Science Days for the Gulf of Finland and the eastern Baltic Sea.

"Science shakes a hand with coastal life and citizens"

30th of November 1st of December, 2022

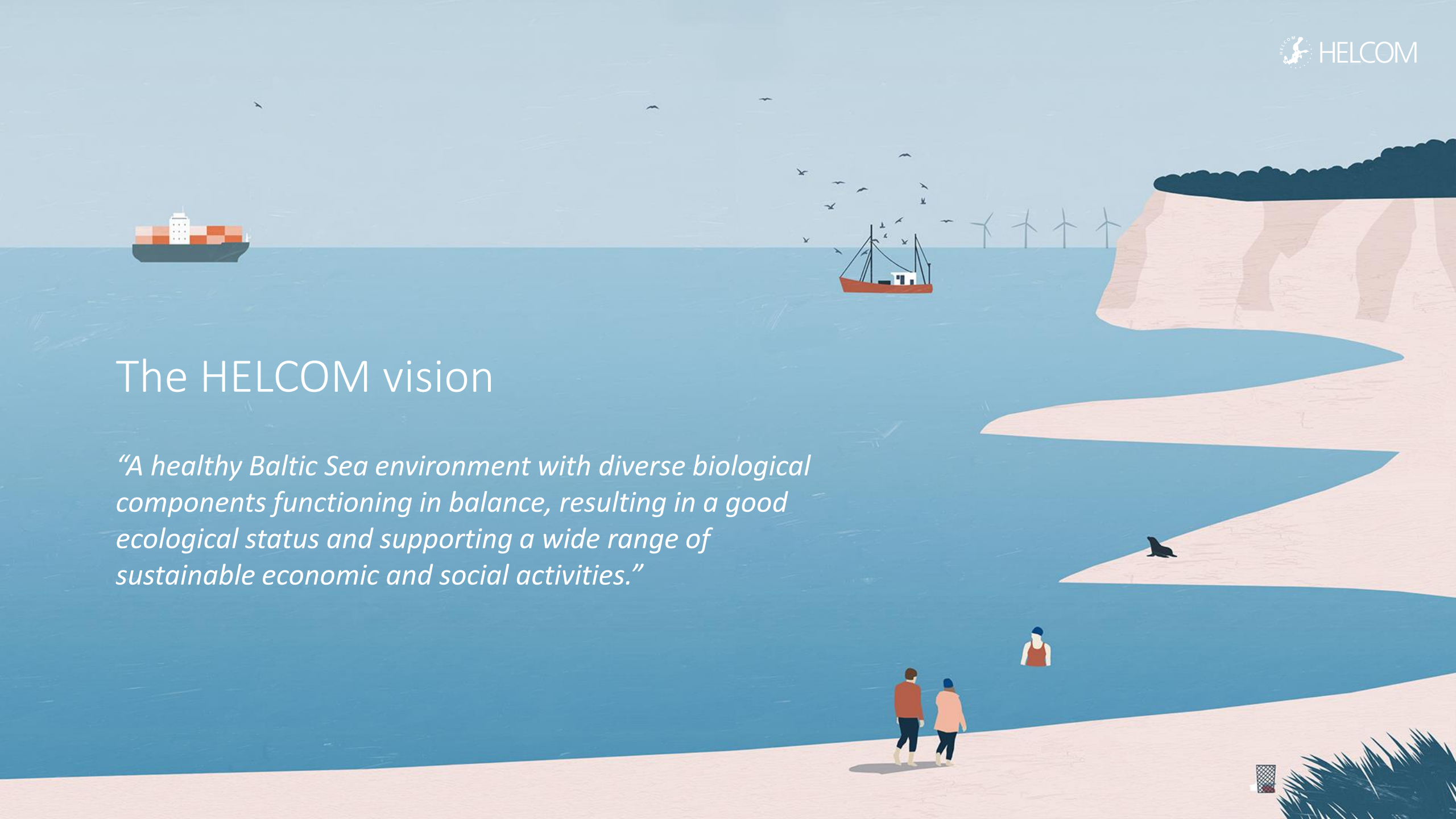
1. *Lotta Ruokanen*: Subregional Baltic Sea co-operation contributing to the work of HELCOM
2. *Loreta Kelpšaitė-Rimkienė*: Natural and anthropogenic factors impact on the use of the sandy beaches in Klaipėda municipality
3. *Kevin Parnell*: Baltic Sea coasts under the influence of climate change
4. *Anda Ikauniece*: Synthesising our knowledge about functioning of the Baltic Sea food web
5. *Ville Junttila*: Harmful substances in the Gulf of Finland
6. *Sergej Olenin*: Biological invasions in the Baltic Sea: myths and reality
7. *Kari Hyytiäinen*: Economic viewpoint and other perspectives to the sea.
8. *Ieva Putna-Nīmane:* Active pharmaceutical ingredients in environment – from data gaps to educational campaign (case study, Latvia and Lithuania).
9. *Andrea Giudici, Rain Männikus, Fatemeh Najafzadeh, Mikolaj Zbigniew Jankowski, Tarmo Soomere, Ülo Suursaar*: High-resolution wave model for coastal management and engineering.
10. *Uldis Žaimis*: Application of the Lattice Boltzmann method in coastal erosion modelling.
11. *Majid Mostafavi, N. Delpeche-Ellmann, A. Ellmann*: Bi-directional Sea Level Data Gap-filling using High-inclination Satellite Altimetry Missions in Baltic Sea.
12. *Tarmo Soomere*: Spatially varying role of manifestations of climate change on coastal processes from the German Bight to the Gulf of Finland.
13. *Sintija Ozolina, Uldis Zaimis*: Some aspects of extraction and application of seaweed furcellaria lumbricalis carrageenan in the production of recycled paper.
14. *Jukka Mehtonen, Katri Siimes, Matti Leppänen, Ville Junttila, Lauri Äystö, Emmi Vähä*: Proposal on Finnish River Basin Specific Pollutants under WFD – Substances relevant for Baltic Sea.
15. *Arun Mishra*: Rapid quantification of microplastics by using Nile Red staining - A cost-effective and semiautomated

Subregional Baltic Sea co-operation contributing to the work of HELCOM

Lotta Ruokanen

Professional Secretary

Baltic Marine Environment Protection Commission - HELCOM

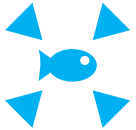


The HELCOM vision

“A healthy Baltic Sea environment with diverse biological components functioning in balance, resulting in a good ecological status and supporting a wide range of sustainable economic and social activities.”

HELCOM is a regional…

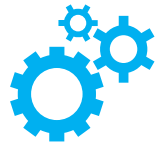
environmental policy maker
e.g. BSAP



environmental focal point *e.g. HOLAS*

body for developing regional recommendations
e.g. HELCOM recommendations

supervisory body
e.g. MAI



coordinating body
e.g. HELCOM Response & BALEX DELTA

▲ Signing of the Helsinki Convention in 1974

12000 t *in 1910*

Phosphorus (P) input to the Baltic Sea (waterborne)

71295 t *in 1981*

22749 t *in 2020*

1972 UN Conference on the Human Environment

1974 **Signing of the Helsinki Convention** (7 members)

1980 **Establishment of HELCOM Secretariat**

1992 **Revision of the Helsinki Convention** (expanded to 10 members)

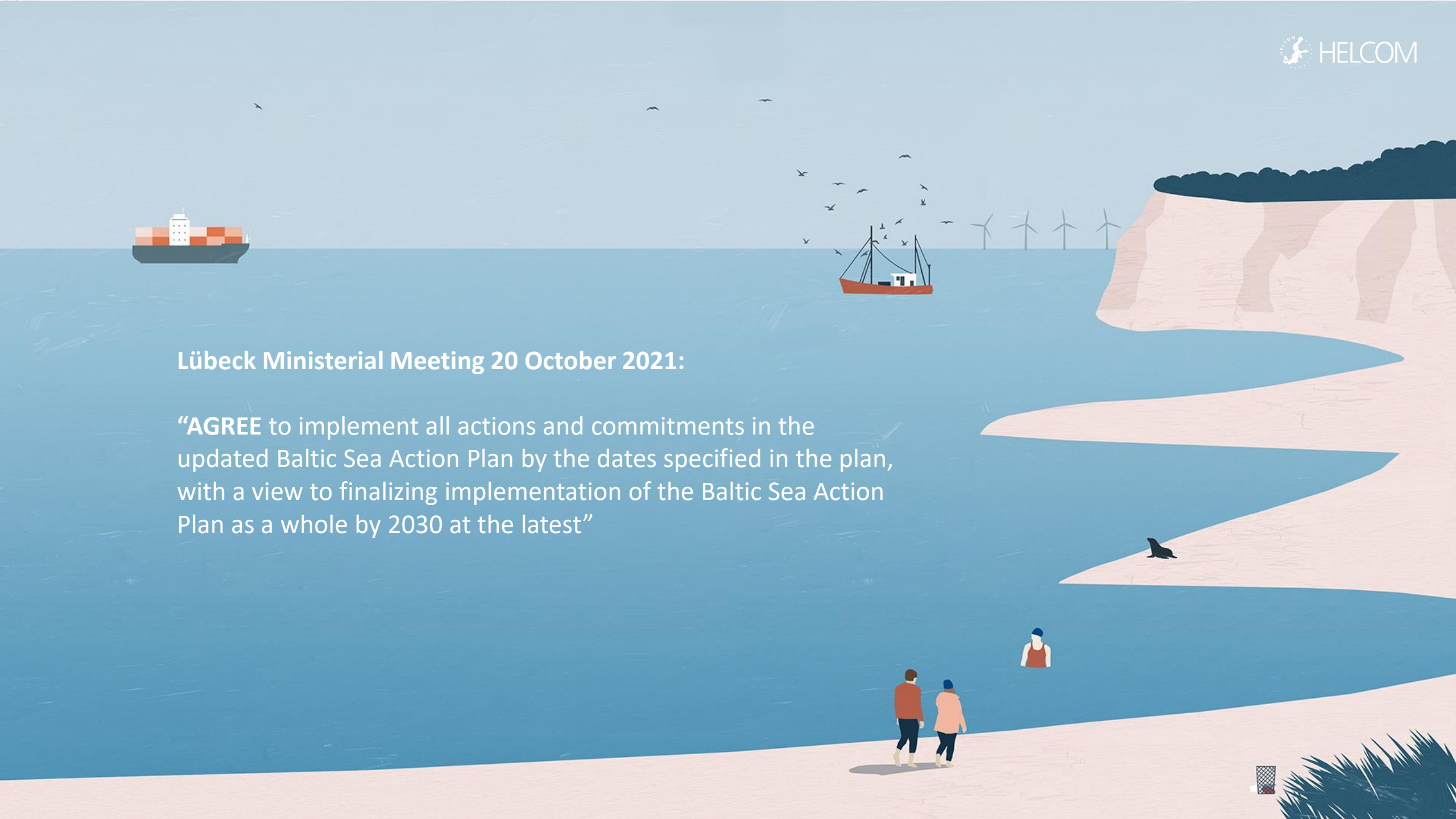
2000 **Ratification of the 1992 Helsinki Convention**

2007 **Baltic Sea Action Plan**

2007 **HOLAS I** Assessment of the ecosystem health of the Baltic Sea

2021 **Baltic Sea Action Plan update**

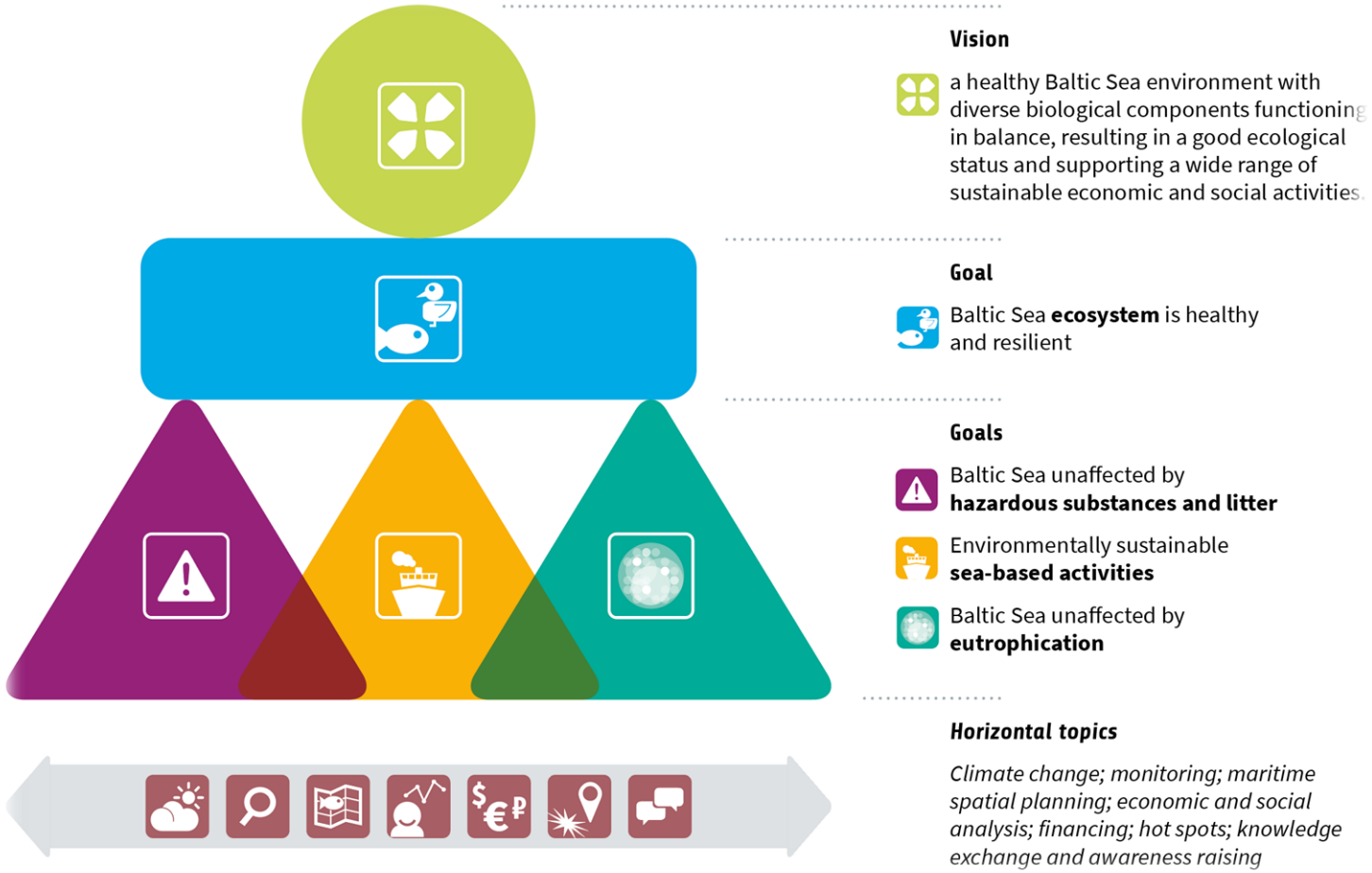
1900 1950 2000 2020



Lübeck Ministerial Meeting 20 October 2021:

“AGREE to implement all actions and commitments in the updated Baltic Sea Action Plan by the dates specified in the plan, with a view to finalizing implementation of the Baltic Sea Action Plan as a whole by 2030 at the latest”

2021 Baltic Sea Action Plan: structure & goals



Vision

a healthy Baltic Sea environment with diverse biological components functioning in balance, resulting in a good ecological status and supporting a wide range of sustainable economic and social activities

Goal

Baltic Sea **ecosystem** is healthy and resilient

Goals

Baltic Sea unaffected by **hazardous substances and litter**

Environmentally sustainable **sea-based activities**

Baltic Sea unaffected by **eutrophication**

Horizontal topics

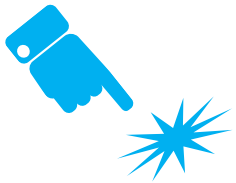
Climate change; monitoring; maritime spatial planning; economic and social analysis; financing; hot spots; knowledge exchange and awareness raising

Logic in the structure:
Chain of consequence, whereby human activities result in pressures on the environment, which in turn affect the state of biodiversity, which has been used as a basis when elaborating the updated BSAP

Associated action documents to 2021 BSAP

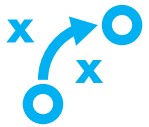
- HELCOM Recommendation 42-43/1 on Regional Action Plan on **Underwater Noise**
- HELCOM Recommendation 42-43/2 on Amendments to Part II Annex III "Criteria and Measures Concerning the Prevention of **Pollution from Land-Based Sources**" of the 1992 Helsinki Convention
- HELCOM Recommendation 42-43/3 on Regional Action Plan on **Marine Litter**
- Baltic Sea Regional **Nutrient Recycling Strategy**
- Regional Maritime **Spatial Planning Roadmap** 2021-2030
- Guidelines for Sea Based Measures to Manage **Internal Nutrient Reserves** in the Baltic Sea Region

Decision making process in HELCOM: a bottom-up, science-based approach

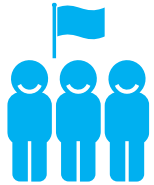


1) A **mandate or impulse** to look into a specific issue is usually given by the **Contracting Parties**

2) The **HELCOM Expert Groups** constituted of national experts provide the scientific or technical background



3) The **HELCOM Working Groups (WG)**, also constituted of national experts, translate the scientific findings into draft recommendations, strategies or actions



4) The **Heads of Delegation** formally approve the work of the Working Groups

5) Sometimes, decision are taken at **a higher level**: Annual Meeting of the Helsinki Commission, Ministerial Meeting (every three years)

Projects supporting HELCOM work

- HELCOM's main tasks are carried out by the main groups (subsidiary bodies) WGs, EGs
- HELCOM projects or ad hoc groups can be established to provide an adaptive and flexible system for dealing with specific issues from a more thematic perspective
- Projects and drafting or ad hoc groups can be subregional and provide direct support and increase expert/stakeholder involvement with the work carried out within the permanent groups
- Projects within the HELCOM core budget & externally funded projects

Examples of current projects

- BalticDataFlows 2020-23 – FI, SE, LV and ICES
  - enhancing sharing and harmonisation of data on the marine environment from existing monitoring programmes, moving towards service-based data sharing
  - Open datasets are made available

Baltic DataFlows

Co-financed by the Connecting Europe Facility of the European Union

- BLUES - HELCOM biodiversity, litter, underwater noise and effective regional measures for the Baltic Sea 2021-23 – DE, EE, FI, LV, LT, SE
  - biodiversity, marine litter and underwater noise
  - support development of new and regionally coordinated measures addressing pressures
  - back assessments of the state of the sea through improved monitoring and indicators
  - Supporting the HOLAS III

BLUES

Co-funded by the European Union

Small projects

- Holistic Action Plan – Hazardous substances (HAPhazard) 2022-24
  - NEFCO BSAP Fund co-funding
  - Project researcher to support BSAP action HL1 implementation
- BALLOONS 2022 - Phasing out the intentional releases of inflated balloons as well as considering phasing out confetti outdoors
  - SE, DK co-funding
  - Contracted work from KIMO International to support RAP Marine Litter action RL13, RL14

Other important subregional work…

- Input directly to the WG and EG work from HELCOM Observers
  - interest organisations, NGOs, networks

- Local implementation of regional commitments
  - 2021 BSAP, RAP Marine Litter and Underwater Noise
  - Roadmaps, Recommendations, Guidelines... To national guidance documents, training systems or support shemes
  - Regions, municipalities, ports, farmers and their subregional/national cooperation

…Other important subregional work

- Processes and bilateral agreements building towards regional work
  - transnational research
  - joint piloting, innovation competitions
  - sectorwise development of methods or technologies
  - co-development via networking like the *Baltic Sea Challenge*
- Also via projects
  - *WaterDrive* in rural water management > Policy brief, support to BSAP implementation in actions within agriculture
  - *BSR WATER* platform for stormwater management > Policy briefs, revision of a HELCOM Recommendation 23/5
  - *BALTICITIES* kicking off tomorrow?

Implementation of the 2021 BSAP

- The actions have:

individual target years

been identified as supporting action or measure

been linked to relevant pressures and activities

been assigned one or several HELCOM bodies responsible for taking the work on the action forward

been dedicated criteria for achievement

...and the level of implementation of each action has been identified as national or joint.

Tracking progress

Tracking progress of implementation:

HELCOM Explorer (2025 and 2029)

Tracking effect of implementation:

HELCOM joint monitoring

HELCOM indicators

HELCOM assessments


HELCOM

Science Forum and BALTICITIES Kick off meeting
30 November -01 December 2022, Helsiki (Finland

NATURAL AND ANTHROPOGENIC FACTORS IMPACT ON THE USE OF THE SANDY BEACHES IN KLAIPĖDA MUNICIPALITY

Kelpšaitė-Rimkienė, L., Baltranaitė, E., R., Šakurova, I. & Kondrat, V.

loreta.kelpsaite-rimkiene@ku.lt

Marine Research Institute, Klaipėda University, Lithuania

INTRODUCTION


Lithuania, © T.Ruginis


Poland, © LKR

South Baltic Region (© E. Jurkus [12]);


Sweeden © G.Kazelskis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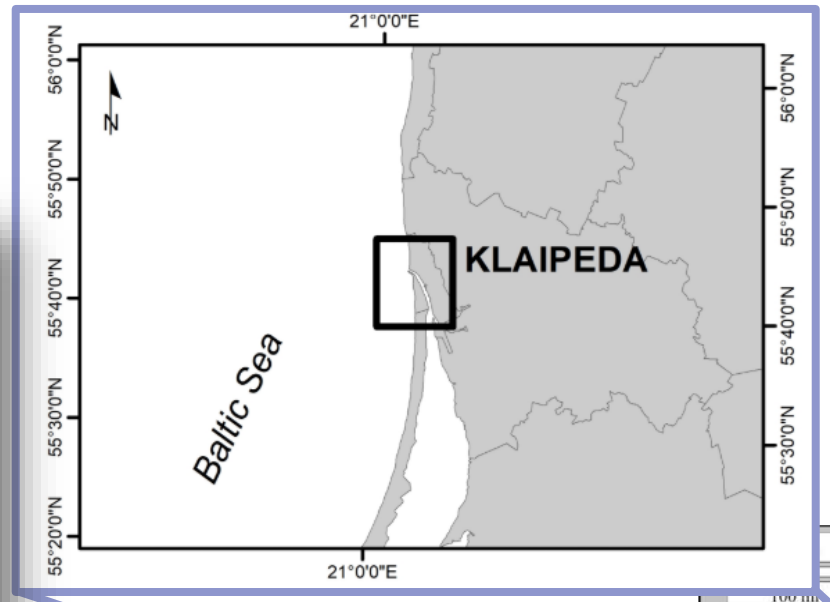
Latvija, © LKR

Helsiki (Finland

HOW TO?...



To identify and substantiate significant physical geographical factors & socioeconomical factors impacting the sustainability of South Baltic coastal resorts.

South Baltic Region (© E. Jurkus [12]);

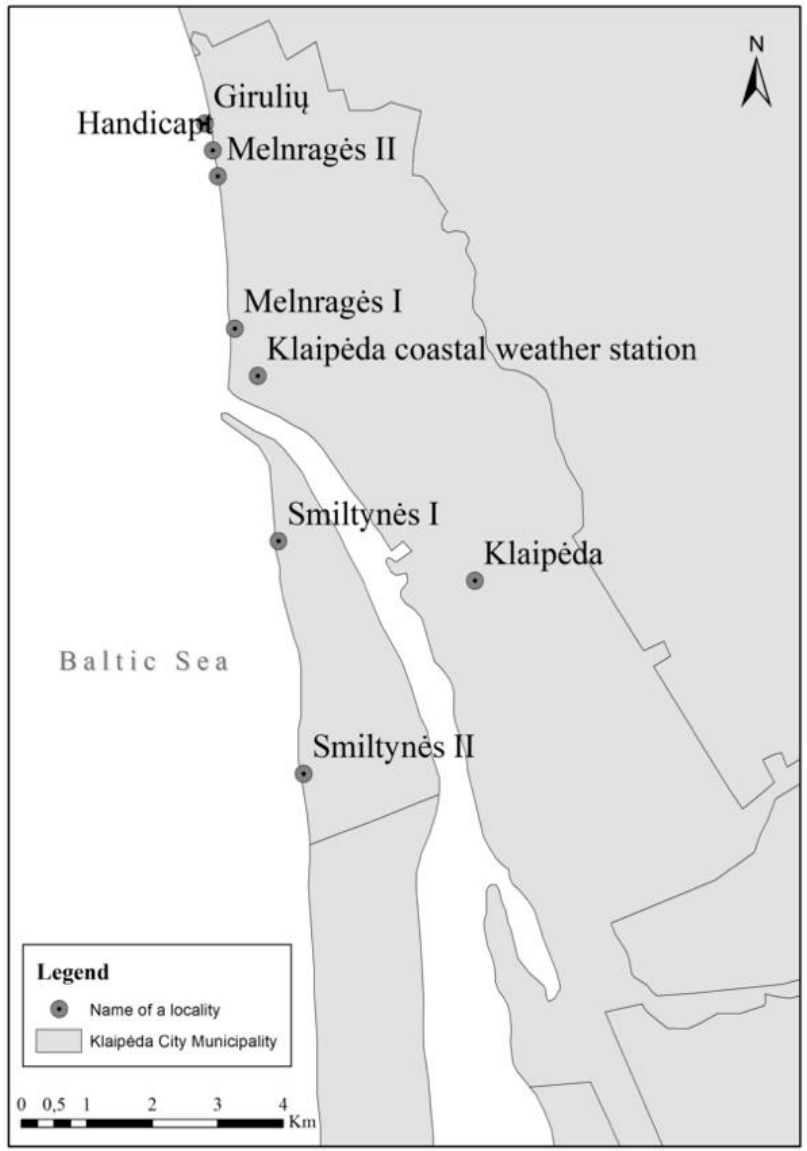
SANDY COASTS OF KLAIPEDA


Melnaragė I, © VK


Handicap, © EB


Melnaragė II, © EB


Smiltinė, © EB



PORT OF KLAIPĖDA

- ✓ KNOWN FROM 1252;
- ✓ LOCATED SE COAST OF THE BS, IN THE STRAIT OF KLAIPĖDA;
- ✓ 12 KM LONG, 1.5 KM WIDE INLET;
- ✓ SEPARATES CURONIAN SPIT AND MAINLAND COAST;
- ✓ WIDTH OF THE FREE-FLOWING PART OF KLAIPĖDA STRAIT IS 0.4 KM;
- ✓ LAST RECONSTRUCTION IN 2002, PROLONGED ENTRANCE CANAL.

LAST RECONSTRUCTION OF PORT PIER

METHODS

Analysis of cartographical & bathymetrical data

Were evaluated shoreline position changes for 35 years 1984–2019:

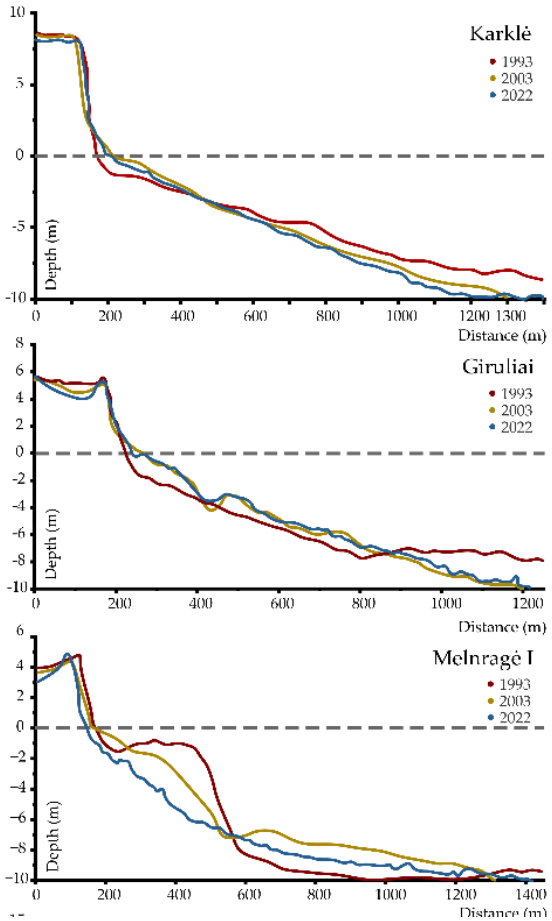
- ✓ T-Sheets (1984, 1990);
- ✓ Orthophotos (1995, 2005);
- ✓ GPS survey data (2010, 2015, 2019);
- ✓ Cross-shore profiles changes & ΔV.

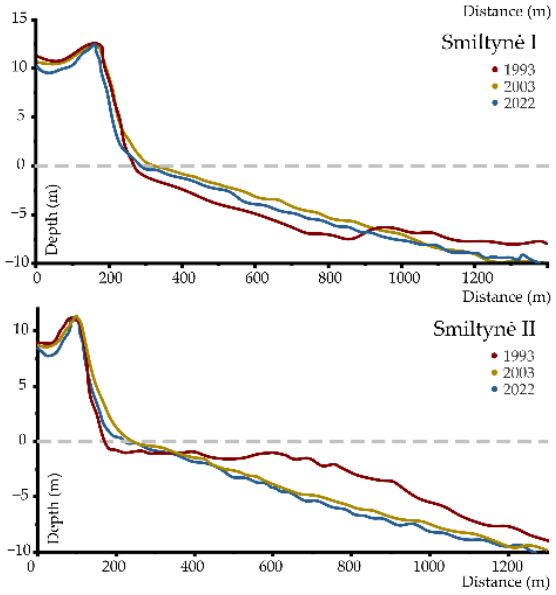
Shoreline changes rates detection

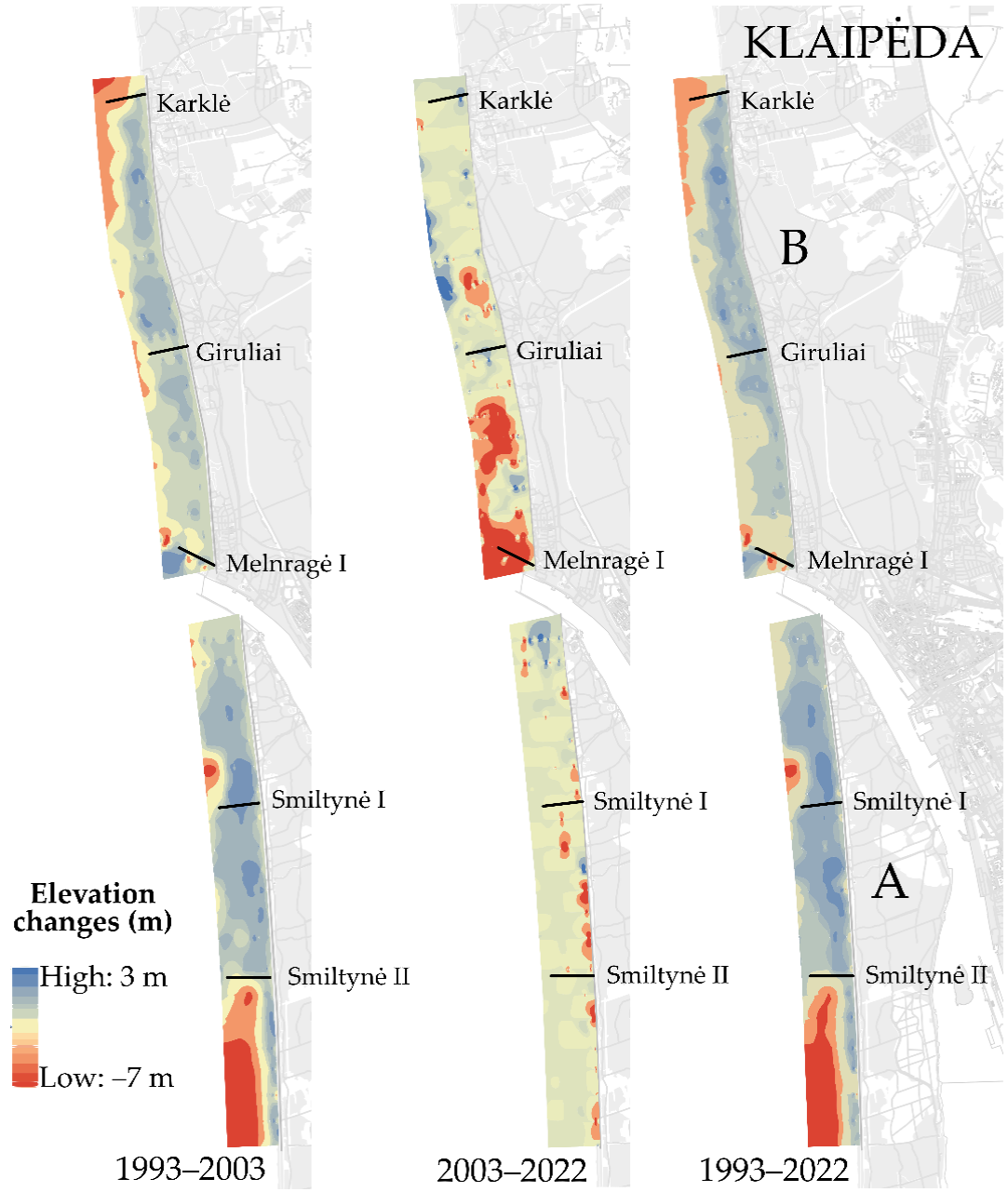
ArcGIS → DSAS v. 5.0

NSM - net shoreline movement;
EPR - end point rate;
SCE - shoreline change envelope.

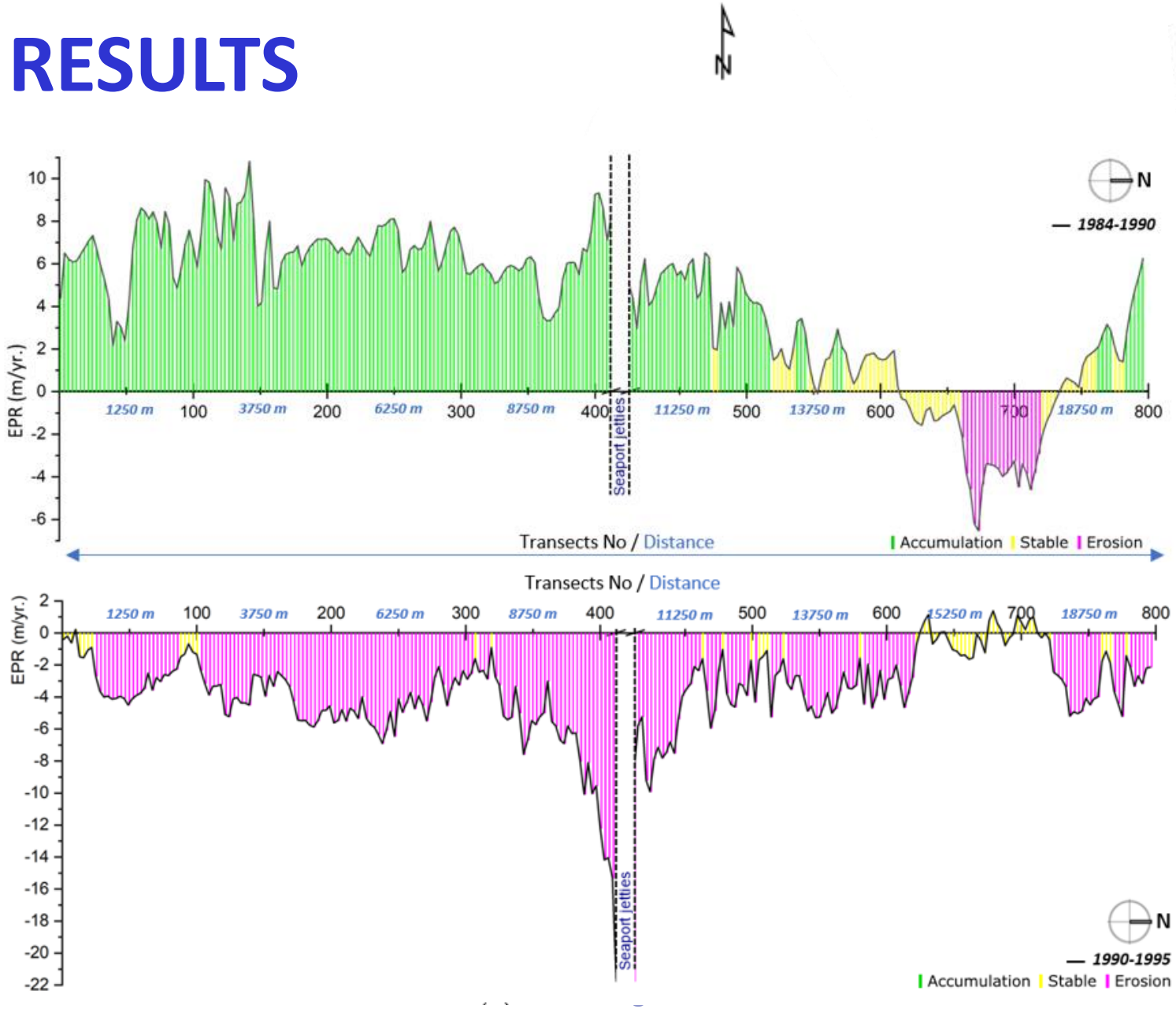
RESULTS

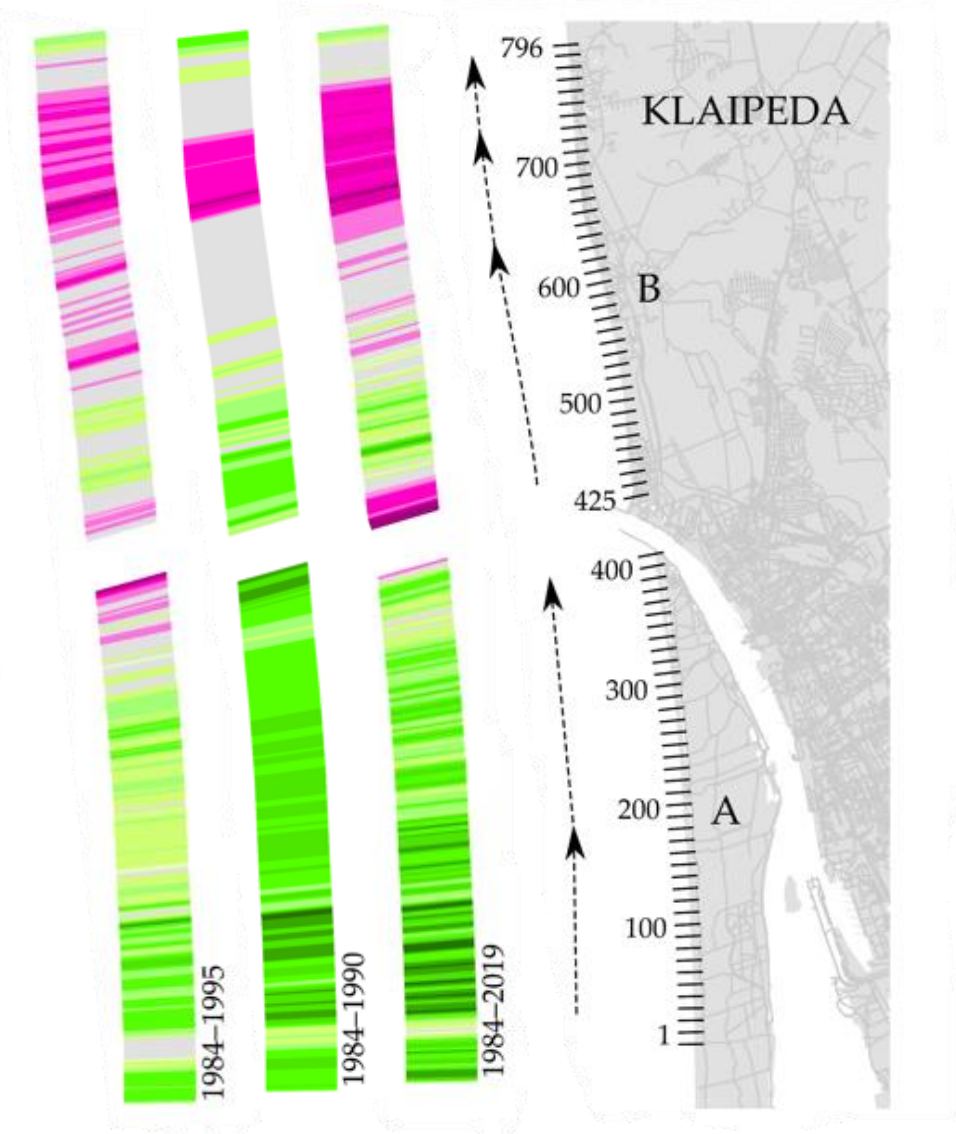

Karklė
1993
2003
2022
Depth (m)
Distance (m)
Giruliai
1993
2003
2022
Depth (m)
Distance (m)
Melnragė I
1993
2003
2022
Depth (m)
Distance (m)


Distance (m)
Smiltynė I
1993
2003
2022
Depth (m)
Distance (m)
Smiltynė II
1993
2003
2022
Depth (m)
Distance (m)

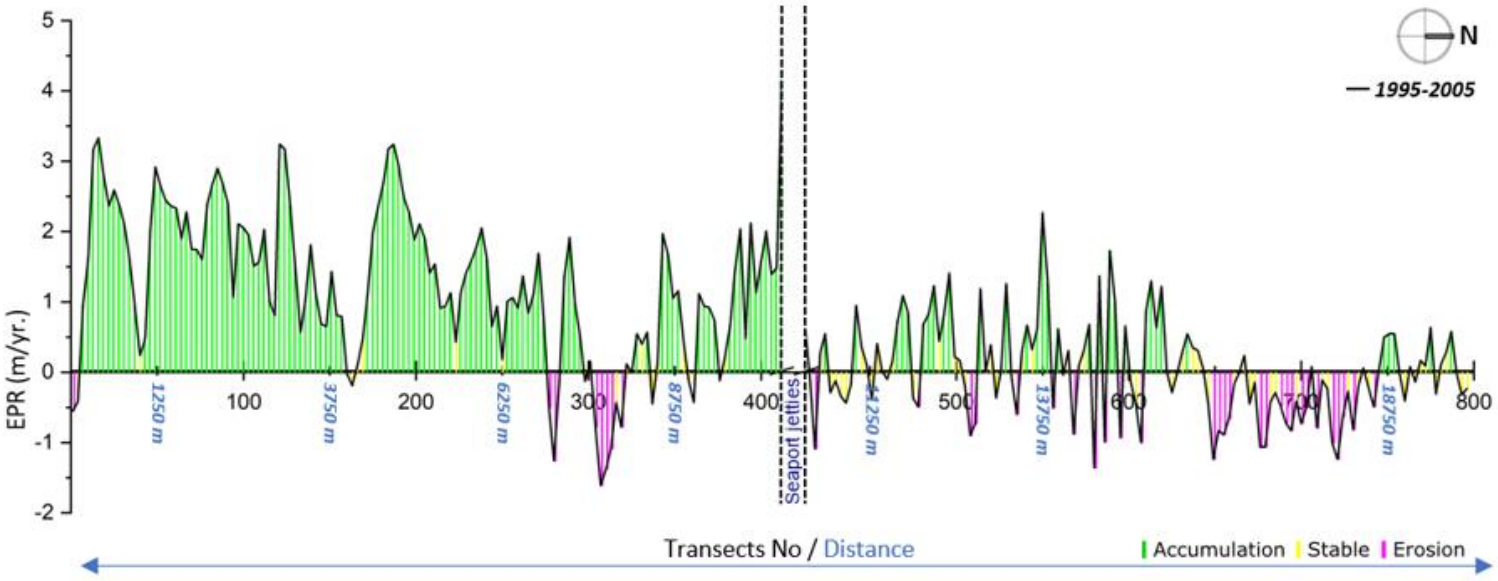

KLAIPĖDA
Karklė
Giruliai
Melnragė I
Smiltynė I
Smiltynė II
B
A
Elevation changes (m)
High: 3 m
Low: –7 m
1993–2003
2003–2022
1993–2022

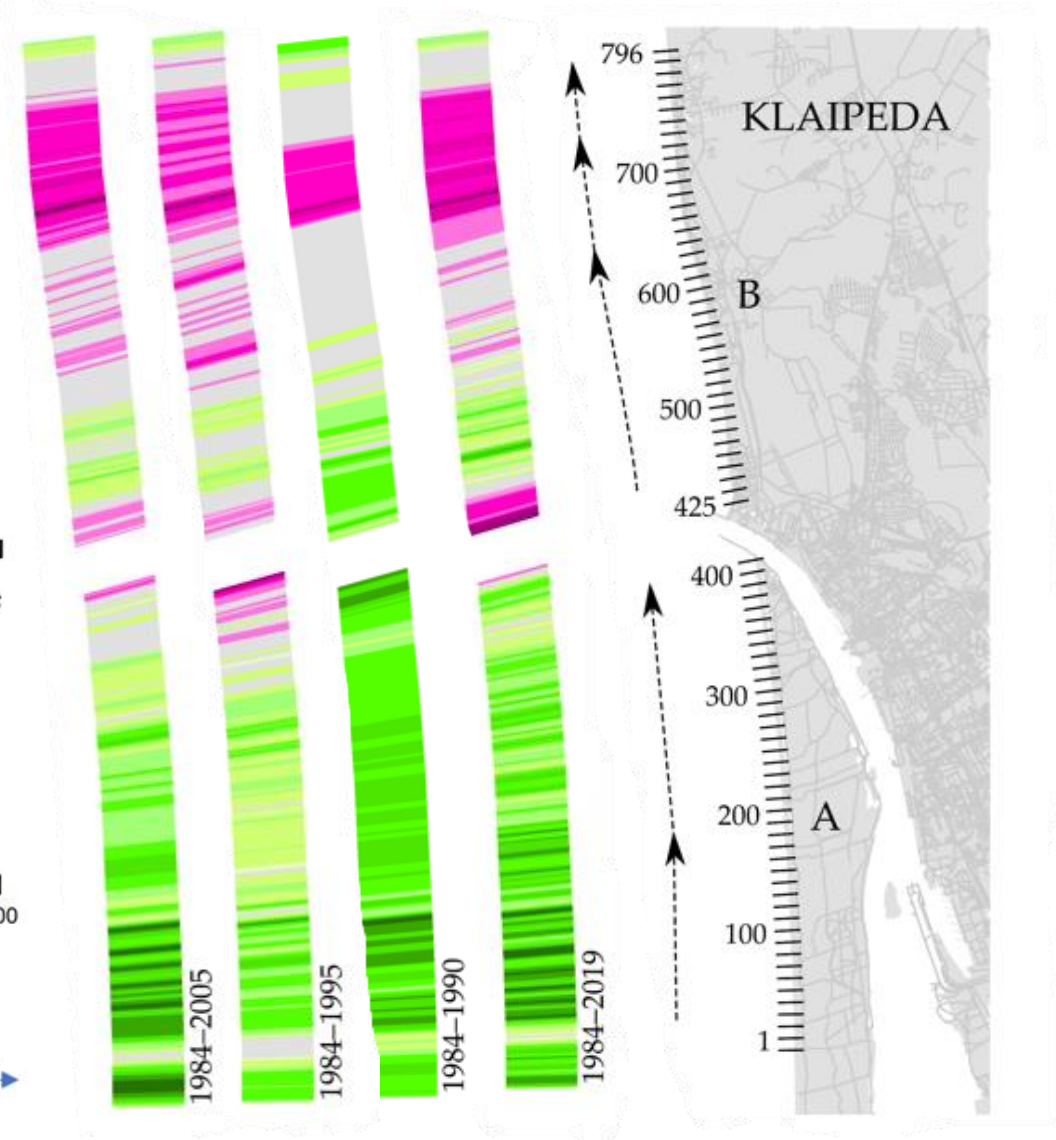
RESULTS


N
— 1984-1990
EPR (m/yr.)
10
8
6
4
2
0
-2
-4
-6
1250 m
100
3750 m
200
6250 m
300
8750 m
400
Seaport Jetties
11250 m
500
13750 m
600
700
18750 m
800
Transects No / Distance
Accumulation
Stable
Erosion
Transects No / Distance
EPR (m/yr.)
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
1250 m
100
3750 m
200
6250 m
300
8750 m
400
11250 m
500
13750 m
600
15250 m
700
18750 m
800
Seaport Jetties
N
— 1990-1995
Accumulation
Stable
Erosion

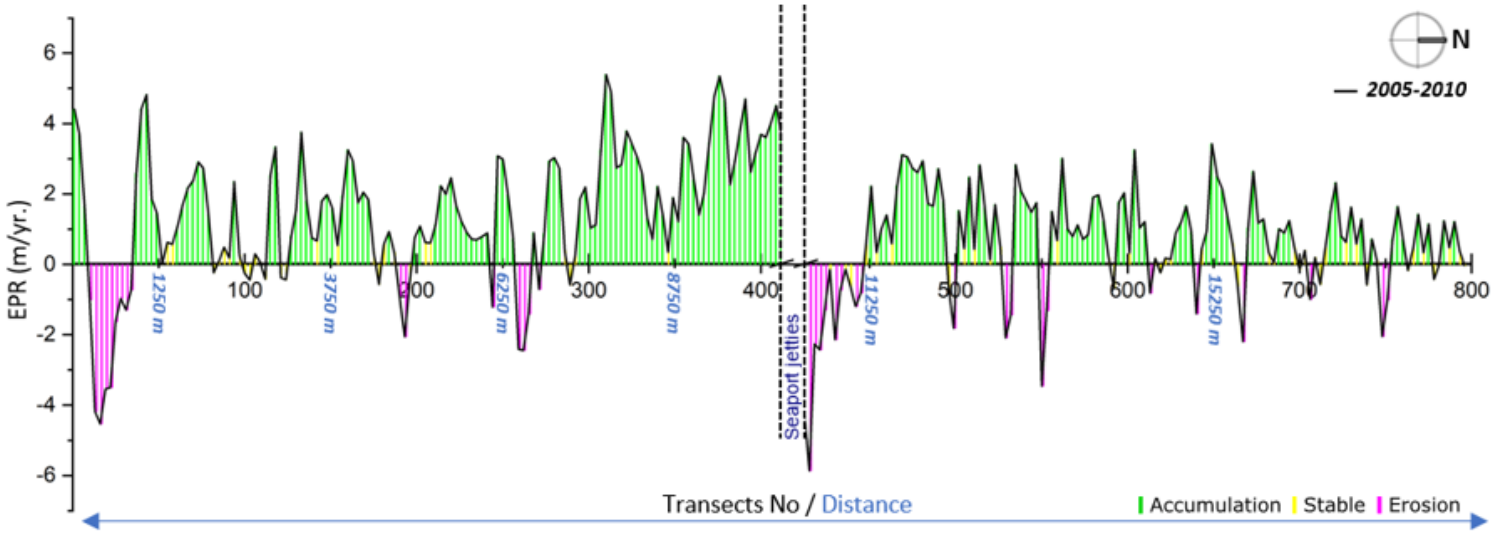

796
700
600
500
425
400
300
200
100
1
KLAIPEDA
B
A
1984–1995
1984–1990
1984–2019

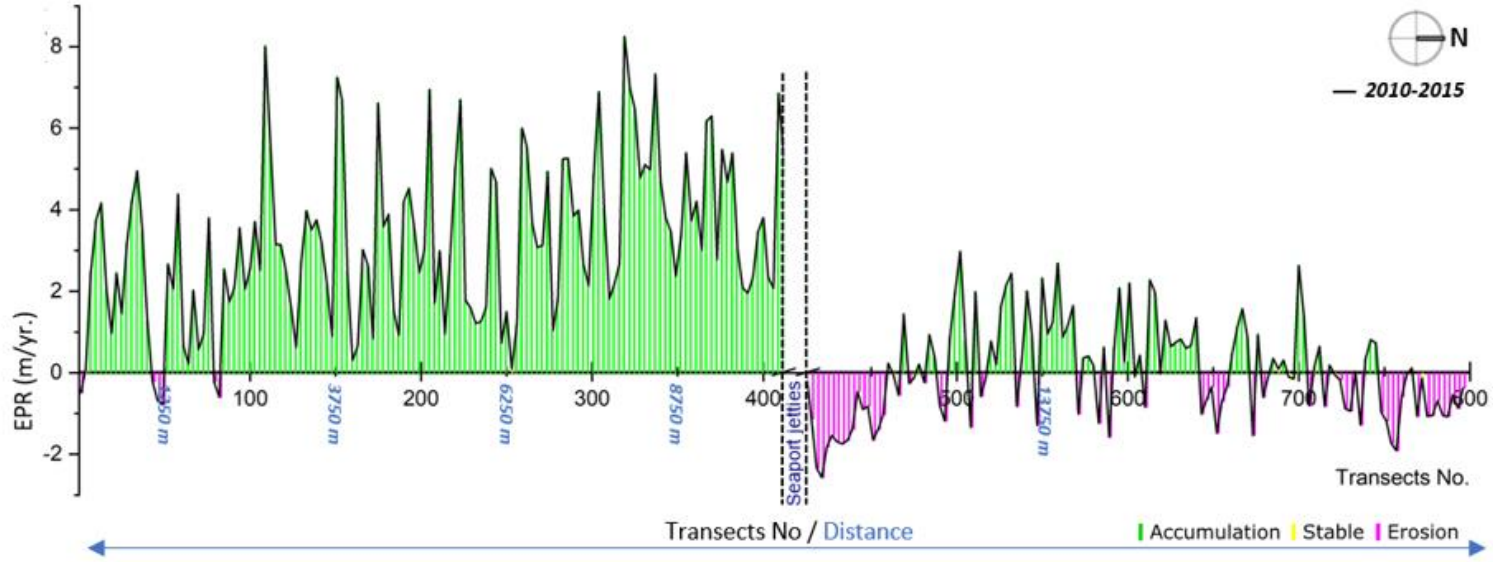
RESULTS

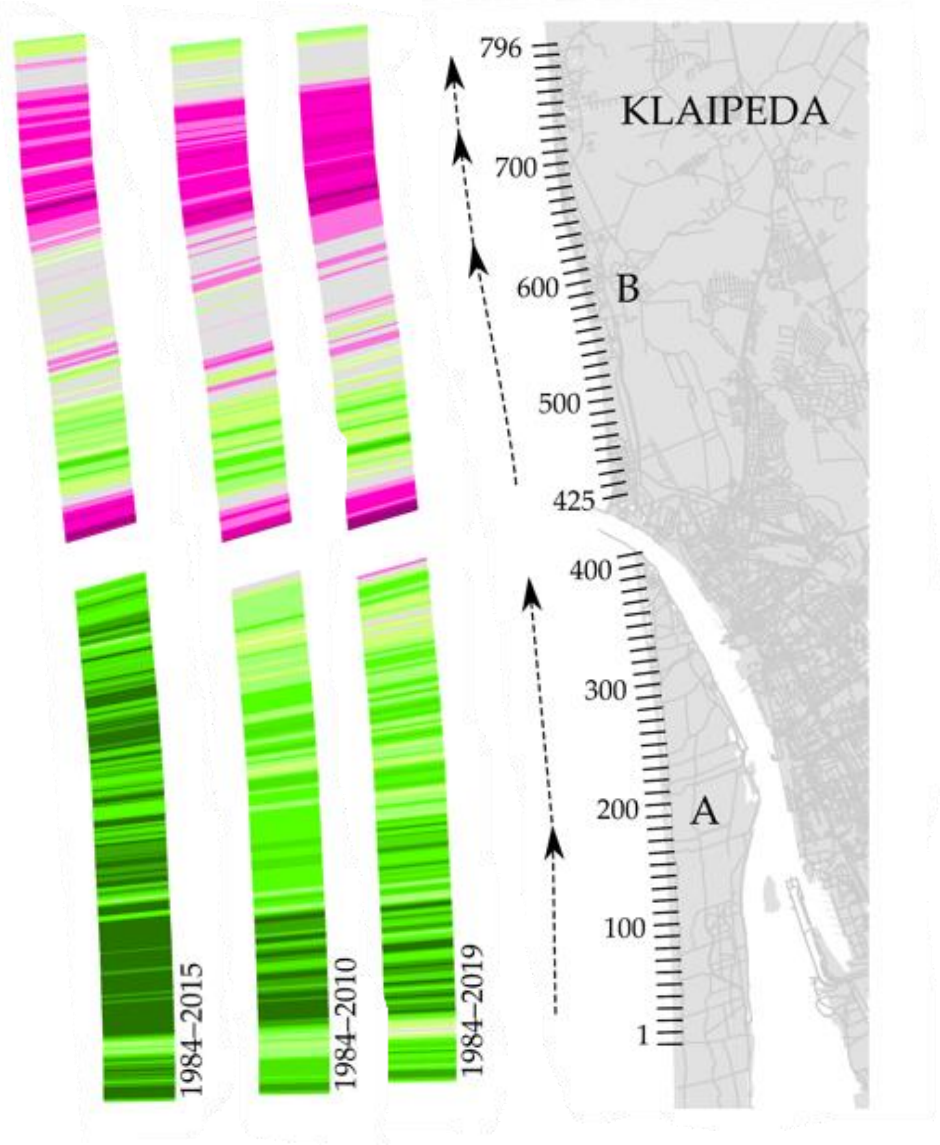

N
— 1995-2005
EPR (m/yr.)
5
4
3
2
1
0
-1
-2
100
200
300
400
500
600
700
800
1250 m
3750 m
6250 m
8750 m
Seaport jetties
11250 m
13750 m
18750 m
Transects No / Distance
Accumulation
Stable
Erosion


KLAIPEDA
796
700
600
500
425
400
300
200
100
1
B
A
1984–2005
1984–1995
1984–1990
1984–2019

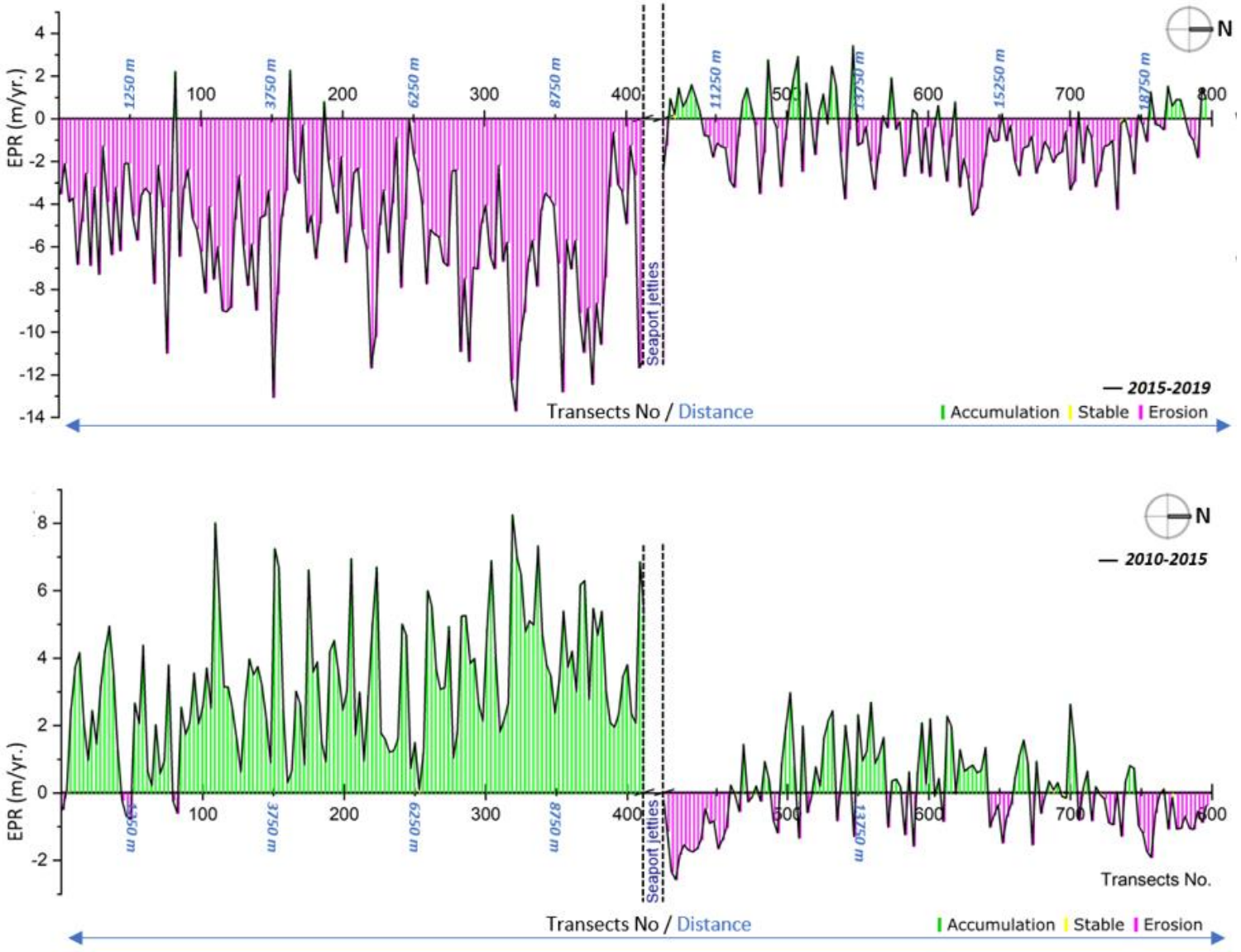
RESULTS

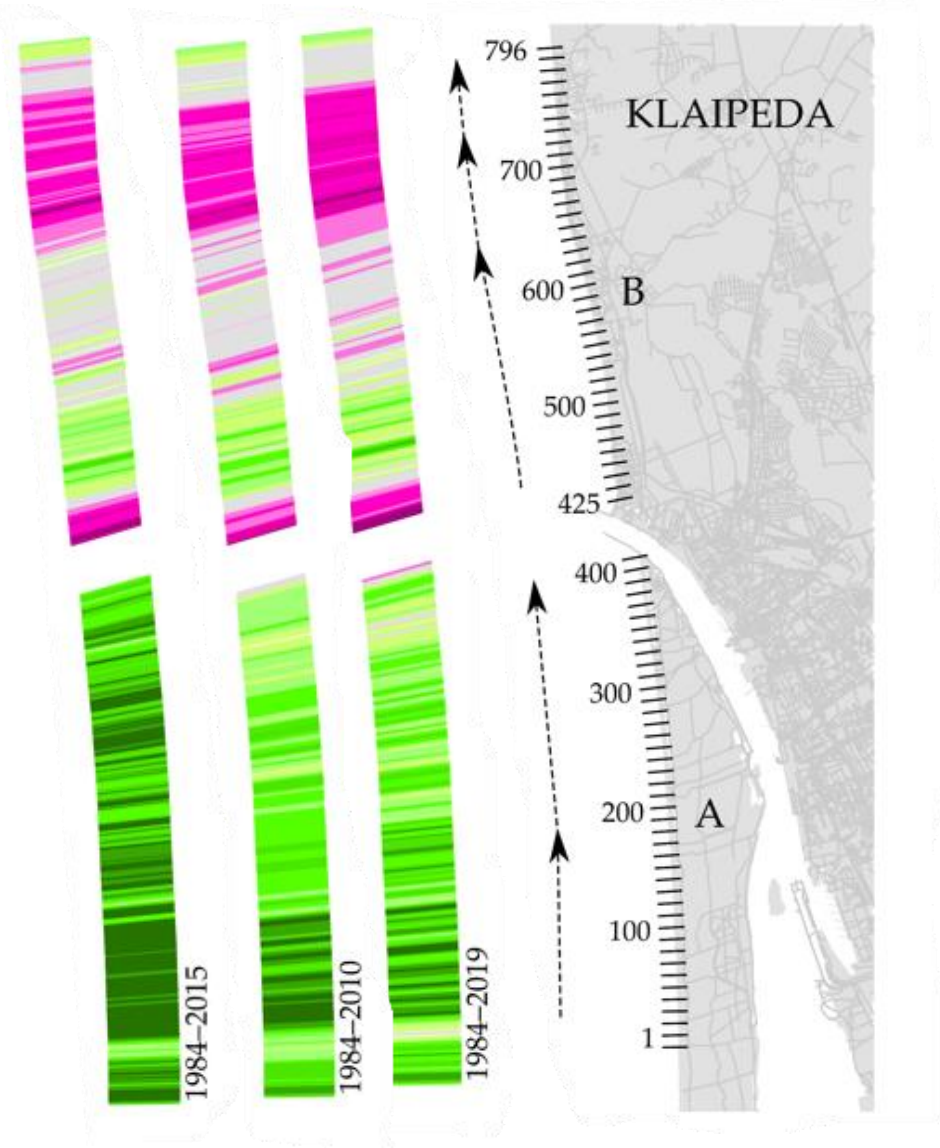

N
— 2005-2010
EPR (m/yr.)
6
4
2
0
-2
-4
-6
100
200
300
400
500
600
700
800
1250 m
3750 m
6250 m
8750 m
11250 m
13750 m
15250 m
Seaport jetties
Transects No / Distance
Accumulation
Stable
Erosion


N
— 2010-2015
EPR (m/yr.)
8
6
4
2
0
-2
100
200
300
400
500
600
700
800
1250 m
3750 m
6250 m
8750 m
13750 m
Seaport jetties
Transects No.
Transects No / Distance
Accumulation
Stable
Erosion


KLAIPEDA
796
700
600
500
425
400
300
200
100
1
B
A
1984–2015
1984–2010
1984–2019

RESULTS


EPR (m/yr.)
1250 m
3750 m
6250 m
8750 m
11250 m
13750 m
15250 m
18750 m
Seaport jetties
N
— 2015-2019
Transects No / Distance
Accumulation
Stable
Erosion
— 2010-2015
Transects No.


KLAIPEDA
796
700
600
500
425
400
300
200
100
1
B
A
1984–2015
1984–2010
1984–2019

METHODS

Basic steps of the Bayesian analysis:

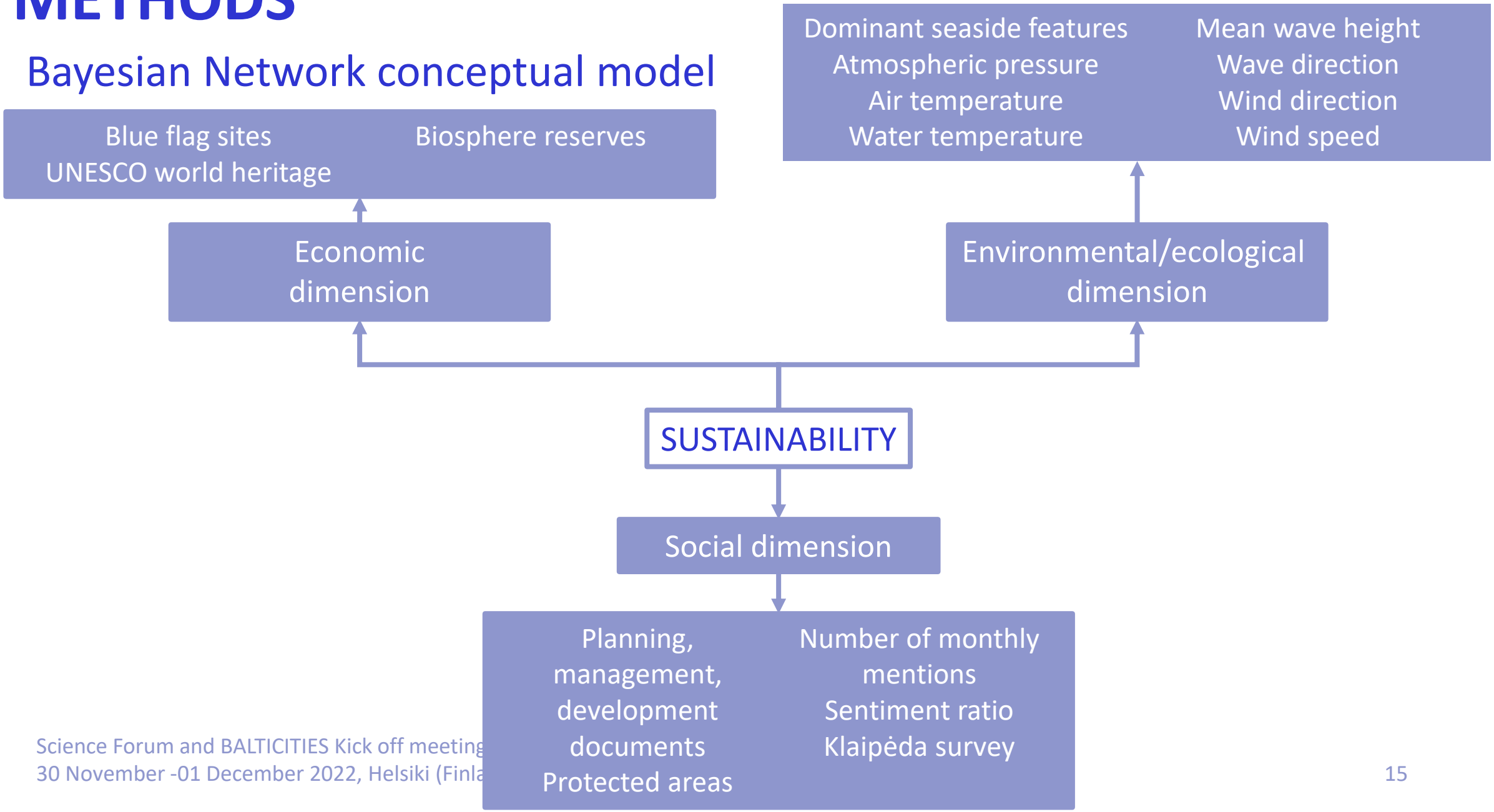
Quantifying current beliefs via a prior distribution;

Quantifying information provided by new data via the likelihood;

Using Bayes' Theorem to update beliefs and form the posterior distribution

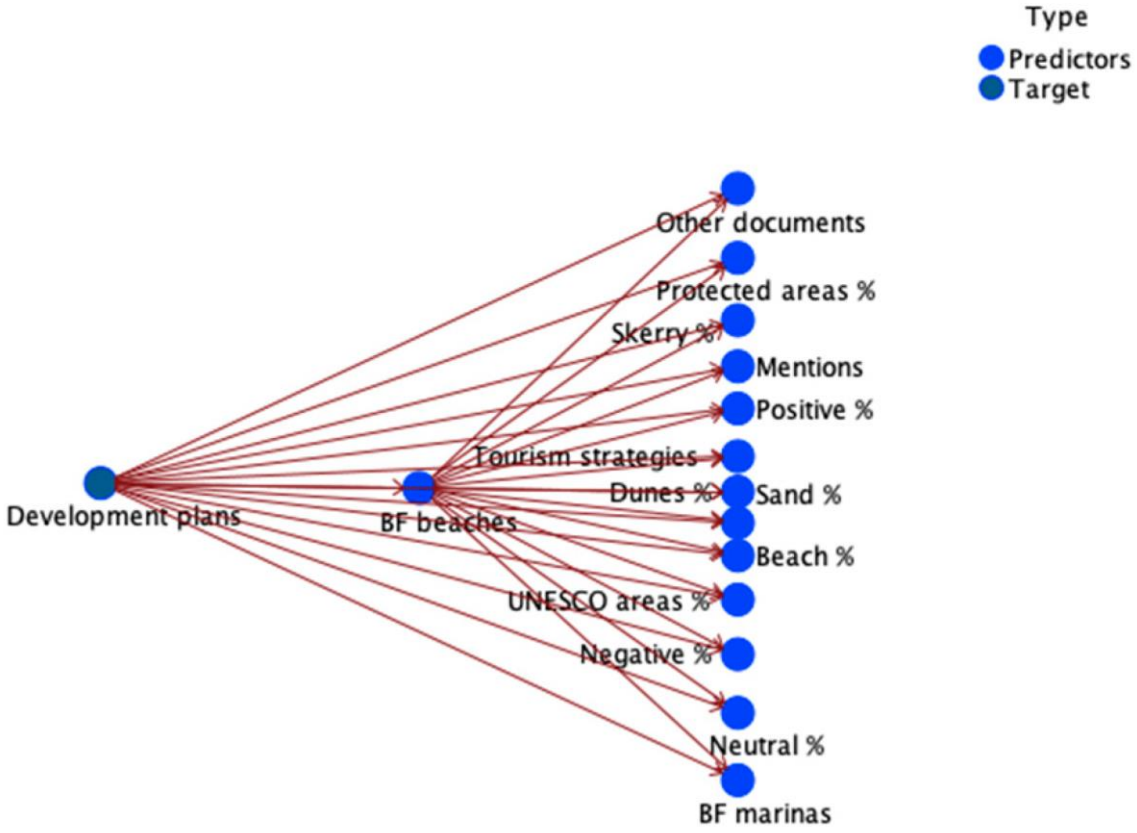
METHODS

Bayesian Network conceptual model

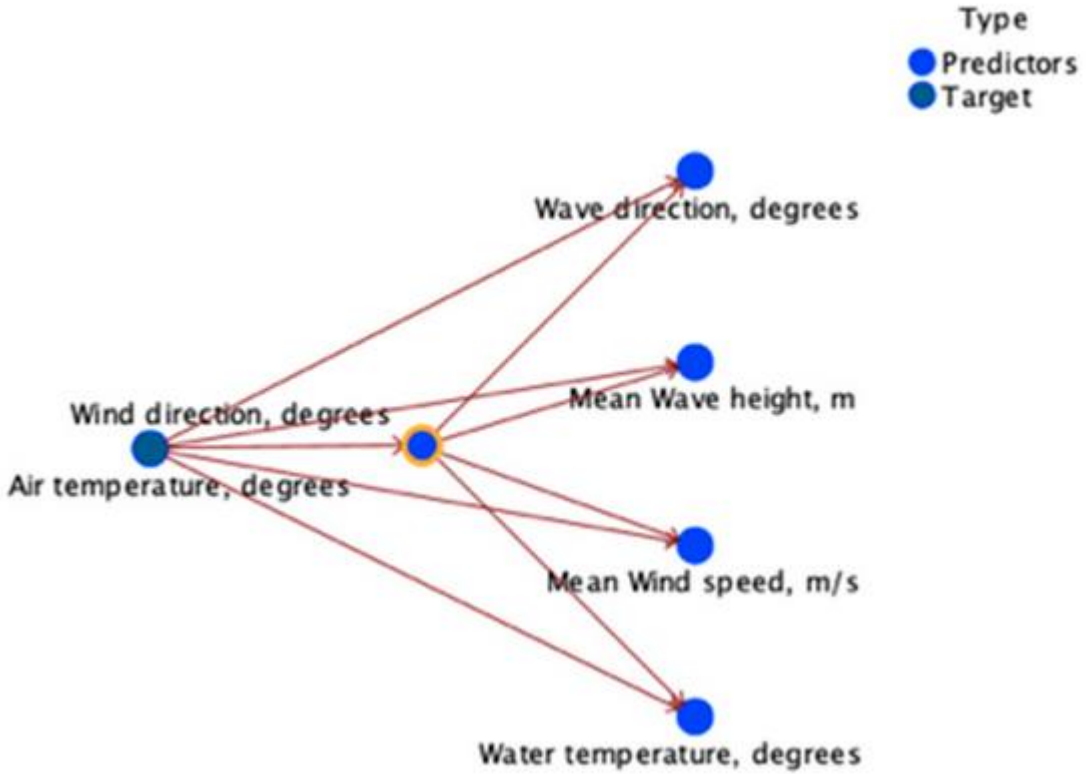


RESULTS

South Baltic data



Hydrometeorological data;



RESULTS

SUMMARY

- Air temperature and wind direction were shown to be of greater importance in relation to other physical geographical factors;
- Beach for the recreation – most important predictor: distance to the beach;
- In the off-season, the highest conditional probability was shown in the Melnragės I and Girulių beaches, as well as other, nonofficial beaches;
- The existence of a Blue Flag award was a significant predictor concerning development plans;
- The presence of sandy beaches and dunes were shown to be the highest influential predictors.

CONCLUSIONS

- ✓ Physical geographical affected by factors of the other two pillars of sustainability—the economy and society—than by the system itself;
- ✓ Physical geographical factors such as ***location***, beach type (sandy beaches and dunes), acceptable bathing water temperature, and air temperature play a significant role'
- ✓ Significance of the sandy beaches and dunes is widely reflected in the planning documents at the regional level.

Klaipeda University

EU CONEXUS

ACKNOWLEDGMENT:

BALTIC RESEARCH PROGRAMME (EEA FINANCIAL MECHANISMS 2014-2021) PROJECT "SOLUTIONS TO CURRENT AND FUTURE PROBLEMS ON NATURAL AND CONSTRUCTED SHORELINES, EASTERN BALTIC SEA" (EMP480).

Baltic Sea coasts under the influence of climate change

Science Days for the Gulf of Finland and the eastern Baltic States

Kevin Parnell

Wave Engineering Laboratory

Department of Cybernetics

Tallinn University of Technology

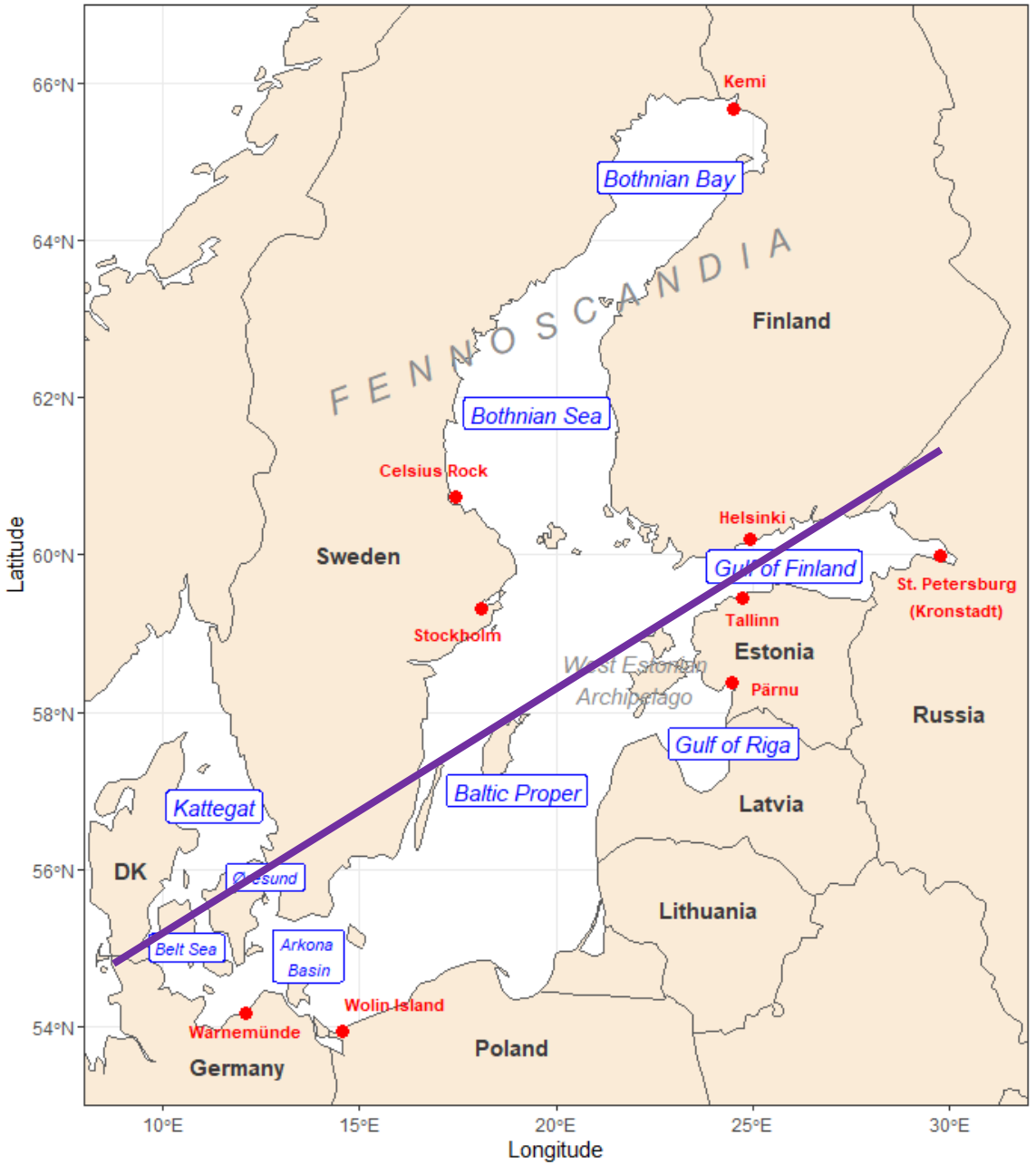
Estonia

Beaches and other coastal landforms will always perfectly adapt to a changing climate

- A natural beach never needs protection from the forces of nature; it is perfectly adapted to cope with anything that is thrown at it. Without the impact of humans, a beach will always be there and in good shape, although after a storm, it might be a different shape or in a new location" (Pilkey and Cooper, 2014, *The Last Beach).*
- That change in shape or location is the problem for society.

Baltic Sea coastal processes and change: A story of two halves.

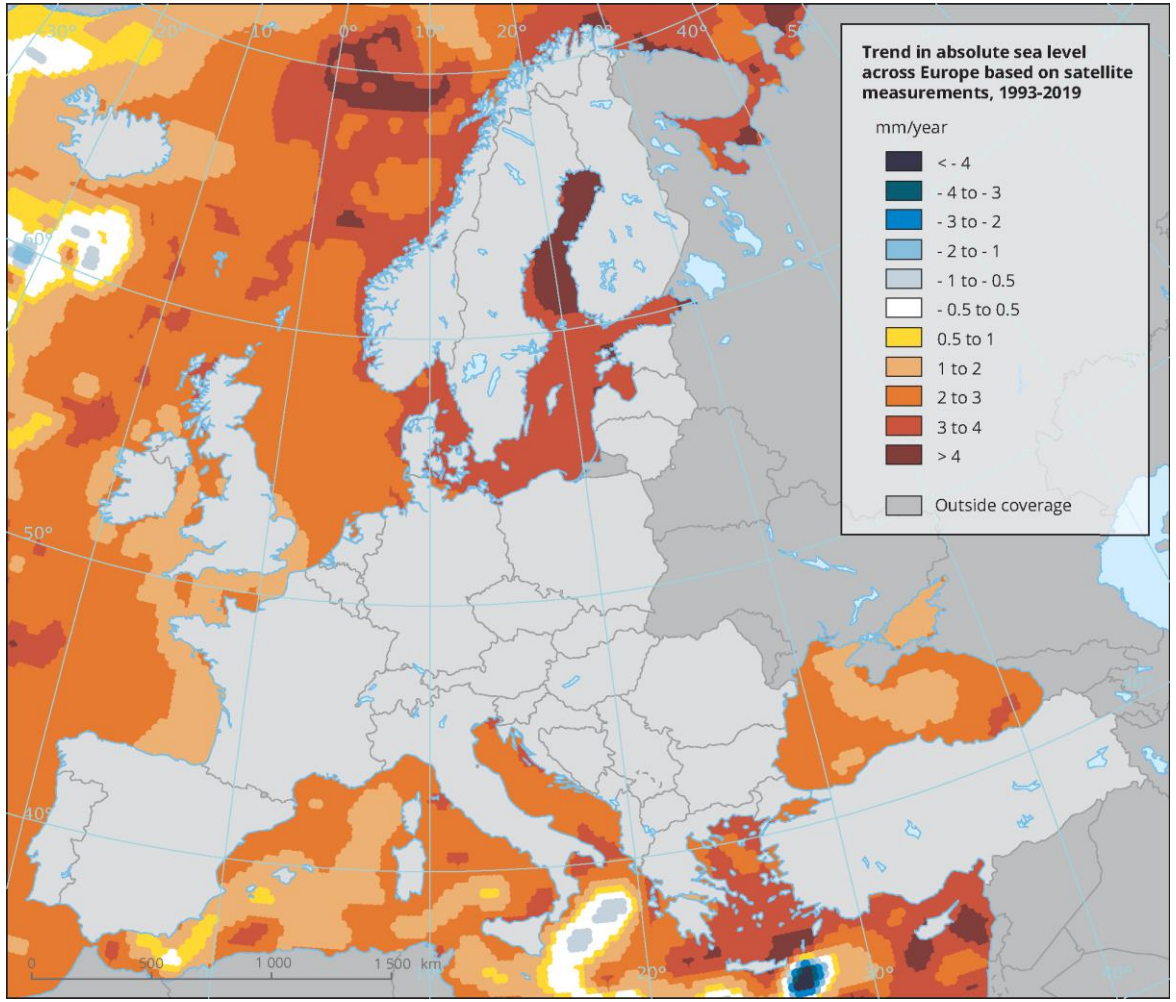
- Absolute sea level
- Relative sea level
- Geology
- Sediment availability
- Exposure to wind (and therefore wave) forcing
- Sediment transport
- Sediment compartment size

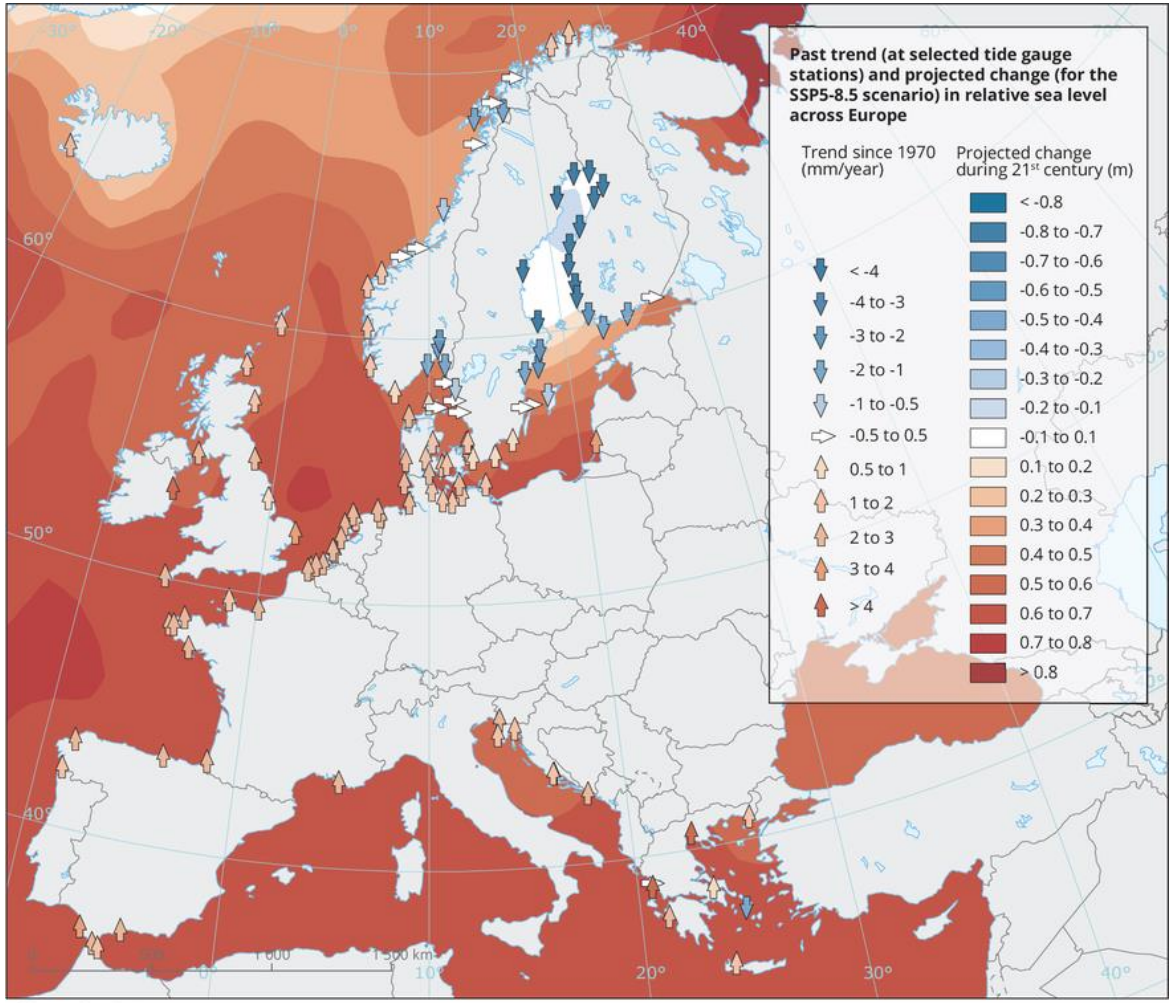


Sea level is the ultimate control

Absolute

Relative

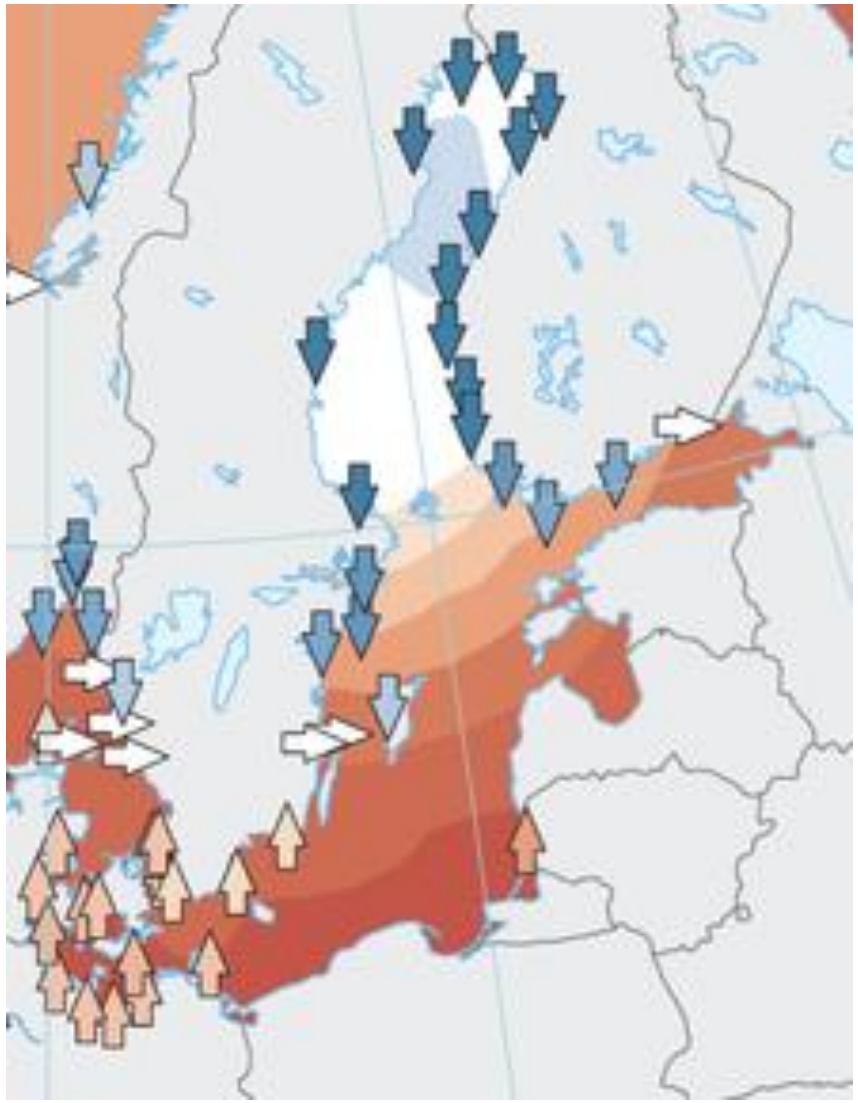


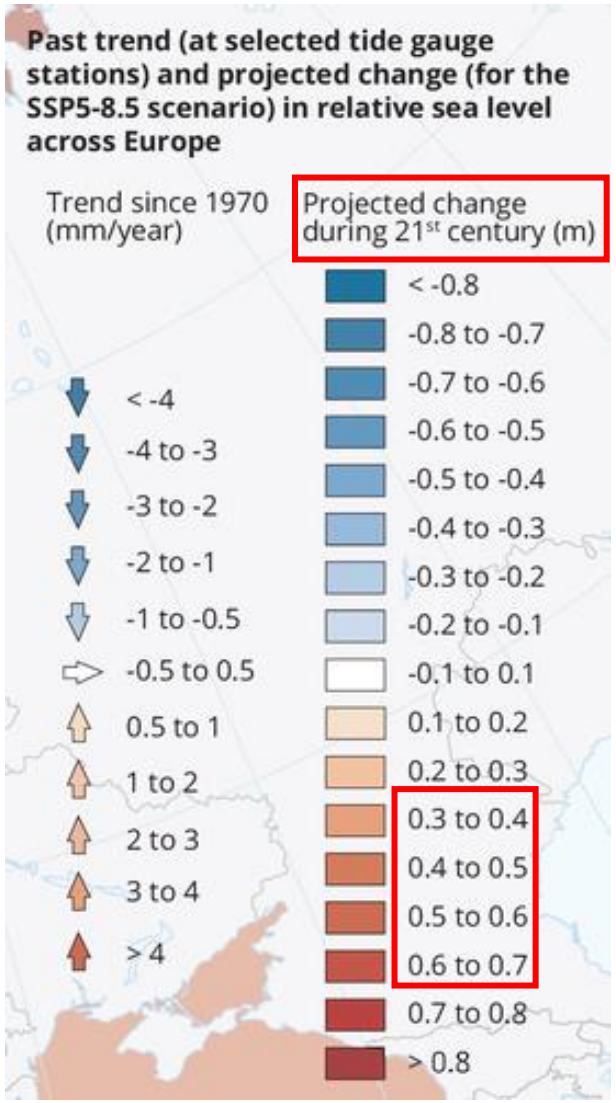


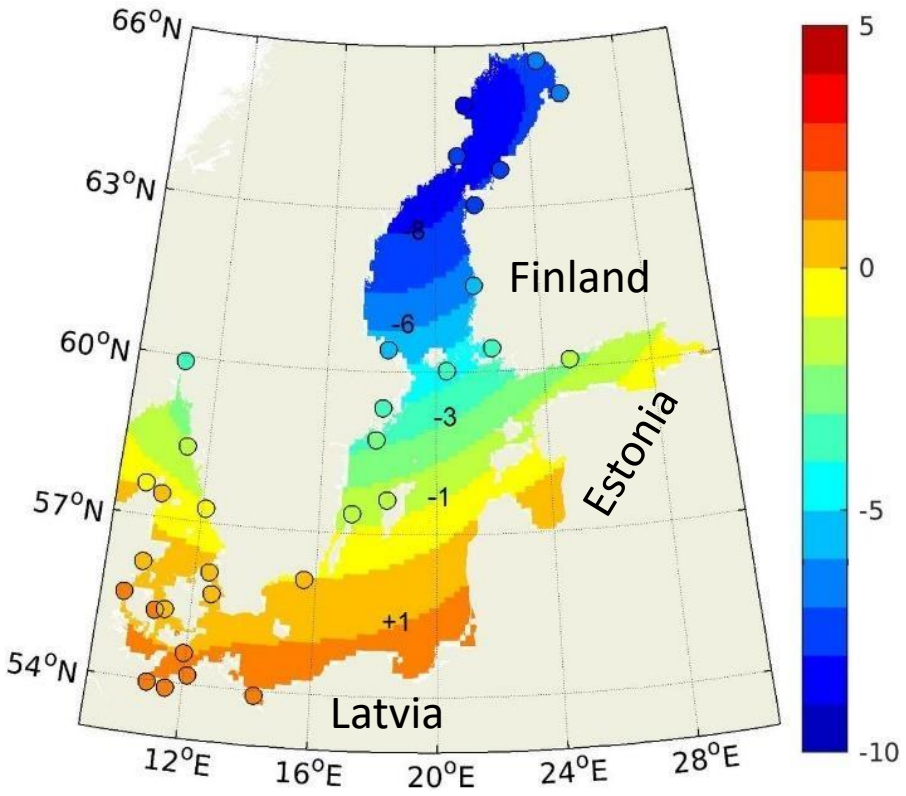
Reference data: ©ESRI

While Absolute Sea Level is important to science and at a global level, Relative Sea Level has application at the coast. The different messages may be confusing to non-specialists.

Relative sea level



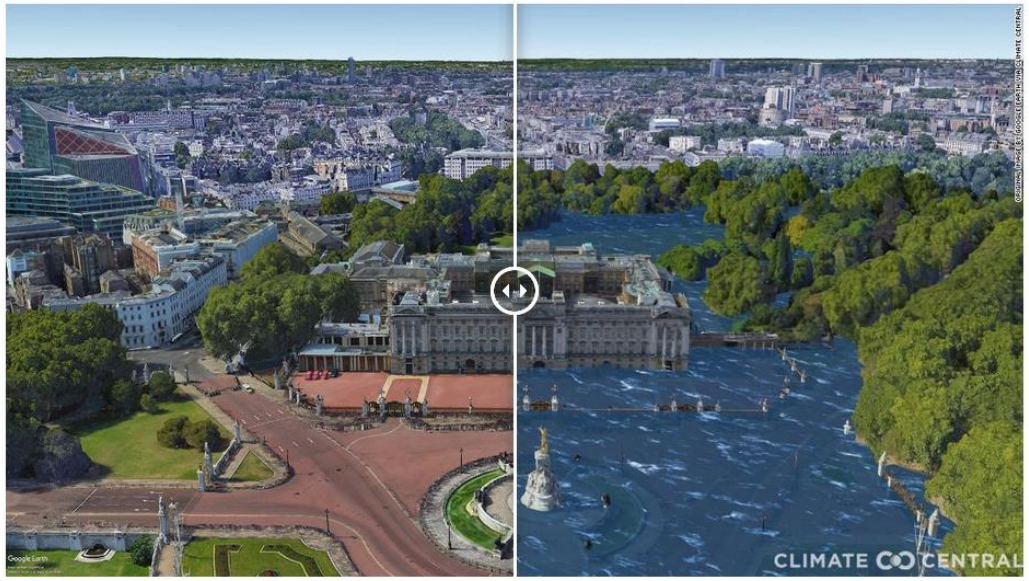




Relative sea level change (mm/yr)
Weisse et al., 2021

- Education has led to ‘the general public’ over-estimating sea level rise (Priestley et al., 2021, PlosOne). This may or may not be a good thing.
- Sea level is often portrayed in terms of a ‘bath-tub’ model but in terms of coastal processes. . .

  . . . sea level rise/change (absolute and relative) is only part (maybe only a small part) of the sea level experience (for coasts and people).
- For coastal processes, other climate-change related drivers (considered on a backdrop of sea-level) are more important, particularly:
  - Water level extremes and shorter term changes in sea level (such as storm surge, wave setup, . . .)
  - Wind and wave energy and direction
  - Sea ice extent and duration (both have decreased, which decreases coastal protection and can modify the distribution of wave approach directions).



How Buckingham Palace in London looks today, and how it might look with sea levels rising from global warming.

Extreme sea levels

- Basin-wide, [in the future] there are no statistically significant, long-term changes in extreme sea levels relative to the mean sea level of the Baltic Sea [expected] (low confidence) (Meier et al. 2022), however . . .
- Some studies show that locally, extreme water levels are increasing (probably due to small changes in wind direction and perhaps changing sea ice conditions) . . .

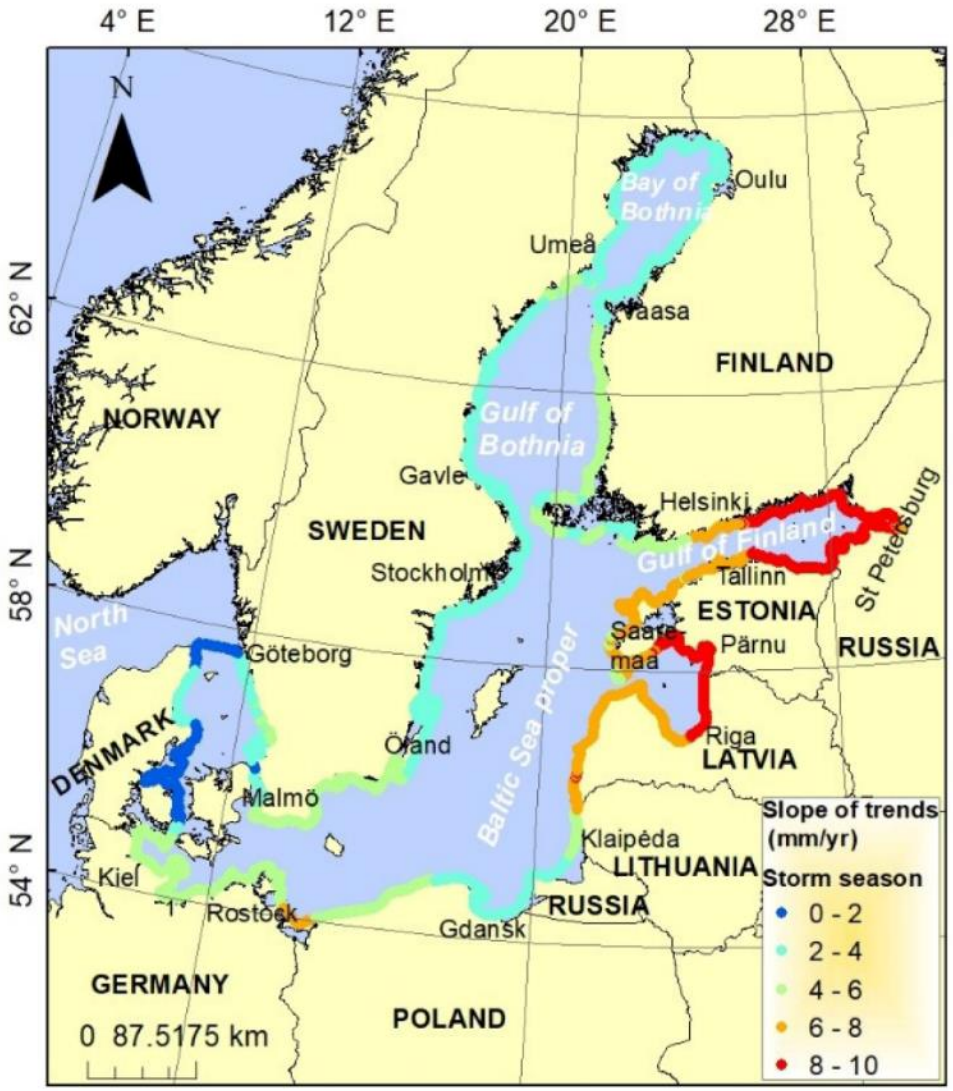


Figure 7. Trends of storm season (from July to June of the subsequent year) maximum water level derived from simulated total water level in 1961–2004/2005. Reproduced from Pindsoo and Soomere (2020) with permission from Elsevier and the authors.

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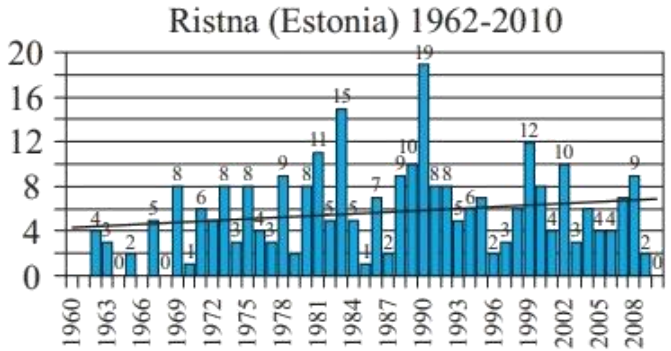
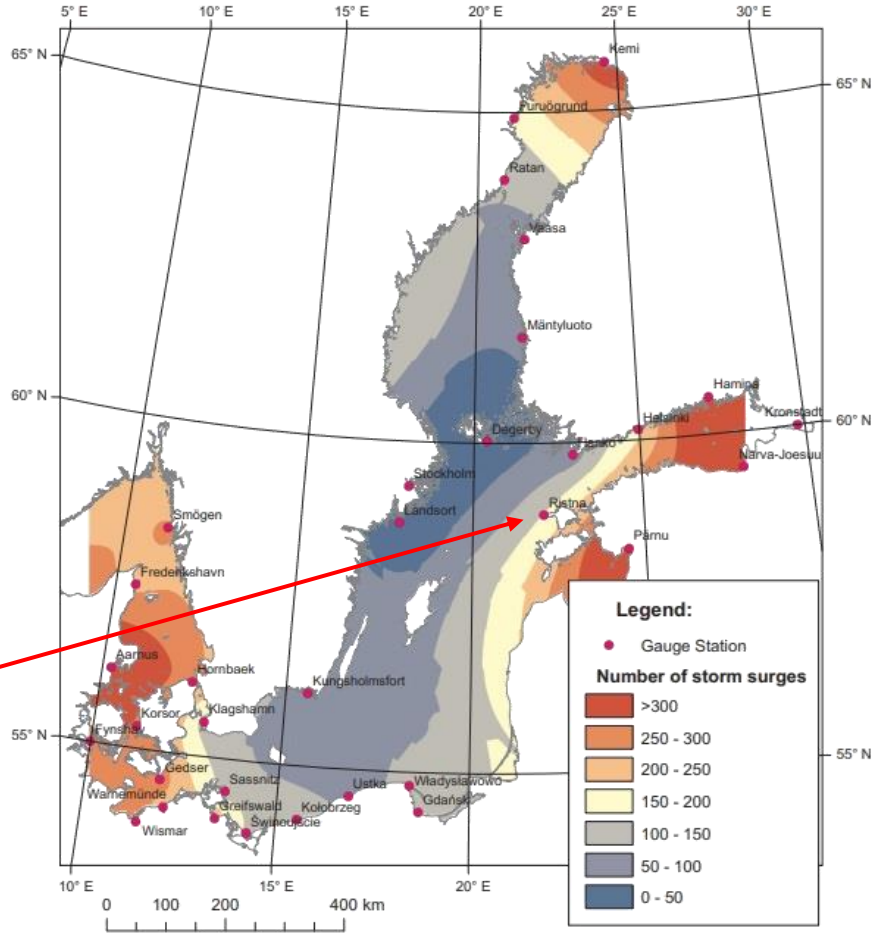


Figure 5. Number of storm surges (maximum of surge ≥ 70 cm above zero NAP) at selected Baltic tide gauge stations

Number of storm surges (maximum surge ≥ 70 cm above zero NAP) on the coasts of the Baltic Sea 1962 - 2010



Tomasz Wolski et al., 2014. Extreme sea levels at selected stations on the Baltic Sea coast. OCEANOLOGIA 56(2):259-290

Extreme sea levels

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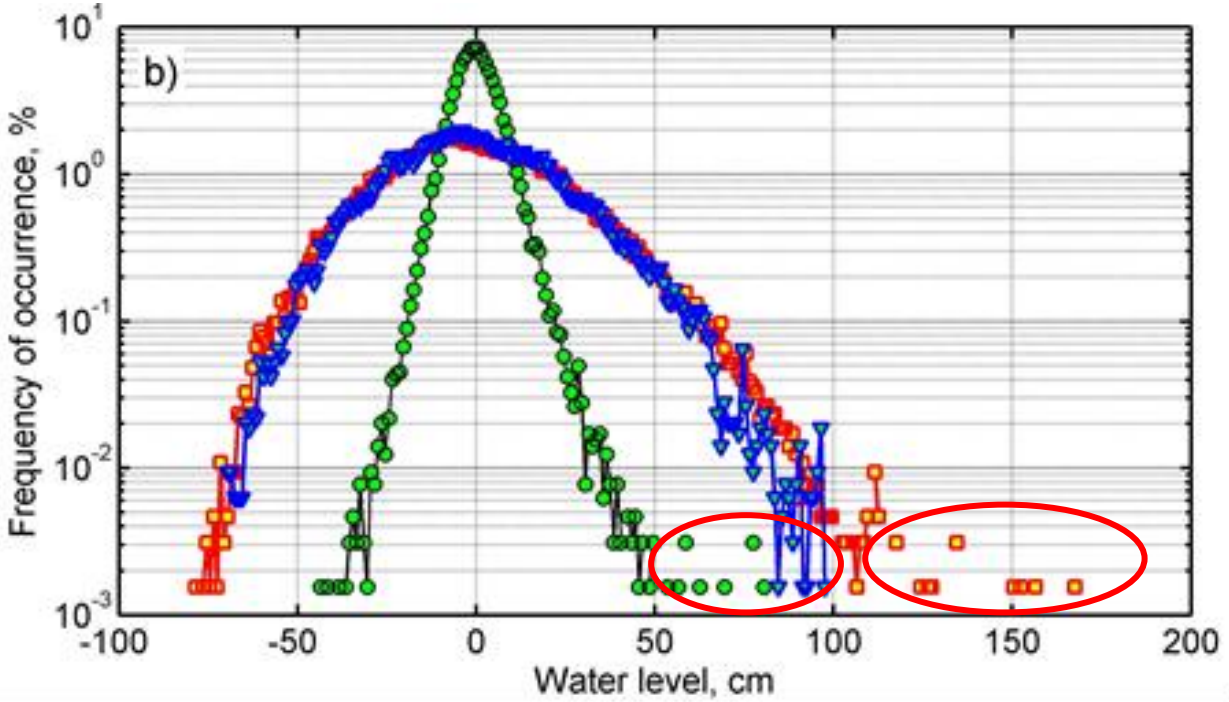
- . . . and maybe occurring more frequently.
- There are examples of extreme sea-levels which are statistically 'almost impossible' outliers.



Water levels near Tallinn. Red: total, blue: Baltic Sea water volume, green: storm surge (Soomere, Eelsalu, Kurkin and Rybin, 2015)

Extreme sea levels

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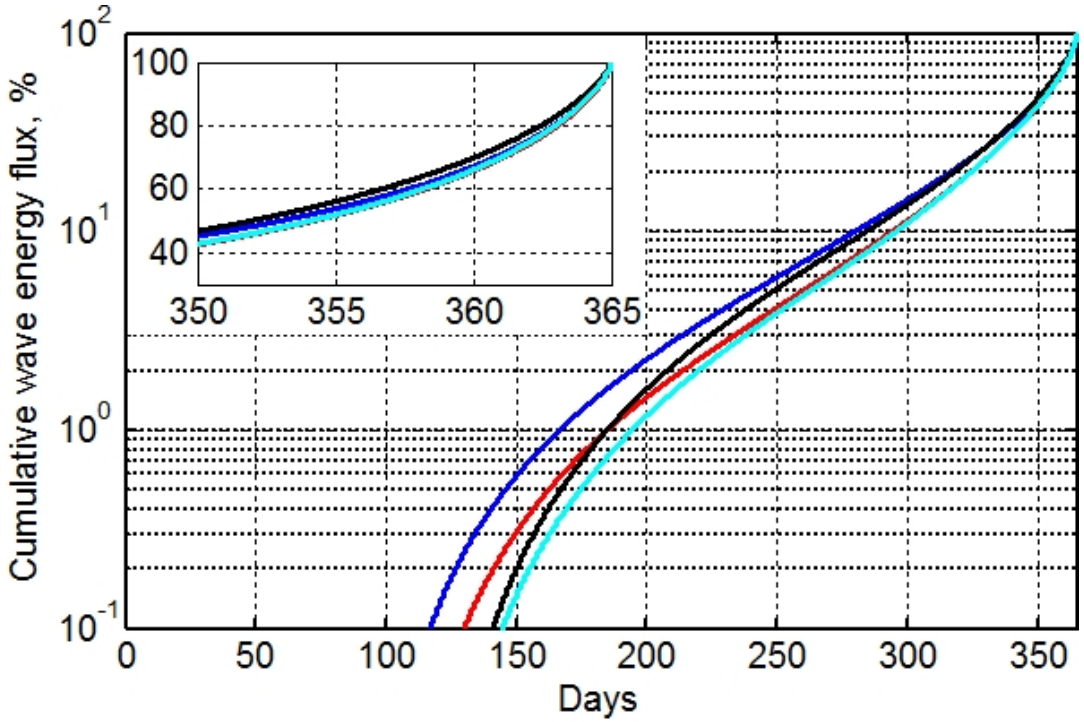
- Some studies show that locally, extreme water levels are increasing (probably due to small changes in wind direction and perhaps changing sea ice conditions) . . .
- . . . and maybe occurring more frequently.
- There are examples of extreme sea-levels which are statistically 'almost impossible' outliers.
- Under such conditions, the geomorphic effects of storms are massively amplified.
- Extreme water levels can be maintained for long periods (no tides).
- The geomorphic effects during such periods are most affected by wind speed and DIRECTION.
- Rates of coastal processes (including erosion) are at their highest when water levels are very high.

Pärnu, Estonia, on 9 Jan. 2005 (J. Ramez)

Sea level extremes result from Baltic Sea preconditioning and more local effects (e.g. surge). Some drivers (e.g. wave setup and wave runup) are frequently overlooked.

Geomorphic work is concentrated on a very few days of the year

- Geomorphic work is concentrated on a very few high water level, stormy days, therefore **angle of wave attack** during those times in important. In Estonia, about 60 % of the energy flux arrives within 20 days and as much as ~30% of the energy flux arrives during the 3–4 most stormy days (Soomere and Eelsalu, 2014).



Soomere and Eelsalu (2014)

A very brief and much simplified ‘textbook’ course in coastal processes

MORPHODYNAMICS

Feedback

Waves

Fluid motions

Morphology

Beaches

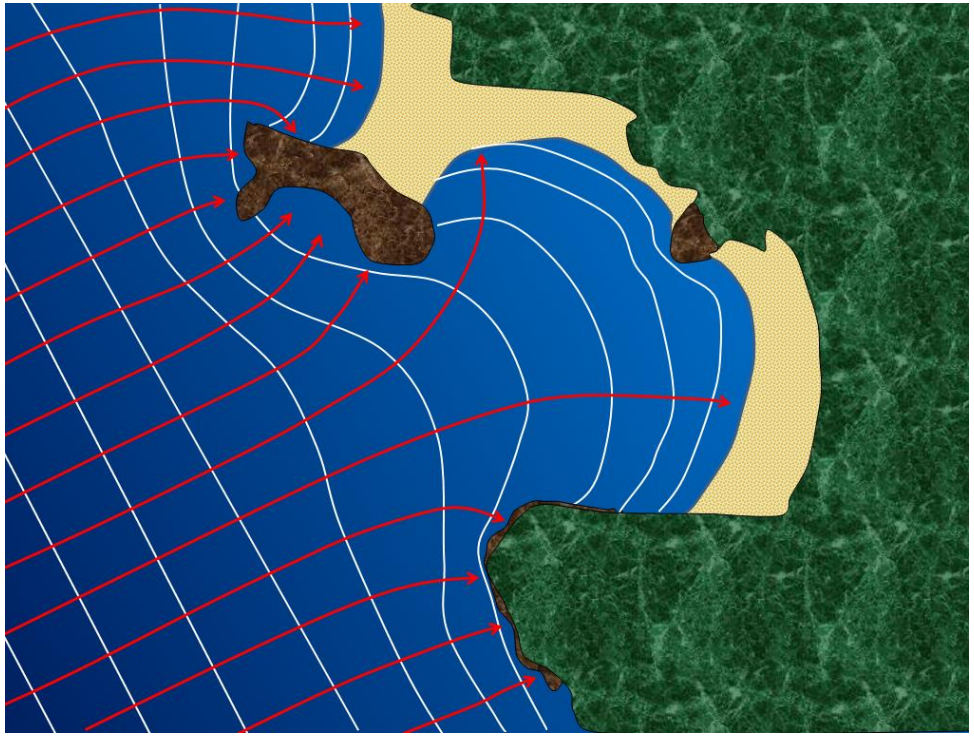
Δt

Sediment Transport

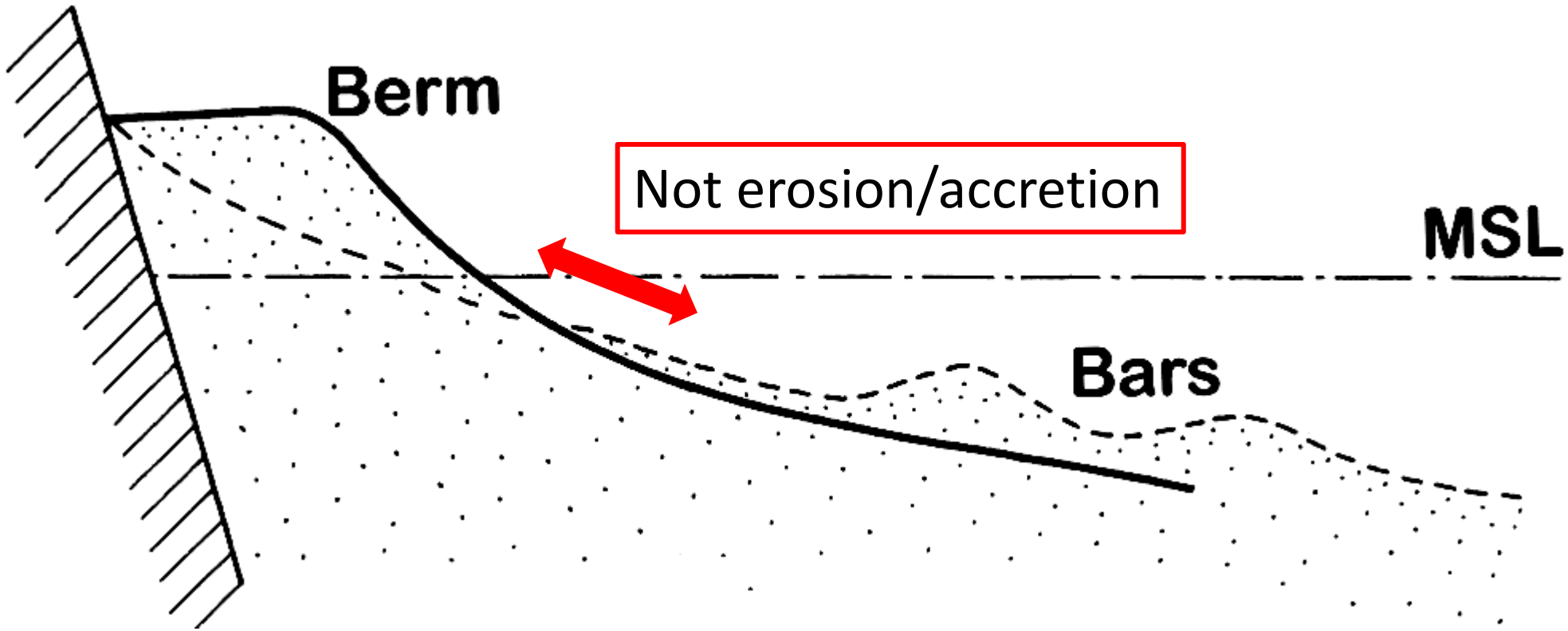
Sand

Wave refraction

- Where the process starts depends on water depth. Long period (swell) generally waves approach the coast shore parallel.
- With short period waves (waves in the process of generation such as normal in the Baltic) the process starts later, and waves get to shallow water where sediment can be entrained, still at a high angle to the shore.
- The nearshore angle of approach is a major influence on sediment transport and other important variables.



Beach processes: The classic concept of beach ‘cut and fill’



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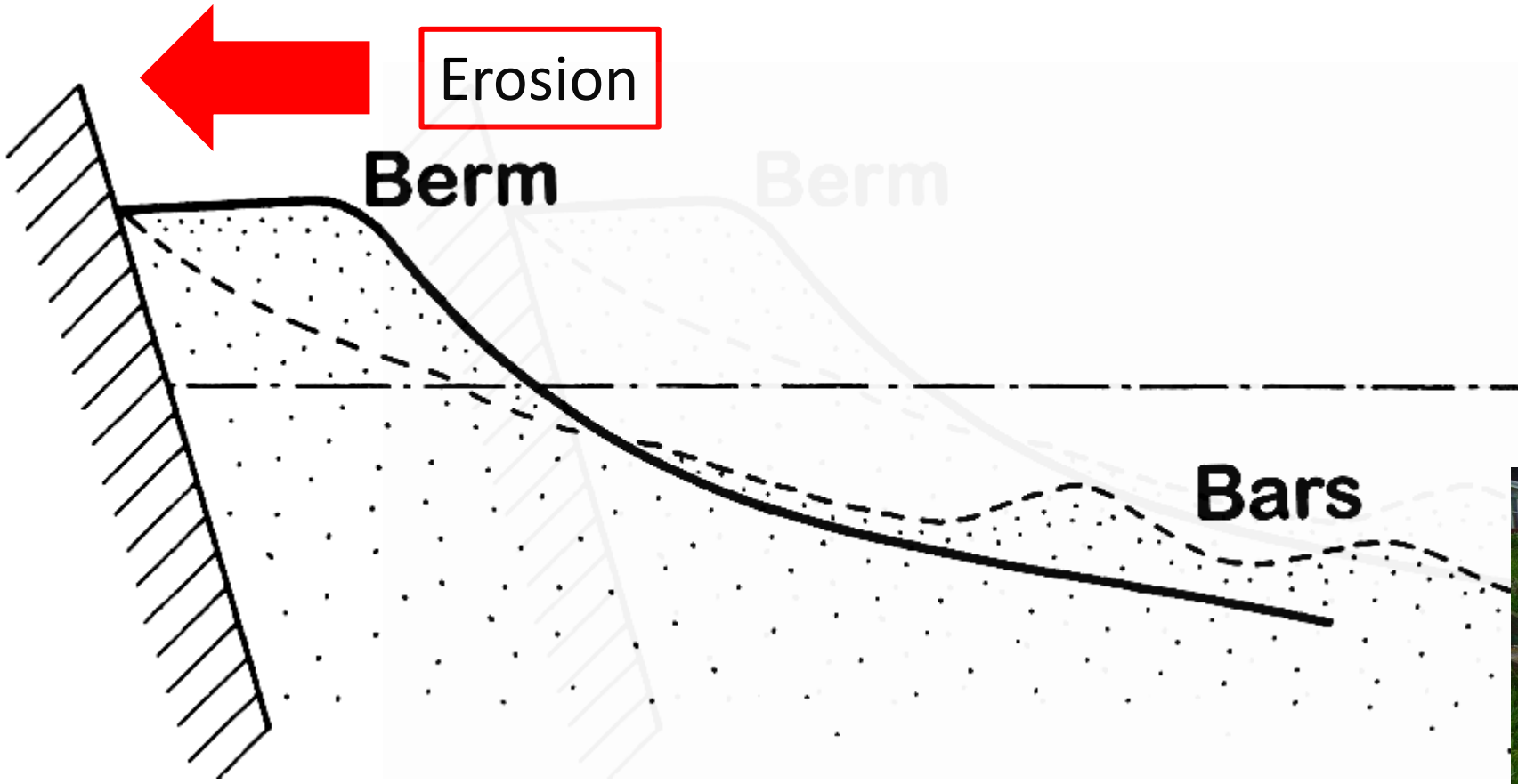
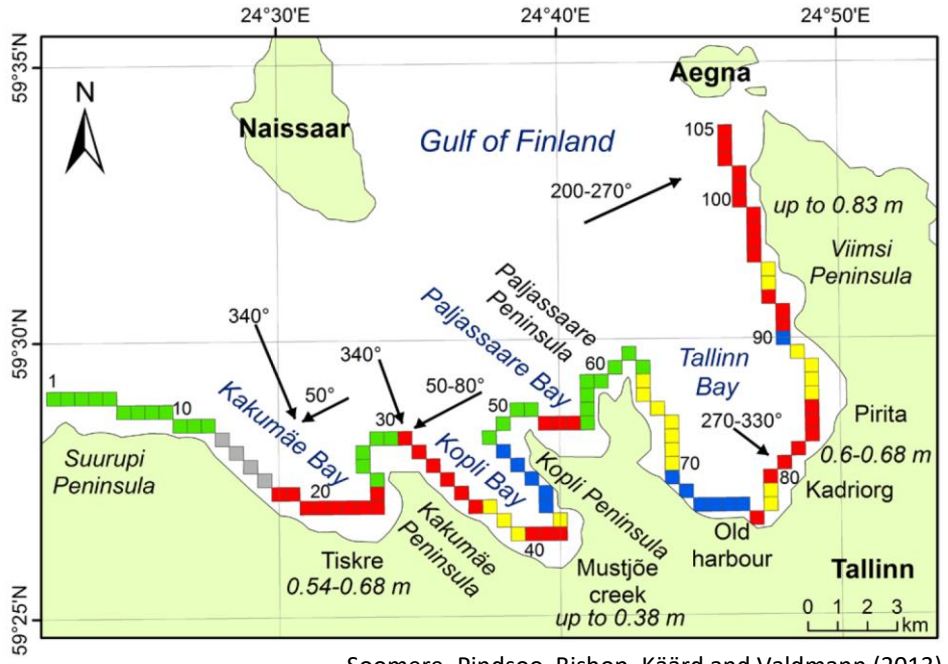


Because most waves are of short period (3-6 sec), wind direction is of very high importance

- Closure depths (the offshore extent of the active beach) are small (~3-7m).
- Wave refraction is delayed. Waves approach the coast at high angle and alongshore sediment transport is high.
- Many coastal segments are likely to be only sensitive to a small range of wind/wave directions. e.g. wave setup
- Coastal change is therefore highly variable both in space and time.
- Disruption to alongshore sediment transport can cause very significant problems.

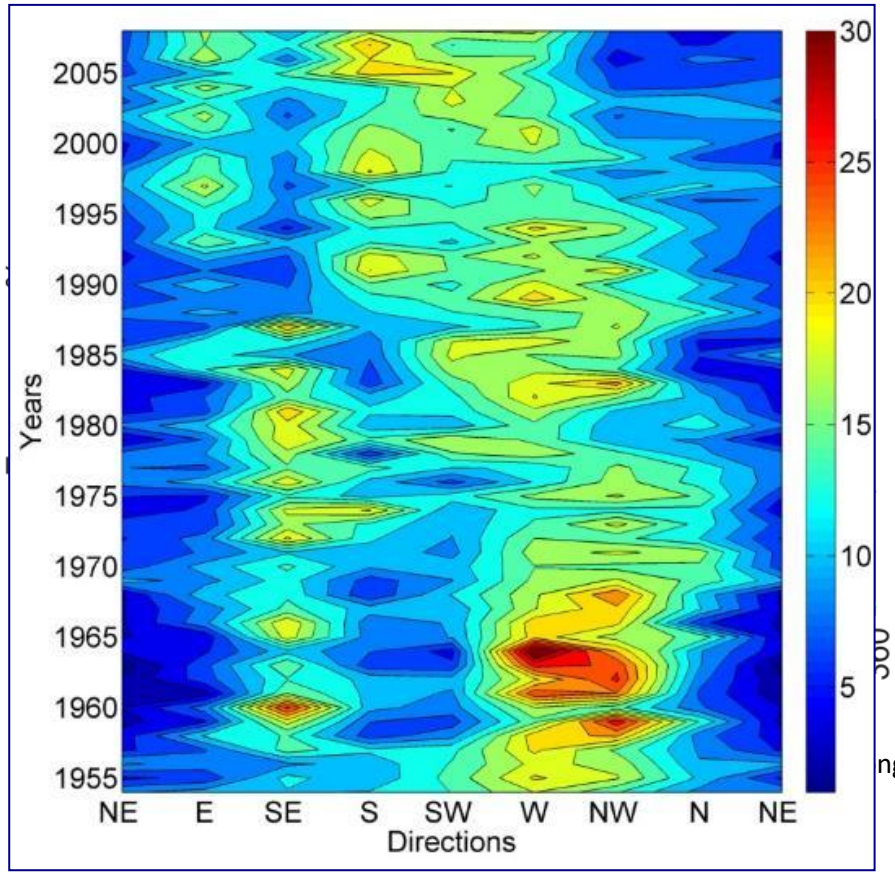


Soomere, Pindsoo, Bishop, Käärd and Valdmann (2013)

- ➢ The effects of storms in the Baltic Sea are much more variable than on more open “textbook” coastlines.
- ➢ Classic concepts of beach profile ‘cut and fill’ are less relevant.

Because most waves are of short period (3-6 sec), wind direction is of very high importance

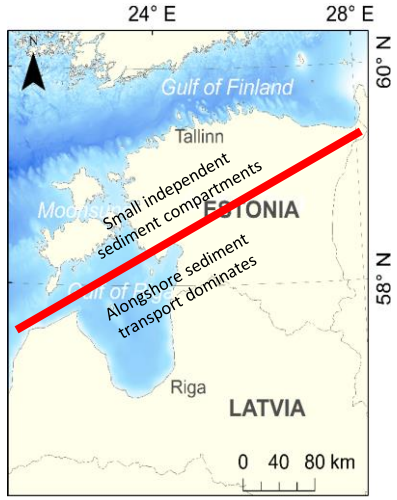
- Minor changes in wind/wave direction can lead to vastly different geomorphic outcomes
- Wind and wave characteristics ARE changing, the implications are significant

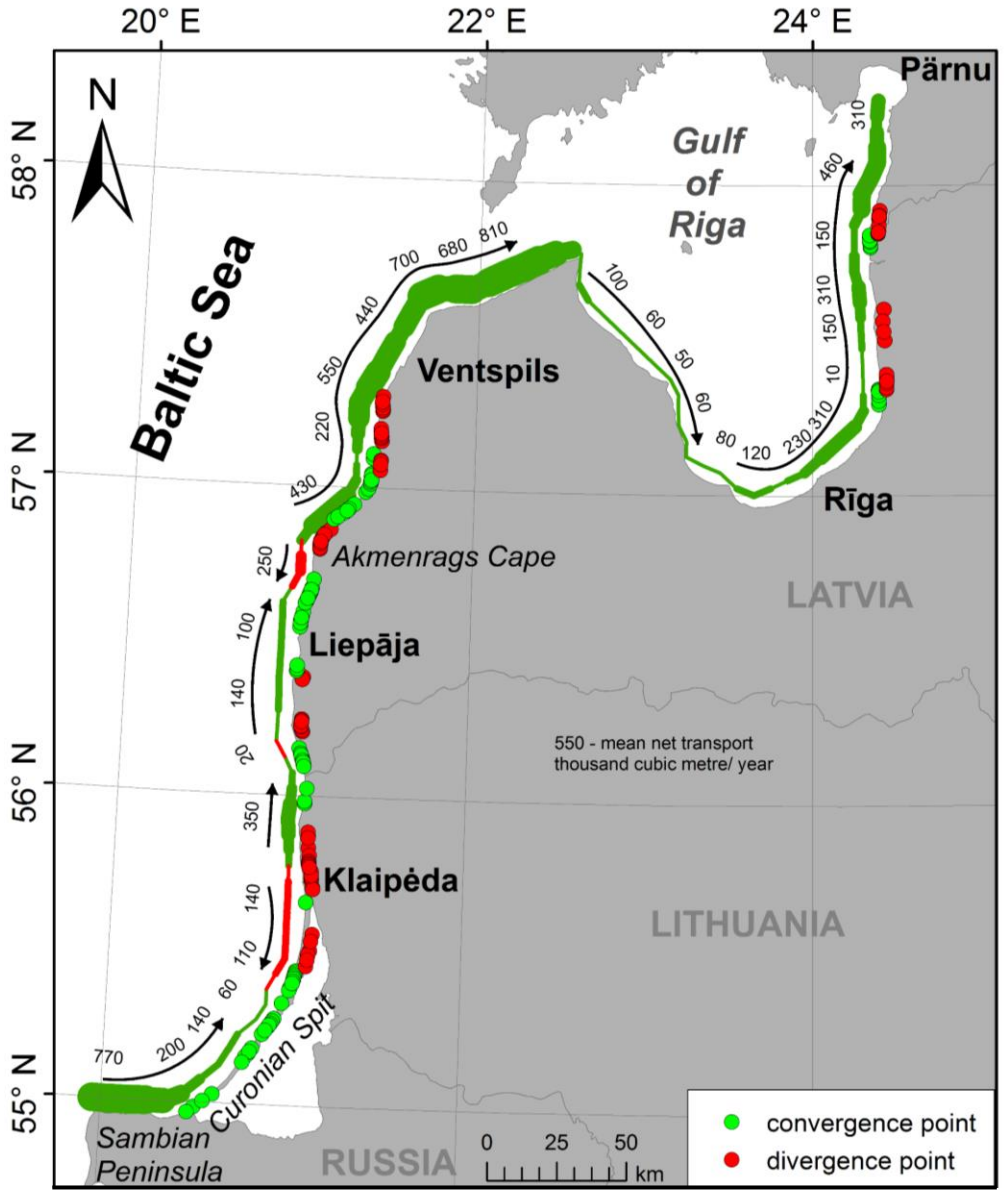


Changes in the wave approach direction in the eastern Gulf of Finland in 1954-2007 (Soomere et al., 2010)

Sediment transport (Gulf of Riga and south)

- Due to high wave approach angles maintained through the surf zone, **large alongshore sediment transport volumes are possible** (even at the world scale).
- Small changes in wave angle of approach has a very significant impact on the results.

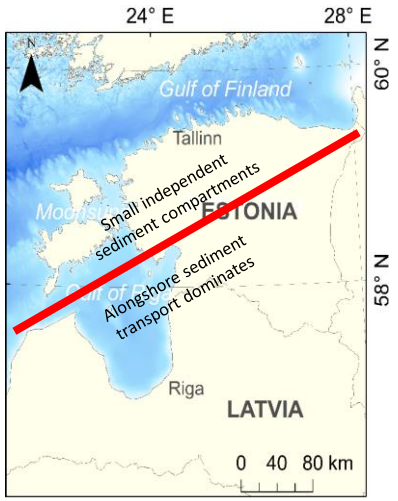




Modelled **potential** sediment transport (in 1000m^3/yr) (Viška and Soomere, 2013), using CERC formula which is highly dependent on wave angle of approach at breaker line.

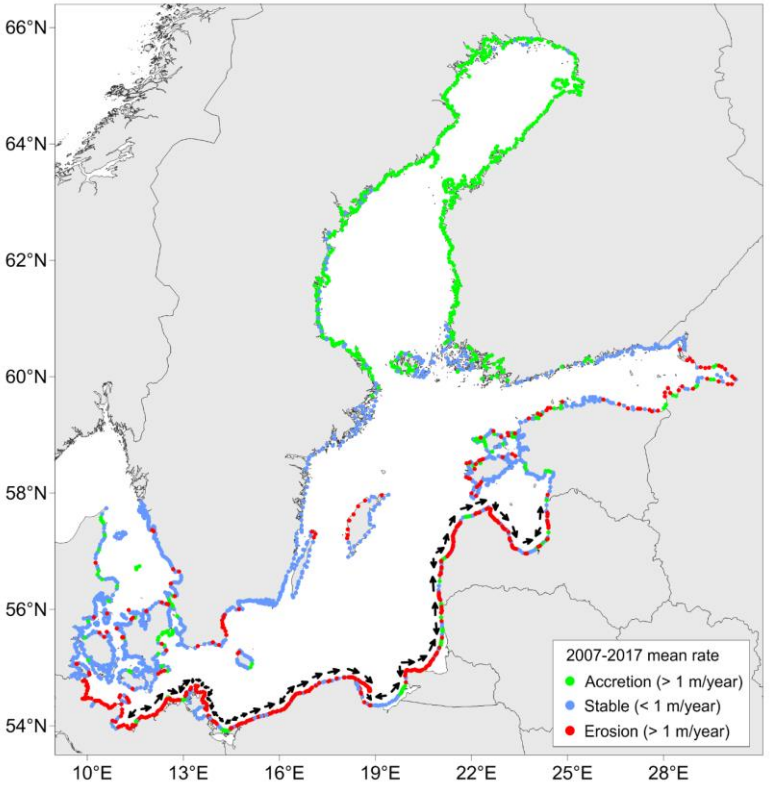
Sediment transport (north of the Gulf of Riga)

- Limited sediment movement between sediment compartments.
- Small changes in wave angle of approach has very significant local impact.
- **Beaches can remain stable for long periods** (even under high water level and high wave conditions), until a storm from an unusual direction causes massive change.



Coastal erosion and sedimentation

- **Processes relevant to erosion and accretion in the Baltic Sea are largely different to processes on 'textbook' ocean shores.**
  - Lack of tides – extreme water levels are maintained.
  - Waves are short period, refraction is limited, and waves approach the coast at a high angle. This implies high alongshore sediment transport and high sensitivity to wave direction (particularly when the angle is unusual).
  - Classic cut-and-fill cycles do not operate.
- Effects are amplified by the systematic synchronisation of high water levels and intense waves.
- For small (pocket) beaches, orientation in relation to waves is most important and therefore there is a lot of spatial variability.
- Beaches can remain stable for long periods (even under high water level and high wave conditions), until a storm from an unusual direction causes massive change.



Stability data is based on satellite image analysis and field measurements.
Arrows show sand transport direction

Baltic Sea coasts operate differently to ‘textbook’ coasts

- Almost no tides => elevated water levels can remain for long periods of time.
- Waves are directly influenced by local winds => wind direction during a storm coinciding with extreme water level can massively amplify effects.
- There are some already observable long-term changes in process drivers such as:
  - water level extremes are increasing
  - wind direction changes, such as increased frequency of westerly winds
  - less sea ice and coastal ice

=> significant impact on coastal morphology likely.

- Classic concepts of beach change do not work => we must modify our thinking for effective management.
- Maintaining alongshore sediment transport is particularly important => do not interrupt transport without understanding the consequences.

Classic beach theory (expected)

- Storm waves (NW) deposit sand in relatively deep water.
- Small frequent waves (SW) cannot mobilise the sand to bring it back to the upper beach, and there is a sediment deficit for transport back to the north.
- Sediment moves north to south.
- Erosion in the north, net loss of beach.

Eelsalu, Parnell and Soomere (2022), *Geomorphology,* 108383

Classic beach theory (expected)

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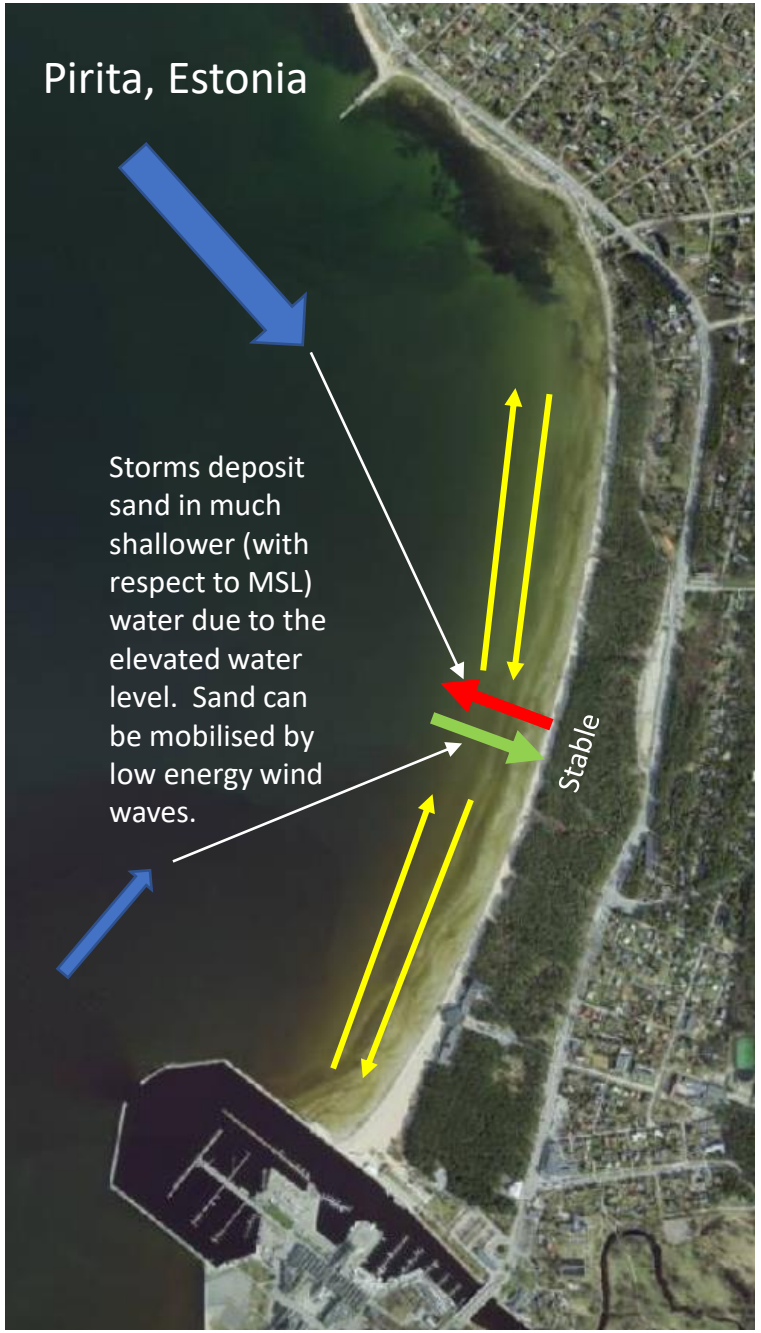
- Sediment moves north to south.
- Erosion in the north, net loss of beach.

When storms coincide with extreme water levels (actual)

- Storm waves (NW) deposit sand in relatively shallow water (~-0.5m MSL).
- Small frequent waves (SW) CAN remobilise the sand to bring it back to the upper beach, due to the water depth being average or below average.
- Sediment moves both north and south.
- The beach is stable.

Eelsalu, Parnell and Soomere (2022), *Geomorphology,* 108383



Conclusions

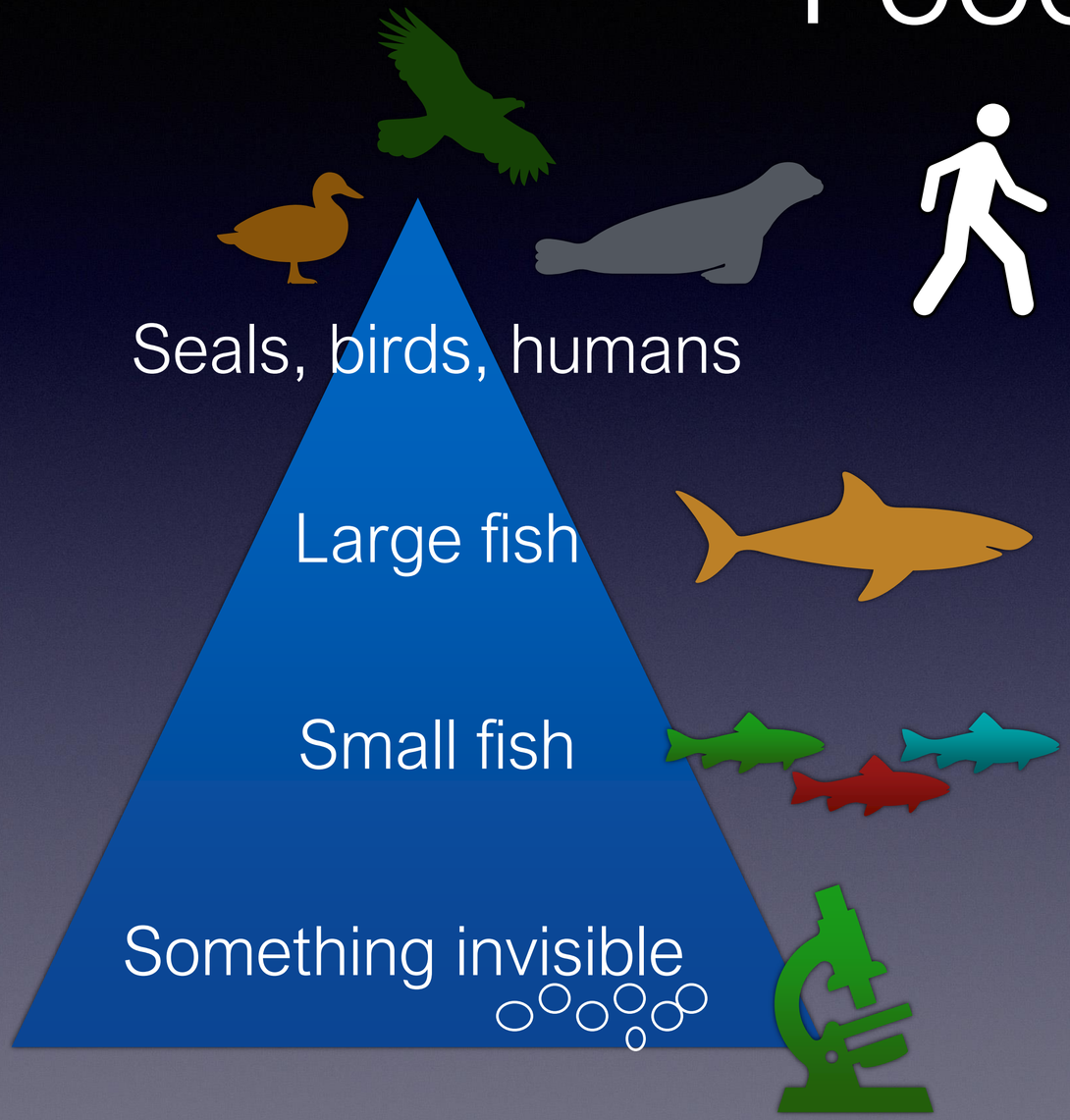
- Not all changes are climate-change induced.
- We must think beyond sea-level rise as the main climate-change related driver of coastal processes and coastal change.
- We can not rely on ‘textbook’ explanations linking coastal processes and coastal landforms. Semi-enclosed seas are different.
- Wind and wave characteristics (energy and DIRECTION) are particularly important.
- Understanding climate change effects on coastal compartment sediment budgets is probably the most useful thing we can do.

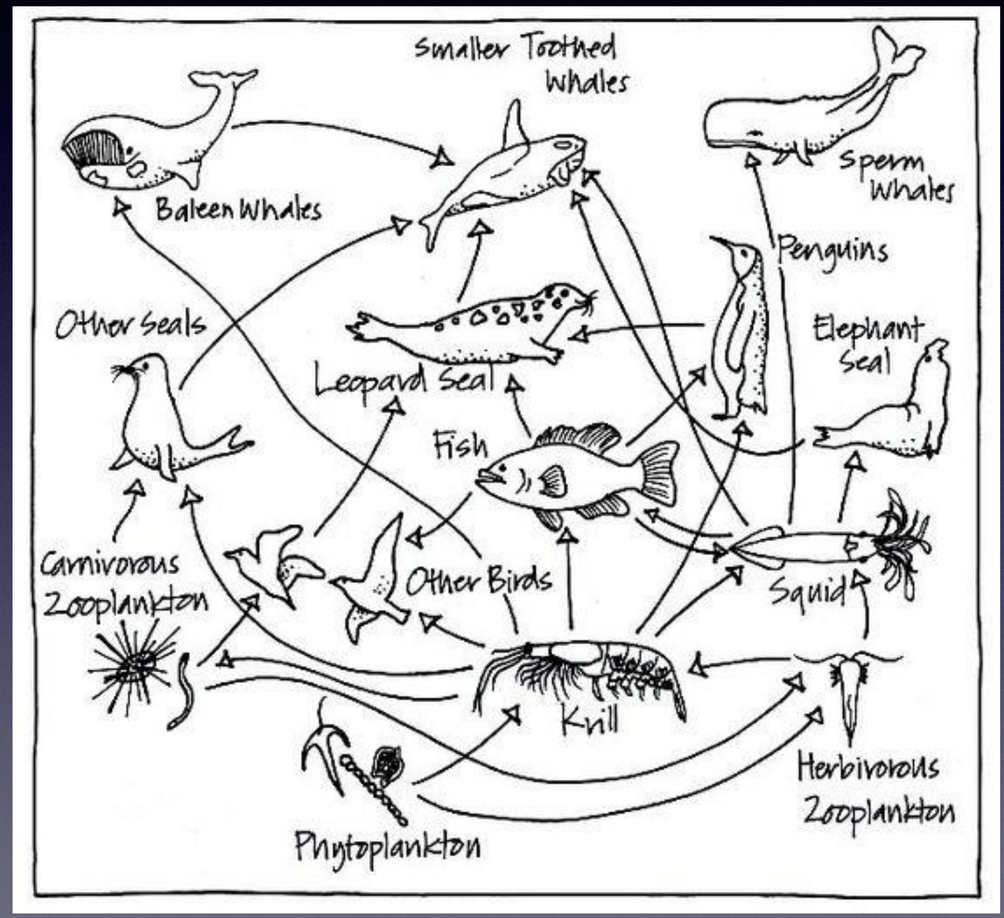
Synthesising our knowledge about functioning of the Baltic Sea food web

Anda IKAUNIECE, Astra LABUCE, Iveta JURGENSONE
Latvian Institute of Aquatic Ecology

SCIENCE FORUM, SCIENCE DAYS FOR GULF OF FINLAND AND THE EASTERN BALTIC SEA NOV 30 – DEC 01, 2022 HELSINKI, FINLAND

Food webs

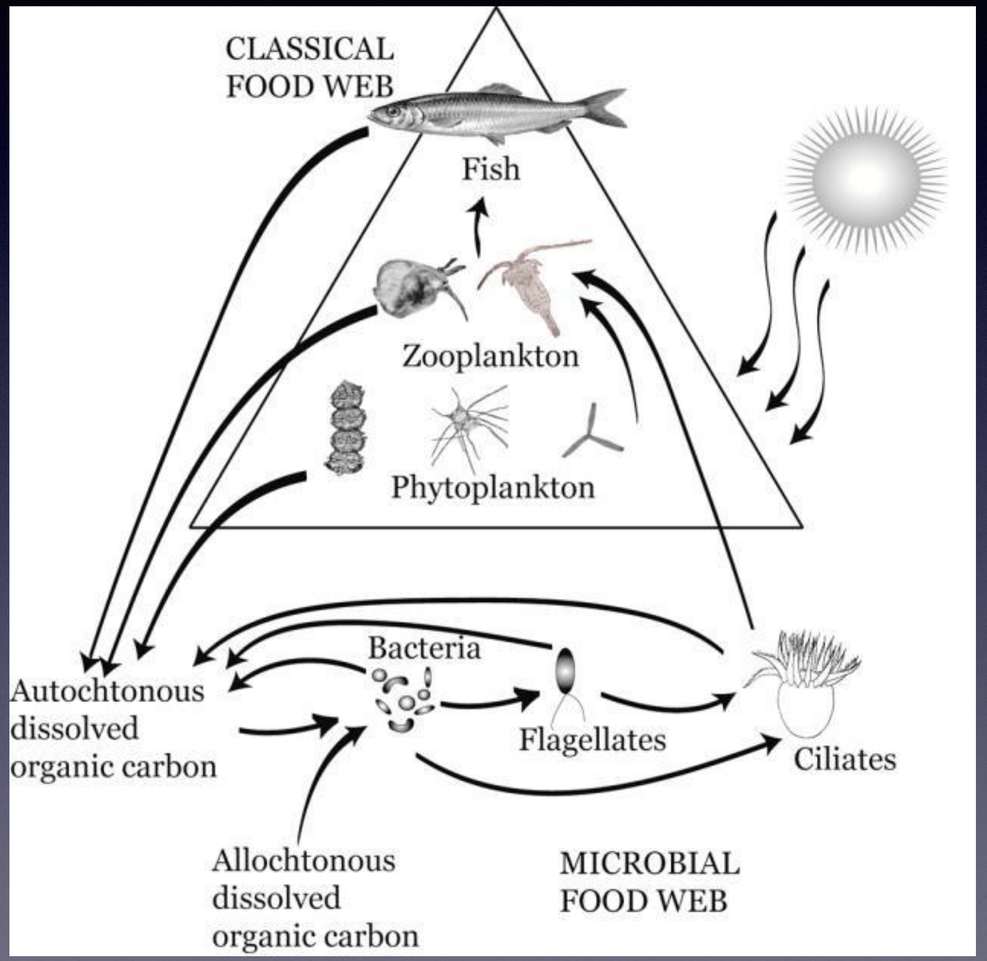




www.coolaustralia.org

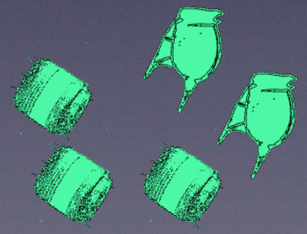
Baltic Sea food webs

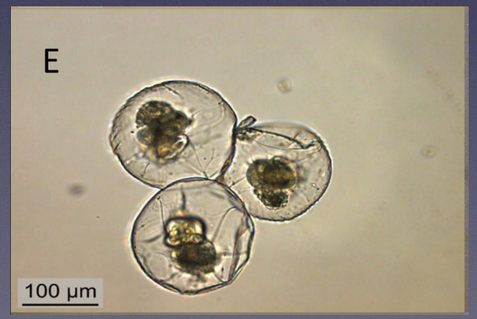
- High share of small size plants and animals
- Complexity in the “invisible” part
- Changing components due to invasive species
- Impact of climate and fishing

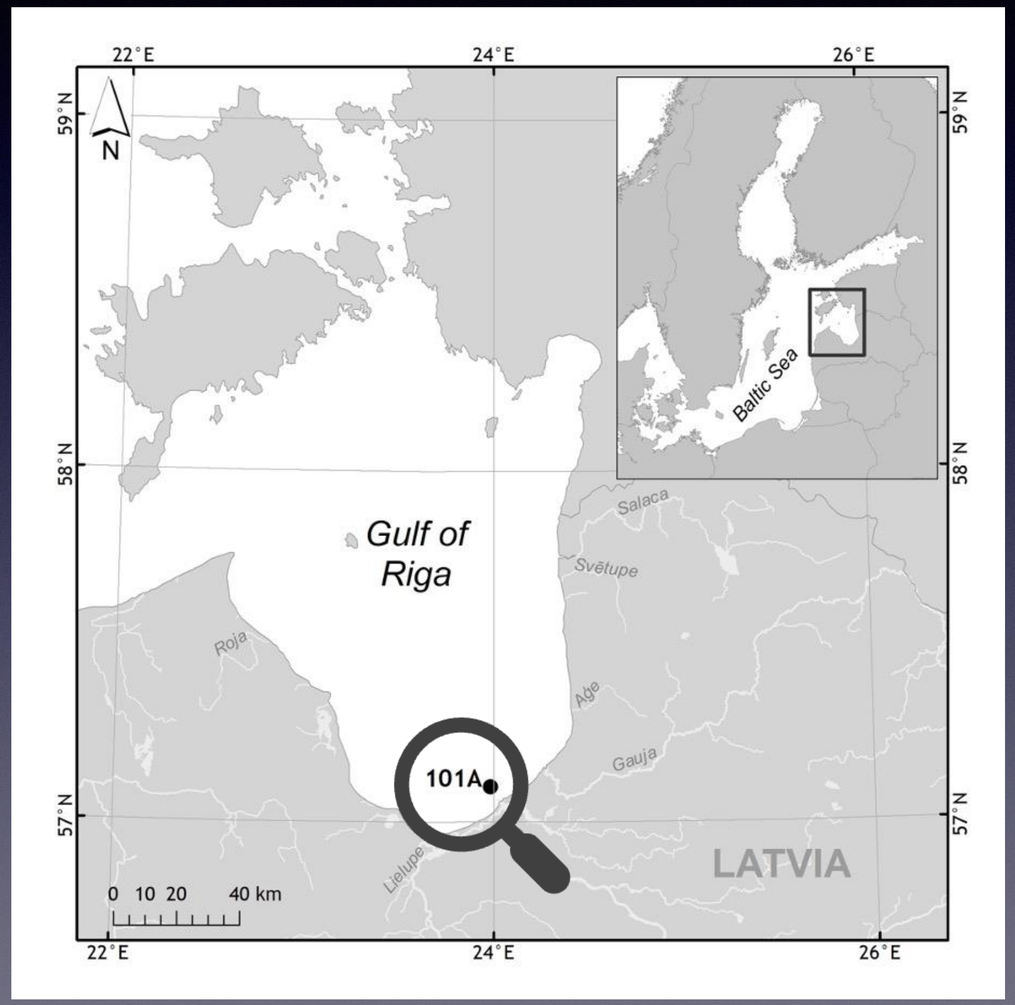


I. Gulf of Riga

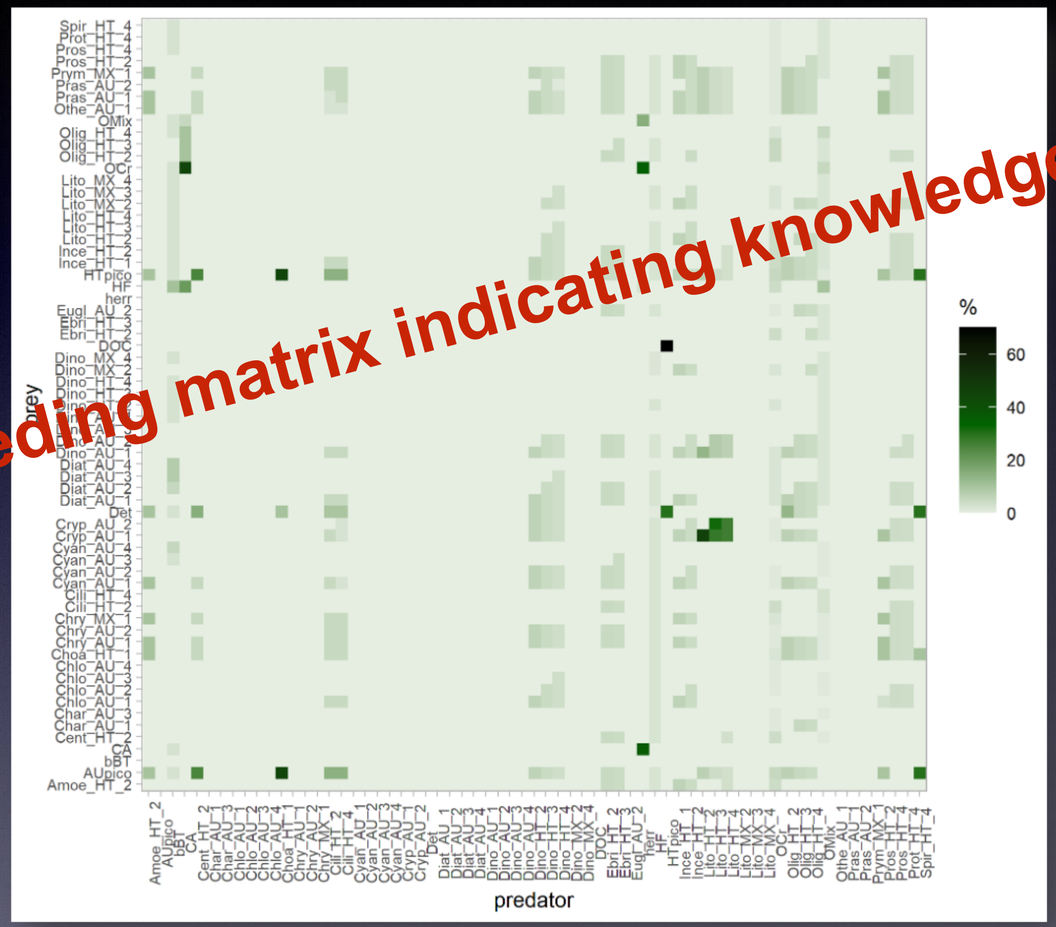
- Average depth 26 m, deepest spot 62 m
- Freshwater-impacted ecosystem
- Strongly stratified from May to October
- Research on the “invisible” part of the food web

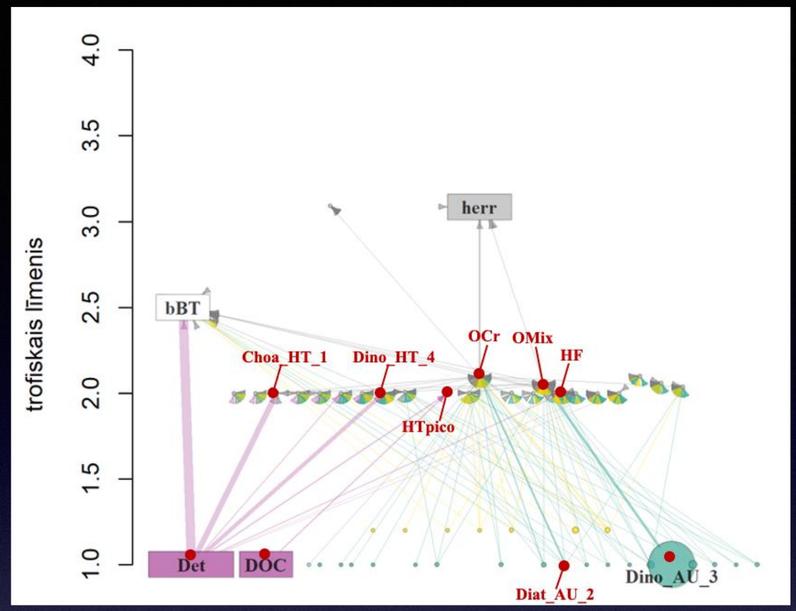




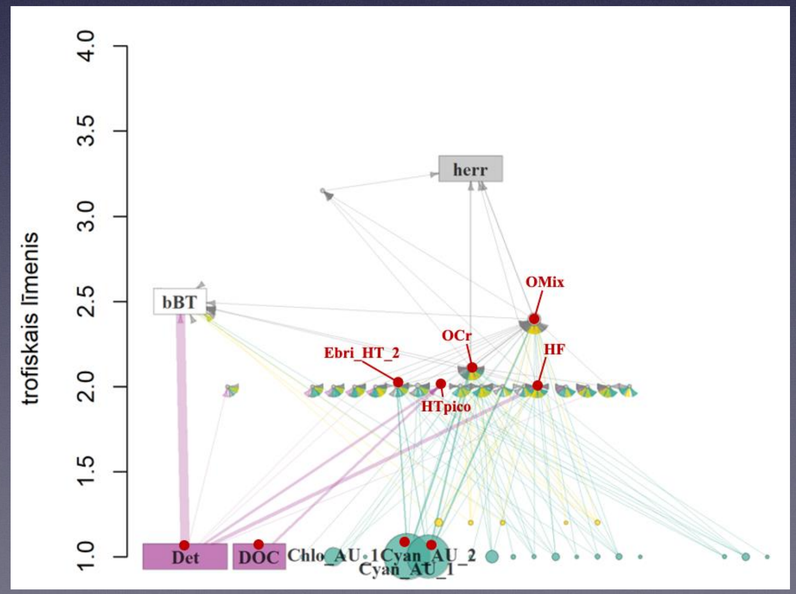


Feeding matrix indicating knowledge gaps

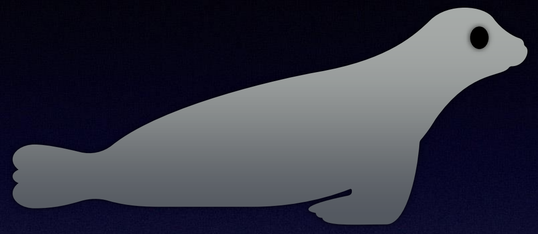




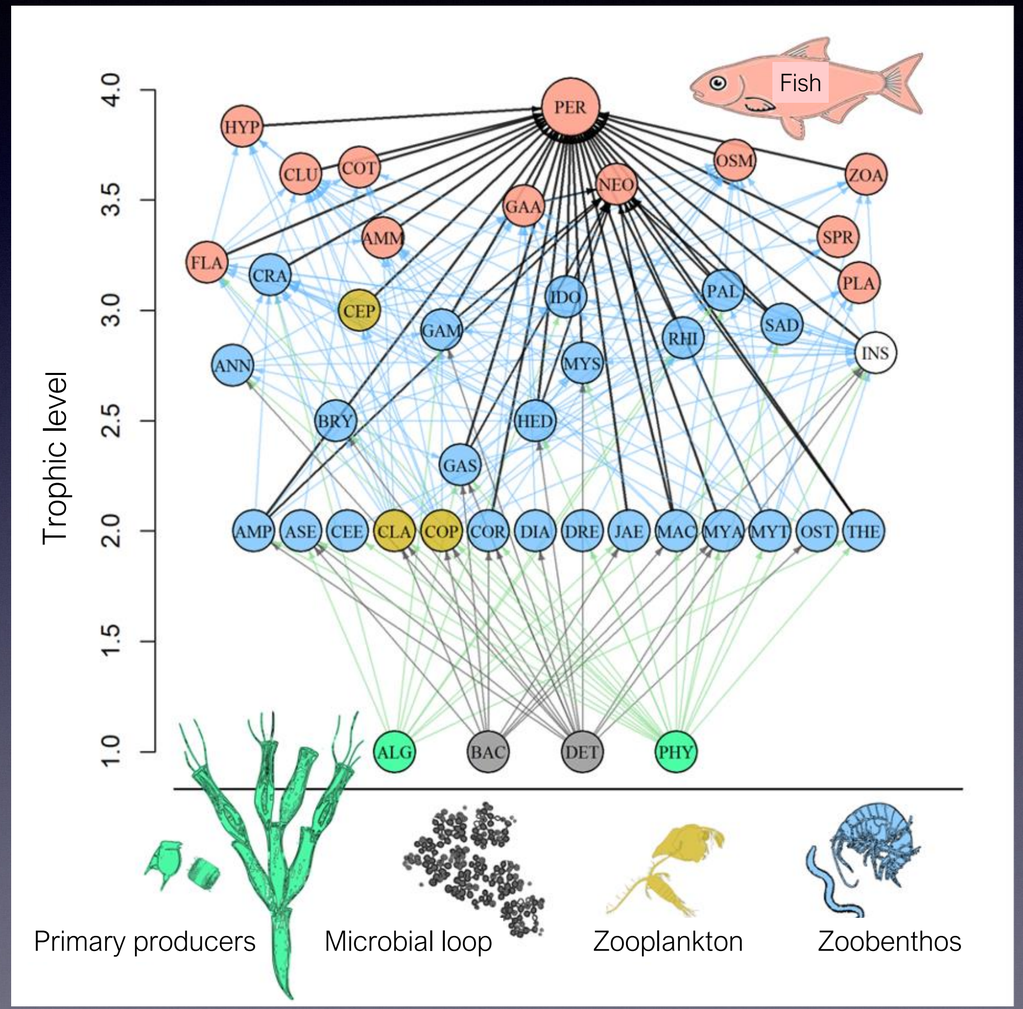
Non-living organic matter - really so important?



What’s next?



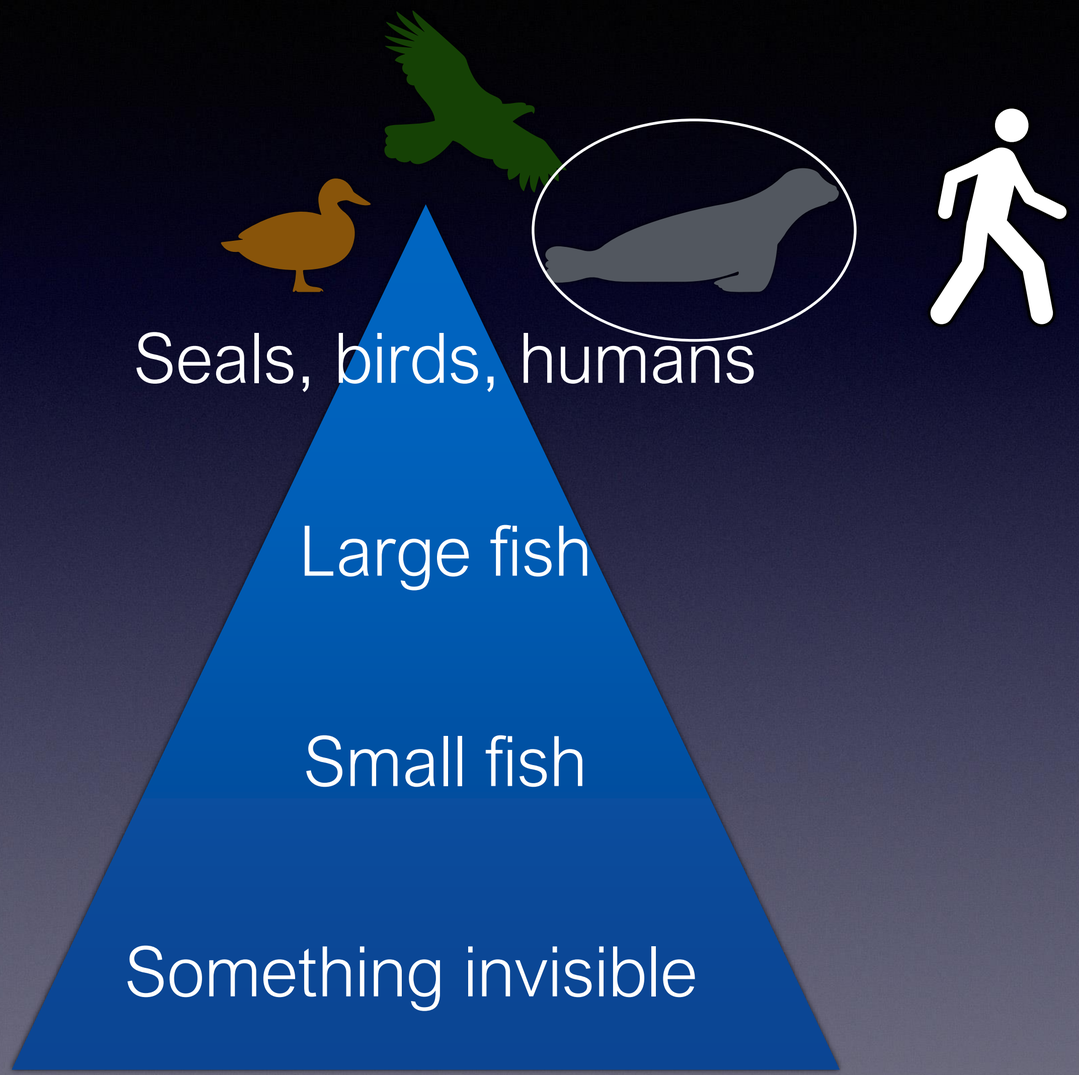
- Herring, seals and birds
- Other habitats



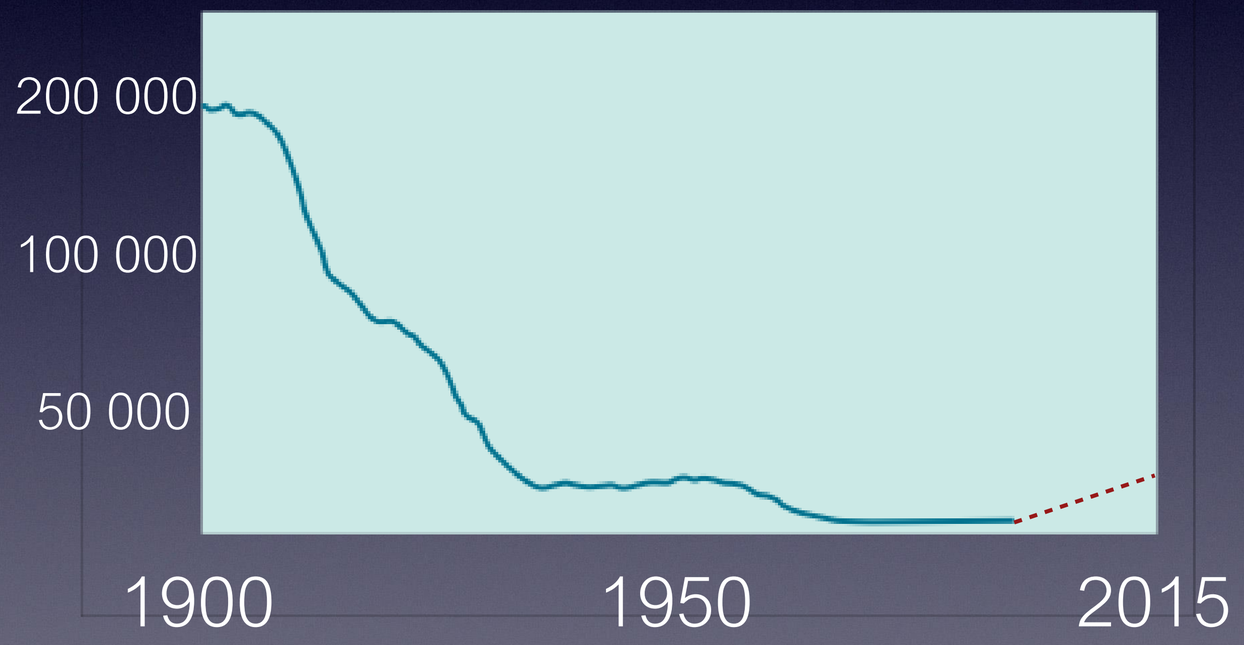
II. Gulf of Finland

- 2 x larger area than Gulf of Riga
- 2 x maximum depth
- Differing coastline

How is life for top predators?



Ringed seals in the Baltic Sea

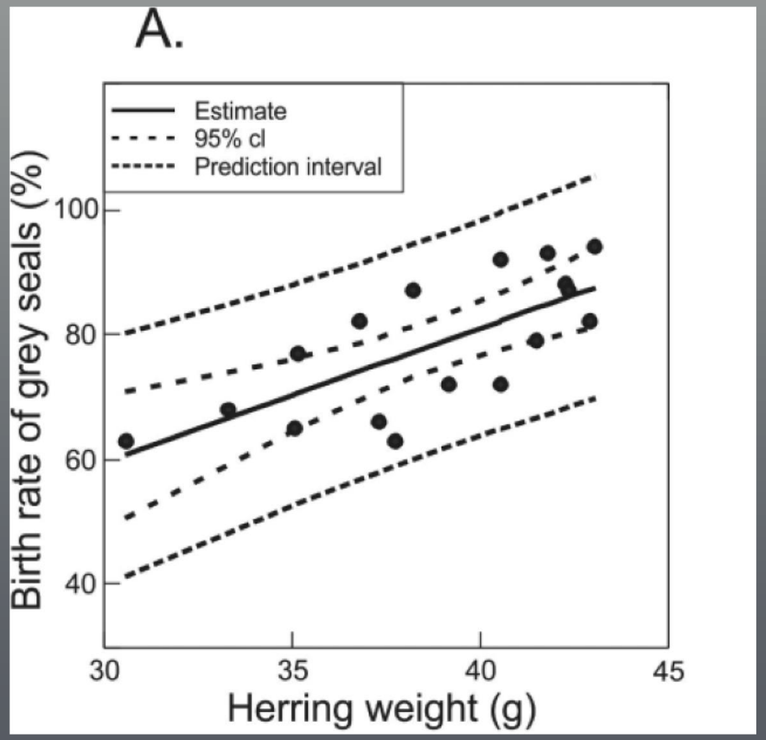


Hårding & Härkönen (1999)

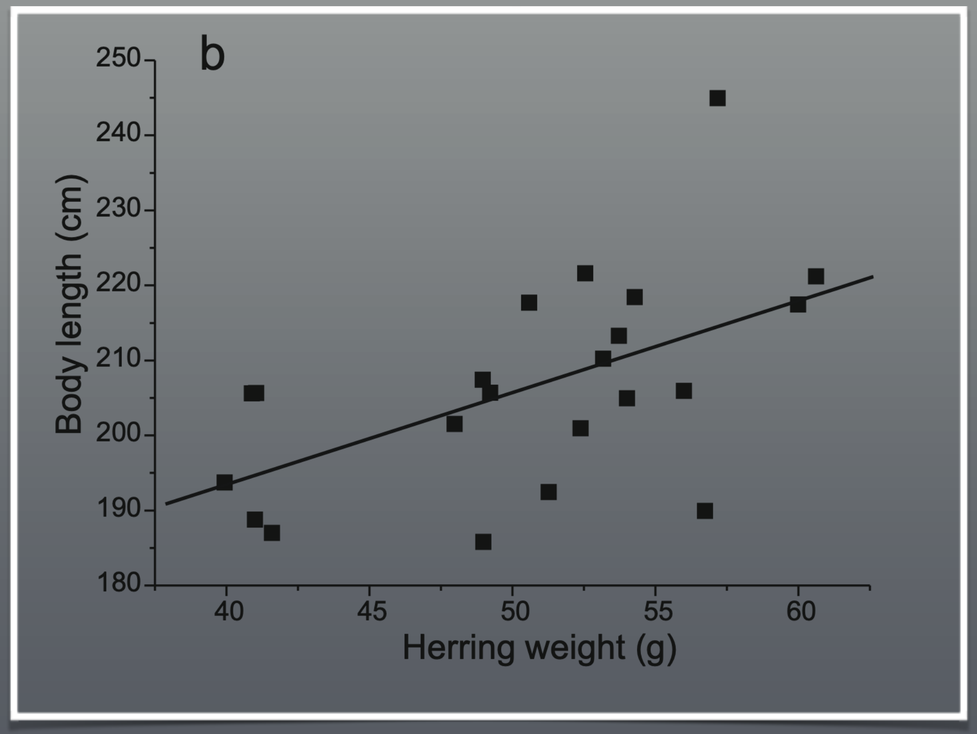
IUCN (2016)

Quality of herring

Herring weight and birth rate



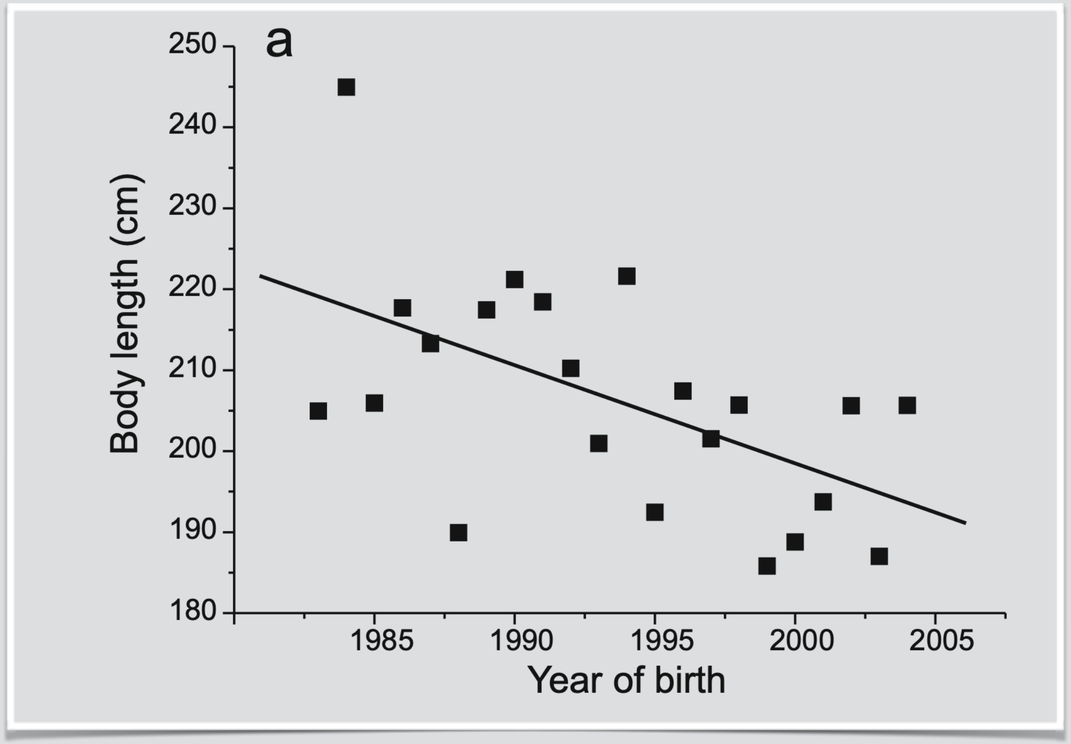
Herring weight and body length



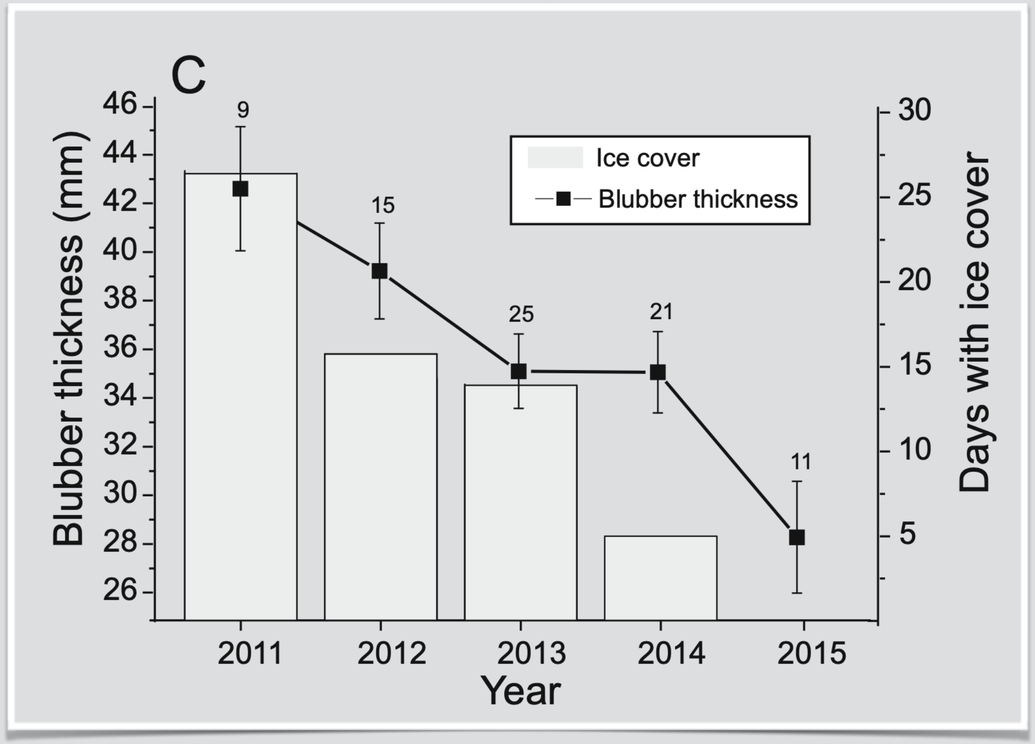
Kauhala et al., 2019, 2020

Prospering in colder winters

Body length relation to winter temperature



Nutritional status of grey seal pups



Kauhala et al., 2017, 2020

Next steps?

CLIMATE CHANGE

- Seals + herring
- Herring + zooplankton
- Zooplankton + cyanobacteria
- Other bacteria in the microbial loop + zooplankton + herring + seals

THANK YOU!

HARMFUL SUBSTANCES IN THE GULF OF FINLAND

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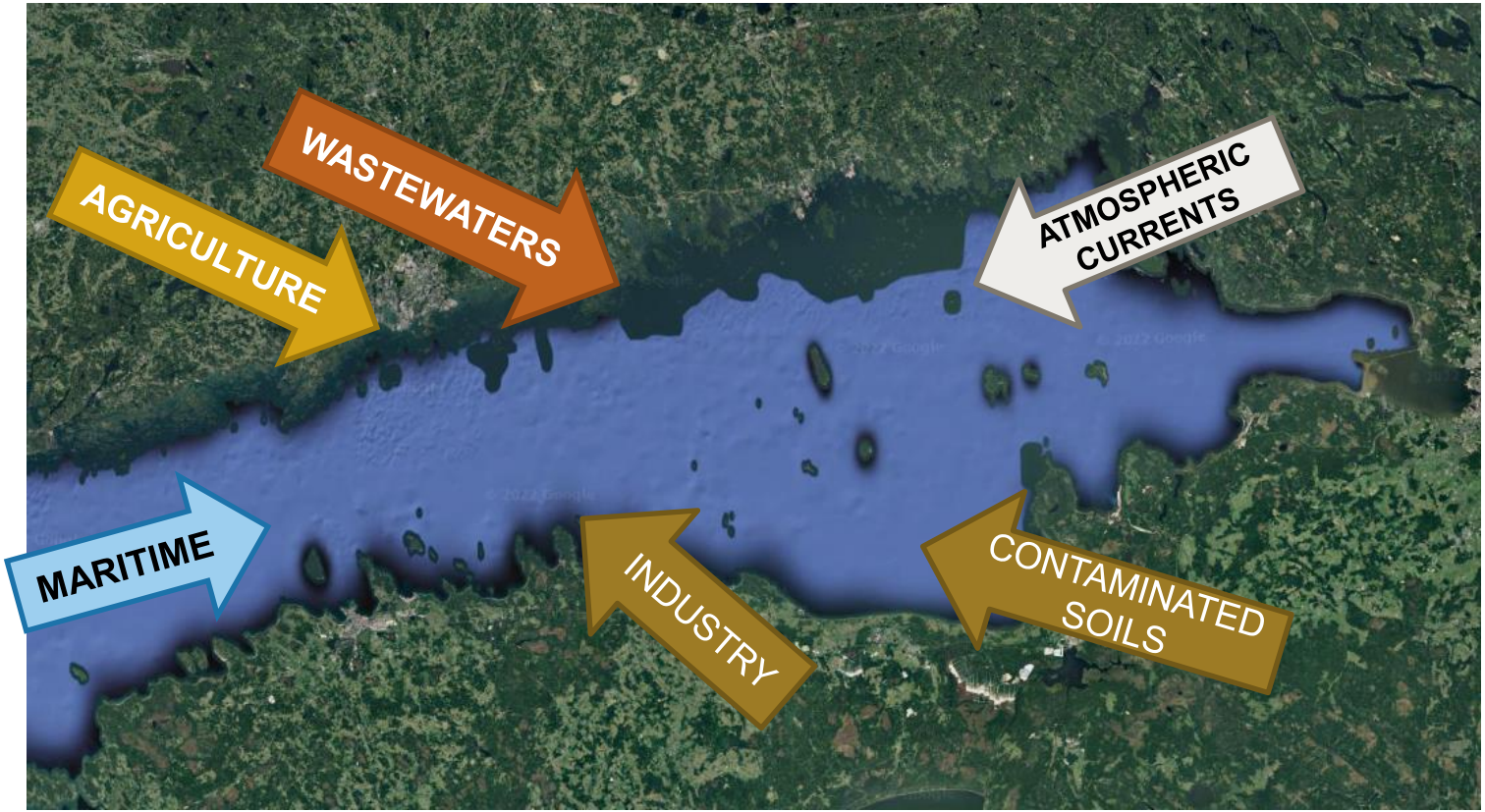
Finnish environment institute Syke

SYKE

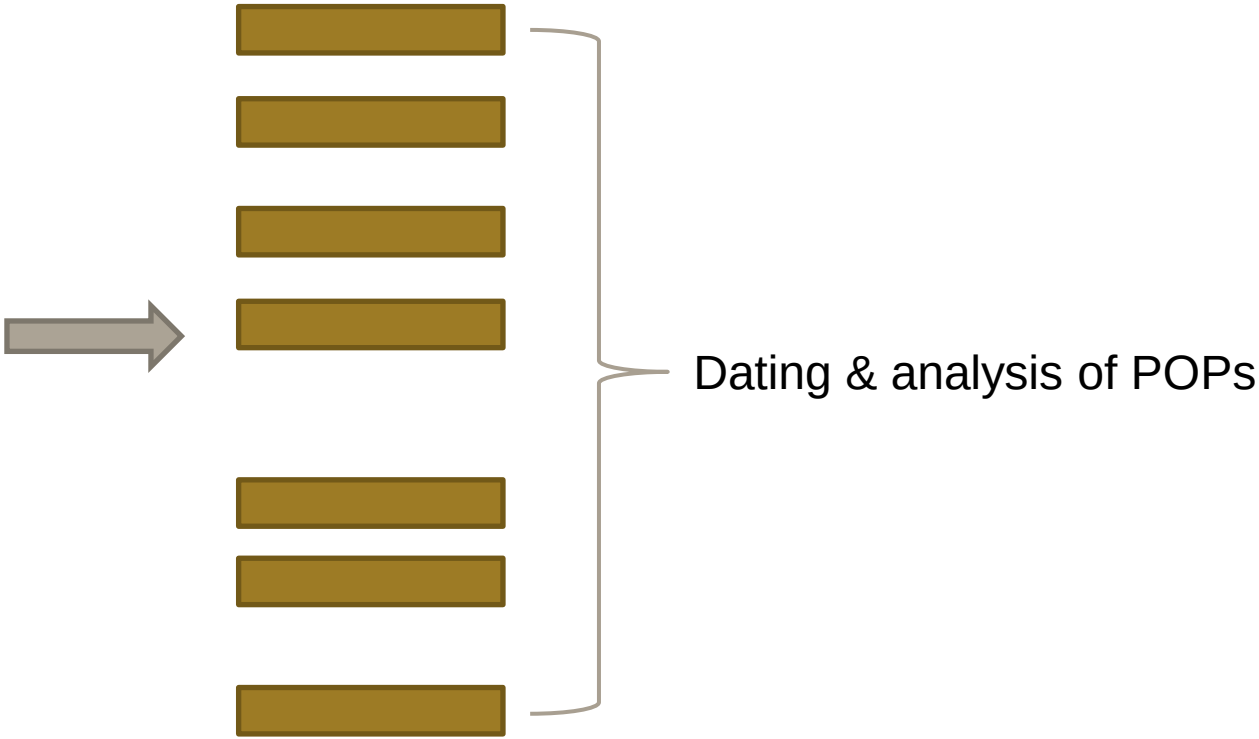
ville.junttila@syke.fi

SOURCES OF HARMFUL SUBSTANCES TO THE GULF OF FINLAND



SYKE

SEDIMENT CORES – NATURAL ARCHIEVES OF POLLUTANT CONCENTRATIONS



SYKE

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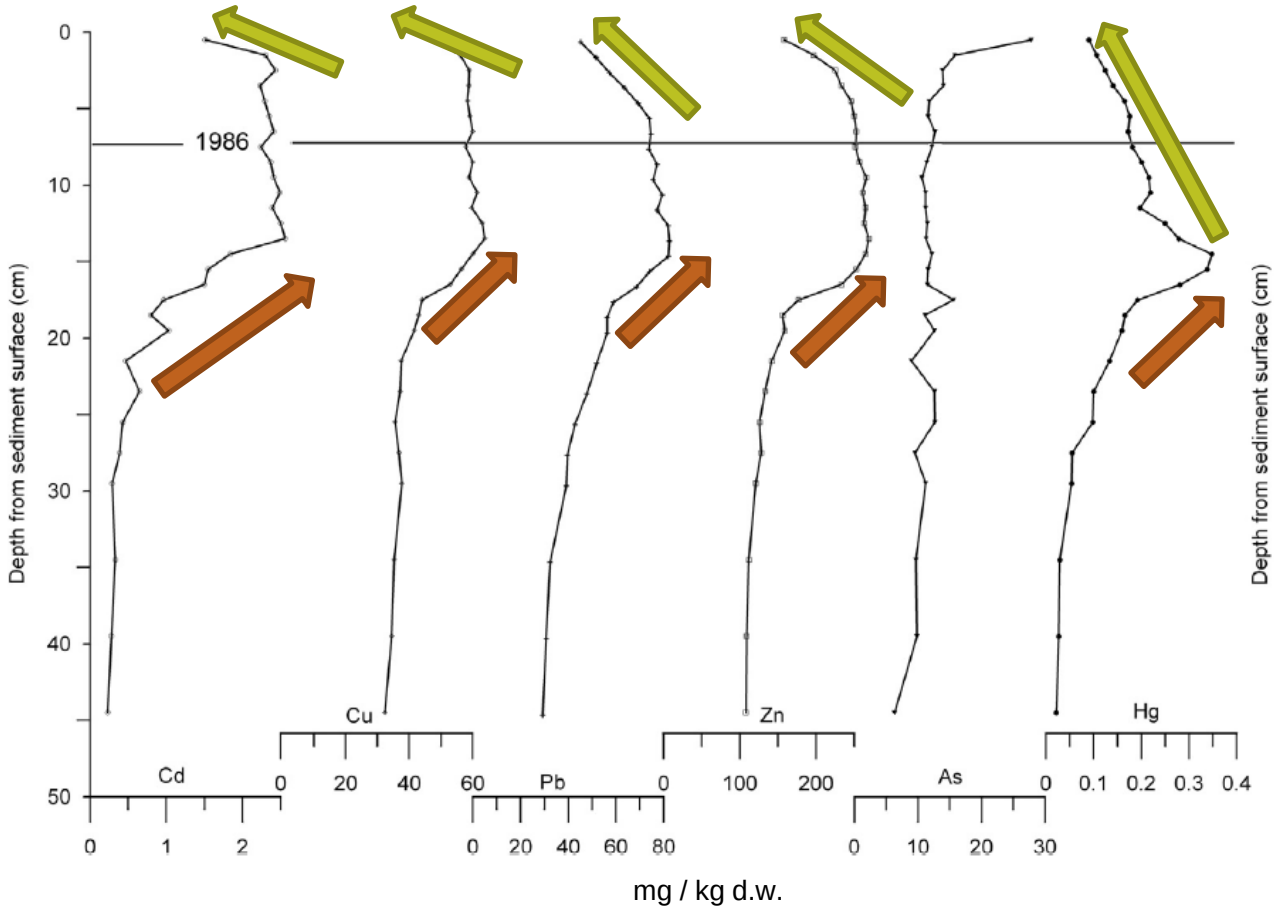
HEAVY METAL POLLUTION HAS DECLINED (Vallius 2014)

Results from the eastern Gulf of Finland



SYKE

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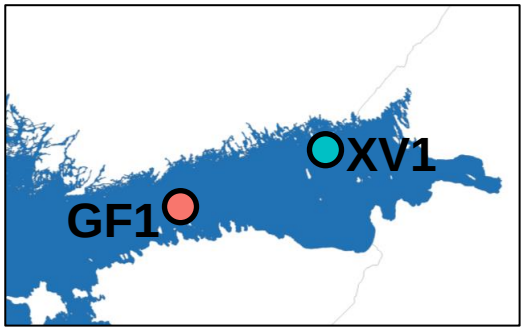
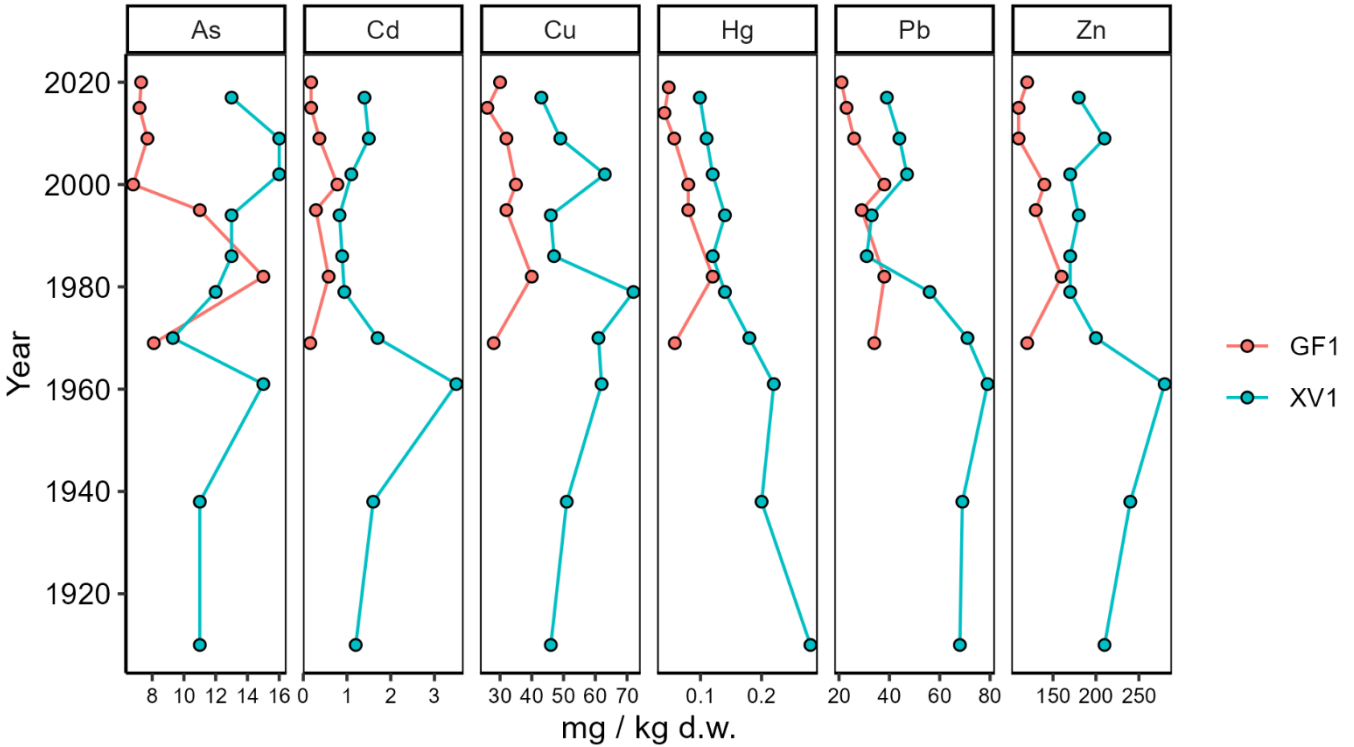
HEAVY METAL POLLUTION HAS DECLINED

(PROJECT GOFHAZ 2022)





SYKE

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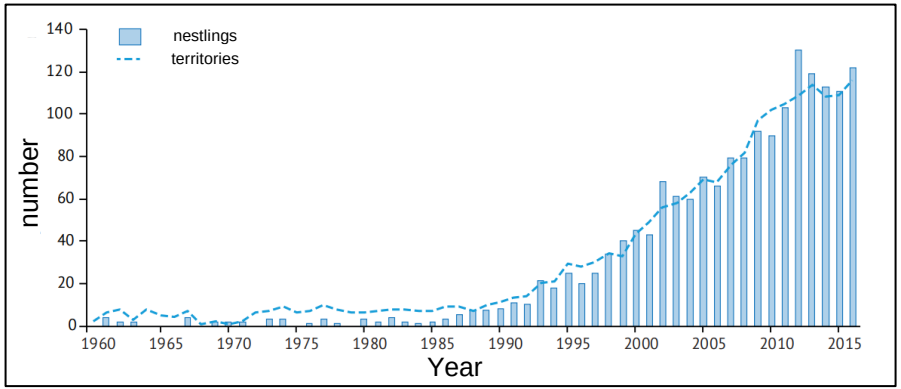
HOW ABOUT ORGANIC POLLUTANTS?

SYKE

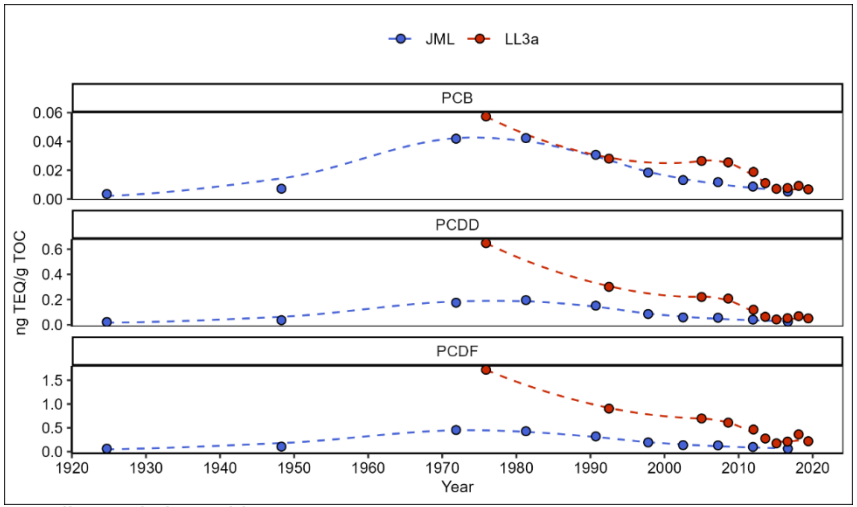
PCDD/Fs & PCBs – ALSO DECLINING

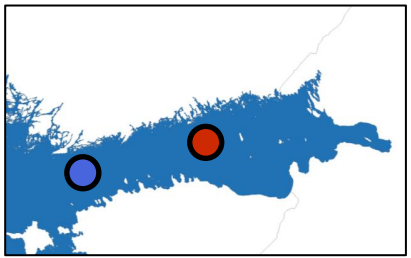
Number of *H. albicilla* nestlings and territories 1960 – 2016 in Finnish Archipelago



Vösa et al. 2017

Concentration of PCDD/Fs and PCBs in sediment cores





Junttila et al. (unpub)

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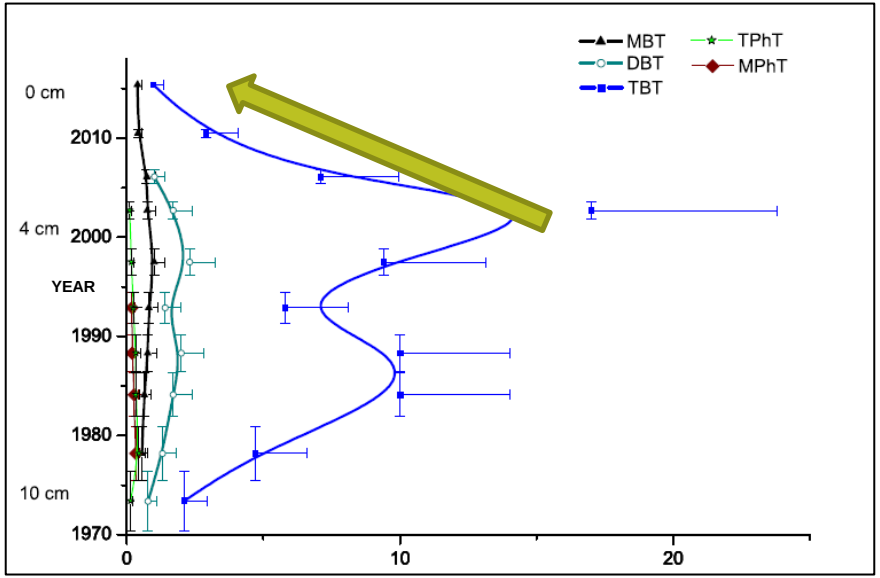
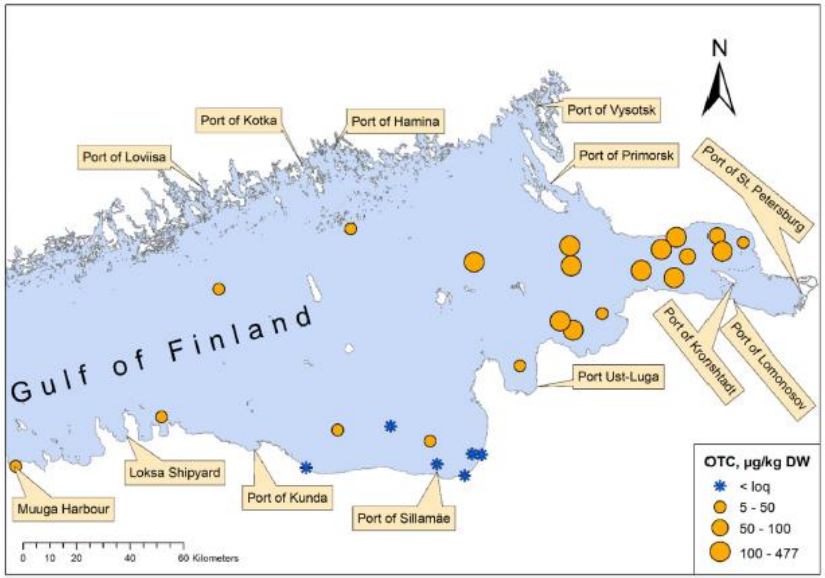
ANTIFOULING AGENTS HAVE ALSO DECLINED
(BUT STILL REMAIN)



Organotins in sediment core at Western Gulf of Finland. (µg / kg d.w.) (data by Syke/Kankaanpää)



Organotins in surface sediment samples (Kuprijanov et al. 2021.)

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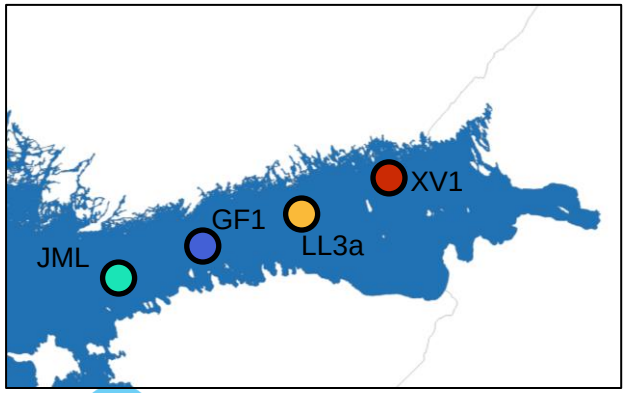
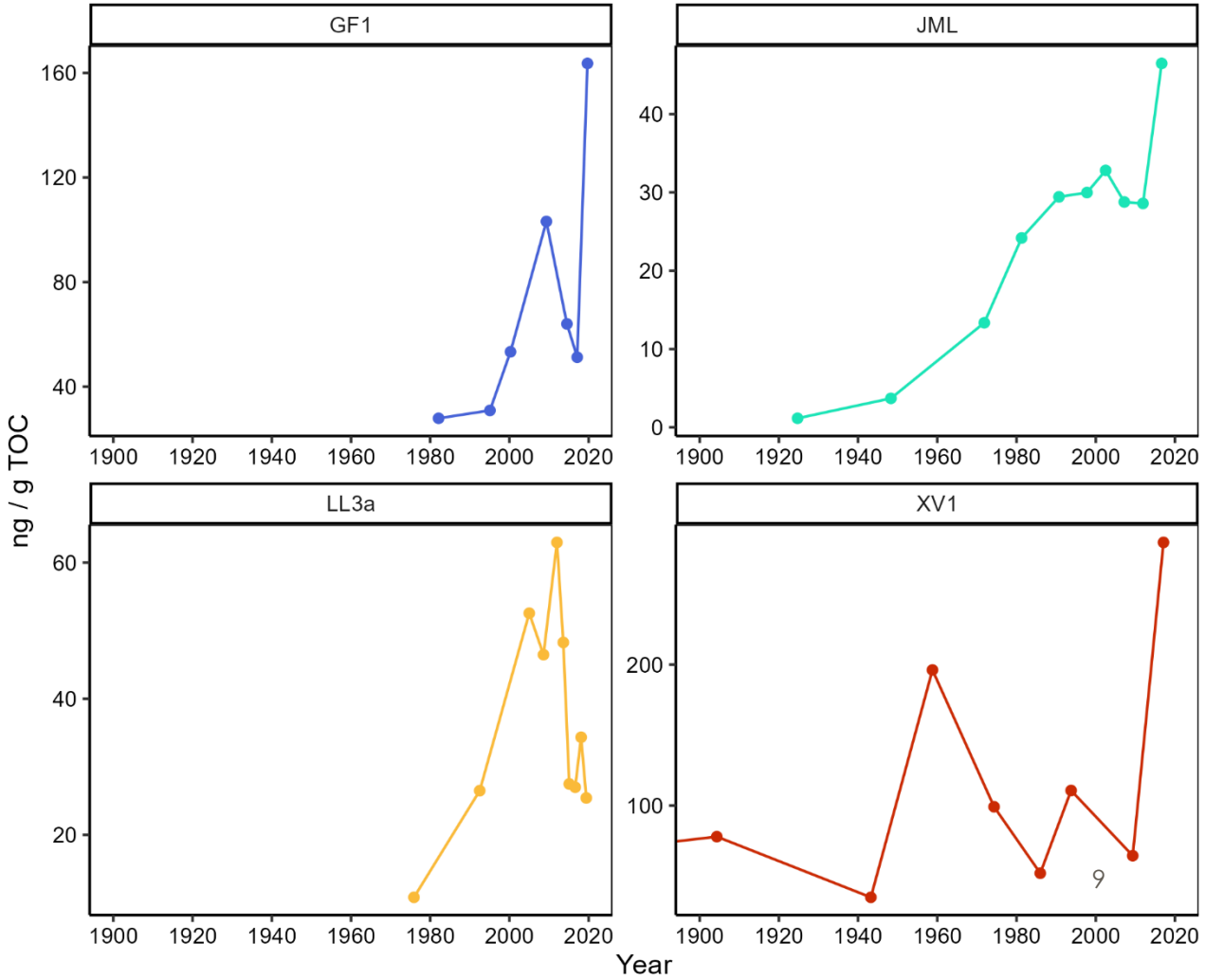
PFAS CONCENTRATIONS ARE RISING

(Junttila et al. *unpub*)

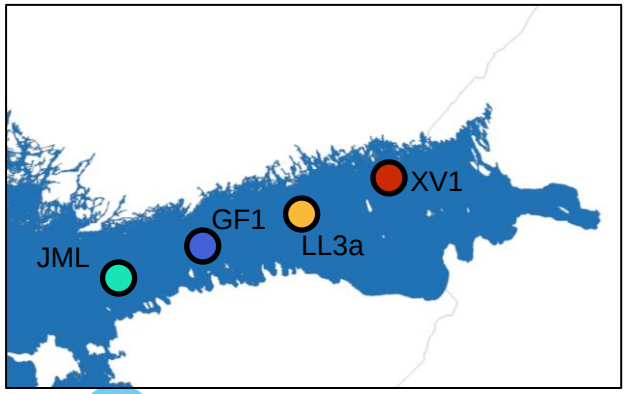


S Y K E

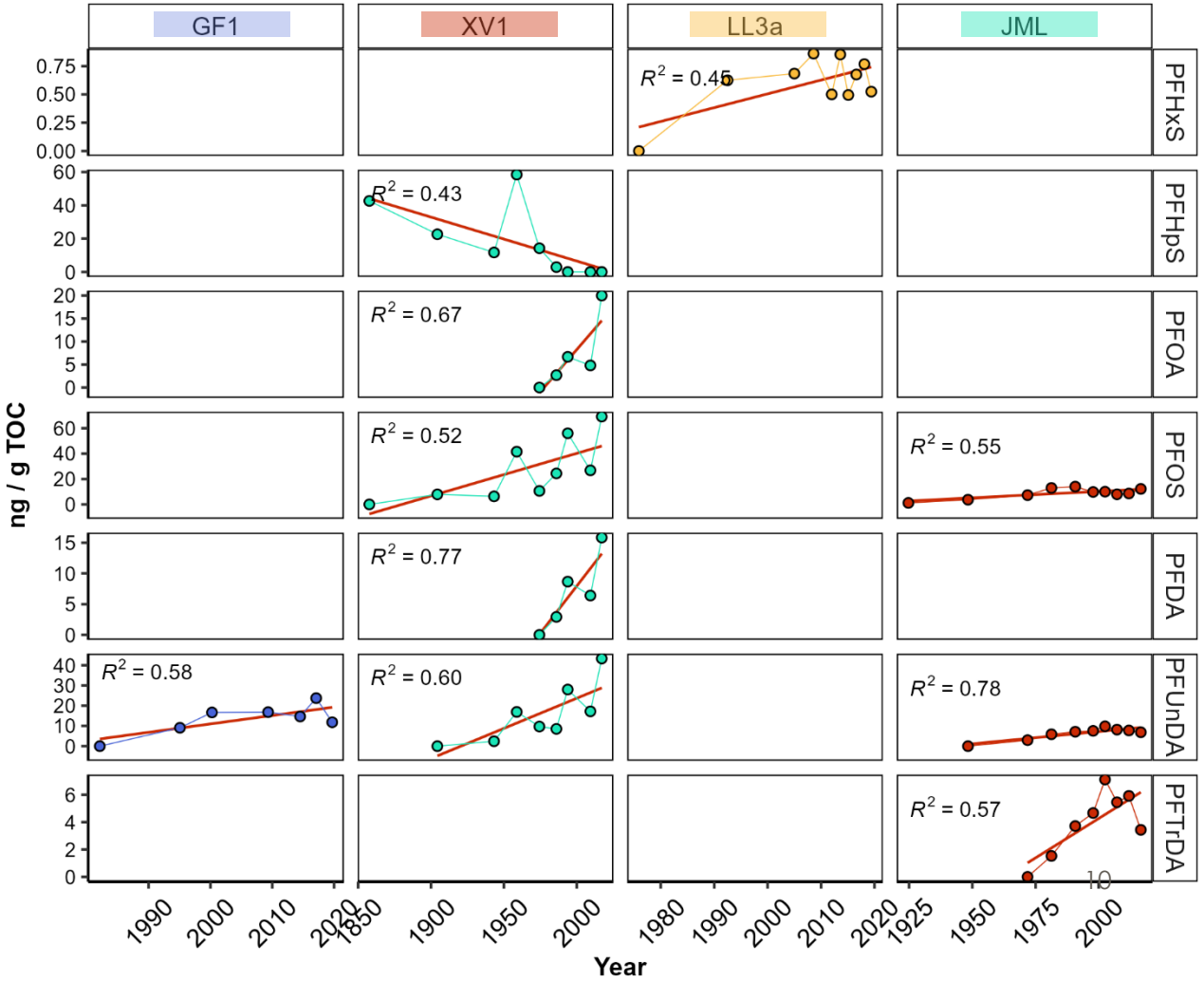


PFAS CONCENTRATIONS ARE RISING

(Junttila et al. *unpub*)



SYKE



RISK ASSESSMENT

ONE COMPOUND + ONE THRESHOLD =

THOUSANDS OF COMPOUNDS + LACK OF THRESHOLDS =

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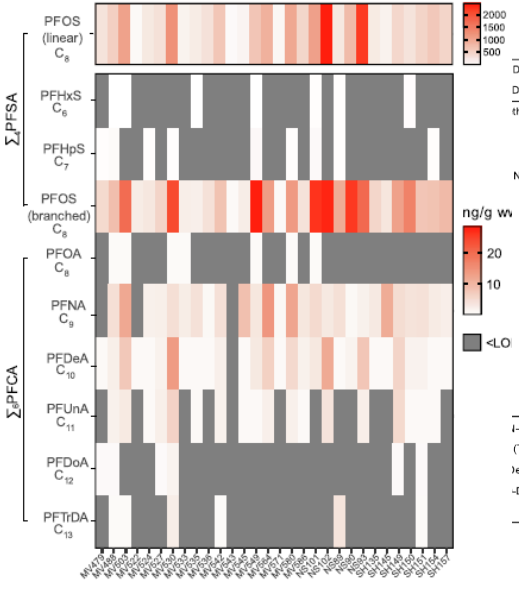
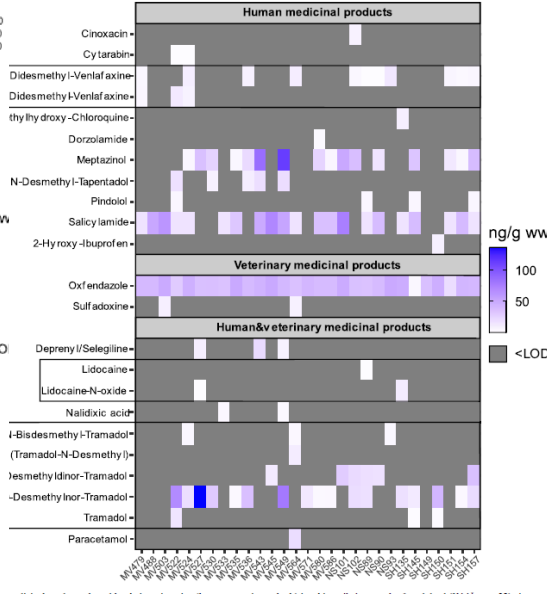
VARIETY OF HARMFUL SUBSTANCES IN WHITE-TAILED SEA EAGLE LIVERS (Badry et al. 2022)

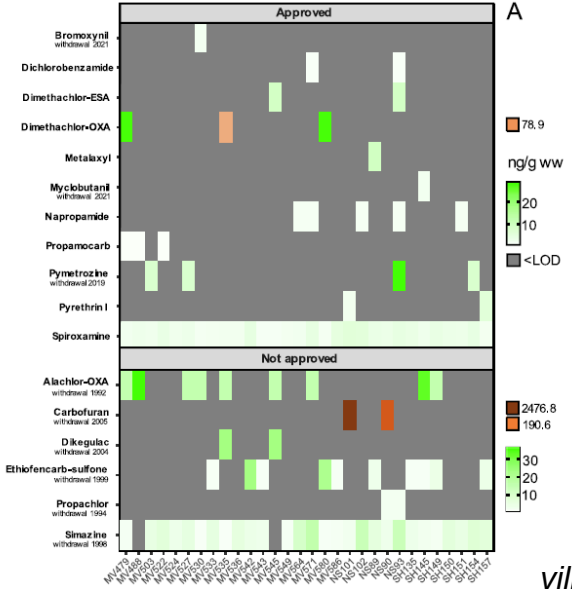
PFASs



Pharmaceuticals



Pesticides



ville.junttila@syke.fi

THANK YOU!

Ville Junttila
ville.junttila@syke.fi

SYKE

SCIENCE DAYS FOR THE GULF OF FINLAND AND THE EASTERN BALTIC SEA
Science forum: "Science shakes a hand with coastal life and citizens"
Venue: Helsinki City Hall; November 30, 2022

Biological invasions in the Baltic Sea: myths and reality

Sergej Olenin

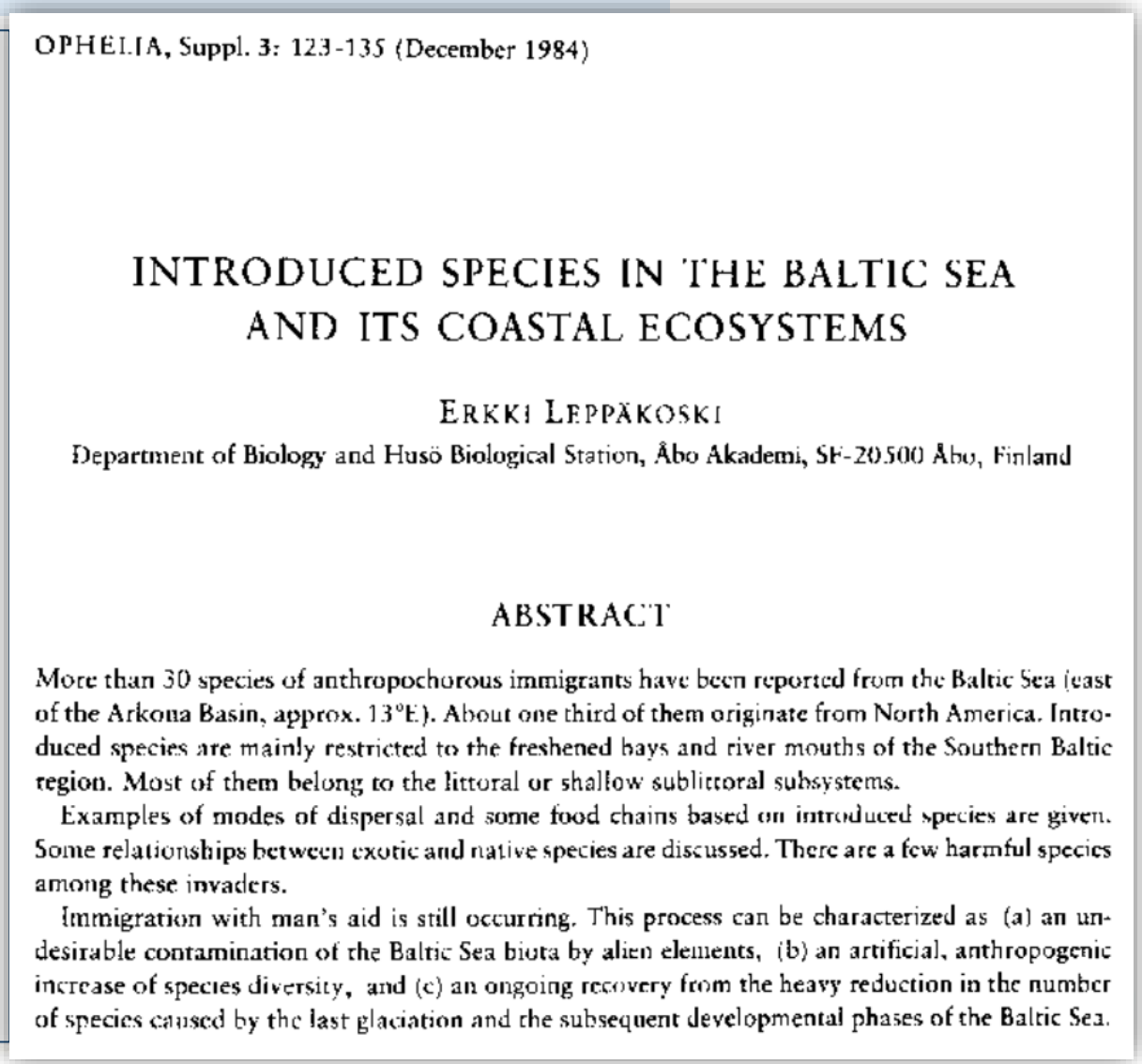
Marine Research Institute, Klaipėda University
Lithuania

<sergej.olenin@ku.lt>

Klaipeda University
Marine Research Institute

40 years ago:
the beginning of invasion biology in the Baltic Sea

- Leppäkoski, 1984: the first basin-wide approach to invasion biology in the Baltic Sea;
- 35 non-indigenous species (NIS) reviewed;
- The process of "immigration with man's aid", characterized as
  - an undesirable contamination of the Baltic Sea biota by alien elements,
  - an artificial, anthropogenic increase in of species diversity,
  - an ongoing recovery from the heavy reduction in the number of species caused by the last glaciation and subsequent developmental phases of the Baltic Sea.



OPHELIA, Suppl. 3: 123-135 (December 1984)

INTRODUCED SPECIES IN THE BALTIC SEA AND ITS COASTAL ECOSYSTEMS

ERKKI LEPPÄKOSKI
Department of Biology and Husö Biological Station, Åbo Akademi, SF-20500 Åbo, Finland

ABSTRACT

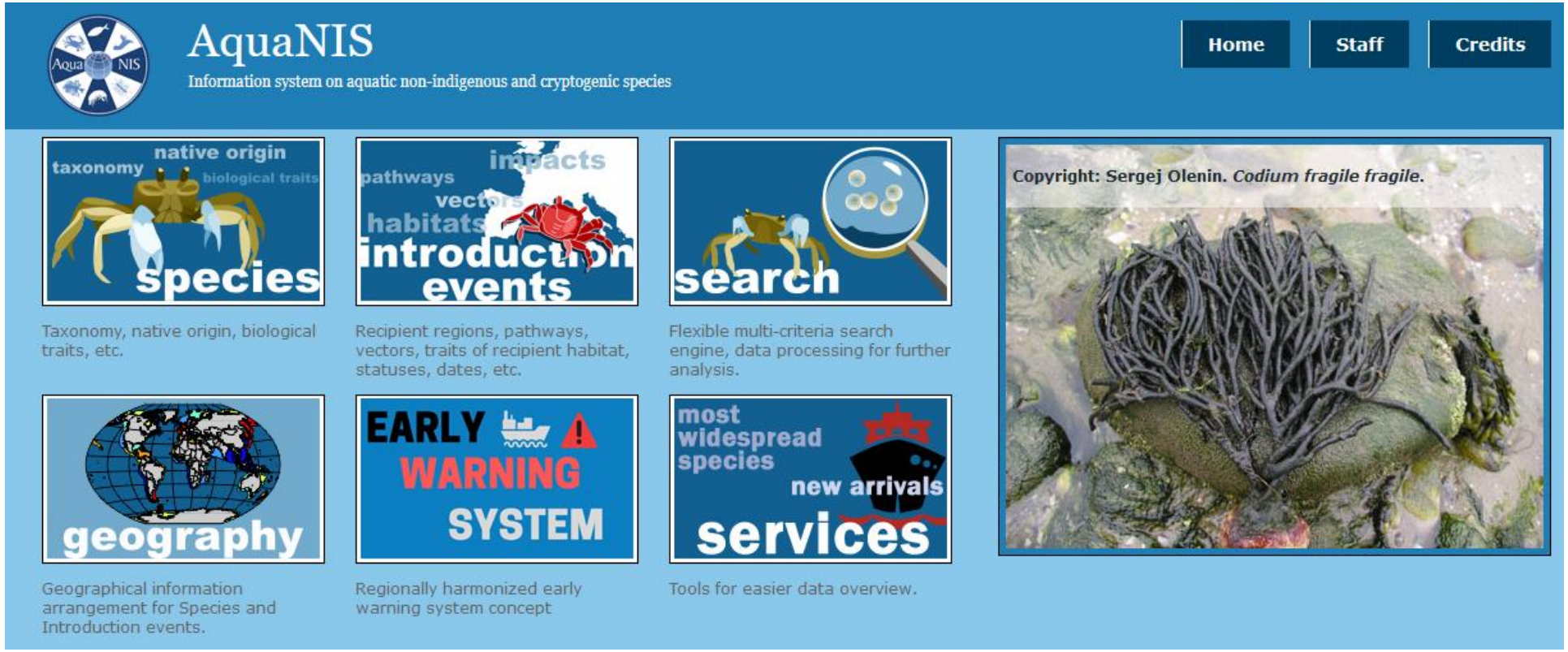
More than 30 species of anthropochorous immigrants have been reported from the Baltic Sea (east of the Arkona Basin, approx. 13°E). About one third of them originate from North America. Introduced species are mainly restricted to the freshened bays and river mouths of the Southern Baltic region. Most of them belong to the littoral or shallow sublittoral subsystems.

Examples of modes of dispersal and some food chains based on introduced species are given. Some relationships between exotic and native species are discussed. There are a few harmful species among these invaders.

Immigration with man's aid is still occurring. This process can be characterized as (a) an undesirable contamination of the Baltic Sea biota by alien elements, (b) an artificial, anthropogenic increase of species diversity, and (c) an ongoing recovery from the heavy reduction in the number of species caused by the last glaciation and the subsequent developmental phases of the Baltic Sea.

How many alien species in the Baltic today?

- **220 species in total**
- **66 arrived to the Baltic since the beginning of the XXI century**
- **3 new species per year**



AquaNIS – started as the world's first regional database (1997), ***the Baltic Alien Species Database***, now the global aquatic NIS information system.

~2,000 species

~5,500 introduction event records

Data from 27 Large Marine Ecosystems

http://aquanis.ku.lt

Klaipeda University
Marine Research Institute

Fundamental and applied aspects of modern Invasion Biology

Invasion biology

a rapidly growing interdisciplinary field of science

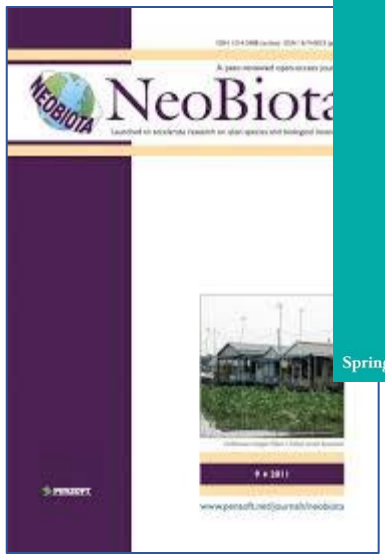
Fundamental aspects:

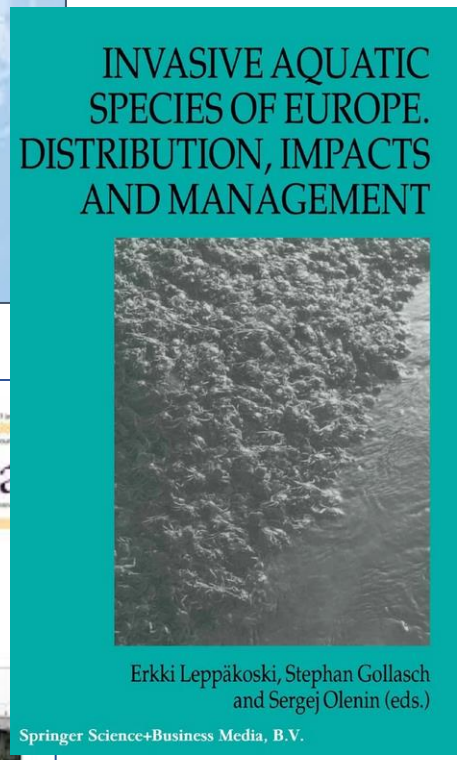
- **Biogeography**
  - Non-indigenous species inventories, invasion history, patterns of invasions, pathways and vectors of introductions
- **Molecular ecology**
  - Origin of invasive species and pathways, hybridisation process, implications for micro- and macroevolution
- **Ecophysiology**
  - Physiological tolerance, life strategies, reproduction modes
- **Functional ecology**
  - Benthic-pelagic interaction, trophodynamic of invaded ecosystems, habitat changes

Applied aspects:

- **Ecological economics**
  - Estimation of costs related to bioinvasions
- **Technical/technological aspects**
  - Ship ballast water management options
- **Environmental Law**
  - Development of administrative rules and legislative acts aimed on bioinvasions
- **Information Technology**
  - Databases, decision support systems, risk assessment models
- **Conservation biology**
  - Pest management, restoration
- **Environmental quality assessments**
  - Bioinvasion indicators, bio-pollution indexes

(Olenin et al. 2017. In: Biological oceanography of the Baltic Sea)





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Why study biological invasions?

Impacts of invasive alien species

Economy
- Fisheries
- Aquaculture
- Navigation
- Irrigation and abstraction
- Tourism
- Health care costs
- Biotechnology
- General management costs
- Opportunity costs

Health
- Human pathogens
- Human parasites
- Toxic compounds
- Poisoning organisms
- Venomous organisms
- Sharp shells and structures

Social-cultural aspects
- Recreational activities
- Spiritual involvement
- Education and research
- Interference with environmental monitoring

Environment
- Native species pathogens
- Native species parasites
- Pest vector
- Habitat alteration, fragmentation and loss
- Native species abundance
- Keystone species
- Toxicity on native species
- Predation
- Herbivory/grazing
- Competition
- Hybridization
- Nutrient regime alteration
- Hydrological cycle changes
- Food web changes
- Biodiversity alteration
- Red List species
- Ecosystem service alteration

Undesirable, adverse impacts of IAS **= biopollution**

(Elliott, 2003; Olenin et al 2007, 2010; Olenin & Minchin, in press)

Four principal types and different categories of bioinvasion impact of aquatic invasive alien species.

(Katsanevakis et al., 2016; Olenin et al., 2017; Srėbalienė et al., 2019; Tsirintanis et al., 2022; Olenin & Minchin, in press)

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Who's "alien" and who's not?

The "native-*versus*-alien species" dichotomy remains the main guiding principle in the field of environmental restoration and management
(Bonanno, 2016. *Env. Science & Policy*)

"native"

"not spreading"

"not influencing"

"harmless"

"good"

vs

"alien"

"spreading"

"influencing"
(on local communities, ecosystems, economic activities, etc.)

"harmful"

"bad"

Uncertainty in marine invasion science:

1. alien status
2. alien species inventories
3. pathway assessment
4. impact and risk assessments
5. field surveys
6. distribution modeling

(Katsanevakis, Moustakas, 2018. *Frontiers Mar. Sc.*)

Dogmas of invasion biology

- ***"Biological invasions are the second most important threat to biodiversity worldwide (after habitat destruction)"***
- ***"Biological invasions are the leading cause of marine species extinctions"***
- ***"Biological invasions lead to loss of marine biodiversity"***
- ***"Alien species cannot become part of the accepted native biota"***

(e.g. Wilson 1992; Perrings et al 2005; Schaffelke et al 2006; Zhu & Wang 2008; Molnar et al 2008; Felline et al; 2014; Assis et al 2015; Giakoumi et al 2016 ; Schmiedel et al 2016; Ricciardi et al 2017…)

Don't judge species on their origins

Conservationists should assess organisms on environmental impact rather than on whether they are natives, argue **Mark Davis** and 18 other ecologists.

(NATURE | VOL 474 | 9 JUNE 2011)

Conservation Biology

Review

The Potential Conservation Value of Non-Native Species

MARTIN A. SCHLAEPFER, DOV F. SAX, JULIAN D. OLDEN

First published: 22 February 2011

DOI: 10.1111/j.1523-1739.2010.01646.x

Cited by (CrossRef): 208 articles

Environmental Science & Policy 59 (2016) 67–73

Contents lists available at ScienceDirect

Environmental Science & Policy

journal homepage: www.elsevier.com/locate/envsci

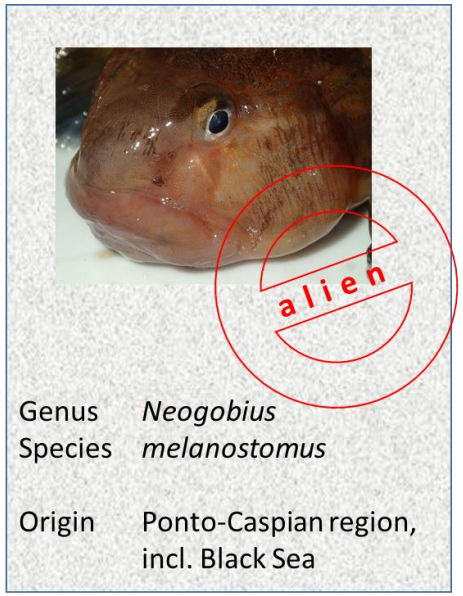
ELSEVIER

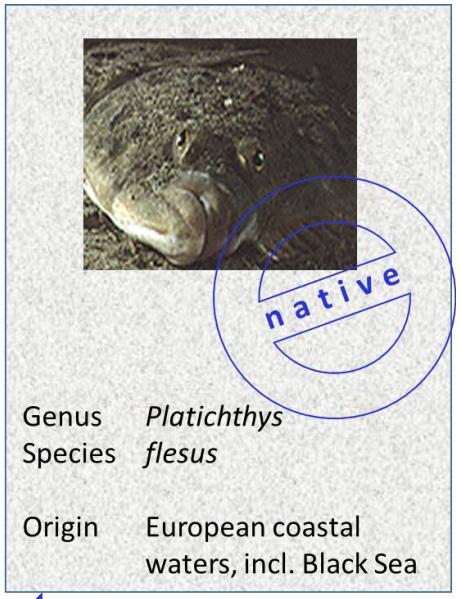
Alien species: to remove or not to remove? That is the question

Giuseppe Bonanno*

"Alien species cannot become part of the accepted native biota"

(e.g. Sala et al 2000; IUCN Red List 2015; Pauchard et al 2018; ...)





Possible criteria of "acceptance":

- **Population status**
  (self-reproducing, ceased expansion)
- **Environmental impact**
  (predictable, both negative and positive)
- **Position in the food web**
  (stable; not a 'dead-end'; not simplifying FW; native parasite burden)
- **Anthropocentric**
  (humans adopted to negative impacts, if any; ecosystem service provider; an exploitable resource?)

(Olenin et al. in prep.)

Alien → colonisation - naturalisation - indigenisation → **Native**

Time of residency

The extent of evolutionary and ecological interactions with other long-term residents (*sensu*: Davis, 2009)

Klaipeda University
Marine Research Institute

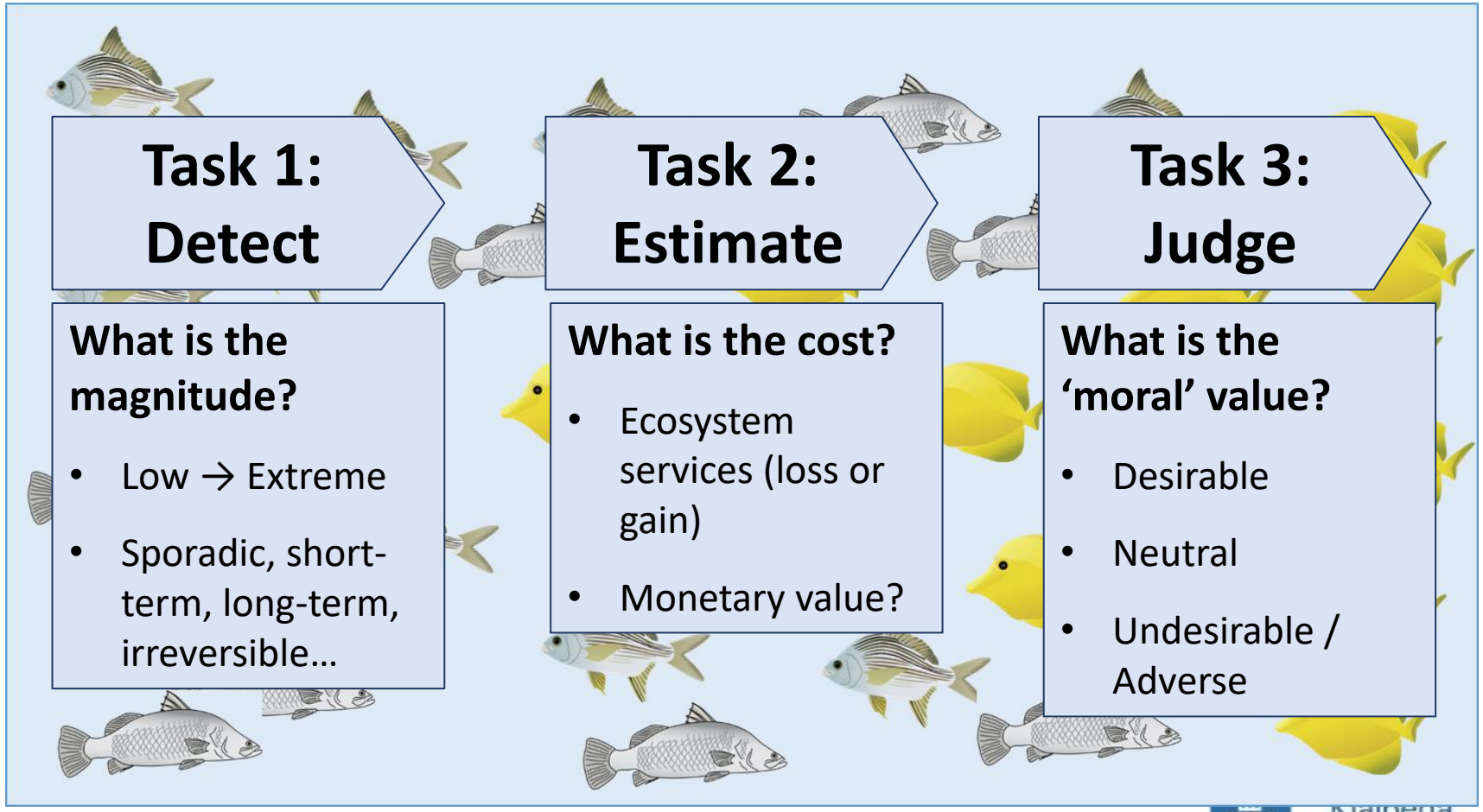
"Biological invasions lead to loss of [marine] biodiversity"

(e.g. Schaffelke et al 2006; Zhu & Wang 2008; Molnar et al 2008; Felline et al; 2014; Assis et al 2015; Giakoumi et al 2016...)

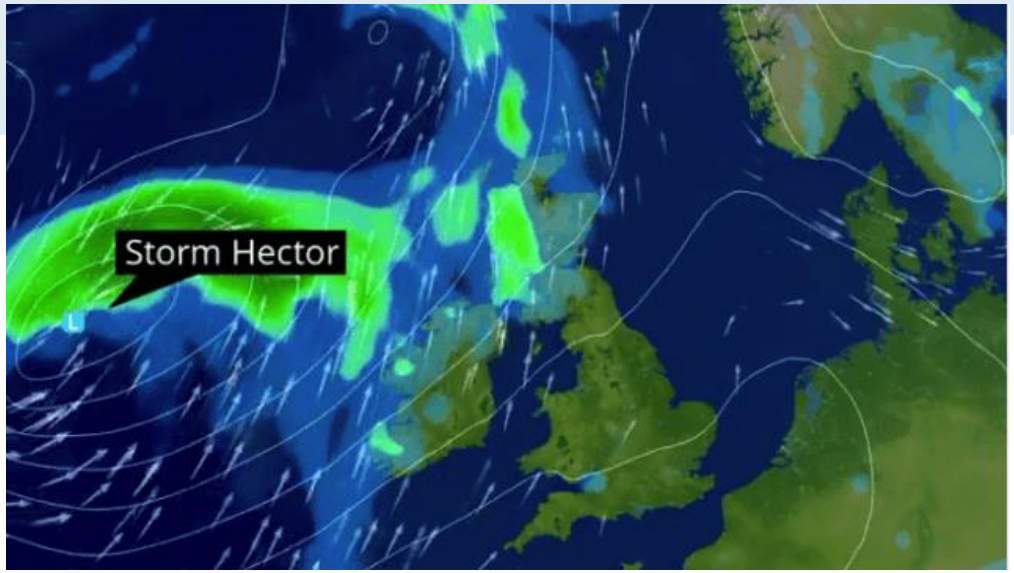
Levels of marine biodiversity:

- **Genetic**
- **Species**
- **Functional**
- **Phyletic**
- **Habitat**
- **Ecosystem**

(Gray 1997. Marine biodiversity: patterns, threats and conservation needs. *Biodiversity and Conservation*, 6.)



Consequences of a biological invasion? Difficult to predict!



NewScientist

News Technology Space Physics Health Environment Mind Video | Tours Events Jobs

AI detective analyses police data to learn how to crack cases

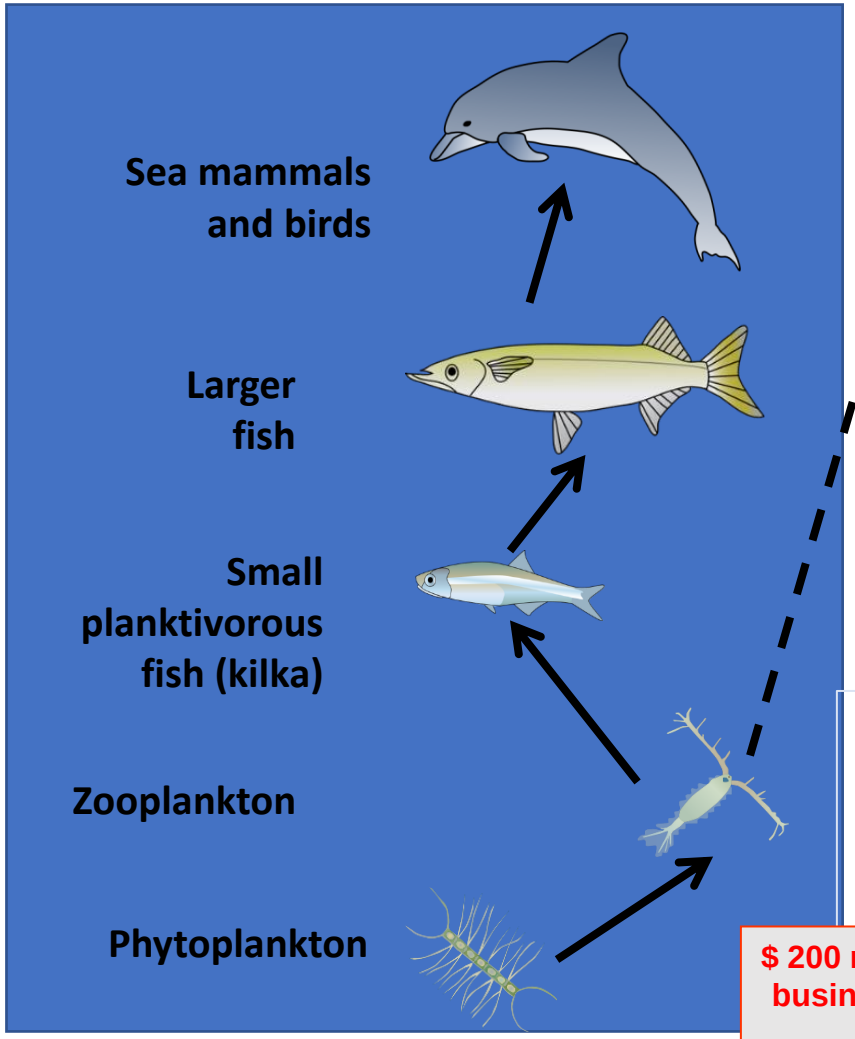
A system called VALCRI should do the laborious parts of a crime analyst's job in seconds, while also suggesting new lines of enquiry and possible motives

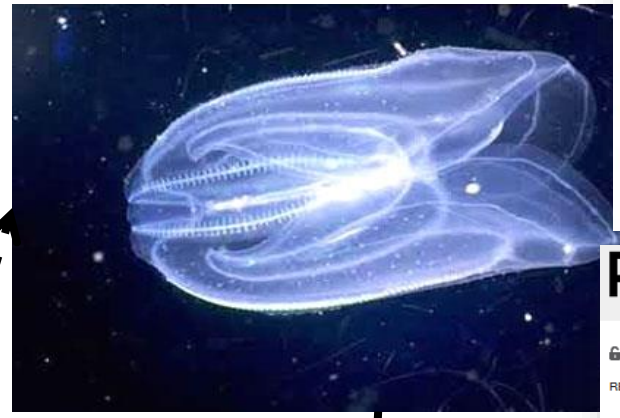
TECHNOLOGY 10 May 2017

By Timothy Revell

- ✓ **Life form, e.g. planktonic larval stage**
- ✓ **Feeding method, Mobility**
- ✓ **Toxicity, Bioaccumulation potential**
- ✓ **Habitat modifying ability**
- ✓ **Environmental requirements**
- ✓ **Invasion history (incl. closely related species)**
- ✓ **An invaded range**
- ✓ **Environmental conditions and availability of resources in invaded ecosystem**
- ✓ **…**

Ecological and economic consequences of the comb jelly *Mnemiopsis leidyi* invasion in the Black, Caspian Seas…and the Baltic





'dead end'

Invasive comb-jelly *Mnemiopsis leidyi* drastically changing the Black Sea food we… sharp declines in zooplankton and fish larvae abundance and in landings of anchovies and other pelagic fish.

$ 200 mln: economic losses to the Turkish fishin… business alone in 1989 due to a sharp decline i… catches of anchovy (kilka)

LIMNOLOGY AND OCEANOGRAPHY

ASLO Association for the Sciences of Limnology and Oceanography

Article | Free Access

The invasive ctenophore *Mnemiopsis leidyi* poses no direct threat to Baltic cod eggs and larva

Cornelia Jaspers, Josefin Titelman, Lars Johan Hansson, Matilda Haraldsson, Christine Røllike Ditlefsen

PLOS ONE

OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

Salinity Gradient of the Baltic Sea Limits the Reproduction and Population Expansion of the Newly Invaded Comb Jelly *Mnemiopsis leidyi*

Cornelia Jaspers, Lene Friis Møller, Thomas Kiørboe

Published: August 26, 2011 • https://doi.org/10.1371/journal.pone.0024065

Biol Invasions (2012) 14:341–354
DOI 10.1007/s10530-011-0066-z

ORIGINAL PAPER

Spreading and physico-biological reproduction limitations of the invasive American comb jelly *Mnemiopsis leidyi* in the Baltic Sea

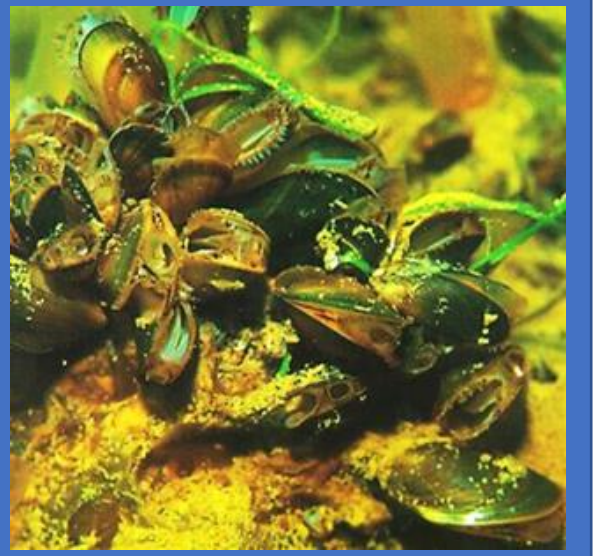
Maiju Lehtiniemi · Andreas Lehmann · Jamileh Javidpour · Kai Myrberg

If an invasive species is already here? Be pragmatic!

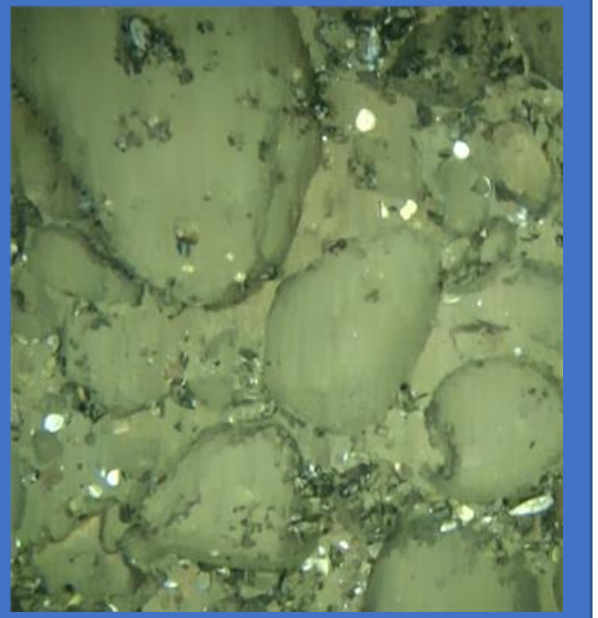
The round goby *Neogobius melanostomus*

Blue mussel beds

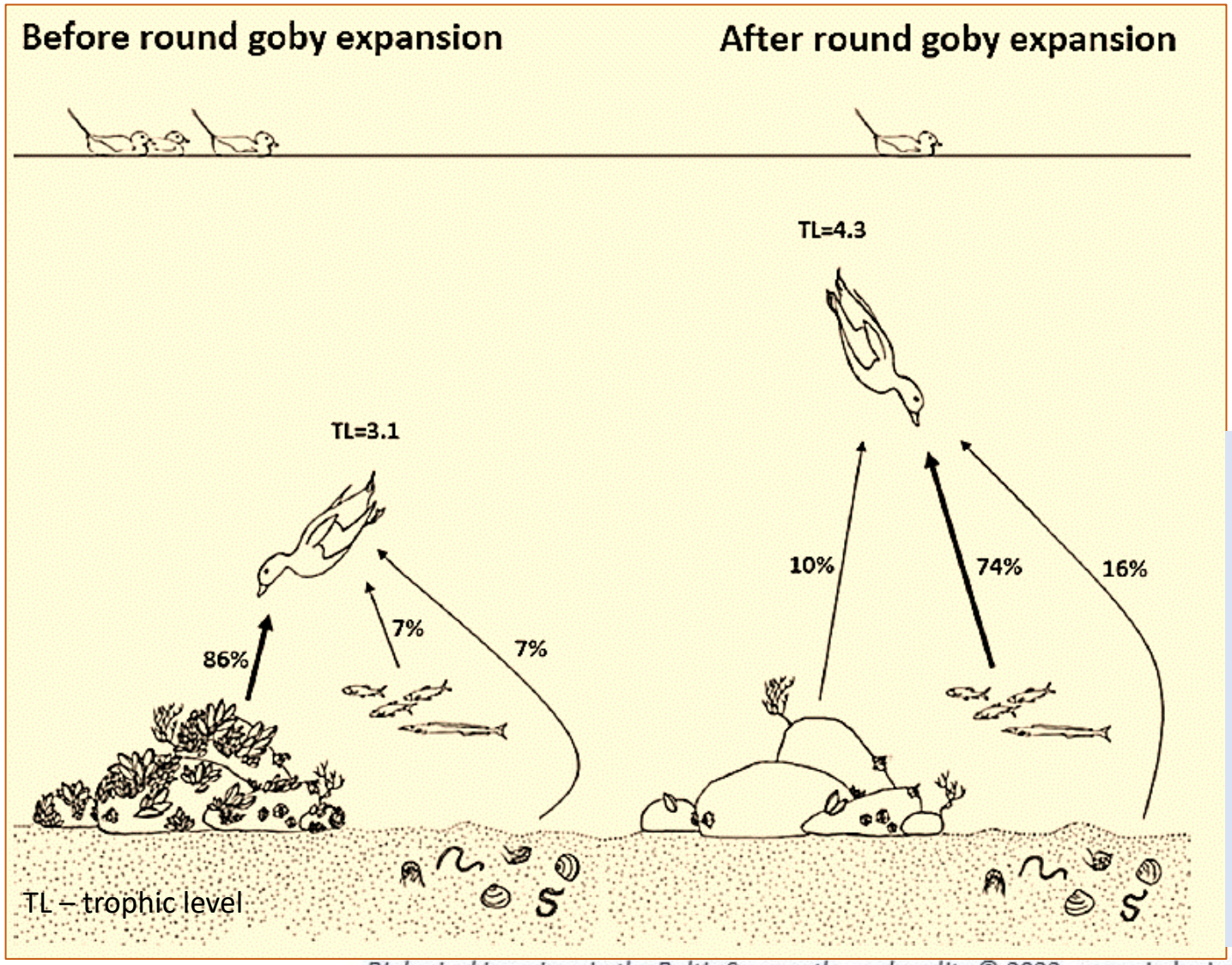
2009



2013



The cascading effect of the round goby invasion



(Skabeikis et al. 2018. Biol. Invasions)


Photo: A. Razmas

- **Devastation of mussel beds.**
- **Change in blue mussel size structure.**
- **The long-tailed duck diet: shift from blue mussels to fishes**
- **Decline in feeding efficiency**
- **Decline in the wintering population of the long-tailed duck .**

The round goby fest in Palanga, Lithuania

The round goby fest in Palanga, Lithuania

The monument to
“The Round Goby - the Breadwinner”
in Berdiansk, Ukraine.

Towards a pragmatic, innovative and open-minded Invasion Biology

- Precautionary approach to prevent all new introductions because of their unpredictable consequences.
- AI aided biosecurity risk assessment.
- Ecosystem services damaged and provided by IAS (the impacts may be negative, neutral or positive).
- Naturalization continuum instead of "the native-*vs*-alien species" dichotomy in management.
- The use of established alien species as a measure of their control (the round goby example)

Thank you for your attention!

Economic viewpoint and other perspectives to the sea

Kari Hyytiäinen

What is the sea?

Aspects:
Physics

Physics

Topography = forms and features of land surface
Hydrography = physical properties water
Laws of thermophysics
Solar energy, earth rotation -> winds, waves, streams

What is the sea?

Aspects:
Physics
Chemistry

Chemistry

Interplay of matter, compounds and energy in aquatic ecosystems
Biogeochemical processes: flow of carbon, phosphorus, nitrogen and water between living organisms and the environment.

What is the sea?

Aspects:
Physics
Chemistry
Biology & ecology

Biology & ecology

Plants and animals
Structure and functioning of the food web
Bacteria - lower and upper trophic levels - top predators

What is the sea?

Aspects:
Physics
Chemistry
Biology & ecology
Money & work

Money & work

Maritime traffic
Commercial fisheries
Coastal tourism (blue tourism)
Energy production, off-shore wind

What is the sea?

Aspects:
Physics
Chemistry
Biology & ecology
Money & work
Assets, property, homes

Assets, property, homes

Houses and other infrastructure by the sea (connectedness to the sea)
… and even broader: home, living environment, community

What is the sea?

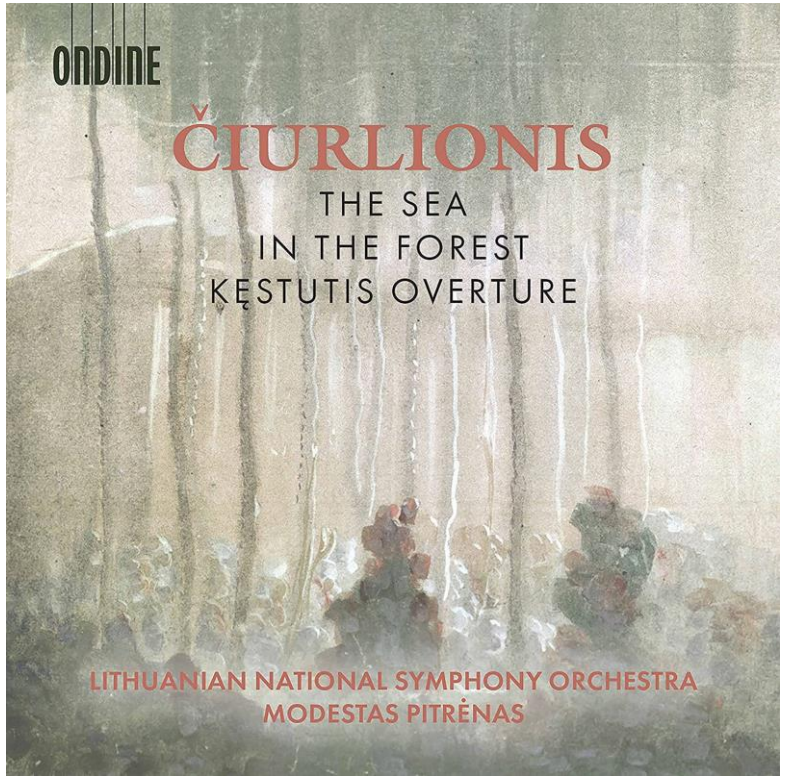
Aspects:
Physics
Chemistry
Biology & ecology
Money & work
Assets, property, homes
Emotions & inspiration

Emotions & inspiration

Personal experiences -> part of our identity
Other peoples' emotions
-> art, literature, music
-> our shared cultural property and shared heritage

Mikalojus Konstantinas Čiurlionis

Lithuanian painter, composer and writer, spent summers in Palanga



Thomas Mann

1929 Nobel Prize in Literature laureate, stayed and wrote in the Neringa peninsula, in Nida

Tove Jansson

Artist, the creator of Moomins, stayed much of her time in Porvoo archipelago

What is the sea?

Aspects:
Physics
Chemistry
Biology & ecology
Money & work
Assets, property, homes
Emotions & inspiration
Freetime, travel

Freetime & travel

Recreation, adventure
Sailing, recreational fishing, beach recreation, water sports

What is the sea?

Aspects:
Physics
Chemistry
Biology & ecology
Money & work
Assets, property, homes
Emotions & inspiration
Freetime, travel
Health

Human health

Health impacts: quality of seafood, microplastics, hazardous substances
Mental capacity: our brains relax, perception develops, creativity improves, greater mental sharpness

What is the sea?

Aspects:
Physics
Chemistry
Biology & ecology
Money & work
Assets, property, homes
Emotions & inspiration
Freetime, travel
Health
Sacred

Sacred

Personal values connected to righteousness, human-nature relationship and existence values
Strong and weak sustainability (natural vs. man-made capital)
Binary choice that can sometimes be interpreted as minimum ecological conditions that must be secured (at any cost)

How important is the sea?

Aspects:
Physics
Chemistry
Biology & ecology
Money & work
Assets, property, homes
Emotions & inspiration
Freetime, travel
Health
Sacred

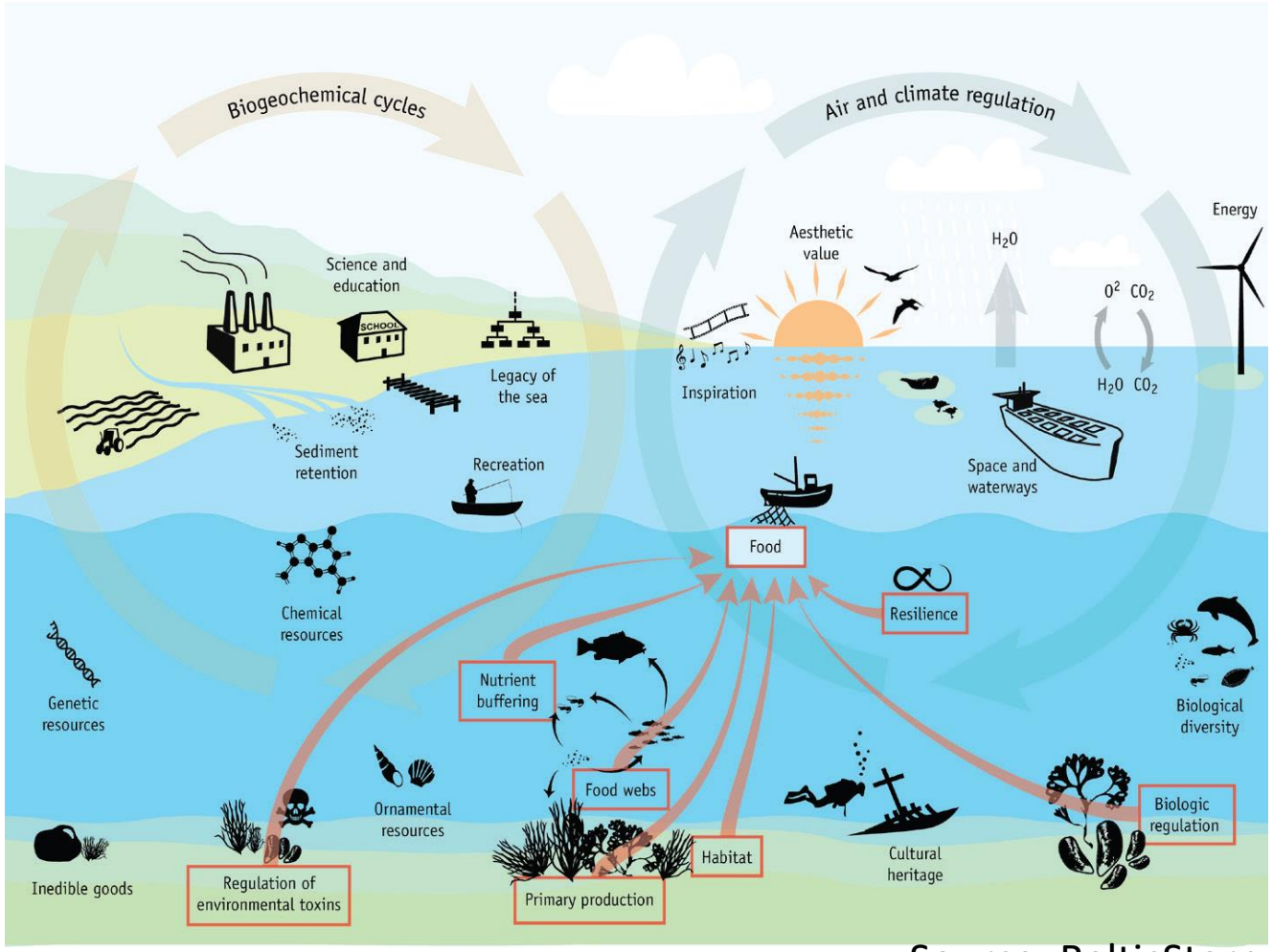
Supporting and regulating ecosystem services

Life-supporting services

Enable all provisioning and cultural ecosystem services

Importance? Value?

Ecosystems critical at regional or global scale-> sustained functioning of ecosystems must be maintained



Source: BalticStern

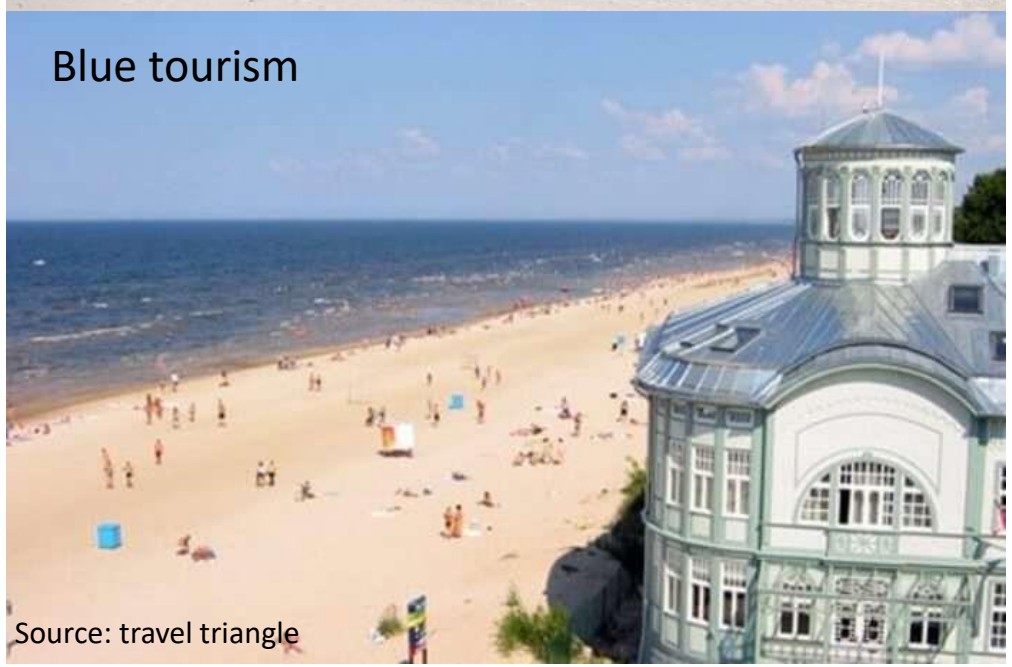
How important is the sea?

Aspects:
Physics
Chemistry
Biology & ecology
Money & work
Assets, property, homes
Emotions & inspiration
Freetime, travel
Health
Sacred

Provisioning ecosystem services

Products and services exhanged in markets
-> directly measurable in economic metrics

- Blue economy = sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem
- Metrics such as turnover and value added are available to assess the contribution of blue economy sectors on national economy and welfare



Source: travel triangle

Marine Traffic

Passanger and freight

Enabler of global trade - large majority of goods transported via seas

Friendlier for environment than many other forms of transport

How important is the sea?

Aspects:
Physics
Chemistry
Biology & ecology
Money & work
Assets, property, homes
Emotions
Freetime, travel
Health
Sacred

The proximity, views to the sea and environmental state of the adjacent aquatic ecosystems increase the values of properties

Hedonic pricing: a method to estimate economic values for ecosystem or environmental services that directly affect market prices (e.g. Artell, 2013)

How important is the sea?

Aspects:
Physics
Chemistry
Biology & ecology
Money & work
Assets, property, homes
Freetime, travel
Emotions & inspiration
Health
Sacred

Cultural ecosystem services:
- Not (or only partly) exchanged in markets

Non-market valuation
- Methods to indirectly assess the value of ecosystem services
- Thinking behind: people value aspects of the environment, in the sense that they would be willing to give up something else of value to continue to enjoy them, or to ensure they are available for future generations.
- Contingent valuation & choice experiments (e.g. Ahtiainen et al. , 2015)
- eliciting benefit/damage estimates for changed environment
- Willingness to pay for improvements (eg. additional taxes)

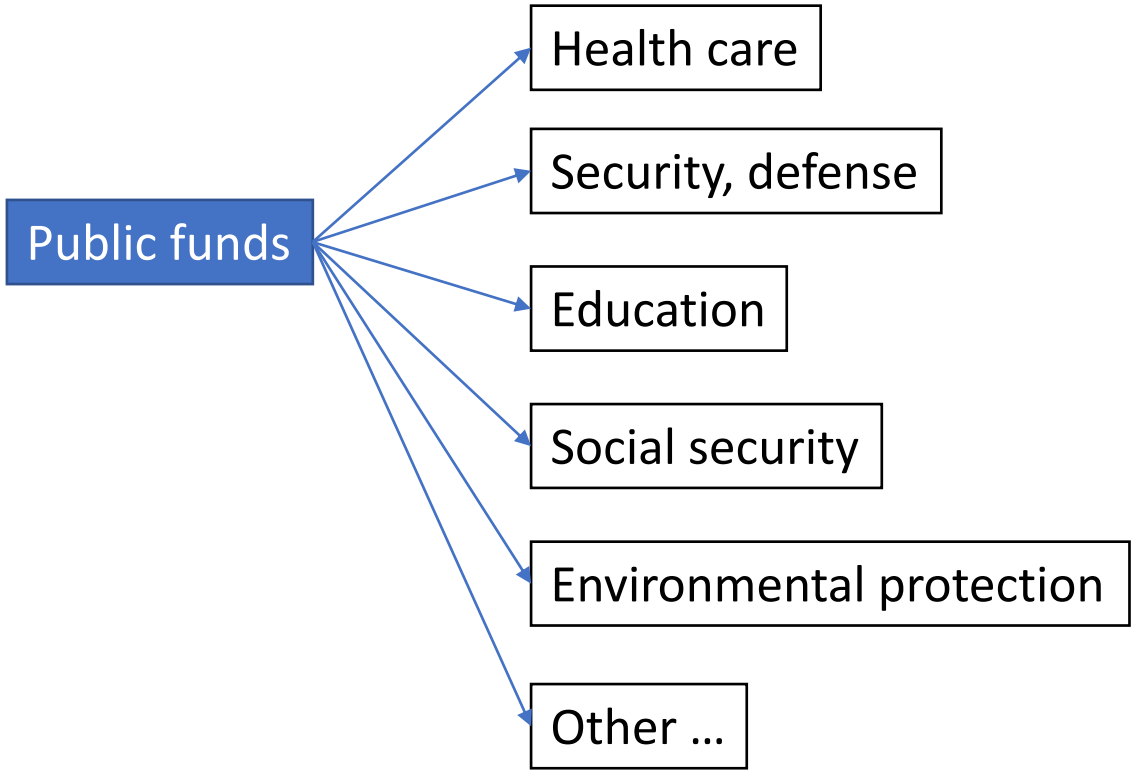
Change in environmental state
- Improves -> increase in human welfare
- Decreases -> reduction in human welfare -> cost of degration

Attempt at valuing ecosystem services – why?

1 Marginal value - not total value

2 Public decision making
(resource allocation)

3 Design of environmental policies
(focus of efforts - actors, areas and environmental problems)



Summary

The sea and coastal areas – multiple aspects and values

Some of the benefits are measurable in economic metrics, others not

Value considerations important for societal decision making:

1. Understanding the multiple benefits of environmental protection (or the damages caused by environmental degradation)

   -> proper weight in resourcing nature protection

2. Identify areas of conficting values

   -> processes seeking consensus & compromise

   -> enhancing social cohesion

References

Ahtiainen, 2015 Benefits of meeting nutrient reduction targets for the Baltic Sea–a contingent valuation study in the nine coastal states. Journal of Environmental Economics and Policy

Artell, 2013 Lots of value? A spatial hedonic approach to water quality valuation Journal of Environmental Planning and Management

Active pharmaceutical ingredients in environment – from data gaps to educational campaign (case study of Latvia and Lithuania)

"Pharmaceuticals in wastewaters – levels, impacts and reduction"
MEDWwater (Project LLI-527)

Ieva Putna-Nimane[1], Sergej Suzdalev[2], Liena Freimane[3]
[1] Latvian Institute of Aquatic Ecology
[2] Marine Research Institute, Klaipeda University,
[3] Kurzeme Planning Region
Annual Science Days and BALTICITIES Kick-off meeting,
Helsinki, Finland 30.11 - 1.12.2022.

Nature Needs No Pill

- Why Active Pharmaceutical Ingredients (API) ?
  - Designed to be biologically active human body -and also animals- for treatment purposes
  - Potentially harmful when they enter the environment
  - (Some) are shown to have adverse effects on e.g. crustaceans, fish, mammals
- Should work together in strategic way in order to reduce amounts in environment

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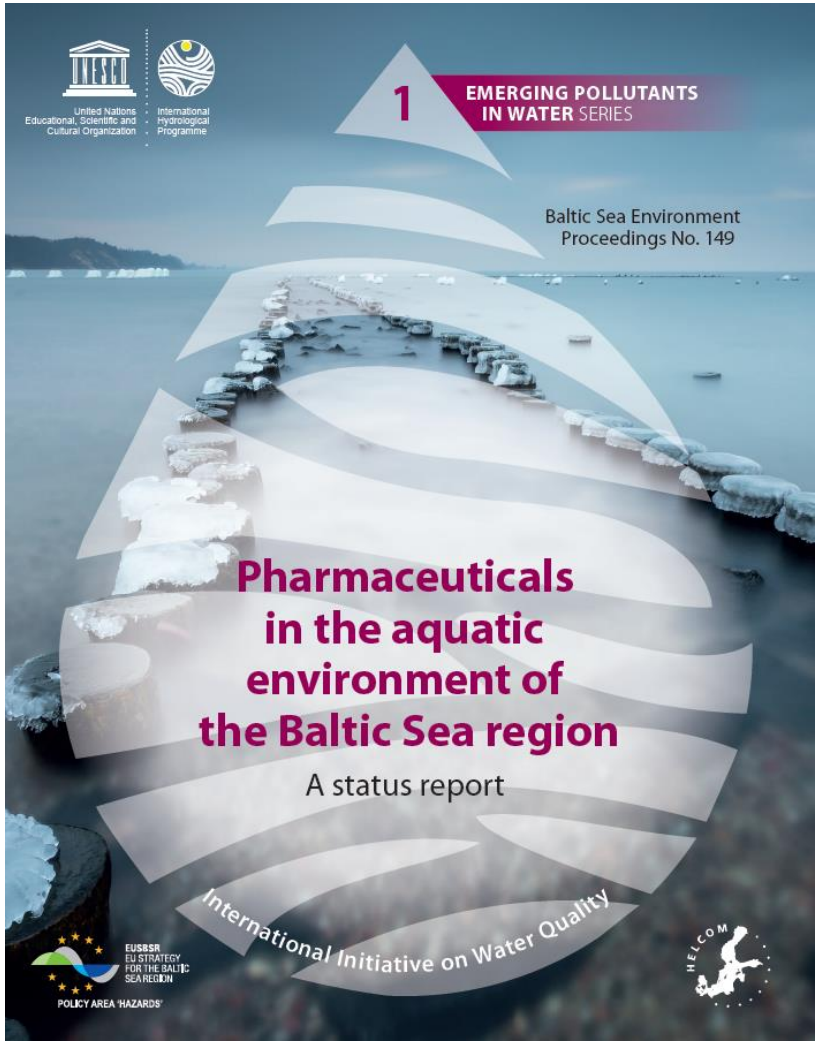

5 year ago…

The Status report on pharmaceuticals in the Baltic Sea region (PDF) was published by UNESCO and HELCOM in 2017.
The report was developed jointly by the Baltic Marine Environment Protection Commission (Helsinki Commission, HELCOM) and Policy Area Hazards of the European Union Strategy for the Baltic Sea Region (EUSBSR).

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Table 1. *An overview of data provided in response to a HELCOM questionnaire on occurrence, sources and pathways of pharmaceuticals in the Baltic Sea region.*

Source: Original data.

Country	Production & waste		Sales, Consumption		Monitoring data					
	Production	Waste management	Human	Veterinary	WWTPs	Sludge	Rivers	Sea water	Sediments	Biota
Denmark					●	●	●	●		
Estonia		●	●		●		●	●	●	
Finland	●	●	●	●	●	●	●	●	●	
Germany		●	●	●	●		●	●		
Poland								●		
Russia			●		●			●		
Sweden		●	●		●	●	●	●	●	●

In total 47,621 data points from the period 2003-2014 were included in the data set on sources and pathways of pharmaceuticals (i.e. monitoring of wastewater influent and effluents, sludge and river water).

Only nine out of 118 assessed pharmaceuticals were removed from wastewater during the treatment processes with an efficiency over 95%, and nearly half of the compounds were removed with an efficiency of less than 50%. Sixteen compounds were found in higher concentrations in effluents from MWWTP than in influents.

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- **Inetrreg SBR MORPHEUS**
  - **Duration: 2017 – 2019**
  - **7 partners in 4 countries**
  - **4 WWTP and receiving waterbodies in Lithuania investigated**

- **Interreg BSR CWPharma**
  - **Duration 2017 – 2020**
  - **15 partners in 7 countries**
  - **3 WWTP and receiving waterbodies in Latvia investigated**

LATVIJAS HIDROEKOLOĢIJAS INSTITŪTS
KURZEMES PLĀNOŠANAS REĢIONS
LATVIJAS VIDES, ĢEOLOĢIJAS UN METEOROLOĢIJAS CENTRS
Klaipeda University
Zāļu valsts aģentūra
STATE MEDICINES CONTROL AGENCY

EUROPEAN COMMISSION

Brussels, 11.3.2019
COM(2019) 128 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL AND THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE

European Union Strategic Approach to Pharmaceuticals in the Environment

Proposed EU actions/strategic approach

... **monitoring/assessment of existing WWTPs** and investigate the feasibility for upgrading selected, use EU programmes to **invest in technologies to improve the efficiency of removal of pharmaceuticals …**

... **expand environmental monitoring** (select potentially relevant pharmaceuticals-EC Watch List, research on **monitoring individual substances and mixtures of substances** in fresh and marine waters …

In 2019 European Commission published communication

Pharmaceuticals mainly reach the environment through:

.... the **<u>discharge of effluent from urban waste water (sewage) treatment plants</u>** – containing excreted pharmaceuticals as well as unused pharmaceuticals thrown away into sinks and toilets, despite the existence of collection schemes..

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VIDES, ĢEOLOĢIJAS UN HIDROLOĢIJAS CENTRS

Klaipeda University

Zāļu valsts aģentūra

STATE MEDICINES CONTROL AGENCY

- **What Next?**

- **We have recommendations…**
- **We have good examples…**

- **We also have specific needs identified (important!)**
  - **Specific partnership; Education; Reminders**

- **Need to act in local level with specific needs!**

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“Pharmaceuticals in wastewaters – levels, impacts and reduction”
MEDWwater
(LLI-527) 2021 – 2022 (waiting for extension)

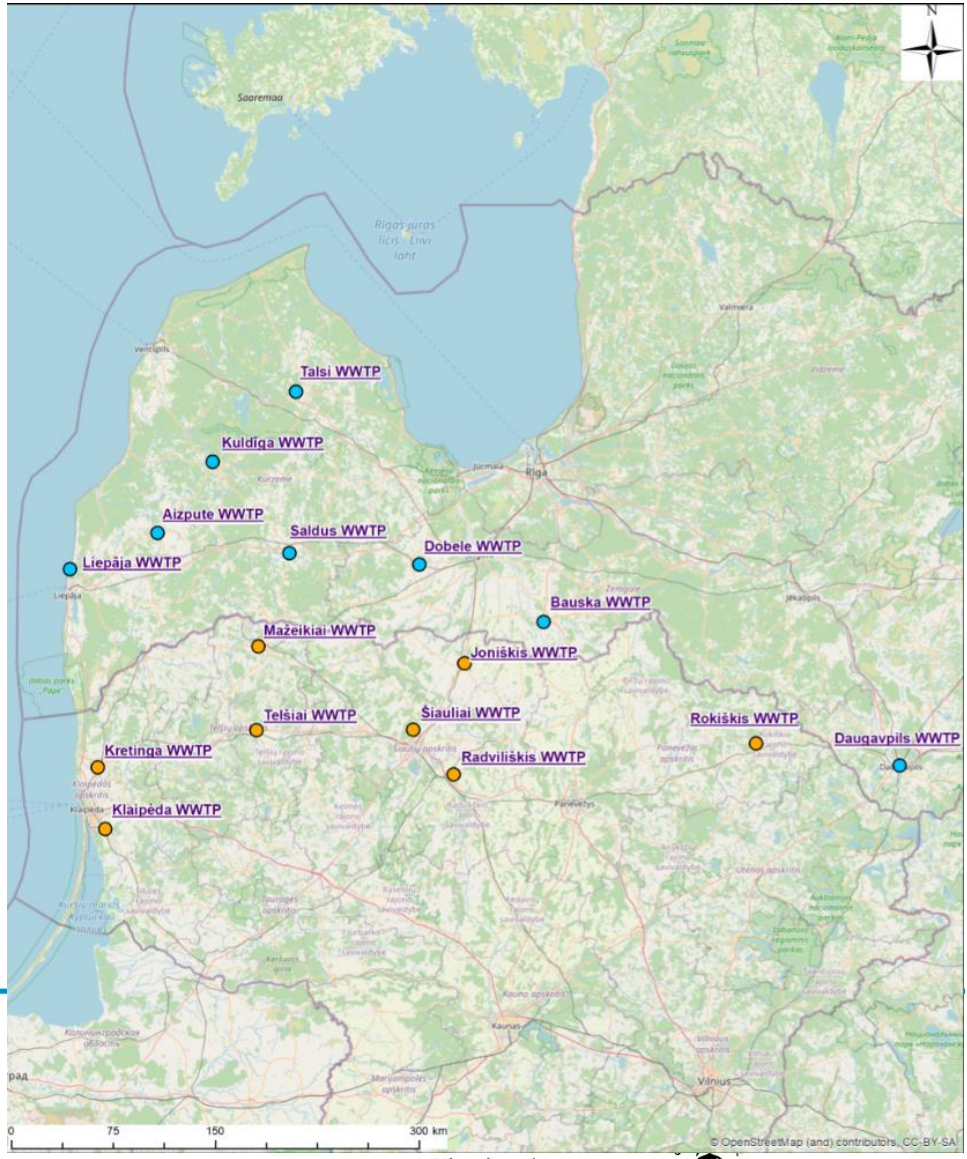
- Decrease the emissions and adverse effects of Active Pharmaceutical Ingredients in the Latvia and Lithuania
  - Suggest practical ways to decrease the emissions
  - Knowledge transfer

PP:

- Latvian Institute of Aquatic Ecology
- Kurzeme Planning region
- Latvian Environment, Geology and Meteorology Centre
- Klaipeda University
- State Agency of Medicines of Latvia
- State Medicines Control Agency under the Ministry of Health of Republic of Lithuania
- **Advisory Board (Provide Letter of Support during project preparation process):**

- Ministry of Environment of the Republic of Lithuania
- Environmental Protection Agency of Lithuania
- Lithuanian Water Suppliers Association
- Ministry of Environmental Protection and Regional Development of the Republic of Latvia
- Zemgale Planning region
- Latgale Planning region
- Ltd. Daugavpils Ūdens (WWTP of City Daugavpils)
- Ltd. Liepājas Ūdens (WWTP of City Liepāja)

- + external observer -> Latvian water and wastewater works association (lwwwa)



Main Outputs

- Number of organizations supported by developing a **priority list of WWTPs for future upgrading depending** on APIs pollution loads and contamination status of **receiving water bodies**
- Number of organizations supported by developing a list of **priority pharmaceuticals for further monitoring** in Programme area
- Number of organizations supported by the **strategic recommendations for wastewater treatment plants for safe removal of pharmaceuticals** and list of pharmaceuticals to be monitored

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In project -> 5 work packages

- M - Management
- T 1 Implementation - Consumption and risks of active pharmaceutical substances in Program area
- T 2 Implementation - Pharmaceuticals loads in WWTPs systems and relevant water bodies
- T 3 Implementation - Strategic approaches to the reduction of APIs discharges from WWTPs
- **C – Communication***(WWTP -> high expenses; push on population)

Nature Needs No Pill

- **Campaign «Nature needs no Pills»**
- **Cooperation with Pharmacies**
  - Cooperation with **Pharmaceutical Care Association of Latvia**, **Pharmacist' society of Latvia**, **Pharmacy association**, State Agency of Medicines of Latvia and State Medicines Control Agency under the Ministry of Health of Republic of Lithuania

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Stickers for pharmacies

placed on the entrance door to the pharmacies that

- inform on possibility to dispose the unused medications
- planned number of Pharmacies - 200
- distributed – 750

Nature Needs No Pill

Informative materials - flyers

- 10 000 flyers
- created for the general public to educate on eco toxicity of pharmaceuticals and what to do with unnecessary medicine
- spread among libraries, institutions, culture buildings and pharmacies and other places, mainly owned by municipalities

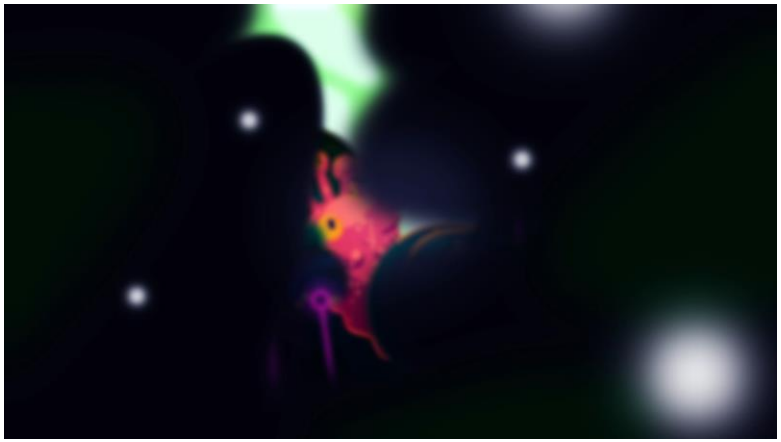
Cooperation with Pharmacies

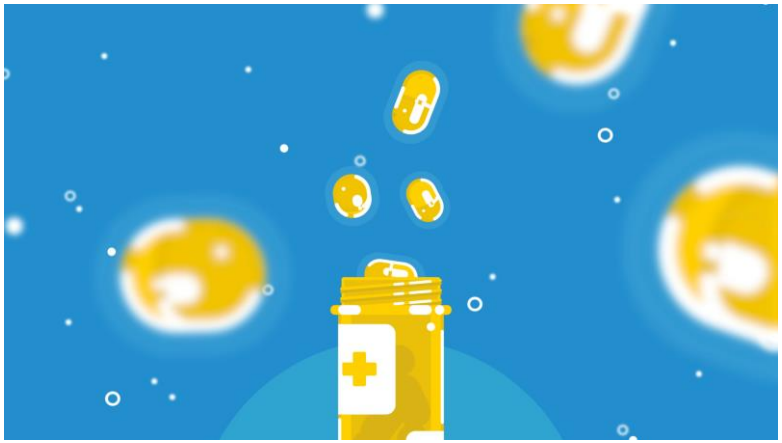
- In Lithuania all pharmacies have agreements with waste management companies for safe disposal medicine (set by the law), so we could not realise idea about stickers
- Cooperation with Camelia's (newspaper's circulation is about 450 000 per month) and Eurovaistine's (circulation 440 700). Also distributed through e-mails

Campaign on digital platform

2 educational videos, infographics for social media and cooperation with bloggers

- 1st video and infographics focuses on eco-toxicity caused by pharmaceuticals
- 2nd video and infographics calls to action – what to do with unnecessary pharmaceuticals



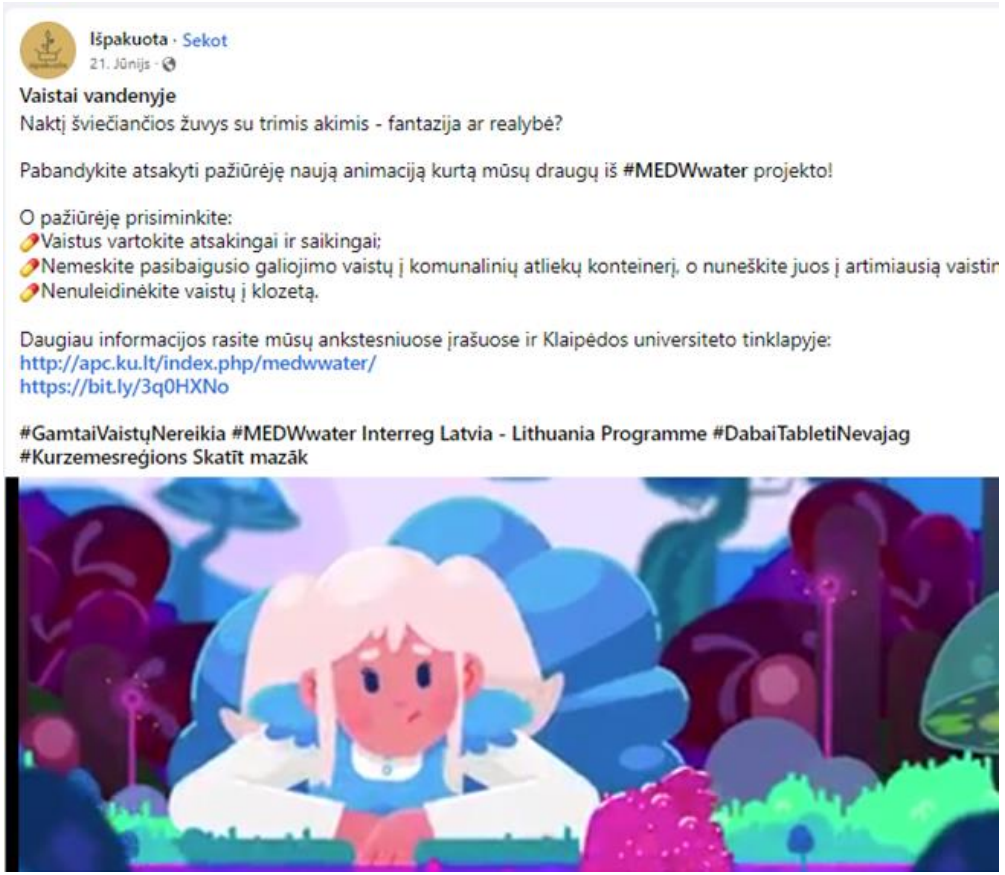


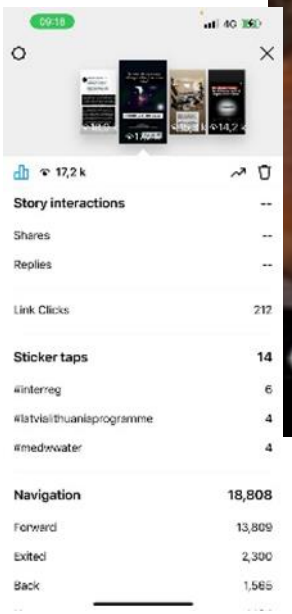
- Distributed to owned channels (e-mails, web pages etc.), social media, sent to national and regional media in both countries, sent to stakeholders, presented to public in second public event
- 2-3 minutes, LT and LV voice and subtitles

Nature Needs No Pill

Cooperation with bloggers

- **@Kristine Garklava – 79818 views**
- **@Išpakuota – 21874 views**





Latvia

Press:

https://www.lsm.lv/raksts/dzive--stils/vide-un-dzivnieki/petijums-zalu-paliekas-latvijas-un-lietuvas-notekudenos-daudzviet-ir-videi-bistama-daudzuma.a456038/

https://www.apollo.lv/7519100/petnieki-bridina-par-zalu-aktivo-vielu-klatbutni-notekudenos-un-latvijas-udenstilpes

https://www.la.lv/petijums-zalu-aktivo-vielu-klatbutne-notekudenos-daudzviet-sasniedz-videi-nedrosu-koncentraciju

https://www.tvnet.lv/7519075/zalu-aktivo-vielu-klatbutne-notekudenos-daudzviet-sasniedz-videi-nedrosu-koncentraciju-liecina-petijums

https://farmacija-mic.lv/zalu-aktivas-vielas-notekudenos-daudzviet-sasniedz-videi-nedrosu-koncentraciju/

Radio:

https://lr1.lsm.lv/lv/lr/arhivs/?adv=1&d=10&m=5&y=2022&d2=&m2=&y2=&channel=1&keyword=p%C4%93cpusdiena

TV:

https://zinas.tv3.lv/latvija/petnieki-zalu-aktivo-vielu-klatbutne-notekudenos-un-udenstilpes-sasniedz-videi-nedrosu-koncentraciju/

Lithuania

TV stories
https://www.lrt.lt/mediateka/irasas/2000221090/zinios-ek-teiks-rekomendacija-del-ukrainos-siuloma-nedelsiant-suteikti-europos-sajungos-kandidates-statusa [from 04:01 min]
https://www.lrt.lt/mediateka/irasas/2000221029/tyrimas-apie-vandens-tarsa-farmacinemis-medziagomis-jame-issiskyre-vienas-lietuvos-miestas
https://www.tv3.lt/naujiena/video/aiskeja-kokius-vaistus-zmones-lietuvoje-geria-dazniausiai-viename-regione-antidepresantu-lygis-10-kartu-didesnis-n1173272
https://lnk.lt/zinios-1830/Visi/167149 [from 26:27 min]

Press
https://ve.lt/gyvenimas/vaistu-pedsakus-vandens-telkiniuose-tyre-klaipedos-mokslininkai-gamtai-vaistu-nereikia?utm_source=ve.lt&utm_medium=referer&utm_campaign=nblokas_karstos
https://www.15min.lt/verslas/naujiena/mokslas-it/ku-mokslininkai-pagamine-vaistus-pagaminame-problema-1290-1694746
https://www.lrt.lt/naujienos/sveikata/682/1721636/mokslininkai-istyre-nuotekas-25-farmaciniu-medziagu-koncentracija-virsijo-pavojingas-normas
https://kaunas.kasvyksta.lt/2022/06/16/lietuvoje/nuotekose-ir-telkiniuose-kai-kuriu-vaistu-kiekiai-virsija-pavojingas-koncentracijas/
https://www.lrytas.lt/sveikata/medicinos-zinios/2022/06/16/news/nuotekose-ir-telkiniuose-kai-kuriu-vaistu-kiekiai-virsija-pavojingas-koncentracijas-23696717
https://www.delfi.lt/tvarilietuva/aplinka/naujausio-tyrimo-rezultatai-vercia-sunerimti-vandenyje-randami-vaistu-kiekiai-didziuliai.d?id=90513451

But…

Does it work if legislation is not into place and we have to relay on social responsibility?

Nature Needs No Pill

Thank you!

Ieva Putna-Nimane
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WAVE MODEL FOR THE BALTIC SEA FOR COASTAL MANAGEMENT AND ENGINEERING APPLICATIONS

Andrea Giudici, Rain Mannikus, Fatemeh Najafzadeh, Mikolaj Zbigniew Jankowski,
Tarmo Soomere, Ülo Suursaar
Laboratory of Wave Dynamics / Department of Cybernetics
Tallinn University of Technology

30.11.2022

Methods - The Model

SWAN wave model - cycle III, version 41.31A.

It is a third-generation spectral waves model, that creates sets of waves sequences through solving the wave action balance equation.

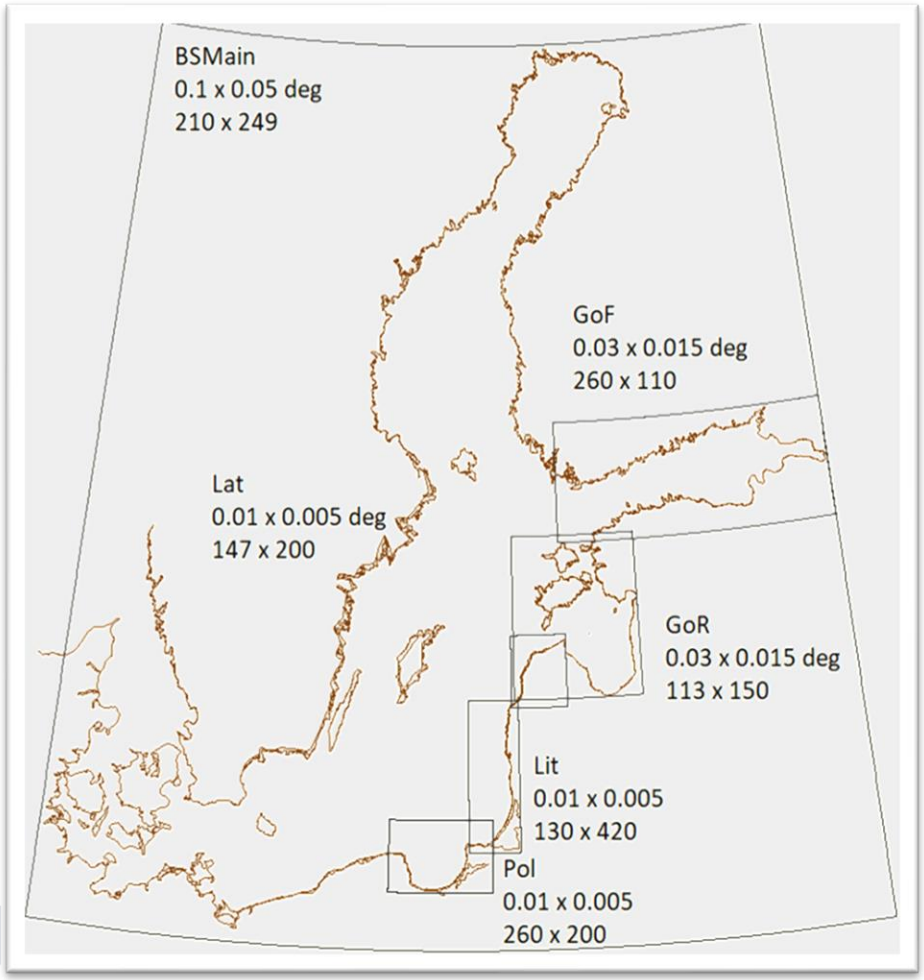
- inputs: bathymetry, wind
- outputs: wave spectra and spatio-temporal parameters

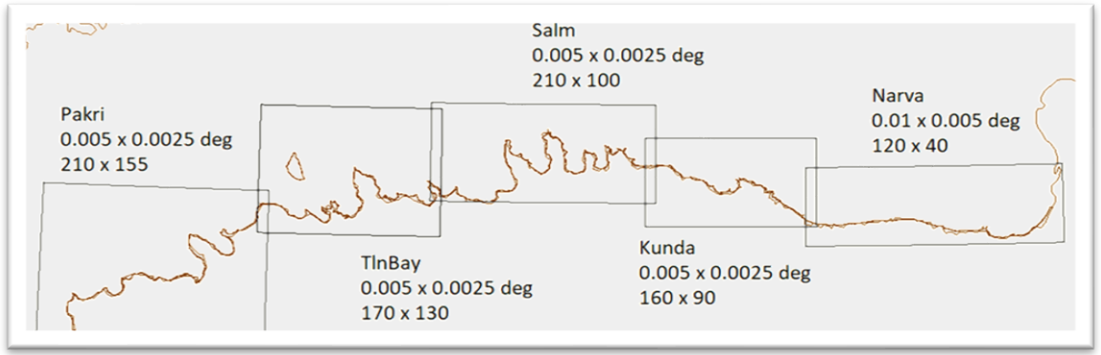
The model was fine-tuned to provide optimal performance using two wind datasets.

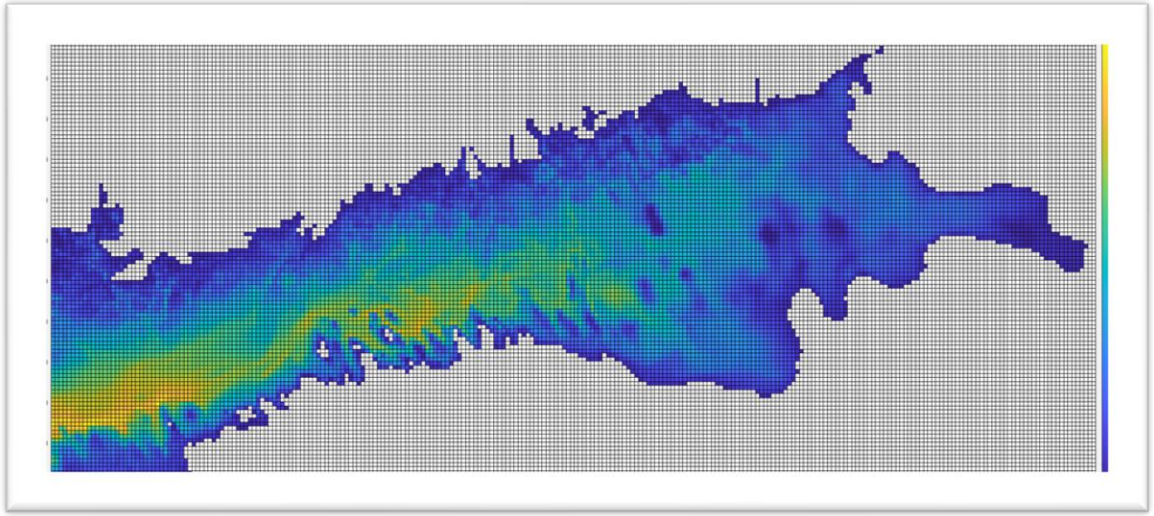
TAL TECH

Methods – the Grid System

Triple-nested rectangular grid system, each level of increased density. Finest resolution reaches about 260m.







Gulf of Finland (2nd nest) as an example grid.

TAL TECH

Methods – Data Sources (Wind)

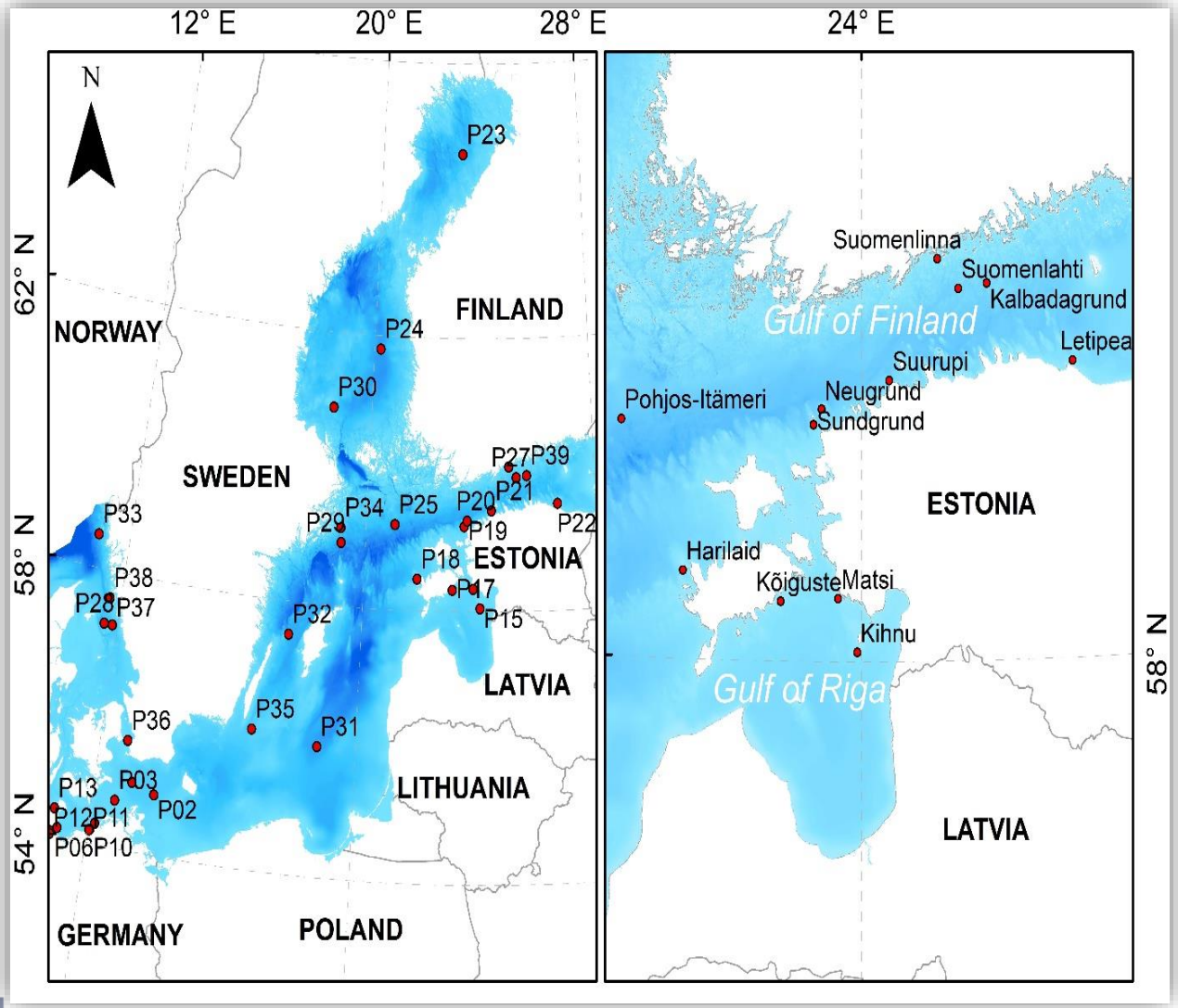
Forcing winds:
1) ERA5 (5th generation ECMWF)
2) BaltAn65+ (regionalisation of ERA-40 and ERA-Interim)

ERA 5 is the provides new reanalysis in real time + 3 months.
BaltAn65+ has been good reputation based on its previous publication record.

Modelled wind data was validated with data from the Finnish Meteorological Institute (FMI) (1960s-present).

TAL TECH

Methods – Data Sources (Waves)



Wave and wind measurement locations

Model runs were validated by comparing calculated significant wave heights and peak periods with available measurements.

Data sources:

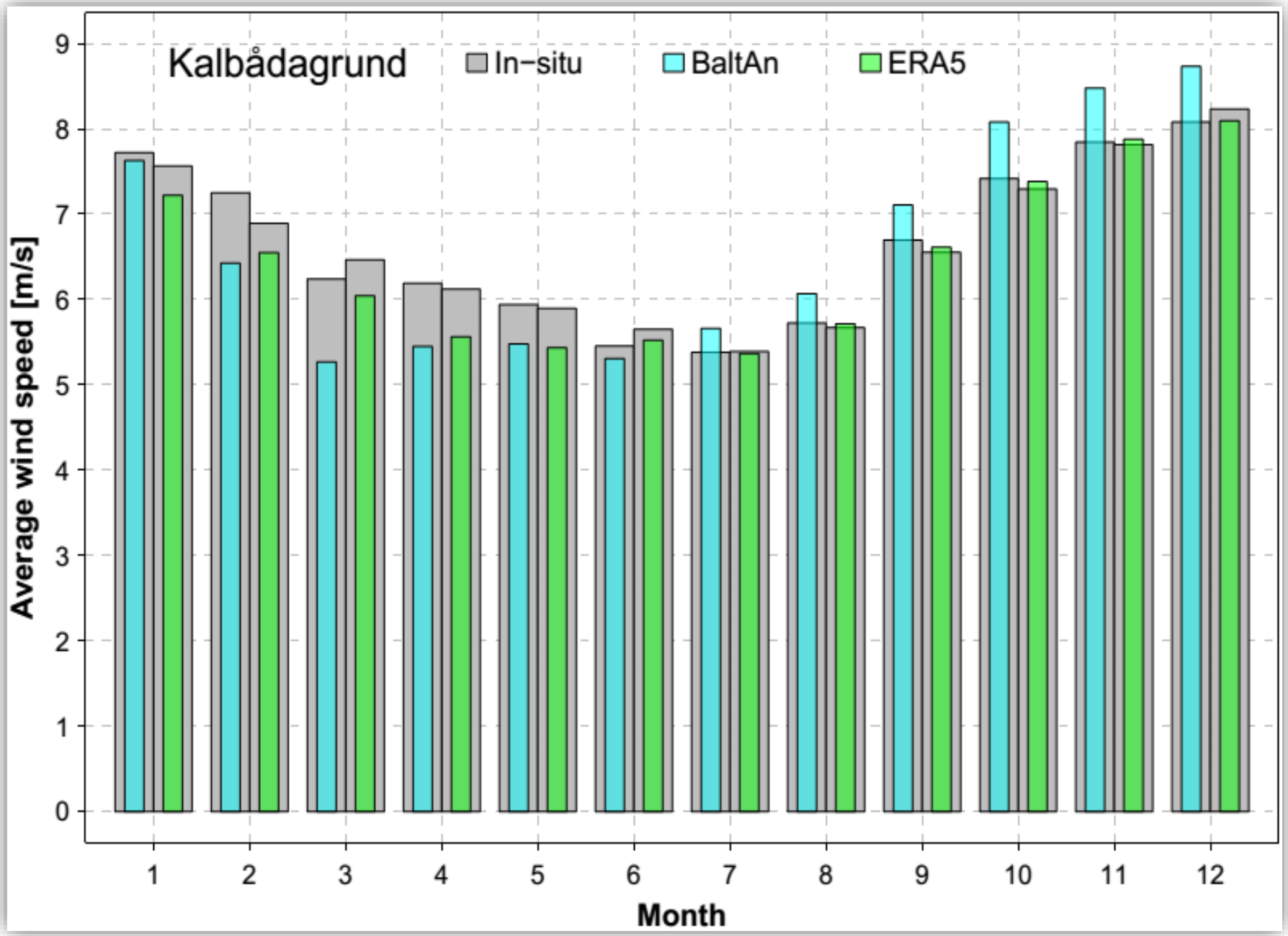
1) Localized data collection campaigns

2) FMI (Finnish Meteorological Institute)

3) SMHI (Swedish Meteorological and Hydrological Institute)

4) Estonian Marine Institute

Model Validation (Wind)



Kalbadagrund is in middle of the Gulf of Finland.

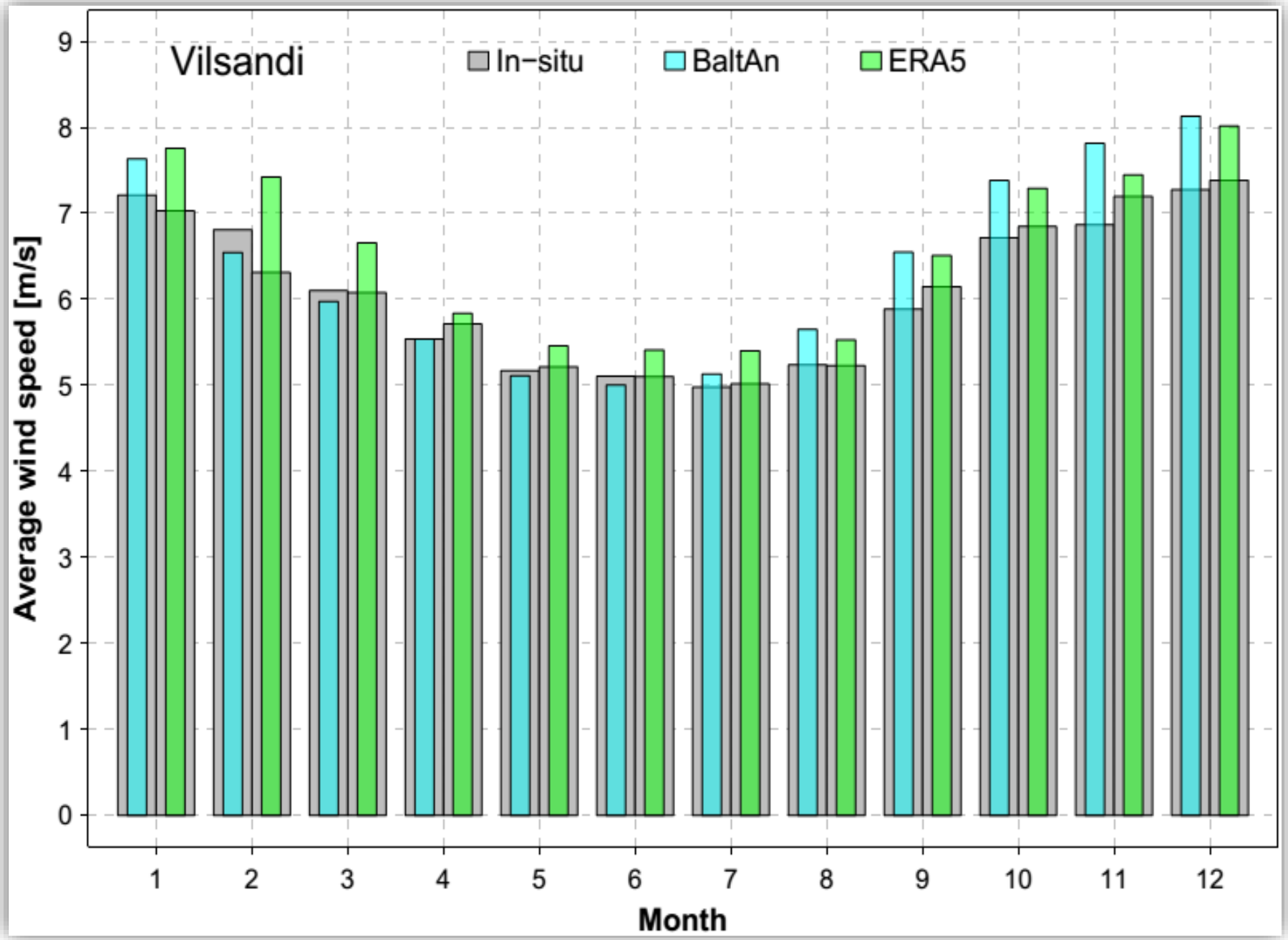
Correlation:
ERA5= 0.97
BaltAn65+ = 0.90

Bias:
ERA5 =0.18
BaltAn65+ = 0.02

Key points:

- ERA5 underestimates wind speed
- BaltAn65+ overestimates wind speed
- Both datasets have high statistical accuracy
- Slight differences may be attributed to satellite data tuning

Model Validation (Wind)



Vilsandi is located at western coastline of Saaremaa.

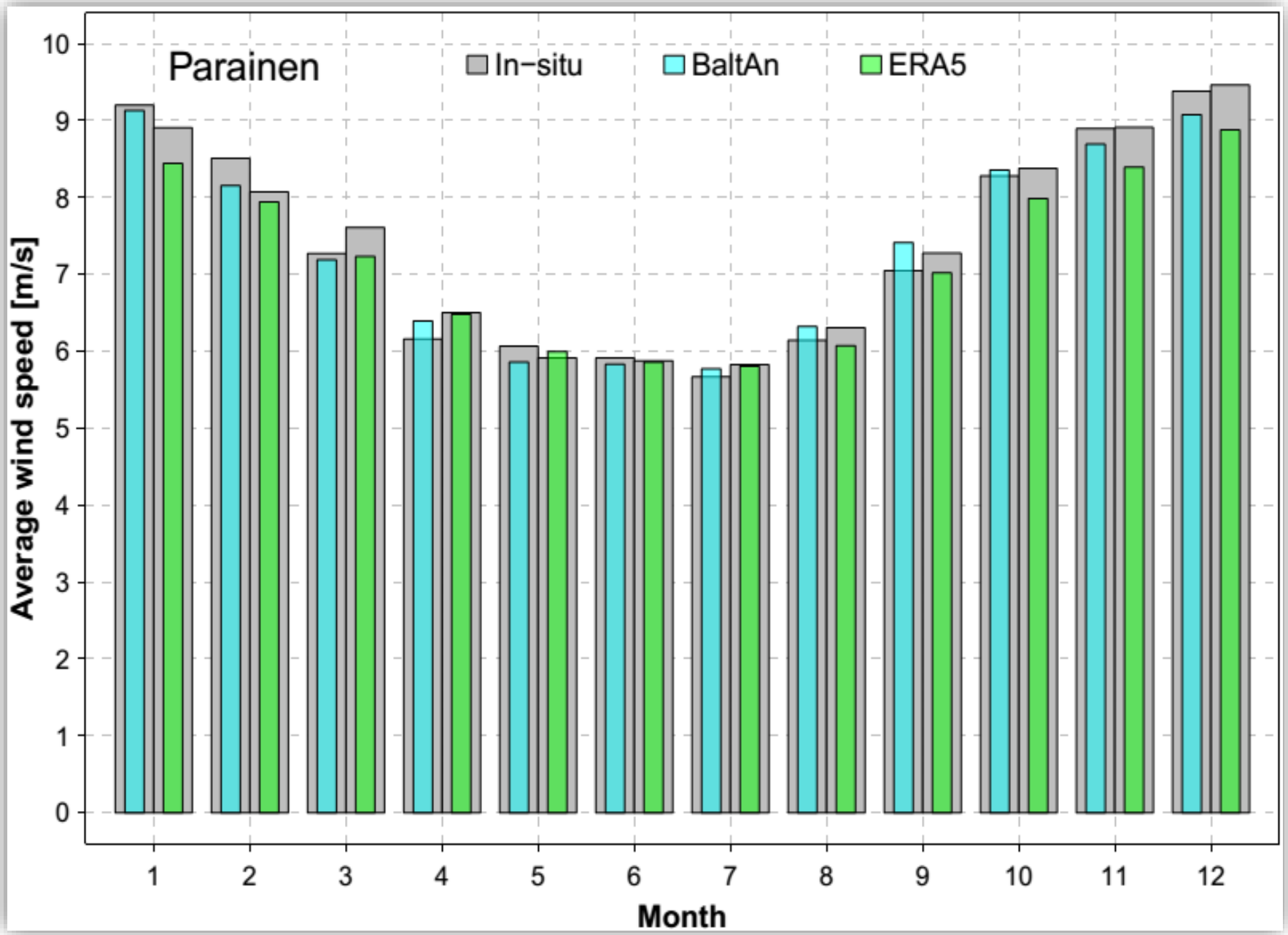
Correlation:
ERA5= 0.97
BaltAn65+ = 0.95

Bias:
ERA5 = -0.45
BaltAn65+ = -0.30

Key points:

- All data overestimates the wind speeds at Vilsandi
- The correlation and bias remain acceptable
- Local coastline features are potentially to blame for the slight differences.

Model Validation (Wind)



Parainen is located within the Turku archipelago in Finland.

Correlation:
ERA5= 1.0
BaltAn65+ = 0.99

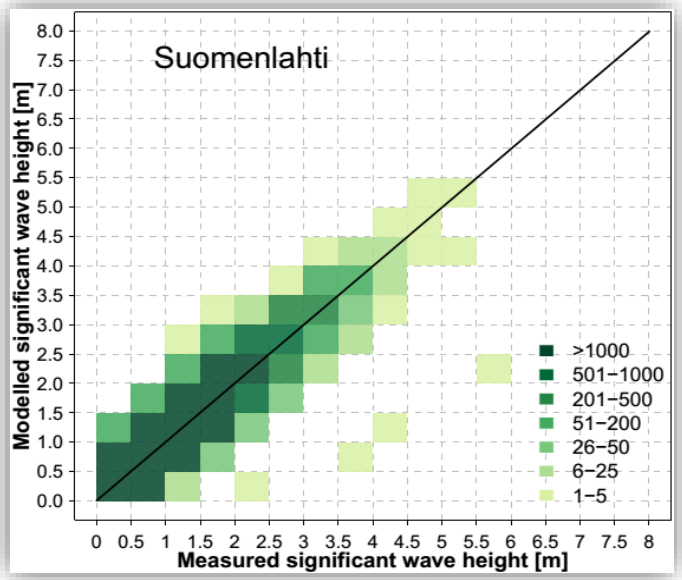
Bias:
ERA5 = 0.24
BaltAn65+ = -0.03

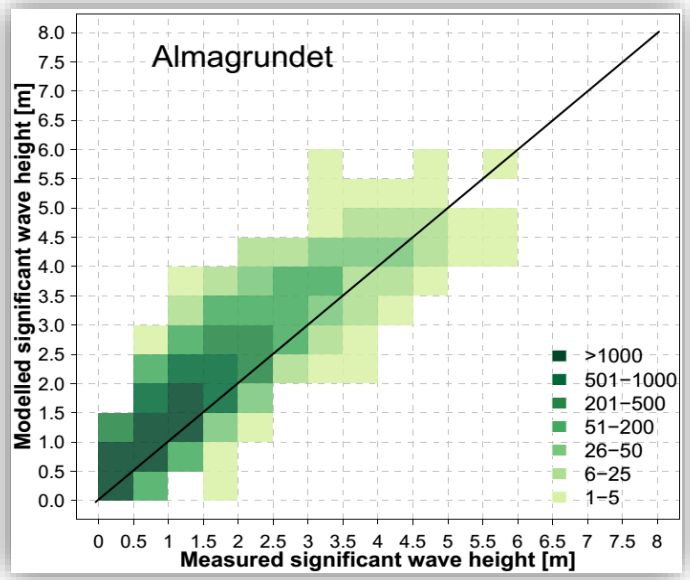
Key points:

- Both of the wind datasets underestimate the speed
- Data maintains high level of accuracy for the model
- Slight deviation can potentially be attributed to local coastline features

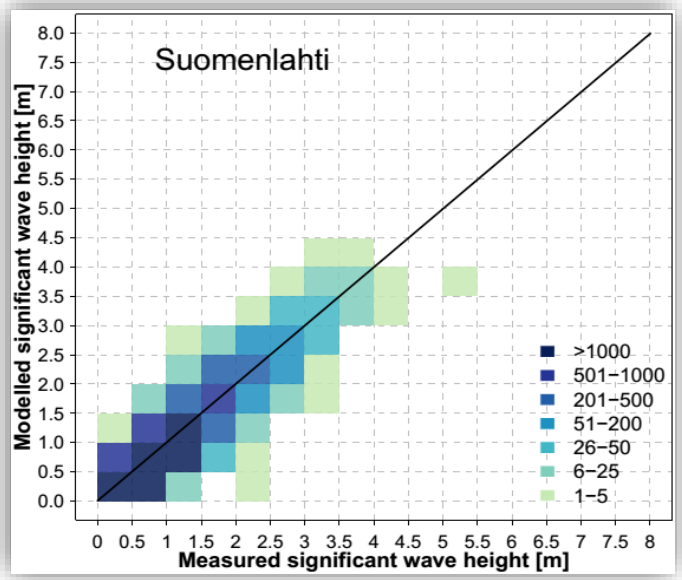
Model validation (significant wave height)

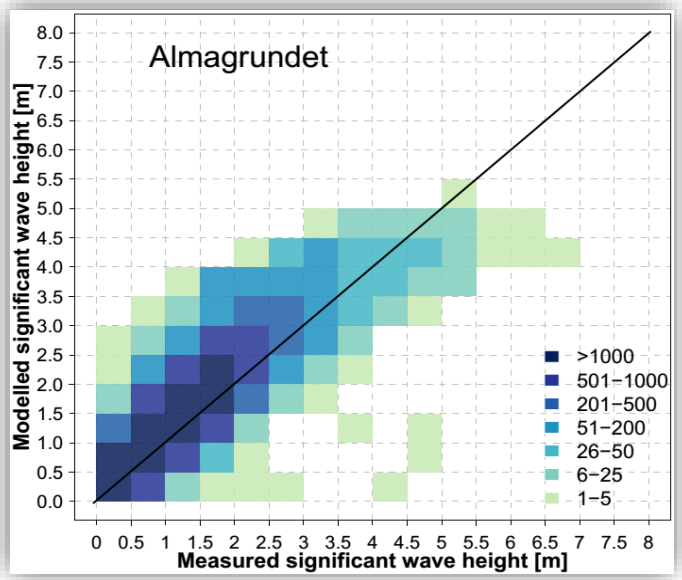
ERA 5





BaltAn65+





SWAN modelled significant wave height compared against observations at 2 example measurement stations

<u>Locations background:</u>

Suomenlahti is within Gulf of Finland with about 20 years of measurement data.

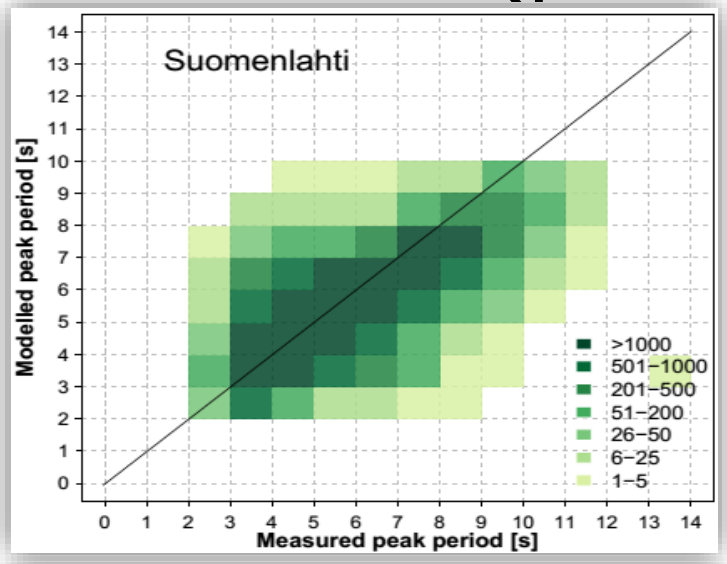
Almagrundet is located within centre of the Baltic Proper, with 5 years of measurement data.

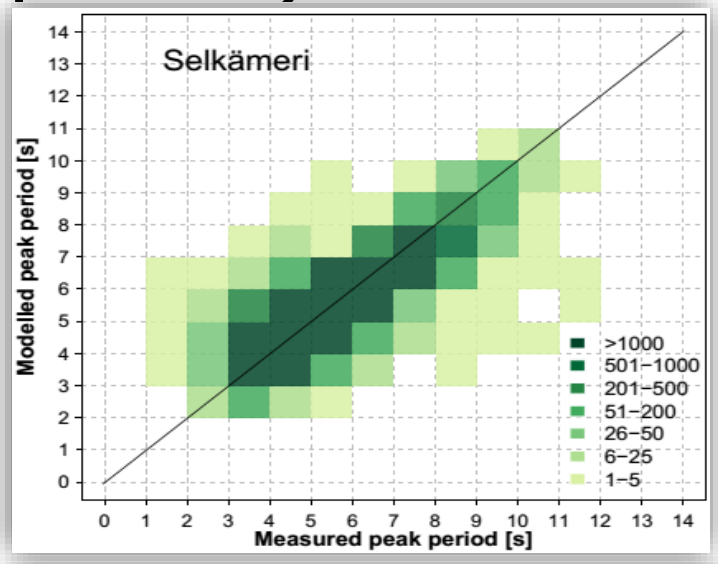
<u>Key points:</u>

- The SWAN model data replicates the significant wave height parameter well in both cases
- Precision of modelled results increases with higher grid resolution grids

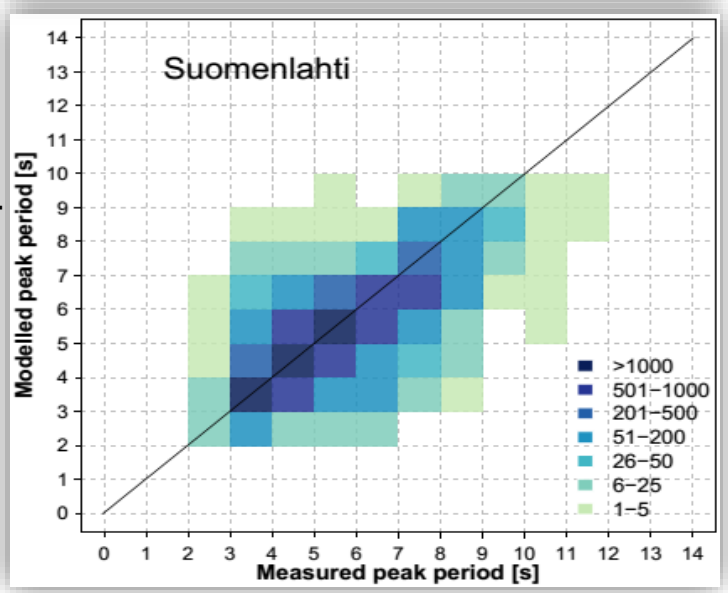
Model validation(peak period)

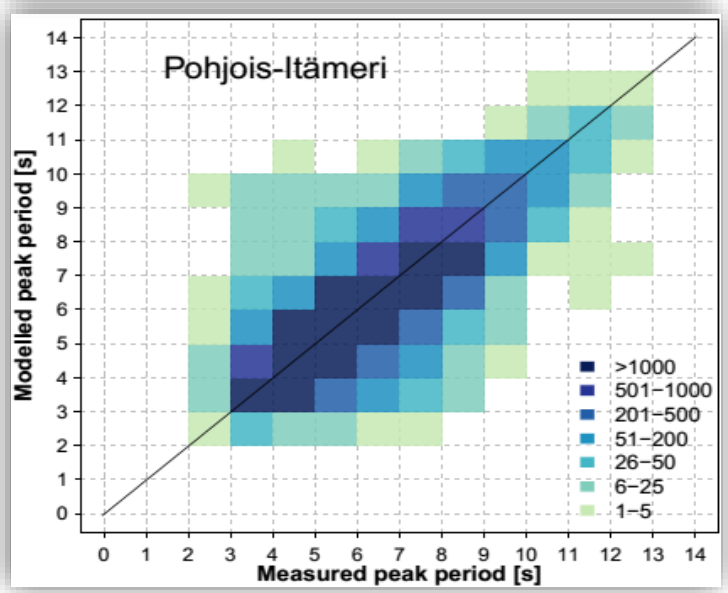
ERA 5





BaltAn65+





Locations background:
Suomenlahti – point in Gulf of Finland, 20 years of data

Selkämeri – point in Bay of Bothnia, 11 years of data

Pohjois-Itämeri – centre of Baltic Proper, 10 years of data

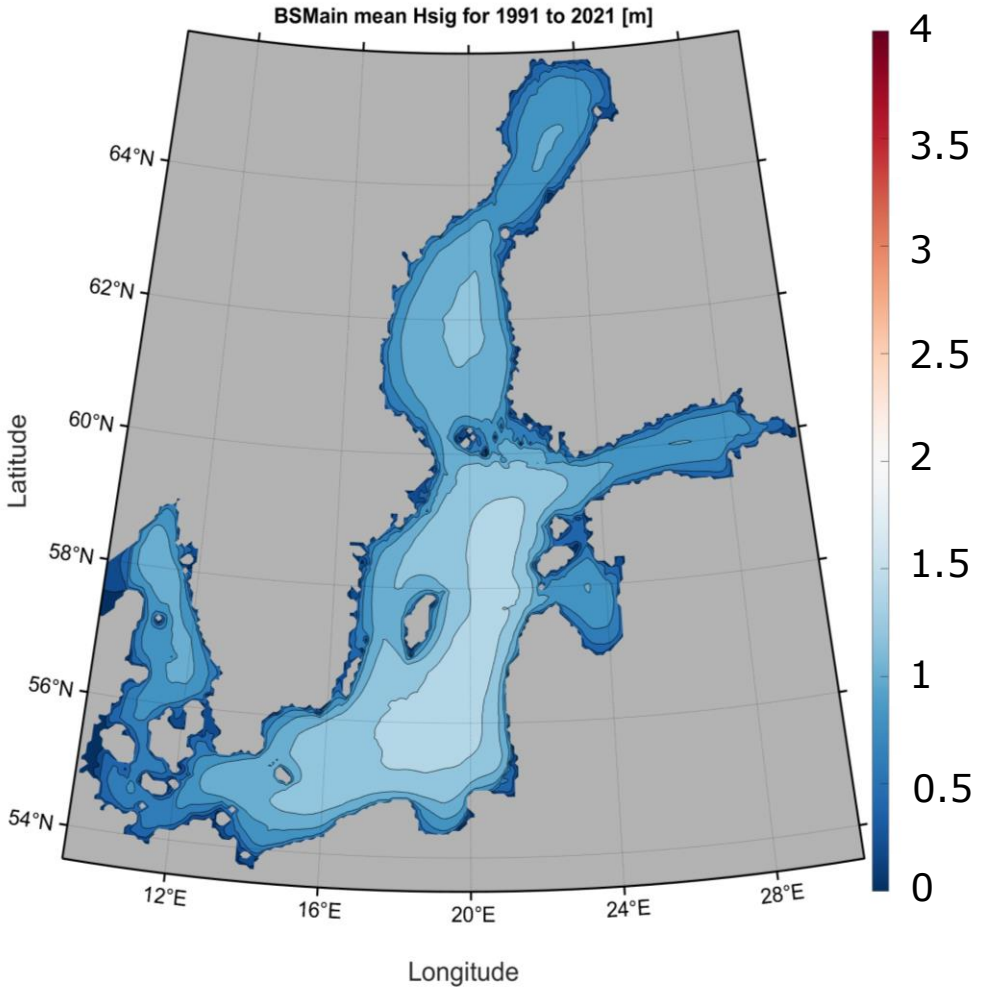
Key points:

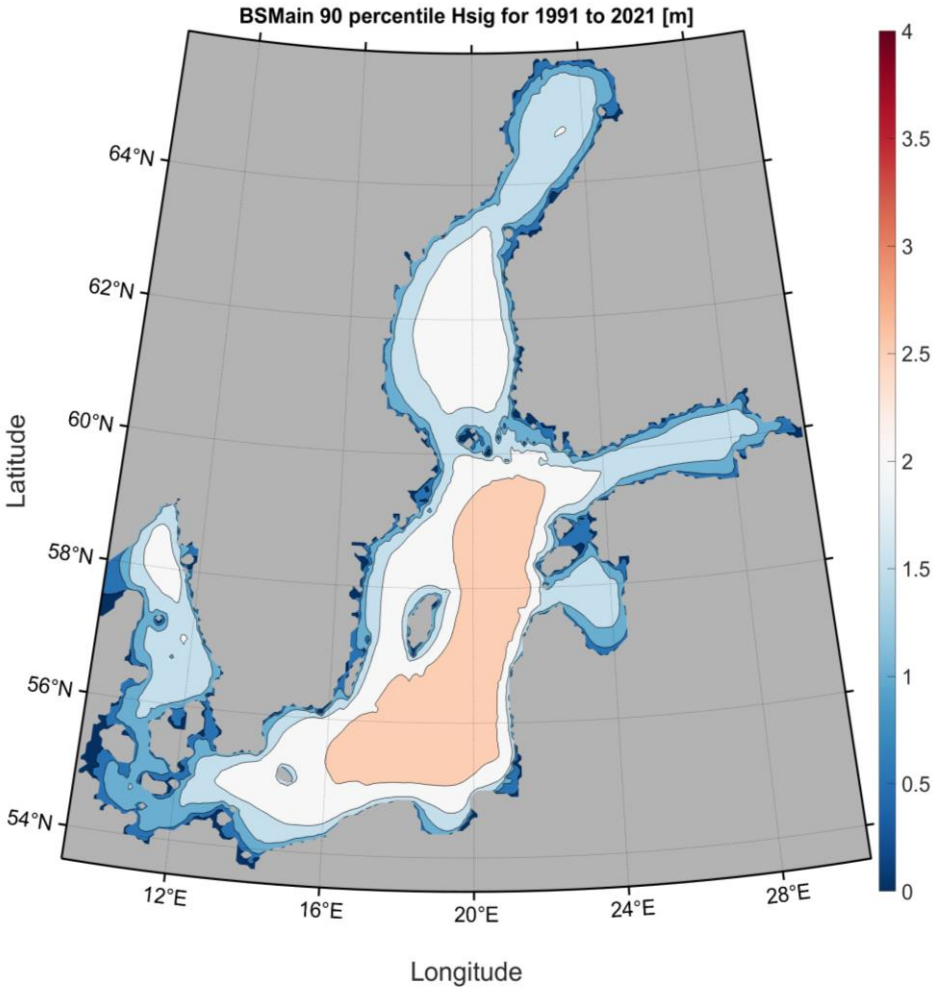
- Observations and modelled values match reasonably well
- Data from higher resolution grid (like Suomenlahti) provides a better match for parameter values

TAL TECH

SWAN modelled peak period compared against available observations at select points in the Baltic Sea.

Wave fields – Baltic Sea (1st level grid)





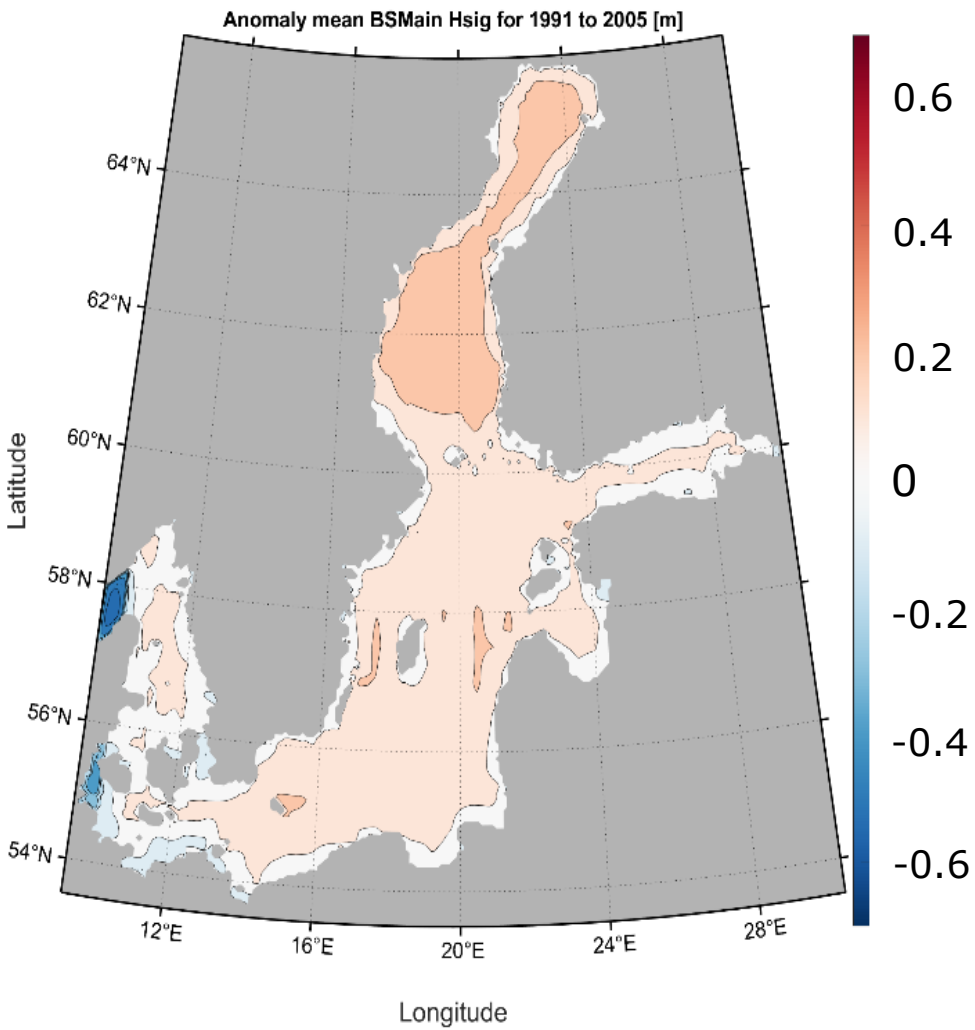
Mean (left) and top 10% (right) of SWH from ERA5 data for 1991-2021

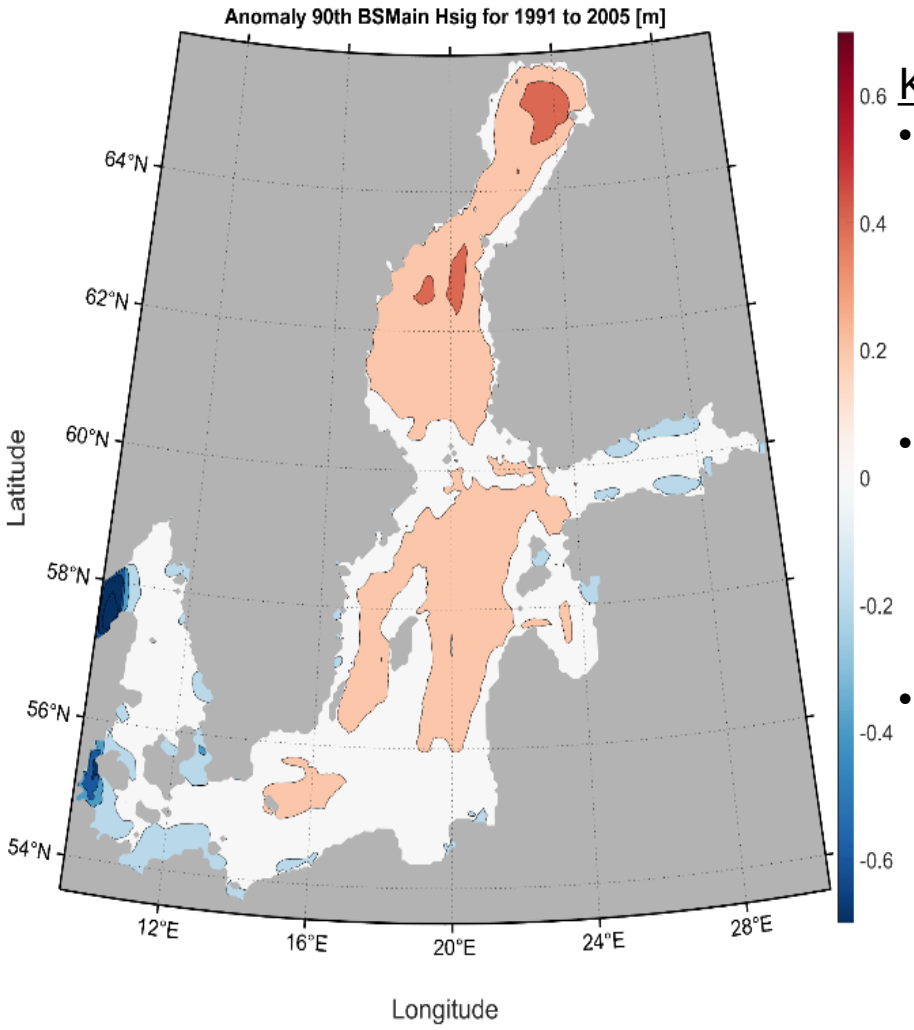
<u>Key notes</u>:

- Spatial distribution of average wave heights, as well as their range make physical sense
- Wave propagation reaches all areas of concern to the run, setting the base for comparison

TAL TECH

Wave fields' differences – Baltic Sea





Key notes:

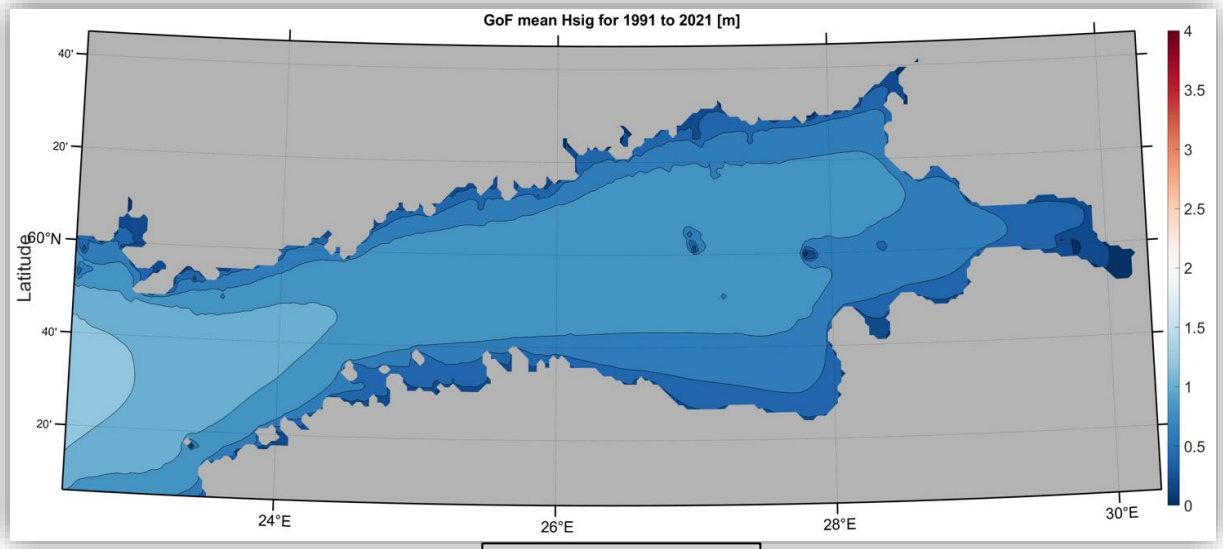
- There are differences between model results, particularly in the bay of Bothnia and Baltic Proper.
- On average, modelling with ERA5 yields higher SWH by than with BaltAn65+
- Further differences can be spotted in the extreme values (averaged top 10%)

Anomaly maps note:
Positives = ERA > BaltAn65+
Negatives = ERA < BaltAn65+

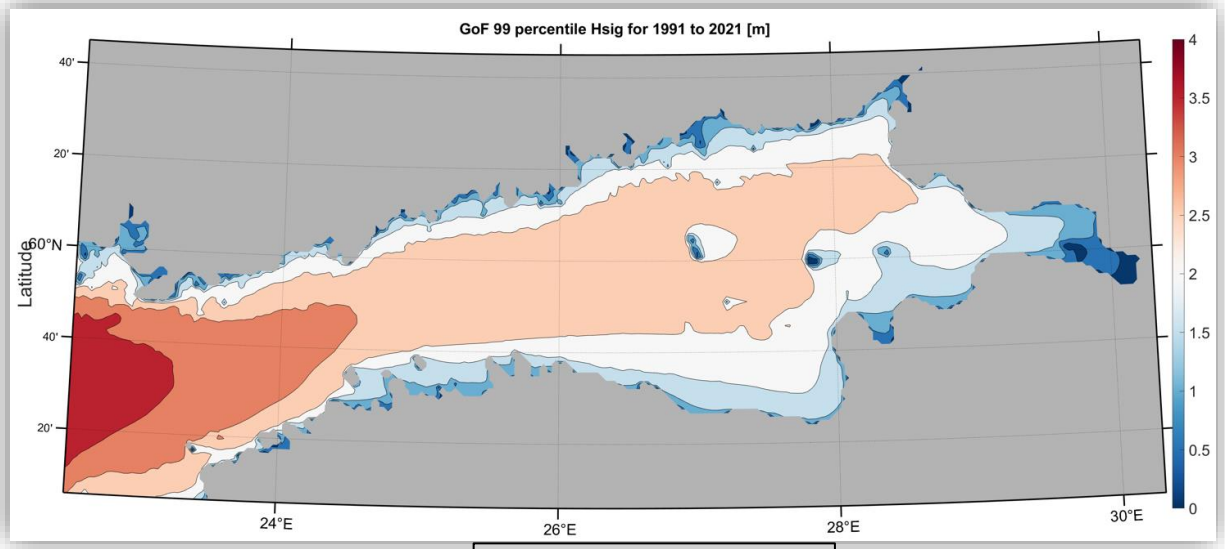
TAL TECH

Mean (left) and top 10% (right) difference maps between ERA5 and BaltAn65+ data for the overlap period of 1991-2005

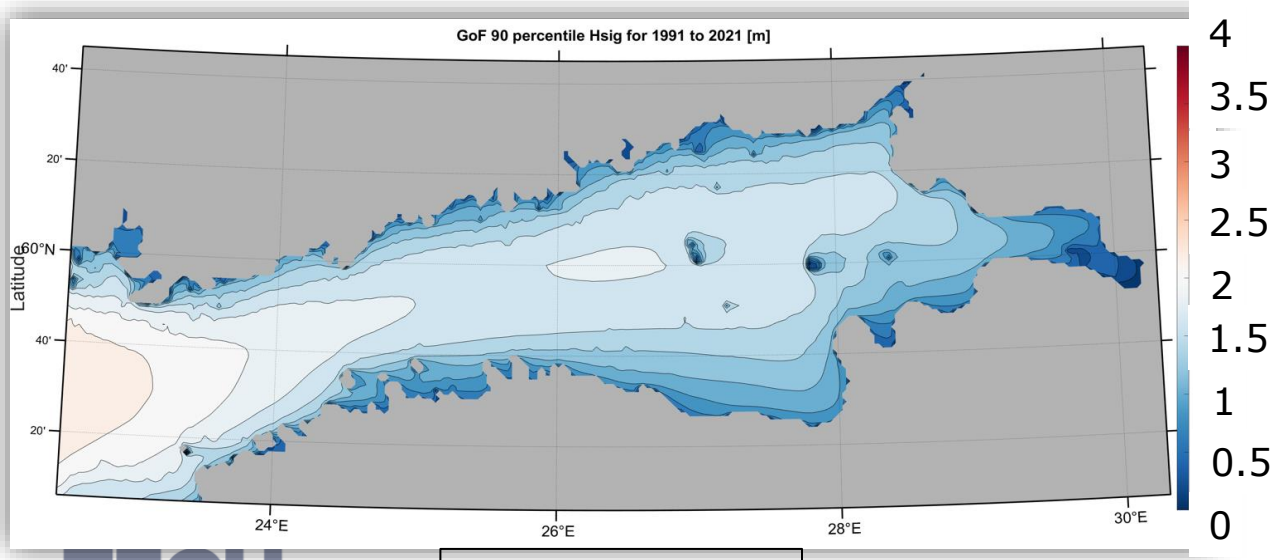
Wave fields – Gulf of Finland (2nd level grid)



Mean SWH



Top 1% SWH



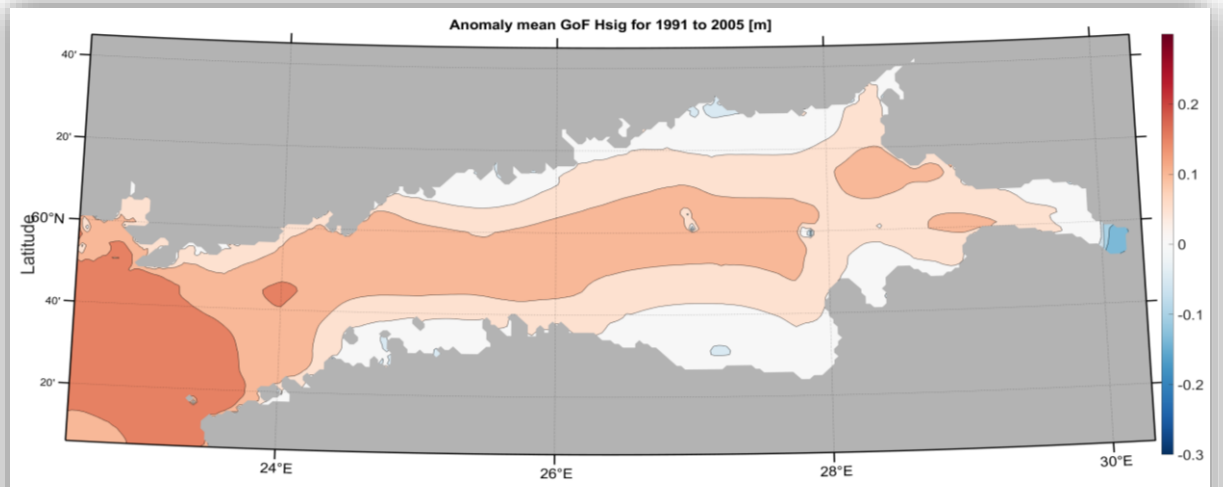
Top 10% SWH

<u>Key points</u>:

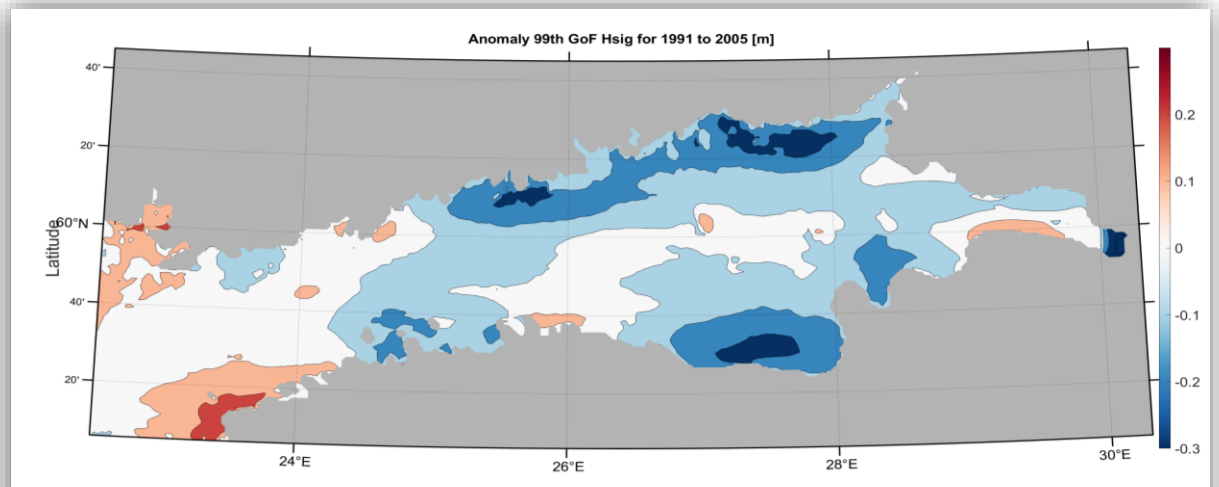
- Coastal features are well-reflected in height of wave propagation within the Gulf of Finland
- Model produces reasonable values for SWH
- Map detail is much higher than on a lower resolution grid

TECH

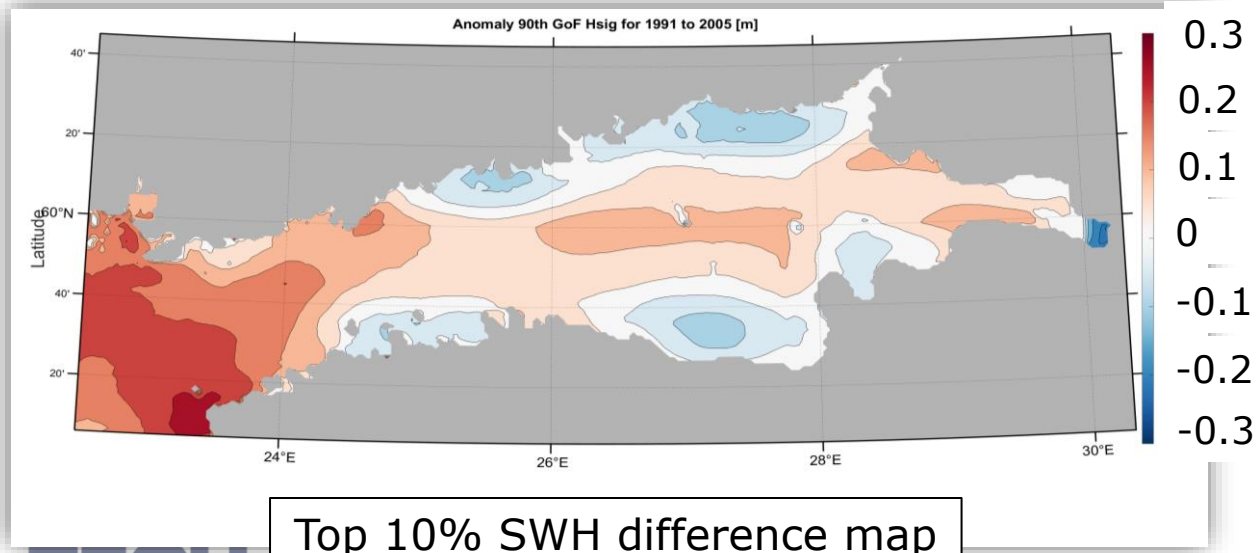
Wave fields' differences – Gulf of Finland



Mean SWH difference map



Top 1% SWH difference map



Top 10% SWH difference map

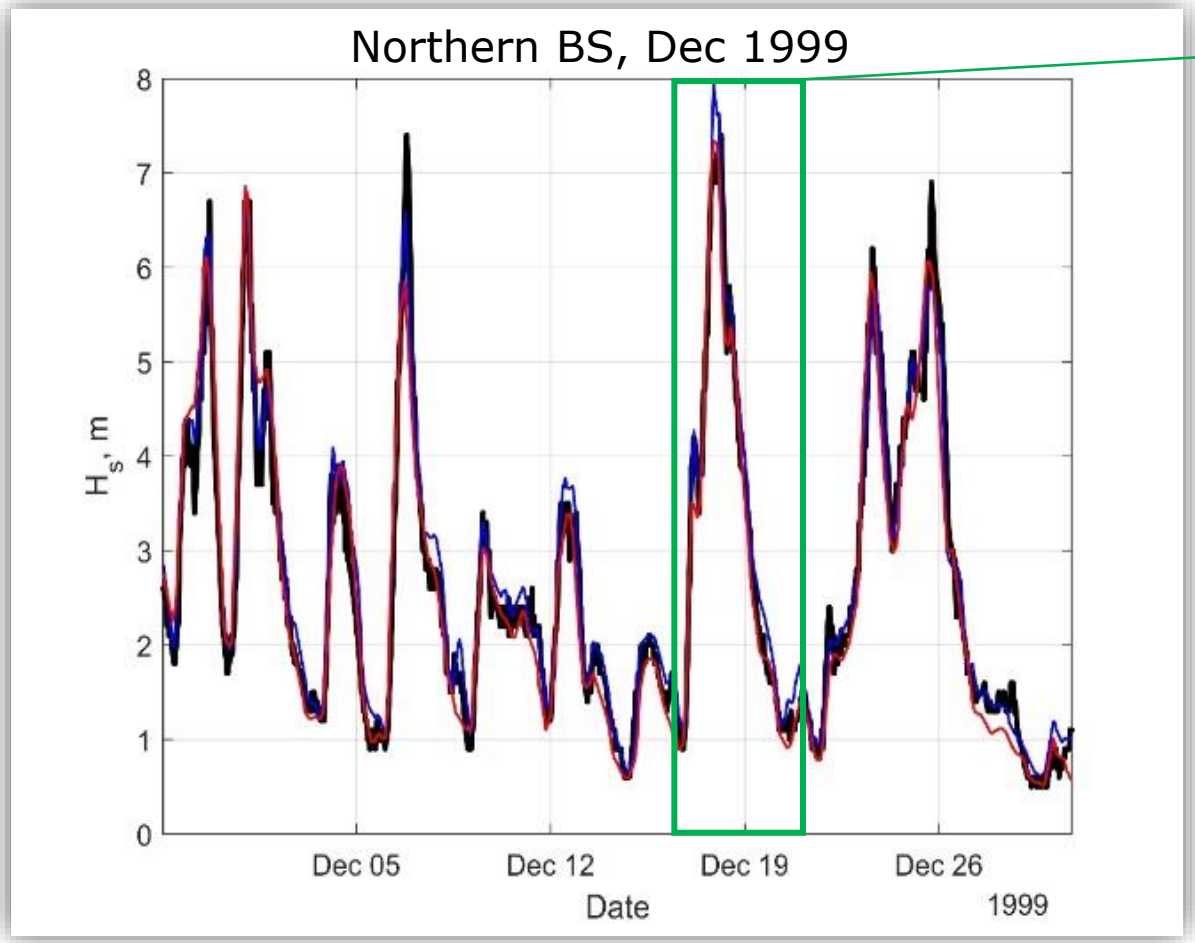
Key points:

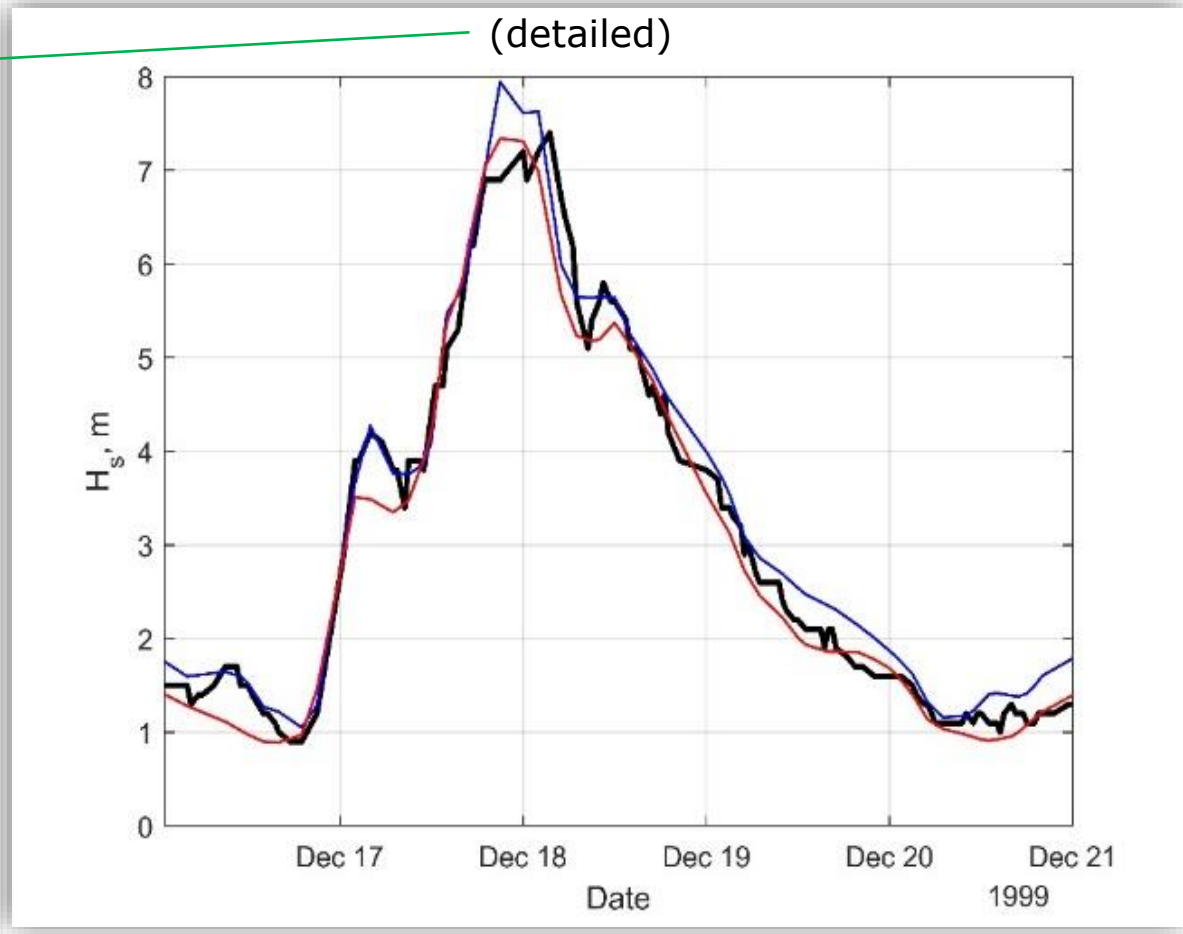
- Further differences can be spotted between ERA5 and BaltAn65+ model results
- Higher resolution grid provides much better insight into differences between model results

Differences note:
Positives (Red) = ERA > BaltAn65+
Negatives (Blue) = ERA < BaltAn65+

TECH

Extreme Events – example case 1/2





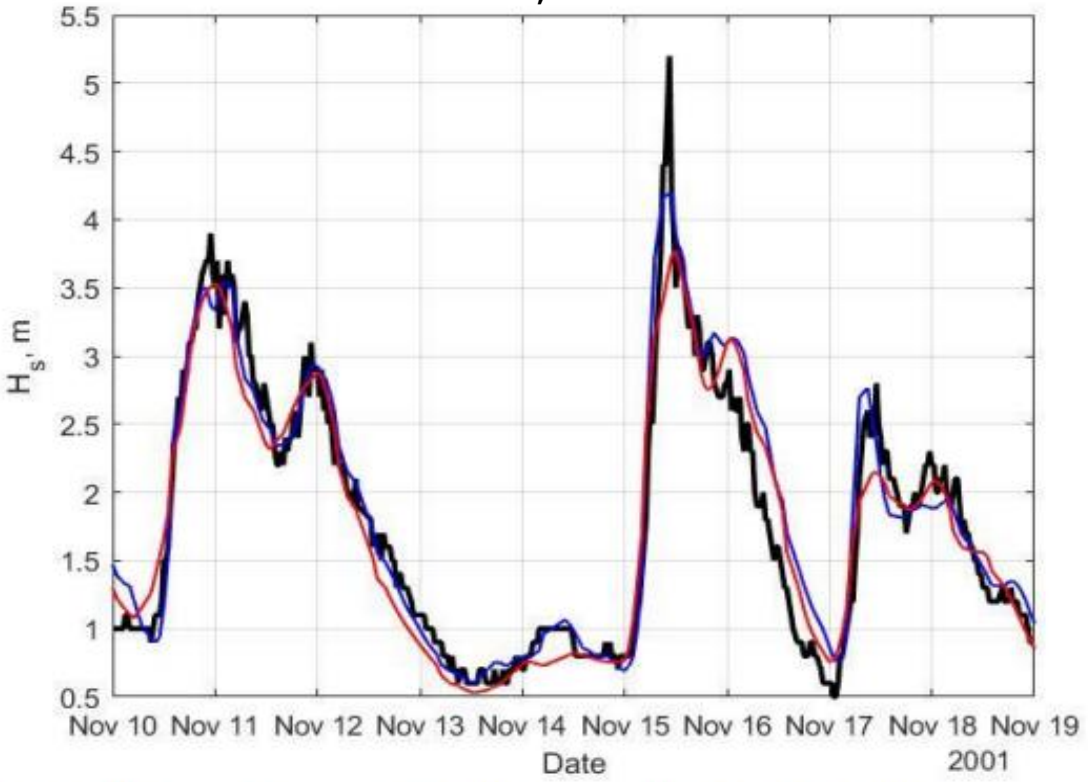
TAL TECH

Key points:

- Timing and magnitude of extreme events match very well with available measurements
- BaltAn65+ data has tendency for slight underestimation of the extremes and is less accurate

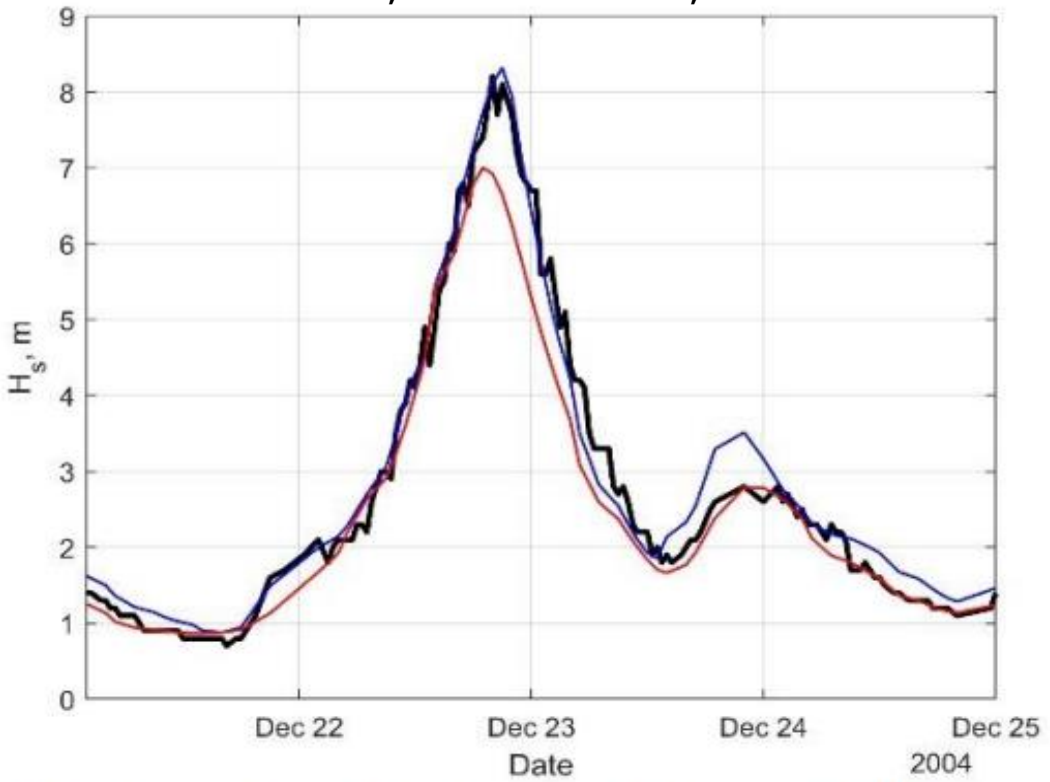
Extreme Events – example cases 2/2

Suomenlahti, Nov 2001



ERA5 (blue): D_{max}= 0.821 D_{rms}= 0.250 R= 0.968
BaltAn65+ (red): D_{max}= 0.995 D_{rms}= 0.250 R= 0.964

Northern BS, storm Rafael, Dec 2004



ERA5 (blue): D_{max}= 0.714 D_{rms}= 0.293 R= 0.992
BaltAn65+ (red): D_{max}= 1.456 D_{rms}= 0.520 R= 0.986

TAL TECH

Key points:

- The timing and magnitude of extreme events match very well
- ERA5 overestimates extremes sometimes, while BaltAn65+ underestimates them

Concluding Remarks

Conclusions:

1) Contemporary wave models replicate well wave properties in the open part of Baltic Sea
2) There is significant differences between model results using different wind datasets, particularly identified in the Bay of Bothnia and in the Gulf of Finland
3) Continued modelling at higher resolution is expected to yield even more findings in the future

Thank you for your attention ☺

TAL TECH

Science Days for the Gulf of Finland and the eastern Baltic Sea
"Science shakes a hand with coastal life and citizens"

Application of the Lattice Boltzmann method in coastal erosion modelling

Uldis Žaimis

Liepaja University

Latvia

The aim of the study

Fig. 1. Construction of the Liepaja sea breakwater

The aim of the study

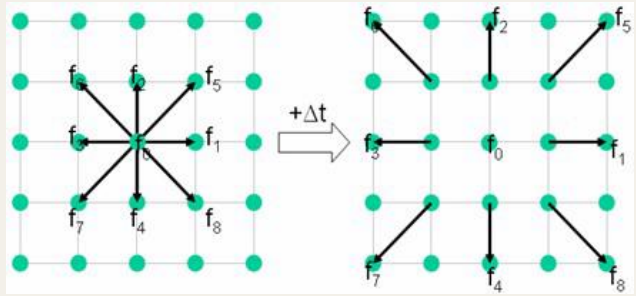
Fig. 2. Breakwater near Ainaži (Latvia)

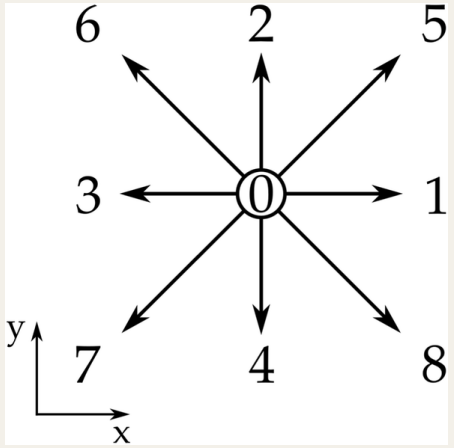
Lattice Boltzmann method - 1

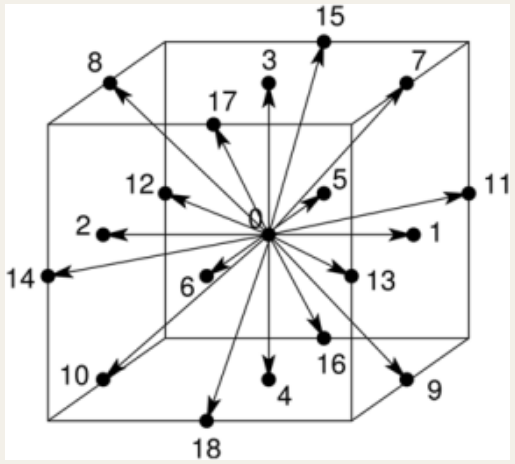
- The lattice Boltzmann methods (LBM), originated from the lattice gas automata (LGA) method (Hardy-Pomeau-Pazzis and Frisch-Hasslacher-Pomeau models), is a class of computational fluid dynamics (CFD) methods for fluid simulation
- Instead of solving the Navier–Stokes equations directly, a fluid density on a lattice is simulated with streaming and collision (relaxation) processes
- The method is versatile as the model fluid can straightforwardly be made to mimic common fluid behaviour like vapour/liquid coexistence, and so fluid systems such as liquid droplets can be simulated

Lattice Boltzmann method - 2

Schematic of D2Q9 and D3Q27 lattice vectors for 2D Lattice Boltzmann







The collision step

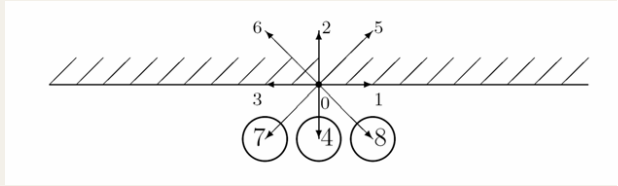
$$f_i(\vec{x}, t+\delta_t) = f_i(\vec{x}, t) + \frac{f_i^{eq}(\vec{x}, t) - f_i(\vec{x}, t)}{\tau_f}$$

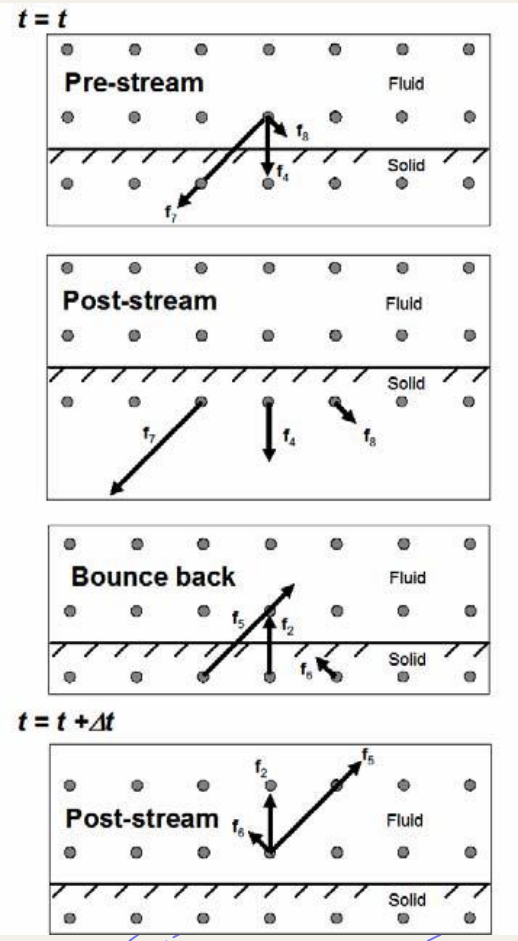
The streaming step

$$f_i(\vec{x}+\vec{e_i}, t+\delta_t) = f_i(\vec{x}, t)$$

Lattice Boltzmann method - 3

- At the boundary of the area, in order to realize the principle of wall impermeability and liquid (gas) non-sticking, the rebound condition is used in LBM
- The marginal rows do not relax to the equilibrium distribution function, but instead the distribution functions take on values of the distribution function of the opposite direction
- In the next step, the particles that got there return back to the flow



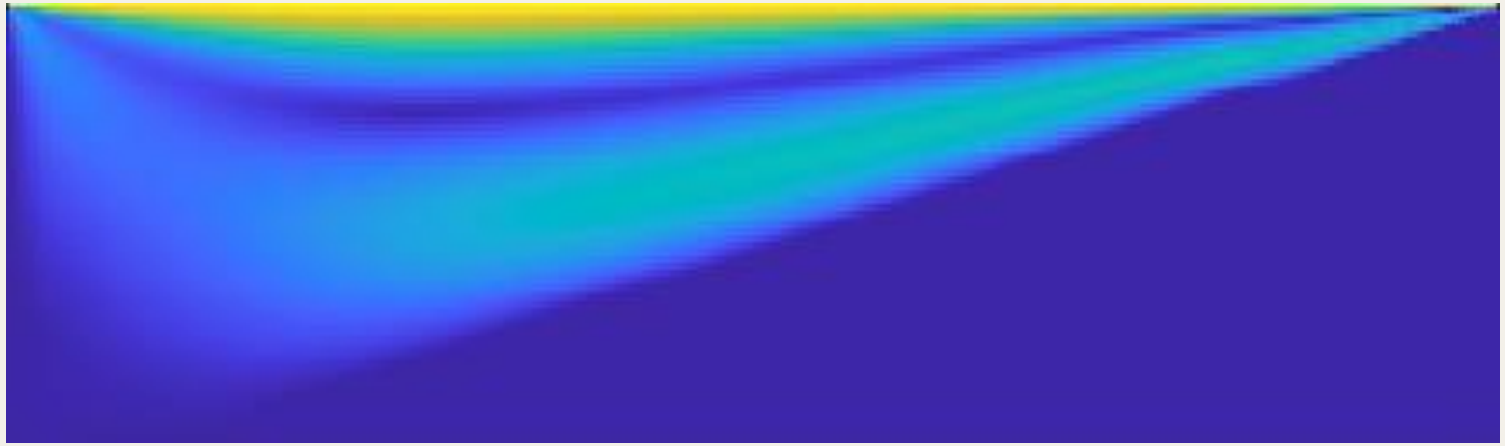


Lattice Boltzmann method - 4

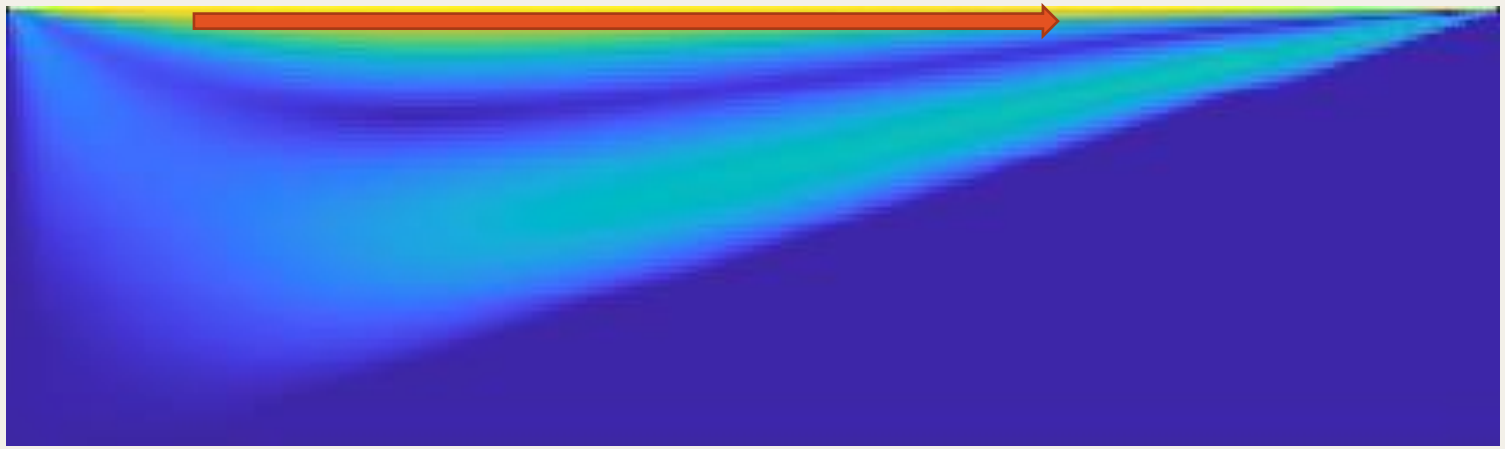
The main part of the calculation algorithm:

1. initialize (set) the initial macroscopic parameters $\vec{u}$, f_i and f_i^{eq}
2. transfer step: moves $f_i \rightarrow f_i^*$ in each of the directions $\vec{e}_i$
3. knowing the new f_i^*, calculated macroscopic quantities ρ and $\vec{u}$
4. calculated f_i^{eq} according to relation (38)
5. collision step: recalculates the distribution function $f_i = f_i^* - \frac{1}{\tau}\left(f_i^* - f_i^{eq} \right)$
6. repeat steps 2-5

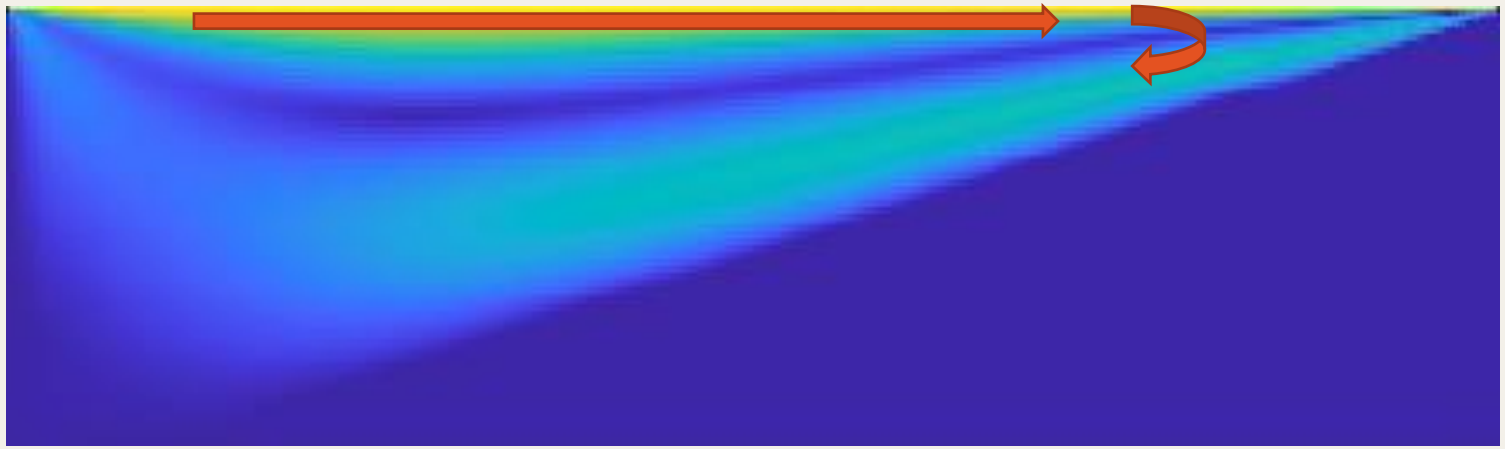
Numerical result: side view



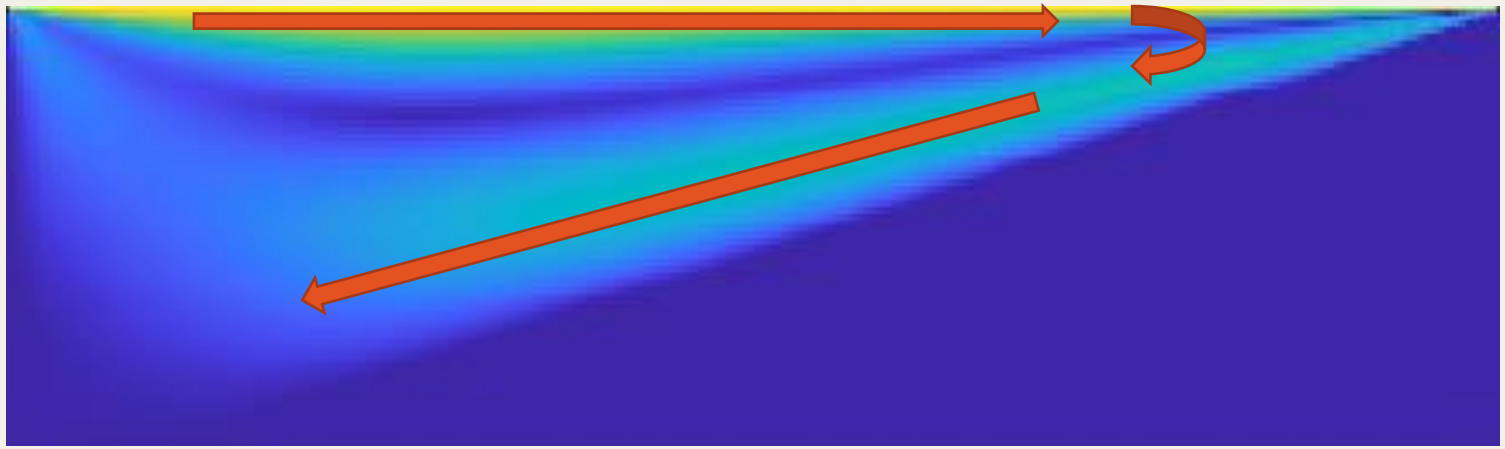
Numerical result: side view



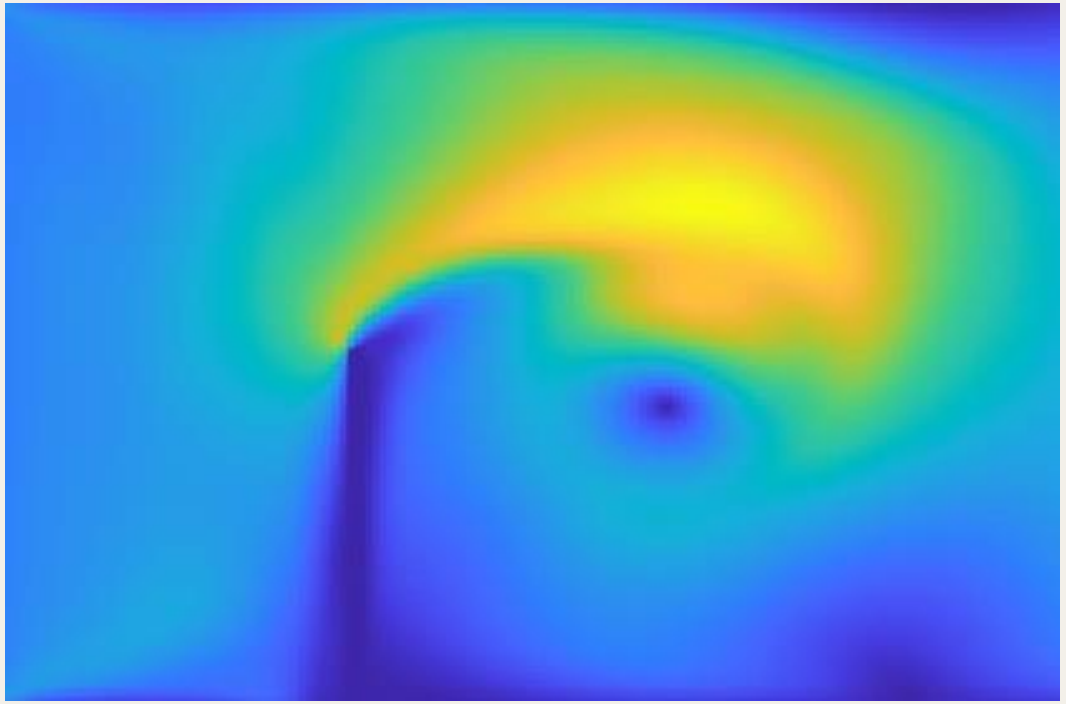
Numerical result: side view



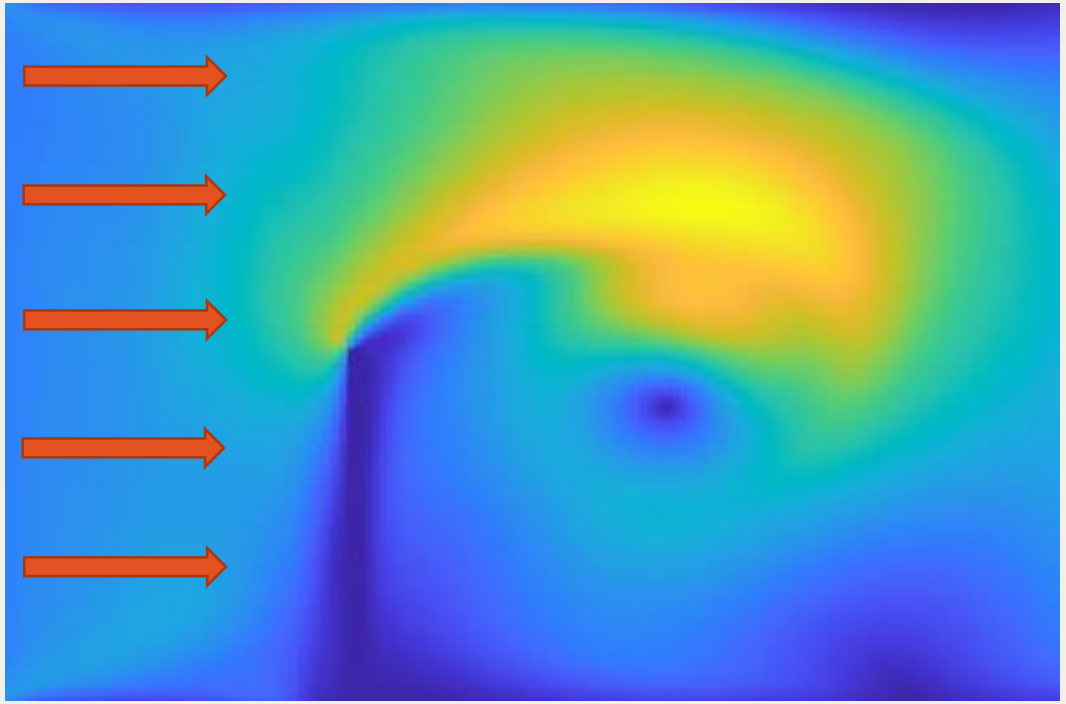
Numerical result: side view



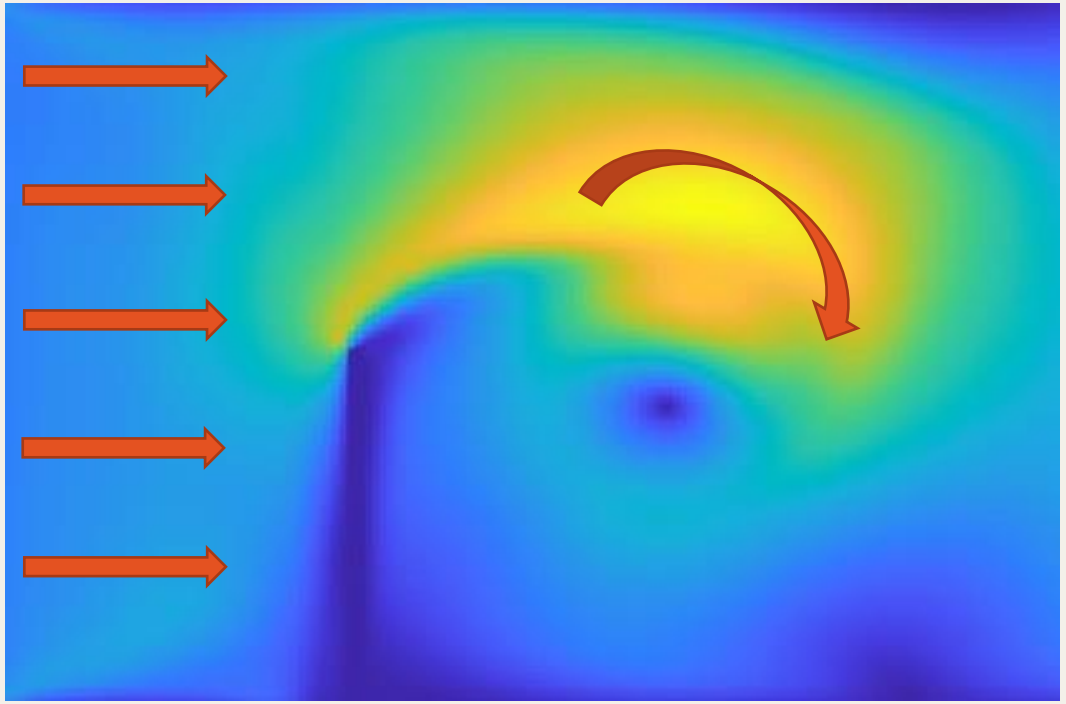
Numerical results: flow from the side - 1



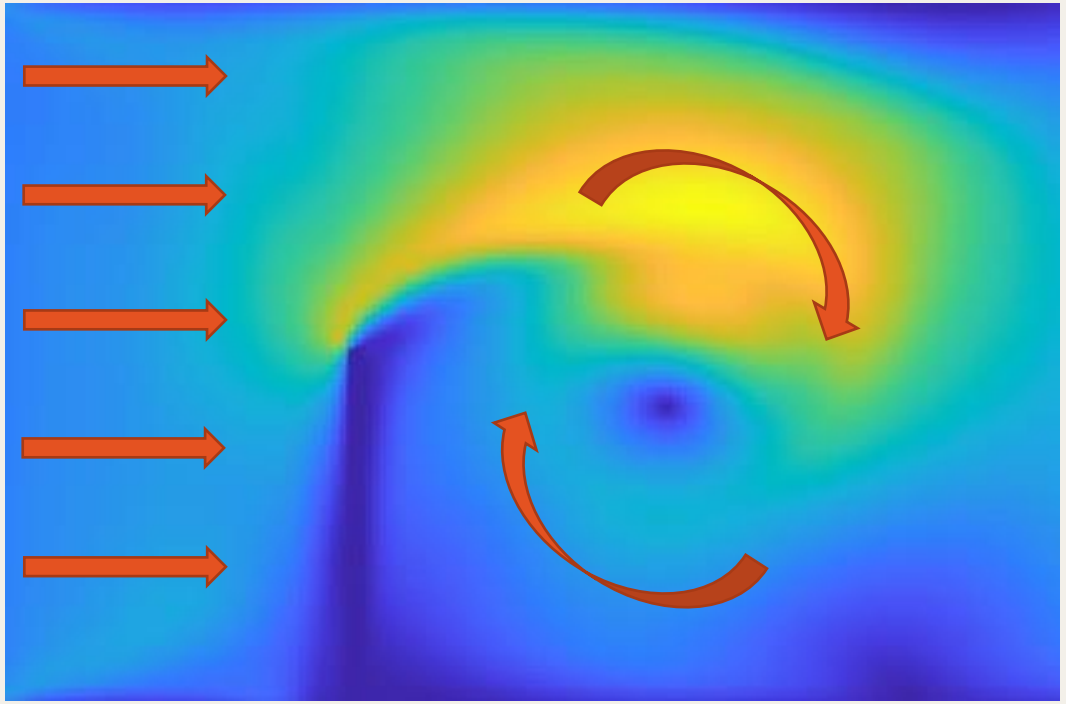
Numerical results: flow from the side - 1



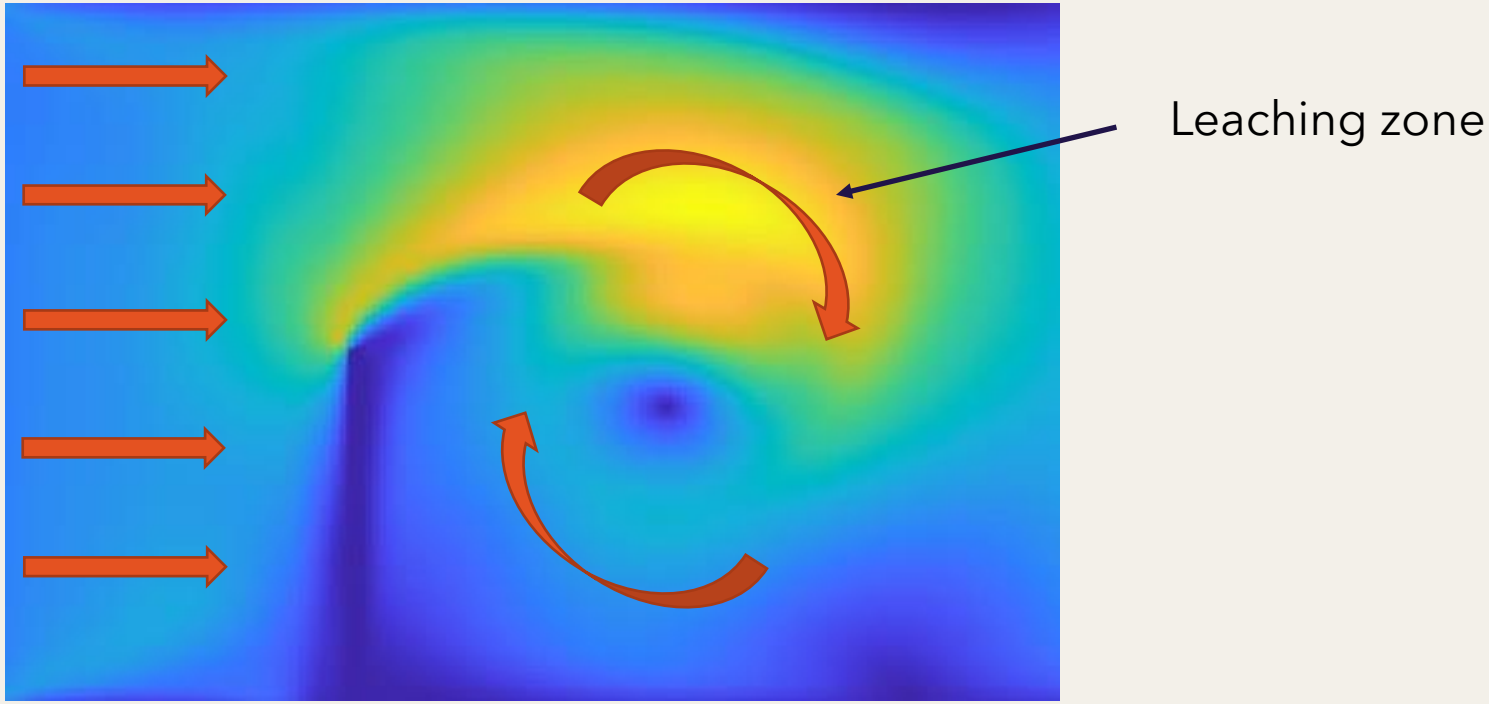
Numerical results: flow from the side - 1



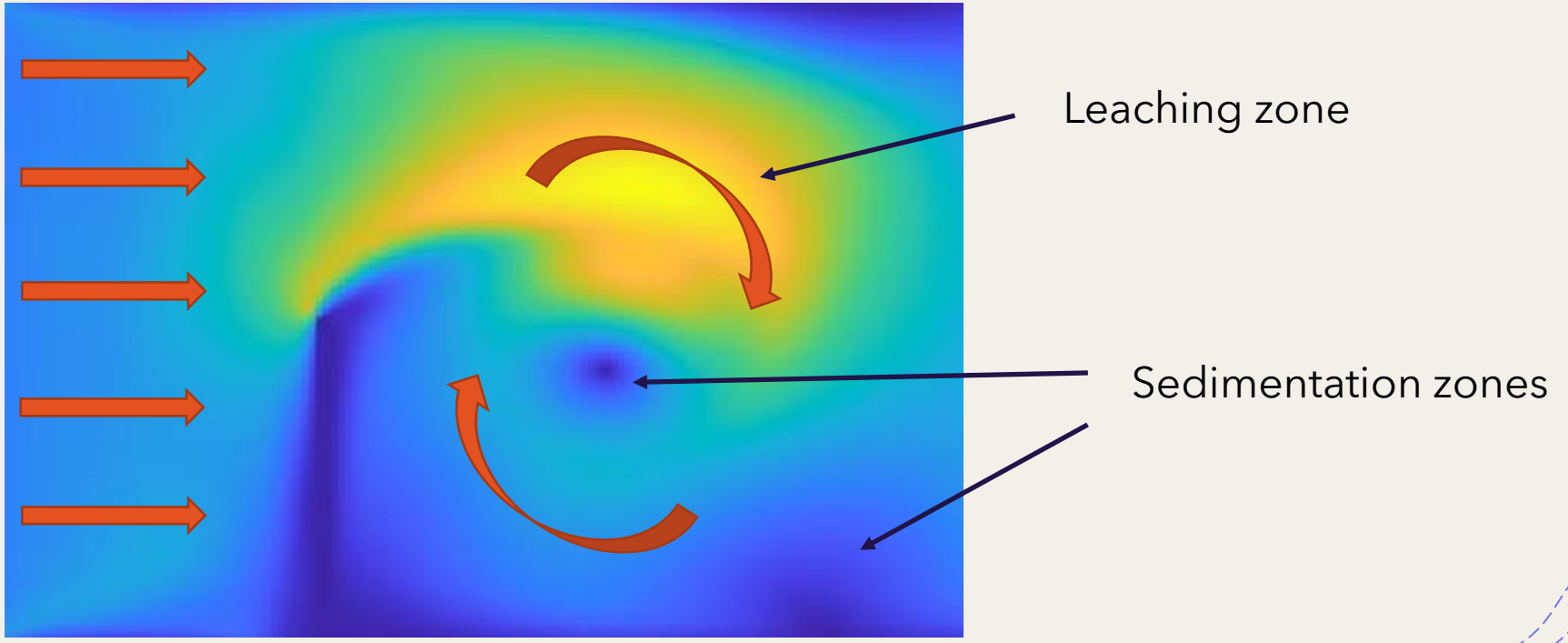
Numerical results: flow from the side - 1



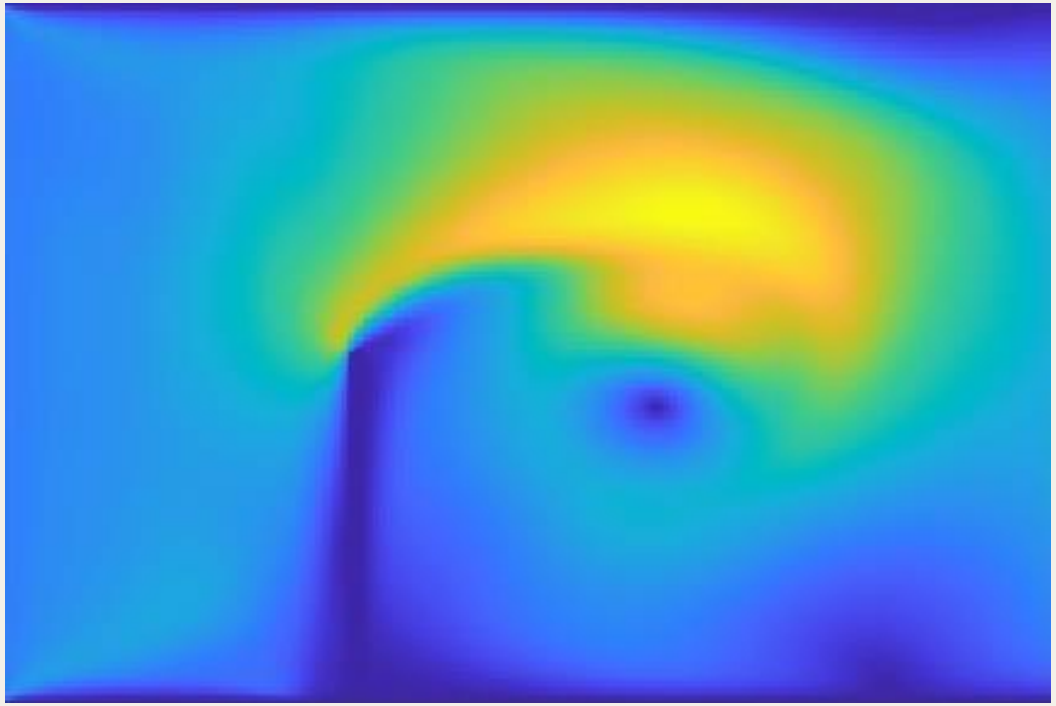
Numerical results: flow from the side - 1



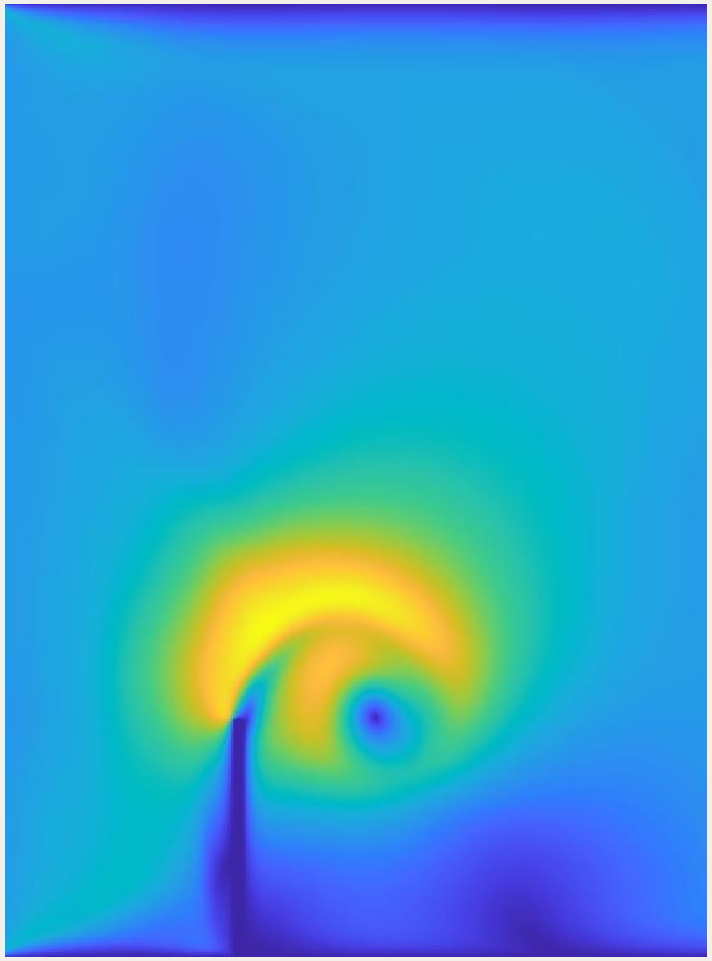
Numerical results: flow from the side - 1



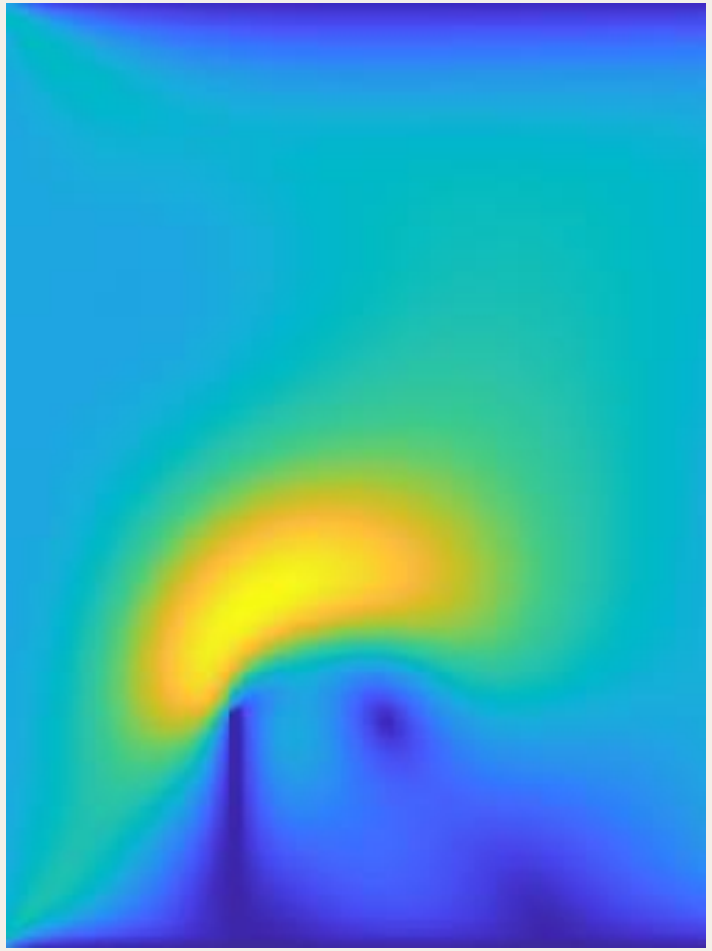
Numerical results: flow from the side - 2



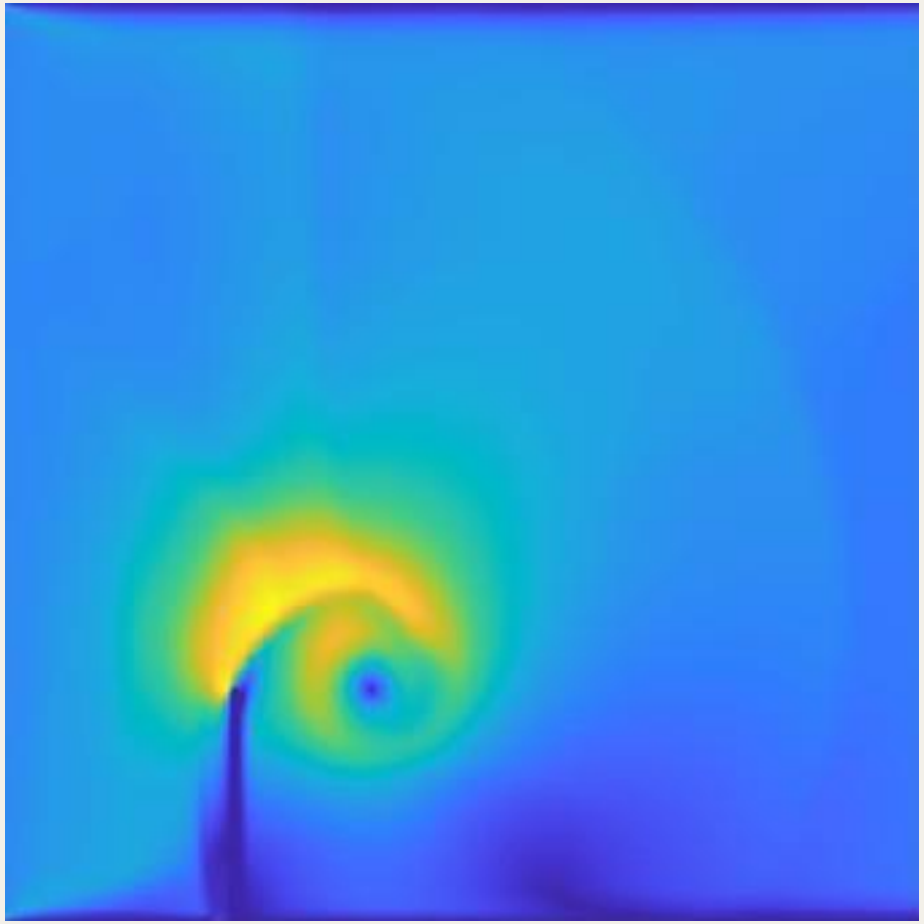
Numerical results: flow from the side - 3



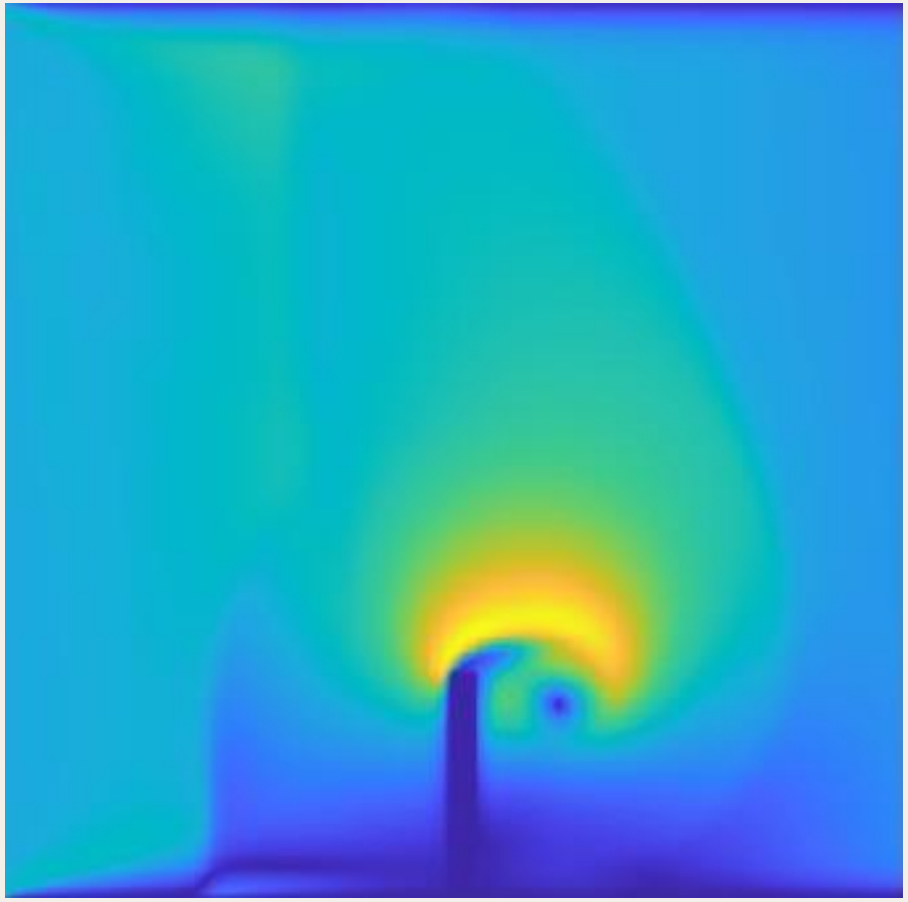
Numerical results: flow from the side - 4



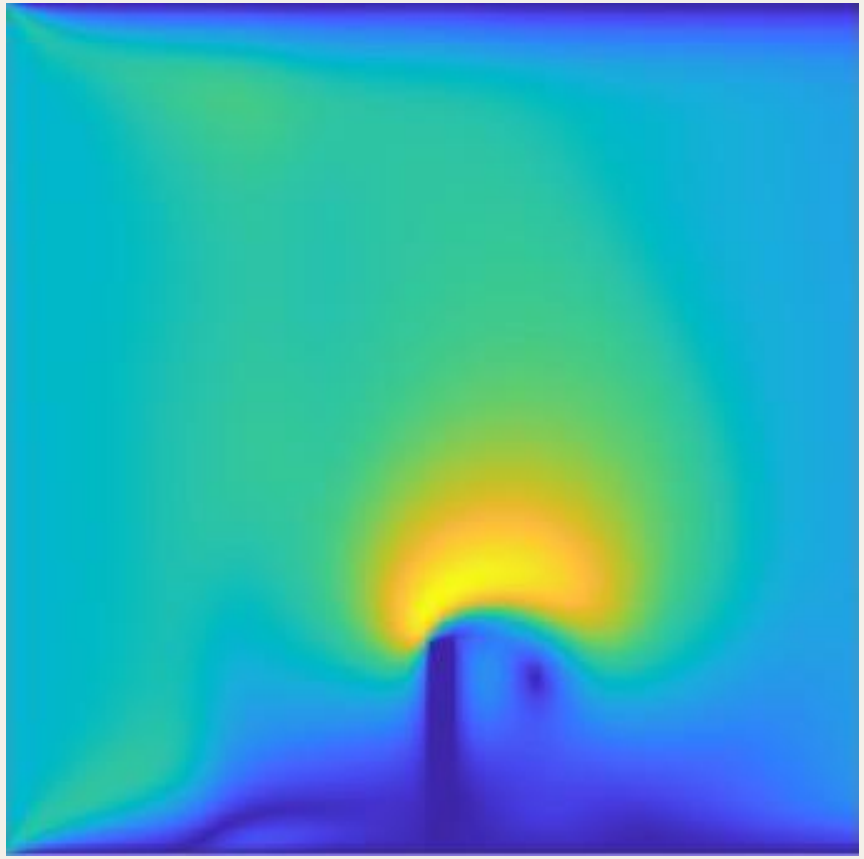
Numerical results: flow from the side - 5



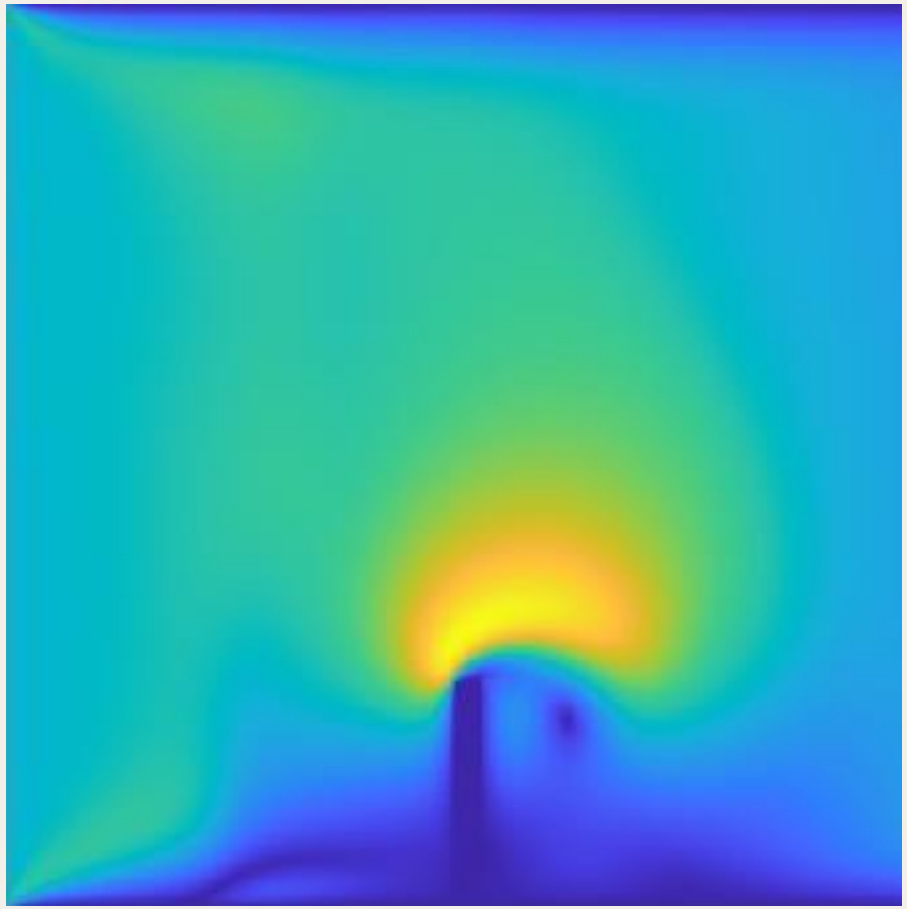
Numerical results: flow from the side - 6



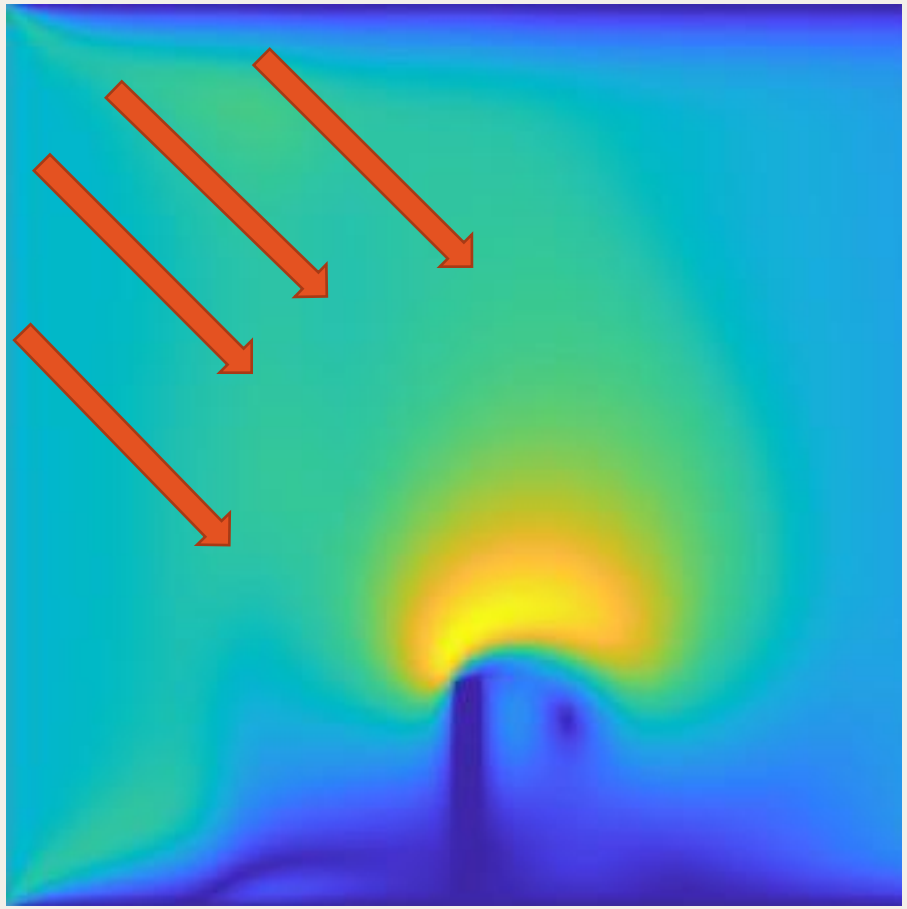
Numerical results: flow from the side - 7



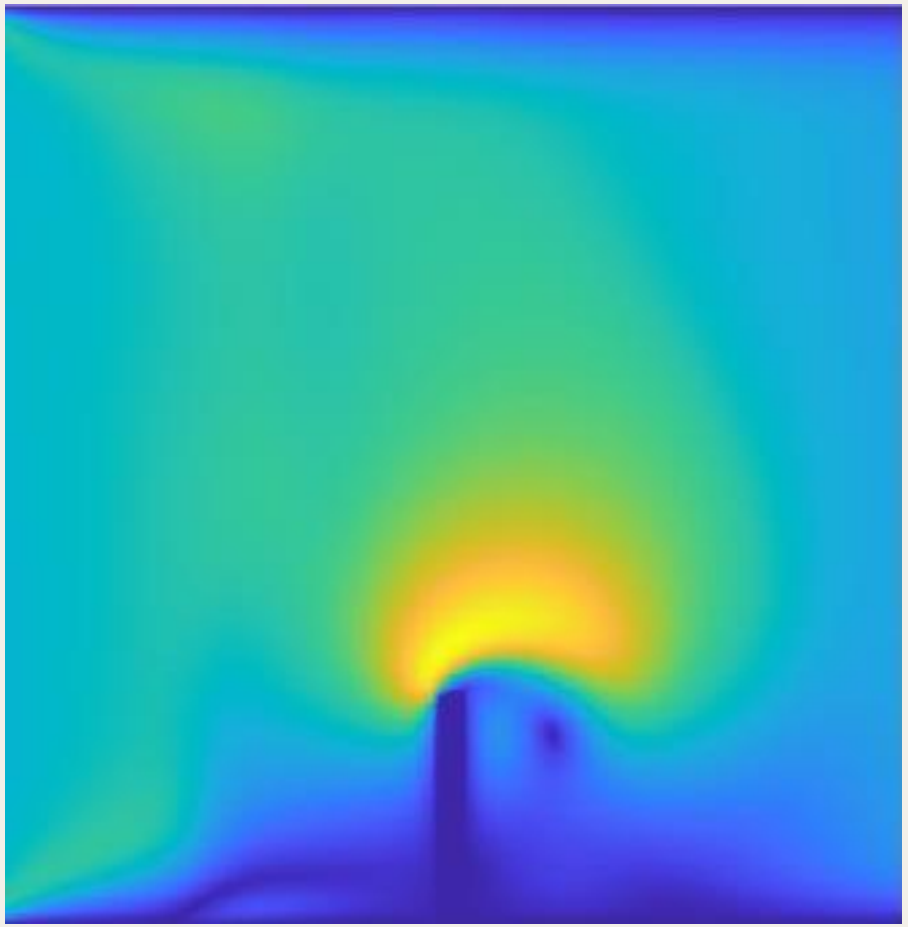
Numerical results: flow from the upper left corner - 1



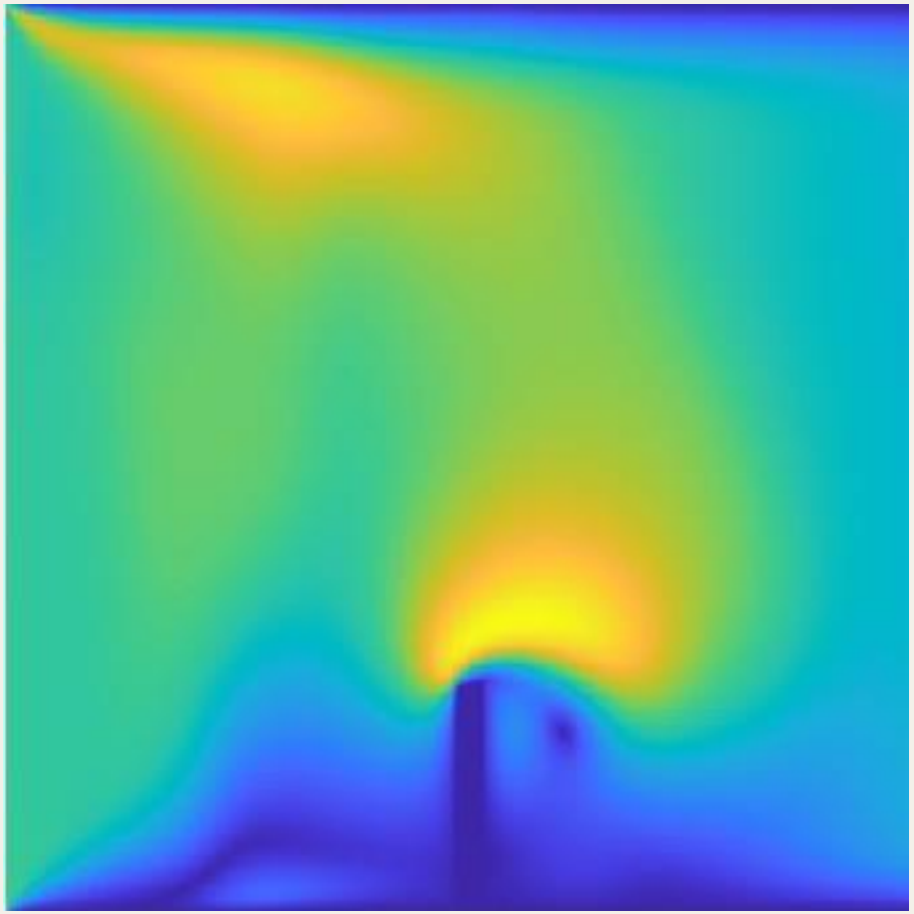
Numerical results: flow from the upper left corner - 1



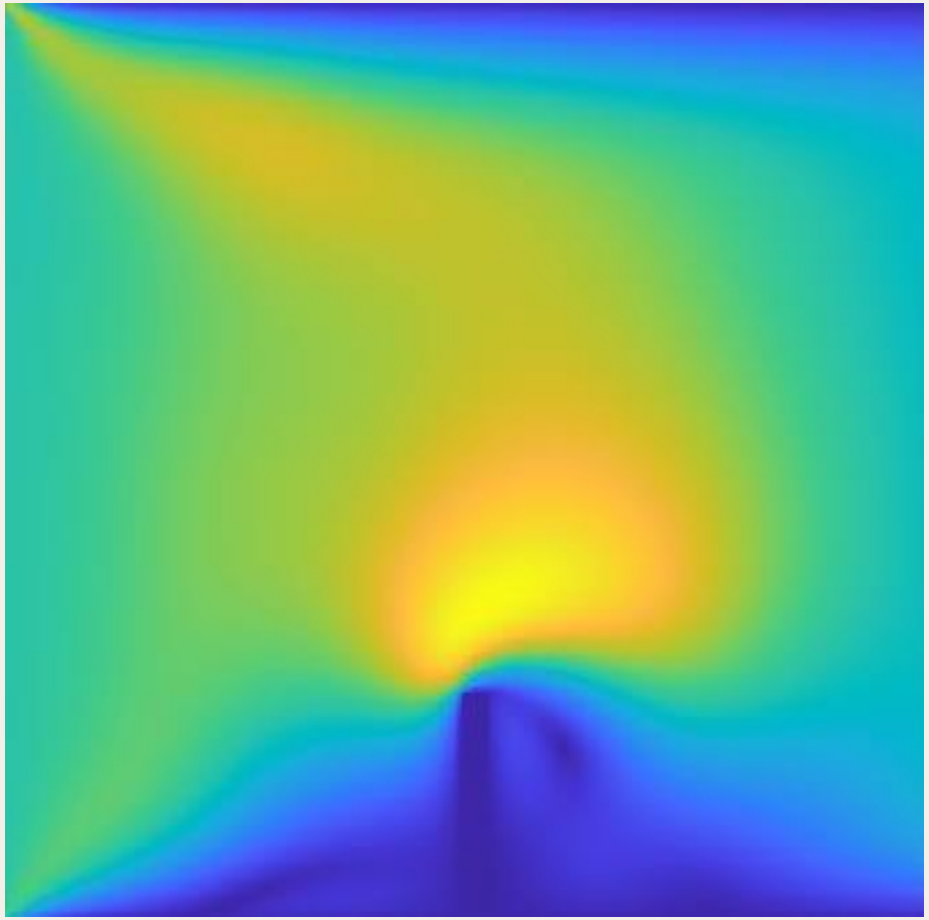
Numerical results: flow from the upper left corner - 2



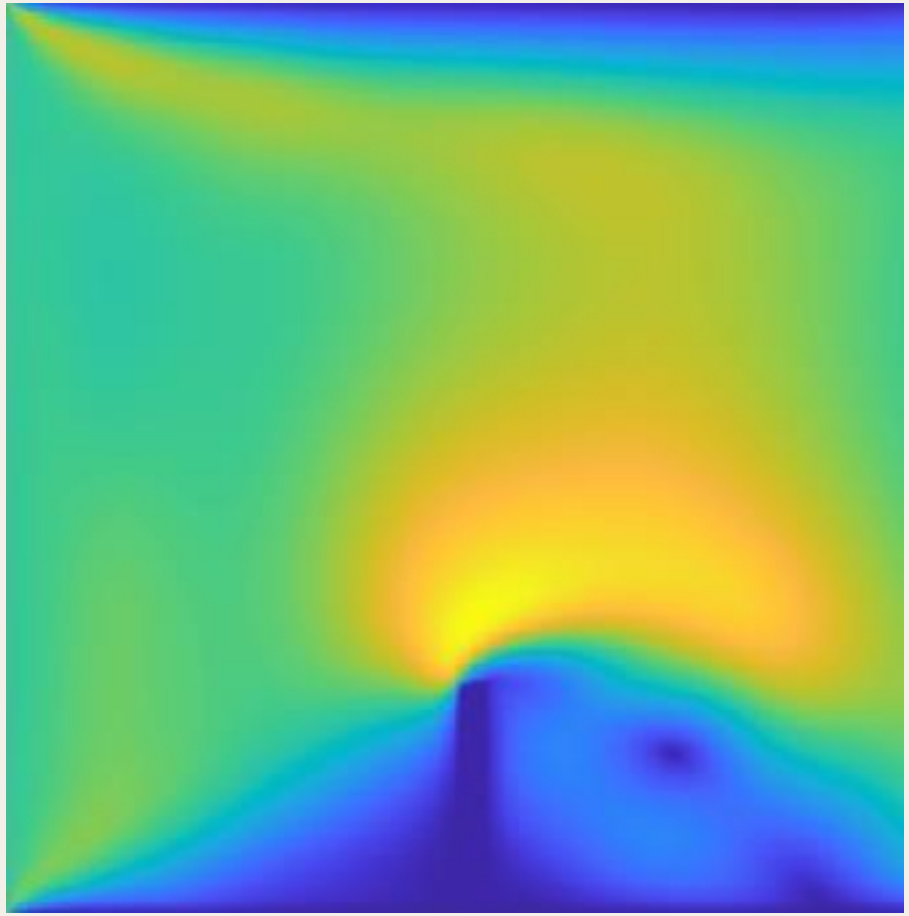
Numerical results: flow from the upper left corner - 3



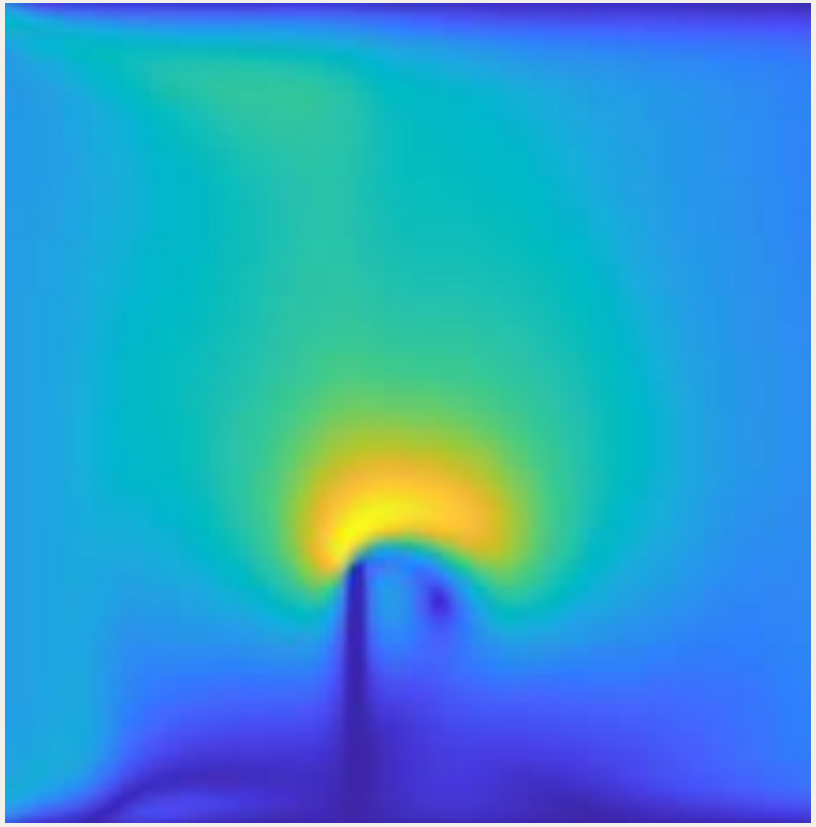
Numerical results: flow from the upper left corner - 4



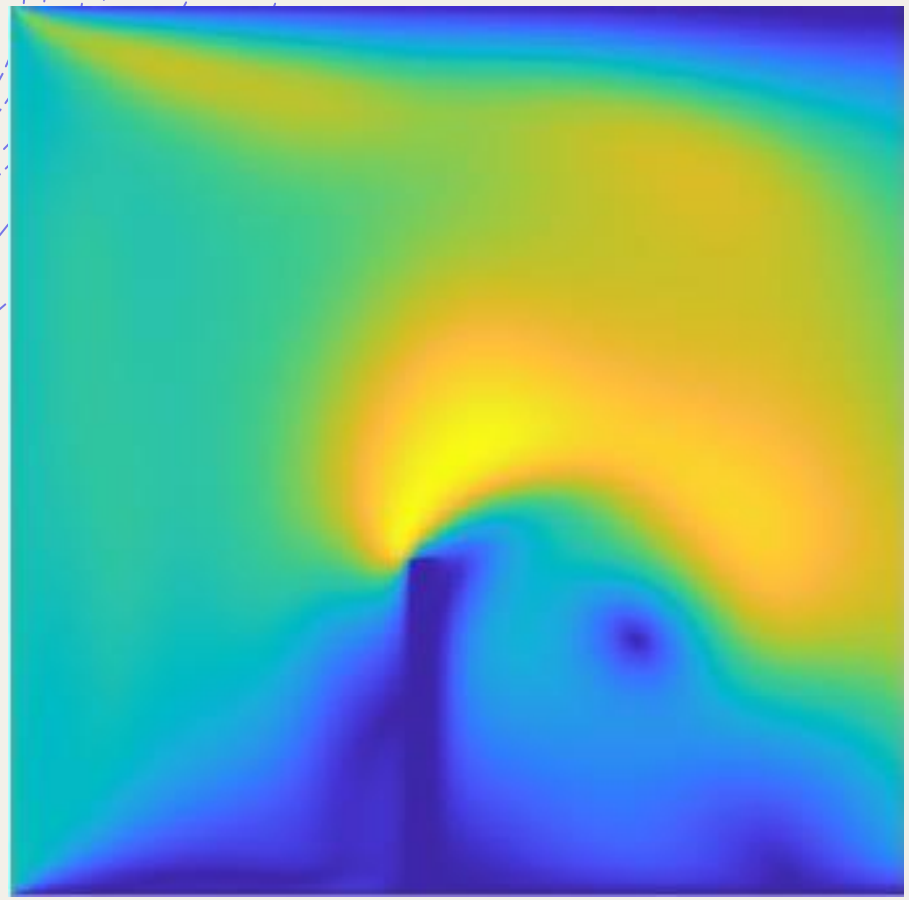
Numerical results: flow from the upper left corner - 5



Numerical results: flow from the upper left corner - 6



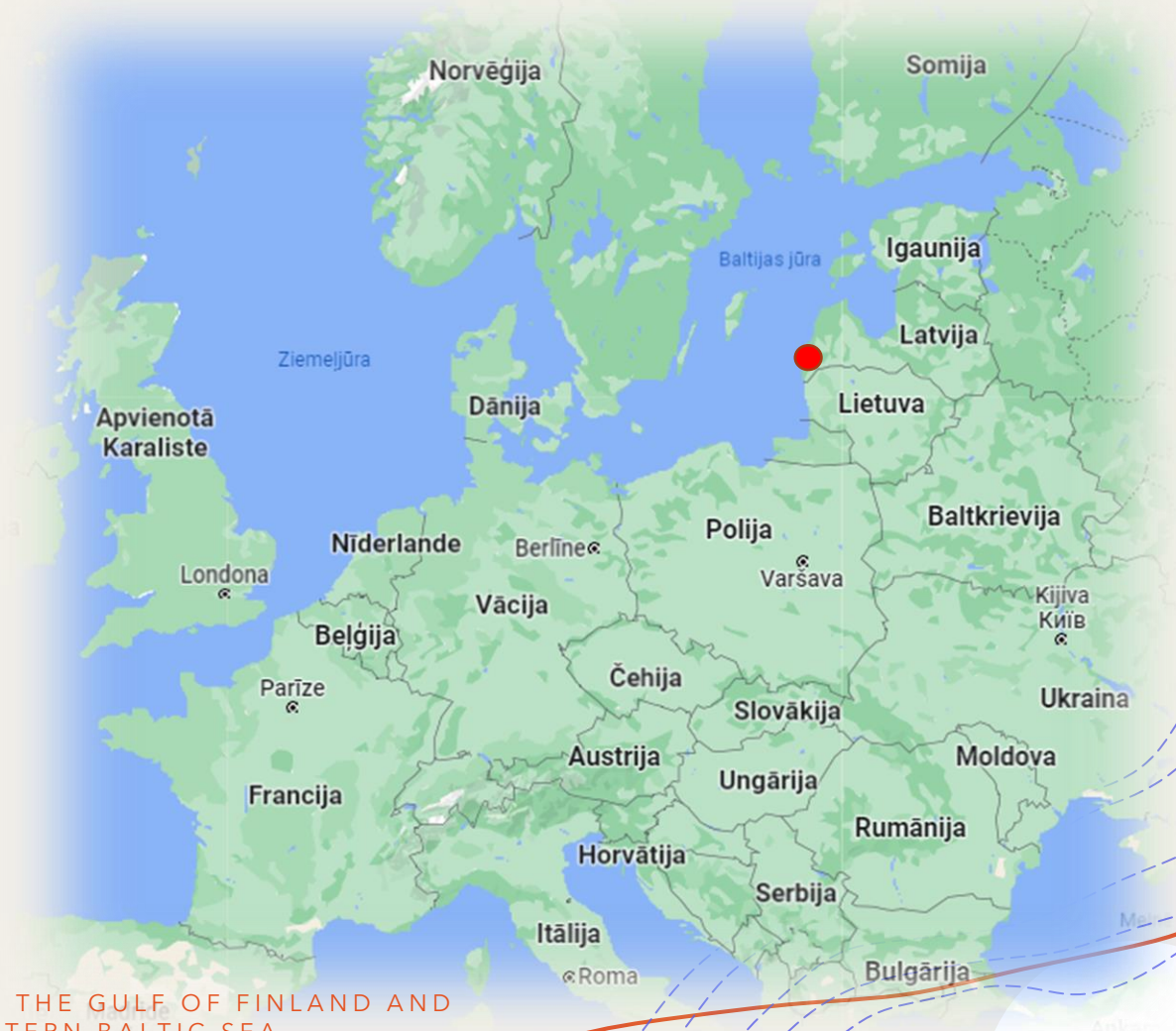
Numerical results: flow from the upper left corner - 7



Conclusions/observations

1. Flow modeling using LBM allows estimation of flow velocity distribution and visualization of bed self-cleaning and sedimentation zones
2. The location of coastal erosion/sedimentation in simulations is in good agreement with observations in nature
3. The Lattice Boltzmann method makes it easy to use parallel calculations
4. Solutions can be supplemented with heat transfer equation

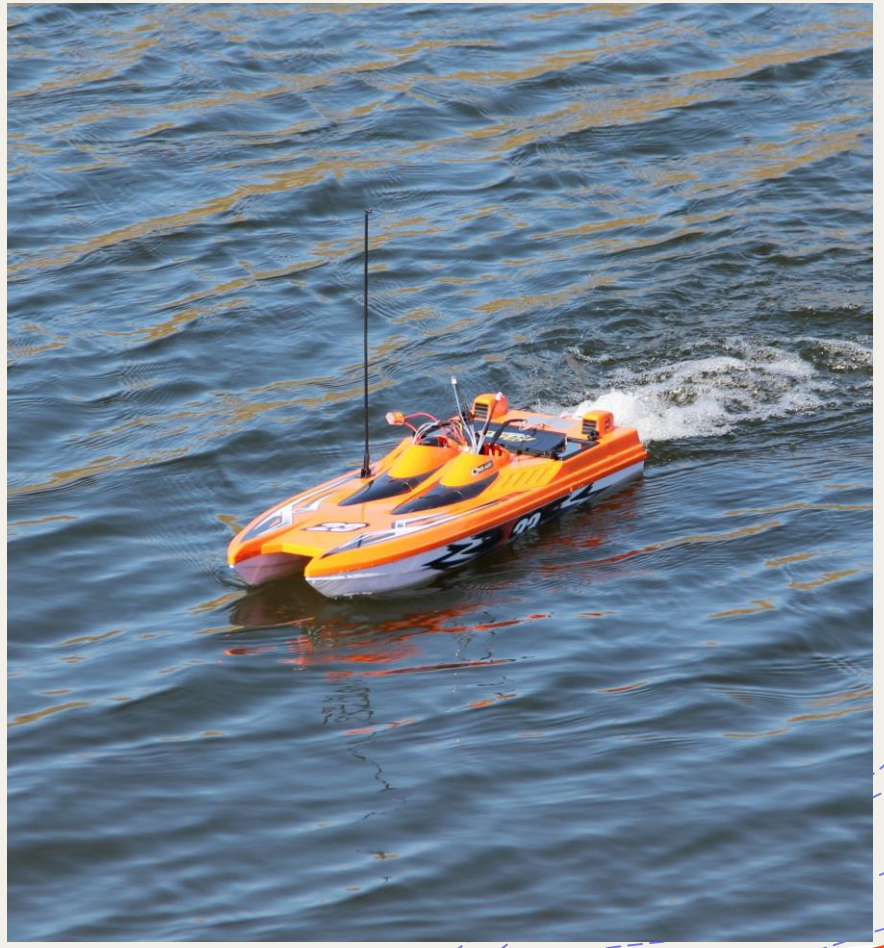
Liepaja University



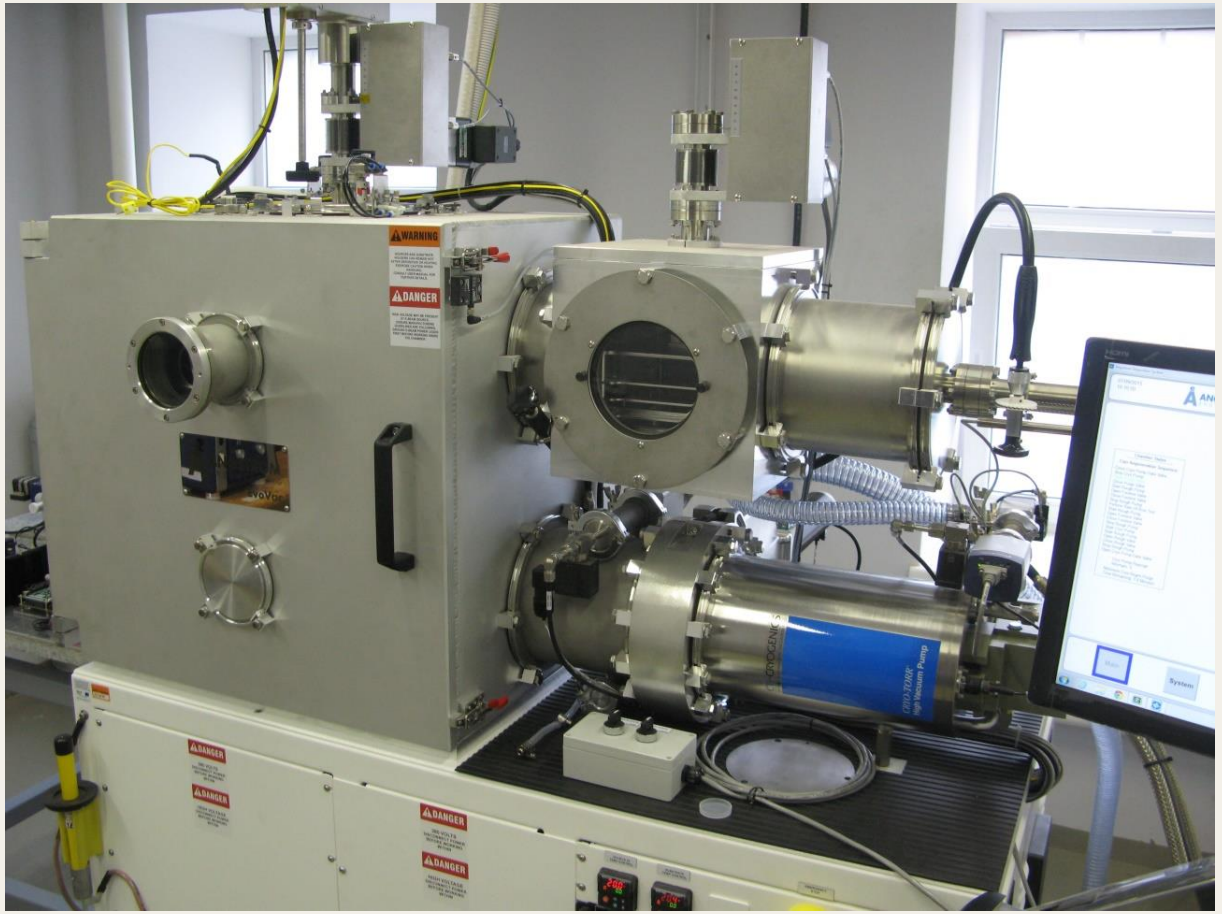
Autonomous environmental monitoring robot

Equipment with sensors in the basic version:

GPS sensor
US sonar
Temperature sensor
pH sensor
Dissolved oxygen sensor
Oxidation-reduction potential sensor
Water transparency sensor
Electrical conductivity (salinity) sensor



Institute of Science and Innovative technologies - 1



Institute of Science and Innovative technologies - 2

Uldis Žaimis

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Latvia

SEA LEVEL GAP-FILLING USING SATELLITE ALTIMETRY MISSIONS IN THE BALTIC SEA

Majid Mostafavi[1], Nicole Delpeche Ellmann[2], Artu Ellmann[1]

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Email: majid.mostafavi@taltech.ee

Science Days for the Gulf of Finland and the eastern Baltic Sea "Science shakes a hand with coastal life and citizens"

Helsinki, Dec 2022

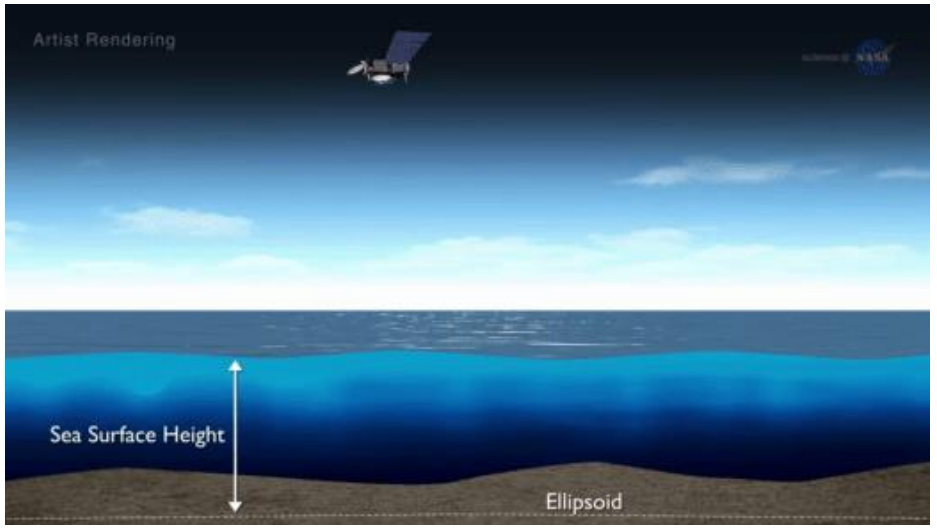
MOTIVATION

Challenges

- **Tide Gauges** observe sea level at the coast within limited site locations
- **Satellite Altimetry** sea level data accuracy changes by their constellations: Sentinel series (98° inclination) are more accurate than T/P series (66° inclination) in the Baltic Sea due to their orbits, although with a gap of data [Oct 2011-Mar 2013] & [Jul 2016-Jan 2017]

Solutions

- **Gap-filling methods** could overcome the constraint Sentinel missions
- **Geoid** as a reliable reference datum



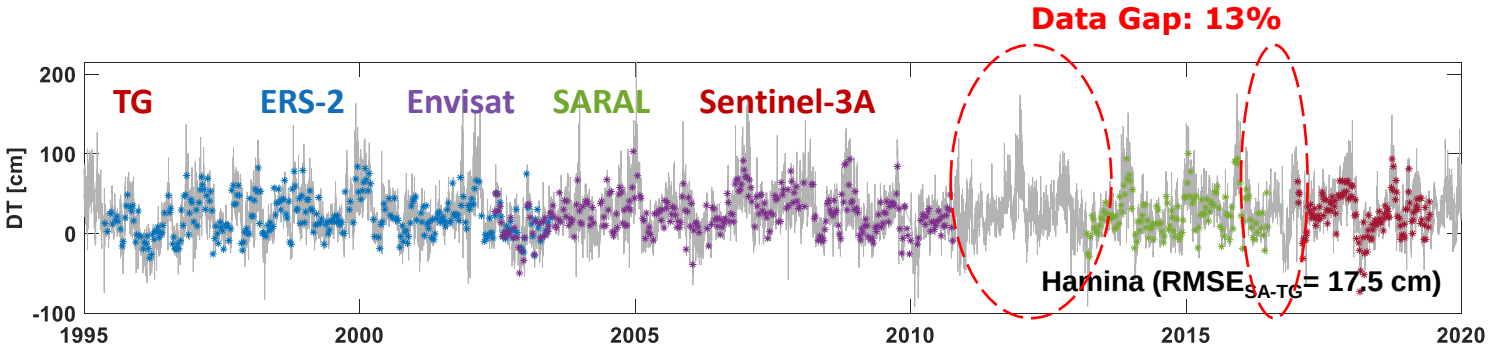


Figure 1: Sea Level time-series at Hamina TG station by continuous TG (294 months) and gapped SA data (37 months gap)

MOTIVATION

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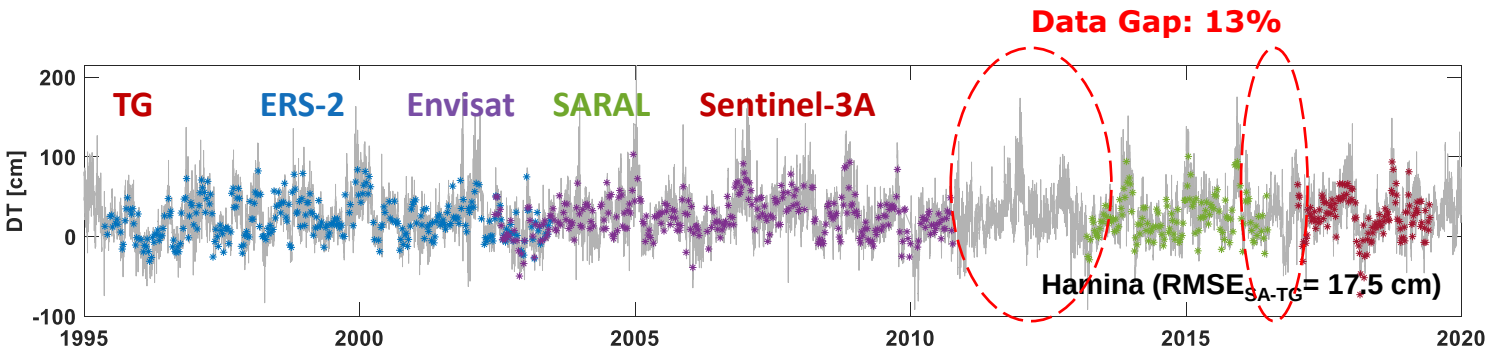


Figure 1: Sea Level time-series at Hamina TG station by continuous TG (294 months) and gapped SA data (37 months gap)

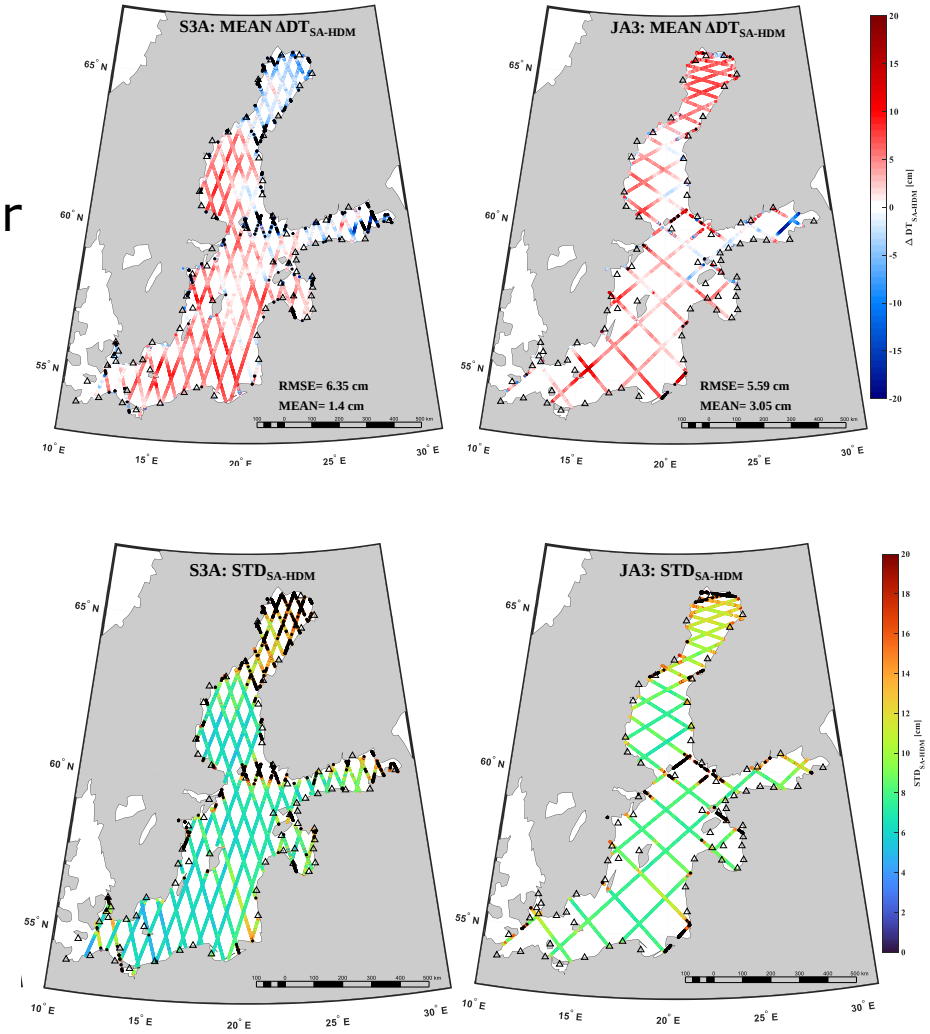


Figure 2: Mean of discrepancies and associated STD between SA along track Dynamic Topography data and Nemo-Nordic Hydrodynamic Model data for S3A and JA3 missions [2017-2019]

METHODOLOGY

- **Data treatment steps:**
  - Absolute DT using geoid (NKG2015) and by removing Vertical Land Motion (NKG2016LU) and
  - De-trend absolute DT data by fitting 1st degree polynomial model
  - De-season absolute DT data by finding the seasonality using spectral analysis of DT

$$m(t) = a_0 + a_1 t + a_2 \cos(\omega t) + a_3 \sin(\omega t) + a_4 \cos(2\omega t) + a_5 \sin(2\omega t)$$

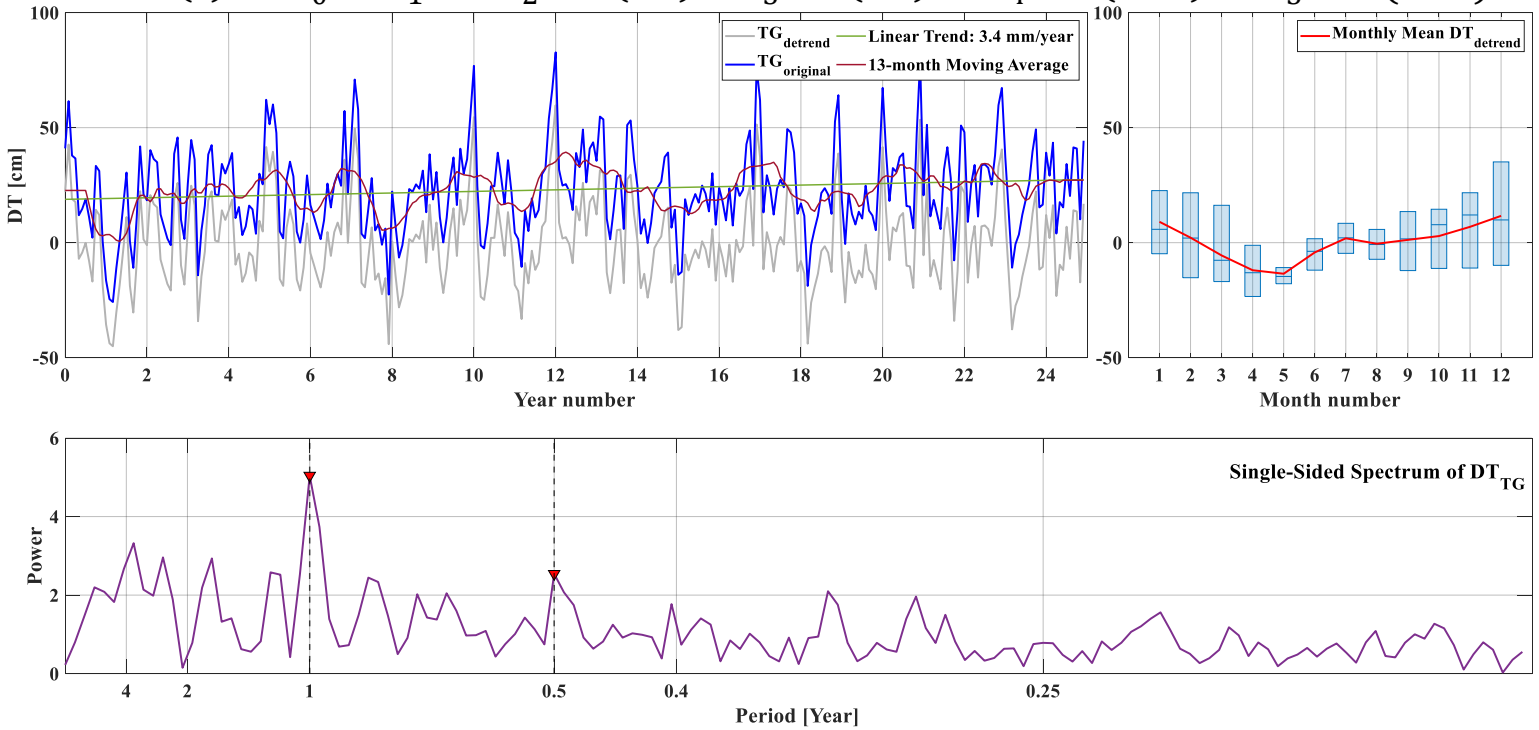


Figure 3. monthly DT of TG observation (blue line) at TG#1 for 25 years (from 1995 to 2020). The linear trend (green line) used to detrend (gray line) the TG. 13 month moving average trend (red line) is also presented. box chart of DT at the TG along with monthly mean DT which shows some seasonality and the power spectral density of detrended DT of TG shows two main time periods (annual and semi-annual) seasonality of DT.

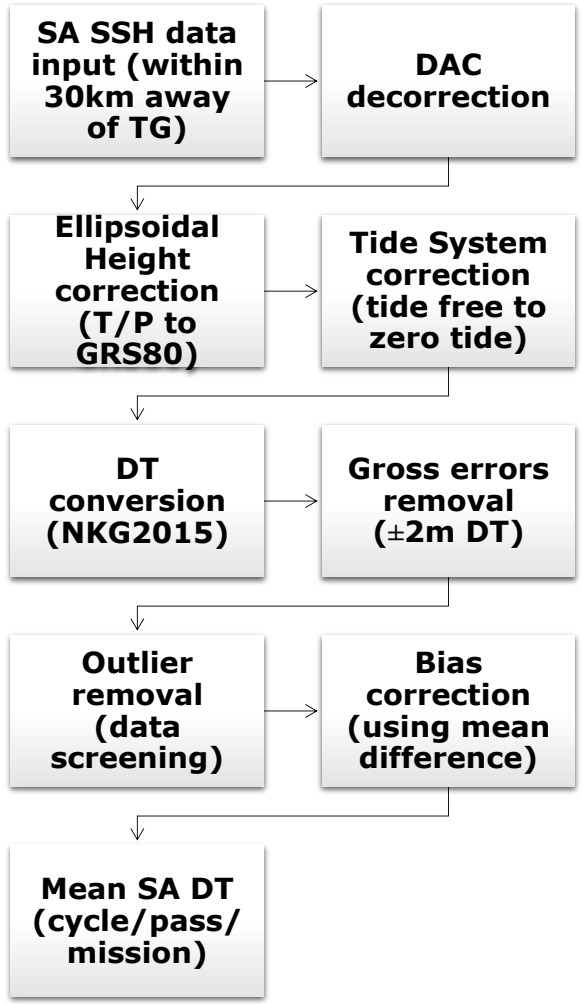


Figure 4. SA data treatment

METHODOLOGY

- **Gap filling steps:**
  - Stationary Test: Augmented Dickey-Fuller test
  - Stability Test
  - Box-Jenkins Methodology: ACF(Auto-correlation function)/PACF to find MA and AR lags
  - Goodness-of-Fit: Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) to find the seasonality lags
  - Seasonal Autoregressive Integrated Moving-Average (SARIMA) is best model for prediction & gap filling
  - Compare the gap-filled data from Forecasting and Hindcasting data

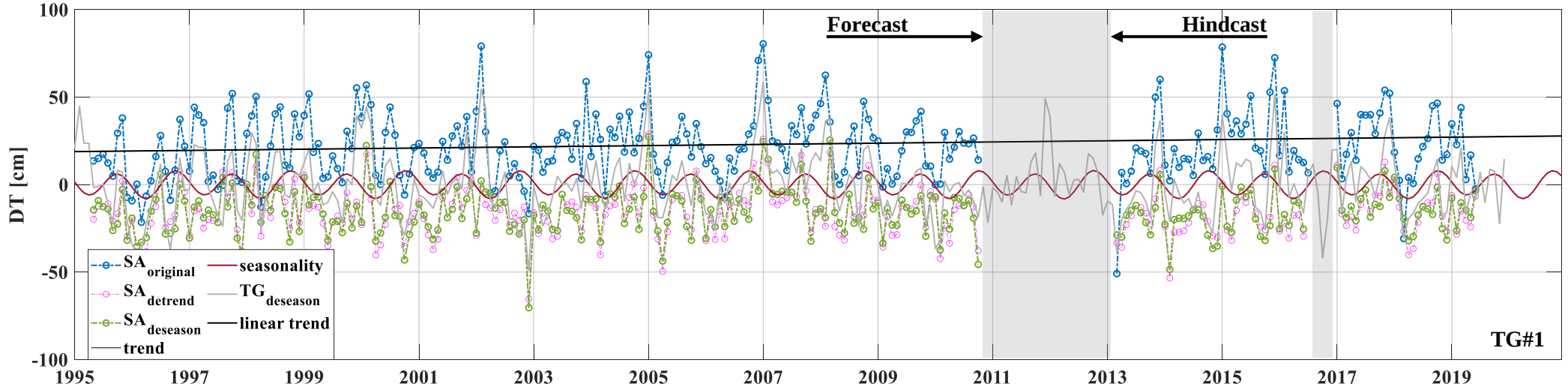
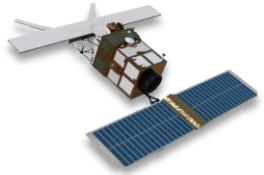
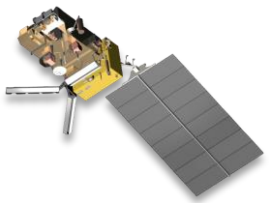


Figure 7: DT time-series by SA data (blue line) and TG#1 data (gray line) at one location (e.g., TG#1). Both data have been detrended by the first-degree polynomial function (black line) and deseasoned by the annual and semi-annual function (red line). The detrended SA data is showed by a magenta line and then the deseasoned SA data is showed by green line. The gray shading areas are the gapped times of SA data.

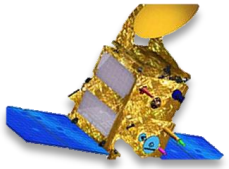
DATASETS & STUDY AREA



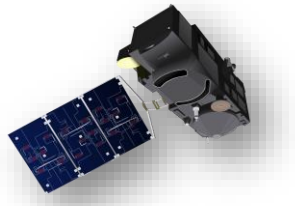
ERS-2 [1995-2003]



Envisat [2002-2010]



SARAL [2013-2016]



Sentinel-3A [2017-2020]

Table 1. Selected TG stations over the Baltic Sea

TG ID	TG station	Latitude	Longitude	Country
1	Helsinki Kaivopuisto	60.15363	24.95622	FI
2	Hanko Pikku Kolalahti	59.82287	22.97658	FI
3	Hamina Pitäjänsaari	60.56277	27.1792	FI
4	Pietarsaari Leppäluoto	63.70857	22.68958	FI
5	Kaskinen Ådskär	62.34395	21.21483	FI
6	Rauma Petäjäs	61.13353	21.42582	FI
7	Oulu Toppila	65.0403	25.4182	FI
8	Spikarna	62.3633	17.5311	SW
9	Marviken	58.5536	16.8372	SW
10	Simrishamn	55.5575	14.3578	SW
11	Forsmark	60.4086	18.2108	SW
12	Furuögrund	64.9158	21.2306	SW
13	Świnoujście	53.9084	14.2543	PL
14	Kołobrzeg	54.1866	15.5534	PL
15	Ustka	54.588	16.8538	PL
16	Sassnitz	54.5108	13.6431	GR

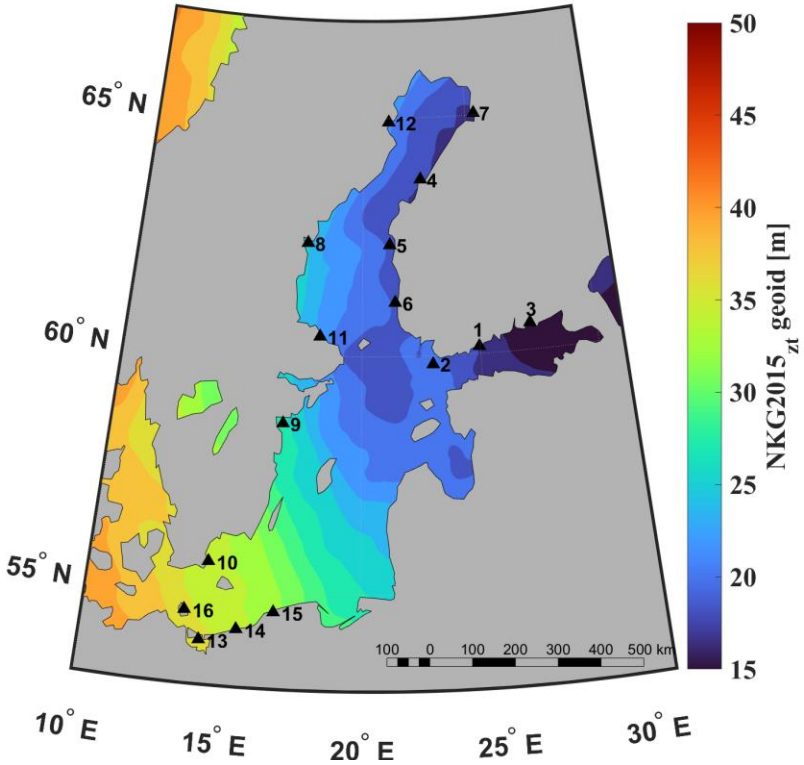


Figure 6. selected TG station locations over the Baltic Sea together with the high-resolution marine geoid

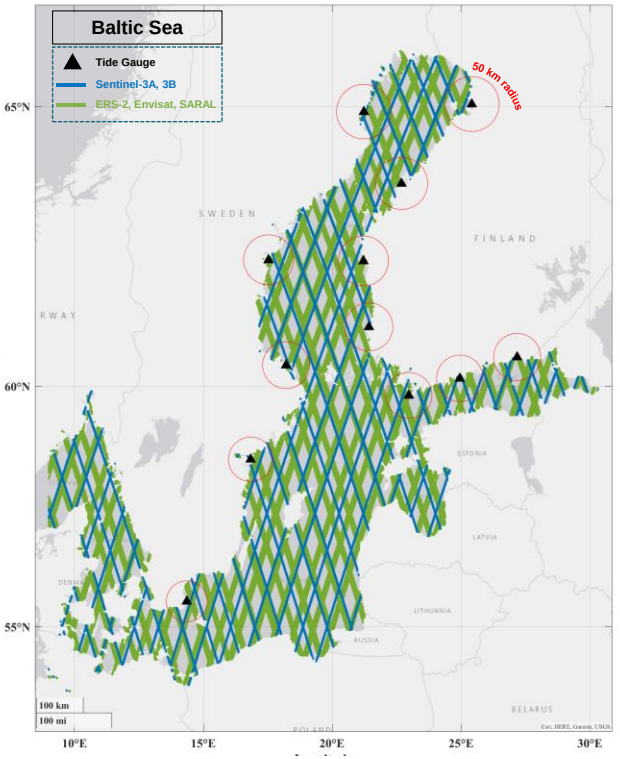


Figure 5. Location of TG stations and SA passes in the Baltic Sea

RESULTS

- The Seasonal Autoregressive Integrated Moving average (SARIMA) could detect the seasonal variations, hence, leading to the best result compared to other ARMA models
- Best model for forecasting: SARIMA with AR:1, I:0 MA:1, SAR:[12:6:60], SAR:[12:6:60] and Seasonality 12 month
- The gap-filling over the entire Baltic Sea could lead to a more realistic sea level trend analysis and coastal management

$$RMSE = \sqrt{\frac{1}{n}\sum_{t=1}^{n}\left(y_t^o - y_t^p\right)^2}$$

$$y^o = TG\ DT(\varphi_{TG}, \lambda_{TG}, t_{month})$$

$$y^p = Model\ DT(\varphi_{TG}, \lambda_{TG}, t_{month})$$

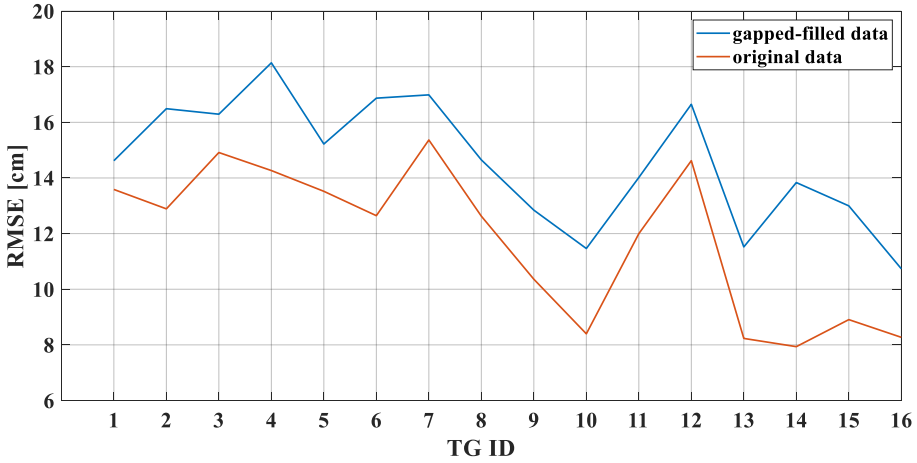


Figure 8: RMSE of gap filled data vs. the original data

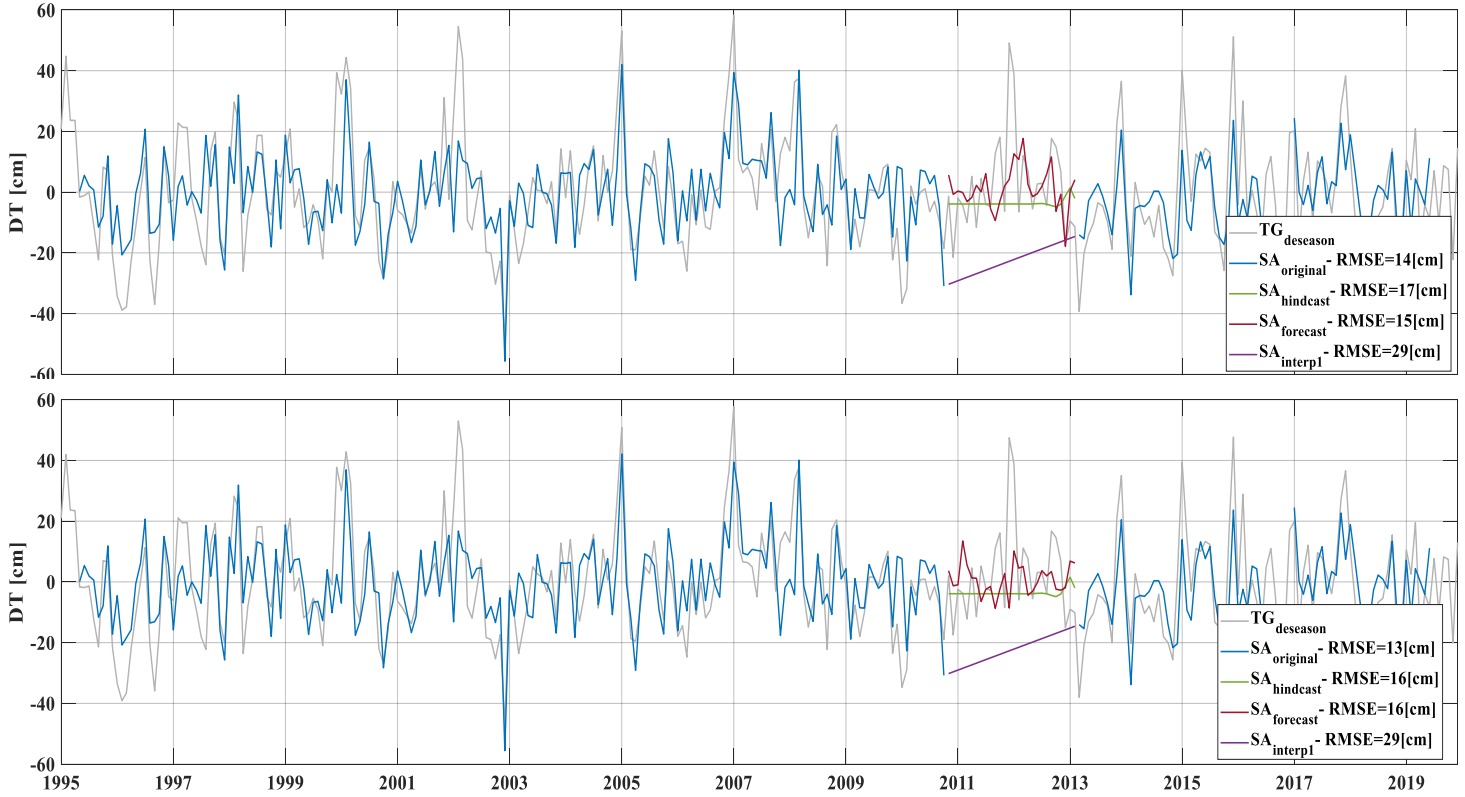


Figure 9: Bi-directional gap filled Data via forecasting (red) and hindcasting (green) vs the linear interpolation

Thank you!

Majid.Mostafavi@TALTECH.ee

ResearchGate

LinkedIn

Spatially varying role of

MANIFESTATIONS OF CLIMATE CHANGE

on coastal processes from the German Bight to the Gulf of Finland

Tarmo Soomere

Tallinn University of Technology, School of Science

Department of Cybernetics, Wave Engineering Laboratory

Estonian Academy of Sciences

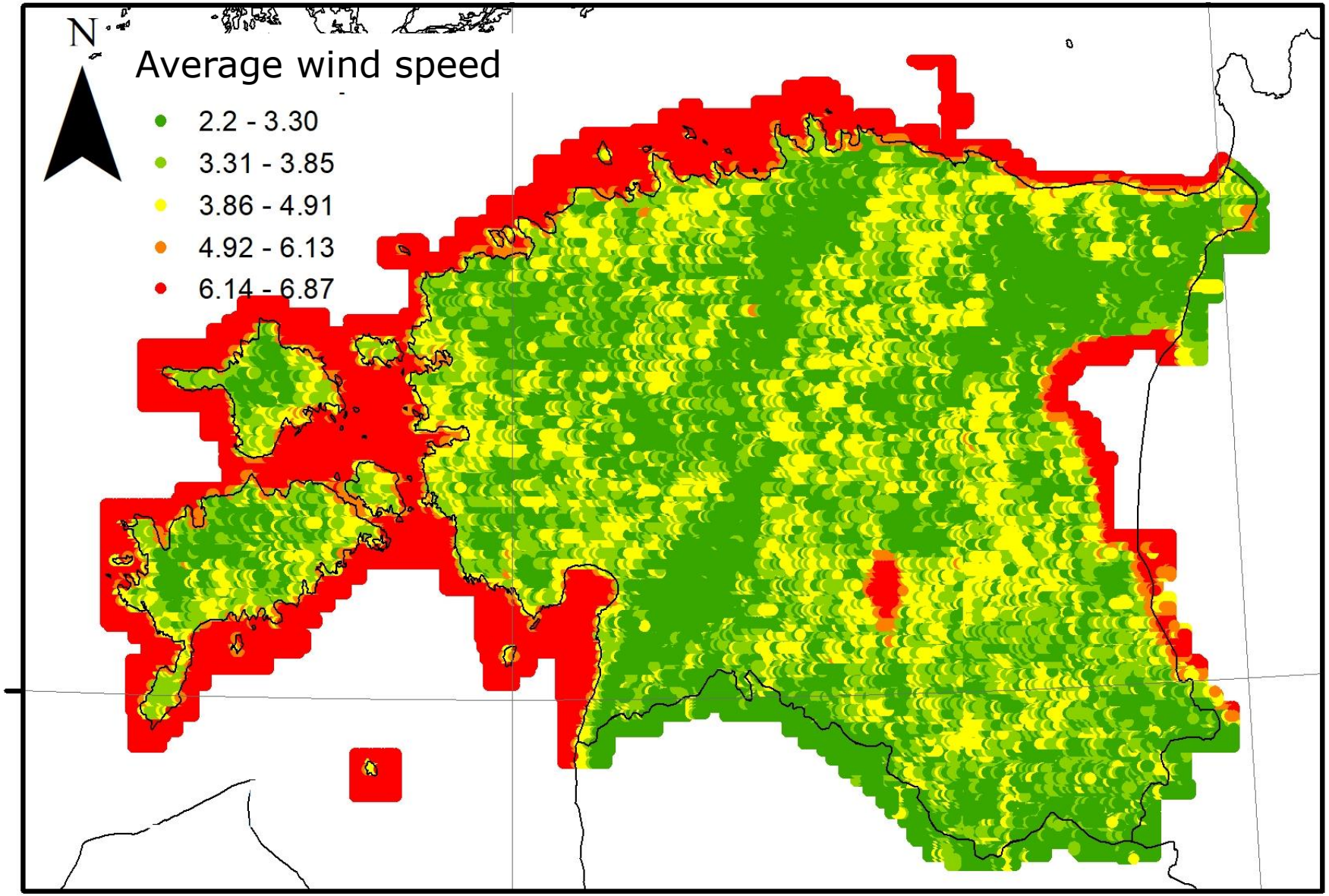
01.12.2022

WAVE ENGINEERING

Instead of Introduction

or winds of future may be very strong
even if there is no climate change

An expected result: average wind speed over Estonia

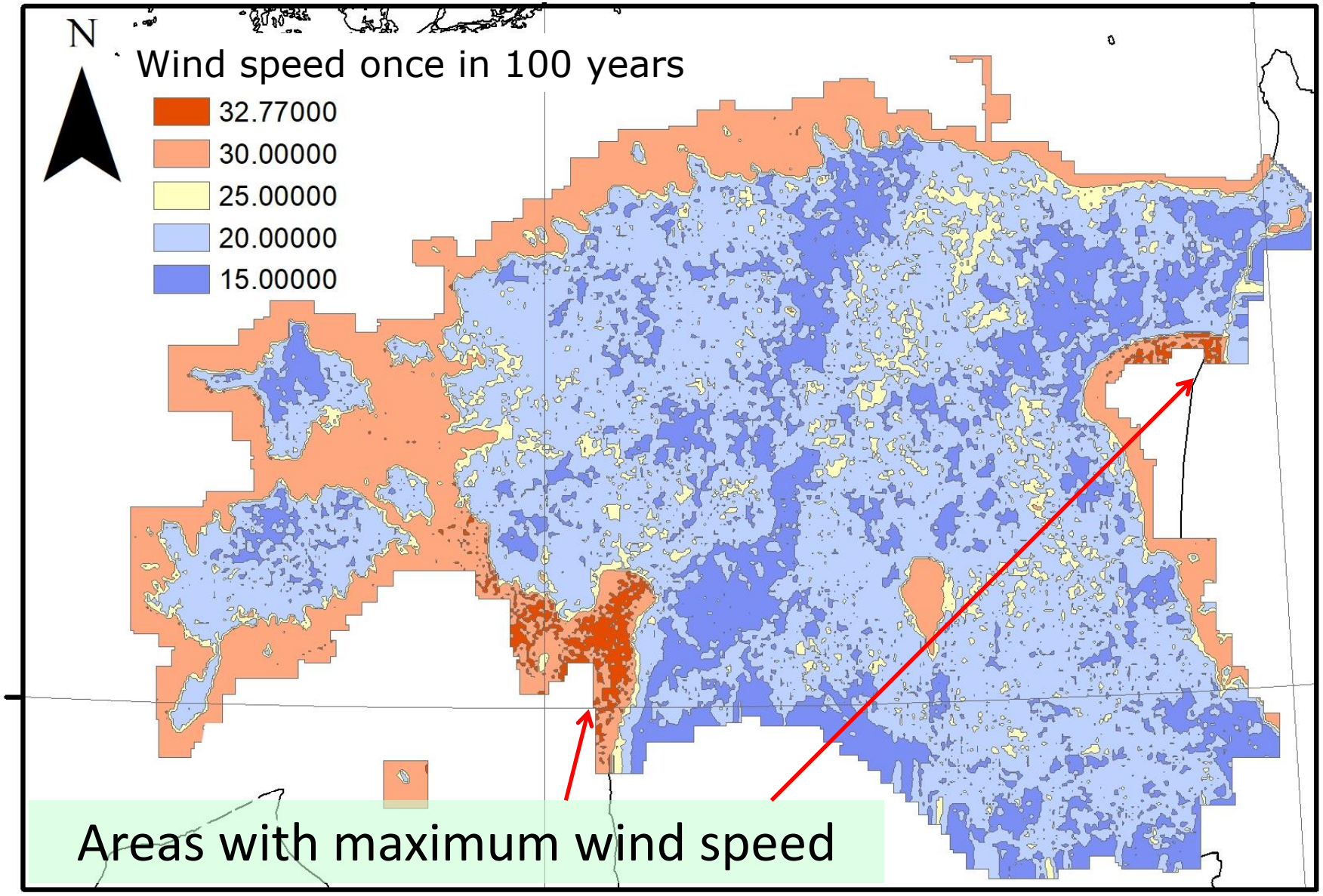


- Larger over the sea
- Somewhat larger over large lakes
- Follows the pattern of forests and agricultural lands

Partially restricted material.
Map by Ain Kull, University of Tartu

WAVE ENGINEERING

Also expected result: max wind speed 1x100 yr

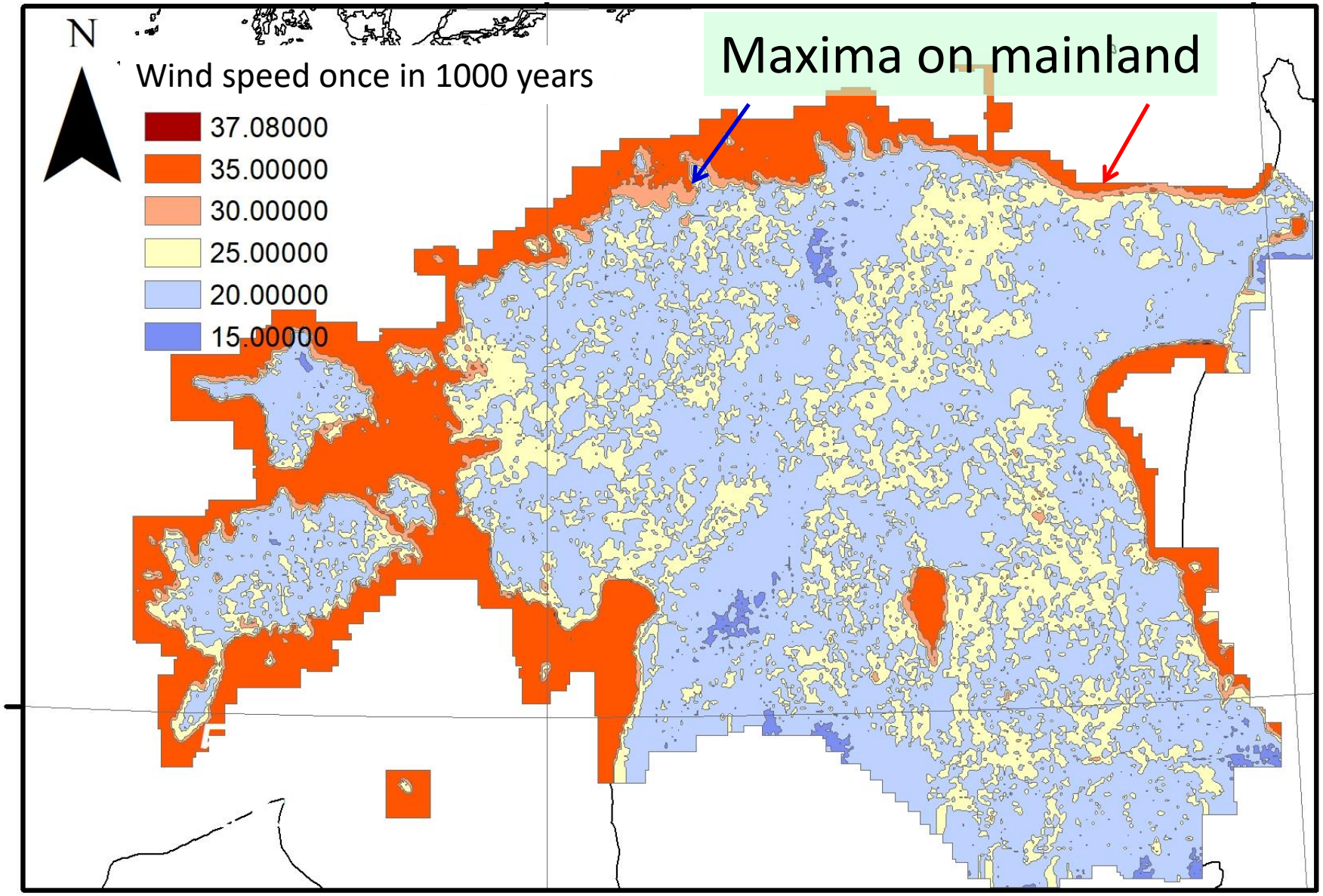


- Maxima 30-32 m/s
- Pärnu Bay and north of Lake Peipus
- Strongest: SW winds

Partially restricted material. Map by Ain Kull, University of Tartu

WAVE ENGINEERING

Unexpected result: max wind speed 1x1000 yr



- Maxima 35-37 m/s
- The northern shore
- Strongest: **northerly winds!**

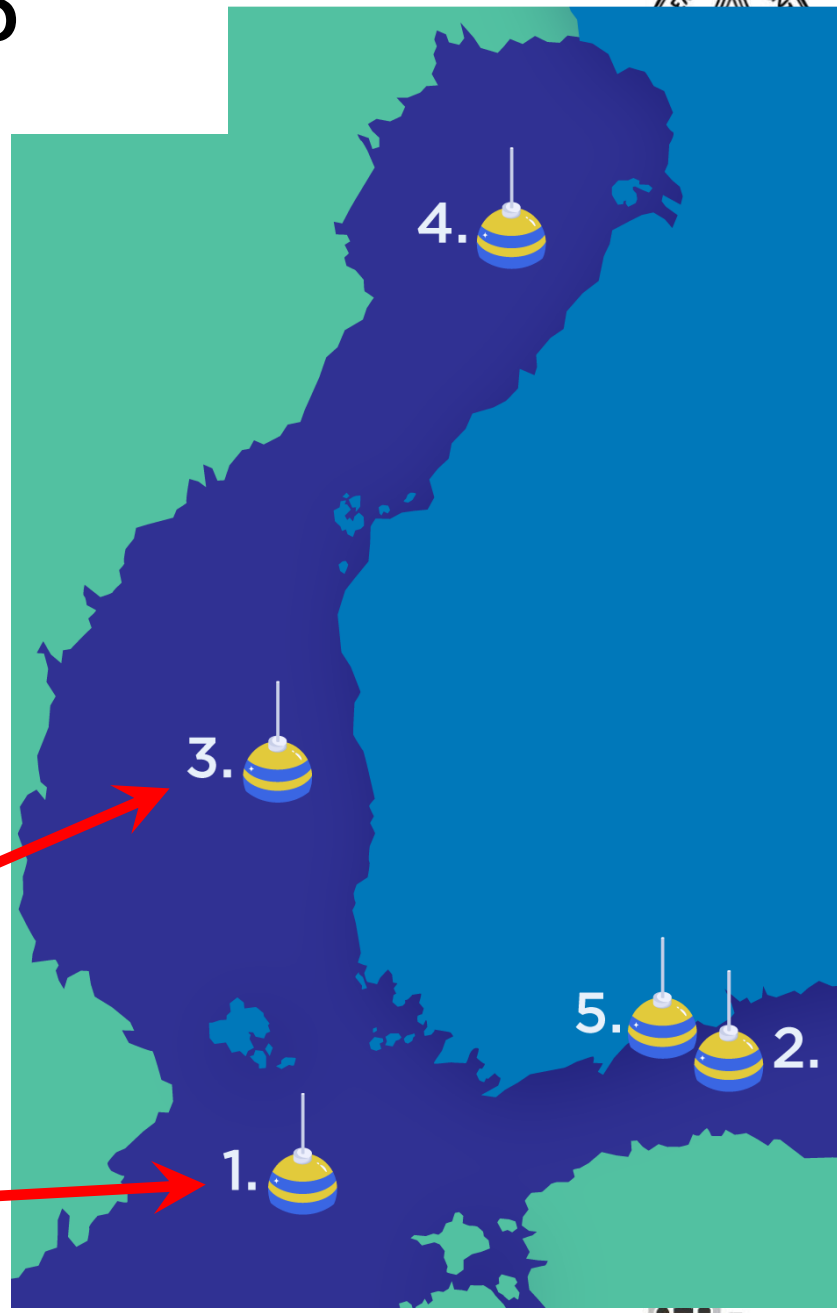
Partially restricted material.
Map by Ain Kull, University of Tartu

WAVE ENGINEERING

Has the future already arrived?

01 January 2019, Sea of Bothnia, Aapeli:

- **North wind** 32.5 m/s
  - <30 m/s in January 2005
    - Usually SW winds the most frequent and strongest
- **Unexpectedly severe waves** Björkqvist et al., 2019
  - **Significant wave height 8.1 m**
- All-time maximum in Baltic proper:
  8.2 m, Dec 2004



Simple consequences

- A climate system may have very strong natural variability (=noise)
- Major events/extremes occur with some frequency even in the stationary climate system
- Manifestations of climate change more reliable identified from changes to average values (or various distributions)

A feature (not a bug) of random systems:

Extreme values increase in time even in a stationary climate

- Common distributions in marine science & geophysics: Gauss or Weibull distribution
  - wind speed, wave height etc
- Extremes increase as ~log(t)
- Also in a statistically stationary system
  - Even when there is no climate change

Nobel Prize laureates 2021

- Weather forecast possible for max 2 weeks
- Climate forecast possible for decades (Klaus Hasselmann)
  - **Because our Earth has the ocean**
- Climate as a Brownian parcel
  - Impossible to exactly forecast its position
  - Fairly easy to forecast the distance from initial location
  - Sufficient to observe during short time + math
  - (Important to have good signal/noise ratio)

THE question / Facing the challenge: how to identify climate changes?

A hint:

The coastal sea and coastal processes as natural indicators and integrators of hydrodynamic loads (smoothing out short-term noise)

The main drivers of the coast

Wind: the background of almost all other drivers

- **Waves**
  - Reflect properties of winds over large sea areas
  - Bring massive energy flux to the shore
  - Entrain and move sediment
  - Affect functioning of river mouths
  - Contribute to the local water level
- **Water level**
  - Supports penetration of wave energy to the upper beach
  - Extreme water levels: reflect properties of large and strong storms
- **Sea ice**
  - Protect sediment from erosion
  - Damp the generation and impact of waves and (high) water level

Their impact is radically different in different parts of the Baltic Sea

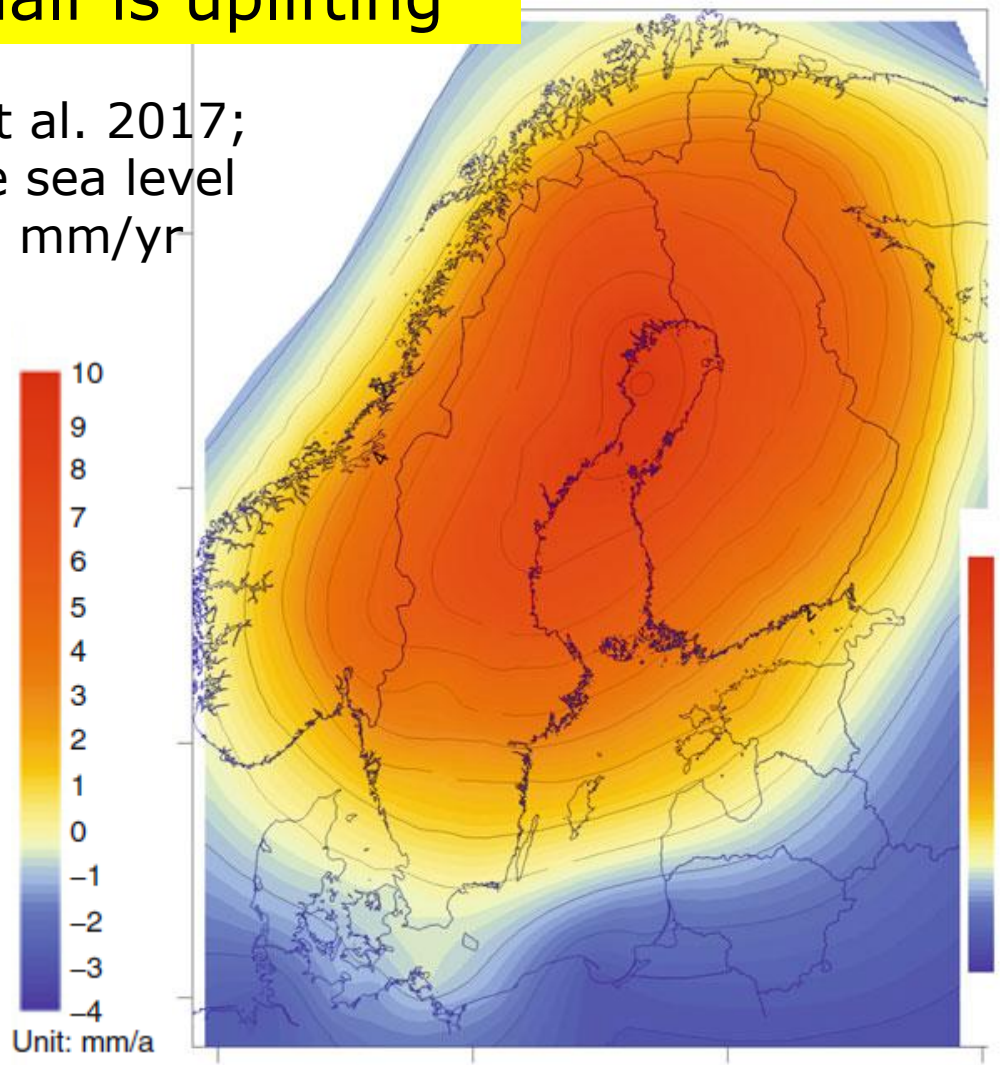
Driver 1:

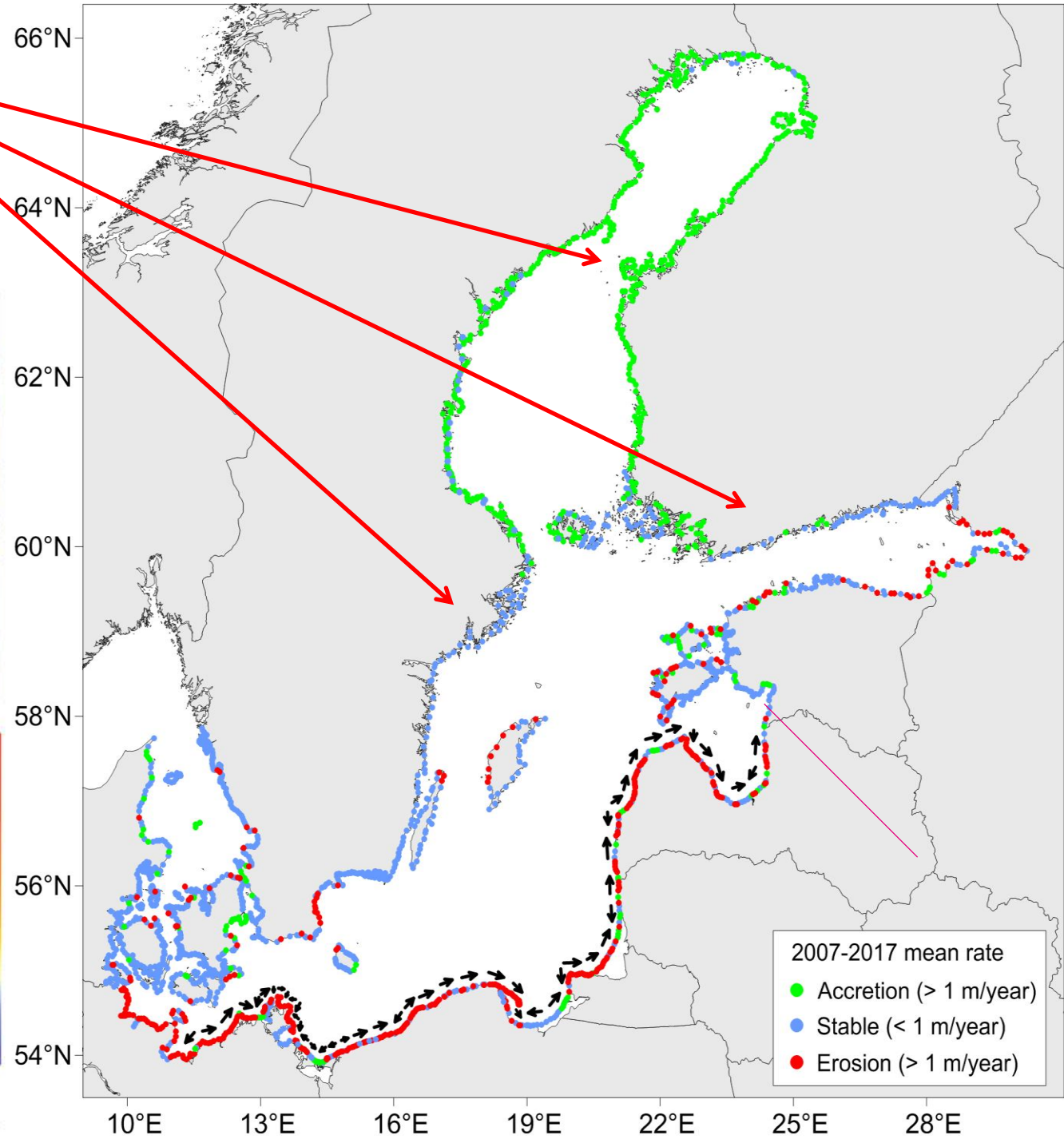
Changes to the average water level

Half of BS shores are bedrock or limestone

What an injustice: this half is uplifting

Harff et al. 2017; relative sea level change mm/yr





An (almost trivial) conjecture

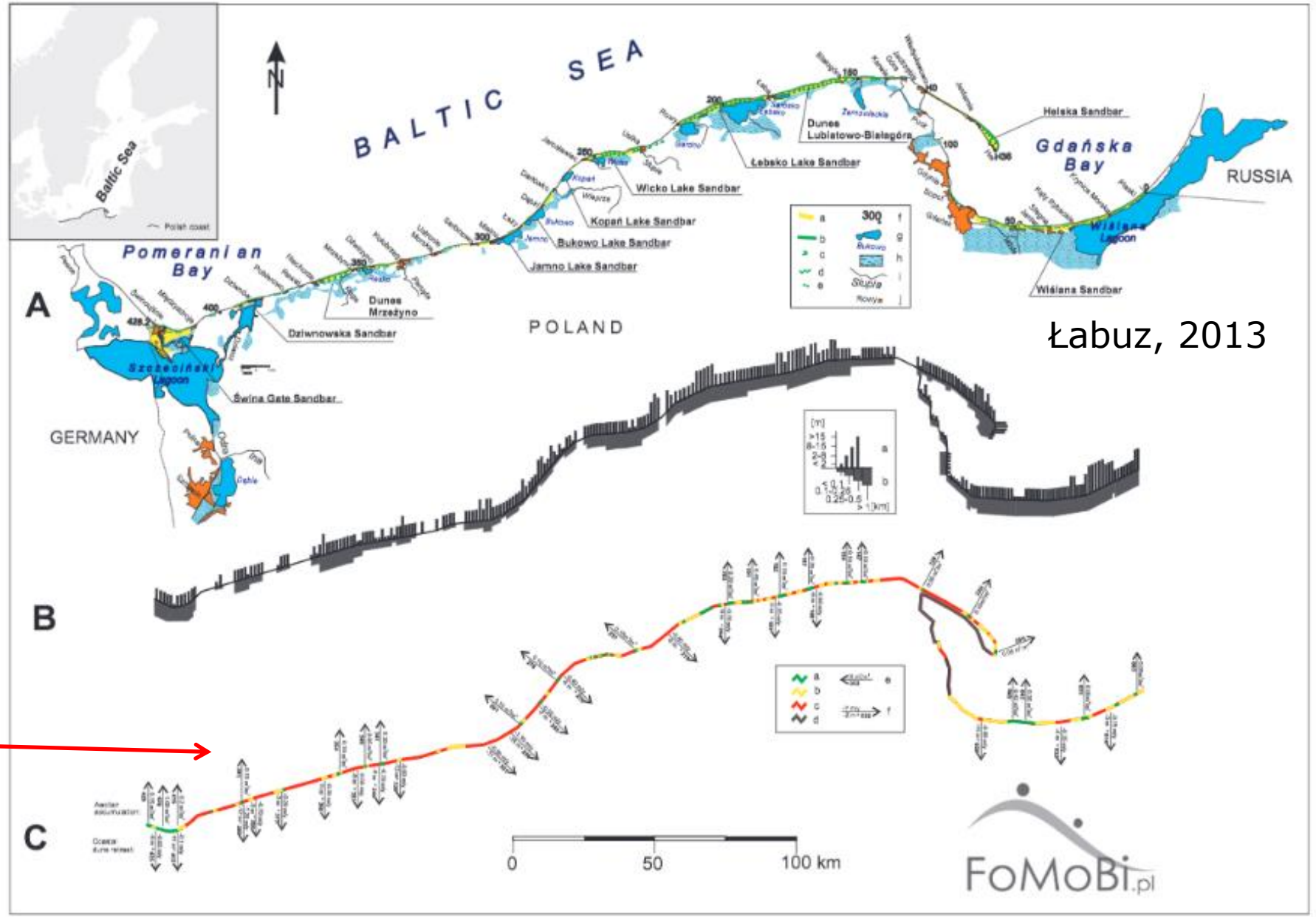
The (negative) impact of climate change driven sea level rise

- Largest in the south of the Baltic Sea
- Decreases towards NE
  - [Strong SW→NE gradient of the impact]
- Consequences reversed in the north of the sea

The largest impact of sea level rise: in Poland

- Sea level rise 2-3 mm/yr
- Accumulation areas: only 15% of shore
- Rapid erosion: 40% of the shore

The dynamics of the shores 2002-2012: predominantly red == erosion



Łabuz, 2013

Fig. 1. Polish Baltic Sea coast

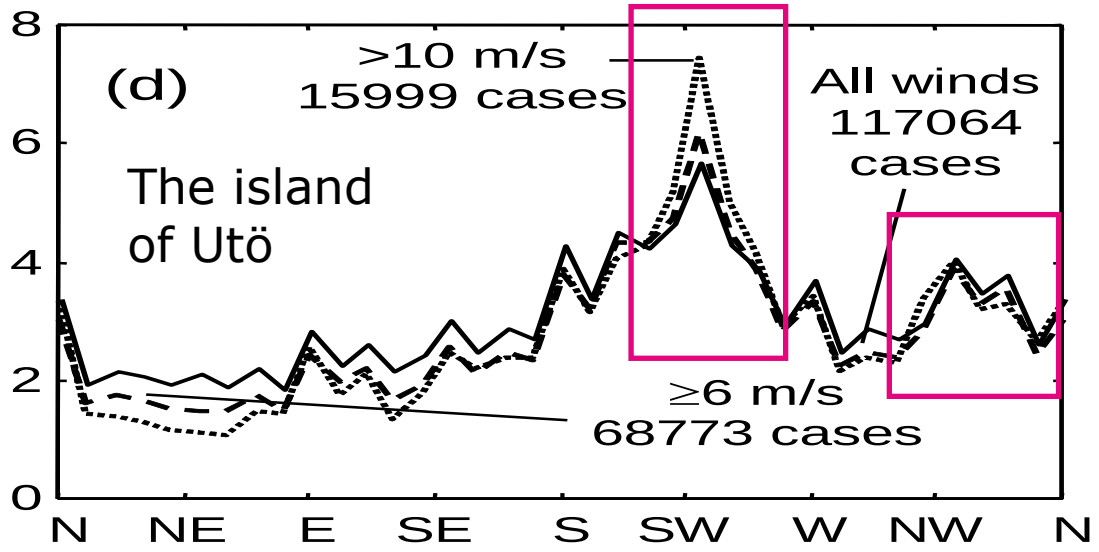
Driver 2

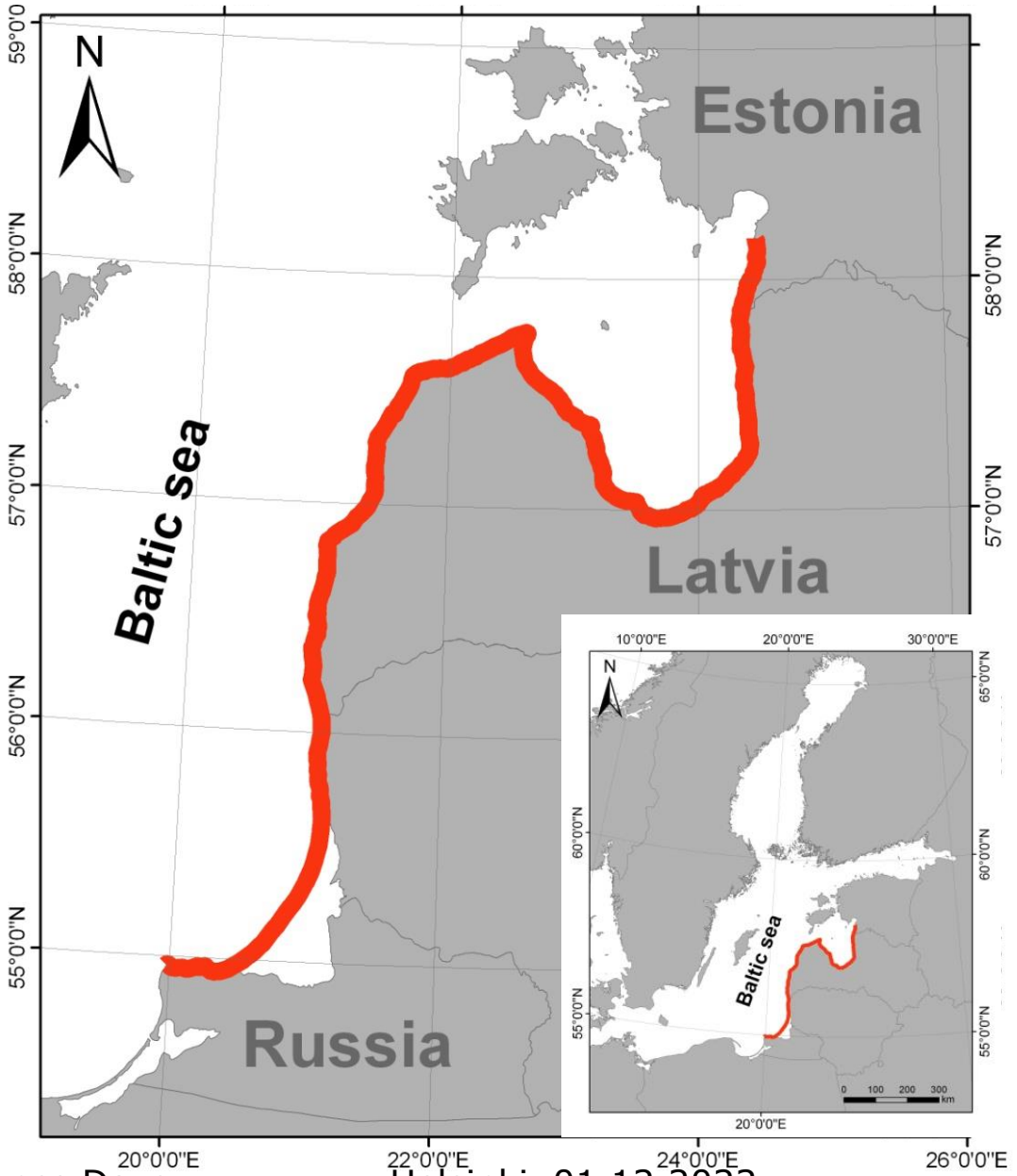
or the meaning of wave direction for the shores

(We know that wind speed and wave height have had no substantial changes)

A very long interconnected sedimentary system

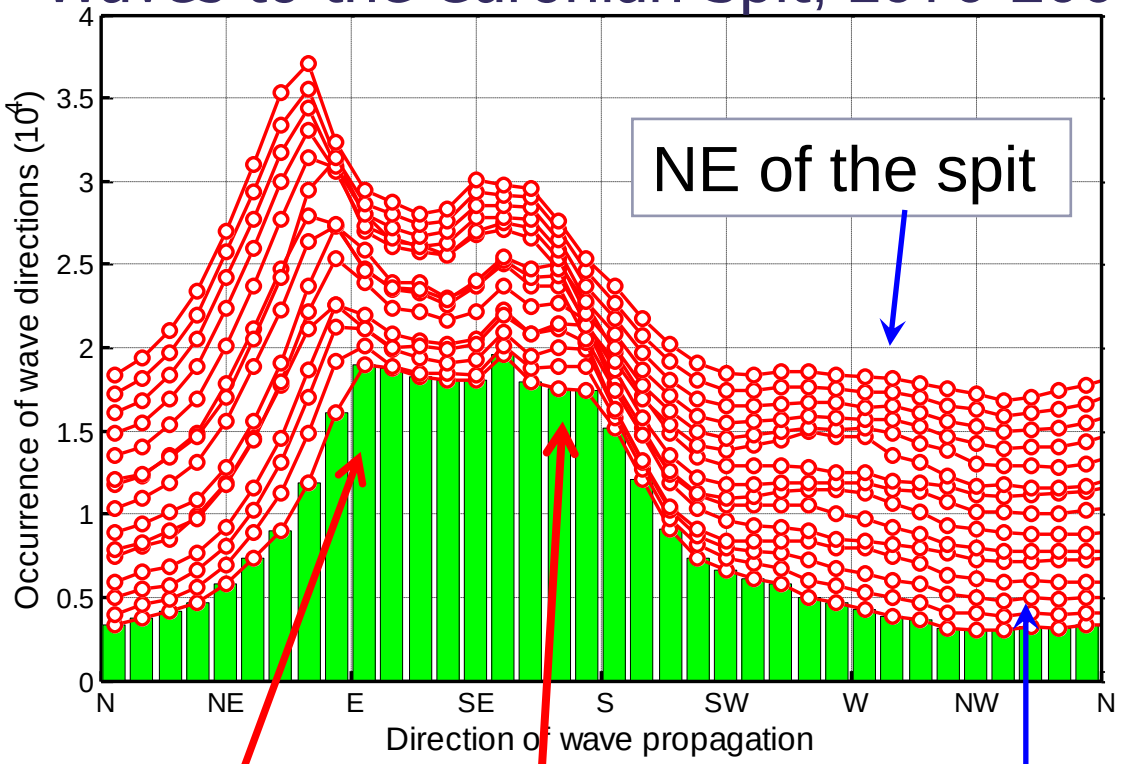
- ~700 km; Russia-Lithuania-Latvia-Estonia
- Mainly relatively soft and easily erodable sediment
- Generally sediment deficit
  - ~60% of the coasts highly vulnerable
- Classics: counter-clockwise transport
  - 2-peak wind structure (SW/W & NNW)

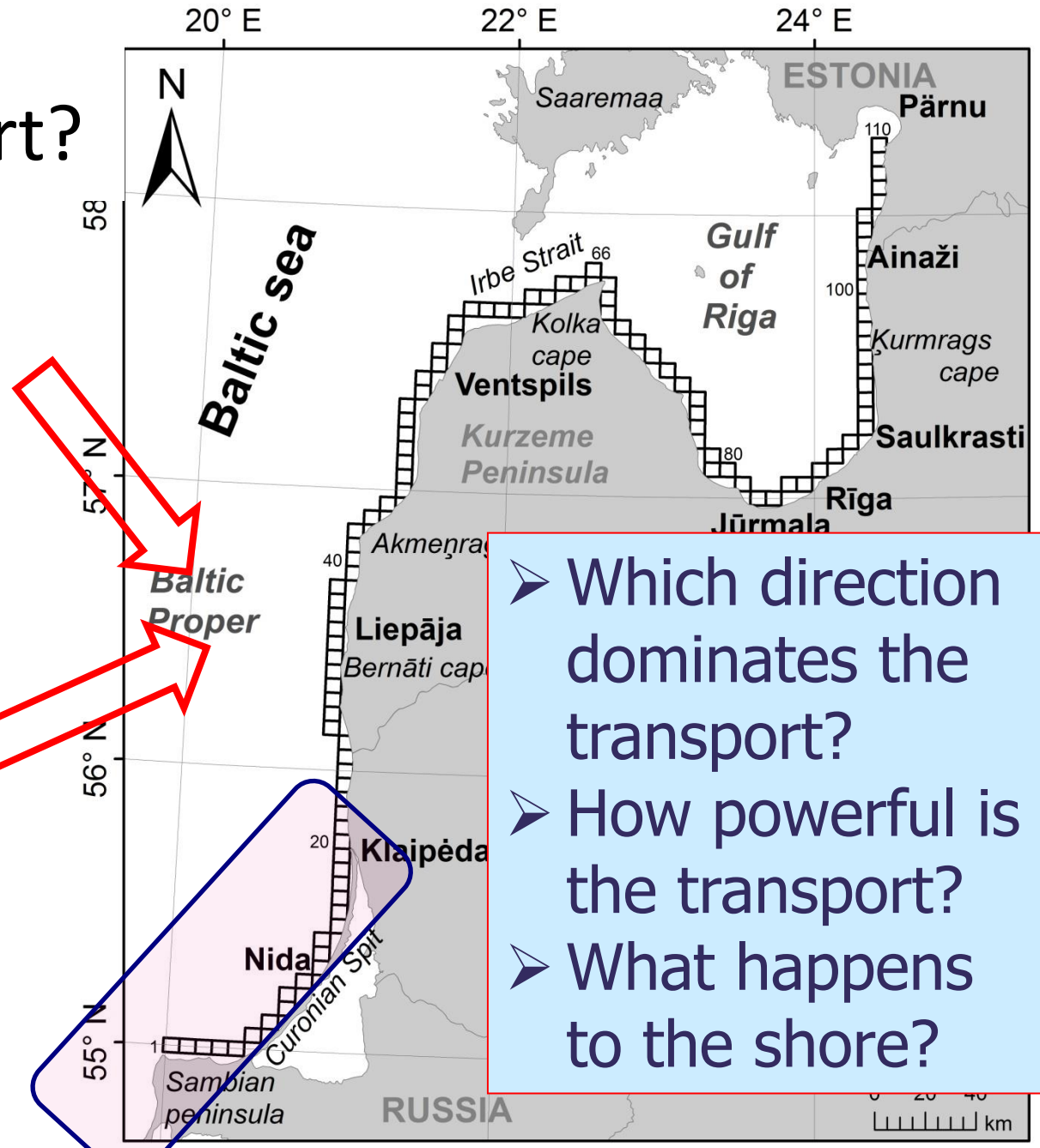




What does it mean in terms of wave-driven sediment transport?

Waves to the Curonian Spit, 1970-2007





- Which direction dominates the transport?
- How powerful is the transport?
- What happens to the shore?

750 000 m³/yr

1 000 000 m³/yr

The transport **IS** powerful

R.Knaps

500 -sanešu plūsmas jauda tūkst.m³ / g. (pēc R. Knapa)

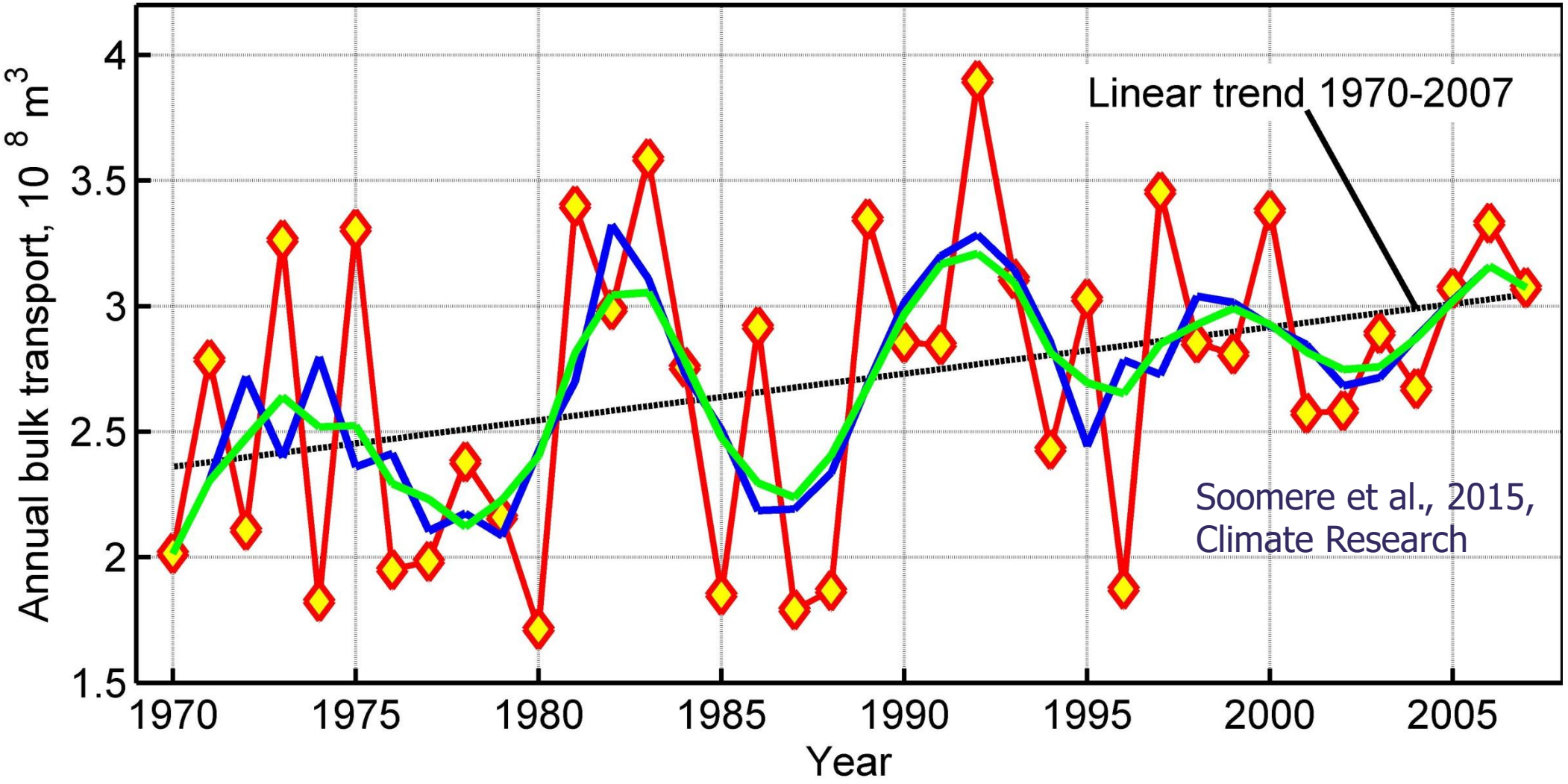
The capacity of longshore sand flow thousand cub. m per year (after R. Knaps)

>700 000 m³/yr

Simulations reflecting reality

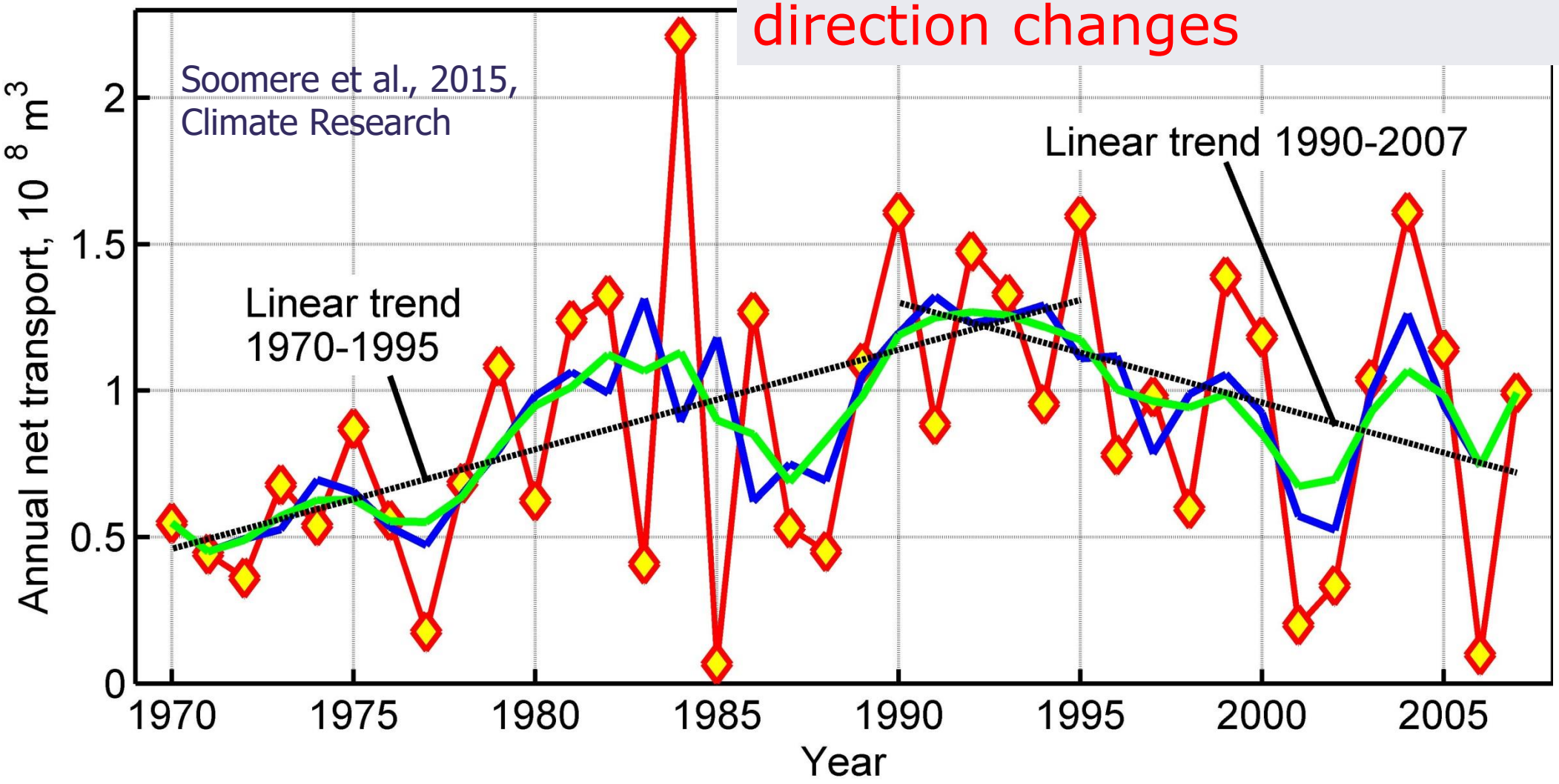
Viška, Soomere *Baltica*, 2013

Expected old result: bulk transport increases



Unexpected old result: net transport does not!

Only possible if wave approach direction changes



What happens in such conditions: Some shores are badly damaged - Gulf of Riga

Some others as well: Baltic Proper shore of Latvia

Jūrkalne, Latvia

Another conjecture

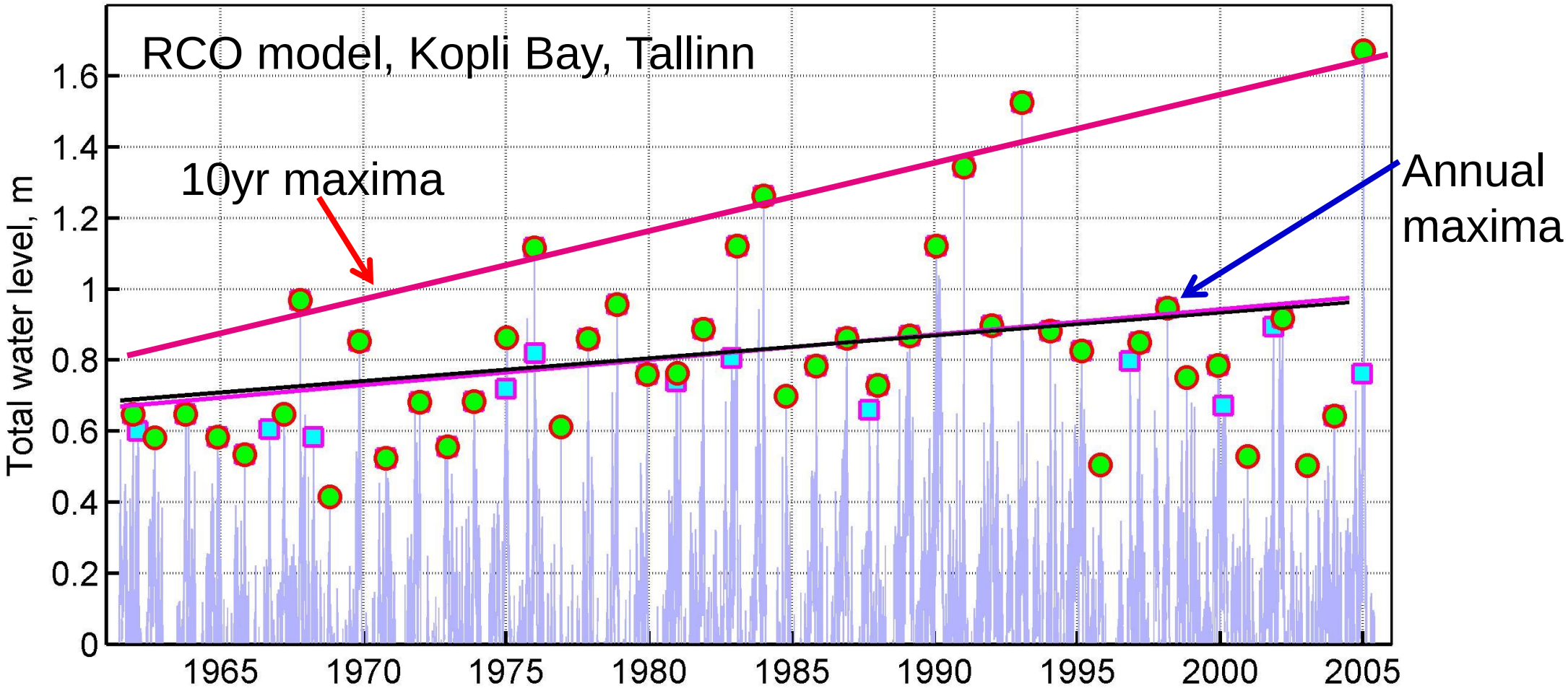
The (negative) impact of climate change driven systematic rotation of wave approach directions:

- Relatively small in the south of the Baltic Sea
  - Strong drift to the east anyway
- Large at the eastern shores of the Baltic proper
  - Variations in the share of SW/NW winds
- Smaller in the north of the sea
  - Bedrock shores or strong drift to the east anyway

Driver 3

or the potential impact of frequently occurring high water levels

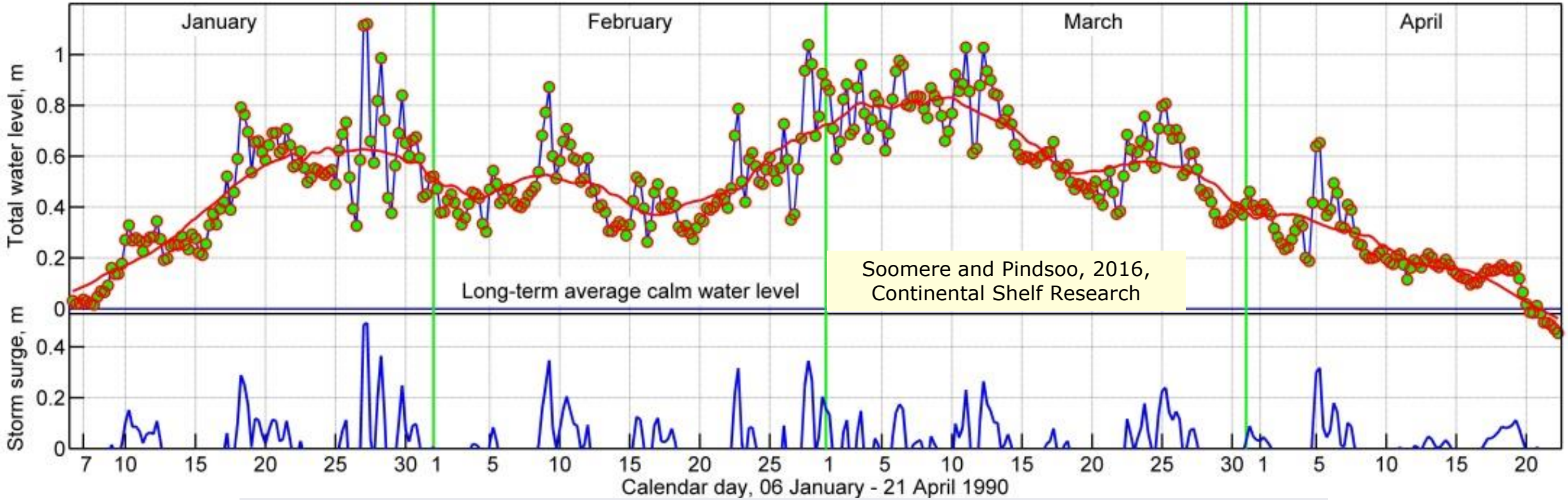
Rapid changes to the shore occur when strong waves arrive during high water level



The maxima increase rapidly
The process is definitely nonstationary

The problem: Water volume of the Baltic Sea varies

Water level at Tallinn, Kopli Bay

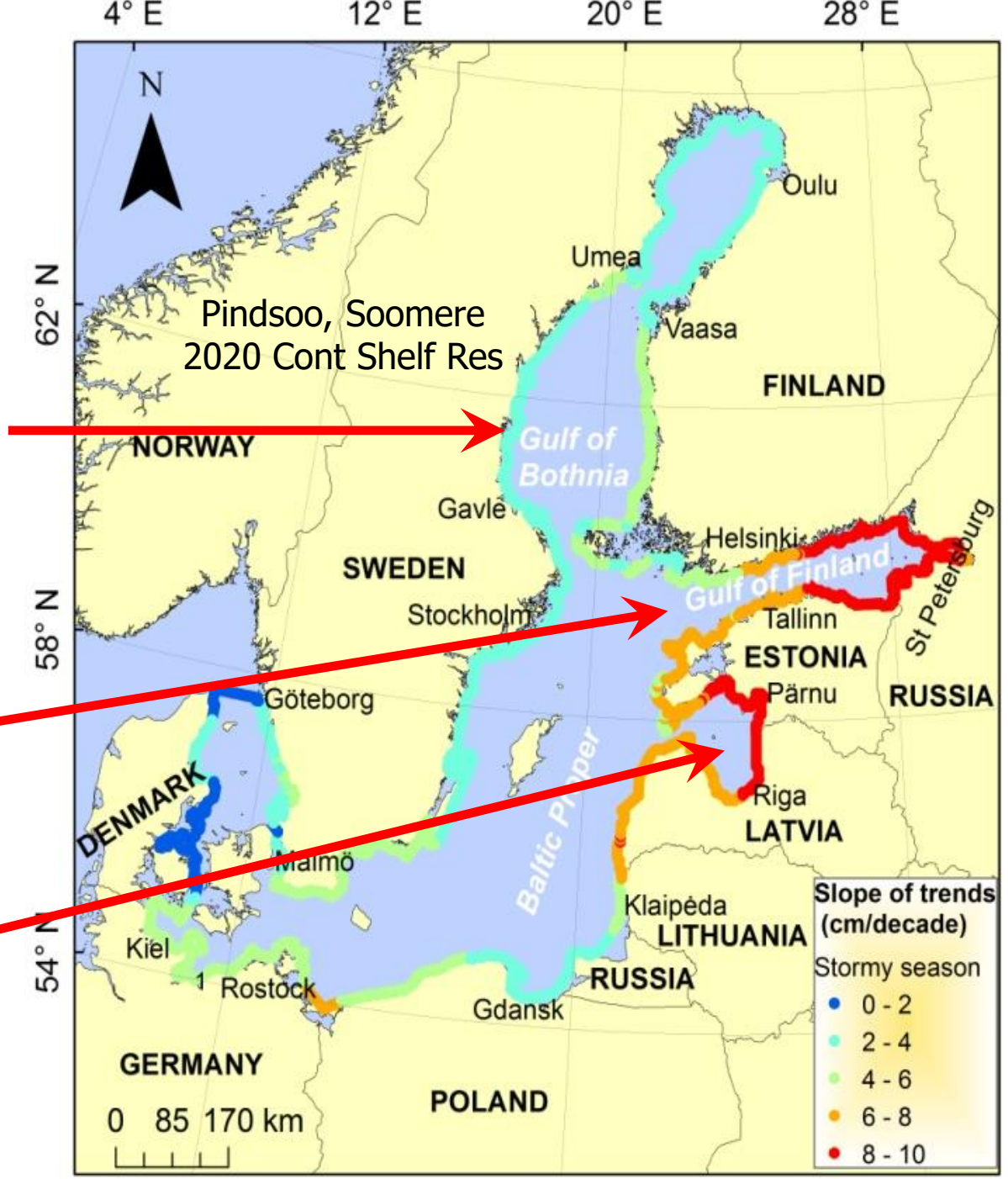


Specific feature of the Baltic Sea

- Increase in the water volume of the entire sea
  - High water level events over a few weeks, ~1 m

The maxima increase everywhere in the Baltic Sea

- About ~4 mm/yr in most of the sea
  - Reflects increase in the extreme filling of the sea
  - Longer sequences of storms in the area of Danish straits
- Up 9-10 mm/yr in the eastern Gulf of Finland
  - Reflects new strong wind directions
- Up 9-10 mm/yr in the Gulf of Riga
  - Reflects specific storms that press water into the Gulf of Riga (Männikus et al., 2019)
- The same process for frequently occurring high water levels



And another conjecture

The (negative) impact of climate change driven changes in elevated water levels

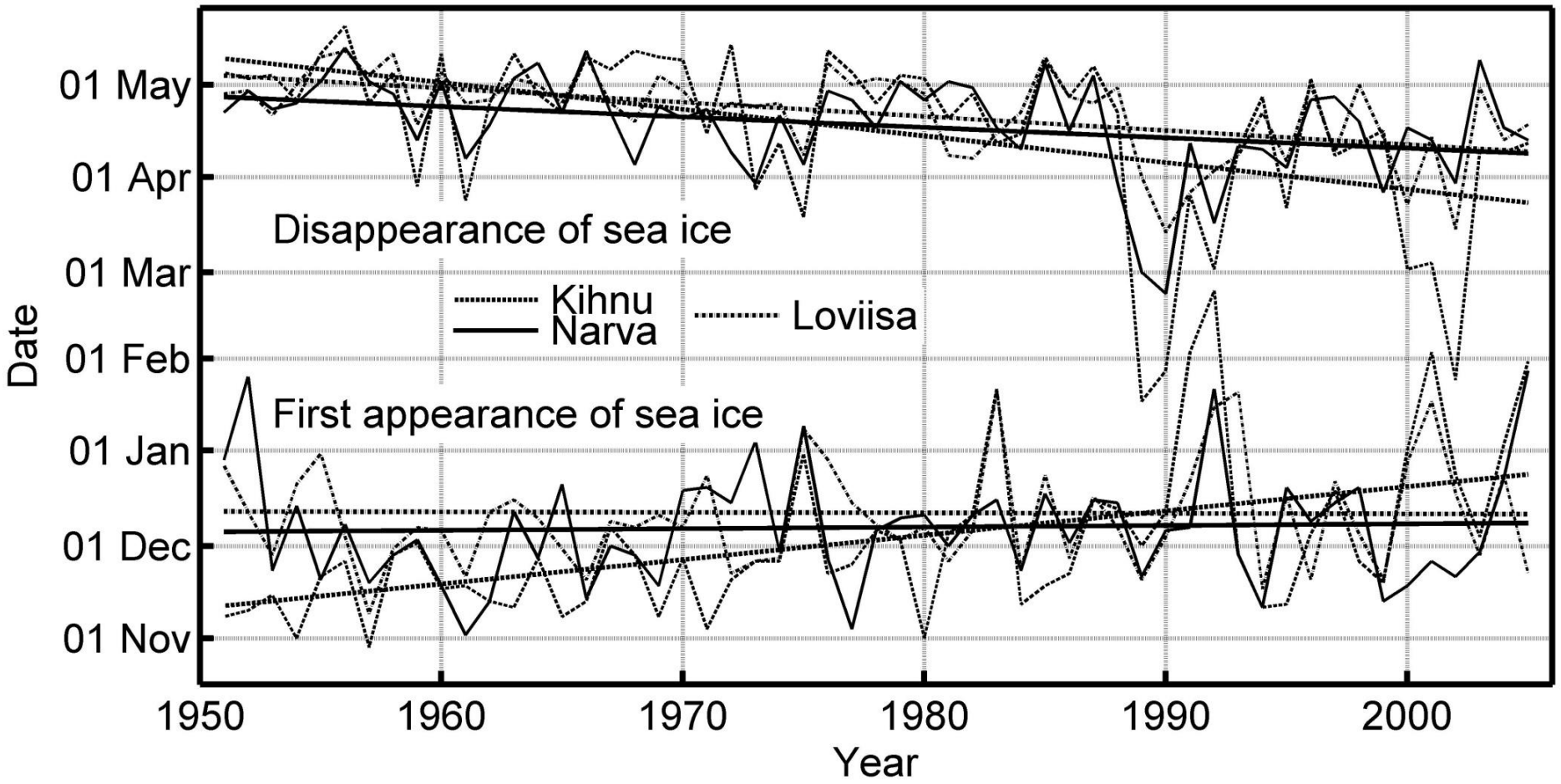
- Localised in the eastern bayheads: Gulf of Riga, Gulf of Finland
  - Larger than average: Latvian and Estonian shores of the Baltic proper
  - Commeasurable with the sea level rise in the rest of the sea

Driver 4

The presence or missing of sea ice

The concealed threat: less ice

Sooäär and Jaagus 2007



- The probability of freezing has decreased by 20% per 100yr
- Ice break-up has become earlier by 10 days/100 years (Utö) (Jevrejeva and Leppäranta)

Ice protects our shores

- Damps storm surges
- Damps waves
- Directly protects sediments

(Komarovo, Neva Bight, 29.11.2006 11.01.2007)

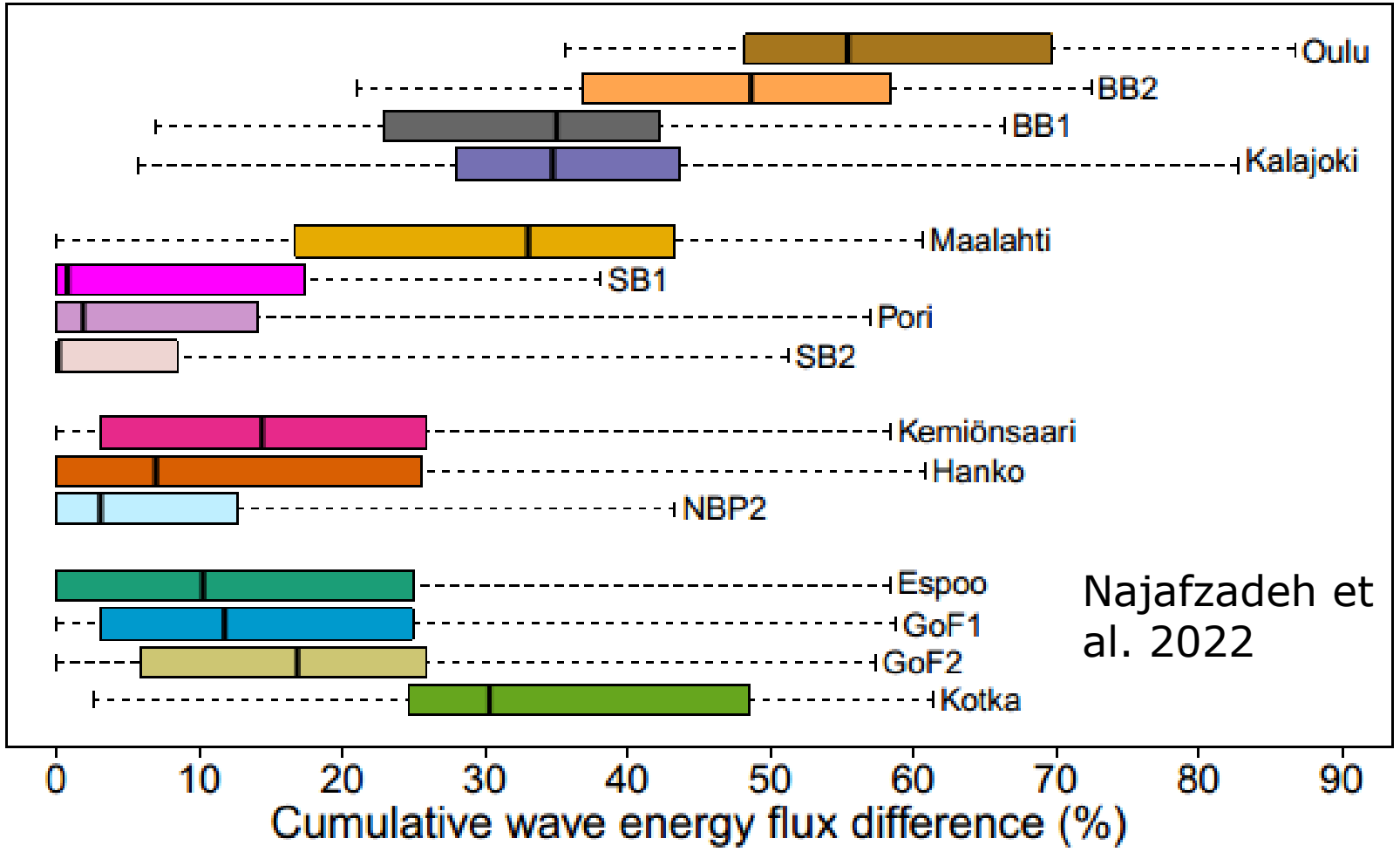
Ryabchuk *et al*. 2009, 2011

WAVE ENGINEERING

No ice in the future = increase of wave impact ~1,7 times

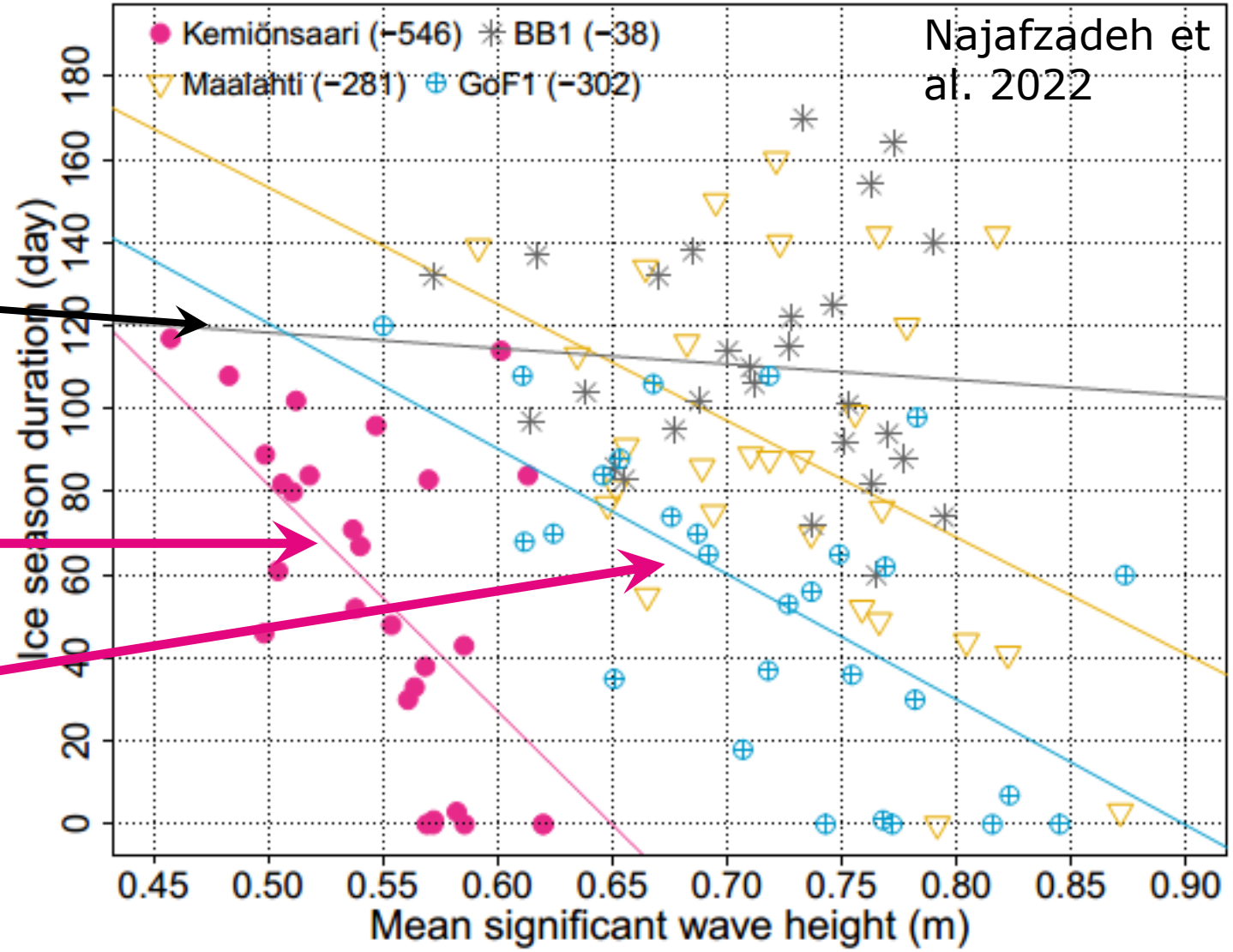
- The largest impact: Bay of Bothnia
- Lesser impact: Quark
- Within uncertainty : Sea of Bothnia, most of Baltic Proper, entrance to the Gulf of Finland
- Unexpectedly large: eastern Gulf of Finland

Comparison the current and ice-free climates



Decrease in ice cover: the strongest impact right now at the latitudes of the Gulf of Finland

- North of the sea / Sea of Bothnia: current decrease in ice cover has almost no impact on classic properties of wave climate (average Hs)
- Gulf of Finland: current decrease in ice → rapid increase in average Hs
- → ? today ice cover exists mostly during windy time



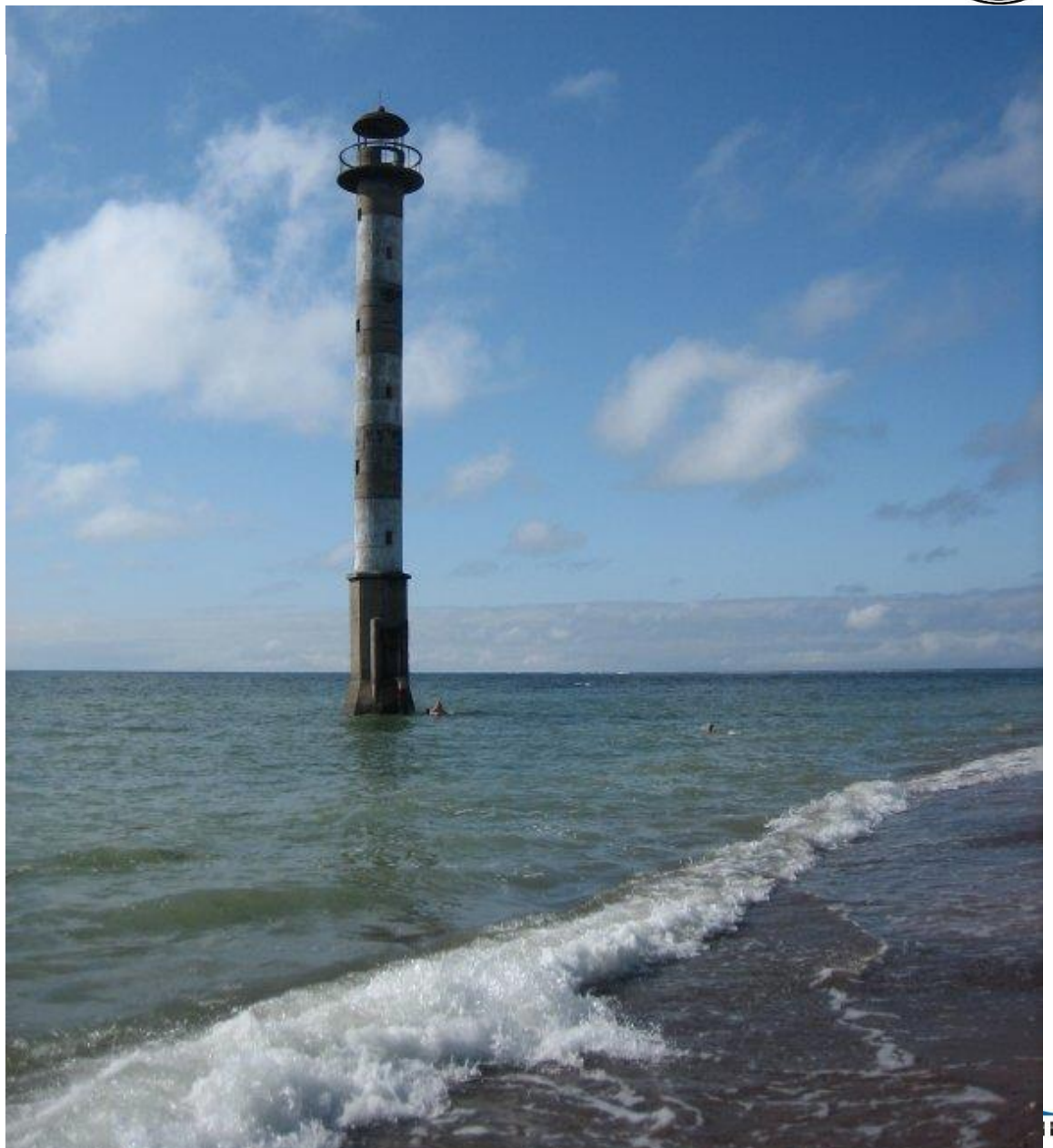
The joint impact of waves and lack of ice

(Orviku et al., 2003)

2009

Rapid retreat of several eastern Baltic Sea coasts since the 1990s

Kiipsaare lighthouse, Estonia, 2004



Estonian beaches are not immune

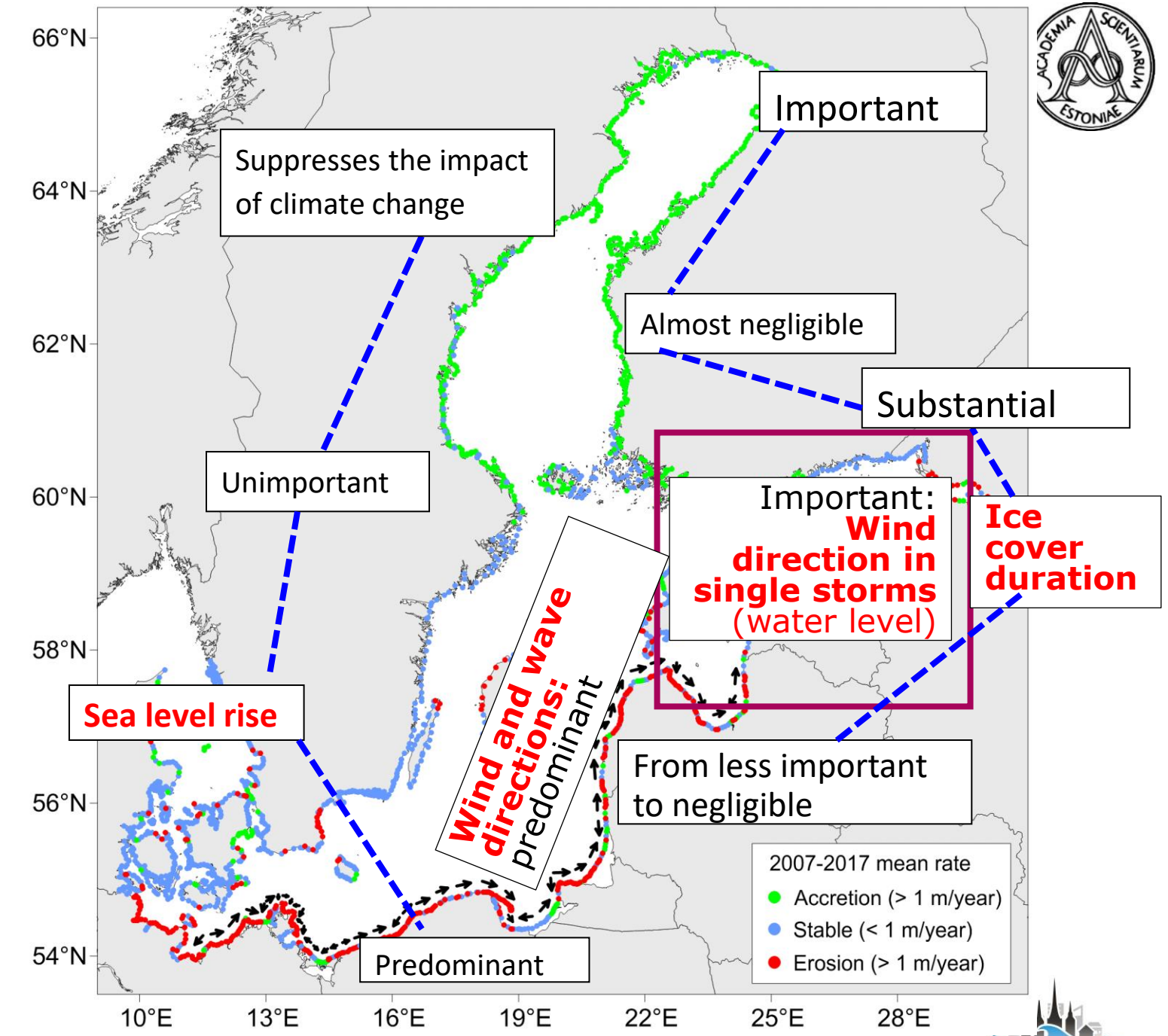
1970s

Photo: K.Orviku

WAVE ENGINEERING

Spatial variation of the four drivers

The idea of the concept: Maris Eelsalu



Spatial variations of climate change

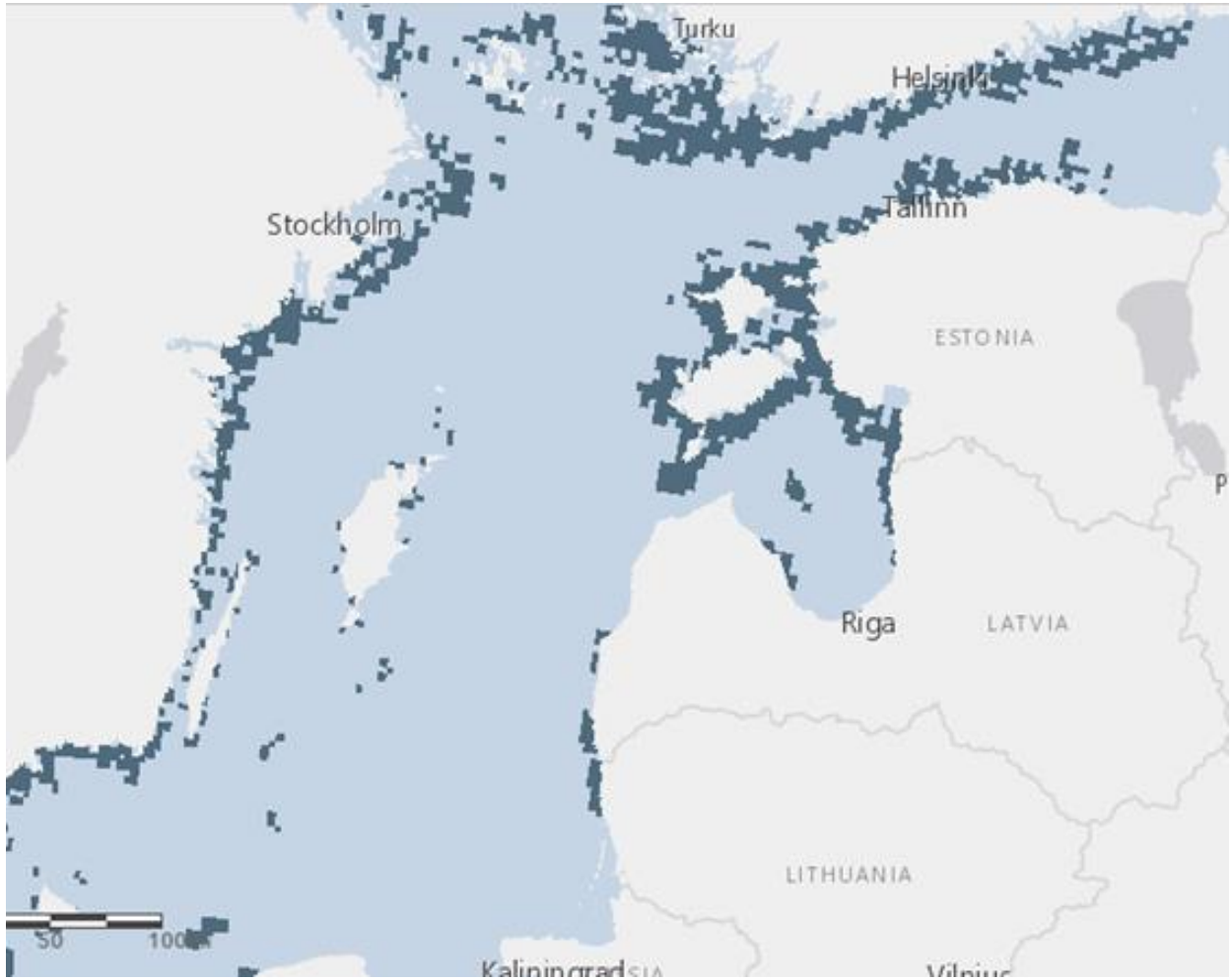
Implications radically different in different parts of the Baltic Sea

- Sea level rise
  - Predominant in the south (Polish shores)
- Changes in wind and wave directions
  - Predominant at middle latitudes of the eastern Baltic Sea
- Wind direction in strong storms (elevated water level)
  - Very strong in the eastern basins (GoF, GoR)
- Ice cover duration
  - Implications have a complicated spatial pattern

Thank you for your attention

SOME ASPECTS OF EXTRACTION AND APPLICATION OF SEAWEED FURCELLARIA LUMBRICALIS CARRAGEENAN IN THE PRODUCTION OF RECYCLED PAPER

Sintija Ozolina, Uldis Zaimis
Faculty of Science and Engineering
Institute of Science and Innovative Technologies
Liepaja University, Latvia



Fixed distribution of Furcellaria Lumbricalis in the Baltic Sea (dark blue) (HELCOM metadata information, https://metadata.helcom.fi/ 2022.)

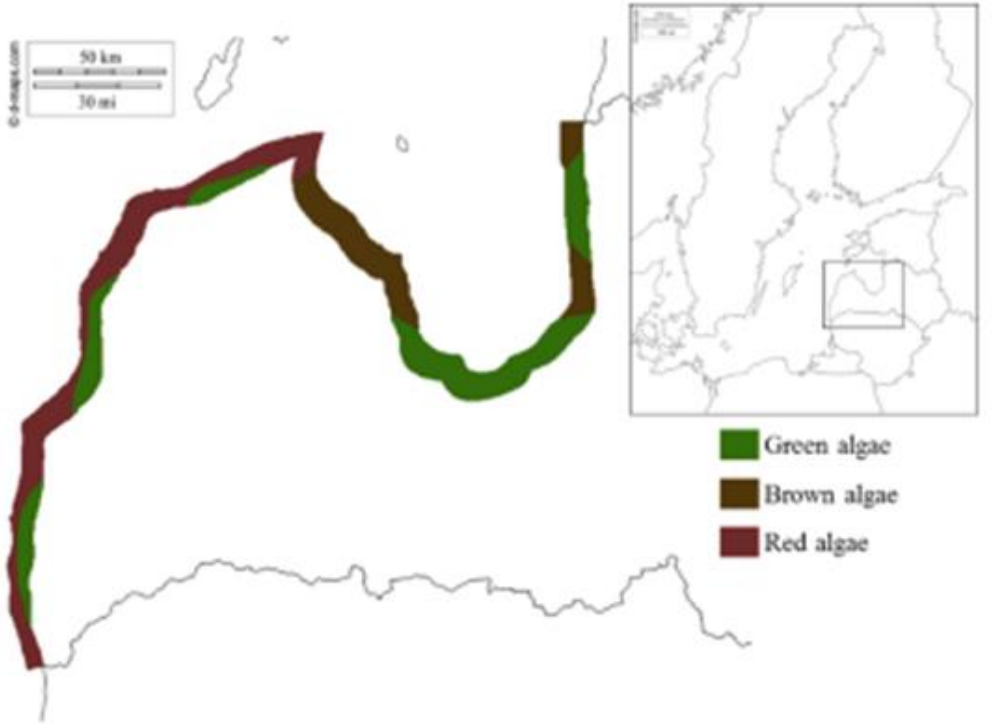


Fig. 3.2. Seaweed species distribution on the coastline of Latvia.

(Bāliņa 2020)
BALTIC SEAWEED BIOREFINERY

**Red macroalgae Furcellaria lumbricalis*

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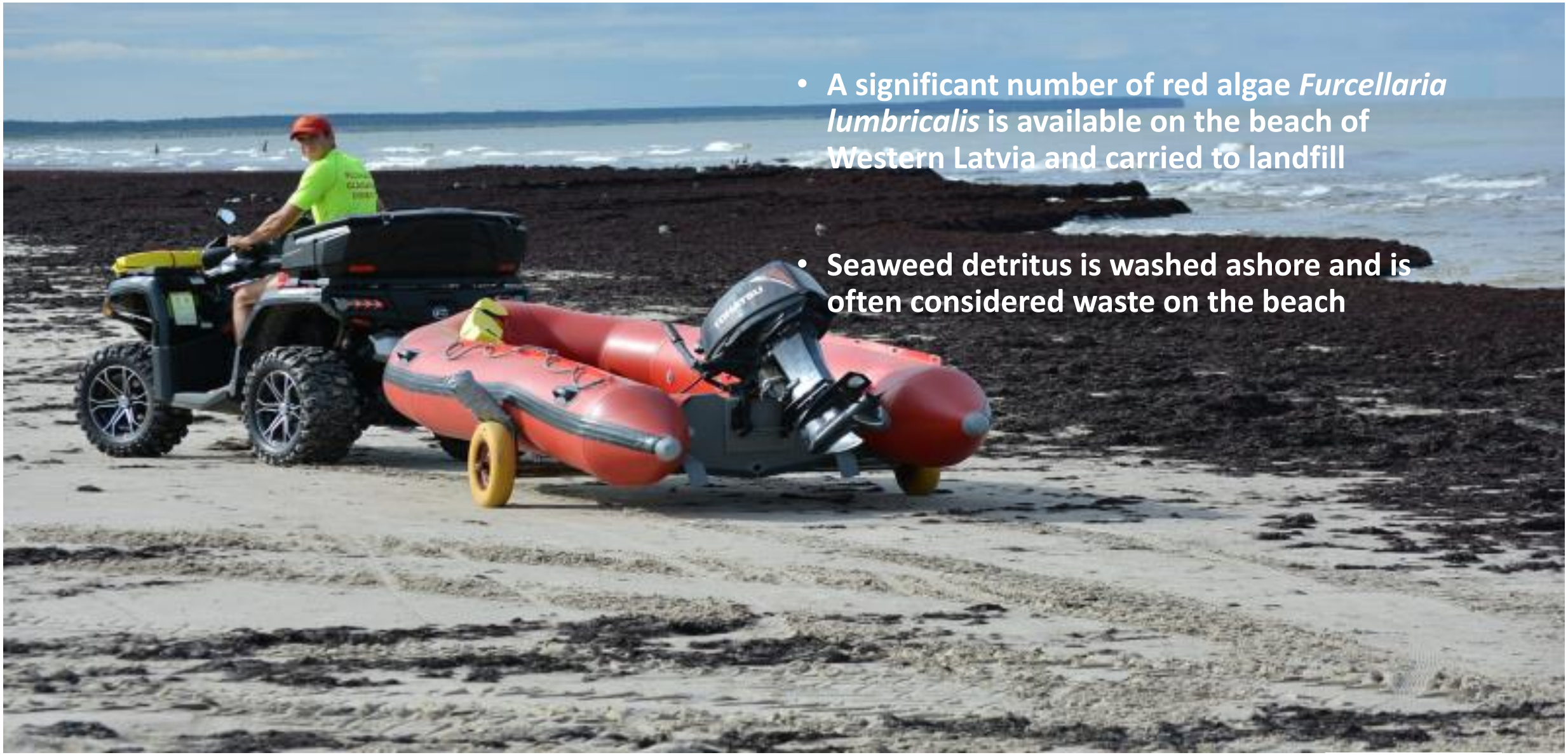

- A significant number of red algae *Furcellaria lumbricalis* is available on the beach of Western Latvia and carried to landfill
- Seaweed detritus is washed ashore and is often considered waste on the beach

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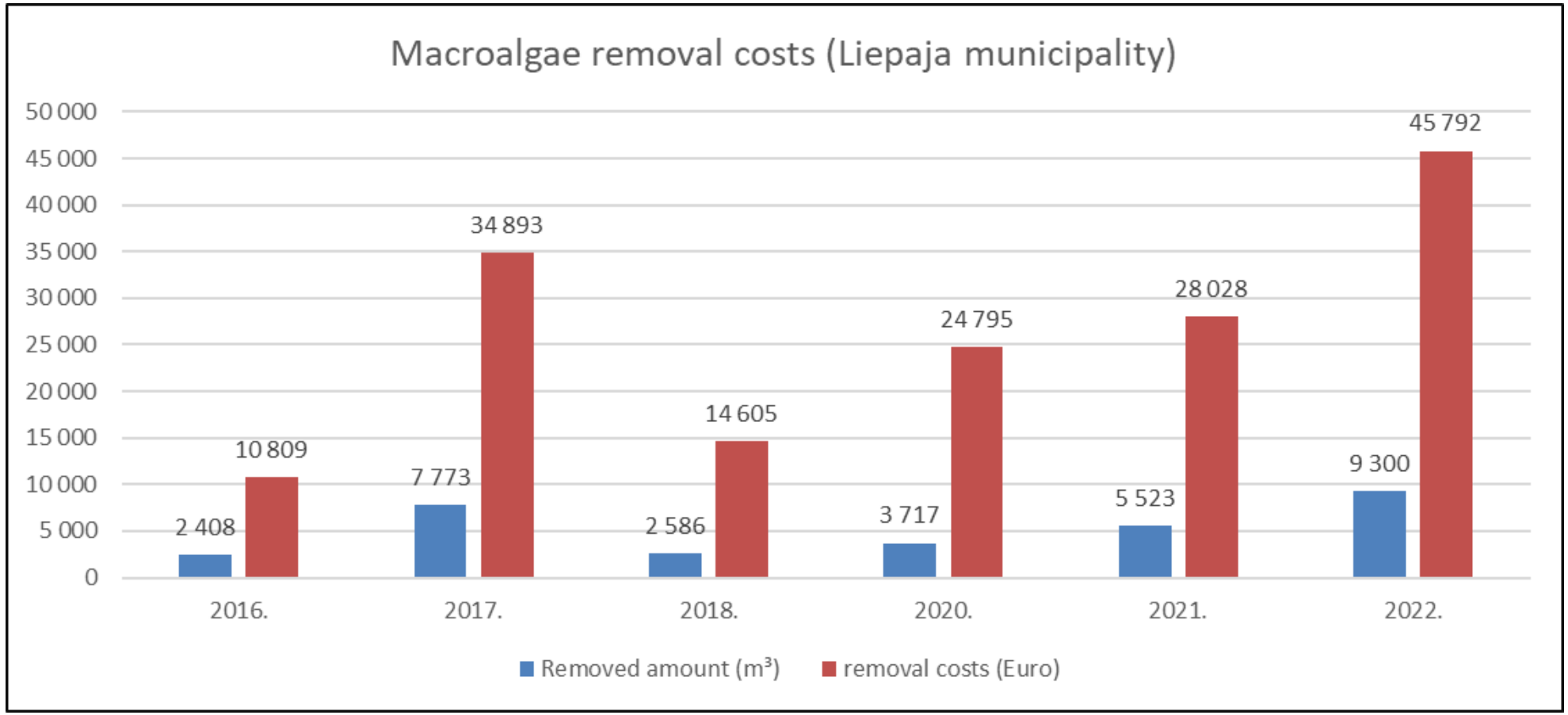
- The local municipal administration recognizes it as a disturbance (according to rough estimates, 9300 m3 of algae waste material has been transported from the Liepāja beach per year (according to 2022 data) and **removal costs 45792 euros**

- **This dead macroalgae biomass could be interpreted not as an unwanted material but as a resource**



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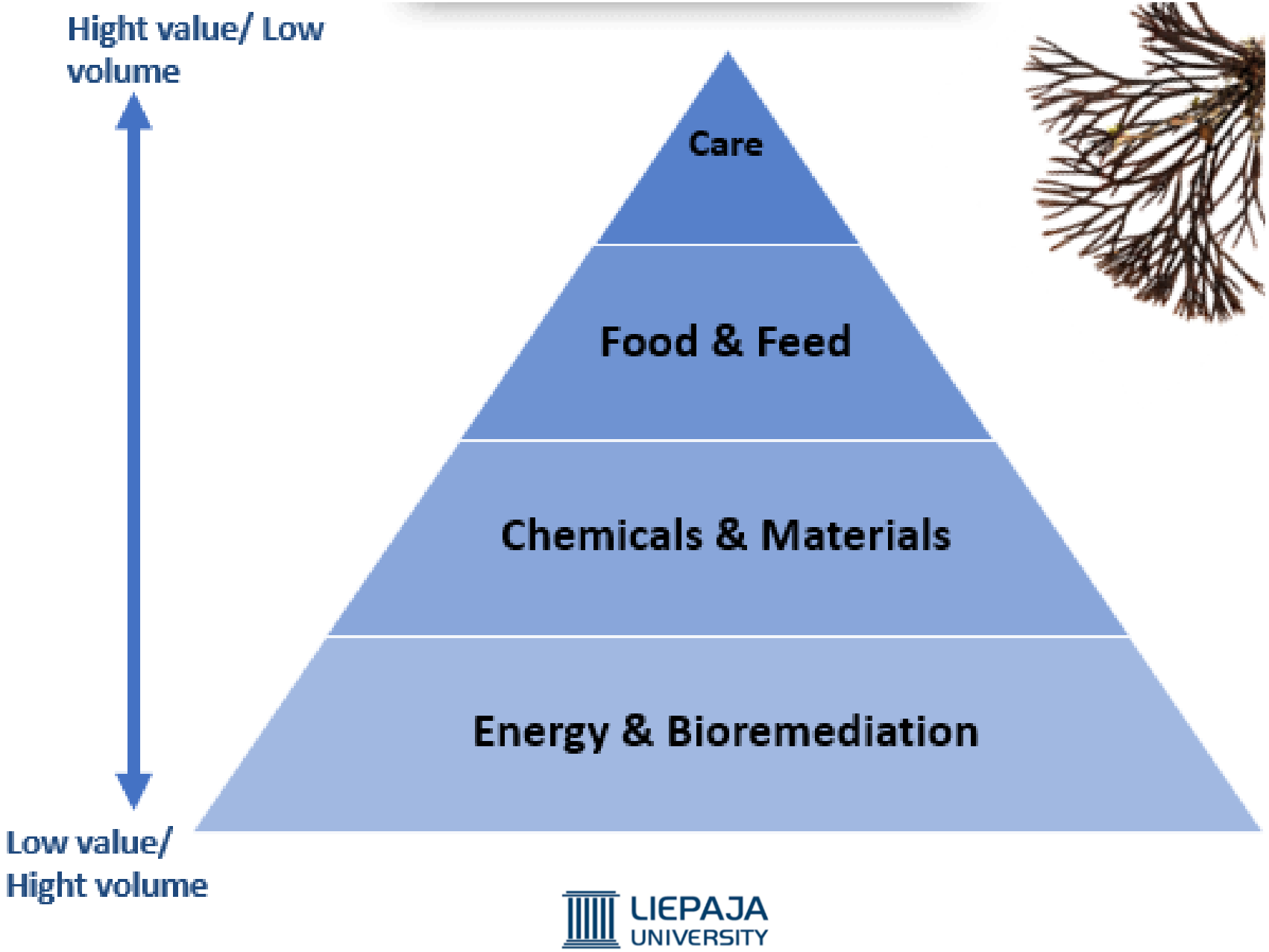
[PROF]

'22 11 02

Since the beginning of the year, 103 people have had their permits to enter the beach for sea manure removed.

Last year, 126 permits were issued throughout the year.



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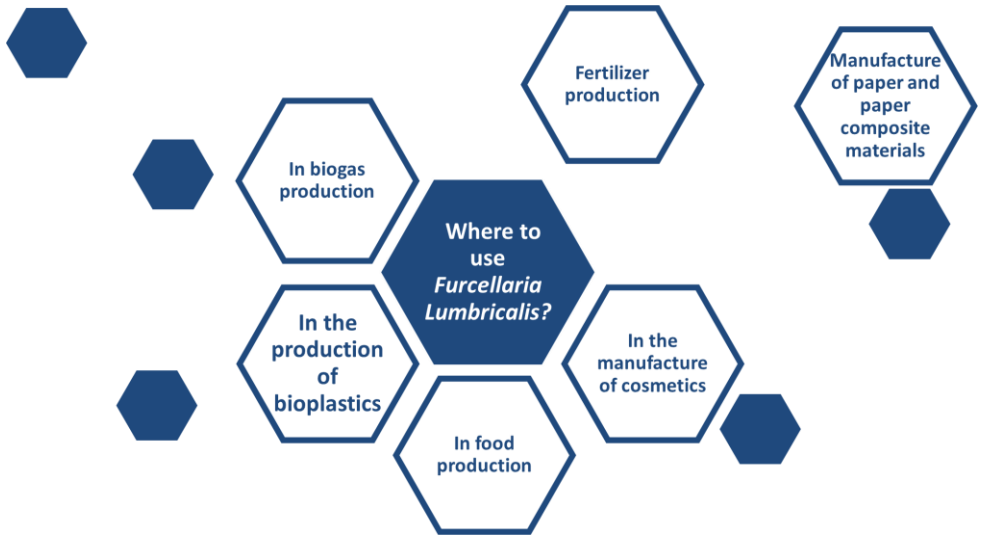

Loading of macroalgae into a biogas facility in Trelleborg, Sweden. → Retrieved from (www.trelleborg.se) February 2022.

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Est-Agar AS is the only producer of the unique texturant – furcellaran from the red seaweed *Furcellaria lumbricalis* in the world.

Est-Agar AS main business areas are:

– Production and sale of gelling agent furcellaran

– Trawling, gathering, buying up, processing and sale of red seaweed *Furcellaria lumbricalis*.

In the photo, a member of the board of Est Agar AS in the furcellaria biomass warehouse in Urmas Pau. Author Ivar Soopan →

Orkla

ANNO 1806 KALEV

*During the year, Est-Agar processes approximately 1000-4000 tons of wet weight algae mass. (11.06.2020)

Prezidents Rucavas un Nidas zvejniekciemos

Pa tālruni no mūsu līdzstrādnieka Liepājā

Pēc svinībām Liepājā valsts prezidents Dr. K. Ulmanis vakar pl. 5 p. p. ar pavadoņiem — kara ministru ģen. J. Balodi, iekšlietu ministru V. Gulbi, zemkopības ministru J. Birznieku un izglītības ministru prof. A. Tenteli izbrauca uz Nīcu un Rucavu, jo vēlējās iepazīties ar to ļaužu dzīvi, kas dzīvo un strādā smilšainajā un nabadzīgajā jūrmalas rajonā. Prezidentam vēl līdzi brauca armijas štāba priekšnieks ģen. Hartmanis, valsts kancelejas direktors D. Rudzītis, Liepājas garnizona priekšnieks ģen. Dankers, Liepājas apriņķa vecākais E. Līcis, Liepājas pilsētas galva E. Rimbenieks, Liepājas prefekts F. Šāberts un citi. Automašīnas braucienā devās gar jūrmalu līdz Klampju ciemam un Jūrmalciemam, tālāk uz Rucavu, Nidu un Bārtu. Klampju ciemā Prezidents iepazinās ar jūras mēslu uztvērēja — mola būvi. Šeit vietējie zvejnieki sumināja Prezidentu un pateicās par valdības gādību zvejnieku dzīves un darba uzbūvē. Zvejnieces Prezidentam un zemkopības ministram aplika

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- Magazine article from 1937.

- **In the territory of Latvia, in 1965, agar began to be produced in the "Nākotne" collective farm of the Dobele district. Furcellaria was delivered from various farms, technical equipment for the farms was provided by the collective, and already in 1966 furcellaria was collected and dried in large quantities. A workshop and auxiliary premises for the production of agar were built in the collective farm, where 200 tons of agar was produced annually** (Rudovica, 2021)

- Soap from furcellaria algae extract in olive oil and furcellaria hydrolat "Sārtaļģe". Made by Vaira Kārkliņa. Photo: V. Kārkliņa, obtained from: https://www.kurzemesregions.lv/ (KPR, 2020)

RESEARCH AIM

Investigate whether carrageenan derived from the seaweed *Furcellaria lumbricalis* can be used as a binding agent in paper composite- material production

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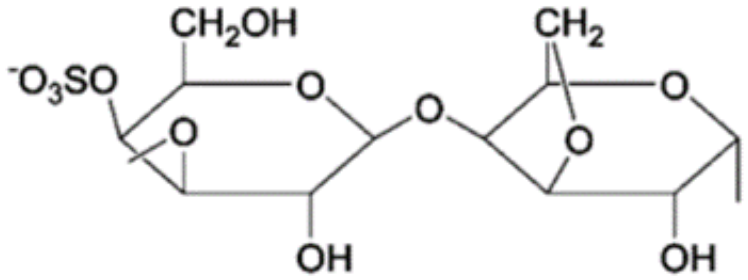
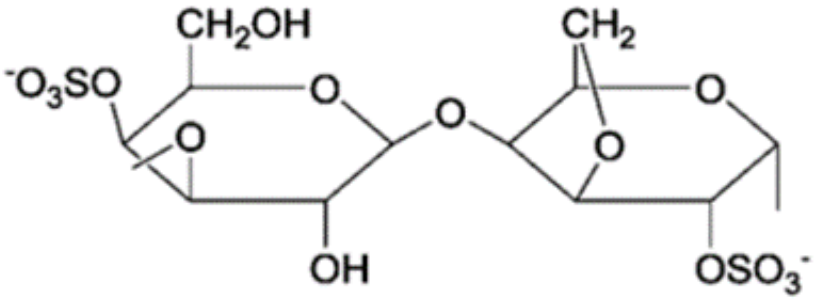
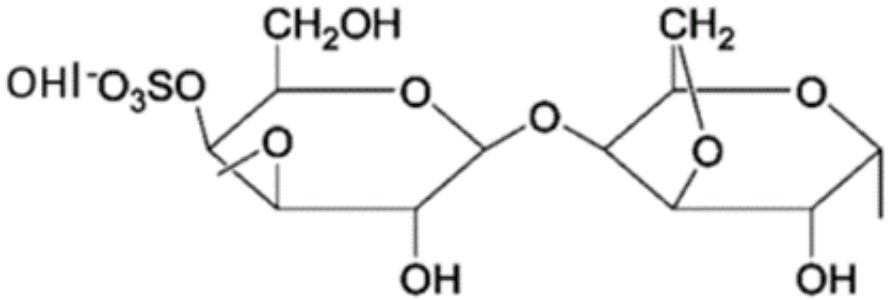


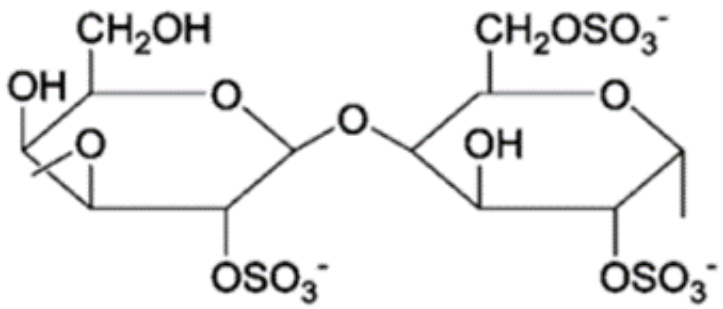
kappa carrageenan



iota carrageenan



furcellaran



lambda carrageenan

Chemical structures of the main carrageenans (Eha, 2021)

***Furcellaran is a combination of kappa and lambda carrageenan**

- Kappa carrageenan forms strong, firm gels
- iota carrageenan forms soft gels
- lambda does not gel and is more used to thicken dairy products

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MATERIALS AND METHODS

- **The preparation of paper pulp takes place in the paper recycling laboratory of Liepaja University**
- **Red seaweed *Furcellaria lumbricalis* detritus is harvested from the coastal area of Liepaja municipality's public beach**
- **Extraction of carrageenan of red algae, for further use as binding material, takes place in Liepaja University environmental chemistry laboratory**
- **In the current experiment, carrageenan is used as a binder in the production of seaweed paper composites immediately after extraction**

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Fresh or dried algae

Boiling

Form creation, drying process

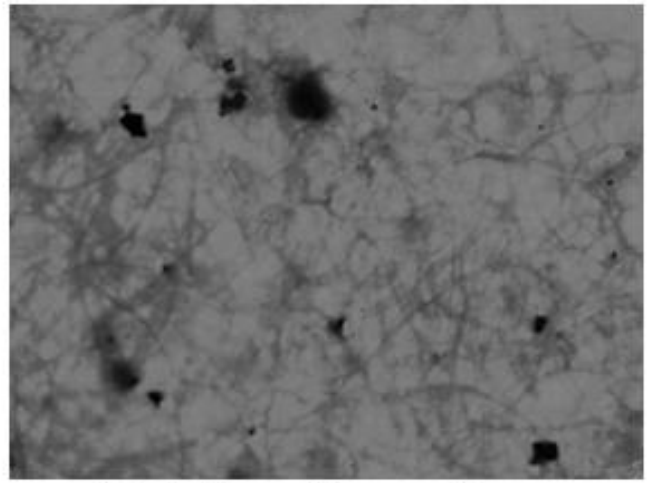
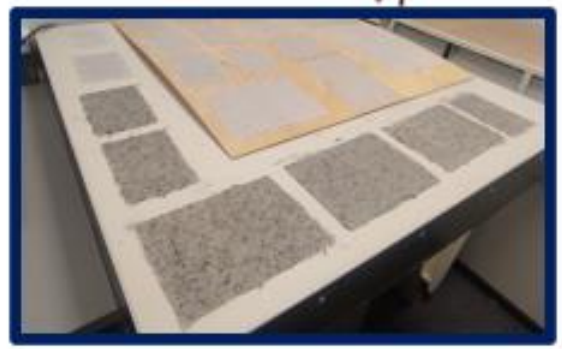


Fig. 1. Composite seaweed-paper
OM image by 720 nm, unedited, grayscale

Used office paper, paper pulp, then shredded

Extracted carrageenan



Red algae Furcellaria Lumbricalis

paper composite material with different variations of algae additives

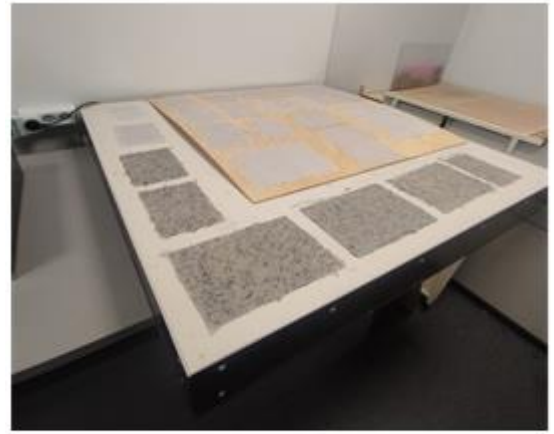


Fig. 2. Composite seaweed-paper in drying process

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PERFORMED TEST

Strength tests were performed with 4 different paper types:

- **regular office paper**
- **recycled paper without any binding agent added**
- **recycled paper with added carrageenan**
- **recycled paper with added polyvinyl acetate binding agent**

-Each paper type was tested 10 times

-Strip dimensions 100 mm x 10mm

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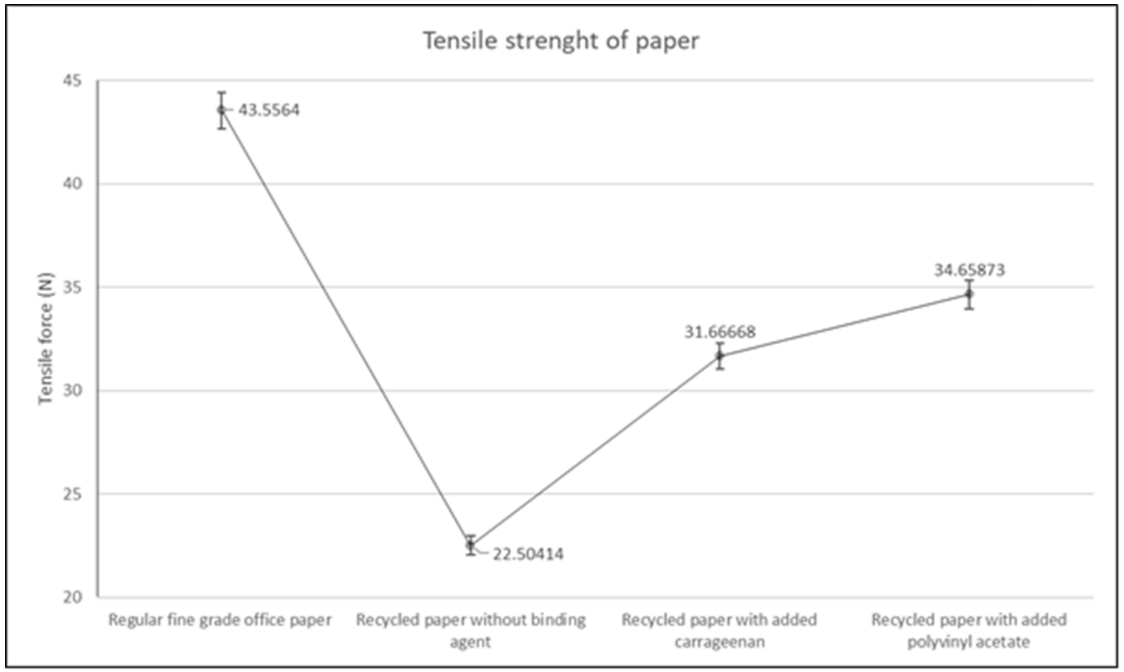
RESULTS

- **Paper with algae binder is 9% less resistant than recycled paper with added PVA glue, but 40% stronger than recycled paper without any added binders.**
- **Regular fine grade office paper was tested for comparison for industrial manufactured paper.**
- **The results show that the carrageenan binder can be used in the production of paper to replace chemical inorganic compounds.**

Strength test results

Test attempts	Weight capacity in grams, accuracy ±2 %			
	Regular fine grade office paper	Recycled paper without binding agent	Recycled paper with added carrageenan	Recycled paper with added polyvinyl acetate
1.	3888	2360	2370	2709
2.	4760	2310	2365	3850
3.	4191	2663	3575	3156
4.	4189	2362	3180	4123
5.	3981	2160	3478	3258
6.	3765	2263	3231	3201
7.	4182	2257	3232	3203
8.	3872	2260	3759	3200
9.	5644	2214	3553	5284
10.	5928	2087	3540	3348
Average values	**4440**	**2294**	**3228**	**3533**



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- **Carrageenan from red algae *Furcellaria lumbricalis* can be used as a binder for paper recycling (for later use in seedling pots manufacturing)**

- **Method adapted for seaweed treatment is appropriate for low-input paper composite manufacturing**
- **Biomass leached from the Baltic seashore can be a resource rather than bio-waste**
- **The use of seaweed can reduce management costs for local authorities, which must deal with the collection and transport of biomass to landfills**

Why replace polyvinyl acetate for better natural binding agent from our local resources?

Plant seedling pots with red macroalgae additive

- Breaks down well in the soil (6-7 weeks)
- Plant roots easily grow through the pot
- Under the influence of soil moisture, the roots grow through the walls of the pot, but by the end of the season there is nothing left of the pot
- The root system is not «injured» and all root tips continue to supply the plant with water and nutrients without interruption and stress
- Furcellaria lumbricalis acts as fertilizer

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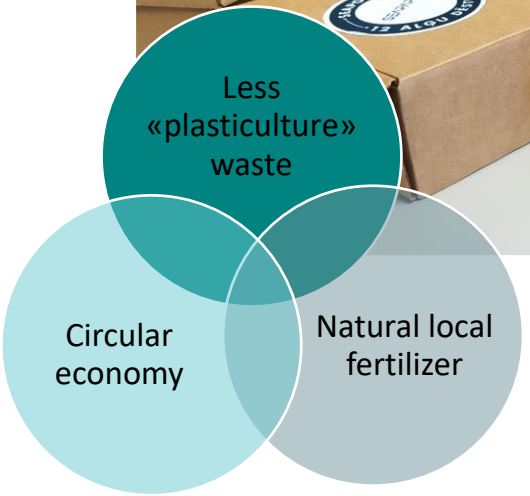
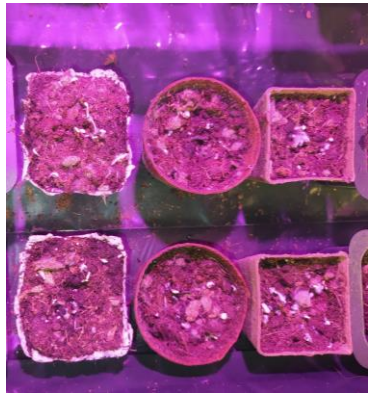
Ķīmiskie savienojumi Baltijas jūras makroaļģēs

	Zaļaļģe (*Ulva intestinalis*)	**Brūnaļģe (*Fucus vesiculosus)***	**Sārtaļģe (*Furcellaria lumbricalis*)**
Minerāli mg/100 g	(Benjama, 2011; Biancarosa, 2018)	(Rupérez, 2002; Mæhre, 2014; Truus 2004; Biancarosa, 2018)	(Biancarosa, 2018)
Magnijs (Magnesium)	11	6.7	8.9
Kālijs (Pottasium)	12	25	42
Kalcijs (Calcium)	29	30	3.7
Nātrijs (Sodium)	8.5	18	10
Fosfors (Phosphorus)	1.7	1	1.2
Varš (Copper)	5.7	3.7	6.2
Dzelzs (Ferrum)	580	290	130
Jods (Iodine)	130	260	84
Mangāns (Manganese)	180	37	7.5
Selēns (Selenium)	0.76	0.08	0.1
Cinks (Zinc)	21	28	23
Lipīdi % sausnā	1.6 (Haroon, 2000)	3.95 (Peinado, 2014)	1(Cherry, 2019)
Ogļhidrāti % sausnā (Carbohydrates DW)	31-92(Haroon, 2000)	65.7(Rioux, 2007)	55.4(Stiger-Pouvreau, 2016)
Celuloze	-	-	3.4-5.7 Variē atkarībā no ievākšanas laika, vietas (Bird, 1991)
Furcelarāns	-	-	40-50 (Šimkovic, 2021)

An eco-technological approach to simple things

- **About 500 million plastic plant pots and seed trays are produced every year, in various sizes and shapes. Most are either buried in a landfill or burned (Tomadoni, 2020).**





On average in Latvia - 100 small gardens per 10,000 inhabitants - around 200,000 small gardens
Population and Economics 3(1): 107–124
DOI 10.3897/popecon.3.e34783 (2022)

Metropolia University of Applied Sciences, Myyrmäki

Deep-sea research laboratory, PLOCAN, Gran Canaria

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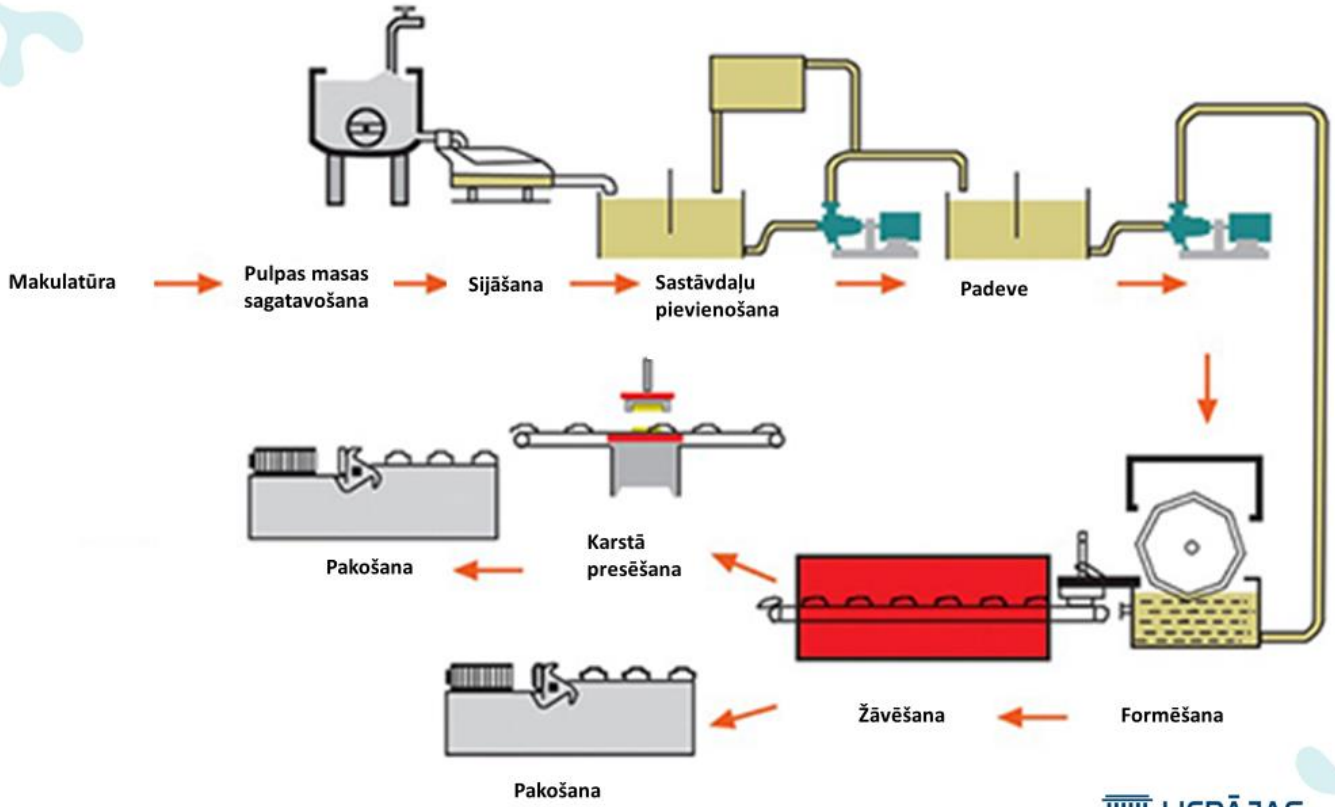
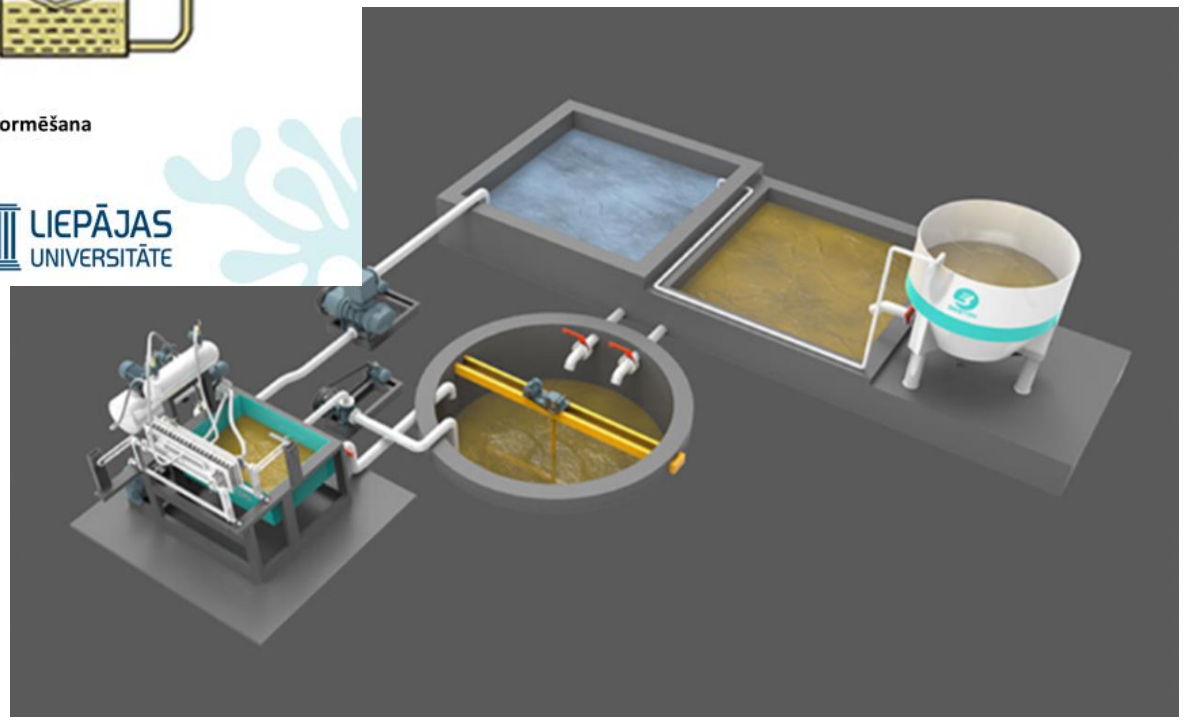


https://www.bestongroup.com/



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Capacity (pieces/h)		800-1000	1200-1500
Forming Mould Quantity		3	4
Total Power (kw)		33	42
Electricity Consumption (kw/h)		23.1	29.4
Labor Force		3-5	4-6
Material Consumption (kg/h)	Paper	85	102
	Water	255	306

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Raising environmental awareness, workshops, algae paper production, bioplastic production, application, their types, pre-treatment for use.

Photo- Teacher training in the Nature House (Norvay grants) (ZIIC) Liepaja, Latvia (october 2022)

CONTACTS

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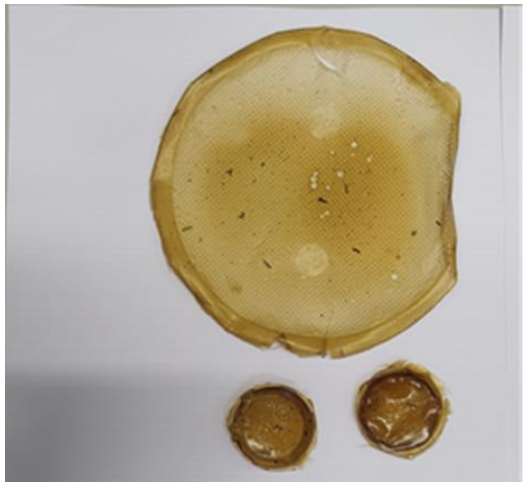
Uldis Zaimis Faculty of Science and Engineering Institute of Science and Innovative Technologies Liepaja University
email: uldis.zaimis@liepu.lv



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Proposal on Finnish River Basin Specific Pollutants (RBSPs) under WFD – Substances relevant for Baltic Sea

Jukka Mehtonen, Katri Siimes,
Matti Leppänen, Ville Junttila,
Lauri Äystö & Emmi Vähä
Finnish Environment Institute

1st Dec 2022

"Science shakes a hand with coastal life and citizens"

– Science Days for the Gulf of Finland and the eastern Baltic Sea, Helsinki

SYKE

Background – Decree on substances dangerous & harmful to the aquatic environment (1022/2006)

- Based on WFD and its daughter directives
- Goal: protect surface waters via preventing pollution due to Substances Dangerous and Harmful to the Aquatic Environment
- Currently 15 nationally selected Finnish RBSPs
  - entered into force first time Dec 2006

SYKE

Degree 1022/2006 12 § assessment

- SYKE will assess every 6 year the RBSP list and propose changes
- Proposal is based on risk assessment and monitoring data
- Evaluation of
  - current RBSPs
  - candidate substances for new RBSPs

SYKE

Current 15 Finnish RBSPs (= degree 1022/2006 annex 1D substances)

- **9 industrial chemicals**
  - chlorobentzene, 1,2- & 1,4-dichlorobenzene
  - benzylbutylphthalate (BBP) & dibutylphthalate (DBP)
  - resorcinol
  - TCMTB & MBeT
  - bronopol
- **6 pesticides**
  - incecticide dimethoate
  - herbicides MCPA, metamitron & tribenuron-methyl
  - fungicides prochloraz & ethylene thiourea (degradation prod. of mancozeb)

SYKE

Criteria & methods applied

SYKE

Substances considered

- industrial and consumer chemicals
- pharmaceuticals
- hormones
- pesticides & biocides
- SVHCs
- metals

+ EU COM proposal 26.10.2022 substances for new EU surface water priority substances (COM (2022) 540)

SYKE

aims to identify substances posing a risk to aquatic environment, or via aquatic environment to human health

- … but only substances for which env. levels can be decreased
  - i.e. **substances still used or discharged** and
- **Risk for PNEC exceedances at least in areas with high emissions**
  - RQ - measured env. concentration compared to PNEC (predicted no effect concentration)
  - criteria for risk substance: **RQ surface waters > 0,5**, when 95. percentile env. concentration applied

$$RQ95 = \frac{95.percentile\ conc.}{PNEC}$$

- Pesticides - slightly different criteria:
  - **RQ95 ≥ 0,1** and
  - **quantified >1 % of samples** and
  - **still used**

SYKE

Chemical data sources

- Finnish data from several national databases were utilized
- **Env. concentations in Finland:**
  - **VESLA & KERTY registers,**
  - **scientific studies**
  - **results from years 2010-2021**
- Import and manufacture of chemicals: KETU register
- Discharges to surface waters: YLVA register
- Pharmaceutical use: medicine statistics (Fimea & Kela)
- Pesticide sales: Tukes, partly confidential data

SYKE

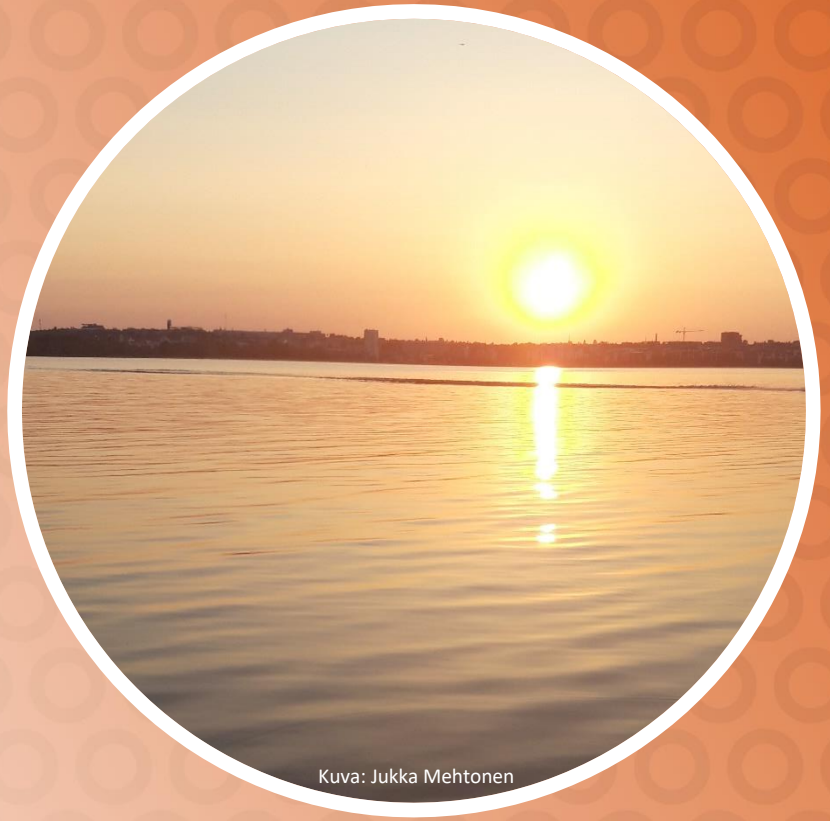
PNEC values & proposed EQS values

- Primarily chronic PNECs applied in risk assessment
- EU level PNECs & EQS proposals available for some substances
- The lowest scientifically sound PNEC proposed as EQS value
- EQS value proposed as
  - total, dissolved or bioavailable concentration in surface water or
  - concentration in biota or sediment

EQS = Environmental Quality Standard

SYKE

Current Finnish RBSPs - proposal



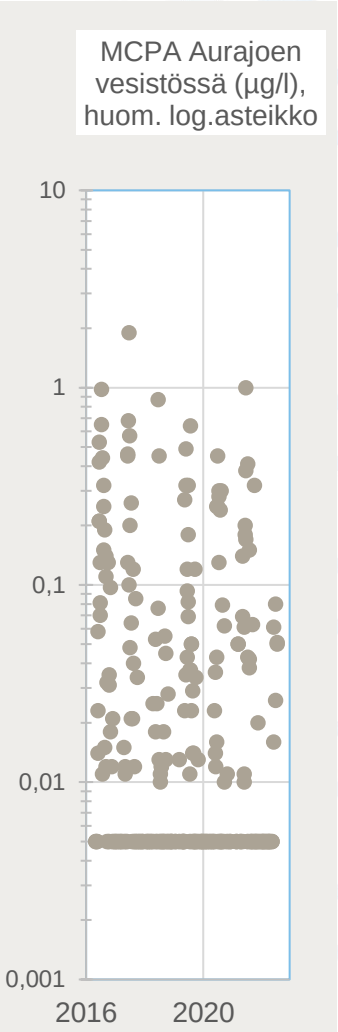
SYKE

MBet & MCPA to be left as Finnish RBSP

- **benzothiazole-2-thiol (MBeT) with new EQS values**:
  - AA-EQS freshwaters 0,8 µg/l & marine waters 0,08 µg/l
  - MAC-EQS freshwaters 2,5 µg/l marine waters 0,25 µg/l

- **MCPA with new EQS values**:
  - AA-EQS freshwaters 1,0 µg/l & marine waters 0,1 µg/l
  - MAC-EQS freshwaters 15 µg/l marine waters 1,5 µg/l

Other 13 substances proposed to be left out



SYKE

New Finnish RBSPs - proposal

SYKE

Evaluation of candidate substances

- Candidate substances are classified to three classes:
  - **substances with cause or may cause risk → proposed as new RBSPs with necessary EQS values**
  - substances posing not enough data, but suspected risk substance → proposed to national screening with aim receive necessary data for next ”degree 1022/2006 12 § assessment”
  - substances not causing risk → no actions

SYKE

12 new substances with EQS values proposed

- industrial chemicals PFASs (∑PFAS24)*,
- pharmaceuticals diclofenac* & ibuprofen*,
- hormones 17a-ethinylestradiol (EE2)* & estrone (E1)*,
- metals silver (Ag)*, zinc (Zn) & copper (Cu),
- sulphate,
- pesticides florasulam, glyphosate* & tritosulfuron

* EU COM proposal 26.10.2022 substances for new EU surface water priority substances (COM (2022) 540); BUT substance **not** to be proposed as Finnish RBSP if it end up as EU priority substance

SYKE

Proposal - Baltic Sea point of view

- EQS values proposed mainly as total, dissolved or bioavailable concentration in surface water, sometimes in biota
- Not always possible to propose EQS values for Baltic Sea
  - silver & sulphate
- General remark: measured data mainly from freshwaters, significantly less from BS
- Substances preliminarily relevant for Baltic marine environment:
  - Zn & Cu: exceedances of the proposed EQSs expected
  - Diclofenac & estrone: exceedances detected in coastal areas
    - diclofenac ~50% of samples, estrone 35% of samples (LOQ > EQS)
  - PFASs: exceed proposed EQS in all Finnish coastal areas

SYKE

Zinc, Zn

- Emission sources: acid sulphate soils, industry (e.g. P & P, metal, mining), municipal wastewater, antifouling use, stormwater (e.g. traffic, urban metal constr. surfaces), other biocide uses
- AA-EQS proposals & prel. estimation on exceedances
  - 14,4 µg/l bioavailable for freshwaters
    - seldom exceeded
  - 7,2 µg/l dissolved for marine waters
    - inner coastal waters: sometimes exceeded, outer coastal waters: seldom

EQS	SYKE	Estonia, diss.	Sweden, bioav.
$AA\text{-}EQS_{freshwater}$	14,4 µg/l	10,9 µg/l	5,5 µg/l
$AA\text{-}EQS_{marine\ water}$	7,2 µg/l	10,9 µg/l	1,1 µg/l

SYKE

Copper, Cu

- Emission sources: antifouling use, acid sulphate soils, industry (e.g. P & P, metal), stormwater (e.g. traffic, roofs), municipal wastewater, other biocide uses
- AA-EQS proposals & prel. estimation on exceedances
  - 1,1 µg/l bioavailable for freshwaters
    - seldom exceeded
  - 2,6 µg/l dissolved for marine waters
    - exceeded in inner coastal waters, not in outer coastal waters

EQS	SYKE	Estonia, diss.	Sweden, bioav.
$AA\text{-}EQS_{freshwater}$	1,1 µg/l	7,8 µg/l	0,5 µg/l
$AA\text{-}EQS_{marine\ water}$	2,6 µg/l	7,8 µg/l	0,87 µg/l

SYKE

Proposal – other remarks

- Current status: hearing round on-going
- Example for legislative act that utilizes results from monitoring + several scientific projects (incl. Baltic Sea wide cooperative projects)

SYKE

Thank you!

Final proposal to be published in Finnish in spring 2023 (Reports of the Finnish Environment Institute)

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RAPID QUANTIFICATICATION OF MICROPLASTICS BY USING NILE RED STAINING – A COST-EFFECTIVE AND SEMIAUTOMATED APPROACH

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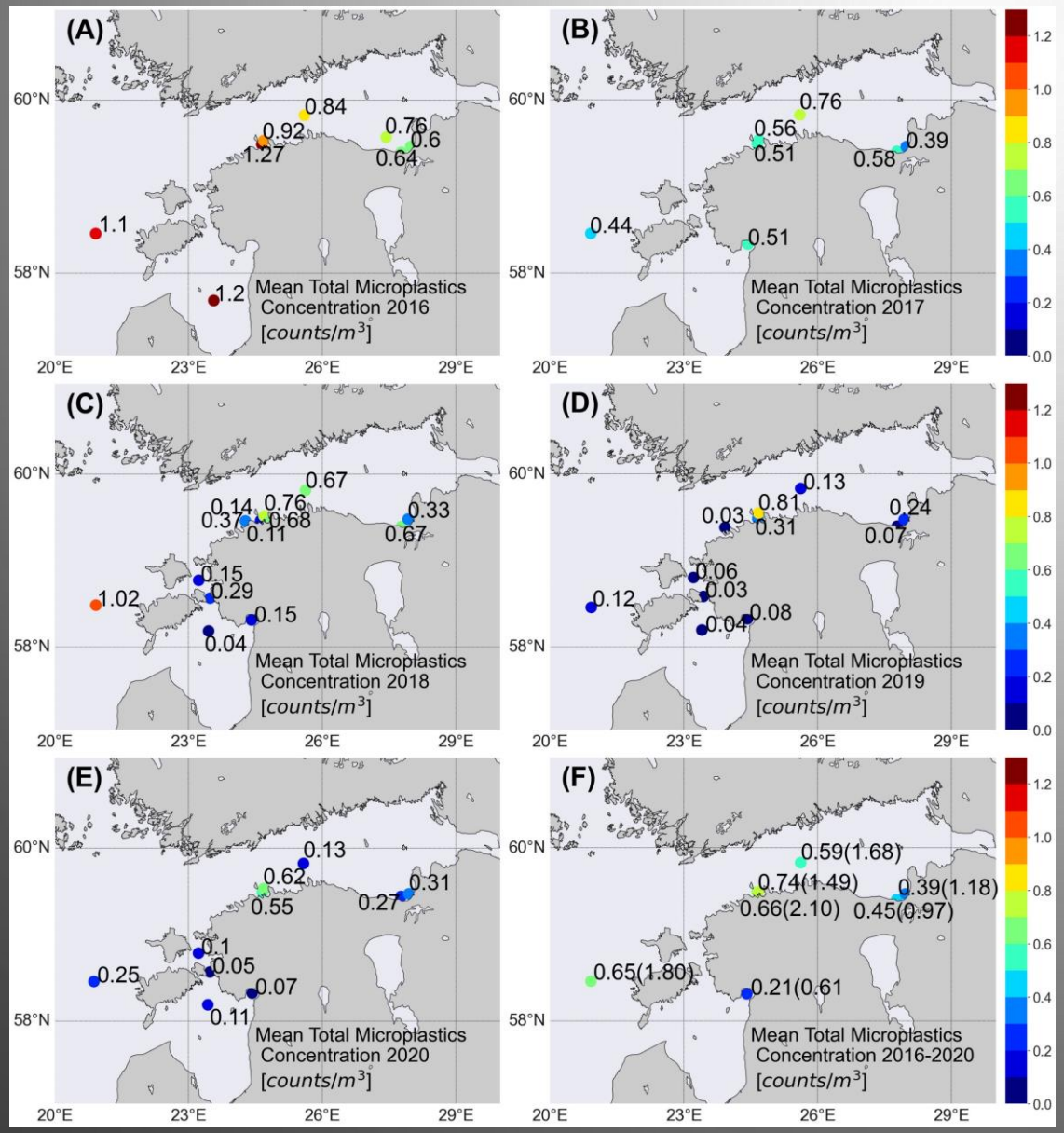
Method
Uncertainties
Nile Red
Image Analysis
Results
Conclusion

What is Microplastics?

Microplastic Uncertainties in the Eastern Baltic Sea



Uncertainties in MP measurements are mainly caused by three major error sources:

- ❖ Sampling error
- ❖ Instrumental error
- ❖ Laboratorial analysis error

Existing Identification Methods

FTIR

Advantages

- Plastic confirmation of subset samples
- Polymer composition of major or typical plastic types
- Detection down to 10 µm plastics in size

Disadvantages

- Possibility of false positive or negative (dependent on used library od polymers and operator decisions, problems with identifying fibers, tyre wear)
- Expensive instrument
- Time consuming and labour intensive for plastic identification

Microscopy

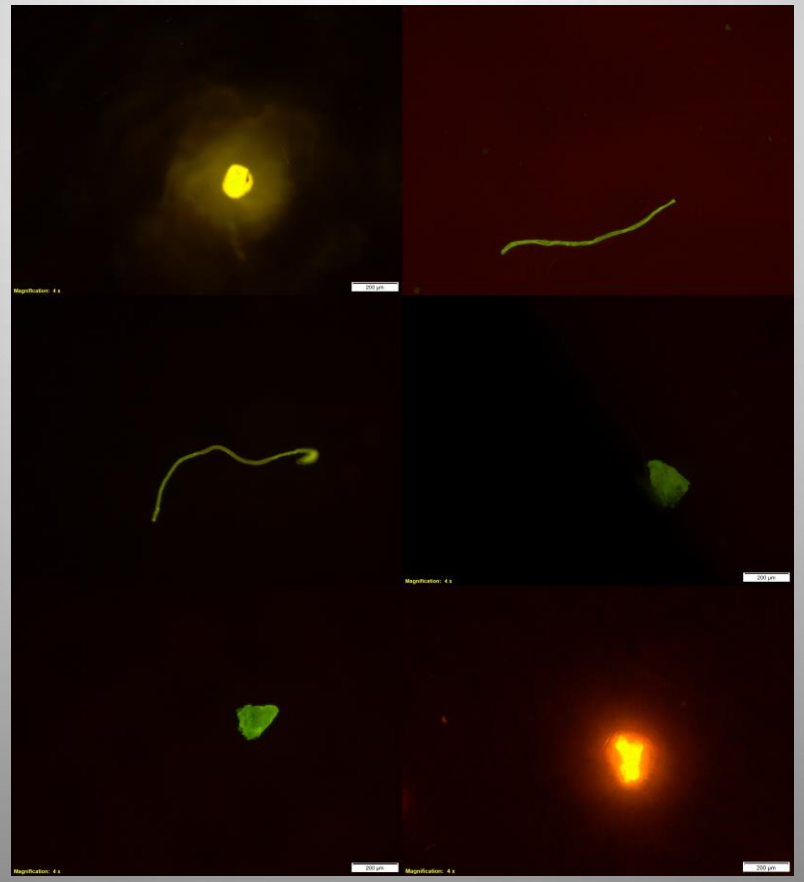
Advantages

- Simple fast and easy

Disadvantages

- No chemical confirmation
- High possibility of false positive
- High possibility of missing small and transparent plastic particles
- No polymer composition data

Potential Analytics of Fluorescent dyes



Advantages

- ❑ Easy to operate
- ❑ Short measuring times
- ❑ Expensive measuring equipment is not necessary

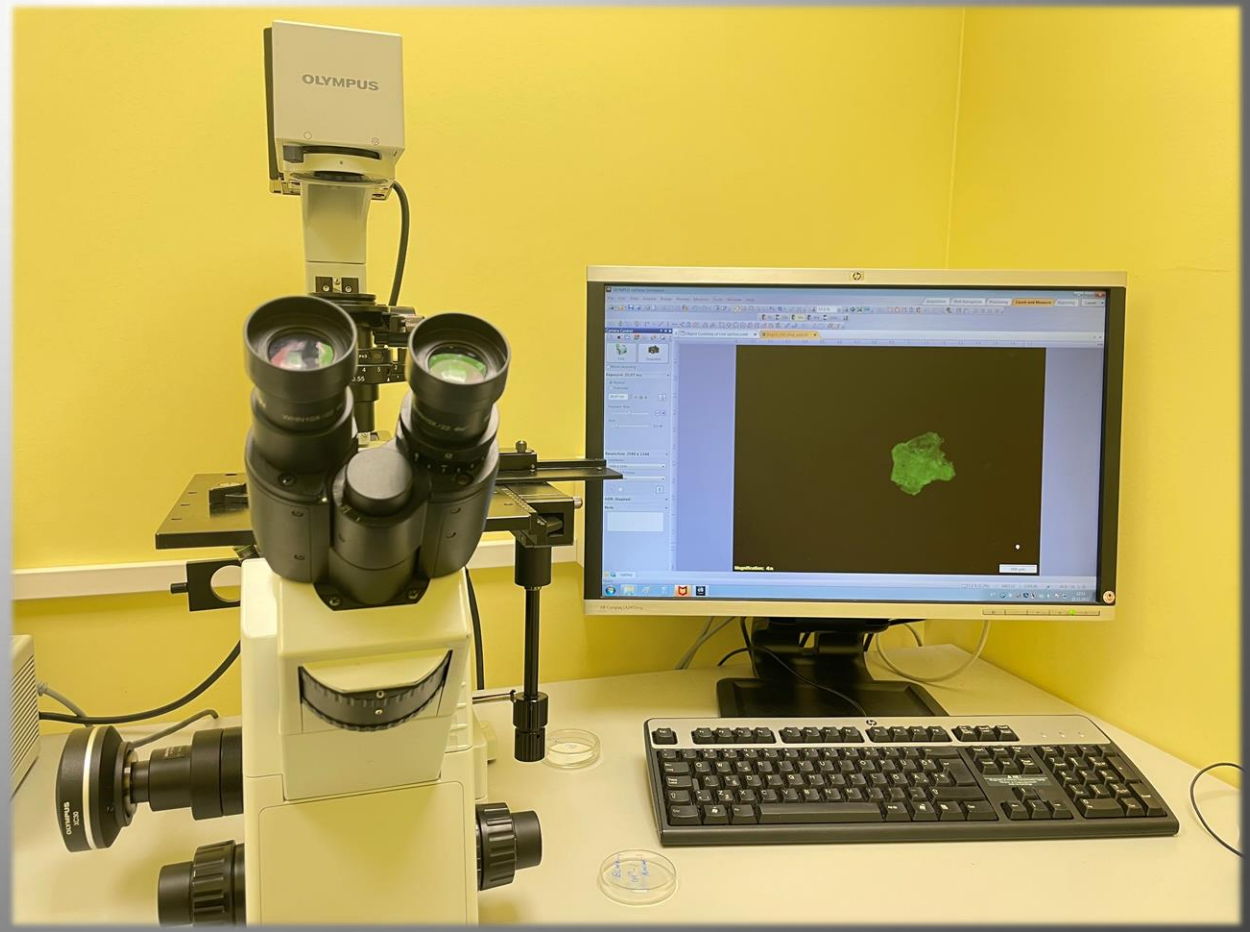
Disadvantages

- ❑ Not yet standardized
- ❑ Natural particles can interfere
- ❑ Some polymer types difficult to detect

Fluorescence microscopy

Filters used

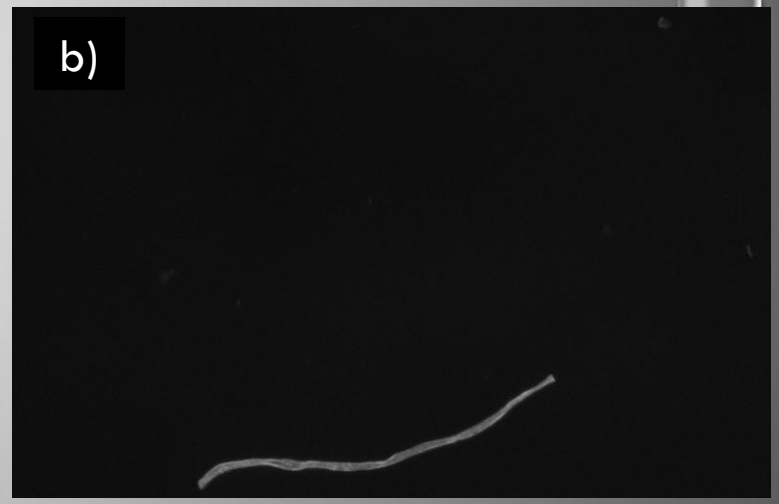
- Blue excitation filter (BP 470-495 nm)
- Green excitation filter (BP 530-550 nm)
- UV excitation filter BP (360-370 nm)
- Exposure time – the exposure time varied between 50ms to 500ms
- Magnification – 4x
- cellSens Dimension software

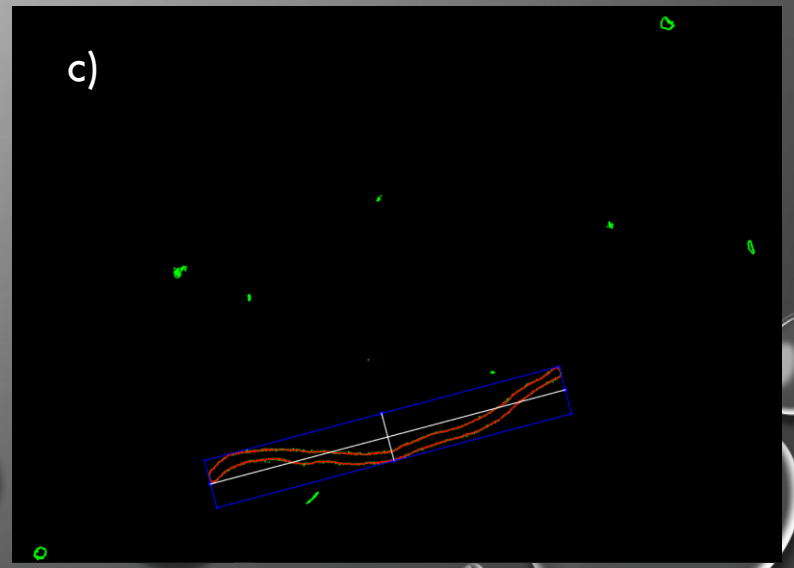


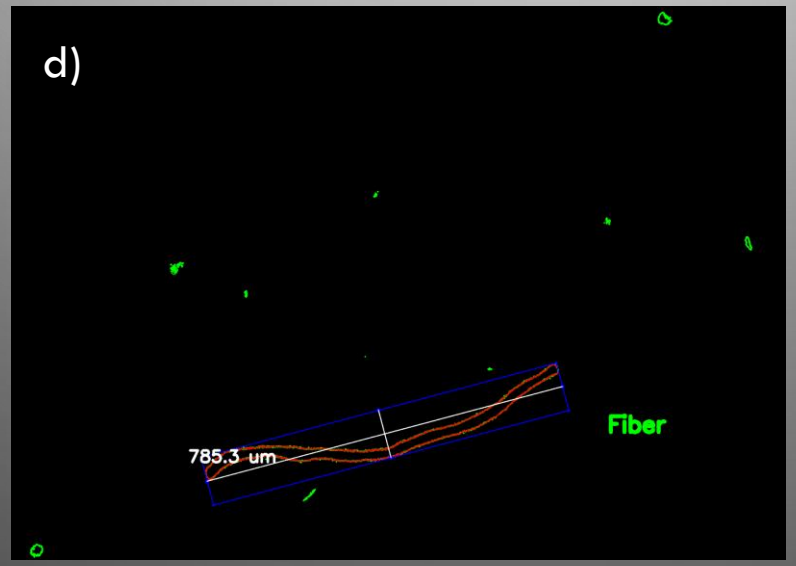
NILE RED

IMAGE ANALYSIS

- Image Acquisition
- Thresholding process
- Find and draw contours
- Calculate euclidean distance based on Midpoints
- Logic to differentiate between Fibers and Fragments
- Final report in excel

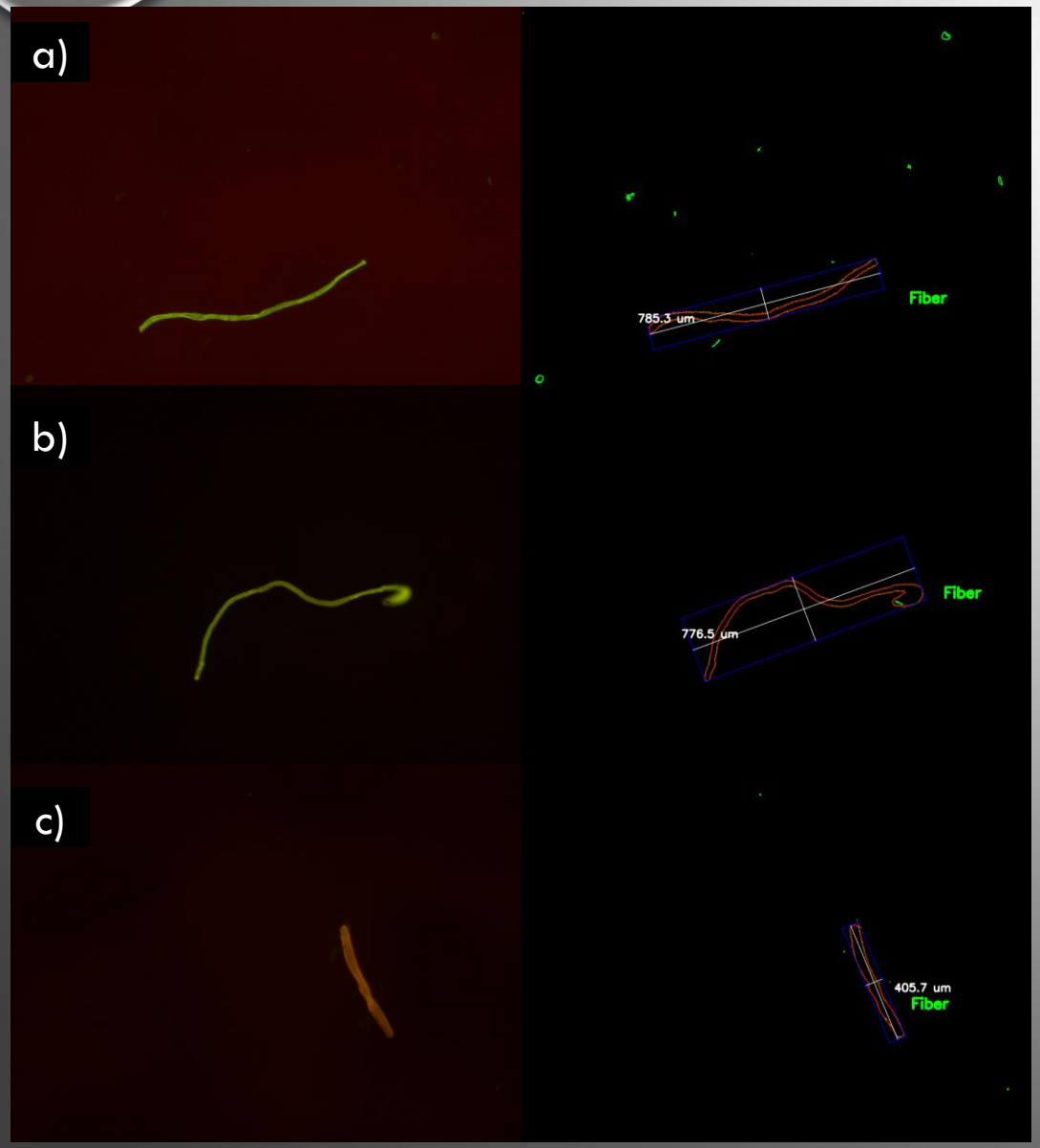


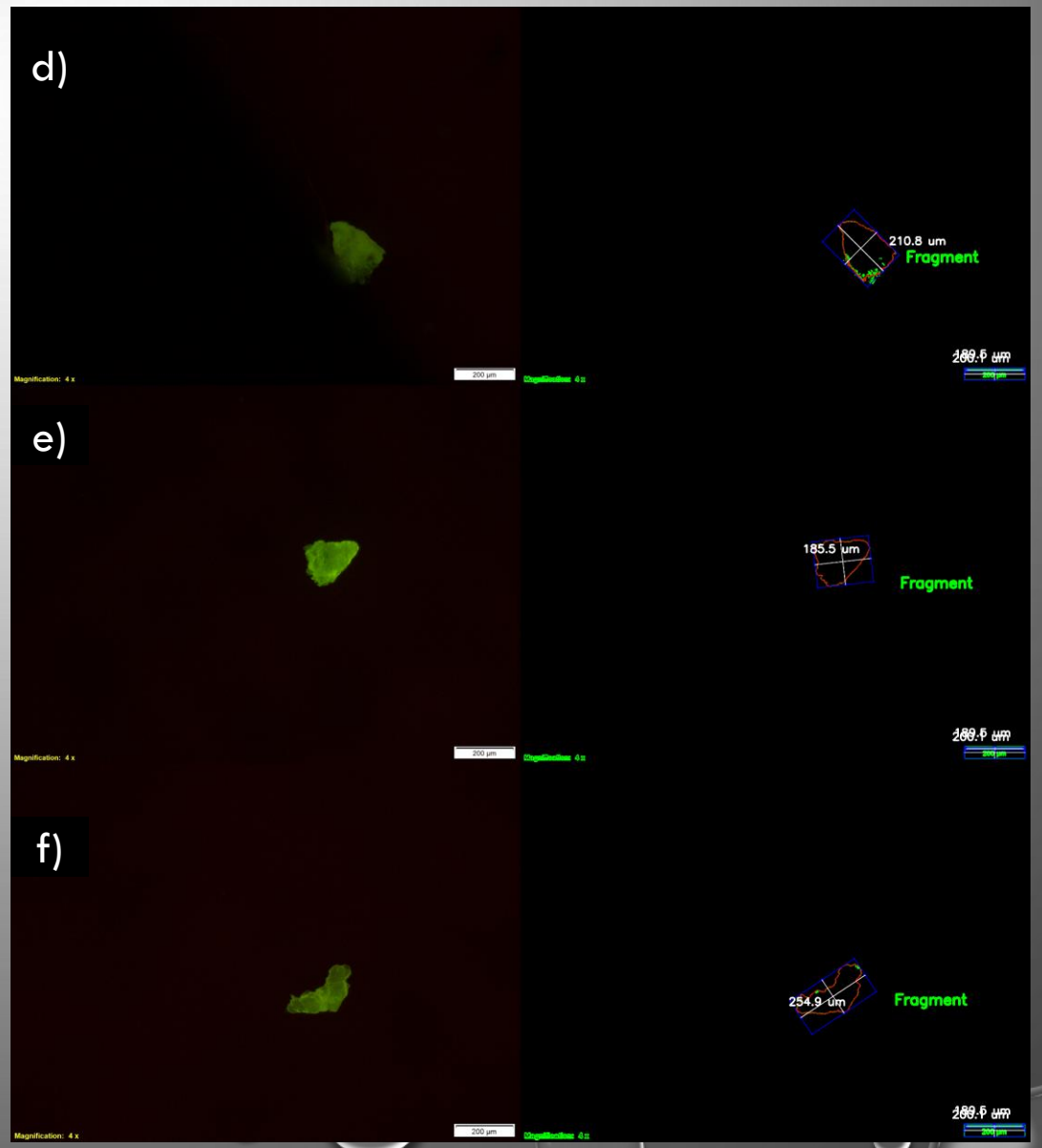


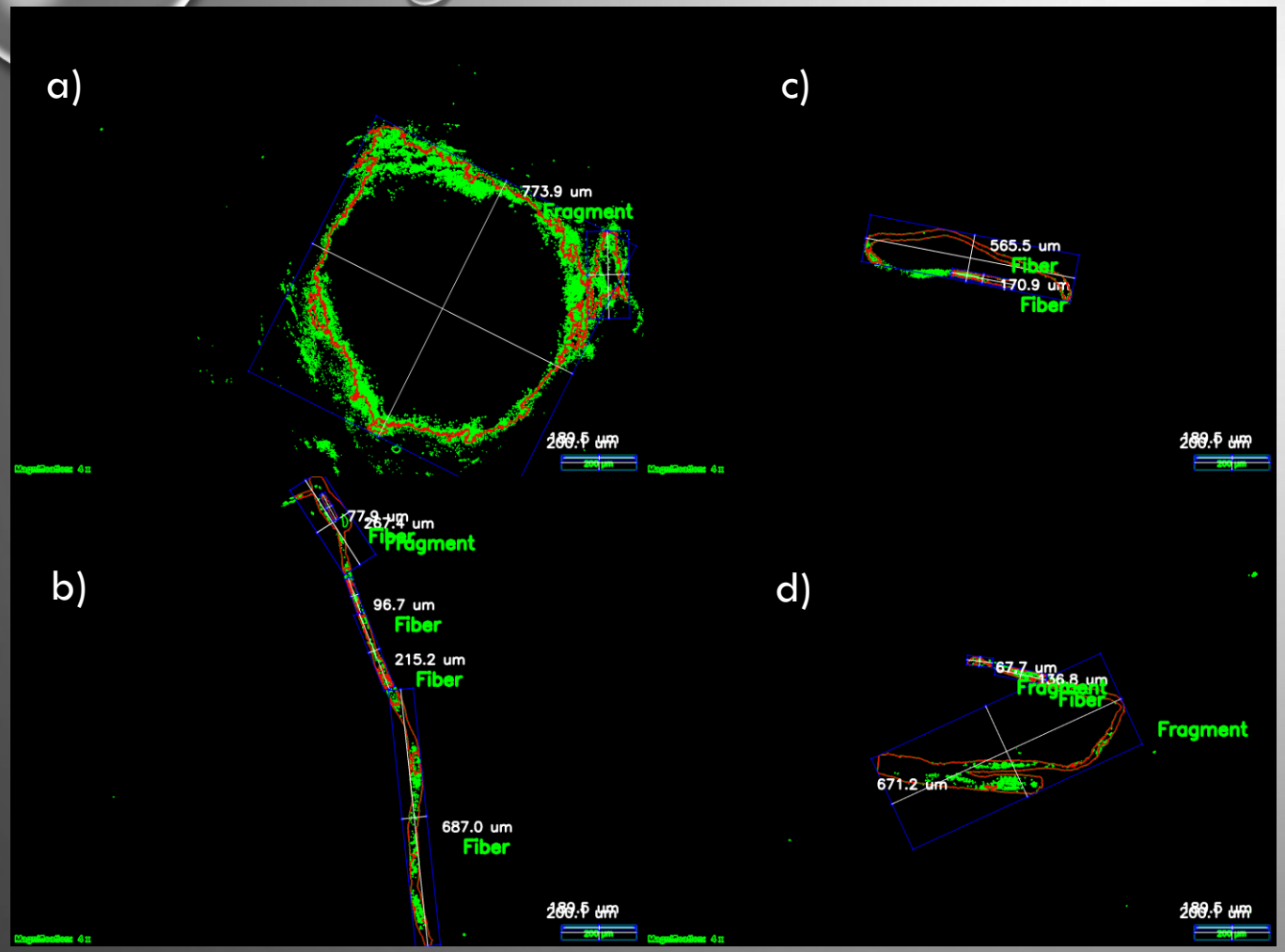


Fiber

Fragment



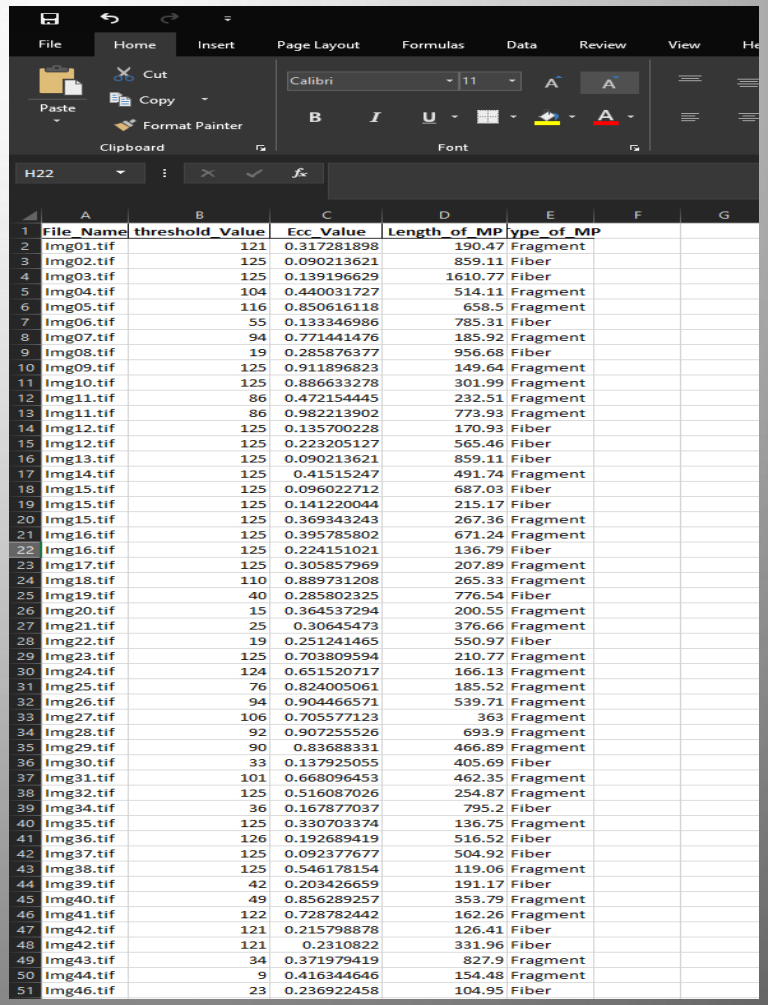




False negative Microplastic detected and accordingly detection rate was calculated.

RESULTS

- We assume that all particles which emitt flourescence are microplastics.
- 53 images was successfully tested
- 90% of particles were detected
- Finally a microplastic report is automatically generated having necessary Microplastic details.



	A	B	C	D	E	F	G
1	File_Name	threshold_Value	Ecc_Value	Length_of_MP	ype_of_MP		
2	Img01.tif	121	0.317281898	190.47	Fragment		
3	Img02.tif	125	0.090213621	859.11	Fiber		
4	Img03.tif	125	0.139196629	1610.77	Fiber		
5	Img04.tif	104	0.440031727	514.11	Fragment		
6	Img05.tif	116	0.850616118	658.5	Fragment		
7	Img06.tif	55	0.133346986	785.31	Fiber		
8	Img07.tif	94	0.771441476	185.92	Fragment		
9	Img08.tif	19	0.285876377	956.68	Fiber		
10	Img09.tif	125	0.911896823	149.64	Fragment		
11	Img10.tif	125	0.886633278	301.99	Fragment		
12	Img11.tif	86	0.472154445	232.51	Fragment		
13	Img11.tif	86	0.982213902	773.93	Fragment		
14	Img12.tif	125	0.135700228	170.93	Fiber		
15	Img12.tif	125	0.223205127	565.46	Fiber		
16	Img13.tif	125	0.090213621	859.11	Fiber		
17	Img14.tif	125	0.41515247	491.74	Fragment		
18	Img15.tif	125	0.096022712	687.03	Fiber		
19	Img15.tif	125	0.141220044	215.17	Fiber		
20	Img15.tif	125	0.369343243	267.36	Fragment		
21	Img16.tif	125	0.395785802	671.24	Fragment		
22	Img16.tif	125	0.224151021	136.79	Fiber		
23	Img17.tif	125	0.305857969	207.89	Fragment		
24	Img18.tif	110	0.889731208	265.33	Fragment		
25	Img19.tif	40	0.285802325	776.54	Fiber		
26	Img20.tif	15	0.364537294	200.55	Fragment		
27	Img21.tif	25	0.30645473	376.66	Fragment		
28	Img22.tif	19	0.251241465	550.97	Fiber		
29	Img23.tif	125	0.703809594	210.77	Fragment		
30	Img24.tif	124	0.651520717	166.13	Fragment		
31	Img25.tif	76	0.824005061	185.52	Fragment		
32	Img26.tif	94	0.904466571	539.71	Fragment		
33	Img27.tif	106	0.705577123	363	Fragment		
34	Img28.tif	92	0.907255526	693.9	Fragment		
35	Img29.tif	90	0.83688331	466.89	Fragment		
36	Img30.tif	33	0.137925055	405.69	Fiber		
37	Img31.tif	101	0.668096453	462.35	Fragment		
38	Img32.tif	125	0.516087026	254.87	Fragment		
39	Img34.tif	36	0.167877037	795.2	Fiber		
40	Img35.tif	125	0.330703374	136.75	Fragment		
41	Img36.tif	126	0.192689419	516.52	Fiber		
42	Img37.tif	125	0.092377677	504.92	Fiber		
43	Img38.tif	125	0.546178154	119.06	Fragment		
44	Img39.tif	42	0.203426659	191.17	Fiber		
45	Img40.tif	49	0.856289257	353.79	Fragment		
46	Img41.tif	122	0.728782442	162.26	Fragment		
47	Img42.tif	121	0.215798878	126.41	Fiber		
48	Img42.tif	121	0.2310822	331.96	Fiber		
49	Img43.tif	34	0.371979419	827.9	Fragment		
50	Img44.tif	9	0.416344646	154.48	Fragment		
51	Img46.tif	23	0.236922458	104.95	Fiber		

Conclusion & Future Work

- Nile Red methodology should be considered for further microplastic research.
- Nile Red in conjunction with Machine Learning is the preferred method for quick quantification of microplastics since it is reusable, time- and cost-effective, and requires no human intervention.
- Next, we are working to increase our fluorescence image collection in order to train these images using machine learning and lower the microplastics analysis time with high accuracy.
- In Future, we are planning to implement Polymer Identification Model.
- We also intend to compare the results between three different methods: FTIR, microscopy and Nile Red methodology.

THANK YOU FOR YOUR ATTENTION!

QUESTIONS??

TAL TECH

JPI OCEANS

ANDROMEDA