Observing Baltic Sea exchanges: results from a new multi-platform autonomous observatory

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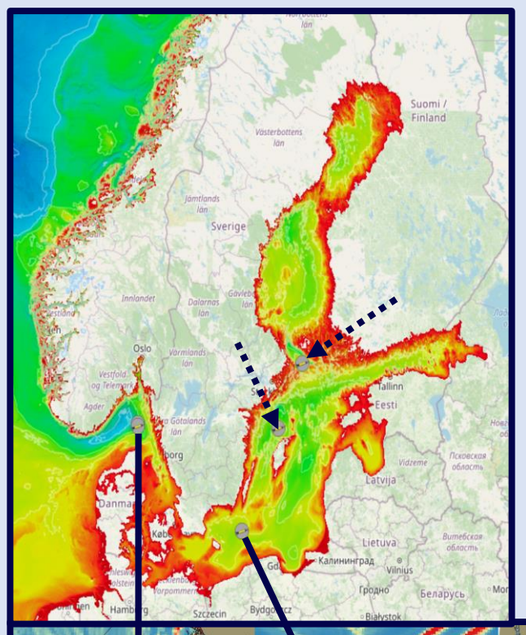
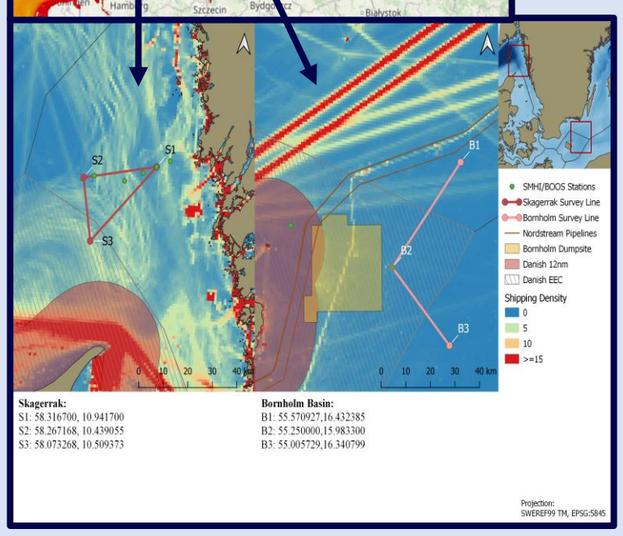


Smart Autonomous Monitoring of the Baltic Sea (SAMBA) is an infrastructure project, funded by **Voice of the Ocean Foundation** (VOTO), combining short term science objectives detailed further below and the long-term vision of establishing several persistent ocean observatories across the Baltic Sea for international collaboration.

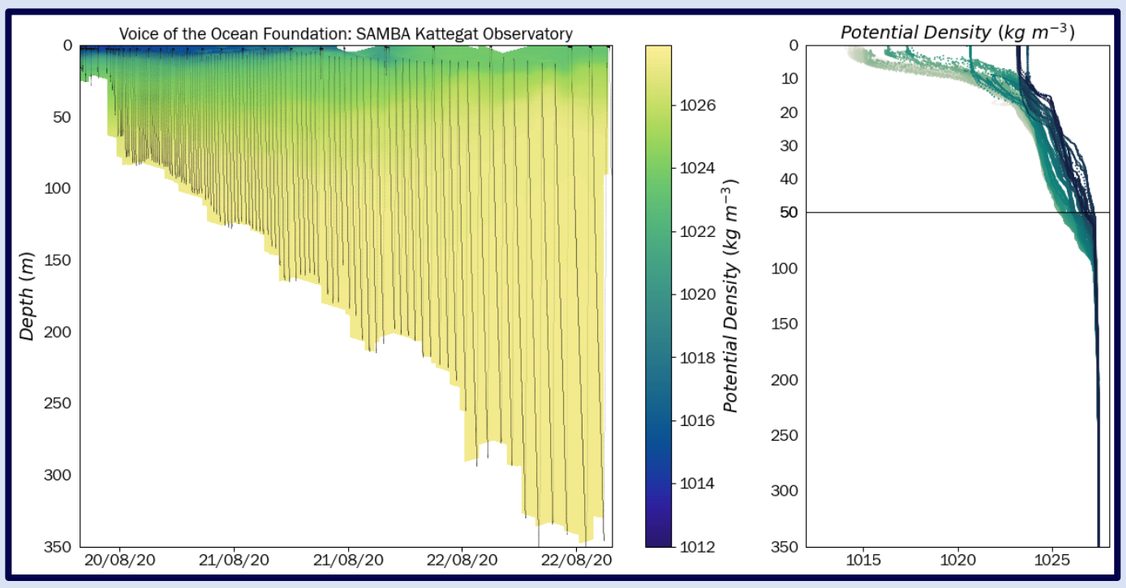
Both the Kattegat and Bornholm observatories (*left, below*) began March ’21, and another two sites are planned in the next year. Final locations are subject to modification.

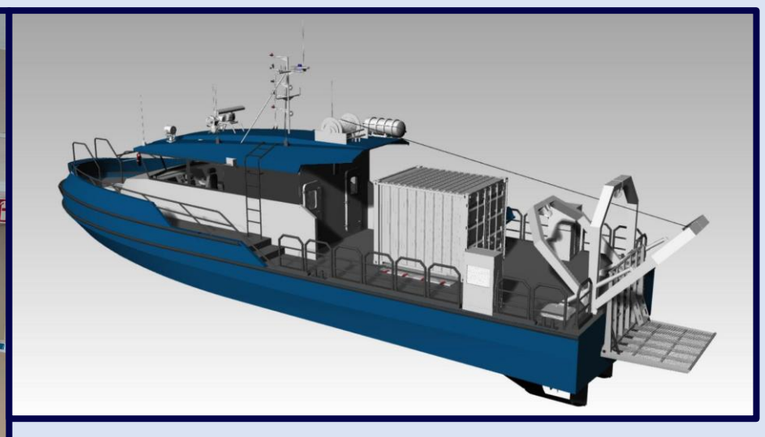


VOTO’s Ocean Knowledge division wants to help scientists understand the sea as a system through the collection of data and provision of infrastructure. Ocean Knowledge works along two different timelines: (*1*) collection of data for current scientific research, (*2*) collection of data to contribute to long-term data series, with the aim of helping science in the future (10 years and beyond) to answer questions that may arise over time.

Persistent deployments in the region are challenging. Autonomous vehicles are particularly sensitive to strong density gradients, fast currents, shipping and fishing. The complications of international permits and cooperation agreements has often slowed the growth of glider infrastructure around the world.

VOTO, SAMBA and the platform manufacturers have been working together to optimise glider capabilities in such regions. Incremental increases in capabilities are being made available to the other users through collaborative work in the region. The partnership of academia, industry and the VOTO foundation is a cornerstone of the project and key to future success.





Data collected by the ***Ocean Knowledge*** division at Voice of the Ocean provides its data publicly, with a data delivery system for direct delivery to EMODnet under construction. In the meantime, access to VOTO infrastructure, described below, or data can be done by getting in touch with the foundation through the website:

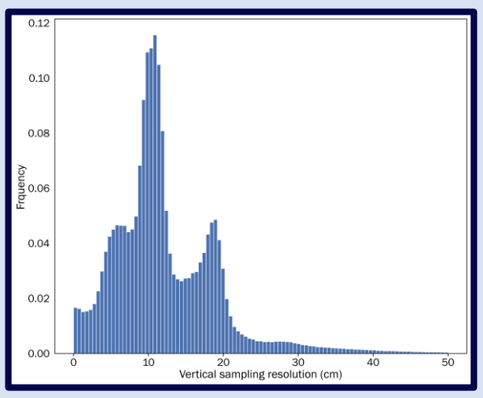
http://voiceoftheocean.org/knowledge/

10 x SeaExplorer gliders (*left, yellow).* Equipped with rechargeable batteries and interdisciplinary sensor payloads: RBR Legato temperature and salinity sensors; RBR Coda or JFE Rinko AROD-FT oxygen sensors; Wetlabs Triplet ECOpucks for chlorophyll *a*, phycocyanin and optical backscatter; SeaBird OCR504i 4-channel PAR sensors; Nortek 1MHz ADCP.
4 x Sailbuoy surface vehicles (*left, blue*). Equipped with combinations of N.Brown G-CTD, Aanderaa 4319, or RBR Legato temperature and salinity sensors, Airmar 200WX meteorology, FT Technologies FT7 wind sensor, Datawell wave recorder, EK80 WBT mini echosounder, Aanderaa DCPS current profiler.
2 x Rapid science vessels (*above*) for quick and easy autonomous vehicle turnarounds (recover/recharge/redeploy) over a single day, along with *in situ* calibration of sensors using a full CTD and rosette configuration.

The following plots show data from the first **40 days of the Bornholm Observatory**. These figures are composites of **5876 individual profiles**, sampled at vertical resolutions of **~10 cm**. The observatories are still new, and we do not yet exploit the full capability of the gliders in terms of endurance or resolution. Piloting in such conditions is challenging and significant effort is dedicated to optimising flight to increase endurance. As is always the case in science, a luck component is ever present, and the first glider turnaround at this location occurred during the peak of the spring bloom.

Each observatory will be surveyed by two underwater gliders and one surface vehicle. The combination of platforms allows distinction between spatial and temporal changes in such a dynamic environment (*“are observed changes due to the glider moving elsewhere, or to an evolution of the environment over time?”*). Surface vehicles will measure local air-sea processes, while gliders are split between *biogeochemical* payloads for estimating primary productivity and *physical* payloads for measuring of fine-scale ocean currents and shear.

In the short term, the data collected by VOTO Ocean Knowledge’s SAMBA project will serve to address a few key questions before the wider infrastructure can be used to investigate questions across the Baltic and longer periods:



- What is the variability of water mass properties and transport across the Danish Straits, and how do these influence both small and large scale Baltic inflows?
- How do physical processes affect rates of primary production, export of organic matter and remineralisation at depth across the Baltic?
- How is the upper ocean impacted by heat and momentum fluxes, and how do these affect oxygenation of Baltic deep water?
- What is the optimal strategy for long-term gliders observations in the Baltic Sea?