ISSN 0032-9452, Journal of Ichthyology, 2022, Vol. 62, No. 5, pp. 863–884. © Pleiades Publishing, Ltd., 2022.
Russian Text © The Author(s), 2022, published in Voprosy Ikhtiologii, 2022, Vol. 62, No. 5, pp. 572–593.

Features of the Biology of Mass Fish Species in Russian Waters of the Chukchi Sea. 2. Families Pleuronectidae and Cottidae

A. V. Datsky[a], *, E. V. Vedishcheva[a], and A. O. Trofimova[a]

[a] *Russian Federal Research Institute of Fisheries and Oceanography, Moscow, Russia*

**e-mail: adatsky@vniro.ru*

Received September 22, 2021; revised December 6, 2021; accepted December 6, 2021

Abstract—Based on research materials for 1995–2020 mass and potentially commercial fish species have been identified in Russian waters of the Chukchi Sea. Among the 72 species recorded in trawl catches, 16 species from six families were mass species; among them, the average proportions of the families Pleuronectidae and Cottidae were 4.8 and 0.9% of the total commercial marine fish biomass, respectively. The main stock of these fishes was formed by Bering flounder *Hippoglossoides robustus*; catches of other species were not so significant. The size–age and weight characteristics of mass flounder and cottid species, features of their linear and weight growth, and their spawning period, scale, and conditions have been analyzed. The biological parameters of the fish species from the Chukchi and Bering seas have been compared. It has been revealed that most of the species (Bering flounder, yellowfin sole *Limanda aspera,* Sakhalin sole *L. sakhalinensis*, longhead dab *L. proboscidea*, and shorthorn sculpin *Myoxocephalus verrucosus*) had a smaller body size within the Chukchi shelf than in the northwestern part of the Bering Sea. Larger individuals has been recorded among some representatives (Alaska plaice *Pleuronectes quadrituberculatus*, starry flounder *Platichthys stellatus,* and Arctic staghorn sculpin *Gymnocanthus tricuspis*). Other species (Greenland halibut *Reinhardtius hippoglossoides* and several sculpin species) were represented exclusively by juveniles and immature individuals.

Keywords: family Pleuronectidae, Bering flounder *Hippoglossoides robustus*, Alaska plaice *Pleuronectes quadrituberculatus*, yellowfin sole *Limanda aspera*, Greenland halibut *Reinhardtius hippoglossoides*, Cottidae, shorthorn sculpin *Myoxocephalus verrucosus*, Arctic staghorn sculpin *Gymnocanthus tricuspis*, biology, Chukchi Sea, Bering Sea

DOI: 10.1134/S0032945222050046

In our previous work (Datsky et al., 2022), we published long-term materials on the commercial biomass of marine fishes and biological features of representatives of the dominant cod family (Gadidae) within Russian waters of the Chukchi Sea. For four species (Alaska pollock *Gadus chalcogrammus*, Pacific cod *G. macrocephalus*, Saffron cod *Eleginus gracilis*, and Polar cod *Boreogadus saida*), we analyzed the size–age and weight characteristics of individuals, features of their linear and weight growth, and spawning period, scale, and conditions in the studied water body and adjacent water area in the northwestern part of the Bering Sea. This article presents data on these parameters for the mass species of the families Pleuronectidae and Cottidae.

Data on the material and methodology and commercial biomass of widespread fishes were given in our previous studies (Datsky et al., 2022). It should be noted that materials of nine integrated trawl surveys, which were performed on research vessels of the Research Fleet Base of the Russian Federal Research Institute of Fisheries and Oceanography (the Research Fleet Base of the Pacific Research Fisheries Center until 2018) from 1995 to 2020 and included 366 trawlings, served as a basis for this study. Surveys in the summer–autumn period covered a significant water area of the Russian sector of the Chukchi Sea, except its coastal shallow part with depths of less than 26 m. Trawl surveys were pelagic in 2003, 2007, and 2008 and bottom in other years (in addition to bottom trawl surveys, five pelagic trawlings were also carried out in early September 2020). The results of the study of the biology of fishes from the Chukchi shelf were compared with the materials of trawl surveys in the northwestern part of the Bering Sea, which were previously presented in separate publications (Datsky and Andronov, 2007; Datsky, 2015; Datsky and Maznikova, 2017), as well as with data on other Arctic seas.

RESULTS AND DISCUSSION

Family Pleuronectidae

Bering flounder Hippoglossoides robustus in the northern part of the Pacific Ocean reaches a fork length (*FL*) of 58 cm, a body weight of 1.8 kg, and an age of 27 years; individuals with *FL* 27–40 cm and a

Table 1. Length, weight, and sex ratio of Bering flounder *Hippoglossoides robustus* from catches in Russian waters of the Chukchi Sea

Study period	*n*, ind.	Length (*FL*), cm				Weight, g				Female/male ratio
		immature	mature			immature	mature			
			females	males	both sex		females	males	both sexes	
September 2010	233	7.0–16.2 / 10.8	10.0–29.0 / 17.9	12.0–20.8 / 14.5	10.0–29.0 / 16.8	3.0–35.0 / 12.3	15.0–200.0 / 66.7	15.0–90.0 / 29.6	15.0–200.0 / 54.6	2.1 : 1.0
August–September 2018	235	7.3–17.7 / 11.1	11.2–45.5 / 21.6	11.1–19.9 / 16.7	11.1–45.5 / 20.1	2.0–43.0 / 11.7	9.0–813.0 / 106.9	11.0–78.0 / 37.0	9.0–813.0 / 86.5	2.6 : 1.0
August 2019	272	4.3–12.5 / 9.1	8.4–29.3 / 19.2	10.5–19.2 / 13.7	8.4–29.3 / 17.5	1.0–16.0 / 5.3	7.0–235.0 / 75.4	4.0–55.0 / 20.2	4.0–235.0 / 57.3	2.0 : 1.0
August–September 2020	75	–	–	–	7.8–29.7 / 17.5	–	–	–	4.0–308.0 / 65.5	–

Here and in Table 4: above the line—variation limits of the parameter, below the line—mean value; here and in Tables 2–4: –, no data, *n* is the fish number.

weight of 0.23–0.88 kg prevail in catches (Fadeev, 1987; Munk, 2001). Along with Alaska pollock and Polar cod, this flounder species is included in the list of most abundant fishes in Russian waters of the Chukchi Sea (Datsky et al., 2022. Table 2). Its main aggregations are confined to the southwestern part of the sea (Mecklenburg et al., 2016; Orlov et al., 2019). Catches were represented by individuals with *FL* 4–46 cm, dominated (up to 88%) by individuals with *FL* 10–23 cm in different years (Fig. 1). Larger individuals, as well as juveniles with *FL* 4–7 cm, which were recorded mainly in the pelagic zone (Figs. 1b, 1c), occurred in much smaller numbers. The largest fish size was recorded in relatively warm years: in 1997 and 2018–2020.

On the whole, Bering flounder captured on the Chukchi shelf was much smaller than its individuals from the adjacent waters of the Bering Sea. Thus, individuals with *FL* 12–22 cm at the age of 5–9 years prevailed in the Chukchi Sea, while Bering flounder with *FL* 14–29 cm at the age of 8–15 years was dominant in the northwestern part of the Bering Sea (Fig. 2). The increase in the proportion of smaller individuals is even more noticeable in the direction from south to north. The largest representatives of the species were recorded in Koryak region and the western part of the Gulf of Anadyr; similar size–age series are characteristic of individuals from the adjacent areas (the Chukchi shelf and Chirikov Basin) (Fig. 3).

The weight of immature Bering flounder individuals with *FL* 4–18 cm was 1–43 g in the study area. Among the mature individuals, females were larger than males: 9–46 cm, 7–813 g and 11–21 cm, 4–90 g, respectively (Table 1). In addition, the former were numerically dominant, which is also very typical for this species in its other habitat areas (Zolotov, 2007; Datsky and Maznikova, 2017). The dependence of weight (W, g) on length (FL, cm) is described by the equation: $W = 0.005FL^{3.1942}$ ($r = 0.97$, $n = 711$ ind.).

The highest growth increments within the Chukchi shelf were recorded for 2–7-year-old individuals with the maximum level at the age of 3–4 years (up to 3.7 cm per year). The fish weight began to rapidly increase somewhat later, by the age of 5 years, and reached the peak in 6–7-year-old individuals, up to 50 g per year (Table 2). Taking into account that Bering flounder males massively mature at the age of 3–5 years (*FL* 14–19 cm) and females at the age of 7–9 years (*FL* 21–24 cm) (Zolotov, 2007; Datsky and Maznikova, 2017), it can be assumed that these accelerated increments in the fish body weight are determined by the process of sexual maturity. On the whole, unlike other flounder species, this species, inhabiting mainly cold-water areas, is characterized by a low growth rate at an earlier sexual maturity (Zolotov, 2007).

Bering flounder is a spring-spawning species: it spawns from mid-April to mid-June at depths of less than 100 m at a bottom water temperature of 1.7–2.4°C in the northwestern part of the Bering Sea (Pertseva-Ostroumova, 1961; Fadeev, 1987) and from May to September in the Chukchi Sea (D'yakov, 2011). The largest aggregations of Bering flounder eggs (up to 71 pcs./m^2) were recorded in the southwestern part of the Gulf of Anadyr and across the Ugolnaya Bay above the depth of 65 m (Pertseva-Ostroumova, 1961). Unfortunately, no mass breeding grounds of the species and further habitation of larvae and fry have yet been found in the Chukchi Sea and adjacent water areas of the Bering Sea. At the same time, the occurrence of some individuals (up to 23% of females and 8% of males) in the post-spawning state (gonads at maturity stages VI–II) in August 2019 (Table 3) sug-

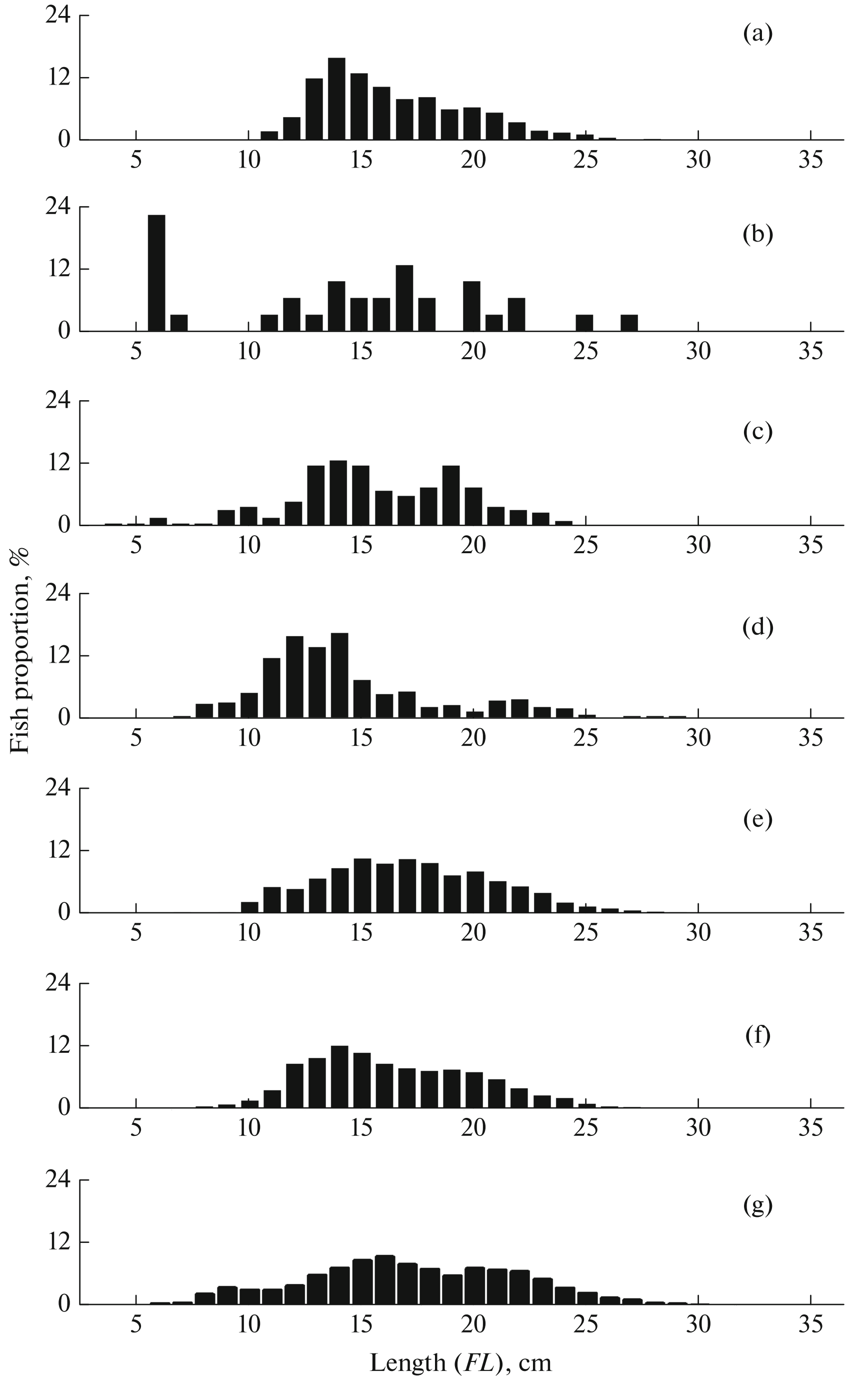

Fig. 1. Size composition of Bering flounder *Hippoglossoides robustus* from trawl catches in Russian waters of the Chukchi Sea: (a) August–September 1997 (M = 16.6 cm, n = 513 ind.), (b) August 2007 (M = 14.6 cm, n = 33 ind.), (c) September 2008 (M = 15.7 cm, n = 194 ind.), (d) September 2010 (M = 14.3 cm, n = 341 ind.), (e) September 2018 (M = 17.4 cm, n = 3103 ind.), (f) August 2019 (M = 16.4 cm, n = 4533 ind.), (g) August–September 2020 (M = 17.2 cm, n = 5244 ind.).

gests that the species may spawn within the Chukchi shelf in summer. This can be indirectly confirmed by the presence of Bering flounder eggs and larvae in the northeastern part of the Chukchi Sea in August–September (Logerwell et al., 2020), which may result from their transport to this water area by currents. The increase in the average duration of the spawning period and its shift to later dates in the Chukchi Sea are probably flounder adaptations to harsh environmental conditions (D'yakov, 2006). In late summer–early autumn, new reproductive products were formed in most spawners and rapidly matured in males (Table 3).

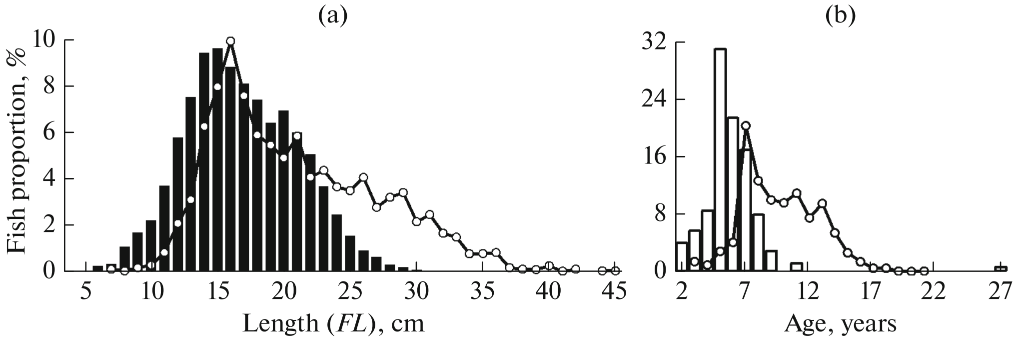

Fig. 2. Size (a) and age (b) composition of Bering flounder *Hippoglossoides robustus* from bottom trawl catches in Russian waters in 1997–2020: (■), (□) Chukchi Sea (M = 16.4 cm, average age 5.8 years, n = 13734 ind.); (–○–) Bering Sea (M = 20.9 cm, 9.6 years, n = 5875 ind.).

Alaska plaice Pleuronectes quadrituberculatus is a large species that reaches the maximum *FL* of 66 cm, weight of 3.8 kg, and age of 30 years in the northwestern part of the Bering Sea. However, mature individuals of this species with *FL* 25–51 cm and a weight of 0.3–1.4 kg at the age of 8–17 years occur most frequently in catches (Datsky and Andronov, 2007). In the Chukchi Sea, it is not as abundant as Bering flounder; however, it can form local commercial aggregations in some years (Datsky et al., 2022. Table 2).

Alaska plaice on the Chukchi shelf was represented by individuals with *FL* 19–45 cm and dominated by individuals of the 26–29 cm size group (39%). Since the males and females of this species within the Bering Sea adjacent to the study area reach mass sexual maturity at a length of 23–24 and 27–30 cm, respectively (Fadeev, 1987; Datsky and Maznikova, 2017), the proportion of immature individuals with *FL* < 23 cm was very insignificant (7.7%) (Fig. 4). On the whole, in contrast to the northwestern Bering Sea waters, the absence of Alaska plaice juveniles with *FL* < 19 cm and older individuals with *FL* > 45 cm in the Chukchi Sea can be explained both by the biological features of the species and by low collections of primary material from trawl catches. At the same time, the occurrence of medium-sized individuals on the Chukchi shelf is quite natural. They have the widest spatial distribution (Datsky and Andronov, 2007) and form the northern boundary of the species range in different years depending on the hydrological conditions (Allen and Smith, 1988; D'yakov, 2011; Mecklenburg et al., 2018).

The size composition of Alaska plaice in catches is illustrated in Fig. 5. The largest individuals stayed in the northern and central parts of the Gulf of Anadyr. Individuals encountered on the Chukchi shelf, in the western part of the gulf, and in the water area southwest of Cape Navarin were generally medium-sized.

Table 2. Length and weight of Bering flounder *Hippoglossoides robustus* of different ages from catches in Russian waters of the Chukchi Sea, according to 2018 data

Age, years	Length (*FL*), cm		Weight, g		*n*, ind.
	min–max	*M*	min–max	*M*	
2	7.0–10.0	8.8	2–7	5	7
3	11.1–12.6	11.9	11–17	13	10
4	13.5–17.4	15.6	18–40	28	15
5	15.7–20.8	17.9	25–94	45	55
6	18.2–24.3	21.0	42–134	83	38
7	22.1–25.8	24.2	71–220	133	30
8	23.8–28.3	25.9	128–234	162	14
9	26.4–29.0	27.4	180–229	204	5
10	–	–	–	–	0
11	30.6–32.7	31.6	274–365	320	2
27	–	45.5	–	813	1

Min–max, variation limits of the parameter, *M*, mean value.

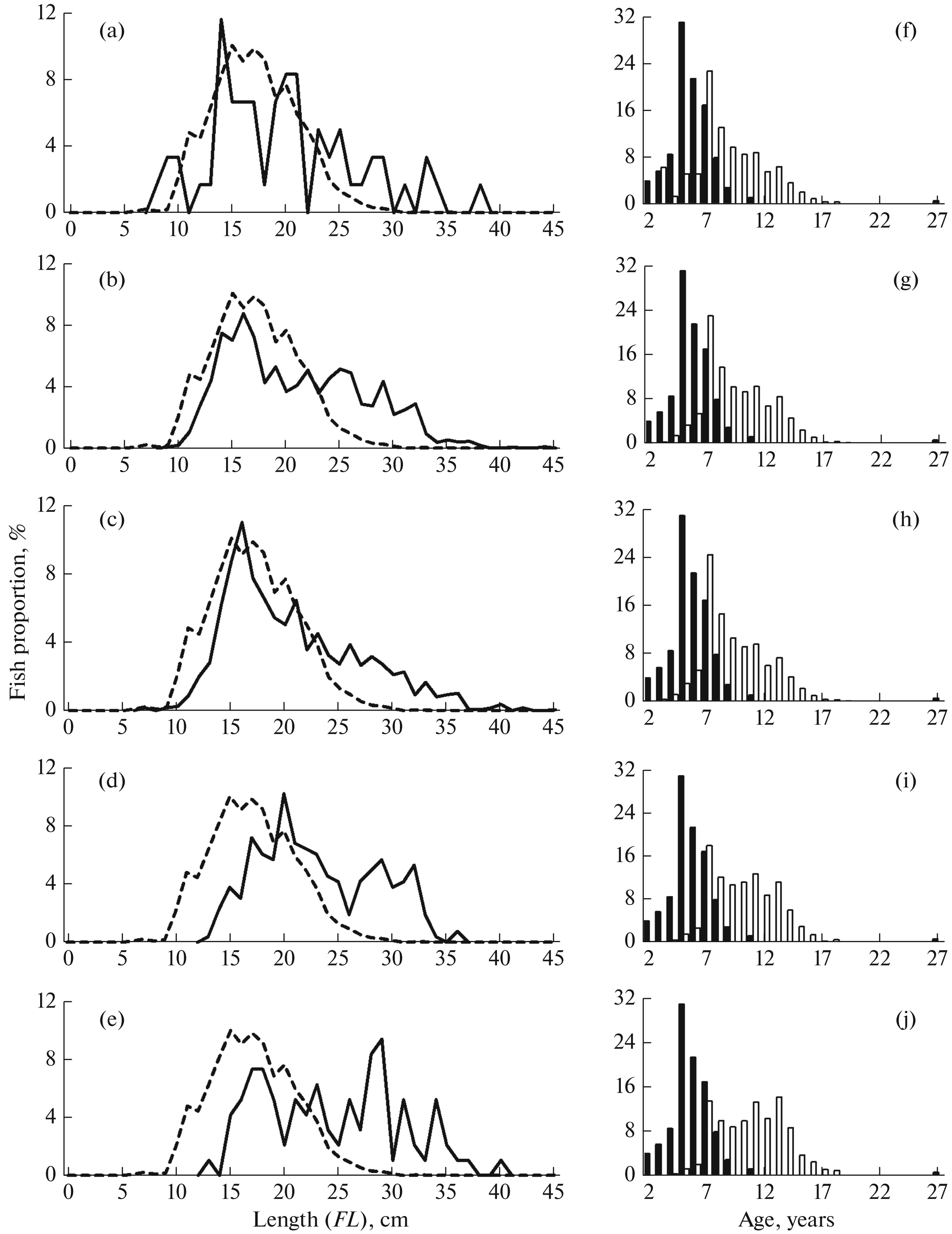

Fig. 3. Size (a)–(e) and age (f)–(j) composition of Bering flounder *Hippoglossoides robustus* in bottom trawl catches from Russian waters in 1997–2020: (a)–(j), (- -), (■) Chukchi Sea (M = 17.4 cm, average age 5.8 years, n = 3103 ind.); (—), (□) Bering Sea: (a), (f) Chirikov Basin (M = 19.8 cm, 8.7 years, n = 90 ind.); (b), (g) the northern (M = 21.0 cm, 9.4 years, n = 1604 individuals); (c), (h) central (M = 20.7 cm, 9.2 years, n = 3823 ind.) and (d), (i) western parts of the Gulf of Anadyr (M = 23.1 cm, 10.1 years, n = 263 ind.); (e), (j) Koryak region (M = 25.0 cm, 10.7 years, n = 95 ind.).

At the same time, juveniles were also recorded in the two latter areas and partly in the north of the gulf. On the whole, Alaska plaice prefers the more saline and warmer waters of the Navarin current (Kharitonova et al., 1999); its abundance decreases as the current gets colder and more desalinated in the northern direction.

In Alaska plaice, the average linear–weight values are higher in females than in males: the largest individ-

Table 3. Distribution of Bering flounder *Hippoglossoides robustus* by stages of gonad maturity in Russian waters of the Chukchi Sea in August–September 2007–2019, %

Month, year	Sex	Gonad maturity stage					*n*, ind.
		II	III	IV	V	VI–II	
August, 2007	Females	100.0	0	0	0	0	1
	Males	0	0	0	0	0	0
September, 2010	Females	54.6	23.7	20.6	1.1	0	97
	Males	44.7	38.3	17.0	0	0	47
September, 2018	Females	43.1	51.0	5.9	0	0	153
	Males	11.7	36.7	43.3	8.3	0	63
August, 2019	Females	40.4	51.3	0	0	8.3	156
	Males	65.8	7.6	3.8	0	22.8	76

uals were usually females. For instance, the average difference in the length and weight between individuals of different sexes in the northwestern part of the Bering Sea was 5.8 cm and 570 g, respectively, with the number of females prevailing in trawl catches (Datsky and Maznikova, 2017). With respect to the Chukchi Sea, there are insufficient data for this analysis; it can only be noted that two Alaska plaice individuals with *FL* 45 cm that were biologically analyzed were females and had a body weight of 1190 and 2000 g.

In the northwestern part of the Bering Sea, Alaska plaice spawns in May–June at depths of 180–200 m. Eggs are spawned both at the bottom at a water temperature of –1.7 to 1.4°C and in surface layers at a temperature of –1.5 to 3.1°C (Fadeev, 1987). Larvae 5.9–6.5 mm long stay at spawning sites or close to them at depths of 71–100 m; juveniles 5.8–8.7 cm long concentrate in bays at depths of 9–10 m (Pertseva-Ostroumova, 1961). Data on the spawning areas of Alaska plaice in the Chukchi Sea were not found; the probability of their detection is low, taking into account the absence of large mature individuals, as well as the above-mentioned spawning depths for this species. However, the larvae of this species were found in the eastern part of the sea in August–September 2012–2013 (Logerwell et al., 2020).

Yellowfin sole Limanda aspera is another relatively large and widespread flounder, the range of which extends almost to the northern border of the Chukchi Sea (Allen and Smith, 1988; Lindberg and Fedorov, 1993; D’yakov, 2011; Mecklenburg et al., 2016, 2018). Yellowfin sole reaches the maximum *FL* of 49 cm, weight of 1.7 kg, and age of 39 years within its range (Fadeev, 2005; Love et al., 2016). In addition to the Sea of Okhotsk, the main aggregations of this species were recorded in the northwestern part of the Bering Sea on the Koryak shelf. Individuals with *FL* 12–44 cm and the prevailing size of 17–21 and 28–32 cm occur in trawl catches from this area. A specimen with *FL* 45 cm and a weight of 1.42 kg at the age of 19 years was also caught in this area (Datsky and Maznikova, 2017). In the Chukchi Sea, yellowfin sole was not recorded in all trawl surveys; however, it formed local aggregations as

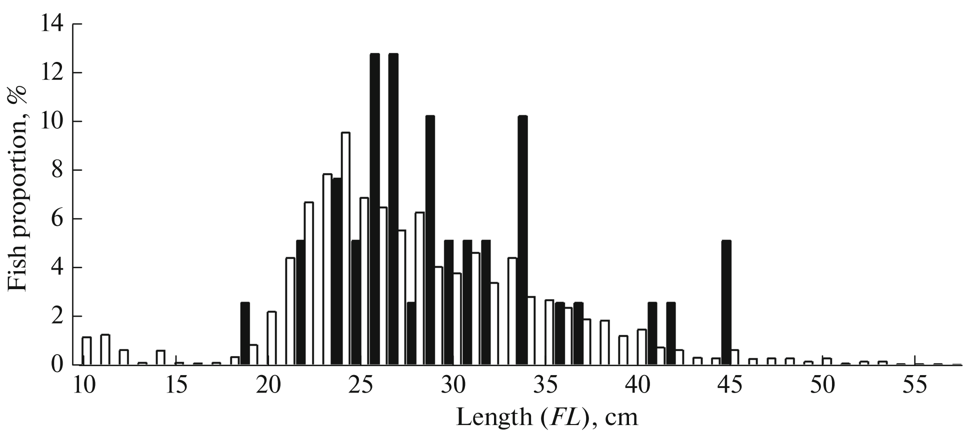

Fig. 4. Size composition of Alaska plaice *Pleuronectes quadrituberculatus* in bottom trawl catches on the Russian shelf in 1996–2020: (■) Chukchi Sea (M = 29.8 cm, n = 39 ind.), (□) Bering Sea (M = 27.8 cm, n = 9353 ind.).

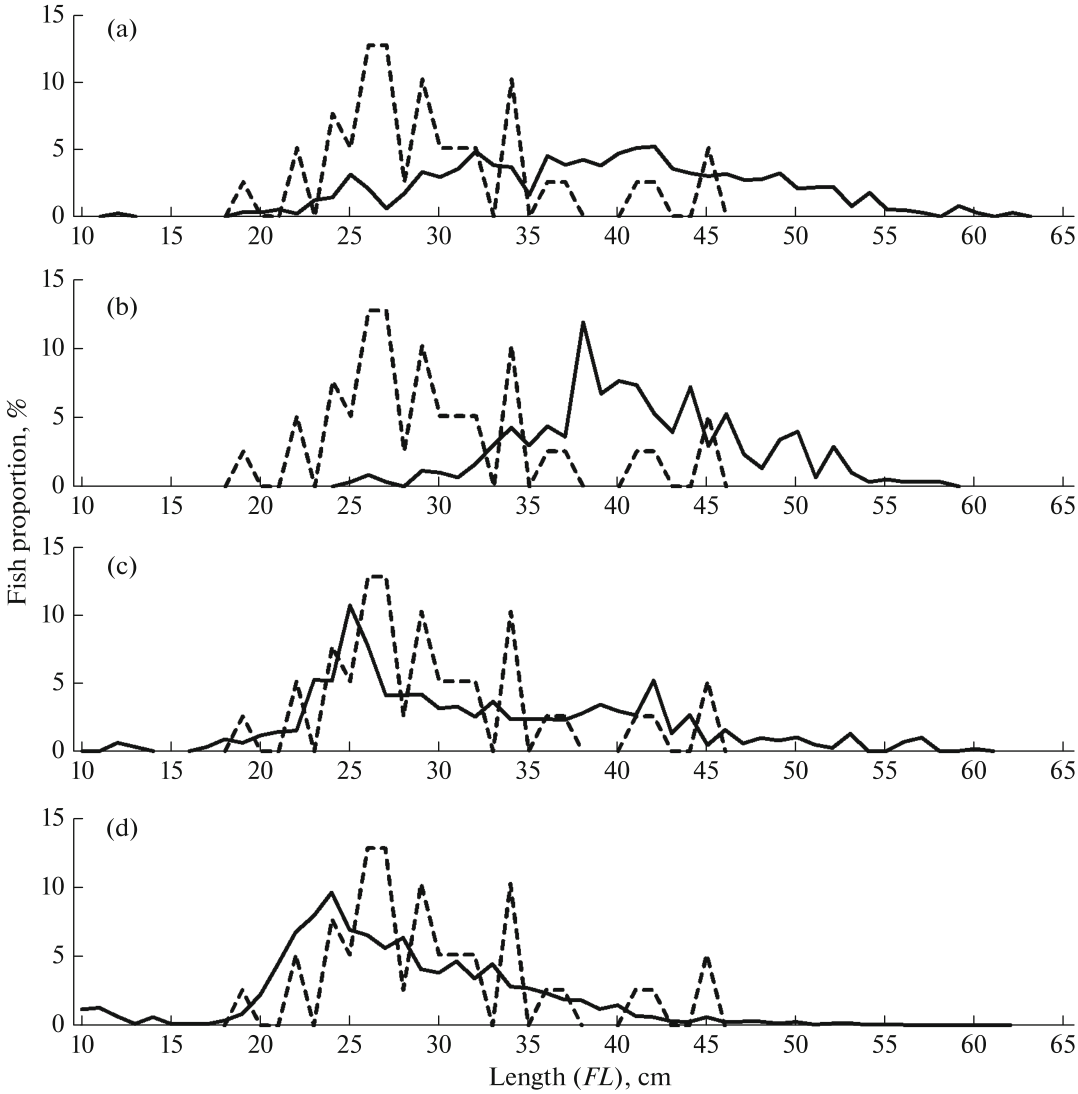

Fig. 5. Size composition of Alaska plaice *Pleuronectes quadrituberculatus* in bottom trawl catches from Russian waters in 1996–2020: (a)–(d), (- -) Chukchi Sea (M = 29.8 cm, n = 39 ind.); (—) Bering Sea: (a), (b), (c) northern (M = 38.9 cm, n = 1115 ind.), central (M = 41.1 cm, n = 980 ind.), and western (M = 32.3 cm, n = 920 ind.) parts of the Gulf of Anadyr, respectively; (d) Koryak Region (M = 27.7 cm, n = 6339 ind.).

the water masses warmed up in the summer–autumn period in 2018 and 2020 (Datsky et al., 2022. Table 2).

Materials on this flounder indicate the occurrence of individuals with *FL* 14–37 cm on the Chukchi shelf. Medium-sized individuals with *FL* 19–22 cm occurred most often in the study area; they also prevailed in trawl catches in the adjacent northwestern part of the Bering Sea (Fig. 6). At the same time, the widest range of the yellowfin sole size was recorded within the Koryak shelf, where individuals of this species generally have a smaller size due to the presence of juveniles with *FL* < 19 cm. (Fig. 7). The size of yellowfin sole increased towards the north; accordingly, the proportion of older individuals (which preferred the broad Gulf of Anadyr with favorable food conditions) increased in this direction (Fig. 7). Only part of the fish shifted to the northern border of the range, where their appearance was probably facilitated by the warm Navarin current, which intensified in years with warm climatic conditions (2018–2020).

In the northwestern part of the Bering Sea, yellowfin sole is characterized by a larger size and weight of females. After the onset of sexual maturity, males slowed down their growth; the difference in the average values of the body length and weight between males and females reached 3.0 cm and 220 g. Females surpassed males in length and weight even more sig-

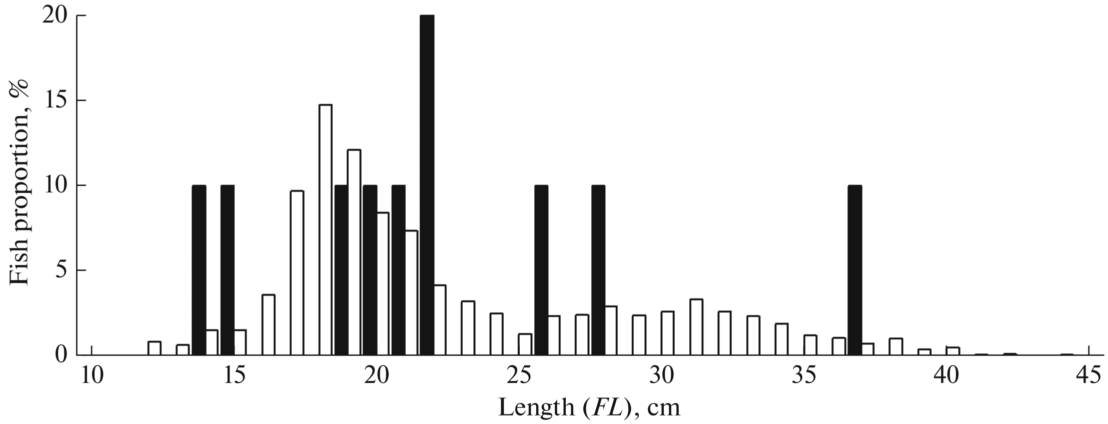

Fig. 6. Size composition of yellowfin sole *Limanda aspera* in bottom trawl catches on the Russian shelf in 1999–2020: (■) Chukchi Sea ($M = 22.4$ cm, $n = 10$ ind.), (□) Bering Sea ($M = 22.5$ cm, $n = 7047$ ind.).

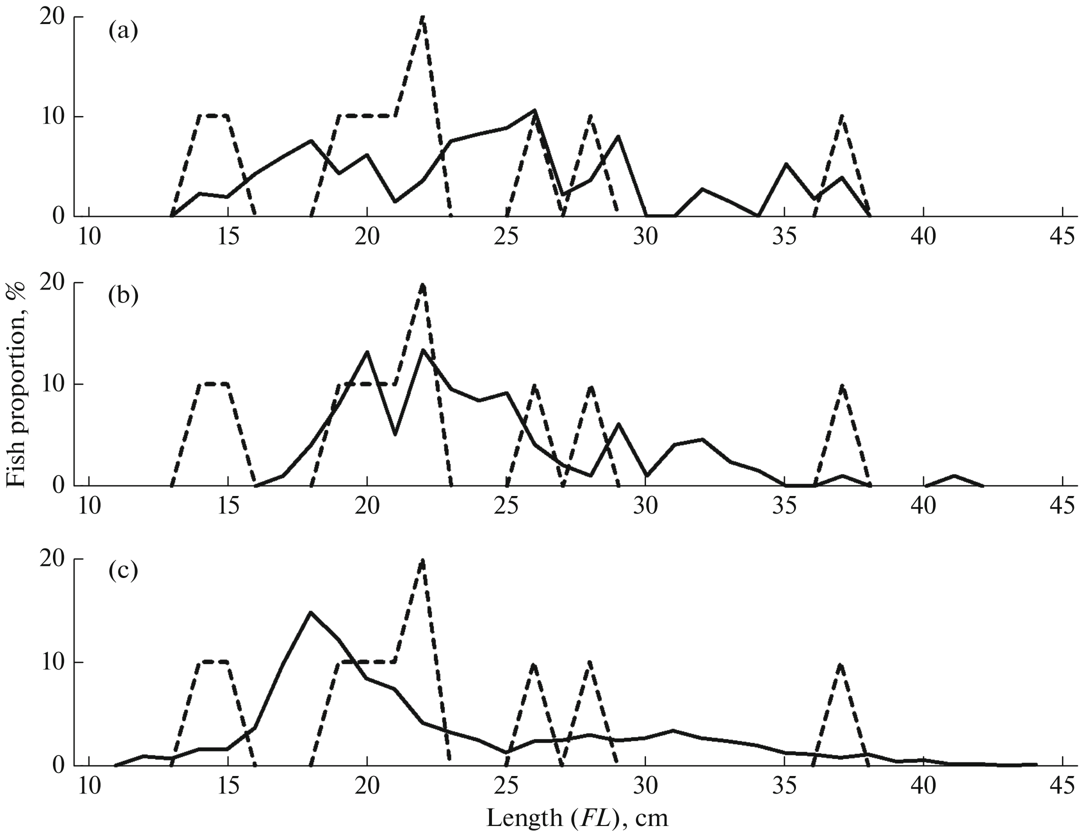

Fig. 7. Size composition of yellowfin sole *Limanda aspera* in bottom trawl catches from Russian waters in 1999–2020: (a)–(c), (- -) Chukchi Sea ($M = 22.4$ cm, $n = 10$ ind.); (—) Bering Sea: (a), (b) the northern ($M = 24.3$ cm, $n = 71$ ind.) and western ($M = 24.2$ cm, $n = 99$ ind.) parts of the Gulf of Anadyr, respectively; (c) Koryak Region ($M = 22.5$ cm, $n = 6877$ ind.).

nificantly with age; they were numerically dominant in catches (Datsky and Maznikova, 2017).

Yellowfin sole grows quite rapidly in the first two years and reach *FL* 9–16 cm, depending on the habitat area. Its annual growth then decreases to 3–6 cm upon reaching the age of 5 years and to 1.5–2.0 cm in older individuals. In the Bering Sea, males mature for the first time at *FL* 12–25 cm and their mass maturation is observed at *FL* 17 cm at the age of 3–4 years. Females reach their maturity at *FL* 19–35 cm and mass maturation at *FL* 29 cm at the age of 8–9 years (Fadeev, 1987). We failed to collect data on these parameters for yellofin sole from the Chukchi Sea.

In the western part of the Bering Sea, yellowfin sole reproduces from June to early August at a water temperature of 1–4°C at depths of less than 50 m and sometimes finishes its spawning in late August–early September (Pertseva-Ostroumova, 1961). Materials from the northwestern part of the Bering Sea showed the presence of spawning and recently post-spawned individuals in August in years with the development of cold-type hydrological conditions (Datsky and Maznikova, 2017). No data on the spawning grounds of yellowfin sole and amount and distribution of its eggs on the Chukchi shelf were found. Given the small number of spawners in the study area, it is highly probable that the species does not spawn here. This is also indicated by data on the distribution of eggs of yellowfin sole: its northern distribution is limited by Cape Navarin (D'yakov, 2011). At the same time, *L. aspera* larvae were also found (in greater numbers) in August–September 2012–2013 in the eastern part of the Chukchi Sea (as in the case of Alaska plaice) (Logerwell et al., 2020).

The other flounder species (starry flounder *Platichthys stellatus,* Sakhalin sole *L. sakhalinensis*, and longhead dab *L. proboscidea*) were less abundant on the Chukchi shelf than the above-described species. Starry flounder is a large representative of the family, which reaches *FL* 46 cm, a body weight of 1.97 kg, and an age of 38 years in waters of the western Bering Sea (Zolotov, 2010); thanks to its size, it can form a local commercial stock in the study area in some years (Datsky et al., 2022. Table 2). At the same time, studies should cover shallow depths for more exact determination of this stock, taking into account that this flounder species prefers the shallow water shelf of the Chukchi Peninsula (D'yakov, 2011; Chernova, 2011). Collections of starry flounder are minimal: there are data on the capture of three individuals with *FL* 24, 44, and 45 cm in waters of the Chukchi Sea (Fig. 8a); the weight of the smallest individual is 190 g. The paucity of data was exacerbated by the absence of trawlings at depths of less than 25 m, where this species generally lives in the summer–autumn period (Zolotov, 2010). At the same time, the large size of the captured specimens indicates the permanent habitation of starry flounder in the shallow waters of the Chukchi shelf, taking into account its feeding migrations to greater depths, as well as the fact that it does not make long-distance migrations throughout its life.

The occurrence of relatively small Sakhalin sole and longhead dab is relatively low on the Chukchi shelf, which is quite natural, taking into account the northern boundary of their ranges, which passes along the Chukchi shelf (Allen and Smith, 1988; D'yakov, 2011; Mecklenburg et al., 2018). The length, weight, and age of the former species reach 34 cm, 500 g, and 17 years in the western part of the Bering Sea (Zolotov, 2010). The largest individuals were recorded on the Koryak shelf; the size of the species decreased towards the north (Figs. 8b–8d). Within the study area, catches of Sakhalin sole with *FL* 13, 15, 18, and 24 cm were recorded in 2018 and 2020; their occurrence in this area was most likely determined by the general warming of water masses, characteristic of the late 2010s (Eisner, 2019). Taking into account the sexual maturity of males and females of this species at *FL* 13 and 16 cm at the age of 2 and 4 years, respectively (Zolotov, 2010), it can be assumed that all the individuals of this species were sexually mature on the shelf of the Chukchi Sea. As for longhead dab, which reaches *FL* 42 cm, a weight of 740 g, and an age of 13 years (Zolotov, 2010), it can be noted that only one specimen of this species with *FL* 18 cm was caught in 2018. The bulk of individuals of this species was recorded south of the Bering Strait; a trend towards an increase in the proportion of larger individuals in the southwest direction was revealed for them. In this water area, males and females mature for the first time at *FL* 16 and 18 cm in the third or fourth year of life (Zolotov, 2010).

Starry flounder and longhead dab start spawning in April and Sakhalin sole in May (the peak is observed in July for all species) and finish by September. The main spawning grounds for these fishes are in the southwestern part of the Bering Sea; eggs and larvae were not found north of Cape Navarin (D'yakov, 2019). Their spawning was not recorded in Russian waters of the Chukchi Sea and, given the absence of a large number of Sakhalin sole and longhead dab spawners, it is also unlikely that these species spawn there. However, there is evidence about the presence of larvae of these species in the eastern part of the sea (Logerwell et al., 2020). Apparently, starry flounder can form local spawning grounds in shallow water; however, specialized studies are needed to test this assumption. At the same time, there is information about its reproduction in Arctic waters at a temperature of 1.5–6.8°C (Coad et al., 1995).

Along with Pacific halibut *Hippoglossus stenolepis*, Greenland halibut *Reinhardtius hippoglossoides* is the largest representative of flounder fishes, reaching *FL* 130 cm, a weight of 13 kg, and an age of 24 years (Novikov, 1974; Novikov et al., 1992). In trawl catches, Greenland halibut juveniles begin to occur in large numbers at *FL* 10–15 cm at the age of 1 year. Upon reaching *FL* ~30 cm and the age of 3 years, juveniles live mainly within the shelf, moving to greater depths with their growth. Within the continental slope (≥200 m), catches were represented mainly by individuals aged 4–21 years with *FL* 30–90 cm (Shuntov, 1971; Maznikova et al., 2015).

Taking into account the patterns of the bathymetric distribution of greenland halibut, the presence of predominantly juvenile individuals of this species at age of

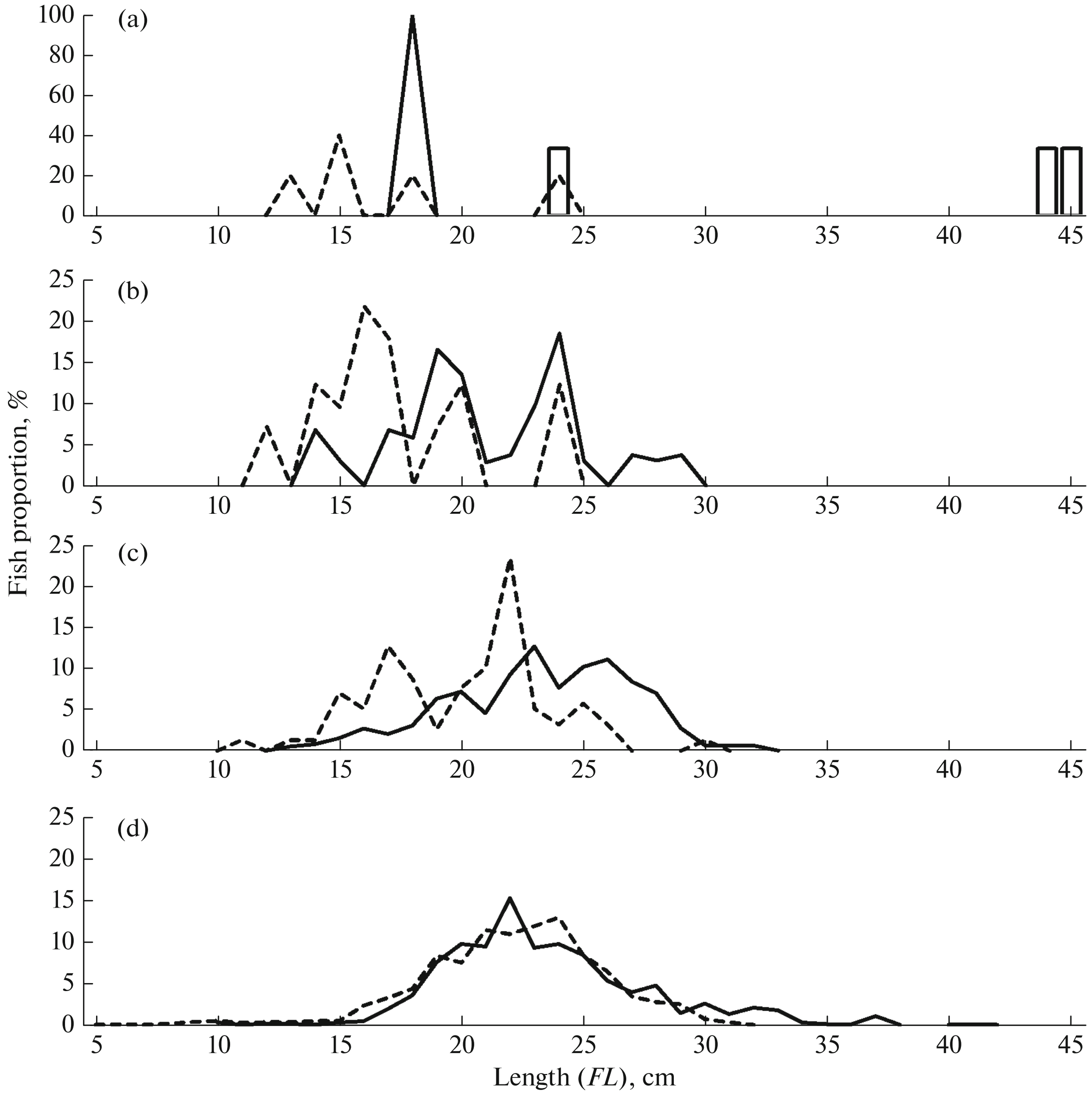

Fig. 8. Size composition of Sakhalin sole *Limanda sakhalinensis,* longhead dab *L. proboscidea,* and starry flounder *Platichthys stellatus* in bottom trawl catches from Russian waters in 1996–2020: (a) Chukchi Sea, (b)–(d) Bering Sea: (b), (c) the northern and western parts of the Gulf of Anadyr, respectively; (d) Koryak Region. Flounders: (- -) Sakhalin sole (n = 1079 ind.), (—) longhead dab (n = 856 ind.), (□) starry flounder (n = three ind.).

0+ to 2+ with *FL* up to 5–21 cm seems to be expected on the shallow Chukchi shelf. Insignificant migrations of the fish with *FL* 22–44 cm were recorded only in 2018 (Fig. 9). It should be noted that single catches of Greenland halibut with *FL* 44–65 cm in the north and northwest of the Chukchi Sea within its foreshelf at depths of 230–370 m were also described earlier (Tsinovskii, 1981; Mecklenburg et al., 2014); however, mass aggregations of the species were not found. The resulting data confirm the transport of Greenland halibut juveniles to the Chukchi shelf by Pacific currents (along the coast of Alaska to Cape Lisburn and towards the Chukchi submarine plateau) from the Bering Sea (where the main spawning grounds and feeding areas of the Pacific group of the species are located) through the Bering Strait (D'yakov, 1990, 2011; Shuntov et al., 1994; Barber et al., 1997; Mecklenburg et al., 2002; Chernova, 2017). A similar transport of juveniles with warm Atlantic waters from the Barents Sea to the Kara and Laptev seas was also recorded for the northeastern Arctic Greenland halibut *R. hippoglossoides* (Filina and Budanova, 2015; Glebov et al., 2016). On the whole, the remoteness of the Chukchi Sea from the habitats of adult individuals of the Pacific Greenland halibut and their low occurrence here (Datsky et al., 2022. Table 2), as well as the fact that the fish matures at *FL* 42–52 cm (Fadeev, 2005), indicate a low commercial importance of this species in the study area.

The features of the distribution of juveniles on the shelf of the Chukchi and Bering seas are illustrated in

Table 4. Length, weight, and sex ratio of Greenland halibut *Reinhardtius hippoglossoides* from catches in Russian waters of the Chukchi Sea

Study period	*n*, ind.	Length (*FL*), cm				Weight, g				Female/male ratio
		immature	mature			immature	mature			
			females	males	both sexes		females	males	both sexes	
August–September 1997	10	9.0–21.0 / 13.7	–	–	–	9.0–100.0 / 27.4	–	–	–	–
September 2010	5	7.0–13.0 / 8.8	–	–	–	1.0–12.0 / 3.8	–	–	–	–
August–September 2018	11	5.5–7.8 / 6.5	19.4–44.2 / 30.3	24.7–38.2 / 31.0	19.4–44.2 / 30.6	1.0–2.0 / 1.3	38.0–780.0 / 312.0	103.0–489.0 / 262.0	38.0–780.0 / 291.0	1.3 : 1.0

Figs. 10 and 11. Whereas individuals with *FL* 6–14 cm were dominant in the Chukchi Sea (up to 83% of the total fish number), larger individuals with *FL* 22–28 cm (43%) prevailed in the Bering Sea, where a few large-sized halibut individuals entered the shelf. Most of the captures of large individuals were recorded in Koryak region, where a relatively narrow shelf favors feeding migrations of mature individuals from the continental slope to this area. The occurrence of such individuals in trawl catches naturally decreases towards the north, thereby influencing the average size of the species. It should be noted that trawl gear better captures small-sized fish, which makes it possible to assess the yield of separate generations of the species, while older individuals are caught mainly in bottom longlines and gillnets (Maznikova et al., 2015).

In waters of the Chukchi Sea, immature individuals of halibut with *FL* 6–21 cm had a weight of 1–100 g. Females with a larger maximum size were generally smaller than males; however, they surpassed them in weight (Table 4). The difference between larger females and males in the same age group reaches 7 cm with age; males prevail among individuals with *FL* < 50 cm in catches and the number of females increases by three times among older individuals (Datsky and Maznikova, 2017). In our case, the number of females was slightly higher than that of males; however, small collections may not reflect the real sex ratio. A similar predominance of females among individuals with *FL* 15–45 cm, but in a higher ratio (2.8:1.0), was recorded for halibut from the East Siberian and Laptev seas (Chernova, 2017).

The length–weight dependence for Greenland halibut within the Chukchi shelf is as follows: $W = 0.0022\ FL^{3.3793}$ ($r = 0.98$, $n = 26$ ind.).

All the studied individuals were mainly at the stage of dormancy of reproductive products in late summer (three female specimens and three male specimens); gonads began to mature only in one female (*FL* 44.2 cm, 780 g). The resulting data for this period are comparable with data on the fish from the northwestern part of the Bering and Kara seas for this period (Filina and Budanova, 2015; Maznikova et al., 2018).

Breeding sites of Greenland halibut have not yet been found in the Chukchi Sea,; there are only hypotheses about possible fish spawning in the Arctic Ocean and Beaufort Sea, adjacent to the study area (Chernova, 2017). It can be assumed that the reproduction conditions in the Arctic area that we studied are unfavorable for this species and the capture of the only individual with maturing reproductive products only confirms this assumption. A similar situation was also recorded in the western sector of the Arctic, where general warming in 2007–2010 led to the appearance of a small number of mature halibut in the pre- and post-spawning state in the Kara Sea, which indicates its possible local spawning in this water area generally unfavorable for the species (Filina and Budanova, 2015).

In the Bering Sea adjacent to the Chukchi Sea, Greenland halibut spawns in October–December between the Unimak Strait and Pribilof Islands (Alton et al., 1988), as well as along the Koryak coast and in the southern part of the Gulf of Anadyr and between Cape Navarin and the St. Matthew Island at depths of 100–680 m at a water temperature of 1.0–3.5°C (Novikov, 1974). Eggs mature in a water column at depths over 550 m; larvae are moved to shallow areas in the course of their development. Greenland halibut fry with *FL* 59–65 mm was recorded in the southern part of the Gulf of Anadyr at depths of 18–40 m (Musienko, 1957).

Family Cottidae

Shorthorn sculpin Myoxocephalus verrucosus is a large sculpin, which reaches *FL* 54 cm, a weight of 2.2 kg, and an age of 13 years within its range. As a rule, females of this species reach these values, while the maximum length and age of males do not exceed 26 cm and 9 years (Andriyashev, 1954; Tokranov, 1986). In the northwestern part of the Bering Sea, adjacent to the study area, shorthorn sculpin prefers a shelf with

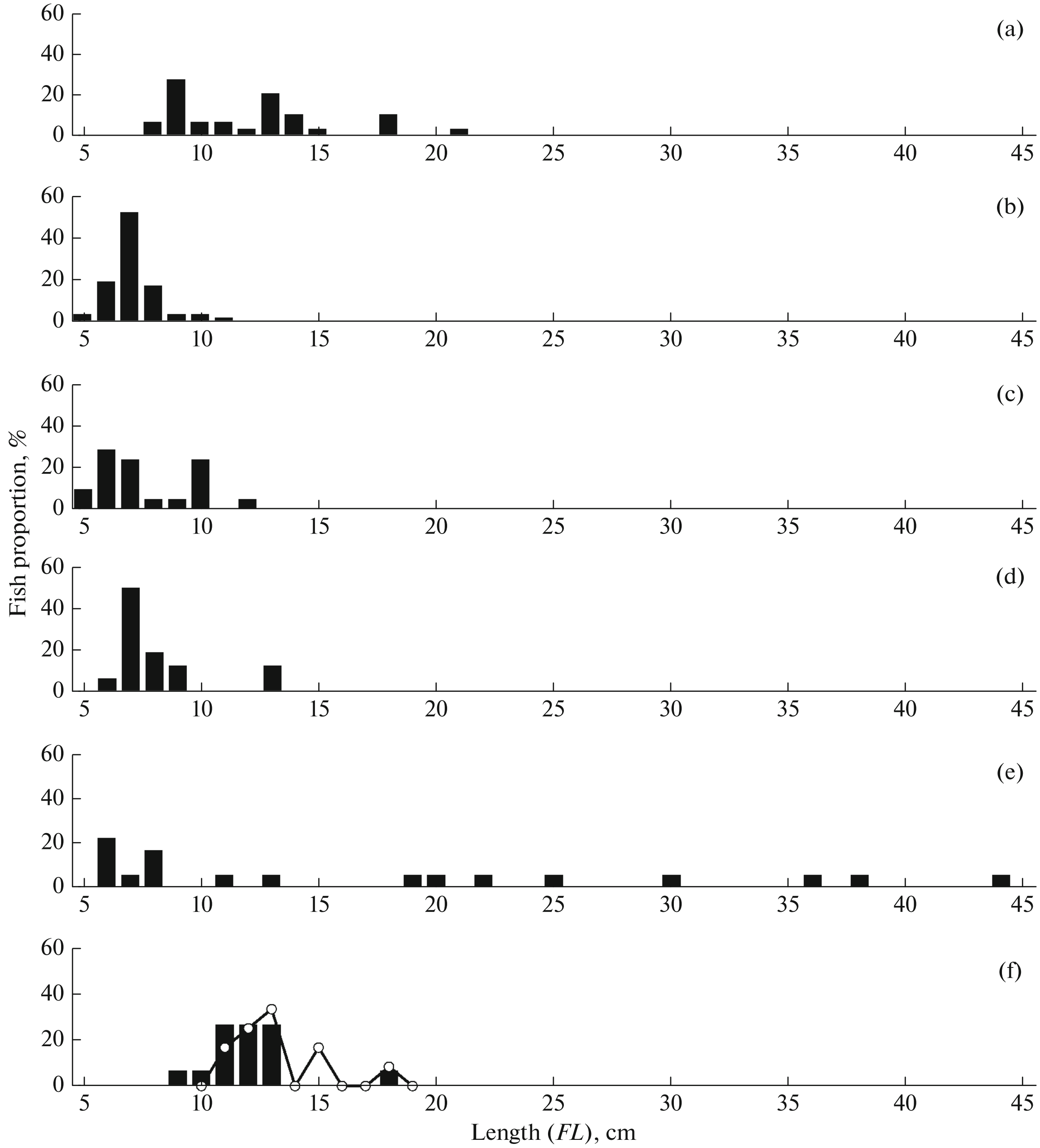

Fig. 9. Size composition of Greenland halibut *Reinhardtius hippoglossoides* in trawl catches from Russian waters of the Chukchi Sea: (a) August–September 1997 (M = 12.1 cm, n = 29 ind.), (b) August 2007 (M = 7.2 cm, n = 117 ind.), (c) September 2008 (M = 7.6 cm, n = 21 ind.), (d) September 2010 (M = 8.1 cm, n = 16 ind.), (e) September 2018 (M = 17.4 cm, n = 18 ind.); (f) August–September 2020: (■) bottom scientific trawlings (M = 12.1 cm, n = 15 ind.), (–○–) pelagic commercial trawlings (M = 13.2 cm, n = 12 ind.).

depths of less than 70 m, being absolutely dominant in fish communities between capes Chukotsky and Dezhnev (Datsky and Andronov, 2007). In the Chukchi Sea, it is widespread along the coast of Alaska up to Cape Lisburn (Allen and Smith, 1988); its occurrence is also high in Russian waters (Orlov et al., 2019).

On the Chukchi shelf, trawl catches contained shorthorn sculpin with *FL* 6–50 cm (most often with *FL* 30–42 cm—about 59% of the total number). The latter were dominant mainly in the near-bottom horizons, while the proportion of juveniles with *FL* 6–20 cm was high in the pelagic zone (Fig. 12). On the whole, individuals of this species are somewhat smaller in the study area than from the northwestern part of the Bering Sea due to a greater proportion of immature individuals with *FL* 9–14 cm and the absence of large-

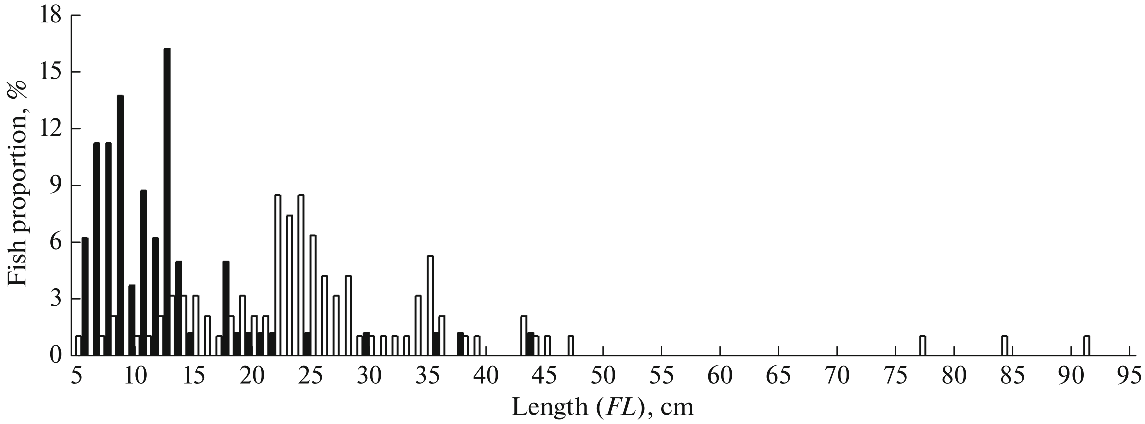

Fig. 10. Size composition of Greenland halibut *Reinhardtius hippoglossoides* in bottom trawl catches on the Russian shelf in 1997–2020: (■) Chukchi Sea (M = 12.5 cm, n = 80 ind.), (□) Bering Sea (M = 26.1 cm, n = 94 ind.).

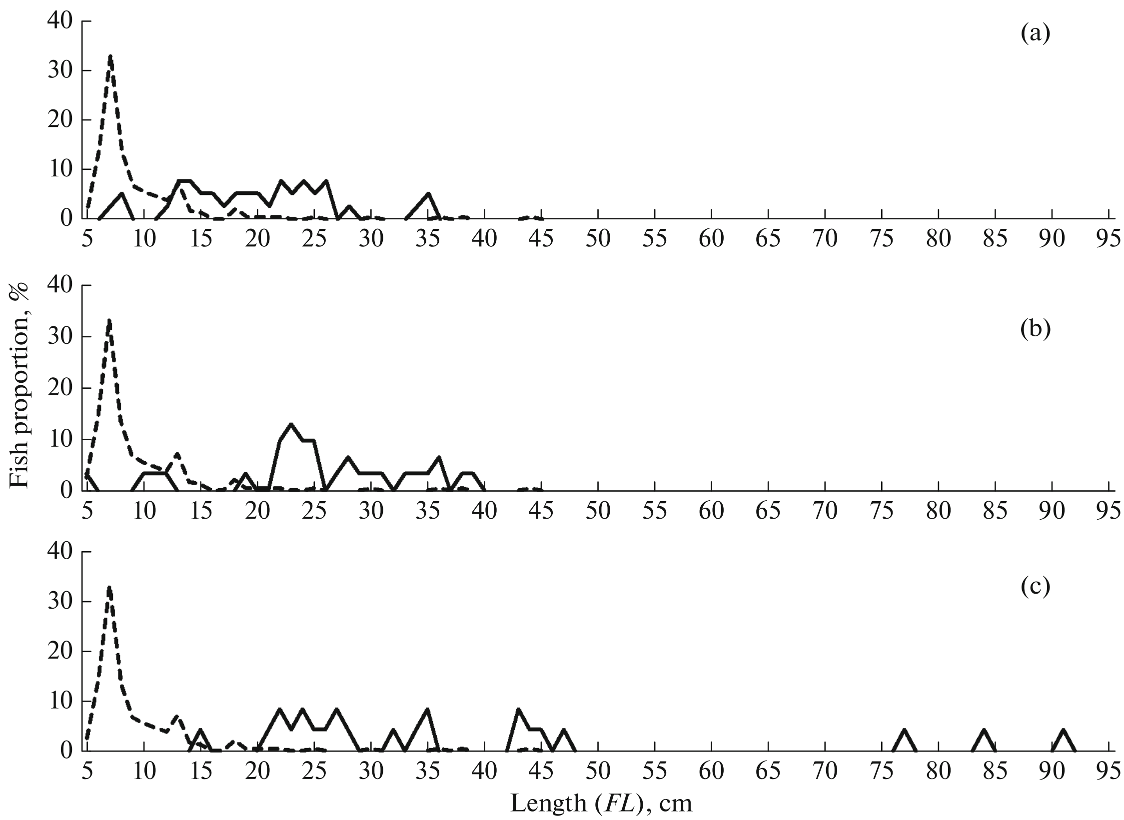

Fig. 11. Size composition of Greenland halibut *Reinhardtius hippoglossoides* in bottom trawl catches from Russian waters in 1997–2020: (a)–(c), (- -) Chukchi Sea (M = 9.3 cm, n = 238 ind.); (—) Bering Sea: (a), (b) the central (M = 19.8 cm, n = 39 ind.) and western (M = 25.3 cm, n = 31 ind.) parts of the Gulf of Anadyr, respectively; (c) Koryak Region (M = 37.3 cm, n = 24 ind.).

sized sculpins with FL > 50 cm (Fig. 13) at the age of 10–11 years (Datsky and Andronov, 2007).

In terms of the size of sculpins from separate areas of the shelf within the Russian waters of the Chukchi and Bering seas, individuals from most of the areas in the Chukchi shelf were characterized by a wide range of their length in the modal group (Fig. 14). The fish size composition in the water area south of the Bering Strait (the Chirikov Basin) was most similar to that on the Chukchi shelf. The smallest individuals were recorded in the north of the Gulf of Anadyr; large-sized individuals were absent there. On the contrary, the proportion of large individuals was higher in the

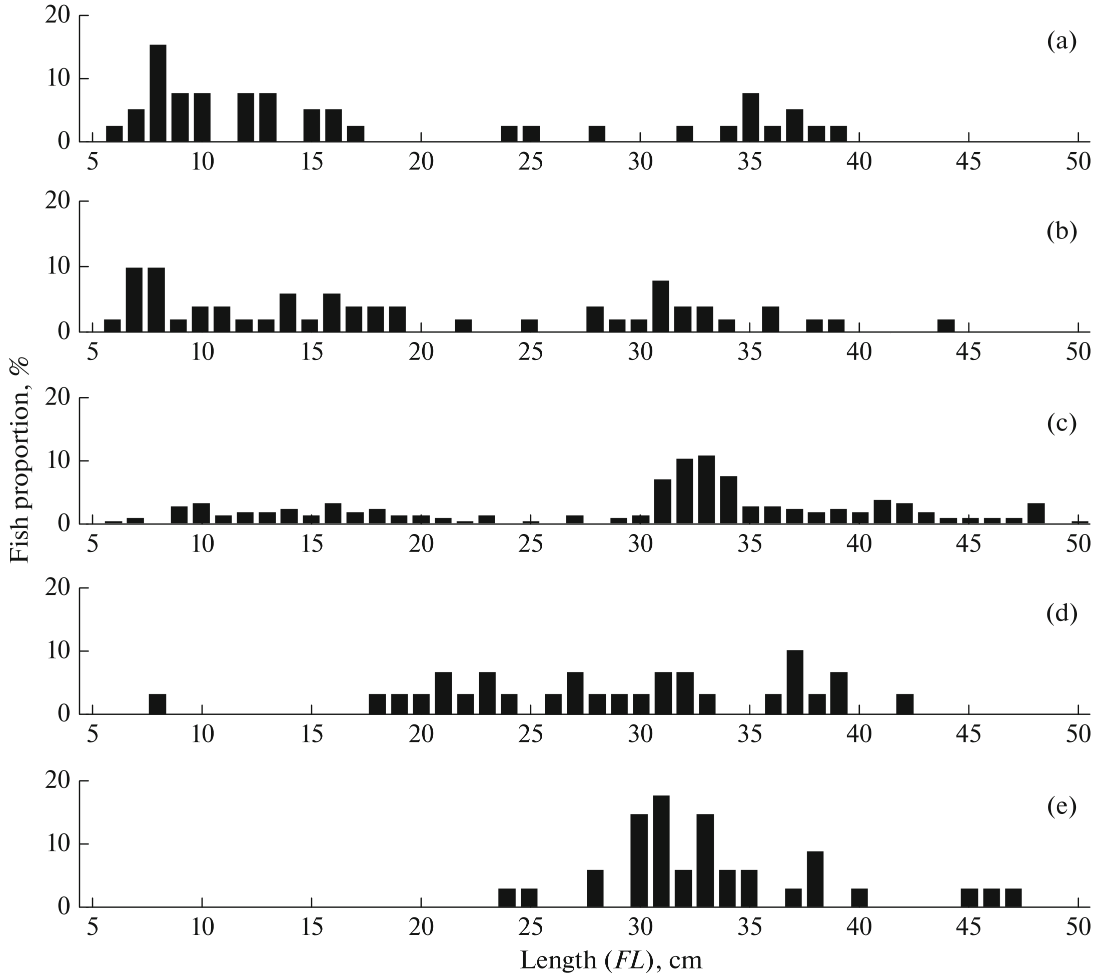

Fig. 12. Size composition of shorthorn sculpin *Myoxocephalus verrucosus* from trawl catches in Russian waters of the Chukchi Sea: (a) August 2007 (M = 18.3 cm, n = 39 ind.), (b) September 2008 (M = 19.9 cm, n = 51 ind.), (c) September 2010 (M = 29.6 cm, n = 213 ind.), (d) September 2018 (M = 28.6 cm, n = 29 ind.), (e) August 2019 (M = 33.4 cm, n = 34 ind.).

western part of the gulf and on the Koryak shelf than in the Chukchi Sea. Exceptionally mature individuals stayed in the central part of the Gulf of Anadyr, while the majority of sculpins preferred the coastal areas of the shelf with depths of less than 70 m (Datsky, 2017). The presence of a significant number of juveniles with $FL < 12$ cm is also a feature of the distribution of the species within the Chukchi shelf, while it was almost completely absent in trawl catches from the southern areas except the Chirikov Basin.

The length and weight of shorthorn sculpin juveniles on the Chukchi shelf varied from 7 to 16 cm and 4 to 79 g, respectively. Females were larger than males: their average size and weight were 8.8 cm and 638 g higher (41.0 vs. 32.2 cm and 1178 vs. 540 g, respectively). This is also indicated by the maximum values of the length and weight of sculpins in trawl catches: 21–38 cm and 140–820 g for males and 22–48 cm and 145–1645 g for females. On the whole, these data confirm the viewpoint of sexual dimorphism of shorthorn sculpin, which is expressed in different sizes of males and females. The latter are larger, grow more rapidly, mature later, and live longer (Tokranov, 1986; Borets, 1997). For example, in the northwestern part of the Bering Sea, females begin to surpass males in linear and weight growth from the age of 4 years and the average difference reaches 10.9 cm and 590 g (Datsky and Andronov, 2007). The length–weight dependence for shorthorn sculpin within the Chukchi shelf is as follows: $W = 0.0109FL^{3.0934}$ ($r = 0.99$, $n = 40$ ind.).

In waters of the northwestern part of the Bering Sea, the mass maturation of shorthorn sculpin is observed at the age of 5 years (FL 31 cm) for females and 3–4 years (FL 12 cm) for males (Datsky and Andronov, 2007). On the Chukchi shelf, most females (83.3%) had gonads at maturity stage IV and 100% of males had gonads at stages I–II. Shorthorn sculpin usually spawns in late autumn in shallow areas of the shelf at a bottom water layer temperature of 1°C; the number of females prevails (Andriyashev, 1954).

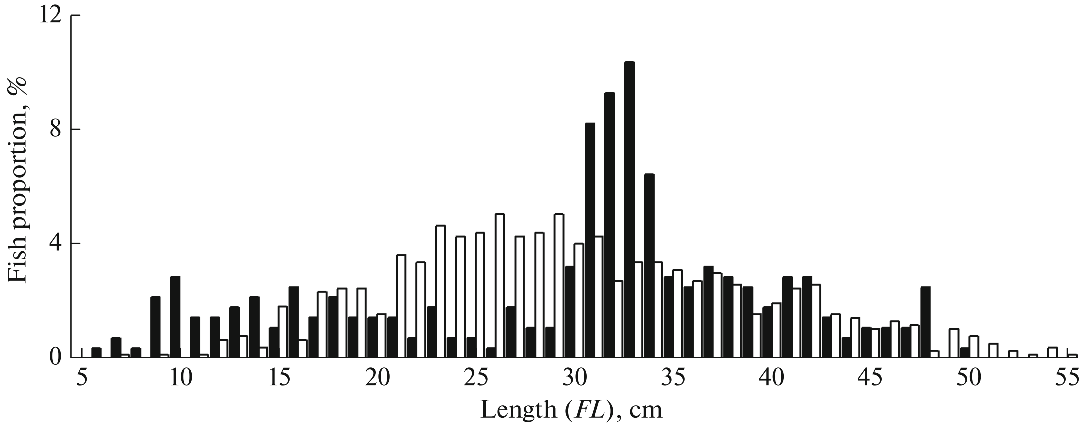

Fig. 13. Size composition of shorthorn sculpin *Myoxocephalus verrucosus* in bottom trawl catches on the Russian shelf in 2001–2019: (■) Chukchi Sea (M = 29.7 cm, n = 280 ind.), (□) Bering Sea (M = 30.0 cm, n = 774 ind.).

Arctic staghorn sculpin Gymnocanthus tricuspis is an Arctic species with the southern boundary of the range in the Gulf of Anadyr near Cape Navarin (Chernova, 2011) and northern circumpolar boundary mainly within the shelf zone of the Arctic seas (Mecklenburg et al., 2016). This relatively small sculpin occurs everywhere in the southwestern part of the Chukchi Sea (Mecklenburg et al., 2016; Orlov et al., 2019); it usually lives at depths of less than 100 m at negative or near zero water temperatures (Andriyashev, 1954).

The size of Arctic staghorn sculpin in trawl catches varied from 5 to 20 cm; the pelagic layers were dominated by juveniles with *FL* 6–8 cm (58%); individuals with *FL* 11–16 cm were dominant at the bottom (up to 91%). The largest individuals were recorded in bottom trawls in 2018–2019; in 2020, relatively small sculpins with *FL* 9–12 cm formed the basis of aggregations (Fig. 15). It should be noted that a similar but slightly smaller size was recorded for this species in autumn on the Kara Sea shelf: catches were represented by individuals with *FL* 4–17 cm, dominated by individuals with *FL* 4–8 cm (Tokranov and Orlov, 2021). Presumably, more suitable living conditions for the species on the Chukchi shelf were reflected in its larger size than that of the fish from the northwestern part of the Bering Sea (Fig. 16). Whereas individuals with *FL* 10–16 cm were dominant in the study area (about 87% of all shorthorn sculpin catches), aggregations on the northern Bering Sea shelf were dominated by individuals with *FL* 9–14 cm (about 78%). The weight of individuals with *FL* 8–10 cm was 10–19 g. On the whole, Arctic staghorn sculpin is the smallest among the six species of the genus *Gymnocanthus*: the length, weight, and age of males and females do not exceed 14 and 25 cm, 75 and 120 g, and 7 and 8 years, respectively (Tokranov and Orlov, 2021). At the same time, there is evidence that females from the northeastern part of the Chukchi Sea reach an age of at least 9 years and males not less than 8 years (Smith et al., 1997).

Similarly to other staghorn sculpins, Arctic staghorn sculpin males are much smaller than females, mature at an earlier age, and have a shorter lifespan (Tokranov, 2016). This species reaches *FL* 4–5 cm during the first year of life and 7–8 cm during the second; females then grow more rapidly than males, reaching sexual maturity by the 4th year of life. For instance, the average difference in body length and weight between individuals of different sexes on the shelf of the Kara Sea reaches almost 1.7 cm and 20 g at the age of 7 years (Tokranov and Orlov, 2021).

The dates and areas of breeding of Arctic staghorn sculpin, as well as the dates of its embryonic period, have not been precisely determined; however, it probably begins to spawn within a shallow shelf from late September (Andriyashev, 1954). Single captures of larvae of this species were recorded in the eastern part of the Chukchi Sea (Logerwell et al., 2020).

Other sculpins (great sculpin *M. polyacanthocephalus*, butterfly sculpin *Hemilepidotus papilio,* and yellow Irish lord *H. jordani*, armorhead sculpin *G. galeatus*) are large-sized cottid representatives, which are highly abundant in the Bering Sea and adjacent waters to the south. Despite a rather vast range (Tuponogov and Kodolov, 2014; Mecklenburg et al., 2018), the mass presence of these fishes in Russian waters is limited to the southwestern part of the Gulf of Anadyr (Datsky and Andronov, 2007); only immature individuals were recorded on the Chukchi shelf (Fig. 17). Thus, one of the largest sculpin species, namely, great sculpin (which reaches *FL* 85 cm in the northwestern part of the Bering Sea, a weight of 9 kg, and an age of 16 years) (Datsky, 2017), was represented by individuals with *FL* 7–27 cm in Russian waters of the Chukchi Sea and dominated by juveniles with *FL* 7–11 cm (70.6% of all catches). Taking into account that females and males of this species begin to mature at *FL* 36–40 and 25 cm, respectively (Datsky and Andronov, 2007), we can state the complete absence of mature individuals in the

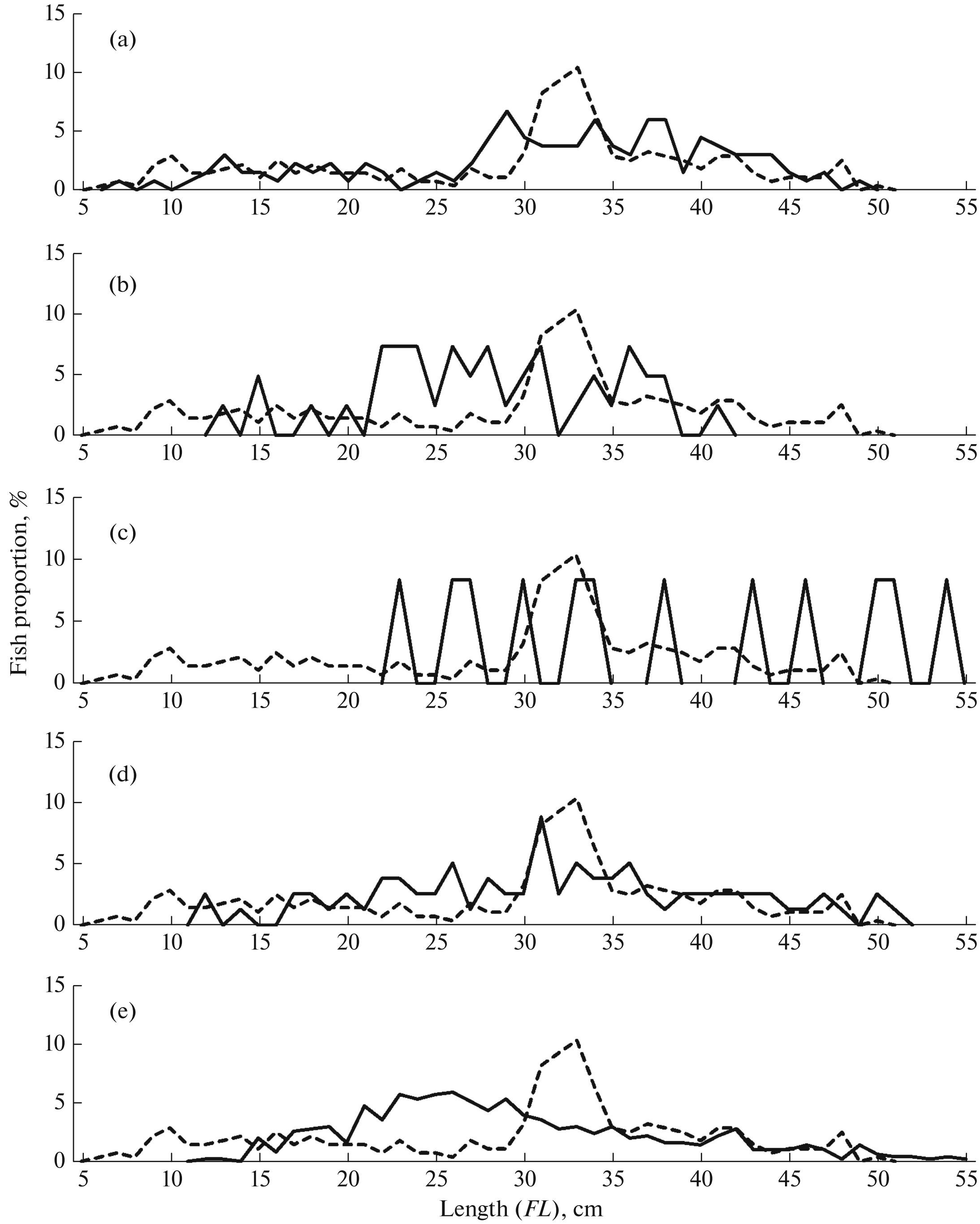

Fig. 14. Size composition of shorthorn sculpin *Myoxocephalus verrucosus* from bottom trawl catches in Russian waters in 2001–2019: (a)–(e), (- -) Chukchi Sea (M = 29.7 cm, n = 280 ind.); (—) Bering Sea: (a) Chirikov Basin (M = 31.3 cm, n = 135 ind.); (b, c, d) the northern (M = 28.0 cm, n = 41 ind.), central (M = 37.9 cm, n = 12 ind.), and western parts (M = 31.8 cm, n = 79 ind.) of the Gulf of Anadyr; (e) Koryak Region (M = 29.4 cm, n = 507 ind.).

study area, despite a large number of trawl surveys performed there (Fig. 17a). The largest individuals of the species were recorded southwest of Cape Navarin (the limits of the fish length are the greatest in this water area) and in the north of the Gulf of Anadyr (Fig. 18), where the hydrological conditions limit the northern distribution of mature individuals. Juveniles of this species are transported to the northern part of the Bering Sea and to the Chukchi shelf (probably, by the warm Navarin current). It should be noted that almost all the sculpin individuals were caught from the Chukchi Sea with pelagic trawls.

Over 98% of butterfly sculpin individuals were caught from the pelagic zone of the Chukchi shelf.

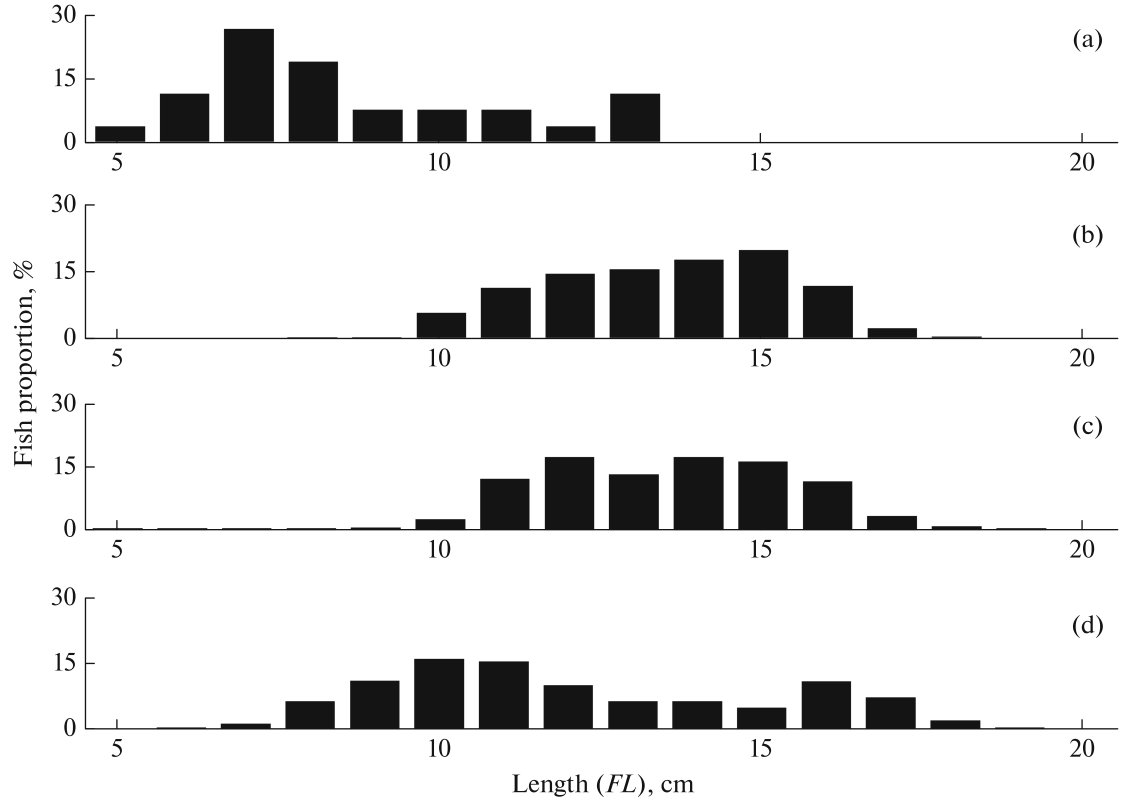

Fig. 15. Size composition of Arctic staghorn sculpin *Gymnocanthus tricuspis* from bottom trawl catches in Russian waters of the Chukchi Sea: (a) August 2007 (*M* = 8.6 cm, *n* = 26 ind.), (b) September 2018 (*M* = 13.5 cm, *n* = 728 ind.), (c) August 2019 (*M* = 13.4 cm, *n* = 365 ind.), (d) August–September 2020 (*M* = 12.2 cm, *n* = 522 ind.).

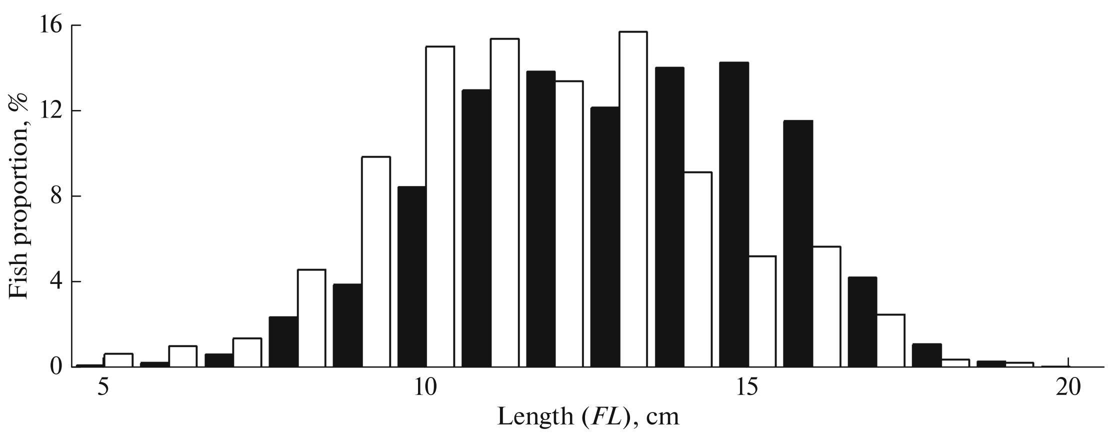

Fig. 16. Size composition of cumulative samples of Arctic staghorn sculpin *Gymnocanthus tricuspis* from bottom trawl catches in Russian waters in 2005–2020: (■) Chukchi Sea (*M* = 13.0 cm, *n* = 1615 ind.), (□) Bering Sea (*M* = 11.8 cm, *n* = 605 specimens).

This lord species, which has the maximum body length and weight of 8–37 cm and 0.05–1.66 kg in the northwestern part of the Bering Sea (Datsky, 2017), was represented mainly by juveniles with *FL* 3–12 cm (modal group of 4–5 cm) in the study area (93.0% of all catches) (Fig. 17b). Since only one individual with *FL* 19 cm was caught during the trawl operations, while the species reaches sexual maturity at the age of 4–8 years at *FL* 18-28 cm (Datsky, 2017), it can be concluded that all individuals were immature and their presence here (as well as great sculpin juveniles) is most likely due to their drift by the warm currents of the Bering Sea. Note that settling of juveniles with *FL* 4–5 cm from pelagic to bottom layers was recorded

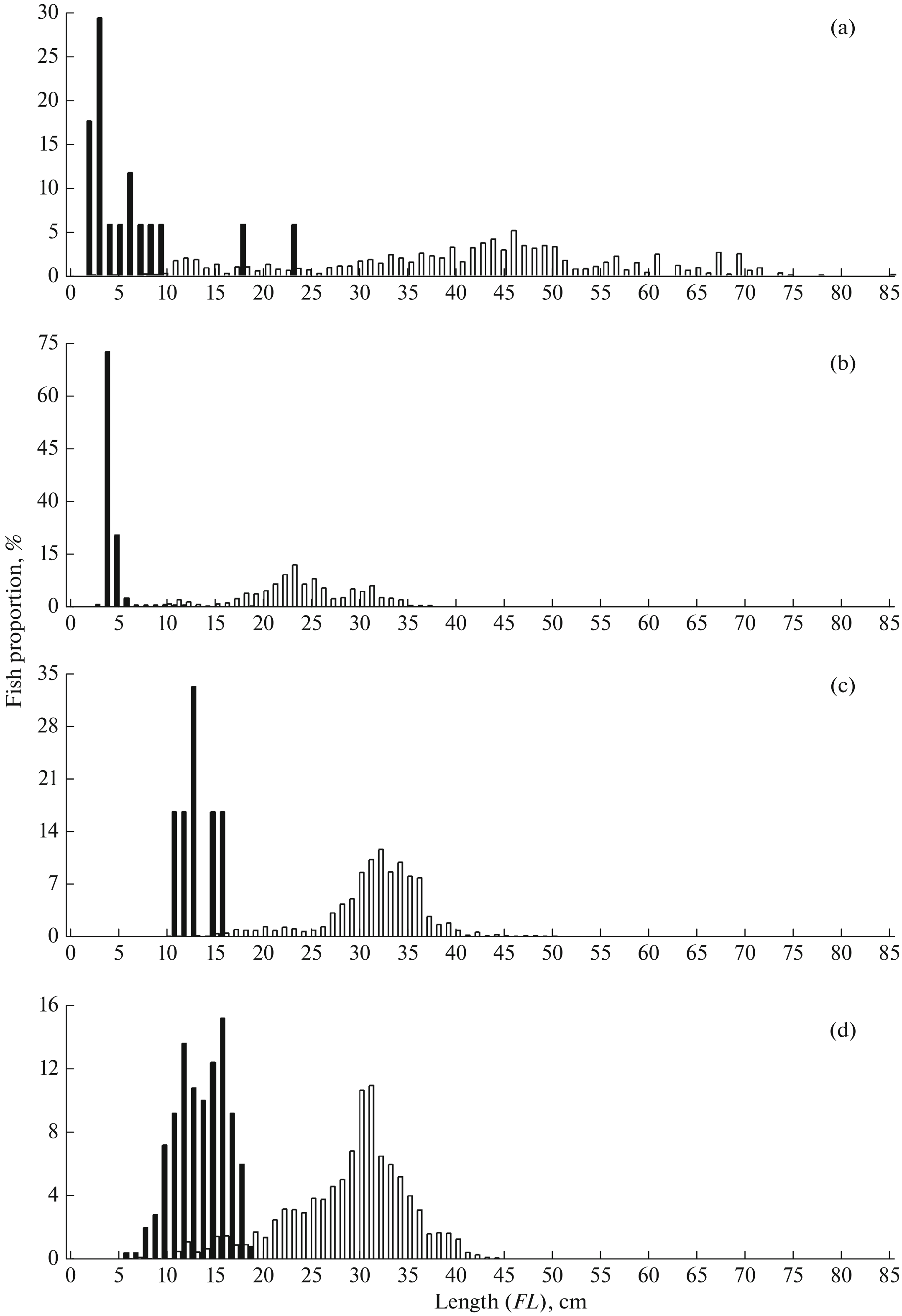

Fig. 17. Size composition of some species of the family Cottidae from trawl catches in Russian waters of the Chukchi (■) and Bering (□) seas in 2001–2020: (a) great sculpin *Myoxocephalus polyacanthocephalus* (Chukchi Sea: $M = 11.2$ cm, $n = 17$ ind.; Bering Sea: $M = 44.2$ cm, $n = 2197$ ind.), (b) butterfly sculpin *Hemilepidotus papilio* (Chukchi Sea: $M = 4.5$ cm, $n = 387$ ind.; Bering Sea: $M = 24.0$ cm, $n = 915$ ind.); (c) yellow Irish lord *Hemilepidotus jordani* (Chukchi Sea: $M = 4.5$ cm, $n = 387$ ind.; Bering Sea: $M = 24.0$ cm, $n = 915$ ind.), (d) armorhead sculpin *Gymnocanthus galeatus* (Chukchi Sea: $M = 13.7$ cm, $n = 250$ ind.; Bering Sea: $M = 28.6$ cm, $n = 2337$ ind.).

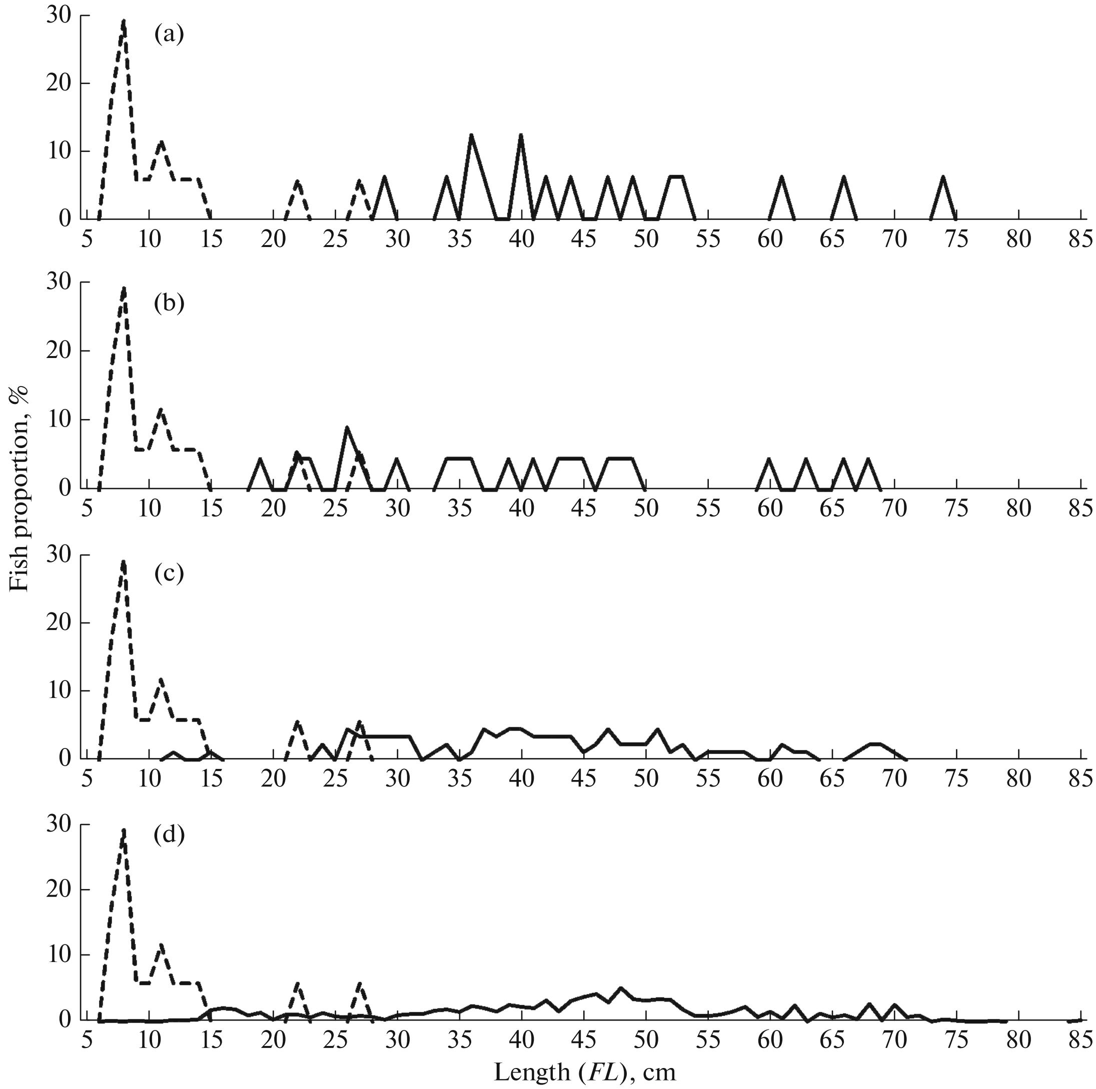

Fig. 18. Size composition of great sculpin *Myoxocephalus polyacanthocephalus* from trawl catches in Russian waters in 2001-2020: (a)–(d), (- -) Chukchi Sea (M = 11.2 cm, n = 17 ind.); (—) Bering Sea: (a), (b), (c) the northern (M = 46.3 cm, n = 154 ind.), central (M = 40.4 cm, n = 259 ind.), and western (M = 42.1 cm, n = 1123 ind.) parts of the Gulf of Anadyr; (d) Koryak area (M = 44.2 cm, n = 661 ind.).

both in the northeastern part of the Chukchi Sea (Mecklenburg et al., 2018) and in its southwestern part (juveniles with *FL* 4– 7 cm were caught at the bottom).

Another lord species, yellow Irish lord, was recorded in waters of the Chukchi Sea in smaller numbers than butterfly sculpin, which is quite understandable, given its generally less northern distribution (Mecklenburg et al., 2018). As with butterfly sculpin, only immature individuals with *FL* 11–16 cm were recorded here; their presence presumably determines the northern boundary of the species range. For instance, more favorable living conditions for this lord species in the northwestern part of the Bering Sea contribute to the presence of individuals with *FL* 8–53 cm (with a mode of 30–36 cm) (65.2%) in the water area (Fig. 17c). The weight of these individuals varies from 0.10 to 1.91 kg and they mature in the 4th–7th year of life at *FL* 26–40 cm. At the same time, yellow Irish lord can reach *FL* 62 cm, a weight of 2.8 kg, and an age of 28 years in other areas (Fadeev, 2005; Hutchinson and TenBrink, 2011; TenBrink and Buckley, 2013).

Armorhead sculpin, which is a mass cottid species in the Bering Sea, was found exclusively in the bottom layers within the Chukchi shelf and represented by immature individuals with *FL* 6–19 cm (modal group of 12–16 cm) (62.0%). Comparative data indicate the minimum size of the species on the Chukchi shelf. For instance, armorhead sculpin in the northwestern part of the Bering Sea (mainly to the south of Cape Navarin) had the maximum size of 6–44 cm and its composition was dominated by individuals with *FL* 25–35 cm (67.4%) (Fig. 17d). Accordingly, the average fish size also differed significantly: 13.7 vs. 7 years. Some armorhead sculpin individuals mature at the 4th year of life at *FL* 18–22 cm; mass maturation occurs at the age of 5–6 years in males and 6–7 years in females at *FL* 24–26 cm (Borets, 1997). On the whole, this species is the largest among the six species of the genus *Gymnocanthus*: the length, weight, and age of males and females in the western Pacific Ocean reach 36 and 49 cm, 640 and 1400 g, and 11 and 17 years, respectively (Tokranov and Orlov, 2012, 2021).

Spawning of the above-mentioned sculpins was not recorded in the Chukchi Sea and immediately adjacent waters. In other areas of the northwestern part of the Pacific Ocean, great sculpin reproduces in autumn–winter at depths of 120–210 m at a bottom water layer temperature of 0.8–1.9°C. Similar spawning conditions were also recorded for Arctic staghorn sculpin in December–January in the depth range of 120–180 m at a bottom water temperature of 1.3–1.8°C. Yellow Irish lord spawns in June–September at depths of 10–30 m at a temperature of 5–10°C (Tokranov, 1985, 1986, 1987; Chereshnev et al., 2001). Significant depths typical for great sculpin and staghorn sculpins and high water temperature (characteristic of lords) during the spawning period probably leave no prospects for discovering breeding areas of these species on the Chukchi shelf.

On the whole, the absence of mature individuals and their spawning grounds, as well as their low occurrence and catches, indicate unfavorable living conditions for great sculpin, butterfly sculpin, yellow Irish lord, and armorhead sculpin in Russian waters of the Chukchi Sea, which shows no prospects for their commercial use in this water area.

ACKNOWLEDGMENTS

The authors are sincerely grateful to all members of the Pacific, Kamchatka, and Polar branches and Central Office of the Russian Federal Research Institute of Fisheries and Oceanography, who were involved in the scientific research in the Chukchi and Bering seas in different years, as well as to ship crew members for assistance in collecting the primary material used in this article.

REFERENCES

Allen, M.J. and Smith, G.B., *Atlas and Zoogeography of Common Fishes in the Bering Sea and Northeastern Pacific*, NOAA Tech. Rept. NMFS, no. 66, Seattle, WA: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 1988. https://doi.org/10.5962/bhl.title.62517

Alton, M.S., Bakkala, R.G., Walters, G.E., and Munro, P.T., *Greenland Turbot Reinhardtius Hippoglossoides of the Eastern Bering Sea and Aleutian Islands Region*, NOAA Tech. Rept. NMFS, no. 71, Seattle, WA: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 1988.

Andriyashev, A.P., *Ryby severnykh morei SSSR* (Fishes of the Northern Seas of Soviet Union), Moscow: Akad. Nauk SSSR, 1954.

Barber, W.E., Smith, R.L., Vallarino, M., and Meyer, R.M., Demersal fish assemblages of the northeastern Chukchi Sea, Alaska, *Fish. Bull.*, 1997, no. 95, pp. 195–209.

Borets, L.A., *Donnye ikhtiotseny rossiiskogo shel'fa dal'nevostochnykh morei: sostav, struktura, elementy funktsionirovaniya i promyslovoe znachenie* (Bottom Ichthyocenes of the Russian Shelf of Far Eastern Seas: Composition, Structure, Functional Elements, and Commercial Use), Vladivostok: TINRO-Tsentr, 1997.

Buckley, T.W., 2013. life?history aspects of the yellow irish lord (hemilepidotus jordani) in the eastern bering sea and aleutian islands, *Northwest. Nat*, vol. 94, pp. 126–136.

Chereshnev, I.A., Volobuev, V.V., Khovanskii, I.E., and Shestakov A.V., *Pribrezhnye ryby severnoi chasti Okhotskogo morya (Coastal Fishes of the Northern Part of the Sea of Okhotsk)*, Vladivostok: Dal'nauka, 2001.

Chernova, N.V., Distribution patterns and chorological analysis of fish fauna of the Arctic region, *J. Ichthyol.*, 2011, vol. 51, no. 10, pp. 825–924. https://doi.org/10.1134/S0032945211100043

Chernova, N.V., Catching of Greenland halibut *Reinhardtius hippoglossoides* (Pleuronectidae) on the shelf edge of the Laptev and East Siberian Seas, *J. Ichthyol.*, 2017, vol. 57, no. 2, pp. 219–227. https://doi.org/10.1134/S0032945217020059

Coad, B.W., Waszczuk, H., and Labignan, I., *Encyclopedia of Canadian Fishes*, Waterdown: CMN and Canad. Sportfish. Prod., 1995.

D'yakov, Yu.P., Distribution of juveniles of Greenland halibut in the Bering Strait and the Chukchi Sea, in *Biologicheskie resursy shel'fovykh i okrainnykh morei Sovetskogo Soyuza* (Biological Resources of the Shelf and Marginal Seas of the Soviet Union), Moscow: Nauka, 1990, pp. 177–180.

D'yakov, Yu.P., Geographical variability of the seasonal-spawning structure of the fauna of flatfish (Pleuronectiformes) in the seas of the northern part of the Pacific Ocean, *Issled. Vodn. Biol. Resur. Kamchatki Sev.-Zap. Ch. Tikh. Okeana*, 2006, no. 8, pp. 85–97.

D'yakov, Yu.P., *Kambaloobraznye (Pleuronectiformes) dal'nevostochnykh morei Rossii (prostranstvennaya organizatsiya fauny, sezony i prodolzhitel'nost' neresta, populyatsionnaya struktura vida, dinamika populyatsii* (Flatfish (Pleuronectiformes) of the Russian Far Eastern Seas (Spatial Organization of Fauna, Seasons and Duration of Spawning, Population Structure of the Species, and Population Dynamics)), Petropavlovsk-Kamchatskii: Kamchat. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr., 2011.

D'yakov, Yu.P, Distribution of eggs and larvae of flatfish (Pleuronectiformes) in the northern part of the Pacific Ocean, *Issled. Vodn. Biol. Resur. Kamchatki Sev.-Zap. Ch. Tikh. Okeana*, 2019, no. 52, pp. 5–49. https://doi.org/10.15853/2072-8212.2019.52.5-49

Datsky, A.V., Ichthyofauna of the Russian exclusive economic zone of the Bering Sea: 1. Taxonomic diversity, *J. Ichthyol.*, 2015, vol. 55, no. 6, pp. 792–826. https://doi.org/10.1134/S0032945215060065

Datsky, A.V., Biological features of the common fish species in Olyutorsky-Navarin region and the adjacent waters of the Bering Sea: 4. family sculpins (Cottidae), *J. Ichthyol.*

2017, vol. 57, no. 3, pp. 341–353.
https://doi.org/10.1134/S0032945217030031

Datsky, A.V. and Andronov, P.Yu., *Ikhtiotsen verkhnego shel'fa severo-zapadnoi chasti Beringova morya* (Ichthyocene of the Upper Shelf of Northwestern Part of Bering Sea), Magadan: Sev.-Vost. Nauchn. Tsentr, Dal'nevost. Otd., Ross. Akad. Nauk, 2007.

Datsky, A.V. and Maznikova, O.A, Biological features of common fish species in Olyutorsky-Navarin region and the adjacent areas of the Bering Sea: 3. Right-eye flounders (Pleuronectidae), *J. Ichthyol.*, 2017, vol. 57, no. 2, pp. 228–256.
https://doi.org/10.1134/S0032945217020060

Datsky, A.V., Vedishcheva, E.V., and Trofimova, A.O., Biological features of common fish species in the Russian waters of the Chukchi Sea. 1. Commercial fish biomass. Codfishes (Gadidae), *Vopr. Ikhtiol.*, 2022, vol. 62, no. 4, pp. 387–412.
https://doi.org/10.31857/S0042875222040075

Eisner, L., The Bering Sea: Current status and recent trends, *PICES Press*, 2019, vol. 27, no. 1, pp. 33–35. https://meetings.pices.int/publications/pices-press/volume27/PPJan2019.pdf#page=33.

Fadeev, N.S., *Severotikhookeanskie kambaly* (North Pacific Flounders), Moscow: Agropromizdat, 1987.

Fadeev, N.S., *Spravochnik po biologii i promyslu ryb severnoi chasti Tikhogo okeana* (Handbook on Biology and Commercial Fishery in the North Pacific Ocean), Vladivostok: TINRO-Tsentr, 2005.

Filina, E.A. and Budanova, L.K., On the finding of mature individuals of the Greenland halibut *Reinhardtius hippoglossoides* (Pleuronectidae) in the Kara Sea, *J. Ichthyol.*, 2015, vol. 55, no 1, pp. 114–118.
https://doi.org/10.1134/S0032945214060058

Glebov, I.I., Nadtochii, V.A., Savin, A.B., et al, Results of complex biological studies in the Laptev Sea in August–September 2015, *Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr.*, 2016, vol. 187, pp. 72–88.
https://doi.org/10.26428/1606-9919-2016-187-72-88

Hutchinson, C.E. and TenBrink, T.T. Age determination of the yellow Irish lord: Management implications as a result of new estimates of maximum age, *N. Am. J. Fish. Manag.*, 2011, vol. 31, pp. 1116–1122.
https://doi.org/10.1080/02755947.2011.646453

Kharitonova, E.V., Batanov, R.L., and Datsky, A.V., *Peculiarities of distribution of common flounder species in Anadyr Bay in summer*, *Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr.*, 1999, vol. 126, Ch. 1, pp. 285–295.

Lindberg, G.U. and Fedorov, V.V., *Ryby Yaponskogo morya i sopredel'nykh chastei Okhotskogo i Zheltogo morei. Ch. 6* (Fishes of the Sea of Japan and Adjacent Parts of the Sea of Okhotsk and the Yellow Sea. Pt. 6), St-Petersburg: Nauka, 1993.

Logerwell, E.A., Busby, M., Mier, K.L., et al., The effect of oceanographic variability on the distribution of larval fishes of the northern Bering and Chukchi seas, *Deep-Sea Res. II. Top. Stud. Oceanogr.*, 2020, vol. 177, Article 104784.
https://doi.org/10.1016/j.dsr2.2020.104784

Love, M.S., Elder, N., Mecklenburg, C.W., et al., Alaska Arctic marine fish species accounts, in *Alaska Arctic Marine Fish Ecology Catalog*, Thorsteinson, L.K. and Love, M.S., Eds., Scientific Investigations Report 2016–5038 (OCS Study, BOEM 2016–048), U.S. Geological Survey, 2016, pp. 41–615.
https://doi.org/10.3133/sir20165038

Maznikova, O.A., Afanas'ev, P.K., Datsky, A.V., et al., Distribution, biology and stock status of the Greenland halibut *Reinhardtius hippoglossoides matsuurae* according to various fishing gear in the western part of the Bering Sea and off the eastern coast of Kamchatka, *Tr. Vseross. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr.*, 2015, vol. 155, pp. 31–55.

Maznikova, O.A., Novikov, R.N., Datsky, A.V., et al., Current state of the fishery of the Greenland halibut *Reinhardtius hippoglossoides matsuurae* (family Pleuronectidae) in the western part of the Bering Sea and off the eastern coast of Kamchatka, *Vopr. Rybolovstva*, 2018, vol. 19, no. 1, pp. 42–57.

Mecklenburg, C.W., Mecklenburg, T.A., and Thorsteinson, L.K., *Fishes of Alaska*, Bethesda, Maryland: Am. Fish. Soc., 2002.

Mecklenburg, C.W., Byrkjedal, I., Karamushko, O.V., and Moller, P.R., Atlantic fishes in the Chukchi borderland, *Mar. Biodivers.*, 2014, vol. 44, no. 1, pp. 127–150.
https://doi.org/10.1007/s12526-013-0192-1

Mecklenburg, C.W., Mecklenburg, T.A., Sheiko, B.A., and Steinke, D., *Pacific Arctic Marine Fishes*. Akureyri: CAFF Internat. Secretariat, 2016.

Mecklenburg, C.W., Lynghammar, A., Johannesen, E., et al., *Marine Fishes of the Arctic Region*. Akureyri: CAFF Internat. Secretariat, 2018.

Munk, K.M., Maximum ages of groundfishes in waters off Alaska and British Columbia and consideration of age determination, *Alaska Fish. Res. Bull.*, 2001, vol. 8, no. 1, pp. 12–21.

Musienko, L.N., Juvenile flounders (family Pleuronectidae) of the Far Eastern seas. 2. Distribution, age, and growth, *Tr. Inst. Okeanol., Akad. Nauk SSSR*, 1957, vol. 20, pp. 312–346.

Novikov, N.P., *Promyslovye ryby materikovogo sklona severnoi chasti Tikhogo okeana* (Commercial Fish Species of the Continental Slope of the Northern Part of the Pacific Ocean), Moscow: Pishchevaya Prom-st, 1974.

Novikov, N.P., Snytko, V.A., and Dolgikh, I.P., *Promyslovyi atlas Dal'nevostochnykh morei* (Commercial Atlas of the Far Eastern Seas), Vladivostok: Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr., 1992.

Orlov, A.M., Benzik, A.N., Vedishcheva, E.V., et al., Fisheries research in the Chukchi Sea onboard the R/V *Professor Levanidov* in August 2019: some preliminary results, *Tr. Vseross. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr.*, 2019, vol. 178, pp. 206–220.
https://doi.org/10.36038/2307-3497-2019-178-206-220

Pertseva-Ostroumova, T.A., *Razmnozhenie i razvitie dal'nevostochnykh kambal* (Reproduction and Development of Far Eastern Flounders), Moscow: Akad. Nauk SSSR, 1961.

Shuntov, V.P., Some patterns of distribution of Greenland halibut and arrow-toothed flounder in the northern part of the Pacific Ocean, *Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr.*, 1971, vol. 75, pp. 3–36.

Shuntov, V.P., Lapko, V.V., Nadtochii, V.V., and Samko, E.V., Interannual changes in the ichthyocenes of the upper epipelagial of the western part of the Bering Sea and the Pacific waters of Kamchatka, *Vopr. Ikhtiol.*, 1994, vol. 34, no 5, pp. 642–648.

Smith, R.L., Vallarino, M., Barbour, E., et al., Population biology of the Bering flounder in the northeastern Chukchi sea, in *Fish Ecology in Arctic North America*, Bethesda: Am. Fish. Soc, 1997, pp. 127–132.

TenBrink, T.T. and Buckley, T.W., Life-history aspects of the yellow Irish lord (*Hemilepidotus jordani*) in the eastern Bering Sea and Aleutian Islands, *Northwest. Nat.*, 2013, vol. 94, pp. 126–136.
https://doi.org/10.1898/12-33.1

Tokranov, A.M., Biology of common species of sculpins (family Cottidae) in Kamchatka waters, *Extended Abstract of Cand. Sci. (Biol.) Dissertation*, Dal'nevost. Nauch. Tsentr Akad. Nauk SSSR, Vladivostok, 1985.

Tokranov, A.M., Sculpins and lords, in *Biologicheskie resursy Tikhogo okeana* (Biological Resources of the Pacific Ocean), M.: Nauka, 1986, pp. 319–328.

Tokranov, A.M., Reproduction of sculpins of the genus Gymnacanthus (Cottidae) in coastal waters of Kamchatka, *Vopr. Ikhtiol.*, 1987, vol. 27, no. 6, pp. 1026–1030.

Tokranov, A.M., *On sexual dimorphism in sculpins (Cottidae, Pisces) of Kamchatka waters, Mater. XXX Lyubishchevskikh chtenii "Sovremennye problemy evolyutsii i ekologii" (Mater. of the XXX Lyubishchev Readings "Modern problems of Evolution and Ecology")*, Ulyanovsk: Ulyanovsk Gos. Ped. Univ., 2016, pp. 124–131.

Tokranov, A.M. and Orlov, A.M., Specific features of distribution and ecology of two species of armorhead sculpins of the genus *Gymnocanthus* (Cottidae) in Pacific waters of the northern Kuril Islands and Southeastern Kamchatka, *J. Ichthyol.,* 2012, vol. 52, no. 9, pp. 599–612.

Tokranov, A.M. and Orlov A.M., Biological characteristics of the Arctic staghorn sculpin *Gymnocanthus tricuspis* (Cottidae) of the Kara Sea, *Mater. XII Nats. (Vseros.) nauch.-prakt. konf. "Prirodnye resursy, ikh sovremennoe sostoyanie, okhrana, promyslovoe i tekhnicheskoe ispol'zovanie". Ch. 1* (Mater. of the XII National (All-Russian) Scientific and Practical Conf. "Natural Resources, Their Current State, Protection, Commercial and Technical Use." Part 1) Petropavlovsk-Kamchatsky: Kamchat. Gos. Tekhn. Univ., 2021, pp. 76–80.

Tsinovskii, V.D., Fish caught at the drifting station "Severny Polyus-22" in the winter of 1978–79 and 1979–80, in *Ryby otkrytogo okeana* (Fishes of the Open Ocean), Moscow: Inst. Okeanol., Akad. Nauk SSSR, 1981, pp. 110–112.

Tuponogov, V.N. and Kodolov L.S., *Polevoi opredelitel' promyslovykh i massovykh vidov ryb dal'nevostochnykh morei Rossii* (Field Guide to Commercial and Common Fish Species of the Far Eastern Seas of Russia), Vladivostok: Russkii Ostrov, 2014.

Zolotov, A.O., On the population structure of halibut flounders in the Pacific waters of Kamchatka and the western part of the Bering Sea, *Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr.*, 2007, vol. 148, pp. 113–129.

Zolotov, A.O., Flounders of the western part of the Bering Sea: dynamics of abundance and features of biology, *Extended Abstract of Cand. Sci. (Biol.) Dissertation*, Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr., Vladivostok, 2010.

Translated by D. Zabolotny