

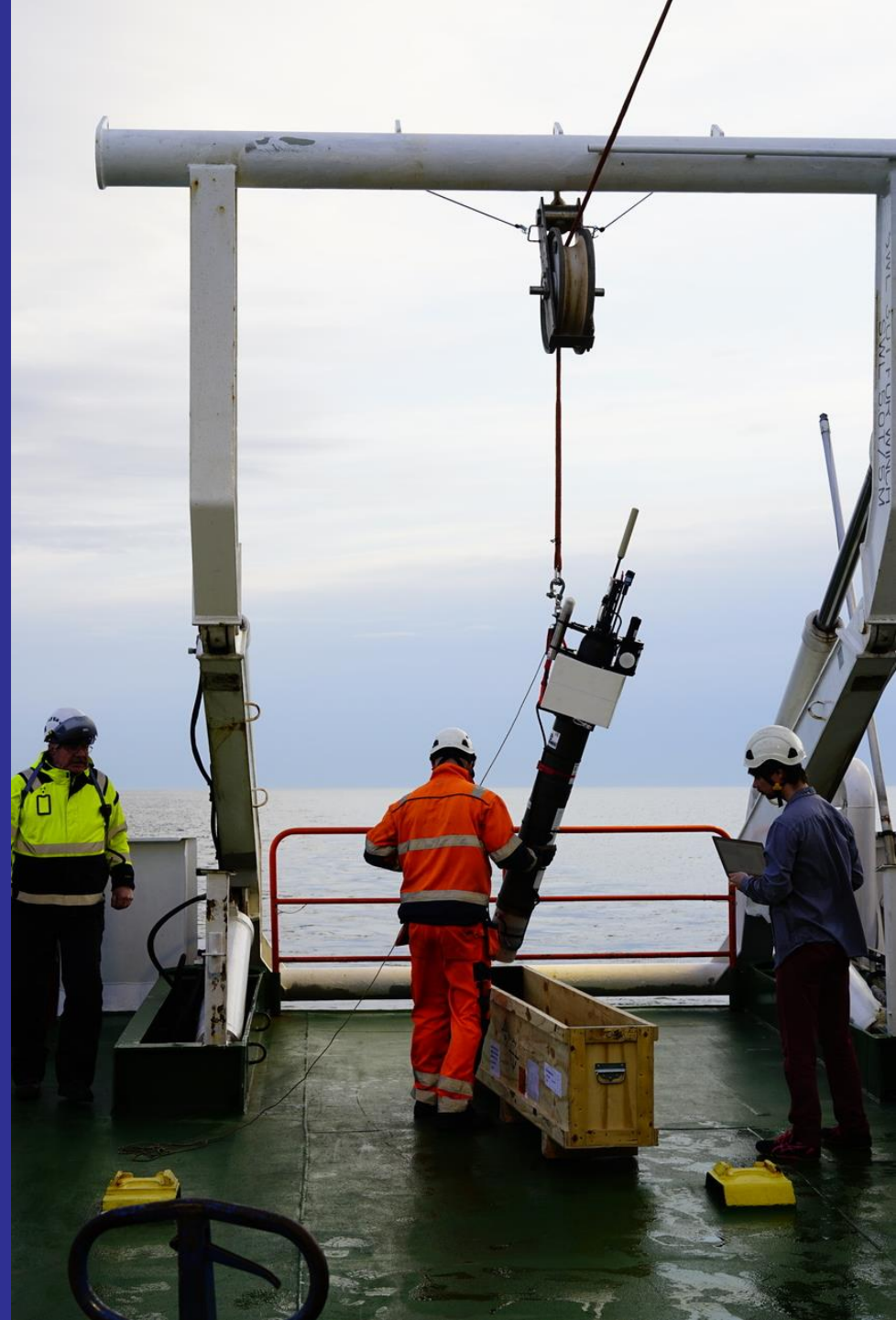


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# Enhancing the monitoring of the Baltic Sea environmental state using Argo floats

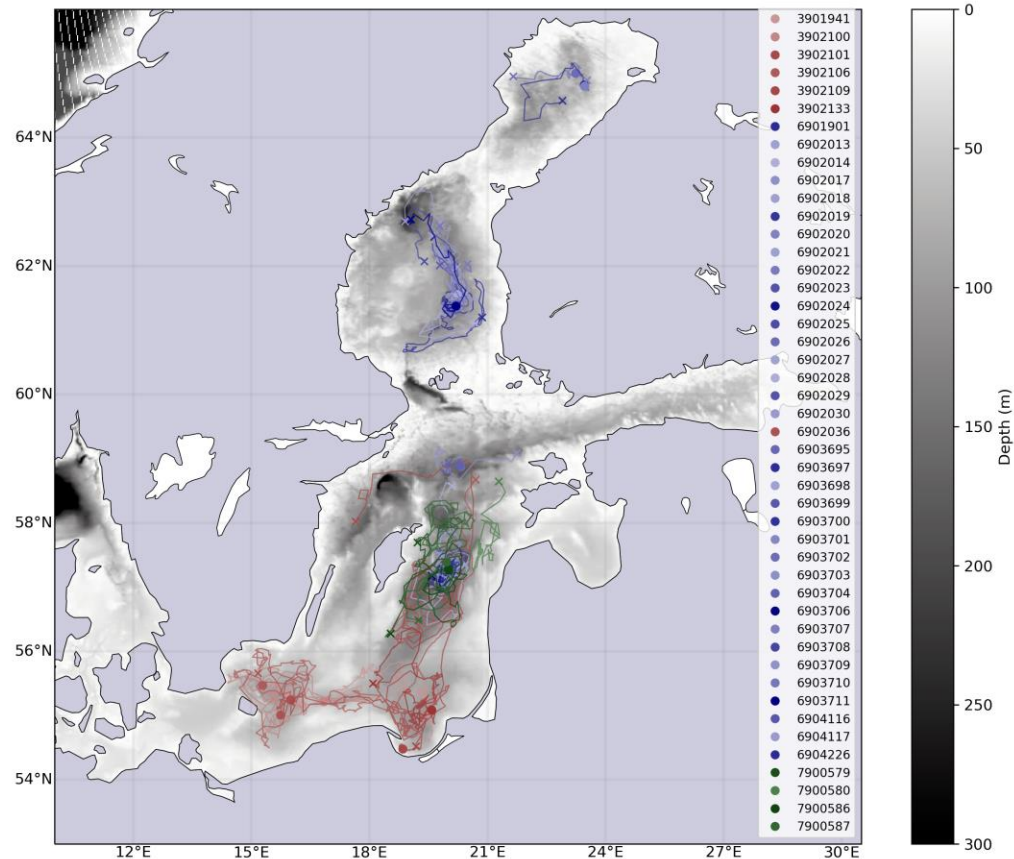
7.10.2022

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# Argo floats in the Baltic

- 2011 First FMI tests (Bothnian Sea)
- 2012 First FMI official missions (CTD sensors only)
- 2013 First FMI float into Gotland Deep
  - At least one float there continuously since then
  - First Oxygen, backscatter float deployed
- 2016 First IO-PAN floats on Bornholm Basin
- 2017 First FMI float on Bothnian Bay (Ice avoidance tests)
- 2020 First FMI floats on Northern Baltic Proper
- 2021 First German floats (with five-parameter BGC sensors)
- May 2021 Four Euro-Argo RISE floats testing new sensors (TS+BGC) in the Gotland Deep and Bothnian Sea



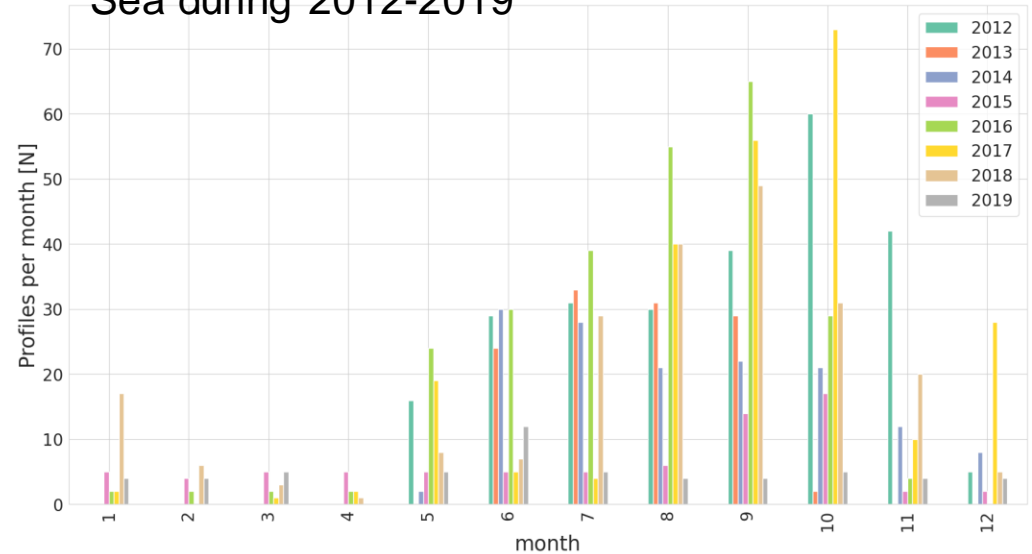
Argo float trajectories in the Baltic Sea since 2011 including Finnish, Polish, German and EU floats

# Impact of Argo floats on data availability in Baltic

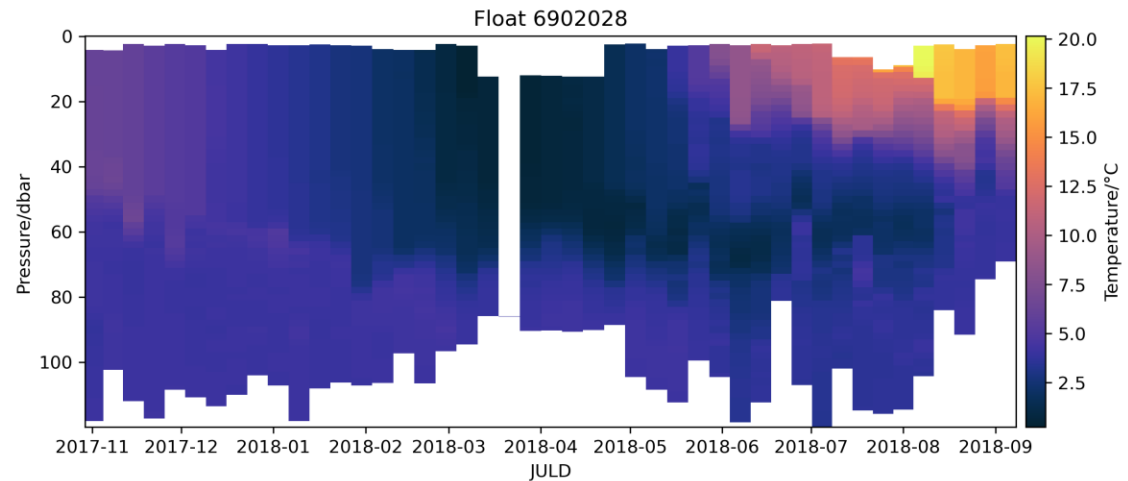
In the northern part of the Baltic Sea the monitoring cruises are done 3-4 times a year and the number of additional T/S-profiles provided by Argo floats is considerable. Increasing the number of floats with biogeochemical sensors most importantly oxygen would further benefit the monitoring activities.

Also, possibility to operate floats under ice during winter has improved the availability of data from these regions from winter-time since 2016.

Number of Argo profiles from the Bothnian Sea during 2012-2019



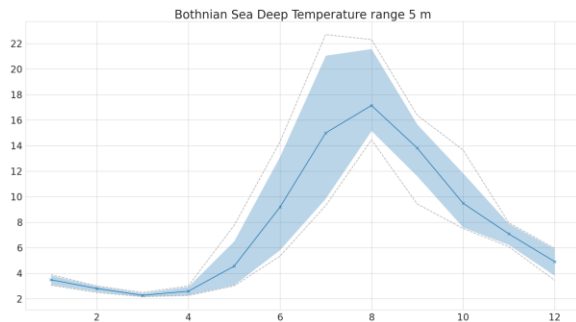
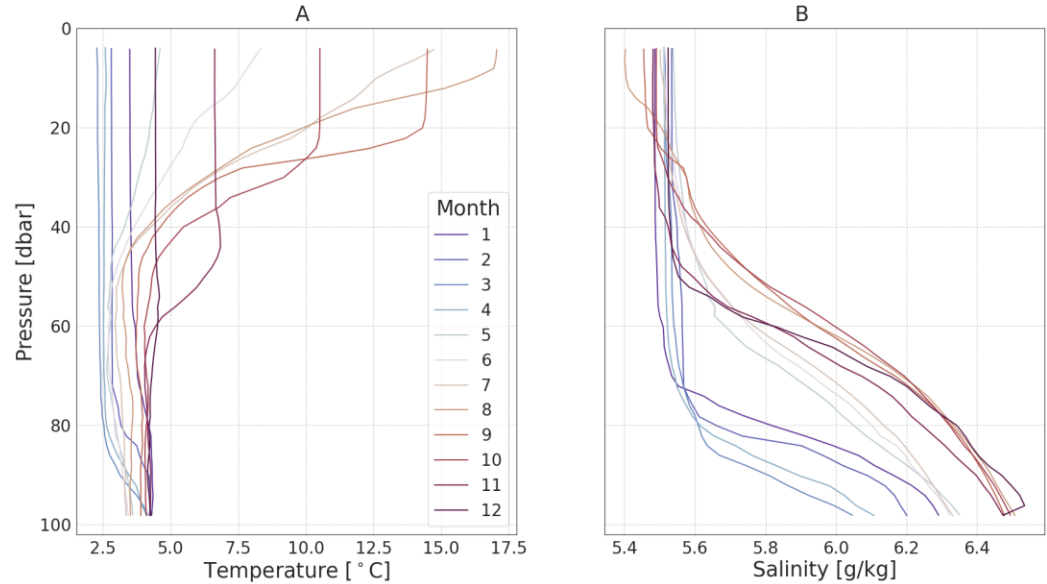
Temperature measurements at Bothnian Sea during ice winter 2017/2018.



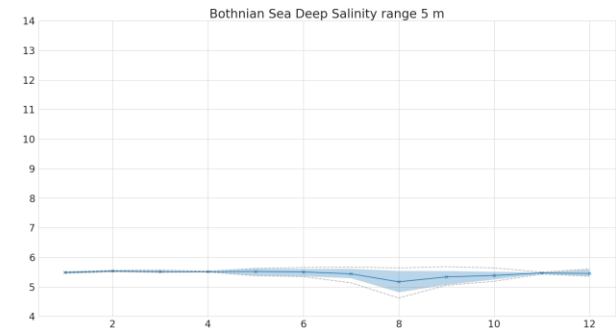
# Monitoring seasonal variability

With Argo floats we get more frequent measurements compared to traditional monitoring data allowing us to capture the seasonal cycles and estimate extreme events.

Monthly mean profiles from the Bothnian Sea Argo floats showing the seasonal variation in the halocline and thermocline depths.



Annual cycle of surface layer temperature (on the left) and salinity (on the right) in the Bothnian Sea based on Argo float data




# Baltic Sea Argo Use Case

To highlight the importance of the Argo floats in the Baltic and give examples for end-user applications we made a Use Case for Baltic Sea in the Euro-Ago RISE project.

## Argo in the Baltic sea: a breakthrough in monitoring!






### 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 km<sup>2</sup> 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.



#### 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. These unique conditions shape fishes 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 21<sup>st</sup> 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 fish farming – 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.

#### 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.

#### WHERE AND WHEN ARGO FLOATS COLLECT DATA?

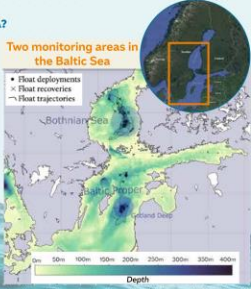
In order to better observe and detect the changes of this sensitive area within a global change context, FMI has been deploying and operating 31 Argo missions since 2012. The data acquired (see table below) allow scientists to provide maps of Argo trajectories in the selected two sub-basins of the Baltic 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	61 to 6.6 PSU
Baltic Proper (2013 – 2019)	5.9 to 6.4 °C	110 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

- Float deployments
- × Float recoveries
- Float trajectories



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

#### WHO OPERATED THIS USE CASE?

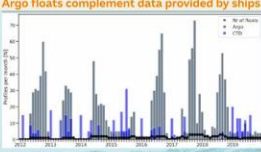


The Finnish Meteorological Institute (FMI) is producing observations and research data for the needs of public safety, companies and citizens. FMI is an administrative branch of the Finnish Ministry of Transport and Communications.

#### 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 the hydrography of the Bothnian Sea. Neven Haurio et al (2018). DOI:10.3389/fmars.2018.00324

#### 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.

#### CONCLUSIONS


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.



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<https://www.euro-argo.eu/EU-Projects/Euro-Argo-RISE-2019-2022>

 #EARISE

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