Cruise Report RV Littorina

LIT/1907

(11.06.2019 – 14.06.2019)

Hydroacoustic assessment of the seagrass Zostera marina with modern multibeam echosounding in the Geltinger Bucht and the Kolberger Heide

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Scientific Crew

Name	Affiliation	Function
Jens Schneider von Deimling	CAU	Cruise Leader
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Florian Gausepohl	CAU	Hydroacoustics
Florian Weinberger	GEOMAR	Biologie
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Research programme

The cruise was carried out as part of the European joint project BONUS ECOMAP, coordinated by the CAU. The aim of the research&development project ECOMAP is to significantly improve the remote sensing of different habitats in the Baltic Sea and therefore to better understand the underlying control mechanisms and the environment. Various optical and acoustic methods are currently being developed for this purpose. For LIT1907 a NORBIT multibeam echosounder was optimized for the mapping of submarine vegetation. We here focus on the seagrass Zostera marina which is known for its large potential in terms of longer term CO_2 storage in the sediment, for being a nursery ground for fish, for mitigating coastal erosion, and even for improving the water quality. The interested reader is referred to related work in ECOMAP, which is dedicated to seagrass assessments in the Baltic Sea (www.bonus-ecomap.eu).

Cruise narrative

Tuedsay, 11th of June: Embarking the vessel, installation of the multibeam via the Littorina pole, steaming to Geltinger Bucht, calibration of the motion reference unit. RTK operated unstable via a radio connection. First multibeam survey lines were run including a roll calibration which was measured to -0.21°. Moderate wind and sea state during this day.

Wednesday, 12th of June: Achieving permanent RTK fix with a cabled ethernet solution to the ships mobile connection. Continuation of surveying the shallow parts of the Geltinger Bucht between 3 and 7 meters. Groundtruthing by video and grab sampling. Calm weather and sea state.

Thursday, 13th of June: Continuation of surveying the shallow parts of the Geltinger Bucht between 3 and 7 meters. Survey along the east coast off Damp to Boknis Eck along the 5 m contour line. Transit to the Kolberger Heide in the late afternoon and subsequent survey during the night. Surveying transect lines normal to the coastline from 5 m to 10 m water depth with a line spacing of about 420 m, to derive maximum growing depth of Zostera Marina in the main EcoMap test area. Calm weather.

Friday, 14th of June: Completion of the profile lines normal to the coastline. Then several lines were sailed approximately parallel to the coast over the found maximum growth depths of Zostera Marina. Sailing one test line with the new STX-Modus of the Norbit MBES. Subsequently, groundtruthing with underwater video and grabs at locations marked during the MBES measurements. Finally, calibration profiles were run for the MBES. Transit back to Kiel.

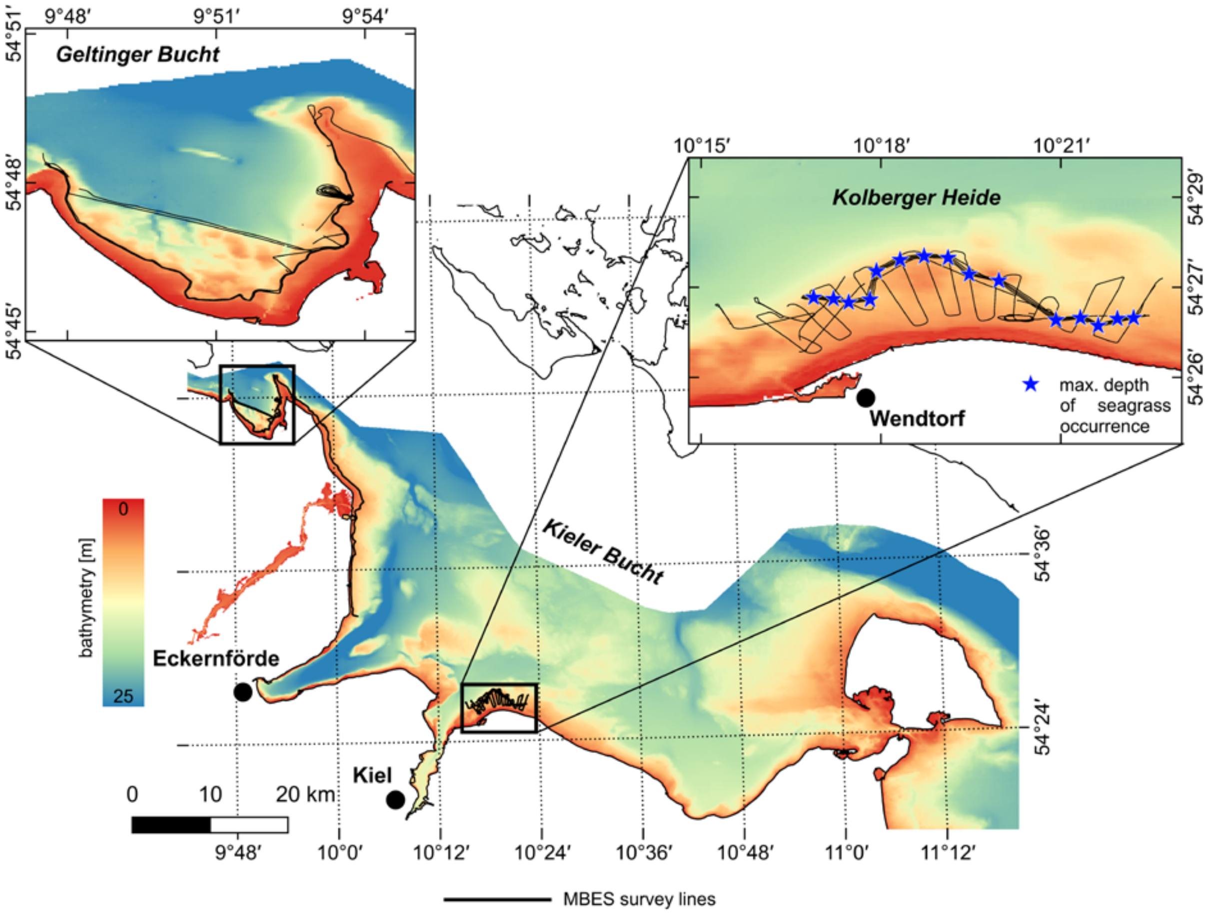

Figure 1: Overview over the recorded MBES data during cruise L1907, with zooms into the main research areas: Geltinger Bucht and the main EcoMap test area at Kolberger Heide off Heidkate.

Scientific report and first results

The *Geltinger Bucht* and a transect from *Kalkberg* to *Boknis Eck* were selected as the first working areas with the focus on the 5 m depth contour line and the acoustic detection of the seagrass Zostera Marina thereon. Afterwards, mapping of the seagrass in the *Kolberger Heide* continued to assess the maximum depth of occurrence as a baseline study. Both study sites are known to be populated by Zostera marina (Schubert et al. 2015).

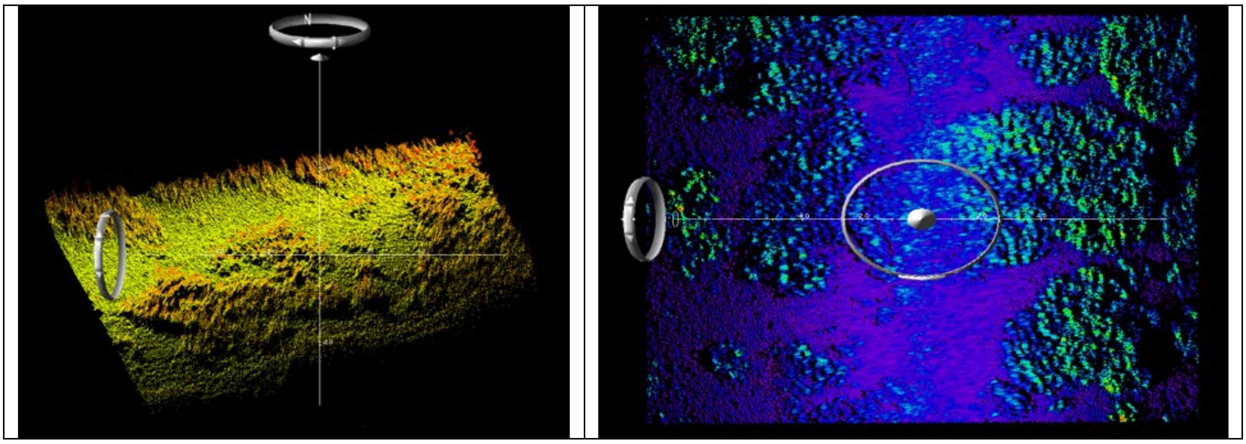

Fig. 2: (left) perspective view on a multibeam echosounder point cloud spanning a few meters showing Zostera marina as depth anomalies (orange) in the Geltinger Bucht (b) adjacent patch where each sounding is color-coded by uncompensated backscatter amplitude also redrawing the seagrass distribution.

Sonar is known to be sensitive to seagrass, but there is no consensus of the ideal system yet (Gumusay et al., 2019), and many unsolved questions remain from a bio-acoustic point of view. We here present data from a novel and very promising approach.

We sailed our survey lines with 3.5-4.5 knots. The prototype NORBIT STX was operated at 400 kHz with 80 kHz bandwidth sending out a 150° swath angle 20-35 times a second. Therefore we achieved very dense point cloud data with more than 80 soundings per square meter. The system was calibrated before with spheres in an acoustic test basin by our project partner NORBIT. The sonar parameters were fine-tuned to achieve a best performance for detection of submerged aquatic vegetation (SAV), afterwards we kept the sonar parameters constant to make the data comparable throughout the survey. CTDs were taken to later correct for sound refraction and absorption effects and also to evaluate temperature, salinity, pH, O_2 saturation, and sound velocity of the water column. The multibeam system performed very well and we achieved high quality point cloud data in the centimeter (vertical) to decimeter (horizontal) positioning accuracy that are prone for our automatic detection of seagrass (Held and Schneider von Deimling, 2019).

In the Geltinger Bucht seagrass was acoustically detected in depths between ca. 3-6 m, exact depth values will be available after postprocessing. Fig. 2 shows both, the characteristic depth anomalies redrawing the seagrass canopy height, and the beam backscatter intensity amplitude being indicative for seagrass. The acoustic interpretation of Fig. 2 was validated by video and grab samples both showing Zostera marina growing on a well-sorted fine sand (Fig. 3).

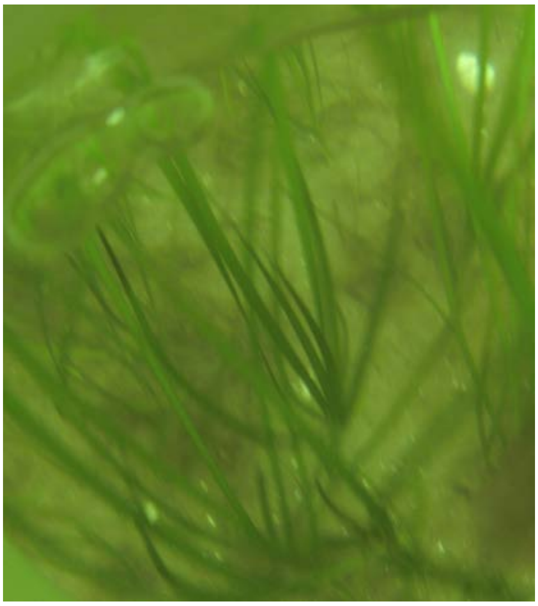

Fig. 3: Video still shot showing Zostera marina growing on sand.

Sediment samples were sieved for grain size analyzes and collected for later analyses of total organic carbon onshore. Other acoustic anomalies were found in in the Bay (Grab01-04), but here, groundtruthing showed the existence of appr. 10 cm high algae (*Ceramium*) in a poorly sorted sediment with silty sand to gravel grain sizes.

The succeeding survey from *Kalkberg* to *Boknis Eck* along the shoreline in 5 m water depth was designed to detect stones ~0.5 m, which are known to occur in this area. From an acoustic perspective, rocks of such size present a possible candidate to be confused with *Zostera* marina showing typically a canopy height of similar magnitude during this time of the year. Overall, the acoustic signatures between the two candidates appear visually very diverse and are most likely discernable after re-training of our data-driven, machine learning classification model (Held and Schneider von Deimling, 2019).

The Kolberger Heide area was acoustically surveyed for seagrass in 2017 and a maximum water depth of occurrence of Zostera was determined at 7.5 m below sea level in a Msc thesis (Lübmann, 2018). Next to seagrass occurrences the seabed here is characterized by sand and sorted bedforms like sandbars along the shoreline as well as ripple structures. The ripples and the acoustic seagrass anomalies are well visible in the snippet multibeam backscatter data (Fig. 4), plotting similar to sidescan, but providing precise geolocation of the backscattered signals. Characteristic patterns of Zostera are elevated backscatter at near-nadir often occurring in a patch-like manner. Towards the outer beams the backscatter remains high, but dedicated shadowing effects occur. Beyond the outer beams the snippet sidescan data often extend in a blurry manner with elongated sonar travel time, which we interpret as multipath effects between seagrass canopy-canopy and/or canopy-seafloor acoustic interaction.

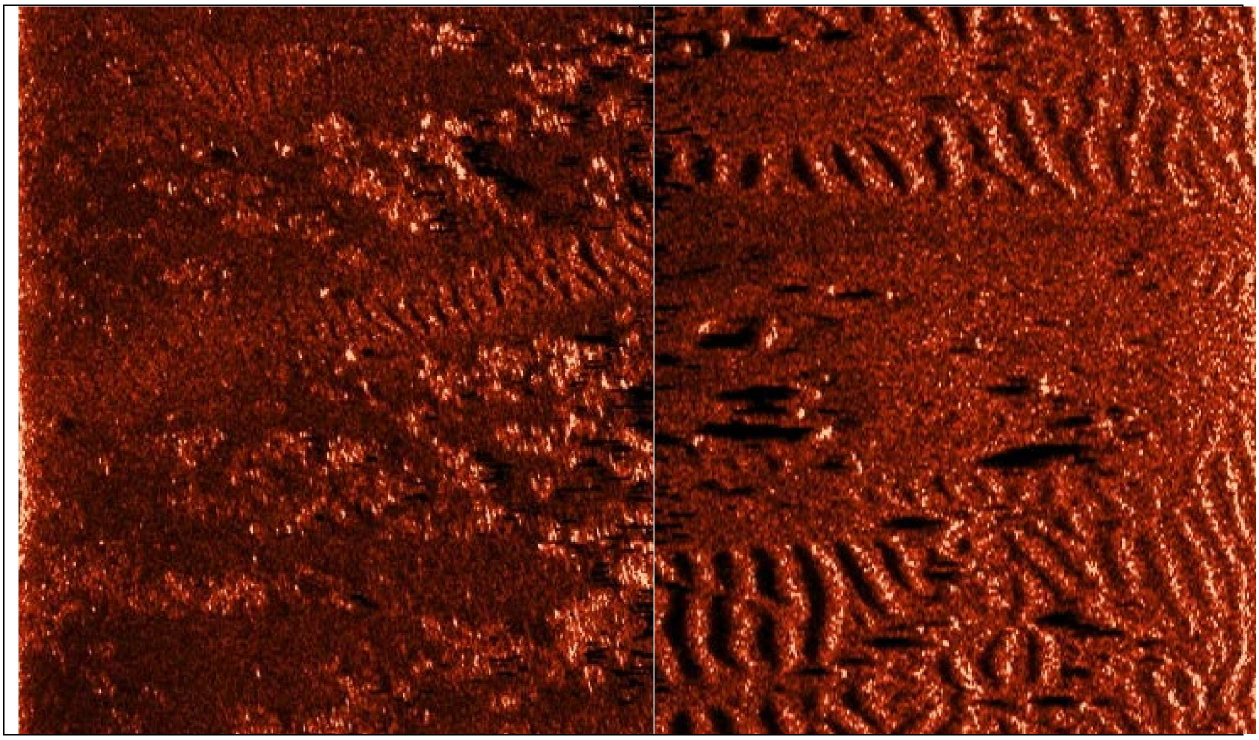

Fig.: 4: Multibeam echosounder snippet backscatter data showing (left) ripples and seagrass. Across distance is around 10 m, bright colors indicate high acoustic energy. (right) sand ripples and a few stones with prominent acoustic shadows similar to sidescan imagery.

To map out the maximum depth of Zostera marina on a larger extent we performed in-and-out surveying with lines perpendicular to the coastline every 400 meters within the depth interval of 5-10 m. Therein, the maximum depth occurrence of Zostera was mapped out (Fig. 1).

Scientific equipment and sampling

Multibeam: NORBIT iWBMS prototype STX with 400 kHz center frequency. Survey settings were fixed to Static Gain: 6 dB; Spreading: 40 dB/km; Absorption: 75 db/km (T=15, S=16, @ 5 m → 75.2 dB, after Ainslie); Backscatter mode: snippets/scan; F: 400kHz, Mode: FM deep; range res. 0.9 cm; ping rate adaptive, up to 35 Hz; Adaptive gates: off; roll/pitch stab.: off; Pulse amp.: 15; beam distr. Equiang. 512; multidetect, on max sens. upper/lower on. Data were recorded as .wbm and .s7k via NORBIT Version 10.4FW5.1., and in parallel as .db and .qpd with Qinsy 8.18.3 (ETRS 89, GCG2016).

Intertial Navigation and motion reference unit: Applanix Wavemaster provided with Axio Net RTK RTCM 3.1 correction with ID#15 (ETRS 89, GCG2011).

CTD: Sea and Sun Technology CTD60M, equipped with a Pt 100 temperature sensor, a pressure sensor of type PA7-10, a cylindrical 7 electrode conductivity sensor, an oxygen sensor of type AMT-DO and a PH sensor of type AMT-pH.

GoPro: GoPro Hero3. Video settings: wide angle, 1080p and 24 fps; additionally, every 3 s a still shot with 24 Mpx.

Underwater camera: towed live-view camera, equipped with a CMOS image sensor with 100 TV lines.

Van-veen-grab

Acknowledgements

We highly acknowledge the expertise of captain Volkmar Marks and his crew and appreciate their great support throughout the cruise with RV Littorina. This work resulted from the BONUS ECOMAP project, supported by BONUS (Art 185), funded jointly by the EU and the Federal Ministry of Education and Research of Germany (BMBF), the National Centre for Research and Development of Poland (NCBR), and the Innovation Fund Denmark (Innovationsfonden). We also appreciate the free use of the RTK service kindly provided by the AXIOnet GmbH. The authors would also like to thank the German Federal Maritime and Marine Hydrographic Agency BSH, and the environmental authorities LLUR, and LKN.SH for knowledge exchange and continuous support of ECOMAP.

References

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Stationbook

Date/UTC	Station[#]	Gear	Location	Lat []	Long []	Water depth	Comment	Grab table
11.06.2019								
	St 1	MBES Transit						
	St2	CTD1, O2 1	Geltinger Bucht					
	St3	MBES Survey	Geltinger Bucht					
12.06.2019								
06:10	St4	CTD02	Geltinger Bucht			5		
06:50	St5	Grab01-1	Geltinger Bucht	54:46.580	9:52.921	5	2 pictures taken	#1
07:04		Grab01-2	Geltinger Bucht	54:46.580	9:52.921	5	2 pictures taken	#2
07:11	St6	Grab02	Geltinger Bucht	54:46.604	9:52.963		with St# in photo	#3
07:20		MBES Transit	Geltinger Bucht				now with RTK via Eth0 Brücke	
08:00	St7	Grab03	Geltinger Bucht	54:47.798	9:47.999		with video	#4
08:03	St8	Grab04-01	Geltinger Bucht	54:47.924	9:48.015		leer	
08:07		Grab04-02	Geltinger Bucht	54:47.924	9:48.015		sand, kies, steine , Algenaufwuchs	#5
08:15		MBES Transit	Geltinger Bucht				TRK fix	
08:53	St9	MBES Roll Calib	Geltinger Bucht	54:46.776	9:53.637		to N, 3.5kn	
09:01		MBES Roll Calib	Geltinger Bucht				to S, 3.5kn	
09:14	St10	CTD03	Geltinger Bucht	54:46.742	9:53.603			
09:23	St11	MBES survey	Geltinger Bucht				4-5 knots	
09:50		MBES survey	Geltinger Bucht				strong noise, restart	
10:01		MBES survey	Geltinger Bucht				back to survey	
10:20		MBES survey	Geltinger Bucht				adjacent survey line	
12:27		MBES survey	Geltinger Bucht				now without MD	
13:23		MBES survey	Geltinger Bucht				now without WCI	
14:29	St12	Video start	Geltinger Bucht	54:47.731	9:53.730		tow track GoPro	
14:44		Video stop	Geltinger Bucht	54:47.588	9:53.693		tow ende	
14:49	St13	MBES video validation	Geltinger Bucht					
14:58	St14	Grab 05	Geltinger Bucht	54:47.747	9:53.745		validate Zostera ground; 5 pictures taken	#6
13.06.2019			Geltinger Bucht					
06:05	St15	CTD04	Geltinger Bucht	54:47.841	09:53.210	10		
06:10	St16	MBES survey	Geltinger Bucht				WCI on, MD on	
06:55	06:55						WCI res set to highest for 1 line	
	07:24						Test ELAC record 1 line	
10:07	St17	CTD05	Ostküste Pottloch	54:44.435	09:59.650			
12:08							giant stone site	
13:29	St18	CTD06	Boknis Eck	54:32.799	10:02.642			
16:06	St19	CTD07	Kollberger Heide	54:27.317	10:17.433	10	O2 Kalib Schwankung +-10 %	
16:29	St20	MBES Roll Calib	Kollberger Heide			10		
16:42		Ende Roll calib						
	St21	Survey ZigZag	Kollberger Heide					
14.06.2019								
02:25	St22	Survey Max Depth zostera	Kollberger Heide				standard setting	
02:32							Pockmark?	
02:42							UXO?	
06:28	St23	Yaw Calib	Kollberger Heide					
06:52	St24	Drop Camera 01	Kollberger Heide	54:26.526	10:20.232		stones overgrown with algae; sparse seagrass occurrences on more sandy parts	
07:05	St25	Drop Camera 02	Kollberger Heide	54:26.568	10:20.615		sandy bottom; frequent ripple occurrences; some seagrass, only individual stalks; high amount of mussels/mussel shells	
07:16	St26	Drop Camera 03	Kollberger Heide	54:26.474	10:20.812		some dense seagrass patches; sandy bottom; few rocks with algae	
07:32	St27	Drop Camera 04	Kollberger Heide	54:26.788	10:20.246		sandy bottom; frequent overgrown cobbles; some shell fragments	
07:52	St28	Drop Camera 05	Kollberger Heide	54:27.486	10:18.605		sparse seagrass occurrences (individuals; 3-5 leaves); sandy; shell fragments; benthic life (Ostracoda) and Lebensspuren	
08:08	St29	Drop Camera 06	Kollberger Heide	54:27.093	10:17.850		sandy bottom; frequent seagrass occurrences; shell fragments; benthic life (Ostracoda) and Lebensspuren	
	St30	Drop Camera 07	Kollberger Heide					
08:36	St31	Grab06	Kollberger Heide				with full res WCI, seagrass with 0.8m length, fine sand, turning anoxic	#7
08:54	St32	MBES STX test	Kollberger Heide				STX scan on	
09:06	St33	MBES Pitch calib forth	Kollberger Heide				STX scan off	
09:13		pitch back	Kollberger Heide					
CTD (Weinberger) ᚨ	UTC+2h 10 min							
MBES has time	UTC							
Screenshots has tin	UTC							

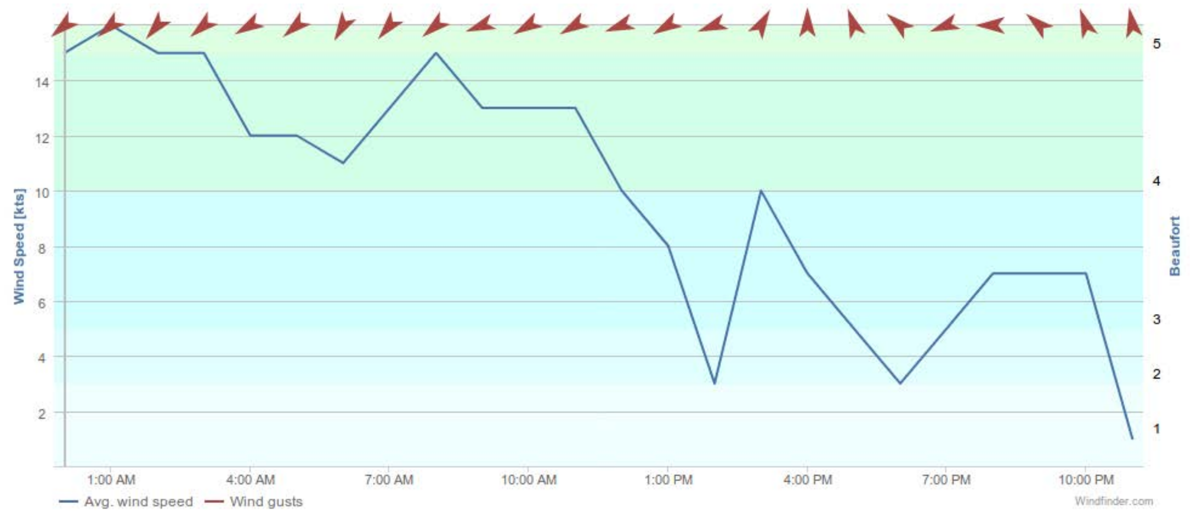
Water level at lighthouse Kalkgrund

Water level time series from wsv for later RTK height validation (WSV).

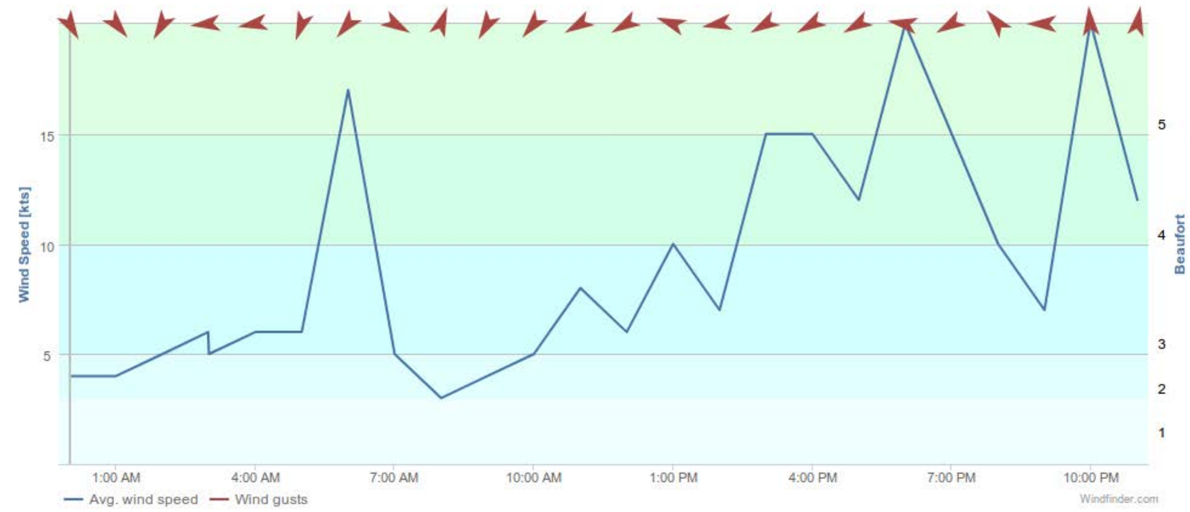
Wind conditions during the survey:

Screenshots from www.windfinder.de

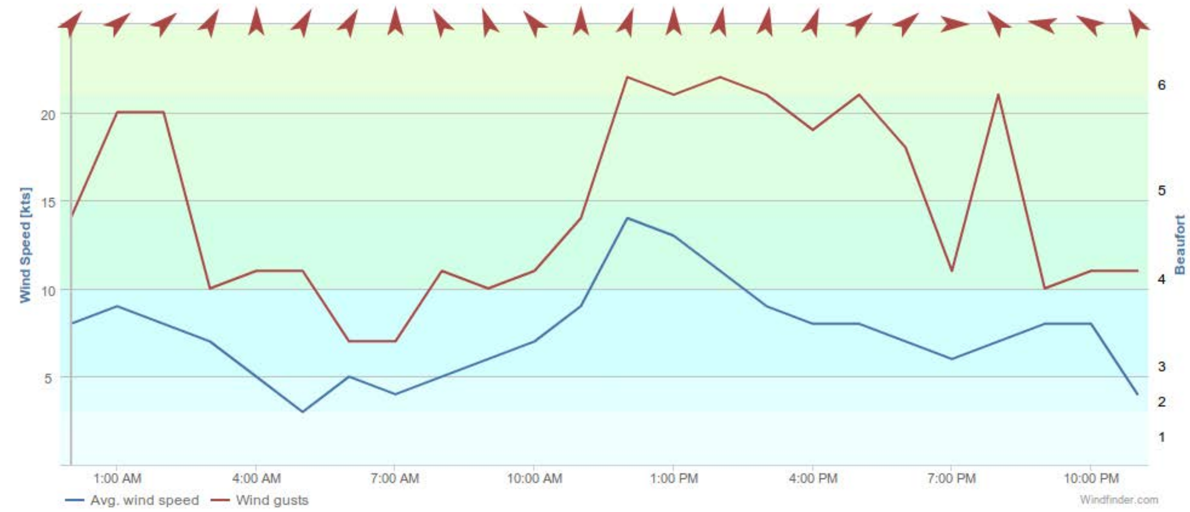
11.06.2019: Station Kegnæs Fyr



12.06.2019 station Kegnæs Fyr:



13.06.2019 Station Schönhagen



station Kieler lighthouse

14.06.2019 Station Kieler lighthouse