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ВСТРЕЧАЕМОСТЬ И МНОГОЛЕТНЯЯ ДИНАМИКА ВИДА-ВСЕЛЕНЦА ДИНОФИТОВЫХ ВОДОРОСЛЕЙ *PROROCENTRUM MINIMUM* В ВИСЛИНСКОМ ЗАЛИВЕ БАЛТИЙСКОГО МОРЯ В 2002–2010 ГОДАХ

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Дмитриева О.А. Встречаемость и многолетняя динамика вида-вселенца динофитовых водорослей *Prorocentrum minimum* в Вислинском заливе Балтийского моря в 2002–2010 годах // Труды АтлантНИРО. 2018. Том 2, № 1(5). Калининград: АтлантНИРО. С. 29–37.

Вислинский залив – крупная прибрежная солоноватоводная лагуна Балтийского моря. В последние десятилетия актуальной задачей исследований залива является проблема вселения и натурализации чужеродных видов в его экосистему. Потенциально токсичный вид динофлагеллят *Prorocentrum minimum* – один из вселенцев, известный в этом водоеме с 1997 г. Для описания сезонной и межгодовой динамики количественного развития этого вида в Вислинском заливе в 2002–2010 гг. пробы фитопланктона отбирали ежемесячно с апреля по ноябрь на 5–6 станциях. В результате было установлено, что чаще всего этот вид отмечался в составе фитопланктонных сообществ на всех станциях залива осенью. Весной и летом *P. minimum* встречался на отдельных станциях гораздо реже. Высокие значения численности вселенца наблюдались в весенний период (542 тыс. кл/л), к лету численность снижалась и была минимальной (80 тыс. кл/л), а к осени снова возрастала (202 тыс. кл/л). Биомасса *P. minimum* была максимальной осенью за счет высокой численности водорослей с большими размерами клеток, по сравнению с весной и летом. Установлено, что наибольшего обилия *P. minimum* достигал при температуре не выше 11°С и солености не менее 5 ‰. В весенние месяцы увеличению численности, по-видимому, способствовали высокие концентрации аммонийного, нитратного и нитритного азота в воде.

Ключевые слова: Вислинский залив, фитопланктон, вид-вселенец, динофлагелляты, *Prorocentrum minimum*

Dmitrieva O.A. Occurrence and long-term dynamic of the invasive dinoflagellate *Prorocentrum minimum* in the Vistula Lagoon of the Baltic Sea in 2002–2010 // Trudy AtlantNIRO. 2018. Vol. 2, № 1(5). Kaliningrad: AtlantNIRO. P. 29–37.

The Vistula Lagoon is a large coastal brackish-water lagoon of the Baltic Sea. In recent decades, a live issue for research of lagoon is the problem of introducing and naturalizing alien species into its ecosystem. One of the invaders, known in this water body since 1997, is a potentially toxic species of dinoflagellate *Prorocentrum minimum*. To describe the seasonal and inter–annual dynamics of quantitative development of this species in the Vistula Lagoon, phytoplankton samples were taken monthly from April to November 2002–2010 at 5–6 stations in Russian part of the Vistula Lagoon. As a result, it was found that more often this species was observed in the composition of phytoplankton communities at all stations of Lagoon in the autumn. In the spring and summer *P. minimum* was observed only at some stations and it was more rare. High abundance of the invader were detected in the spring (542 thous. cells/liter), by the summer the number was decreasing and was minimal (80 thous. cells/liter), and by autumn it

increased again (202 thous. cells/liter). The *P. minimum* biomass of was the highest in autumn due to the development of large sizes cells, compared to spring and summer. It was found that the maximum abundance of *P. minimum* reached at a temperature of no higher than 11^0C and a salinity of at least 5 ‰. In the spring months, the increase in abundance was apparently due to high concentrations of ammonium, nitrate and nitrite nitrogen in water.

Key words: Vistula Lagoon, phytoplankton, alien species, dinoflagellate, *Prorocentrum minimum*

Introduction

Prorocentrum minimum (Pavillard) Schiller (Dinophyceae) is euryhaline and eutythermal, potentially toxic dinoflagellate that has a global distribution and it has caused a "red" tides in different regions of the World [Grzebyk et al., 1997; Heil et al., 2005]. *P. minimum* is commonly found in Atlantic Ocean along the west coast of the USA, Japan, Gulf of Mexico, Caspian, Adriatic, Mediterranean and Black Seas, and Scandinavian waters often in large numbers.

It was found in Oslo Fiord for first time in 1974 [Tangen, 1980; Dodge, 1982; Tangen, 1983; Marasovic et. al., 1990; Janson, 1994]. In the Baltic Sea it may be defined as an invasive species [Hajdu et al., 2000; Olenina et al., 2010]. This species has shown increase in abundance and distribution range and could have arrived in the Baltic Sea by means of a natural range expansion from the North Sea [Hajdu et al., 2000] where this species has been known since the early XXs century [Pertola, 2006] or by human-mediated transport was first recorded in the North Sea in 1976 [Smayda et al., 1992]. It was found in the south-eastern Baltic in 1992. In the current period, it is the dominant species of autumn phytoplankton communities [Olenina, 2007]. «Blooms» of *P. minimum* was observed in the region of removal of the Curonian Lagoon waters of the Baltic Sea in October–November in the Lithuanian part of the Curonian Lagoon [Olenina, 2004]. *P. minimum* was first recorded in Kattegat in 1981 and in the Baltic Proper in 1983, and today it is also present in the Skagerrak [Jansson, 1994]. The single species assemblages have begun to appear in the Gulf of Gdañsk and the Pomeranian Bay and are most frequent in the coastal area and usually consist of one of the dinoflagellate species *Prorocentrum minimum* and are often associated with the mass algal occurrences. In the Gulf of Gdañsk late summer assemblages dominated by dinoflagellate *P. minimum* [Ochocki et al., 1995; Hajdu et al., 2000; Witek, Pliński, 2000]. In the 1990s, such an assemblage (with dominated by dinoflagellate *P. minimum*) was observed between August and September in both the Gulf of Gdañsk [Hajdu et al., 2000; Witek, Pliński, 2000], and the Pomeranian Bay [Ochocki et al., 1995; Gromisz et al., 1999].

According to the summary characteristic from data-base of alien species, this species has negative ecological impact on water ecosystem, on aquaculture and human health because it species of phytoplankton is toxicity [Olenin, 2007]. It can produce two kinds of toxins: hepatotoxic and diarrhetic shellfish toxin [White, 1988; Grzebyk et al., 1997]. It is responsible for the death of fish and shellfish [Steidinger, 1993].

The Vistula Lagoon is a large coastal brackish-water lagoon of the Baltic Sea. Despite the fact that for the Baltic Sea the long–term dynamics, distribution, and ecology of *P. minimum* are well researched, in the Vistula Lagoon characteristics of this species is less investigated. This species was noted only in the Russian part of the Vistula Lagoon [Ecology…, 2008; Semenova, Smyslov, 2009]. The aim of this paper is to describe own data that were obtained in 2000-2010 on the occurrence and seasonal dynamic of *P. minimum* in the Russian part of the Vistula Lagoon.

Material and methods

The area of investigation was the Vistula lagoon, which located in the though-eastern part of the Baltic. The phytoplankton samples were usually taken once a month from April until October 2002–2010 at 5-6 stations (Fig. 1). Integrated water samples were collected at each station

and preserved with Lugol solution. The analysis under an inverted microscope «Olympus» was performed in accordance with HELCOM recommendation [HELCOM, 1997]. In total, 386 samples of phytoplankton were analyzed. Biomass was calculated by multiplying the cell number with the individual cell volume, received from the measurements of cell size.

The hydrochemical parameters such as dissolved oxygen, BOD_5, ammonium nitrogen, nitrate nitrogen, mineral phosphorus, total nitrogen and phosphorus, and water salinity, that were performed by standard methods were determined On each station [Methods ..., 1978; Manual..., 2003].

Fig. 1. Schematic map of the Vistula Lagoon (the Baltic Sea). Numbers indicate sampling stations
Рис. 1. Схематическая карта Куршского залива (Балтийское море). Цифрами указаны станции отбора проб

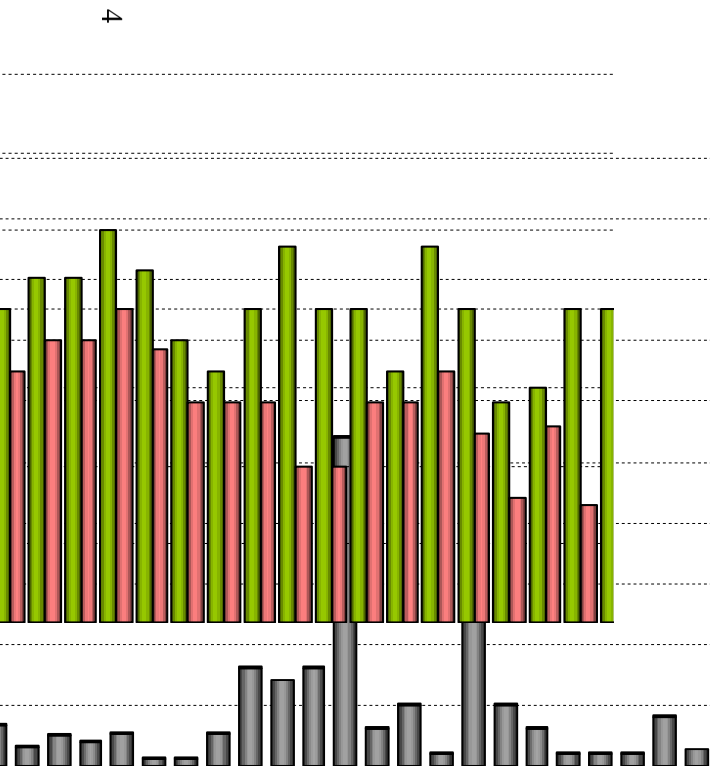
Results

The conducted studies showed, that *P. minimum* was found at all of stations of Vistula Lagoon in 2002–2010. This species occurred irregularly between years. In some years it was more abundant and in 2004 it was absent in phytoplankton community**.** As a resuls of the of seasonal changes investigation of the abundance of the *P. minimum* in the Lagoon in 2002–2010, it was found that this species was a more common in autumn phytoplankton but it was rare in the spring and summer months (Fig.2).

The invader abundance of the varied throughout the seasons and was on the average higher (541 thous. cells/liter) in the spring than in the summer (80 thous. cells/liter) and in the autumn (202 thous. cells/liter). Due to the fact that the size of the cells of this species in autumn was larger (length 20.6 μm; width 15 μm) than in spring (length 15.7 μm; width 13.7 μm) – the biomass of this species in autumn was higher – 0.35 mg/l, than in spring – 0.27 mg/l (Fig. 2, 3). The average value of the total abundance in the period when *P. minimum* was observed in the phytoplankton, varied from 32.56 thous. cells/liter, up to 44.97 thous. cells/liter (Table1).

The *P. minimum* share in the total abundance was small and varied from 0.25% to 1.21%. The average values of the total biomass of phytoplankton during the development of the *P. minimum* ranged from 12.3 mg/l to 17.1 mg/l. The *P. minimum* share in the total biomass was also small and varied from 0.23 % to 2.85 % (Table 1).

The abiotic parameters of the aquatic environment in the Vistula Lagoon in the *P. minimum* vegetation period were characterized by seasonal variability. In the spring and autumn period, the average temperature didn't exceed 10°C. In summer, the average water temperature was above 21.4°C. Transparency changed slightly 0.6–0.8. The content of nitrogen forms in water was characterized by considerable variability. The concentration of ammonium, nitrate and nitrite nitrogen was a maximal in spring. In the summer and autumn, the values of these biogenic substances were declined. The concentration of mineral and total phosphorus has a maximum values in summer (Table 1).



idth (w)

Fig. 3. The length (l) and width (w) of *Prorocentrum minimum* cell in the Vistula Lagoon in different seasons of 2002–2010

Рис. 3. Длина (l) и ширина (w) клеток *Prorocentrum minimum* в Вислинском заливе в различные сезоны 2002–2010 гг.

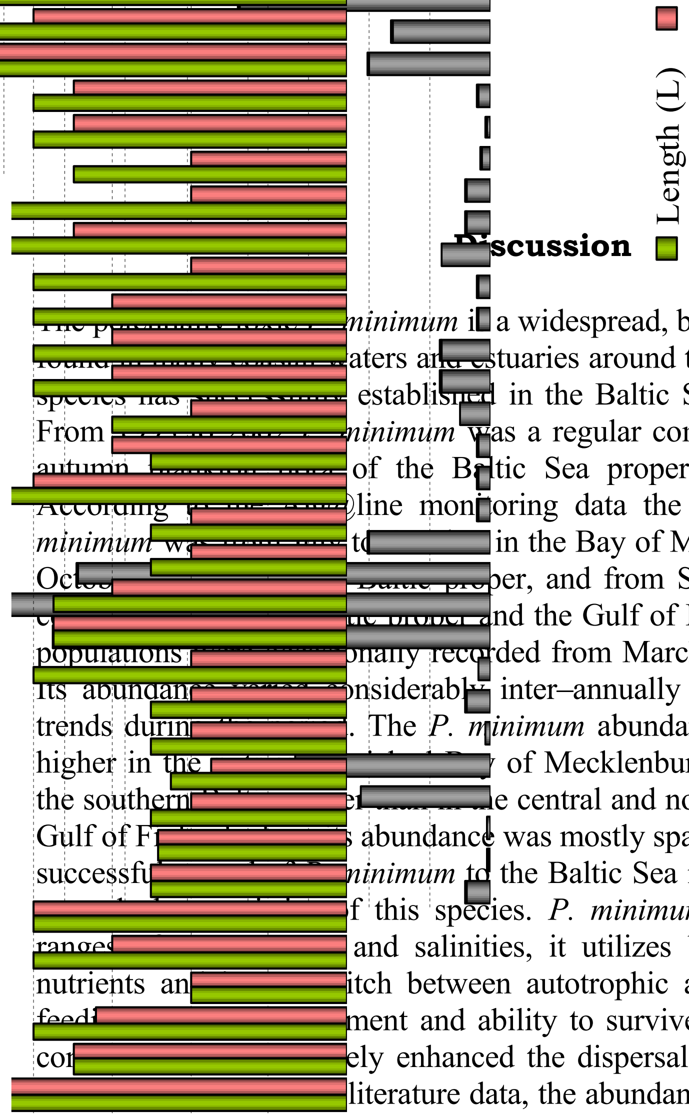


Table 1

Indices of quantitative development of phytoplankton and *Prorocentrum minimum* and abiotic parameters of the aquatic environment in 2002–2010

Показатели количественного развития фитопланктона и динофлагелляты *Prorocentrum minimum* и абиотические параметры водной среды в 2002–2010

Discussion

The p[illegible] *minimum* is a widespread, bloom-forming dinoflagellate found [illegible] aters and estuaries around the World [Heil, 2005]. This species has [illegible] established in the Baltic Sea in the last two decades. From [illegible] *minimum* was a regular component of the summer and autumn [illegible] of the Baltic Sea proper and the Gulf of Finland. According [illegible])line monitoring data the main growth period of *P. minimum* wa[illegible] t[illegible] in the Bay of Mecklenburg, from August to Oct[illegible]per, and from September to October in the c[illegible]and the Gulf of Finland. Sparse *P. minimum* populations [illegible]recorded from March to June and in November. Its abundan[illegible]nsiderably inter–annually and didn't show any clear trends durin[illegible]. The *P. minimum* abundance of the was significantly higher in the [illegible] of Mecklenburg on the German coast and the southern [illegible]e central and northern Baltic proper and the Gulf of F[illegible]s abundance was mostly sparse [Hajdu et al., 2005]. The successfu[illegible]*inimum* to the Baltic Sea is most likely a reflection of [illegible]f this species. *P. minimum* is able to adapt to wide ranges [illegible] and salinities, it utilizes both inorganic and organic nutrients an[illegible]itch between autotrophic and heterotrophic modes of feedi[illegible]ment and ability to survive under temporarily adverse co[illegible]ely enhanced the dispersal of this species [Heil et al., [illegible]literature data, the abundance of the Baltic *P. minimum* was generally not related to salinity or temperature. It could be a dominant species at both high and low salinity (over 15 and 4.8 PSU), and temperature range was broad (from 2.7°C to 26.4°C). However, dense populations usually occurred from July to October at temperature above 10°C, and the lower limit of salinity under which this species should be found, is 0.7 PSU [Hajdu et al., 2005]. The *P. minimum* was found in the Russian part of the Vistula lagoon in 1997 firstly in summer-autumn season [Semenova, Smyslov, 2009].

As a result of our studies it was found that the quantitative characteristics, seasonal and inter–annual variability of distribution and ecological features of *P. minimum* in the Vistula Lagoon were consistent with the previously identified patterns for this species in the Baltic Sea. In the spring months, the species was rarely observed and only at individual stations, but its abundance was high that may be due to the increased content of nitrogen (ammonium, nitrate and nitrate forms) in water. According to literary data, there appears to be a positive correlation between the successes of *P. minimum* in the Baltic Sea and high concentrations of total phosphorous and nitrogen [Hajdu et al., 2005]. Probably, the low salinity values prevented the spread and development of this species in the spring months in our observations in 2002–2010. Although a combination of low temperatures below 10ºC and salinities less than 15 psu are unfavourable to some *P. minimum* clones [Tyler, Seliger, 1981]. Different clones of the same species can have dissimilar temperature–and salinity–dependent growth rates [Wood, Leatham, 1992]. The Baltic may be inhabited by clones that are especially well adapted to low temperature and salinity [Grzebyk, Berland, 1996]. Abundance and biomass of *P. minimum* were minimal for the period under our study in summer 2002–2010 despite the high concentrations of mineral and total forms of phosphorus in the water.

Perhaps the lower (in compared to the spring) concentration of nitrogen forms in water and the water temperature above 20°C were not favorable for the development of this species in the summer. In the autumn months when the *P. minimum* was found in phytoplankton communities and was more abundant, the salinity was 5‰ and the water temperature was 11^0C. The combination of these factors, apparently, was favorable for the development of this species in the Vistula Lagoon in the autumn.

Conclusions

As a result of the studies it was established that the potentially toxic species *P. minimum* was a constant component of the autumn phytoplankton communities of the Vistula Lagoon in 2002–2010. The abundance of this species had varied from 80 thous. cells/liter (in summer) to 542 thous. cells/liter (in spring). In autumn, the abundance was in averaged – 202 thous. cells/liter. Biomass of *P. minimum* was the highest in autumn (an average of 0.35 mg/l) due to the development large cell sizes (an average of length 20.6 μm; width 15 μm). In the spring, the biomass value in averaged was – 0.27 mg/l and the biomass was comparable to the value of autumn biomass – 0.35 mg/l due to the fact that the species in this period was abundant, despite the fact that the cell sizes in spring were smaller in averaged – length 15.7 μm; width 13.7 μm in compared the autumn in averaged – length 20.0 μm; width 15.0. In summer the biomass of the alien species was minimal, in averaged – 0.04 mg/l, it is explained by the fact that the species had a low abundance in the samples, although the cell sizes were comparable with those recorded in the spring of length 17.9; width 13.6 μm.

The environmental conditions under which the species reached its maximum development were comparable with those known for other areas of the Baltic Sea. The *P. minimum* maximum abundance in Vistula Lagoon reached at a temperature of no higher than 11^0C and a salinity of at least 5 ‰. In the spring, the increase in abundance was apparently due to high concentrations of ammonium, nitrate and nitrite nitrogen in water.

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