

# Backscatter Patch Test – inter-comparison of systems using shared reference areas for testing, calibration, and quality assessment

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## Monitoring the seabed = EU legal obligation



### The European Union Marine Strategy Framework Directive ("MSFD")

"Coastal waters, including their seabed and subsoil, are an integral part of the marine environment, and as such should also be covered by this Directive..."

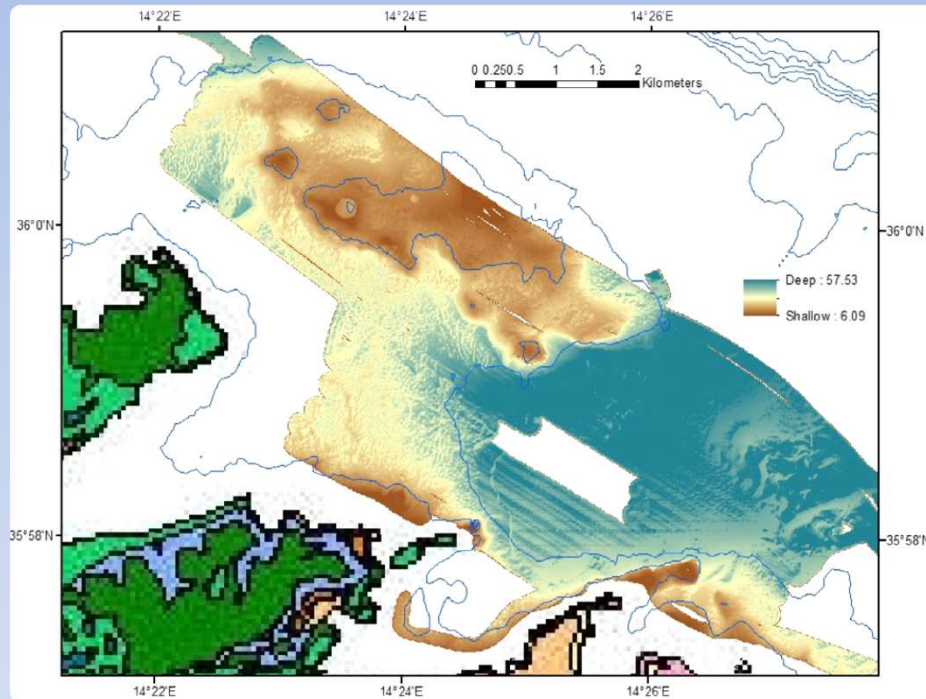


*dura lex, sed lex...*

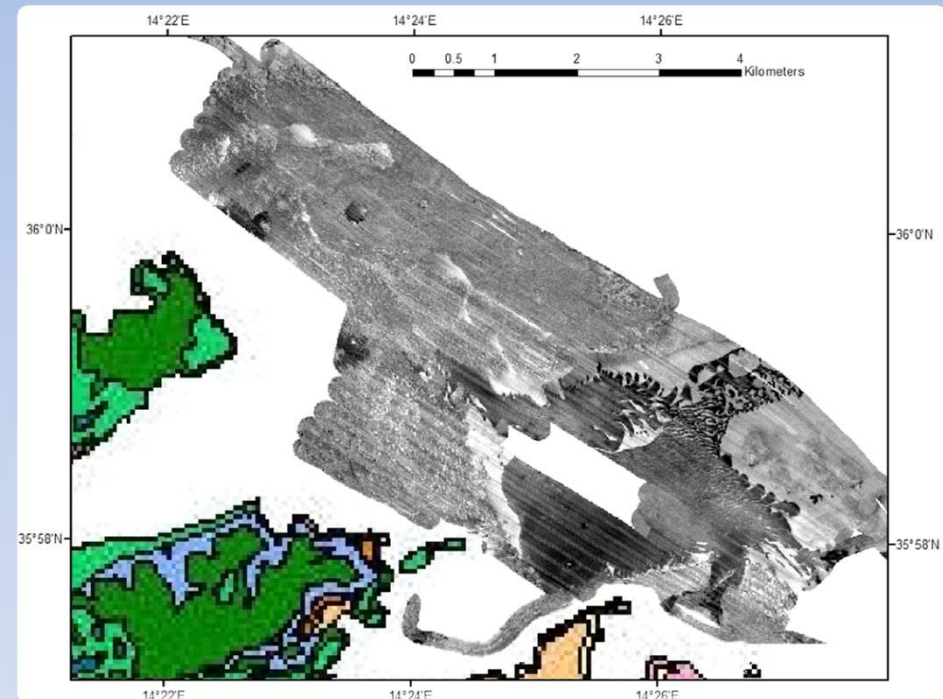


# Combined MBES Bathy + BS = the standard technology for mapping the seabed

## Bathymetry



## Backscatter Strength

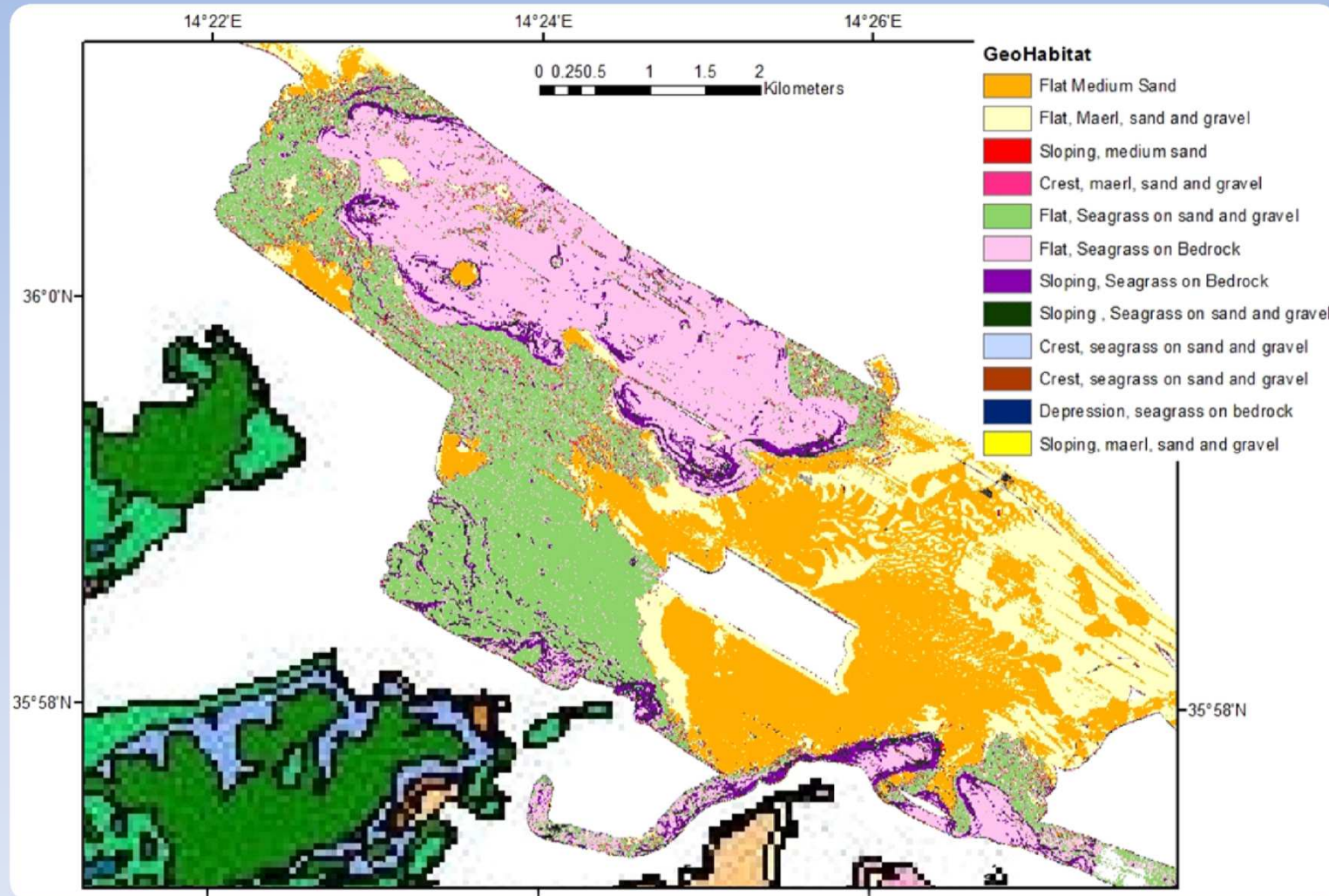


NE Malta – EM3002D – acquired April 2010 on RV Hercules

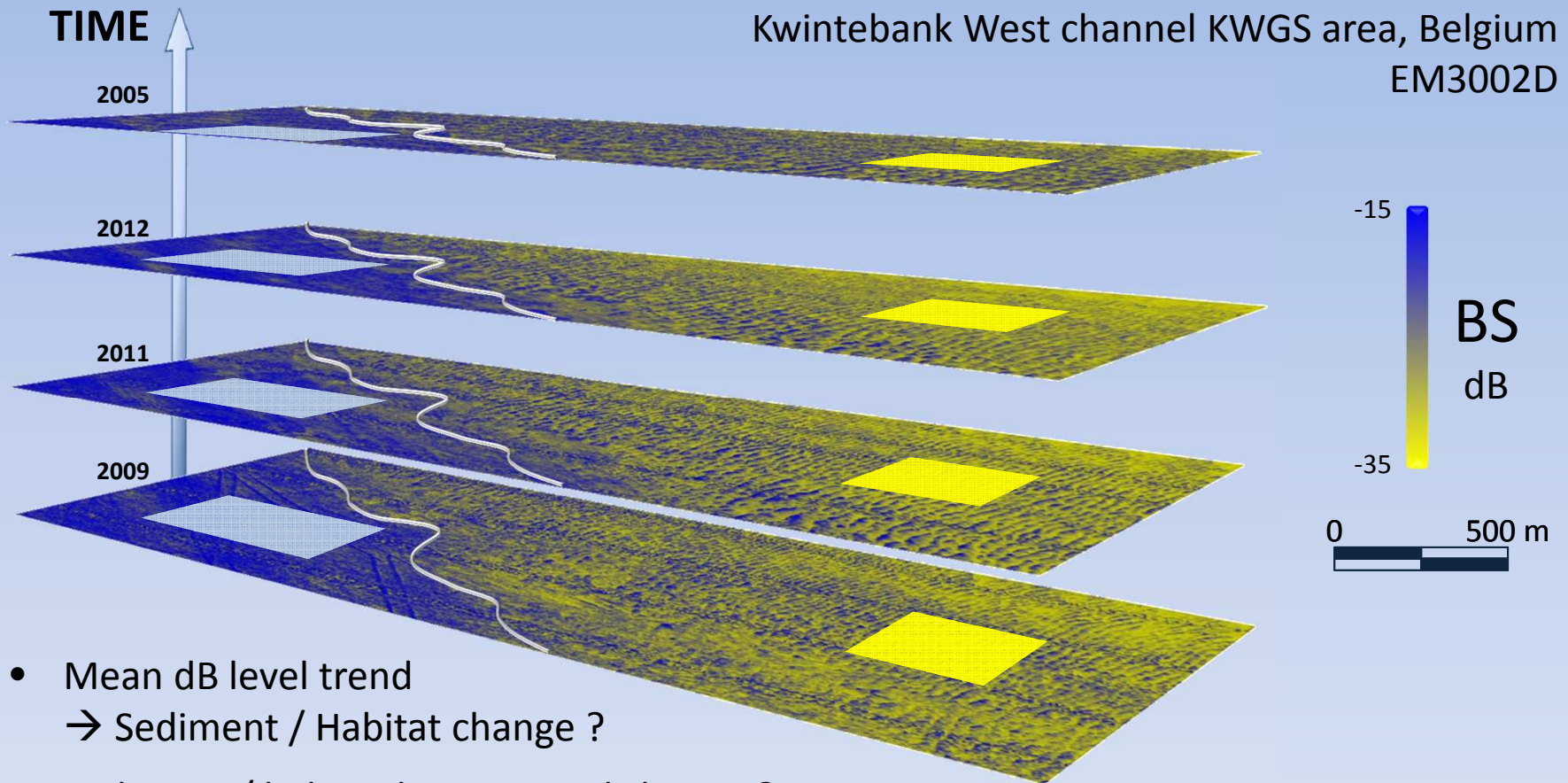
Ref: Aaron Micallef, **Tim Le Bas**, Veerle Huvenne, Philippe Blondel, Veit Hühnerbach, Alan Deidun, (2012) A multi-method approach for benthic habitat mapping of shallow coastal areas with high-resolution multibeam data, *Continental Shelf Research*, 10.1016/j.csr.2012.03.008.

# Combined MBES Bathy + BS = the standard technology for mapping the seabed

Benthic Terrain Mapping and supervised backscatter texture analysis



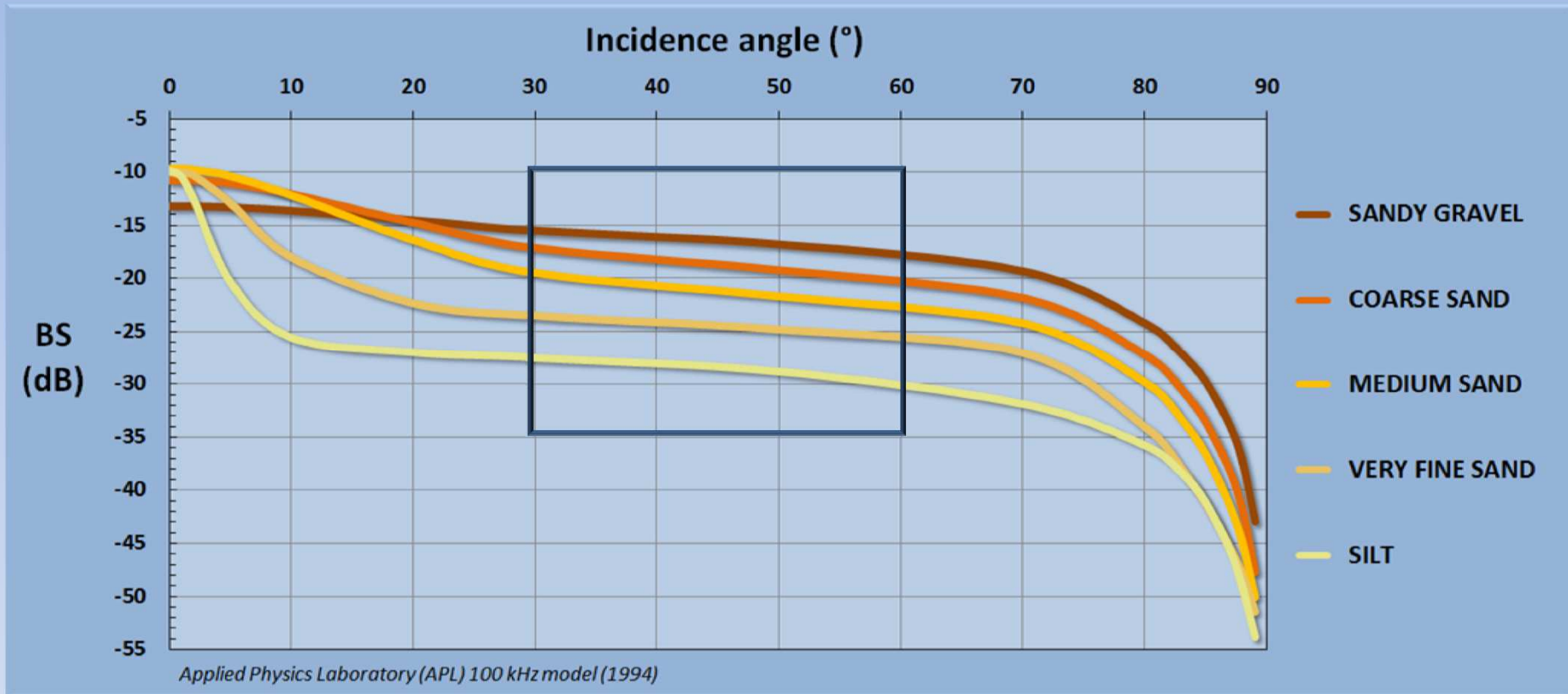
## MBES BS for monitoring the seabed nature variation? Yes, if...



- Mean dB level trend  
→ Sediment / Habitat change ?
- Sediment / habitat limits spatial change ?

**Yes, if BS measurements are enough accurate and stable...**

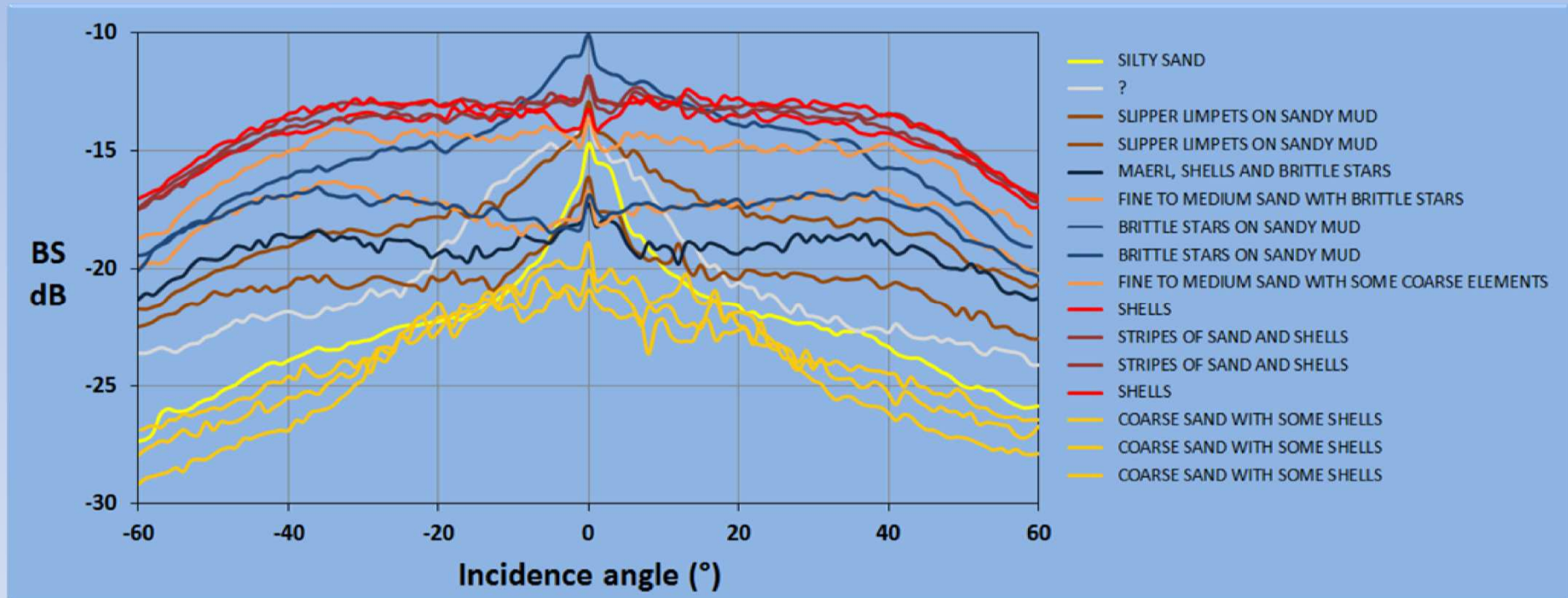
## BS required accuracy for detecting sediment change trends



- average difference between the mean BS levels of the different sediment types  $\pm 2$  dB  
→ 1 dB (1/2 average difference) = accuracy required
- Plateau = most discriminant part = MBES BS PARADISE

## The plateau approach to quantify the mean BS level

BS versus Incidence angle for different seafloor interfaces from various sites

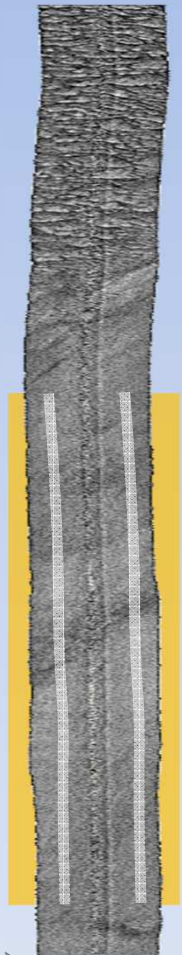


IFREMER dataset (RV Thalia EM2040 dual receiver @ 200 kHz)

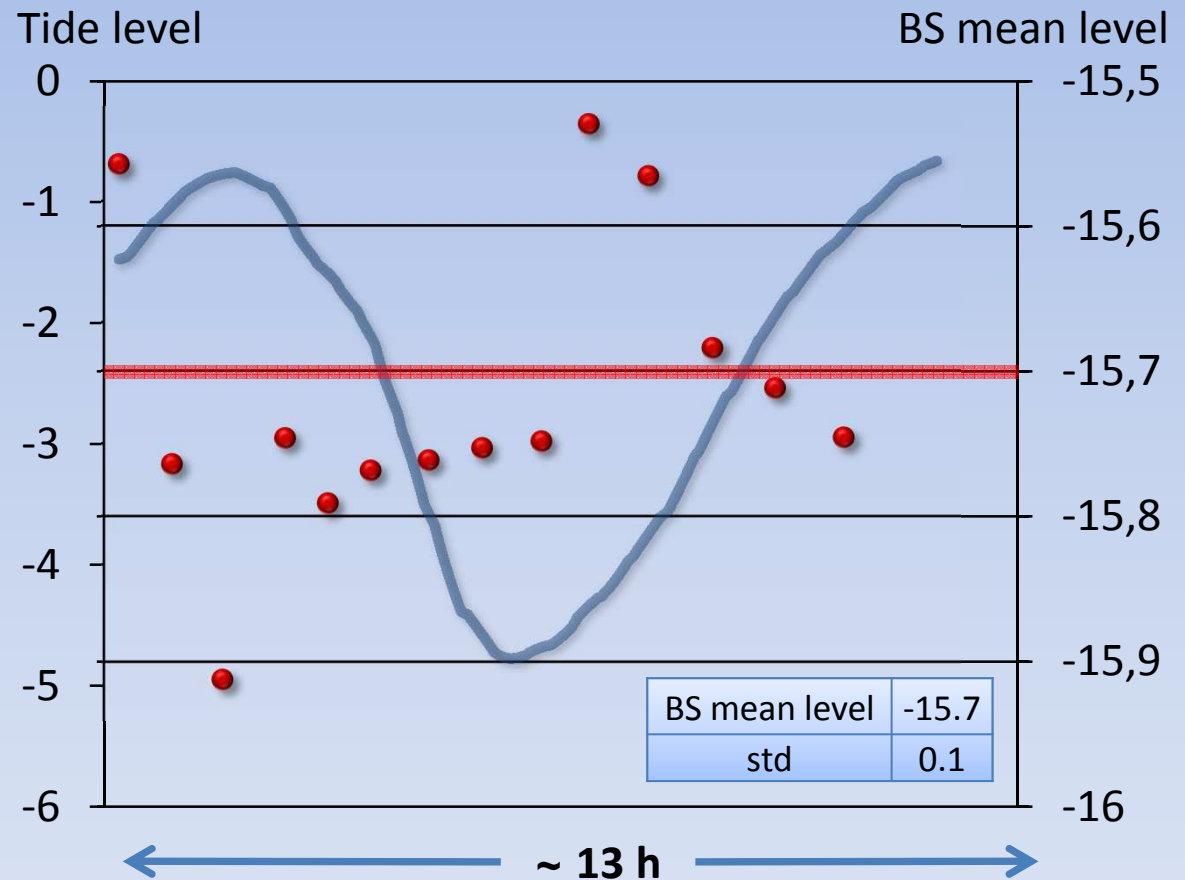
- Restriction to sector 35°-45° → Loss of information (specular + fall-off)
- Remains the most relevant BS data derived from only oblique insonification

## BS mean level stability ?

BS mean level variance evaluation by repetitive measurements during a tide cycle:



- same one line area surveyed several times (heading = cst)
- Beam averaged 1x1 m mosaic
- Stats on BS mosaic values from the same area and for incidence angle interval 35°-45°



**Average level of BS is fully stable over a short period**

## Sources of instability (out of the sonar equation)

### The Very Big Question:

To what extent mean BS level variation from one cruise to another really represents significant change in seabed properties and not change due to the followings?

Potential sources of instability (non exhaustive list, see BSWG C3 and C5)	Scientific literature Manufacturer references
Changes of acquisition parameters on board	±
Antenna state - biofouling	?
Aging of antenna (electronic and coating)	?

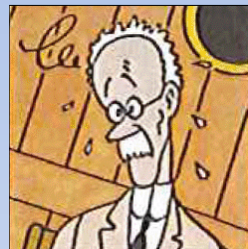
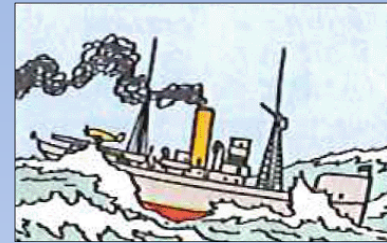
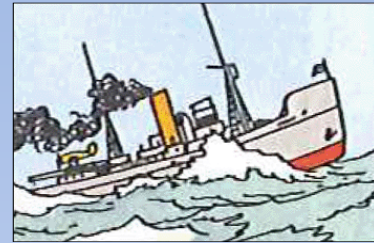
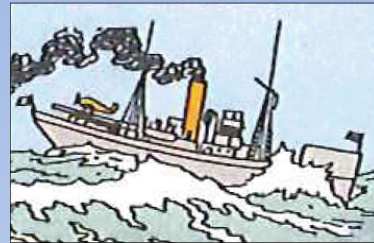
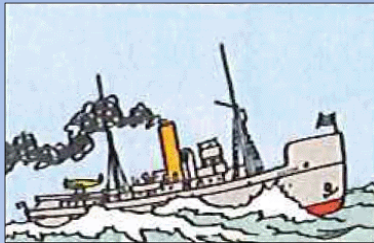
### Water column influence?

Influence of dense near-bed and water column suspensions on the MBES BS?

- MBES + acoustic doppler current profiler (ADP) measurements
- Benthic landers + ADPs + acoustic backscatter sensor (ABS) → near-bed sand transport
- Water samples to calibrate the optical and acoustical sensors

## Sea state?

### Beaufort 6-7



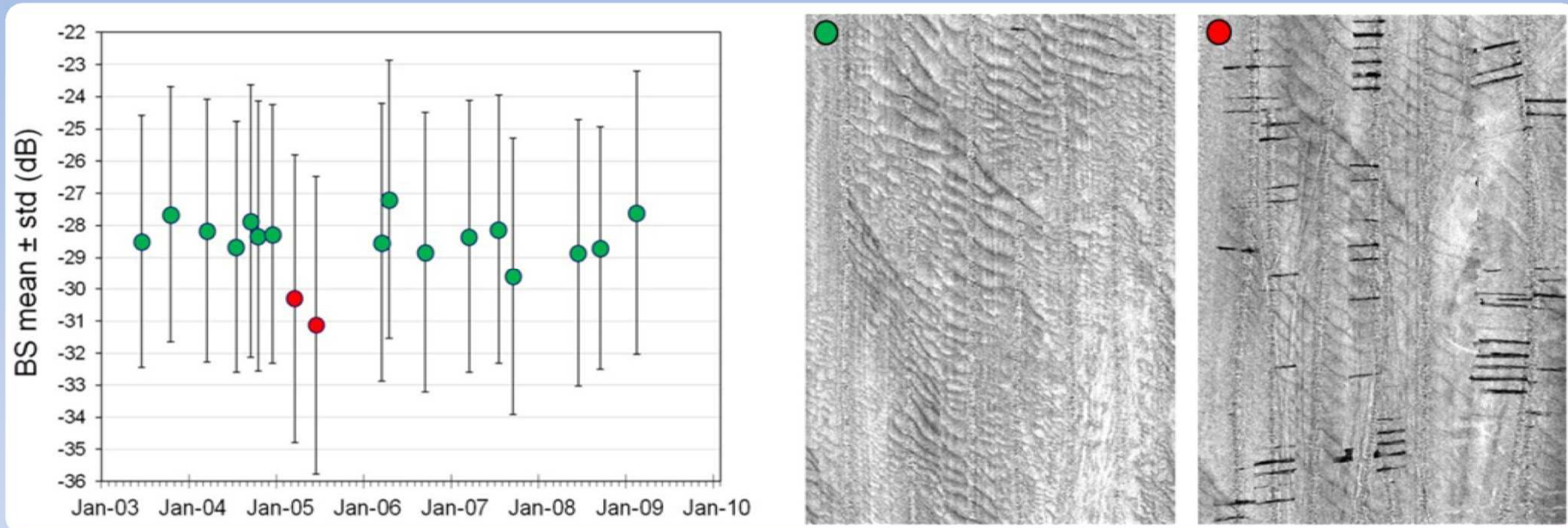
The Scientists...



The Captain and a world-famous Belgian surveyor...

## Sea state?

BS time series on a sandbank area covered by very large dunes:



*EM1002 RV Belgica*

● calm sea

● rough sea

Negative offset of up to 3 dB of the mean dB levels

**If target is to monitor the seabed, stop the survey if the weather is too rough!**

## MBES BS reference area

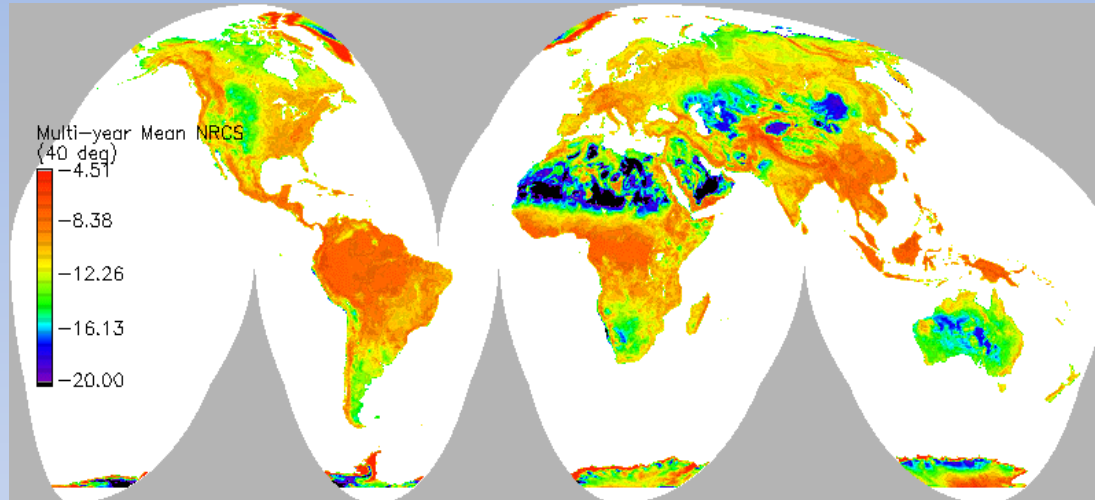
- Check BS stability = mandatory
- Seafloor reference area = most practical approach
- **Basic assumption =**  
**Reference area seafloor cst against required accuracy of BS measurement (~ 1 dB)**
- The ideal reference area:
  - Flat
  - Deep and large enough
  - Isotropic homogenous seafloor
  - Not subject to seasonal change
  - Easily accessible
  - Ground truthing data
  - Time series



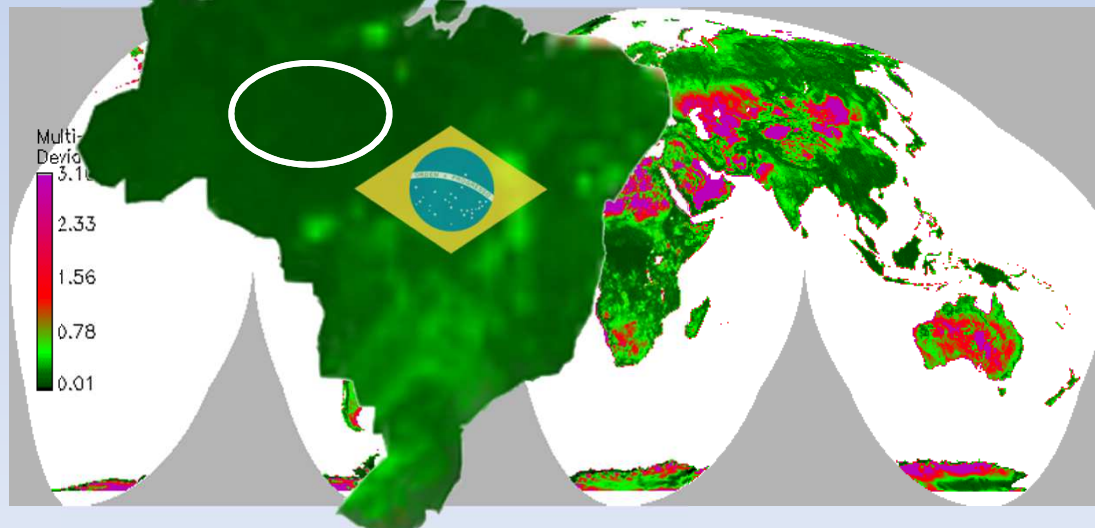
***Belgian BS reference area and RV Belgica II***  
*(futuristic vision inspired from the world's largest swimming pool of San Alfonso del Mar, Algarrobo, Chile)*

## MBES BS reference area

Similar as the approach used to calibrate the SAR scatterometer



From C. H. Buck, *Alternative large-scale distributed targets for SAR elevation beam pattern characterization*, Tech. rep., ENVISAT project, ESA-ESTEC, 2001.



Reference surface =  
Amazonian rain forest  
Used for years by satellite radars

Forest canopy:

- High reflectivity (-10 dB)
- Isotropic angular response
- Excellent stability over the year  
(one more point for Brazil!)

## BS patch test

**Goal = estimate the relative stability of the BS with a reference model**

### Reference model based on reference area BS data:

Ultra dense survey of a reference area at  
Time Zero using calibrated sensor  
→ BS reference model with 35°- 45° data

Time series of the reference area  
mean of all the 35°- 45° data  
→ BS reference model

### Relative stability estimation:

New survey 35°- 45° BS data are compared with the reference model

- Gap statistics (mean and standard deviation)
- Relative Quality Level / Acceptability Thresholds remain to be defined
  - Under study approach

**Analog to a IHO bathymetric quality test using a reference surface**

## Reference area

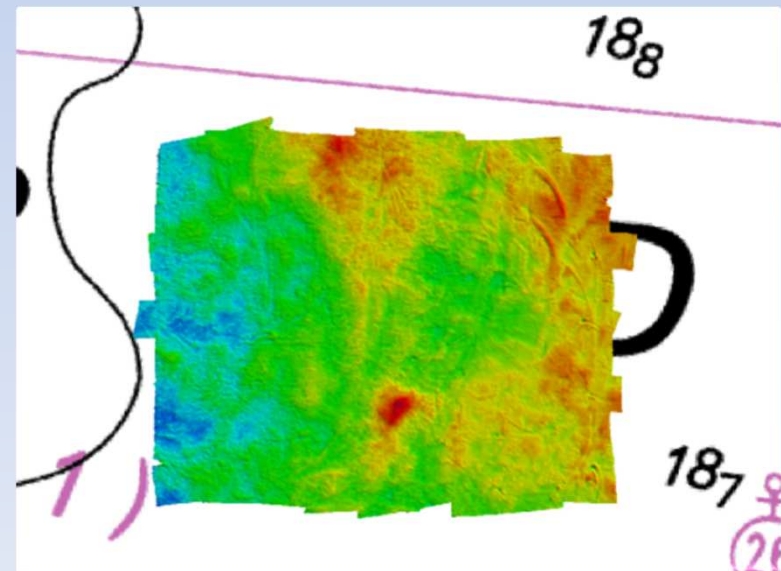
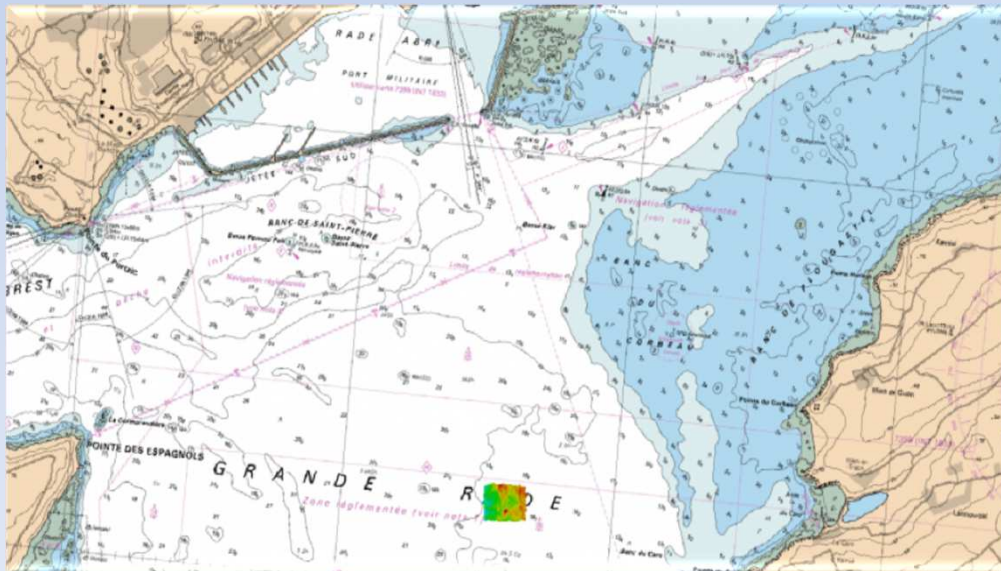
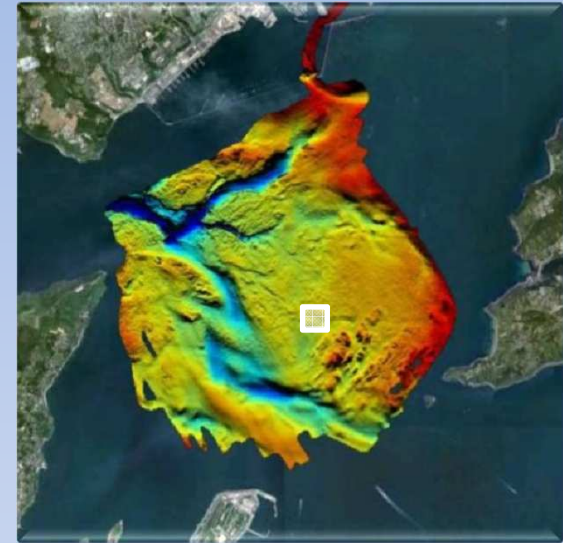
### FR - SHOM - IFREMER areas

- Several reference areas
- Depth 25 to 60 m – Flat + wrecks
- Selected by SHOM for bathymetry trials
- Candidates for becoming BS reference areas

E.g. Carré Renard:

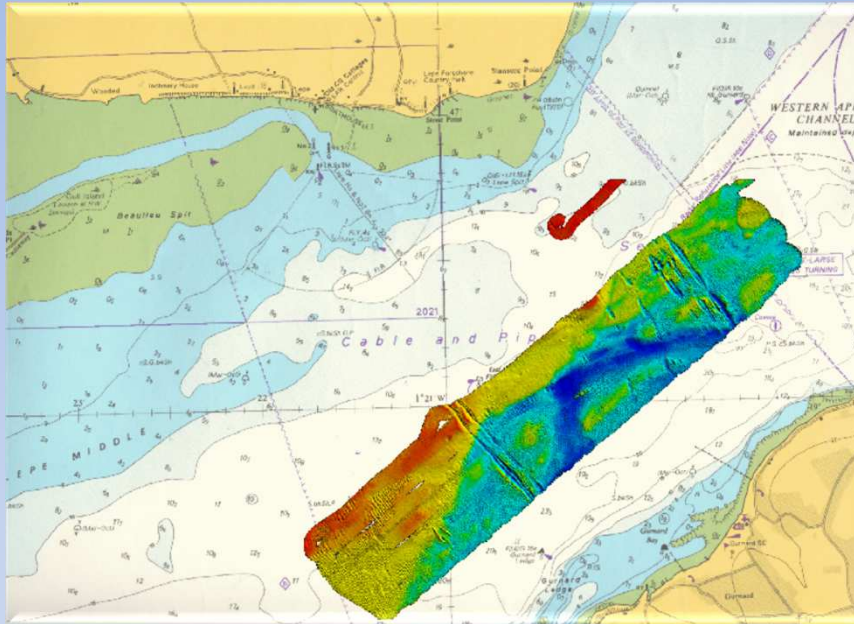
- Depth  $\pm 25$  m
- Coarse sediment
- Long time series with HF MBES (EM 3002, EM 2040)

### In/around the Bay of Brest



## Reference area

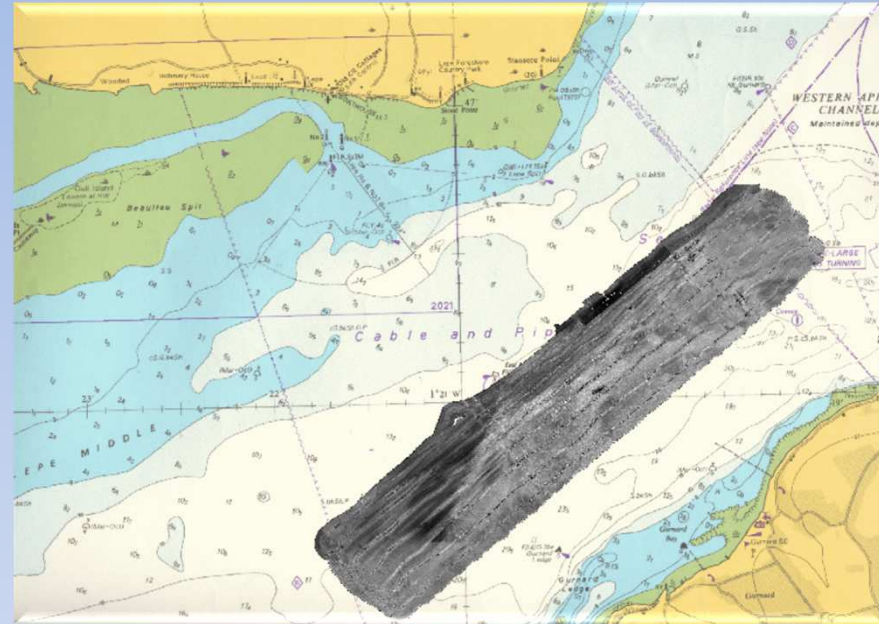
### UK - National Oceanography Centre area



Teledyne Reson 7101 – 240 kHz

- 7 km<sup>2</sup>, depth from 10 to 30 m
- sand + gravels
- strong tidal currents
- non-mooring area (pipelines + cables)

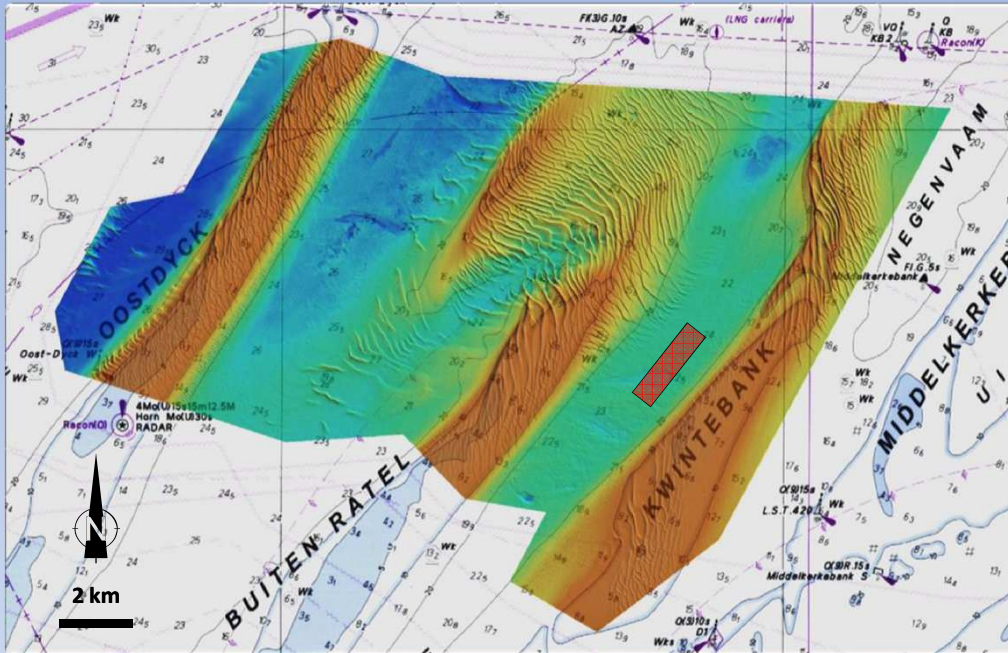
### Western Solent area



- MBES Teledyne Reson 8101 or 7101 surveys for 2008 to 2014 (1 per year)
- Plus some sidescan and ground truth data.

## Reference area

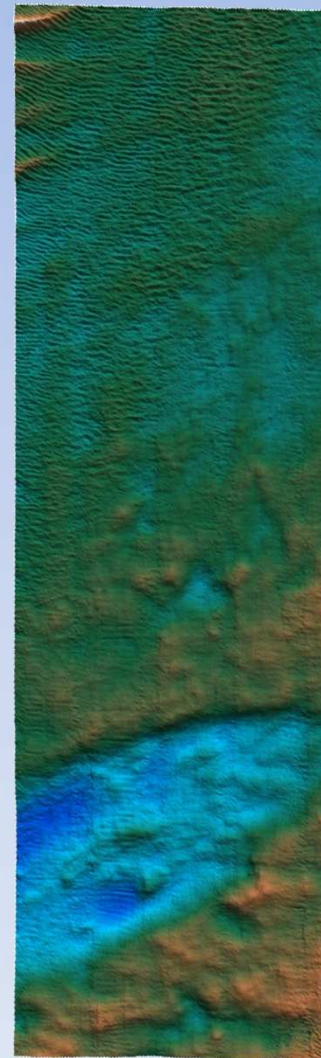
### Belgian Teams



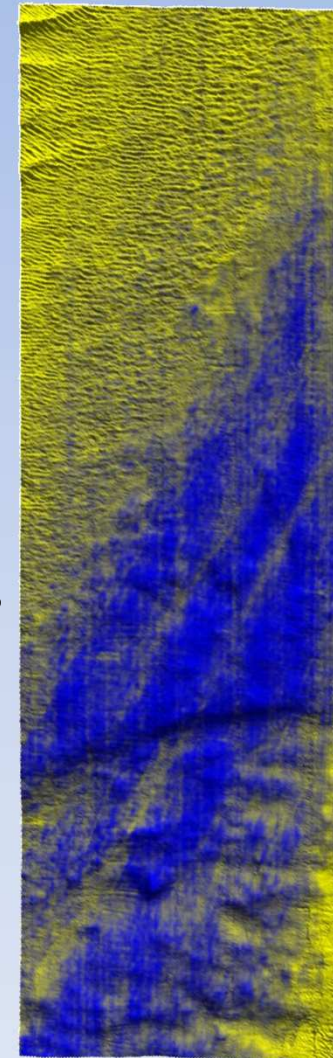
- 6.5 km<sup>2</sup>, depth from 22 to 26 m MLLWS
- sand + gravels
- strong tidal currents
- EM1002 (4 surveys from 2008 to 2011)
- EM3002D (9 surveys from 2009 to 2015)
- EM2040 (2 surveys from 2013 to 2014)
- Sidescan sonar (Remus – SS 900 kHz)
- Ground truth data: SPI, video, grab samples...

### Flemish sandbank KWGS area

#### Bathymetry



#### BS draped



## Inter comparison on reference area

HV Ter Streep  
EM3002D 300 kHz



21/09/2012

RV Belgica  
EM3002D 300 kHz

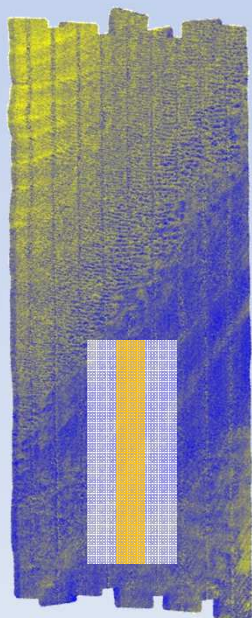


18/09/2012

RV Simon Stevin  
EM2040 @ 300 kHz



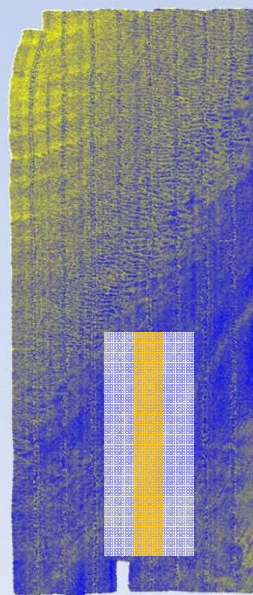
18/09/2012



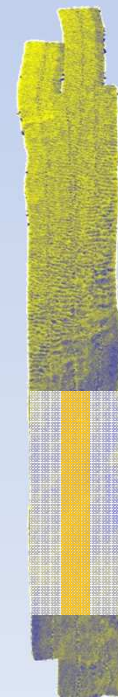
-15  
BS  
dB

-35

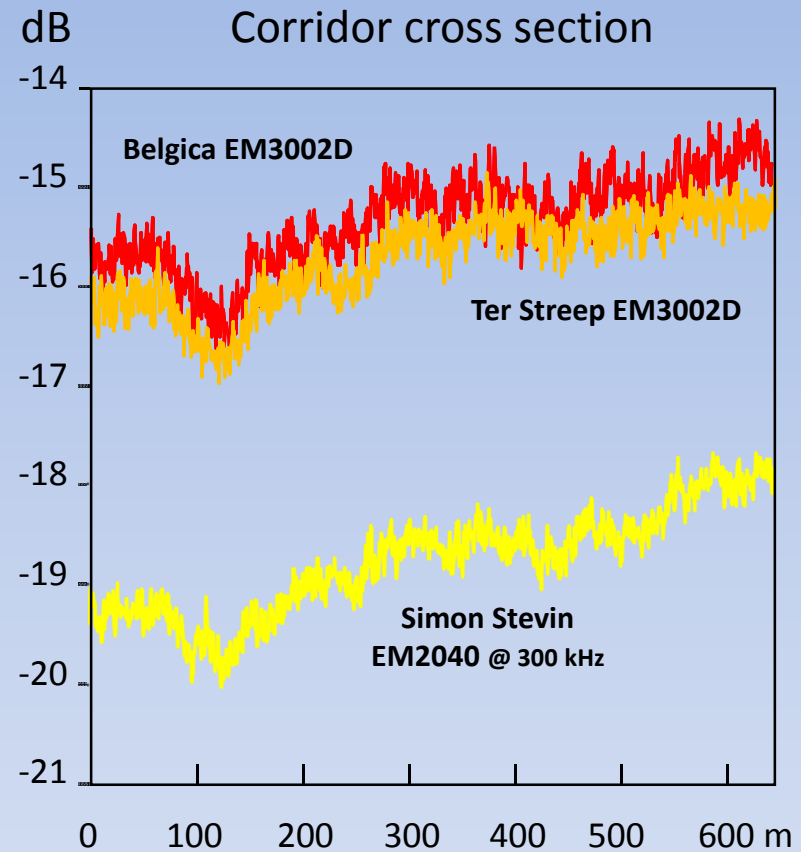
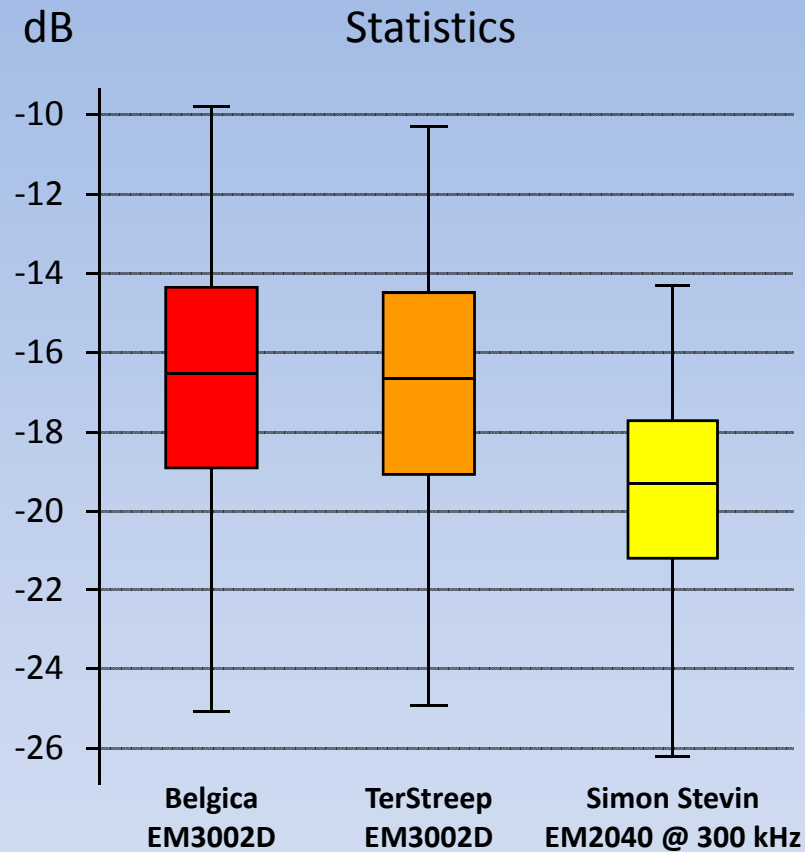
0 200 m



- Statistics on common area
- Along corridor cross section

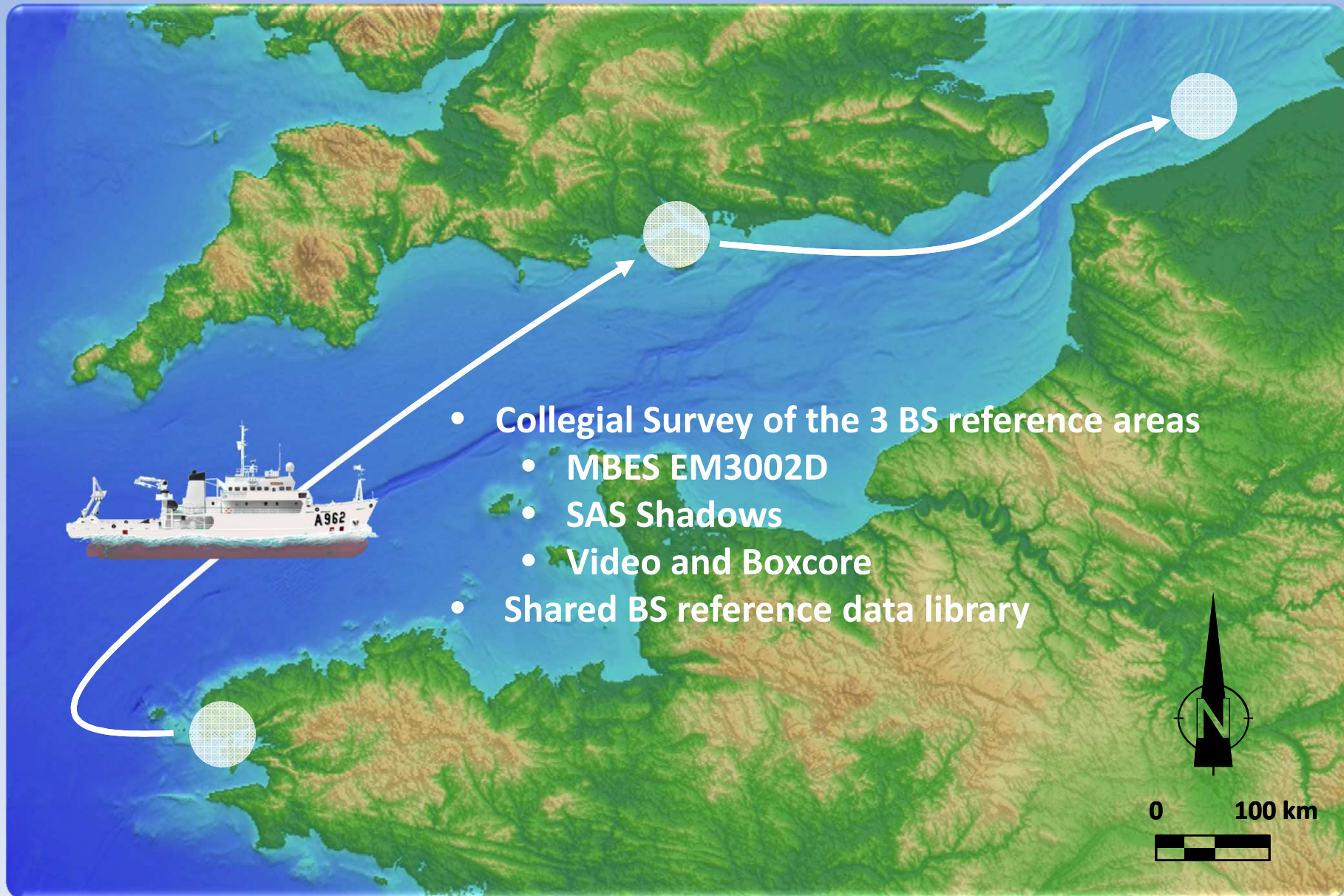


## Inter comparison on reference area: results

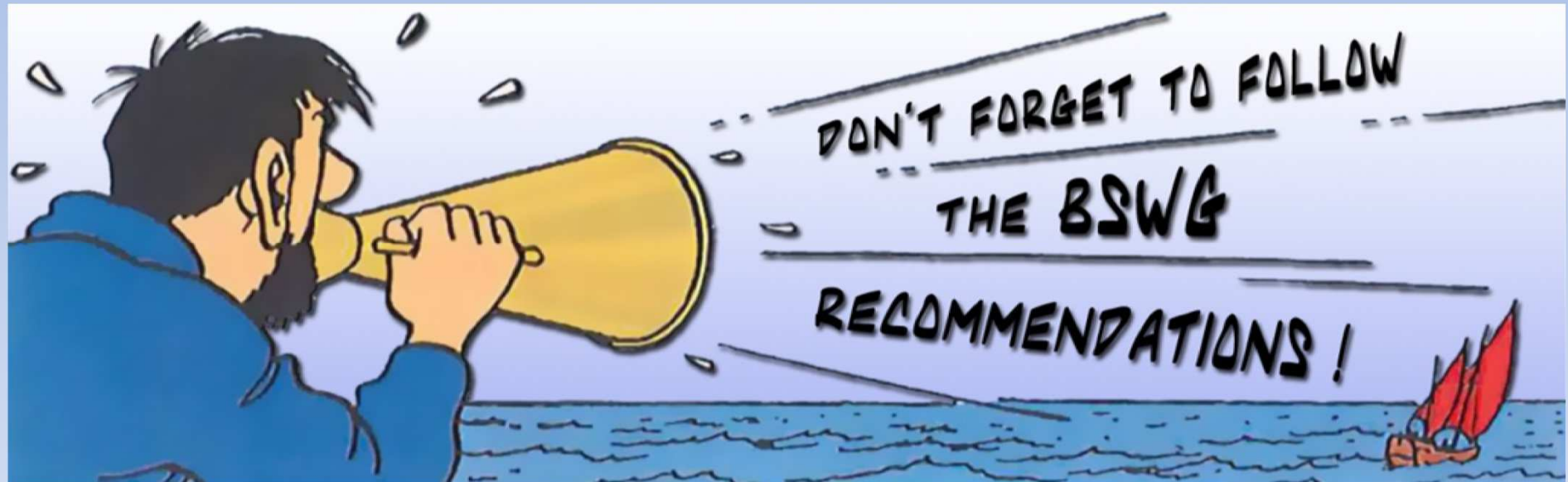


- dB level from Ter Streep and Belgica EM3002D fully comparable
- EM2040 @ 300 kHz not comparable with EM3002 300 kHz ( $\Delta$  2-3 dB)

## Sharing BS reference area: RV Belgica C1516 – 10-16/06/2015



## Concluding message



*Thank you for your attention!*

*Special thanks to the BSWG Chairing Committee  
and Editors.*



*Os meus sincero agradecimentos aos  
colegas brasileiros pela vossa  
hospitalidade em Salvador da Bahia,  
cidade de todos os Santos e dos grandes  
Jorge Amado e Dorival Caymmi.*