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Ifremer

The Belgian Kwinte reference area. Part B: its use for calibrating backscatter levels of shallow water multibeam echo sounders

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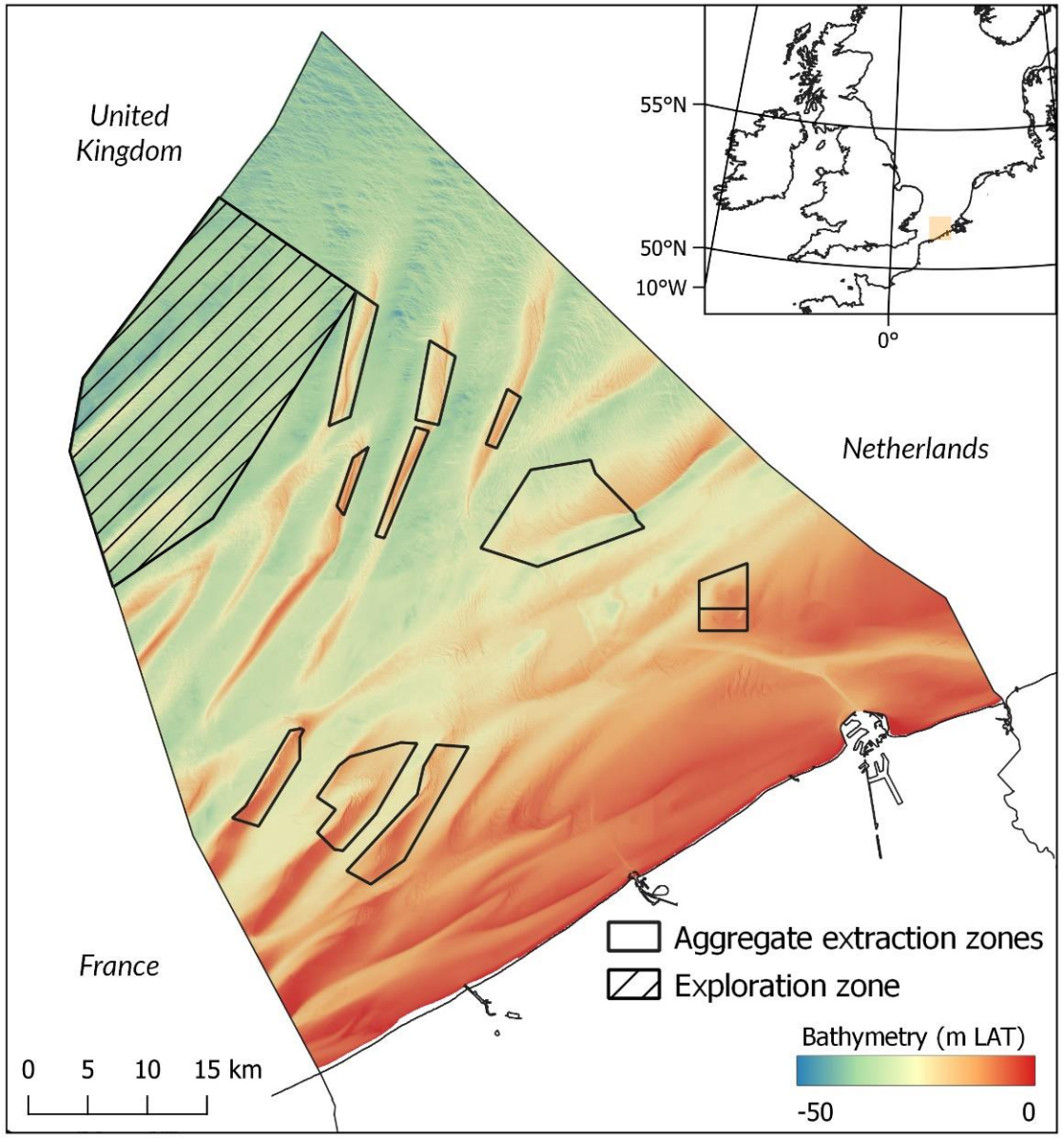
HYDRO 2024
Hydrographic Conference

2024 - Rostock - Germany

Session
Quality aspects of MBES measurements (10A)
Wednesday 8 May 2024

The context: Sand extraction - Belgian part of the North Sea

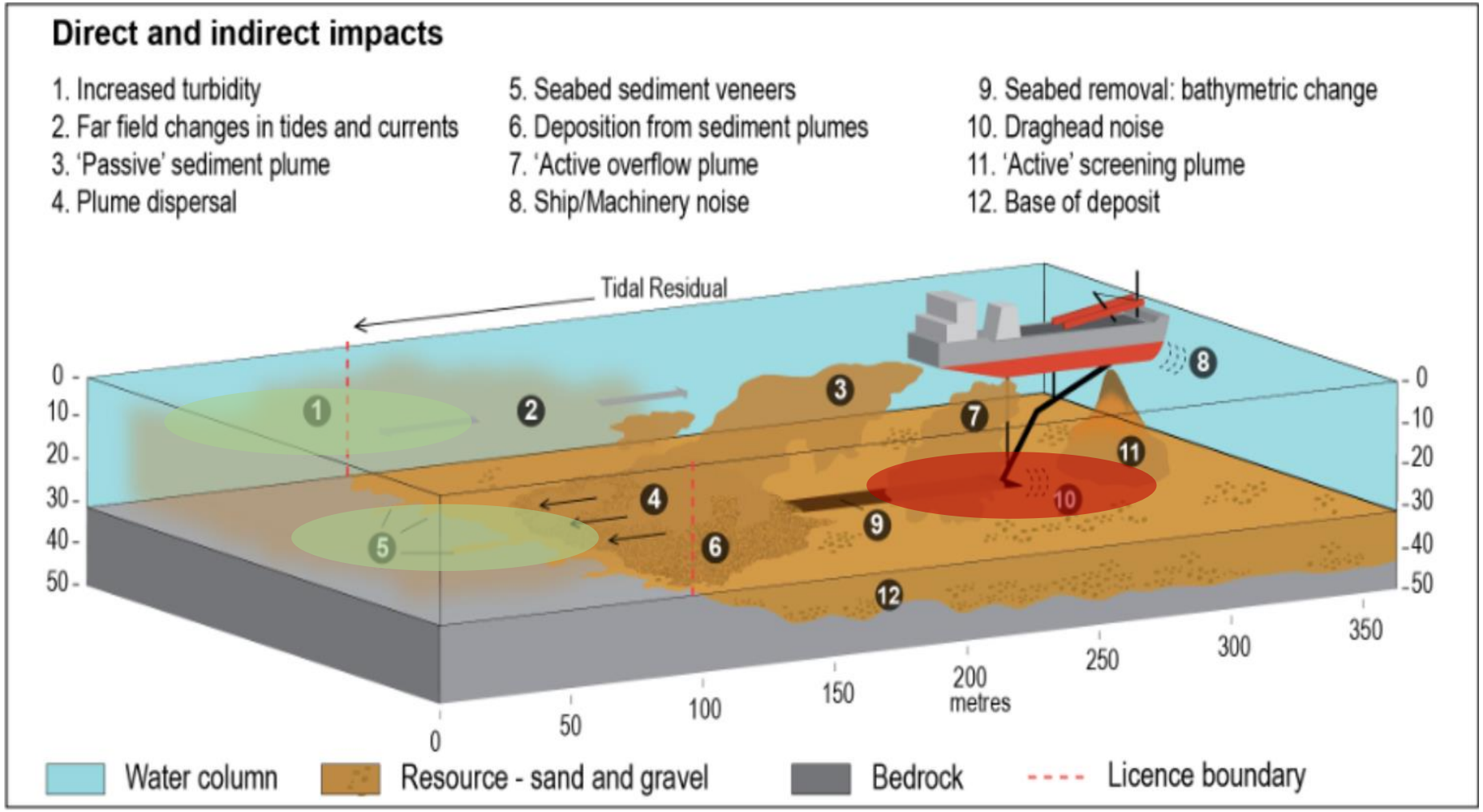


Source: Bathymetric model of the Belgian part of the North Sea (Flemish Hydrography and Continental Shelf Service)

Industry
3 millions m^3/year

Beach maintenance
Up to now 2 million m^3/ year

The context: Monitoring the impact of sand extraction



Tillin et al. 2011

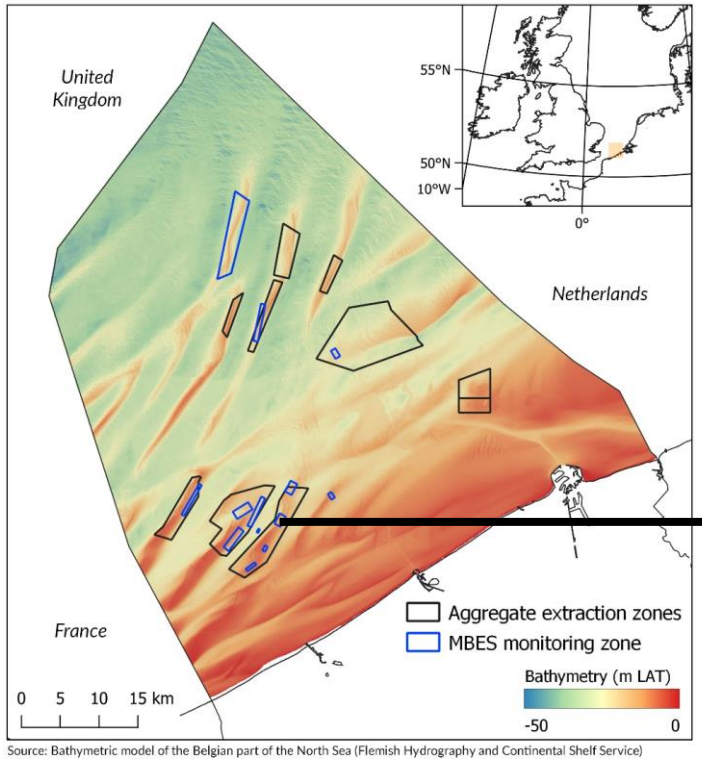
To monitor the impact of sand extraction

Near field impact
Bathymetry
Bottom BS

Far field impact
Water Column BS

Monitoring the impact of sand extraction = National and EU legal obligation

The context: Monitoring the impact of sand extraction

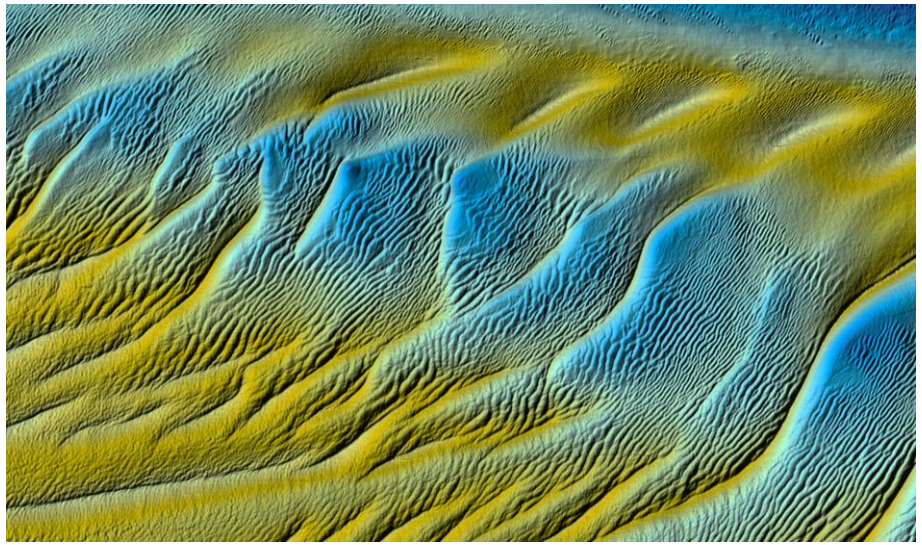


Source: Bathymetric model of the Belgian part of the North Sea (Flemish Hydrography and Continental Shelf Service)

In monitoring areas :
BS time series = proxy for seabed evolution

e.g.

KBMA area



250 m

Bathymetry (m LAT)

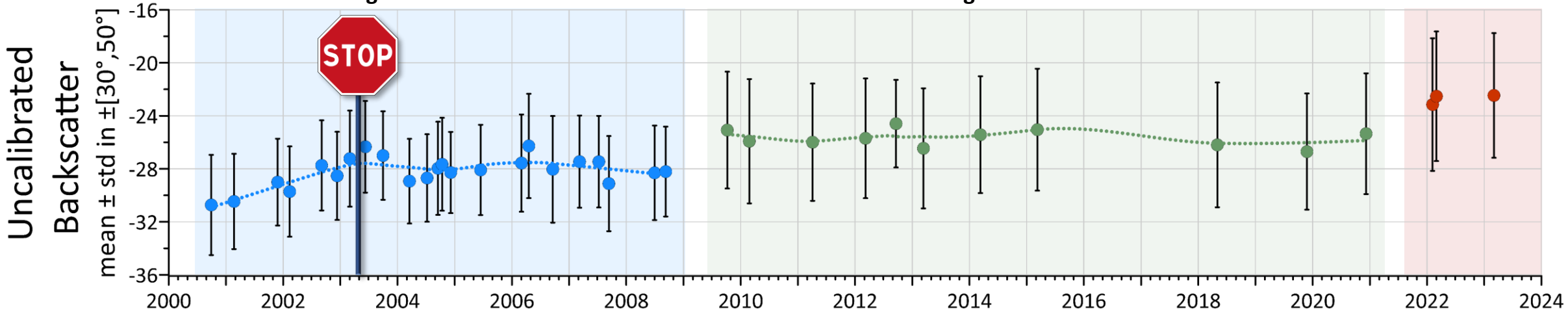
10

20

New RV Belgica EM2040 300 kHz

RV Belgica EM1002 100 kHz

RV Belgica EM3002D 300 kHz



Backscatter quality requirements depend on the objectives

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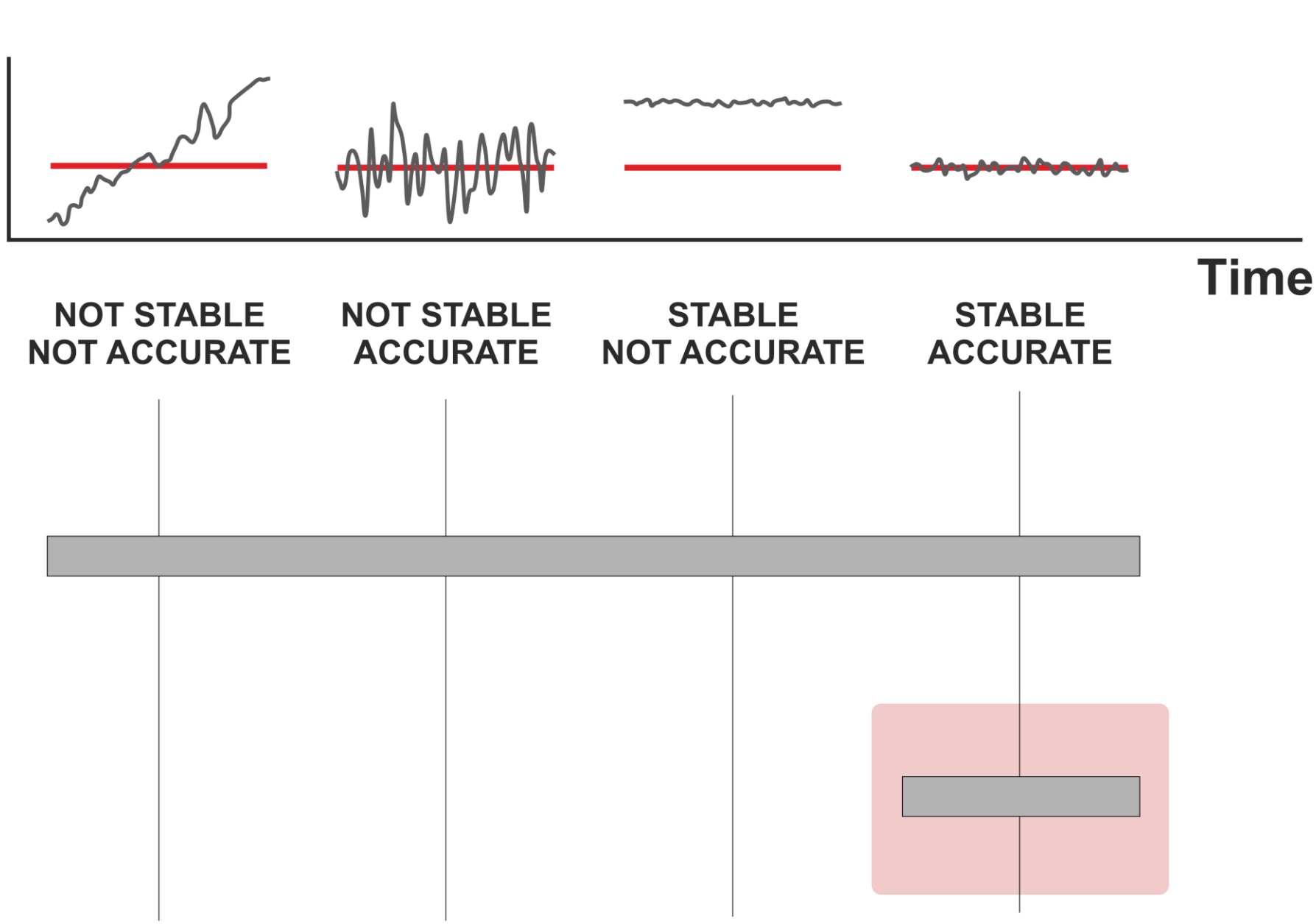


single survey
exploration-discovery mapping
ponctual
no data comparison
relative scale

monitoring program
seabed integrity
medium to long term time series
data comparison
absolute dB scale

MBES past and future

RV Belgica A962

EM1002

EM3002 DUAL

2000 2010 2020

EM2040 DUAL RX

New RV Belgica

EM2040 DUAL RX

RV Simon Stevin

EM2040 DUAL SWATH

HV
Sirius

Optimal sharing of BS data

≠ MBES

≠ Acquisition mode

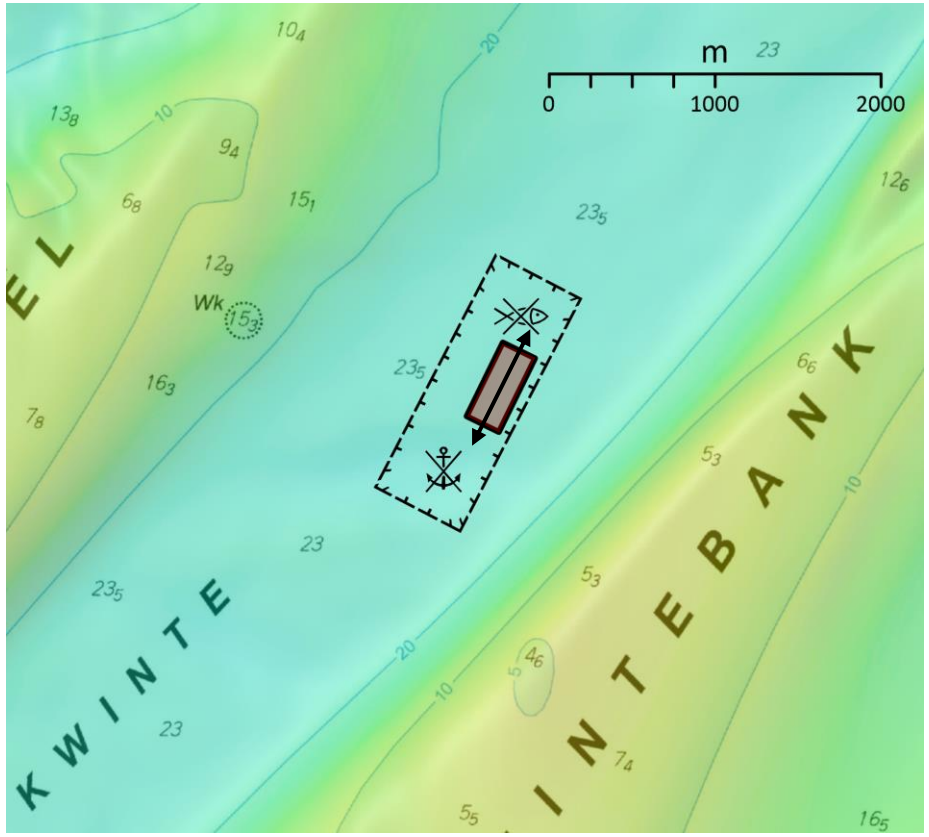
For integration in seabed sediment mapping and monitoring

Backscatter calibration now required

Recipe of BS calibration. Two ingredients:

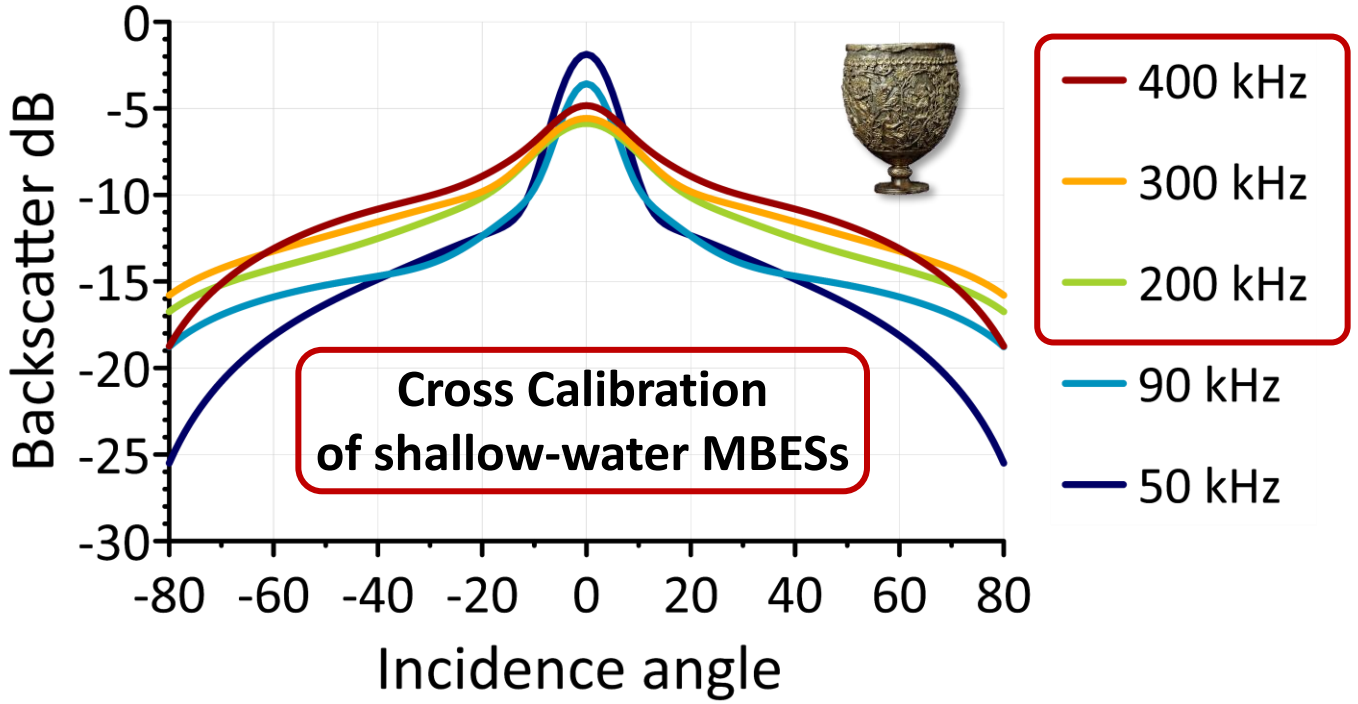
1. Reference area

- Stability
- Flat morphology
- Homogenous sediment cover
- Open-Science compliant!

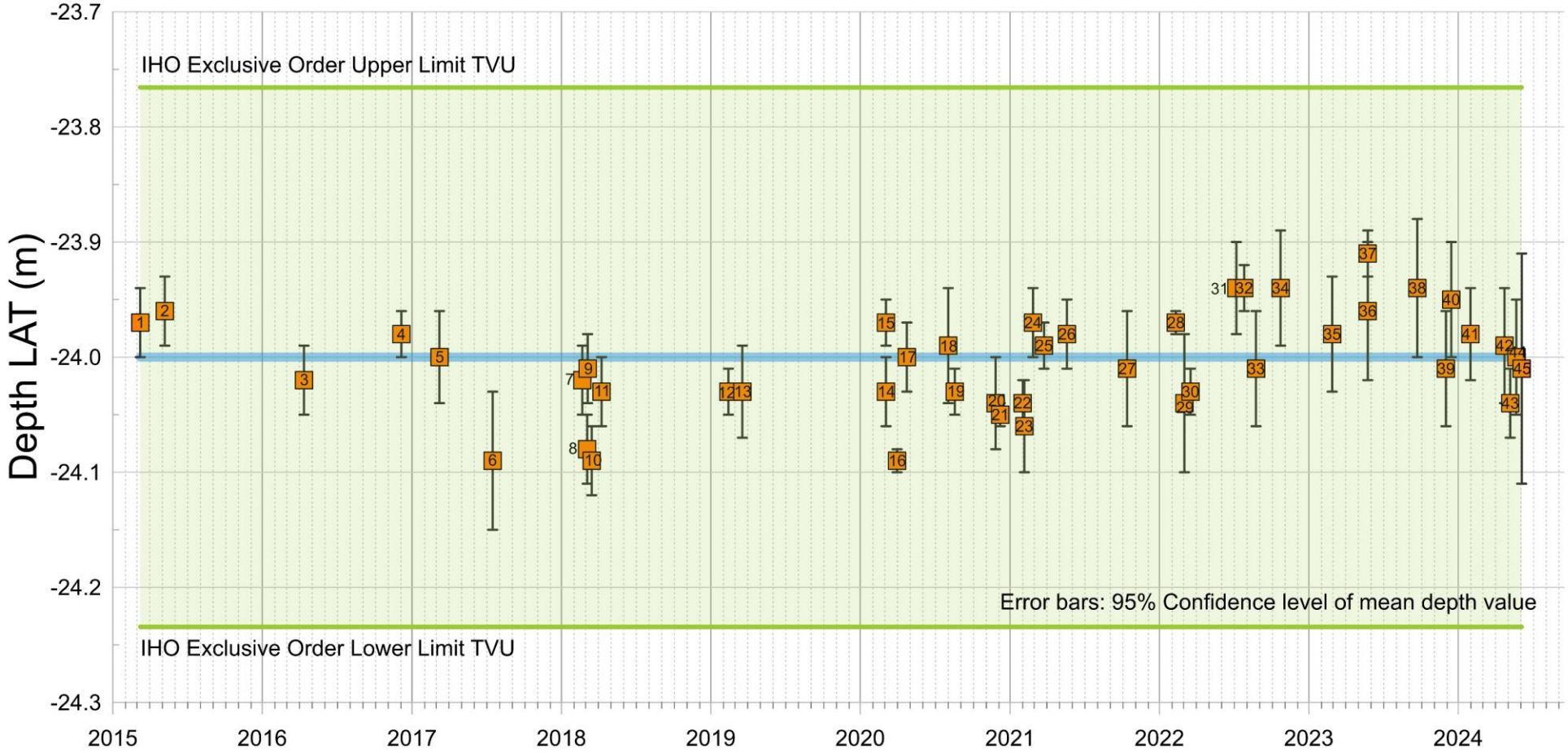


2. Reference angular response model

- HV Sirius
- Calibrated EK80
- Pan&Tilt device
- Kwinte sub-area
  - 50 to 440 kHz
  - -10° to 75° step 5°



Kwinte area stability demonstrated by bathymetric time-series



1 Libertas
2 Libertas
3 Simon Stevin
4 Simon Stevin
5 Simon Stevin
6 Ter Streep
7 Simon Stevin
8 Sirius
9 Simon Stevin
10 Ter Streep
11 Ter Streep
12 Sirius
13 Patriot
14 Geosurveyor XI
15 Geosurveyor VI
16 Patriot
17 Geosurveyor XVI
18 Simon Stevin
19 Geosurveyor VIII
20 Geoocean IV
21 Geosurveyor VIII
22 Geosurveyor X
23 Geosurveyor XI
24 Geosurveyor XVI
25 Geosurveyor IV
26 Geosurveyor VI
27 Zr. Ms. Luymes
28 Anais
29 Belgica
30 Jan Breydel
31 Simon Stevin
32 Aquaway
33 Ter Streep
34 Zr. Ms. Snellius
35 Belgica
36 Sirius
37 Geosurveyor XVII
38 Belgica
39 Belgica
40 Sirius
41 Zirfaea
42 Belgica
43 Arca
44 Zr. Ms. Luymes
45 Belgica

- **Stable bathymetry inside ± 10 cm around -24 m LAT overall mean**
- **No significant trend → No sedimentary accretion or erosion.**

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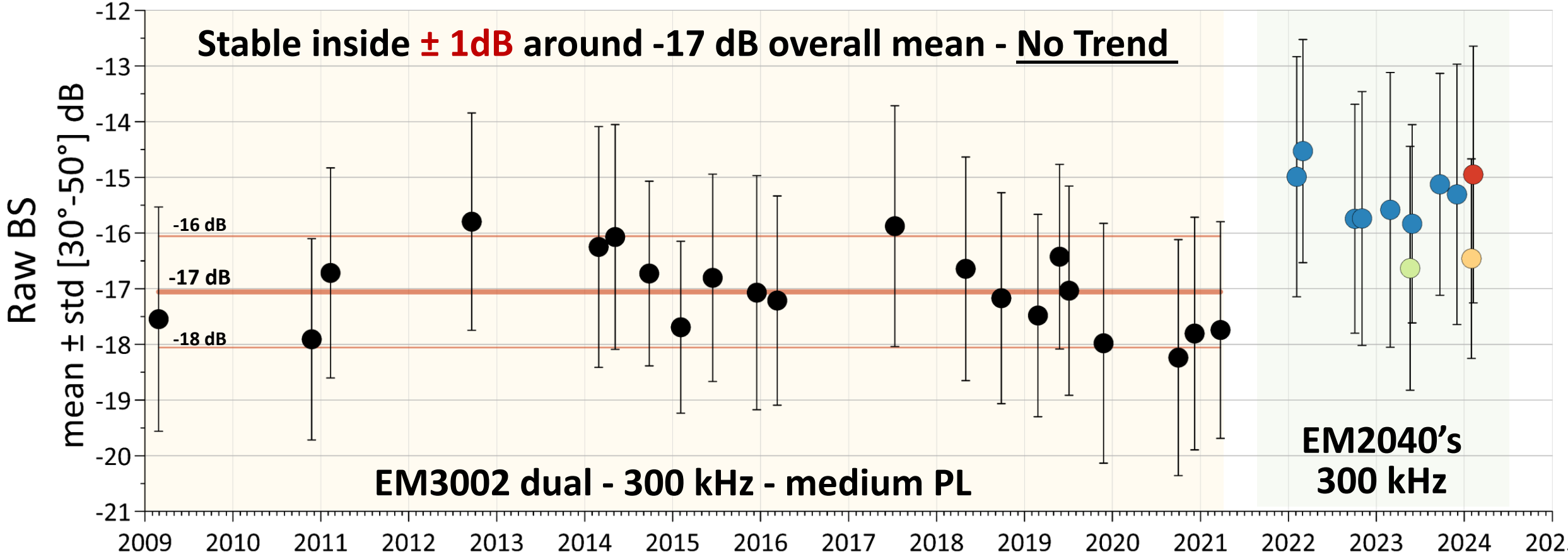
www.afdelingkust.be/en/acoustic-reference-area-kwinte

Kwinte area stability demonstrated by backscatter time-series



The old time series

● RV Belgica A962

The new time series

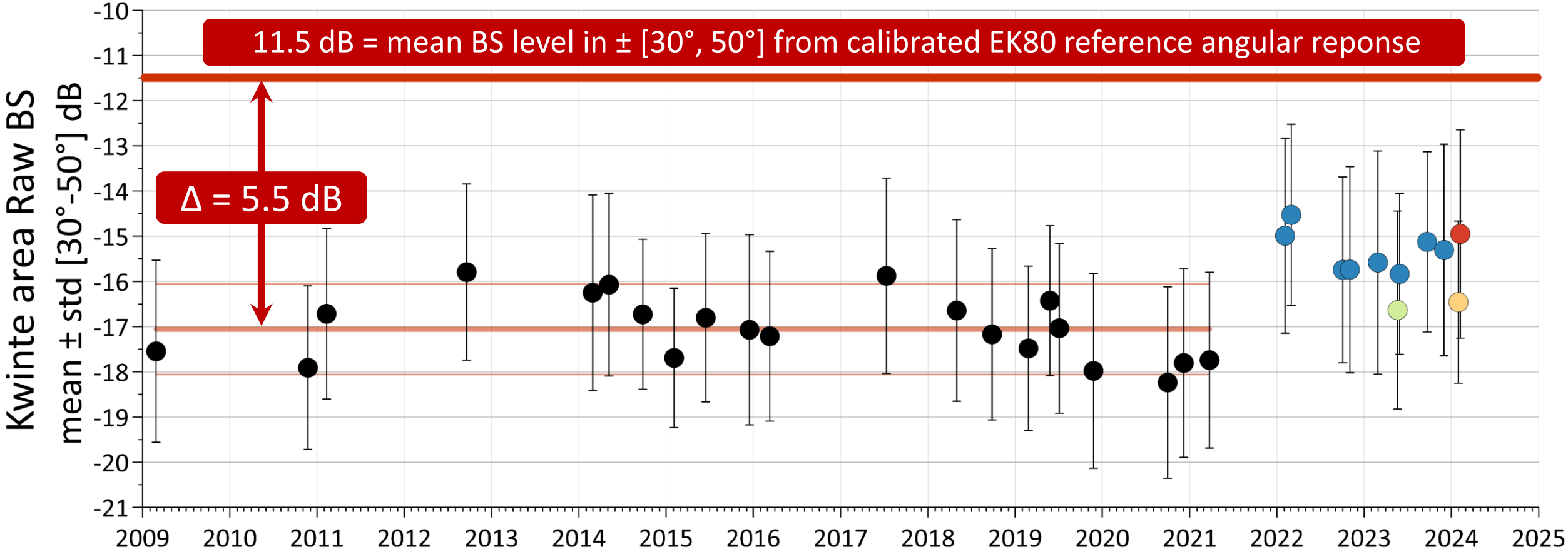
● New RV Belgica

● RV Simon Stevin

● HV Sirius

● RV Zirfaea

Accuracy of these measurements?



The old time series

● RV Belgica A962

The new time series

● New RV Belgica

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● RV Zirfaea

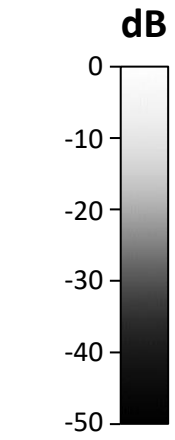
Recipe of BS calibration on reference area:

Raw BS

0004_20220204_052559_Belgica.all
300 kHz – normal mode – medium pulse length

Calibrated BS
+ beam pattern correction

Calibrated BS
+ beam pattern correction
+ flattening – angular compensation



ping

beam

One line recorded on the Kwinte reference area

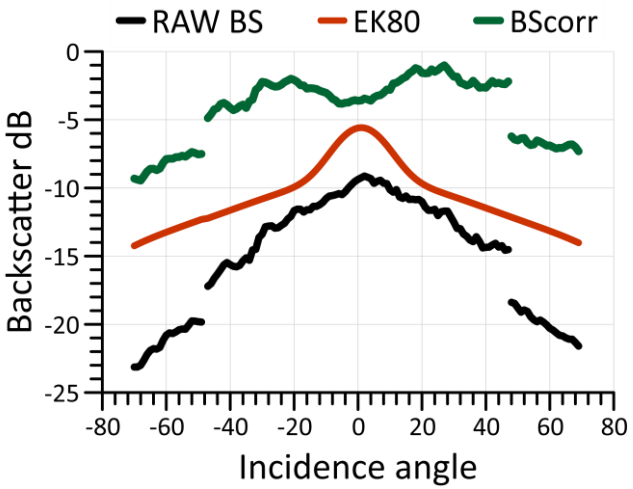
→ Seabed classification based on angular response

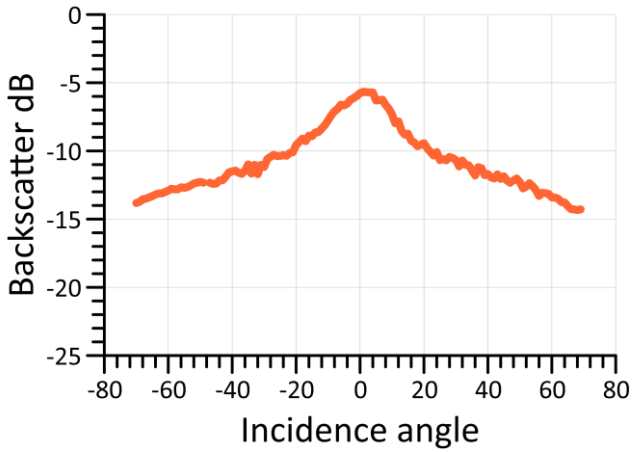
“La Belle Image”
Every geologists want it!

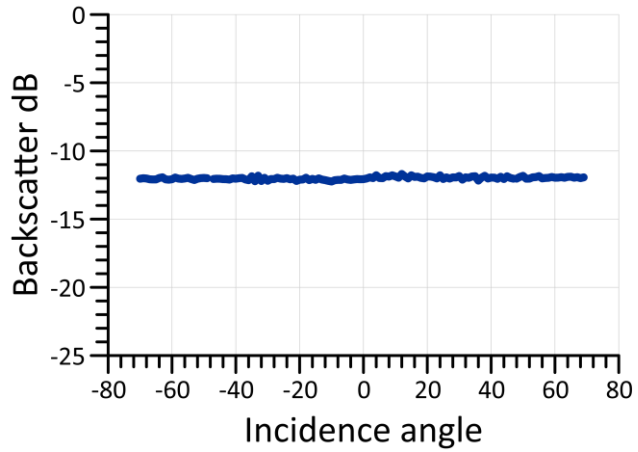
Raw BS

Calibrated SBES = Reference

BS correction = Reference - Raw





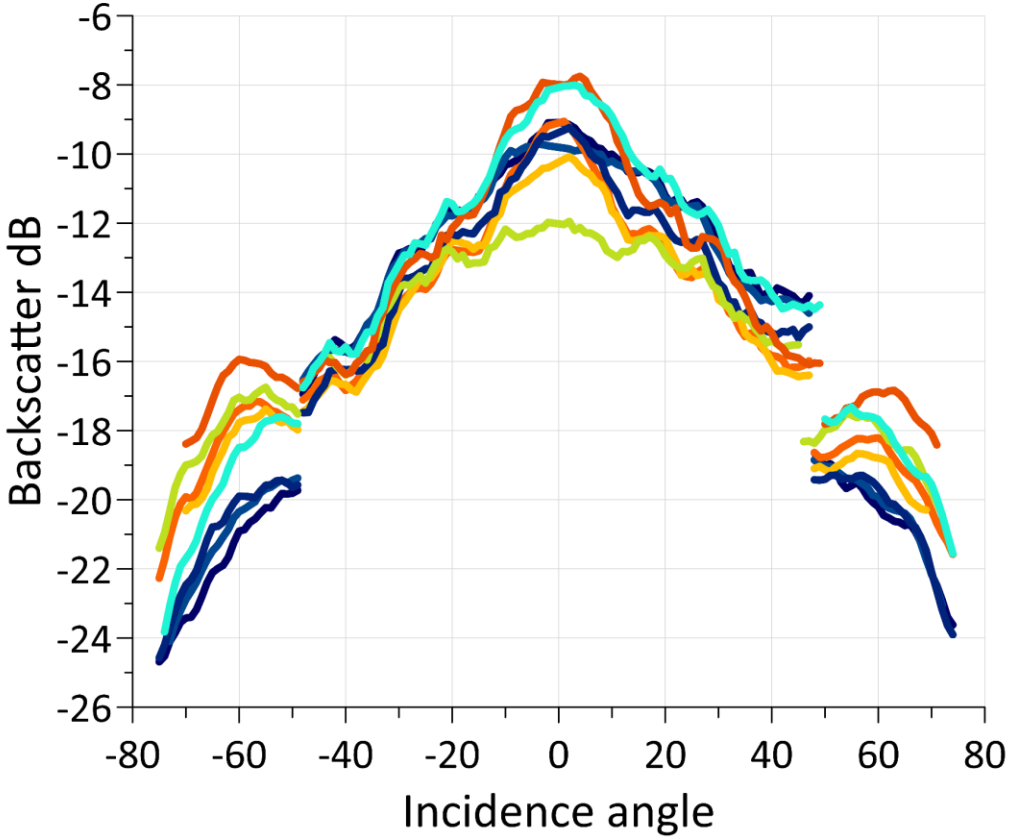


SonarScope

BS dependence on T° observed as well on RV Thalia EM2040 data

RV Belgica - Kwinte area - 2022-2023

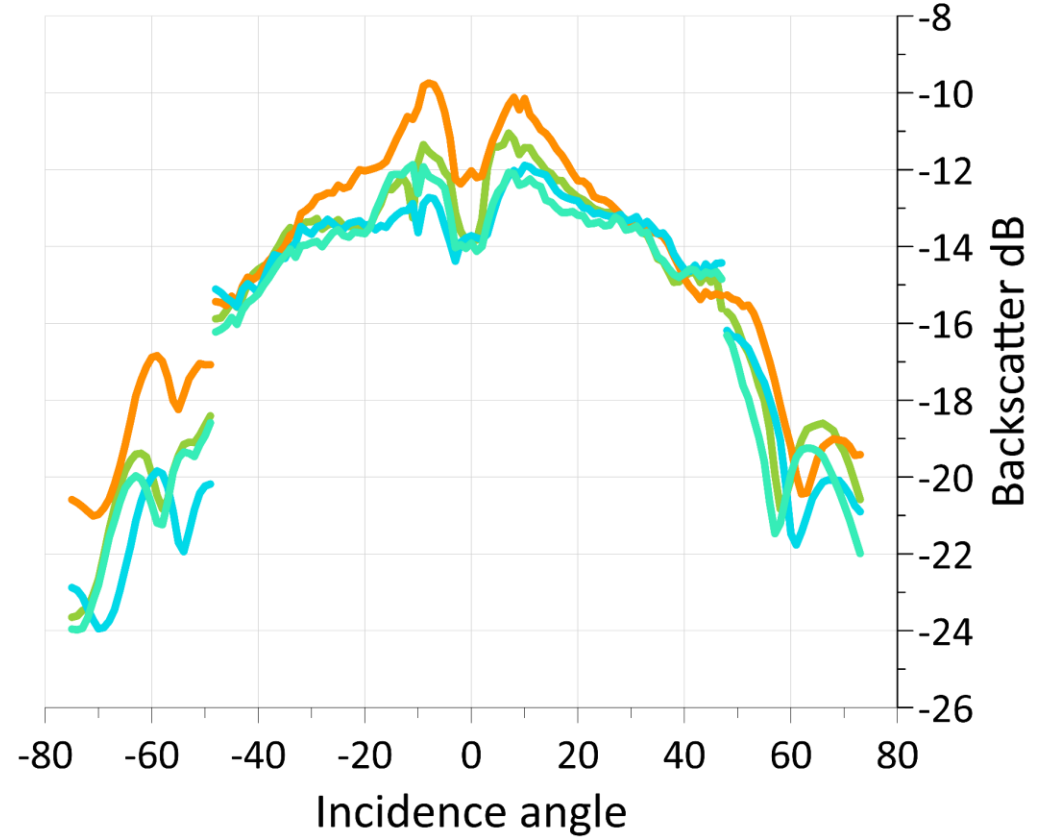
300 kHz, normal mode, medium pulse length



Line color = Seawater °C

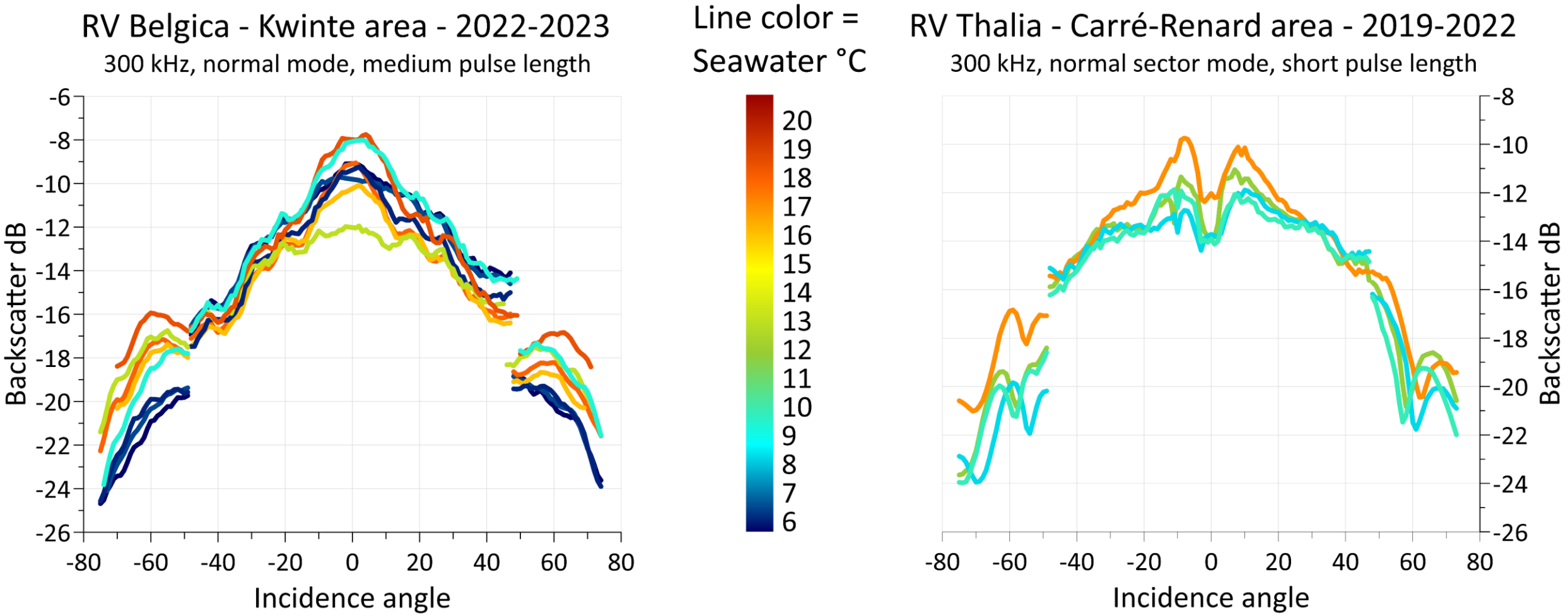
RV Thalia - Carré-Renard area - 2019-2022

300 kHz, normal sector mode, short pulse length



By courtesy of Hervé Bisquay, GENAVIR

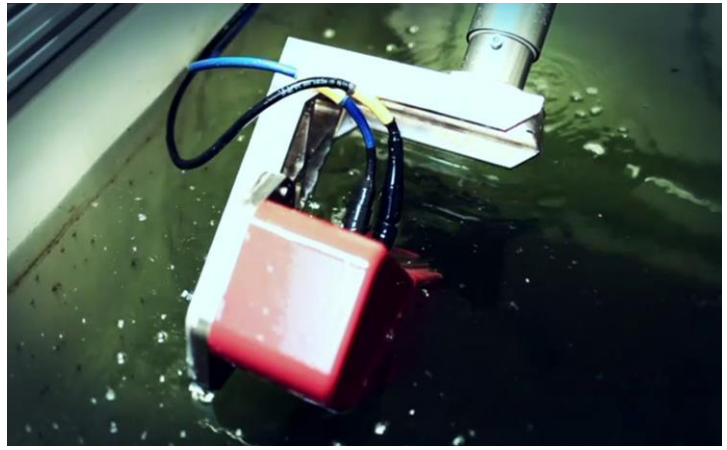
BS dependence on T° observed as well on RV Thalia EM2040 data



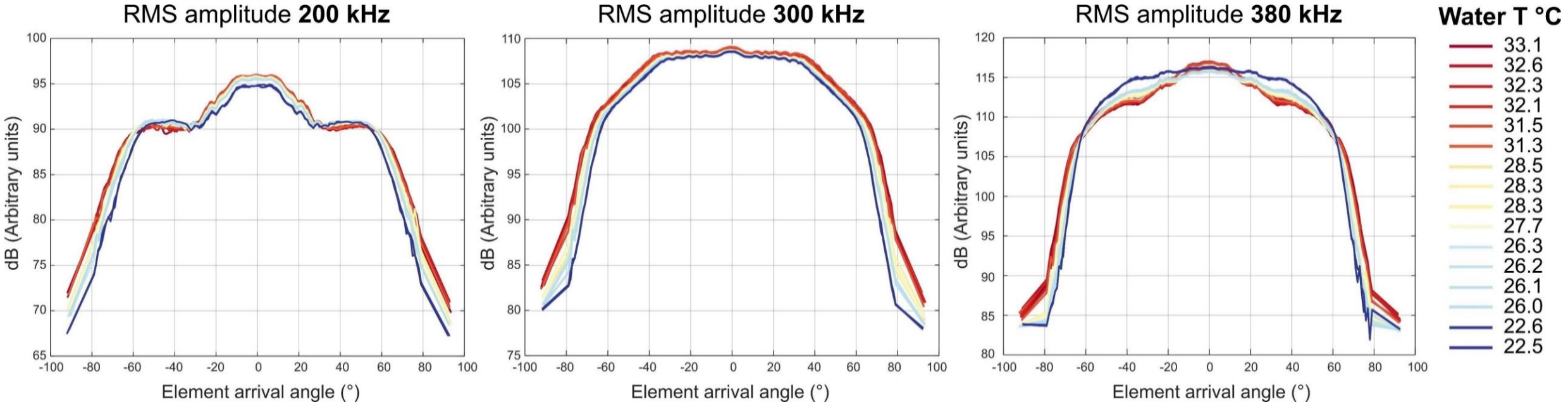
- **BS angular response correlated with sea water temperature**
- **On average: BS increases by 4 dB for every 10°C**

One calibration is only valid within a limited temperature range!

In-tank measurements confirm the T° dependence



- With one of the earliest EM2040 RX units
- RX directivity change with T °C
- Complex, changes with frequency

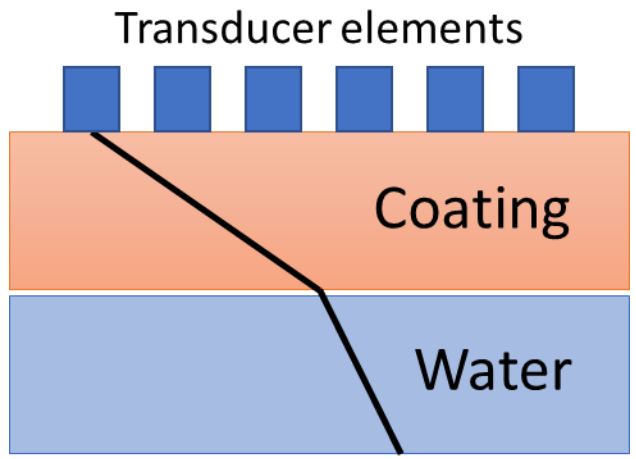


By courtesy of Tor Inge Birkenes Lønmo.

T° dependence causes? Kongsberg Discovery's hypotheses:

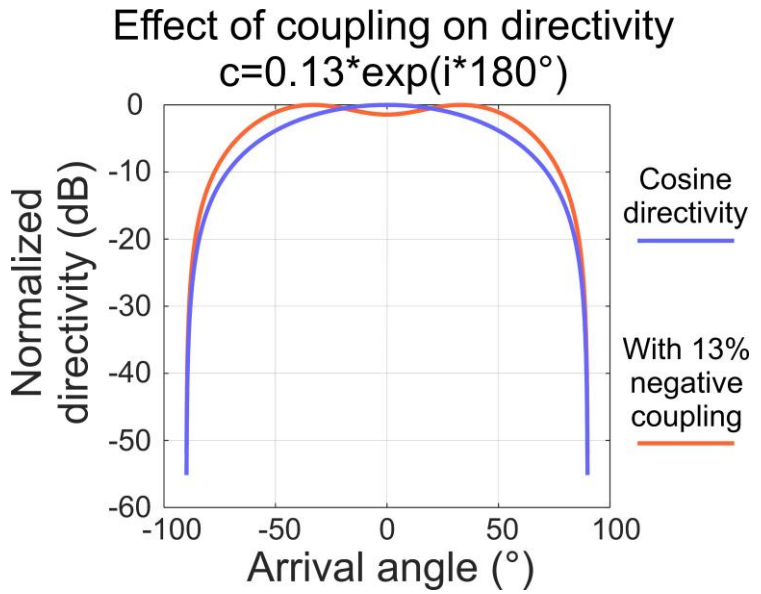
1. Snell law – Refraction

- Coating sound speed change with T°
- Leads to a change in refraction
- Not sufficiently taken into account?
- But should only cause a scaled directivity



2. Coupling

- Interaction between neighboring transducer elements
- Can produce various effects
- Complex relation to material parameters
- A probable cause of significant directivity variations
- Hard to model for real-time compensation

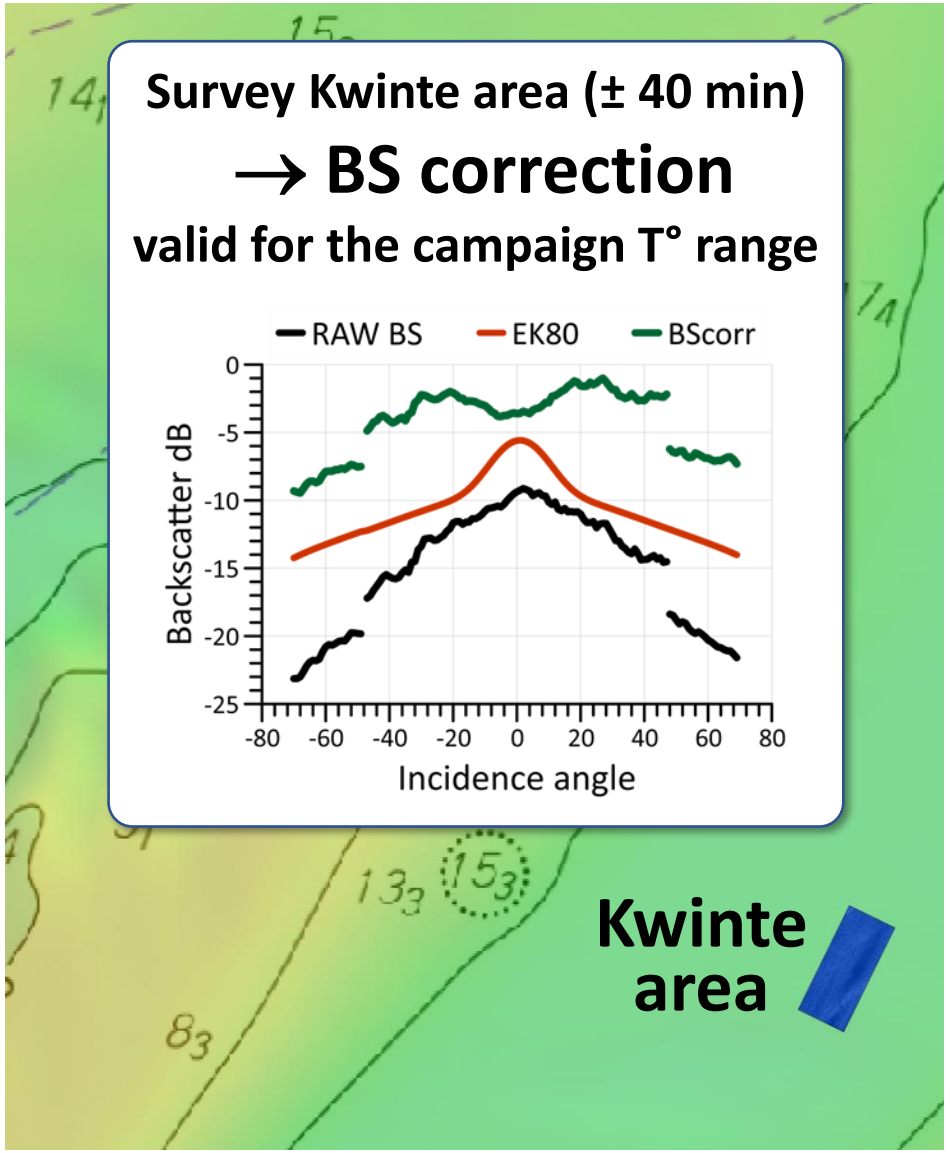


By courtesy of Tor Inge Birkenes Lønmo.

Implications of the temperature dependence of backscatter:
Paper in progress for Frontiers in Remote Sensing
Special Issue: Multibeam Echosounder Backscatter: Advances and Applications

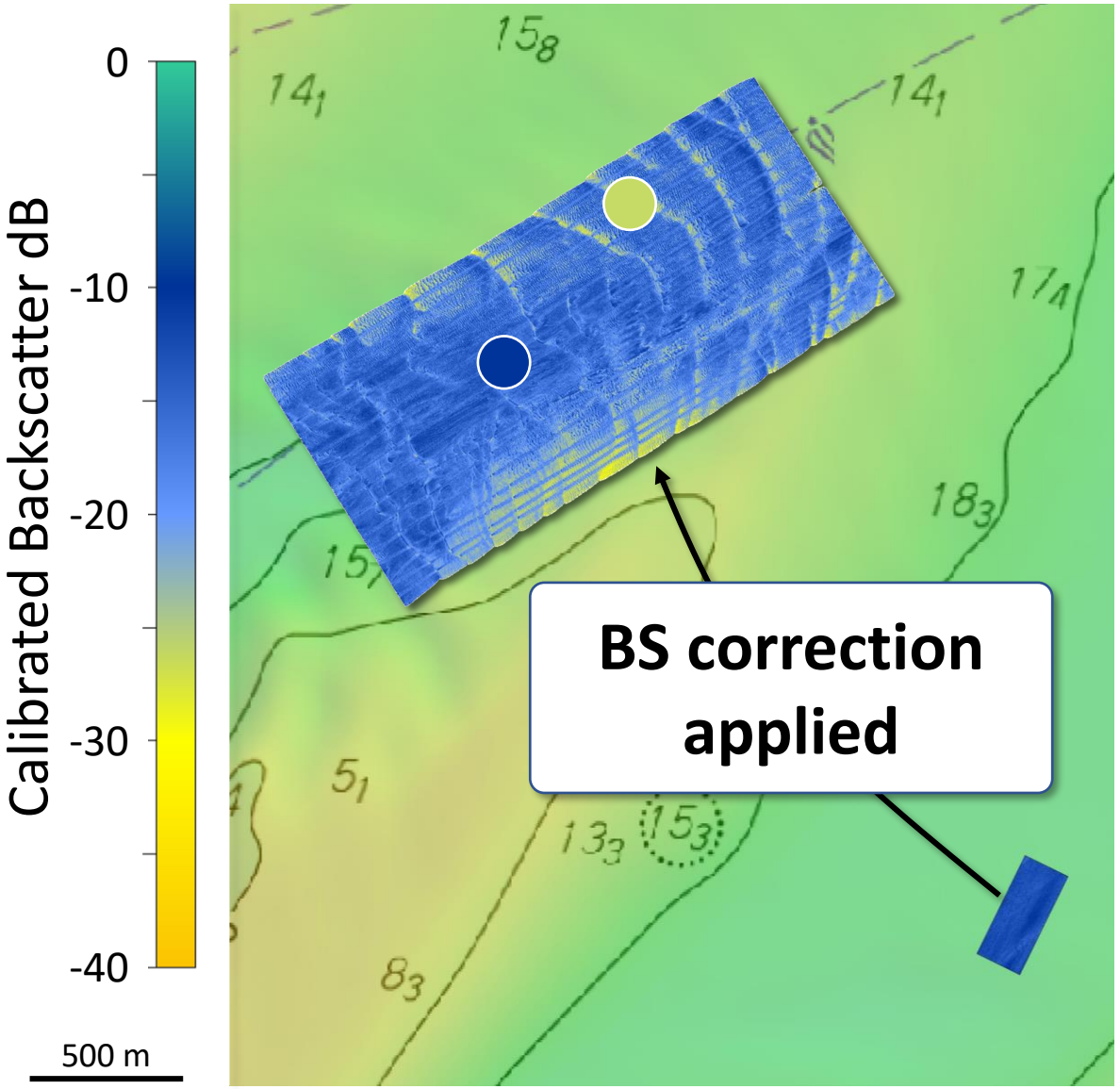
The solution: Survey of the Kwinte area during each campaign

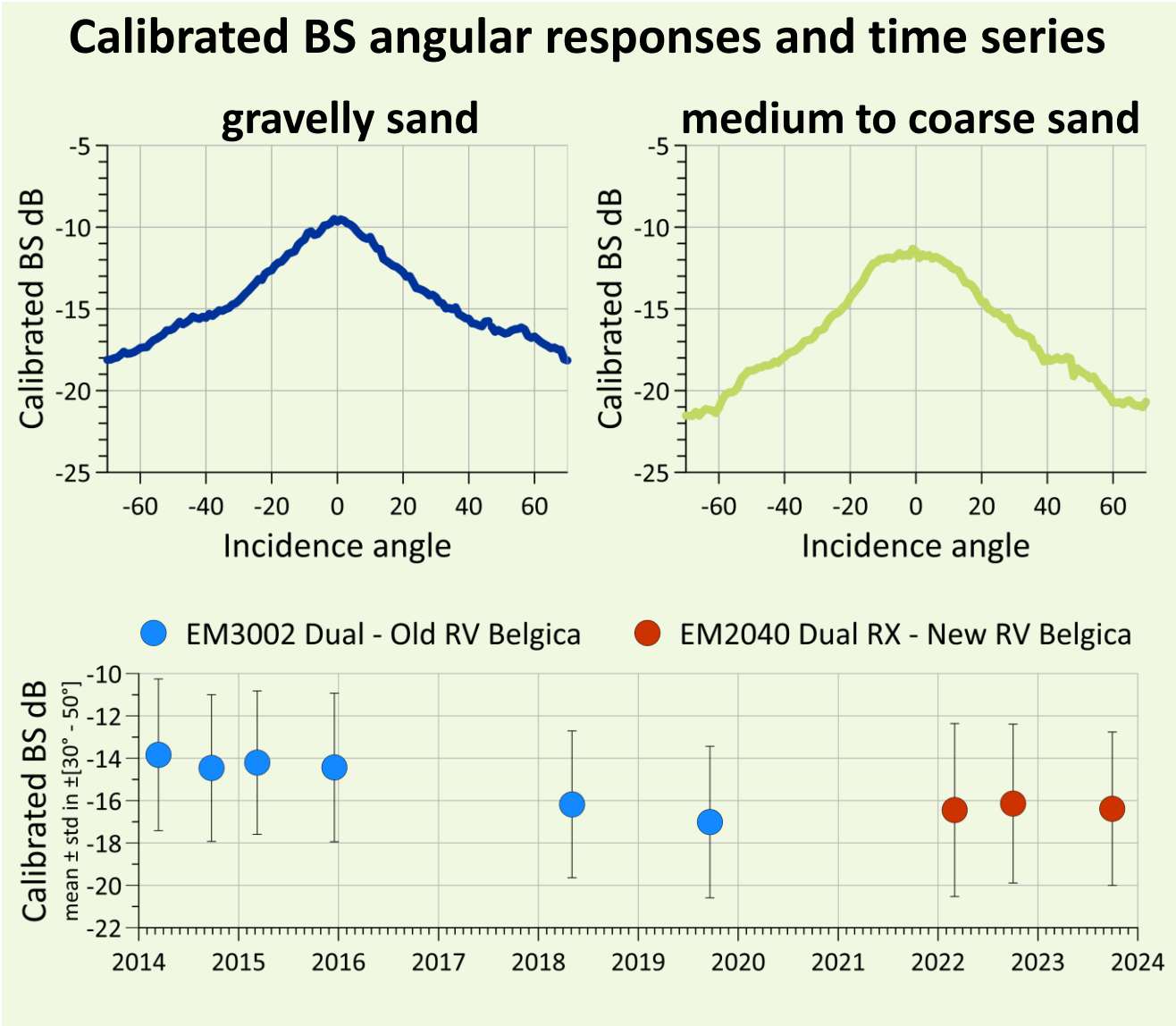
Using our usual monitoring mode (300 kHz, normal mode, medium pulse length)

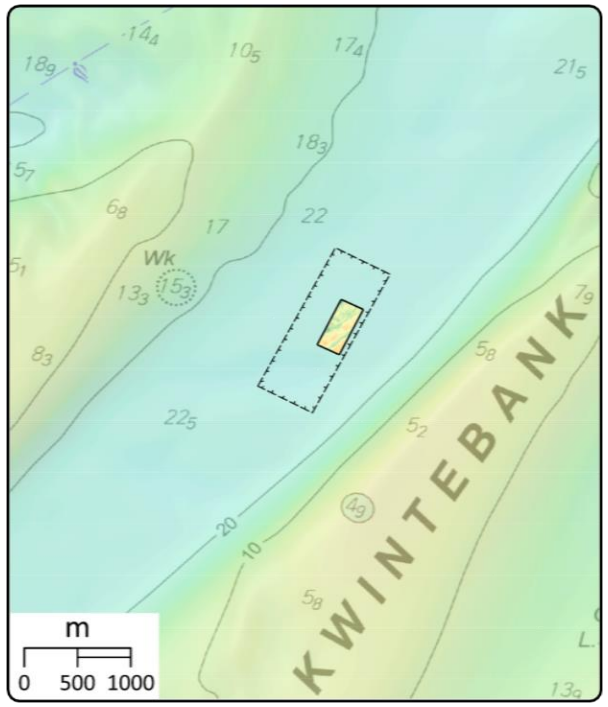


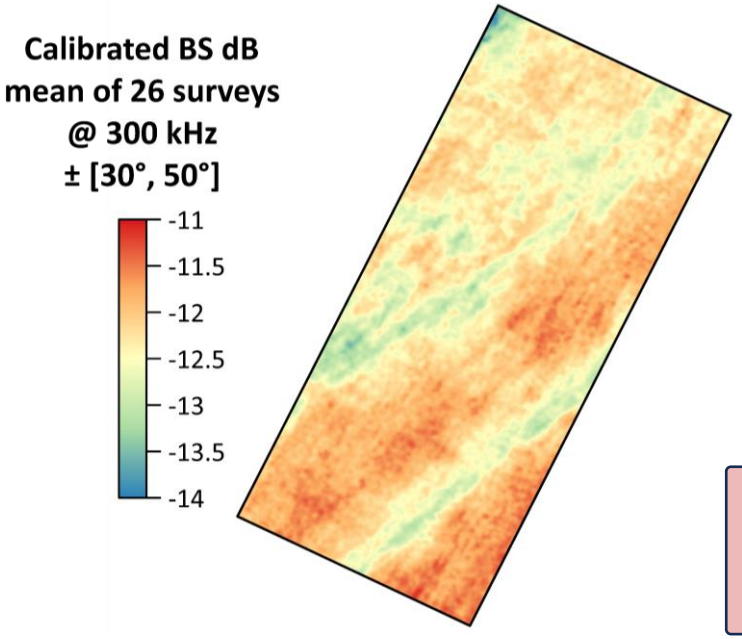
The solution: Survey of the Kwinte area during each campaign

☑ One calibration per measurement campaign applied to all data









The Kwinte reference area is accessible to all.

Surveyors from Belgium and neighboring countries are encouraged to conduct bathymetric and backscatter measurements in the area and to share their data.

Recommendations for conducting surveys in this area:

- Refer to Samuel Deleu's previous presentation for the prerequisites of bathymetric measurements.
- For backscatter: Follow the recommendations of the Backscatter Working Group (BSWG): Backscatter measurements by seafloor-mapping sonars. Guidelines and Recommendations; 2015; https://zenodo.org/records/10089261

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Backscatter Working Group

Two related initiatives in progress:

1. Definition of a protocol for the creation of reference seafloor areas for the control of repeatability, quality and calibration of backscatter measurements.

2. Building a quality scale of backscatter data, to enhance reliability, promote standardization and facilitate comparison between datasets.

Online questionnaire gathers interest in MBES backscatter quality.
Interested? Fill out the questionnaire!