The Allocation of Some Pelagic Larvae of Bivalve Mollusks in the Western Part of Chukchi Sea

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Abstract: Collected in September-October 2016 in the 48th cruise of SRS “Academician Oparin” the plankton samples with the assistance of Norpac net with the cell of 150 μm in the horizon 15-0 m have shown the plenty of pelagic larvae of bivalve mollusk in Chukchi Sea. Its biggest quantity was found in the period from the 22nd of September until the 1st of October. The most yield area was situated on the opposite side of the Bering Strait and the second maximum of larvae quantity was found on the Herald’s bank. Most valuable factors influencing the territorial allocation of the researched larvae are the water surface temperature and the water depth.

Key words: Chukchi Sea, allocation of pelagic larvae of bivalve mollusks.

1. Introduction

The Chukchi Sea researching by the multi-national collective of scientists was separated from the East-Siberian Sea not only due to its particular qualities of hydrological conditions but also in consequence of the peculiar content of the bottom dwellers [1]. There are significant stocks of oil, natural gas, coal, gold, tin, tungsten and mercury [2] on the coast and the global warming which is being observed during long years already [3] makes attractive the researching of the arctic seas where the Chukchi Sea is one of the most productive in the world [4, 5]. The climate warming makes favor not only for the North marine way and the excavation of natural resources but also for the cognition and using of the arctic seas animal world. It is important to observe the Chukchi peninsula ecological conditions and its washing seas before the starting of its industrial development and it is important for the identification of the ecosystem changes after oil and gas production and commercial fishing [6, 7]. After the short term of the Chukchi Sea, researches conducted in the first part of last century the silent period came at the end of the last century and at the beginning of the new century stimulated by the shipping opportunities and oil production the interest to this Sea has arisen again. This Sea represents itself the unique region which is located at the edge of two oceans: the Pacific and the Arctic. The Bering Sea water at estimate of 85 m³/s comes to the Chukchi Sea in the significant degree through the Bering Strait [8] together with the intensive stream system and the zooplankton [9] in estimate amount of 1.8 millions of metric tons annually comes together with this water. The warm Bering Sea water and the phytoplankton influx provide high productivity of the Chukchi Sea comparing to adjacent areas of the Arctic Ocean [10]. The water masses coming into the Chukchi Sea are represented by the coastal Alaska Sea water, coastal Bering Sea water and Anadyr Sea water (Fig. 1), each one with its unique zoo plankton community and quantity [11]. Some hydrographic peculiarities observed in the Chukchi Sea are the constant meanwhile the other peculiarities are changing and this way they become the very important...
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determinatives of plankton and fishes allocation [12]. In summer, the Bering Sea water (independently from the synoptic situation) is covering southern, eastern and partly central (until the Herald Strait) Sea areas [13]. Though in particular years, for example in 2007, almost all of the Chukchi Sea was filled with the Bering Sea water [14].

As the result of the meeting of the Bering Sea water stream and the Chukchi Sea water stream in the southern and middle parts of the Chukchi Sea the several circles of the cyclonic type [1, 15] are being established, the biggest one from them is situated to the north and north-east from the cape Heart-Stone [16] and due to the low depth of the sea the autumn cycle increases the vertical flow of the material [17]. The impact of the Bering Sea warm waters with the Chukchi Sea cold waters leads to the mass death of south zooplankton and together with phytoplankton it enriches the benthos with the organic material [18].

Though the differences in time of ice melting, water temperature, water masses transportation, nutritions and chlorophyll- $a$ make influence for the inter annual peculiarities of plankton communities [19], the stream directed to the North dominates in a year, that is why the inter annual changes of balanus larvae and larvae of bivalve mollusk plenty (which were not met during the summer 2012) were called by the water masses in summer 2012 coming from Canadian Bays which waters due to the high depths consist of a little amount of benthos animals [20]. The benthos biomass mainly is controlled by the food produced from the water surface and which reached the bottom through pelagic-benthos connecting processes [21]. The same way the space models in micro fauna biomasses of the

Fig. 1 The most recent scheme of the Chukchi Sea circulations and geographical place names. Adopted from Ref. [39].
Chukchi Sea are connected with the variations in pelagic primary production and carbon flow to the ocean bottom under the different masses [22]. Due to the low depth of the Chukchi Sea the part of phytodetritus coming on to the bottom from the surface waters is the highest one, that is why with the almost three times less square than the Barintsev Sea square the Chukchi Sea zoobenthos bio-resources are less than the Barintsev Sea only for one and half times [5]. Though the sediment carbon and the integrated chlorophyll-a concentration give no explanations the biomasses differences of the epifauna as the variation of food plenty do not correlate with macro fauna biomass [15]. The highest benthos biomass is peculiar for the south-east part of the Sea to the north of Bering Strait which reaches up to 4,231 g/m² with the average biomass of ~1,500 g/m² in this area and the lowest biomass is peculiar for its northern and deeper part [23].

Although the quite long research period of the bottom eco-system of the Chukchi Sea started at the end of the 19th century, it is still not studied quite well [4] and for the studying of the sea bottom communities and the sea mammal animals the insignificant researches were made [6]. The species diversity (more than 1,435 species) of the Chukchi Sea bottom biocenosis is higher than in other east-arctic seas: 1,143—in the Laptev Sea and 1,008 in the East-Siberian Sea [24]. Like every other Eurasia arctic seas the Chukchi Sea has invertebrates dominating groups zonal allocation [25], and the allocation of bivalve mollusk biomass reminds the allocation of common zoobenthos biomass [11]. On the south of central and south-east part of the Chukchi Sea, it was noted there was existence of significantly high productive benthos communities with extremely high biomass and bio-diversity created most likely under the influence of the water circles rich with biogen that comes through the eastern part of Bering Strait [26]. On the slope of Herald’s bank, at estimate 10 to 25 km from its center, comparing to the top, the biodiversity is increasing and the bivalve mollusk and polychaete dominate in biocenosis [27]. The analysis of benthos data in Chukchi Sea does not show any significant changes for the last 30 years, though the local penetration in it of quite warm water pacific species: crabs Telmessus cheiragomis and Oregonia grasilis and bivalve mollusk Pododesmus macrochisma indicates its warming [4]. This way, climate change has potential consequences on the benthos of the Chukchi Sea: there are moves in its species content and quantity to the north [28] and in warm years it is possible to improve the reproduction conditions among thermophilic invertebrates [29]. That is why it is possible to assume that in future, the movement direction of boreal species to the north will be saved with the replacement of trade arctic species [7].

The available publications, as a rule, do not reveal the peculiarities of even mass species allocation, and in the tables, characterizing structure of the meroplankton on explored water area the bivalve mollusks either are absent [30, 31] or presented in the total quantity [11, 32, 33]. Thereof, the authors do not give the factors affecting abundance and area allocation of types and species. From the available literature, regarding meroplankton of the polar seas it is known the only one researching work is seasonal allocation of three species and one type of pelagic larvae of the bivalve mollusk [34]. That is why our publication, partly, can help the researchers wishing to define types or species of larvae of bivalve mollusk of the Chukchi Sea and to specify their area allocation and the defining factors.

The aim of the present research is to identify the pelagic larvae of the bivalve mollusks of the Chukchi Sea and to study their allocation area and abundance in relation with the abiotic factors influencing these processes.

**2. Material and Methods**

The 48th cruise of the SRS “Academician Omarion” was 48 days since the 2nd of September till 19th of
October 2016. Since 12th of September till 5th of October 2016, the researches have been made on the polygons of the Chukchi Sea. During the expedition to the 31st station in Chukchi Sea and Bering Sea, the works on sea plankton were collected by the Norpak net with the diameter incoming hole of 39 cm and the cell 150 μm (Table 1).

At all stations the Norpak net was lowered on the depth of 15 m, though in the Bering Strait and near the Ratmanov’s Island due to the strong stream it was not possible to lower the net deeper than 4 meters. Right after the meroplankton tests taken it was fixed in 4% solution of buffering formaldehyde, and in 2018, before the tests contents research they were washed out and fixed in 90% methanol. The tests of plankton were researched with the help of Bogorov camera and binocular microscope MBS-10. At mass species of bivalve mollusks the shell length and height were measured. My colleague N. K. Kolotukhina has wide experience of work with the planktonic and recently settled larvae of bivalve mollusks [35-38], therefore, the cosmopolitans were defined up to type and the Chukchi Sea autochthonic larvae up to a sort. Together with the plankton caught by the means of

| Date       | Station | Latitude | Longitude | Depth, m | Abund. ind./m³ | O₂ surf. | O₂ bott. | T °C surf. | T °C bott. |
|------------|---------|----------|-----------|----------|----------------|----------|----------|------------|------------|
| 12.09.2016 | 0       | 68.19    | 172.51    | 50       | 833            | 6.37     | 3.04     | 7          | 1.4        |
| 14.09.2016 | 1       | 71.21    | 175.37    | 36       | 217            | 7.67     | 7.31     | 3.1        | -1.4       |
| 16.09.2016 | 2       | 71.03    | 177.46    | 15       | 68             | 8.36     | 7.94     | 0.6        | 0.7        |
| 19.09.2016 | 3       | 70.53    | 179.50    | 12       | 70             | 7.78     | 6.86     | 0          | -0.1       |
| 19.09.2016 | 4       | 70.54    | 179.55    | 10       | 38             | 7.77     | 7.86     | 0.2        | 0.2        |
| 19.09.2016 | 5       | 70.5     | 179.42    | 18       | 300            | 7.68     | 7.72     | 0.9        | 0.02       |
| 19.09.2016 | 6       | 70.31    | 177.26    | 50       | 778            | 7.78     | 5.09     | 2.3        | -1.6       |
| 20.09.2016 | 7       | 71.05    | 177.36    | 10       | 80             | 7.71     | 7.73     | 0.7        | 0.6        |
| 21.09.2016 | 8       | 71.11    | 175.54    | 44       | 19             | 7.86     | 5.82     | 2          | -1.6       |
| 21.09.2016 | 10      | 71.13    | 174.5     | 95       | 828            | 7.59     | 5.02     | 2.6        | -1.7       |
| 22.09.2016 | 11      | 71.2     | 173.05    | 50       | 79             | 7.94     | 5.55     | 0.9        | -0.2       |
| 22.09.2016 | 12      | 70.32    | 173.05    | 42       | 4,987          | 7.15     | 4.03     | 3.8        | 1.5        |
| 23.09.2016 | 13      | 70.32    | 172.05    | 20       | 1,330          | 6.68     | 6.85     | 3.9        | 5          |
| 23.09.2016 | 14      | 69.54    | 171.1     | 42       | 218            | 6.96     | 7.08     | 5          | -0.5       |
| 24.09.2016 | 15      | 69.01    | 169.16    | 50       | 790            | 7.04     | 6.53     | 5.9        | 1.1        |
| 24.09.2016 | 16      | 68.11    | 169.1     | 58       | 3,200          | 6.68     | 4.46     | 6.7        | 2.7        |
| 25.09.2016 | 17      | 67.26    | 169.37    | 50       | 12,400         | 7.04     | 2.83     | 5.1        | 2.6        |
| 25.09.2016 | 18      | 67.31    | 171.22    | 48       | 4,865          | 6.53     | 2.28     | 5.5        | 2.3        |
| 25.09.2016 | 19      | 67.27    | 172.33    | 48       | 2,000          | 7.27     | 3.22     | 4.6        | 3.1        |
| 26.09.2016 | 20      | 67.26    | 173.45    | 30       | 194            | 7.27     | 4.16     | 3.8        | 3.8        |
| 26.09.2016 | 21      | 67.32    | 173.37    | 42       | 144            | 7.31     | 4.22     | 4.1        | -0.5       |
| 27.09.2016 | 22      | 67.14    | 173.39    | 20       | 61             |          |          |            | 5.5        |
| 28.09.2016 | 23      | 67.7     | 173.46    | 15       | 44             |          |          |            | 5.5        |
| 01.10.2016 | 24      | 67.07    | 173.46    | 21       | 194            | 6.53     | 4.78     | 4.3        | 2.6        |
| 01.10.2016 | 25      | 67.39    | 173.24    | 45       | 4,052          | 7.08     | 3.8      | 4.2        | 1.5        |
| 02.10.2016 | 26      | 67.03    | 173.6     | 12       | 644            |          |          |            | 5          |
| 03.10.2016 | 27      | 68.18    | 172.50    | 50       | 118            | 6.37     | 3.04     | 3.7        | 2.7        |
| 04.10.2016 | 28      | 66.45    | 169.03    | 46       | 33             | 6.53     | 6.45     | 6.7        | 4.5        |
| 05.10.2016 | 29      | 65.42    | 169.24    | 48       | 181            | 6.45     | 6.53     | 6.5        | 4.2        |
| 06.10.2016 | 30      | 64.21    | 173.23    | 23       | 749            |          |          |            |            |
Fig. 2 Appearance of investigated pelagian larvae of the bivalve molluscs. a-Zirfaea spp., b-Kellia spp., c-Macoma spp.,
d-Mactra spp., e-Mya spp., f-S. groenlandicus, g-Chlamys spp., h-H. arctica.
Sigsbi trawl and Van-Win’s bottom scooper the benthos samples were taken and by the Sekki disk the water transparency was defined. The authors identified the species content larvae of bivalve mollusks on adult bivalve mollusks in the benthos tests. In order to get the material of the station which compares to the previous test researches, the sampling was located at the same coordinates as it was indicated in those publications.

The statistical material processing was executed with the help of the program STATISTICA 6 and tested at the level of $\alpha = 0.05$. The graphic material for the publication was made by the means of the Serfer 7 Golden Software and Excel 2007.
3. Results and Discussion

Processing of planktonic tests has shown a high abundance of pelagian larvae of the bivalve molluscs. Spatial distribution was investigated at 9 species (Fig. 2). On shares in total number, in decreasing order, they located as follows: Hiatella arctica (58.7%); Serripes groenlandicus (15.3%); Macoma spp. (14.0%); Mya spp. (8.0%); Kellia spp. (2.5%); Chlamys spp. (0.52%); Mytilus trossulus (0.52%); Zirfaea spp. (0.38%); Mactra spp. (0.22%). The length of their shells fluctuated from 261.5 to 378.3 μm, and height from 225.5 to 309.2 μm. Its biggest quantity was found in the period from the 22nd of September to the 1st of October. Their maximum total abundance was observed at three stations: No. 12, No. 17 and No. 18 where it reached 4,987, 12,400 and 4,865 ind./m3 accordingly (Fig. 3). The most yield area was situated on the opposite side of the Bering Strait and the second maximum of larvae quantity was found on the Herald’s bank. The statistical processing of the collected material lets us define that the most valuable factors influencing the territorial allocation of the researched larvae are the water surface temperature and the water depth. The comparison of collected material with the literature sources lets us make a suggestion that unusually warm year 2016 was not the most favorable year for the larvae of bivalve mollusk reproduction. The materials received in anomaly warm year let us consider that the similar results of larvae territorial allocation are on the top of the global warming.

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