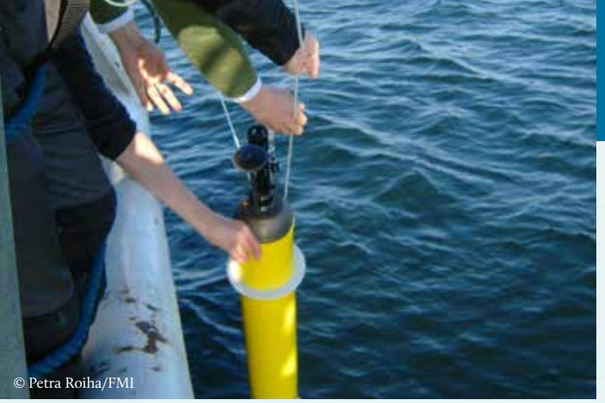
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ARGO IN THE **BALTIC SEA :** A BREAKTHROUGH IN **MONITORING**

The Baltic Sea is a favourite playground for oceanographers: with a surface area of 420,000 km² and shallow waters, it is one of the largest brackish waters zones in the world. Thus, it has large river inflows and limited exchange with the World Ocean, just like a wide estuary.*

Why is it so crucial to study this Sea? Because the Baltic is especially vulnerable to environmental pressures due to its enclosed nature and relatively low biodiversity. Since 2012, FMI has been operating Argo floats to better assess the changes in the hydrographical conditions of this specific, sensitive and high-stakes area.

First years of operation have shown that Argo floats can be successfully operated in the challenging conditions of the Baltic Sea and they are shown to be an excellent addition to the monitoring network in place.


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WHY ARGO DATA ARE REQUIRED AND CRUCIAL IN THE BALTIC SEA?

The specificities of the brackish and shallow waters make **the Baltic Sea a tricky system**. Those unique conditions shape fluxes in the Baltic Sea and therefore have effects on its chemistry, biology and ecosystems. A real puzzle for scientists! In addition, **the Baltic Sea is affected by various environmental and human induced changes**. As a matter of fact, the region is warming and the trend is not about to be reversed throughout the 21st century. For instance, the maximum extent of ice cover is lower today than the historical average, with a sharp decline in recent years, and a decrease in the mean number of ice days.

Yet, **the Baltic Sea is a high-stakes area**, as a source for aquaculture and production of environmentally sustainable energy, which is likely to be profoundly hit by these changes.

That's why there is an **urgent need to better assess this zone** and get a more comprehensive data sets of physical conditions. Salinity, for example, deeply affects species in brackish waters. Temperature is also a key information for fishing and fishfarming – as the temperature range is the limit for the productivity – and for wind energy production since wind farms in northern marine waters can be disturbed by ice conditions.

WHERE AND WHEN ARGO FLOATS COLLECT DATA?

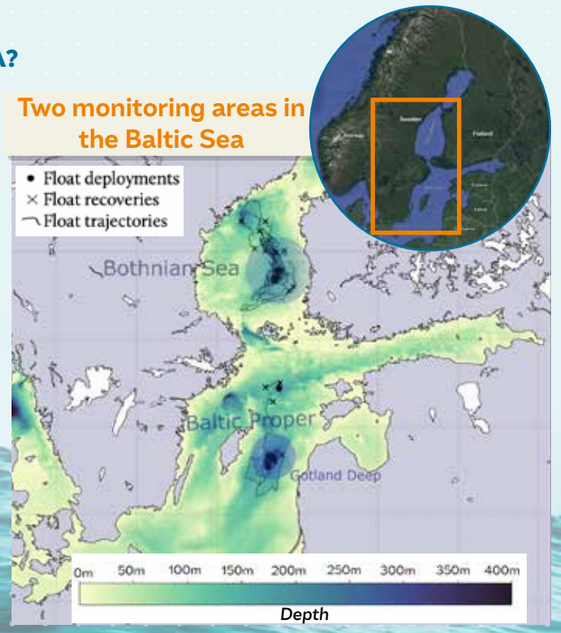
In order **to better observe and detect the changes of this sensitive area** within a global change context, FMI has been deploying and operating 31 Argo missions since 2012. The data acquired (**see table below**) allow scientists to provide maps of Argo trajectories in the selected two sub-basins of the Baltic Sea (**see map on the right**), as well as analysis of the year-to-year changes of temperature and salinity in the water column*.

Two measured seawater parameters

AREA	TEMPERATURE*	SALINITY*
Bothnian Sea (2012 – 2019)	3.5 to 4.4 °C	6.1 to 6.6 PSU
Baltic Proper (2013 – 2019)	5.9 to 6.4 °C	11.0 to 11.5 PSU

*mean values in the depth of 100 meters
PSU: 1 g of salt per kg of seawater

Two monitoring areas in the Baltic Sea



Locations of the two basins where Argo floats were deployed by FMI.

WHO OPERATED THIS USE CASE?

FMI

The Finnish Meteorological Institute (FMI). It produces observations and research data for the needs of public safety, companies and citizens. FMI is an administrative branch of the Finnish Ministry of Transport and Communications.

REFERENCES AND LINKS

- State of the Baltic Sea – Second HELCOM holistic assessment 2011-2016. **https://helcom.fi/baltic-sea-trends/holistic-assessments/state-of-the-baltic-sea-2018/reports-and-materials/**
- Argo floats as a novel part of the monitoring of the hydrography of the Bothnian Sea. Noora Haavisto et al (2018). **DOI: 10.3389/fmars.2018.00324**

HOW ARGO FLOATS IMPROVE THE BALTIC SEA MONITORING?

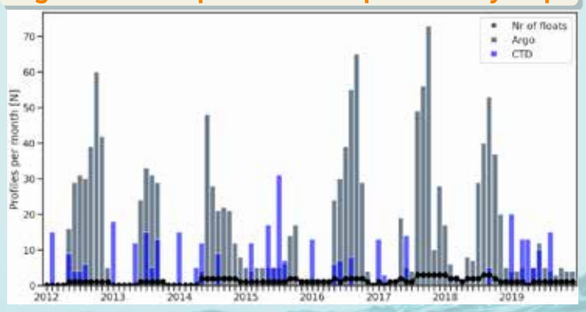
So far, the observation of the Baltic Sea has relied on measurements from research vessels which provide data during time-limited campaigns at sea, covering a restricted geographical area and depending on weather conditions. **Argo campaigns have significantly improved the monitoring of the Baltic Sea open sea areas.**

Complementary Argo observations provided a **real leap forward in understanding the evolution of ocean parameters (see graph below)**. Indeed, Argo floats perform temperature, salinity and pressure measurements while actively going up and down the water column, from the surface to various depths. The results of these vertical surveys are called "profiles". Since 2012, they have been measuring in average **one profile every five days**. All this data is almost real-time and describes the hydrographical conditions* that are essential for gaining knowledge of the evolution of the water column, as well as **the effect of climate change**.

Benefits for Argo data end-users

- Tools for environmental management
- New data for research & development in oceanography
- Background information for aquaculture
- Potential for supporting European Union "Green Deal"*

Argo floats complement data provided by ships



Number of measured Argo profiles (gray) and CTD profiles (blue) per month in the Bothnian Sea for 2012–2017. The black dots represent the amount of simultaneous floats each month.

Argo floats **complement the information provided by traditional monitoring** and should contribute to the **«Baltic Marine Environment Protection Commission (HELCOM)» monitoring.**

They take sufficient **measurements in time and space** to provide valuable information on the annual cycles. Indeed, floats are able to measure frequently and for long time periods and are practically weather-independent. Using ice avoidance algorithms* allows **providing profile data even during the Baltic Sea ice winter**.

As a result, **the seasonal cycle of the water column was observed for the first time** in the open sea areas of the Bothnian Sea and Baltic Proper, on a weekly scale. This knowledge can be used **to predict the upcoming ice winter** or timing and magnitude of summer algae blooms.

The possibility to adjust the float profiling frequency according to weather forecasts was successfully demonstrated and found a feasible way to **get measurements from storms and other short-term phenomena unreachable with research vessels**.

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GLOSSARY

Water column: the water column is a concept used in oceanography to describe the physical (temperature, salinity, light penetration) and chemical (pH, dissolved oxygen, nutrient salts) characteristics of seawater at different depths for a defined geographical point.

Ice avoidance algorithms (ISA): this algorithm allows to detect ice and to postpone the surfacing of the float if there is a risk of it being blocked by ice when it reaches the surface to send its data to the satellite operators.

Hydrographical conditions: they describe basic physical features of the water bodies and include bathymetry of the seabed, sea level, temperature, salinity, currents, tides, waves and turbidity.

Brackish waters: waters occurring in a natural environment having more salinity than freshwater, but not as much as seawater.

Green deal: set of policy initiatives by the European Commission with the overall objective of making Europe climate neutral by 2050.

The work was carried out during the Euro-Argo RISE project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 824131