About the mechanism of the winter-spring phytoplankton bloom in Peter the Great Bay (Sea of Japan)

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Composite distribution of chlorophyll-a concentration in Sea of Japan (the left) for the period of March 5-12, 2000 and bathymetric map of Peter the Great Bay (the right). The location of Peter the Great Bay is shown and locations for analysis of chlorophyll-a concentration.
According to 8-day (“week”) composite data we distinguished 2 basic zones of phytoplankton bloom: 1) coastal and 2) the zone of the Primorye Current. In zone 1, the Cchl-a maximum was observed in February - March, and in zone 2 - in April-May.

Variation of satellite 8-days (“week”) chlorophyll-a concentration (Cchl-a, mg/m³), averaged for Peter the Great Bay, from 1st to 19th “week” (week 1 is the period of January 1-8 and week 19 – May 24-31 for leap year and May 25 - June 01 for none leap year).

Distributions of Cchl-a for “week” 8 (top panel) and “week” 14 (bottom panel) of 2001
Characteristics of phytoplankton bloom in zones 1 and 2

<table>
<thead>
<tr>
<th></th>
<th>Zone 1</th>
<th>Zone 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of the Cchl-a maximum</td>
<td>February-March</td>
<td>April-May</td>
</tr>
<tr>
<td>Sea Surface Temperature, °C</td>
<td>(-1)-1</td>
<td>2-6</td>
</tr>
<tr>
<td>Wind Speed, m/s</td>
<td>6-8</td>
<td>3-6</td>
</tr>
<tr>
<td>Photosynthetically Available Radiation, Einsteins/m²×day</td>
<td>15-40</td>
<td>25-50</td>
</tr>
</tbody>
</table>

The goal of this work is to identify the mechanisms leading to phytoplankton blooms in these zones.
Data

**Satellite data**
A series of 8-day ("week") composite estimates on Chlorophyll-a concentration (Cchl-a), Photosynthetically Available Radiation (FAR) from SeaWiFS (OrbView-2) color scanner, Sea Surface Temperature (SST) from MODIS (Aqua) for January - May, 2003-2007 and MODIS (Terra) for January - May, 2000-2002, Near-Surface Wind Speed (obtained as 1-day data and composed to 8-day estimates) from QuikSCAT satellite.

**Ship data**
Profiles of the water temperature and salinity, which were obtained during cruises of R/V “Lugovoye” (March 3-12, 2000) and “Akademik M.A. Lavrentiev” (February 26-March 9, 2003). Data for construction of these profiles were taken from the electronic archive of POI FEB RAS cruise observations.

**Acknowledgements**
We thank NASA/DAAC, Remote Sensing Systems Group for satellite data and distributions.
Value of 10 mg/m$^3$ for Chl-a was considered as the maximum value. However, value to 15 mg/m$^3$ were are taken in attention.
Variation of satellite 8-days ("week") chlorophyll-a concentration (Cchl-a, mg/m$^3$) in zones 1, 2 of Peter the Great Bay from 1st to 19th "week" for 2004-2007 and corresponding values of SST (red line), wind speed (blue line), FAR (yellow line). Values were normalized by maximum value.

Maxima:
- Cchl-a - 10 mg/m$^3$
- SST - 13°C,
- wind speed - 15 m/sec,
- FAR - 60 Einsteins/m$^2$ day.

Value of 10 mg/m$^3$ for Cchl-a was considered as the maximum value. However, value to 15 mg/m$^3$ were are taken in attention.
Scattering diagrams: Cchl-a vs. SST, Cchl-a vs. wind speed (V), Cchl-a vs. FAR in zone 1 from 1st “week” to the chl-a maximum (top panel) and from beginning of the Chl-a increase to its maximum (bottom panel). Below diagrams the data of correlation coefficient (R) and a number of diagram points are presented. Statistical significant correlation coefficients are shown by red color, while the insignificant correlation- by blue color.
Scattering diagrams: Cchl-a vs. SST, Cchl-a vs. wind speed (V), Cchl-a vs. FAR in zone 2 from 1st “week” to the chl-a maximum (top panel) and from beginning of the Chl-a increase to its maximum (bottom panel). Below diagrams the data of correlation coefficient (R) and number of diagram points are presented. Statistical significant correlation coefficients are shown by red color, while the insignificant correlation - by blue color.
Stratification of water in zone 1 at stations, implemented in cruise of R/V “Lugovoye” (March 3-12, 2000): a, b- profiles of the water temperature (°C) and salinity (‰) on stations 9,10,11,12, c-location for scenes of these profiles in temporal course of satellite data, d- location of mentioned above stations in Peter the Great Bay.

Temporal course of Chl-a (mg/m³) and corresponding values of SST (red line), wind speed (blue line), FAR (yellow line), quantity of atmospheric precipitation (violet line).
Stratification of water in zone 1 at stations, implemented in cruise of R/V “Akademik M.A. Lavrentiev” (February 26-March 9, 2003): a, b - profiles of the water temperature (°C) and salinity (‰) on stations 9, 10, 11, 12, c - location for scenes of these profiles in temporal course of satellite data, d - location of mentioned above stations in Peter the Great Bay.

Temporal course of Chl-a (mg/m³) and corresponding values of SST (red line), wind speed (blue line), FAR (yellow line), quantity of atmospheric precipitation (violet line).

Time of implementation of ship stations:

<table>
<thead>
<tr>
<th>Station</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>st.1</td>
<td>2003.02.26</td>
<td>12:32</td>
</tr>
<tr>
<td>st.2</td>
<td>2003.02.26</td>
<td>14:03</td>
</tr>
<tr>
<td>st.3</td>
<td>2003.02.26</td>
<td>15:37</td>
</tr>
<tr>
<td>st.64</td>
<td>2003.03.08</td>
<td>15:54</td>
</tr>
<tr>
<td>st.65</td>
<td>2003.03.08</td>
<td>18:31</td>
</tr>
<tr>
<td>st.66</td>
<td>2003.03.08</td>
<td>20:23</td>
</tr>
</tbody>
</table>

7th week in 2003 is period of 02.18-02.25
8th “week” in 2003 is period of 02.26-03.05
9th “week” in 2003 is period of 03.06-03.13
Comparison of hydrobiological conditions in zone 2 in March of 2000 and 2003: 
a-temporal course of Chl-a, SST, wind speed, FAR; b, c-
profiles of the water temperature (°C) and salinity (‰); 
d-location of ship stations in Peter the Great Bay
Comparison the temperature ( °C) and salinity(‰) profiles between zones 1 and 2 for the late February-early March 2003 according to data of R/V “Akademik M.A. Lavrentiev” . Top panel shows the profiles for zone 1 and bottom panel - for zone 2.
CONCLUSIONS

- The winter-spring phytoplankton bloom begins with the restratification due to the decrease of wind mixing and, for zone 1 - the desalination of the surface layer, for zone 2 - the seasonal warming. However, the desalination of the surface layer also influences the phytoplankton bloom in the zone 2. Increase of FAR favors the chlorophyll-a concentration increase.

- Different timing of the Cchl-a maximum in zones 1 and 2 is determined by the different salinity gradients between the surface and underlying layers.
Thank you for attention