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

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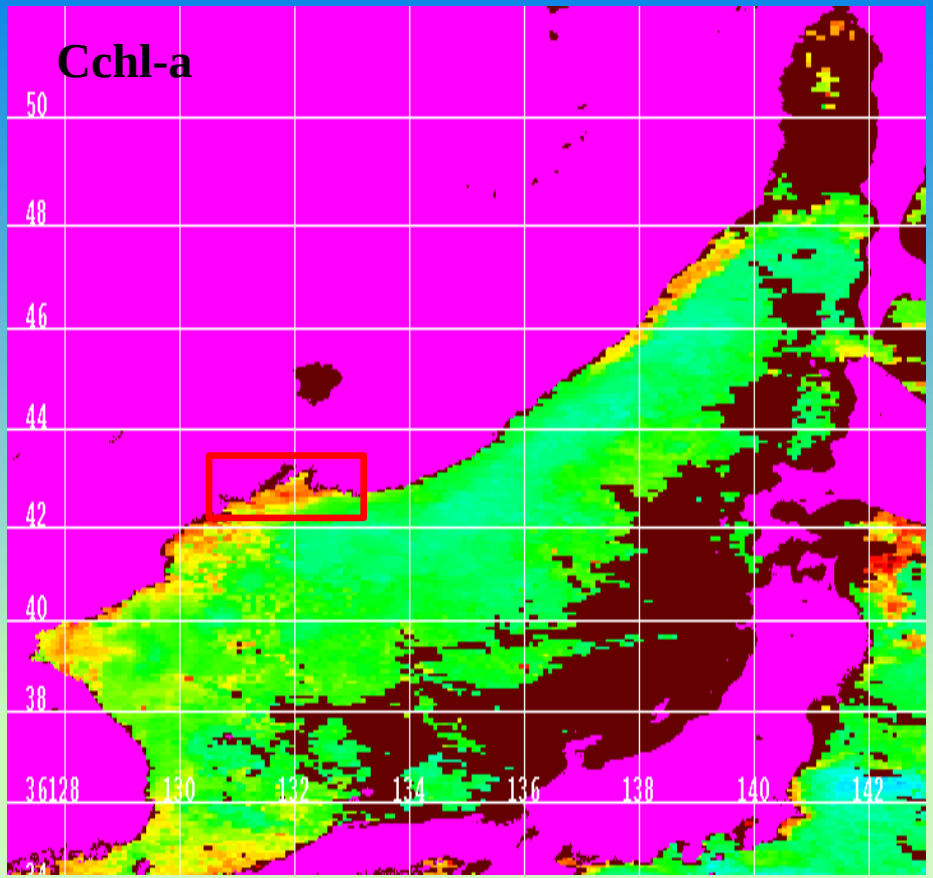
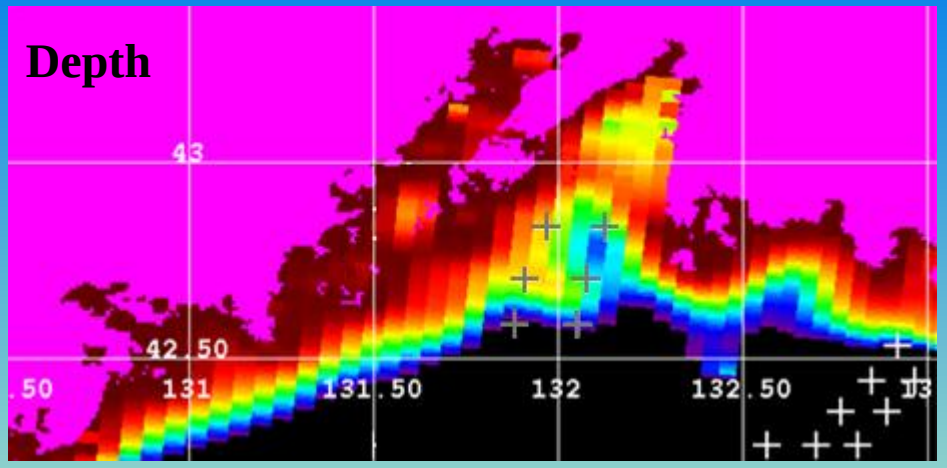


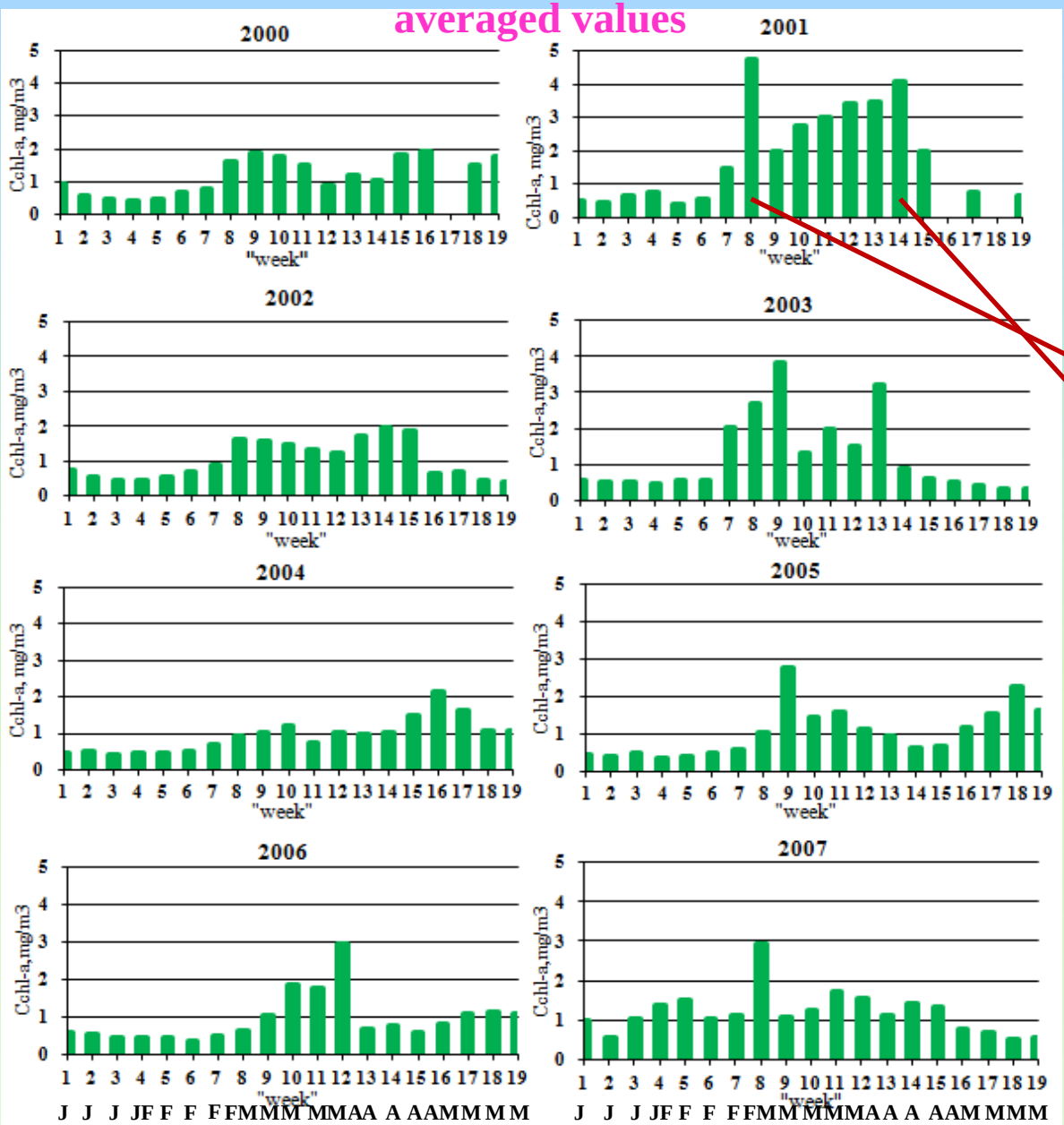


scale for the depth distribution

scale for the Cchl-a distribution

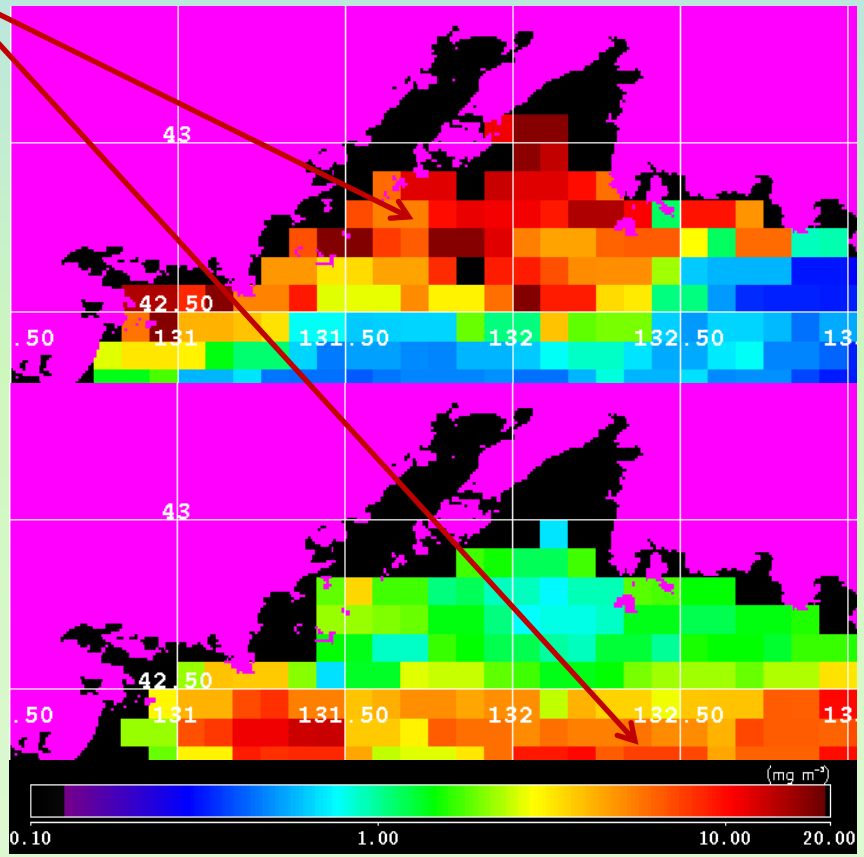
Composite distribution of chlorophyll-a concentration in Sea of Japan (the left) for the period of March 5-12, 2000 and bathymetric map of Peter the Great Bay (the right). The location of Peter the Great Bay is shown and locations for analysis of chlorophyll-a concentration.

averaged values



Variation of satellite 8-days ("week") chlorophyll-a concentration (Cchl-a, mg/m^3), 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).

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.

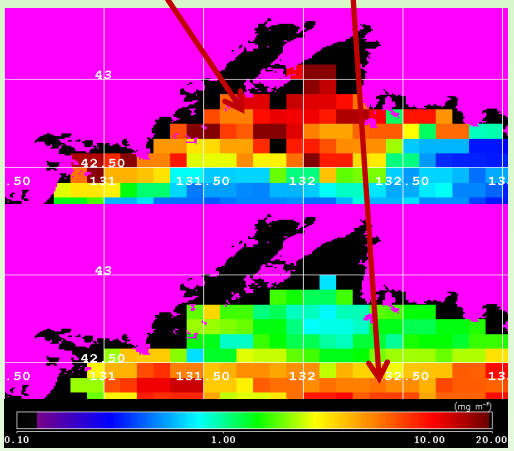


Distributions of Cchl-a for "week" 8 (top panel) and "week" 14 (bottom panel) of 2001

Characteristics of phytoplankton bloom in zones 1 and 2

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

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



Data

Satellite data

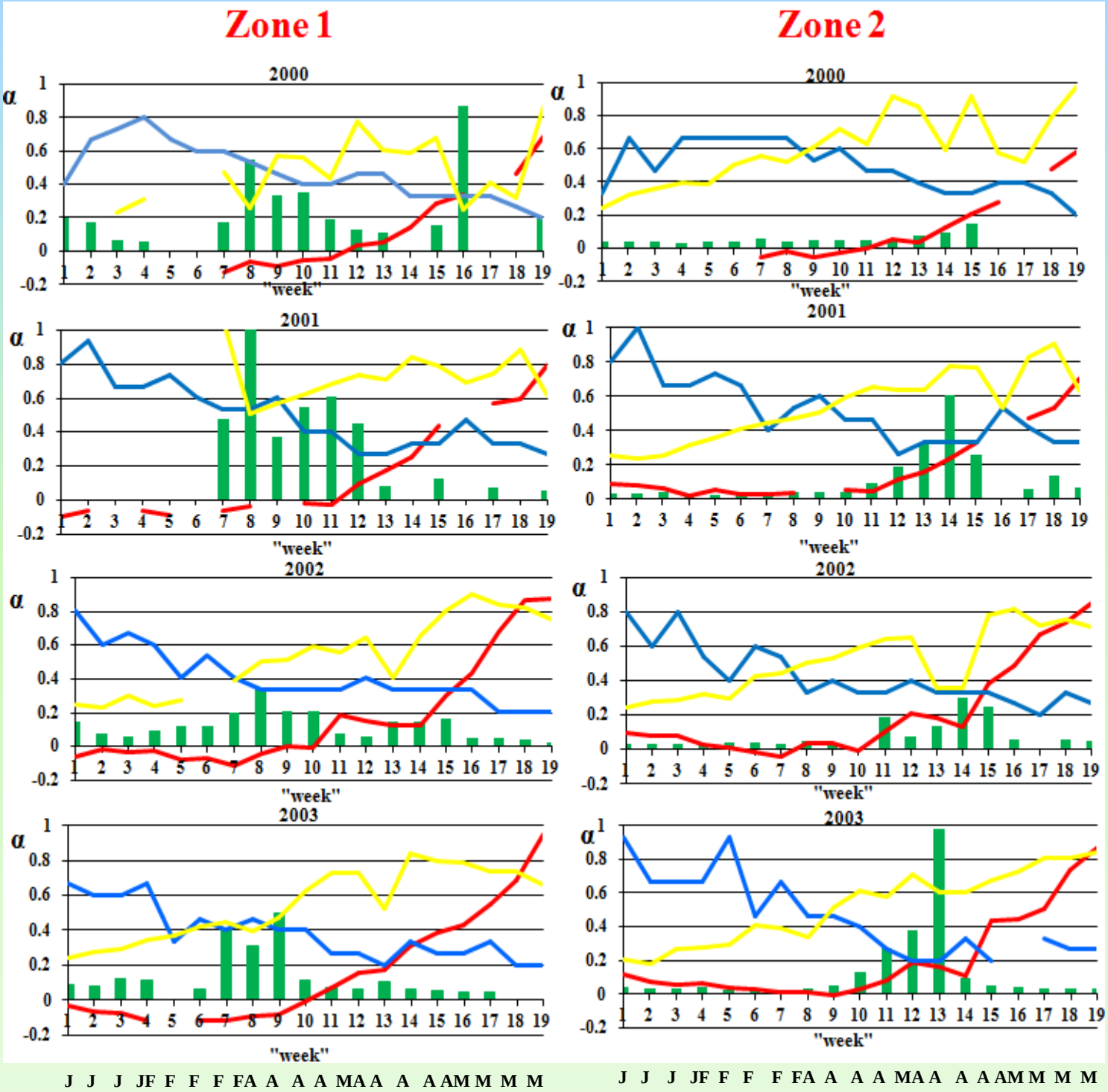
A series of 8-day ("week") composite estimates on Chlorophyll-a concentration (Cchl-a), Photosynthetically Available Radiation (FAR) from SeaWiFS (OrbView-2) color scanner, Sea Surface Temperature (SST) from MODIS (Aqua) for January - May, 2003-2007 and MODIS (Terra) for January - May, 2000-2002, Near-Surface 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.



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:

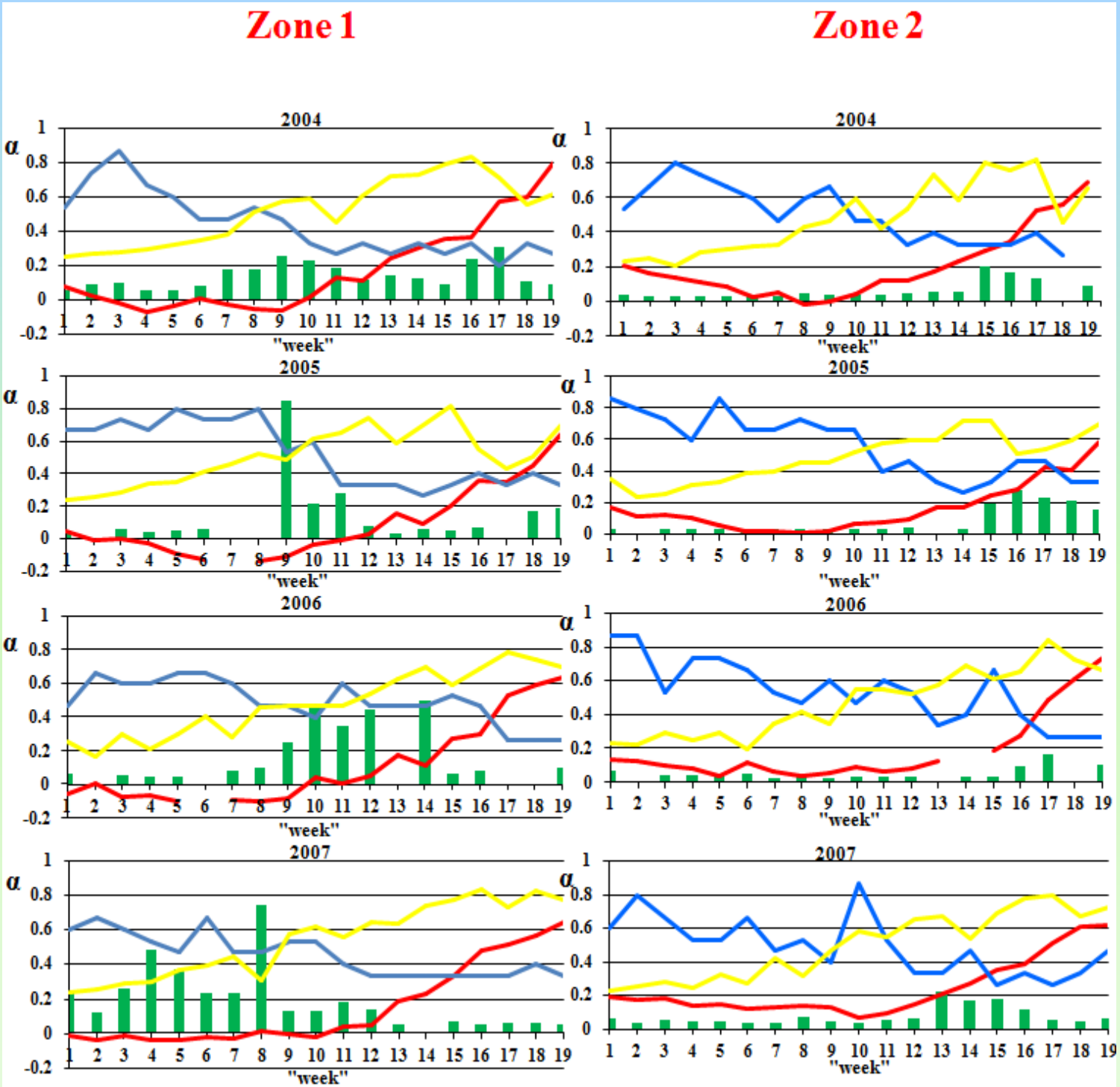
Cchl-a - 10 mg/m^3

SST - 13°C,

wind speed - 15 m/sec,

FAR - 60Einsteins/m^2 day.

Value of 10 mg/m3 for Cchl-a was considered as the maximum value. However, value to 15 mg/m3 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.

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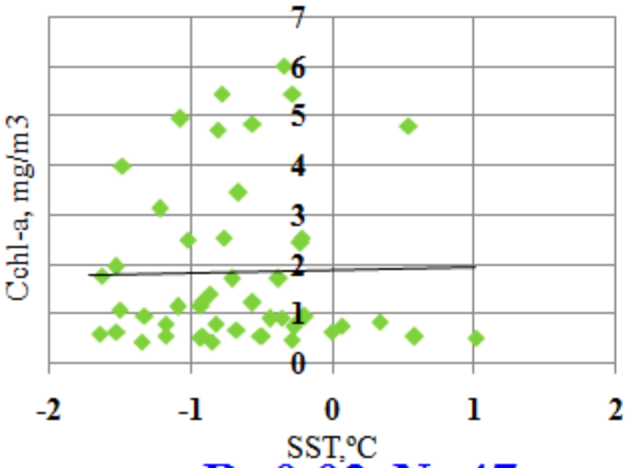
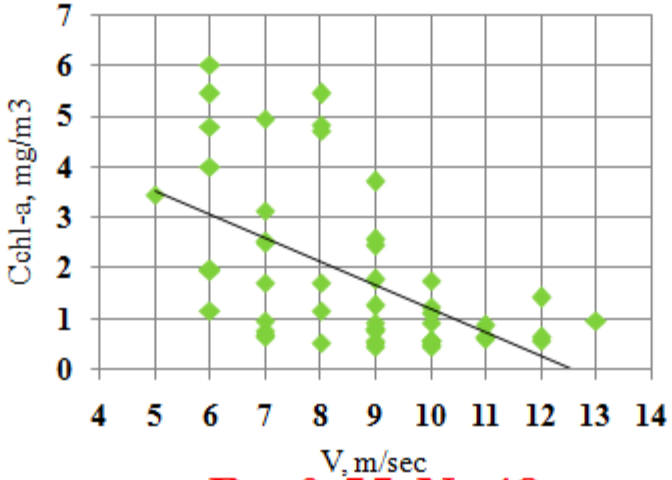
Value of 10 mg/m3 for Cchl-a was considered as the maximum value. However, value to 15 mg/m3 were are taken in attention.

Zone 1

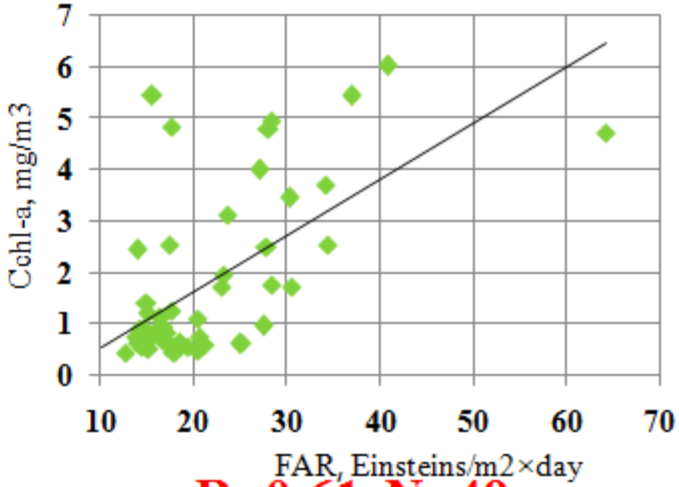


R=0.02, N=47

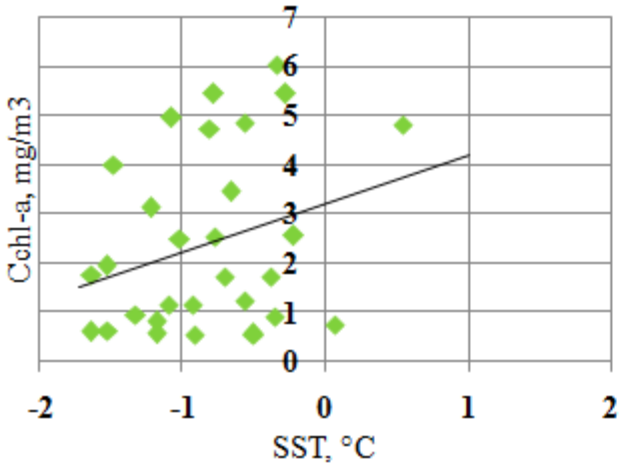
No dependence on temperature



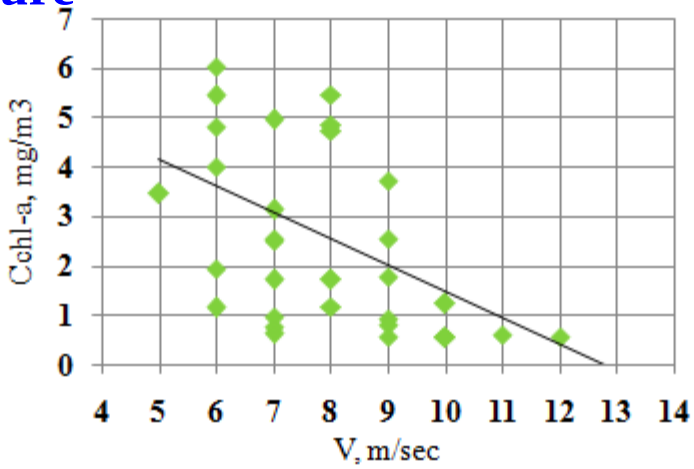
R=-0.55, N=48



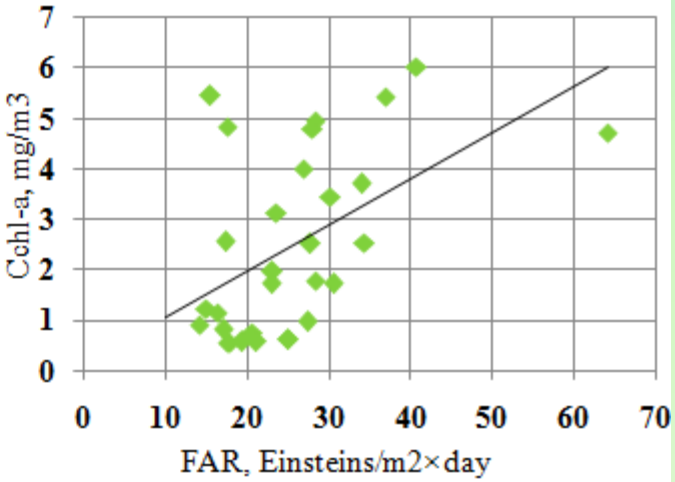
R=0.61, N=49



R=0.28, N=30



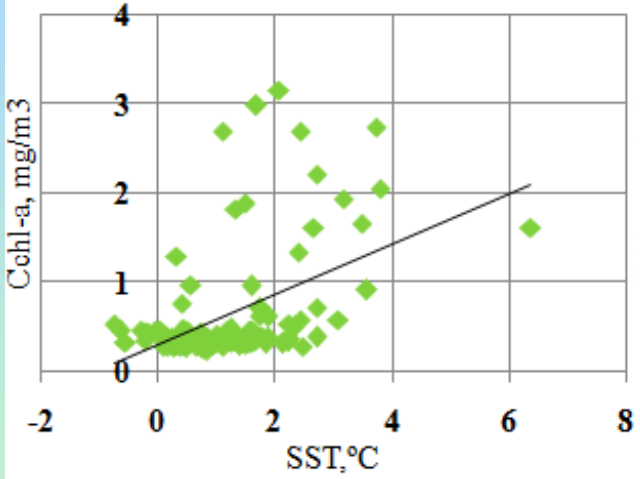
R=-0.43, N=32



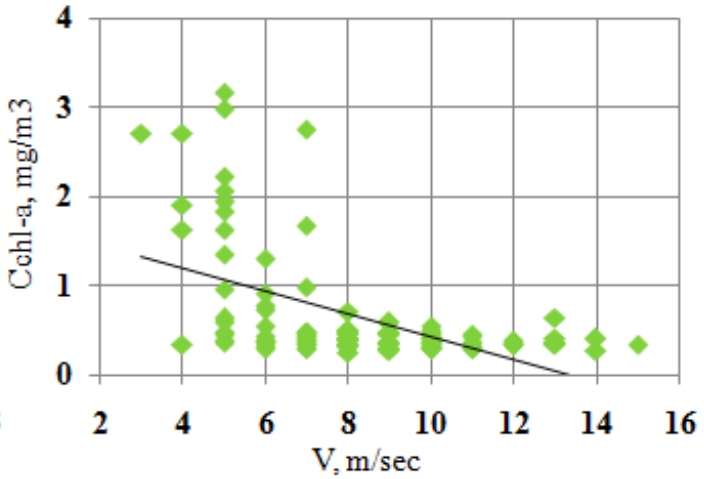
R=0.51, N=30

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.**

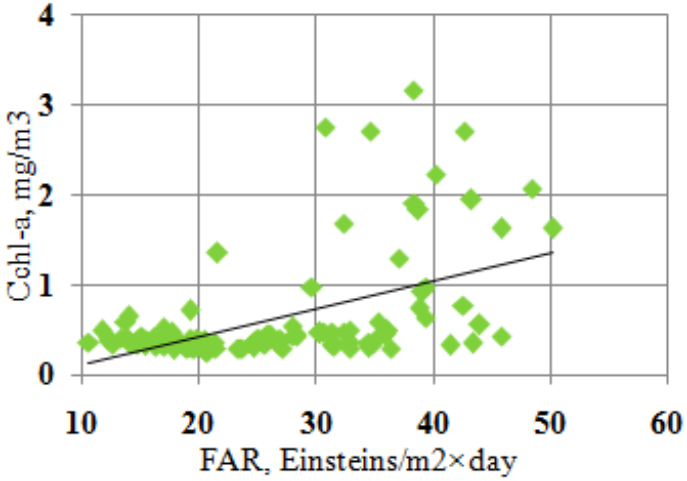
Zone 2



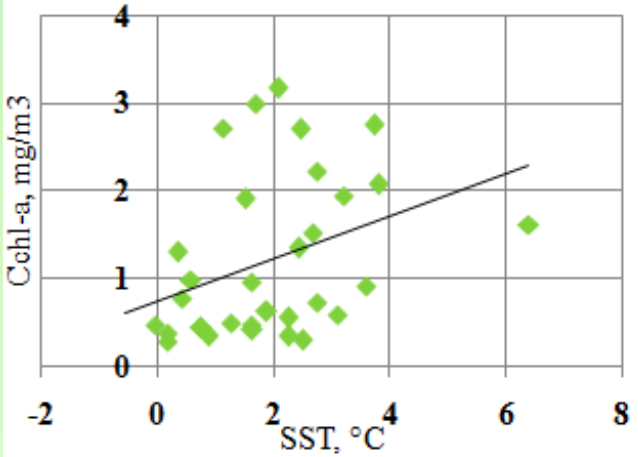
R=0.5, N=106



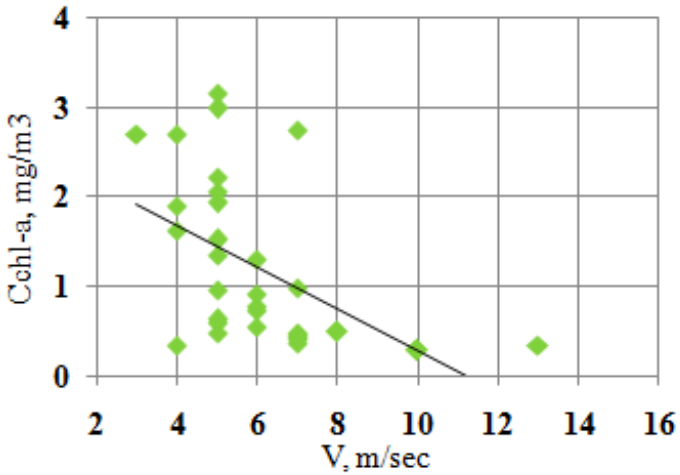
R=-0.54, N=117



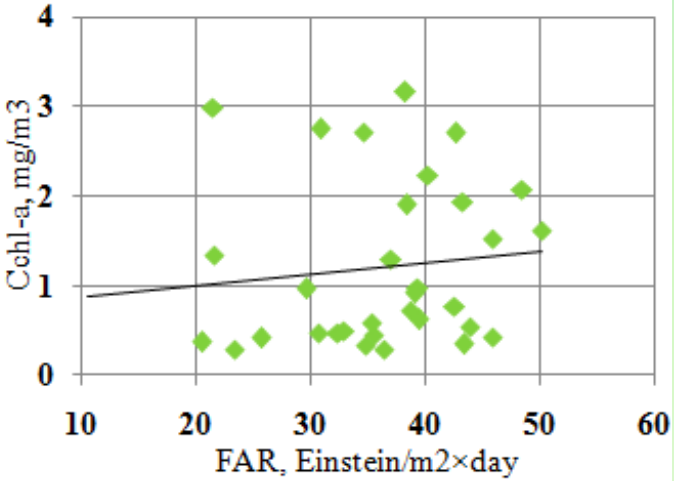
R=0.52, N=116



R=0.36, N=34



R=-0.52, N=34

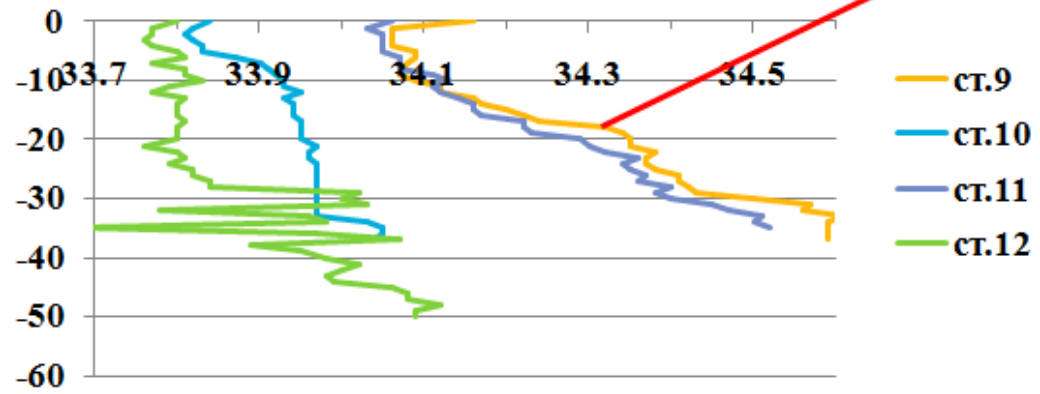


R=0.11, N=34

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.**

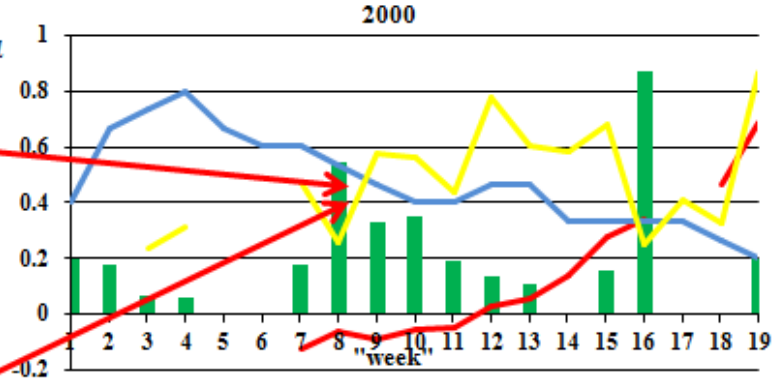
a)

b)



Temporal course of Cchl-a (mg/m^3) and corresponding values of SST (red line), wind speed (blue line), FAR (yellow line). quantity of atmospheric precipitation (violet line)

c)



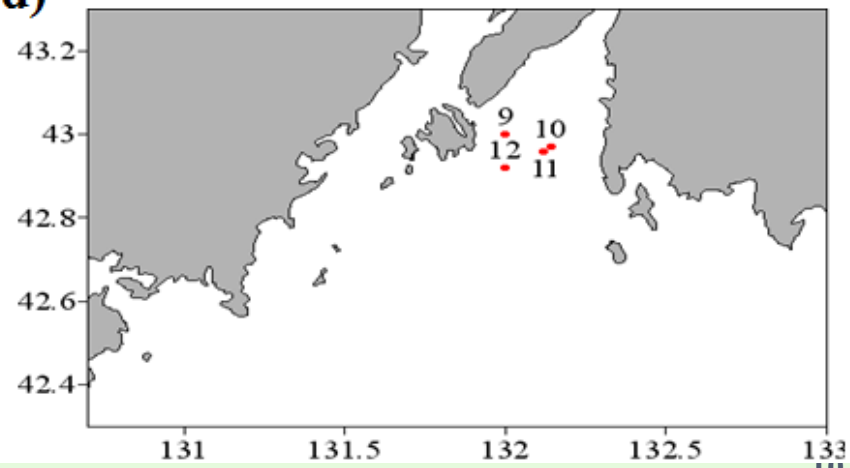
8th "week" in 2000 is period of 02.26-03.04

9th "week" in 2000 is period of 03.05-03.12

Time of implementation of ship stations

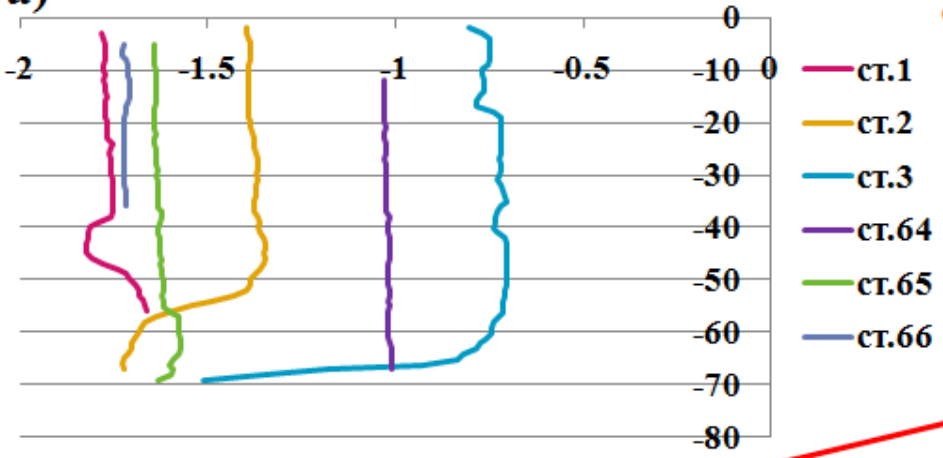
Station	Date	Time
St.9	2000.03.04	23:10
St.10	2000.03.05	0:19
St.11	2000.03.05	1:19
St.12	2000.03.05	1:42

d) Location of stations in Peter the Great Bay

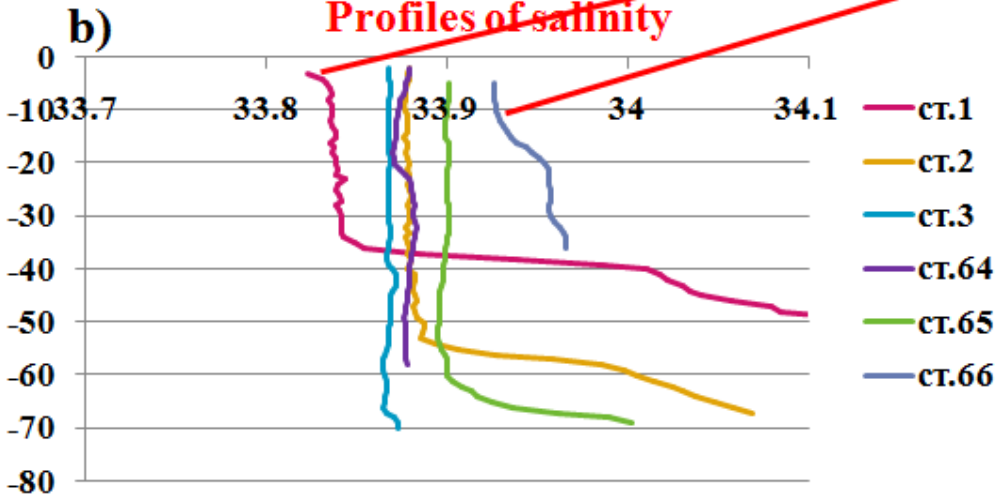


Stratification of water in zone 1 at stations, implemented in cruise of R/V "*Lugovoye*" (March 3-12, 2000): a, b- profiles of the water temperature (C) and salinity (‰)on stations 9,10,11,12, c-location for scenes of these profiles in temporal course of satellite data, d –location of mentioned above stations in Peter the Great Bay

a)

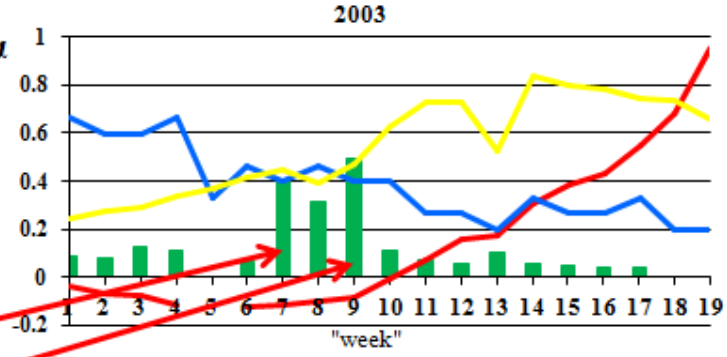


b)



Temporal course of Cchl-a (mg/m^3) and corresponding values of SST (red line), wind speed (blue line), FAR (yellow line). quantity of atmospheric precipitation (violet line)

c) α



7th week" in 2003 is period of 02.18-02.25

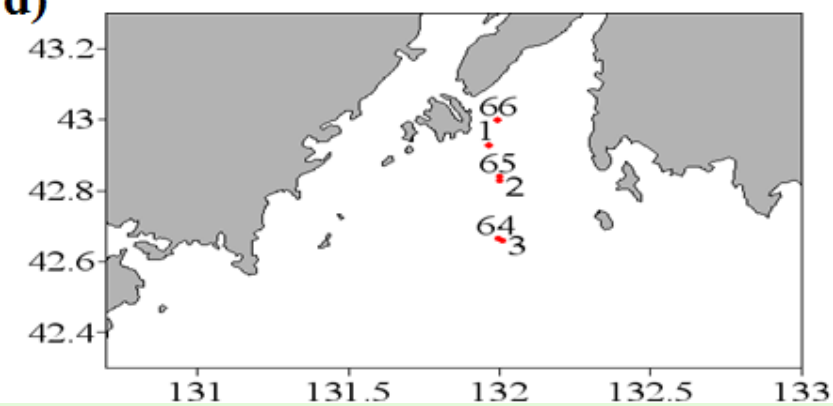
8th "week" in 2003 is period of 02.26-03.05

9th "week" in 2003 is period of 03.06-03.13

Time of implementation of ship stations

Station	Date	Time
st.1	2003.02.26	12:32
st.2	2003.02.26	14:03
st.3	2003.02.26	15:37
st.64	2003.03.08	15:54
st.65	2003.03.08	18:31
st.66	2003.03.08	20:23

d) Location of stations in Peter the Great Bay

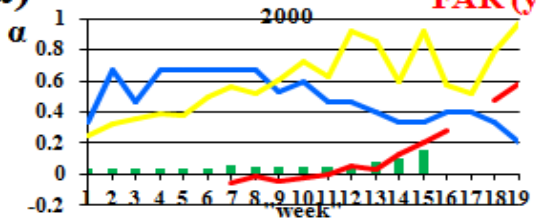


Stratification of water in zone 1 at stations, implemented in cruise of R/V "*Akademik M.A. Lavrentiev*" (February 26-March 9, 2003): a, b- profiles of the water temperature (C) and salinity (‰) on stations 9, 10, 11, 12, c-location for scenes of these profiles in temporal course of satellite data, d –location of mentioned above stations in Peter the Great Bay

2000

Temporal course of Cchl-a (green lines), SST(red line), wind speed (blue line)
FAR (yellow line) in relative units

a)



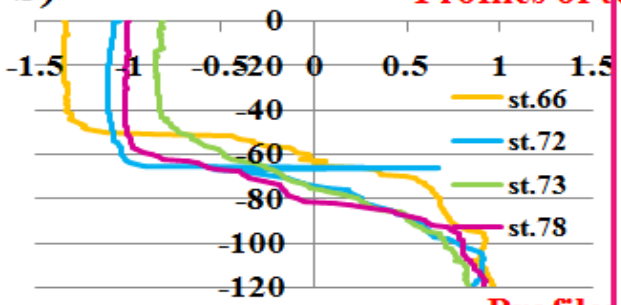
9th "week" in 2000 is period of 03.05-03.12

Time of implementation of ship stations

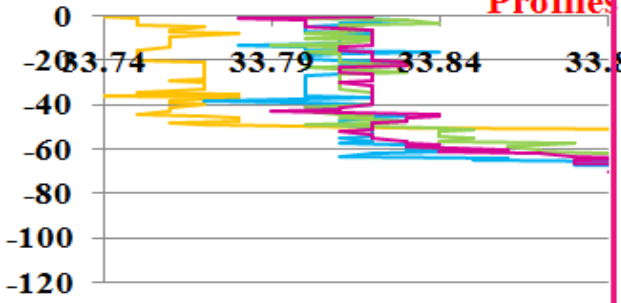
Station	Date	Time
st.66	2000.03.09	22:10
st.72	2000.03.11	2:07
st.73	2000.03.11	3:40
st.78	2000.03.11	10:28

b)

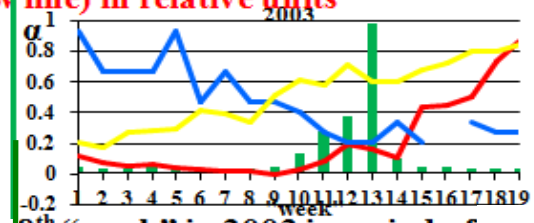
Profiles of temperature (°C)



Profiles of salinity(‰)

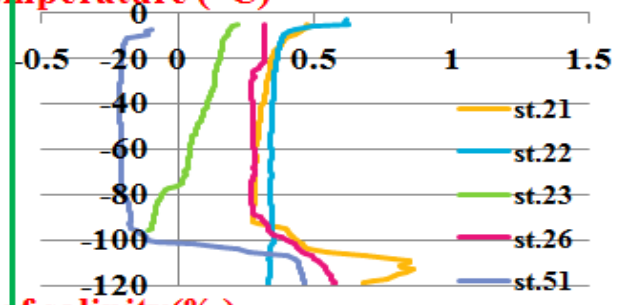


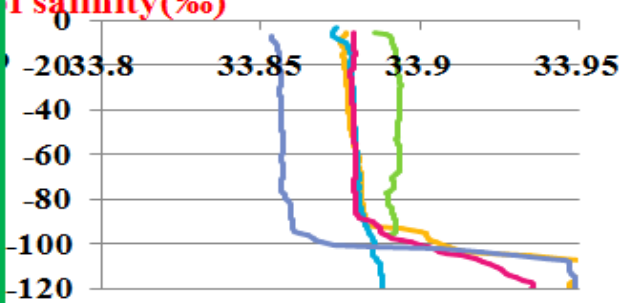
2003



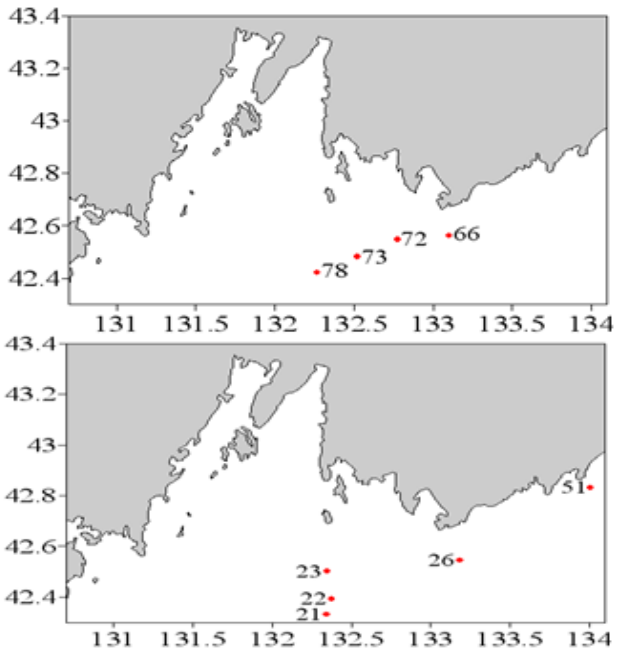
8th "week" in 2003 is period of 02.26-03.05
9th "week" in 2003 is period of 03.06-03.13

Station	Date	Time
st.21	2003.03.01	3:30
st.22	2003.03.01	5:28
st.23	2003.03.01	6:44
st.26	2003.03.01	13:01
st.51	2003.03.06	8:20

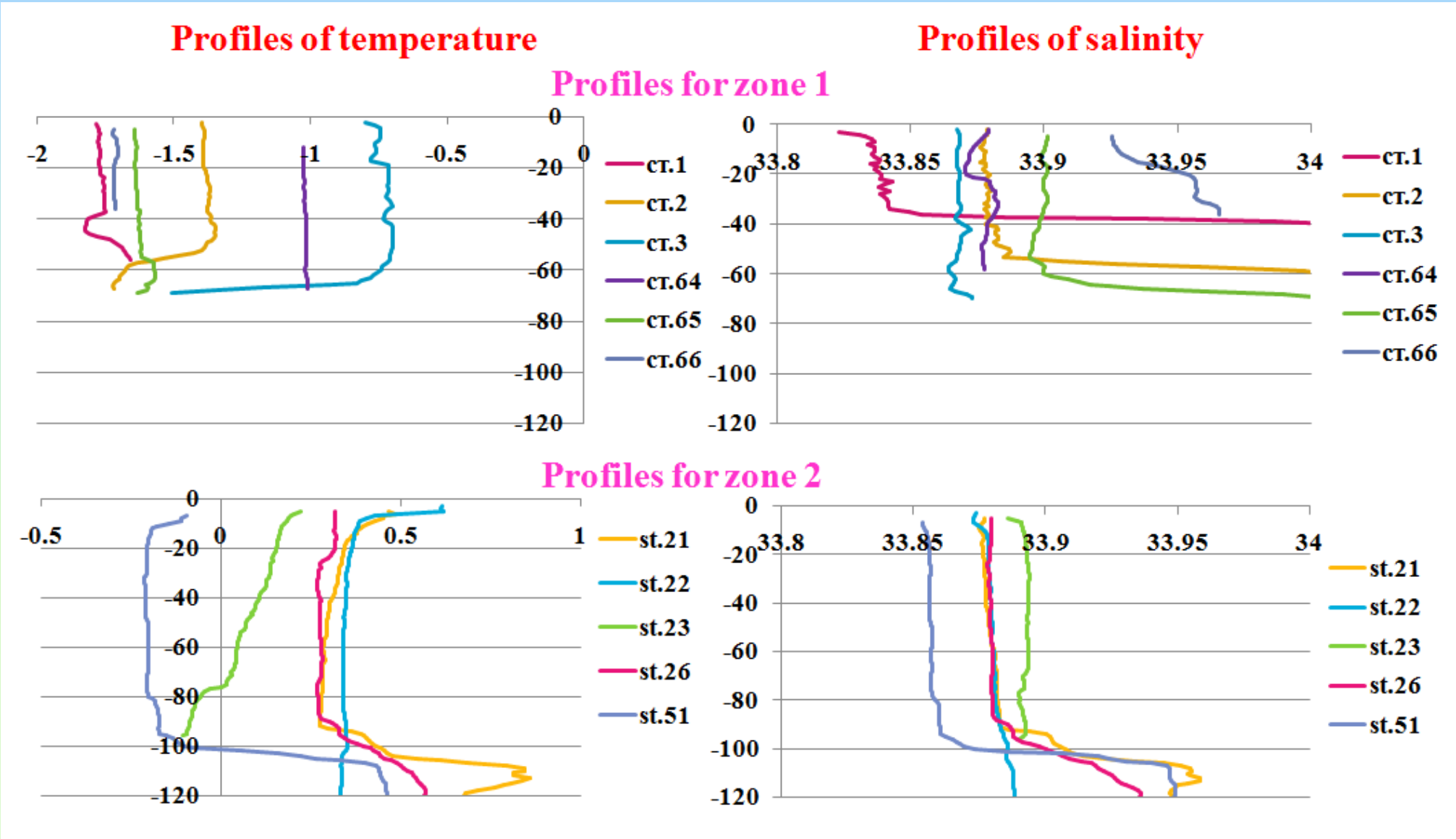




Location of ship stations in 2000 (top figure) and 2003 (bottom figure)



Comparison of hydrobiological conditions in zone 2 in March of 2000 and *2003*: a-temporal course of Cchl-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