Geological hazards of the Eastern Gulf of Finland coastal zone

Опасные геологические процессы береговых зон восточной части Финского залива

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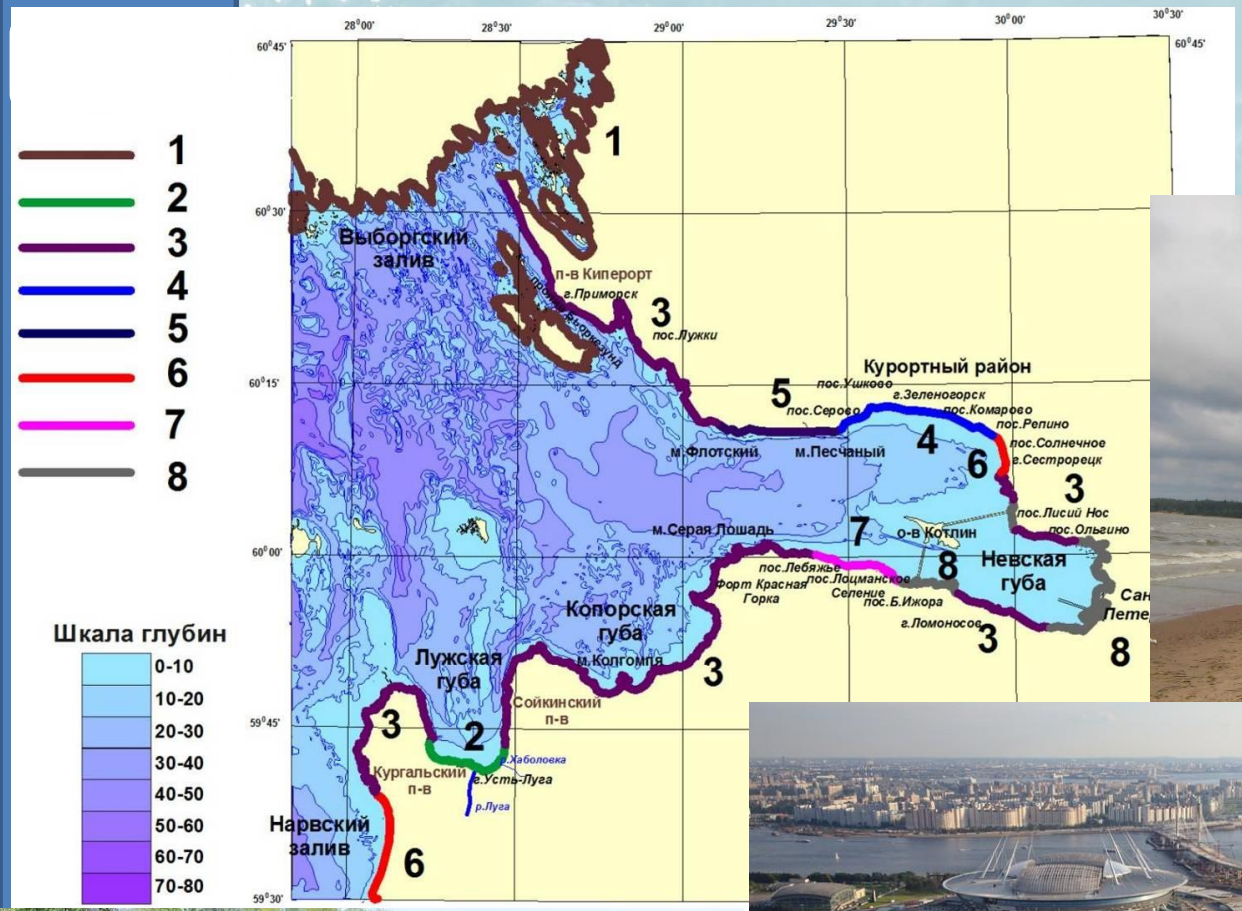
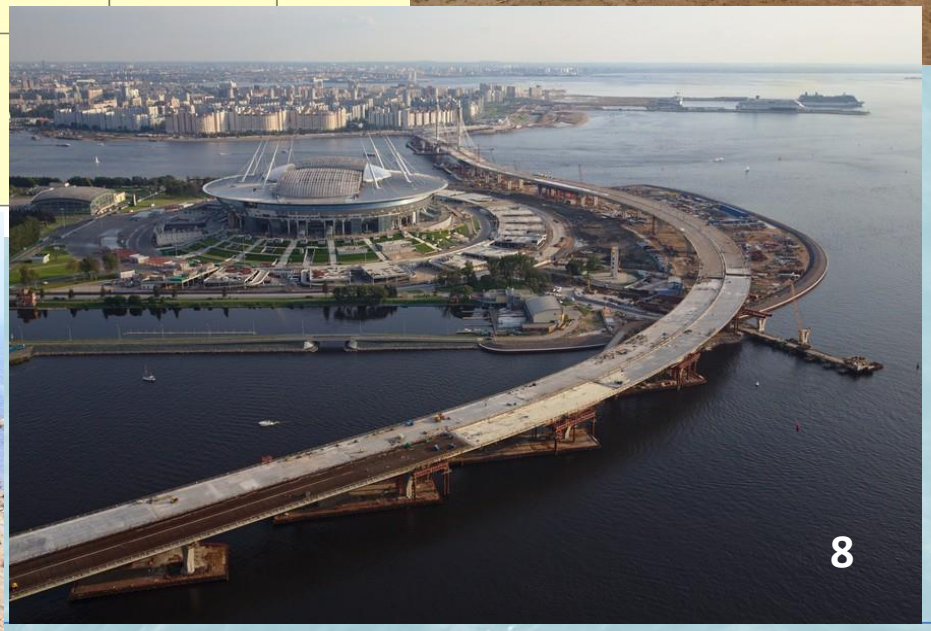
ВСЕГЕИ


1
2
3
4
5
6
7
8
Шкала глубин
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
Выборгский залив
п-в Киперорт
г.Приморск
пос.Лужки
Курортный район
пос.Ушково
г.Зеленогорск
пос.Серово
пос.Комарово
пос.Репино
пос.Солнечное
г.Сестрорецк
м.Флотский
м.Песчаный
пос.Лисий Нос
пос.Ольгино
м.Серая Лошадь
о-в Котлин
Невская губа
пос.Лебяжье
пос.Лоцманское
Форт Красная Горка
Сепение
пос.Б.Ижора
г.Ломоносов
Копорская губа
м.Колгомпя
Лужская губа
Сойкинский п-в
Кургальский п-в
г.Хаболовка
г.Усть-Луга
р.Луга
Нарвский залив
28°00'
28°30'
29°00'
29°30'
30°00'
30°30'
60°45'
60°30'
60°15'
60°00'
59°45'
59°30'


6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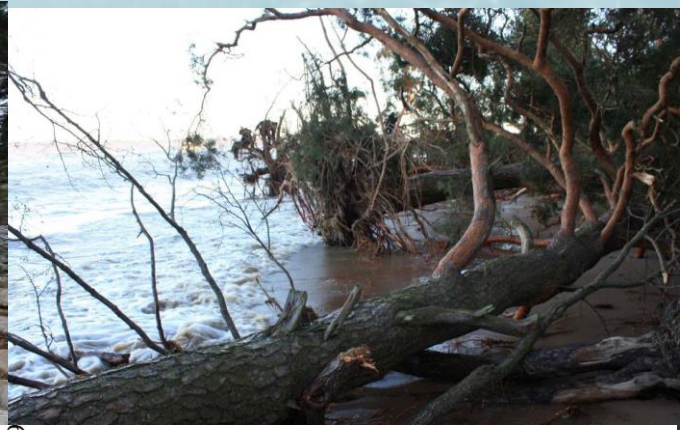
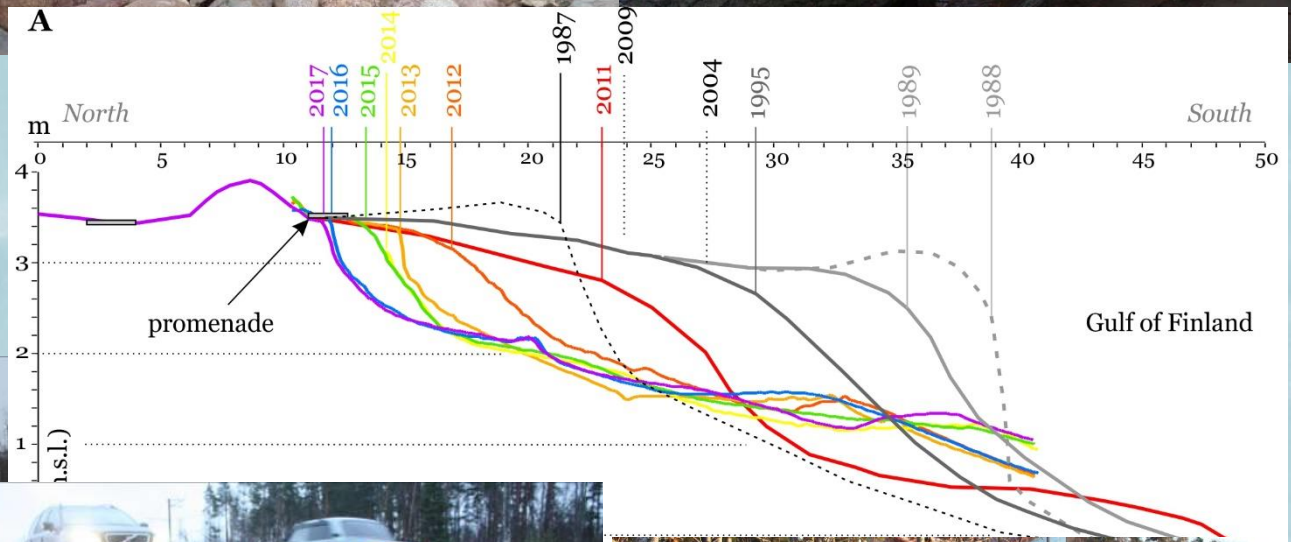
4



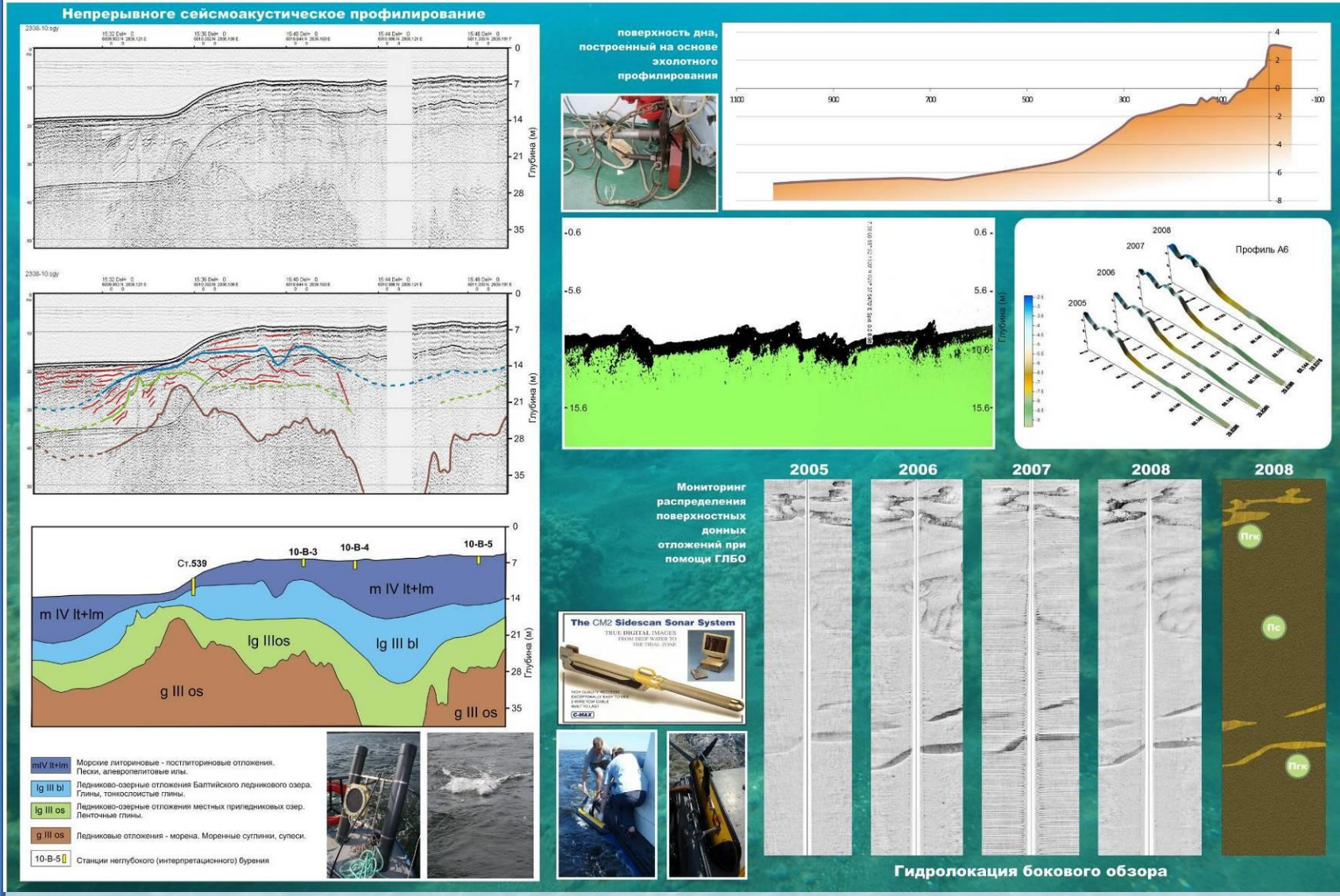

A
North
South
m
0
5
10
15
20
25
30
35
40
45
50
4
3
2
1
2017
2016
2015
2014
2013
2012
1987
2011
2009
2004
1995
1989
1988
promenade
Gulf of Finland

ВСЕГЕИ

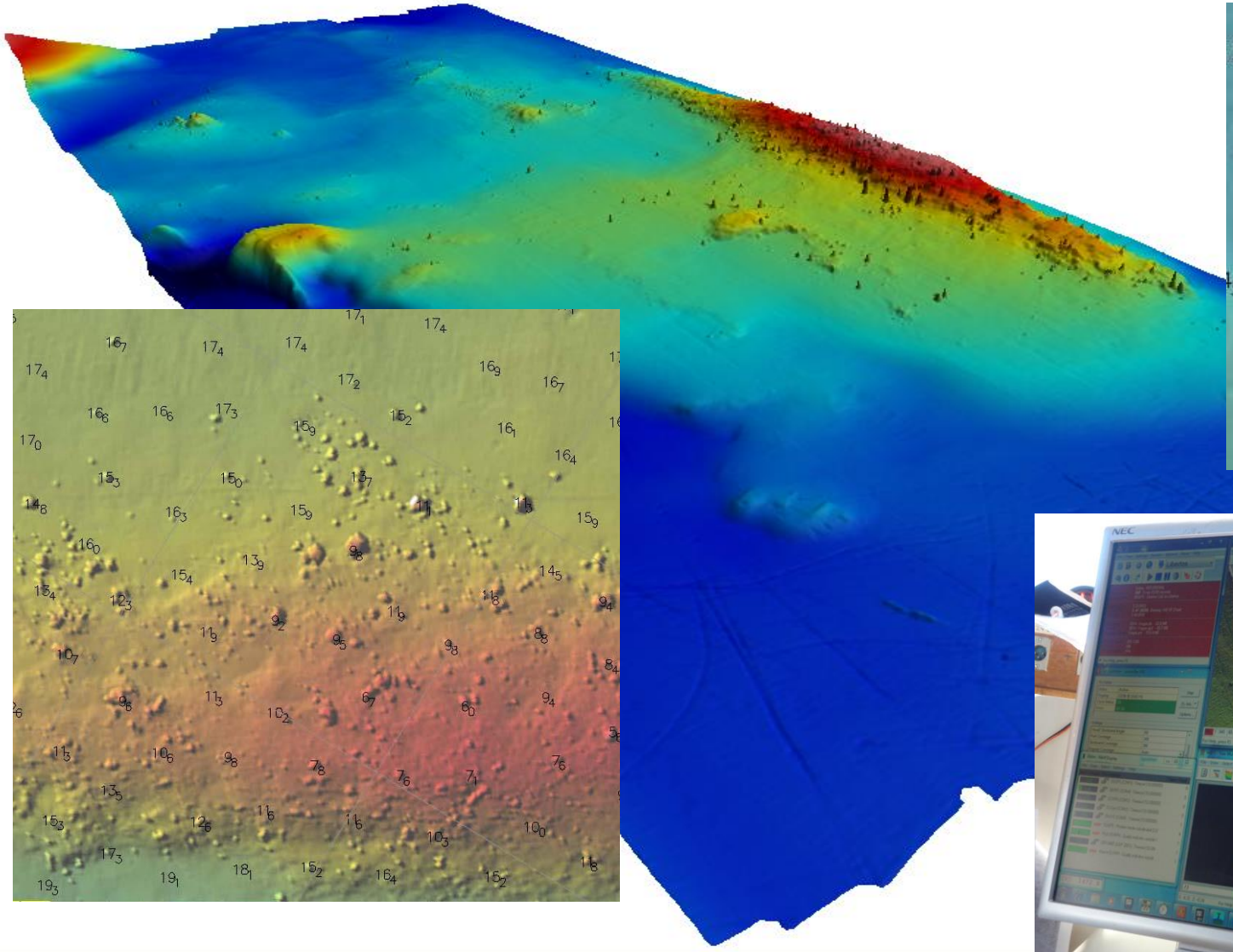
Main goals of coastal processes analyses
Основные задачи исследования береговых зон

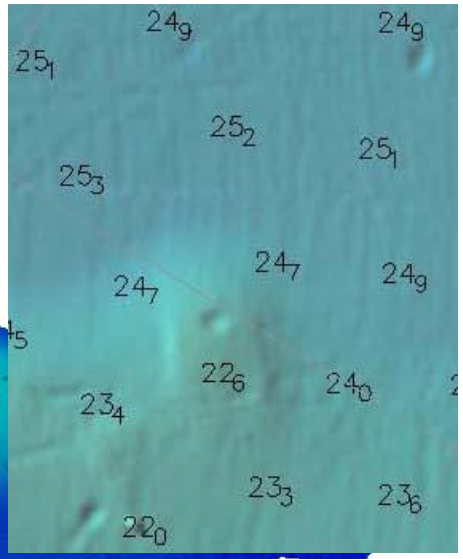
1. **Study of coastal zone evolution in Holocene and revealing of main natural factors controlled long-term coastal development**. Анализ эволюции береговых зон в голоцене и выявление природных факторов, контролирующих долговременные тренды формирования и развития береговых зон
2. **Study and monitoring of recent coastal processes (e.g. geological hazards) (dominated trends, intensity, natural and anthropogenic driving forces).** Изучение современных береговых процессов (в том числе, потенциально опасных)(основные тенденции, интенсивность, природные и антропогенные факторы, воздействующие на них)
3. **Prediction of future coastal development and recommendations for risk mitigation.** Прогноз развития и рекомендации снижения рисков воздействия в будущем

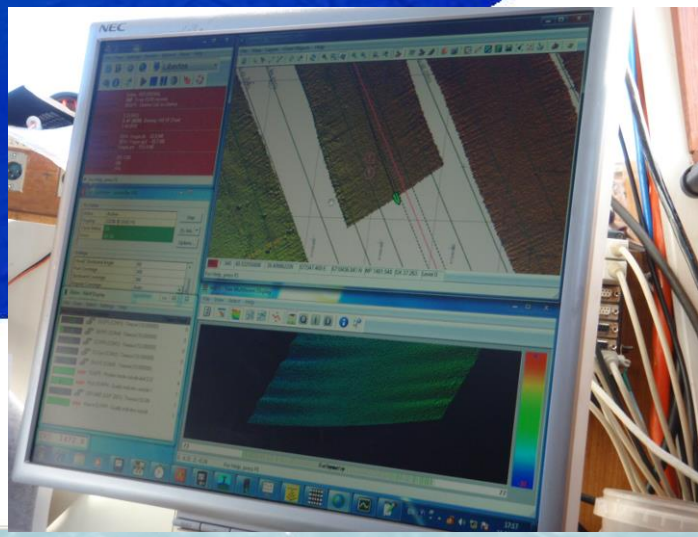
Методы исследования и мониторинга береговых зон
Coastal zone study methods



Многолучевое эхолотирование
Multibeam echosounding

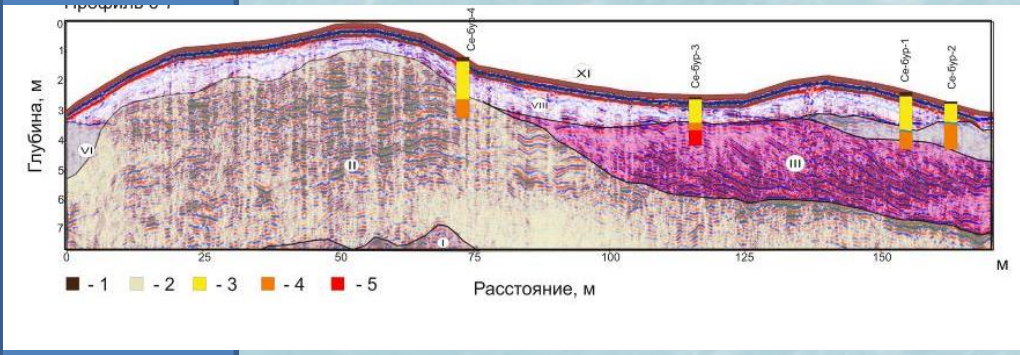


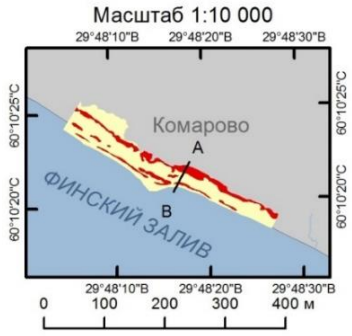


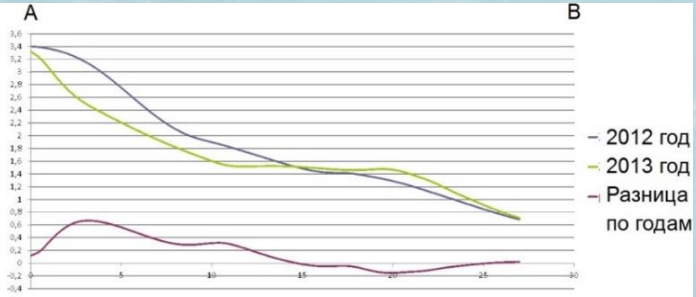


Ground penetration radar profiling

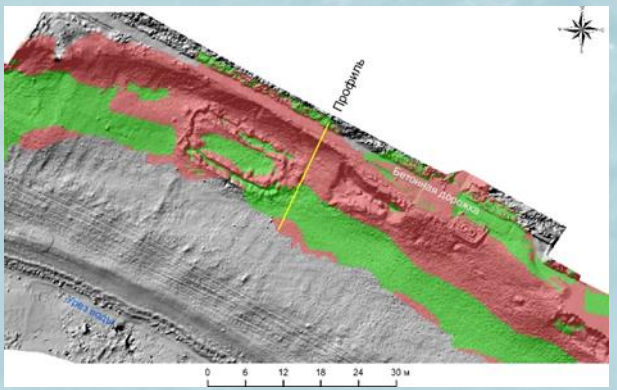
Георадиолокационное профилирование





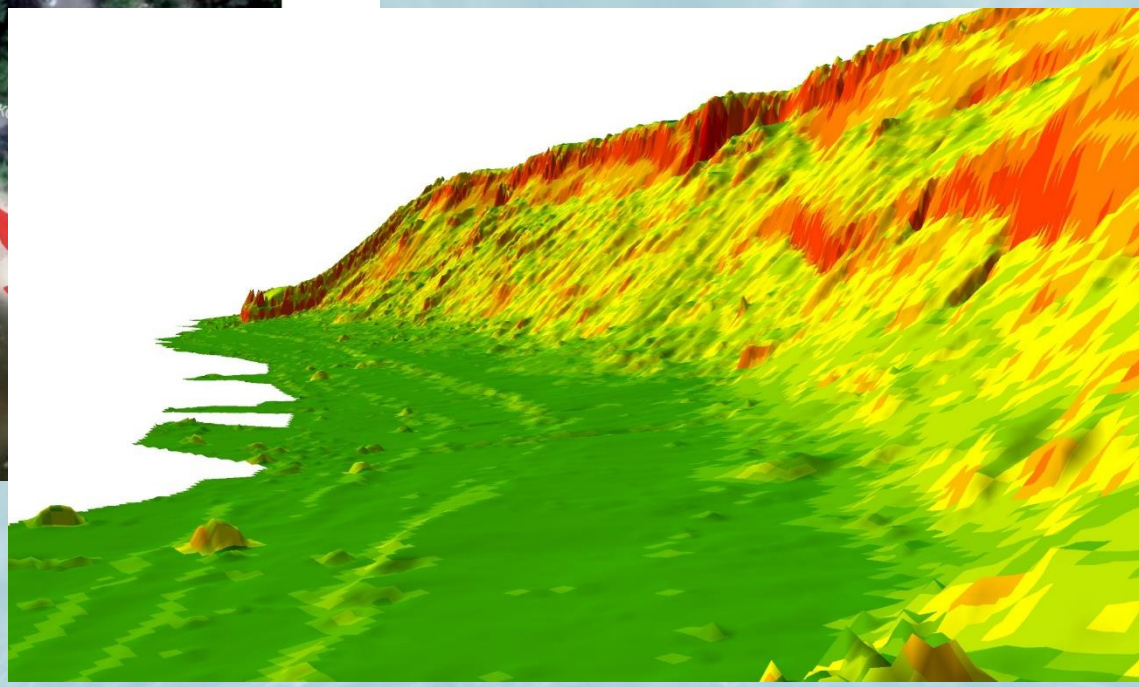


Профиль рельефа пляжа и разница между двумя профилями по линии А - В



Опасные геологические процессы

Размыв — Отсутствие процесса размыва и локальная аккумуляция



Main factors controlled costal processes

Основные факторы, определяющие развитие береговых процессов

1. **Geological structure and relief**

Геологическое строение и рельеф

2. Tectonics

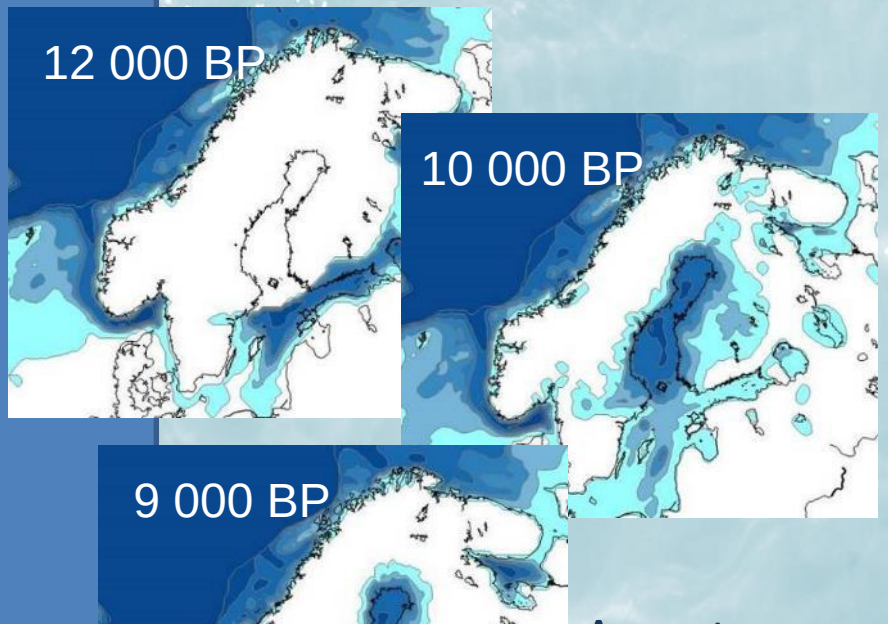
Тектонический режим

3. Hydrodynamics

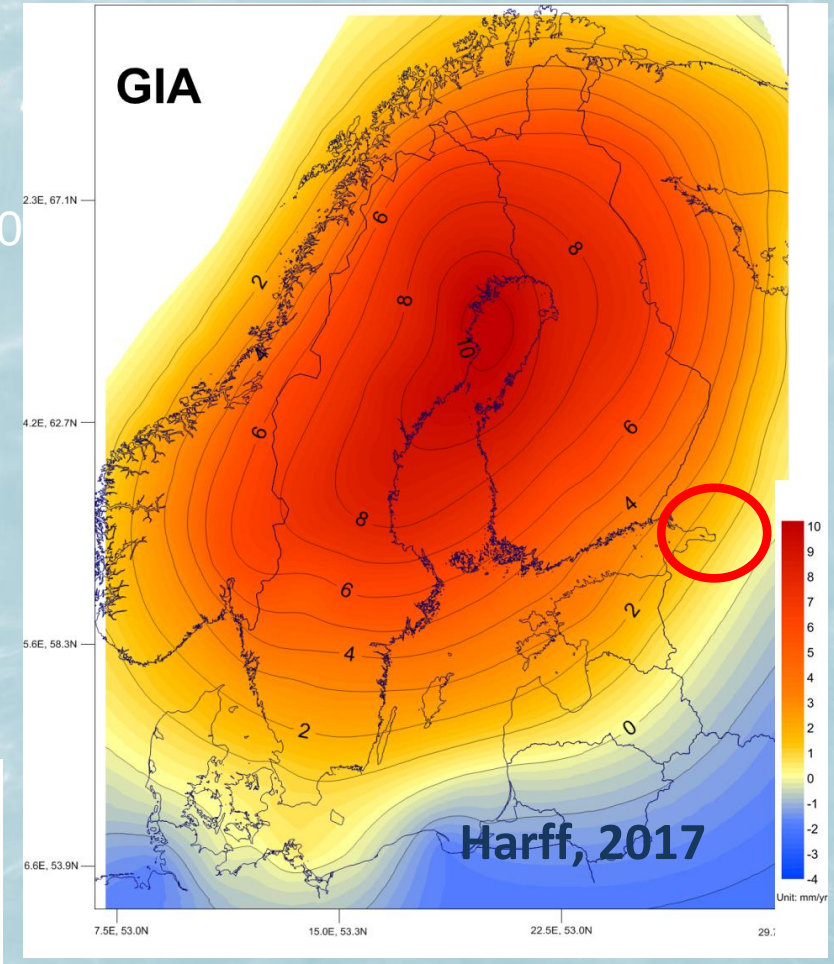
Гидродинамическое воздействие

4. Anthropogenic impact

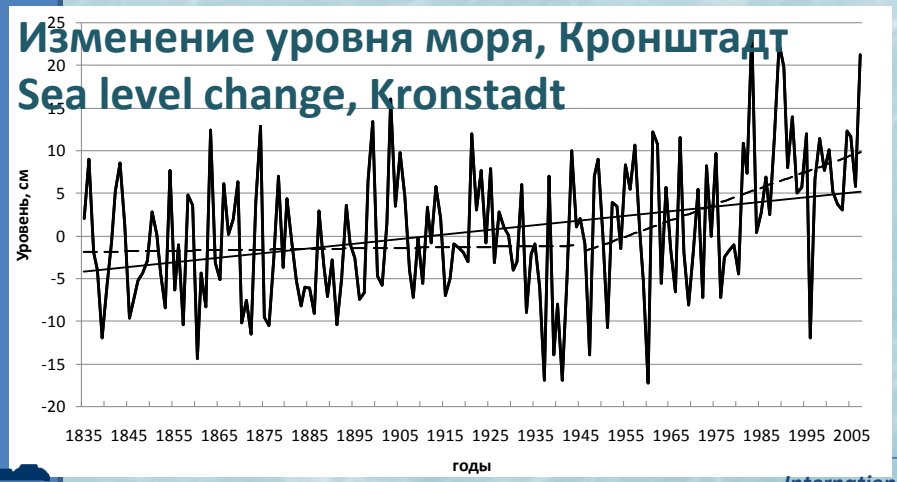
Техногенное воздействие



Amantov, Fjeldskaar, 2011

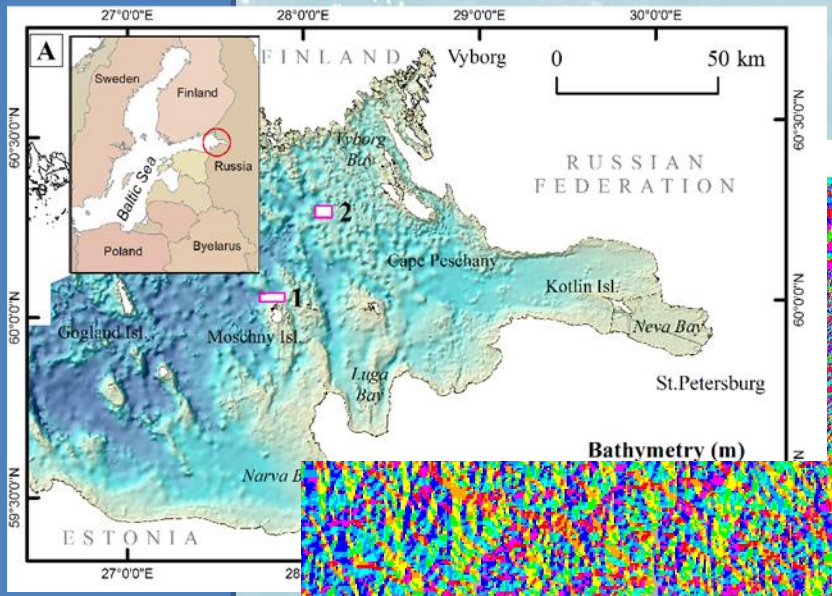


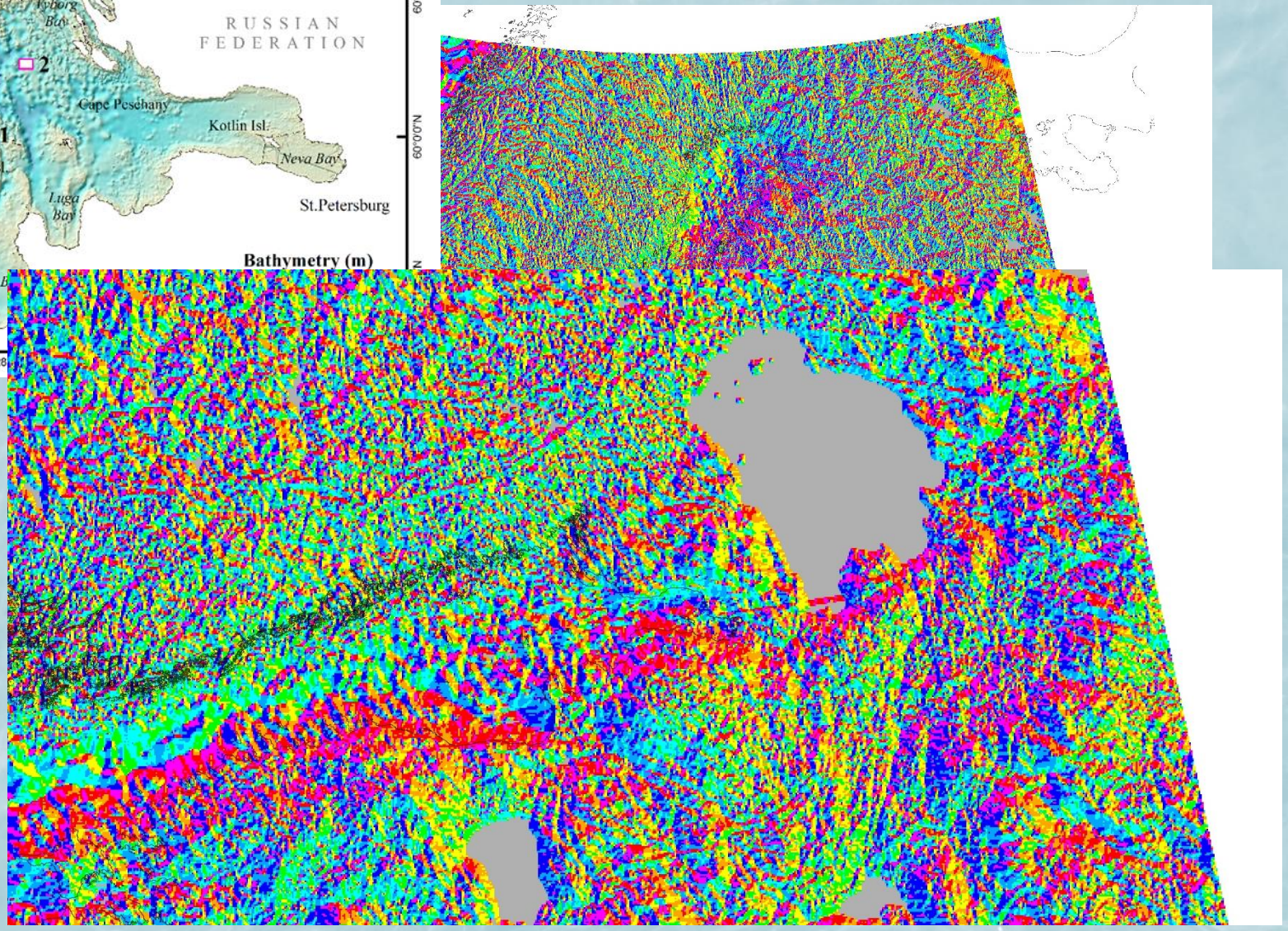
Скорости гляциоизостатического выравнивания
Rated of glacioisostatic rebound

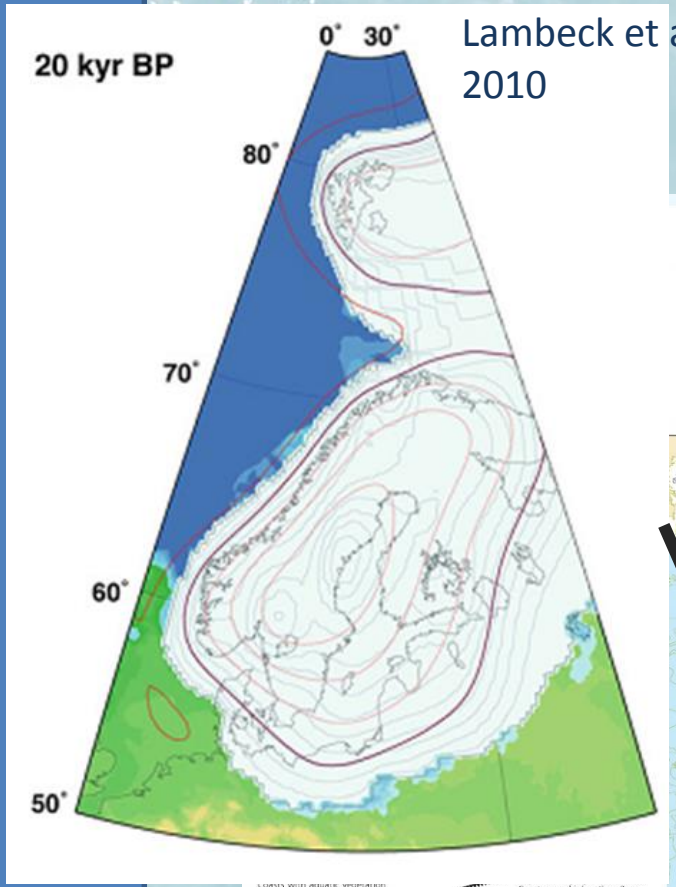


Gorgeeva, Malinin, 2016

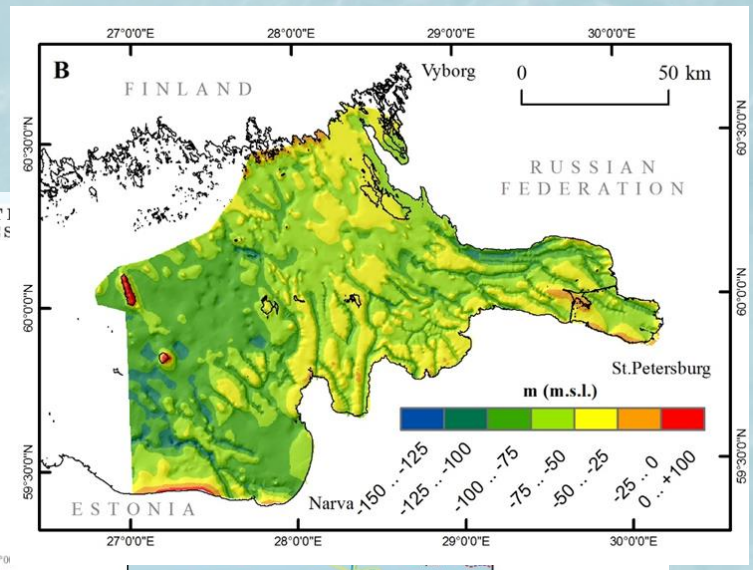
Aspect relief map of Baltics Region
Схема направления уклонов Балтийского региона







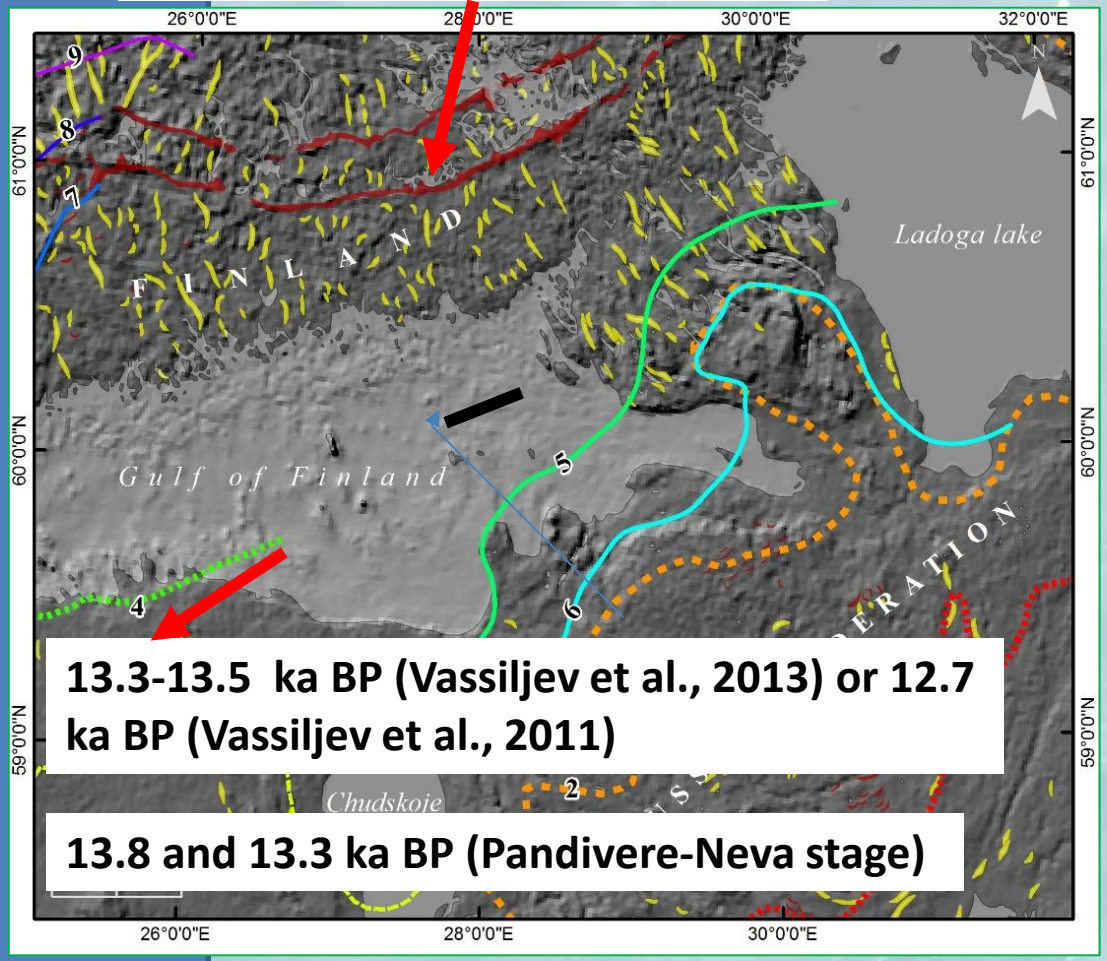
Lambeck et al. 2010



Ледниковая экзарация
Glacial erosion

Ледниковая и последниковая аккумуляция
Glacial and fluvioglacial accumulation

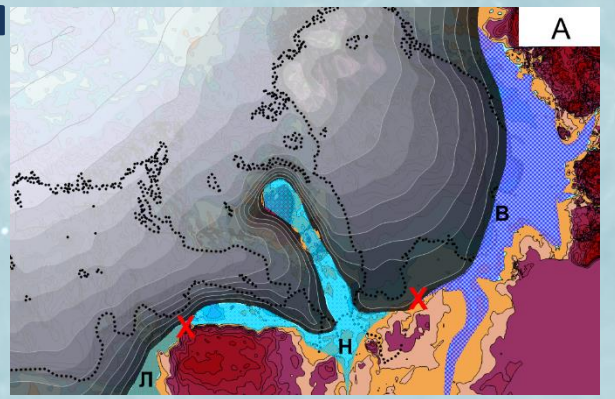
12.25 ka BP (Salpausselkä I stage)

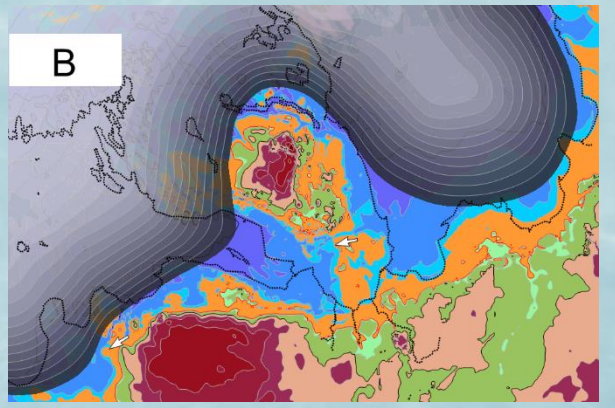


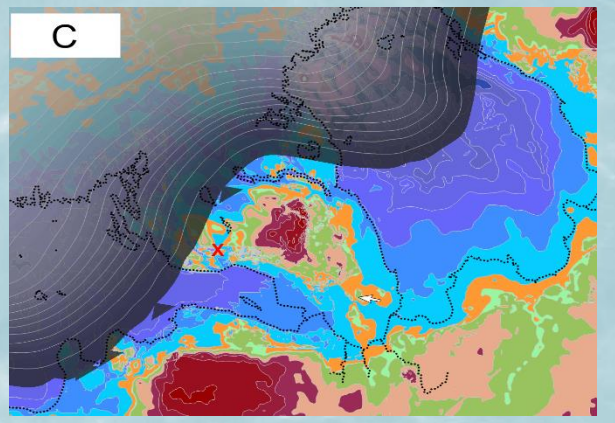
13.3-13.5 ka BP (Vassiljev et al., 2013) or 12.7 ka BP (Vassiljev et al., 2011)

13.8 and 13.3 ka BP (Pandivere-Neva stage)

Vassiljev J. et al., 2011; 2013;
Saarnisto, M.; Saarinen, T., 2001

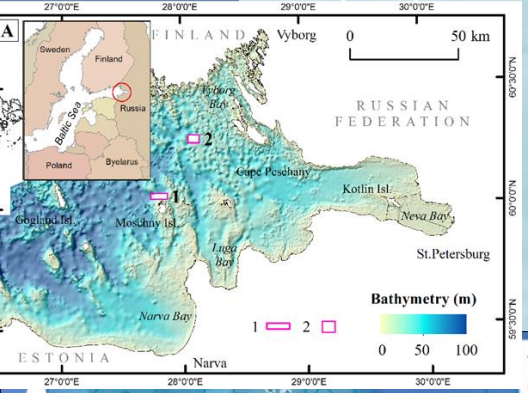


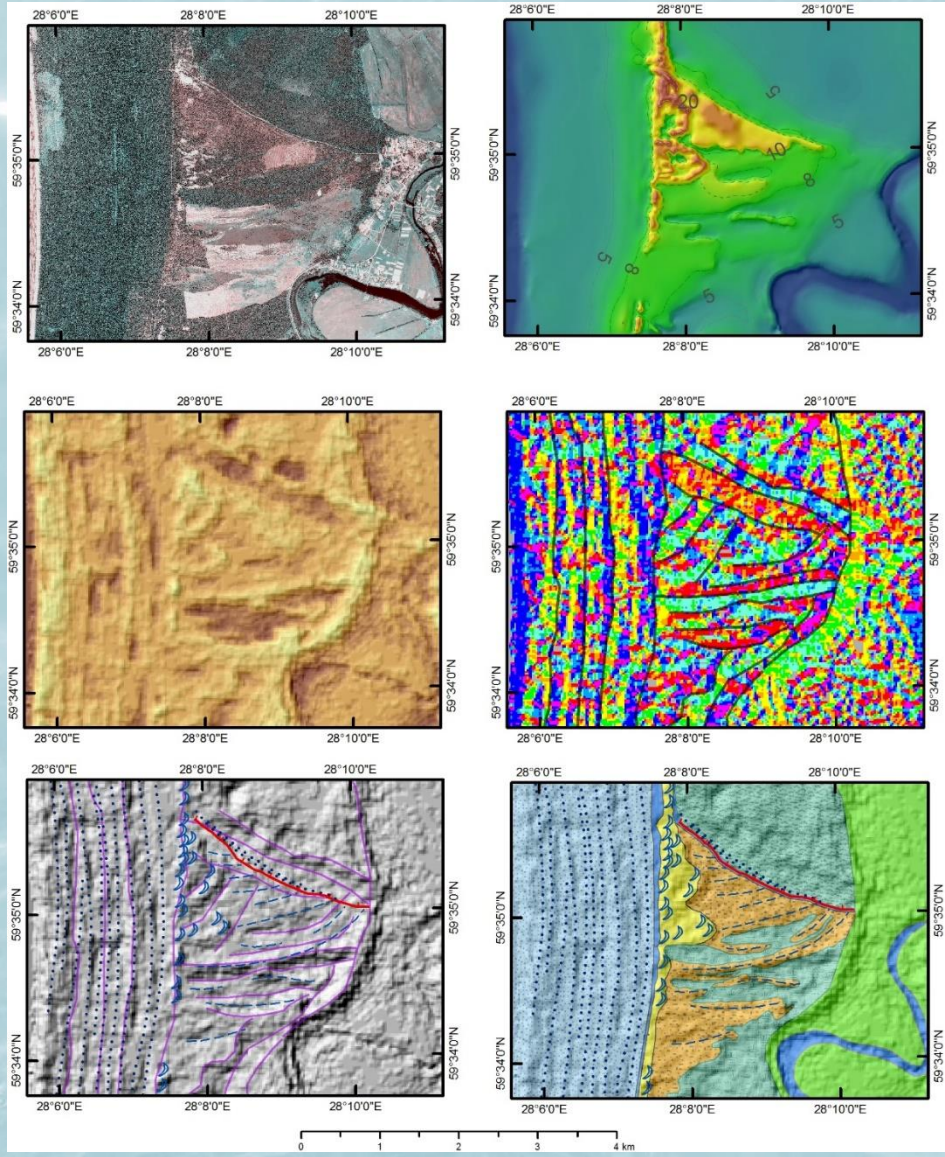


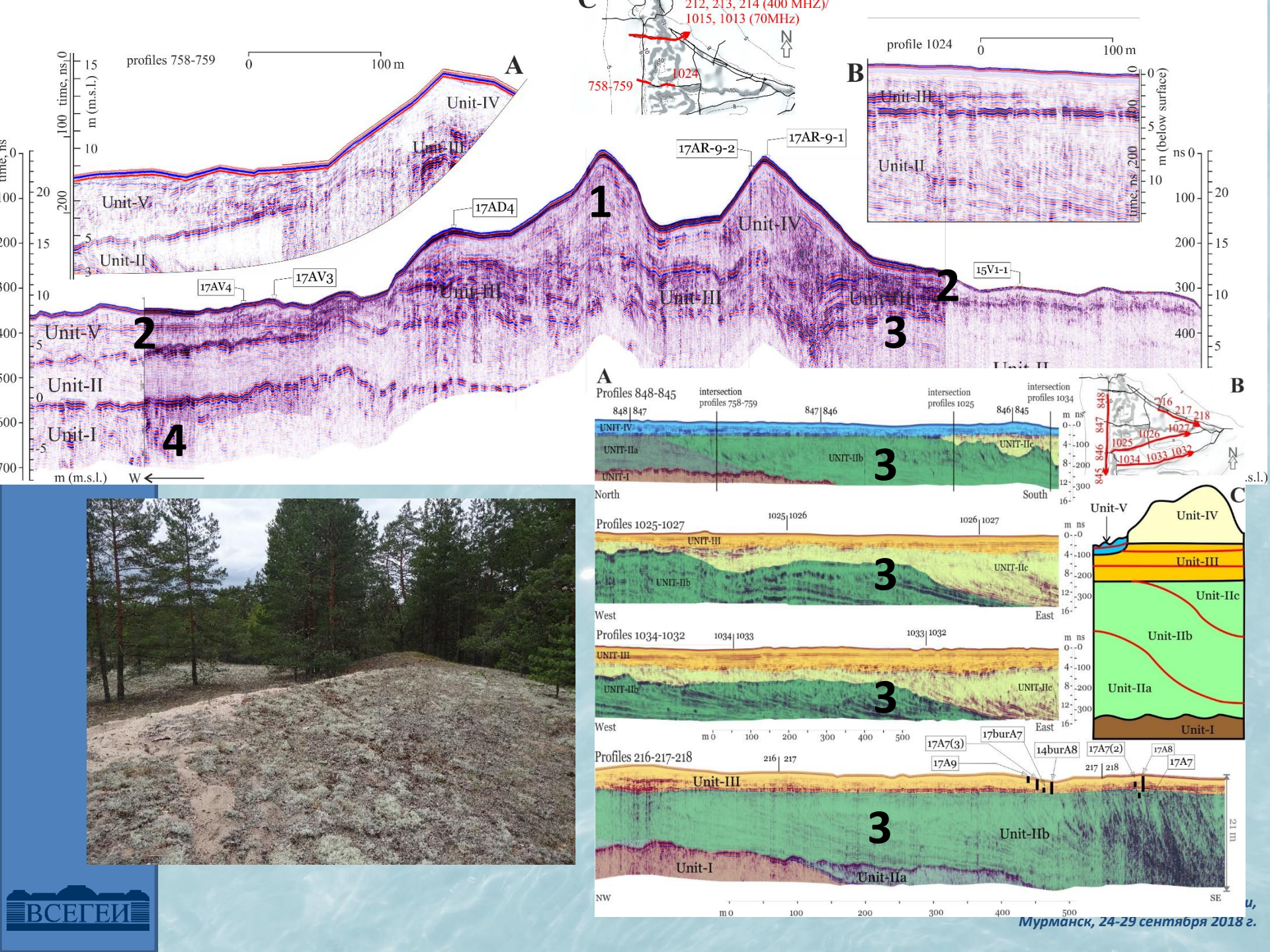


Amantov, Amantova, 2017

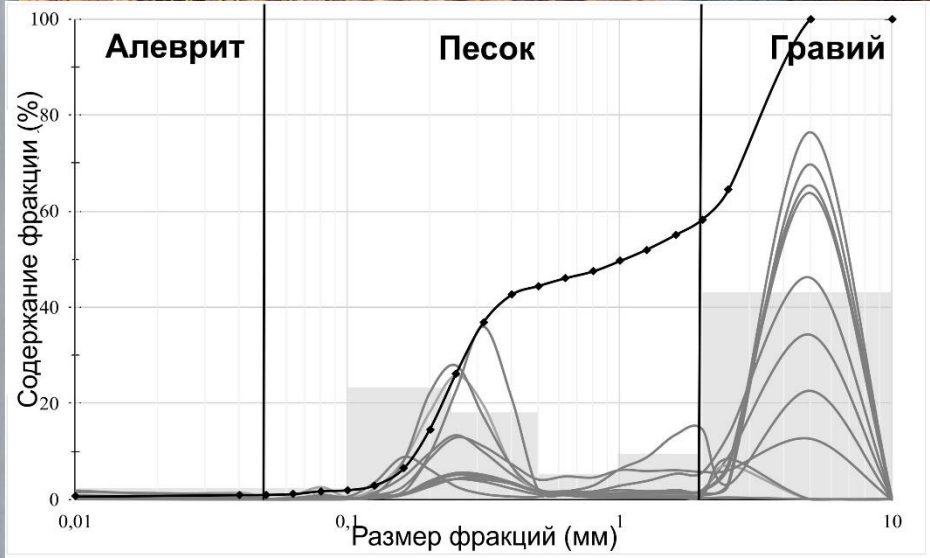
Narva-Luga Klint Bay
Нарвско-Лужская предглинтовая низменность



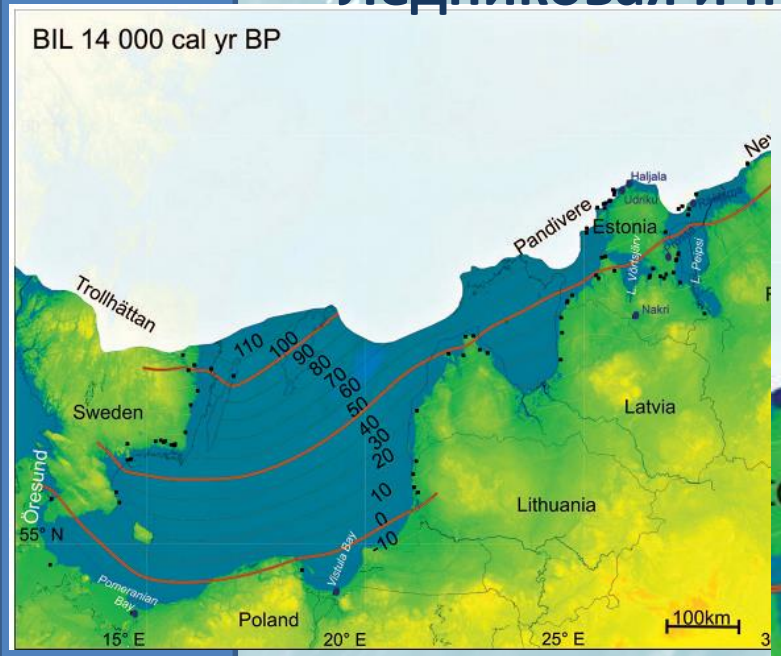


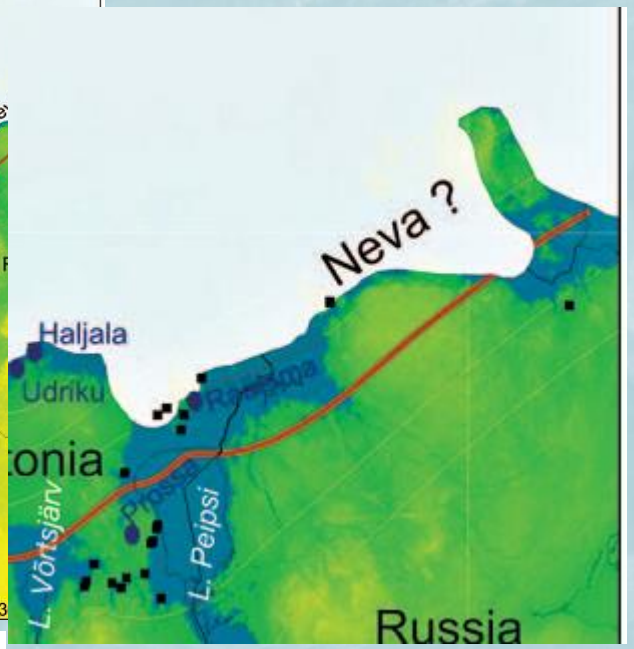

A
profiles 758-759
0
100 m
time, ns
m (m.s.l.)
Unit-IV
Unit-III
Unit-V
Unit-II
17AD4
17AV4
17AV3
17AR-9-2
17AR-9-1
15V1-1
1
2
3
4
Unit-V
Unit-II
Unit-I
m (m.s.l.)
W
C
212, 213, 214 (400 MHZ)/
1015, 1013 (70MHz)
N
758-759
1024
B
profile 1024
0
100 m
Unit-III
Unit-II
m (below surface)
time, ns
A
Profiles 848-845
intersection
profiles 758-759
intersection
profiles 1025
intersection
profiles 1034
848|847
847|846
846|845
UNIT-IV
UNIT-IIa
UNIT-I
UNIT-IIb
UNIT-IIc
North
South
Profiles 1025-1027
1025|1026
1026|1027
UNIT-III
West
East
Profiles 1034-1032
1034|1033
1033|1032
m 0
100
200
300
400
500
B
216
217
218
1027
1026
1025
1034
1033
1032
848
847
846
845
N
C
Unit-V
Unit-IV
Unit-III
Unit-IIc
Unit-IIb
Unit-IIa
Unit-I
Profiles 216-217-218
216|217
217|218
17A7(3)
17burA7
17A9
14burA8
17A7(2)
17A8
17A7
Unit-III
Unit-IIb
Unit-I
Unit-IIa
21 m
NW
SE

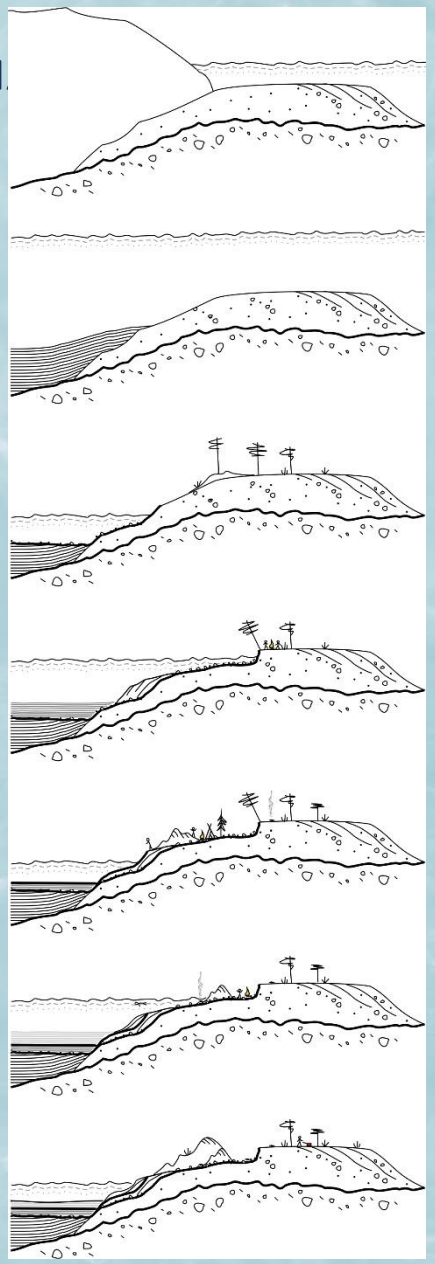

17-A-5-5
0cm 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
ACTION!

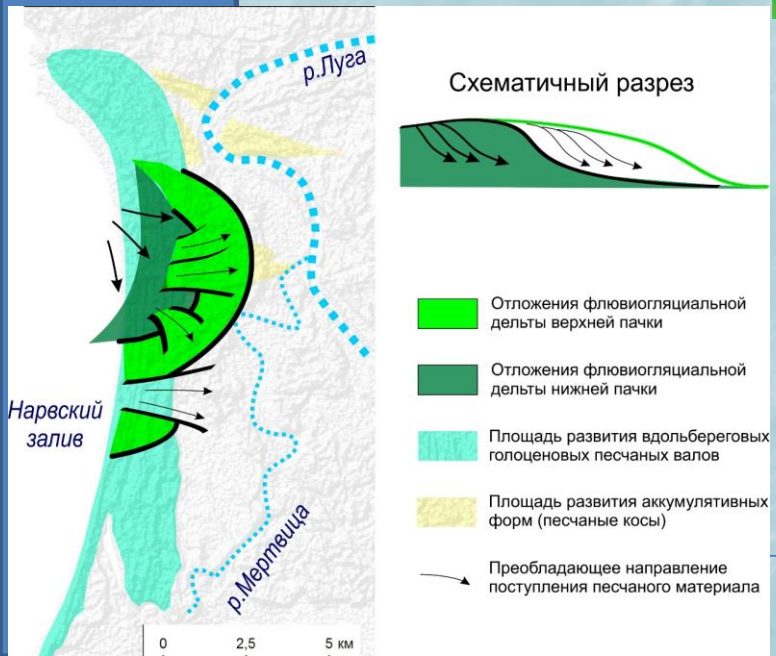

Алеврит
Песок
Гравий
Содержание фракции (%)
100
80
60
40
20
0
0,01
0,1
1
10
Размер фракций (мм)

Glacial and fluvioglacial accumulation
Ледниковая и последниковая аккумул









Отложения флювиогляциальной дельты верхней пачки

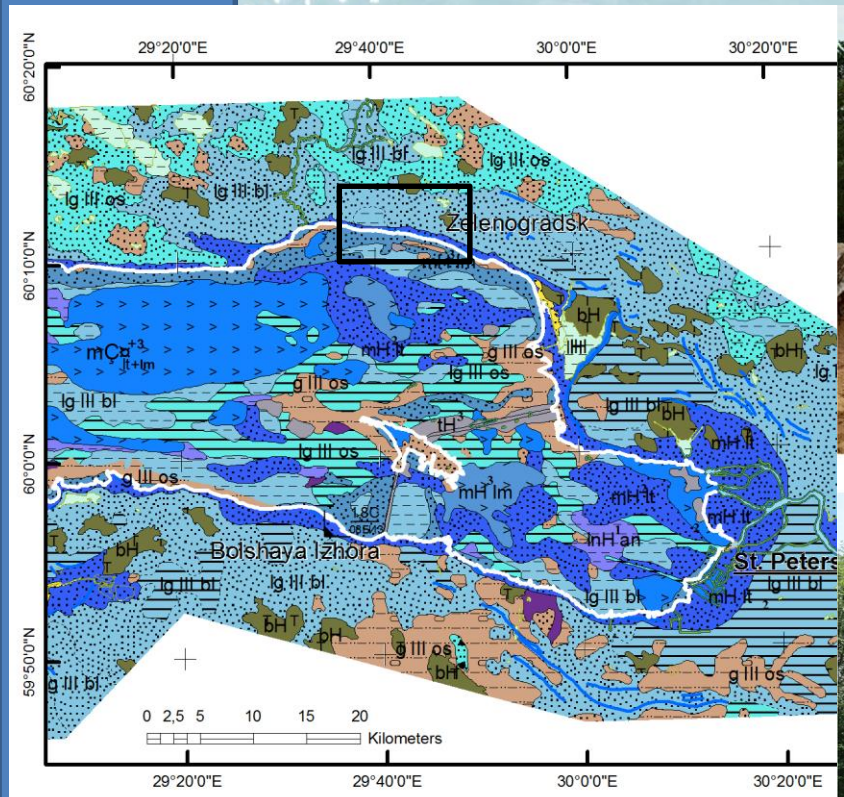
Отложения флювиогляциальной дельты нижней пачки

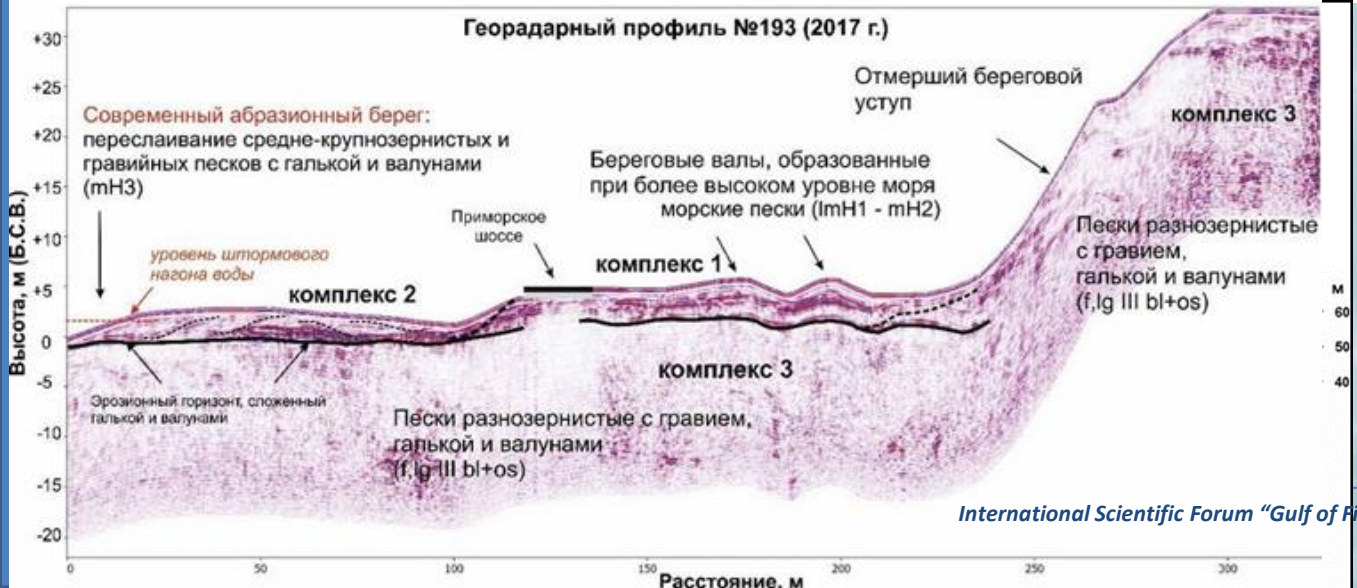
Площадь развития вдольбереговых голоценовых песчаных валов

Площадь развития аккумулятивных форм (песчаные косы)

Преобладающее направление поступления песчаного материала

Segreev et al., 2018,
in preparation

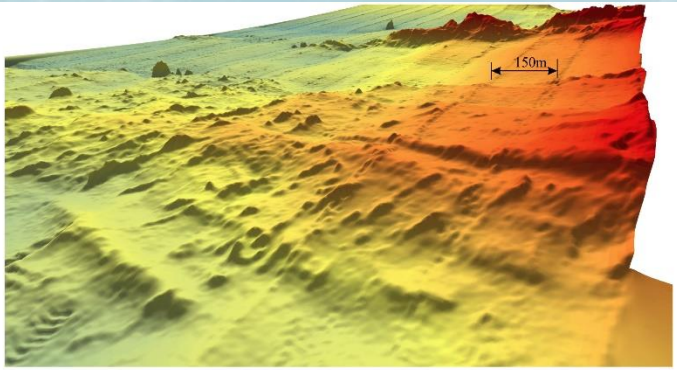


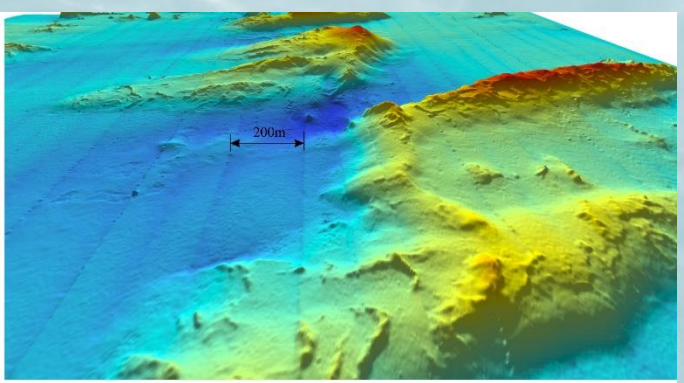


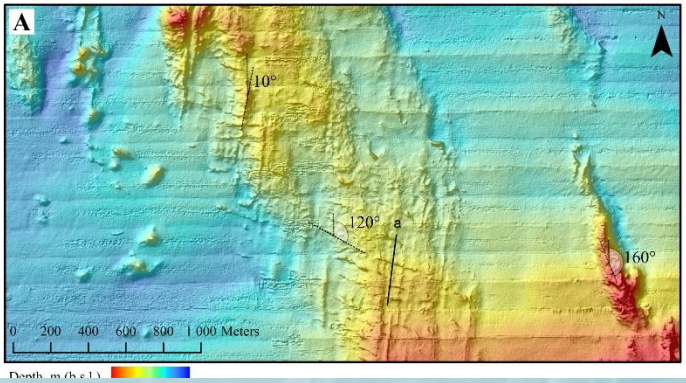
Erosion escarpment of Littorina transgression in Pleistocene sands
Абразионный уступ Литориноой трансгрессии в песчаных водно-ледниковых отложениях (пос. Серово)

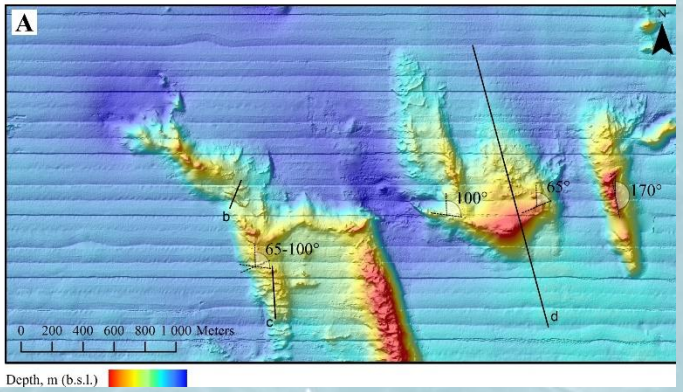
International Scientific Forum "Gulf of Finland – natural dynamics and anthropogenic impact", St. Petersburg, October 17-18, 2018

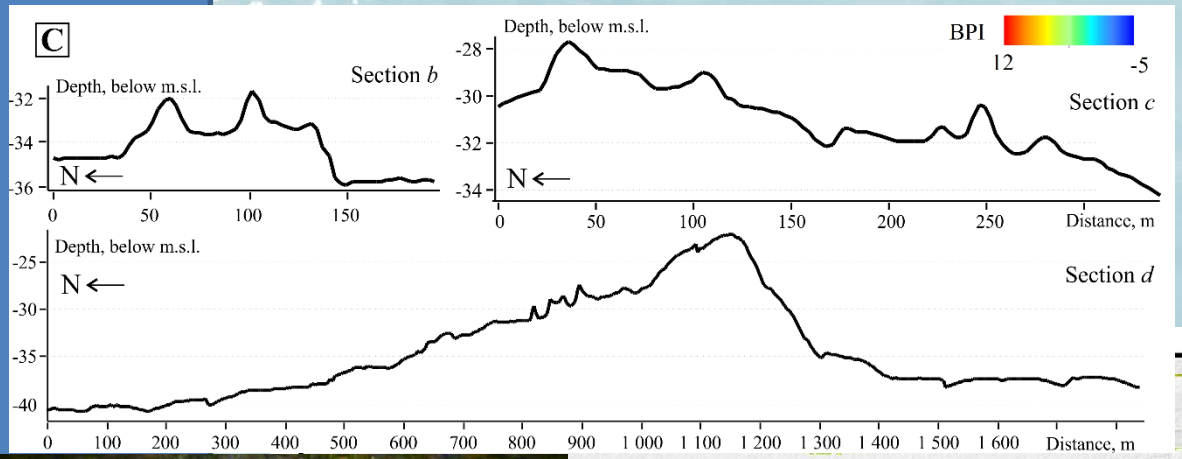
Расположение	Форма	Направление	Высота от пов.дна, м	Высота от подножия, м	Ширина в основании, м	Длина, м	Уго склона	Интервал между гребнями, м
Выборгский залив	**Линейные**	**SSE–NNW (170°)**	**10–15**	**15-20**	**130–170**	**1000**	**5–20°**	**-**
О-в Мощный	**Линейные**	**SSE–NNW (170°)**	**10–15**	**15-20**	**130–170**	**1000**	**5–20°**	**-**

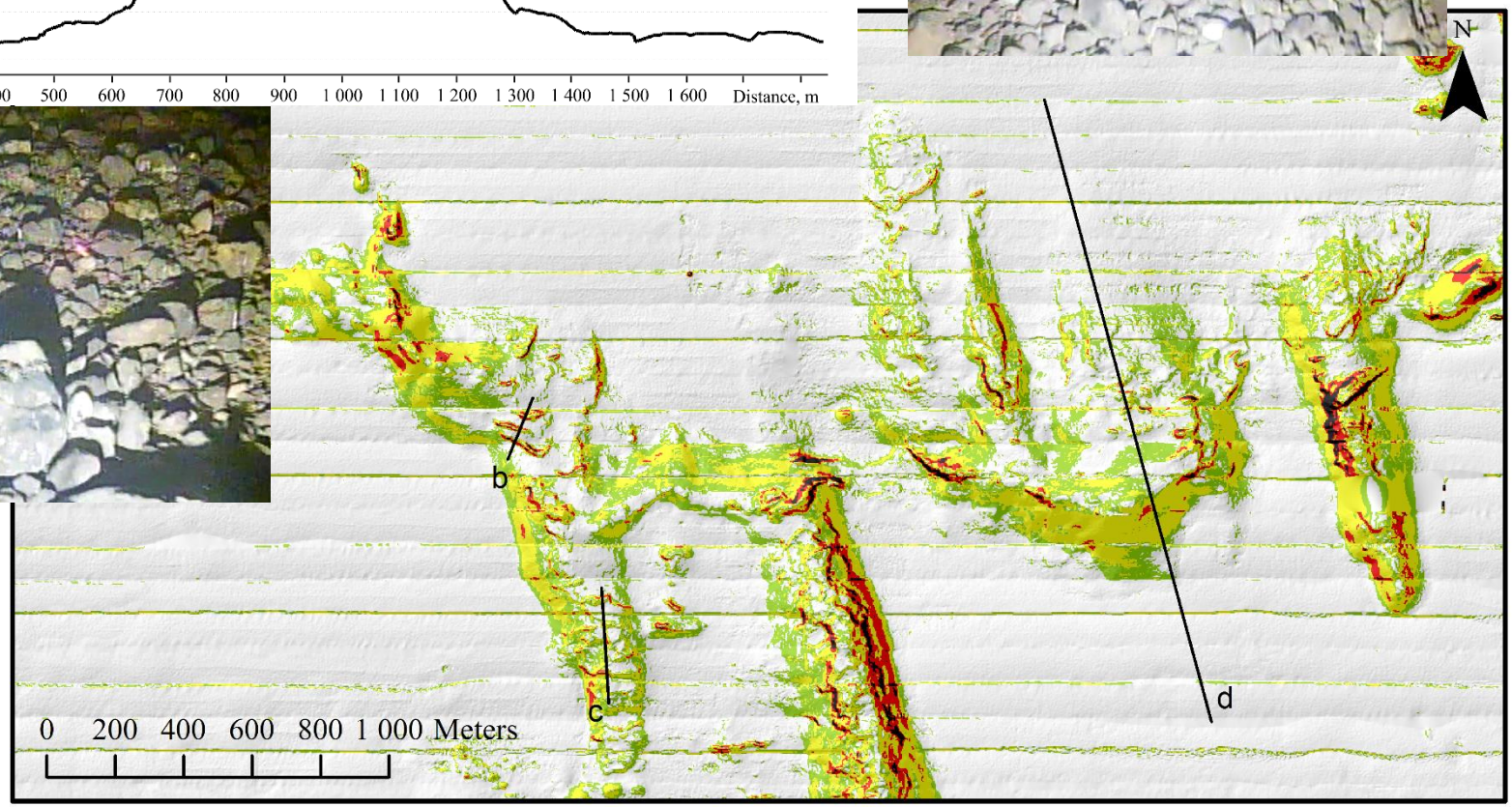




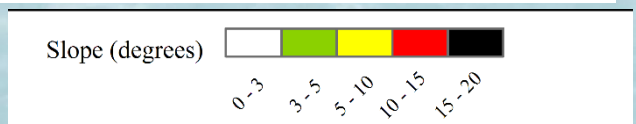








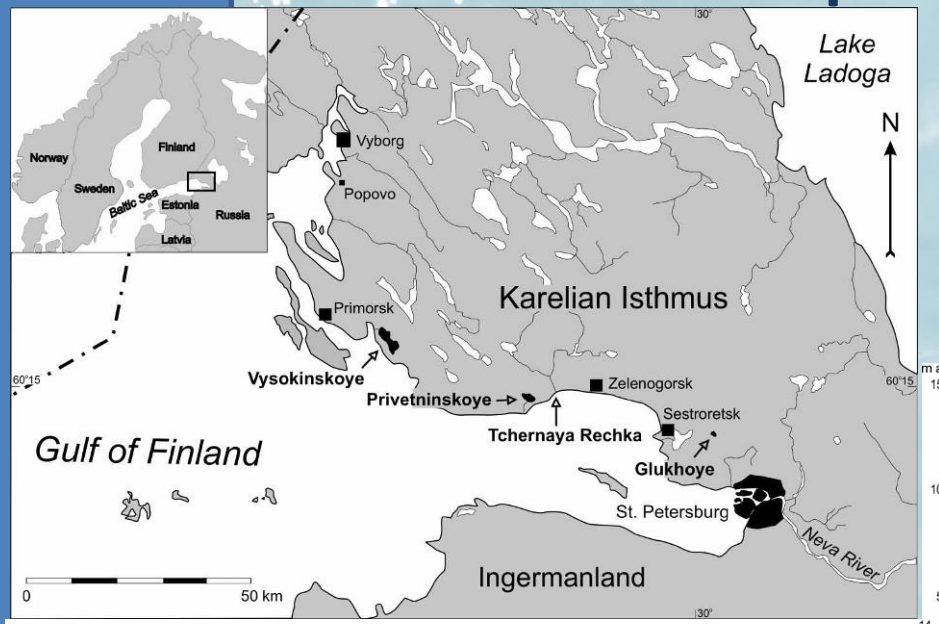
Submerged marginal moraine, Vyborg Bay
Краевая морена, Выборгский залив



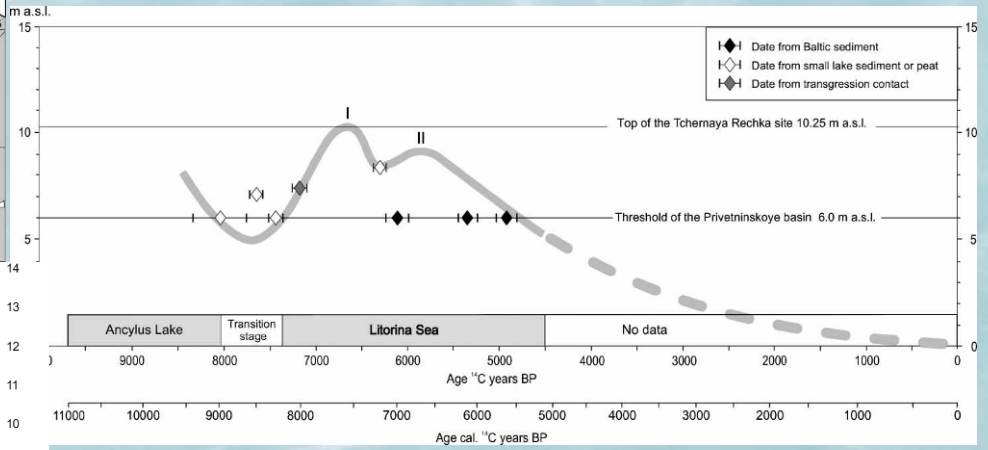
ВСЕГЕИ

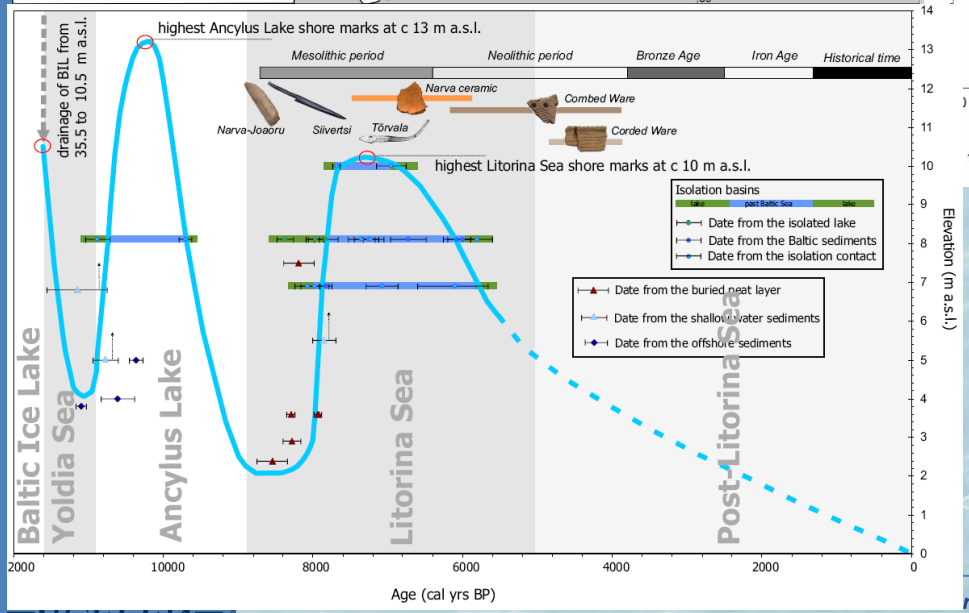
1. During repeated ice-sheets' advances within sedimentary rocks cover the shape of southern coastline was formed
2. Deglaciation of the Gulf of Finland occurred between 13.5 and 11.5 ka BP with at least one stop (re-advance) and resulted in deposition of huge volume of sediments
3. Glacial and glaciofluvial deposits are the main source of material for coastal zone development during Holocene

Holocene coastal zone development
Развитие береговых зон в голоцене

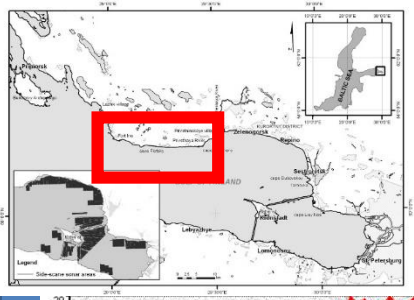


Miettinen, A., Savelieva, L., Subetto, D. A., Dzhinoridze, R., Arslanov, K. & Hyva.rinen, H. 2007 (October): Palaeoenvironment of the Karelian Isthmus, the easternmost part of the Gulf of Finland, during the Litorina Sea stage of the Baltic Sea history.

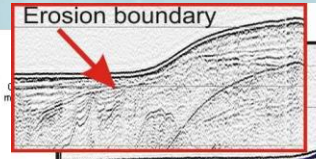




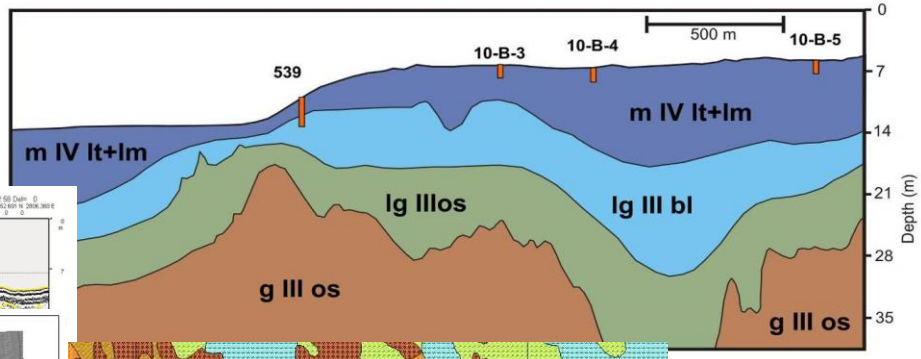
Rosentau, A., Subetto, D., Letjuka, N., Kriiska, A., Lisitsyn, S., Gerasimov, D., Nordqvist, K. Holocene water-level changes of the Baltic Sea in Narva-Luga klint bay area and its relations with stone age settlement pattern, 2010

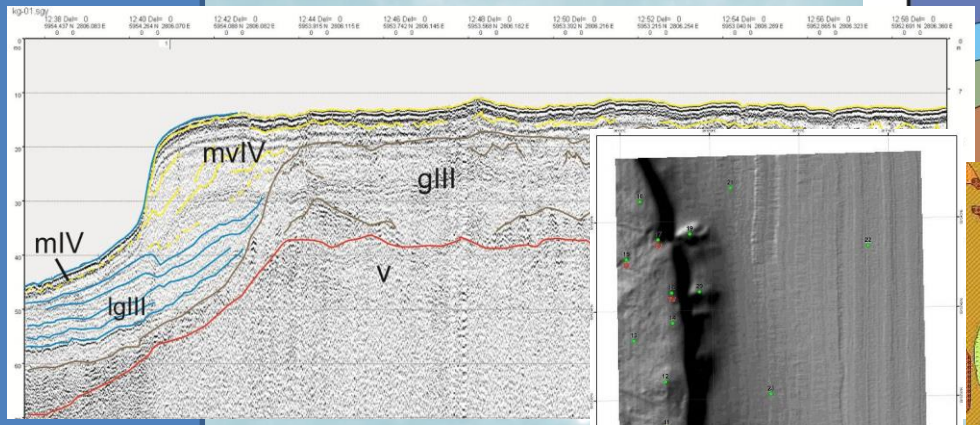


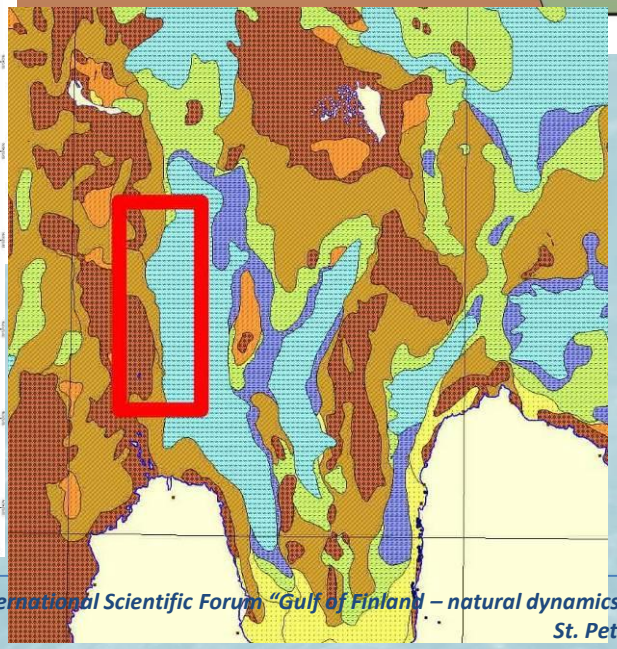
m IV lt+lm
lg II bl
fg III (?)
g III os
lg II bl
?
lg II osl


Erosion boundary

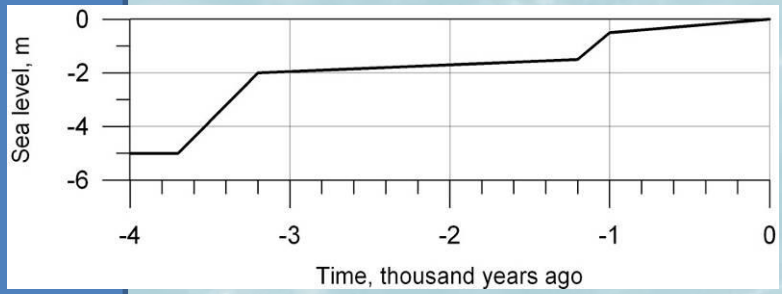
539
10-B-3
m IV lt+lm
lg III bl
lg IIIos
g III os
g III os

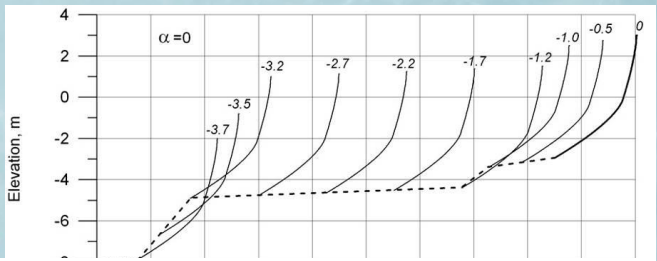

500 m
539
10-B-3
10-B-4
10-B-5
m IV lt+lm
m IV lt+lm
lg IIIos
lg III bl
g III os
g III os
Depth (m)

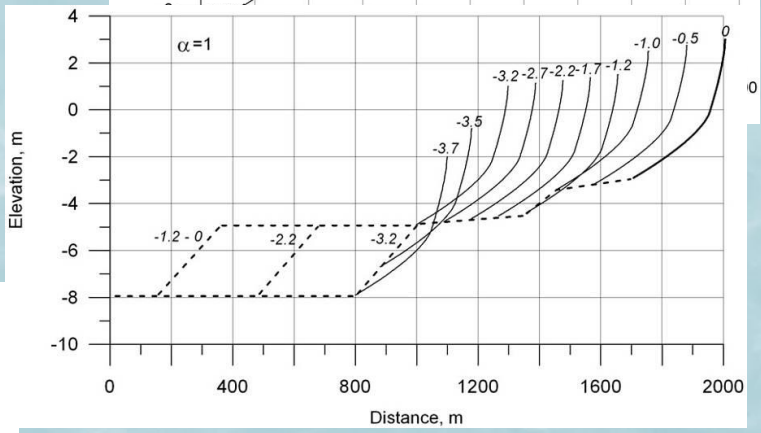

mvIV
gIII
mIV
V
lgIII



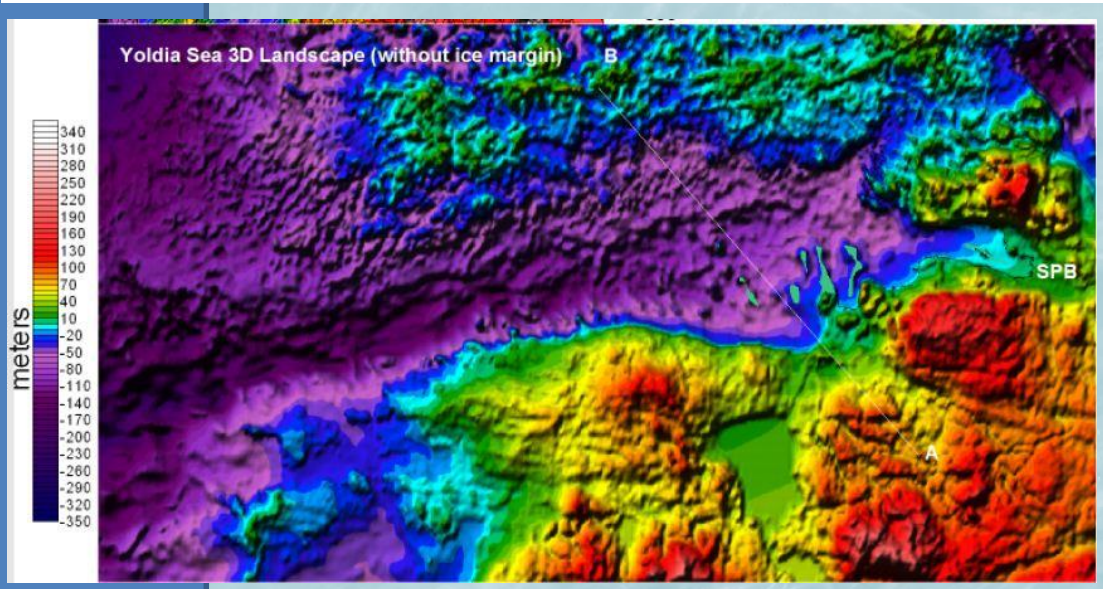
Leont'yev, I. et al. Reconstruction of Late Holocene development of the submarine terrace in the Eastern Gulf of Finland. 2010

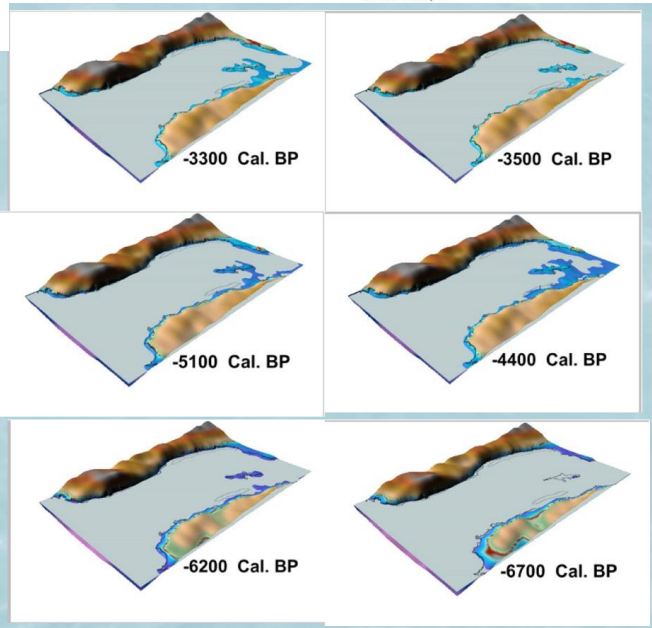






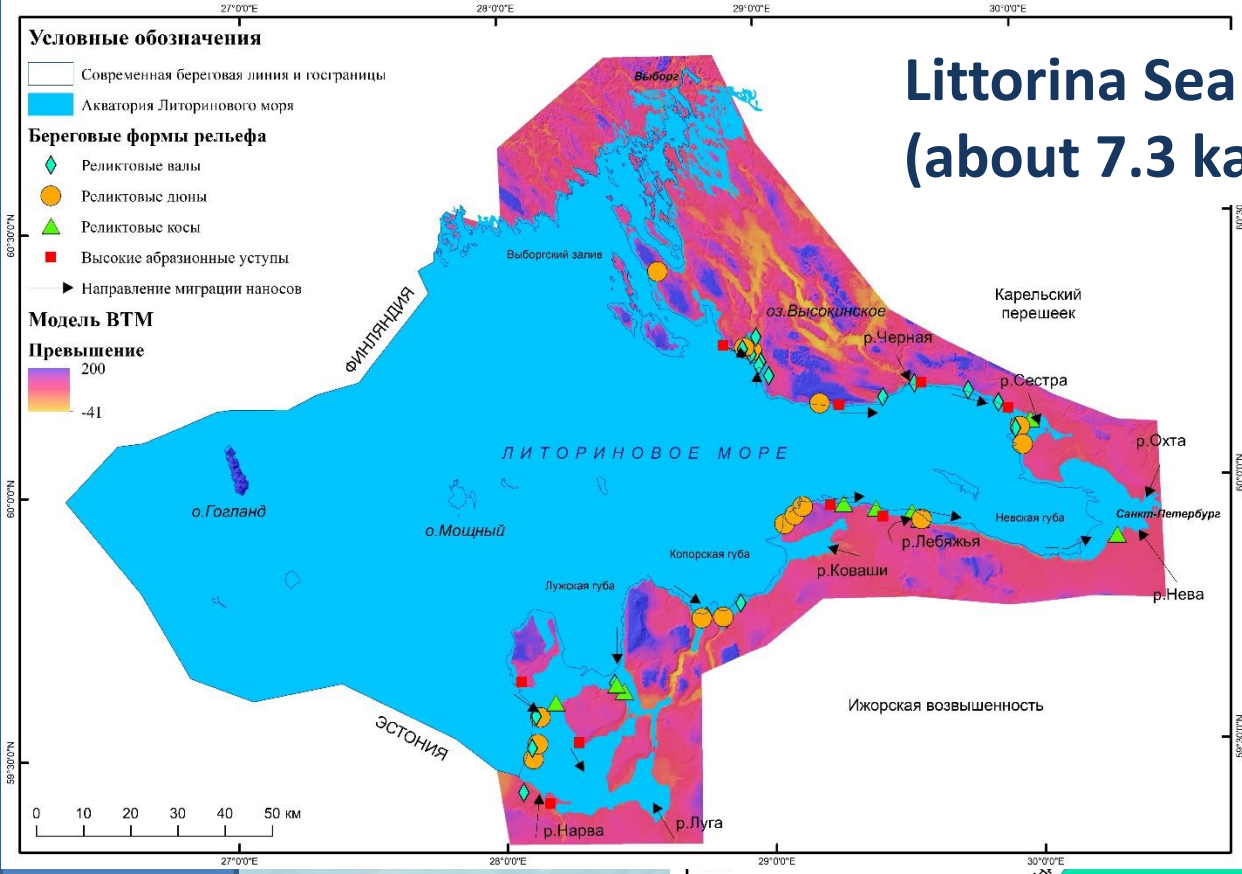
Amantov et al., 2013. Possible role of glacioisostasy in peculiarities of lateglacial-postglacial sedimentation of the Eastern Gulf of Finland and Ladoga Lake



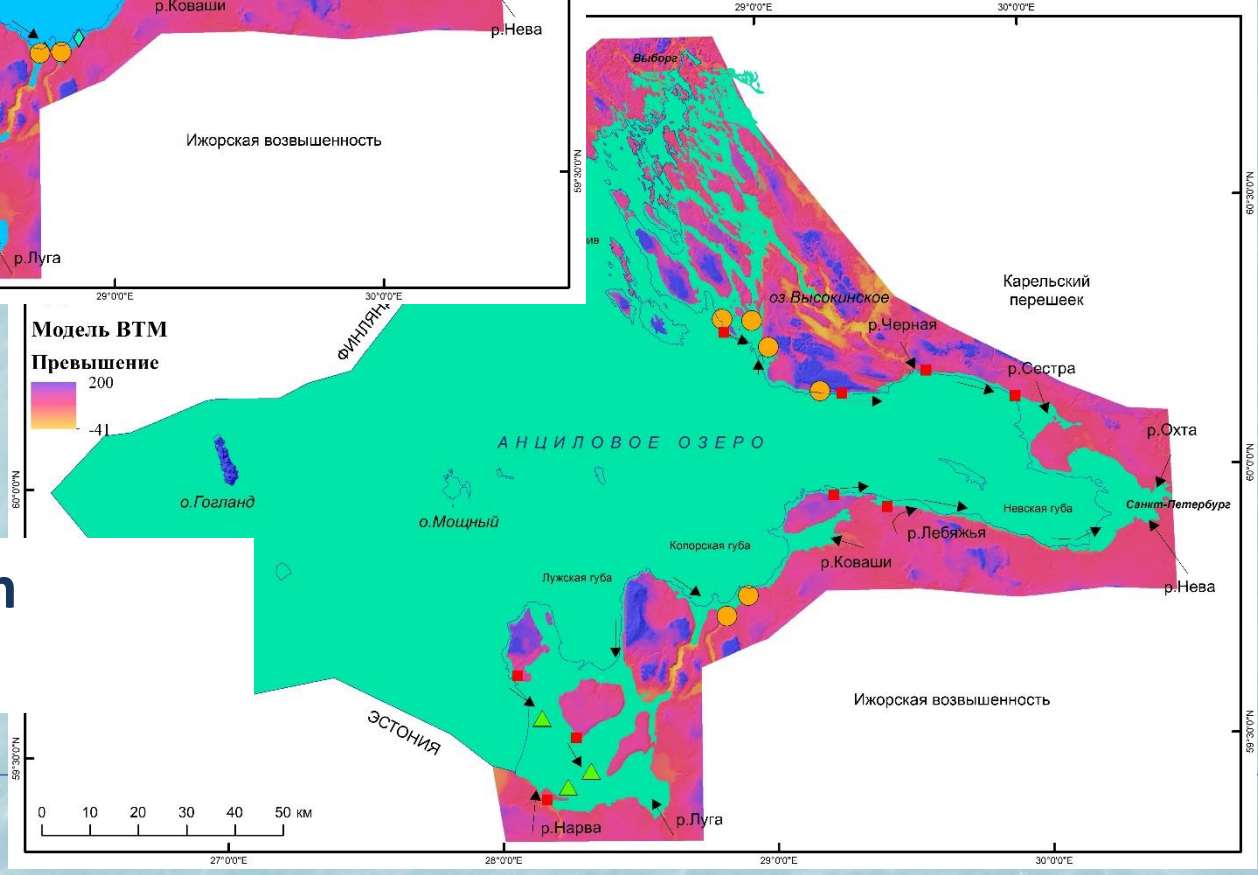


Littorina Sea maximum (about 7.3 ka BP)

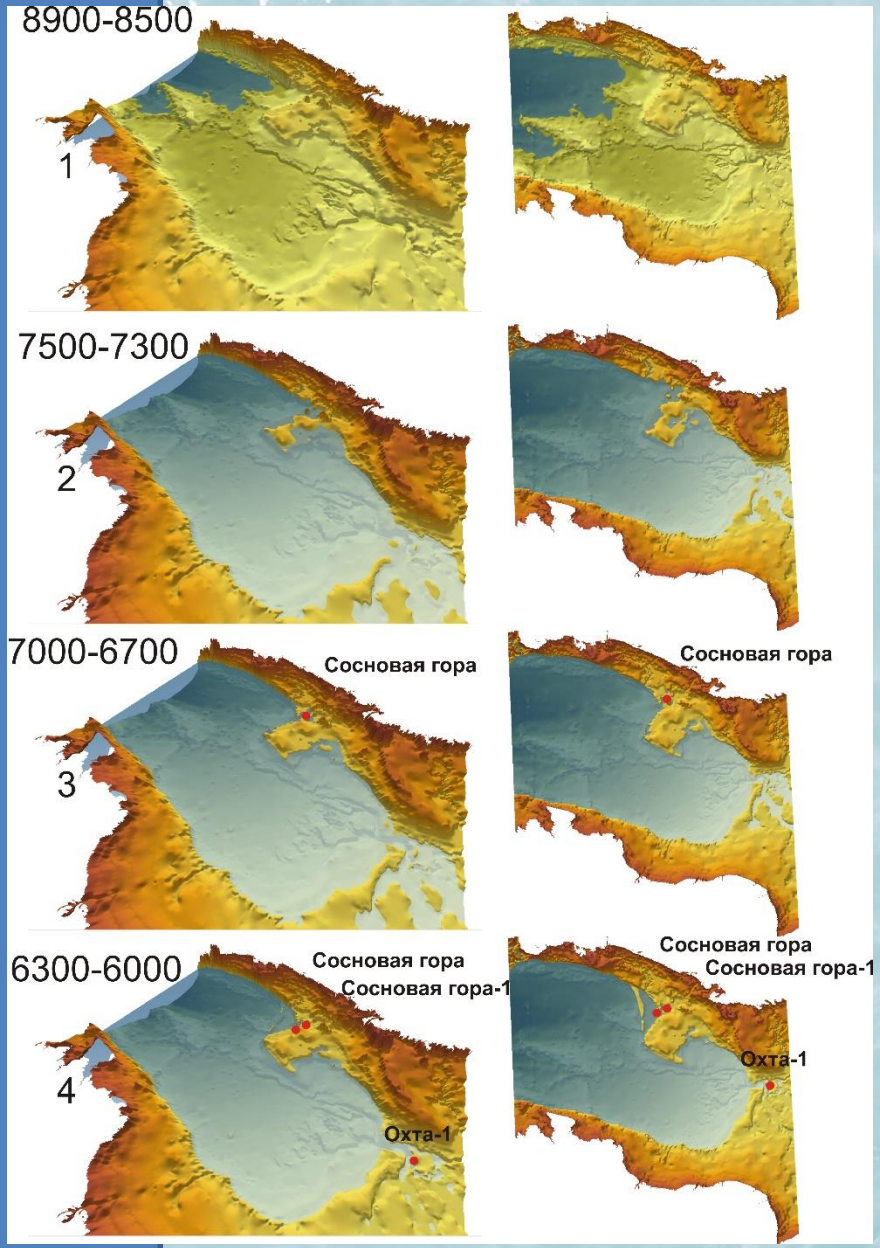
Kovaleva, Sergeev, 2018 (in preparation)

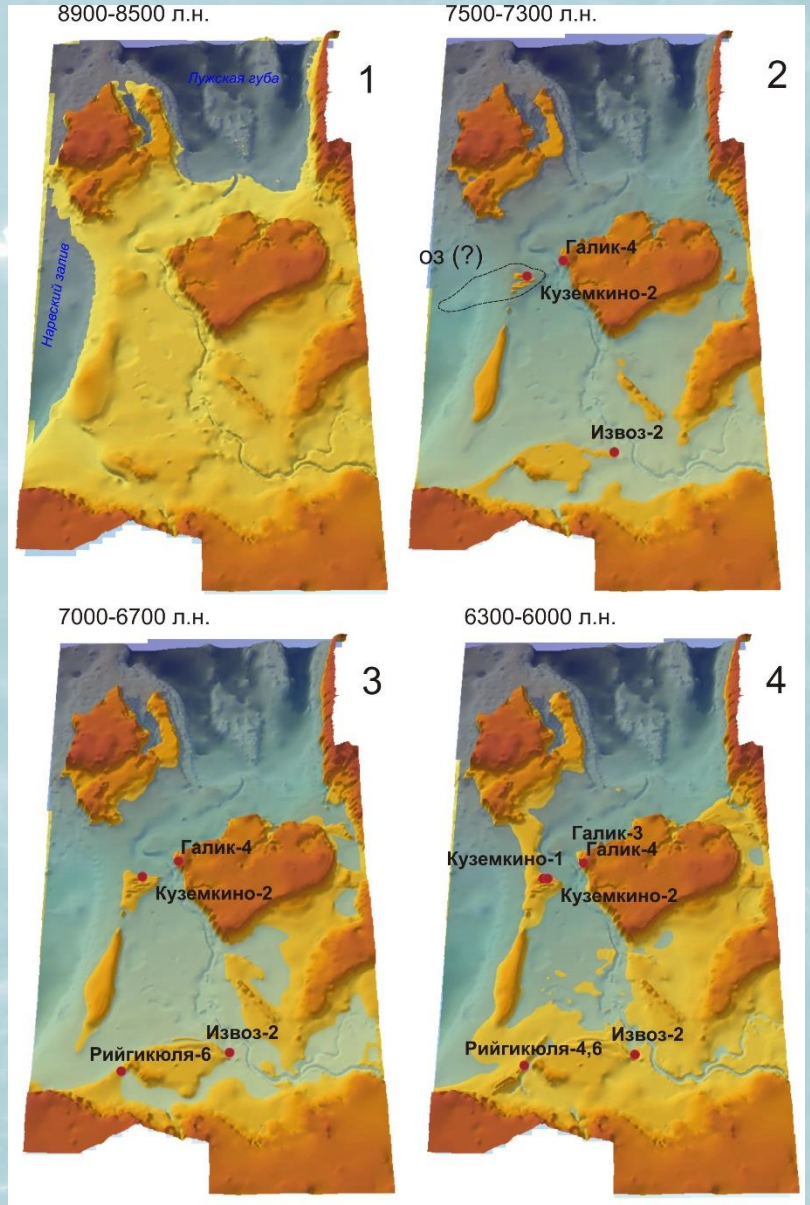


Ancylus Lake maximum (about 10,8 ka BP)



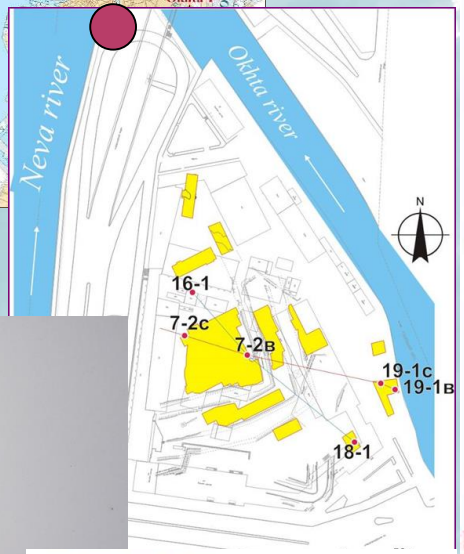
ВСЕГЕИ

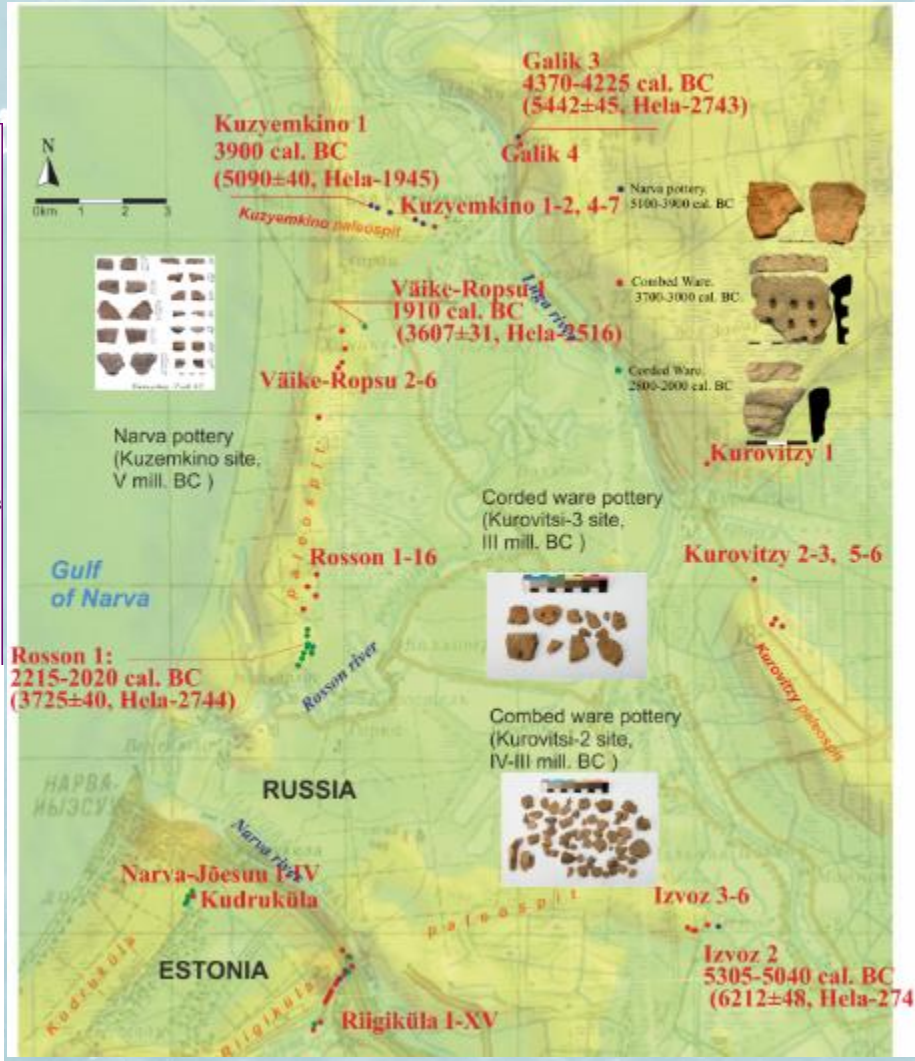

8900-8500
1
7500-7300
2
7000-6700
Сосновая гора
3
Сосновая гора
6300-6000
Сосновая гора
Сосновая гора-1
4
Охта-1
Сосновая гора
Сосновая гора-1
Охта-1


8900-8500 л.н.
Лужская губа
1
Нарвский залив
7500-7300 л.н.
2
оз (?)
Галик-4
Куземкино-2
Извоз-2
7000-6700 л.н.
3
Галик-4
Куземкино-2
Извоз-2
Рийгикюля-6
6300-6000 л.н.
4
Галик-3
Куземкино-1
Галик-4
Куземкино-2
Извоз-2
Рийгикюля-4,6

Okhta-1

Gusentsova et al., 2011





Gerasimov et al., 2013

1. Holocene EGoF coastal zone development controlled by alternation of several transgressions and regression. During the maximal stages of the Ancylus and Littorina transgressions vast areas of modern land were flooded.

2. The lagoon systems and sand accretion bodies (spits and bars) were formed during the following decreasing of the sea level. During Holocene main glacial and glaciofluvial landforms of the coastal areas have been eroded

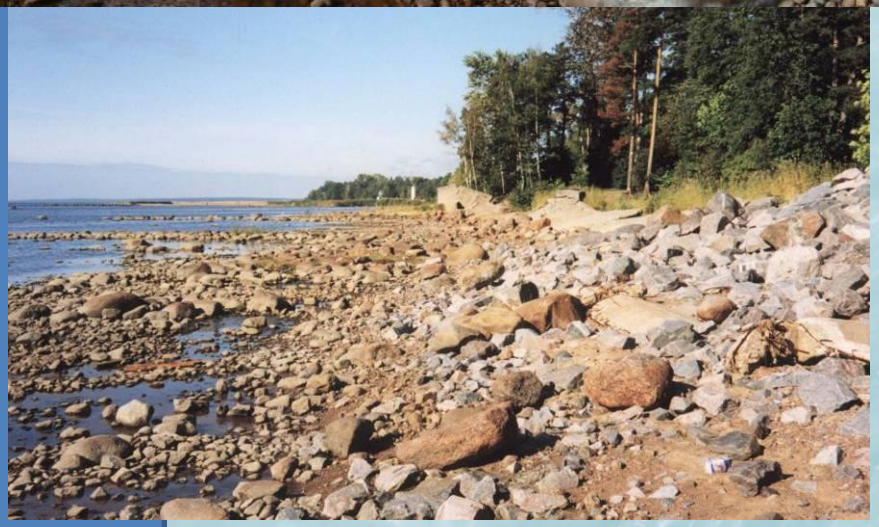
3. Coastal processes of the EGoF have been very active since the beginning of Holocene but during Mesolithic and Neolithic time people was adjusting to the natural processes , following shifted coastline

Recent coastal dynamics
Современная лито- и морфодинамика

Recent coastal dynamics
Современная лито- и морфодинамика

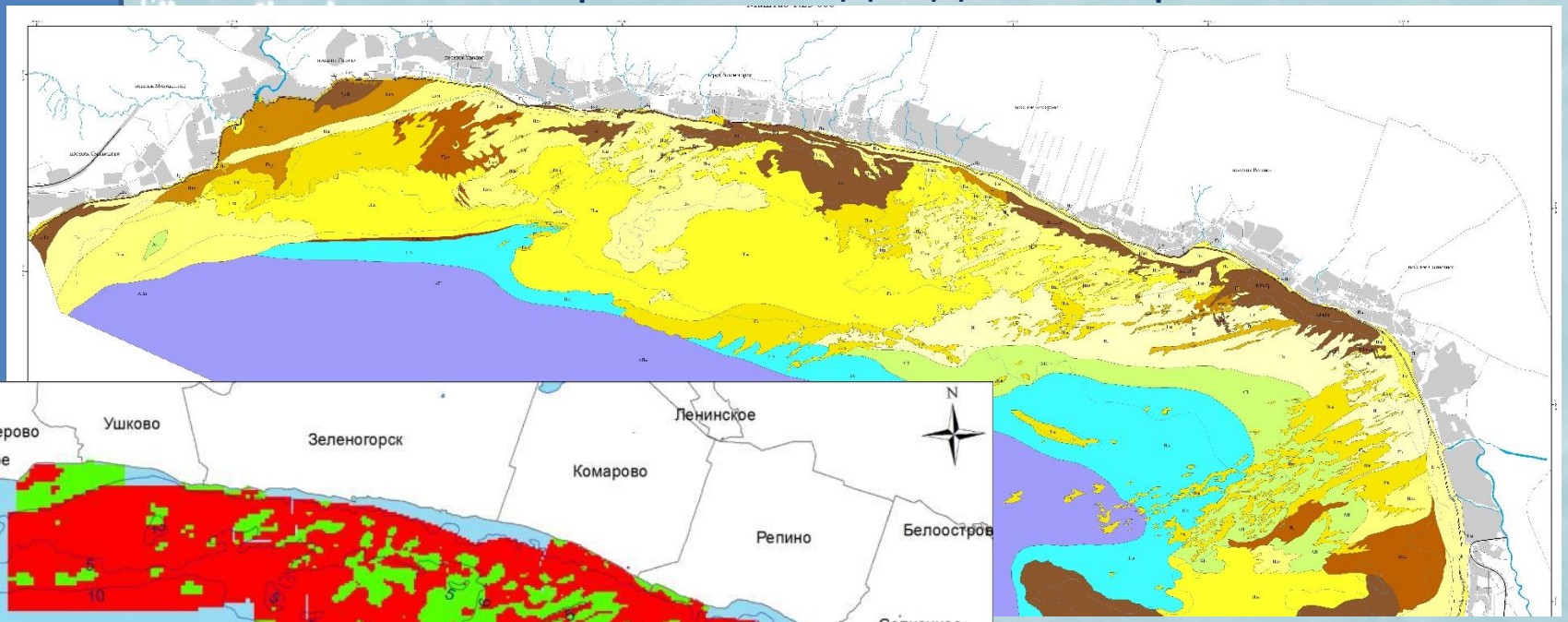
Sediment defiency
Boulder-pebble benches

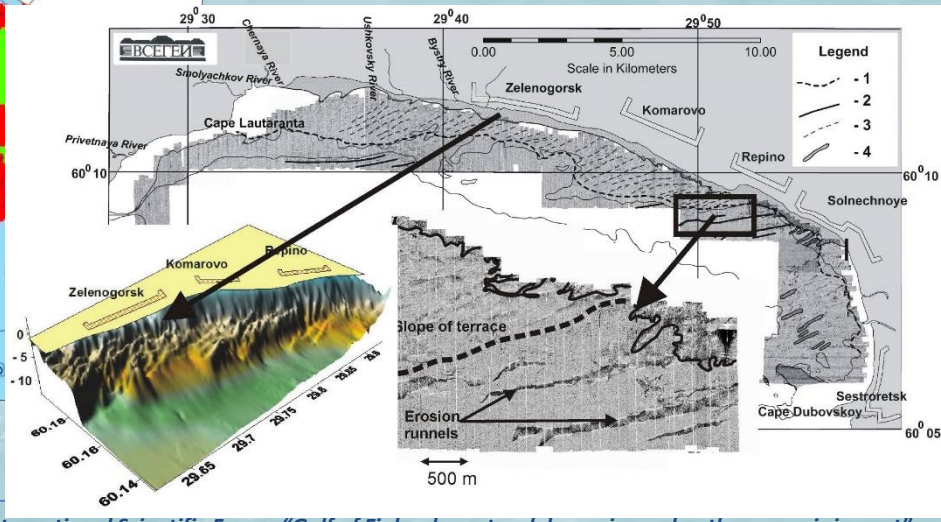
Дефицит осадочного материала в береговой зоне
Валунные бенчи



Intense erosion in nearshore

Интенсивный размыв подводного берегового склона





Hydrometeorological factors

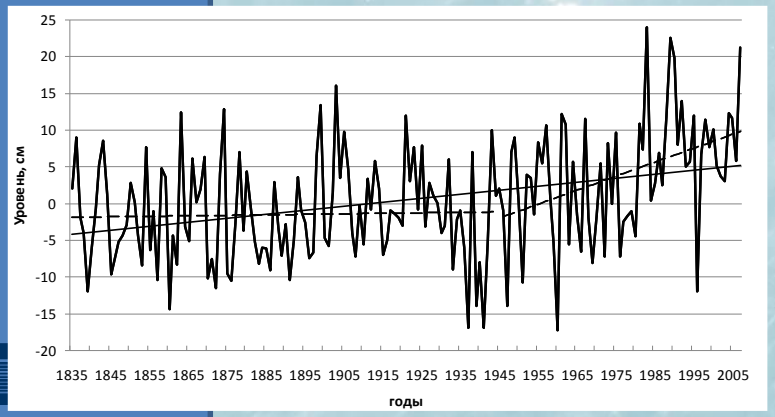
Гидрометеорологические и гидрологические факторы

(i) long-lasting western or south-western storms that bring high waves

(ii) high water level (more than 2 m above the mean level as measured by the Gorny Institute WL measurement post),

(iii) absence of stable sea ice during such events

Изменение уровня моря, Кронштадт
Sea level change, Kronstadt

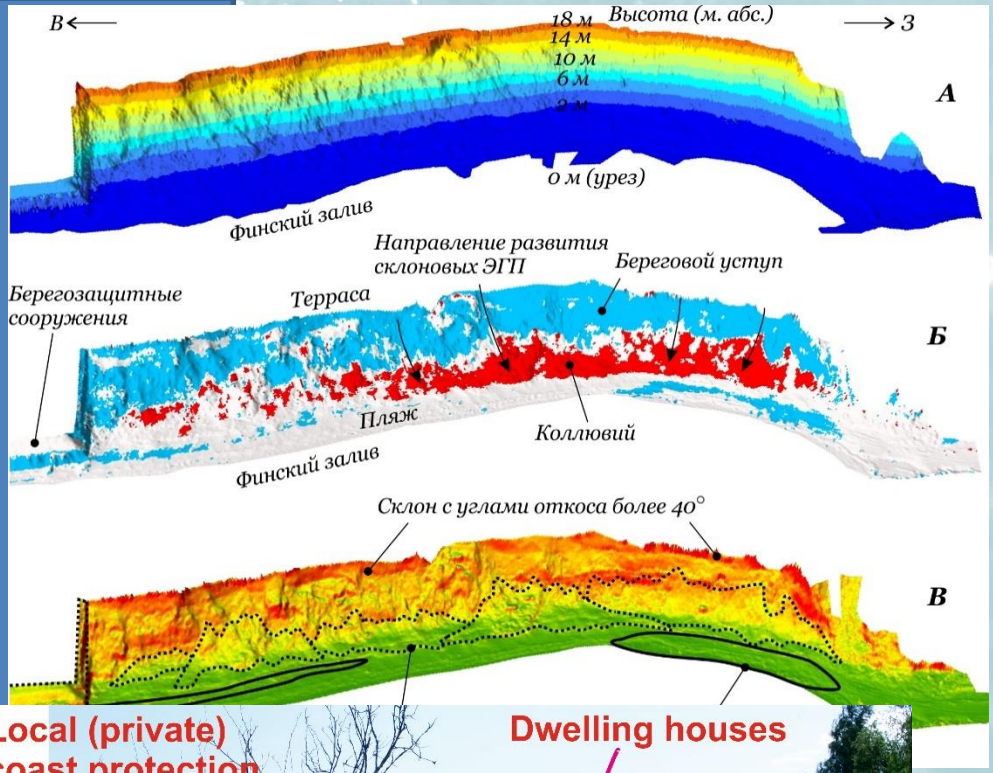


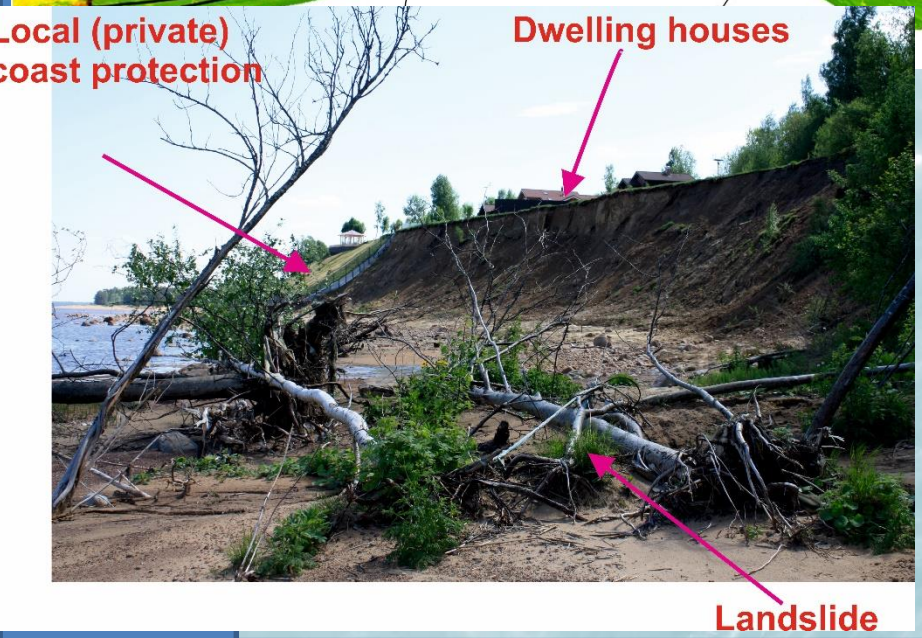
Опасные размывы берегов возникают при сочетании:

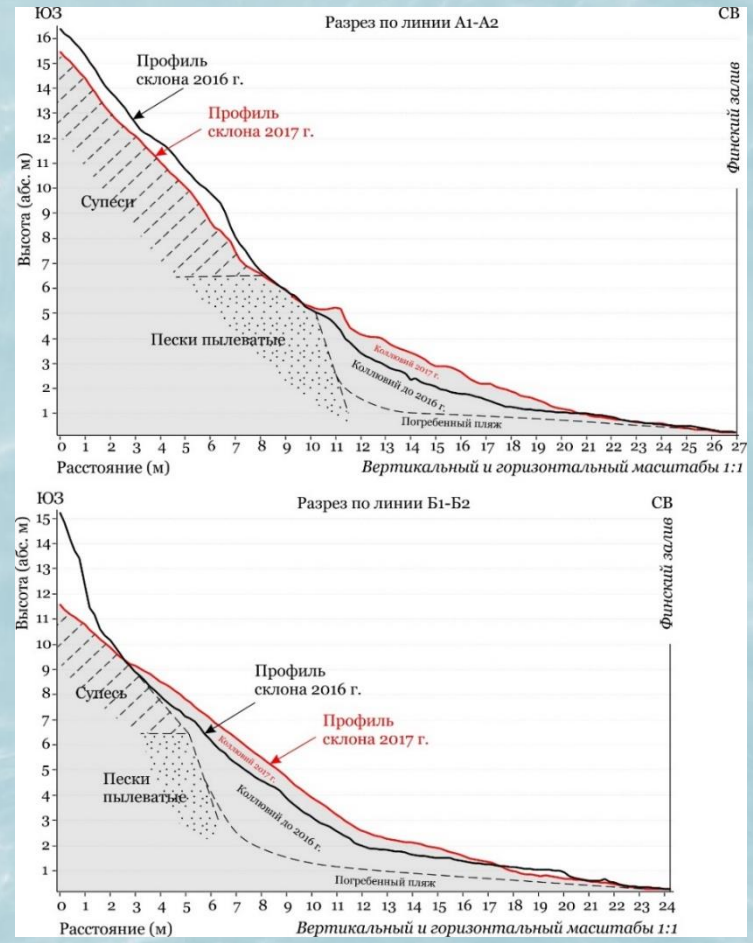
(i) штормов западных и юго-западных направлений;

(ii) повышения уровня воды (более 2 м по гидрологическому посту Горный Институт;

(iii) отсутствия ледяного покрова







Landslides caused by coastal erosion

Оползни, спровоцированные абразией

Technogenic processes
Техногенные процессы

St Petersburg Flood Protection Facility

Комплекс защитных сооружений Санкт-Петербурга от наводнений

October 29, 2013

To the west from the FPF

Neva Bay

Exploration of submarine sand deposits, dyne destruction

Подводная добыча песка, разрушение дюн

Ineffective old system of coast protection
Устаревшая неэффективная система берегозащиты

June 2014

September 14, 2017

Conclusions

1. Eastern Gulf of Finland coastal zone is characterized by high intensity of hazardous exogenous processes (coastal erosion, landslides etc.).
2. Level of geological hazards caused mainly by natural factors (geology, relief, tectonics, hydrodynamic impact) and will be growing due to climate change.
3. Anthropogenic impact play very important role in coastal processes.
4. Marine erosion is a dominant geological hazard of the Eastern Gulf of Finland coastal zone. It lead to shoreline retreat, dune and beach erosion and loss of high valuable lands.
5. Realization of effective Coast Protection Program is urgently needed.


Thank you for attention!