This doctoral dissertation investigates the role allelopathic properties of three dominant *Synechococcus* sp. phenotypes in shaping the diversity of phytoplankton communities. The study focuses on picocyanobacteria from the genus *Synechococcus* and microalgae isolated from the coastal waters of the Gulf of Gdańsk. The methodological approach combines laboratory experiments and ecological modeling to examine the allelopathic effects of *Synechococcus* sp. phenotypes on phytoplankton community structure. Initially, short-term allelopathic assays were conducted under various abiotic conditions to assess the influence of environmental factors on the allelopathic activity of co-occurring phenotypes. Subsequently, a screening of allelopathic activity against co-occurring phytoplankton species was performed. Once these basic grounds were set, we tested the effect of allelopathy in long-term competition experiments that were conducted with *Synechococcus* and a selected group of coexisting phytoplankton species, also developing a mechanistic model to assess whether allelopathy and nutrient competition drive species dynamics. Finally, in a further step to upscale complexity, we tested whether *Synechococcus* sp. allelopathy can act as a key factor in structuring natural phytoplankton communities driven to equilibrium in the laboratory.

To achieve this aim, the following hypotheses were formulated:

H1 Abiotic factors that promote the growth of *Synechococcus* phenotypes enhance their allelopathic activity.

H2 Allelopathy exhibited by different *Synechococcus* phenotypes affect co-occurring phytoplankton species. The allelopathic effect is different depending on the *Synechococcus* phenotype, and target phytoplankton species.

H3 The strength of allelopathy from *Synechococcus* phenotypes influences plankton community diversity: Low allelopathic strength is associated with lower diversity due to dominance by strongest competitors. Intermediate allelopathic intensity increases community diversity due to coexistence between allelopathic weak competitors and sensitive stronger competitors. High allelopathic intensity reduces diversity due to dominance by *Synechococcus* phenotypes.

Based on formulated hypotheses the main conclusions of the thesis include:

- The abiotic factors that enhance the growth of the studied *Synechococcus* phenotypes also increase their allelopathic activity. However, optimal salinity does not always have the same effect, with moderate salinity (8 PSU) intensifying interspecific interactions. This salinity was related to their place of origin.
- The allelopathic effect varied depending on the *Synechococcus* phenotype and the target phytoplankton species. Both positive and negative allelopathic effects were observed. *Synechococcus* Type 3a exhibited the strongest allelopathic activity, while the diatoms showed the most sensitive among the studied species.
- Allelopathy in interplay with competition for a limiting resource (nitrate) promoted oscillatory coexistence of four selected phytoplankton species. However, the initial strength of allelopathy did not influence the outcome of competition experiments.

- The allelopathy of *Synechococcus* was shown to enhance the diversity of natural phytoplankton communities driven to equilibrium in long-term experiments only for the Type 1 (BA-124). This indicates that, given equal inoculum sizes, Type 1 was more allelopathic than Type 3a (BA-132) on a per-cell basis.