Study on marine microbial ecology in the Arctic — From the picoeukaryotic aspect

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2019-9-22
Introduction

- Picophytoplankton in the Central Arctic Ocean
  - Physicochemical factors
  - Abundance and community structure of picophytoplankton
  - Environmental correlations of picophytoplankton community

- Picoeukaryotes in the southern Chukchi Sea
  - Community structure in midsummer
  - Community structure in early autumn
  - Environmental correlations of picoeukaryotes community
Why picoeukaryotes?

- Picoeukaryotes are vital to polar marine ecosystems, as they dominate the photosynthetic biomass throughout much of the year.
- They feature both abundant and diverse heterotrophic populations.
- The heterotrophic fractions are also very important for carbon flows and nutrient remineralization.
• The Arctic is warming much faster than are other regions
• Temperature, salinity, and nutrient levels in seawater are altered, transformations in global circulation may also be changed
• Picoeukaryotes are sensitive to these changes
• It is imperative to gain a better understanding of picoeukaryote community composition and diversity, as well as the extent to which physicochemical factors influence the microbial community.
Picophytoplankton in the Central Arctic Ocean
Background

- Sea ice melts drastically at the polar region, both irradiance and fresh water increase along with this change;
- Fresh water increase will induce strong halocline and hinder the replenishment of nutrients from the deep water column.
Study area & Sampling sites

Zhang et al. 2015 《Polar Biology》
Environmental parameters, Chlorophyll a concentrations, and picophytoplankton abundance at each sampling station

<table>
<thead>
<tr>
<th>Station</th>
<th>Longitude (°W)</th>
<th>Latitude (°N)</th>
<th>Ice cover (%)</th>
<th>Temperature (°C)</th>
<th>Salinity (psu)</th>
<th>P (μmol L⁻¹)</th>
<th>NO₂⁺NO₃ (μmol L⁻¹)</th>
<th>Si (μmol L⁻¹)</th>
<th>Chl a (μg L⁻¹)</th>
<th>Picophytoplankton abundance (×10⁴ cells L⁻¹)</th>
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<td>NP01</td>
<td>164.64</td>
<td>84.17</td>
<td>60</td>
<td>-0.6</td>
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<td>85.48</td>
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<td>-0.7</td>
<td>30.1</td>
<td>0.46</td>
<td>-</td>
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<td>0.186</td>
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<td>-</td>
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<td>29.7</td>
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</table>
Composition of picophytoplankton community determined by HPLC pigment and CHEMTEX
Community composition at genus level obtained by pyrosequencing

- Prasinophytes were mainly composed of *Pyramimonas* and *Micromonas*.
- Diatoms were mainly composed of *Chaetoceros*, *Thalassiosira*, *Actinocyclus*, *Pleurosigma* and *Navicula* with *Chaetoceros* as dominant genus.
- Haptophytes were composed of *Prymnesiales*, *Chromulinales*, and *Ochromonadales* with *Phaeocystis* as the dominant genus.
- *Gyrodinium* and *Gymnodinium* were the main genera composing dinoflagellates.
Picophytoplankton phylotype relationships in an ordination diagram of physiochemical factors

salinity > latitude > temperature
> ice coverage > silicate > phosphorous > nitrogen
Conclusion

- The dominance of picophytoplankton in the phytoplankton population will increase.
- The total amount of Chl a would decrease along with the melting; this decrease trend would be weaker closer to the North Pole.
Picoeukaryotes in the southern Chukchi Sea
Study area & Sampling sites

Zhang et al. unpubl. data
Temperature and Salinity

July T: -0.47 °C to 6.73 °C; S: 31.05 to 32.77 Water mass: BSW
Sep. T: -0.64 °C to 7.21 °C; S: 27.46 to 33.17 Water mass: ACW
(0-10 m) & BSW (>10 m)
pH, DO, Chl a and macronutrients in July
pH, DO, Chl $\alpha$ and macronutrients in September
pH, DO, and macronutrients in September
Venn diagram for OTUs in different water masses
Main classes in different water masses

![Bar chart showing reads contribution to the picoeukaryote library for different water masses (ACW-S, BSW-S, BSW-J) across picoeukaryote classes.](chart)

- Trebouxiophyceae: 16.2%, 7.8%, 6.1%, 6.4%, 2.0%, 2.9%, 0.5%, 0.5%, 0.8%, 0.8%, 0.8%, 0.6%, 0.6%, 0.8%, 0.5%
- Dinophyceae: 4.6%, 6.4%, 5.3%, 2.9%, 0.5%, 0.8%, 0.8%, 0.8%, 3.1%, 3.1%, 3.1%, 3.1%, 1.6%, 0.5%
- Prasinophyceae: 6.4%, 7.8%, 2.9%, 0.5%, 0.8%, 0.8%, 3.1%, 3.1%, 1.6%, 0.5%
- Choanoflagellata: 7.4%, 0.5%, 0.8%, 0.8%, 3.1%, 1.6%, 0.5%
- Chrysophyceae: 6.8%, 0.5%, 0.5%, 0.8%, 0.8%, 0.8%, 0.8%
- Bolidophyceae: 6.3%, 3.1%, 1.6%, 0.5%
- Teonema: 0.5%, 0.5%, 0.5%
- Dictyochophyceae: 0.5%, 0.5%
- Spirorichea: 0.5%
- Mamiellophyceae: 42.3%, 48.3%

Picoeukaryote classes

Reads contribution to the picoeukaryote library
Main genera in different water masses
Picoeukaryote community relationships in an ordination diagram of physiochemical factors

July

nitrogen > phosphate > Chl a > salinity > pH > DO > temperature > silicate
September

DO > temperature > Chl a > silicate > salinity > nitrogen > phosphate > pH
Discussion and Conclusion

- The Chukchi Sea is one of most N-limiting area in the global ocean and severely N-limited during the phytoplankton growth season.
- Diatom blooming inhibited the growth of Mamiellophyceae, which would be more abundant in a postbloom situation.
- The diatom blooming exhausted silicate, whereas relatively high nitrogen and phosphate were still detected.
- These nutrients could still support the growth of other picophytoplankton but Mamiellophyceae, i.e., Trebouxiophyceae and Chrysophyceae.
The increase of contributions of picophytoplankton to total sequencing libraries of the picoeukaryotic community (70.7% : 83.8%), and the increases of both pico-fraction to the total Chl a (38% : 53%) and the abundance of picophytoplankton (2.09 : 8.76 $\times 10^6$ cells L-1), along with decrease of total Chl a (3.06 : 1.08 $\mu$g L-1) and nutrients supplement in September, does not hold the classical assumption that larger phytoplankton would be associated with higher nutrient levels and higher biomass.
As in other oceanic waters, the picoleukaryotic community has distinct compositions and diversities at different water masses in the southern Chuckchi Sea.

- Some species in Trebouxiophyceae and Bathycoccus (Mamiellophyceae) were likely carried by the ACW.
- Prasinoderma (Prasinophyceae), Bolidomonas (Bolidophyceae), Diaphanoeca (Choanoflagellatea) and some species in Chrysophyceae, Dictyochophyceae and Spirotrichea were brought by the BSW.
The abundance of picophytoplankton in the southern Chukchi Sea in 2012 (July: $2.09 \times 10^6$, Sep.: $8.76$ cells L$^{-1}$) was slightly higher than that in 2008 (July: $1.00 \times 10^6$ cells L$^{-1}$) and comparable to that in the Northern Bering Sea in 2008 (July: $3.48 \times 10^6$ cells L$^{-1}$) and the central Arctic Ocean in 2010 (August: $4.97 \times 10^6$ cells L$^{-1}$)

The picoeukaryote community composition in the southern Chukchi Sea is different from those in both the Central Arctic Ocean and European polar Seas
Publications

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Thanks for your attention!