramma* in the trawl catches, snurrevad, and setline catches in Olyutorsky-Navarin region of the Bering Sea in different years: (a) 1996, (b) 1997, (c) 1998, (d) 1999, (e) 2000 (snurrevad and setline) and 2001 (trawl), (f) 2002, (g) 2004, (h) 2005; (–○–) setline; refer to Fig. 1 for the legend.

Table 1. Body length, body weight, and the sex ratio of pollock *Theragra chalcogramma* in the catches in Olyutorsky-Navarin region of the Bering Sea

Catching period (month, year)	Number of fish, ind.	Length (*FL*), cm			Weight, kg			Females : males ratio
		females	males	both sexes	females	males	both sexes	
Allopelagic trawl, mesh size in the cod end 30–110 mm								
Jul–Sept 1996	300	41.6	40.8	41.3	0.539	0.488	0.509	1.2 : 1.0
Jul–Sept 1997	252	34.1	34.8	34.5	0.295	0.344	0.315	1.1 : 1.0
June–Aug 2014	1092	43.4	40.4	42.1	0.572	0.456	0.521	1.3 : 1.0
Bottom trawl, mesh size in the cod end 10–12 mm								
Sept 1996	80	45.6	40.9	43.8	0.989	0.797	0.925	1.7 : 1.0
Aug–Sept 1999	569	42.9	35.2	40.0	0.788	0.458	0.664	1.7 : 1.0
Sept–Oct 2001	192	41.0	36.0	38.0	0.752	0.530	0.643	1.1 : 1.0
Aug 2002	461	42.1	38.3	40.4	0.844	0.583	0.725	1.2 : 1.0
Oct–Nov 2004	2739	38.0	37.3	37.8	0.325	0.236	0.283	1.0 : 1.0
Aug–Sept 2005	921	44.0	42.4	43.2	–	–	0.427	1.0 : 1.0
Snurrevad, mesh size of 35–40 mm								
Aug–Sept 1997	900	53.7	52.2	53.1	1.136	1.038	1.095	1.6 : 1.0
Aug–Sept 1998	650	59.5	56.8	58.8	1.456	1.286	1.414	1.9 : 1.0
Jul–Sept 1999	450	62.1	59.1	61.2	1.558	1.377	1.507	2.3 : 1.0
Jul–Aug 2000	500	62.8	59.0	61.5	2.034	1.730	1.942	2.3 : 1.0
Sept 2004	50	60.9	57.8	60.1	1.658	1.457	1.609	2.8 : 1.0
Aug–Sept 2005	296	57.0	53.1	55.8	1.363	1.069	1.270	2.1 : 1.0
Setline								
Jul–Sept 1997	67	60.9	58.9	60.3	1.618	1.387	1.546	2.2 : 1.0
June–Jul 2015	221	65.0	55.2	63.9	–	–	–	8.4 : 1.0
Bottom gill nets, mesh size 115 mm								
Jul 1997	100	53.6	50.9	52.8	0.992	0.881	0.961	1.9 : 1.0

the similar range limits, the modal size groups differ in the fishing gear significantly. According to the average long-term data, the young fish comprise a large part of the catch (approximately 60% of all the catches); their modal size groups are 9–11 cm (mostly young-of-the-year), 14–18 cm (yearlings), and 24–30 cm (2-year old); and the mature fish are presented mostly by the specimens of *FL* 37–43 cm (4–5-year old); the ratio of the large fish *FL* > 45 cm does not exceed 8% by abundance (Fig. 2). On the other hand, mostly large fish are caught by snurrevad; they comprise approximately 90% of the catch in this gear (Figs. 2b–2e, and 2g). The specimens of *FL* 50–68 cm and 7–13-year old specimens are caught most frequently (Datsky, 2004a; Datsky and Andronov, 2007). Similar size range of the fish is observed in the setline catches, where the specimens of *FL* 53–71 cm (57–63-cm mode) dominate (46.3%) (Table 1, Fig. 2e). These data are supported by the data provided by the other authors (Balykin, 2006); they state that trawl catches the smallest and the youngest fish, but snurrevad, bottom nets, and setline catch the largest. Generally, taking into account the interannual variability of the size spectra of pollock, the large part of the trawl catches (up 85%) belongs permanently to the specimens of the body weight of 0.3–0.6 kg (Fig. 3).

The dependence between the body length (*FL*, cm) and the body weight (*W*, g) of pollock in the study area is well described by the following equations: in the bottom trawl, $W = 0.0044\ FL^{3.1273}$ ($r = 0.99$, $n = 1252$ ind.); in snurrevad, $W = 0.0198\ FL^{2.7309}$ ($r = 0.86$, $n = 2448$ ind.); in setline, $W = 0.006\ FL^{3.0554}$ ($r = 0.86$, $n = 41$ ind.); and in bottom gill nets, $W = 0.0364\ FL^{2.5556}$ ($r = 0.87$, $n = 100$ ind.).

The interannual variability of the size–age spectra of pollock depends on the abundance of the different generations in the catches. The youngest specimens are of 0+–2+ age, their peaks of occurrence in the graphs of the size–age spectra are shifted to the right every year.

For example, in 1997 and 2004, significant catches of the young-of-the-year (*FL* 7–13 cm) were obtained, 54.3 and 48.2%, respectively (Figs. 2b and 2g). Alongside with that, the generation of 1997 was abundant in the catches a year and two years later, in 1998

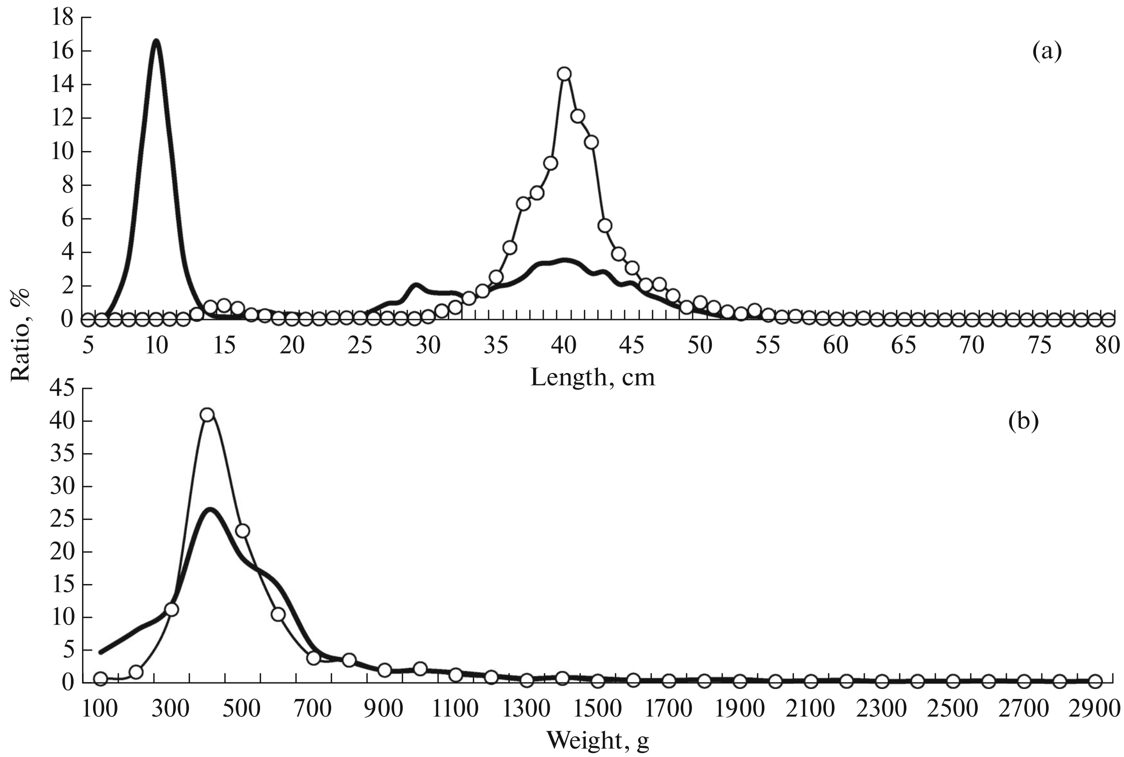

Fig. 3. Size structure (*FL*) and body weight spectra of pollock *Theragra chalcogramma* in Olyutorsky-Navarin region in the trawl catches in (—) 2004 and (–○–) 2005: (a) body length (2004: M = 24.4 cm, n = 11598 ind.; 2005: M = 39.8 cm, n = 5065 ind.), (b) body weight (2004: M = 204 g, n = 11 598 ind.; 2005: M = 427 g, n = 5065 ind.).

(29.3% of yearlings) and 1999 (53.9% of 2+), but the ratio of the poor year-class of 2004 in the next year did not exceed 3.0% in the catches (Fig. 2h). The generation of 1999–2001 was very abundant, so they comprised the majority of the trawl catches up to 2007–2008 in this part of the sea.

As the specimens of the abundant brood of pollock reaches the size that is not the subject of the commercial trawl catches, they appear as the large catch of the large-size specimens in the coastal waters of Olyutorsky-Navarin region. Most of the snurrevad catches in the late 1990s were the pollock generations of 1988–1991; they were presented by the fish of 6–9 years, 7–10 years, 8–11 years, and 9–12 years in 1997, 1998, 1999, and 2000, respectively. The modal age group was formed by the abundant generations of 1989–1990 (Datsky, 2004a; Datsky and Andronov, 2007). The increase of the ratio of the elder specimens also affects the average size of the fish in this period (Table 1). The moderate exploitation of pollock in 1990–1995, when their average catch in the northwestern Bering Sea was 270000 tons—whereas it was approximately 600000 tons in 1996–2001—allowed the generations of that period to keep their population abundance relatively high. For example, the generation of 1990 in 1998 (9-year old) comprised approximately 20% of the snurrevad catches, whereas the ratio of the specimens of the same age from the abundant brood of 1992, which was exploited quite intensively, did not exceed 10% in 2000 (Datsky et al., 1999a; Datsky, 2004a).

The distribution of pollock of different stages of ontogenesis is characterized by the significant differences (Fadeev, 1991; Shuntov, 1991; Shuntov et al., 1993; Stepanenko, 1997). Mostly young-of-the-year, yearlings, and large specimens (*FL* > 50 cm) keep in the shallow areas (80–100-m depths) in the Gulf of Anadyr and the adjacent Navarin shelf (Datsky, 2004a; Datsky and Andronov, 2007). The large pollock prefers to feed on the fish (Pacific sand lance *Ammodytes hexapterus*, Pacific capelin, and polar cod), that are abundant in the coastal areas, and the large schoolings of the young fish on the vast shallow zone help them to avoid the predators (including the large pollock), which prefer to keep at the greater depths. The significant catches of pollock of *FL* 31–50 cm, i.e. of the intermediate size groups, are obtained close to the continental slope.

In Olyutorsky-Navarin region of the Bering Sea, the pattern differs: the great depths come close to the shore, and the shelf zone is narrow (Udintsev et al., 1959). This is why the separate inhabiting of the fish of different size–age groups is not pronounced here so clear. If the administrative margin of the territorial waters (12-mile coastal zone) is taken as the bathymetric line, then this area becomes a growth zone for the young fish, but a significant ratio of the mature fish of

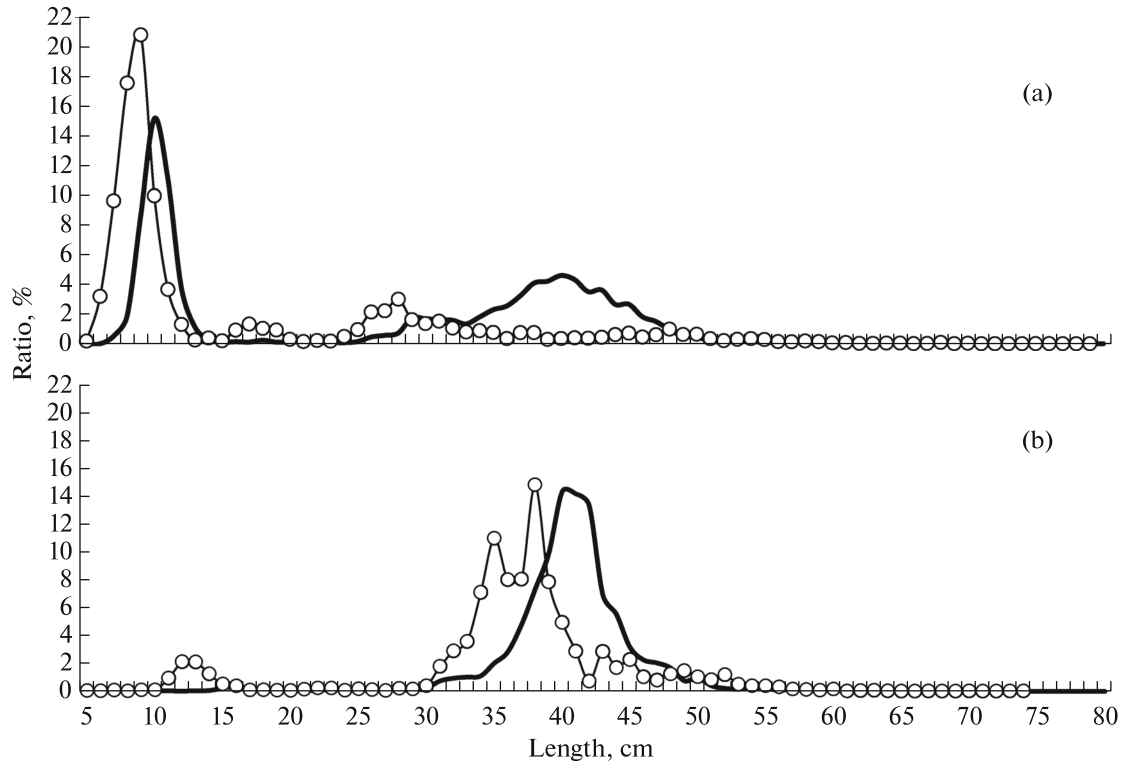

Fig. 4. Size structure (*FL*) of pollock *Theragra chalcogramma* in exclusive economic zone, (—) EEZ and (–○–) territorial waters of Olyutorsky-Navarin region in the trawl catches: (a) 2004 (EEZ: $M = 26.6$ cm, $n = 8733$ ind.; territorial waters: $M = 17.7$ cm, $n = 2865$ ind.), (b) 2005 ($M = 40.5$ cm, $n = 3343$ ind.; $M = 38.4$ cm, $n = 1722$ ind., respectively).

FL 35–48 cm is observed here in particular years (seasons) (Fig. 4). On the other hand, the young fish (mostly yearlings) may form the schoolings far from the shore, on the margin between the continental slope and the shelf.

Pollock is characterized by a fast growth in the first months of its life. In the western Bering Sea, its average body length and body weight increase from 5.4 mm and 0.7 mg up to 10.2 cm and 10.0 g for the first 6 months of life (Balykin and Bonk, 1987). In the northern areas, the average body length of the young-of-the-year is 2–3 cm less. In general, the body length of the young-of-the-year varies from 4 to 15 cm in the northwestern part of the sea (Balykin and Bonk, 1987; Balykin and Maksimenko, 1990; Fadeev, 1991; Shuntov et al., 1993). On average, the difference between the minimal and maximal body length within the size class of the adult specimens is 9–11 cm, reaching up to 18 and 16 cm in the groups of 4-year-old fish and 12-year-old fish, respectively. Most of the specimens of the same age belong to the 5–6 size classes. Even more variability within the same age group was found for the body weight, and the difference between the limits increases with the age. In immature fish, this difference does not exceed 250–450 g, but, for example, it reaches 2000 g in 13-year-old fish (Datsky and Andronov, 2007).

The linear growth of pollock in the northwestern Bering Sea during the life span is uneven. The maximal increase of the body weight is observed for the first two years of life, according to the catch data (Fig. 5a). The shift to the feeding on the shrimp and fish and the beginning of the maturation at the fourth year of life results as the next peak of the body length increase, when the fish reaches *FL* 35 cm and more (Kachina and Savicheva, 1987; Shuntov et al., 2000). The increase of the growth rate at the same age was observed for the western Bering Sea population of pollock (Balykin and Maksimenko, 1990). Later, the rate of the linear growth decreases and reaches its minimum at the seventh year of life; this links to the period of maturing, when a significant amount of energy is spent for the gonad development and maturation but not for the growth, as it does at the first three years of life (Zver'kova, 1972; Nikol'sky, 1974). The increase of the body weight of pollock decreases down to the minimal values also at the seventh year of life. Similar linear growth and weight increase are observed for the pollock from snurrevad and setline catches (Figs. 5b and 5c); it differs slightly from the fish from the trawl catches, where the linear growth and the body weight increase in the particular size classes differs insignificantly.

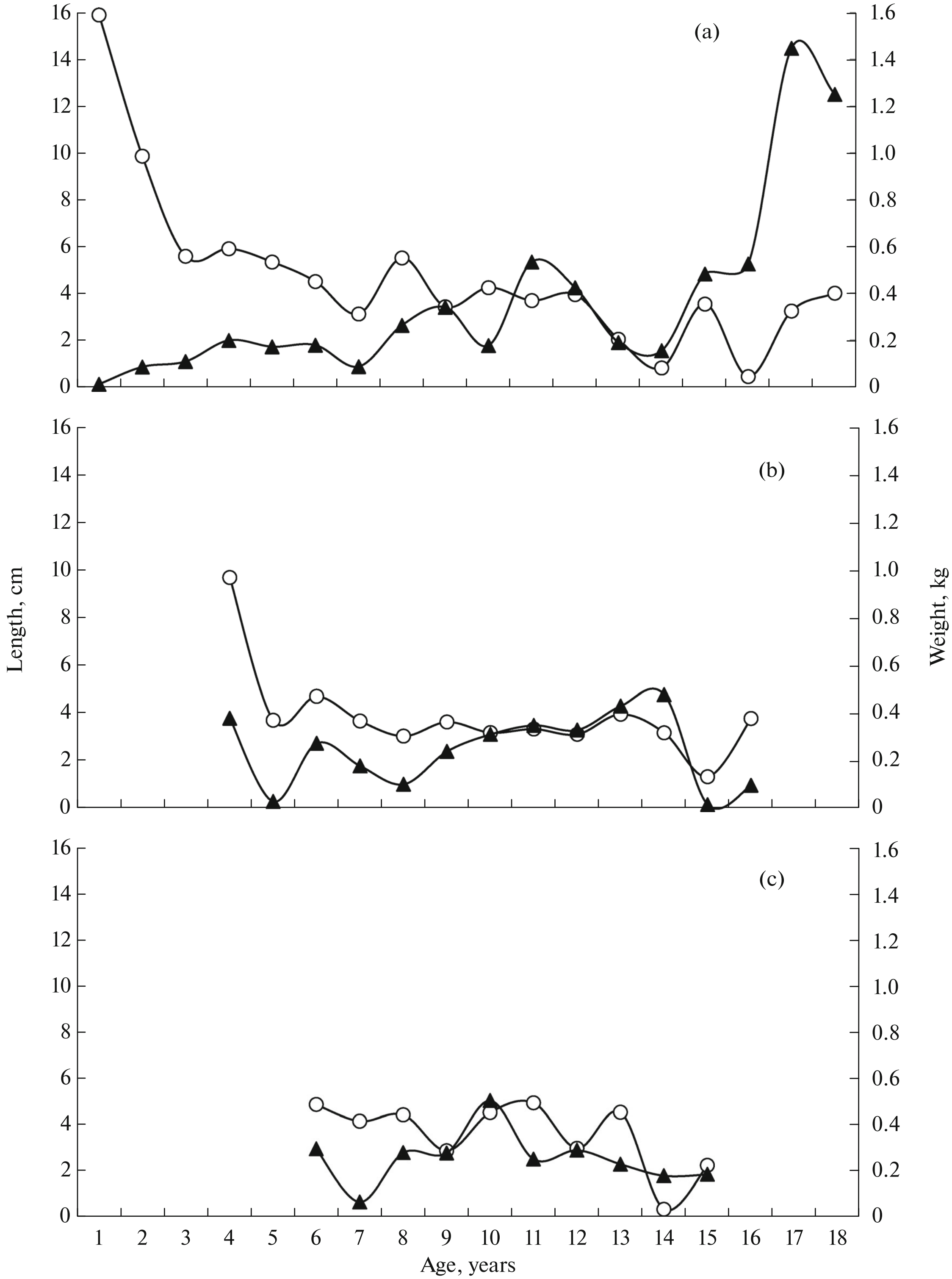

Fig. 5. Body length and the body weight growth dynamics of pollock *Theragra chalcogramma* in the (a) trawl catches, (b) snurrevad, and (c) setline in Olyutorsky-Navarin region of the Bering Sea in summer–autumn period; (–○–) body length (*FL*) and (–▲–) body weight.

Generally, such age-dependent dynamics of the linear growth and the body weight increase of pollock may be explained by the changes both in the physiological state and in the food spectra. The earlier studies evidenced that pollock changes its diet through the life span, and the elder specimens consume large invertebrates (squids (Teuthida), shrimps of Pandalidae, Crangonidae, and Hippolytidae families, gastropods, etc.) and the fish (Kachina and Savicheva, 1987; Volkov et al., 1990; Shuntov et al., 1993, 2000; Napazakov et al., 2001). The specimens of the middle age and the elder specimens feed mostly in the near-bottom water layer, whereas the young specimens perform vertical migrations in regard to their physiological state and to the environmental conditions, including the migrations and drift of the zooplankton (Serobaba, 1974; Fadeev, 1986). Particularly, the fish of *FL* < 50 cm prefer copepods (Copepoda) and krill (Euphausiacea); however, these objects are most actively consumed by the immature fish of *FL* < 35 cm. The role of the common species of the zooplankton in the diet of the large fish is insignificant, but the ratio of nekton, nektobenthos, and benthos increases. For example, the fish food objects comprise 40–94% of the food of pollock of *FL* 51–60 cm and 42–90%, of the specimens of *FL* > 60 cm (Radchenko et al., 1990; Shuntov et al., 2000). Therefore, the food spectra of the fish change greatly at the age of 8–9 years; they become predators. Undoubtedly, this promotes the increase of their linear growth and the body weight increase. When reaching the age limit, the pollock starts ageing, when all the organism functions are targeted for the supporting of the necessary metabolic rates. In this case, the rate of the linear growth decreases, but that of the body weight increases.

Regard must be paid to the linear growth rates of the particular generations of pollock that depend greatly on their abundance. Usually, the fish of the abundant brood grow slowly and do not reach the multiyear averages (Antonov, 1991; Fadeev and Gritsai, 1999). Here, the population density is a limiting factor, when the food resources are insufficient to cover all the needs due to the high abundance of the fish. Such a rule was well described for the young-of-the-year (Shuntov et al., 1993). In addition to the population density, the water temperature may also be a limiting factor for the linear growth of pollock (Sobolevskii et al., 1991). During the study period, the largest average size of the young-of-the-year was registered in the warm year of 1997, while the smallest was recorded in the cold year of 1999. Similar regularity was observed for the rates of the linear growth of the 1–3-year-old fish (Kuznetsov et al., 2004).

The age of the start of the maturation of pollock is an important characteristic for the harvesting. Maturing of 50% of the pollock population in the western Bering Sea occurs at *FL* 40–43 cm (Balykin, 1986, 2006; Balykin and Maksimenko, 1990), while that of the migrant specimens from the eastern Bering Sea occurs at *FL* 30–34 cm (Fadeev, 1986; Shuntov et al., 1993). Males mature a bit earlier than females and are characterized by the bigger size up to *FL* 40 cm than the females of the same age. On the other hand, the females later become larger than males; the females prevail in the elder age groups (Table 1); this is the feature of the pollock population in this part of the sea, and for this species in general (Zver'kova, 1980; Balykin and Maksimenko, 1990; Antonov, 1991; Shuntov et al., 1993; Datsky et al., 1999a; Datsky, 2004a).

Within the Bering Sea, pollock spawns in the southeastern areas along the eastern coast of the Aleutian Islands and at the southeastern shelf between Pribilof Islands and Alaska, in the area of Unimak Island, and at the shelf and its border with the continental slope of Olyutorskii Bay. Less important spawning grounds are located in Olyutorsky-Navarin region (Serobaba, 1968, 1974; Kachina and Balykin, 1981; Bulatov, 1986, 1987; Fadeev, 1991; Shuntov et al., 1993; Stepanenko, 2003) and the northern Gulf of Anadyr (Datsky, 2004b). Major spawning in the northern Bering Sea takes place at Navarin shelf and continental slope under the ice fields during their melting period (April–May) at the water temperature of 0.4–1.2°C. The spawning may last to the autumn for 6 months and even more (Balykin, 1981; Kachina and Balykin, 1981; Fadeev, 1981, 1986; Balykin and Maksimenko, 1990; Shuntov et al., 1993; Datsky, 2002, 2004b). The relatively high ratio of the fish carrying the gonads of VI-II stage may serve as evidence of the recent spawning of pollock in Olyutorsky-Navarin region. Such specimens are found in August and even in September–October (Table 2); they are mostly represented by the females in autumn. Due to the active fish-growing period, most of the pollock in this area carry the gonads of stage II in summer and autumn (in particular years, up to 94.2% of females and 84.0% of males) and stage III (up to 33.3% and 37.7%, respectively).

The separate patches of the pollock eggs are found in May–June in the whole study area, and the highest abundance (up to 122 eggs/km^2) at Olyutorsky Cape and Navarin Cape mostly at the depths of 45–75 m (Kachina and Balykin, 1981; Bulatov, 1986; Balykin and Varkentin, 2002).

Cod (Pacific cod) is a large commercial fish species that reaches the maximal body length of 118 cm and body weight of 20.7 kg; the specimens of *FL* 30–60 cm and the body weight of 1.0–1.6 kg at the age of 3–6 years are usual in the catches (Moiseev, 1953; Vershinin, 1987; Batanov et al., 1999a, 1999b; Datsky and Andronov, 2007). In the northwestern Bering Sea, the large specimens of cod are usual at the shelf close to the continental slope, while the young fish keep in the coastal water with the depths of less than 100 m.

In Olyutorsky-Navarin region of the Bering Sea, in the summer–autumn period, the cod is harvested mostly by setlines and snurrevads, and to a lesser

Table 2. Gonad maturation stage structure (%) of the population of pollock *Theragra chalcogramma* in Olyutorsky-Navarin region of the Bering Sea in June–November

Month, year	Sex	Stage of gonad ripeness					Number of fish, ind.
		II	III	IV	V	VI–II	
Sept 1996	Females	66.7	33.3	0	0	0	48
	Males	76.7	20.0	3.3	0	0	30
Sept–Oct 1999	Females	68.8	14.3	2.5	0.3	14.0	356
	Males	60.8	37.7	0.9	0	0.5	212
Sept–Oct 2001	Females	76.5	20.4	2.0	0	1.0	98
	Males	84.0	12.8	2.1	1.1	0	94
Aug 2002	Females	68.0	2.0	0	1.2	28.8	250
	Males	72.5	13.3	0	0	14.2	211
Oct–Nov 2004	Females	82.4	15.8	1.7	0.1	0	3179
	Males	68.1	30.0	1.6	0.1	0.2	3080
Aug–Sept 2005	Females	94.2	4.4	1.3	0.1	0	1069
	Males	78.1	21.8	0.1	0	0	1047
June–Aug 2014	Females	61.3	15.1	0.2	1.6	21.8	597
	Males	68.9	12.7	0.2	0.7	17.5	458

extent by trawls (Balykin, 2006). The setline catches are presented mostly by the fish of *FL* 39–105 cm, the snurrevad catches by 16–87 cm, and the bottom trawl catches by 7–93 cm (Figs. 6, 7, and 8a). Due to the different selectivity of the gear, the catches differ by the modal groups: cod of *FL* 59–72 cm prevails (53.4%) in the setline catches, *FL* 38–55 cm (71.1%) in snurrevad catches, and *FL* 36–46 cm (49.6%) in trawl catches. Therefore, the smallest fish are found in the trawl and snurrevad catches (the bycatch of the mostly immature specimens of *FL* < 40 cm, 39.1% and 20.7%, respectively), and the setline catches are presented by the

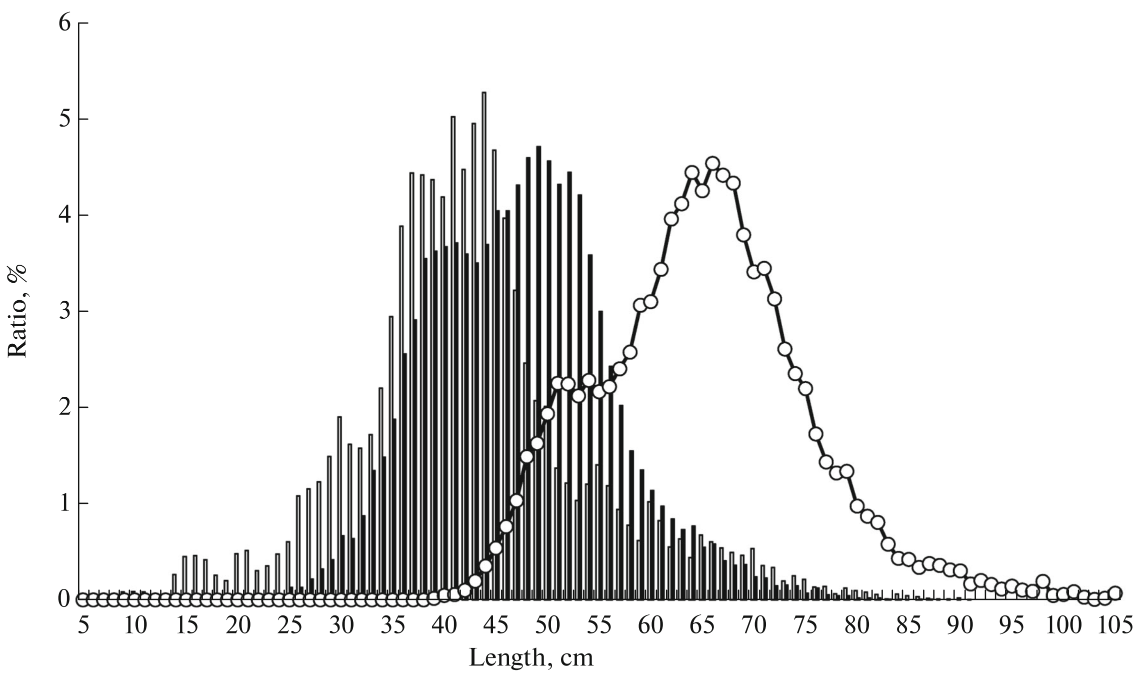

Fig. 6. Size structure (*FL*) of cod *Gadus macrocephalus* in Olyutorsky-Navarin region of the Bering Sea in 1995–2015 in the trawl catches ($M = 42.7$ cm, $n = 10044$ ind.), snurrevads ($M = 47.2$ cm, $n = 17293$ ind.), and setline catches ($M = 64.9$ cm, $n = 17715$ ind.); refer to Figs. 1 and 2 for the legend.

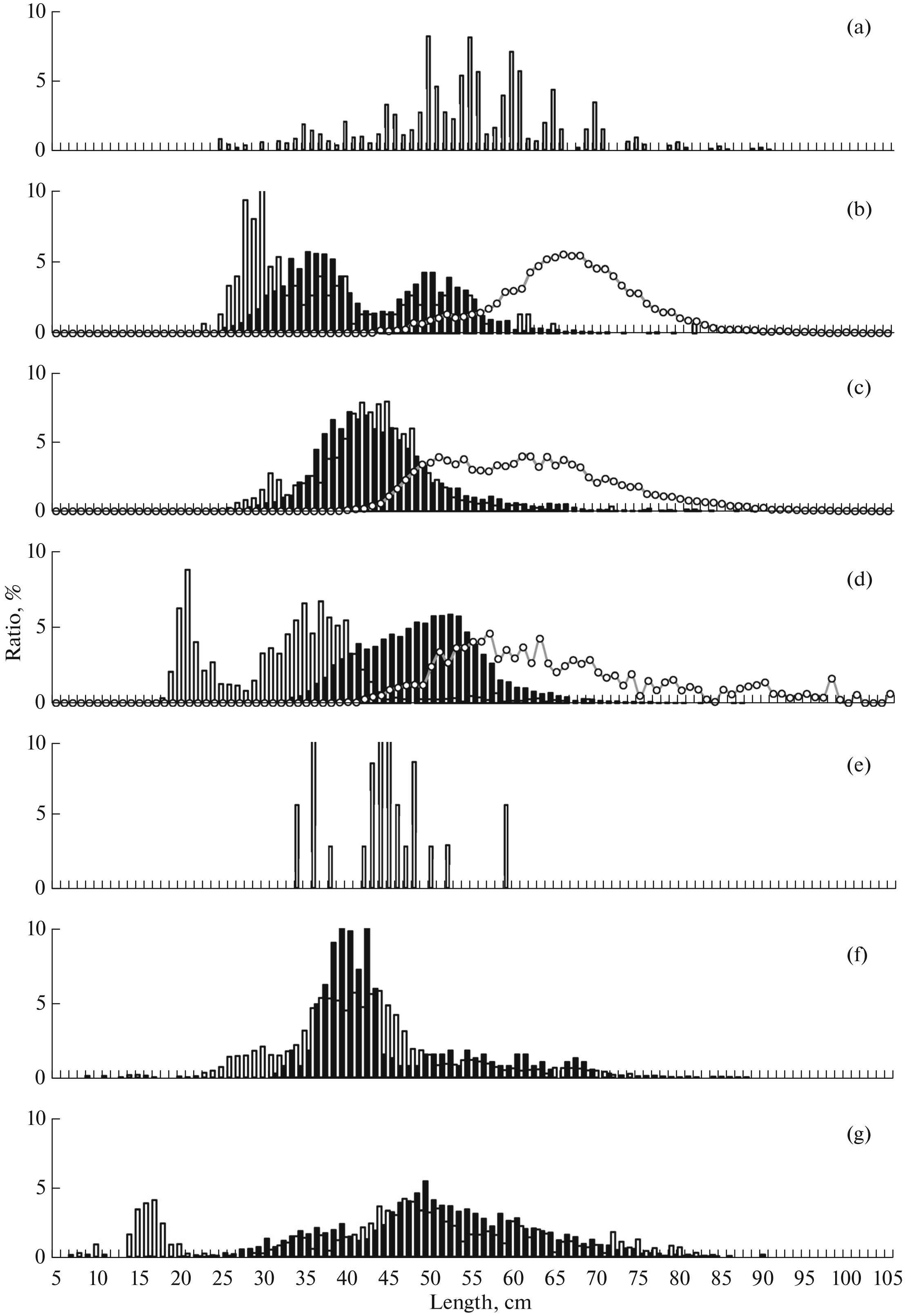

Fig. 7. Size structure (*FL*) of cod *Gadus macrocephalus* in the trawl catches, snurrevad, and setline catches in Olyutorsky-Navarin region of the Bering Sea in different years: (a) 1996, (b) 1997 (setline) and 1998 (trawl and snurrevad), (c) 1999, (d) 2000 (snurrevad and setline) and 2001 (trawl), (e) 2002, (f) 2004, (g) 2005; refer to Figs. 1 and 2 for the legend.

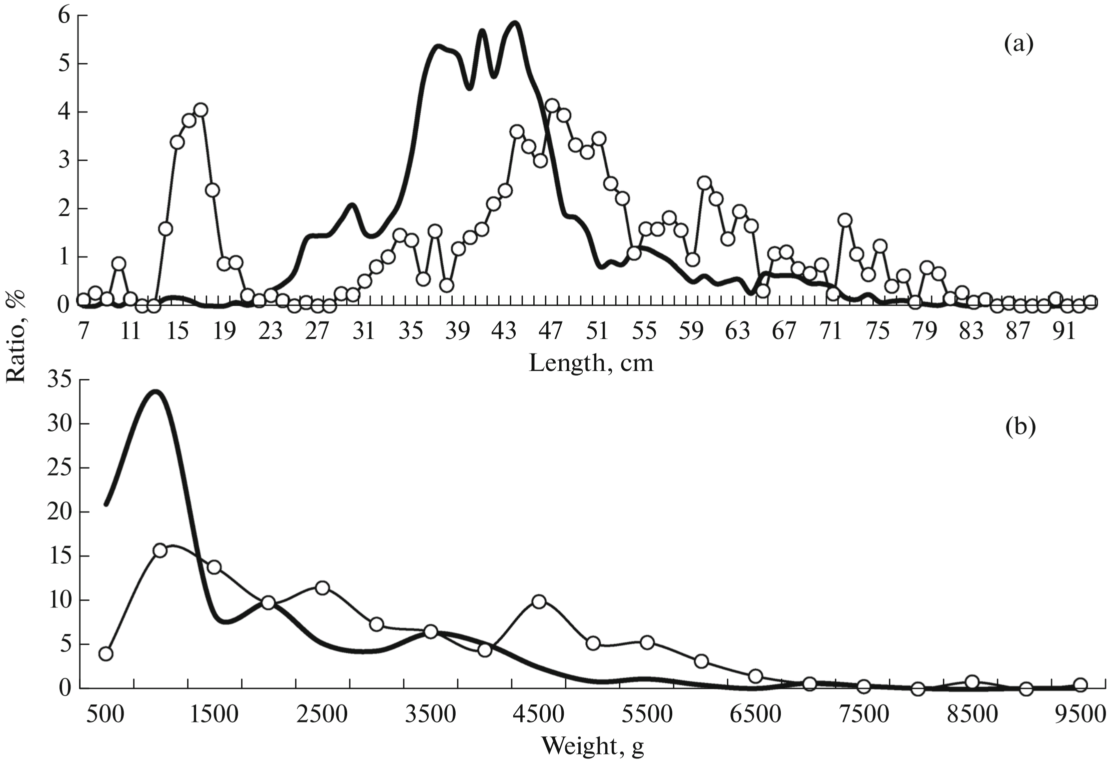

Fig. 8. Size structure (*FL*) and body weight spectra of cod *Gadus macrocephalus* in Olyutorsky-Navarin region in the trawl catches in 2004 and 2005: (a) body length (2004: $M = 42.4$ cm, $n = 3497$ ind.; 2005: $M = 45.6$ cm, $n = 984$ ind.), (b) body weight (2004: $M = 1006$ g, $n = 3497$ ind.; 2005: $M = 1553$ g, $n = 984$ ind.); refer to Fig. 3 for the legend.

mature fish only. The average body weight of the fish in the setline catch is approximately 1 kg more than in the trawl catches and snurrevad catches (Table 3). The long-term average of body weight of cod, caught by the active fishing gear, is approximately 2 kg (Batanov et al., 1999a, 1999b), whereas the average body weight of the fish in the trawl catches in 2004–2005 varied as 1.0–1.5 kg with the absolute dominance of the fish of the body weight of 0.8–1.3 kg (Fig. 8b). Generally, the females are larger than males in the study area (Table 3). As was observed for the pollock, the small cod is largely presented by males, and the majority of the specimens of $FL > 80$ cm are females (Borets, 1997).

In Olyutorsky-Navarin region, the size–weight relation of cod is $W = 0.005\ FL^{3.2384}$ in the bottom trawl ($r = 0.99$, $n = 2082$ ind.), $W = 0.0017\ FL^{3.5071}$ in snurrevad ($r = 0.94$, $n = 850$ ind.), and $W = 0.0095\ FL^{3.0672}$ in the setline ($r = 0.98$, $n = 199$ ind.).

According to the long-term average, the age structure of the Anadyr-Navarin cod stock is characterized by the presence of the fish of the age of 2–13 years with prevalence of the 3–6-year-old specimens in the trawl catches and in snurrevad catches and 5–6-year-old specimens in the setline catches (Batanov et al., 1999a; Datsky and Andronov, 2007). The large-scale maturing of the fish occurs at the age of 5–6 years; this age is characterized by the largest individual body weight increase (Sokolovsky, 1991); after that, the natural mortality of cod increases greatly. This is considered as one of the reasons why the fish of the age of 7 years and older usually comprise 2% and less of the commercial catches.

The fishery stock of cod depends mostly on the productivity of the particular generations. The cod specimens may reach the *FL* 30–35 cm at the second year of life, and these specimens are found in numbers in the catches in particular years. For example, in the summer–autumn period of 1998, the abundant generation of 1996, together with the generation of 1995, was the basis of the catches of the snurrevad-equipped vessels along Koryak coast; this was observed for the next two more years (Datsky and Andronov, 2007). The dominating of the fish of these generations is tracked well in the trawl catches also (Figs. 7b and 7c). In the mid-2000s, the fish of the 2000–2002 generations affected the trawl fishery greatly; their effect was then tracked in the setline catches.

Earlier, it was shown that the 2–3-year-old cod (*FL* 23–35 cm) dominated in the northwestern Bering Sea at the depths of less than 40 m, and the ratio of the elder specimens increased with the depth (Datsky and Andronov, 2007). Assuming the margin of the territorial waters as the boundary, the pattern of the cod distribution appears as follows: small specimens tend to

Table 3. Body length, body weight, and sex ratio of cod *Gadus macrocephalus* in the catches in Olyutorsky-Navarin region of the Bering Sea

Catching period (month, year)	Number of fish, ind.	Length (*FL*), cm			Weight, kg			Females : males ratio
		females	males	both sexes	females	males	both sexes	
Bottom trawl, mesh size in cod end 10–12 mm								
Aug–Sept 1999	1399	48.1	47.0	47.5	1.729	1.568	1.645	1.3 : 1.0
Sept–Oct 2001	466	45.7	45.6	45.7	1.720	1.612	1.664	0.9 : 1.0
Aug 2002	321	48.9	48.1	48.4	1.861	1.732	1.794	0.9 : 1.0
Aug–Sept 2003	200	45.8	46.9	46.4	1.369	1.450	1.414	0.8 : 1.0
Oct–Nov 2004	1765	43.2	42.6	43.0	0.944	0.831	0.905	1.1 : 1.0
Aug–Sept 2005	984	51.7	51.3	51.5	–	–	1.553	0.9 : 1.0
Snurrevad, 35–40-mm mesh size								
Aug–Sept 1998	450	47.4	45.4	45.8	1.383	1.275	1.323	1.0 : 1.2
Jul–Sept 1999	450	43.9	43.6	43.7	0.980	0.934	0.957	1.0 : 1.2
Jul–Aug 2000	500	48.1	48.6	48.2	1.608	1.570	1.566	1.0 : 1.1
Sept 2004	50	56.7	53.8	55.6	2.438	2.075	2.300	1.6 : 1.0
Aug–Sept 2005	250	48.7	49.0	48.8	1.762	1.756	1.759	0.9 : 1.0
Setline								
Jul–Oct 1997	251	–	–	65.5	–	–	3.490	1.1 : 1.0
Jul–Sept 1999	1117	–	–	61.3	–	–	2.800	1.0 : 1.0
Jul–Sept 2000	151	67.9	62.9	65.8	4.435	3.318	3.976	1.4 : 1.0
June–Jul 2015	925	60.9	58.2	59.6	2.485	2.081	2.305	1.1 : 1.0

remain at the shallow areas; the large cod prefers greater depths. Like pollock, cod prefers coastal areas (Fig. 9).

The spawning period is the least studied in the life cycle of the Anadyr-Navarin cod stock. It is known that the females mature at *FL* 55–85 cm at the age of 3–8 years, while the males at 50–80 cm and 4–9 years (Fadeev, 2005). On average, the large-scale maturation of the population (50% of the specimens and more) is observed at *FL* 70 cm at the age of 6+. The spawning of cod (as far as it is ready for) and the egg and larvae development occur in the northern Bering Sea from March through May, usually in the ice period. During the cold years (hydrological conditions), the spawning may probably last in summer. For example, in August 1999, 2002, and in July 2015, a large part of the population carried gonads in Olyutorsky-Navarin region (up to 19% of females and 25% of males); this evidences to the recent end of the spawning period (Table 4). Alongside with that, the rest of the fish carried the resting gonads or the gonads of the early developmental stages in the summer–autumn period.

The major spawning grounds of cod are located far from the coastal waters. The spawning occurs at the depths of 100–250 m and at the water temperature of 0–3°C (Musienko, 1970).

The cod larvae are found in June in the areas of 160–1300-m depth at the water temperature of 1.7–2.2°C. Their abundance in the samples is low; the maximal catch in Navarin area is 6 ind./m^2 and 5 ind./m^2 in the eastern Bering Sea. In June, the larvae size varies from 10.0 up to 15.6 mm (Bulatov, 1986).

Saffron cod is another abundant species of Gadidae, which is characterized by the relatively smaller body size comparing to the cod and pollock. The maximal registered body length and body weight in the northwestern Bering Sea do not exceed 57 cm and 1.3 kg. Such large specimens are harvested mostly along Koryak coast (Datsky et al., 2000). In the northern areas (Neshkanskaya Lagoon, the Chukchi Sea), saffron cod is relatively small; their maximal registered body length and body weight there are 37 cm and 0.42 kg (Semenenko, 1965).

In Olyutorsky-Navarin region, the saffron cod is found in the trawls and snurrevads, mostly in the coastal shelf areas with the depths of less than 100 m (Balykin, 2006; Trofimov and Pochinok, 2014; Trofimov, 2015). The trawls bring smaller fish than snurrevads (Figs. 10, 11). In 1996–2010, the trawls brought the fish of *FL* 8–51 cm, the size group of *FL* 29–40 cm dominated (more than 83% of the catches); *FL* 28–57 cm for the snurrevads, and the dominant size group was *FL* 36–47 cm (71.8%). In the trawl catches, the young specimens (*FL* 8–15 cm) were found in low numbers (4.1%); no young saffron cod at all was registered in snurrevads that only caught the mature specimens (Fig. 11).

Table 4. Gonad maturation stage structure (%) of the population of cod *Gadus macrocephalus* in Olyutorsky-Navarin region of the Bering Sea in June–November

Month, year	Sex	Stage of gonad ripeness					Number of fish, ind.
		II	III	IV	V	VI–II	
Aug–Sept 1999	Females	94.6	0.7	0.1	0.6	3.9	669
	Males	84.4	3.7	0.3	1.2	10.4	730
Sept–Oct 2001	Females	83.5	16.5	0	0	0	224
	Males	86.3	13.3	0	0	0.4	240
Aug 2002	Females	81.2	0	0	0	18.8	154
	Males	71.9	3.0	0	0	25.1	167
Oct–Nov 2004	Females	92.2	7.7	0.1	0	0	1548
	Males	84.1	15.0	1.0	0	0	1470
Aug–Sept 2005	Females	100.0	0	0	0	0	247
	Males	98.5	1.5	0	0	0	273
June–July 2015	Females	90.6	7.6	0	0	1.8	537
	Males	63.5	11.5	0	0	25.0	388

The modal and the average body length and body weight of saffron cod inhabiting different areas differ and depend on the abundance of the generation that constitute the majority of the population. For example, in 2004, in the trawl catches, the modal body length (*FL*) and body weight were 30–33 cm and 0.3–0.4 kg (Fig. 12a), while those in 2005 were 34–36 cm and 0.4–0.6 kg (Fig. 12b); i.e., the specimens of the same generation dominated in both years. As the depth and the distance from the shore increase, the

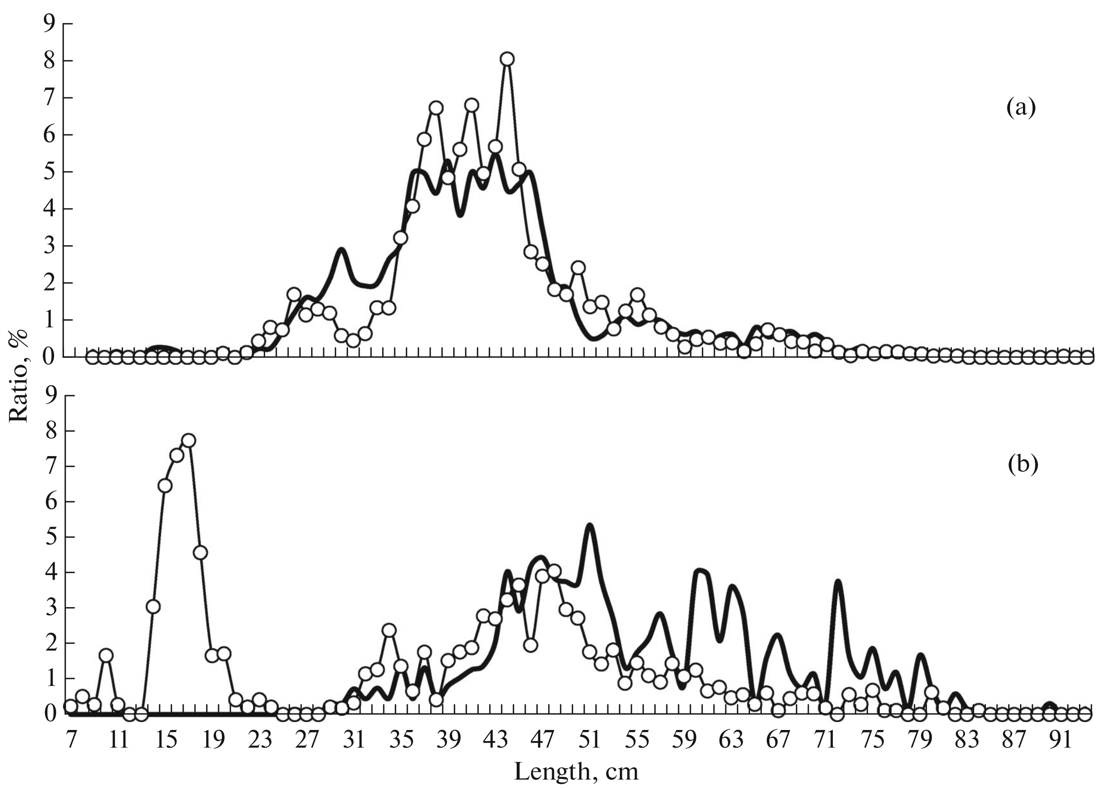

Fig. 9. Size structure (*FL*) of cod *Gadus macrocephalus* in exclusive economic zone, EEZ, and territorial waters of Olyutorsky-Navarin region in the trawl catches: (a) 2004 (EEZ: $M = 42.2$ cm, $n = 2238$ ind.; territorial waters: $M = 42.8$ cm, $n = 1259$ ind.), (b) 2005 (respectively, $M = 55.4$ cm, $n = 472$ ind.; $M = 36.7$ cm, $n = 512$ ind.); refer to Fig. 4 for the legend.

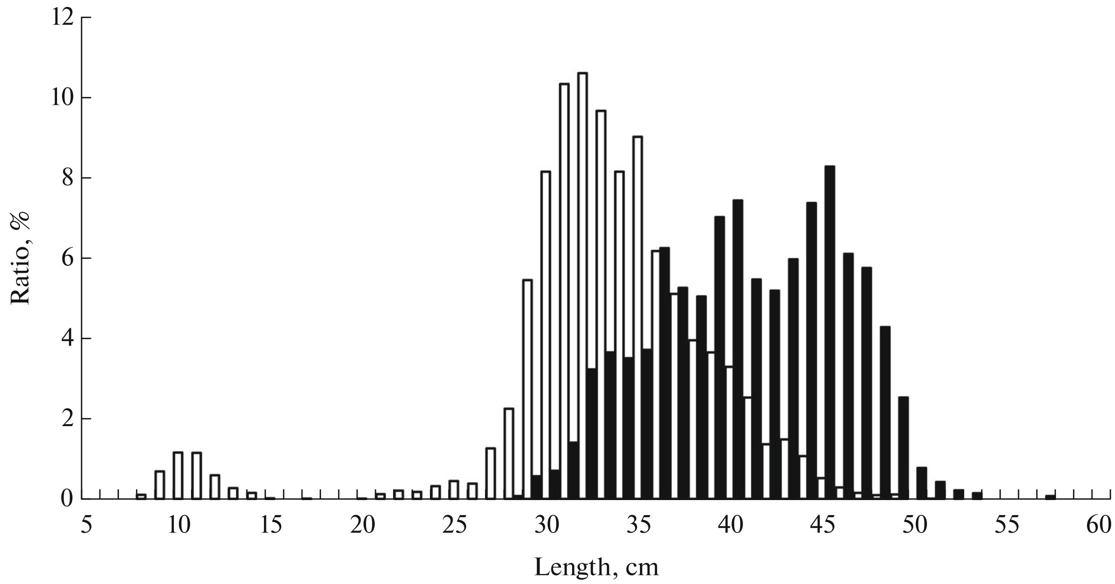

Fig. 10. Size structure (*FL*) of saffron cod *Eleginus gracilis in* Olyutorsky-Navarin region of the Bering Sea in 1995–2015 in the trawl catches ($M = 33.0$ cm, $n = 4733$ ind.) and snurrevads ($M = 40.8$ cm, $n = 1431$ ind.); refer to Fig. 1 for the legend.

ratio of the large fish increases also; however, the young specimens are found outside the coastal waters from time to time (Fig. 13). The small fish are mostly males; females prevail in the elder groups. In the catches, the average body length and body weight of females are greater than of males (Table 5).

The relationship of the body weight and body length of saffron cod is described by the following equations: in snurrevad, $W = 0.007\ FL^{3.0373}$ ($r = 0.94$, $n = 350$ ind.); in bottom trawl, $W = 0.0062\ FL^{3.0907}$ ($r = 0.97$, $n = 193$ ind.).

In the northwestern Bering Sea, the maximal registered age of the saffron cod is 15 years. This was observed in the northern part of its range (Nekshanskaya Lagoon), where the population is characterized by the most complicated age structure (15 age-size classes) and the prevalence of the fish of the age of 6–11 years (Semenenko, 1965). The maximal registered age of the saffron cod along Koryak coast (Khatyrskaya Lagoon) is lower, 13 years (Safronov, 1986). In 1998–2005, on the shelf of Olyutorsky-Navarin region, the saffron cod in the catches was

Table 5. Body length, body weight sex ratio of saffron cod *Eleginus gracilis* in the catches in Olyutorsky-Navarin region of the Bering Sea

Catching period (month, year)	Number of fish, ind.	Length (*FL*), cm			Weight, kg			Females : males ratio
		females	males	both sexes	females	males	both sexes	
	Bottom trawl, mesh size in the cod end 10–12 mm							
Sept 1996	48	40.5	38.3	39.9	0.603	0.499	0.571	2.3 : 1.0
Aug–Sept 2001	69	36.3	34.7	35.5	0.380	0.310	0.350	2.3 : 1.0
Sept–Oct 2001	137	32.2	32.5	32.3	0.329	0.332	0.331	0.9 : 1.0
Aug–Sept 2003	100	43.7	40.8	42.8	0.758	0.643	0.723	2.3 : 1.0
Oct–Nov 2004	3128	34.0	32.5	33.2	0.271	0.206	0.244	1.0 : 1.0
Aug–Sept 2005	966	37.0	35.7	36.5	–	–	0.455	2.6 : 1.0
Jul–Aug 2010	285	38.2	38.0	38.1	–	–	–	0.8 : 1.0
	Snurrevad, 35–40-mm mesh size							
Aug–Sept 1998	200	47.2	45.4	46.8	0.882	0.843	0.871	3.1 : 1.0
Jul–Sept 1999	150	44.8	38.5	38.4	0.655	0.695	0.685	3.5 : 1.0
Sept 2004	61	–	–	40.6	–	–	–	–
Aug–Sept 2005	100	43.7	40.8	42.8	0.758	0.643	0.723	2.3 : 1.0

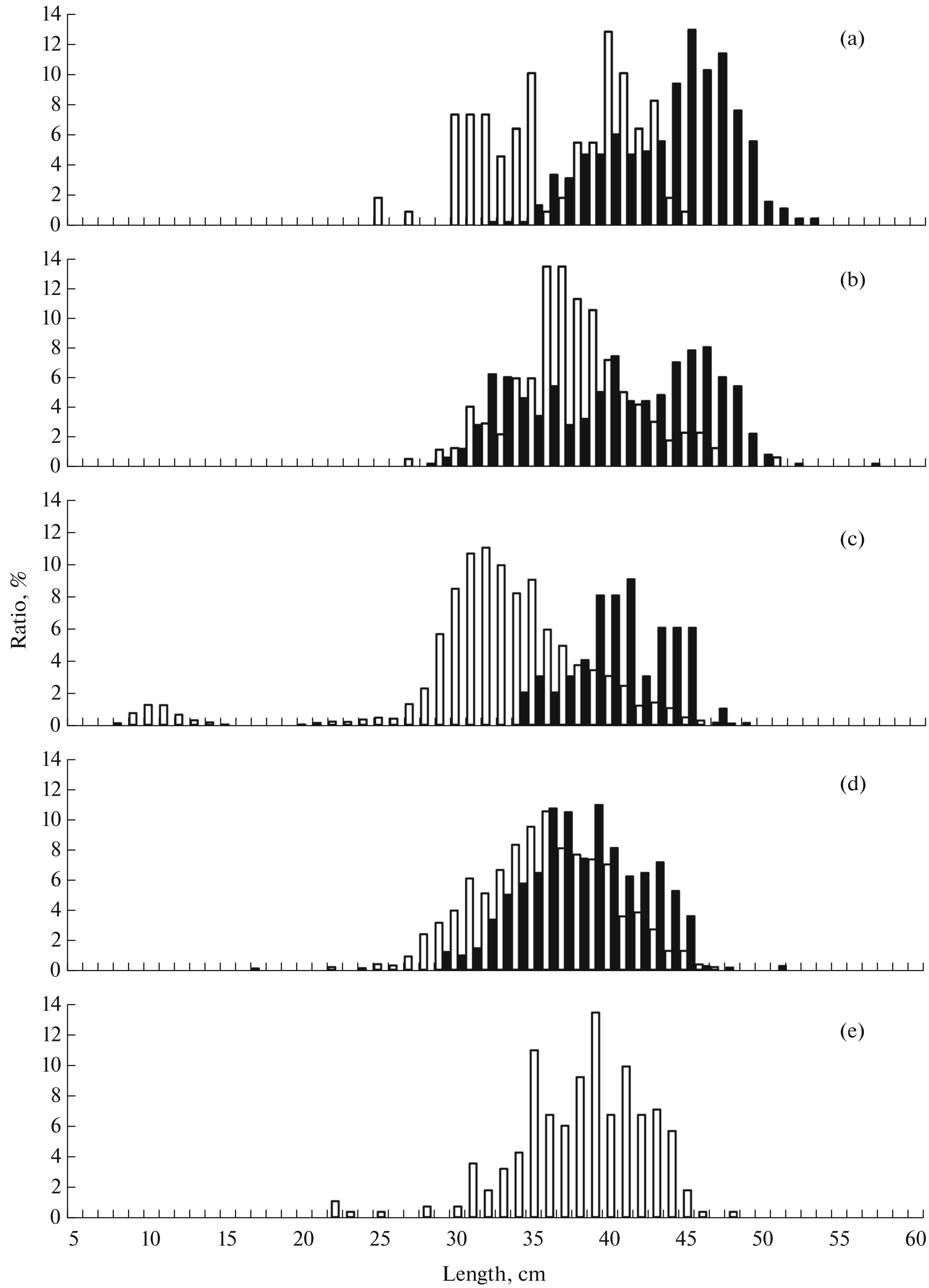

Fig. 11. Size structure (*FL*) of saffron cod *Eleginus gracilis* in the trawl catches and snurrevads in Olyutorsky-Navarin region of the Bering Sea in different years: (a) 1996 (trawl) and 1998 (snurrevad), (b) 1999 (snurrevad) and 2001 (trawl), (c) 2004, (d) 2005, (e) 2010; refer to Fig. 1 for the legend.

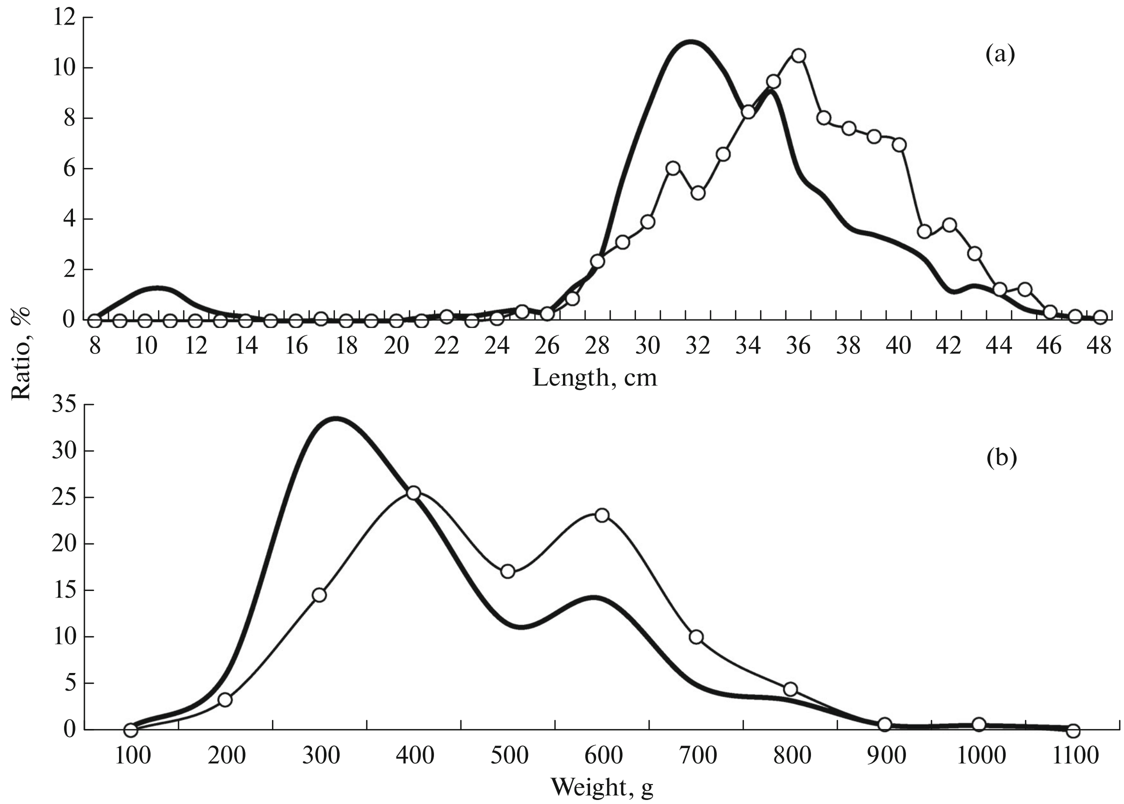

Fig. 12. Size structure (*FL*) and body weight spectra of saffron cod *Eleginus gracilis* in Olyutorsky-Navarin region in the trawl catches in 2004 and 2005: (a) body length (2004: $M = 32.8$ cm, $n = 3128$ ind.; 2005: $M = 35.8$ cm, $n = 966$ ind.), (b) body weight (2004: $M = 371$ g, $n = 3128$ ind.; 2005: $M = 455$ g, $n = 966$ ind.); refer to Fig. 3 for the legend.

3–13-years old. In snurrevads, the majority of the saffron cod was 8–10-years old, while 3–5-years old in trawls (less, 7–8 years) (Datsky and Andronov, 2007).

The productivity of the particular generations greatly affects the age structure of the saffron cod population. When several poor-quality generations appear one by one, the species abundance decreases dramatically. The interannual variability is usually tracked by the change of the ratio of the fish of the age of 2–5 years; the high-yielding generations of this age are usually the

Table 6. Gonad maturation stage structure (%) of the population of saffron cod *Eleginus gracilis* in Olyutorsky-Navarin region of the Bering Sea in June–November

Month, year	Sex	Stage of gonad ripeness					Number of fish, ind.
		II	III	IV	V	VI–II	
Aug–Sept 1996	Females	0	54.5	45.5	0	0	33
	Males	0	6.3	87.5	0	6.3	16
Aug–Sept 1999	Females	50.0	50.0	0.0	0	0	6
	Males	50.0	50.0	0.0	0	0	2
Sept–Oct 2001	Females	10.8	72.3	16.9	0	0	65
	Males	5.6	73.2	12.7	8.5	0	71
Oct–Nov 2004	Females	6.0	30.6	63.4	0	0	1628
	Males	5.9	4.7	89.4	0	0	1350
Aug–Sept 2005	Females	6.1	73.8	20.1	0	0	229
	Males	4.6	52.9	42.5	0	0	87
July–Aug 2010	Females	94.7	5.3	0	0	0	76
	Males	93.7	6.3	0	0	0	95

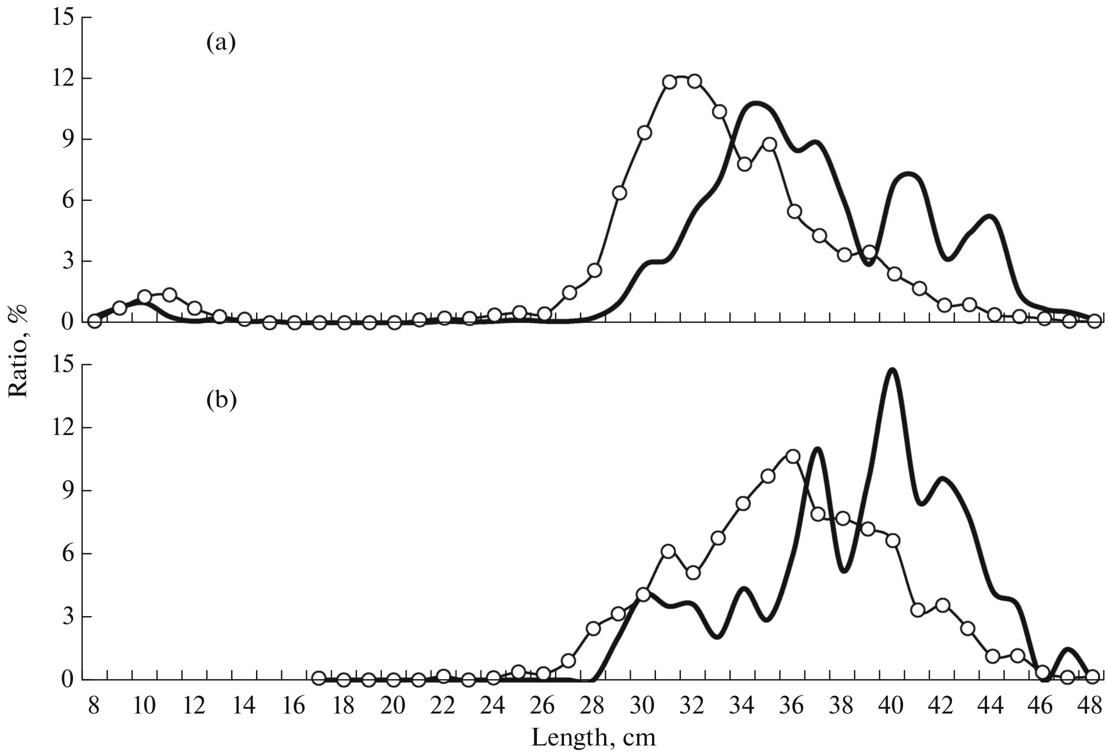

Fig. 13. Size structure (*FL*) of saffron cod *Eleginus gracilis* in exclusive economic zone, EEZ, and territorial waters Of Olyutorsky-Navarin region in the trawl catches: (a) 2004 (EEZ: M = 36.3 cm, n = 435 ind.; territorial waters: M = 32.3 cm, n = 2693 ind.), (b) 2005 (M = 39.4 cm, n = 37 ind.; M = 35.7 cm, n = 929 ind., respectively); refer to Fig. 4 for the legend.

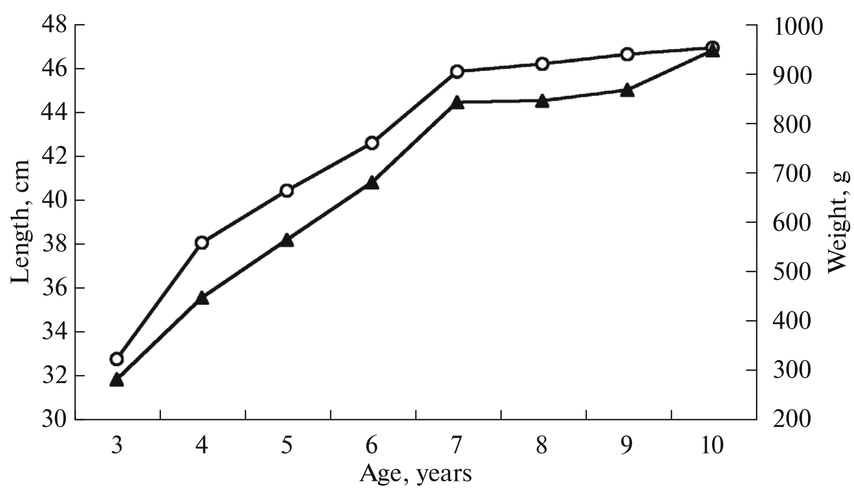

Fig. 14. Body length and the body weight growth dynamics of saffron cod *Eleginus gracilis* (n = 200 ind.) in snurrevad catches in Olyutorsky-Navarin region of the Bering Sea in summer–autumn period; refer to Fig. 5 for the legend.

basis of the catches (Gavrilov and Sharapova, 1982; Safronov, 1990).

In the studied area, the saffron cod is characterized by the relatively high linear growth rate, reaching the body length of 32.8 cm and 38.1 cm at the age of 3+ and 4+, respectively (Fig. 14). The most intensive growth is observed for the first four years of life; then, the annual increase does not exceed 2–3 cm. The significant increase of the body weight occurs at the age of 5–8 years; later, the increase of the body weight is insignificant.

Saffron cod reaches maturity at the end of the second year at *FL* 18–26 cm; nine tenths of the fish are mature at the age of 4+. The maturation of the gonads starts in August and ends in winter, and the males mature quicker than females (Table 6). In December–February, the saffron cod spawns at a water temperature below zero, −1.0...−1.9 °C (Bulatov, 1986; Safronov, 1986). In the shallow area of the shelf between Olyutorsky Cape and Navarin Cape, the large-scale spawning migrations of saffron cod to the near shore waters are observed in the second half of January. Its larvae (*FL* 6.9–7.6 mm) are found in the same area above the depths of 30–55 m; the maximal catch was 16 ind./m^2 southwestwards Dezhnev Inlet (Bulatov, 1986).

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Translated by D. Martynova