Evolution of the thermohaline structure of water under ice of Amurskii Bay

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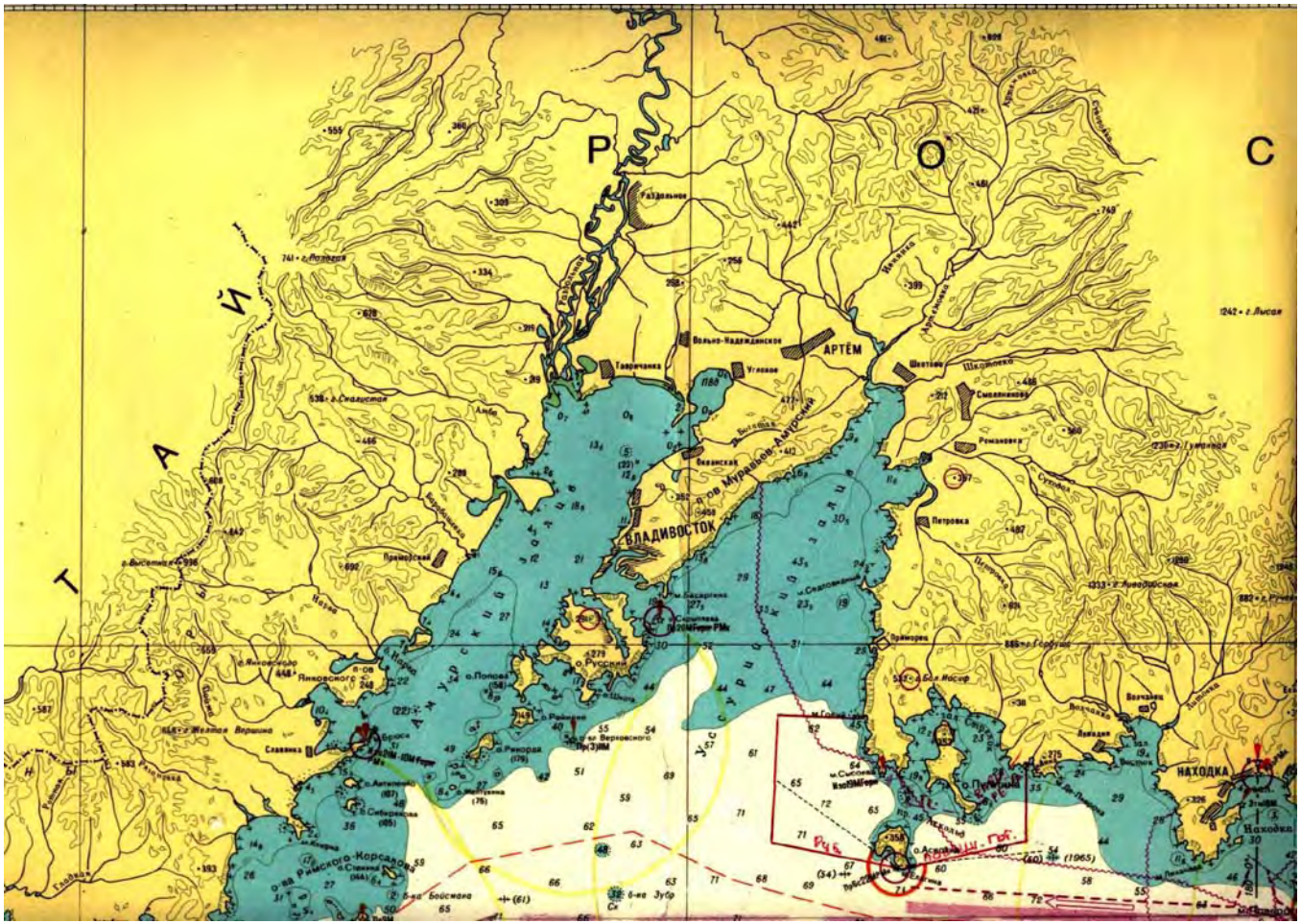
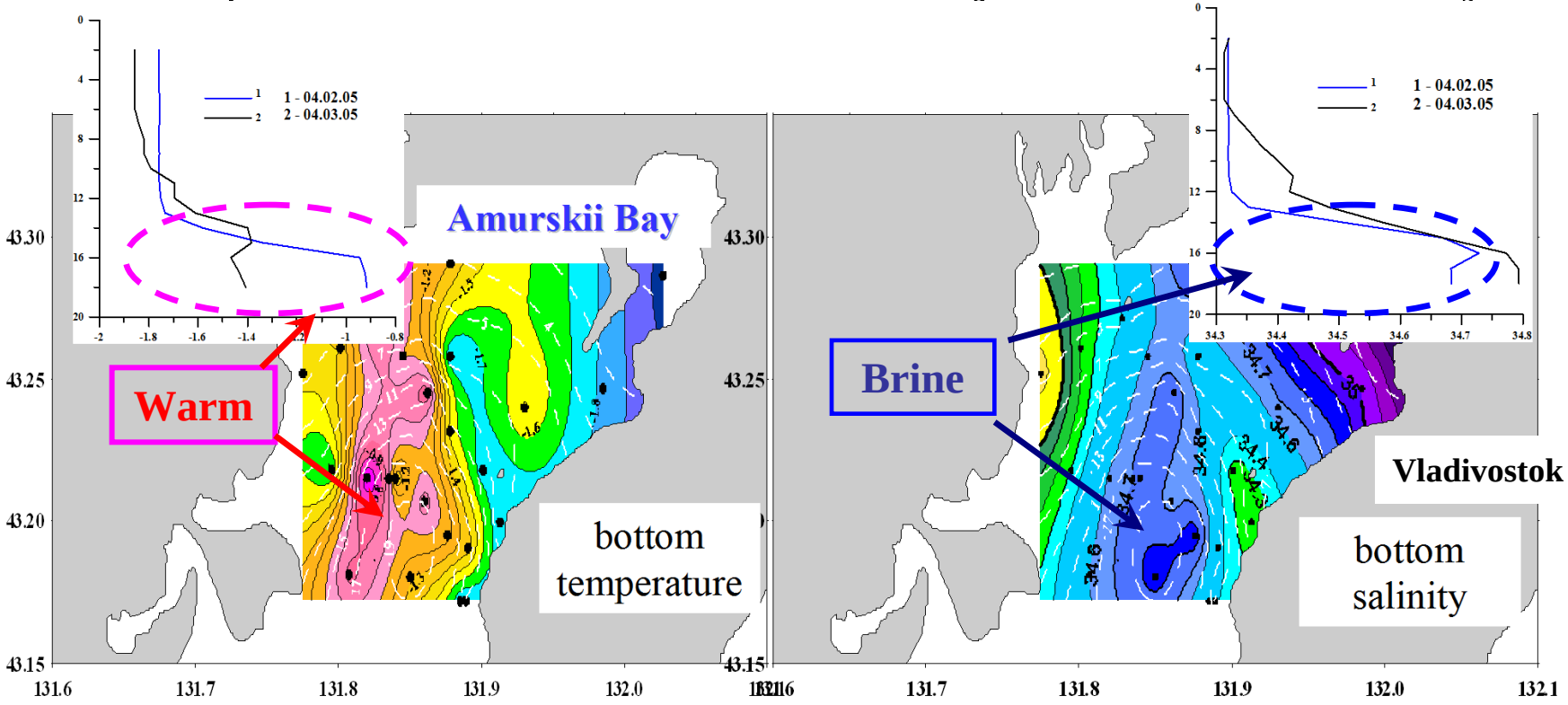


History of problem

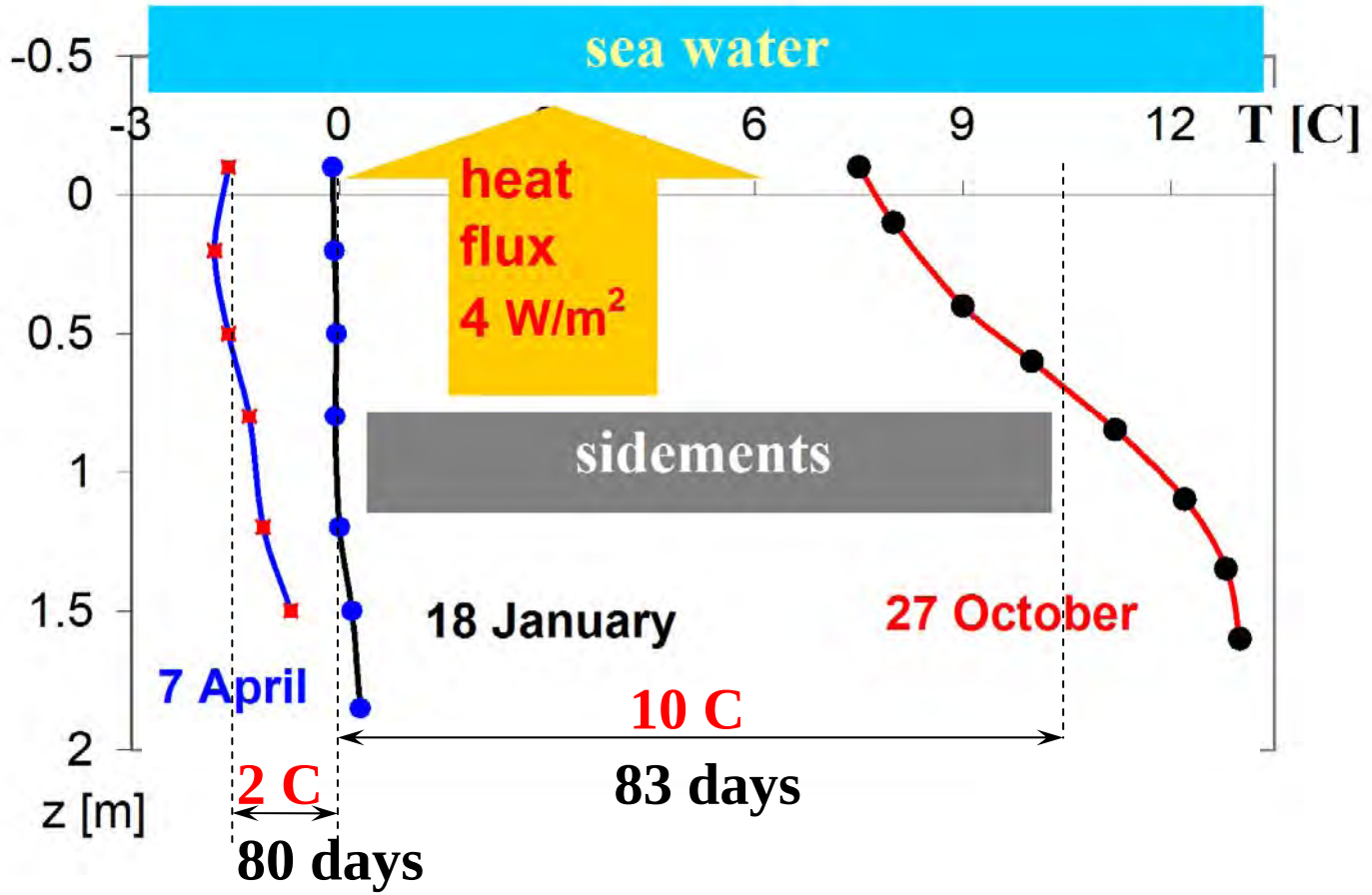
2005 - CTD measurements of **Lobanov and Ponomarev** (made the winter) showed the presence of **warm brine bottom layer** in the Amurskii Bay



When seawater temperature drops to -1.8 C formed fine needles of ice, which contain only fresh water. Salt is left in seawater. Seawater with high concentrations of salt called **brine**. Its temperature is about -1.8 C.

History of problem

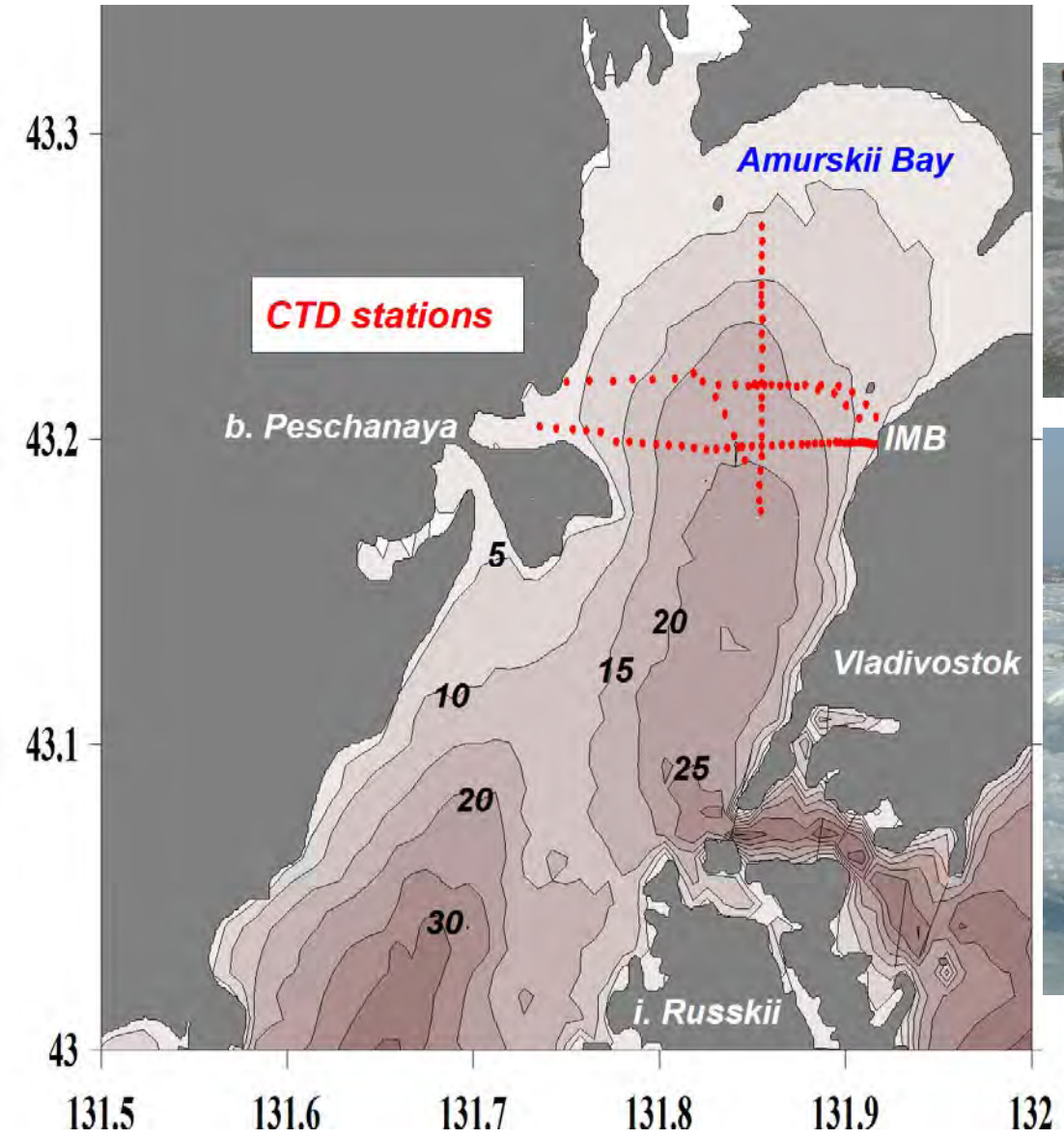
2007 - the sediments temperature profiles measured by **Burov, Lazaryuk and Ponomarev** in different seasons, showed the **heat flux from the sediments** to sea water is about **4 W/m^2** during winter. There are in 10 times higher then maximal geothermal flux in the Japan Sea, and it is inversed the flux in summer



Main goal is to

- investigate the **evolution of brine water** in the Amurskii Bay during the cold season.

Bathymetrical map of the Amurskii Bay and field observations from ice in winter 2010-2011



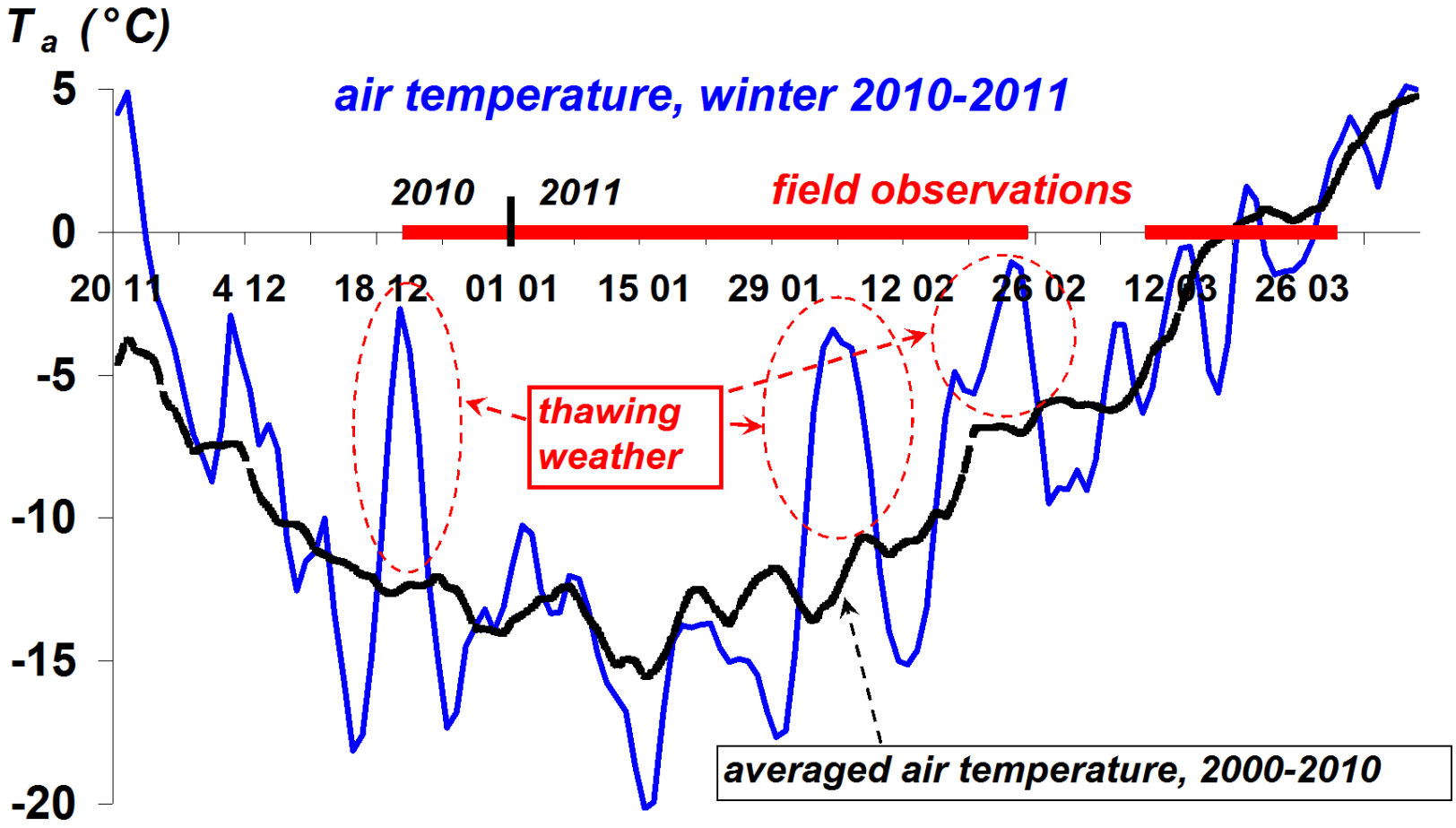
devices and measured parameters of sea water

-**XR-620** (RBR, Canada) probes: pressure, temperature, conductivity **(more 600 stations)**

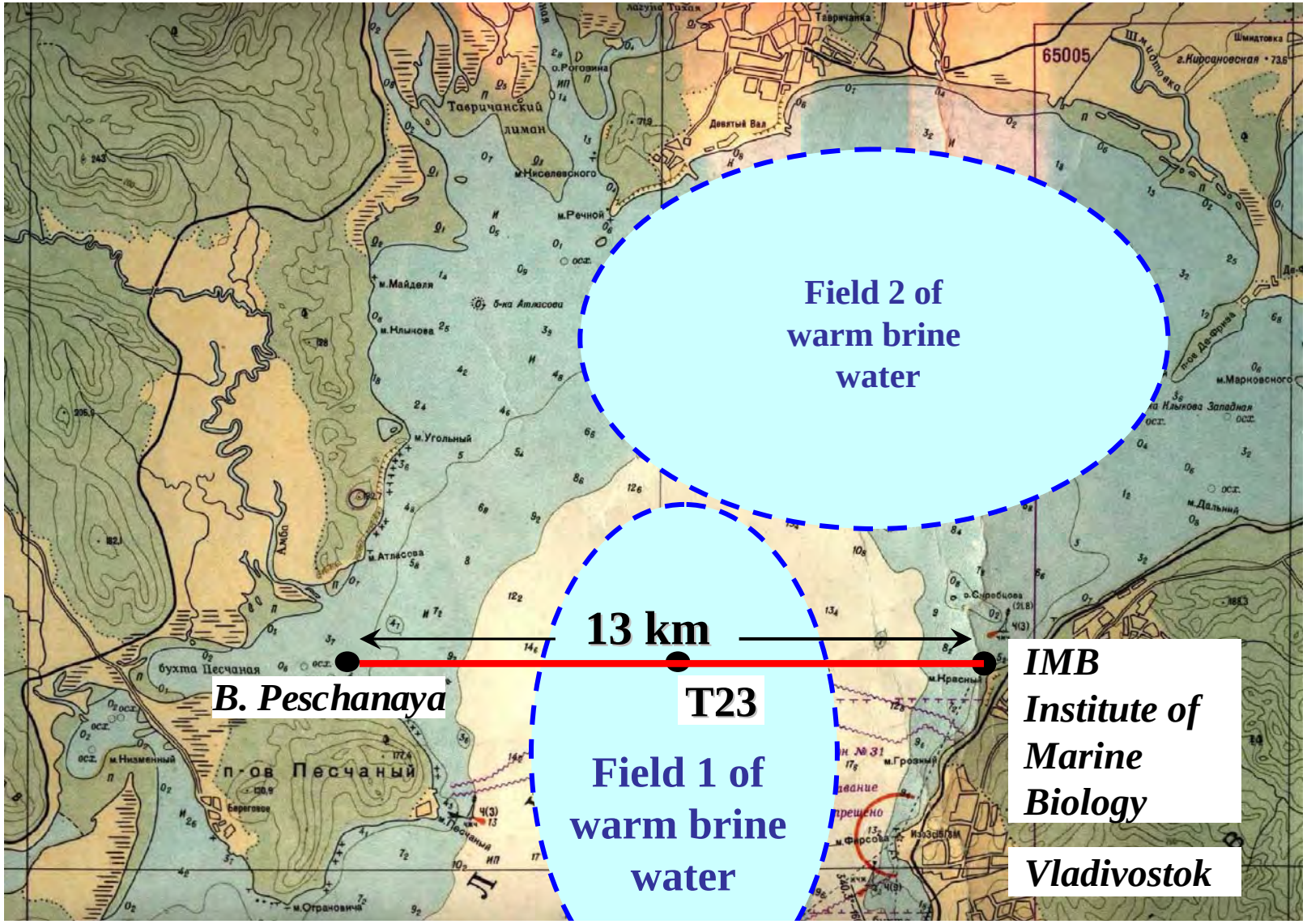
- **SBE-19+V2** (SBE, USA) probes: pressure, temperature, conductivity, oxygen, Fluorescence, PAR/Irradiance, turbidity **(more 110 stations)**

ice thickness is measured by a ruler

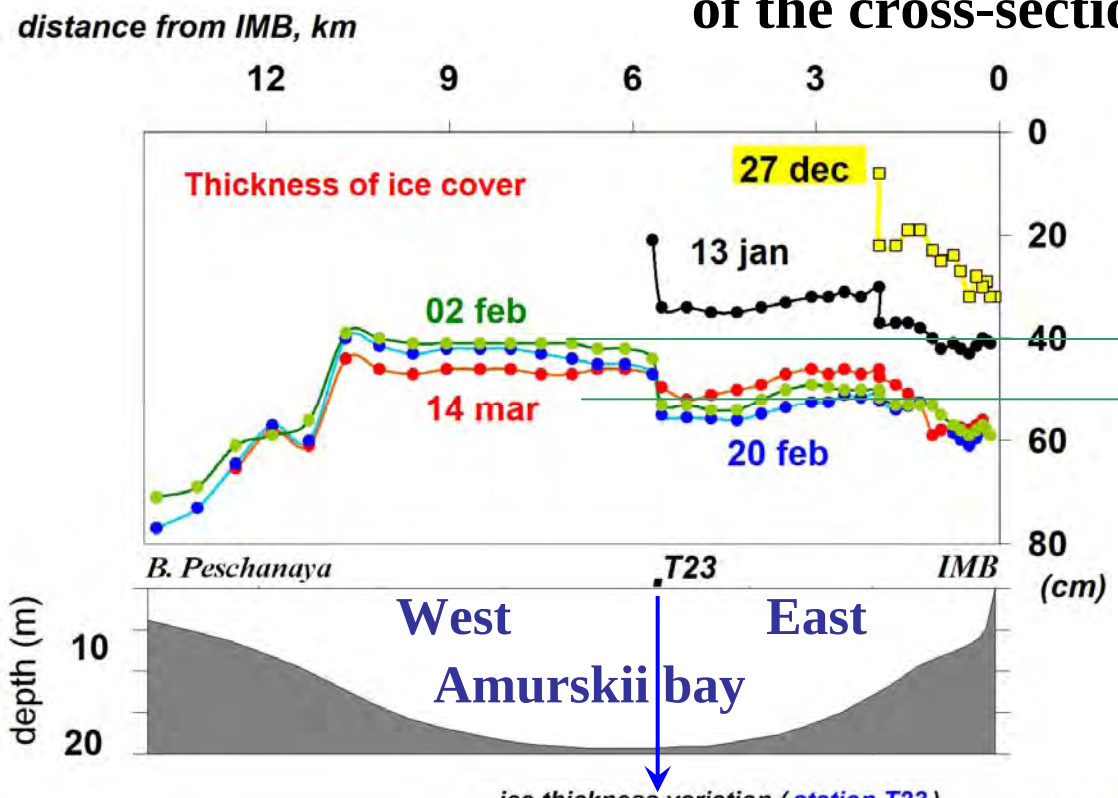
Winter 2010-2011
mean daily air temperature and field observations



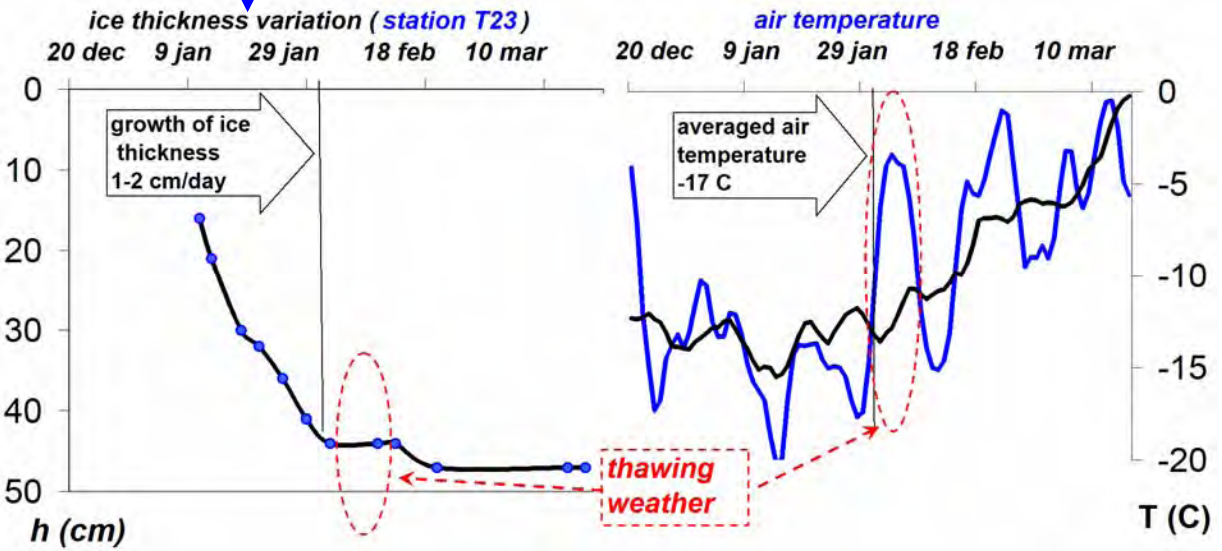
Amurskii Bay shallow, where the most of the Brine Water is forming due to brine rejection during ice formation



ice thickness, measured at the stations of the cross-section IMB-b. Peschanaya



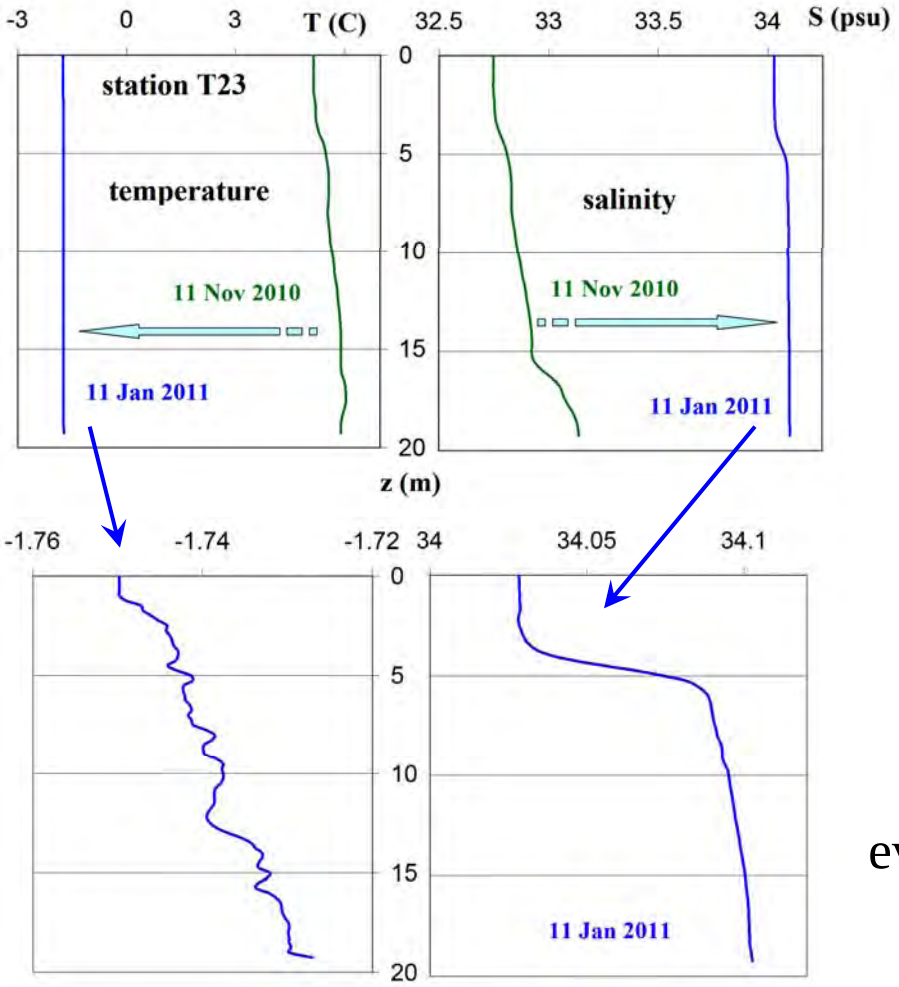
12 cm – difference in ice thickness between Eastern and Western parts of Amurskii bay



Evolution of water thermohaline structure in Amurskii Bay

Stage 1 - formation of the quasihomogeneous seawater

CTD measurements 11 November 2010 and 11 January 2011 (station T23)



During 2 months:

daily **air temperature**
decreased from 0 to -20 C,

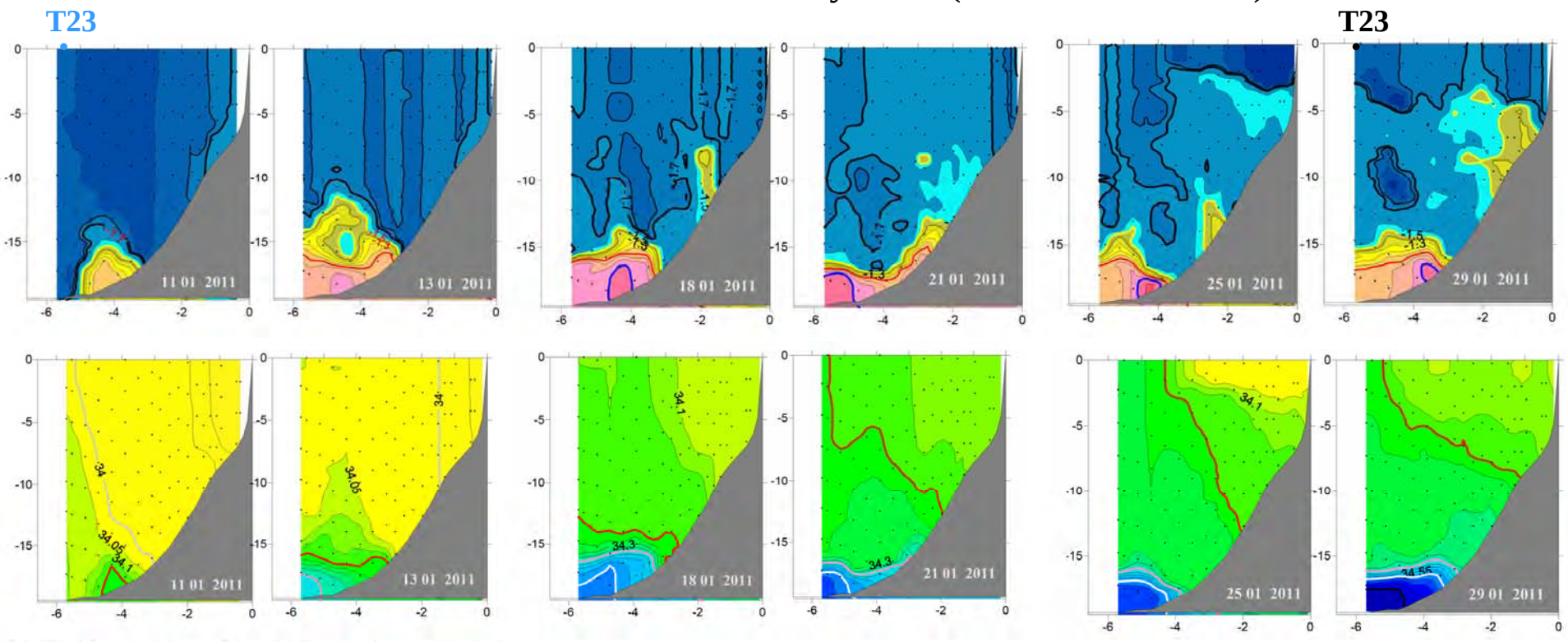
the average **water salinity**
has increased from 32.9 to 34.07 psu,

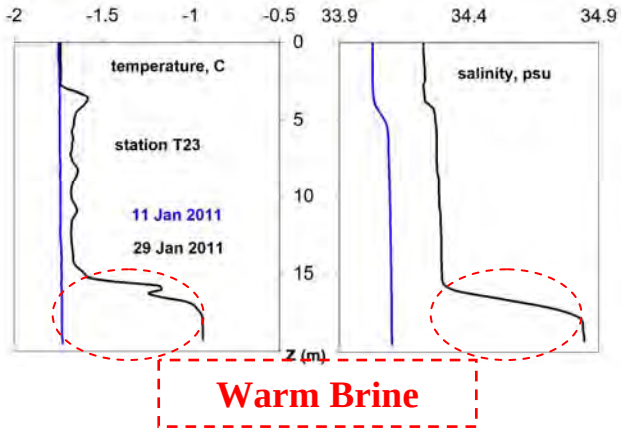
the average **water temperature**
has decreased from 5.7 to -1.74 C.

Quasihomogeneous seawater
is formed by processes:
outflow of heat into the atmosphere,
evaporation, heat flux from the sediments,
thermal and salinity convections,
brine rejection ….

Evolution of water thermohaline structure in Amurskii Bay
Stage 2 - brine rejection and formation of the bottom layer

field observations 11 - 29 January 2011 (section T23 - IMB)





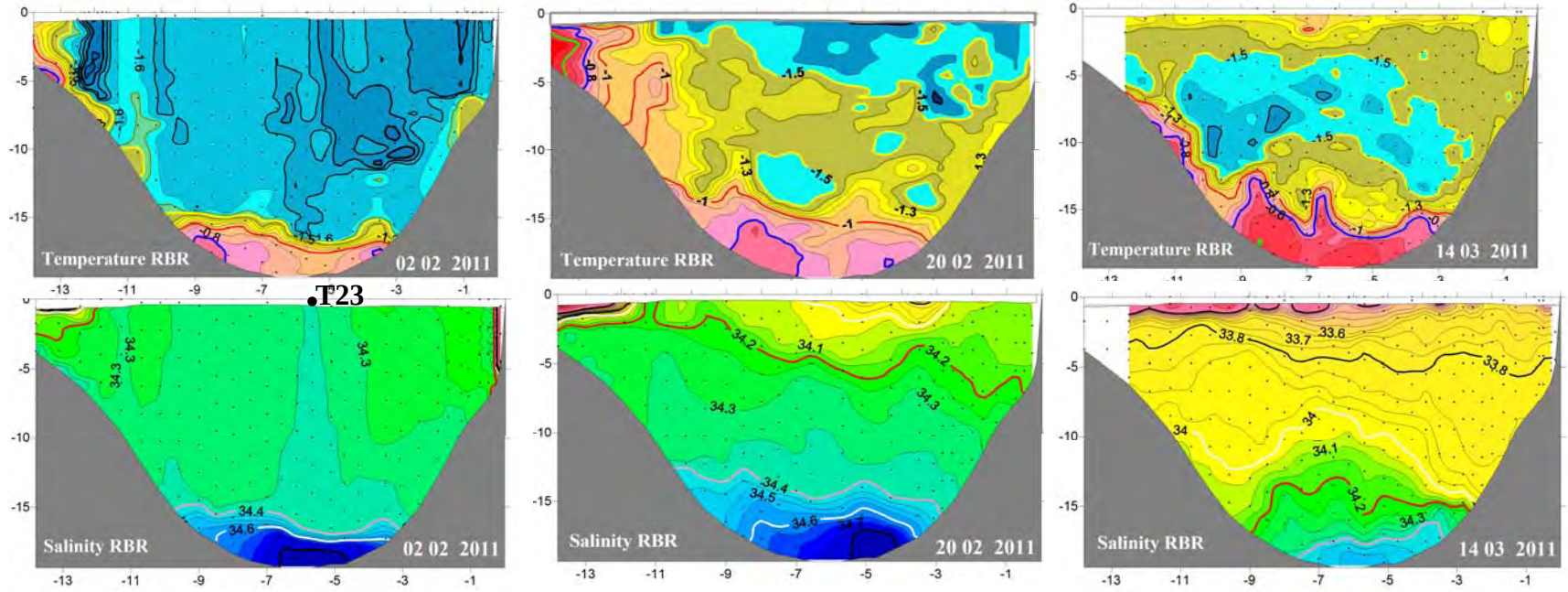
During 18 days

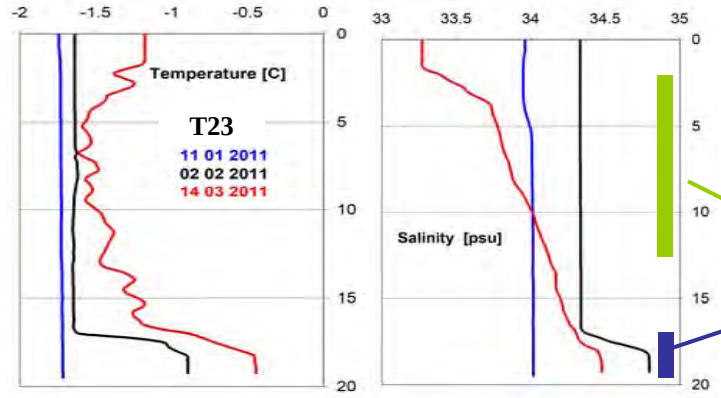
mean daily **air temperature** varied from -15 to -20 C **,**
the average **ice thickness** has increased from 32 cm to 50 cm
(from ice area of 1 cm^2 **brine rejection** - 0.5 gram of salt**),**
the average **water salinity** has increased from 33.89 to 34.12 psu,
the average **water temperature** has increased from -1.70 to -1.58 C,

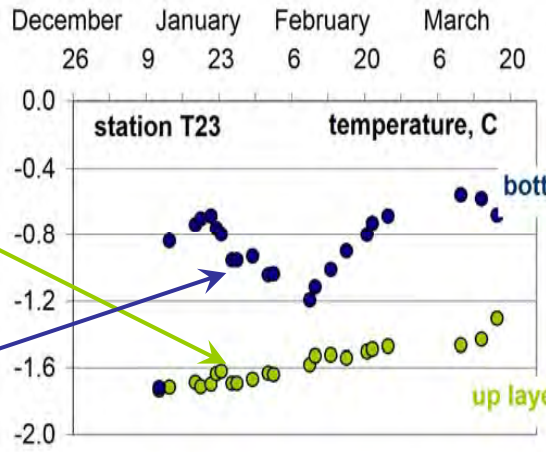
Evolution of water thermohaline structure in Amurskii Bay

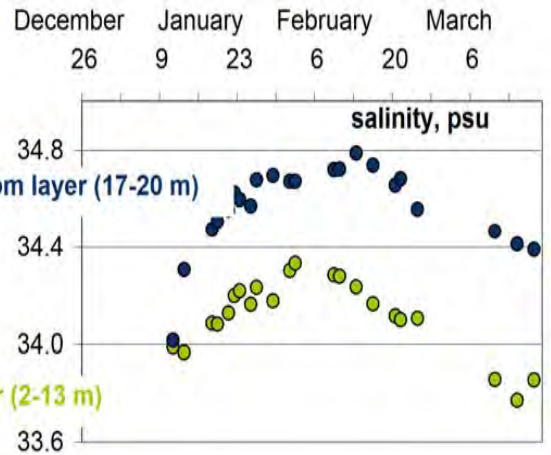
Stage 3 - degradation of the brine bottom layer

field observations 2 February – 14 March 2011 (section b. Peschnaya -IMB)

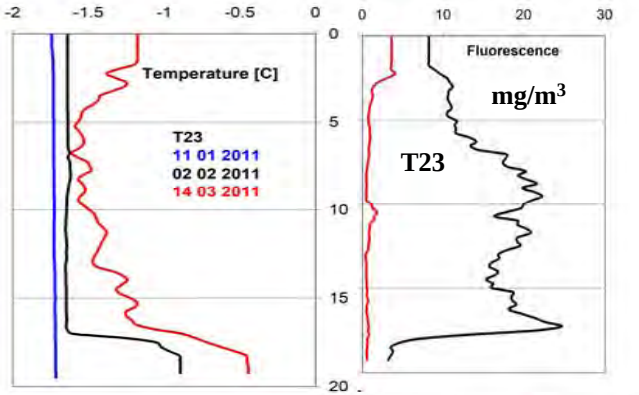


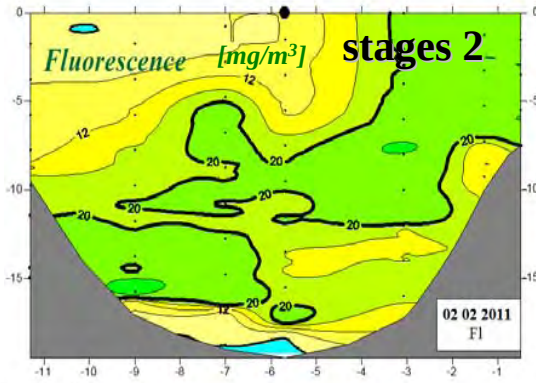


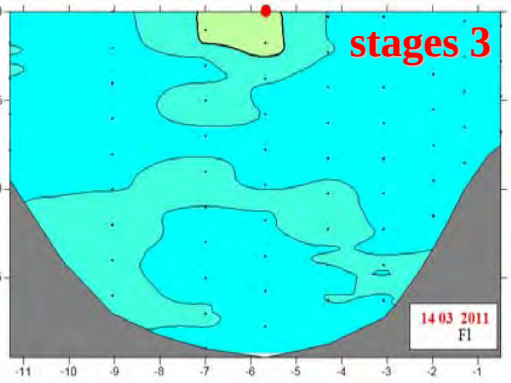


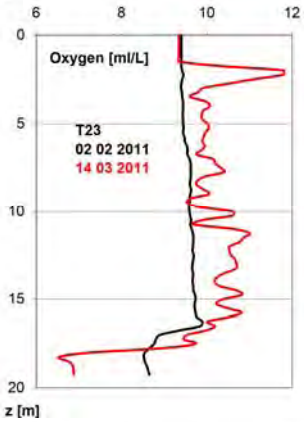


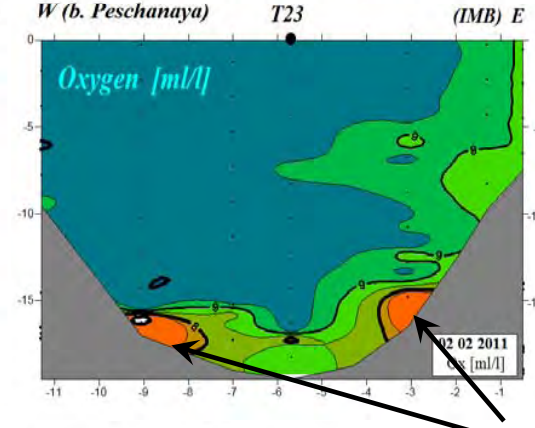
Concentration of oxygen and fluorescence of sea water column in the Amurskii Bay (2 February and 14 March 2011)

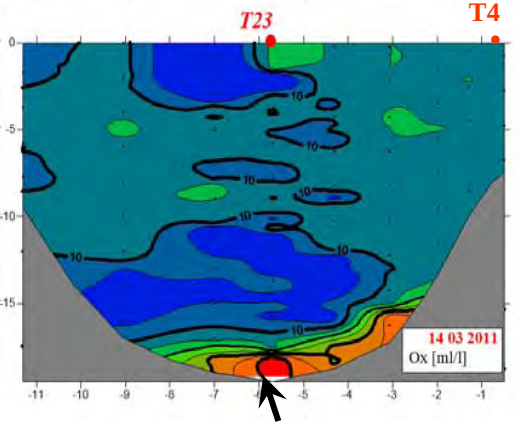


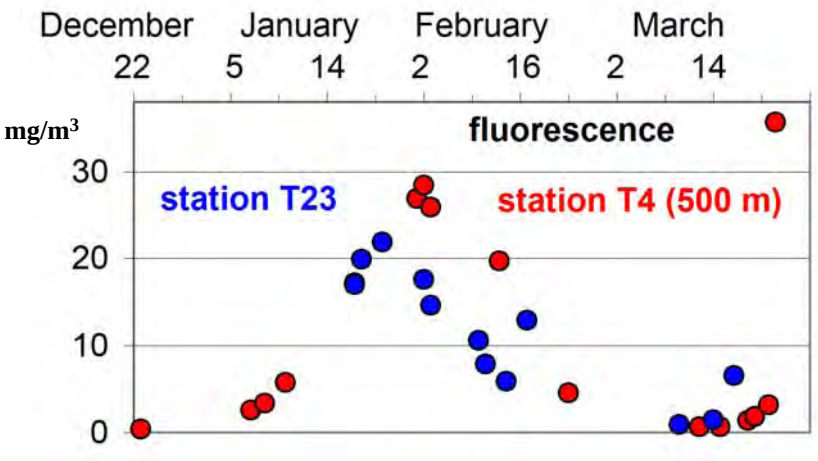










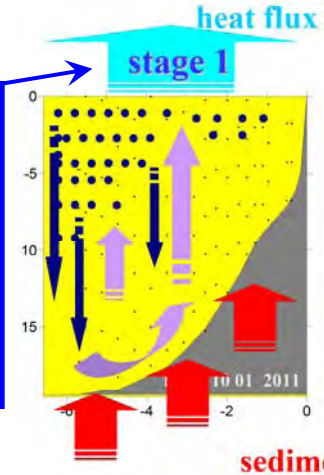


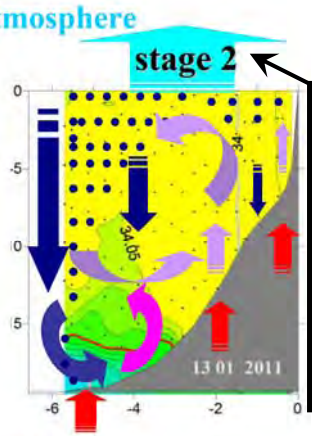
The water micro-convection in the sediment pore facilitates the removal of substances that lower the oxygen concentration in the bottom layer.

Evolution stages of the brine water under ice of Amurskii Bay

formation of homogeneous seawater

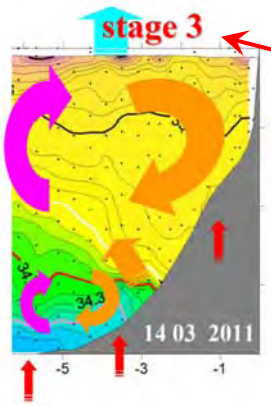
convection covers the entire column





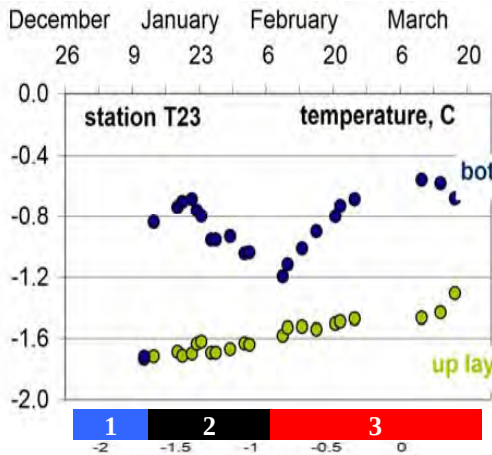
formation of warm brine bottom layer

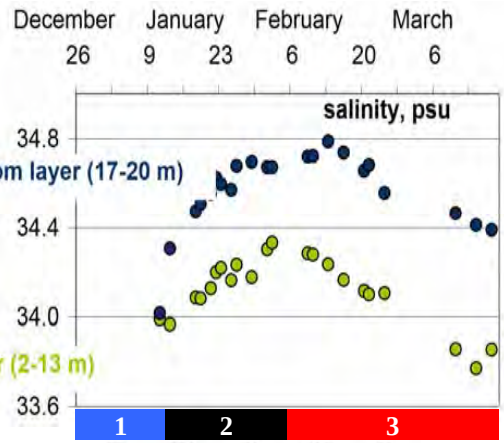
layered convection

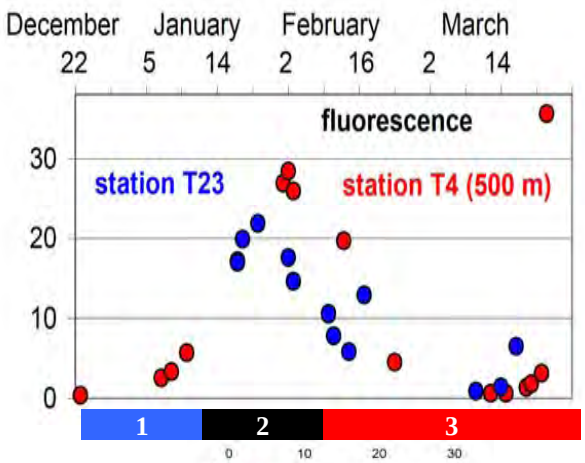


degradation of warm brine bottom layer

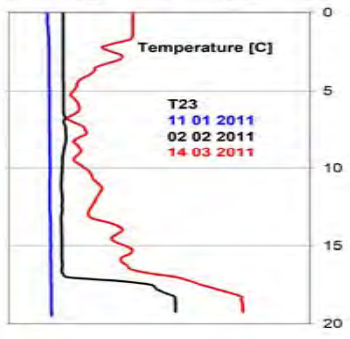
layered convection

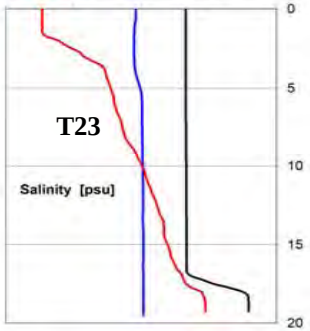


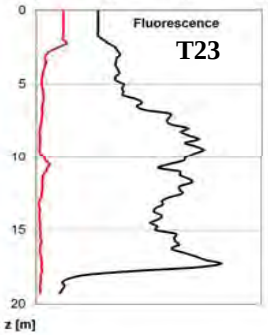




← Stages







Conclusion

Field observations in winter 2011 showed three stages of the thermohaline structure of the seawater under the ice of Amurskii Bay.

- **Stage 1 – formation of quasi-homogeneous sea water.** The sea water column is uniform in temperature and salinity. Its temperature is about -1.8 C and salinity is about 34 ppm. Substances released from sediments are spread throughout the seawater column. There are adverse conditions for the phytoplankton. Phytoplankton concentrations are low.
- **Stage 2 - formation of warm brine bottom layer**. Ice grows at 1 cm each day. Brine formed the bottom layer. Its salinity increase to 35 ppm, and this is higher than the salinity of the upper layer. Heat flux from the sediments and their substances are accumulated in bottom layer. Conditions are favorable for the phytoplankton in the upper layer.
- **Stage 3 - degradation of warm brine bottom layer.** Ice thickness is stable and ice melts at the end of the stage. Salinity decreases in both layers. The water temperature increases. The bottom layer is destroyed. Harmful substances enter the upper layer. There are adverse conditions for the phytoplankton.

Ecology and biological productivity of the Amurskii Bay in winter depend on the brine rejection and heat flux from the sediments, namely, their intensities.


Thank you for attention