From small scales to large scales
–The Gulf of Finland Science Days 2017

9th – 10th October 2017
Estonian Academy of Sciences, Tallinn

Gulf of Finland Co-operation

PRESENTATIONS

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Presentations Day 1 • 9th October 2017

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1st Day

Gulf of Finland Co-operation

T. Soomere

Climate change: is there a focal point

Climate change:

is there a focal point?

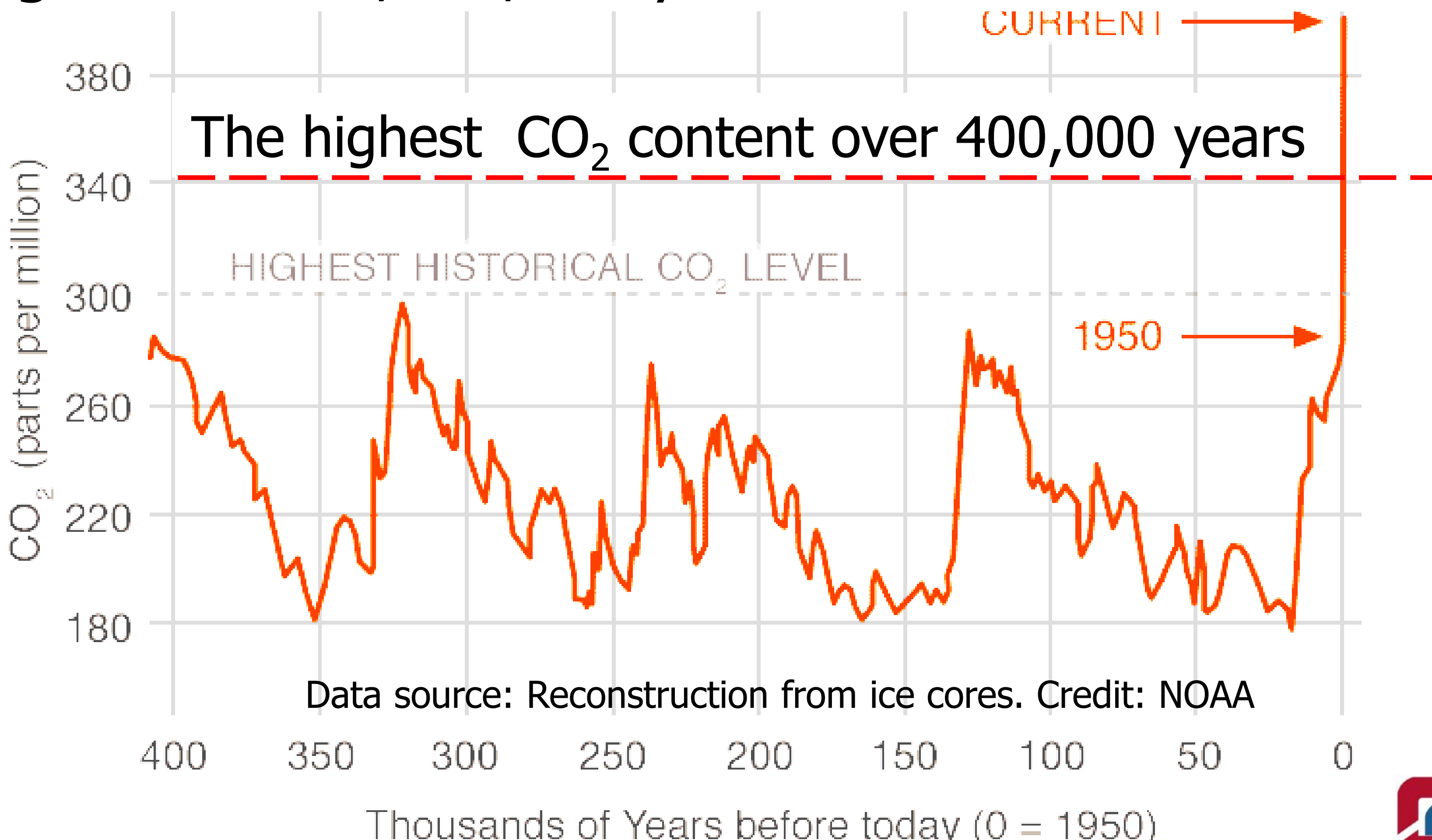
Tarmo Soomere

Estonian Academy of Sciences

Wave Engineering Laboratory
Department of Cybernetics, School of Science
Department of Civil Engineering and Architecture, School of Engineering
Tallinn University of Technology

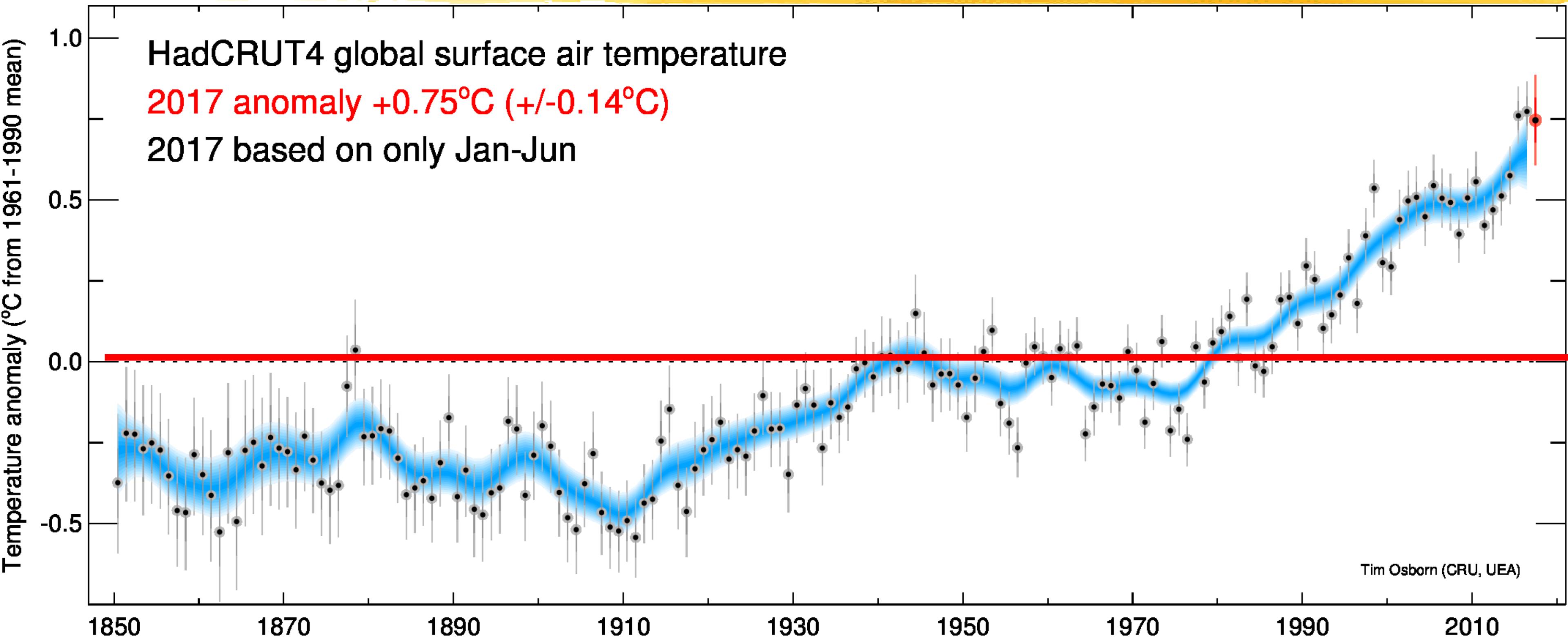
The messages about changes are massive

CO_2 content in the atmosphere: highest over 1,000,000 years

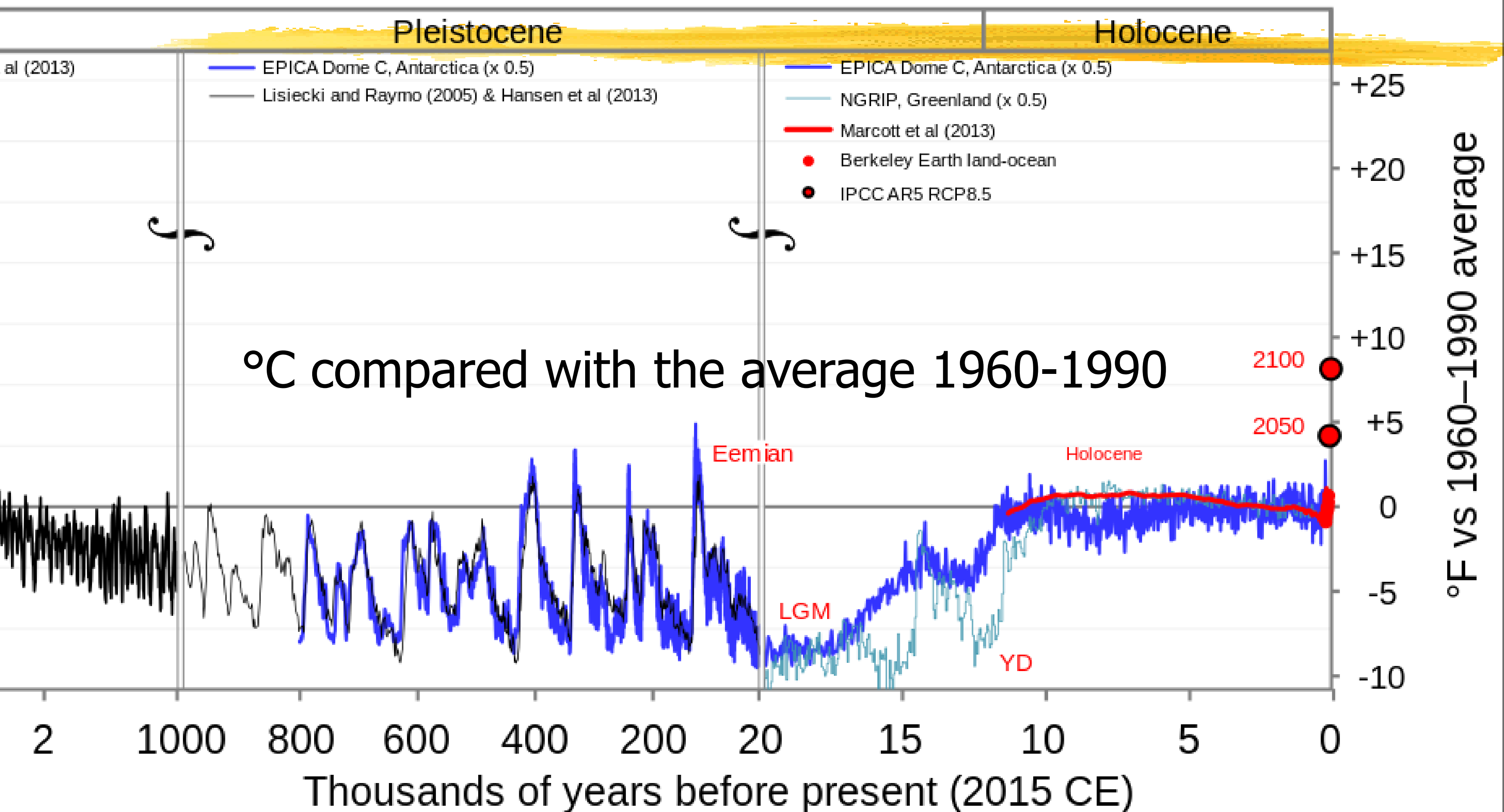


Data source: Reconstruction from ice cores. Credit: NOAA

The average temperature increases



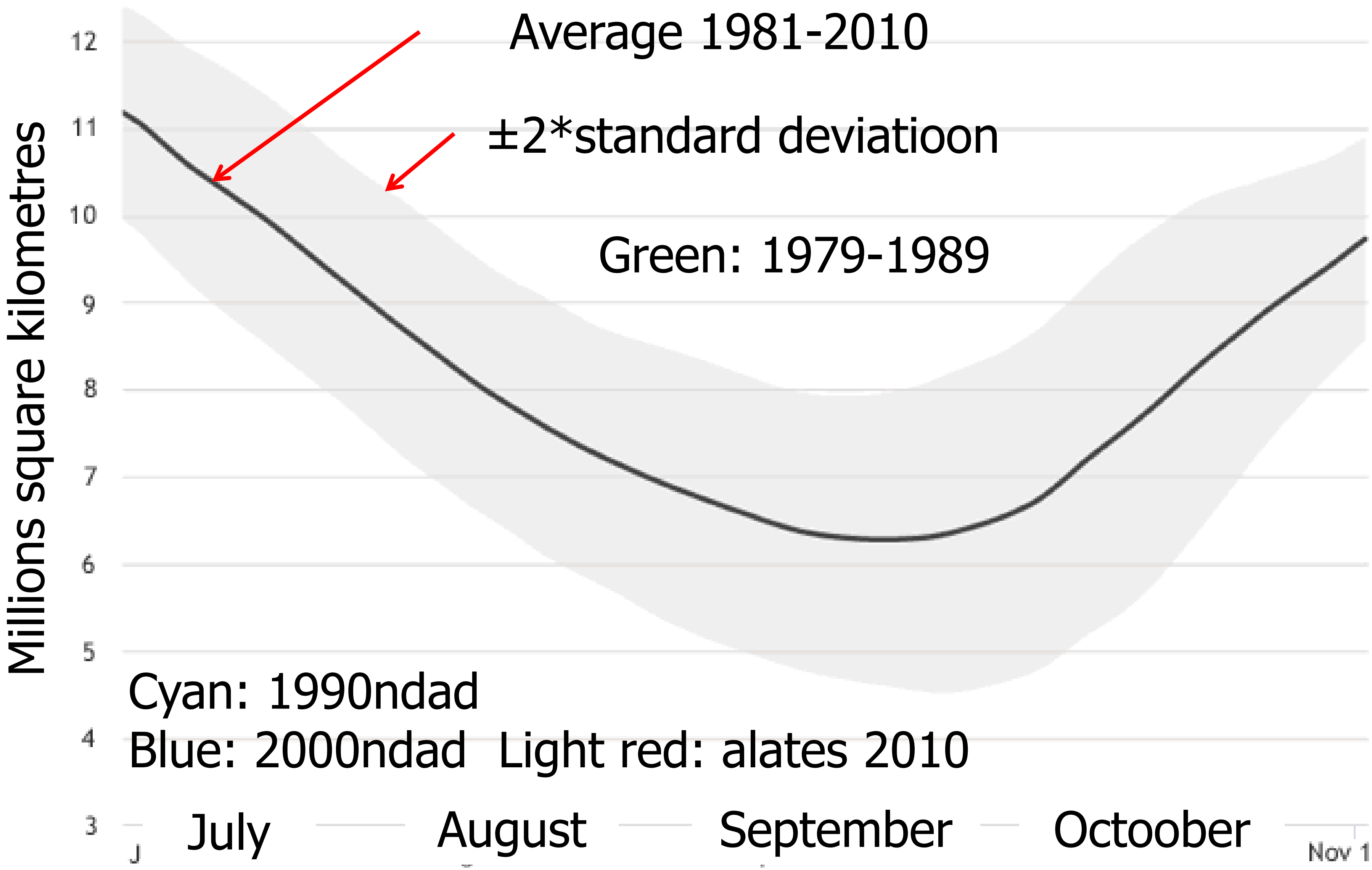
The typical state of the Earth: frozen
net Earth



Wikipedia

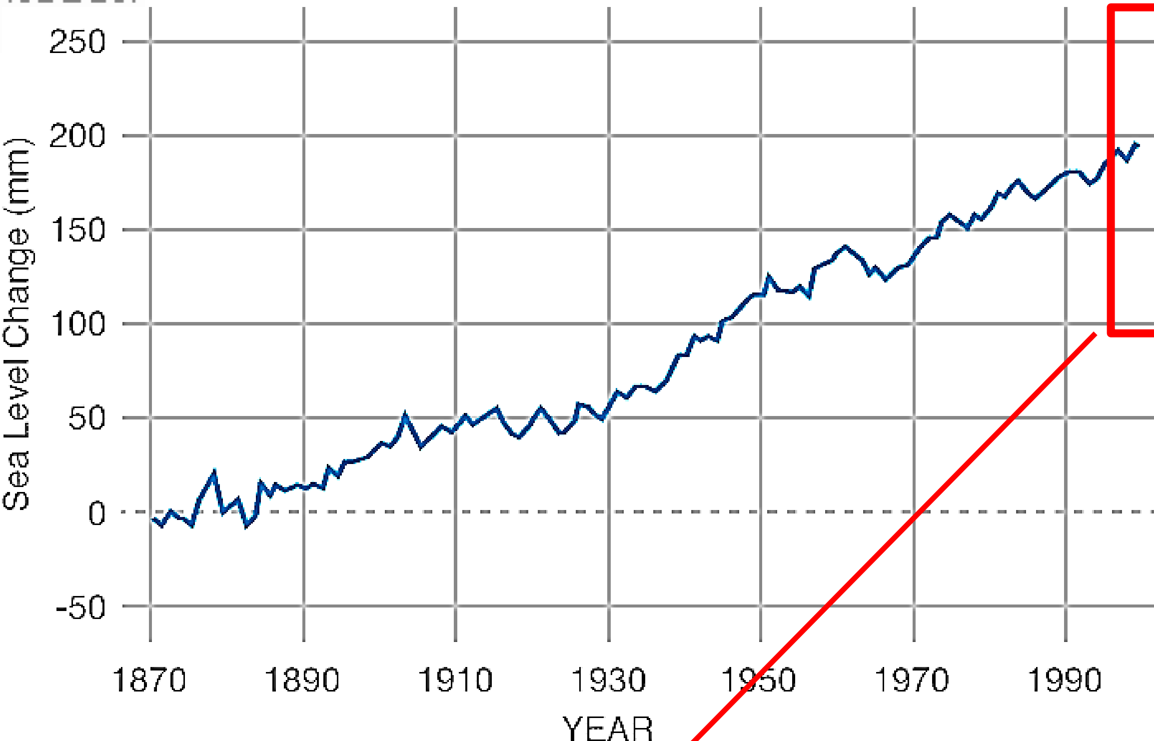
Pieter Bruegel (older) 1525/30-1569

Sea ice in the Arctic Ocean 1979-2016



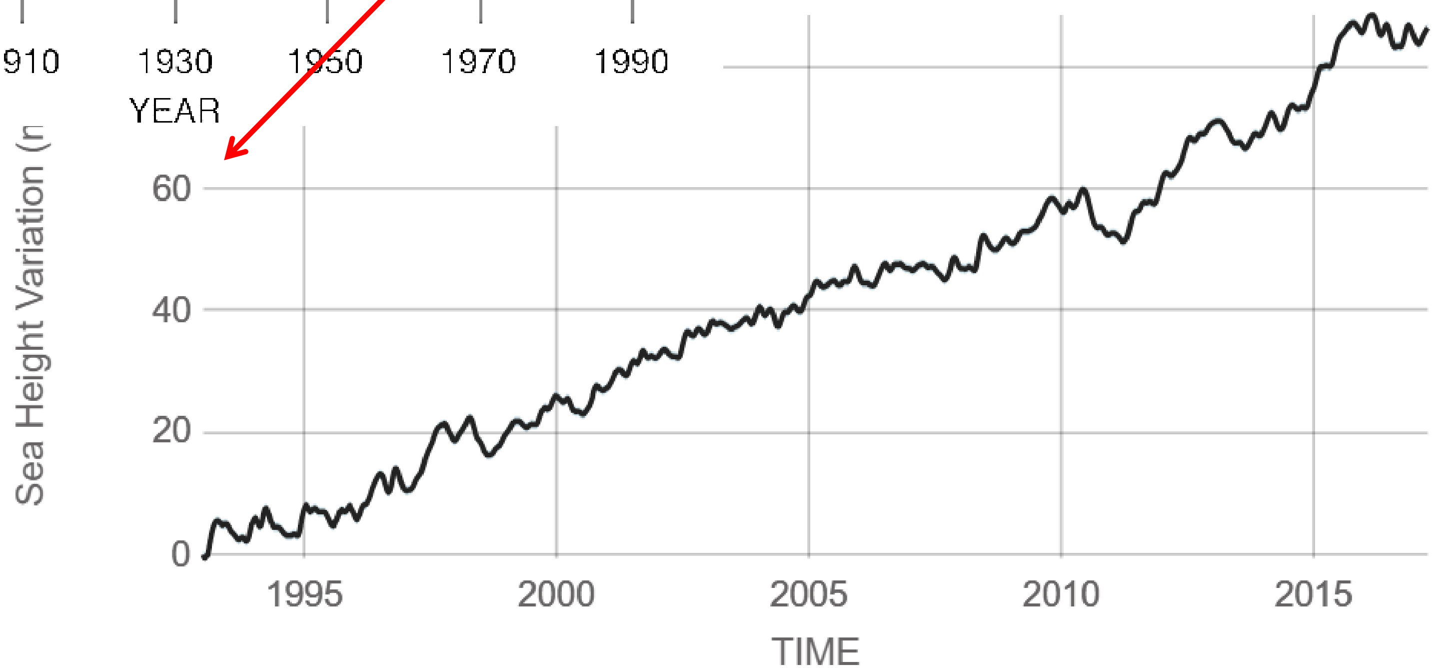
by Climate.gov, adapted from NSIDC's Charctic (http://nsidc.org/arcticseaicenews/charctic-interactive-sea-ice-graph/)

Sea level in World Ocean is rising



climate.nasa.gov

Acceleration: the rate today ~3 mm/a



The role of the sea or where the extra heat has gone / is located since 1970

- Heating of water masses: 93%
- Melting of ice (glaciers, sea ice): 3%
- Heating of land: 3%
- Heating of the atmosphere: **1%**

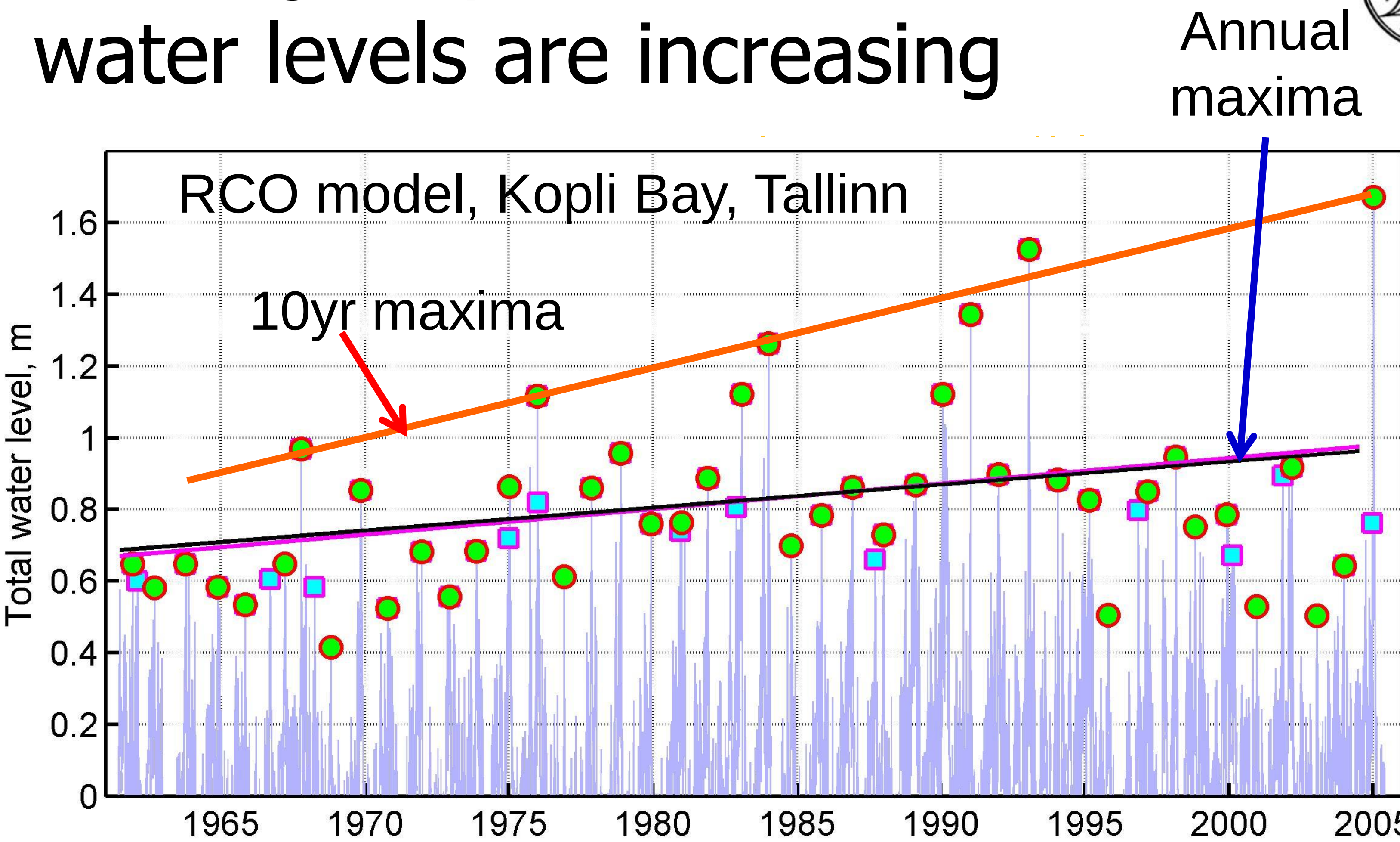
Before 1970: insufficient data (IPCC, 2013)


The power of the sea:
in motions of water
Meriválja jetty

Sometimes it happens


Küllike Roováli, Postimees

The urgent problem: extreme water levels are increasing



Two important numbers about global sea level:

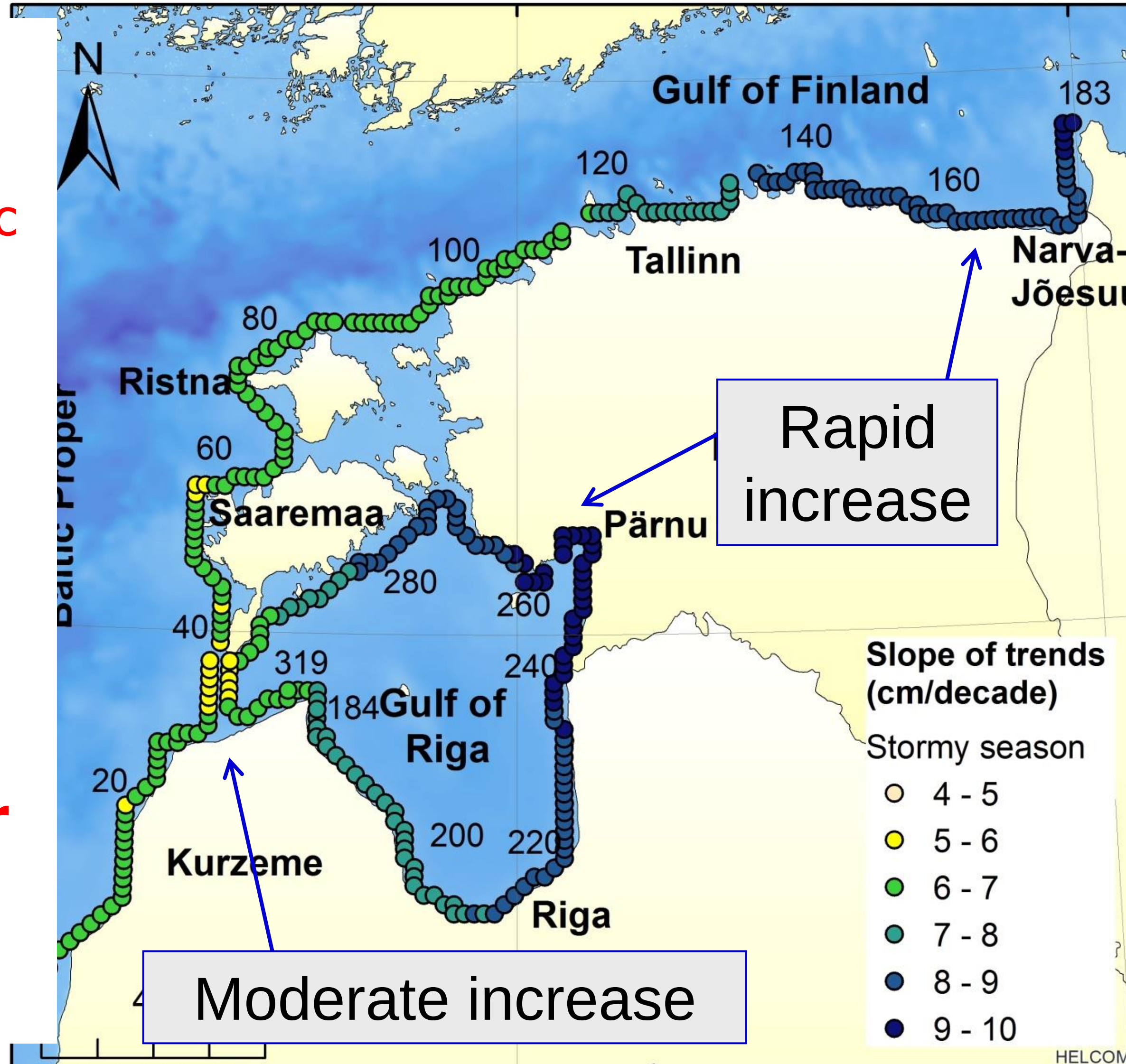
- Increase in the last 100yrs: **1-2 mm/yr**
- Last 20 yrs: **3 mm/yr**

A simple question: how rapid is the increase in my home city?

Soomere & Pindsoo 2016, *Continental Shelf Research*

- Moderate increase ~4 mm/yr
  - Open part of the Baltic Sea
- Typical increase 6-7 mm/yr
- Rapid increase: 9-10 mm/yr
  - Eastern bayheads

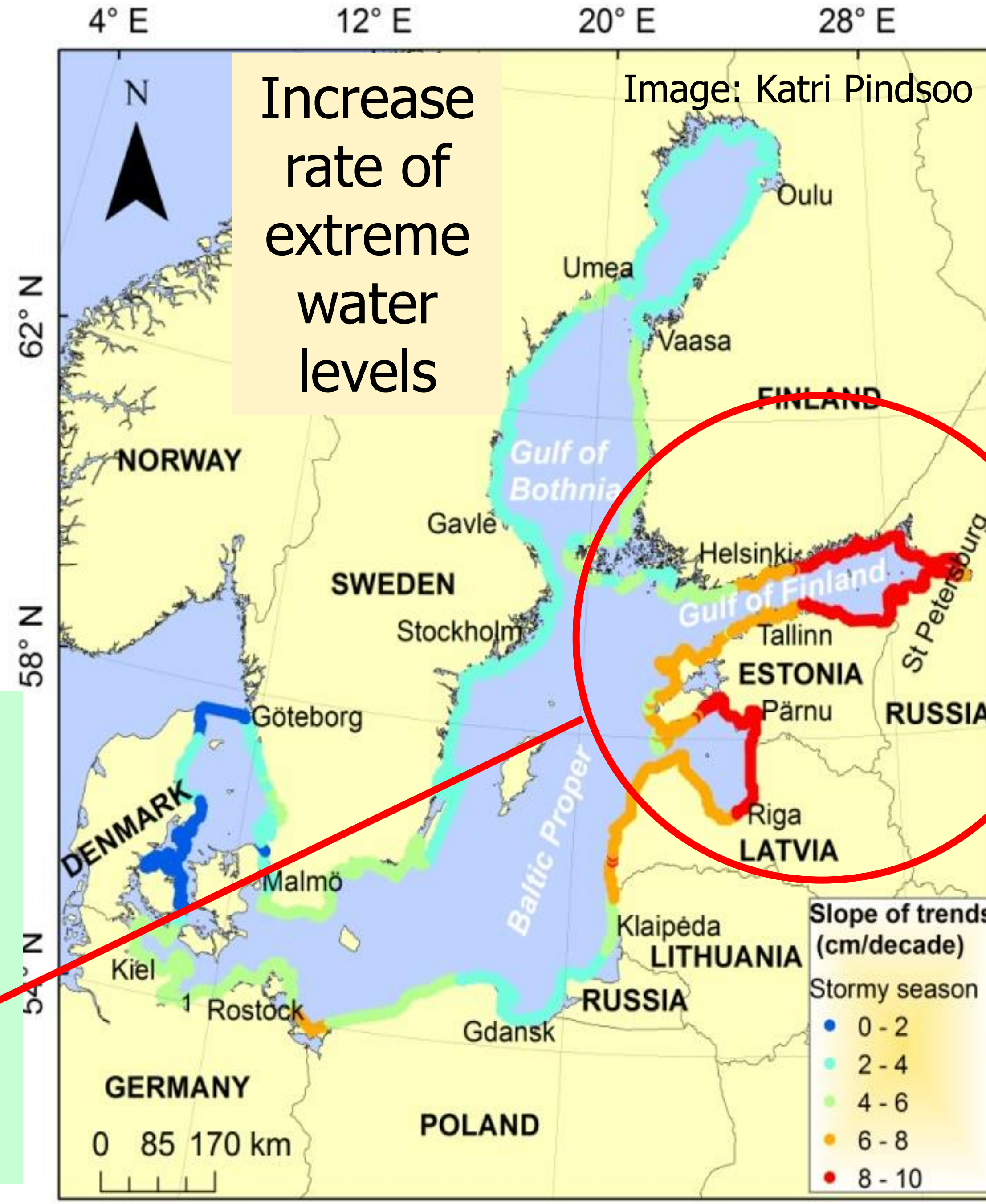
- **Up to 5 times faster than on the open ocean coasts(!?)**



What happens in the rest of the Baltic Sea?

A simple answer: almost nothing

A (non-scientific) conclusion:
The focal point of climate changes is the Gulf of Finland




Thank you
and have a nice forum!

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Gulf of Finland Co-operation

K. Myrberg, L. Vesikko, M. Raateoja, S. Jernberg

The trilateral Gulf of Finland co-operation

Gulf of Finland
Co-operation

The trilateral Gulf of Finland co-operation

Tallinn, on the 9th October, 2017

Kai Myrberg, Ljudmila Vesikko, Mika Raateoja, Susanna Jernberg

Gulf of Finland Special Issue, Journal of Marine Systems

Gulf of Finland Co-operation

JOURNAL OF MARINE SYSTEMS

ELSEVIER

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Coordination committee meeting March 2017

Gulf of Finland Co-operation

- Acceptance of the expert group members
- Monitoring programme
  - Data exchange will continue as before
- Road Map was acknowledged
- Events for 2017 were acknowledged

GoF declaration

Gulf of Finland Co-operation

- Declaration signed by the ministers of Environment of Estonia, Finland and Russia in spring 2016
- Declaration:
  - Co-operation program
  - Monitoring program
  - Road Map (regular updates)

Trilateral Expert Group

Gulf of Finland Co-operation

Eutrophication	Harri	Kuosa	Finnish Environment Institute (SYKE)	FIN
	Tatiana	Eremina	Russian State Hydrometeorological University (RSHU)	RUS
	Inga	Lips	Marine Systems Institute, Tallinn University of Technology	EST
Biodiversity	Kirsi	Kostamo	Finnish Environment Institute (SYKE)	FIN
	Sergei	Golubkov	Zoological Institute RAS	RUS
	Georg	Martin	University of Tartu	EST
Geodiversity	Aarno	Kotilainen	Geological Survey of Finland	FIN
	Darya	Ryabchuk	A. P. Karpinsky Russian Geological Research Institute (VSEGEI)	RUS
	Sten	Suuroja	Geological Survey of Estonia	EST
Pollution and Ecosystem Health	Kari	Lehtonen	Finnish Environment Institute (SYKE)	FIN
	Aleksandr	Rybalko	Vniioceangeologia	RUS
	Mailis	Laht	Estonian Environmental Research Centre	EST
Fish and fisheries	Tapani	Pakarinen	Natural Resources Institute Finland (LUKE)	FIN
	Andrey	Pedchenko	State research Institute of Lakes and Rivers Fisheries	RUS
	Tiit	Raid	University of Tartu	EST
Maritime safety	Jorma	Rytkönen	Finnish Environment Institute (SYKE)	FIN
	Sergey	Aysinov	Admiral Makarov State University of Maritime and Inland Shipping	RUS
	Tarmo	Kõuts	Marine Systems Institute, Tallinn University of Technology	EST
Maritime spatial planning (MSP)	Frank	Hering	Centres for Economic Development, Transport and the	FIN
	Oleg	Korneev	Marine Geological Prospecting Subdivision of JSC "Rosgeo"	RUS
	Robert	Aps	University of Tartu	EST
Climate change	Markku	Viitasalo	Finnish Environment Institute (SYKE)	FIN
	Vladimir	Ryabchenko	P.P. Shirshov Institute of Oceanology RAS SPB Branch	RUS
	Taavi	Liblik	Marine Systems Institute, Tallinn University of Technology	EST
Monitoring	Heikki	Pitkänen	Finnish Environment Institute (SYKE)	FIN
	Tatyana	Zagrebina	North-West Administration for Hydrometeorology and Environmental Monitoring	RUS
	Urmas	Lips	Marine Systems Institute, Tallinn University of Technology	EST

Road Map

Gulf of Finland Co-operation

Research themes:

- Eutrophication
- Biological and geological diversity
- Pollution and Ecosystem Health
- Fish and fisheries
- Maritime safety
- Maritime spatial planning
- Climate change
- Monitoring

Main findings of the research themes

Recommendations based on the GOF assessment (incl. monitoring)

Road Map

lists the concrete steps to improve the state of the GOF

The Road Map is a living document - the 2nd version March 2017

Gulf of Finland Co-operation

- One — GOF Expert Group — Updates
- Two — GOF Secretariat — Editing
- Three — Ministries — Priorities
- Four — GOF Co-ordination Committee — Acknowledgement

Monitoring programme will ensure...

Gulf of Finland
Co-operation

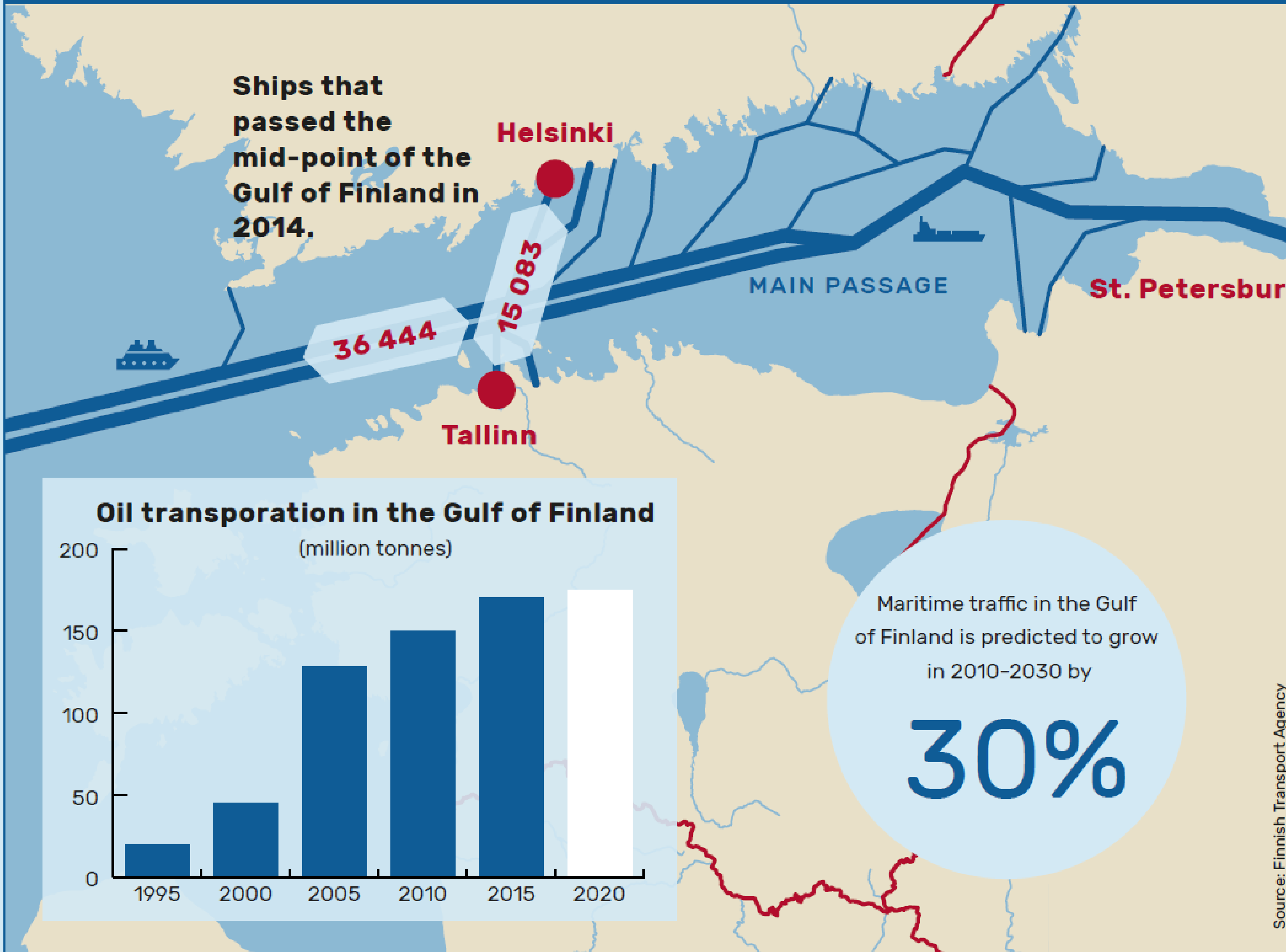
- Data exchange between the three countries
- Based on the jointly collected monitoring data, a joint report will be issued every second year and results will be presented to the Trilateral Co-ordination Committee
- Inter-calibration of measurement methods is carried out on regular basis

Maritime traffic continues to grow in the Gulf of Finland

Maritime traffic continues to grow in the Gulf of Finland

Passenger ferry traffic between Helsinki and Tallinn as well as the crossing oil and cargo traffic along the Gulf form together a densely trafficked area.

Maritime traffic constitutes the biggest environmental threat for the Gulf regardless of advanced surveillance systems monitoring the traffic in the Gulf.



SYKE

Finnish Environment Institute
www.syke.fi/en-US

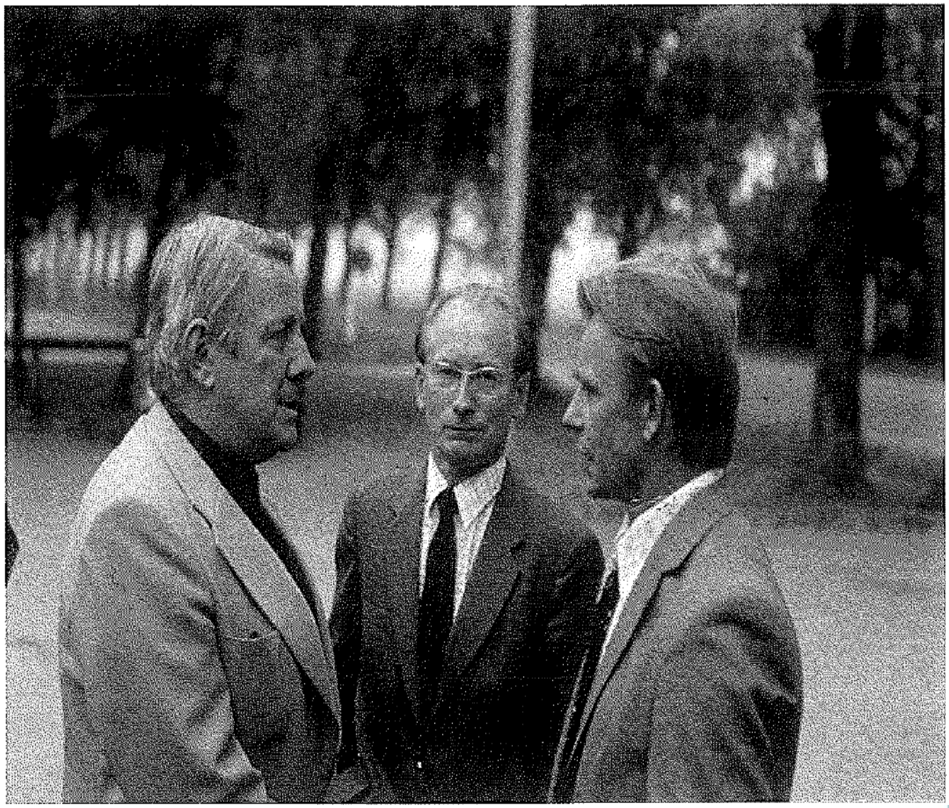
Events 2017

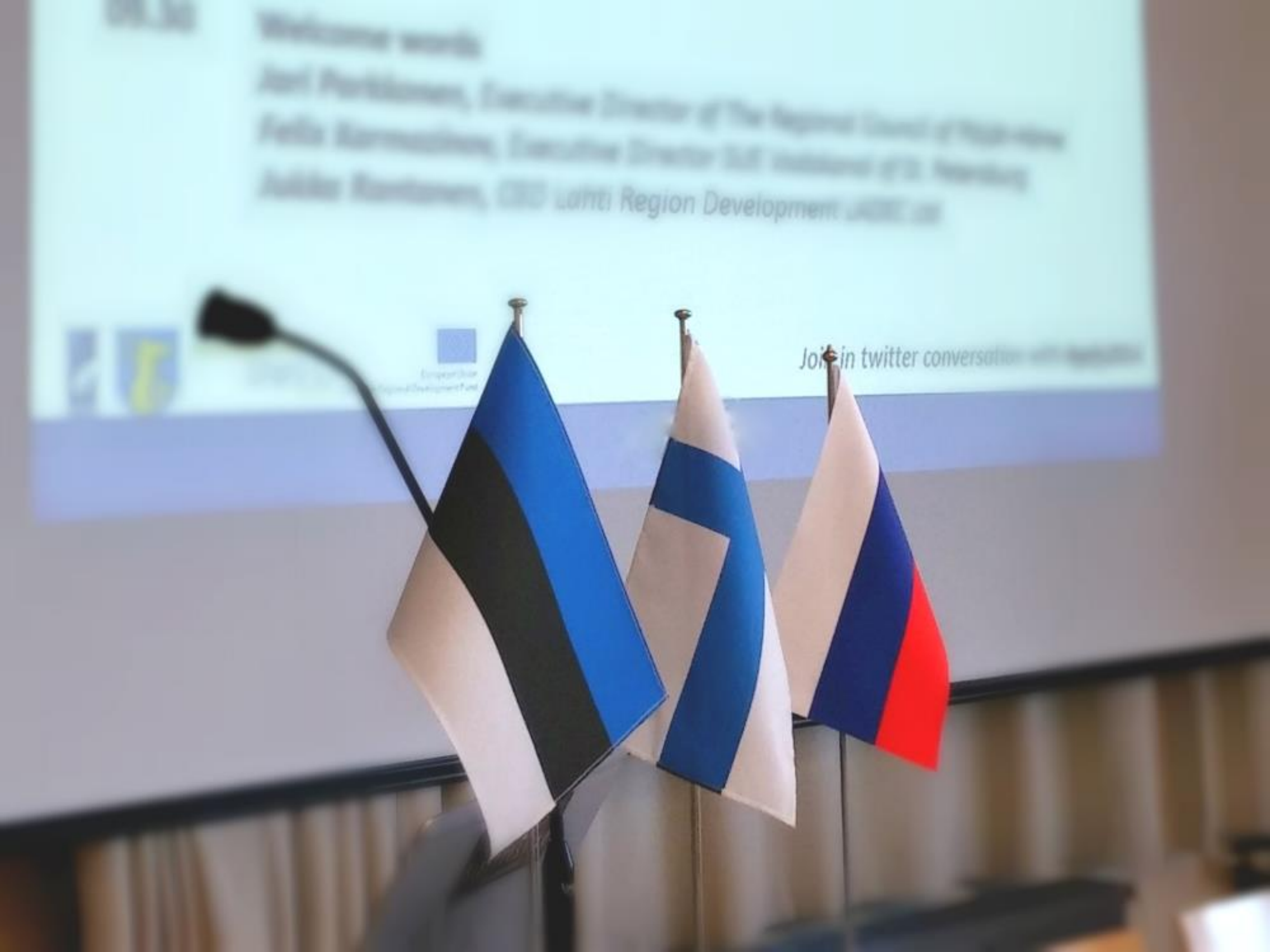
Gulf of Finland Co-operation

- The **nature documentary** Matka Merelle (by Jouni Hiltunen) devoted to the Gulf of Finland had its premiere in Feburary with a Recepetion of the Major of Helsinki
- **Aranda VIP-cruise** for decision-makers was organised in May to make public the info graphs
- Info graphs were made available for citizens during the **Kotka Maritime festival** in July in the Baltic Sea village
- **Environmental Camp** was organised in July at the Island of Aegna
- **GoF Science days** in Tallinn
- **GoF expert group meeting** in November/December in Helsinki

Trilateral work in the next year

- The trilateral cooperation has its **50 years Anniversary** in 2018 which will be celebrated by a specific event
- An inquiry among the GoF network will be carried out
- The trilateral team will participate to the **Baltic Sea Day** in St. Petersburg
- **Coordination committee** meeting will be held
- Infographs will be presented during Helsinki International Boat Show
- Expert group meetings
- **GoF Science Days** in St.Petersburg?




Welcome words
Lahti Region Development
in twitter conversation


I GULF OF FINLAND
Thank you!
Äitah!
Kiitos!
Спасибо !

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E. Pelinovsky, T. Talipova, O. Kurkina, T. Soomere

Modelling of Internal Waves in the Baltic Sea

Modelling of Internal Waves in the Baltic Sea

Efim Pelinovsky

Institute of Applied Physics, Nizhny Novgorod, Russia

Nizhny Novgorod State Technical University

Contributors: Tatiana Talipova, Oxana Kurkina, and Tarmo Soomere

From small scales to large scales –The Gulf of Finland Science Days, 9 October 2017

Outline

1. Observations

2. Theory

3. Modelling

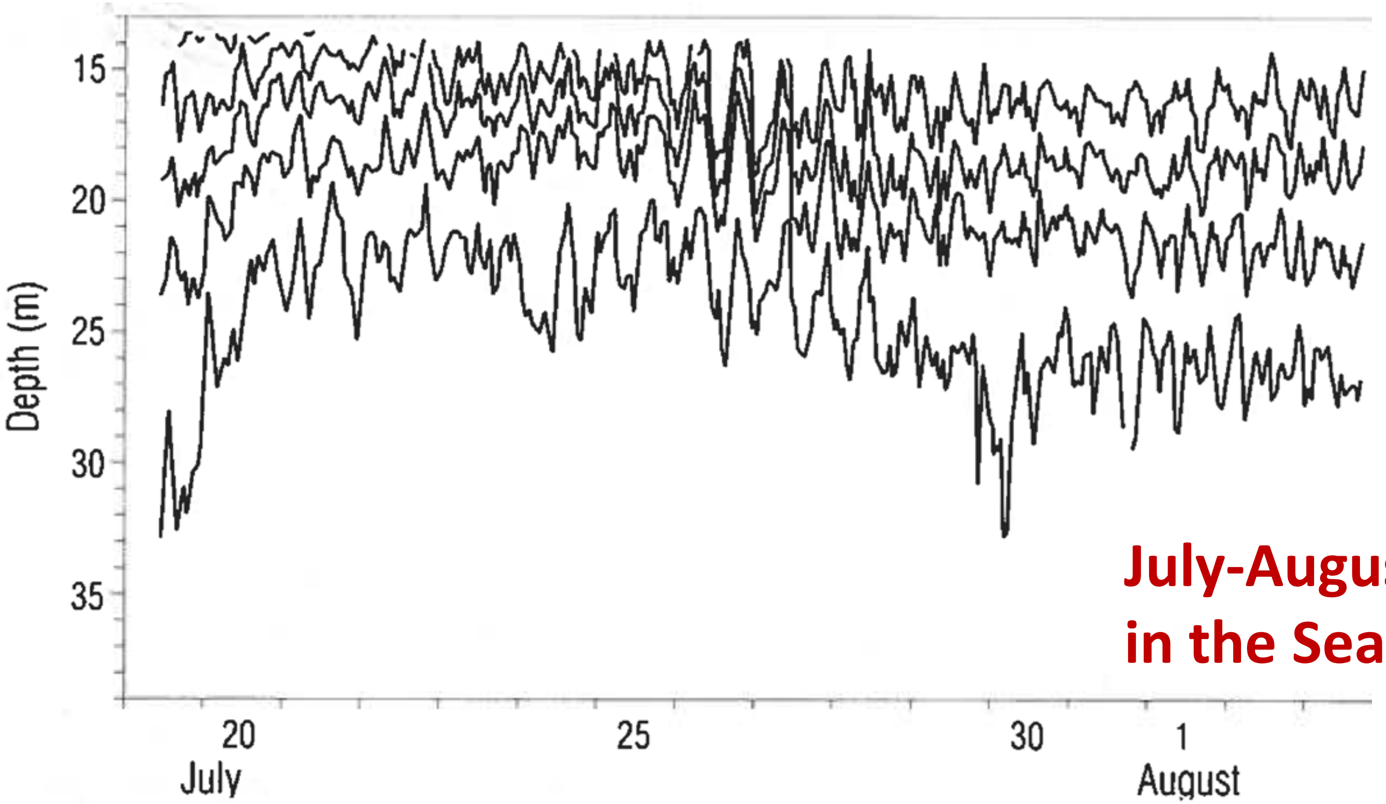
Observations of Internal Waves (IW)

Since the stratification of the Baltic Sea is stable, IWs must be a common feature there, even though the number of studies into such waves is relatively small (Leppäranta and Myrberg, 2009). Several kinds of IWs can exist in this water body because of the variety of forcing factors and the complexity of its bathymetry. The relevant field data are limited. In the existing studies the generation of IWs in the Baltic Sea is mainly explained by the strong winds.

Tidal oscillations of the Baltic Sea level are extremely small: from 4 cm (Klaipeda) up to 10 cm in some sections of the Gulf of Finland (Alenius et al. 1998). The associated current speed, however, cannot be neglected. It reaches about 10 cm/s in the middle of the Gulf of Finland (Lilover, 2012) but still remains much below the level of motions driven by IWs.

Generation of IGWs in microtidal seas is possible due to several other dynamic processes such as the development and relaxation of coastal upwelling, vortices of different scales, surge phenomena, oscillations of hydrological fronts, etc. Several studies are devoted to in situ observations and numerical modelling of the generation and propagation of short-period IWs in microtidal and nontidal seas, based on experimental data obtained by contact probes (Vlasenko et al., 1998).

In-situ measurements in the Baltic Sea show fluctuations in current velocities and motions of isotherms on different timescales (*Leppäranta and Myrberg, 2009*). Periods of 1–30 min have been observed in the Kiel Bight, while periods of 5–6 h have been reported from the Gulf of Finland, the Arcona Basin and the Darss Sill area. The resulting temperature and velocity variations can be quite large.

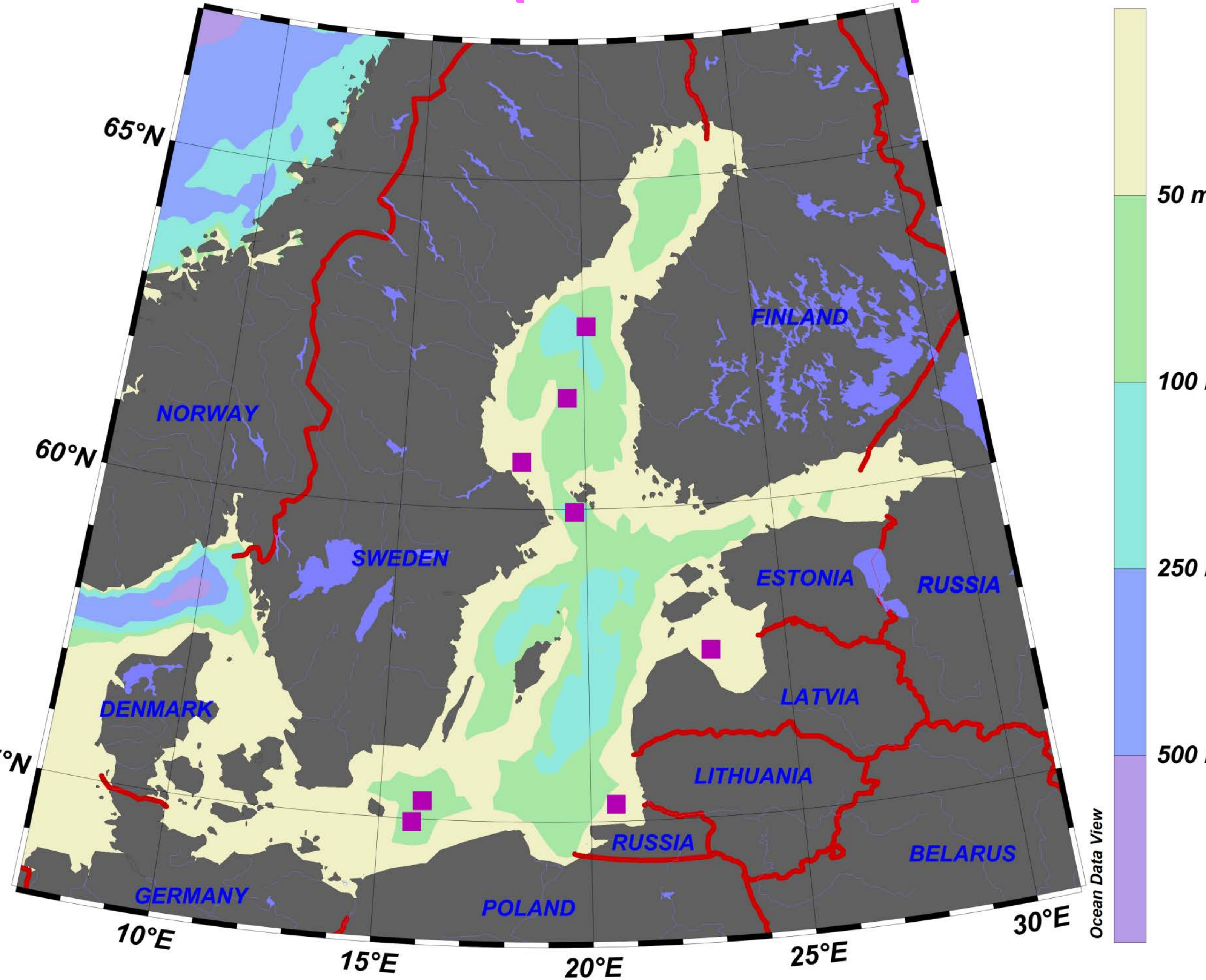


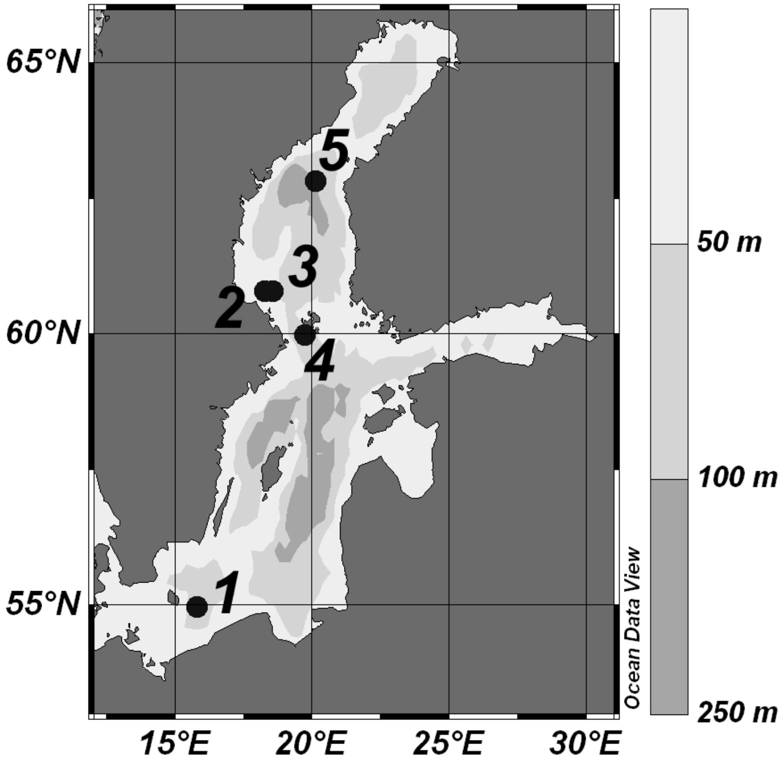
July-August 1978
in the Sea of Bothnia

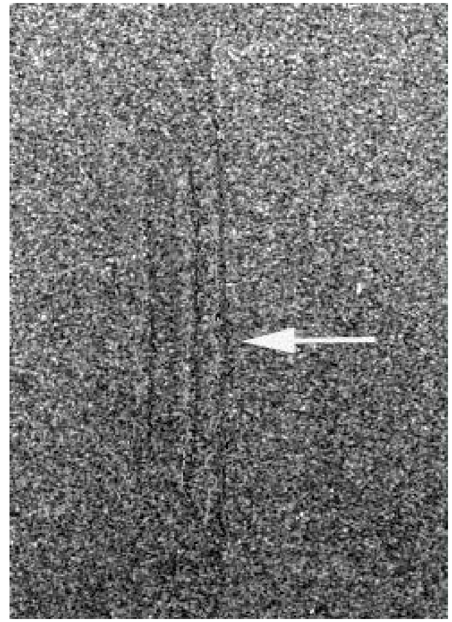
Cyclones providing winds of 10–15 m/s in the Baltic Sea cause the generation of IWs with amplitudes of 11–15 m. The associated current velocities in the upper layer are about 11–15 cm/s and in the lower layer about 5–8 cm/s (Chernysheva, 1987). The characteristics of IWs and internal seiches measured in the Baltic Sea are given in (Kol′chitskii et al., 1996; Golenko and Mel′nikov, 2007). In particular, IWs with periods of 0.1–1 h, observed in the central part of the Gotland Deep formed IW trains with duration of several hours and current amplitudes of about 3 cm/s. IWs in the inertial frequency range can induce currents reaching 20 cm/s.

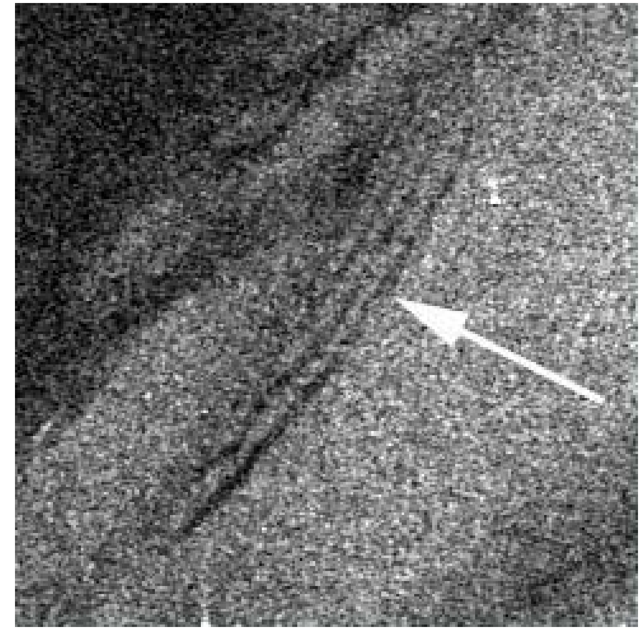
Internal waves in the Baltic Sea cannot be described by the Garrett-Munk spectrum. From *"State and evolution of the Baltic Sea, 1952-2005" by R Feistel, G Nausch, N Wasmund - 2008*

Satellite observations (Lavrova et al)









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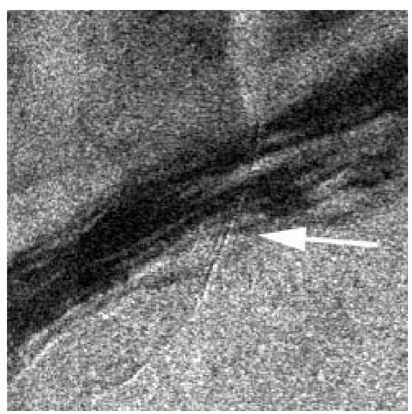
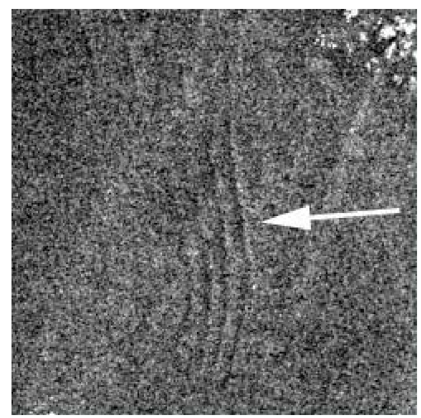
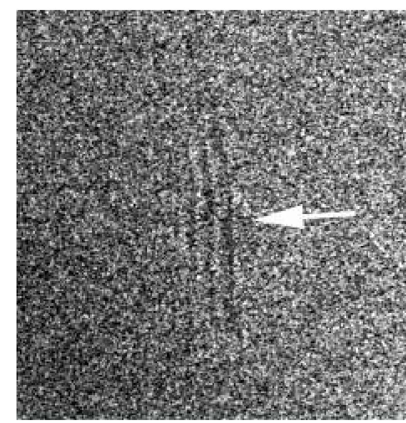






Envisat SAR Images

4

5

Lavrova et al. (2010) detected 11 events of surface manifestations of IWs in the Baltic Proper and in the Gulf of Bothnia and 12 events in the Danish Straits in 2009–2010. The IWs in the Danish Straits are generated by tides. The number of waves in the trains was usually , maximal wavelength did not exceed 1 km, and the length of the leading wave front was less than 25 km. In July 2010 surface manifestations of IWs were periodically detected in the southern part of the Gulf of Bothnia and to the north and north-west of Gotland.

SAR observations of surface manifestations of IWs over the Baltic Sea area are quite difficult because of unstable meteorological conditions. A number of factors such as intensification or weakening of wind (calm, windless regions), development of choppiness, rough sea, algal blooms, heavy precipitation, passage of sharp atmospheric and wind fronts or appearance of atmospheric IWs undermine the identification of surface manifestations of sea IWs. They can be masked by the processes in the near-water layer of the atmosphere (Mityagina and Lavrova, 2010). Therefore it is not surprising that events of surface manifestations of IWs are relatively rare for the Baltic Sea, and that only a few of them were detected from satellite SAR images.

Theory of Nonlinear Internal Waves

The asymptotic theory model used for horizontally variable background is based on the Gardner equation

$$\frac{\partial \varsigma}{\partial x} + (\alpha \varsigma + \alpha_1 \varsigma^2) \frac{\partial \varsigma}{\partial t} + \beta \frac{\partial^3 \varsigma}{\partial t^3} = 0$$

Equation is written in the reference system *t, x-ct*

ζ is vertical displacement of water particles on the mode Φ maximum level, coefficients α, α_1 and β are determined by horizontally variable stratification, depth and vertical mode structure.

Eigenvalue problem for Φ and c

$$\frac{d}{dz}\left[(c - U(z))^2 \frac{d\Phi}{dz} \right] + N(z)^2 \Phi = 0,$$

$$\Phi(0) = \Phi(H) = 0 \qquad \Phi_{max} = 1$$

Nonlinear Correction to Mode Structure

$$\frac{d}{dz}\left[(c-U)^2\frac{dT}{dz}\right]+N^2T=$$

$$=\frac{3}{2}\frac{d}{dz}\left[(c-U)^2\left(\frac{d\Phi}{dz}\right)^2\right]-\alpha\frac{d}{dz}\left[(c-U)\frac{d\Phi}{dz}\right]$$

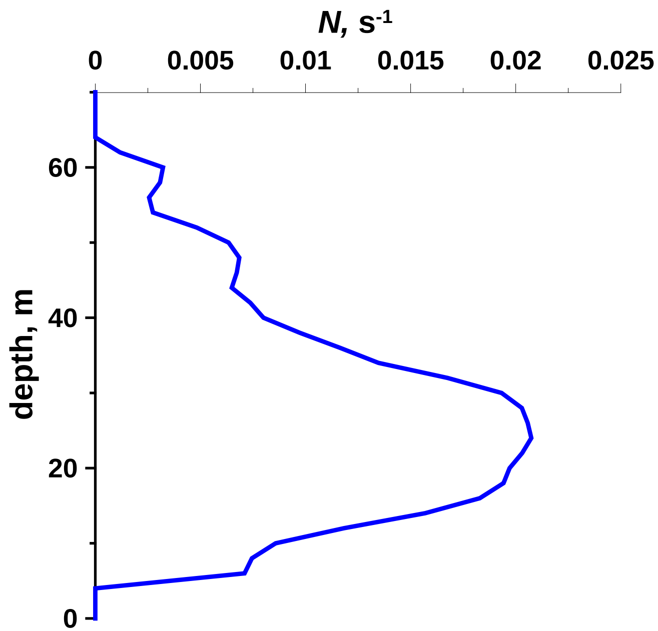
T = 0 *where* z = 0, H

T = 0 *where* Φ(z) = 1

$$\zeta(z,x,t)=\varsigma(x,t)\Phi(z)+\varsigma^2T(z)$$

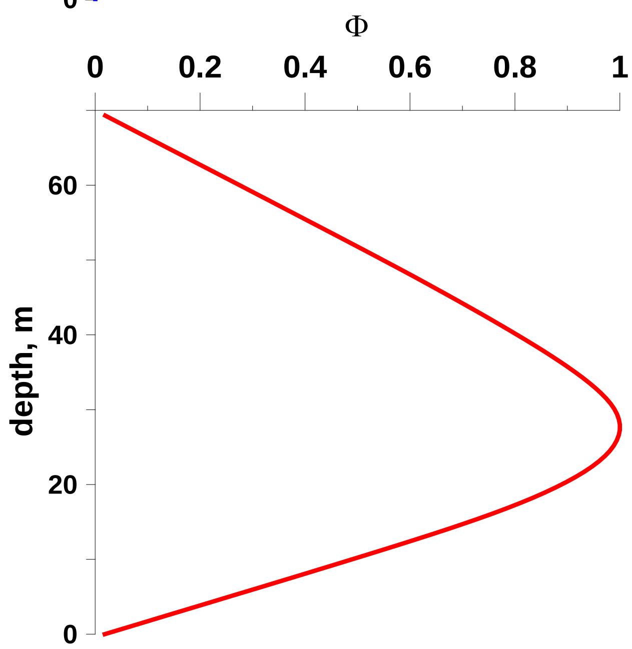
Mode structure

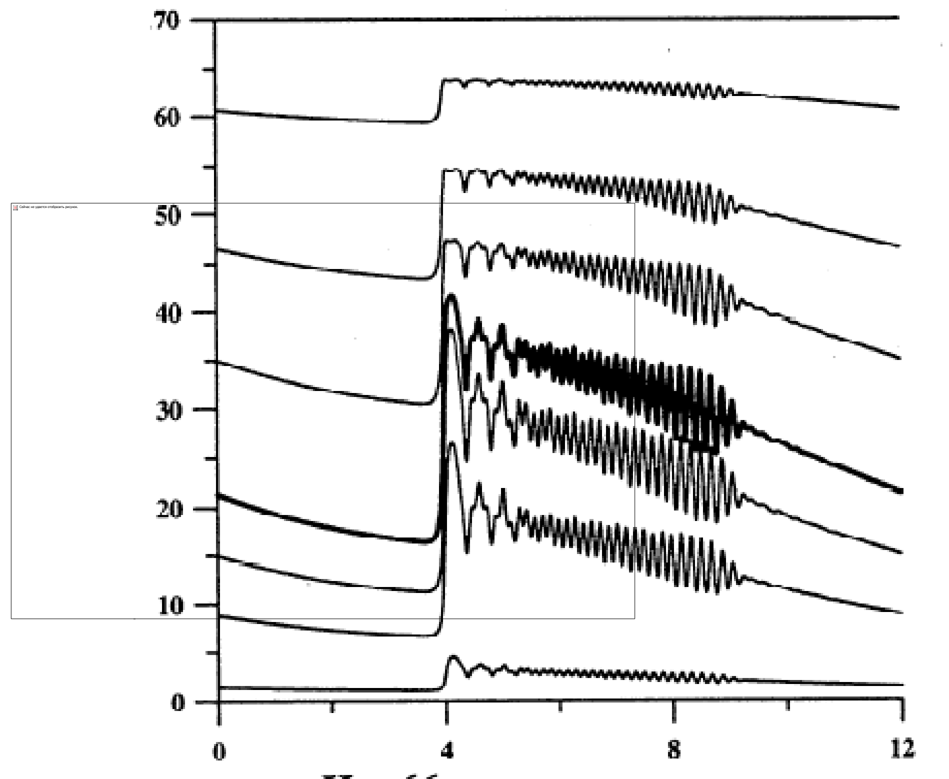
Brunt-Vaisala Frequency



$$N^2(y) = -\frac{g}{\rho_0(y)}\frac{d\rho_0}{dy}$$

The first mode





Model Coefficients

Dispersion

$$\beta = \frac{\int (c-U)^2 \Phi^2 dz}{2\int (c-U)(d\Phi/dz)^2 dz}$$

Quadratic Nonlinearity

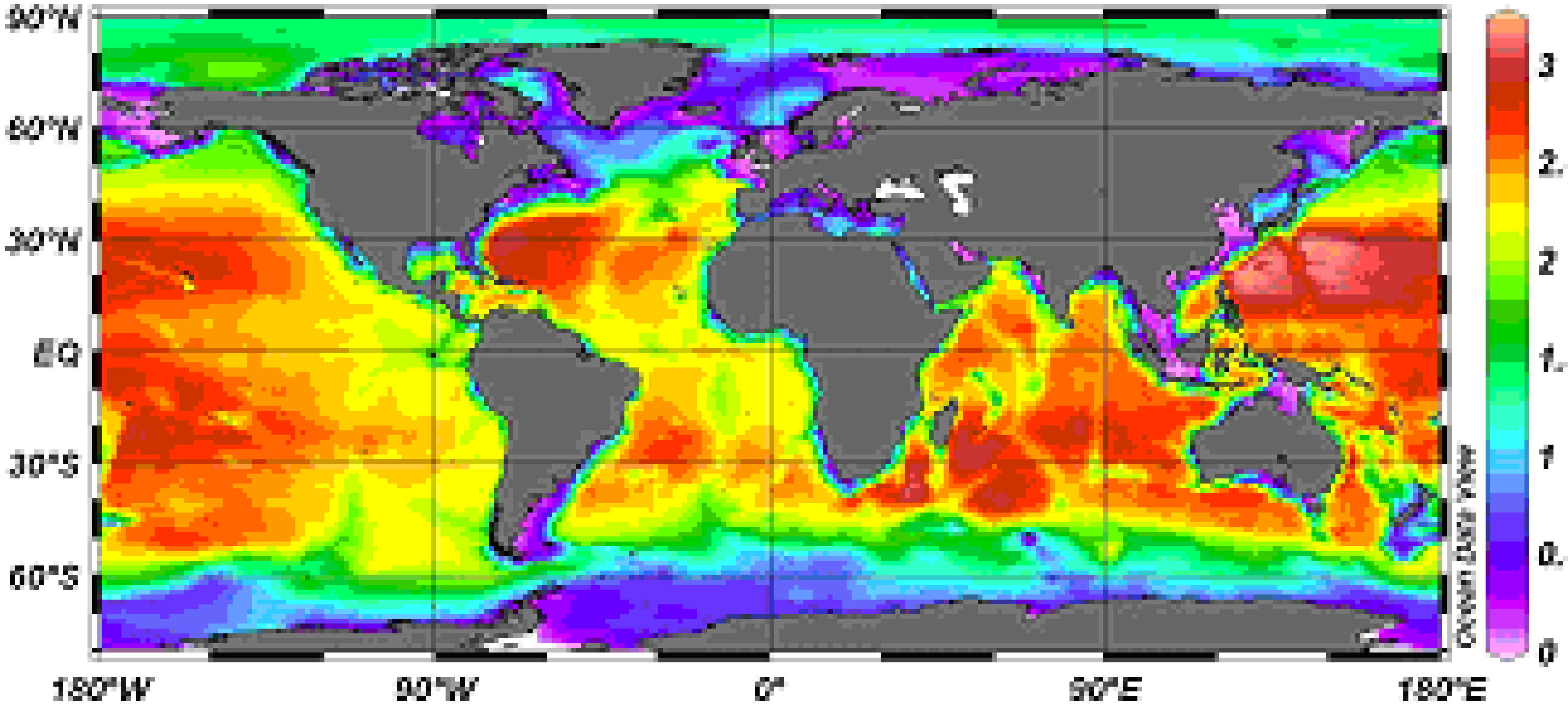
$$\alpha = \frac{3}{2}\frac{\int (c-U)^2 (d\Phi/dz)^3 dz}{\int (c-U)(d\Phi/dz)^2 dz}$$

Cubic nonlinearity

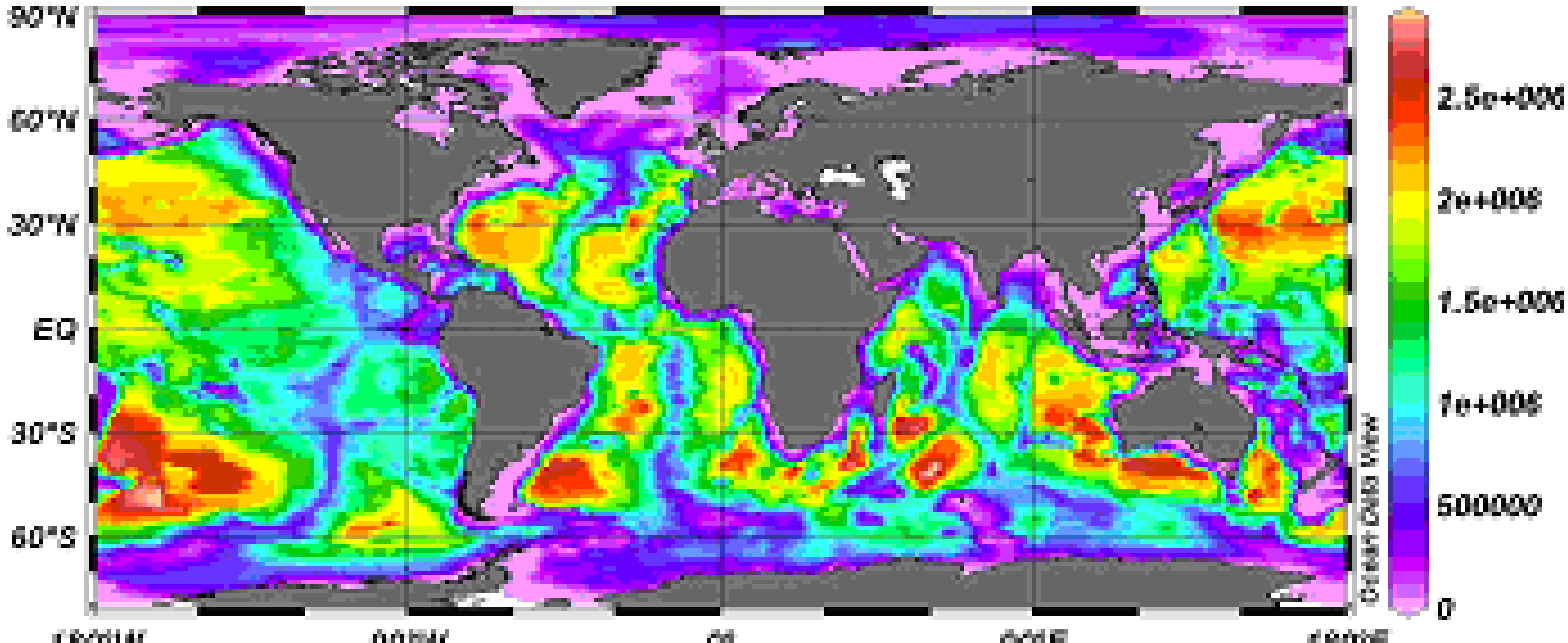
$$\alpha_1 = -\frac{3}{2}\frac{\int \Theta dz}{\int (c-U)(d\Phi/dz)^2 dz}$$

$$\Theta = (c-U)^2 (d\Phi/dz)^2 \left[2(d\Phi/dz)^2 - 3(dT/dz)\right] -$$

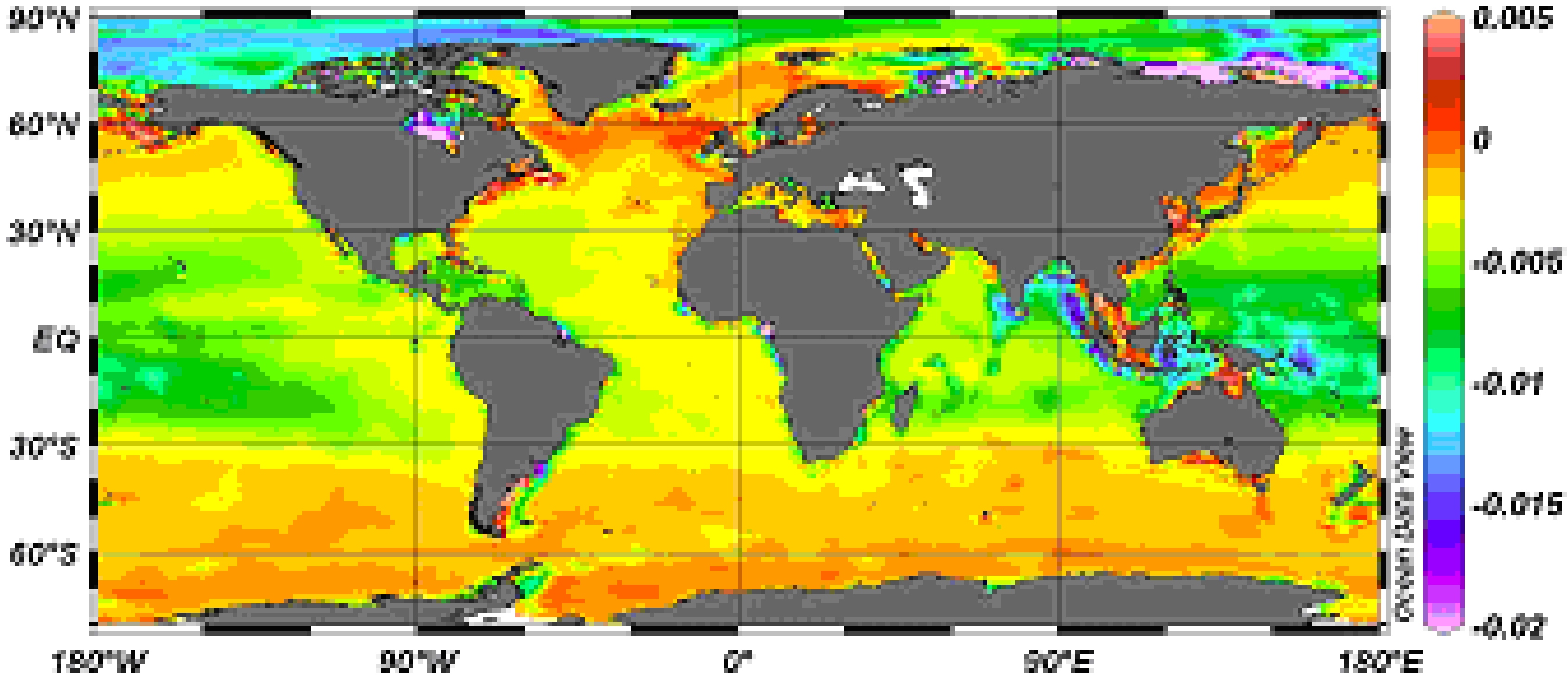
$$-\frac{\alpha}{3}(c-U)(d\Phi/dz)\left[5(d\Phi/dz)^2 - 4(dT/dz)\right] + \frac{\alpha^2}{3}(d\Phi/dz)^2$$



Linear Long Internal Wave Speed, c

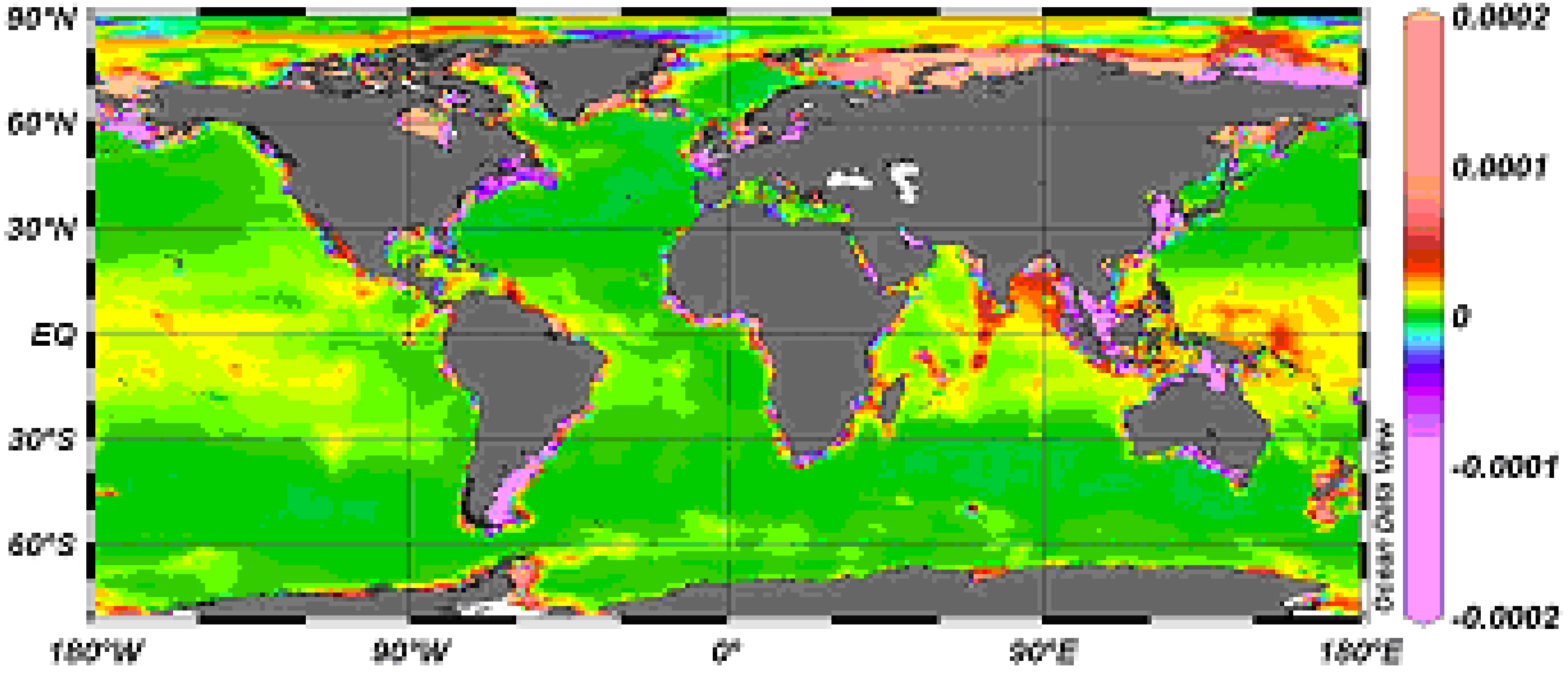


Dispersion Coefficient



Quadratic Nonlinear Term

Varied Sign!



Cubic Nonlinear Term

Varied Sign!

Gardner's Solitons

$$u(x,t) = \frac{A}{1 + B\,\mathrm{ch}(\gamma(x - Vt))},$$

$$A = \frac{6\lambda\gamma^2}{\alpha},$$

$$B^2 = 1 + \frac{6\alpha_1\lambda\gamma^2}{\alpha^2},$$

$$V = \lambda\gamma^2$$

$$\alpha_1 < 0$$

Limited amplitude

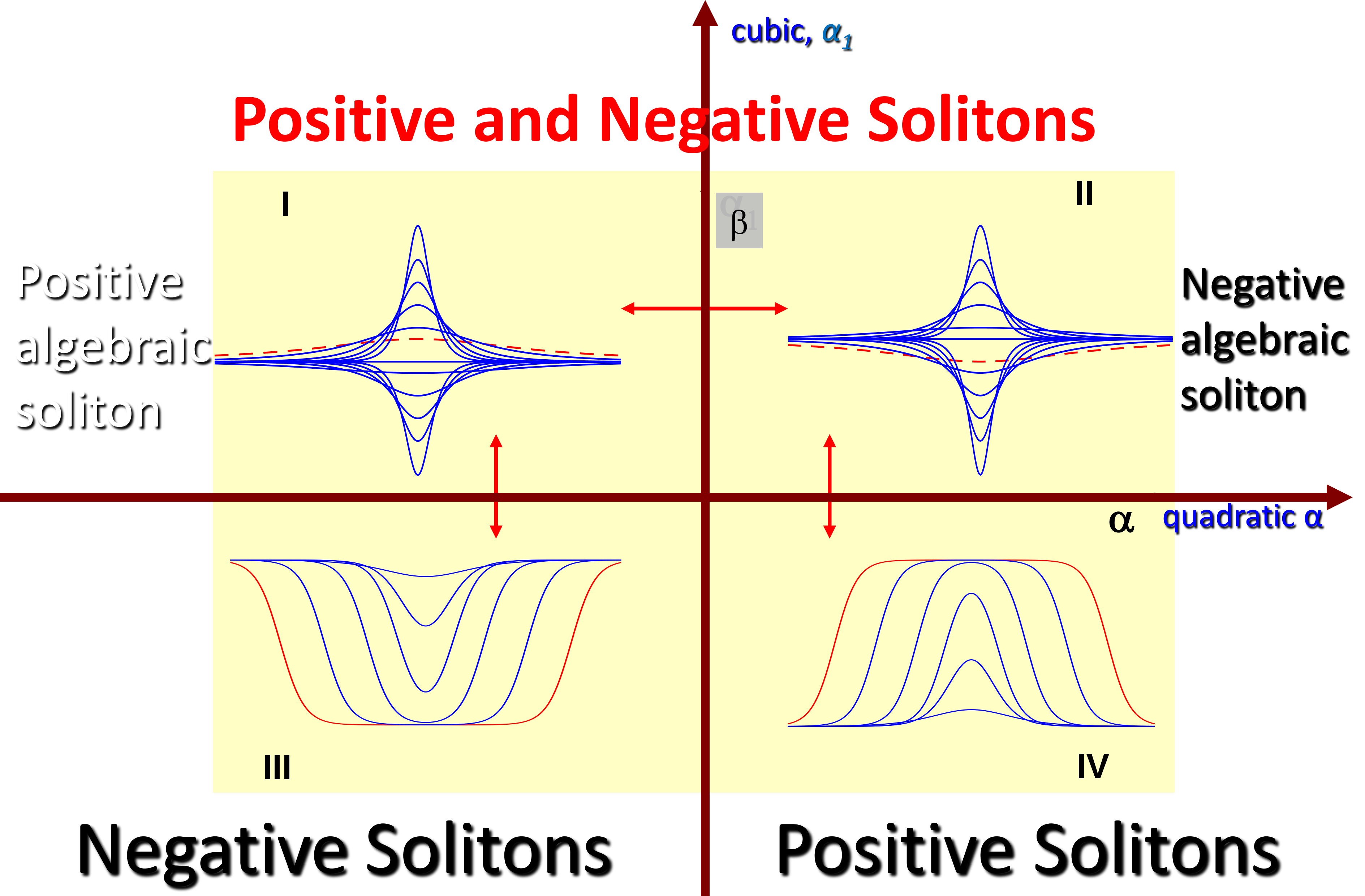
$a_{lim} = -\alpha/\alpha_1$

$$a = \frac{A}{1+B}$$

$$\alpha_1 > 0$$

Two branches of solitons of both polarities, algebraic soliton $a_{lim} = -2\alpha/\alpha_1$

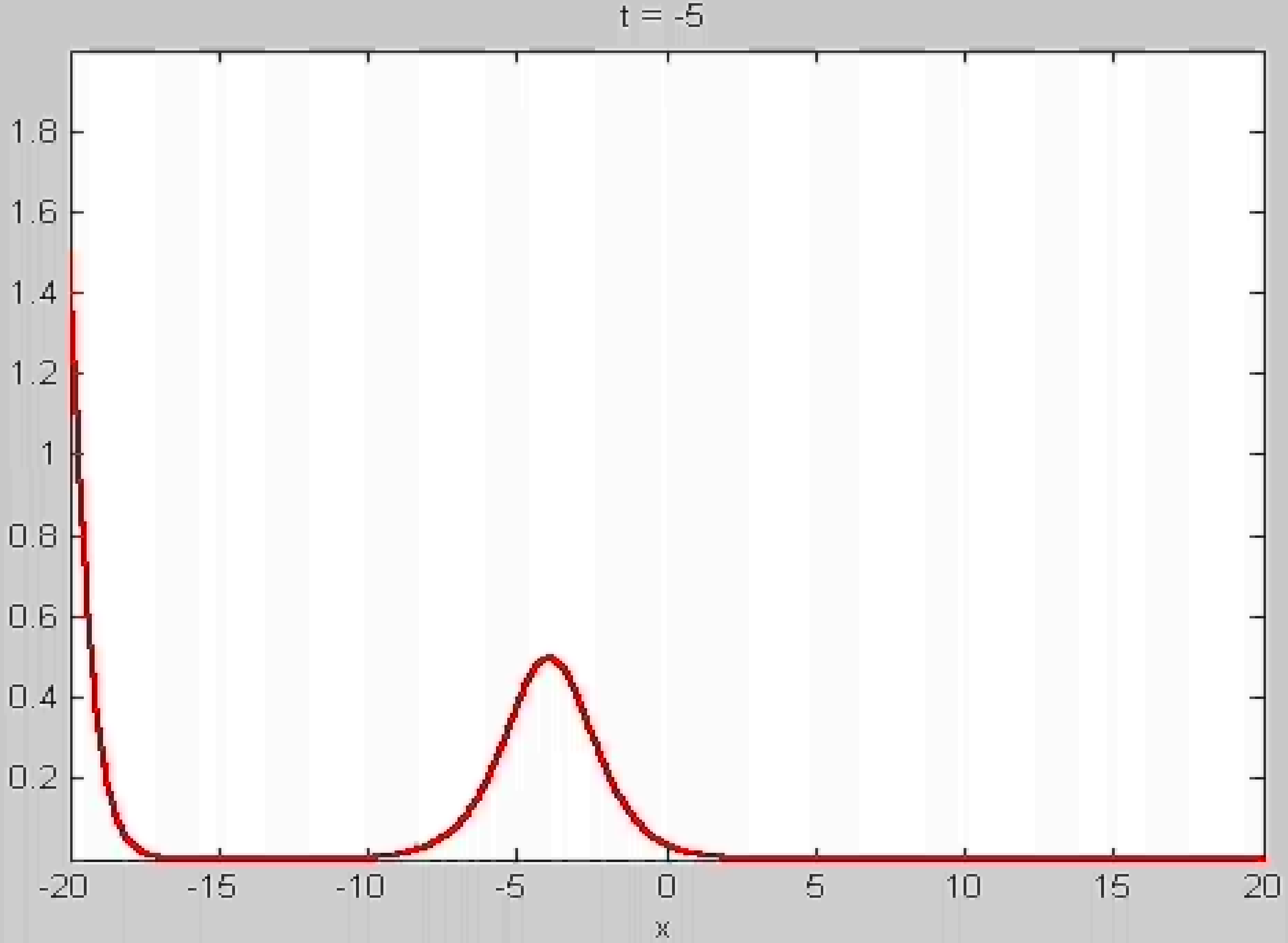
Positive and Negative Solitons



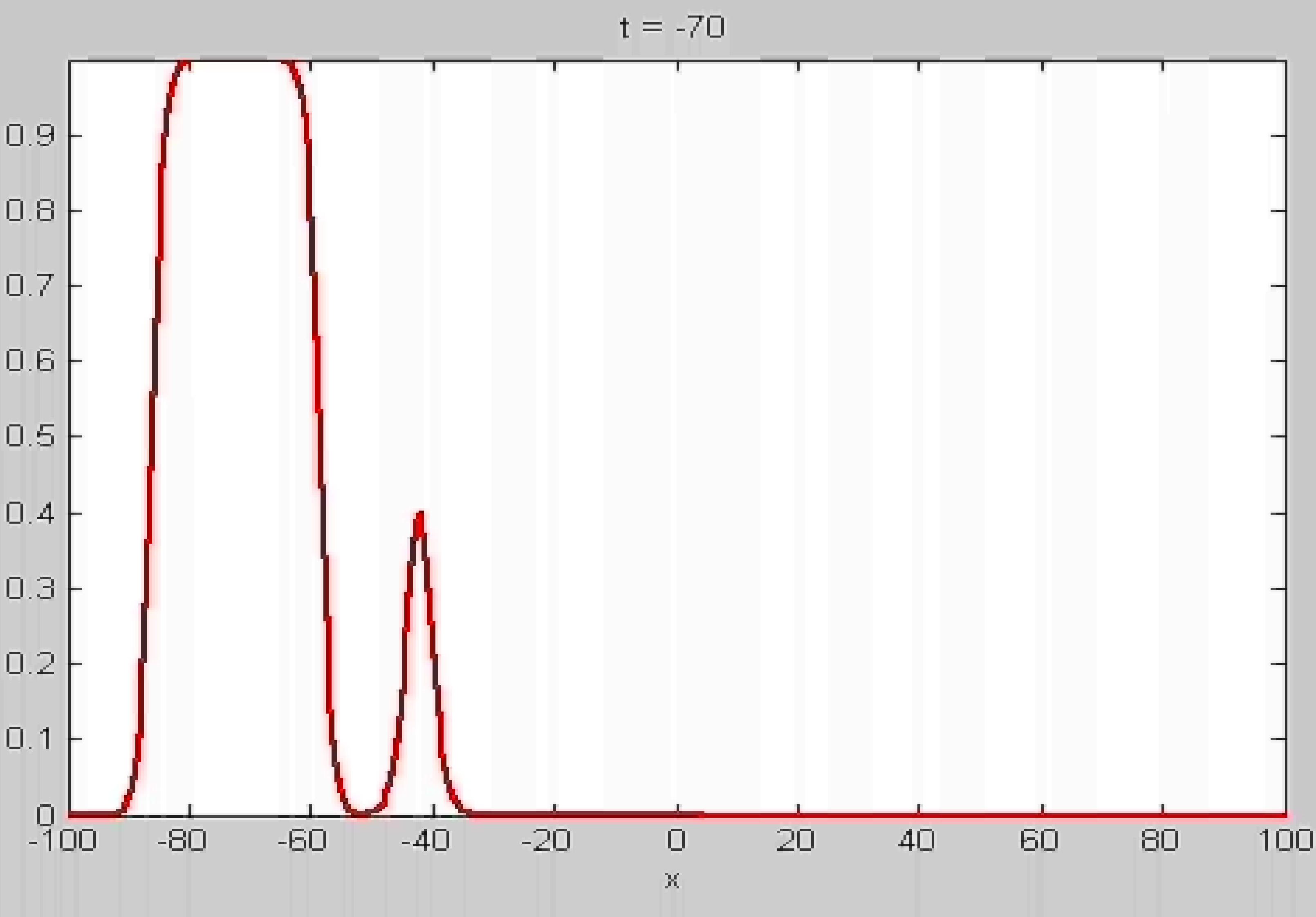
Negative Solitons **Positive Solitons**

Sign of the cubic term is principal!

Exact Two Soliton Solutions: KdV



Exact Two Exact 2 GE (negative cubic term): $\alpha_1 < 0$



Gardner's Breathers

cubic, $\alpha_1 > 0$

λ = 1, α = 12q, α_1 = 6, where q is arbitrary)

$$u = 2\frac{\partial}{\partial x}\,\mathrm{atan}\,\frac{l\,\mathrm{ch}(\Psi)\cos(\theta) - k\cos(\Phi)\mathrm{sh}(\kappa)}{l\,\mathrm{sh}(\Psi)\sin(\theta) + k\sin(\Phi)\mathrm{ch}(\kappa)}$$

θ and κ are the phases of carrier wave and envelope

$$\theta = k(x - wt) + \theta_0\,, \quad \kappa = l(x - vt) + \kappa_0$$

propagating with speeds

$$w = -k^2 + 3l^2\,, \quad v = -3k^2 + l^2$$

There are 4 free parameters: θ_0, κ_0 and two energetic parameters

Pelinovsky D&Grimshaw, 1997

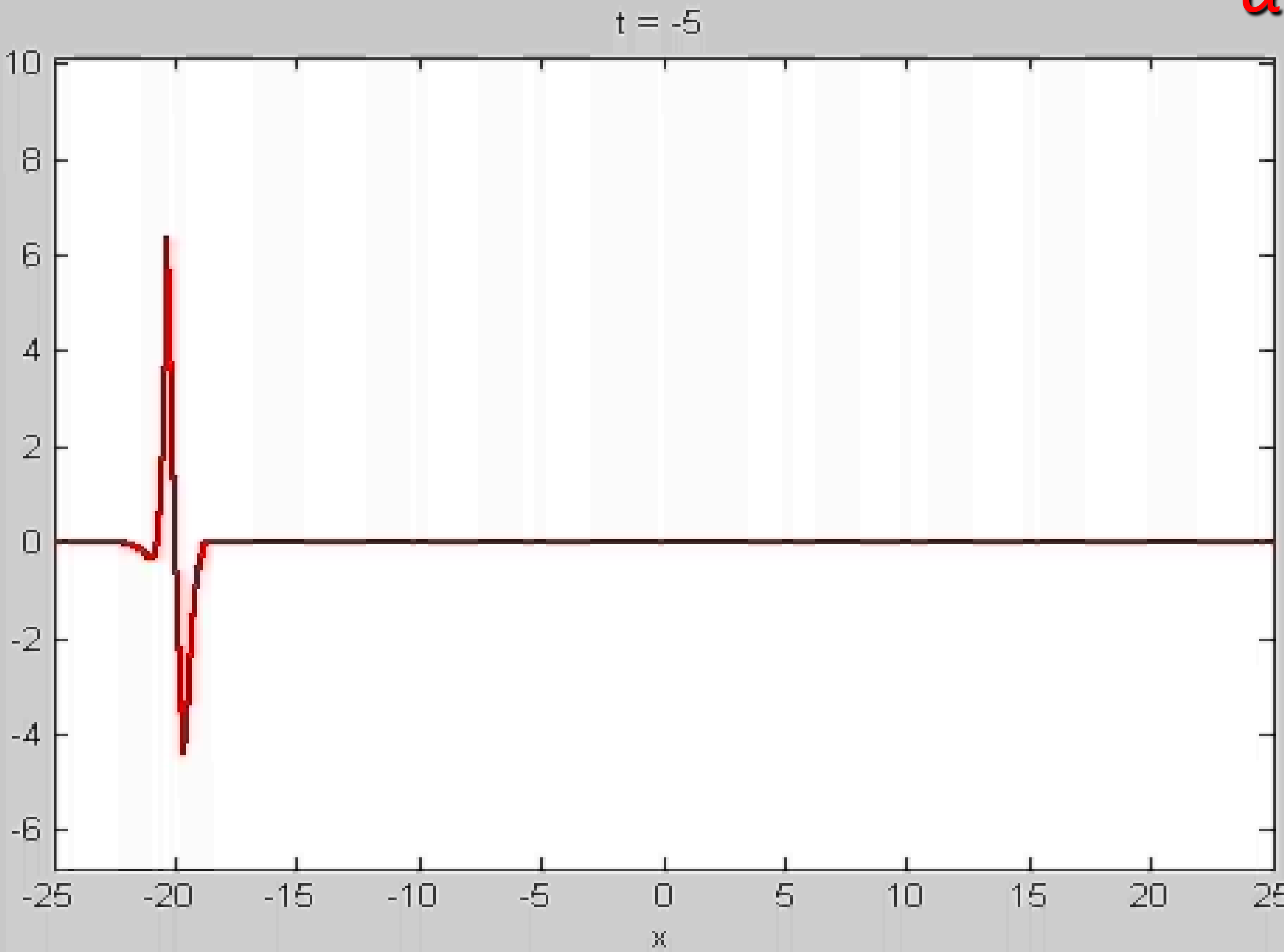
$$\Phi + i\Psi = tg^{-1}\left[\frac{l + ik}{2q}\right]$$

$$k = q\frac{\mathrm{sh}(2\Psi)}{\cos^2(\Phi)\mathrm{ch}^2(\Psi) + \sin^2(\Phi)\mathrm{sh}^2(\Psi)}$$

$$l = q\frac{\sin(2\Phi)}{\cos^2(\Phi)\mathrm{ch}^2(\Psi) + \sin^2(\Phi)\mathrm{sh}^2(\Psi)}$$

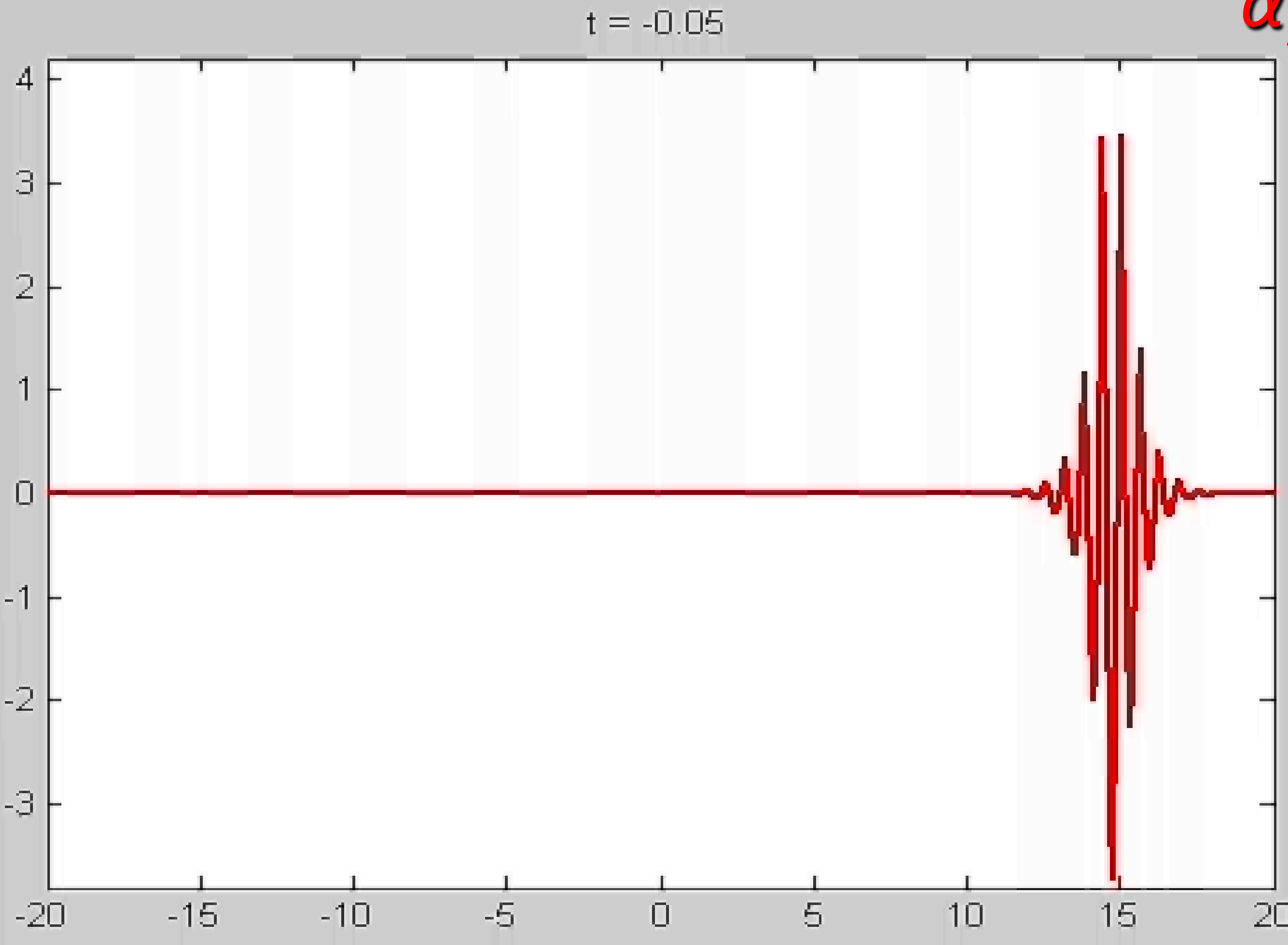
Breathers: positive cubic term

$\alpha_1 > 0$

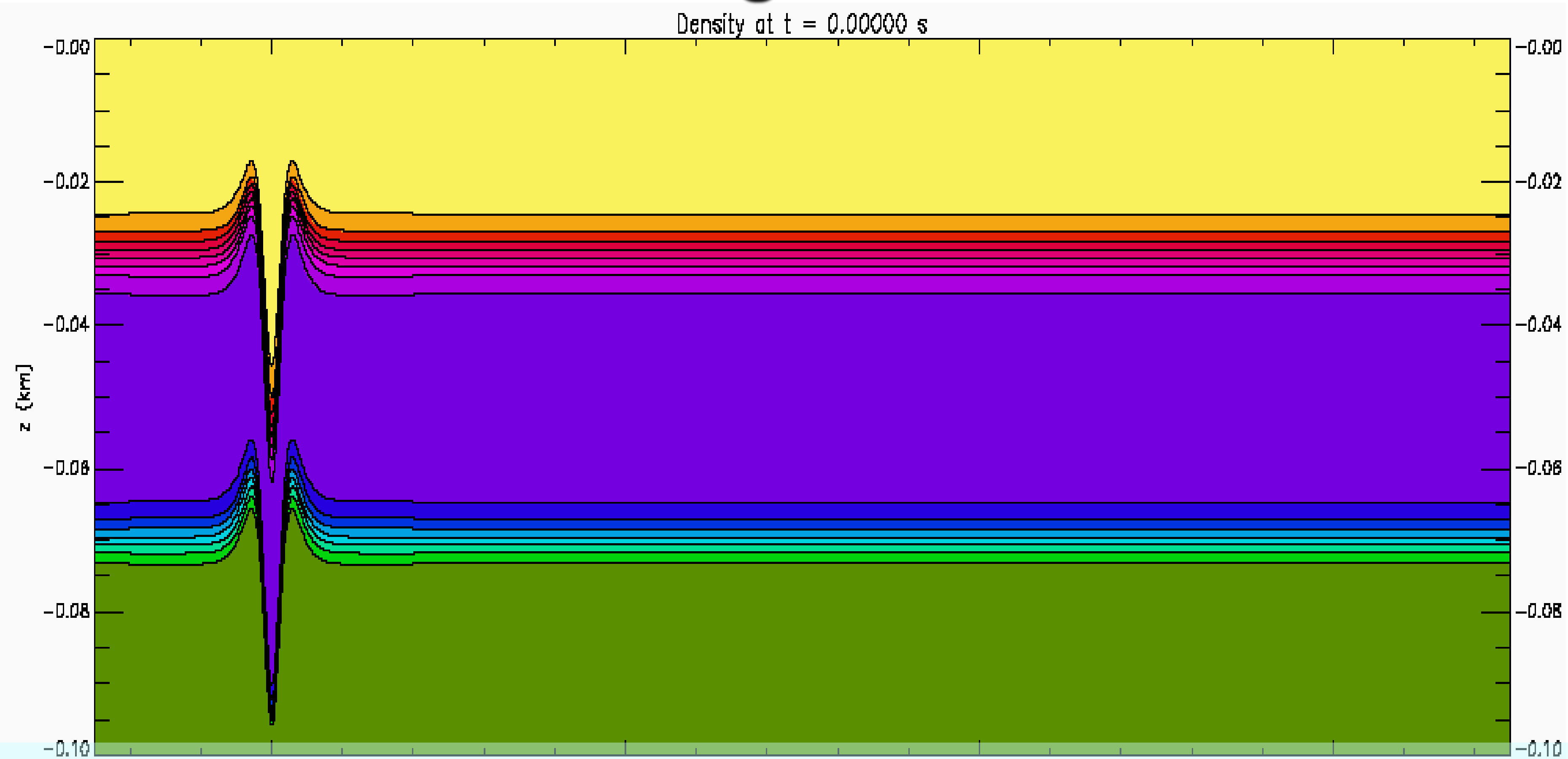


Breathers: positive cubic term

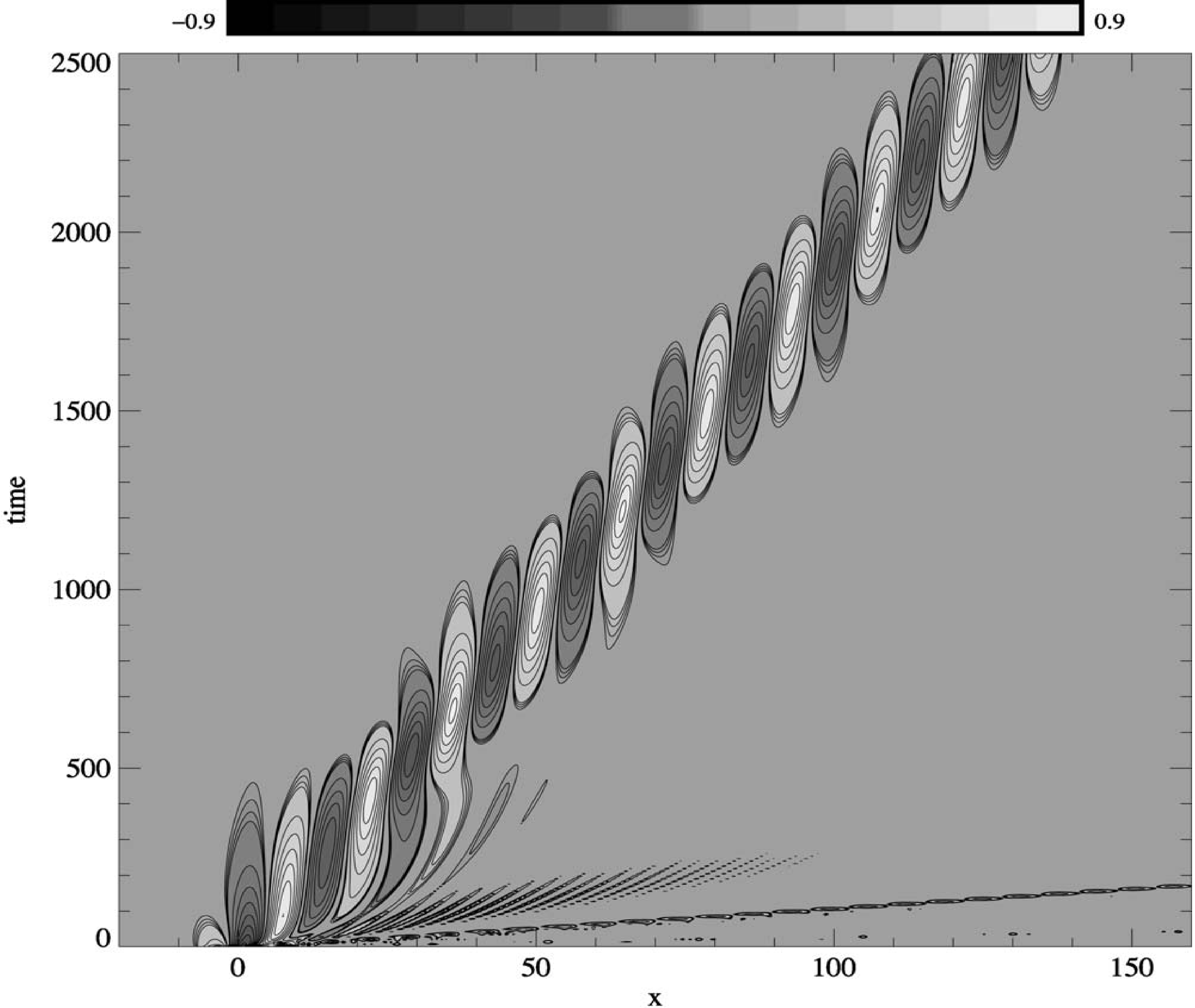
$\alpha_1 > 0$



Numerical (Euler Equations) modeling of breather

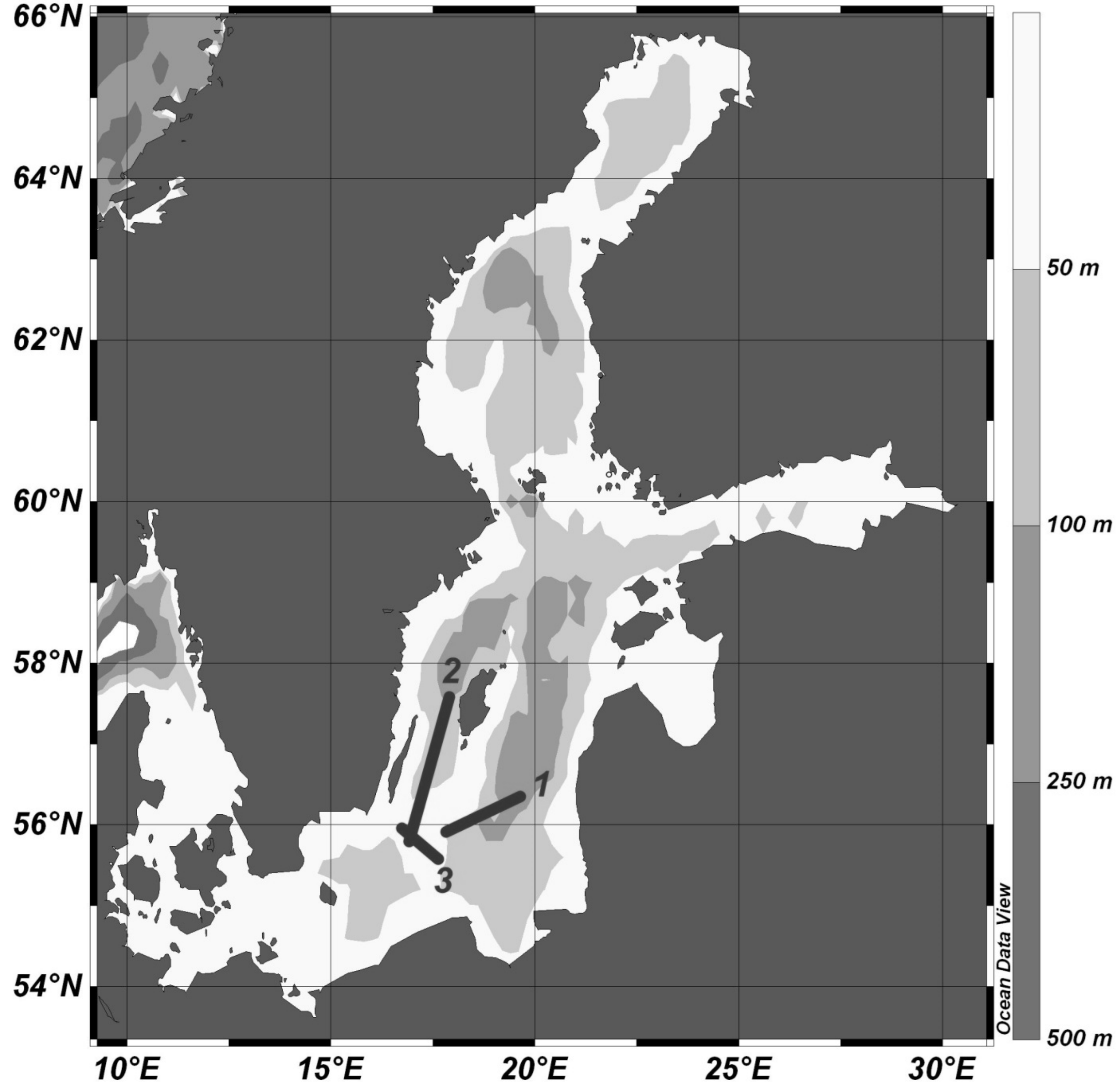


K. Lamb, O. Polukhina, T. Talipova, E. Pelinovsky, W. Xiao, A. Kurkin. Breather Generation in the Fully Nonlinear Models of a Stratified Fluid. *Physical Rev. E*. 2007, 75, 4, 046306

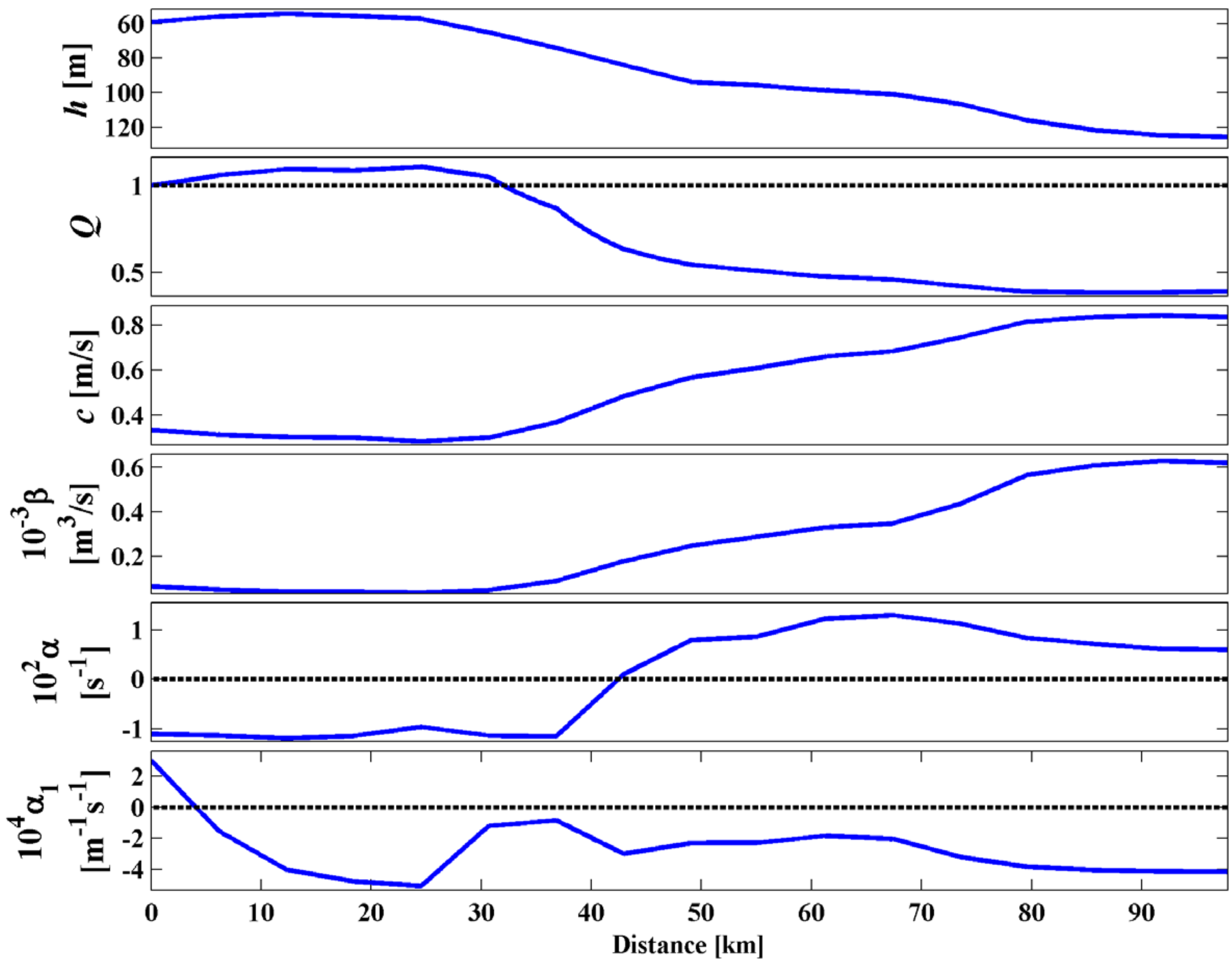


−0.9
0.9
2500
2000
1500
1000
500
0
time
0
50
100
150
x

Modelling of internal solitons and breathers

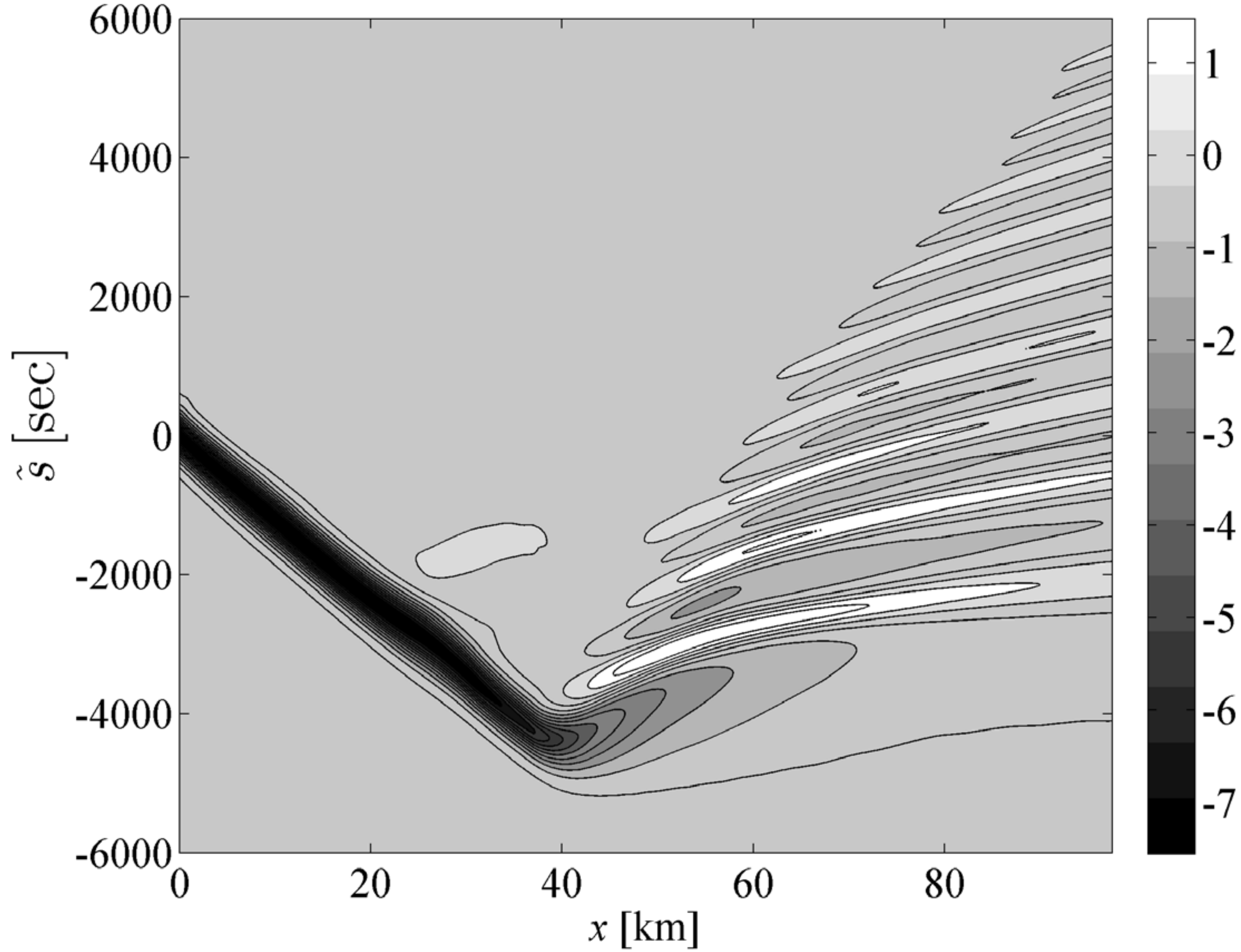


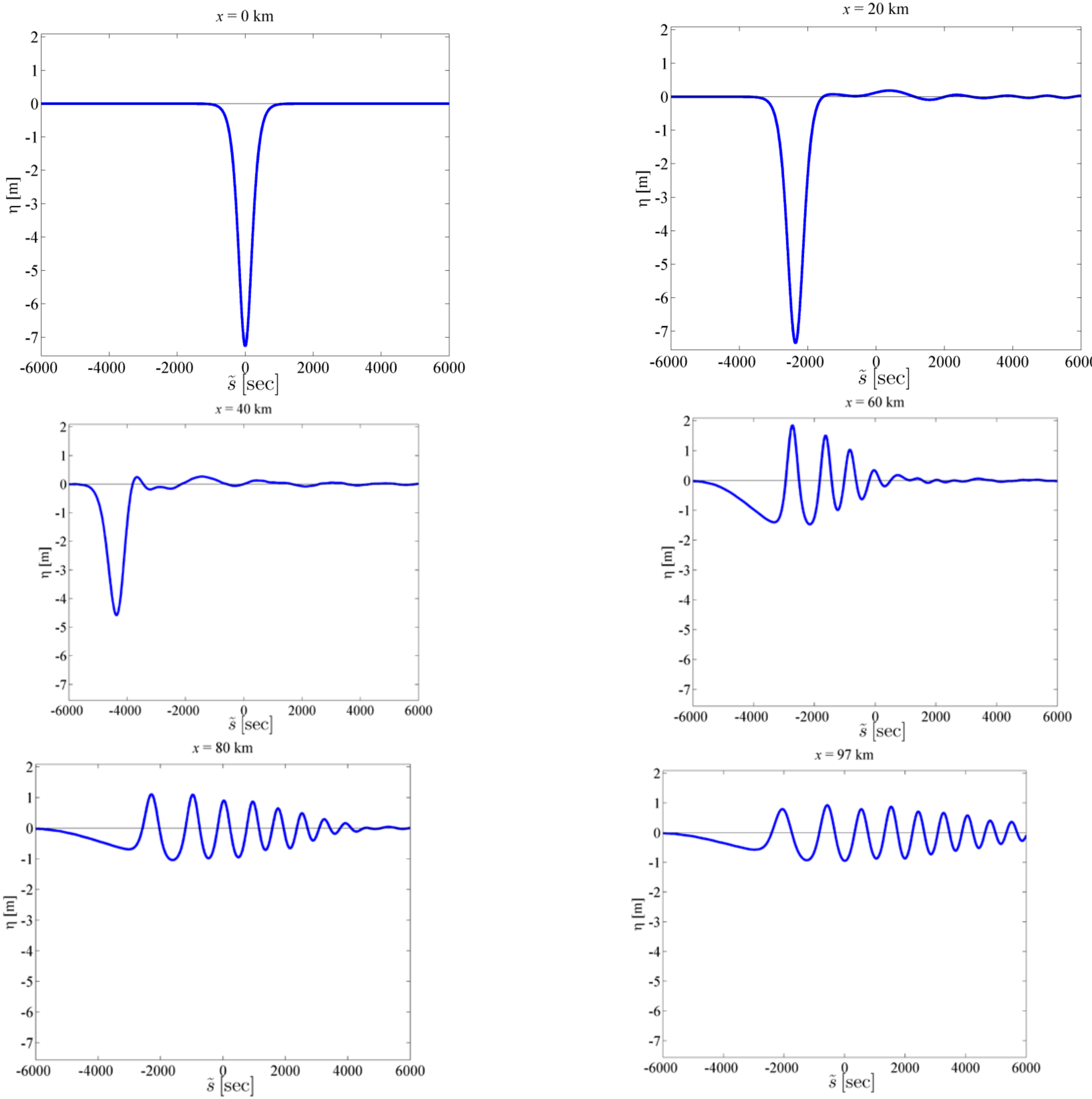
Coefficients, section 1



Change Signs!!!

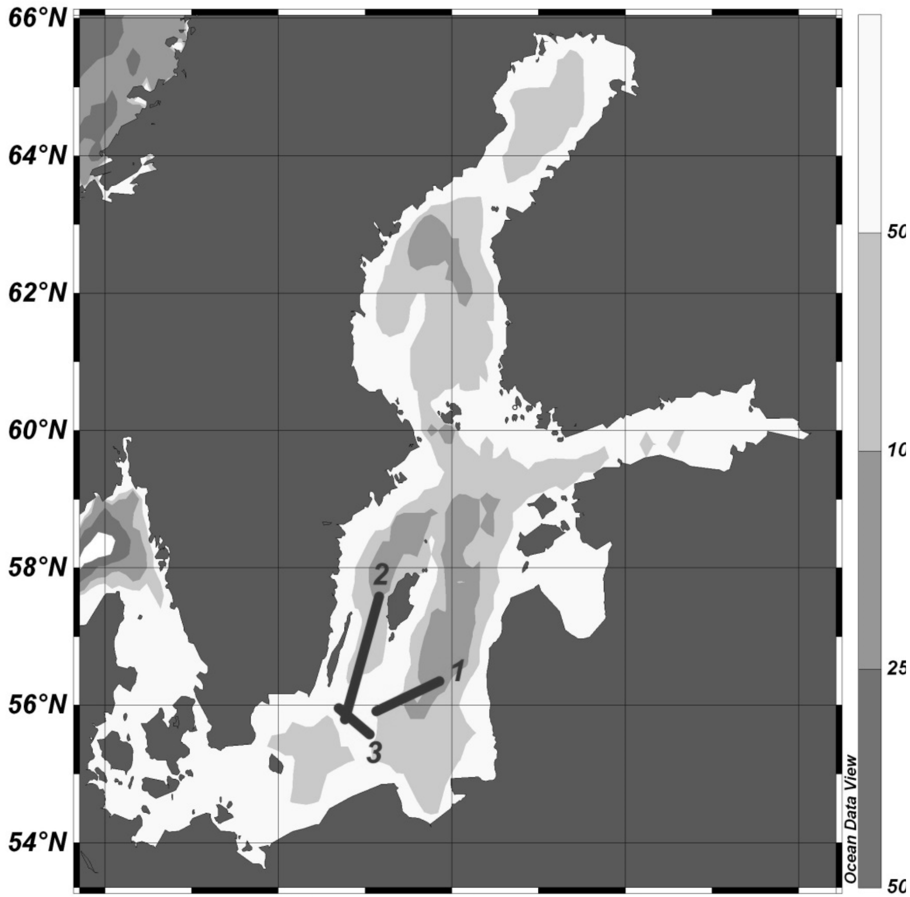
x-t diagram. Soliton into Breather

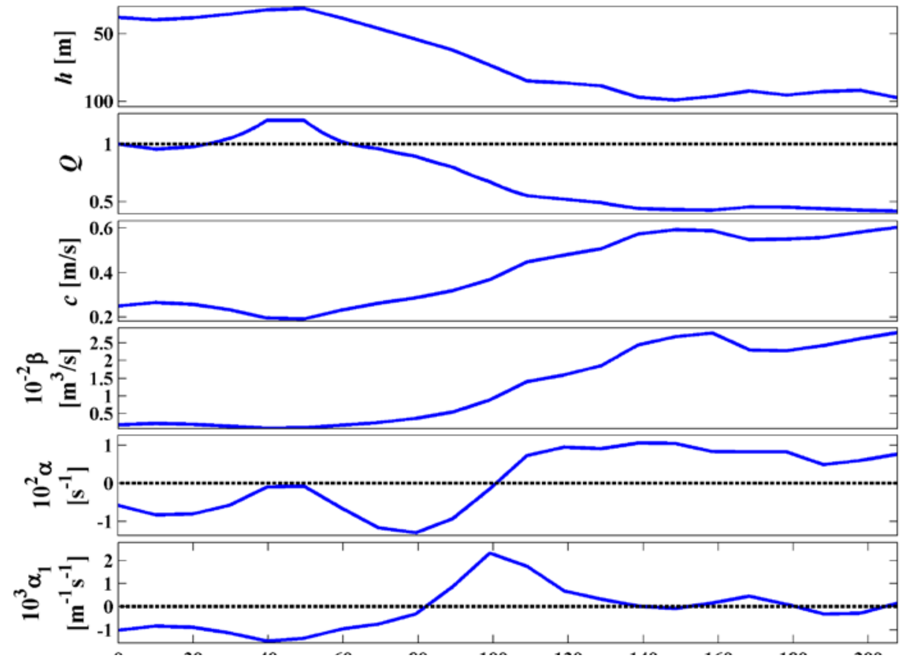


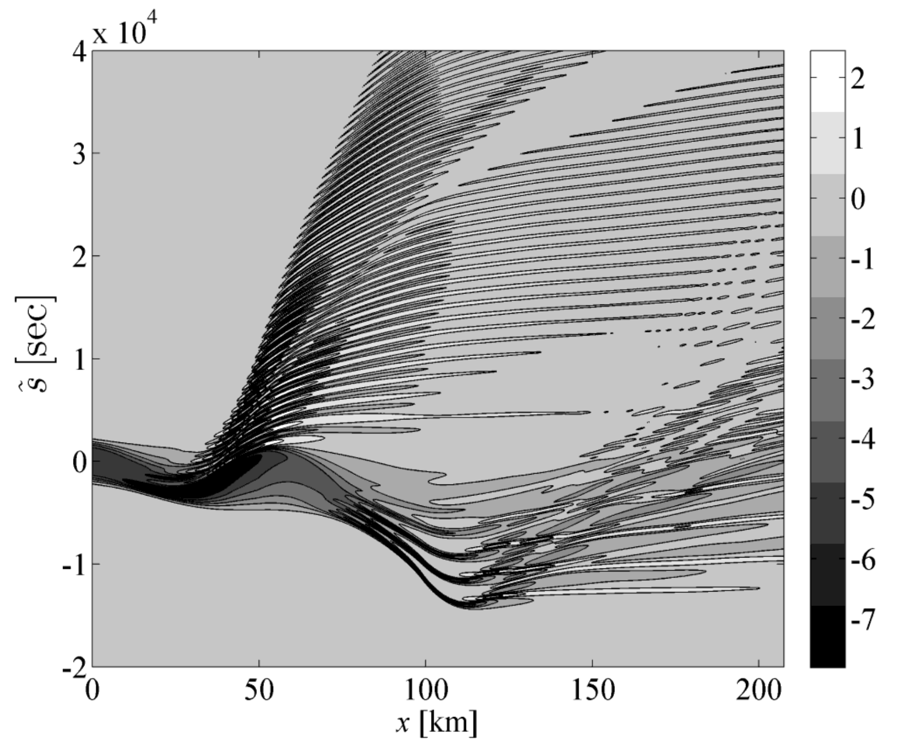


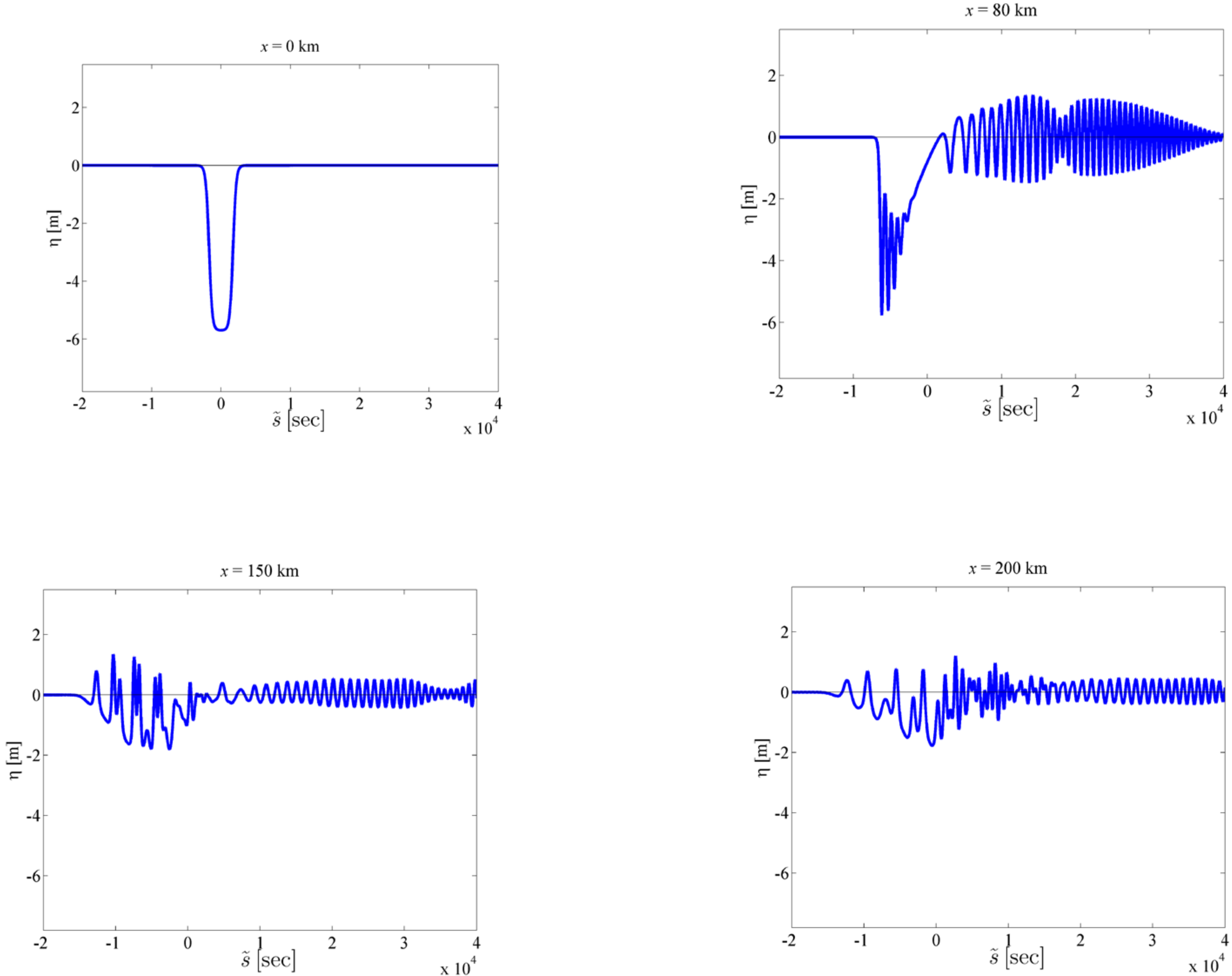
x = 0 km
x = 20 km
x = 40 km
x = 60 km
x = 80 km
x = 97 km
η [m]
s̃ [sec]
2
1
0
-1
-2
-3
-4
-5
-6
-7
-6000
-4000
-2000
0
2000
4000
6000

Section 2

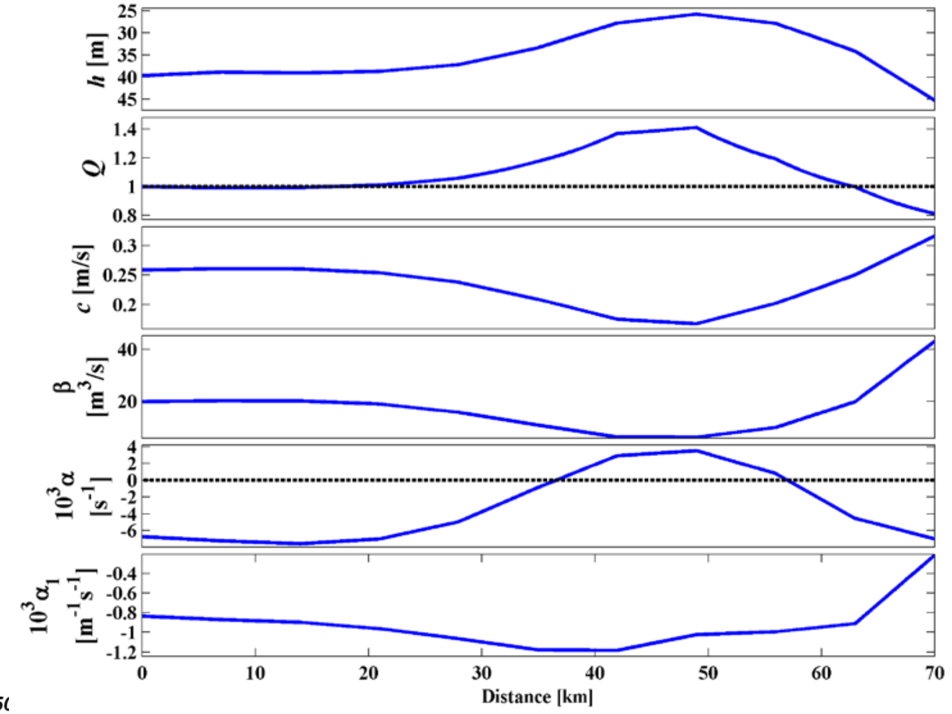

66°N
64°N
62°N
60°N
58°N
56°N
54°N
10°E
15°E
20°E
25°E
30°E
1
2
3
Ocean Data View

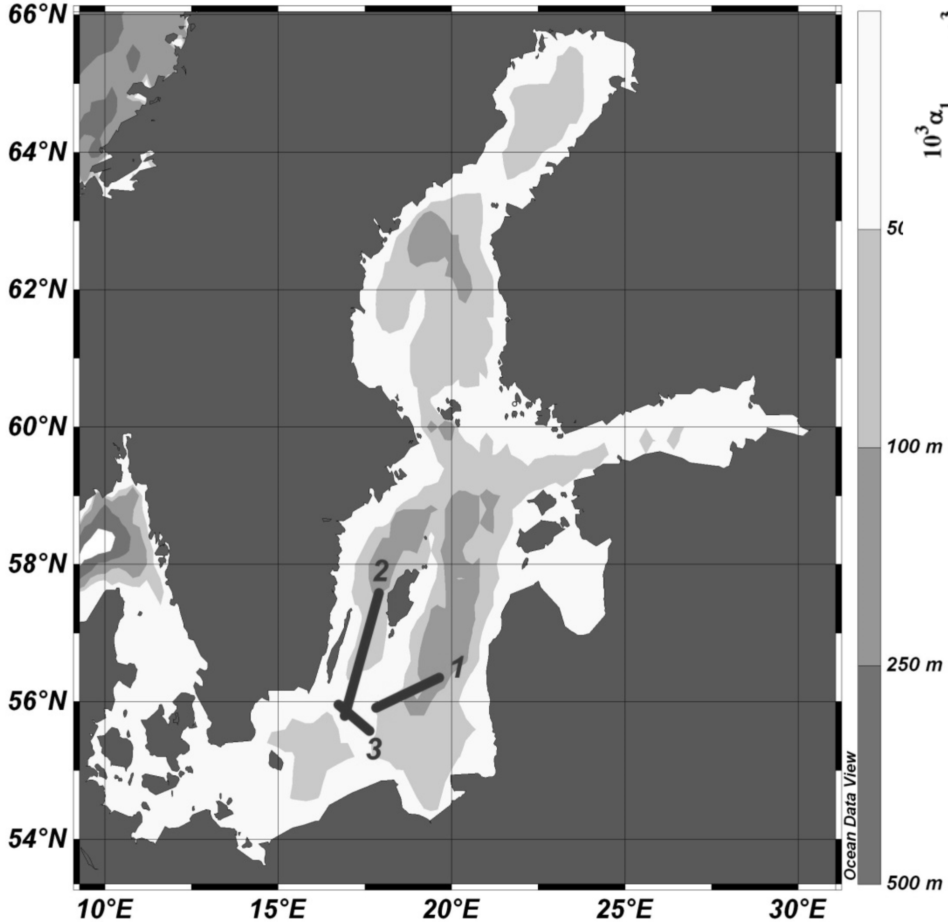

h [m]
50
100
Q
1
0.5
c [m/s]
0.6
0.4
0.2
$10^{-2}\beta$ [m^3/s]
2.5
2
1.5
1
0.5
$10^{2}\alpha$ [s^{-1}]
1
0
-1
$10^{3}\alpha_1$ [$m^{-1}s^{-1}$]
2
1
0
-1

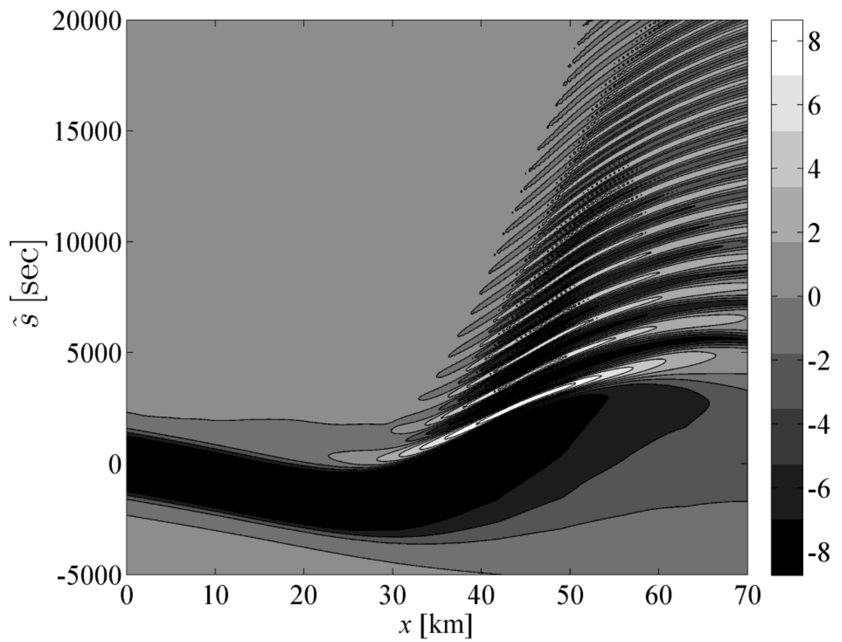

x 10^4
4
3
2
1
0
-1
-2
$\tilde{s}$ [sec]
0
50
100
150
200
x [km]
2
1
0
-1
-2
-3
-4
-5
-6
-7

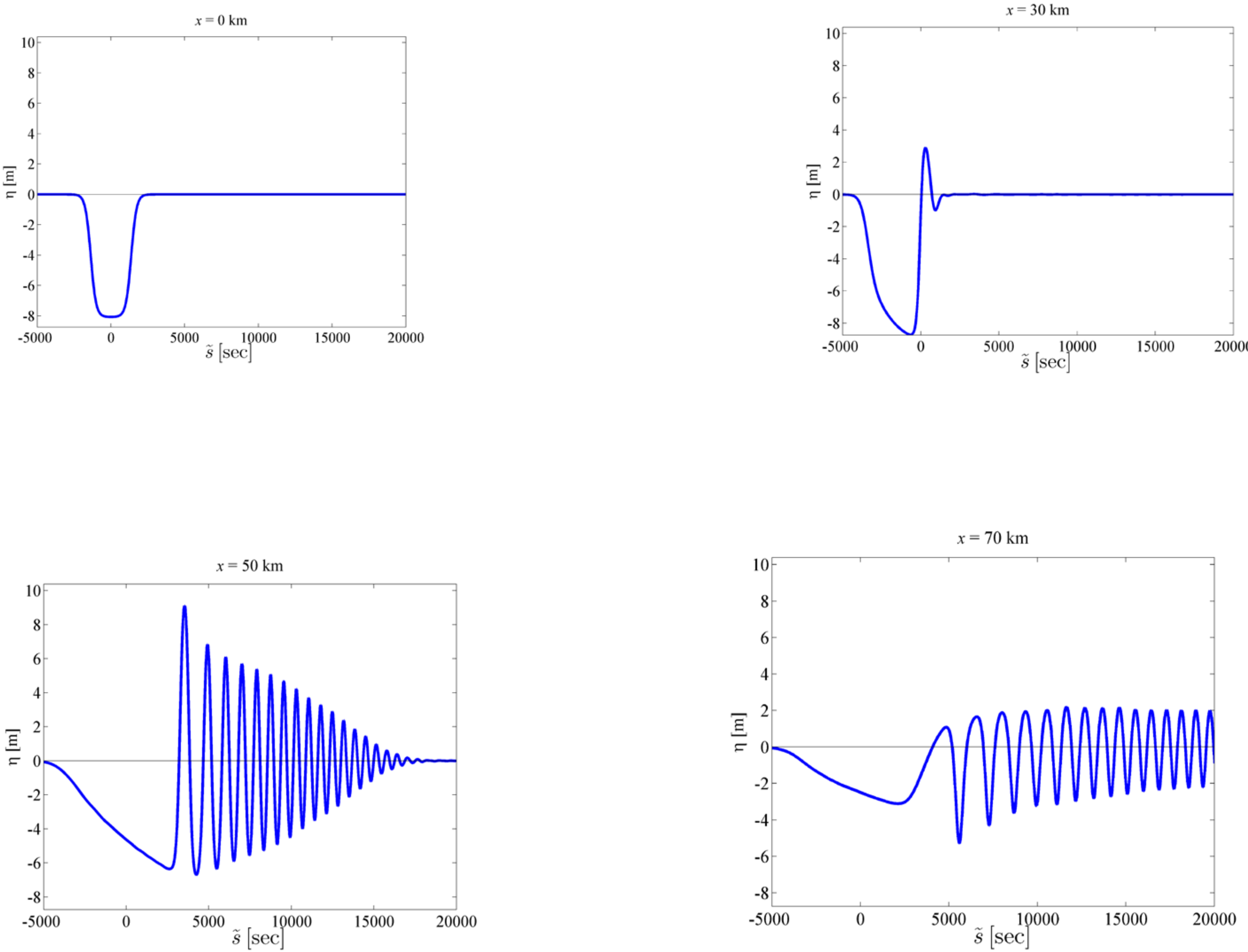

x = 0 km
x = 80 km
x = 150 km
x = 200 km
η [m]
s̃ [sec]
x 10^4
2
0
-2
-4
-6
-1
1
3
4

Section 3


h [m]
Q
c [m/s]
β [m^3/s]
10^3 α [s^-1]
10^3 α_1 [m^-1 s^-1]
Distance [km]

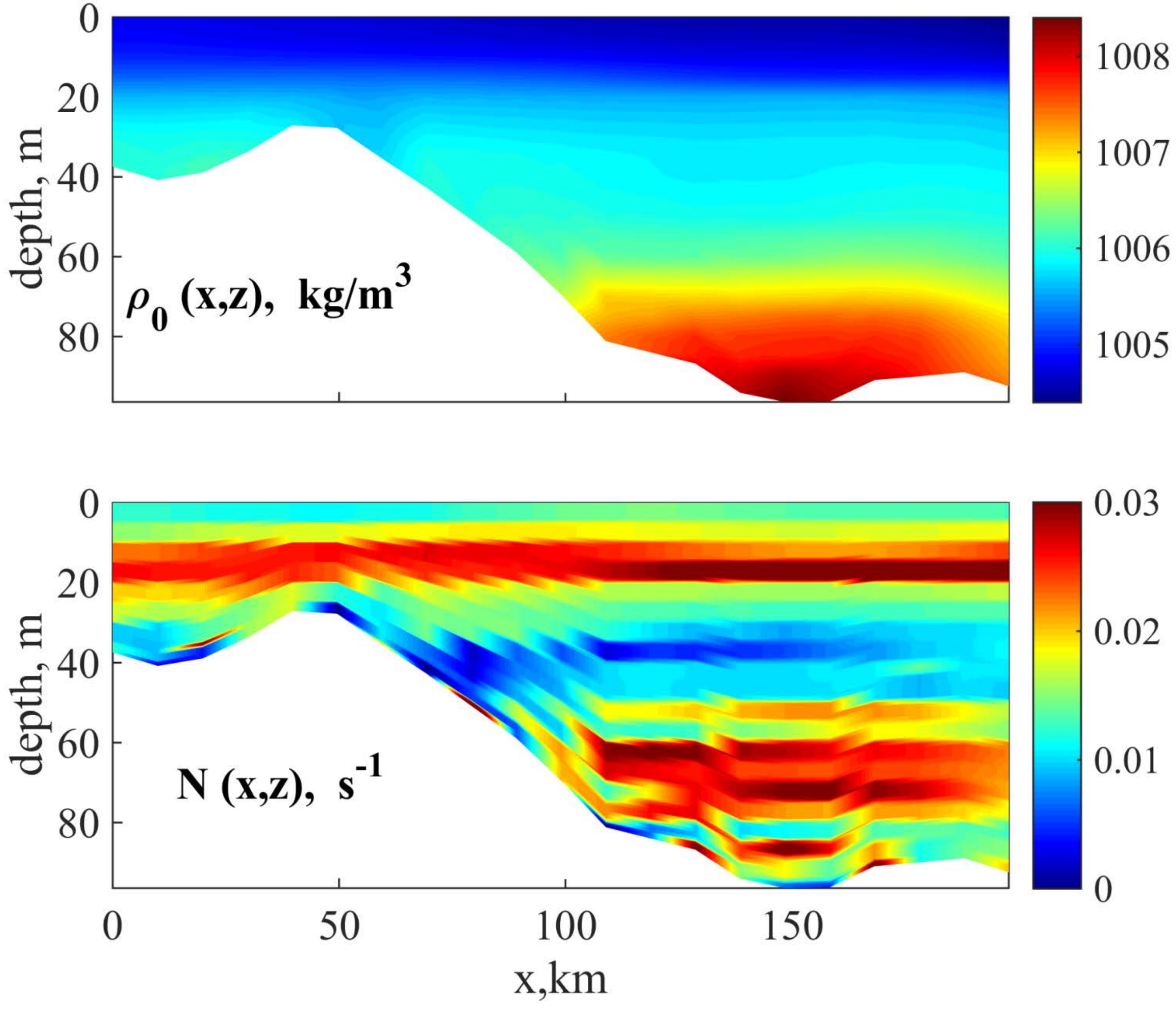

66°N
64°N
62°N
60°N
58°N
56°N
54°N
10°E
15°E
20°E
25°E
30°E
1
2
3
100 m
250 m
500 m
Ocean Data View


s̃ [sec]
x [km]

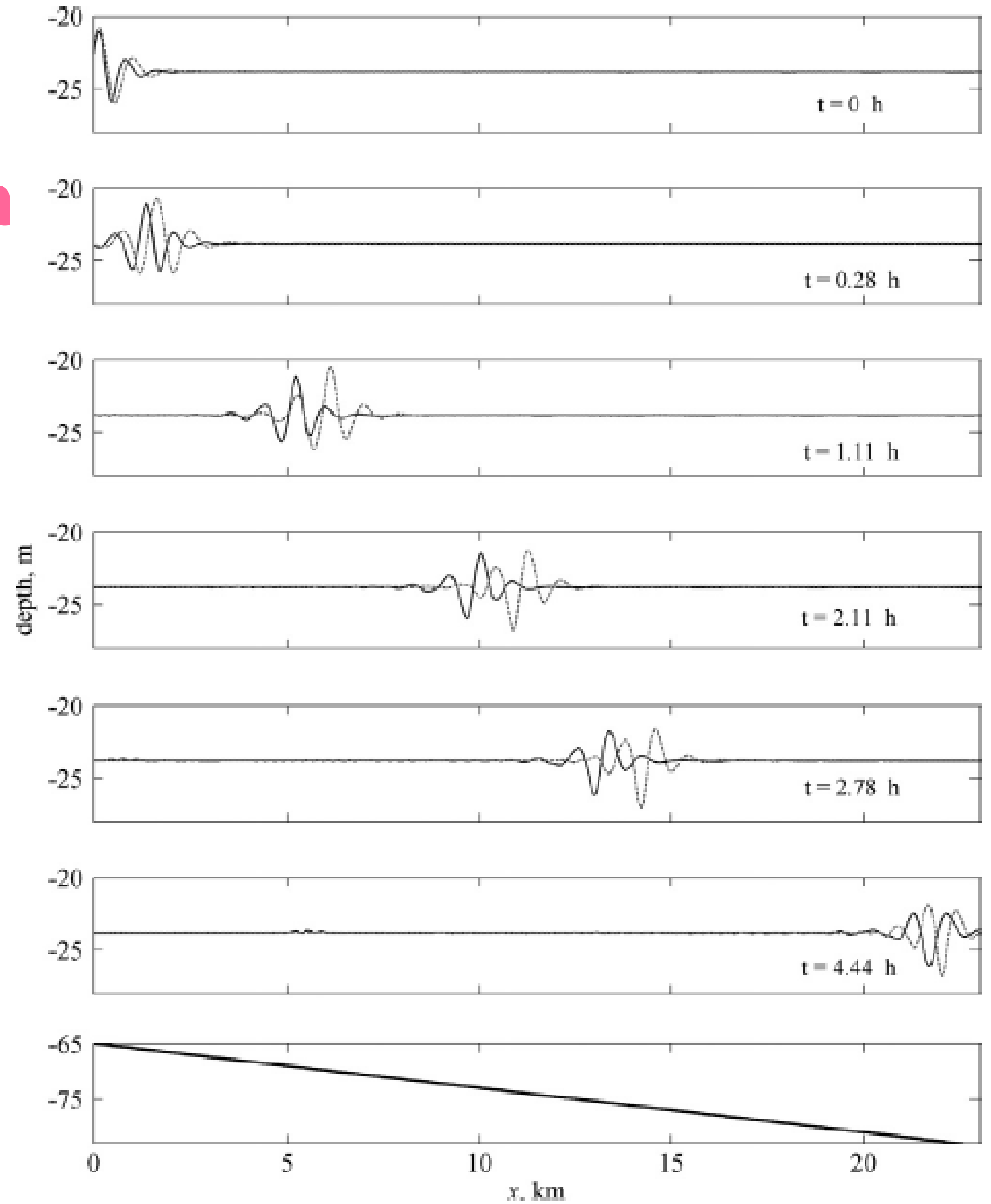


x = 0 km
η [m]
s̃ [sec]
x = 30 km
η [m]
s̃ [sec]
x = 50 km
η [m]
s̃ [sec]
x = 70 km
η [m]
s̃ [sec]

Euler Equations



Breather transformation



Euler – solid

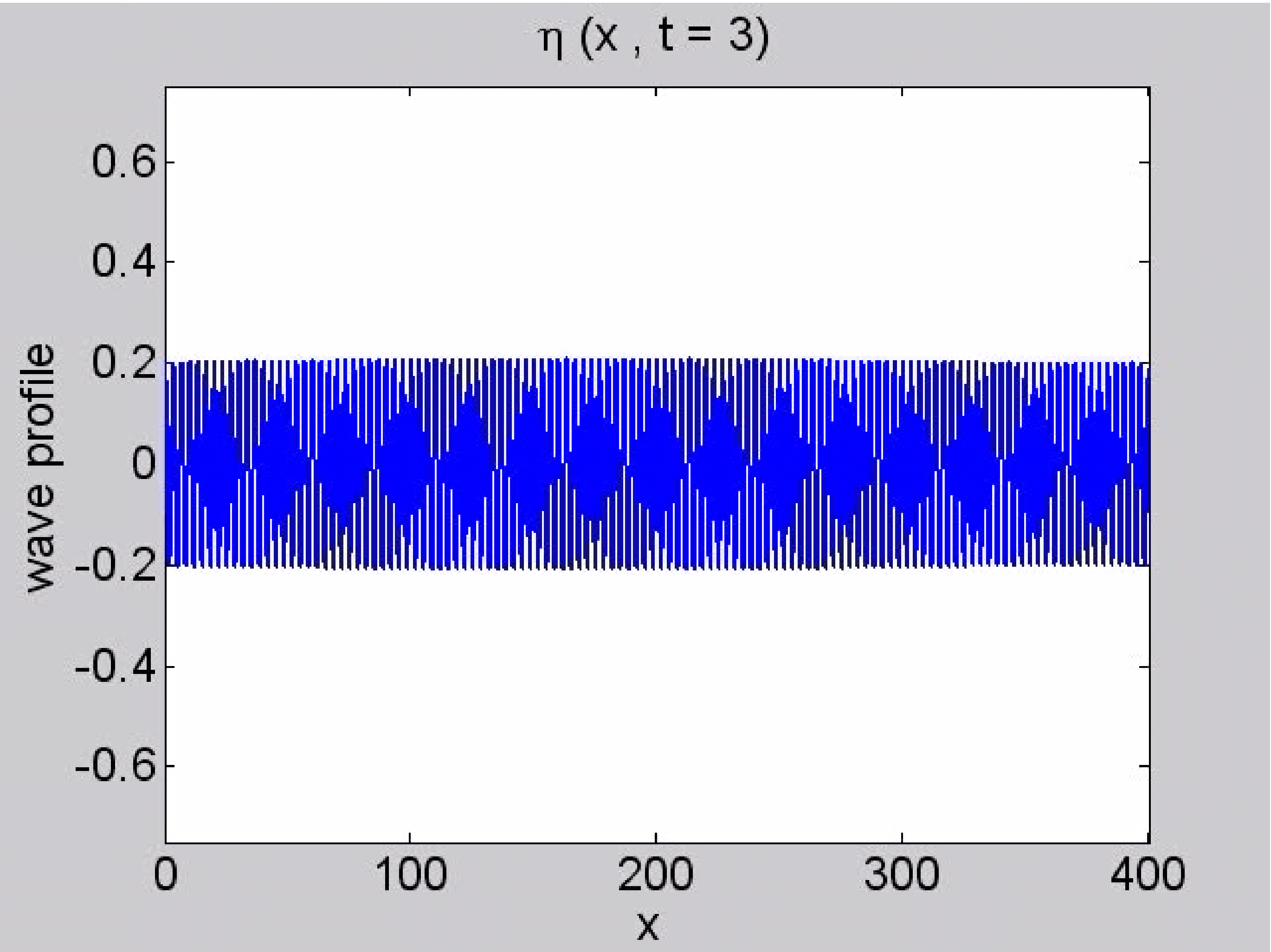
Gardner - dashed

Bendjamin- Feir instability in the Gardner framework

$\alpha = 0$

$\alpha_1 > 0$

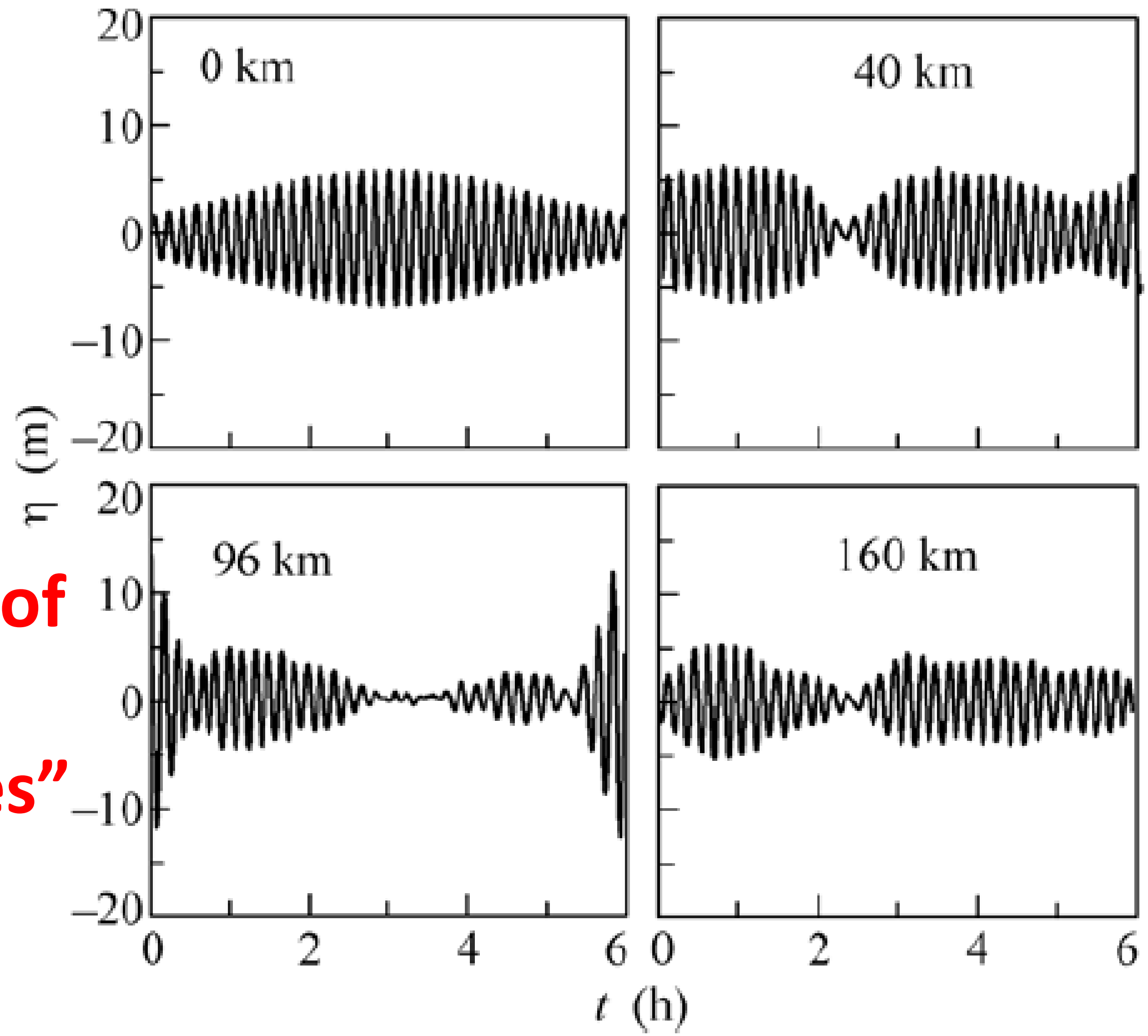
$\eta(x,0) = a(1+m\cos Kx)\cos kx$



a = 0.2
m = 0.05
k = 1.884
K = 0.00785

amplification factor is between 3 to 3.5

Modulation Instability



leads to formation of Internal "Rogue Waves"

Conclusions:

1. No big data of internal waves

2. Many sources of their generation

3. No uniform model and mapping for Baltic Sea

4. Many expected phenomena: solitons.
   breathers, rogue waves

5. Too much work for Baltic Internal Waves…

From small scales to large scales
–The Gulf of Finland Science Days 2017
9th-10th October 2017
Estonian Academy of Sciences, Tallinn

1st Day

Gulf of Finland Co-operation

V. Fleming-Lehtinen, J. Kaitaranta, H. Parner

Assessing the sea together

Assessing the sea together

HELCOM HOLAS II eutrophication status assessment

Vivi Fleming-Lehtinen, SYKE

Joni Kaitaranta, HELCOM secretariat

Hjalte Parner, ICES

9.10. 2017

From small scales to large scales –

The Gulf of Finland Days 2017

SYKE

HELCOM, BSAP and eutrophication

The Helsinki Convention was initiated in1974, includes all Baltic Sea coastal states

Baltic Sea Action Plan ratified in 2007, modifications in 2010

- an agreement
- ecosystem-based management of human actions, adaptive management

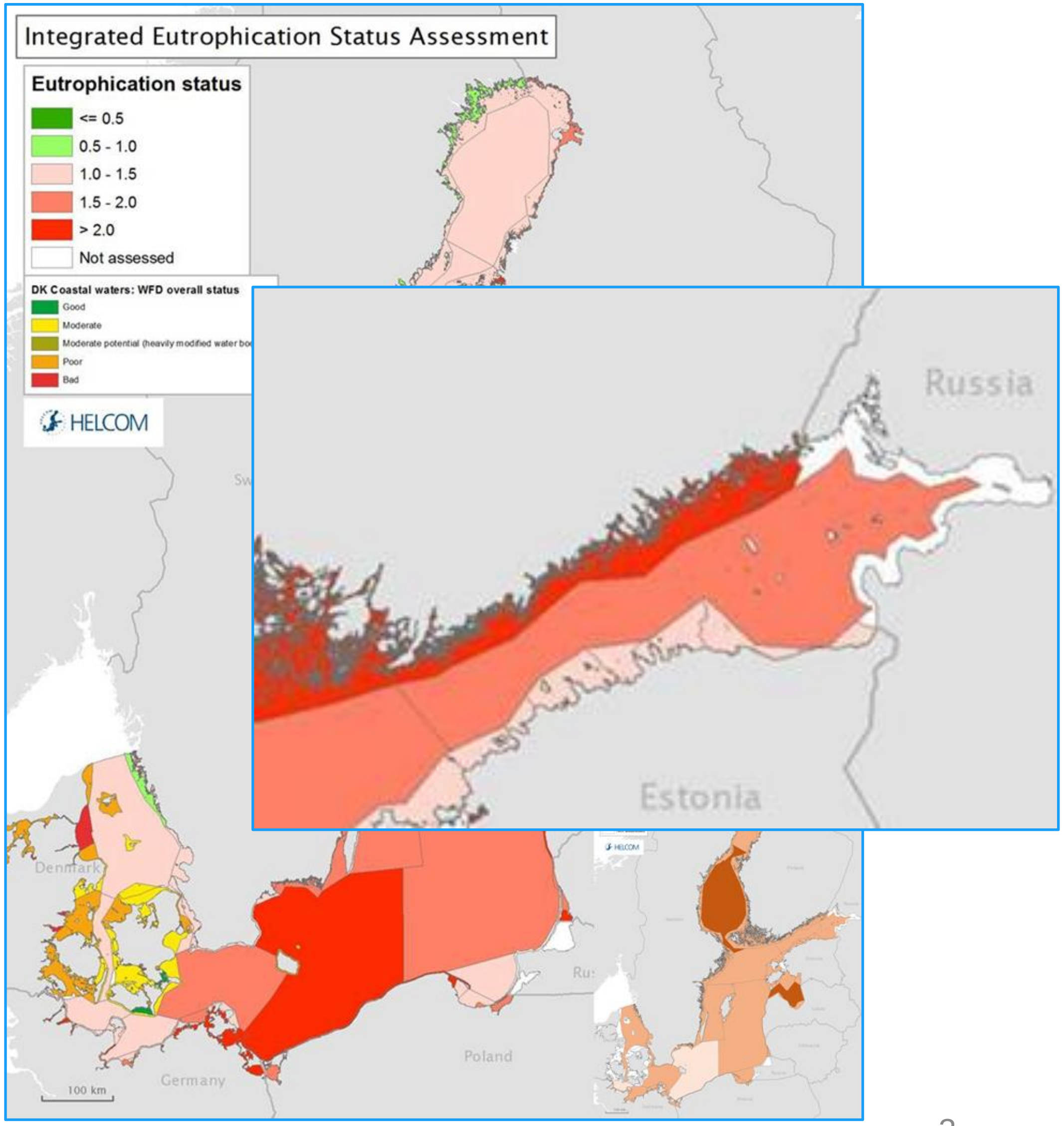
HELCOM eutrophication status assessment

- common monitoring programme (COMBINE) since 1979
- first quantitative eutrophication status assessment in 2009
- following response to nutrient load reductions

SYKE

HELCOM Eutrophication status assessment

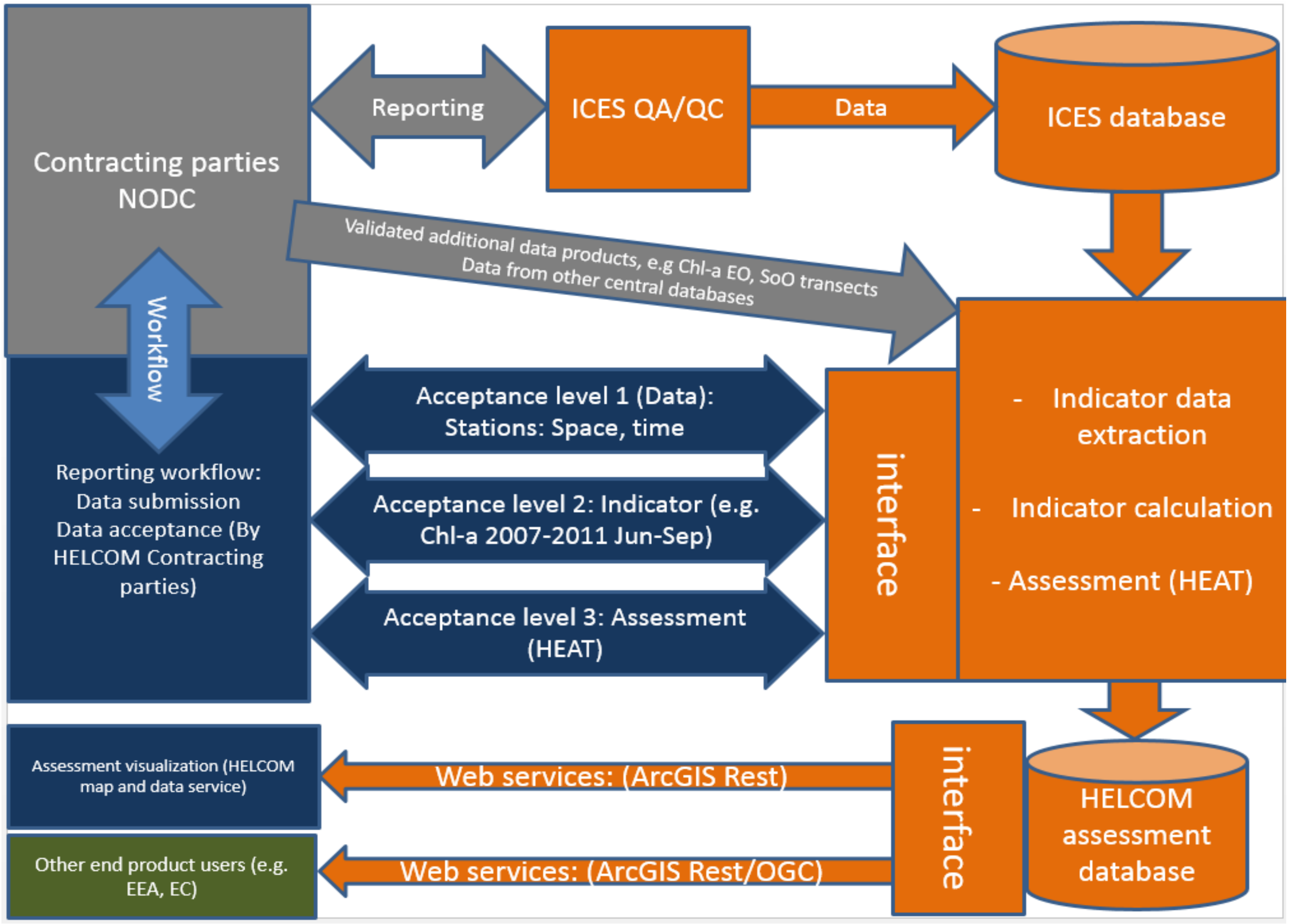
- Made for 6-year periods, present assessment: 2011-2016
- Open sea: data reported to ICES by contracting parties, indicators updated by algorithms
- Coastal areas: contracting parties report indicator results
- Overall assessment is produced automatically according to common agreement
- Assessment products are checked and accepted by contracting parties
- Coordination and development: HELCOM IN-Eutrophication expert network



HELCOM HOLAS II (1st stage), eutrophication status

SYKE

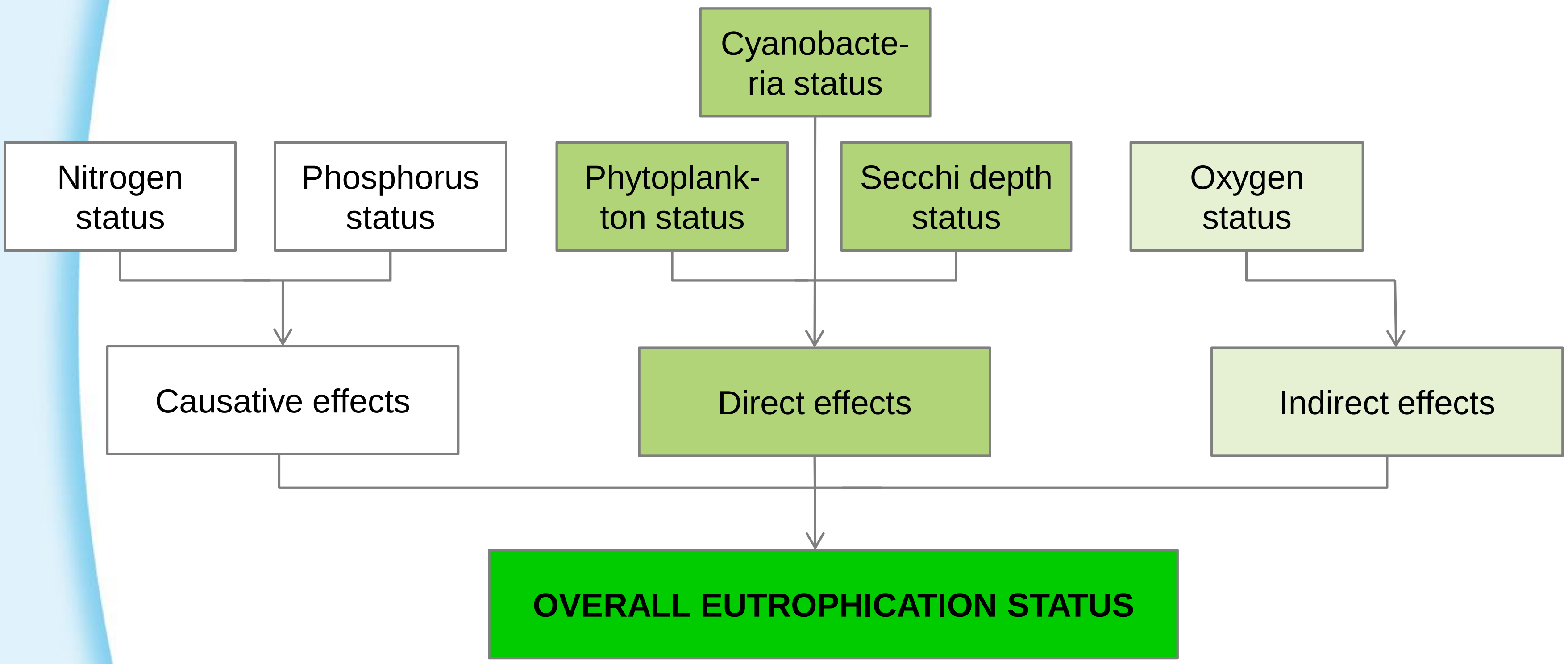
Eutrophication assessment data and information flow



Host: Grey = Contracting Parties,
Blue = HELCOM portal at the HELCOM Secretariat,
Orange = ICES,
Green = Other end-users

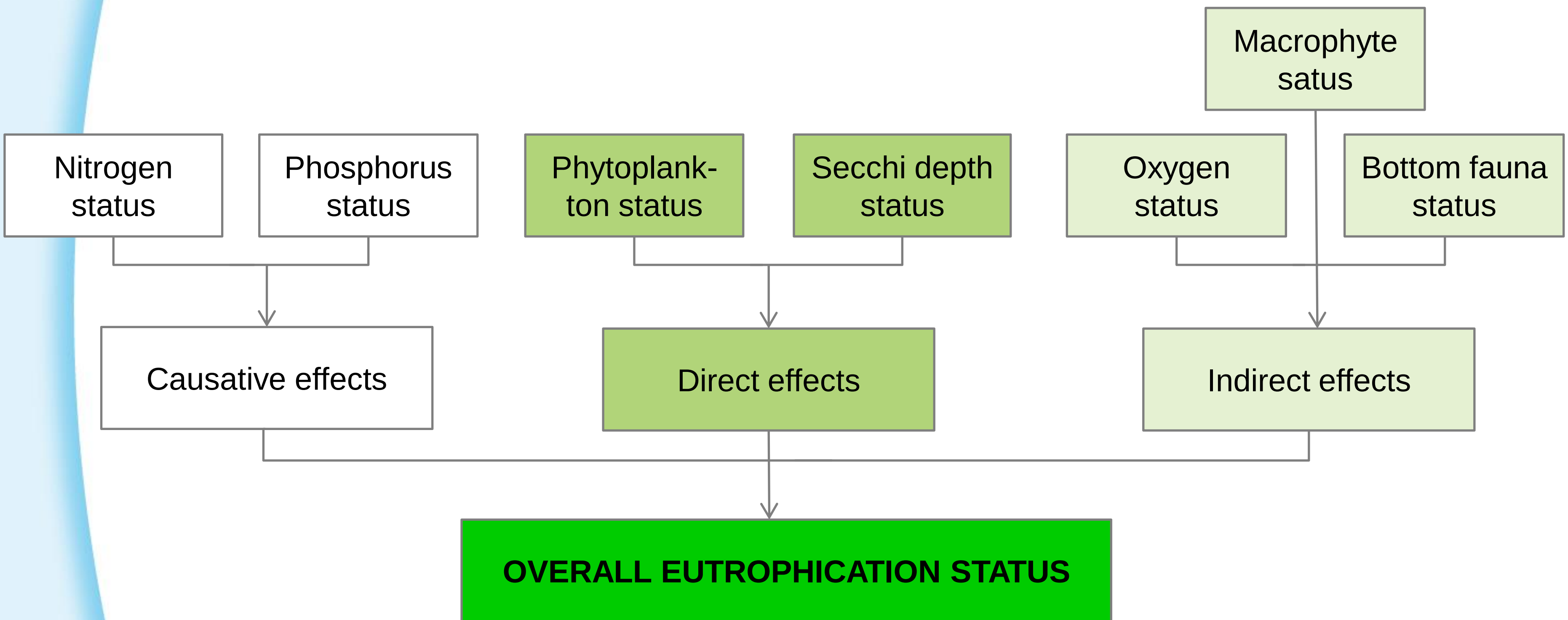
SYKE

Indicators are combined to an assessment



Eutrophication indicators used in the open Gulf of Finland

Indicators are combined to an assessment



Coastal indicators vary depending on reporting country

SYKE

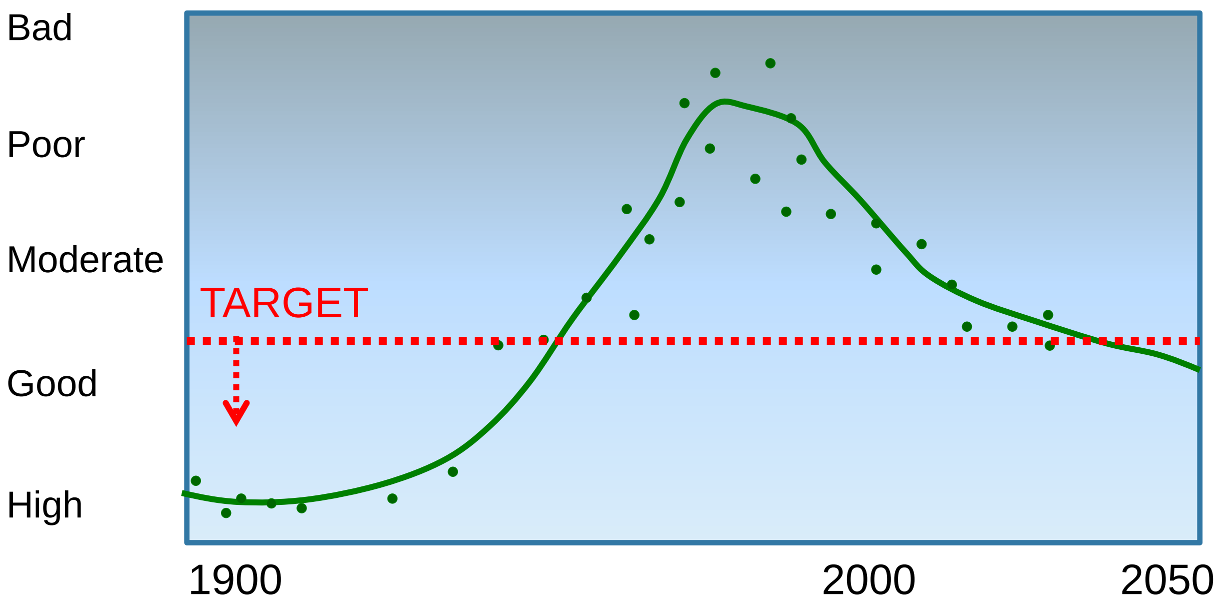
Indicators communicate the status of key features

Abilities of a good environmental indicator
Shows fidelity to the assessed feature and process
Reacts robustly to change
Responds to environmental pressures caused by humans
Is applicable in different geographical areas and at different times
Understandable, also to non-experts
Can be monitored and easily updated
Well documented and scientifically based

”As opposed to regular metrics, indicators are supposed to tell us more than what they actually measure” (Daan 2005)

SYKE

Indicator status is estimated in relation to a target level

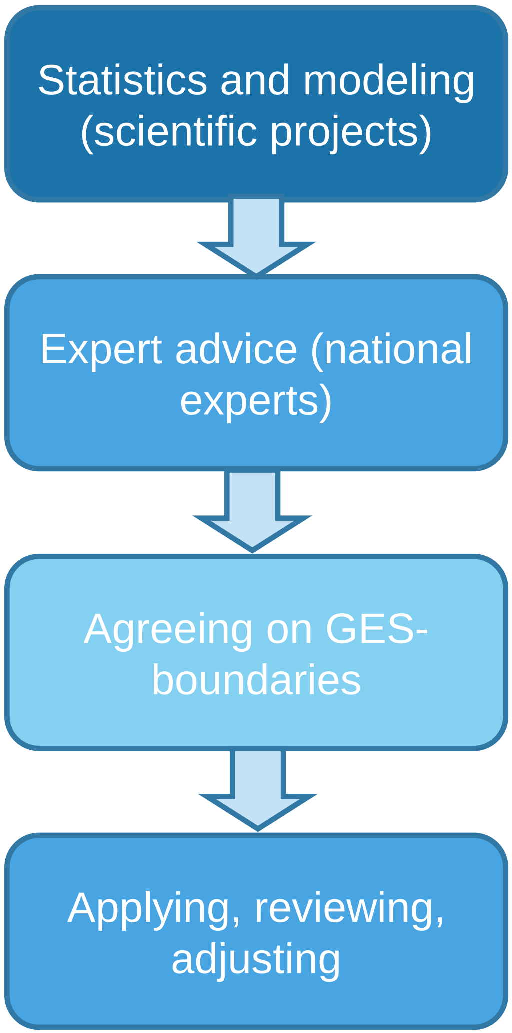


The Baltic environment can cope with pressures from human activities, but only to a certain extent

- Define good status
- Aim at sustainable use of seas, not at a level without human activities
- Operational goal, actions shall be taken when level is exceeded
- Scientifically based, commonly agreed

Modified from picture by *Juha-Markku Leppänen*

Setting the GES boundaries



- Change point detection to time-series
- Historical monitoring data, ecosystem modelling

- Comparison with other results
- Attempt to harmonize between sub-basins and indicators

- Consensus at Baltic Sea level

- Applied in eutrophication status assessment 2007-2011 and 2011-2016
- To be reviewed at regular intervals

SYKE

Conclusions

- Most important: Setting the key parameters to assess eutrophication as a whole – a political decision relying ecological expertise
- All assessment information is a compromise between availability, confidence and usability
- Learning process: the assessment methodology is under constant improvement, adapting to increased scientific knowledge
- Challenge: to create a transparent system where all developmental and update phases are accepted by all contracting parties – and keep it labour-efficient

SYKE

From small scales to large scales
–The Gulf of Finland Science Days 2017
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Estonian Academy of Sciences, Tallinn

1st Day

Gulf of Finland Co-operation

S-T. Stoicescu, U. Lips, I. Lips, T. Liblik, N. Rünk, V. Kikas

Monitoring and assessment of eutrophication status: observations and recommendations emerging from the GOF assessment work and the most recent data

Monitoring and assessment of eutrophication status: observations and recommendations emerging from the GOF assessment work and the most recent data

Stella-Theresa Stoicescu, Urmas Lips, Inga Lips, Taavi Liblik, Nelli Rünk, and Villu Kikas

Department of Marine Systems, Tallinn University of Technology, Estonia

Eutrophication assessment

Eutrophication indicators

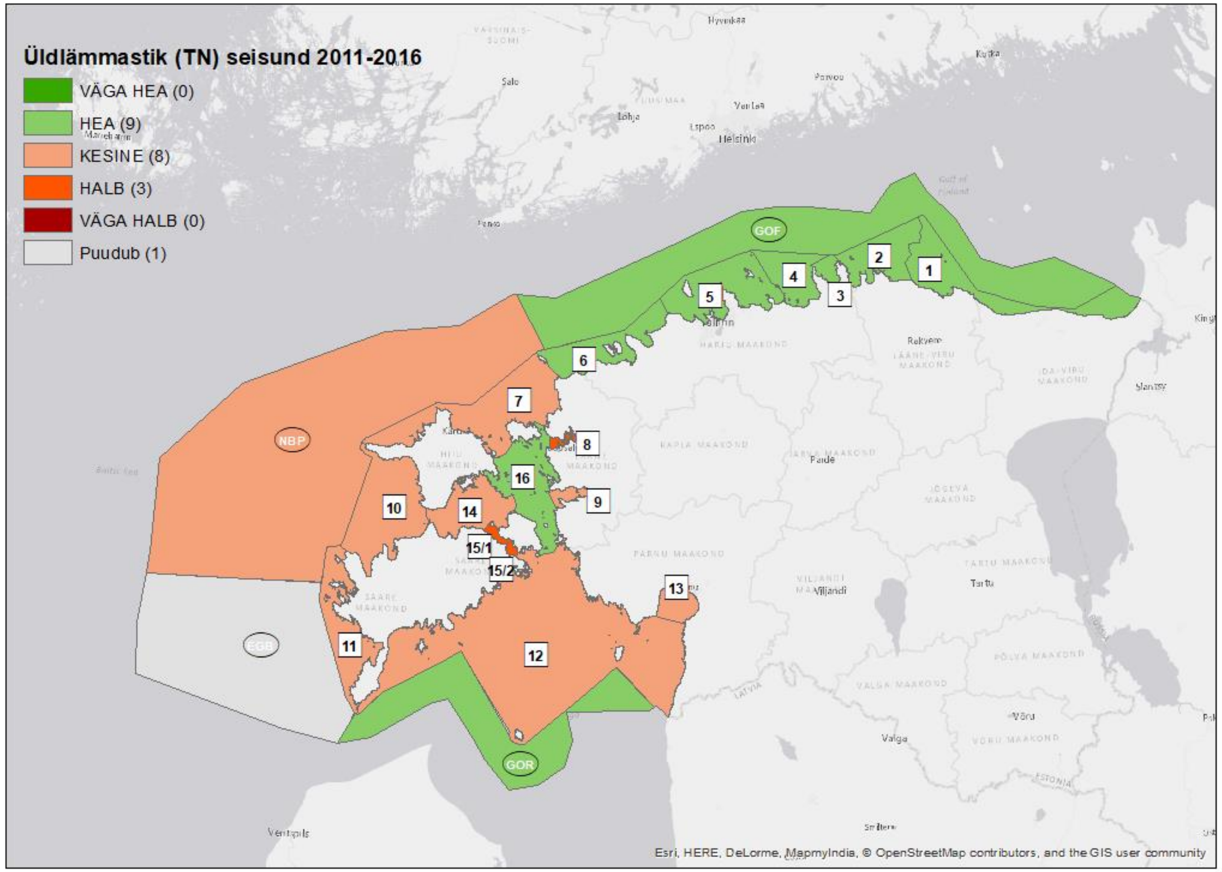
- Nutrients – dissolved inorganic nitrogen, dissolved inorganic phosphorus, total nitrogen, total phosphorus
- Direct effects – chlorophyll-a, phytoplankton biomass, water transparency, surface blooms of phytoplankton
- Indirect effects – oxygen conditions, bottom vegetation, soft-bottom macrofauna

HEAT (HELCOM Eutrophication Assessment Tool) – measured value / threshold value

Aims of this presentations:

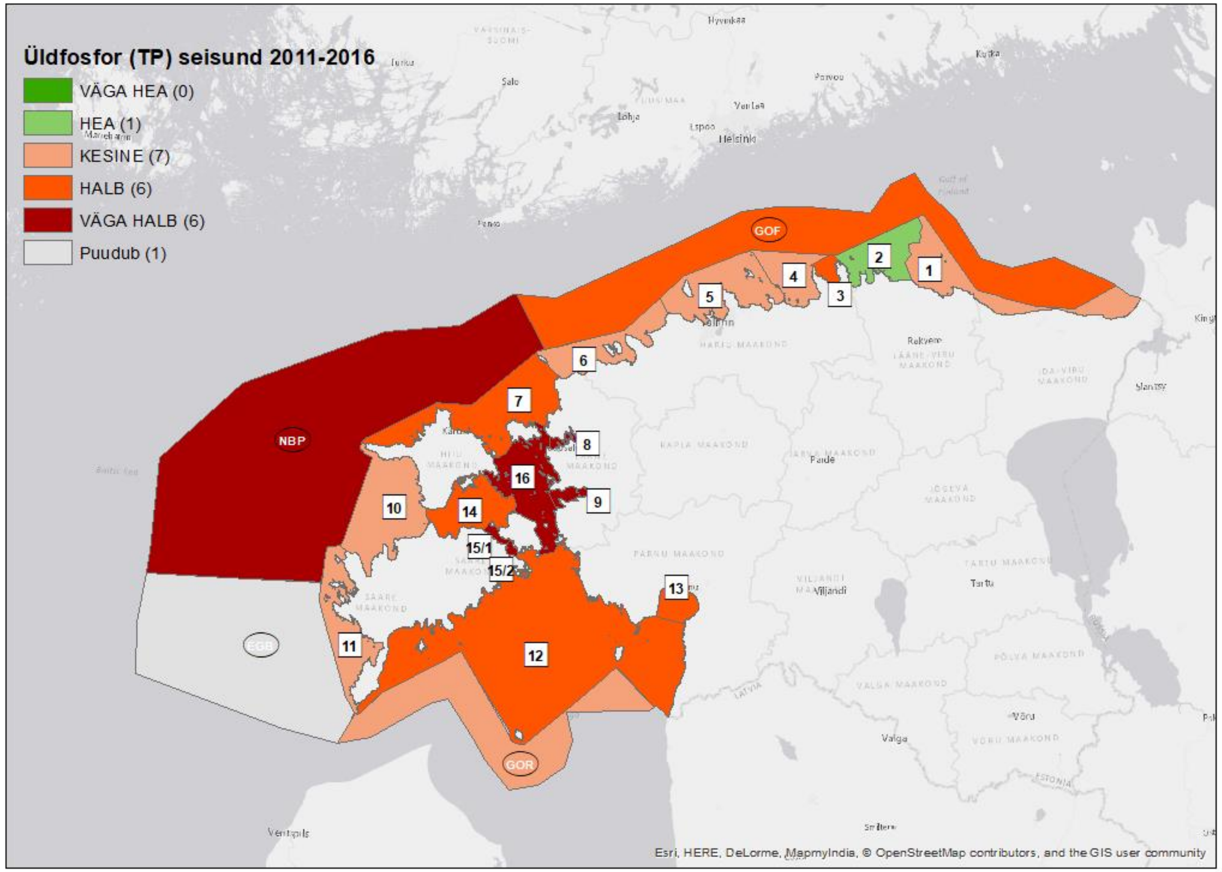
- Preliminary results of eutrophication status assessment for Estonian waters
- To test different oxygen indicators and try to separate anthropogenic effects from hydrography using high resolution data from autonomous profilers – oxygen debt, oxygen consumption and hypoxic area

Eutrophication assessment – total nitrogen



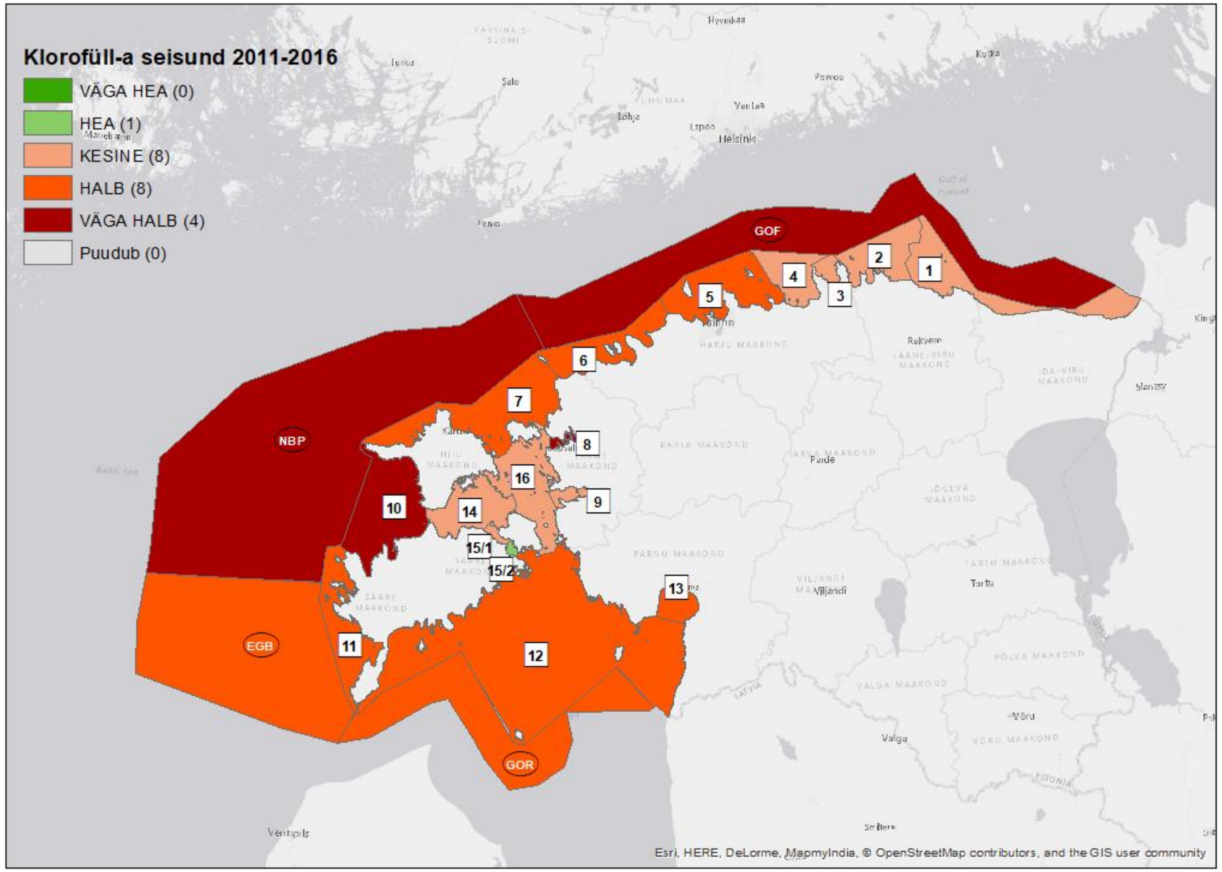
Area	Threshold value (uM)	Mean (period 2011-2016)	EQR	Result
EE_1	26,8	23,30	0,87	GES
EE_2	26,8	20,80	0,78	GES
EE_3	22,8	21,26	0,93	GES
EE_4	22,8	19,71	0,86	GES
EE_5	22,8	20,65	0,91	GES
EE_6	22,8	19,67	0,86	GES
EE_7	18,3	19,94	1,09	Sub-GES
EE_8	21,0	35,65	1,70	Sub-GES
EE_9	21,0	26,46	1,26	Sub-GES
EE_10	18,3	23,90	1,31	Sub-GES
EE_11	18,3	23,31	1,27	Sub-GES
EE_12	23,7	26,62	1,12	Sub-GES
EE_13	29,2	32,32	1,11	Sub-GES
EE_14	21,0	21,52	1,02	Sub-GES
EE_15/1	21,0	31,89	1,52	Sub-GES
EE_15/2	23,7	38,91	1,64	Sub-GES
EE_16	21,0	19,99	0,95	GES
GOF	21,3	20,87	0,98	GES
GOR	28,0	23,34	0,83	GES
NBP	16,2	19,57	1,21	Sub-GES
EGB	-	19,17	-	-

Eutrophication assessment – total phosphorus



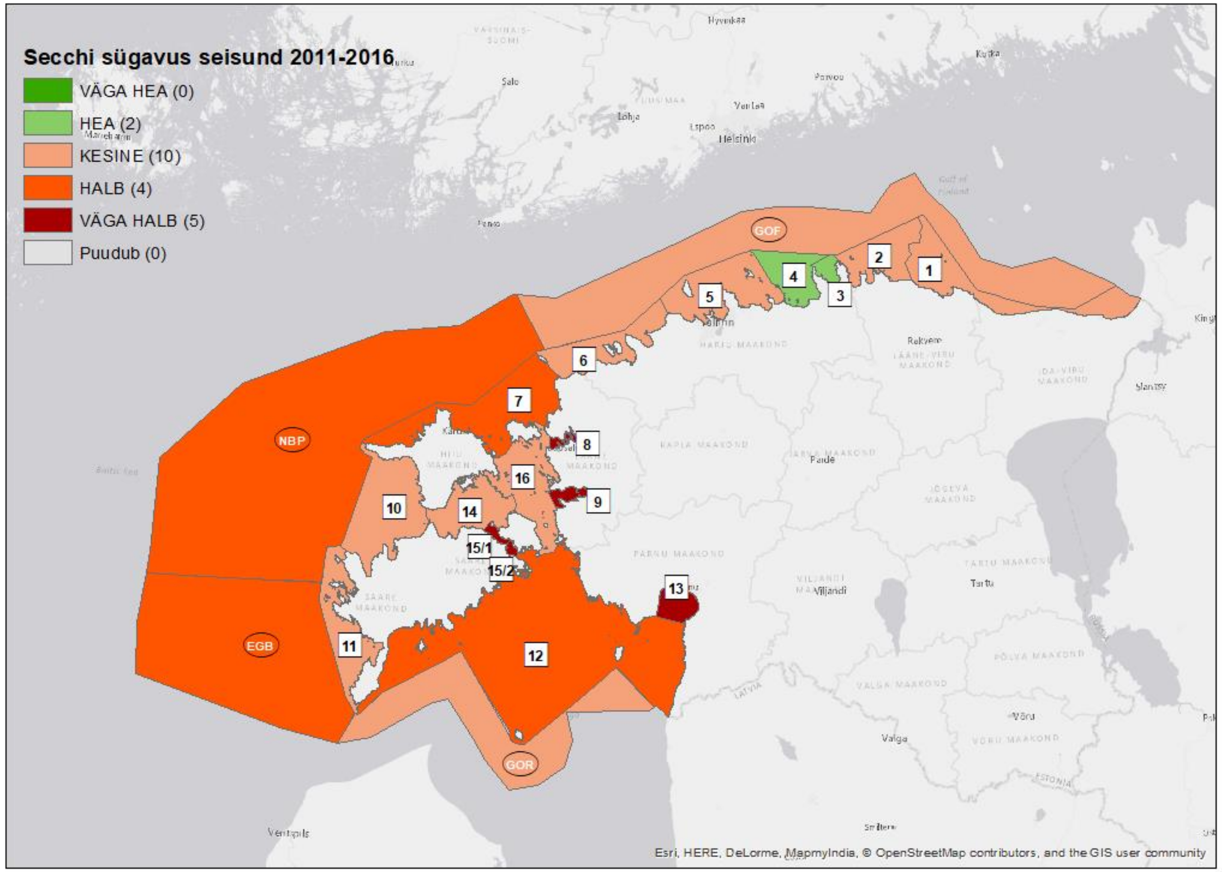
Area	Threshold value (uM)	Mean (period 2011-2016)	EQR	Result
EE_1	0,84	0,92	1,09	Sub-GES
EE_2	0,84	0,52	0,62	GES
EE_3	0,72	1,16	1,61	Sub-GES
EE_4	0,72	0,91	1,26	Sub-GES
EE_5	0,72	0,90	1,24	Sub-GES
EE_6	0,72	0,80	1,10	Sub-GES
EE_7	0,42	0,80	1,91	Sub-GES
EE_8	0,30	1,57	5,25	Sub-GES
EE_9	0,30	0,65	2,18	Sub-GES
EE_10	0,42	0,57	1,37	Sub-GES
EE_11	0,42	0,61	1,46	Sub-GES
EE_12	0,50	0,94	1,88	Sub-GES
EE_13	0,67	1,12	1,67	Sub-GEs
EE_14	0,30	0,45	1,51	Sub-GES
EE_15/1	0,30	1,16	3,85	Sub-GES
EE_15/2	0,50	1,41	2,81	Sub-GES
EE_16	0,30	0,82	2,75	Sub-GES
GOF	0,55	0,89	1,61	Sub-GES
GOR	0,70	0,94	1,35	Sub-GES
NBP	0,38	0,85	2,23	Sub-GES
EGB	-	0,80	-	-

Eutrophication assessment – chlorophyll-a

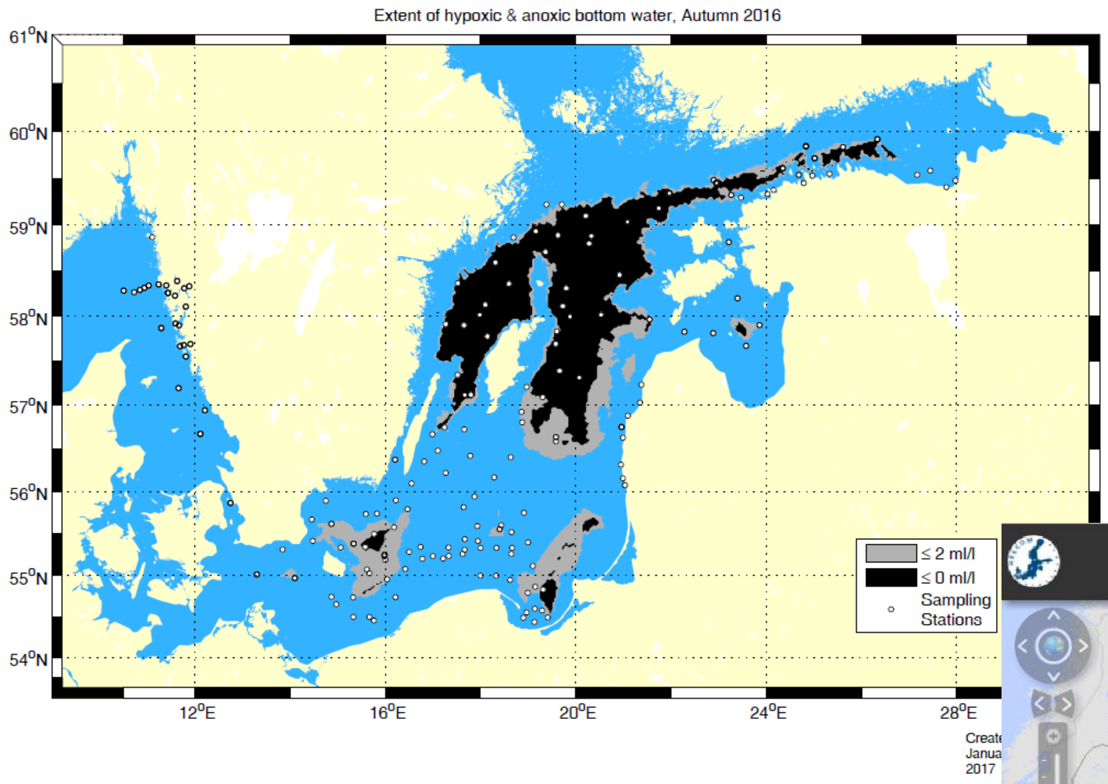


Area	Threshold value (ug/l)	Mean (period 2011-2016)	EQR	Result
EE_1	3,7	5,21	1,41	Sub-GES
EE_2	3,7	5,03	1,36	Sub-GES
EE_3	2,7	2,90	1,07	Sub-GES
EE_4	2,7	3,68	1,36	Sub-GES
EE_5	2,7	4,41	1,63	Sub-GES
EE_6	2,7	4,21	1,56	Sub-GES
EE_7	1,6	2,75	1,72	Sub-GES
EE_8	2,4	9,55	3,98	Sub-GES
EE_9	2,4	3,50	1,46	Sub-GES
EE_10	1,6	4,08	2,55	Sub-GES
EE_11	1,6	2,50	1,56	Sub-GES
EE_12	3,0	4,88	1,63	Sub-GES
EE_13	4,5	7,31	1,63	Sub-GES
EE_14	2,4	2,67	1,11	Sub-GES
EE_15/1	2,4	3,13	1,30	Sub-GES
EE_15/2	3,0	3,13	1,04	Sub-GES
EE_16	2,4	2,43	1,01	Sub-GES
GOF	2,0	4,08	2,04	Sub-GES
GOR	2,7	4,21	1,56	Sub-GES
NBP	1,7	3,80	2,23	Sub-GES
EGB	1,9	3,40	1,79	Sub-GES

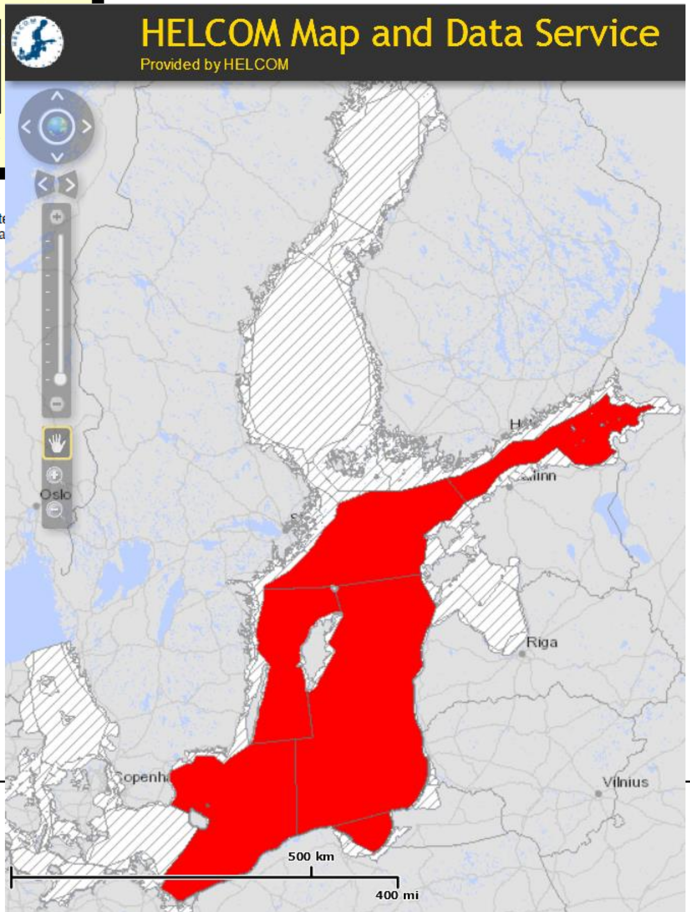
Eutrophication assessment – Secchi depth



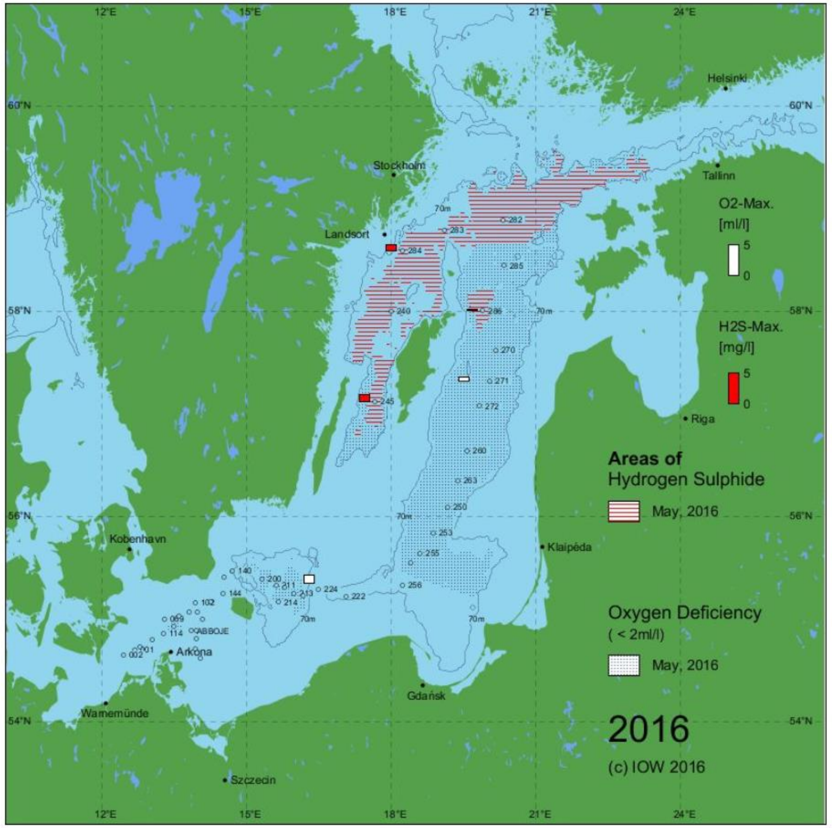
Area	Threshold value (m)	Mean (period 2011-2016)	EQR	Result
EE_1	3,6	2,78	1,29	Sub-GES
EE_2	3,6	3,55	1,01	Sub-GES
EE_3	4,5	4,54	0,99	GES
EE_4	4,5	4,56	0,99	GES
EE_5	4,5	3,80	1,18	Sub-GES
EE_6	4,5	3,56	1,27	Sub-GES
EE_7	6,5	3,45	1,88	Sub-GES
EE_8	4,9	1,70	2,89	Sub-GES
EE_9	4,9	1,60	3,07	Sub-GES
EE_10	6,5	5,40	1,20	Sub-GES
EE_11	6,5	5,81	1,12	Sub-GES
EE_12	4,2	2,61	1,61	Sub-GES
EE_13	3,2	1,27	2,51	Sub-GES
EE_14	4,9	4,41	1,11	Sub-GES
EE_15/1	4,9	1,85	2,65	Sub-GES
EE_15/2	4,2	1,85	2,27	Sub-GES
EE_16	4,9	3,35	1,46	Sub-GES
GOF	5,5	3,77	1,46	Sub-GES
GOR	5,0	3,48	1,44	Sub-GES
NBP	7,1	4,59	1,55	Sub-GES
EGB	7,6	4,59	1,66	Sub-GES



SMHI - Report Oceanography No. 58, 2016

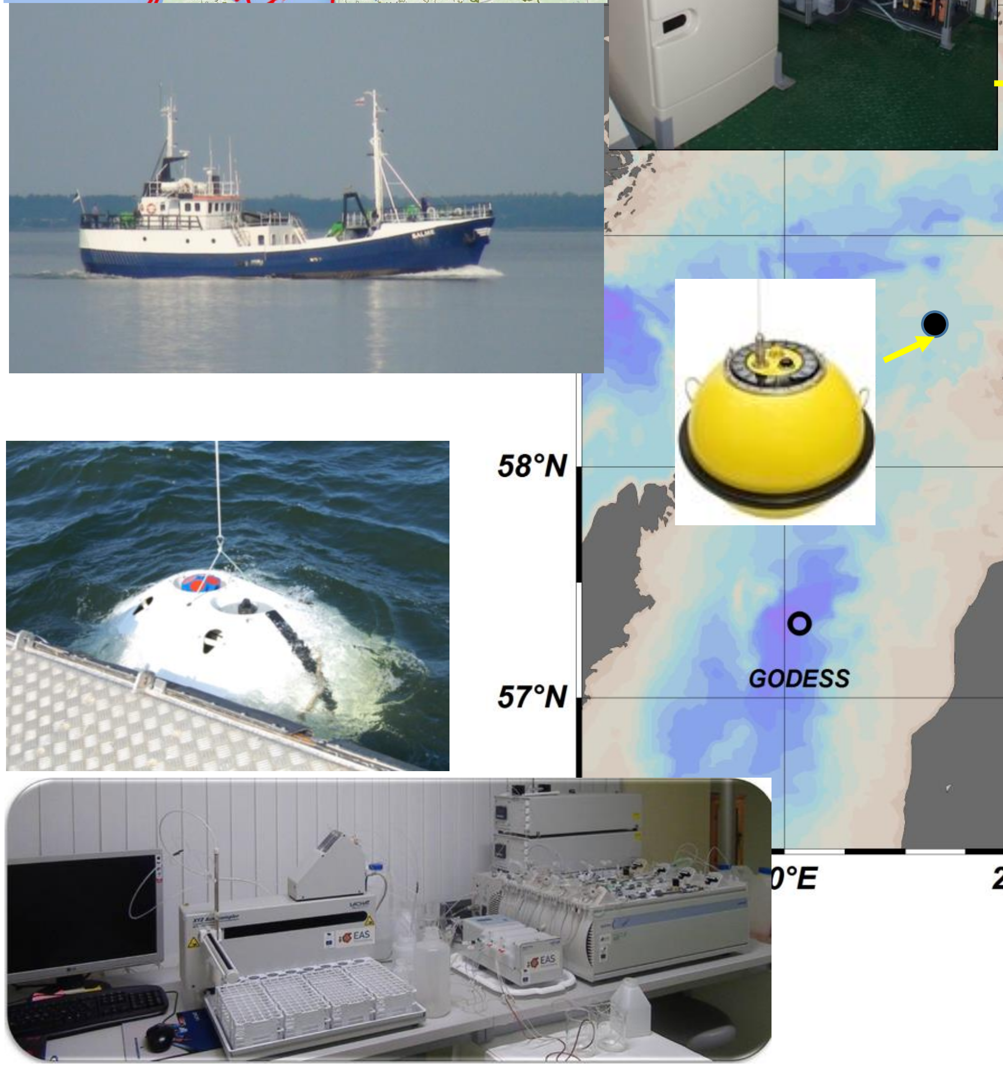


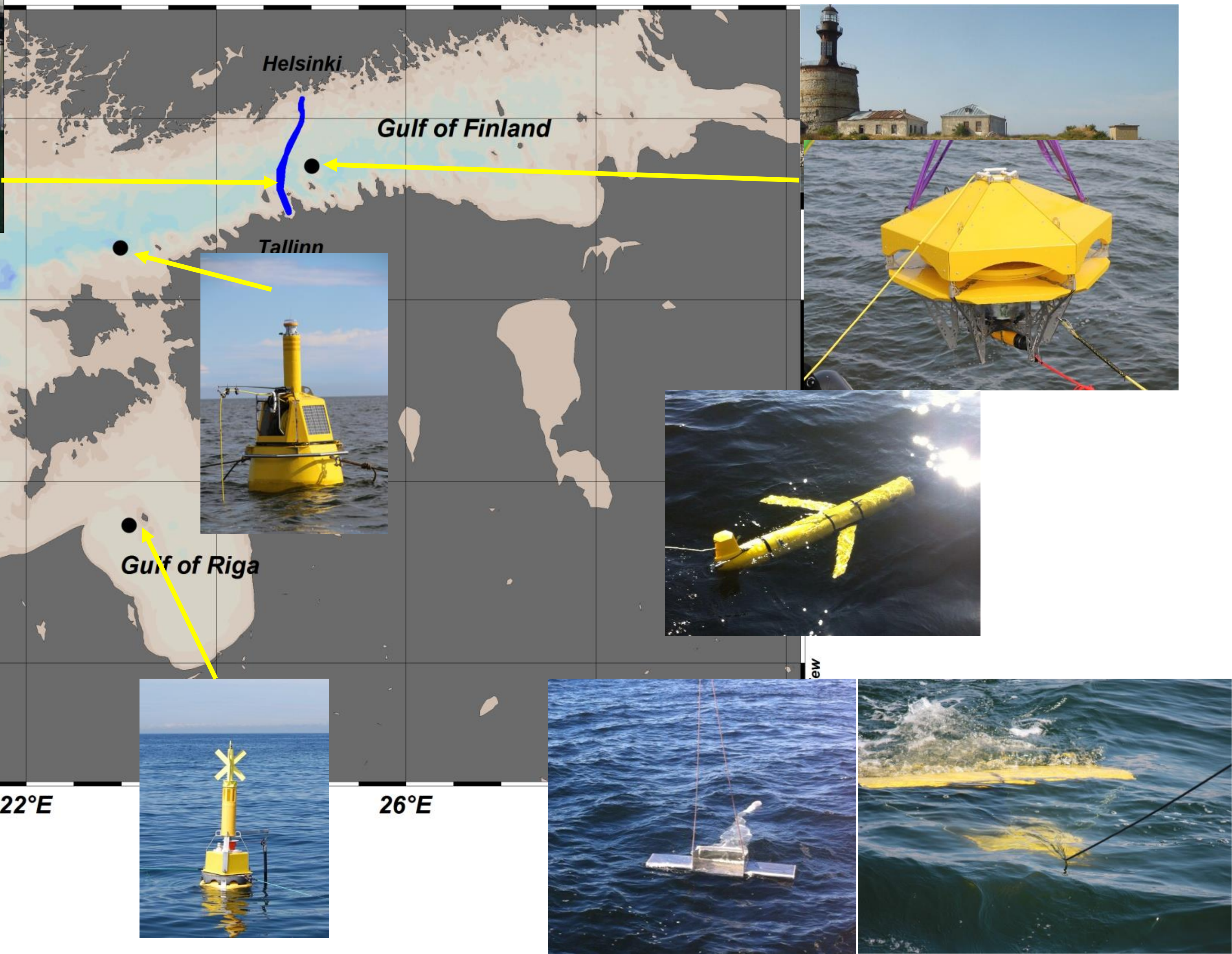
HELCOM 2007-2011
oxygen debt assessment



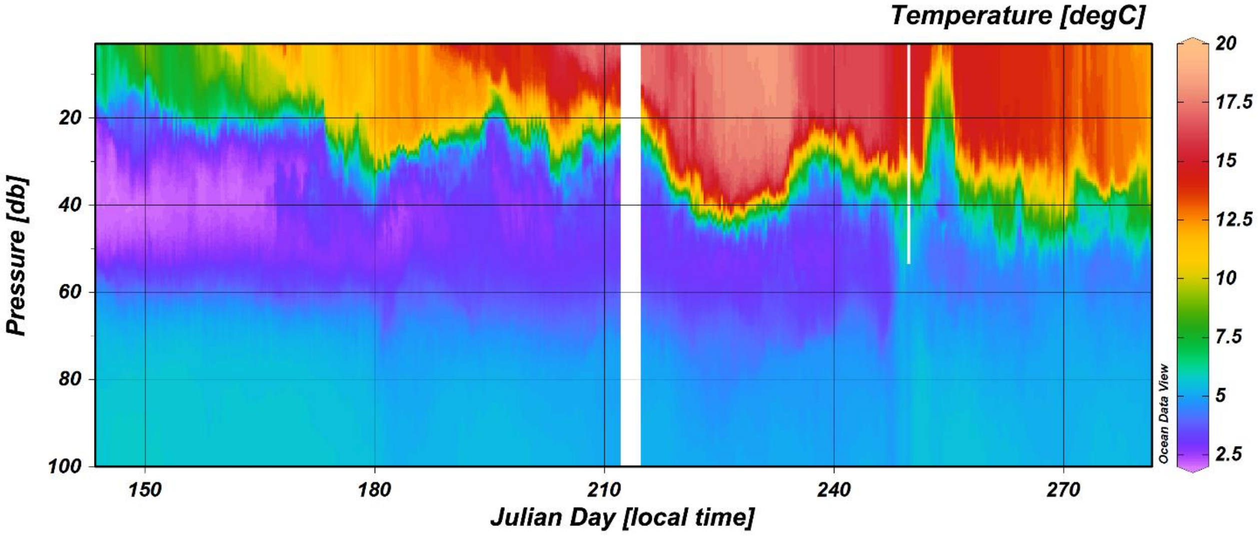
IOW - HELCOM Baltic Sea Environment Fact Sheet 2016, Published 21.12.2016

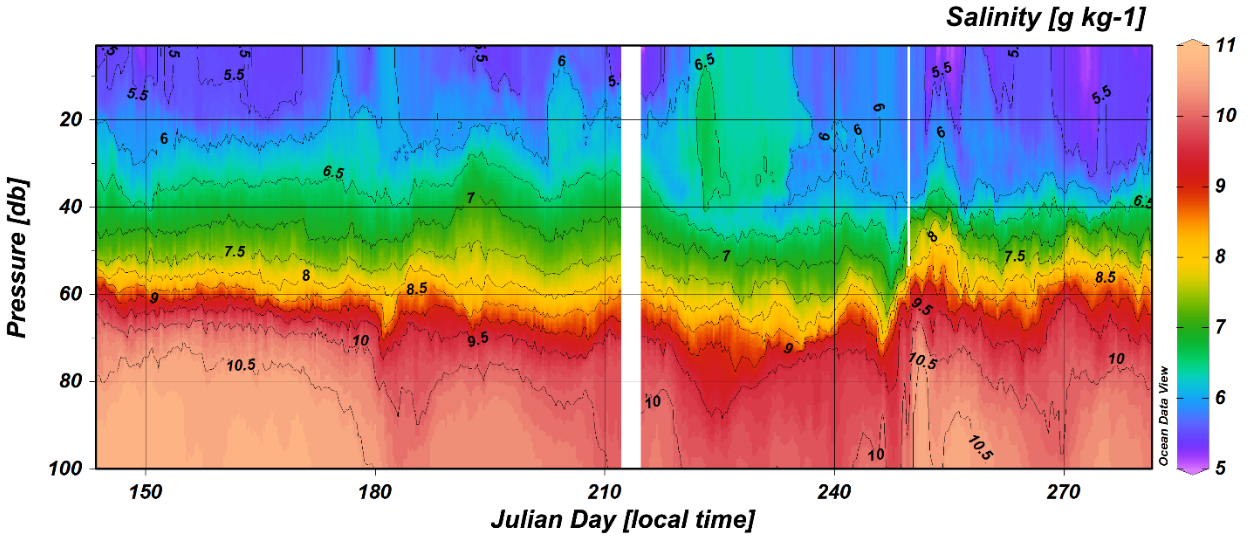
TTU off-shore measurement systems

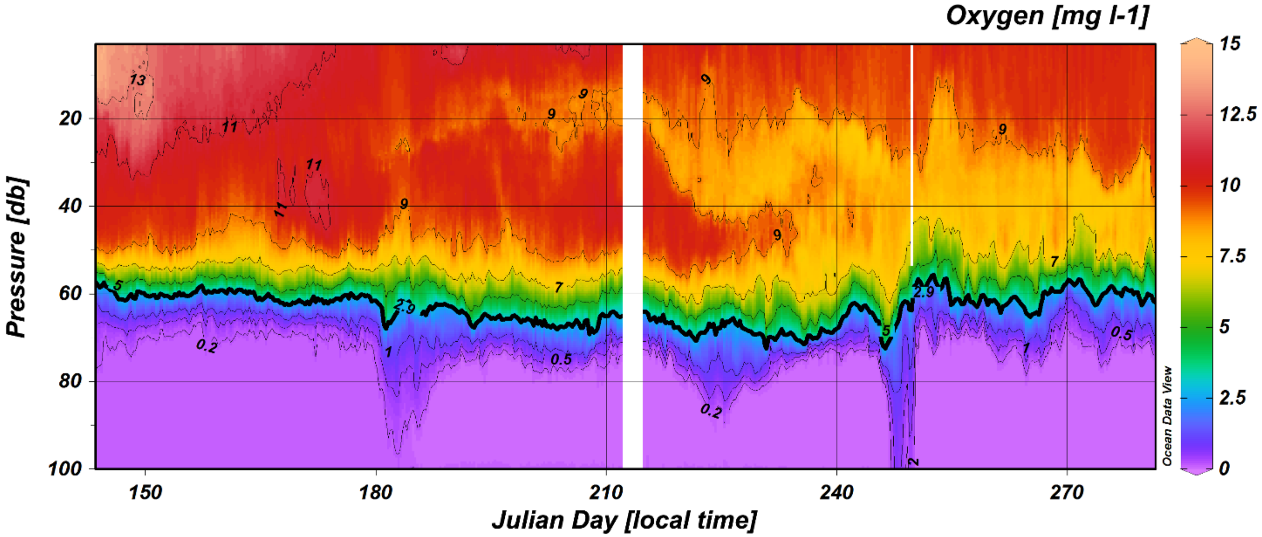




GOF deep water dynamics as observed at Keri in 2017

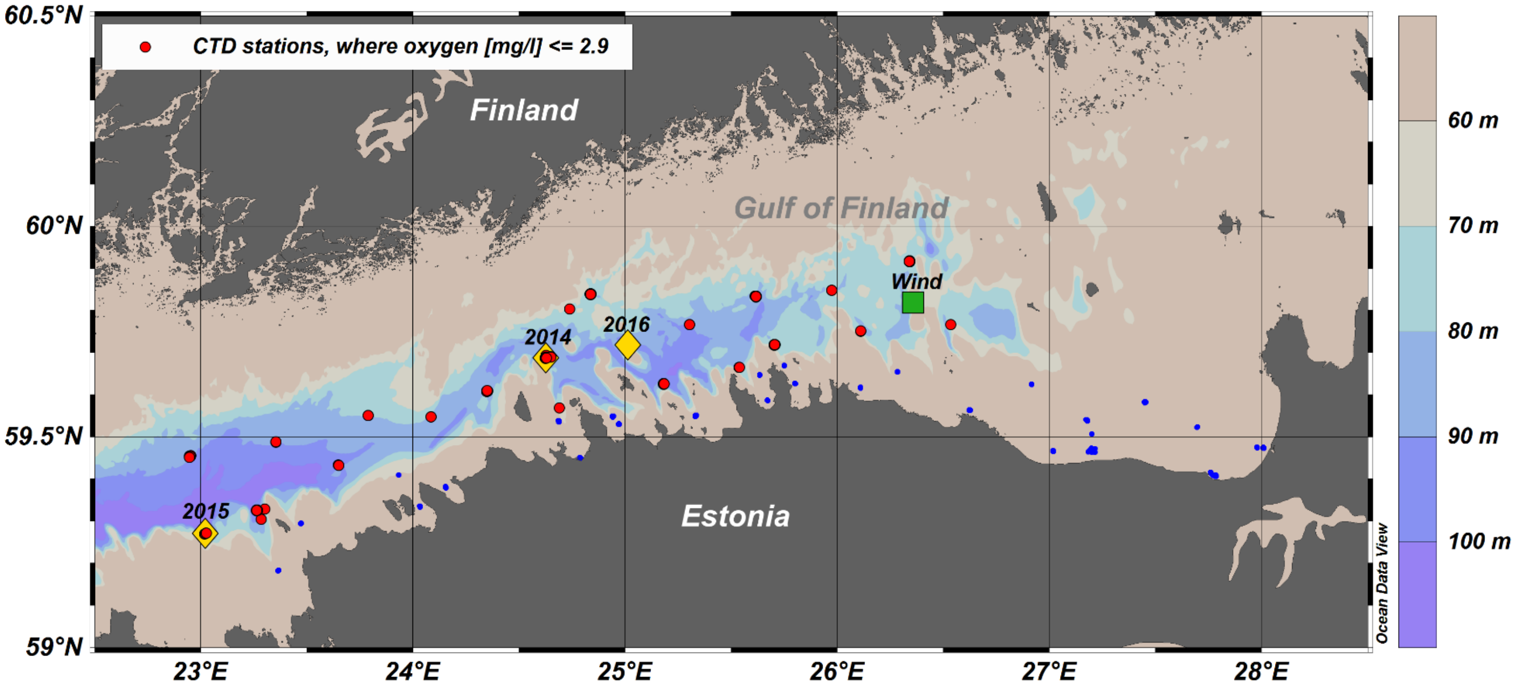






Department of Marine Systems
Tallinn University of Technology

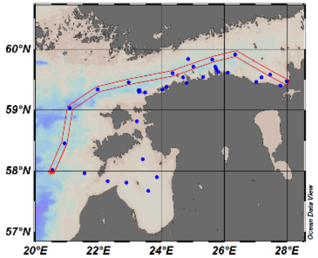
Monitoring stations used in the analysis



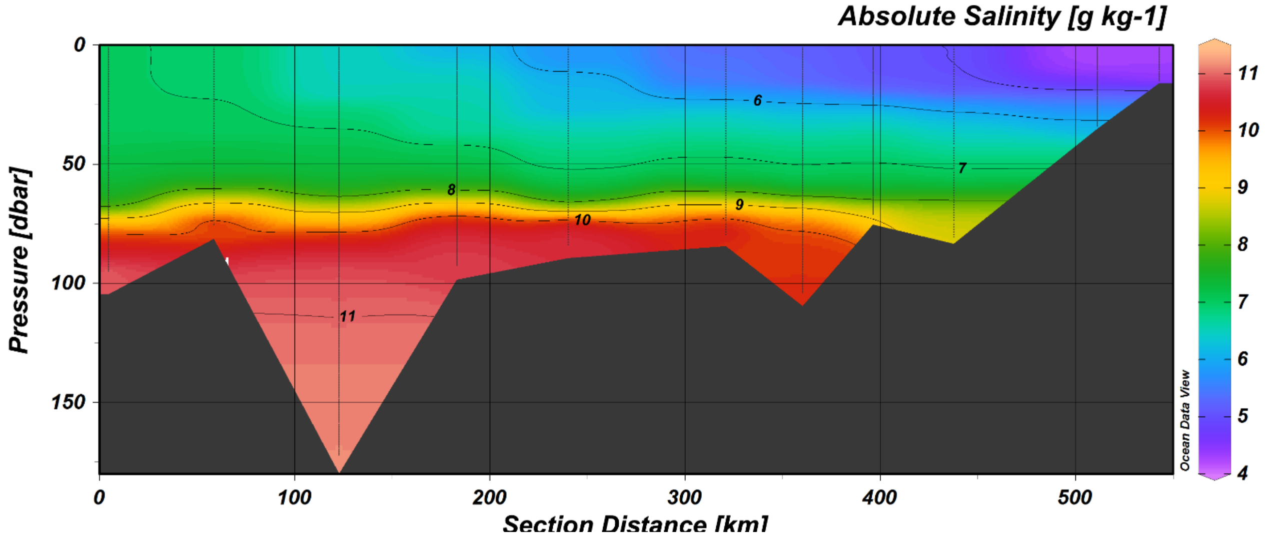
- CTD measurements by Department of Marine Systems, Tallinn University of Technology. 2014 - national monitoring and the Gulf of Finland year 2014 programmes. 2016 - national monitoring.
- Wind data from Estonian Environmental Agency. Wind direction and speed was measured at 10 m height every hour and displayed as average values of the last 10 minutes of every hour.

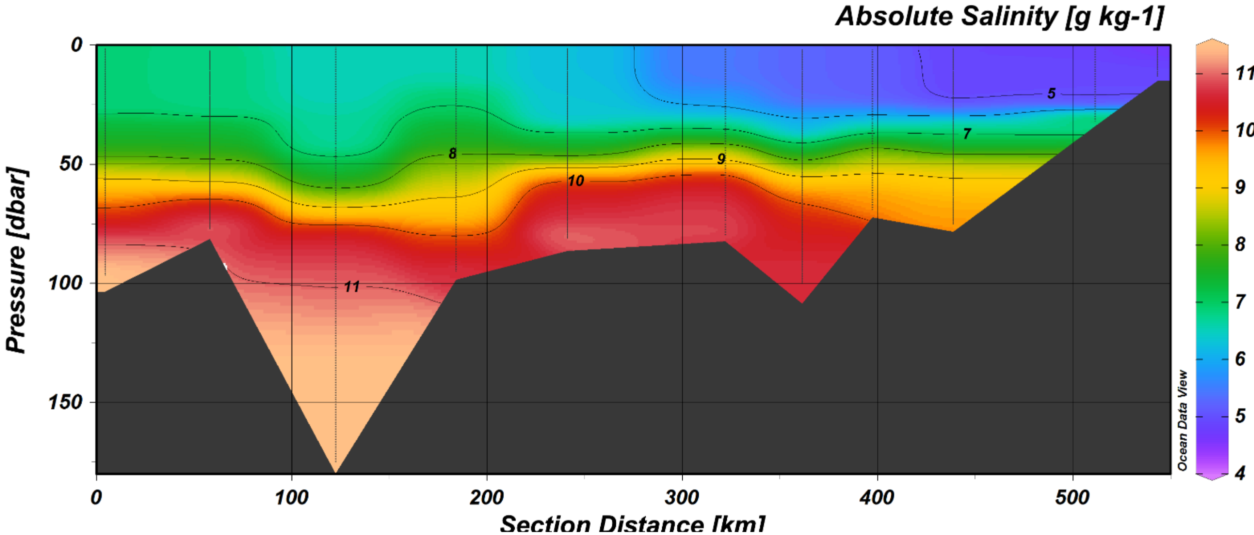
The number of profiles measured:

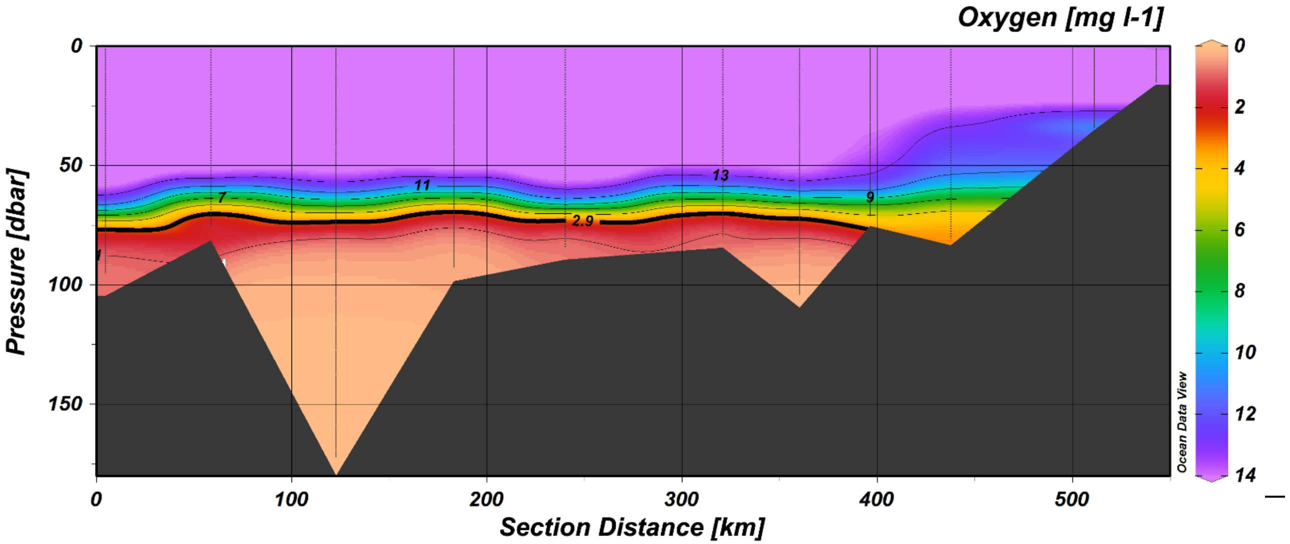
	2014 profiler	2014 CTD	2016 profiler	2016 CTD
January	-	19	-	-
February	-	-	-	-
March	-	-	125	-
April	96	15	119	25
May	209	55	96	7
June	172	3	117	23
July	177	23	113	27
August	7	60	119	30
September	173	-	117	-
October	137	-	96	22
November	-	27	10	-
December	-	-	17	-
ALL YEAR	**971**	**202**	**929**	**134**
April to September	834	156	681	112

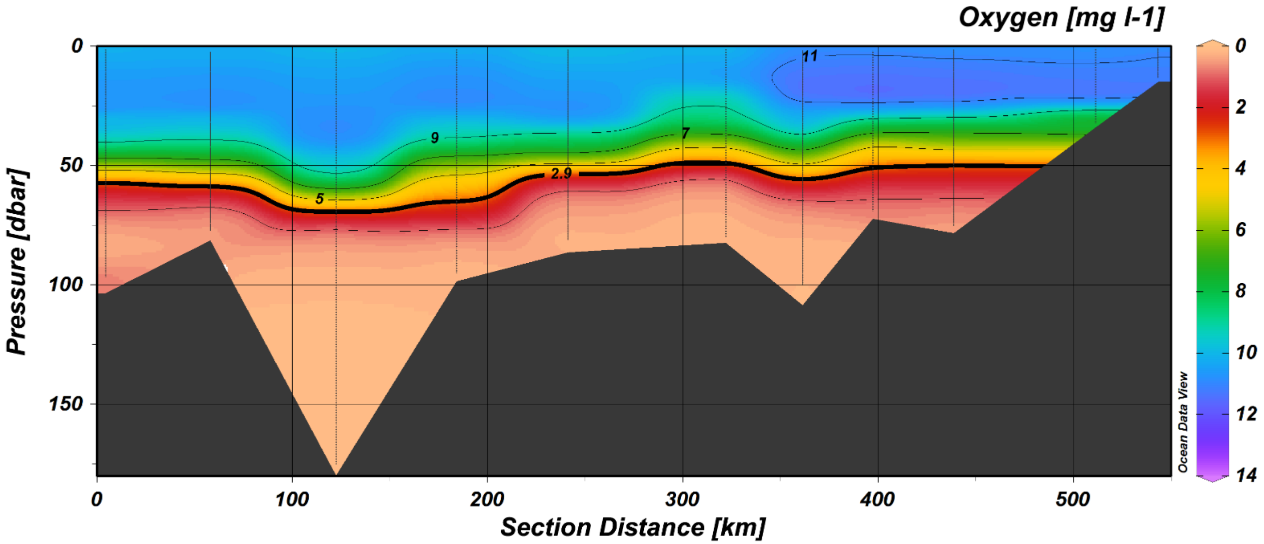


GOF salinity and oxygen in April and October 2016







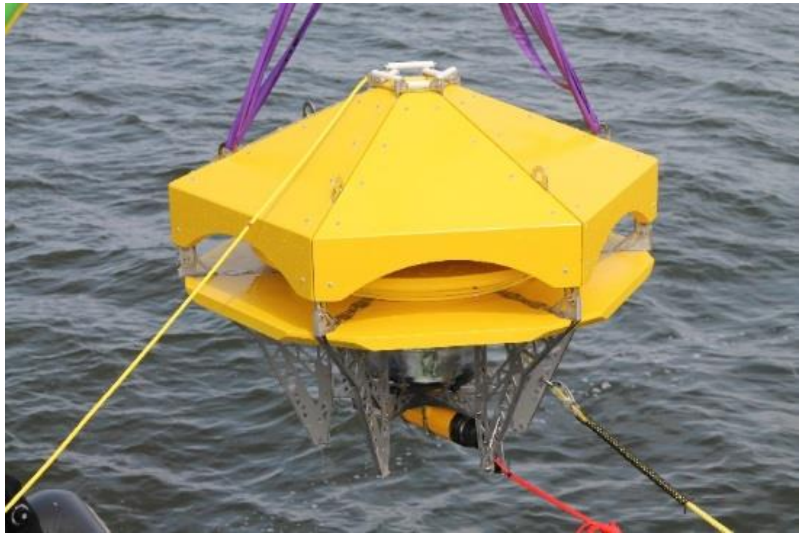


Autonomous profiling stations

- Developed by Flydog Solutions Ltd. (Estonia)
- Main measurement device - OS316plus CTD probe (Idronaut s.r.l., Italy) with Idronaut oxygen sensor
- Temperature, salinity, dissolved oxygen content etc. at the rate of 9Hz while moving down (in 2014) or up (in 2016) with an average speed of 10 cm s^{-1}

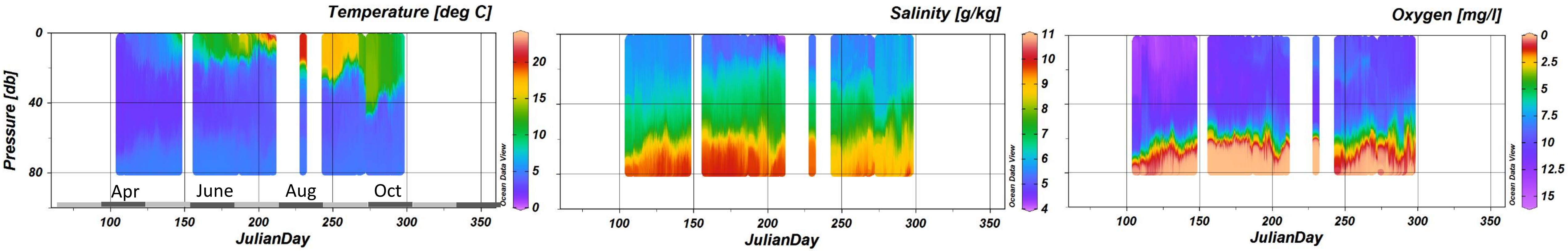
2014 – Buoy based profiler

2016 – Bottom mounted profiler

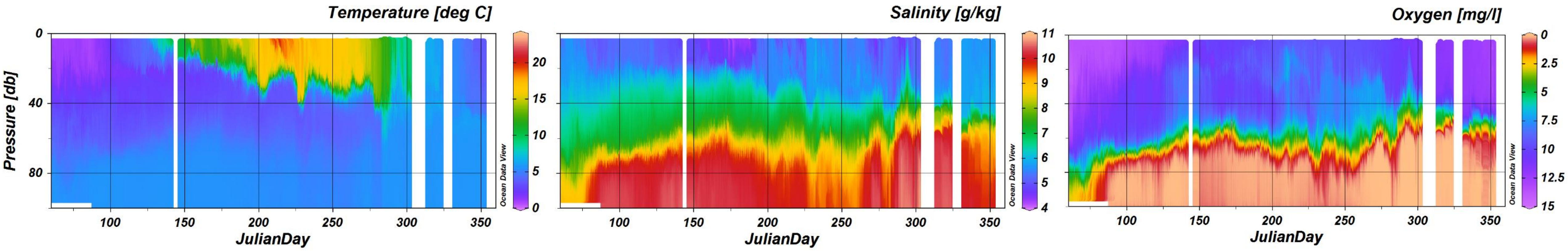


Variability of vertical distributions of temperature, salinity and oxygen in 2014 and 2016

2014 profiler

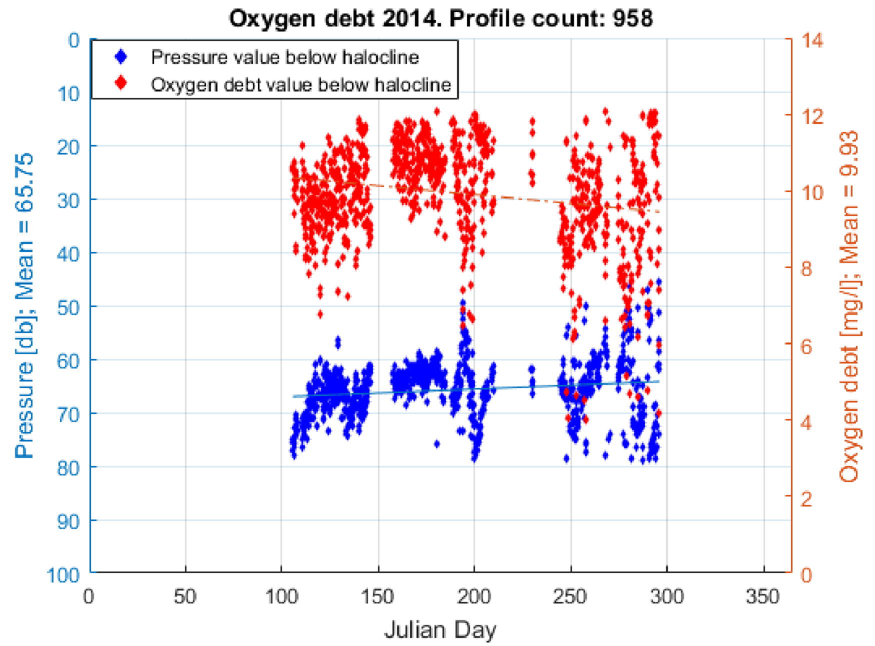


2016 profiler



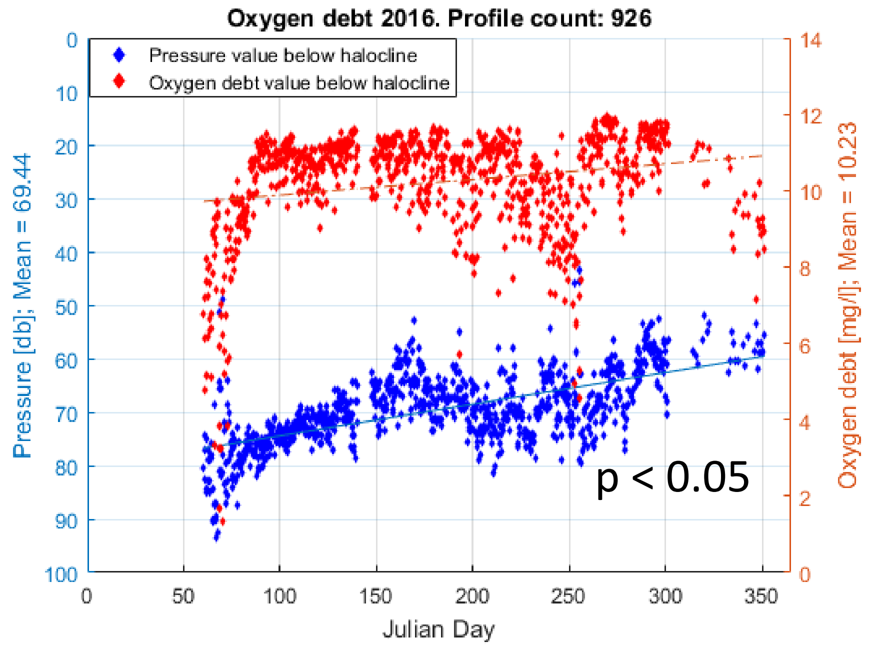
Oxygen debt

- Oxygen debt = Saturated oxygen content – Measured oxygen value
- Value below halocline (salinity gradient >= 0.07 g/kg per meter)
- GOF threshold value – **8.66 mg/l**



Halocline found in 98.7% of profiles

2014	Below halocline pressure	Oxygen debt April-September	Oxygen debt whole year
Minimum	45.5	4.0	4.0
5th percentile	56.0	8.2	7.5
Mean	**65.8**	**10.1**	**9.9**
95th percentile	75.5	11.66	11.7
Maximum	79.0	12.07	12.1



Halocline found in 99.7% of profiles

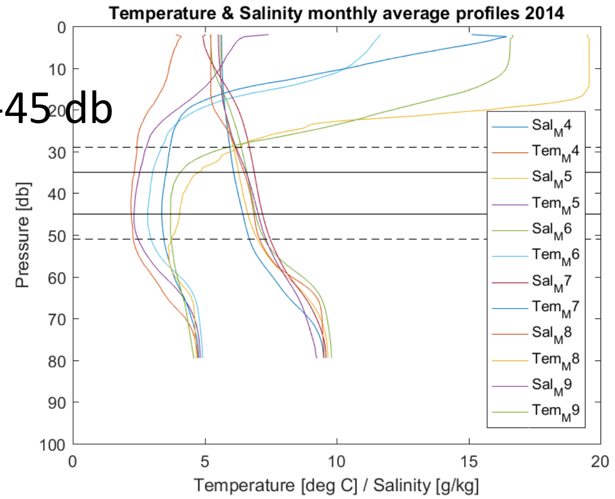
2016	Below halocline pressure	Oxygen debt April-September	Oxygen debt whole year
Minimum	43.5	4.6	1.3
5th percentile	58.0	8.4	7.6
Mean	**69.4**	**10.5**	**10.2**
95th percentile	79.8	11.6	11.6
Maximum	93.5	12.0	12.0

HELCOM 2007-2011: GoF – 10.542 (mg/l)

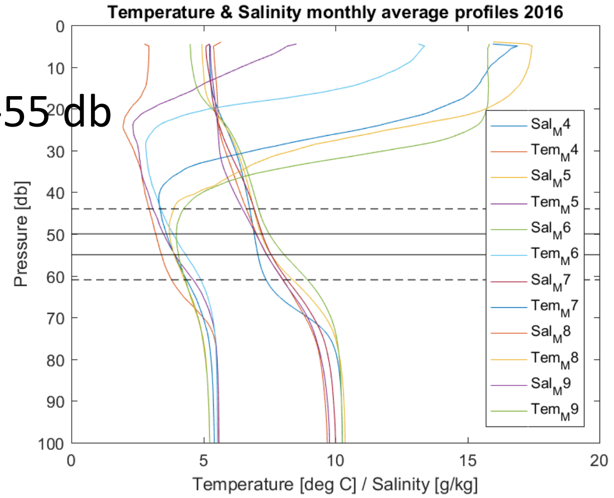
Oxygen Consumption

Oxygen consumption for the summer season below the productive layer but above the halocline – 'stagnant layer'

35-45db

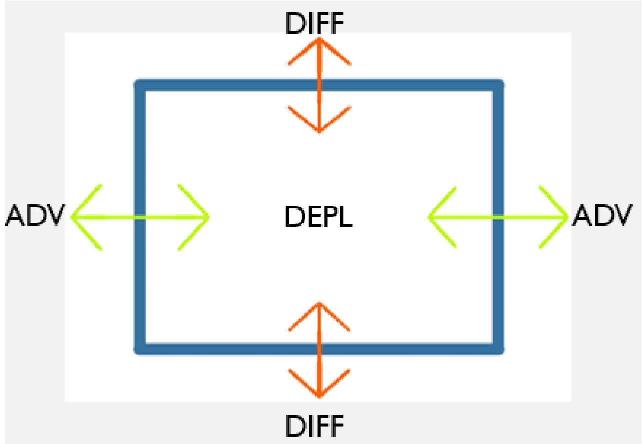


50-55db



$$ADV(Sal) = DEPL(Sal) - DIFF(Sal)$$

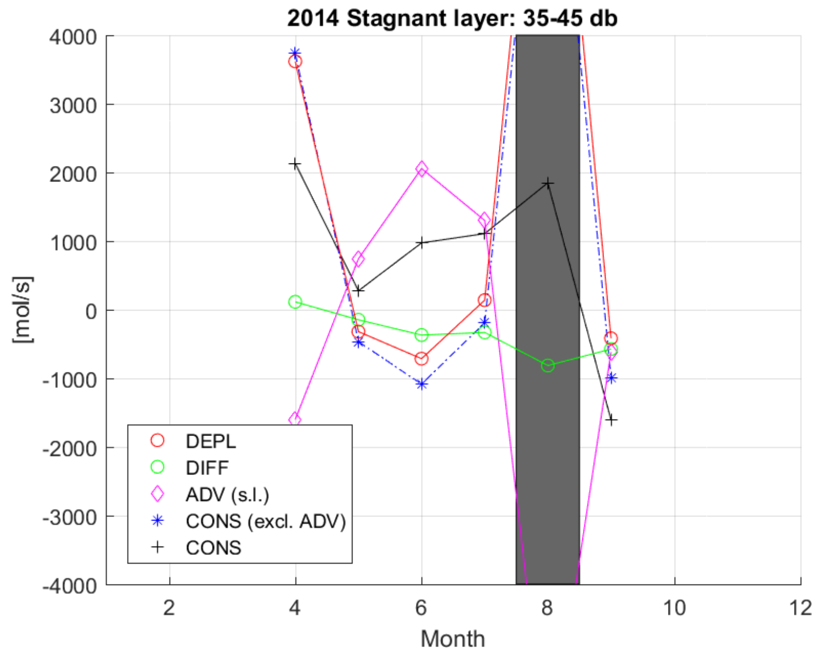
$$ADV(O_2) = (a * ADV(Sal) + b)/32$$



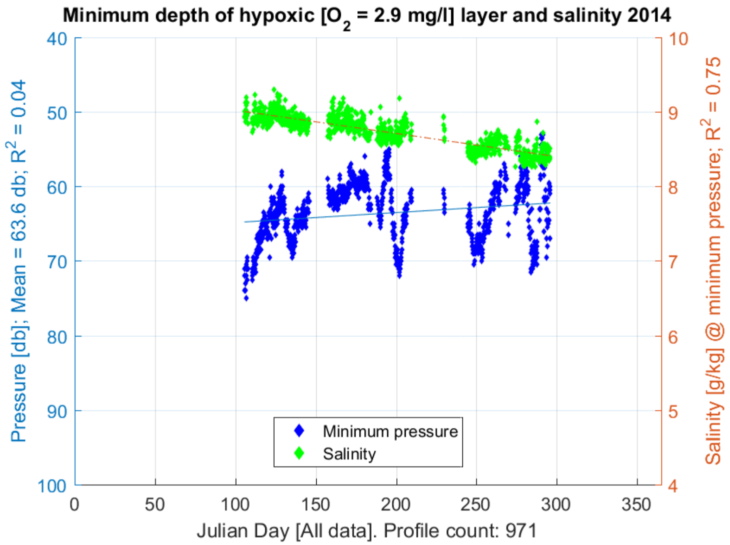
[V*mol/s]	2014 mean
Depletion	1946
Diffusion	-353
Advection (s.l.)	-803
Consumption	**790**

$$CONS = DEPL + DIFF + ADVb$$

If advection is not taken into account, the consumption could be a negative value

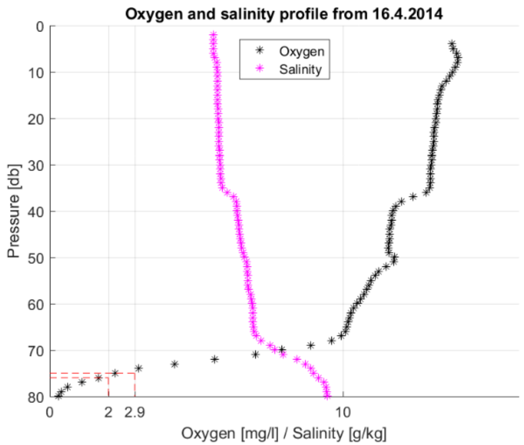


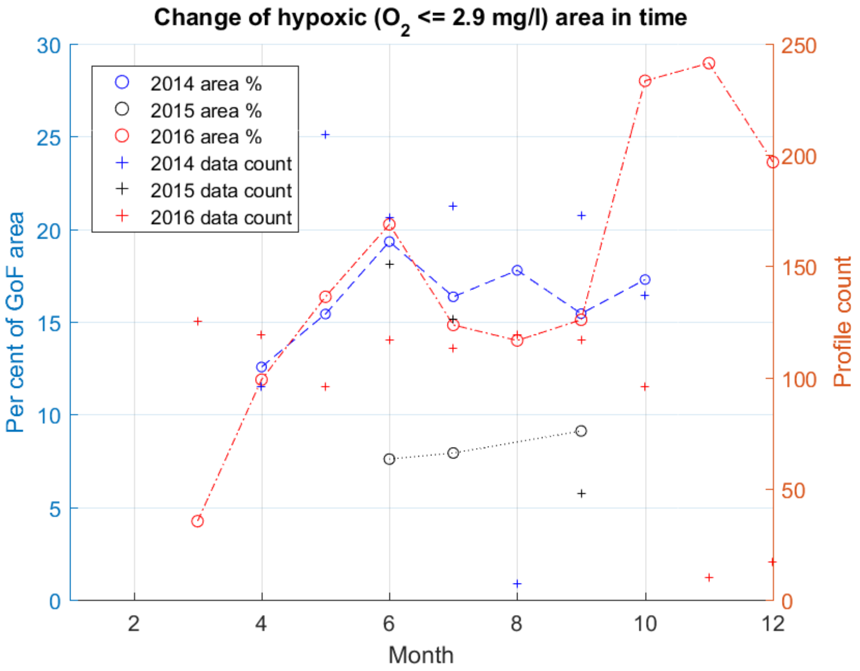
Hypoxic area

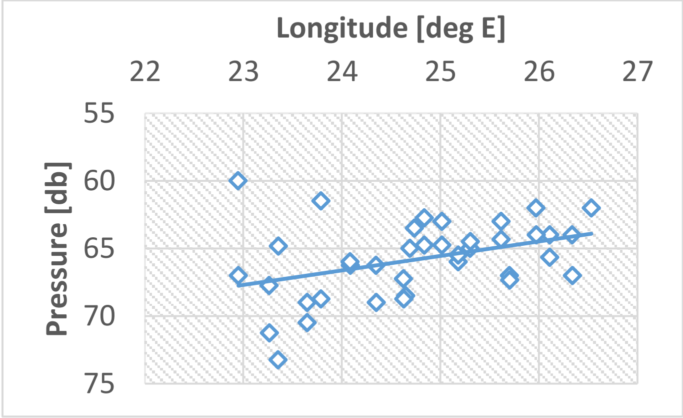


2.9 mg l (= 2.00 ml/l = 89.3 µmol/l)

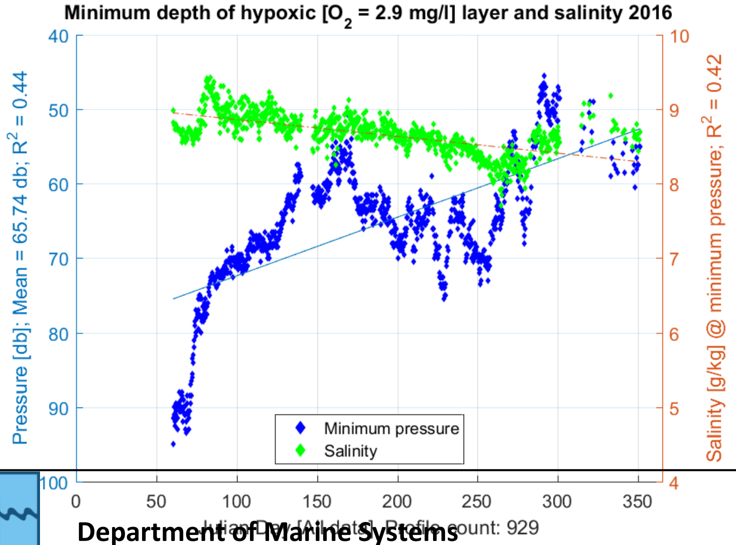
On average, about **15%** of GoF bottom is hypoxic





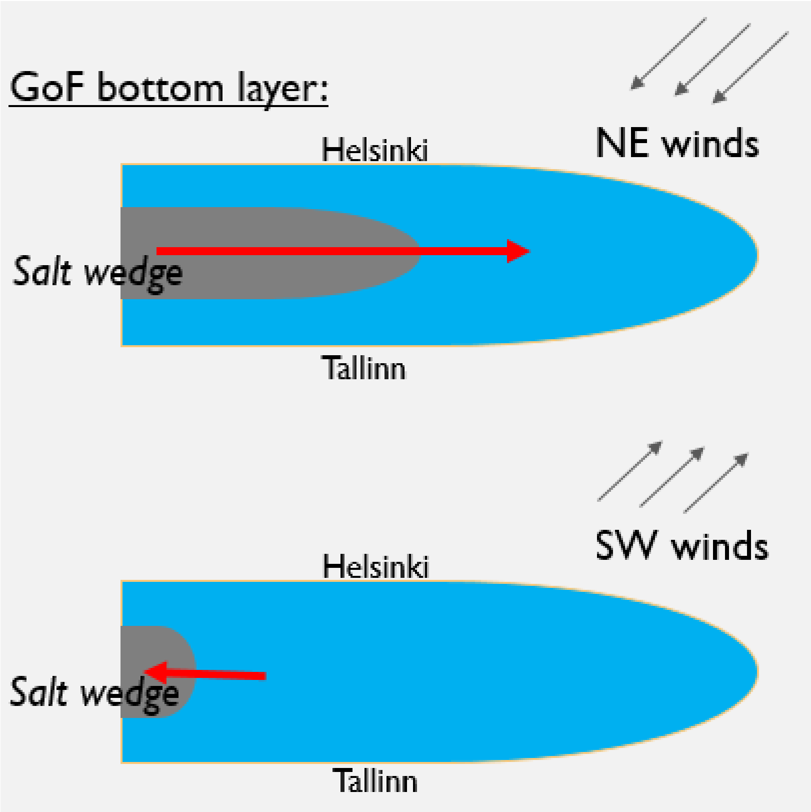


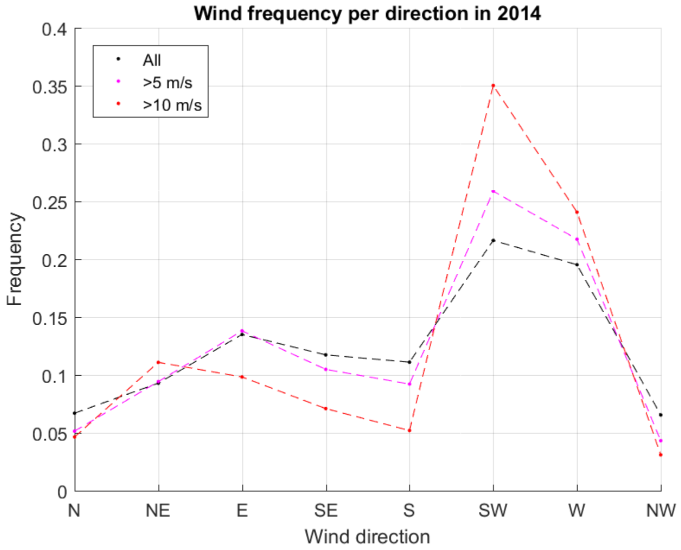
CTD May & August 2014
Inclination: -1.07 db/degE
(-1.91 db/100 km)
N = 38; R^2 = 0.16; p = 0.012

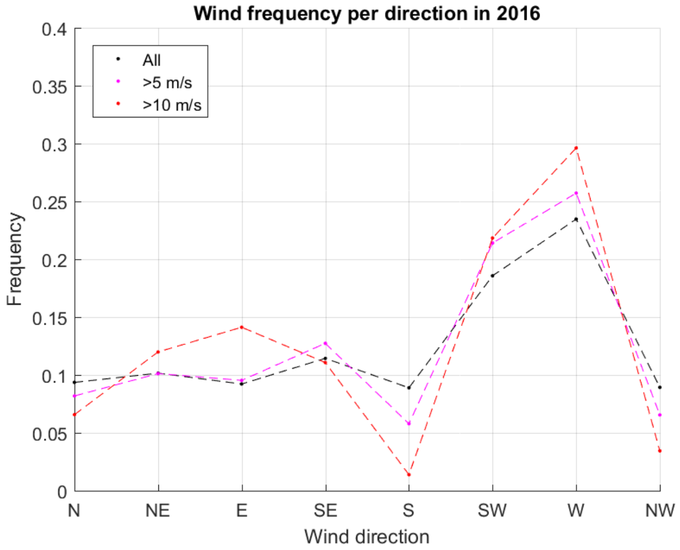


Wind conditions

Since the extent of the near-bottom salt wedge in the GoF depends on the wind forcing (enhancing or acting against the estuarine circulation), the prevailed wind conditions have to be taken into account
Average along gulf wind component from ENE (70°) was calculated to relate the along-gulf movement of the salt wedge to the wind forcing







Conclusions and future outlook

- Analysis of behaviour of indicators in relation to loads and natural variability still has to be carried out using all available data and modelling, e.g.,
  - is it reliable to assess the status only based on one year of monitoring?
  - how to take into account the impact of the natural variability in near-bottom conditions on nutrient concentrations?
- Better coordination of development of indicators and threshold values at a regional level (between the countries and between the HELCOM and contracting parties) to reduce the mismatch between the coastal and open sea threshold values
- Development of an oxygen indicator is not an easy task – hydrographic conditions influenced by salt water inflows and wind generated circulation have to be taken into account
- Oxygen consumption indicator is complicated to use even having high-resolution profile data available – no such „stagnant layer“ exists
- Automated high-frequency observations have to be applied to get natural variability due to hydrographic conditions

Thank you for your attention!

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Infrastructure was supported by the EU through the European Regional Development Fund and Estonian-Swiss Cooperation Programme

European Union
Regional Development Fund

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EESTI-ŠVEITSI KOOSTÖÖPROGRAMM
ESTONIAN-SWISS COOPERATION PROGRAMME

From small scales to large scales
–The Gulf of Finland Science Days 2017
9th-10th October 2017
Estonian Academy of Sciences, Tallinn

1st Day

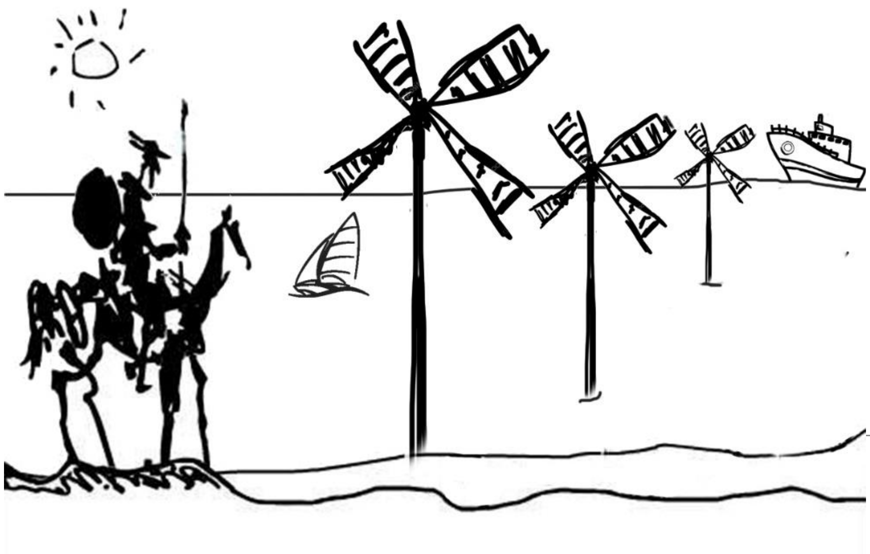
Gulf of Finland Co-operation

L. Danilova, A. Lappo

Social aspects of maritime spatial planning

НАУЧНО-ИССЛЕДОВАТЕЛЬСКИЙ ПРОЕКТНЫЙ ИНСТИТУТ
АКВА-ТЕРРИТОРИАЛЬНОГО ПЛАНИРОВАНИЯ
«ЕРМАК СЕВЕРО-ЗАПАД»
Scientific and Research Institute of Maritime
Spatial Planning Ermak North-West

СЕВЕРО-ЗАПАДНЫЙ
ИНСТИТУТ
УПРАВЛЕНИЯ



SOCIAL ASPECTS OF MARITIME SPATIAL PLANNING

Социальные аспекты
Морского Пространственного Планирования

Larisa Danilova
Andrei Lappo

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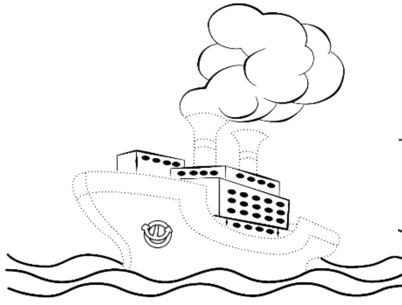
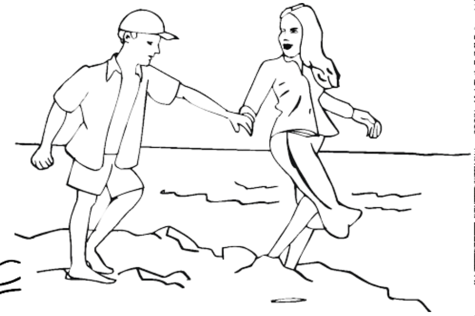
Tallin
October 2017

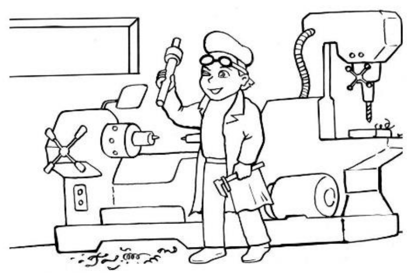

Toast to the Common GoF Capacity Building!

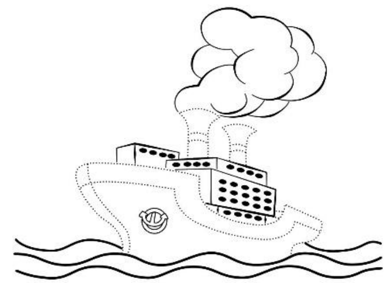
Coastal areas of the Gulf of Finland

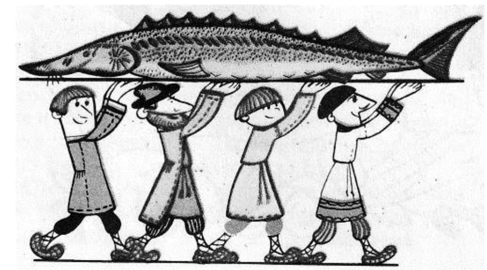
Приморские территории Финского залива

How many people work in the sectors related to the sea use?

Сколько человек работают в отраслях, связанных с морем?







FAMILY RATIO:

For large cities - 3-3,2
For medium-sized cities - 2.5
For small and rural settlements - 2,1-2,2

Working population =
(P1/300 + P2/250 + P3/210) x 100 =

3.5-4 million people

Working population in the sectors related to the sea use (near 50%):

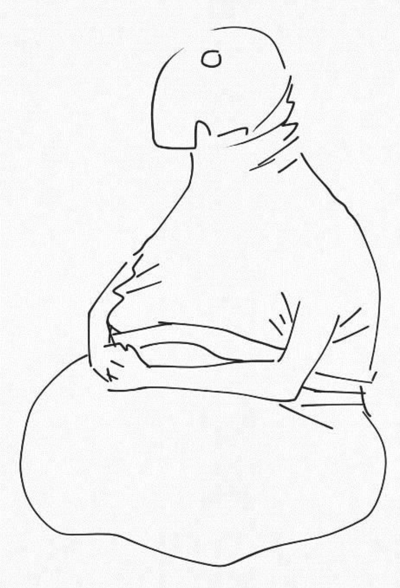
1,5-2 million people

P1 - Population of large cities
P2 - Population of medium-sized cities
P3 - Population of small towns and rural areas

Problems of coastal regions of the North-West Federal District of Russia. Imbalance.

Проблемы приморских Субъектов СЗФО РФ. Дисбалансы.

- the structure of personnel training and value orientations of the working population do not correspond to the structure of demand for skilled labor;
- The geography of work places does not correspond to the settlement pattern;
- Investment proposals do not correspond to the needs of infrastructure development;
- the population's expectations of quality of life do not correspond to the possibilities of the area;
- inadequate administrative support for a business, focused on the innovative sectors.



Strategy for smart sustainable and comprehensive growth.

Стратегия умного устойчивого и всеобъемлющего роста.

Directive 2014/89/EU on MSP

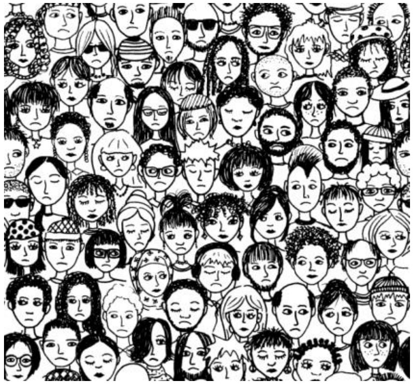
“(4) Maritime spatial planning supports and facilitates the implementation of the Europe 2020 Strategy for smart, sustainable and inclusive growth, which aims to deliver high levels of employment, productivity and social cohesion, including promotion of a more competitive, resource-efficient and green economy. The coastal and maritime sectors have significant potential for sustainable growth…”

Strategic directions of development of St. Petersburg and Leningrad region of Russian Federation:

- Ensuring sustainable economic growth;
- Development of human capital;
- Improving the quality of the urban environment;
- Ensuring the effectiveness of management and the development of civil society.

Socio-economic indicators of coastal areas and cities proposed for MSP of The Gulf of Finland.

Социально-экономические показатели приморских районов и городов, предлагаемые к учету в МПП Финского залива.



SOCIAL INDICATORS:

- Population;
- income per capita;
- the proportion of the population working in the stabilizing sectors of the Blue Economy;
- indicators of the natural movement of the population (natural increase / decrease in life expectancy, average number of children);
- indicators of mechanical movement of the population (migration);
- indicators of morbidity, disability and physical development of the population.

ECONOMIC INDICATORS:

- GRP;
- share of marine activities in GRP;
- level of employment;
- unemployment rate;
- quality of life (degree of satisfaction of material, spiritual and social needs of a person)

Socio-ecological development of coastal regions and sanitary and hygienic living conditions.

Социально-экологическое развитие приморских регионов и санитарно-гигиенические условия проживания.

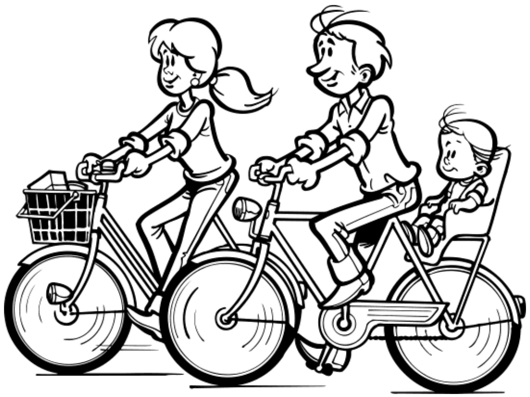
.

MEDICAL AND DEMOGRAPHIC INDICATORS:

- total infant mortality;
- life expectancy;
- natural increase (loss) of the population.

THE TASKS OF INCREASING THE INDIVIDUAL AND GROUP HEALTH STATUS OF THE POPULATION:

- - optimization of demographic situation;
- - Improvement of health;
- - reliability of life support systems.



Statement of the project task

Постановка задачи

Baltic SCOPE
Towards coherence and cross-border solutions in Baltic Maritime Spatial Plans

Baltic LINes
Coherent Linear Infrastructures in Baltic Maritime Spatial Plans

PLAN4BLUE

Pan-Baltic comprehensive and sectoral projects:
BaltScope, Baltic LINes, BaltRIM

Regional projects on the Gulf of Finland:

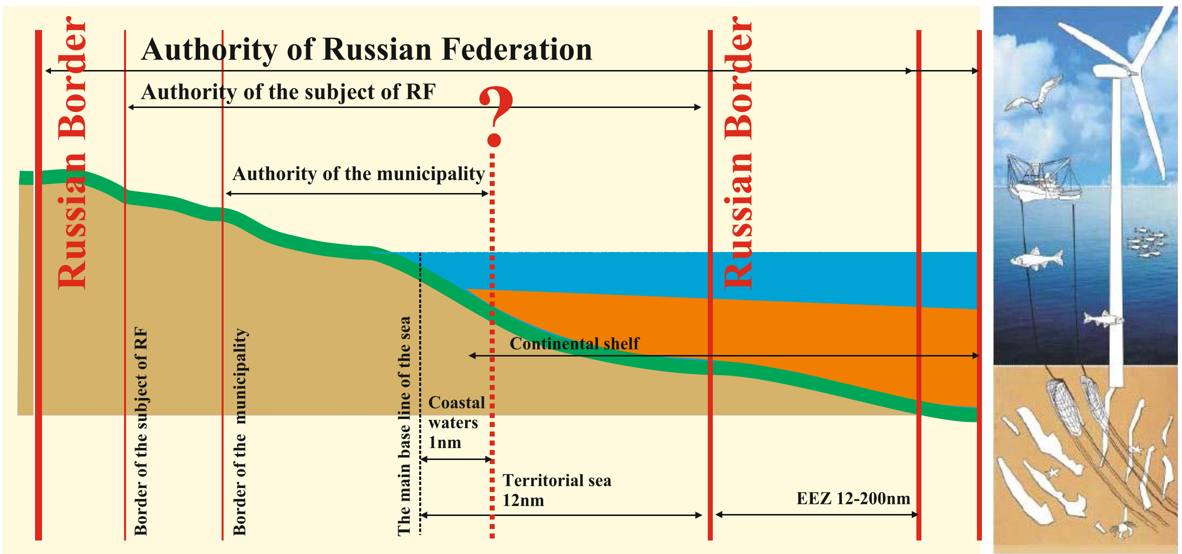
30 miles + 30 milesFinRus + 30 milesEstRus = Yachting tourism on the GoF

Plan4Blue + PlanGoF + Plan(GoFEstRus?) = MSP of the GoF

The boundaries of powers of authorities of different levels

Границы полномочий органов власти различных уровней

Boundaries of powers of the RF authorities of different levels (proposal)



Federal Level

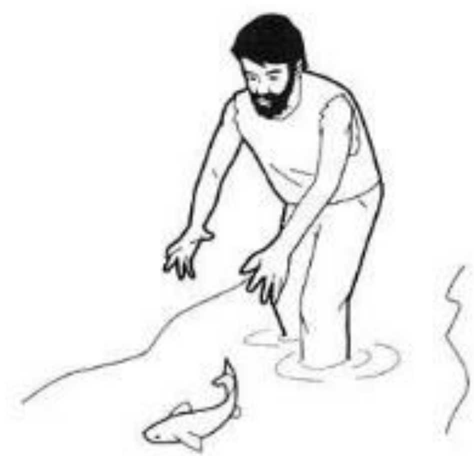
From the border of the exclusive economic zone (the continental shelf) to the land borders of the Russian Federation

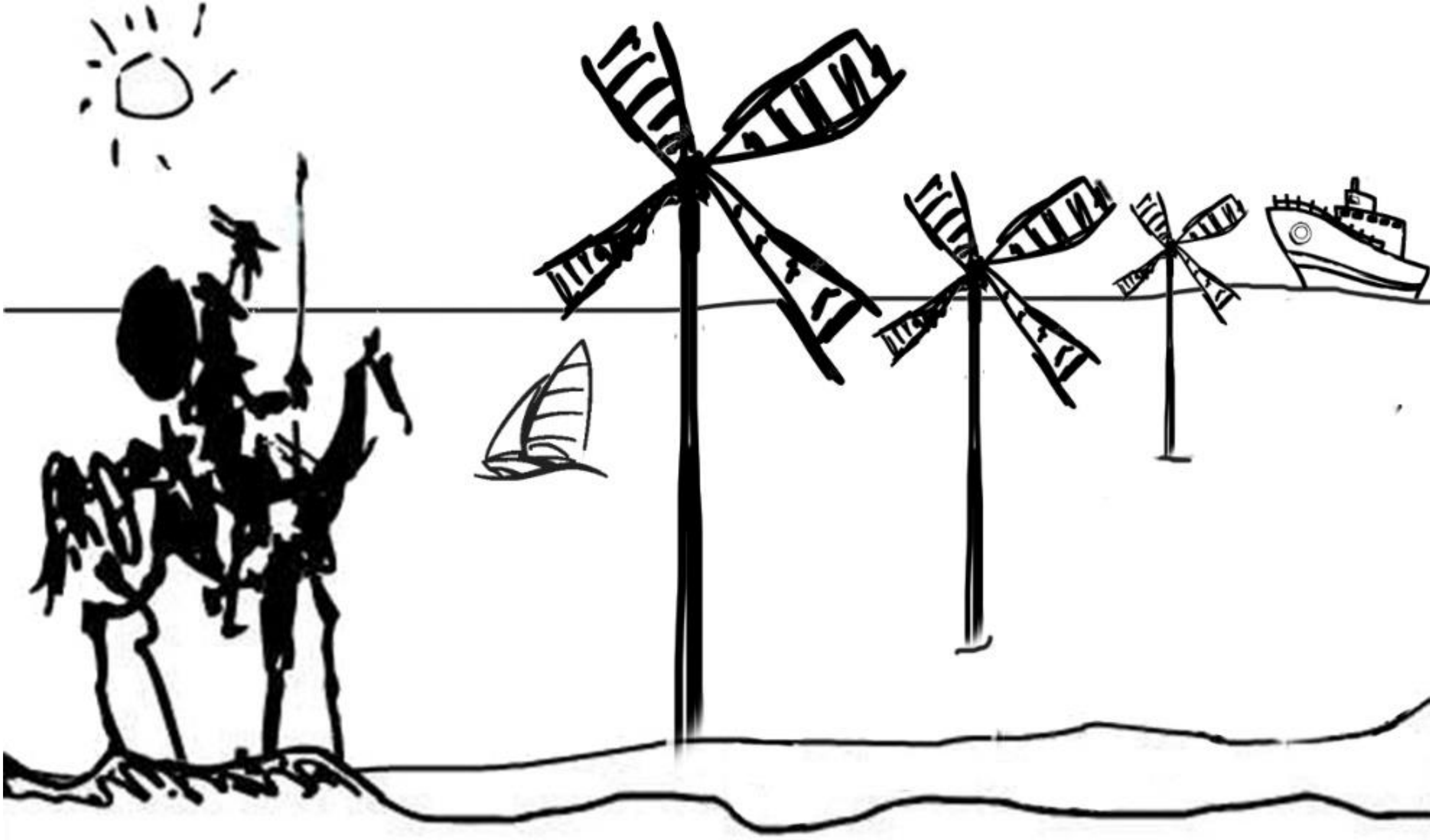
Regional Level

From the boundary of the territorial sea (12 miles) to the border of the Subject of the Russian Federation in relation to the powers of the subject;

Municipal Level (district)

From the conventional boundary of the coastal zone (one mile) to the border of the municipality





Спасибо за внимание! Kiitos! Täname!

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1st Day

Gulf of Finland Co-operation

J. Mannio, K. Siimes, E. Vähä, V. Junttila, H. Kankaanpää

Towards harmonisation of monitoring hazardous substances

Towards harmonisation of monitoring hazardous substances

Jaakko Mannio, Katri Siimes, Emmi Vähä, Ville Junttila & Harri Kankaanpää
Finnish Environment Institute
jaakko.mannio@ymparisto.fi

SYKE

Gulf of Finland tri-lateral Forum Tallinn, Oct 9-10, 2017

Gulf of Finland, Road Map 2017

Pollution and Ecosystem Health

This presentation highlights:

Improved monitoring of hazardous substances

- **Assessment threshold values for hazardous substances and their effects should be harmonized**

  ➔ enable harmonised status assessments

- **A set of regional priority substances for the monitoring of both “old” and “emerging” substances is needed**

Other topics within monitoring:

- The methods used for the assessment of biological effects should be harmonised
- An expert group for the harmonisation and optimisation
- A joint open-access database for the available monitoring data

Other issues in Road Map

Reduced emissions of hazardous substances to air, land, and water

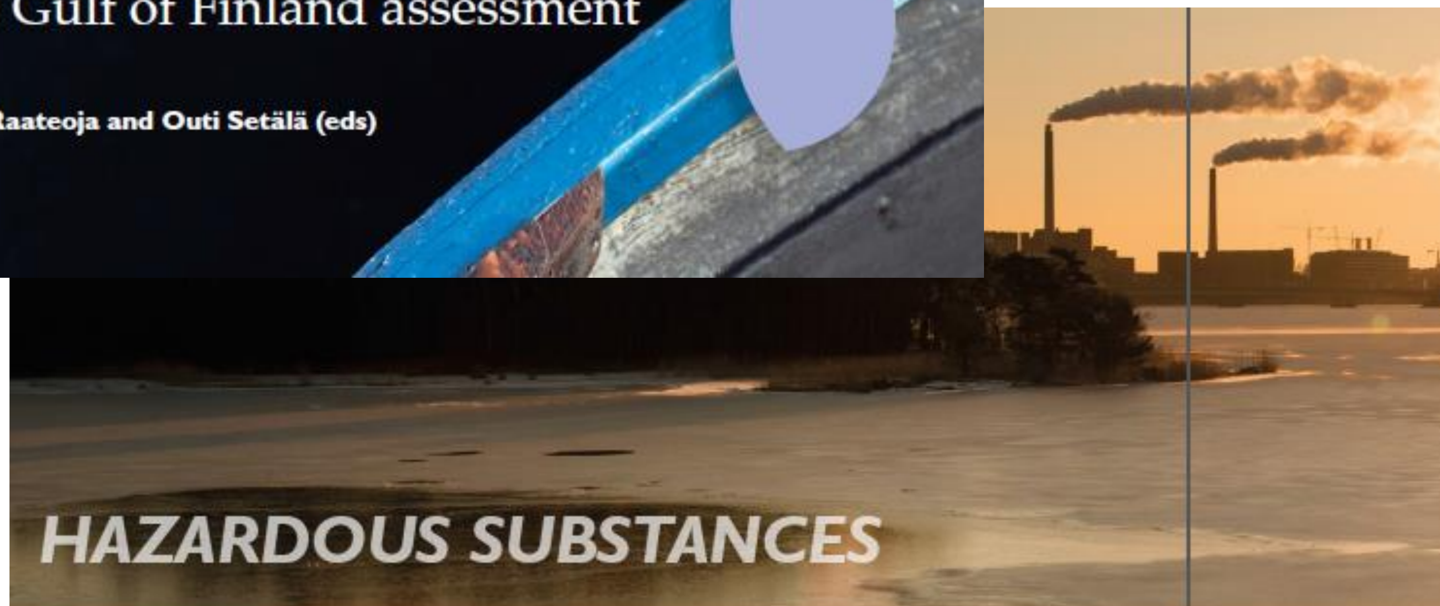
- More accurate emission inventories of hazardous substances
- Better technologies for hazardous substance removal

Targeted research on emerging problems; pharmaceuticals, microplastics

Dredging of contaminated sediments to be minimized and performed in an environmentally acceptable manner

SYKE

Published results 2016



Hazardous substances

Jaakko Mannio[1], Kari Lehtonen[1], Kirsten Jørgensen[1], Harri Kankaanpää[1], Oleg Korneev[2], Jukka Mehtonen[1], Ott Roots[3], Henry Vallius[4], Pekka Vuorinen[5], Lauri Äystö[1], Natalia Fedorova[2], Marja Keinänen[5], Tiit Lukki[6], Oksana Lyachenko[7], Alexander Rybalko[2], Simo Salo[1], Sara Söderström[1], Raisa Turja[1], Zoya Zhakovskaja[8]

[1] Finnish Environment Institute
[2] Federal State Unitary Research and Production Enterprise for Marine Exploration
[3] Estonian Environmental Research Centre Ltd.
[4] Geological Survey of Finland
[5] Natural Resources Institute Finland
[6] University of Tallinn
[7] State Research Institute of Lakes and Rivers Fishery
[8] Scientific Research Center for Ecological Safety, Russian Academy of Sciences

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HAZARDOUS SUBSTANCE C

STATE OF THE BALTIC SEA
- HOLISTIC ASSESSMENT -
First version 2017

THE INTEGRATED ASSESSMENT OF HAZARDOUS SUBSTANCES

TO BE UPDATED IN 2018

-Supplementary Report to the First Version of the 'State of the Baltic Sea' Report 2017

HELCOM INDICATORS

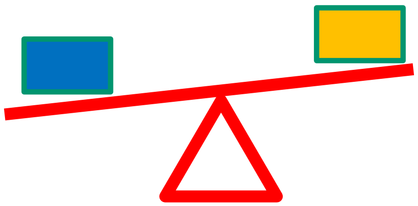
Browse the HELCOM hazardous substance core indicators

- **Brominated diphenyl ethers (PBDE)**
- **Perfluoroalkyl substances (PFOS, other PFAS)**
- **Dioxins (PCDD/F) and dl-PCB**
- **Trace metals (Hg, Cd, Pb)**
- **Hexabromocyclododecane (HBCDD)**
- **TBT and imposex**
- **PAHs and their metabolites**
- **Radioactive substances (Cs-137)**

Risk for "bad status"

Not assessed
in this presentation

Risk based prioritisation and assessment



EXPOSURE ASSESSMENT
- Subst. usage & pattern
- emissions
- persistence
- accumulation
- mobility

EFFECTS ASSESSMENT
Toxicity to biota:
- ”traditional effects”
- endocrine effects
- Other adverse effects (?)

measured conc.
threshold

RELATIVE RISK =
Are the concentrations higher than the treshold value ?

Hazardous Substances Indicators

HELCOM "CORE" and Finnish indicators (perch and herring)	EQS, QS or GES boundary in BIOTA
I	µg/kg wet wt.
PBDE	EQS 0,0085 < QS 44
PCDD/F + dl-PCB	EQS 0,0065 TEQ > QS 0,0012
PFOS HBCDD	EQS 9,1 < QS 33 167
Organochlorine pesticides PCB	10 (HCB), 55 (HCBD) not CORE 75 (not CORE)
Mercury	20 (*Finland 20+180 backgr.*) (food 500, EFSA)
Radioactivity Cs-137) (fish, sedim, water	2.5 Bq/kg (fish) 1640 Bq/m2 (sedim) 14.6 Bq/m3 (water)

EQS based on human health protection

EQS based on secondary poisoning of predators

- **Black = WFD substances with EQS in biota**

Haz Subst indicators cont.

Indicators	EQS, QS or GES Boundary in BIOTA	EQS or GES *In WATER*	STATUS
I	µg/kg wet wt.	µg/l	
Cadmium Cd **Lead Pb** **Nickel Ni** **Arsenic As**	160 (in food 50) 120 mg/kg (sedim) (in food 300) In food 500-1000	EQS 0,2 EQS 7,2 (bioavailable 1,3) 20 (bioavail. 4,0)	CORE CORE not HELCOM indic not HELCOM indic
TBT **TBT, TPhT, DBT, DOT**	2 (TBT in sedim)	0,0002	CORE secondary GES
LMS biomarker (perch liver)	10 min.		Pre-core
PAH-substances	5 (BaP) molluscs		CORE
Algal toxins (fish, plankton, water)	800 (food, neurotox)	1 (WHO, liver tox)	National indicator

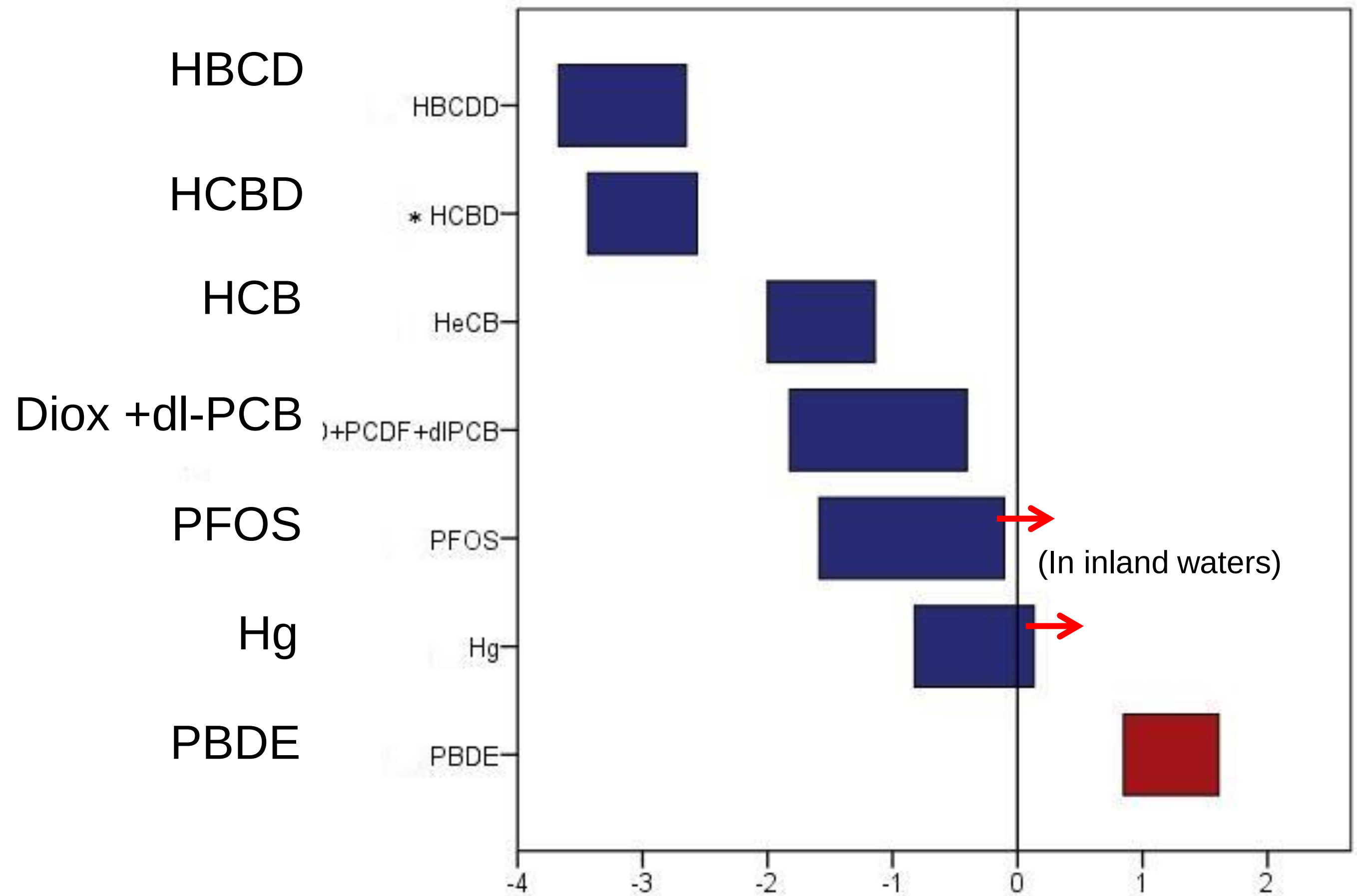
- **Black = WFD substances with EQS in water (except PAH)**

10.10.2017

Contaminants in fish in Finnish coastal/open sea areas 2010-2016

New results:

UUPRI



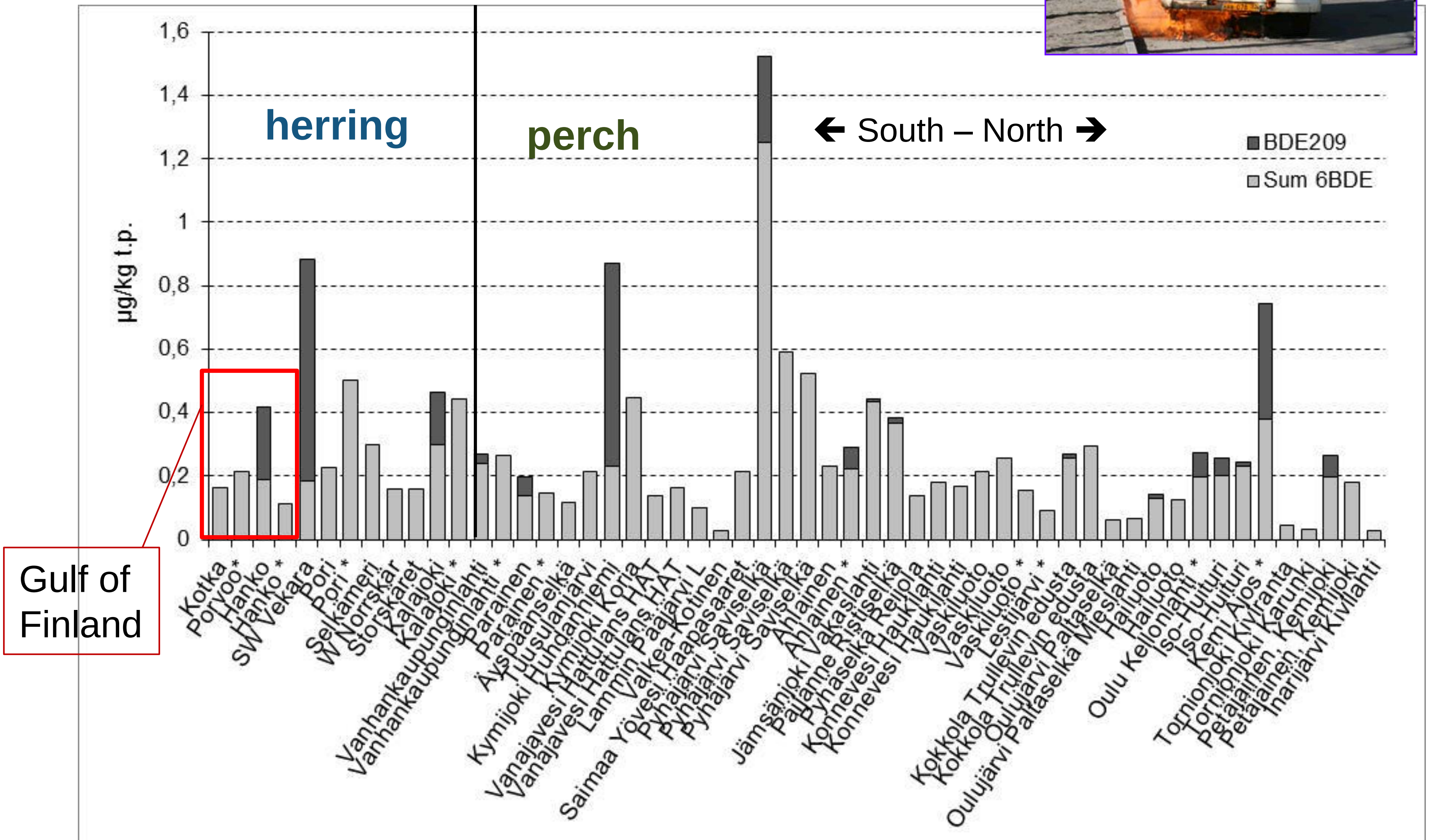
- perch + herring muscle
- Contaminant risk ratio (measured conc. in fish / HELCOM treshold)
- (10 ja 90 percentile, logarithmic scale)

- Red bar: average conc. >HELCOM treshold

SYKE

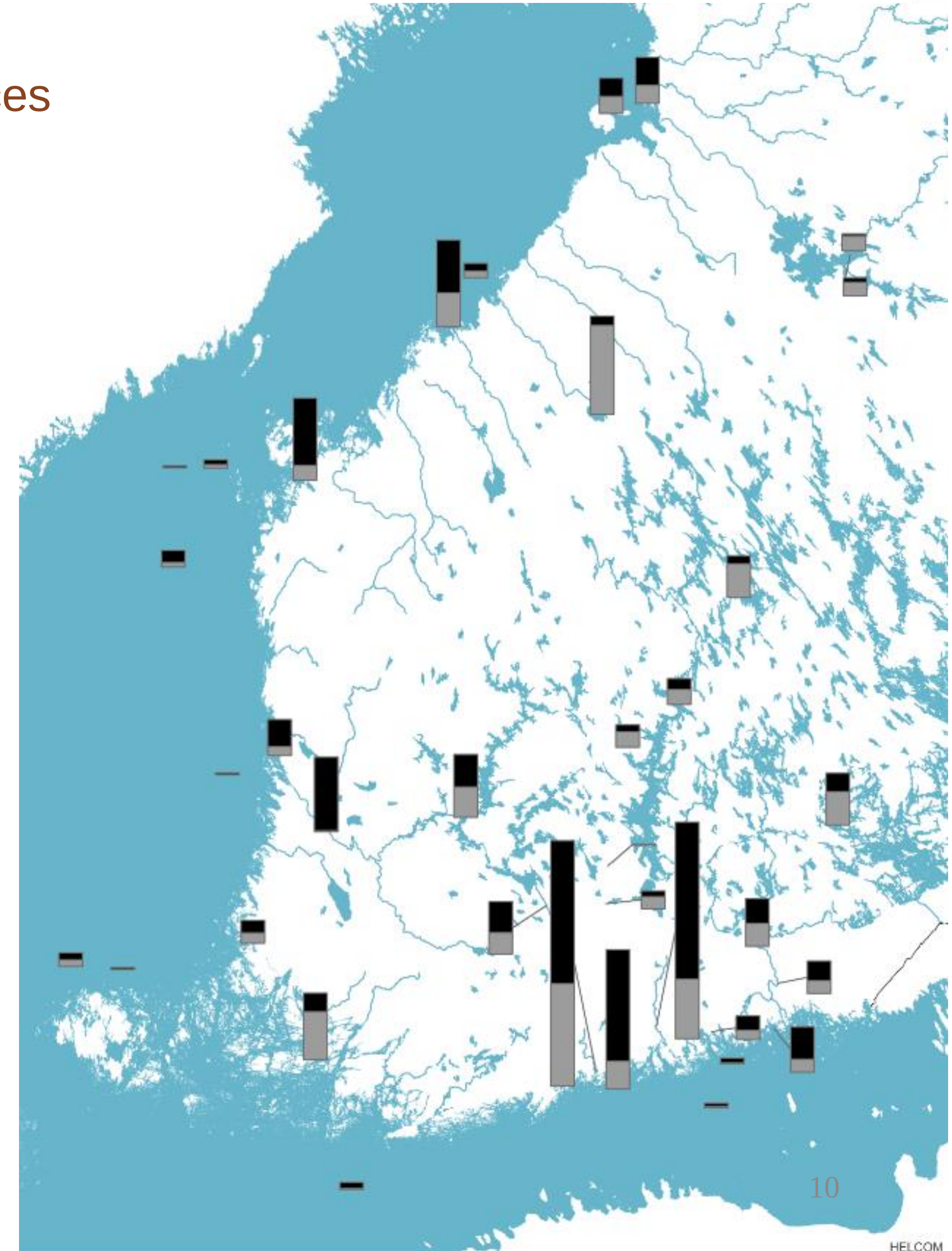
PBDEs in fish in Finland 2010-2016

- PBDE; Brominated flame retardant



PFAS in perch and herring muscle (2012 – 2016)

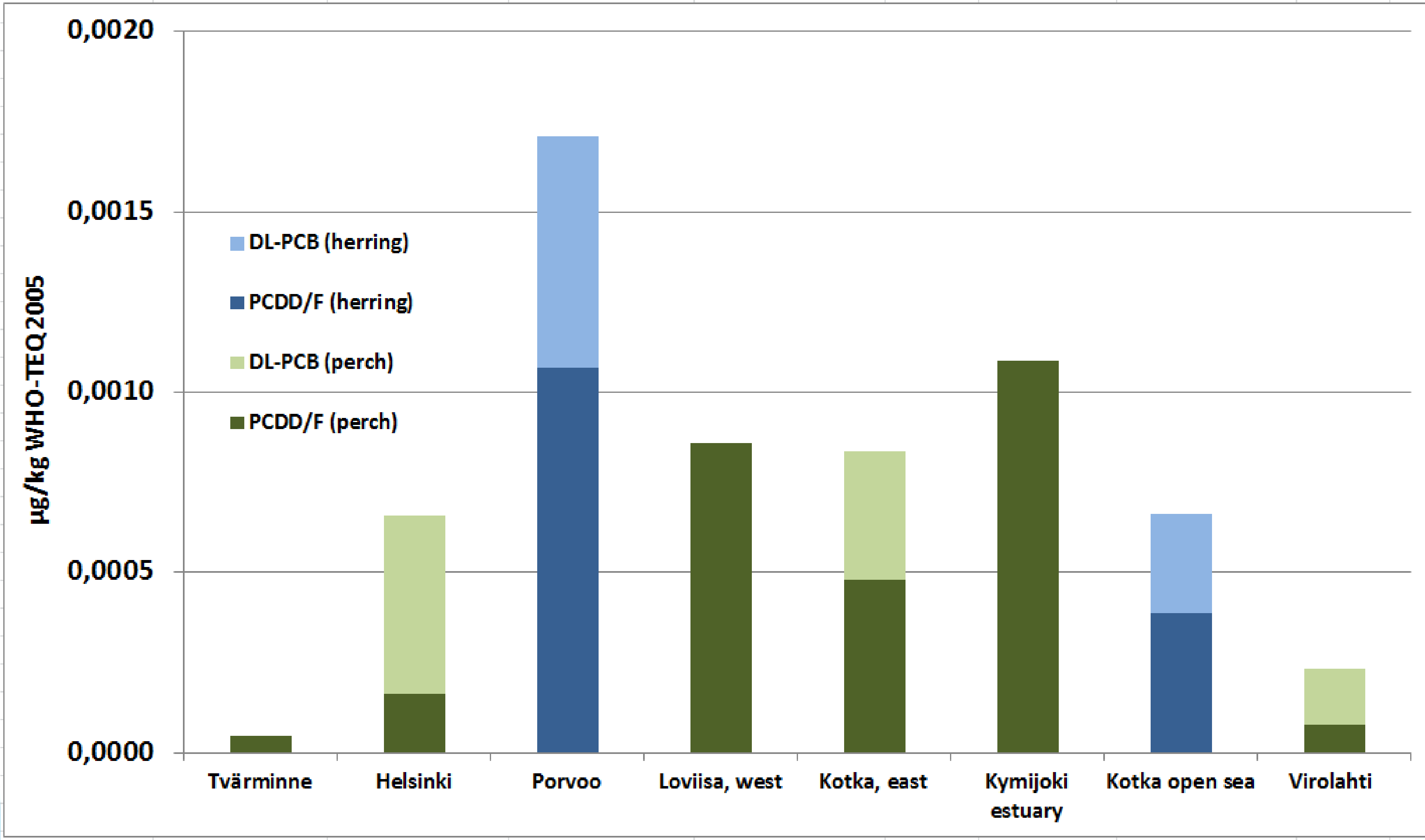
- Perfluorinated, surface active substances
  - Fire fighting foams
  - Textiles
  - Coatings, etc.



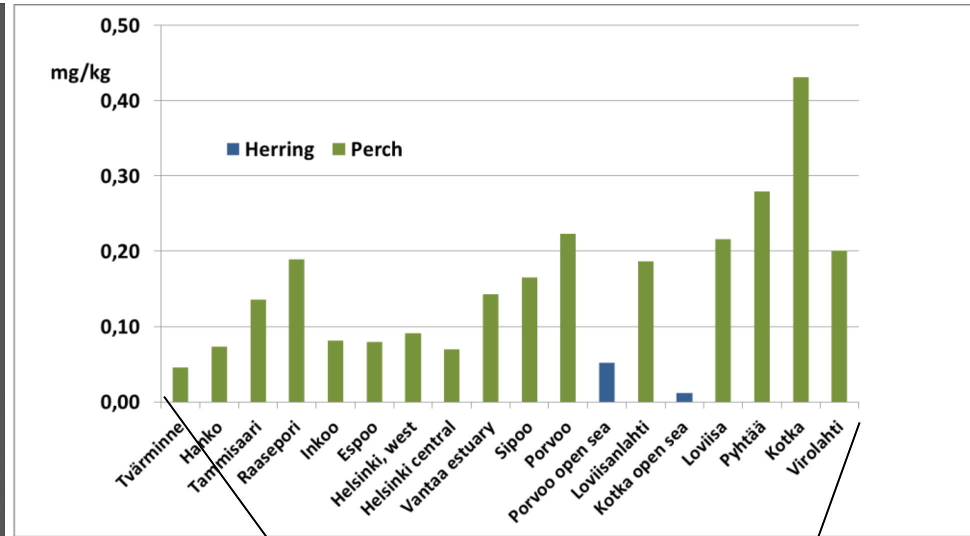
PFOS treshold (9,1 µg/kg)
- exceeded in some sites

No threshold for other PFAS

Dioxins in perch and herring muscle, Gulf of Finland (2012 – 2016)



SYKE



Mercury in fish is above HELCOM threshold value

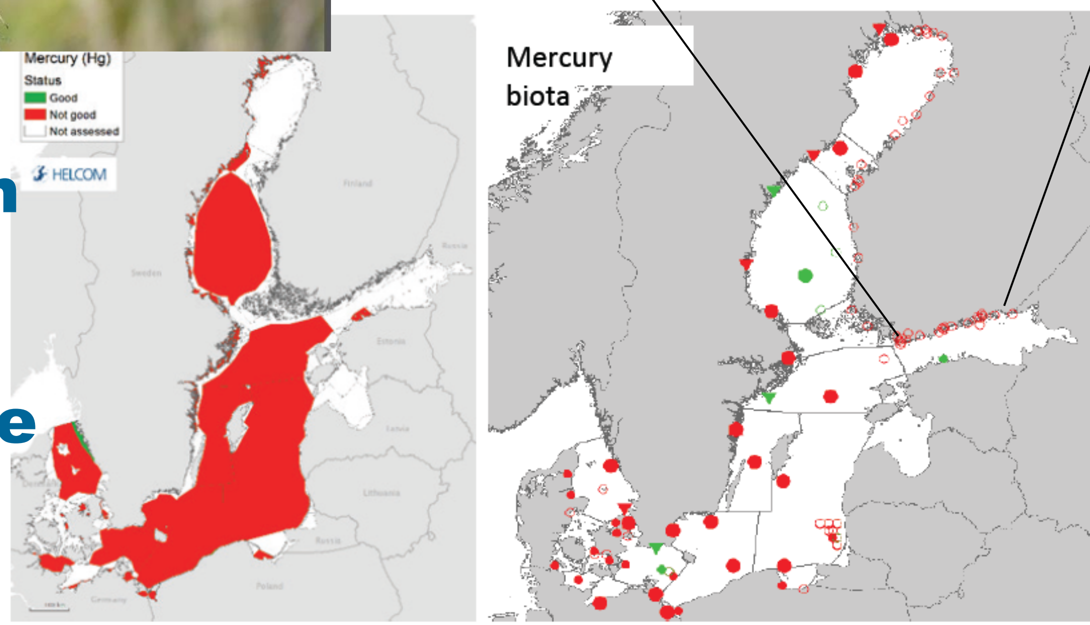
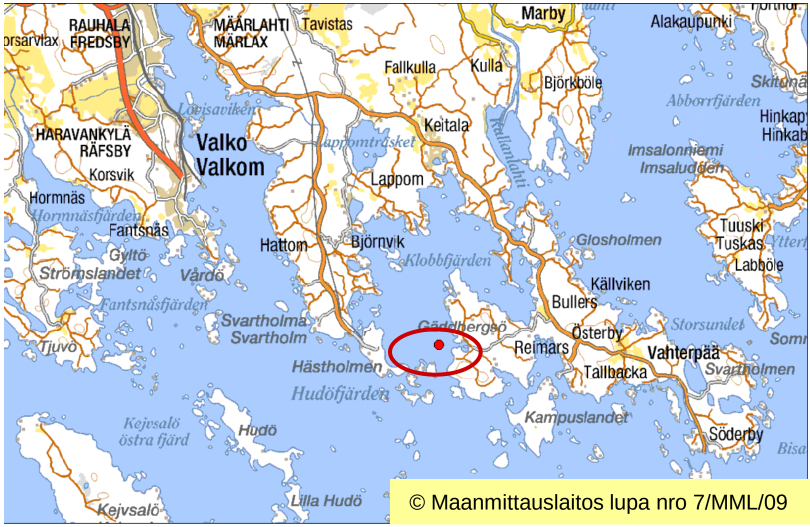


Figure 14. Assessment result for mercury (left) and underlying status calculated per station for the fish muscle (right). Small open circles indicate 'initial status assessment' data (only 1-2 years of data), small filled circles indicate that there is not enough data to assess a trend, large filled circles that concentrations have been stable during the whole monitoring period and the filled arrow that there is an upward or downward trend during the monitoring period, pointing in the direction of the arrow.

TBT concentration in surface sediment is decreasing

– but still exceeding the threshold value

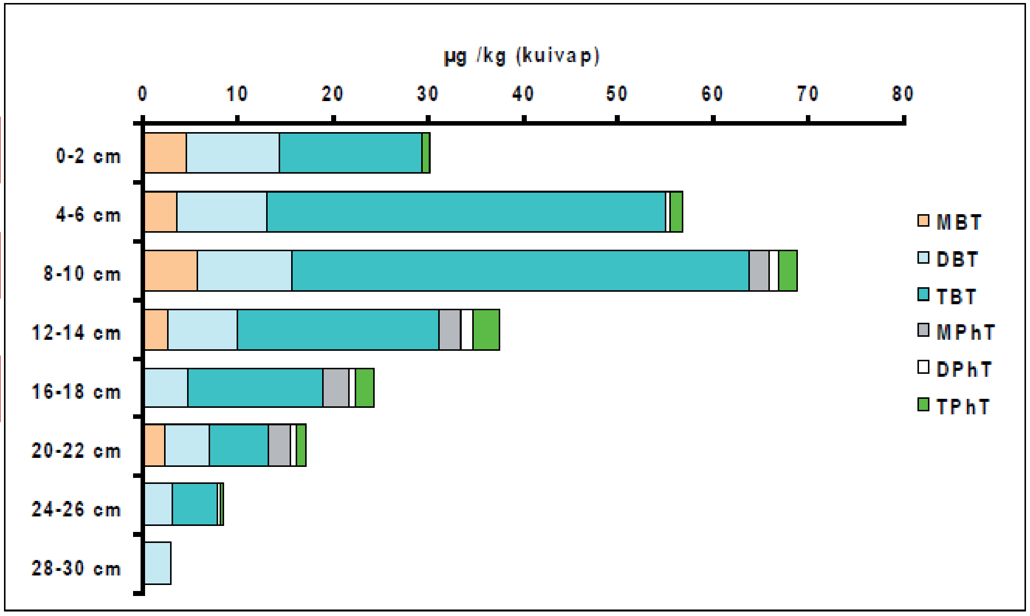
Loviisa



n. 2005 -07

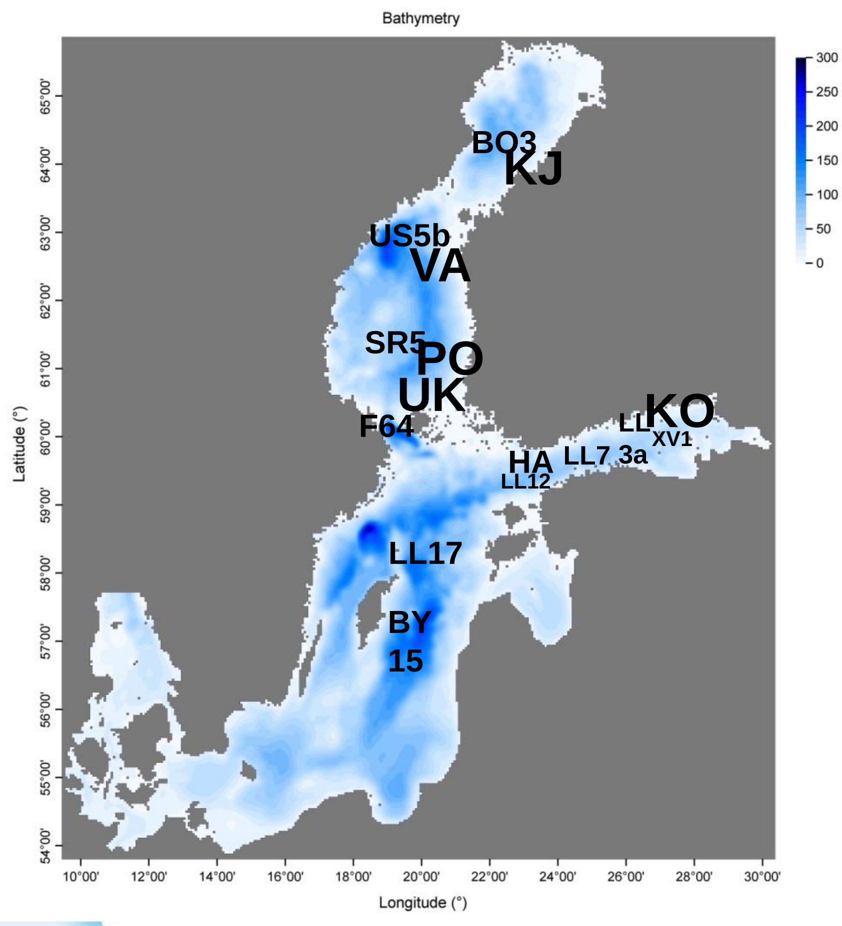
n. 1995

n. 1986

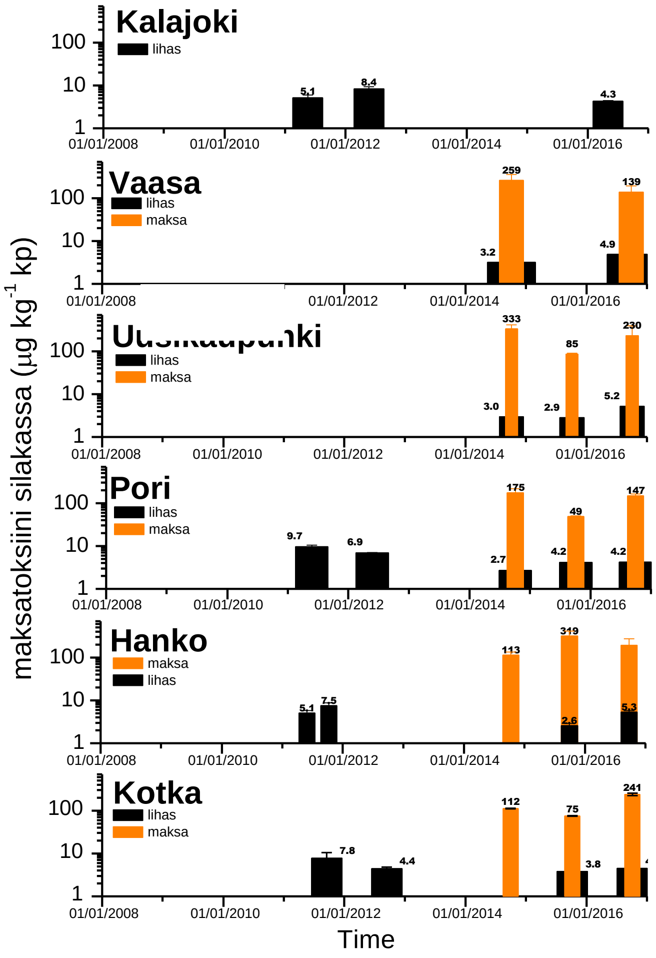


S Y K E

Example of National Indicator: hepatotoxins 2009-2016



Herring:
Muscle ~ 3 – 10 µg/kg
Liver ~ 50 – 300 µg/kg



Conclusions

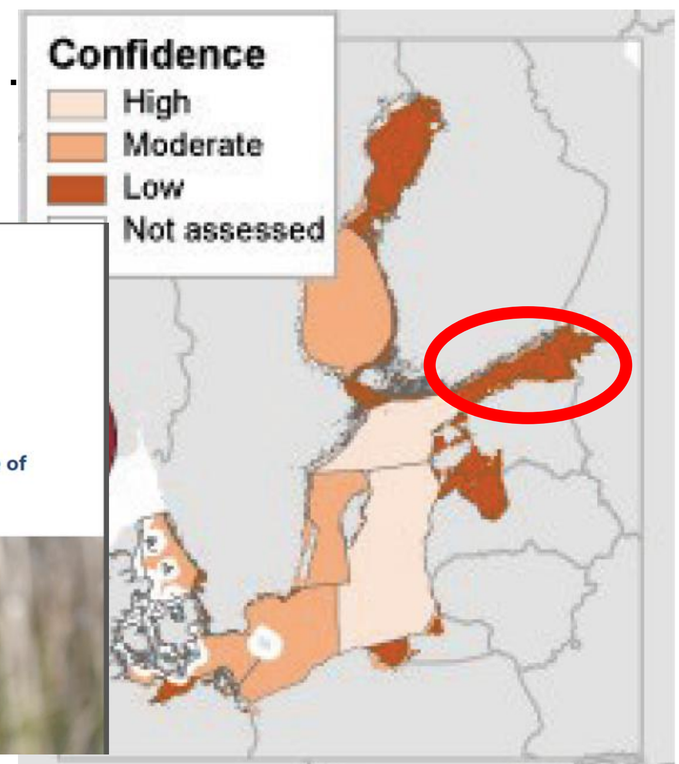
- **Threshold values do exist!**
  - For all BSAP Hazardous Substances and their indicators
  - Mostly for fish (biota), few for sediments, some for water
- **Gulf of Finland data lacking!**
  - Compared to other Baltic Sea regions
  - …ICES database not easy for uploading…
  - ➔ With too little data, **confidence is low**


STATE OF THE BALTIC SEA
- HOLISTIC ASSESSMENT -
First version 2017

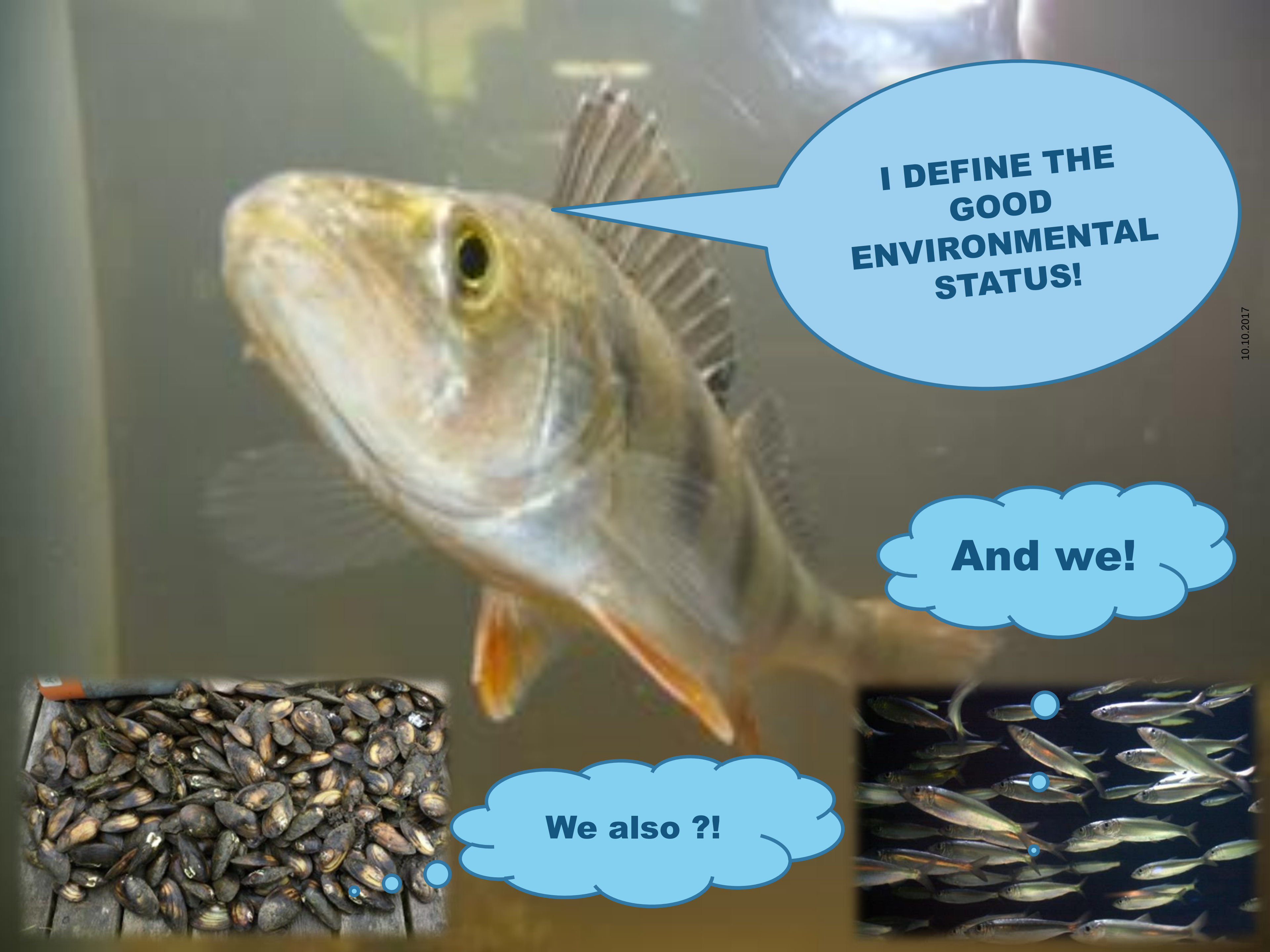
THE INTEGRATED ASSESSMENT OF HAZARDOUS SUBSTANCES

TO BE UPDATED IN 2018

-Supplementary Report to the First Version of the 'State of the Baltic Sea' Report 2017



SYKE


I DEFINE THE GOOD ENVIRONMENTAL STATUS!
And we!
We also ?!
10.10.2017

Thank you

More information
www.syke.fi/hankkeet/uupri

S Y K E

From small scales to large scales
–The Gulf of Finland Science Days 2017
9th-10th October 2017
Estonian Academy of Sciences, Tallinn

1st Day

Gulf of Finland Co-operation

M. Fetissov, R. Aps, P. Heinla, J. Kinnunen, O. Korneev, L. Lees, R. Varjopuro

Ecosystem-based Maritime Spatial Planning –impact on navigational safety from offshore renewable energy developments

The Gulf of Finland Science Days, Tallinn, 9-10 October 2017

Ecosystem-based Maritime Spatial Planning – impact on navigational safety from offshore renewable energy developments

Mihhail Fetissov[1, 2], Robert Aps[1], Priit Heinla[3], Jouko Kinnunen[4], Oleg Korneev[5], Liisi Lees[1], Riku Varjopuro[6]

[1] University of Tartu, Estonian Marine Institute, Tallinn, Estonia

[2] Tallinn University of Technology, Estonian Maritime Academy, Tallinn, Estonia

[3] Elering AS, Tallinn, Estonia

[4] Baltic Connector, Helsinki, Finland

[5] JSC "Rosgeo", Saint Petersburg, Russian Federation

[6] Finnish Environment Institute, Helsinki, Finland

Baltic LINes

Coherent Linear Infrastructures in Baltic Maritime Spatial Plans

Gulf of Finland Co-operation

Interreg Baltic Sea Region

EUROPEAN UNION EUROPEAN REGIONAL DEVELOPMENT FUND

Project's lifetime: March 2016 – February 2019

Total project budget: € 3 409 458;
European Regional Development Fund: € 2 674 451,50.

The overall objective of the Project: to increase transnational coherence of shipping routes and energy corridors in Maritime Spatial Plans (MSP) in the Baltic Sea Region (BSR). This prevents cross-border mismatches and secures transnational connectivity as well as efficient use of Baltic Sea space. Thereby Baltic LINes helps to develop the most appropriate framework conditions for Blue Growth activities (e.g. maritime transportation, offshore energy exploitation, coastal tourism etc.) for the coming 10-15 years increasing investors' security.

The main project activities include:

- Developing requirements for MSP in relation to the shipping and energy sector in BSR;
- Harmonizing BSR MSP data infrastructure for shipping routes and energy corridors, drafting guidelines for MSP data exchange and dissemination;
- Identifying and agreement on transnationally coherent planning of linear infrastructures;
- Providing recommendations for a formalized BSR agreement on transboundary consultations on linear infrastructure within the MSP process.

Outline

- Maritime Spatial Planning and identification of transnational, cross sectoral planning issues
- Interactive Boundaries
- Marine traffic survey information
- Simulations based analysis in progress
- Conclusions

Maritime Spatial Planning

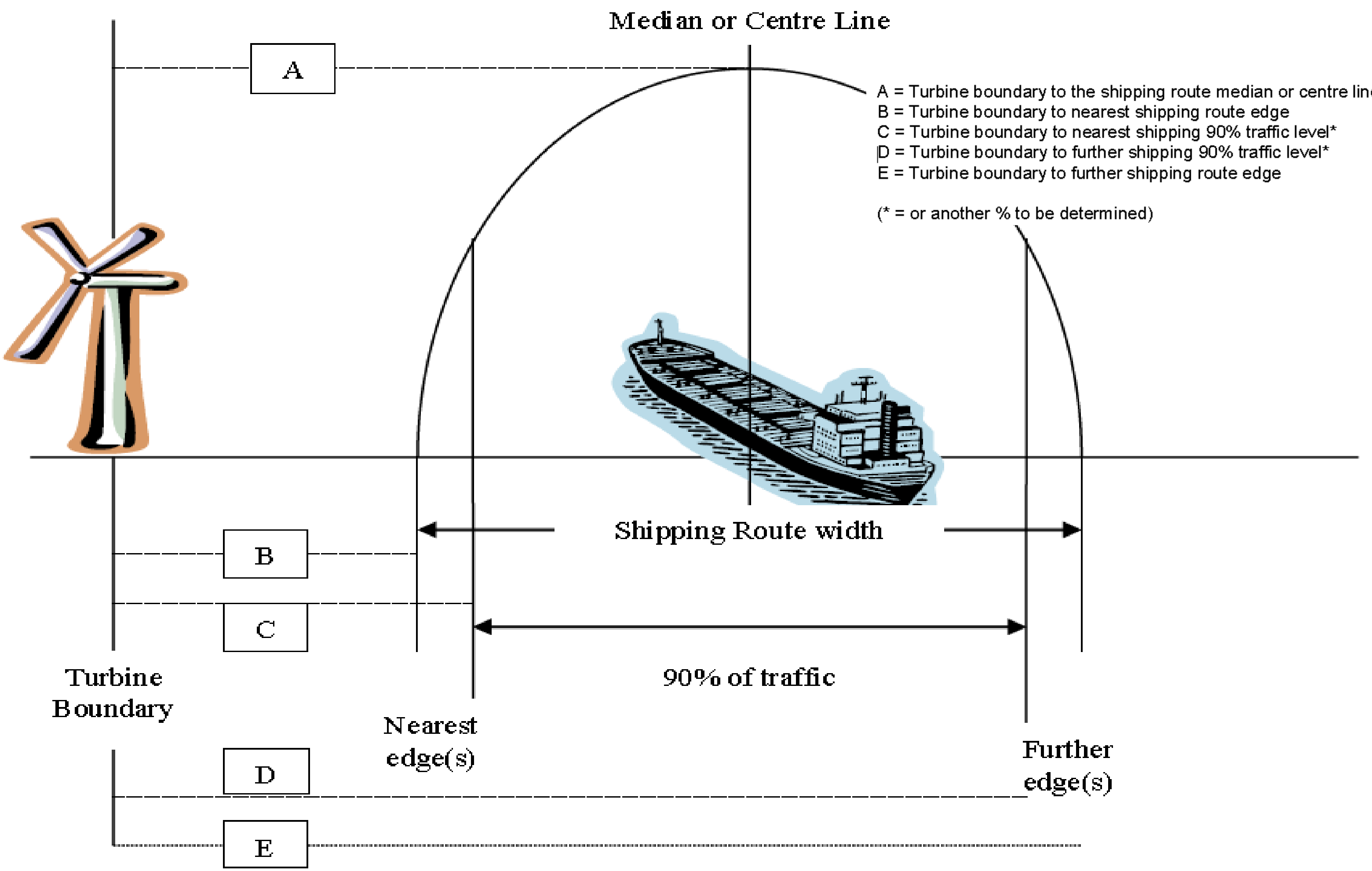
- According to EU Directive establishing a framework for Maritime Spatial Planning (MSP) the main purpose of MSP is to promote sustainable development and to identify the utilization of maritime space for different sea uses as well as to manage spatial uses and conflicts in marine areas
- The offshore wind energy production is considered to be one of the main drivers of MSP in the Baltic Sea Region

Identification of transnational, cross sectoral planning issues

- **Potential impact on navigational safety from offshore renewable energy installations (OREI) is identified as one of the critical transnational and cross sectoral planning issues**
- **Issue is exemplified by addressing the potential impact on navigational safety of planned Hiiumaa OREI developments**

Interactive Boundaries

[UK Maritime and Coastguard Agency, MGN 543 (M+F), 2016]



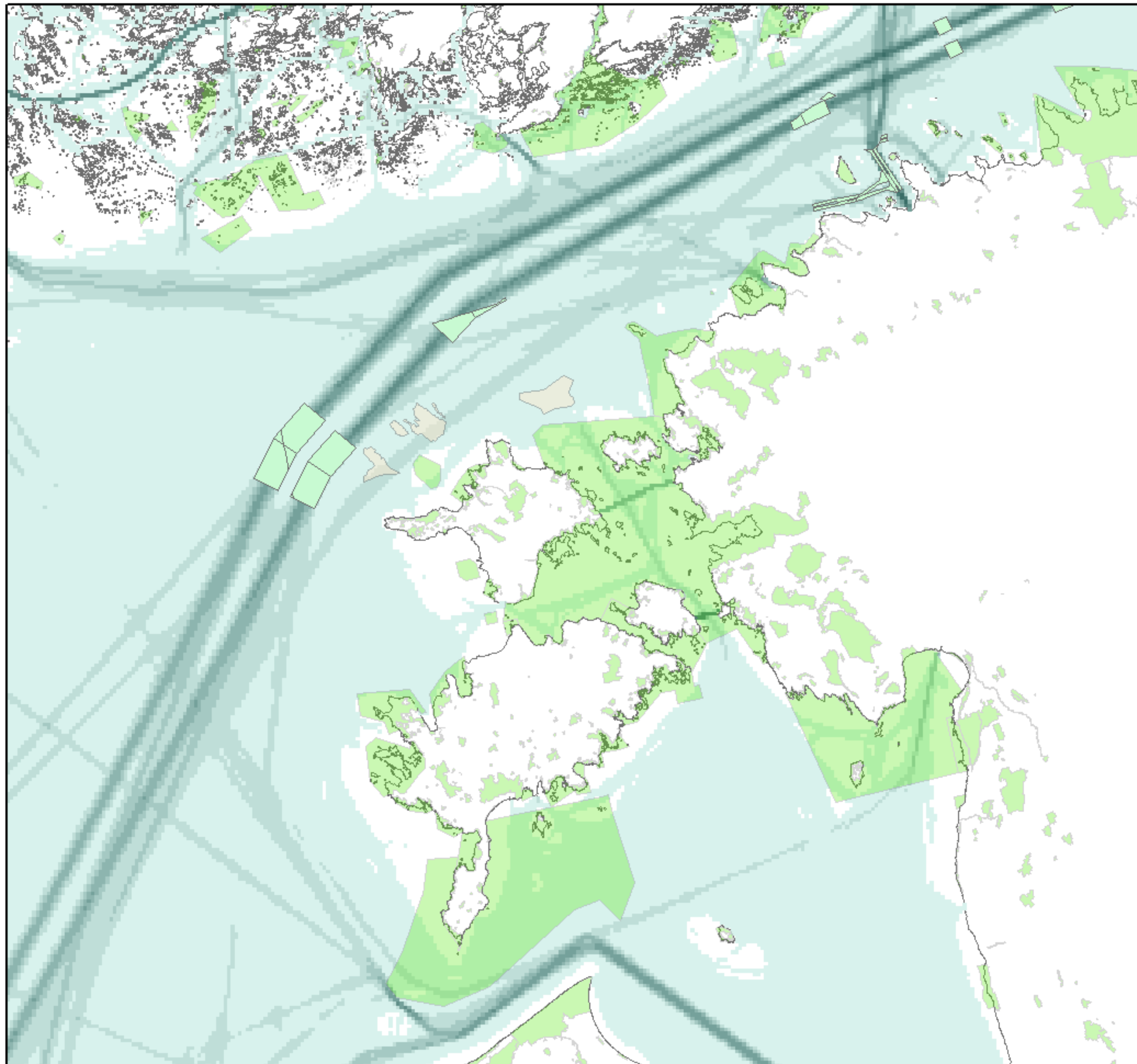
Interactive Boundaries

[UK Maritime and Coastguard Agency, MGN 543 (M+F), 2016]

Distance of turbine boundary from shipping route (90% of traffic, as per Distance C)	Factors for consideration	Tolerability
<0.5nm (<926m)	X-Band radar interference Vessels may generate multiple echoes on shore based radars	INTOLERABLE
0.5nm – 3.5nm (926m – 6482m)	Mariners' Ship Domain (vessel size and manoeuvrability) Distance to parallel boundary of a TSS S Band radar interference Effects on ARPA (or other automatic target tracking means) Compliance with COLREG	TOLERABLE IF ALARP Additional risk assessment and proposed mitigation measures required
>3.5nm (>6482m)	Minimum separation distance between turbines opposite sides of a route	BROADLY ACCEPTABLE

Marine traffic survey information is required to inform Interactive Boundaries

Overview map



Legend

- Planned windfarms
- TSS zones
- Natura 2000

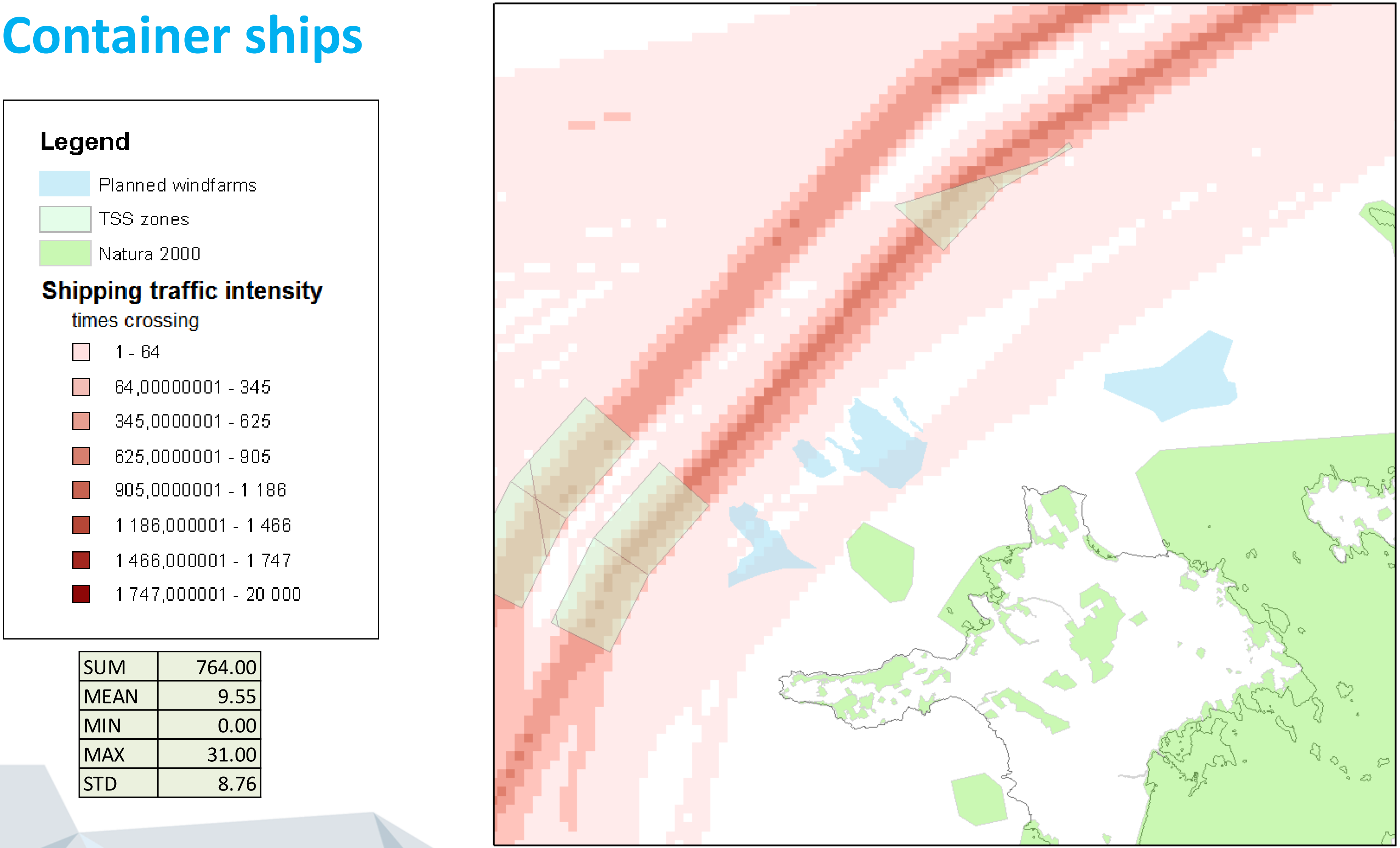
AIS 2011-2015 MEAN

Normalized 0-100%

- 0.010000 - 0.920000
- 0.920001 - 2.630000
- 2.630001 - 5.340000
- 5.340001 - 9.070000
- 9.070001 - 13.760000
- 13.760001 - 19.520000
- 19.520001 - 26.890000
- 26.890001 - 37.550000
- 37.550001 - 58.670000
- 58.670001 - 100.000000

HELCOM Secretariat, based on HELCOM AIS data

Container ships



SUM	764.00
MEAN	9.55
MIN	0.00
MAX	31.00
STD	8.76

HELCOM Secretariat, based on HELCOM AIS data

Cargo vessels

Legend

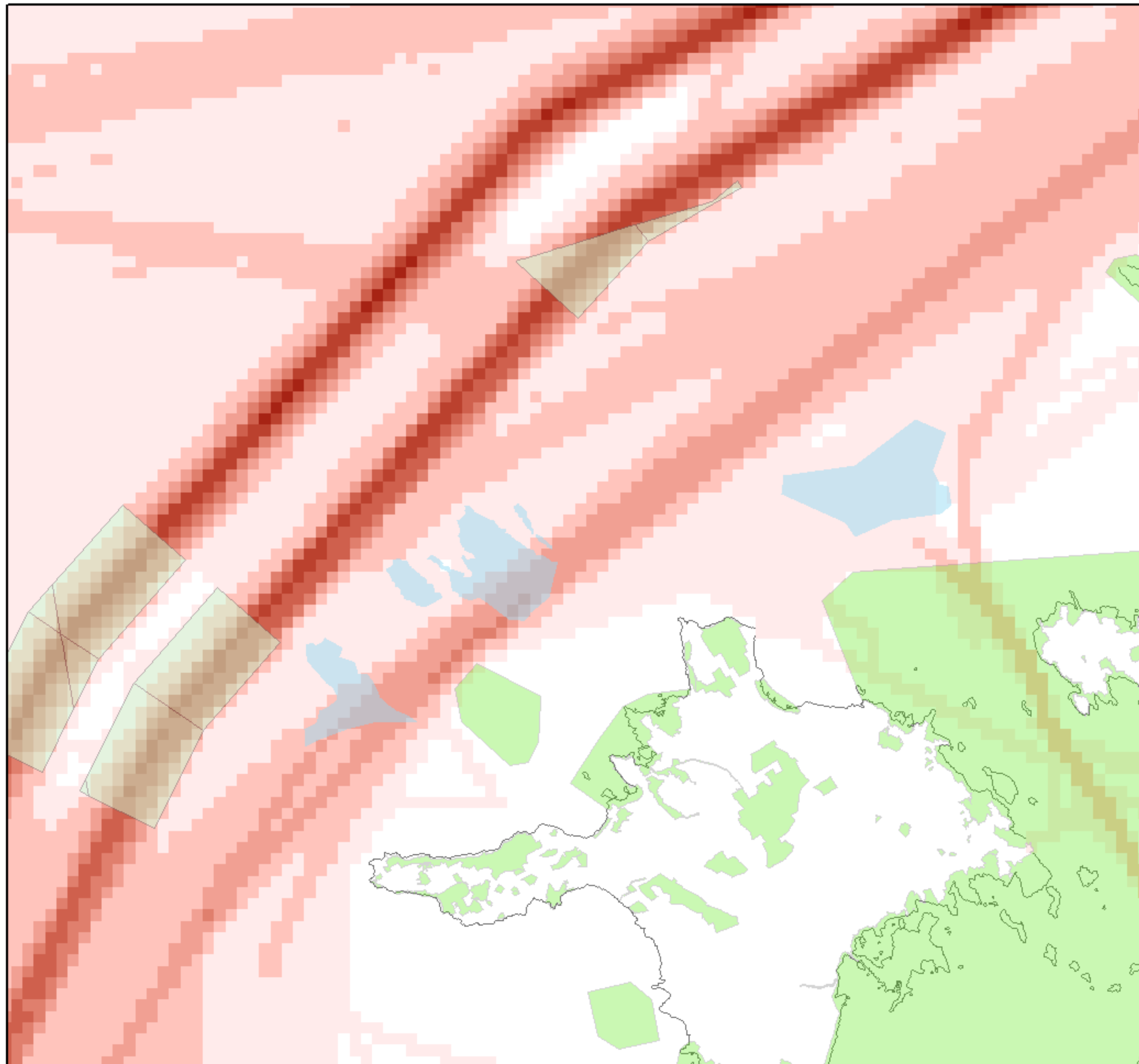
- Planned windfarms
- TSS zones
- Natura 2000

Shipping traffic intensity

times crossing

- 1 - 64
- 64,00000001 - 345
- 345,0000001 - 625
- 625,0000001 - 905
- 905,0000001 - 1 186
- 1 186,000001 - 1 466
- 1 466,000001 - 1 747
- 1 747,000001 - 20 000

SUM	31510.00
MEAN	125.04
MIN	0.00
MAX	651.00
STD	179.54



HELCOM Secretariat, based on HELCOM AIS data

Passenger ships

Legend

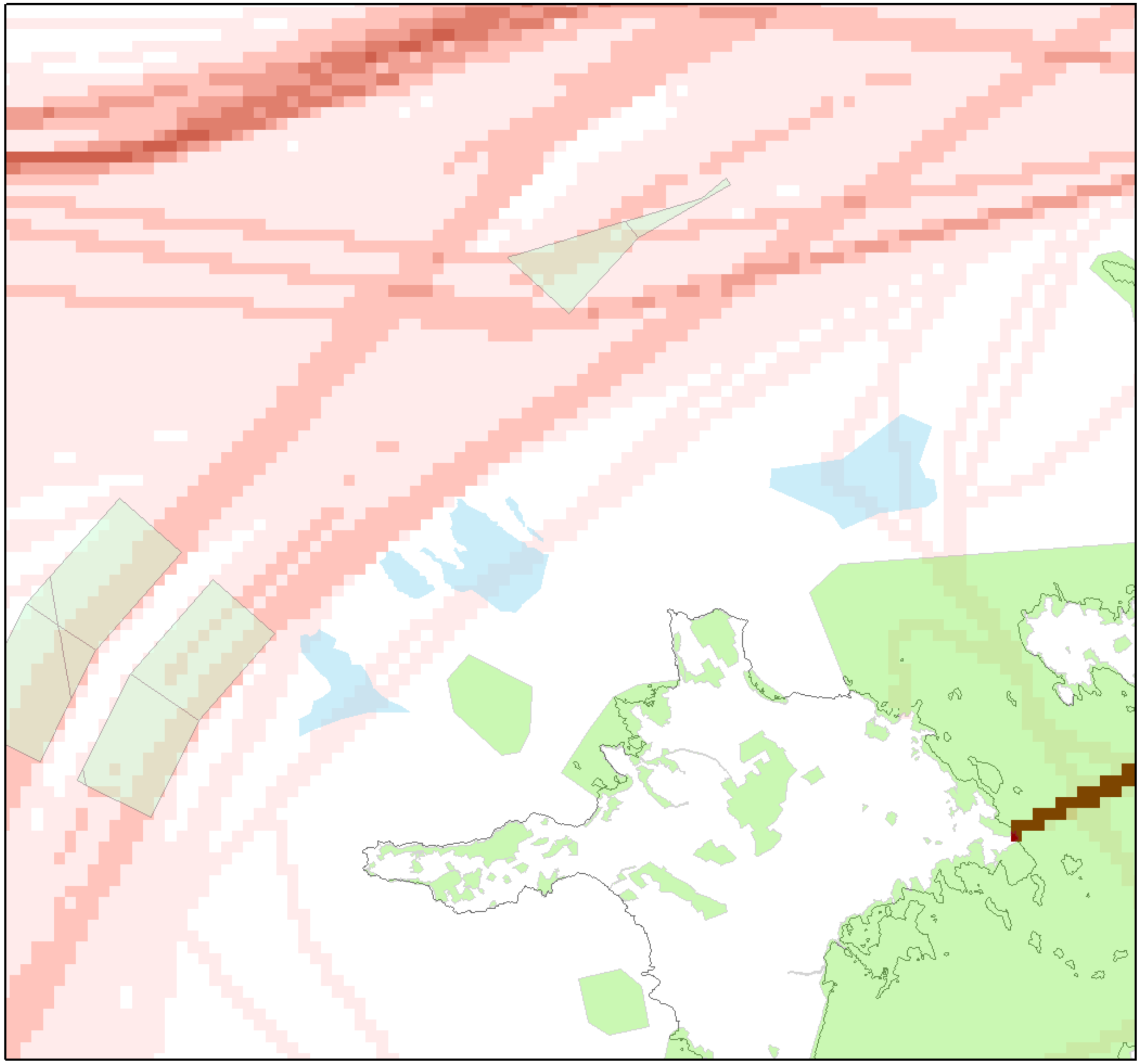
- Planned windfarms
- TSS zones
- Natura 2000

Shipping traffic intensity

times crossing

- 1 - 64
- 64,00000001 - 345
- 345,0000001 - 625
- 625,0000001 - 905
- 905,0000001 - 1 186
- 1 186,000001 - 1 466
- 1 466,000001 - 1 747
- 1 747,000001 - 20 000

SUM	190.00
MEAN	4.42
MIN	0.00
MAX	131.00
STD	19.79



HELCOM Secretariat, based on HELCOM AIS data

Tankers

Legend

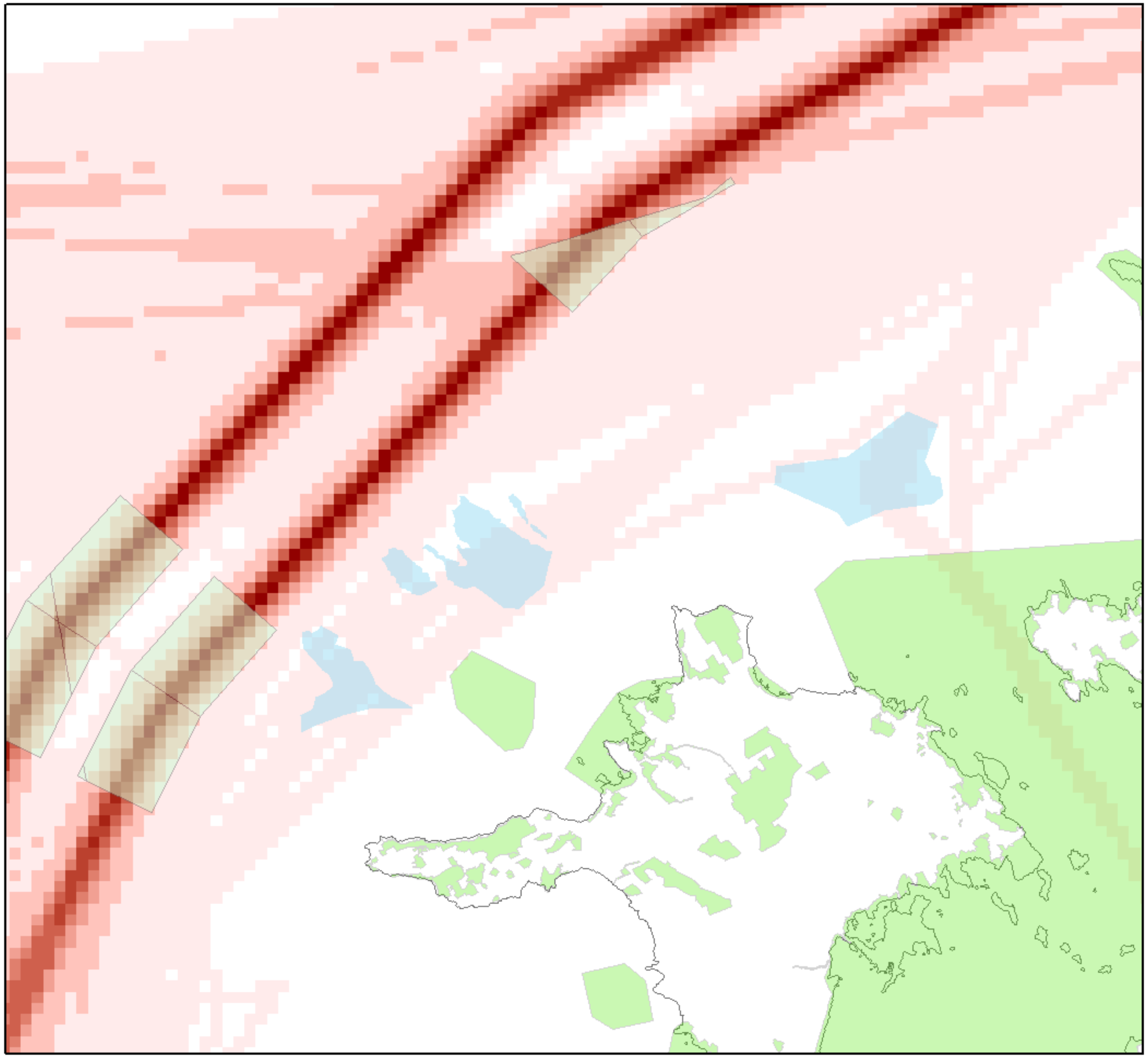
(swatch)	Planned windfarms
(swatch)	TSS zones
(swatch)	Natura 2000

Shipping traffic intensity

times crossing

- 1 - 64
- 64,00000001 - 345
- 345,0000001 - 625
- 625,0000001 - 905
- 905,0000001 - 1 186
- 1 186,000001 - 1 466
- 1 466,000001 - 1 747
- 1 747,000001 - 20 000

SUM	666.00
MEAN	4.86
MIN	0.00
MAX	23.00
STD	5.40



HELCOM Secretariat, based on HELCOM AIS data

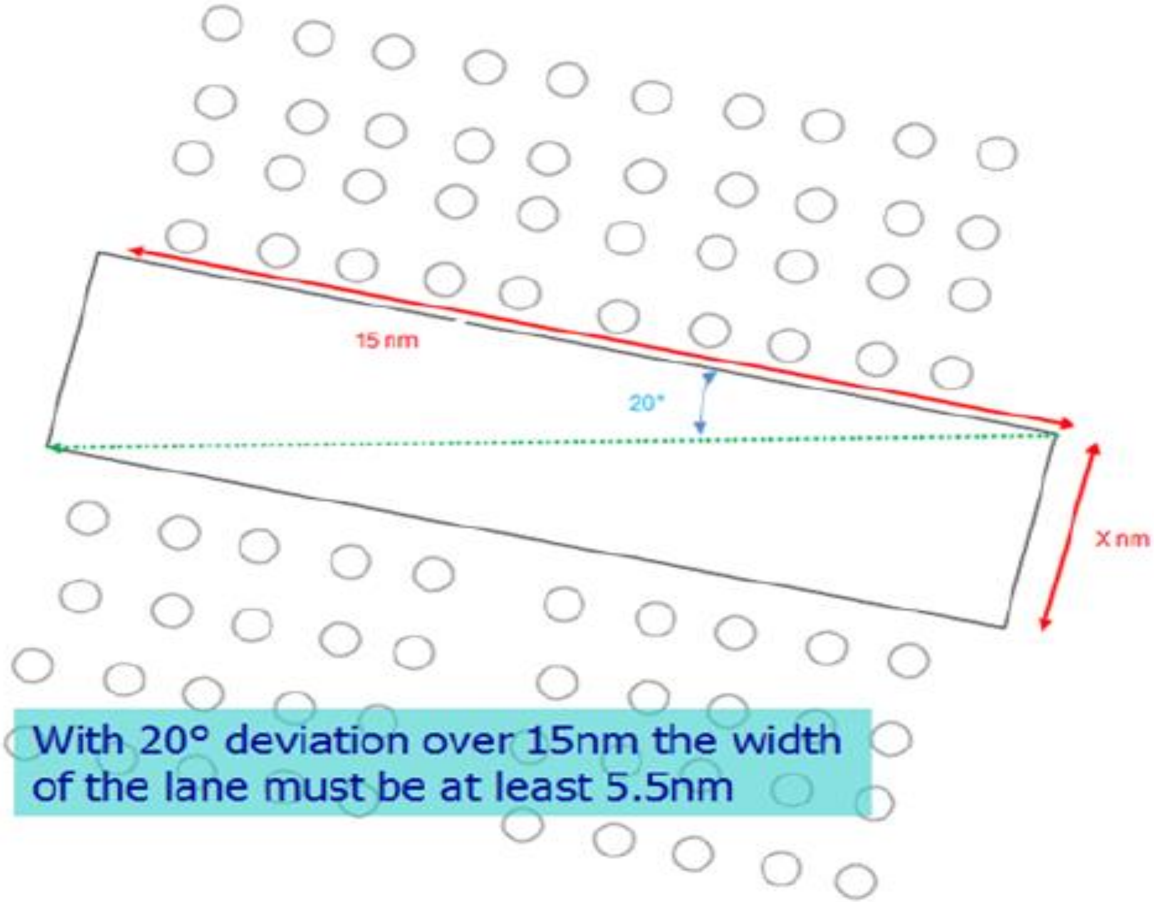
Interactive Boundaries

[UK Maritime and Coastguard Agency, MGN 543 (M+F), 2016]

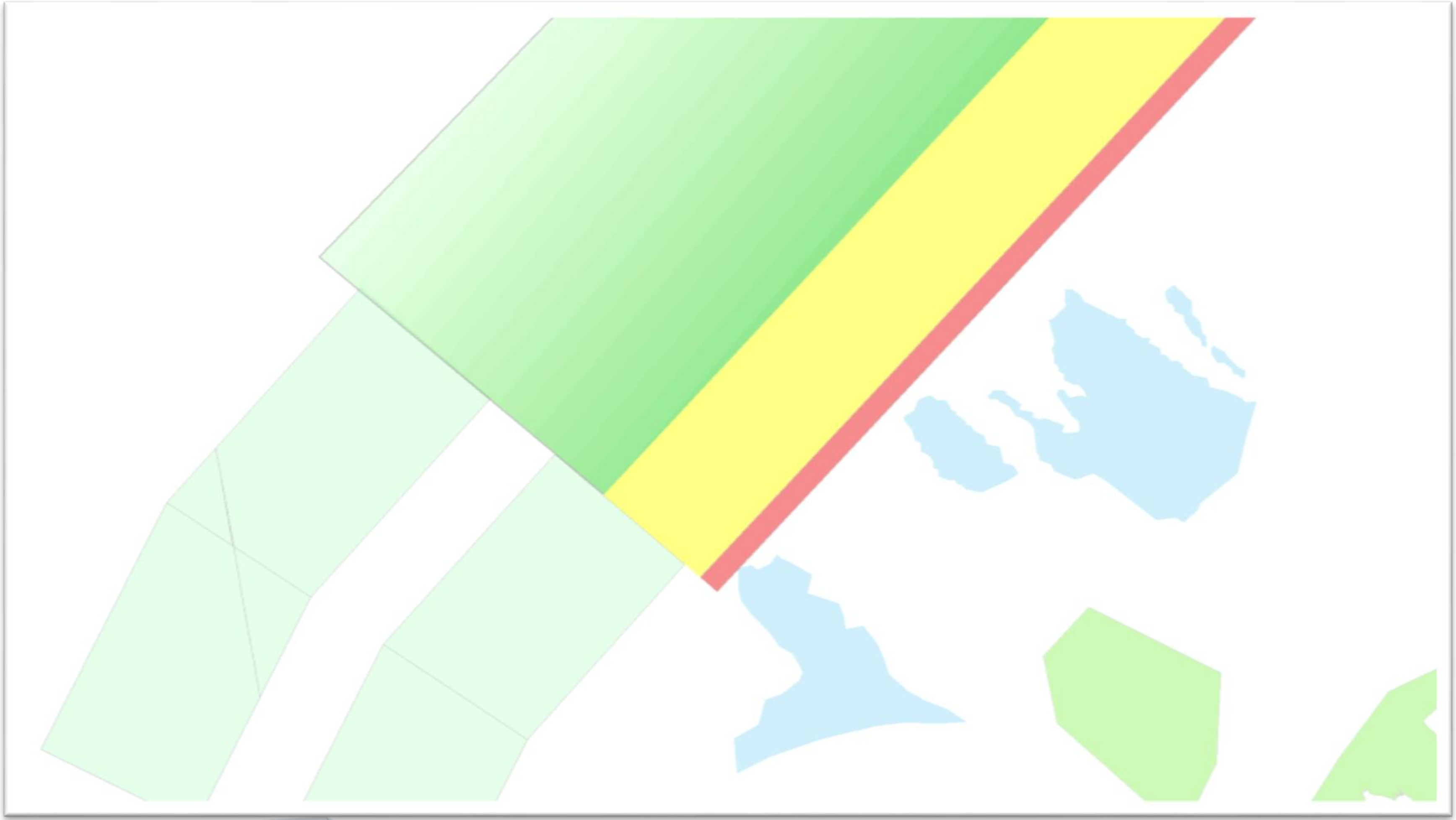
- Where larger OREI developments have to provide corridors between sites to allow safe passage of shipping a detailed assessment is required to establish the minimum width of the corridor
- Ship's deviations from track by as much as 20°, or more, are common and are used as the baseline for calculating corridor widths contained in the OREI shipping route template

Interactive Boundaries

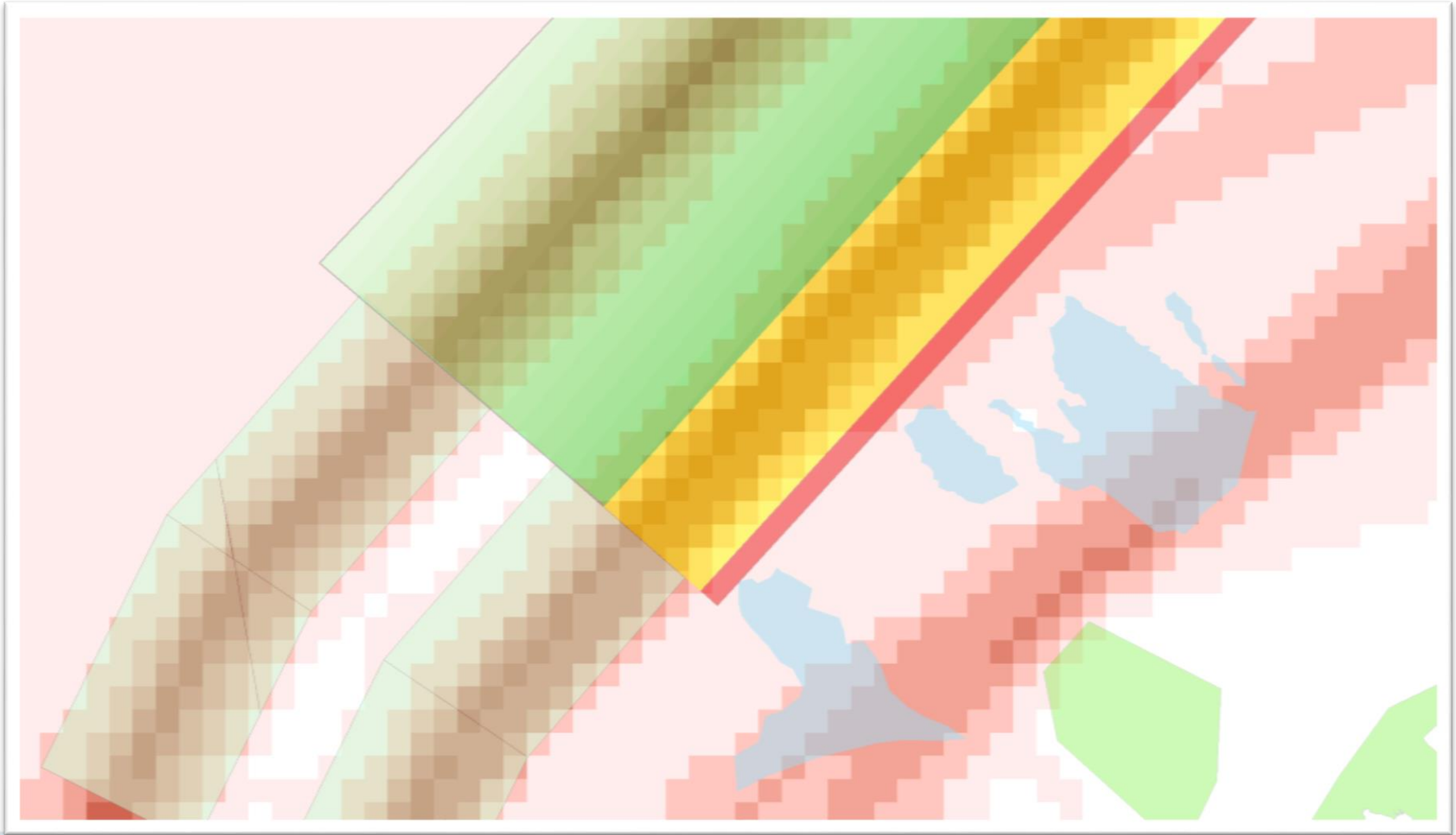
[UK Maritime and Coastguard Agency, MGN 543 (M+F), 2016]



Interactive Boundaries – Hiiumaa Case



Interactive Boundaries – Hiiumaa Case

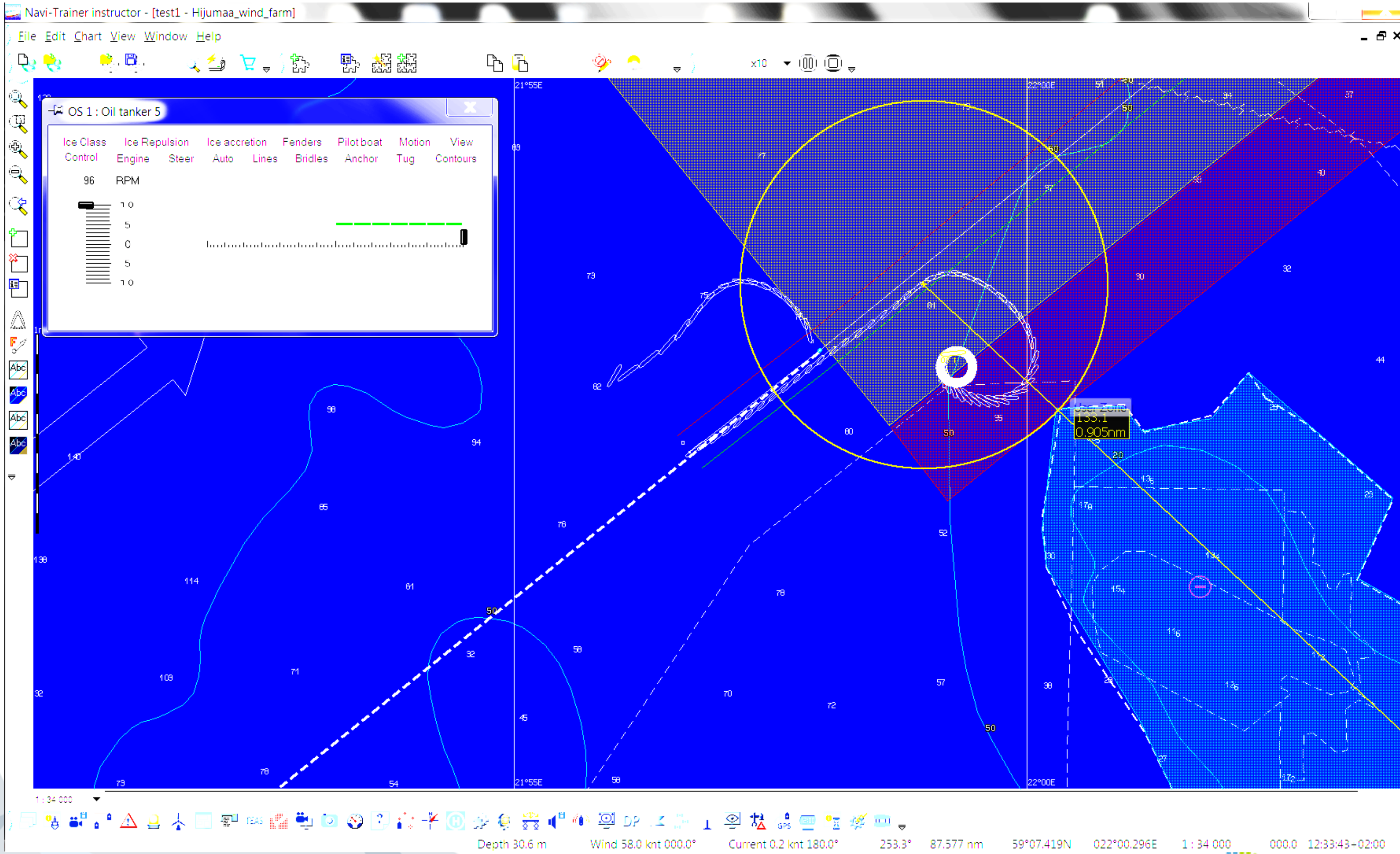


HELCOM Secretariat, based on HELCOM AIS data

Simulations based analysis in progress of the potential impact on navigational safety from planned offshore wind parks off the Hiiumaa Island in the Baltic Sea

Baltic LINes

TRANSAS NTPro 5000 - Simulations



Interreg Baltic Sea Region

EUROPEAN UNION EUROPEAN REGIONAL DEVELOPMENT FUND

Submarine cables and other obstructions

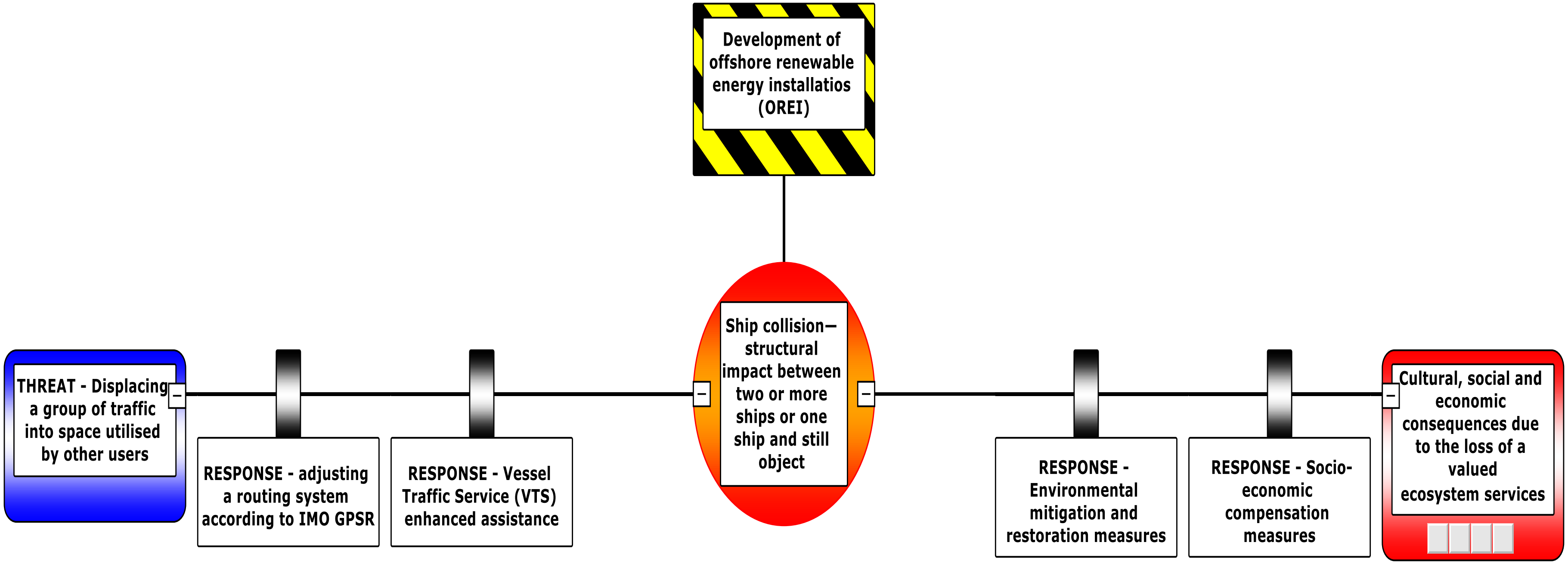
[UK Maritime and Coastguard Agency, MGN 543 (M+F), 2016]

The existence of submarine cables or other seabed obstructions (e.g. gas pipelines) may affect the ability of a vessel to anchor safely away from other traffic and this may be another consideration when assessing sea room requirements

Maritime traffic safety issue

Planned offshore wind parks off the Hiiumaa Island are likely displacing a group of maritime traffic into space utilised by other users where available sea room is already confined

Bow-tie conceptual representation – Driver, Threat, Event (ship collision), Consequences and the Response measures



Conclusions

According to preliminary results of this study in progress the assessments should be made of the planned OREI caused potential consequences of ships deviating from normal routes and recreational or fishing vessels entering shipping routes in order to avoid proposed OREI sites

Acknowledgements

Authors would like to offer special thanks to Manuel Frias Vega and Florent Nicolas from HELCOM Secretariat for providing the spatial data used by this study

Acknowledgements

This study is supported by European Regional Development Fund, INTERREG Baltic Sea Region project Baltic LINes "Coherent Linear Infrastructures in Baltic Maritime Spatial Plans"

Baltic LINes

Lead partner

BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

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Swedish Agency for Marine and Water Management

NHTV Breda University of Applied Sciences

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Thank you very much fot your attention!

From small scales to large scales
–The Gulf of Finland Science Days 2017
9th-10th October 2017
Estonian Academy of Sciences, Tallinn

1st Day

Gulf of Finland Co-operation

A. Peterson, R. Aps, K. Herkül, S. Korpinen, K. Kostamo, L. Laamanen, J. Lappalainen

Environmental vulnerability profile and HELCOM Baltic Sea Pressure Index as tools in site selection of offshore wind parks

Gulf of Finland Co-operation

Environmental vulnerability profile and HELCOM Baltic Sea Pressure Index as tools in site selection of offshore wind parks

Anneliis Peterson[1*], Robert Aps[1], Kristjan Herkül[1], Samuli Korpinen[2], Kirsi Kostamo[2], Leena Laamanen[2], Juho Lappalainen[2]

[1] University of Tartu, Estonian Marine Institute, Tallinn, Estonia

[2] Finnish Environment Institute, Helsinki, Finland

9th October, 2017 ,Tallinn

European Union
European Regional Development Fund

KIK
KESKKONNAINVESTEERINGUTE KESKUS

PLAN4BLUE
MARITIME SPATIAL PLANNING FOR SUSTAINABLE BLUE ECONOMIES

Interreg
Central Baltic

Introduction

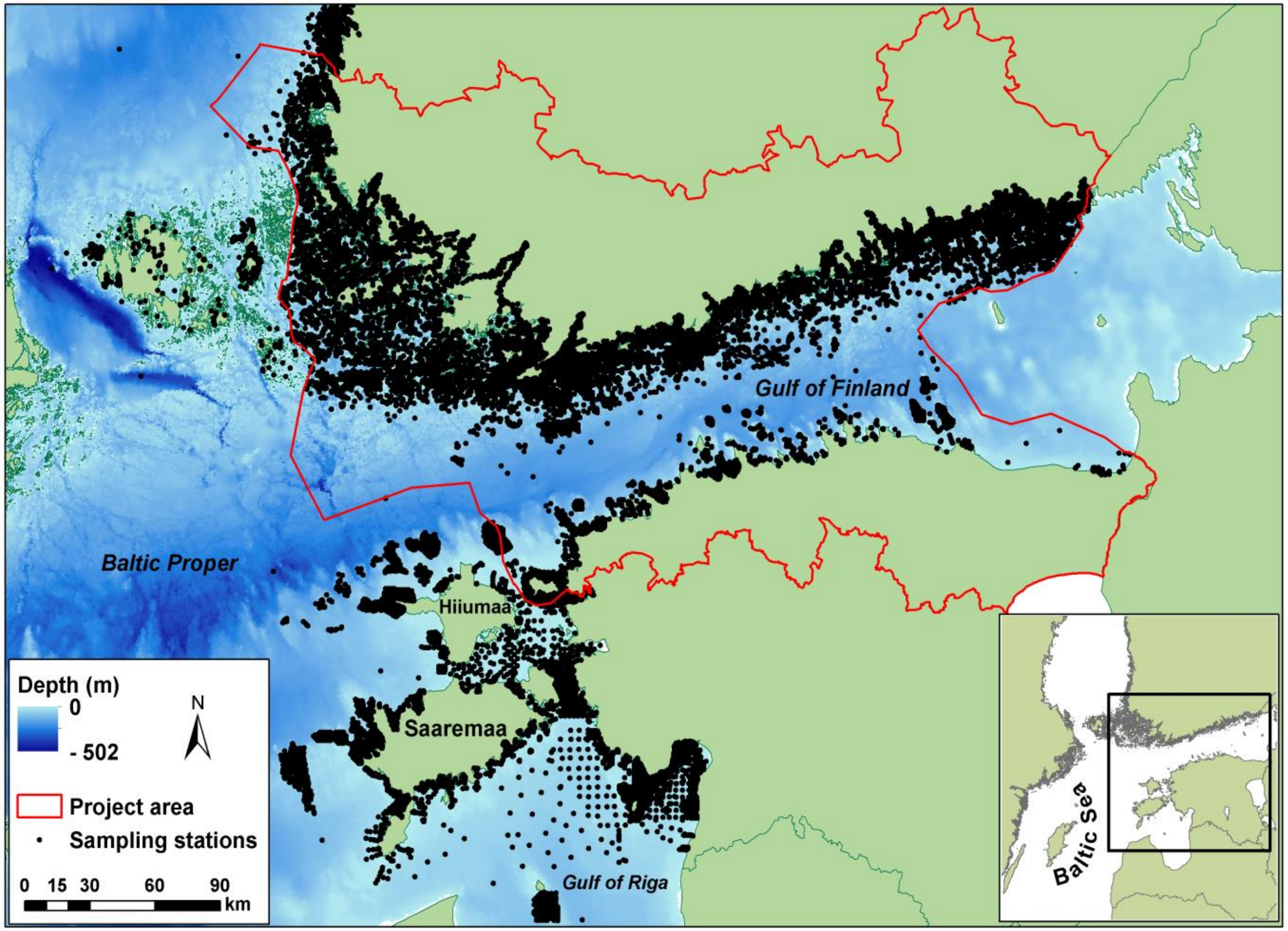
- Human use of marine and coastal areas is increasing worldwide, resulting in conflicts between different interests for the space and resources and environmental sustainability

- To successfully support blue growth, while also preserving the capacity of ecosystems to provide valued services, marine spatial planning (MSP) processes are in a need of spatial data on nature values and human pressures to minimize the potential harm on ecosystem.

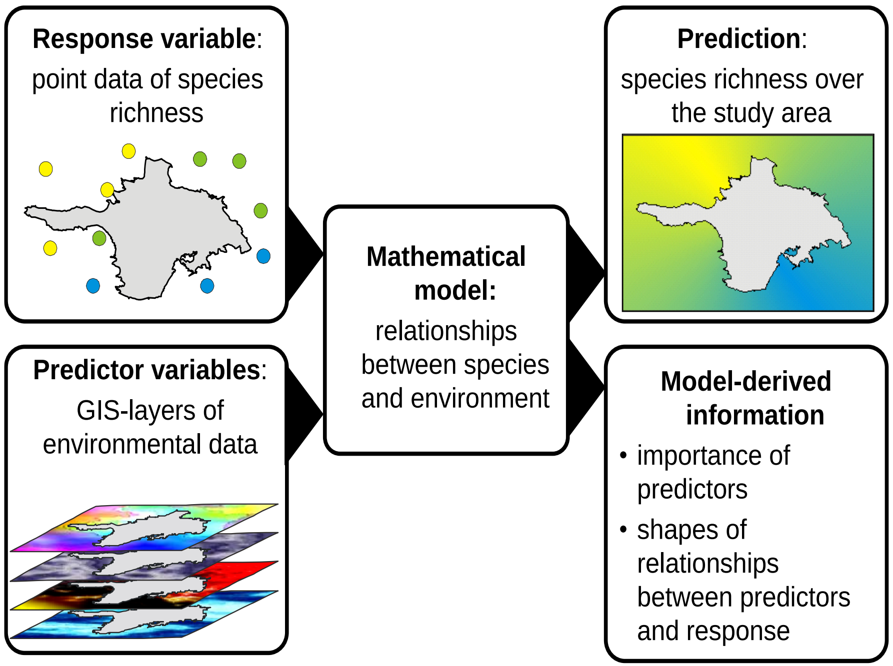
The aim of this study was to…

… develop cross-border environmental vulnerability profile (EVP) of the Gulf of Finland, which can be used for ecosystem based MSP processes in Estonia and Finland, in order to find solutions that lead to sustainable use of resources and to improved planning and management of the marine and coastal areas.

Methods
Study area



Modeling

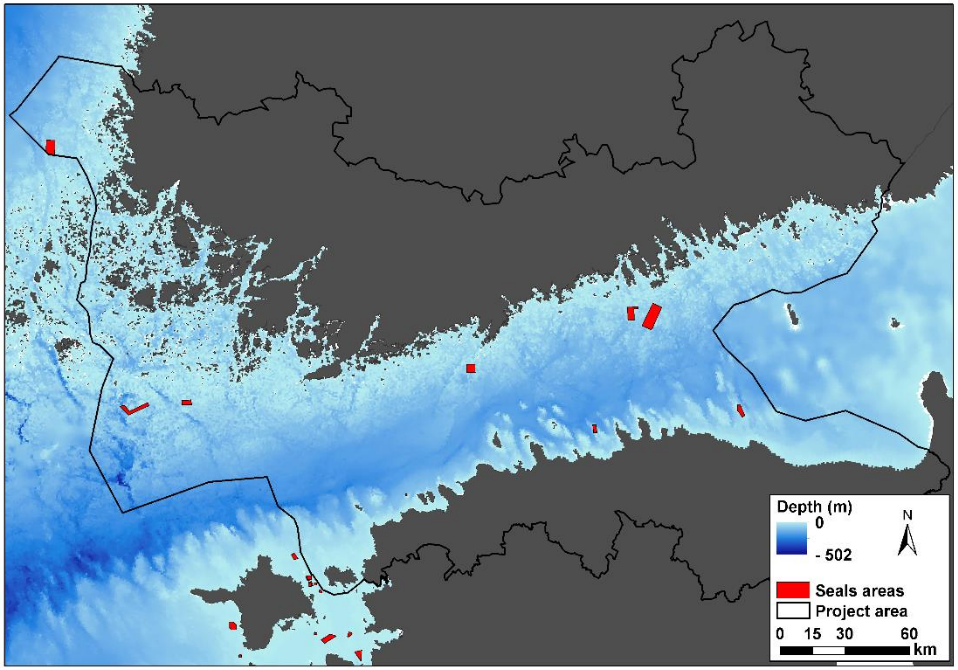


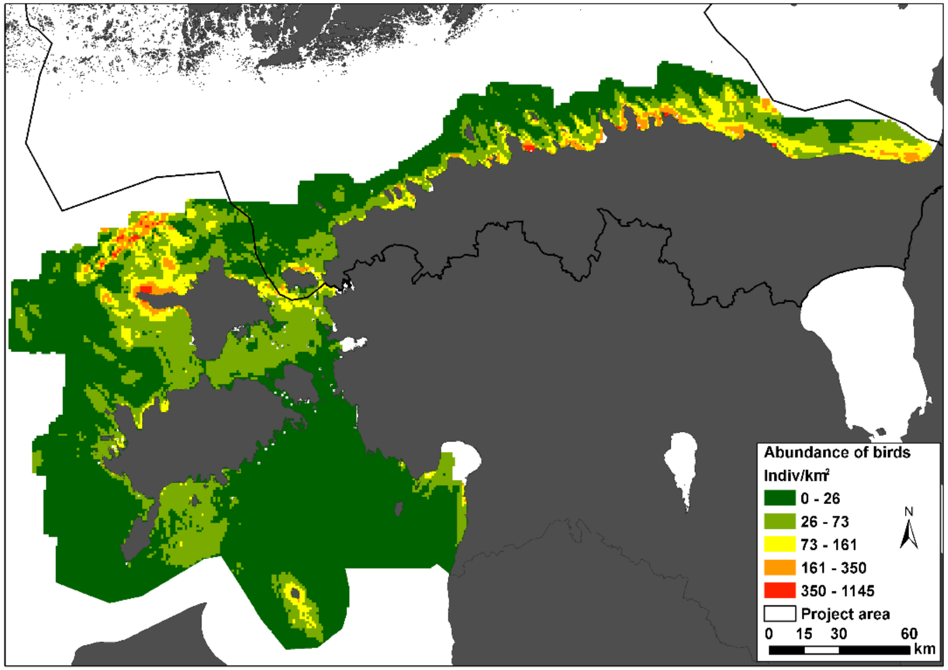
18 Estonian and 23 Finnish environmental variables

Nature values (NV):

- *Fucus vesiculosus*,
- *Furcellaria lumbricalis*,
- Filamentous algae,
- Epibenthic bivalves (*Mytilus trossulus*, *Dreissena polymorpha*),
- Vascular plants (excluding *Zostera marina*),
- *Zostera marina*,
- Charophytes (*Chara* spp., *Tolypella nidifica*),
- Infaunal bivalves (*Limecola balthica*, *Cerastoderma glaucum*, *Mya areanaria*),
- Benthic biodiversity
- Sea birds
- Seals

Seals and sea birds





Nationally protected moulting, resting, and breeding areas of seals.

Finnish seal data that was used in this project, originated from Parks & Wildlife Finland and was issued by the "Government Decree 736/2001".

Estonian seal data that was used in this project, originated from EELIS (Estonian Natura Information System) – Estonian Environmental Register: Estonian Environment Agency.

Total abundance of wintering birds based on aerial survey and modeling study by Luigujõe and Auniņš (2016) that was used as an input in the current study.

Luigujõe L and Auniņš A (2016) Talvituvate lindude rahvusvaheline lennuloendus. Report.
http://www.keskkonnaamet.ee/public/LuigujoeAunins_2016_talvituvate_veelindude-rahvusvaheline_lennuloendus_lopparuanne.pdf

Environmental variables

Water depth
Average water depth in 2000 m radius
Slope of seabed
Slope of seabed in 2000 m radius
Salinity
Wave exposure based on simplified wave model
Chlorophyll a content of sea surface based on satellite imagery
Water transparency estimated as attenuation coefficient based on satellite imagery
Ice coverage
Water temperature in cold season
Water temperature in warm season
Current velocity
Orbital speed of water movement at seabed induced by wind waves
Proportion of soft sediment
Secchi depth
Concentration of ammonium
Concentration of nitrates
Concentration of phosphates

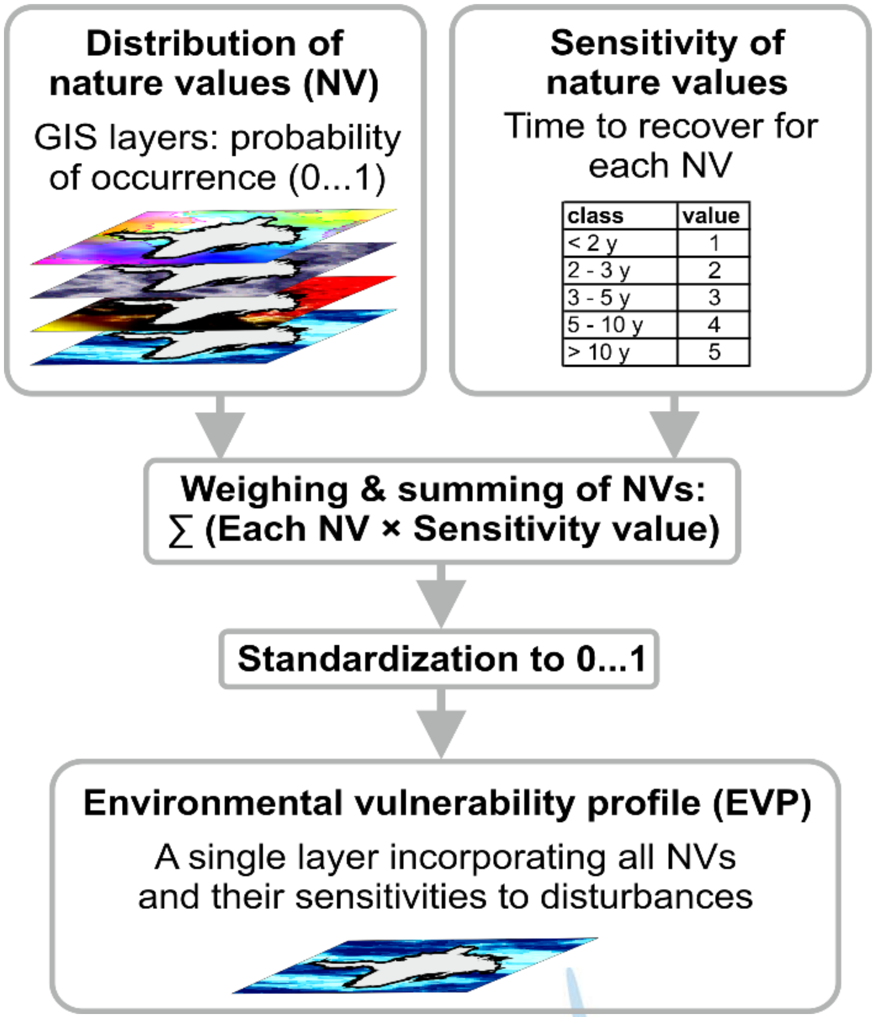
Bathymetric Position Index (BPI) 100x4000
Bathymetric Position Index (BPI) 1200x500
Bathymetric Position Index (BPI) 20x100
Bathymetric Position Index (BPI) 300x1000
Concentration of humic substances
Concentration of oxygen on the bottom
Concentration of phosporus on the bottom
Coverage of rock
Coverage of sand
Coverage of stones and boulders
Depth attenuated wave exposure
Distance to sandy shore
Euphotic depth
Maximum temperature on the bottom
Minimum temperature on the bottom
Natural habitats
Salinity on the bottom
Salinity on the surface
Share of the sea area (1 km radius)
Share of the sea area (10 km radius)
Share of the sea area (5 km radius)
Slope of seabed
Water depth

Sensitivity of nature values (NV)

- **There is a lack of empirical knowledge to quantitatively formalize species sensitivity as functions of environmental variables.**
- **A practical approach – recovery potential of an environmental value that is measured in time that is needed to recover from a destruction after an impact has ceased**
- **Recovery estimations are based on literatur**

NV	Recovery class	NV coefficient
filamentous algae	<2 years	1
Fucus vesiculosus, charophytes, infaunal bivalves	2-3 years	2
Vascular plants and epibenthic bivalves	3-5 years	3
Furcellaria lumbricalis	5-10 years	4
Zostera marina, birds, seals	>10 years	5

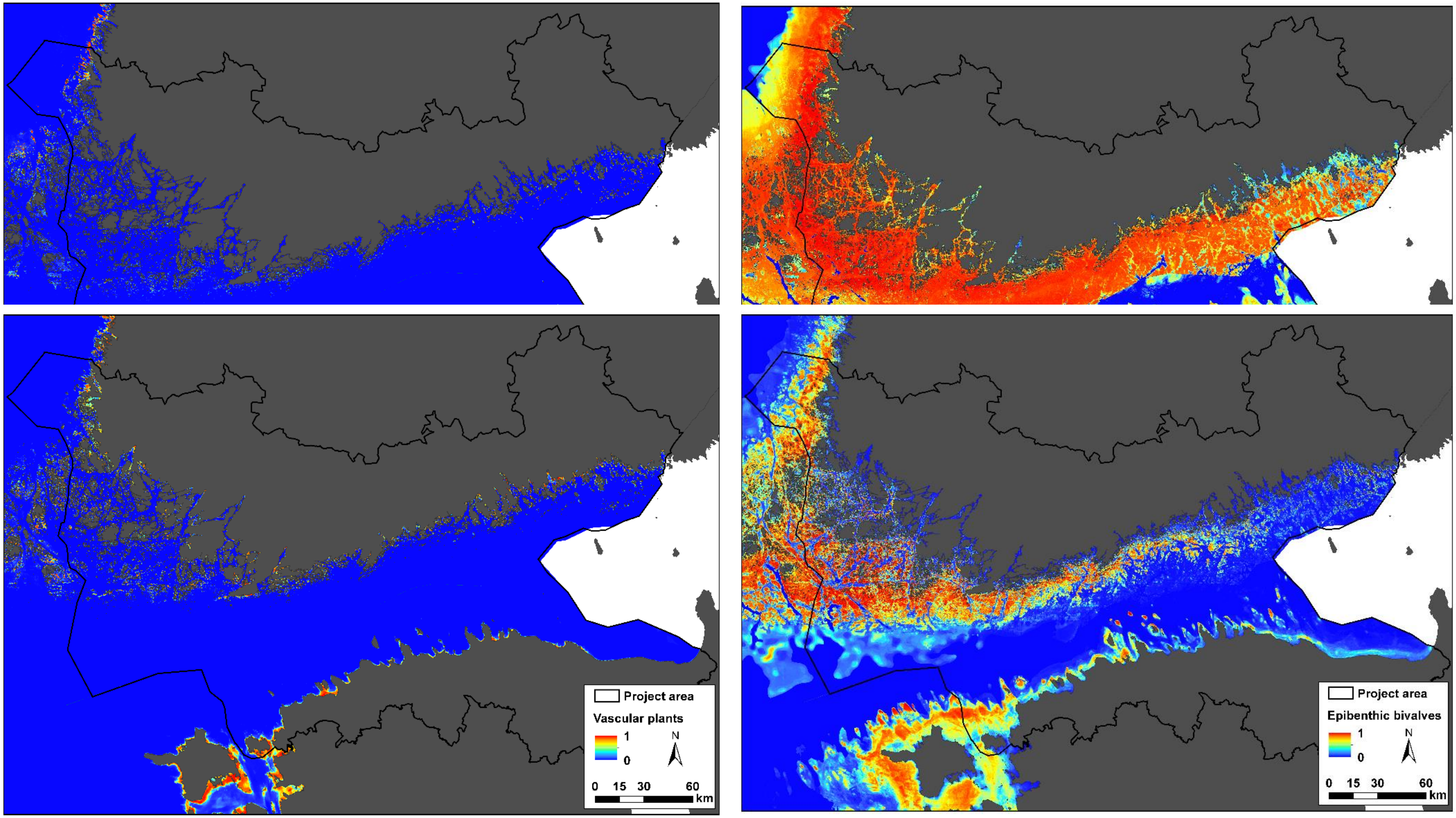
Calculation of EVP



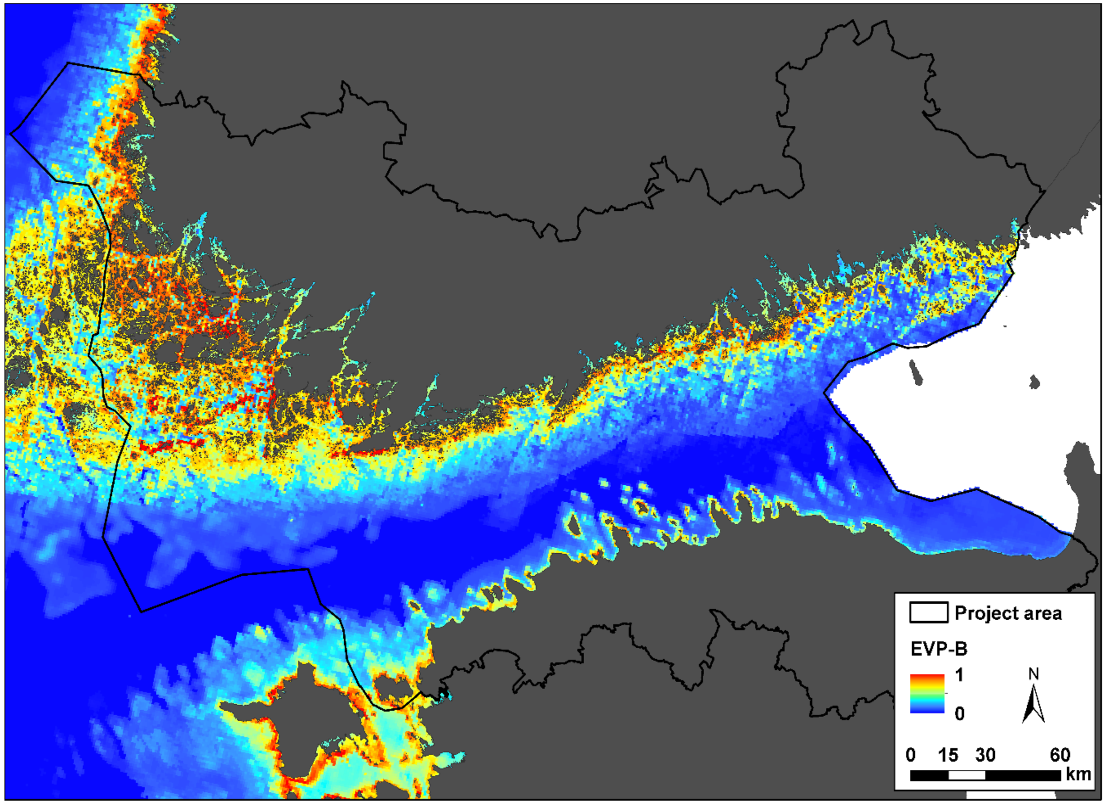
- The spatial analyses were based on the European Environmental Agency's 1 km rectangular grid
  - the 1 km × 1 km cells were the units of calculation.

- In each cell mean and maximum values of the nature values were calculated using the modelled GIS layers that were produced in the previous step

Results


Project area
Vascular plants
1
0
N
0 15 30 60
km
Project area
Epibenthic bivalves
1
0
N
0 15 30 60
km

Results

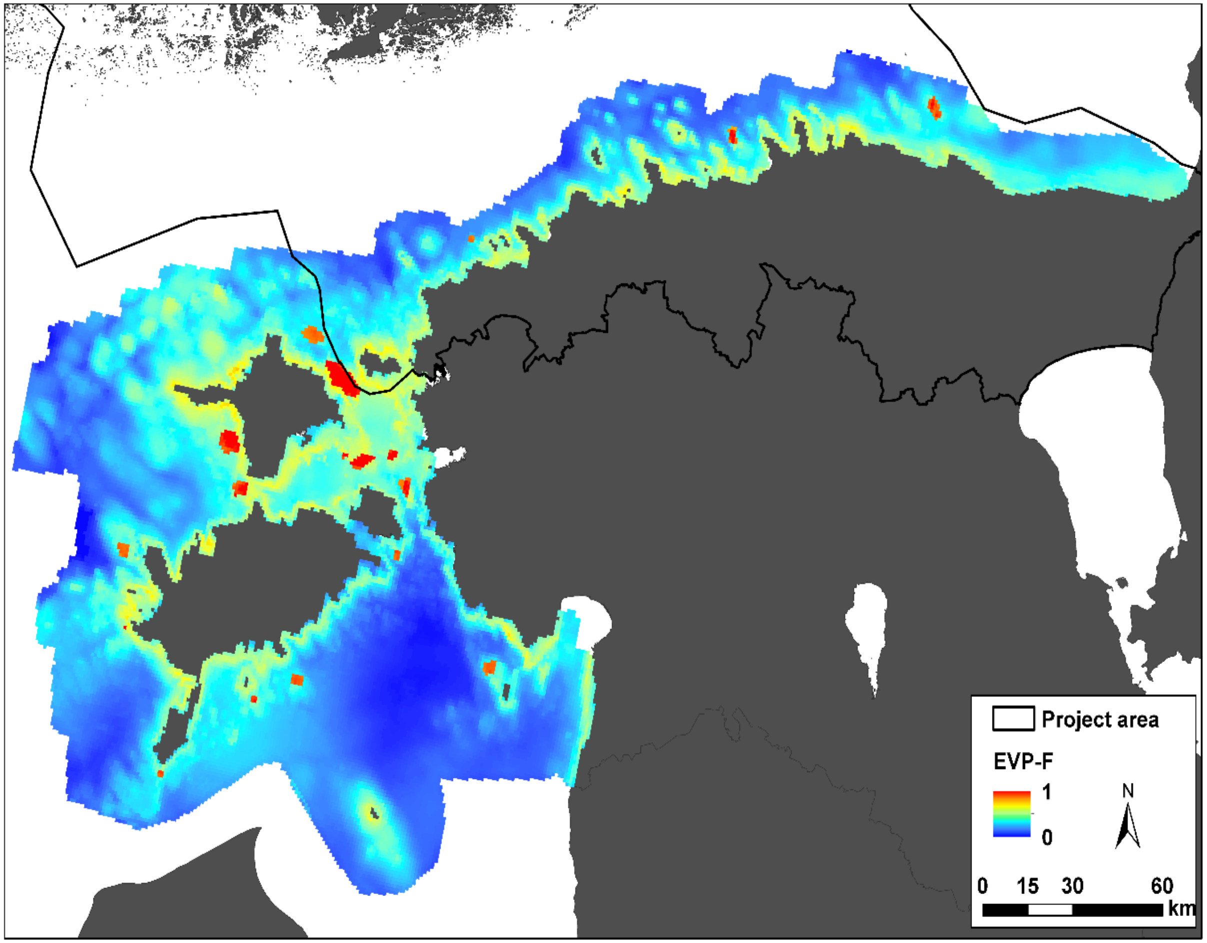


Main products:

- For the whole area: EVP-B

✓ EVP-B: consists only benthic species

Results



Main products:

- <u>Estonian area</u>: EVP-F

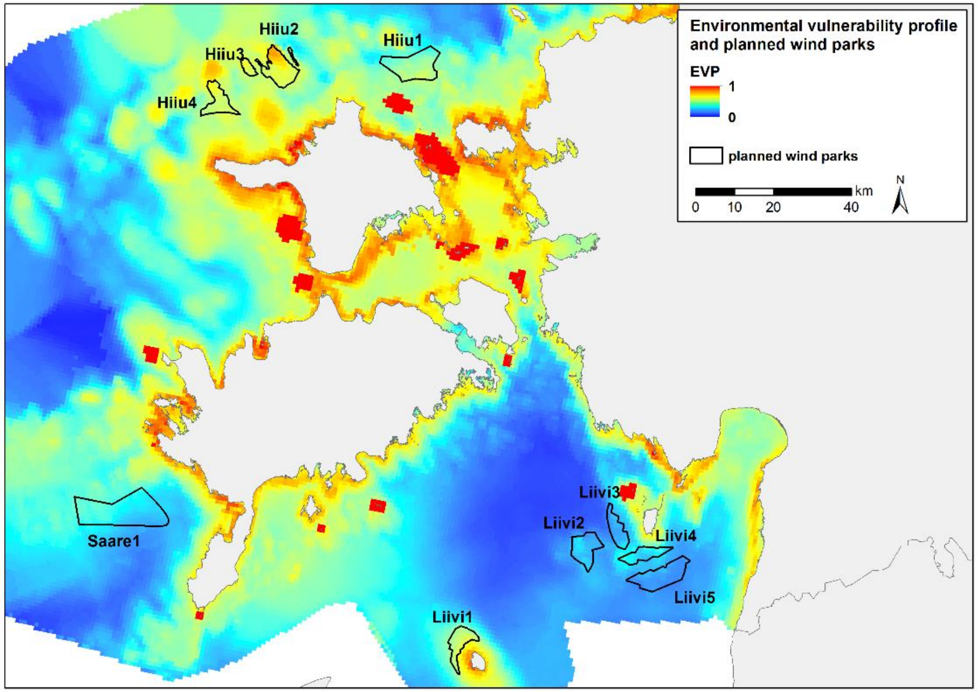
✓ EVP-F: consists of bird, seal and benthic data

Use case: Study area

There were three WP areas:

- Liivi area (five sites) in the Gulf of Riga
- Saare area (one site) west of Island Saaremaa
- Hiiu area (4 sites) north of Island Hiiumaa

The depth range over all WP sites was 4 -38 m



Methods

1. All pixel values of EVP and ERP raster that overlapped with the wind park polygons were extracted and stored in a table

2. All pixel values of all the other pixels not overlapping with WPs (hereafter "no WP") were also extracted

3. The "no WP" pixels were filtered to include only those points that fell into the depth range of WPs (4 – 38 m).

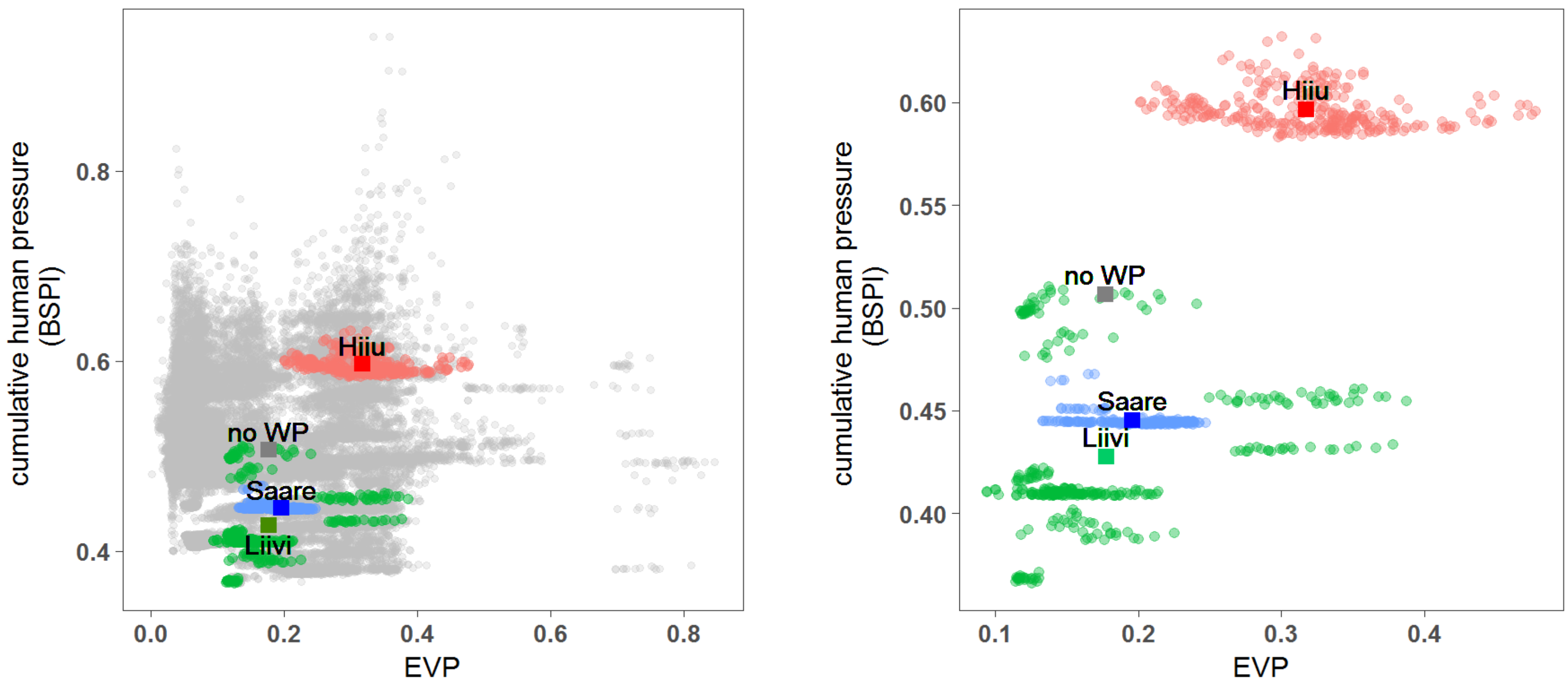
4. After depth filtering the WP and "no WP" tables were merged for further plotting and testing of differences

Methods: Analysis

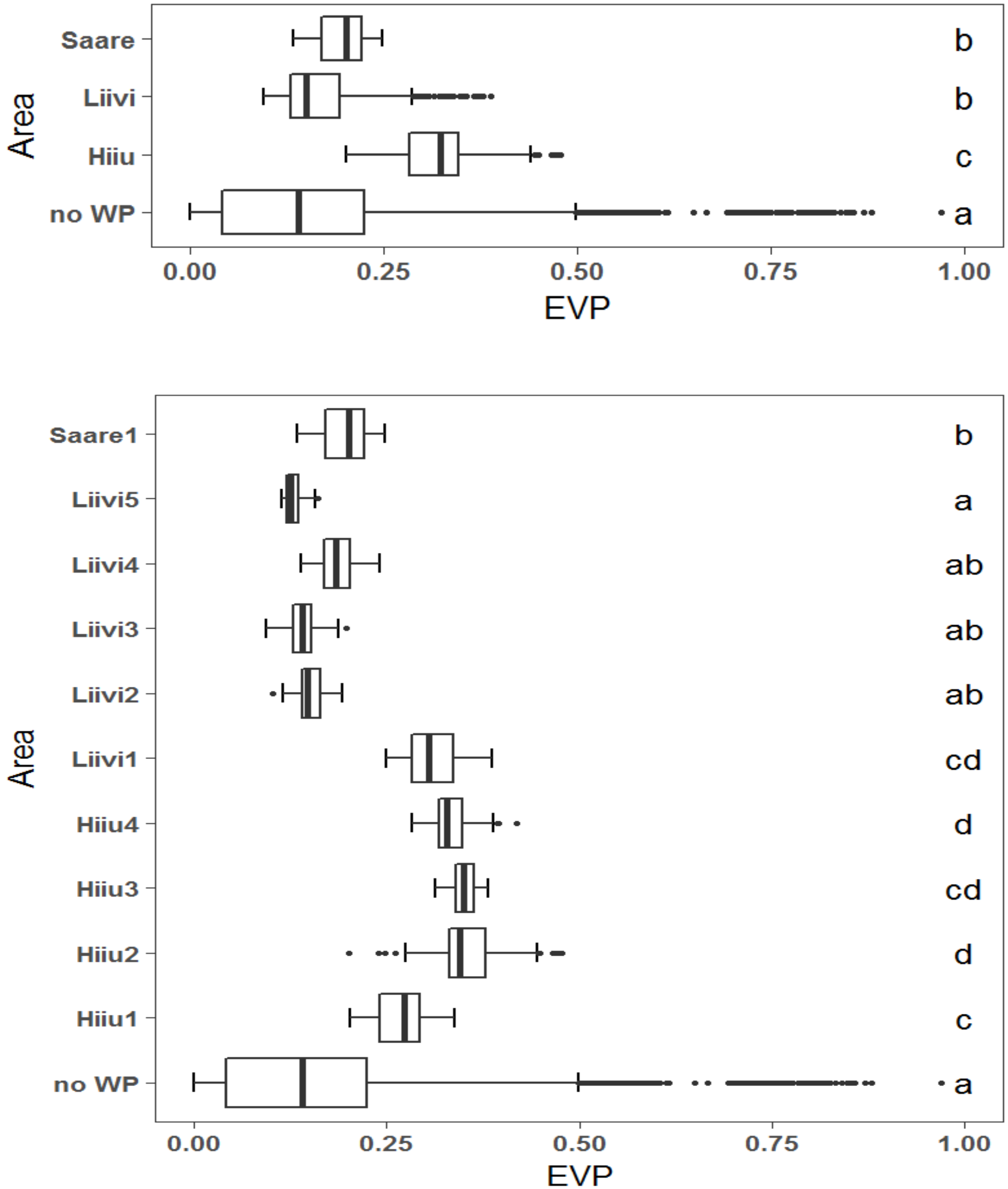
- Two-dimensional scatterplots of pixel values with EVP on the horizontal axis and cumulative human pressures (HELCOM BSPI) on the vertical axis were produced to visualize the differences between WP areas, WP sites and “no WP”.

- ANOVA test followed by Tukey post-hoc pairwise comparison was used to test for the differences between WP areas and sites

Results



The mean values of inside WP areas and outside WP areas (“no WP”) are shown with rectangles. Colors indicate WP areas: red – Hiiu, blue – Saare, green – Liivi, gray – no WP. The left side panel shows all pixels; the right side panel is focused on the WP areas and only mean value is shown for “no WP”.



Boxplots of EVP values in WP areas (upper panel), WP sites (lower panel), and in the area outside of WPs ("no WP"). The letters on the right sides of plots indicate ANOVA post-hoc pairwise differences: areas are significantly different ($p < 0.05$) in case they do not have any letters in common.

Conclusions

- **The results reveal variation and differentiation of environmental vulnerability and cumulative human pressure (BSPI) among the potential WP development areas**

- **EVP and BSPI based analytical framework can be successfully used as a decision support tool for efficient ecosystem-based evaluation of WP site selection**

Acknowledgements

This study is supported by European Regional Development Fund, INTERREG Central Baltic project Plan4Blue "Maritime Spatial Planning for Sustainable Blue Economies" and the Estonian Environmental Investment Centre

Partners

SYKE

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REGIONAL COUNCIL OF SOUTHWEST FINLAND

Baltic Environmental Forum
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Thank you!

MORE INFORMATION
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PLAN4BLUE
MARITIME SPATIAL PLANNING FOR SUSTAINABLE BLUE ECONOMIES

Interreg
Central Baltic

From small scales to large scales
–The Gulf of Finland Science Days 2017
9th-10th October 2017
Estonian Academy of Sciences, Tallinn

1st Day

Gulf of Finland
Co-operation

R. Aps, M. Fetissov , F. Goerlandt , P. Kujala , A. Piel, J. Thomas

Systems approach based maritime traffic safety management in the Gulf of Finland (Baltic Sea)

The Gulf of Finland Science Days, Tallinn, 9-10 October 2017

Systems approach based maritime traffic safety management in the Gulf of Finland (Baltic Sea)

Robert Aps[1], Mihhail Fetissov [1, 2], Floris Goerlandt [3], Pentti Kujala [3], Are Piel [4], John Thomas[5]

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STORMWINDS
Strategic and operational risk management for wintertime maritime transportation system

STORMWINDS
Strategic and operational risk management
for wintertime maritime transportation system

BONUS STORMWINDS

Strategic and operational risk management for wintertime maritime transportation system

Coordinator: Pentti Kujala, Aalto University
Total budget: EUR 1.8 million
Duration: 3 years, 1.4.2015-31.3.2018

Outline

- Study area - the Gulf of Finland
- System Theoretic Accident Modelling and Processes (STAMP)
- STAMP-Mar - safety management of eco-socio-technical maritime navigation systems
- System Theoretic Process Analysis (STPA)
- Ships' routing design - important safety-critical element of ecosystem-based transboundary MSP solutions
- Rapid developments in ship intelligence
- Future work - towards STAMP-Mar based sustainable marine management

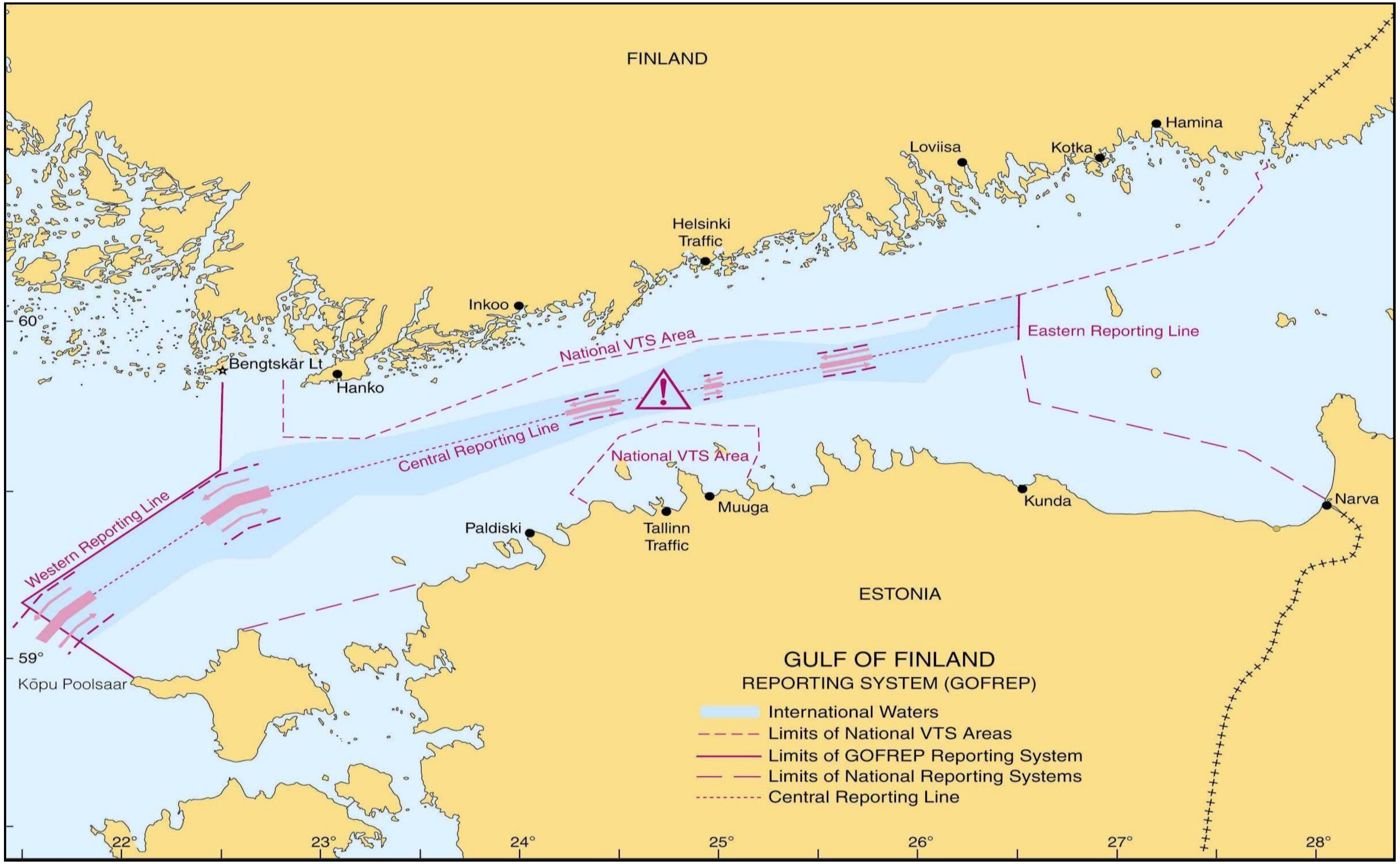
The Gulf of Finland

Study area

- According to International Maritime Organization (IMO) the Baltic Sea Area has some of the densest maritime traffic in the world. The Baltic Sea was designated as a Particularly Sensitive Sea Area (PSSA) at IMO Marine Environment Protection Committee's 53rd session in July 2005
- The Mandatory Ship Reporting System in the Gulf of Finland Traffic Area (GOFREP) was established by IMO in 2003 and has been in efficient operation since 2004

The mandatory ship reporting system in the Gulf of Finland - GOFREP

(source: Estonian Maritime Administration)



System Theoretic Accident Modelling and Processes (STAMP)

- STAMP considers safety an emergent property of the system, arising from the interaction of system components within a given environment
- Rather than focusing on particular errors or component failures as in traditional engineering risk analysis, STAMP focuses on safety constraints, hierarchical control structures and control loops
- In STAMP the safety is viewed as a control problem, and safety is managed by a control structure embedded in an adaptive socio-technical system while the system itself is viewed as interrelated components that are kept in a state of dynamic equilibrium by feedback loops of information and control

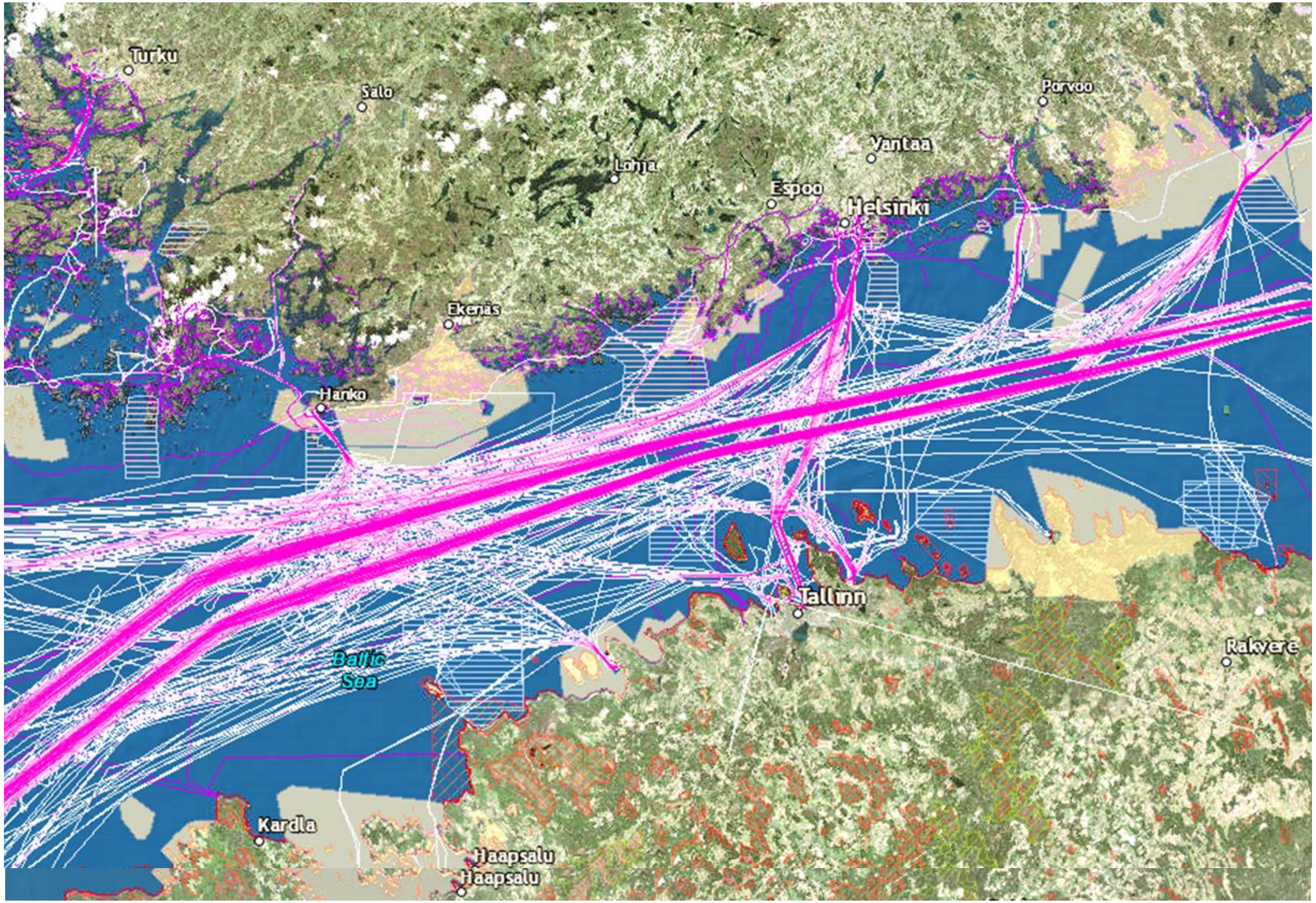
Leveson, 2011

System Theoretic Accident Modelling and Processes (STAMP)

- Control process operate between levels to control the processes at lower levels in the hierarchy and these control processes enforce the safety constraints for which the control process is responsible
- Accidents occur when these processes provide inadequate control and the safety constraints are violated in the behaviour of the lower-level components

Leveson, 2011

GOFREP area - sensitive environment and heavy maritime traffic



Safety management of eco-socio-technical systems

- Systems Theoretic Accident Models and Processes (STAMP) is extended beyond the area of socio-technical systems safety into realm of complex eco-socio-technical systems safety
- The integrated safety management of holistic eco-socio-technical system builds on the monitoring of environmental performance of maritime traffic and port operations including accident response activities, and on the feedback based appropriate corrective management actions

Aps et al., 2015

The STAMP-Mar research concept

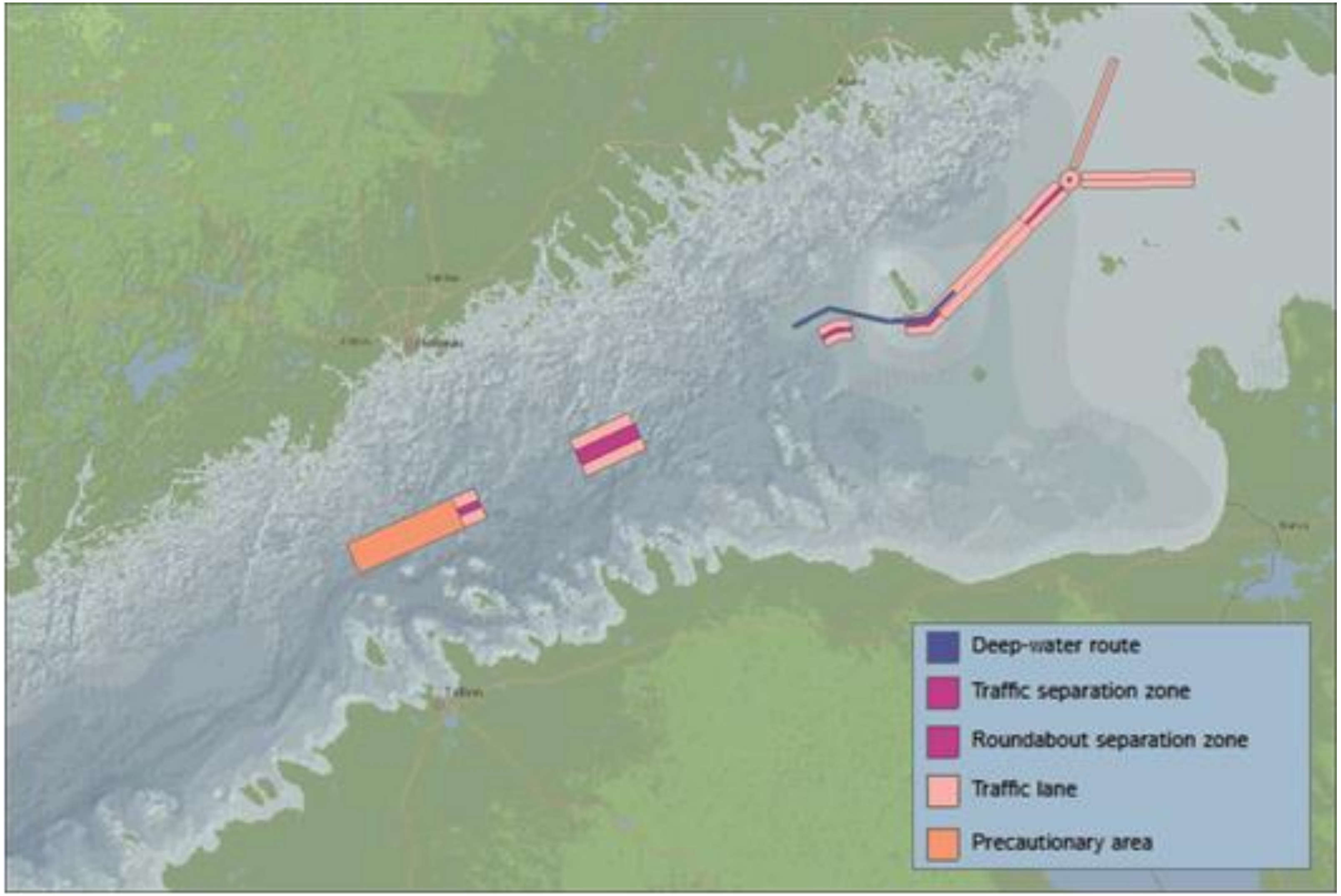
- The STAMP-Mar research concept and application positions under development are aimed at dynamic safety management of eco-socio-technical maritime navigation system that will network existing systems, systems already under development, and systems to be developed to meet the system safety requirements and to enable high levels of joint connectivity, situational awareness and understanding.

Aps et al., 2016

IMO General Provisions on Ships’ Routing

According to International Maritime Organizations' (IMO) General Provisions on Ships’ Routing (GPSR) the purpose of ships' routing is to improve the safety of navigation in converging areas and in areas where the density of traffic is great or where freedom of movement of shipping is inhibited by restricted sea-room, the existence of obstructions to navigation, limited depths or unfavorable meteorological conditions

Ships’ routing measures established in the GOFREP sea area
(source: HELCOM http://maps.helcom.fi/website/mapservice/)



Systems-Theoretic Process Analysis (STPA)

- According to John Thomas (2012) the Systems Theoretic Process Analysis (STPA) is a powerful new hazard analysis method built on STAMP and designed to go beyond traditional safety techniques—such as Fault Tree Analysis (FTA)—that overlook important causes of accidents like flawed requirements, dysfunctional component interactions, and software errors

Ships' routing design - important safety-critical element of ecosystem-based transboundary MSP solutions

In this study in progress the ships' routing design is considered to be an important safety-critical element of ecosystem-based transboundary MSP solutions in the Gulf of Finland sea area

The STPA hazard analysis methodology is applied to identify ships' routing design related system level hazards, corresponding safety constraints and the potentially unsafe control actions that may lead to ships' routing hazardous design

- The ships' routing design not meeting the IMO General Provisions on Ships' Routing (GPRS) safety requirements is identified as the system-level hazard and
- The IMO GPRS design criteria are considered to be the system safety constraints to be imposed on the ships' routing design

As the first step of STPA, the potentially unsafe control actions that may lead to the ship's routing hazardous design are identified

The second step of STPA hazard analysis

- The second step of STPA hazard analysis is performed on a STAMP-Mar functional control diagram of the ships' routing design processes with aim to identify the causal factors for potentially hazardous control actions based on expert interviews and discussions
- It was suggested by experts that without systems approach the hazard analysis may sometimes be performed after the major design decisions on ships' routing design have been done and as a consequence not all potential and hidden hazards are identified and designed out of the system
- Therefore it is suggested to use STPA in a proactive way guiding the ships' routing design by integrating the design and hazard analysis into the safety-guided design processes

Rapid developments in ship intelligence

- The rapid developments in ship intelligence are transforming the future of marine operations and are adding the new complexity to maritime transportation safety management including the amendment of existing and development of new ships’ routing measures being ecosystem based and meeting also the requirements of unmanned shipping operations
- These are the external factors shown in the STAMP-Mar functional control diagram of the ships’ routing safety-guided design processes

The future work

STPA based safety-guided MSP solutions

- **Based on results of this study it is suggested to use STPA in a proactive way guiding the maritime spatial planning processes including the ships' routing design by integrating the planning options hazard analysis into the safety-guided MSP solutions including the requirements of emerging unmanned, remote-controlled or autonomous shipping operations**
- **It is further suggested to use the *Ten tenets* of Elliott (Elliott, 2017) for integrated, successful and sustainable maritime management as the safety constraints to be satisfied in a course of ecosystem based development and implementation of the integrated transboundary maritime planning solutions in terms of environment, legislation, policies, governance, cultural, social, economic, and technological considerations**

The future belongs to those who see the opportunities before they became a reality!

Stig Löfberg

The sustainable marine management as the feedback based control process

Where to from here?

Towards STAMP-Mar based sustainable marine management – the future is now!

Acknowledgements

This work resulted from the BONUS project “Strategic and operational risk management for wintertime maritime transportation system (BONUS STORMWINDS)". Project was supported by BONUS (Art 185), funded jointly by the EU and the national funding institutions: the Academy of Finland (Finland), the Estonian Research Council (Estonia), the Research Council for Environment Agricultural Sciences and Spatial Planning (FORMAS) (Sweden).

BONUS
SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

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BONUS STORMWINDS

STORMWINDS
Strategic and operational risk management
for wintertime maritime transportation system

Aalto University · Tartu Ülikool (Universitas Tartuensis 1632) · Finnish Meteorological Institute · TUT · SMHI

NLS Finnish Geospatial Research Institute FGI · NOVIA University of Applied Sciences · SYKE · Russian academy of sciences

Thank you very much for your attention!

From small scales to large scales
–The Gulf of Finland Science Days 2017
9th-10th October 2017
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Gulf of Finland Co-operation

J. Häkkinen

Developing the guidelines for the ecological post-spill monitoring of the accidental chemical spills

Gulf of Finland Co-operation

Developing the guidelines for the ecological post-spill monitoring of the accidental chemical spills

Jani Häkkinen, Finnish Environment Institute (SYKE)

Gulf of Finland Science Days in Tallinn Oct 9-10, 2017

SYKE

ULKOASIAINMINISTERIÖ
UTRIKESMINISTERIET

Ympäristöministeriö
Miljöministeriet
Ministry of the Environment

The main aim

- The main purpose of the EKOMON project is to make guidance for such post-spill environmental monitoring of spilled chemicals and their ecological effects.
- The EKOMON-project is a follow-up to the Environmental Administration Guidelines 6/2012: The Ecological effects of Oil Spills in the Baltic Sea; The National Action Plan of Finland.
- The basic principles are generally developed to enable a wide use of the guidance in the Baltic Sea and also in other cold waters

Financiers: Ministry for Foreign Affairs of Finland (IBA), Ministry of the Environment (TEAS) and SYKE

Several Finnish experts involved to work: Vuokko Malk, Kari Lehtonen, Matti Leppänen, Harri Kankaanpää, Jari Nuutinen, Heidi Ahkola, Magnus Nyström etc.

Why?

- The assessment of the environmental impact is crucial for the decision-making process over the selection and implementation of a prominent response and restoration plans

- In addition, from a legal standpoint, the development of adequate monitoring tools are of chief importance, since they can be used to demonstrate ecological damage and economic losses in the context of spill-related claims and compensations.

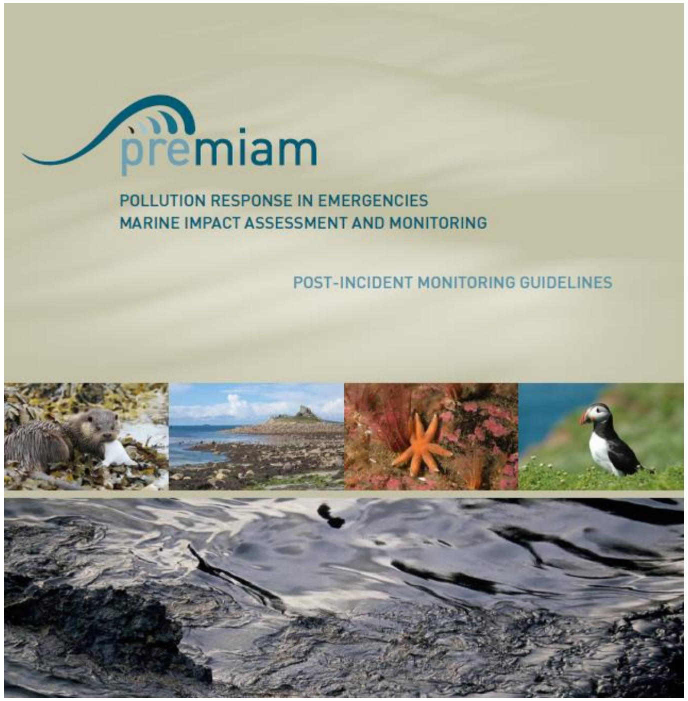
Studies of the ecological impacts of the incident are usually conducted in parallel with measurement of the concentration of the chemical in order to establish a pathway between the observed damage and the spilled chemical components.

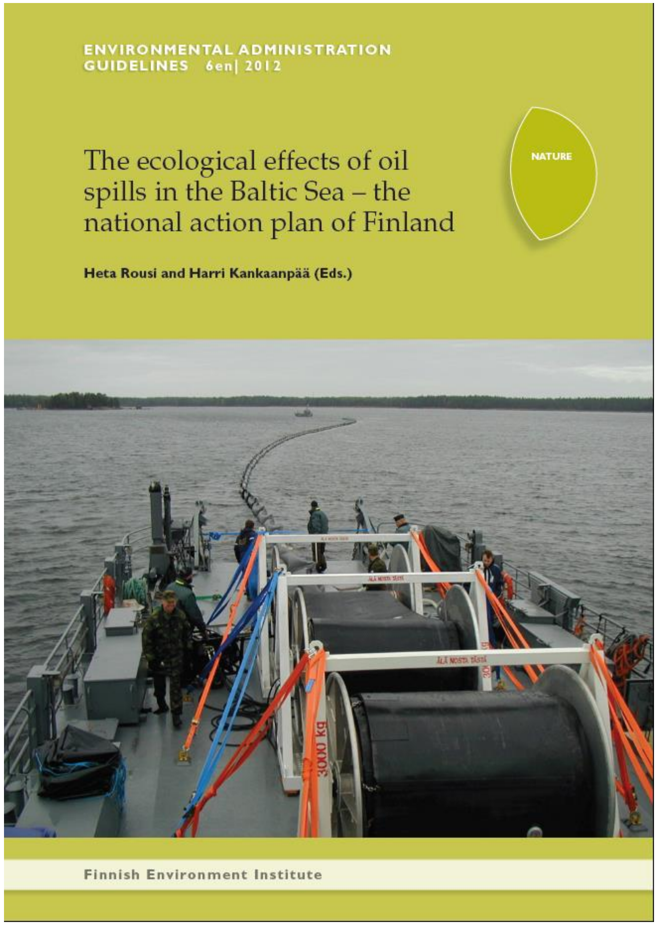
Post-incident studies might also include surveys of members of the public who make use of the affected area for outdoor recreational for example, bathing, recreational fishing, boating, hiking, etc., to determine the extent of restrictions imposed upon them by the spill

Monitoring do not require that the monitoring continues until environments have fully recovered but until it can be demonstrated that the process of recovery has been comprehensively established. In fact, because of the high natural variability that exists in the marine environment it may be quite difficult to recognise conclusively when the environment has fully recovered.

SYKE

Other existing guidelines





SYKE

CHEMBALTIC - project

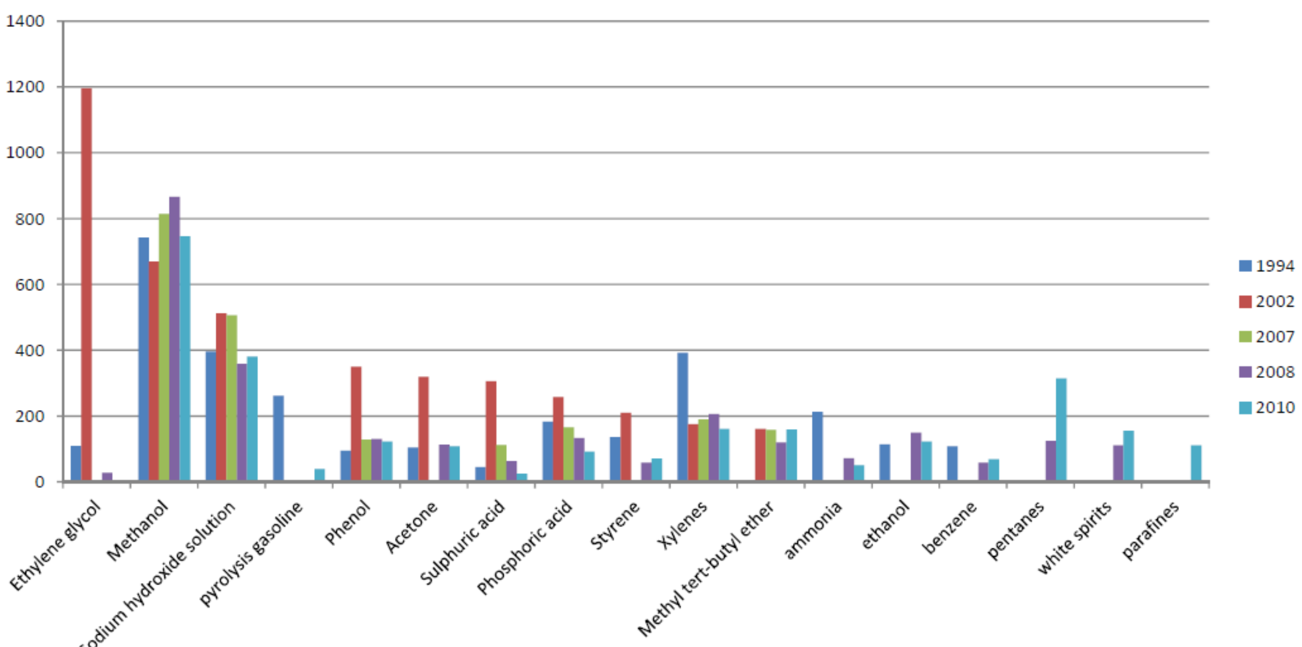
http://www.merikotka.fi/chembaltic/

Chemicals handled in Finnish Ports

2008	
Methanol	866,323
Sodium hydroxide solution	359,424
Xylenes	206,558
Ethanol and ethanol solutions	149,535
Phosphoric acid	133,147
Pentanes	124,548
Methyl tert-butyl ether (MTBE)	119,539
Phenol + acetone	119,065
Aromatic free solvents (e.g. white spirit and NESSOL)	111,479
Propane	107,260
Ethyl tert-butyl ether (ETBE)	73,646
Phenol	73,040
Ammonia	72,088
Propylene	66,818
Sulphuric acid	62,822

2010	
Methanol	746,141
Sodium hydroxide solution	380,331
Pentanes	315,978
Xylenes	161,894
Methyl tert-butyl ether (MTBE)	159,660
Aromatic free solvents (e.g. white spirit and NESSOL)	155,363
Ethanol and ethanol solutions	122,018
Parafines	111,079
Phosphoric acid	91,797
Phenol	87,359
Propane	84,027
Acetone	73,815
NExBTL	73,298
Phenol + acetone	72,427
Styrene	71,934
Benzene	69,240
Formic acid	68,427
Butanoles	67,890
Hexafluorosilicic acid	56,006
Ammonia	51,632
Ethylene	45,166
Pyrolysis gasoline	39,426
Butadiene	38,852
Coal tar	36,114
Propylene	29,919
Sulphuric acid	25,172
Tert-amyl ethyl ether (TAEE)	23,186
Nexbase	20,401
Hydrogen peroxide	20,059
Ethyl tert-butyl ether (ETBE)	19,273
Nitric acid	16,838
CO_2	13,592
VERSENEX 80/100	12,968
ETBE + TAEE	[illegible]

Most handled chemicals in Finnish ports (thousand tonnes)



References: Posti & Häkkinen 2012, Häkkinen 2004, 2009, Hänninen & Rytkönen 2006

IMO list of the top 20 chemicals likely to pose the highest risk of being involved in an HNS incident

Itopf tip17 ” response to marine chemical incidents”

Rank	Chemical	Behaviour	Main hazard
1	Sulphuric acid	Sinker/dissolver	Corrosive / exothermic reaction with water / fumes
2	Hydrochloric acid	Sinker/dissolver	Corrosive / exothermic reaction with water / fumes
3	Sodium hydroxide / caustic soda	Sinker/dissolver	Corrosive / exothermic reaction with water
4	Phosphoric acid	Sinker/dissolver	Corrosive / exothermic reaction with water / fumes
5	Nitric acid	Sinker/dissolver	Corrosive / exothermic reaction with water / fumes
6	LPG/LNG	Gas (transported as a liquid)	Flammable / explosive
7	Ammonia	Gas (transported as a liquid)	Toxic
8	Benzene	Floater/evaporator	Flammable / explosive
9	Xylene	Floater/evaporator	Flammable / explosive
10	Phenol	Dissolver/evaporator	Toxic / flammable
11	Styrene	Floater/evaporator	Flammable / toxic / polymerisation
12	Methanol	Floater/dissolver	Flammable / explosive
13	Ethylene glycol	Sinker/dissolver	Toxic
14	Chlorine	Gas (transported as a liquid)	Toxic
15	Acetone	Floater/evaporator/dissolver	Flammable / explosive
16	Ammonium nitrate	Sinker/dissolver	Oxidizer / explosive
17	Urea	Sinker/dissolver	Irritating
18	Toluene	Floater/evaporator	Flammable / explosive
19	Acrylonitrile	Floater/evaporator/dissolver	Flammable / toxic / polymerisation
20	Vinyl acetate	Floater/evaporator/dissolver	Flammable /toxic / polymerisation

▲ *Table 2: IMO list of the top 20 chemicals likely to pose the highest risk of being involved in an HNS incident, not including crude oil, liquid distilled crude oil products or vegetable oils (source: MEPC/OPRC-HNS/TG 10/5/4, see www.imo.org).*

SYKE

Dangerous diversity

Transport and handling of hazardous and noxious substances (HNS) have significantly increased during the past 20 years. It is estimated that about 37 mln different chemicals are used worldwide and 2,000 of these are transported regularly by sea.

HNS are transported either in bulk or in packaged form, and their transportation differs significantly. Packaged HNS are carried using many different types and sizes of vessels, including e.g. general cargo ships, container ships and ro-ro cargo ships. Unlike bulk transport, packaged HNS are carried together with non-hazardous goods. The same transport unit (e.g. a container) can also contain numerous, different HNS, which can mix with each other and form destructive compounds. In addition, packaged HNS are very commonly transported together with passengers on board (e.g. ro-ro vessels) causing a considerable risk to human health. Because of these reasons, it is very important to be aware of what kinds of packaged hazardous and noxious substances are handled in ports and transported by sea.

Packaged HNS in Finnish ports

The Centre for Maritime Studies at the University of Turku and the North European Logistics Institute examined the handlings of packaged hazardous and noxious substances in Finnish ports by using a Finnish, nationwide vessel traffic system called PortNet. The study showed that packaged HNS were handled in 16 Finnish ports in 2012. These ports handled about 1,020 different packaged HNS which altogether totalled approx. 820,000 tn. Of the total volume, 53% constituted export and 47% – import. 16 types of substances were handled in an amount of more than 10,000 tn, 84 substances – 1,000-10,000 tn each, 148 substances – 100-1,000 tn each, and 770 substances in an amount of less than 100 tn each.

The IMDG classes transported most often were: class 3 flammable liquids (256,000 tn), class 9 miscellaneous dangerous substances and articles (204,000 tn), and class 8 corrosives (187,000 tn). Many of the HNS handled most often were refined compounds or similar combinations of unspecified chemicals

Tab. 1. Top 20 packaged HNS handled in Finnish ports in 2012 (import & export)

No.	UK number	Name of HNS	Total turnover [tn]
1	3077	Environmentally hazardous substance, solid, n.o.s.	77,984
2	1263	Paint or paint-related material	68,161
3	1779	Formic acid	52,974
4	2211	Polymeric beads	47,629
5	1866	Resin solution	44,971
6	3257	Elevated temperature liquid, n.o.s.	30,489
7	3082	Environmentally hazardous substance, liquid, n.o.s.	27,345
8	3496	Batteries, nickel-metal hydride	22,564
9	1202	Gas oil, diesel fuel or heating oil, light	22,473
10	2014	Hydrogen peroxide, aqueous solution	16,004
11	1495	Sodium chlorate	14,845
12	1993	Flammable liquid, n.o.s.	14,824
13	3166	Engine internal combustion or vehicle flammable gas powered or vehicle flammable liquid powered	14,095
14	1942	Ammonium nitrate	13,446
15	2312	Phenol, molten	12,996
16	1750	Chloroacetic acid, solution	11,957
17	3264	Corrosive liquid, acidic, inorganic, n.o.s.	9,806
18	1203	Motor spirit or gasoline or petrol	9,613
19	1268	Petroleum products and distillates, n.o.s.	9,137
20	1170	Ethanol or ethanol solution	9,110
		Other HNS (about 1,000 pcs) total	286,400
		ALL HNS TOTAL	**816,822**

solution of hydrogen peroxide, sodium chlorate, ammonium nitrate, phenol, and chloroacetic acid solution. All of these were handled in an amount of more than 10,000 tonnes in Finnish ports in 2012.

A ro-ro ship was the vessel type most frequently used (over half of the total volume in 2012). The next in rank were passenger/car ferries (27%), container vessels (14%) and dry cargo vessels (8%). A container (41% share), in turn, was the most commonly used transport unit, followed by a truck (33%) or trailer (16%).

Statistics do not tell the whole truth

HNS have a high diversity of hazardous properties, which makes them a risk that is difficult to control. However, that is not the whole picture. In addition to the

packaged HNS reported correctly in transport documents, HNS are surprisingly often transported in vessels without any markings in the documents or symbols on the transport units, or they may be reported incompletely. These kinds of undeclared and partly reported cargoes pose a huge safety risk to all involved in the related transport operation. If there is no knowledge about the presence of HNS, the cargo may not be handled, stowed and transported correctly in the transport chain. The fire and explosion on the container vessel *Sea-Land Mariner* in 1998, the fire on the container vessel *Sea Elegance* in 2003, and the explosion and fire on the containership *Zim Haifa* in 2007, just to mention a few, are regrettable real-life examples of what could be in store.

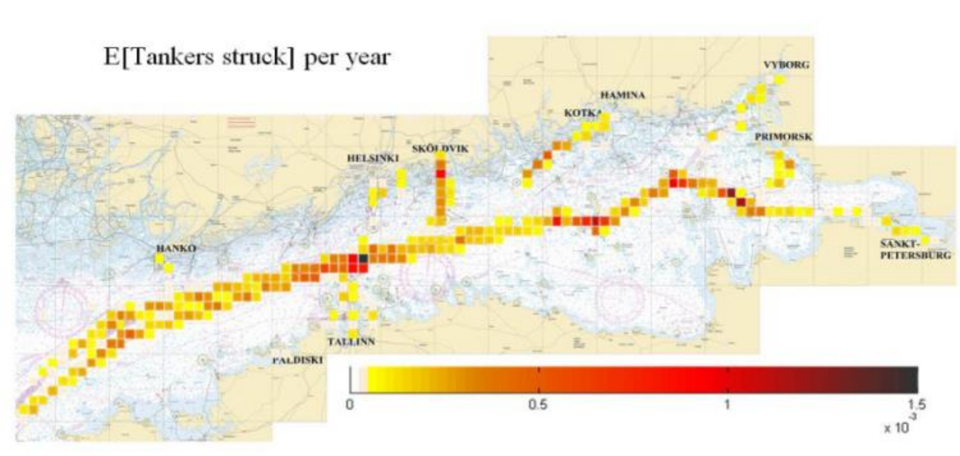
International regulations, training and education, as well as increasing general knowledge play a key role in improving safety when transporting dangerous goods. All parties in the transport chain should understand how activities conducted early in the transport chain affect it all. Therefore, it is important to find means to identify undeclared HNS from the other cargo. These means will be studied in the next step of the NOSE project. ■

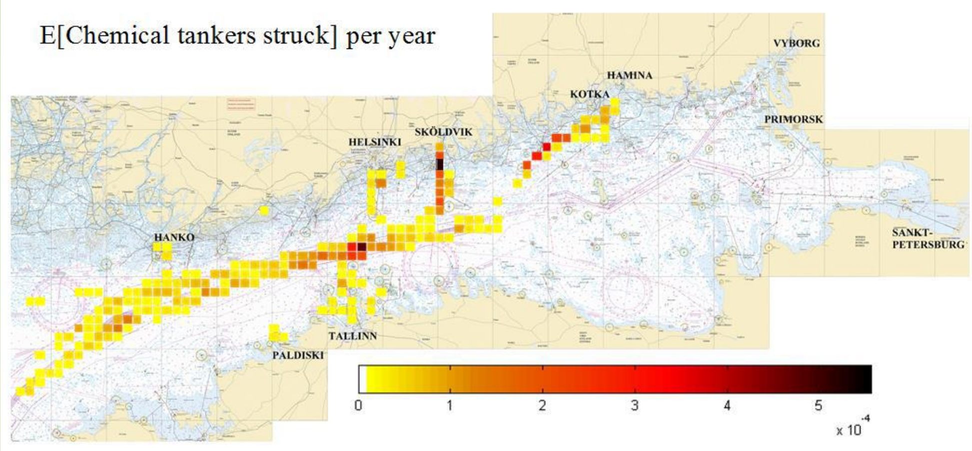
Antti Posti and Jani Häkkinen,
Centre for Maritime Studies, University of Turku
Mikko Mylläri, North European Logistics Institute

SYKE

Modelling the scenario - tankers traffic in the GoF

The collision probability - Division of GoF into 5 x 5 km squares





Expected number of struck chemical tankers per year using causation factors (AI). Map: © Finnish Transport Agency licence no. 1803/1024/2010..

The expected collision return period is once every 17 years for all tankers and once every 77 years for chemical tankers

The expected number of tanker groundings per year calculated in this manner is once every 6.54 years for HaminaKotka and once every 3.41 years for Sköldvik

However, both the spill probability in case of an accident as well as the average chemical spill size are larger for collisions than for groundings

Source: O. Sormunen 2016

Risk of the tankers traffic in the GoF

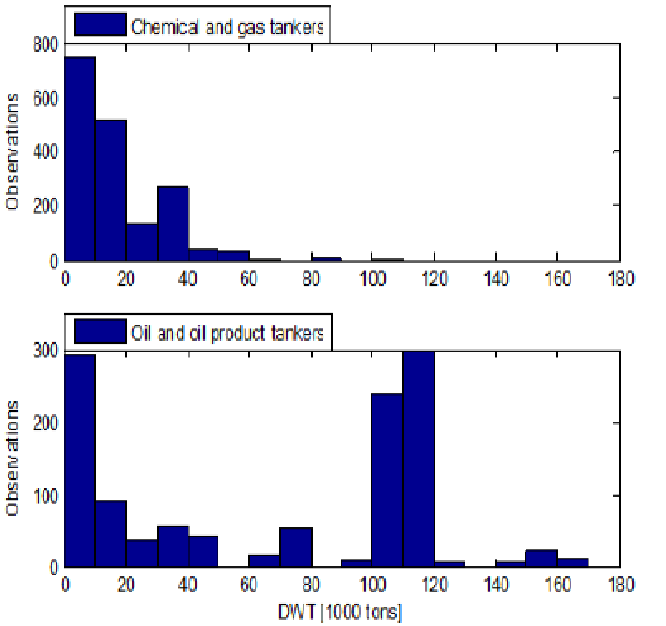
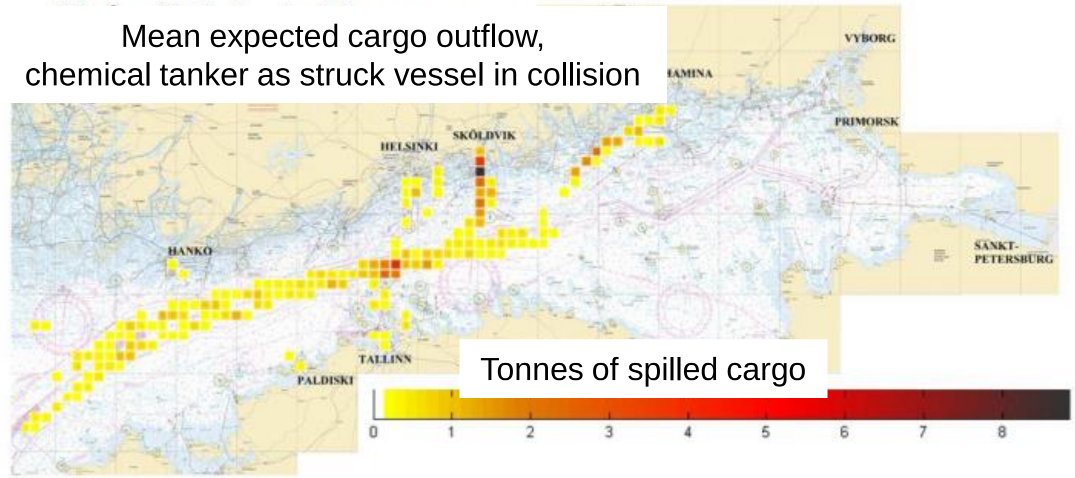
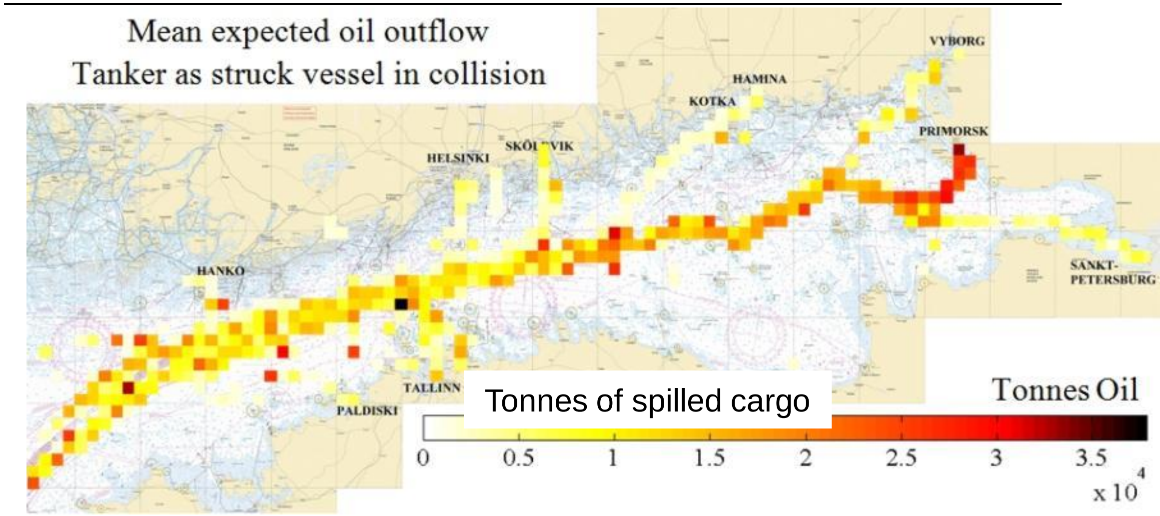


Fig. 3. Histograms of chemical and gas tankers and oil and oil product tankers in 2007 (adapted from Sormunen 2011)





S Y K E

Sormunen 2016

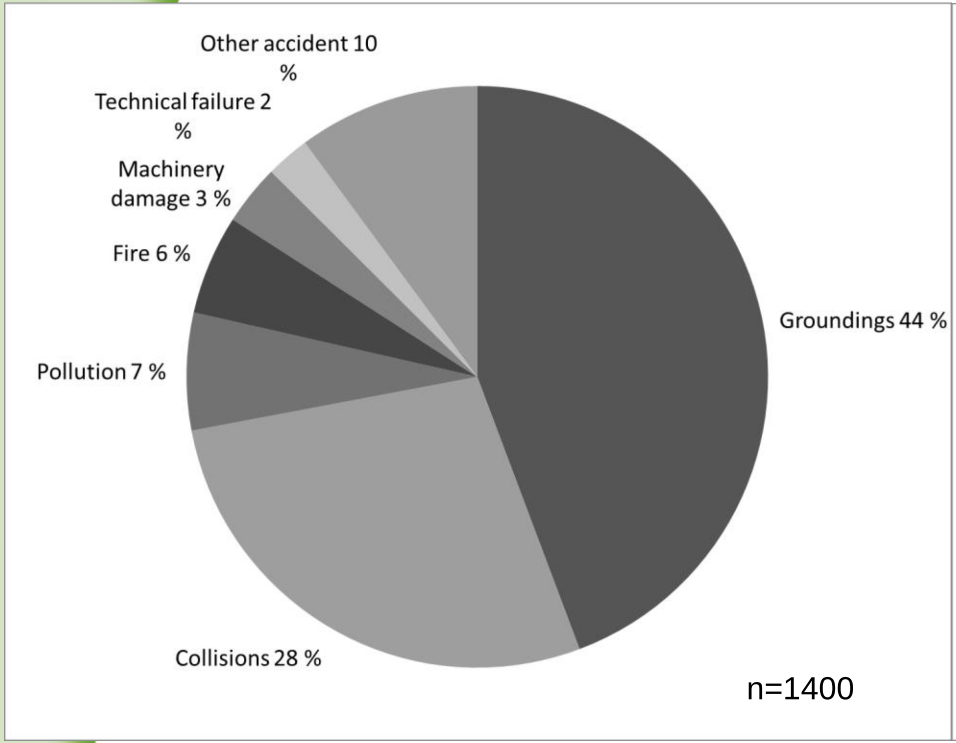


Figure 1. Vessel accidents in the Baltic Sea in 1989–2010 by accident types. (Häkkinen and Posti 2013 based on HELCOM 2012)

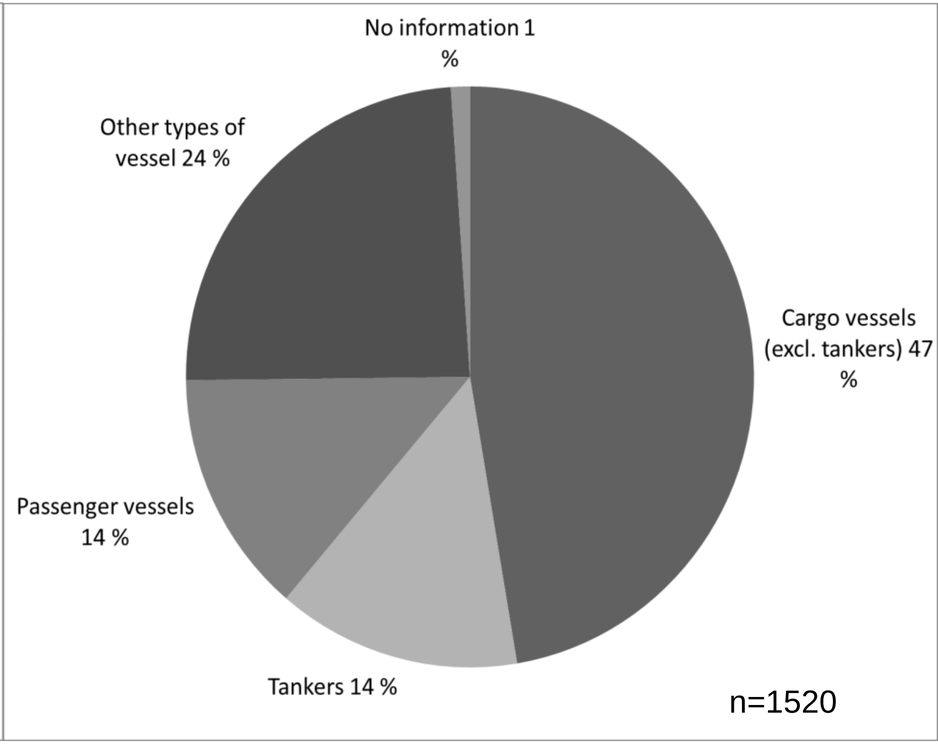


Figure 2. Vessel accidents in the Baltic Sea in 1989–2010 by vessel types. (Häkkinen and Posti 2013 based on HELCOM 2012)

- Collisions and grounding main types of accident/incidents.
- Human factor main cause, followed by technical reasons
- No major chemical spills nor oil accident like Erika, Prestige have happened etc.
- The latest severe oil spill in the Baltic Sea was in 2001: The Bulk Carrier Tern and the tanker B collided. Appr. 20,000 seabirds were contaminated
- Antonio Gramsci 1987, grounding, spill 650 tonnes

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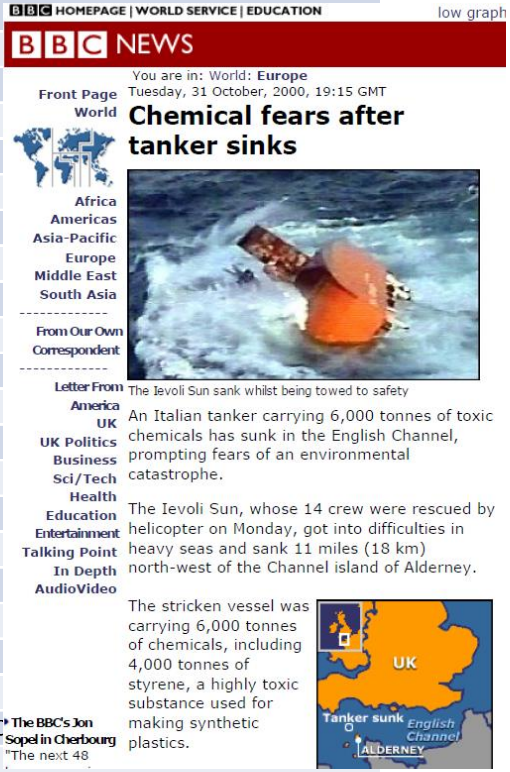
Ship	Place and year	Chemical involved
Grandcamp	Texas City, USA, 1947	ammonium nitrate
Ocean Liberty	France, 1947	ammonium nitrate
Mundogas Oslo	Finland/Sweden 1966	Ammonia (2000 t)
Poona	Sweden, 1971	Sodium chlorate and rapeseed oil
Amalie Essberger	Sweden, 1973	Phenol
Yoyo Maru N°10	Japan, 1974	Propane, butane and naphtha
Lindenbank	Hawaii, 1975	Sugars, foodstuff and vegetable oils (palm and coconut oil)
René 16	Sweden, 1976	Anhydrous ammonia
Stanislaw Dubois	Netherland, 1981	Calcium carbide + caustic soda
Brigitta Montanari	Yugoslavia, 1984	Vinyl chloride monomer (VCM)
Castillo De Salas	Spain, 1984	Coal (100000 t)
Puerto Rican	USA, 1984	Caustic soda
Anna Broere	Netherland, 1988	Acrylonitrile and Dodecylbenzene
Ocean Spirit	Malta,1988	Lead concentrate
Val Rosanda	Italy, 1990	Propylene
Alessandro Primo	Italy, 1991	Acrylonitrile and Dichloroethane
Continental Lotus	Eastern Mediterranean, 1991	Iron ore
Erato	Algeria, 1991	Phosphate and bunker fuel
Kimya	UK, 1991	Sunflower oil
Nordfrakt	Germany, 1992	Lead sulphur (1600 t)
Weisshorn	Spain, 1992	Rice
Grape One	UK, 1993	Xylene
Cynthia M	New Jersey, USA, 1994	Caustic soda
Infiniti	Curacao, 1995	Rice
N°1 Chung Mu	China, 1995	Styrene
Fenes	France, 1996	Wheat
Formosa Eight	Japan, 1996	Acrylonitrile
Igloo Moon	USA, 1996	Butadiene
Kira	Greece, 1996	Phosphoric acid
Kowloon Bridge	USA, 1996	Iron ore
Albion II	Bay of Biscay, France, 1997	10 dangerous chemicals (IMO code) and 11C
Allegra	France, 1997	Palm nut oil
Bow Panther	Japan, 1997	Xylene
Panam Perla	Atlantic, 1998	Sulphuric acid
Bahamas	Brazil, 1998	Sulphuric acid
Champion Trader	Mississippi River, USA, 1998	Palm oil
Multi-Tank Ascania	UK, 1999	Vinyl acetate
Jessie Maersk	Gibraltar, 1999	Ammonia
Young Chemi	South Korea, 1999	Chloroform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BBC NEWS
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Front Page
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Africa
Americas
Asia-Pacific
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Middle East
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Letter From America
UK
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Health
Education
Entertainment
Talking Point
In Depth
AudioVideo

Chemical fears after tanker sinks

The Ievoli Sun sank whilst being towed to safety

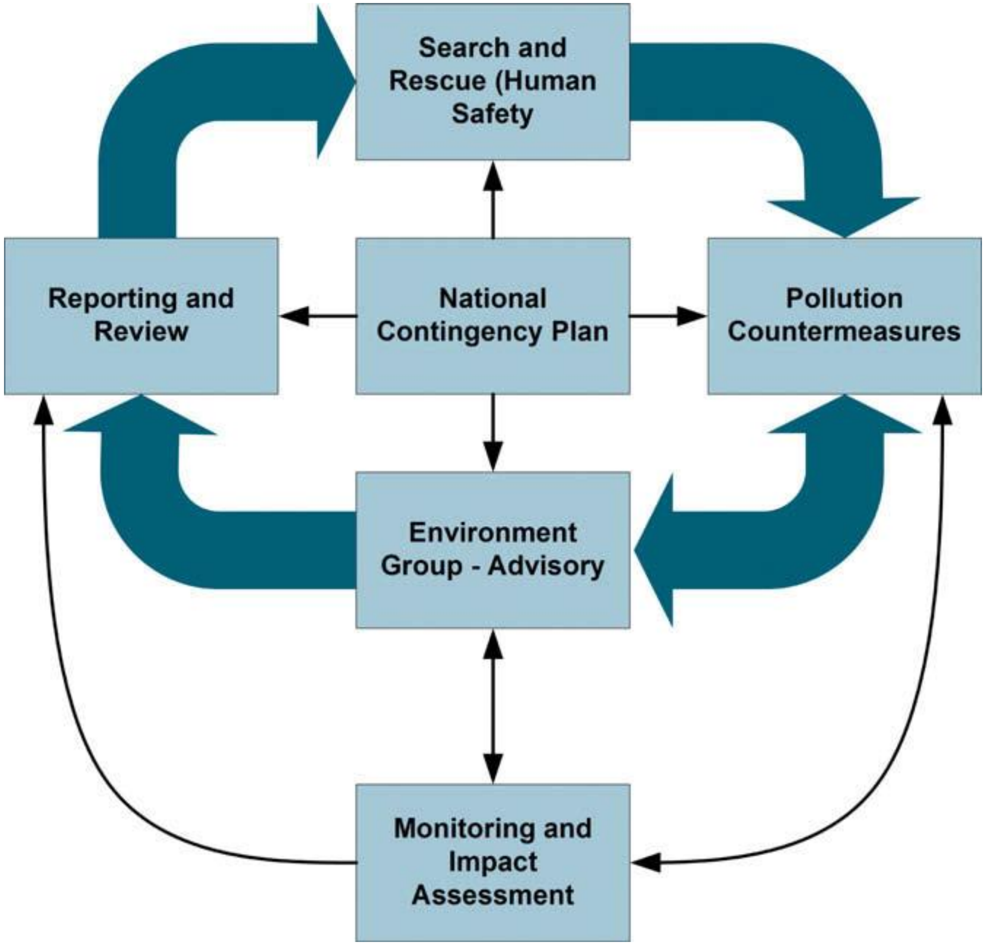
An Italian tanker carrying 6,000 tonnes of toxic chemicals has sunk in the English Channel, prompting fears of an environmental catastrophe.

The Ievoli Sun, whose 14 crew were rescued by helicopter on Monday, got into difficulties in heavy seas and sank 11 miles (18 km) north-west of the Channel island of Alderney.

The stricken vessel was carrying 6,000 tonnes of chemicals, including 4,000 tonnes of styrene, a highly toxic substance used for making synthetic plastics.

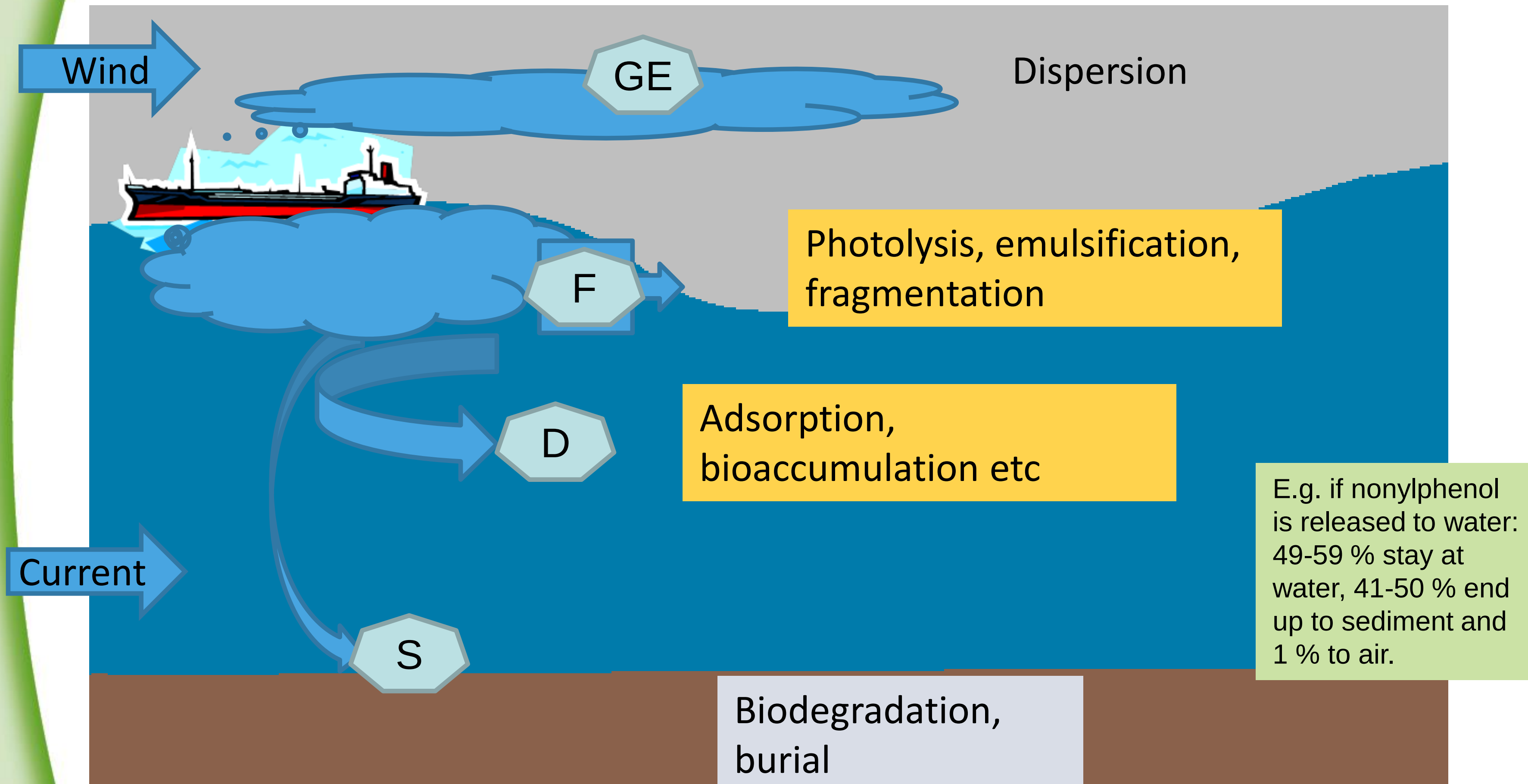
The BBC's Jon Sopel in Cherbourg
"The next 48

Post-spill environmental monitoring



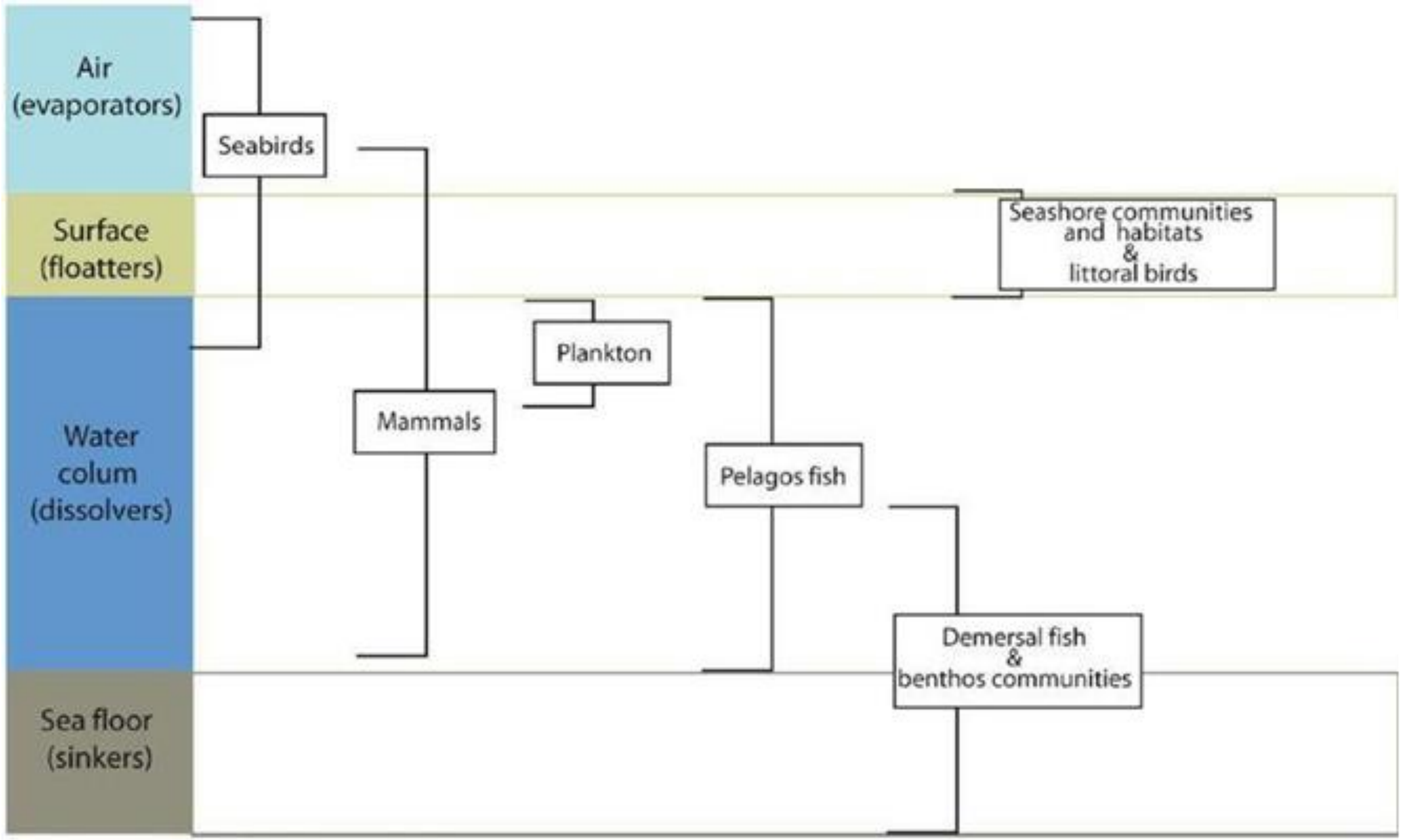
Kirby & Law 2010

Fate of chemical



Main Category	Gas (G) (methane)	Evaporator (E) (benzene)	Floater (F) (palm oil)	Sinker (S) (coal tar)	Dissolver (D) (phosphoric acid)
Sub-categories	GD Gas/Dissolves (ammonia)	ED Evaporates/ Dissolves (MTBE)	FD Floats/Dissolves (butanol) FE Floats/Evaporates (xylenes) FED	SD Sinks/Dissolves (dichloroethane)	DE Dissolves/ Evaporates (acetone)

SYKE



L. Poncet (CEDRE) 2016

Based on real accident cases

three common types of scientific approaches were identified:

(A) Chemical contamination monitoring: measurement of the chemical concentration in the various marine compartments.

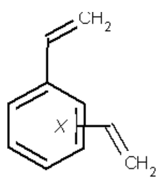
(B) Biological monitoring – responses at sub-individual and individual level: physiological and epidemiological markers, biomarkers of exposure/effect and/or biological responses in ecotoxicological assays.

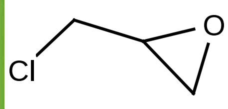
(C) Ecological monitoring: monitoring studies at population or community level (population dynamic and/or community structure parameters). (Neuparth et al. 2012)

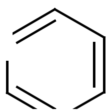
Post-spill monitoring?

Release	Analysis	Assessment

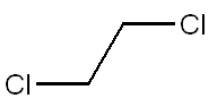
CAS 8001-58-9

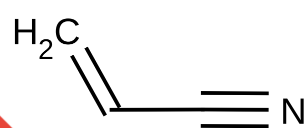






NH3





Fate modelling, spreading models etc

EC50 LC50

PEC/PNEC

Reduced breeding

Biochemical

physiological

Growth

Population

Community

ICP TOF

GC MS

Results for ecological damage analysis; also for the compensation and restoration plans

Where do we monitor?

- Impacted areas
- Unimpacted areas nearby, which may be impacted later
- Unimpacted areas nearby, likely to remain so, as reference sites
- Use of fate and transport modelling to predict chemical behaviour helps to identify sites likely and unlikely to be impacted later.

(Premiam report 2011)

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CONTENTS

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Challenges

- Chemical dependent what you monitor
- Also need for modelling
- For many chemicals no baseline data exists
- Carefully chosen reference sites
- Choose the indicator species and sensitive species
- Need for laboratory and field testing as well as chemical and biota sampling
- Many endpoints: SSD curves, Hazard quetient (PEC/PNEC), biomarkers, bioindicators, acute and chronic toxicity and ecosystem/community level changes. Also recovery rates important.
- Have to demonstrate strong causal relationship for claims
- Good quality reporting all the way
- In case of major accident may take months or even years
- HNS convention not ratified yet

Activities related

- SYKE will arrange an international seminar on the topics of the project in connection with the MOSPA exercise in March 2018 as well as an arctic oil spill conference.
- For the final evaluation of the guidelines SYKE asks for national ecological and chemical experts to take part in a correspondence group that will be established later on.
- The project is also interested to know if any national guidelines for monitoring and assessment of contamination and ecological effects are prepared and available in other countries.

Hosted by Finnish Environment Institute (SYKE)

7-8 MARCH, 2018
Scandic Hotel/Kinopalatsi
Oulu, Finland

Wednesday 7th March

Opening session 9-12	Arctic Council's priorities in oil spill response in the Arctic (Arctic council, EPPR, MOSPA agreement) Session coordinated by:
Session I 13-17	Search and Rescue in the Arctic areas Session coordinated by:
Session II 13-17	Ecological consequences of oil spills in the arctic Session coordinated by:

Thursday 8th March

Session IV 9-16	Technology for oil in ice response (Mechanical, In situ burning, Dispersants) Session coordinated by:
Session V 9-12	Ice management and weather services in the Arctic (Ice monitoring, Ice breaking, Weather forecasts) Session coordinated by:
Session VI 13-16	Latest research … tms (Grace, App4Sea, Stormwinds) Session coordinated by:
Final session	Closing of the seminar (Closing remarks, main conclusions, way forward) Session coordinated by:

Participation is free of charge…
Speakers are called to…
Registrations…etc.

EKOMON-seminar on Ecological Consequences of Chemical Spills will be held simultaneously. Schedule and information available at XXX.

The international MOSPA oil spill response excercise held in the Bothnian Bay

EKOMON SEMINAR
Ecological Consequences of Marine Chemical Spills
7-8 MARCH, 2018
Oulu, Finland

Concurrent event with the MOSPA-seminar!
More info at:
www.syke.fi/projects/mospa2018
www.syke.fi/projects/ekomon

Wednesday 7th March

9:00	Opening speech of the EKOMON-seminar in the MOSPA-seminar opening session
9-12	EKOMON-session: - The fate and behaviour of different HNS in case of sudden spill - EKOMON - The guidelines for the post-spill monitoring of the accidental chemical spills in the Baltic sea and cold waters. - National approaches to post-incident monitoring. - Ecological monitoring and risk assessment of accidental pollution. - Protocols for HNS environmental impact assessment .
13-17	Participating MOSPA-seminar Session II: Ecological consequences of oil spills in the arctic

Thursday 8th March

9-12	EKOMON-workshop/session:
13-16	Participating MOSPA-seminar session VI: Latest research
16-17	Closing of the seminar (Possibly together with MOSPA-seminar)

SYKE

ULKOASIAINMINISTERIÖ
UTRIKESMINISTERIET

Ympäristöministeriö
Miljöministeriet
Ministry of the Environment

SYKE

Thank you!

- For more information:

  jani.hakkinen@ymparisto.fi

  www.syke.fi/projects/ekomon

SYKE

From small scales to large scales
–The Gulf of Finland Science Days 2017
9th-10th October 2017
Estonian Academy of Sciences, Tallinn

1st Day

Gulf of Finland Co-operation

J. Lappalainen, W. Niemelä, M. Rosenberg, M. Viitasalo

A novel leisure boating index reveals the supply and demand of services for boaters in the Finnish marine area

A novel leisure boating index reveals the supply and demand of services for boaters in the Finnish marine area

LAPPALAINEN JUHO, NIEMELÄ WALTTERI, ROSENBERG MIRJA, VIITASALO MARKKU

Finnish Environment Institute SYKE

9.10.2017 Gulf Of Finland Science Days, Estonian Academy of Science


SWEDEN
FINLAND
GULF OF BOTHNIA
HEISINKI

- How much boating is there on the Finnish coast and how is it dispersed?

- What kind of services are there for sailors and do they meet the boating spatially?

Boating in Finland

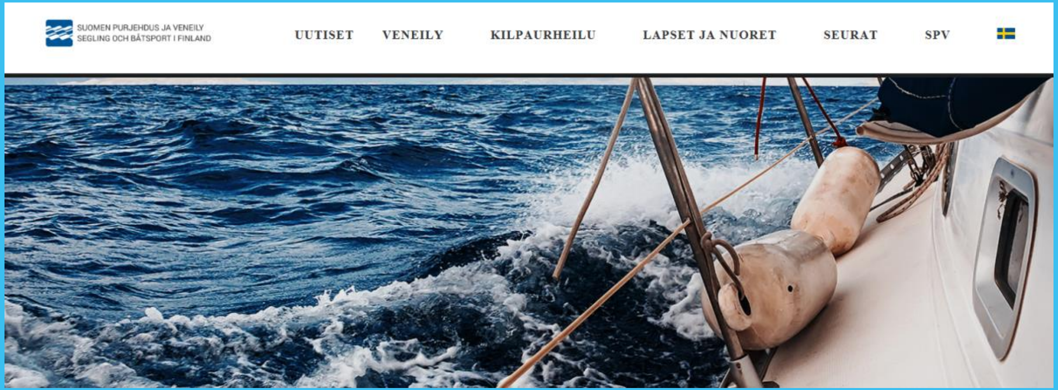
- Boating is a prevalent activity in Finnish waters
- Its related economy is significant
  - 627 mil € / year (Trafi, 2017)

The services available for boaters are important

- To the boating
- To the economy of the area

Suomen purjehdus ja veneily

Finnish Sailing and Boating Association



An umbrella organization for Finnish sailing and boating clubs

- 330 clubs
- 60 000 enthusiasts

http://spv.fi/

Essential and important services

1. Drinking water
2. Electricity
3. Food: Cafe, grocery store or kiosk, restaurant
4. Fuel
5. Septic tank emptying
6. Shower or sauna

- Barbeque grill
- Boat ramp
- Bus
- Dock
- Doctor
- Engine repair
- Ferry
- Info board
- Laundry
- Marina
- Marina forklift
- Medic First Aid
- Nature trail
- Pharmacy
- Playground
- Taxi
- Trash can
- WC

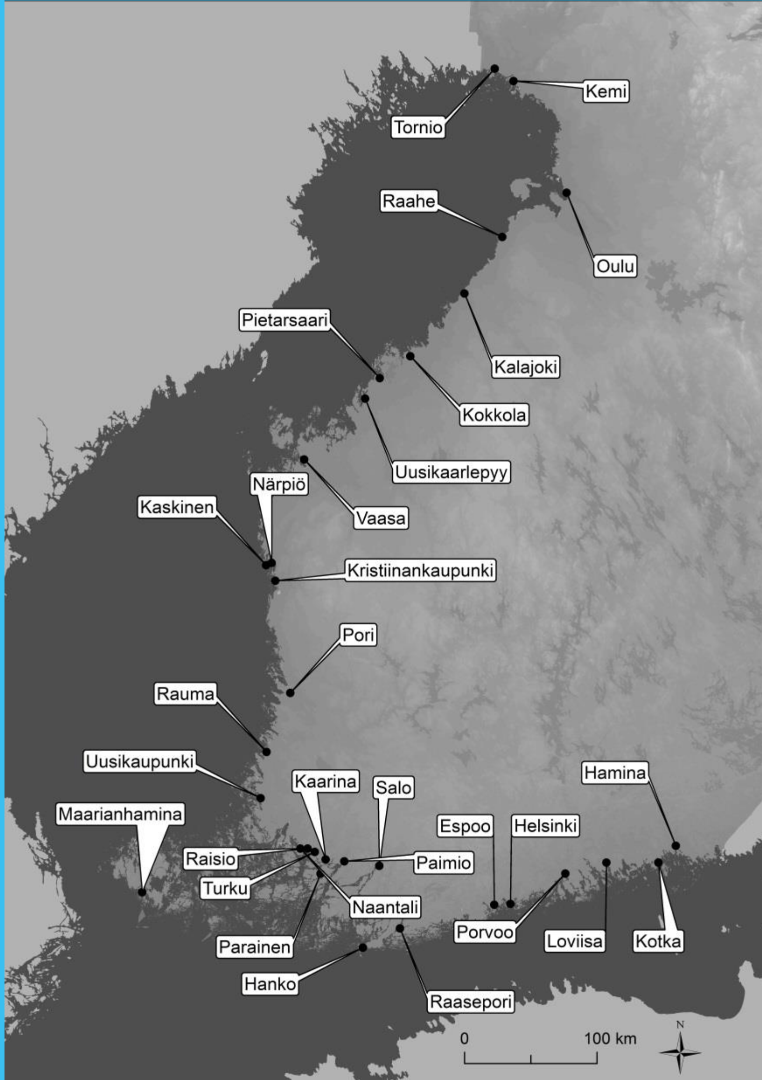
Other services

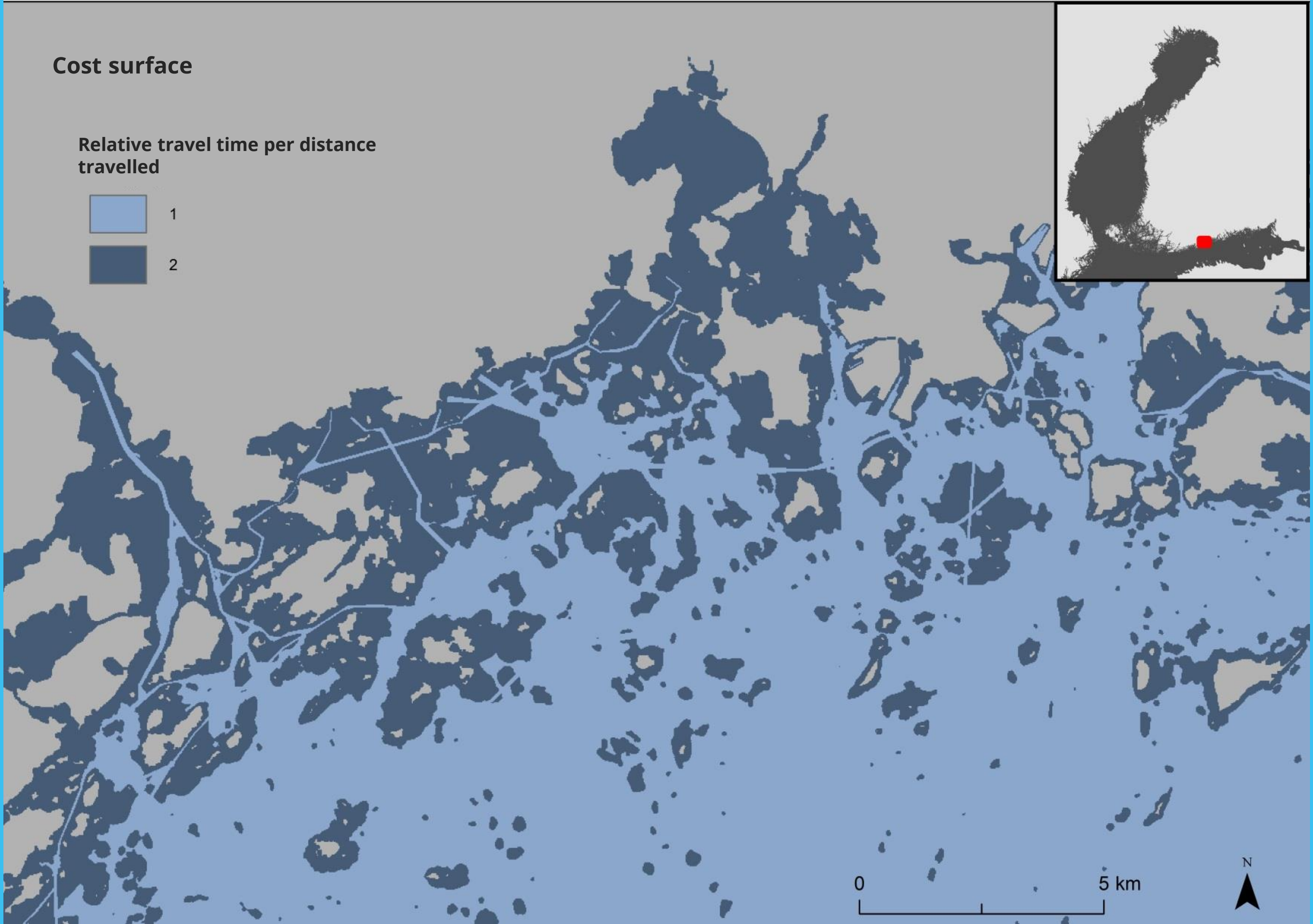
- Alko
- Veterinarian
- Dentist
- Entertainment
- Accommodation
- Other maintenance
- Other service
- Sightseeing
- Bank
- Post
- Market
- Beach

Distribution of boats

- SPV: 209 sailing clubs
  - 18 306 boats
- Cities
  - 27 212 boats
- Summer cottages
  - 59 832 boats

→ 105 350 boats




Cost surface
Relative travel time per distance travelled
1
2
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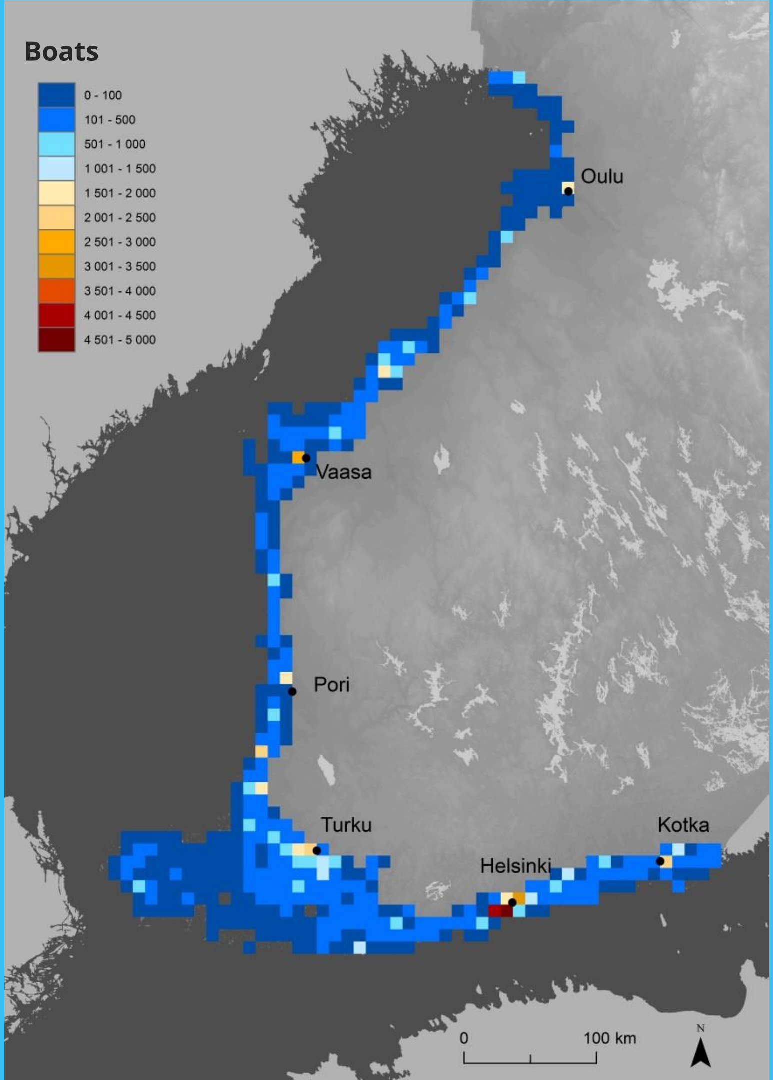
HOW ABOUT THE RESULTS?


Boats
0 - 100
101 - 500
501 - 1 000
1 001 - 1 500
1 501 - 2 000
2 001 - 2 500
2 501 - 3 000
3 001 - 3 500
3 501 - 4 000
4 001 - 4 500
4 501 - 5 000
Oulu
Vaasa
Pori
Turku
Helsinki
Kotka
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100 km
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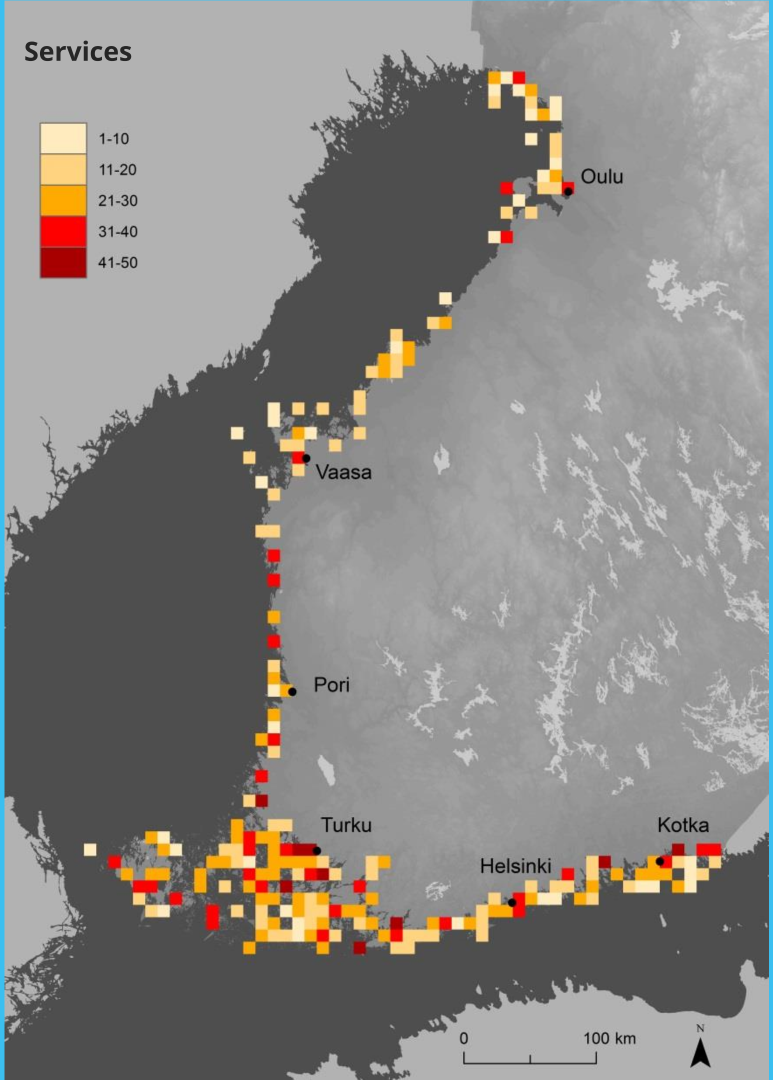
Services
1-10
11-20
21-30
31-40
41-50
Oulu
Vaasa
Pori
Turku
Helsinki
Kotka
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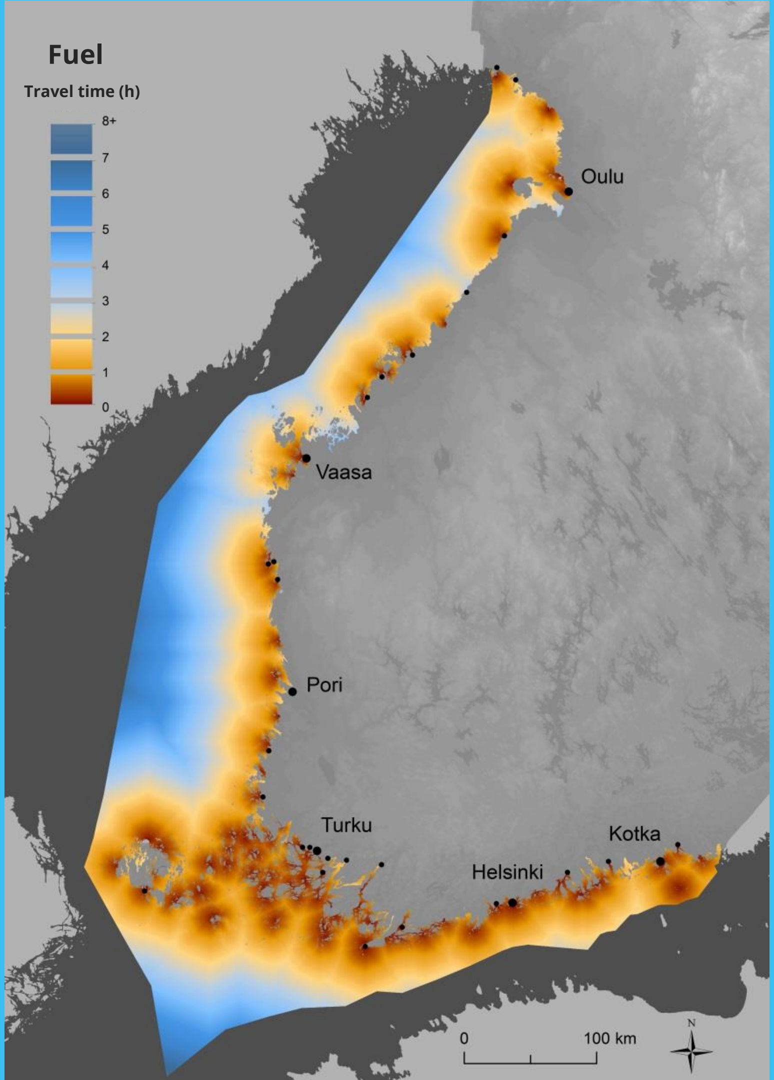
Fuel
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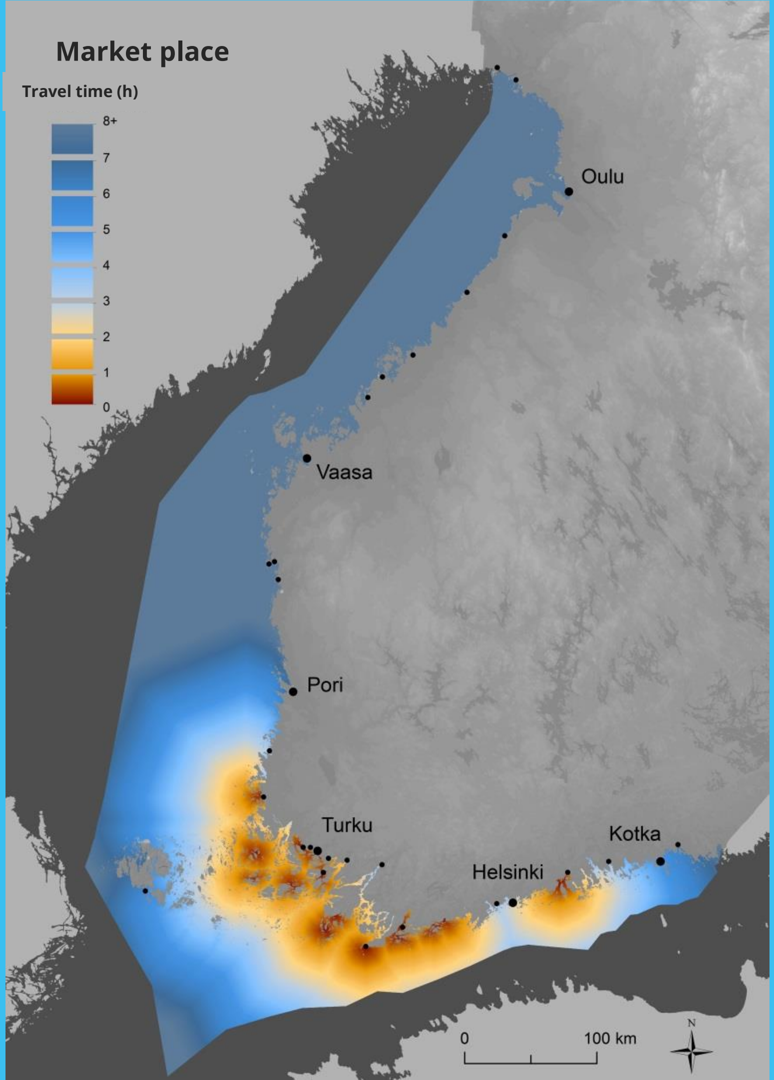
Market place
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Helsinki
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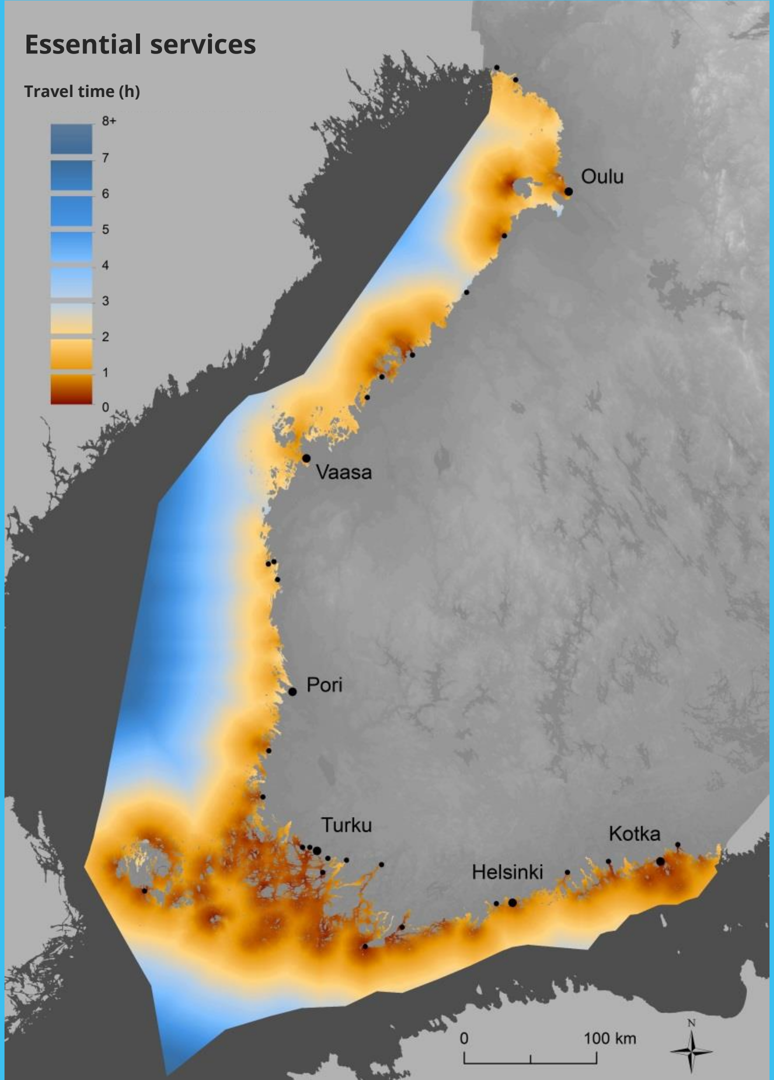
Essential services
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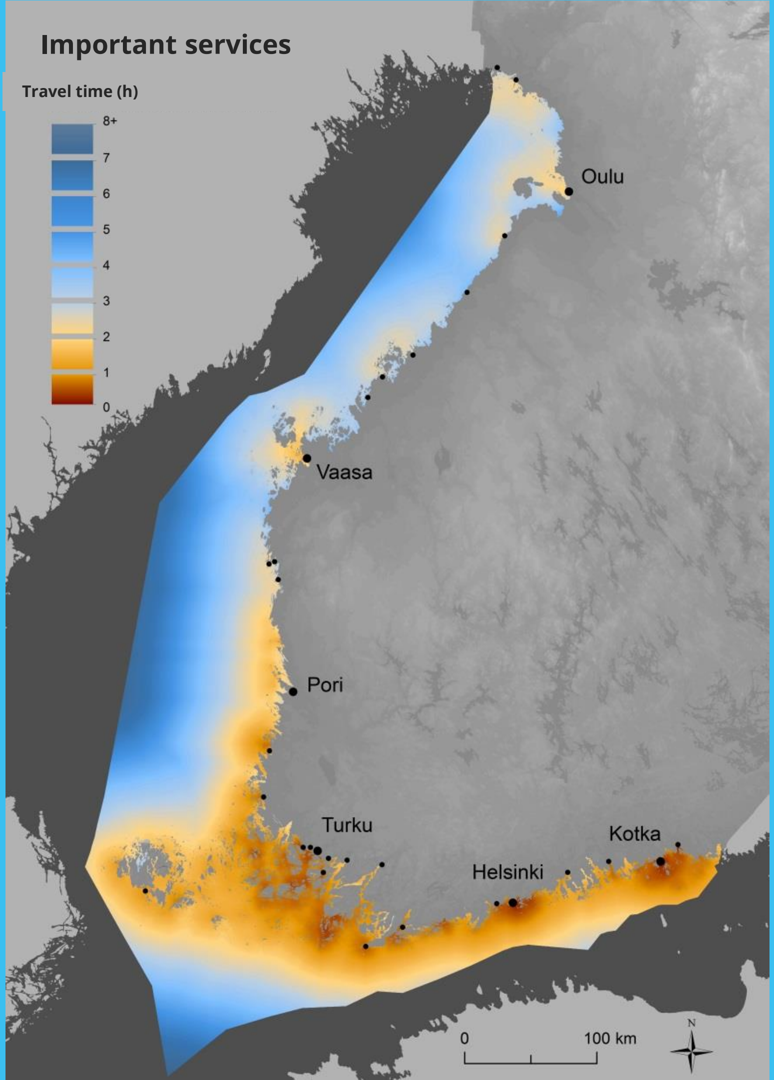
Important services
Travel time (h)
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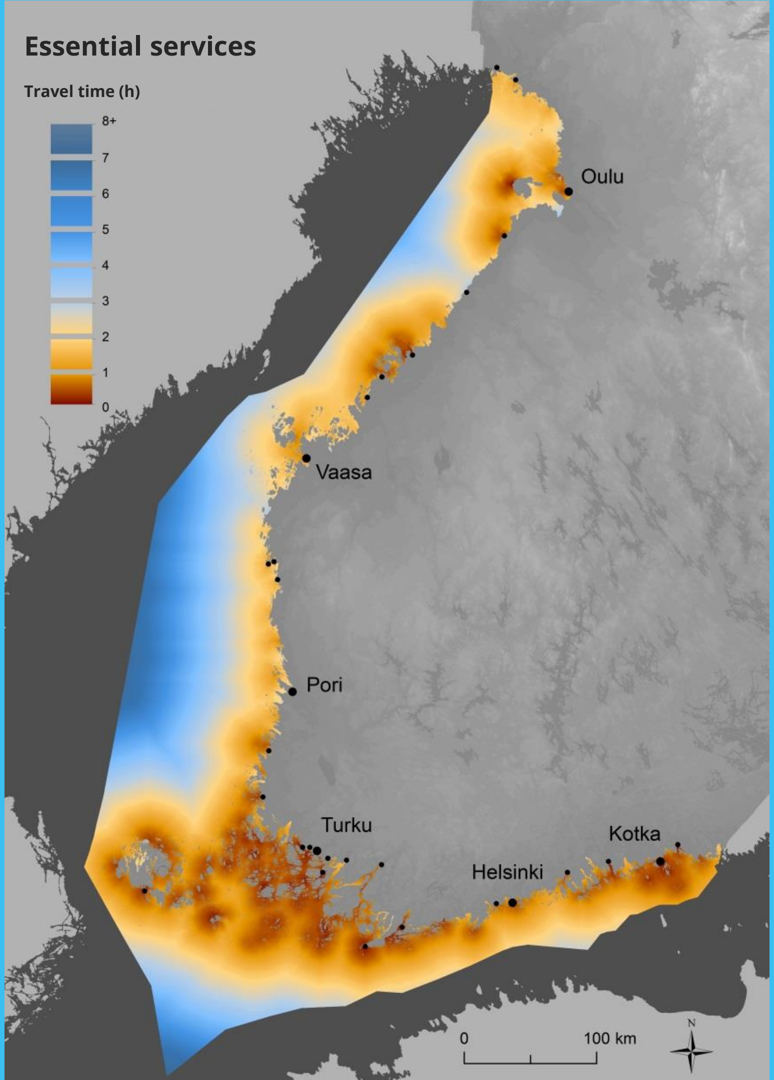
Essential services
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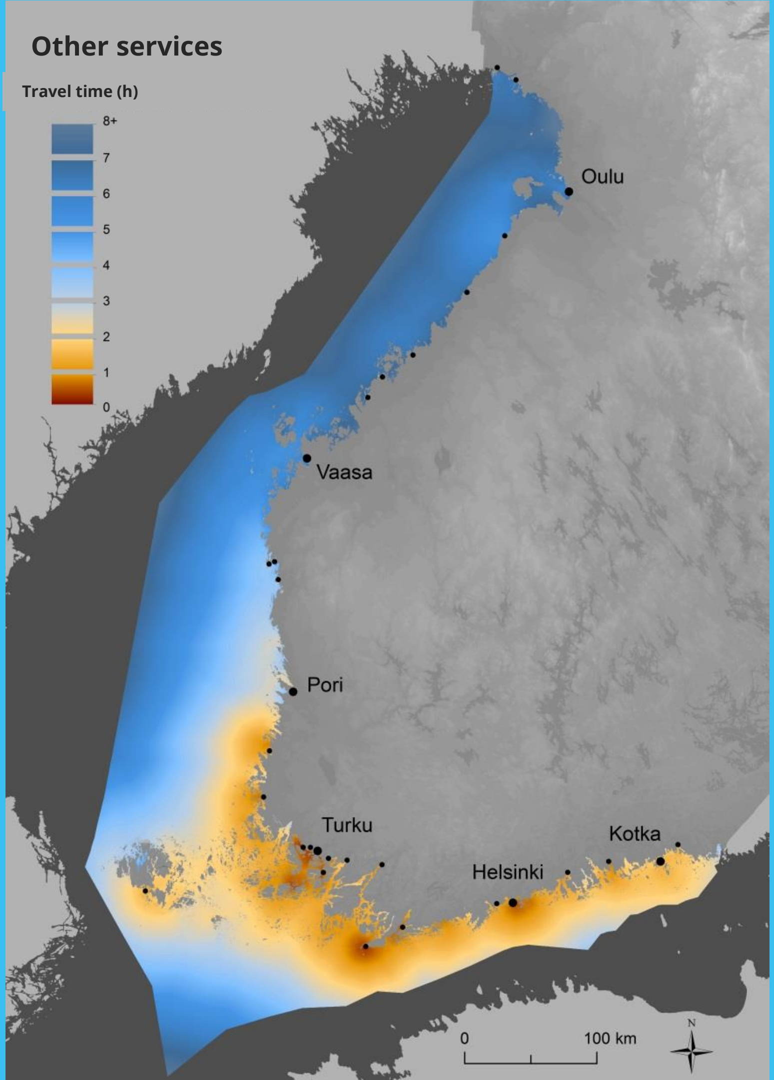
Other services
Travel time (h)
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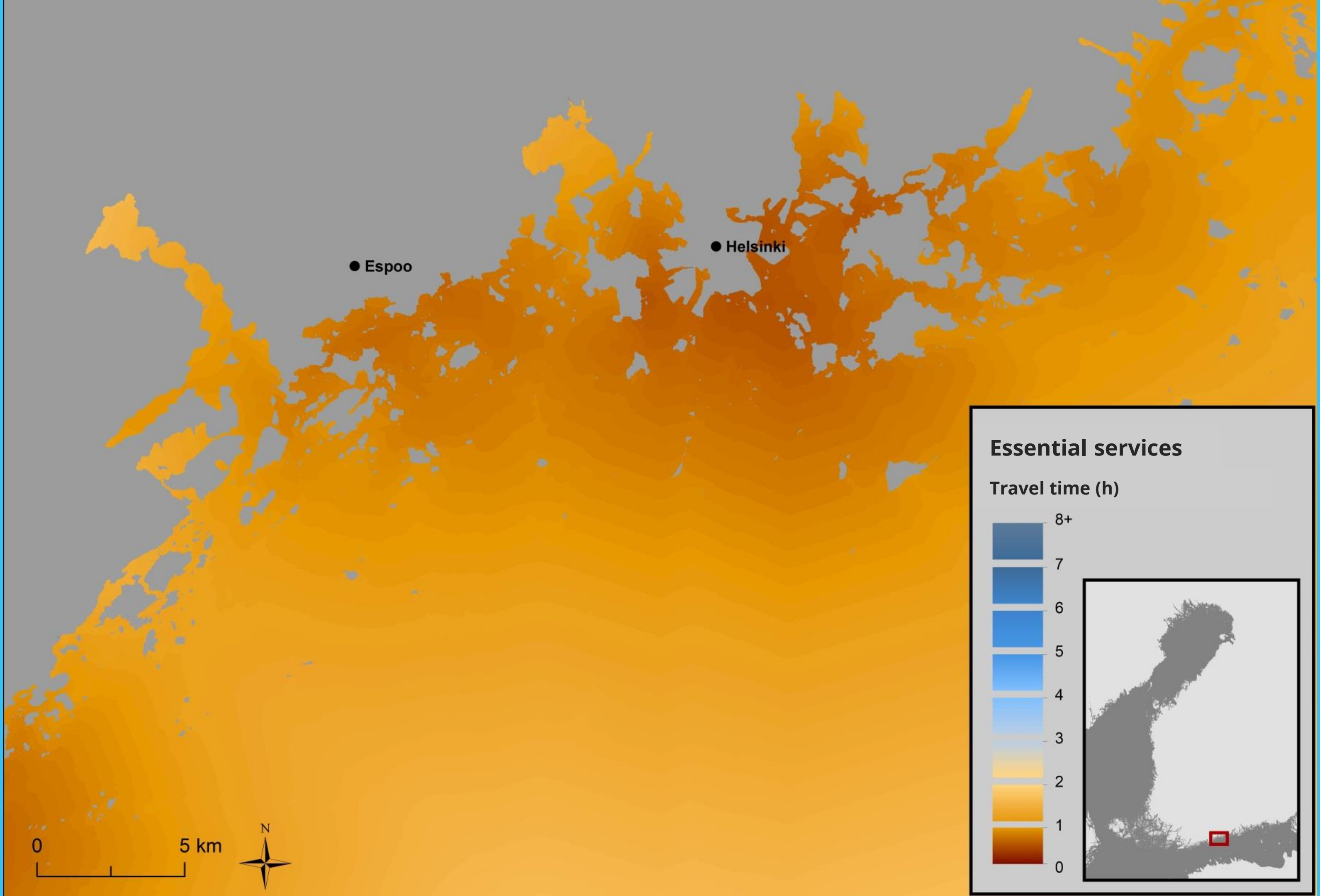
Espoo
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Essential services
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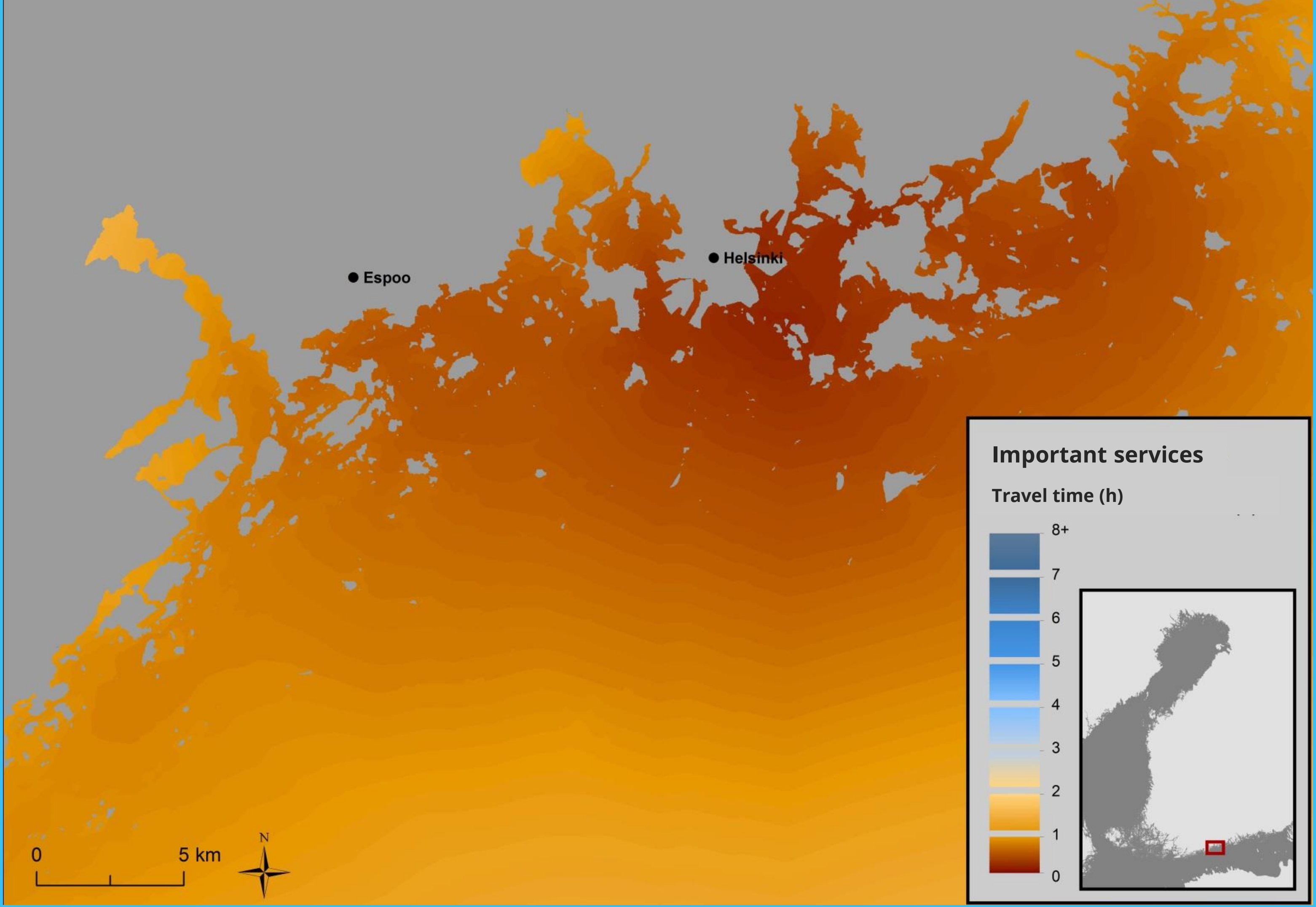

Espoo
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Important services
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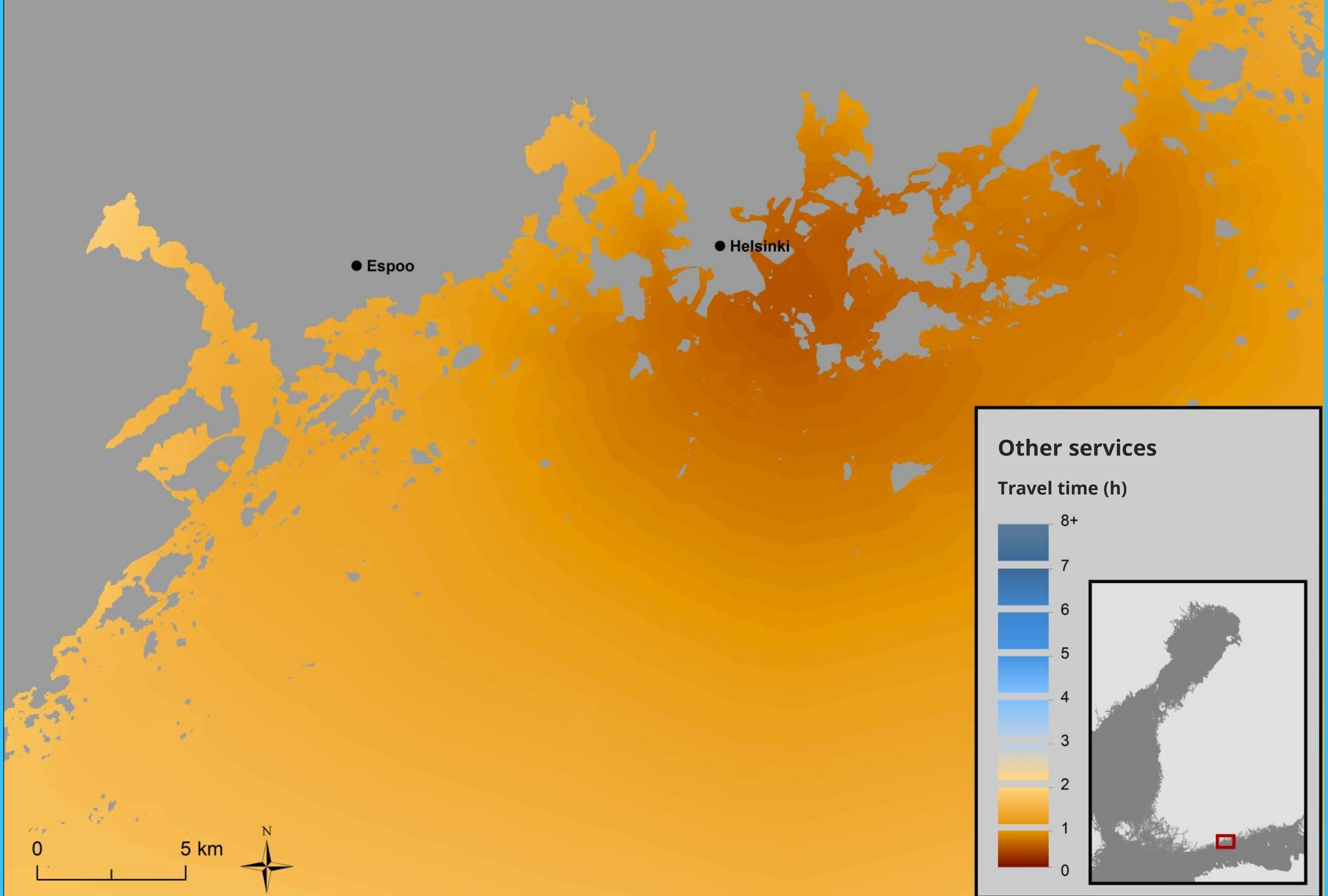

Espoo
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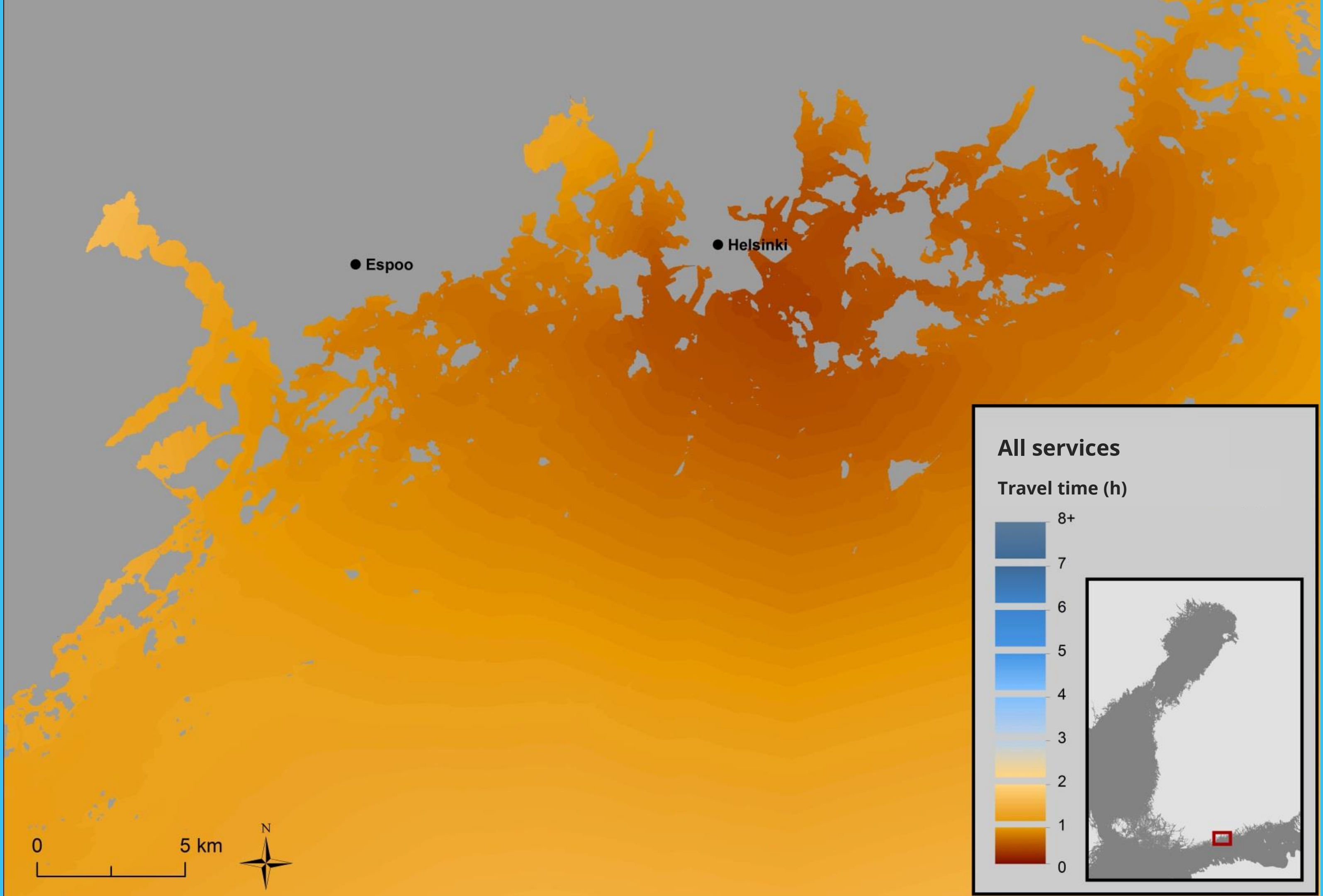

Espoo
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All services
Travel time (h)
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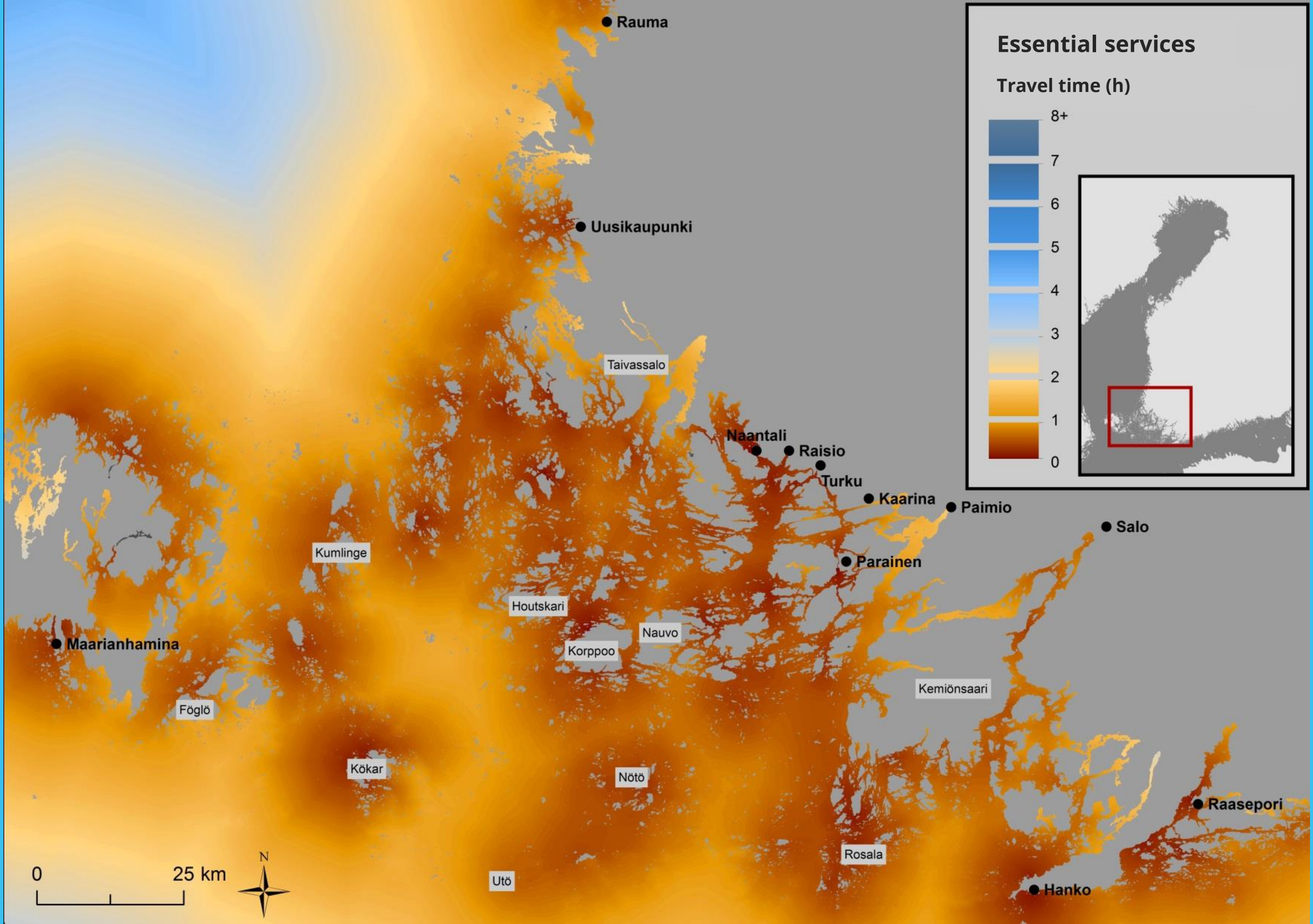
Essential services
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Rauma
Uusikaupunki
Taivassalo
Naantali
Raisio
Turku
Kaarina
Paimio
Salo
Parainen
Kumlinge
Houtskari
Nauvo
Korppoo
Maarianhamina
Kemiönsaari
Föglö
Kökar
Nötö
Raasepori
Rosala
Utö
Hanko
0
25 km
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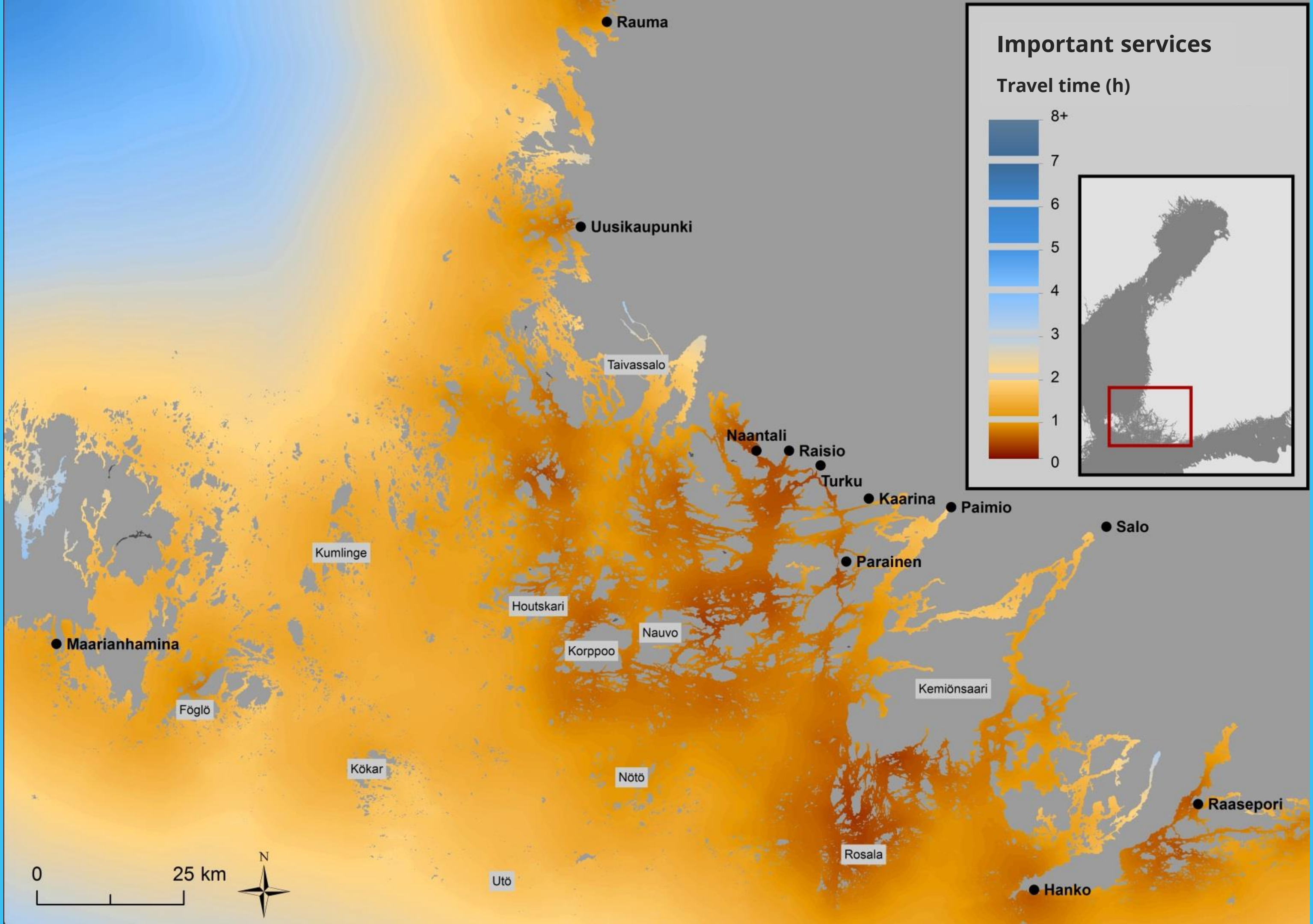
Important services
Travel time (h)
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Naantali
Raisio
Turku
Kaarina
Paimio
Salo
Parainen
Kumlinge
Houtskari
Nauvo
Korppoo
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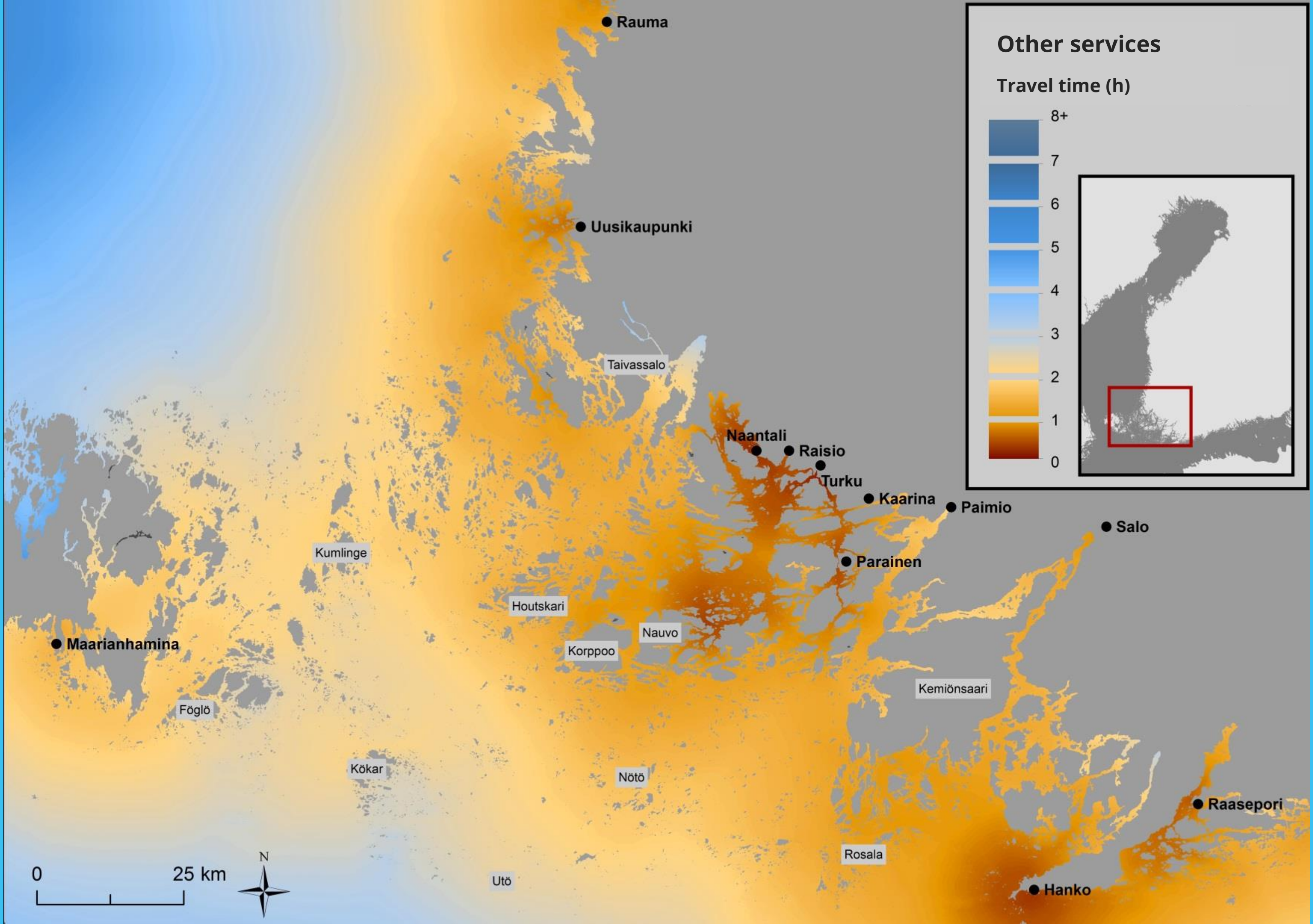
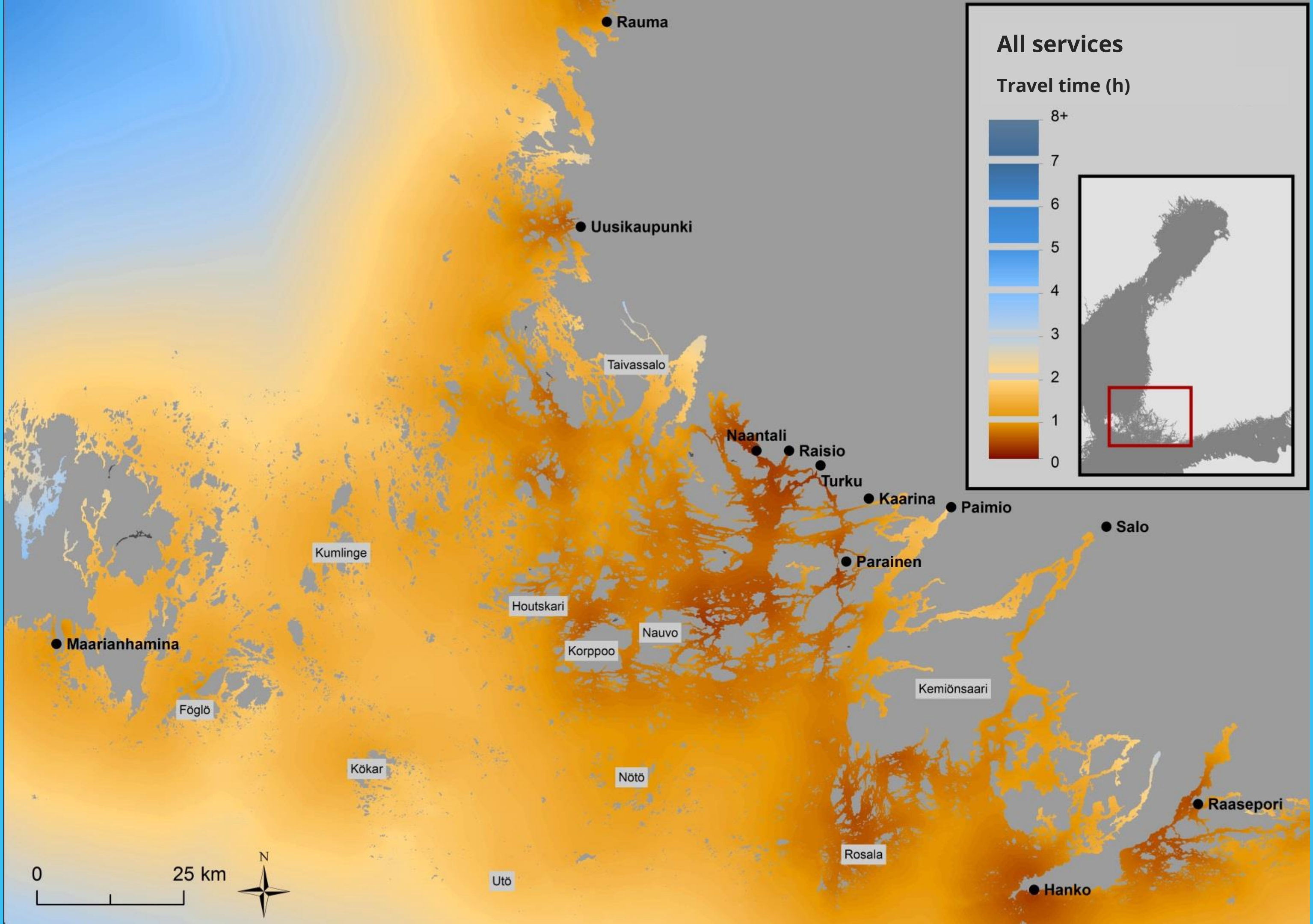


Other services
Travel time (h)
8+
7
6
5
4
3
2
1
0
Rauma
Uusikaupunki
Taivassalo
Naantali
Raisio
Turku
Kaarina
Paimio
Salo
Parainen
Kumlinge
Houtskari
Nauvo
Korppoo
Maarianhamina
Kemiönsaari
Föglö
Kökar
Nötö
Rosala
Raasepori
Hanko
Utö
0
25 km
N


All services
Travel time (h)
8+
7
6
5
4
3
2
1
0
Rauma
Uusikaupunki
Taivassalo
Naantali
Raisio
Turku
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Korppoo
Maarianhamina
Föglö
Kemiönsaari
Kökar
Nötö
Rosala
Raasepori
Hanko
Utö
0
25 km
N

Thank you!

Waltteri Niemelä
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&
Juho Lappalainen
juho.lappalainen@environment.fi

Finnish Environment Institute SYKE

http://smartsea.fmi.fi/ @SmartSeaProject

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–The Gulf of Finland Science Days 2017
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Estonian Academy of Sciences, Tallinn

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Gulf of Finland Co-operation

D. Burkov, A. Ivanchenko, A. Ivanchenko

Assessment of air pollution from transport vessels in Gulf of Finland

Admiral Makarov State University of Maritime and Inland Shipping

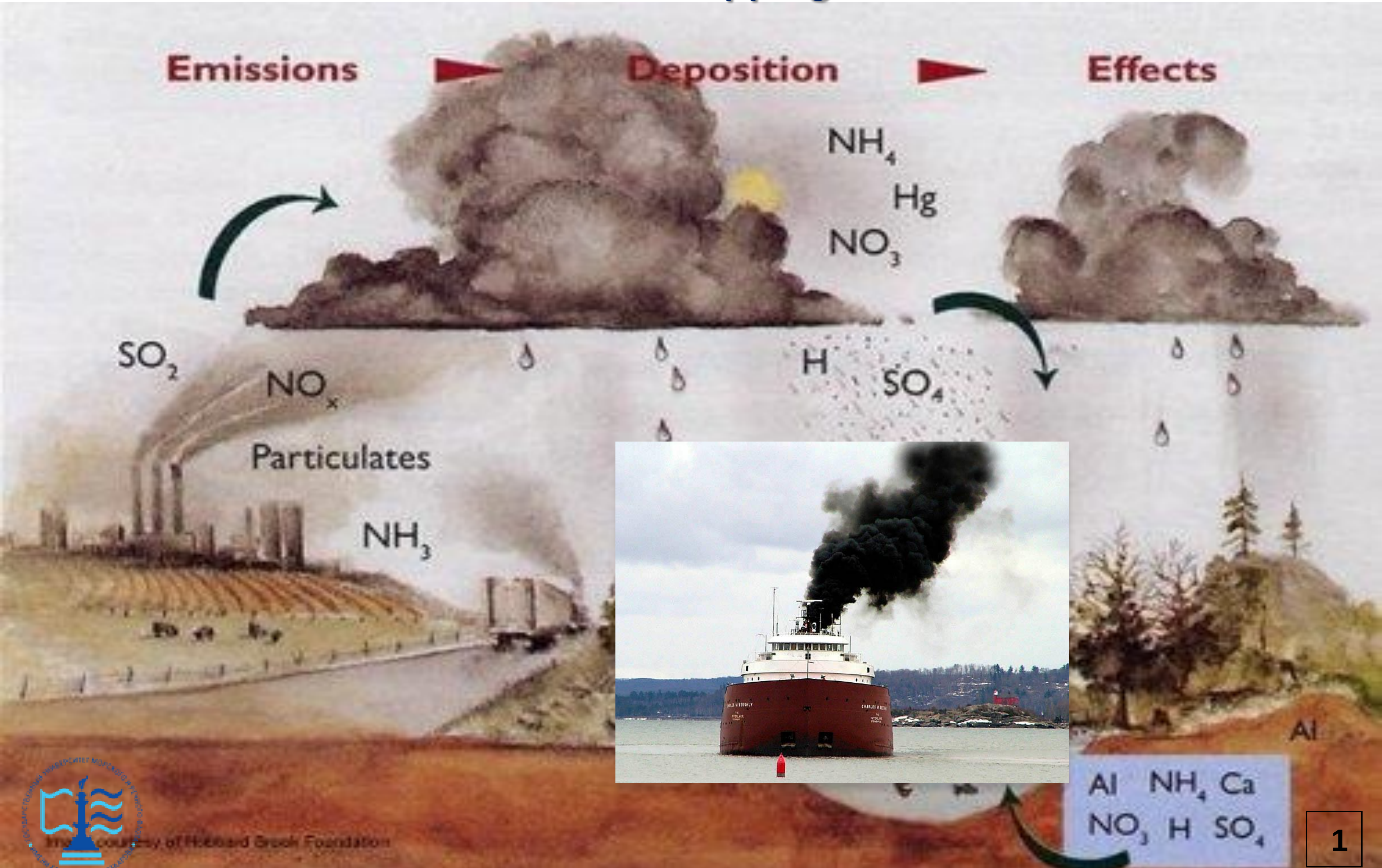
Assessment of air pollution from transport vessels in Gulf of Finland

Dmitriy Burkov, Alexandre Ivanchenko, Andrey Ivanchenko

BurkovDE@gumrf.ru

Gulf of Finland
Trilateral Scientific Forum
09.10 – 10.10 2017: Tallinn

The model for calculating the concentration of harmful impurities in the area of shipping traffic



$$C_i = \frac{Q_i}{\sqrt{2}\pi \times 2\sigma_z u f(\theta)} \left[\exp\left\{ -\frac{1}{2}\left(\frac{Z-H}{\sigma_z}\right)^2 \right\} + \exp\left\{ -\frac{1}{2}\left(\frac{Z+H}{\sigma_z}\right)^2 \right\} \right] \times$$

$$\times \left\{ erf\left| \left(\frac{Sin\theta\left(\frac{L}{2} - Y\right) - XCos\theta}{\sqrt{2} \times \sigma_y} \right) \right| + erf\left| \left(\frac{Sin\theta\left(\frac{L}{2} + Y\right) + XCos\theta}{\sqrt{2} \times \sigma_y} \right) \right| \right\}$$

$Q_i = N \sum \frac{N_i}{N} q_i$ - the emission power of the i-th harmful substance mg / m.

N - is the number of vessels;

Ni - number of vessels of individual projects;

qi *- specific emission of harmful substances vessel mg / m;*

V - wind speed, m / sec;

θ- angle between the direction of the wind and the channel;

H - height of the exhaust pipe, m;

L - length of the channel, m;

x; y; z - independent coordinates across the fairway, along the fairway and in the vertical direction, respectively;

$\sigma_Z = \left[a + b\frac{X}{f(\theta)} \right]^C$ - standard deviation in *z* direction; $\sigma_Y = \frac{X}{d + lf(\theta)}$ - standard deviation in *y* direction

erf - probability interval.

The method of investigation of harmful substances from diesel ships standing in ports of the MGO Voeikov

$$C_i = \frac{A_{mn} M F_{\eta}}{H^2} \sqrt[3]{\frac{N}{V_i \Delta T}}$$

where:

A - coefficient of temperature stratification of the atmosphere under unfavorable meteorological conditions;

M - total pollutant emission, g / s;

H - height of exhaust pipe, m;

Vi - the volume of exhaust gases from each source (pipe), m3 / s;

T - temperature difference between gases and atmosphere air, o C;

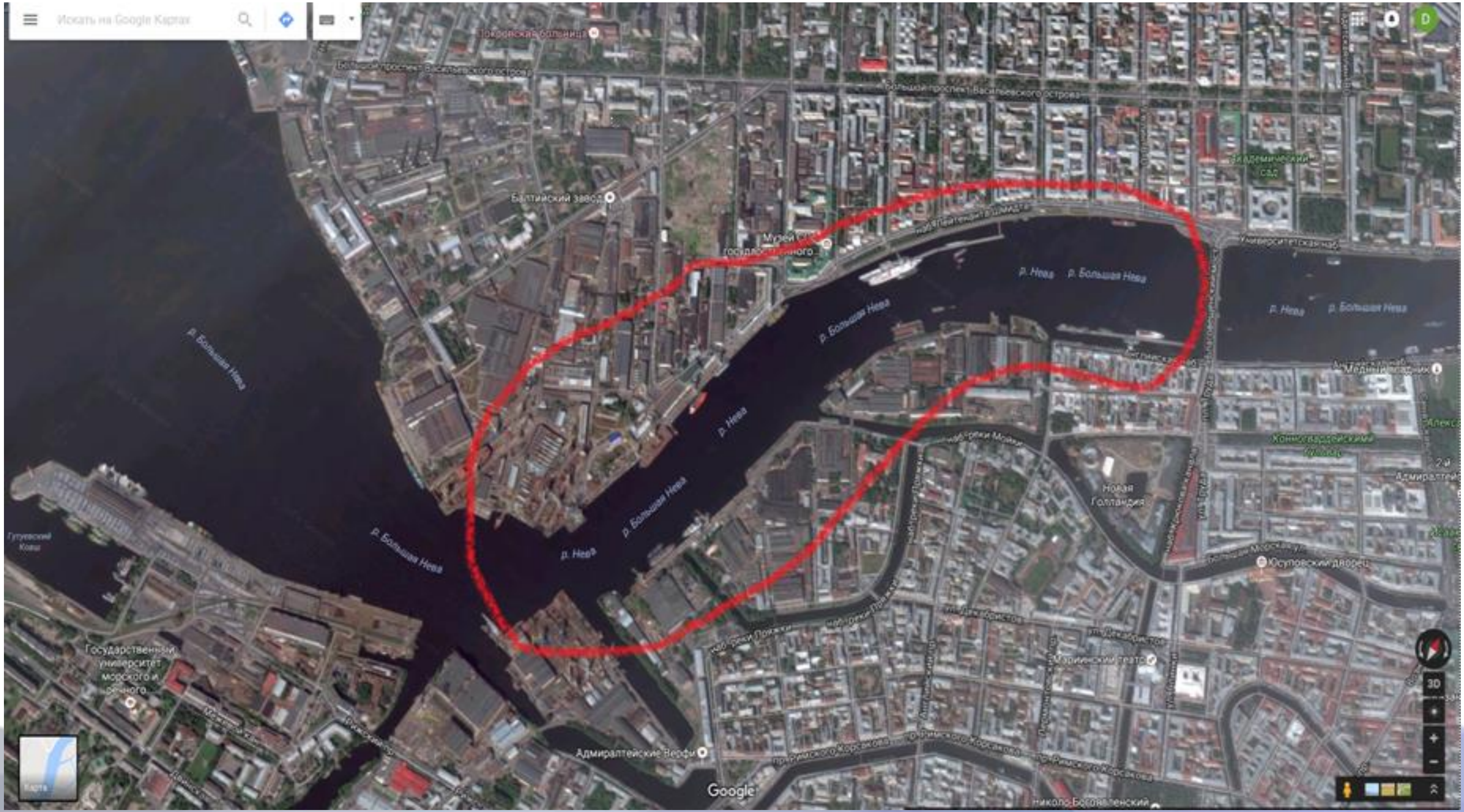
m and ***n*** are dimensionless coefficients, depending on the rate of gas escape from the exhaust pipe;

F - is a dimensionless coefficient that takes into account the deposition rate of solid particles;

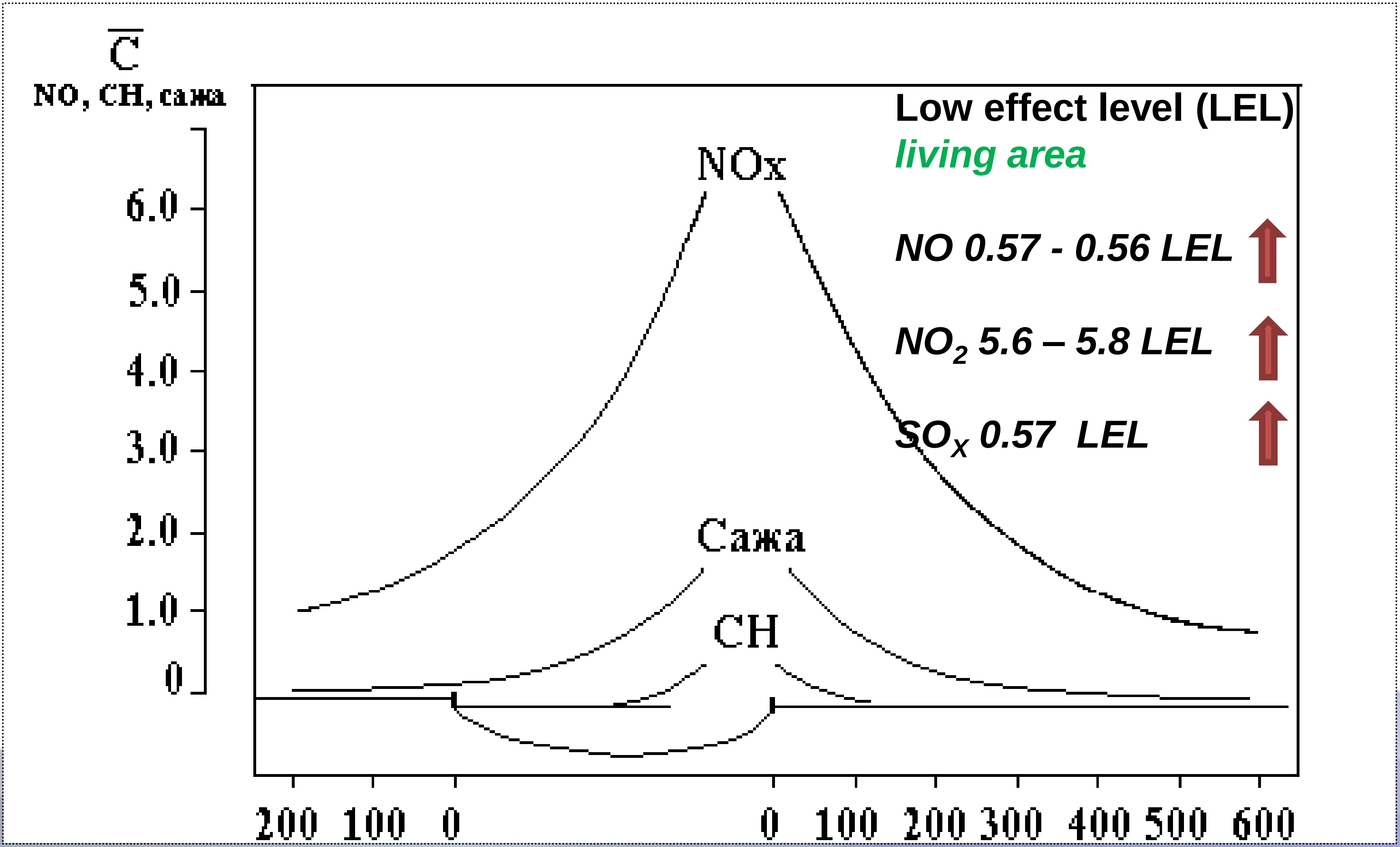
N - number of exhaust pipe;

n - dimensionless coefficient that takes into account the influence of terrain.

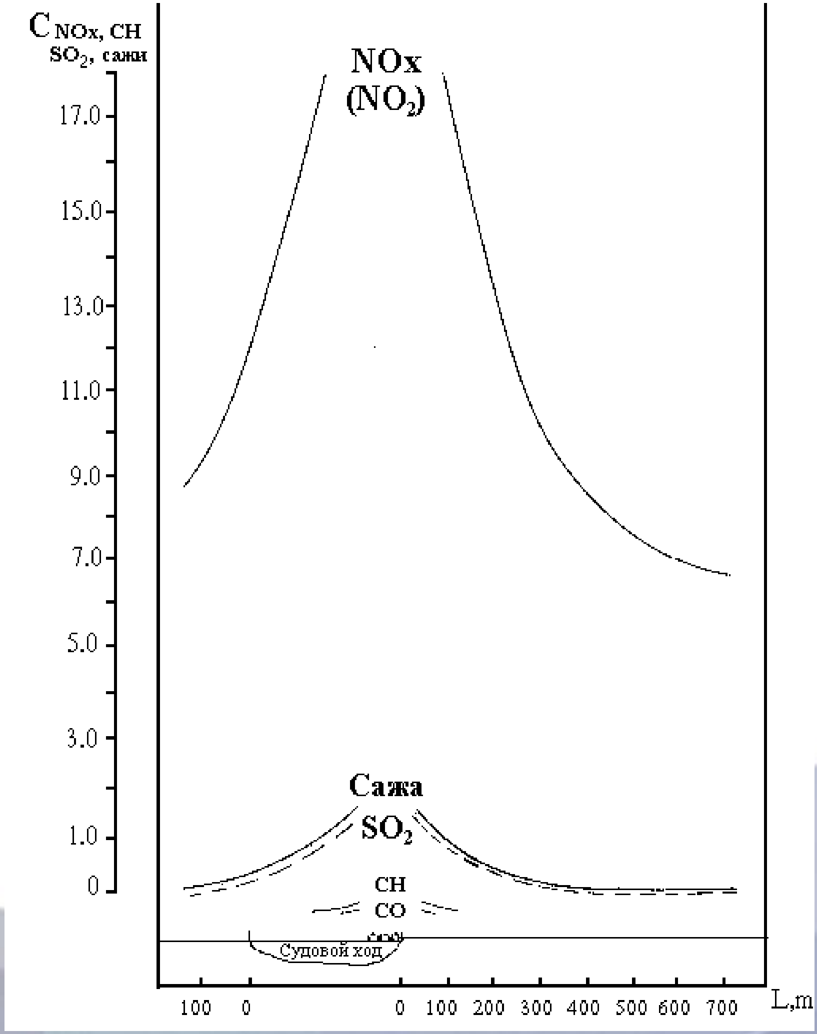
Scheme for investigating area



Changing concentrations of NOx, soot or CH in the atmosphere at the main engines stopped and the most adverse weather conditions



Changes concentrations of NOx, CH, CO, SO2 and soot in the atmosphere in the port area



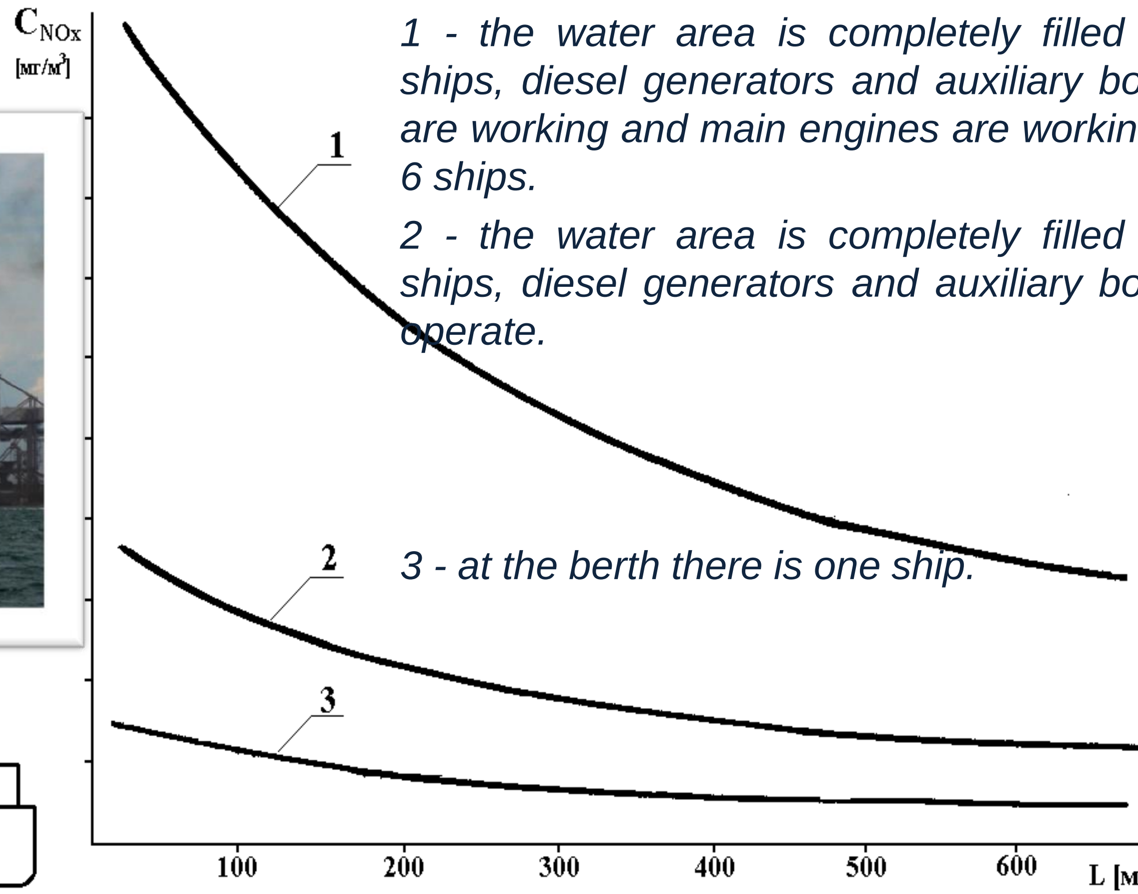
Low effect level (LEL)
work area

NO 0.01 - 0.03 LEL ↑

NO_2 0.05 – 0.06 LEL ↑

SO_X 0.17 LEL ↑

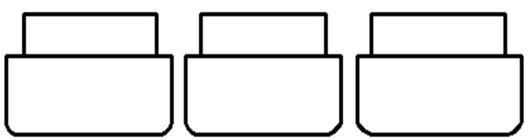
Calculation of surface concentrations of NOx for various filling of the water area by ships



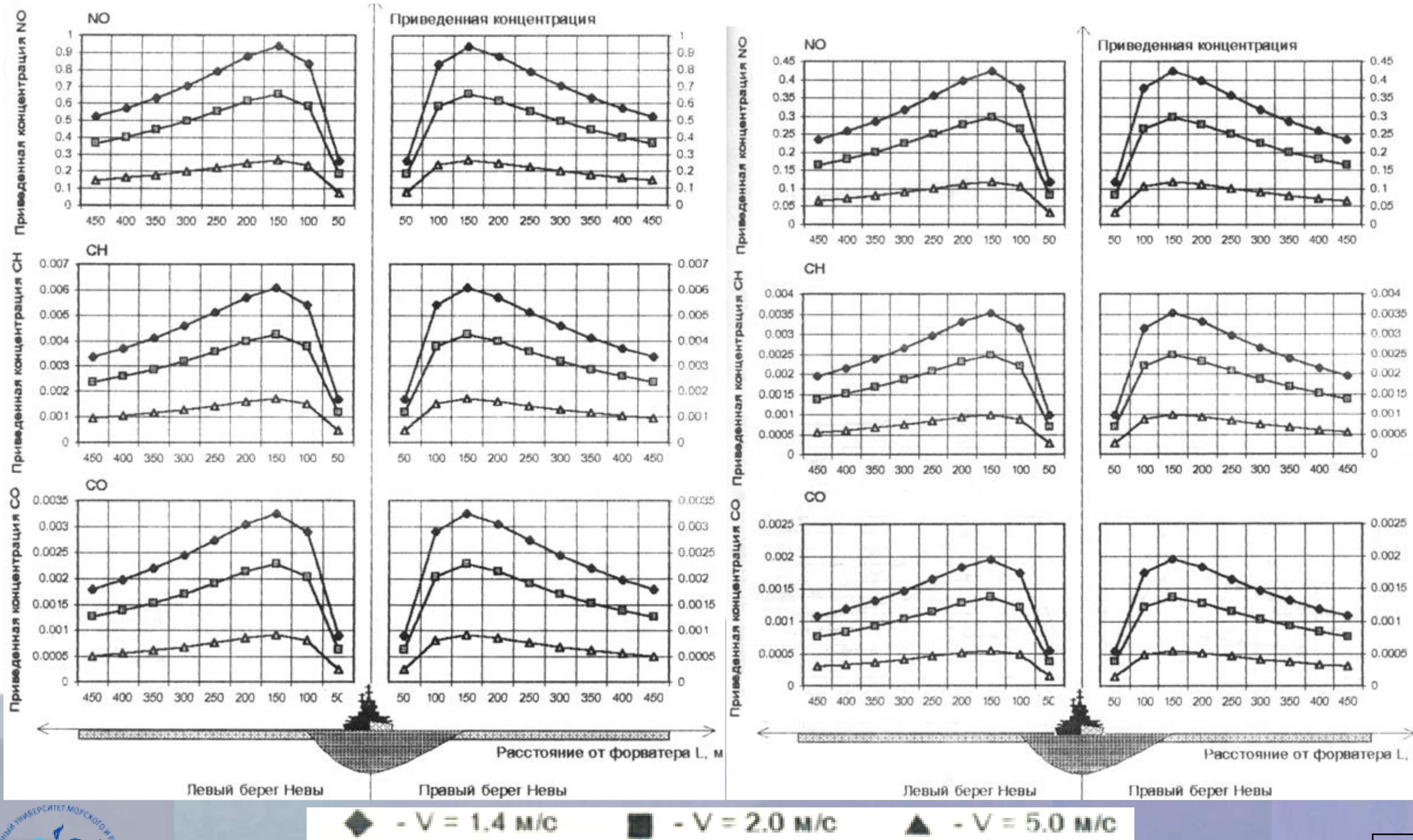
1 - the water area is completely filled with ships, diesel generators and auxiliary boilers are working and main engines are working on 6 ships.

2 - the water area is completely filled with ships, diesel generators and auxiliary boilers operate.

3 - at the berth there is one ship.



The change concentration of harmful substances in the atmosphere at different wind speeds



CONCLUSION:

1. The materials show that by regulating the filling of the water area by ships, it is possible to provide the required quality of the atmosphere in the port area.

2. Problems of improving the design of ship power plants, improving the environmental performance of engines, remain relevant for all types of vessels.

3. Questions of objective environmental impact assessment of ship fairways and vessel traffic management are very important.

Thank you for attention !

greenport.com

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Gulf of Finland Co-operation

A. Tronin

Nitrogen dioxide over the Gulf of Finland

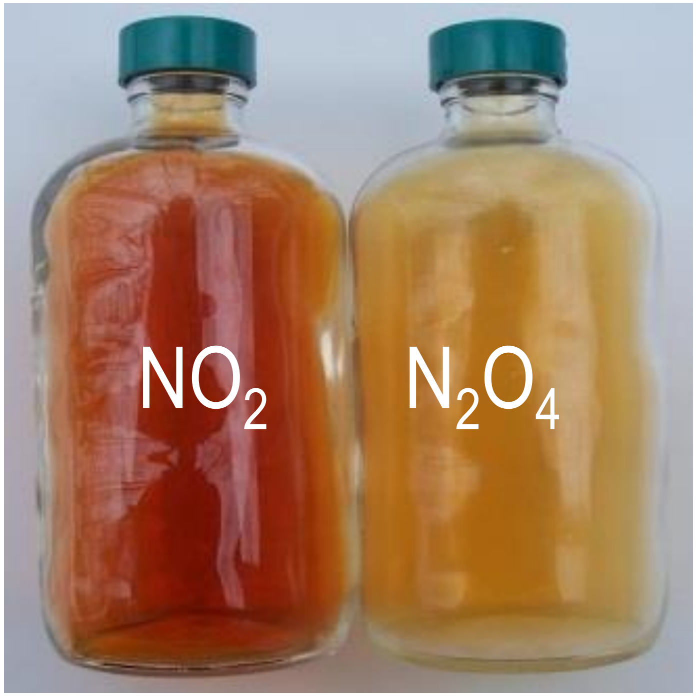
Saint-Petersburg Scientific-Research Centre for Ecological Safety
Russian Academy of Sciences

NITROGEN DIOXIDE OVER THE GULF OF FINLAND

Andrei Tronin

Korpusnaya st., 18, Saint-Petersburg, 197110
E-mail: a.a.tronin@ecosafety-spb.ru

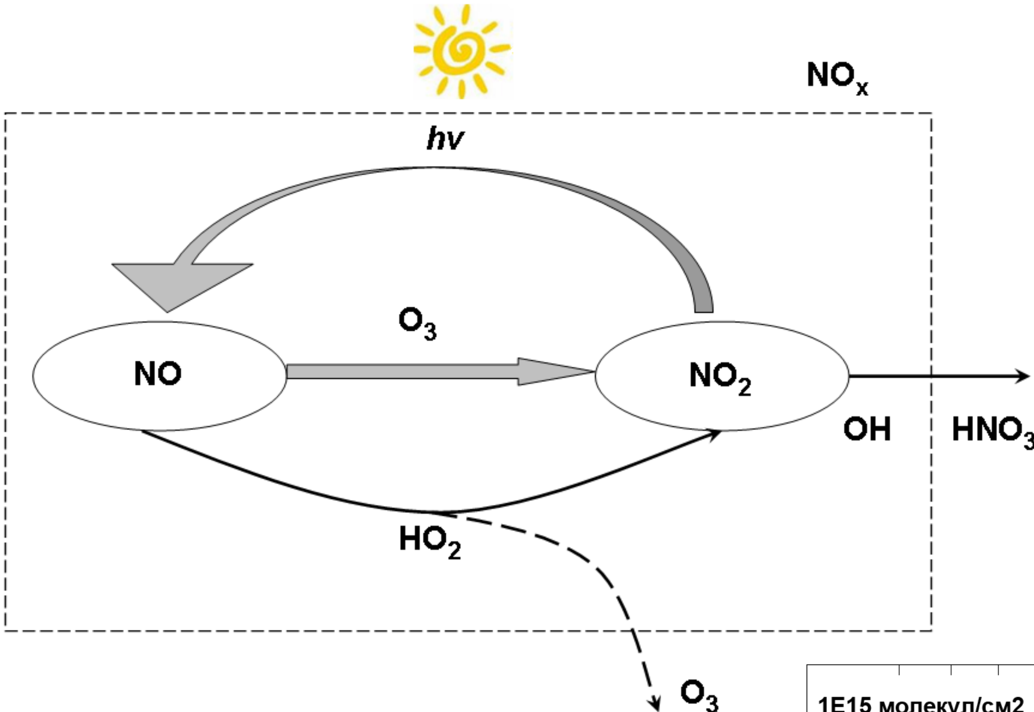
View to St-Petersburg from the Gulf



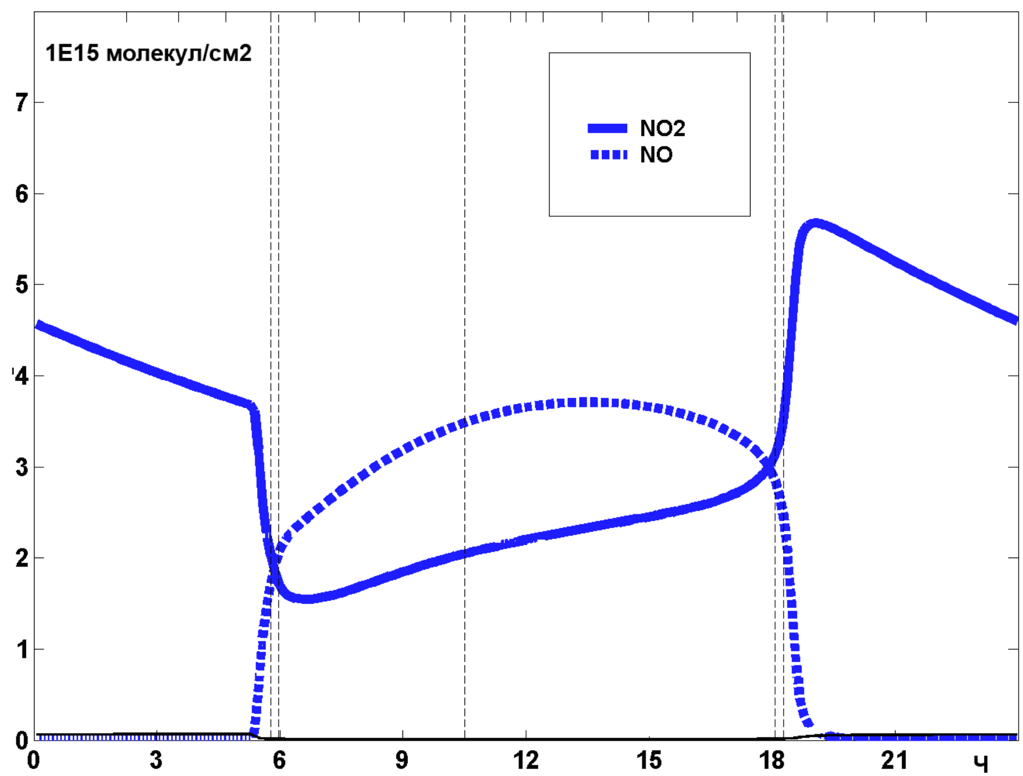
NO_2 — nitrogen dioxide

Extremely hazardous substance in the US
Directives regulating ambient air quality – EU
2nd class danger in Russia

Average concentration in atmosphere	**0.4–9.4 µg/m3 in nature** **20–90 µg/m3 in cities**
The threshold limit value(daily average)	**40 µg/m3**

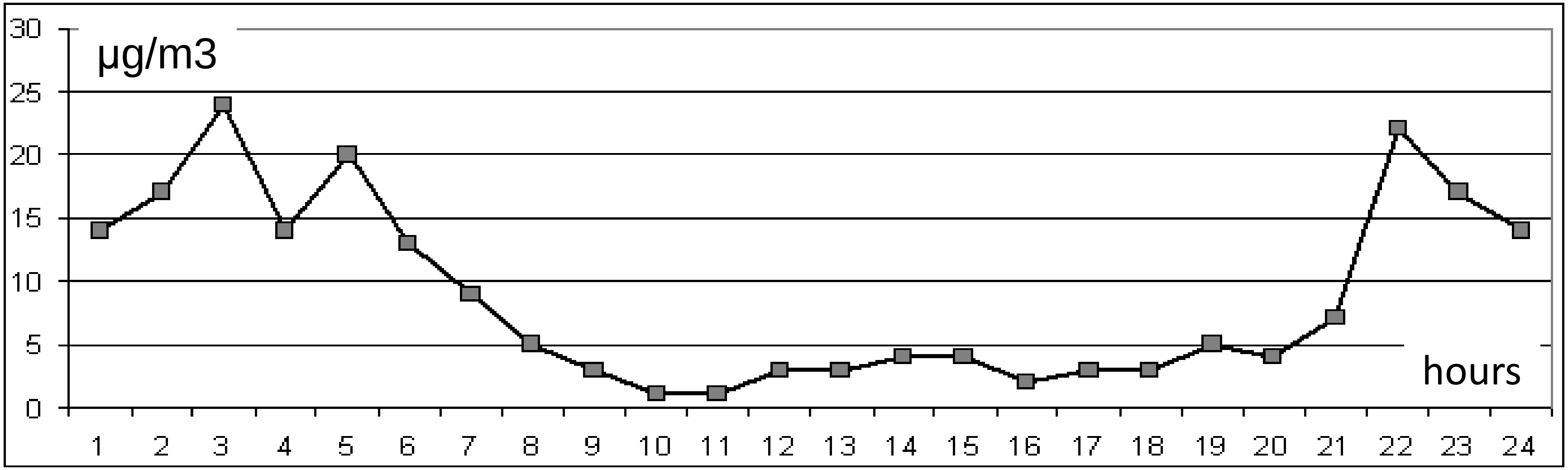


Transformation cycle of NOx in atmosphere

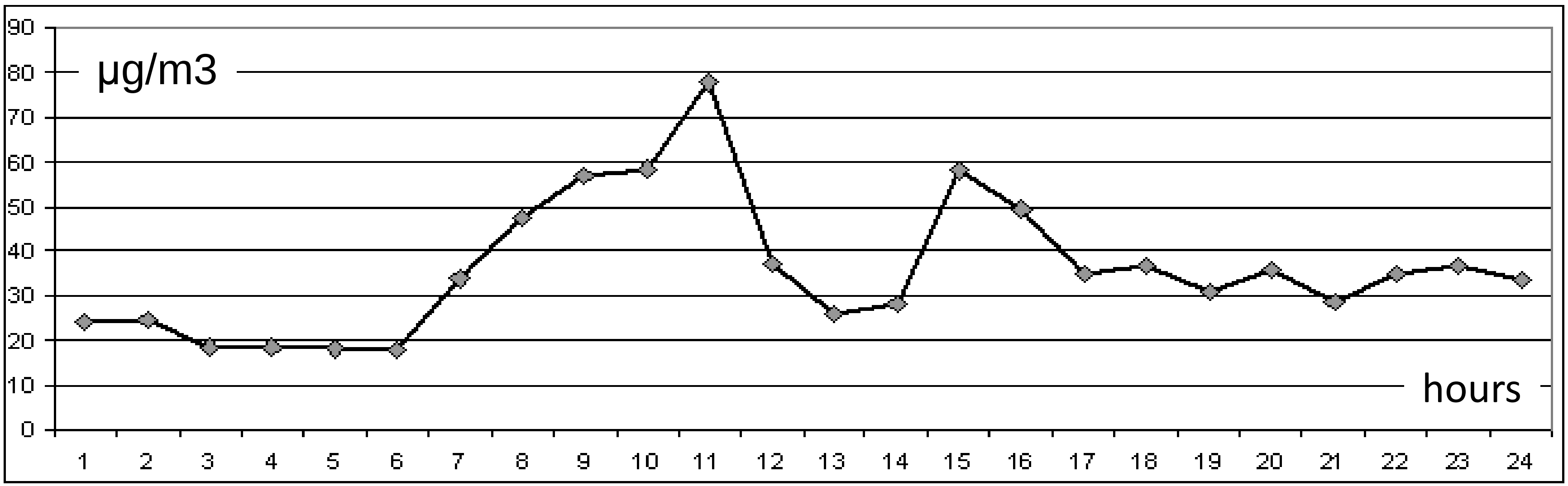


Model of NOx concentration in transformation cycle of NOx in temperate latitudes atmosphere

[Envisat Validation Workshop...]

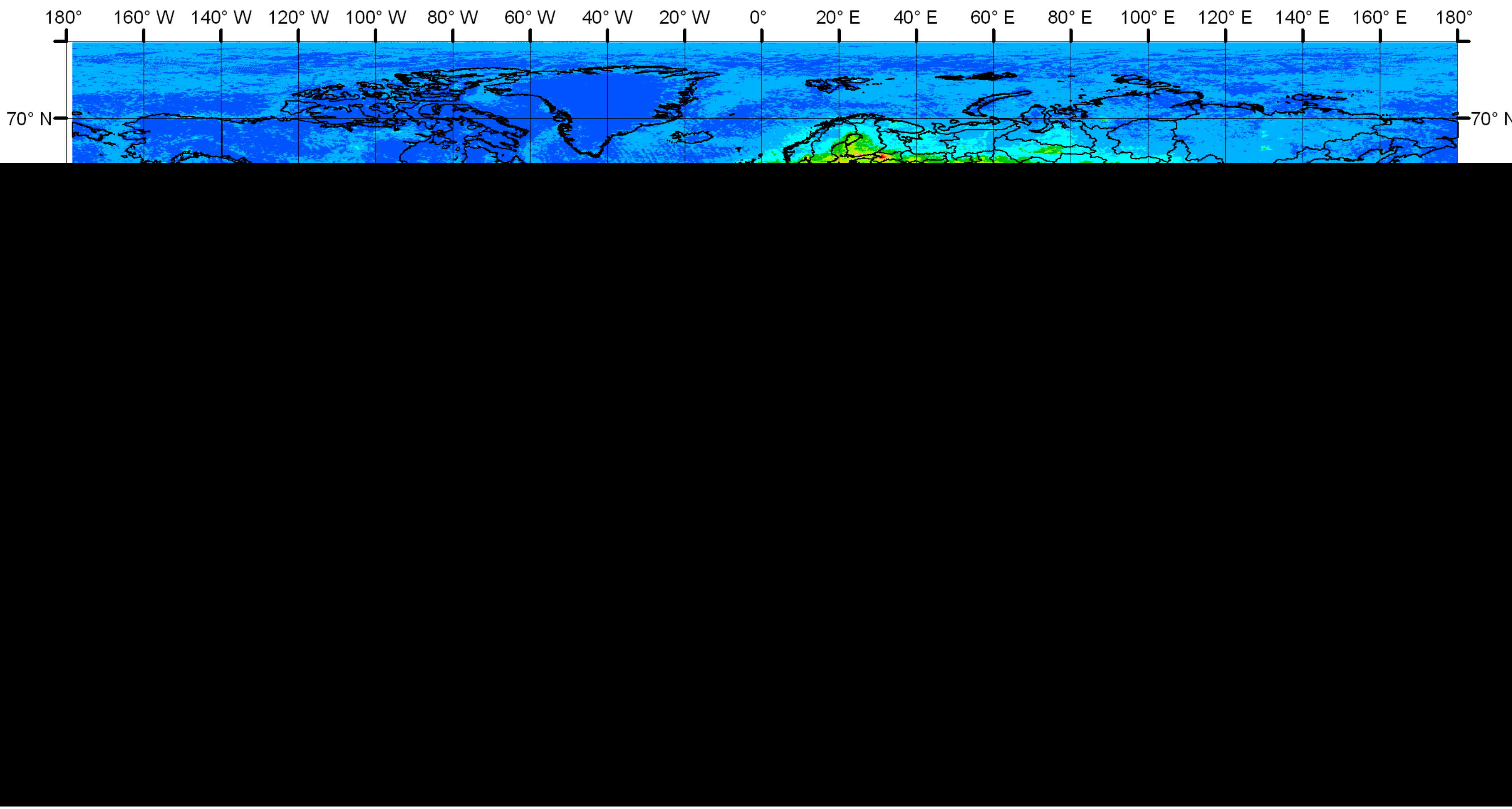


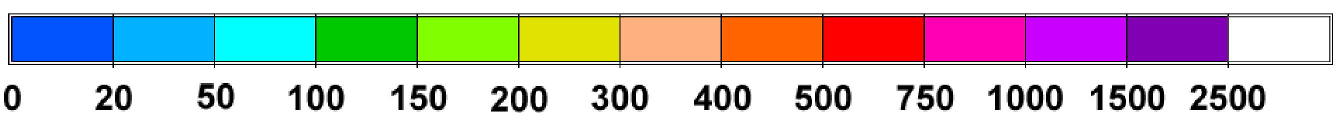
NO2 measurements on Lauritsa station (Lappeenranta, Finland) 2.08.2009 (Sunday). http://www.ilmanlaatu.fi/



NO2 measurements on Mannerheimintie (Helsinki, Finland) 5.08.2009 (Wednesday). http://www.ilmanlaatu.fi/

Year average gas content in 2007



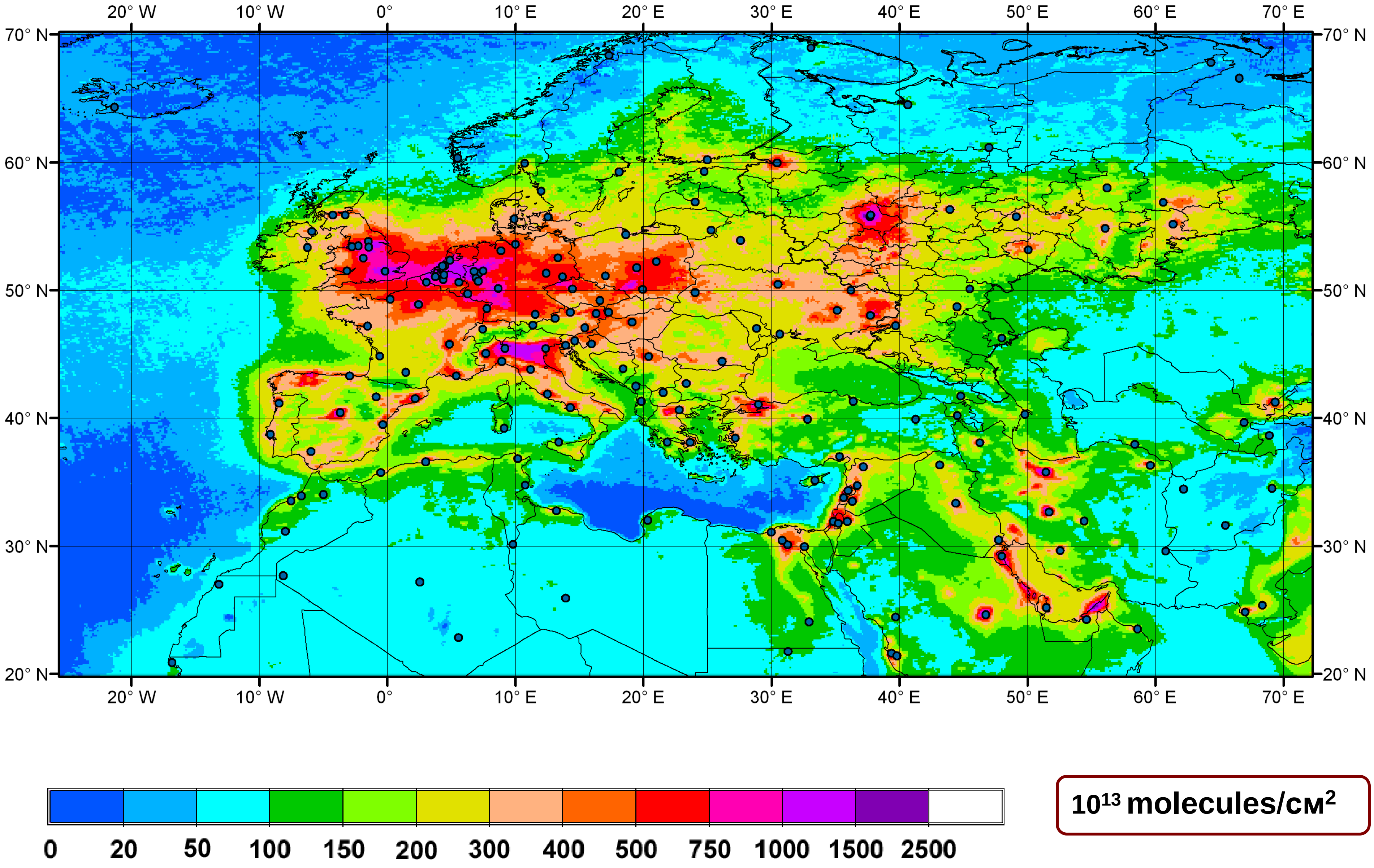


10^{13} molecules/cм^2

OMI

NO2

Year average gas content in 2007

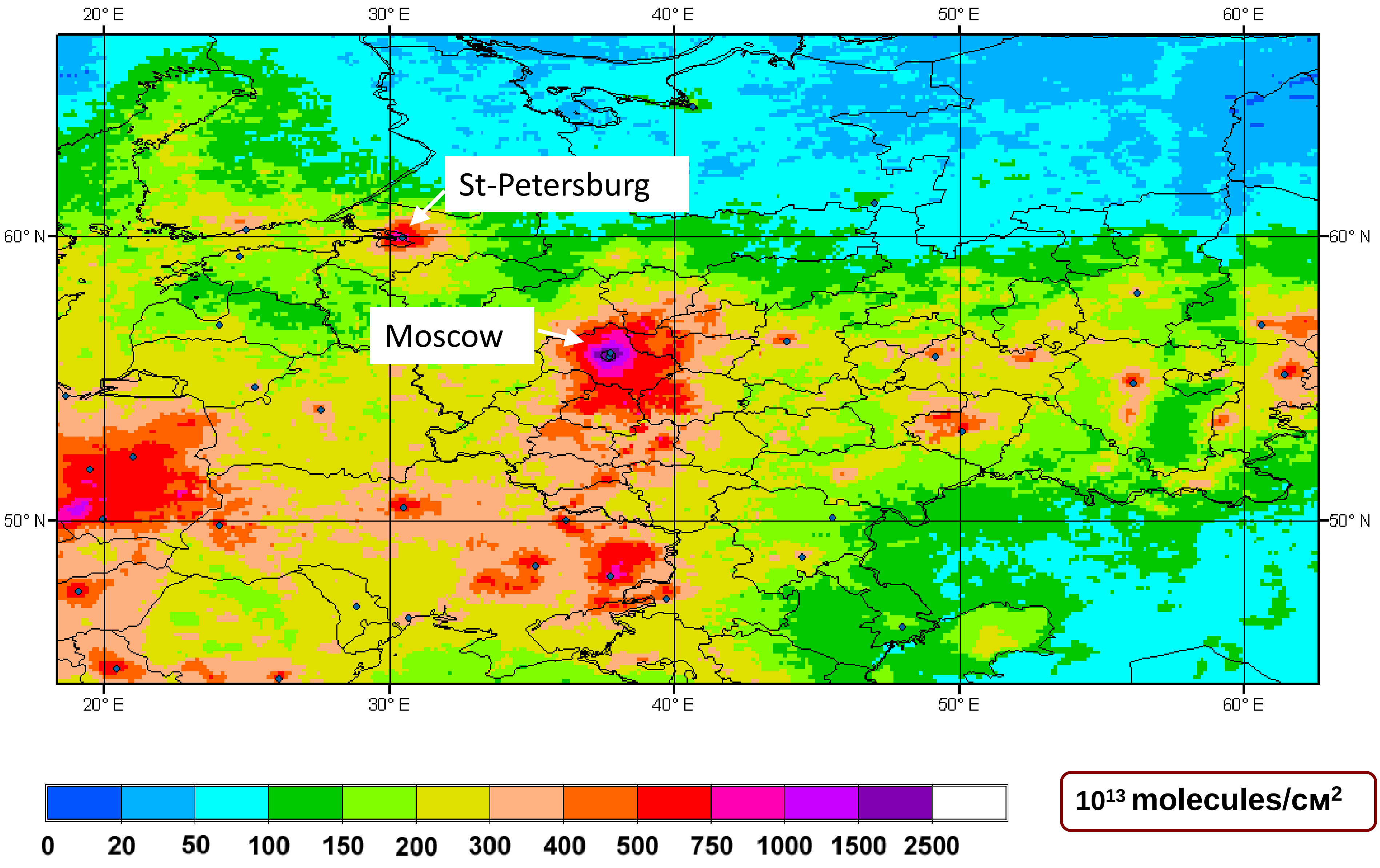


10^{13} molecules/cм^2

OMI

NO2

Year average gas content in 2007, Western part of Russia

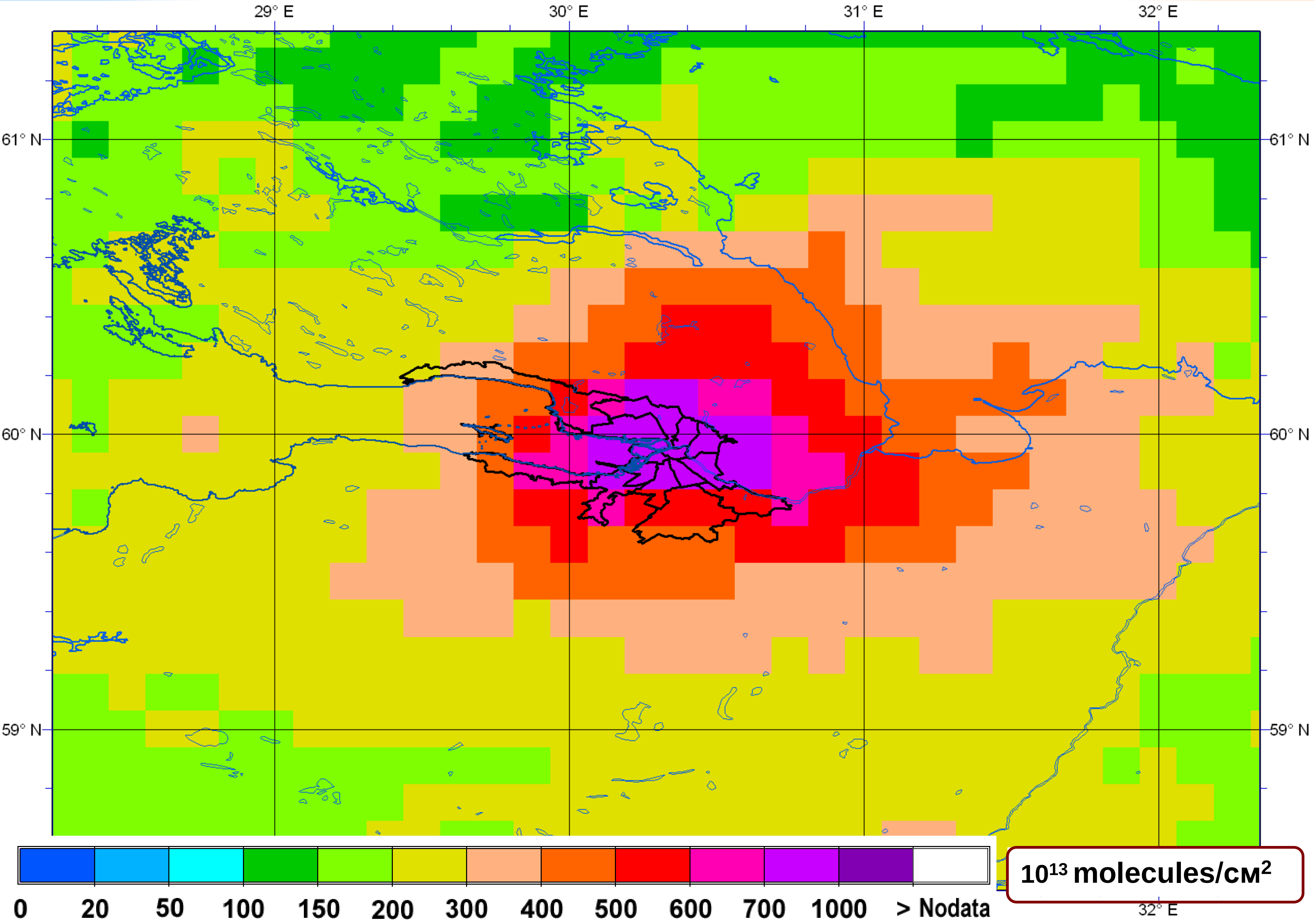


10^{13} molecules/cм^2

OMI

Year average gas content in 2007, St-Petersburg

NO2

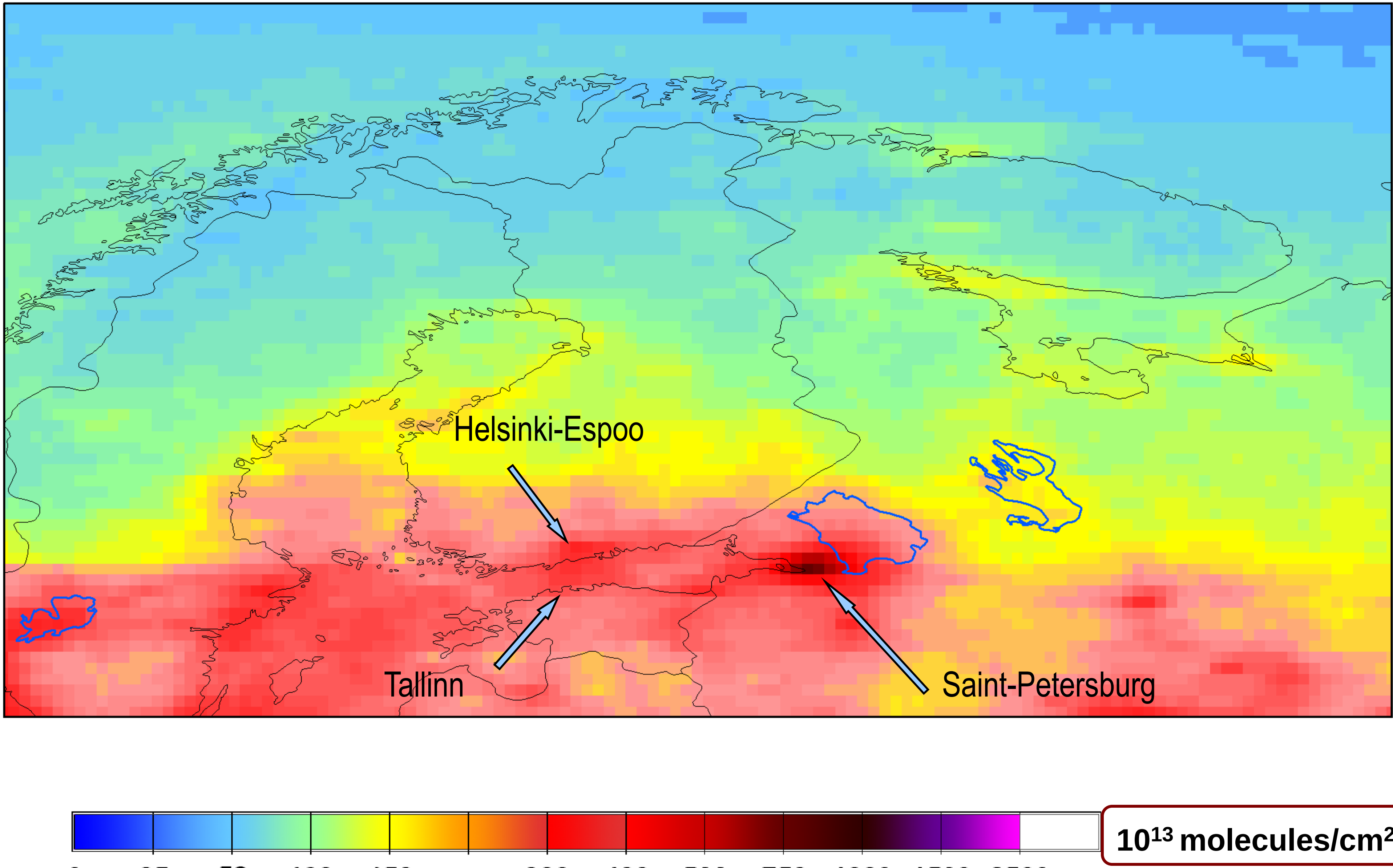


10^{13} molecules/см^2

Mean nitrogen dioxide concentrations 2005-2009
The Gulf of Finland

OMI

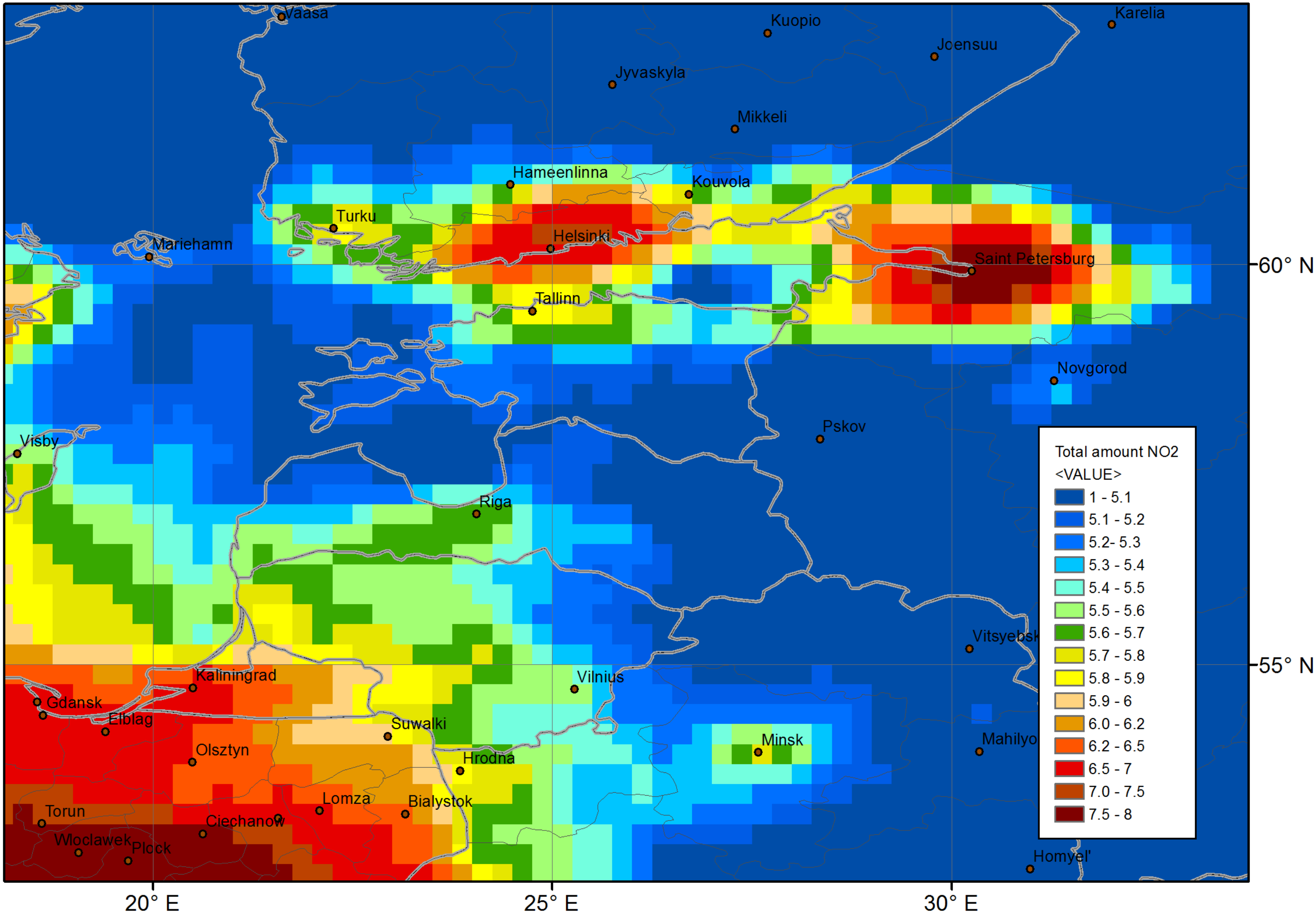
NO2



OMI

Mean nitrogen dioxide concentrations 2004-2014
The Gulf of Finland

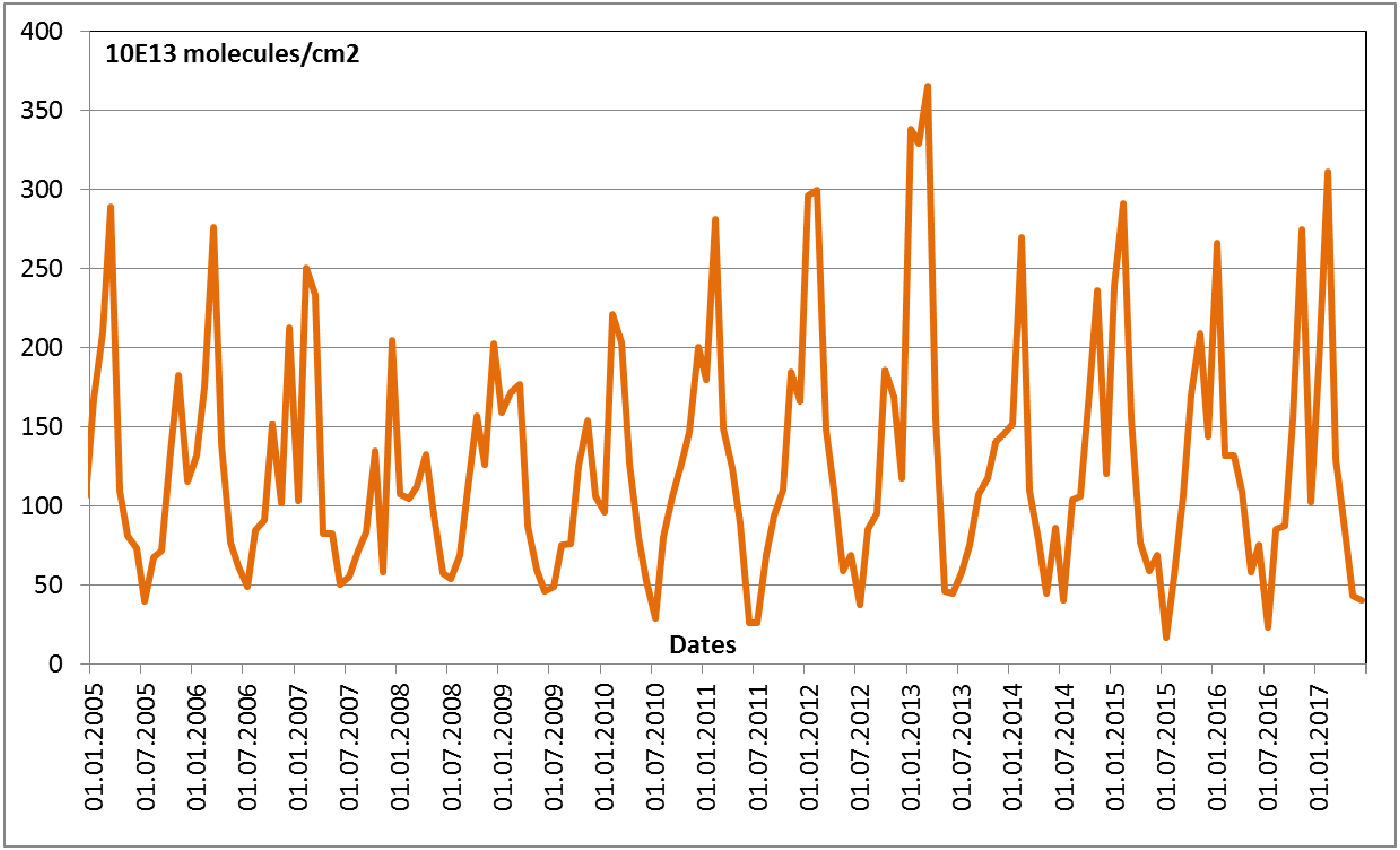
NO2



OMI

Monthly mean nitrogen dioxide concentrations 2005-2017
The Gulf of Finland

NO2



NO2 observation problem in our latitudes

Winter

- **High** gas **concentration**
- The lack of sunlight
- Continuous clouds

- **Low** data **reliability**

Summer

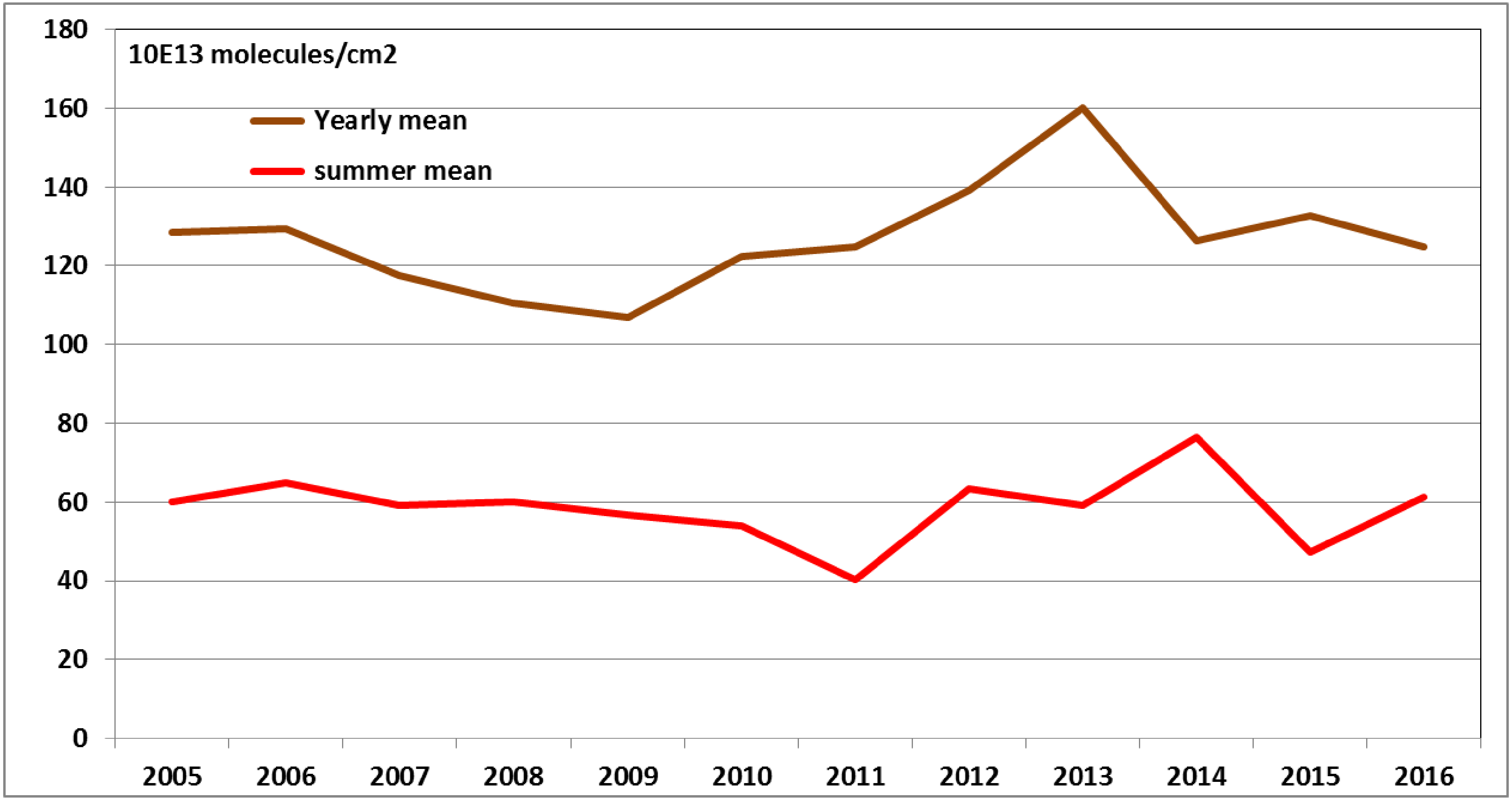
- **Low** gas **concentration**
- White nights
- Usual clouds

- **High** data **reliability**

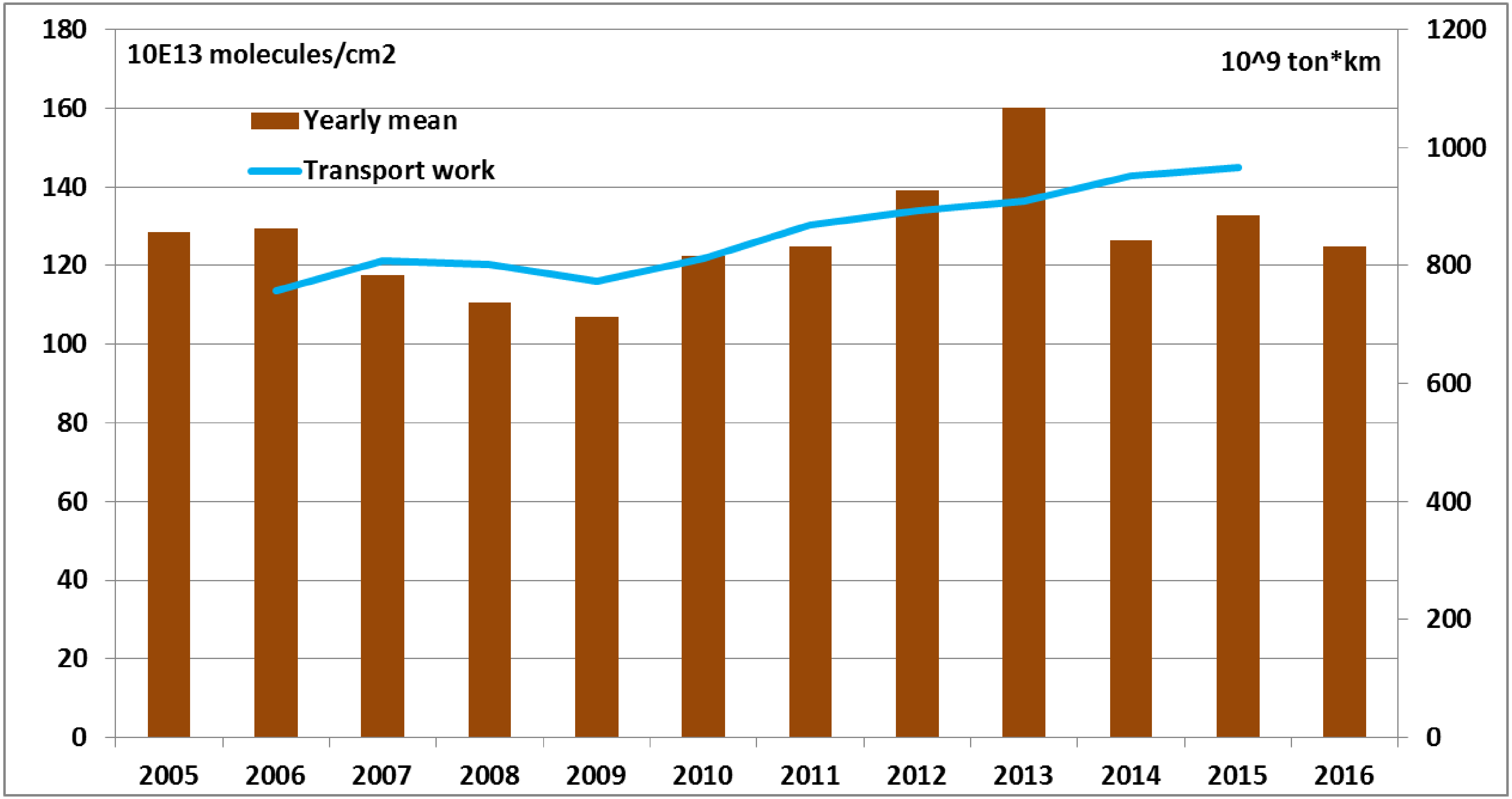
OMI

NO2

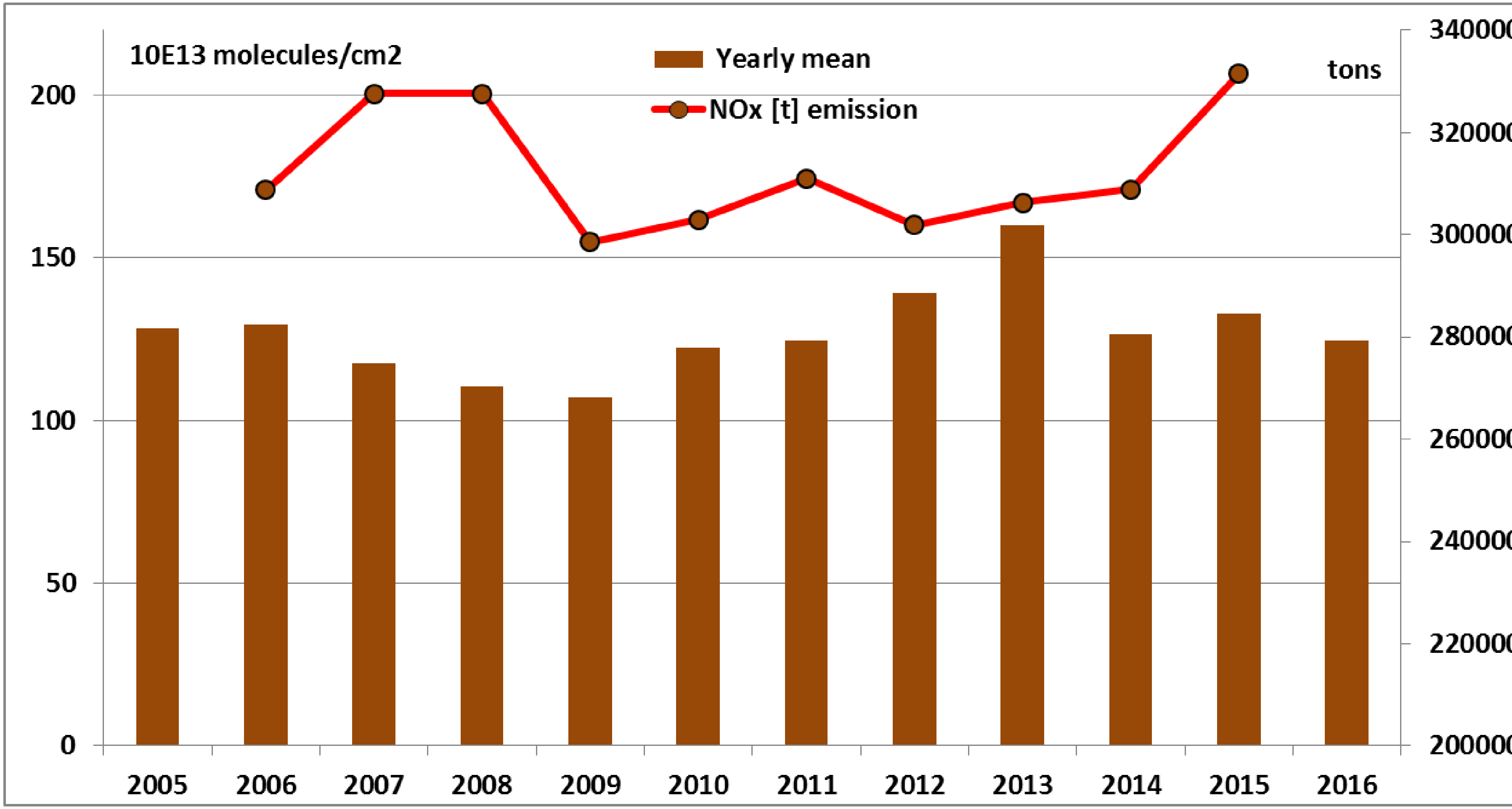
Yearly and summer mean nitrogen dioxide concentrations
The Gulf of Finland



Yearly mean nitrogen dioxide concentrations and transport work
The Gulf of Finland

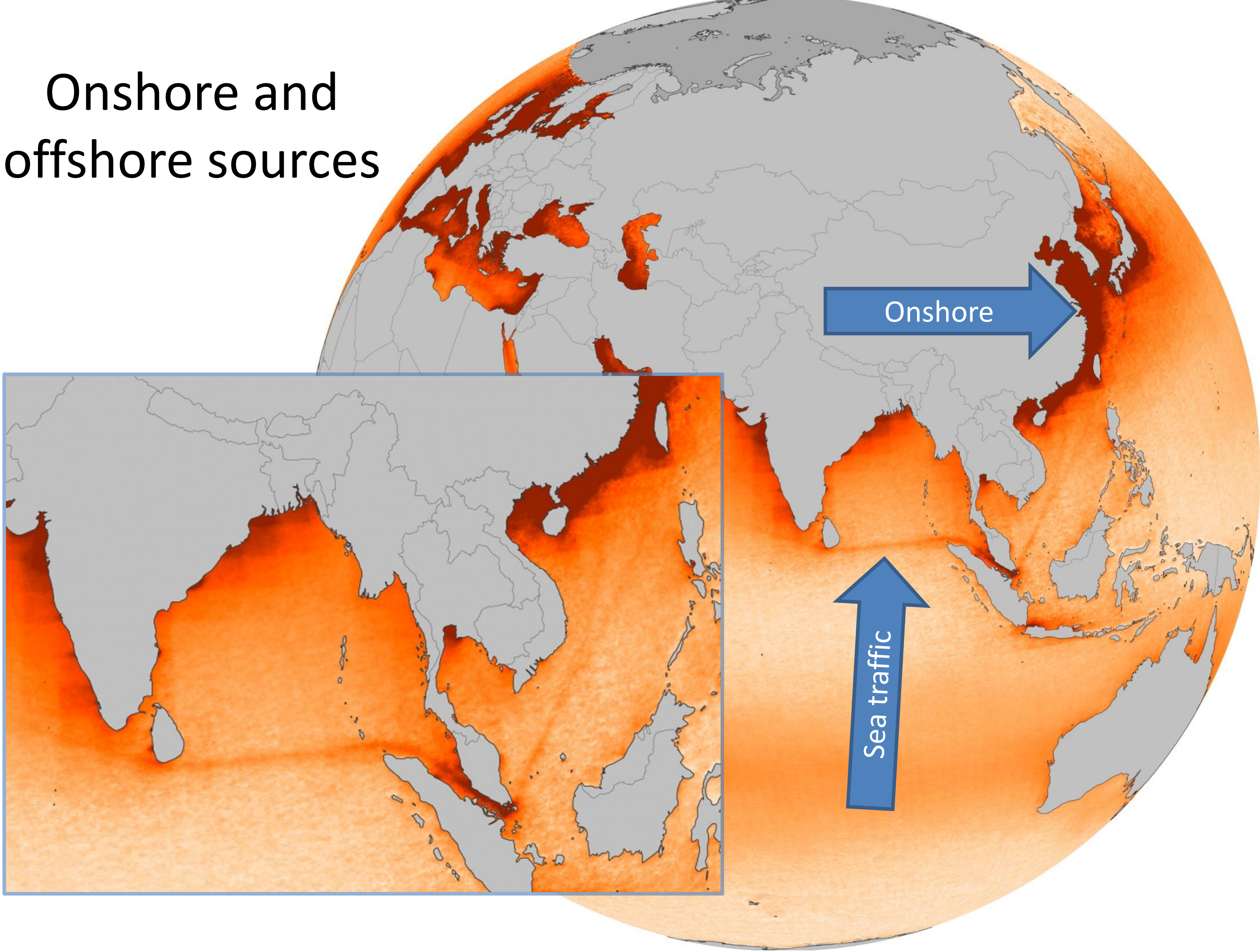


Yearly mean nitrogen dioxide concentrations and NOx emission from all vessels. The Gulf of Finland



HELCOM Baltic Sea Environment Fact Sheets

Onshore and offshore sources



Conclusions

- nitrogen dioxide concentrations over the Gulf of Finland keep stable last decade
- comparison with volumes of transport work and estimated NOx emission by HELCOM Baltic Sea Environment Fact Sheets do not indicates evident correlations
- Highest gas concentrations related with cities: St-Petersburg, Helsinki and Tallinn

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Gulf of Finland Co-operation

N. Lemeshko

Greenhouse Gas Inventory as the first stage of reducing energy consumption in the Leningrad region

Greenhouse Gas Inventory as the first stage of reducing energy consumption in the Leningrad region

Natalia Lemeshko
Saint-Petersburg State University, Institute of Earth Sciences.
199178 St-Petersburg, Russia, 10-ya Liniya, 33
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The increase of carbon dioxide concentration in the atmosphere has led to global warming in recent decades

To mitigate the negative effects of GW we should reduce the concentration of greenhouse gases in the atmosphere by lowering anthropogenic emissions.

In the framework of international agreements
and the RF Concept
for the first time for the Leningrad region there has been held
GHG Inventory for the sectors:
Energy
Industrial processes and product use
Agriculture
Land use, land-use change and forestry
Waste
for the 2008 - 2013

"The Concept of monitoring, reporting and verification of greenhouse gas emissions system in the Russian Federation" was introduced by the order of the Government of the Russian Federation dated 22.04.2015 N 716-R.

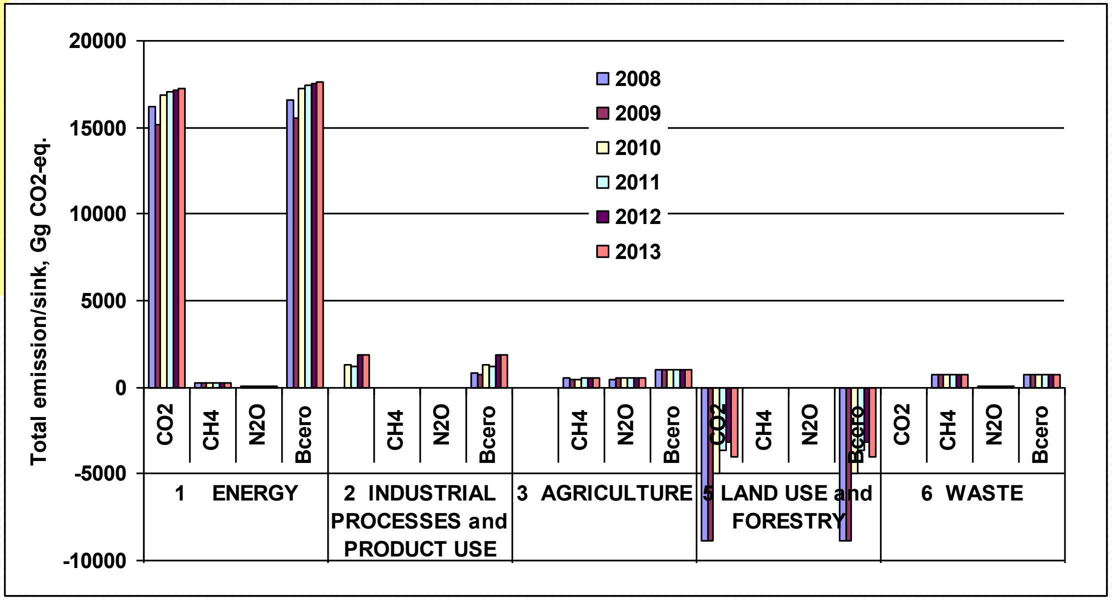

Figure 1–The contribution of the economic sectors to the emission of greenhouse gases (CO_2, CH_4, N_2O)

Carbon dioxide is the absolute leader among contributors to greenhouse gases

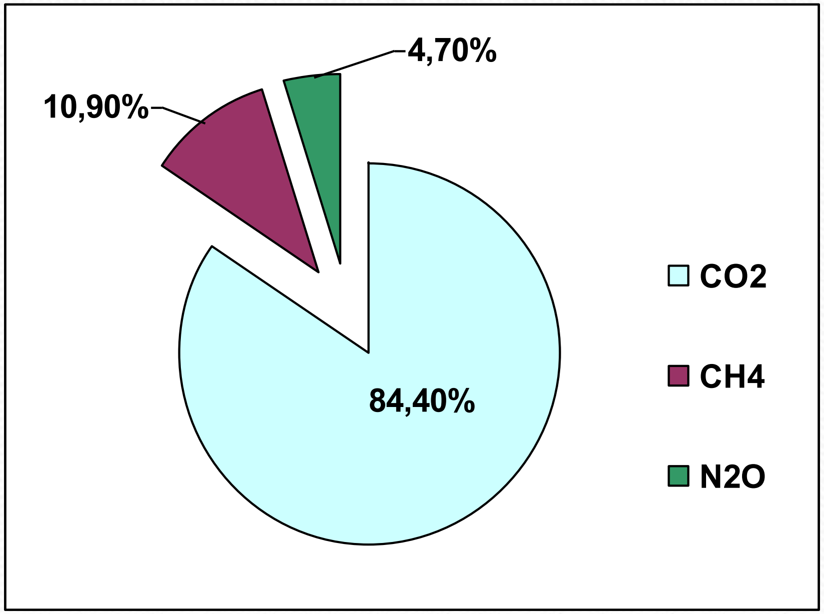

Figure 2 - The contribution of CO_2, CH_4, N_2O in total greenhouse gas emissions in the Leningrad region over 2008-2013

The distribution of greenhouse gases emissions by source categories of the relevant five sectors *2008-2013*

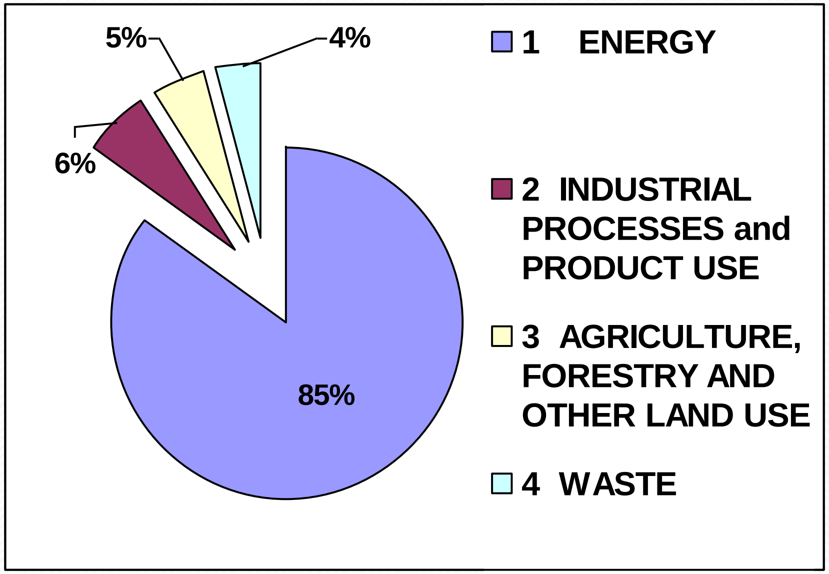

Figure 3–The contribution of the economic sectors in Leningrad region to the emission of greenhouse gases

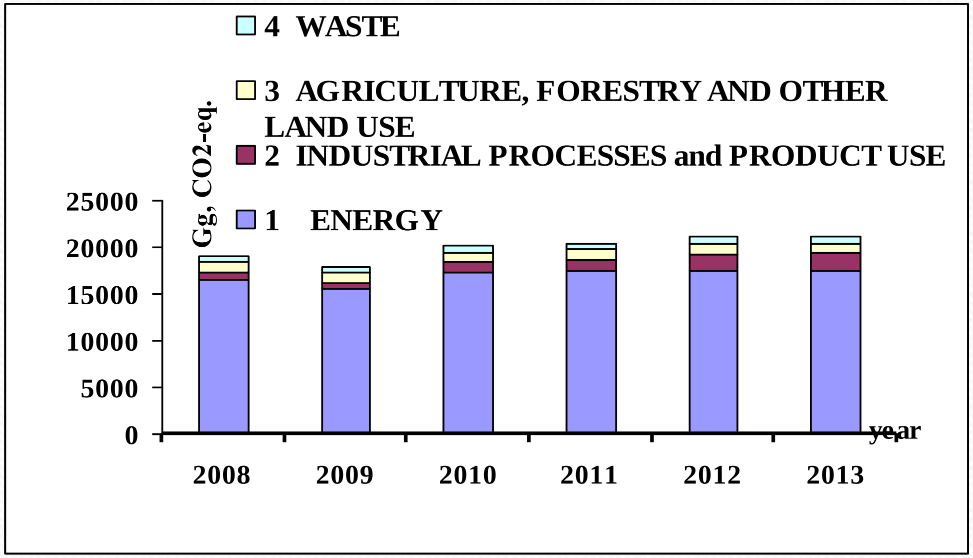

Figure 4– The dynamics of greenhouse gas emissions for the period of 2008-2013.

The greatest contribution to greenhouse gas emissions gives the "Energy" sector (85%), (Fig.3) on the background of positive dynamics for the entire period (Fig. 4)

The Energy sector makes the greatest contribution to greenhouse gas emissions, so it is important to assess the dynamics in this industry over the available period (since 1993)

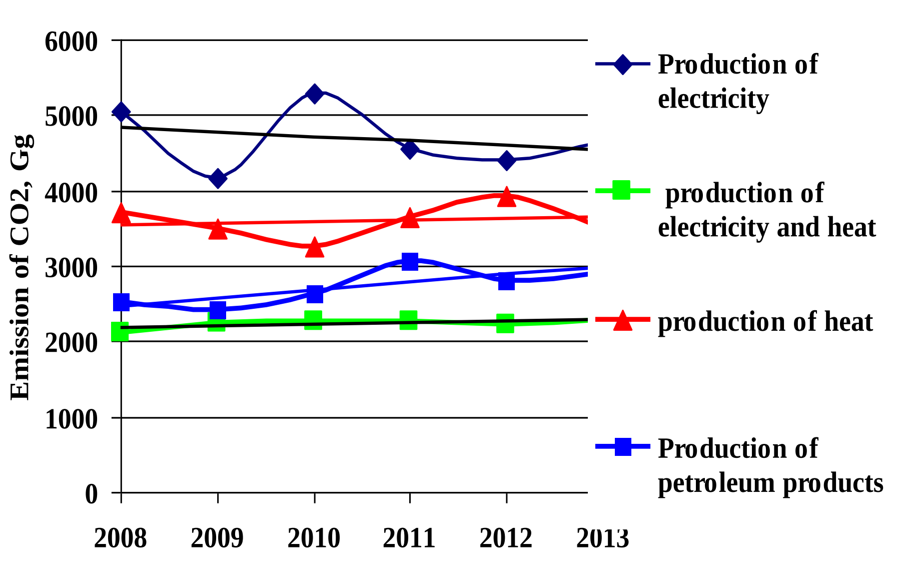

Figure 5 – Dynamics of CO_2 emissions for source category of the Energy in the Energy industry

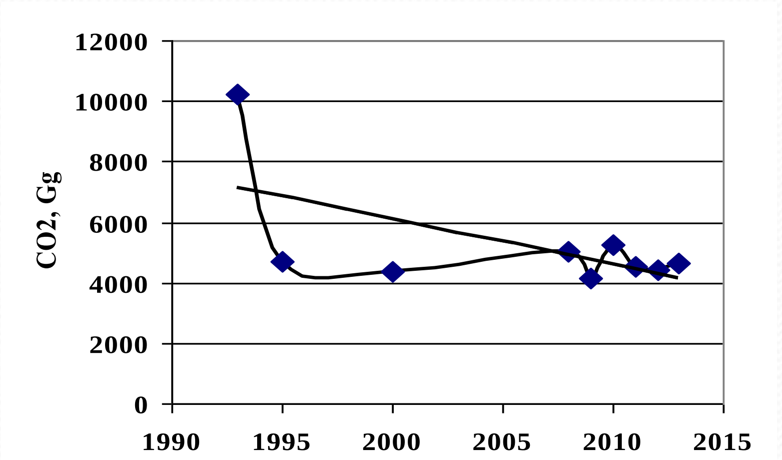

Figure 6 – Dynamics of CO2 emissions by source electricity production.

The emission of GHG shows:

- *largest emissions derive from the sources of electricity Production with greatest fluctuations and negative trend over six-year period.*
- *a steady growth in the sources of Production of petroleum products*
- *the lack of dynamics in the sources of Production of heat and Production of electricity and heat.*

***CO2 emissions* by source electricity production**

have significantly decreased, particularly from 1993 to 1995

The estimates of carbon dioxide absorption by forests for the sector "Land use, land use change and forestry" and its temporal dynamics

- **Emissions/sinks for the sector Land use, land use change and forestry should not be calculated when compiling regional inventories, as outlined in the new guidance (2015). This sector is accounted for only at the national level for the whole territory of the Russian Federation.**
- **However, these calculations were performed with the inventory of emissions and removals of source category Forest lands, since forest is the most important absorber of carbon dioxide and generates carbon dioxide balance (Emissions-sinks)**
- **This sector is the carbon dioxide absorbent, with a total annual value of absorption from 3000 to 9000 Gg in different years.**

The absorption of carbon dioxide compensates for approximately 28% of greenhouse gas emissions for the territory of Leningrad region.

"Forest land" in the Leningrad region is carbon dioxide sink

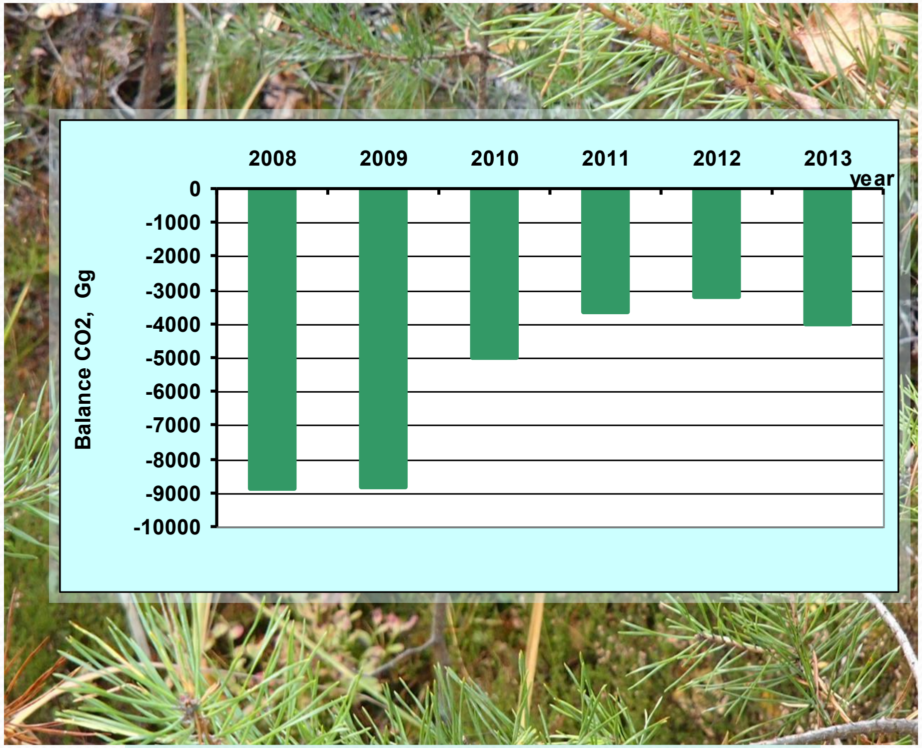

Figure 4 – the CO_2 Balance (Gg) for the sector Land use, land-use change and forestry.

In conclusion,

this work is of great importance for the Leningrad region, as obtained Inventory can become the basis for strategic planning of economic development of the region:

- *Improvement of the efficiency of energy consumption*
- *More extensive use of noncarbon and renewable sources of energy*
- *Development of new environmentally friendly, innovative low-carbon technologies;*
- *Reforestation, as forests are natural sinks of carbon dioxide.*

The most promising way of reducing greenhouse gas emissions which gets in line with the scares environmental resources and current structure of the economy of the region is switching to the use of natural gas as a more environmentally friendly type of fuel in production of heat and energy

Such projects for transformation of coal and oil-fired boiler plants to gas use have already being implemented in the Gatchinsky and Slantsevsky districts of the Leningrad region.

We need specialists on inventory now

- An important aspect of the project is training of specialists for the operating of monitoring system and the performing of regional inventory. For this purpose we have developed a special graduate programme "Greenhouse gas Inventory for the regions of Russia"
- St. Petersburg Institute of nature management, industrial safety and environmental protection http:/www.ipkecol.ru.

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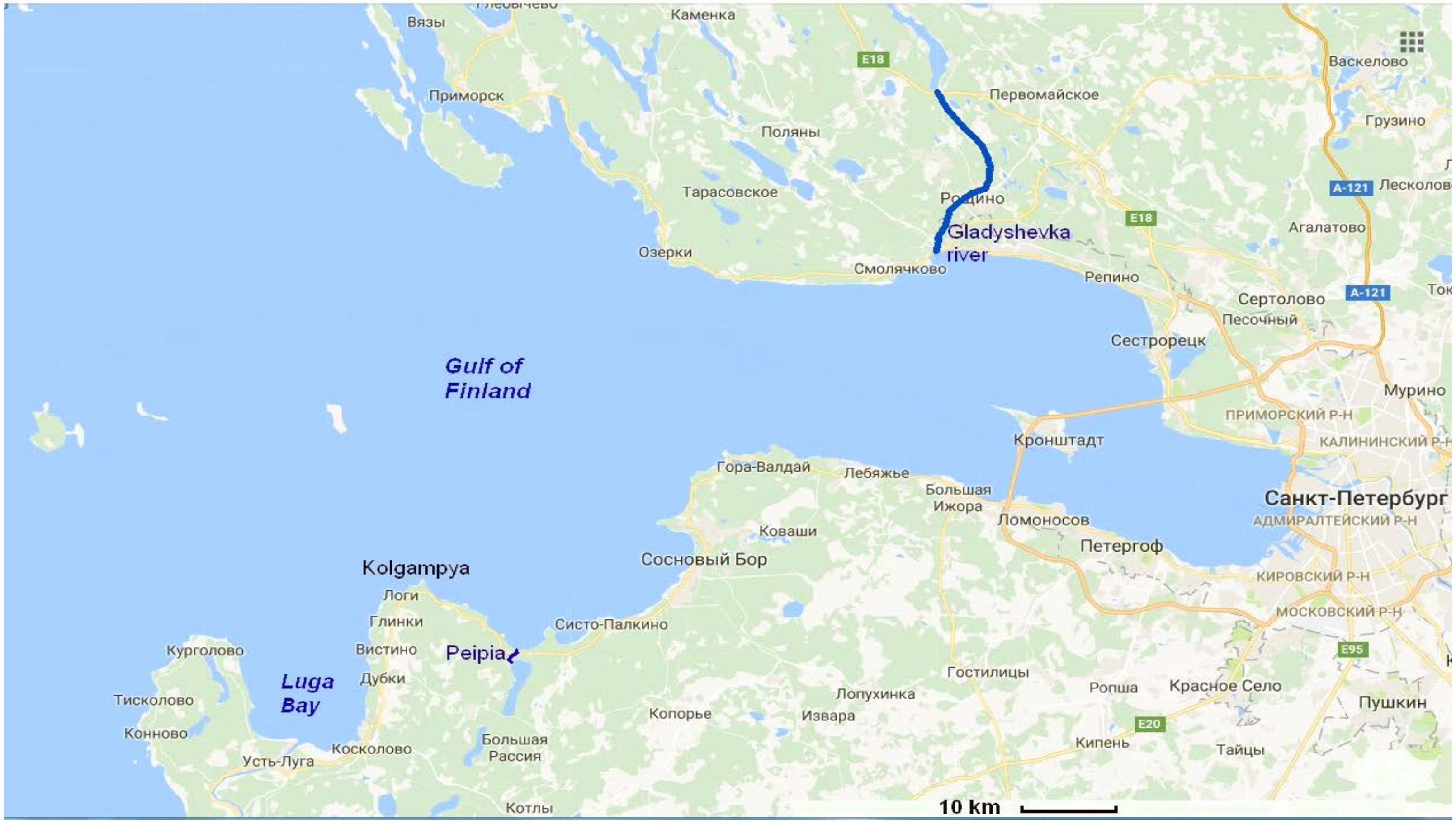
A. Antsulevich, S. Titov

Development of the program for combined restoration of European pearl mussel (Margaritifera margaritifera) and salmonid fishes local populations in two rivers inflowing to the Gulf of Finland in nature protected areas of Leningrad Oblast.

Antsulevich A.E., *Nord Stream 2 AG*
Titov S.F., *GosNIORH, St.-Petersburg*

Development of the program for combined restoration of European pearl mussel (*Margaritifera margaritifera*) and salmonid fishes local populations in two rivers inflowing to the Gulf of Finland in nature protected areas of Leningrad Oblast.



The life circle of European pearl mussel

The strict linkage of it with salmonids (fig. Vihrev, Mahrov, 2016)

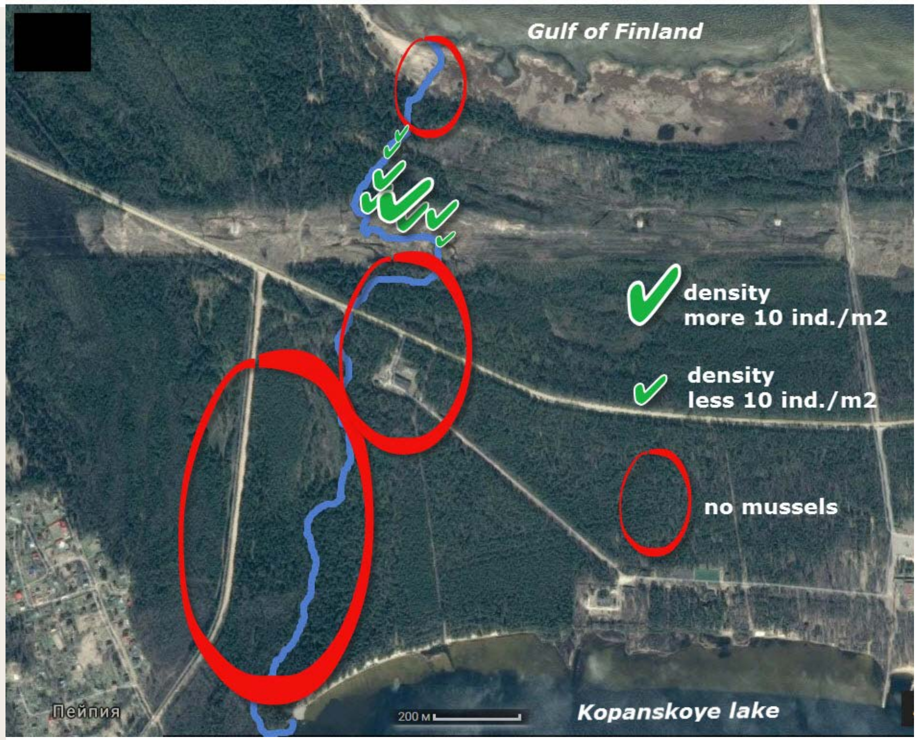
Material and methods. Aquascope

Material and methods. Snorkelling surveys

Material and methods. Electric fishing

Material and methods. Fish investigations (and release back)

Peipia river



Geographical position

Pearl mussels distribution

Peipia population is represented by mature mussels of 40-60 years old and more (close to natural death age). No young ones.

Shell length 120 mm

Peipia drying off because of beaver’s dams

Beaver’s dams in a middle part of the river

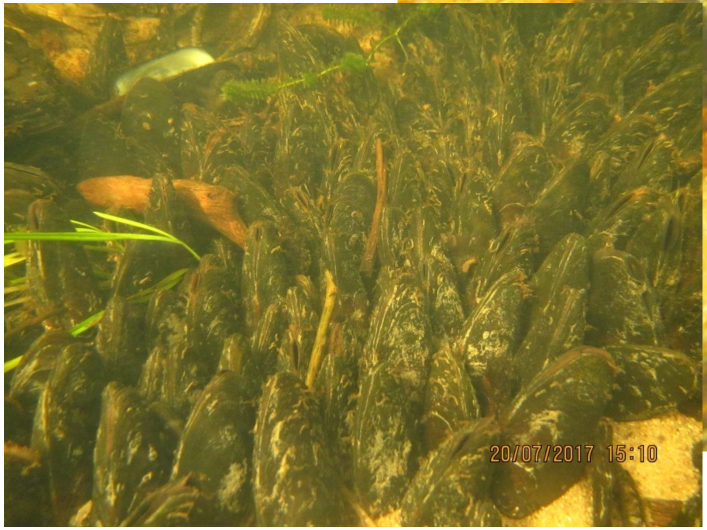
Residual “stream” downstream dams

Moving mussels try to find a “deep water”, at least 10-20 cm to survive

The depth is about 3 – 5 cm. Some little pools were separated and already dried out together with mussels (4/11/2015)

Most densy known in the world aggregation of *M. margaritifera*

Up to
200 ind.m-2
of the settlement
(in the aggregation)



Totally the resources of mussels in Peipia river
were calculated as 4700 individuals

The composition of fish fauna in two rivers

	*R. Gladyshevka	R. Peipia
Salmon *Salmo salar* L.	+	—
Sea trout *Salmo trutta* L.	+	—
Stone loach *Barbatula barbatula* L.	+	+
Burbot *Lota lota* L.	+	+
Minnow *Phoxinus phoxinus* L.	+	+
Gudgeon *Gobio gobio* L.	+	+
Bleak *Alburnus alburnus* L.	+	+
Roach *Rutilus rutilus* L.	+	+
Perch *Perca fluviatilis* L.	+	+
Pike *Esox lucius* L.	+	+
Lamprey *Lampetra fluviatilis* L.	+	+

** additionally 5 other species*

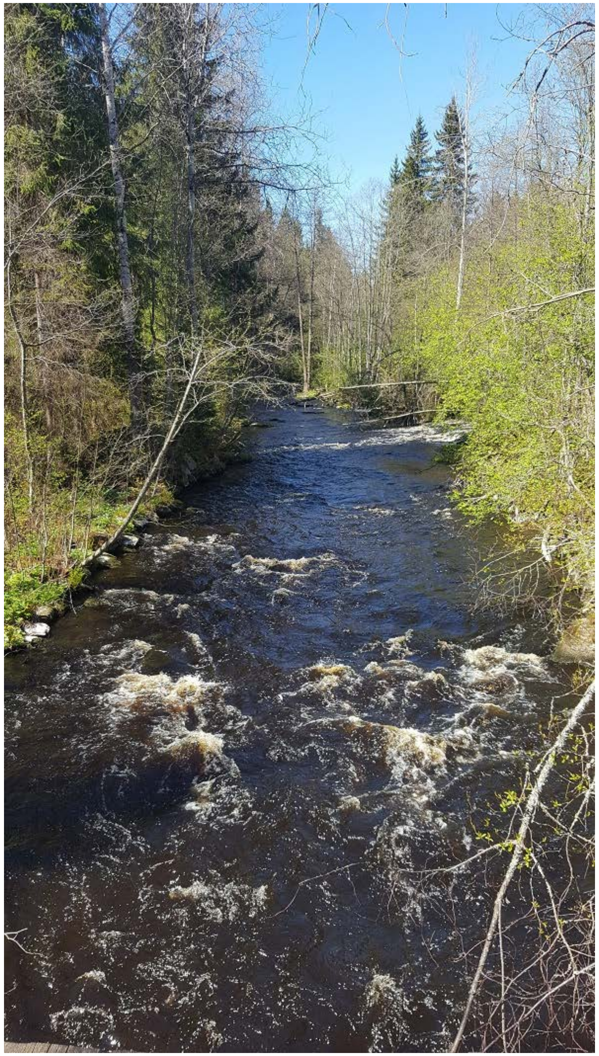
During the last several years not a single trout parr has been caught in the Peipia River

in spite of numerous nice spawning and nursery areas in the River

Gladyshevka River.
Annual artificial support for salmon reproduction (May, 2017)

Containers with young fish

Marked salmon parr

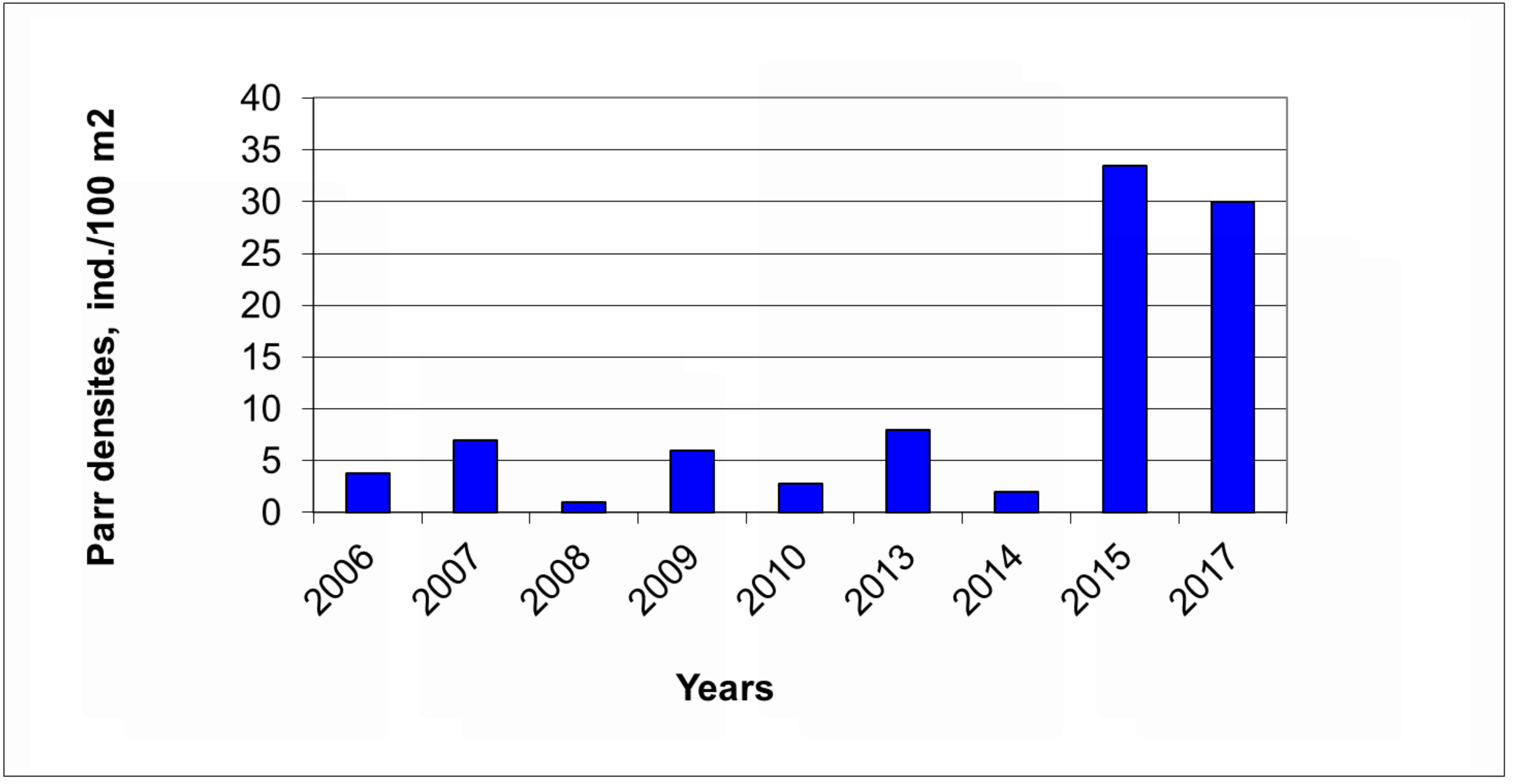


One of rapids

Reared salmon released to the Gladyshevka River

To reestablish the Atlantic salmon population more than 180 thousand reared Neva salmons were released into the Gladyshevka River since 2001.

Wild salmon parr densities (ind./100 m2) in the Gladyshevka River



- Since 2005-2006 there is a stable reproduction of Atlantic salmon in the River. Densities of parrs has increased during the last years.

Conclusions

Peipia river
There is big local population of the European pearl mussels still exist in the very small Peipia river (4700 individuals; mature ones only, no juveniles). No salmonid fish were registered. Population is extremely endangered to be extinct soon.

Gladyshevka river
Last several years 7 individuals of the European pearl mussels were found and none in 2017 year.
The population of mussels is already extinct there (may be few singles still left). Both species of salmonids (*Salmo salar* & *S. trutta*) are common in the river thanks to special effective artificial support for fish reproduction.

General
Restoration of salmonid (*S. trutta*) local population by artificial reproduction is urgently needed in Peipia river.
Mussels from Peipia may serve as mother population for introductions to river Gladyshevka, where suitable environmental conditions are provided.

Recommendations

- To support the natural population of Atlantic salmon (*Salmo salar*) by annual releasing of reared salmon into the Gladyshevka River during some next years.

- To support the European pearl mussels of the Peipia River, the Trout (*Salmo trutta*) population should be reestablished. It is recommended to release 500-1000 trout parr annually (the donor population – trout from the Luga hatchery plant). An artificial «spawning nests» may be created as well.

- To use mussels from Peipia as a donor population for restoration of Gladyshevka River former mussels population.

Thank you for attention

From small scales to large scales
–The Gulf of Finland Science Days 2017
9th-10th October 2017
Estonian Academy of Sciences, Tallinn

1st Day

Gulf of Finland Co-operation

M. Verevkin, L. Voyta

Aerial estimating abundance of ringed seals in the Russian part of the Gulf of Finland on April 2017

Aerial estimating abundance of ringed seals in the Russian part of the Gulf of Finland on April 2017

Mikhail V. Verevkin[1] and Leonid L.Voyta[2]

[1] *St. Petersburg Research Center of the Russian Academy of Sciences,*

[2] *Zoological Institute, Russian Academy of Sciences.*

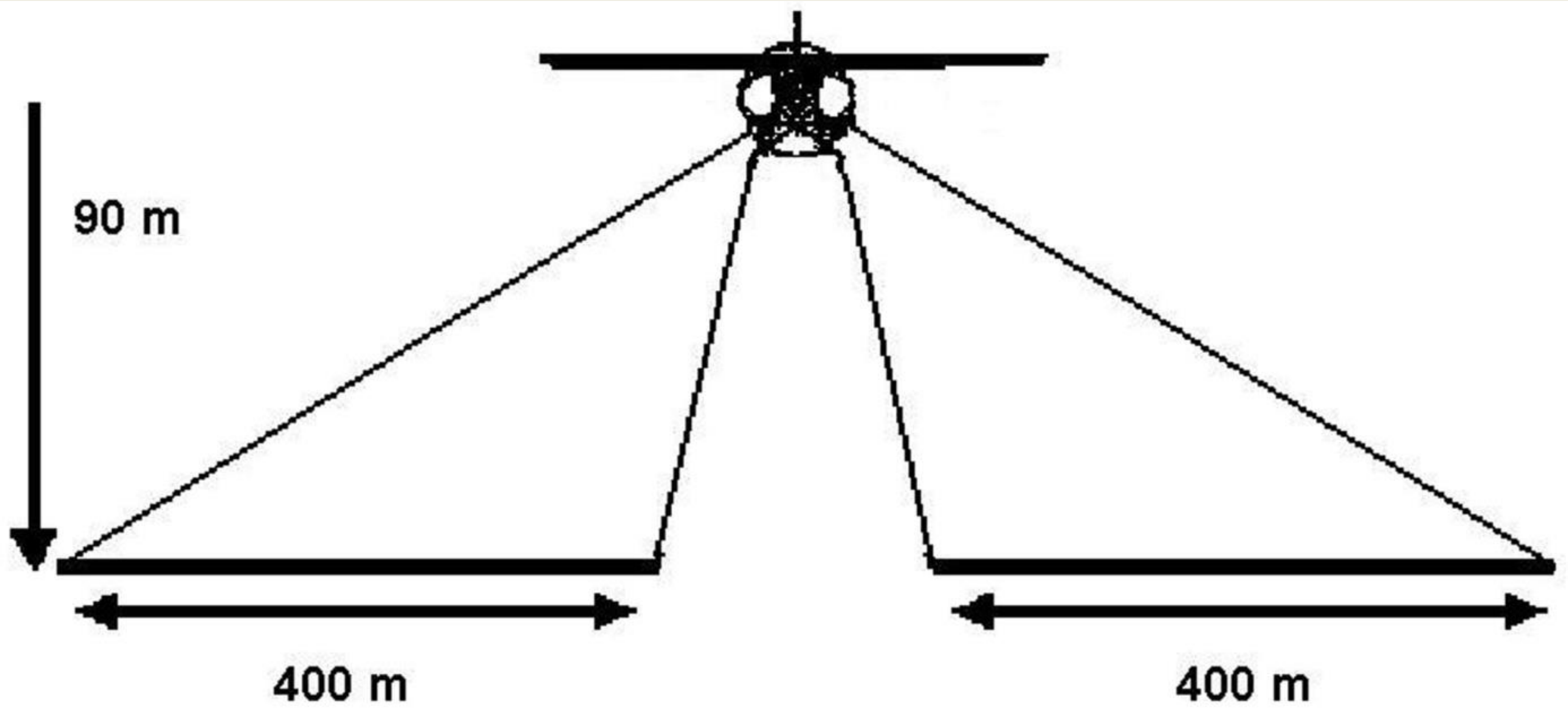
* ***vermiv@yandex.ru***

Gulf of Finland Co-operation

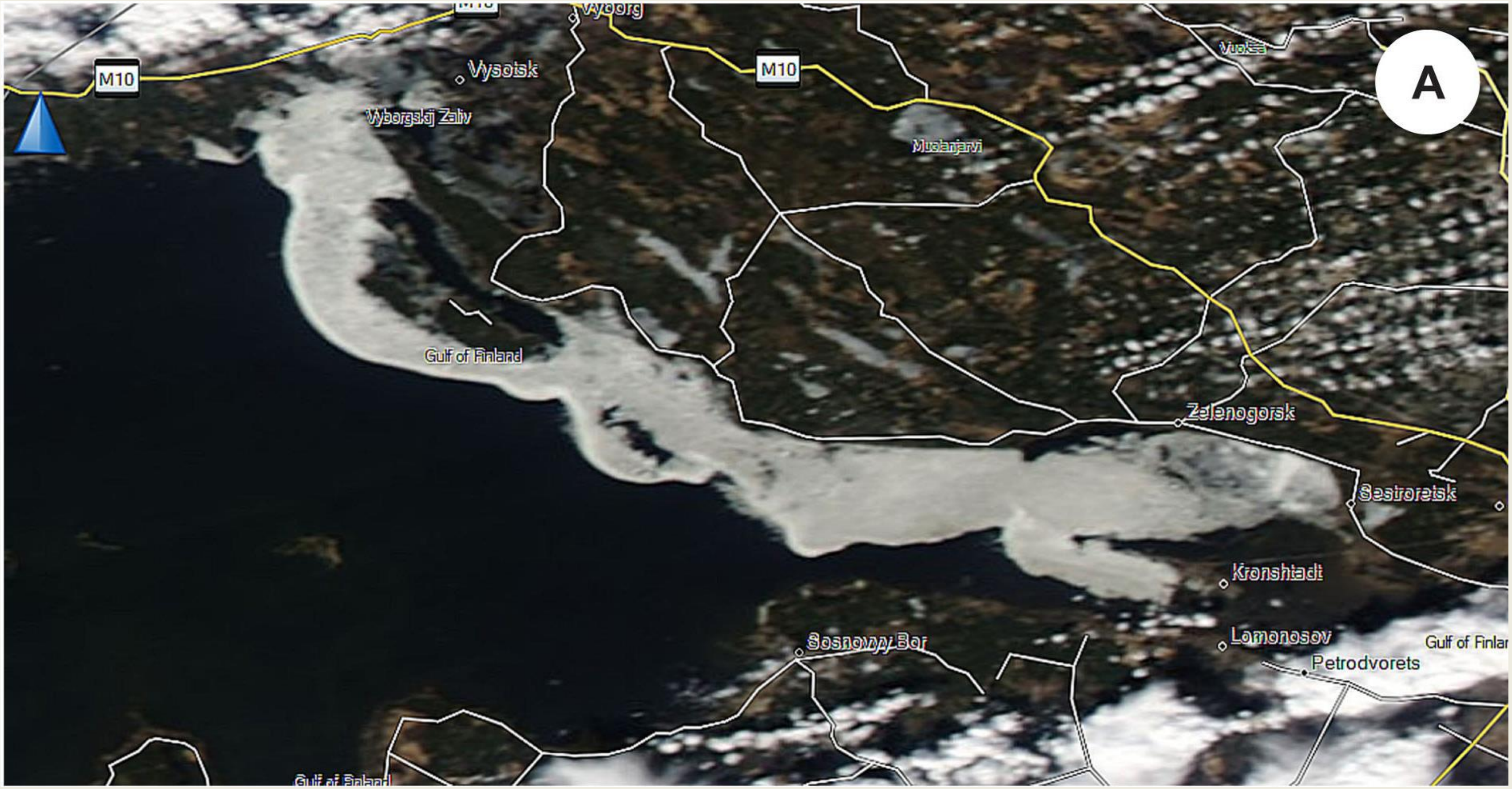
9-10 of October 2017 Tallinn

The Cessna 182 aircraft prepared to the ringed seals survey on April 11th and 15th 2017. The red arrows indicate the observation sector, which at a flight altitude of 90 m corresponds to the 400 m band. Orange arrows indicate the position of visual marks on the wing's frame.

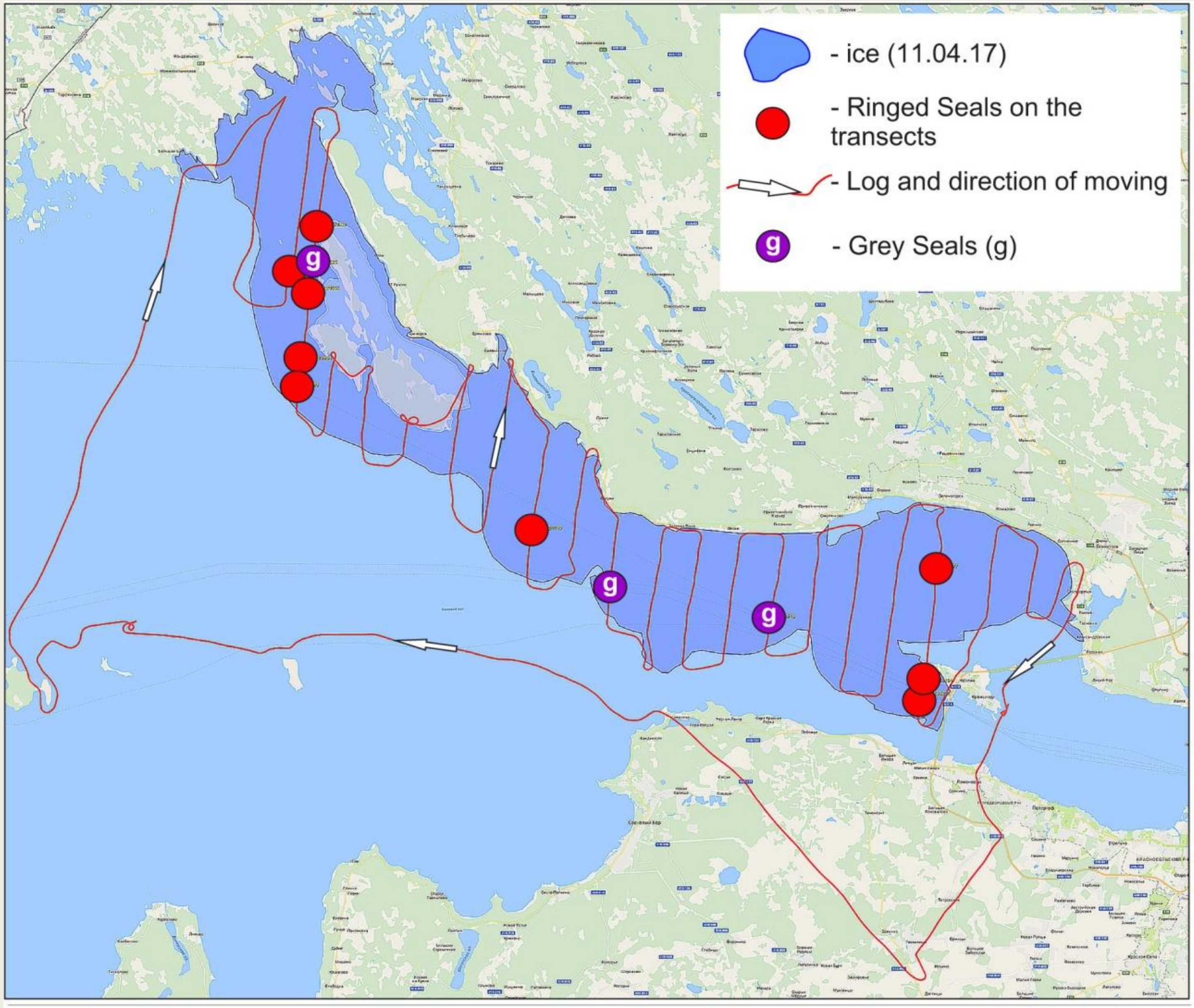
The scheme of observation sectors for both boards of aircraft. Two bands of 400 m are shown, according to the HELCOM method (Härkönen & Lunneryd 1992, Galatius et al., 2014).



Satellite image of the ice cover on the Russian part of the Gulf of Finland according to NASA satellite data on April 11th, 2017.



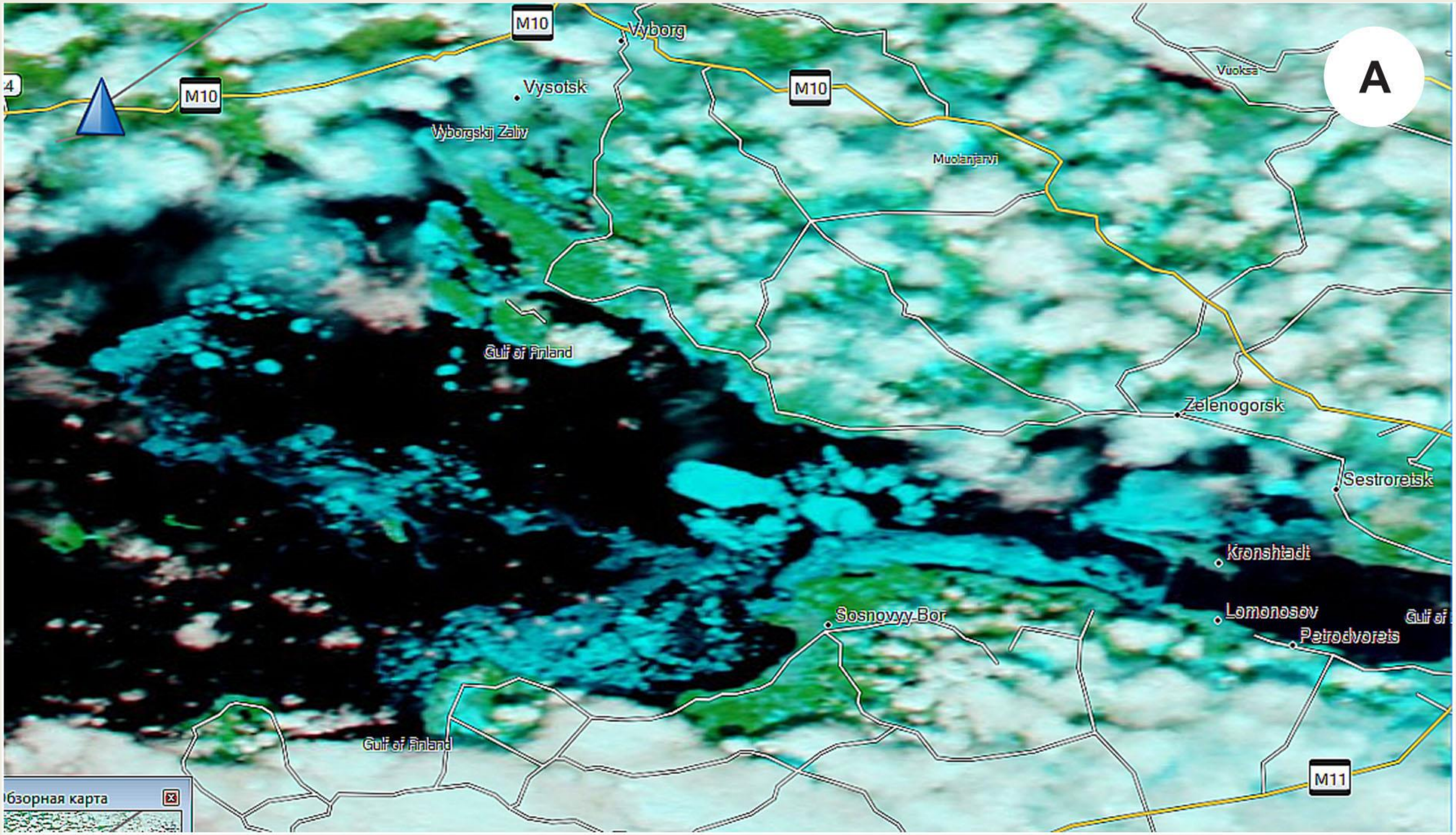
Schematic map of the aerial survey on April 11th with meeting points of Baltic ringed seals (red points) and grey seals (g).



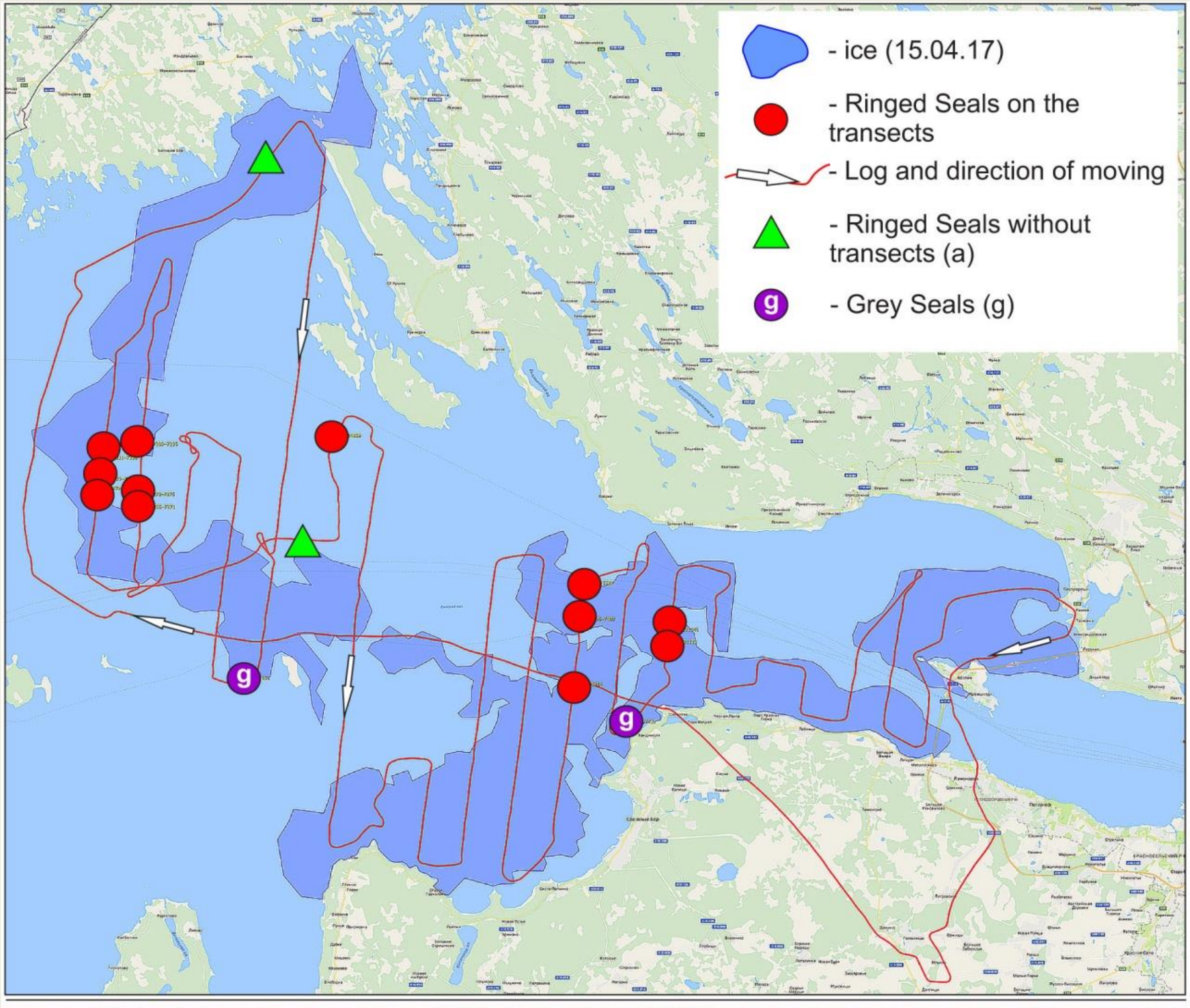
The result of the survey on the 11 of April

- On April 11th between 10:30 and 14:30 a total of 1 639.84 km2 was surveyed; the length of the flight route was 361.199 km. In total 22 transects of meridional direction were worked out; the average distance between transects was 4.5 km. The actual studied area was 289 km^2, which corresponds to the number of elementary segments of the route (1 segment = 1 km^2). The total number of the met animals was nine specimens. Relative spatial density of individuals per 1 segment (= 1 km^2) of the route was 0.031 ± 0.004 (m±95% confidence interval), SD = 0.17. The expected number of ringed seals within the studied area was 51 individuals, with a 95% confidence interval of 44 to 57 individuals.

Satellite image of the ice cover on the Russian part of the Gulf of Finland according to NASA satellite data on April 15th, 2017.



Schematic map of the aerial survey on April 15th with meeting points of Baltic ringed seals (red points) and grey seals (g); light-green triangles are meeting points of ringed seals without the transects.



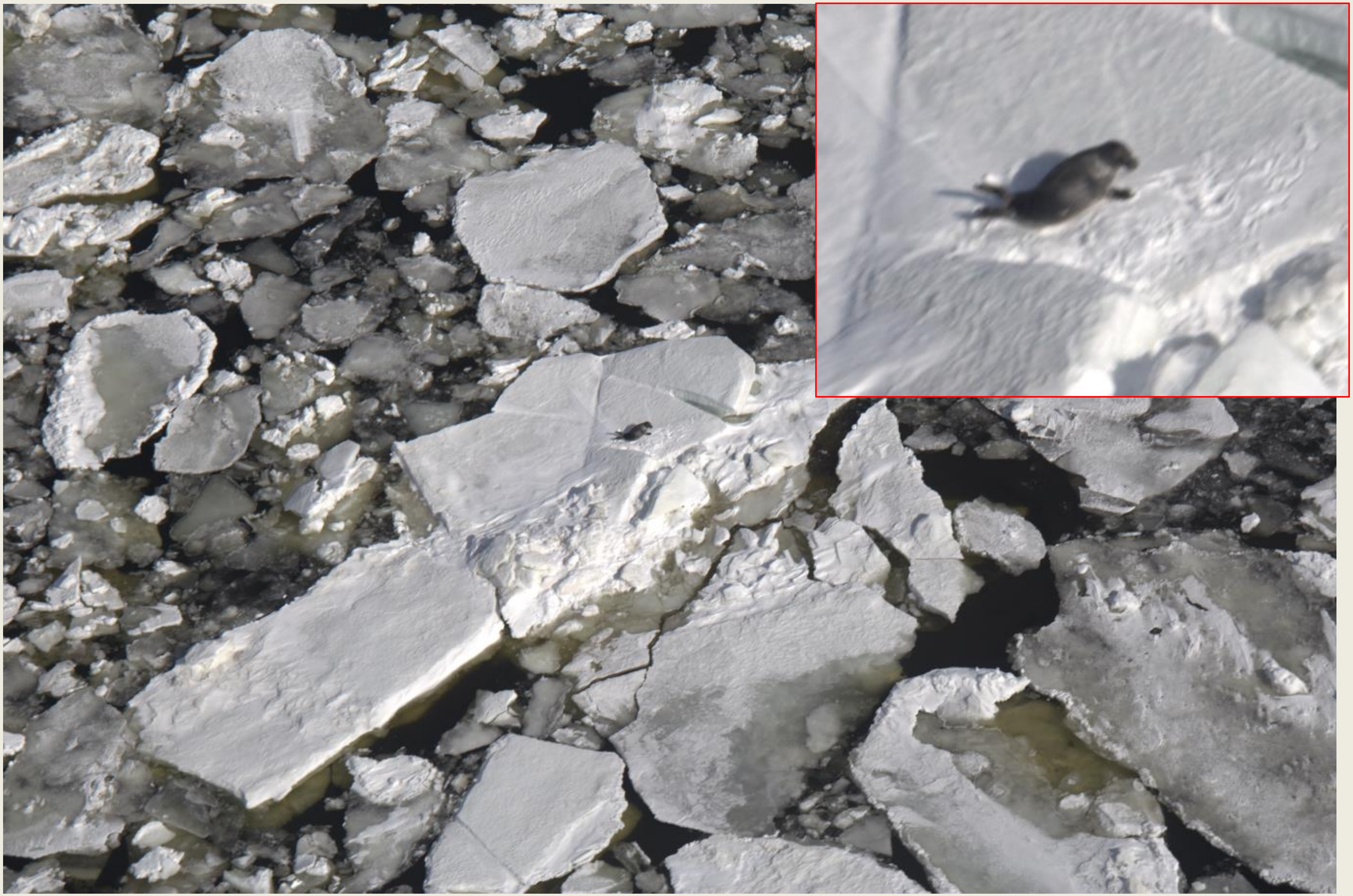
The result of the survey on the 11 of April

- On April 15th between 9:16 and 14:11 a total area of 2451 km^2 was surveyed; the length of the flight route was 490.2 km. In total 21 transect of meridional direction were worked out; the average distance between transects was 5 km. The actual studied area was 392.16 km^2, which corresponds to the number of elementary segments of the route. 15 individuals were recorded, but the calculation included only 13, two meeting points were excluded from the calculation of the relative density, because these animals were marked outside the transect. The relative density of individuals per 1 segment was 0.033±0.004 (m±95% confidence interval), SD = 0.19. The expected number of ringed seals within the studied area was 81 individuals, with a 95% confidence interval from 71 to 90 individuals. The number of Baltic ringed seals in the Russian part of the Finland Gulf from 2012 to 2017 stably remains low, and amounts to approximately 71–90 individuals (maximum up to 95–100 individuals).

The Baltic ringed seals on April 15th 2017 (point time 10:40:08) on the open ice of the Gulf of Finland

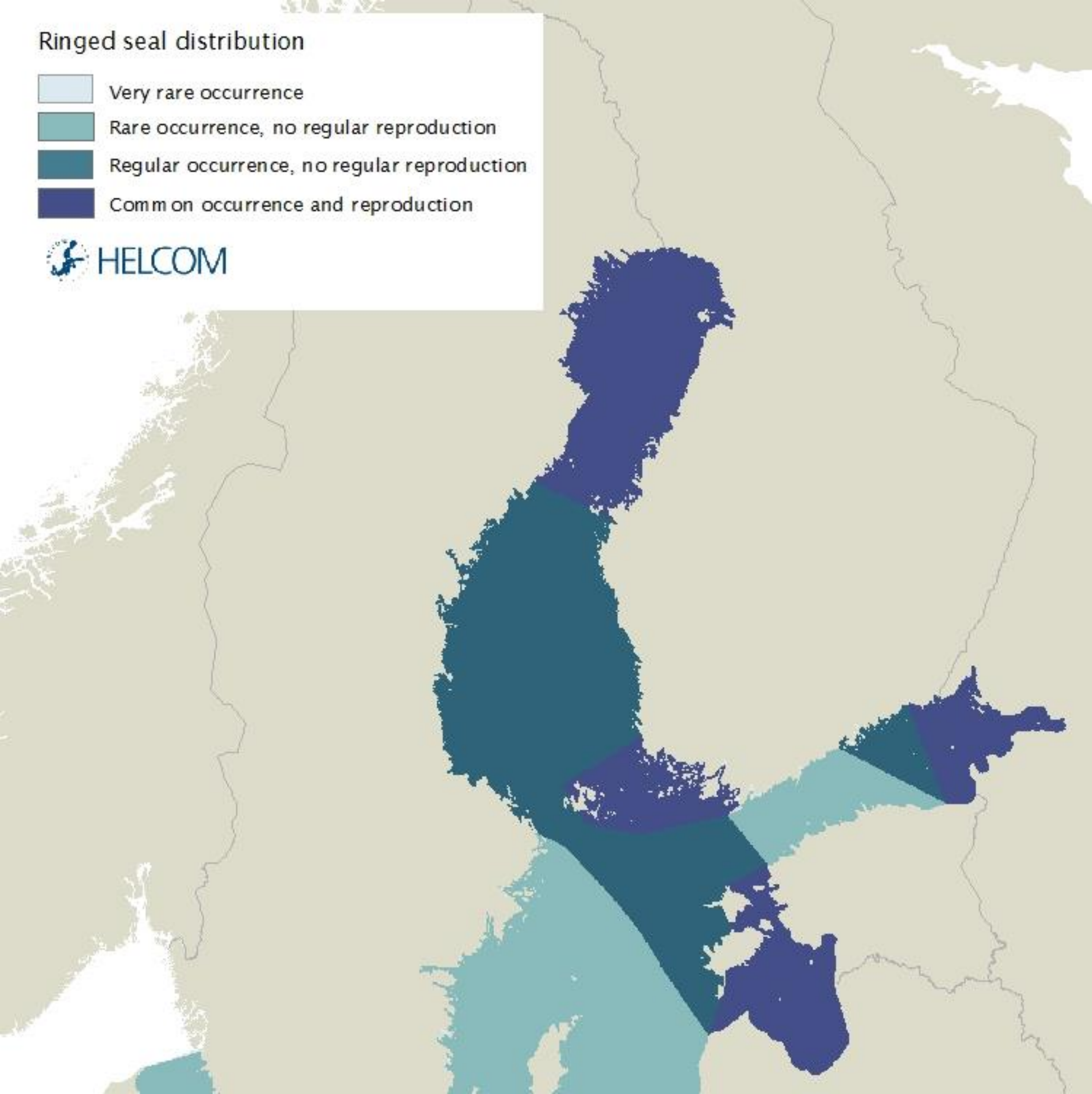
The adult Baltic grey seal on April 11th 2017 on the open ice of the Gulf of Finland .

The young Baltic grey seal on April 11th 2017 (point time 10:46:54) on the open ice of the Gulf of Finland .



Results of abundance estimation of ringed seal from 2010 to 2017

Year	Length of the route (km)	Observed area (km^2)	Total ice covered area (км^2)	Percent of ice surface surveyed	Ringed seal	
					specimens	number on the ice
2010	347,5	278	1193	23.3	6	16–34
2012	642,2	517	3916	13,2	12	72–94
2017	361,2	289	1640	17,7	9	44-57
	490,2	392	2451	16	13	71-90


Ringed seal distribution
Very rare occurrence
Rare occurrence, no regular reproduction
Regular occurrence, no regular reproduction
Common occurrence and reproduction
HELCOM

Conclusions:

- 1. The number of Baltic ringed seals in the Russian part of the Gulf of Finland from 2012 to 2017 stably remains low, and amounts to approximately 71-90 individuals (maximum up to 95-100 individuals).
- 2. The number of this pagophilous species is closely related to the ice situation in the waters of the Gulf of Finland. Soft winters, marked since the beginning of the 21st century, stabilized the number of ringed seals at low abundance. Reducing the mass of ice in the future may lead to a further reduction in the population size, respectively.
- 3. To assess the breeding potential of the local Baltic ringed seal population in the eastern part of the Gulf of Finland in the future, it is required to record the pups on ice.

The survey have been done with the support of Nord Stream 2 AG

Nord Stream 2

Thank You!

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Gulf of Finland
Co-operation

J. Kotta, R. Aps, M. Futter, K. Herkül

Assessing the environmental impacts and nutrient removal potential of mussel farms in the Northeastern Baltic Sea

Interreg Baltic Sea Region

EUROPEAN REGIONAL DEVELOPMENT FUND

EUROPEAN UNION

Baltic Blue Growth

Gulf of Finland Co-operation

ASSESSING THE ENVIRONMENTAL IMPACTS AND NUTRIENT REMOVAL POTENTIAL OF MUSSEL FARMS IN THE NORTHEASTERN BALTIC SEA

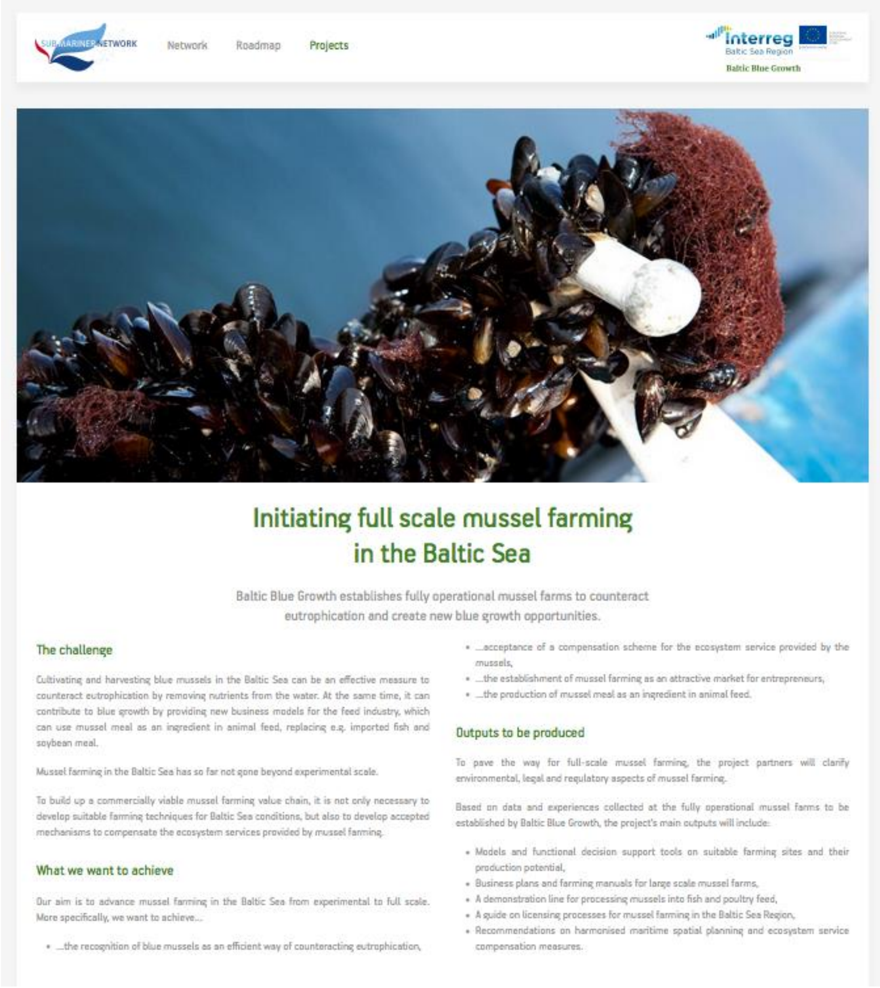
Jonne Kotta, Robert Aps, Martyn Futter & Kristjan Herkül

Baltic Blue Growth project

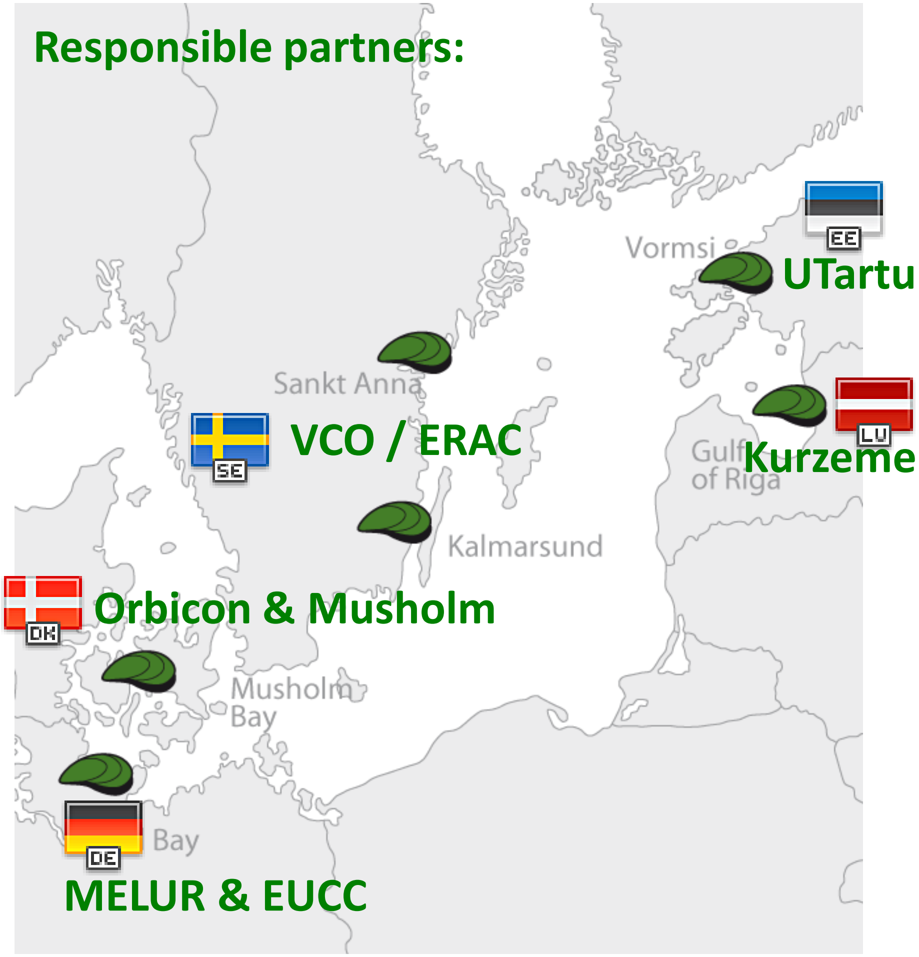
www.balticbluegrowth.eu

Cultivating and harvesting blue mussels in the Baltic Sea can substantially improve the water quality as mussels take up nutrients through their food intake.

It can contribute to blue growth by providing new business models for the feed industry, which can use mussel meal as an ingredient in animal feed, replacing e.g. imported fish and soybean meal.

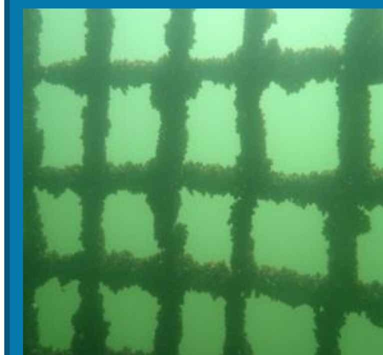


Regional mussel coordination groups



+Associated mussel farmers:

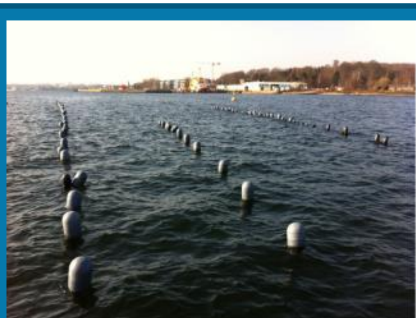
Vormsi Agar



Åland fish farmers association

Västervik municipality

Hasselo island local fish protection and administration



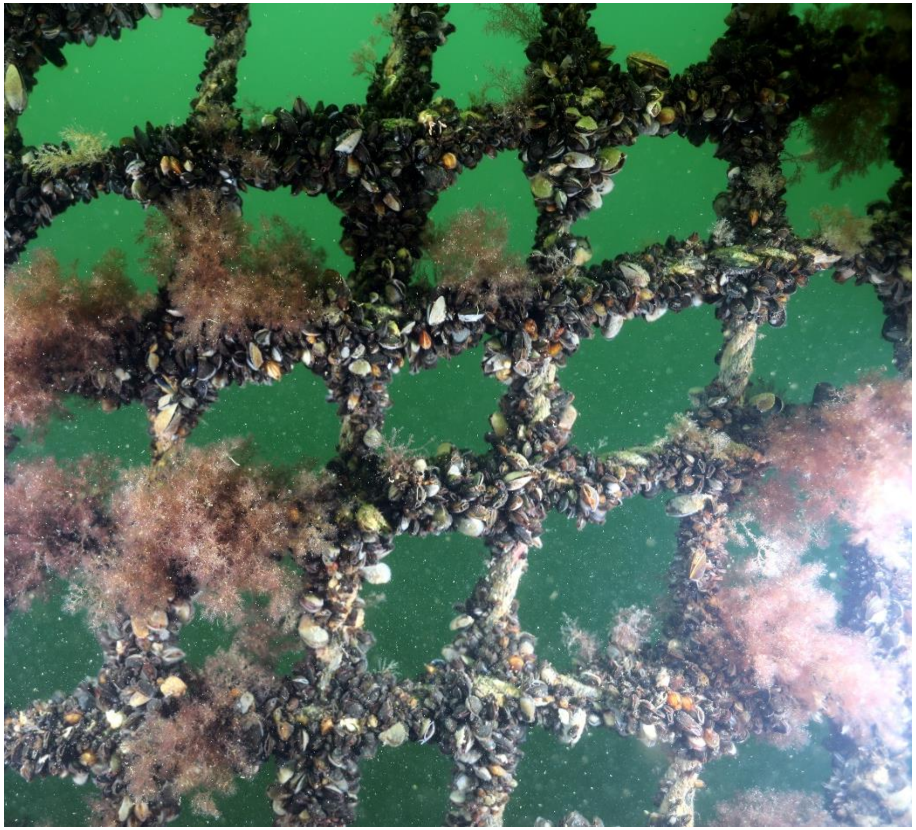
Kiel Marine farm

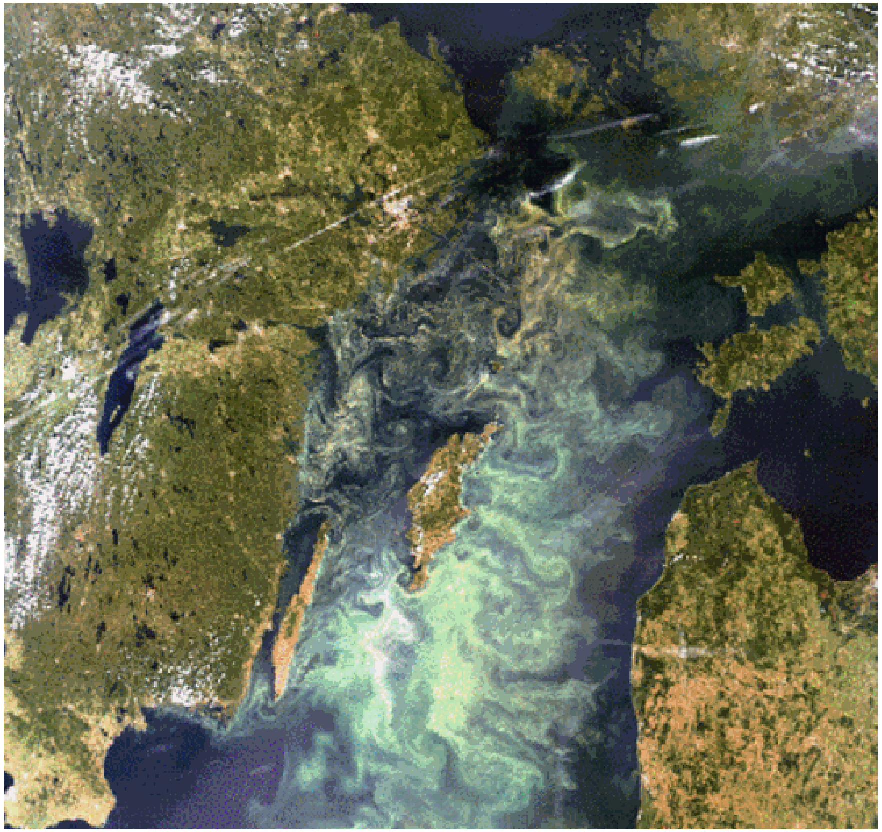
Jan Anderssons dykeri

What is special with the Baltic Sea?

- Low salinity: Smaller and more slow-growing mussels than sold on today's European market
- Risk for ice-cover and drift ice
- Blue mussels make up 80% of invertebrate biomass
- High nutrient levels: mussel cultivation is a rewarding tool for diffuse nutrient removal

Why not use mussel farms to combat eutrophication?





https://www.smhi.se/en/theme/algal-blooms-in-the-baltic-sea-1.11006

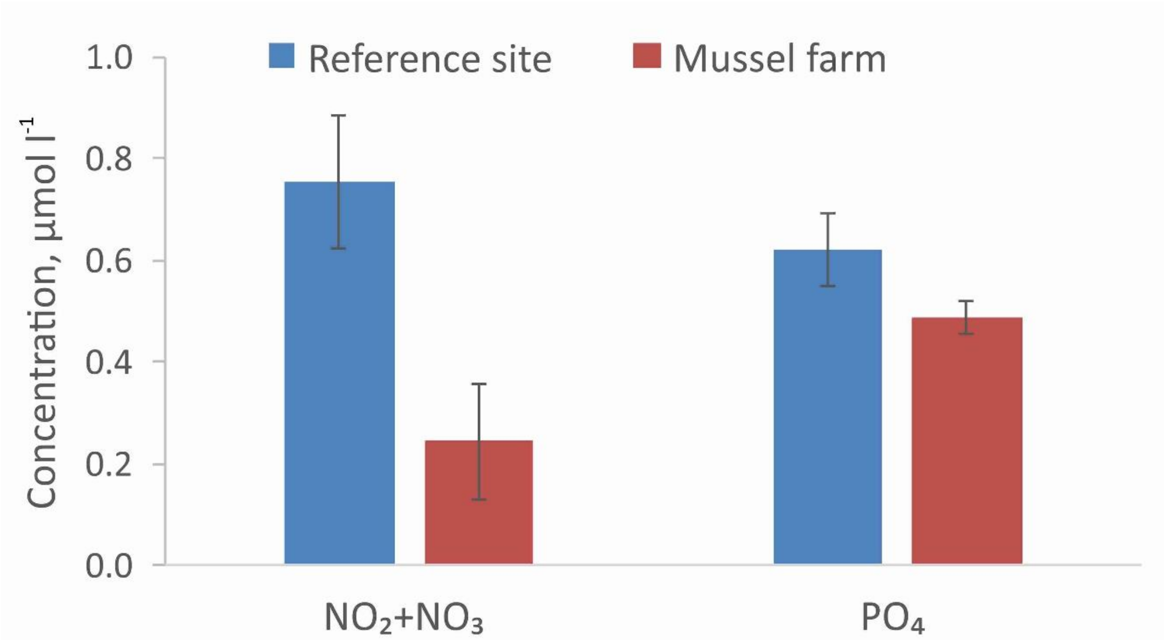
Environmental issues under BBG

- Identify areas in the Baltic Sea having environmental **conditions** conducive to mussel production
- Quantify the potential environmental **impacts** of mussel farms.
- Communicate this to stakeholders and thereby support balanced and **environmentally friendly mussel farming** in the Baltic Sea.

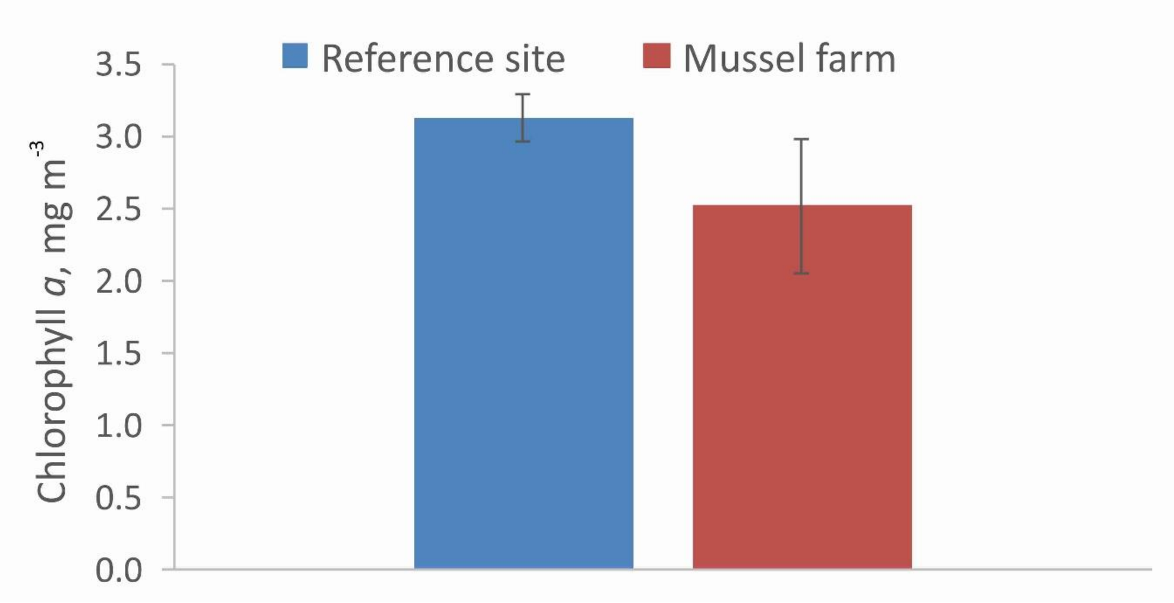
The Vormsi Agar farm (EE)

- Private company
- From 2015
- Net strings, 45mm mesh size

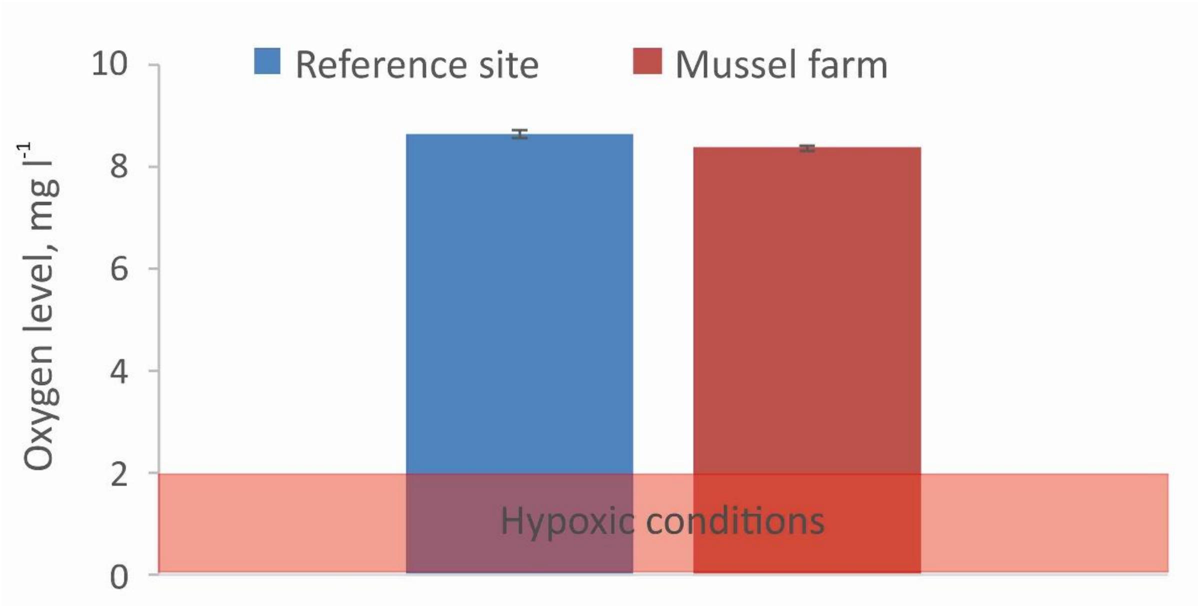
Vormsi farm monitoring



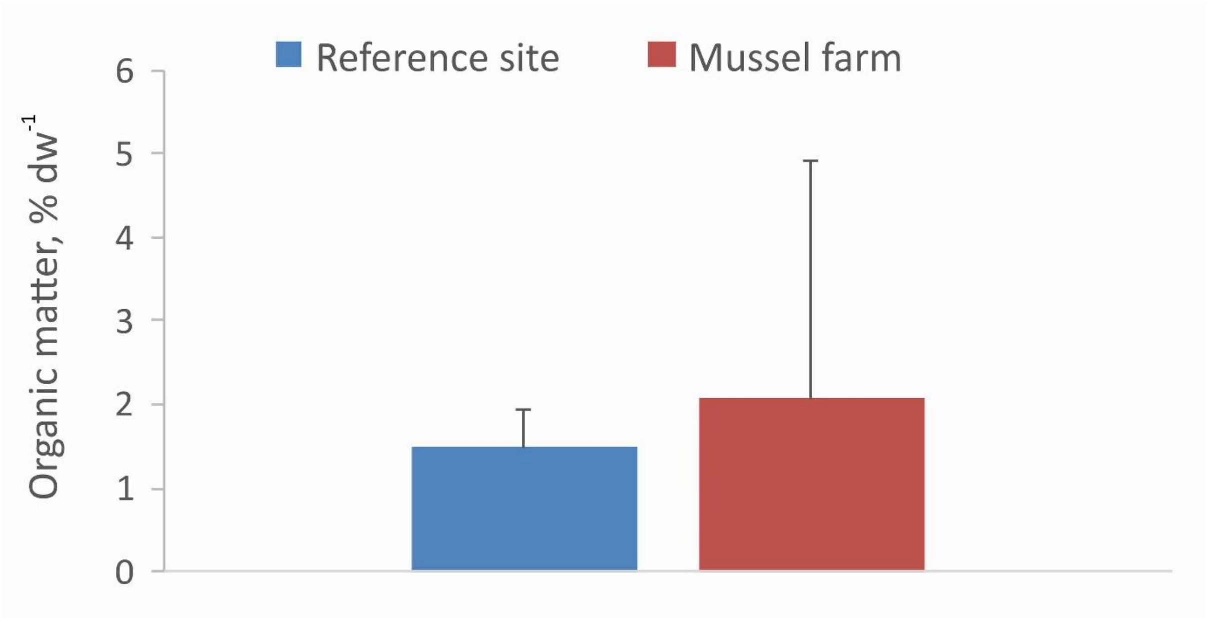
Vormsi farm monitoring



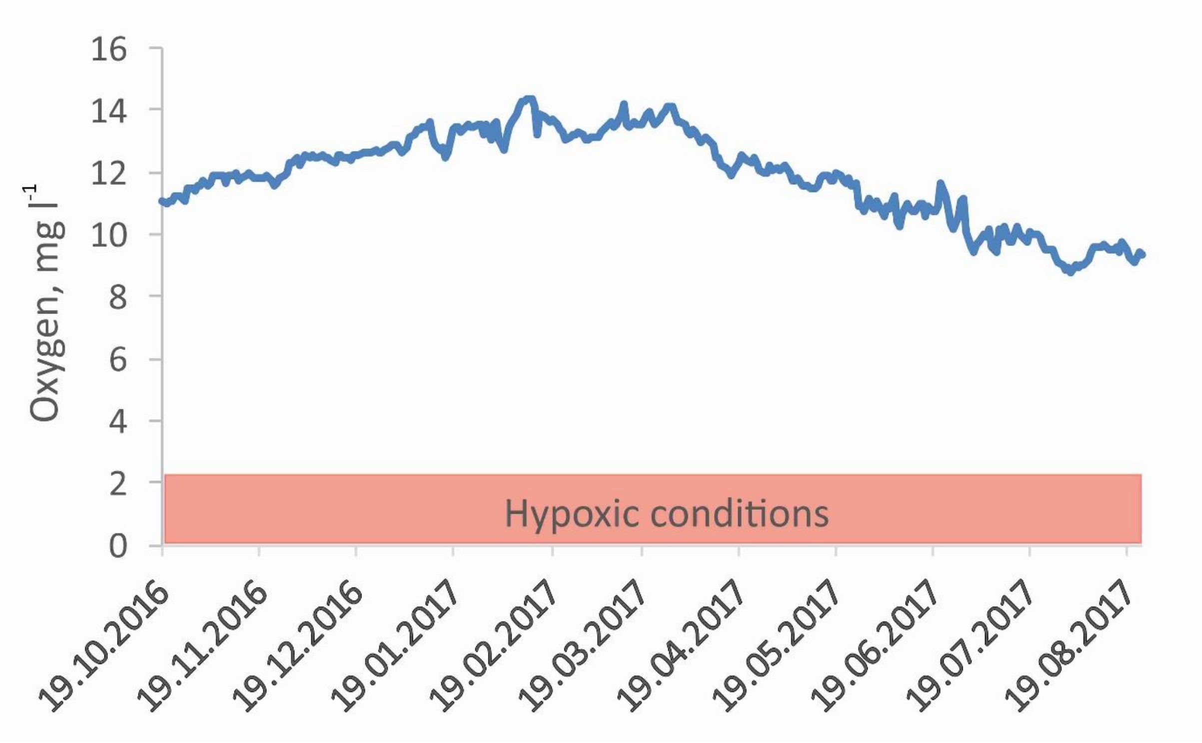
Vormsi farm monitoring



Vormsi farm monitoring



Vormsi farm monitoring



Continuous measurement of oceanographic conditions under mussel farm

What did we learn so far?

- **Mussel farm has no adverse environmental impacts.**
- **Mussel farm significantly reduces nutrient concentratons in the water column.**

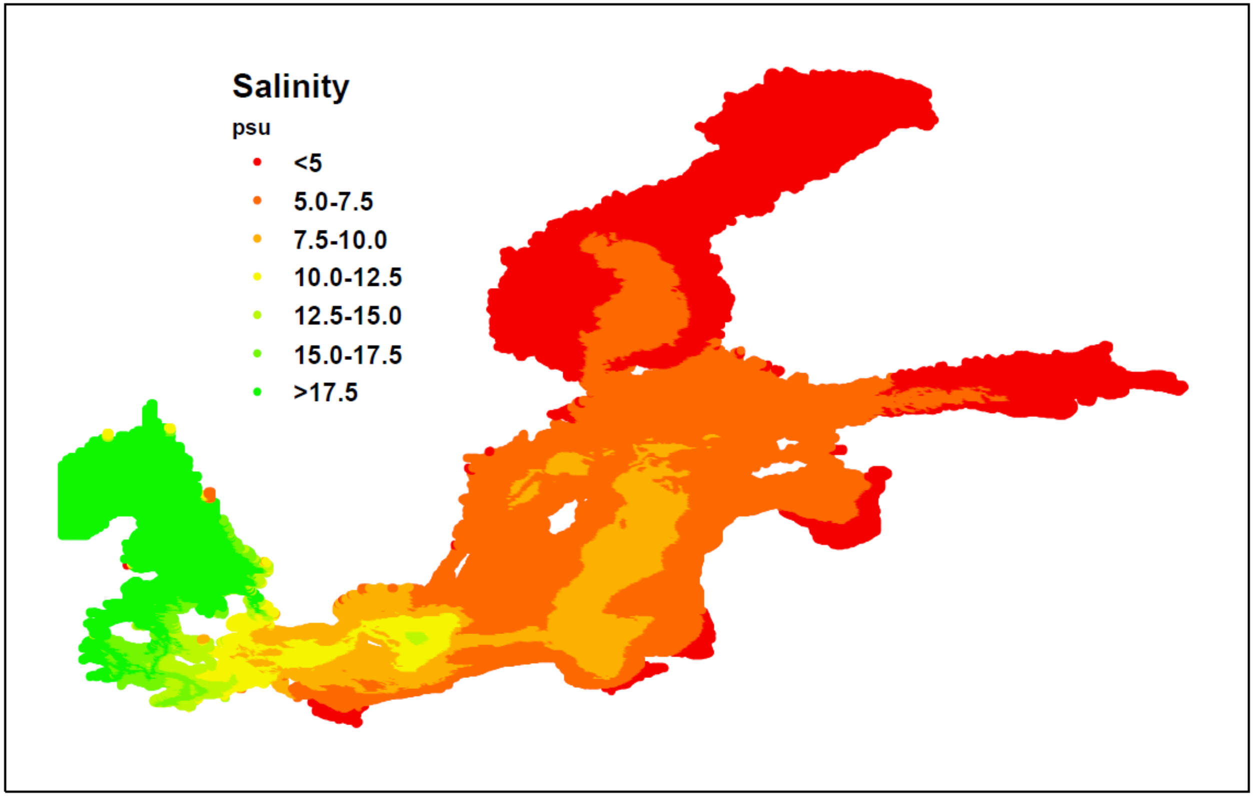
Modelling nutrient removal by farmed mussels

- Estimate of nitrogen (N) and phosphorus (P) removal per metre rope
- Produce estimates for project farms and the whole Baltic
- Rely on published equations and relationships as much as possible
- Use Copernicus pan-Baltic environmental data to force model
- Calibrate against real farm mussel measurements

Constraints to mussel growth

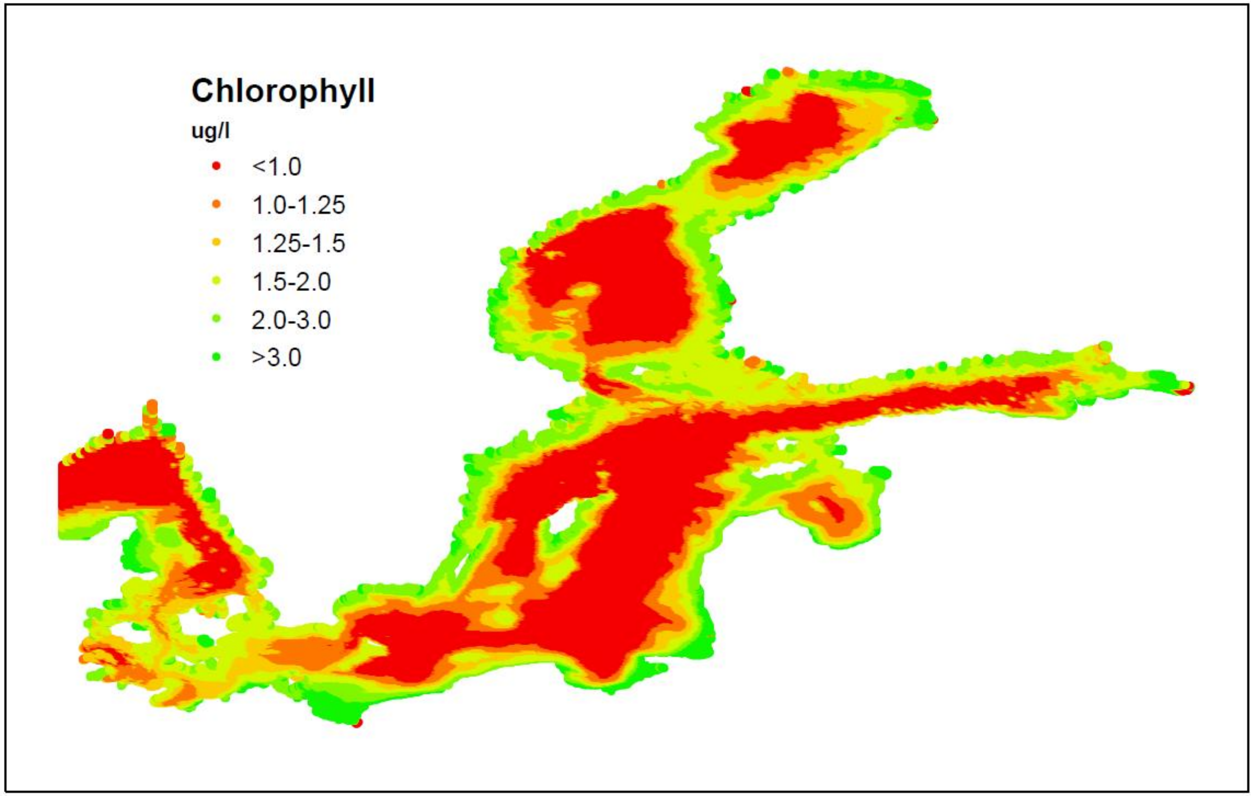
- **Salinity**
- **Food availability (chlorophyll)**
- Temperature
- Crowding
- Other factors (e.g. predation, algae, etc.)

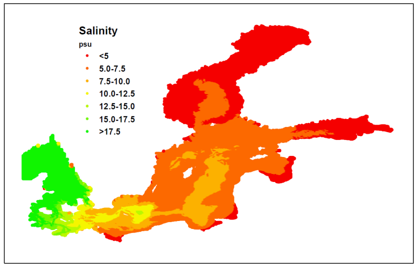
Limits to mussel growth - salinity



Blue mussel cannot survive salinities below 4 psu

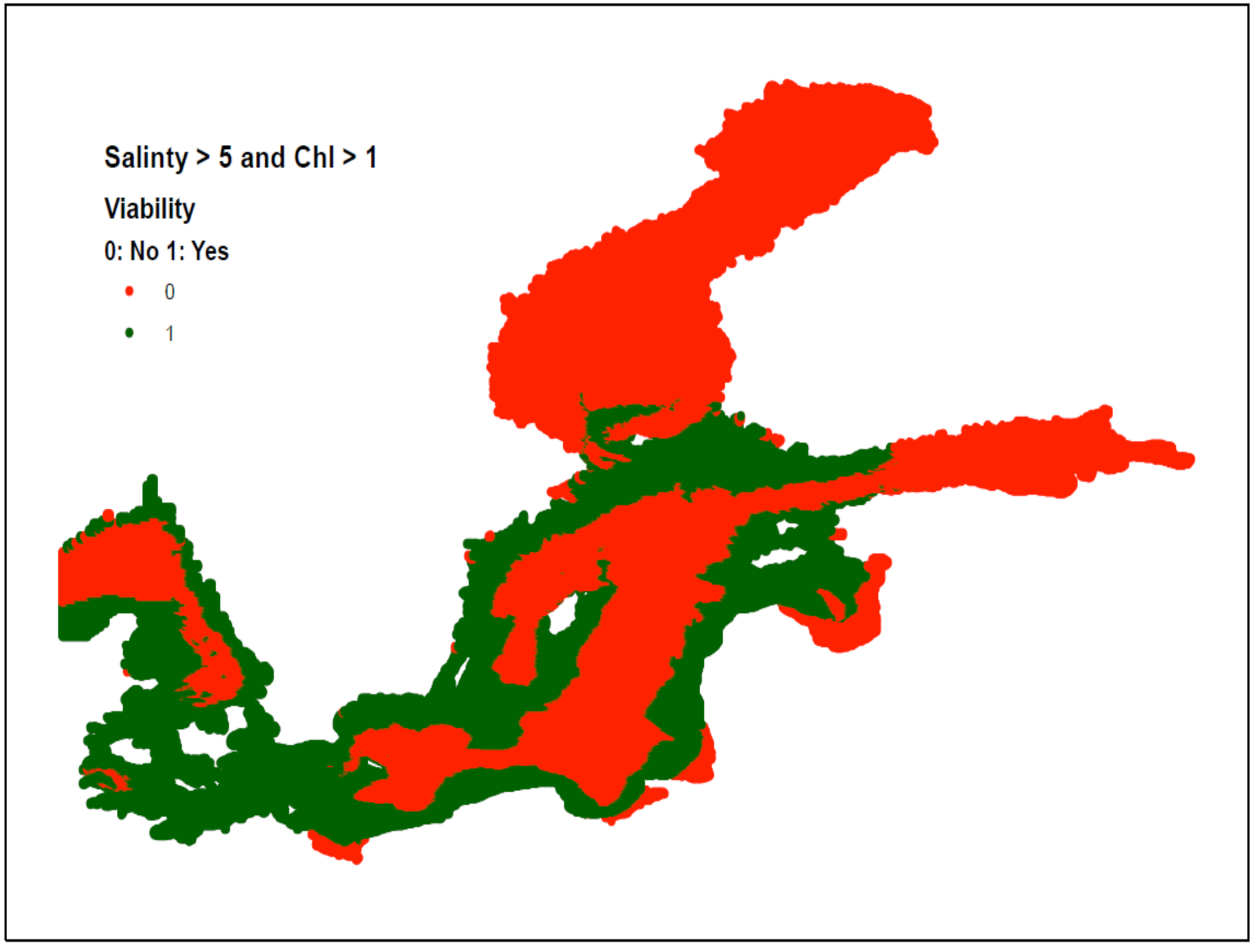
Limits to mussel growth - chlorophyll

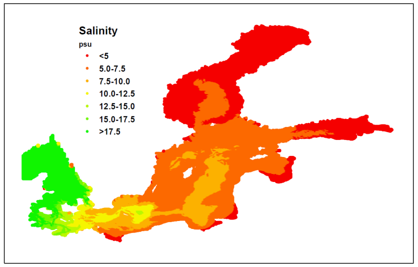


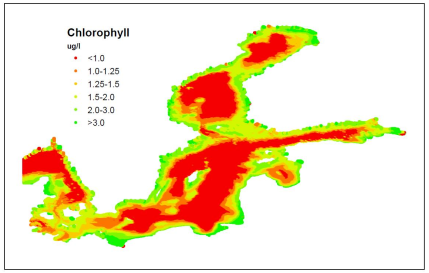


Elevated chlorophyll a concentration improves growth rates of blue mussel but too high concentrations are no good

Viable regions for mussel growth from farming perspective



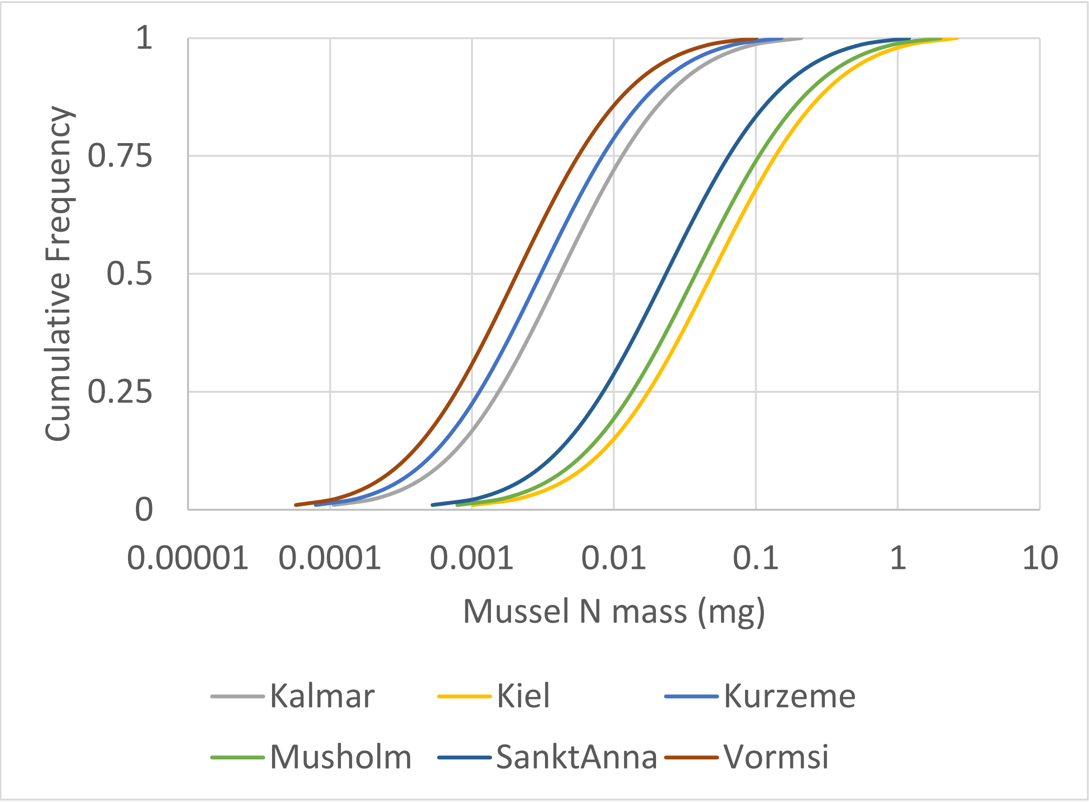




Stoichiometry: elemental composition of soft tissues

Element	Percent
Nitrogen	7.79
Phosphorus	0.54
Carbon, etc.	91.67

Modelled N removal per individual

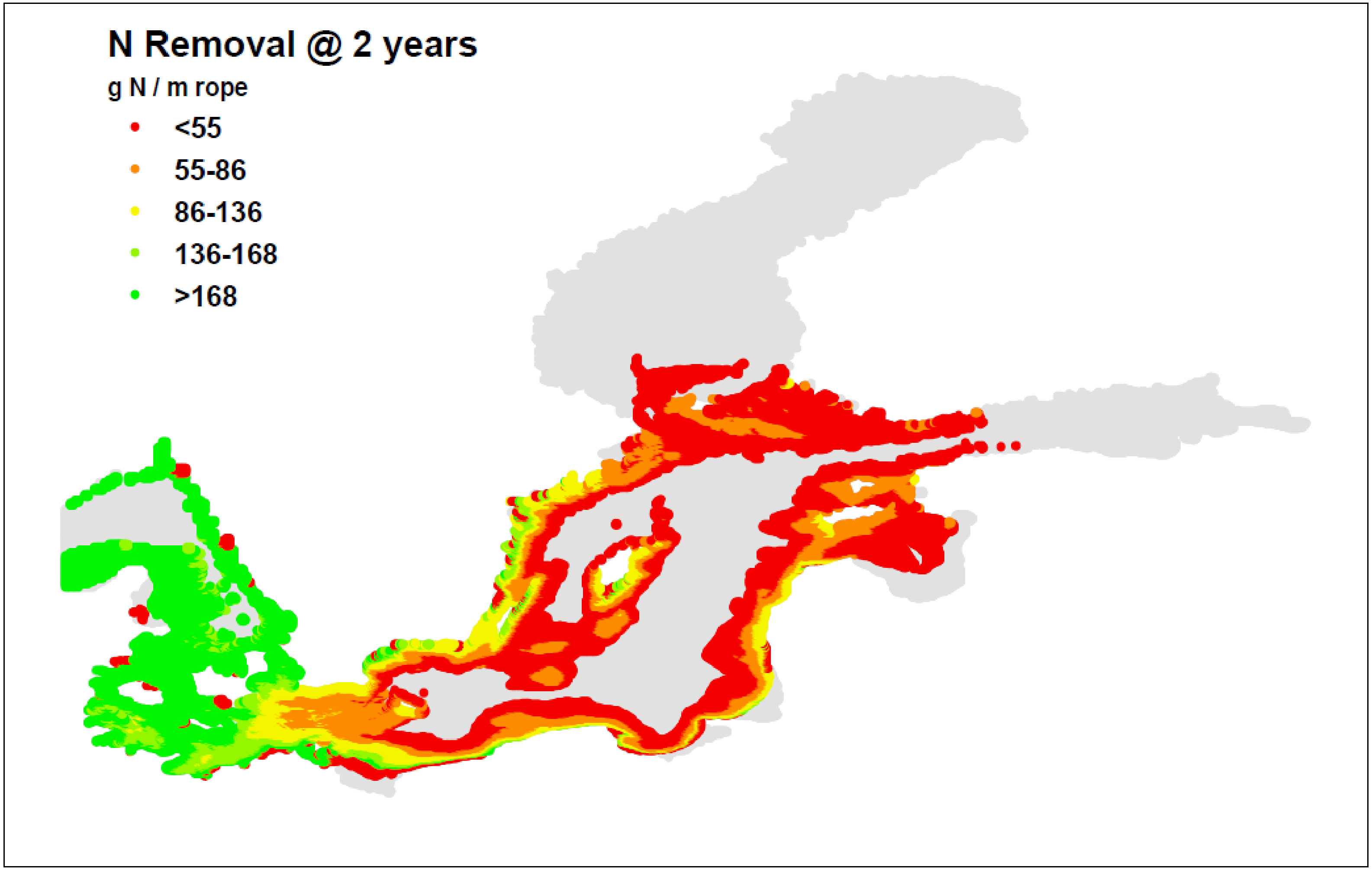


Upscaling

Farm	N	P
Kiel	230	16.0
Musholm	200	14.0
Sankt Anna	150	10.5
Kalmar	60	4.0
Kurzeme	50	3.5
Vormsi	40	3.0

g N or P per metre rope during 2 years of incubation

Preliminary Estimates of N removal



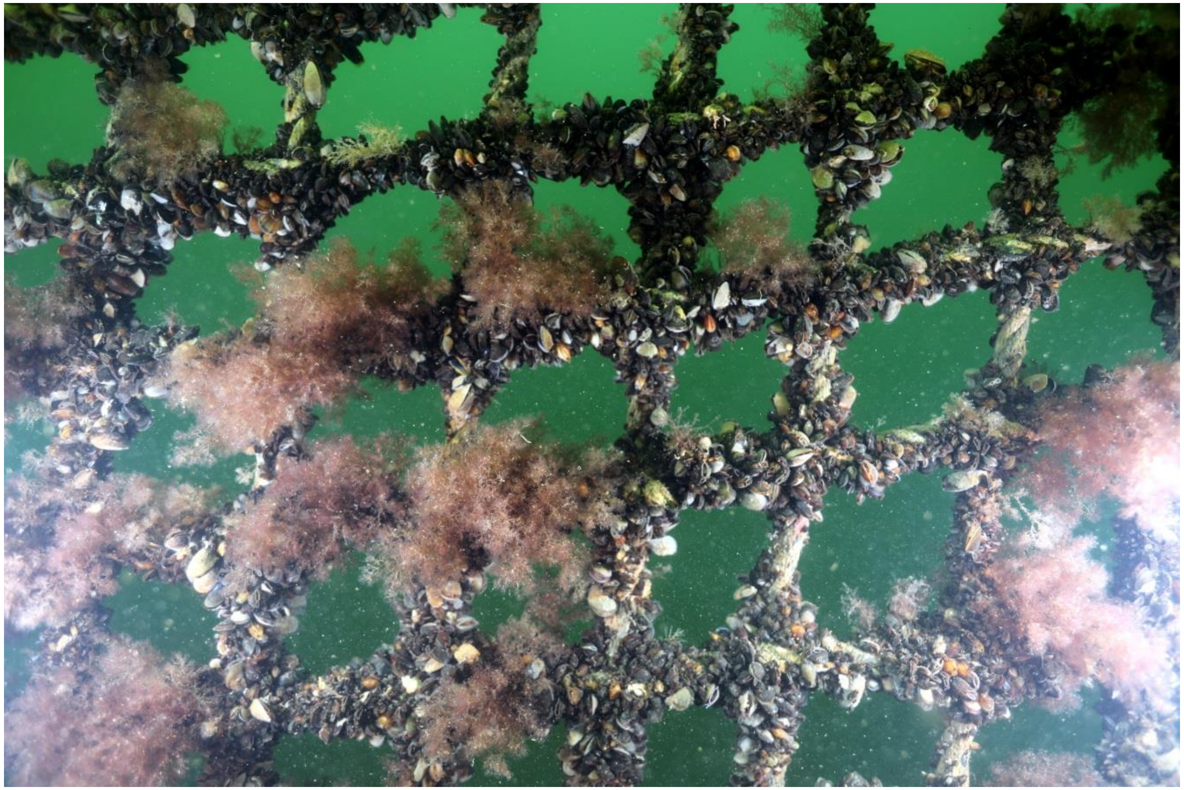
What did we learn so far?

- **Mussel farms are a rewarding (low cost) tool for nutrient removal, especially in highly eutrophicated embayments. In such environments higher temperatures and better food availability yield better mussel growth.**
- **An „average“ mussel farm with dimensions of 200-300 m in the northeastern Baltic Sea can remove 1-4 tons of nitrogen in each year.**
- **In order to achieve such a production potential, there is an utmost need to experimentally compare available methodologies in field as different sites require different approaches/cultivation techniques.**
- **To date, private companies still fail to develop such innovative capabilities only by themselves.**

Acknowledgements

This study is supported by European Regional Development Fund, INTERREG Baltic Sea Region project Baltic Blue Growth "Initiation of full scale mussel farming in the Baltic sea" and the Estonian Research Council

Thank you for your attention!



Baltic Blue Growth

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A. Maximov

Interannual and long-term changes in the benthic communities: analysis of 30-years data series from the eastern Gulf of Finland

Interannual and long-term changes in the benthic communities: analysis of 30-years data series from the eastern Gulf of Finland

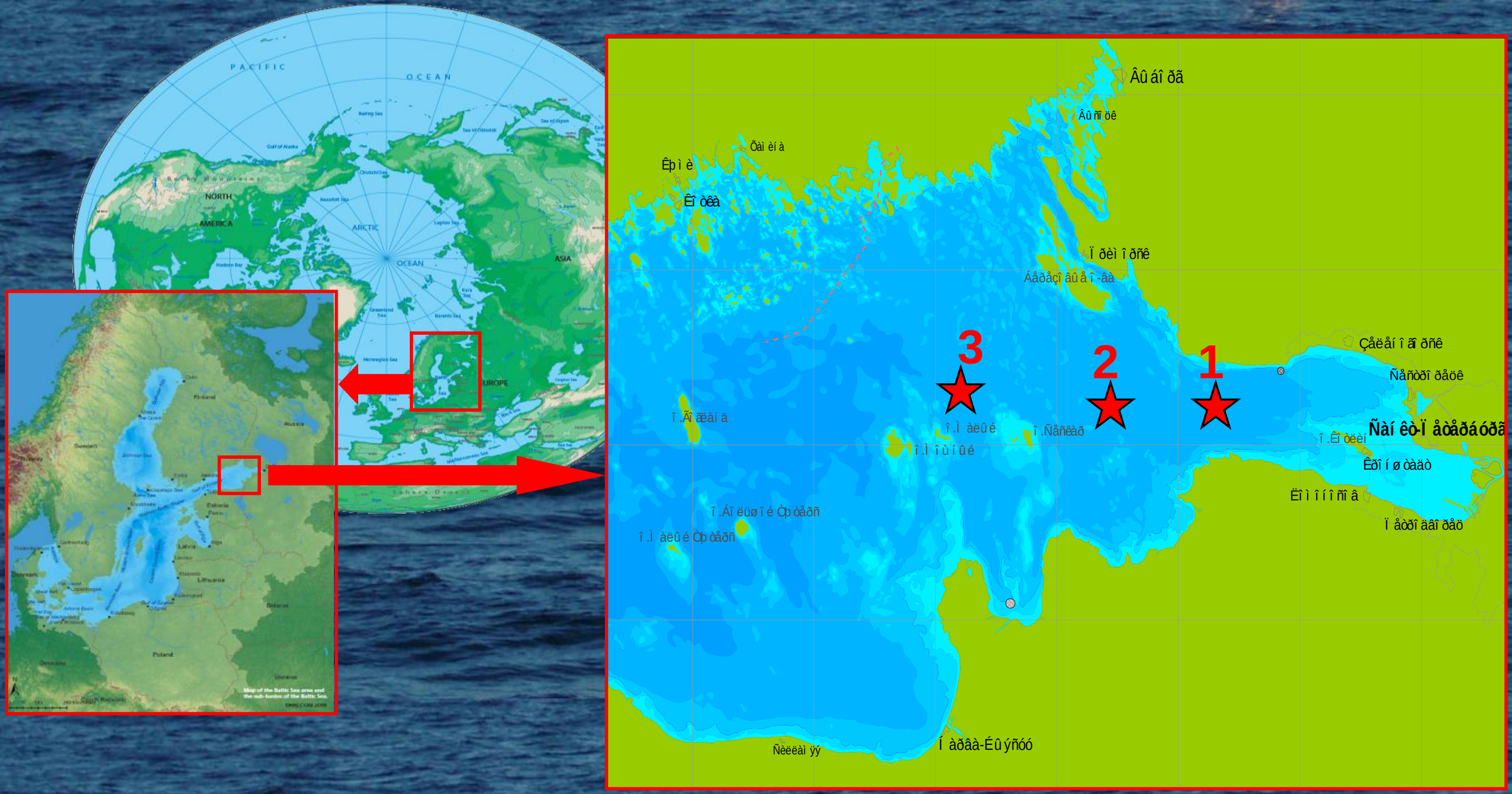
Alexey Maximov

Zoological Institute Russian Academy of Sciences

ЗООЛОГИЧЕСКИЙ ИНСТИТУТ РАН 1832

Gulf of Finland Co-operation

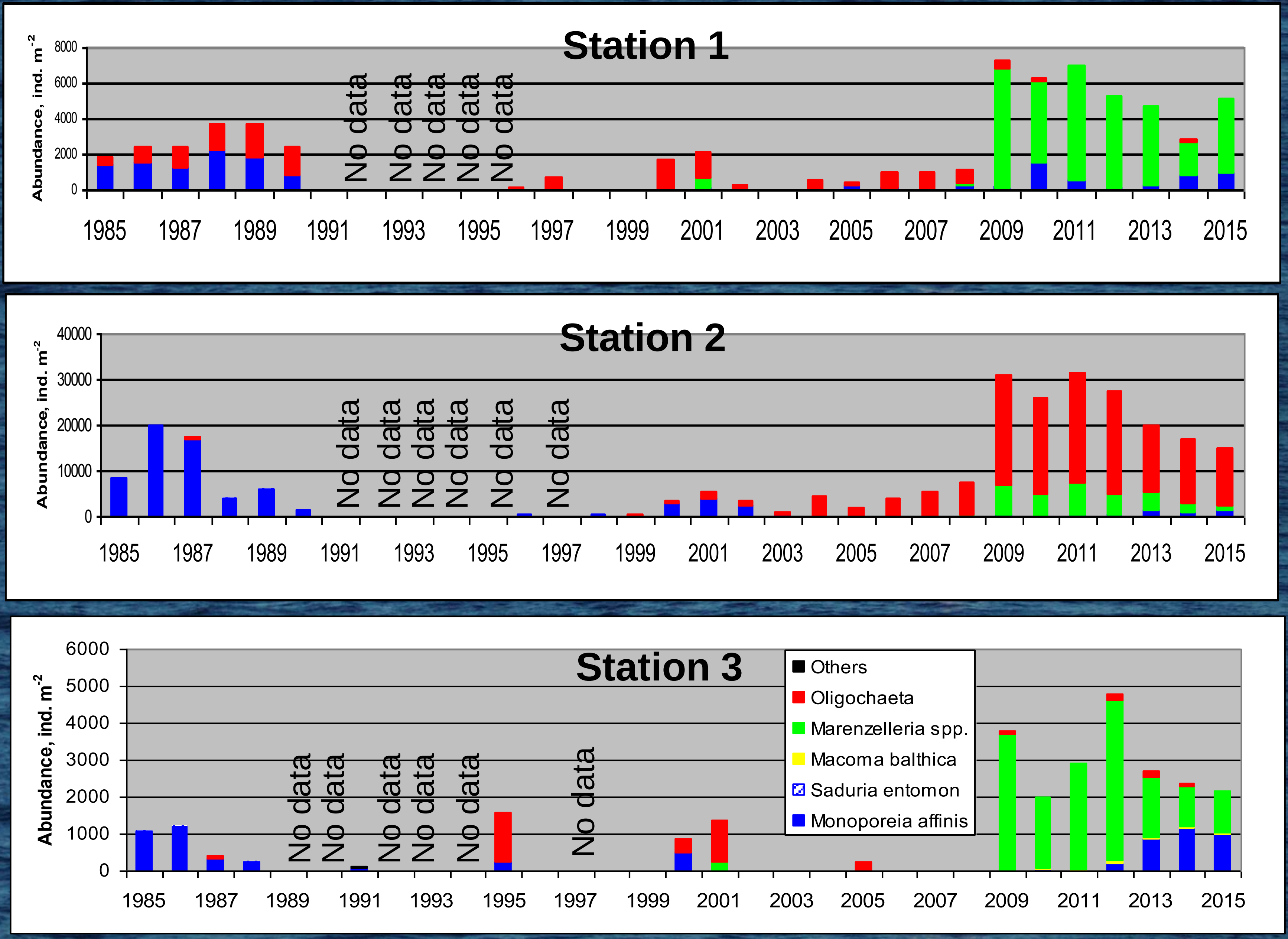
Study area



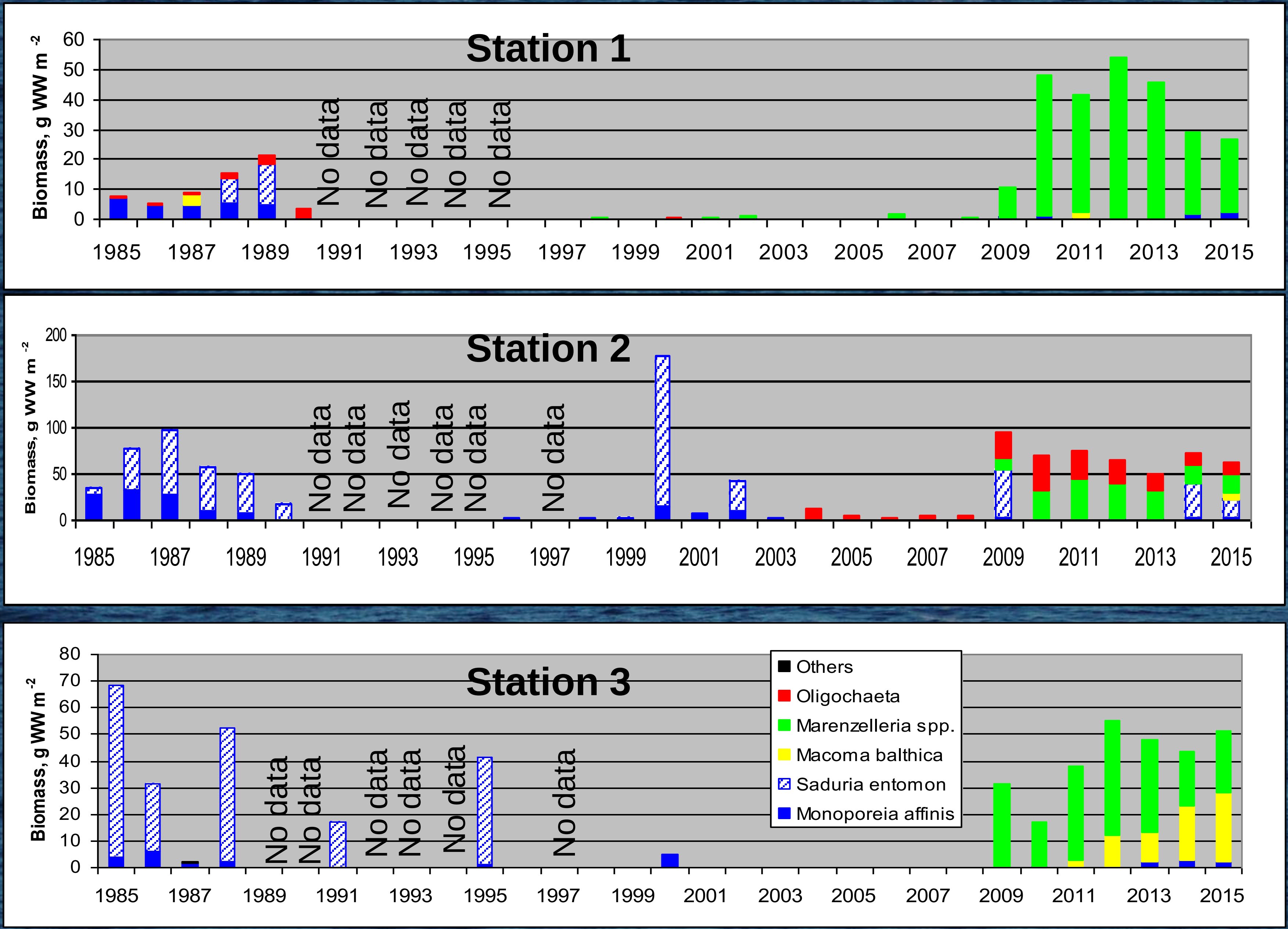
Area ~ 12 000 km^2
Maximal depth – 75 m
Mean depth ~ 22 m
Near bottom salinity – < 8 psu

Site	Depth, m	Salinity, psu
1	30	~5
2	36	~6
3	50	~7

Changes in abundance (ind. m^{-2}) of macrobenthic species at study sites in 1985-2015 (July – August data).



Changes in biomass (g WW m^{-2}) of macrobenthic species at study sites in 1985-2015 (July – August data).



The great interannual fluctuations are very common for Baltic populations of glacial relict amphipods *Monoporeia affinis* . These fluctuations are cyclic (6-7 years) and are explained by intraspecific competition for limited food resources and density dependent factors (Sarvala, 1986; Lehtonen, Andersin, 1998; Wenngren, Ólafsson, 2002).

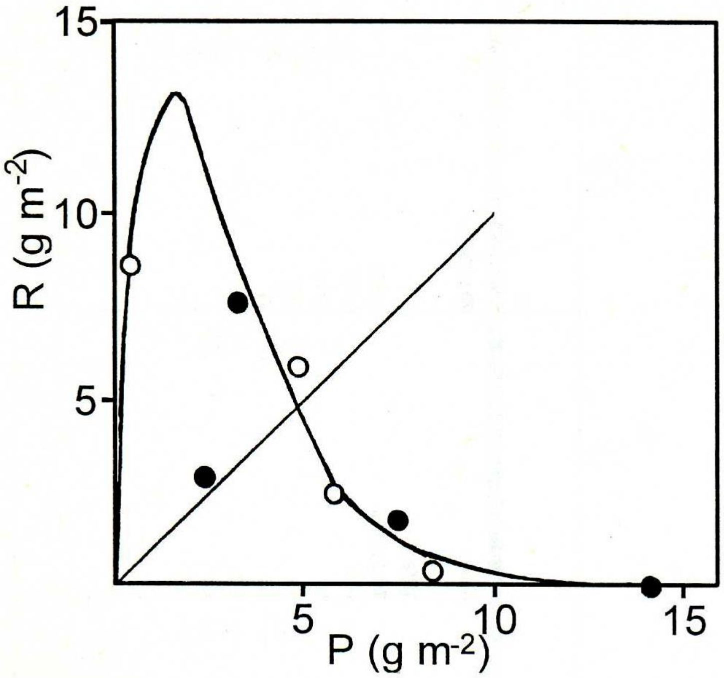


Figure 5. Reproduction curve. Biomasses of parental (P, g m^{-2}) and filial (R, g m^{-2}) generations before reproduction (biomass in September-October) at station No.1 (open circles) and station No.2 (filled circles). The equation is: $R = P\ e^{3,2(1- P/4,7)}$.

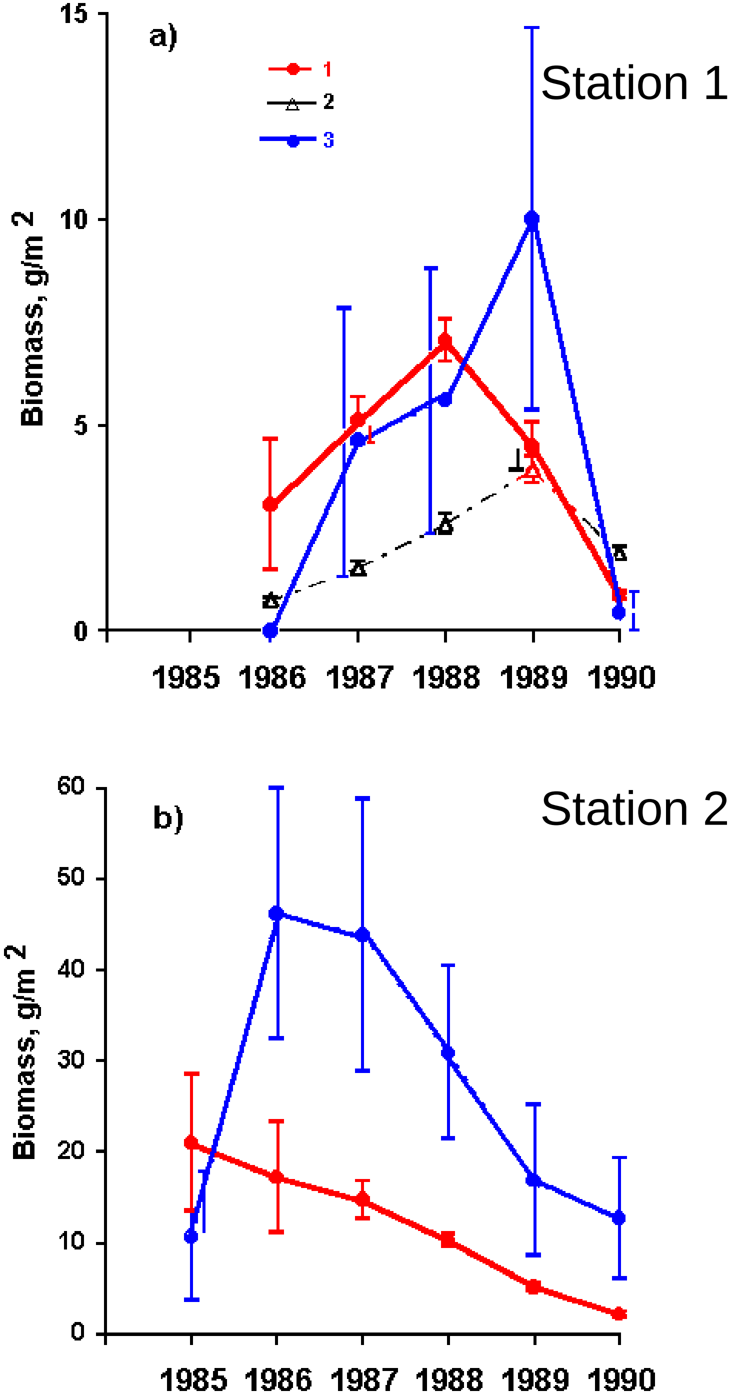
At sites 1 and 2 abundance fluctuations of *M. affinis* were specially studied in 1980s (Maximov, 1996,1997). This study confirmed the important role of inraspecific density-dependent factors in abundance regulation.

Competition results in negative relationship between biomass of parental and filial generations.
This type of reproduction curve should generate 6-7 year population cycles (Ricker, 1975).

Maximov, 1996

Mean annual biomass (±S.E.) of main macrobenthic species at Station 1 (depth 30 m) and Station 2 (depth 36 m) in 1985 – 1990.

All dominant species exhibited similar trends: biomass of predatory *Saduria entomon* followed the changes of populations of its victims *Monoporeia affinis* resulting in considerable variations of biomass of whole macrobenthic community



1– *Monoporeia affinis*
2 – Oligochaeta
3 – *Saduria entomon*

Maximov, 1997

Amplitude of interannual variations is significant. From 1985 to 1990 at study stations the mean annual biomass changed 4 – 6 times.

… but interannual variations are not synchronic at different sites

Period	Biomass g m^{-2}	Reference
1965-66	9	[285]
1969-72	27	[358]
1987	27	unpubl. res.
1990	28	[610]
1991-92	25	unpubl. res.
1995	21	unpubl. res.

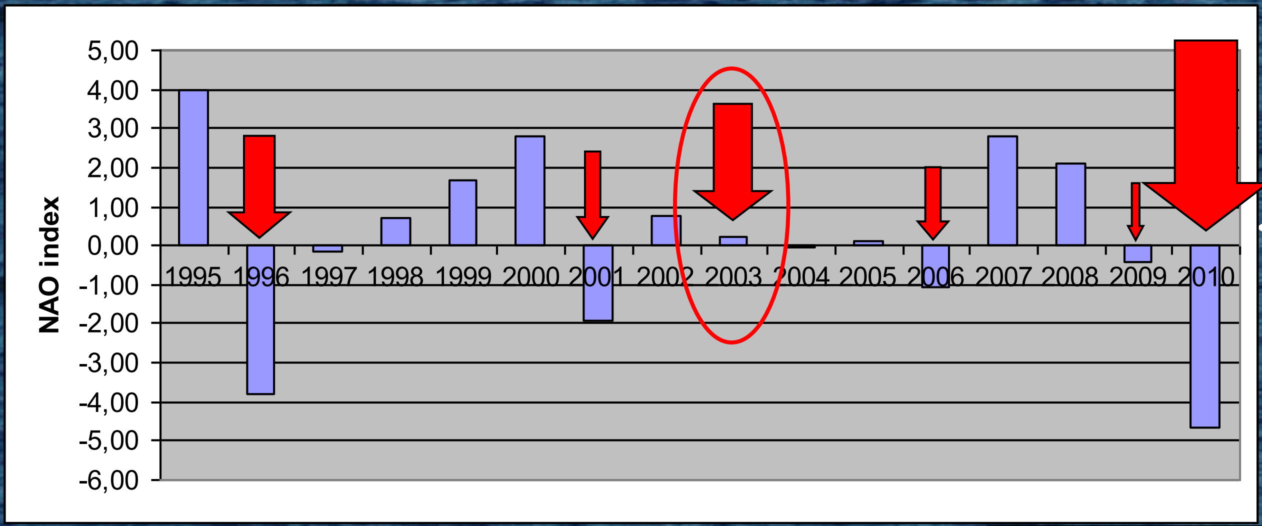
Table 4.2.5 *Average macrozoobenthos biomass values for the eastern Gulf of Finland*

Averaged data over more extensive water areas did not demonstrate considerable difference.

During almost 30-year period (1969 – 1995) the mean macrozoobenthos biomass values in the eastern Gulf of Finland varied within narrow range between 21 and 28 g WW m^{-2}

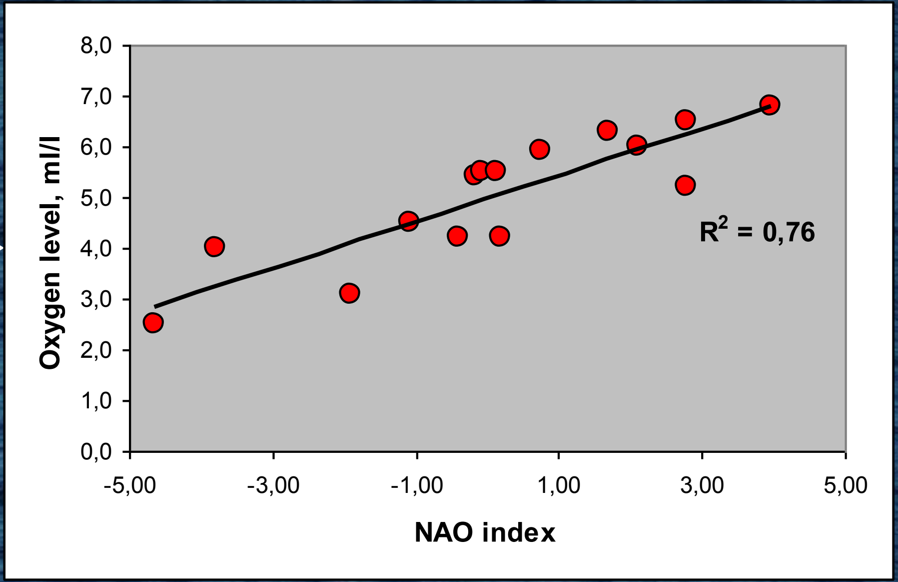
HELCOM, 1996

The more long-term and large-scale changes were triggered by periodical hypoxic events leading to mass mortality of benthic organisms. These events were connected with basin-wide variations of hydrographic conditions in the Baltic Sea controlled by large-scale climatic factors



Winter Index (Hurell, 1995) of the North Atlantic Oscillation (NAO) and hypoxic events in the eastern Gulf of Finland (red arrows)

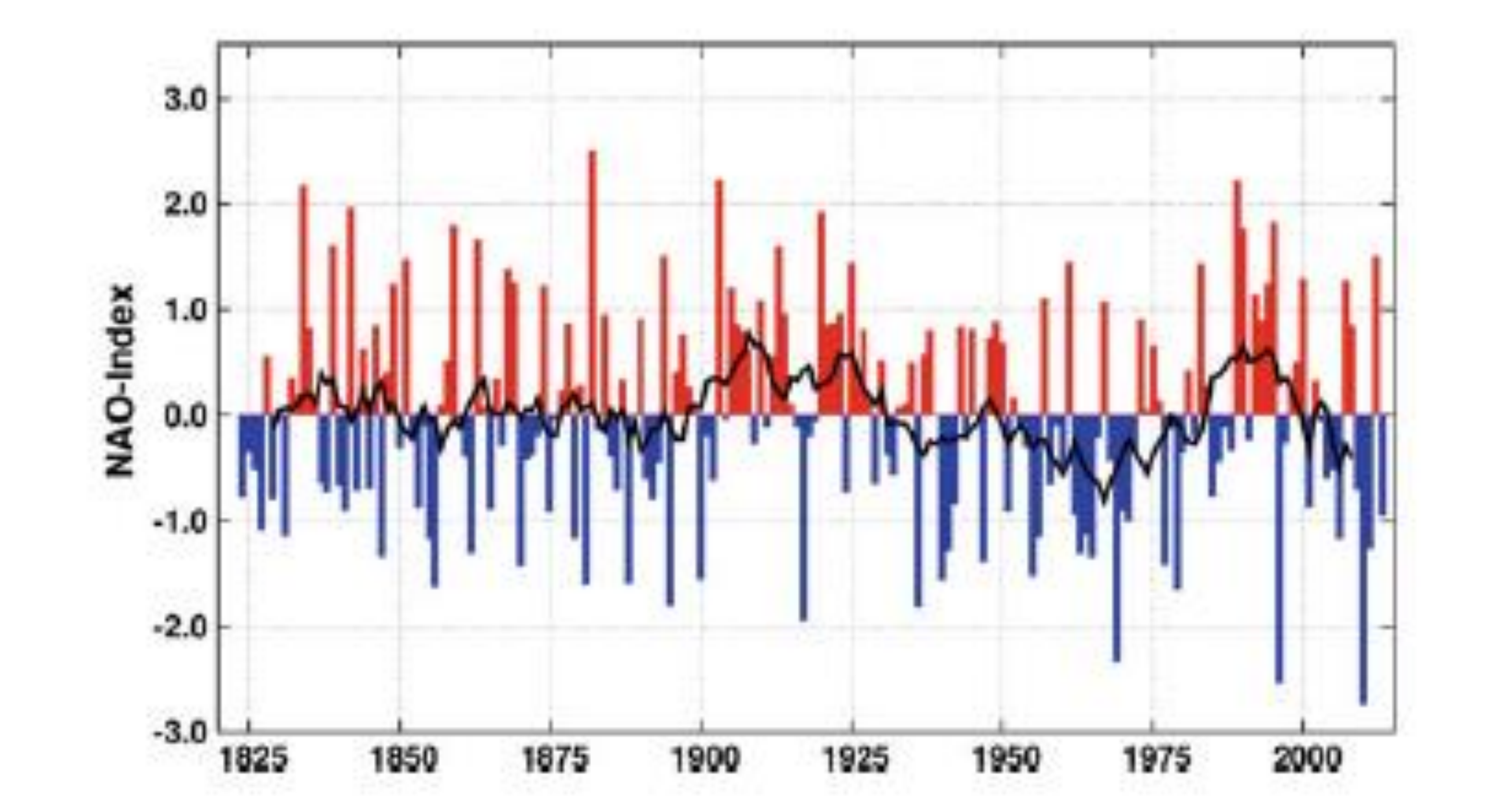
Correlation between mean oxygen level in the eastern Gulf of Finland (depth 40 m, 1995-2010) and winter index of the North Atlantic Oscillation



NAO Index data provided by the Climate Analysis Section, NCAR, Boulder, USA, Hurrell (1995)

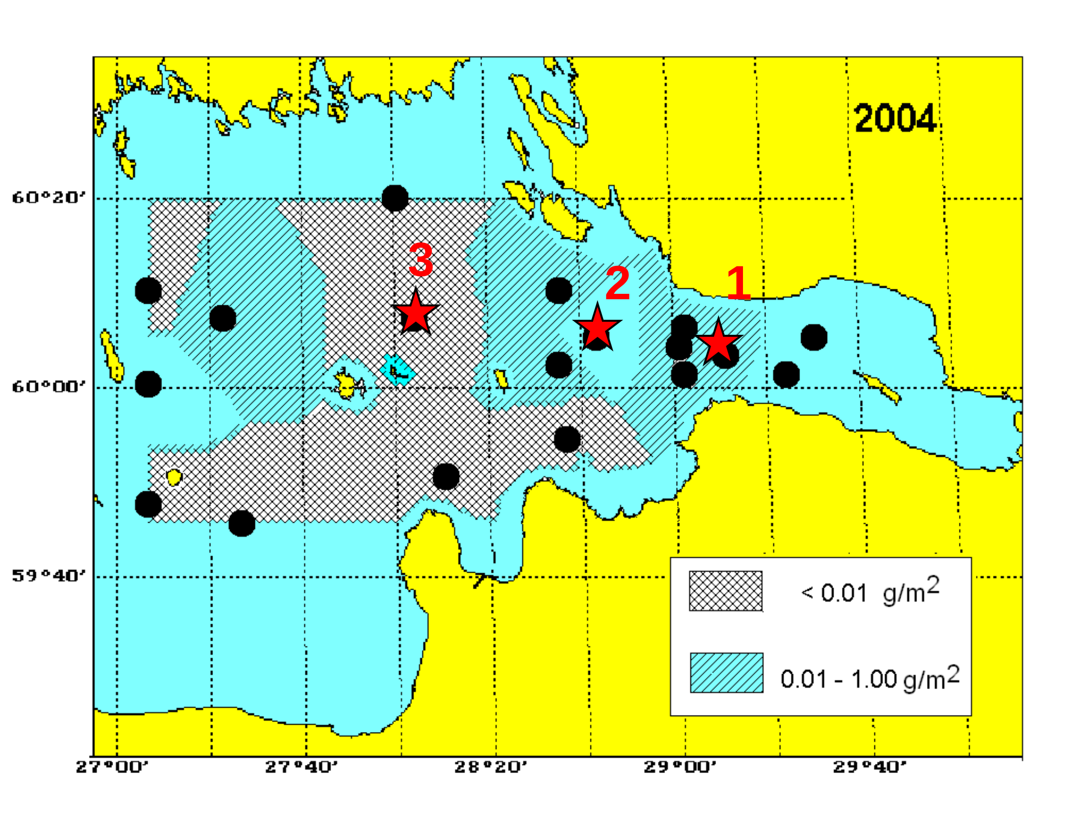
Eremina, Maximov, Voloshchuk, 2012

The NAO index demonstrates considerable inter-decadal variability. The first hypoxic event during study period coincided with return to the strong negative phase of the North Atlantic oscillation (NAO) in 1996 after 15yr period of positive-phase NAO conditions.
The repeated hypoxic events in early 2000s leaded to strong impoverishment of benthic communities in areas that were affected by hypoxia.



Rutgersson et al., 2015

The spatial scales of hypoxic events are large

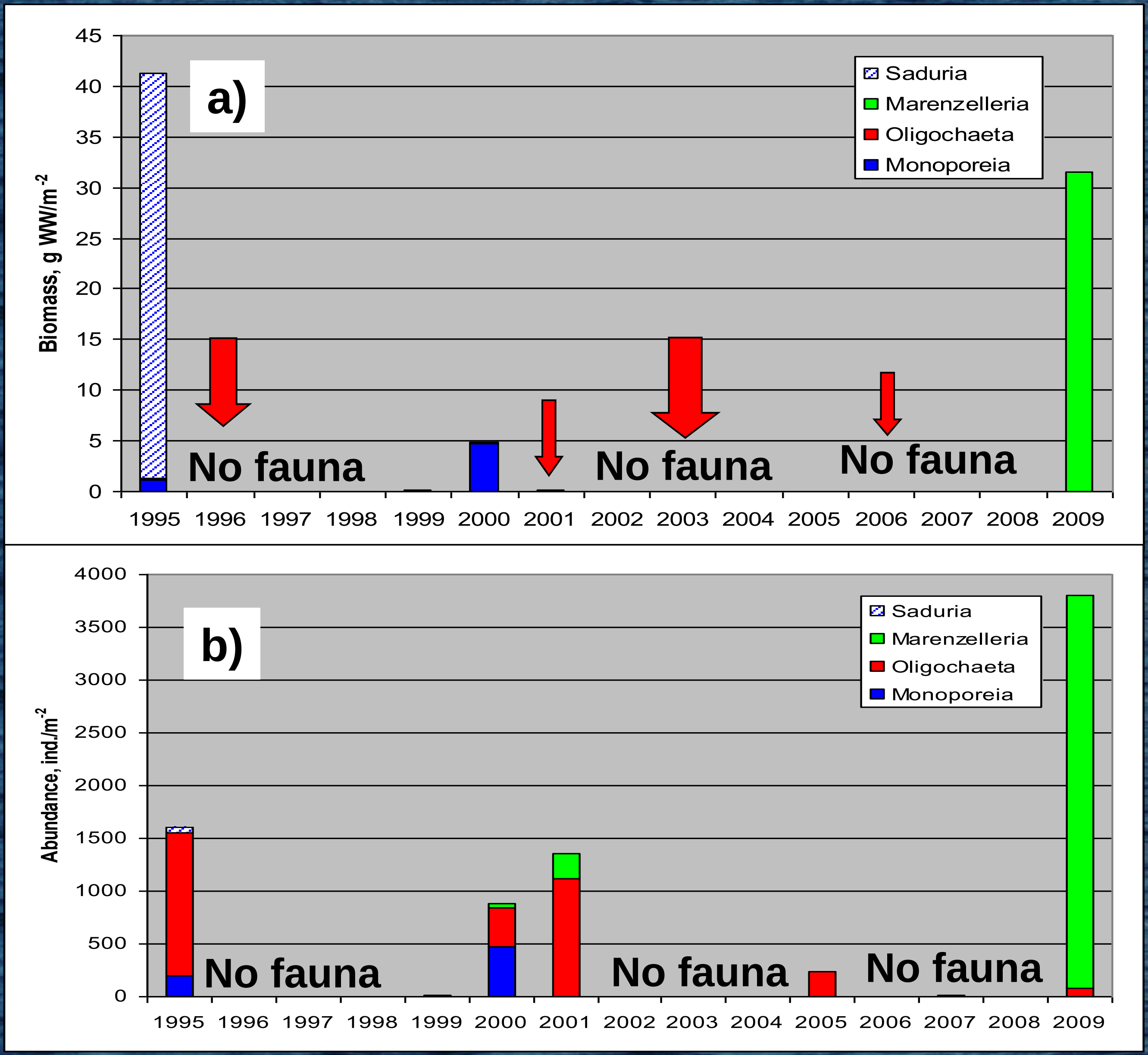


The distribution of defaunated and impoverished benthic communities (biomass < 0,01 g WW m^{-2}) in 2004

Hypoxic events leaded to the formation of extensive life-less or strongly impoverished bottom areas.

Maximov, 2008

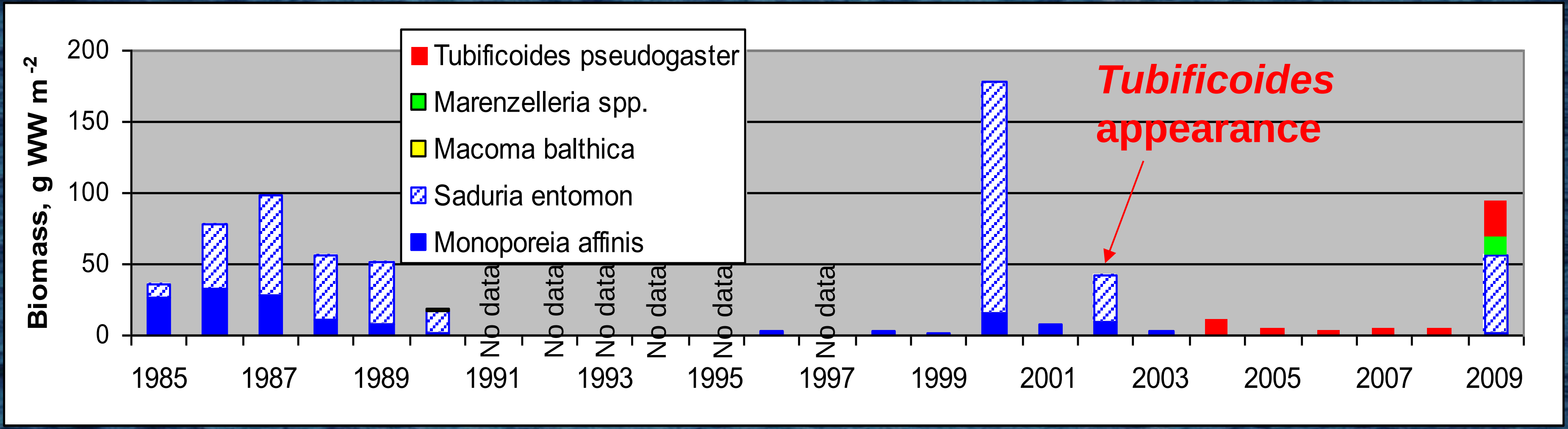
Hypoxia-induced changes were the most considerable at the deepest study station 3 where total disappearance of macrofauna was recorded



Changes in biomass (a, g WW m^{-2}) and abundance (b, ind.m^{-2}) of macrobenthic species at station 3 (depth 50 m) in 1995-2009.
Red arrows are hypoxic events.

On non-affected by hypoxia Station 2 the native crustaceans-dominated community was replaced by new for the Gulf of Finland species –oligochate *Tubificoides pseudogaster*

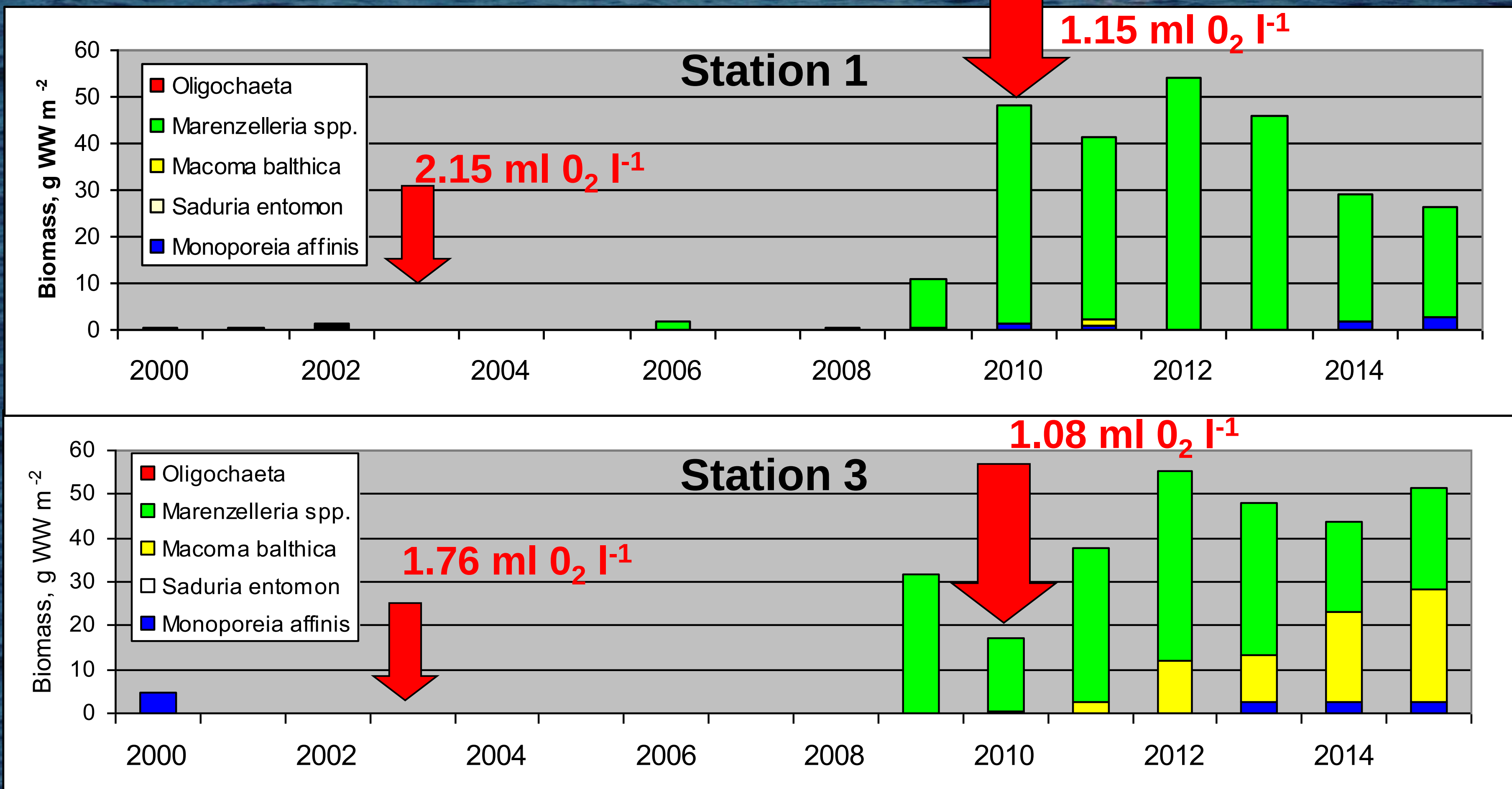
Changes in the biomass (g WW m^{-2}) and composition of bottom macrofauna at station 2 (depth 36 m)



In 2009 this site was invaded by polychaete *Marenzelleria arctia*

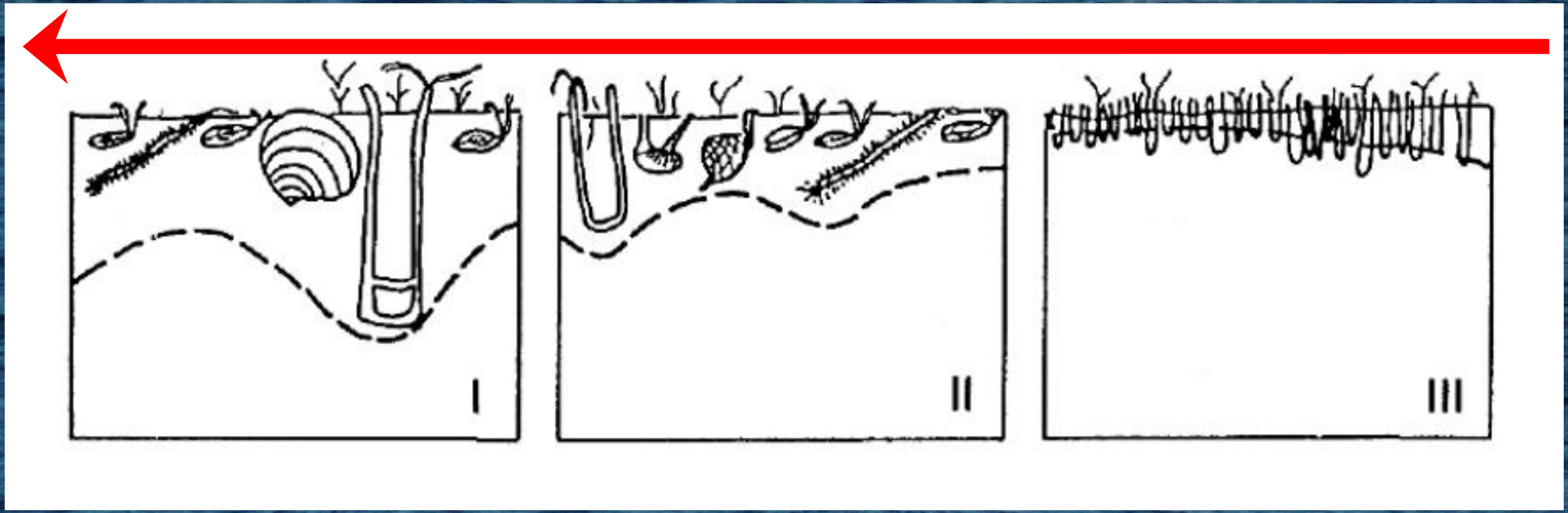
At sites, where macrofauna early was killed by oxygen depletion, introduction of hypoxic-tolerant polychaetes compensates for negative effects of hypoxia. Biomass increased drastically despite of the record low oxygen level in 2010

Changes in biomass (g WW m^{-2}) of macrobenthic species at sites 1 and 3 in 2000-2015



In contrast to the reversible population cycles and climate-driven variations invasion-induced changes can be characterized as irreversible regime shifts resulting in formation of new alternative communities.

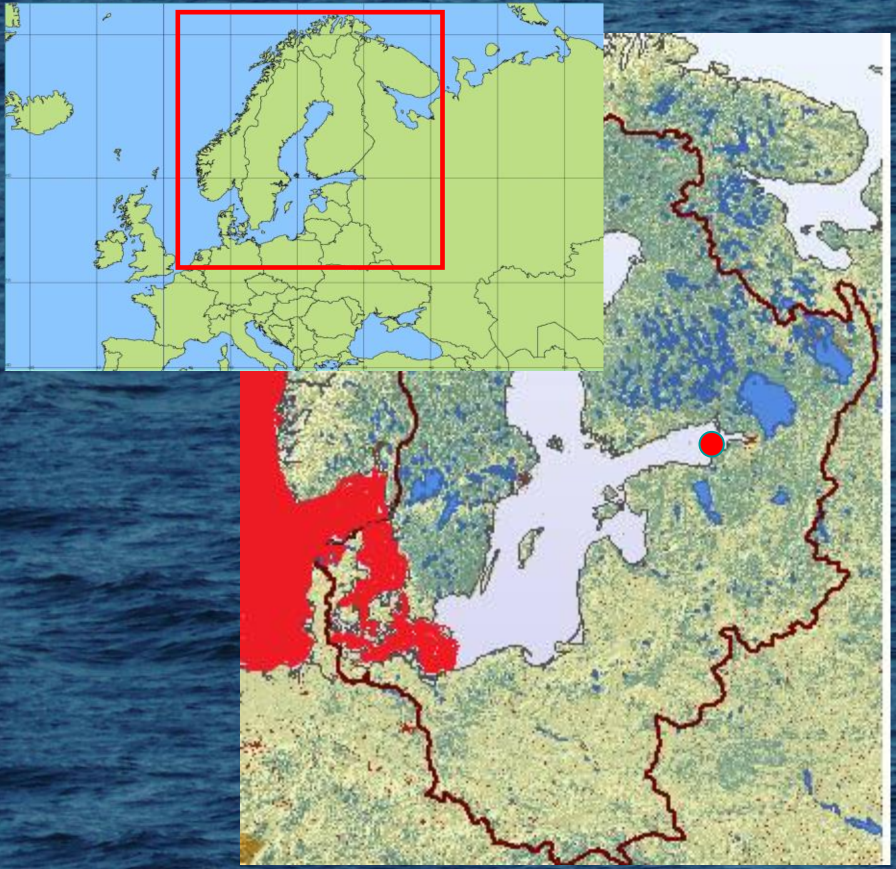
This shift is consistent with the general model of zoobenthic succession in Baltic sedimentary habitats predicting a few successional stages with final "climax community" dominated by deep-burrowing species (Rumohr et al., 1996)



Rumohr et al., 1996

The appearance of new species is in line with the concept of continuing postglacial succession of the Baltic Sea (Bonsdorff, 2006). The both species are representatives of two main components of Baltic fauna.

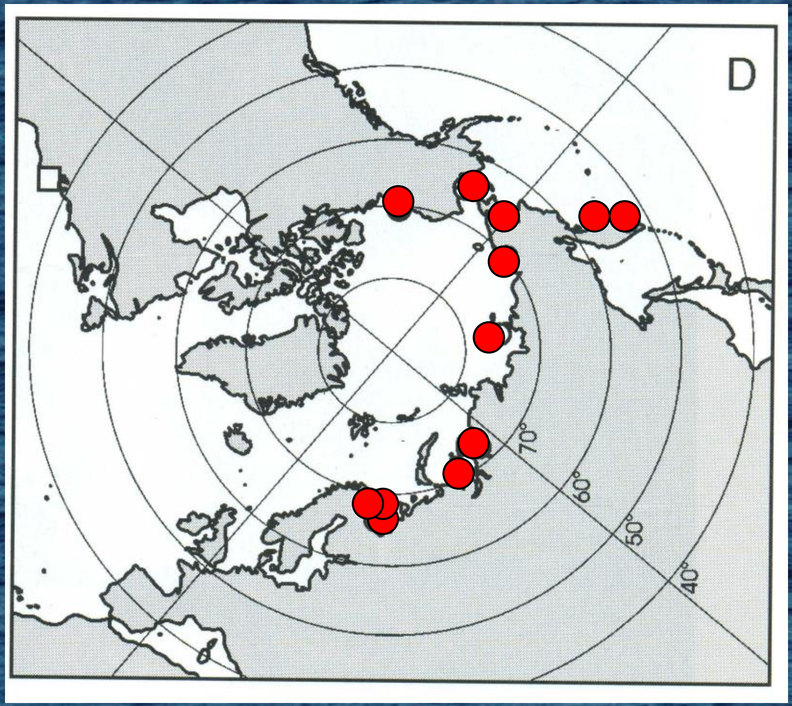
The majority of Baltic benthic species originate from estuaries and littoral zone of northwest Europe.



Distribution of *Tubificoides pseudogaster* in the Baltic Sea. Data source: HELCOM 2012

T. pseudogaster is one of the common and abundant macrobenthic species in the littoral zone and estuaries of the North Sea.

***Marenzelleria arctia* has arctic origin. It is species from estuarine arctic faunistic complex inhabiting mouth areas of large northern rivers.**



Distribution of *Marenzelleria arctia* in native area

Sikorski, Bick, 2004

In **Arctic estuaries benthic communities are strongly dominated by polychaetes *Marenzelleria arctia*, crustaceans *Saduria entomon* and *Monoporeia affinis*, priapulids *Halicryptus spinulosus* and bivalves *Macoma balthica* (*Denisenko et al. 1999*)**

Until recently, *Marenzelleria arctia* was the only species from this list that was absent in the Baltic Sea.

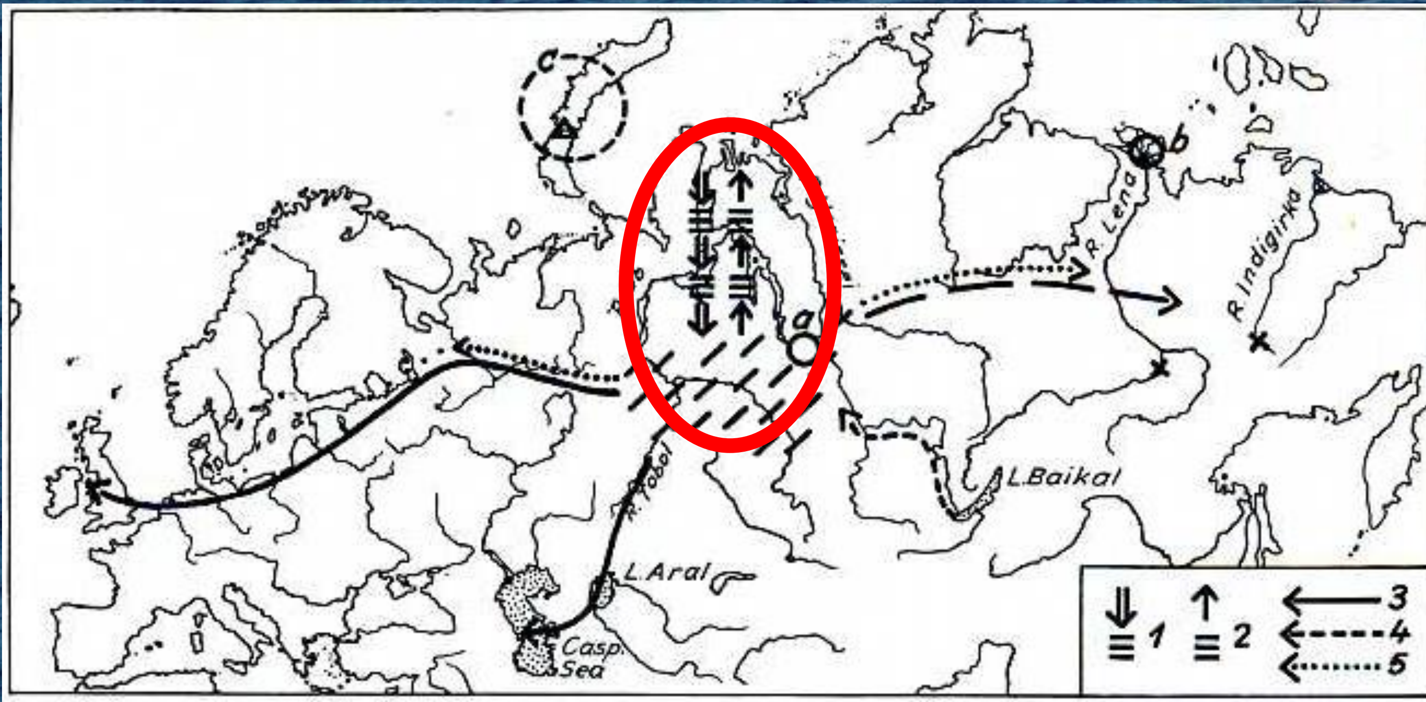


Fig. 2. The suggested role of the Siberian ice-lake of the maximum glaciation in the development and spread of glacial relicts. The extent of the lake at its highest level tentatively hatched. After Segerstråle 1957.

The immigration pathways of glacial relicts into the Northern Europe

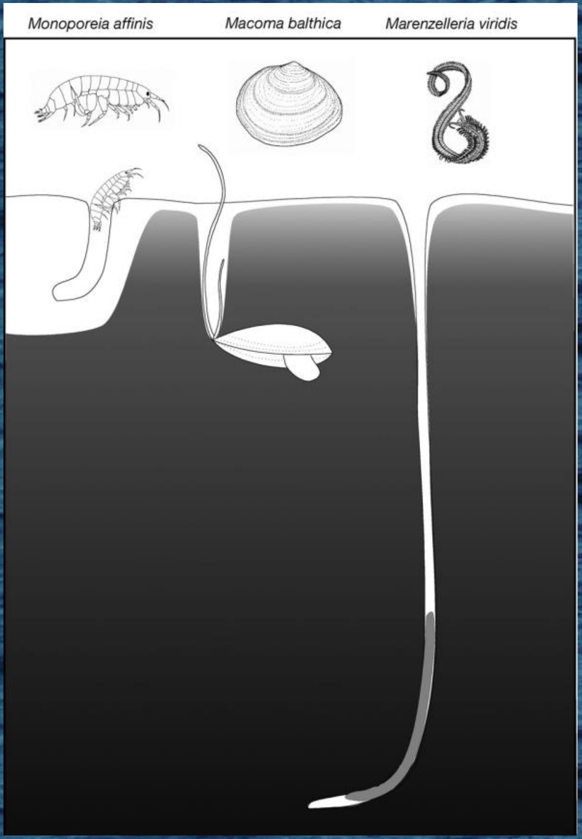
Segerstråle, 1976

During the last Ice Age the other representatives of arctic estuarine complex (so-called "glacial relicts) - crustaceans *Monoporeia affinis* and *Saduruia entomon* - reached the Baltic Sea. It is suggested that the special role in this processes was played by large freshwater lake in Siberia. The polychaetes were not able to breed in freshwater conditions and remained in the old area.

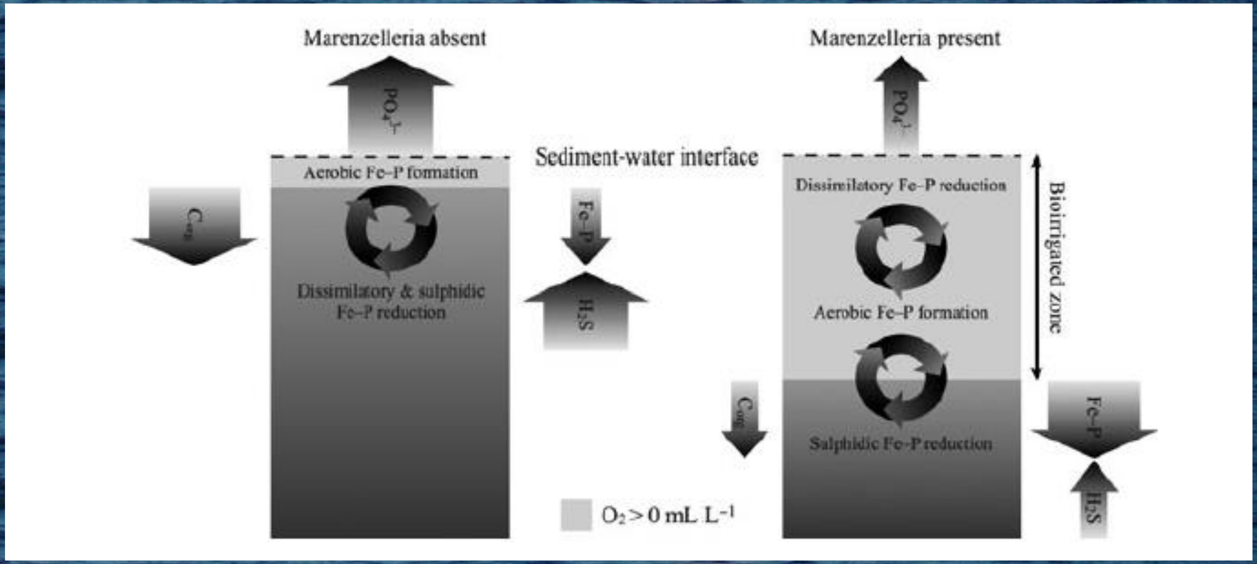
The recent *Marenzelleria* invasion can be considered as logical completion of post-glacial expansion of arctic brackish water fauna to the Baltic Sea leaded to restoration of normal natural community destroyed by large-scale disturbance during Ice Age

Ecosystem-level consequences of *Marenzelleria* invasion

Marenzelleria **spp. dig the bottom deeper than native Baltic species performing previously lacking ecosystem functions**



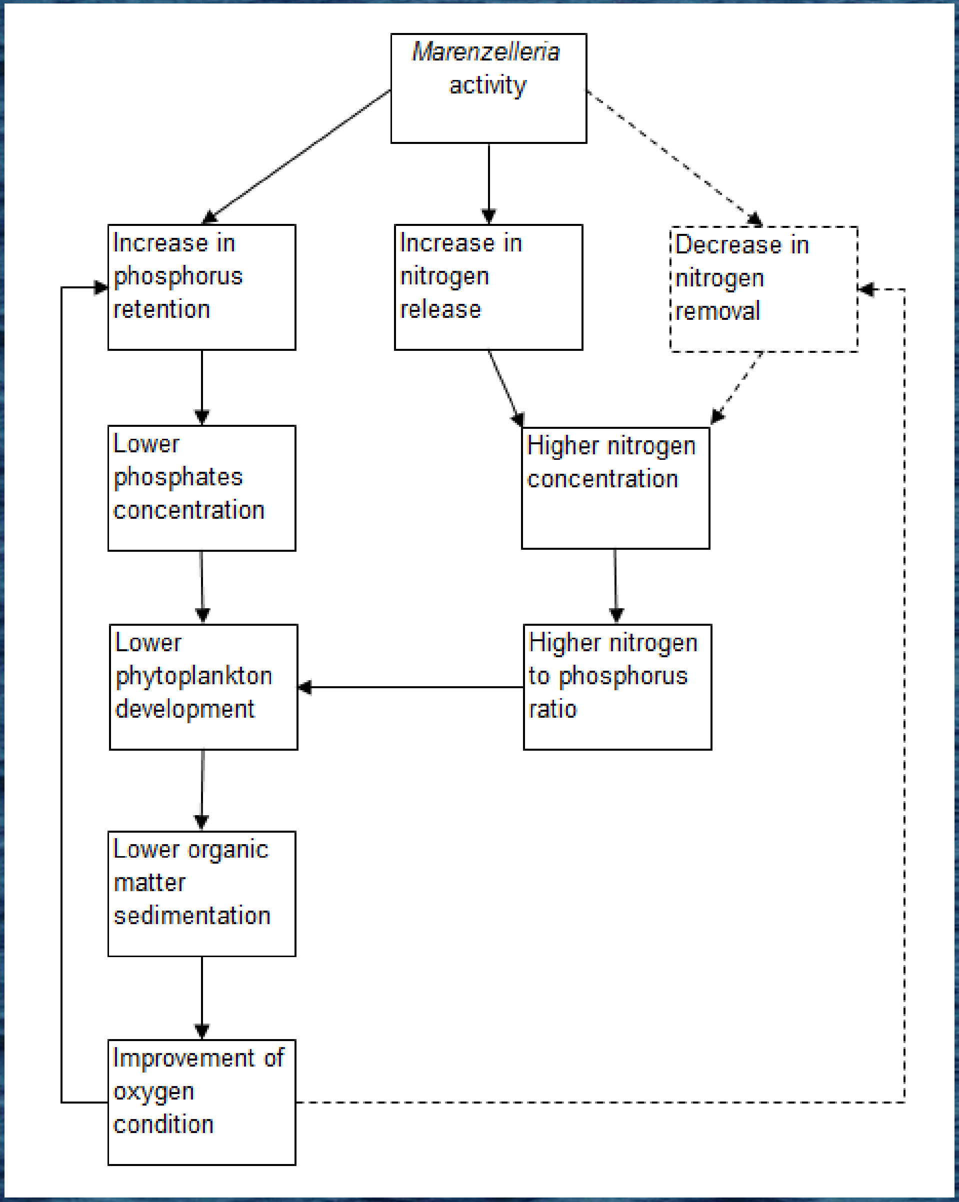
Karlsson et al. 2005



Bioirrigation activity of *Marenzelleria* increases the phosphorus retention in sediments because of deeper oxygen penetration into sediments and formation of powerful oxidized layer. In the Stockholm area this activity of polychaetes result in decline of phosphates concentration

Norkko, Reed et al. 2012

Marenzelleria spp. affect nutrient cycling and biogeochemical processes at the sediment – water interface enhancing some ecosystem services



Potential effects of *Marenzelleria* spp. on nutrient cycling in the ecosystems of the Northern Baltic Sea. Dashed box and lines indicate a hypothesized process and effects with little data at this time.

Maximov, Bonsdorff, Eremina et al., 2015

Summary

	Space scale	**Time scale**	**Organisation level**
Population cycles	local	interannual	Population
Hydrographic changes	biotope-scale	interdecadal	Community/ ecosystem
Faunistic changes	gulf-scale	Intercenturial ?	Ecosystem

Factors controlling changes in macrobenthic communities are scale-dependent

Important at the small temporal, spatial and organizational scales factors are not significant in controlling of the large-scale processes

The most large-scale effects in the study area connected with invasion-induced changes in benthic biodiversity

Thank you for attention!

BONUS
SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

cocoa
Nutrient cocktails in the coastal zone of the Baltic Sea

РФФИ
РОССИЙСКИЙ ФОНД ФУНДАМЕНТАЛЬНЫХ ИССЛЕДОВАНИЙ

РУССКОЕ ГЕОГРАФИЧЕСКОЕ ОБЩЕСТВО
ОСНОВАНО В 1845 г.

From small scales to large scales
–The Gulf of Finland Science Days 2017
9th-10th October 2017
Estonian Academy of Sciences, Tallinn

1st Day

Gulf of Finland Co-operation

A. Kaskela, A. Kotilainen, U. Alanen, D. Ryabchuk, S. Suuroja, H. Vallius, V. Zhamoida, EMODnet Geology partners

EMODnet Geology - Geological data from the European marine areas

EMODnet Geology - Geological data from the European marine areas

Gulf of Finland trilateral Forum in Tallinn

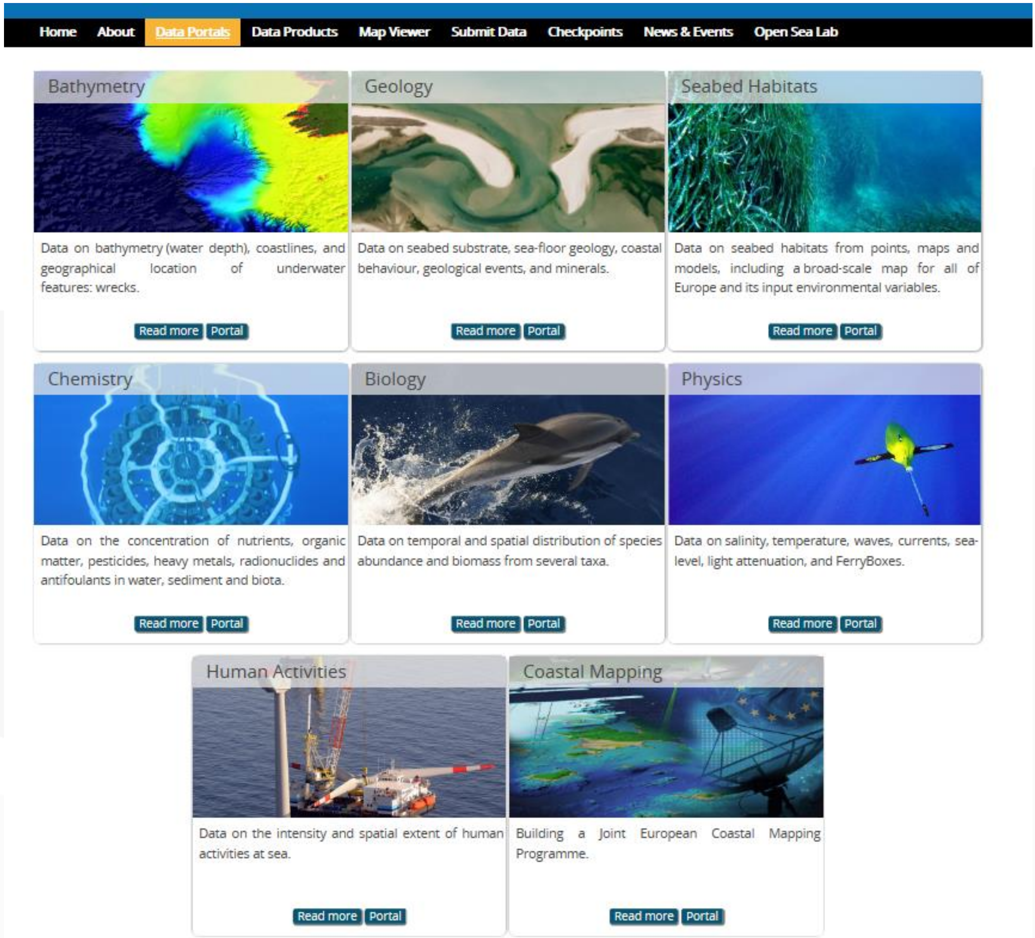
Anu Kaskela, Aarno Kotilainen, Ulla Alanen,
Daria Ryabchuk, Sten Suuroja, Henry Vallius,
Vladimir Zhamoida and EMODnet Geology partners

anu.kaskela@gtk.fi

The European Marine Observation and Data Network (EMODnet) is financed by the European Union under Regulation (EU) No 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund.

EMODnet – What is it?
www.emodnet.eu

- **EU/Marine Strategy Framework Directive**
- Problem: Scattered knowledge and data
- Collate marine spatial knowledge
- Make data available
- European Commission
  - 1^{st} phase 2009-2012
  - 2^{nd} phase 2013-2016
  - 3^{rd} phase 2017-2019



EMODnet Geology 3rd Phase

- Lead by GTK/Henry Vallius
- ~40 organisations/30 countries (~EurogeoSurveys)
  - Budget 4.5 milj. €/2 years + potentially 4.5 milj./€2years
- Themes: Sea-bed substrate & Sediment accumulation rate
  Sea-floor geology
  Coastal behaviour
  Mineral occurrences
  Geological events and probabilities
  Submerged landscapes

- DATA AVAILABLE At: http://www.emodnet-geology.eu/

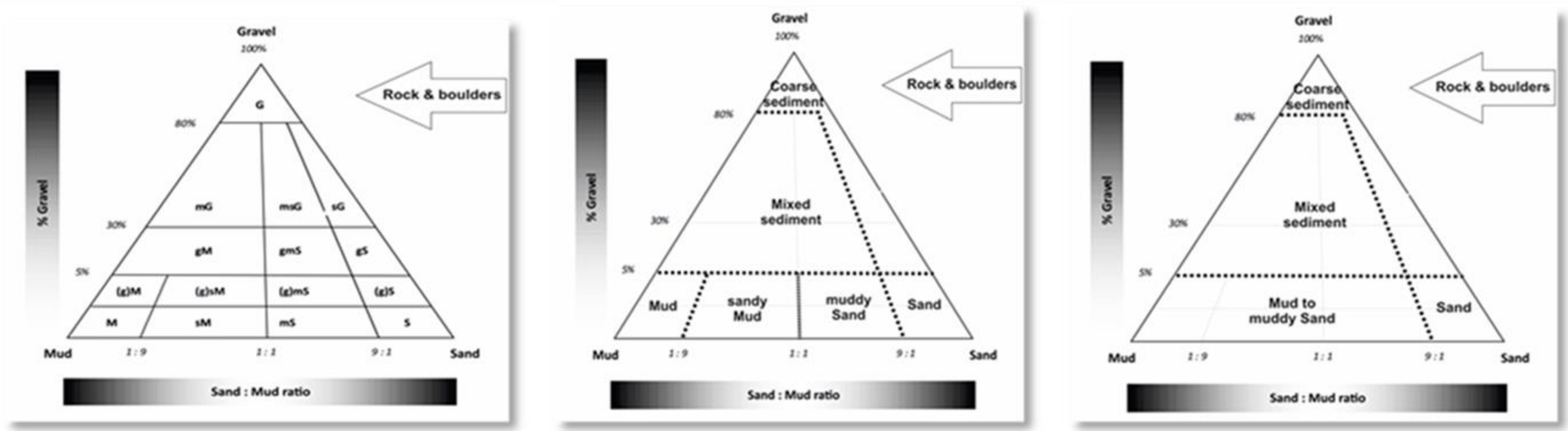
EMODnet Geology Data area

2[nd] & 3[rd] phase 2013 -

EMODnet Geology
Seabed substrate

- Aims:
  - Harmonised Seabed substrate information (~maps)
  - Rate of accumulation/sedimentation on the sea floor

Folk Triangle/Hierarchy

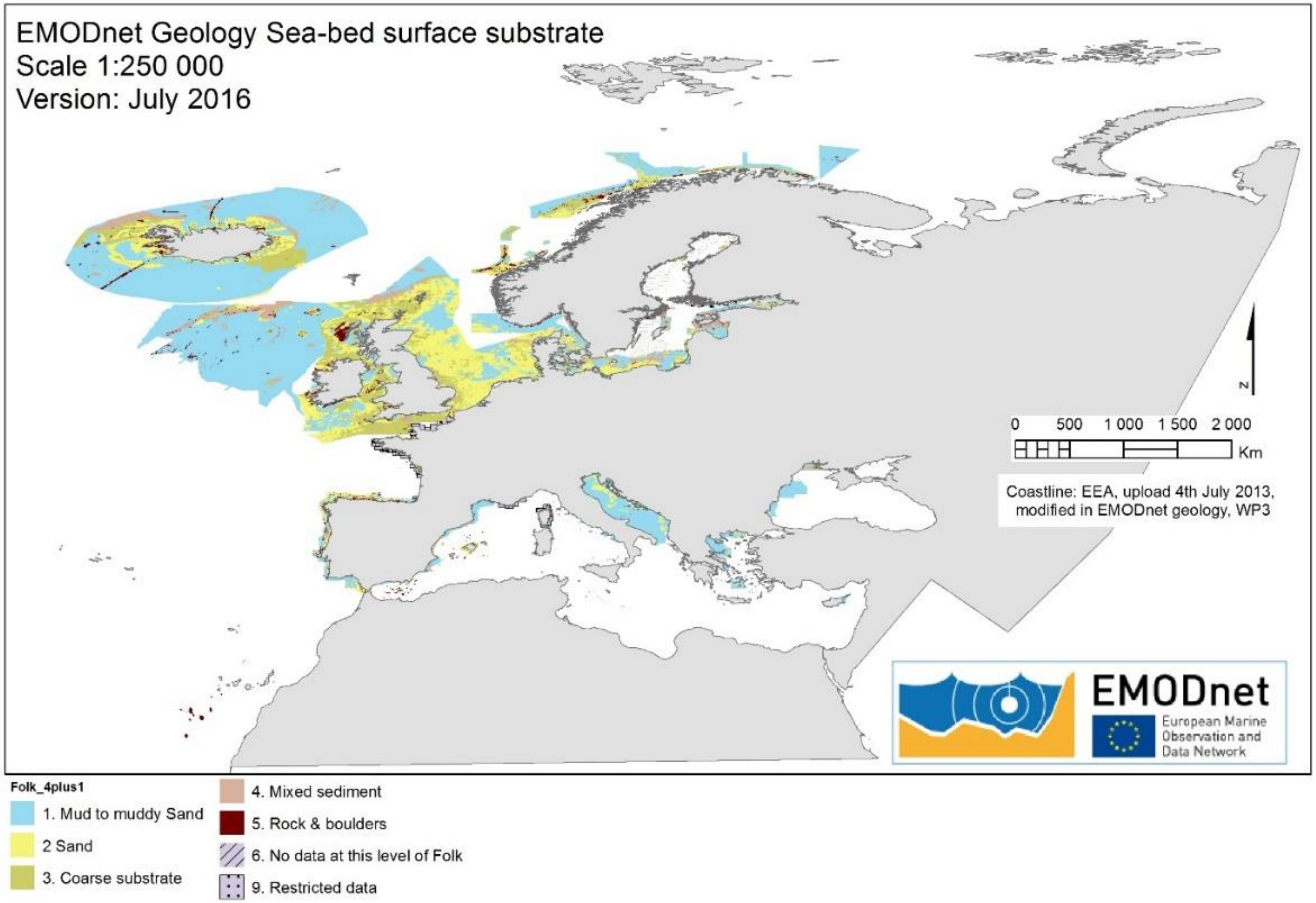


EMODnet Geology
Seabed substrate

Scales:

- 1 M
- 250 k
- *100 k*

Available at the portal!



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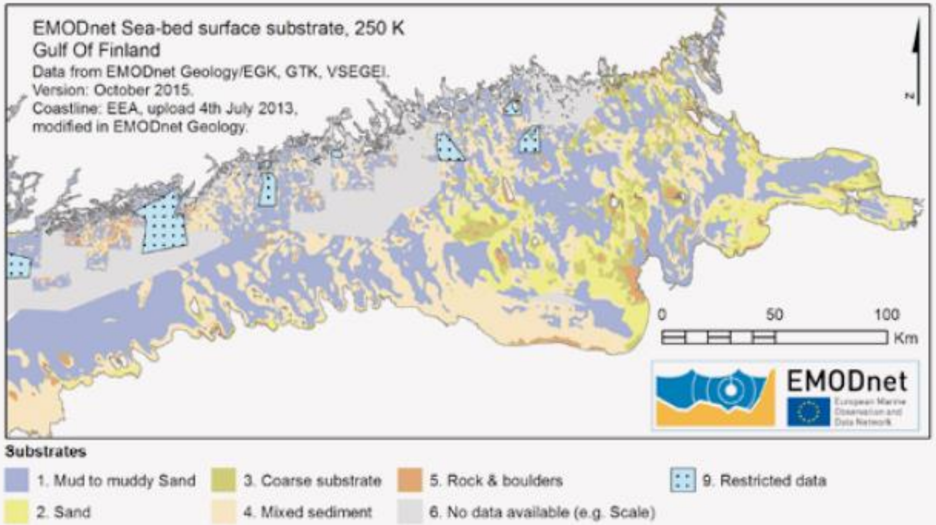
3.3. Gulf of Finland assessment

The development of EMODnet standard classifications for the various categories of seabed substrate allowed a digital map layer covering Russian, Finnish and Estonian waters to contribute towards the Gulf of Finland assessment published in 2016. This was one of the most important outcomes of the Gulf of Finland Year arranged by the three countries in 2014. The map, which shows that erosion, transportation, and accumulation bottoms have combined to give a patchy substrate distribution, also formed the basis of the regional spatial plan for the sea area created by the Regional Council of Kymenlaakso.



Seabed substrate map over the Gulf of Finland in scale 1:250.000

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Geomorphology 295 (2017) 419–435

Contents lists available at ScienceDirect

ELSEVIER

Geomorphology

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

Seabed geodiversity in a glaciated shelf area, the Baltic Sea

CrossMark

Anu Marii Kaskela*, Aarno Tapio Kotilainen

Marine Geology, Geological Survey of Finland, P.O. Box 96, 02151 Espoo, Finland

Describes the seabed geodiversity distribution of the Baltic Sea and discusses the linkages between geodiversity and selected geological processes.

Geodiversity = the natural range of geological, geomorphological, and soil features and their assemblages, relationships, properties, interpretations, and systems (Gray, 2004).

Geomorphology 295 (2017) 419–435

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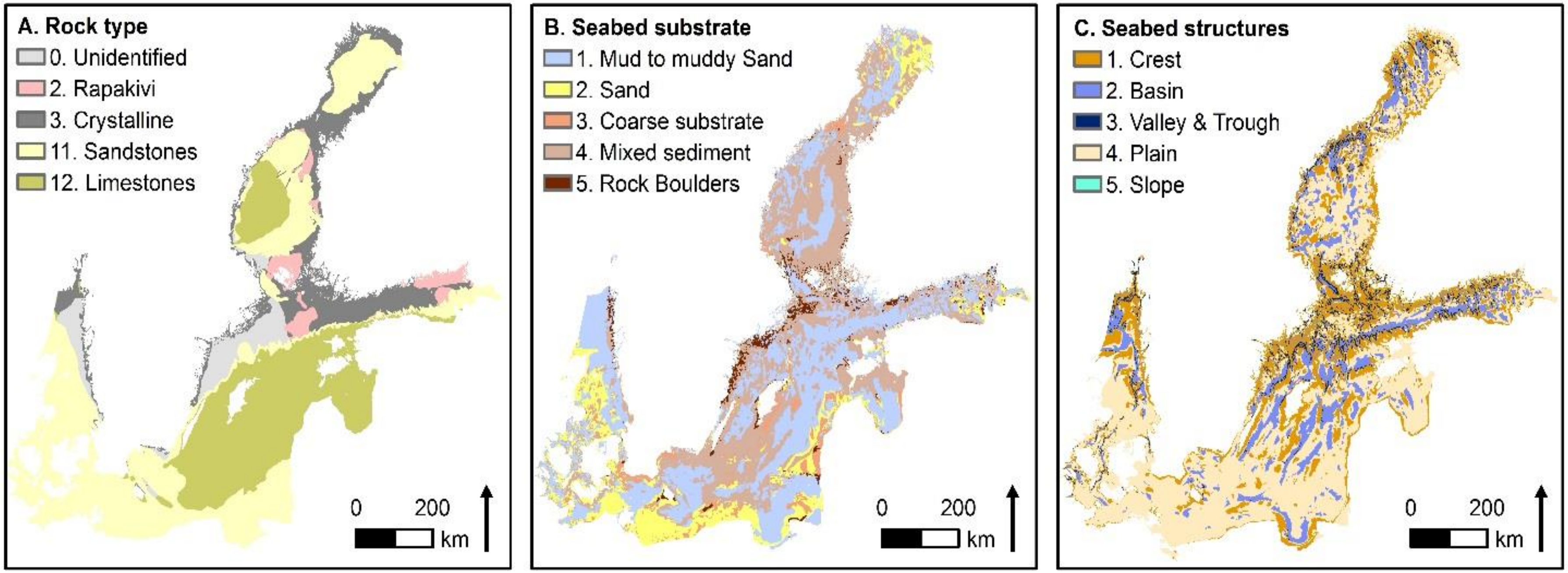
WHY?

- To VISUALIZE broad scale geological characteristics of the seafloor environment, which is largely invisible
- To provide SCIENCE-BASED SPATIAL knowledge for the ESBM
- To study contributing PROCESSES
- Linkage with Biodiversity

Seabed geodiversity Material

(Kaskela & Kotilainen, 2017)



Bedrock geology, Koistinen et al. 1 M

Seabed substrate, EMODnet Geology,1M

Geomorphology:
Seabed structures modelled

- Along Kaskela et al 2012
- EMODnet bathymetry

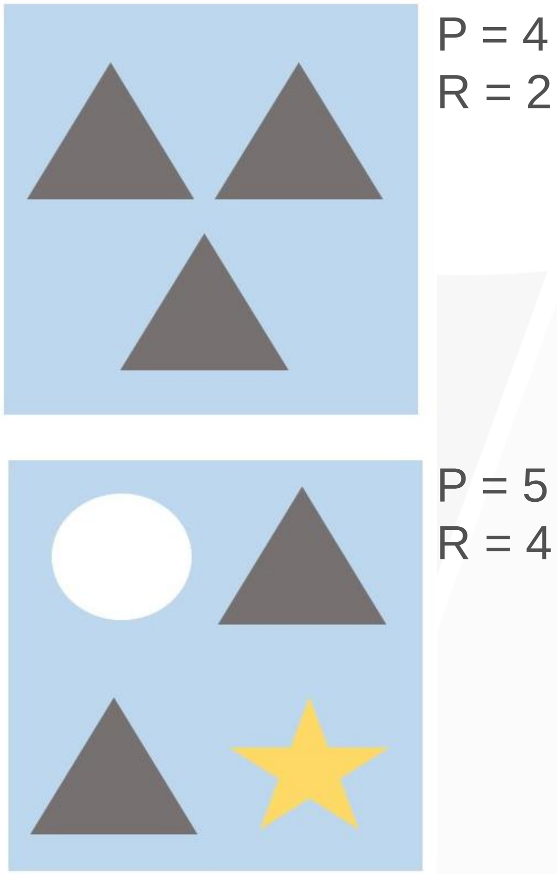
How to quantify geodiversity?

(Kaskela & Kotilainen, 2017)

- Patchiness: Amount of all patches
- Patch Richness: Amount of patch types
- Geodiversity index: GD = EG R/lnS,

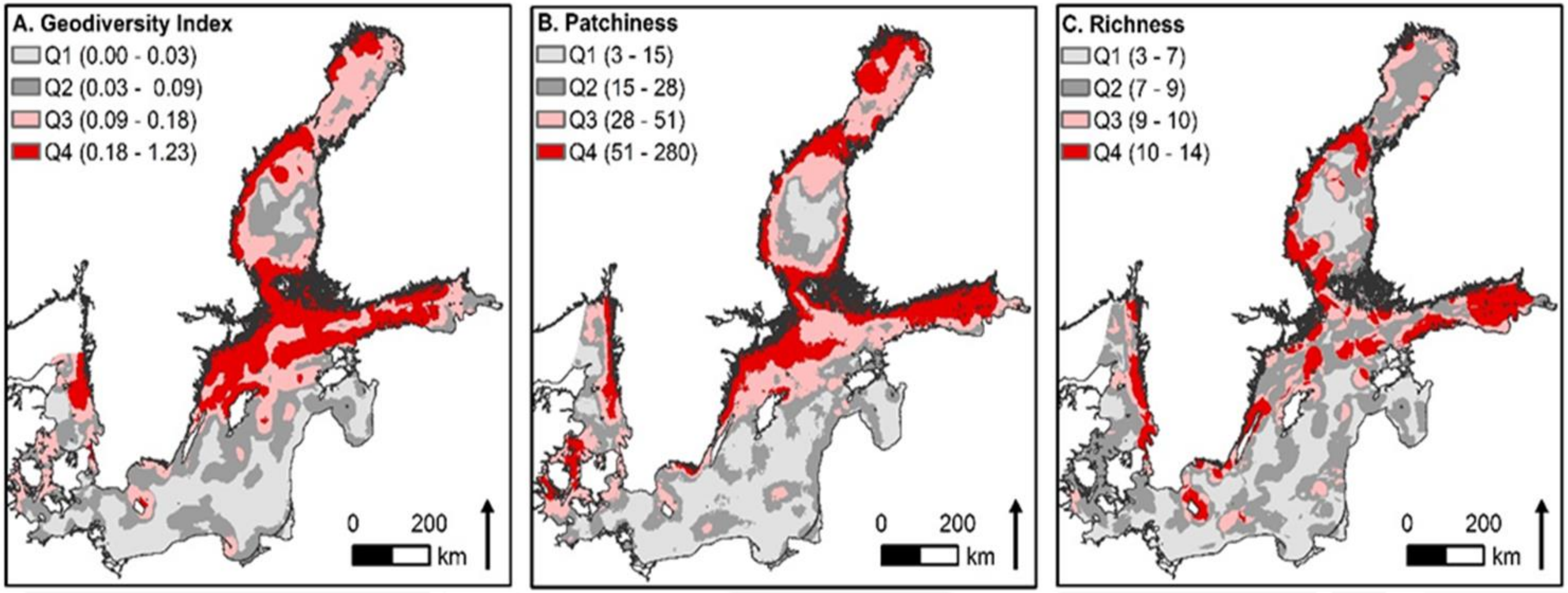
  EG= number of different patch types,
  R = roughness,
  S = surface area,
  ln = natural logarithm

- ArcGIS Spatial Analysis, Focal statistics
  - 20 km analysis radius



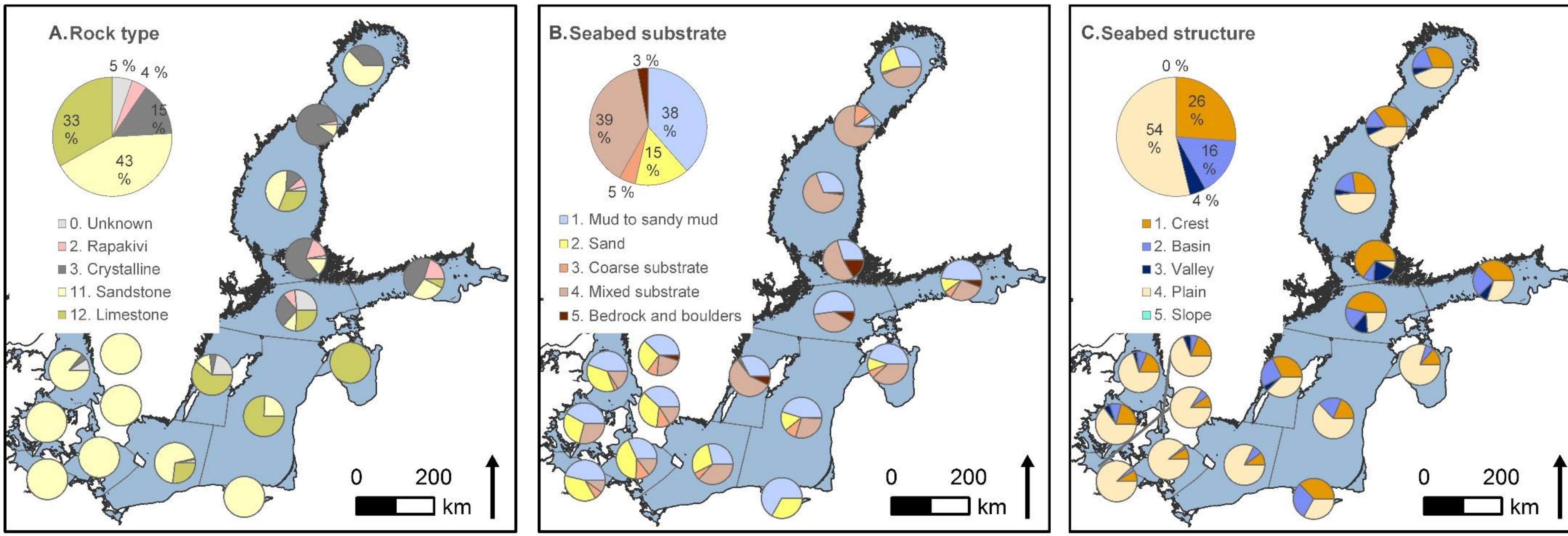
Geodiversity distribution

(Kaskela & Kotilainen, 2017)



Geodiversity distribution Gulf of Finland

(Kaskela & Kotilainen, 2017)



Subregions are different by their geological characteristics and geodiversity

EMODnet

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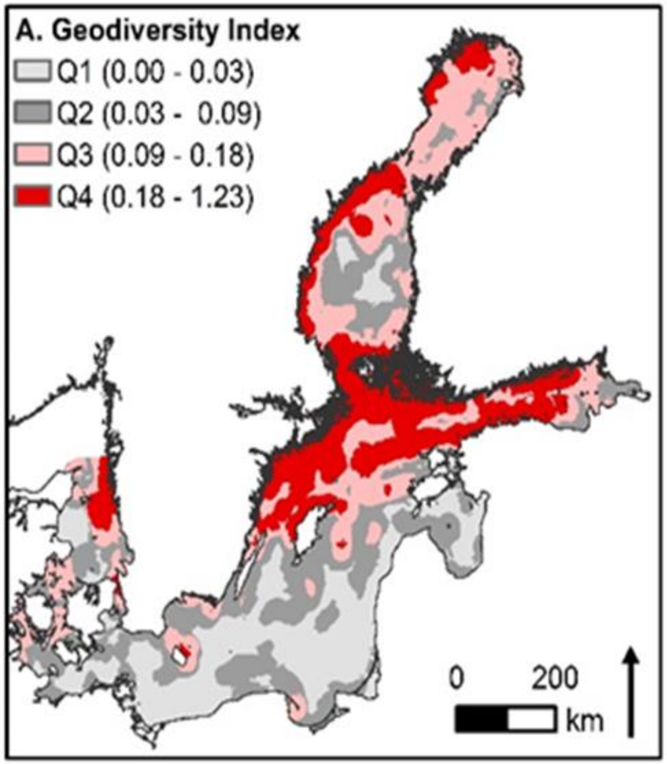
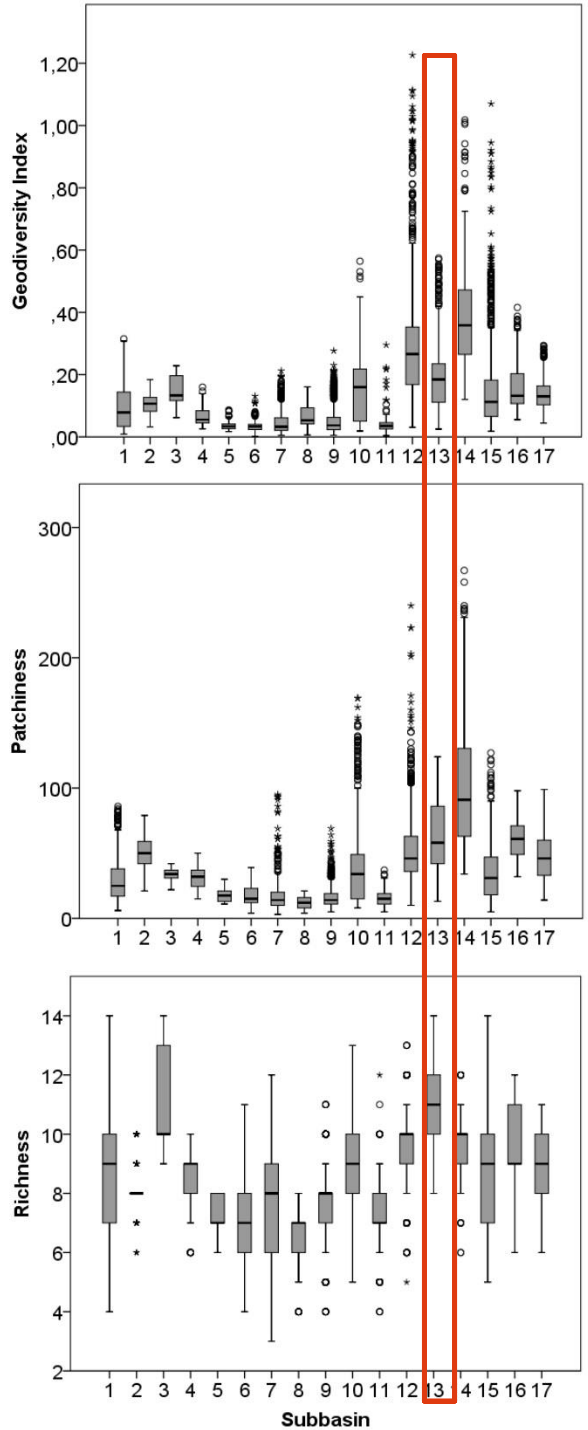




Subbasins:
1 = Kattegat
2 = Great Belt
3 = Sound
4 = Kiel Bay
5 = Bay of Mecklenburg
6 = Arkona Basin
7 = Bornholm Basin
8 = Gdansk Basin
9 = E. Gotland Basin
10 = W. Gotland Basin
11 = Gulf of Riga
12 = North Baltic Proper
13 = Gulf of Finland
14 = Åland and Archipelago S.
15 = Bothnian Sea
16 = Kvarken
17 = Bothnian Bay

Geodiversity is high in the GoF in comparison to other subregions

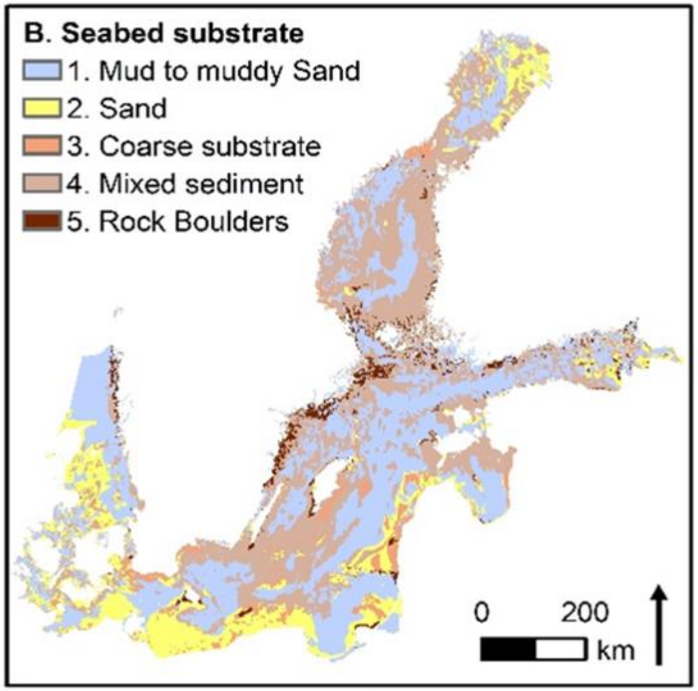
CONCLUSIONS

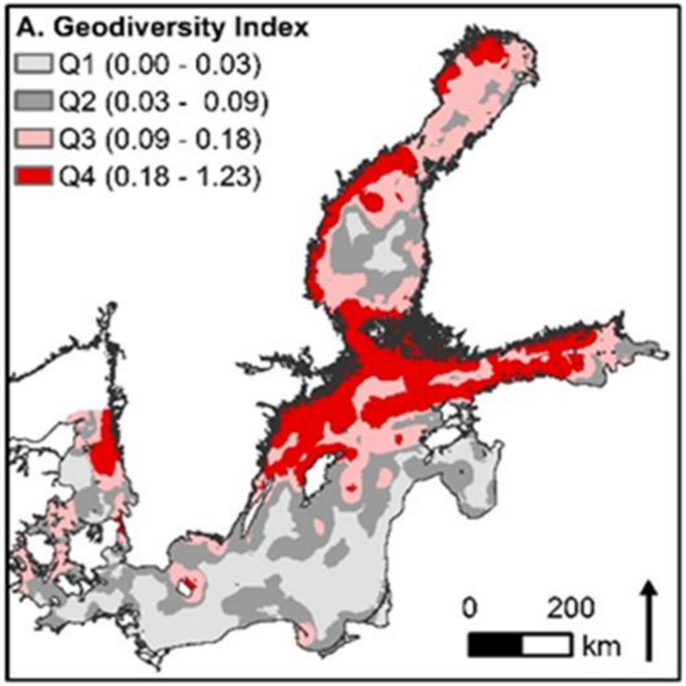
- EMODnet collects and harmonises marine data from Europe
  - Geological data available at: http://www.emodnet-geology.eu/

- Seabed geodiversity
  - Informs about abiotic conservation values, seabed dynamics, and sustainable use of resources
  - Guides future surveys
  - Added value to broad scale/low resolution data
  - GoF High geodiversity area/Baltic Sea

Thank you for your attention!

contact: anu.kaskela@gtk.fi





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