SUMMARY OF PROFESSIONAL ACCOMPLISHMENTS

Sylwia Śliwińska-Wilczewska

University of Gdańsk

Gdynia, 2019

1. Name and surname:

Sylwia Śliwińska-Wilczewska

2. Diplomas and academic degrees:

2015	**Doctor of Natural Sciences in the field of Oceanology** (4th December 2015 r.), University of Gdansk, Faculty of Oceanography and Geography, Institute of Oceanography, doctoral thesis entitled „*Allelopathic interactions of Baltic cyanobacteria Synechococcus sp. and Nodularia spumigena under selected environmental conditions*" – executed under the supervision of doctor Sabina Jodłowska and Professor Adam Latała.
2009	**M.Sc. degree in Oceanography** (29th July 2009 r.), University of Gdansk, Faculty of Oceanography and Geography, Institute of Oceanography, master thesis entitled „*The influence of selected environmental factors on growth, photosynthetic pigments, chlorophyll fluorescence and the photosynthesis performance in Baltic picocyanobacteria from the genus Synechococcus*" – executed under the supervision of doctor Sabina Jodłowska.

3. Information on employment in scientific institutions:

since 2016	University of Gdansk, Institute of Oceanography, Division of Marine Ecosystems Functioning, position: Assistant Professor
2013-2016	University of Gdansk, Institute of Oceanography, Division of Marine Ecosystems Functioning, position: Assistant
2012-2013	University of Gdansk, Institute of Oceanography, Division of Marine Ecosystems Functioning, position: Specialist
2011-2015	Environmental Doctoral Institute, University of Gdansk, Faculty of Oceanography and Geography

4. Scientific achievement being the basis for the habilitation procedure (in accordance with article 16 paragraph 2 of the Act on Academic Degrees and Academic Titles as well as Degrees and Titles in Art as of 14th March 2003; Journal of Laws 2016, item 882, as amended in Journal of Laws 2016, item 1311):

a) Title of the scientific achievement:

Allelopathic activity and acclimatization properties of picocyanobacterium *Synechococcus* sp. in aquatic ecosystem

b) List of publications (author(s), title(s), year of publication, name of publisher, reviewers):

		Publication	MNiSW points	Impact Factor (IF)*	5-Year Impact Factor (5-Year IF)*
4.b	**I**	**Śliwińska-Wilczewska S.**, Pniewski F., Latała A. 2016. Allelopathic activity of the picocyanobacterium *Synechococcus* sp. under varied light, temperature and salinity conditions. International Review of Hydrobiology 101, 69–77. DOI: 10.1002/iroh.201501819	25	1.459	1.459
4.b	**II**	**Śliwińska-Wilczewska S.**, Maculewicz J., Barreiro Felpeto A., Vasconcelos V., Latała A. 2017. Allelopathic activity of the picocyanobacterium *Synechococcus* sp. on filamentous cyanobacteria. Journal of Experimental Marine Biology and Ecology 496, 16–21. DOI: 10.1016/j.jembe.2017.07.008	30	1.937	2.310
4.b	**III**	**Śliwińska-Wilczewska S.**, Maculewicz J., Tuszer J., Dobosz K., Kulasa D., Latała A. 2017. First record of allelopathic activity of the picocyanobacterium *Synechococcus* sp. on a natural plankton community. Ecohydrology & Hydrobiology 17, 227–234. DOI: 10.1016/j.ecohyd.2017.05.001	15	1.592	1.592

4.b	**IV**	**Śliwińska-Wilczewska S.**, Maculewicz J., Barreiro Felpeto A., Latała A. 2018. Allelopathic and bloom-forming picocyanobacteria in a changing world. Toxins 10, 48; DOI:10.3390/toxins10010048	35	3.030	3.450
4.b	**V**	Barreiro Felpeto A., **Śliwińska-Wilczewska S.**, Złoch I., Vasconcelos V. 2018. Light-dependent cytolysis in the allelopathic interaction between picoplanktic and filamentous cyanobacteria. Journal of Plankton Research 40(2), 165–177. DOI: 10.1093/plankt/fby004	35	1.983	2.194
4.b	**VI**	**Śliwińska-Wilczewska S.**, Barreiro Felpeto A., Maculewicz J., Sobczyk A., Vasconcelos V., Latała A. 2018. Allelopathic activity of the picocyanobacterium *Synechococcus* sp. on unicellular eukaryote planktonic microalgae. Marine and Freshwater Research 69(9), 1472–1479. DOI: 10.1071/MF18024	30	1.757	1.757
4.b	**VII**	**Śliwińska-Wilczewska S.**, Latała A. 2018. Allelopathic activity of the bloom-forming picocyanobacterium *Synechococcus* sp. on the coexisting microalgae: the role of eutrophication. International Review of Hydrobiology 103(3-4), 37–47. DOI: 10.1002/iroh.201801940	25	2.281	2.281
4.b	**VIII**	**Śliwińska-Wilczewska S.**, Cieszyńska A., Maculewicz J., Latała A. 2018. Ecophysiological characteristics of red, green and brown strains of the Baltic picocyanobacterium *Synechococcus* sp. – a laboratory study. Biogeosciences 15, 6257–6276. DOI: 10.5194/bg-15-6257-2018	40	3.441	4.373
		Total	**235**	**17.480**	**19.416**

*In the year of publication (or in 2016 for publications from 2017 and 2018)

c) description of the scientific goals of the above-mentioned papers, and the obtained results with their possible application.

Allelopathic activity and acclimatization properties of picocyanobacterium *Synechococcus* sp. in aquatic ecosystem

Introduction

The presence of picoplankton, as well as its share in biomass and primary production has been neglected for a long time in research regarding the structure and functioning of aquatic ecosystems. This was due to the small size of the cells (0.2 – 2.0 μm) achieved by this plankton fraction and the difficulty in identifying them using light microscopy and other classic methods (Sieburth et al., 1978). The use of modern techniques, such as epifluorescence microscopy, electron microscopy or flow cytometry, allowed to learn and develop knowledge about autotrophic picoplankton (Jakubowska and Szeląg-Wasielewska, 2015; Jasser and Callieri, 2017).

Today, it is known that picocyanobacteria are an extremely important component of the world's oceans and seas, as well as freshwater and brackish reservoirs (Mazur-Marzec et al., 2015, Worden and Wilken, 2016, Jasser and Callieri, 2017). Their biomass, like primary production, can account for up to 90% of the total phytoplankton biomass, and up to 43% in freshwater ecosystems (Stockner, 1988). Picocyanobacteria can produce a wide range of secondary metabolites that disrupt the functioning of many animal organisms (Costa et al., 2015), including vertebrates (Hamilton et al., 2014). These organisms are also capable of secretion of toxins (e.g., Bláha and Maršálek, 1999) that are subject to bioaccumulation and biomagnification (Mazur-Marzec, 2006). Therefore, their harmful effects on the environment may concern further links in the trophic chain, and consequently also people (Cox et al., 2003). Research from recent years show that picocyanobacteria are also capable of forming massive blooms and can be the dominant fraction of plankton in many aquatic ecosystems around the world (Sorokin i in., 2004; Sorokin i Zakuskina, 2010). However, current information on these organisms is largely incomplete and dispersed in the literature. Therefore, in a **publication 4.b IV**, the current state of knowledge on the picocyanobacteria as well as the latest information confirming their ability to produce harmful secondary metabolites and to create massive blooms in many aquatic ecosystems is summarized.

Autotrophic picoplankton also plays an important role in the Baltic Sea (Stal et al., 2003; Mazur-Marzec et al., 2013). Numerous studies indicate that in the Baltic Sea, the picocyanobacteria obtain high biomass and are responsible for higher primary production than filamentous cyanobacteria *Aphanizomenon flos-aquae* and *Nodularia spumigena* (Jochem, 1988). Subsequent research indicated that the average value of primary production was 56% for picocyanobacteria, 28% for *Aphanizomenon* sp. and 16% for *Nodularia* sp. (Stal and Walsby, 2000). In addition, environmental studies showed that in the Baltic Sea, the picocyanobacteria may constitute even more than 90% of the cyanobacterial biomass during the summer bloom (Mazur-Marzec et al., 2013). These authors also state that among the picocyanobacteria, the *Synechococcus* species predominates in the Baltic Sea.

Picocyanobacteria *Synechococcus* sp. also show high acclimation abilities to changing environmental conditions (**publication 4.b VIII**). In surface layers, the number of picocyanobacteria varies from several thousand to sometimes even several million cells in 1 milliliter of water (Sorokin and Dallocchio, 2008; Parvathi et al., 2014). Due to their small size, the picoplanktonic cyanobacteria also have a very favorable, high ratio of the cell surface to its volume. This allows them to accelerate the rate of nutrients uptake as compared to larger phytoplankton cells (Stockner, 1988; Scanlan, 2012). In addition, recent studies have confirmed that the picocyanobacteria of the genus *Synechococcus* exhibit the allelopathic activity on the coexisting cyanobacteria and microalgae (**publication 4.b I**, **II**, **III**, **V**, **VI**, **VII**). Therefore, picoplankton organisms can effectively compete with larger autotrophic organisms and determine the primary production of entire aquatic ecosystems. Recognition of the mechanisms responsible for the expansion of these organisms is an extremely important issue for a better understanding of the functioning of the aquatic environment, including the role of allelopathy in the dynamics of phytoplankton assemblages.

According to the information provided in section 4.b, my habilitation work consists of scientific achievements published in eight papers in journals from the Journal Citation Reports (JCR) database. Their total Impact Factor equals 17.480 (5-year IF = 19.416), and their total score equals 235 points according to the List of Scientific Journals published by the Polish Ministry of Science and Higher Education from year 2016. The results described in those publications reflect the gradual progress of my work on the allelopathic activity and acclimatization properties of picocyanobacteria *Synechococcus* sp. in aquatic environment.

It is worth emphasizing here that in my research, included in the habilitation thesis, I focused on expanding the existing state of knowledge about the picocyanobacteria of the genus *Synechococcus*. In my master's thesis I made a pilot study on the autecology of picoplanktonic cyanobacteria, while in my doctoral thesis I documented for the first time the possibility of allelopathic effects occurring in *Synechococcus* sp. These results gave me the basis for more detailed research and further research hypotheses. A novelty of the works presented below was the demonstration of allelopathic effects of *Synechococcus* sp. on previously unidentified species of cyanobacteria and microalgae. Furthermore, for the first time, the allelopathic activity of *Synechococcus* sp. was found in mixed cultures, as well as on whole phytoplankton communities. In addition, new effects of allelopathic compounds produced and secreted by *Synechococcus* sp. have been demonstrated, as well as identified previously uncharted environmental factors affecting the allelopathic activity of these organisms. Also, to determine the acclimatization properties of different strains of *Synechococcus* sp., a broader range of environmental factors than the one presented in the master's thesis was used, and for the first time the preferences of these organisms to a different range of salinity were documented. The research results included in the habilitation work are coherent and comprehensive, which is why they can be the basis for modeling ecological processes.

The main goal was to (i) determine the allelopathic activity of Synechococcus sp. on selected monocultures of cyanobacteria and microalgae, mixed cultures and on natural phytoplankton communities, (ii) demonstrate the mechanisms of action of allelopathic compounds produced and secreted by *Synechococcus* sp., (iii) examine the environmental factors influencing the allelopathic effect of picocyanobacteria on target organisms and (iv) show the acclimatization properties of different strains of the picocyanobacteria from the genus *Synechococcus* in aquatic ecosystem. Therefore, a detailed description of the obtained results has been divided into four parts.

Description of the obtained results

1. Allelopathic activity of *Synechococcus* sp. on selected cyanobacteria and microalgae in monocultures, mixed cultures and on natural phytoplankton communities

In the obtained work, it was demonstrated for the first time, that picocyanobacterium *Synechococcus* sp. shows the allelopathic activity on cyanobacteria (**publications 4.b II**, **V**), green algae (**publications 4.b VI**, **VII**), diatoms (**publications 4.b I**, **VI**, **VII**), prymnesiophytes and unicellular red algae (**publication 4.b VI**). This selection of organisms, differing in the systematic position, size and structure of the cells, made it possible to obtain an extended response of various species of cyanobacteria and microalgae, and also allowed the assessment of the range of differentiated sensitivity of these organisms to picocyanobacterial allelochemicals. An interesting concept in the evolutionary context is the allelopathic interaction between cyanobacteria. The results obtained in our work indicated strong allelopathic activity of picocyanobacteria *Synechococcus* sp. on selected filamentous cyanobacteria. In the above-mentioned paper (**publication 4.b II**), it was demonstrated the allelopathic activity of *Synechococcus* sp. on filamentous cyanobacteria from the genus *Aphanizomenon*, *Nostoc*, *Phormidium* and *Rivularia*. It was shown that the filtrate obtained from *Synechococcus* sp. caused a significant inhibitory effect on the number of cells of *Phormidium* sp. and *Nostoc* sp. The greatest inhibition of the growth of these cyanobacteria was due to the addition of repeated filtrate obtained from *Synechococcus* sp. cultures after 2 weeks exposure, which for these cyanobacteria amounted to 53% and 44%, respectively, relative to the control conditions. In turn, for *Aphanizomenon* sp., the stimulating effect of picocyanobacterial allelopathic compounds was observed. The study showed that the number of cells of tested cyanobacteria on the 14th day of the experiment after addition of filtrate was 26% higher than in the control. The study also demonstrated that filtrate addition had no significant effect on the *Rivularia* sp. In connection with these interesting reports, in the next paper (**publication 4.b V**) it was attempted to study the allelopathic activity of *Synechococcus* sp. on toxic and bloom-forming cyanobacterium *Nodularia spumigena*. It was found that secondary metabolites produced and secreted by picocyanobacteria caused the greatest decrease in growth after a week of exposure to *Synechococcus* sp. filtrate, which was about 60%, compared to the control treatment. Allelopathy in the natural environment is one of the competitive strategies for cyanobacteria, which by secretion of allelopathic compounds cause inhibition and decrease in the number of cells of other species of cyanobacteria. This approach could explain the inhibition of growth of cyanobacteria *N. spumigena*, *Phormidium* sp. and *Nostoc* sp. by the picocyanobacteria

Synechococcus sp. In turn, stimulation of *Aphanizomenon* sp. growth after filtrate addition may indicate a hormesis effect which stimulates growth by low levels of inhibitors (Stebbing, 1982). On the other hand, the lack of sensitivity of *Rivularia* sp. to the presence of allelopathic compounds secreted by *Synechococcus* sp. may suggest that this cyanobacterium has developed detoxification enzymes (Pflugmacher and Steinberg, 1997) or that the metabolites produced by planktonic *Synechococcus* sp. have little effect on benthic organisms.

To better understand the allelopathic effects of picocyanobacteria in the aquatic environment, the experiments on different species of microalgae in monocultures were also examined (**publications 4.b I**, **VI**, **VII**). Analyzing the effect of picocyanobacterial allelopathic compounds, it was shown that the addition of filtrate caused the greatest inhibition of growth on diatoms *Skeletonema marinoi* and *Navicula perminuta*, for which the response was 39% and 61% respectively, compared to the control. In turn, it was noted that the examined green algae *Chlorella vulgaris* and *Stichococcus bacillaris*, and benthic red algae *Porphyridium purpureum* and diatom *Bacillaria paxillifer* were much more resistant to the filtrate obtained from picocyanobacteria, and significant inhibition of growth for these organisms occurred mainly on the last day of the experiment, and was over 80% compared to the control conditions. It was also shown that allelopathic compounds secreted to the medium stimulated the growth of the prymnesiophytes *Prymnesium parvum* by 19% in relation to the control conditions. On the basis of the obtained results, it was also found that the filtrate obtained from *Synechococcus* sp. had no effect on diatom *Nitzschia dissipata* and green algae *Oocystis submarina*. Various characteristics, such as membrane permeability, may contribute to the differential sensitivity of certain phytoplankton species to allelopathic compounds (Suikkanen et al., 2004). Differences in response may also depend on specificity in cell structure (Ribalet et al., 2007) or cell size (Lyczkowski and Karp-Boss, 2014). It has been found that the size of target species can also have significant effect for the observed allelopathic activity of *Synechococcus* sp. Analyzing the effect of the microalgae cells size on the observed effect of allelopathic compounds of *Synechococcus* sp., it was shown that the addition of the filtrate resulted in the greatest inhibition of growth in small cells (up to several μm), such as *S. marinoi* and *N. perminuta*. In contrast, a slight or no effect of the allelopathic compounds of picocyanobacteria was noted on the *B. paxillifer*, *N. dissipata* and *O. submarina*, which are approximately 50 μm, 30 μm and 20 μm, respectively. *O. submarina* cells are additionally surrounded by parental walls after division. For organisms that reach a larger cells size and thus a larger volume, a larger amount of allelopathic compounds is needed to cause the allelopathic effect. Therefore, the same volume of filtrate addition for larger organisms may not be sufficient to observe the allelopathic effect compared to smaller organisms. On the other hand, the high

metabolism achieved by small cells may cause allelopathic compounds to enter the cell more quickly, which indicates that the mechanism of action of these compounds occurs inside the target organism. In addition, some co-evolutionary aspects may contribute to the observed results. Diatoms, which predominate in the Baltic Sea in the spring and autumn, usually have no contact with the massive occurrence of cyanobacteria in the natural environment. Therefore, the studied diatoms may not have developed any defense mechanisms for allelopathic compounds secreted by picocyanobacteria, which results in significant inhibition of their growth. The existence of co-evolution is also confirmed by the fact that the examined green algae, which co-exist with cyanobacteria, showed a weaker allelopathic effect on the filtrate obtained from *Synechococcus* sp. than the tested diatoms. However, in some cases, allelopathic activity is stronger *in situ* than observed in laboratory studies (Figueredo et al., 2007) and even weaker allelopathic effects may be important for changes occurring in natural phytoplankton communities. In turn, the stimulation of the growth of *P. parvum*, a species in which allelopathic activity has been well documented (e.g., Fistarol et al., 2003) indicates that this organism could develop protective mechanisms against the inhibitory metabolites of the picocyanobacteria and even benefit from them. Produced and secreted by the picocyanobacteria *Synechococcus* sp. allelopathic compounds may be responsible for the natural selection of organisms and ecological succession. They also testify to their competitive advantage over other phytoplankton species. As a consequence, allelopathic activity of picocyanobacteria *Synechococcus* sp., which causes inhibition of growth of some species of cyanobacteria and microalgae, may be a key factor causing the dominance of these organisms in many aquatic ecosystems, including the Baltic Sea.

Knowing that the allelopathic compounds contained in the *Synechococcus* sp. filtrate are capable of allelopathic effects on selected cyanobacteria and microalgae, in subsequent works it was undertaken to check whether this effect will be enhanced in mixed cultures. Conducted research has shown that the picocyanobacteria *Synechococcus* sp. show a stronger allelopathic effect in mixed cultures than in monocultures (**publications 4.b V**, **VI**). Studies on the allelopathic effects of *Synechococcus* sp. in mixed cultures have been investigated by two independent methods. In the first study discussed above, the growth of target organisms was measured using the classical method of cell counting in the hemocytometric chamber (**publication 4.b V**). In the second study, published in the same year, the allelopathic effects of *Synechococcus* sp. in mixed cultures were determined using novel techniques - a flow cytometer (**publication 4.b VI**). In the **publication 4.b V**, the range of occurrence of the allelopathy phenomenon between dominant Baltic cyanobacteria *Synechococcus* sp. and *N. spumigena* in mixed cultures was examined. On the basis of the obtained results, it was found that *Synechococcus* sp. showed, similarly as in the case of filtrate addition to

monocultures, negative allelopathic effects on *N. spumigena*. The highest inhibition of the growth of this filamentous cyanobacteria was observed after 7 days of the experiment, which was almost 2-fold lower ($18 \cdot 10^5$ cells mL^{-1}) than in controls ($34 \cdot 10^5$ cells mL^{-1}). On the other hand, it was shown that *N. spumigena* had no allelopathic effect on *Synechococcus* sp. Our study (**publication 4.b V**) confirms the hypothesis proposed by Stal et al (2003) and Mazur-Marzec et al. (2013) that the picocyanobacteria keep the diazotrophic cyanobacteria in check by their allelopathic activity. The main aim of the second mentioned work (**publication 4.b VI**) was to show the allelopathic activity of *Synechococcus* sp. on the growth of the eukaryotic microalgae *S. bacillaris*, *P. purpureum*, *N. dissipata* and *P. parvum* in mixed cultures. We demonstrated that the presence of *Synechococcus* sp. in co-culture inhibited the growth of red algae *P. purpureum* and green algae *S. bacillaris*. Significant differences were found on days 1, 3 and 7 of the experiment, when the number of cells of *P. purpureum* was 38%, 17% and 1%, respectively, and the number of cells of *S. bacillaris* was 80%, 86% and 94%, of control, respectively. It was also shown that *Synechococcus* sp. had a stimulating effect on the prymnesiophyte *P. parvum*, in which the number of cells on day 3 and 7 of the experiment was 14% and 31%, respectively, higher than in control treatments. In contrast, *N. dissipata* was not affected with the presence of picocyanobacteria in coculture. This research helped to assess what effect on different phytoplankton groups (green algae, prymnesiophytes, diatoms and unicellular red algae) had the allelopathic compounds produced and secreted by picocyanobacteria *Synechococcus* sp. These results suggest that the negative allelopathic effect of *Synechococcus* sp. should be taken into account in the interactions between picocyanobacteria and eukaryote competitors coexisting in a planktonic system.

In order to refer the results to the natural environment, in the next experiments we demonstrated the allelopathic effects of *Synechococcus* sp. on phytoplankton communities. Studies have shown that compounds produced and released by *Synechococcus* sp. affect the structure and biomass of phytoplankton communities from the Baltic Sea (**publication 4.b III**). It was observed that after a single filtrate addition, after a week's exposure, the percentage of diatoms and green algae decreased by 10% and by 2%, respectively. On the other hand, the percentage of cyanobacteria in the control was 24%, while in the experiment it was 36%. The study also noted that the filtrate addition did not affect dinoflagellates, which in both control and experimental cultures accounted about 4%. However, when the repeated filtrate was added, the percentage of diatoms, green algae and dinoflagellates decreased by 12%, 7% and 2%, respectively, and the percentage of cyanobacteria increased significantly by 21%. This study also showed that the degree of inhibition was different for each species, causing a change in the phytoplankton abundance and dominance during the experiment. It was found that diatoms of the genera *Navicula*, *Chaetoceros*,

Amphora, *Coscinodiscus*, *Grammatophora* and *Nitzschia* were the most affected organisms. The species composition analysis also showed that the cyanobacteria *N. spumigena* and *Gloeocapsa* sp. were significantly stimulated in experimental cultures, in which the single and repeated filtrate were being added. The study also showed that the filtrate obtained from *Synechococcus* sp. caused a decrease in the total biomass (expressed as chlorophyll *a* and chlorophyll *c* content) of natural phytoplankton assemblages which were 50% and 64%, respectively, compared to the control treatment. It was found that the compounds produced by the picocyanobacteria *Synechococcus* sp. affect the phytoplankton communities in a different ways. As a result of the addition of allelopathic compounds contained in the filtrate, both the decrease in the total biomass of target organisms and changes in the structure of phytoplankton communities were recorded. It was shown that picocyanobacterial allelochemicals caused strong inhibition of growth of microalgae, while cyanobacteria were stimulated. The research conducted on the Baltic Sea material indicates that allelopathic compounds produced by the picocyanobacteria *Synechococcus* sp. are important from an ecological point of view, because they can affect changes in species composition of phytoplankton communities by limiting the occurrence of different species of microalgae or stimulating the growth of cyanobacteria.

One of the main questions that arise in the study of the phenomenon of allelopathy is the indication of what compounds are responsible for the observed effects. This study investigated the allelopathic effects of the picocyanobacteria *Synechococcus* sp., which could potentially produce microcystins (Bláha and Maršálek, 1999). However, the present study does not detect the presence of microcystin in the filtrate obtained from *Synechococcus* sp. The currently detected allelopathic compounds produced by *Synechococcus* sp. using the HPLC technique are phenolic compounds that are similar to chlorogenic acid. In addition, the GC-MS analysis showed that *Synechococcus* sp. also produces a number of volatile compounds, the largest of which was attributable to oxime, eicosane and silanediol (Śliwińska-Wilczewska et al., unpublished results). However, because cyanobacteria can produce many different metabolites, whose properties change depending on their mutual proportion, their determination poses huge problems. Therefore, a more detailed determination of the composition of allelopathic compounds secreted by picocyanobacteria requires further research.

2. Modes of action of allelopathic compounds produced and secreted by *Synechococcus* sp.

The documented ability to allelopathic activity of the picocyanobacteria *Synechococcus* sp. by inhibiting the growth of target organisms was the reason why in the next work we demonstrated

in details the mode of action of picocyanobacterial allelopathic compounds on coexisting cyanobacteria and microalgae (**publications 4.b I**, **II**, **V**, **VI**, **VII**).

The study has shown that destruction of cell membranes is a possible mode of action of picocyanobacterial allelopathic compounds (**publication 4.b V**). This study demonstrated that *N. spumigena* cells showed statistically significant morphological and structural changes after exposure to allelopathic compounds from *Synechococcus* sp. On the basis of light microscopy analyzes, it was shown that filtrate from *Synechococcus* sp. had a visible and negative effect in the morphology of *N. spumigena* cells, causing the collapse of large portions of filaments. In addition, it was shown that the tested allelopathic compounds caused restriction of pigmentation and cell lysis of *N. spumigena* compared to the control culture. The results obtained in this work indicated that the observed destruction of cell membranes by *Synechococcus* sp. may be associated with physiological changes in competing target organisms.

Another mode of action of picocyanobacteria *Synechococcus* sp. is by altering the pigment content (**paper 4.b II** and **V**). In this work, we showed that filtrates from picocyanobacterium *Synechococcus* sp. caused significant increase of the carotenoids contents of *A. flos-aquae* and *Nostoc* sp. Carotenoids are a class of accessory pigments that occur in all photosynthetic organisms and play an important role in protecting plants against photo-oxidation. Carotenoids are also effective antioxidants and participate in the removal of singlet oxygen and free radicals (Stahl and Sies, 2003). It can be assumed that the growth of carotenoid pigments in *A. flos-aquae* and *Nostoc* sp. cells indicates an attempt to protect the cell from the harmful effects of allelopathic compounds contained in the filtrate. Furthermore, it was found that *Synechococcus* sp. cell-free filtrate caused reductions of chlorophyll *a* content of filamentous cyanobacterium *N. spumigena*, *Phormidium* sp. and *Rivularia* sp. Reducing the chlorophyll *a* content in the tested organisms may result in inhibition of photosynthesis, the most important process occurring in all aquatic photoautotrophs. Since similar results for *N. spumigena* and *Aphanizomenon flos-aquae* were also obtained by Suikkanen et al. (2006), therefore it can be concluded that the above-described mode of action may be characteristic for cyanobacteria dominating in the Baltic Sea (Suikkanen et al., 2006).

The picocyanobacteria *Synechococcus* sp. showed an allelopathic effect on chlorophyll fluorescence of the tested cyanobacteria and microalgae (**publications 4.b I**, **II**, **VI** i **VII**). The most widely used method of chlorophyll fluorescence measurement is the method of fluorescence induction and quenching analysis modulated by saturating light impulses – it is referred to as the pulse amplitude modulation (PAM) method. Different parameters have a physiological significance, but the maximum quantum yield of photosystem II (PSII) photochemistry (F_v/F_m) is the most correlated with the photosynthesis and plant viability (Kolber et al., 1988). That is why, in the

presented works the allelopathic effect of *Synechococcus* sp. on the chlorophyll fluorescence parameter – F_v/F_m of tested cyanobacteria and microalgae was investigated using the PAM method. It was found that the response of the fluorescence parameter after addition of *Synechococcus* sp. cell-free filtrate depended on the target organisms and the time of exposure to allelopathic compounds. It was found that allelopathic compounds contained in the *Synechococcus* sp. filtrate have a significant influence on chlorophyll fluorescence on filamentous cyanobacteria (**publication 4.b II**), green algae (**publications 4.b VI**, **VII**), diatoms (**publications 4.b I**, **VI**, **VII**), prymnesiophytes and unicellular red algae (**publication 4.b VI**). The organisms in which the F_v/F_m parameter was most inhibited by the addition of the cell-free filtrate obtained from *Synechococcus* sp. were filamentous cyanobacteria *Phormidium* sp. and unicellular red algae *P. purpureum*. In these organisms, the value of the mentioned fluorescence parameter was more than 2-fold lower than observed under control conditions. It was also shown that *Synechococcus* sp. significantly affected the fluorescence parameter of the accompanying diatom species, particularly *N. perminuta* and *S. marinoi*, in which the value of the F_v/F_m was about 65%. In turn, the examined green algae *C. vulgaris*, *O. submarina*, and *S. bacillaris* showed moderate sensitivity to allelopathic compounds released by *Synechococcus* sp., and the inhibition of the F_v/F_m parameter was at least: 79%, 93% and 83%, respectively, relative to the control. In the obtained works, it was also documented that for the tested organisms, the decrease in the F_v/F_m parameter was usually recorded faster than the inhibition of growth in cultures. Analysis of fluorescence parameters using a PAM-Fluorometer showed that the addition of *Synechococcus* sp. filtrate reduces the F_v/F_m fluorescence parameter after 1 day of exposure, while inhibition of growth was noticed until after 3-7, and sometimes even 14 days of the experiment. Due to the sensitivity of this method, the measurement of PSII performance provided information when target organisms are most susceptible to picocyanobacterial allelopathic compounds. Since the fluorescence measurement is correlated with gross photosynthesis, we concluded that the reduction of photosynthetic activity by *Synechococcus* sp. allelochemicals affects the growth of tested photoautotrophs.

Inhibition of photosynthesis, the primary physiological process in competing primary producers, is a valid defense strategy in picocyanobacteria *Synechococcus* sp. (**publication 4.b I**, **VI** and **VII**). By using the Clark oxygen electrode, it was possible to demonstrate the allelopathic activity of *Synechococcus* sp. on the *P-E* curves and maximal photosynthesis (P_m) on tested microorganisms. Similarly, as in the case of the fluorescence parameter analysis, it was shown that the filtrate obtained from *Synechococcus* sp. strongly affected two diatoms *S. marinoi* and *N. perminuta*, for which the P_m parameter was more than 2-fold lower than the control treatments. On the basis of the obtained results, it was also shown that the filtrate obtained from the Baltic

picocyanobacterium *Synechococcus* sp. moderately inhibited photosynthesis of green algae *C. vulgaris* and *S. bacillaris*, which was 69% and 75%, respectively, compared to the control. The filtrate from *Synechococcus* sp. negatively affected the value of P_m parameter of red algae *P. purpureum*, which after a week's exposure was 67% in comparison to the control. There was also a slight decrease in the analyzed parameter of prymnesiophytes *P. parvum*, however, this effect was not statistically significant. Literature data indicate that the reduction of the rate of photosynthesis and the photosynthesis parameters is frequently recorded mode of action of cyanobacterial secondary metabolites (Ma et al., 2015). Studies have shown that many allelochemicals are generally soluble in organic solvents, insoluble in water and have low molecular weight. Such properties help them to penetrate the membrane of the thylakoids where photosynthesis occurs (Smith and Doan, 1999). On the basis of the results, it was demonstrated that the examined picocyanobacteria *Synechococcus* sp. inhibited photosynthesis in target organisms, which indicates their another mechanism of action.

On the basis of the works cited here, it can be concluded that the mode of action of allelopathic compounds of the picocyanobacteria *Synechococcus* sp. is highly diverse, and these organisms can affect the competing species of cyanobacteria and microalgae in many different ways. In the majority of cases, allelopathic compounds of the picocyanobacteria resulted in death of target organisms or reduction of their growth rate and total biomass. Allelopathic compounds secreted by picocyanobacteria can reduce the target organisms by inhibiting fluorescence and photosynthesis process. Moreover, allelopathic compounds of these organisms may also reduce pigment content, and negatively affect cell morphology. The ability of the picocyanobacteria *Synechococcus* sp. to produce and secrete compounds with such a wide range of activity, can give them an advantage over competing phytoplankton species and cause the dominance of these organisms in many aquatic ecosystems.

3. Environmental factors determining the allelopathic effect of picocyanobacteria on target organisms

Effective recognition of allelopathic activity of *Synechococcus* sp. on selected cyanobacteria and microalgae and determination of the modes of actions of their secondary metabolites, prompted me to carry out further work to examine the environmental factors regulating the effect of picocyanobacteria on target organisms. Allelopathic compounds produced by cyanobacteria and microalgae can affect the surrounding ecosystem and cause a variety of responses in target organisms, but the factors affecting allelopathy phenomenon are still not fully recognized.

The studies have shown that the light intensity is a factor that can significantly affect the allelopathic effects of picoplanktonic cyanobacteria (**publications 4.b I**, **V**). In **publication 4.b I** we noted that the highest decline in growth of diatom *N. perminuta* was observed after the addition of cell-free filtrate obtained from picocyanobacterium *Synechococcus* sp. grown at the highest light which was 190 μmol photons m^{-2} s^{-1}. In turn, the lowest allelopathic activity for *Synechococcus* sp. was shown in the light of 10 μmol photons m^{-2} s^{-1}. Also, in **publication 4.b V** we demonstrated light-dependent cytolysis in the allelopathic interaction between two co-occurring bloom-forming species of cyanobacteria: the picocyanobacterium *Synechococcus* sp. and the filamentous *N. spumigena*. These studies indicated that high light (190 μmol photons m^{-2} s^{-1}) affects picocyanobacterium *Synechococcus* sp. by increasing its allelopathic activity which coincided with the optimal growth conditions for the picocyanobacteria *Synechococcus* sp. Cyanobacteria have developed many adaptive mechanisms that allow them to expand under different light conditions (Whitton and Potts, 2012). Picocyanobacteria *Synechococcus* sp. have acclimatization capacity for various light intensities (Jodłowska i Śliwińska, 2014). The adaptive abilities of picocyanobacteria for various irradiance levels are of great importance for competitive relations among other organisms (Kohl and Nicklish, 1981). In addition, their documented allelopathic activity, depending on the light conditions, may give them an advantage over other photoautotrophs. The obtained results also indicated that the light environment influences the production of secondary metabolites and may be a crucial factor in assessing picocyanobacterial toxicity in aquatic environment.

Temperature is one of the most important factors affecting the vital functions of organisms however, relatively little is known about how temperature affects the allelopathic activity of cyanobacteria. Therefore, the main aim of the presented work was to determine whether the temperature determines allelopathic activity in *Synechococcus* sp. (**publication 4.b I**). On the basis of the obtained results, it was found that the addition of cell-free filtrate from *Synechococcus* sp. cultures grown in different temperatures (15, 20 and 25 °C) inhibits diatom *N. perminuta* growth. In this paper we noted that high temperature affects tested cyanobacteria by increasing its allelopathic activity and the highest decrease of analyzed diatom growth was observed after the addition of cell-free filtrate obtained from *Synechococcus* sp. grown at 25 °C. The study noted that the highest analyzed temperature of 25 °C was also optimal for the growth of the studied picocyanobacteria. Studies have shown that in water at a temperature higher than 20 °C, cyanobacteria are the dominant group of phytoplankton organisms, and they reach the highest growth rate at temperatures above 25 °C (Whitton and Potts, 2012; Paerl, 2018). The increase in temperature causes the acceleration of cell processes. This indicates that the optimal temperature stimulates the production of allelopathic compounds, which explains the highest allelopathic activity of the studied

picocyanobacteria at the highest temperature. Therefore, it is believed that the predicted increase in temperature caused by global changes may favor the formation of massive picocyanobacterial blooms by increasing the production of harmful secondary metabolites (O'Neil et al., 2012).

In another work we indicated that the production of allelochemicals by *Synechococcus* sp. is dependent on salinity (**publication 4.b I**). Salinity is an important factor that explains the distribution of phytoplankton species in some coastal and shallow reservoirs, including the Baltic Sea. Thus, in the present work, we investigated the allelopathic activity of *Synechococcus* sp. on the Baltic diatom *N. perminuta* by the addition of cell-free filtrate obtained from picocyanobacterium cultures grown under different salinity conditions (8, 16 and 32 psu). The highest decline in diatom growth was observed after the addition of the filtrate obtained from *Synechococcus* sp. grown at optimum salinity which was 8 psu. Similar observations have also been made for the Baltic filamentous cyanobacteria *Dolichospermum* sp., in which the highest allelopathic activity and the concentration of intracellular toxins were recorded at low salinity, not exceeding 6 psu (Brutemark et al., 2015). To the best of author's knowledge, only these two works indicated that salinity is a factor affecting the cyanobacterial allelopathy in the Baltic Sea. Based on the obtained results, it can be concluded that salinity plays a significant role in Baltic cyanobacteria growth and allelopathic properties. These results demonstrated that variation in salinity should be considered when estimating the potential effects of picocyanobacterial allelopathy in aquatic environments.

The availability of nutrients is another factor affecting the allelopathic activity of picocyanobacteria *Synechococcus* sp. in aquatic environment (**publication 4.b VII**). The increase in the availability of nutrient, mainly nitrogen (N) and phosphorus (P) in aquatic ecosystems, as a consequence of eutrophication, is a global phenomenon (Thornton et al., 2013). The most obvious effect of eutrophication is the change in species composition, increased cyanobacterial biomass and the formation of harmful blooms of these organisms (Heisler, 2008). However, this phenomenon cannot be explained only by abiotic factors, hence allelopathic interactions between cyanobacteria and other phytoplankton organisms should be considered and examined in details (Lucas, 1947). Therefore, the conducted research (**publication 4.b VII**) allowed to determine the allelopathic activity of picocyanobacteria *Synechococcus* sp. on selected target organisms under the influence of different availability of nutrients. We demonstrated that the strongest allelopathic activity on tested green algae (*C. vulgaris* and *O. submarina*) and diatoms (*S. marinoi* and *B. paxillifer*) were recorded after the addition of a filtrate obtained from *Synechococcus* sp. grown at nitrogen-sufficient medium. These results suggest that the availability of nutrients is an essential factor in the regulation of allelopathic compounds production by picocyanobacteria. The unbalanced availability of nutrient in the Baltic Sea, as a result of eutrophication, is a problem especially in the coastal

regions of this basin (Granéli et al., 2008). As a consequence, it can be assumed that the enrichment with nutrients of water reservoirs may be one of the main factors causing the formation of harmful picocyanobacterial blooms through the intensification of allelopathic interactions between organisms.

In the natural environment, many factors can simultaneously change the production and secretion of allelochemicals. It is believed that abiotic factors may affect the production of allelopathic compounds. The same factors may also affect the sensitivity of the target organism (Granéli and Hansen, 2006). Therefore, the obtained works indicated that factors that increase the allelopathic activity of *Synechococcus* sp., i.e. high light intensity, high temperature, low salinity and unlimited availability of nutrients, may also change the proportions between organisms that occur in the same aquatic ecosystem.

4. Acclimatization properties of different strains of the picocyanobacterium *Synechococcus* sp. in aquatic ecosystem

Because the works cited above clearly confirmed that *Synechococcus* sp. has a varied allelopathic effect depending on the light intensity, temperature, salinity and availability of nutrients, therefore the last study focused on determining the acclimatization capacity of picocyanobacteria under various environmental conditions. Based on the factorial experiments published recently (**publication 4.b VIII**), three different Baltic strains of picocyanobacteria from the genus *Synechococcus* (red strain – BA-120, green strain – BA-124 and brown strain – BA-132), which characteristics are presented in **publication 4.b IV**, showed good acclimation to high intensity of PAR radiation, high temperature values and low salinity. This study described number of cells, pigmentation, Chl *a* fluorescence parameters, and photosynthesis performance of picocyanobacteria cells grown in different environmental conditions. These conditions were as follows: temperature from 10 by 5 to 25 °C, salinity from 3 by 5 to 18 psu, and photosynthetically active radiation (PAR) from 10 by 90 to 280 μmol photons m^{-2} s^{-1}, which gave 64 combinations of environmental scenarios. It is worth mentioning here that the red and brown strains of Baltic *Synechococcus* sp. are rich in phycoerythrin (PE), while the green strain is rich in phycocyanin (PC). The difference between the red and brown strain is the proportion of two different bilin pigments known as phycoerythrobilin (PEB) and phycourobilin (PUB), which bind to PE apoprotein. In addition, these strains are characterized by different cell sizes (**publication 4.b IV**). Thanks to these properties and developed cytometric technique, it became possible to distinguish three Baltic strains of picoplanktonic *Synechococcus* sp. in the environment, which was not feasible using classical

methods using the light microscopy (**publication 4.b IV**). The legitimacy of conducting experiments on these three strains of *Synechococcus* sp. was dictated by the fact that they showed the strongest allelopathic activity on the target organisms tested (Śliwińska-Wilczewska et al., unpublished results).

Based on the conducted factor experiments (**publication 4.b VIII**), it was found that the tested picocyanobacterial strains showed acclimation to high light intensities and high temperature values. The optimal light conditions for the growth of green and brown strains are in the range of 190 – 280 μmol photons m^{-2} s^{-1}, while for the red strain this range is 100 – 190 μmol photons m^{-2} s^{-1}. The most favorable conditions for the growth of the three picocyanobacterial strains are in the range of 20 – 25 °C and depend on the light intensity. It was also found that salinity is a factor significantly affecting the number of cells of picocyanobacteria of the genus *Synechococcus*. The studied strains of picocyanobacteria showed an euryhaline character, as their active growth was noted throughout the entire range of tested salinity. At the same time, salinity close to 3 and 8 psu was optimal for these picocyanobacteria and under these conditions the highest concentration of cells in cultures was recorded. In addition, tested strains of *Synechococcus* sp. showed a different growth rate and doubling time of cells. The highest growth rate was noted for the green strain – BA-124. Its average abundance under optimal conditions of the tested factors was over $25 \cdot 10^6$ cells mL^{-1}. On the other hand, the lowest growth rate was observed for the red strain – BA-120. The average number of cells in the conditions optimal for their growth was about $8 \cdot 10^6$ cells mL^{-1}.

In this study, it was shown that the studied picocyanobacterial strains showed changes in the pigments content in cells under the influence of various light intensity, temperature and salinity conditions. The negative effect of increasing irradiance on chlorophyll *a* and carotenoid pigments in cells for the three picocyanobacterial strains was found, obtaining the highest pigments content for the lowest range of light intensity from 10 to 100 μmol photons m^{-2} s^{-1}, and the lowest pigments content for the range of irradiance from 190 to 280 μmol photons m^{-2} s^{-1}. In turn, the conducted experiments did not show the influence of temperature and salinity on the chlorophyll *a* and carotenoid pigments content in cells for the tested picocyanobacteria strains.

The acclimatization of the tested picocyanobacterial strains were also analyzed on the level of chlorophyll fluorescence changes. The maximum photochemical efficiency of photosystem II (PSII) at the dark-adapted state (F_v/F_m) and the photochemical efficiency of PSII under actinic light intensity (ΦPSII) were estimated. Based on the conducted experiments, the increasing irradiance on the values of chlorophyll fluorescence parameters - F_v/F_m and ΦPSII was found. The highest values for the three studied picocyanobacterial strains were obtained for the light intensity range of 10 – 100 μmol photons m^{-2} s^{-1}, and the lowest for the range of 190 – 280 μmol photons m^{-2} s^{-1}. The

conducted research also showed a significant influence of temperature on the values of the analyzed parameters for the mentioned picocyanobacterial strains. It was shown that for the red and brown strain the highest values occurred at low temperature (10 – 15 °C), while for the green strain the maximum was noted at high temperature of 25 °C. In turn, the conducted experiments did not show the effect of salinity on the values of the fluorescence parameters for the studied picocyanobacterial strains.

Acclimatization capacities for the three studied picocyanobacterial strains were also analyzed at the level of changes in the photosynthesis–irradiance response (*P-E*) curves and photosynthetic parameters, i.e., the photosynthetic capacity (P_m) and the initial slope of *P-E* curve (α). The obtained results for the tested picocyanobacteria strains suggest the existence of two photoacclimation mechanisms related to the photosynthesis process carried out by these organisms. The results of the present study indicated changes in photosynthetic unit (PSU) sizes, and changes in PSU numbers as the photoacclimation mechanisms.

In this study, a close relationship was found between the growth of the Baltic strains from the genus *Synechococcus* and the proportion of their photosynthetic pigments, chlorophyll fluorescence and the photosynthesis performance. Picocyanobacteria *Synechococcus* sp. require less light intensity to achieve the maximum rate of photosynthesis than larger algae. This is due to the better ability of these cells to absorb available light and to better use photons in photosynthesis. In contrast, in high light intensity studied strains of picocyanobacteria have easier access to light quanta, therefore, they can effectively use solar energy even with low concentration of photosynthetic pigments in cells, which allows to maintain the photosynthesis at a high level. The preference for both low and high values of light, as well as wide range of temperature and salinity by these picocyanobacteria enables these organisms to existence under varying environmental conditions, which strongly confirms their importance in aquatic ecosystems.

Summary

Picoplanktonic cyanobacteria, despite their widespread presence in the aquatic environment, still remain a group of poorly understood organisms. However, the development of analytical methods caused that the chances of expanding knowledge about the physiology of picocyanobacteria are still increasing. Picoplanktonic cyanobacteria appear in all types of water bodies, posing a potential threat to other organisms and people using natural water reservoirs. Understanding this group of organisms is extremely important, especially since they are capable of producing harmful secondary metabolites and sometimes creating massive blooms. They are also

responsible for a significant part of the production of biomass and oxygen and are an important element of the trophic network in freshwater, brackish and marine environments. Therefore, it is necessary to carefully examine the role of these small organisms in aquatic ecosystems. Works published here indicated both their acclimatization properties and allelopathic activity. In these works we demonstrated for the first time the information about the range of allelopathic interactions of picocyanobacteria *Synechococcus* sp. both on the cyanobacteria and microalgae cultures as well as on natural phytoplankton communities in the Baltic Sea. We also examined the mechanisms of action of allelopathic compounds produced and secreted by *Synechococcus* sp. under the influence of various environmental factors. The information on the allelopathic activity and autecology of picocyanobacteria *Synechococcus* sp. may therefore be of great importance in better understanding the reasons for the dominance of these organisms in many aquatic ecosystems, as well as explain their occurrence of seasonal changes in the phytoplankton composition in the Baltic Sea.

References

Bláha, L., Maršálek, B., 1999. Microcystin production and toxicity of picocyanobacteria as a risk factor for drinking water treatment plants. Algological Studies/Archiv für Hydrobiologie 92, 95–108.

Brutemark, A., Vandelannoote, A., Engström-Öst, J., Suikkanen, S., 2015. A less saline Baltic Sea promotes cyanobacterial growth, hampers intracellular microcystin production, and leads to strain-specific differences in allelopathy. PloS One 10, e0128904.

Costa, M.S., Costa, M., Ramos, V., Leão, P.N., Barreiro, A., Vasconcelos, V., Martins, R., 2015. Picocyanobacteria from a clade of marine *Cyanobium* revealed bioactive potential against microalgae, bacteria, and marine invertebrates. Journal of Toxicology and Environmental Health, Part A 78, 432–442.

Cox, P.A., Banack, S.A., Murch, S.J., 2003. Biomagnification of cyanobacterial neurotoxins and neurodegenerative disease among the Chamorro people of Guam. Proceedings of the National Academy of Sciences 100, 13380–13383.

Figueredo C.C., Giani A., Bird D.F. 2007. Does allelopathy contribute to *Cylindrospermopsis raciborskii* (cyanobacteria) bloom occurrence and geographic expansion? Journal of Phycology 43, 256–265.

Fistarol G.O., Legrand C., Granéli E. 2003. Allelopathic effect of *Prymnesium parvum* on a natural plankton community. Marine Ecology Progress Series 255, 115–125.

Granéli E., Hansen P.J. 2006. Allelopathy in Harmful Algae: a mechanism to compete for resources? In: Granéli E., Turner J. (eds.). Ecology of Harmful Algae, Series: Ecological Studies 189, 189–201.

Granéli E., Weberg M, Salomon P.S. 2008. Harmful algal blooms of allelopathic microalgal species: The role of eutrophication. Harmful Algae 8, 94–102.

Hamilton, T.J., Paz-Yepes, J., Morrison, R.A., Palenik, B., Tresguerres, M., 2014. Exposure to bloom-like concentrations of two marine *Synechococcus* cyanobacteria (strains CC9311 and CC9902) differentially alters fish behaviour. Conservation Physiology 2 (1).

Heisler, J., Glibert, P. M., Burkholder, J. M., Anderson, D. M., Cochlan, W., Dennison, W. C., Lewitus, A. 2008. Eutrophication and harmful algal blooms: a scientific consensus. Harmful Algae, 8, 3–13.

Jakubowska, N., Szeląg-Wasielewska, E., 2015. Toxic picoplanktonic cyanobacteria. Marine Drugs 13, 1497–1518.

Jasser, I., Callieri, C., 2017. Picocyanobacteria: the smallest cell-size cyanobacteria. In: J., Meriluoto, L., Spoof, G. A., Codd, (eds), Handbook on Cyanobacterial Monitoring and Cyanotoxin Analysis. John Wiley & Sons, Ltd., pp. 19–27.

Jochem, F., 1988. On the distribution and importance of picocyanobacteria in a boreal inshore area (Kiel Bight, Western Baltic). Journal of Plankton Research 10, 1009–1022.

Jodłowska, S., Śliwińska, S. 2014. Effects of light intensity and temperature on the photosynthetic irradiance response curves and chlorophyll fluorescence in three picocyanobacterial strains of *Synechococcus*. Photosynthetica 52, 223–232.

Kohl J.G., Nicklish A. 1981. Chromatic adaptation of the planktonic blue-green alga *Oscillatoria redekei* van Goor and its ecological significance. Internationale Revue der gesamten Hydrobiologie und Hydrographie 66, 83–94.

Kolber Z.S, Zehr J., Falkowski P.G. 1988. Effects of growth irradiance and nitrogen limitation on photosynthetic energy conversion in Photosystem II. Plant Physiology 88, 72–79.

Lucas C.E. 1947. The ecological effects of external metabolites. Biological Reviews 22, 270–295.

Lyczkowski E.R., Karp-Boss L. 2014. Allelopathic effects of *Alexandrium fundyense* (Dinophyceae) on *Thalassiosira* cf. *gravida* (Bacillariophyceae): a matter of size. Journal of Phycology 50, 376–387.

Ma, Z.L., Fang, T.X., Thring, R.W., Li, Y.B., Yu, H.G., Zhou, Q., Zhao, M., 2015. Toxic and non-toxic strains of *Microcystis aeruginosa* induce temperature dependent allelopathy toward growth and photosynthesis of *Chlorella vulgaris*. Harmful Algae 48, 21–29.

Mazur-Marzec, H., 2006. Characterization of phycotoxins produced by cyanobacteria. Oceanological and Hydrobiological Studies 35, 85–109.

Mazur-Marzec, H., Sutryk, K., Kobos, J., Hebel, A., Hohlfeld, N., Błaszczyk, A., Toruńska, A., Kaczkowska, M.J., Łysiak-Pastuszak, E., Krasniewski, W., Jasser, I., 2013. Occurrence of cyanobacteria and cyanotoxin in the Southern Baltic Proper. Filamentous cyanobacteria versus single-celled picocyanobacteria. Hydrobiologia 701, 235–252.

O'Neil, J.M., Davis, T.W., 2012. Burford, M.A.; Gobler, C.J. The rise of harmful cyanobacteria blooms: the potential roles of eutrophication and climate change. Harmful Algae 14, 313–334.

Paerl, H. 2018. Mitigating toxic planktonic cyanobacterial blooms in aquatic ecosystems facing increasing anthropogenic and climatic pressures. Toxins 10, 76.

Parvathi, A., Zhong, X., Ram, A.P., Jacquet, S., 2014. Dynamics of auto-and heterotrophic picoplankton and associated viruses in Lake Geneva. Hydrology and Earth System Sciences 18, 1073–1087.

Pflugmacher S., Steinberg C. 1997. Activity of phase I and phase II detoxication enzymes in aquatic macrophytes. Journal of Applied Botany and Food Quality 71, 144–146.

Ribalet F., Berges J.A., Ianora A., Casotti R. 2007. Growth inhibition of culture marine phytoplankton by toxic algal derived polyunsaturated aldehydes. Aquatic Toxicology 85, 219–27.

Scanlan, D.J., 2012. Marine picocyanobacteria. In: Ecology of Cyanobacteria II (pp. 503–533). Springer, Dordrecht.

Sieburth, J.M., Smetacek, V., Lenz, J., 1978. Pelagic ecosystem structure: Heterotrophic compartments of the plankton and their relationship to plankton size fractions. Limnology and Oceanography 23, 1256–1263.

Smith G.D, Doan D.T. 1999. Cyanobacterial metabolites with bioactivity against photosynthesis in cyanobacteria, algae and higher plants. Journal of Applied Phycology 11, 337–344.

Sorokin, P.Y., Sorokin, Y.I., Boscolo, R., Giovanardi, O., 2004. Bloom of picocyanobacteria in the Venice lagoon during summer–autumn 2001: ecological sequences. Hydrobiologia 523, 71–85.

Sorokin, Y.I., Dallocchio, F., 2008. Dynamics of phosphorus in the Venice lagoon during a picocyanobacteria bloom. Journal of Plankton Research 30, 1019–1026.

Sorokin, Y.I., Zakuskina, O.Y., 2010. Features of the Comacchio ecosystem transformed during persistent bloom of picocyanobacteria. Journal of Oceanography 66, 373–387.

Stahl, W., Sies, H., 2003. Antioxidant activity of carotenoids. Molecular Aspects of Medicine 246, 345–351.

Stal, L.J., Albertano, P., Bergman, B., von Bröckel, K., Gallon, J.R., Hayes, P.K., Sivonen, K., Walsby, A.E., 2003. BASIC: Baltic Sea cyanobacteria. An investigation of the structure and dynamics of water blooms of cyanobacteria in the Baltic Sea-responses to a changing environment. Continental Shelf Research 23, 1695–1714.

Stal, L.J., Walsby, A.E., 2000. Photosynthesis and nitrogen fixation in a cyanobacterial bloom in the Baltic Sea. European Journal of Phycology 35, 97–108.

Stebbing, A.R.D., 1982. Hormesis-the stimulation of growth by low levels of inhibitors. Science of the Total Environment 22, 213–234.

Stockner, J.G., 1988. Phototrophic picoplankton: an overview from marine and freshwater ecosystems. Limnology and Oceanography 33, 765–775.

Suikkanen, S., Engström-Öst, J., Jokela, J., Sivonen, K., Viitasalo, M., 2006. Allelopathy of Baltic Sea cyanobacteria: no evidence for the role of nodularin. Journal of Plankton Research 28, 543–550.

Suikkanen, S., Fistarol, G.O., Granéli, E., 2004. Allelopathic effects of the Baltic Cyanobacteria *Nodularia spumigena*, *Aphanizomenon flos-aquae* and *Anabaena lemmermannii* on algal monocultures. Journal of Experimental Marine Biology and Ecology 308, 85–101.

Thornton, J.A., Harding, W.R., Dent, M., Hart, R.C., Lin, H., Rast, C.L., Sven-Olof, R., Slawski, T.M., 2013. Eutrophication as a 'wicked' problem. Lakes & Reservoirs Research & Management 18, 298–316.

Whitton, B.A., Potts, M., 2012. Introduction to the cyanobacteria. In Ecology of Cyanobacteria II (pp. 1-13). Springer, Dordrecht.

Worden, A.Z., Wilken, S., 2016. A plankton bloom shifts as the ocean warms. Science 354, 287–288.

5. Overview of other academic and scientific achievements.

Scientific achievements

From the beginning of my scientific activity at the Faculty of Oceanography and Geography, University of Gdansk, I have associated research with ecophysiology and the mass occurrence of cyanobacteria in the aquatic environment. During the work on master's thesis, the title of which was: "*The influence of selected environmental factors on growth, photosynthetic pigments, chlorophyll fluorescence and the photosynthesis performance in Baltic picocyanobacteria from the genus Synechococcus"*, that I defended in 2009 at the Faculty of Oceanography and Geography, at the University of Gdansk, I gained knowledge about autecology of picocyanobacteria. In this work I used a number of ecophysiological methods that gave me the basis for further scientific work. In 2009 – 2010, still as a student, I participated in the BW grant, where I was the **Co-Principal Investigator**. The research results collected during the project were published in two articles, and were presented at several scientific conferences as an oral presentations and posters:

	RESEARCH PROJECTS
1.	2009-2010 - Project ID: BW/G245-5-0502-0. Sources of funding: University of Gdańsk. Project title: Photosynthetic activity and composition of photosynthetic pigments of Baltic picocyanobacterium of the genus *Synechococcus*. Principal Investigator: Jodłowska S. Co-Principal Investigator: **Śliwińska S.**
	PUBLICATIONS
1.	Jodłowska S., **Śliwińska S.** 2014. Effects of light intensity and temperature on the photosynthesis irradiance response curves and chlorophyll fluorescence of three picocyanobacterial strains of *Synechococcus* (Cyanobacteria, Synechococcales). Photosynthetica 52, 223-232, DOI: 10.1007/s11099-014-0024-y, ISSN: 0300-3604, IF=1.409.
2.	Jodłowska S., **Śliwińska S.**, Latała A. 2010. The influence of irradiance on the growth and photosynthetic pigments of three Baltic picocyanobacterial strains of *Synechococcus*. In: K. Olańczuk-Neyman, H. Mazur-Marzec (eds.). Microorganisms in the environment and environmental engineering from ecology to technology, Printing House Perfecta, Lublin, 85-92, ISBN 978-83-89293-88-6.
	PRESENTATIONS AT SCIENTIFIC CONFERENCES
1.	**Śliwińska S.**, Jodłowska S., Latała A. 2009. The influence of selected environmental factors on growth, pigments, chlorophyll *a* fluorescence and photosynthesis performance in three Baltic strains of *Synechococcus* sp. [in Polish]. VIII Symposium of the Young Oceanographers, 27.11.09, Gdynia, Poland. *(oral presentation)*
2.	Jodłowska S., **Śliwińska S.** 2010. Photosynthetic activity and pigment content of three Baltic picocyanobacterial strains of *Synechococcus* by factorial experiments approach. XXIX International Conference of the Polish Phycological Society, 19-23.5.10, Kraków-Niedzica, Poland, p. 45-46, ISBN 978-83-89648-83-9. *(oral presentation)*
3.	Jodłowska S., **Śliwińska S.**, Latała A. 2010. Effect of irradiance, temperature, salinity and nutrient concentration on the growth of Baltic cyanobacterial strains of *Synechococcus* sp. and *Nodularia spumigena*. XXIX International Conference of the Polish Phycological Society, 19-23.5.10, Kraków-Niedzica, Poland, p. 102-103, ISBN 978-83-89648-83-9. *(poster)*
4.	**Śliwińska S.**, Jodłowska S., Latała A. 2010. The growth and photosynthetic pigments of three Baltic picocyanobacterial strains of *Synechococcus* under the influence of irradiance. VI Hydromicrobiological Conference "Microorganisms from ecology to technology", 06-10.06.10, Gdańsk-Gdynia, Poland, p. 29-30, ISBN 978-83-60956-21-2. *(poster)*
5.	Jodłowska S., **Śliwińska S.** 2011. Photosynthesis irradiance curves and chlorophyll fluorescence of three Baltic picocyanobacterial strains of *Synechococcus*. XXX International Conference of the Polish Phycological Society, 19-21.05.11, Wrocław, Poland, p. 134-135, ISBN 978-83-7717-045-8. *(poster)*

After completing my master's studies, in 2009 I started doctoral studies as part of the **Doctoral Studies at the Faculty of Oceanography and Geography at the University of Gdansk**, under the supervision of dr Sabina Jodłowska and prof. dr hab. Adam Latała. The main goal of my doctoral thesis was to determine the extent of the occurrence of allelopathy phenomenon and characterize the effect of allelopathic compounds produced by Baltic cyanobacteria: bloom-forming *Nodularia spumigena* and an important component of the aquatic environment, picoplanktonic *Synechococcus* sp. on selected species of microalgae and cyanobacteria. An important task was also to examine whether and to what extent the allelopathic effects are affected by selected environmental factors. The legitimacy of this kind of research was dictated by very few papers dealing with the impact of *N. spumigena* allelopathy in the Baltic Sea, and picoplanktonic *Synechococcus* sp., in which allelopathic effects on phytoplankton species have not been demonstrated at all. In this study, the allelopathic effects occurring in *Synechococcus* sp. were documented for the first time, and the occurrence of allelopathy in the larger, filamentous cyanobacteria *N. spumigena* was confirmed. The studies also documented the modes of action of allelopathic compounds produced by Baltic cyanobacteria on target organisms under the influence of various biotic and abiotic factors. Providing new information on the manner and extent of allelopathic cyanobacteria on microalgae has contributed to a more comprehensive understanding of the emergence of massive cyanobacterial blooms in many aquatic ecosystems, including the Baltic Sea.

During the PhD studies I received several awards, including the **Minister of Science and Higher Education Scholarship** in 2013 for outstanding scientific achievements, and Scholarship project "Development of the University of Gdansk in the areas of Europe 2020 (UG 2020)", task no. 4 "Scholarship support for Ph.D students and young doctors of the University of Gdansk". In addition, in the period 2010 – 2015, I received a scholarship on the third, fourth, fifth and sixth year of doctoral studies.

For research related to the implementation of the doctoral dissertation, I have obtained a total of **6 scientific grants**, including the **Ministry of Science and Higher Education (MNiSW)** and the **National Science Center (NCN, PRELUDIUM)**, where I was the **Principal Investigator**. The results of my research have been published in 15 publications and presented at many scientific conferences (18 oral presentations and 20 posters):

RESEARCH PROJECTS	
1.	2010-2013 - Project ID: 2952/B/P01/2011/40. Sources of funding: Ministry of Science and Higher Education (MNiSW). Project title: Influence of selected environmental factors on the allelopathic activity of Baltic cyanobacteria and microalgae. Principal Investigator: **Śliwińska S.** Co-Principal Investigator: Latała A.
2.	2012-2013 - Project ID: BMN 538-G245-1197-12. Sources of funding: University of Gdańsk. Project title: The

influence of light intensity on the allelopathic interaction of some Baltic cyanobacteria. Principal Investigator: **Śliwińska S.**

3. 2013-2014 - Project ID: BMN 538-G245-B279-13. Sources of funding: University of Gdańsk. Project title: Allelopathic interaction of picocyanobacteria *Synechococcus* sp. on *Navicula perminuta* under different light, temperature and salinity condition. Principal Investigator: **Śliwińska S.**
4. 2013-2015 - Project ID: 2013/09/N/ST10/01929. Sources of funding: National Science Centre (NCN), PRELUDIUM 5. Project title: The importance of allelopathic interactions in the formation of massive cyanobacteria blooms. Principal Investigator: **Śliwińska S.** Co-Principal Investigator: Latała A.
5. 2014-2015 - Project ID: BMN 538-G245-B562-14. Sources of funding: University of Gdańsk. Project title: The influence of availability of nutrients on allelopathic interactions between *Synechococcus* sp. and *Nodularia spumigena*. Principal Investigator: **Śliwińska S.**
6. 2015-2016 - Project ID: BMN 538-G245-B890-15. Sources of funding: University of Gdańsk. Project title: Allelopathic interaction of *Synechococcus* sp. on selected Baltic cyanobacteria. Principal Investigator: **Śliwińska S.**

PUBLICATIONS

1. **Śliwińska S.**, Jodłowska S., Latała A. 2011. Ecophysiological and allelopathic properties of picocyanobacteria *Synechococcus* sp. [in Pilosh]. Acta Geographica Silesiana 1, 63-66, ISSN 1897-5100.
2. **Śliwińska S.**, Latała A. 2012. Allelopathic effects of cyanobacterial filtrates on Baltic diatoms. Contemporary Trends in Geoscience 1, 103-107, ISSN 2084-5707, DOI: 10.2478/ctg-2012-0016.
3. **Śliwińska S.**, Latała A. 2012. To present the research on the phenomenon of cyanobacteria and microalgae allelopathy [in Polish]. In: Kuczera M. (Ed.). New trends in natural sciences 2, Creativetime, Creative Science, Cracow, 146-153, ISBN 978-83-63058-17-3.
4. **Śliwińska S.**, Latała A. 2012. The phenomenon of the influence of allelopathic cyanobacteria and microalgae in the aquatic environment [in Polish]. In: Kuczera M. (Ed.). Young scientists for Polish science, Creativetime, Cracow, 152-160, ISBN 978-83-63058-14-2.
5. Dopierała Ł., **Śliwińska S.**, Latała A. 2012. The effect of algae mass blooms on tourist traffic in the eastern part of the Polish Baltic coast [in Polish]. In: Grochowicz J. (Ed.). Opportunities and barriers to the development of domestic and foreign tourism, Scientific Papers of the European University of Sopot, 277-291, ISBN 97883925512-4-9.
6. **Śliwińska S.**, Parusel T., Latała A. 2013. Human impact on the allelopathic effects of cyanobacteria and microalgae in the Baltic Sea - a review. Acta Geographica Silesiana 13, 87-92, ISSN 1897-5100.
7. Dopierała Ł., **Śliwińska S.**, Latała A. 2013. The effects of Harmful Algal Blooms (HABs) on tourism and recreation in the east part of the Polish Baltic Sea coast. In: Meyer B. (Ed.). Economic Tourism Problems, Scientific Papers of the University of Szczecin no 782, 53-63, ISSN 1640-6818.
8. **Śliwińska S.**, Mazurkiewicz M., Dopierała Ł., Kacprzak P., Korneluk M., Wawrzynek J., Rzemykowska H., Latała A. 2013. The influence of allelopathic effects of Baltic cyanobacteria on the survival of *Neomysis integer* [in Polish]. In: Pilarski M., Wiskulski T. (Eds.). Contemporary issues, problems and challenges in the research of geographical space, University of Gdansk Publishing House, 17-26, ISBN 978-83-7865-071-3.
9. **Śliwińska S.**, Latała A. 2014. Effect of light intensity on the allelopathic interaction of selected species of Baltic cyanobacteria [in Polish]. In: Górska A., Ślachciak D., Szałajda T. (Eds.). Scientific monograph "Science has many names", Volume I, University Publications of the University of Technology and Life Sciences in Bydgoszcz, 145-156, ISBN 978-83-64235-22-1.
10. **Śliwińska S.**, Latała A. 2014. The effect of selected environmental factors on the allelopathic activity of cyanobacteria *Synechococcus* sp. [in Polish]. In: Kuczera M., Piech K. (Eds.). Achievements of Young Scientists, Creativetime 5: 222-227, ISSN 2300-4436.
11. **Śliwińska S.**, Gergella K., Jasińska A., Bolałek J., Latała A. 2014. Allelopathic effects of the picocyanobacteria *Synechococcus* sp. on the diatom *Skeletonema marinoi*. In: Kuczera M., Piech K. (Eds.). Achievements of Young Scientists, Creativetime 5: 228-233, ISSN 2300-4436.
12. **Śliwińska S.**, Skauradszun M., Niemirycz E., Latała A. 2014. The production and release of allelopathic compounds by Baltic cyanobacteria. Ecology and Safety 8: 583-589, ISSN 1314-7234.
13. **Śliwińska S.**, Latała A. 2015. The effect of the availability of nutrients on allelopathic effects of Baltic cyanobacteria [in Polish]. In: Woźniak M., Pilarz Ł.B., Drewniak M. (Eds.). Polish doctors and PhD students in the development of world scientific thought - Innovation and interdisciplinarity in natural sciences, NETWORK SOLUTION, Słupsk, 220-230, ISBN: 978-83-63216-02-3.
14. **Śliwińska S.**, Latała A. 2015. The influence of biotic factors on the allelopathic effect of cyanobacteria and microalgae in aquatic ecosystems [in Polish]. In: Kuczera M., Piech K. (Eds.). Issues currently being addressed by young scientists, Creativetime, 80-85, ISBN: 978-83-63058-50-0.
15. **Śliwińska S.**, Latała A. 2015. The influence of nutrients on the allelopathic effect of the Baltic cyanobacteria *Nodularia spumigena* [in Polish]. In: Kuczera M., Piech K. (Eds.). Issues currently being addressed by young scientists, Creativetime, 86-91, ISBN: 978-83-63058-50-0.

PRESENTATIONS AT SCIENTIFIC CONFERENCES

1. **Śliwińska S.**, Latała A. 2010. The influence of light intensity on the allelopathy phenomenon in selected Baltic cyanobacteria and microalgae [in Polish]. IX Symposium of the Young Oceanographers, 26.11.10, Gdynia, Poland. *(oral presentation)*

2. **Śliwińska S.**, Latała A. 2011. The allelopathy phenomenon in cyanobacteria and microalgae - a better understanding of the causes of massive cyanobacterial blooms in the Baltic Sea [in Polish]. IV Symposium of Young Scientists, 19-21.10.11, Cieszyn, Poland, p. 85, ISBN 978-83-61644-23-1. *(oral presentation)*
3. **Śliwińska S.**, Latała A. 2011. Effect of light intensity on allelopathic activity of *Synechococcus* sp. and *Nodularia spumigena* [in Polish]. X Symposium of the Young Oceanographers, 25.11.11, Gdynia, Poland. *(oral presentation)*
4. **Śliwińska S.**, Lemke P., Latała A. 2012. Allelopathic effects of cyanobacteria on diatom monocultures under different environmental conditions. International Algal Summit, 21-22.02.12, New Delhi, India, p. 17. *(oral presentation)*
5. Lemke P., Jodłowska S., Pniewski F., **Śliwińska S.**, Latała A. 2012. Application of microalgae from the Culture Collection of Baltic Algae (CCBA) in science, biotechnology, industry and education. International Algal Summit, 21-22.02.12, New Delhi, India, p. 23. *(oral presentation)*
6. **Śliwińska S.**, Latała A. 2012. Causes and consequences of the influence of allelopathic cyanobacteria in the Baltic Sea [in Polish]. I Geographical Symposium „Contemporary issues, problems and challenges in the study of geographical space", 23-24.03.12, Gdańsk, Poland. *(oral presentation)*
7. **Śliwińska S.**, Latała A. 2012. The allelopathic effect on the growth and ecophysiology of Baltic microalgae and cyanobacteria [in Polish]. Science Conference „Impact of Young Scientists on the Polish Science Achievement - new trends in life sciences", 20-22.04.12, Gdańsk, Poland. *(oral presentation)*
8. **Śliwińska S.**, Latała A. 2012. The role of allelopathic cyanobacteria in the Baltic Sea [in Polish]. V Geosymposium of Young Researchers Silesia 2012, 26-28.09.12, Zawiercie, Poland. *(oral presentation)*
9. **Śliwińska S.**, Dopierała Ł., Latała A. 2012. The effect of cyanobacterial blooms on tourism in the Baltic Sea [in Polish]. IV International Scientific Conference „Opportunities and barriers to the development of national and international tourism", 25-26.10.12, Sopot, Poland. *(oral presentation)*
10. **Śliwińska S.**, Latała A. 2012. The influence of allelopathic cyanobacteria on the aquatic ecosystem [in Polish]. International Conference of PhD Students at the University of Szczecin „Modern aspects of the study of geographical space", 26-27.10.12, Szczecin, Poland. *(oral presentation)*
11. **Śliwińska S.**, Latała A. 2013. Effect of light intensity on allelopathic interactions of Baltic cyanobacteria *Synechococcus* sp. and *Nodularia spumigena* [in Polish]. V Sopot Youth Conference, 18.05.13, Sopot, Poland. *(oral presentation)*
12. **Śliwińska S.**, Latała A. 2013. The influence of light, temperature and salinity on allelopathic activity of picocyanobacteria *Synechococcus* sp. [in Polish]. I Interdisciplinary Symposium of PhD Students from Kujawsko-Pomorskie „Science has many names…", 01.06.13, Bydgoszcz, Poland, p. 60. *(oral presentation)*
13. **Śliwińska S.**, Latała A. 2014. Influence of light, temperature and the availability of nutrients on the allelopathic effects of picocyanobacteria *Synechococcus* sp. [in Polish]. Science Conference „Impact of Young Scientists on the Polish Science Achievement - new trends in life sciences", 25-27.04.14, Gdańsk, Poland, p. 139, ISBN 978-83-63058-39-5. *(oral presentation)*
14. **Śliwińska S.**, Latała A. 2015. Allelopathic effects of Baltic cyanobacteria under different environmental factors. IV Young Scientists Conference, World Water Day, 12-13.05.15, Poznań, Poland, p. 56. *(oral presentation)*
15. **Śliwińska S.**, Latała A. 2015. The influence of selected environmental factors on allelopathic effects of *Synechococcus* sp. [in polish]. I Symposium of PhD Students of Natural Sciences from Toruń, 20-22.03.15, Toruń, Poland, p. 60. *(oral presentation)*
16. **Śliwińska S.**, Latała A. 2015. The influence of allelopathic activity of picoplankton cyanobacteria *Synechococcus* sp. on selected species of Baltic cyanobacteria and microalgae [in Polish]. Science Conference „Innovation in the life sciences, engineering, humanities and socio-economic and also agricultural and earth sciences", 25.03.15, Olsztyn, Poland. *(oral presentation)*
17. **Śliwińska S.**, Kowalska Z., Sobczyk A., Latała A. 2015. The phenomenon of the allelopathic effect of picoplanktonic cyanobacteria *Synechococcus* sp. In the aquatic environment [in Polish]. Science Conference „Impact of Young Scientists on the Polish Science Achievement - new trends in life sciences", 11.04.15, Gdańsk, Poland, p. 217, ISBN 978-83-63058-48-7. *(oral presentation)*
18. **Śliwińska-Wilczewska S.**, Maculewicz J., Gergella K., Latała A. 2015. The influence of allelopathic effects of *Synechococcus* sp. on selected strains of Baltic cyanobacteria [in Polish]. VIII International Conference of PhD Students at the University of Szczecin, 16.10.15, Szczecin, Poland, p. 101. *(oral presentation)*
19. **Śliwińska S.**, Latała A. 2011. Allelopathic effects of the picocyanobacteria *Synechococcus* sp. on green alga *Chlorella vulgaris* and diatom *Skeletonema maronoi*. XXX International Conference of the Polish Phycological Society, 19-21.05.11, Wrocław, Poland, p. 182-183, ISBN 978-83-7717-045-8. *(poster)*
20. Lemke P., Jodłowska S., Pniewski F., **Śliwińska S.**, Latała A. 2011. Involvement of the Culture Collection of Baltic Algae (CCBA) in discovering unique properties of Baltic microalgae. XVIII Cryptogamic Botany Symposium, 13-16.07.11, Barcelona, Spain, p. 62. *(poster)*
21. **Śliwińska S.**, Latała A. 2011. Allelopathy in *Synechococcus* sp.: effect on algal and cyanobacterial monocultures. V European Phycological Congress, 04-09.09.11, Rodos, Greece, p. 156, ISSN 0967-0262, DOI: 10.1080/09670262.2011.613163. *(poster)*
22. Lemke P., Jodłowska S., Pniewski F., **Śliwińska S.**, Latała A. 2011. Role of the Culture Collection of Baltic Algae in discovering unique properties of Baltic microalgae. V European Phycological Congress, 04-09.09.11, Rodos, Greece, p. 178-179, ISSN 0967-0262, DOI: 10.1080/09670262.2011.613163. *(poster)*
23. **Śliwińska S.**, Latała A. 2011. Allelopathic effects of the cyanobacteria *Nodularia spumigena* on green algae

Chlorella vulgaris and *Oocystis submarina*. ICES Annual Science Conference 2011, 19-23.09.11, Gdańsk, Poland, p. 34. *(poster)*

24. **Śliwińska S.**, Mazurkiewicz M., Kacprzak P., Korneluk M., Wawrzynek J., Lemke P., Rzemykowska H., Latała A. 2012. Allelopathic effects of cyanobacteria on feeding and survival of the mysid shrimp *Neomysis integer*. International Algal Summit, 21-22.02.12, New Delhi, India, p. 32. *(poster)*
25. Mazurkiewicz M., **Śliwińska S.**, Kacprzak P., Korneluk M., Wawrzynek J., Rzemykowska H., Latała A. 2012. The influence of allelopathic effects of Baltic cyanobacteria on the survival of *Neomysis integer* [in Polish]. I Geographical Symposium, Contemporary issues, problems and challenges in the research of geographical space, 23-24.03.12, Gdańsk, Poland. *(poster)*
26. Mazurkiewicz M., Kacprzak P., Korneluk M., Wawrzynek J., **Śliwińska S.**, Rzemykowska H., Latała A. 2012. The influence of allelopathic effects of *Synechococcus* sp. and *Nodularia spumigena* on the survival of *Neomysis integer* [in Polish]. IV Scientific Conference "Young in Paleontology" Paleontology in Oceanology - Oceanology in Paleontology, 19-20.04.12, Sopot, Poland, p. 46-47 *(poster)*
27. **Śliwińska S.**, Lemke P., Latała A. 2012. The effects of environmental factors on allelopathic interactions between cyanobacteria and microalgae. XXXI International Conference of the Polish Phycological Society, 17-20.05.12, Olsztyn, Poland, p. 96, ISBN 978-83-60111-64-2. *(poster)*
28. Lemke P., Pniewski F., **Śliwińska S.**, Latała A. 2012. Interactive effects of salinity, irradiance and temperature on the development of salt stress tolerance in benthic diatom *Fistulifera saprophila* (Lange-Bertalot & Bonik) Lange-Bertalot. XXXI International Conference of the Polish Phycological Society, 17-20.05.12, Olsztyn, Poland, p. 56, ISBN 978-83-60111-64-2. *(poster)*
29. **Śliwińska S.**, Parusel T., Latała A. 2012. The influence of nutrients on allelopathic effects of Baltic cyanobacteria [in Polish]. V Geo Symposium of Young Explorers Silesia 2012, 26-28.09.12, Zawiercie, Poland. *(poster)*
30. **Śliwińska S.**, Skauradszun M., Niemirycz E., Latała A. 2012. Allelopathic effects of Baltic cyanobacteria on green algae monocultures. VI International Student Conference „Aquatic environmental research", 17-19.10.12, Palanga, Lithuania. *(poster)*
31. Jodłowska S, **Śliwińska S.** 2013. *Synechococcus* strains (picocyanobacteria) from the Baltic Sea – ecophysiology and their vertical and seasonal distribution in the photic zone. XXXII International Conference of the Polish Phycological Society, 20-23.05.13, Konin-Mikorzyn, Poland, p. 73-74. *(poster)*
32. **Śliwińska S.**, Latała A. 2014. The importance of allelopathic interactions in the formation of massive cyanobacterial blooms [in Polish]. VI Polish Symposium of the Sopot Youth Forum titled "Where the world is going", 16.05.14, Sopot, Poland, p. 25. *(poster)*
33. **Śliwińska S.**, Latała A. 2014. Allelopathic effects of picocyanobacterium *Synechococcus* sp. on Baltic microalgae. XXXIII International Conference of the Polish Phycological Society, 19-22.05.14, Cetniewo, Poland, p. 115, ISBN 978-83-7865-222-9. *(poster)*
34. Sylwestrzak Z., **Śliwińska S.**, Zgrundo A., Pniewski F., Latała A. 2015. Effects of allelochemicals, herbicide glyphosate, ionic liquids and copper oxide on the Baltic diatom *Bacillaria paxillifer*. XXXIV International Conference of the Polish Phycological Society, 18-21.05.15, Rzeszów-Polańczyk, Poland, p. 91, ISBN 978-83-7996-126-9. *(poster)*
35. **Śliwińska S.**, Bubak I., Sylwestrzak Z., Pniewski F., Latała A. 2015. Allelopathic effects and anthropogenic substances on cyanobacteria and microalgae in aquatic ecosystems. VI European Phycological Congress (EPC6), 23-28.08.15, London, UK, p. 187-188. *(poster)*
36. Serwatka M., Zgrundo A., Sylwestrzak Z., **Śliwińska S.** 2015. Effect of $CuCl_2$ on growth and motility of the marine diatom *Cylinrotheca closterium* (Ehremberg) Lewin and Reimann. VI European Phycological Congress (EPC6), 23-28.08.15, London, UK, p. 170. *(poster)*
37. Sylwestrzak Z., Zgrundo A., Jurowska J., **Śliwińska S.**, Pniewski F., Latała A. 2015. Assessment of the condition of microfitobenthos communities as a method of pollution monitoring in the Baltic Sea [in Polish]. Science Conference BAŁTYK 2015 "The status, trends, changes and contemporary methods for monitoring the environment of the Baltic Sea", 14-16.10.15, Sopot, Poland. *(poster)*
38. **Śliwińska-Wilczewska S.**, Maculewicz J., Gergella K., Sylwestrzak Z., Latała A. 2015. Analysis of allelopathic effects of *Synechococcus* sp. and its consequences for the environmental condition of the Baltic Sea [in Polish]. Science Conference BAŁTYK 2015 "The status, trends, changes and contemporary methods for monitoring the environment of the Baltic Sea", 14-16.10.15, Sopot, Poland. *(poster)*

These works were based on original, independently analyzed material and allowed to recognize the allelopathic activity of dominating cyanobacteria in the Baltic Sea. These were comprehensive results that could form the basis for modeling ecological processes. Doctoral dissertation, which title was: "*Allelopathic interactions of Baltic cyanobacteria Synechococcus sp. and Nodularia spumigena under selected environmental conditions*", I defended in 2015, and

Resolution No. 188/15, the Council of the Faculty of Oceanography and Geography, University of Gdansk recognized my **dissertation as outstanding**.

During the doctoral studies, in 2012, I was employed as a **specialist** (scientific and technical worker), and from October 2013 to January 2016 I was a **research assistant** at the Laboratory of Marine Plant Ecophysiology at the Faculty of Oceanography and Geography, University of Gdansk. Working at these positions enabled me to acquire detailed knowledge on the physiology of cyanobacteria and microalgae. My duties included conducting microalgae and cyanobacterial cultures, setting optimal conditions for their growth, isolation to pure algal monocultures and performing photographic documentation of microalgae and cyanobacteria under the light and epifluorescence microscope. In addition, my numerous trips abroad and involvement in laboratory work have resulted in the fact that since 2012 I am the person responsible for **supporting the development of the Culture Collection of Baltic Algae (CCBA)** in the Laboratory of Marine Plant Ecophysiology at the University of Gdansk. For many years I organized and participated in scientific expeditions of the University of Gdansk during which I collected phytoplanktonic and phytobenthic material, which was used for later cultivation and isolation of microalgal and cyanobacterial monocultures. The species thus obtained enriched the CCBA Collection with new strains of microalgae and cyanobacteria, including the strains of picocyanobacteria. In addition, I attended the **19th International Ecological Summer School - Freshwater Dinophyta Workshop**, where I obtained a certificate confirming my ability to recognize some microalgae species.

In 2009 – 2015 I attended many **trainings and courses**, where I broadened my knowledge and improved skills. For two years I attended a series of specialist trainings as part of the project titled "A comprehensive program for the development of PhD students, young doctors and academic teaching staff of the University of Gdansk (Human Capital National Cohesion Strategy)". In addition, since 2015 I have completed different trainings on the operation of scientific equipment, including two courses: "HPLC technique" and "Isolation of nucleic acids" organized by A & A Biotechnology. I also attended the specialized courses: "TISCH Environmental International, Model: TE-6070 High Volume Particle Sampler with Cascade Impactor", and "TISCH Environmental International, Model: TE-10-800 Six stage ambient viable sampler/impactor", ECO Monitoring, Gdynia, Poland, as well as "FlowCam training" conducted by Kevin Stewart, Manager of Customer Support Fluid Imaging Technologies. In order to raise my qualifications, in 2012 I have completed training and passed the exam at the Faculty of Chemistry at the Gdansk University of Technology, after which I received a certificate in the scope of auditing research laboratories and obtained the title **"Laboratory Auditor, ISO 17025:2005"**.

I was employed as an **assistant professor** at the Department of Marine Ecosystems Functioning in February 2016. During only three years of scientific work in this position, I published a total of **14** articles in journals from **List A of Ministry of Science and Higher Education (total IF = 32.060**, **5-year IF = 35.612)** and **8** in journals from **List B of the Ministry of Science and Higher Education**, obtaining a total of **517 MNiSW points**. In addition, I published **10 chapters and 2 scientific books** in which I am the first author. It's worth mentioning that one scientific book, published in the University of Gdansk Publishing House, was the result of the award I received from the Council of the Faculty of Oceanography and Geography, University of Gdansk for the outstanding doctoral dissertation. I was also repeatedly invited to review scientific articles in leading international journals from the A List of the Ministry of Science and Higher Education, such as: *Journal of Marine Systems*, *Environmental Science and Pollution Research*, *Journal of Bioscience and Bioengineering*, *International Review of Hydrobiology*, *Photosynthetica*, *Oceanologia*, *Oceanological and Hydrobiological Studies*, *Forests*, *Molecules*, *Toxins*, *Ecotoxicology and Environmental Safety* and *Chemosphere*. I also received the **award from the Dean of the Faculty of Oceanography and Geography, University of Gdansk** for scientific and research achievements and especially valuable scientific publications in 2017. In addition, in 2018 I received a **Scholarship from the Minister of Science and Higher Education** for a young scientist for outstanding scientific achievements.

Being employed as an assistant professor, I focused mainly on the continuation of studies related to the allelopathic effects of picocyanobacteria. In order to establish cooperation with scientists dealing with similar issues and research topics, I joined Scientific Societies, where I am a member of the **Polish Phycological Society** (PTF) and the **Polish Hydrobiological Society** (PTH), as well as a member of the **Federation of European Phycological Societies** (FEPS), **International Phycological Societies** (IPS) and **International Society of Limnology** (SIL). Recently, I have also established cooperation with prof. Vitor Vasconcelos and dr Aldo Barreiro Felpeto from **Interdisciplinary Center of Marine and Environmental Research–CIMAR/CIIMAR** and **University of Porto**. Thanks to this cooperation and the funding obtained from 3 grants, in which I was the Principal Investigator, it was possible to perform further and more detailed studies on the allelopathic impact of picocyanobacteria, the results of which were published in a total of 25 scientific articles and presented at 14 conferences:

RESEARCH PROJECTS

1. 2016-2017 - Project ID: BMN 538-G245-B211-16. Sources of funding: University of Gdańsk. Project title: Allelopathic ativity of *Synechococcus* sp. on Baltic cyanobacteria from the genus *Aphanizomenon*, *Nostoc* and *Rivularia*. Principal Investigator: **Śliwińska-Wilczewska S.** Co-Principal Investigator: Maculewicz J.
2. 2017-2018 – Project ID: 538-G245-B568-17. Sources of funding: University of Gdańsk. Project title: Allelopathic

activity of the picocyanobacteria on a natural plankton community. Principal Investigator: **Śliwińska-Wilczewska S.** Co-Principal Investigators: Maculewicz J., Marszewska L.

3. 2018-2019 – Project ID: 538-G245-B116-18. Sources of funding: University of Gdańsk. Project title: Comparison of the allelopathic effects of three strains of picocyanobacteria *Synechococcus* sp. on selected cyanobacteria and microalgae. Principal Investigator: **Śliwińska-Wilczewska S.** Co-Principal Investigator: Konarzewska Z.

PUBLICATIONS

1. **Śliwińska-Wilczewska S.**, Pniewski F., Latała A. 2016. Allelopathic activity of the picocyanobacterium *Synechococcus* sp. under varied light, temperature and salinity conditions. International Review of Hydrobiology 101, 69–77. DOI: 10.1016/j.ecohyd.2017.05.001, ISSN 1434-2944, IF = 1.459.
2. **Śliwińska-Wilczewska S.**, Pniewski F., Latała A. 2016. Allelopathic interactions between *Synechococcus* sp. and *Nodularia spumigena* under different light conditions. Allelopathy Journal 37(2), 241-252. ISSN 0971-4693, IF = 1.050.
3. **Śliwińska-Wilczewska S.**, Sylwestrzak Z., Maculewicz J., Zgrundo A., Pniewski F., Latała A. 2016. The effects of allelochemicals and selected anthropogenic substances on the diatom *Bacillaria paxillifera*. Biological and Environmental Education 1(58), 21-27, ISSN 1643-8779.
4. **Śliwińska-Wilczewska S.**, Maculewicz J., Latała A. 2016. Allelopathic effects of *Synechococcus* sp. on selected cyanobacteria. Biological and Environmental Education 3(60), 11-18, ISSN 1643-8779.
5. **Śliwińska-Wilczewska S.**, Maculewicz J., Sobczyk A., Latała A. 2016. The influence of allelopathic effects of *Synechococcus* sp. on selected species of cyanobacteria [in Polish]. In: Kuczera M., Piech K. (Eds.). Issues currently being addressed by young scientists 8, 52-57. ISBN 978-83-63058-62-3.
6. **Śliwińska-Wilczewska S.**, Sobczyk A., Maculewicz J., Latała A. 2016. Determination of allelopathic effects occurring between *Synechococcus* sp. and selected species of Baltic microalgae. In: Kuczera M., Piech K. (red.). Issues currently being addressed by young scientists 8, 58-63. ISBN 978-83-63058-62-3.
7. **Śliwińska-Wilczewska S.**, Gergella K., Latała A. 2016. Allelopathic activity of the *Synechococcus* sp. (Cyanobacteria, Chroococcales) on selected cyanobacteria species. In: Barabasz-Krasny B. (Ed.), Annales Universitatis Paedagogicae Cracoviensis Studia Naturae 1, 115-126, ISSN 2543-8832.
8. **Śliwińska-Wilczewska S.**, Maculewicz J., Barreiro Felpeto A., Vasconcelos V., Latała A. 2017. Allelopathic activity of the picocyanobacterium *Synechococcus* sp. on filamentous cyanobacteria. Journal of Experimental Marine Biology and Ecology 496, 16–21. DOI: 10.1016/j.jembe.2017.07.008, ISSN 0022-0981, IF = 1.937 (5-Year IF = 2.310).
9. **Śliwińska-Wilczewska S.**, Latała A. 2017. Allelopathic effects of cyanobacteria and microalgae in the aquatic environment [in Polish]. Cosmos 66(2), 217-224. ISSN 0023-4249.
10. **Śliwińska-Wilczewska S.**, Maculewicz J., Tuszer J., Dobosz K., Kalusa D., Latała A. 2017. First record of allelopathic activity of the picocyanobacterium *Synechococcus* sp. on a natural plankton community. Ecohydrology & Hydrobiology 17, 227–234. DOI: 10.1016/j.ecohyd.2017.05.001, ISSN 1642-3593.
11. Maculewicz J., **Śliwińska-Wilczewska S.**, Latała A. 2017. The allelopathic phenomenon of *Synechococcus* sp. on filamentous cyanobacteria *Geitlerinema amphibium* and *Rivularia* sp. [in Polish]. Biological and Environmental Education 2(63), 3-9. ISSN 1643-8779.
12. Maculewicz J., **Śliwińska-Wilczewska S.**, Latała A. 2017. Expansion of picocyanobacteria in aquatic ecosystems [in Polish]. Cosmos 66(3), 465–474. ISSN 0023-4249.
13. Tuszer J., Dobosz K, Kulasa D., **Śliwińska-Wilczewska S.** 2017. Allelopathic activity of cyanobacteria *Synechococcus* sp. and its effect on natural phytoplankton community [in Polish]. Tutoring Gedanensis 2(1), 15-22. ISSN 2451-1862.
14. Konarzewska Z., **Śliwińska-Wilczewska S.**, Latała A. 2017. Allelopathic effect of the Baltic picocyanobacterium *Synechococcus* sp. on selected diatoms. In: Barabasz-Krasny B. (Ed.), Annales Universitatis Paedagogicae Cracoviensis Studia Naturae 2, 114–123, DOI: 10.24917/25438832.2.9. ISSN 2543-8832.
15. **Śliwińska-Wilczewska S.**, Knitter A., Cisło D., Latała A. 2017. Allelopathic activity of the Baltic picocyanobacterium *Synechocystis* sp. In: Barabasz-Krasny B. (Ed.), Annales Universitatis Paedagogicae Cracoviensis Studia Naturae 2, 124–134, DOI: 10.24917/25438832.2.10. ISSN 2543-8832.
16. **Śliwińska-Wilczewska S.** 2017. The influence of environmental factors on allelopathic effects of Baltic cyanobacteria *Synechococcus* sp. and *Nodularia spumigena* [in Polish]. In: Zgaińska D. (Ed.), Dissertationes Laudatissimae Universitas Gedanensis. University of Gdansk Printing House p. 1-223. ISBN 978-83-7865-522-0.
17. **Śliwińska-Wilczewska S.**, Maculewicz J., Latała A. 2017. Allelopathic interactions of cyanobacteria and microalgae. LAP LAMBERT Academic Publishing, International Book Market Service Ltd., Mauritius, p. 1-112. ISBN 978-620-2-06155-1.
18. **Śliwińska-Wilczewska S.**, Maculewicz J., Barreiro Felpeto A., Latała A. 2018. Allelopathic and bloom-forming picocyanobacteria in a changing world. Toxins 10, 48; doi:10.3390/toxins10010048, ISSN 2072-6651, IF = 3.030 (5-Year IF = 3.450).
19. Barreiro Felpeto A., **Śliwińska-Wilczewska S.**, Złoch I., Vasconcelos V. 2018. Light-dependent cytolysis in the allelopathic interaction between picoplanktic and filamentous cyanobacteria. Journal of Plankton Research 40(2), 165–177. DOI: 10.1093/plankt/fby004. ISSN 0142-7873, IF = 1.983 (5-Year IF = 2.194).
20. **Śliwińska-Wilczewska S.**, Barreiro Felpeto A., Maculewicz J., Sobczyk A., Vasconcelos V., Latała A. 2018. Allelopathic activity of the picocyanobacterium *Synechococcus* sp. on unicellular eukaryote planktonic microalgae. Marine and Freshwater Research 69(9), 1472–1479. DOI: 10.1071/MF18024. ISSN 1323-1650, IF = 1.757.

21. **Śliwińska-Wilczewska S.**, Latała A. 2018. Allelopathic activity of the bloom-forming picocyanobacterium *Synechococcus* sp. on the coexisting microalgae: the role of eutrophication. International Review of Hydrobiology 103(3-4), 37–47. DOI: 10.1002/iroh.201801940. ISSN 1522-2632, IF = 2.281.
22. **Śliwińska-Wilczewska S.**, Latała A. 2018. Factors determining the allelopathy phenomenon in cyanobacteria and microalgae in aquatic ecosystems [in Polish]. Cosmos 67, 583–589. ISSN 0023-4249.
23. Dobosz K., Tuszer-Kunc J., Kulasa D., Śliwińska-Wilczewska S. 2018. The use of cyanobacteria in mass cultures [in Polish]. Cosmos 67(4), 833-840. ISSN 0023-4249.
24. Konarzewska Z., **Śliwińska-Wilczewska S.**, Latała A. 2018. Allelopathic activity of the three strains of Baltic picocyanobacterium *Synechococcus* sp. on selected algae and cyanobacteria. ACTA UNIVERSITATIS MATTHIAE BELII series Environmental Management [online]. Banská Bystrica, 2018, XX(1), 89-100. DOI: 10.24040/actaem.2018.20.1.89-100. ISSN 1338-4430.
25. Barreiro Felpeto A., **Śliwińska-Wilczewska S.**, Klin M., Konarzewska Z., Vasconcelos V. 2019. Temperature-dependent impacts of allelopathy on growth, pigment and lipid content between a sub-polar strain of Synechocystis sp. CCBA MA-01 and coexisting microalgae. Hydrobiologia. DOI: 10.1007/s10750-019-3933-8. ISSN: 0018-8158, IF = 2.165, 30 pkt. MNiSW. (in press).

PRESENTATIONS AT SCIENTIFIC CONFERENCES

1. Maculewicz J, **Śliwińska-Wilczewska S.**, Sobczyk A., Latała A. 2016. Determination of allelopathic effects occurring between *Synechococcus* sp. and selected strains of filamentous cyanobacteria from the genus *Nostoc* and *Rivularia* [in Polish]. Science Conference "New challenges for Polish science", 03.04.16, Gdańsk, Poland, p. 33, ISBN 978-83-63058-60-9. *(oral presentation)*
2. **Śliwińska-Wilczewska S.**, Maculewicz J., Latała A. 2016. Allelopathic activity of the picocyanobacterium *Synechococcu* sp. on selected cyanobacteria and microalgae. SIL Congress, 31.07- 05.08.16, Torino, Italy, p. 249-250. *(oral presentation)*
3. Maculewicz J., **Śliwińska-Wilczewska S.**, Latała A. 2017. Allelopathic effects of *Synechococcus* sp. on filamentous cyanobacteria. XXXVI International Conference of the Polish Phycological Society, 24.05-27.05.2017, Lublin-Kazimierz Dolny, Polska, p. 34, ISBN 978-83-948000-0-0. *(oral presentation)*
4. Maculewicz J., **Śliwińska-Wilczewska S.**, Sobczyk A., Klin M., Latała A. 2016. Allelopathic effects of *Synechococcus* sp. on blooms of filamentous Baltic cyanobacteria. International Sopot Youth Conference 2016, 20.05.16, Sopot, Poland. *(poster)*
5. Sobczyk A., **Śliwińska-Wilczewska S.**, Maculewicz J., Klin M., Latała A. 2016. Allelopathic activity of picocyanobacterium *Synechococcus* sp. on selected microalgae and pelagic larvae of benthic invertebrates. International Sopot Youth Conference 2016, 20.05.16, Sopot, Poland. *(poster)*
6. **Śliwińska-Wilczewska S.**, Maculewicz J., Sobczyk A., Klin M., Latała A. 2016. Allelopathic effects of picocyanobacterium *Synechococcus* sp. on Baltic filamentous cyanobacteria. XXXV International Conference of the Polish Phycological Society, 01.06- 04.06.16, Łódź-Stryków, Poland, p. 98, ISBN 978-83-8088-127-3. *(poster)*
7. **Śliwińska-Wilczewska S.**, Możdżeń K., Maculewicz J., Latała A. 2017. Allelopathic interaction of Baltic picocyanobacteria results in the formation of massive blooms in aquatic environment. II Interdisciplinary Academic Conference on Environmental Protection, 17-20.03.2017, Gdańsk, Poland, p.133, ISBN 978-83-947159. *(poster)*
8. Maculewicz J., **Śliwińska-Wilczewska S.**, Możdżeń K., Latała A. 2017. Determination of allelopathic effects between *Synechococcus* sp. and selected species of Baltic cyanobacteria [in Polish]. II Interdisciplinary Academic Conference on Environmental Protection, 17-20.03.2017, Gdańsk, Poland, p. 103, ISBN 978-83-947159. *(poster)*
9. **Śliwińska-Wilczewska S.**, Maculewicz J., Latała A. 2017. Physiological adaptations and allelopathic activity of expansive picocyanobacteria *Synechococcus* sp. XXXVI International Conference of the Polish Phycological Society, 24.05-27.05.2017, Lublin-Kazimierz Dolny, Polska, p. 70, ISBN 978-83-948000-0-0. *(poster)*
10. Maculewicz J., **Śliwińska-Wilczewska S.**, Latała A. 2017. Allelopathic interactions between three strains of Baltic picocyanobacterium *Synechococcus* sp. International Sopot Youth Conference 2017, 26.05.2017, Sopot, Polska, p. 36. *(poster)*
11. **Śliwińska-Wilczewska S.**, Konarzewska Z., Możdżeń K., Latała A. 2018. The phenomenon of allelopathic effect of the Baltic picocyanobacteria *Synechococcus* sp. on selected diatom [in Polish]. Conference of Young Biologists - Biologus 2018, 12-13.04.18 Szczecin, Poland, p. 86. *(poster)*
12. **Śliwińska-Wilczewska S.**, Możdżeń K., Konarzewska Z., Wolff G., Budzałek G., Latała A. 2018. Influence of allelopathic effects of picocyanobacteria *Synechococcus* sp. on photosynthetic activity of selected phytoplankton species [in Polish]. Conference of Young Biologists - Biologus 2018, 12-13.04.18 Szczecin, Poland, p. 87. *(poster)*
13. **Śliwińska-Wilczewska S.**, Barreiro Felpeto A., Możdżeń K., Klin M., Konarzewska Z., Wolff G., Korneluk P., Latała A. 2018. Allelopathic activity of the picocyanobacterium *Synechocystis* sp. on cyanobacterial and algal monocultures and on natural plankton community. 37th International Conference of the Polish Phycological Society, 22-25.05.2018, Kraków-Dobczyce, Góra Jałowcowa, Poland. *(poster)*
14. **Śliwińska-Wilczewska S.**, Możdżeń K., Rzepka A., Zandi P., Latała A. 2018. Allelopathic activity of the picocyanobacterium *Synechococcus* sp. under environmental stress. 11th International Conference "Plant Functioning Under Environmental Stress", 12-15.09.2018, Kraków, Poland. *(poster)*

Another research task in which I was involved was the recognition of the role of the allelopathic effect of macroalgae on selected species of cyanobacteria, including the picocyanobacteria. I carried out these allelopathic tests in cooperation with dr Ilona Złoch from the **Division of Marine Biology and Ecology at the University of Gdansk**. The lack of recognition of allelopathic activity of macroalgae from the Baltic Sea on the coexisting species of filamentous cyanobacteria induced us to carry out a series of laboratory experiments. We demonstrated that Baltic macroalgae present a diverse allelopathic effect, depending on the properties and physiology of the donor and target organisms. Investigation of allelopathic activity of macroalgae may help to determine their possible role as an important biological factor affecting the cyanobacterial blooms. Therefore, this issue is being explored in detail by my student as part of her master's thesis, which I am a supervisor. The presented studies were presented in two articles and one posters:

	PUBLICATIONS
1.	Złoch I., **Śliwińska-Wilczewska S.**, Kucharska M., Kozłowska W. 2018. Allelopathic effects of *Chara* species (*C. aspera*, *C. baltica*, and *C. canescens*) on the bloom-forming picocyanobacterium *Synechococcus* sp. Environmental Science and Pollution Research 25(36), 36403–36411. DOI: 10.1007/s11356-018-3579-5. ISSN 0944-1344, IF = 2.741.
2.	Budzałek G., **Śliwińska-Wilczewska S.**, Latała A. 2018. Allelopathic effect of *Ulva intestinalis* L. on the Baltic filamentous cyanobacterium *Nostoc* sp. In: Barabasz-Krasny B. (Ed.), Annales Universitatis Paedagogicae Cracoviensis Studia Naturae 3, 80–89. DOI: 10.24917/25438832.3.6. ISSN 2543-8832.
	PRESENTATIONS AT SCIENTIFIC CONFERENCES
1.	Złoch I., **Śliwińska-Wilczewska S.**, Kucharska M., Kozłowska W., Surosz W. 2018. Allelopathic effect of *Chara aspera*, *Chara baltica* and *Chara canescens* on the bloom-forming picocyanobacterium *Synechococcus* sp. 37th International Conference of the Polish Phycological Society, 22-25.05.2018, Kraków-Dobczyce, Góra Jałowcowa, Poland. *(poster)*

I also established cooperation with a team of scientists from the **Department of Plant Physiology at the Pedagogical University of Cracow**, and dr Peiman Zandi from **Institute of Environmental and Sustainable Development in Agriculture, Chinese Academy of Agricultural Science**, thanks to which I had the opportunity to continue work related to the microalgae physiology in the context of global warming. Furthermore, I had the opportunity to learn about the allelopathy phenomenon of higher plants. The results obtained during these studies were presented in the article listed in List A and at six posters:

	PUBLICATIONS
1.	Możdżeń K., Zagata-Leśnicka P., Burnecki T., **Śliwińska-Wilczewska S.**, Skoczowski A., Greczek-Stachura M. 2018. The photosynthetic efficiency of endosymbiotic algae of *Paramecium bursaria* originating from locations with cold and warm climates. Oceanological and Hydrobiological Studies 47, 202–210. DOI: 10.1515/ohs-2018-0019. ISSN 1730-413X, IF = 0.544 (5-Year IF = 0.778).
	PRESENTATIONS AT SCIENTIFIC CONFERENCES
1.	Możdżeń K., **Śliwińska-Wilczewska S.**, Zandi P., Rzepka A. 2017. The influence of drought stress on the wheat grains (*Triticum aestivum* L. cv. Igna). II Interdisciplinary Academic Conference on Environmental Protection, 17-20.03.2017, Gdańsk, Poland, p. 110, ISBN 978-83-947159. *(poster)*
2.	Możdżeń E., Możdżeń K., Wanic T., **Śliwińska-Wilczewska S.**, Rzepka A. 2017. The intensity of the fluorescence

emission spectra of the Scots pine (*Pinus sylvestris* L.) needles in Warcino Forest District (northern Poland). II Interdisciplinary Academic Conference on Environmental Protection, 17-20.03.2017, Gdańsk, Poland, p. 109, ISBN 978-83-947159. *(poster)*

3. Zandi P., Możdżeń K., **Śliwińska-Wilczewska S.**, Kumar Basu S., Cetzal-Ix W., Martínez-Puc J.F. 2017. The photosynthetic activity of maize cv. Landmark in cadmium stress conditions. VI Wrocław Conference of Technical Sciences - Puzzel, 01-02.04.2017, Wrocław, Poland, ISBN 978-83-937278-6-5. *(poster)*
4. Możdżeń K., Barabasz-Krasny B., **Śliwińska-Wilczewska S.**, Konarzewska Z., Zandi P. 2018. Allelopathic effect of *Dactylis glomerata* L. on sprouting and growth of *Trifolium pratense* L. [in Polish]. Conference of Young Biologists - Biologus 2018, 12-13.04.18 Szczecin, Poland, 68. *(poster)*
5. Możdżeń K., Barabasz-Krasny B., **Śliwińska-Wilczewska S.**, Konarzewska Z., Zandi P. 2018. Evaluation of allelopathic activity of Galinsoga parviflora Cav. and Oxalis fontana Bunge for the early growth stages of cultivars Raphanus sativus L. var. radicula Pers [in Polish]. Conference of Young Biologists - Biologus 2018, 12-13.04.18 Szczecin, Poland, p. 67. *(poster)*
6. Konieczna I., Możdżeń K., Barabasz-Krasny B**., Śliwińska-Wilczewska S.**, Zandi P., Puła J. 2018. Allelopathic interaction of *Solidago canadensis* L. on germination and early stages of growth of *Trifolium pratense* L. IV International IX Interdisciplinary Conference Nature–Human–Culture, 14-17.06.2018, Kraków, Poland, p. 53. *(poster)*

Thanks to scientific cooperation with prof. Anita Lewandowska from the **Division of Marine Chemistry and Environmental Protection, University of Gdansk**, I had the opportunity to broaden my research interests to identify and analyze the composition of cyanobacteria and microalgae occurring in aerosols in the Baltic Sea region. I studied this topic during my research work with a student, which consisted in validating the method of collecting cyanobacteria and microalgae from aerosols, as well as analyzing and determining the collected material. In 2016, I was also a reviewer of master's thesis, which title was "*Identification of cyanobacteria and microalgae in bioaerosols of the South Baltic region*". Biological components of aerosols, like chemical compounds, can penetrate into the human body via the respiratory system. Therefore, the purpose of the conducted research was to identify what species of cyanobacteria and microalgae occur in the aerosols of the coastal zone of the Baltic Sea and over its open waters. We have shown that among the identified organisms there were potentially toxic species that could pose a threat to human health. The most numerous among them were the picoplanktonic cyanobacteria *Synechococcus* sp. and *Synechocystis* sp., as well as *Microcystis* sp., which are able to produce microcystin. We proved that in the ambient air the species of cyanobacteria and microalgae are often a component of small particles (with a diameter not exceeding 3 μm). That is why there is a special need for further research in this area. Currently, we concern the role of cyanobacteria and microalgae present in aerosols in transport to the human body, e.g. heavy metals, pesticides, herbicides and carcinogenic and mutagenic substances. I am currently helping a PhD student who is continuing research on the transfer of dangerous and toxic substances in aerosols of the coastal zone. In December 2018 we submitted a project to the National Science Center (OPUS), entitled: "*Cyanobacteria and microalgae in aerosols as a source of toxic substances in the coastal atmosphere*", where I am one of the Co-Principal Investigator of this project. The preliminary

research have already been presented in a high-impact journal publication and at the two conferences:

	PUBLICATIONS
1.	Lewandowska A.U, **Śliwińska-Wilczewska S.**, Woźniczka D. 2017. Identification of cyanobacteria and microalgae in aerosols of various sizes in the air over the Southern Baltic Sea. Marine Pollution Bulletin 125, 30-38. DOI: 10.1016/j.marpolbul.2017.07.064, IF = 3.146 (5-Year IF = 3.780).
	PRESENTATIONS AT SCIENTIFIC CONFERENCES
1.	Lewandowska A.U., **Śliwińska-Wilczewska S.**, Wiśniewska K., Woźniczka D. 2018. Sea surface as a source for bioaerosols in the coastal zone of the southern Baltic Sea. 12th Edition of International Conference on Oceanography & Marine Biology, 03.012-04.12.2018, Rome, Italy. *(oral presentation)*
2.	Lewandowska A., **Śliwińska-Wilczewska S.**, Woźniczka D. 2016. Identification of cyanobacteria and microalgae in aerosols of various sizes in the air above the southern Baltic Sea [in Polish]. XII Conference "Chemistry, Geochemistry and Marine Environment Protection", 21.10.16, Sopot, Poland, p. 62. *(poster)*

In 2017, I also established cooperation with scientists from the **Department of Marine Physics, Institute of Oceanology Polish Academy of Sciences in Sopot** and **Leibniz Institute for Baltic Sea Research in Germany**. Cyanobacteria inhabits all types of water reservoirs, and through rapid metabolism and numerous adaptations have enormous potential for creating significant biomass and massive blooms. Therefore, the aim of our work was to show full physiological characteristics for three strains of picocyanobacteria of the genus *Synechococcus* and filamentous cyanobacteria *Nodularia spumingena*, *Aphanizomenon* sp. and *Dolichospermum lemmermannii*. Various synthetic environmental scenarios were created in which seven-day laboratory cultures of the studied cyanobacteria strains were carried out. Each of the cultures was conducted in a different environmental characteristics, different from other temperatures, salinity and irradiation conditions. In the next stage of work, the results of obtained laboratory experiments will be used to create numerical algorithms, allowing to determine conversions of Baltic concentrations, creating massive cyanobacterial blooms over time, depending on the environmental conditions. The algorithms will be created on the basis of numerical formulas, which have been used in the biogeochemical model developed for research in the Baltic Sea - *Ecological Regional Ocean Model*. Work on further development of the algorithm is still ongoing. The results of the study were the basis for writing 5 publications, including two in high-impact journals (Biogeosciences, IF = 3.441, 5-Year IF = 4.373 and Estuarine, Coastal and Shelf Science, IF = 2.413, 5-Year IF = 2.732), and also for presentations in two oral presentations and six posters:

	PUBLICATIONS
1.	**Śliwińska-Wilczewska S.**, Cieszyńska A., Latała A. 2017. The impact of temperature and photosynthetically active radiation on the growth and pigments concentration in Baltic picocyanobacterium *Synechococcus* sp. In: Barabasz-Krasny B. (ed.), Annales Universitatis Paedagogicae Cracoviensis Studia Naturae 2, 59–68, DOI: 10.24917/25438832.2.4. ISSN 2543-8832.
2.	Cieszyńska A., **Śliwińska-Wilczewska S.**, Maculewicz J. 2017. Influence of Baltic Pococanobacteria cells on the pH value of the marine center in which they live [in Polish]. In: Nyćkowiak J., Leśny J., (Eds.). Research and

Development of Young Scientists in Poland. Natural Sciences, pp. 7-16. ISBN 978-83-65677-19-8.

3. Cieszyńska A., **Śliwińska-Wilczewska S.**, Maculewicz J. 2017. Number and growth rate of the Baltic picocyanobacteria as a function of environmental conditions [in Polish]. In: Nyćkowiak J., Leśny J., (Eds.). Research and Development of Young Scientists in Poland. Natural Sciences, pp. 17-25. ISBN 978-83-65677-19-8.
4. **Śliwińska-Wilczewska S.**, Cieszyńska A., Maculewicz J., Latała A.. 2018. Ecophysiological characteristics of red, green and brown strains of the Baltic picocyanobacterium *Synechococcus* sp. – a laboratory study. Biogeosciences 15, 6257–6276. DOI: 10.5194/bg-15-6257-2018. ISSN 1726-4170, IF = 3.441 (5-Year IF = 4.373).
5. **Śliwińska-Wilczewska S.**, Cieszyńska A., Konik M., Latała A. 2019. Environmental drivers of bloom-forming cyanobacteria in the Baltic Sea: effects of salinity, temperature, and irradiance. Estuarine, Coastal and Shelf Science 219, 139–150. DOI: doi.org/10.1016/j.ecss.2019.01.016. ISSN: 0272-7714, IF = 2.413 (5-Year IF = 2.732).

PRESENTATIONS AT SCIENTIFIC CONFERENCES

1. Cieszyńska A., **Śliwińska-Wilczewska S.**, Maculewicz J. 2017. Characteristics of the Baltic picoplankton *Synechococcus* sp. (green strain) based on laboratory analysis and preliminary implementation of results for numerical considerations [in Polish]. Scientific Conference "Research and Development of Young Scientists in Poland", 23-24.02.17, Będlewo, Poland, p. 15, ISBN 978-83-65677-21-1. *(oral presentation)*
2. **Śliwińska-Wilczewska S.**, Maculewicz J., Cieszyńska A., Latała A. 2017. The importance of allelopathic effects of *Synechococcus* sp. in the dynamic formation of biomass of filamentous cyanobacteria in aquatic ecosystems [in Polish]. Hydrological Conference "The World Water Day", 22.03.2017, Poznań, Poland, p. 22. *(oral presentation)*
3. Cieszyńska A., **Śliwińska-Wilczewska S.** 2017. Eco-physiological Baltic picoplankton analysis and its implementation in *Synechoccocus* species life cycle numerical algorithm. European Geosciences Union General Assembly 2017, 23-28.04.2017, Vienna, Austria. *(poster)*
4. **Śliwińska-Wilczewska S.**, Maculewicz J., Cieszyńska A, Latała A. 2017. Allelopathic activity of the picocyanobacterium *Synechococcus* sp. on a natural plankton community. International Sopot Youth Conference 2017, 26.05.2017, Sopot, Poland, p. 31. *(poster)*
5. Cieszyńska A., **Śliwińska-Wilczewska S.**, Maculewicz J., Stramska M. 2017. Recognition of picocyanobacteria photochemical characteristics on the basis of laboratory experiments. International Sopot Youth Conference 2017, 26.05.2017, Sopot, Poland, p. 42. *(poster)*
6. Cieszyńska A., **Śliwińska-Wilczewska S.**, Stramska M. 2017. Baltic filamentous cyanobacteria and picocyanobacteria growth characteristics at different environmental conditions simulated in laboratory experiments. XXI Baltic Sea Science Congress, 12-16.06.2017, Rostock, Germany, p. 124. *(poster)*
7. Cieszyńska A., Neumann T., **Śliwińska-Wilczewska S.**, Stramska M. 2018. Phytoplankton-driven pH changes in the Baltic Sea area. International Sopot Youth Conference, 25.05.2018, Sopot, Poland. P. 43. *(poster)*
8. Cieszyńska A., Neumann T., Stramska M., **Śliwińska-Wilczewska S.** 2018. On the picocyanobacteria modelling in the Baltic Sea – pico-bioalgorithms development. International Sopot Youth Conference, 25.05.2018, Sopot, Poland, p. 44. *(poster)*

In order to improve my technical and IT qualifications, I also completed the **GIS (Geographic Information System) Postgraduate Studies**, conducted at the University of Gdansk, thanks to which I obtained the title: **GIS Analyst**. In addition, for two years I attended the Post-secondary School with an IT profile, after which I passed an external exam confirming my professional qualifications in the **IT profession**. I also completed the course "Programming with the use of Python in ArcGis 10.4", the course "Cisco Networking Academy" in English, after which I obtained the **IT Essentials Certificate** and took part in training in the operation of the meteorological station on the "Oceanograf" scientific vessel. The acquired new skills and scientific cooperation with prof. Jacek Urbański and his employees from the GIS Center (Geographic Information Systems) as well as scientists from the **University of Gdańsk**, **the Institute of Oceanology of the Polish Academy of Sciences** in Sopot and employees from **CSIRO Oceans & Atmosphere** from Australia have resulted in a high-impact journal article:

	PUBLICATIONS
1.	Urbański J.A., Wochna A., Bubak I., Grzybowski W., Łukawska-Matuszewska K., Łącka M., **Śliwińska S.**, Wojtasiewicz B., Zajączkowski M. 2016. Application of Landsat 8 imagery to regional-scale assessment of lake water quality. International Journal of Applied Earth Observation and Geoinformation 51, 28–36. DOI: 10.1016/j.jag.2016.04.004, ISSN 0303-2434, IF = 3.930 (5-Year IF = 4.359).

Comparing the information cited above, I would like to emphasize that my scientific achievements, which were not included in the scientific achievement, include **7** articles in journals from **List A** from Ministry of Science and Higher Education and **11** in magazines from **List B** of the Ministry of Science and Higher Education, thanks to which I obtained a total of **323 points**. In addition, I am the author or co-author of **23 articles** published in the form of monographs and **2 books**. The total Impact Factor of the above publications, according to the Journal Citation Reports (JCR) list, according to the year of publication, is **17.398**, and from 5-year periods covering the publication year: **19.014**.

Academic achievements

Since February 2016 I have been working as an associate professor at the Marine Ecosystem Functioning Department at the Faculty of Oceanography and Geography at the University of Gdansk, thanks to which I can fully realize my teaching interests. I have didactic classes with master and bachelor students of Oceanography (Faculty of Oceanography and Geography), Aquaculture - Business and Technology (Faculty of Oceanography and Geography), and Environmental Protection (Faculty of Chemistry), i.e. Fundamentals of Marine Botany, Systematics and basics of biology of organisms, Biogeography of the sea, Environmental monitoring, Specialized classes in the sea and coastal zone, Mariculture, Biotechnology in aquaculture – algae, The project workshop, Workshop for master students I, II and III, and Workshop for bachelor students I and II.

Employment at the University of Gdansk, first as a research assistant, then the assistant professor, gave me the opportunity to work directly with students, help in planning their research, and diploma theses. In the 2015/2016 and 2016/2017 I was a supervisor of **two bachelor theses**. In 2017, I also **promoted two masters**. Currently, I am the supervisor of three students preparing their master's theses and six students preparing bachelor's thesis at the Laboratory of Marine Plant Ecophysiology. It is worth emphasizing here that one of my students, before graduating from the master's studies, has twice received the **Scholarship of the Minister of Science and Higher Education** for outstanding scientific achievements.

	SUPERVISOR OF MASTER THESIS
1.	2015/2017 - Amanda Sobczyk – "The influence of allelopathic effects of picocyanobacteria *Synechococcus* sp. on selected Baltic microalgae and meroplankton species".
2.	2015/2017 - Marzena Płatek – "The influence of selected environmental factors on the bioluminescence of heterotrophic bacteria". Second supervisor – professor Agata Weydmann (University of Gdansk).
3.	2017/2019 - Zofia Konarzewska – "Determination and comparison of allelopathic effects of three strains of picocyanobacteria *Synechococcus* sp. on selected cyanobacteria, green algae and diatoms species". Second supervisor – dr Aldo Barreiro Felpeto (University of Porto)
4.	2017/2019 - Grzegorz Wolff – "The influence of allelopathic effects of *Synechococcus* sp. on natural phytoplankton communities".
5.	2018/2020 - Gracjana Budzałek – "The allelopathic effect of macroalgae on selected cyanobacteria".
	SUPERVISOR OF BACHELOR THESIS
1.	2015/2016 - Jakub Maculewicz – „The influence of allelopathic effects of *Synechococcus* sp. on selected cyanobacteria from the genus *Aphanizomenon*, *Nostoc*, Phormidium, and *Rivularia*".
2.	2016/2017 - Arkadiusz Knitter – „The use of flow cytometry to determine the allelopathic effect of picoplanktonic cyanobacteria in monocultures and mixed cultures".
3.	2018/2019 - Patryk Korneluk – „The effect of allelopathic compounds of cyanobacteria and microalgae on heterotrophic bacteria and the possibility of their practical use".
4.	2018/2019 - Aleksandra Górna- „The use of macroalgae in industry and medicine".
5.	2018/2019 - Ewelina Chylewska – „Allelopathic compounds of cyanobacteria used in the pharmaceutical and medical industries".
6.	2018/2019 - Magdalena Frelich – „The impact of climate change on the occurrence of cyanobacterial blooms".
7.	2018/2019 - Marta Górczak – „ Potential use of microalgae in the pharmaceutical and medical industries".
8.	2018/2019 - Patrycja Szwedowska – „Possibility of practical use of cyanobacterial secondary metabolites in biotechnology".

Since 2014, I have also provided scientific supervision over **two high school students** from III Liceum Ogolnoksztalcace im. Marynarki Wojennej in Gdynia, during the **Biological Olympiad** and the **Scientific Competition E(x)plory**. It is worth emphasizing here that the work of the one high school student, Kinga Gergella, was awarded on the XLIV Biology Olympiad. Moreover, during the Special Edition of Scientific Competition E(x)plory in Warsaw, her work won at the final stage of elimination. In turn, the work of the second high school student, Daria Cisło, was awarded on the National Final of the Scientific Competition E(x)plory 2017 in Gdynia. It is worth mention here that I also attended at the Academic Tutors course at Collegium Wratislaviense, after which in 2013 I obtained the title: **Academic Tutor - 1st degree**. For several years I have been taking part in the Professional Academic Tutoring System for students at the Faculty of Oceanography and Geography, University of Gdansk titled **"TUTOR-WOIG"**.

	OTHER DIDACTIC ACTIVITY
1.	01.07-01.10.2013 - participation in the Collegium Wratislaviense Academic Tutor training and obtaining the title Academic Tutor - 1st degree.
2.	2014/2015 - scientific supervision over high school student Kinga Gergella from III Liceum Ogolnoksztalcace im. Marynarki Wojennej in Gdynia, during the Biological Olympiad and the Scientific Competition E(x)plory. The title of the work "Allelopathic effect of cyanobacteria *Synechococcus* sp. on selected species of microalgae and cyanobacteria". Work awarded at the regional elimination stage.
3.	2015/2016 - scientific supervision over high school student Kinga Gergella from III Liceum Ogolnoksztalcace im. Marynarki Wojennej in Gdynia, during the Biological Olympiad and the Scientific Competition E(x)plory. The title of the work „The phenomenon of the influence of allelopathic cyanobacteria *Synechococcus* sp. on selected species of Baltic cyanobacteria". Work awarded at the nationwide elimination stage.
4.	02.12.2015 - scientific supervision over high school student Kinga Gergella from III Liceum Ogolnoksztalcace im. Marynarki Wojennej in Gdynia, during the Special Edition of Scientific Competition E(x)plory in Warsaw, Poland. Work awarded at the final stage of elimination.
5.	2016/2017 - scientific supervision over high school student Daria Cisło from III Liceum Ogolnoksztalcace im. Marynarki Wojennej in Gdynia, during the Biological Olympiad and the Scientific Competition E(x)plory. The title of the work „The allelopathic effect of picocyanobacteria *Synechocystis* sp. in the aquatic environment". Work awarded at the second stage of elimination.
6.	18-20.10.2017 - scientific supervision over high school student Daria Cisło from III Liceum Ogolnoksztalcace im. Marynarki Wojennej in Gdynia, during the National Final of the Scientific Competition E(x)plory 2017 in Gdynia. The title of the work „The allelopathic effect of picocyanobacteria *Synechocystis* sp. in the aquatic environment". Work awarded at the final elimination stage.
7.	2015 - 2019 - participation in the Professional Academic Tutoring System for students at the Faculty of Oceanography and Geography, University of Gdansk "TUTOR-WOIG", Gdynia, Poland.

I have also organizing and popularizing achievements. For many years I participated in the organization of the **"Baltic Festival"**, the **"Science Picnics"**, and the **"Targi Akademia"** events. I was also a co-organizer of the **"Oceanographic Picnic: Sea Festival 2016"** and the **"Open Information and Adaptive Day IOUG"** events. I also represented the Institute of Oceanography at the University of Gdansk on several events organized by the **Experyment Science Center** (e.g., "Dive in the Baltic Sea" and "Recipe for a good form").

	ORGANIZING AND POPULARIZING ACHIEVEMENTS
1.	30.05.2010 - organization and participation in VIII Baltic Festival of Science event „The use of algae and cyanobacteria in everyday life".
2.	21-23.03.2011 - participation in "Targi Akademia" event, University of Gdansk.
3.	29.05.2011 - organization and participation in IX Baltic Festival of Science event „Check to see what they can do! The amazing world of Baltic algae and cyanobacteria"
4.	25.05.2012 - organization and participation in X Baltic Festival of Science event „Oceanographic trips".
5.	27.05.2012 - organization and participation in X Baltic Festival of Science event „Catch the algae!".
6.	20.03.2013 - participation in "Targi Akademia" event, Institute of Oceanography, University of Gdansk.
7.	26.05.2013 - organization and participation in X Baltic Festival of Science event „Algae and cyanobacteria in the sea, food and cosmetics".
8.	21-22.03.2016 - participation in "Targi Akademia" event, Institute of Oceanography, University of Gdansk.
9.	25.06.16 - organization and participation in "Oceanographic Picnic: Sea Festival 2016" event, Institute of Oceanography, University of Gdansk.
10.	06-07.08.2016 - organization and participation in Experyment Science Center, "Dive in the Baltic Sea" event, Gdynia, Poland.
11.	27.10.2017 - organization and participation in "Open Information and Adaptive Day IOUG" event, Institute of Oceanography, University of Gdansk.
12.	27.10.2017 - organization and participation in Experyment Science Center, "Recipe for a good form" event, Gdynia, Poland.
13.	Cieszyńska A., Stramska M., Śliwińska-Wilczewska S. 2017. The terminator is in cyanobacteria. Baltic Sea under the microscope. Part 2. [in Polish]. Econatura. *(publication)*
14.	Cieszyńska A., Śliwińska-Wilczewska S., Marks R., Wereszka M. 2017. Baltic Sea under the microscope. Part 3. Can the seas be fertile? [in Polish]. Econatura. *(publication)*

Between 2007 and 2017, I organized and participated in scientific expeditions to research centers in **Iceland**, **Morocco**, **Turkey**, **Syria** and **Montenegro**. My duties included planning the trip, preparing the schedule, providing transport and accommodation to participants, as well as conducting settlements and preparing invoices upon return. In 2016, I attended in the **Scientific Committee** work during the national conference - New challenges for Polish Science, and I was a reviewer of projects submitted under the **28th European Union Contest for Young Scientists (EUCYS)**. At the end I would like to add that I am a co-author of **two publications**, published in the Econatura journal, one of the Editors of the scientific journal for students: **"Tutoring Gedanensis"** and I am entering into a Review Committee of **Annales Universitatis Paedagogicae Cracoviensis Studia Naturae** journal.

	OTHER ACTIVITY
1.	12.06-17.07.2007 - organization and participation in science expedition to Iceland, Reykjavík University and Sandgerdi Marine Centre (SMC).
2.	07-28.02. 2008 - organization and participation in science expedition to Morocco, Rabat University.
3.	03-15.05.2010 - organization and participation in science expedition to Turkey, Middle East Technical University, Institute of Marine Sciences.
4.	10-26.04.2011 - organization and participation in science expedition to Syria.
5.	24.02.2016 - reviewer of scientific project: "European Union Contest for Young Scientists (EUCYS)".
6.	03.04.2016 - participation in the Scientific Committee: „New challenges for Polish Science".
7.	since 2016 - participation in the Editorial Committee of „Tutoring Gedanensis" journal.
8.	09-19.06.2017 - organization and participation in science expedition to Montenegro.
9.	since 2017 - participation in the Review Committee of „Annales Universitatis Paedagogicae Cracoviensis Studia Naturae" journal.

Summary

In summary, my scientific achievements include **15 papers** published in English (of which **14** after obtaining the doctoral degree), in journals indexed by the Philadelphia Institute of Scientific Information, so-called Philadelphia List or List A of Ministry of Science and Higher Education (after which I obtained **455 points**). In addition, I am the co-author of **12 papers** on List B of the Ministry of Science and Higher Education (after which I obtained **103 points**) and **23 chapters**. My work includes also **2 books** of which I am the first author. My **Hirsh index** is **6** (**4** excluding self-citations), and according to the Web of Science database my work has been cited **84 times**. The total Impact Factor of the above publications, according to the Journal Citation Reports (JCR) list, according to the year of publication, is **33.469**, and my 5-year Impact Factor is **37.021**.

The results of my research I presented at numerous conferences, both national and international, being the author or co-author of a total of **76 oral presentations or posters**. I was also the **Principal Investigator of 9 scientific projects**, including the grant of the **Ministry of Science and Higher Education (MNiSW) and the National Science Center (NCN, PRELUDIUM)**, all of which concerned the role of picocyanobacteria in aquatic ecosystems.

I am also a laureate of several **awards and scholarships**. In 2015, the Council of the Faculty of Oceanography and Geography **awarded me for a distinguished doctoral dissertation**, which resulted in the publication in the form of a scientific book. I also received the **award from the Dean of the Faculty of Oceanography and Geography, University of Gdansk** for scientific and research achievements and especially valuable scientific publications in 2017. In addition, I received several awards, including Scholarship project "Development of the University of Gdansk in the areas of Europe 2020 (UG 2020)", task no. 4 "Scholarship support for Ph.D students and young doctors of the University of Gdansk", the **Minister of Science and Higher Education Scholarship** in 2013 for outstanding scientific achievements, and the **Minister of Science and Higher Education Scholarship** in 2018 for outstanding scientific achievements for scientists with doctor degree.

During my career at the University of Gdansk, I obtained the title of **GIS Analyst**, **Academic Tutor - 1st degree**, **Laboratory Auditor, ISO 17025:2005**, as well as I passed an external exam confirming my professional qualifications in the **IT profession**. I have established cooperation with foreign centers, including **Interdisciplinary Center of Marine and Environmental Research–CIMAR/CIIMAR** and **University of Porto**. I have also actively participated in courses, scientific trainings, and taken part in didactic and organizational activities, as well as events aimed at popularizing science.

Planned future research

Currently I am implementing a research work focusing on the recognition of the spatial and seasonal occurrence of various phenotypes of picocyanobacteria in the Baltic Sea region. Picocyanobacteria, despite their widespread presence in the aquatic environment, still remain a group of poorly understood organisms. Picoplanktonic cyanobacteria constitute an important element of the trophic network, account for a large part of biomass and oxygen production, are capable of creating massive blooms and production of harmful secondary metabolites. Therefore, understanding the ecophysiology of different picocyanobacteria is a current issue in order to better understand the functioning of aquatic environments.

I am planning to carry out research work using the catamaran "Oceanograf" and the recently purchased Becton Dickinson flow cytometer (BD Biosciences, FACS Jazz). I am assisted in this task by scientific team from Interdisciplinary Center of Marine and Environmental Research–CIMAR/CIIMAR and University of Porto and one master student from University of Gdansk. I estimate that it will result in several publications in high-impact journals.

Sylwia Śliwińska-Wilczewska