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Application Note
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Environmental impact of ship traffic: mixing and pollution spreading

R/V Svea is a new 70 m long research and monitoring ship owned by the Swedish University of Agricultural Sciences (SLU). In 2021 a competition was announced to win ship time on board to conduct your own research. Three groups were selected to share one week at sea in October 2021.

One of the groups from Chalmers University of Technology is investigating how coastal ship traffic can mix the water column and what environmental impacts this could have. Bringing up nutrients and methane from deeper layers and spreading of pollution, e.g., from ships with open-loop scrubbers, are two examples of the potential impact that are in focus.

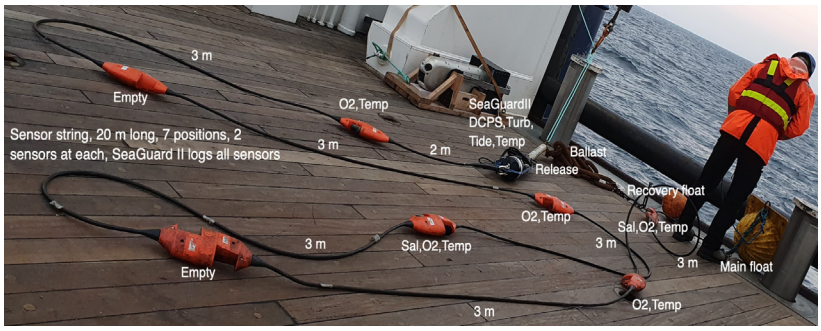

Fig 1: SeaGuardII string system laid out on deck before deployment. (Photo: Amanda Nylund)

Study Area

The selected study area was between Sweden and Denmark at the main shipping lane that exit from the Baltic Sea. All larger vessels, including Balti Max oil tankers with a max draft of 15.4 m, follow this route when they exit from the Baltic Sea.

Two ADCPs and one inverted echosounder were deployed on the bottom below the north-going ship lane. These data were complemented by measurements from the ship using a cabled CTD instrument to obtain temperature and salinity stratification measurements. One of the ADCPs was a SeaguardII string system deployed at 45 m water depth (Fig. 1).

The collected acoustic data demonstrate that the instrument detects ship passages. Both by the automatically calculated standard deviation of the horizontal currents and by the increase in acoustic reflections because of the ships' bubble wake or direct reflection against the ship hull, for ships passing directly over the instrument (Fig. 2).

The string system was permanently installed for +10 years in a Swedish fjord before this short deployment. It was used to give input to a fjord model that predicts hypoxia/anoxia. It also served for instrument/sensor development and targeted studies of the carbonate system.

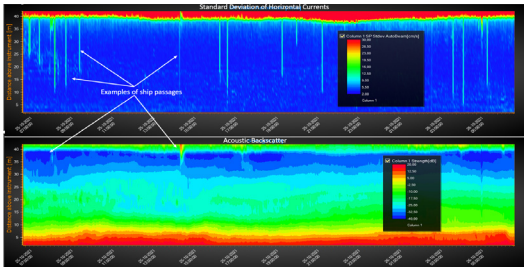

Fig 2: Passing ships are detected in the standard deviation of the horizontal currents (upper panel) and from the acoustic backscatter (lower panel). Parameters are delivered from the instrument, and the plots are made in the Datastudio-3D software, which is included with the instrument.

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In this expedition, the system measured currents in the entire water column, oxygen at four levels, the temperature at five, salinity at two, turbidity at 1 level, and the depth/tide.

The salinity was variable and ranged between 31.5-32.5 at 35 meter depth and between 30-32.5 at 26 m. This results in the density graphs, calculated from salinity and temperature, presented in (Fig. 3). The variability demonstrates the importance of continuous measurement at multiple levels if the goal is to understand how the stratification changes over time. For future deployments, the string will be equipped with more CT sensors.

Fig 3: Continuous Temperature (upper graph) and Density (lower graph) measurements with string system. The green line in the density plot is from 35 m and the red from 26 m. Please note the variability and that at occasions, the density is similar at both levels, which indicates that the water is mixed.

The CTD casts from the ship agreed moderately well with string measurements, with temperature and salinity differences of up to 0.5 °C and 0.5, respectively (Fig. 4).

The system is dynamic, and to understand the mixing effects of passing ships, the CTD casts are needed at a much higher frequency and after passages of ships. The CTD with water bottles is large in size, and there is a risk of disturbing the water column stratification. A continuously measuring system, like the SeaGuardII string assembly, is better. Still, the spatial resolution of the sensors has to be better, and the string needs to be longer or placed so that it is reaching across the stratification layer.

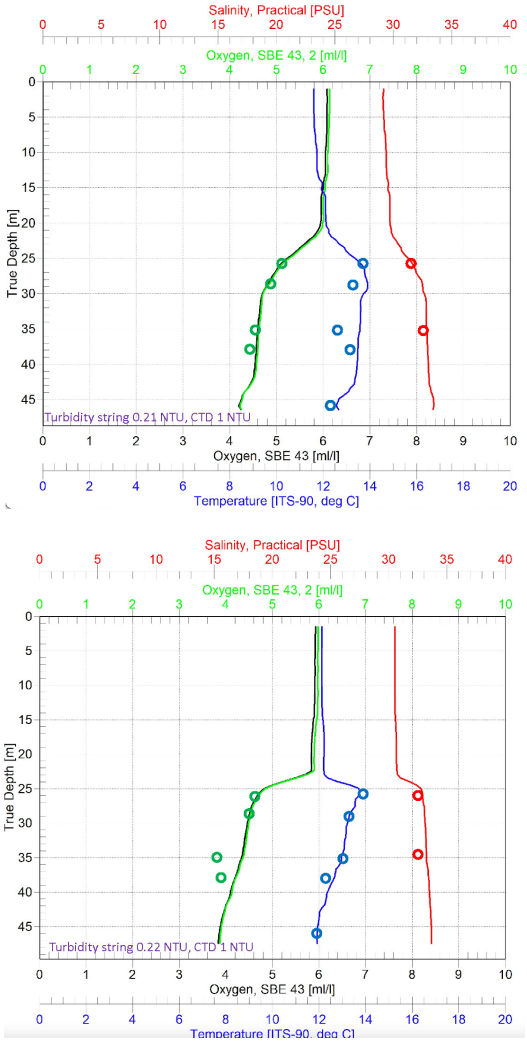

Fig 4: CTD-profiles close to the SeaGuardII mooring before deployment (left) and at the time of recovery (right). The Circles in the left profile indicate the oxygen (green), temperature (blue), and salinity (red) observations by the sensor string connected to the SeaGuardII instrument.

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