Oil detection with ferrybox system: project GRACE

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GRACE objectives

- Improve the observation and predictions of oil movements in the sea using **novel on-line sensors** on vessels, fixed structures, smart buoys or gliders, and smart data transfer to operational awareness systems;

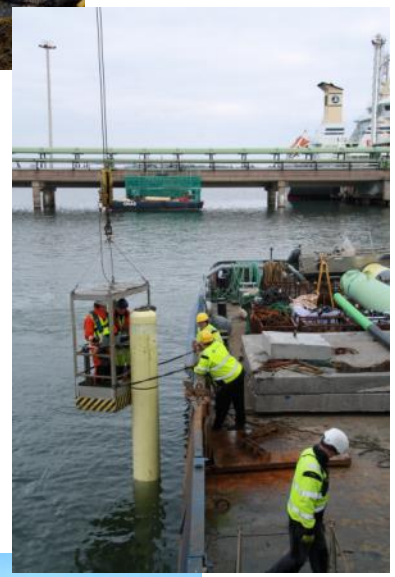
- Explore the true environmental impacts and benefits of a suite of marine **oil spill response technologies** in the cold climate and ice-infested areas in the northern Atlantic Ocean and the Baltic Sea. Methods included are:
  - **mechanical collection** in water and below ice,
  - **in situ burning,**
  - use of **chemical dispersants**,
  - natural **biodegradation**
  - and combinations of these;

- Assess in particular the **impacts on fish, invertebrates** (e.g., mussels, crustaceans) and macro algae of naturally and chemically dispersed oil, in situ burning residues and non-collected oil using highly sensitive biomarker methods, and to develop specific methods for the rapid detection of the effects of oil pollution on biota

- Develop a **strategic Net Environmental Benefit Analysis tool (sNEBA)** for oil spill response strategy decision making in cold climate and ice-infested areas.

GRACE period 1
1.3.2016-31.8.2017

- Consortium works well together – all partners dedicated
- Much field and laboratory work initiated
- Unique possibilities to perform field tests e.g with in situ burning in Greenland, Smart buoy trials in oil harbour, FerryBox on passenger ship, electrokinetic treatment in the heart of Helsinki
- Successful communication of the project to the right end users

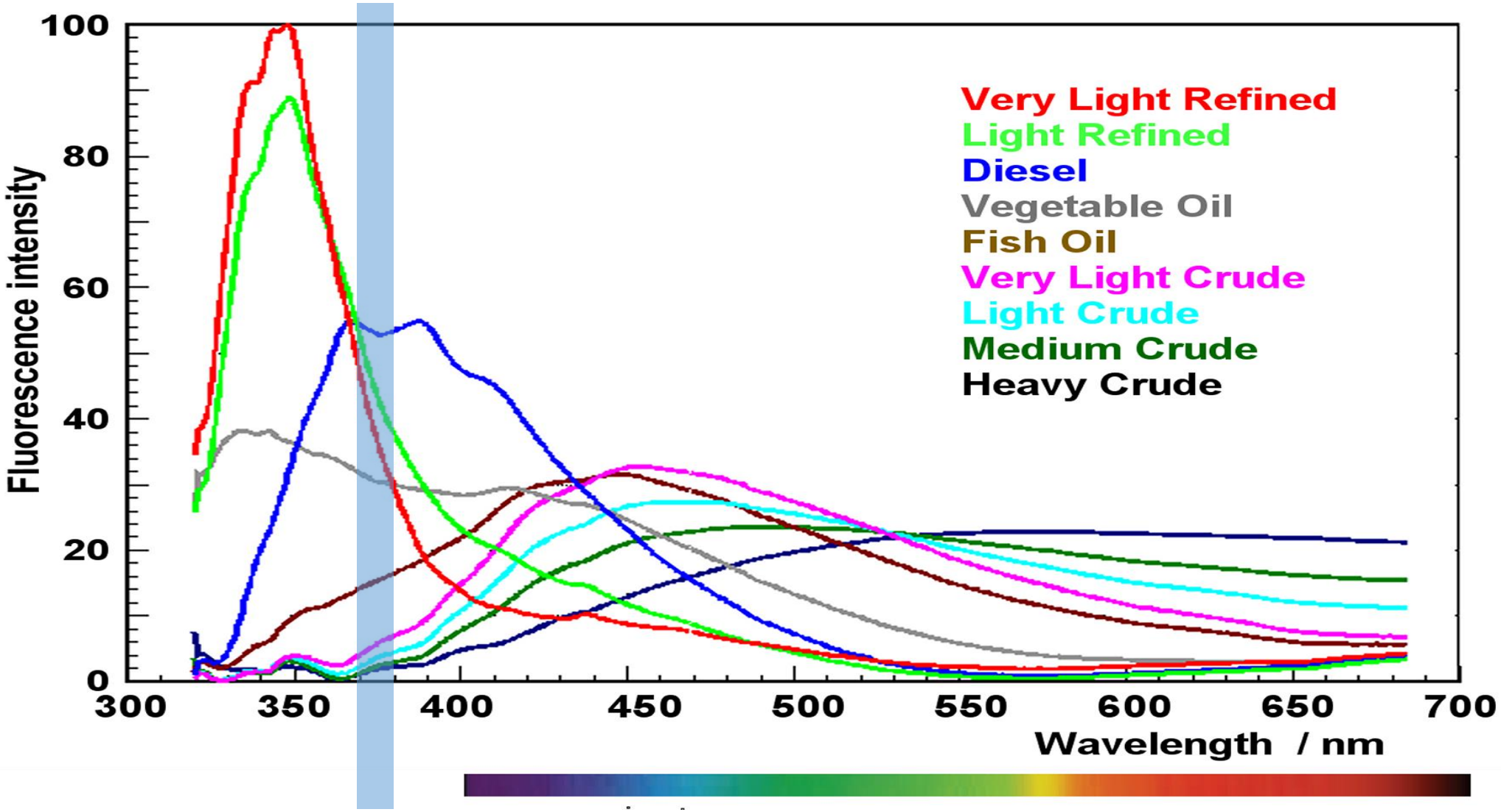


FerryBox on M/S BALTIC QUEEN

Measurement of Polycyclic Aromatic Hydrocarbons (PAH-s)

- Crude oil and other fossil fuels contain polycyclic aromatic hydrocarbons (PAHs).
- PAHs are hydrocarbons containing only carbon and hydrogen—they are composed of multiple aromatic rings.
- Most PAHs are also fluorescent, emitting characteristic wavelengths of light when they are excited (when the molecules absorb light)
- Ultra-violet fluorescence (UVF) is considered to be a highly sensitive, reasonably selective, simple, rapid and straight-forward method to determine oil-based aromatic compounds in seawater. The method is based on the similarities between the fluorescence excitation and emission spectra of nonpolar organic compounds.

Measurement of Polycyclic Aromatic Hydrocarbons (PAH-s)



On-line data management and user interface

Sensors

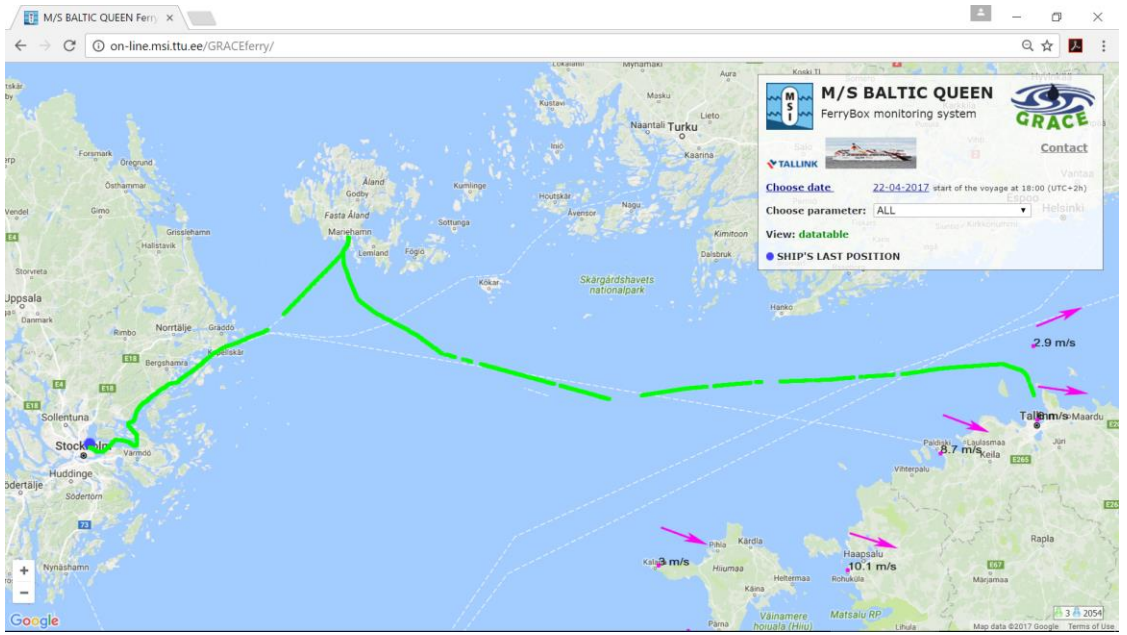
GSM Modem

GPRS Gateway

FTP server

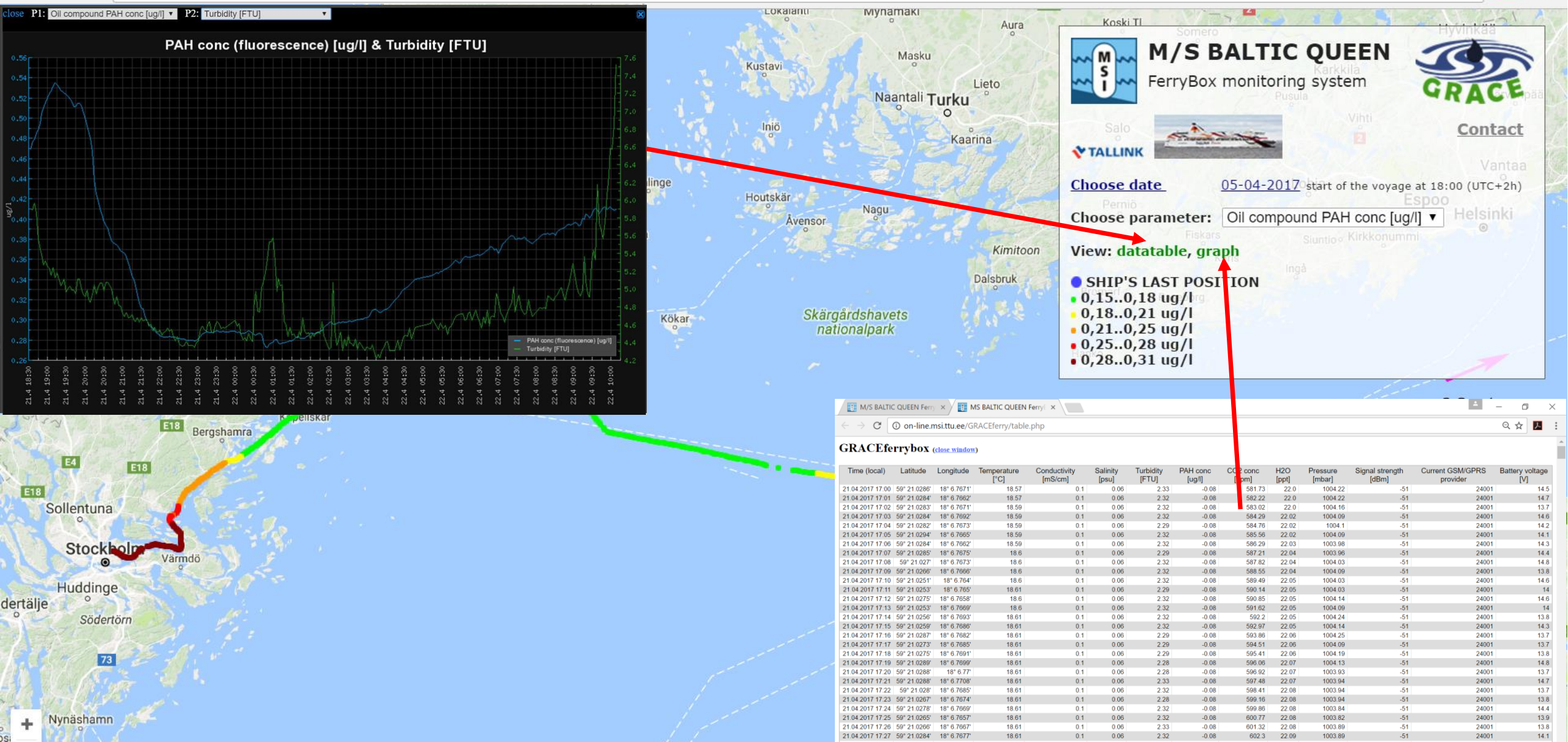
Web Application

Users



Data management and visualisation via web-based user interface

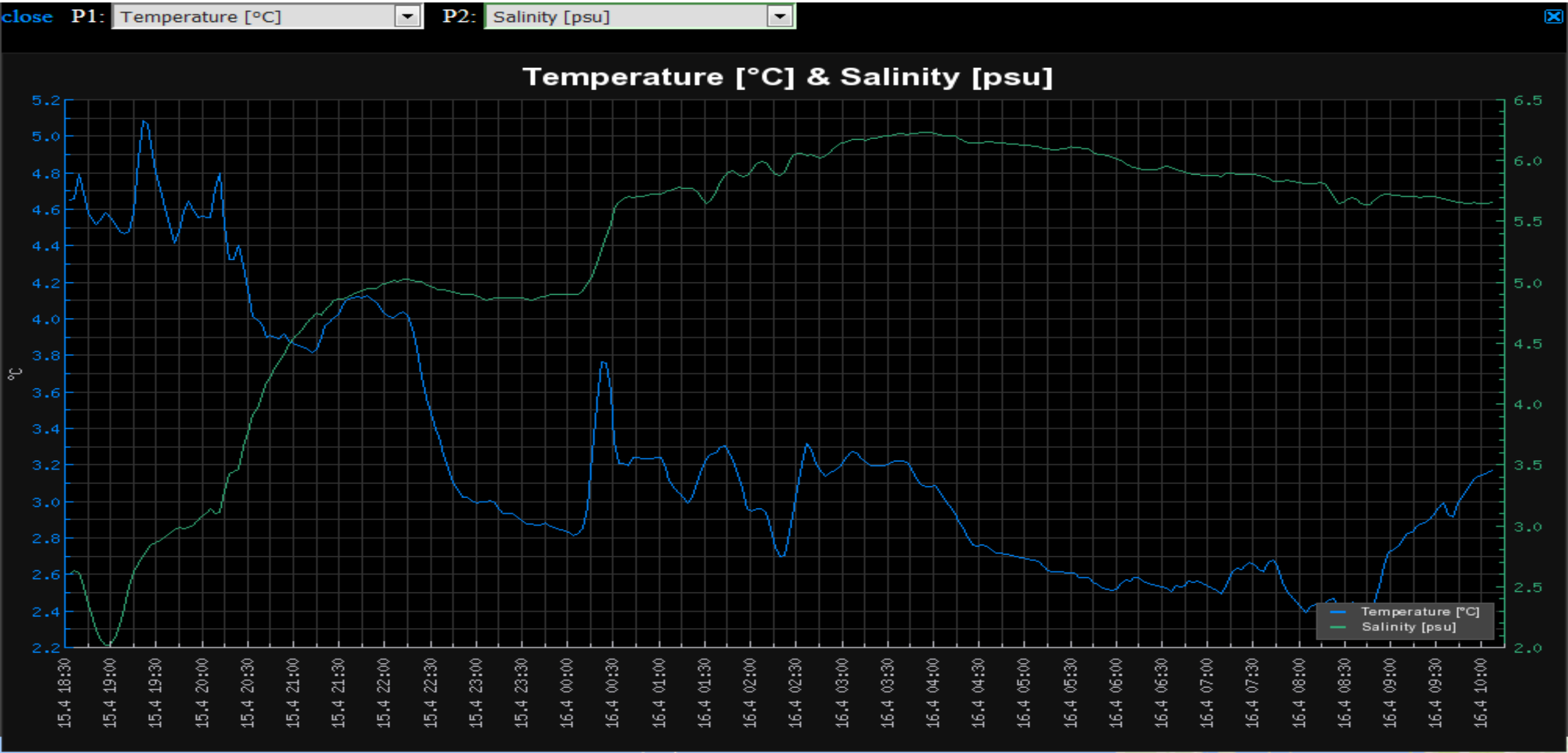
http://on-line.msi.ttu.ee/GRACEferry/



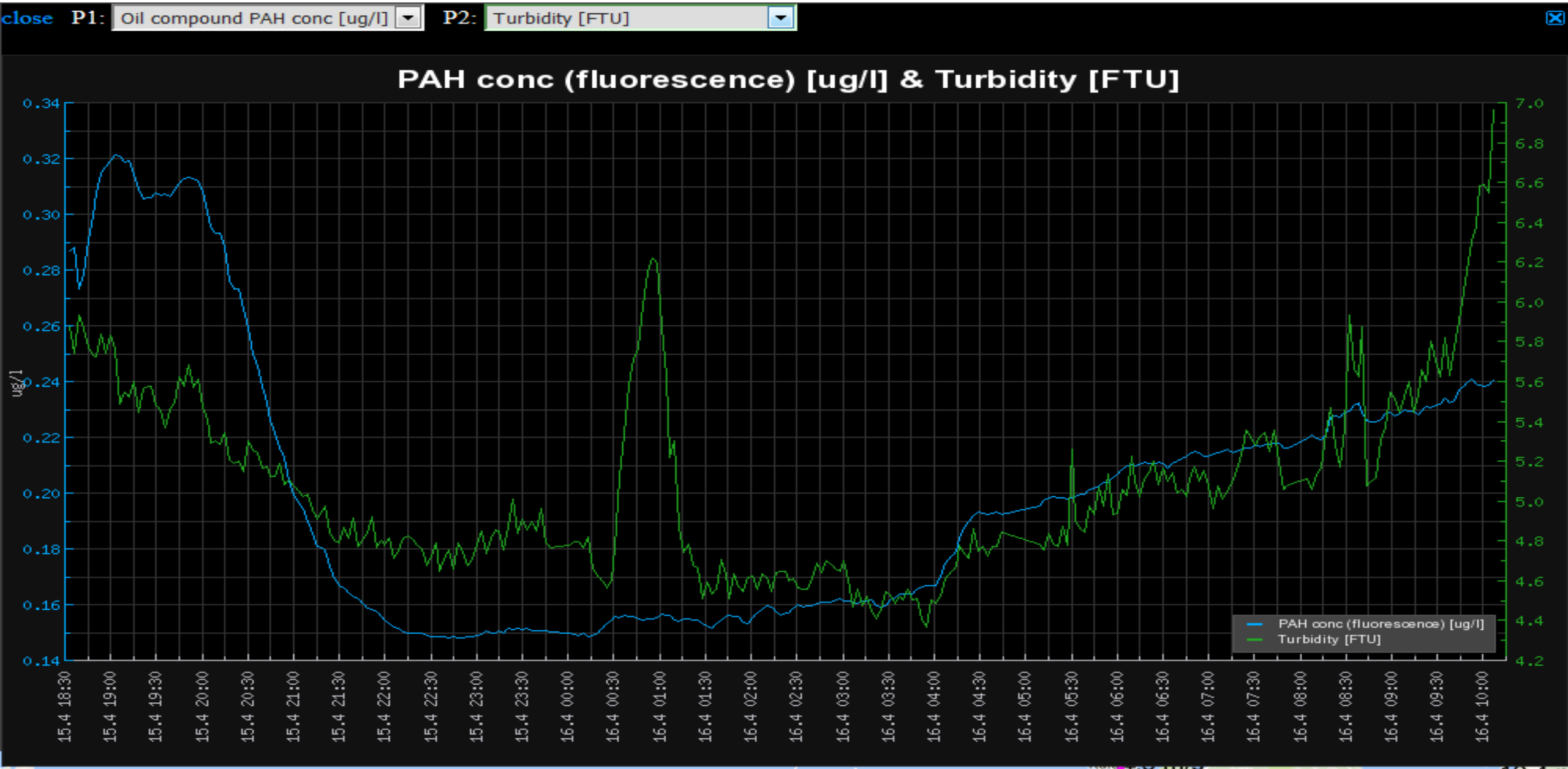
GRACEferrybox (close window)

Time (local)	Latitude	Longitude	Temperature [°C]	Conductivity [mS/cm]	Salinity [psu]	Turbidity [FTU]	PAH conc [ug/l]	CO2 conc [ppm]	H2O [ppt]	Pressure [mbar]	Signal strength [dBm]	Current GSM/GPRS provider	Battery voltage [V]
21.04.2017 17:00	59° 21.0286'	18° 6.7671'	18.57	0.1	0.06	2.33	-0.08	581.73	22.0	1004.22	-51	24001	14.5
21.04.2017 17:01	59° 21.0284'	18° 6.7662'	18.57	0.1	0.06	2.32	-0.08	582.22	22.0	1004.22	-51	24001	14.7
21.04.2017 17:02	59° 21.0283'	18° 6.7671'	18.59	0.1	0.06	2.32	-0.08	583.02	22.0	1004.16	-51	24001	13.7
21.04.2017 17:03	59° 21.0284'	18° 6.7692'	18.59	0.1	0.06	2.32	-0.08	584.29	22.02	1004.09	-51	24001	14.6
21.04.2017 17:04	59° 21.0282'	18° 6.7673'	18.59	0.1	0.06	2.29	-0.08	584.76	22.02	1004.1	-51	24001	14.2
21.04.2017 17:05	59° 21.0294'	18° 6.7665'	18.59	0.1	0.06	2.32	-0.08	585.56	22.02	1004.09	-51	24001	14.1
21.04.2017 17:06	59° 21.0284'	18° 6.7662'	18.59	0.1	0.06	2.32	-0.08	586.29	22.03	1003.98	-51	24001	14.3
21.04.2017 17:07	59° 21.0285'	18° 6.7675'	18.6	0.1	0.06	2.29	-0.08	587.21	22.04	1003.96	-51	24001	14.4
21.04.2017 17:08	59° 21.027'	18° 6.7673'	18.6	0.1	0.06	2.32	-0.08	587.82	22.04	1004.03	-51	24001	14.8
21.04.2017 17:09	59° 21.0266'	18° 6.7666'	18.6	0.1	0.06	2.32	-0.08	588.55	22.04	1004.09	-51	24001	13.8
21.04.2017 17:10	59° 21.0251'	18° 6.764'	18.6	0.1	0.06	2.32	-0.08	589.49	22.05	1004.03	-51	24001	14.6
21.04.2017 17:11	59° 21.0253'	18° 6.765'	18.61	0.1	0.06	2.29	-0.08	590.14	22.05	1004.03	-51	24001	14
21.04.2017 17:12	59° 21.0275'	18° 6.7658'	18.6	0.1	0.06	2.32	-0.08	590.85	22.05	1004.14	-51	24001	14.6
21.04.2017 17:13	59° 21.0253'	18° 6.7669'	18.6	0.1	0.06	2.32	-0.08	591.62	22.05	1004.09	-51	24001	14
21.04.2017 17:14	59° 21.0256'	18° 6.7693'	18.61	0.1	0.06	2.32	-0.08	592.2	22.05	1004.24	-51	24001	13.8
21.04.2017 17:15	59° 21.0259'	18° 6.7686'	18.61	0.1	0.06	2.32	-0.08	592.97	22.05	1004.14	-51	24001	14.3
21.04.2017 17:16	59° 21.0287'	18° 6.7682'	18.61	0.1	0.06	2.29	-0.08	593.86	22.06	1004.25	-51	24001	13.7
21.04.2017 17:17	59° 21.0273'	18° 6.7685'	18.61	0.1	0.06	2.29	-0.08	594.51	22.06	1004.09	-51	24001	13.7
21.04.2017 17:18	59° 21.0275'	18° 6.7691'	18.61	0.1	0.06	2.29	-0.08	595.41	22.06	1004.19	-51	24001	13.8
21.04.2017 17:19	59° 21.0289'	18° 6.7699'	18.61	0.1	0.06	2.28	-0.08	596.06	22.07	1004.13	-51	24001	14.8
21.04.2017 17:20	59° 21.0288'	18° 6.77'	18.61	0.1	0.06	2.28	-0.08	596.92	22.07	1003.93	-51	24001	13.7
21.04.2017 17:21	59° 21.0288'	18° 6.7708'	18.61	0.1	0.06	2.33	-0.08	597.48	22.07	1003.94	-51	24001	14.7
21.04.2017 17:22	59° 21.028'	18° 6.7685'	18.61	0.1	0.06	2.32	-0.08	598.41	22.08	1003.94	-51	24001	13.7
21.04.2017 17:23	59° 21.0267'	18° 6.7674'	18.61	0.1	0.06	2.28	-0.08	599.16	22.08	1003.94	-51	24001	13.8
21.04.2017 17:24	59° 21.0278'	18° 6.7669'	18.61	0.1	0.06	2.32	-0.08	599.86	22.08	1003.84	-51	24001	14.4
21.04.2017 17:25	59° 21.0265'	18° 6.7657'	18.61	0.1	0.06	2.32	-0.08	600.77	22.08	1003.82	-51	24001	13.9
21.04.2017 17:26	59° 21.0266'	18° 6.7667'	18.61	0.1	0.06	2.33	-0.08	601.32	22.08	1003.89	-51	24001	13.8
21.04.2017 17:27	59° 21.0284'	18° 6.7677'	18.61	0.1	0.06	2.32	-0.08	602.3	22.09	1003.89	-51	24001	14.1

General distribution pattern of physical properties on Stockholm-Tallinn route

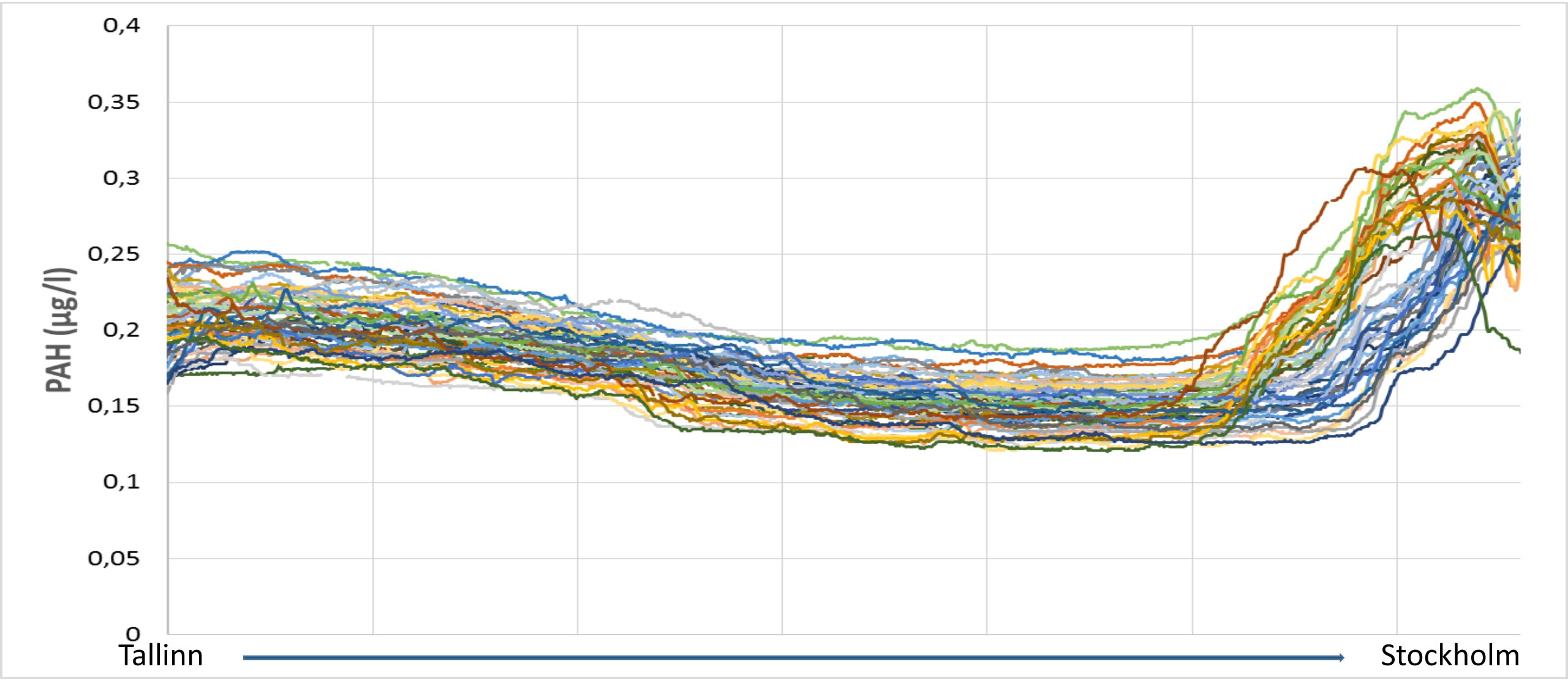


General distribution pattern of PAH and turbidity on Stockholm-Tallinn route



Variability of oil compound PAH concentrations

16.02.2017 – 11.04.2017



M/S BALTIC QUEEN Ferry

on-line.msi.ttu.ee/GRACEferry/?ts=1492894800&param=salinity

M/S BALTIC QUEEN

FerryBox monitoring system

GRACE

Contact

TALLINK

Choose date 23-04-2017 start of the voyage at 18:00 (UTC+2h)

Choose parameter: Salinity [psu]

View: datatable, graph

- SHIP'S LAST POSITION
- 2,6..2,72 psu
- 2,72..2,84 psu
- 2,84..2,97 psu
- 2,97..3,09 psu
- 3,09..3,21 psu

Stockholm (Värtahamnen) - Åland (Mariehamn)

Stockholm (Värtahamnen) - Åland (Mariehamn)

Stockholm (Värtahamnen), SE - St Petersburg, RU

Riga, LV - Stockholm, SE

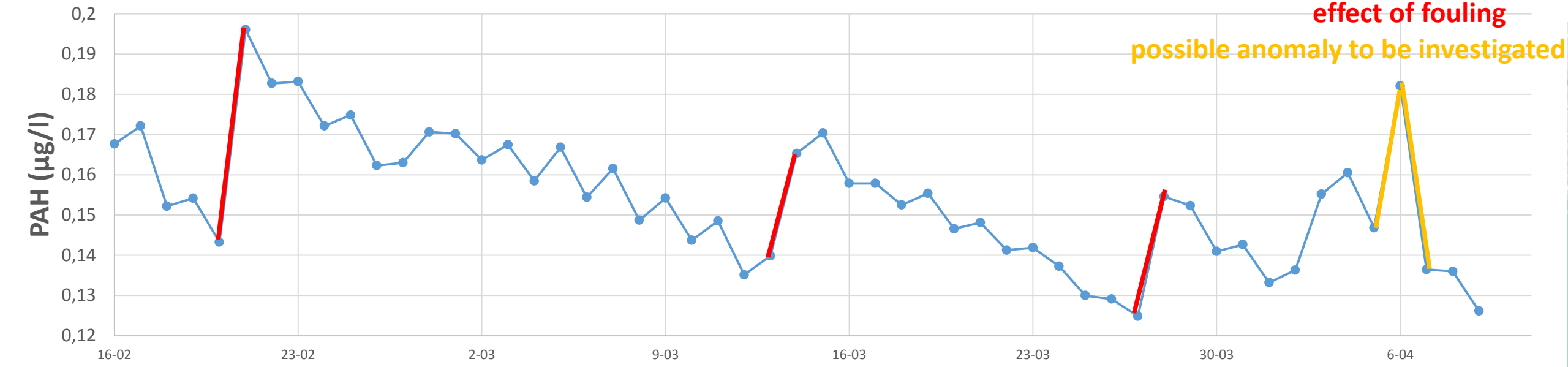
Stockholm (Värtahamnen) - Åland (Mariehamn)

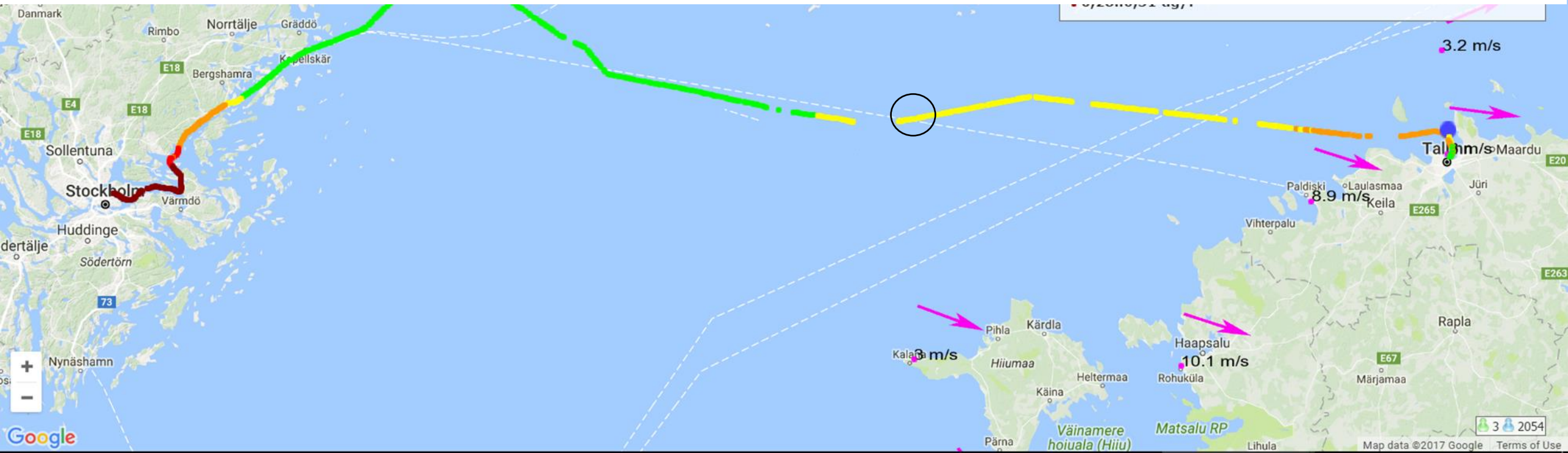
Stockholm (Värtahamnen) - Åland (Mariehamn)

Riga, LV - Stockholm, SE

Map data ©2017 Google Terms of Use

Temporal variability of PAH concentrations in single locations





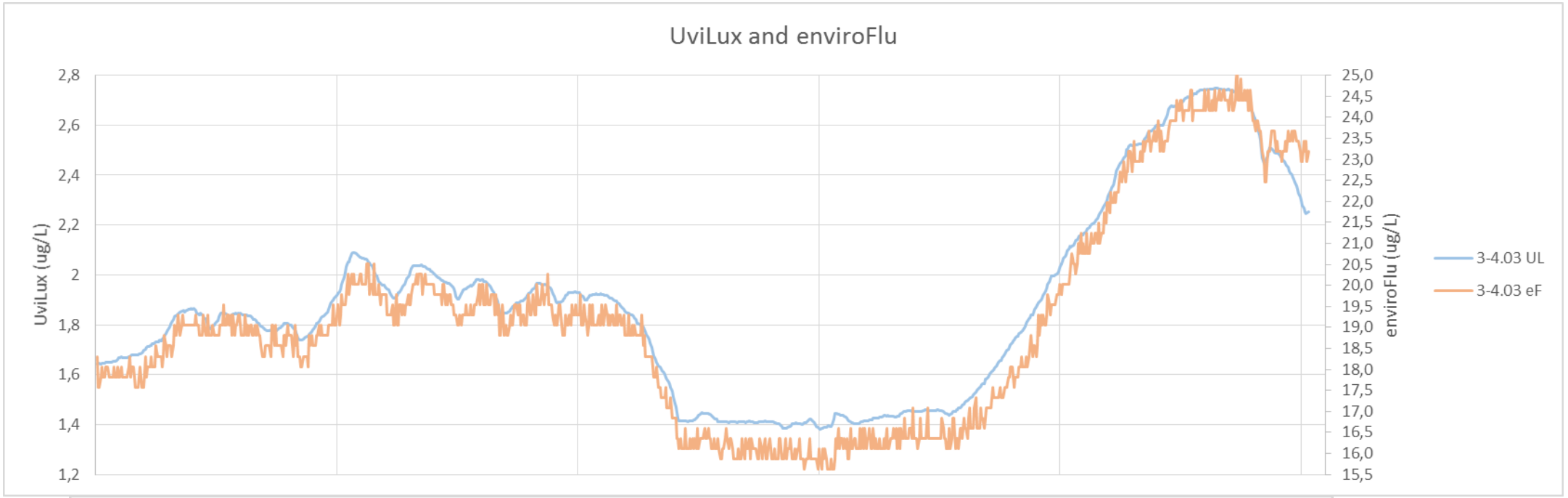
Comparision of UV fluoressence sensors

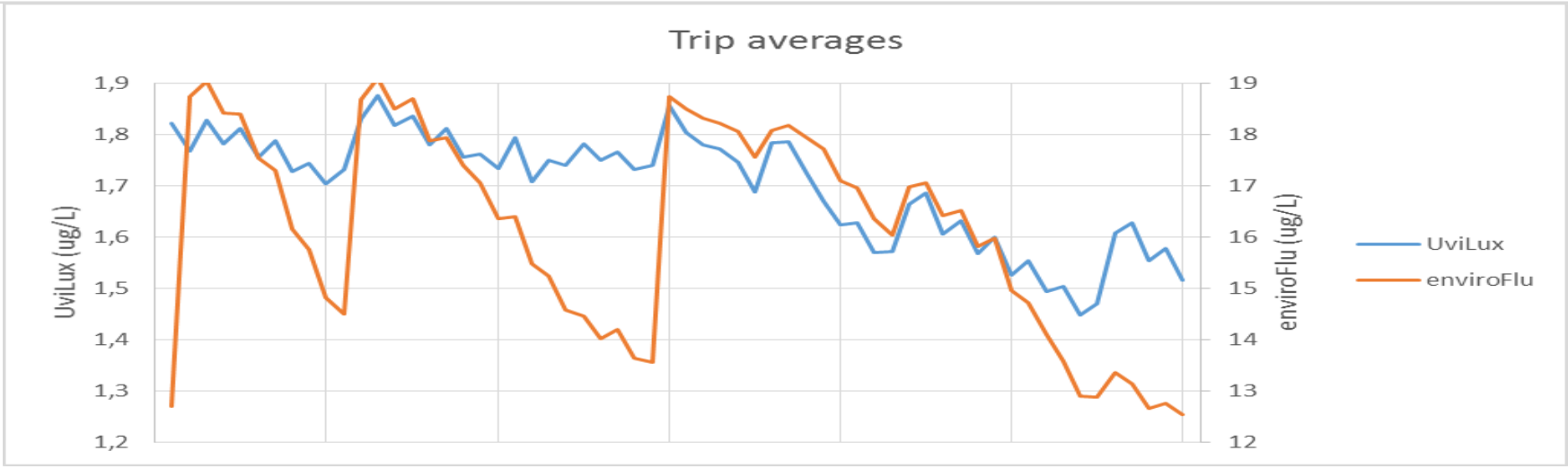
- UviLux UV-fluorometer measures oil compounds polycyclic aromatic hydrocarbons (PAH) concentrations (in terms of Carbazole). Sensitivityof the sensor is 0,005 µg/l or 5ppt (**Carbazole**), calibrated range 0,005 – 2000 µg/l, excitation light 255nm and emission light 360nm.
- enviroFlu-HC measures PAH concentrations. in terms of Phenantrene. Sensitivity of the sensor is 0,3ppt (**Phenant**
  500 ppb, excitation light 254nm and emissi

UviLux

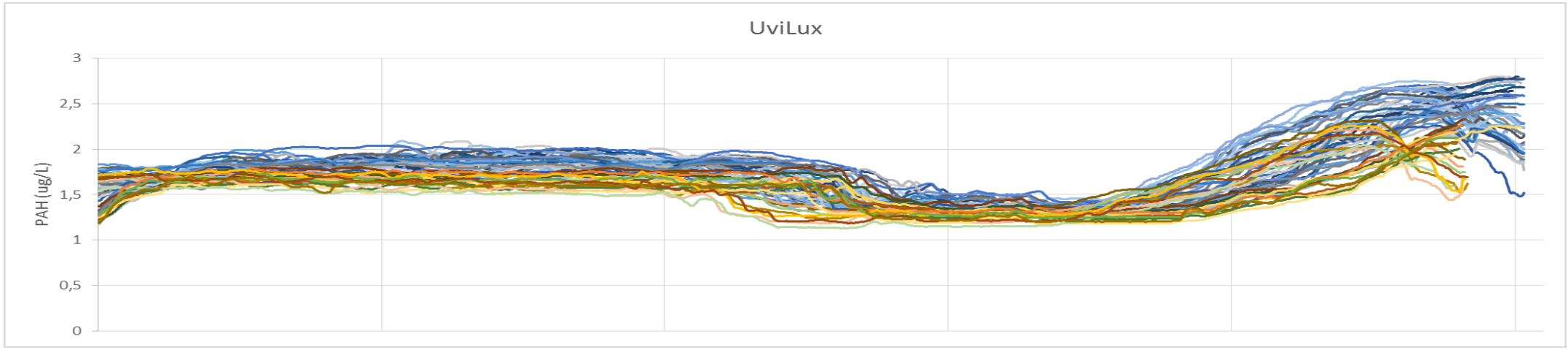
enivroFlu-HC

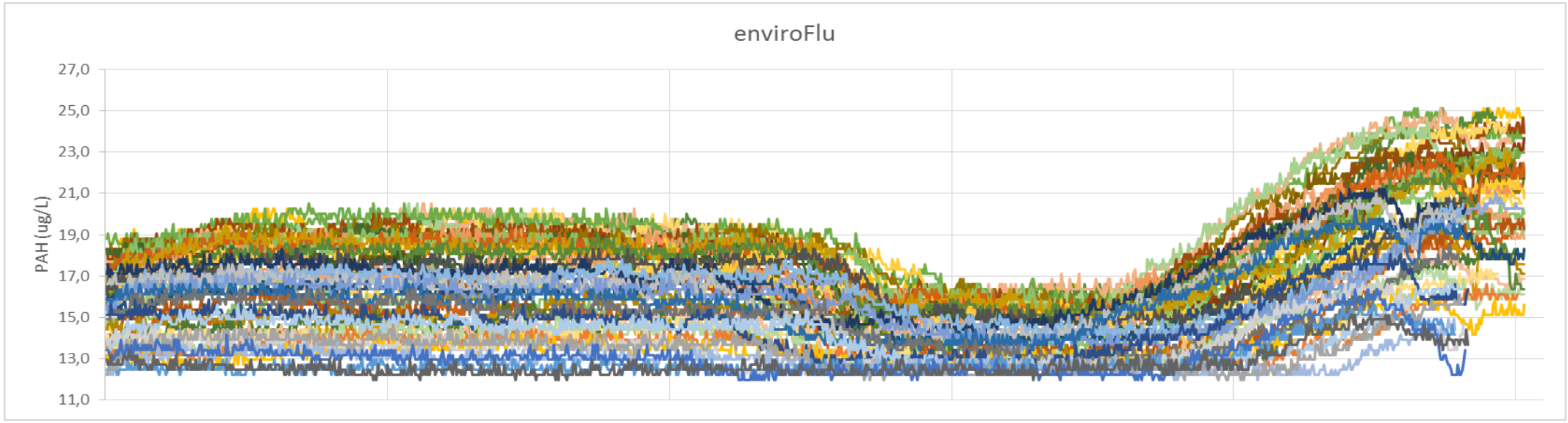
PAH concentration measurements with UviLux and Trios sensors





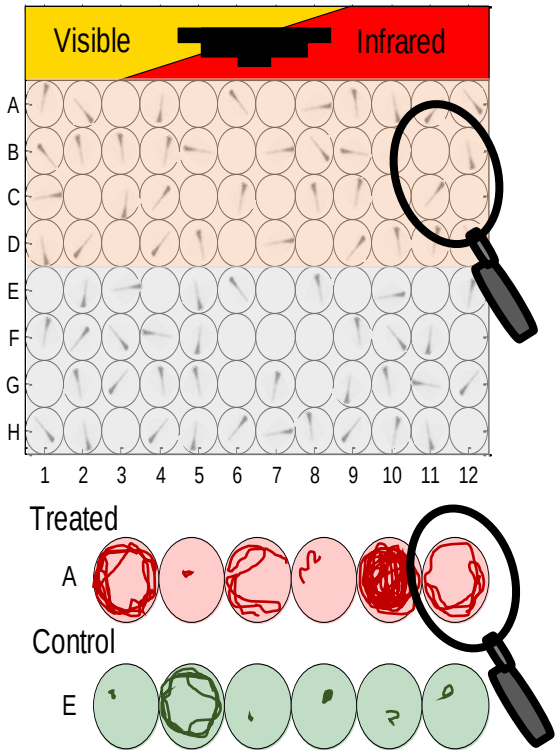
PAH concentration measurements with UviLux and Trios sensors

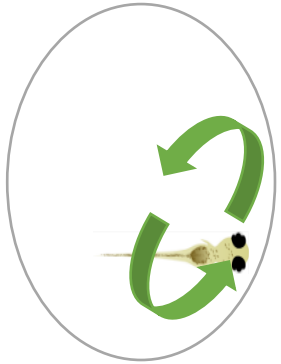




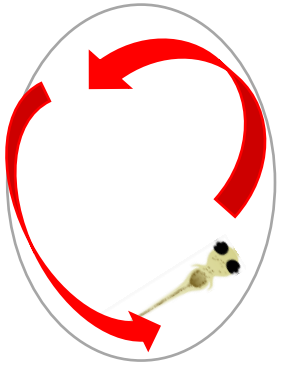
Tallinn → Stockholm

Novel Biosensor for FerryBox systems – Zebrafish embryo behavior





Control embryo

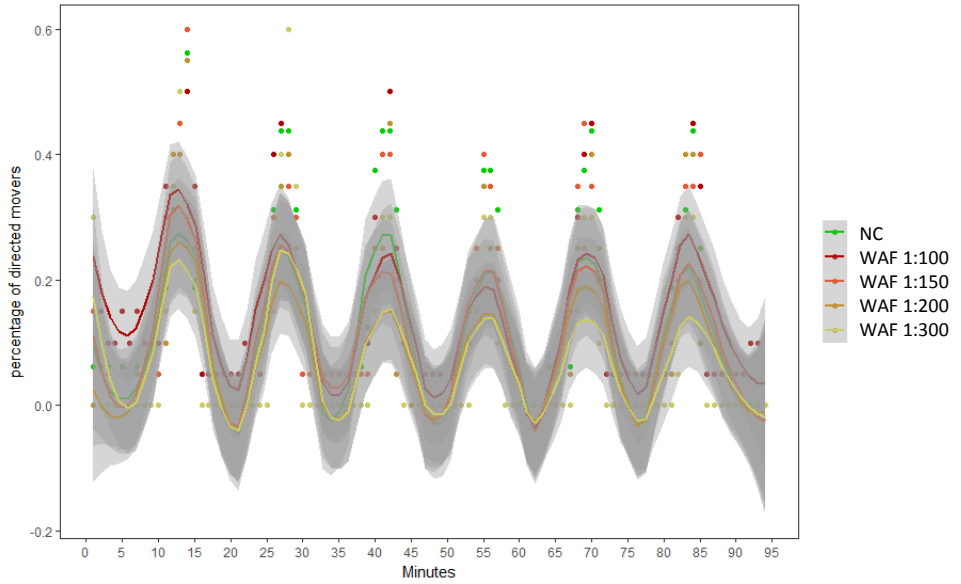


Embryo treated with toxicant show elevated movement levels

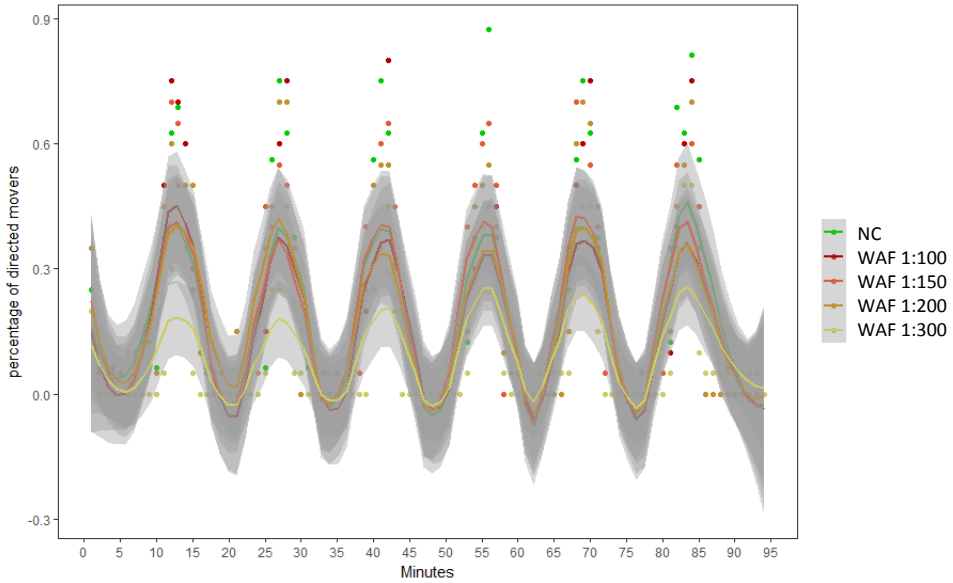
WAF exposure – effects on behavior

- Zebrafish embryos exposed to different WAF dilutions were tested
- Effects not clearly distinguishable from control activity
- Highest tested dilution 1:100
- Refined tests will be applied to test higher WAF levels

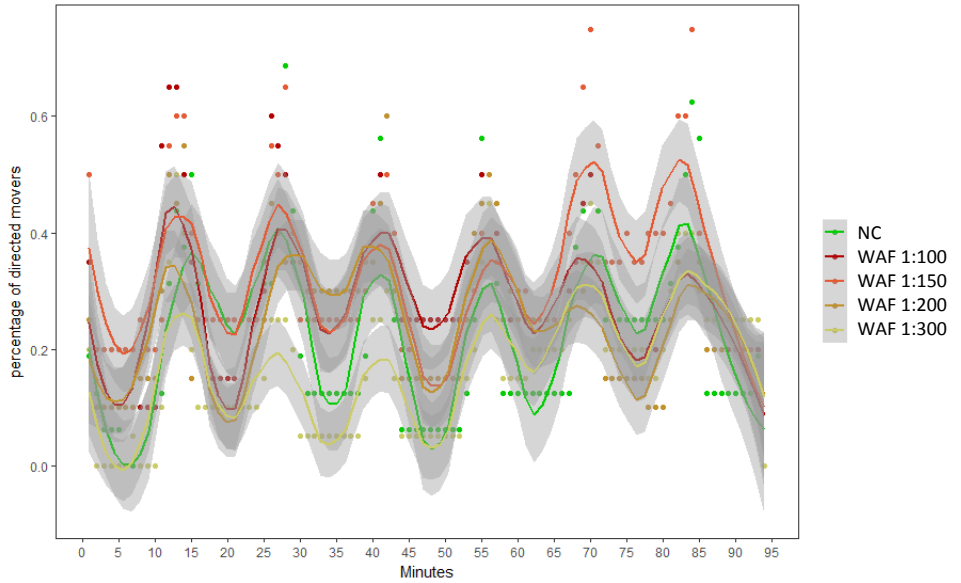
WAF replicate 1



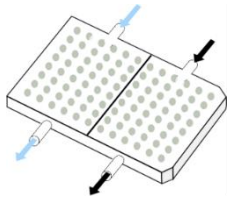
WAF replicate 3



WAF replicate 2



Biosensor – next steps



First prototype of customized flow through well plate available beginning of 2018

1. testing of salinity threshold under flow-through conditions
2. testing of WAFs under flow-through conditions
3. testing of model substances under flow-through conditions

-> Determination of sensitivity of the system

Summary

- All together 60 ship voyages were analysed (19.02 – 19.04.2018). PAH concentrations varied between 1-2,6 µg/L (**Carbazole**) and 12,4-25,5 µg/L (**Phenantrene**)
- Measured PAH concentrations are not absolute values, but rather relative, still variability patterns can be estimated
- UviLux and enviroFlu Trios showed similar variability patterns
- No sudden concentration rises which directly would indicate the oil spills, have been detected during the test period, all PAH concentrations stayed below those defining an oil spill
- Pilot versioon of novel biosensor going to be integrated in MS BALTIC QUEEN FerryBox