Sensors for *in situ* oil spill detection – problems and outlook

Harri T. Kankaanpää, Siim Pärt and Leonie Nüßer
SYKE / RWTH / TUT

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Final conference of Integrated oil spill response actions and environmental effects (GRACE project), Tallinn 23.5.2019

Why should we want to detect oil?

- fossil oils and their refined products are mixtures of toxic chemicals (e.g. PAHs)
- oil and refined oil products such as diesel fuel oil generate chemical pressure in marine systems
    - oil spills, land and marine traffic contribute to the input of these chemicals
    - marine traffic is increasing constantly
    - fuel-containing wrecks in the Baltic Sea pose a risk

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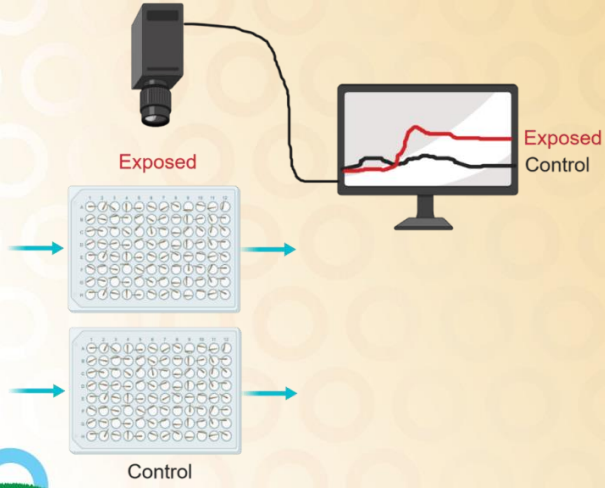
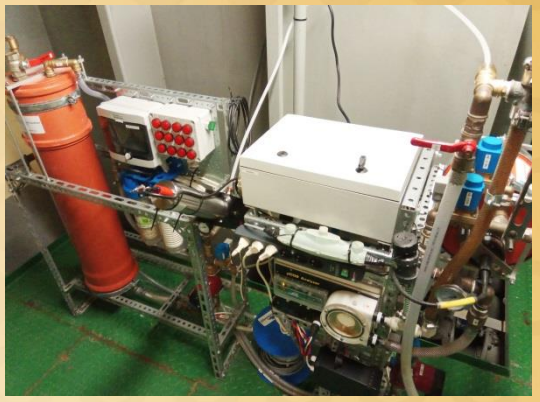
What did we do under GRACE?

- GRACE gave us a good chance to test oil sensors in laboratory and field conditions for the first time

Laboratory biosensor tests using zebrafish embryos



Sensor field tests in Ferrybox



M/S Baltic Queen
Tallinn – Åland – Stockholm

Sensor tests in laboratory

GRACE D1.6. 8/2017

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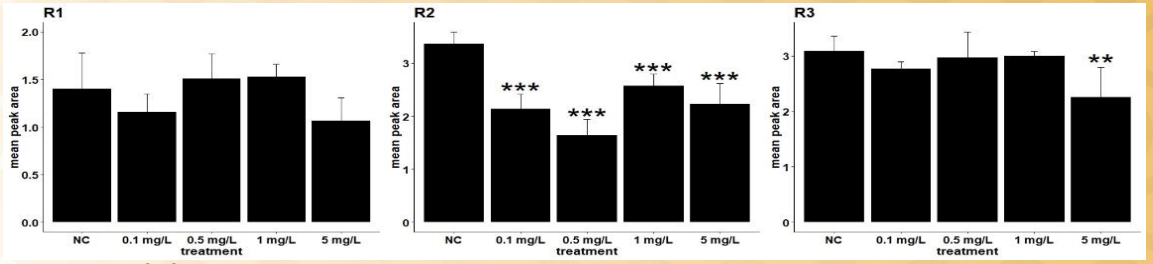
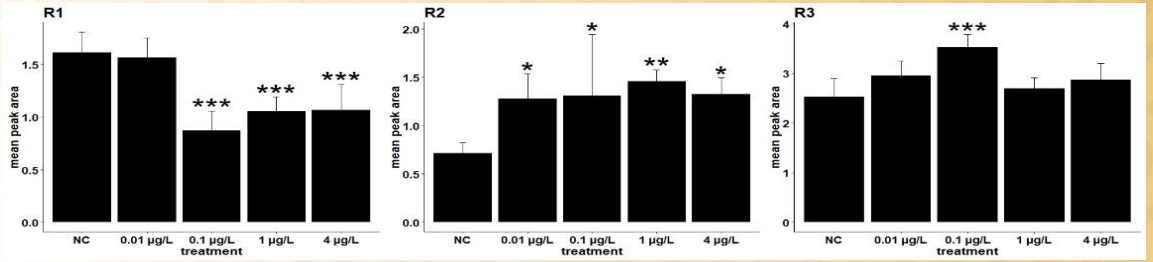
Biosensors are promising tools to detecting PAHs

Naphthalene



Benzo(a)pyrene



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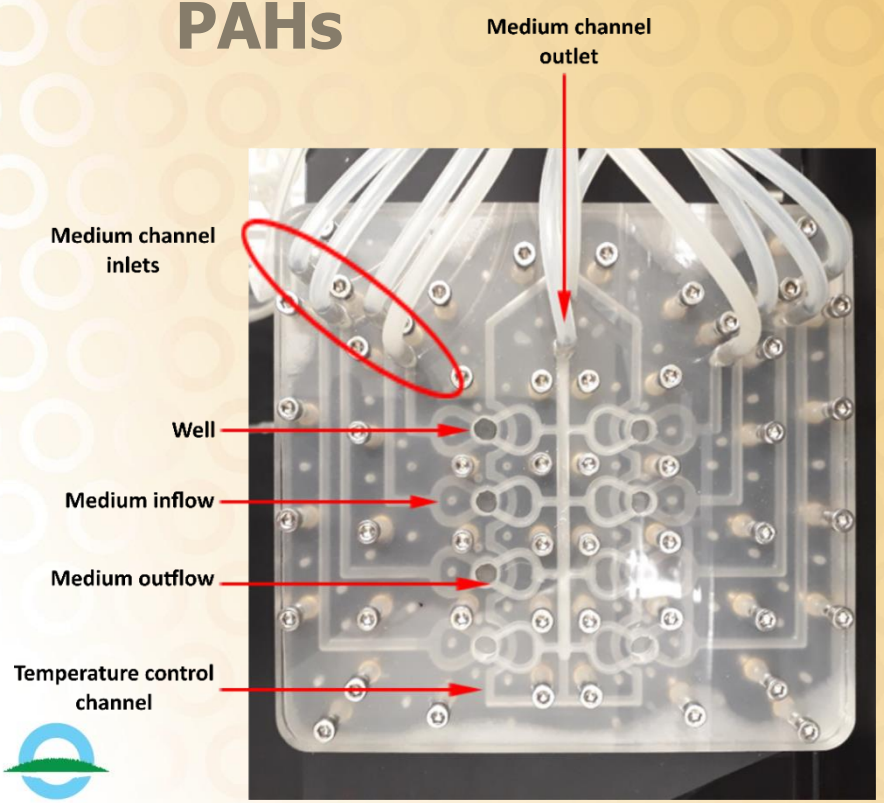
- sensitive
- specific
- no animal testing

- The periodical replacement of the test organisms ensures no adaptation (saturation) of detection occurs

Biosensors are promising tools to detecting PAHs



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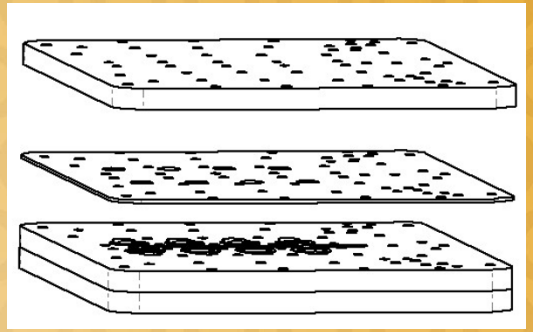
The well plate includes 8 singular wells connected to individual channels enclosed by temperature channels that ensure stable and optimal temperature conditions for zebrafish embryos



The well plate assembly was closed using a sufficient amount of screws

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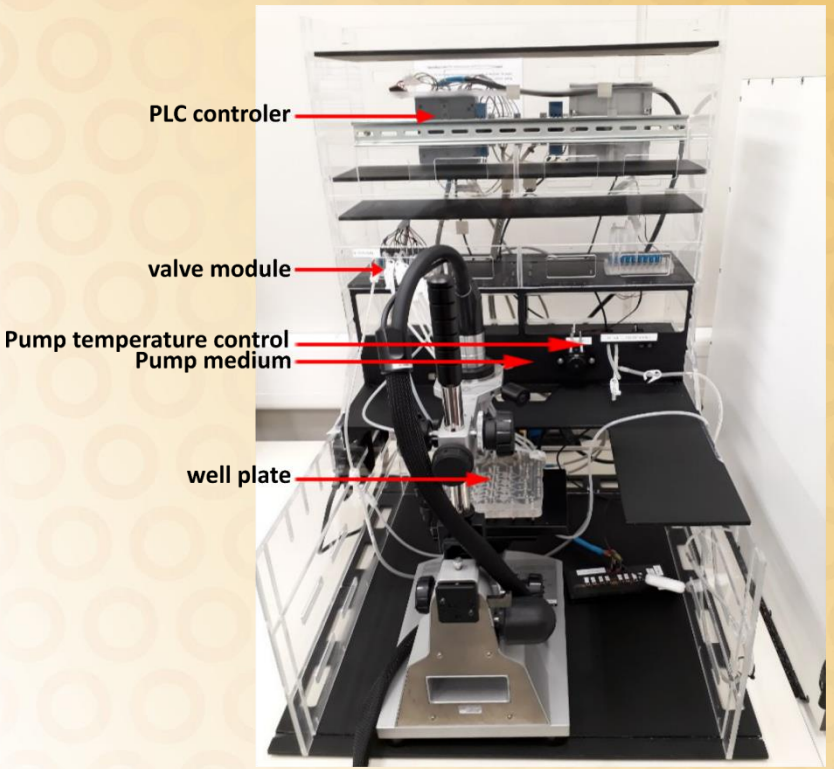
Biosensors are promising tools to detecting PAHs



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Complete assembly of parts for biosensor

First experiments with embryos under flow-through conditions

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UV fluorometer sensors used during GRACE

- Turner C3, Chelsea UviLux and TriOS EnviroFlu HC 500
- all used in laboratory testing. UviLux and TriOS used in Ferrybox installations
- Laboratory setup based on marine diesel water accommodated fraction, clay suspension, humic substance extract and cyanobacteria extract

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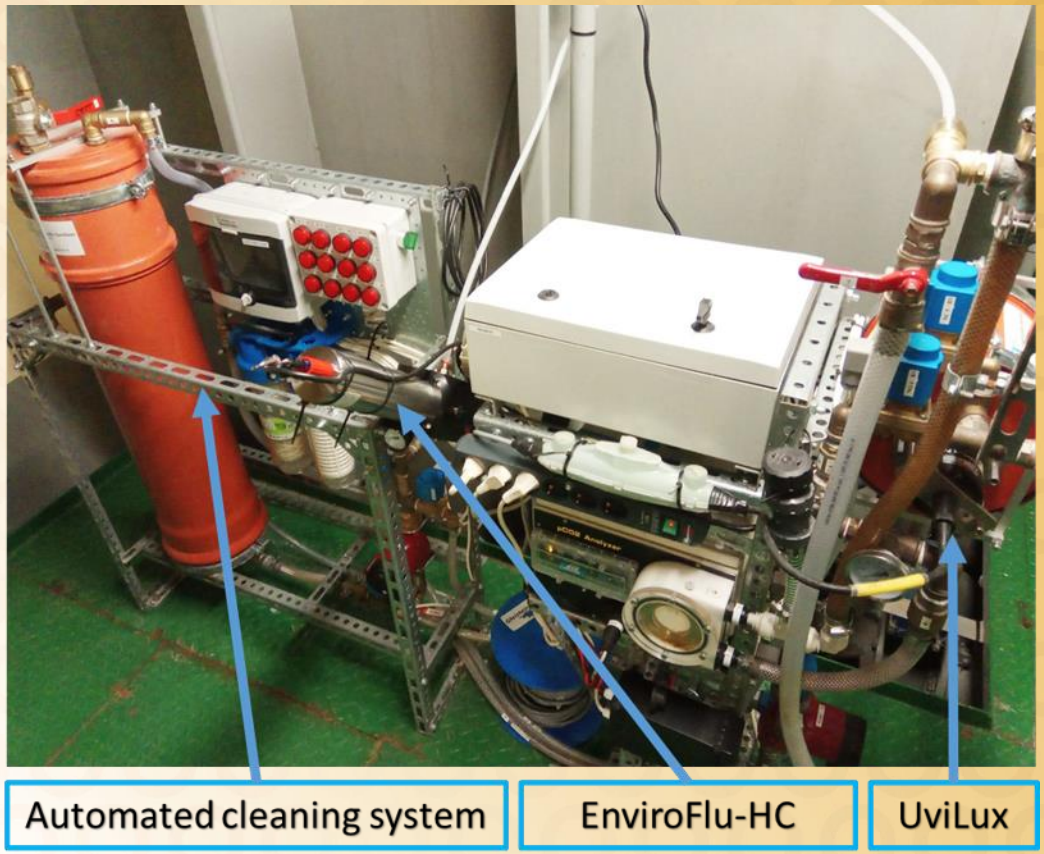
Parallel use of two sensors in Ferrybox



- Long term use proven reliable

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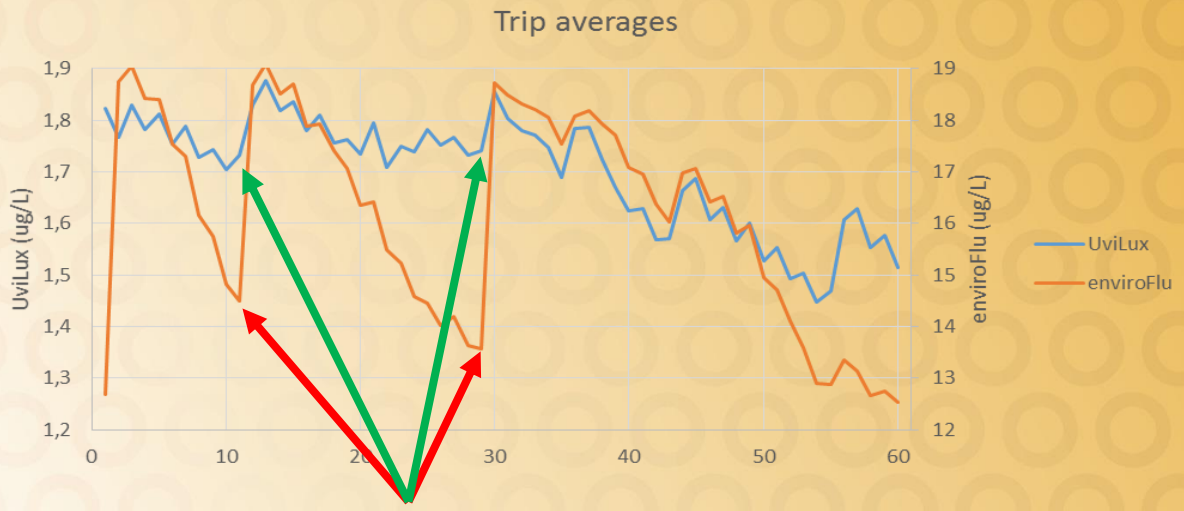
Biofouling in Ferrybox use

- Biofouling is a big issue with the optical UV-fluorometers
- TriOS EnviroFlu seems to be more sensitive to the fouling than UviLux



Sensor cleaning

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UV fluorometer laboratory performance

- unsatisfactory (C3) to good (UviLux, TriOS) sensitivity to oil
- operate mostly reliably
- all prone to interferences in natural waters
- generate different response scales (factory calibration based on different compounds)
- quality (interferences, sensitivity) ranking: TriOS ≥ UviLux >> C3
- off-line highlights: 2-methylnaphthalene (GC/MS) and n-hexane extract fluorescence were sensitive indicators for diesel fuel

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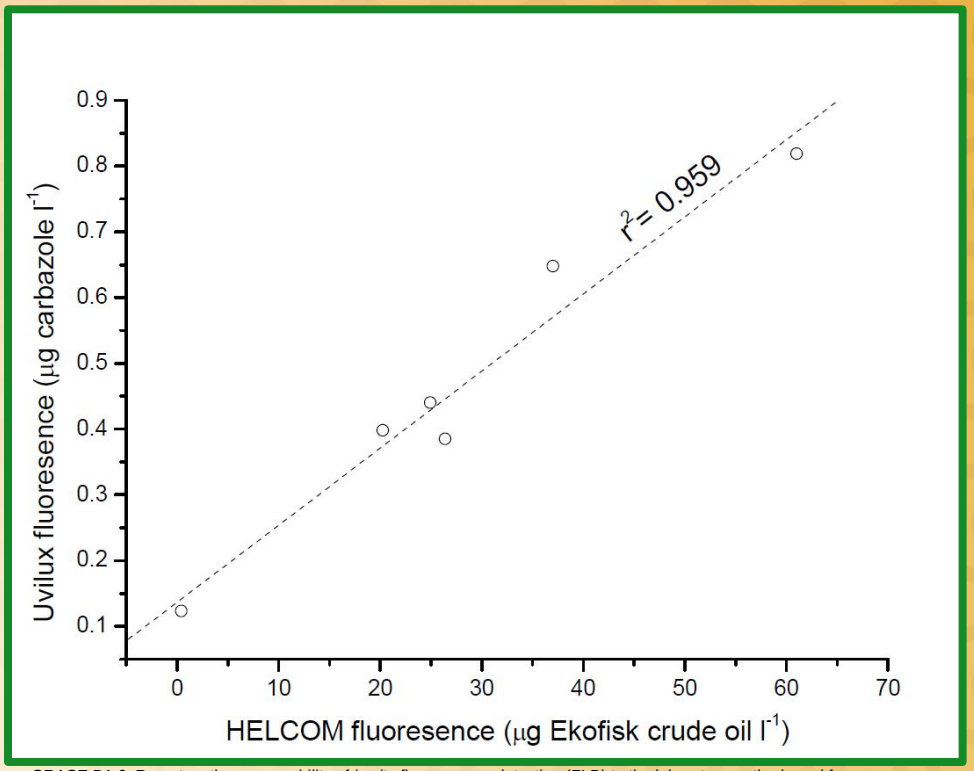
UV sensors that have good sensitivity: good agreement with monitoring protocol in laboratory conditions



GRACE D1.6. Report on the comparability of *in situ* fluorescence detection (FLD) to the laboratory method used for HELCOM monitoring

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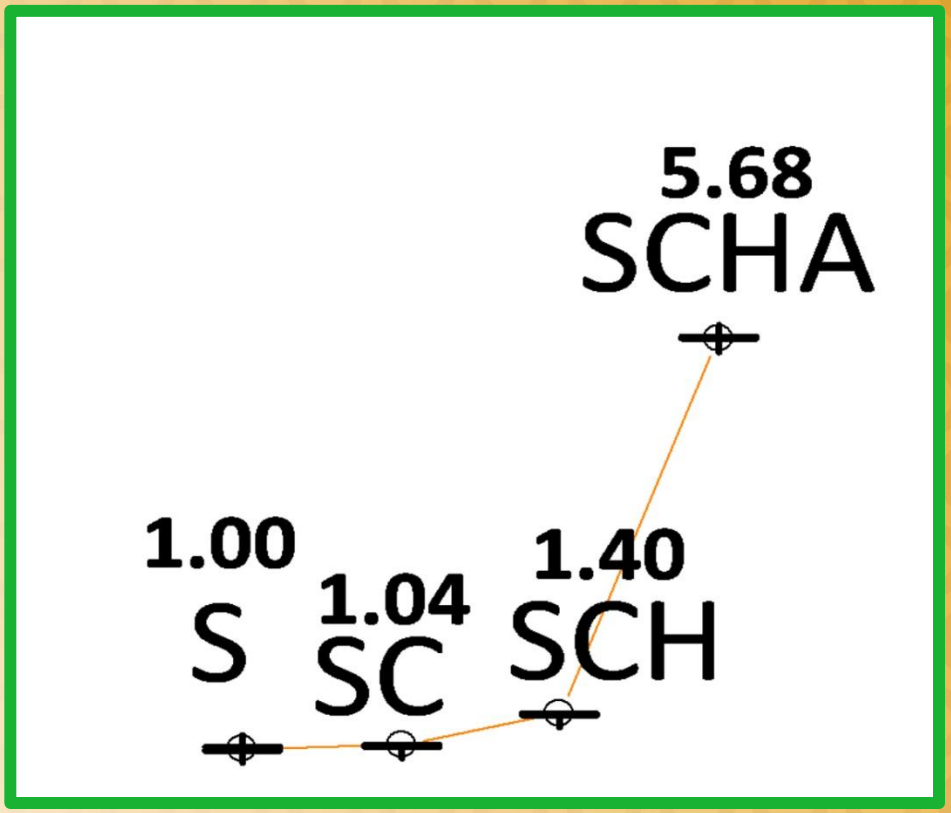
Biases due to natural constituents in sea water

S = clean seawater
C = clay (turbidity)
H = humics
A = algae (cyanobacteria)



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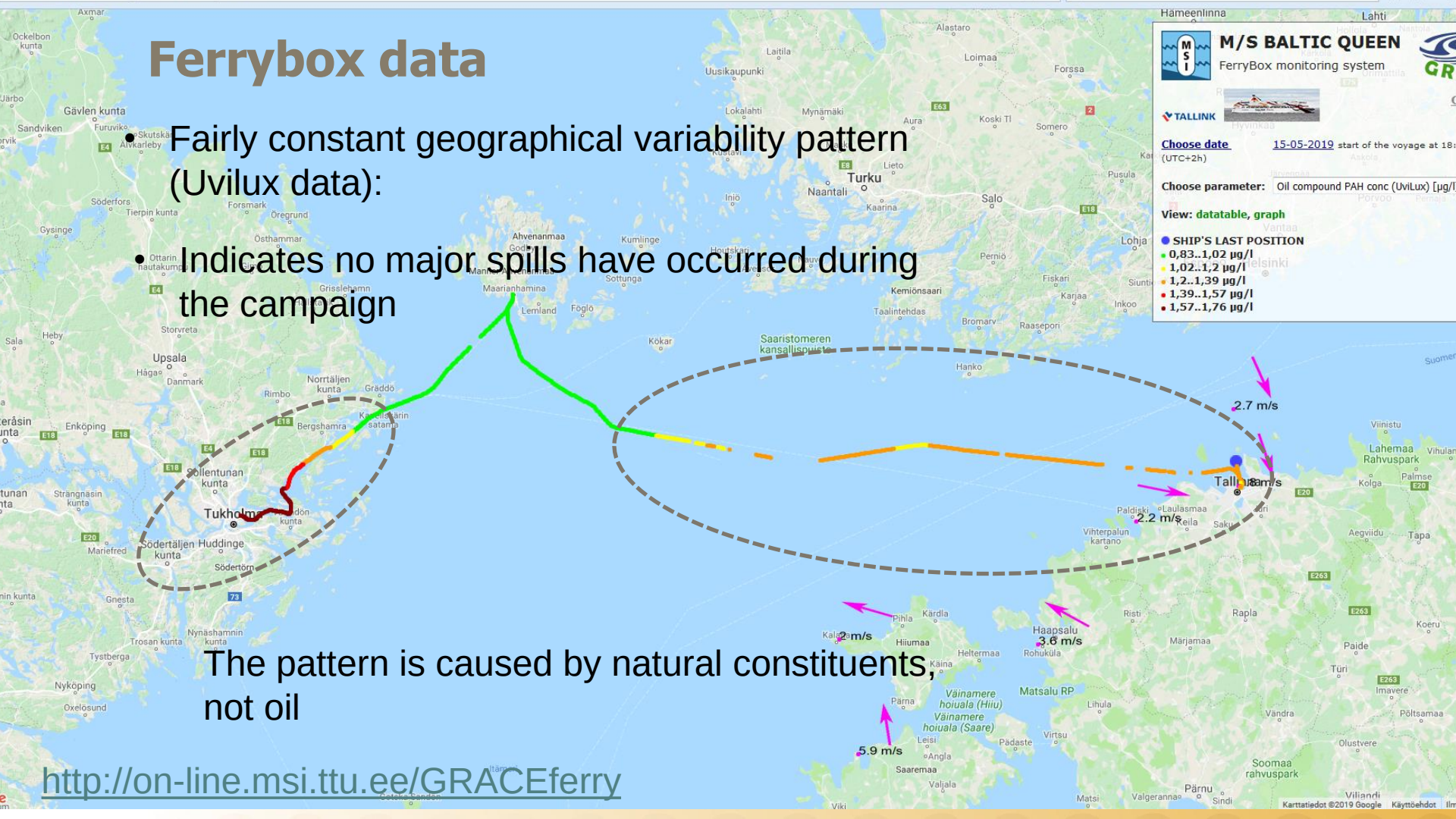
Ferrybox data

- Fairly constant geographical variability pattern (Uvilux data):
- Indicates no major spills have occurred during the campaign

The pattern is caused by natural constituents, not oil



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

In conclusion

- the biosensor technique detects effects by PAHs well
- The UV sensors can stream large amounts of data. Laboratory, Ferrybox, smart buoy and satellite setups work fine
- in UV sensor field use, the raw data produced is heavily biased, i.e. incorrect
- a rather constant natural optical background was present in the Baltic Sea
- biofouling is a risk to data quality

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Steps ahead

- development to miniaturize biosensor system for testing in FerryBox system
- defining lowest detectable effect concentrations in zebrafish biosensor
- developing correction algorithms for biased UV sensor data
- testing new Chelsea technologies V-lux reduced-interference oil sensor
- switching to low-emission shipping (LNG, electric, quiet propulsion, exhaust gas scrubbing)

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Thank you for your kind attention

GRACE participants in challenging weather conditions in Nuuk, Greenland, June 2018

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