Challenges of using Argo in marginal seas

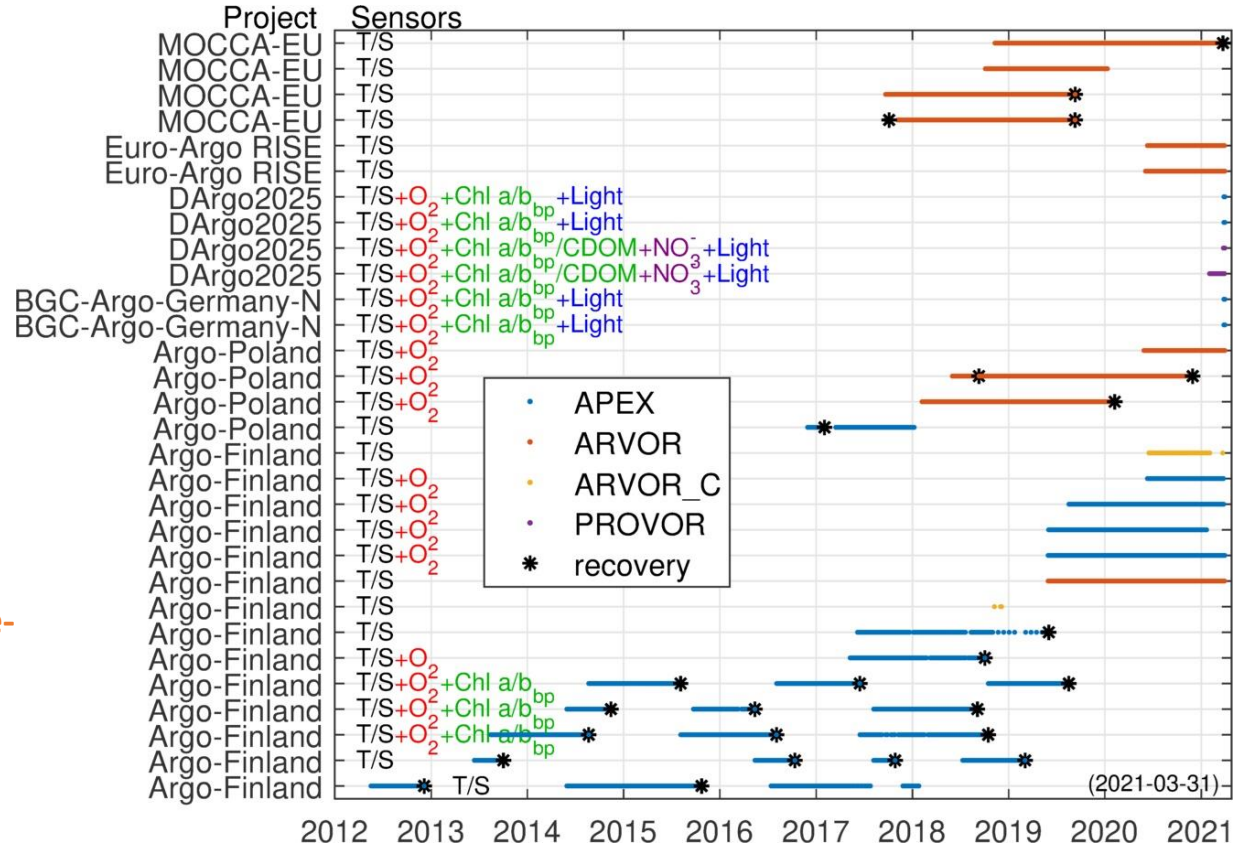
Baltic Sea as use case

Simo Siiriä, Birgit Klein, Laura Tuomi, Ingrid Angel Benavides

Marginal Seas Argo DMQC workshop, Sopot, Poland 18.04.2023-19.04.2023

(Short) history of Argo floats in Baltic Sea

- 2011 First tests (Bothnian Sea)
- 2012 First official missions (CTD sensors only)
- 2013 First 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 float on Bay of Bothnia (Ice avoidance tests)
- 2020 First floats on Northern Baltic Proper
- 2021 First German floats (with five-parameter BGC sensors)



Baltic Argo Activities

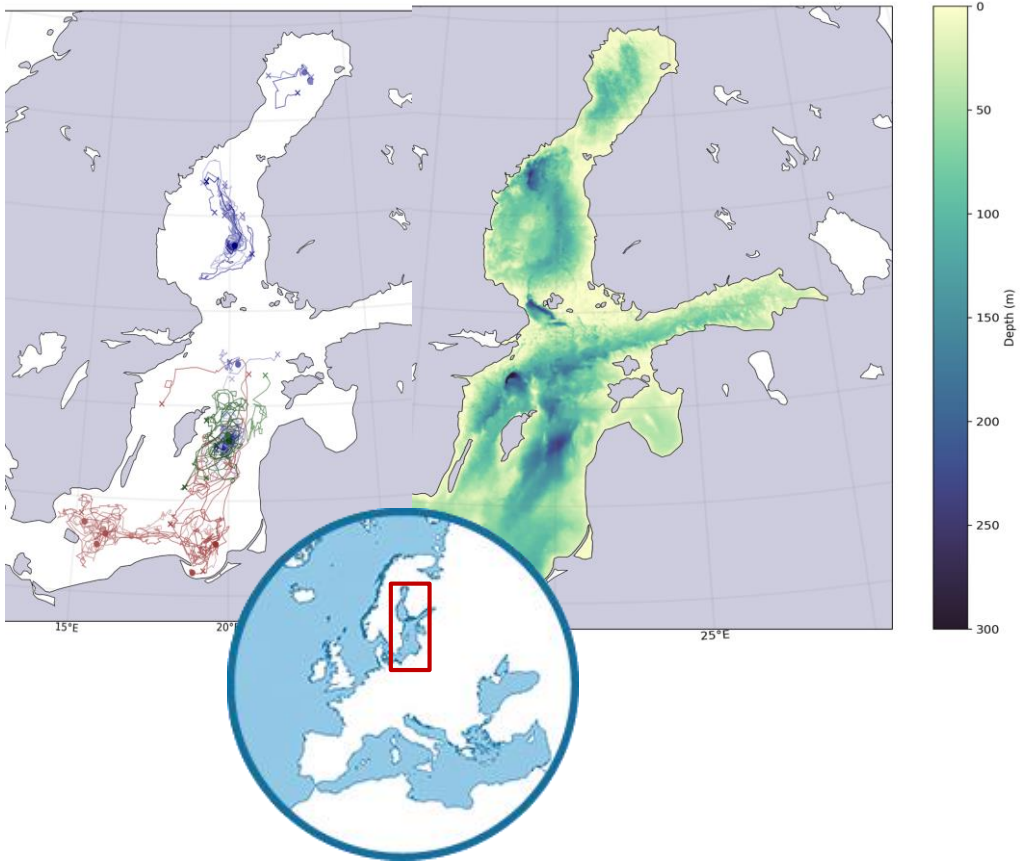
Float types applied

- Apex (Webb)
  - First ones in Baltic Sea
  - Most FMI's floats, AWI
- Arvor (NKE)
  - IO-PAN, FMI floats,
  - Euro Argo RISE floats, MOCCA-floats
- One Arvor-C (NKE) with bottom lander
- Provor (NKE)
  - IOW BGC floats
  - Prototypes with extra sensors upcoming

Challenge: Shallow operations

- Typical profiles 100-200 m
  - in comparison to 2000 m in oceans
  - deep stable layer rather rare
- Bottom contact always a risk
  - Possibility of getting stuck
  - But profiling too shallow means loss of data
- Area need to be selected carefully
  - Deep enough
  - possibility to stay in region

Baltic Sea argo operations

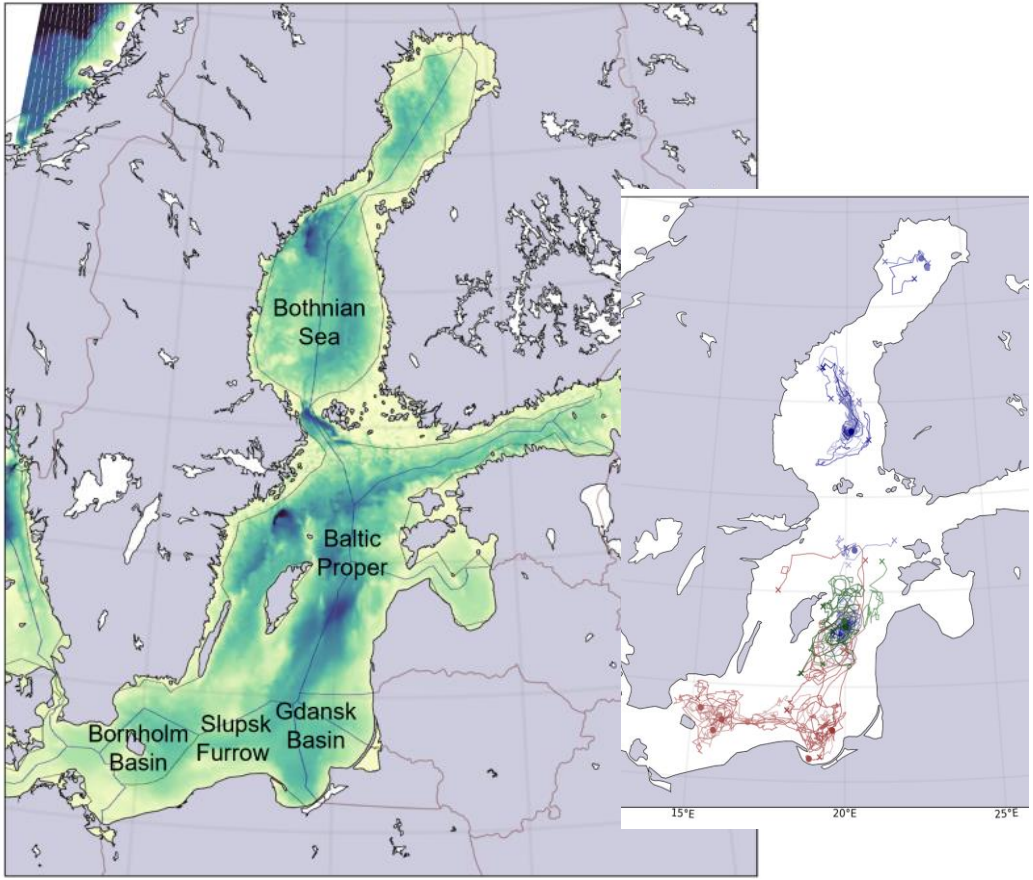


- Conditions deviate from the open deep ocean characteristics:
  - Shallow: average depth 55 m
    - Typical operation depth 100-200 m

Challenge: Limited area

- Shores always near
  - Stranding a possibility
  - Deep enough area limited
- Everything is EEZ
  - Float can drift on several EEZ's
  - Permissions for deployments and recoveries
- Area need to be selected carefully
  - Not every place is optimal
  - Suitable currents
  - Traffic/other activities

Baltic Sea argo operations

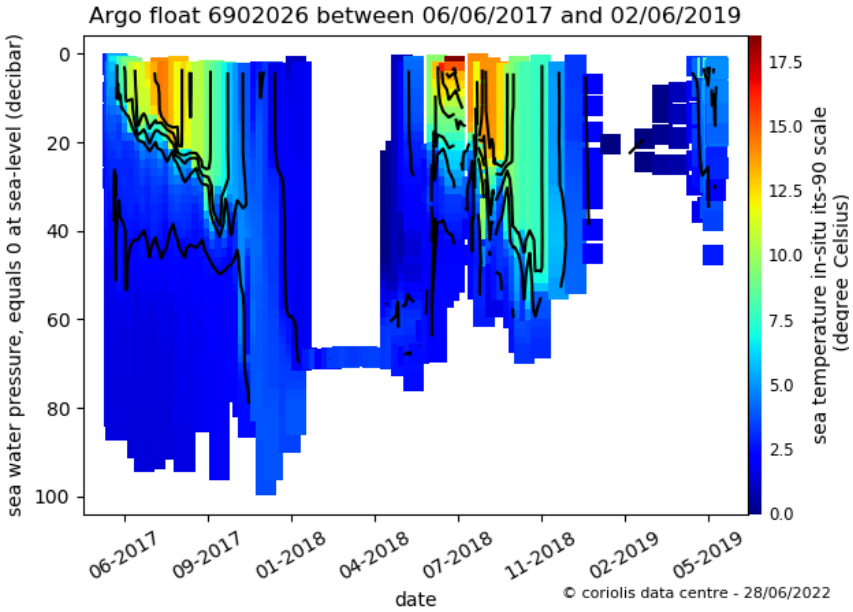


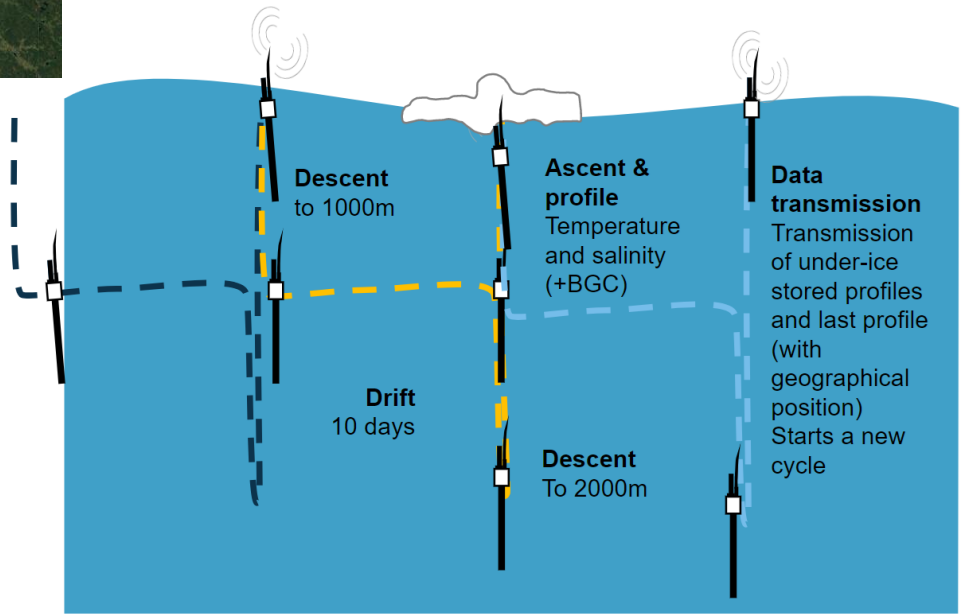
- Everything EEZ

Challenge: Cold region

- Ice will break the float
  - Method to avoid collisions
- Ice Sensing Algorithms are solution
  - But can’t get GPS while under
- Not needed everywhere

Challenge: Cold region

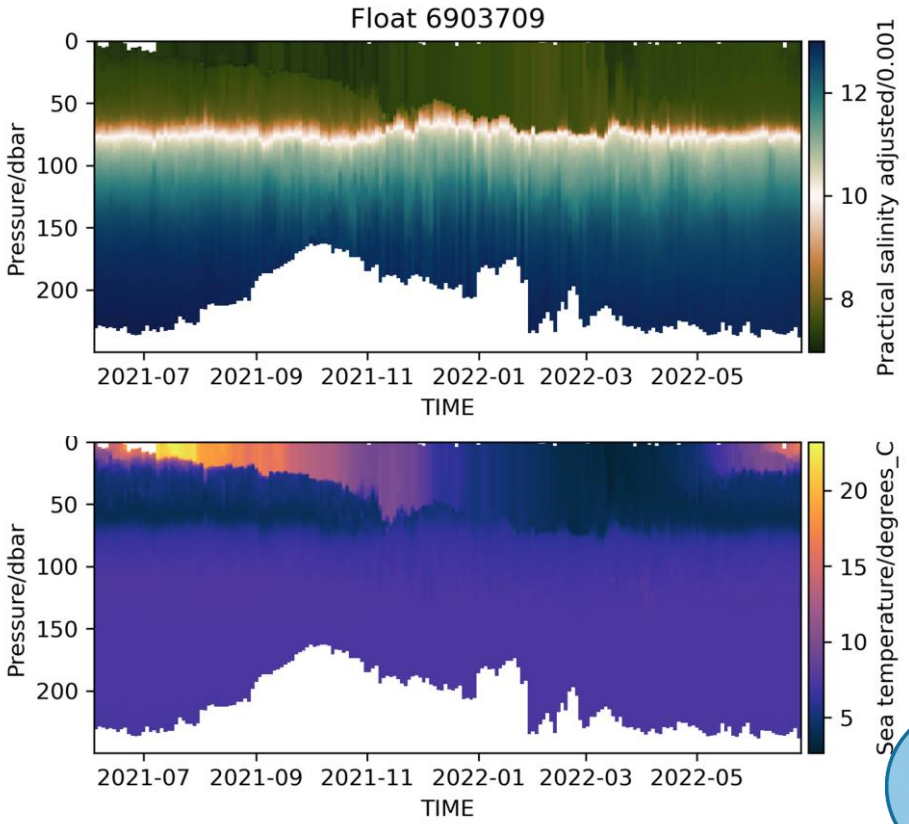


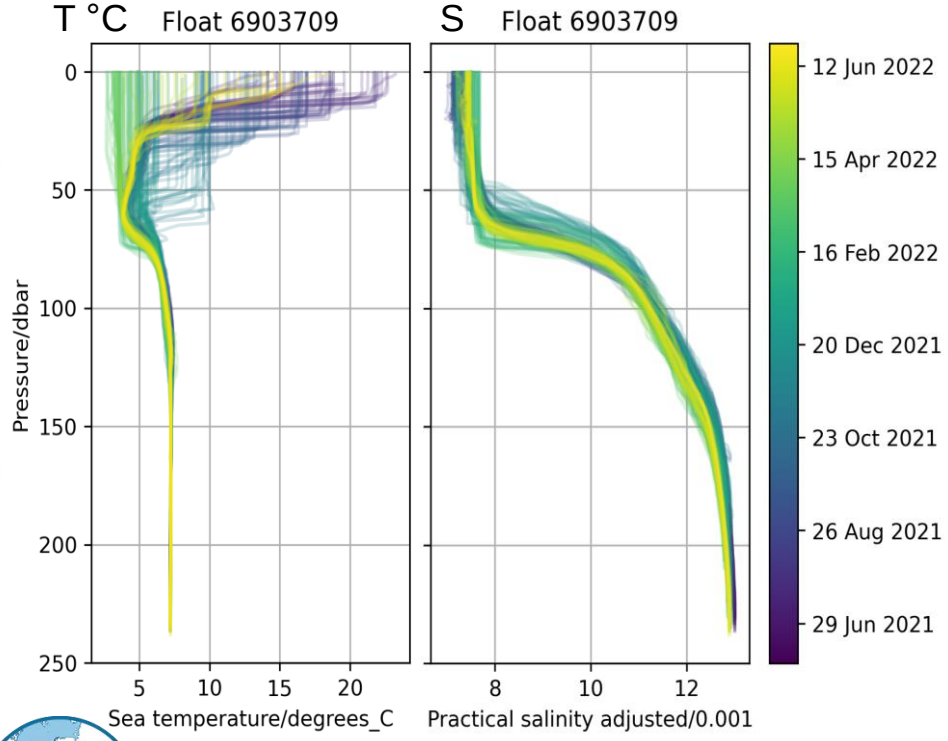


Challenge: Varied hydrography and bathymetry

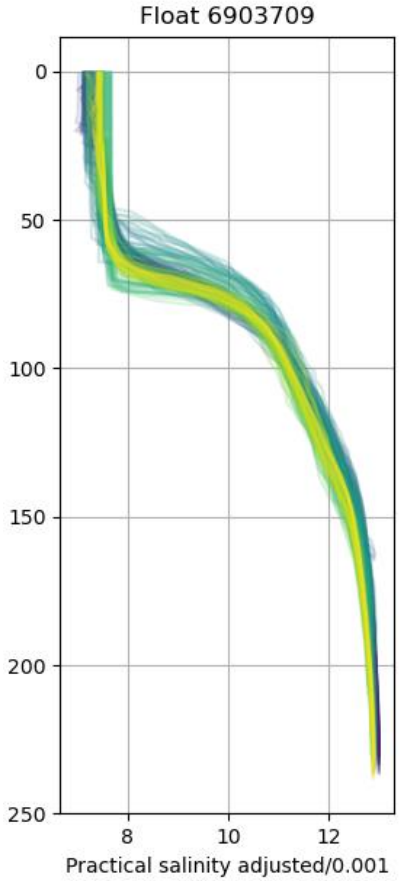
- Strong density differences
  - Floats need to be calibrated with certain deployment area in mind
  - Even in same area strong density gradients are challenging for some float types
- Depths vary a lot
  - If float moves from original area the configuration might need to be adjusted

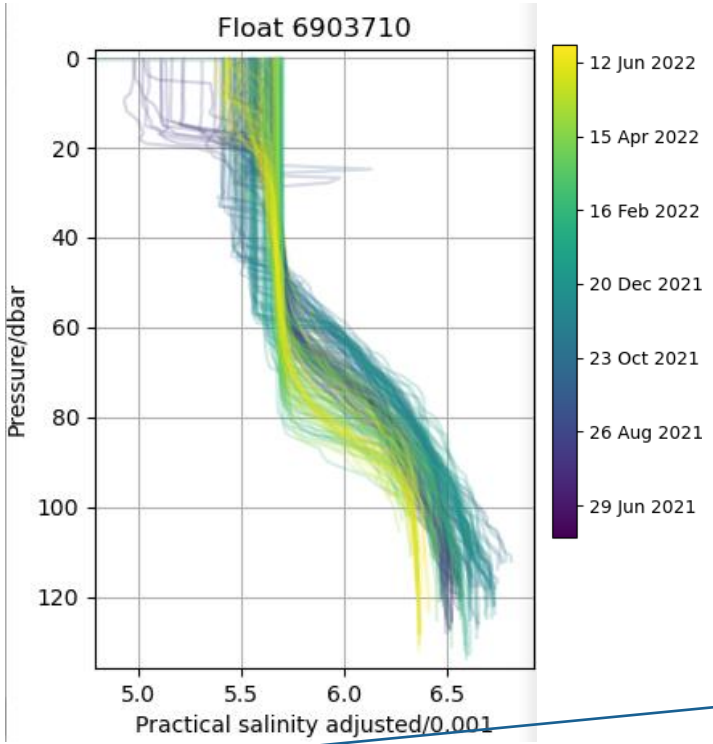
Baltic Sea argo operations, example





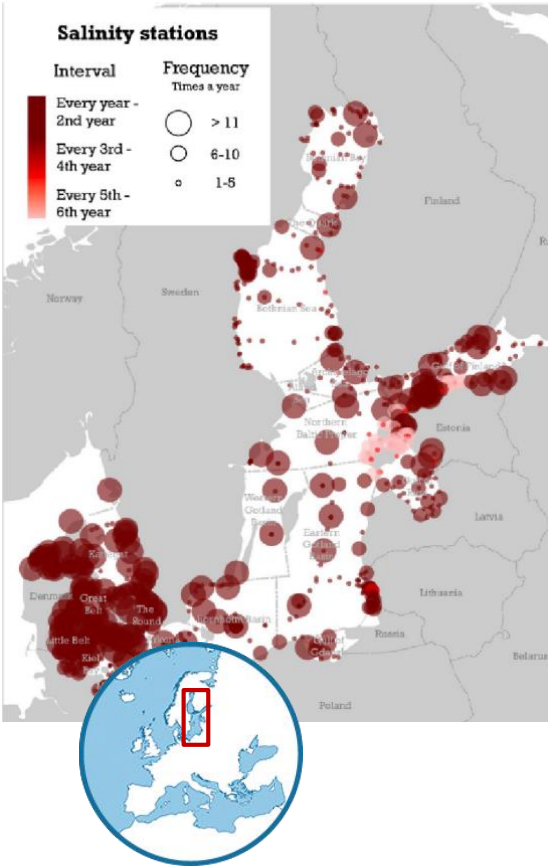
Expected values vary a lot





- More details in our deliverable 2.7:
  - https://www.euro-argo.eu/EU-Projects/Euro-Argo-RISE-2019-2022/Deliverables

Some good sides too:



- +Reference database is good because of international monitoring obligations (HELCOM)
- +Small area makes it possible to recover the floats
  - Less time to drift per float
  - Can be recalibrated/verified
  - Not all float can be recovered
- - Higher variability requires new uncertainty thresholds for correctability
  - +due to large signals this is not a serious limitation

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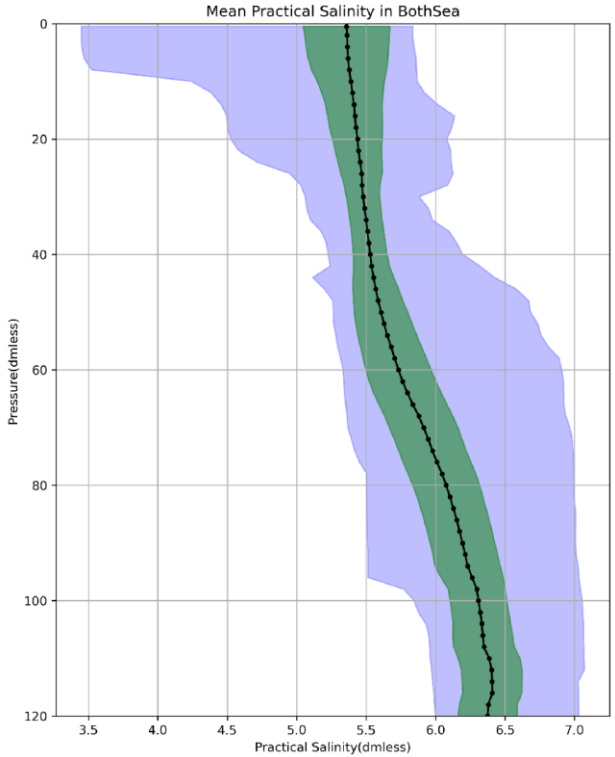
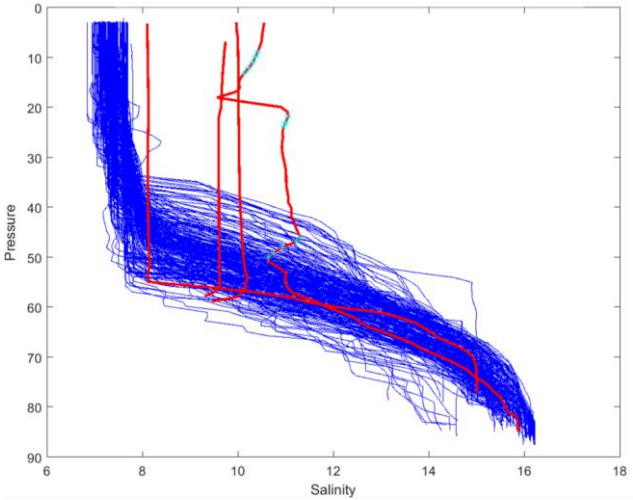
Revisiting the RTQC tests

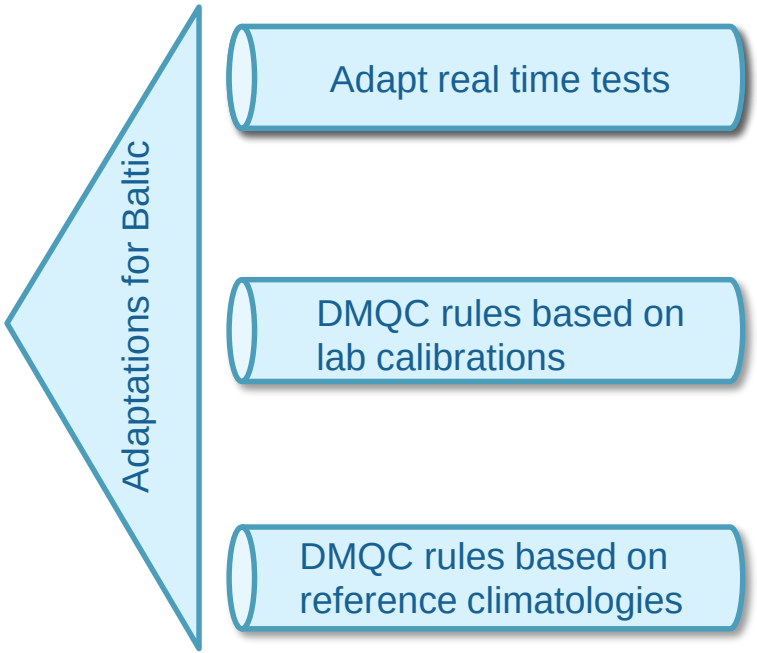


Mean value, 1 std, min/max range

- Real time tests were checked for applicability to Baltic
- Density inversion, digit rollover, stuck value are examined
- New test for ‘incorrect near surface salinities’ has been devised and tested
- For the min/max tests at Coriolis local variants are proposed to replace the global ones
- Of these more in later presentations



How to approach DMQC in the Baltic



Checked performance of existing real time tests and made recommendations set of rules for Baltic.

➲ Improved near real-time quality control in the Baltic

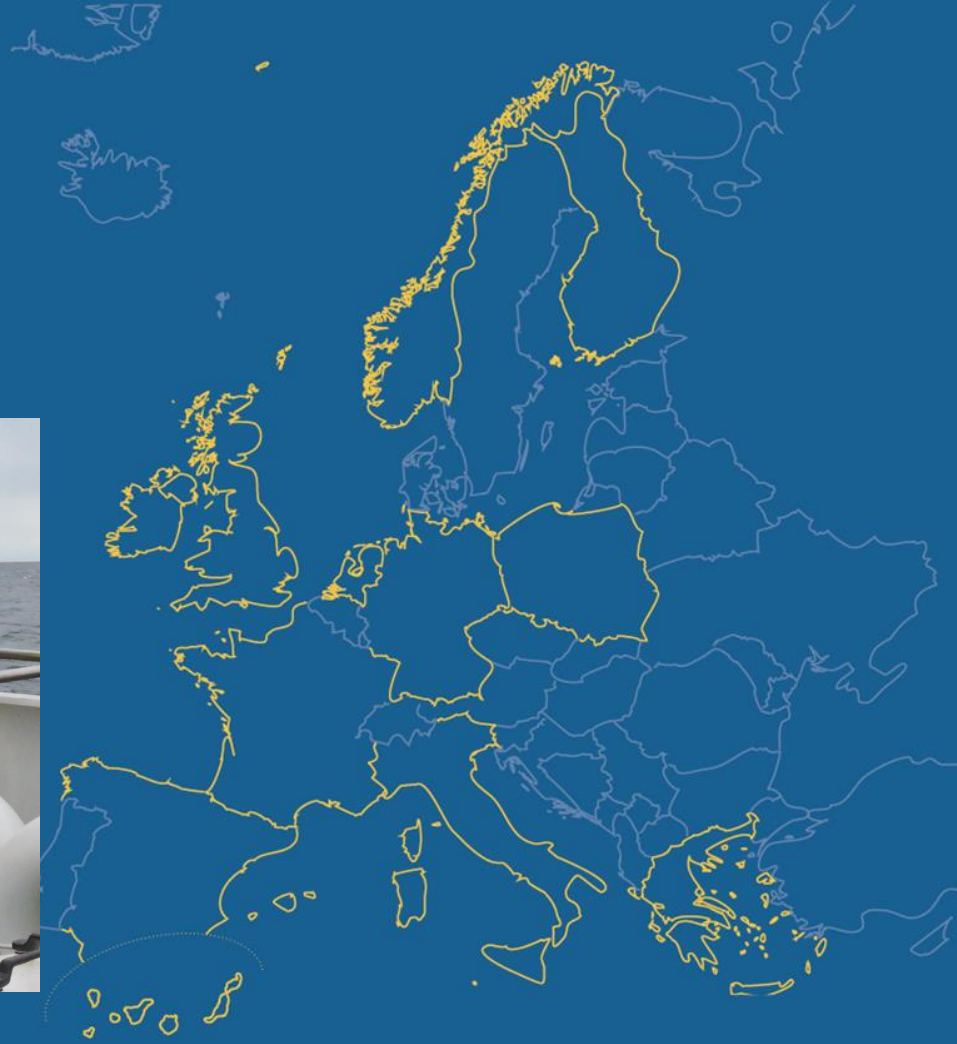
Rules based on the laboratory calibrations of recovered floats were devised.

➲ DMQC operators are given thresholds for application

Methods for comparing reference and float data were devised and tested

➲ DMQC operators are advised how to construct time series of differences to evaluate potential salinity drift;

THANKS!



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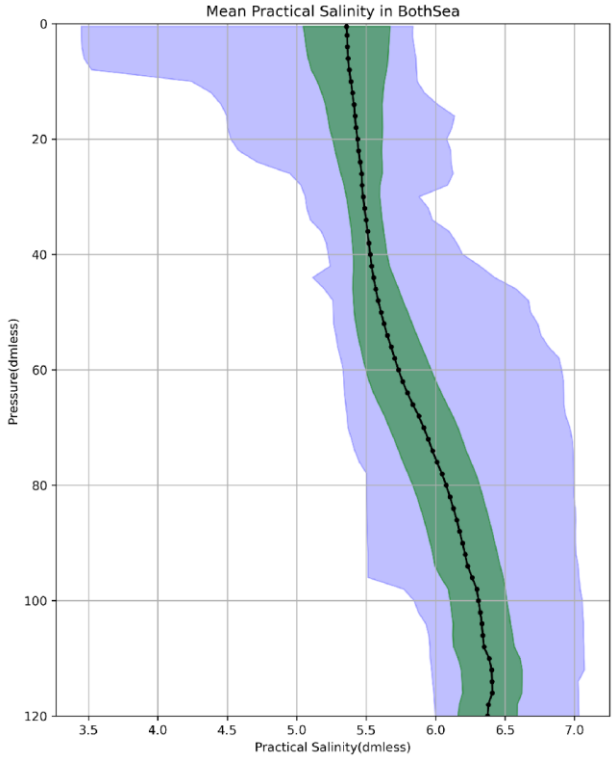

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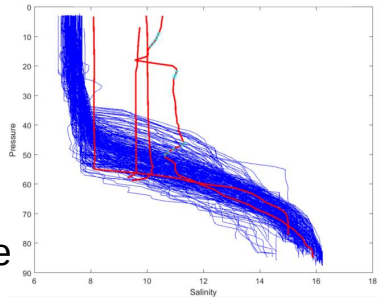


Recommendations for RTQC (real-time quality control tests)

- Disable the digit rollover and stuck values tests for the Baltic.
- Continue to use a threshold of 0.03 kg/m3 for density inversions in the Baltic and apply thermal lag corrections in delayed-mode.
- Add a regional real time test for Baltic to catch excessively high surface salinities. The proposed test would look at salinities at depth of 10-25 m and assign a QC of 3 to the entire profiles if these are larger than a regionally varying threshold.
- Communicate and discuss the proposed new set of rules at the next ADMT. If these are endorsed, then communicate with the GDAC/DAC about the reprocessing of all Baltic floats, for implementation.
- Explore if the implementation of the min/max near real-time quality control is appropriate for the Baltic.

DMQC methods for the Baltic

SENSOR SERIAL NUMBER: 4793
CALIBRATION DATE: 27-Mar-13

COEFFICIENTS:

g = -9.821290e-001
h = 1.423607e-001
i = -3.273814e-004
j = 4.338152e-005

SENSOR SERIAL NUMBER: 4793
CALIBRATION DATE: 29-Mar-15

COEFFICIENTS:

g = -9.821266e-001
h = 1.423310e-001
i = -3.134470e-004
j = 4.250802e-005

SENSOR SERIAL NUMBER: 4793
CALIBRATION DATE: 24-Jan-17

COEFFICIENTS:

g = -9.836474e-001
h = 1.427120e-001
i = -4.180454e-004
j = 5.025814e-005

WMO number	Float serial. No	CTD serial no.	Float type	Country/ Programme	Deployment date
6901901	5397	3511	APEX	Argo Finland	17.05.2012
6902013	5396	3503	APEX	Argo Finland	13.06.2013
6902014	6711	4793	APEX	Argo Finland	14.08.2013
6902017	5397	3511	APEX	Argo Finland	31.05.2014
6902018	6710	5051	APEX	Argo Finland	31.05.2014
6902019	7191	5699	APEX	Argo Finland	21.08.2014
6902020	6711	4793	APEX	Argo Finland	05.08.2015
6902021	6710	5051	APEX	Argo Finland	22.09.2015
6902022	5396	3503	APEX	Argo Finland	13.05.2016
6902023	5397	3511	APEX	Argo Finland	13.07.2016
6902024	7191	5699	APEX	Argo Finland	03.08.2016
6902036	7507	7248	APEX	Argo Poland	29.11.2016
6902025	7958	8893	APEX	Argo Finland	09.05.2017
6902026	7959	8894	APEX	Argo Finland	06.06.2017
6902027	6711	4793	APEX	Argo Finland	15.06.2017
6902028	6710	5051	APEX	Argo Finland	06.08.2017

Recovery of floats is practised routinely in the Baltic.
Floats are redeployment many times (example SN4793) and drift can be calculated from SBE‘s laboratory analysis

$$\text{Conductivity (S/m)} = (g + h * f^2 + i * f^3 + j * f^4) / 10 (1 + \delta * t + \varepsilon * p)$$

Recommendations given in EA-Rise project for DMQC for the Baltic

Recommendations for real time quality control

- Disable ‘digit rollover’ and ‘stuck value test’
- Add regional test for excessively high surface salinities

Recommendations for DMQC of non recovered floats:

- for non recovered floats find best matches to ref data between 30 km ± 30 days
- create times series of differences and check for trends

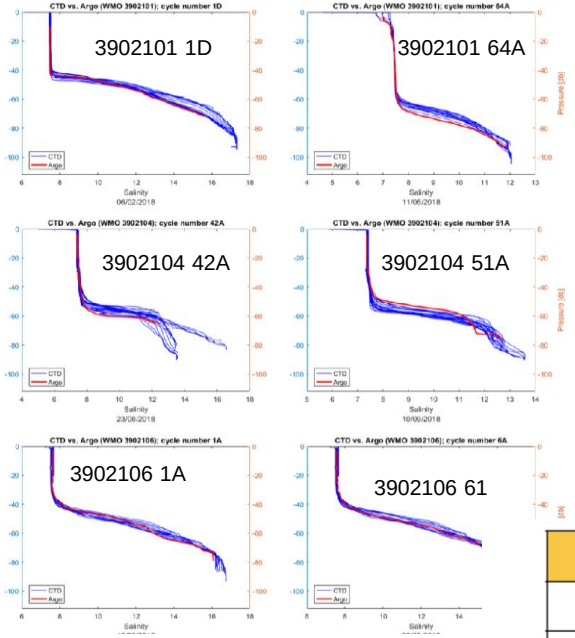
Recommendations for DMQC of recovered floats:

- Aim for recovery on annual or biannual basis, recalibrate the float before redeployment
- After consecutive lab calibrations only correct for significant drift (>0.1 conductivity units /12 month)
- Give DMQC operators access to the calibration sheets

Further things to do:

- Organize DMQC workshop to train operators in next spring in Poland (April 2023)
- Build capacity of DMQC operators, identity issues from practical applications

DMQC methods for the Baltic



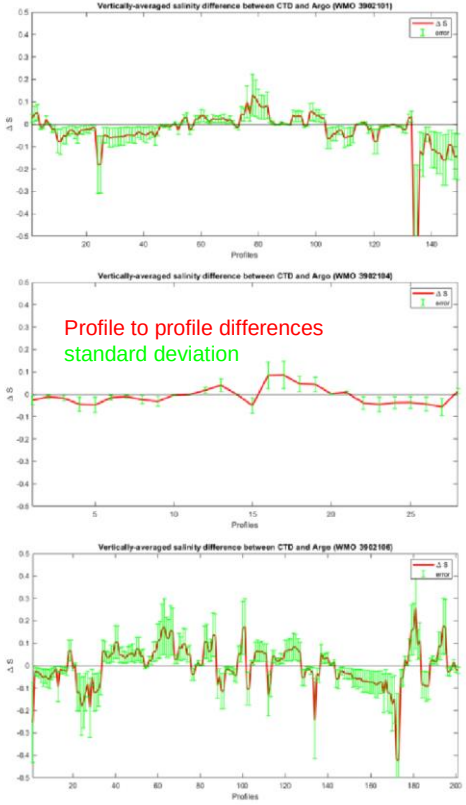
Argo data, reference data

Tests have been performed to define search criteria and thresholds.

If floats can not be recovered than dmqc will aim at finding nearby profiles from the reference data set within 30 days and 30 km and will build time series of differences in layers.

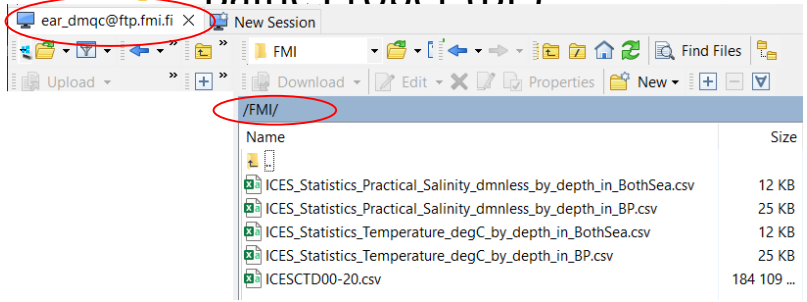
Layers suitable for comparison are either mixed layer or bottom depending on area.

Float WMO	Salinity (10-30 m)	Temperature (70-90 m)
3902101	0.0508	0.6892
3902104	0.0316	0.8689
3902106	0.0706	0.4608

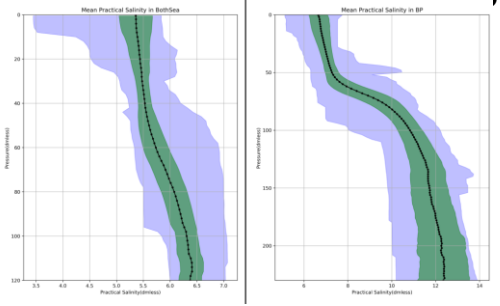


FMI reference dataset in FTP server

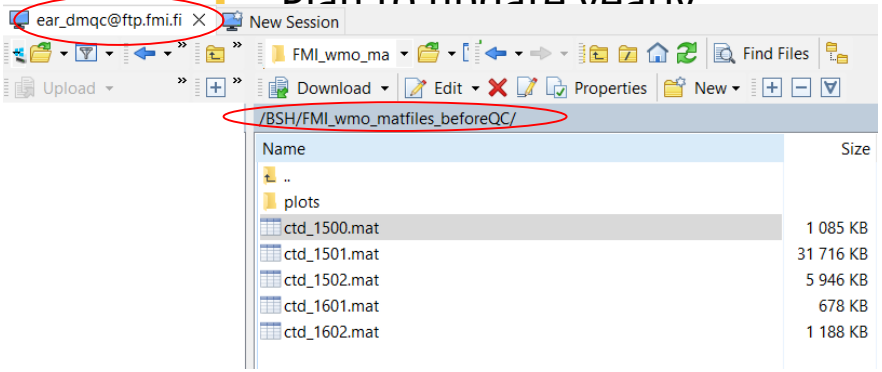
- Climatolocical dataset
  - Bothnian Sea (BothSea)
  - Baltic Proper (BP)



- Generated from ICES
  - Raw data: ICESCTD00-20.csv



- Reference dataset
  - Gathered from ICES data
  - Plan to update yearly



- .mat files, plots, and scripts to do them.