

Cruise Report Littorina L19-10a

South of Amrumbank

15.07- 25.07.2019

Institut für Geowissenschaften (IfG)

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Sidescan Sonar (towed with depressor and buoyancy)	SSS
Multibeam Echosounder (pole mounted)	MBES
Innomar Subbottom Profiler – SES 2000 (pole mounted)	SES
HELCOM Grab Sampler	GS
Conductivity Temperature Depth	CTD

1 List of Participants

Anett Jannasch	Bachelor Student	Scientist	15.07.-19.07.
Christian Pape	Master Student	Scientist	19.07.-26.07.
Gianna Persichini	PhD Student	Scientist, Chief Scientist	Entire cruise
Penele Borgest	Bachelor Student	Scientist	19.07.-26.07.
Peter Richter	PostDoc	Chief Scientist	15.07.-19.07.
Tim Willems	PhD Student	Scientist	Entire cruise

2 Introduction

The cruise L19-10a was part of the research project "Nordfriesland Süd – Der geologisch/sedimentologische Aufbau und die Habitatverteilung im Übergangsbereich Watt – Schelf zwischen der Amrumbank und der Eiderrinne" (the geological / geological built up and the habitat distribution between Amrum Bank and Eider channel), which is a cooperation between the Agency for Coastal Protection, National Park and Marine Conservation of Schleswig-Holstein (LKN), the State Office for Agriculture, Environment and Rural Areas Schleswig-Holstein (LLUR) and the Institute of Geosciences (working groups Coastal Geology and Sedimentology; Hydroacoustics and Marine Geophysics) of Kiel University (CAU).

Objectives of the survey:

- Investigation of the structure, resistance and biodiversity of shell accumulations, already observed in previous work.
- Repeated investigation of formerly mapped areas showing rippled scour depressions and wide distributions of the sand tube building worm *Lanice conchilega*.
- Acquisition of high resolution hydroacoustic data of the subsurface built-up in order to identify the geological architecture, especially at sites of important sediment cores, collected during former investigation. Further data was collected to enhance a complex, three-dimensional model of a fossil, filled channel-system.
- Identifying source regions for mobile sand. How is the material at the surface coupled to the geological subsurface?

3 Cruise Narrative

Due to bad weather conditions, departure was set to 19:00 UTC on 16th of July.

Tu. 16th July 2019

19:00	Departure in Büsum
23:45	Arrival in work area

We. 17th July 2019

00:32	CTD station
01:00	Calibration profiling, test profiling (MBES, SES), troubleshooting RTK
05:20	Start of profiling (SSS)
16:00	End of profiling, transit
17:57	Start of profiling (MBES, SES)

Th. 18th July 2019

08:15	End of profiling, transit
14:10	Start of profiling (MBES, SES)
19:40	End of profiling
20:11-21:04	Sediment sampling, transit

Fr. 19th July 2019

01:47	Start of profiling (MBES, SES)
06:21	End of profiling, transit
08:48-10:25	Sediment sampling, transit for crew change in Büsum
17:07	Start of profiling (MBES, SES, SSS)

Sa. 20th July 2019

10:27 End of profiling
11:15-13:21 Sediment sampling, transit
14:30 Start of profiling (MBES, SES)

Sun. 21th July 2019

07:20 End of profiling
07:28-15:30 Sediment sampling, transit
18:58 Start of profiling (MBES, SES)

Mo. 22th July 2019

00:00-24:00 Profiling (MBES, SES, SSS)

Tu. 23th July 2019

00:00-24:00 Profiling (MBES, SES, SSS)

We. 24th July 2019

05:18-10:45 Sediment sampling, transit
11:04 Start of profiling (MBES, SES)
23:53 End of profiling due to technical malfunction
after attempts of troubleshooting transit to Kiel

4 Equipment

4.1 Hydroacoustics

In order to collect information about the material and topography of the seafloor surface, and the subsurface build-up, several hydroacoustic systems were deployed. During hydroacoustic measurements the vessel speed did not exceed 4.5 knots to ensure reasonable quality in resolution along track.

4.1.1 Sidescan Sonar System (Teledyne Benthos SIS-1624)

The Teledyne Benthos SIS-1624 is a towed dual frequency sonar system (Figure 1a).

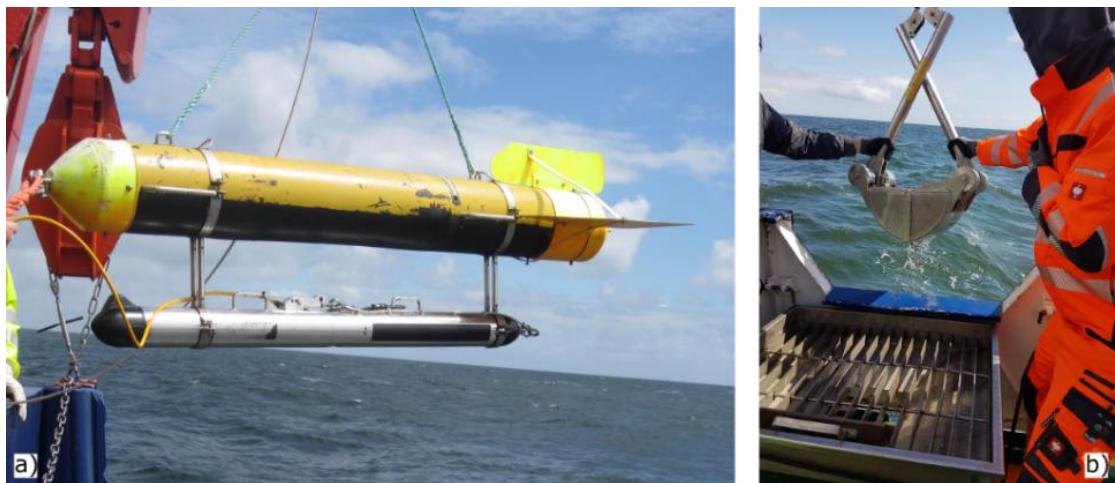


Figure 1: Sidescan Sonar System, attached to bouncy element (a) and HELCOM grab sampler (b).

Operating frequencies are 200 and 400 kHz. By measuring the backscatter intensities of the seafloor, it is possible to draw conclusions about material properties and sometimes its morphology and the distribution of certain benthic species (Blondel & Murton, 1997; Lurton, 2002; Blondel, 2009, Figure 2).

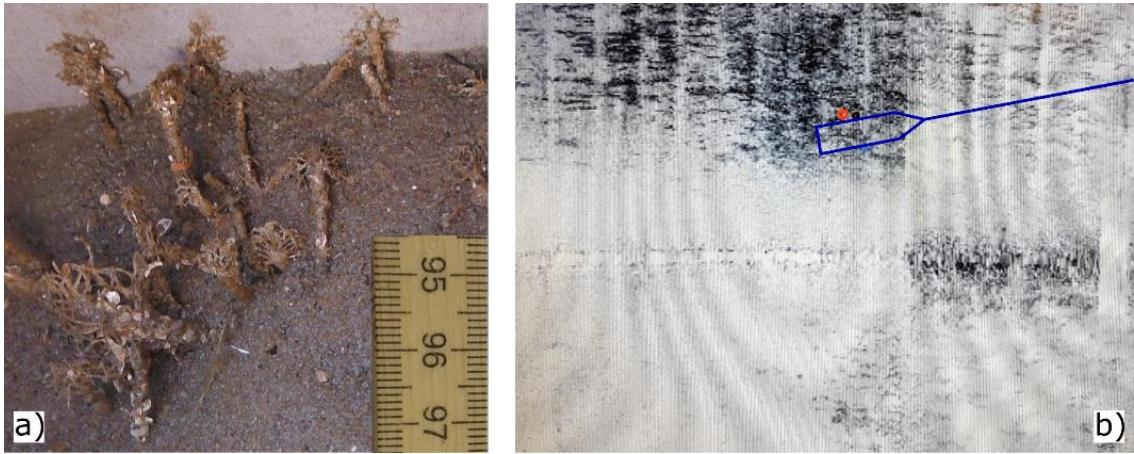


Figure 2: Dense fields of *L. Conchilega* sand tubes (a) can result in texture anomalies in backscatter data (b).

A range of 100 m on each side was set for the measurements. Line spacing between the profiles was 0.1 nautical mile which results in an overlap of about 20 m. After post-processing the data, high resolving acoustic images of the SSS will be used to elaborate geological facies of the seafloor (see Lurton, 2002).

4.1.2 Multibeam Echo Sounder (NORBIT iWBMS)

NORBIT iWBMS collects information about both, the topography and the backscatter of the seafloor. The swath coverage (range of 5-210°) medially set to around 140° led to across track coverage of around 80m. The primarily adjusted frequency (set range 200-700kHz) was 400kHz. As additional recording and visualising software we used HYSWEEP by HYPACK. Accurate positioning was enhanced by RTK-corrected navigation data.

4.1.3 Parametric Sediment Echosounder System (INNOMAR SES 2000 compact)

INNOMAR SES-2000 compact, operating with 100 kHz as primary (85 – 115 kHz frequency band for the second primary frequency) and resulting 8 kHz as secondary frequency, was applied to obtain further information about the subsurface built-up (Innomar Technologie, 2009).

4.2 HELCOM Grab Sampler

For ground truthing, sediment samples were collected applying the HELCOM Grab Sampler (Figure 1b). It enables very quick sampling of the upper 10-20cm of the sediment.

5 Performed work and preliminary Results

Several research subjects divided the cruise schedule into subunits in different sites.

For imaging the seafloor surface, we applied hydroacoustic systems producing bathymetric (MBES) and backscatter (MBES and SSS) data. Varying backscatter intensities represent differences in sediment properties. Homogenous areas of high backscatter intensity (for used system: high pixel intensity/ dark colour) indicate coarse sand and gravel, whereas low backscatter intensity (low pixel intensity/ light colour) represents areas of fine to medium sand (Diesing and Schwarzer, 2006). In the western part of the work area, very coarse sand is covered by a layer of fine sand with alternating thickness (Figure 3a). With thinner fine sand sediment cover towards north, backscatter intensities gradually become higher.

During the last days of the research cruise AL511 in July 2018, circle formed patches of high backscatter intensity were detected. They were identified as shell accumulations (see Figure 3b). Among other topics cruise L19-10a served for learning more about their resistivity, and to further investigate these structures. The shell accumulations were still present. Figure 3b shows that the patches elongated to NW-SE striking chains. Many patches were surrounded by a frame of very low backscatter intensity, pointing to fine material (Figure 3b). Mostly fine sand containing sediment samples of those patches didn't comprise any living mussels, but brittle stars and worms.

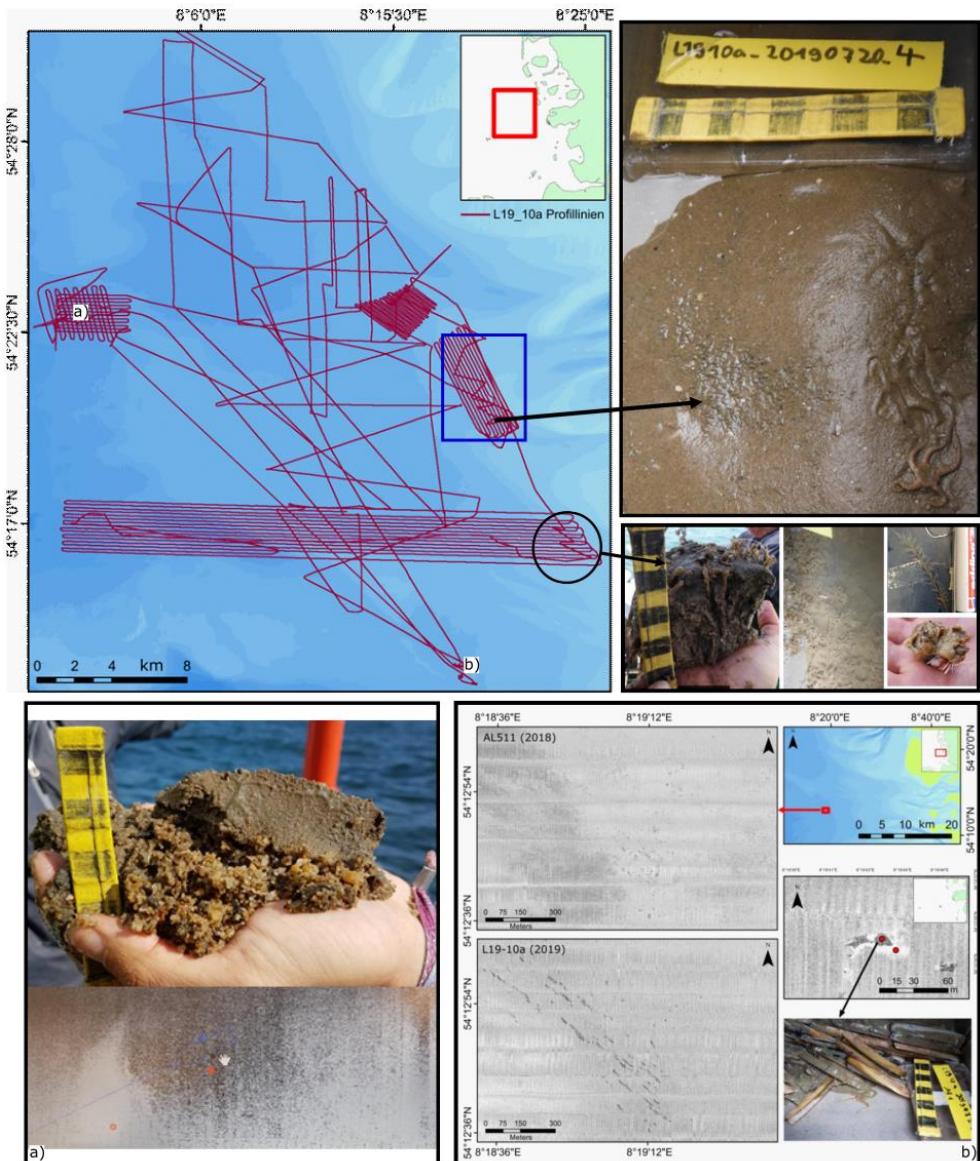


Figure 3: Overview over the investigation areas during cruise L19-10a. Some samples and hydroacoustic data concerning the seafloor surface are shown in detail.

The backscatter signal can also provide information about the roughness of the seafloor surface by resulting to specific textures. In this way, it is e.g. possible to identify sand tubes, constructed by the polychaete *L. conchilega* (Heinrich et al. 2016, Figure 2b). In the eastern part (Figure 3, blue frame in map) we repeated measurements already carried out in summer 2018. Just comparing those two temporally punctual situations, the suggestion arises that the distribution of the tube worm *L. conchilega* might have been shifted further to the south (Figure 3, circled frame in map).

The subbottom profiler (SES) was used for seismic profiling across existing borehole positions in approximately cross- and longshore direction (N-S & W-E). The boreholes were drilled with the help of a vibrocoring during research cruise AL-496 in 2017. The improved, RTK corrected ship positioning enabled exactly positioned profiling across the boreholes. Figure 4 shows an example of a SES profile that crosses two AL-496 vibrocore positions. The borehole contains marine sediments overlying terrestrial sands, separated by transgressive lag deposits (Figge, 1980; Uffenorde, 1982, Zeiler et al. 2000b). Thus, distinct sediment layers of the drillings can be correlated to seismo-acoustic units in the seismic profiles. In addition, some sediment layers and other features, like palaeo-channels or ravinement surfaces can be traced over longer distances.

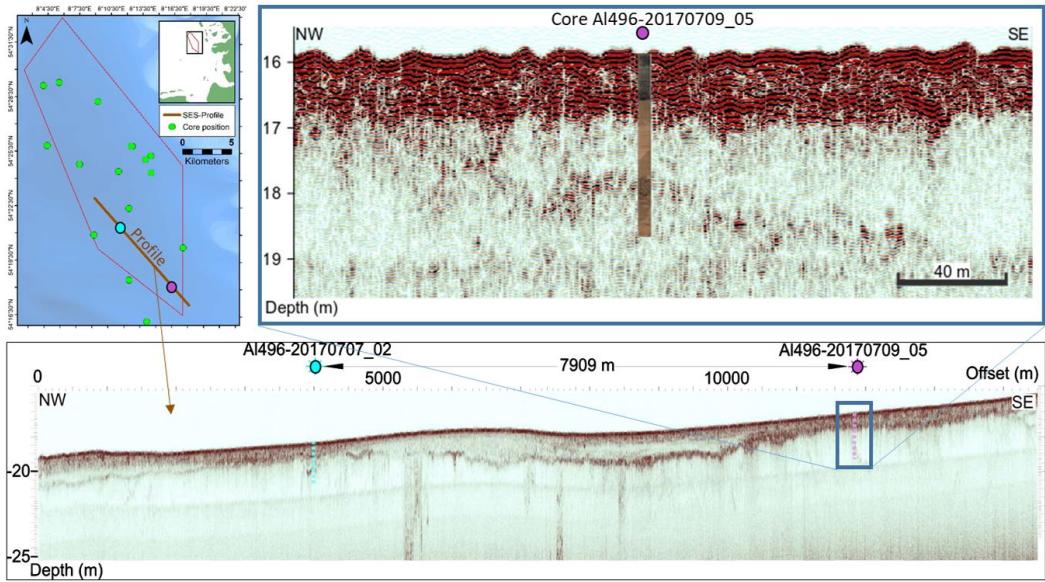


Figure 4: Upper left: Map with location of the central working area of cruise AL-496 (marked in red), AL-496-boreholes and SES profile; bottom: SES- profile with two vibrocoring drillings (obtained on cruise AL-496) into seismo-acoustic transparent layer underneath continuous reflector; upper right: zoom to borehole location Al496-20170709_05.

Further, the SES was used to trace incised fossil drainage-system-structures underneath a continuous reflector, interpreted as the Holocene Basement, in the centre of the working area (Figure 5).

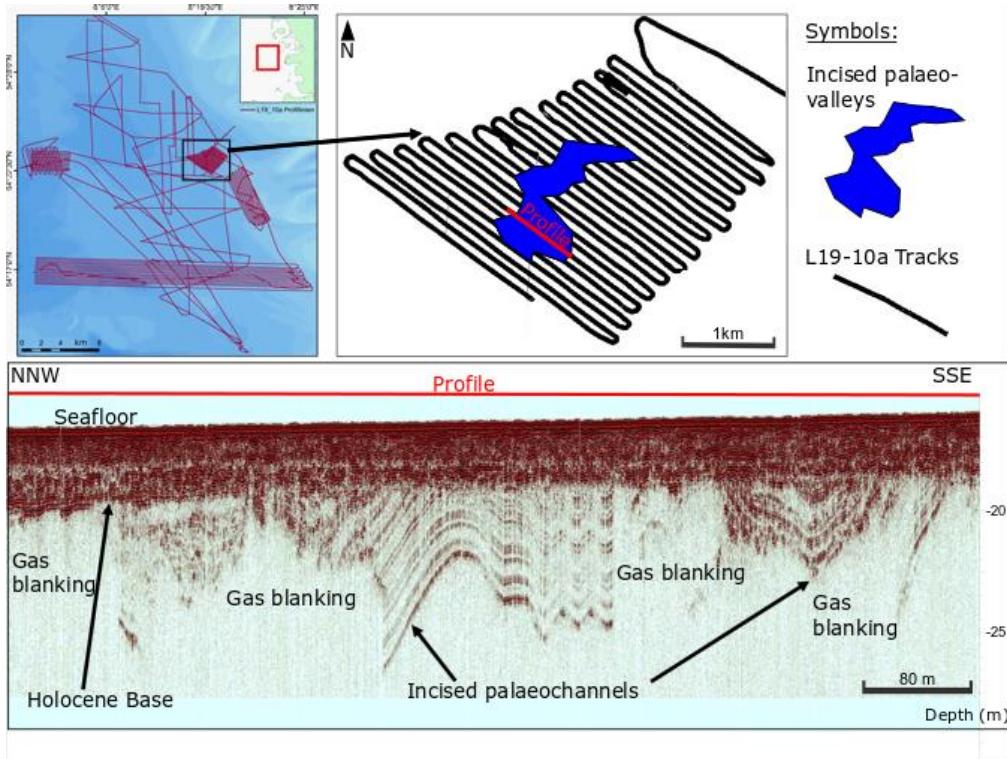


Figure 5: Upper left: All seismic lines, Upper middle: area with paleovalley- structures, with 100 m line- spacing between ship- tracks (black lines); Mapped geometry of palaeovalley-system.

The line spacing was 100 m in order to record a detailed picture of the geometry of the former drainage system. On most lines, a varying amount of incised structures with stratified infill can clearly be seen, despite some local acoustic turbidity, due to shallow gas (gas blanking), hampering seismic records (Fader, 1997). Gas blanking, appearing solely inside the stratified channel infill, speaks for a higher amount of organic matter in comparison to surrounding sands. Organic matter is consumed by microbes

that release gas during consumption. The gas is trapped underneath dense sediments like clay and silt. The meandering channels of the drainage system also widen, deepen and show increasing ramifications towards the SW.

Since the cruise targeted different questions in various investigation areas, and for saving transit time, towed systems that require at least three crew members on deck for deployment, were not active on all cruise tracks (see Table 1). In the end hydroacoustic data visualizing the seafloor surface coherently covers 90km². For ground truthing 45 sediment samples were collected.

6 Acknowledgement

We would like to thank the crew of FK LITTORINA for the great work on deck, the highly accurate positioning during sediment sampling and profiling, and the great food. The captain was ok.

7 References

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8 Appendices

Table 1: Hydroacoustic measurements

No.	Latitude	Longitude	AG	Date	Time (UTC)	Remarks	MBES	SES	SSS
1	54°12.842	08°17.348	1	17.07.2019	05:20	start profile	1	1	1
1	54°12.700	08°17.348	1	17.07.2019	05:43	stop profile	1	1	1
2	54°12.598	08°21.331	1	17.07.2019	05:54	start profile	1	1	1
2	54°12.554	08°18.005	1	17.07.2019	06:15	stop profile	1	1	1
3	54°12.554	08°18.465	1	17.07.2019	06:23	start profile	1	1	1
3	54°12.887	08°21.147	1	17.07.2019	06:43	stop profile	1	1	1
4	54°12.788	08°21.076	1	17.07.2019	06:50	start profile	1	1	1
4	54°12.789	08°18.080	1	17.07.2019	07:11	stop profile	1	1	1
5	54°13.080	08°18.167	1	17.07.2019	07:17	start profile	1	1	1
5	54°13.081	08°21.205	1	17.07.2019	07:40	stop profile	1	1	1
6	54°12.985	08°21.206	1	17.07.2019	07:45	start profile	1	1	1
6	54°12.981	08°18.065	1	17.07.2019	08:09	stop profile	1	1	1
7	54°13.277	08°18.061	1	17.07.2019	08:15	start profile	1	1	1
7	54°13.276	08°21.151	1	17.07.2019	08:38	stop profile	1	1	1
8	54°13.183	08°21.167	1	17.07.2019	08:42	start profile	1	1	1
8	54°13.178	08°18.068	1	17.07.2019	09:05	stop profile	1	1	1
9	54°13.466	08°18.016	1	17.07.2019	09:11	start profile	1	1	1
9	54°13.496	08°21.140	1	17.07.2019	09:35	stop profile	1	1	1
10	54°13.376	08°21.186	1	17.07.2019	09:39	start profile	1	1	1
10	54°13.372	08°18.098	1	17.07.2019	10:02	stop profile	1	1	1
11	54°13.668	08°18.077	1	17.07.2019	10:08	start profile	1	1	1
11	54°13.666	08°21.130	1	17.07.2019	10:31	stop profile	1	1	1
12	54°13.571	08°13.571	1	17.07.2019	10:35	start profile	1	1	1
12	54°13.566	08°18.083	1	17.07.2019	10:58	stop profile	1	1	1
13	54°17.366	08°24.305	4	17.07.2019	12:17	start profile	1	1	1
13	54°17.481	08°11.105	4	17.07.2019	16:00	stop profile	1	1	1
14	54° 14.610	08°14.232	2	17.07.2019	17:01	M1	1	1	
15	54°17.387	08°14.027	2	17.07.2019	17:35	M2	1	1	
16	54°17.381	08°13.285	2	17.07.2019	17:40	M3	1	1	
17	54°19.467	08°11.643	2	17.07.2019	18:11	M4	1	1	
18	54°23.307	08°04.848	2	17.07.2019	19:22	M5	1	1	
19	55°29.046	08°04.132	2	17.07.2019	20:56	M6	1	1	
20	55°29.076	08°05.552	2	17.07.2019	21:06	M7	1	1	
21	54°28.278	08°05.749	2	17.07.2019	21:39	M8	1	1	
22	54° 25.480	08°07.609	2	17.07.2019	22:23	M9	1	1	
23	54°22.964	08°07.986	2	17.07.2019	22:57	M10	1	1	
24	54°22.951	08°09.130	2	17.07.2019	23:06	M11	1	1	
25	54°17.068	08°18.299	2	18.07.2019	00:48	M12	1	1	
26	54°21.829	08°17.471	2	18.07.2019	01:48	M13	1	1	
27	54°26.261	08°14.270	2	18.07.2019	03:02	M14	1	1	
28	54°26.735	08°14.210	2	18.07.2019	03:07	M15	1	1	

No.	Latitude	Longitude	AG	Date	Time (UTC)	Remarks	MBES	SES	SSS
29	54°26.686	08°13.716	2	18.07.2019	03:11	M16	1	1	
30	54°23.402	08°14.001	2	18.07.2019	03:53	M17	1	1	
31	54°23.396	08°12.815	2	18.07.2019	04:05	M18	1	1	
32	54°27.085	08°12.527	2	18.07.2019	04:51	M19	1	1	
33	54°27.054	08°12.428	2	18.07.2019	04:53	M20	1	1	
34	54°23.982	08°12.626	2	18.07.2019	05:29	M21	1	1	
35	54°24.005	08°12.158	2	18.07.2019	05:32	M22	1	1	
36	54°20.221	08°12.405	2	18.07.2019	06:18	M23	1	1	
37	54°20.329	08°11.622	2	18.07.2019	06:26	M24	1	1	
38	54°26.387	08°11.174	2	18.07.2019	07:39	M25	1	1	
39	54°26.404	08° 09.434	2	18.07.2019	07:52	M26	1	1	
40	54°28.406	08° 09.321	2	18.07.2019	08:18	M27	1	1	
41	54°29.626	08° 09.204	2	18.07.2019	08:33	M28	1	1	
42	54°47.199	07°15.259	3	18.07.2019	14:23	start profile	1	1	
42	54°47.239	07°17.913	3	18.07.2019	14:50	stop profile	1	1	
43	54°47.289	07°17.700	3	18.07.2019	14:53	start profile	1	1	
43	54°47.279	07°15.360	3	18.07.2019	15:10	stop profile	1	1	
44	54°47.318	07°15.515	3	18.07.2019	15:13	start profile	1	1	
44	54°47.311	07°17.854	3	18.07.2019	15:29	stop profile	1	1	
45	54°47.361	07°17.447	3	18.07.2019	15:31	start profile	1	1	
45	54°47.360	07°15.337	3	18.07.2019	11:16	stop profile	1	1	
46	54°47.404	07°15.405	3	18.07.2019	15:50	start profile	1	1	
46	54°47.395	07°17.815	3	18.07.2019	16:06	stop profile	1	1	
47	54°47.436	07°17.650	3	18.07.2019	16:10	start profile	1	1	
47	54°47.441	07°15.354	3	18.07.2019	16:26	stop profile	1	1	
48	54°47.475	07°15.403	3	18.07.2019	16:29	start profile	1	1	
48	54°47.477	07°17.810	3	18.07.2019	16:46	stop profile	1	1	
49	54°47.521	07°17.640	3	18.07.2019	16:48	start profile	1	1	
49	54°47.521	07°15.348	3	18.07.2019	17:04	stop profile	1	1	
50	54°47.555	07°15.441	3	18.07.2019	17:07	start profile	1	1	
50	54°47.557	07°17.820	3	18.07.2019	17:23	stop profile	1	1	
51	54°07.606	07°17.753	3	18.07.2019	17:25	start profile	1	1	
51	54°47.599	07°15.355	3	18.07.2019	17:41	stop profile	1	1	
52	54°47.638	07°15.399	3	18.07.2019	17:45	start profile	1	1	
52	54°47.640	07°17.840	3	18.07.2019	18:02	stop profile	1	1	
53	54°47.682	07°17.840	3	18.07.2019	18:04	start profile	1	1	
53	54°47.685	07°15.281	3	18.07.2019	18:21	stop profile	1	1	
54	54°47.715	07°15.390	3	18.07.2019	18:23	start profile	1	1	
54	54°47.719	07°17.831	3	18.07.2019	18:40	stop profile	1	1	
55	54°47.700	07°17.761	3	18.07.2019	18:42	start profile	1	1	
55	54°47.765	07°15.314	3	18.07.2019	18:59	stop profile	1	1	
56	54°47.796	07°15.407	3	18.07.2019	19:00	start profile	1	1	
56	54°47.800	07°17.822	3	18.07.2019	19:17	stop profile	1	1	
57	54°47.524	07°16.885	3	18.07.2019	19:27	start profile	1	1	

No.	Latitude	Longitude	AG	Date	Time (UTC)	Remarks	MBES	SES	SSS
57	54°47.521	07°15.724	3	18.07.2019	19:35	stop profile	1	1	
58	54°47.470	07°15.720	3	18.07.2019	19:36	start profile	1	1	
58	54°47.475	07°16.769	3	18.07.2019	19:40	stop profile	1	1	
59	54°29.316	08°05.828	2	19.07.2019	01:47	WP1	1	1	
60	54°29.143	08°04.358	2	19.07.2019	01:58	WP2	1	1	
61	54°28.932	08°02.455	2	19.07.2019	02:11	WP3	1	1	
62	54°28.277	08°09.284	2	19.07.2019	03:05	WP4	1	1	
63	54°28.067	08°11.800	2	19.07.2019	03:25	WP5	1	1	
64	54°25.779	08°15.179	2	19.07.2019	04:03	WP6	1	1	
65	54°25.833	08°12.758	2	19.07.2019	04:23	WP7	1	1	
66	54°25.802	08°10.670	2	19.07.2019	04:36	WP9	1	1	
67	54°26.272	08°03.102	2	19.07.2019	05:32	WP10	1	1	
68	54°25.868	08°04.434	2	19.07.2019	05:48	WP11	1	1	
69	54°24.791	08°07.712	2	19.07.2019	06:13	WP12	1	1	
70	54°24.437	08°08.681	2	19.07.2019	06:21	WP13	1	1	
71	54°22.744	07°59.410	5	19.07.2019	18:34	start profile	1	1	1
71	54°22.539	08°02.254	5	19.07.2019	18:58	stop profile	1	1	1
72	54°22.921	07°59.290	5	19.07.2019	06:00	start profile	1	1	1
72	54°22.931	08°00.434	5	19.07.2019	19:32	stop profile	1	1	1
73	54°22.832	08°02.294	5	19.07.2019	19:52	start profile	1	1	1
73	54°23.122	07°59.321	5	19.07.2019	20:19	stop profile	1	1	1
74	54°23.028	08°02.151	5	19.07.2019	20:46	start profile	1	1	1
74	54°23.322	07°59.380	5	19.07.2019	21:13	stop profile	1	1	1
75	54°23.225	08°02.425	5	19.07.2019	21:39	start profile	1	1	1
75	54°23.508	07°59.354	5	19.07.2019	22:09	stop profile	1	1	1
76	54°23.421	08°02.332	5	19.07.2019	08:52	start profile	1	1	1
76	54°23.610	07°59.484	5	19.07.2019	23:07	stop profile	1	1	1
77	54°20.063	08°21.516	7	20.07.2019	02:10	start profile	1	1	1
78	54°22.731	08°19.333	7	20.07.2019	02:50	stop profile	1	1	1
78	54°19.865	08°21.272	7	20.07.2019	03:34	start profile	1	1	1
79	54°22.548	08°19.131	7	20.07.2019	04:18	stop profile	1	1	1
79	54°19.808	08°20.962	7	20.07.2019	05:03	start profile	1	1	1
80	54°22.466	08°18.841	7	20.07.2019	05:47	stop profile	1	1	1
80	54°19.729	08°19.749	7	20.07.2019	06:30	start profile	1	1	1
81	54°22.465	07°13.180	7	20.07.2019	07:10	stop profile	1	1	1
81	54°22.304	08°18.224	7	20.07.2019	08:36	start profile	1	1	1
82	54°24.016	08°19.690	7	20.07.2019	09:19	stop profile	1	1	1
82	54°22.104	08°17.585	7	20.07.2019	09:54	start profile	1	1	1
83	54°19.796	08°20.075	7	20.07.2019	10:27	stop profile	1	1	1
83	54°22.528	08°14.580	2	20.07.2019	14:30	start profile	1	1	
84	54°26.7611	08°14.150	2	20.07.2019	15:25	WP8	1	1	
85	54°26.672	08°13.703	2	20.07.2019	15:29	WP9	1	1	
86	54°25.983	08°13.809	2	20.07.2019	16:54	stop profile	1	1	
86	54°22.963	08°07.986	2	20.07.2019	17:29	start profile	1	1	

No.	Latitude	Longitude	AG	Date	Time (UTC)	Remarks	MBES	SES	SSS
87	54°24.732	08°07.906	2	20.07.2019	19:29	WP12	1	1	
88	54°24.479	08°08.644	2	20.07.2019	19:37	WP13	1	1	
89	54°24.438	08°11.378	2	20.07.2019	19:57	WP14	1	1	
90	54°24.381	08°14.495	2	20.07.2019	20:19	WP15	1	1	
91	54°24.329	08°16.812	2	20.07.2019	20:35	WP16	1	1	
92	54°25.601	08°15.332	2	20.07.2019	20:56	WP17	1	1	
93	54°25.337	08°14.402	2	20.07.2019	21:05	WP18	1	1	
94	54°25.110	08°13.644	2	20.07.2019	21:11	WP19	1	1	
95	54°24.835	08°13.309	2	20.07.2019	21:16	WP20	1	1	
96	54°24.431	08°11.297	2	20.07.2019	21:32	WP21	1	1	
97	54°23.835	08°08.657	2	20.07.2019	21:54	WP22	1	1	
98	54°22.389	08°10.154	2	20.07.2019	22:15	WP23	1	1	
99	54°22.404	08°12.431	2	20.07.2019	22:32	WP24	1	1	
100	54°22.324	08°17.191	2	20.07.2019	23:07	WP25	1	1	
101	54°21.353	08°11.464	2	20.07.2019	23:54	WP26	1	1	
102	54°20.922	08°09.0952	2	21.07.2019	00:13	WP27	1	1	
103	54°20.540	08°07.051	2	21.07.2019	00:30	WP28	1	1	
104	54°20.537	08°18.966	2	21.07.2019	02:05	WP29	1	1	
105	54°20.277	08°17.544	2	21.07.2019	02:20	WP30	1	1	
106	54°18.650	08°09.521	2	21.07.2019	03:22	WP31	1	1	
107	54°18.652	08°09.749	2	21.07.2019	03:25	WP32	1	1	
108	54°18.505	08°11.947	2	21.07.2019	03:41	WP33	1	1	
109	54°18.462	08°12.588	2	21.07.2019	03:46	WP34	1	1	
110	54°18.191	08°16.399	2	21.07.2019	04:17	WP35	1	1	
111	54°17.935	08°19.612	2	21.07.2019	04:40	WP36	1	1	
112	54°16.166	08°14.060	2	21.07.2019	05:38	WP37	1	1	
113	54°15.649	08°11.654	2	21.07.2019	00:00	WP38	1	1	
114	54°16.517	08°13.466	2	21.07.2019	10:57	WP39	1	1	
115	54°23.663	07°58.507	5	21.07.2019	19:12	start profile	1	1	
115	54°22.410	07°59.499	5	21.07.2019	19:37	stop profile	1	1	
116	54°23.654	07°59.199	5	21.07.2019	19:59	start profile	1	1	
116	54°22.403	07°59.923	5	21.07.2019	20:18	stop profile	1	1	
117	54°23.670	07°59.642	5	21.07.2019	20:41	start profile	1	1	
117	54°22.459	08°00.415	5	21.07.2019	21:02	stop profile	1	1	
118	54°23.667	08°00.105	5	21.07.2019	21:25	start profile	1	1	
118	54°22.462	08°00.847	5	21.07.2019	21:47	stop profile	1	1	
119	54°23.696	08°00.537	5	21.07.2019	22:10	start profile	1	1	
119	54°22.422	08°01.376	5	21.07.2019	22:35	stop profile	1	1	
120	54°23.656	08°01.452	5	21.07.2019	23:01	start profile	1	1	
120	54°22.467	08°01.776	5	21.07.2019	23:25	stop profile	1	1	
121	54°23.686	08°01.473	5	21.07.2019	23:51	start profile	1	1	
121	54°22.489	08°01.984	5	22.07.2019	00:10	stop profile	1	1	
122	54°17.489	08°11.034	4	22.07.2019	04:37	start profile	1	1	1
122	54°17.678	07°59.968	4	22.07.2019	06:03	stop profile	1	1	1

No.	Latitude	Longitude	AG	Date	Time (UTC)	Remarks	MBES	SES	SSS
123	54°17.106	08°24.065	4	22.07.2019	09:03	start profile	1	1	1
123	54°17.487	07°53.793	4	22.07.2019	12:11	stop profile	1	1	1
124	54°16.981	08°24.532	4	22.07.2019	15:17	start profile	1	1	1
124	54°17.295	07°59.727	4	22.07.2019	18:18	stop profile	1	1	1
125	54°16.779	08°24.773	4	22.07.2019	21:28	start profile	1	1	1
125	54°17.092	08°00.180	4	22.07.2019	00:47	stop profile	1	1	1
126	54°16.585	08°24.710	4	22.07.2019	04:04	start profile	1	1	1
126	54°16.899	07°59.750	4	22.07.2019	07:11	stop profile	1	1	1
127	54°16.381	08°25.294	4	22.07.2019	10:23	start profile	1	1	1
127	54°16.704	07°59.832	4	22.07.2019	13:47	stop profile	1	1	1
128	54°16.976	08°24.702	4	22.07.2019	15:16	start profile	1	1	1
128	54°17.294	07°55.685	4	22.07.2019	18:18	stop profile	1	1	1
129	54°17.094	07°59.767	4	23.07.2019	00:44	start profile	1	1	1
129	54°16.307	07°09.950	4	23.07.2019	02:50	stop profile	1	1	1
130	54°16.230	08°09.827	4	23.07.2019	04:07	start profile	1	1	1
130	54°16.823	08°00.552	4	23.07.2019	07:06	stop profile	1	1	1
131	54°16.888	08° 00.611	4	23.07.2019	07:07	start profile	1	1	1
131	54°16.668	08°25.019	4	23.07.2019	10:16	stop profile	1	1	1
132	54°16.384	08° 25.380	4	23.07.2019	10:23	start profile	1	1	1
132	54°16.611	08° 00.278	4	23.07.2019	13:42	stop profile	1	1	1
133	54°16.698	08° 00.338	4	23.07.2019	13:46	start profile	1	1	1
133	54° 16.480	08°25.183	4	23.07.2019	16:57	stop profile	1	1	1
134	54°16.179	08°25.583	4	23.07.2019	17:06	start profile	1	1	1
134	54°16.427	08° 00.459	4	23.07.2019	20:08	stop profile	1	1	1
135	54° 16.510	08° 00.382	4	23.07.2019	20:11	start profile	1	1	1
135	54°16.273	08°25.614	4	23.07.2019	23:23	stop profile	1	1	1
136	54°15.999	08°25.848	4	23.07.2019	23:30	start profile	1	1	1
136	54° 16.240	08° 00.475	4	24.07.2019	02:47	stop profile	1	1	1
137	54°16.314	08° 00.467	4	24.07.2019	02:48	start profile	1	1	1
137	54°16.223	08°09.765	4	24.07.2019	04:06	stop profile	1	1	1
138	54°23.941	08°16.628	8	24.07.2019	12:48	start profile	1	1	
138	54°23.466	08°17.734	8	24.07.2019	12:59	stop profile	1	1	
139	54°23.447	08°17.697	8	24.07.2019	13:01	start profile	1	1	
139	54°24.004	08°16.291	8	24.07.2019	13:15	stop profile	1	1	
140	54°23.965	08°16.226	8	24.07.2019	13:16	start profile	1	1	
140	54°23.362	08°17.667	8	24.07.2019	13:31	stop profile	1	1	
141	54°23.333	08°17.623	8	24.07.2019	13:33	start profile	1	1	
141	54°23.926	08°16.135	8	24.07.2019	13:58	stop profile	1	1	
142	54°23.895	08°16.109	8	24.07.2019	13:59	start profile	1	1	
142	54°23.330	08°17.436	8	24.07.2019	14:11	stop profile	1	1	
143	54°23.283	08°17.404	8	24.07.2019	14:13	start profile	1	1	
143	54°23.864	08°15.993	8	24.07.2019	14:27	stop profile	1	1	
144	54°23.851	08°15.906	8	24.07.2019	14:28	start profile	1	1	
144	54°23.238	08°17.348	8	24.07.2019	14:41	stop profile	1	1	

No.	Latitude	Longitude	AG	Date	Time (UTC)	Remarks	MBES	SES	SSS
145	54°23.187	08°17.324	8	24.07.2019	14:43	start profile	1	1	
145	54°23.803	08°15.824	8	24.07.2019	14:57	stop profile	1	1	
146	54°23.759	08°15.756	8	24.07.2019	14:58	start profile	1	1	
146	54°23.122	08°17.316	8	24.07.2019	15:12	stop profile	1	1	
147	54° 23.080	08°17.261	8	24.07.2019	15:13	start profile	1	1	
147	54°23.754	08°15.626	8	24.07.2019	15:28	stop profile	1	1	
148	54°23.716	08°15.591	8	24.07.2019	15:29	start profile	1	1	
148	54°23.064	08°17.118	8	24.07.2019	15:43	stop profile	1	1	
149	54°23.022	08°17.092	8	24.07.2019	15:44	start profile	1	1	
149	54°23.712	08°15.385	8	24.07.2019	15:59	stop profile	1	1	
150	54°23.672	08°15.314	8	24.07.2019	16:00	start profile	1	1	
150	54°22.977	08°17.013	8	24.07.2019	16:16	stop profile	1	1	
151	54°22.926	08°16.980	8	24.07.2019	16:17	start profile	1	1	
151	54° 23.66	08°15.202	8	24.07.2019	16:33	stop profile	1	1	
152	54° 23.64	08°15.135	8	24.07.2019	16:33	start profile	1	1	
152	54°22.877	08°16.919	8	24.07.2019	16:50	stop profile	1	1	
153	54°22.839	08°16.851	8	24.07.2019	16:52	start profile	1	1	
153	54°23.613	08°15.041	8	24.07.2019	18:14	stop profile	1	1	
154	54°23.592	08°14.963	8	24.07.2019	18:14	start profile	1	1	
154	54°22.811	08°16.774	8	24.07.2019	18:32	stop profile	1	1	
155	54°22.767	08°16.719	8	24.07.2019	18:34	start profile	1	1	
155	54°23.565	08°14.801	8	24.07.2019	18:49	stop profile	1	1	
156	54°23.546	08°14.707	8	24.07.2019	18:51	start profile	1	1	
156	54°22.728	08°16.636	8	24.07.2019	19:09	stop profile	1	1	
157	54°22.698	08°16.548	8	24.07.2019	19:11	start profile	1	1	
157	54°23.545	08°14.530	8	24.07.2019	19:27	stop profile	1	1	
158	54°23.513	08°14.452	8	24.07.2019	19:28	start profile	1	1	
158	54°22.653	08° 16.510	8	24.07.2019	19:48	stop profile	1	1	
159	54° 22.61	08°16.456	8	24.07.2019	19:50	start profile	1	1	
159	54°23.501	08°14.309	8	24.07.2019	20:07	stop profile	1	1	
160	54°23.479	08°14.221	8	24.07.2019	20:08	start profile	1	1	
160	54°22.559	08°16.421	8	24.07.2019	20:29	stop profile	1	1	
161	54°22.521	08°16.380	8	24.07.2019	20:30	start profile	1	1	
161	54°23.471	08°14.066	8	24.07.2019	20:50	stop profile	1	1	
162	54°23.453	08°13.996	8	24.07.2019	20:51	start profile	1	1	
162	54°22.476	08°16.302	8	24.07.2019	21:11	stop profile	1	1	
163	54°22.454	08°16.222	8	24.07.2019	21:13	start profile	1	1	
163	54°23.443	08°13.830	8	24.07.2019	21:35	stop profile	1	1	
164	54°23.421	08°13.756	8	24.07.2019	21:36	start profile	1	1	
164	54°22.677	08°15.505	8	24.07.2019	21:53	stop profile	1	1	

Table 2: CTD profiles

No.	Latitude	Longitude	Date	Time (UTC)
1	54°14.765	08°13.308	17.07.2019	03:32

2	54°16.691	8°1.525	23.07.2019	13:30
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Table 3: HELCOM Grab Samples

No.	Latitude	Longitude	Date	Time (UTC)	Remarks
1	54° 47.478	07° 16.260	18.07.2019	20:01	AG3
2	54° 47.486	07° 16.238	18.07.2019	20:15	AG3
3	54° 47.489	07° 16.189	18.07.2019	20:29	AG3
4	54° 47.555	07° 16.164	18.07.2019	20:43	AG3
5	54° 47.503	07° 16.159	18.07.2019	20:54	AG3
6	54° 47.502	07° 16.146	18.07.2019	21:13	AG3
7	54° 20.014	08° 20.334	20.07.2019	11:09	AG7
8	54° 20.105	08° 21.238	20.07.2019	11:31	AG7
9	54° 20.322	08° 20.331	20.07.2019	11:43	AG7
10	54° 20.513	08° 19.848	20.07.2019	11:56	AG7
11	54° 20.565	08° 20.582	20.07.2019	12:07	AG7
12	54° 20.772	08° 19.569	20.07.2019	12:20	AG7
13	54° 21.167	08° 20.146	20.07.2019	12:31	AG7
14	54° 21.455	08° 18.695	20.07.2019	12:47	AG7
15	54° 22.242	08° 19.217	20.07.2019	13:02	AG7
16	54° 22.407	08° 19.712	20.07.2019	13:13	AG7
17	54° 13.069	08° 18.787	21.07.2019	07:30	AG1
18	54° 13.098	08° 18.817	21.07.2019	07:40	AG1
19	54° 12.760	08° 19.118	21.07.2019	07:58	AG1
20	54° 12.767	08° 19.099	21.07.2019	08:14	AG1
21	54° 12.734	08° 19.103	21.07.2019	08:38	AG1
22	54° 12.584	08° 19.730	21.07.2019	08:53	AG1
23	54° 12.586	08° 19.718	21.07.2019	09:05	AG1
24	54° 23.178	08° 02.273	21.07.2019	12:58	AG5
25	54° 23.045	08° 01.237	21.07.2019	13:17	AG5
26	54° 23.037	08° 01.064	21.07.2019	13:28	AG5
27	54° 23.044	08° 00.990	21.07.2019	13:36	AG5
28	54° 22.925	08° 04.437	21.07.2019	13:46	AG5
29	54° 22.844	08° 00.419	21.07.2019	14:00	AG5
30	54° 22.813	08° 00.046	21.07.2019	14:16	AG5
31	54° 22.854	07° 59.554	21.07.2019	14:31	AG5
32	54° 22.889	07° 59.420	21.07.2019	14:42	AG5
33	54° 22.909	07° 59.446	21.07.2019	14:50	AG5
34	54° 17.019	08° 06.073	24.07.2019	05:20	AG4
35	54° 17.301	08° 01.536	24.07.2019	05:52	AG4
36	54° 16.694	08° 02.511	24.07.2019	06:12	AG4
37	54° 16.691	08° 02.600	24.07.2019	06:23	AG4
38	54° 16.698	08° 02.777	24.07.2019	06:38	AG4
39	54° 16.575	08° 12.358	24.07.2019	07:54	AG4
40	54° 16.822	08° 20.439	24.07.2019	08:50	AG4

No.	Latitude	Longitude	Date	Time (UTC)	Remarks
41	54° 16.497	08° 21.799	24.07.2019	09:07	AG4
42	54° 16.199	08° 22.167	24.07.2019	09:19	AG4
43	54° 16.192	08° 25.392	24.07.2019	10:01	AG4
44	54° 16.648	08° 24.564	24.07.2019	10:24	AG4
45	54° 16.995	08° 24.150	24.07.2019	10:46	AG4