Coastal upwelling and its ecological effects in the northwestern Japan Sea

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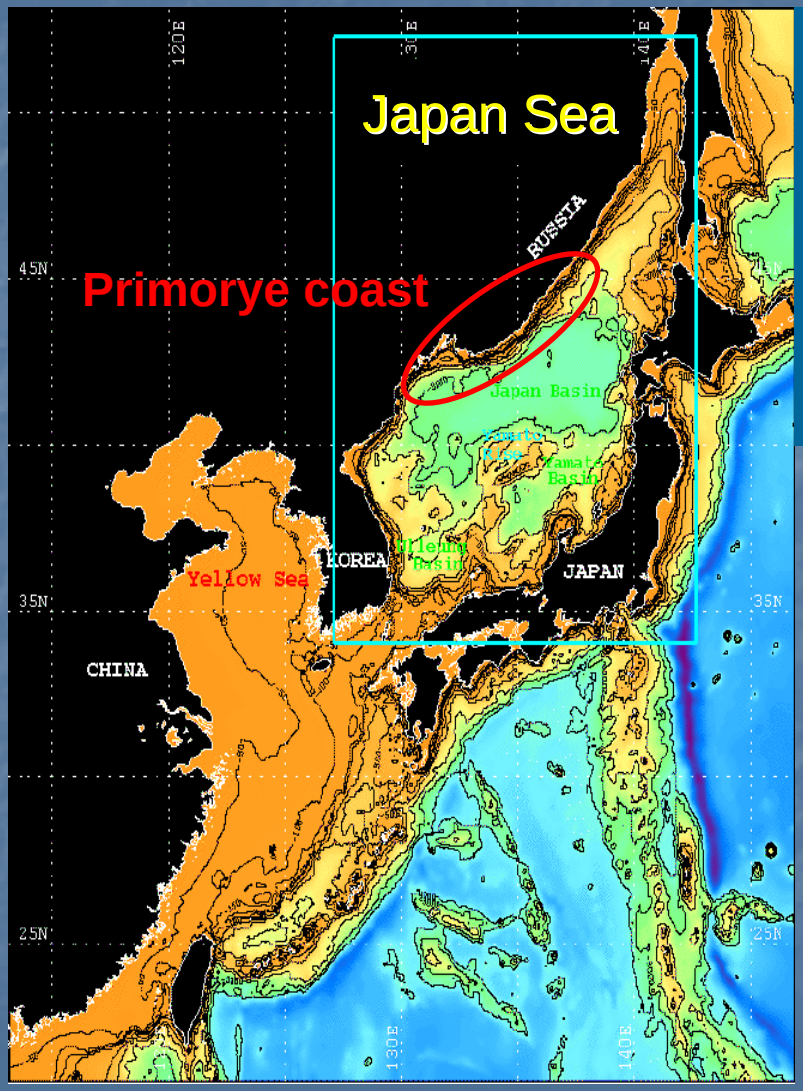
Main geographic features

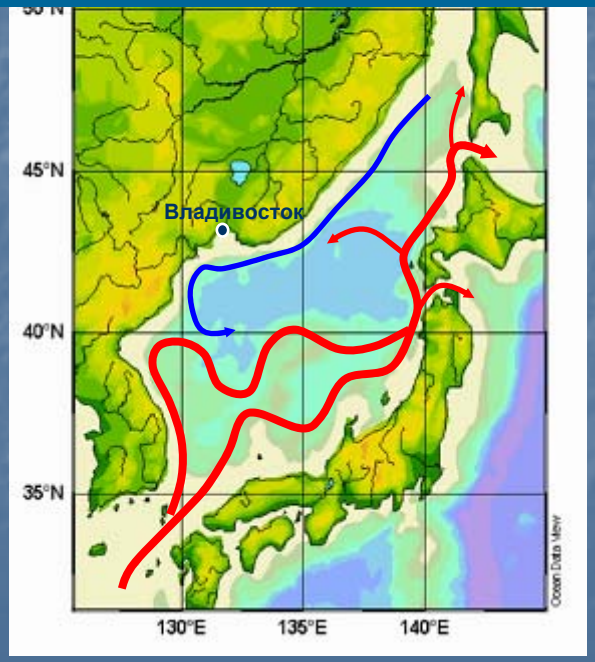


-Deep semi-isolated basin (>3500 m), narrow shelf

-Along slope current, shelf waves, coastal eddies

-Monsoon winds, upwelling

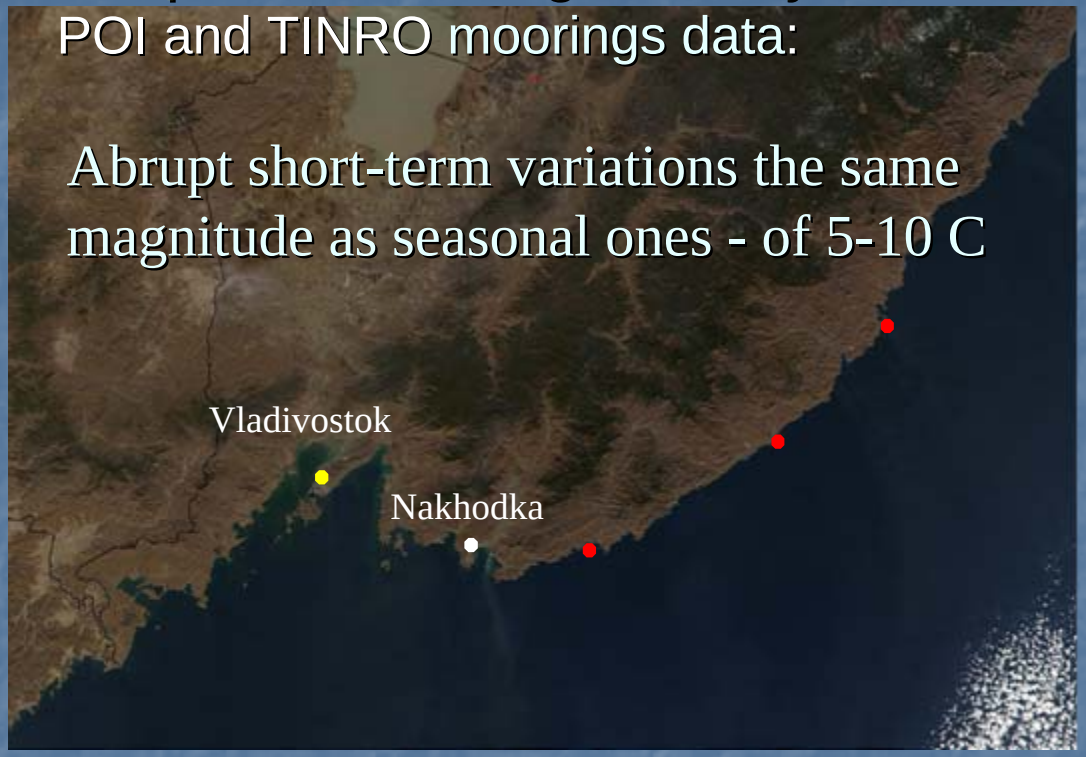
-Strong seasonal variation of SST, SSS and stratification

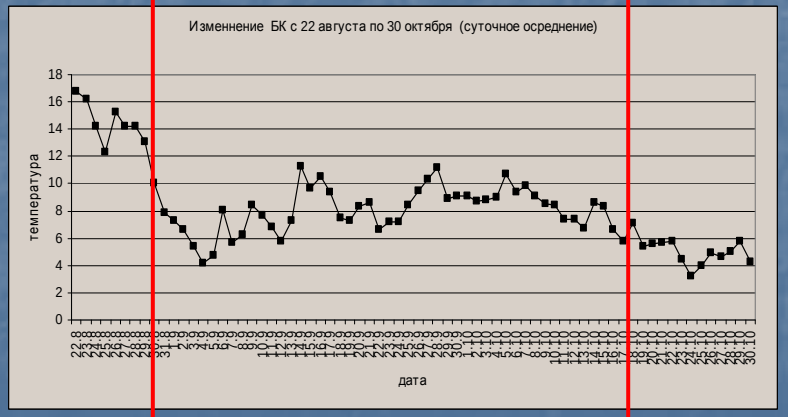


Short-term variation of water temperature along Primorye Coast

POI and TINRO moorings data:

Abrupt short-term variations the same magnitude as seasonal ones - of 5-10 C



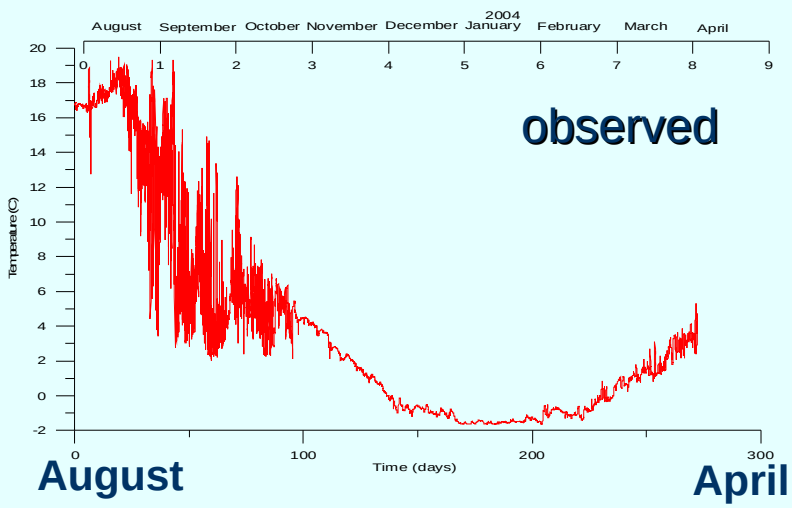


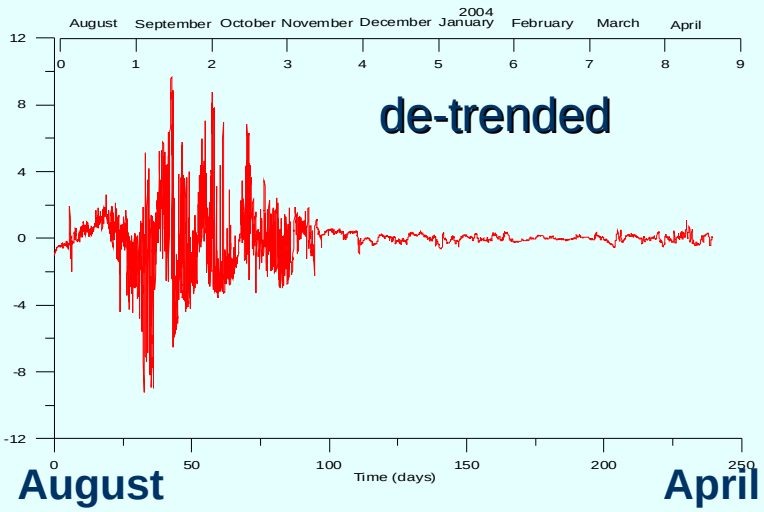
30.08 **18.10.2003**

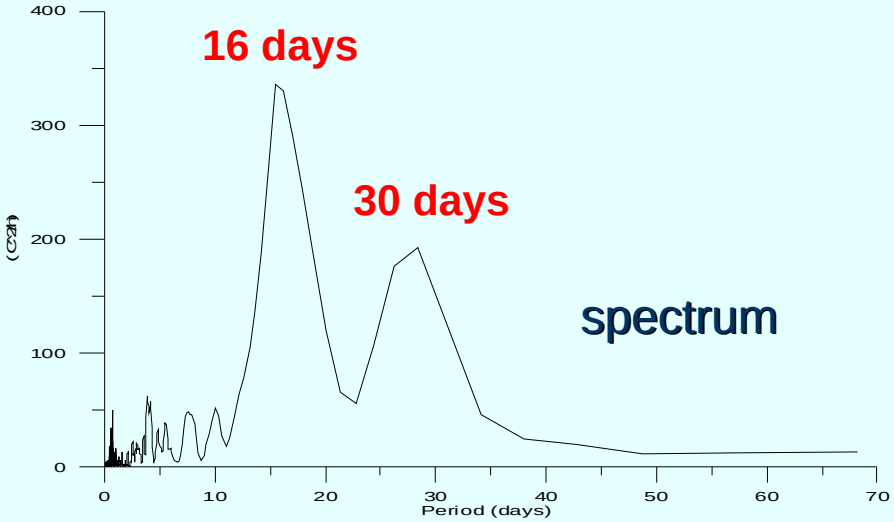
Should impact on :

- Fishery and aquaculture (shell-fishes, sea-urchin, laminaria)
- Biodiversity
- Recreation and health etc.

Water temperature variability – bottom moorings







Variability of bottom water temperature at 20 m depth at the shelf of Primorye from August through April (2003-2004)

Objectives

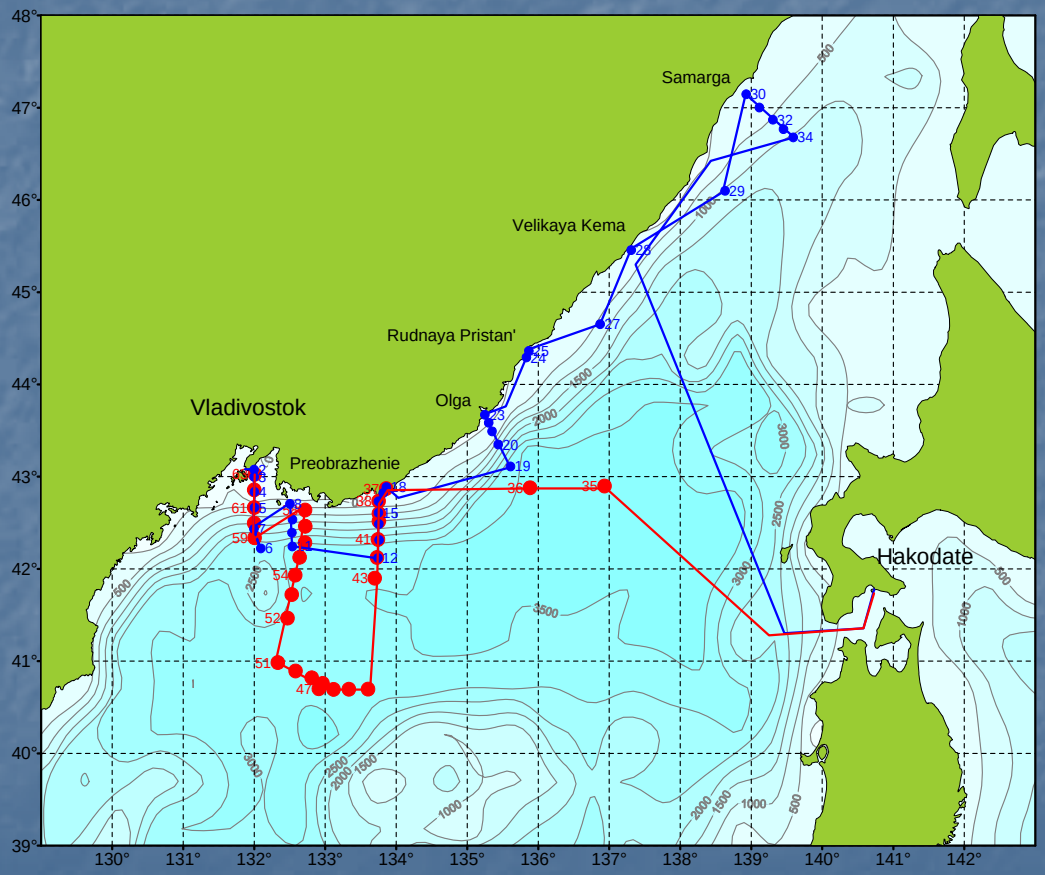
to understand main physical processes responsible for abrupt changes of water temperature and other properties at the Primorye coast in Fall season and an ecosystem response to these changes

Data

- two repeated ship surveys October 12-November 4, 2000 (CTD, chemical, biological)
- NOAA AVHRR images
- SeaWiFS ocean color images
- hydrometeorological data

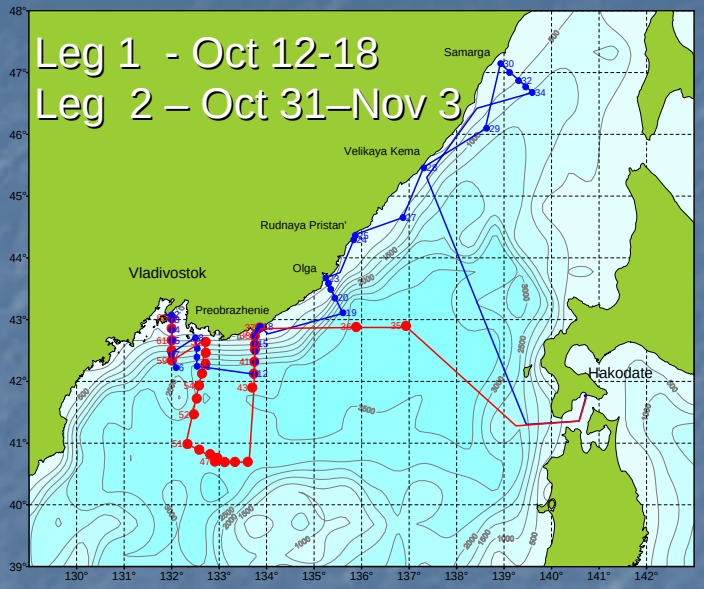
In situ observations

PICES JES Cruise 2000, *r/v Professor Gagarinskiy*
1 leg - Oct 12-18 (blue line)
2 leg – Oct 31–Nov 3 (red line)

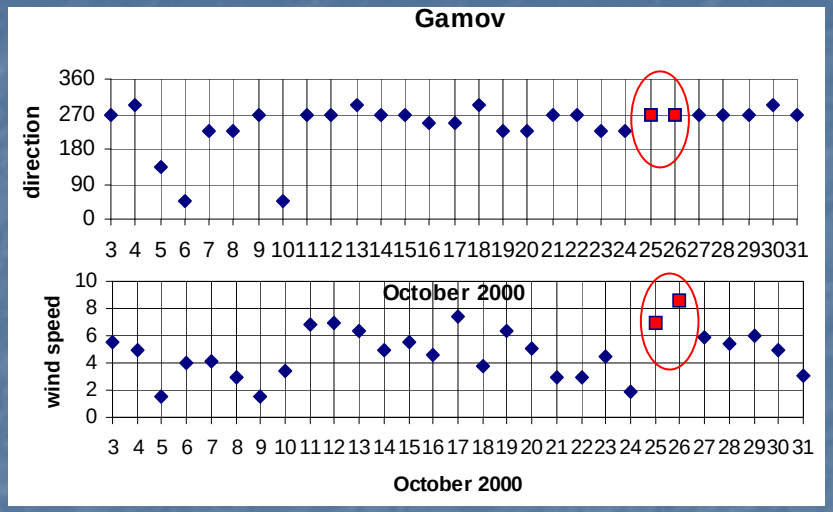


Measurements:
CTD,
DO,
Nitrates,
Nitrites,
Phosphates,
Silica,
pH, Alkalinity,
Chl-a, PP, plankton

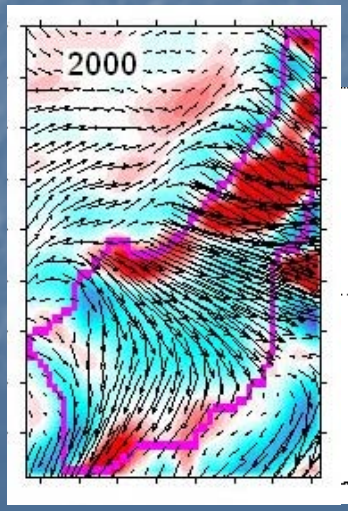
Upwelling Winds



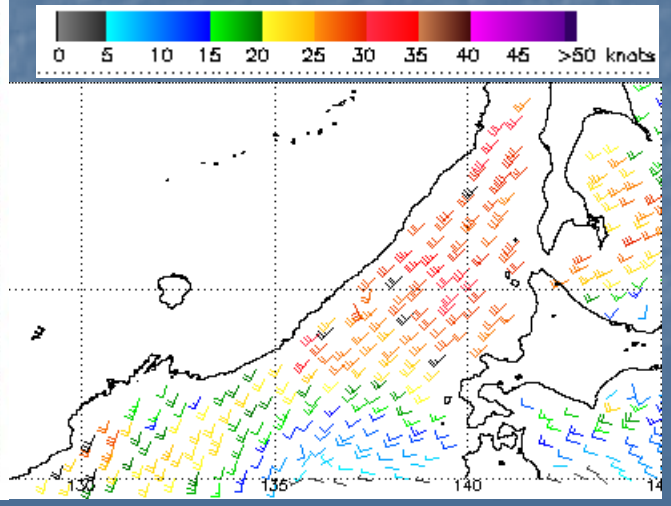
Coastal station



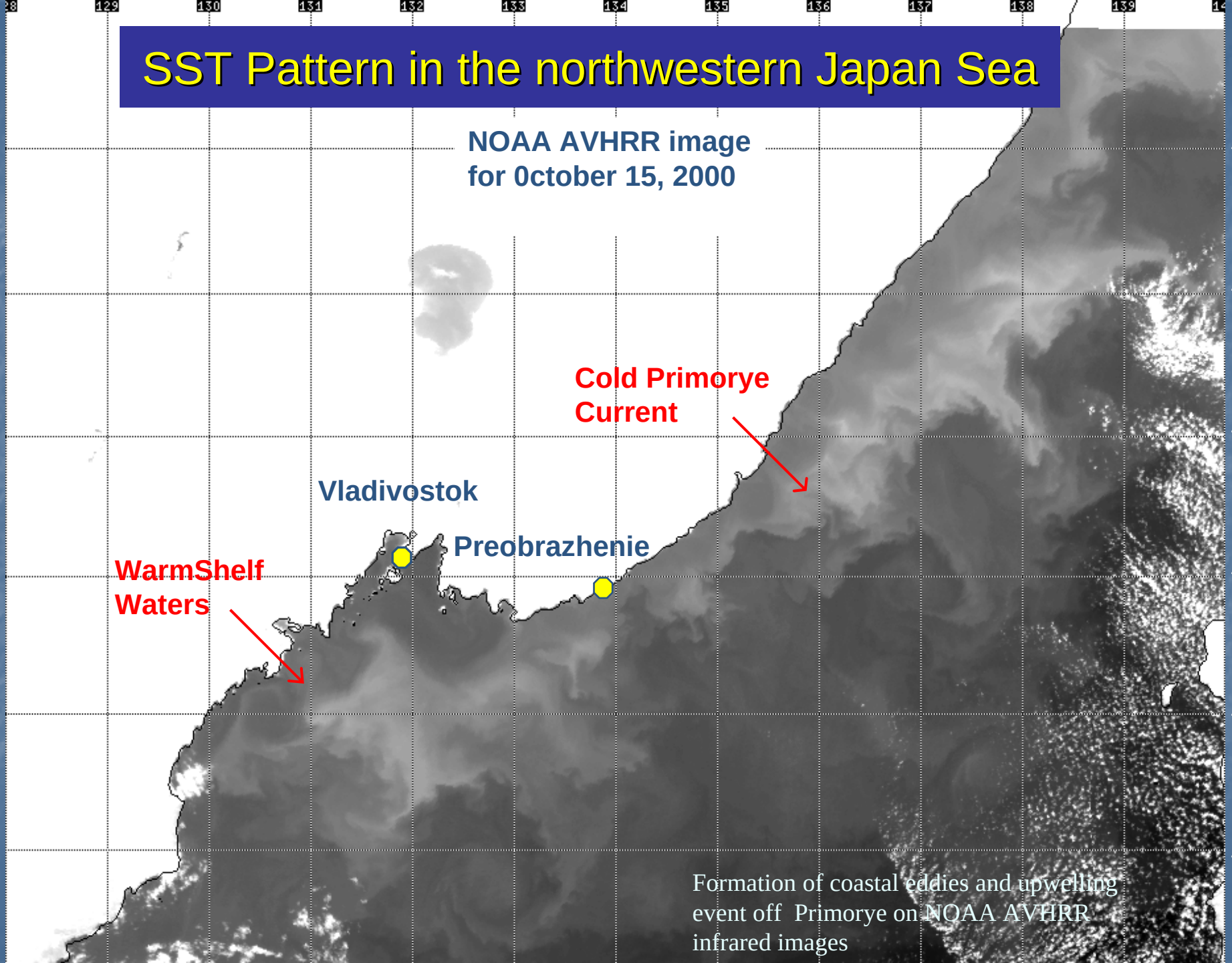
NCEP/NCAR Oct.



QuickScat

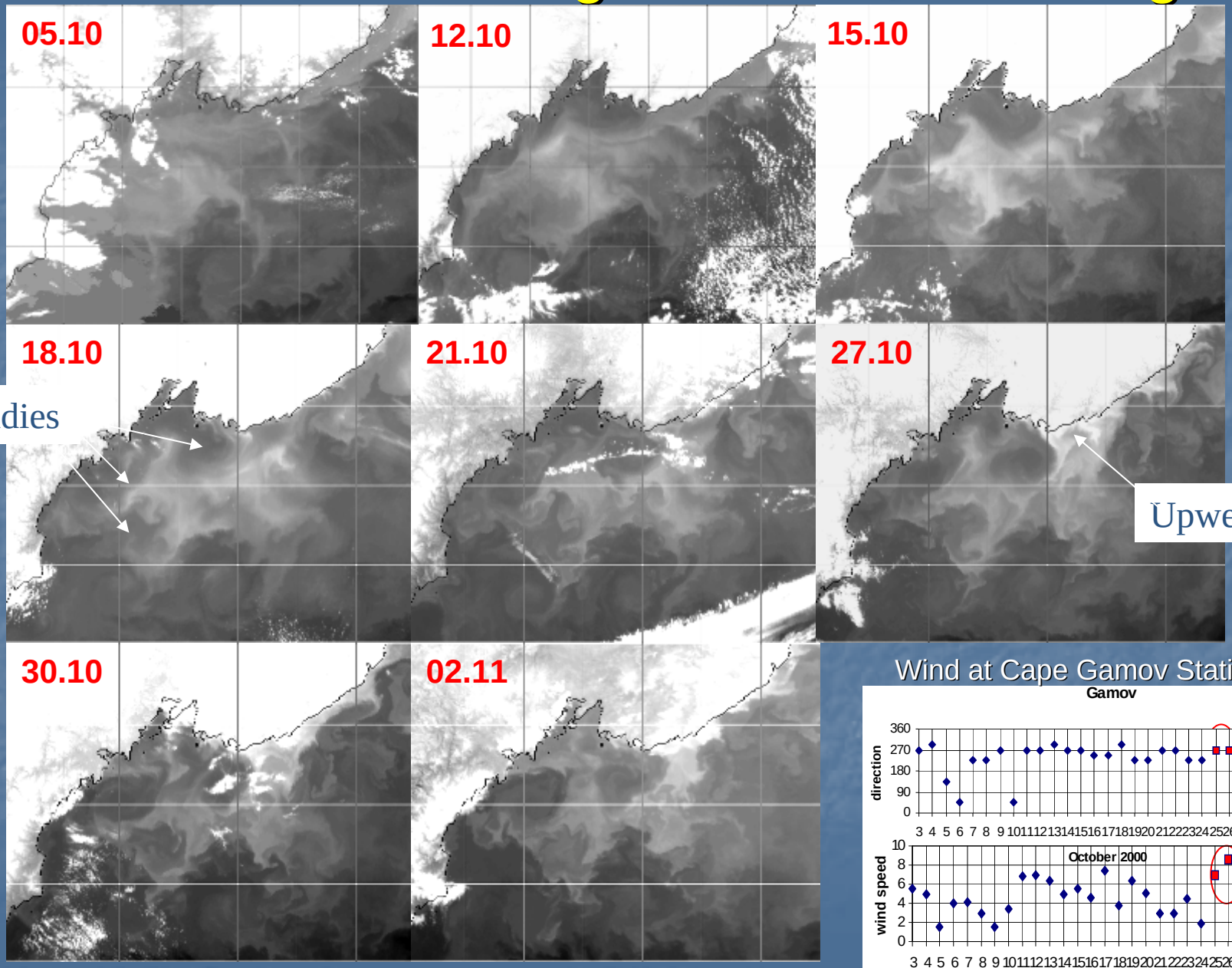


SST Pattern in the northwestern Japan Sea

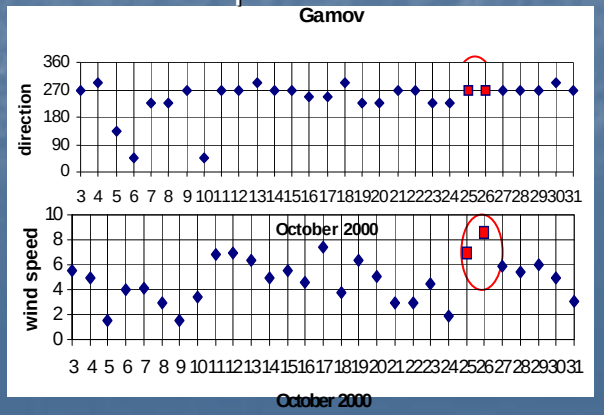


Formation of coastal eddies and upwelling event off Primorye on NOAA AVHRR infrared images

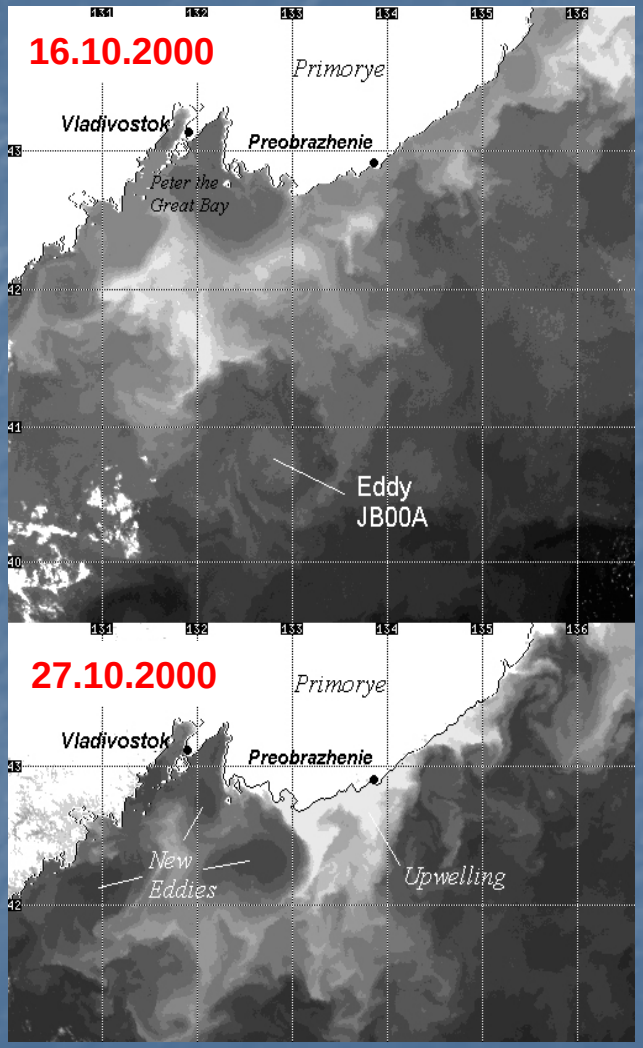
SST Structure Changes on Satellite Images



Wind at Cape Gamov Station

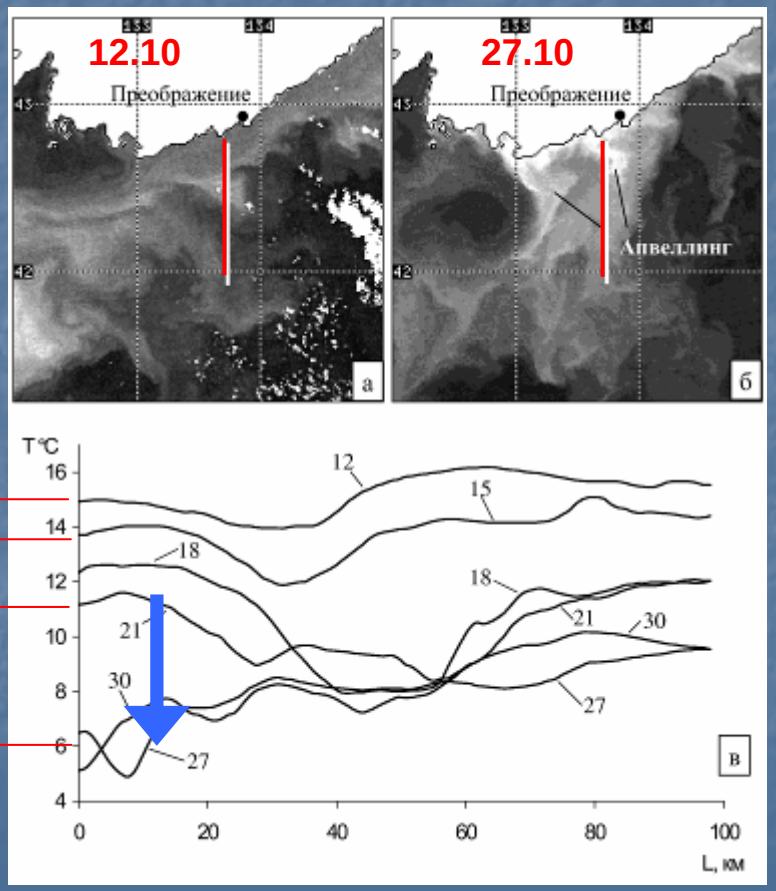


SST Changes in Fall Season



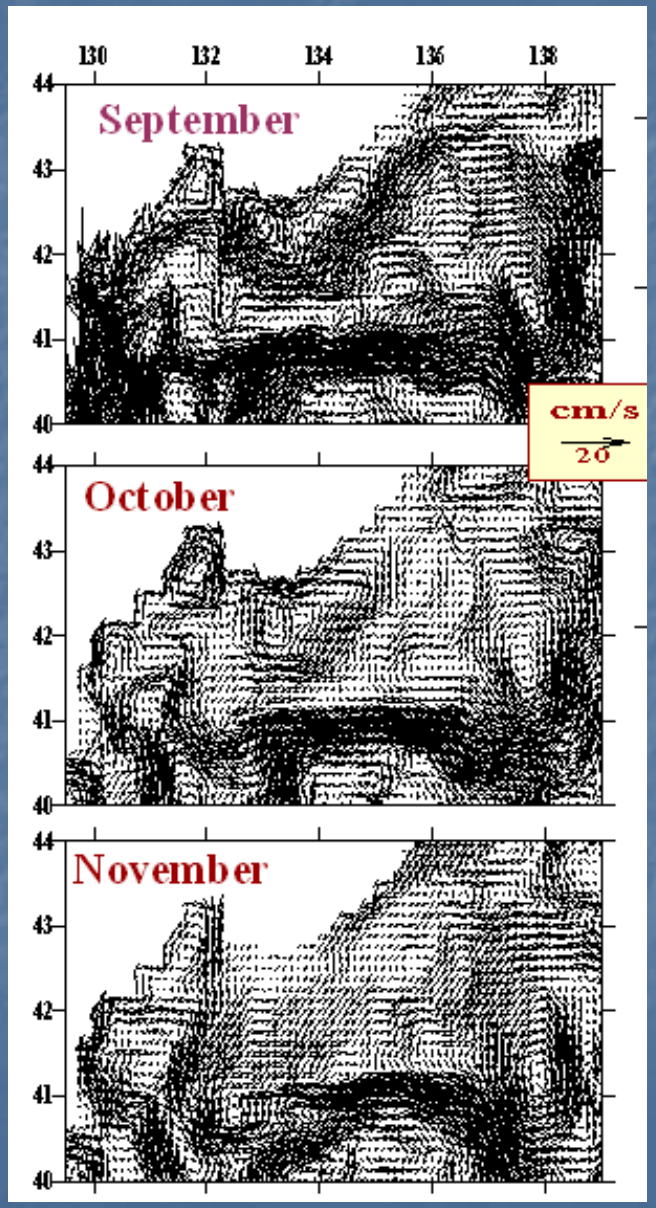
Formation of coastal eddies and upwelling event off Primorye on NOAA AVHRR infrared images

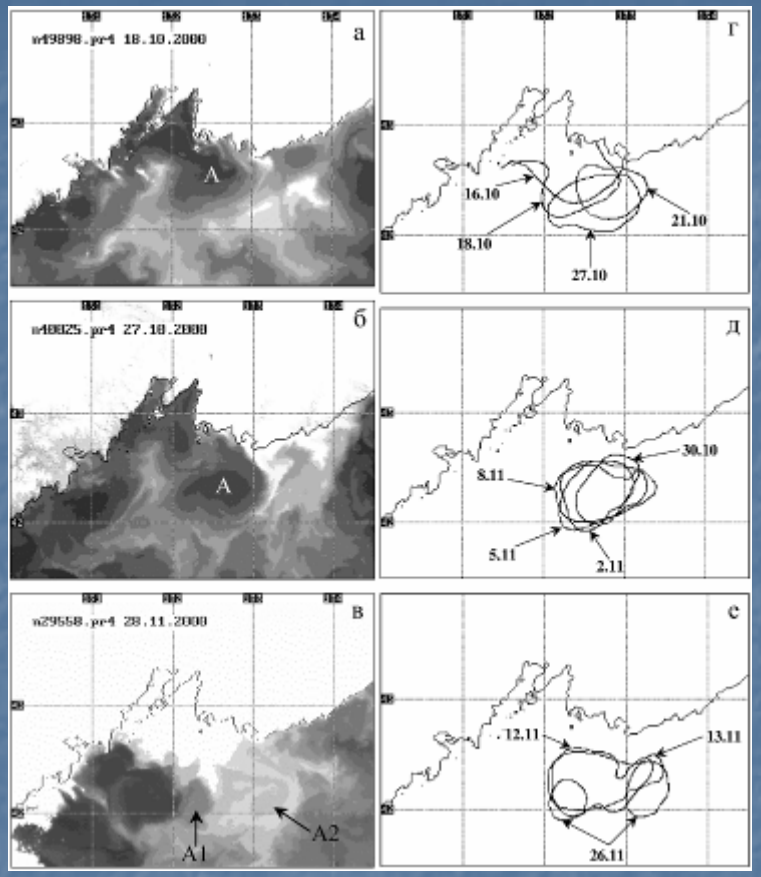
- Wind induced upwelling
- Mesoscale eddies formation
- Fast cooling, convection



Slow decrease of SST on the shelf 12-21 and fast drop 21-27.10

Coastal Mesoscale Eddies





Eddies evolution on infrared images

Numerical isopycnal model *(Trusenkova, 2004)*

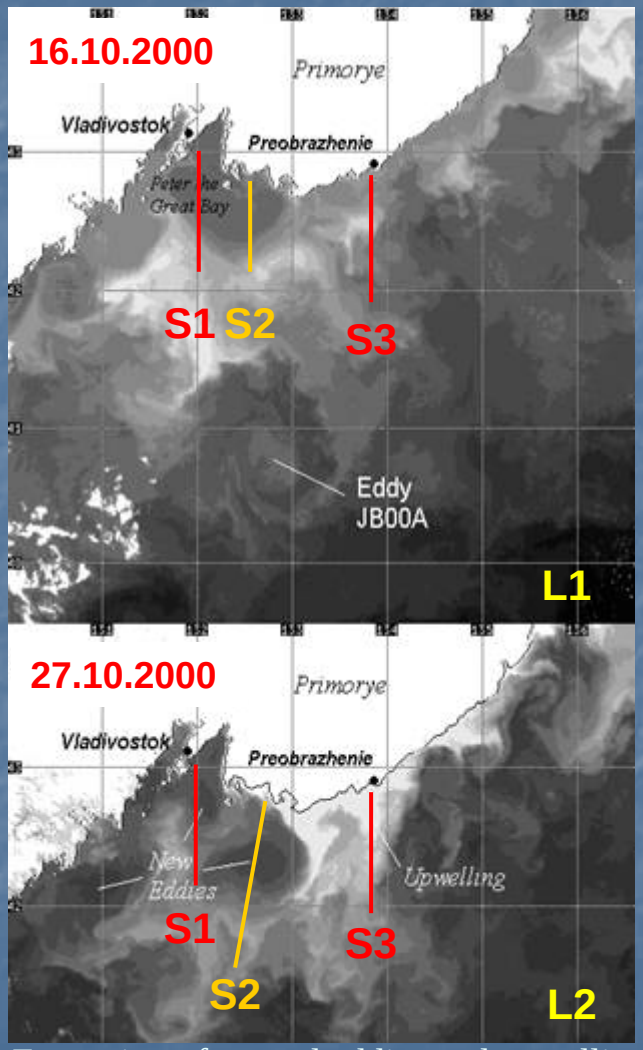
with NCEP monthly winds:

-discontinuity and reverse of Prymorye Current

-formation of antycyclonic eddy

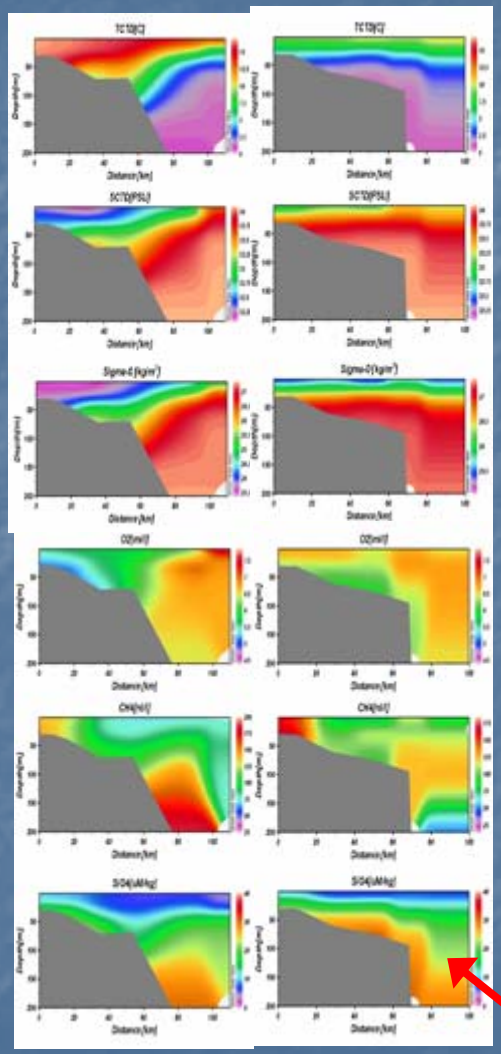
Hydrographic sections:

different changes at bottom layers at the eastern and western coastal stations



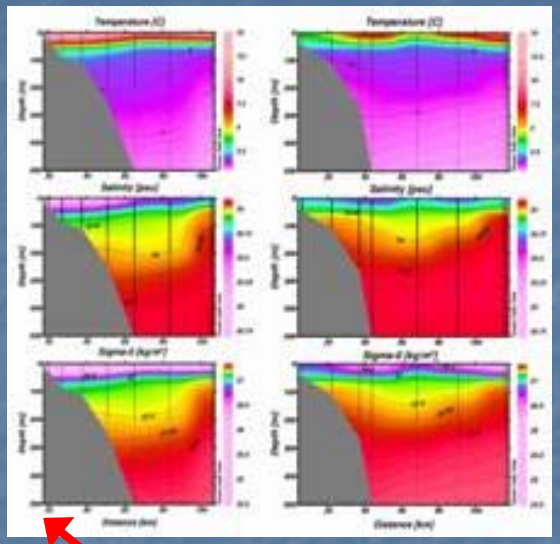
Formation of coastal eddies and upwelling event off Primorye on NOAA AVHRR infrared images

12-13.10 3.11.2000



Changes in T, S, density and nutrients along the sections S1 and S3 over 2-3 weeks period

15-16.10 30.10.2000



S3: Upwelling and convective mixing off Preobrazhenie (134E)

ΔT,°C	S1	S3
10 m	3.5	5.2
50 m	9.6	0.5

S1: Intrusion of deep sea water onto the shelf of Peter the Great Bay

Chl-a and Primary Production

Observations and Analyses:

Chl-a – filtration and spectrophotometer;

PP – radiocarbon marker (19 stations);

Delayed fluorescence – DF system;

Photic layer depth – Secchi disc;

Nutrients, pH, Talk (pCO2, DIC) – standard

Primary Production Estimation: *(Behrenfeld and Falkowski, 1997; Zvalinsky et al.,2002);*

$PP = 0.66 * P^b * C_{chl} * T_d$, where

P^b - chlorophyll-specific photosynthesis (mgC / mgChl * h)

C_{chl} – mean chlorophyll concentration in a photic layer

T_d – daylight duration

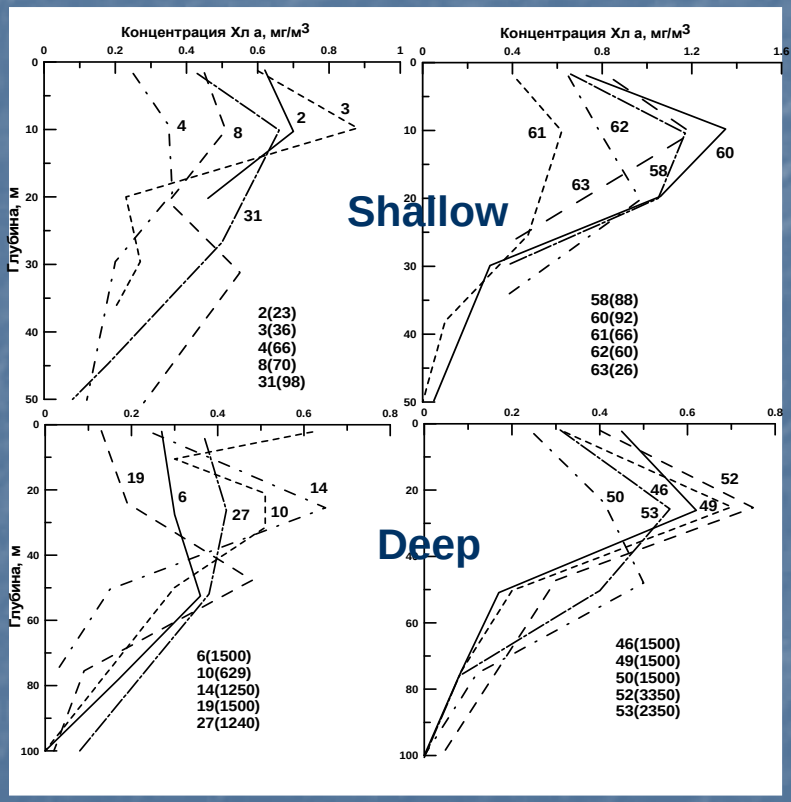
$PP = 0.66 * P^f * I_{fl} * T_d$, where

P^f - fluorescence-specific photosynthesis

I_{fl} – mean delayed fluorescence intensity in a photic layer

Chl-a and Primary Production

increase of Chl and PP by the end of cruise especially at the shelf area



L1 **L2**

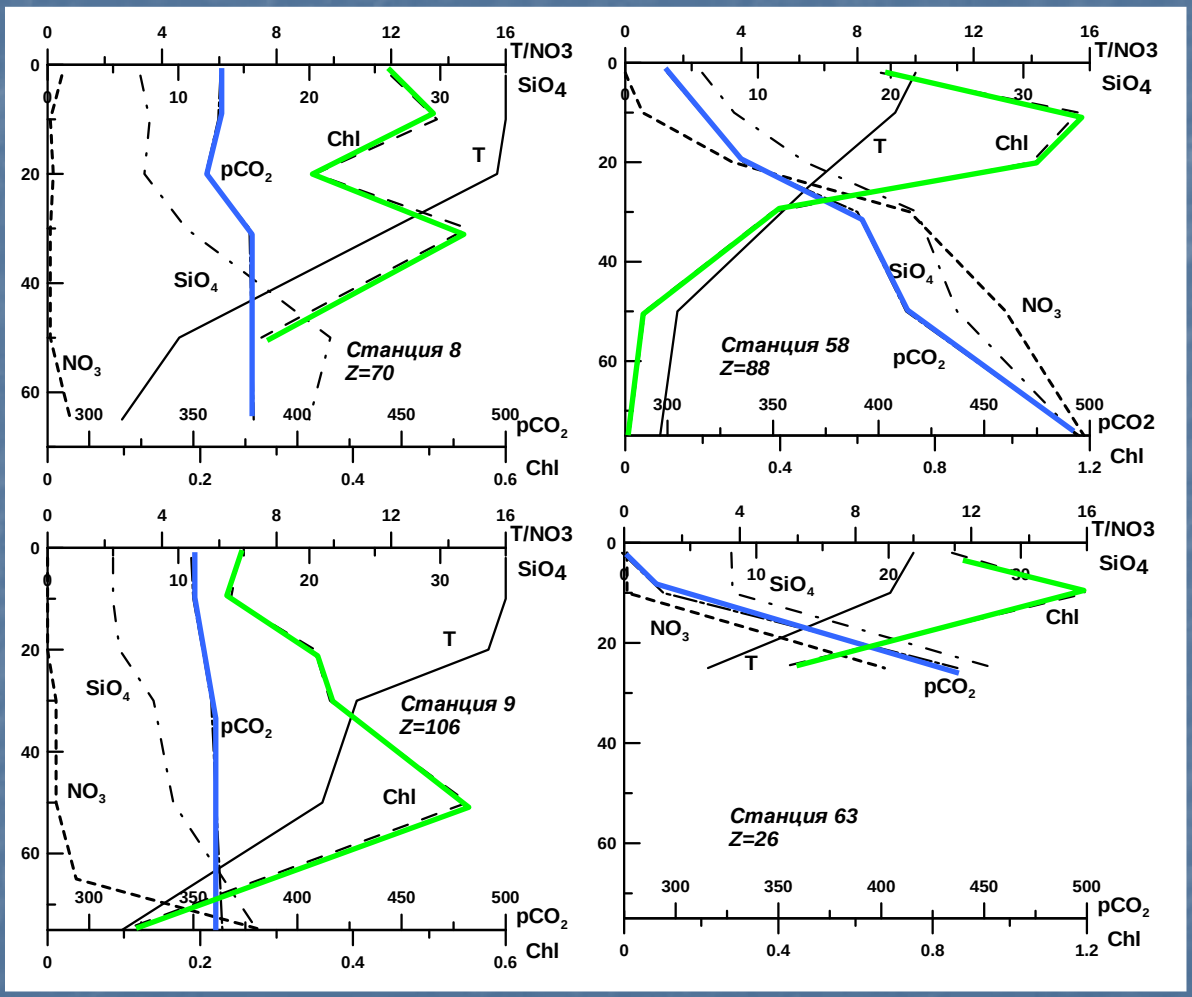
Vertical profiles of Chl a – increase and deepening of max

	Shallow stations		Deep stations		Total
Leg	L1	L2	L1	L2	L1+L2
Chl (mg/m³)	0.47	0.77 164%	0.37	0.43 116%	0.45
Chl (mg/m²) Range	15.0 8 – 22	21.4 13 – 28 143%	18.5 13 – 28	22,7 12–30 123%	19,5 8 – 30
Daylight, (hour)	11.1– 10.8	10.1 – 10.0	11.1 – 10.7	10.2 – 10.0	11.1 – 10.0
PAR (mol/m²d)	28 – 27	23 – 22 80%	28 – 26	23– 22	28 – 22
PP(mgC/m²d) Range	268 120- 400	370 240–420 138%	356 250–450	377 210–520 106%	325 120– 520

Even under decrease of PAR between L1 and L2, increase of Chl and PP by ~60% at shelf area

Chl-a, pCO2, Nutrients

L1 L2



Vertical profiles of *T, pCO2, NO3, SiO4* and *Chl a* for some stations before (L1) and after (L2) upwelling

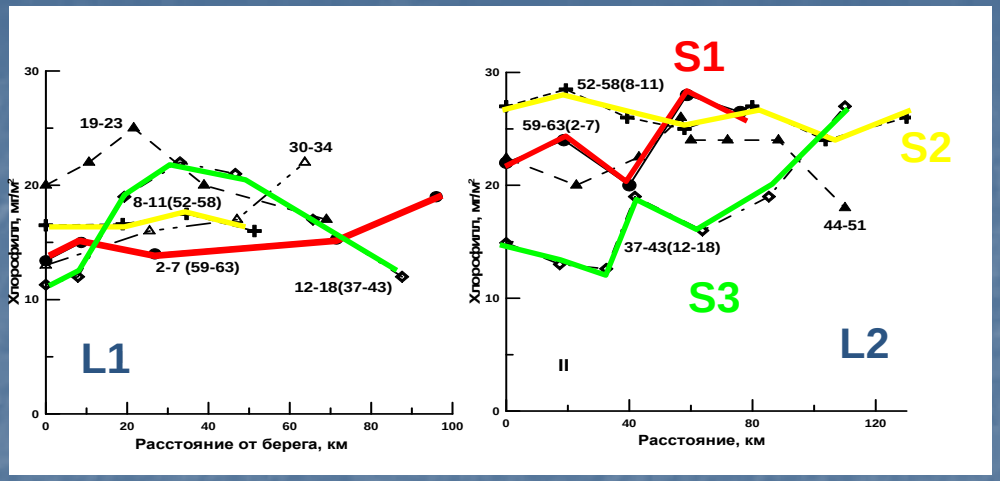
Nutrients:

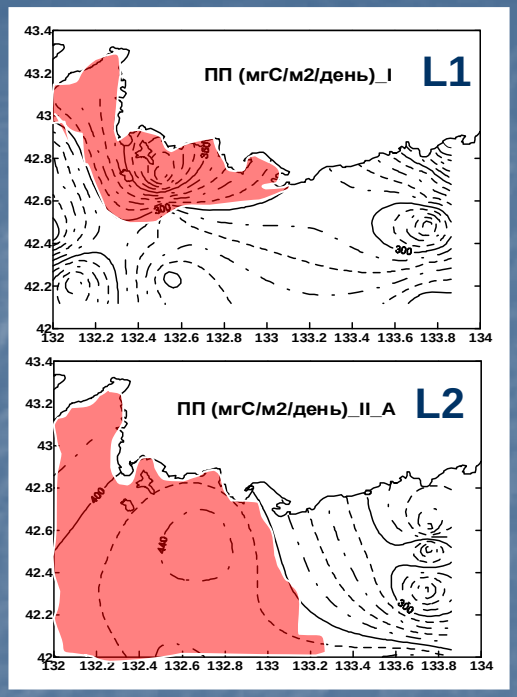
- L1: PP was limited by low nutrients, esp. Nitrates
- L2: Gradual increase of nutrients caused by weakened stratification and uplift of picnocline

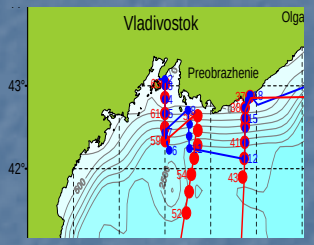
pCO2 profiles:

- increased production in upper layer and destruction in lower layer on L2

Chl-a and Primary Production



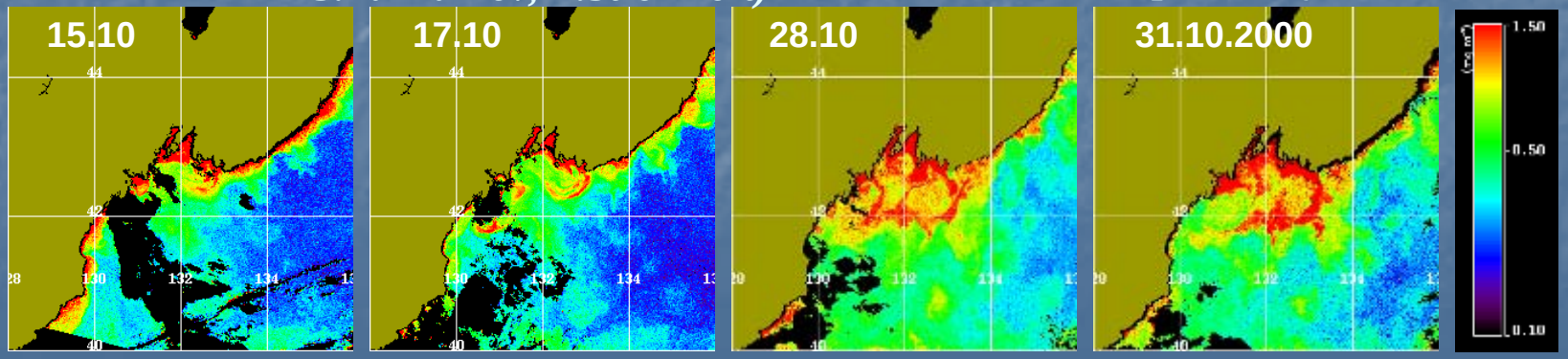




Chl a content in a photic layer along the sections – *in situ*
(more increasing in the west)

Chl a – SeaWiFS data *(O.Kopelevich, S.Zakharkov, E.Streikhert)*

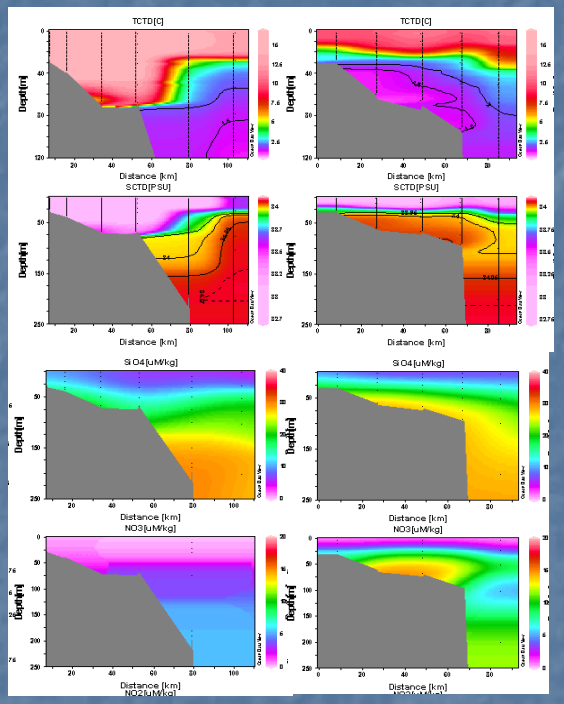
Daily Primary Production in a photic layer



before **after**

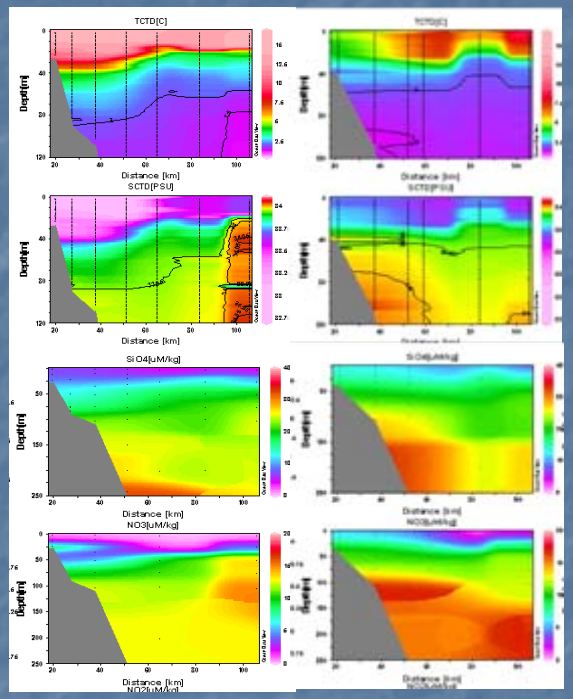
Changes in water mass structure and stratification: wind upwelling, eddies and convection

S1



before **after**

S3



before **after**

ΔT,°C	S1	S3
10 m	3.5	5.2
50 m	9.6	0.5

MLD, m	S1	S3
L1	55	30
L2	35	35

<u>Intrusion area, wide shelf:</u>

-Initially: well mixed

-Nutrients supply

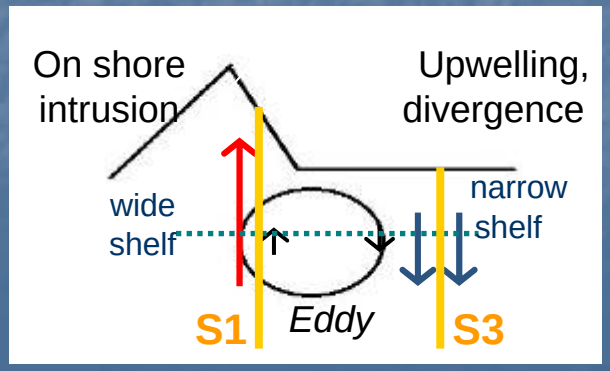
-Uplift of picnocline

-Convective mixing - upper lr.

-Decrease MLD

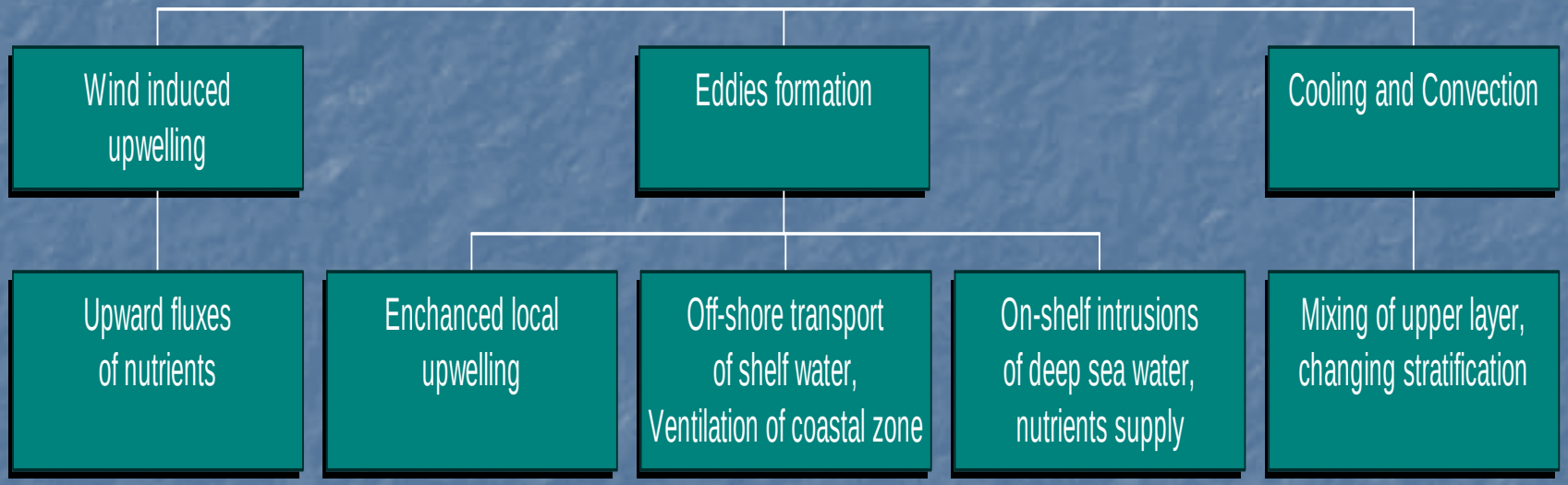
<u>Upwelling area, narrow shelf:</u>

- Initially: stratified
- Nutrients supply
- Vertical mixing
- Weakening of stratification
- Increase MLD



Conclusion

1. The major processes responsible for abrupt changes of physical and biological parameters of the Primorye coast in Fall season are:




Thank you!