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THE STRUCTURE OF COASTAL ICHTHYOPLANKTON IN THE AREA OF THE DUDINKA RIVER CONFLUENCE (EASTERN SAKHALIN)

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The structure of ichthyoplankton complex and features of early fish ontogeny were analyzed in the coastal area off the Eastern Sakhalin. The study area is characterized by strong variations of temperature and salinity in May–July. Minimum temperature (+0.4 °C) was registered at a depth of 20 m in May, and maximum one (+15.7 °C) was recorded at a depth of 3 m in September. During the entire study period, salinity varied from 3.5 PSU in littoral zone close to the Dudinka River mouth to 31 PSU at a depth of 13–20 m. Eggs and larvae of 17 fish species from 5 families, typical for the Eastern Sakhalin, were identified in ichthyoplankton. Pleuronectidae species prevailed in taxonomic list with ratio of 71%. *Gadus chalcogrammus* eggs and larvae (71% of total value) prevailed in the second decade of May; *Clupea pallasii* bottom eggs (70%), in the third decade of May; and Pleuronectidae eggs and larvae (91–100%), in June–September. Mean ichthyoplankton abundance decreased from 52 ind.·m^{-3} in littoral zone to 21–22 ind.·m^{-3} above depths of 5–10 m and 13 ind.·m^{-3} above 20 m. The proportion of dead *G. chalcogrammus* eggs and Pleuronectidae eggs did not exceed the values obtained for the Northeastern Sakhalin and was lower than in Aniva Bay. In May, the proportion of *G. chalcogrammus* and *Hippoglossoides robustus* prelarvae with pathologies increased. It could be caused by the development of eggs at late stages in adverse conditions. Maximum species diversity was observed in June. Seventy-seven percent of cumulative abundance was composed by eggs of four species, *G. chalcogrammus*, *H. robustus*, *Myzopsetta punctatissima*, and *Limanda aspera*.

Keywords: fish eggs, fish larvae, ichthyoplankton, abundance, species diversity, Eastern Sakhalin

Southeastern Sakhalin waters are inhabited by more than 100 fish species [Dyldin et al., 2021], and out of them, 79 are found in trawl catches. In terms of the number of species (16) and biomass (up to 47–60% of the total value), righteye flounders Pleuronectidae Rafinesque, 1815 prevail. Codfishes Gadidae Rafinesque, 1810 and sculpins Cottidae Bonaparte, 1831 have a high biomass as well (up to 32–44% and 6–11%, respectively). The abundance of species with a long life cycle – the Alaska pollock *Gadus chalcogrammus* Pallas, 1814, the Bering flounder *Hippoglossoides robustus* Gill & Townsend, 1897, the yellowfin sole *Limanda aspera* (Pallas, 1814), the Sakhalin sole *Limanda sakhalinensis* Hubbs, 1915, and the starry flounder *Platichthys stellatus* (Pallas, 1787), as well as sculpins of the genus *Myoxocephalus* Tilesius, 1811 – can remain relatively stable for a long time [Shuntov, Temnykh, 2018; Shuntov et al., 1993]. The abundance of species with a shorter cycle – the Pacific herring *Clupea pallasii* Valenciennes, 1847, the Far Eastern capelin

Mallotus villosus (Müller, 1776), the saffron cod *Eleginus gracilis* (Tilesius, 1810), and the Japanese anchovy *Engraulis japonicus* Temminck & Schlegel, 1846 (a migrant fish) – experiences significant fluctuations [Davydova, 1994; Velikanov, 2006].

In the Southeastern Sakhalin coastal areas, ichthyoplankton is formed both by eggs and larvae of marine fish species occurring in shallow waters because of drift and by resident species reproducing off the coast. For many years, off the eastern coast of Sakhalin, only research vessel studies of ichthyoplankton were carried out during the hydrological spring (May–June); these investigations were aimed at assessing the stocks of *G. chalcogrammus* and less often *H. robustus*. Off the southeastern coast of Sakhalin Island, the largest spawning grounds for these species are located in the Terpeniya Bay. The main egg aggregations are formed both in the central bay above isobaths of 60–70 m [Shuntov et al., 1993; Tarasyuk, Pushnikov, 1982; Zverkova, 2003] and north of N48° off the western coast [Moukhametov, Chastikov, 2013]. *G. chalcogrammus* and *H. robustus* spawning coincides in time and space [Moukhametov, Chastikov, 2015; Mukhametov, Mukhametova, 2017]. Drift of eggs and larvae of these two species has a similar direction, and increases in their concentrations in coastal areas usually occur simultaneously [Mukhametova, 2020a, b].

During the warm period of the year, the role of shallow waters in fish reproduction increases. The coastal area of Southeastern Sakhalin becomes a spot for formation of spawning aggregations of many Pleuronectidae, *Cl. pallasii*, *M. villosus*, and the Japanese smelt *Hypomesus japonicus* (Brevoort, 1856) [Kim Sen Tok, 2011]. The mean abundance of ichthyoplankton can be high, 300–400 ind.·m^{-3} and more [Moukhametova, Moukhametov, 2013]. In the area of the southeastern coast between N46° and N48°, eggs and larvae of 37 species from 14 families were identified in ichthyoplankton. Due to a rise in the diversity and abundance of fish in the Terpeniya Bay [Kim Sen Tok, 2002], there was an increase in species diversity and abundance of fish from south to north, mainly due to representatives of Pleuronectidae. Similar changes were noted in ichthyoplankton. The total concentrations of ichthyoplankton and the proportion of Pleuronectidae rose in a northerly direction. With a generally high abundance of eggs of the longsnout flounder *Myzopsetta punctatissima* (Steindachner, 1879) south of N47°, the predominant forms also included eggs and larvae of *Pl. stellatus* and *E. japonicus*. The maximum abundance of ichthyoplankton was recorded in August. North of N47°, eggs and larvae of *G. chalcogrammus*, *H. robustus*, *Cl. pallasii*, and *L. aspera* dominated. This area, in comparison with the southern one, was characterized by the fact that the peak abundance of ichthyoplankton was shifted to May–June [Mukhametova, 2014, 2020a, b].

Despite the high significance of shallow areas of the Southeastern Sakhalin in the reproduction of coastal and marine fish, data on the development of their eggs and larvae are scarce. The aim of this work is to describe ichthyoplankton in a coastal area off the eastern Sakhalin Island, at the confluence of the Dudinka River. The objectives of the research included studying seasonal changes in ichthyoplankton species composition, abundance, and diversity, as well as the development of eggs and larvae of abundant fish species depending on the environmental conditions.

MATERIAL AND METHODS

Ichthyoplankton was sampled in the inshore site at the confluence of the Dudinka River from May to October 2020. For sampling, an ichthyoplankton conical net (50 cm in diameter) with an inlet area of 0.2 m^2 and a mesh of 0.35 mm was used [Rass, Kazanova, 1966]. The stations were located at isobaths of 0–0.5 m (littoral), 5 m, 10 m, and 20 m. From the second decade of May to late June, during mass spawning of coastal fish species, surveys were carried out every ten days. In July, due to bad weather conditions, there were two surveys – in the second and third decades. From August to October, sampling was carried out monthly. Once a calendar season, samples were taken from four sections (in the second decade of May, in the third decade of July, and in October); in other periods, from two central sections (Fig. 1). A total of 104 ichthyoplankton samples were taken in 10 surveys.

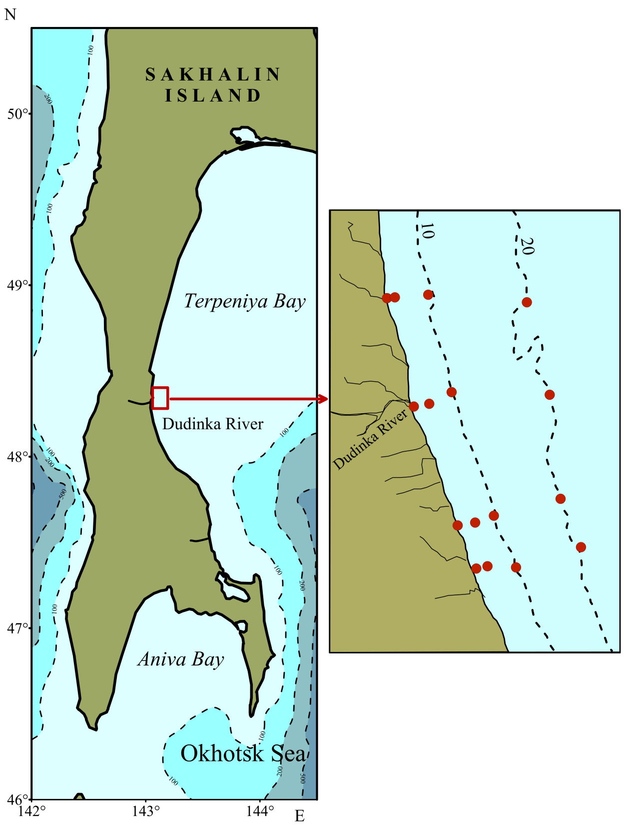

Fig. 1. Scheme of ichthyoplankton sampling in the inshore site at the confluence of the Dudinka River in 2020

Above depths of 5–20 m, the ichthyoplankton net was lifted from a motor boat vertically from the bottom to the surface. In the littoral zone, 100 L of seawater were poured through the net [Rukovodstvo po metodam, 1983]. Samples were fixed with 4% formaldehyde solution.

For vertical catches, ichthyoplankton abundance was calculated *per* 1 m^3 by the formula:

$$N = (n \times 5)/S \ ,$$

where N is ichthyoplankton abundance in 1 m^3, ind.·m^{-3};

n is ichthyoplankton abundance in the catch, ind.;

S is the distance covered by the net, m;

5 is the coefficient for reducing the net inlet area to 1 m^2.

During sampling in the littoral zone, the abundance was determined by the formula:

$$N = n \times 10 \ ,$$

where N is ichthyoplankton abundance, ind.·m^{-3};

n is ichthyoplankton abundance in the catch, ind.;

10 is the coefficient for reducing the abundance to 1 m^3.

At each station, YSI Model 85 probe was used to measure temperature, salinity, and oxygen concentration from the surface to the bottom with a resolution of 1 m. Oxygen was measured only in May–June. For the analysis, we used temperature and salinity values averaged for each survey in the layer from the bottom to the surface, in the surface and near-bottom horizons. Data on wind direction and force were taken from the weather archive of the website https://rp5.ru/ [2021].

Ichthyoplankton samples were processed in a laboratory under an Olympus SZX10 binocular equipped with an eyepiece micrometer. Eggs and larvae of each species were measured to the nearest 0.01 mm. The stages of egg development were determined according to conventional methods [Rass, Kazanova, 1966]. When identifying disorders in embryos and larvae, we were guided by descriptions of normal development and pathologies in the early fish ontogeny [Davydova, 1994; Pertseva-Ostroumova, 1961].

The taxonomy of species is given in accordance with the WoRMS database [2021]. To identify dominance classes, the Lubarsky scale was used. According to it, species with a relative abundance of 64–100% were absolute dominants; 36–64%, dominants; and 16–36%, subdominants [Bakanov, 2005]. The period when the total proportion of eggs and larvae of a given species accounted for at least 50% of all studied species was considered as the time of mass spawning of fish and development of the early stages of ontogenesis.

For statistical processing, MS Office Excel data analysis package was used. To assess the significance of the difference between the means, the Student's *t*-test was applied.

Based on the data obtained on ichthyoplankton species composition and abundance, a dominance–diversity curve was constructed [Odum, 1983; Whittaker, 1975], and ecological indices were calculated [Margalef, 1958; Pielou, 1966; Shannon, Weaver, 1949; Simpson, 1949] (Table 1).

Table 1. Indices of biodiversity used for the description of ichthyoplankton

Index	Calculation	Designations	References
Shannon–Wiener diversity	$H = -\sum p_i \times \log_2 p_i$	p_i is the proportion of the i-th species in abundance	Odum, 1983; Shannon, Weaver, 1949
Pielou's evenness	$E = \frac{H}{\log_2 S}$	H is the Shannon–Wiener diversity index; S is the number of species	Odum, 1983; Pielou, 1966
Simpson's diversity	$D = \sum_i^s (\frac{n_i}{N})^2$	n_i is the abundance of the i-th species; N is the total abundance	Odum, 1983; Simpson, 1949
Margalef's diversity	$D_{Mg} = (S-1)/\ln N$	S is the number of species; N is the total abundance of individuals	Margalef, 1958; Odum, 1983

RESULTS AND DISCUSSION

The ecosystem of the Terpeniya Bay, *inter alia* ichthyoplankton transport, is structurally affected by waters of the East Sakhalin Current penetrating from the east, a complex system of eddies, and an alongshore current off the western coast, mainly of the south direction [Pak et al., 2017; Shevchenko et al., 2020]. In the Dudinka River vicinity, as well as in the previously studied inshore sites located to the south, there was a noticeable variability in environmental parameters, especially in the spring hydrological season. It was due to the mixing of warmer desalinated surface water with colder and saltier seawater from the bottom horizons, which results from coastal upwellings and downwellings formed under the effect of offshore western winds and surge eastern winds [Shevchenko et al., 2021]. Apparently, the formation of coastal flows is affected mainly by southeastern and eastern winds and an alongshore current with a meridional orientation [Shevchenko et al., 2021].

During the ichthyoplankton surveys, the temperature averaged for the entire water column, increased from +5.8 °C in May to +13.3 °C in October with an approximation reliability value (R^2) of 0.92. Until August, water warming occurred simultaneously with an increase in air temperature with a correlation coefficient (R) equal to 0.93. The absolute minimum for the study period (+0.4 °C) was recorded at a depth of 20 m in May, and the maximum (+ 15.7 °C) was registered at a depth of 3 m in September. Throughout the study period, reduced salinity values were noted in the water area, on average 26.2–30.4 PSU. The minimum (3.5 PSU) was observed in the first decade of June at the Dudinka River mouth; the maximum (31 PSU and more), at the bottom, at a depth of 13–20 m. A trend towards a decrease in salinity was revealed at the height of the flood, from late May to early June ($R^2 = 1$), and during the flood period, in September–October ($R^2 = 0.93$) [Onishchenko, 1987]. Strong desalination affected mainly the mouth areas, where eggs and larvae of euryhaline fish species with bottom eggs develop, such as *H. japonicus*, *M. villosus*, and *Cl. pallasii*. At the same time, significant temperature fluctuations were recorded throughout the studied inshore site on spawning grounds and in nursery areas of both coastal and marine fish. Because of the formation of coastal upwellings under the effect of southwestern winds, there were cases of sharp drops in temperature – to subzero values in May and from +12 °C to +2…+3 °C in July. Eastern winds prevailing in spring cause additional transport of eggs and larvae of marine species to the coastal area. A positive relationship was found between the mean ichthyoplankton abundance and northern and eastern winds ($R = 0.69$). A negative relationship was revealed with the predominance of winds of the southeast–west section ($R = -0.65$). Ichthyoplankton abundance also depended on wind speed ($R = 0.64$). Maximum density values of ichthyoplankton at depths of 0–0.5 m were recorded in May–June during the predominance of northern and eastern winds and at the highest average speeds, 3.9–4.5 $m \cdot s^{-1}$. The obtained correlation coefficients indicate a significant effect of wind transport of ichthyoplankton in the study area and the predominance of transport from the north–east section.

Fluctuations in temperature and salinity, as well as the effect of shockwaves, including a swell typical for this area, are not optimal conditions for the development of planktonic communities, in particular, pelagic eggs and early fish larvae [Pertseva-Ostroumova, 1961; Tarasyuk, 1994]. A factor positively affecting ichthyoplankton structure in the Dudinka River area can be the proximity to the vast shelf protected from the east by the Terpeniya Peninsula, which is characterized by better warming than open southern areas [Lozhkin et al., 2018; Shevchenko et al., 2020]. The East Sakhalin Current branch flowing into the Terpeniya Bay and the powerful Poronay River flowing along the western coast [Pak et al., 2017] contribute to the supply of nutrients into the water column. This results in high phytoplankton biomass [Mukhametova et al., 2022], which serves as the starting food for fish larvae [Kim Sen Tok et al., 2017] and increases productivity of organisms representing other trophic levels – zooplankton, benthos, and fish.

Fish eggs and larvae were recorded in the inshore site in the confluence of the Dudinka River from May to September. In total, 17 fish species from 5 families were identified in ichthyoplankton. In addition to pelagic eggs, the catches included bottom eggs of the Pacific herring *Cl. pallasii* and the cresthead flounder *Pseudopleuronectes schrenki* (Schmidt, 1904). The occurrence of bottom eggs in the water column is common for species with littoral spawning grounds – *Cl. pallasii*, *M. villosus*, *H. japonicus*, and the Japanese icefish *Salangichthys microdon* (Bleeker, 1860) – during their mass spawning [Mukhametova, 2020b; Mukhametova, Balanov, 2013]. By the number of species (12; ≈ 71% of the taxonomic composition), representatives of the family Pleuronectidae prevailed. In October, there was no ichthyoplankton in the catches. The period of the increased species abundance lasted from May to late July and was accompanied by minor fluctuations: the number of species was 7–10. Except for several low-boreal flounder species [the yellow striped flounder *Pseudopleuronectes herzensteini* (Jordan et Snyder, 1901), the Black plaice *Pseudopleuronectes obscurus* (Herzenstein, 1890), *Ps. schrenki*, and *M. punctatissima*], characteristic of ichthyocenes and ichthyoplankton complexes of the southern Sea of Okhotsk and the Tatar Strait, identified species were typical for the Eastern Sakhalin shelf. Many Pleuronectidae species were represented by both eggs and larvae.

In May, the maximum ichthyoplankton abundance, 61.17 ind.·m^{-3}, was observed (Table 2). Same month, the highest heterogeneity in its spatial distribution was noted, due to the predominance of adventive, marine species (mainly eggs of *G. chalcogrammus* and *H. robustus*) and low intensity of fish spawning in shallow waters. The standard deviation in May was twice the mean ichthyoplankton abundance. In June–August, the development of spawning of flounders representing the coastal complex resulted in a more even distribution of catches. However, variations in the abundance of eggs and larvae by stations remained quite high throughout the study period. A significant decrease in concentrations began in August against the backdrop of the completion of spawning of pelagophilic fish.

Table 2. Species composition, abundance, and indices of the ichthyoplankton species diversity in the inshore site at the confluence of the Dudinka River in 2020 (numerator denotes eggs, % of the total abundance of eggs; denominator denotes larvae, % of the total abundance of larvae)

Taxon	May	June	July	August	September	Mean for the entire period, %
Clupeidae						
Pacific herring *Clupea pallasii* Valenciennes, 1847	12.67 / 0.79	1.63 / 0	–	–	–	7.50 / 0.30
Gadidae						
Alaska pollock *Gadus chalcogrammus* Pallas, 1814	61.03 / 62.88	3.75 / 1.96	1.55 / 0	3.28 / 0	–	35.47 / 24.15
Cottidae						
Elegant sculpin *Bero elegans* (Steindachner, 1881)	–	0 / 39.22	–	–	–	0 / 8.00
Threaded sculpin *Gymnocanthus pistilliger* (Pallas, 1814)	0 / 0.40	–	–	–	–	0 / 0.15
Liparidae						
Striped seasnail *Liparis latifrons* Schmidt, 1950	0 / 0.40	–	–	–	–	0 / 0.15
Pleuronectidae						
Blackfin flounder *Glyptocephalus stelleri* (Schmidt, 1904)	–	–	1.70 / 0.75	21.31 / 0	2.22 / 0	1.05 / 0.30

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Taxon	May	June	July	August	September	Mean for the entire period, %
Bering flounder *Hippoglossoides robustus* Gill & Townsend, 1897	25.33/34.76	0.12/1.96	–	–	–	14.24/13.53
Yellowfin sole *Limanda aspera* (Pallas, 1814)	–	23.46/0.98	12.33/67.41	75.41/0	97.78/100.00	11.52/28.99
Sakhalin sole *Limanda sakhalinensis* Hubbs, 1915	–	4.81/0	0.30/0	–	–	1.21/0
Far Eastern smooth flounder *Liopsetta pinnifasciata* (Kner, 1870)	0/0.77	–	–	–	–	0/0.29
Longhead dab *Myzopsetta proboscidea* (Gilbert, 1896)	–	5.18/0.98	–	–	–	1.25/0.20
Longsnout flounder *Myzopsetta punctatissima* (Steindachner, 1879)	0.35/0	27.61/6.86	81.72/31.09	–	–	18.98/13.84
Starry flounder *Platichthys stellatus* (Pallas, 1787)	0.44/0	3.79/15.69	0.30/0	–	–	1.21/3.20
Alaska plaice *Pleuronectes quadrituberculatus* Pallas, 1814	0.15/0	–	–	–	–	0.08/0
Yellow striped flounder *Pseudopleuronectes herzensteini* (Jordan et Snyder, 1901)	0.03/0	10.07/2.94	2.10/0.75	–	–	2.76/0.90
Black plaice *Pseudopleuronectes obscurus* (Herzenstein, 1890)	–	0/23.53	–	–	–	0/4.80
Cresthead flounder *Pseudopleuronectes schrenki* (Schmidt, 1904)	–	19.58/5.88	–	–	–	4.73/1.20
Eggs, ($M \pm \sigma$) ind.·m^{-3}	59.21 ± 126.2	23.54 ± 15.81	15.65 ± 14.41	3.81 ± 4.13	1.41 ± 2.02	21.11 ± 23.31
Larvae, ($M \pm \sigma$) ind.·m^{-3}	1.97 ± 1.49	0.80 ± 0.92	2.09 ± 3.40	–	0.09 ± 0.14	0.99 ± 1.00
Total ichthyoplankton, ($M \pm \sigma$) ind.·m^{-3}	61.17 ± 125.89	26.60 ± 16.46	17.73 ± 15.03	3.81 ± 4.13	1.50 ± 2.16	22.10 ± 24.10
Number of species	10	12	7	3	2	17
Indices						
Shannon–Wiener diversity	1.393	2.837	1.092	0.944	0.146	–
Pielou's evenness	0.419	0.791	0.389	0.596	0.146	–
Simpson's diversity	0.454	0.177	0.610	0.615	0.959	–
Margalef's diversity	2.188	3.353	2.087	1.494	2.466	–

The greatest contributors to the total abundance of ichthyoplankton were Pleuronectidae representatives, which dominated most of the study period. A decrease in their proportion was revealed only in May: in the second decade, with the high concentration of *G. chalcogrammus* eggs, and in the third decade, with the massive appearance of *Cl. pallasii* bottom eggs in the water column.

Throughout the study, fish eggs accounted for 88–100% of the total abundance of ichthyoplankton. In different periods, the predominating forms (absolute dominants, dominants, and subdominants) were eggs of the Alaska pollock *G. chalcogrammus*, *H. robustus*, *M. punctatissima*, the yellowfin sole *L. aspera*, and the blackfin flounder *Glyptocephalus stelleri* (Schmidt, 1904). In May, eggs of *G. chalcogrammus* prevailed, accounting for 61% of the total abundance of eggs. In June, against the backdrop of a rise in spawning intensity of coastal species of the family Pleuronectidae, the dominant group included *M. punctatissima* eggs (39%). In July, *M. punctatissima* eggs accounted for 82% of all fish eggs recorded. In August and September, eggs of *L. aspera* were the absolute dominant, 75 and 98%, respectively.

The larval composition was dominated mainly by species with a high abundance of eggs: *G. chalcogrammus* and *H. robustus* in May; *Pl. stellatus* in June; and *L. aspera* and *M. punctatissima* in July and September. In June, the larval composition was characterized by an increase in abundance of sublittoral species with bottom and benthic eggs – the elegant sculpin *Bero elegans* (Steindachner, 1881) (39% of the total abundance of larvae) and *Ps. obscurus* (24%). In May and June, the proportion of larvae in the total abundance of ichthyoplankton remained at the level of 3%. In July, a rise up to 12%, caused by mass hatching of *L. aspera* and *M. punctatissima*, was registered. An increase in the concentration of eggs of these species began in the previous period. The mean abundance of *M. punctatissima* eggs rose from 0.2 ind.·m^{-3} in May to 7.1 ind.·m^{-3} in June and 12.8 ind.·m^{-3} in July. In May, there were no *L. aspera* eggs; in June and July, their abundance was 2.1 and 1.9 ind.·m^{-3}, respectively.

By the number of species, the Dudinka River area was inferior to coastal waters south of N48°, where the taxonomic list could include eggs and larvae of 20–23 fish species, due to the reproduction of southern migrants in summer [Mukhametova, 2014]. At the same time, the abundance of eggs and larvae of *G. chalcogrammus* and many Pleuronectidae at the confluence of the Dudinka River was significantly higher due to the proximity of this area to the main spawning grounds located to the northeast of the inshore site [Kim Sen Tok, 2011; Zverkova, 2003]. In the Dudinka River area, the abundance of *G. chalcogrammus* eggs averaged for May–October exceeded that in the area of the Dolinka River, which is located 50 km to the south, by more than 100 times, while the abundance of larvae was more than 1,000 times higher. The abundance of *H. robustus* eggs was 7 times higher, and the abundance of its larvae was 32 times higher. The abundance of *L. aspera* eggs and larvae was 19 and 161 times higher, respectively. The mean abundance of *Pl. stellatus* eggs exceeded its concentration in the Dolinka River area by 248 times; *M. punctatissima* eggs, by 8 times; and *L. sakhalinensis* eggs, by 11 times. Interestingly, larvae of these species were not revealed in the Dolinka River area.

For species represented in ichthyoplankton in the Dudinka River vicinity, typical spawning is the one under conditions of sea salinity, except for *Cl. pallasii*, whose spawning occurs in a wide range of salinity, and *L. pinnifasciata*, whose eggs tolerate slight desalination [Pertseva-Ostroumova, 1961]. Sexually mature individuals of several coastal flounder species (*Pl. stellatus*, *L. obscura*, and *M. punctatissima*) can be found in highly desalinated areas, but their eggs and larvae develop only at sea salinity.

In Southeastern Sakhalin, spawning and the maximum abundance of larvae of most fish occur in the hydrological spring, a period of good food supply (phytoplankton and larval forms of invertebrates). A slow increase in water temperature in the coastal area of Southeastern Sakhalin [Shevchenko et al., 2021] is the reason for the prolonged hydrological spring – from early May to late July [Pishchalnik, Bobkov, 2000]. At the same time, the warming of shallow areas, which affects the timing of mass spawning of fish, may differ from the long-term average one for a period from 8–10 days to 3–4 weeks [Lozhkin et al., 2018]. Accordingly, it is quite difficult to establish clear boundaries of biological seasons. Off the southeastern coast of Sakhalin, the summer composition of ichthyoplankton can be formed from late June to late July [Mukhametova, 2020a, b]. Depending on the geographic location of the area, the spawning period and the number of seasonal spawning groups for the same species can vary significantly. Among Pleuronectidae representatives, an increase in the number of such groups was recorded from north to south [Dyakov, 2011].

In the inshore site at the confluence of the Dudinka River, four groups of species were distinguished based on the seasonality of spawning and the presence of eggs and larvae in plankton (Table 3).

Table 3. Ecological groups of ichthyoplankton in the inshore site at the confluence of the Dudinka River in 2020 (grey cells show the period of occurrence; red cells show the periods of maximum concentrations of eggs and larvae; numerator denotes the proportion of total eggs of the species; denominator denotes the proportion of larvae)

Taxon	Stage of development	Habitat characteristic	Biotope	Biogeographical region	Hydrological season								
					Spring							Summer	
					V		VI			VII		VIII	IX
					2nd decade	3rd decade	1st decade	2nd decade	3rd decade	2nd decade	3rd decade	3rd decade	2nd decade
Winter–spring spawning													
Gymnocanthus pistilliger	larvae	coastal	SL	AB	100								
Liopsetta pinnifasciata	larvae	coastal	SL	LB	100								
Liparis latifrons	larvae	marine	EL	WB	100								
Pleuronectes quadrituberculatus	eggs	marine	EL	WB	100								
Spring spawning													
Hippoglossoides robustus	eggs, larvae	marine	EL	AB	99.7/95.6		0.3/4.4						
Gadus chalcogrammus	eggs, larvae	marine	EL	WB	95.4/97.5		3.8/2.5			0.6/0		0.2/0	
Clupea pallasii	eggs, larvae	coastal	N	AB	92.0/100			8.0/0					
Pseudopleuronectes obscurus	larvae	coastal	SL	LB			100						
Pseudopleuronectes schrenki	eggs, larvae	coastal	EL	LB				100/100					
Bero elegans	larvae	coastal	SL	LB					100				
Myzopsetta proboscidea	eggs, larvae	coastal	SL	HB					100/100				
Limanda sakhalinensis	eggs	coastal	EL	WB			90.1			9.9			
Platichthys stellatus	eggs, larvae	coastal	SL	AB	14.8/0		82.5/87.5			2.7/12.5			
Pseudopleuronectes herzensteini	eggs, larvae	coastal	SL	LB		0.4/0	91.8/75.0				7.8/25.0		
Myzopsetta punctatissima	eggs, larvae	coastal	SL	LB	0.9/0		44.8/14.4			54.3/85.6			
Spring–summer spawning													
Limanda aspera	eggs, larvae	coastal	EL	WB			68.9/1.0			14.8/95.8		11.0/0	5.3/3.2
Summer spawning													
Glyptocephalus stelleri	eggs, larvae	marine	EL	WB						38.6/100		59.1/0	2.3/0

Note. Biotope: EL, elittoral; SL, sublittoral; N, neritic. Biogeographical region: AB, arctic-boreal species; HB, high-boreal; WB, wide-boreal; LB, low-boreal.

The group with winter–spring spawning was represented by larval forms of two coastal species, *G. pistilliger* and *L. pinnifasciata*, adventive larvae of the striped seasnail *Liparis latifrons* Schmidt, 1950, and eggs of the Alaska plaice *Pleuronectes quadrituberculatus* Pallas, 1814. Eggs and larvae of this group off the southeastern coast of Sakhalin massively occur in April. Accordingly, by the beginning of research, there abundance in the Dudinka River area was already at its minimum.

The most extensive group was the one with a predominance of spring spawning: it included 11 species (65% of the species composition). This group covered both coastal and marine forms. The typically adventive ones, *G. chalcogrammus* and *H. robustus*, are characterized by earlier spawning away from weakly warmed shallow waters. Therefore, the abundance of their eggs and larvae in the coastal area was maximum in the early hydrological spring, in May. Out of coastal species, the group with early spring spawning included *Cl. pallasii*, which is distributed in Arctic-boreal waters and approaches littoral spawning grounds for spawning earlier than other coastal species.

The maximum abundance of eggs and larvae of most spring-spawning species belonging to Pleuronectidae was recorded in June, except for one Cottidae representative, *B. elegans*. Among them, species with short (within one decade) and long (up to three months) periods of eggs and larvae laying in plankton stood out. Three low-boreal species, *Ps. obscurus*, *Ps. schrenki*, and *B. elegans*, whose main range is to the south, had a short-term occurrence, as well as one high-boreal species, the longhead dab *Myzopsetta proboscidea* (Gilbert, 1896), which is highly abundant off the Northeastern Sakhalin coast [Mukhametov, Mukhametova, 2017] and in the northern Sea of Okhotsk. In the Terpeniya Bay, these species are not abundant [Kim Sen Tok, 2011]. Their abundance in ichthyoplankton is also low. Apparently, spawning and development of pelagic larvae occur within a short period of time. Eggs and larvae of many coastal Pleuronectidae species with spring spawning were characterized by a fairly long period of occurrence – two to three months (Table 3). This group included *L. sakhalinensis*, *Pl. stellatus*, *Ps. herzensteini*, and *M. punctatissima*, often highly abundant in coastal ichthyocenes and, accordingly, in ichthyoplankton of Sakhalin waters.

In terms of the nature of spawning in the Dudinka River area, *L. aspera* stood out. This species usually replaces *M. punctatissima* in the composition of dominants, since the peak of *L. aspera* spawning occurs later. In 2020, in the studied inshore site, a high abundance of *L. aspera* eggs and larvae was registered in June, and it coincided with a high abundance of eggs and larvae of the spring-spawning species, *Pl. stellatus*, *L. sakhalinensis*, and *Ps. herzensteini*. However, *L. aspera* differed from the listed species in the fact that its early stages of development continued to occur until mid-September. This gives grounds to distinguish it from the general group of coastal flounders as a species with a long spring–summer spawning. The occurrence of *L. aspera* eggs and larvae lasted up to four months. The long period of its spawning in this area is related to the availability of two spawning approaches to the Terpeniya Bay. For this species, the duration of occurrence of the early stages of development in the surface layers is estimated at 130 days [Tarasyuk, 1997].

Gl. stelleri is classified as a species with summer spawning. When larvae appeared in July, the highest concentrations of eggs in this area were recorded in August, and single eggs were found in September. Since *Gl. stelleri* eggs are registered off the northeastern coast of Sakhalin in June at depths of 50 m or more, it can be assumed as follows: in the Terpeniya Bay, spawning begins in the same period or earlier, but at a distance from the coast. With a low abundance of eggs on spawning grounds, those are not likely to be revealed in the coastal area.

In the studied inshore site, we did not note the development of an autumn ichthyoplankton complex. In the waters of the Eastern Sakhalin, this complex includes larvae of Irish lords of the genus *Hemilepidotus* Cuvier, 1829 and greenlings, mainly of the genus *Hexagrammos* Tilesius, 1810.

Some species in the Dudinka River area had a longer period of occurrence of early stages of development compared to that for other areas. Eggs and larvae of *M. punctatissima*, *Ps. herzensteini*, and *Gl. stelleri* were registered in the inshore site during three months. Even eggs and larvae of *Pl. stellatus*, a species with a short spawning period (mass spawning, about 20 days; in total, about 45 days) [Yusupov, 2011], had a long period of occurrence in the studied inshore site – from May to late July. Long-term spawning of *G. chalcogrammus* is recorded off the northeastern coast of Sakhalin, while for *L. aspera*, it is known in the Terpeniya Bay [Shuntov et al., 1993; Tarasyuk, 1997].

Adventive, marine species, *H. robustus*, *G. chalcogrammus*, *Pl. quadrituberculatus*, and *Gl. stelleri*, were characterized by the maximum abundance in the inshore site at final stages of egg development. In many areas of Sakhalin, *H. robustus* spawning, which lasts in the northern Sea of Okhotsk from mid-May to mid-July [Yusupov, 2018], coincides in time and space with *G. chalcogrammus* spawning [Moukhametov, Chastikov, 2015]. *H. robustus* spawning grounds are located mainly at depths exceeding 30 m in the northeastern Terpeniya Bay, and in recent years, in its northwestern area as well [Moukhametov, Chastikov, 2015; Tarasyuk, Pushnikov, 1982]. Considering the long period of development of *G. chalcogrammus* and *H. robustus* eggs [Yusupov, 2018; Zverkova, 2003], it can be assumed as follows: in the areas adjacent to the inshore site, their spawning began no later than in mid-April. The maximum abundance of *G. chalcogrammus* and *H. robustus* eggs in the Dudinka River vicinity was registered at the initial stages of seasonal desalination of the coastal area, which occurred in the second decade of May only in the surface layers, while in the deeper ones, rather stable thermohaline conditions persisted [Shevchenko et al., 2021]. The alongshore current of the south direction, as well as northern, northeastern, and eastern winds with a total frequency of 91%, blowing even at a not very high speed, on average 4.5 $m \cdot s^{-1}$, could maintain a fairly stable movement of ichthyoplankton to the south and southwest.

Eggs of the species that reproduce directly in shallow waters, *M. punctatissima* and *Pl. stellatus*, formed aggregations at the initial stages. Some species had relatively high abundance of both initial and final stages throughout the study period. Specifically, the development stages I and III for *L. aspera* had close proportions, more than 40%, already in mid-June. By the end of June, the proportion of stage I (41%) slightly exceeded the proportion of stage III (32%). By mid-July, there was a reduction in the final stages. In late July, stage IV had the highest contribution, 29%, while the relative abundance of other stages remained at 21–26%. In June, with the maximum frequency of surveys, it was impossible to register the predominance of the development stage I, which could result from a constant arrival of *L. aspera* eggs from northern areas, where its main reproduction ground is located [Kim Sen Tok, 2002, 2011]. The high relative contribution of the development stage I for *L. aspera* was registered only from late August, during residual spawning. A similar proportion of development stages was established for *Ps. herzensteini*, with the difference that the abundance of eggs of this species decreased already in July.

The spatial distribution of ichthyoplankton by depth was determined by the seasonal features of fish reproduction in Eastern Sakhalin waters. According to the indicator averaged over May–September, the most productive depths were the minimum ones: the value was about 52 $ind. \cdot m^{-3}$. Above 5–10-m isobaths, mean concentrations of ichthyoplankton remained at the level of 21–22 $ind. \cdot m^{-3}$; to a depth of 20 m, the values decreased by almost half, to 13 ind.·m^{-3}. In shallow areas, mainly fish eggs were found. Larvae were rare. From May to late June, higher densities of ichthyoplankton were observed at the water's edge. The maximum abundance of eggs, more than 260 ind.·m^{-3}, was recorded in mid-May (Fig. 2).

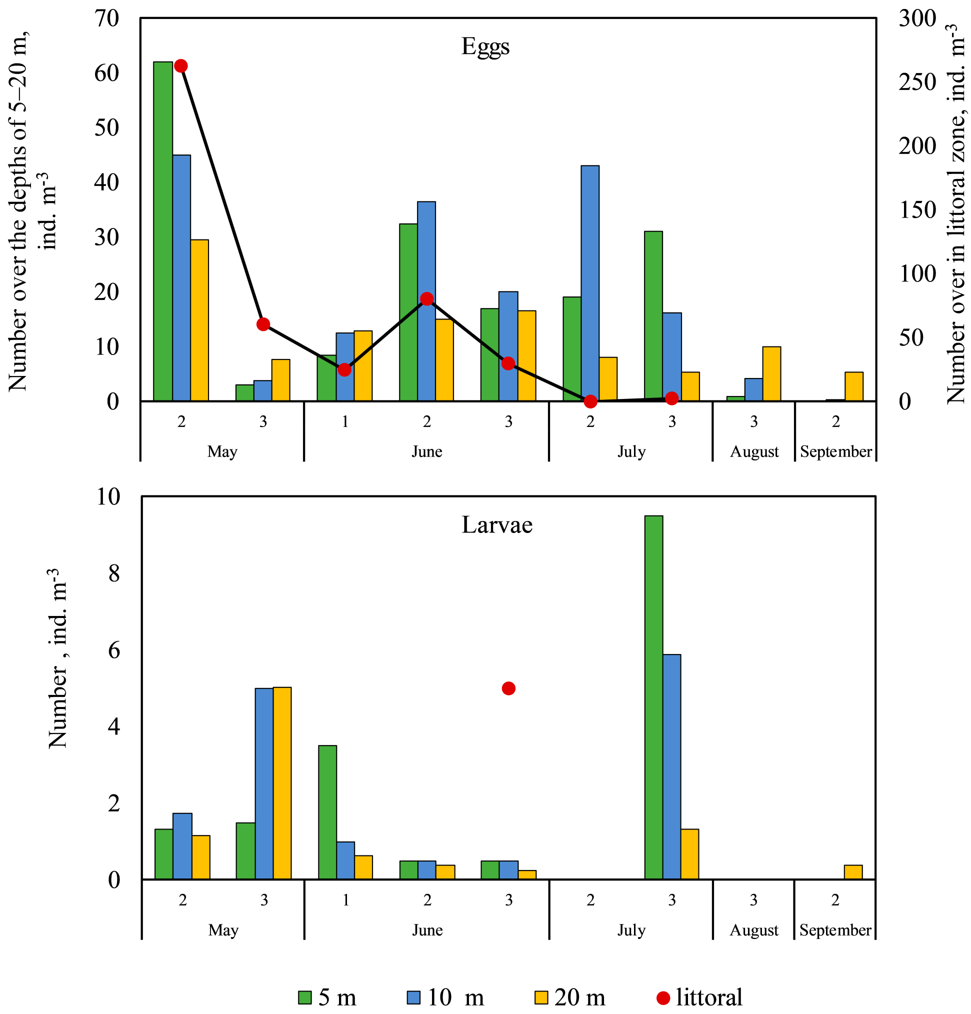

Fig. 2. Dynamics of ichthyoplankton abundance (ind.·m^{-3}) at isobaths of 0.5–20 m in the inshore site at the confluence of the Dudinka River in May–September 2020 (numbers on the abscissa are decades)

Pelagic eggs of most Pleuronectidae and *G. chalcogrammus* arrived to minimum depths with surge winds. Bottom eggs dominated during mass spawning of *Cl. pallasii* (in May) and *Ps. schrenki* (in early June). In July, an increase in egg concentrations was noted in the depth range of 5–10 m; in August and September, above isobaths of more than 10 m. In May, similar densities of larvae were recorded in the entire depth range of 5–20 m. In early June, a rise in concentrations was recorded at 5-m isobath due to mass hatching of *Ps. obscurus*. The maximum abundance of larvae occurred in late July, when larvae of several coastal flounder species, *L. aspera*, *M. punctatissima*, and *Ps. herzensteini*, were characterized by high densities.

At the beginning of the study (the second decade of May), the abundance of *G. chalcogrammus* and *H. robustus* eggs reached its maximum values. Eggs at the final stages of development (III and IV) predominated: their total proportion exceeded 93% for *G. chalcogrammus* and 86% for the Bering flounder.

In the early hydrological spring, when coastal water areas are still slightly warmed up and exposed to freshwater runoff, fish with pelagic eggs (*H. robustus*, *G. chalcogrammus*, *Pl. quadrituberculatus*, and *Gl. stelleri*) spawn outside the 50-m isobath. Flounders of the coastal complex, *Pl. stellatus*, *M. punctatissima*, *L. aspera*, *L. sakhalinensis*, and *Ps. herzensteini*, also begin spawning at depths exceeding 15–20 m. At this stage, the coastal water area becomes a spot of high concentrations of eggs and larvae of species that lay bottom eggs on littoral spawning grounds. In the Dudinka River area, out of these species, only *Cl. pallasii* was found. In other areas, this niche can also be occupied by *M. villosus* and *H. japonicus* [Mukhametova, 2020a]. In May, maximum concentrations are formed in the littoral zone due to the transport of pelagic eggs of marine species by prevailing eastern winds and currents. In June, the role of 5–10-m isobaths increases. In July, the main concentrations of ichthyoplankton shift to depths of 5–10 m. At the height of the hydrological summer, in August, as the water column warms up, the spawners begin to move deeper. The reproductive value of shallow waters decreases. The main concentrations of eggs and larvae from residual spawning are formed above isobaths of 10–20 m (Fig. 2).

The survival rate of early stages of fish development is one of the significant indicators of spawning efficiency, which determine the productivity of recruitment. The formation of embryonic pathologies and high mortality of eggs and larvae under natural conditions can be caused by sudden fluctuations in temperature and salinity, storms, lack of food items, *etc.* Under adverse conditions, egg mortality can reach 90–100% [Davydova, 1994]. In the inshore site at the confluence of the Dudinka River, average mortality of *G. chalcogrammus* eggs (29.2%) coincided with average mortality in the Northeastern Sakhalin waters (29%); the value for *L. aspera* was lower (19.5% *vs.* 30.2%) [Davydova, Cherkashin, 2007]. In May in the Dudinka River area, the proportion of non-viable eggs of *G. chalcogrammus* (1.6%) and *H. robustus* (1.8%) was also lower than in the Aniva Bay (8.3% for *G. chalcogrammus* and 2.1% for *H. robustus*). At the same time, the proportion of postembryonic disorders was quite high, especially for *H. robustus* (Table 4).

Table 4. Larvae characteristics of abundant fish species during periods of high abundance in the inshore site at the confluence of the Dudinka River in 2020

Species	Month	Decade	Length, mm, min–max $M \pm \sigma$	Mean weight of 1 individual, mg, $M \pm \sigma$	Prelarvae, %	Prelarvae with pathologies, %
Gadus chalcogrammus	May	2nd	2.20–5.15 3.78 ± 0.84	0.510 ± 0.418	70.6	5.9
		3rd	3.2–5.9 4.51 ± 0.66	0.460 ± 0.177	100.0	–
Hippoglossoides robustus	May	2nd	1.24–4.87 3.33 ± 1.20	0.223 ± 0.139	72.2	38.9
		3rd	3.5–5.3 4.60 ± 0.72	0.257 ± 0.106	76.9	–
Limanda aspera	July	3rd	0.9–3.5 2.15 ± 0.69	0.050 ± 0.019	69.0	48.3
Myzopsetta punctatissima			1.1–4.2 2.16 ± 0.59	0.049 ± 0.034	10.0	20.0
Platichthys stellatus	June	1st	1.8–4.05 2.85 ± 0.80	0.139 ± 0.086	–	14.3
Pseudopleuronectes obscurus			2.3–3.1 2.72 ± 0.33	0.063 ± 0.025	100.0	–

Apparently, a simultaneous increase in the abundance of *G. chalcogrammus* and *H. robustus* individuals with pathologies (these species have similar spawning areas and the direction of drift of the early stages of development) is related to the exposure of their eggs and larvae to adverse conditions. In May in the inshore site, the most common types of effect, that reduced the survival rate of fish eggs and larvae, were the effect of waves and sudden fluctuations in temperature and salinity in the area of upwellings and downwellings. Considering the long period of egg development at low temperatures and significant distances of their transport, adverse factors could affect fish eggs and larvae outside the inshore site as well.

The mortality rate for eggs of coastal Pleuronectidae was higher, and this may be due to the high intensity of spawning directly in the inshore site and the predominance of the initial stages of development, more sensitive to any effect, throughout the study period. However, the conditions for egg development in the area of the Dudinka River confluence can be considered more favorable than in southern areas. In Aniva Bay, the proportion of non-viable eggs of *L. aspera* in the second decade of July exceeded mortality rate in the Dudinka River area by half (46% *vs.* 23%); that of *M. punctatissima* in the second decade of June, by more than 2.5 times (44% *vs.* 17%). Pleuronectidae embryos before leaving their membranes and larvae at the stage of transition to exogenous nutrition turned out to be more vulnerable. The proportion of non-viable larvae (14–48%) was comparable to egg mortality rate or higher (17–30%). An increase in mortality rate at the early stages of embryogenesis in the inshore site coincided with the known critical periods [Chambers et al., 2001].

Compared to the values for coastal lagoon waters of the southeastern Sakhalin Island [Mukhametova, Balanov, 2013], the period of occurrence of ichthyoplankton in the Dudinka River vicinity lasted a month longer, and the greatest species diversity was formed a month later. The values of the indices of diversity (2.84), evenness (0.79), and species richness (3.35) were the highest in June – with the maximum number of species (12) and with the abundance (26.60 ± 16.46) ind.·m^{-3}, close to the mean value for the period (Table 2). High biotic diversity during this period was also indicated by the minimum value of the Simpson index (0.18). The relatively low values of species richness indices in this study area were due to a decrease in the number of species in the ichthyofauna of the Far Eastern seas in shallow areas compared to the number for deep-water ones [Ashikhmina, 2009]. The minimum diversity and evenness of ichthyoplankton were observed in September, when *L. aspera* eggs and larvae dominated in the catches, and the dominance index reached 0.96.

The ichthyoplankton dominance–diversity curve for the Eastern Sakhalin occupies a high position on the graph (Fig. 3).

The shape of the ichthyoplankton dominance–diversity curve is close to the "MacArthur's broken-stick model" which characterizes natural communities. Most species were evenly distributed in ranked order of dominance. The proportion of eggs and larvae of four abundant species, *G. chalcogrammus*, *M. punctatissima*, *H. robustus*, and *L. aspera*, accounted for 77% of the cumulative abundance. The next eight species accounted for 22% of the cumulative abundance, and the last five ones accounted for only 0.4%. A sharp decline in abundance began only with *Ps. obscurus*, which occupied the 13th position in the ranked list. The presence of a few high-abundant species and many low-abundant ones is a characteristic feature of boreal communities [Odum, 1983].

In general, the basis of the community in the Dudinka River area was formed by the early stages of development of four fish species with different status and characteristics of abundance dynamics. In May, the main concentrations, existing for a short time (within the second decade), were produced by eggs and larvae of *G. chalcogrammus* and *H. robustus* transported from seaward areas: 72 and 28 ind.·m^{-3}, respectively. By the third decade of May, the mean concentration of *G. chalcogrammus* eggs decreased by 24 times, and that of *H. robustus* eggs, by 9.5 times. In June and July, eggs and larvae of resident species, *M. punctatissima* and *L. aspera*, dominated; these species do not form aggregations with high densities, but have a relatively stable abundance for several months. Decade concentrations of *M. punctatissima* eggs and larvae from early June to late July varied from 6.3 to 15.8 ind.·m^{-3}. Variations in *L. aspera* abundance were more pronounced. From mid-June to September, the total abundance of eggs and larvae of this species varied within 0.9–11.9 ind.·m^{-3}. The dominant forms were common for Eastern Sakhalin [Davydova, Cherkashin, 2007; Moukhametov, Chastikov, 2013]. Analysis of the structure and indicators of species abundance for ichthyoplankton in the inshore site at the confluence of the Dudinka River allows us to classify it as a typical natural community.

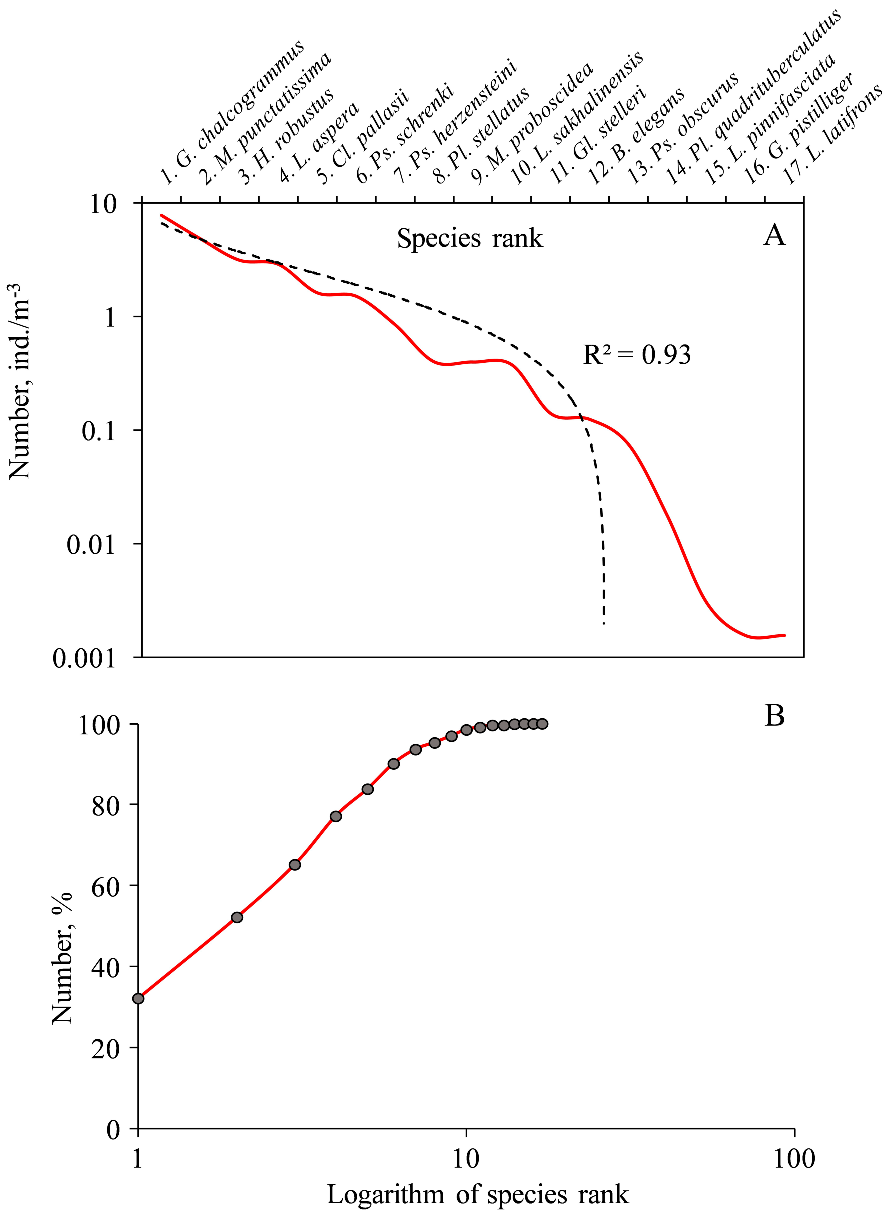

Fig. 3. Dominance–diversity curve (A) and species accumulation curve (B) in the inshore site at the confluence of the Dudinka River in 2020

Conclusion. Development of ichthyoplankton in the Dudinka River area occurred under conditions of significant temperature fluctuations resulting from the formation of coastal upwellings and downwellings during surge phenomena. Maximum fluctuations in temperature were observed throughout the hydrological spring, from May to July; fluctuations in salinity, in June, during the flood period. An additional negative effect in spring was the one of waves and swell caused by the passage of cyclones.

Ichthyoplankton in the Dudinka River vicinity included eggs and larvae of 17 fish species from 5 families typical for the Eastern Sakhalin waters. Their occurrence was limited to the period from May to September. Of the cumulative abundance, 77% were eggs and larvae of four species: *Gadus chalcogrammus*, *Myzopsetta punctatissima*, *Hippoglossoides robustus*, and *Limanda aspera*.

Spawning of most fish in the inshore site and adjacent areas occurred during the spring hydrological season rich in food resources. In May, the maximum abundance of ichthyoplankton, 61 ind.$\cdot$m^{-3}, was recorded, while in August, with the end of the spawning period of pelagophilic fish, a significant drop was observed, down to 3.5 ind.$\cdot$m^{-3}. The abundance averaged for the study period decreased from 52 ind.$\cdot$m^{-3} in the littoral zone to 21–22 ind.$\cdot$m^{-3} above depths of 5–10 m and to 13 ind.$\cdot$m^{-3} above a depth of 20 m.

In the second decade of May, eggs of adventive, marine species dominated in terms of abundance, *G. chalcogrammus* (71% of the total value) and *H. robustus* (28%); in late May, bottom eggs of *Clupea pallasii* (70%); and in June–September, eggs and larvae of Pleuronectidae (91–100%). The abundance of eggs and larvae of *G. chalcogrammus* and Pleuronectidae in the Dudinka River area was significantly higher than in areas south of N48°. An increase in concentrations resulted from the proximity of the studied inshore site to the main spawning grounds of many fish species.

Species with spring spawning dominated, accounting for 65% of the species composition. This group covered both adventive, marine forms (mainly *G. chalcogrammus* and *H. robustus*), which gave high abundance in May, and coastal ones (*Platichthys stellatus*, *M. punctatissima*, *Limanda sakhalinensis*, and *Pseudopleuronectes herzensteini*). The adventive species with pelagic eggs were characterized by a predominance of the final stages of development. Resident species were distinguished by a high abundance of eggs at the initial stages of development, which indicated spawning within the inshore site.

The proportion of dead eggs of *G. chalcogrammus* and Pleuronectidae flounders did not exceed the values for the Northeastern Sakhalin waters and was lower than in Aniva Bay. In May, an increase in the proportion of prelarvae with pathologies was recorded for *G. chalcogrammus* and *H. robustus*, and this could be caused by exposure to adverse conditions.

Indices of diversity had the highest values in June – with the maximum number of species (12) and with the abundance (26.60 ± 16.46) ind.$\cdot$m^{-3}, close to the mean value for the study period. In this month, 78% of the total abundance were eggs and larvae of three subdominants, *M. punctatissima* (27%), *L. aspera* (23%), and *Pseudopleuronectes schrenki* (19%).

The shape of the ichthyoplankton dominance–diversity curve was close to the "MacArthur's broken-stick model" which characterizes natural communities. Most species were evenly distributed in ranked order of dominance.

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СТРУКТУРА ПРИБРЕЖНОГО ИХТИОПЛАНКТОНА В РАЙОНЕ ВПАДЕНИЯ РЕКИ ДУДИНКА (ВОСТОЧНЫЙ САХАЛИН)

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Изучены структура ихтиопланктонного комплекса и особенности раннего развития массовых видов рыб на морском прибрежном полигоне у восточного побережья острова Сахалин. Для района исследований характерны значительные вариации температуры и солёности в мае — июле. Минимальная температура воды (+0,4 °C) отмечена на глубине 20 м в мае, а максимальная (+15,7 °C) — на глубине 3 м в сентябре. Солёность в течение всего периода исследований колебалась от 3,5 PSU на литорали в районе устья реки Дудинка до 31 PSU на глубине 13–20 м. В ихтиопланктоне идентифицированы икра и личинки 17 видов рыб из 5 семейств, типичных для вод Восточного Сахалина. По количеству видов преобладали представители семейства Pleuronectidae, формировавшие 71 % таксономического списка. По численности во второй декаде мая доминировали икра и личинки *Gadus chalcogrammus* (71 % суммарной величины), в третьей декаде мая — донная икра *Clupea pallasii* (70%), с июня по сентябрь — икра и личинки Pleuronectidae (91–100 %). Осреднённая за период исследований численность ихтиопланктона снижалась с 52 экз.·м$^{-3}$ на литорали до 21–22 экз.·м$^{-3}$ над глубинами 5–10 м и до 13 экз.·м$^{-3}$ над глубиной 20 м. Доля мёртвых икринок *G. chalcogrammus* и камбал Pleuronectidae не превышала значений для вод Северо-Восточного Сахалина и была ниже, чем в заливе Анива. В мае у *G. chalcogrammus* и *Hippoglossoides robustus* отмечено увеличение доли предличинок с аномалиями, что может быть вызвано попаданием икры на завершающих стадиях развития в неблагоприятные условия среды. Максимальное видовое разнообразие зарегистрировано в июне. Четыре вида формировали 77 % накопленного обилия — *G. chalcogrammus*, *H. robustus*, *Myzopsetta punctatissima* и *Limanda aspera*.

Ключевые слова: икра рыб, личинки рыб, ихтиопланктон, численность, видовое разнообразие, Восточный Сахалин