

Hydroacoustic monitoring of sorted bedforms west off Sylt (SE North Sea)

Interannual variabilities during five years

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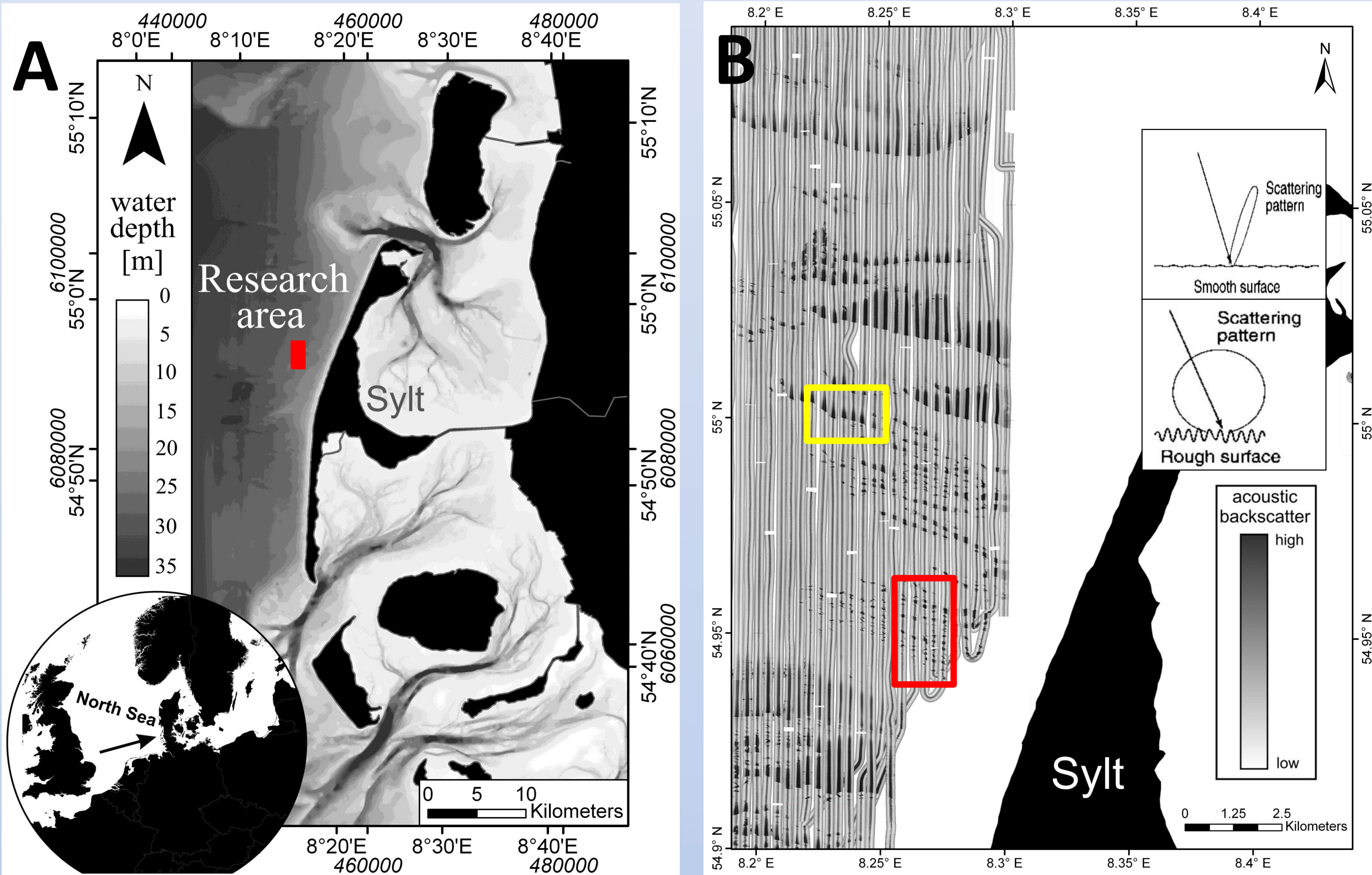


Fig. 1a: Study site located in the shallow North Sea west off the island of Sylt in water depth of ~12 m (red box). Fig. 1b: Sidescan mosaic showing the backscatter intensities of the seafloor. Sorted bedforms are indicated in dark grey. They yield high backscatter intensities because of their rough surface induced by small ripple marks.

2 The measurements reveal sinuous shaped sorted bedforms consisting of rippled medium sand which are surrounded by smooth fine-sand areas (Fig. 3a). Investigations regarding the prevailing morphology show that the coarser grained ripple zones are basically linked to a gully system which crosses the study site and cut through the Holocene layer (Fig. 4). Comparisons between the data sets of the years 2007 – 2012 reveal no significant change regarding the morphology and distribution of the sorted bedforms (Fig.3b). However, small scale changes at the boundaries to the fine-sand areas become apparent. Migration trends could not be detected. In fact, the boundaries are oscillating. Additionally, new minor bedforms and small rippled excavation marks developed and disappeared during the measure campaign.

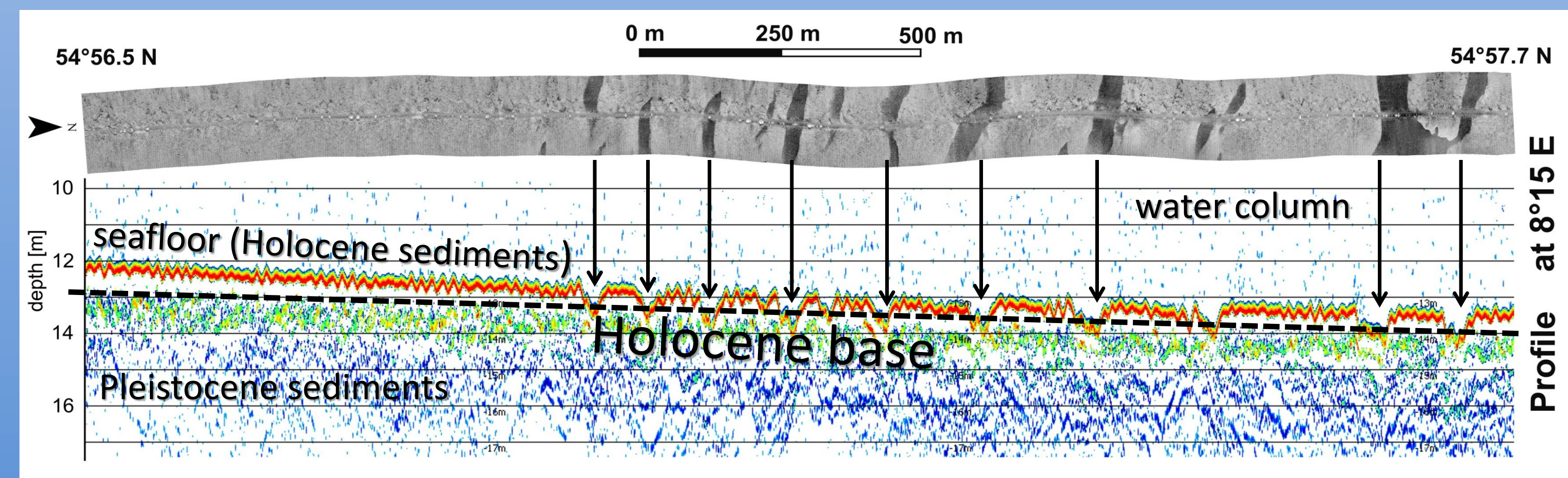


Fig. 4: Sidescan sonar transect and corresponding subbottom profile. The gully system cuts through the Holocene layer (red line) and hence Pleistocene material (rippled medium sand) becomes exposed.

1 Sorted bedforms are grain-size-sorted patterns which can be found in coastal shelf areas worldwide. They are consisting of rippled medium-to-coarse sand and are typically surrounded by fine sand. The narrow sand bands can reach lengths of several kilometers and it is reported that their general appearance remains stable over decades. However the knowledge regarding their development is still sparse. Aim of this study was to investigate short-term and small-scale variabilities of occurring sorted bedforms in an area which is strongly influenced by tidal currents and storm surges. The investigations took place within a time frame of five years in order to obtain new knowledge about the origin and development processes of these seafloor features.

Sorted bedforms are relatively easy to detect by means of hydroacoustic gear because their rippled surface induce high acoustic backscatter. For this study, a small study area (Fig. 1) located west off the island of Sylt (SE North Sea, Germany) was annually surveyed using high-resolution sidescan sonar devices. In order to investigate the seafloor in a multifold way, towfishes with different frequencies and hence different resolutions and ranges were applied (Fig. 2).

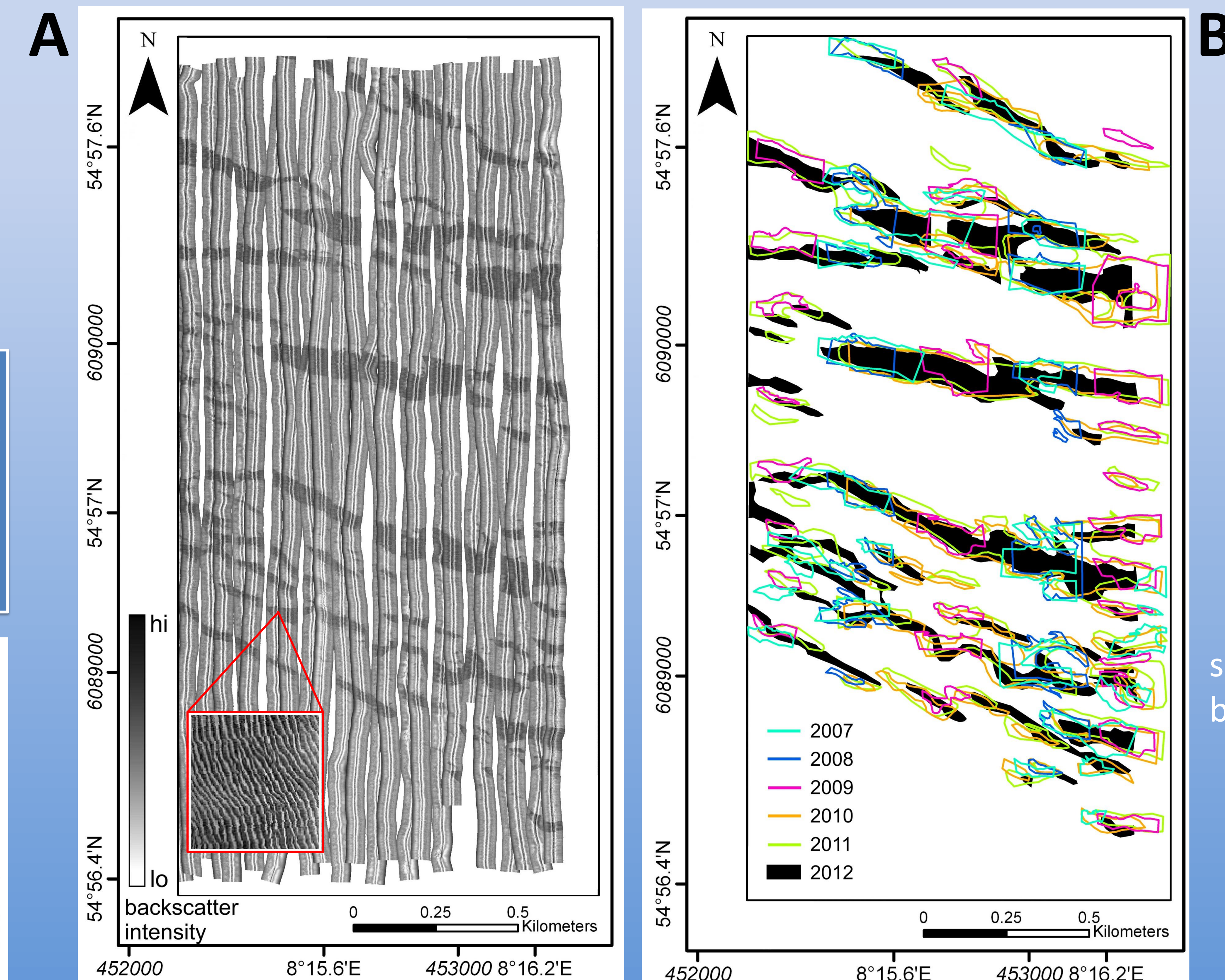


Fig. 3a: Sidescan sonar mosaic of the study area recorded in 2012. A close-up view of the sonography reveals small ripple marks with wavelengths of ~1 m. Fig. 3b: Shape and alignment of the sorted bedforms between the years 2007 and 2012. Straight borders (left and right) are the result of data gaps occurred in the years 2007, 2008, and 2009.

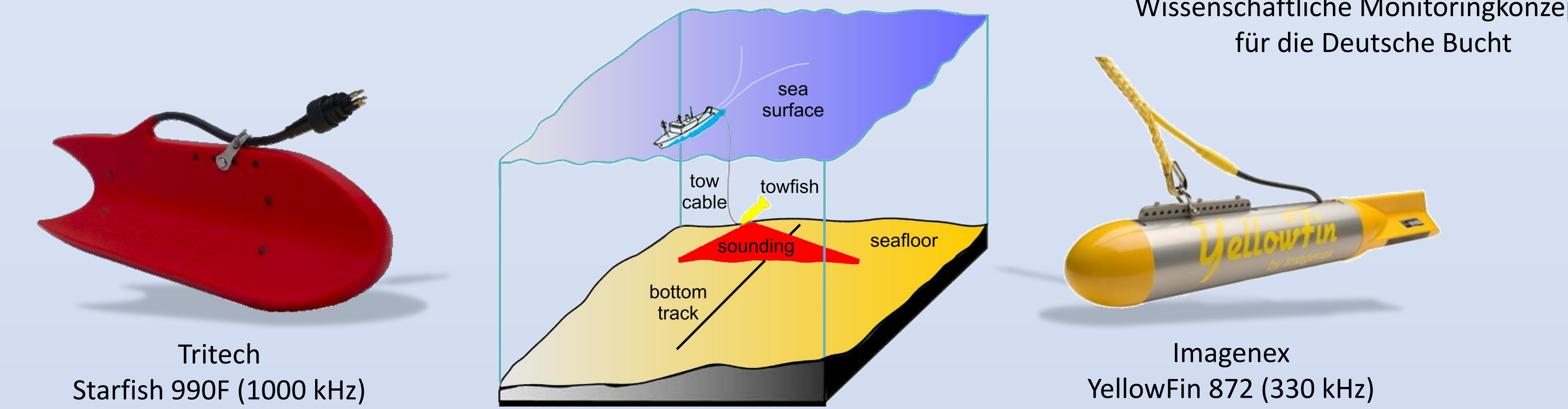


Fig. 2: General functionality of a sidescan survey as well as the applied sonar devices.

3 The studied bedforms are flow-transverse features which were maintained by ebb and flood currents in a bidirectional flow field (northern/southern direction). Both currents are almost of equal strengths (~0.5 m/s). This flow field seems to generate the sharp boundaries between the two sand domains in both directions and hence lead to a symmetric character of the bedforms (Fig. 5a). Further to the North, where the flow-field changes and unidirectional flood currents are dominating, asymmetric bedforms were detected (Fig. 5b). They show only one sharp boundary aligned contrary to the current direction. Leeward a gradual transition from coarse to fine sand becomes apparent. These bedforms seem to migrate in flow direction. Moreover, a change in the alignment and size of the small ripple marks at both symmetric and asymmetric bedforms was determined. We assume that these variations are due to storm events while intensity and direction of the surges were manifested in the size and alignment of the small ripples. Changes regarding the boundaries between the sand domains documented in Fig. 3b might also be the result of strong currents occurring during storm events which transport and relocate the fine-grained sediments.

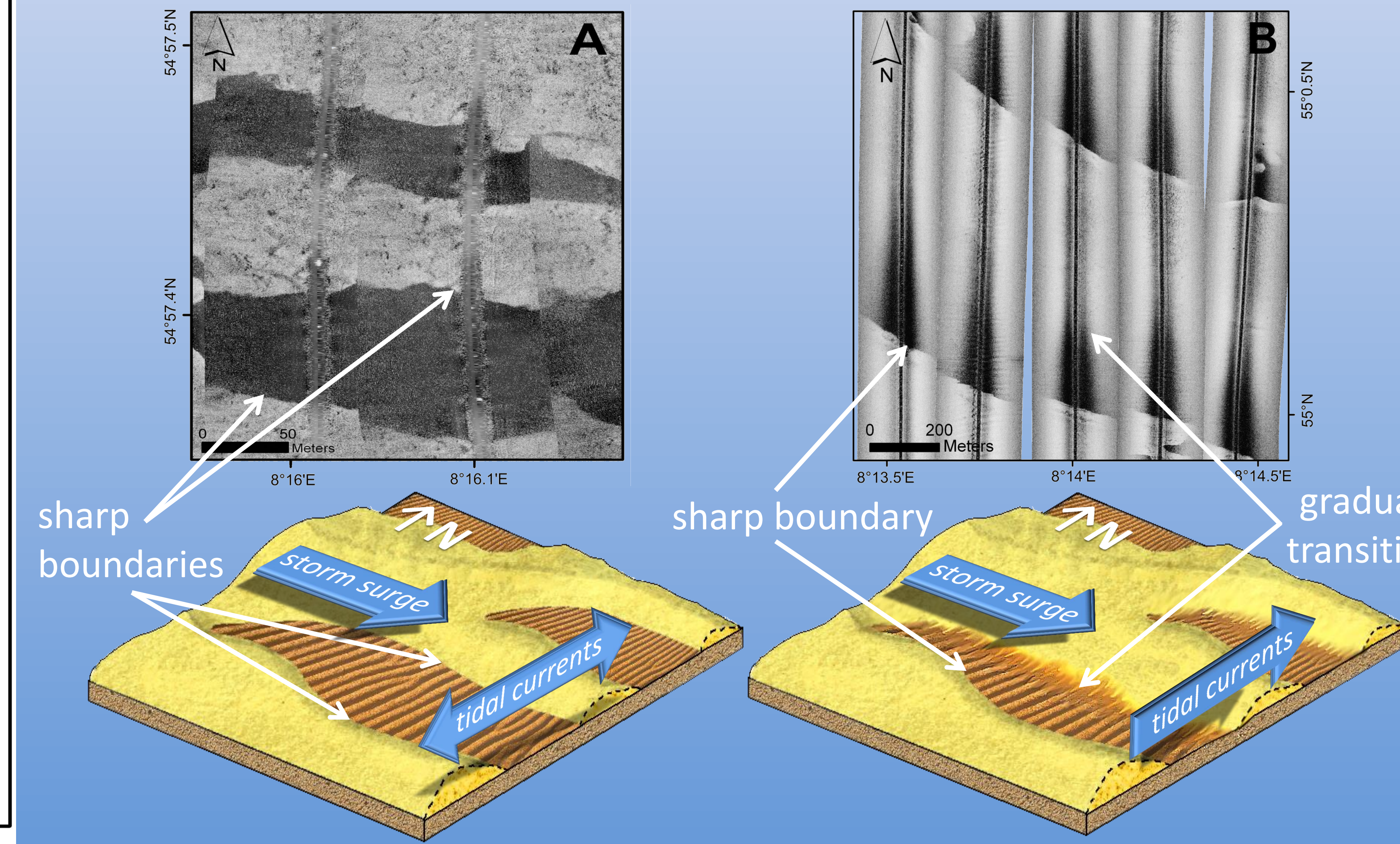


Fig. 5a: Sidescan sonar mosaic of symmetric sorted bedforms (two sharp boundaries) appearing in a bidirectional flow field as well as illustration of the crucial sediment processes.

Fig. 5b: Sidescan sonar mosaic of asymmetric sorted bedforms (one sharp boundary and a transition zone) appearing in a unidirectional flow field as well as illustration of the crucial sediment processes. For location see yellow box in Fig. 1b.