On small- and meso-scale dynamic processes responsible for long-term fluctuations of biological parameters of continental shelves and marginal seas

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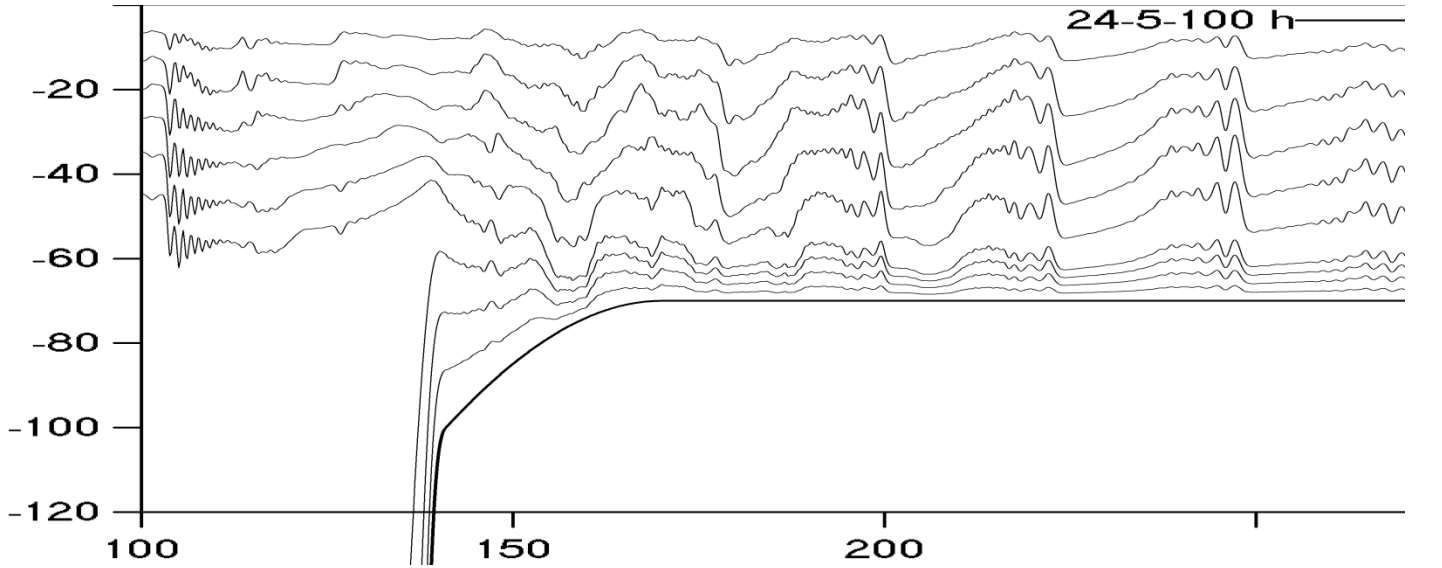
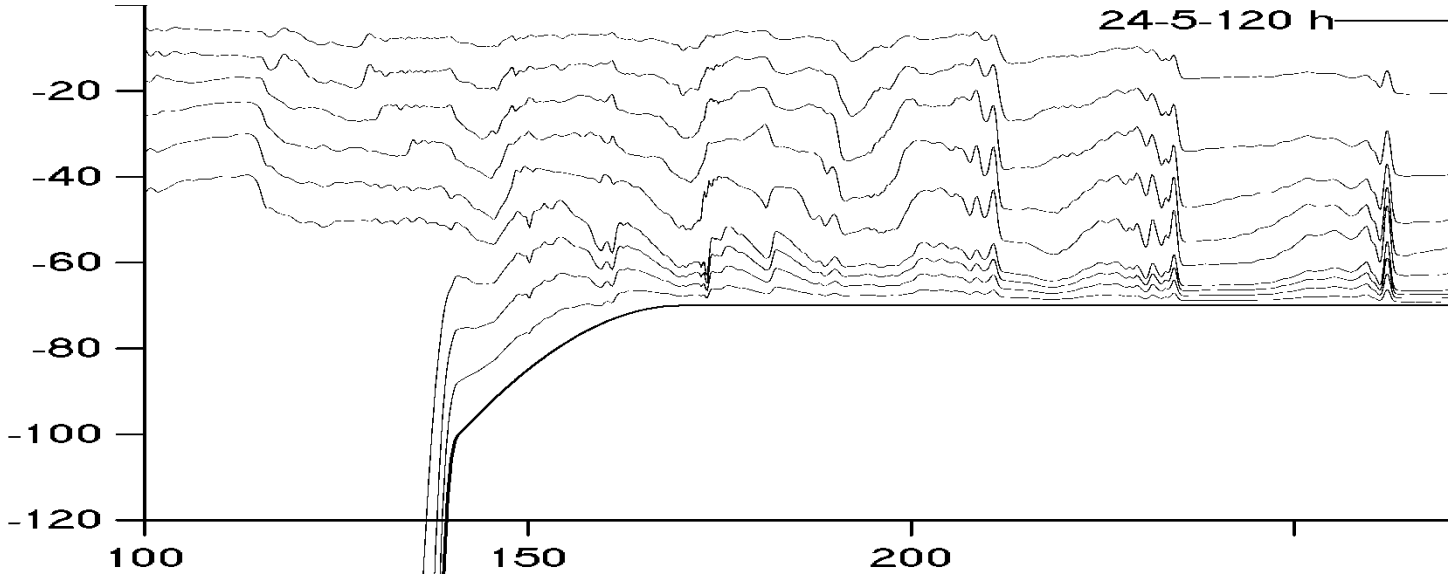
Main points

- Energetics of motions in shelf zones
- Conjugation of multi-scale dynamic processes – how, when and where
- How biological processes depend on different dynamic processes?
- Experimental investigation of processes in the near-bottom thermocline – momentum, energy and matter fluxes
- Internal waves, tides, eddies and primary production – what can we get from in situ and satellite observations?

Spatial structure of IW at the moments 100 and 120 hours after switching on semidiurnal (tidal) fluctuations of velocity from the state of rest



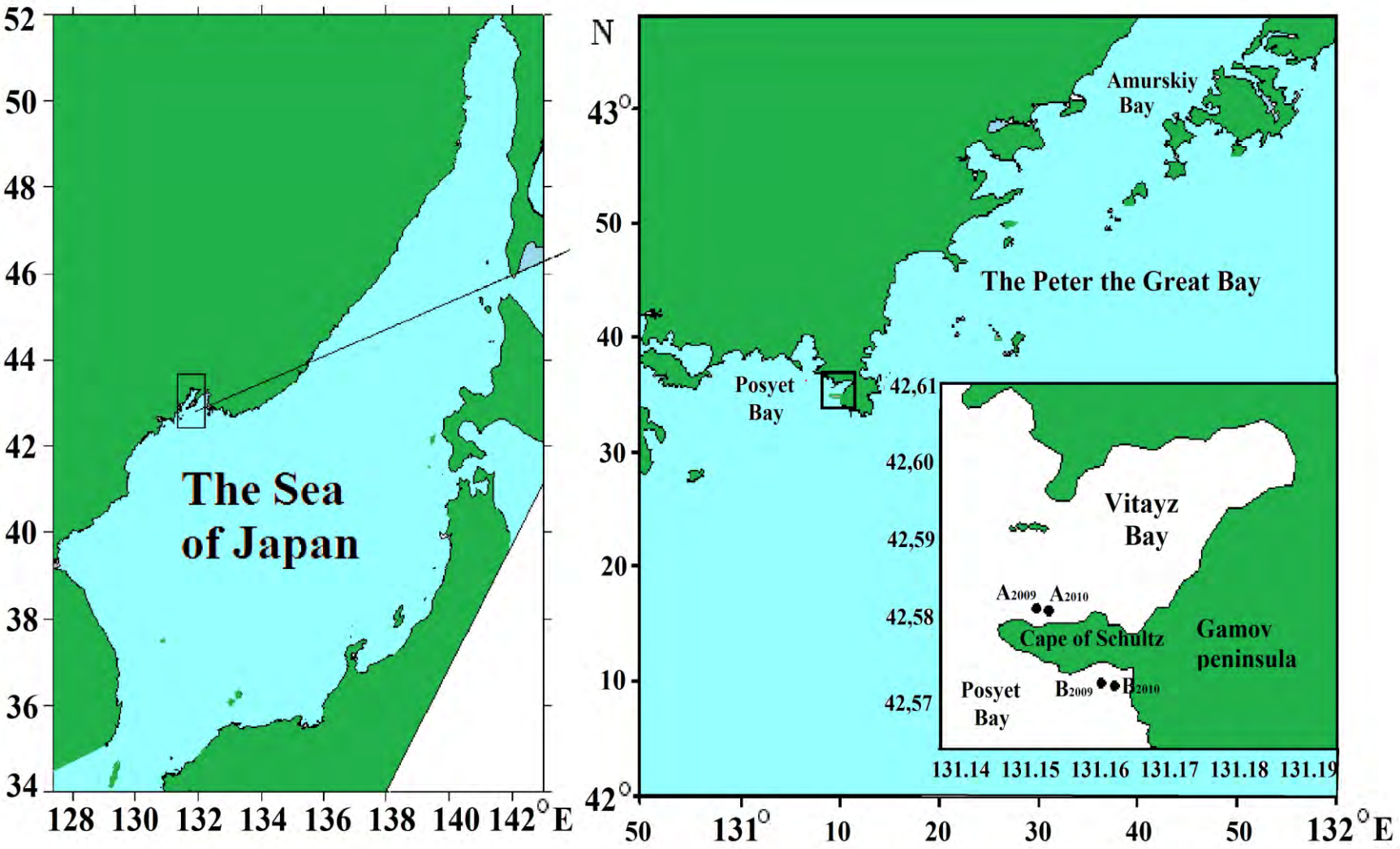


To show animation

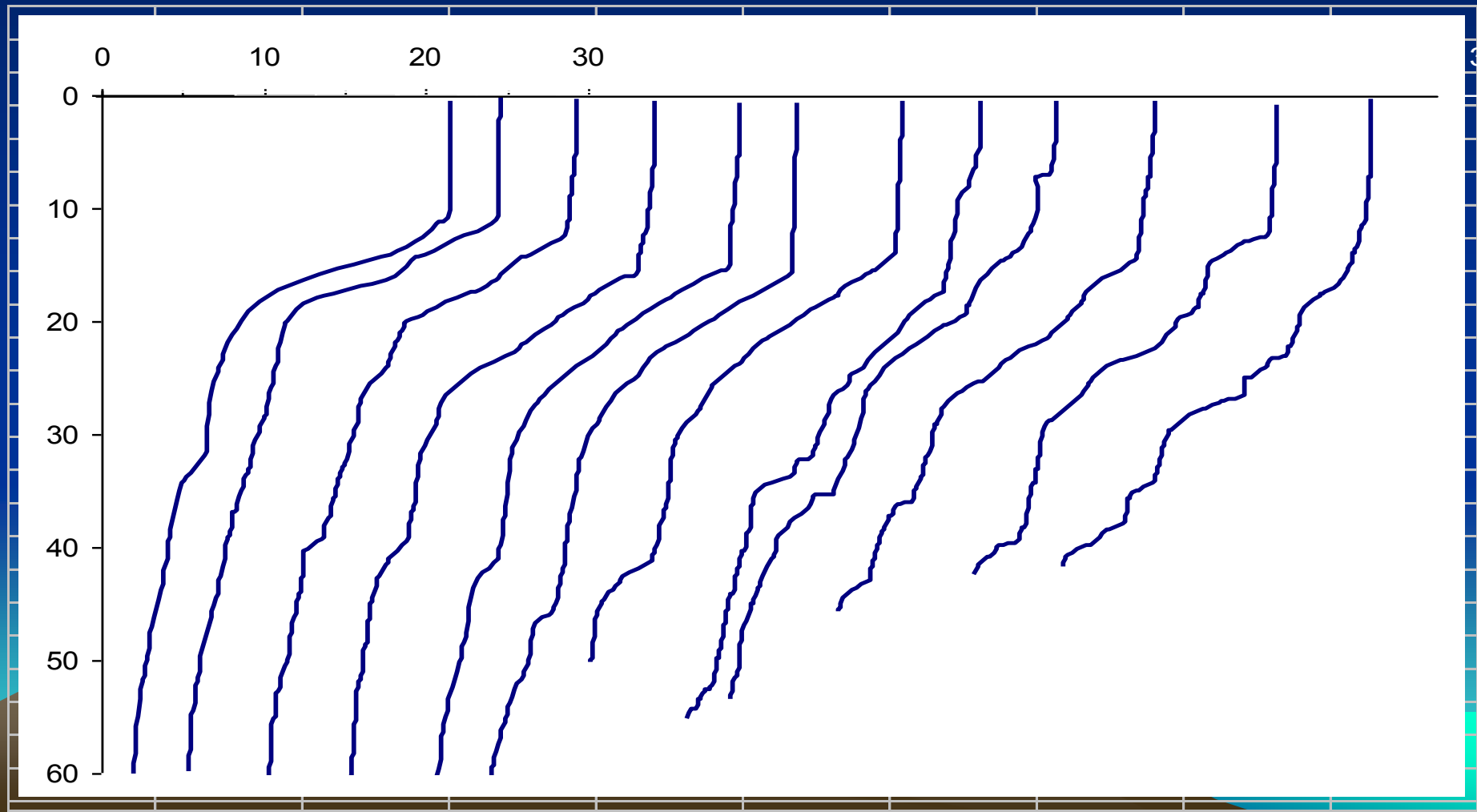
- 08-24-5 – to compare with observed IW deformation from shelf break to a shore
- 08-24-4 – Change of IW structure in time and space
- 08-24-1 – More complex: tide+inertial.

  IW shoaling with distance and time

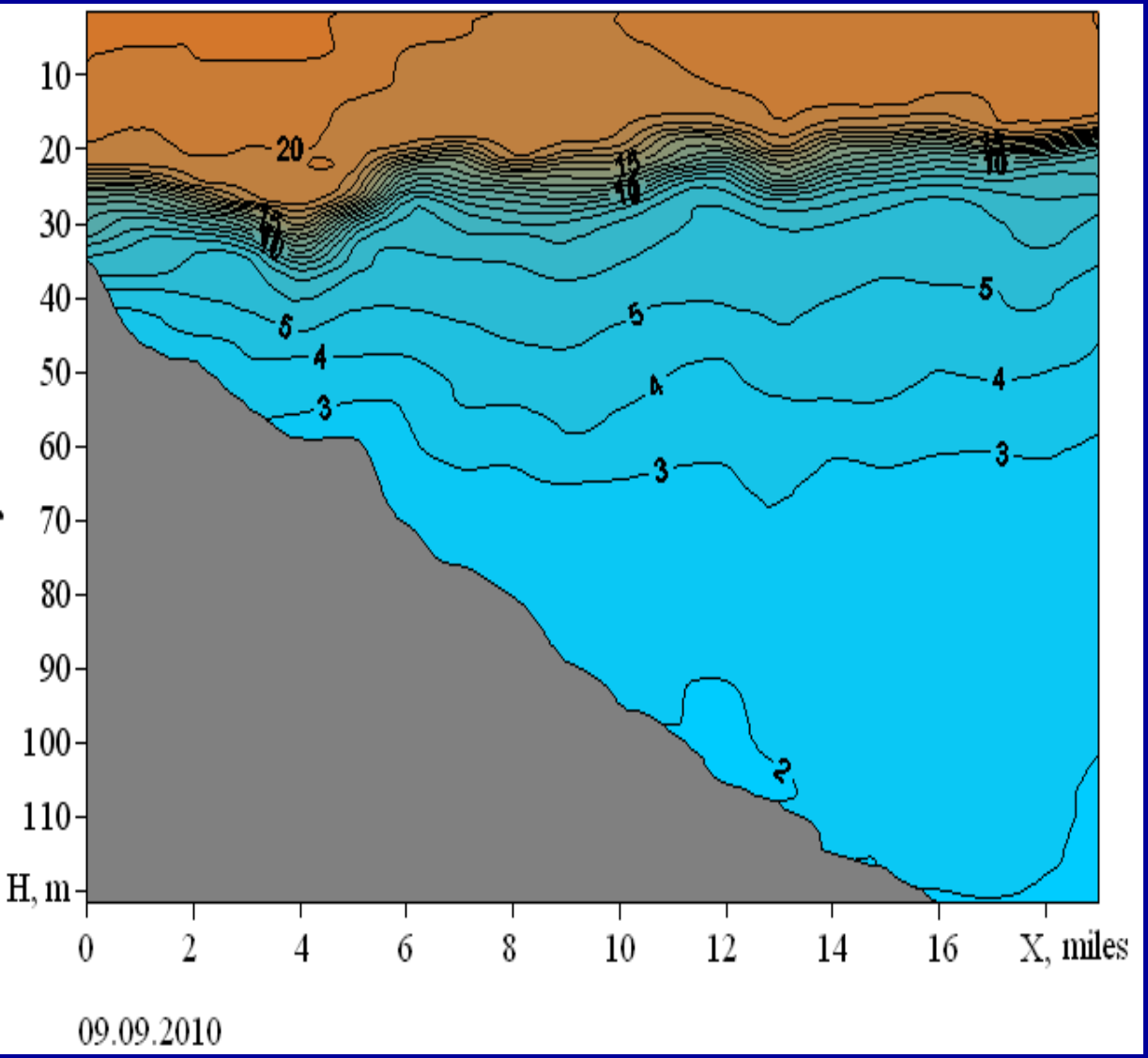
Research area and points of long-term observations



Temperature profiles on transects from the shelf break to the shore (from left to right). Distance between soundings is 1 mile. Fine structure appears. Vertical fine structure formation.

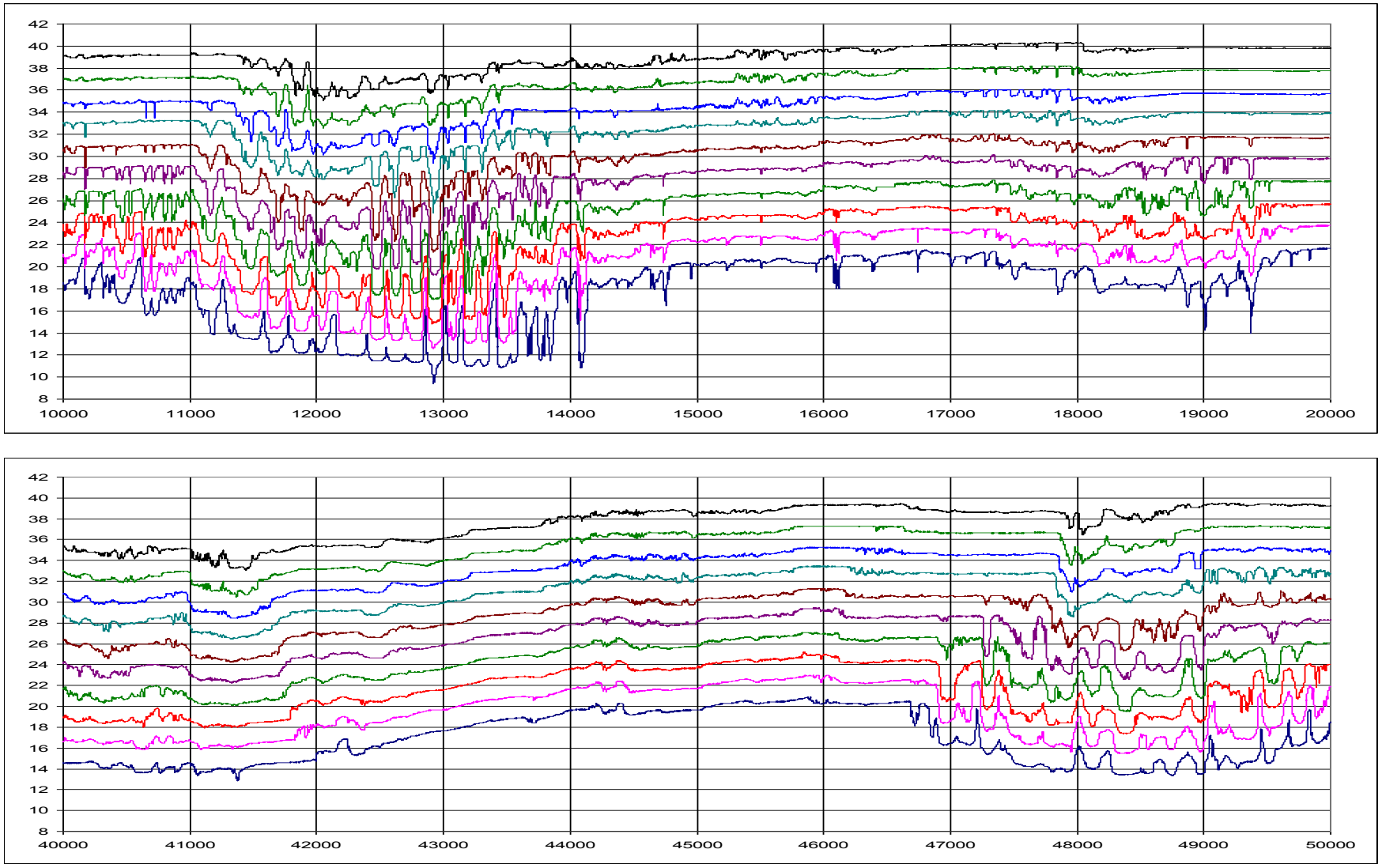


Spatial transect of temperature through the Japanese Sea shelf zone

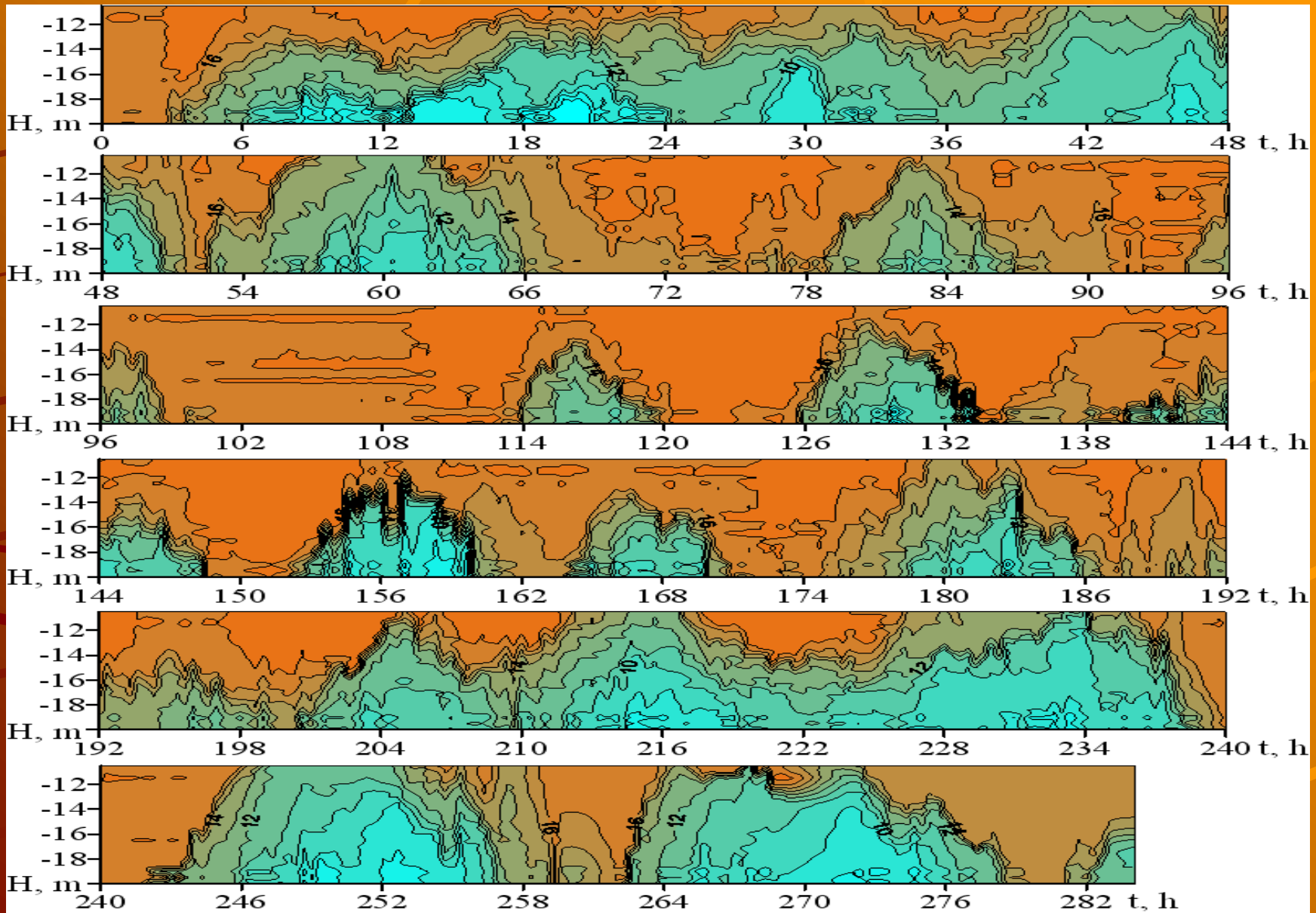


- Sharp thermocline is aproaching the bottom.
- What is going on in the near-bottom layer?

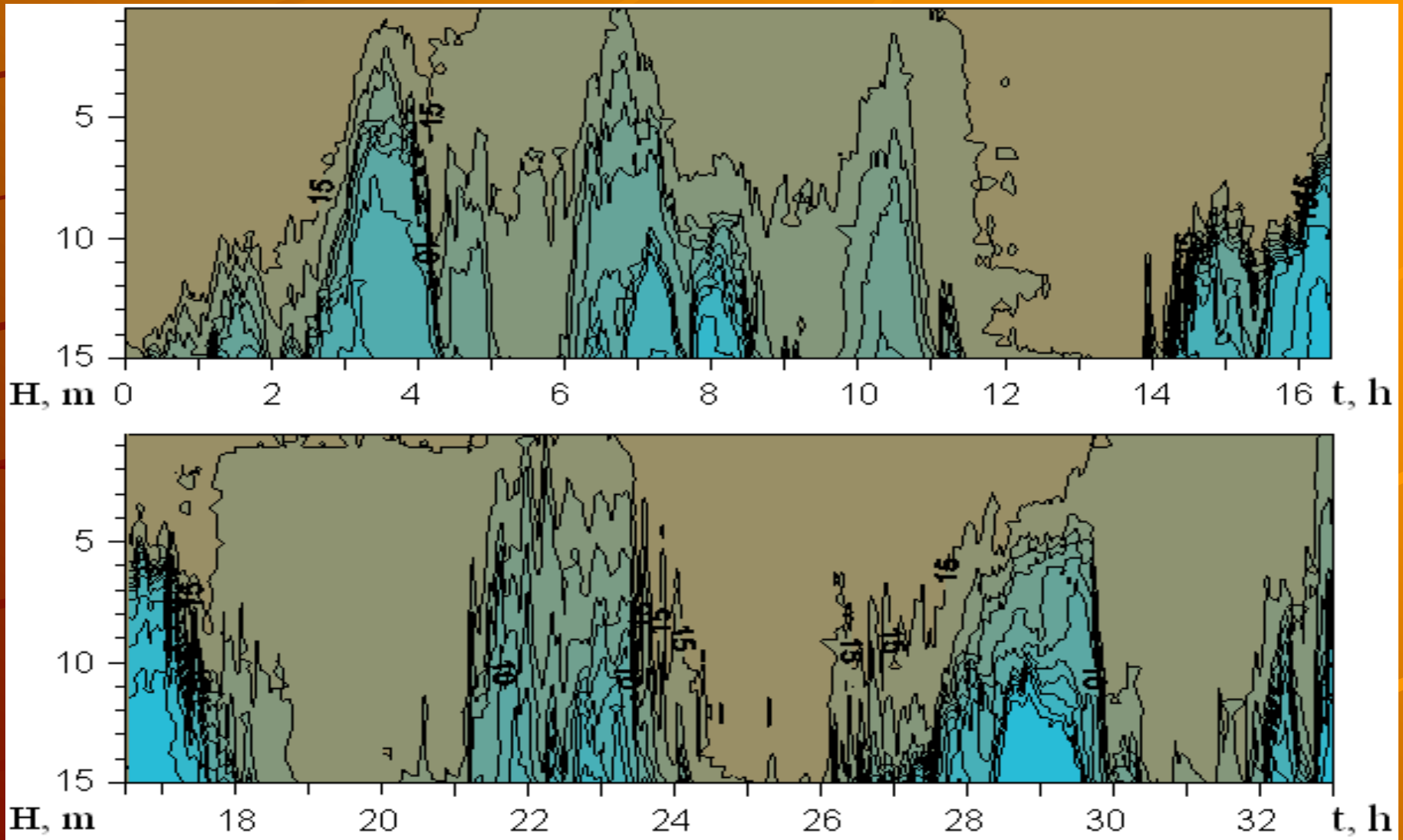
Temperature fluctuations at 10 levels in a 10-meter layer of the near-bottom thermocline. The process is highly intermittent



Internal waves and boluses in the near-bottom thermocline (Sept. 2009, inside the bay Vitiaz). The main periodicity about 12 h. Alternation of waves, boluses and mixed water.

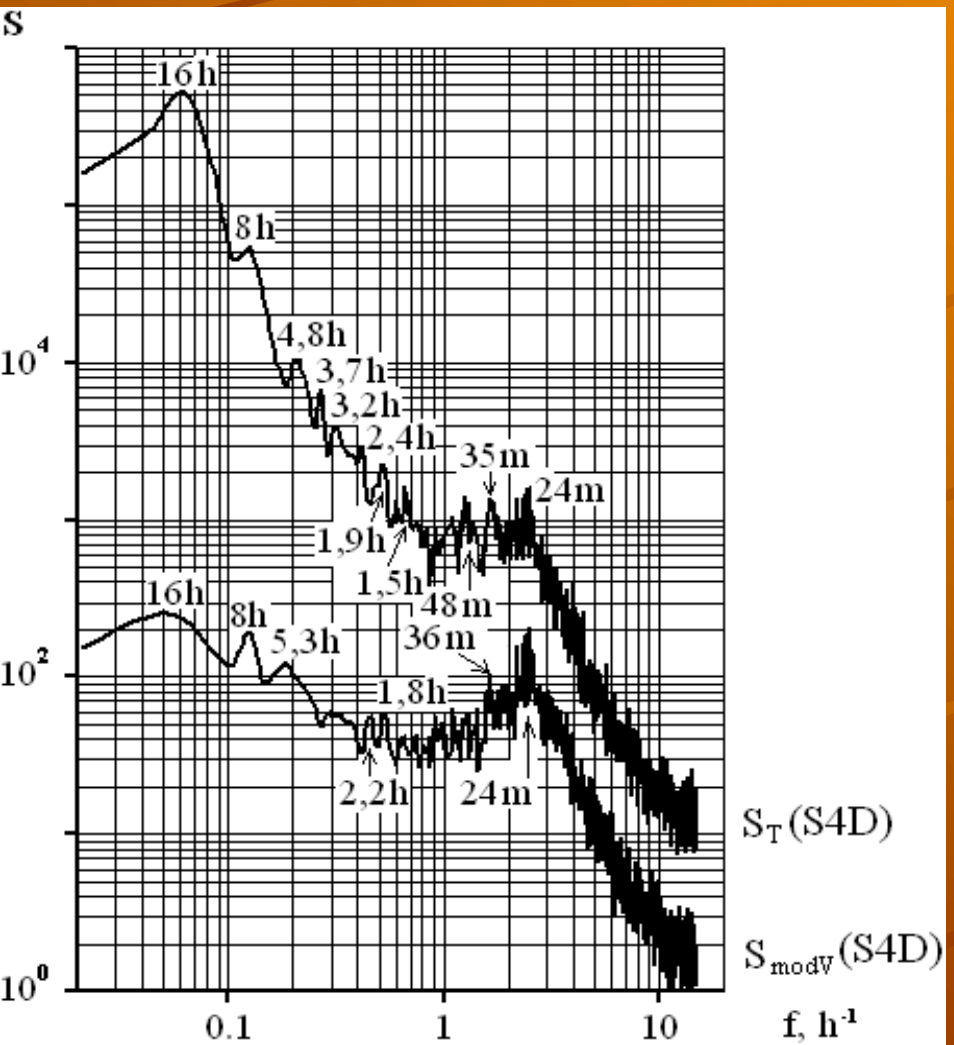


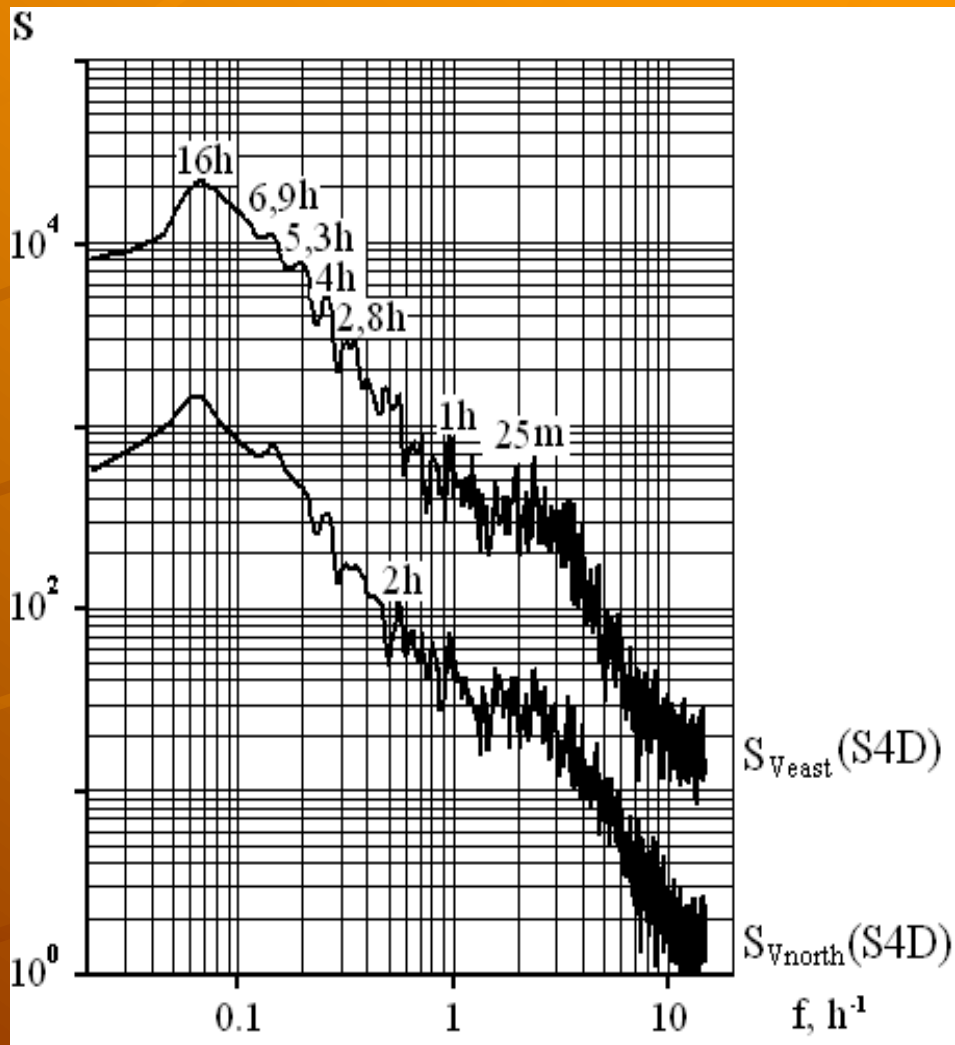
Setup and destruction of short-period internal waves in the 15m thick near-bottom layer (start at 06:22, 01.09.2011).



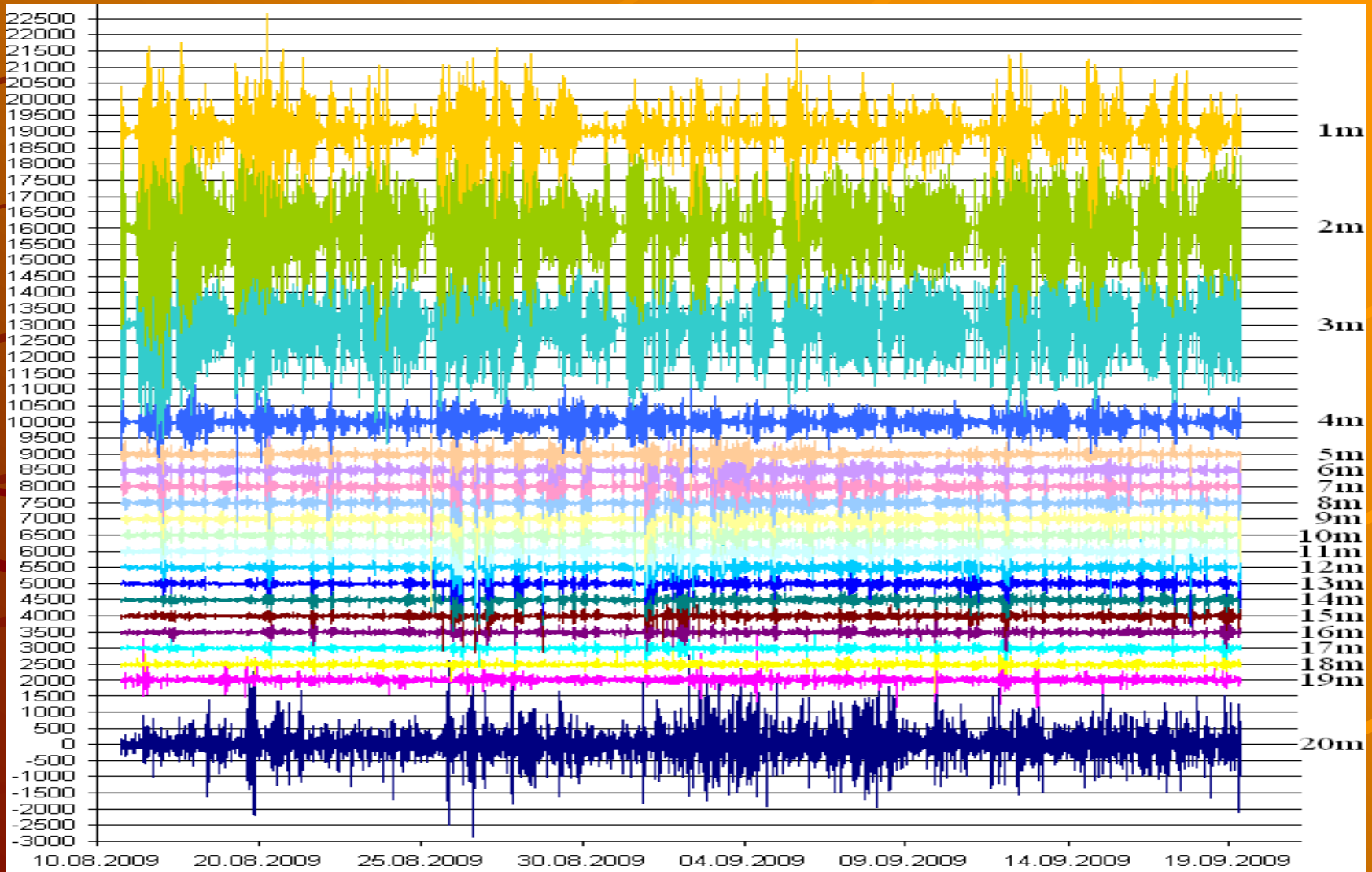
Spectra of mod(V) and temperature fluctuations

The observed velocity field is obviously produced by internal waves.
Max energy is near the inertial frequency. Bumps around 30 min – specific for IW in shelf zones.

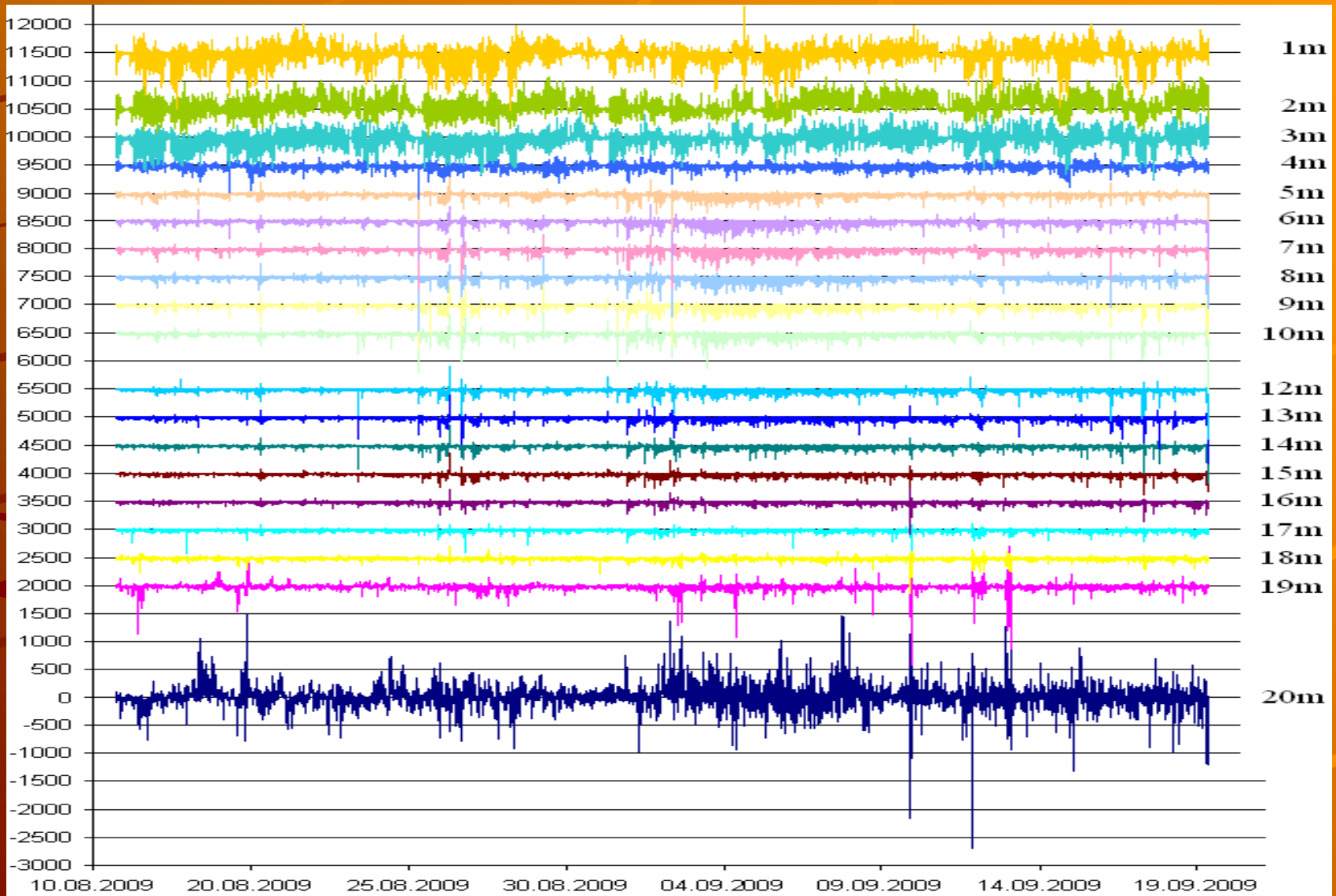




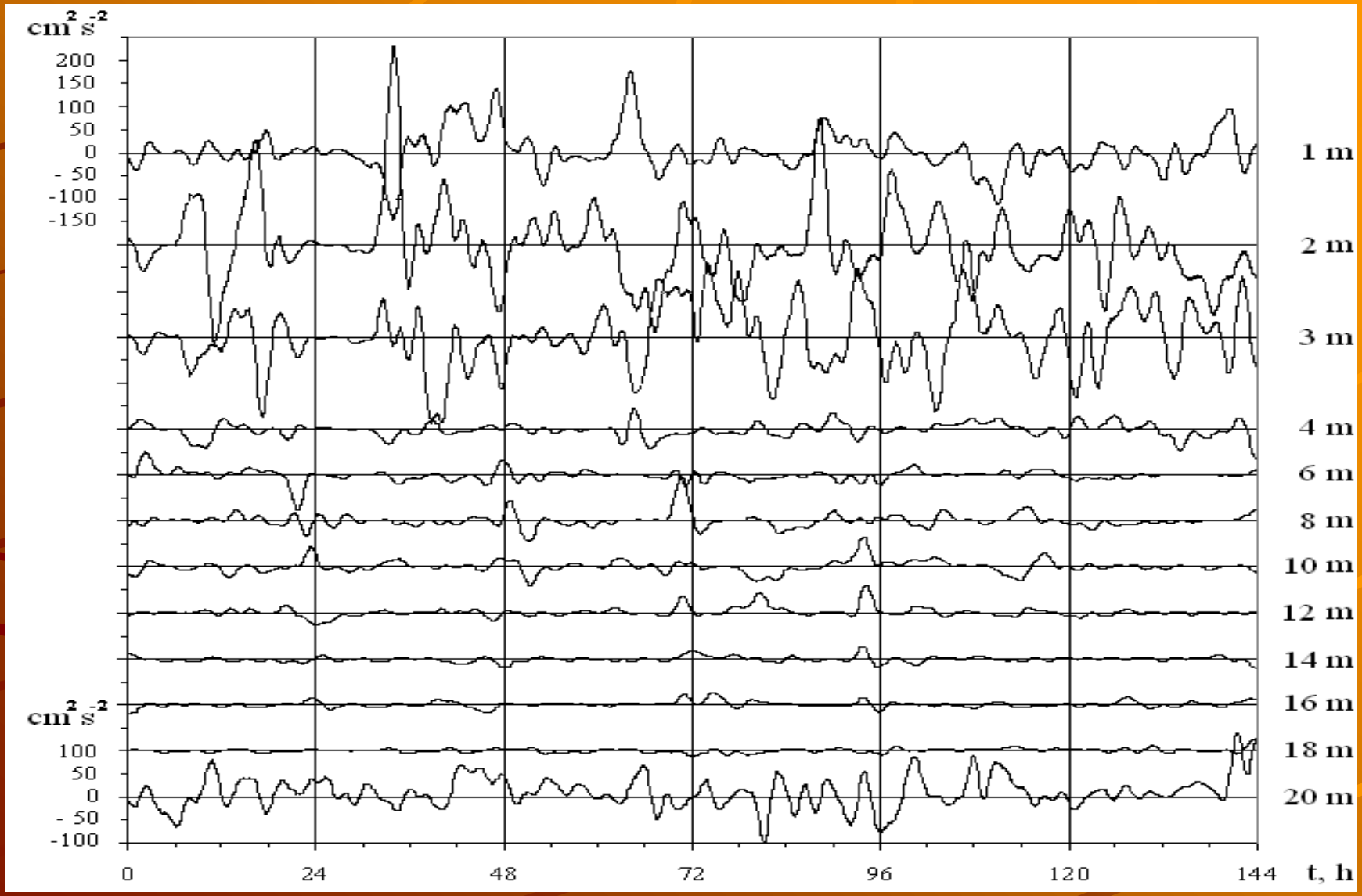
Horizontal momentum fluxes at different levels. Bottom depth 22 m. Maximum fluctuations in the upper and near-bottom layers.



Vertical momentum fluxes at different levels.
Maximum fluctuations in the near-bottom layer can be greater than in the upper layer.

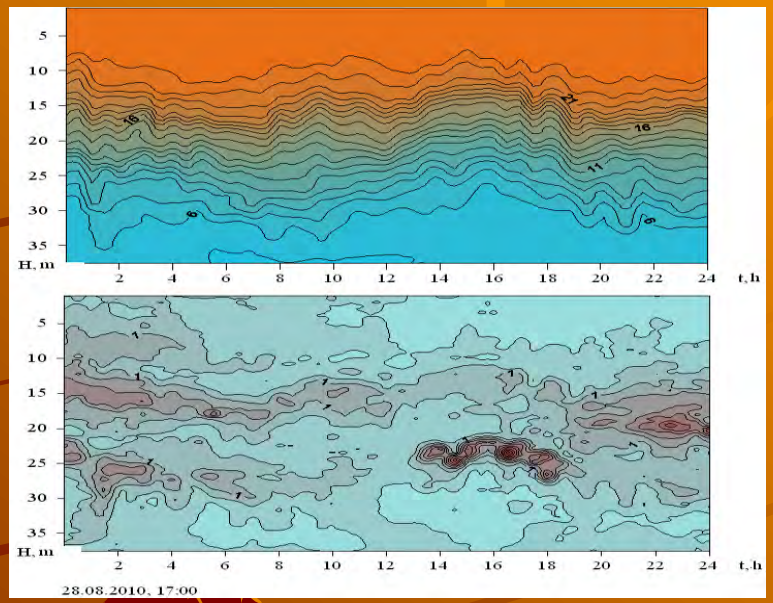


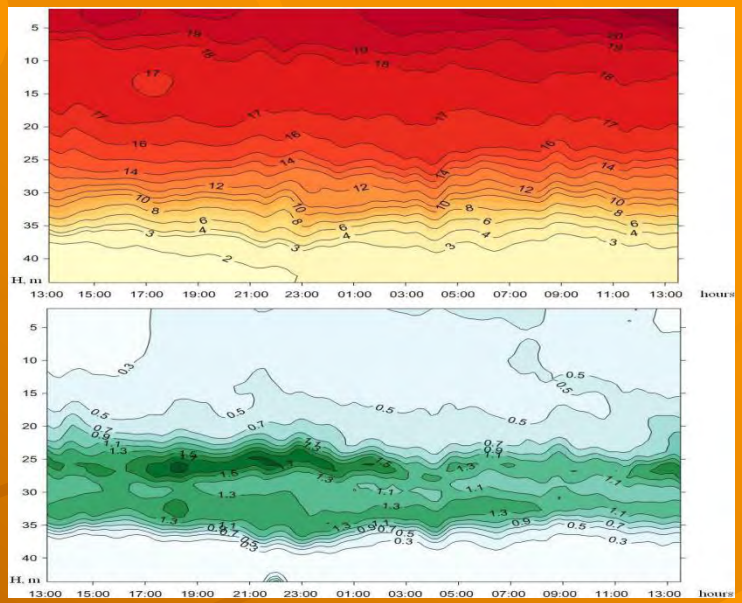
Kinetic energy of horizontal movements at different levels (bottom depth about 22 m)

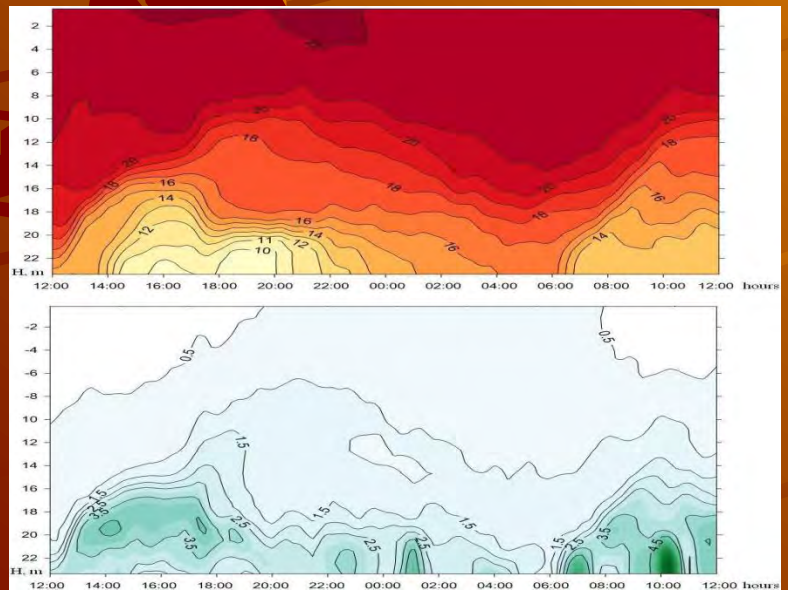


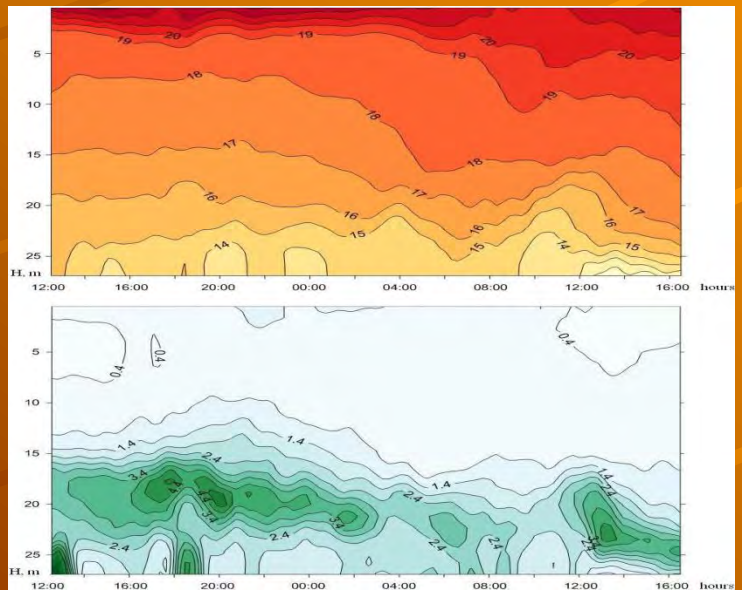
What about connections between biological and small-scale physical processes?
Density structure and its wavy fluctuations - ?

Temporal fluctuations of thermocline and layers with maximum fluorescence. Two fl-layers: physical and biological explanations

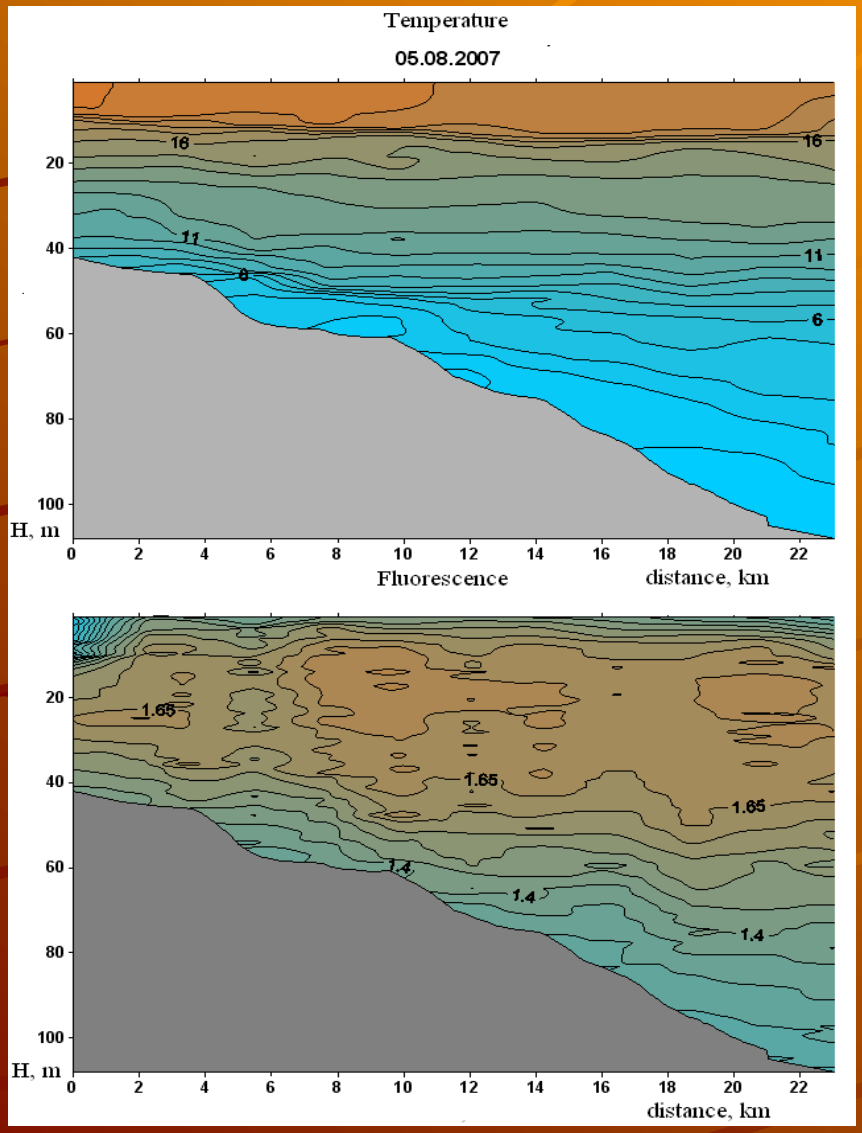


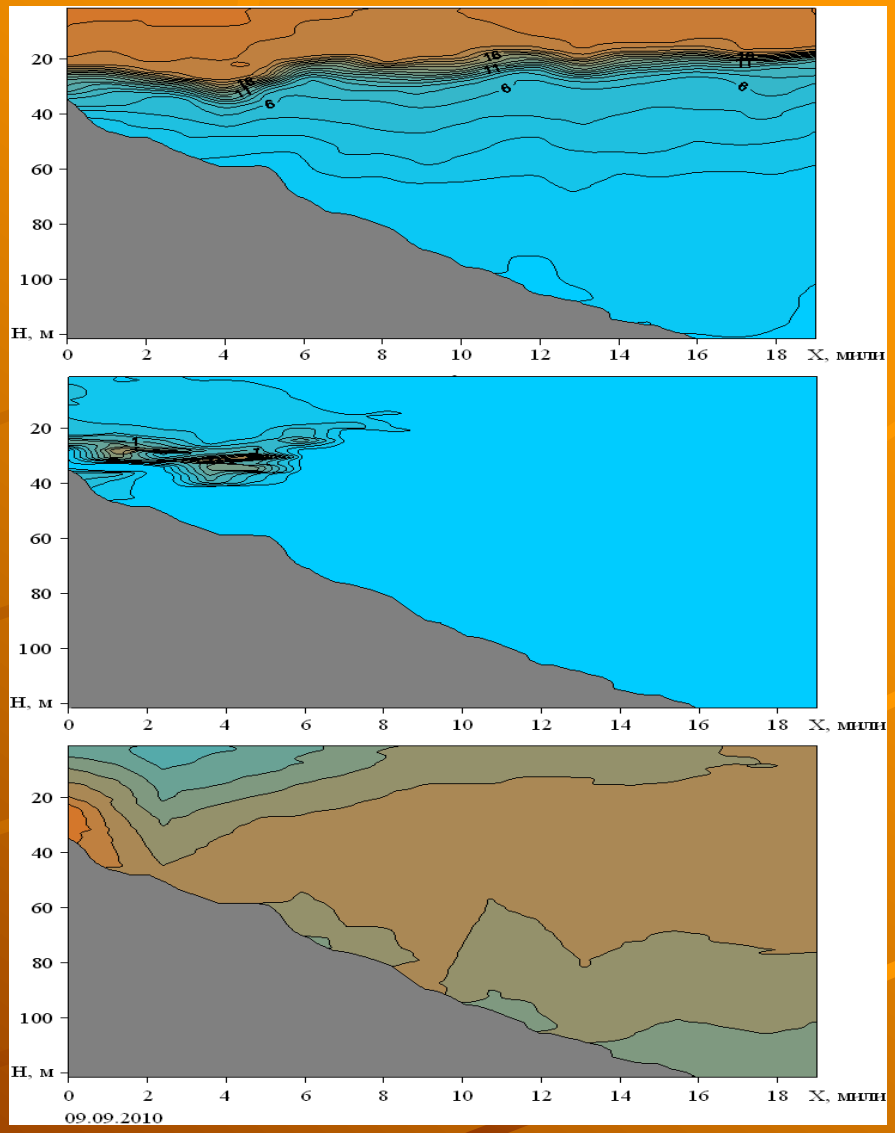




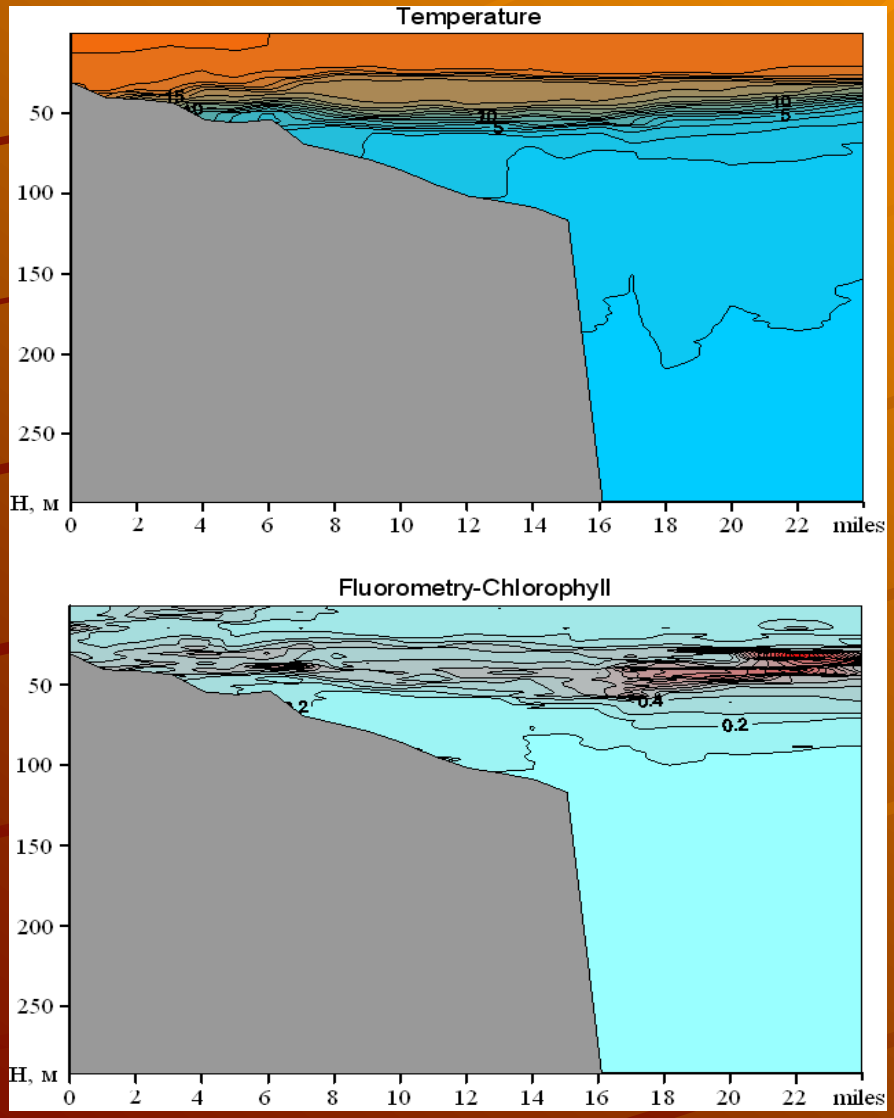


Spatial fluctuations of temperature and biological parameters

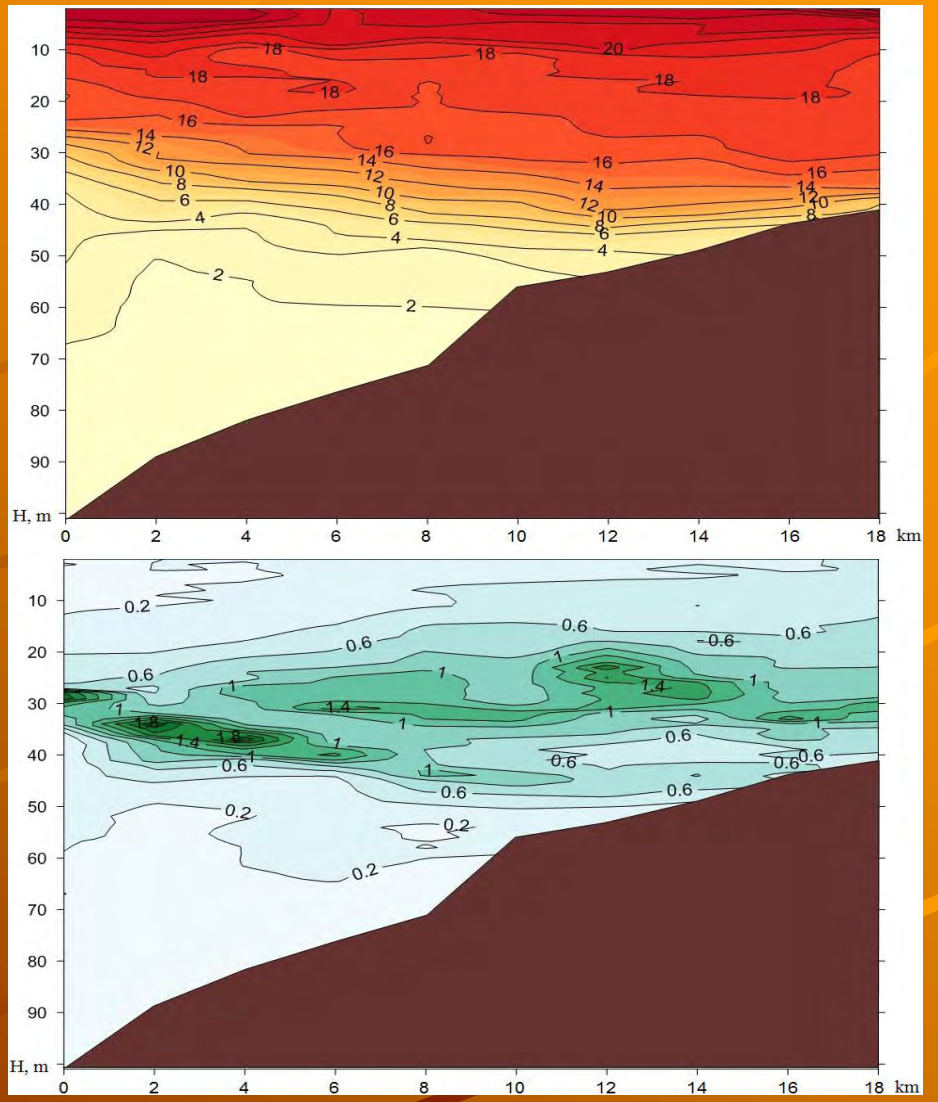




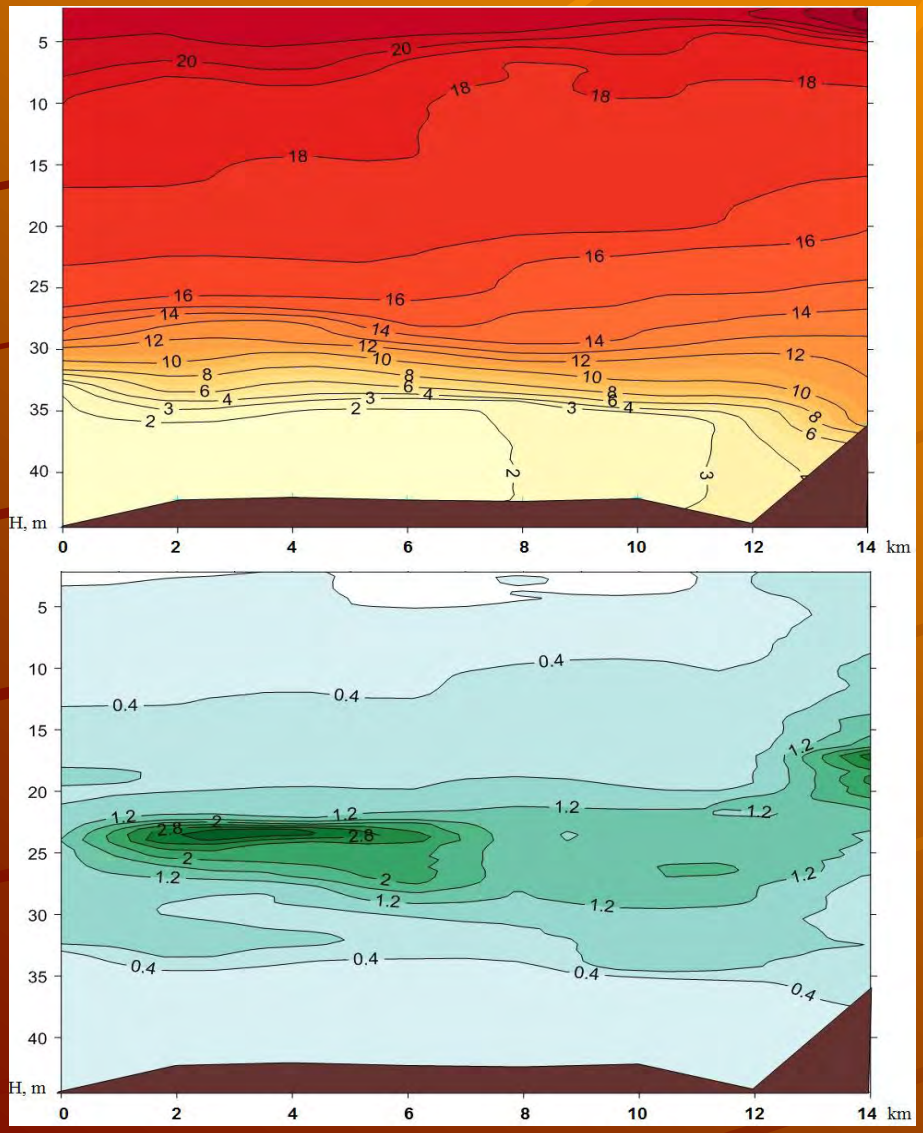
9 September 2012



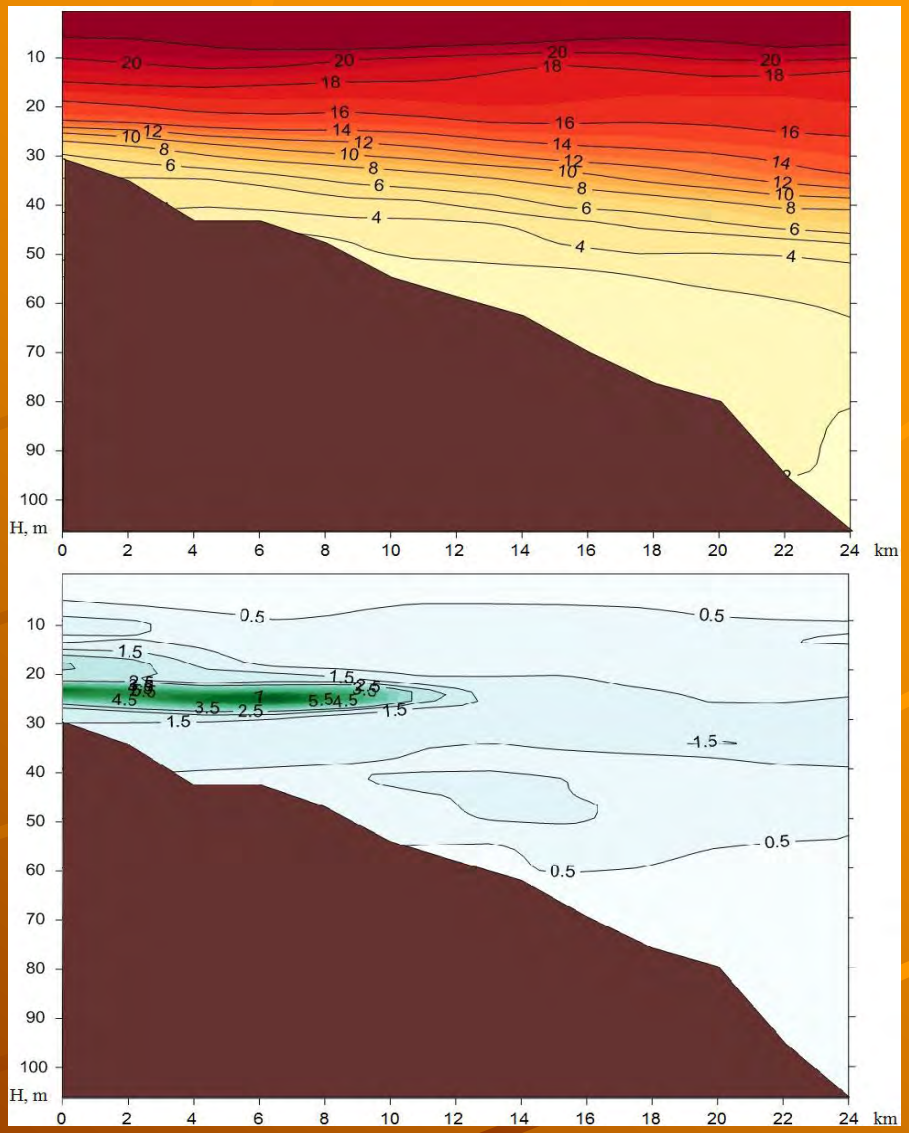
14 August 2013



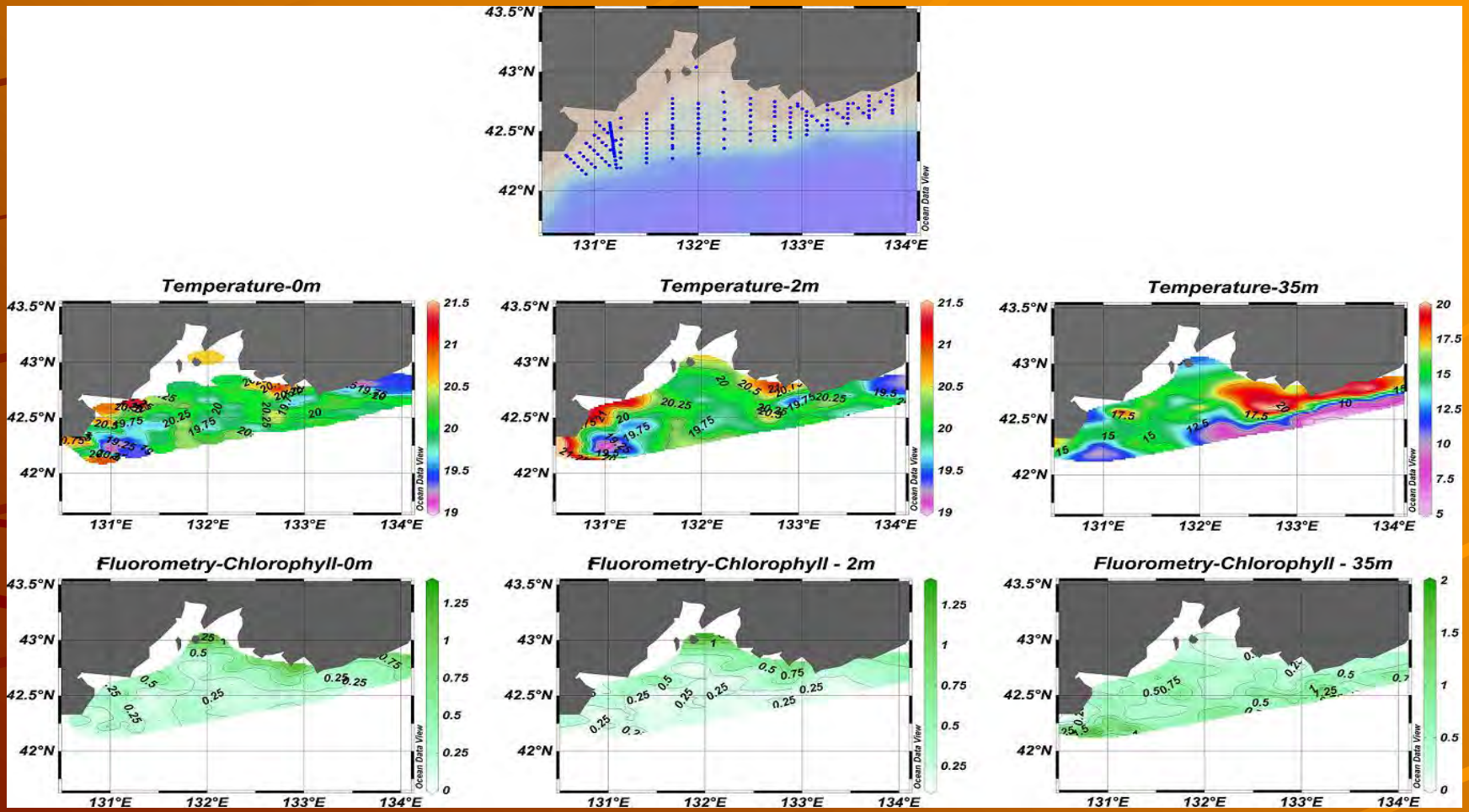
19 Aug Along isobaths

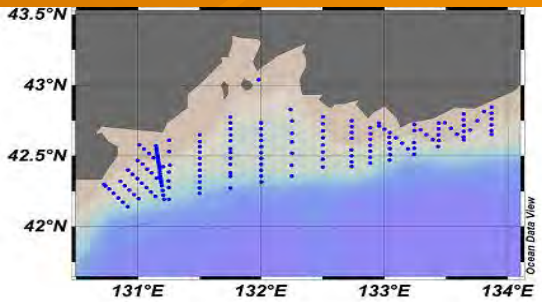


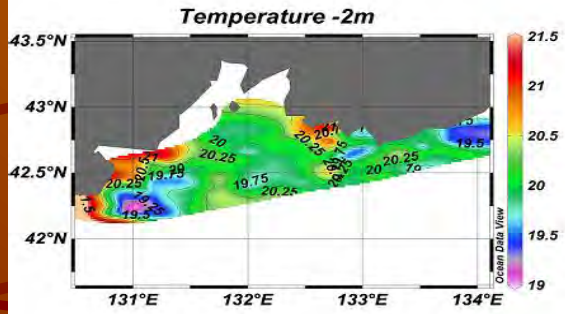
27 Aug Across isobaths

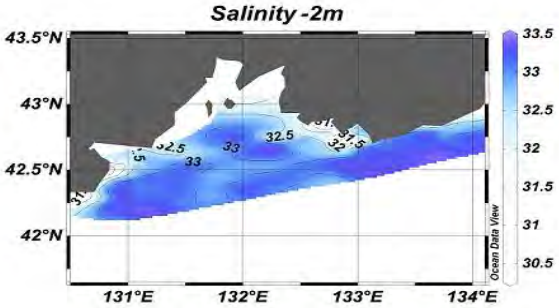


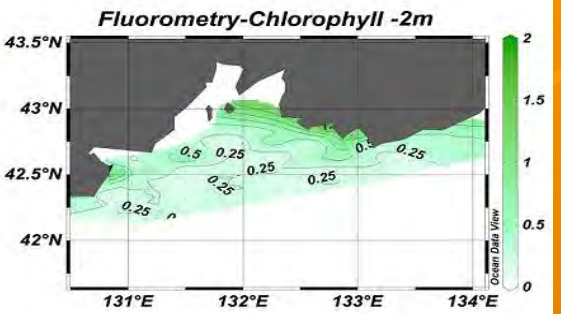
Spatial structure of physical and biological parameters in the Peter the Great bay

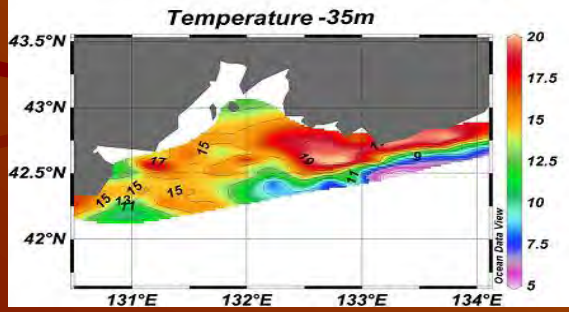



43.5°N
43°N
42.5°N
42°N
131°E
132°E
133°E
134°E
Ocean Data View


Temperature -2m
43.5°N
43°N
42.5°N
42°N
131°E
132°E
133°E
134°E
21.5
21
20.5
20
19.5
19
Ocean Data View


Salinity -2m
43.5°N
43°N
42.5°N
42°N
131°E
132°E
133°E
134°E
33.5
33
32.5
32
31.5
31
30.5
Ocean Data View


Fluorometry-Chlorophyll -2m
43.5°N
43°N
42.5°N
42°N
131°E
132°E
133°E
134°E
2
1.5
1
0.5
0
Ocean Data View


Temperature -35m
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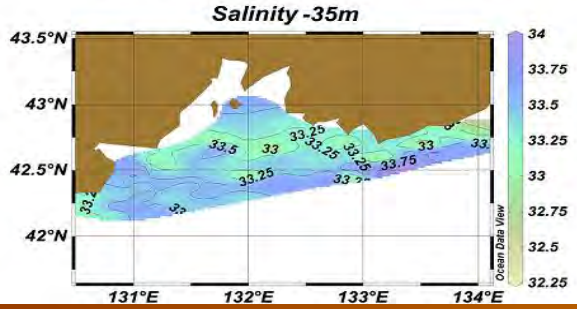
43°N
42.5°N
42°N
131°E
132°E
133°E
134°E
20
17.5
15
12.5
10
7.5
5
Ocean Data View


Salinity -35m
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43°N
42.5°N
42°N
131°E
132°E
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134°E
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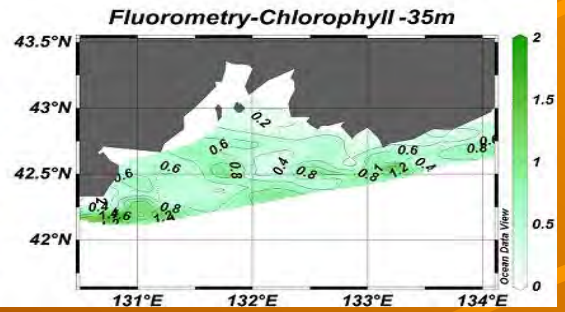
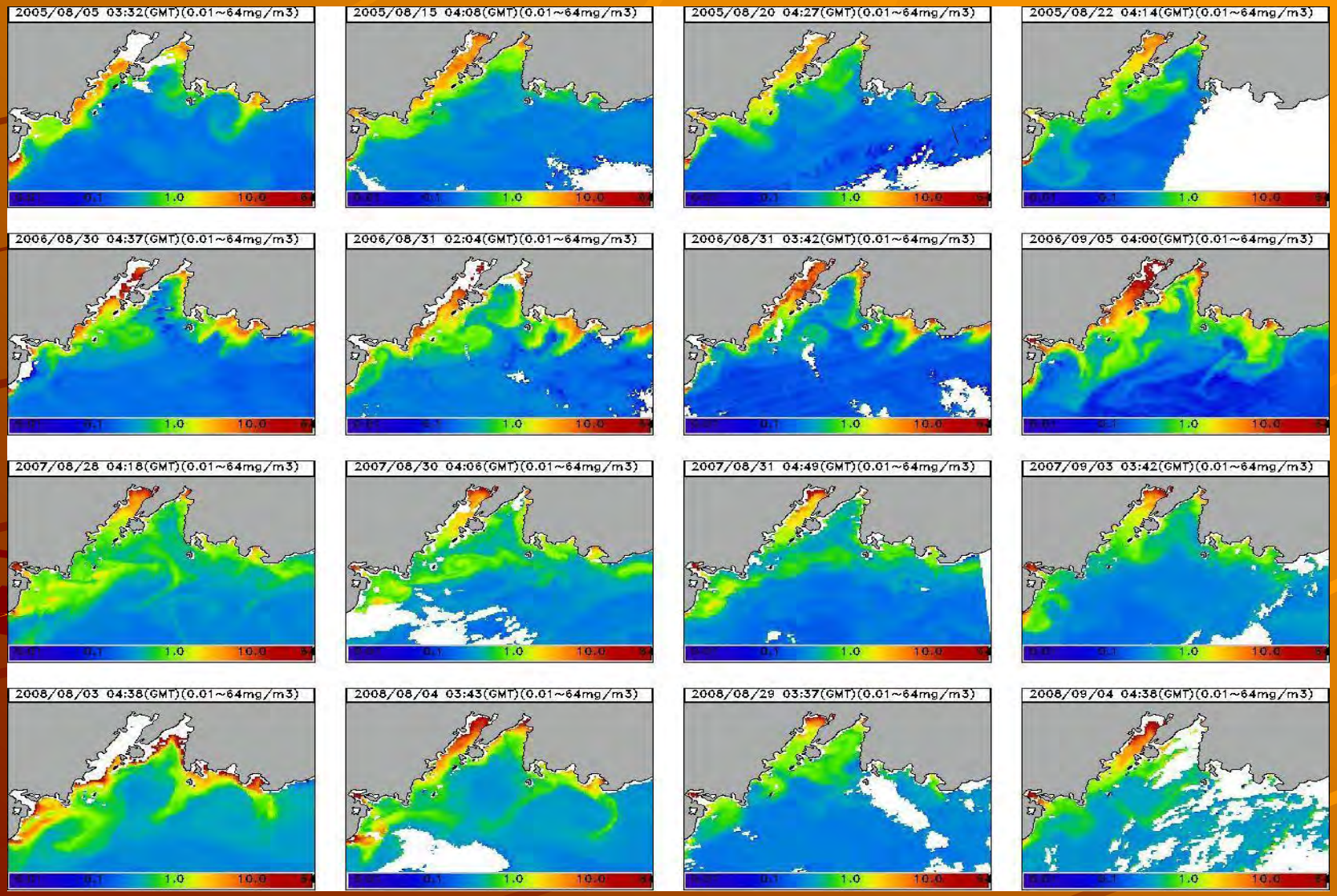
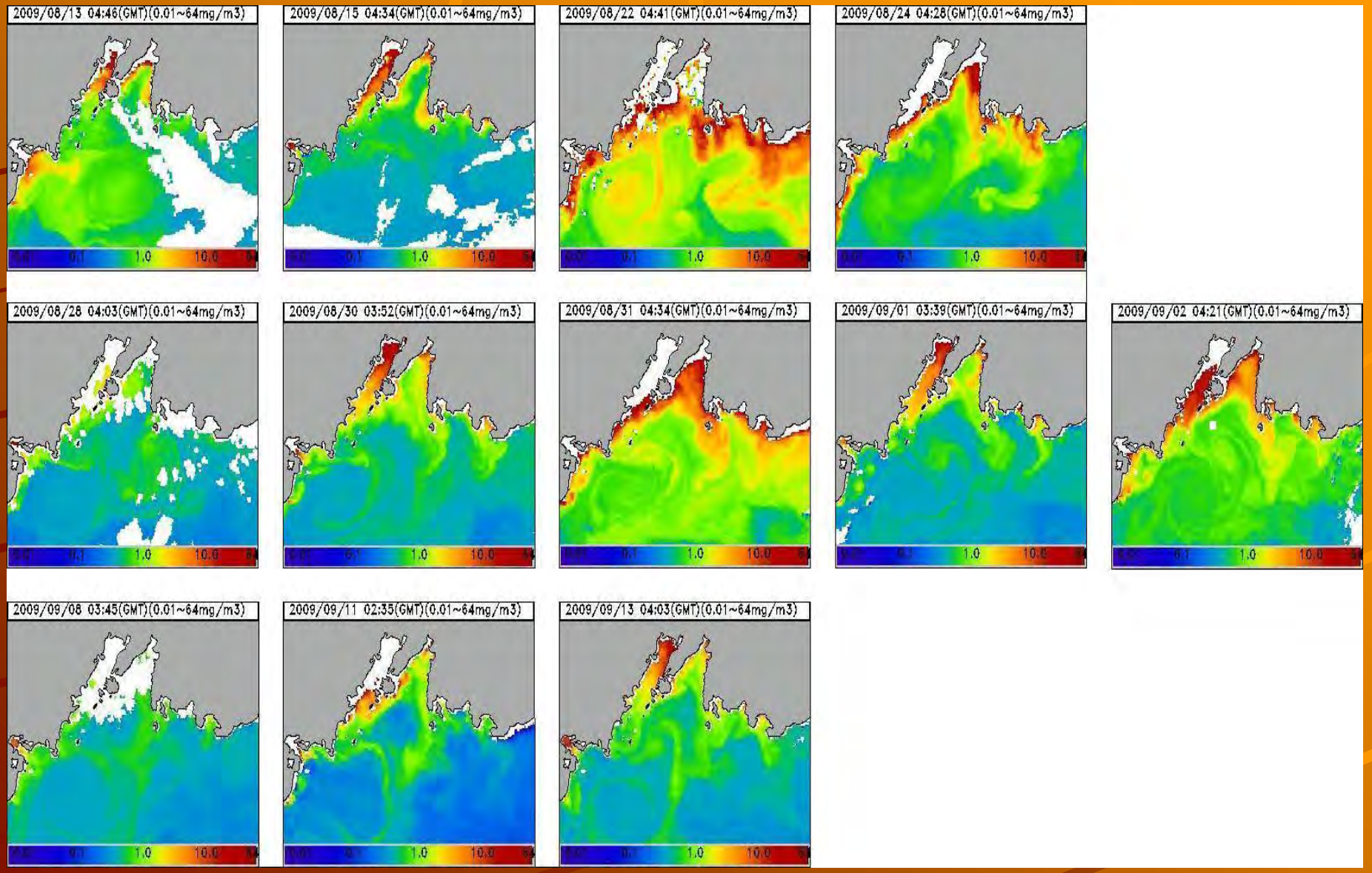
33.75
33.5
33.25
33
32.75
32.5
32.25
Ocean Data View


Fluorometry-Chlorophyll -35m
43.5°N
43°N
42.5°N
42°N
131°E
132°E
133°E
134°E
2
1.5
1
0.5
0
Ocean Data View

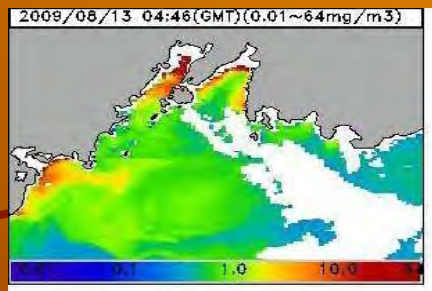
Chlophyll-a and eddies in the Peter the Great bay (2005-08)



2009. Some kind of temporal periodicity Cl-a distribution



2009; 2012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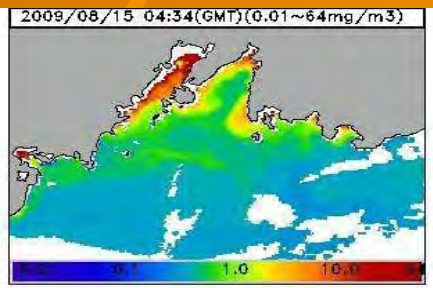
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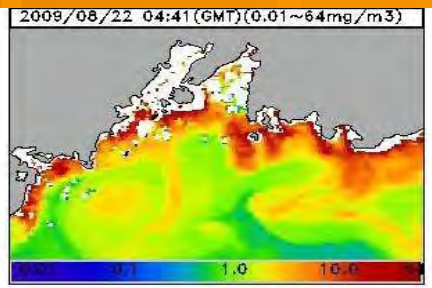
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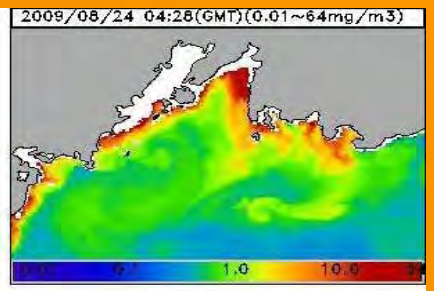
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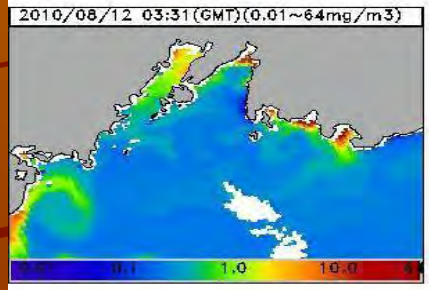
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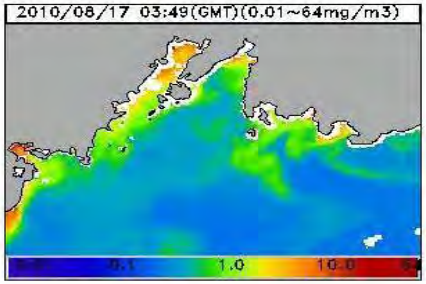
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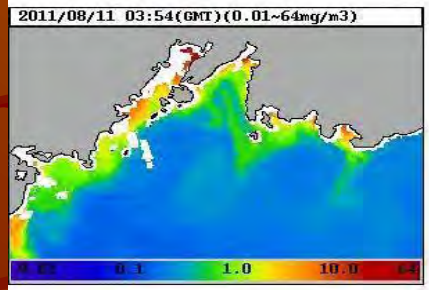
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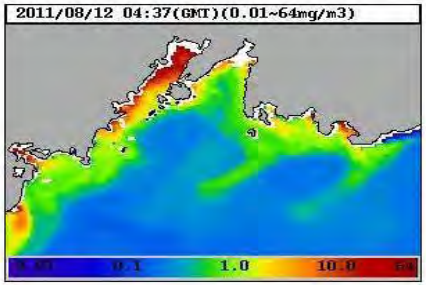
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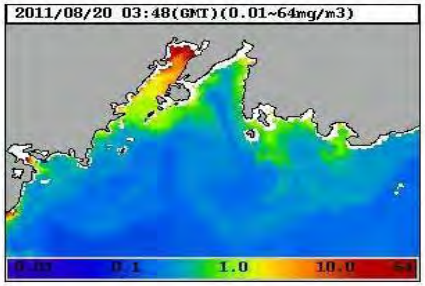
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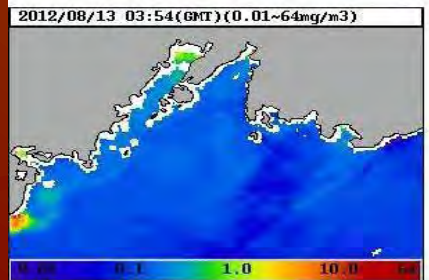
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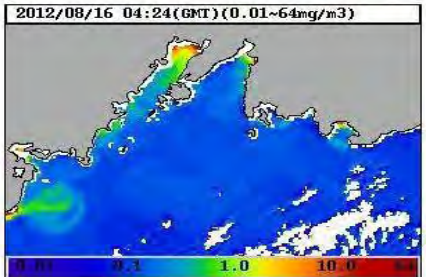
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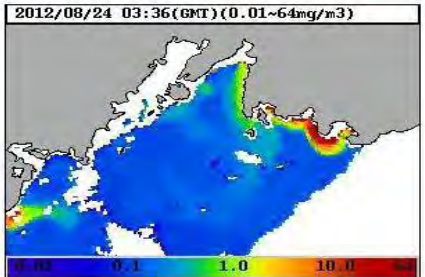
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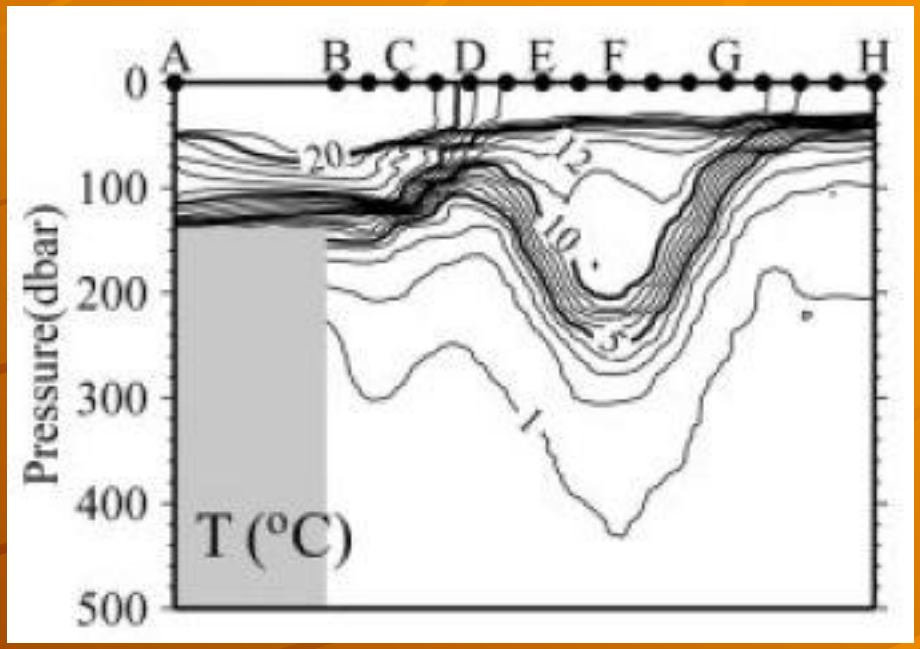
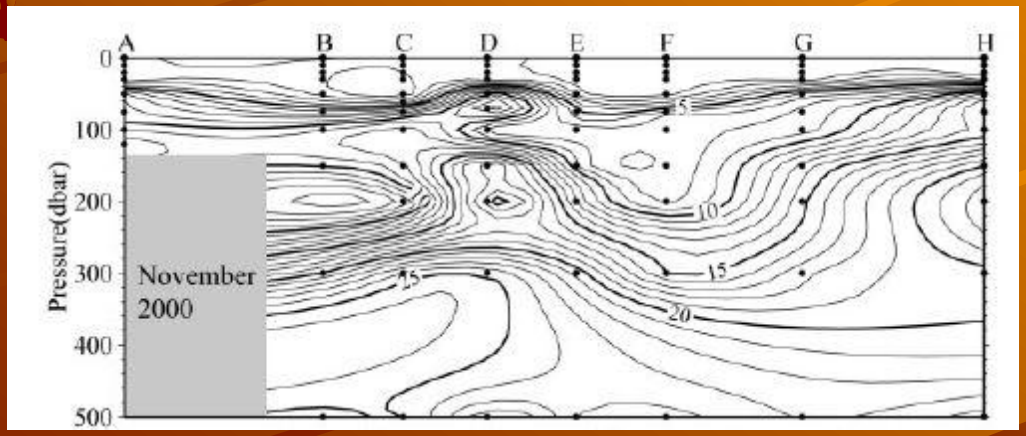
Spatial structure of an anticyclonic eddy (Byun et al., 2009)





Summary

- Internal waves in shelf zones transport energy of tides and stratification to shallow waters and are the most effective mechanism of including nutrients from bottom sediments into food-webs
- Internal wave-caused vertical and horizontal mixing combined with tidal movements leads a) to change in density vertical structure over the shelf zone; b) to effective transport of nutrients, oxygen and other admixtures defining productivity and ecological state of ocean shelf waters.
- Effective exchange of highly productive shelf waters with the open-sea waters takes place mainly in zones around continental slope and shelf boundary
- The main mechanisms of the effective shelf-open waters exchange are tides and meso-scale eddies, the latters being the most important in three-dimensional movements and mixing down to the deepest photic layers
- Due to high alternating vertical velocities in cyclonic and anticyclonic eddies phytoplankton concentration and productivity can fluctuate with time-scales corresponding to scales and velocities of the meso-scale eddies
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- I hope that our presentation
  - was not very boring