Twenty-five years of ferrybox measurements between Tallinn and Helsinki – highlights from the past and future perspectives

Villu Kikas, Sirje Sildever, Natalja Buhhalko, Silvie Lainela, Urmas Lips

TalTech, Department of Marine Systems

HISTORY

History of FerryBox measurements

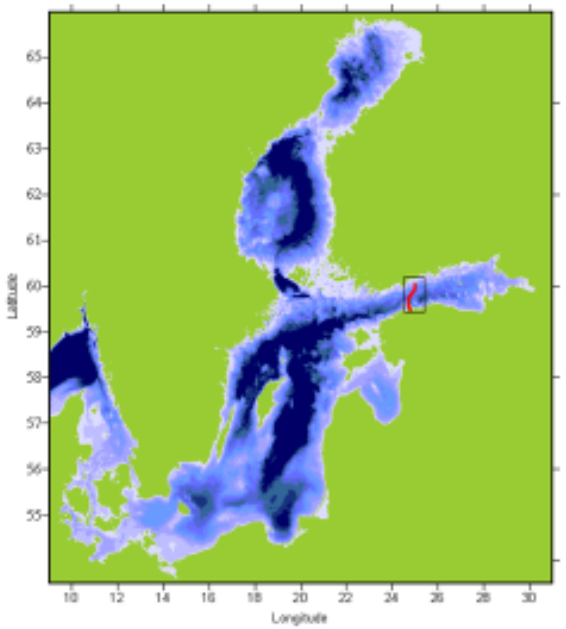
- First trials in 1989-1990; ferry Georg Ots; responsible Mati Kahru (EMI), Juha-Markku Leppänen (FIMR)
- Alg@line started in 1993 (FIMR etc)
- Tallinn-Helsinki on routine basis since 1997 (FIMR, Uusimaa Regional Env. Centre, Helsinki City, EMI), ferries: Wasa Queen, Finnjet, Romantika; responsible Juha-Markku Leppänen, Mikaela Ahlmann, Mika Raateoja, Seppo Kaitala etc
- A new system from 4H-Jena was installed in 2006, ferries: Galaxy, Baltic Princess; responsible Marine Systems Institute, Tallinn University of Technology

- 1992 Estonian Marine Institute (Academy of Scienece)
- 1996 Estonian Marine Institute (Ministry of Environment)
- 1997 EMI and Alg@line cooperation between Tallinn-Helsinki
- 2001 EMI joined University of Tartu
- 2002 Marine Physics unit joined Tallinn University of Technology as Marine Systems Institute

Background for measurements

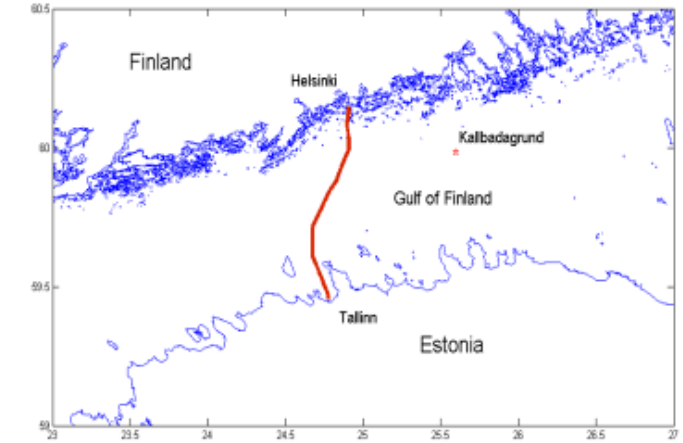
- Eutrophication
- Improve coverage
- Addition to regular monitoring

Gulf of Finland



- The Gulf of Finland is an elongated basin with a length of about 400 km and a maximum width of 140 km
- The large freshwater inflow in the eastern end of Gulf leads to a surface-layer salinity decrease from 6 at its entrance to 1 in the easternmost area
- The vertical stratification is characterized by a permanent halocline at depths of 60-80 m, and a seasonal thermocline, which forms at the depths of 10-30 m in summer
- The residual circulation: the saltier water of the northern Baltic Proper intrudes to the Gulf along the Estonian coast and the seaward flow of fresher gulf water occurs along the Finnish coast

Ferrybox measurements Tallinn-Helsinki



- The FerryBox measurements between Tallinn and Helsinki started in 1997 (Alg@line; spatial resolution 100-200 m, two times a day, water from 3-5 m depth)

Ferry and the system

Passenger Ferry GALAXY
TALLINK Group

Marine Systems Institute
Tallinn University of Technology

US/EU-Baltic Symposium
27-29 May 2008, Tallinn, Estonia

Studies related to cyanobacterial blooms

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Available online at www.sciencedirect.com
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Harmful Algae 2 (2003) 29–41

HARMFUL ALGAE
www.elsevier.com/locate/hal

The influence of weather conditions (temperature and wind) on cyanobacterial bloom development in the Gulf of Finland (Baltic Sea)

Inga Kanoshina [a,*], Urmas Lips [b], Juha-Markku Leppänen [c]

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[b] *Estonian Maritime Academy, Luise 1/3, 10142 Tallinn, Estonia*
[c] *Finnish Institute of Marine Research, P.O. Box 33, FIN-00931 Helsinki, Finland*

Received 1 October 2002; received in revised form 1 November 2002; accepted 8 November 2002

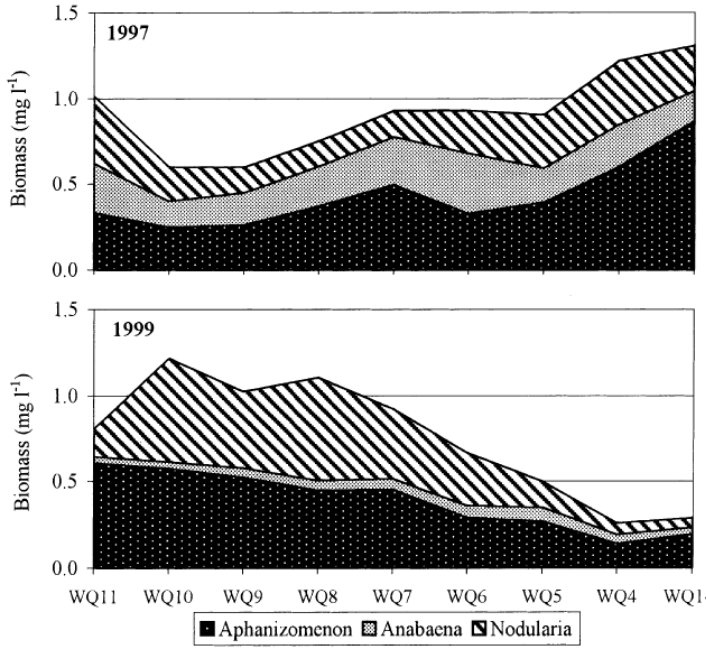

Fig. 3. Distribution of the time-average biomass of cyanobacteria during the bloom period along the ferry route in 1997 and 1999.

Data from 1997-1999

Development of the bloom depends on meteo; spatial distribution on prevailing wind direction

Hydrobiologia (2008) 614:133–140
DOI 10.1007/s10750-008-9449-2

PRIMARY RESEARCH PAPER

Abiotic factors influencing cyanobacterial bloom development in the Gulf of Finland (Baltic Sea)

Inga Lips · Urmas Lips

Received: 26 September 2007 / Revised: 27 May 2008 / Accepted: 29 May 2008 / Published online: 23 June 2008

Abstract Blooms of cyanobacteria are a recurrent phenomenon in the Baltic Sea, including the Gulf of Finland. The spatial extension, duration, intensity and species composition of these blooms varies widely between years. Alg@line data collected regularly from ferries as well as weather service and marine monitoring data from 1997 to 2005 are analysed to

Keywords *Aphanizomenon* · *Nodularia* · Cyanobacteria · Bloom-causing factors · Gulf of Finland · Baltic Sea

Introduction

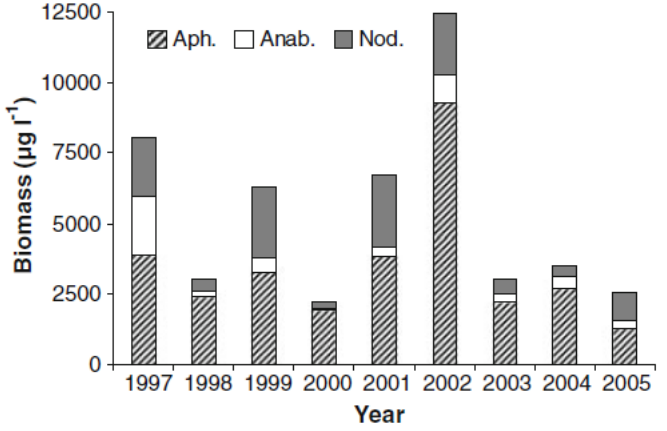

Fig. 2 Integrated biomass of *Aphanizomenon* sp., *Nodularia spumigena* and *Anabaena* spp. over the bloom period along the transect between Tallinn and Helsinki in 1997–2005

Data from 1997-2005

Impact of temperature, wind, upwellingst, etc to bloom development is species-specific

Studies related to spring bloom

Contents lists available at ScienceDirect

Journal of Marine Systems

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

High-resolution dynamics of the spring bloom in the Gulf of Finland of the Baltic Sea

Inga Lips *, Nelli Rünk, Villu Kikas, Aet Meerits, Urmas Lips

Marine Systems Institute, Tallinn University of Technology, Akadeemia Rd. 15A, 12618 Tallinn, Estonia

Data from 2009-2010

ARTICLE INFO

Article history:
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ABSTRACT

During the period from March to the end of May in 2009 and 2010, intensive measurements and sampling were undertaken in the Gulf of Finland. The compiled results indicate a high variability of the phytoplankton uenced by cation, in- nitrogen to tio during inorganic

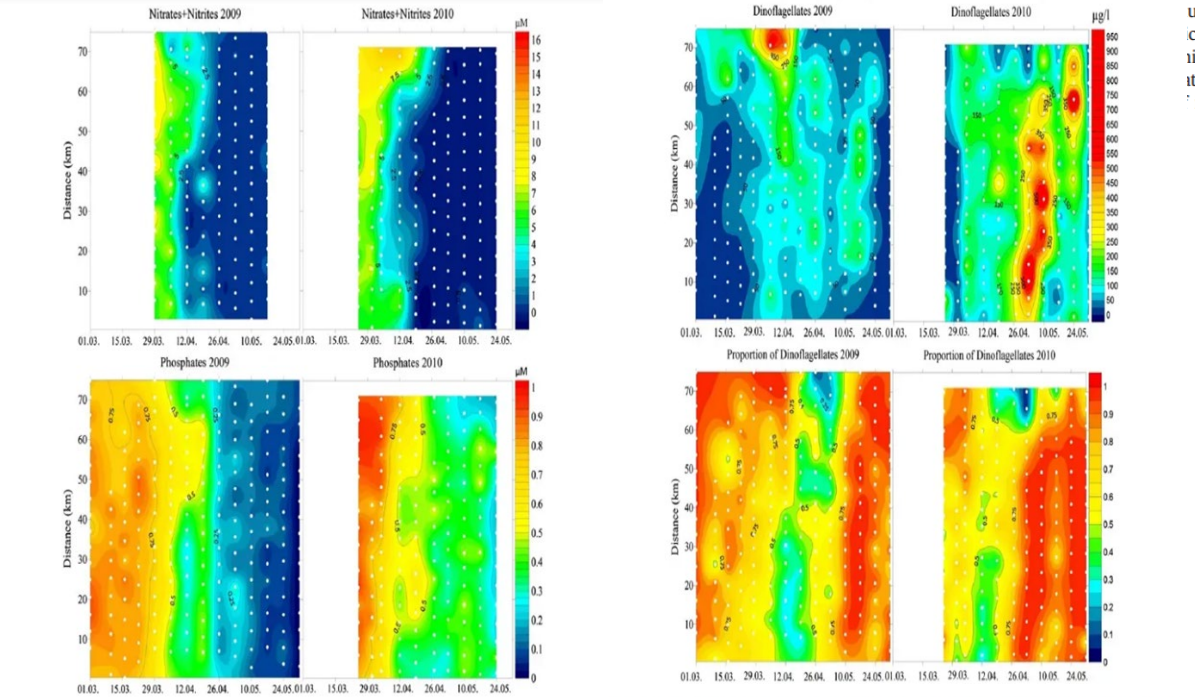

Fig. 4. Temporal variation of the horizontal distribution of the nitrates –nitrites and phosphates in the surface layer along the ferry route from Tallinn to Helsinki in the springs of 2009 and 2010. The sampling sites are indicated as white dots.

Fig. 6. Temporal variation of the horizontal distribution of the carbon biomass of diatoms and dinoflagellates and the proportion of dinoflagellates in the diatom–dinoflagellate community along the ferry route from Tallinn to Helsinki in the springs of 2009 and 2010. The sampling sites are indicated as white dots.

frontiers

ORIGINAL RESEARCH
published: 12 December 2017

The Importance of *Mesodinium rubrum* at Post-Spring Bloom Nutrient and Phytoplankton Dynamics in the Vertically Stratified Baltic Sea

Inga Lips and Urmas Lips*

Department of Marine Systems, Tallinn University of Technology, Tallinn, Estonia

The inter-annual dynamics of the photosynthetic ciliate *Mesodinium rubrum* in the central Gulf of Finland in spring-summer continuum during 5 years were followed. The analysis was mainly based on high-resolution measurements and sampling in the surface layer lsinki. The main purpose was to analyze the dynamics ıtribution to the photosynthetic plankton biomass, and

Data from 2009-2014

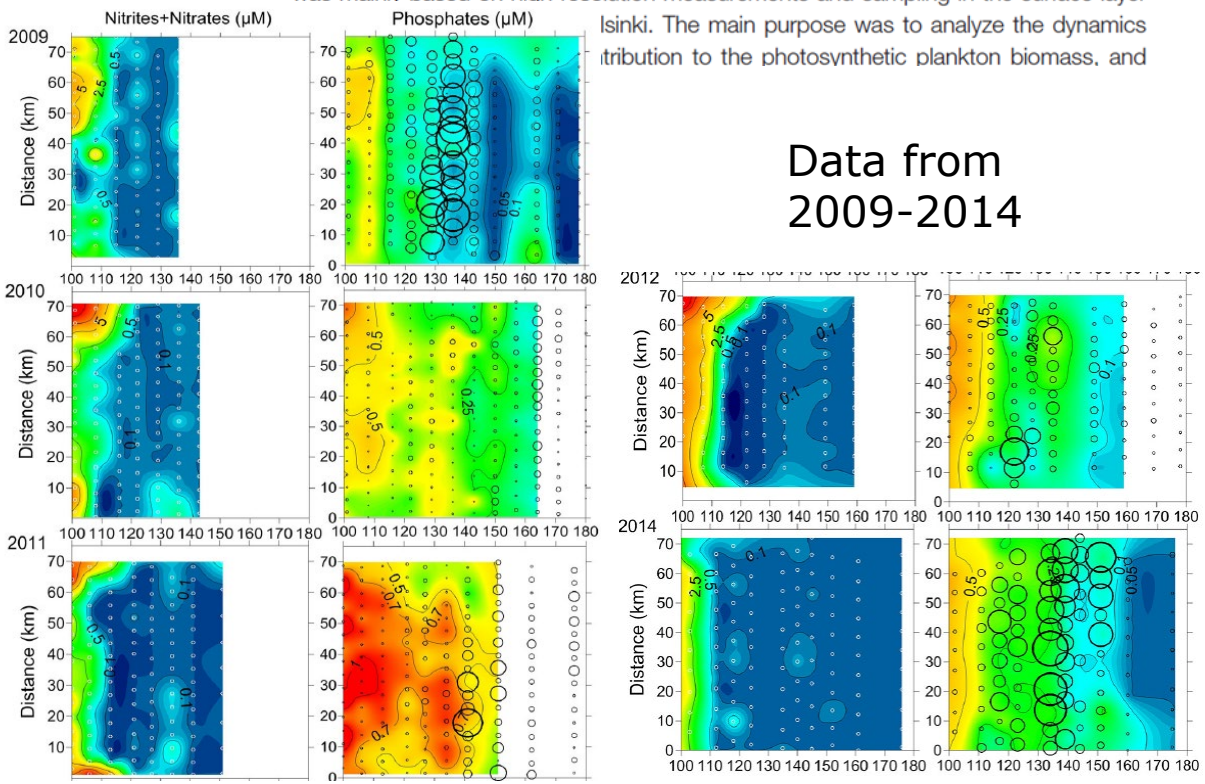

FIGURE 4 | The temporal variation of the horizontal distribution of inorganic nutrients in the surface layer along the cross-gulf section in the Gulf of Finland in 2009-2012 and 2014. Sampling sites are indicated as white circles on left panels. The open circles on right panels indicate the distribution and intensity of *M. rubrum* biomass ($\mu gC\ l^{-1}$; smallest circle = 0 $\mu gC\ l^{-1}$; biggest = 510 $\mu gC\ l^{-1}$).

Upwellings, mesoscale and submesoscale processes

U. Lips, I. Lips, V. Kikas and **N. Kuvaldina (N. Buhhalko)**, "Ferrybox measurements: a tool to study meso-scale processes in the Gulf of Finland (Baltic Sea)," 2008 IEEE/OES US/EU-Baltic International Symposium, 2008, pp. 1-6, doi: 10.1109/BALTIC.2008.4625536.

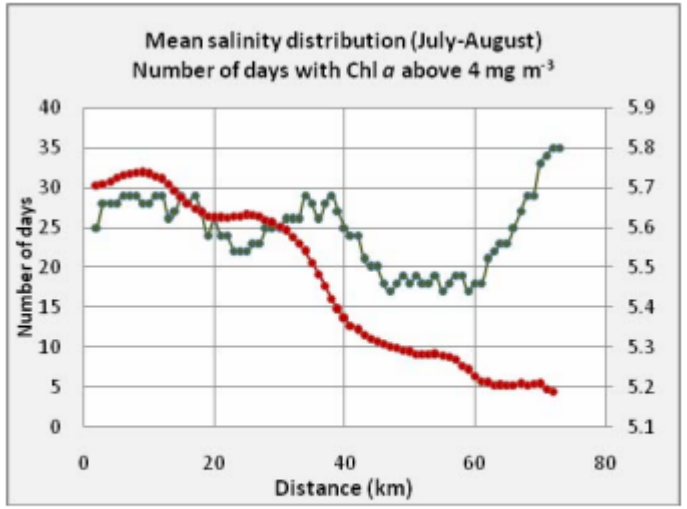

Figure 7. Average salinity distribution along the ferry route (red dots and line) and number of days when Chl a fluorescence value exceeded 4 mg m^{-3} in July-August 2007.

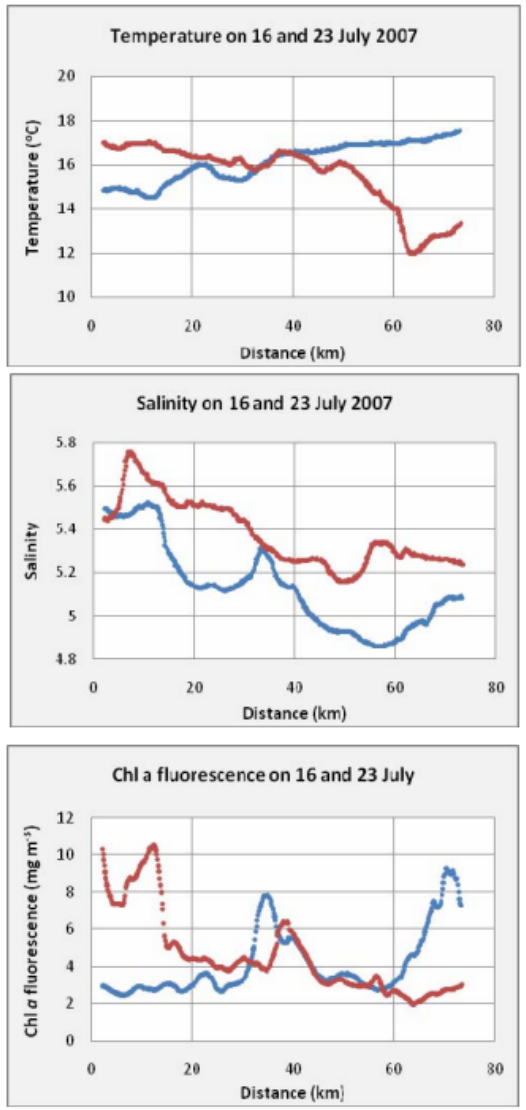

Figure 5. Horizontal profiles of temperature, salinity and chlorophyll *a* fluorescence (mg m^{-3}) along the ferry route Tallinn – Helsinki on 16 July (blue dots) and on 23 July (red dots) 2007.

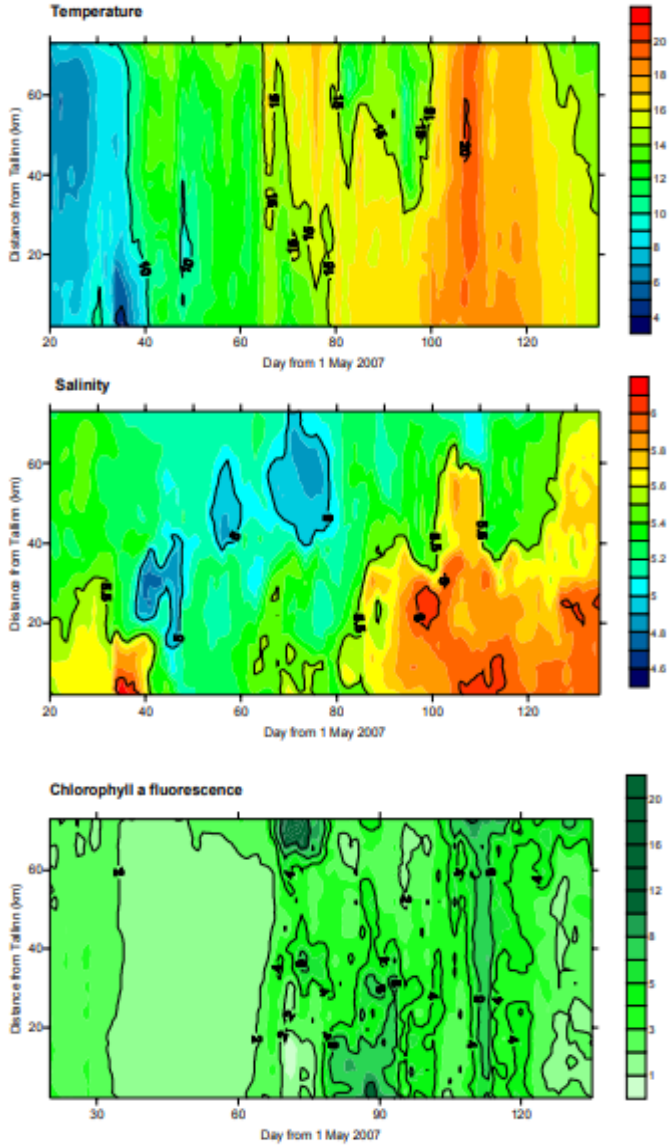

Figure 4. Spatial and temporal variations of temperature, salinity and chlorophyll *a* fluorescence (mg m^{-3}) along the ferry route Tallinn – Helsinki in May-September 2007.

Upwellings, mesoscale and submesoscale processes

Ocean Sci., 12, 843–859, 2016
www.ocean-sci.net/12/843/2016/
doi:10.5194/os-12-843-2016

Ocean Science Open Access EGU

Upwelling characteristics in the Gulf of Finland (Baltic Sea) as revealed by Ferrybox measurements in 2007–2013

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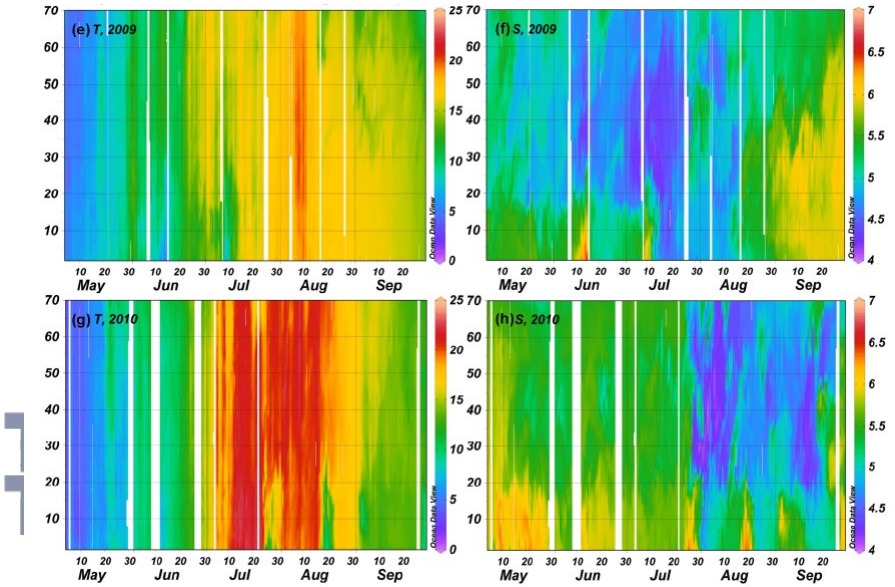
Received: 7 October 2015 – Published in Ocean Sci. Discuss.: 20 November 2015
Revised: 30 May 2016 – Accepted: 9 June 2016 – Published: 1 July 2016

Abstract. Ferrybox measurements have been carried out between Tallinn and Helsinki in the Gulf of Finland (Baltic Sea) on a regular basis since 1997. The system measures autonomously water temperature, salinity, chlorophyll *a* fluo- et al., 2008), including the Baltic Sea and the Gulf of Finland (Rantajärvi, 2003). The measurement systems installed on board commercial ferries or other ships are called "Ferryboxes", and they consist of various sensors, devices creat-



Ocean Sci., 12, 715–732, 2016
www.ocean-sci.net/12/715/2016/
doi:10.5194/os-12-715-2016

Ocean Science Open Access EGU

Multi-sensor in situ observations to resolve the sub-mesoscale features in the stratified Gulf of Finland, Baltic Sea

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Correspondence to: Urmas Lips (urmas.lips@msi.ttu.ee)

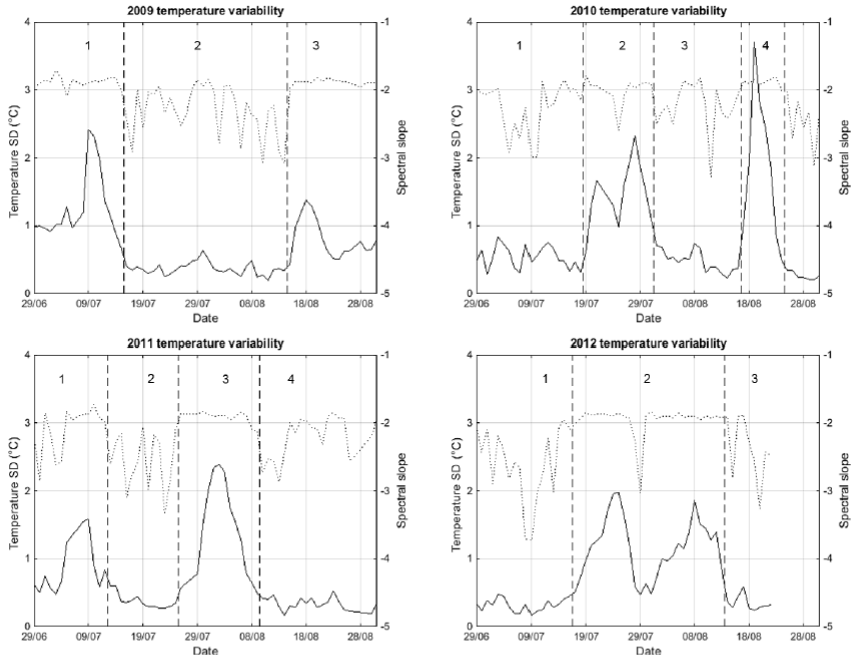


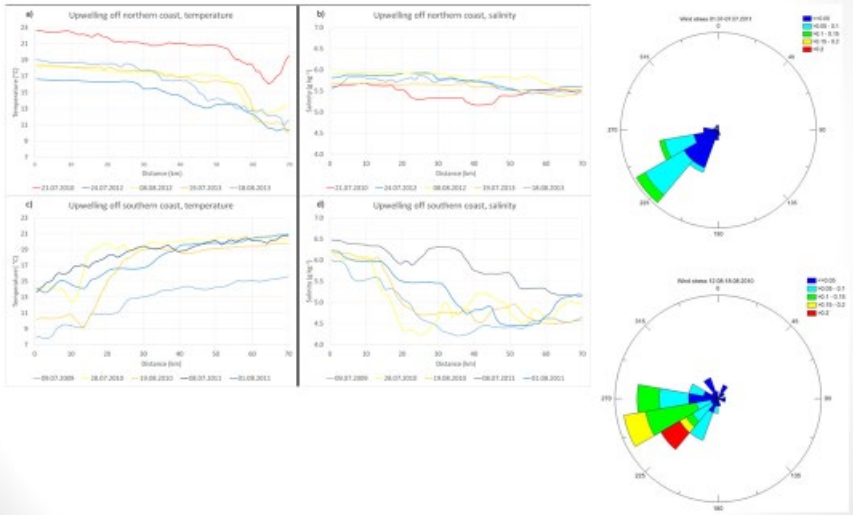
Figure 4. Statistical characteristics of the temperature variability in the surface layer of the Gulf of Finland along the ferry route Tallinn–Helsinki from 29 June to 31 August in 2009, 2010, 2011, and 2012. Standard deviations of temperature are shown as solid lines and spectral slopes of temperature variance between the horizontal scales of 10 and 0.5 km as dotted lines. The vertical dashed lines denote the borders between the selected characteristic periods with similar variability patterns (numbers of periods are shown in the upper part of the panels).

PhD thesis

Villu Kikas

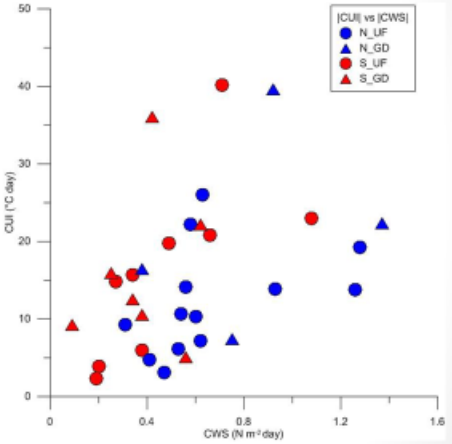
Physical processes controlling the surface layer dynamics in the stratified Gulf of Finland: An application of Ferrybox technology

Results: upwellings & wind stress

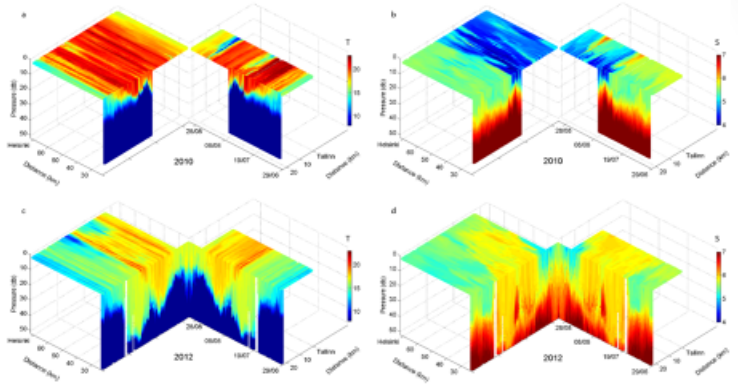


Results: different types of upwellings

- **The relationship between the cumulative upwelling index (CUI) and cumulative along-gulf wind stress (CWS) based on 33 detected upwelling events in May-September 2007-2013. Red symbols indicate the events off the southern coast and blue symbols the events off the northern coast; circles correspond to the events with pronounced upwelling front (N_UF and C_UF) and triangles the events with a gradual decrease in temperature towards the coast (N_GD and S_GD).**



Results: Combined Ferrybox and buoy data

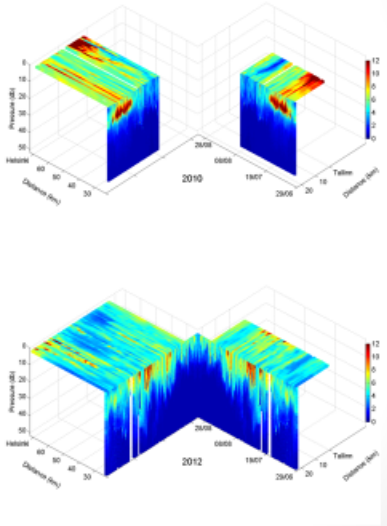


Temporal changes in horizontal and vertical distribution of temperature and salinity in the Gulf of Finland measured by the Ferrybox system between Tallinn and Helsinki and the autonomous buoy profiler at station AP5 from 29 June to 31 August in 2010 and 2012

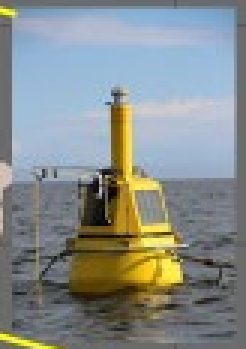
- Vertical structure well explained by the wind forcing – in 2010 with frequent easterly winds the thermocline had a shallower position than in 2012 (with dominating westerly winds)
- Sub-mesoscale features (as patches with different salinity) observed in the sub-surface layer (in 2012)

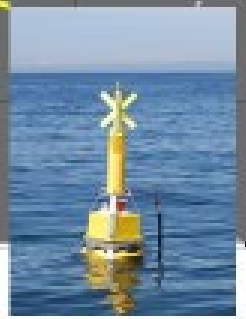
Results: FB and buoy combined data

- Temporal changes in horizontal and vertical distribution of chlorophyll *a* (mg m-3) in the Gulf of Finland measured
- by the Ferrybox system between Tallinn and Helsinki and the autonomous buoy profiler at station AP5 from 29 June to 31
- August in 2010 (a) and 2012 (b).



Measurement systems (MSI, 2015)





NEW FERRYBOX SYSTEM (FLYDOG MARINE) ONBOARD MS SILJA EUROPA

- GO Systemelektronik BlueBox controller and software
- GPS
- Zuwa NIROSTAR 2000 impeller pump (average system flow ~10 l/min)
- Valeport miniCT (Cond. + Temp.)
- Ponsel OPTOD (Oxygen)
- Chelsea Technologies Trilux (Chl a + Turbidity)
- Three custom made micro-litter samplers with Retsch sieves 300 µm, 100 µm ja 50 µm
- WaterSam WS 312 water sampler (24 one litre bottles)
- Data transfer via 4G (daily data download)
- Autonomously operated
- Remotely controlled when necessary (sample triggering)

COLLECTING MICROPLASTICS WITH FERRYBOX (KATI LIND)

- **On board of passenger ferry Silja Europa**
  - **Since july 2020 – 9 samplings**
    - **4 successful samplings**

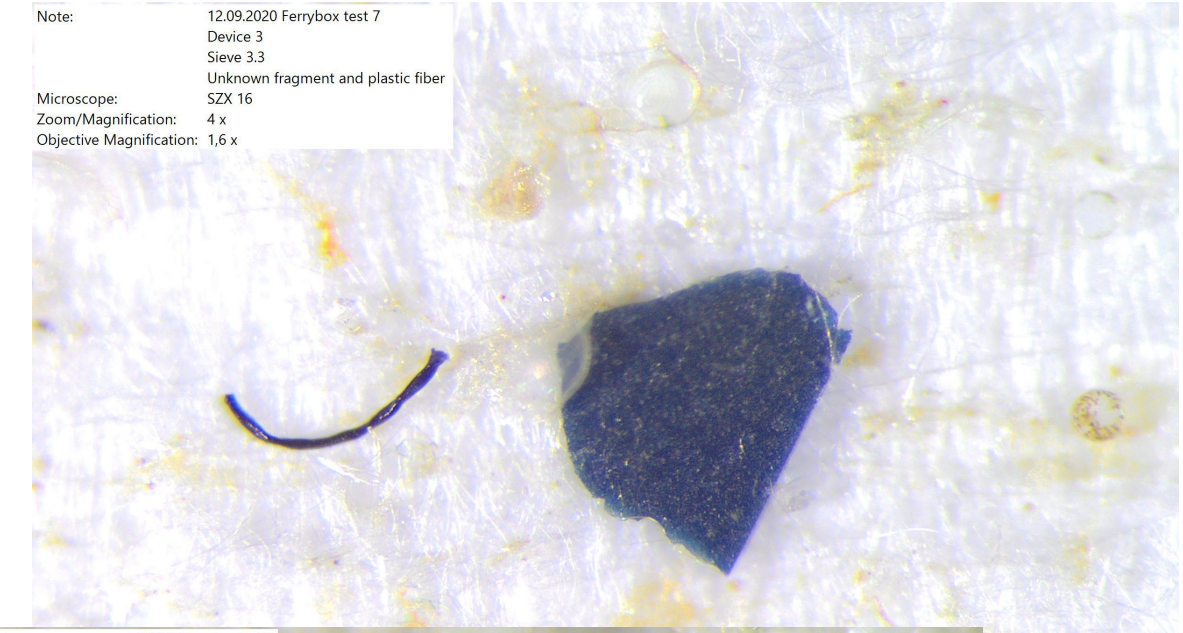
- **On board of R/V Salme**
  - **Since april 2021 – 8 samplings**

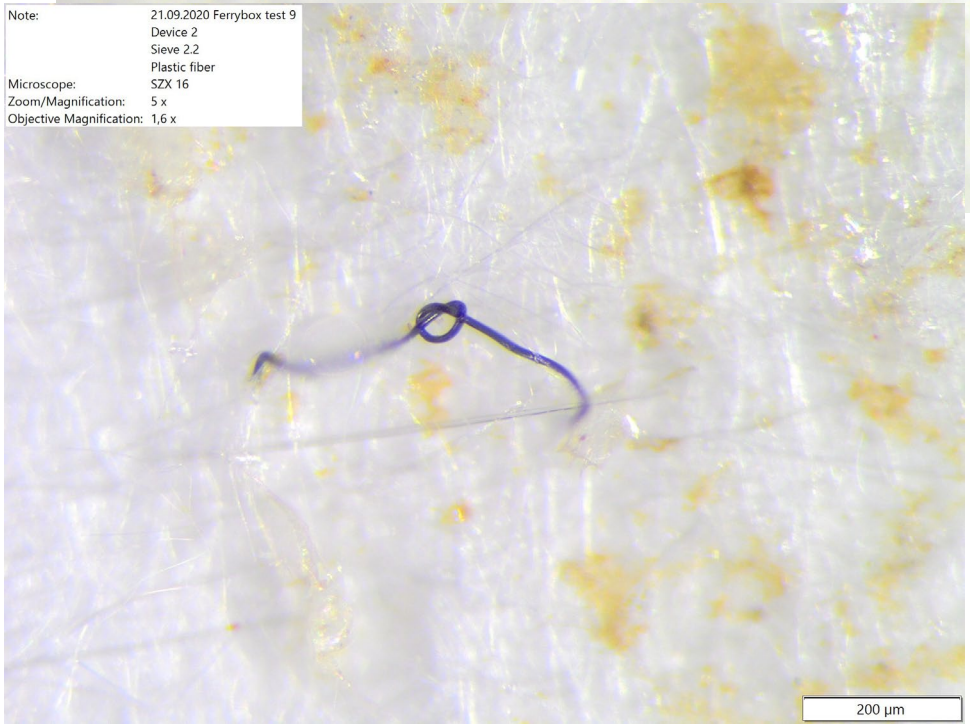
COLLECTING MICROPLASTICS WITH FERRYBOX

	Average amount of microplastics	Microplastics size range	Amount of analysed samples
Silja Europa	7,26 plastics/m3	50-300 µm	4 samples
R/V Salme	7,49 plastics/m3	50-300 µm	4 samples

From R/V Salme

FROM SILJA EUROPA



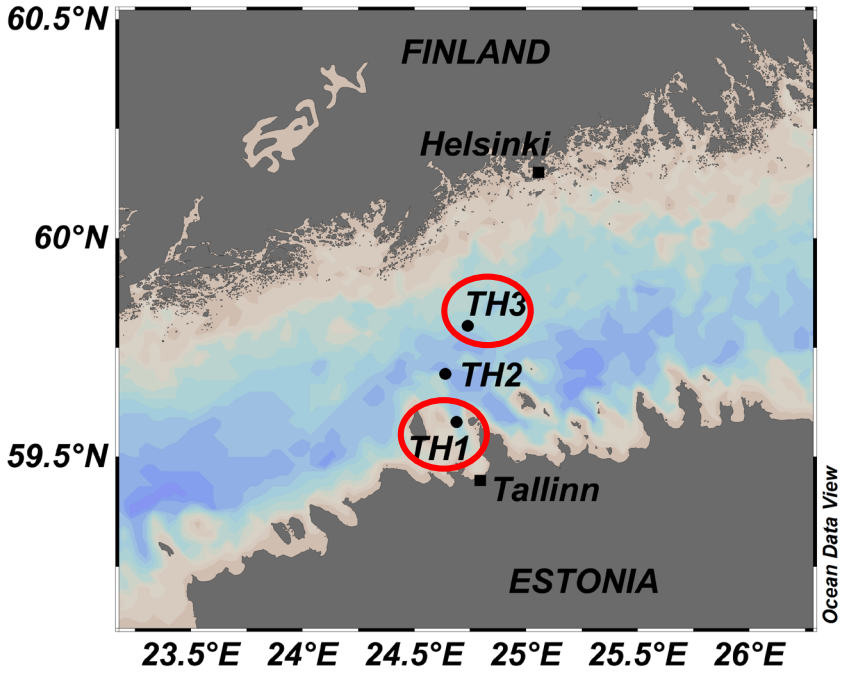


Squeezing more out of environmental DNA data: cell abundance, activity/inactivity and community dynamics

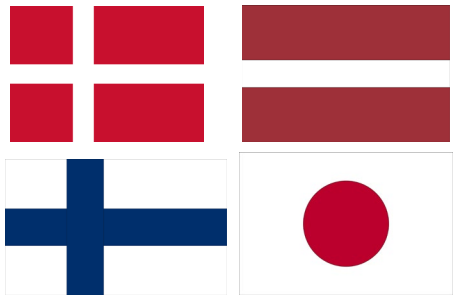
PI: Dr. Sirje Sildever, 2022-2025
Funding: Estonian Research Council (PSG735)

Eesti Teadusagentuur
Estonian Research Council

- **Ferrybox:** eDNA samples & establishing cultures, 30 key phytoplankton species:
  - 12 samples per year per station;
  - Additional data: phytoplankton community composition & biomass, water chemistry, physical parameters;
  - Sampling started in 2020; analysis of time-series data in the future
- **Lab experiments:** Copy number measurements: cell cycle, daily cycle, growth phase, activity/inactivity

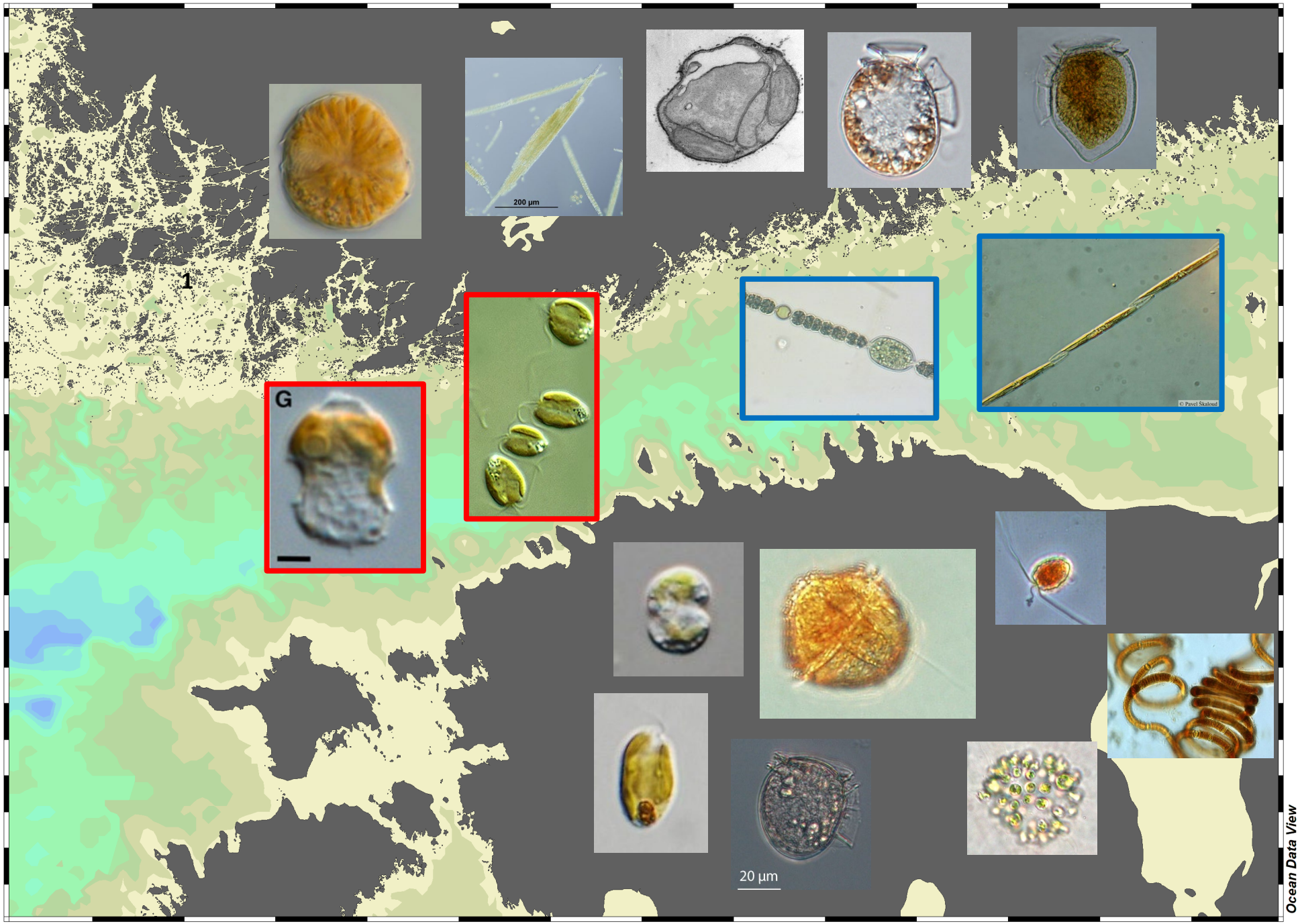


Collaborators:



16 toxin-producing species, 2 novel for the entire Baltic Sea, 2 novel for the Gulf of Finland

Sildever, et al. 2021
Metabarcoding & Metagenomics
10.3897/mbmg.5.72371



MARINE CARBONATE SYSTEM (Silvie Lainela)

- CONTROS HydroFIA pH-analyzer onboard R/V Salme starting from April 2022
- For inflow water cross-flow filter module, 0.2 µm pore size
- Measurements interval 10 minutes (to be increased)
- Salinity data online from R/V Salme ferrybox system using external logger
- Spectrophotometric determination of pH

- Post-processing of pH data according to Müller & Rehder (2018)

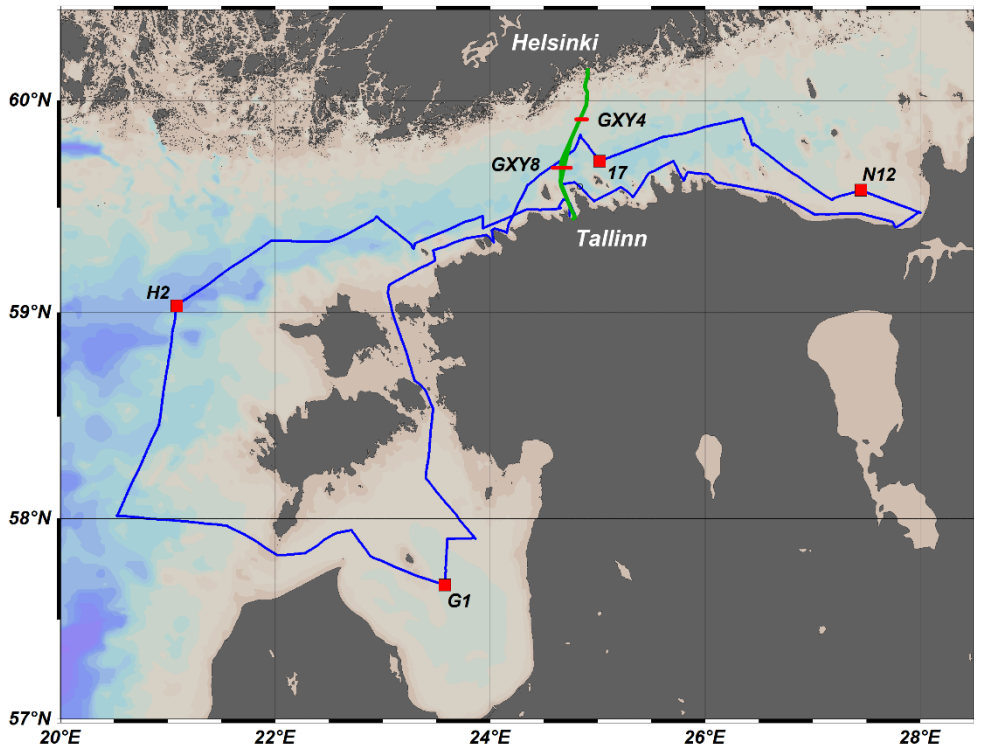
Postponed:

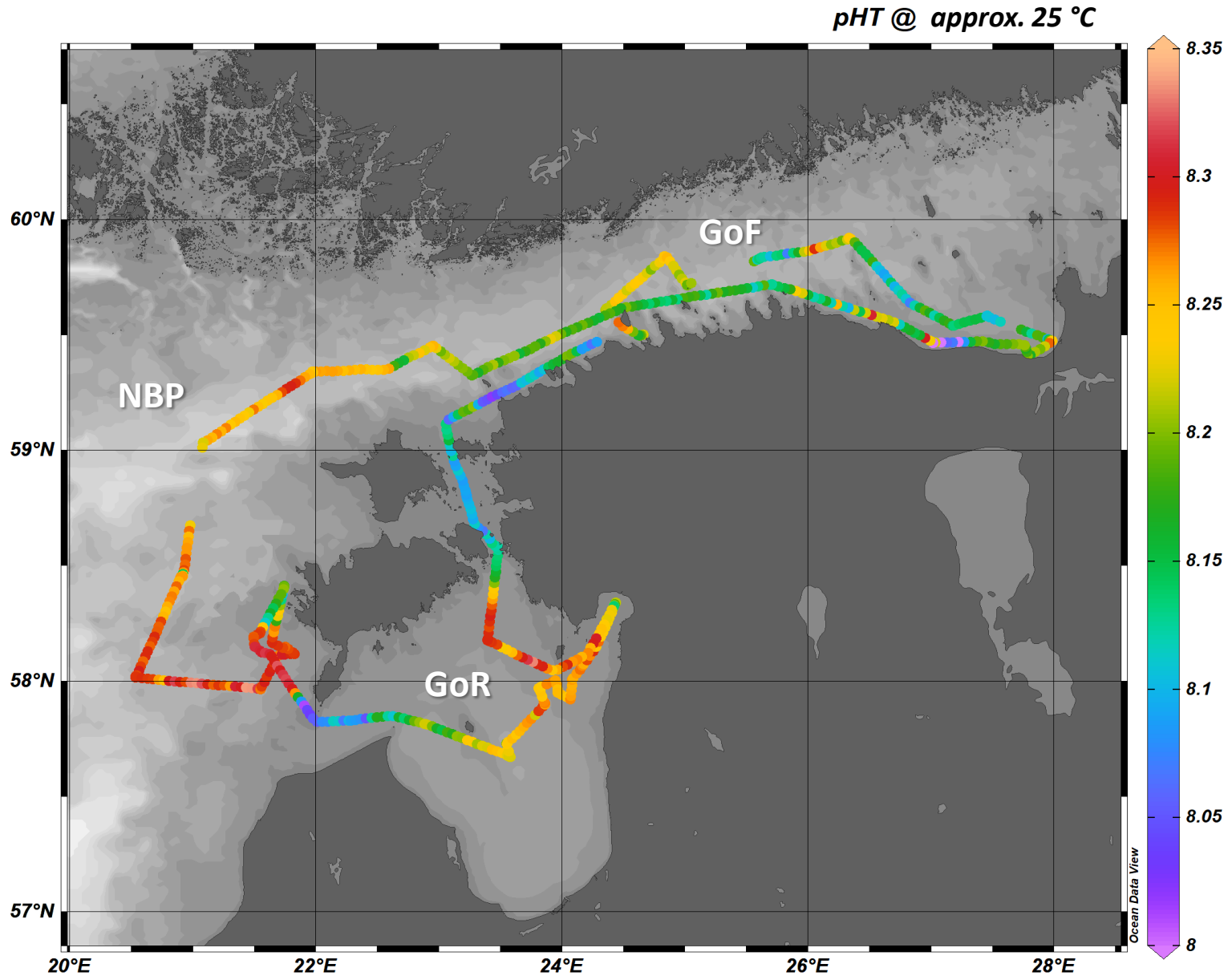
- High spatiotemporal pH measurements along the Tallinn Helsinki ferry route (weekly measurements interval)

ENVIRONMENTAL INVESTMENT CENTRE

FLYDOG

Preliminary pH_T results from August 2022 cruise: characterises the situation after midsummer cyanobacteria bloom. Surface water pH_T shows larger spatial variability in the GoR and GoF than in the NBP.





VESSELS WITH FERRYBOX SYSTEMS BETWEEN TALLINN-HELSINKI

- 1997 Wasa Queen
- 1998 – 2003 FINNJET
- 2003 – 2006 Romantika
- 2006 – 2008 Galaxy (4h-Jena FerryBox I installed)
- 2008 – 2013 Baltic Princess
- 2013 – 2014 Silja Europa
- 2015 – 2016 Baltic Queen
- 2017 – 2022 Silja Europa (2019 new system made by FlyDog Marine)

THANK YOU FOR YOUR ATTENTION!

Villu.Kikas@taltech.ee

TAL TEC