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Amor River water and sea ice on northeastern Sakhalin shelf in June

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Introduction

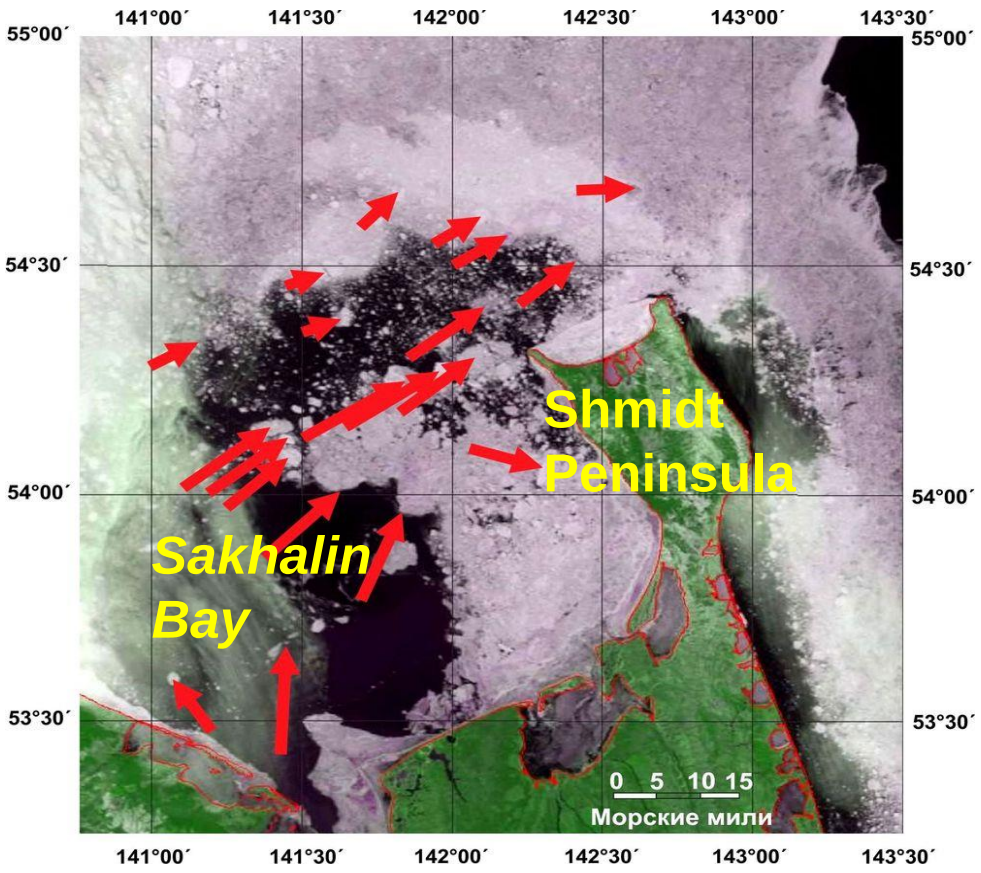
Considerable interest in studying the features of the oceanological conditions of the northeastern shelf of the Sakhalin Island is defined by two practical reasons. The first is related to the industrial development of offshore oil and gas fields in this area, the tasks of assessing possible loads on oil and gas facilities and the consequences of emergency hydrocarbon spills. The second is related to its fishing value (by the significant amount of Pacific salmon caught and the revival of the Okhotsk pollock population). From a scientific point of view, the interest is due to the very complex nature and significant scale of seasonal changes in water temperature and salinity (influence of low salinity water of Amur River runoff) and their manifestation in the entire western part of the Sea of Okhotsk including northern shelf of Hokkaido Island and area adjacent to South Kuril Islands.

The issue of the first appearance of freshened water on the northeastern shelf of Sakhalin Island is least studied. The study of this phenomenon was main the goal of this work.

DATA

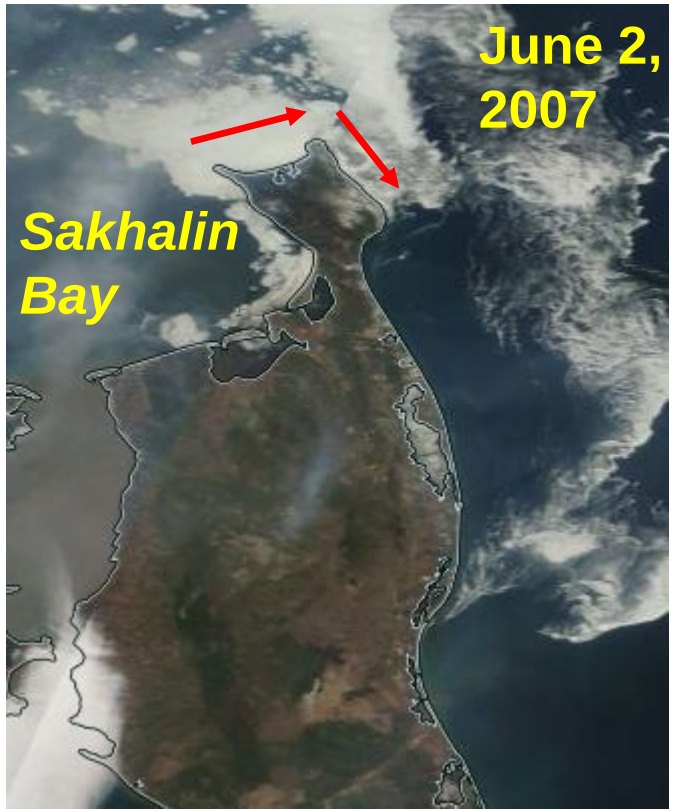
Oceanological surveys during ichthyoplankton studies of the distribution of pollock eggs on the NE shelf of Sakhalin
June 1993, 1996, 2001, 2007, 2009, 2010, 2011, 2012, 2014, 2015, 2017, 2018

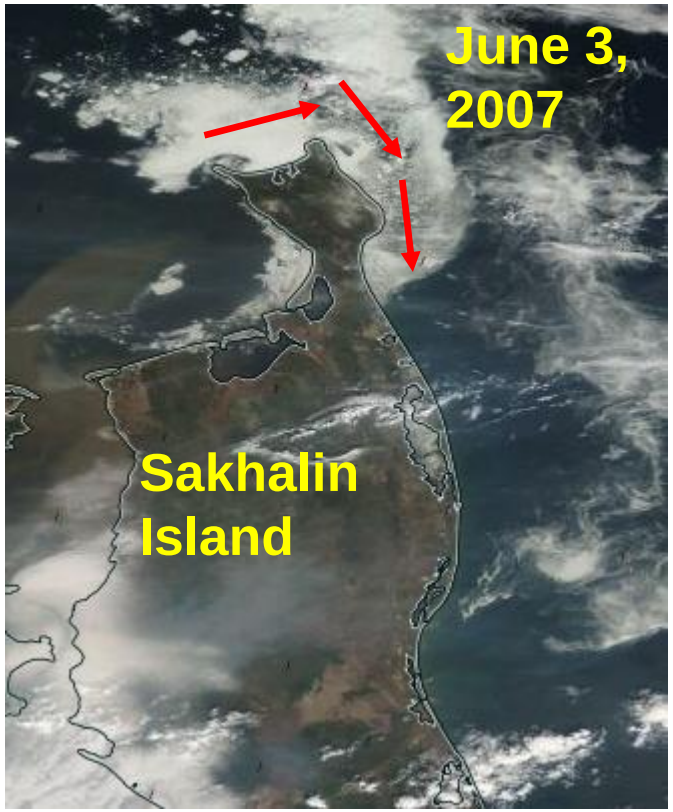
Satellite images of ice cover from the website https://worldview.earthdata.nasa.gov.

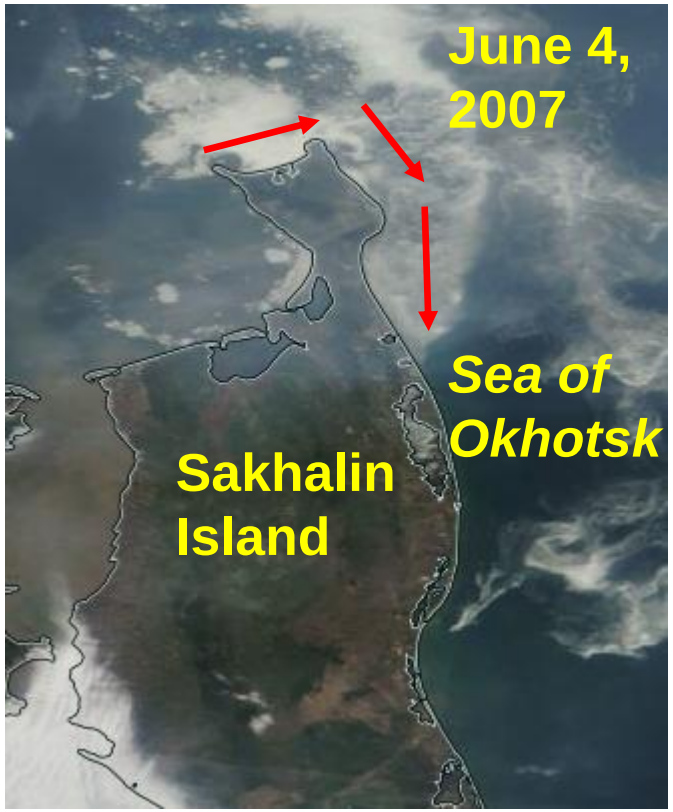


First example

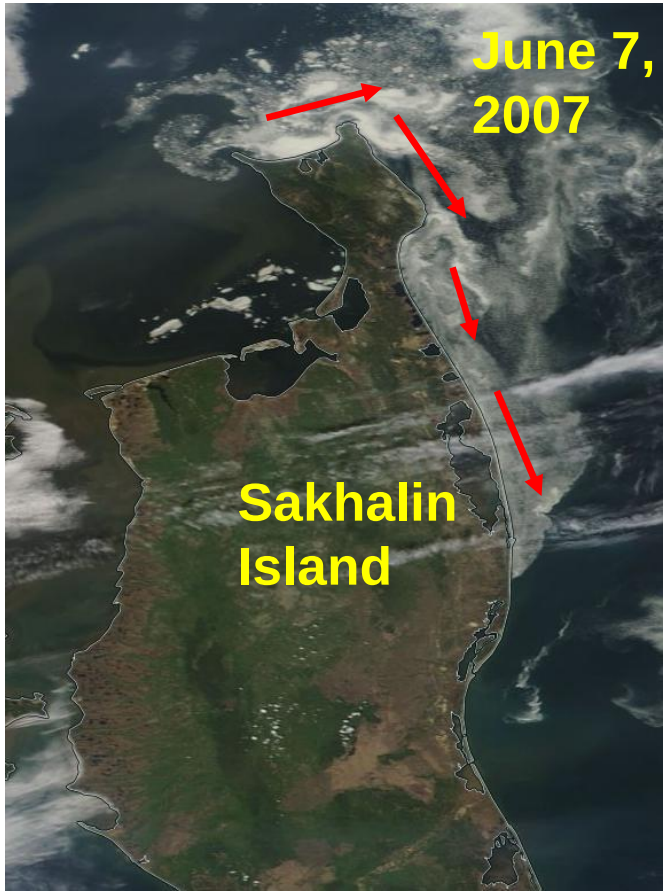
Satellite image of the Sakhalin Bay area on May 18, 2009. Heavy fast ice in the southern part of the bay (it prevented the flood water flow of the Amur River from the Amur estuary, so called ice dam) was broken.
Low density water (warm and fresh) moves around the Schmidt Peninsula to the northeastern Sakhalin shelf. This water carries heavy ice with it.



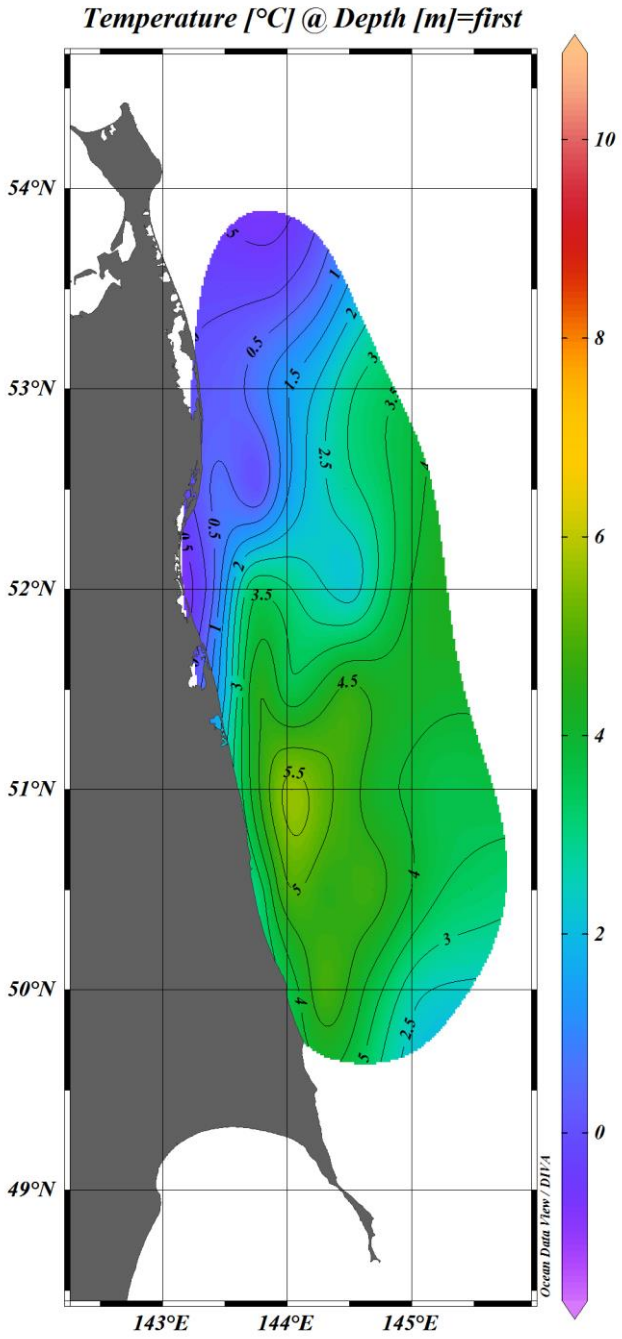


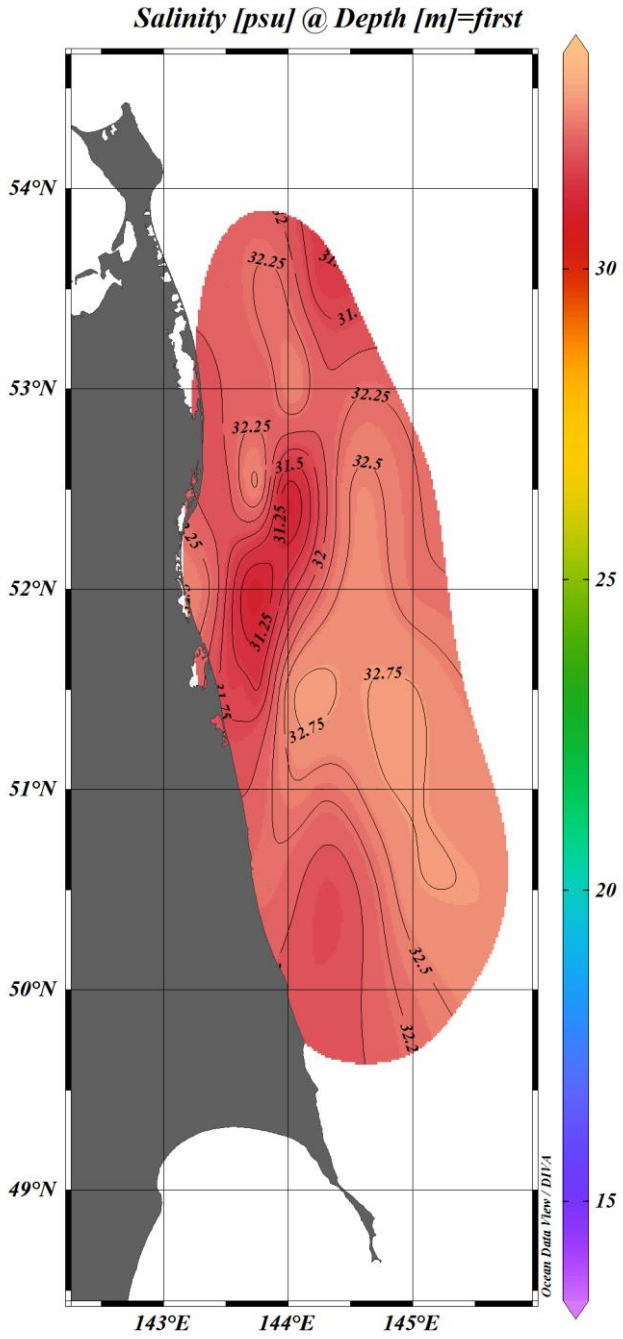


Example 2. On June 2, 2007 sea ice had grouped off the northern coast of the Schmidt Peninsula and began to move to the northeastern Sakhalin shelf and turn south. On June 4, it reached latitude 53.5° N.



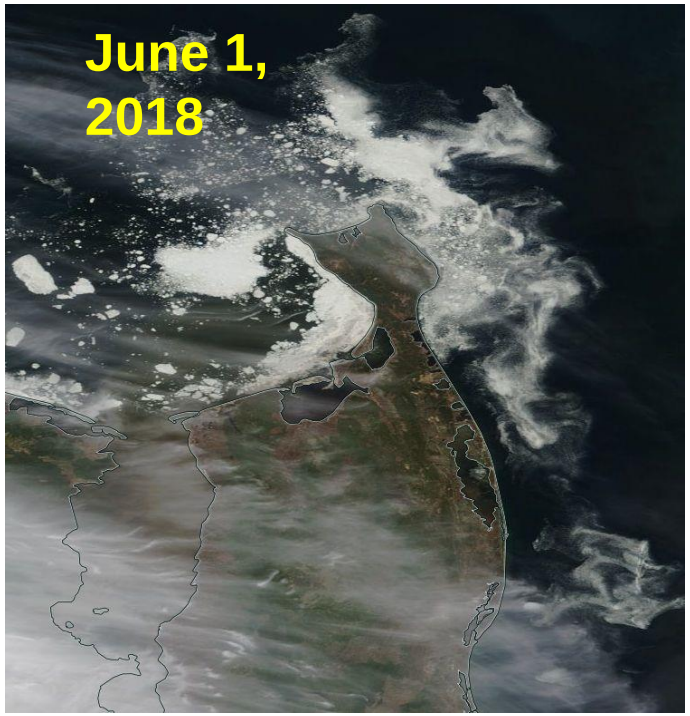
The sea ice moved fast southward and reached latitude 52.5° N on June 7. Here it stopped under the influence of the southerly wind and began to push back from the coast



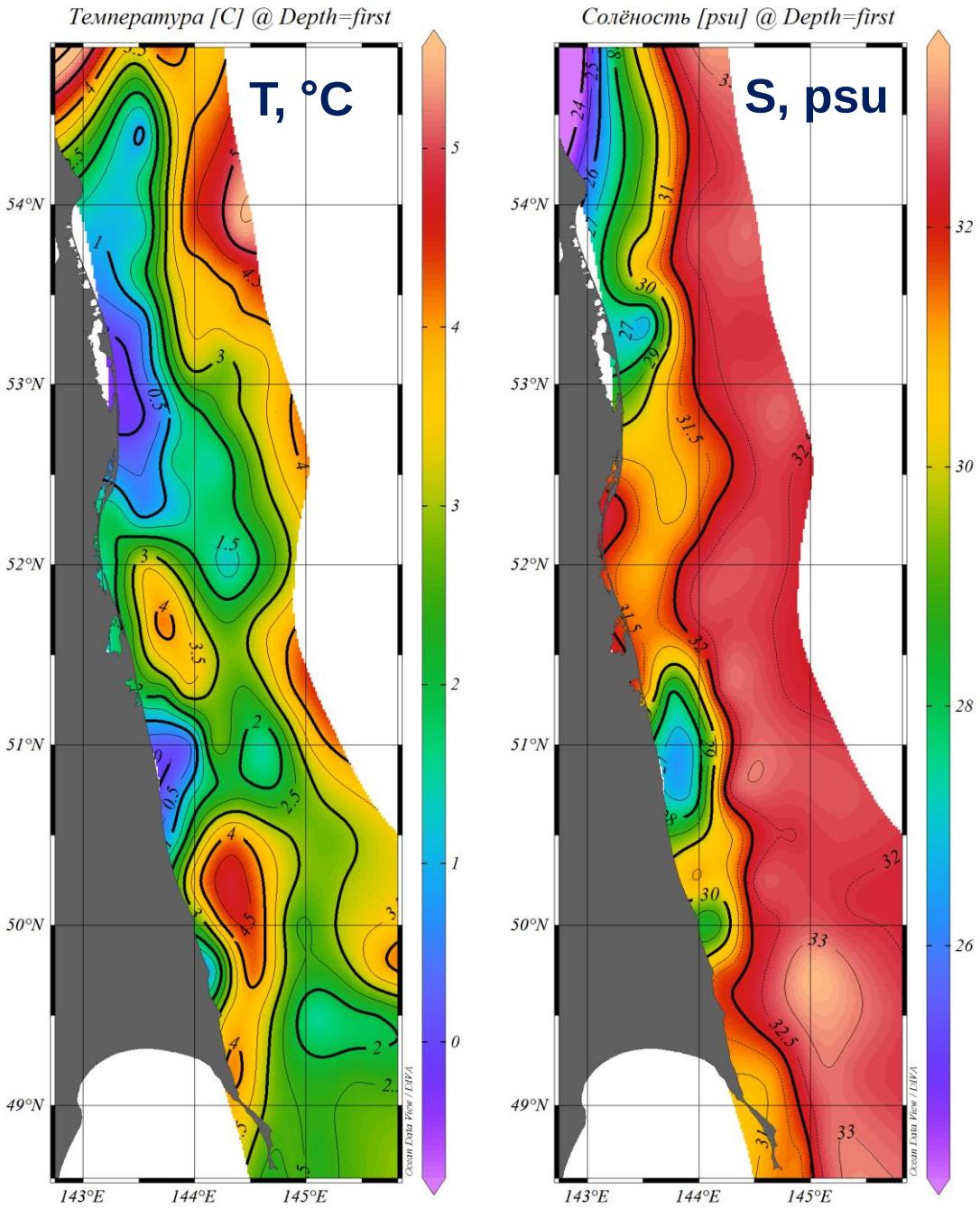


Water temperature and salinity distributions at the sea surface. Oceanological surveying during June 8-14, 2007 (R/V Dmitry Peskov).

The vessel could not carry out survey in the area of drifting ice. Therefore, the modified water of the Amur River was not detected.
The example of the weak influence of low salinity water on the NE Sakhalin shelf

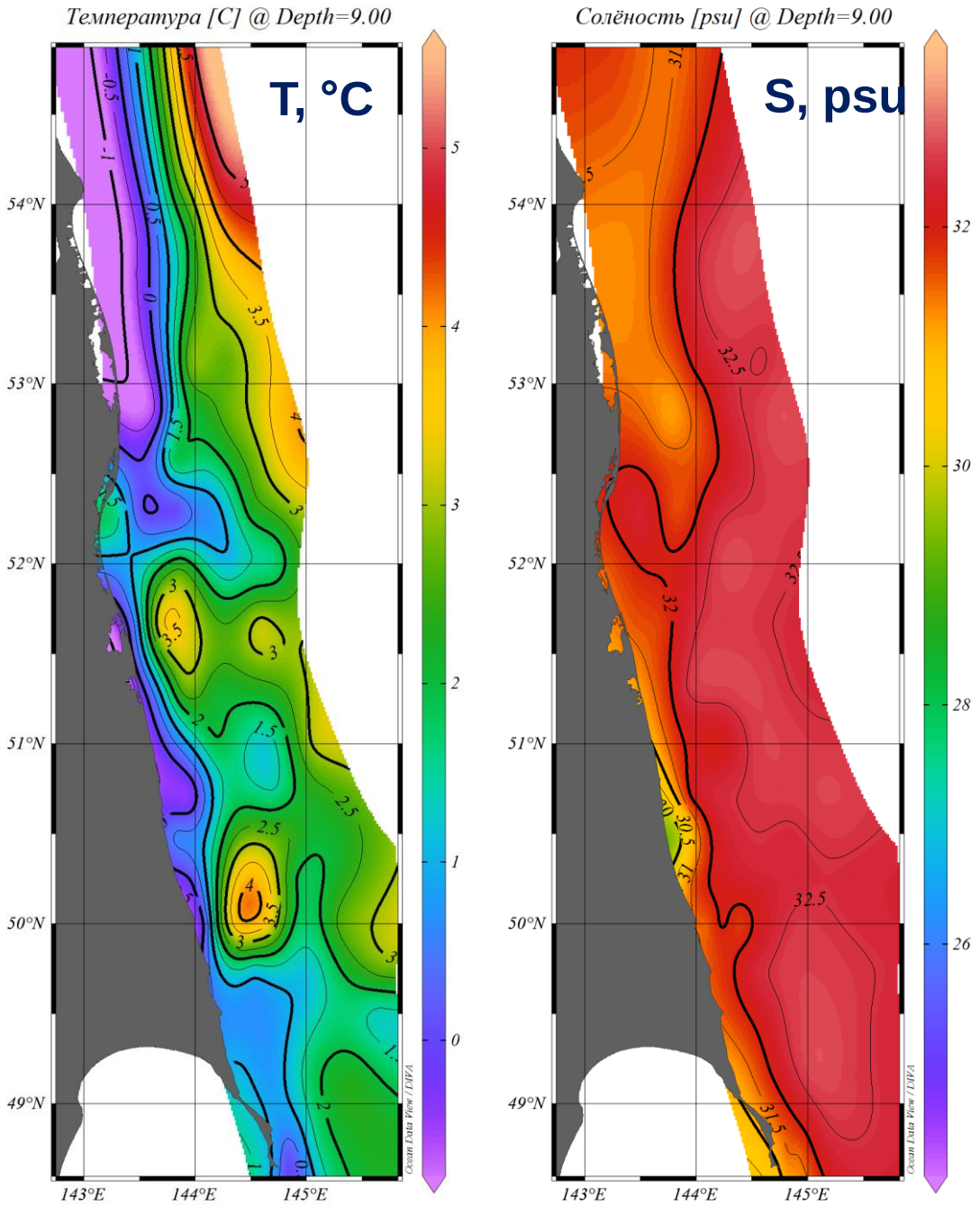


Example 3. A similar situation was observed in June 2018. A heavy fast ice in the southern part of the Sakhalin Bay was broken on 26 May. On June 1, sea ice was north and east of the Schmidt Peninsula. On June 8, it reached its southernmost position near the Piltun Bay. It did not move further south due to the south wind influence.



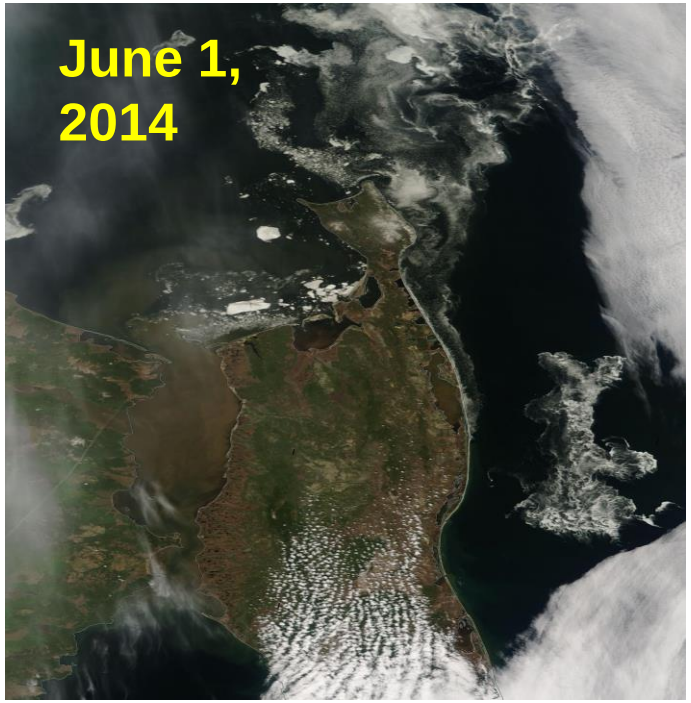
Water temperature and salinity distributions at the sea surface. Oceanological surveying during June 3-11, 2018 (R/V Dmitry Peskov).

The example of the initial stage of propagation of the modified water of the Amur River runoff to the northeastern Sakhalin shelf (in a narrow strip along the coast from Cape Elizabeth to Piltun Bay). In the area of Piltun Bay (53 N), this water is cooled by the sea ice; it is warm only to the north and east of Sakhalin Island.



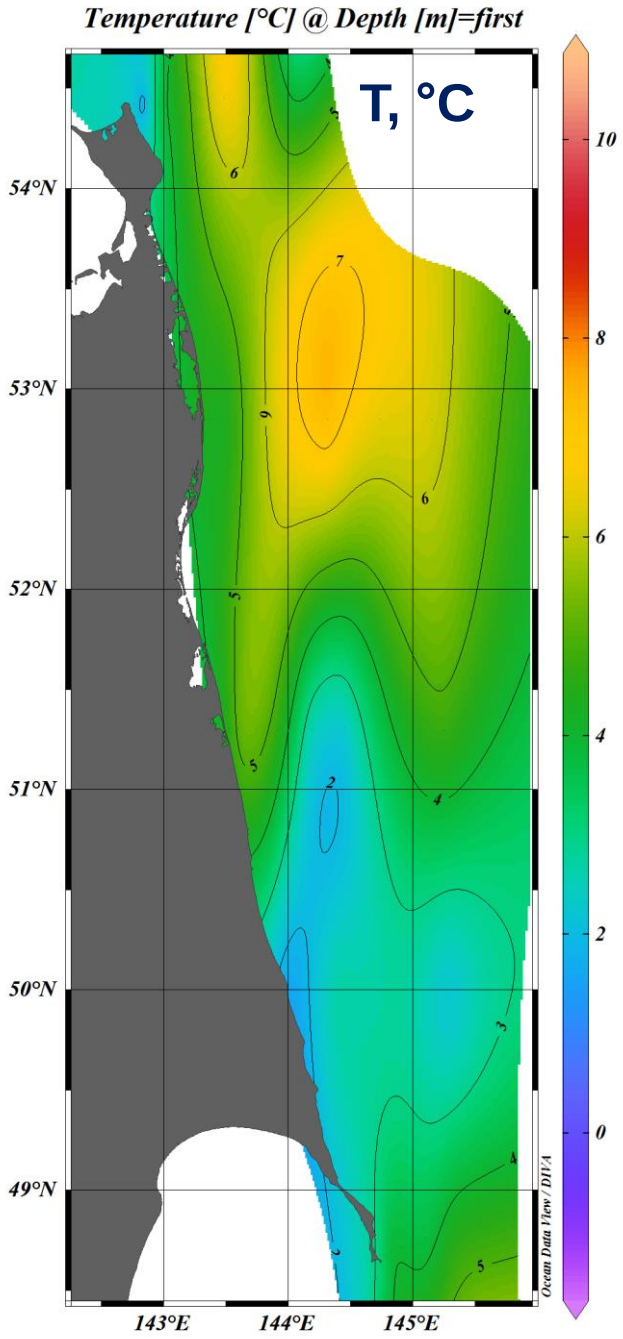
Water temperature and salinity distributions at the depth 9 m. Oceanological surveying during June 3-11, 2018 (R/V Dmitry Peskov).

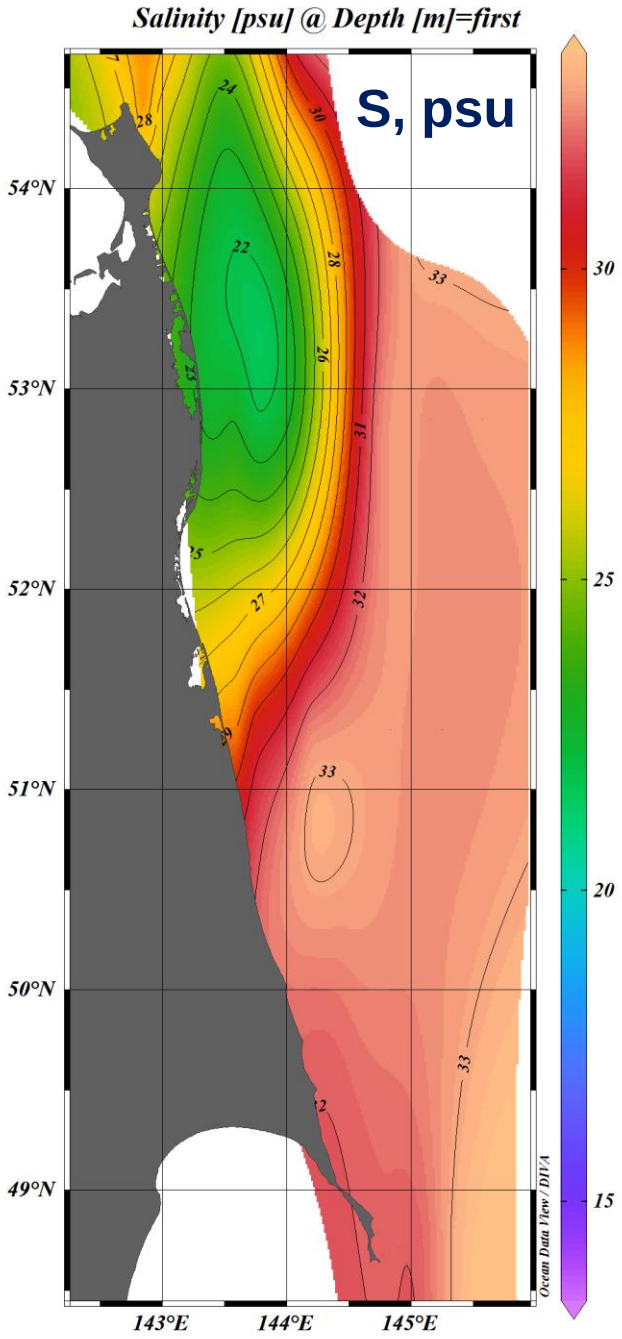
In the area adjacent to the NE Sakhalin coast from Cape Elizabeth to Piltun Bay we found cold low salinity melt water. Warm and salty water is found far from the coast. The salinity front begins to form under influence of southerly wind (summer monsoon) in the area of 52 N.



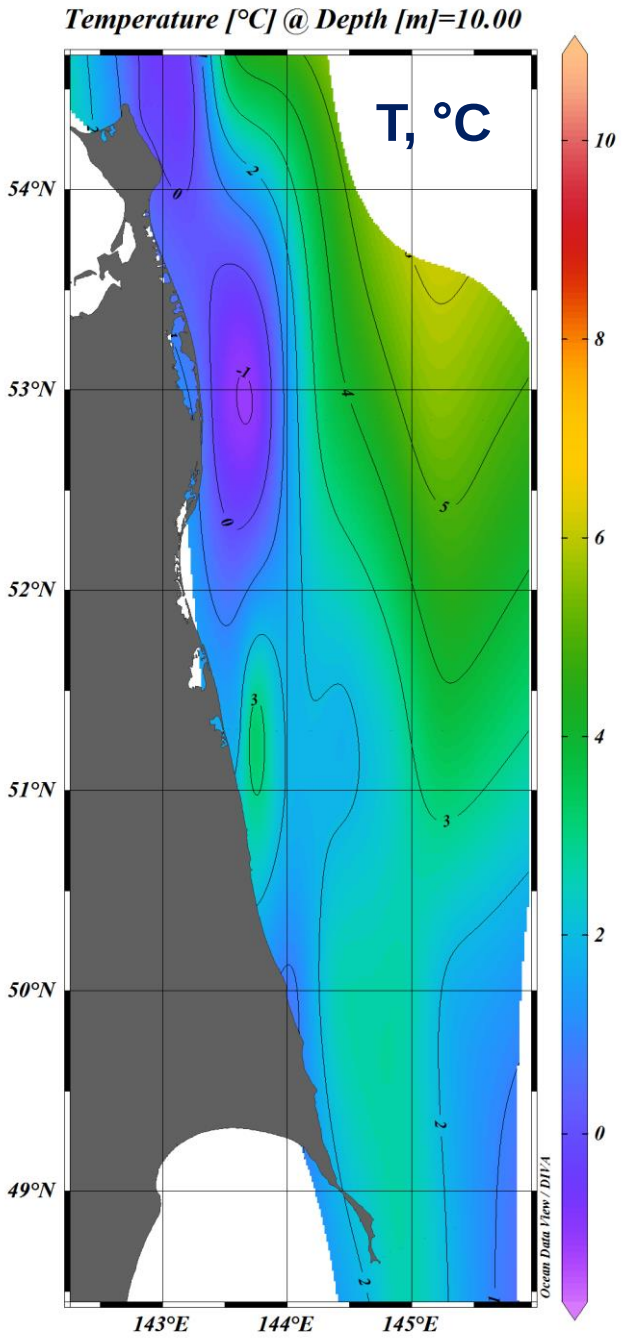
Satellite image on June 1, 2014. Almost no sea ice left in the Sakhalin Bay, and a little ice on the northeastern Sakhalin shelf too.

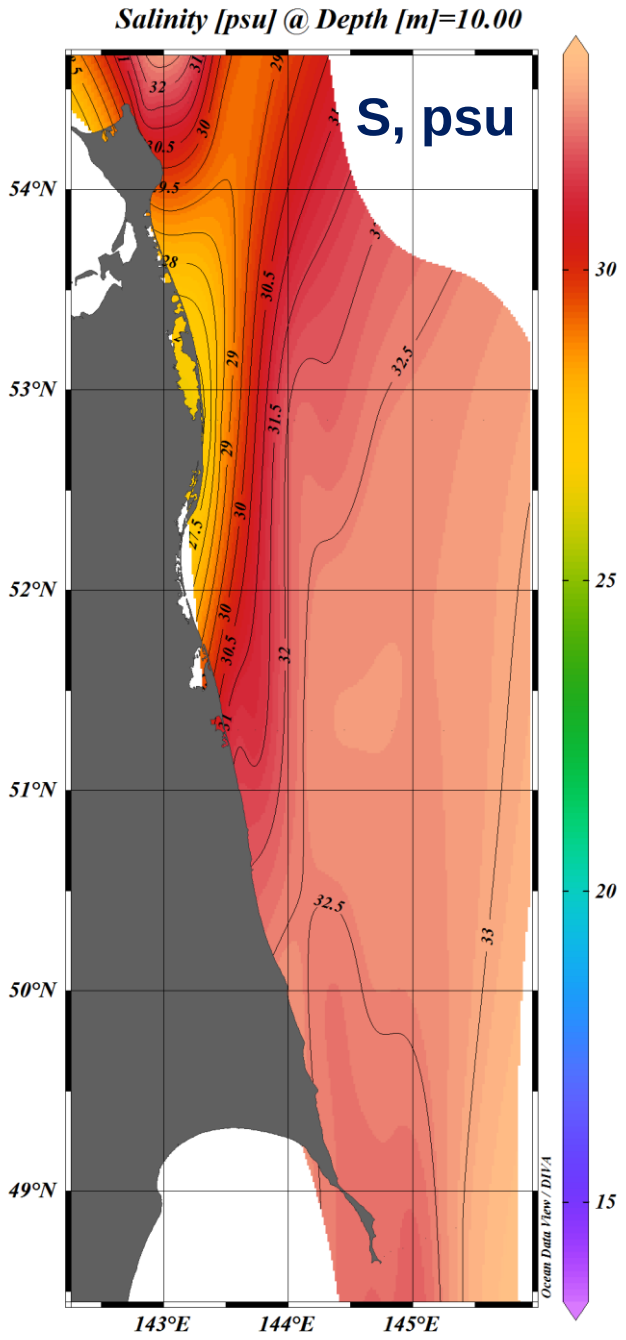
Example 4. Satellite image on May 25, 2014. There was much less sea ice in the Sakhalin Bay than usually; the ice dam had already opened, and the freshened Amur water had already gone from the Amur estuary to the Bay.
On the northeastern shelf, the remnants of the ice cover melted slowly near the Sakhalin coast between 52 and 54 N.





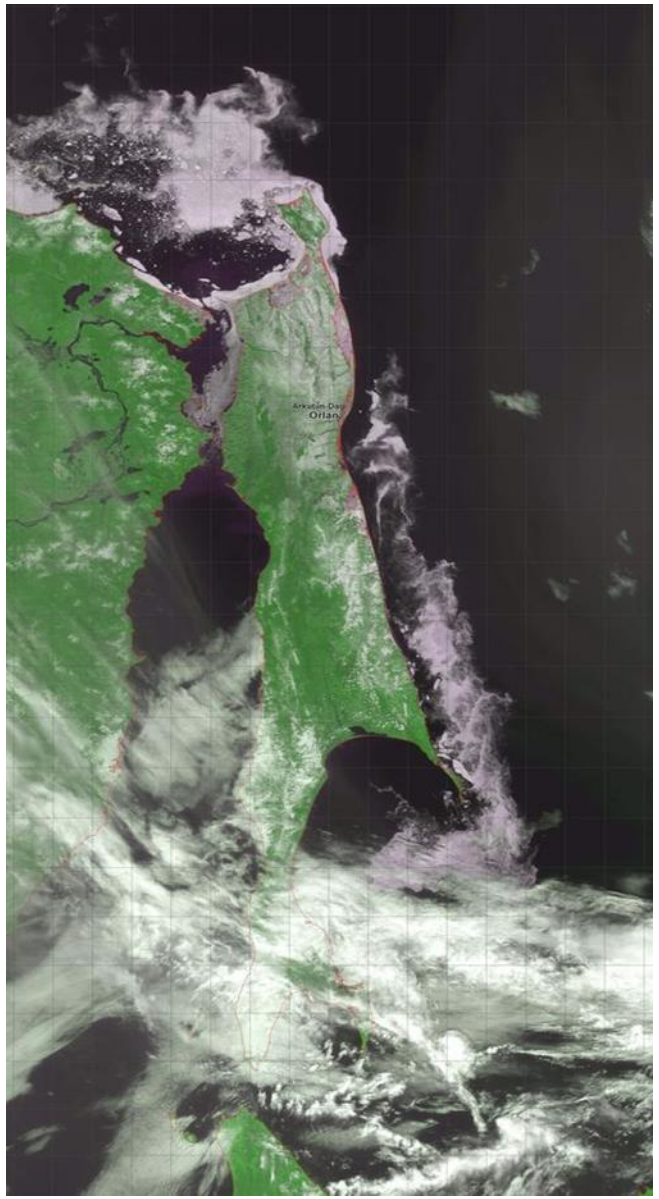
Water temperature and salinity distributions at the sea surface. Oceanological surveying during June 9-16, 2014 (R/V Dmitry Peskov). The freshened water of the Amur River runoff was characterized by a low salinity and high temperature (less than 22 psu, more than + 7°C), it located at some distance from the coast. The pushing of this water from the coast is a typical manifestation of coastal upwelling, which is formed under the influence of the southerly wind. The hydrological front in the salinity field is well defined.
No cooling of freshened water by ice was found.



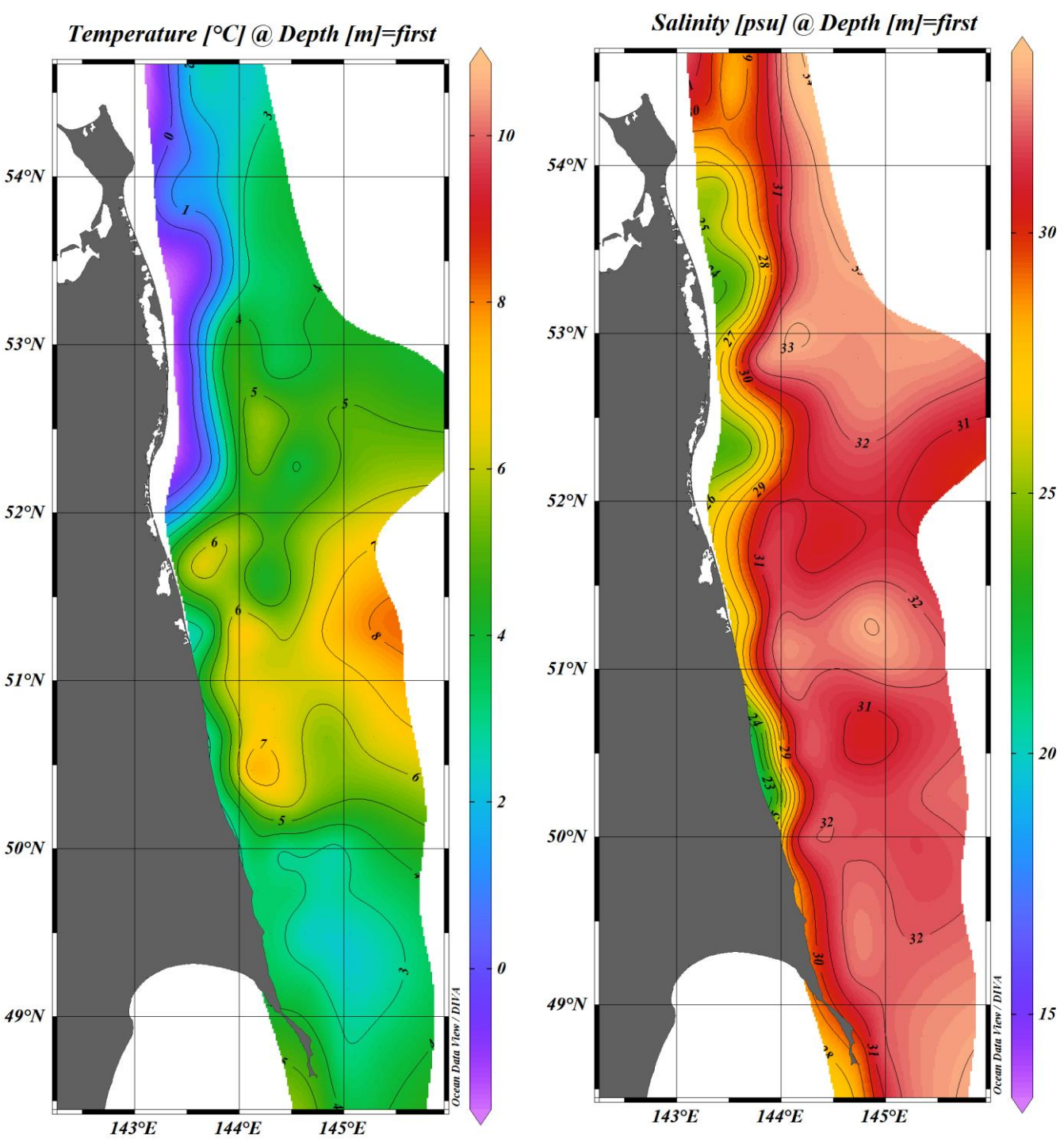


A different picture was revealed at a depth of 10 m. Water of low salinity (less than 29 psu) was located near the coast between 52 and 54° N. This water is cold, below 0° C.

This water was formed as a result of the melting of sea ice, which was in this area before the arrival of Amur River runoff freshened water.



Example 5. Satellite image on June 2, 2011.
At the end of May - the first half of June 2011 there was an unusual meteorological situation. There was no summer monsoon, northerly and northeasterly wind dominated over the region.
A significant part of the ice and freshened water from the Amur River flow remained in the Sakhalin Bay. The other part moved to the northeastern Sakhalin shelf and further southward without stopping (sea ice reached the southeastern coast of Sakhalin Island and caused a cooling of coastal waters during the migration of juvenile salmon).



Water temperature and salinity distributions at the sea surface. Oceanological surveying during June 22-26, 2011 (R/V Dmitry Peskov).

Freshened water stretched out by a narrow strip along the northeastern coast of Sakhalin. Hydrological salinity front was not formed, upwelling did not appear, freshened water is cold (cooled down by ice melting).

Conclusion

1. Based on the materials of oceanographic surveys and satellite observations of the state of the ice cover off the northeastern coast of Sakhalin, the features of the initial appearance of freshened water from the Amur River runoff on the northeastern shelf of Sakhalin are considered
2. Shown that desalinated water caused by the flood of the Amur River appears on the northeastern Sakhalin shelf in the first half of June, after the breaking of an ice dam preventing the flow of this water from the Amur estuary to the Sakhalin Bay.
3. When the freshened Amur water enters the northeastern shelf, a local density gradient arises, which contributes to the movement of this water to the south. The water carries with it heavy ice, which moves against the wind, and in a few days it covers the distance from Cape Elizaveta to Piltun and Chaivo bays (and to stationary drilling platforms for which it poses a serious threat).

Conclusion

4. Melting of sea ice leads to the formation of water with low salinity and low temperature (to negative values) at a depth of about 10 m. On the sea surface, low salinity water can be warm enough (6-7°C), but it can be cooled when the ice melts.
5. Under the influence of the southern wind (summer monsoon), a hydrological salinity front is formed in the Chaivo Bay area. This front prevents the movement of this water and sea ice further south. The threat of the dangerous impact of heavy ice on ice-resistant drilling platforms located south of 52 N significantly lower.
6. This threat increases with the weakening of the summer monsoon and the prevalence of the northerly wind; the hydrological front may not form and heavy ice may reach oil and gas fields located south of 52° N.
7. The obtained results are essential for studying the conditions for the pollock eggs and larvae maturation.