Operational *in situ* oil spill detection in the Baltic Sea, using FerryBox system equipped with oil sensor

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There is a great potential for gathering scientific data using "ships of opportunity" (SOOPs), especially ferries and cargo ships cruising the same route on a regular basis. Some of the many advantages using SOOPs are: no ship costs, no energy restrictions, regular maintenance, transects are sampled repeatedly and biofouling of the installed system and sensors can be better controlled.

So-called FerryBox systems for automated measurements and water sampling by utilising ships of opportunity have reached reliability status. The installed systems can integrate data from water quality and other sensors with GPS information into a data stream that is automatically transferred from ship to shore. In general, all FerryBox systems employ a similar design - the system consists of a water inlet from where the water is pumped into the measuring circuit containing multiple sensors and gathered data is transmitted to shore via GSM/GPRS connection or satellite communication.

The Baltic Sea, with its high maritime traffic has increased probability for oil pollution occurrence. Spatial distribution of detected oil spills show that they are most probably noted on major ship routes, which lead to the idea to detect and monitor oil in water with FerryBox system on board a ferry between Tallinn and Stockholm.

The FerryBox system developed by Marine Systems Institute at Tallinn University of Technology is used on board of the M/S BALTIC QUEEN (Tallink Group). For detecting and monitoring oil in surface layer of the sea an UviLux (Chelsey Instruments Ltd) and enviroFlu-HC (TriOS) UV-fluorometers were used.

In parallel, basic seawater properties are recorded by the same system in real time – temperature, salinity, turbidity, O2 and pCO2 concentration. On M/S BALTIC QUEEN temperature, conductivity, turbidity, PAH and pCO2 are measured. For conductivity and temperature, High-Precision Pressure Level Transmitter Series 36XiW by KELLER (Switzerland) is used. Turbidity is measured with Seapoint Turbidity Meter by Seapoint Sensors, inc. (USA) and a The OceanPack™ pCO2 analyser by SubCtech (Germany).

Water for analysing is taken from the ferry's sea chest. Parameters are measured in one minute intervals, giving a 100-150m spatial resolution along the fairway. Gathered data is transferred on shore in real time. Such system enables automated asset for detection and monitoring of oil spills on fairways, where occurrence of oil spills is highest.

In general, UV (Ultra-violet) fluorescence is considered to be highly sensitive, reasonably selective, simple, rapid and straightforward method to determine oil-based aromatic compounds in seawater, even in low concentrations UV fluorescence oil detection method is used both in lab and also on field, as operable UV fluorometers are nowadays compact, with low power consumption and with high sensitivity - up to 0.001 µg/l.

UviLux UV-fluorometer measures oil compounds polycyclic aromatic hydrocarbons (PAH) concentrations (in terms of Carbazole). Sensitivity of 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 oil compounds polycyclic aromatic hydrocarbons (PAH) concentrations (in terms of Phenantrene). Sensitivity of the sensor is 0,5ppt (Phenantrene), calibrated range 0-5000 ppb, excitation light 254nm and emission light 360nm

Data from the sensors in FerryBox is collected by data logger and transferred in real time into on shore FTP server of the Marine Systems Institute, using GSM/GPRS protocol with one minute interval. GPS data and time stamps are added to the FerryBox measurement data.

Special web-based user interface is built to visualise data on-line **http://on-line.msi.ttu.ee/GRACEferry** where FerryBox data, ship's track, current position and gathered data can be seen both in real-time and in historical views. The web based user interface is equipped with different options: user can make selection of parameters, time periods, construct map view and 2D graphs of single and multiple parameters. Data is available in tabulated form and can be assessed regarding the quality. Individual parameters can be viewed in colour-coded view along ship's track.

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), having remarkable and quite stable variability patterns, as is with other measured parameters. Measured PAH concentrations are not absolute values, rather relative, but variability patterns can be still estimated.

Sudden concentration rises which would directly indicate oil spills, have not been detected during the observation period, all PAH concentrations stayed below those defining an oil spill. Regular maintenance of the FerryBox system was required during the measurement period, as the optical sensors were sensitive to fouling which has an impact on the data quality.

We have summarised the operational experience gathered from tests of the FerryBox systems equipped with the UV-fluorometers and showed good potential as an oil-spill detection and monitoring tool. Repeated tracks of SOOPs allow to obtain statistics of oil compounds in water in different sea areas. Especially important is the monitoring of small spills, which stay undetected with conventional remote sensing methods, but are most numerous and detectable only with in situ measurements. One drawback of the FerryBox-based oil detection system is the quite high sensitivity to biofouling, which can be handled by automated cleaning system.

We tested technology of automatic oil spill detection on board SOOP's along fairways, where probability of oil spill occurrence is highest. Oil detection is based on search of relative anomalies and not on absolute values of oil compound concentrations, which needs further research in order to compensate for the influence of natural substances like clay and chlorophyll from phytoplankton.

Figure 1: FerryBox system installed on board MS Baltic Queen http://on-line.msi.ttu.ee/GRACEferry