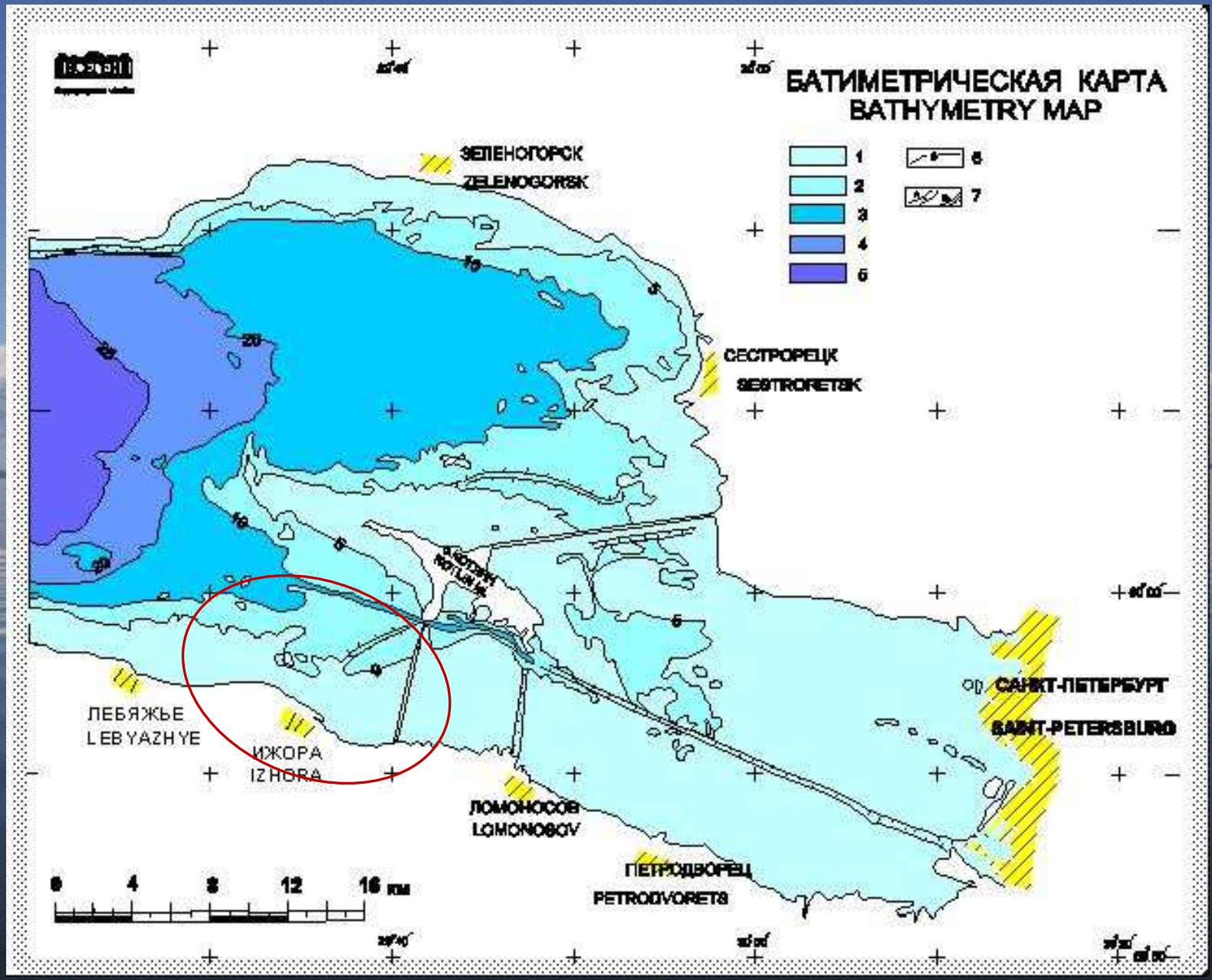
Some results of remote sensed data application for the coastal region of the Eastern Gulf of Finland

Russian State Hydrometeorological University, St.Petersburg

Vitaly Sychev

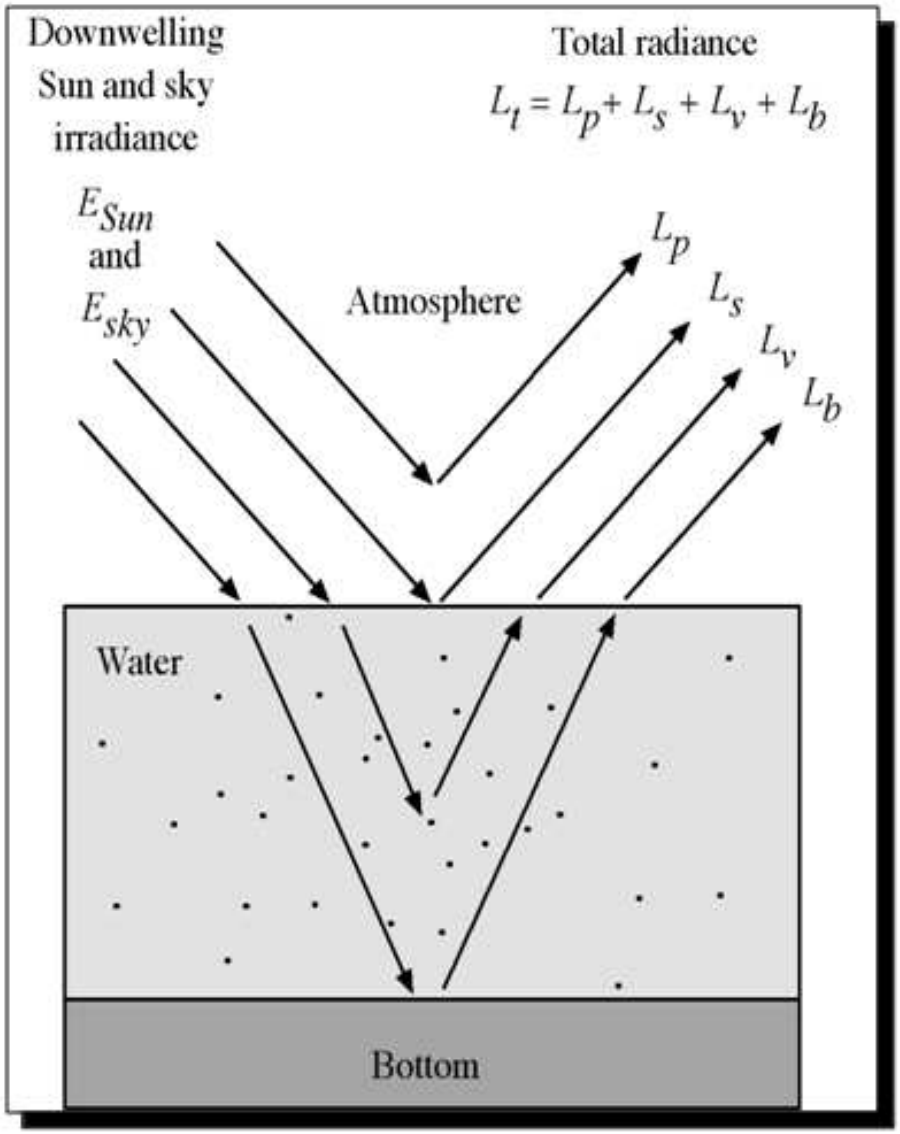
COASTAL ZONE OF THE EASTERN GULF OF FINLAND



RSHU-UNESCO Chair in Remote Sensing and Modeling in Oceanography has participated in the developments of several water quality parameters on the base of the remote sensed data.

Presented research topics include the development of satellite data methods for the studying of chlorophyll-a, algal blooms, turbidity, suspended solids, and bathymetry in the Baltic Sea and coastal areas. The research is performed in collaboration with the IOC/UNESCO Sectors, NIERSC, VSEGEI, and other organizations.

- Currently available Envisat, MERIS, Landsat, Quickbird, Spot and Aqua/Terra MODIS data have been used for the water quality algorithms that were developed for open sea (case 1) and coastal (case 2) waters.
- Water quality regional algorithms are developed for the Eastern Gulf of Finland and Southeastern part of the Baltic proper.
- Concentration of chlorophyll-a retrieval algorithm is based on the ratio of two-four channels.
- Turbidity of sea waters was calculated on the base of MODIS spectrometer data (250-m resolution) and compared with the ground truth turbidity.
- Bathymetry was studied on the base of Jupp's method and is of good results from costal line to the depth of 1-1,5 m in the Eastern part of the Gulf of Finlang.
- These results of multispectral satellite data analysis may be used for studying the coastal areas and shallow water parameters in the Baltic Sea.



Total radiance, (*Lt*) recorded by a remote sensing system over water is a function of the electromagnetic energy received from:

$$L_t = L_p + L_s + L_v + L_b$$

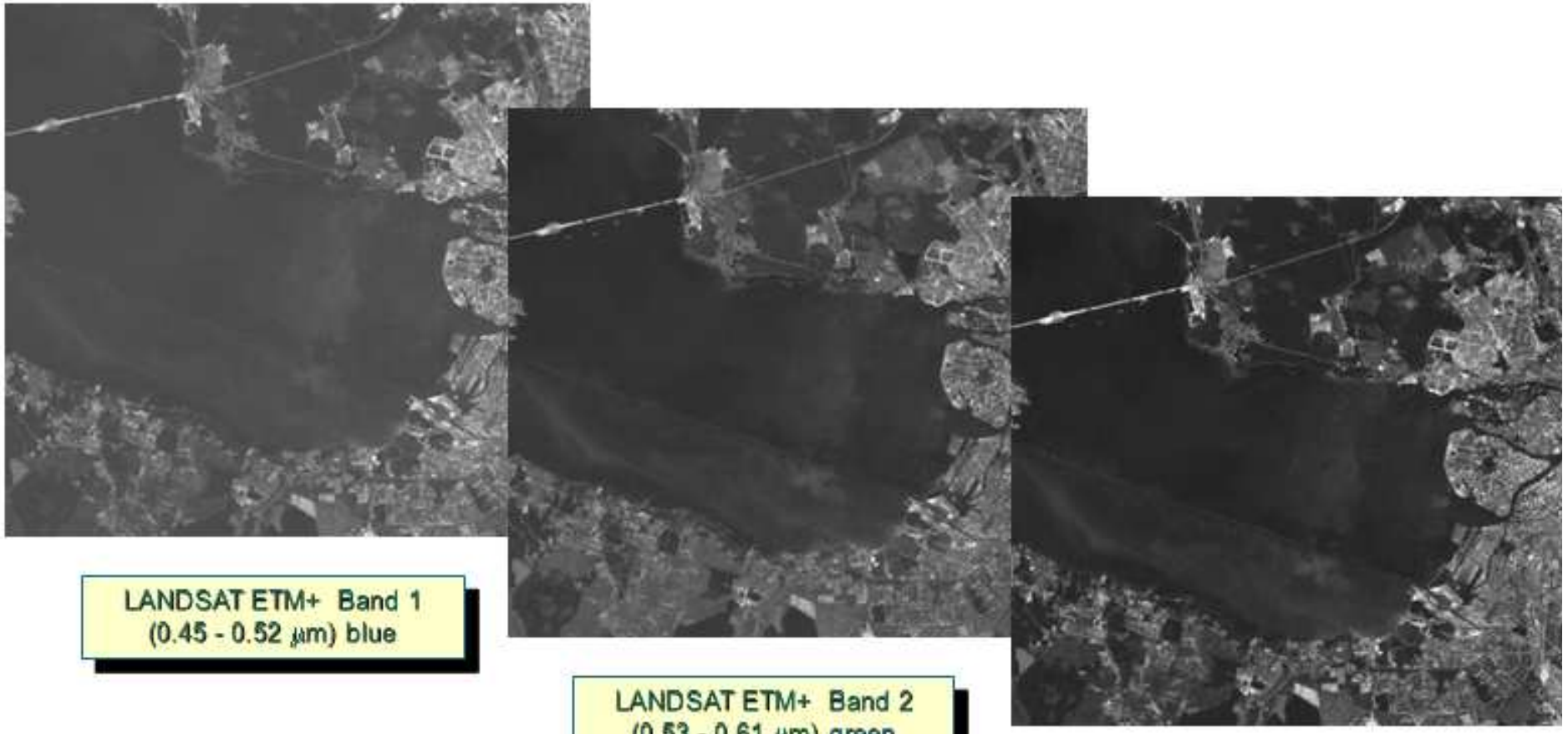
Lp = atmospheric path radiance

Ls = free-surface layer reflectance

Lv = subsurface volumetric reflectance

Lb = bottom reflectance

Water Penetration



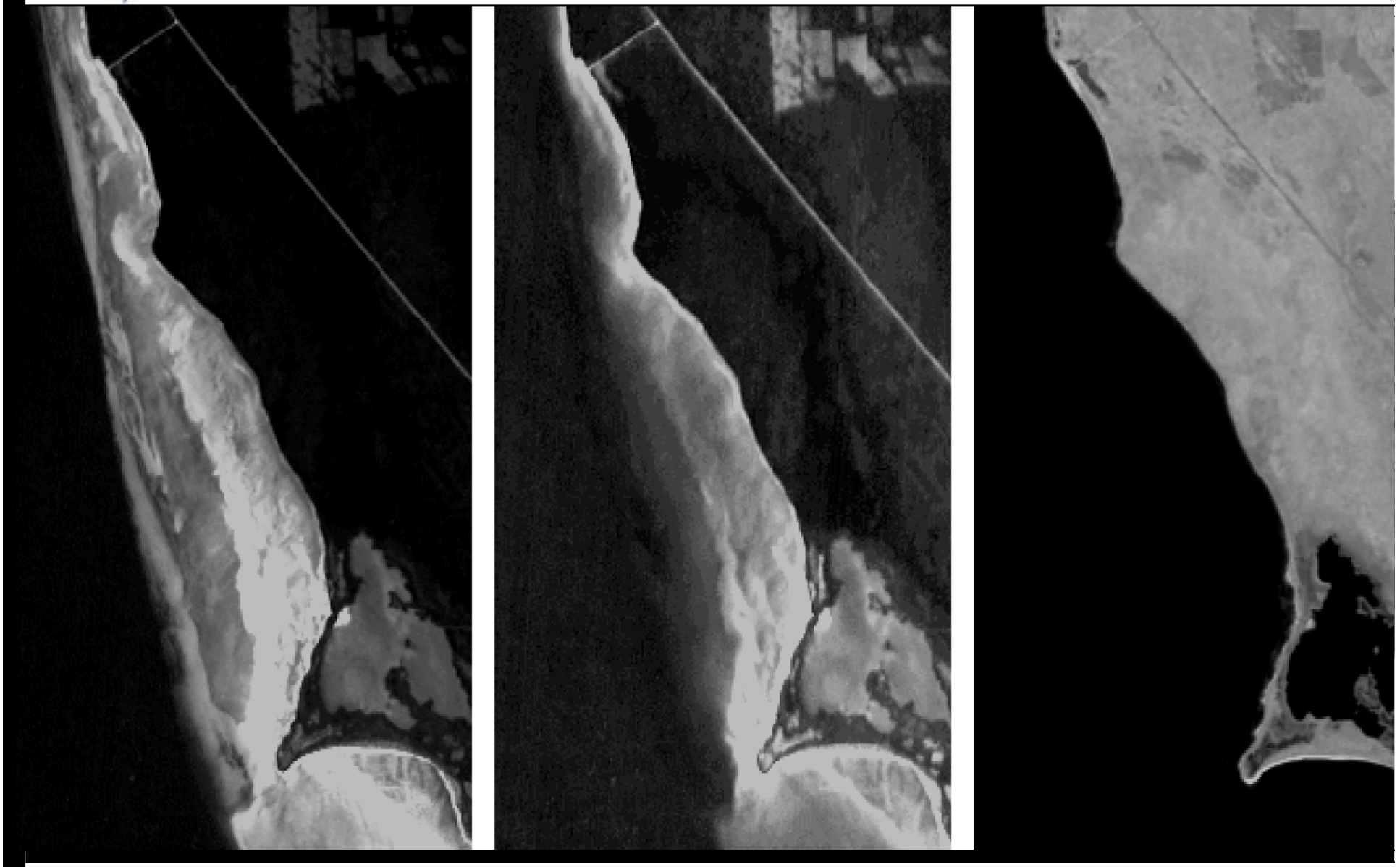
LANDSAT ETM+ Band 1
(0.45 - 0.52 μm) blue

LANDSAT ETM+ Band 2
(0.53 - 0.61 μm) green

LANDSAT ETM+ Band 3
(0.63 - 0.69 μm) red

L71185018_01820050703

Water Penetration

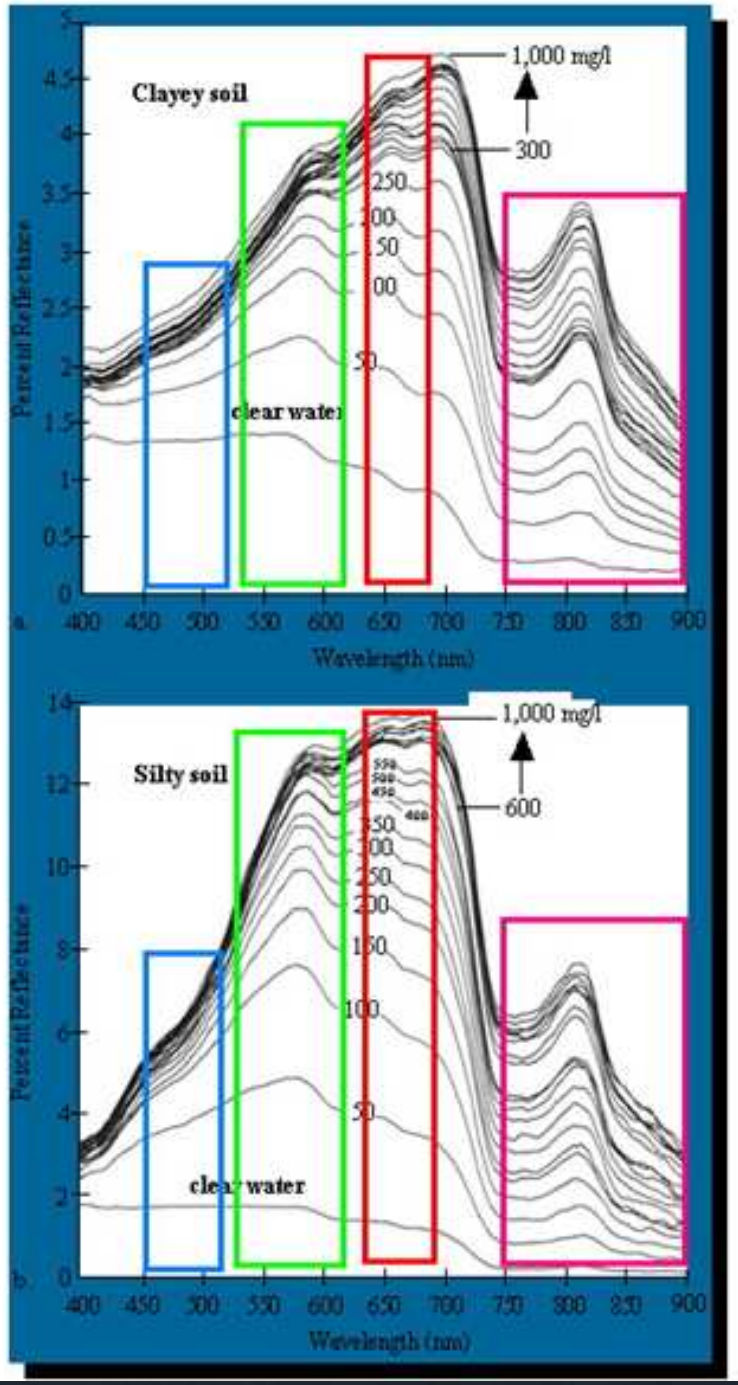


Ил

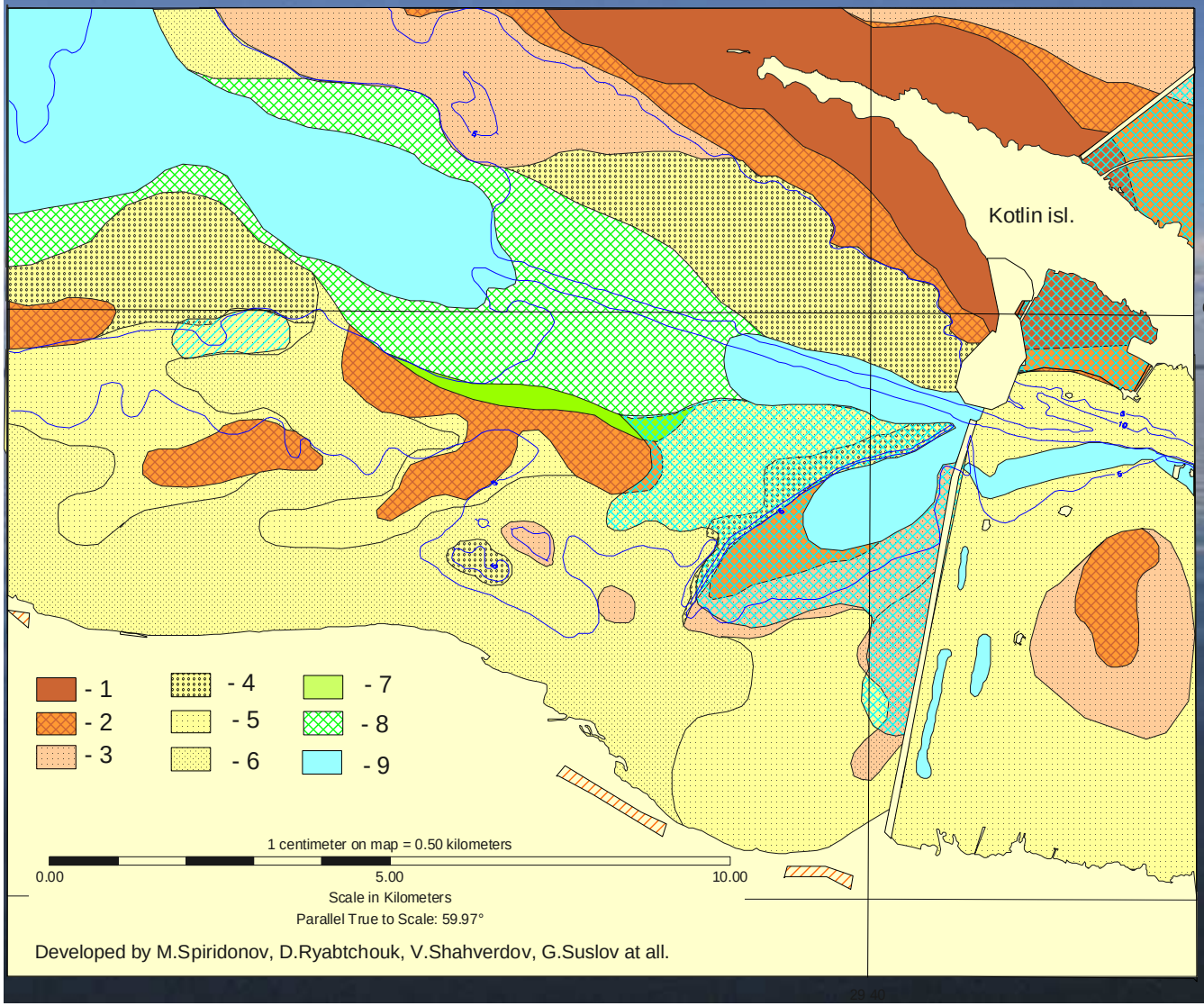
Reflectance peak shifts toward longer wavelengths as more suspended sediment is added

Глина

In situ Spectroradiometer Measurement of Clear Water with Various Levels of Clayey and Silty Soil Suspended Sediment Concentrations

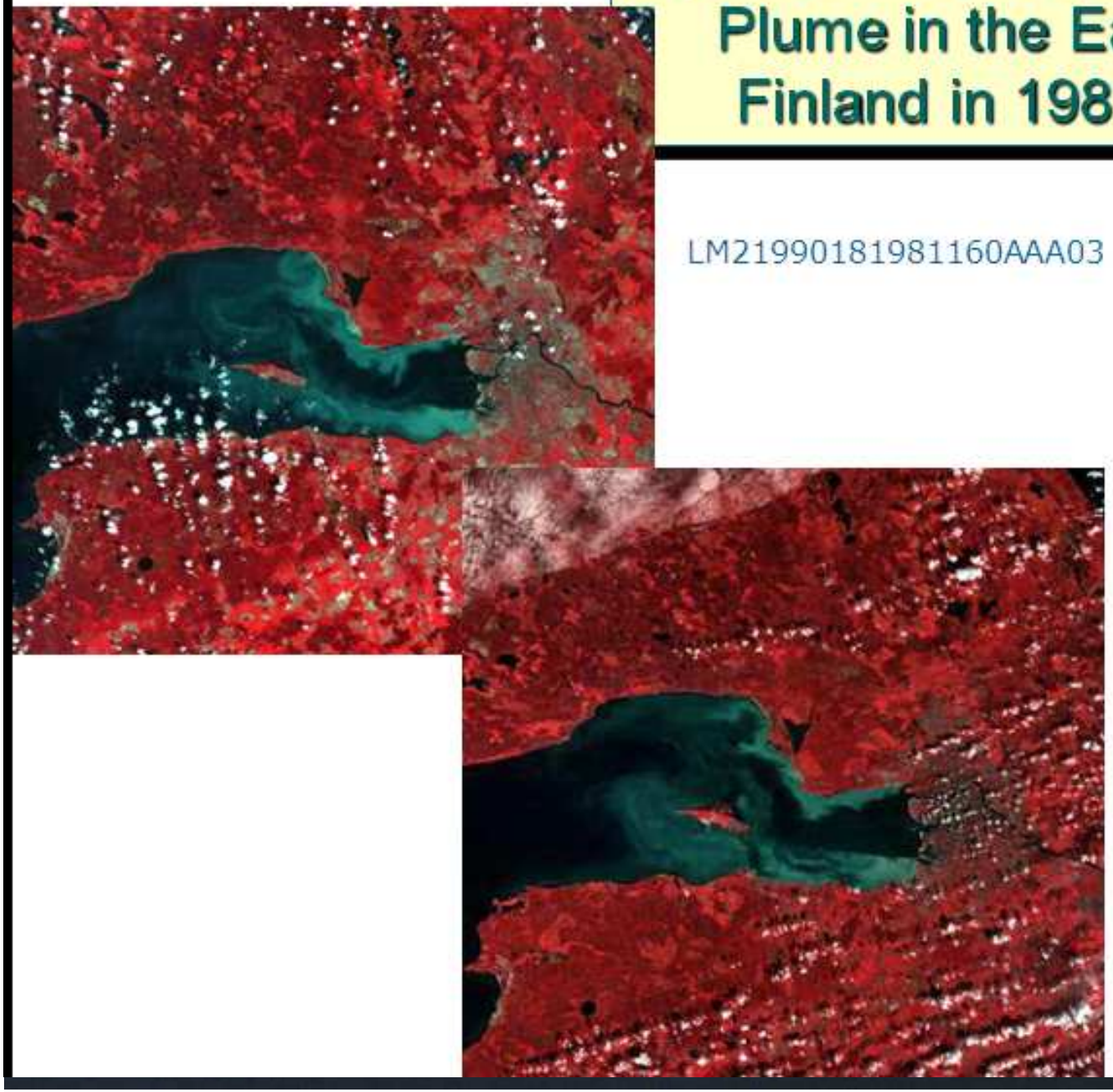


Map of bottom sediments in the Eastern part of the Gulf of Finland (VSEGEI, 2005)



1 - boulders, pebbles, gravel; 2 - sands with gravel; 3 -unsorted sands 4 - coarse-medium grained sands; 5 - medium-fine grained; 6 - fine-grained; 7 - silty-sands; 8 - sandy-silty clays; 9 - silty-clay mud.

Space data Suspended Sediment Plume in the Eastern Gulf of Finland in 1981, Landsat 2

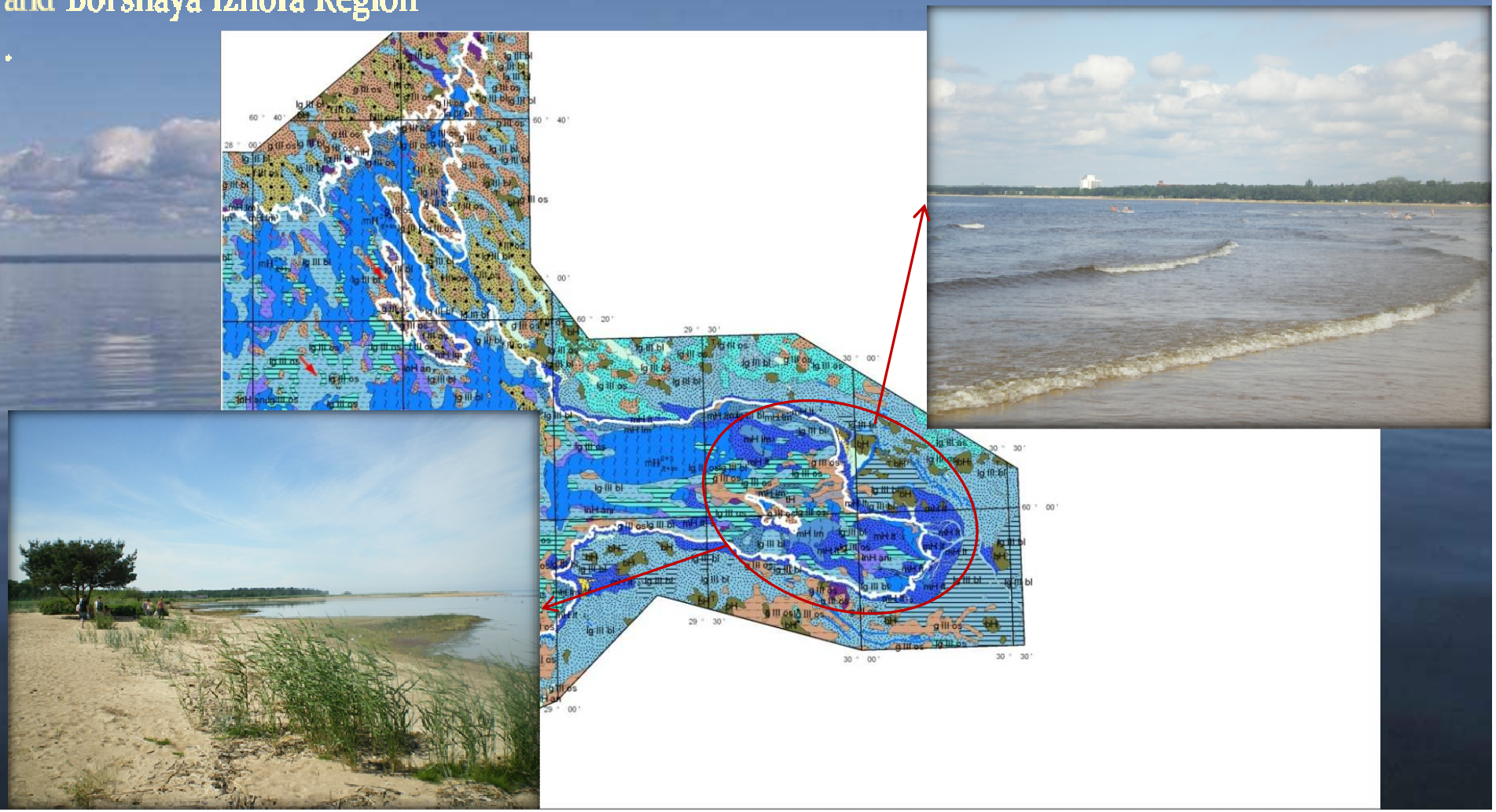


LM21990181981160AAA03

LM21990181981250AAA03

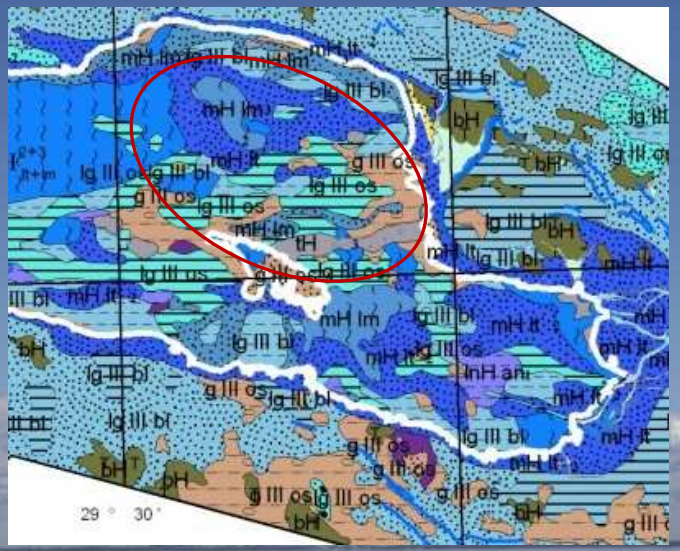
GEOLOGICAL CHARACTERISTICS

Geological map, compiled from the VSEGEI data, shows that the coastal zone of the Gulf of Finland, Russia is composed of glacial deposits, mostly madder: boulder sandy loam and loam. In response to the growing climate impacts on the coastal zone, consider the Eastern part of the Gulf of Finland, as the most valuable in respect of recreational meaning: Zelenogorsk– Sestroretsk Region and Bol'shaya Izhora Region



Zelenogorsk– Sestroretsk Region

The coast is composed of clay, sand and clay sands, which were formed during the Holocene. By design, there is dominated by sand and boulder sandy loam. The coastal part (the underwater part of the coast) is composed of younger rocks: remnants of the Baltic Ice Lake, which in turn formed by clays and sands.



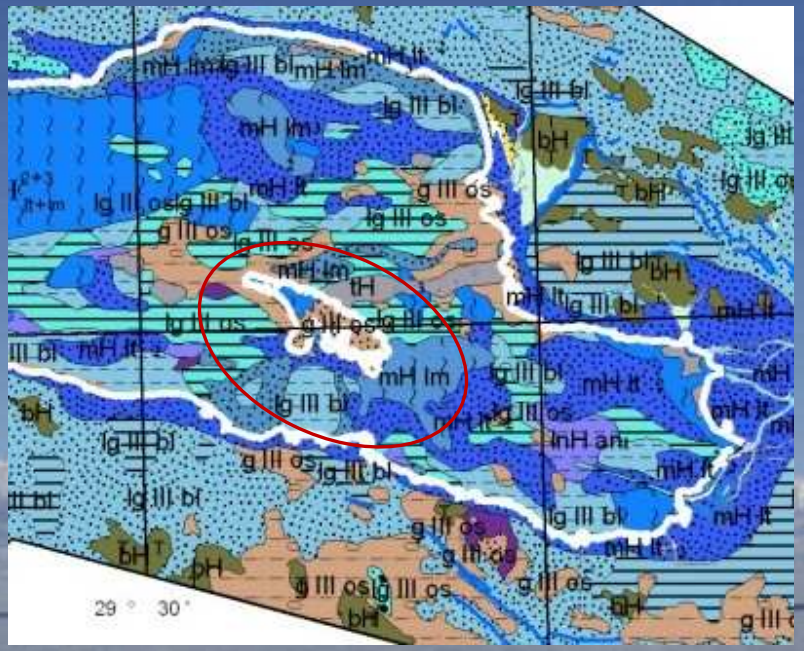
As a result, the area is dominated by accumulative coastal zone, composed of sand and clay.

But as a result of modern influence and lithosphere dynamics processes, banks are heterogeneous in form. In this area the most common is the elementary accumulative landform with stable or growing type of bank. These processes are expressed in the formation of sand, gravel and boulder beaches

Bol'shaya Izhora Region

This area belongs to the younger geological period than the previous one. Most of the coastal zone is composed of rocks of the Baltic Ice Lake. Only a narrow strip of coast is formed by madder, which consists of clayey sand.

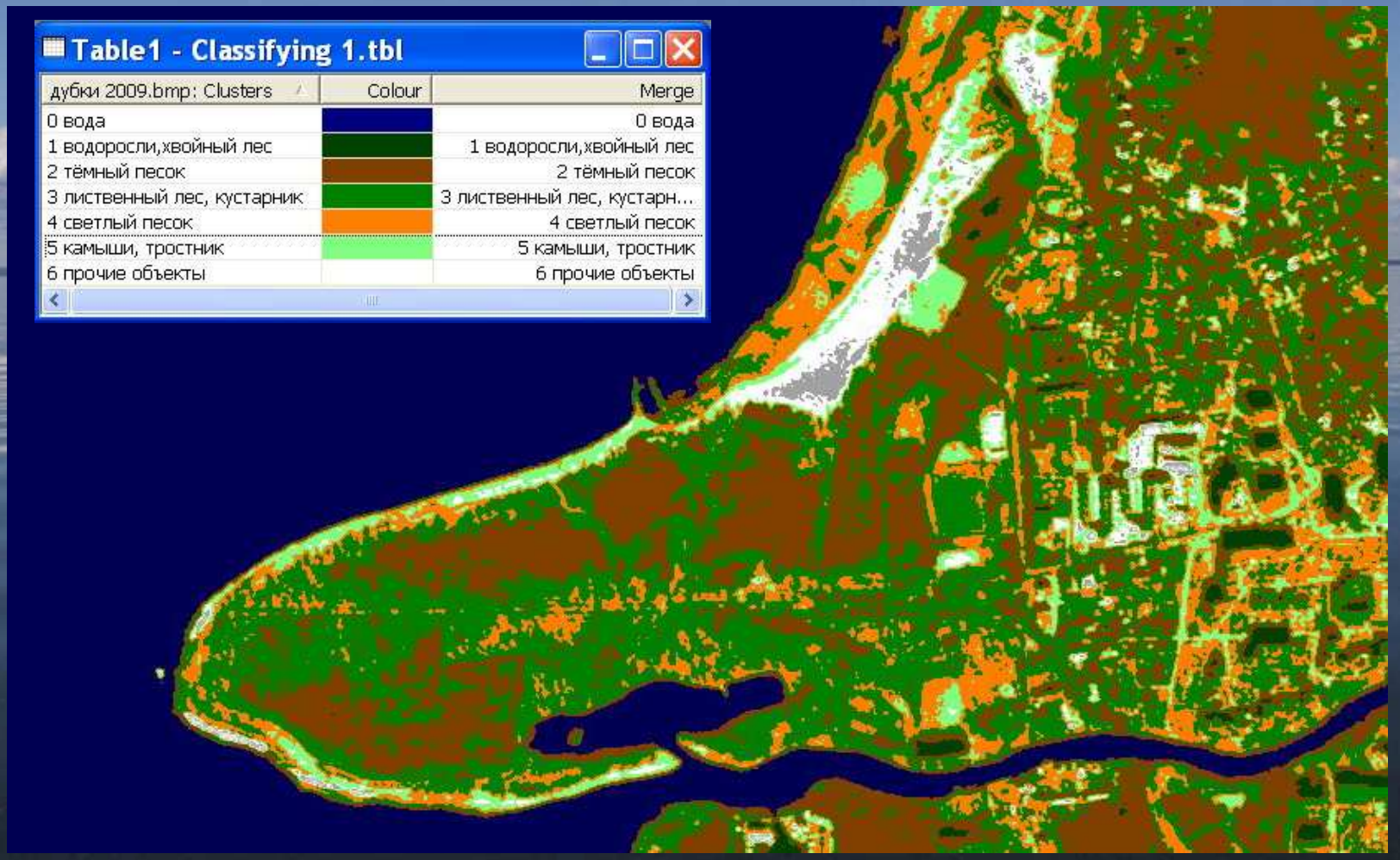
The underwater part is composed of rocks belonging to the remnants of the Baltic Ice Lake, piled from clays of different breeds. Behind the right bank of the river Izhora triangle madder breed: sands and muds are elongated . Sands and muds heavily exposed to modern lithosphere dynamics processes. Geological section of the area makes it possible to talk about unstable lithosphere dynamics.



By origin, both areas were formed in a single geological period, but today there are different processes. In the Region of Bol’shaya Izhora no pronounced accumulation or abrasion forms of relief.

In the geological past this area belongs to the accumulative coastal zone, but currently, because of the modern lithosphere dynamics processes it can not be attributed to the accumulative retreating or increasing the bank.

Result of unsupervised classification, SPOT data (June, 2008) for the Eastern part of the Gulf of Finland. IBEST UNESCO-Bilko results



Result of classification, SPOT data (June, 2008) for the Eastern part of the Gulf of Finland. IBEST UNESCO-Bilko results

unsupervised

Ижора без обучения Таб

Ижора без обучения: Clusters	Colour	Merge	IMAGERY #01 From ...
0 глубокая вода		0 глубокая вода	17.8
1 мелководье		1 мелководье	37.9
2 илы, водоросли, высокие деревья		2 илы, водоросли, высокие деревья	68.7
3 кустарники		3 кустарники	20.1
4 трава,осока		4 трава,осока	43.6
5 мокрый песок		5 мокрый песок	71.7
6 песок с галькой		6 песок с галькой	61.8
7 крупнозернистый песок с мелкой галькой		7 крупнозернистый песок с мелкой галькой	49.4
8 крупнозернистый песок с мелкой галькой		8 крупнозернистый песок с мелкой галькой	75.5
9 осушенная часть побережья		9 осушенная часть побережья	78.6
10 сухой мелкозернистый песок		10 сухой мелкозернистый песок	58.2
11 песок с сухим тростником		11 песок с сухим тростником	83.5
12 сухой тростник		12 сухой тростник	87.6
13 здание		13 здание	74.9
14 здание		14 здание	97.2
15 здание		15 здание	98.6

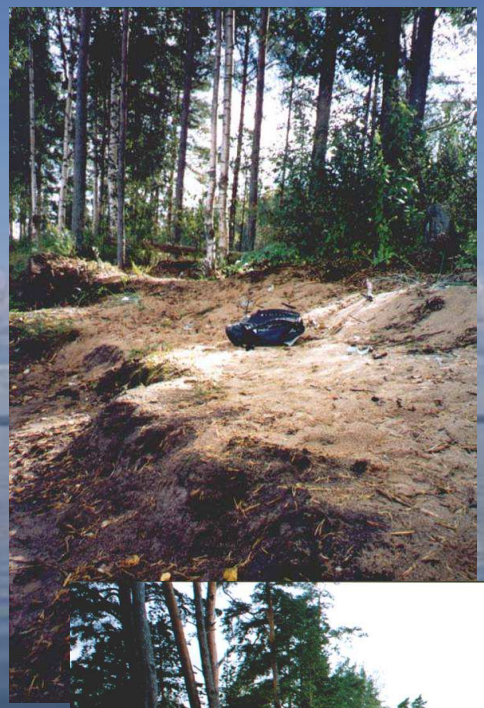
supervised

Table5

Description: Stack	Upper Left	Size	Pixels	Class: Herts landuse classes	Mean TD
TS #000:	(1042, 0006)	(0042, 0050)	2100	Deep water	1401
TS #001:	(0972, 0150)	(0039, 0038)	1482	Deep water	1309
TS #002:	(0701, 0064)	(0040, 0039)	1560	Deep water	1366
TS #003:	(0365, 0004)	(0022, 0011)	242	Deep water	1330
TS #004:	(0015, 0102)	(0027, 0021)	567	Deep water	1261
TS #005:	(0113, 0136)	(0015, 0015)	225	Deep water	1335
TS #006:	(1125, 0006)	(0004, 0004)	16	Deep water	1709
TS #007:	(0165, 0303)	(0010, 0007)	70	Deep water	1713
TS #008:	(0015, 0297)	(0011, 0010)	110	Deep water	1797
TS #009:	(0193, 0267)	(0007, 0007)	49	Deep water	1587
TS #010:	(0245, 0196)	(0012, 0007)	84	Deep water	1335
TS #011:	(0012, 0198)	(0016, 0010)	160	Deep water	1336
TS #012:	(0261, 0309)	(0013, 0005)	65	Deep water	1778
TS #013:	(0320, 0269)	(0009, 0008)	72	Deep water	1581
TS #014:	(0251, 0270)	(0005, 0007)	35	Deep water	1625
TS #015:	(0211, 0209)	(0010, 0008)	80	Deep water	1245
TS #016:	(0369, 0230)	(0007, 0008)	56	Deep water	1526
TS #017:	(0447, 0159)	(0009, 0007)	63	Deep water	1437
TS #018:	(0539, 0085)	(0025, 0026)	650	Deep water	1269
TS #019:	(0481, 0307)	(0007, 0008)	56	Deep water	1572
TS #020:	(0526, 0272)	(0010, 0008)	80	Deep water	1327
TS #021:	(0683, 0261)	(0017, 0012)	204	Deep water	1277
TS #022:	(0656, 0327)	(0011, 0010)	110	Deep water	1357

Dynamics of erosion processes

October, 2004



June, 2007

EXAMPLE OF AN IRRATIONAL USE OF THE COASTLINE

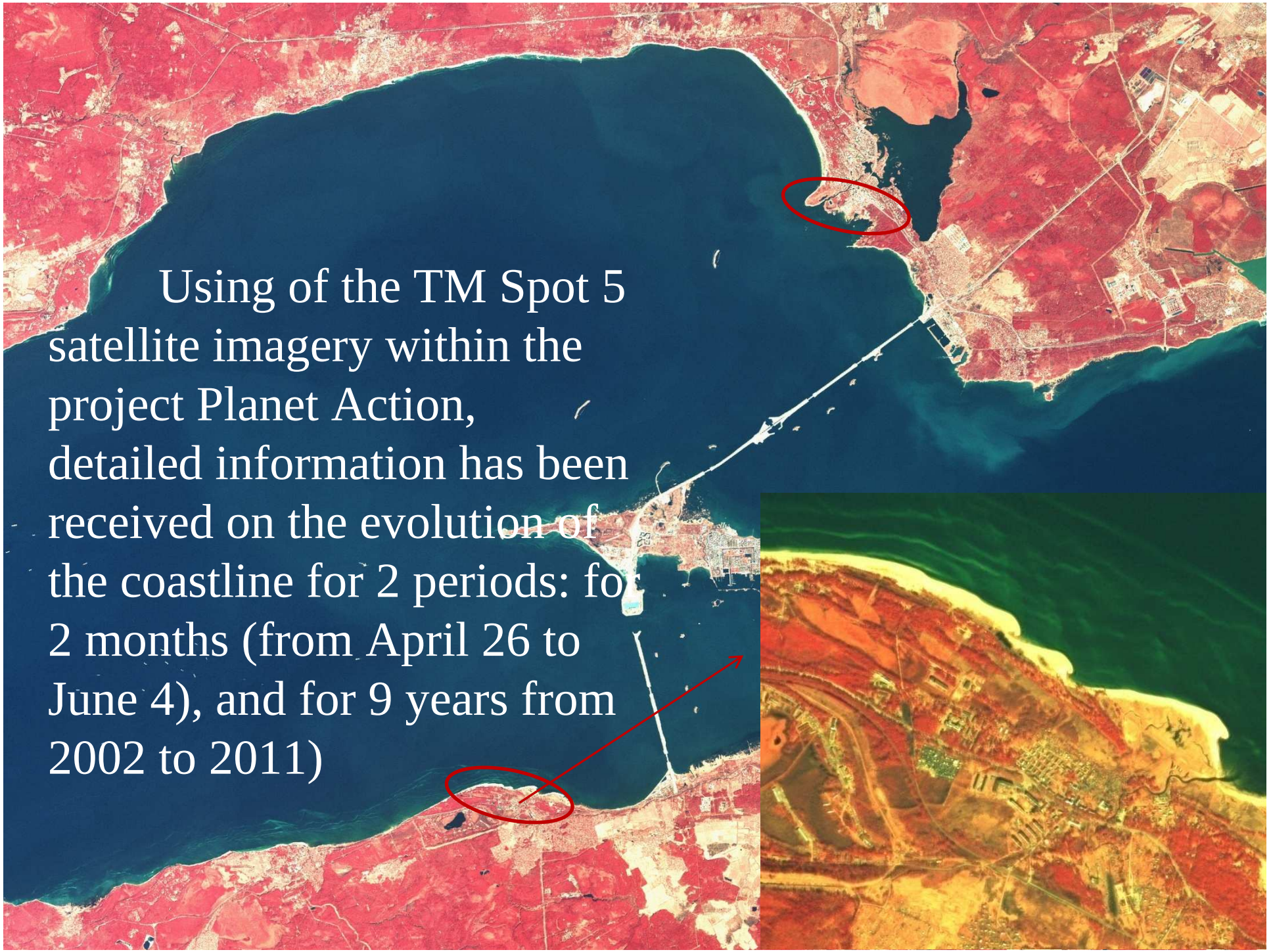
- cafe built within the 50-meter split of the band that does not comply with the law;
- not properly selected construction site (in origin presented beach is accumulative type, but in modern processes - retreating),
- as a result, each year the distance between the water's edge and the building is reduced. Besides western winds in the area act destructively on the coast.

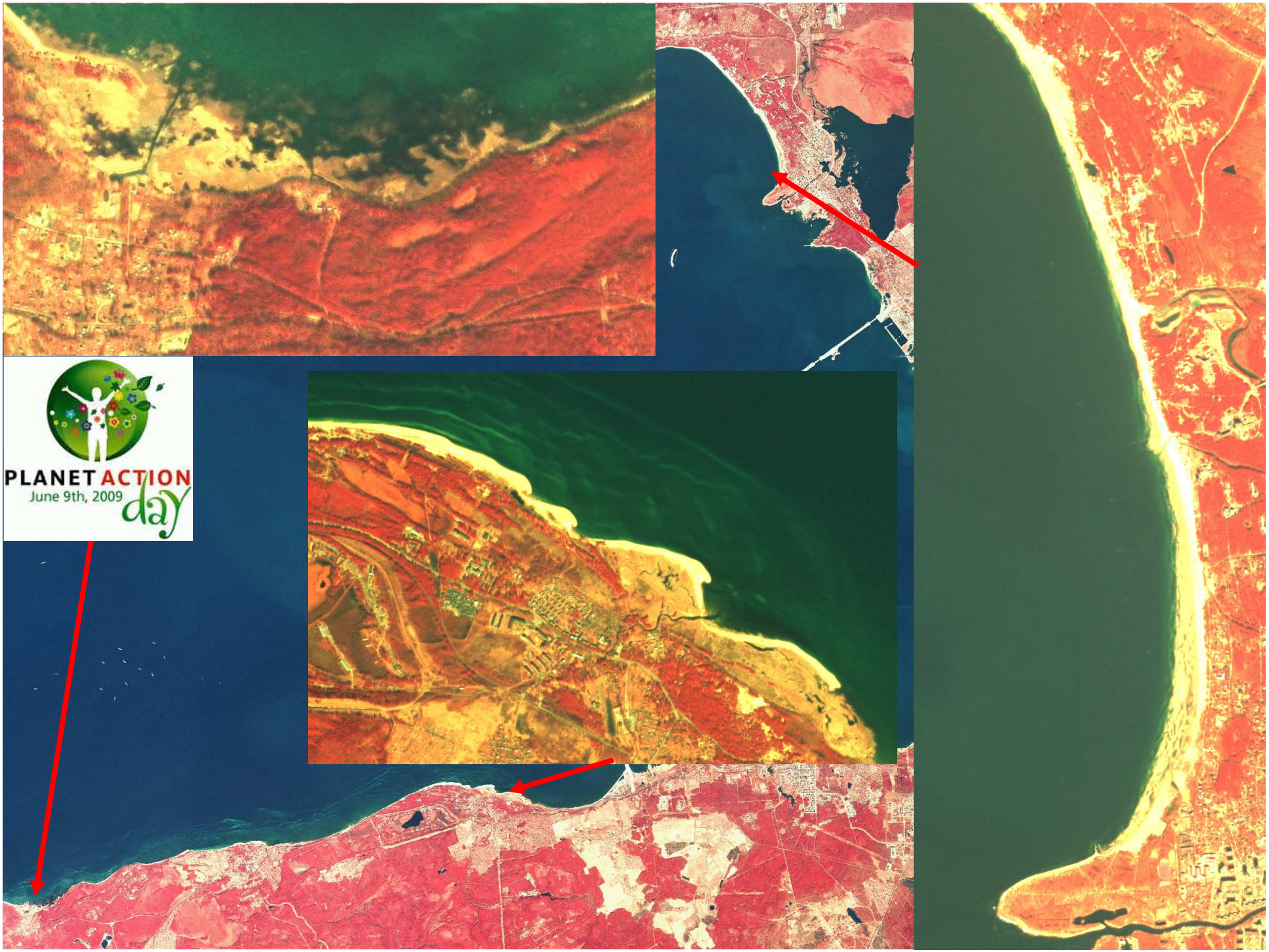
-trying to stop these processes, the owners built primitive bank protection structures, which only delay the water, increasing the amount of mud and algae at the shore, which in turn decay and emit an unpleasant odor.

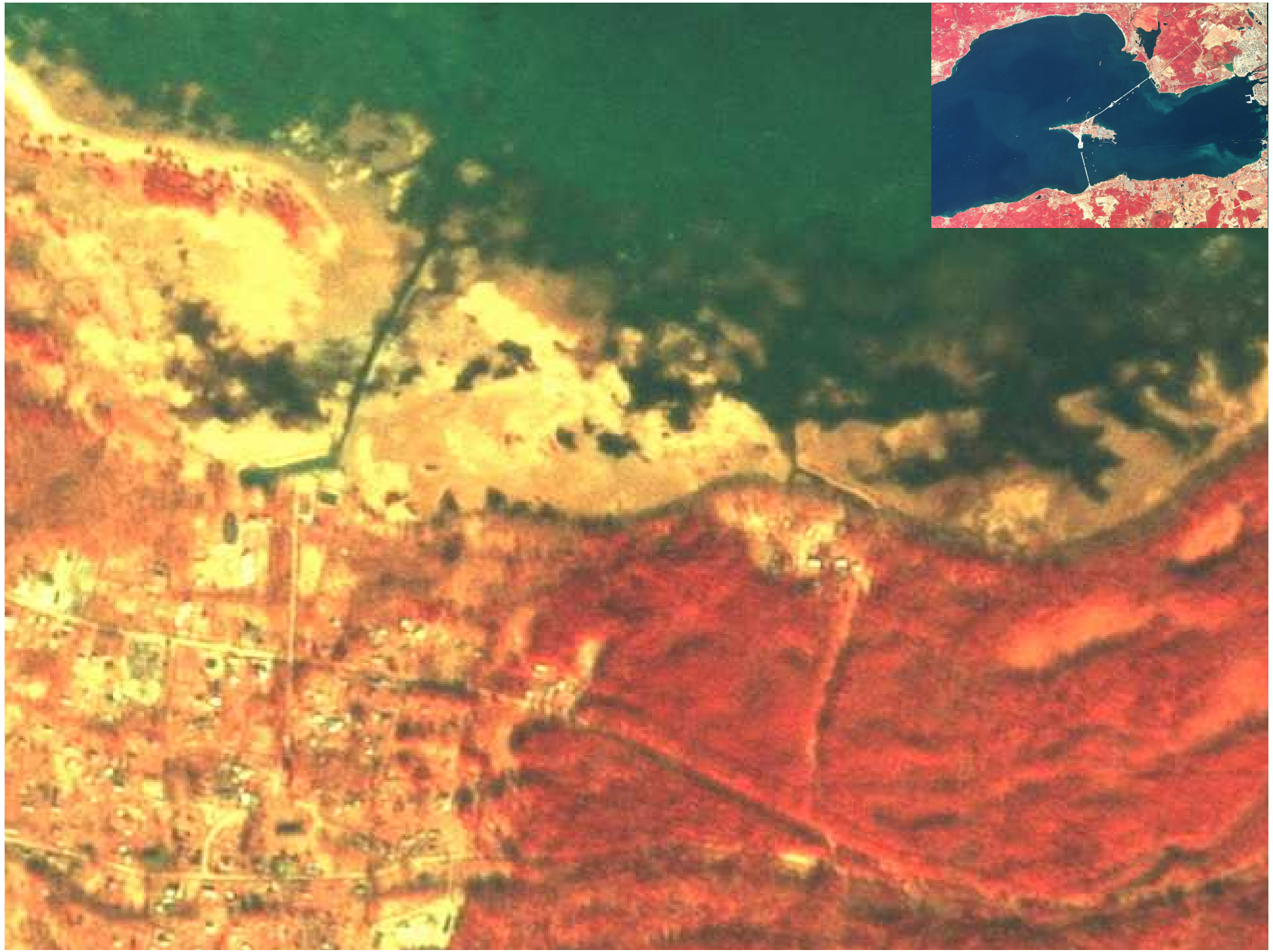
PART 2: Ground works, 2007- 09:

Coastal zone erosion studying

Photos Georgy Gogoberidze


Using of the TM Spot 5 satellite imagery within the project Planet Action, detailed information has been received on the evolution of the coastline for 2 periods: for 2 months (from April 26 to June 4), and for 9 years from 2002 to 2011)

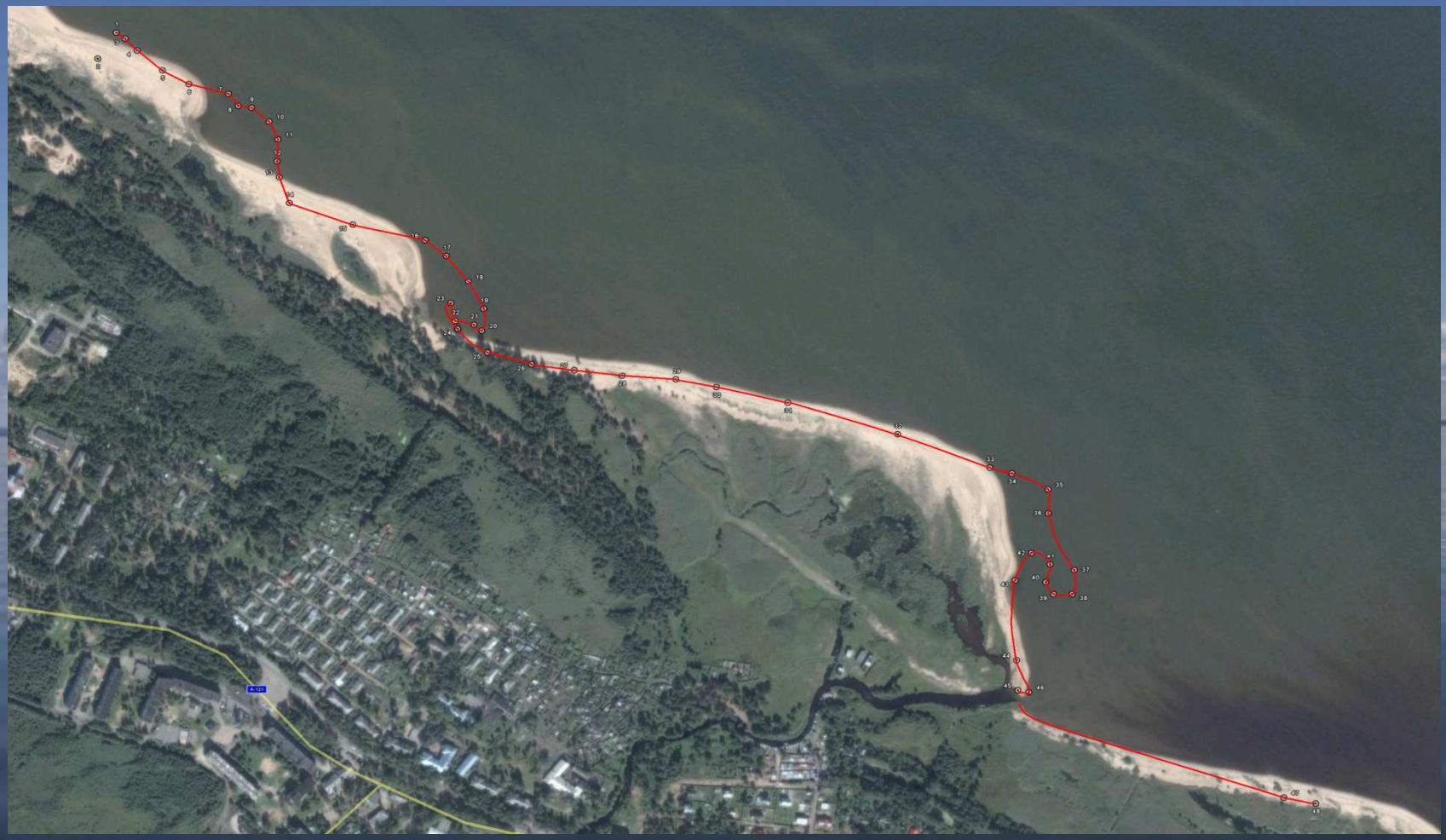

PLANET ACTION
June 9th, 2009
day



Changes of coastline during 9 years

IKONOS Satellite image in 2002.

Red line shows the coastline in July 2009 after students' fieldwork

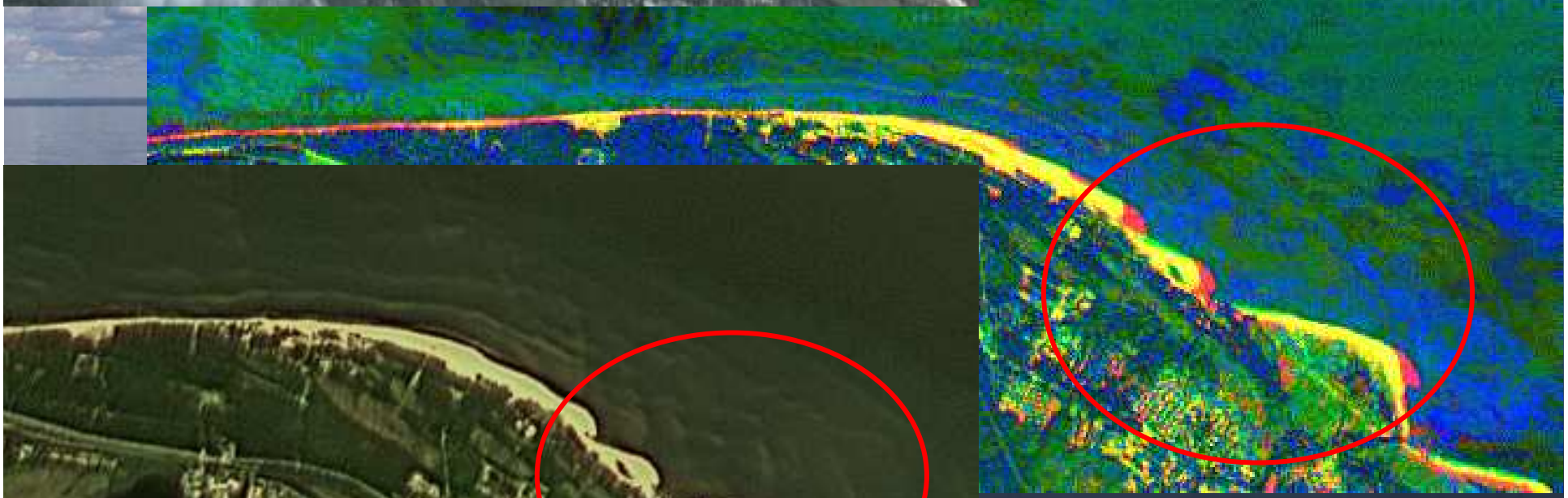


Significant change in the shoreline indicates unstable lithosphere dynamics processes, results in the formation of new braids, sand accumulation, beaches erosion and coastal erosion.

Results of ground works at the test sites compared with remote sensed data:

Coastal line changes, evolution of sand accumulative body

2002



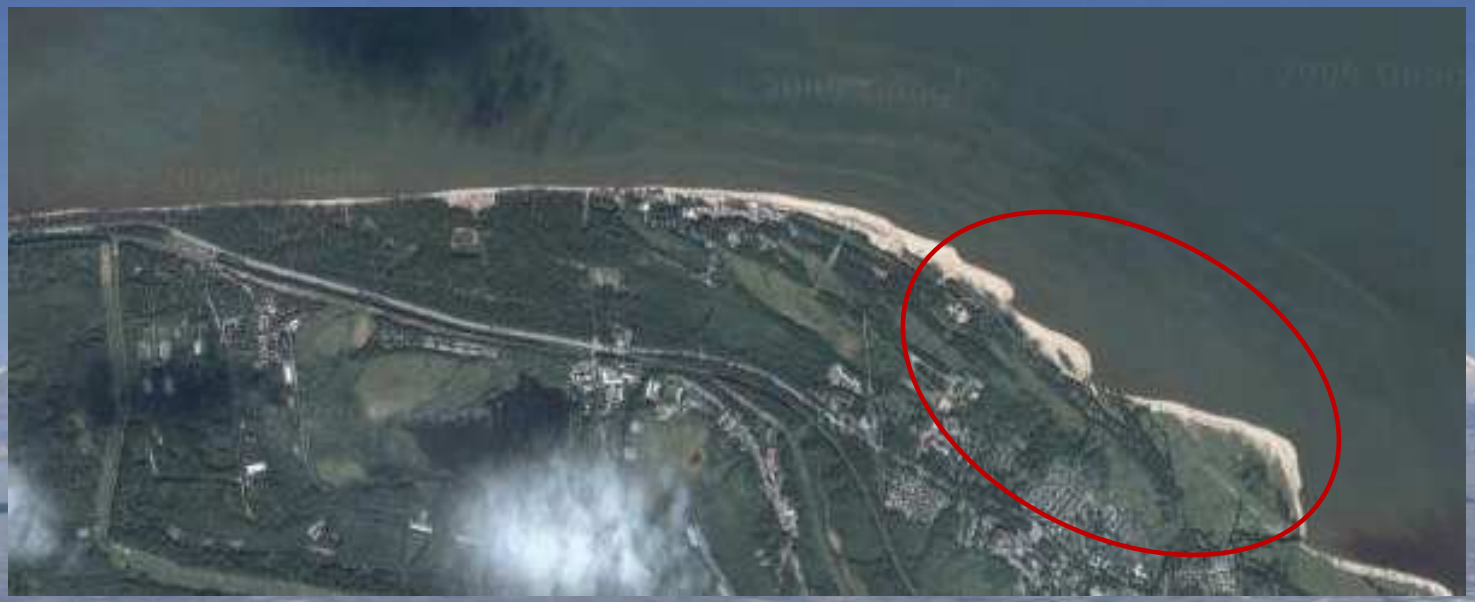
2007

Changes in coastline during 2 months

4 June 2008

26 April 2008

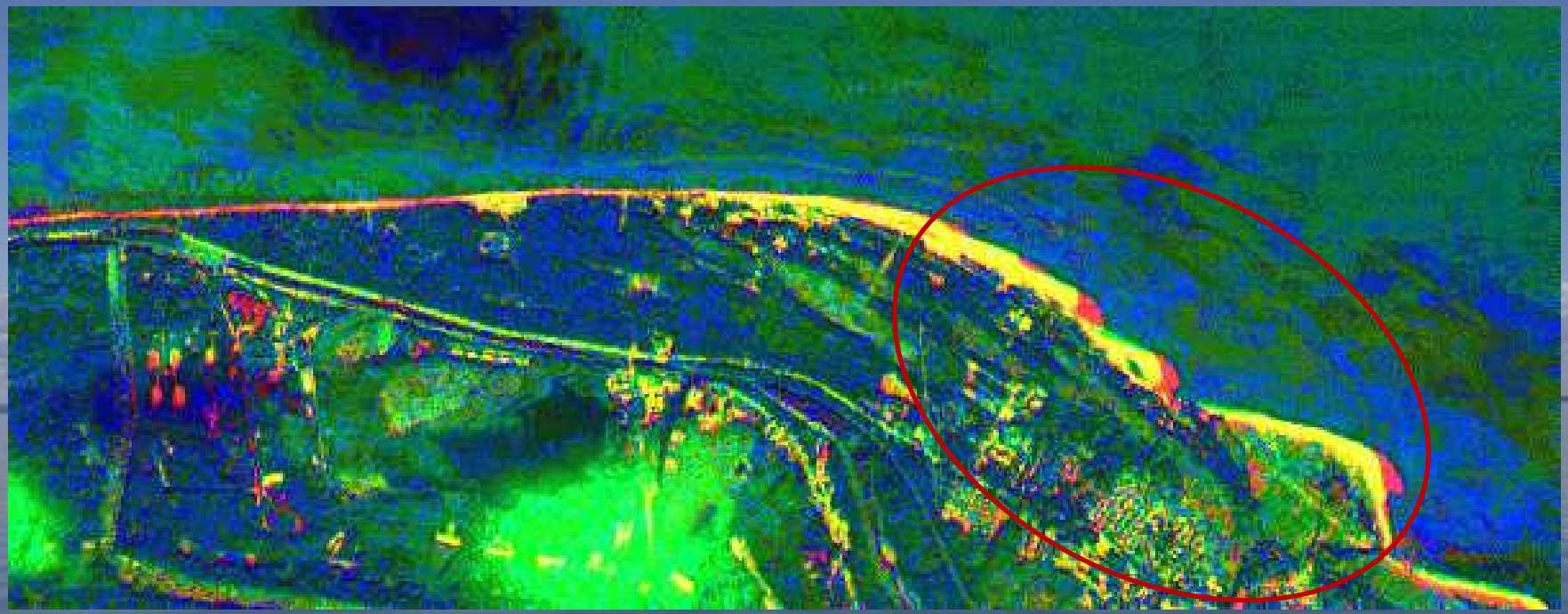
Identification of accumulation and erosion zones for 5 years with use of the Spot-5 data



2007

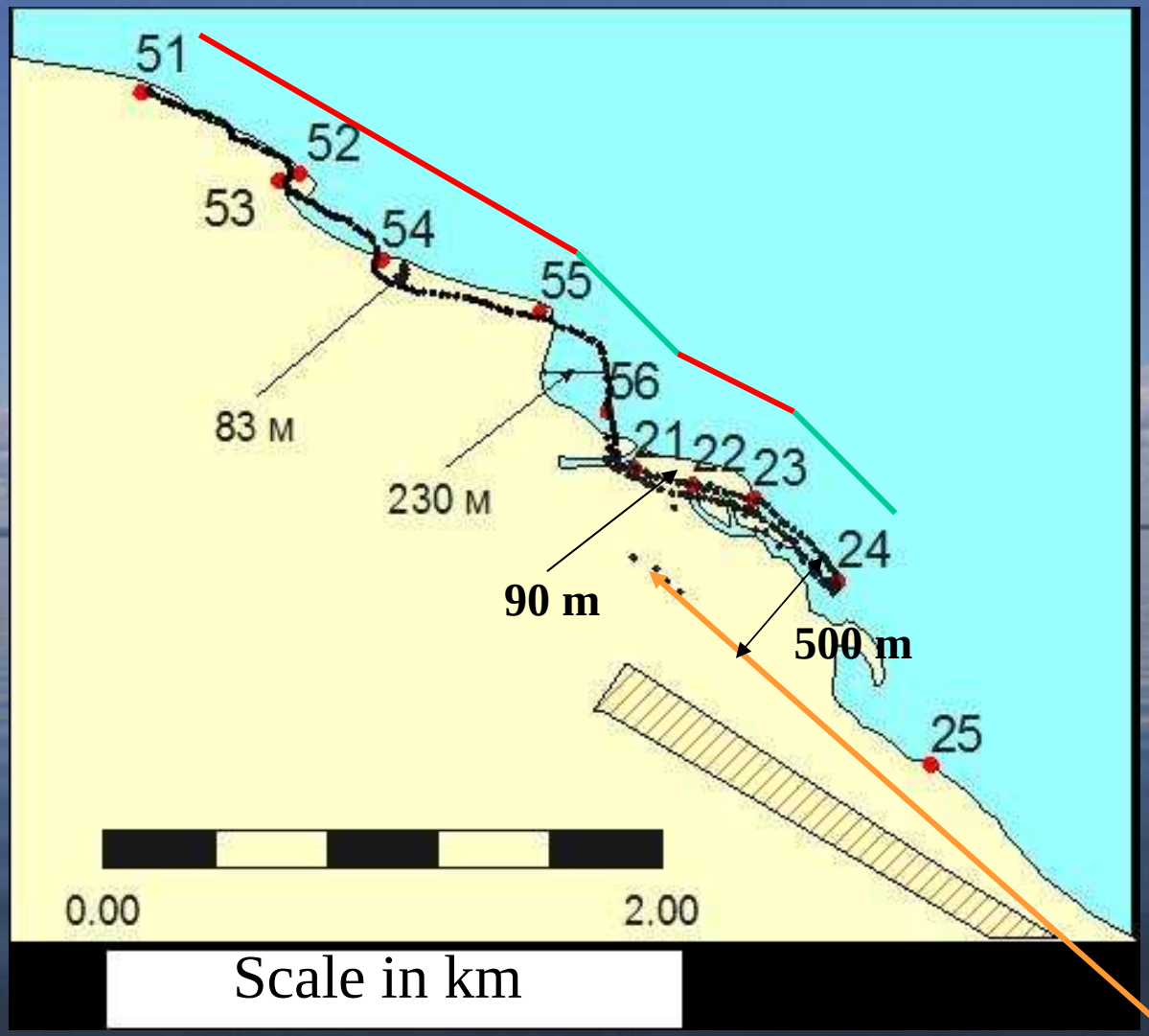
2002

Zones of accumulation (red color) and erosion zones (green color).



Formation of accumulation and erosion zones suggests an unstable dynamics of the shores. Unstable lithosphere dynamics processes, fast-changing climatic conditions (including ice conditions) expose coastal zone to be seriously affected.

Coastal line changes since 1982



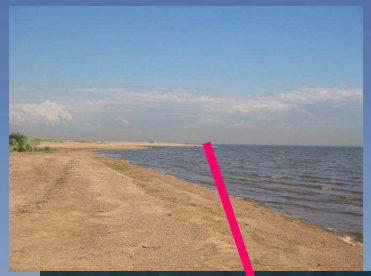
(yellow area – coastal line according to map edited in 1988, black spots – result of GPS survey at spring 2005)

Ancient coast line position

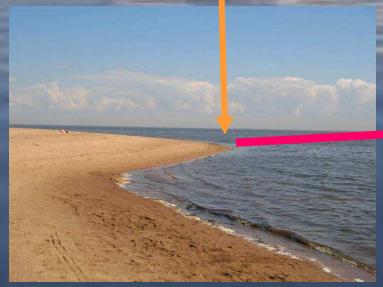
- erosion
- accumulation

Coastal line curves caused by alteration of zones of erosion, transition and accretion

Erosion

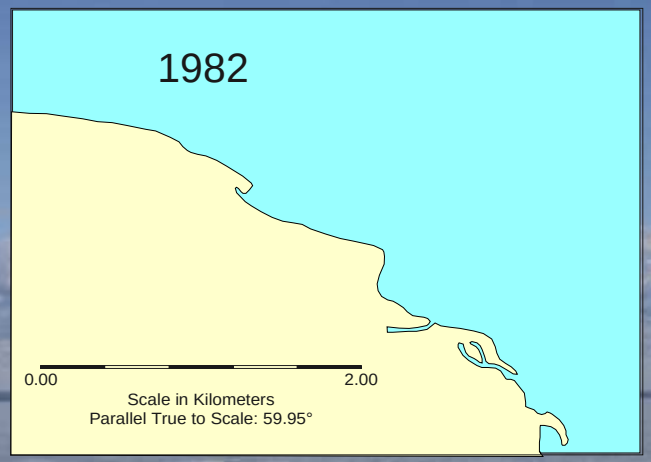


Accretion

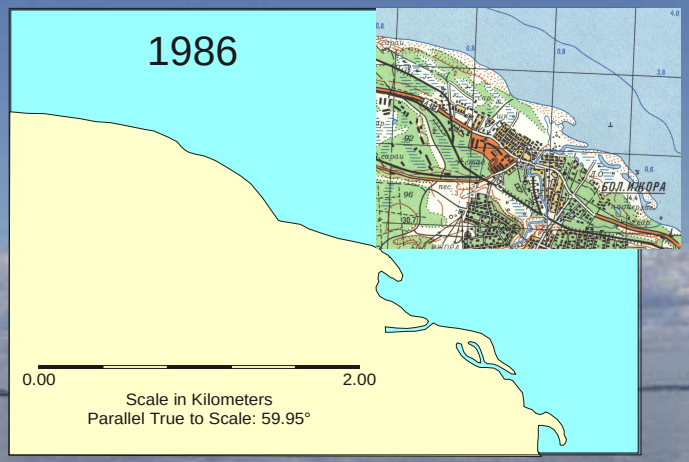


Transit

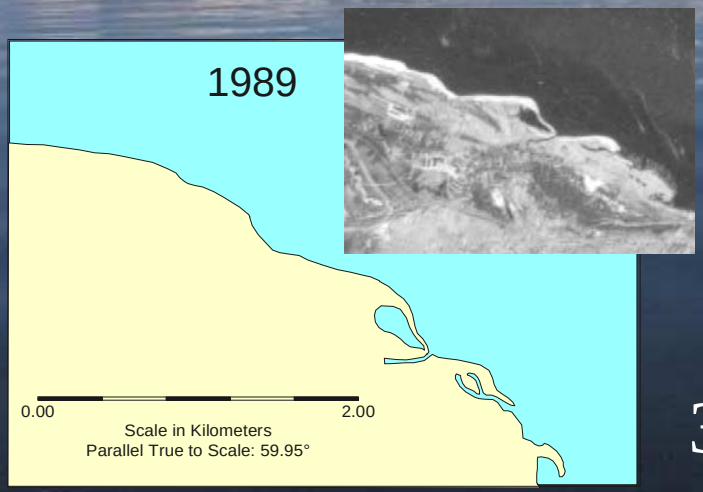
Sand body forming processes



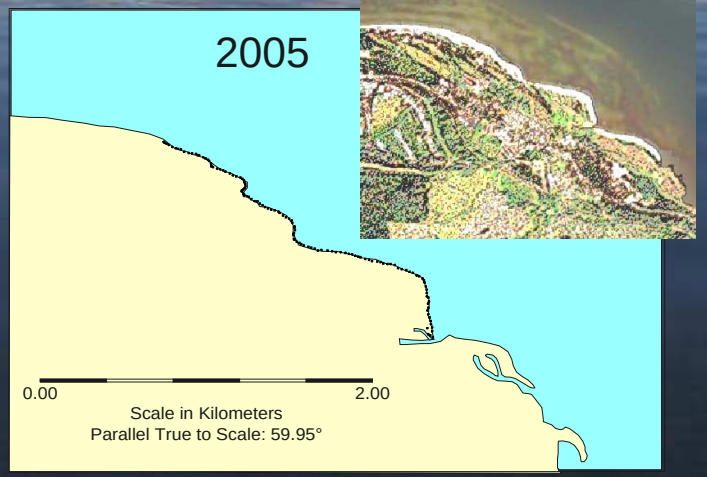
1



2

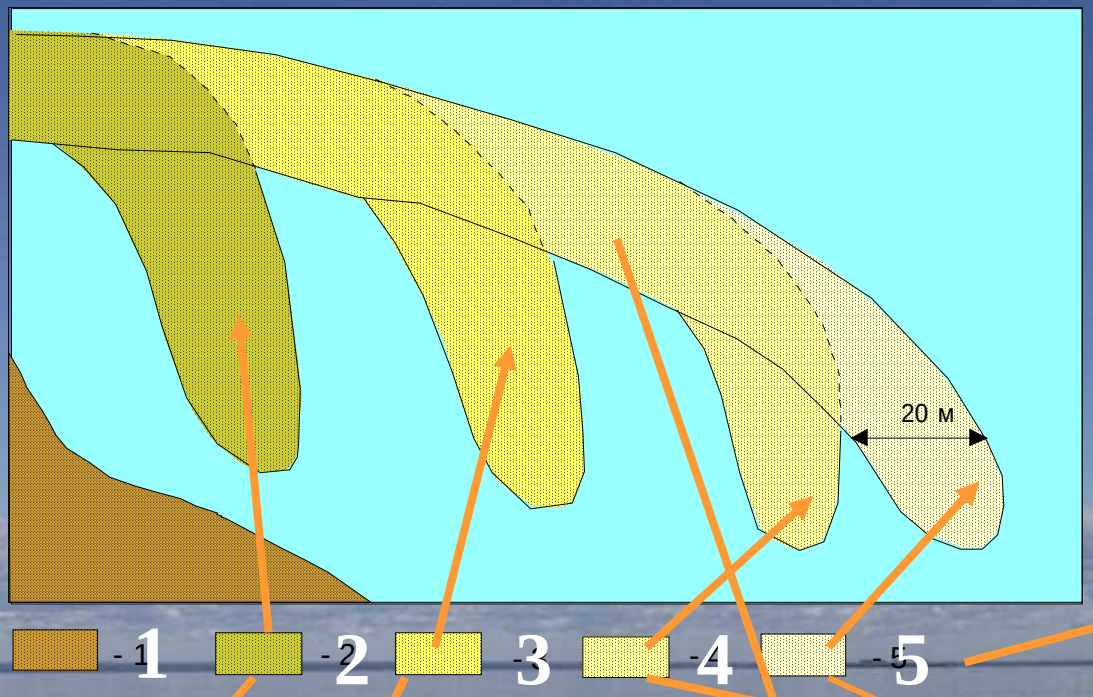


3



4

Growing “hook spit”



1 – relict sand body; 2, 3, 4 – gradual forming sand “hooks”; 5 – new forming “hook”

Dynamic of sand accumulative body

Degradation of the sand spit

2004

2005

2009

RSHU Students during field works in 2009

PART 3: TTR - cruises BFU 2008 2nd – 12th July

Russian → St Petersburg

Portuguese → Aveiro Algarve

Spanish → Cadiz

Italian → Bologna

Colombia

Training:

- Expedition at the sea
- Analyzing data at RSHU
- Participation in the EU-COMET2 meeting

TTR- 2008 cruise

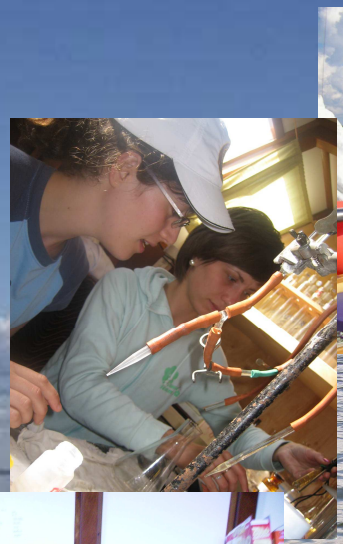
Examples of Methods and Material

→ Oceanographic and Hydro-Biological survey

→ Meteorological studies

→ Lectures

→ Living experience



Hydrology

CTD measurements

Sensors
- Temperature
- Salinity
- Pressure

TTR- 2007, 2008 cruises

Examples of Methods and Material

Biology

- Determination of primary production
- Decomposition of organic matter

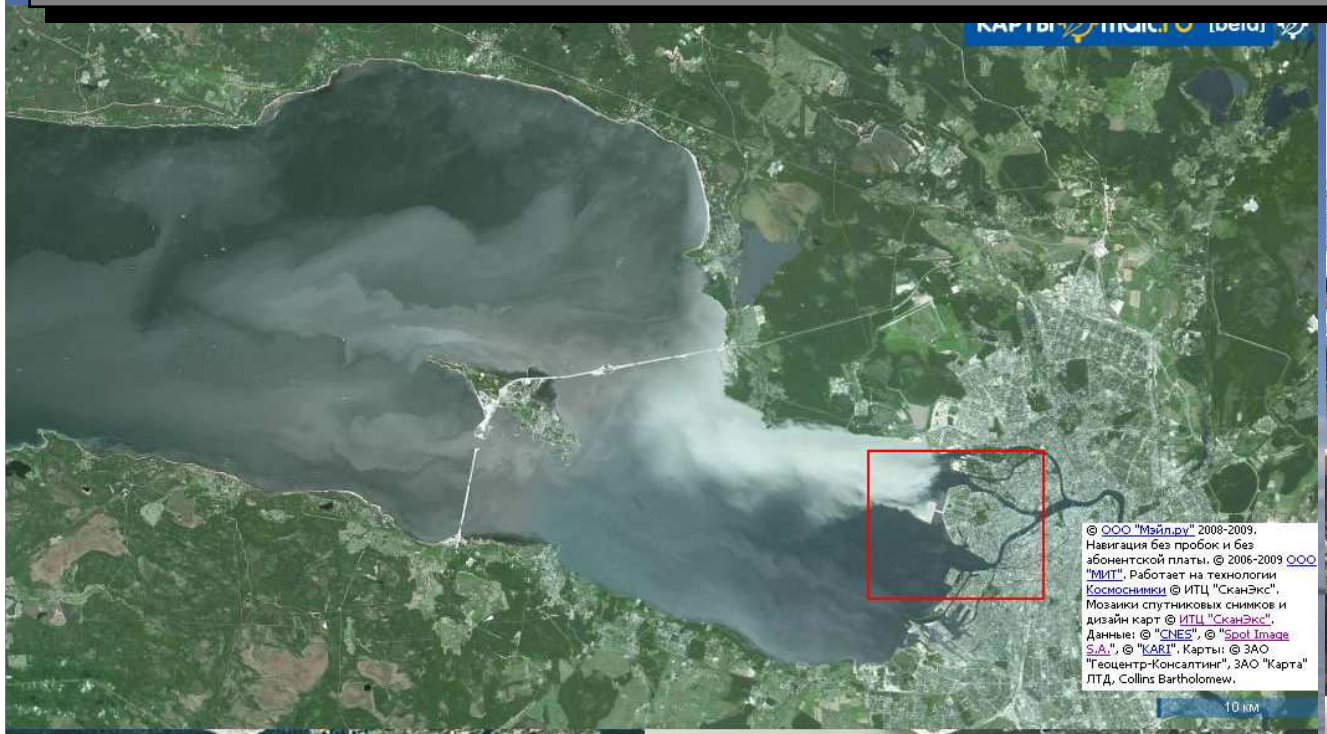
→ Method of light and dark volumes with oxygen modification

- Sampling to determine the composition of zooplancton
- Sampling to determine the composition of phytoplancton

→ Light microscope

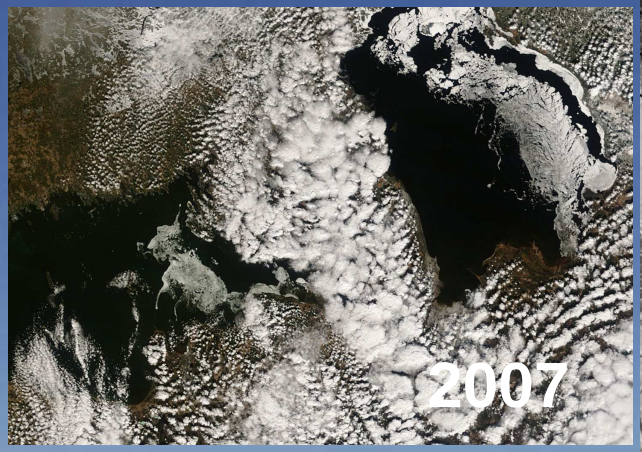
- Chlorophyll concentration → Acetone extraction and determination by mass spectrophotometer
- Phosphorus concentration → Molibdate blue method
- Suspended organic and mineral particles → Gravimetric precipitation oxidation by chromesulphure acid method

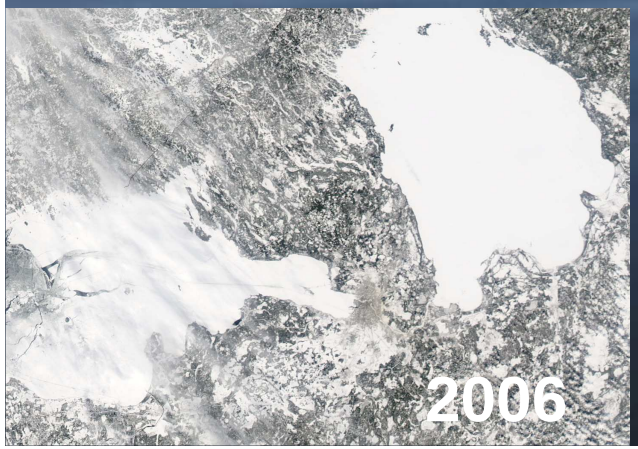
TTR- 2008 cruise observations: *resuspension of bottom sediments during engineering works in the inner part of the Neva Bay*



PART 3: Ground works,2007-08: Sea ice studying in the Gulf of Finland

Remote sensing of Ice in the Gulf of Finland and Lake Ladoga, April, 2004-09

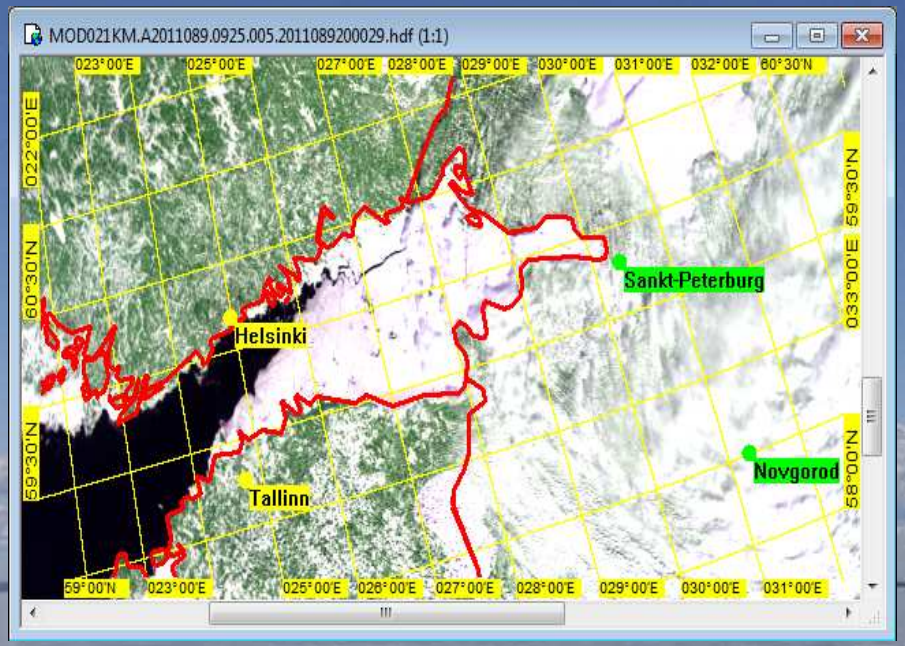




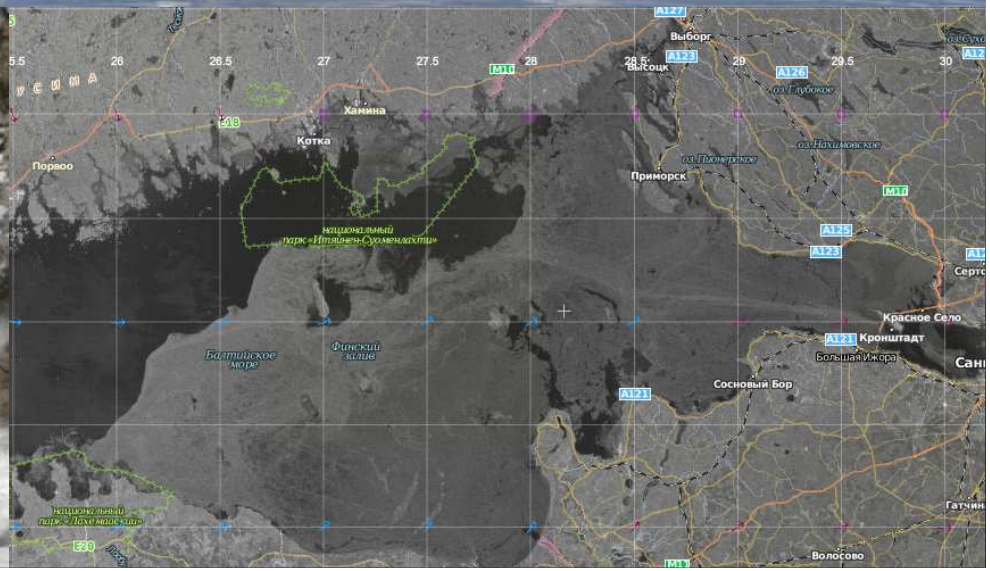
Fishermen on the ice of Lake Ladoga, March, 2009

Visual and RADARSAT-1/SAR data for the sea ice mapping and analysis

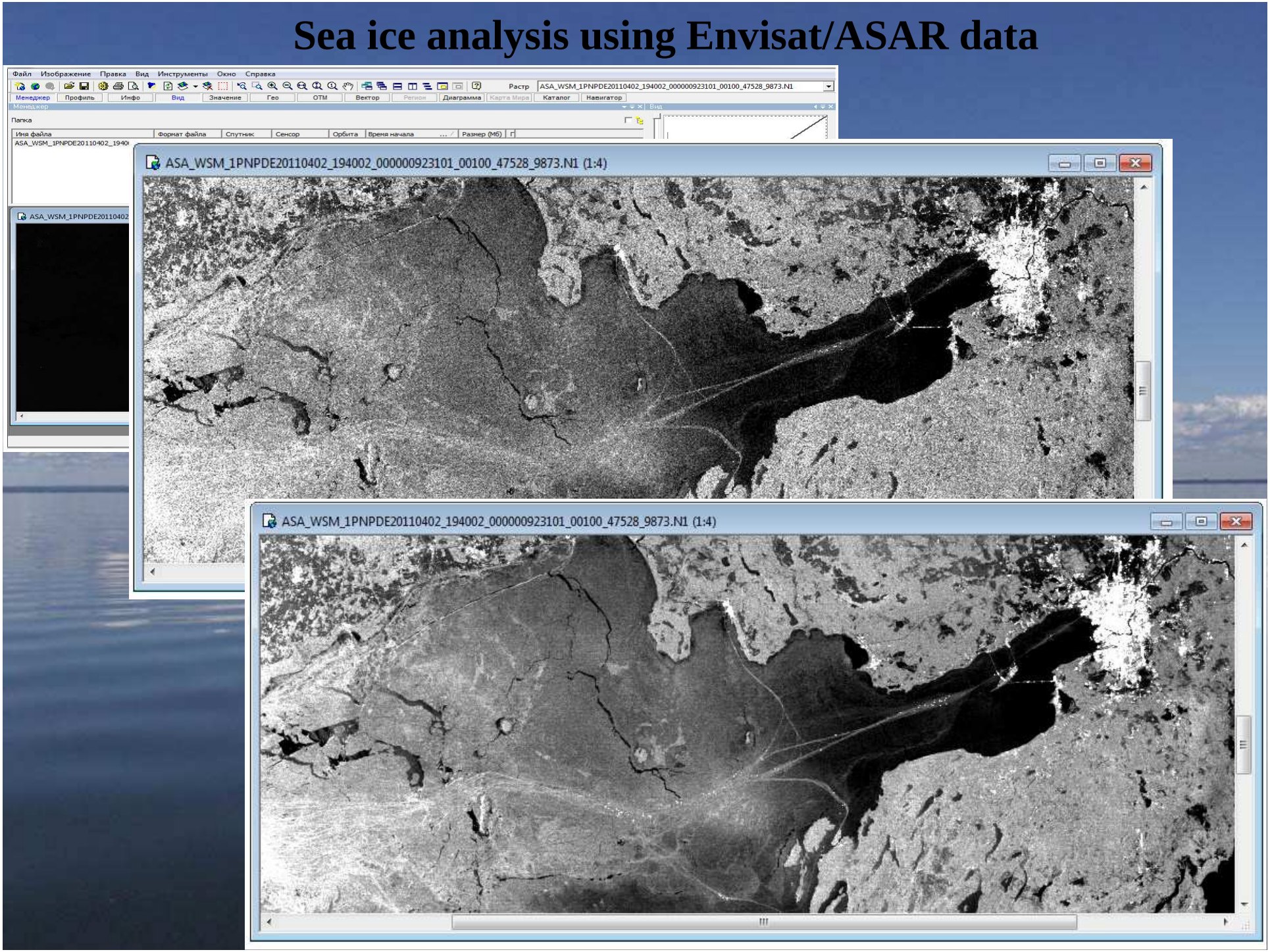
Terra/Modis 03.04.2011 г.



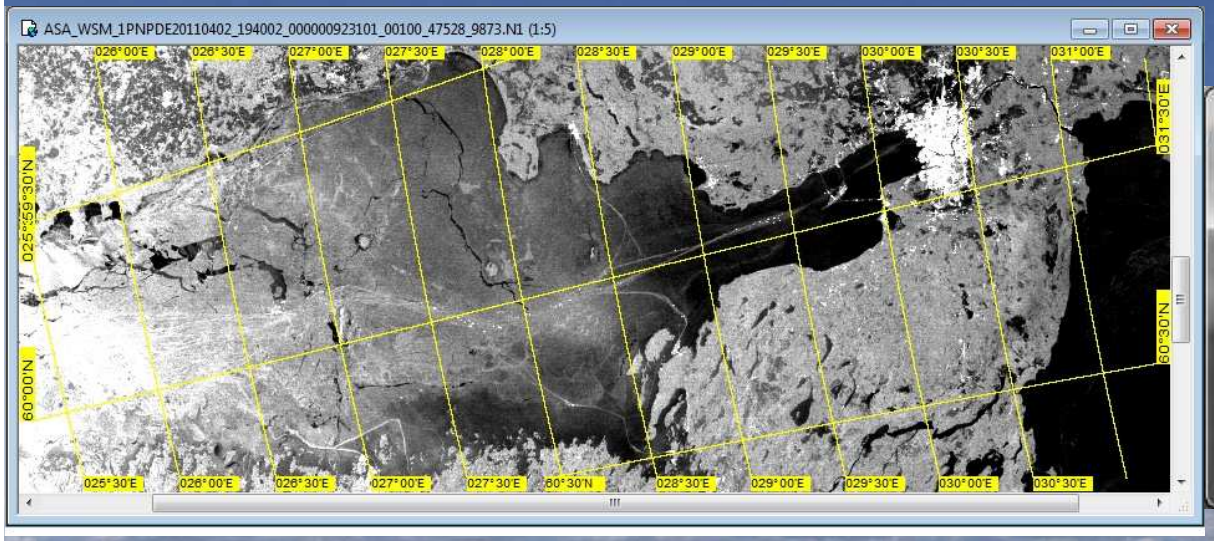
20.04.2011. Terra/Modis and RADARSAT-1/SAR 20.04.2011

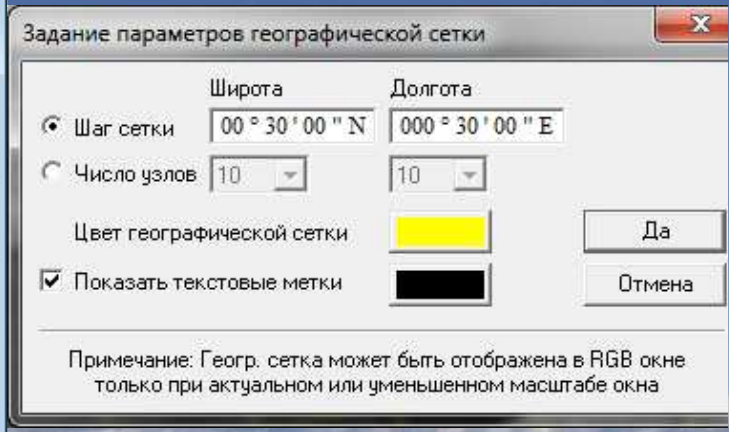


Sea ice analysis using Envisat/ASAR data

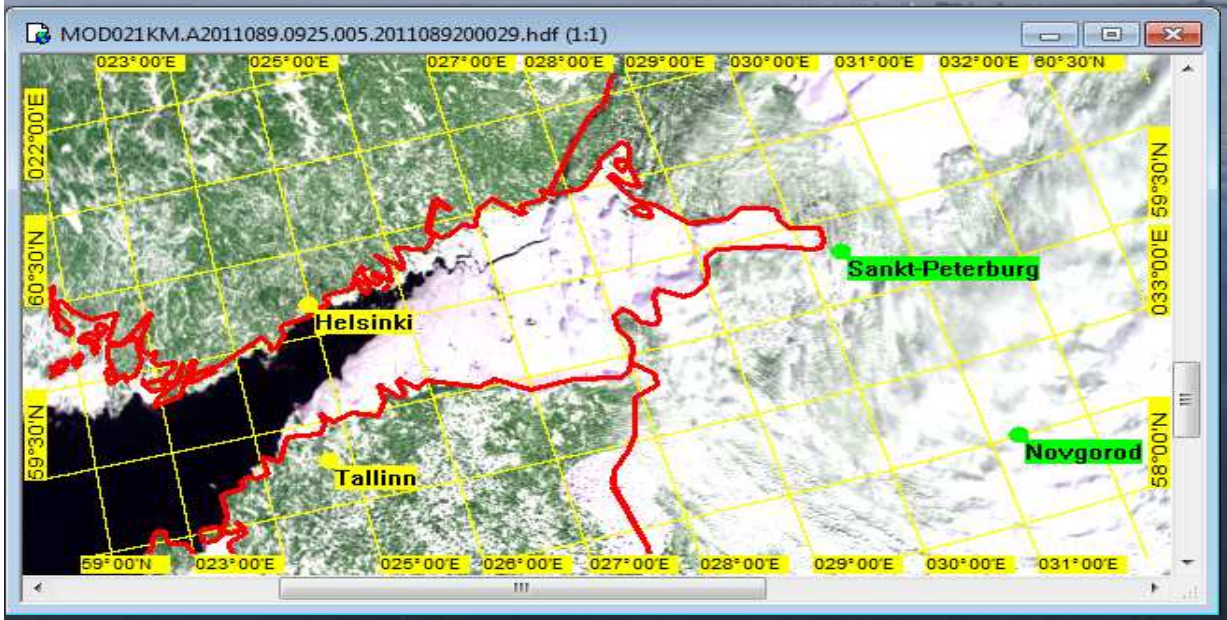


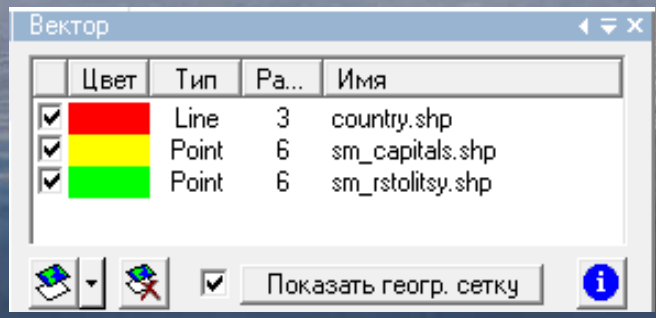
Geolocation





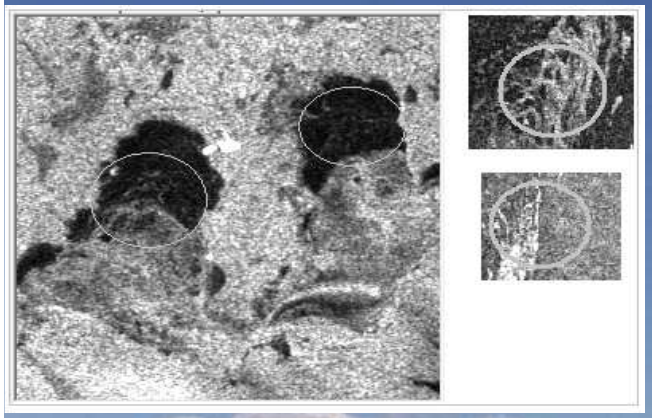
ENVISAT/ASAR 03.04.2011

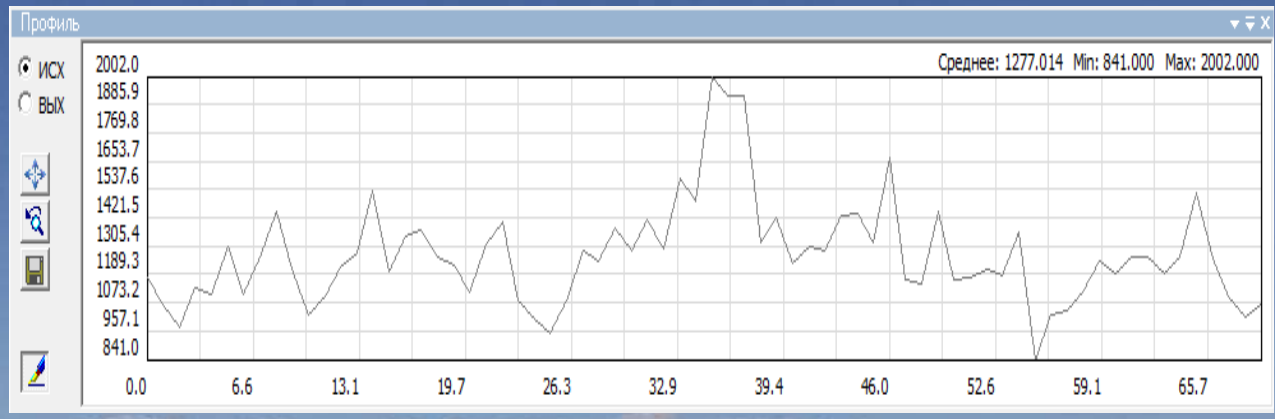




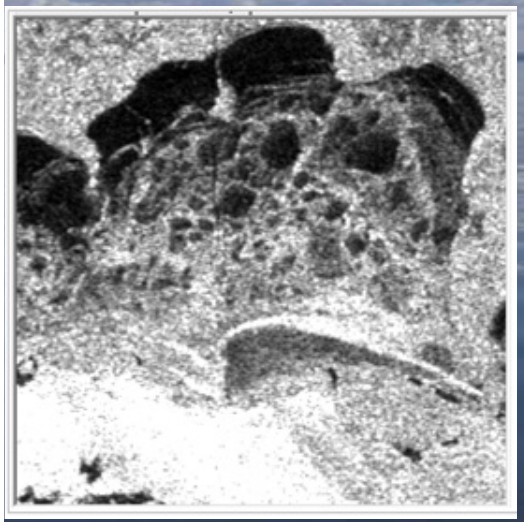
Terra/Modis 03.04.2011

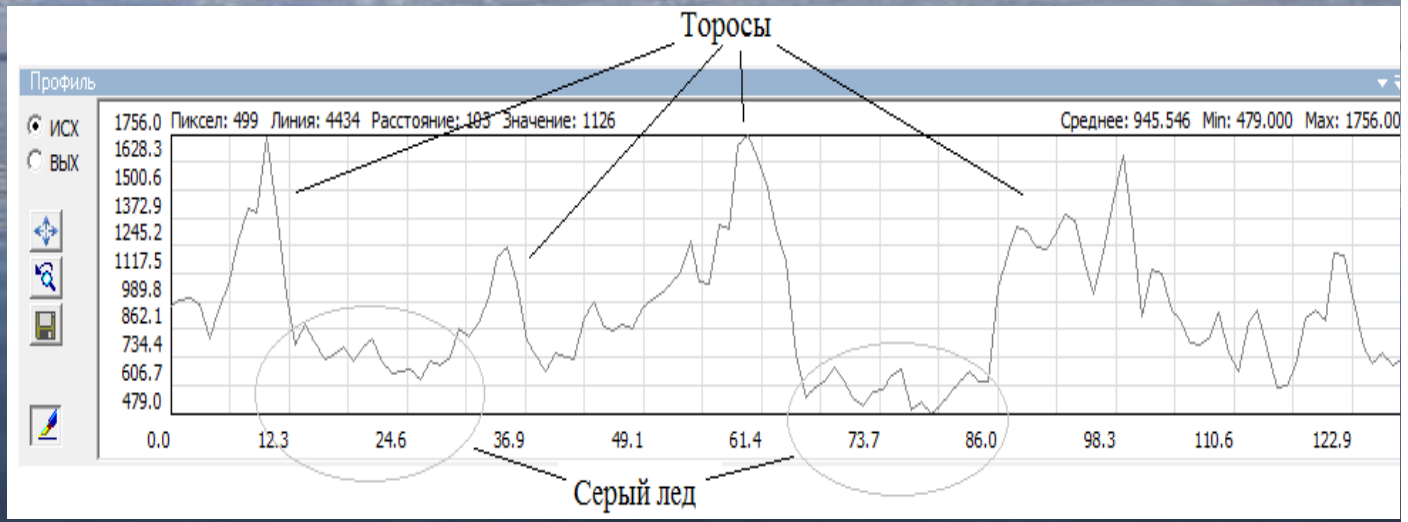
Sea ice detection





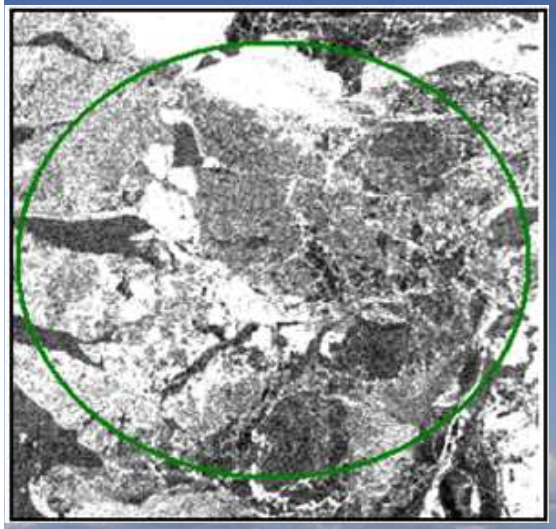
ENVISAT/ASAR 03.04.2011.

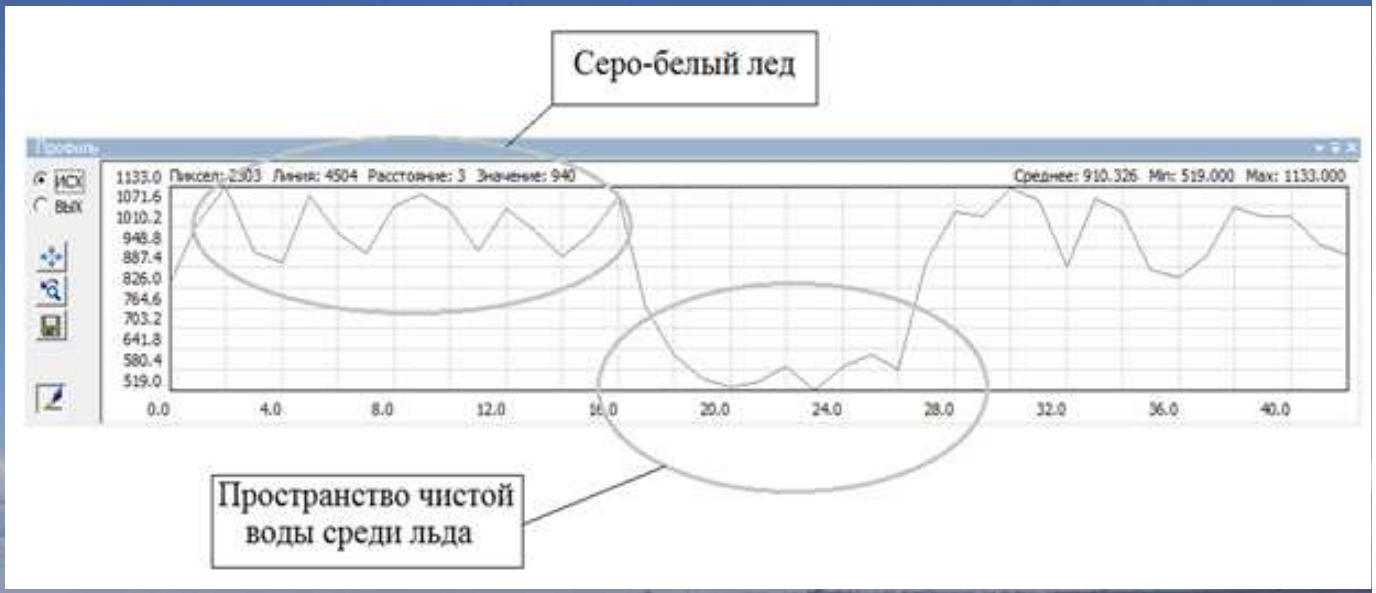




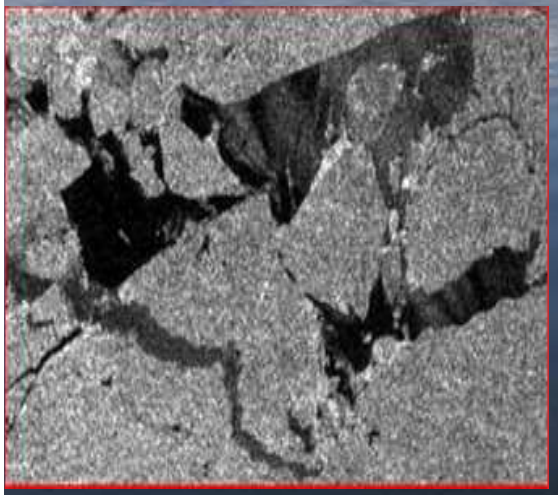
Grey ice, ENVISAT/ASAR 03.04.2011

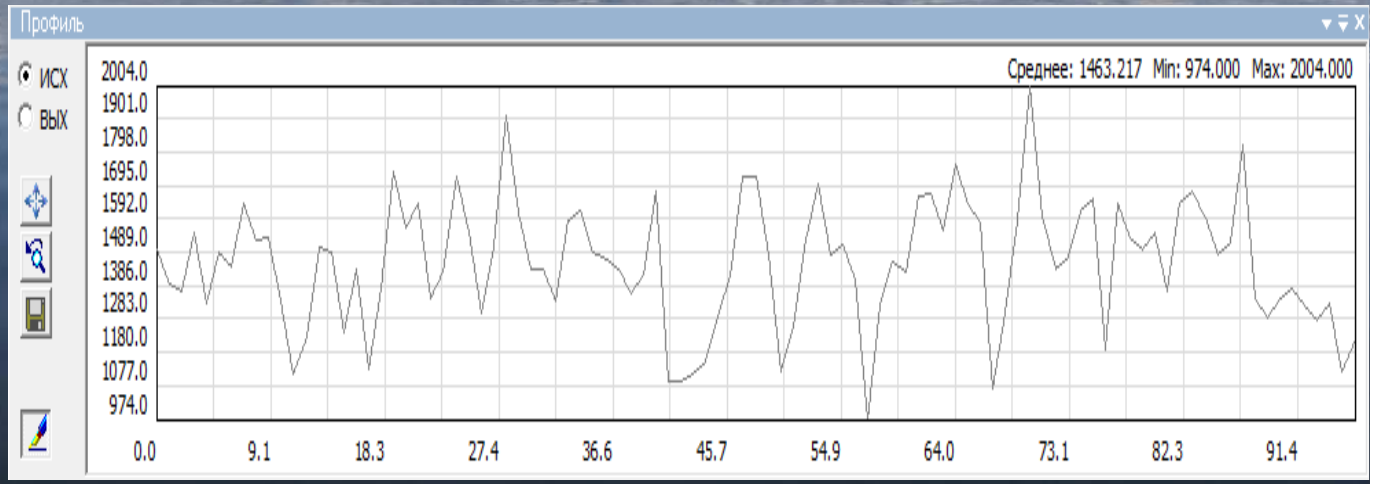
Sea ice detection





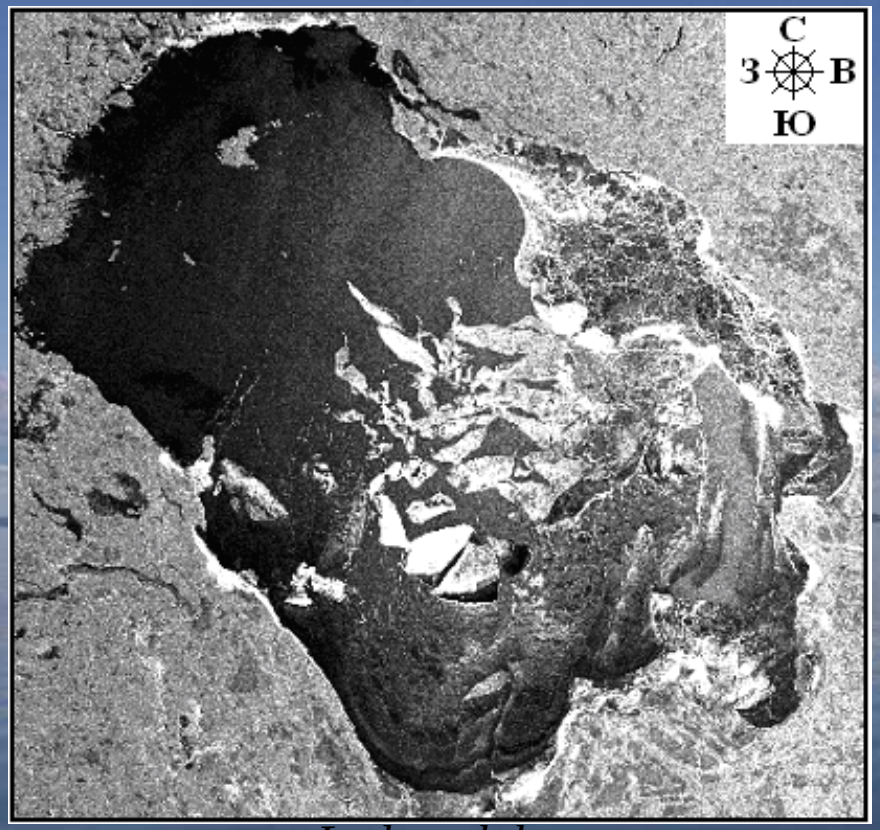
Grey-white ice ENVISAT/ASAR 03.04.2011



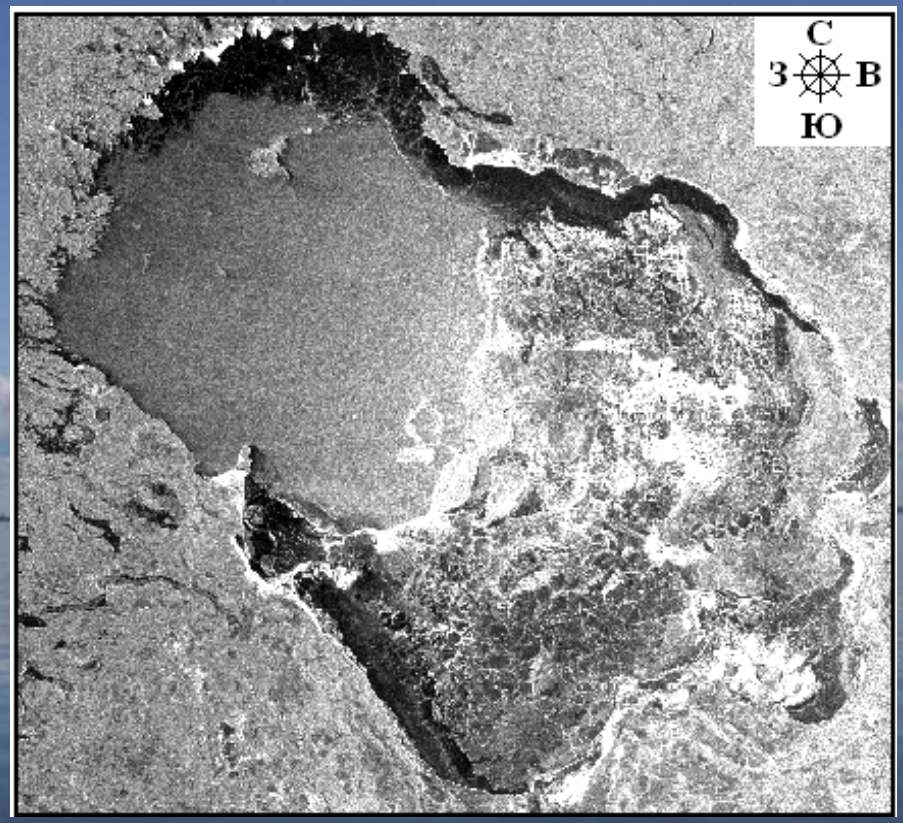


One-year ice, ENVISAT/ASAR 03.04.2011

Ice drift

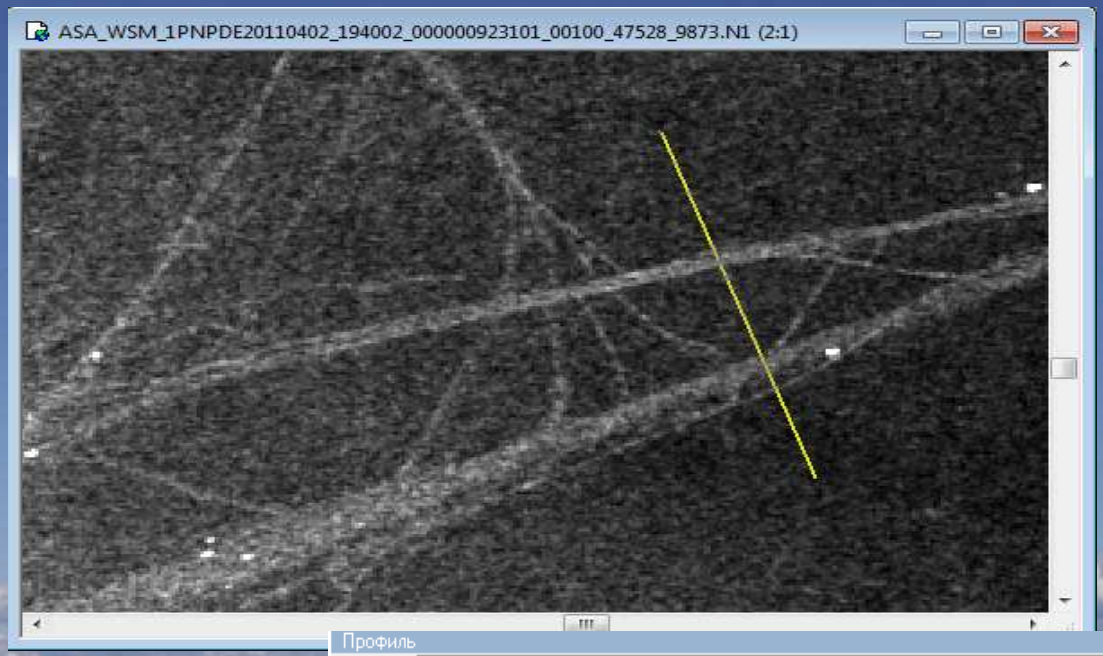


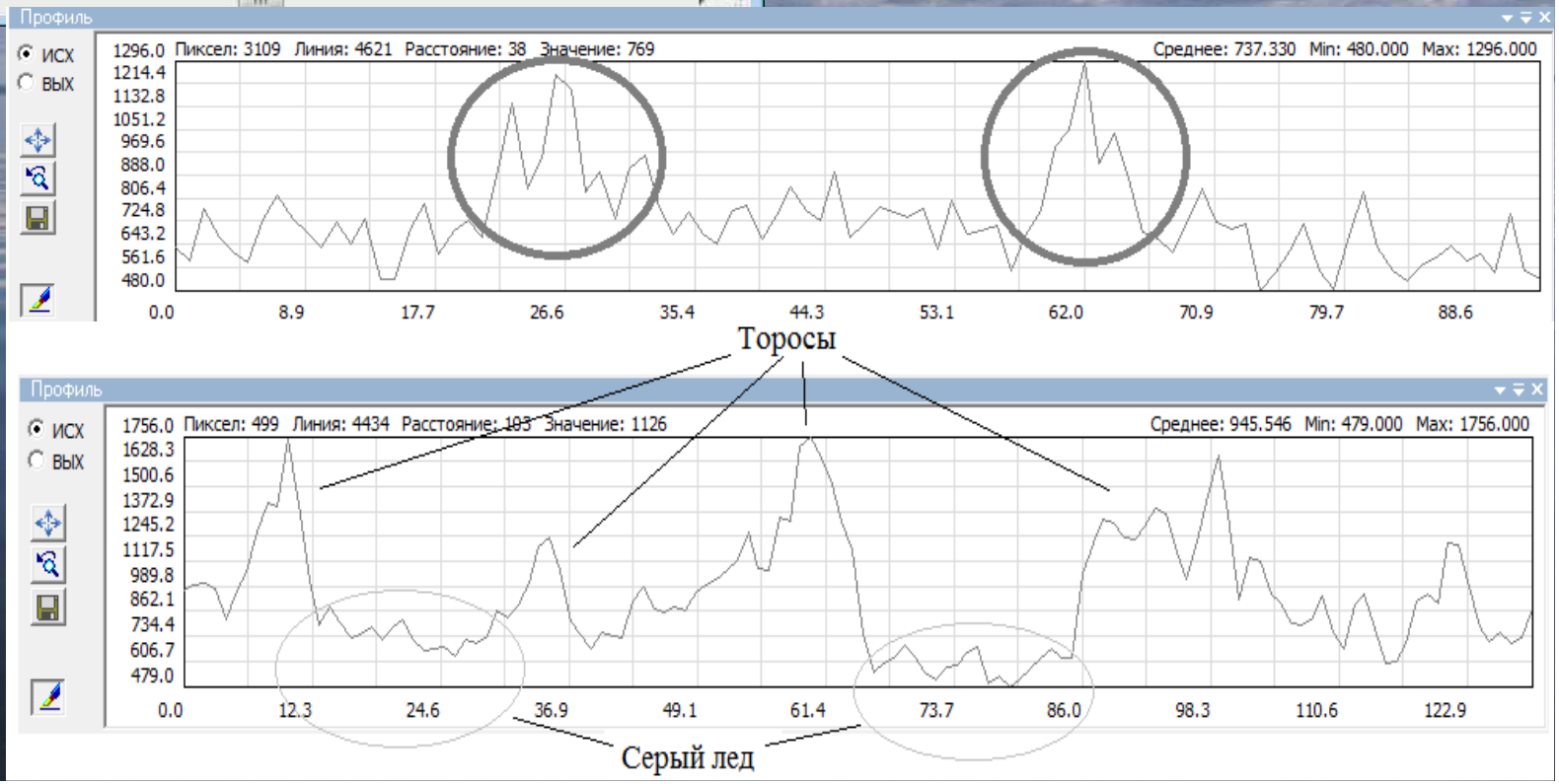
Ladoga lake
ENVISAT/ASAR 06.01.2010.



Ladoga lake
ENVISAT/ASAR 09.01.2010.

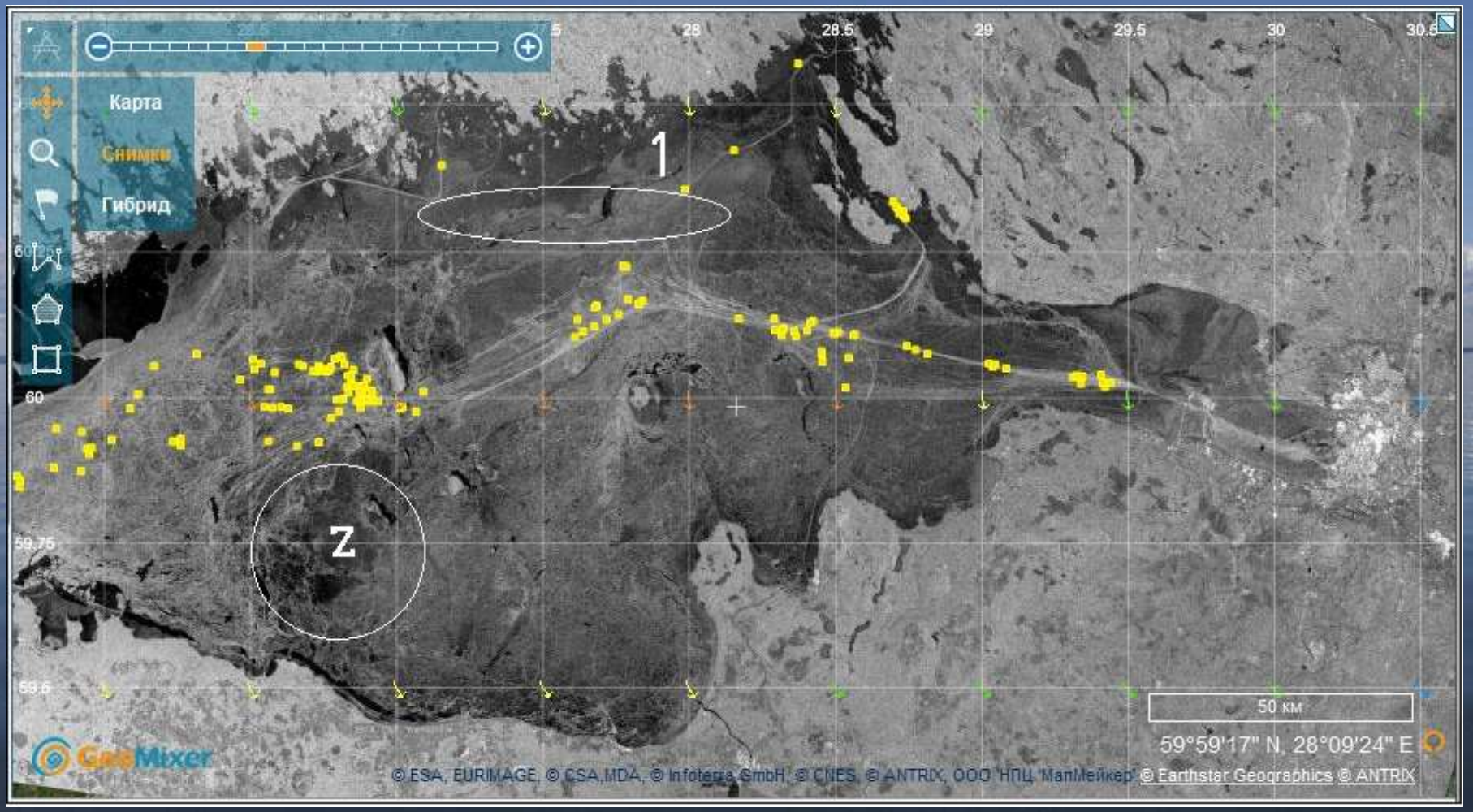
Canals in the ice covered surface





Satellite Monitoring of sea ice

RADARSAT-1/SAR 29.03.2011



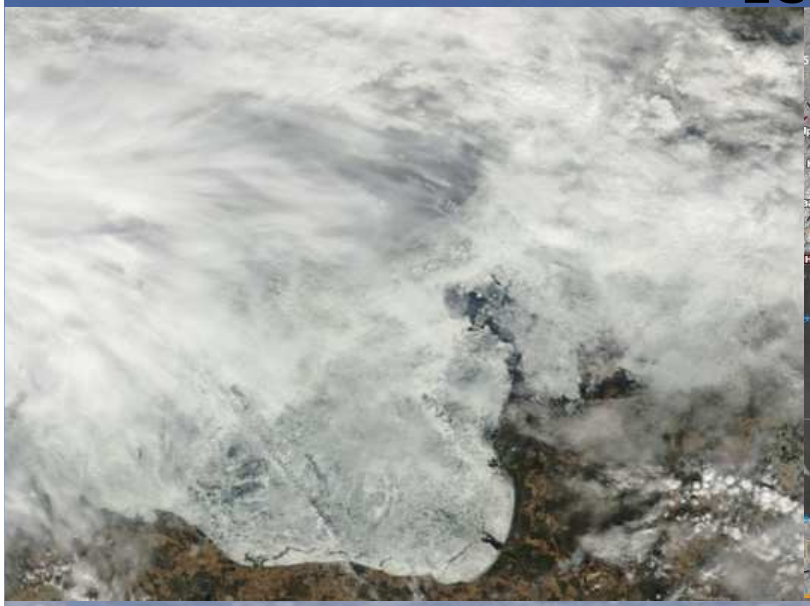
Analysis of SAR imagery of sea ice for the navigation

RADARSAT-1/SAR 02.04.2011.

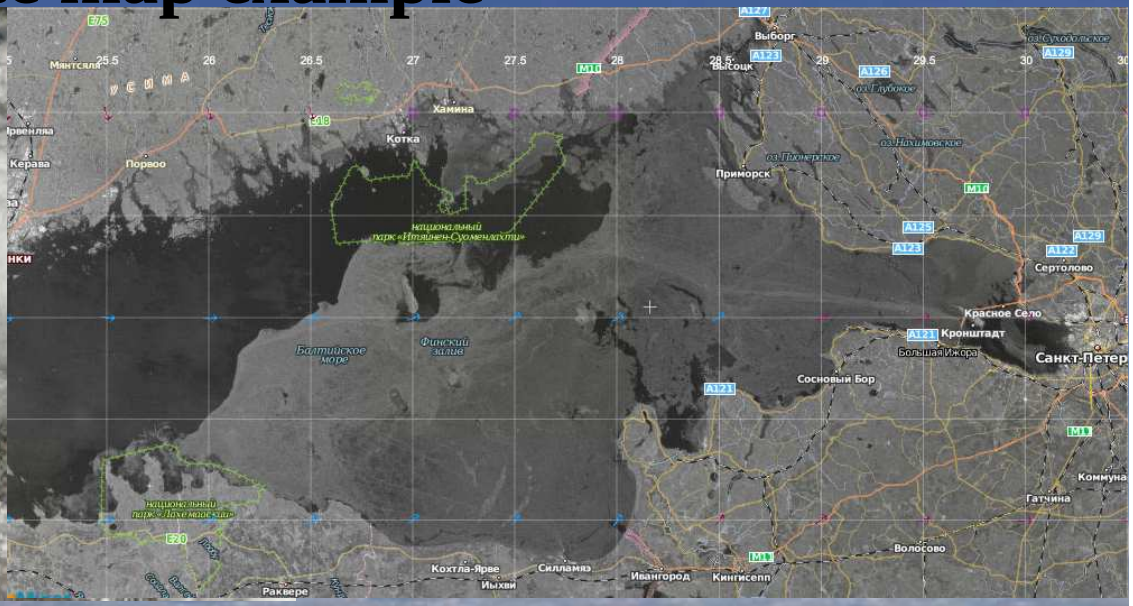
RADARSAT-1/SAR 05.04.2011.

Example of operational service of navigation using MarineTraffic system

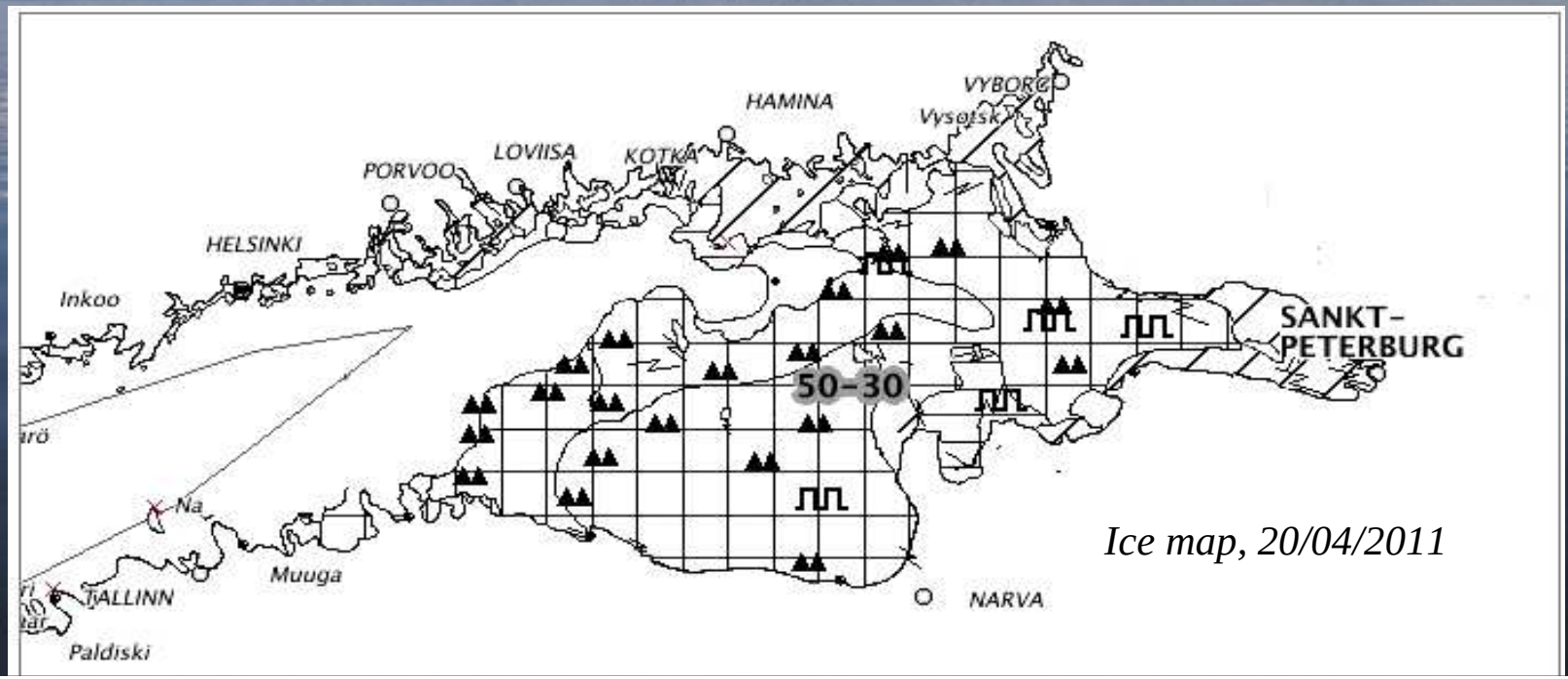
Ice map example



Terra /Modis 20.04.2011

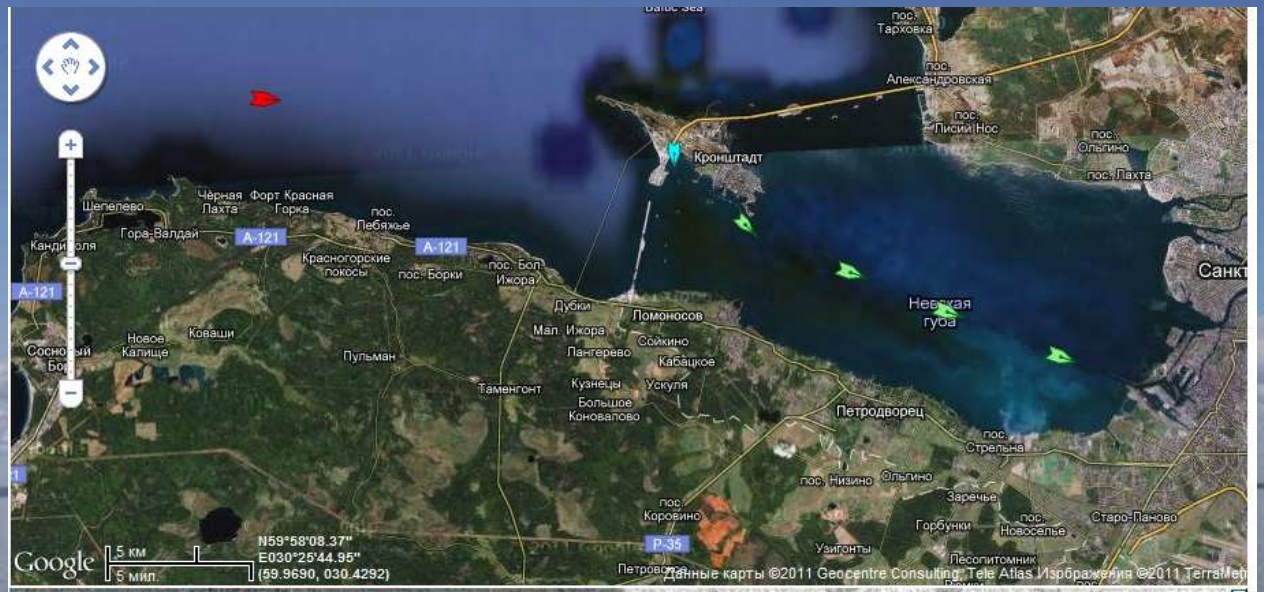


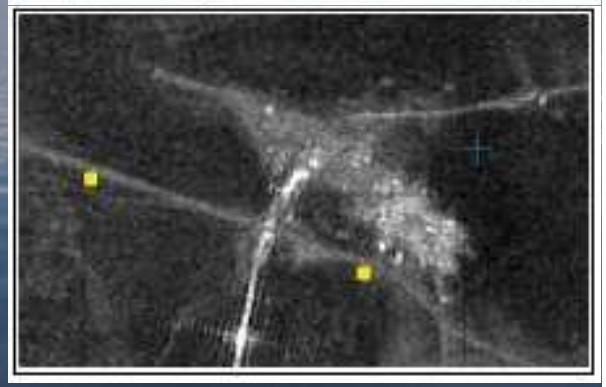
RADARSAT-1/SAR 20.04.2011.



Ice map, 20/04/2011

Example of operational service of navigation in winter using MarineTraffic system





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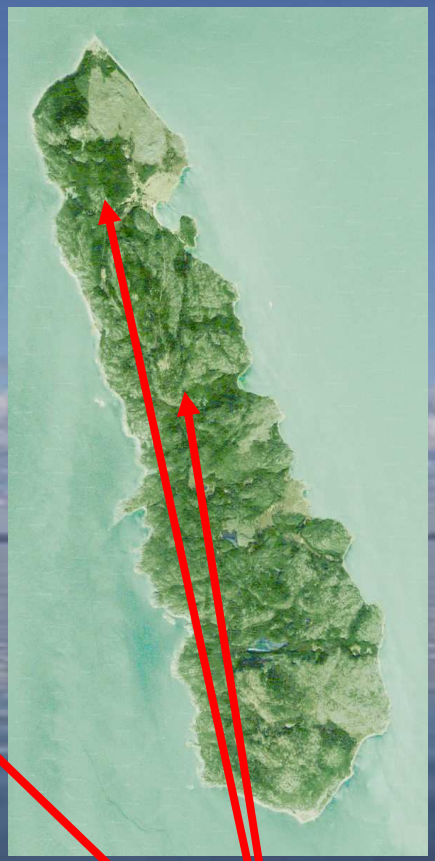
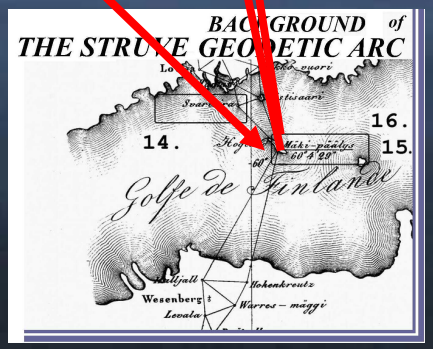
Number of the preserved points

Struve Geodetic Arc





Ten countries (Norway, Sweden, Finland, Russian Federation, Estonia, Latvia, Lithuania, Belarus, Republic of Moldova and Ukraine) through which the Arc passes co-operate since 1994 for the recovery, verification and monumentation of the survey sites of the Arc.

This is a chain of triangulation survey stretching more or less down the 26°E line of longitude from near Hammerfest, Norway over 2,820 km south to near Izmail on the Black Sea. This survey was carried out between 1816 and 1855 under the guidance of F.G.W. Struve.

The scheme included 258 main triangles with 265 main and over 60 subsidiary station points.

Struve Geodetic Arc

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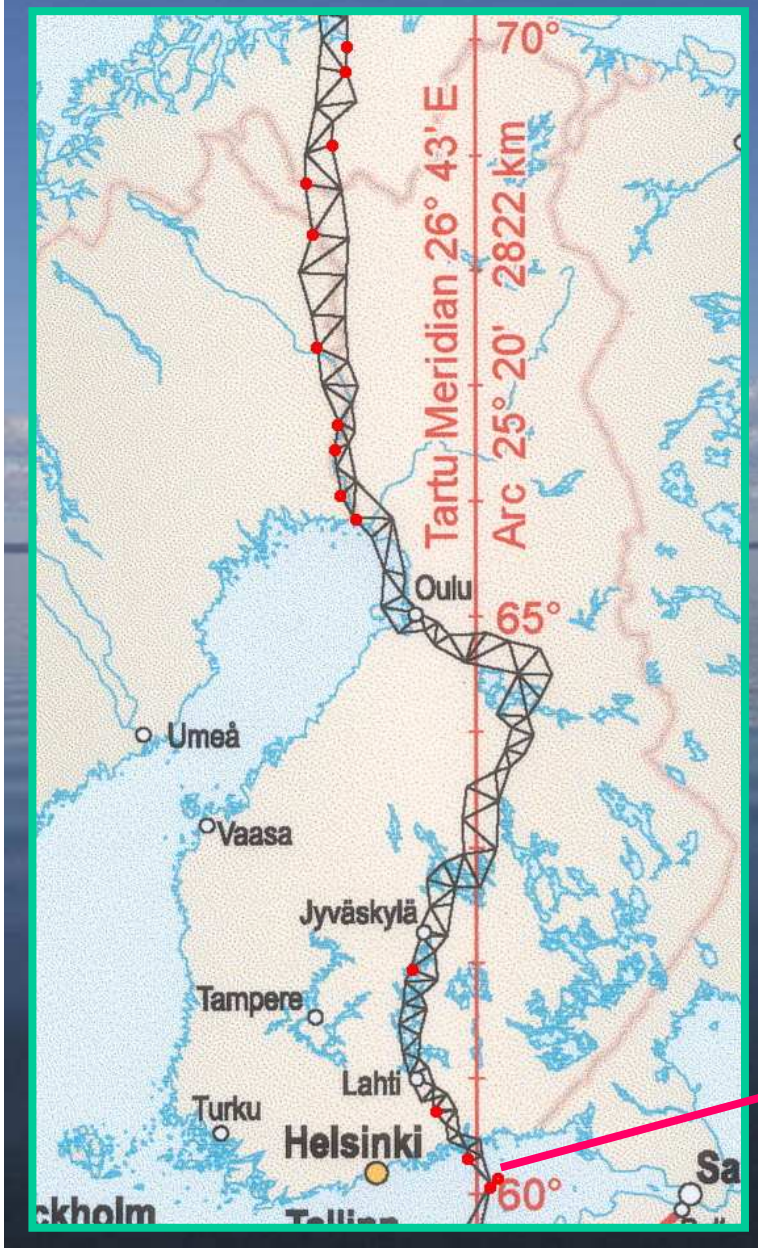

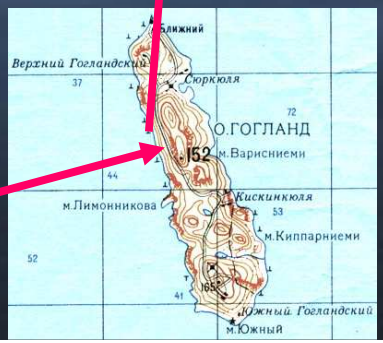

Photos Alexander Kurilo

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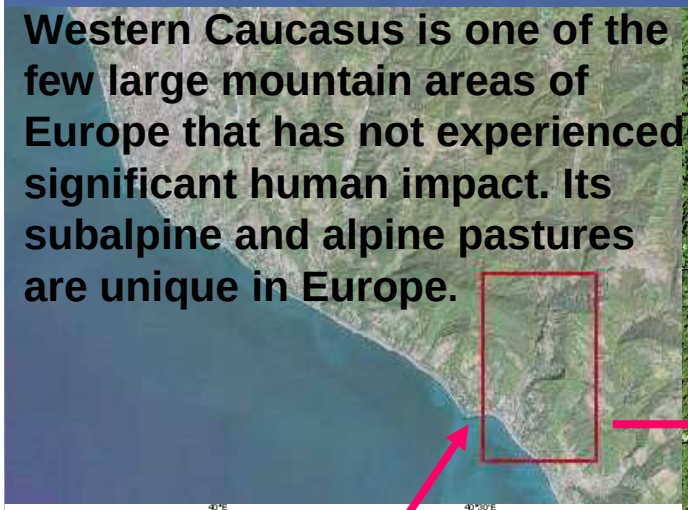
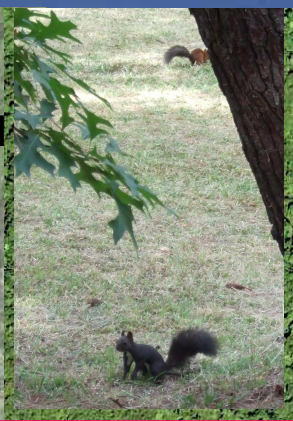
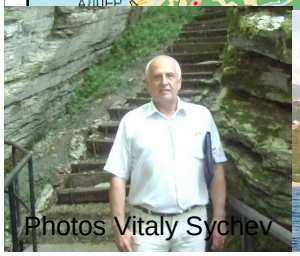
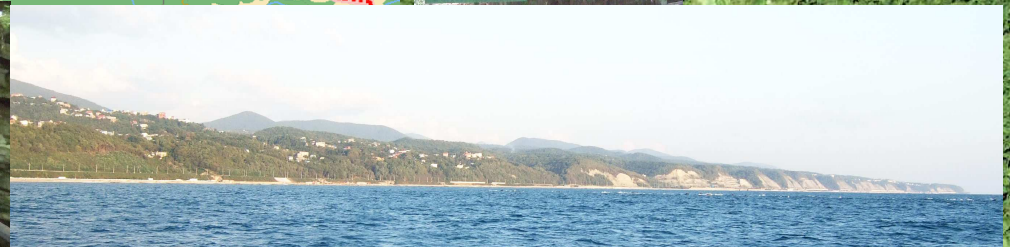
Western Caucasus

Western Caucasus is one of the few large mountain areas of Europe that has not experienced significant human impact. Its subalpine and alpine pastures are unique in Europe.









Photos Vitaly Sychev

Studying World Heritage Sites UNESCO

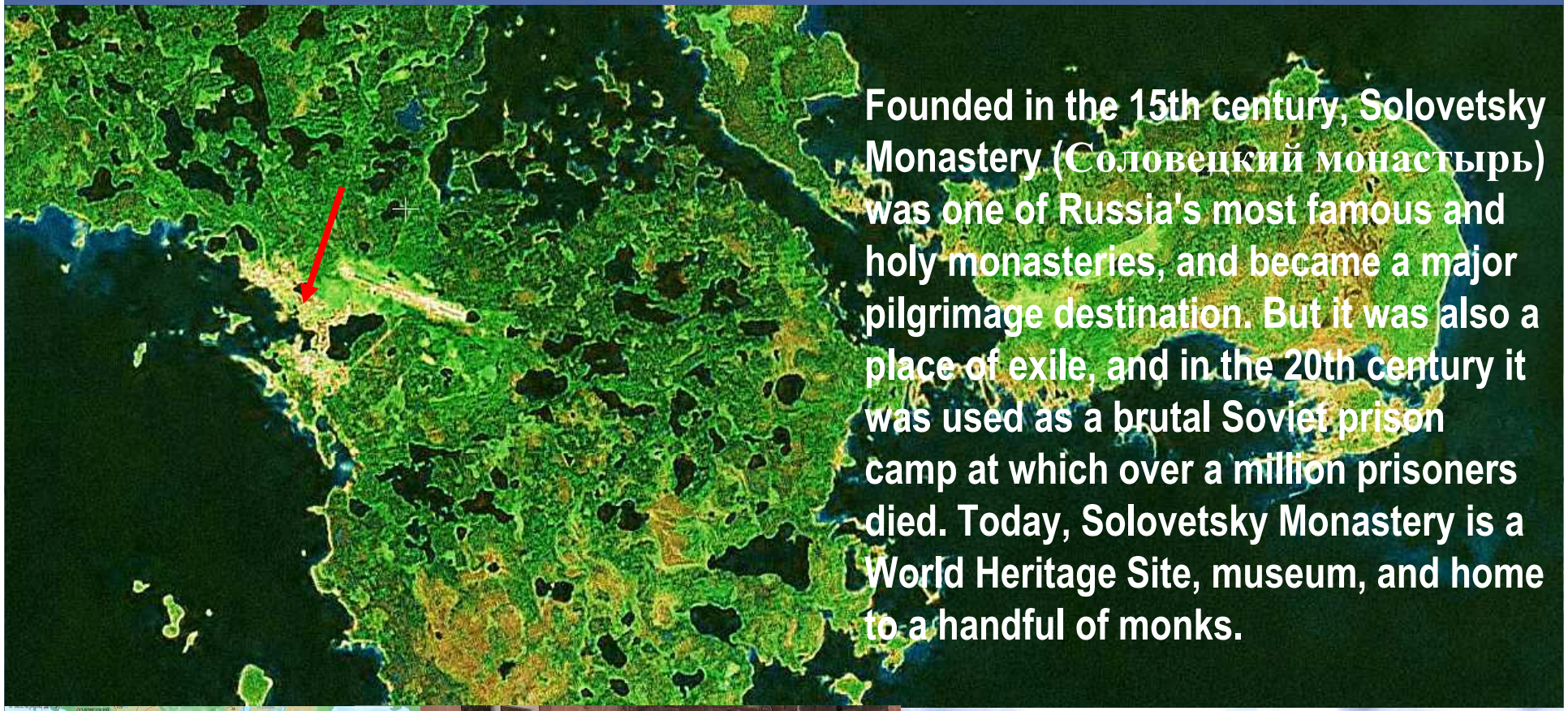
Western Caucasus

Combining with studying of Hydrology, Biology conditions, sea surface colour, and coastal zone transformation, August-September, 2008

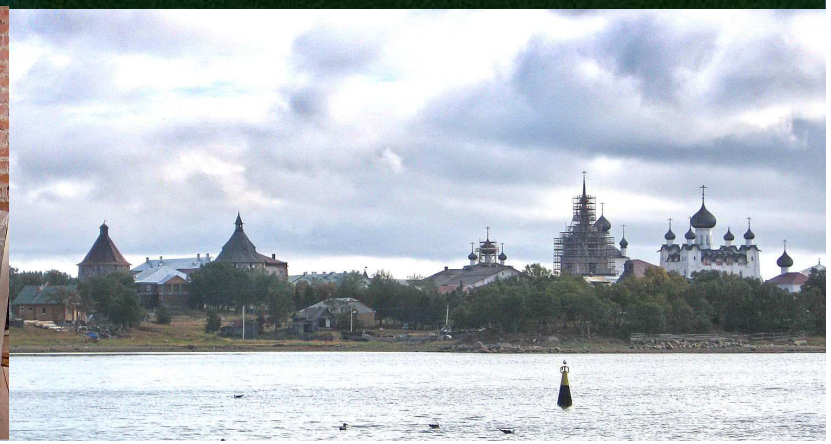
Studying World Heritage Sites UNESCO

Cultural and Historic Ensemble of the Solovetsky Islands

Introduction



Founded in the 15th century, Solovetsky Monastery (Соловецкий монастырь) was one of Russia's most famous and holy monasteries, and became a major pilgrimage destination. But it was also a place of exile, and in the 20th century it was used as a brutal Soviet prison camp at which over a million prisoners died. Today, Solovetsky Monastery is a World Heritage Site, museum, and home to a handful of monks.



Studying World Heritage Sites UNESCO

Cultural and Historic Ensemble of the Solovetsky Islands

Photos Gleb Gegulin

Combining with studying of Hydrology, Biology conditions, and harp seal population in the White Sea, July, 2008