L10-20 Cruise Report

FK Littorina in front of Stohl cliff – photo: C. Winter

25.05. – 04.06.2020

Kiel – Heiligenhafen – Stohl – Schönhagen

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Abstract

Cruise L10-20 was carried out in the framework of the project '*Morphologische Projektionen Ostseeküste 2100' (Morphological projections Baltic Sea Coast; financed by MELUND)*. The purpose of this cruise was to collect information on seafloor topography and sedimentology and shallow sub-seafloor stratigraphy of the morphodynamically active coastal zone of the focus areas *Heiligenhafen*,*Stohl* and *Schönhagen*. All three areas feature erosional cliff coasts acting as a sediment sources during high energy wave events. One of the aims of the project is to identify sediment transport pathways from the cliffs to the nearshore zone and to quantify the sediment budget in the coastal transport cells. This cruise served as a baseline study to be complemented during repetitive future cruises to the focus areas.

Kurzfassung

Die Ausfahrt L10-20 wurde im Rahmen des Projekts „*Morphologische Projektionen Ostseeküste 2100“ (finanziert vom MELUND)* durchgeführt. Ziel dieser Fahrt war es, Informationen zur Meeresbodentopographie und -sedimentologie sowie zur flachen Untergrundstratigraphie der morphodynamisch aktiven Küstenzone der Schwerpunktgebiete *Heiligenhafen, Stohl* und *Schönhagen* zu sammeln. Alle drei Gebiete weisen erosive Steilufer auf, die bei Wellenereignissen mit hoher Energie als Sedimentquelle dienen. Eines der Ziele des Projekts ist es, Sedimenttransportpfade von den Steilufern ins Küstenvorfeld zu identifizieren und das Sedimentbudget in den Küstentransportzellen zu quantifizieren. Diese Fahrt diente als Basisstudie, die bei wiederholten zukünftigen Fahrten zu den Fokusgebieten ergänzt werden soll.

Methods and Data

Seafloor bathymetry and backscatter were acquired with a multibeam echosounder (MBES, *NORBIT iWBMS STX*). Sound velocity profiles were calculated from salinity, temperature and pressure data obtained from CTD casts (*Sea&Sun CTD 48M*). Information on the shallow sub-seafloor stratigraphy was recorded with a parametric sub-bottom profiler (SBP, *Innomar SES-2000 standard*). The hydro-acoustic sensors were mounted on a pole on the starboard side of the vessel (Figure 1a).

Positioning was performed using a RTK GNSS system with online SAPOS corrections allowing for horizontal and vertical accuracy within centimeter range.

Surface sediment samples were taken with a Van Veen grab sampler. Underwater videos were recorded from a flying frame (Figure 1d) using a network camera (*Vivotek IP9191-HT*) and two consumer action cameras (*GoPro HERO7/8*). Live feeds were available from the network camera (via single-conductor cable) and from the GoPro HERO8 (via WIFI extension cable; Figure 1e).

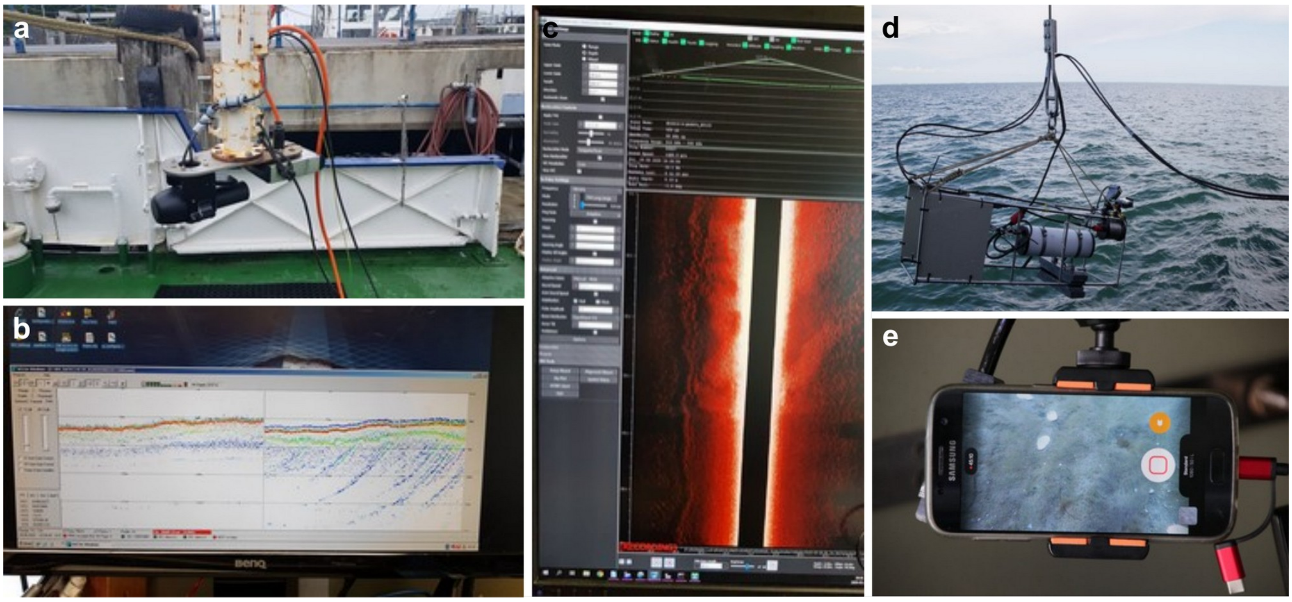

Figure 1: Hydro-acoustic devices and underwater video system.(a) MBES (left) and SBP (right) mounted at the bottom of the pole before deployment over the starboard side. (b) SBP and (c) MBES acquisition software. (d) Flying frame for the underwater video system in forward-looking configuration. (e) Live feed from the GoPro HERO8 camera via WIFI extension cable.

Narrative of the cruise

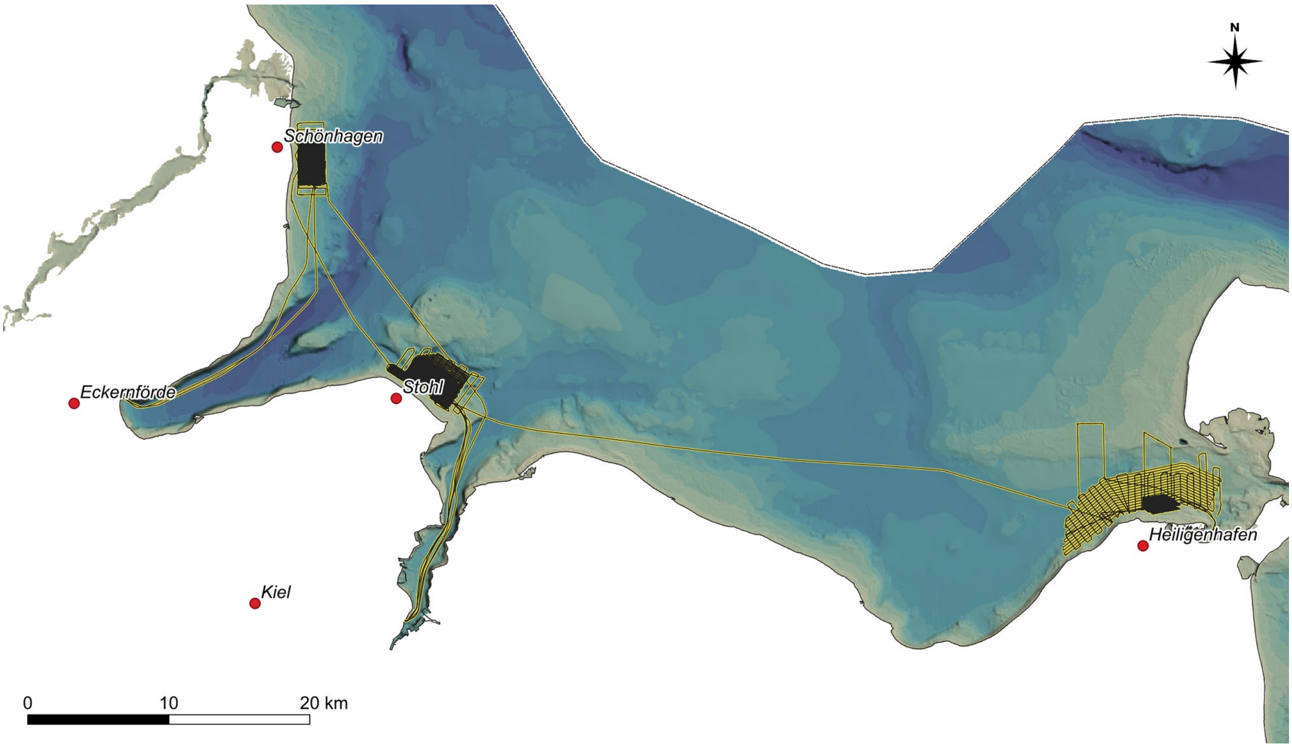

Figure 2: Overview map and track of cruise L10-20 with focus areas Heiligenhafen, Stohl and Schönhagen and port calls in Kiel, Heiligenhafen and Eckernförde.

2020-05-25

After setting up the pole with MBES and SES transducers we left Kiel at 09:15 local time and arrived in the first research area in Heiligenhafen after three hours of transit under a fresh breeze and moderate seas. The pole was lowered and we ran a heading alignment calibration for the MBES system.

At 15:00, we started the first transect following the -5 m contour along from the cliff coast West of Heiligenhafen up to Steinwarder/Graswarder (Figure 3). The -5 m contour was chosen as the landward limit for the following surveys given draft limitations of FK Littorina.

At 17:00, we started a series of coast normal transects extending 1.5 nm from the 5 m baseline with a lateral spacing of 0.25 nm. Two transects were extended across Fehmarnsund up to the 5 m line on its northern shore.

2020-05-26

The coast normal transects were completed around 03:30. At 04:30, we started mapping an area of 1.2 x 2 km offshore Steinwarder/Graswarder Heiligenhafen which features shoreface connected submarine ridges with full spatial coverage. This mapping was continued until 23:30. Afterwards, another pair of transects across Fehmarnsund was collected.

2020-05-27

After completing the Fehmarnsund cross transect at 01:00, we started coast parallel transects with a length of 6 nm and a lateral spacing of 0.1 nm (185 m). The mapping in Heiligenhafen was completed around 17:30 with another pair of transects crossing Fehmarnsund. We then headed into the port of Heiligenhafen.

2020-05-28

The day was spent in the port of Heiligenhafen. We processed the collected hydro-acoustic data, planned the sampling strategy for the next day and tested the underwater video equipment.

2020-05-29

Between 07:30 and 11:00, we took 42 Van Veen grab samples. Two transects covered the nearshore ridges and additional samples were taken in the surrounding area to identify the sediment (). Starting at 12:15 we arranged the camera set up for the underwater video profiling. The first video profile (1h) covered a coast-parallel transect across the investigated ridges in the nearshore area in front of Heiligenhafen East (Graswarder). The second profile followed a regularly investigated divers transect in front of the NW-exposed cliff coast (Figure 3).

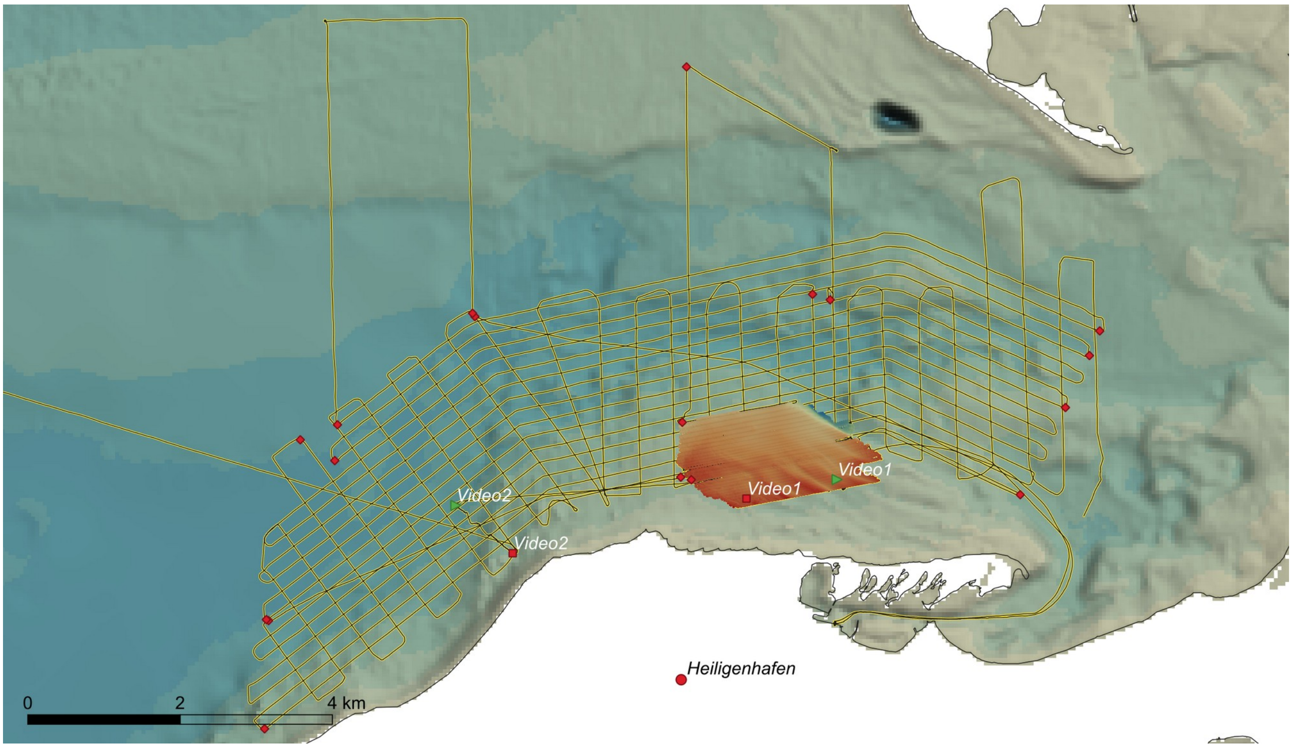

Figure 3: Overview of focus area Heiligenhafen showing coast-parallel and coast-normal MBES and SBP transects, CTD casts (red diamonds) , spatial extent of full coverage mapping area and video profiles.

At 16:30 we started the transit to the second focus area Stohl, where we arrived at 19:00. Here, the pole (MBES, SES) was lowered back into the water, heading alignment calibration and patch and rolltestsfor the MBES systems were carried out. At 20:00 we started the hydroacoustic mapping of the area with a transect along the -5 m NHN contour line. At 20:30 the mapping continued in an area of 0.35 x 1.2 nm with full spatial coverage in front of the NW part of the “Stohler Kliff” (presence of bottom set gill nets in the area). CTD profiles were measured in irregular intervals.

2020-05-30

We finished the grid at 5:30. Between 5:30 and 10:30, a series of coast normal transect were carried out extending 1.6 nm from the -5 m baseline with a lateral spacing of 0.25 nm. Subsequently, another set of CTD profiles were measured in irregular intervals. From 10:30we continued mapping another grid with full spatial coverage extending offshore to Stollergrundrinne.

2020-05-31

We finished the grid at 09:00. Afterwards, we completed the hydro-acoustic mapping in Stohl with another grid covering nearshore ridges seaward of the -5 m line. Measuring activities of the first leg completed at 14:00. We then headed into the port of Kiel. After processing the hydroacoustic data, we decided on a strategy for grab samples and video profiles.

2020-06-01

At 09:00 we left the port of Kiel and returned to Stohl. Between 10:00 and 14:00 we took 34 grab samples covering two coast-parallel and one coast-oblique transects across the Northwest ridge system. At 15:00 to we took a video profile of 0.5 nm length (1h) across the same ridges. We then headed back to Kiel.

2020-06-02

We left Kiel at 07:45 and returned to Stohl. From 09:15 we took a video profile normal to the coast over the nearshore ridges (1h). At 10:30 we started another video profile covering the offshore ridge system (25 min.). At 11:15 we started the final video profile (1h) in Stohl southeast of the first profile of this day.

From 12:45 until 15:00 we took another 13 grab samples covering the offshore ridge system and the slope from the abrasion platform into the deeper Stollergrundrinne. From 16:45 to 18:00 we calibrated the MBES and repeated mapping 5 lines over the Northwest ridge system.

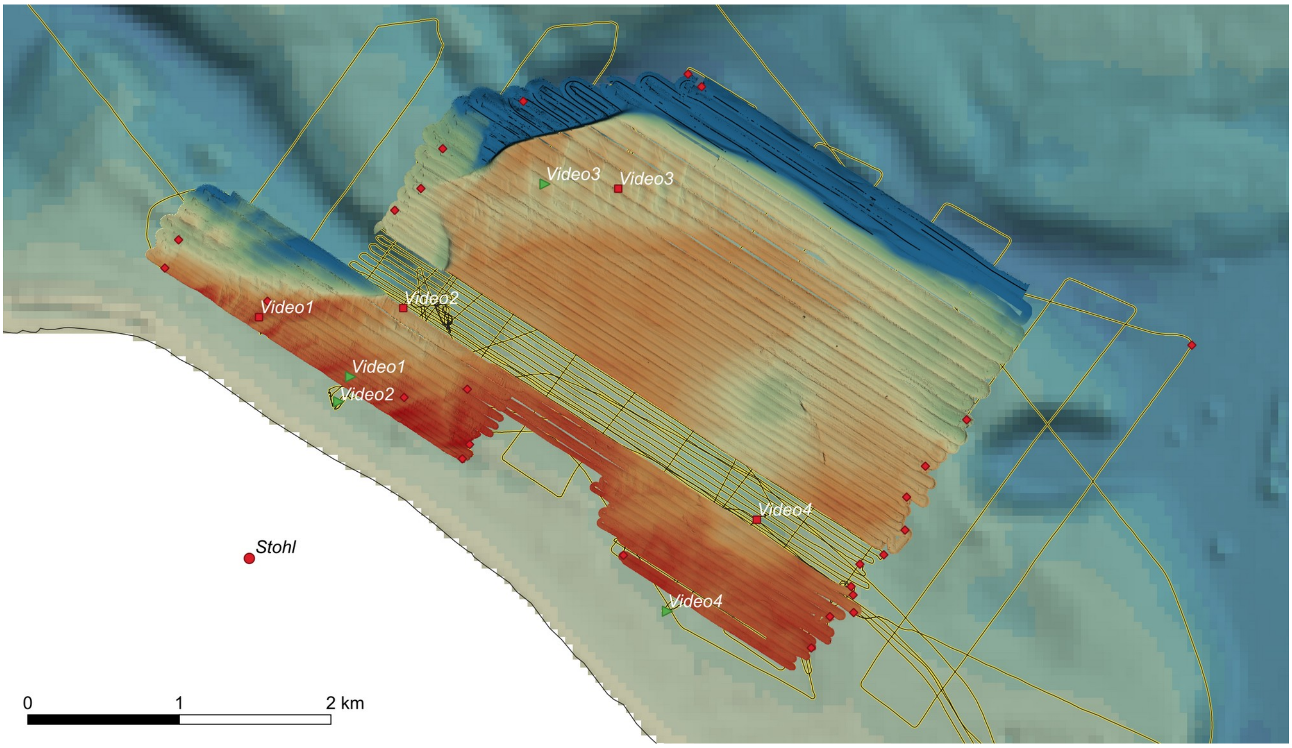

Figure 4: Overview of focus area Stohl showing coast-normal MBES and SBP transects, CTD casts (red diamonds) , spatial extent of full coverage mapping area and video profiles.

At 18:00 we started the transit to the third focus area Schönhagen (Fig.6). At 19:00 we arrived in the area of interest and started the hydro-acoustic mapping of the seafloor with a transect along the -5 m contour line. We mapped a set of coast normal profiles between 20:00 and 23:30 extending about 1nm seawards up to the restricted area. During the night (23:30 - 9:00) we continued mapping an area of 0.5 x 1.5 nm with full spatial coverage in the nearshore area. CTD profiles were measured in irregular intervals.

2020-06-03

At 9:00 we paused the hydro-acoustic mapping and started video profiling. We took in total 3 video profiles in areas of special interest, such as a coast normal profile along regularly investigated divers transect in front of the active cliff and a profile covering potential anthropogenic structures. Between 14:10 and 17:00 we took 21 Van Veen grab samples along 3 coast parallel lines. Some of these grab samples covered the areas, where video profiles were taken.

At 17:15 we continued with hydro-acoustic mapping of the nearshore grid. At 19:45 we started transit to Eckernförde.

2020-06-04

We left the port at 8:00 towards Schönhagen. Here, we finished the mapping of the nearshore grid. About 15:00 we left the study area and started the transit back to Kiel.

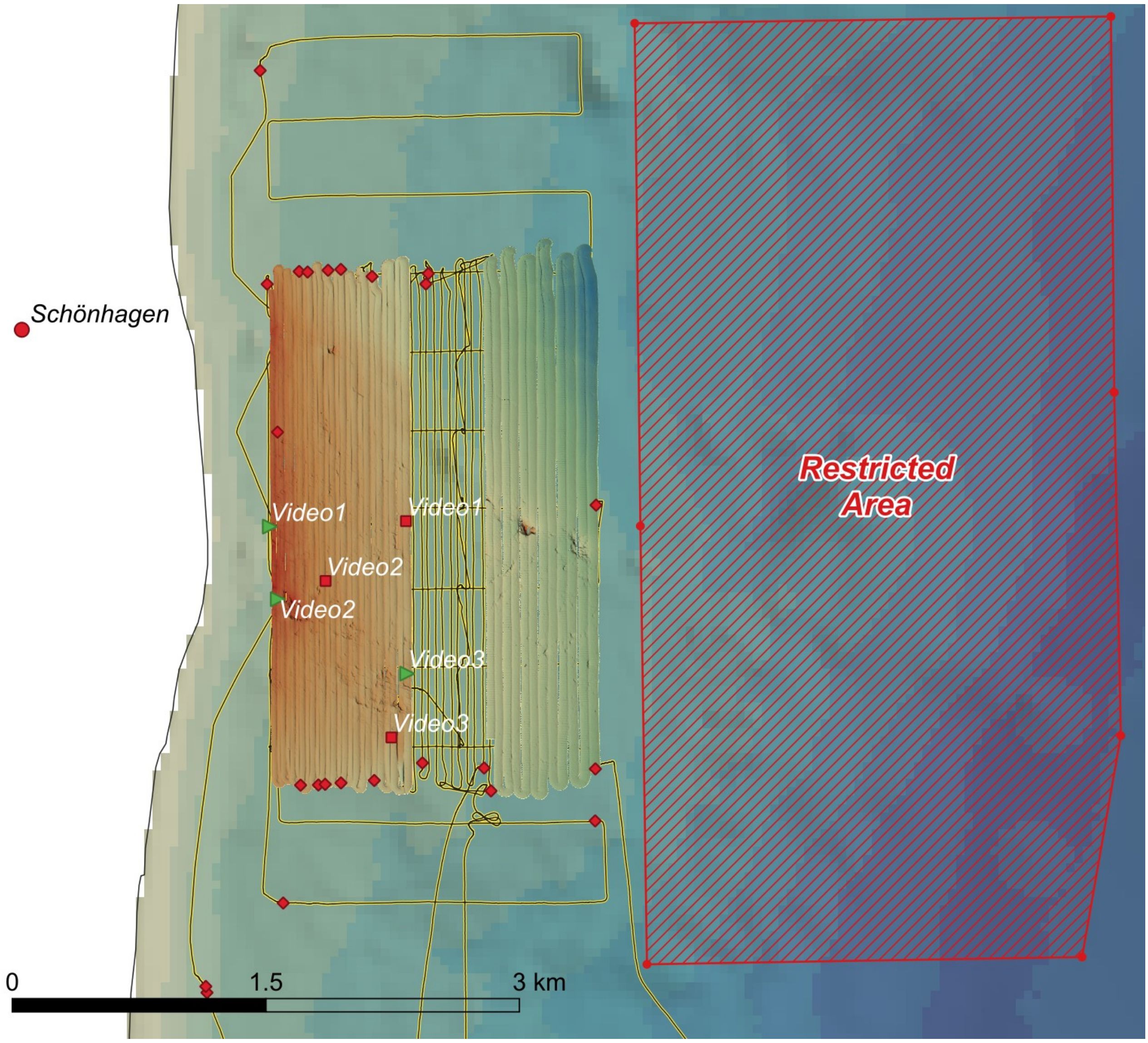

Figure 5: Overview of focus area Schönhagen showing coast-normal MBES and SBP transects, CTD casts (red diamonds) , spatial extent of full coverage mapping area and video profiles.

First results

Heiligenhafen

In the first study area Heiligenhafen the focus was on the morphological and sedimentological character of the nearshore area in front of Steinwarder and Graswarder. The high resolution MBES data and SES data revealed a series of coast-oblique ridges (striking NW to SE; Figure 6a), potentially connected to the coast.

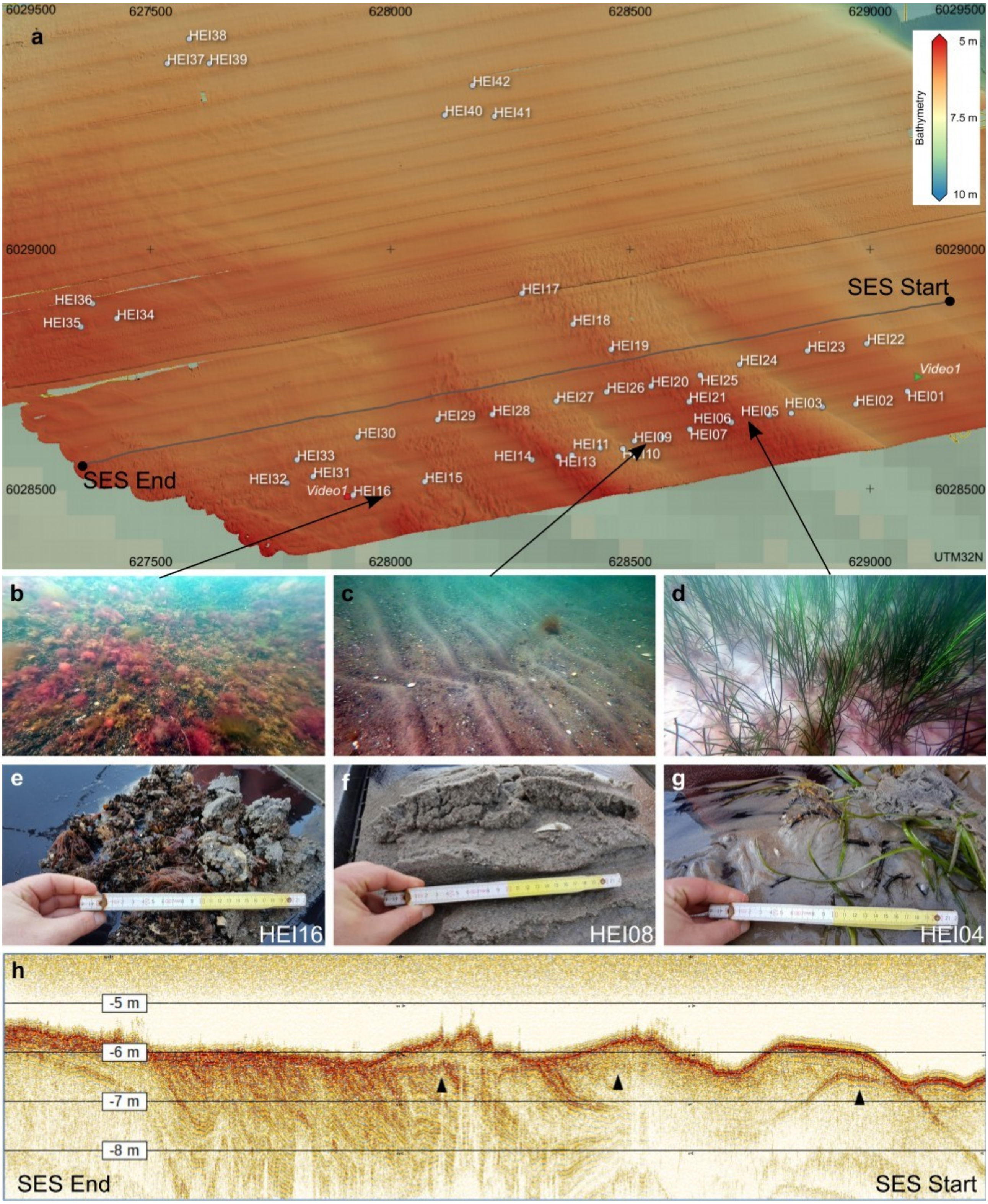

Figure 6: Heiligenhafen nearshore ridge system. (a) Bathymetry, grab sample locations, video profile and SBP track. (b-d) Exemplary still frames from the underwater video transect. (e-f) Exemplary grab samples exhibiting the same sedimentological features as the video stills above. (h) SBP transect over three ridges.

In the SES data we observed a base layer beneath the morphological structures (Figure 6h) . This suggests that the ridges are superimposed on older material.

Sediment analyses via video profiling and grab sampling in the area revealed further information about the seafloor conditions. The videos showed dense sea grass population on top and along the NE flank of the observed ridges, while almost no vegetation was visible in the troughs and along the SW flanks. In the area without vegetation the sediment formed ripples.

Sediment distribution showed the presence of sandy material with some observed amount of small gravel in areas with no vegetation. In the sea grass covered area the sediment tend to be finer (mostly sorted fine sand).

In the western part of the area a change in backscatter represented a change of habitat. Here, we observed dense mussel beds of mostly juvenile *Mytilidaeon* on a coarser substrate (sand, gravel, stones; Figure 6b,e).

Stohl

In front of the Stohl cliff, a large area was mapped with hydro-acoustic techniques with full spatial coverage. Similar to Heiligenhafen, we observed a series of nearshore coast-oblique ridges, most prominent in the north-western part of the study area (Figure 7a). The ridges are orientated SW to NE. The SES profiles again revealed a prominent reflection representing the potential base layer, showing that the ridges are superimposed on older material (Figure 7h).

Heterogenic backscatter and underwater videos showed again the presence of sea grass, which occurred most prominently on the crest and north-western flanks of the ridges. In general, the population occurred less dense than in the previous study area.

The sediment distribution across the ridges appeared less sorted compared to the Heiligenhafen ridge area. From videos and grab samples we observed mostly sandy to gravelly sediment. Overgrown boulders were irregularly distributed in the area. The uppermost sediment surface showed a slight darkening in color. This suggests that the sediment has not been moved for a while.

Another series of ridge-like structures was observed further offshore. These were not connected to the inner shore system and differ in shape and type of observed hydro-acoustic backscatter.

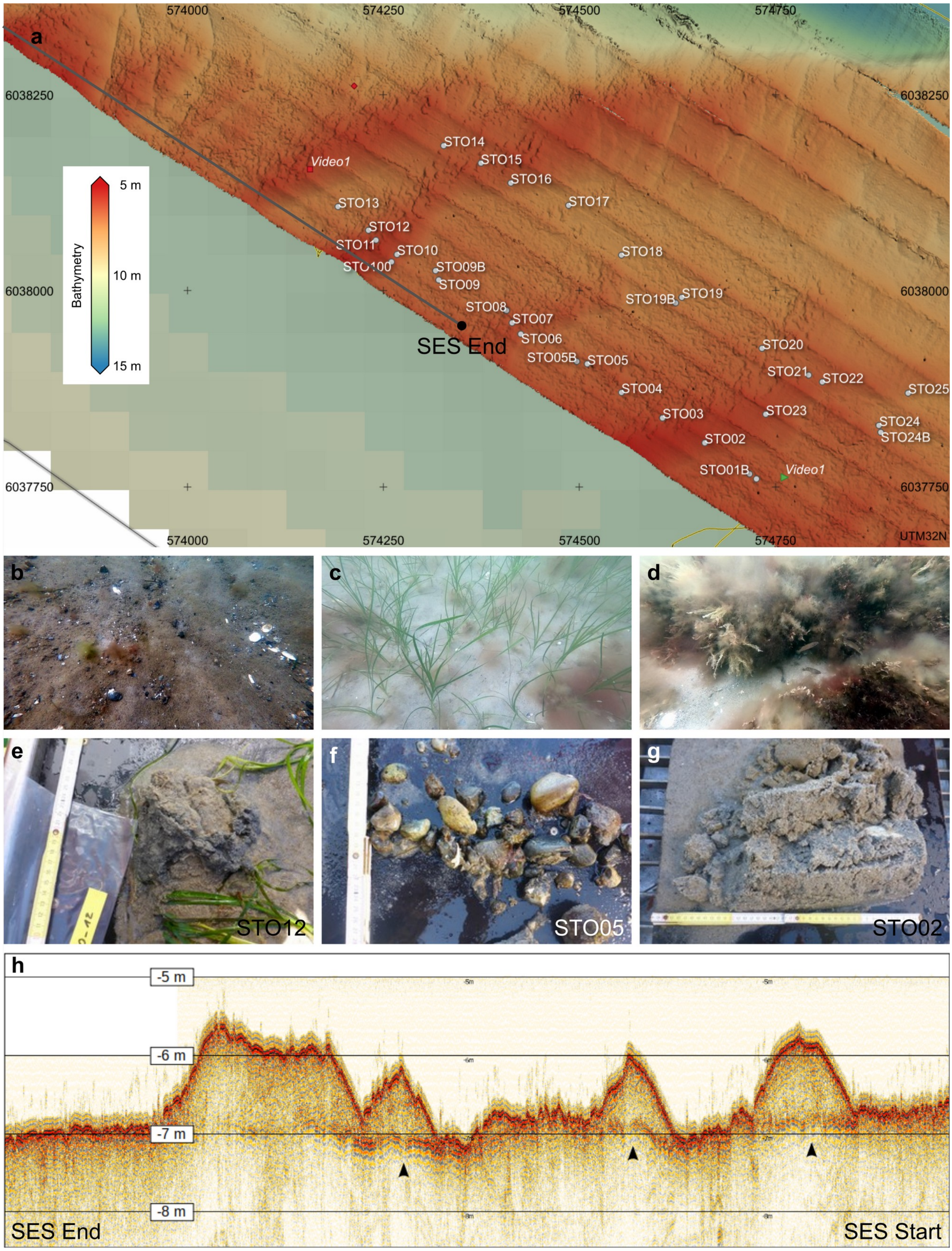

Figure 7: Stohl nearshore ridge system. (a) Bathymetry, grab sample location, video profile and SBP track. (b-d) Exemplary still frames from the underwater video transect showing coarser sand (b), seagrass with fine sand (c) and large boulders (d). (e-f) Exemplary grab samples.(h) SBP transect over three ridges showing an underlying layer (arrows).

Schönhagen

High resolution bathymetry data, videos and sediment samples showed that the near-shore area in front of Schönhagen is dominated by mostly coarse sediment representing an abrasion platform exposed to the East. Sediment grain sizes vary between sand, gravel and large overgrown boulders (Figure 8c,d). The entire area showed dense vegetation.

Unlike to the other study area no near-shore ridge system was observed. Very prominent morphological features in the MBES data were straight, slightly NE orientated tracks that suggested human impact, possibly due to ground fishing gear used in this area (Figure 8a,b). We observed the absence of large boulders in the inner part of these tracks (Figure 8d) and dense mounds of boulders where the lines terminate westward.

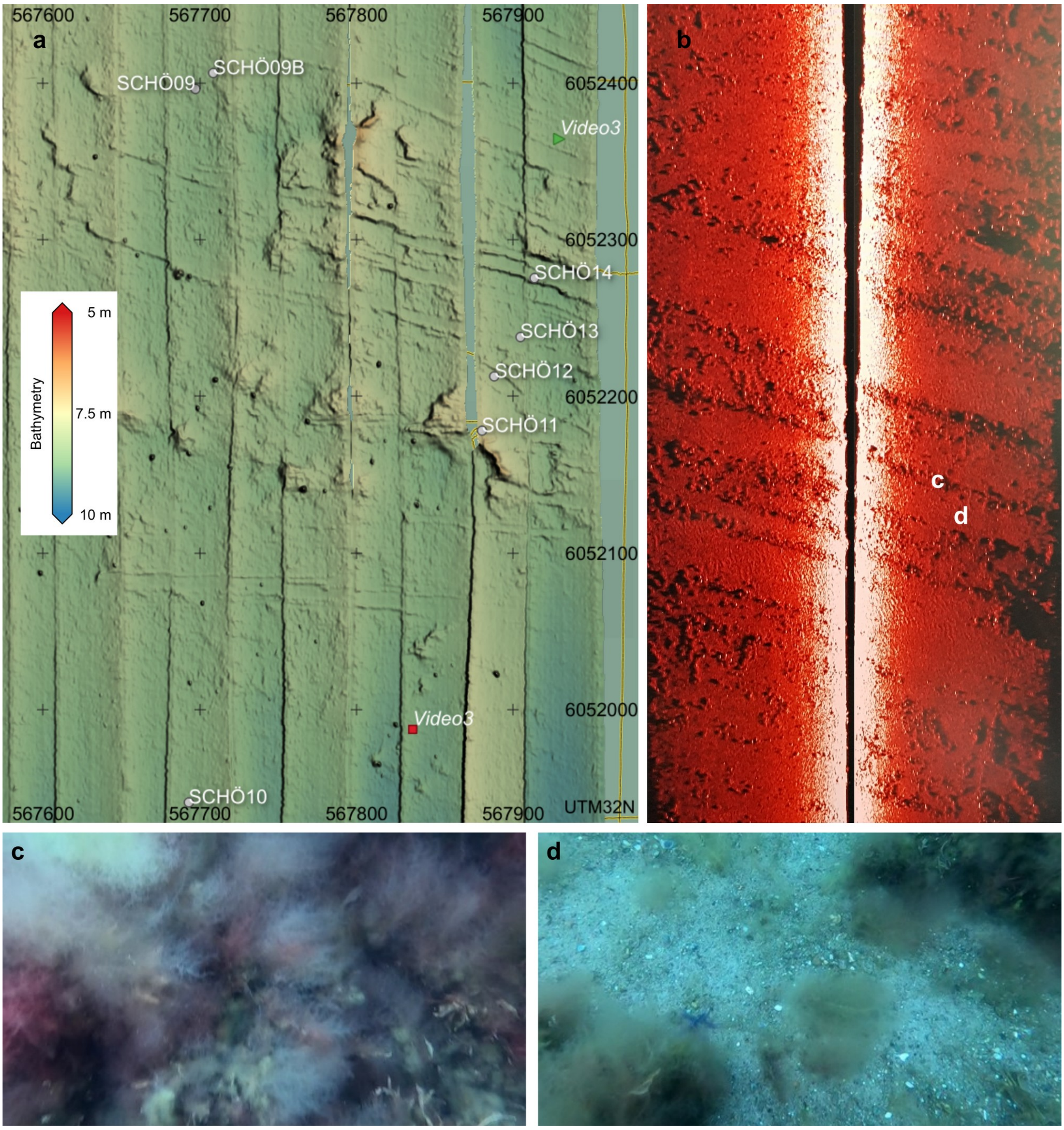

Figure 8: Possible traces of human impact in Schönhagen. (a) Bathymetry exhibiting tracks running in East-West direction. Most tracks have mounds of seafloor material at their westward ends. (b) Screengrab of MBES snippet scan backscatter showing boulders at the edges of the tracks and cleared areas in between. (c) Overgrown boulders at the track edges and (d) areas cleared of boulders inside the tracks.

Research Questions

The main objective of the survey was to acquire comprehensive data in all three study areas in order to improve process understanding of of the near-shore system. The main focus is on understanding the sediment transport processes from the source area, terrestrial soft rock cliffs and the sea floor, to areas of material accumulation. This includes investigating the mobilization of seafloor surface sediments by waves and currents.
Another topic of interest are the observed ridges in two of the study areas, Heiligenhafen and Stohl. Processing and interpretation of the acquired data might give us an idea regarding genesis and mobility/stability of these ridges. Also we aim to learn about the relation between the ridges and habitat distribution.

The upcoming steps for towards answering these questions are

1. Data processing (MBES, SES, grain size analysis)
2. Interpretation of SES data: Tracing subsurface layers, spatial interpolation
3. Further data acquisition (vibro coring) along the ridge systems
4. Repetitive surveys to evaluate temporal changes (e.g. effect of erosive processes)

Stationbook

CTD

Date	Time (local)	Lat	Lon	Name
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2020-05-25	21:47	54° 24.6240' N	010° 54.9583' E	CTD02
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2020-05-26	01:40	54° 22.5103' N	010° 52.3571' E	CTD04
2020-05-26	02:22	54° 23.4471' N	010° 57.4018' E	CTD05
2020-05-26	11:49	54° 23.4267' N	010° 57.5288' E	CTD06
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2020-05-27	06:31	54° 22.5179' N	010° 52.3302' E	CTD12
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2020-05-27	13:28	54° 24.3983' N	011° 02.5337' E	CTD16
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2020-05-29	22:32	54° 29.4162' N	010° 08.1979' E	CTD20
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2020-05-30	02:45	54° 28.6205' N	010° 09.9096' E	CTD22
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2020-05-30	05:08	54° 29.9761' N	010° 11.3277' E	CTD25
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2020-05-30	08:39	54° 29.9303' N	010° 11.4090' E	CTD27
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2020-05-31	00:06	54° 29.5087' N	010° 09.5217' E	CTD34
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2020-06-02	23:23	54° 38.1353' N	010° 02.5510' E	CTD54
2020-06-03	00:05	54° 38.1330' N	010° 02.5975' E	CTD55

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Grab samples

Date	**Time (local)**	**Lat**	**Lon**	**Name**
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2020-05-29	06:04	54° 23.3535' N	010° 58.9333' E	HEI06
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2020-05-29	06:13	54° 23.3389' N	010° 58.8007' E	HEI08
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2020-05-29	07:04	54° 23.4390' N	010° 58.7063' E	HEI19
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2020-05-29	07:39	54° 23.3828' N	010° 58.5981' E	HEI27
2020-05-29	07:44	54° 23.3696' N	010° 58.4743' E	HEI28
2020-05-29	07:47	54° 23.3657' N	010° 58.3687' E	HEI29
2020-05-29	07:52	54° 23.3486' N	010° 58.2140' E	HEI30
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2020-05-29	08:27	54° 23.5068' N	010° 57.7098' E	HEI36
2020-05-29	08:34	54° 23.7744' N	010° 57.8667' E	HEI37
2020-05-29	08:37	54° 23.8009' N	010° 57.9101' E	HEI38
2020-05-29	08:41	54° 23.7731' N	010° 57.9483' E	HEI39
2020-05-29	08:48	54° 23.7080' N	010° 58.3986' E	HEI40

2020-05-29	08:52	54° 23.7046' N	010° 58.4935' E	HEI41
2020-05-29	08:57	54° 23.7402' N	010° 58.4540' E	HEI42
2020-06-01	07:59	54° 28.9180' N	010° 09.2025' E	STO01
2020-06-01	08:06	54° 28.9218' N	010° 09.1945' E	STO01B
2020-06-01	08:11	54° 28.9436' N	010° 09.1421' E	STO02
2020-06-01	08:17	54° 28.9613' N	010° 09.0930' E	STO03
2020-06-01	08:22	54° 28.9791' N	010° 09.0449' E	STO04
2020-06-01	08:26	54° 28.9990' N	010° 09.0051' E	STO05
2020-06-01	08:28	54° 29.0010' N	010° 08.9930' E	STO05B
2020-06-01	08:32	54° 29.0205' N	010° 08.9276' E	STO06
2020-06-01	08:36	54° 29.0283' N	010° 08.9173' E	STO07
2020-06-01	08:39	54° 29.0366' N	010° 08.9111' E	STO08
2020-06-01	08:44	54° 29.0586' N	010° 08.8315' E	STO09
2020-06-01	08:46	54° 29.0715' N	010° 08.7758' E	STO100
2020-06-01	08:54	54° 29.0649' N	010° 08.8282' E	STO09B
2020-06-01	08:58	54° 29.0767' N	010° 08.7825' E	STO10
2020-06-01	09:04	54° 29.0867' N	010° 08.7580' E	STO11
2020-06-01	09:10	54° 29.0933' N	010° 08.7496' E	STO12
2020-06-01	09:17	54° 29.1099' N	010° 08.7139' E	STO13
2020-06-01	10:09	54° 29.1509' N	010° 08.8400' E	STO14
2020-06-01	10:24	54° 29.1382' N	010° 08.8833' E	STO15
2020-06-01	10:30	54° 29.1245' N	010° 08.9181' E	STO16
2020-06-01	10:38	54° 29.1084' N	010° 08.9860' E	STO17
2020-06-01	10:46	54° 29.0734' N	010° 09.0478' E	STO18
2020-06-01	10:53	54° 29.0439' N	010° 09.1180' E	STO19
2020-06-01	10:56	54° 29.0400' N	010° 09.1104' E	STO19B
2020-06-01	11:02	54° 29.0078' N	010° 09.2121' E	STO20
2020-06-01	11:11	54° 28.9888' N	010° 09.2660' E	STO21
2020-06-01	11:18	54° 28.9839' N	010° 09.2824' E	STO22
2020-06-01	11:27	54° 28.9624' N	010° 09.2150' E	STO23
2020-06-01	11:34	54° 28.9536' N	010° 09.3486' E	STO24
2020-06-01	11:36	54° 28.9487' N	010° 09.3504' E	STO24B
2020-06-01	11:42	54° 28.9756' N	010° 09.3835' E	STO25
2020-06-01	11:52	54° 28.9888' N	010° 09.4400' E	STO26
2020-06-01	11:57	54° 28.9939' N	010° 09.5246' E	STO27
2020-06-01	12:10	54° 29.0077' N	010° 09.5934' E	STO28
2020-06-02	10:42	54° 29.1250' N	010° 10.8271' E	STO29
2020-06-02	10:51	54° 29.1333' N	010° 10.7610' E	STO30
2020-06-02	10:55	54° 29.1587' N	010° 10.8208' E	STO31
2020-06-02	11:39	54° 29.3823' N	010° 10.0303' E	STO32
2020-06-02	11:46	54° 29.3786' N	010° 09.8604' E	STO33
2020-06-02	11:54	54° 29.3765' N	010° 09.8341' E	STO34
2020-06-02	12:05	54° 29.5840' N	010° 10.7055' E	STO35
2020-06-02	12:11	54° 29.5815' N	010° 10.7406' E	STO36
2020-06-02	12:18	54° 29.5819' N	010° 10.7659' E	STO37
2020-06-02	12:25	54° 29.5761' N	010° 10.7962' E	STO38
2020-06-02	12:36	54° 29.7614' N	010° 11.0281' E	STO39
2020-06-02	12:42	54° 29.8442' N	010° 11.0282' E	STO40
2020-06-02	12:49	54° 29.9173' N	010° 11.0242' E	STO41
2020-06-03	12:07	54° 36.6270' N	010° 02.4231' E	SCHÖ01
2020-06-03	12:14	54° 36.8745' N	010° 02.4242' E	SCHÖ02
2020-06-03	12:21	54° 37.1235' N	010° 02.4350' E	SCHÖ03
2020-06-03	12:40	54° 38.1284' N	010° 02.9122' E	SCHÖ04
2020-06-03	12:49	54° 37.8716' N	010° 02.9153' E	SCHÖ05
2020-06-03	12:52	54° 37.8745' N	010° 02.9095' E	SCHÖ05B
2020-06-03	12:59	54° 37.6245' N	010° 02.9022' E	SCHÖ06
2020-06-03	13:06	54° 37.3726' N	010° 02.9014' E	SCHÖ07
2020-06-03	13:15	54° 37.1206' N	010° 02.9075' E	SCHÖ08

2020-06-03	13:23	54° 36.8682' N	010° 02.8969' E	SCHÖ09
2020-06-03	13:28	54° 36.8735' N	010° 02.9075' E	SCHÖ09B
2020-06-03	13:35	54° 36.6226' N	010° 02.8866' E	SCHÖ10
2020-06-03	13:46	54° 36.7490' N	010° 03.0636' E	SCHÖ11
2020-06-03	13:54	54° 36.7676' N	010° 03.0717' E	SCHÖ12
2020-06-03	13:59	54° 36.7812' N	010° 03.0873' E	SCHÖ13
2020-06-03	14:04	54° 36.8013' N	010° 03.0961' E	SCHÖ14
2020-06-03	14:17	54° 36.6177' N	010° 03.4102' E	SCHÖ15
2020-06-03	14:25	54° 36.8809' N	010° 03.4194' E	SCHÖ16
2020-06-03	14:33	54° 37.1226' N	010° 03.4209' E	SCHÖ17
2020-06-03	14:45	54° 37.3789' N	010° 03.4355' E	SCHÖ18
2020-06-03	14:52	54° 37.6235' N	010° 03.4312' E	SCHÖ19
2020-06-03	15:00	54° 37.8738' N	010° 03.4436' E	SCHÖ20
2020-06-03	15:06	54° 38.1333' N	010° 03.4480' E	SCHÖ21