Coastal Observatory operated by Marine Systems Institute (Estonia)

Urmas Lips

Marine Systems Institute

Tallinn University of Technology

Co-authors: Inga Lips, Villu Kikas, Taavi Liblik, Natalja Kuvaldina, Nelli Norit, Kristi Altoja

Outline

- Background
- System components
  - Ferrybox measurements
  - Autonomous profiling
  - ADCP
  - Water sampling and analyses
- Plans in 2010
- Conclusions

Background

The main aim of oceanographic research at the Marine Systems Institute is to contribute to the enhanced predictability of the Baltic Sea system

The main topics are:

1) basin-wide and coastal-offshore exchange processes in the north-eastern water cycle loop;
2) atmosphere-ocean interaction and marine forecasts;
3) dynamics of coastal zone;
4) processes controlling the phytoplankton dynamics.

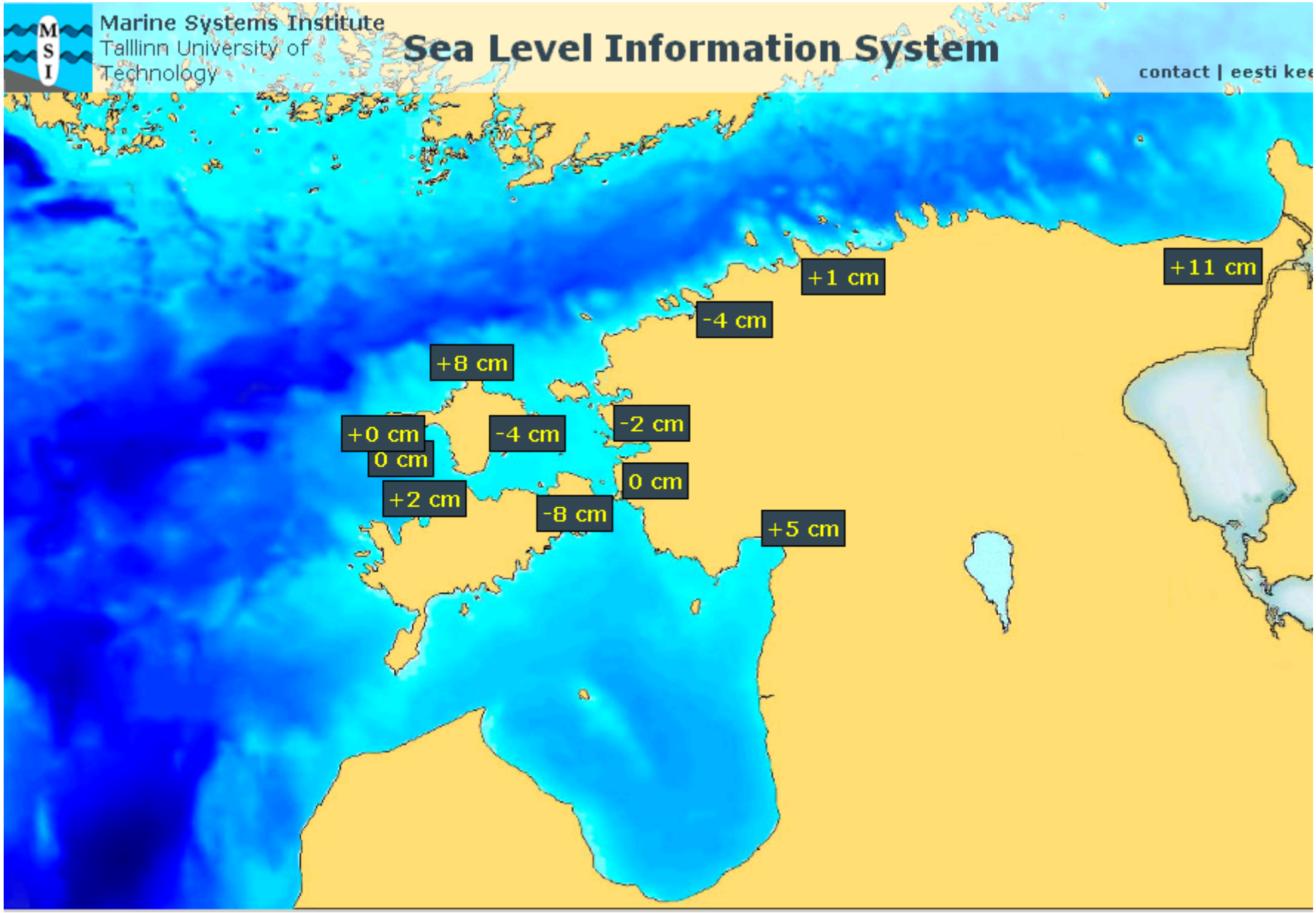
Development of operational forecasts and near real-time *in-situ* observing systems.

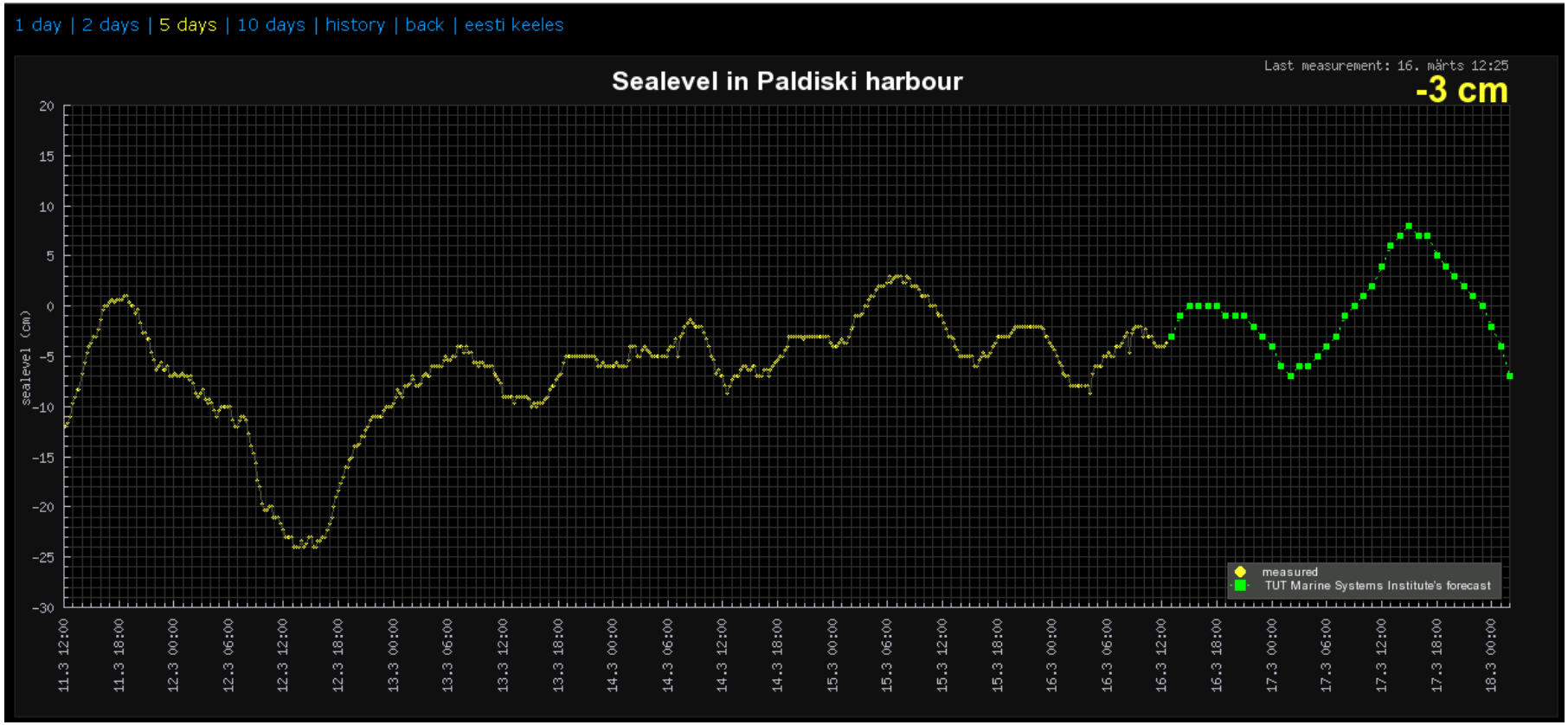
Background

- Operational models need near real-time data
- Classical observations are performed with low frequency or episodically
- Remote sensing methods do not reveal the vertical structure of the water column
- Essential phenomena and mechanisms may remain unnoticed
- New observation tools have been introduced within the last 10-20 years, which enable to improve spatial coverage, spatial and temporal resolution and to employ new marine ecological state variables
- These new observing systems are significantly improving the existing understanding of the ecosystem functioning and may be applied operationally

Background

- Within last 5 years we have established an *in-situ* measurement program in the Estonian coastal waters (main focus area - the Gulf of Finland)
- Sea level information system is operational since 2006, consists of 11 coastal stations and provides 48 hour forecasts
- New Ferrybox system operational since 2007, data delivered for HIROMB since 2008
- Autonomous buoy station for vertical profiling of water column – tests in July-August 2009, will be operational in 2010
- Measurement campaigns onboard research vessel since 2006, r/v Salme reconstructed in 2009


Marine Systems Institute
Talllinn University of
Technology
Sea Level Information System
contact | eesti kee
+1 cm
+11 cm
-4 cm
+8 cm
+0 cm
-4 cm
-2 cm
0 cm
0 cm
+2 cm
-8 cm
+5 cm


1 day | 2 days | 5 days | 10 days | history | back | eesti keeles
Sealevel in Paldiski harbour
Last measurement: 16. märts 12:25
-3 cm
sealevel (cm)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
11.3 12:00
11.3 18:00
12.3 00:00
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13.3 06:00
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14.3 12:00
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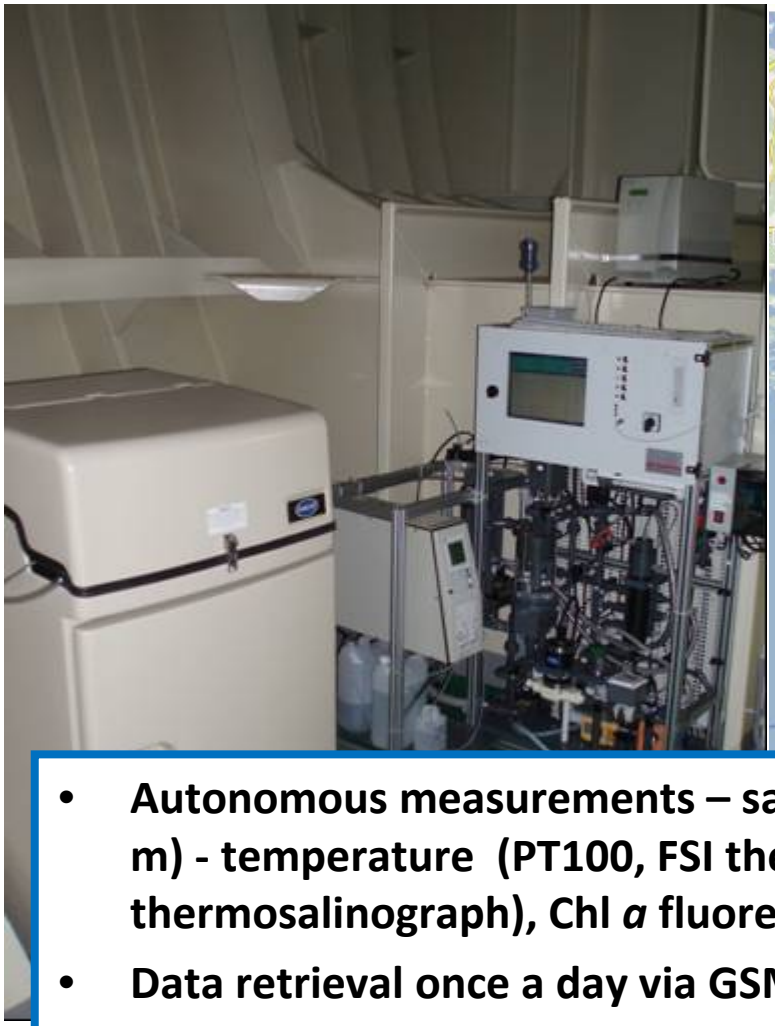
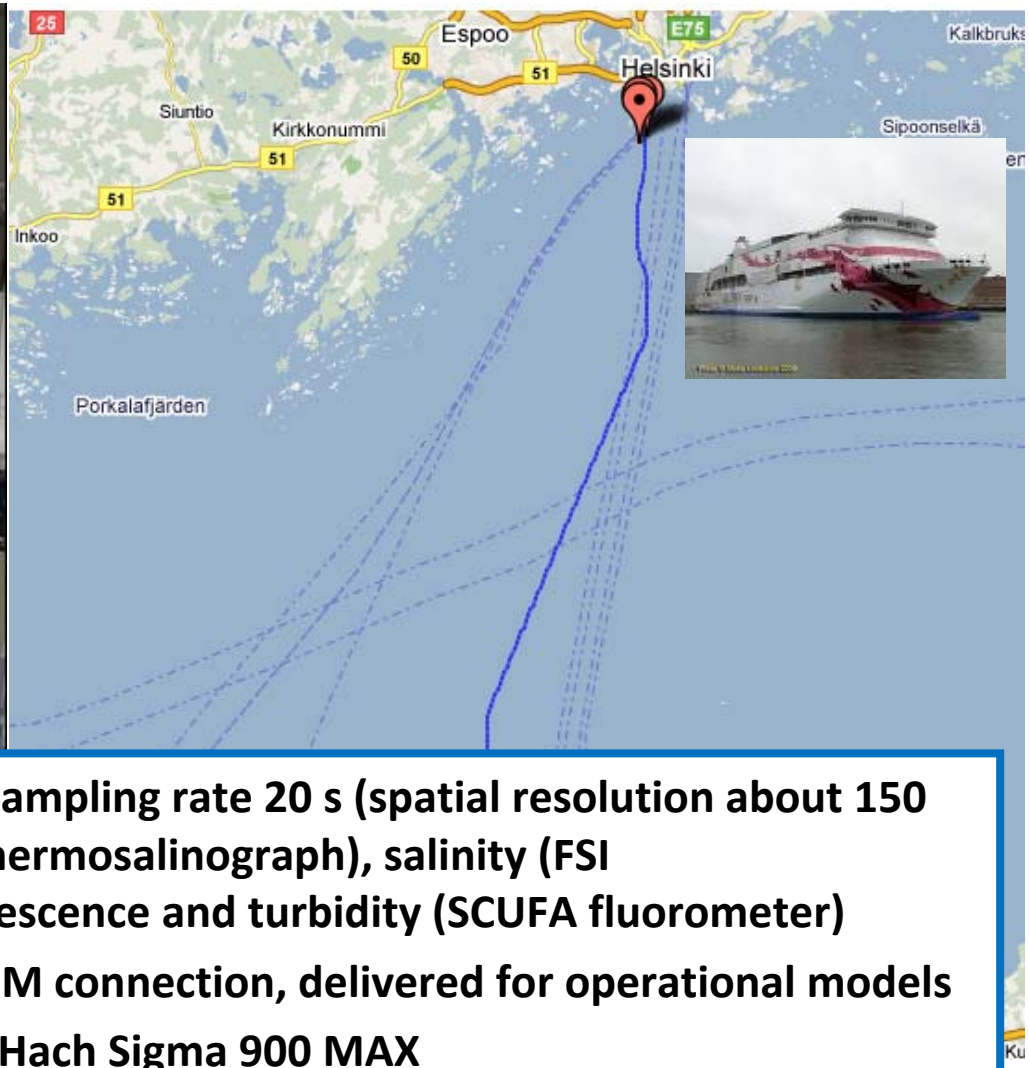
measured
TUT Marine Systems Institute's forecast

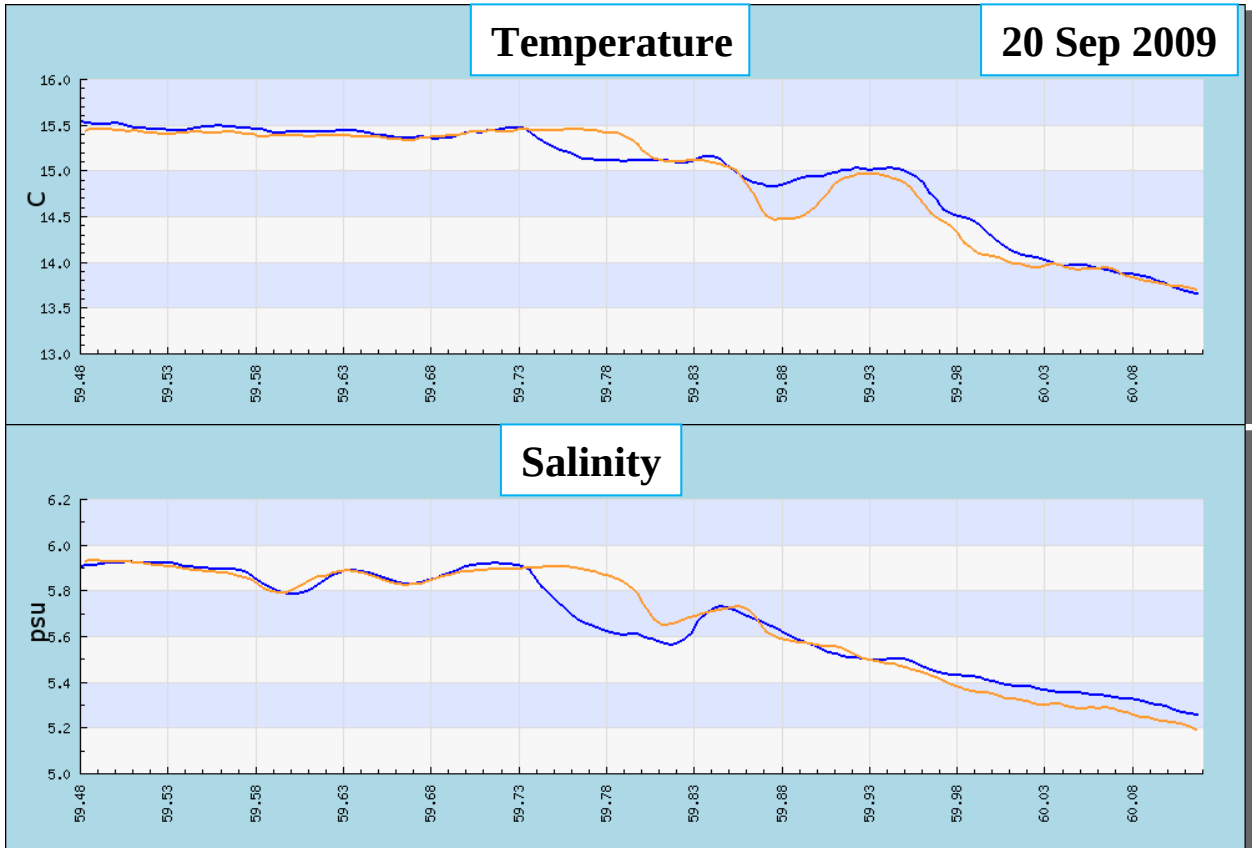




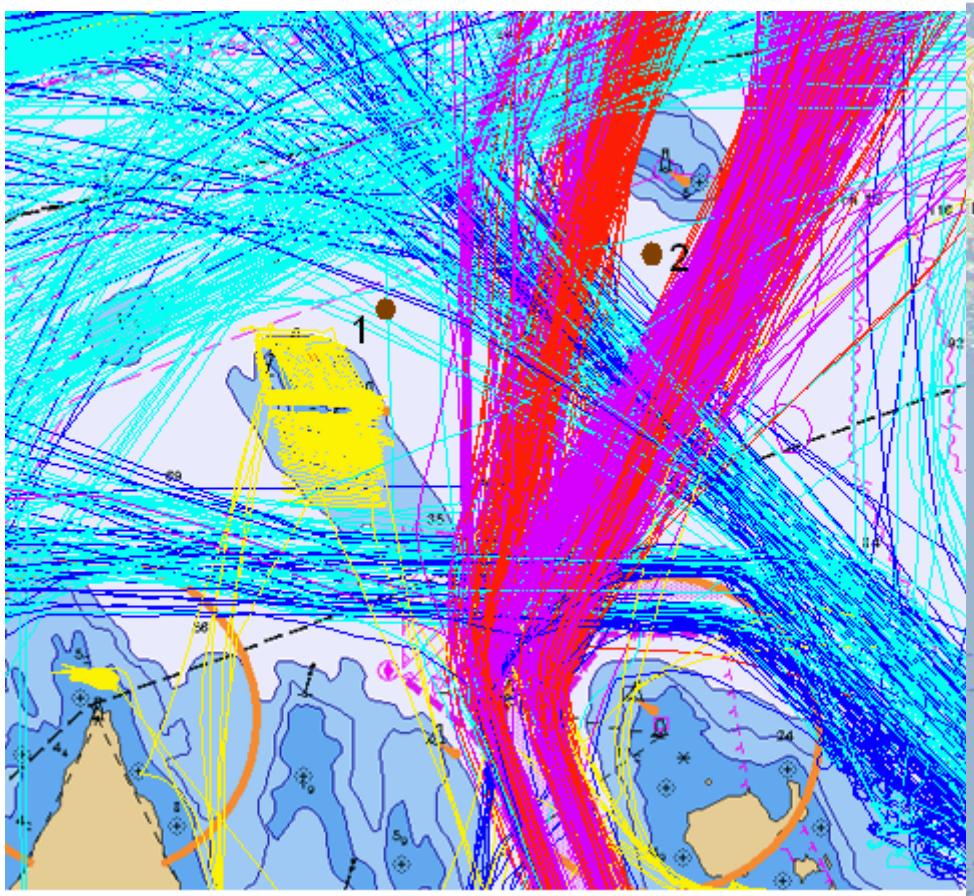
- **Autonomous measurements – sampling rate 20 s (spatial resolution about 150 m) - temperature (PT100, FSI thermosalinograph), salinity (FSI thermosalinograph), Chl *a* fluorescence and turbidity (SCUFA fluorometer)**
- **Data retrieval once a day via GSM connection, delivered for operational models**
- **Water samples once a week by Hach Sigma 900 MAX**
- **Nutrients (PO_4^-, NO_2^-+NO_3^-) nutrient analyzer µMac 1000 and autoanalyzer Lachat; Chl a analyses by spectrophotometer Thermo Helios γ; salinity by Autosal; phytoplankton counting**

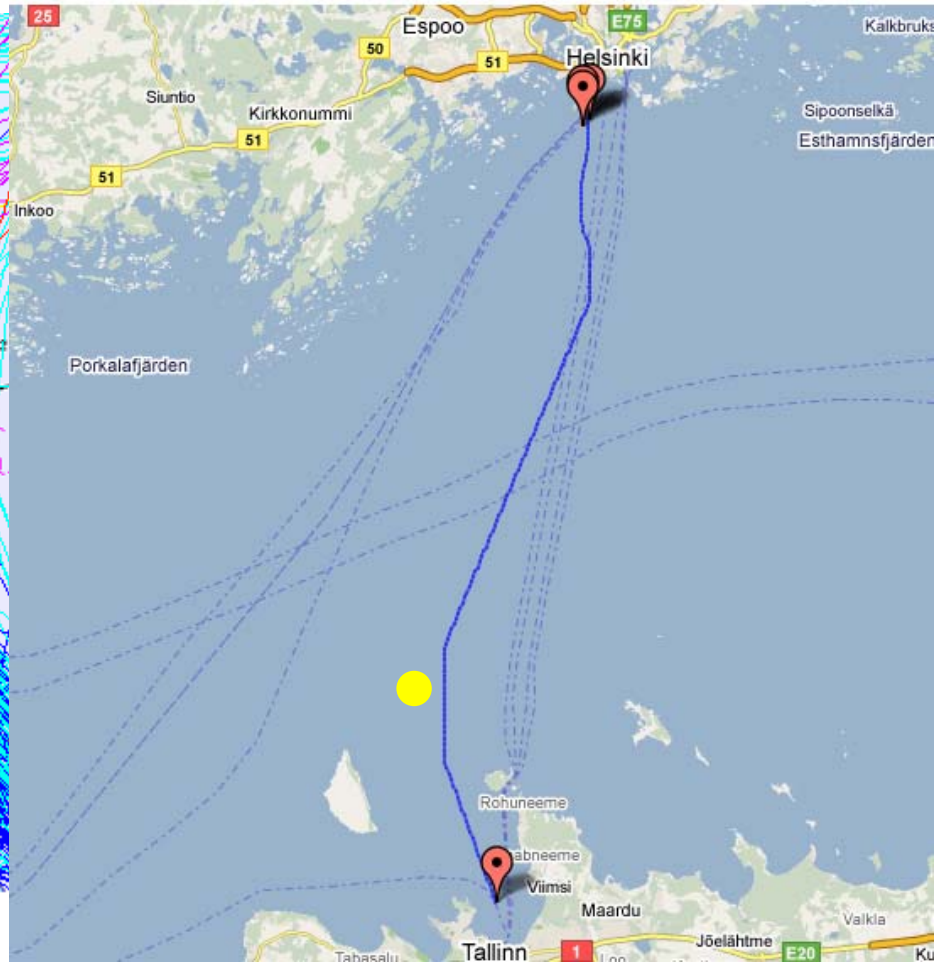
Ferrybox system from 4H Jena, Germany

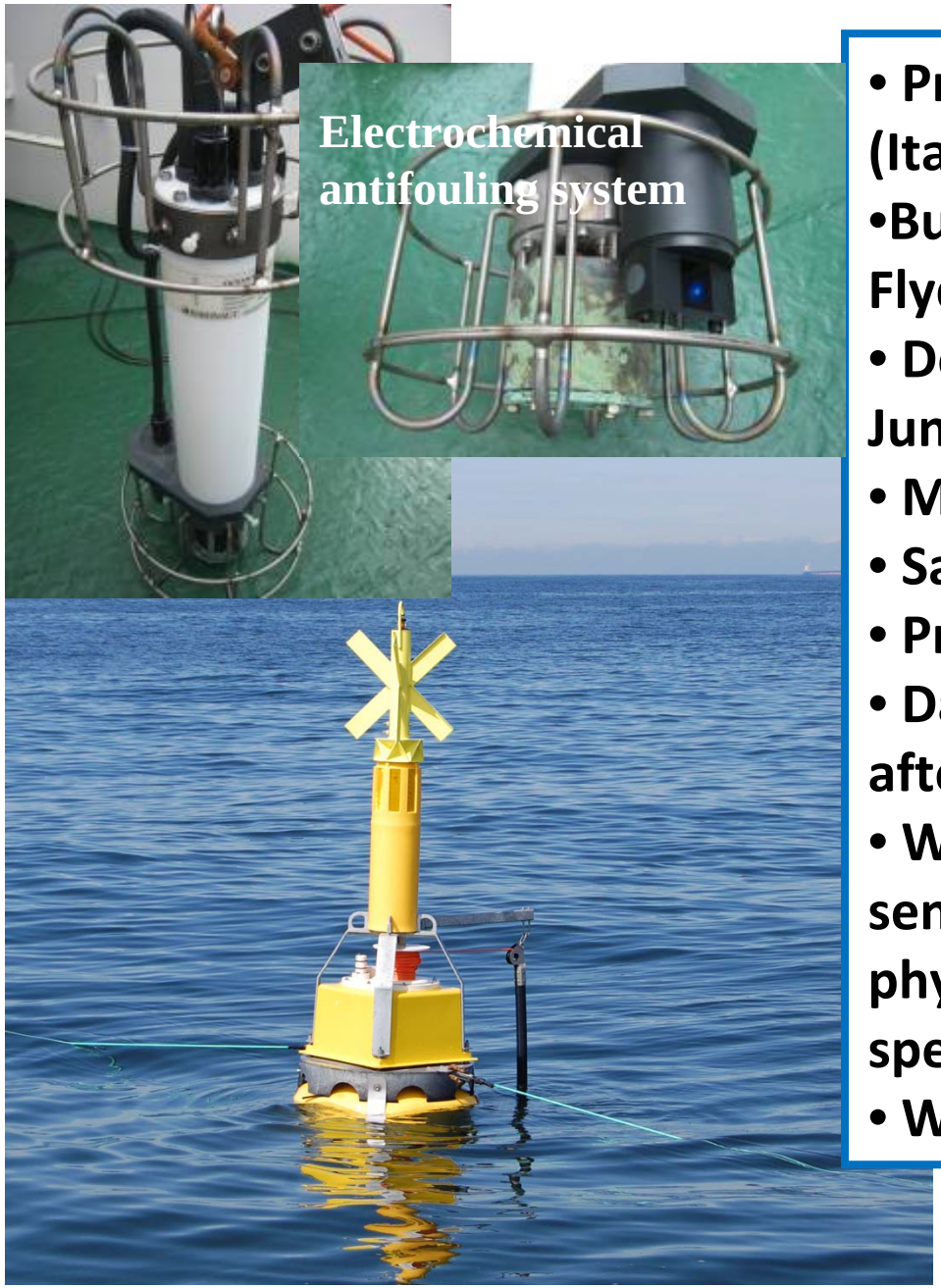
Data are delivered daily for operational models



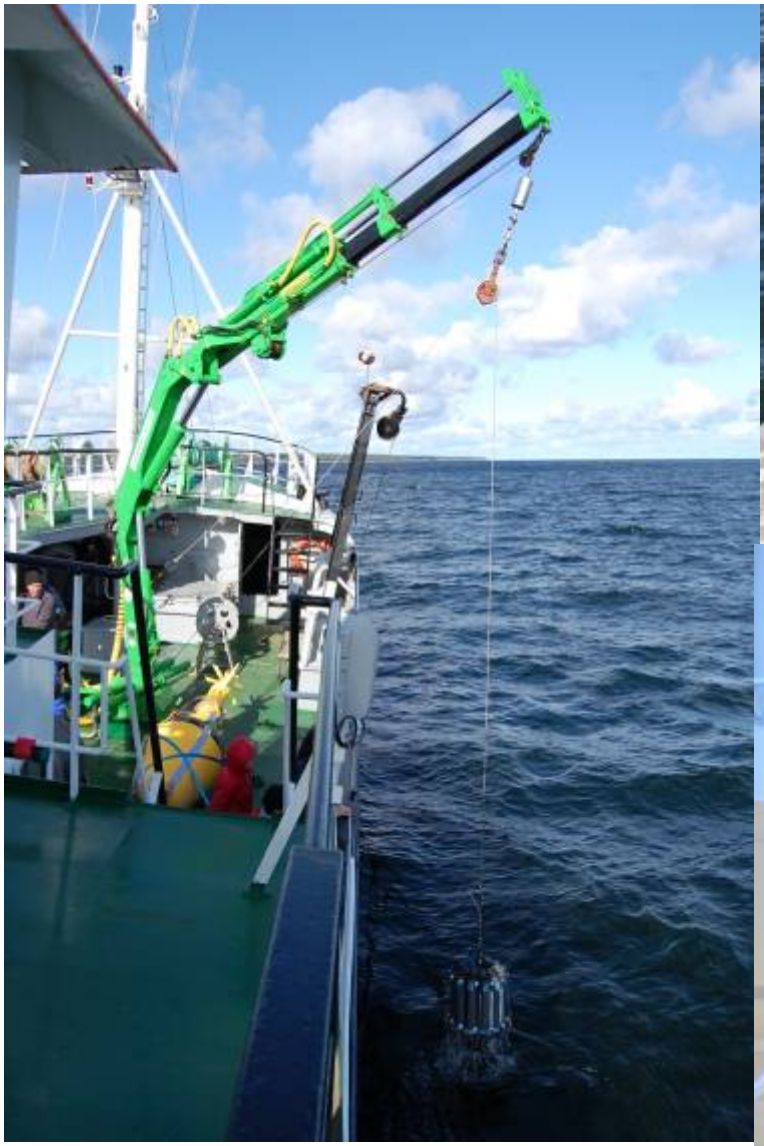
Autonomous profiler for high resolution vertical profiling of water column in the Gulf of Finland







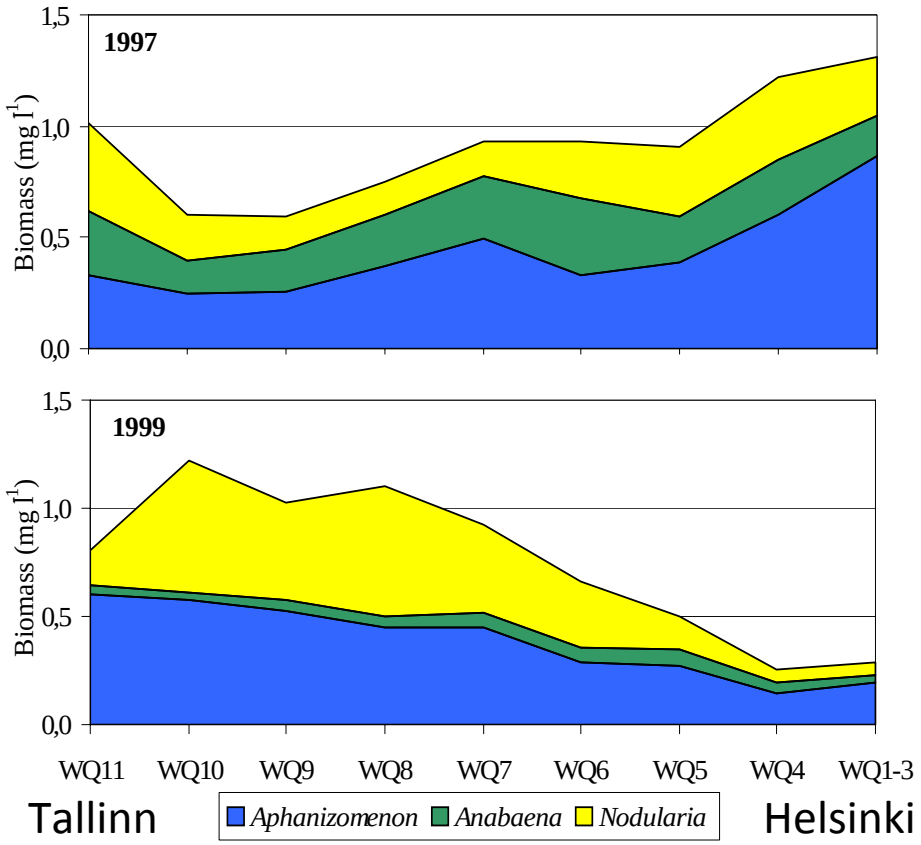
- Profiling system from Idronaut s.r.l. (Italy)
- Buoy designed and constructed by Flydog Solutions (Estonia)
- Deployed for 2 months of testing on 30 June 2009
- Measures T, S, Chl *a* fluorescence
- Sampling interval 3 hours
- Profiles from 2 to 50 m
- Data delivered via GSM connection after every profiling
- Water sampling for calibration of sensors and identification of phytoplankton and micro-zooplankton species performed every second week
- Will be operational in April 2010

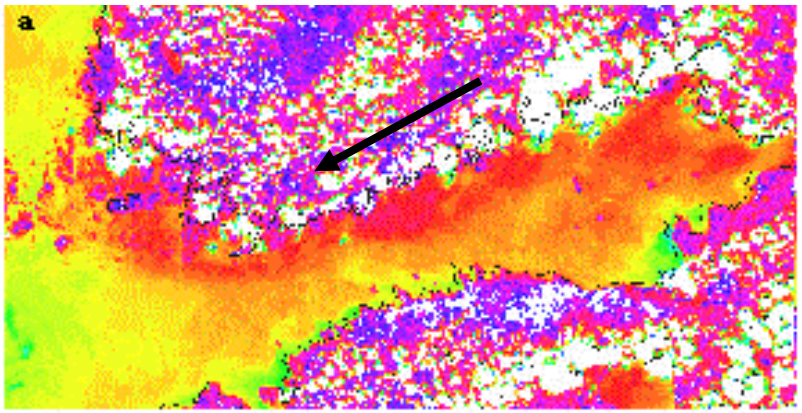


History of Ferrybox measurements Tallinn-Helsinki

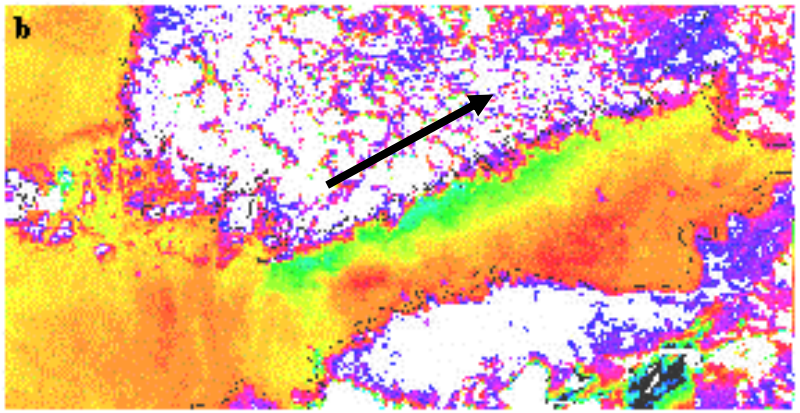
- First trials in 1989-1990; ferry Georg Ots; responsible Mati Kahru (EMI), Juha-Markku Leppänen (FIMR)
- Alg@line started in 1993 (FIMR etc)
- Tallinn-Helsinki on routine basis since 1997 (FIMR, Uusimaa Regional Env. Centre, Helsinki City, EMI), ferries: Wasa Queen, Finnjet, Romantika; responsible Juha-Markku 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
- MSI – Villu Kikas, Nelli Norit, Natalja Kuvaldina, Inga Lips

Influence of meso-scale processes on spatial distribution of biomass





1997



1999

(Kanoshina, Lips & Leppänen, 2003, *Harmful Algae*)

Inter-annual variations of integrated biomass of bloom forming cyanobacteria

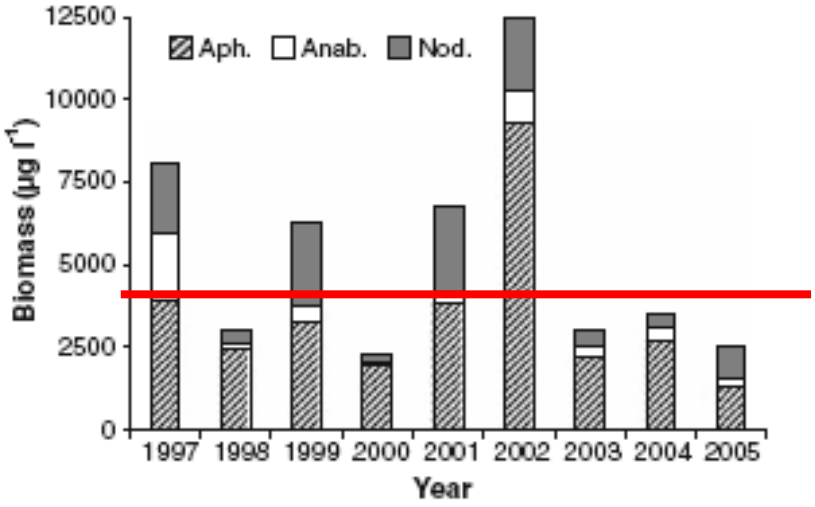


Fig. 2 Integrated biomass of *Aphanizomenon* sp., *Nodularia spumigena* and *Anabaena* spp. over the bloom period along the transect between Tallinn and Helsinki in 1997–2005

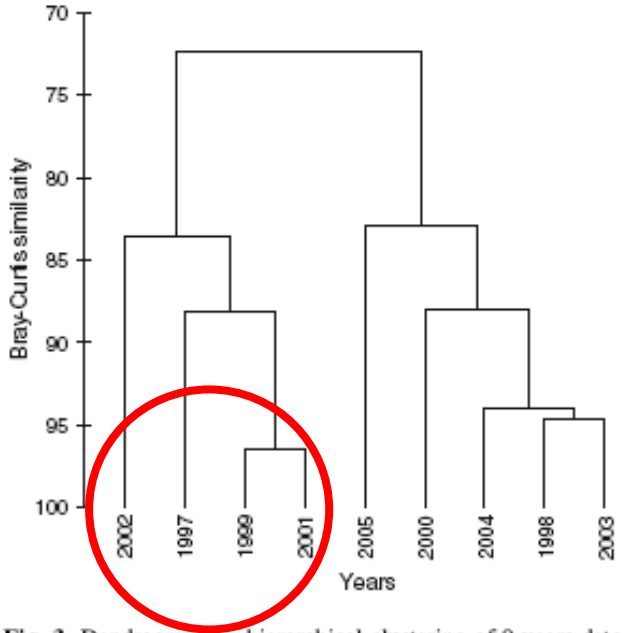
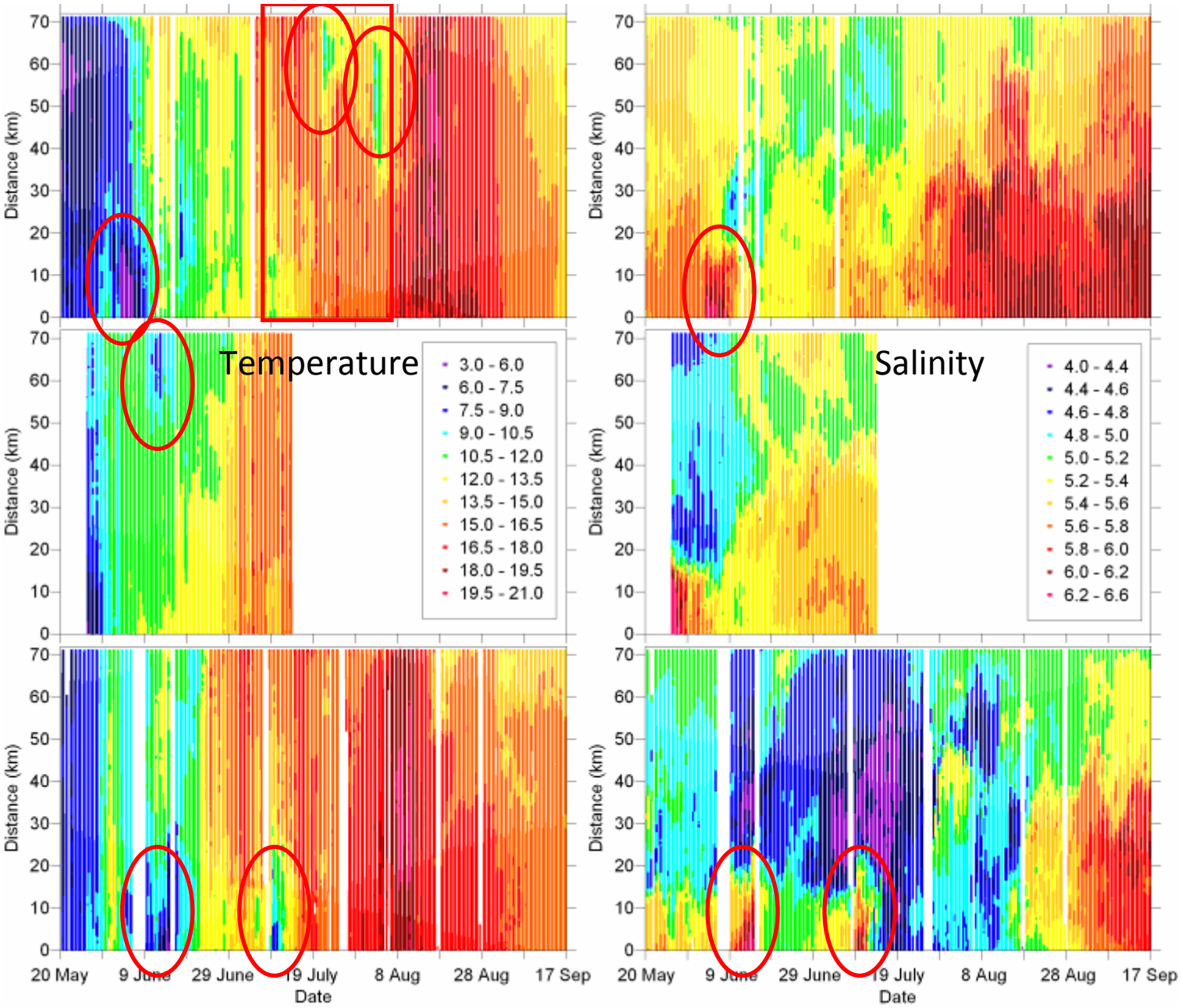


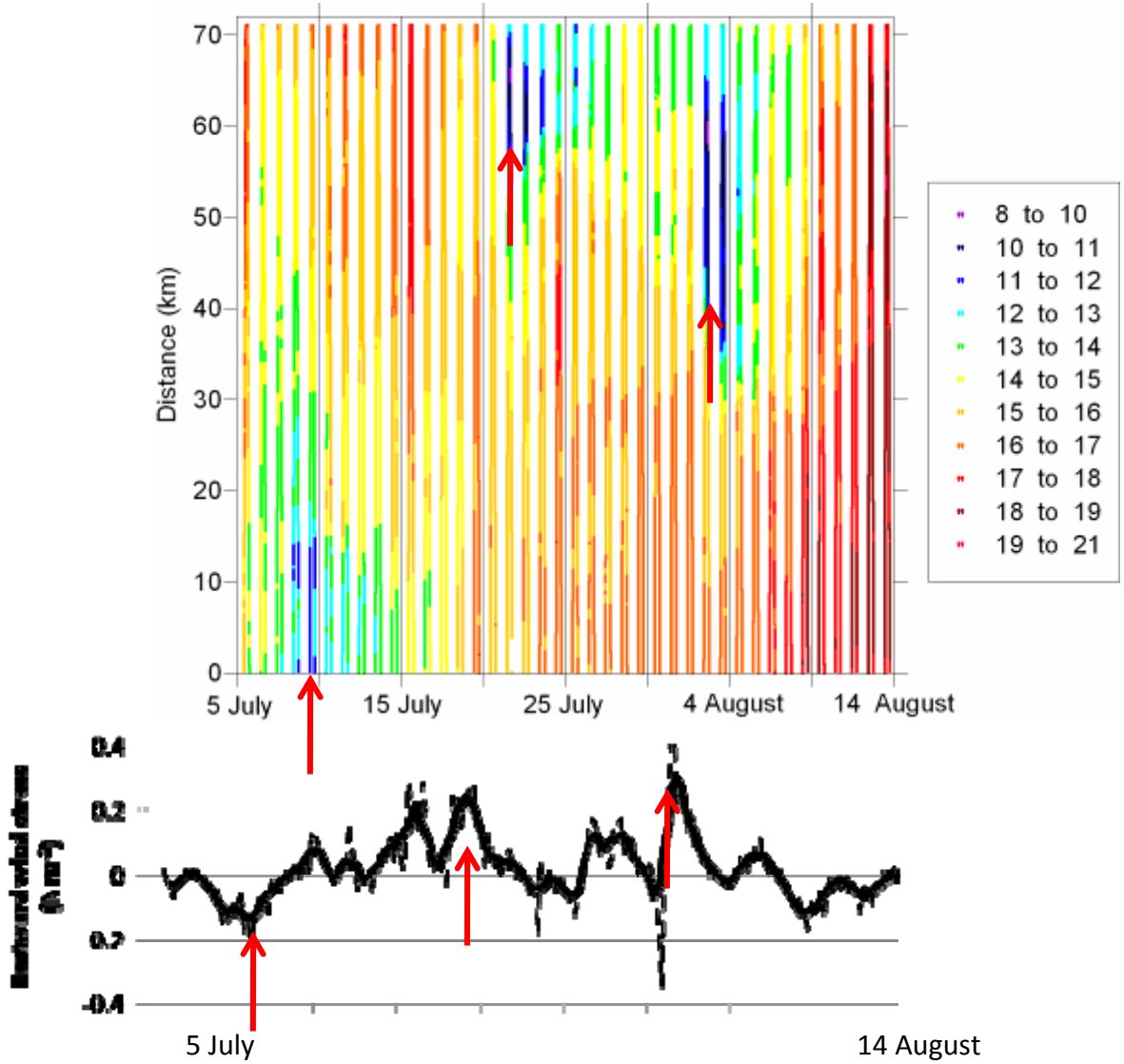
Fig. 3 Dendrogram for hierarchical clustering of 9 years data of *Aphanizomenon* sp., *Nodularia spumigena* and *Anabaena* spp., using Bray-Curtis similarities and calculated on square root biomass data

Factors influencing the bloom intensity (besides excess phosphorus left in the surface layer after the spring bloom) are 1) intensity of pre-bloom upwelling events (May-June) and 2) PAR (sum in June-August)

(Lips & Lips, 2008, *Hydrobiologia*)


Temperature
Salinity
2007
2008
2009
Distance (km)
Date
20 May
9 June
29 June
19 July
8 Aug
28 Aug
17 Sep
3.0 - 6.0
6.0 - 7.5
7.5 - 9.0
9.0 - 10.5
10.5 - 12.0
12.0 - 13.5
13.5 - 15.0
15.0 - 16.5
16.5 - 18.0
18.0 - 19.5
19.5 - 21.0
4.0 - 4.4
4.4 - 4.6
4.6 - 4.8
4.8 - 5.0
5.0 - 5.2
5.2 - 5.4
5.4 - 5.6
5.6 - 5.8
5.8 - 6.0
6.0 - 6.2
6.2 - 6.6

Temperature 5 July – 14 August 2007

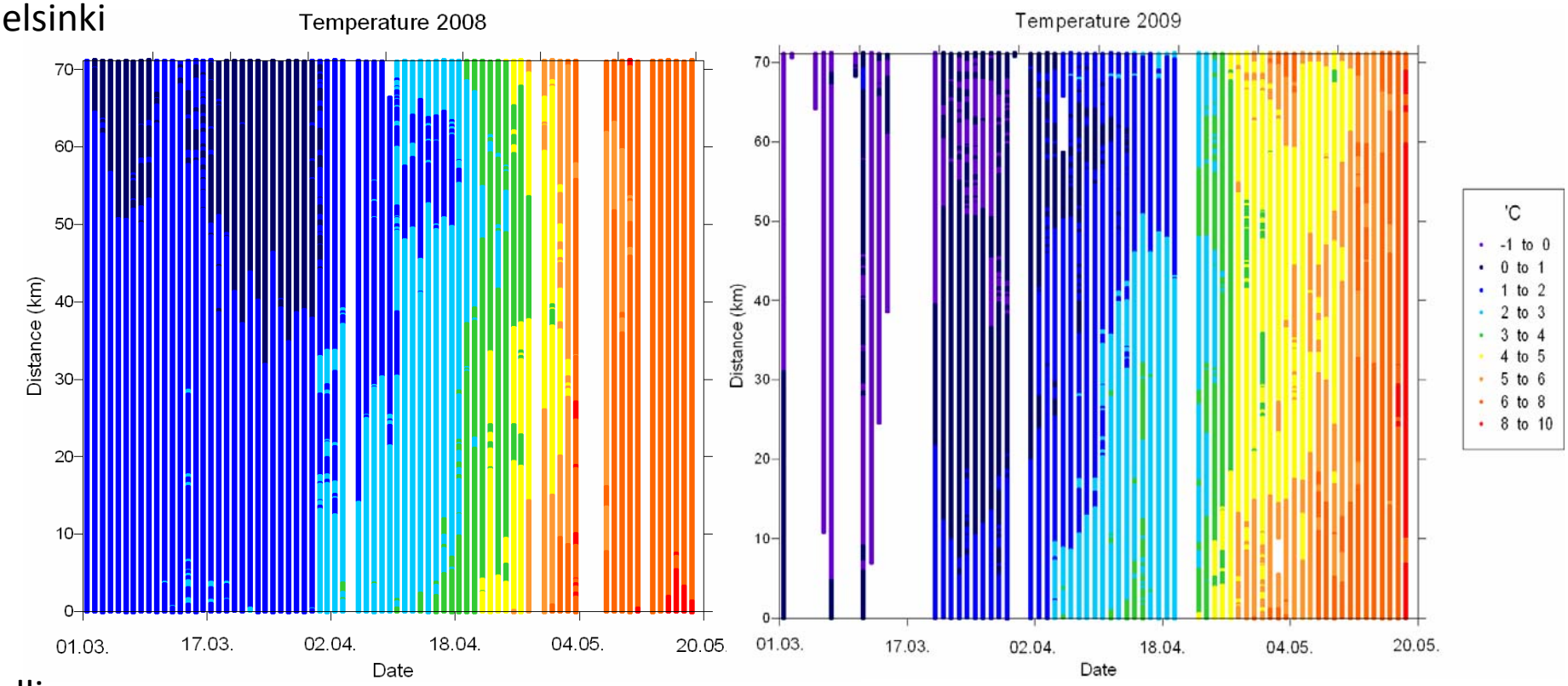


Maximal temperature deviations during upwelling events are observed about 3 days after the maximum along-channel wind stress

Relaxation of an upwelling event takes about 5-6 days (if variable or weak winds prevail)

Temperature variations in March-May 2008 and 2009

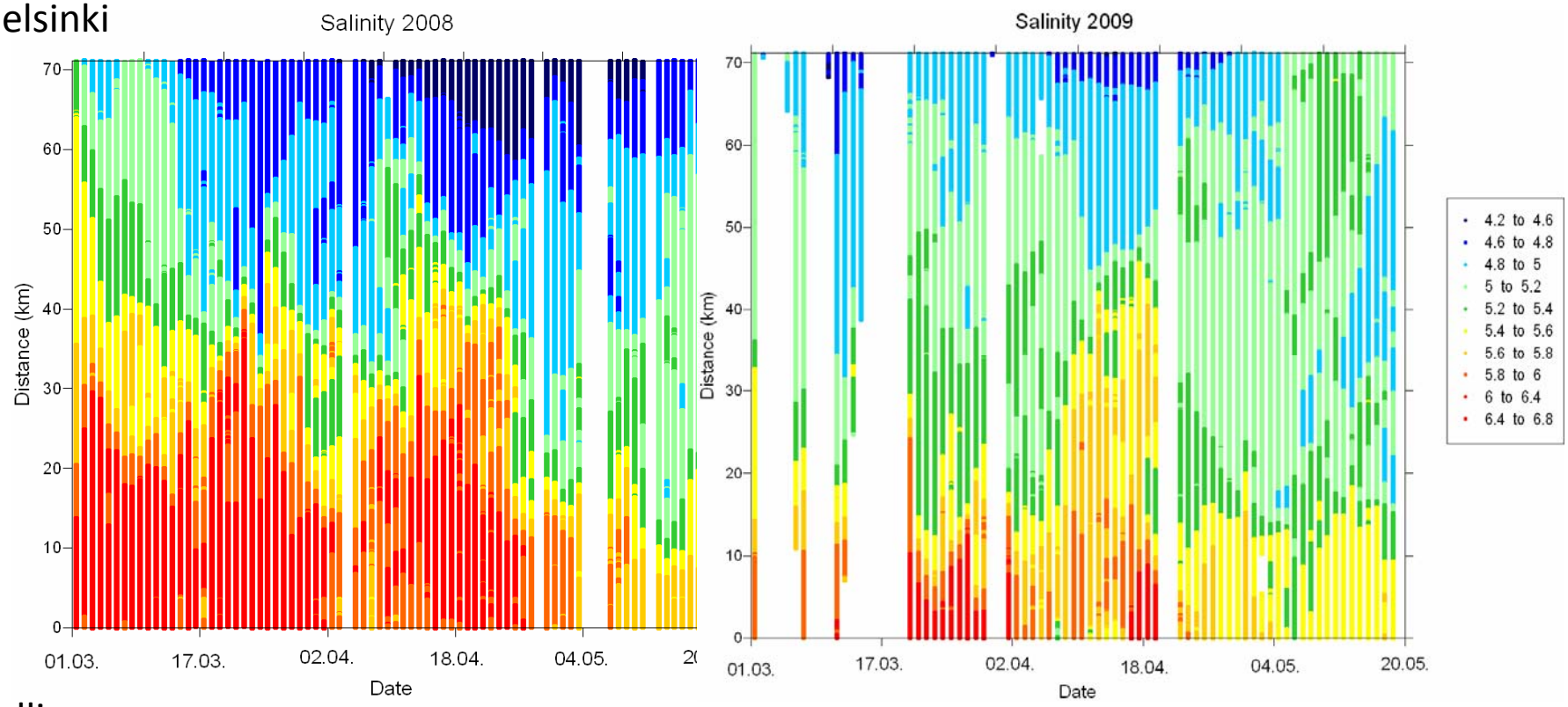
Helsinki



Tallinn

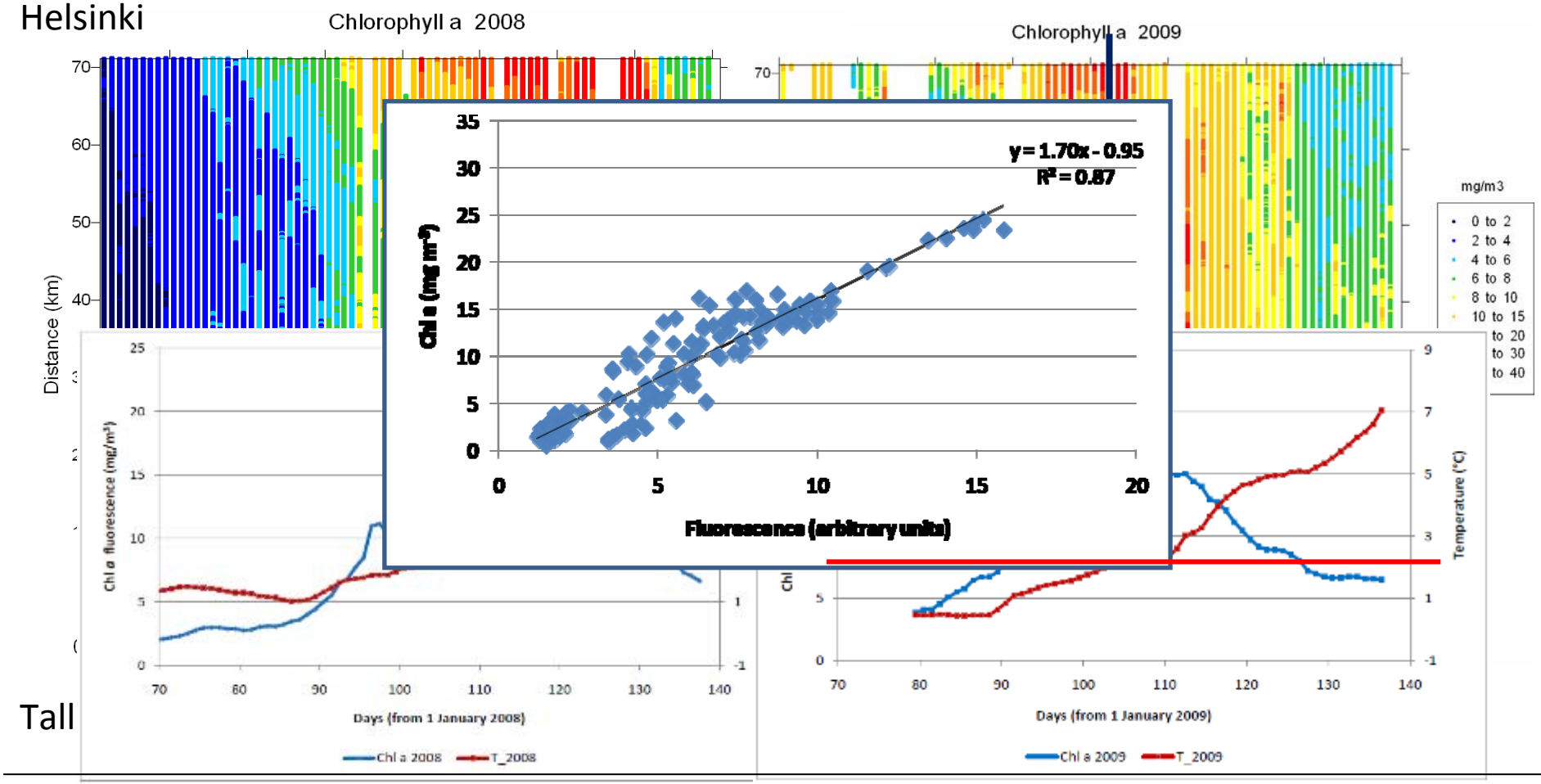
Salinity variations
in March-May 2008 and 2009

Helsinki

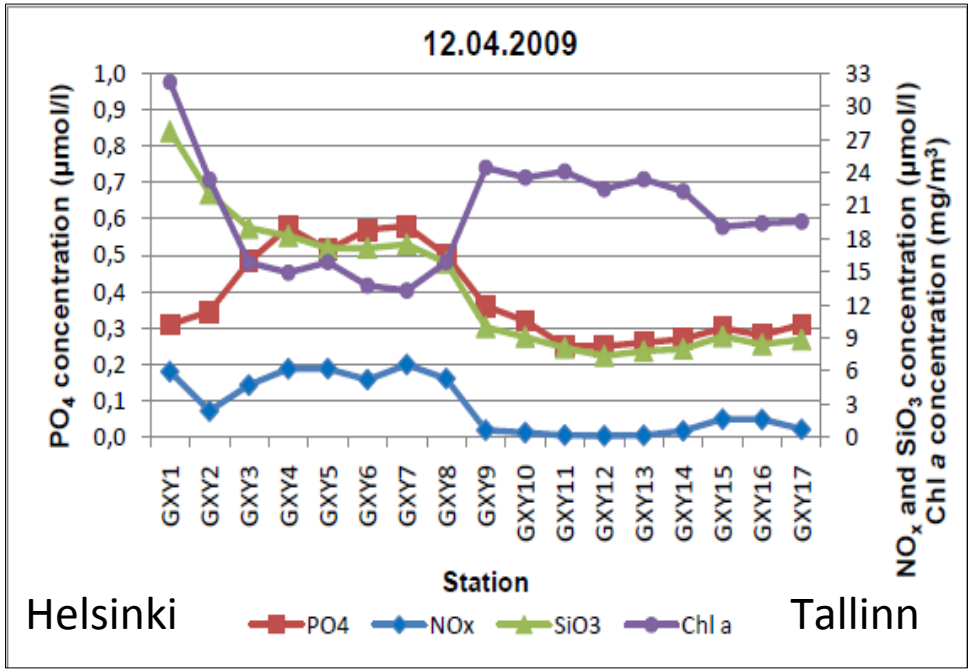


Tallinn

Chlorophyll *a* variations in March-May 2008 and 2009

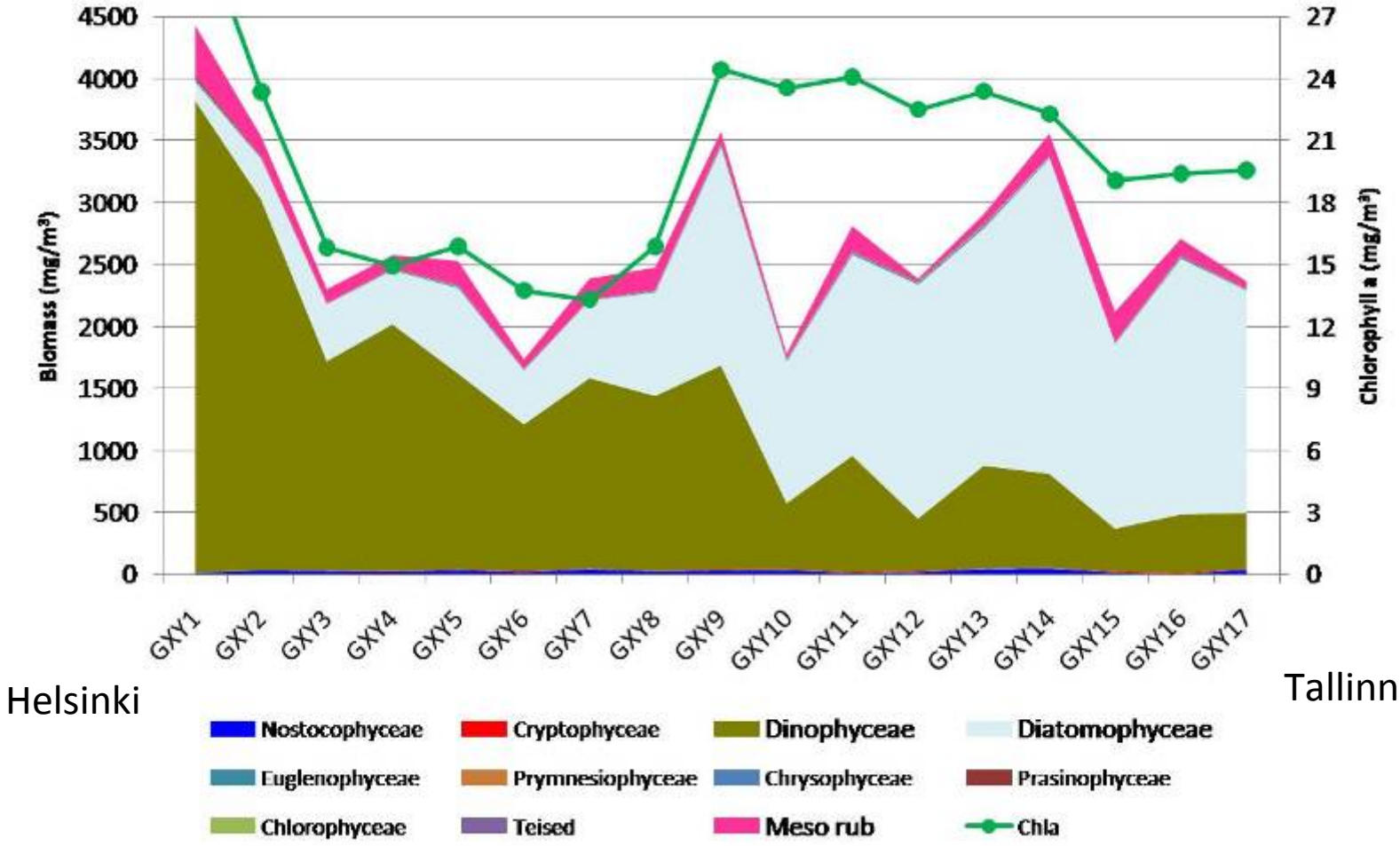


Distribution of nutrients, Chl a and phytoplankton in the surface layer during the bloom peak in 2009



- The bloom peak is controlled not only by nutrient availability
- Bloom could develop faster during the years with ice cover
- Bloom develops before the temperature of maximum density is reached
- Development of stratification must be monitored

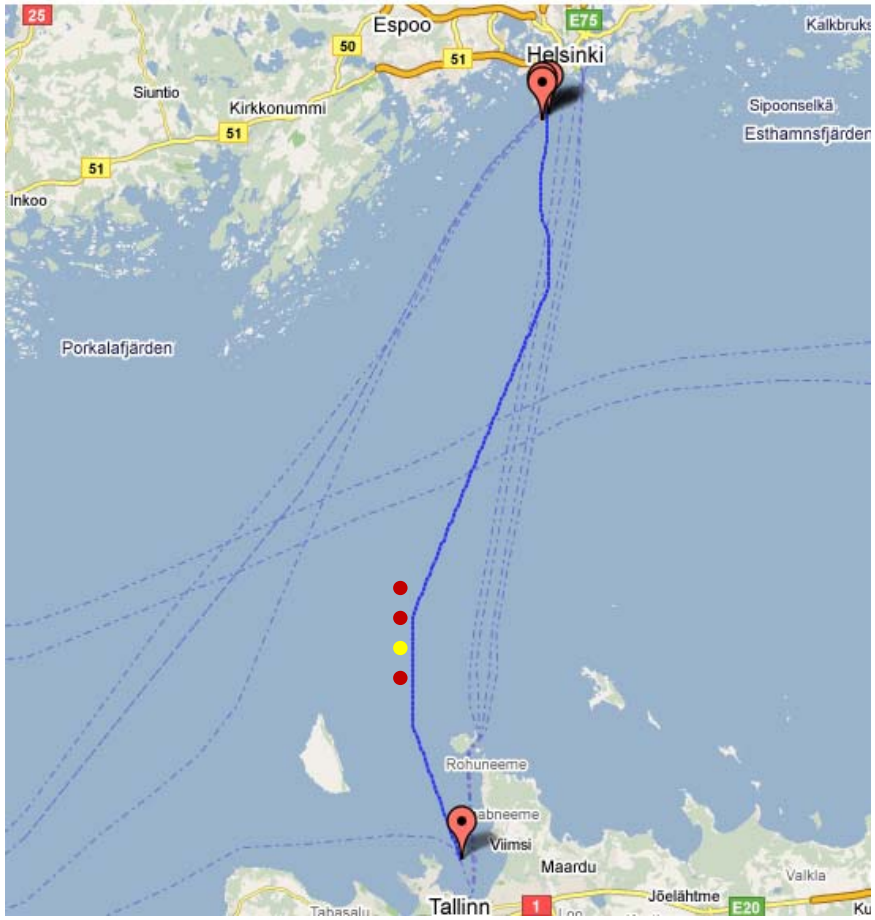
Distribution of nutrients, Chl a and phytoplankton in the surface layer during the bloom peak in 2009



Helsinki

Tallinn

Measurements in summer 2009



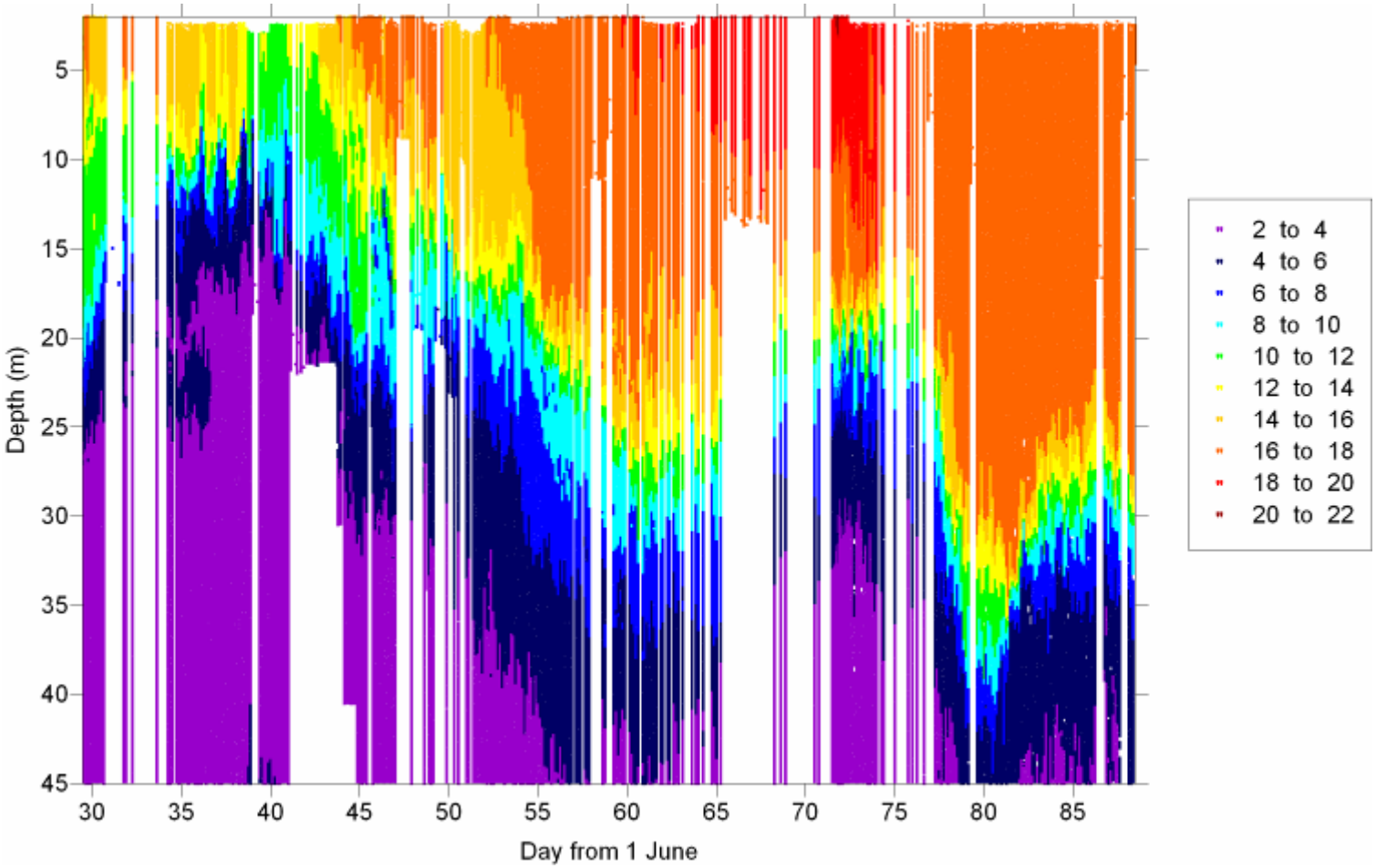
In July-August 2009 high resolution vertical profiling of temperature, salinity and Chl *a* fluorescence was carried out with a time step of 3 hours using the autonomuous profiling system.

Vertical flow structure was registered using a bottom mounted ADCP

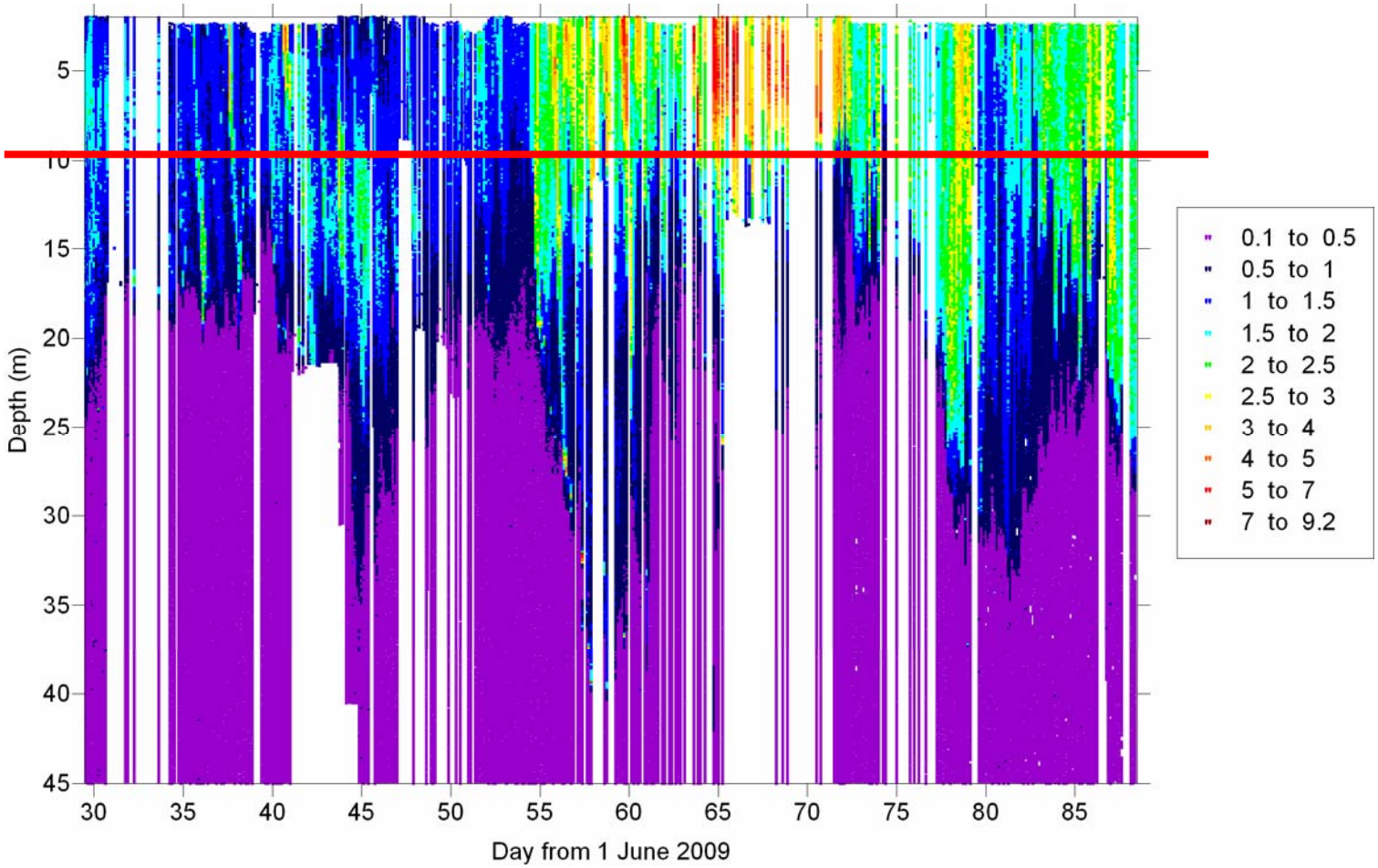
Water sampling for Chl *a*, nutrient and phytoplankton analyses was performed.

Ferrybox measurements twice a day along the ferry line Tallinn-Helsinki and water samples for Chl *a*, nutrient and phytoplankton analyses were taken once a week at 17 locations.

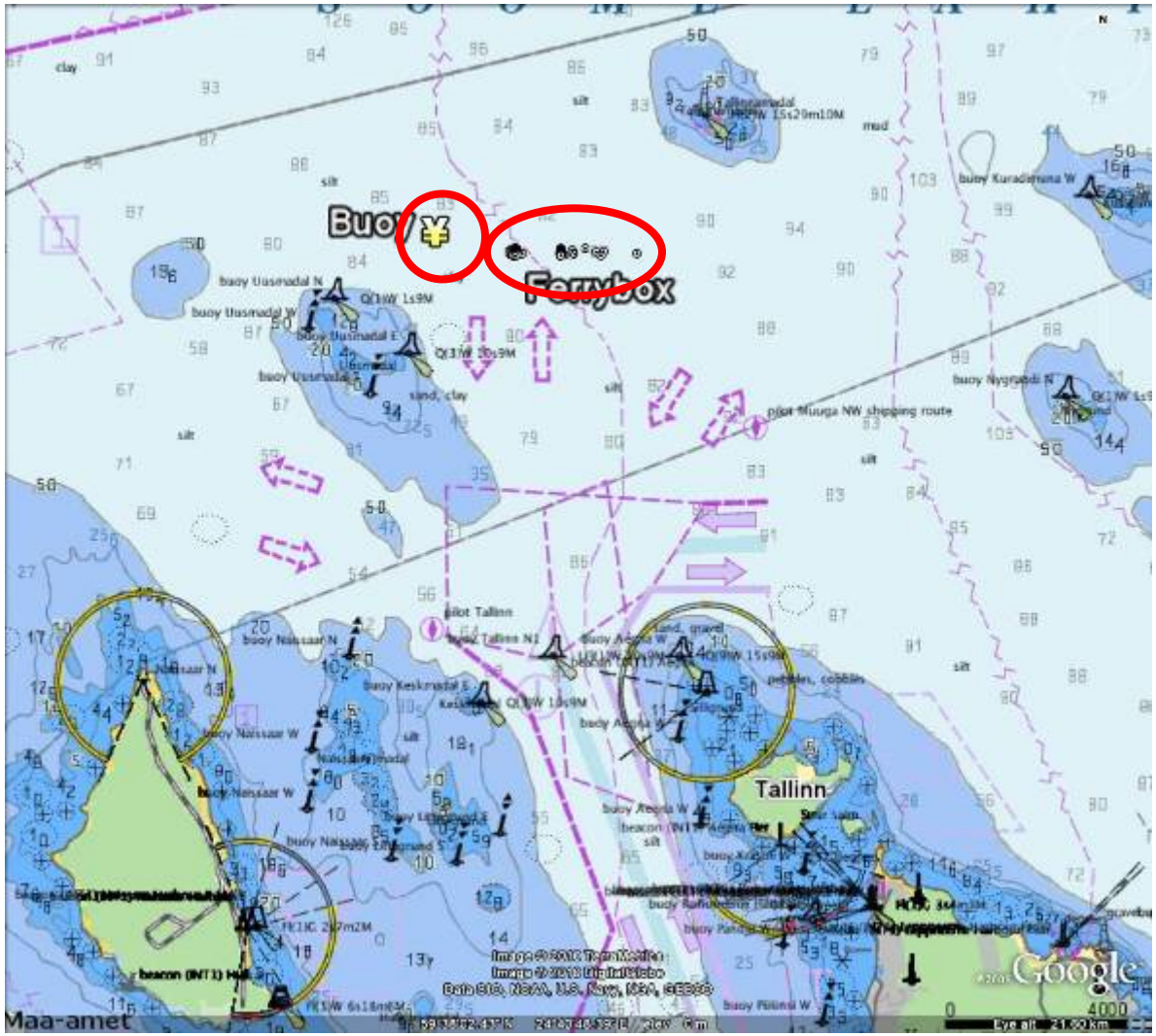
Vertical temperature distribution at the buoy station from 30 June until 29 August 2009



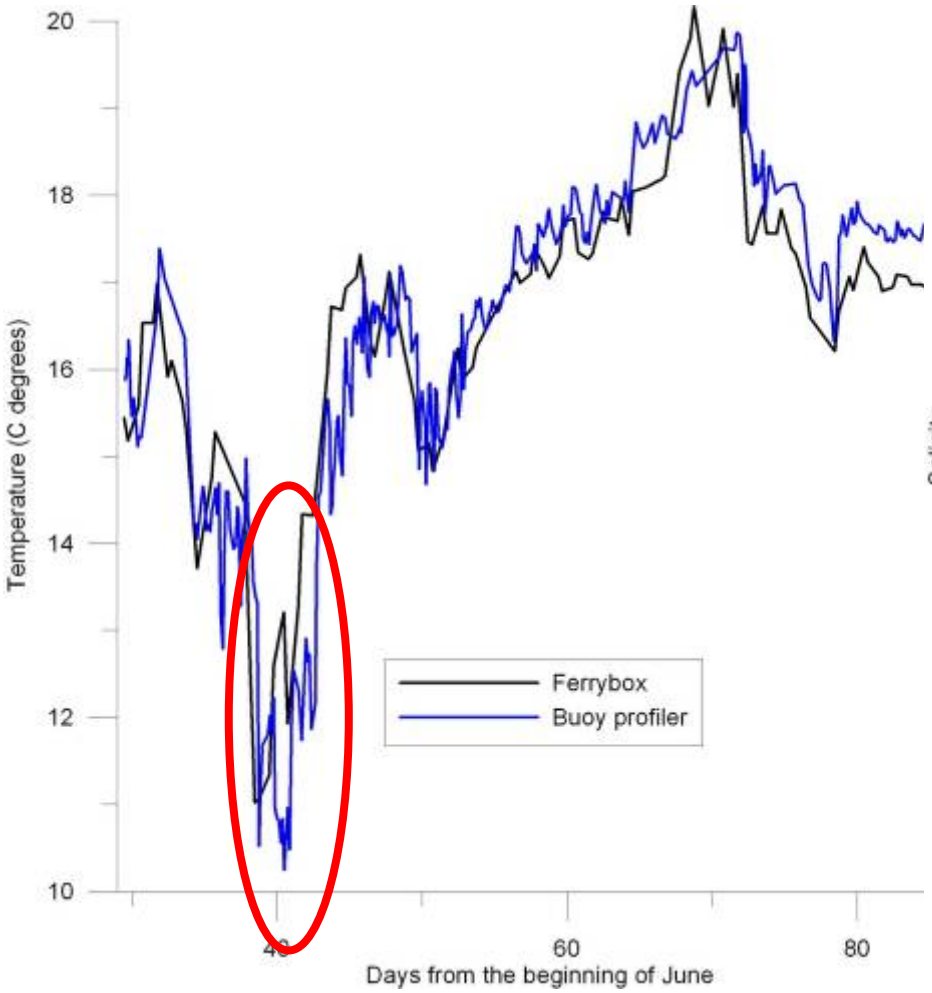
Vertical Chl *a* fluorescence distribution at the buoy station from 30 June until 29 August

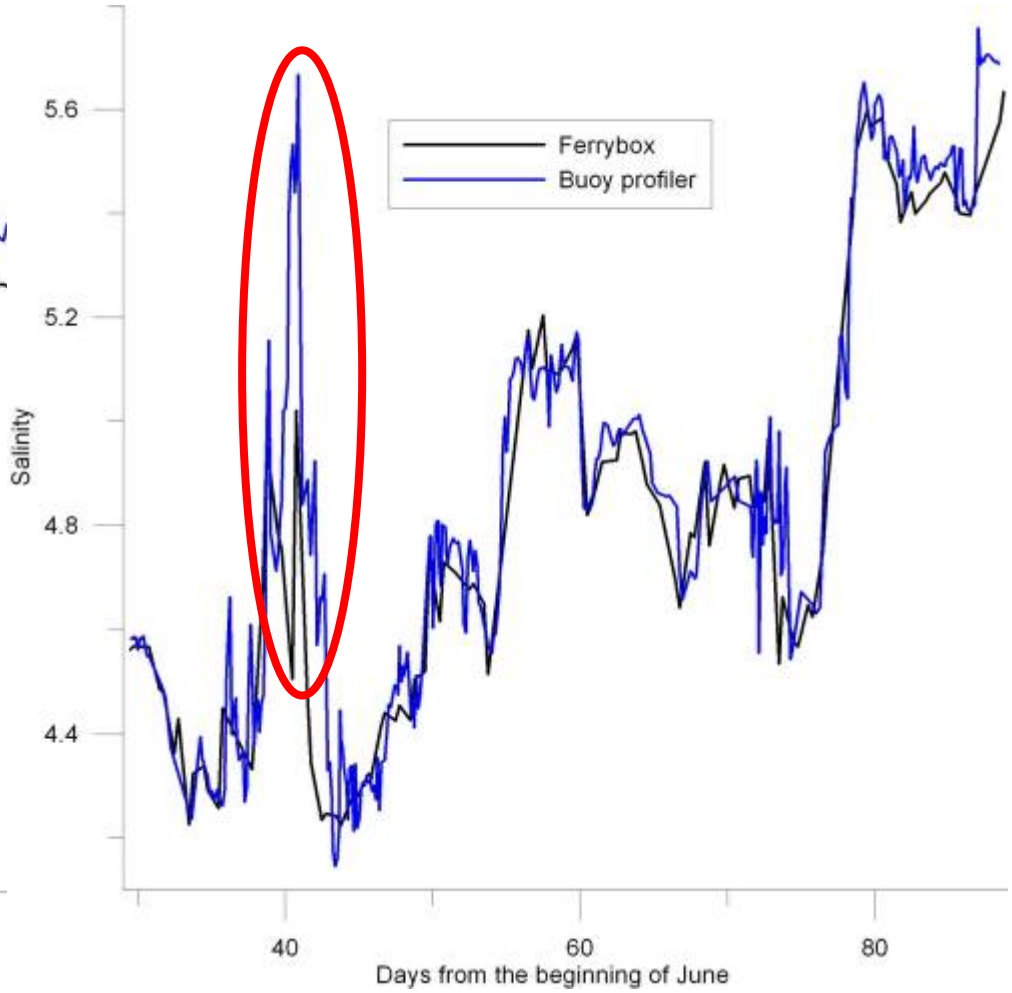


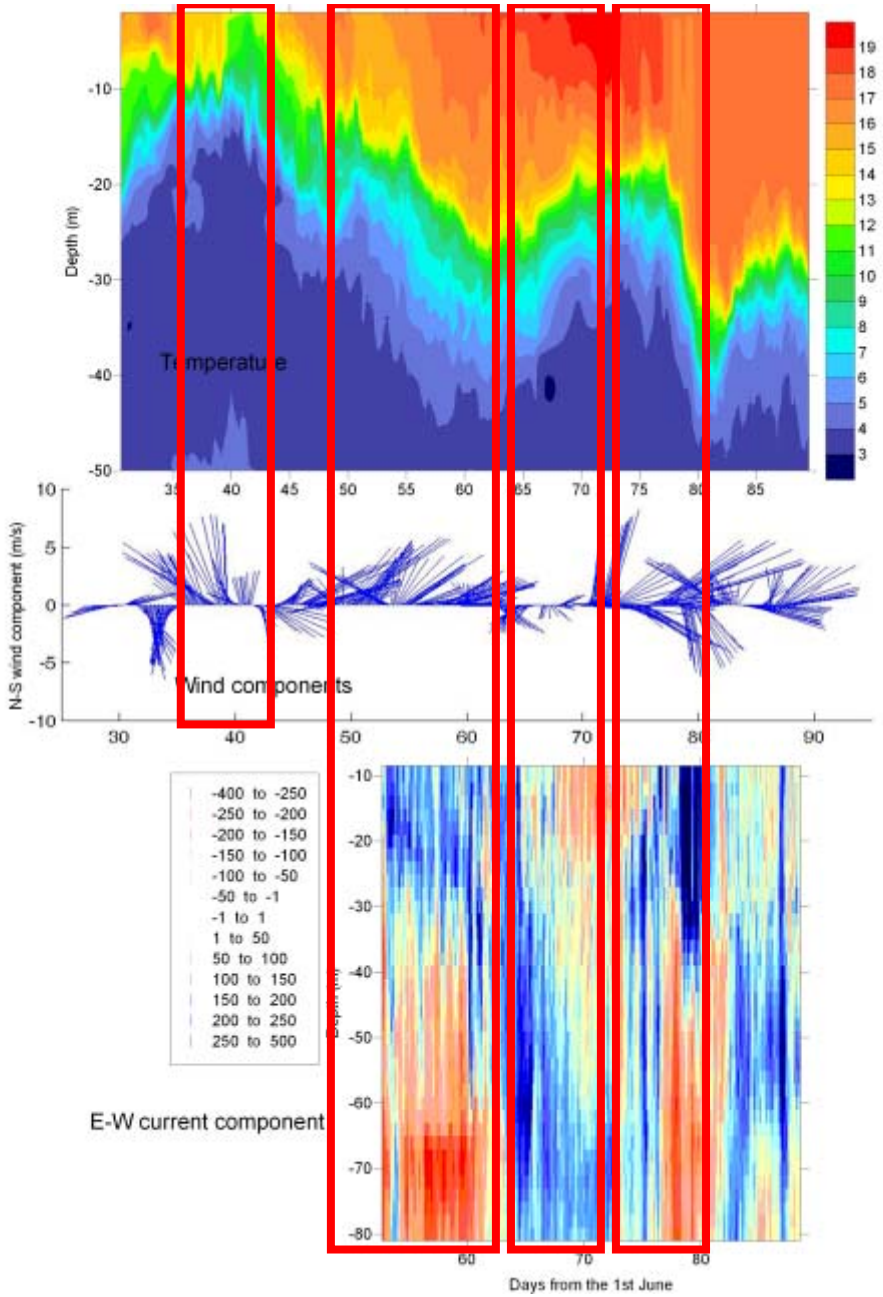
Comparison of data from Ferrybox and from buoy station (30 June until 29 August)



Comparison of data from Ferrybox and from buoy station (30 June until 29 August)







Temporal variations of vertical temperature and current (E-W component) profiles in relation to the wind forcing (from Kalbadagrund, FMI); data analysis by Taavi Liblik

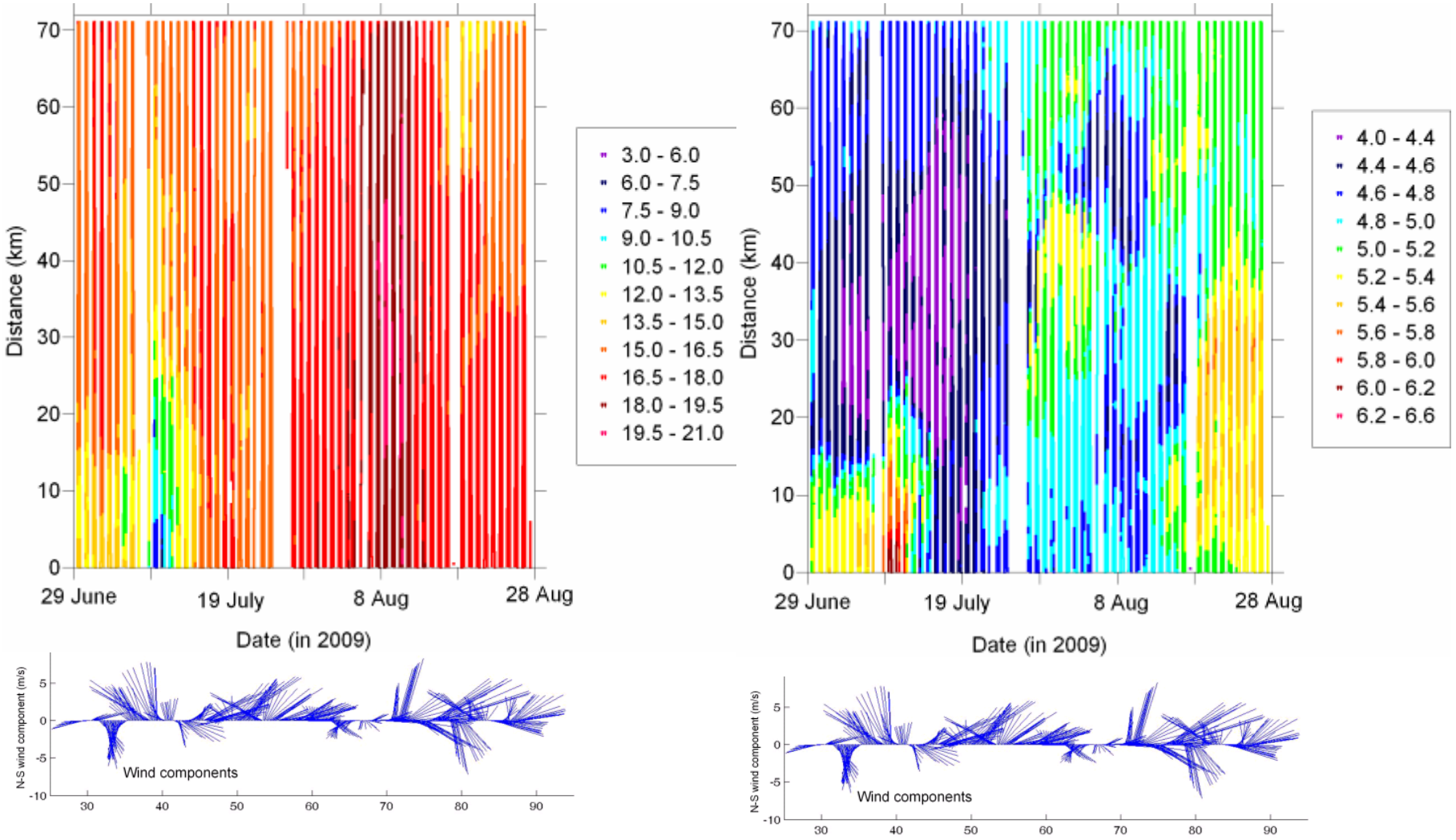
South-easterly winds caused upwelling near the Estonian coast

Westerly – south-westerly winds caused deepening of the seasonal thermocline (inflow in the surface layer; but strong outflow in the near-bottom layer and outflow in the intermediate layer)

Period of weak winds – formation of a warm and shallow surface layer; outflow in the surface and inter-mediate layer, outflow near the bottom

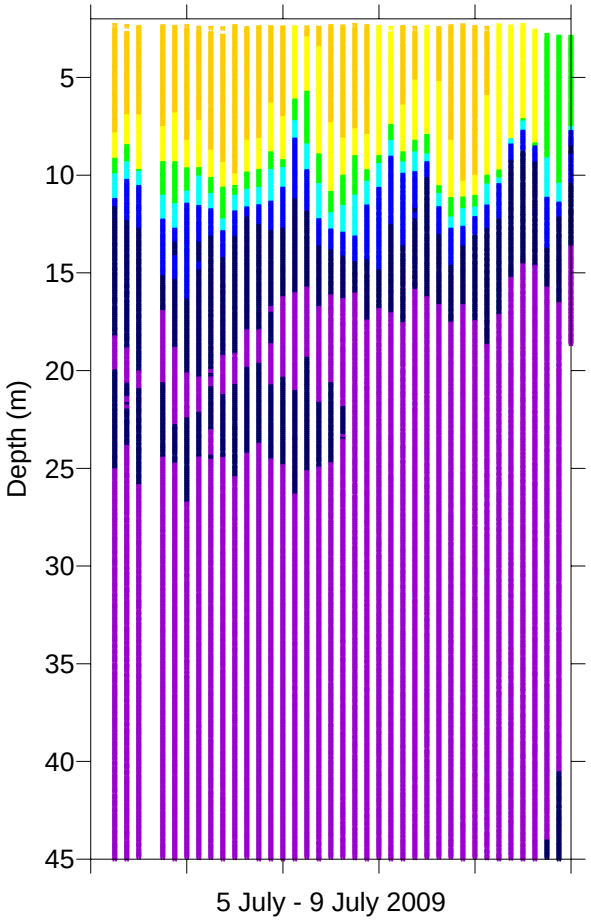
Strong wind pulses caused barotropic oscillations; deepening of thermocline and strong two-layer flow structure

Variations in spatial distribution of temperature and salinity (July-August 2009)

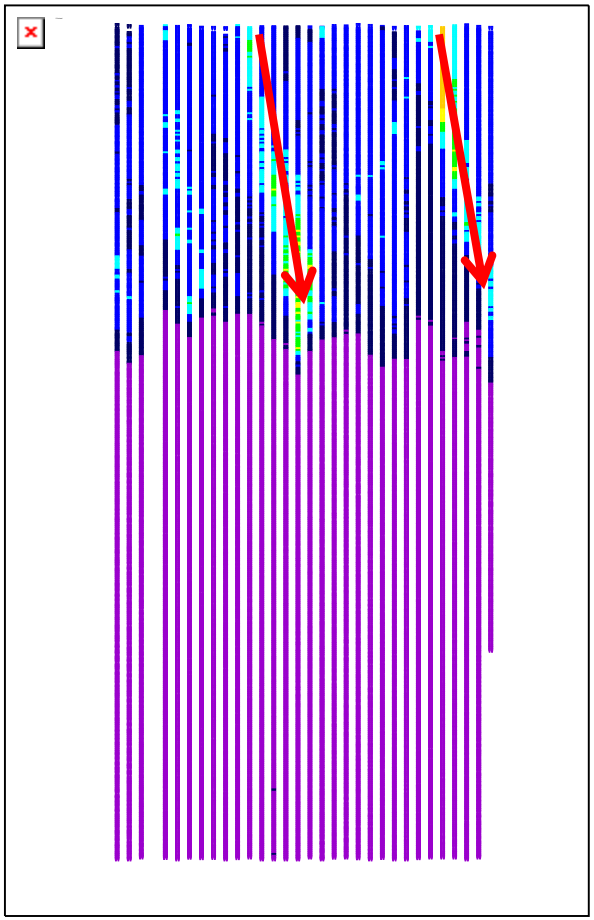


Vertical temperature and Chl *a* fluorescence distribution from 5 July until 9 July

Temperature

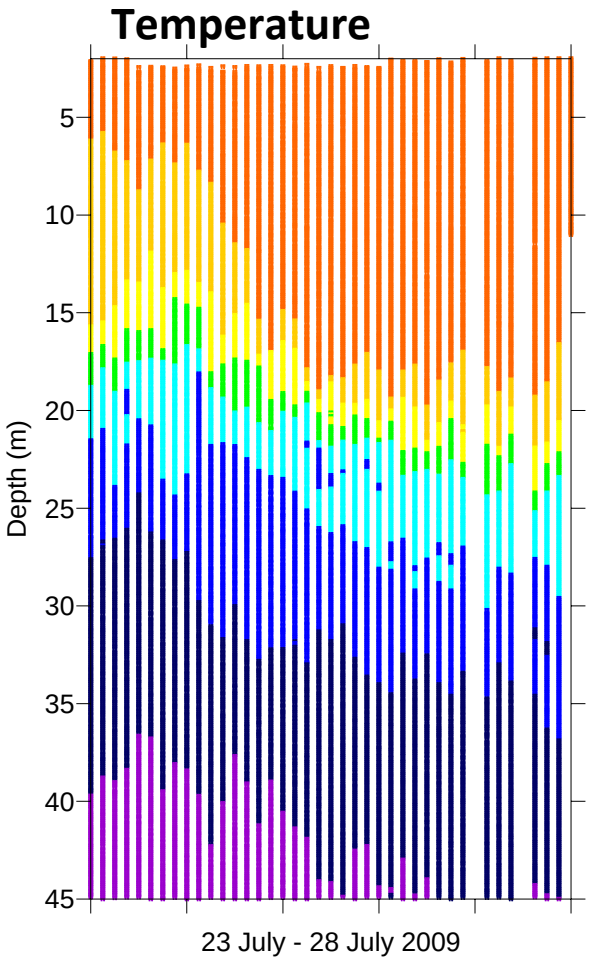


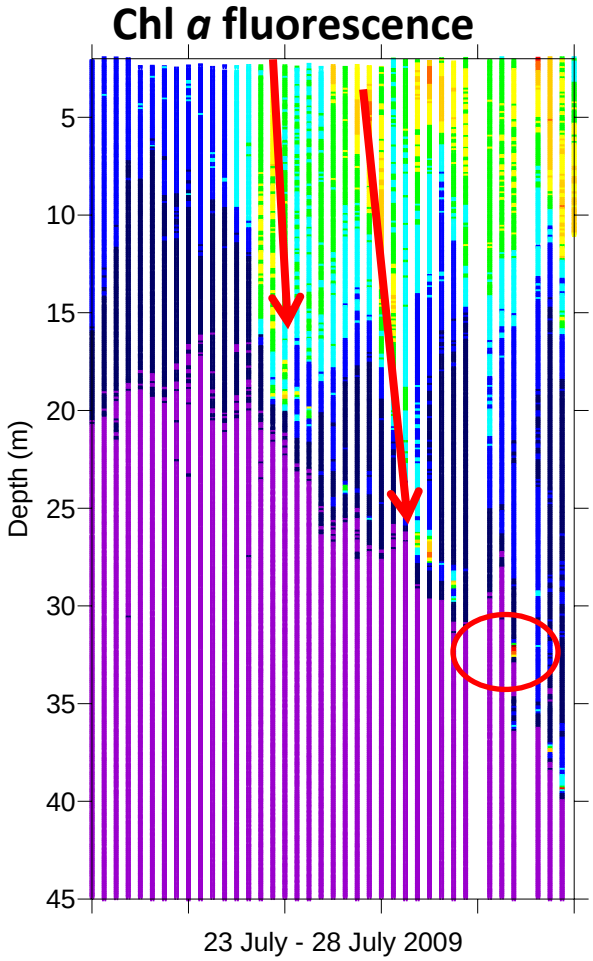
Chl *a* fluorescence



Phytoplankton community dominated by small flagellates

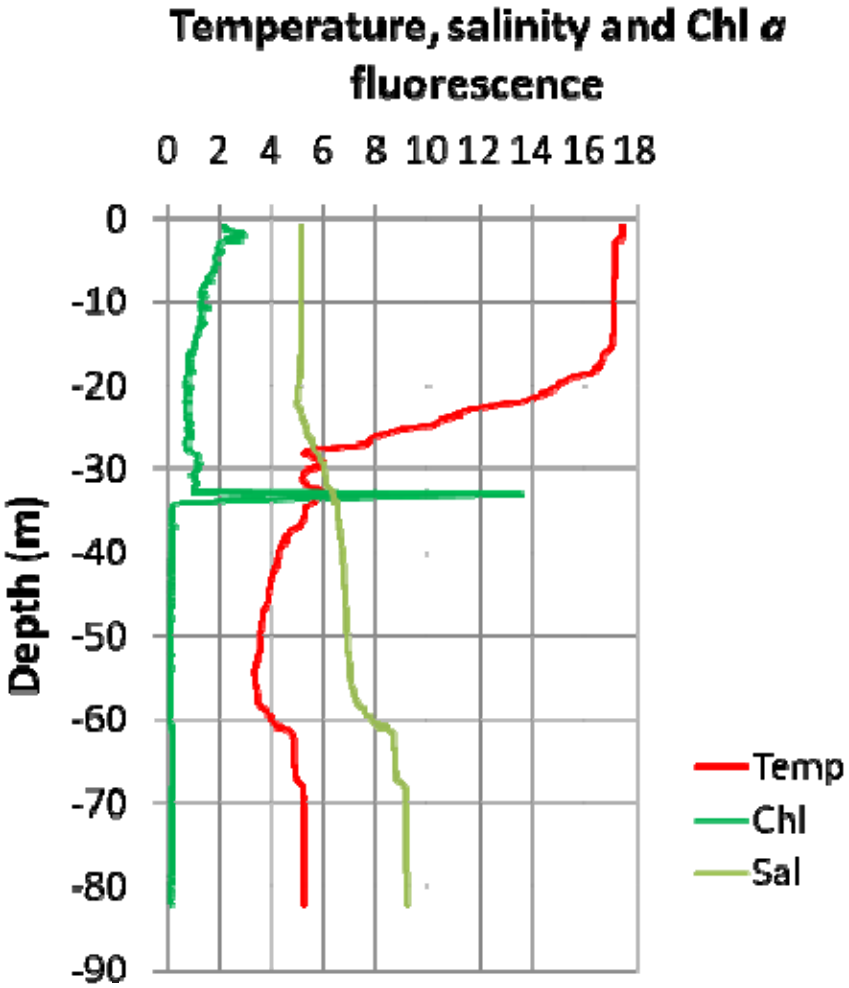
Vertical temperature and Chl *a* fluorescence distribution from 23 July until 28 July

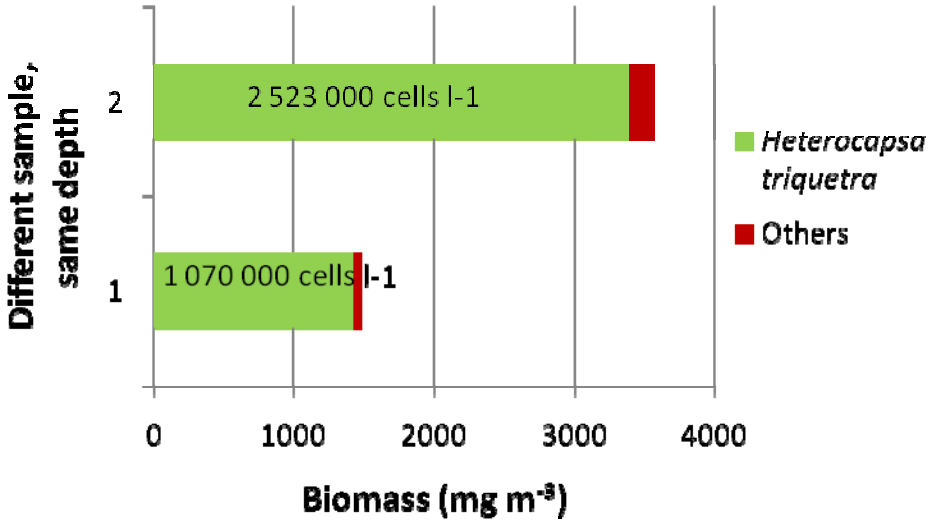




Phytoplankton community dominated by dinoflagellate *Heterocapsa triquetra*

Vertical profiles and phytoplankton counting results from a deep Chl *a* peak

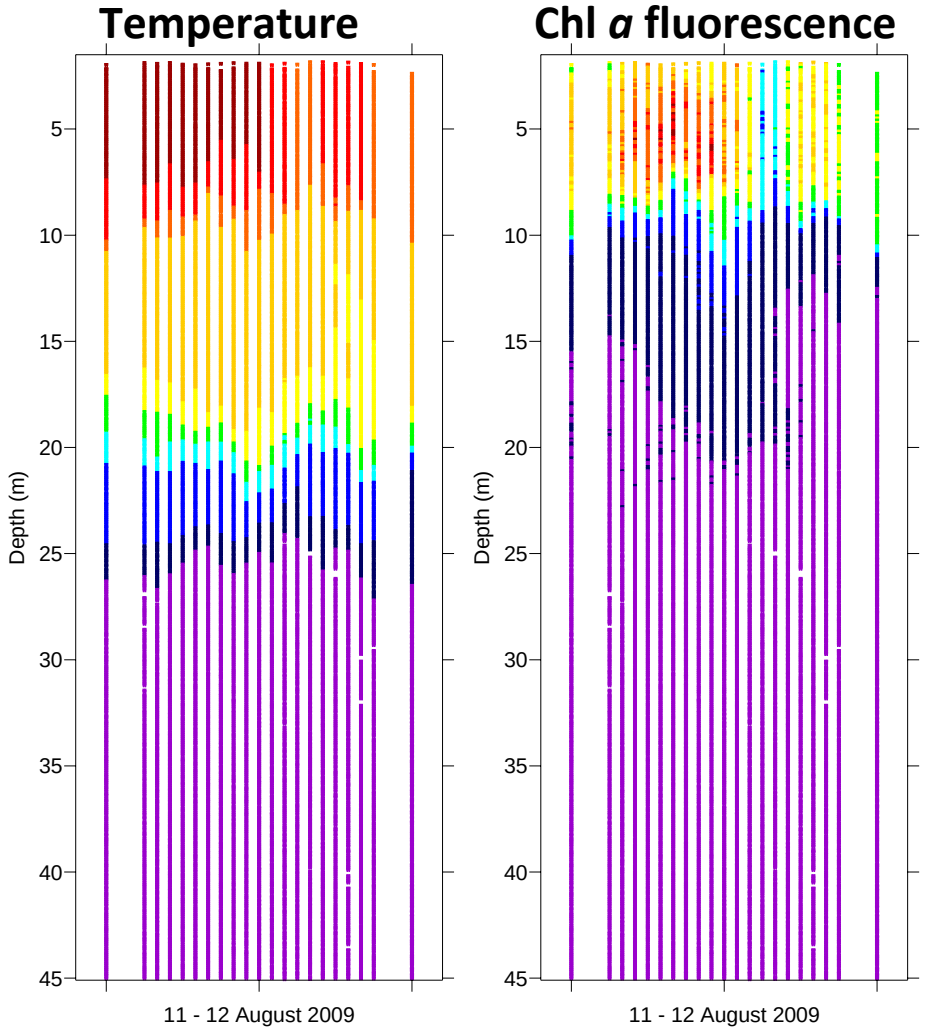




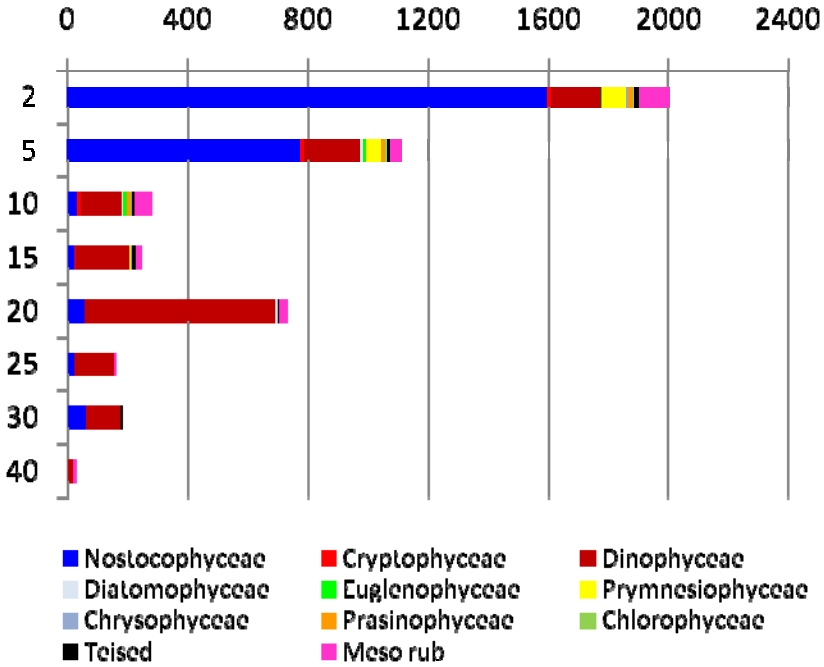
Station 9, 28 July 2009

Chl *a* Fl 2 = 38.9 mg m^{-3}
Chl *a* Fl 1 = 19.4 mg m^{-3}

Vertical temperature and Chl *a* fluorescence distribution on 11-12 August



Phytoplankton community dominated by cyanobacteria



Preliminary conclusions from 2009

- Pronounced hydrodynamic features and related changes in horizontal and vertical distribution of temperature, salinity and chlorophyll *a* were observed
- Different migration patterns of phytoplankton was found; phytoplankton behaviour depends on species composition (dominating species) but the species dominance seems to be controlled by physical processes of various scales
- High biomass of heterotrophic flagellates is commonly observed close to the base of seasonal thermocline
- Very high biomass is formed there under certain conditions by mixotrophic *Heterocapsa triquetra*

Conclusions

- Short-term variability of state variables of pelagic ecosystem is very high – it has to be taken into account while assessing the state
- A combination of high resolution measurements by Ferrybox systems and moored autonomous profilers (incl. ADCP) is a very effective way to obtain near real-time data for the operational models
- Vertical structure of water column and distribution of nutrients, organisms must be monitored with high resolution in order to find the link between the forcing and ecosystem functioning (for instance, productivity) - sampling onboard r/v's will stay as an important component
- New sensors for nutrients and other parameters have to be applied

Future plans

- Ferrybox Tallinn-Helsinki will continue operating as in 2009
  - pCO_2 sensor will be operational in spring 2010
  - Nutrients – from February; March-May weekly
  - Chl *a* – weekly since March, phytoplankton – spring, summer
- Autonomous buoy station
  - Vertical profiles of temperature, salinity, Chl *a* fluorescence since April (real time), ADCP
- Biweekly sampling onboard research vessel (cross-section), intensive measurement campaign in July
  - Nutrient analyses to reveal detailed vertical distribution
  - Analyses of phytoplankton and microzooplankton community structure
- New devices – wave buoys, Ferrybox on r/v, towed instruments, deep station connected to a lighthouse

Thank you for your attention!