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Primary Production and P/B of Phytoplankton on Western Kamchatka Shelf

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Abstract

Radiocarbon measuring of primary production of phytoplankton on the shelf of Western Kamchatka in June-July of 2014 revealed difference among the values in the coastal shallow water area, on the depth fall and in the deep-water stations in the entrance to Shelikhov Gulf. Values of P/B were different also, and that should be considered at ecological monitoring of the area.

Keywords: Primary Production of Phytoplankton; P/B; The Sea of Okhotsk; Western Kamchatka Shelf

Introduction

The shelf of Western Kamchatka is reckoned as one of the most productive parts of the Sea of Okhotsk [1], known as one of principle high-latitude eutrophic zones of the World Ocean [2]. Complex ecosystem research, of the Sea of Okhotsk, including estimation of primary production of phytoplankton (Pp), was accomplished in the early 1990th. Targeted Pp measurements on the shelf of Western Kamchatka (in the middle part) were provided at 5 stations only [3]. In the other parts of the Sea of Okhotsk Pp was recalculated based on the chlorophyll-a concentration [4] or on the nutrients stocked [5].

Geological researches have been provided on the shelf of West Kamchatka since the early 2000th, and estimation of local productivity of sites of the sea interesting for oil-drilling companies is getting vital in this connection. For essence, assessment of aquatic biological resources damage in case of drilling on the shelf uses P/B of phytoplankton. The purpose of this research was to assess the current level of primary production in the northern part of the Western Kamchatka shelf on results of radiocarbon measurements and to recalculate P/B of phytoplankton for locations with different depths.

Materials and Methods

Measurements of Pp were accomplished during cruise of the R/v «TINRO» at 12 stations in the northern part of the Western Kamchatka shelf limited by 54.5 – 58.18 N and 155.09 – 155.31 E (Figure 1) in the period from June 18 to July 10 in 2014. Measuring the temperatures of the water at every station was carried with using the hydrological complex Sea Bird Electronics (USA), consisted of the hydrological probe SBE Sea logger CTD model 25, the sampler Carousel SBE model 32 and the onboard control unit with sampler Deck Unit SBE model 33. The configuration mentioned provided collecting on-line hydrological data with simultaneous taking samples for evaluation of Pp on the surface and in the thermocline, usually coinciding with the horizon of the maximal oxygen concentration.

The primary production of phytoplankton was to measure by ^{14}C method [6, 7]. Samples of water with phytoplankton poured into 2 transparent and 1 dark plastic flasks 0.5 l, and added 0.2 ml of solution of marked bicarbonate with the strength (R) 1018600 impulse minute^{-1} ml^{-1}, and exposed in running water in the transparent containers on the deck during 24 hours. After the exposition the water samples were filtered through membrane filters Vladipor with the filtering surface diameter of 35mm and the filtering pore diameter 0.31-0.45 μm in vacuum <0.2 atm. The filter-deposited phytoplankton activity was estimated using the scintillation counter Tri-Carb 2800TR on preliminary washing the filters with the sediments by hydrochloric acid 0.05 N. Pp was calculated from the equation

$$Pp = \frac{Rs[HCO_3]1000}{R}$$

where Rs – sample radioactivity after 24-hour exposure, impulse minute-1; R – added ^{14}C solution radioactivity; [HCO_3]

– bicarbonate concentration, mg C l^{-1}; 1000 – coefficient to recalculate per 1 l.

The bicarbonates were measured at every station in sampling horizons by the method of direct titration [8]. Light attenuation coefficient at different depths was calculated from empiric curves, obtained for July at 5 stations near the coast of Kamchatka in 1992 [3]. It was found for the sea and Pacific Ocean waters that euphotic layer power largely depends on the aquatic transparency [9], and hence the euphotic zone depths (EZD) were evaluated as:

$$EZD = 1,8151DS^{1,0603}$$

where EZD – the euphotic zone depths (m), DS – the aquatic transparency (m). This correlation was obtained in the analysis of the curves of the «depth – light attenuation» at the stations with known aquatic transparency [3, 9].

Daily integral primary production (Pt) was calculated from multiplication of the means for two horizons (surface and thermocline) of the daily primary production by the euphotic zone depths [8], taking that EZD is generally coinciding with the layer between sampling horizons for evaluation of Pp. The number of the microalgae cells was evaluated in the Naumann chamber of 1 ml after a single counting in the microscope OLYMPUS BX40 at 10- and 20-fold magnification in the water samples collected for evaluation of Pp. Biomass (B) was calculated from multiplication of the number of every microalgae species by individual volume of the cells, taking the cell density as 1, and P/B – as the ratio Pt to B under m^2 in the EZD.

The aquatic transparency was evaluated from Secchi's white disk. Stations were reckoned as shallow water in case of the depth less than 50 m. The stations in the depth range 100–250 m was thought as at the depth fall, and lower 300 m – as the deep-water stations near the entrance of Shelikhova Gulf.

Results and Discussion

During the research period the phytoplankton consisted of diatoms and autotrophic dinophyts microalga. Up to 90% of the biomass of diatoms at majority of stations were *Chaetoceros* (*C. concavicornis, C. debilis, C. decipiens*), somewhere *Eucampia zodiacus, Dactyliosolen fragilissimus, Coscinodiscus sp., Thalassiotrhix* sp. dominated. At several stations up to 4% of the phytoplankton biomass consisted of the dinophyts *Alexandrium, Heterocapsa, Scrippsiella* and the autotrophic representative *Gyrodinium*.

The values of the integral primary production of plankton (Pt) in 2014 in the coastal shallow-water sites (the stations 1–3, 5–7) were highly variable, being averaged in the coastal waters 473 mg C m^{-2} day^{-1}. Positive gradient in the distribution of the values was observed along the coast from the south to the north. The Pt was minimal at the depth-fall sites (the stations 4, 11, 12) everywhere , and the mean was 14,4 mg C m^{-2} day^{-1}. In the deep-water sites nearest to Shelikhov Gulf the value was like the coastal sites (averaged 319 mg C m^{-2} day^{-1}). The biomass of phytoplankton (B), like Pt in the coastal stations, varied extensively (Table 1), averaged being 1978 mg m^{-2}. Very similar values were observed at the depth-fall (the station 12). The mean value for these sites was 2799 mg m^{-2}.

Table 1: Results of phytoplankton primary production measuring in the Sea of Okhotsk near Western Kamchatka in June-July of 2014.

1	2	3	4	5	6	7	8	9	10	11	12
1	18.06	155.311	54.499	56	23.18	6	12.1	20	242.3	1294	0.19
2	19.06	155.175	55.149	40	25.08	7	14.3	15.7	224.4	579	0.39
3	19.06	155.324	55.447	25	24.6	4	7.9	58.2	459.3	6026	0.08
4	19.06	154.202	55.46	243	23.27	14	29.8	0.2	5.1	172	0.03
5	20.06	155.218	56.012	49	24.45	5	10	14.8	147.8	928	0.16
6	20.06	155.352	56.104	24	23.43	7	14.3	50	713.8	1260	0.57
7	21.06	155.523	56.37	16	23.94	4	7.9	133.2	1051.2	1779	0.59
8	27.06	155.374	58.126	351	24.36	8	16.5	31.6	520.9	1056	0.49
9	27.06	155.102	58.178	357	23.73	9	18.7	16.4	305.7	860	0.36
10	2.07	154.204	57.135	560	19.02	13	27.5	4.7	130.4	145	0.9
11	4.07	155.229	57.016	116	21.81	7	14.3	1	14.9	-	-
12	10.07	154.355	54.595	190	22.32	14	29.8	0.8	23.4	5426	0.004

1 – Station; 2 – date; 3 – Longitude N; 4 – Latitude E; 5 – Depth on the station, m; 6 – Bicarbonate concentration, mg l^{-1}; 7 – Secchi depth, m; 8 – EZD, m; 9 – Primary production (Pp), mg C m^{-3} day^{-1}; 10 – Total primary production (Pt), mg C m^{-2} day^{-1}; 11 – Biomass of Phytoplankton (B), mg m^{-2}; 12 – Phytoplankton P/B.

The mean value at the deep-water stations in the entrance to Shelikhov Bay was 687 mg m^{-2}. The evaluation of P/B indicated that the value varied in all zones and averaged was 0.3 for the shallow-water sites, 0.02 for the depth-fall sites and и 0.6 for the deep-water sites. Measuring Pt and P/B in the Sea of Okhotsk in 1992 was made in August generally in more southern area [3]. Only 4 stations in 1992 were situated within the southern part of the research of 2014. According to reports [3], Pt averaged for the stations was 1158 mg m^{-2} day^{-1}. Unfortunately, there were no values of B for the stations mentioned. As for Western

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Kamchatka in the whole and central part of the Sea of Okhotsk, Pt was 650 mg m^{-2} day^{-1} and P/B – 1.6. In this way, the data we have obtained are generally comparable, what implies reliability of the methodological approach and next calculations.

Conclusion

The values of P/B obtained for the waters of the Sea of Okhotsk near Kamchatka, where exploration work is being done, were comparable to earlier data. These data are recommended to use in making simulations of ecological consequences of anthropogenic activities in the area. Moreover, the depth of the activities should be considered depending on the site specifics (coastal shallow-water, depth-fall or deep-water sites), latitudal and seasonal trends.

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