Chlorophyll-a concentration at wind-induced upwelling regions in Peter the Great Bay in 2003-2007

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Scientific background. It is known that high biological productivity is observed in the areas of upwelling. Chlorophyll-a concentration is one of the basic parameters of water bioproduction. Autumn is a favorable season for development of upwelling in Peter the Great Bay. It is why we decided to investigate the chlorophyll-a distribution in Peter the Great Bay in autumn.

Objective of our investigation is to show the features of chlorophyll-a distribution, caused by influence of wind-induced upwelling in Peter the Great Bay.
Data

**Satellite data**
2. Sea Surface Temperature from NOAA and Aqua satellites.

**Meteorological data**
Near-surface wind from WMO (World Meteorological Organization)

**Acknowledgements**
We thank NASA/DAAC, CEARAC, Remote Sensing Systems Group for satellite data and distributions.
Figure 1. Satellite wind distributions averaged for 1 month in the Sea of Japan in the autumn of 2003-2007. Location of Peter the Great Bay is shown by the dark blue rectangle. Arrows on map of Peter the Great Bay mean the wind direction (red arrows) in the co-ordinates system (green arrows).
Figure 2. Location of points, where analysis of wind influence on phytoplankton growth was fulfilled.

Figure 3. Variation of chlorophyll-a concentration (C, mg/m³), upwelling index (M, kg/m sec), velocity (V, m/sec) and direction of wind in 2003 at chosen points in definite days (at 5 points – near north-eastern bay coast (♦) and at 5 -- near western coast of Peter the Great Bay (○)).
Figure 4. Variation of satellite 8-days chlorophyll-a concentration ($C$, mg/m$^3$), averaged for Peter the Great Bay, from August 29 to December 2, 2003-2007.
Figure 5. Variability of chlorophyll-a and SST distributions in Peter the Great Bay in autumn 2003.
Figure 6. Variability of chlorophyll-a and SST distributions in Peter the Great Bay in autumn 2004.
September

October

November

Figure 7. Variability of chlorophyll-a and SST distributions in Peter the Great Bay in autumn 2005.
Figure 8. Variability of chlorophyll-a and SST distributions in Peter the Great Bay in autumn 2006.
Figure 9. Variability of chlorophyll-a and SST distributions in Peter the Great Bay in autumn 2007.
Figure 10. Chlorophyll-a distribution in Peter the Great Bay at the beginning of upwelling (top panel), the maximal appearance of upwelling (middle panel) and the disappearances of upwelling (bottom panel) in 2003-2007.
Figure 11. Chlorophyll-a and SST distribution in Peter the Great Bay at the wind upwelling on November 13, 2007.
Figure 12. Increase of chlorophyll-a concentration during the upwelling events in Peter the Great Bay in 2003 between days: 10.09. and 11.09. (◊), 11.09. and 14.09.(♦), 01.10 and 03.10.(□), 17.10. and 18.10.(▲), 24.10. and 26.10.(×), 04.11. and 05.11.(+), 22.11. and 25.11.(●).

Figure 2. Location of points, where analysis of wind influence on phytoplankton growth was fulfilled.
Figure 13. Influence of a wind on chlorophyll-a distribution in 2007. Distributions of a wind from October to 14, 2007 and below their the corresponding chlorophyll-a distributions. Symbols of m or e in brackets mean the satellite observation of a wind in the morning or in the evening.
Figure 14. Influence of a wind on chlorophyll-a distribution in 2003-2006. Distributions of a wind before the beginning of upwelling and on their right the corresponding SST and chlorophyll-a distributions. Symbols of m or e in brackets mean the satellite observation of a wind in the morning or in the evening.
CONCLUSIONS

-In the late September - the later October the area of the increased chlorophyll-a concentration develops near the north-east coast of Peter the Great Bay. This area extends from the coast offshore towards the deep sea to 30-40 km. The cause of the increased chlorophyll-a concentration is wind upwelling.

-Upwelling characteristics were more strongly pronounced in the early October 2007.

-Increase of chlorophyll-a concentration (biological response on wind influence) begins in 1-2 days at wind blowing with 3.5-4 m/sec velocity.
Thank you for attention