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Wissenschaftliche Monitoringkonzepte für die Deutsche Bucht

Development and validation of hydroacoustic monitoring concepts for the coastal German Bight (SE North Sea)

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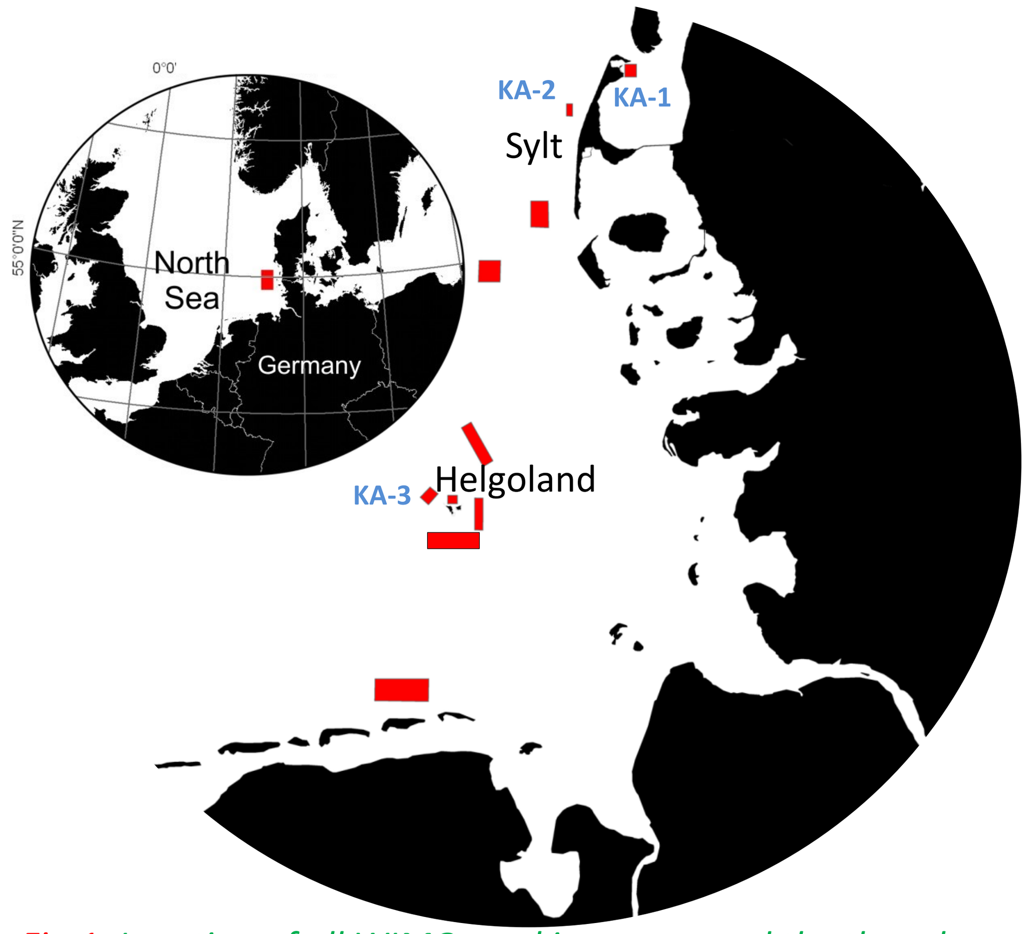


Fig.1: Location of all WIMO-working-areas and the three key areas (KA) which will be introduced on this presentation.

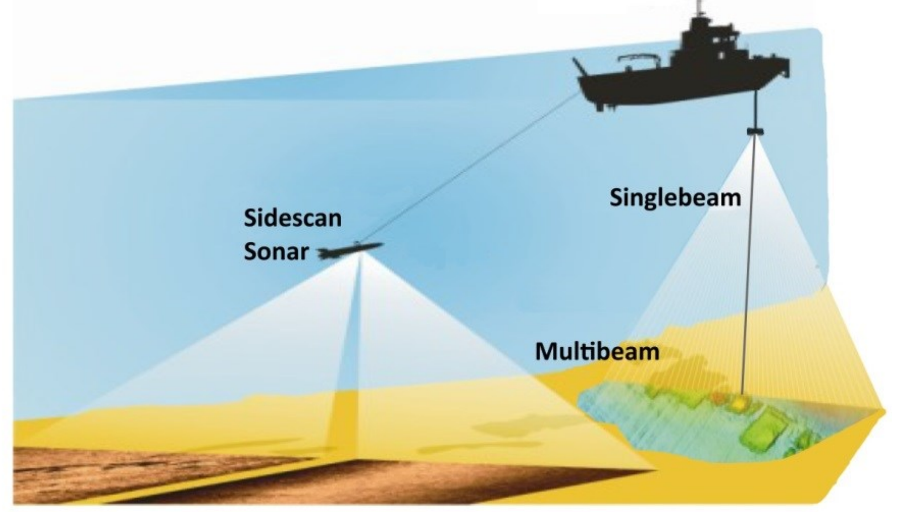


Fig.2: Hydroacoustic methods for determining seafloor properties. Sidescan sonars are towed behind the ship while single/multibeam devices are hull-mounted. All devices emit acoustic waves at different frequencies which are reflected by the seafloor. The backscatter characteristics and intensities can give information about sediment distribution, vegetation and seafloor features like ripples or dunes.

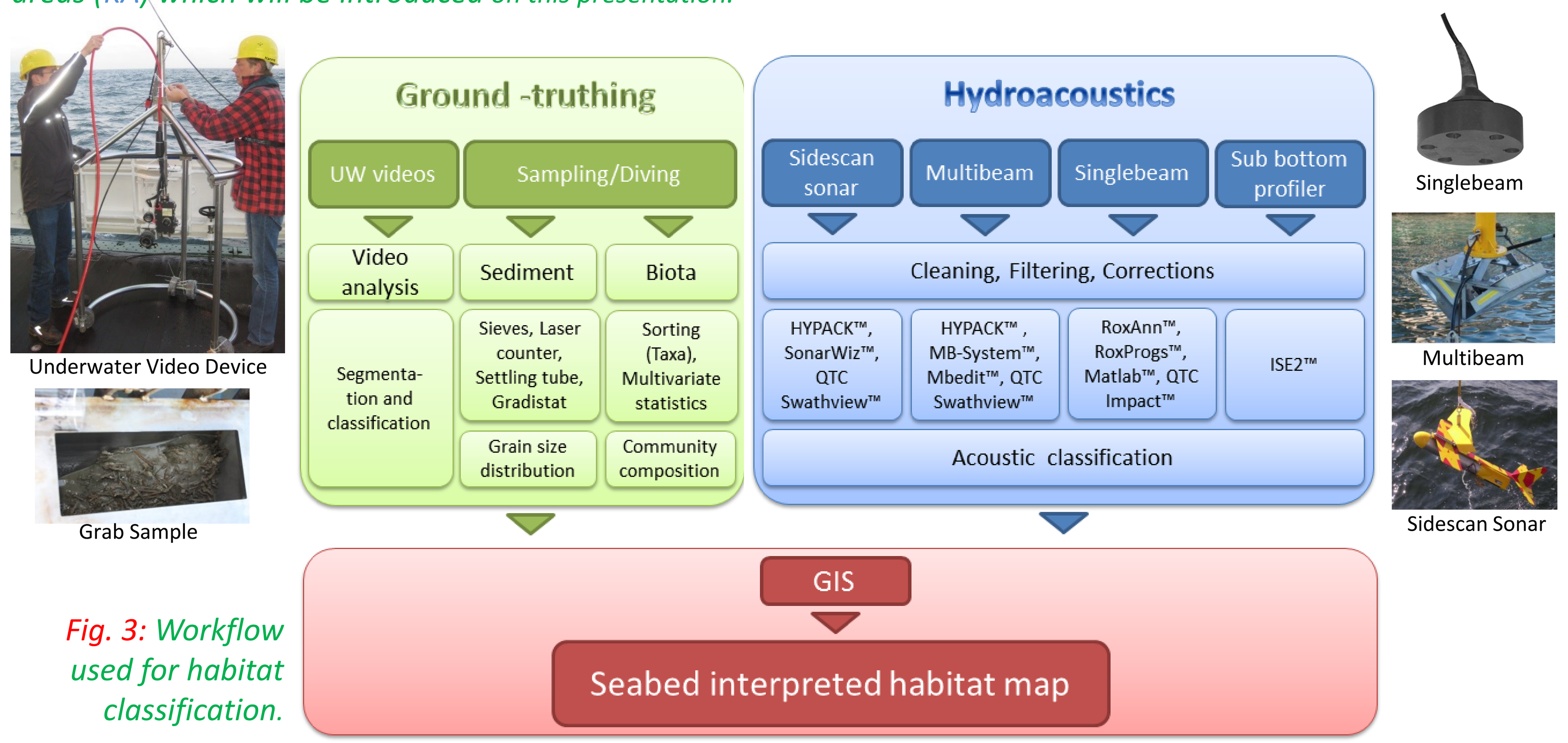


Fig. 3: Workflow used for habitat classification.

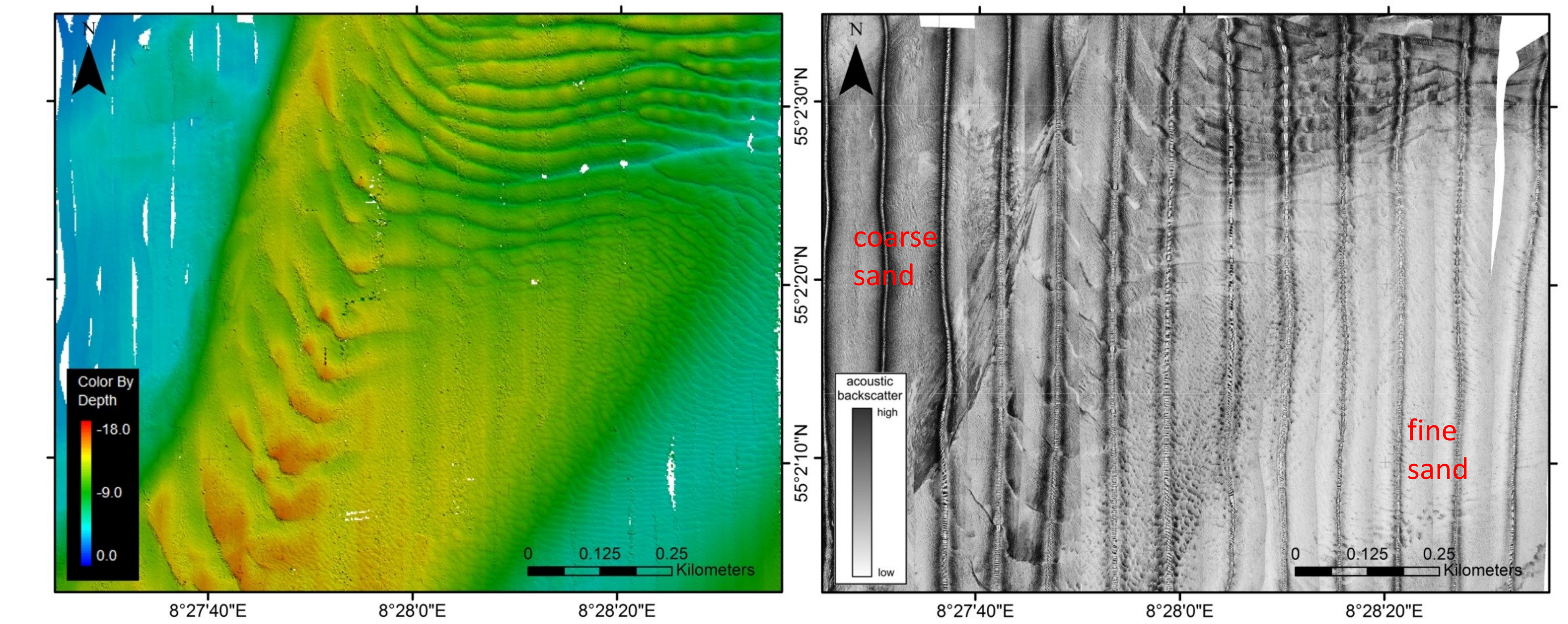


Fig.4: Bathymetric map measured with multibeam showing subaquatic bedforms of different sizes (left). Their alignment and size provide information about migration direction and hence sediment transport. The dunes also become visible in the sidescan records (right), but not as detailed as in the multibeam data. However, sidescan images provide accurate information about seafloor backscatter where high values are an indicator for coarser sediment.

The joint research project **WIMO** (Monitoring Concepts for the German Bight, SE North Sea) aims at providing methods for the detection and analysis of **seabed habitats** using modern remote sensing techniques. We here present spatial information on seafloor environments and sediment dynamics obtained from **hydroacoustic sounding**.

In a timeframe of four years, ten key areas in the German Bight (Fig. 1) were repeatedly observed using different hydroacoustic gear (Fig. 2). Five different **sidescan sonars** were used (frequencies between 100 and 1000 kHz) in consideration of extensively scan the seafloor to determine its backscatter characteristics at different working frequencies. Additionally, **singlebeam** acoustic ground discrimination systems and **multibeam** echosounders were employed. In order to ground-truth the acoustic data, hundreds of grab samples and underwater videos were taken (see flowchart, Fig.3).

The conducted **monitoring program** revealed ongoing **sedimentary processes** driven by tidal currents and wind/storms. It was also possible to determine relationships between sediment characteristics and benthic communities in some key areas such as **seasonal changes** regarding the abundance of the sand mason worm (*Lanice conchilega*) and the brittle star (*Amphiora filiformis*). The results of three important working areas (KA) are described below.

KA-1 is located in the Wadden Sea sheltered by the barrier island of Sylt. The area is characterized by **subaquatic dunes** of different sizes (Fig. 4).

In KA-2, which is located west off the Island of Sylt, sidescan measurements reveal sinuous shaped seafloor features consisting of rippled medium-to-coarse sand. These so-called **sorted bedforms** are surrounded and sometimes even covered by fine sand. Comparisons between the data sets of the years 2012 – 2014 reveal no significant change regarding the morphology and distribution of the sorted bedforms (Fig. 5). However, the boundaries are oscillating, which might be the result of storm events. In this case, sidescan sonars with high range are the **most suitable tools** for observing and monitoring this sandy and relatively smooth domain.

Since the seafloor in the SE North Sea is mostly characterized by unconsolidated sandy sediments, the Island of Helgoland and the surrounding coastal waters are of an exceptional nature because **hard rock ridges** can be found on the seafloor (KA-3). The wide variety of the seafloor sediments ranging from **muddy sand** to **hard ground** was very well suited for a **cross-system comparison**, which was an essential part of our project. The comparision reveals that there could be **distinct differences** in interpreting the data and hence in the determination of prevailing seafloor habitats, especially in very **heterogeneous areas** and at **transition zones** between the habitats (Fig. 6). Therefore, it is recommended to employ more than one hydroacoustic system (preferably a singlebeam device combined with a wide-swath sonar system) **synchronously** during a survey in order to gain more reliable and detailed information about the seafloor environments.

Conclusion:

The presented results are an important contribution to ongoing and future projects, in particular with regard to the technical configuration of the sonar systems, the workflows concerning post-processing and validation of the hydroacoustic data as well as the monitoring concepts. Unfortunately, a full automation of these workflows is not feasible. For the time being, measurements, post-processing and data evaluation still need supervision and expert knowledge.

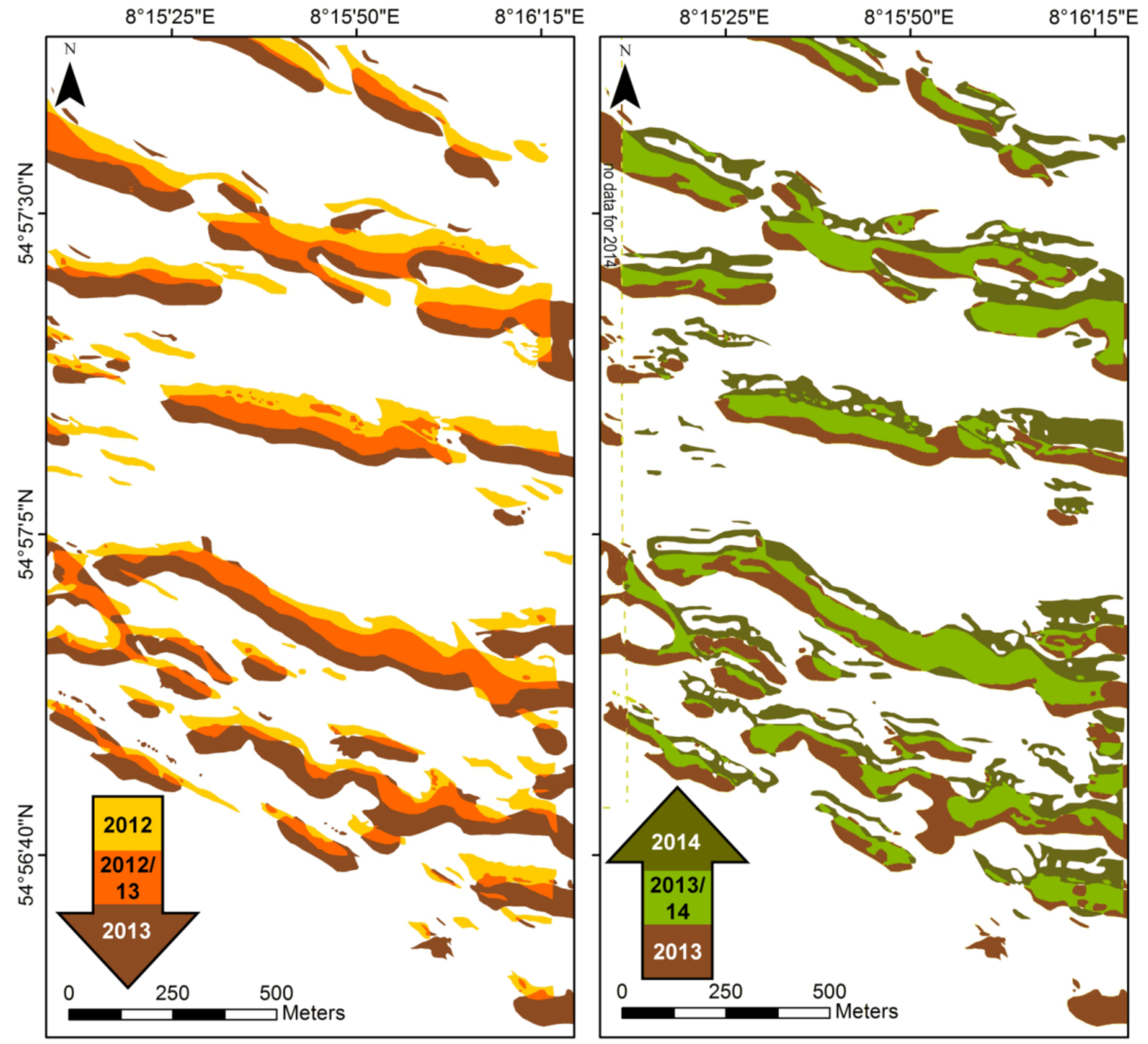
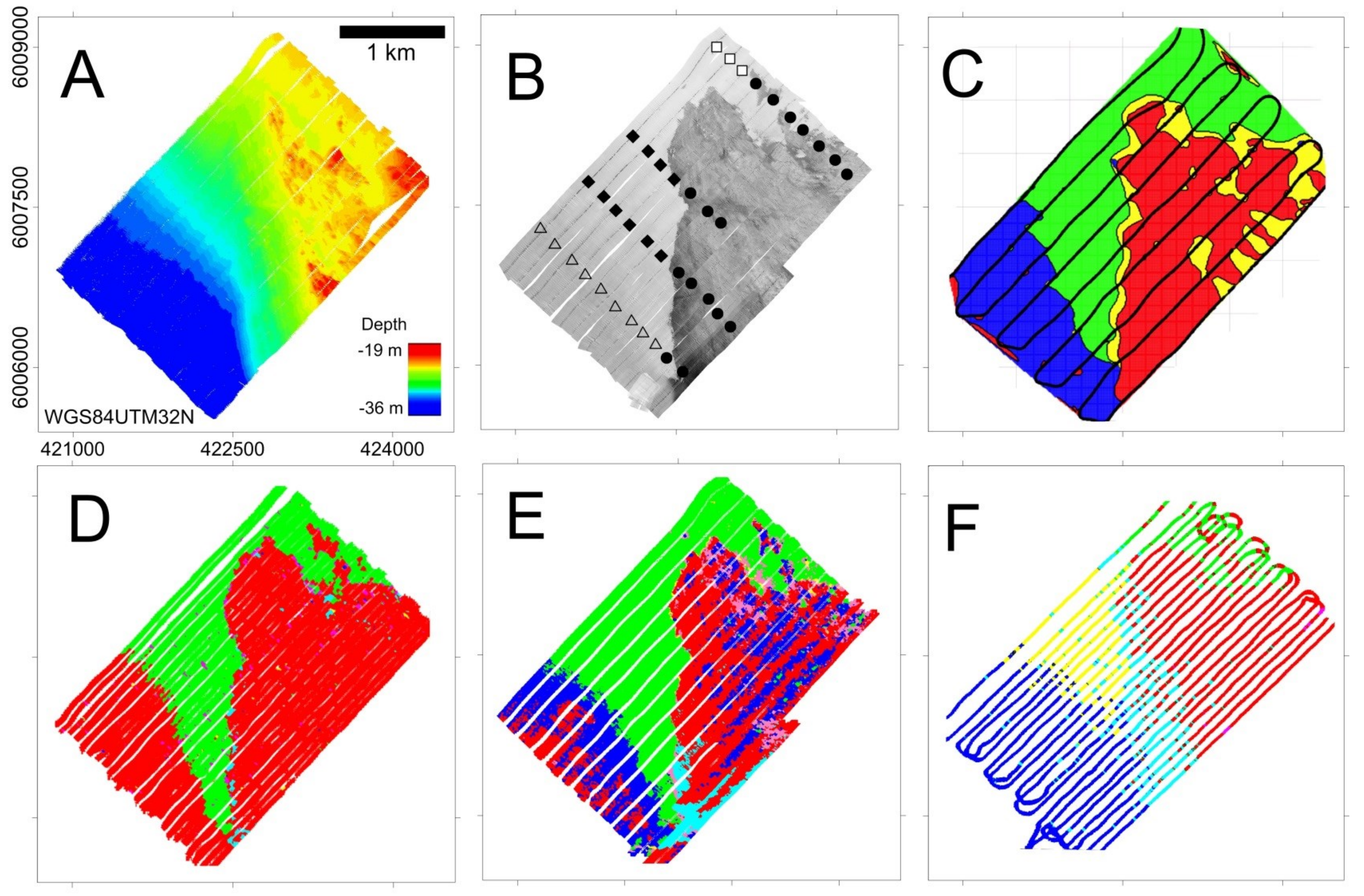


Fig.5.: Shape and alignment of sorted bedforms located in KA-2 and the observed changes between the years 2012 and 2014. Information were collected using sidescan sonar.



C

	Area %	□	◆	△	●
RED	34.6	0.0	27.3	9.1	63.6
GREEN	33.2	15.8	52.6	15.8	15.8
BLUE	21.2	0.0	0.0	100.0	0.0
YELLOW	11.0	0.0	0.0	33.3	66.7

D

	Area %	□	◆	△	●
RED	70.5	0.0	4.2	33.3	62.5
GREEN	28.6	20.0	60.0	6.7	13.3
CYAN	0.7	0.0	0.0	0.0	0.0
PINK	0.2	0.0	0.0	0.0	0.0

E

	Area %	□	◆	△	●
RED	34.0	0.0	11.1	0.0	88.9
GREEN	33.7	21.4	64.3	0.0	14.3
BLUE	23.3	0.0	0.0	64.3	35.7
PINK	5.2	0.0	0.0	0.0	100.0
CYAN	3.3	0.0	0.0	0.0	100.0
YELLOW	0.5	0.0	0.0	0.0	0.0

F

	Area %	□	◆	△	●
RED	36.2	0.0	0.0	0.0	100.0
BLUE	32.2	0.0	0.0	63.6	36.4
CYAN	11.9	0.0	12.5	25.0	62.5
YELLOW	10.6	0.0	100.0	0.0	0.0
GREEN	8.8	75.0	0.0	0.0	25.0
PINK	0.4	0.0	0.0	0.0	0.0

□ Muddy sand , *Nucula nitidosa* and *Abra alba*
◆ Muddy sand , *Nucula nitidosa* and *Amphiura filiformis*
△ Muddy sand, *Amphiura filiformis* and *Kurtiella bidentata*
● Hard ground (coarse sand, gravel and cobbles), hard substrate community

Gravel/Stones · Transition 1 · Transition 2 · Transition 3 · Sand/Mud · Transition 4

Fig.6.: Comparision between different hydroacoustic systems and post-processing methods in WA-3 northwest of Helgoland. Depending on the system and method, different transition zones could be determined.

A: *Bathymetry measured with multibeam echosounder Reson 8125 (455 kHz).*
B: *Sidescan mosaic measured with Benthos 1624 (100 kHz) as well as evaluated ground truth information.*
C: *Singlebeam echosounder RoxAnn (200 kHz) and FCA seafloor classification.*
D: *QTC-Swathview seafloor classification based on backscatter of the multibeam echosounder (455 kHz).*
E: *QTC-Swathview seafloor classification based on backscatter of sidescan sonar Benthos 1624 (100 kHz).*
F: *Singlebeam echosounder Furuno FCV 295 (200 kHz) + QTC 5.5 seafloor classification.*