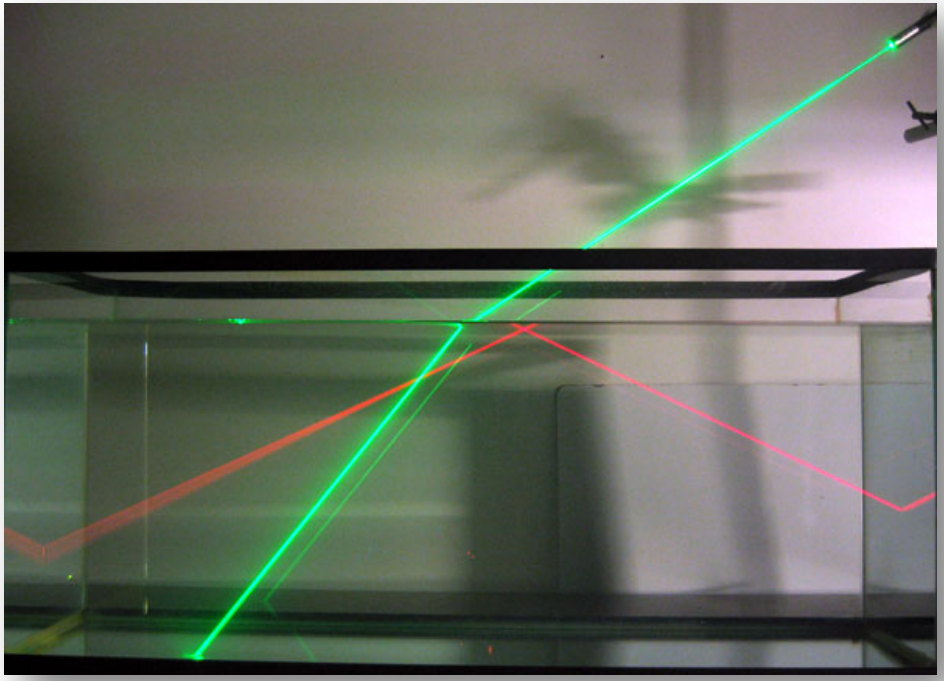
Major Advances on NOSS sensor over the last few years

D. Malardé, A. David, Y. Dégrés, S. Tewes (BSH cruise)

Session 2 : R&D and Manufacturers

Arvor-Provor Technical Workshop, Ifremer, Tuesday, January 28th, 2020

Theoretical basic reminders and performances of NOSS sensor



- Properties of laser light in seawater (Snell-Descartes law)

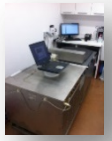
NOSS:

- High-resolution in-situ refractometer :
  - Accuracy : Refractive index (better than **10^{-6}**), Absolute Salinity **±0.005 g/kg**) and Seawater Density **±0.003 kg/m³ ,**
    associated to Temperature and Pressure measurements
- Product already integrated on profiling float and CTD Carousel

NOSS sensor over the last years (2015 -2020)

NOSS Production

NOSS in laboratory



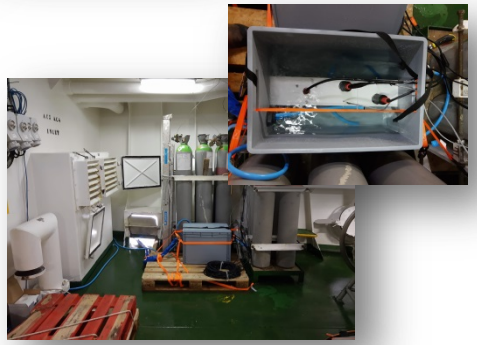
Woods Hole Oceanographic Institution

SHOM L'océan en référence

Leibniz-Institut für Ostseeforschung Warnemünde IOW

OGS

LNE



6 months of data at Patm: Results expected in February 2020 (SOTON Cruise)

NOSS on boat

NOSS on CTD Carousel

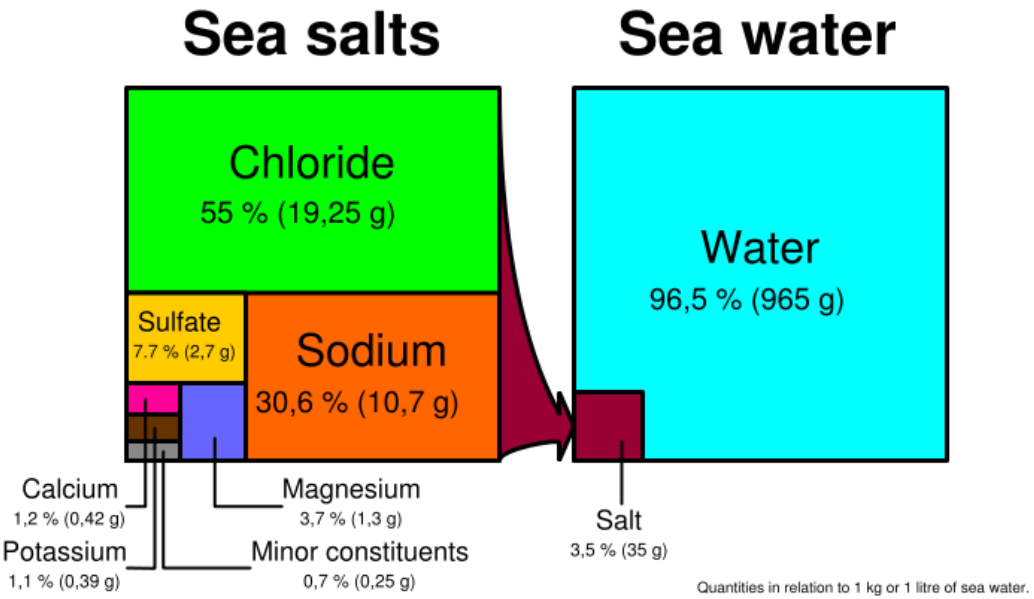
BSH Cruise
LOPS Cruise

NOSS on float

Deployment in 2019 Summer, in February 2020 (Ifremer, LOV)

Study of response time

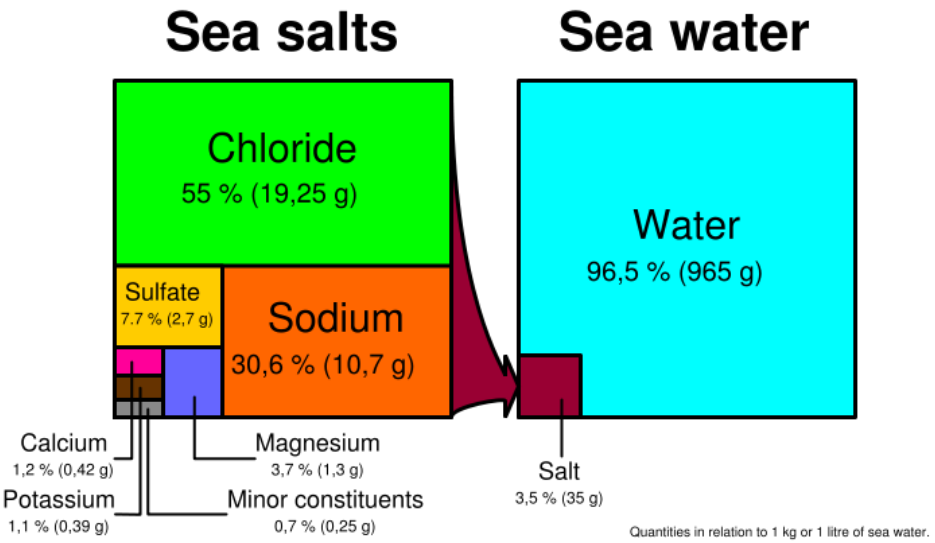
Seawater salinity?



- Since 1978, the measured salinity is Practical Salinity (S_P) but the salinity relevant for thermodynamically describing seawater is Absolute Salinity (S_A). However, this parameter has been accepted and used since 2010 when no instrument can currently measure it operationally.

- Practical Salinity (S_P) is commonly found in the ocean hydrological database (unit less) and is measured using conductivity, i.e. only ionic part of dissolved material (*PSS-78, UNESCO, 1981*)

Seawater salinity?



- Reference-Composition Salinity (S_R) is a best estimates of composition of a Standard Seawater ~ North Atlantic seawater and is derived from Practical salinity (*Millero et al., 2008a*) :

$$S_R = (35.16504/35)S_P \qquad (g.kg^{-1})$$

- Absolute salinity (S_A) is the mass fraction of dissolved material, it is thus related to the density of seawater and is :

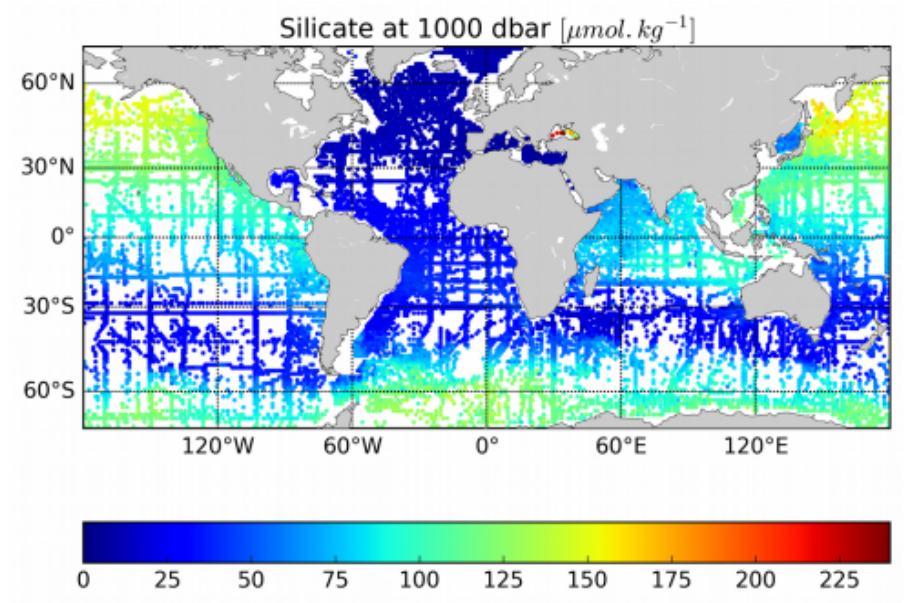
$$S_A = S_R + \delta S_A(lon, lat, p) \qquad (g.kg^{-1})$$

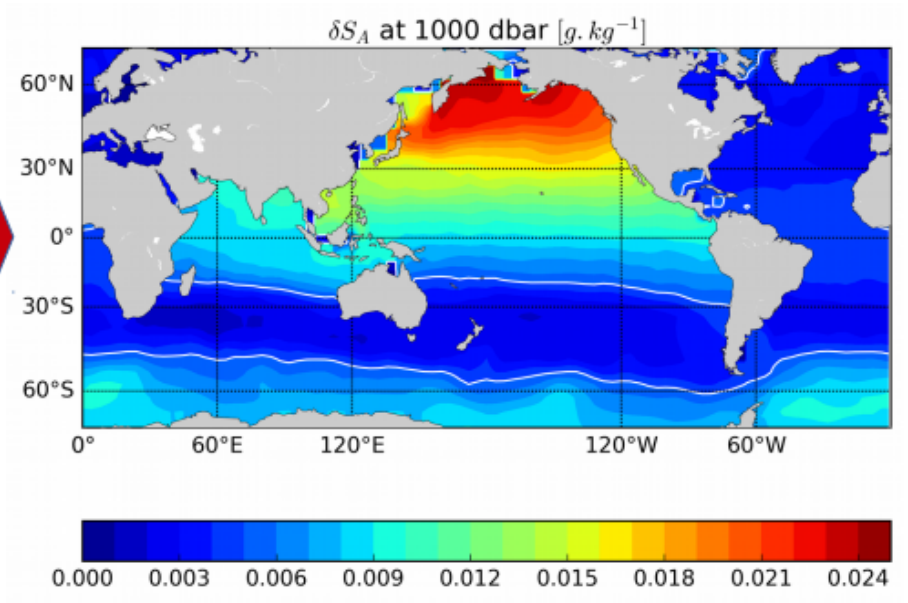
- δS_A is the composition anomalies due to nutrient and others minor components defined by *McDougall et al. (2012)* and *Wright et al. (2011)*

Seawater salinity?

- S_A is thus also a biogeochemical parameter, i.e. depend not only on dilution but also biological pump...

- However, *in TEOS-10* and *McDougall et al. (2012)*, δS_A relies on very limited historical silicate measurements to fit with density sampling → ill contained…

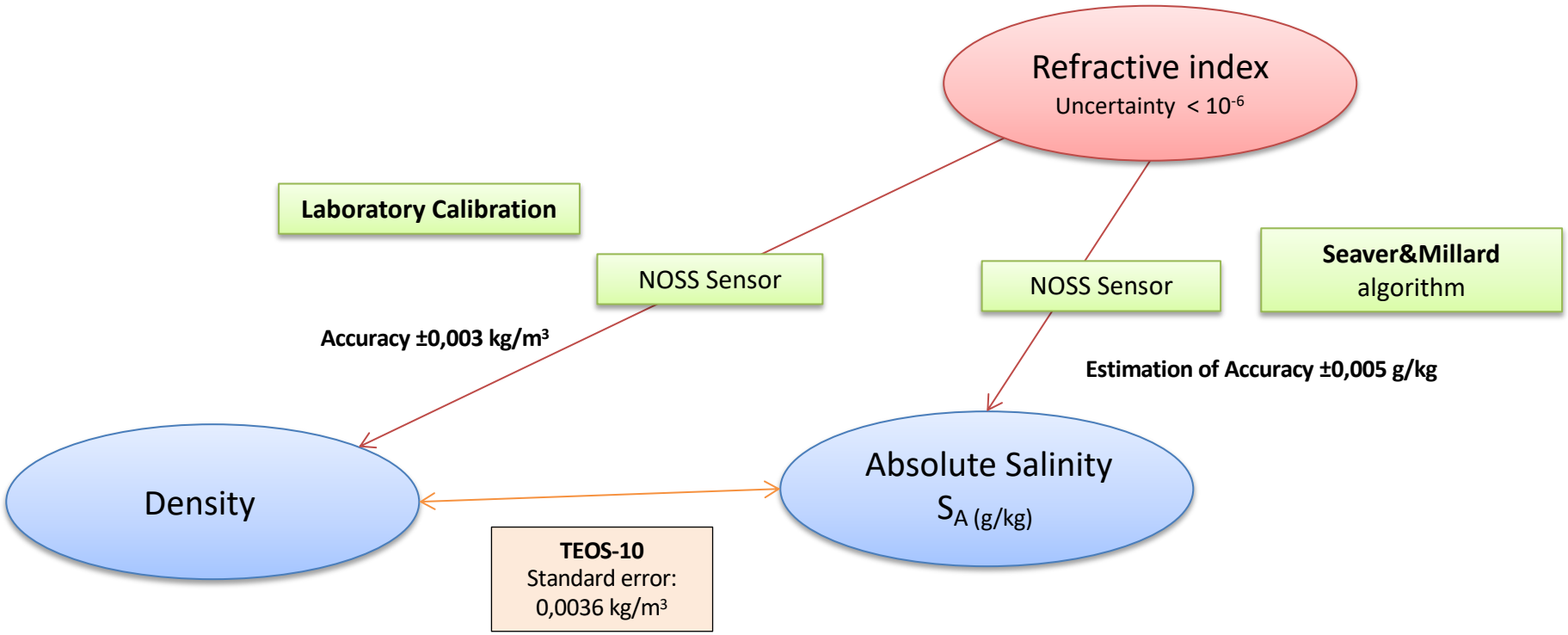




Links between :

Refractive index and absolute salinity

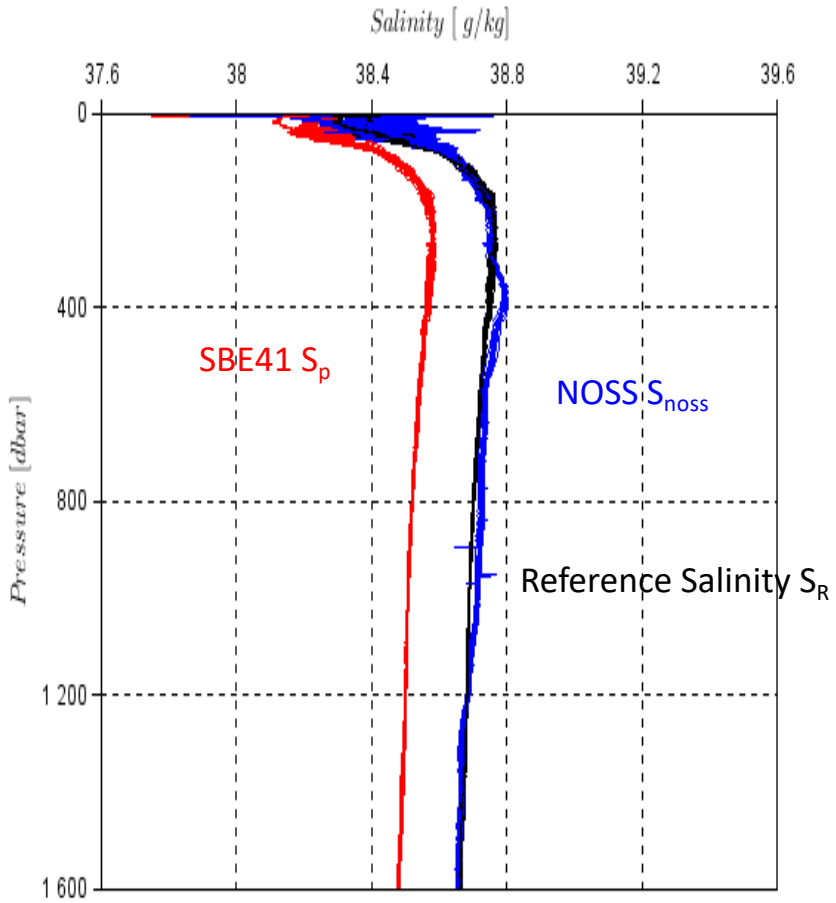
Refractive index and density



Deployment of NOSS on a Provor drifting float, in the Mediterranean Sea (2019)

- Date of float launching: 09th of June 2019 by Laurent Coppola and his team (MOOSE GE 2019 mission)
  - Latitude: 41°55,348 N
  - Longitude: 004°46,964E
  - Bathy (m): 2380
  - Serial number of CTS4 float: OIN 14 NOSS S4-01
  - Serial number of sensor: NOSS 03
- Mission configuration: 1 profile per day on 15 days, then 1 profile every second day.
- Acquisition of S_{noss} and S_{sbe41} (S_p, S_R), T°C, P, Refractive Index profiles
  - S_{noss}: corrected Salinity profiles after post-processing

Deployment of NOSS on a Provor float, in the Mediterranean Sea



- Collection of 50 profiles (S_{noss}, S_p) acquired over 5 months from June to October 2019, up to 2000m
- Validation of NOSS integration on PROVOR float

Deployment of NOSS on a PROVOR float, in the Mediterranean Sea

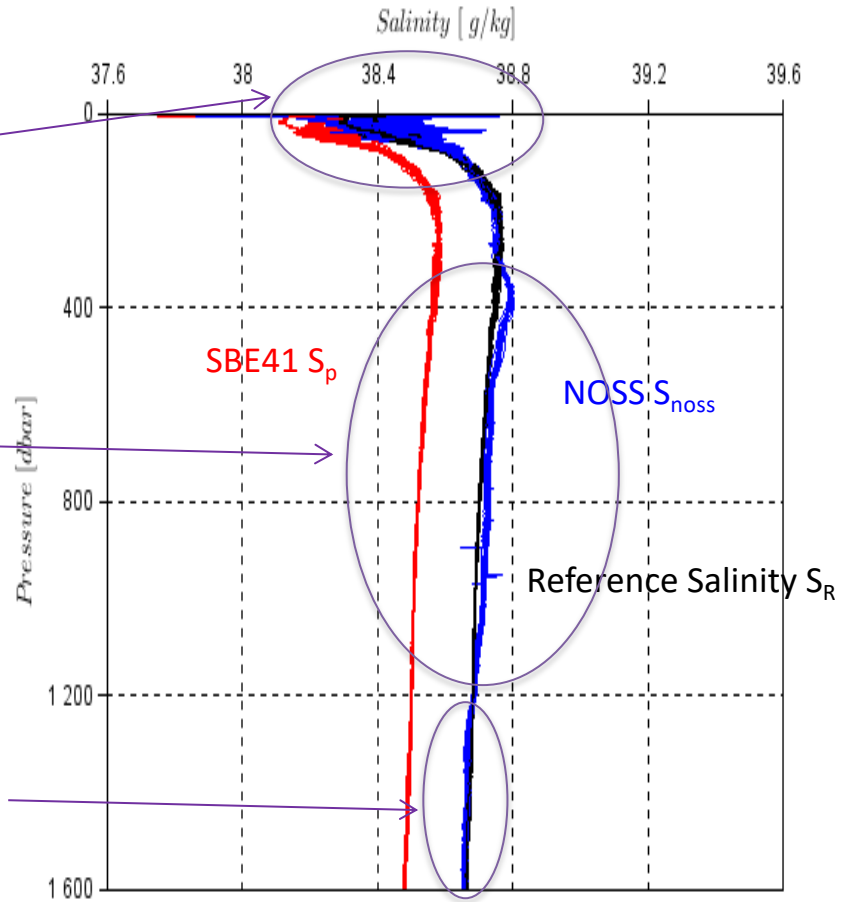
$\delta S_A = S_{noss} - S_{R,\,CTD}$

« up to 0.1g/kg »
Possible biological activities from subsurface to the photic zone

Overestimation of NOSS salinity compared to reference salinity S_R
« up to 0.025g/kg »

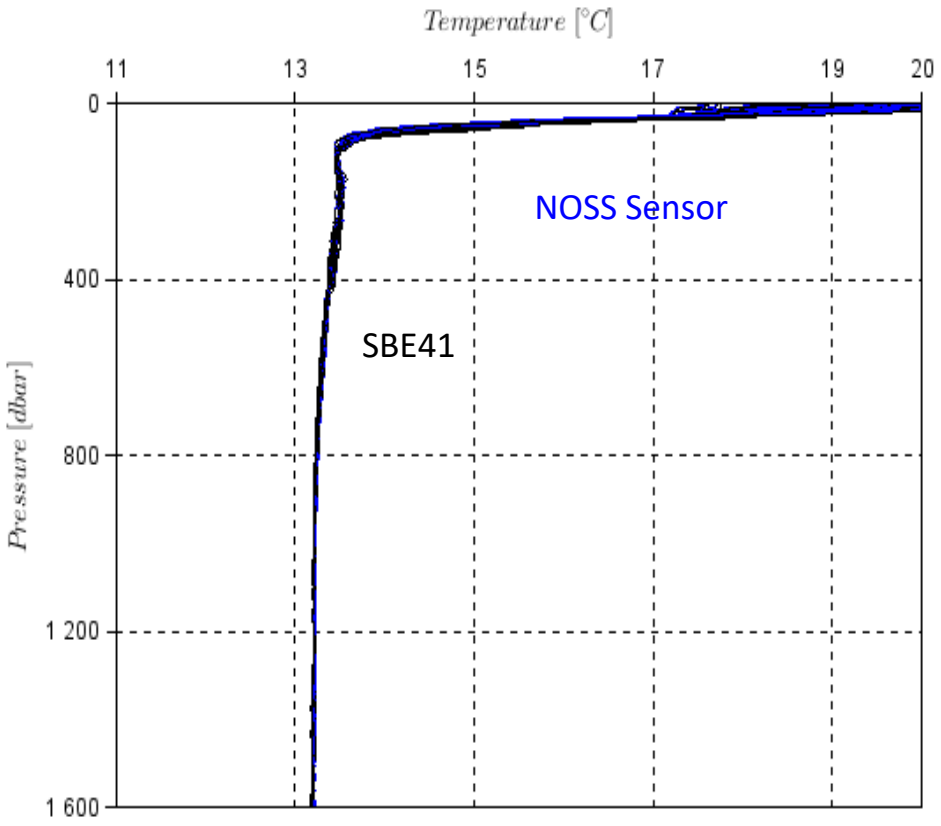
Need to be confirmed with a new cruise in the Mediterranean Sea (Feb 2020 with new version of NOSS sensor optimized), ideally in the same area

« δS_A <0.01 g/kg in deep zone »
NOSS salinity in agreement with the presence of salinity anomalies in the Meditterranean Sea



Deployment of NOSS on a PROVOR float, in the Mediterranean Sea : Temperature profiles

Float recovery successful by TARA Team after 4 months of deployment

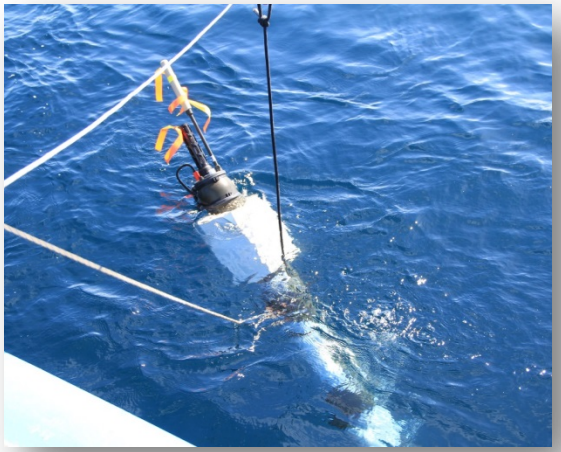


Temperature time series have similar shapes for both NOSS and CTD sensors from 0 to 2000 dbar
$\delta T < 0.01°C$

Deployment of NOSS on a PROVOR float, in the Mediterranean Sea : Conclusions & Perspectives

Provor NOSS float: **First successful long mission**

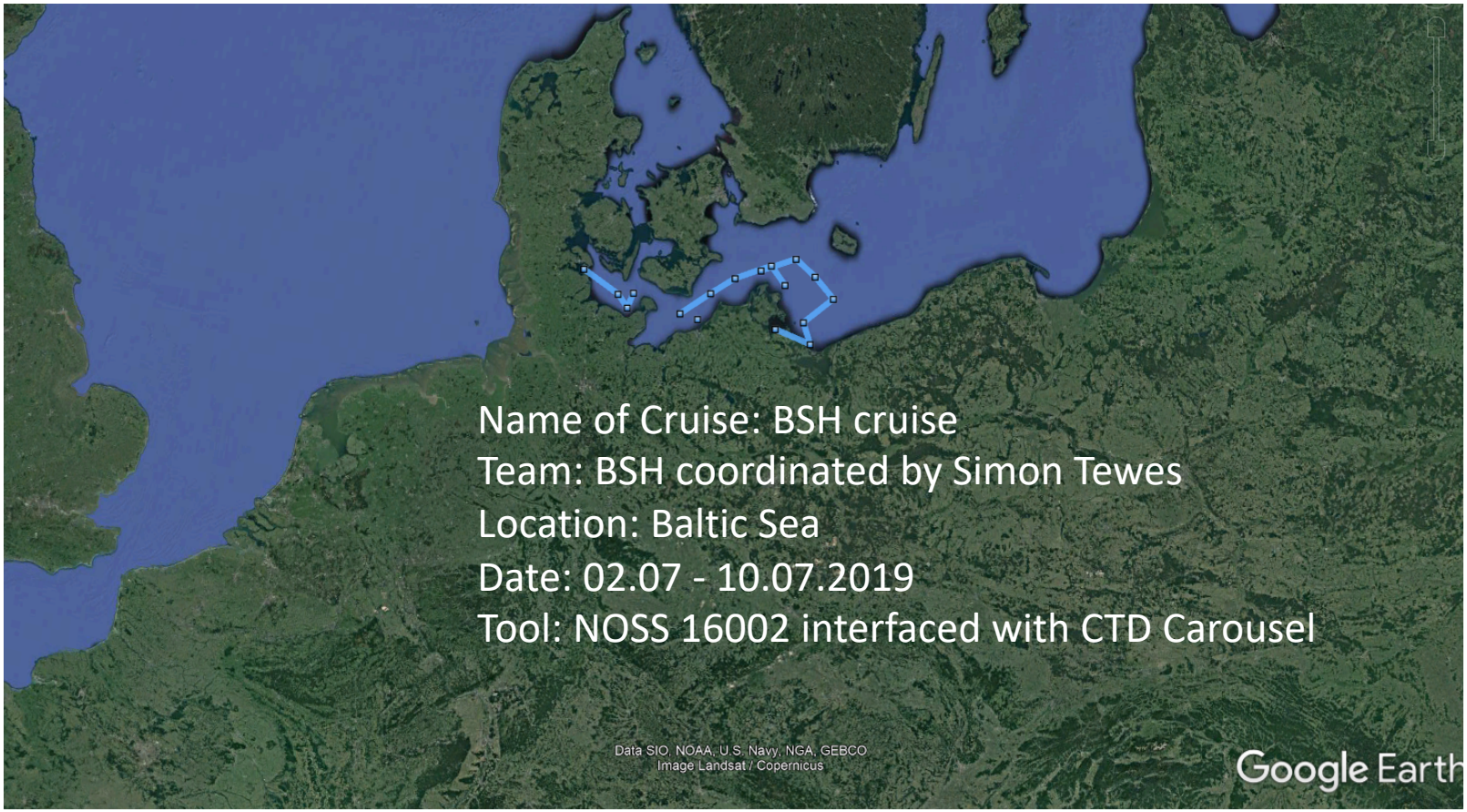
Items focused by the mission on float	**Results**
Data files Acquisition/transmission (50 profiles)…….:	☺
Navigation/behavior……..:	☺
Plug-and-play architecture for profiling float integration….:	☺
Validation *in situ (no biofouling)*……..:	☺
Sampling frequency……..:	😐



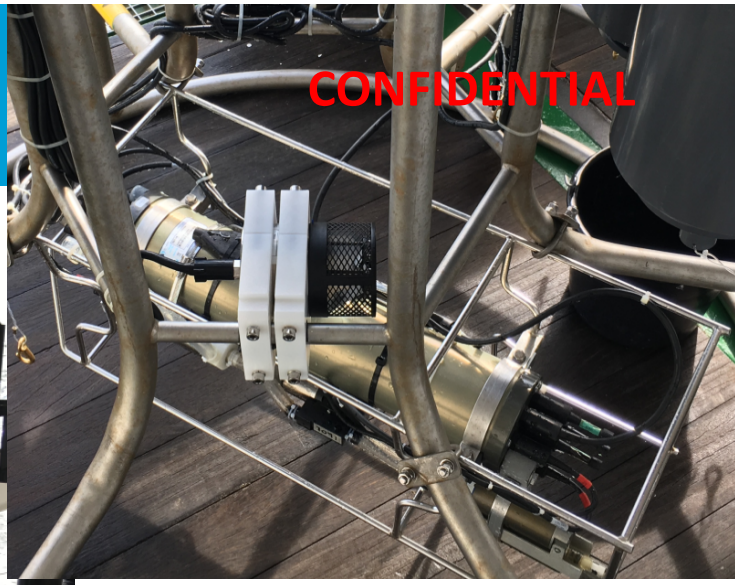
- New Cruise planned in February: reviewed mechanical design, reduction of background light, optimized mission of float
- Post processing analysis

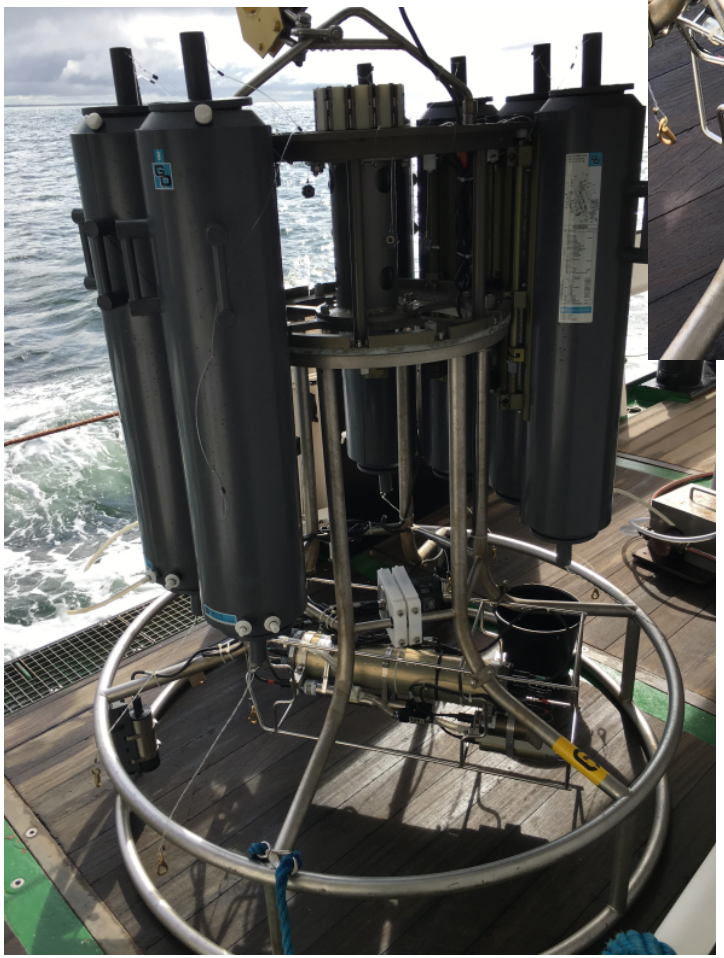
BSH Cruise - Location - July 2019

CONFIDENTIAL



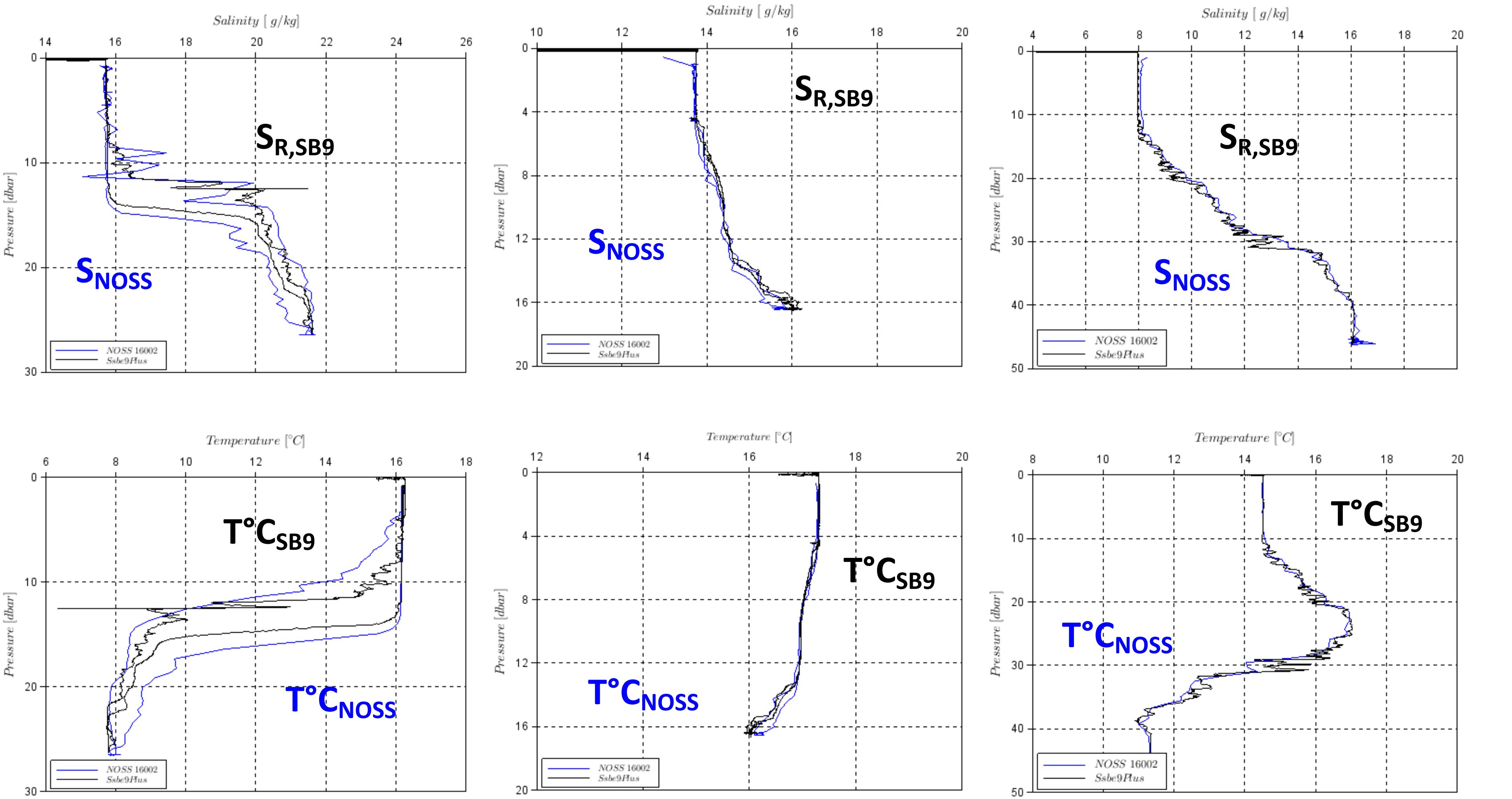
BSH Cruise - Tools - July 2019





- ✓ 16 profiles, 32 Time series of S_{NOSS}, T, P, S_R of SBE9 and NOSS sensors (to be determined S_A by TEOS-10 in Baltic Sea)
- ✓ Maximum depth: Profiles up to 40 m depth
- ✓ Characteristic of environment: 8 – 17 g/kg
- ✓ NOSS attached 40 cm above the SB9 pressure sensor
- ✓ NOSS data logged with a Hyperterminal (1 point NOSS for 22 points of SBE9 measurements)

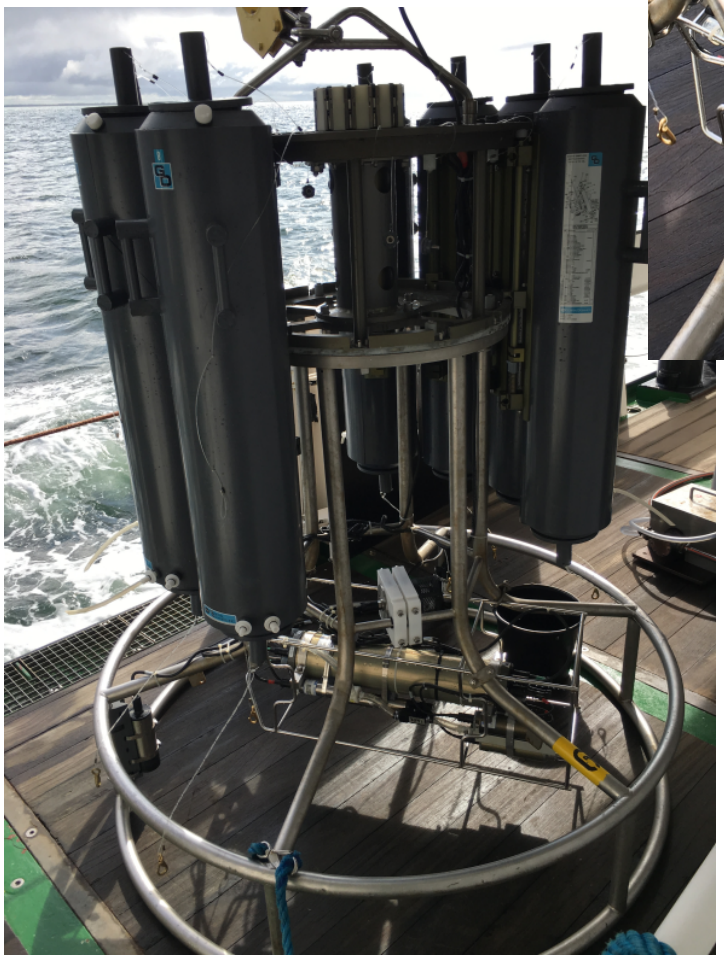
*must be calibrated at low salinities

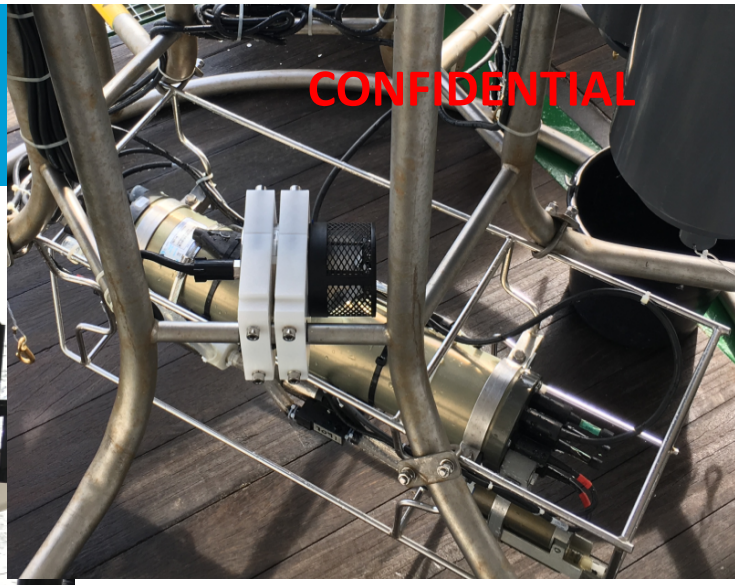

Salinity [g/kg]
Pressure [dbar]
$S_{R,SB9}$
S_{NOSS}
NOSS 16002
Ssbe9Plus
Temperature [°C]
T°C$_{SB9}$
T°C$_{NOSS}$

BSH Cruise - Location - August/Sept 2019

CONFIDENTIAL

BSH Cruise - Tools - July 2019

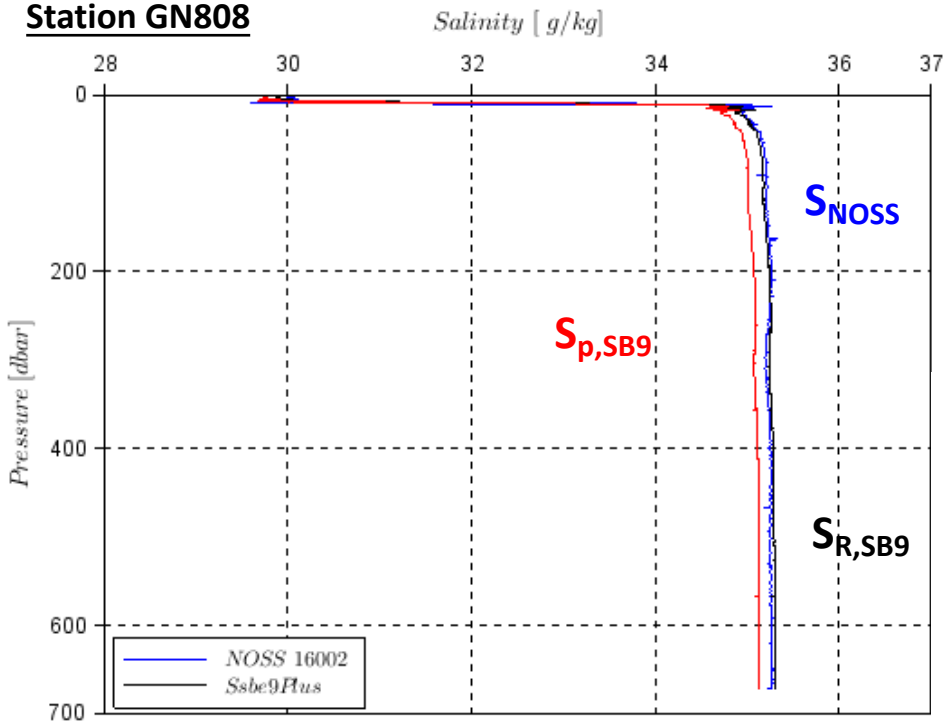


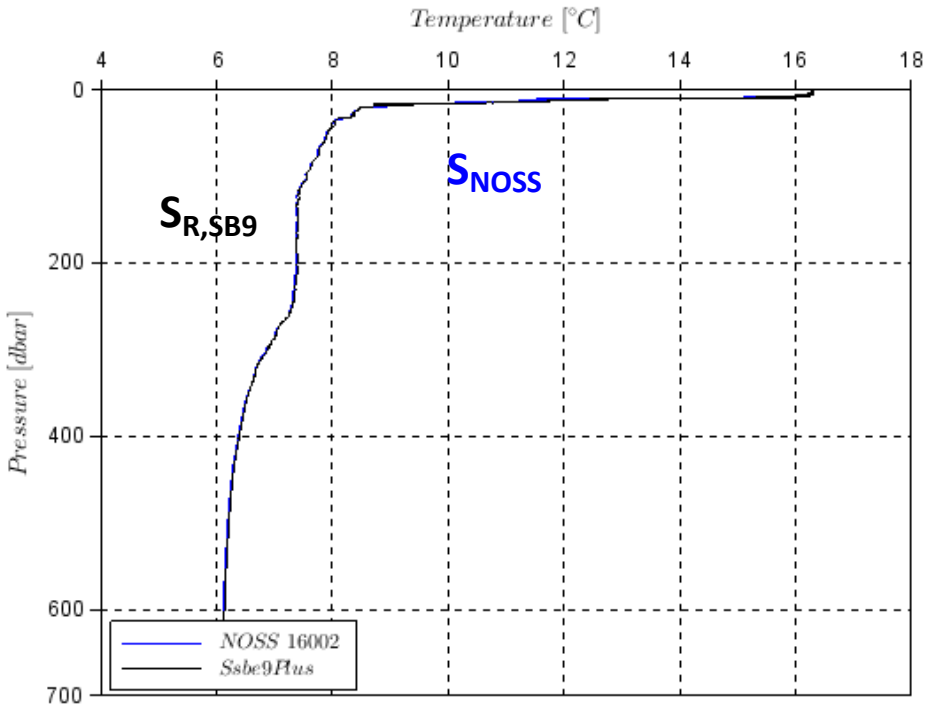


- ✓ 100 profiles, 200 Time series of S_{NOSS}, T, P, S_R of SBE9 and NOSS sensors.
  (S_A not determined in Baltic Sea)
- ✓ Measurements of Chlorophyll, pH, Turbidity, Oxygen in parallel (not shown here).
- ✓ Maximum depth: Profiles up to 700 m depth
- ✓ Characteristic of environment: 29 - 35 g/kg
- ✓ NOSS attached 40 cm above the SB9 pressure sensor
- ✓ NOSS data logged with a Hyperterminal (1 point NOSS for 22 points of SBE9 measurements)

*must be calibrated at low salinities

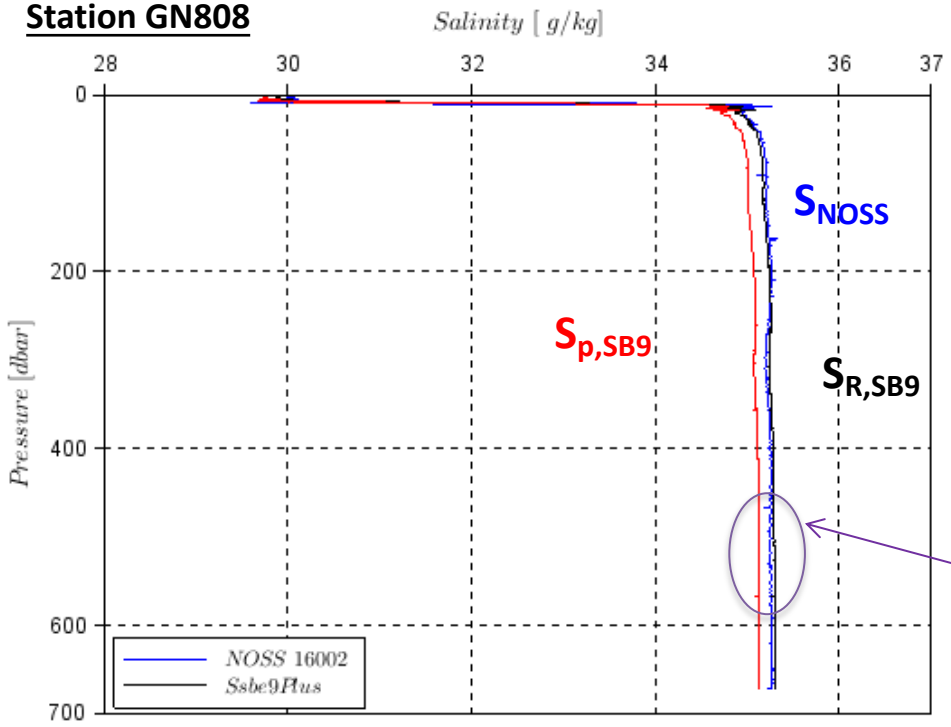
Station GN808

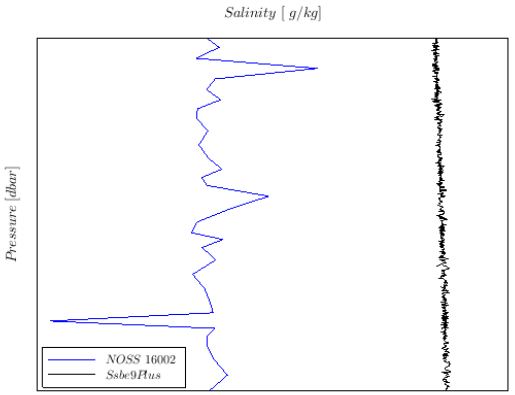




BSH Cruise
Coordinator: Simon Tewes

Station GN808

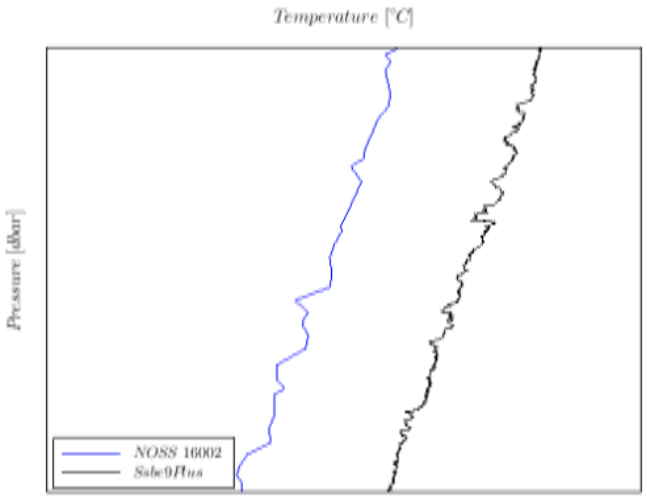




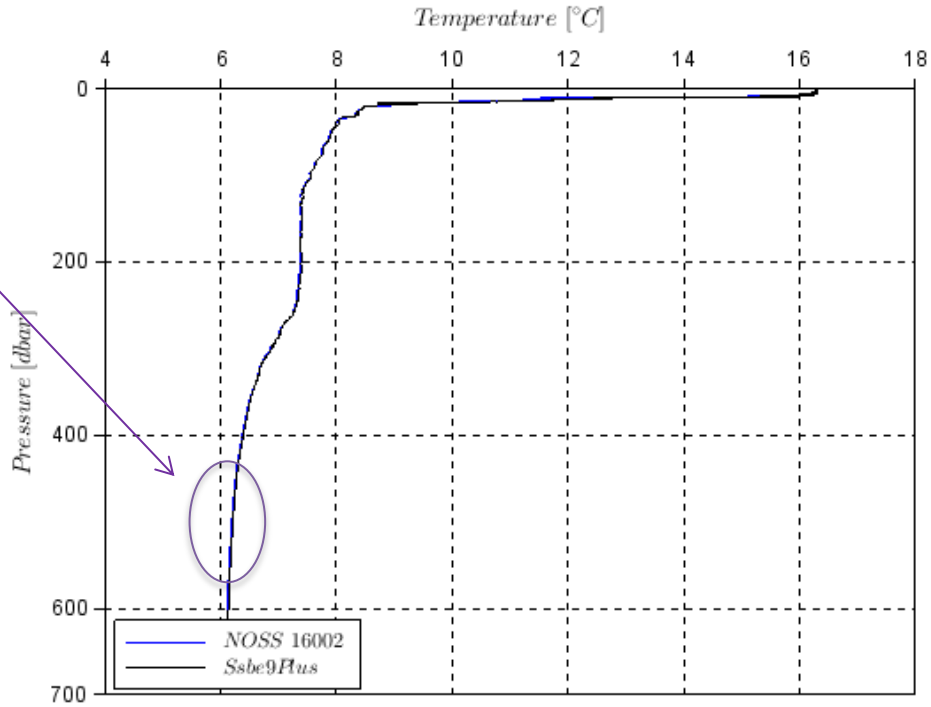
δS ≤ 0.03 g/kg due to disalignement in Temperature (to be corrected)

Station GN808

BSH Cruise
Coordinator: Simon Tewes

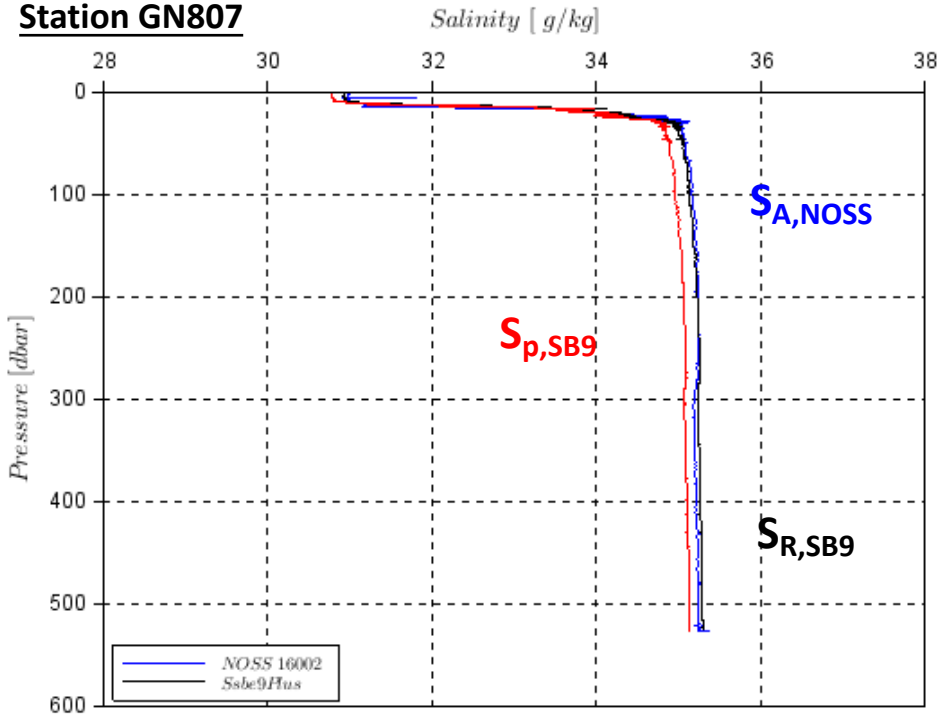


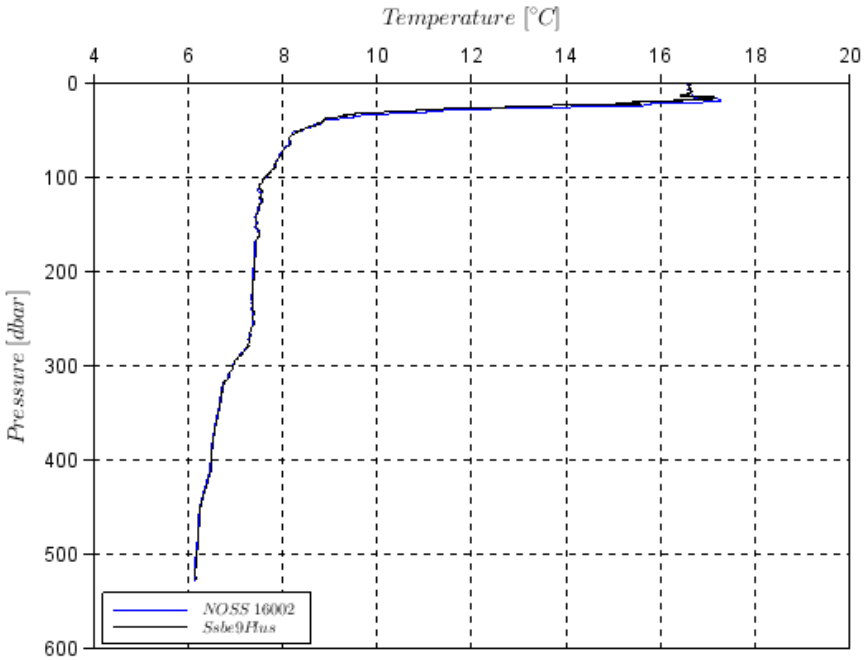
Disalignement in Temperature
δT≤0.02°C between NOSS and
SBE sensors



BSH Cruise
Coordinator: Simon Tewes

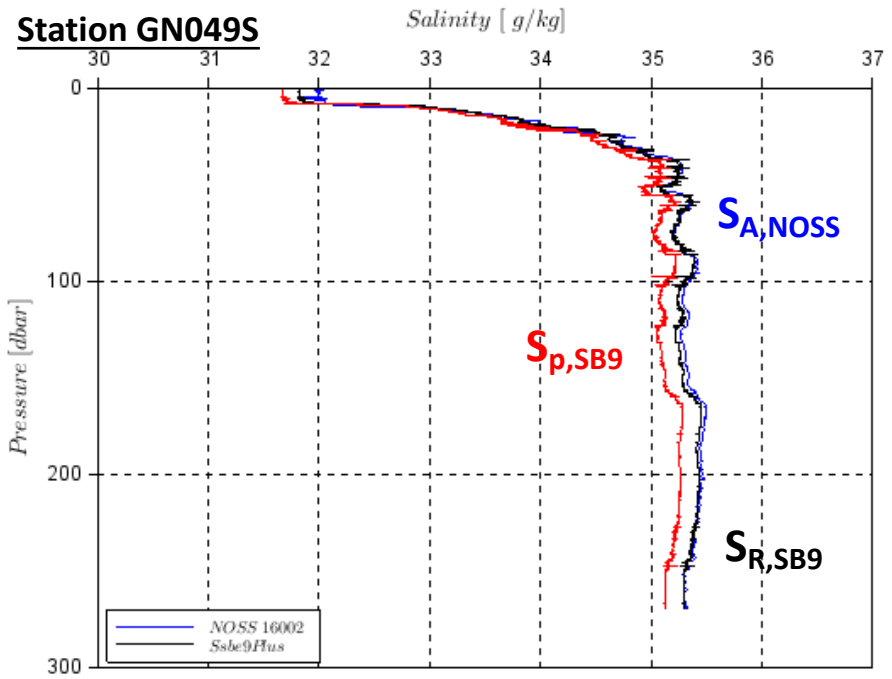
Station GN807

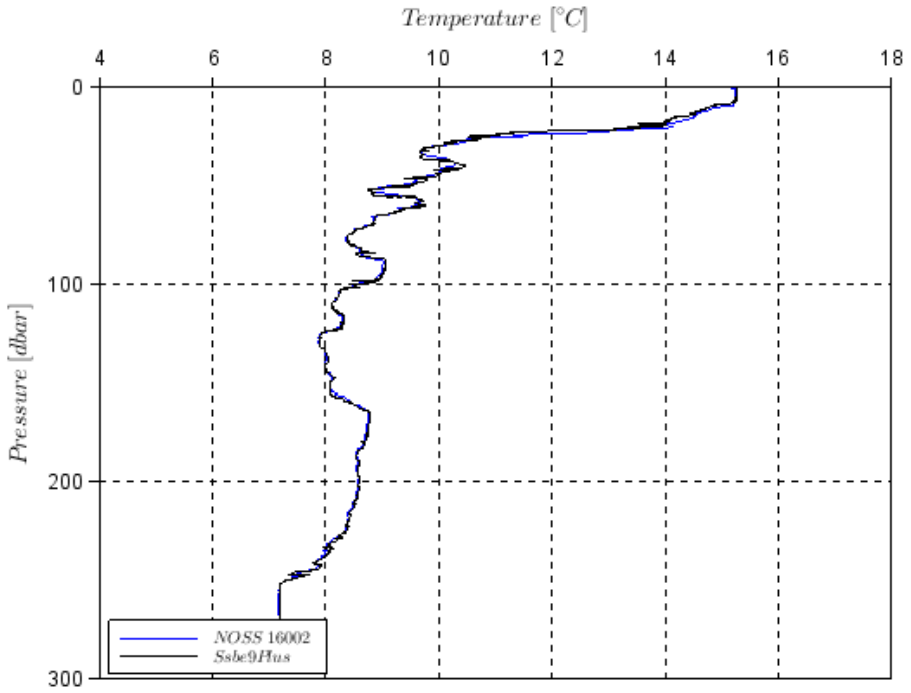




BSH Cruise
Coordinator: Simon Tewes

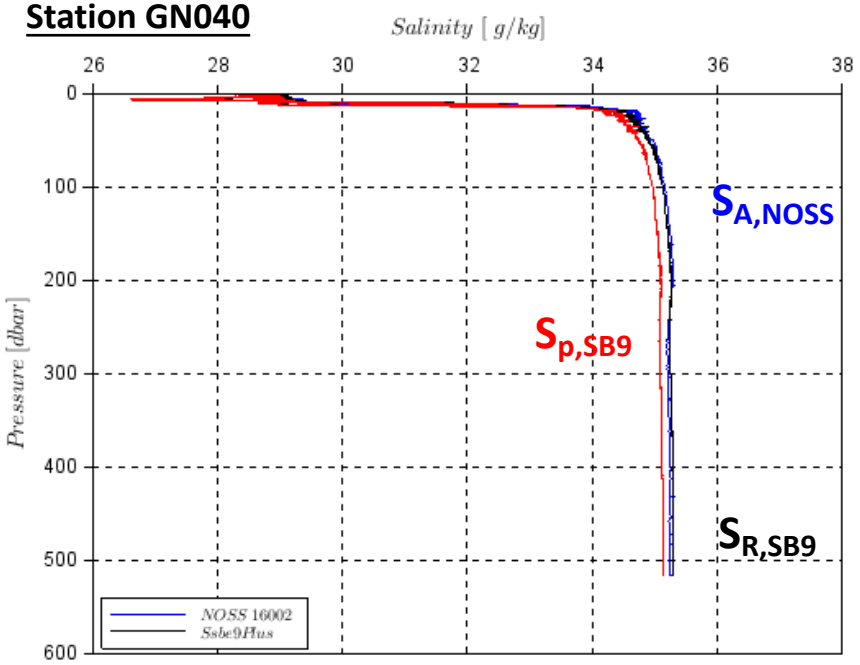
Station GN049S

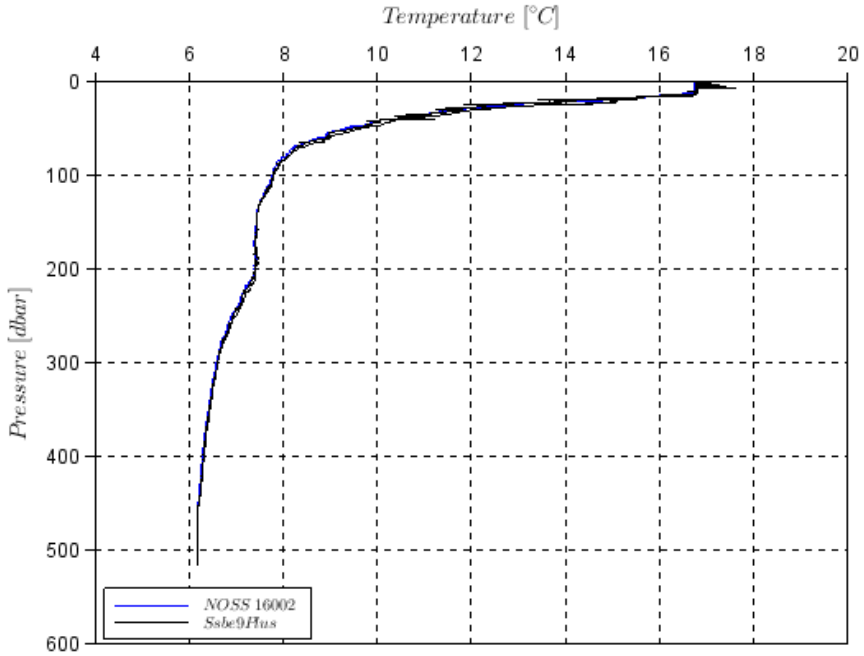




BSH Cruise
Coordinator: Simon Tewes

Station GN040

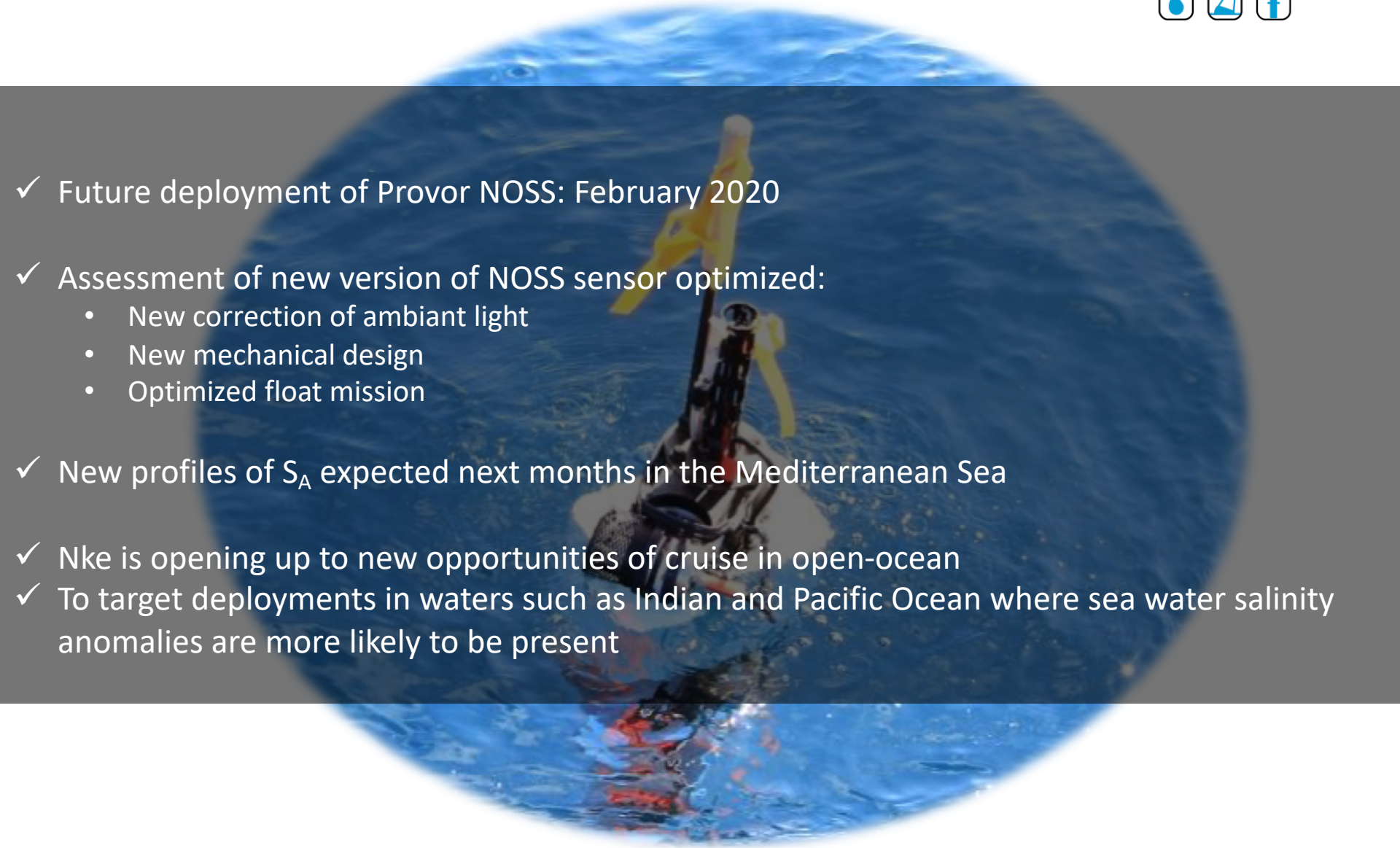




Items focused by the mission on CTD Carousel	Results
Data files Acquisition/transmission (16 and 100 profiles)….:	
Plug-and-play architecture for CTD Carousel integration…..:	
Highlight low response time……..:	
Sampling frequency of measurement. ……..:	

- Need to define a Power-On time for NOSS sensor before launching its acquisition
- Need to increase the sampling frequency of NOSS sensor (6Hz available)
- Correct the thermal lag of NOSS measurement (on assent and decent, Speed of CTD Carousel 1 m/s: 10 times greater than float speed)

New Cruise in 2020



- ✓ Future deployment of Provor NOSS: February 2020
- ✓ Assessment of new version of NOSS sensor optimized:
  - New correction of ambiant light
  - New mechanical design
  - Optimized float mission
- ✓ New profiles of S_A expected next months in the Mediterranean Sea
- ✓ Nke is opening up to new opportunities of cruise in open-ocean
- ✓ To target deployments in waters such as Indian and Pacific Ocean where sea water salinity anomalies are more likely to be present

Thank you for your attention

CONTACT

Damien MALARDE

PhD Optic and Oeanography, R&D Engineer

dmalarde@nke.fr

www.nke-instrumentation.com

6 Rue Gutenberg - ZI de Kerandré - +33 (0)2 97 36 41 31