BUNDESAMT FÜR
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HYDROGRAPHIE

Scientific Cruise Report

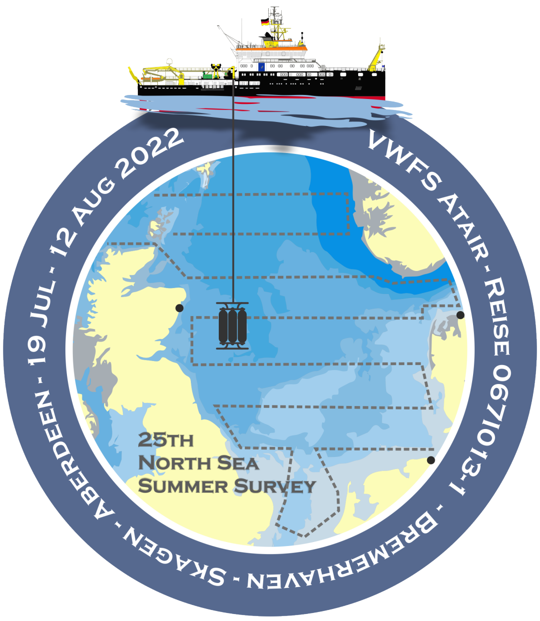
North Sea Summer Survey 2022
RV ATAIR, Cruise 067I013-1

19 Jul – 11 Aug 2022

Bremerhaven/Germany – Skagen/Denmark – Aberdeen/UK

Chief Scientist: Dr. Dagmar Kieke

Captain: Ulrich Klüber



Hamburg, August 2025

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1. Summary

English:

Scientific cruise 067I0131-1, conducted aboard the research vessel ATAIR, investigated the physical and biological state of the North Sea in summer 2022. The focus was on surveying a large-scale network of standard station locations at specific latitudes in order to observe major inflow and outflow conditions into and out of the North Sea. The overall aim was to obtain suitable physical oceanographic data to further extend existing time series on the hydrographic properties of the North Sea's water column. Additionally, biological data from the sea surface with respect to chlorophyll-a will be used to validate and compare satellite data. Furthermore, sampling was conducted to investigate the large-scale distribution of certain radionuclides. Data collected during the cruise consisted of hydrographic casts and sampling at standard stations as well as underway measurements to analyse hydrographic conditions near the sea surface along the route. The resulting data set from cruise 067I0131 is of a high quality, comprising underway measurements and water column data from 97 stations, including one test station and one station visited twice.

German:

Die wissenschaftliche Expedition 067I0131-1, die mit dem Vermessungs-, Wracksuch- und Forschungsschiff (VWFS) ATAIR durchgeführt wurde, untersuchte den physikalischen und biologischen Zustand der Nordsee im Sommer 2022. Der Schwerpunkt lag auf der Vermessung eines großflächigen Netzwerks von Standardstationen an bestimmten Breitengraden, um die wichtigsten Zu- und Abflussbedingungen in die und aus der Nordsee zu beobachten. Das übergeordnete Ziel bestand darin, geeignete physikalisch-ozeanographische Daten zu gewinnen, um dadurch die bestehenden Zeitreihen zu den hydrographischen Eigenschaften der Wassersäule der Nordsee weiter auszubauen. Darüber hinaus wurden biologische Daten von der Meeresoberfläche in Bezug auf Chlorophyll-a für die Validierung von und zum Vergleich mit Satellitendaten erhoben. Zusätzliche Oberflächenprobenahmen wurden durchgeführt, um die großräumige Verteilung bestimmter Radionuklide zu untersuchen. Die während der Fahrt gesammelten Daten umfassten hydrographische Messungen an festgelegten Standardstationen sowie Messungen während der Fahrt zur Analyse der hydrographischen Bedingungen in der Nähe der Meeresoberfläche entlang der Route. Der aus der Fahrt 067I013-1 resultierende Datensatz ist von hoher Qualität und umfasst Unterwegs-Messungen sowie Wassersäulendaten von 97 Stationen, darunter eine Teststation und eine Station, die zweimal angefahren wurde.

2. Participants

	Name	Institute	Field of Activity/Responsibility
1.	Kieke, Dagmar, Dr. *	BSH	chief scientist
2.	Becker, Klaus *	BSH	radionuclides
3.	Köllner, Manuela *	BSH	CTD watch, VMADCP, chlorophyll-a filtration, Secchi disc, CTD/vmADCP data processing
4.	Lommel, Freya **	BSH	CTD watch, chlorophyll-a filtration, Secchi disc
5.	Reißmann, Jan H., Dr. ***	BSH	CTD watch, chlorophyll-a filtration, Secchi disc
6.	Schmied, Stefanie A. K., Dr, *	BSH	radionuclides
7.	Tewes, Simon *	BSH	CTD watch, chlorophyll-a filtration, Secchi disc, thermosalinograph
8.	Weidig, Christopher **	BSH	radionuclides

* Bremerhaven – Aberdeen   ** Bremerhaven – Skagen   *** Skagen – Aberdeen

BSH   *Federal Maritime and Hydrographic Agency, Hamburg, Germany*

Table 1.1. *Scientific participants of cruise 067I013-1, summer 2022.*

3. Purpose of the Cruise and Research Objectives

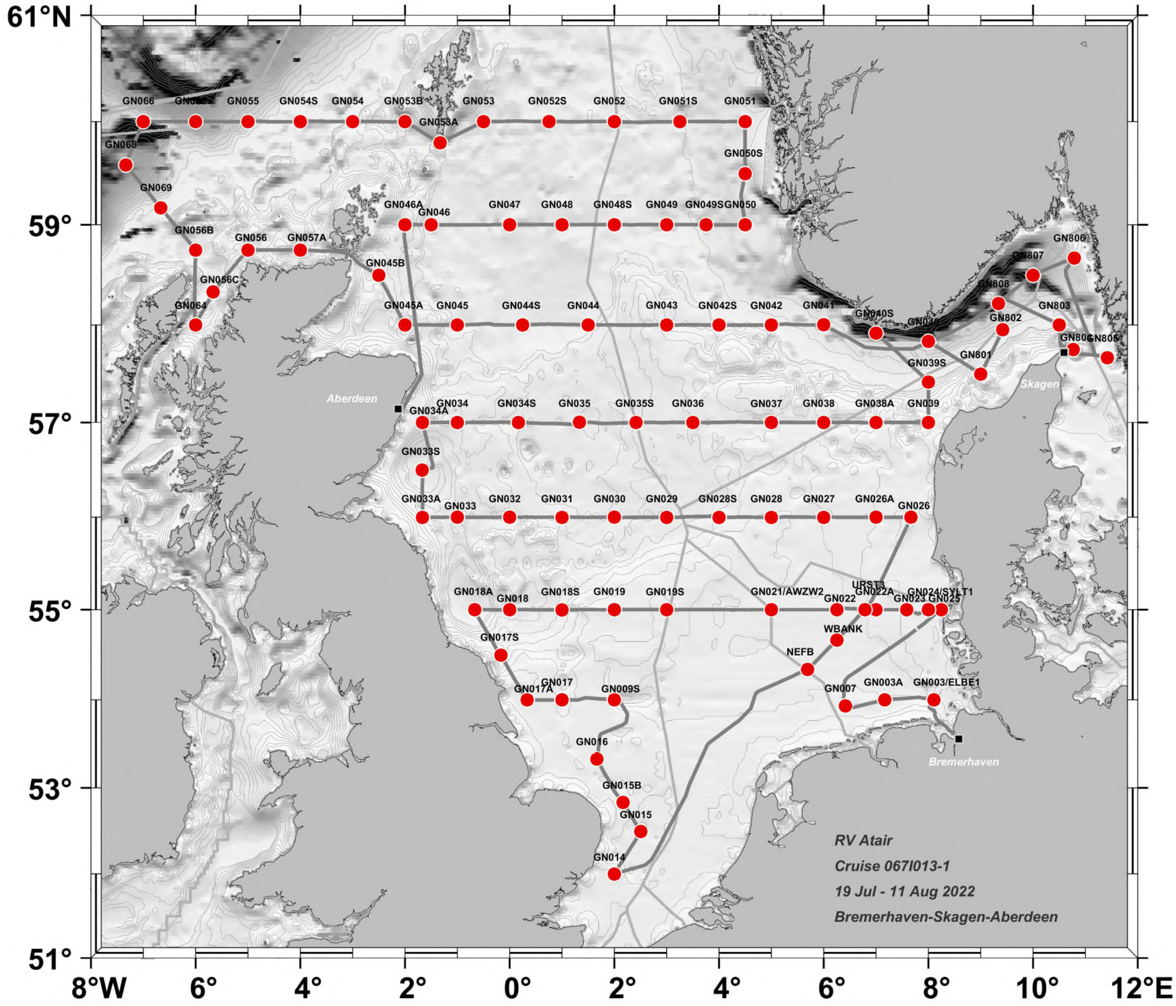

Figure 1.1 *Track of cruise 067I013-1 with RV ATAIR and locations of corresponding hydrographic stations. Text labels denote station names. Thin dashed lines highlight limits of the various Exclusive Economic Zones (EEZ) according to the Maritime Boundaries Geodatabase version 11.0 of Flanders Marine (2019).*

Cruise *067I013-1* with *RV ATAIR* served to conduct the annual large-scale *North Sea Summer Survey* (NSSS) of the BSH. Surveys similar to cruise *067I013-1* have been undertaken annually by the BSH since 1998. These surveys generally follow a predefined network of standard stations forming zonal sections that cross the North Sea at various latitudes between 54°N and 60°N. Additional stations located to the south of 54°N form a loop-like station pattern stretching to about 52°N near the southern entrance to the North Sea. The annual *North Sea Summer Survey* is typically carried out at or close to the time of the expected maximum stratification and phytoplankton productivity having passed its peak.

Cruise *067I013-1* in summer 2022 consisted of two legs. Leg 1 covered the southern and central parts of the North Sea, while Leg 2 addressed the central to northern parts. Leg 1 departed from Bremerhaven, Germany, on 19 July arriving in the port of Skagen, Denmark, on 31 July (see Figure 1.1). The vessel remained in the port from 31 July to 2 August to exchange crew members and scientific participants (see Section 2). The cruise was resumed on 2 August, when the vessel departed from Skagen to pursue the second leg of the cruise in the northern part of the North Sea. The cruise ended when the vessel arrived in Aberdeen, UK, on 11 August 2022.

In addition to the standard stations that cover the North Sea region, cruise *067I013-1* also served to conduct station work in the Skagerrak region and in the Minch, which is located between the Hebrides and the Scottish mainland. It also covered the northwesternmost part of the area under investigation, which is located at the edge of the western Scottish shelf break.

The major purpose of cruise *067I013-1* based on respective measurement data is to assess the state of the North Sea in summer 2022 with focus on the physical state. Large-scale data will contribute to the investigation of the hydrographic state of the water column in different regions of the North Sea. Furthermore, temporal changes in the hydrography, which become apparent when the data is considered alongside data from previous cruises, will be addressed. Sampling water for radionuclide analysis is part of the BSH's standard monitoring of radioactive contamination in the North Sea. This is based on several legal and regulatory provisions, as well as the corresponding requirements for fulfilling them. The sampling will assess spatial changes in the concentrations of these radionuclides, as well as changes over time compared to previous cruises. Particular objectives related to cruise *067I013-1* addressing the state of the North Sea in 2022 are the following:

- How far does the Atlantic Water (AW) that enters the North Sea at its northern limits propagate southward in summer 2022?
- Where does the main inflow take place?
- How far does AW entering the southern North Sea via the English Channel penetrate northwards in summer 2022?
- What is the respective regional sharpness and depth of the thermocline?
- What is the total salt and heat content of the North Sea in summer 2022?
- Where is the Baltic outflow located?
- What is the lateral distribution and concentration level of selected radionuclides in summer 2022?

Overarching objectives that address temporal changes on different time scales are:

- How do changes in the Northeast Atlantic happening on time scales ranging from seasonal to decadal affect the North Sea?
- Which processes are linked to the variability in the North Atlantic Oscillation (NAO) and to what extent?

Chlorophyll sampling carried during the cruise will serve for improving remote-sensing products and satellite sensor validation by means of comparison with in situ data.

4. Narrative of the Cruise

The *RV ATAIR* left its berth at Kohlenkai in Bremerhaven/Germany at 06:00 UTC on 19 July 2022. It subsequently passed the Bremerhaven Sleuth to begin cruise *067I013-1*, the *North Sea Summer Survey* of 2022. The scientific mission began at 10:45 UTC with a test station. The continuous logging of underway data for the vessel-mounted Acoustic Doppler Current Profiler (VMADCP) was activated at 13:03 UTC after having reached station #002/GN003/ELBE1. Underway measurements for the thermosalinograph (TSG) system were activated at 16:10 UTC, after leaving coastal waters enriched with sediment and small-scale particles that could obstruct the system's water flow. Between 19 July 2022 at 19:05 UTC and 21 July 2022 at 17:00 UTC, respective data could not be obtained due to issues with the electronic data transfer and a depleted TSG clock battery. After resolving these issues, the system could be activated again.

The course was set towards the west and initially followed the 54°N latitude. After finishing work at station #004/GN007 on 19 July, the boundary between the German and the Dutch exclusive economic zones (EEZ) was in reach. Unfortunately, the required permission to conduct scientific research in Dutch waters could not be obtained in time. Instead, the course was changed towards the northeast to continue station work at the eastern end of the 55°N section at station #005/GN025, which was reached on 20 July. Between 20 July and 22 July, the 55°N section was completed without any work being carried out within the Dutch EEZ.

From 22 July 2022 onwards, the vessel headed south to conduct work at stations #016/GN017S to #023/GN014. The latter station (#023/GN014), which was reached on 23 July, was the southernmost station of cruise *067I013-1*. Between 23 and 24 July, the vessel transited through the Dutch EEZ on a northeasterly course. Station work and underway measurements were resumed when reaching the German EEZ near station #024/NEFB on 24 July.

With two more stations to be completed in German waters, work on the 56°N section was resumed in Danish waters at station #027/GN026 on 25 July 2022. The section was completed at its western end in UK waters at station #037/GN033A on 27 July. Between 27 and 29 July, station work was carried out at stations along the 57°N section in an eastward direction. The easternmost station of this section was station #048/GN039.

Between 29 and 31 July, the vessel crossed the Norwegian Trench several times, thereby leaving or entering the Danish or Norwegian EEZ, depending on the location of the stations. The first of eight stations that are part of the Skagerrak station net extension was reached on 30 July: #052/GN801. After finishing work at station #053/GN802, the vessel headed north to station #060/GN808 in Norwegian waters. With a water depth of around 680 m, this was the deepest of the Skagerrak stations. After finishing the CTD cast there, a number of large-volume samplers (LVS) with capacities of 270 L and 333 L were attached to a steel wire and one after the other deployed. They were closed at their respective sampling depths by dropping a fall weight that was attached to the wire. Proper closing of the LVS was only partly successful.

After completing work at stations #055/GN803 and #056/GN804, the vessel approached the port of Skagen in Denmark. On 31 July at 14:24 UTC, *RV ATAIR* was towed to Berth 41 in order to finish Leg 1 of cruise *067I013-1*. The scientific mission was then interrupted until 2 August, 05:38 UTC, when the vessel departed Skagen to begin Leg 2 of the same cruise. In between, crew members and scientific participants were exchanged and liquid natural gas (LNG) was supplied to power the vessel.

After leaving Skagen on 2 August, work was carried out at the two Swedish stations #057/GN805 and #058/GN806, which are located within Swedish territorial waters. Underway measurements were switched off while in the territorial zone, and the vessel transited from station #057/GN805 to #058/GN806 in north-westerly direction, remaining within the Swedish EEZ but outside the Swedish territorial limits.

After finishing work in Swedish waters, the vessel arrived at station #060/GN808 in Norwegian waters for the second time on 3 August, to carry out another cast with the 270 L and 333 L capacity LVS, but without conducting any further CTD casts or other water sampling.

Starting from station #061/GN041, which was visited on 3 August 2022, the vessel headed west in order to continue working along the 58°N section. The western end of this section, located in UK waters, was reached at station #068/GN045A in the morning of 5 August. On the same day, between approximately 17:00 and 19:00 UTC, the tidal stream’s flow direction allowed the vessel to pass through the Pentland Firth to the west. Station work was resumed at station #070/GN057A, on the northern side of the Scottish mainland, shortly after 22:00 UTC. On 6 August, the vessel reached the southernmost station in the Minch (#073/GN064). As weather conditions worsened while in the Minch, the decision was made to cancel the original westernmost station, GN067, in Faorese waters in order to save some time for the remaining cruise programme. The westernmost station of the entire cruise *067I013-1* was thus station #076/GN068, which was reached on 8 August. With a water depth exceeding 1000 m, this was also the second deepest station of the cruise; the deepest station was #078/GN065 (1065 m), which was reached shortly afterwards.

Due to the cancellation of one station, work on the 60°N section began at its western end at station #077/GN066 (7 August), after which the vessel continued eastwards. The southern tip of the Shetland Islands (station #083/GN053A) was passed on 8 August, and the section was finally complete at its eastern end off the coast of Norway on 9 August (station #088/GN051).

The final section of the cruise, located at 59°N, was sampled in westerly direction between 9 August (station #090/GN050) and 11 August (station #097/GN046A). Another test with the LVS carrying 333 L was conducted on station #094/GN048 on 10 August. After concluding operations at station #097/GN046A shortly before 01:00 UTC on 11 August, the vessel commenced its transit towards the port of Aberdeen/UK.

In total, 97 stations including a test station at the start of the cruise were completed during the cruise *067I013-1*, and data from 95 CTD casts is available. Data from nine stations located in Dutch waters, which were originally planned to be included, is not available.

The continuous logging of underway data stopped at around 15:20 UTC on 11 August, marking the end of the scientific mission of cruise *067I013-1* with *RV ATAIR*. Shortly before 17:00 UTC, the vessel arrived at the Aberdeen pilot station and took on a pilot. It was finally towed to Regent Quay No. 3 in the Port of Aberdeen at 17:36 UTC, marking the end of cruise *067I013-1*.

5. Scientific Tools and Methods

5.1 Overview

Scientific tools that were in use during the cruise comprised profiling of the entire water column using a Conductivity-Temperature-Depth (CTD) unit attached to a carousel water sampler system and equipped with a number of sensors that will be detailed in the following sections. Additional sensors attached to the CTD-unit involved a sensor measuring dissolved oxygen, a dual-wavelength sensor measuring simultaneously both, fluorescence and turbidity. and an altimeter for determining the distance of the underwater unit to the sea bottom in order to avoid contact.

The carousel water sampler was equipped with a fixed number of 10 litres Niskin bottles to allow for taking water samples at discrete depths of the water column. Water sampling activities consisted of taking salinity samples for the sake of calibrating the conductivity sensors of the CTD unit, water samples for water density and chlorophyll-a for home-based laboratory analyses.

Sampling with respect to radionuclides was mostly limited to the surface layer. At one station in the Skagerrak (GN808), water samples were taken at different depths between the sea surface and the bottom of the Norwegian Trench using large-volume samplers (LVS).

In total, 95 stations involving the CTDO/water sampler system and excluding a test station were carried out. Secchi depth determination and water sampling for chlorophyll-a was conducted on preselected stations and most of the time happened on daylight stations.

A vessel-mounted Acoustic Doppler Current Profiler (VMADCP) system operating at 150 kHz and mostly in narrow-band mode delivered oceanic velocity data of the upper water column during the cruise. Further underway measurements focused on standard meteorological data, water depth and near-surface values for water temperature, salinity, fluorescence/chlorophyll and turbidity.

5.2 CTD Sensor Unit and Water Sampler Setup

During cruise *067I013-1*, a profiling conductivity-temperature-depth (pressure) sensor unit (CTD) of type *Sea-Bird Electronics (SBE) 9plus* (“*CTD Sonde S1”*) was in use. It was operated and powered from out of the vessel’s hydrography lab via a deckunit of type *SBE11plus*. The CTD sensor package was mounted horizontally in the lower part of a water sampler frame of type *SBE32*, which can carry up to 12 Niskin bottles of 10 litres volume. Raw data recording was performed using the BSH software *Seasave_Start*, which internally calls the *SBE* software *SeaSave*, version 7.26.7.121, and the data conversion software (from binary into ASCII) *SBE DataProcessing*, version 7.26.7.129.

The CTD sensor package consisted of two pairs of temperature (T) and conductivity (C) sensors, one primary and one secondary, each of which was connected to a particular pump and the CTD main housing, which carried a pressure sensor. A through-flow oxygen sensor was connected to the primary T/C sensor pair. Additionally, a dual-wavelength sensor of type *WetlabECO* delivering fluorescence and turbidity data simultaneously, as well as a *SBE18* pH-sensor were attached to and powered by the CTD system. The distance to the seabed was estimated using an altimeter of type *Teledyne Benthos PSA-916*. The inlets of the two T/C sensor pairs were soaked in distilled water until the beginning and end of each CTD deployment. All temperature and conductivity sensors wre successfully recalibrated in the BSH's calibration laboratory prior to the cruise.

Table 5.1 lists all the devices and sensors that were in use, and Table 5.2 lists the Niskin bottle setup. Temperatures are reported on the *ITS-90* scale. Derived salinities refer to the *Practical Salinity Scale* of 1978 (PSS-78). All respective densities have been inferred from the *EOS-80* equation.

Device	Serial Number	Calibration Date
CTD main unit with pressure sensor, SBE9plus	09P21787-0577, S1	06 Feb 2019
deckunit, SBE11plus	11P29178-0620, N1	---
temperature sensor 1, SBE3T, part of TC1	2584	25 May 2022
temperature sensor 2, SBE3T, part of TC2	2808	25 May 2022
conductivity sensor 1, SBE4C, part of TC1	2886	12 May 2022
conductivity sensor 2, SBE4C, part of TC2	2602	12 May 2022
oxygen sensor, SBE43	0171	16 Apr 2022
pump 1, SBE5	3126	---
pump 2, SBE5	3336	---
dual-wavelength sensor, WET Labs ECO-AFL/FL, fluorescence	4964	15 Jan 2018
dual-wavelength sensor, WET Labs ECO, turbidity	4964	15 Jan 2018
pH-value sensor, SBE18	1587	24 Mar 2022
altimeter, Teledyne Benthos, PSA-916	978	14 Mar 2002
carousel water sampler with 12 positions for Niskin bottles, SBE32	3232948-0466, K1	---

Table 5.1. *Overview on CTD-related sensors or water sampler devices used during cruise 067I013-1.*

The CTD system worked well throughout the entire cruise, and the sensors produced reliable measurements. The differences between the redundant sensors were small and mostly within the uncertainty range as specified by the manufacturer and confirmed by calibration. Larger differences were observed in rough conditions or when a larger number of particles within the water column clogged the sensor packs temporarily. NMEA-formatted GPS data was always available and added to the casts.

Position	Bottle ID	Manufacturer	Volume	Closing Depth
1	S-ID181001	*General Oceanics*	10 L	bottom
2	S-ID181004	“ “	“	bottom
3	S-ID181005	“ “	“	5 dbar, 10 dbar and > 100 dbar
	S-ID181017	“ “	“	5 dbar
4	S-ID181011	“ “	“	5 dbar, 10 dbar and > 100 dbar
5	S-ID181006	“ “	“	5 dbar
	S-ID191007	“ “	“	5 dbar

Table 5.2. *Overview on the Niskin bottle set-up and sampling scheme of cruise 067I013-1.*

All Niskin bottles were checked at the beginning of the cruise and then closed during the upcast at the designated sampling levels.

5.3 Water Sampling with respect to Salinity

Water sampling was carried out at all stations during cruise *067I013-1* for the purpose of checking the quality of the CTD-derived conductivity and, consequently, salinity. Exceptions were made at the test station at the beginning of the cruise and at a repeated station where only large-volume samplers were used. Water samples were mostly taken from Niksin bottles closed at 5 dbar near the surface and at the bottom (see Table 5.2). The bottles were numbered and rinsed three times with seawater before being filled and sealed airtight. The water samples were analysed using an *OSIL AUTOSAL 8400B* salinometer. For standardisation, IAPSO standard seawater batches P-164 and P-165 were used. All samples were assigned a BSH sample identification number similar to a *Bedford* number.

5.4 Water Sampling with respect to Density

Water sampling with respect to density analysis was carried out on selected stations. Similarly to salinity, water samples were taken from the Niksin bottles that were closed near the surface at 5 dbar and close to the bottom. Numbered glass bottles were used and rinsed three times with seawater before finally filling the bottle. The sample was made air-tight by closing the bottle with a rubber plug and attaching a metal seal on top. All samples were given a BSH sample identification number similar to *Bedford* numbers. Back at the home lab, density samples were analysed with a densitymeter of type *Mettler Toledo Excellence D6*. In total, 46 samples taken from station locations distributed all across the North Sea were analysed for density. Figure 5.2 presents the station locations with density sampling carried out during cruise *067I013-1*. There are no density samples from the Dutch EEZ. The purpose of the density sampling and analysis is to build up a density database for the North Sea for the sake of obtaining absolute salinity data, S_A. These should be based on density measurements that can be traced back to SI units, a prerequisite when considering the *Thermodynamic Equation of Seawater 2010* (TEOS-10).

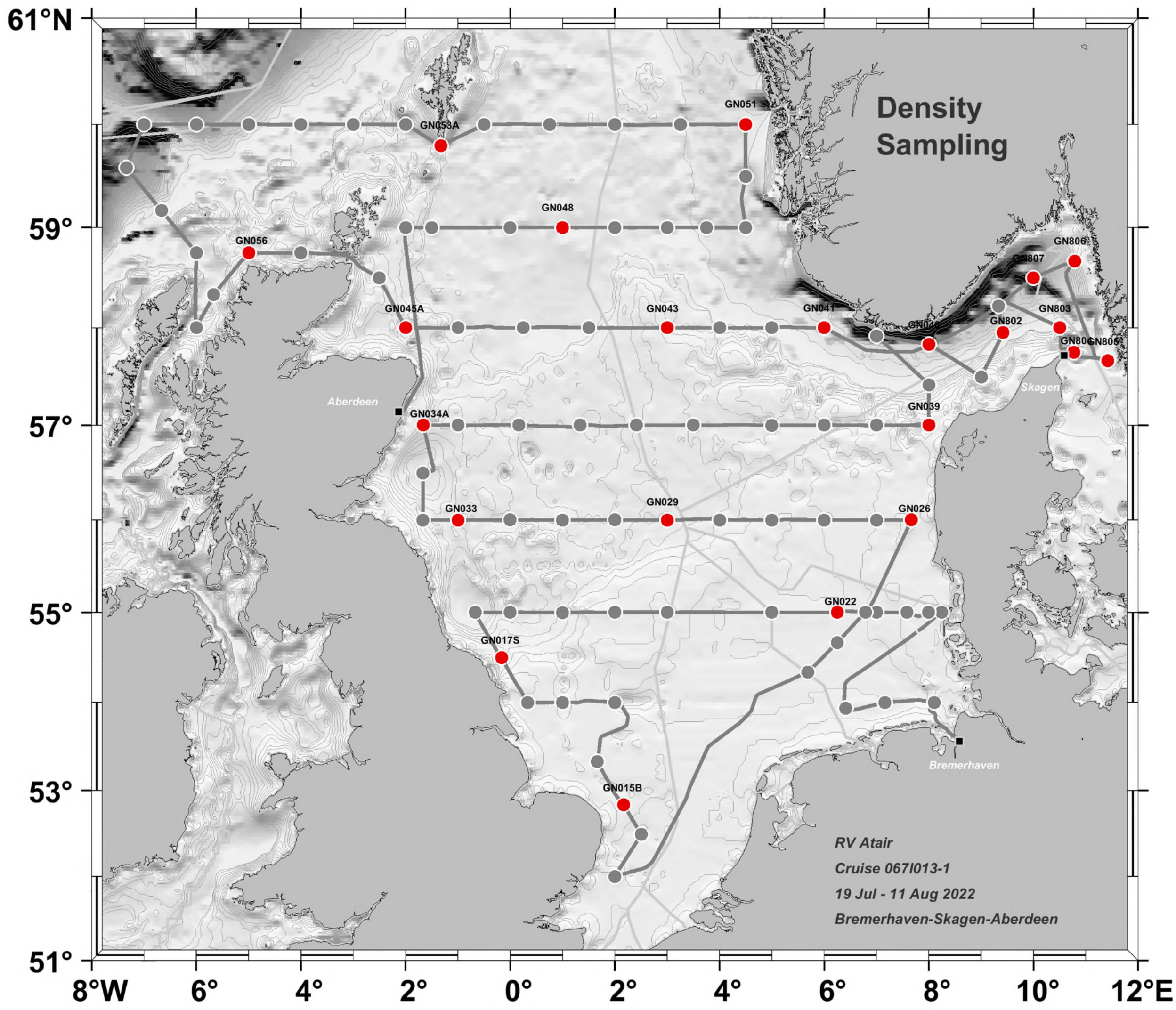

Figure 5.2. Distribution of stations carried out during cruise 067I013-1 with density sampling (red dots).

5.5 Near-Realtime Processing of CTD Data

All CTD data have been recorded at an original resolution of 24 Hz. Data have been checked and pre-processed during the cruise using the *SeaBird SBE Data Processing* software, version 7.26.7.129. The preliminary data taken from the downcast of each CTD profile were binned at 1 dbar resolution and sent on a daily basis during the cruise in near-real-time to the Maritime Data Centre at BSH, Hamburg, Germany and there were uploaded to the CrossDataPortal (https://cdp.srx.bsh.de), the open data portal of BSH, from where the data are available to the public. In total, near-realtime data for 95 CTD profiles were submitted and published during the cruise. Pre-processing of the data showed a better performance of the TC1 sensor pack for most of the cruise.

Pre-processing revealed different behaviour from conductivity sensors 1 and 2 at a depth of 45-65 dbar in profile #068/GN045A. While conductivity sensor 2 produced similar results during the downcast and upcast, conductivity sensor 1 showed enhanced conductivity (and therefore enhanced salinity) during the downcast only, a result that could not be replicated during the upcast. The oxygen sensor attached to pump 1 showed reduced oxygen concentrations within the same depth range during the downcast. It is most likely that pump 1 sucked in biological material, which became stuck in sensor package 1 before it could be flushed out at a greater depth. Consequently, conductivity (salinity) data from sensor package 2 was used, and oxygen data was removed from the near-real-time data for profile #068/GN045A.

5.7 Post-Cruise Processing of CTD Data

Post-cruise comparisons were made between CTD sensor packs TC1 and TC2. Furthermore, a comparison between CTD salinities and AUTOSAL-derived salinities was performed (compare Table 5.3 and Figures 5.3 and 5.4).

The following correction procedure is applied to temperatue and conductivity/salinity measurements as well as oxygen data:

- Assumed measurement accuracy: T-CTD: ± 0.002, C-CTD: ± 0.003, S: estimated: ± 0.004
- A temperature correction will be applied in case the difference between temperature sensors T1 and T2 exceeds 2x 0.002.
- A conductivity correction will be applied in case the salinity difference (AUTOSAL vs. CTD) exceeds 0.003 and/or the difference between conductivity sensors C1 and C2 exceeds 2x 0.003.
- The random error of oxygen samples obtained from titration is approximately 1%. Corrections are made if the oxygen difference (bottle vs. CTD oxygen) exceeds 1%.

Post-cruise quality control showed that differences between the sensor pairs and between sensors and the *AUTOSAL* data were small. All comparisons revealed differences that were within the error bounds, with the smallest differences observed for temperature, conductivity and salinity from the secondary sensors. In summary, any post-cruise correction was not applied, and the temperature, conductivity and salinity data were made available with flag 1 (good data). Using the data from the secondary sensors is recommended.

Sampling and subsequent titration of oxygen samples were not performed on cruise *067I013-1*. However, respective data is available from the subsequent cruise *067I013-2* to the German Bight. The CTD sensor setup, and therefore the use of an CTD-based *SBE43* oxygen sensor, remained the same throughout both cruises. The oxygen analysis including a comparison between CTD-derived oxygen and bottle oxygen was thus solely based on the data set obtained from cruise *067I013-2*. Any correction recommendations resulting from this analysis using the multi-parameter-fit (MPF) method were subsequently applied to the oxygen data from cruise *067I013-1*.

Regarding oxygen, corrections are made when the difference between the CTD-derived oxygen and titrated bottle samples exceeds 1% (titration measurement accuracy). For measured values of 5-6 ml/l, this threshold corresponds to 0.055 ml/l. Without correction, the average difference of the oxygen data is 0.0967 ml/l, i.e. greater than 1%; with correction, it is well below 1%. CTD oxygen was corrected according to:

O_{corr} (ml/l) = 3.778859056281 + -0.016701616065 * time + 0.032361569854 * oxygen (ml/l) + -0.000808096866 * pressure + 0.001502723496 * temperature

Oxygen saturation was recalculated afterwards. The corrected CTD-derived oxygen data was given the quality flag 1 (good data). Any quality control of fluorescence, turbidity or pH-value data was not performed. Thus, the data were made available with flag 0 (no quality control applied). It should be noted that the *SBE18* pH sensor has a rather reduced accuracy (±0.1 pH, according the manufacturer’s data sheet).

Salinity Difference AUTOSAL-CTD	All samples	All samples with differences < +/- 1 standard deviation	All samples with differences < +/- 1 standard deviation for the 2nd mean
AUTOSAL - TSC1			
Number of data pairs	204	200	179
percentage		98%	88%
Mean difference	-0.0021	-0.0062	-0.0040
Median difference	-0.0048	-0.0048	-0.0047
Standard deviation	0.1347	0.0154	0.0034
AUTOSAL – TSC2			
Number of data pairs	204	199	187
percentage		98%	92%
Mean difference	0.0063	0.0002	0.0014
Median difference	0.0014	-0.0014	0.0014
Standard deviation	0.1404	0.0144	0.0032

Table 5.3. *Results of the comparison between bottle salinity samples obtained from salinometer measurements (AUTOSAL) and conductivity/salinity recordings at the time of closing the Niskin bottles, the latter obtained from the two CTD sensor packs (TSC1 and TSC2).*

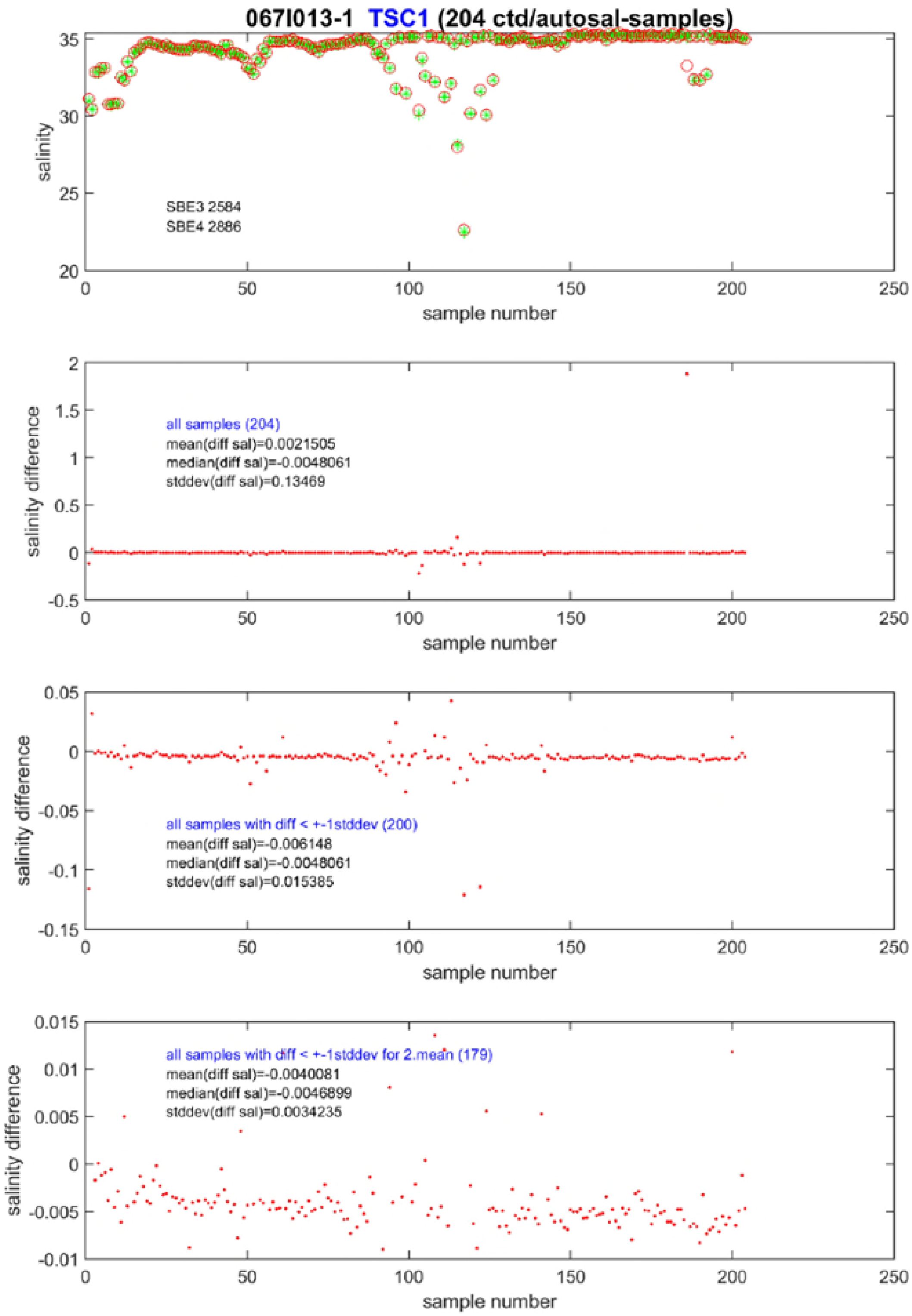

Figure 5.3. *Differences between bottle salinity samples measured with an AUTOSAL salinometer and CTD-derived salinity samples at the time of closing the Niskin bottles, here sensor pack TSC1.*

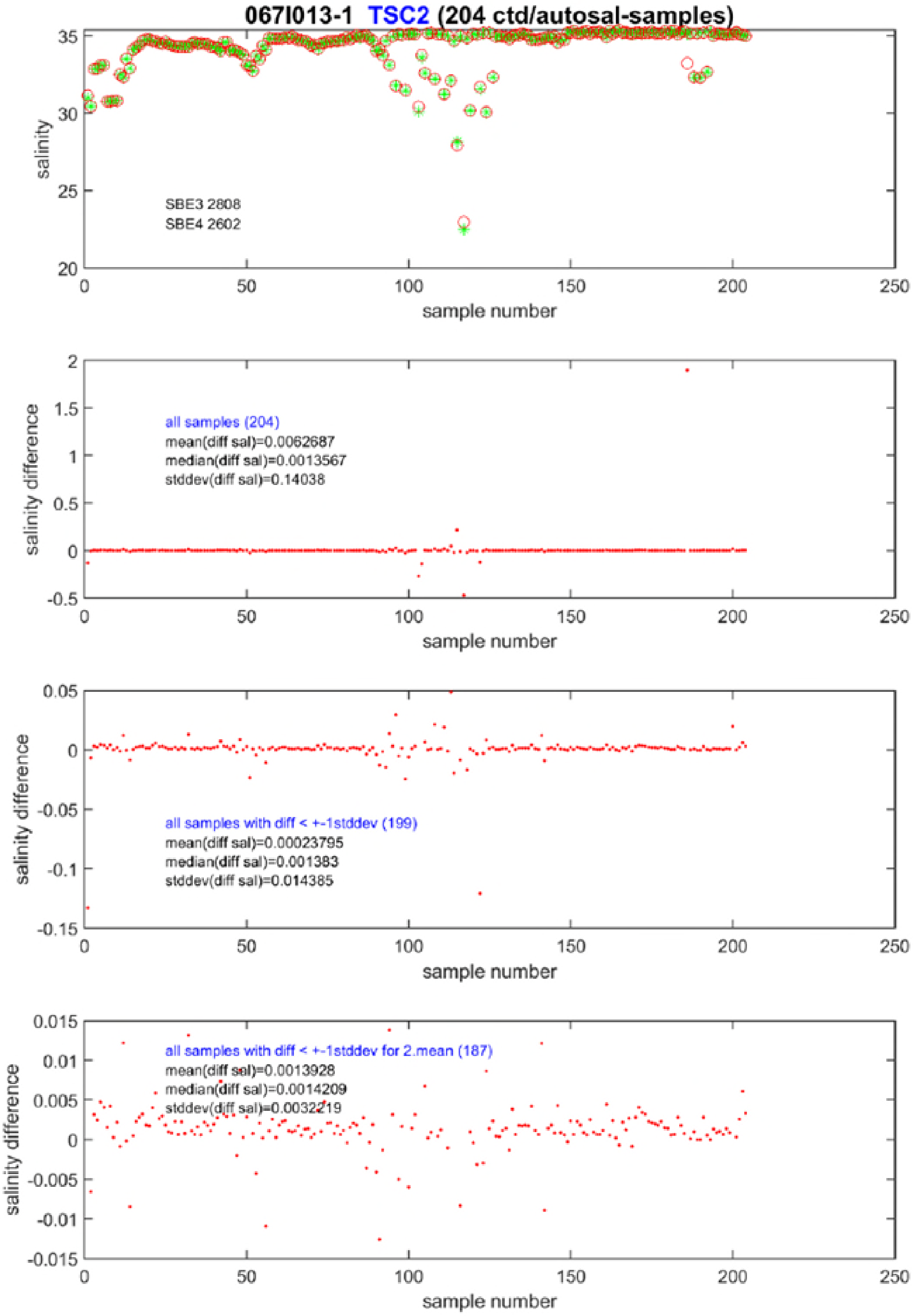

Figure 5.4. *Differences between bottle salinity samples measured with an AUTOSAL salinometer and CTD-derived salinity samples at the time of closing the Niskin bottles. Data as in Figure 5.5, but here shown for sensor pack TSC2.*

5.8 Secchi Disc and Chlorophyll-a Sampling

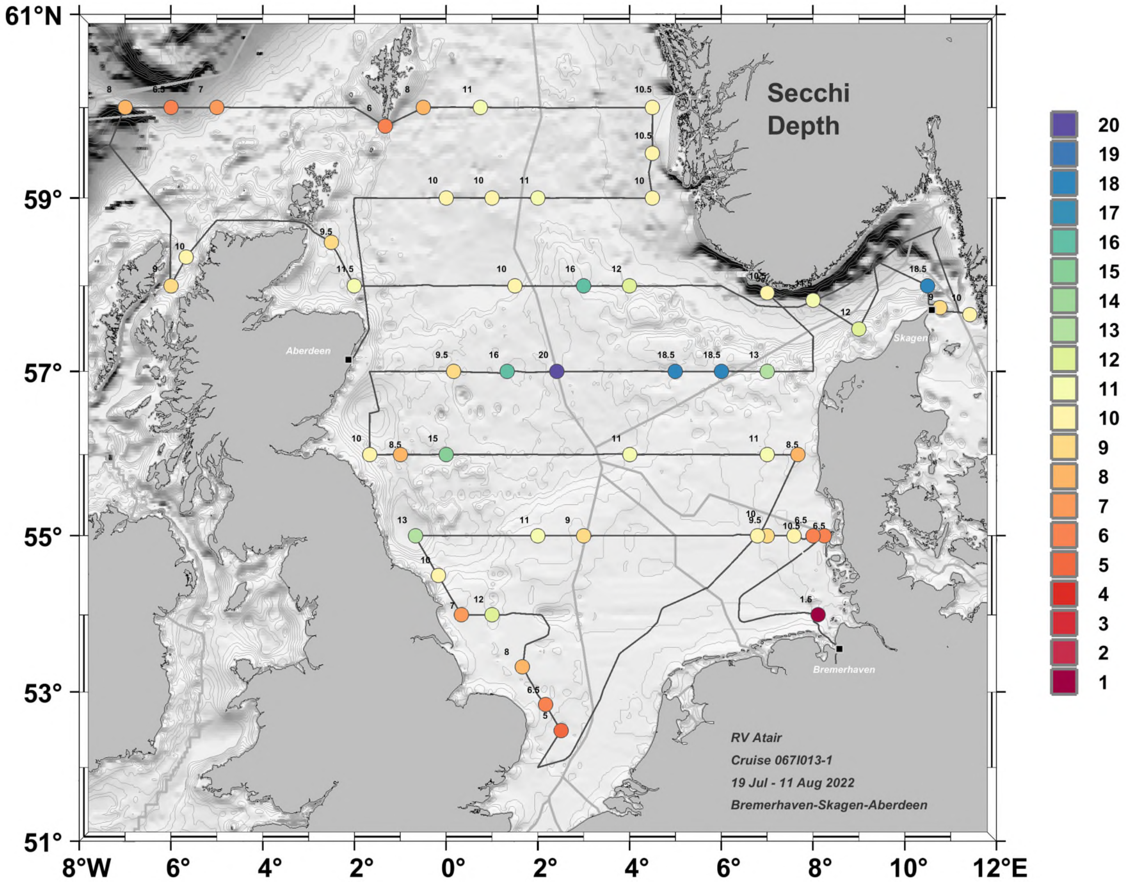

Figure 5.5. *Secchi depths observed during cruise 067I013-1, summer 2022.*

<u>Secchi Depth</u>

The Secchi depth is a measure for the transparency or clarity of the oceanic water column. Values typically range from < 1 m near estuaries to > 12 m in the open North Sea. Secchi depth measurements followed instructions described in *BSH (2007)*. During cruise *067I013-1*, the Secchi depth was measured using a Secchi disc, a white-painted metal plate with an additional weight, both connected to a rope. The rope in turn was connected to a mobile winch installed on the port side of the vessel. Mostly at daylight stations, the Secchi disc was lowered into the surface layer of the ocean until it was no longer visible. Coloured tapes at 0.5 m intervals along the rope marked every 0.5 m, 1 m, and 5 m. The mark on the rope closest to the sea surface represents the Secchi depth, i.e. the depth of transparency at that location. The accuracy of the Secchi depth observation is ±0.5 m. Figure 5.5 highlights the station locations and corresponding Secchi depths observed mostly observed under daylight conditions during cruise *067I013-1*.

<u>Chlorophyll-a Sampling and Filtration</u>

To determine the chlorophyll-a content in the surface waters of the North Sea, water samples were taken during cruise *067I013-1* from the Niskin bottles closed at a depth of 5 m and filled into 3 litre PE bottles. After sampling, the water sample was filtered using a low- pressure filtration system. Filtration is done through a glass fibre filter (ø = 47 mm and pore size 0.4µm) on a glass filter plate. For this purpose, the PE bottle was shaken at first to allow for homogensosation of the water sample. Then, a measured volume was filled into a filtration tulip, which was connected to a suction bottle. The volume to be measured was determined by the previously recorded Secchi depth, see Table 5.4. The exact sampling depth, the Secchi depth, the filtered volume and the room temperature were recorded. After filtration, the glass fibre filter with the sample residue was removed from the filtration tulip, folded twice and transferred to a PE centrifuge tube with a screw cap. This tube was wrapped in aluminium foil to avoid exposure to light. The sample was labelled by assigning a unique sample identification number similar to *Bedford* numbers, which was applied directly to the tube and the aluminium foil. The sample was then frozen and stored at -80°C to allow for later analysis in the home laboratory. One duplicate sample was analysed per day. On-board filtration was performed as described in *BSH (2022)*. Figure 5.6 shows the location of stations with water sampling for subsequent chlorophyll-a determination. Corresponding water sampling was carried out on mostly daylight stations with Secchi depth measurement. If there was a delay between collecting the water from the Niskin bottle and the filtration, the water sample was stored in the dark and cooled in the refridgerator.

Spectrophotometric analysis was carried out in the home laboratory after the cruise to determine the total chlorophyll-a content in seawater. The method follows *Jeffrey and Humphrey (1975).* The interlaboratory performance study (QUASIMEME, R2022.1) for the parameter chlorophyll-a in seawater during the measuring period in our laboratory was successful. The z-scores are 0.5 / 1.2. The mean range for the duplicates (14 samples) taken on this cruise was less than 0.06 µg/L CHLA.

Secchi Depth [m]	Require Volume [ml] for Filtration
0-2	up to 500, only for coastal stations
2-5	up to 1000
5-10	up to 1500
10-15	up to 3000

Table 5.4. *Secchi depth and corresponding sample volume required for the filtration of chlorophyll-a samples.*

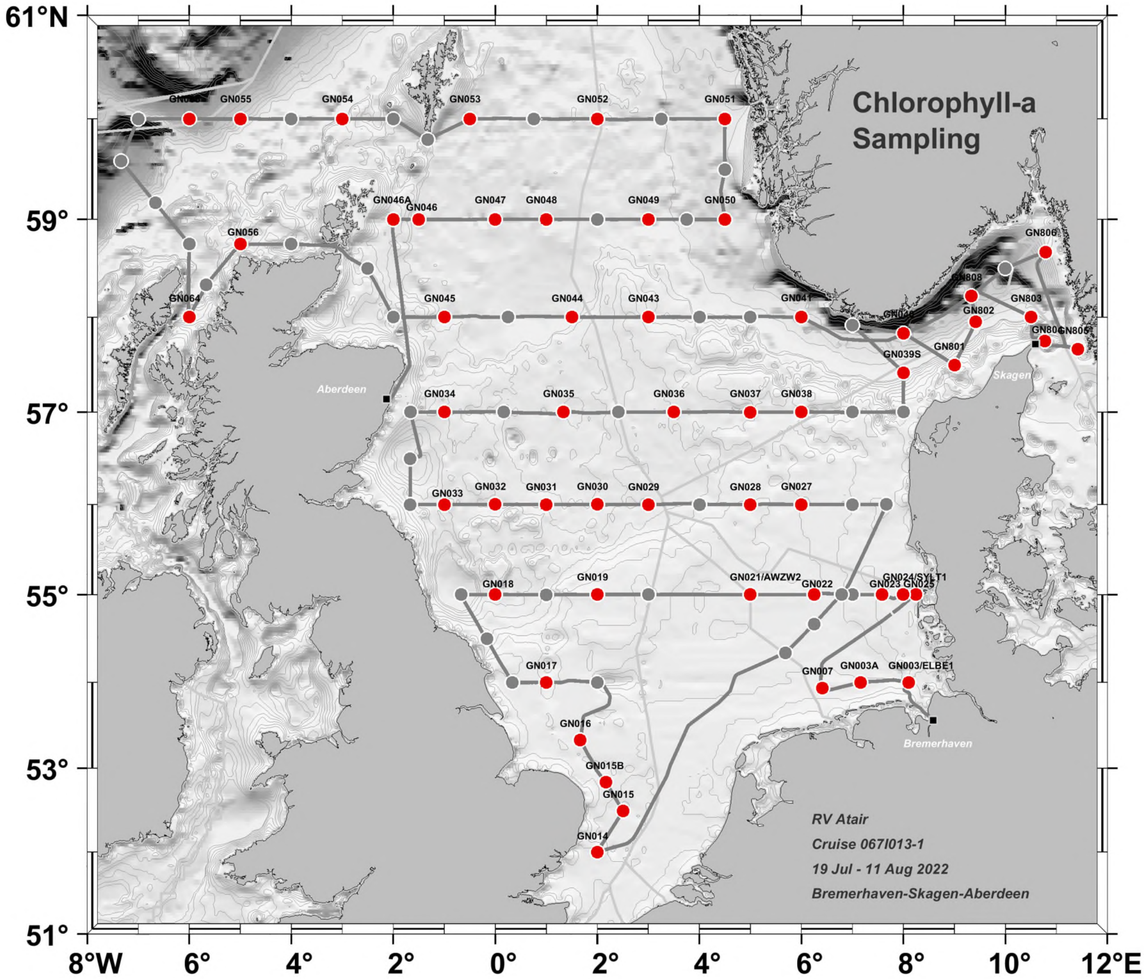

Figure 5.6. *Distribution of stations carried out during cruise 067I013-1 with water sampling and subsequent filtration for chlorophyll-a determination (red dots).*

The chlorophyll-a concentrations measured in the laboratory serve 1) as a rough measure of phytoplankton biomass and 2) are used for comparison with the chlorophyll-a concentrations determined by remote sensing (ground truthing).

5.9 Sampling of Radionuclides

Sampling of radionuclides is based on several legal and regulatory provisions arising from the *Radiation Protection Act*, the *Radiation Protection Ordinance*, the *General Administrative Regulation* relating to the *Integrated Monitoring and Information System* (IMIS), the *IMIS Competence Regulation*, the *1957 Treaty establishing the European Atomic Energy Community*, the *Marine Strategy Framework Directive* (MFSD) and the *Maritime Shipping Responsibilities Act*. In addition, there are international obligations under OSPAR and HELCOM.

Artificial radionuclides can be detected in the North Sea and the Baltic Sea from the following sources:

- global fallout from atmospheric nuclear weapons tests in the 1950s and 1960s
- discharges from the reprocessing plants in Sellafield and La Hague
- fallout from the Chernobyl nuclear reactor accident in 1986
- discharges from nuclear facilities such as nuclear power plants and research reactors.

The task of the *Integrated Monitoring and Information System for Monitoring Radioactivity in the Environment* (IMIS) is to continuously monitor the environment in order to be able to quickly and reliably detect even minor changes in radioactivity in the environment and to record long-term trends. In a radiological emergency, the IMIS is used as a tool to fulfil the tasks of the German *Federal Radiological Situation Centre* (RLZ).

To fulfil these tasks, sampling during cruise *067I013-1* was carried out at selected stations distributed across the entire North Sea and adjacent regions (Figure 5.7). One station (GN808, Skagerrak) was used to collect data from four distinct depth levels of the water column using large-volume samplers (LVS), which had a capacity of either 270 or 333 litres. The 333-litre LVS was tested for the first time during the cruise. Station GN808 was visited twice, with the LVS being used on both occasions to obtain the required amount of water, as closing the LVS properly at the first station visit was only partially successful. All other samples were taken from the sea surface and prepared on board for storage. Subsequent analysis was conducted at the BSH's "M32 – Marine Radioactivity" section.

Samples for determining the activity contration of the following radionuclides were taken during the cruise: cesium-137 (^{137}Cs), strontium-90 (^{90}Sr) and tritium (^{3}H).

- On-board sampling to determine the activity concentration of ^{137}Cs followed the *Procedures' Manual* as outlined by *Hintze et al. (2022)*. Seawater was collected and passed through an ion exchanger. The ion exchanger was then transferred into a container. This container also served as a measurement source. Once on land, any remaining water was pipetted off so that the measurement source could be placed on a suitable detector.
- On-board sampling to determine the activity concentration of ^{90}Sr was carried out according to the *Procedures' Manual* as outlined by *Hintze et al. (2023).* The seawater was acidified and filled into 35-litre barrels. Further processing on board was not possible.
- On-board sampling to determine the activity concentration of ^{3}H was conducted according to the *Procedures' Manual* as outlined by *Becker et al. (2023)*. The seawater was filled into one-litre glass bottles. Initial processing on board was not possible due to limited laboratory capacity.

The underlying *Procedures' Manuals* should be understood in the same way as DIN standards: they are reviewed by a panel of experts and checked editorially and scientifically. They are re-examined every five years, even if no changes have been made to the procedure, to allow for any editorial changes or changes due to the advances in science and technology. Furthermore, the aforementioned procedures are accredited according to DIN EN ISO/IEC 17025.

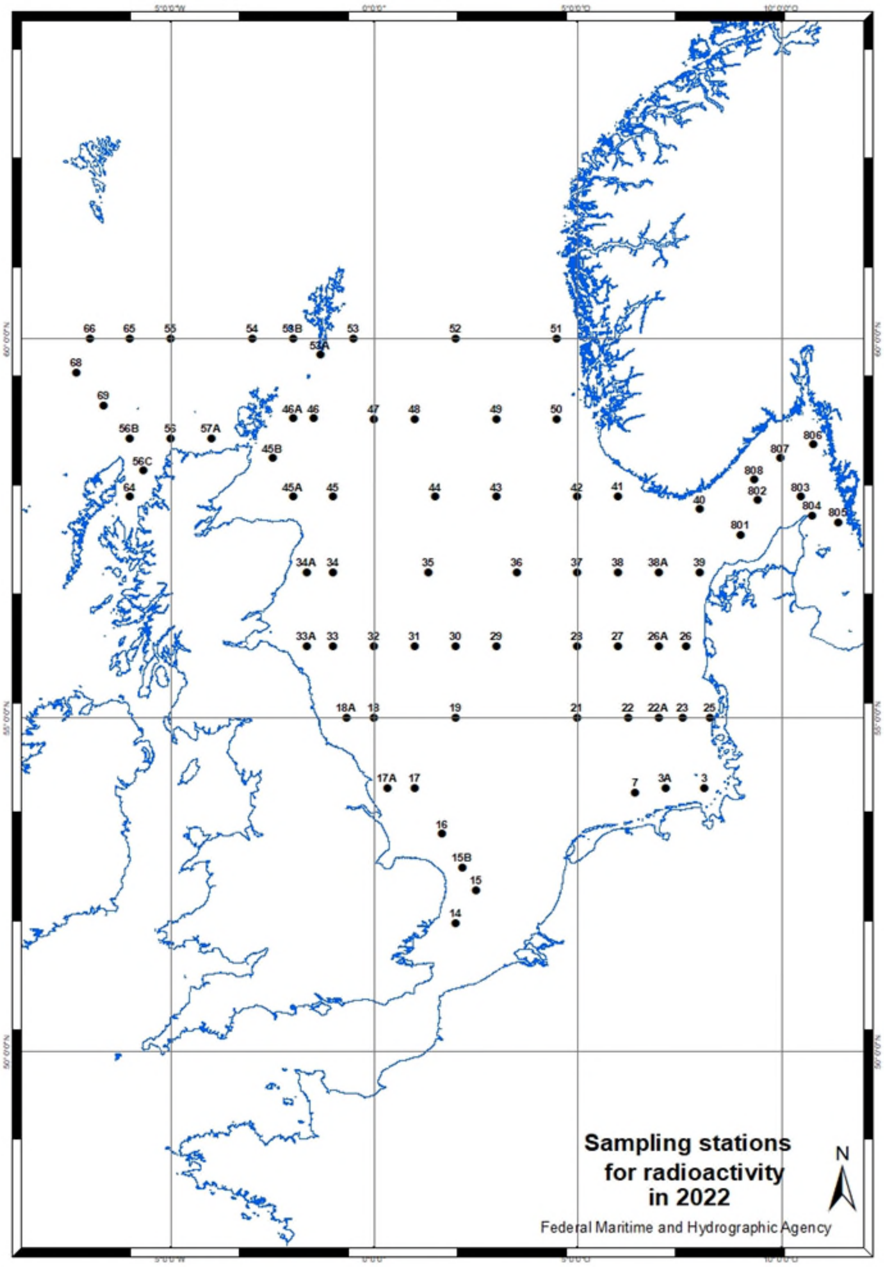

Figure 5.7. *Stations with water sampling regarding radionuclides, cruise 067I013-1, summer 2022.*

Following internal collection and plausibility checks, the data is transferred to IMIS.Some of the data is then used to fulfil international reporting obligations for the *OSPAR Radioactive Substances Committee* (RSC) and the *Helsinki Commission*'s (HELCOM) *Expert Group for Monitoring Radioactive Substances* (EG MoRS). Data is also transferred to the IAEA's MARIS (*Marine Radioactivity Information System*) via these databases. Contributions based on the data are submitted to the *Federal Ministry for the Environment* on an annual basis. These contributions are used to produce the parliamentary report, which is presented to the German

Bundestag and Bundesrat in a timely manner. The data is later made available to the public in the report *Environmental Radioactivity and Radiation Exposure*. The *Report of the Federal Coordinating Offices and the Federal Office for Radiation Protection* is published every three to five years, see *BMUV (2024)*, with data from cruise *067I013-1* already included.

5.8 to 5.10 illustrate the spatial distribution of activity concentrations, as determined by sampling of the respective radionuclides during cruise *067I013-1* in the summer of 2022.

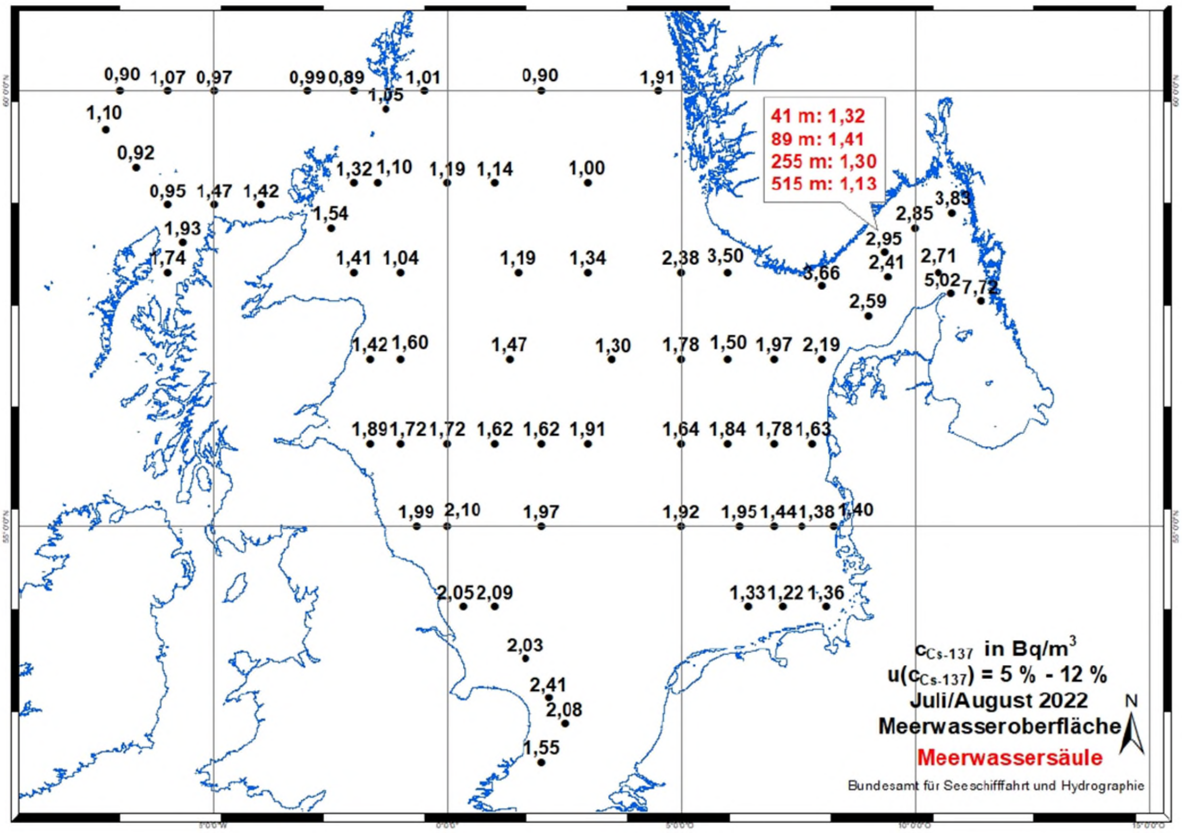

Figure 5.8. Activity concentration of cesium-137 (^{137}Cs) [Bq/m^3] at the sea surface of the North Sea and in the water column (one station, GN808, in the Skagerrak) in Juli/August 2022, cruise *067I013-1*. Data source: BSH. Also see *BMUV (2024)*.

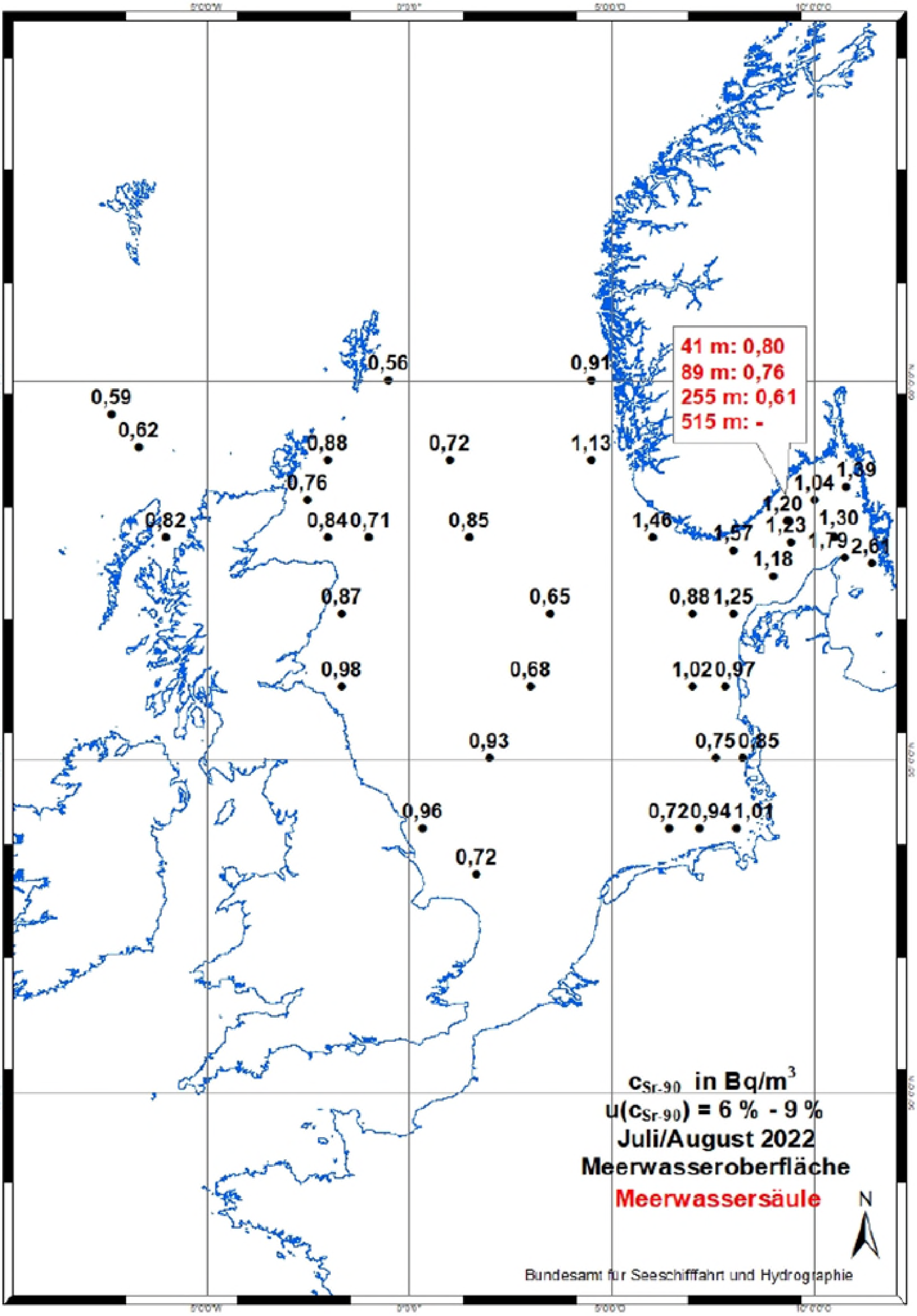

Figure 5.9. Activity concentration of strontium-90 (^{90}Sr) [Bq/m^3] at the sea surface of the North Sea and in the water column (one station, GN808, in the Skagerrak) in Juli/August 2022, cruise *067I013-1*. Data source: BSH. Also see *BMUV (2024)*.

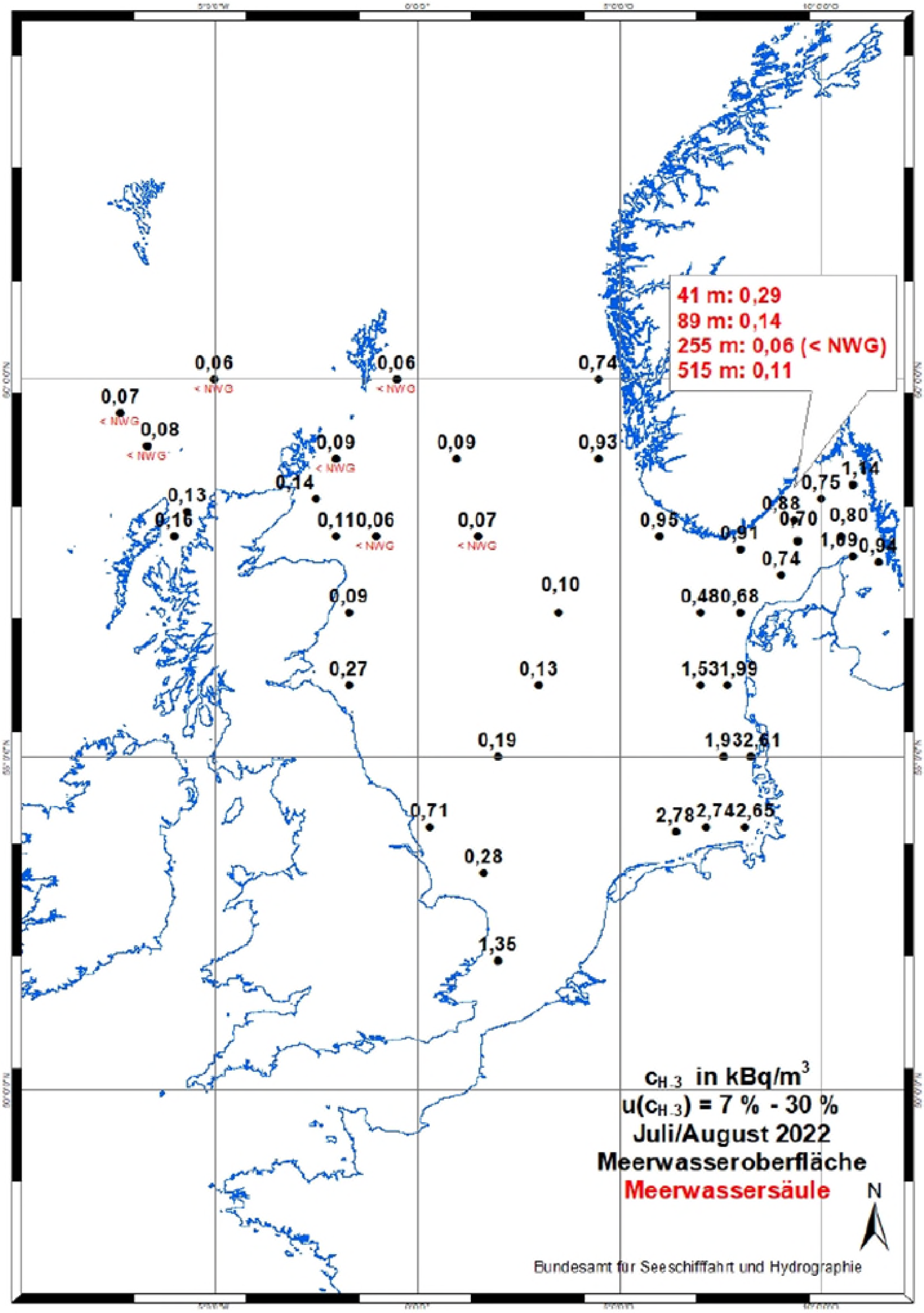

Figure 5.10. *Activity concentration of tritim (H_3) [kBq/m^3] at the sea surface of the North Sea and in the water column (one station, GN808, in the Skagerrak) in Juli/August 2022, cruise 067I013-1. Data source: BSH. Also see BMUV (2024).*

6. Oceanographic Conditions in Summer 2022

The BSH produces and provides a comprehensive weekly analysis of sea surface temperatures (see https://www.bsh.de/EN/DATA/Climate-and-Sea/Sea_temperatures/Sea_surface_temperatures/sea_surface_temperatures_node.html). This approach combines all measurements collected from time series stations and ships with satellite data and uses statistical methods and spatial interpolation to generate a comprehensive data set. This contains estimates for the weekly mean values of sea surface temperature as a raster data set with a spatial resolution (pixel size) of 20 km x 20 km.

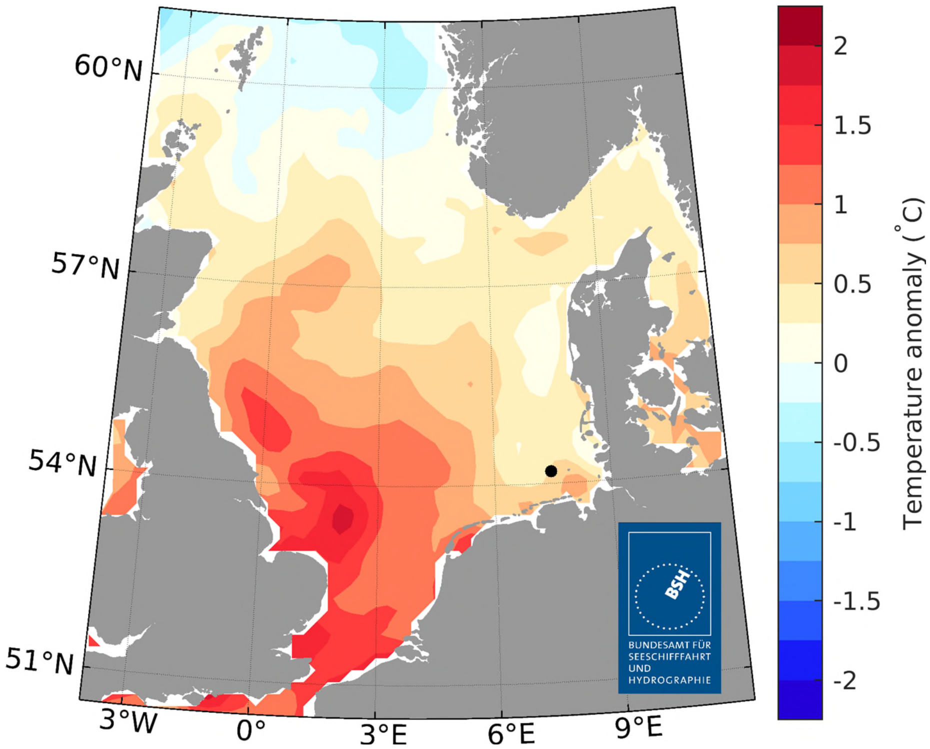

Figure 6.1. *Spatial distribution of sea surface temperature (SST) anomalies for the summer months of 2022 (June, July and August). Anomalies are shown relative to a climatological mean SST field comprising the summers of the years 1997-2021, i.e. 25 years. Source: BSH.*

Information from this blended analysis SST analysis for the summer months of 2022 (June, July and August) reveals a region of pronounced warming in the southern and south-western North Sea (see Figure 6.1). The centre of this region was located at about 53°30’N off the eastern British coast, stretching from the English Channel to around 55°30’N. Here, SSTs were 1.5°C to 1.75°C warmer than the 1997-2021 climatological summer mean. The north-eastern and eastern halves of the North Sea showed a moderate warming with temperature anomalies mostly below +0.5°C. Only the region north of 60°N was slightly cooler than the climatological summer mean. Thus, almost the entire North Sea was warmer than average in summer 2022.

Figure 6.2 shows a respective ranking map, which demonstrates that the sea surface between the Dogger Bank and the English Channel, i.e. the region of the South Bight, had the warmest summer conditions observed between 1997 and 2022. The Western and Eastern Frisian coasts off the Netherlands and Germany also ranked very highly, with local summer surface conditions among the warmest to the third warmest. Conditions in the northern and eastern parts of the North Sea were mostly normal.

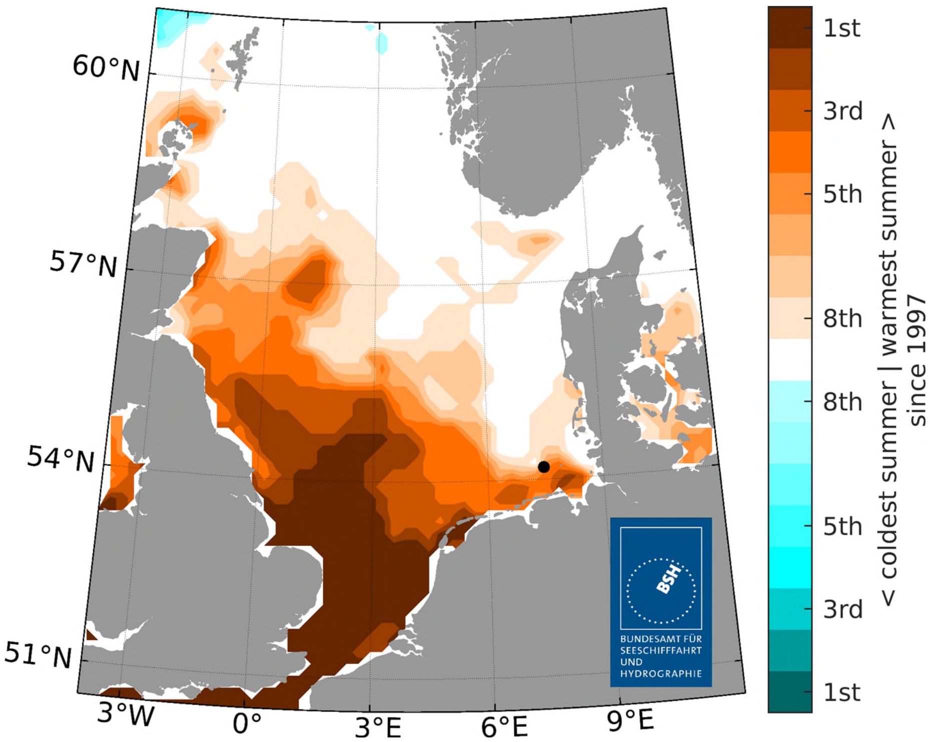

Figure 6.2. *Spatial distribution of the sea surface temperature (SST) ranking for the summer months of 2022 (June, July and August), regionally indicating the nth coldest/warmest summer SST since 1997. Source: BSH.*

Figures 6.3 and 6.4 highlight the potential temperature obtained from CTD measurements during cruise *067I013-1* near the surface (5 dbar) and at the bottom. The respective temperatures are also compared to a long-term mean field comprised of CTD data from the summer months of the years 2000 to 2020 (*NSSS* surveys 2000 to 2020, excluding 2019). Based on the ship observations, temperatures above 18°C were recorded close to the mouth of the River Elbe and near 52°N at the entrance to the English Channel (see Figure 6.3, left). A band-like pattern of cooler temperatures (<16°C) stretched along the eastern British coast from the Shetland Islands to approximately 55°30'N. Additionally, a cool patch with temperatures below 15°C was observed in the region east of the mouth of the Humber Estuary off the British coast.

The North Sea north of 56°N was typically cooler than 16°C, except in the Norwegian Trench off the south coast of Norway, where the warmer outflow from the Baltic Sea was encountered. The 16°C isotherm was oriented rather zonally along 56°N, dividing the North Sea into a warmer half in the south and cooler half in the north.

Deviations in temperature from the long-term mean (Figure 6.3, right) reveal warmer conditions, particularly off and along the east coast of the UK and in the western and southwestern parts of the North Sea. The location of the warmest temperature deviation observed in the CTD data at 5 dbar corresponds with that seen in the SST anomaly distribution (Figure 6.1). Stronger cooling was observed off the western Danish coast, extending into the central North Sea, along 60°N, and over the Norwegian Trench.

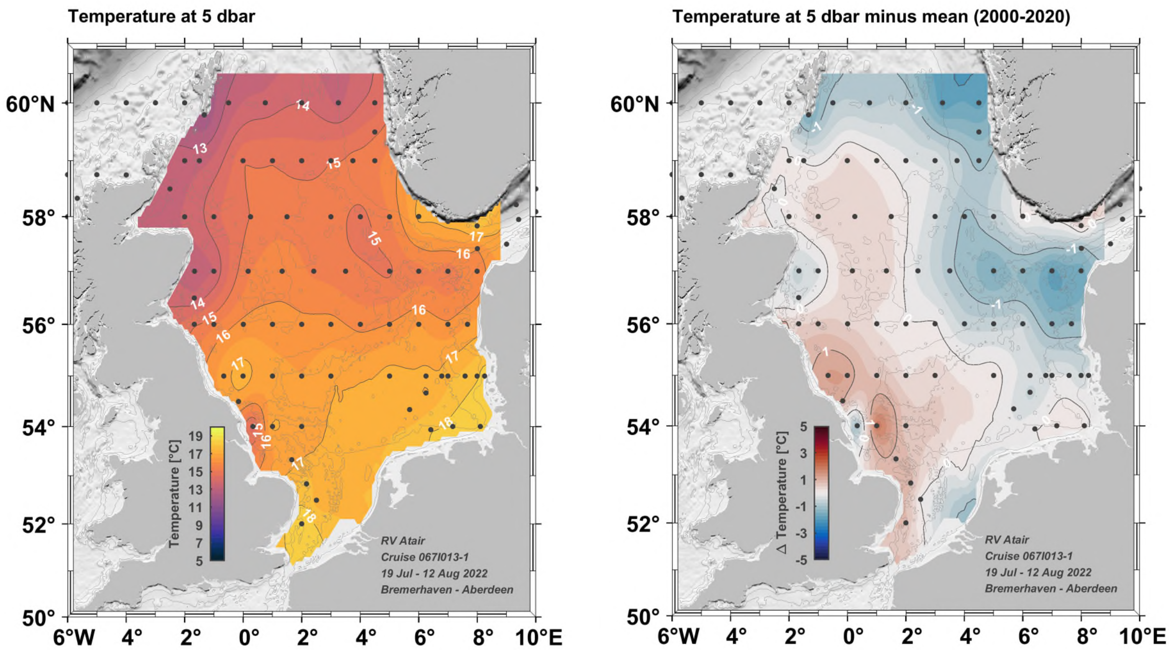

__Figure 6.3.__ CTD-derived spatial distribution for the potential temperature near the surface in summer 2022 (left) and respective temperature deviations (right) from a long-term mean, 20 years, comprising NSSS cruises of the years 2000-2020 (except 2019).

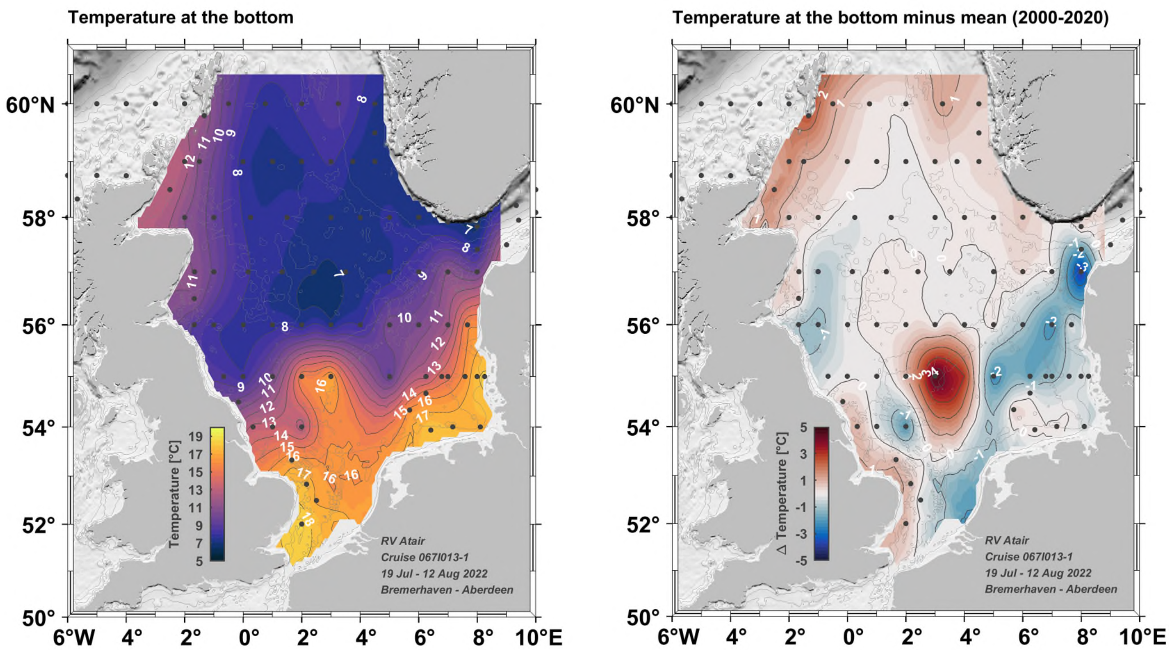

__Figure 6.4.__ CTD-derived spatial distribution for the potential temperature near the bottom in summer 2022 (left) and respective temperature deviations (right) from a long-term mean, 20 years, comprising NSSS cruises of the years 2000-2020 (except 2019).

As shown in Figure 6.4, bottom temperatures were generally warmer in the northern part of the North Sea, where inflow of Atlantic Water is typically expected. Furthermore, temperatures warmer than average were observed on top of the Dogger Bank and along the east coast of Britain, in a pattern stretching from approximately 55°N towards the English Channel in the south. In contrast, the German Bight and regions off Denmark to the south showed temperatures cooler than average.

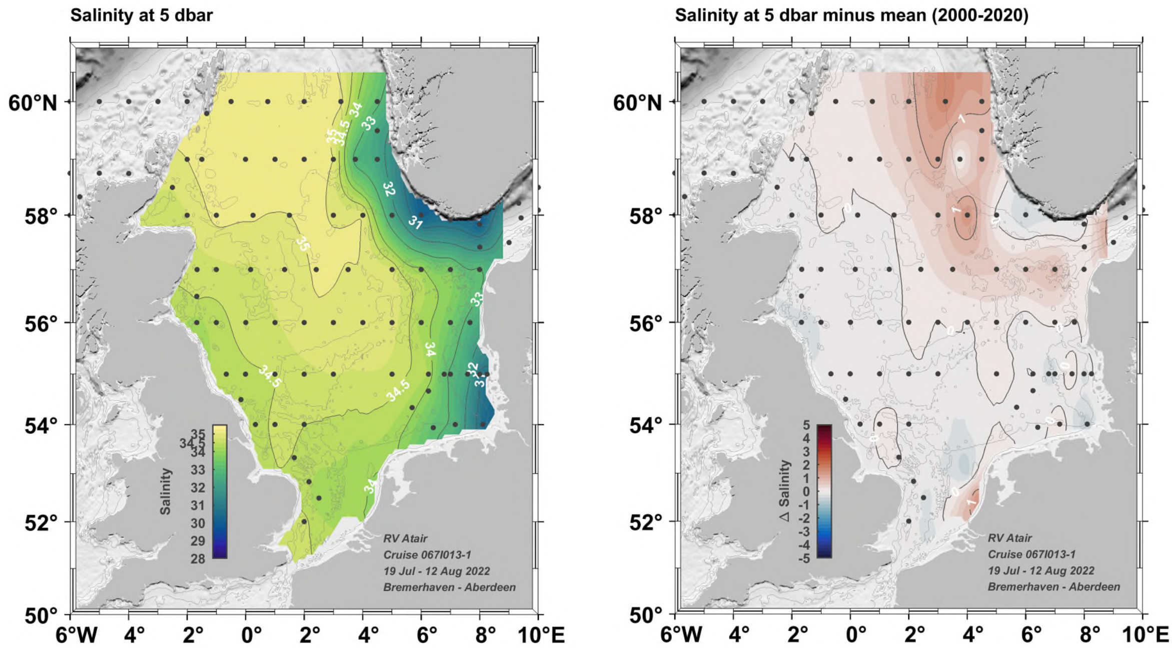

Figure 6.5. *CTD-derived spatial distribution for the salinity near the surface in summer 2022 (left) and respective salinity deviations (right) from a long-term mean, 20 years, comprising NSSS cruises of the years 2000-2020 (except 2019).*

In summer 2022, a large patch of near-surface salinity exceeding 35 was observed in the North Sea (Figure 6.5, left), stretching from the northern and northwestern regions into the central area. This saline patch is associated with the inflow of Atlantic Water, identified by salinities exceeding 35. The isohaline at 34.5 formed a horseshoe pattern stretching from approximately 57°N off the British coast to 54°N south of Dogger Bank and continuing northwards to 60°N, 4°E in the northern part of the North Sea. Near-surface water inside this horseshoe showed salinities ranging from ≥34.5 to 35.2, with the highest values observed near the Shetland Islands and to their west. Coastal salinities on the eastern side of the North Sea revealed minimum salinities at the mouth of the River Elbe (S <31). The Norwegian Trench showed the fresh Baltic outflow close to the Norwegian coast, with salinity mostly below 31. Deviations in surface salinity in summer 2022 from the long-term mean indicate an increase in the salinity of Atlantic Water (Figure 6.5, right) and fresher conditions next to the mouth of the River Elbe.

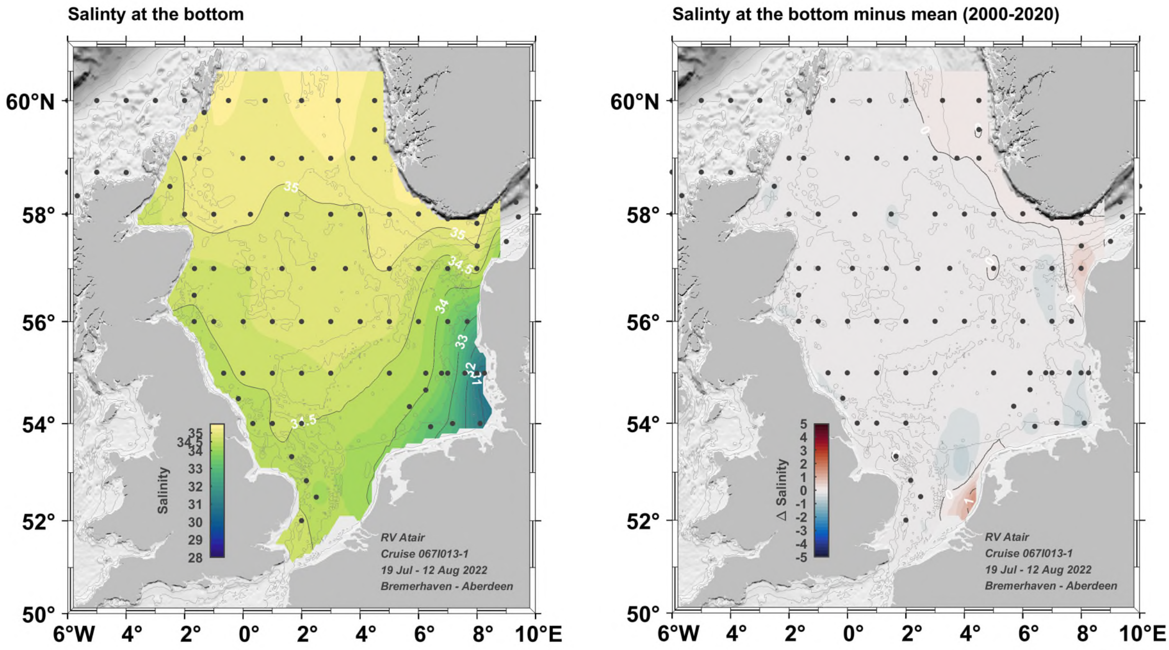

Figure 6.6. *CTD-derived spatial distribution for the salinity near the sea bottom in summer 2022 (left) and respective salinity deviations (right) from a long-term mean, 20 years, comprising NSSS cruises the years 2000-2020 (except 2019).*

Regarding the bottom layer, as shown in Figure 6.6 (left), salinity greater than 35 is present in most of the bottom regions of the North Sea near 58°N and north of this latitude. The highest salinities (S > 35.2) are found along 60°N, near the Shetland Islands and to their west and along the western edge of the Norwegian Trench. Salinity as high as 34.5, spreading from the north, is observed up to 54°N. About north of the River Thames outlet, a local maximum of S = 34.6 indicates traces of saline water entering the North Sea via the English Channel. However, due to missing data in the English Channel south of 52°N, this signal cannot be investigated any further. Fresh salinities < 32 stretch along the western German and Danish coasts, clearly pointing to the impact of runoff coming from the continental rivers like Elbe or Weser. Deviations from the long-term average reveal more saline bottom conditions at the bottom of the Norwegian Trench, and fresher bottom conditions directly at the mouth of the River Elbe.

Figures 6.7 and 6.8 show the temperature and salinity along coast-to-coast sections following the latitudes 60°N, 59°N, 58°N, 57°N, 56°N, 55°N and 54°N. Due to the varying water depths from the deep northern North Sea to the shallow southern North Sea, the lower part of the water column is usually colder in the north. The water column is generally more homogeneous in the south, becoming increasingly stratified towards the north, at least in temperature. The input of Atlantic Water across the northern boundaries of the North Sea and its subsequent propagation within the North Sea is evident in salinities exceeding 35 and in summer 2022 is notable as far south as 57°N.

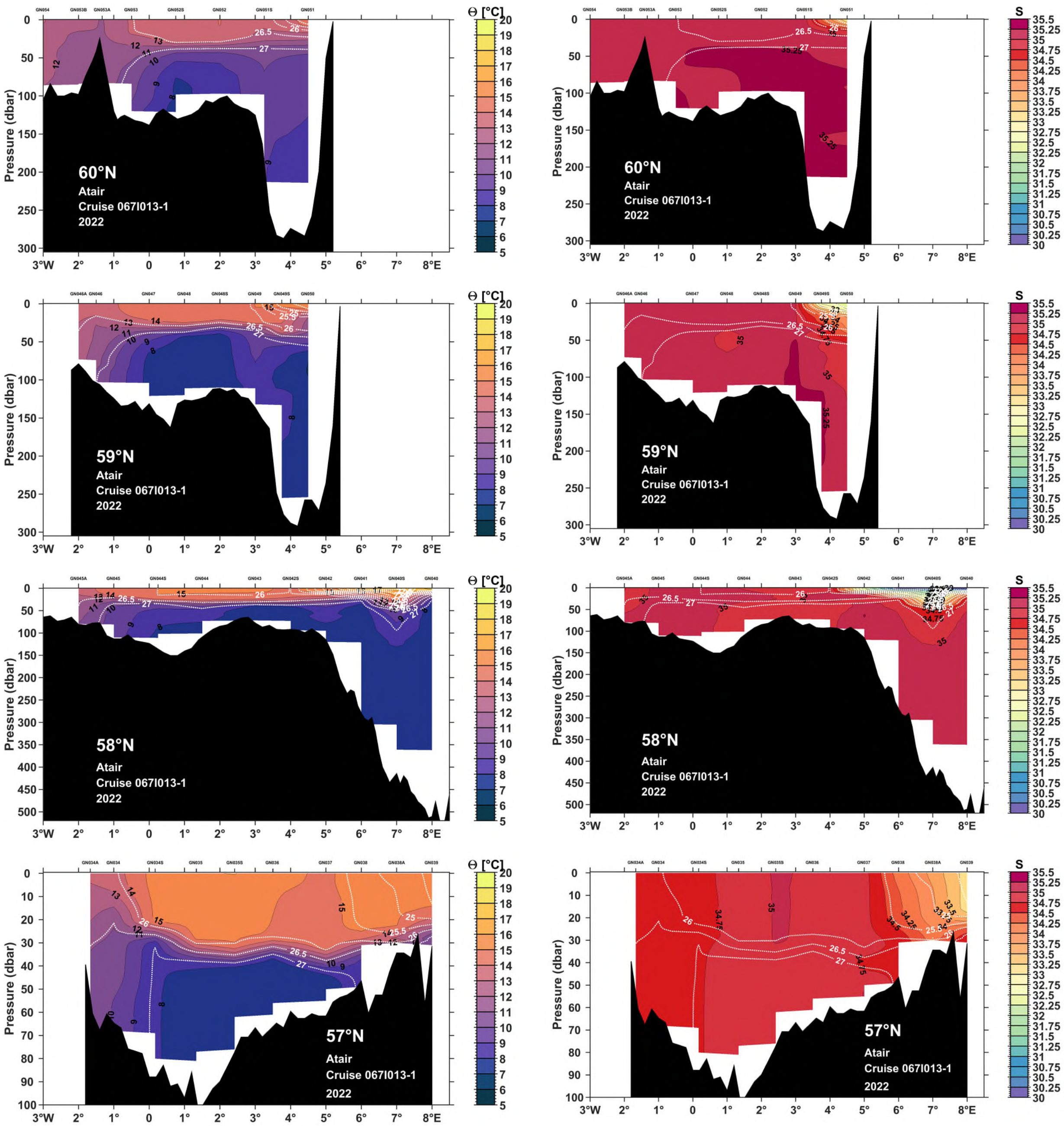

Figure 6.7. *Potential temperature [°C] (left) and salinity (right) along 60°N, 59°N, 58°N and 57°N (from top to bottom) as observed during cruise 067I013-1, summer 2022. Superimposed white contours highlight selected σ_θ-isopycnals.*

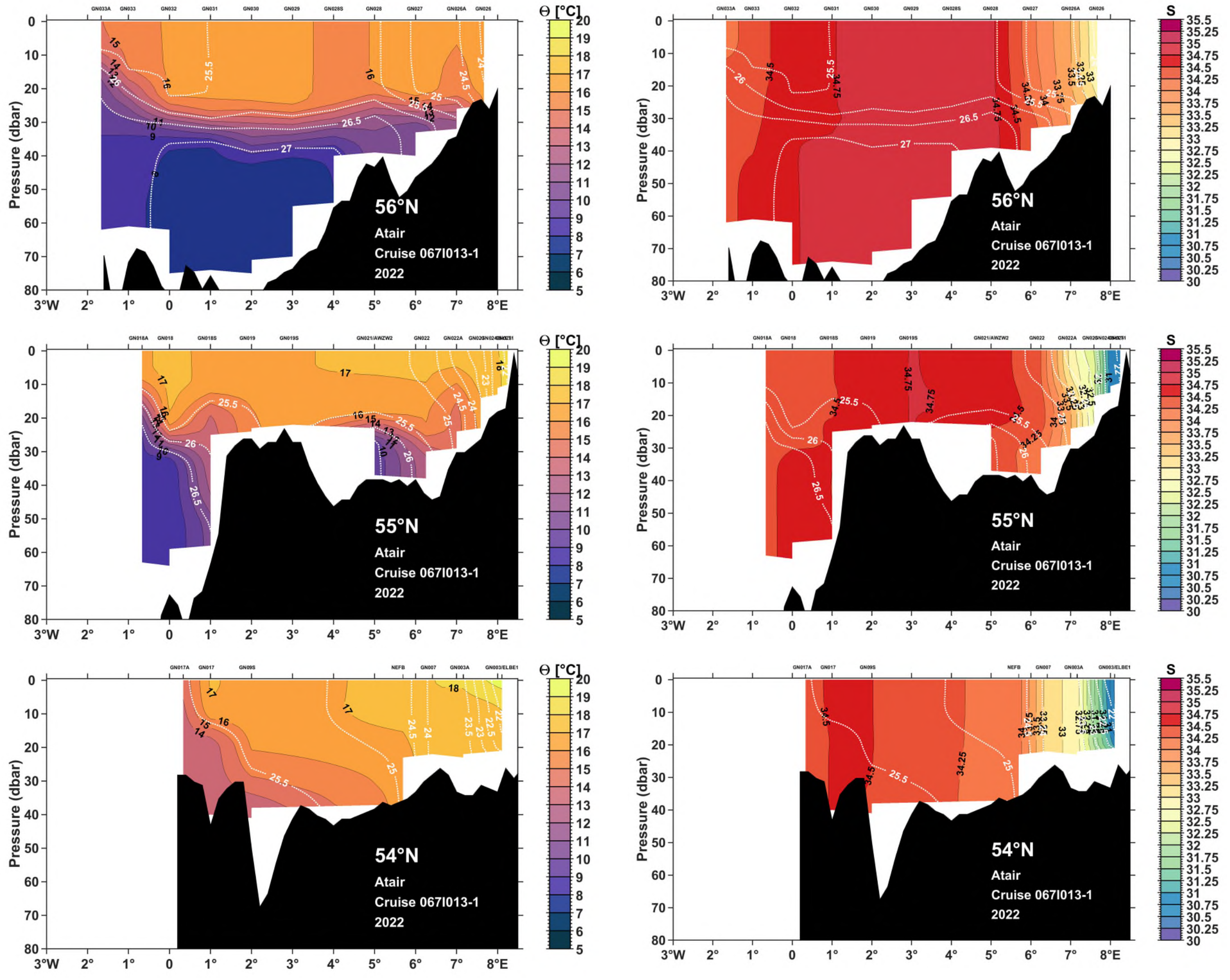

Figure 6.8. *Potential temperature [°C] (left) and salinity (right) along 56°N, 55°N and 54°N (from top to bottom) as observed during cruise 067I013-1, summer 2022. Superimposed white contours highlight selected* σ_θ*-isopycnals.*

7. Underway Measurements

A variety of routine underway measurements were carried out during cruise *067I013-1*. Among the acquired data of interest were navigational information, near surface hydrography (temperature, conductivity, and thus salinity) measured by the vessel's thermosalinograph (TSG), near-surface fluorescence and turbidity obtained from a dual-wavelength *ECO* sensor attached to the TSG system, as well as meteorological parameters and water temperature recorded by the weather station operated by the German Weather Service (DWD) under the identifier *CVTKCAL*. Navigational and meteorological data was recorded from the beginning of the cruise on, recording of additional underway data was interrupted during the port stay in Skagen, Denmark, when transiting through the Dutch EEZ, and while operating within the Swedish territorial waters. It was resumed afterwards. Data was logged in time steps of 1 second by the vessel's DSHIP system. All underway data relevant to this cruise were exported from the DSHIP database on a daily basis. Water depths were measured by a single-beam echosounder along the cruise track and on hydrographic stations. Depths provided by the vessel's echo-sounding device result in water depths when the vessels's draft of 5 m is added. Any further processing or quality control of water depth data was not carried out.

7.1 Ship's Meteorological Station

The autonomous weather station installed aboard *RV ATAIR* and operated by the DWD automatically records every second all meteorological standard parameters like wind speed and direction, air temperature and air pressure, relative humidity and surface water temperature and others. While corresponding data is sent directly to the Global Telecommunication System (GTS), it is also fed into the DSHIP database. Figure 7.1 provides an overview on the meteorological conditions encountered during cruise *067I013-1*. Raw data was smoothed by applying a moving median filter.

The average air temperature throughout the cruise was 16.1°C, temperatures ranged from 10.7°C to 30°C, the latter at the very beginning of the cruise. Maximum water temperatures exceeded 20°C right at the beginning of the cruise, minum water temperatures were 11.7°C, the average was 15.9°C. Average air pressure was 1017.2 hPa, and pressures ranged from 1004.2 hPa to 1027.9 hPa. Notable periods of absolute wind speeds exceeding 7 Bf were observed on 21 July 2022, 26 July 2022, 02 August 2022, and on 05/06 August 2022. The average wind speed throughout the cruise was 7.82 m/s, which corresponds to a wind strength of 4 Bf. The maximum wind speed was 20.5 m/s, corresponding to 8 Bf. Figure 7.2 displays the spatial distribution of absolute wind speeds and directions (15 min average values) along the cruise track.

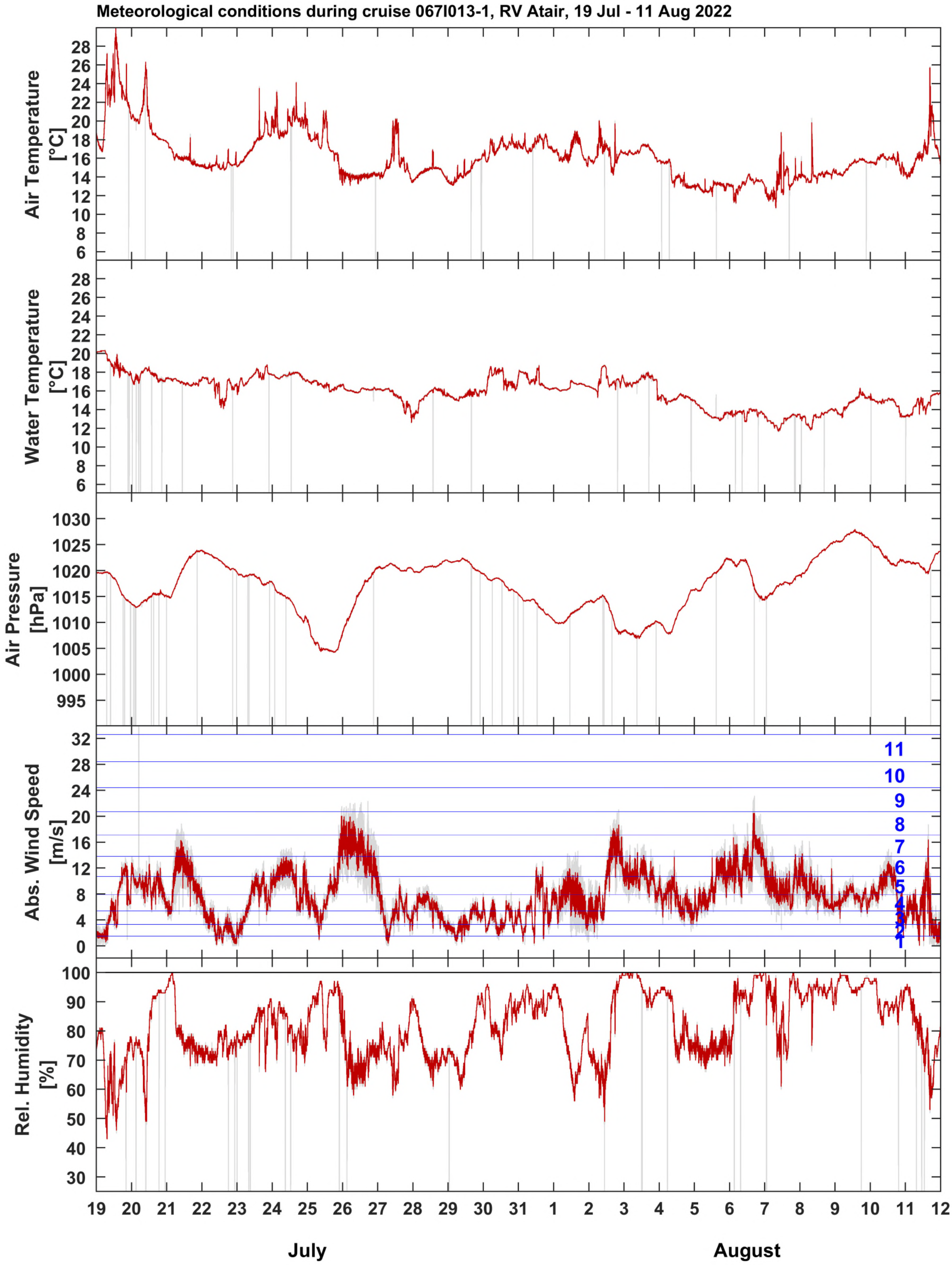

Figure 7.1. *Meteorological conditions observed during 19 July and 11 August, 2022, cruise 067I013-1. From top to bottom: Air temperature, near-surface water temperature, air pressure, absolute wind speed and relative humidity. Blue horizontal lines and labels on the right side of the figure indicate absolute wind speeds reported on the Beaufort scale. Grey: original data including missing values and outliers, red: smoothed data by applying a moving median filter.*

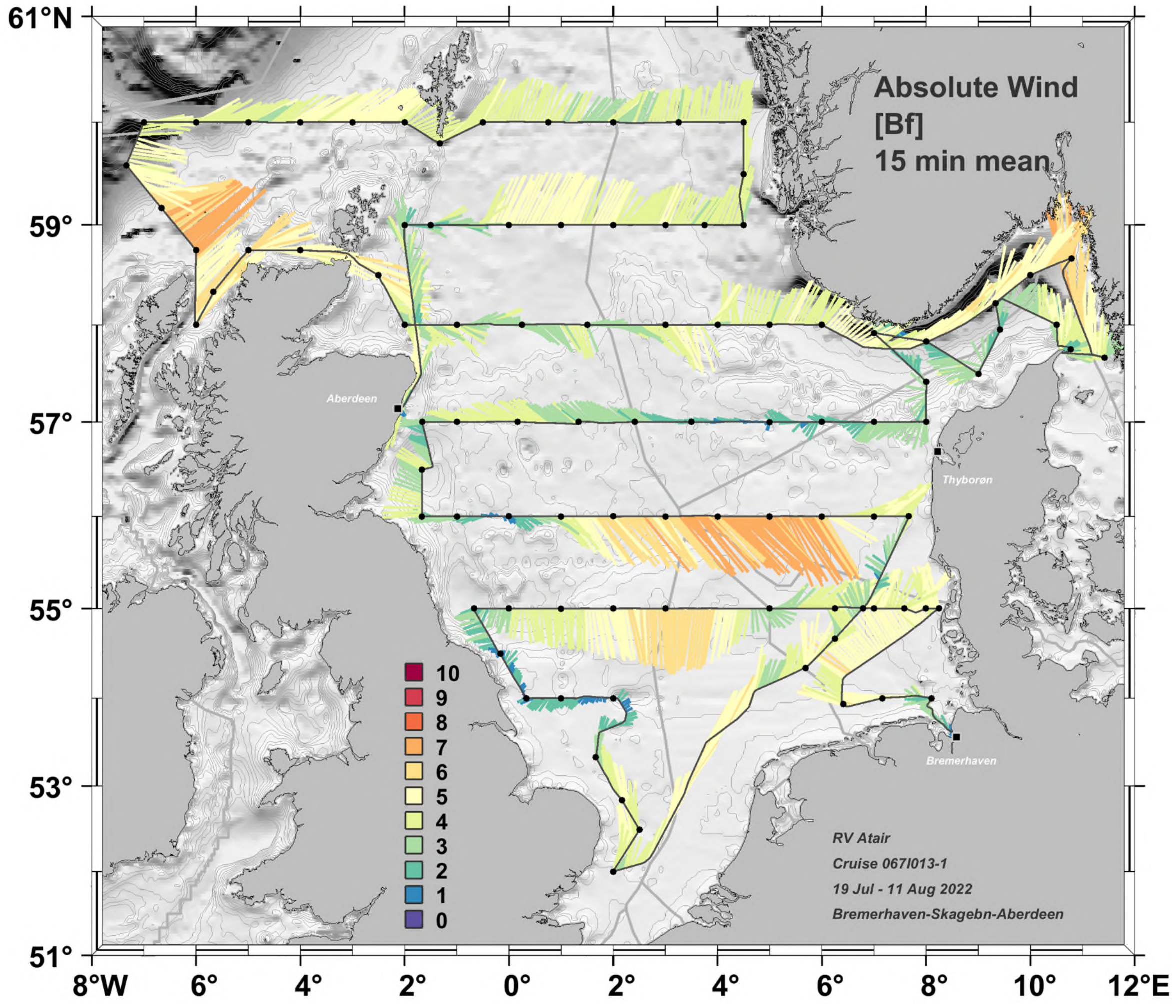

Figure 7.2. *Spatial distribution of the absolute wind strength and direction during cruise 067I013-1. Wind information is reported on the Beaufort scale (see colour bar) and averaged over 15 min intervals. The stick orientation denotes the wind direction.*

7.2 Thermosalinograph and Flourorescence & Turbidity

The thermosalinograph (TSG) system aboard *RV ATAIR* is operated as a throughflow system with the pure seawater inlet installed in the vessel's hull at a depth of 4 m. It consists of a *SBE21 Seacat thermosalinograph* device delivering near-surface conductivity and internal temperature measurements that are matched with an additional external temperature sensor of type *SBE38* located near the water inlet. Next to the TSG system, a dual-wavelength *sensor of type WET Labs Environmental Characterization Optics* (ECO) is installed delivering near-surface underway measurements for fluorescence and turbidity. Table 7.1 provides an over-view on sensor specifications. Data are recorded at time steps of 10 sec. Data recording was switched off when passing through the Ductch EEZ. Swedish authorities demanded to switch off logging while transiting through the Swedish territorial waters. Consequently, there are not any data for this region. A depleted TSG clock battery identified at the beginning of the cruise resulted in a delayed start regarding the data logging.

In order to check on quality performance of the TSG system, water samples were taken about once a day directly from the TSG system and analysed with an *AUTOSAL* salinometer. Standard operational procedures (SOP) to assess the data quality of the near-surface temperature and conductivity/salinity measurements from the TSG system installed aboard *RV ATAIR* are presently under development on a national level and carried out in collaboration with the *German Marine Research Alliance* (DAM). Once the SOP have been implemented, and the data quality control has been finalised and documented, resulting data will be made publically available via submission to the PANGAEA database (https://www.pangaea.de). Regarding the *ECO* sensor data, there are not yet any defined SOP, and any data quality check is presently not carried out regarding near-surface mesurements for fluorescence and turbidity.

Sensor Device	Sensor Type	Serial Number	Calibration Date
SBE21	thermosalinograph, conductivity and internal temperature	3245	24 Mar 2022
SBE38	external temperature	1113	28 Jun 2022
WetLabs ECO FLNTURT	transmissiometer, fluorescence and turbidity	FLNTURT-5883	---

Table 7.1. *Sensor specification of the Thermosalinograph/fluormeter system operated during cruise 067I013-1.*

Figures 7.3 provides an overview on the temporal evolution of the TSG/ECO-sensor-derived properties. TSG-derived temperature at a depth of 4 m ranged from 11.8°C to 21.1°C and was on average 15.5°C. TSG-derived salinity ranged from 27.26 to 35.23 and was on average 33.95. Fluorescence ranged from 0.17 µg/l to 5.05 µg/l and was on average 0.41 µg/l. Turbidity ranged from 0.31 NTU to 4.92 NTU and was on average 0.064 NTU. Strong wind events experienced while crossing the Dogger Bank or while operating in the Skagerrak or in the northwestern corner of the region of interest resulted in air bubbles being trapped in the water and flushed into the TSG system, causing an elevated amount of errorneous data. The strong deviations noted between the *ECO* sensor-based and the underway measurements (lower panels in Figure 7.3) still need to be investigated.

Figures 7.4 to 7.7 show spatial distributions of the respective near-surface temperature, salinity, fluorescence and turbidity during the entire cruise *067I013-1*.

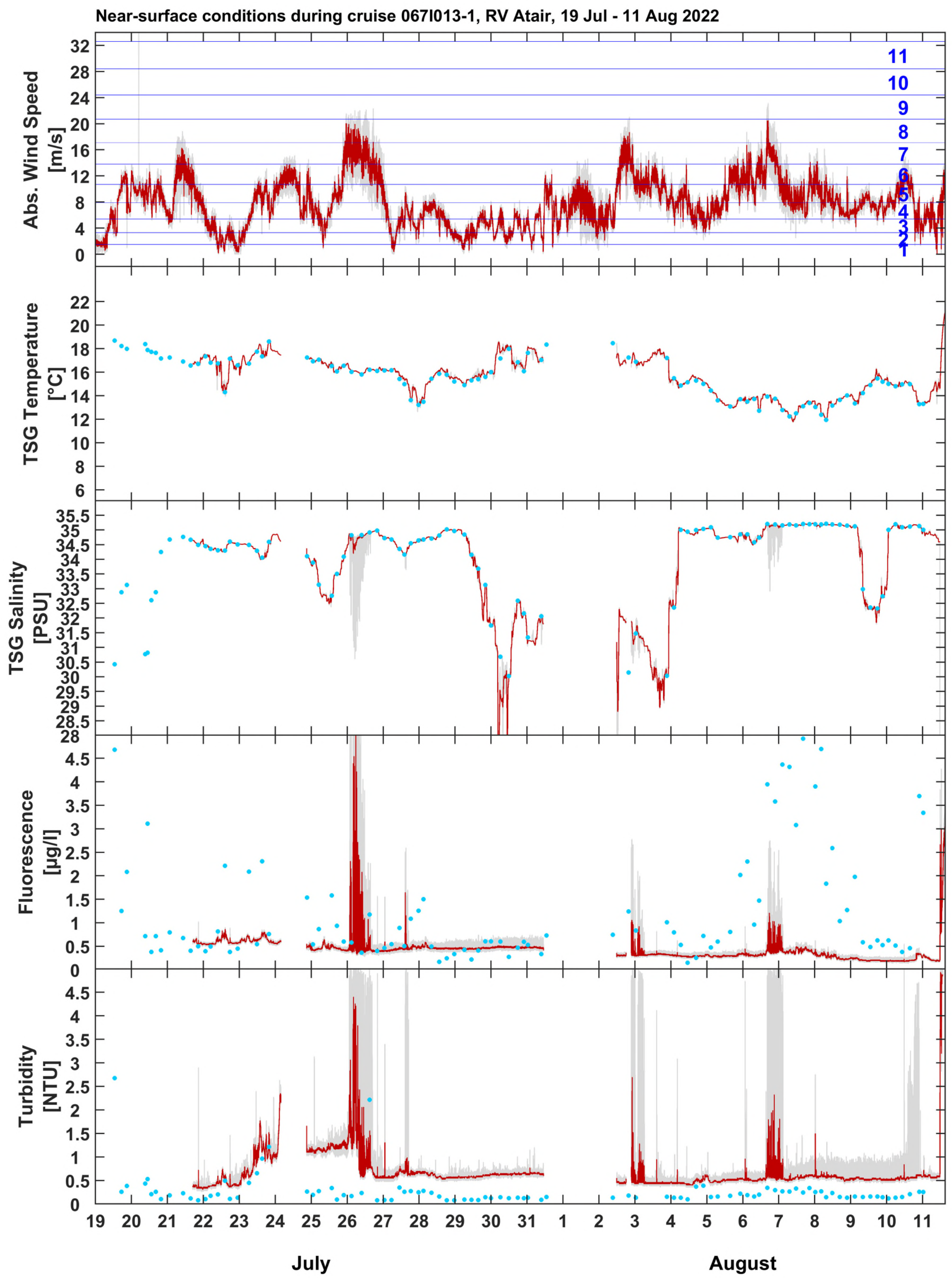

Figure 7.3. *Temporal evolution of absolute wind speed, TSG-derived near-surface (4 m) temperature, TSG-derived near-surface salinity, fluorometer-derived near-surface fluorescence, and fluorometer-derived near-surface turbidity (from top to bottom) recorded during cruise 067I013-1. Grey: original data including outliers, red: smoothed data by applying a moving median filter. Lightblue dots: CTD-derived values from a 4 dbar level.*

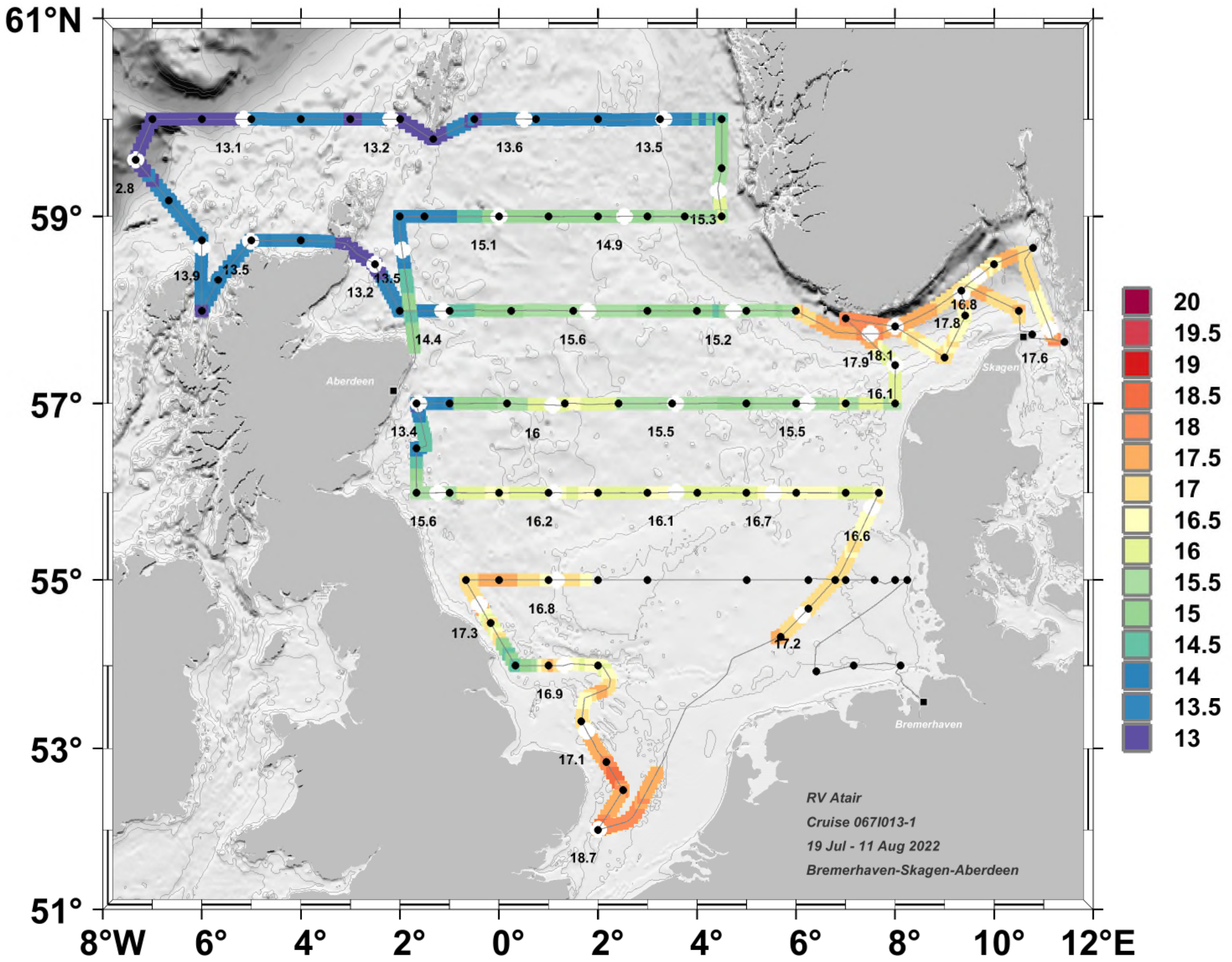

__Figure 7.4.__ Spatial distribution of the near-suface temperature during cruise 067I013-1 obtained from the TSG system and displayed as 30 min averages. Colours denote temperatures in the range 13°-20°C, individual values are highlighted every 12 hours.

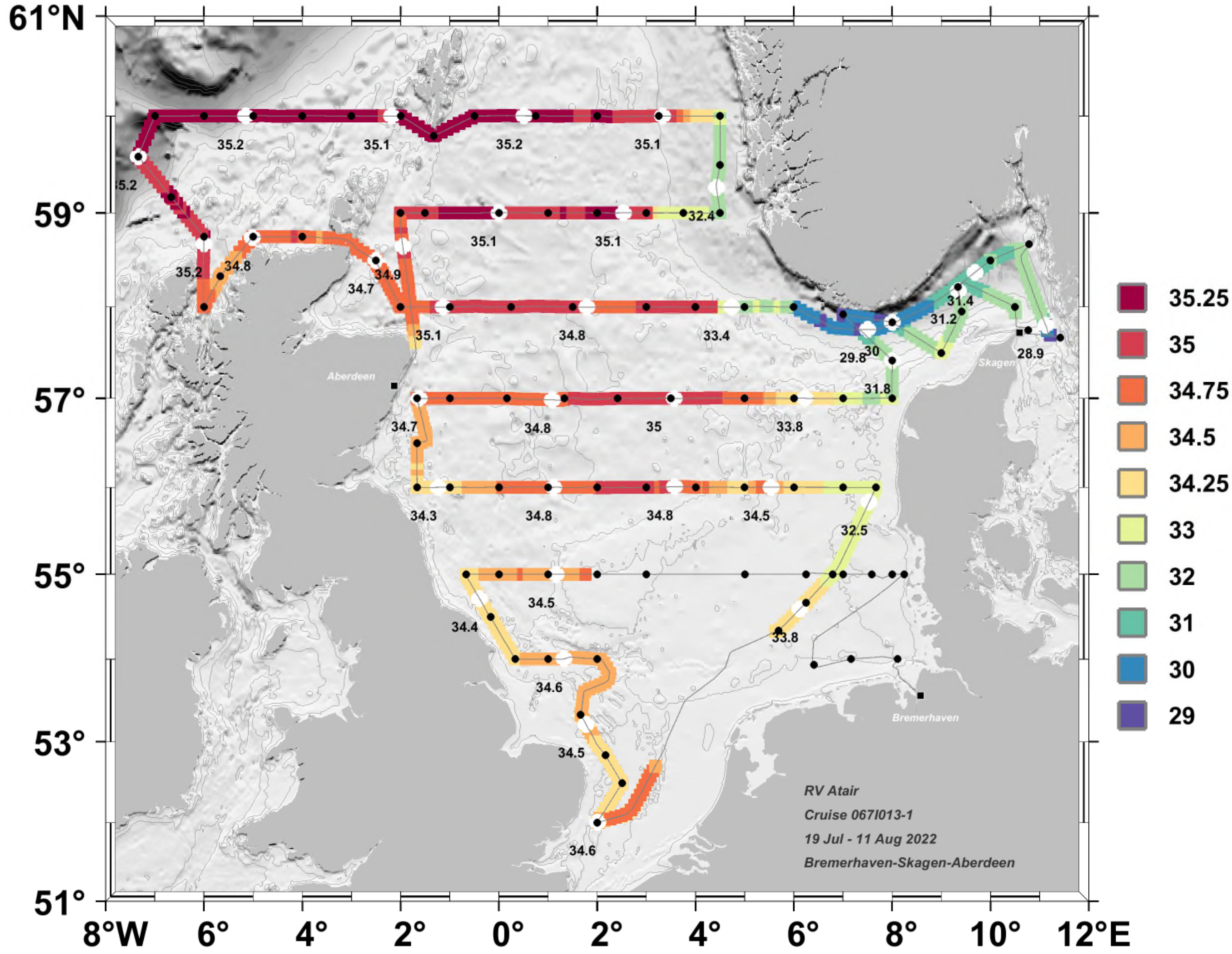

Figure 7.5. *Spatial distribution of the near-suface salinity during cruise 067I013-1 obtained from the TSG system and displayed as 30 min averages. Colours denote salinities in the range 29-35.25, individual values are highlighted every 12 hours.*

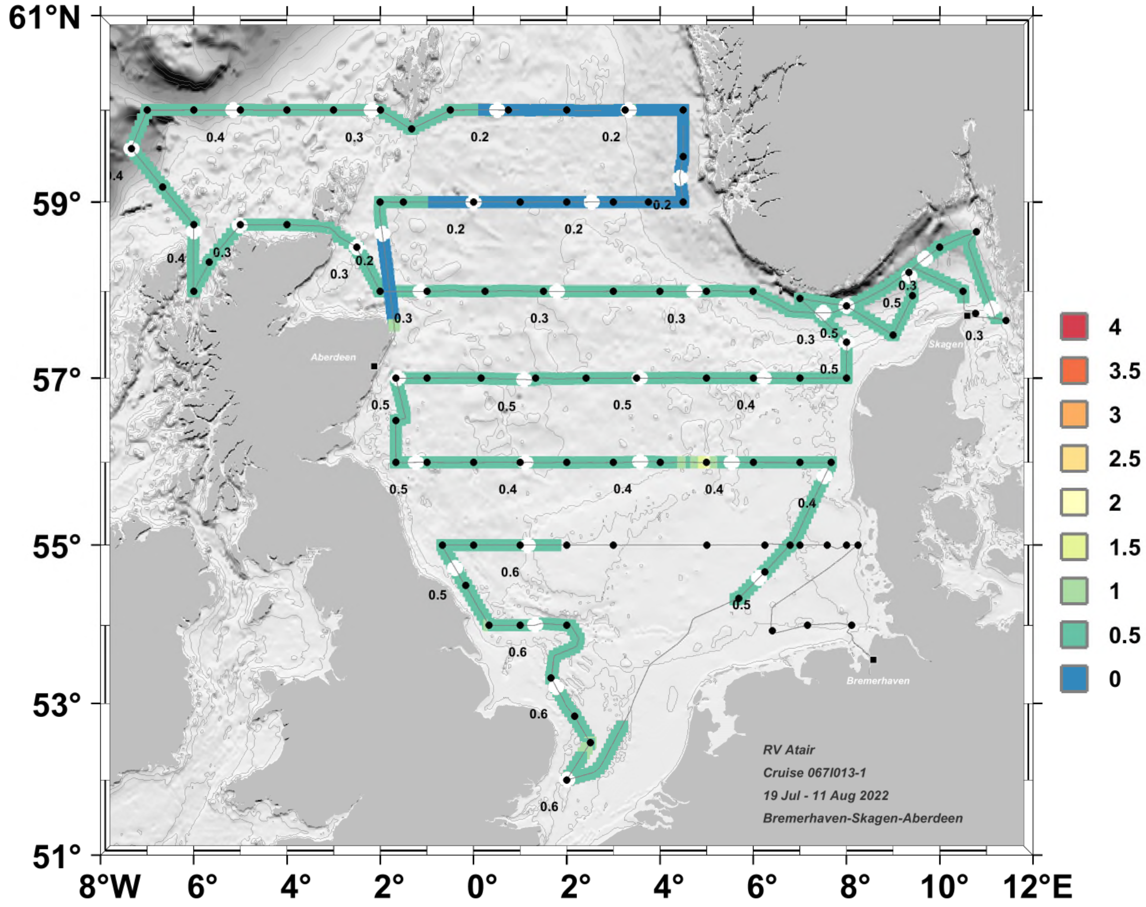

Figure 7.6. *Spatial distribution of the near-suface fluorescence [µg/l] during cruise 067I013-1 obtained from the flow-through ECO sensor and displayed as 30 min averages. Colours denote fluorescence values in the range 0-4 µg/l, individual values are highlighted every 12 hours.*

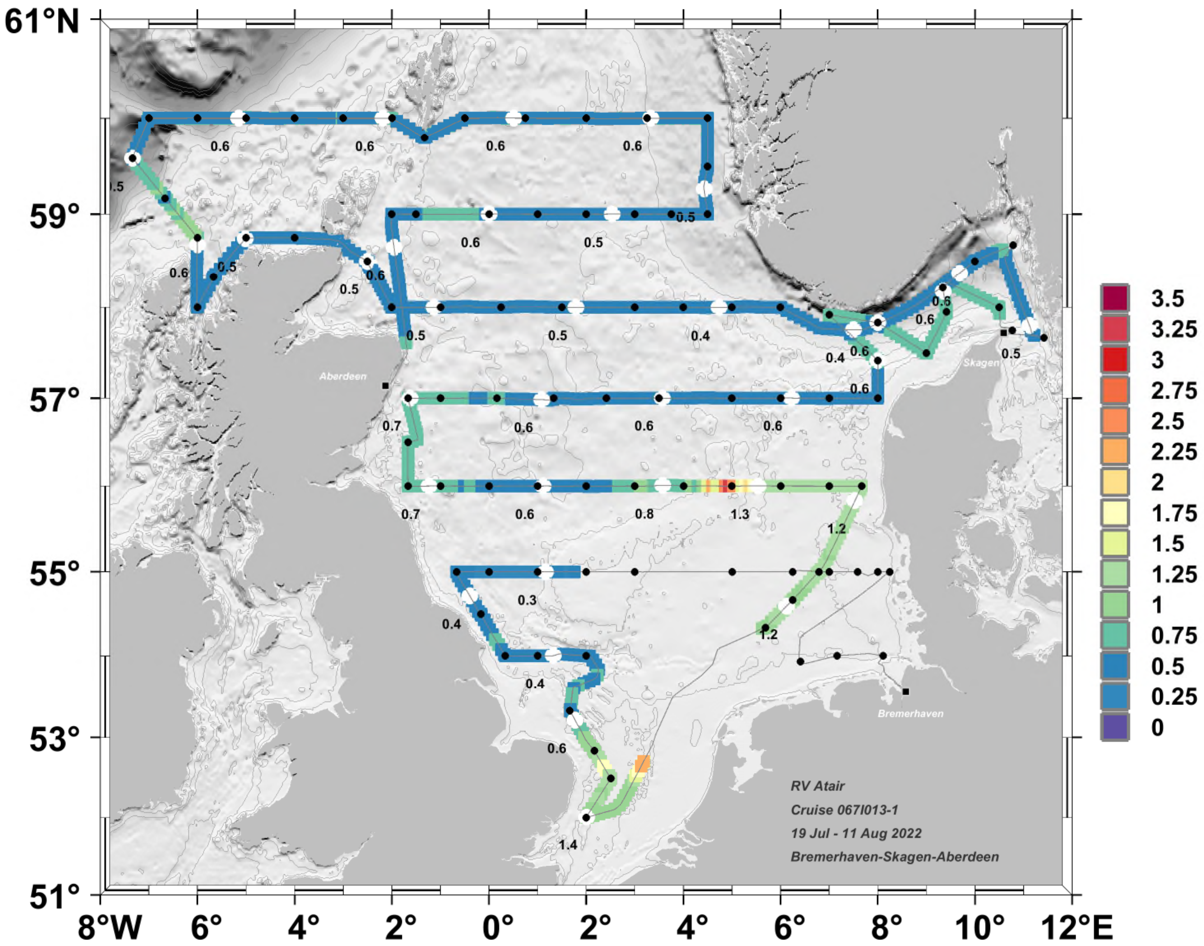

Figure 7.7. *Spatial distribution of the near-suface turbidity [NTU] during cruise 067I013-1 obtained from the flow-through ECO sensor and displayed as 30 min averages. Colours denote turbidity in the range 0- 3.5 NTU, individual values are highlighted every 12 hours.*

7.3 Perfomance of the Vessel-Mounted Acoustic Doppler Current Profiler

A vessel-mounted Acoustic Doppler Current Profiler (VMADCP) was used for continuous recording of single ping velocity data in the water column. The instrument is of type *Teledyne RD Instruments* (TRDI) *Ocean Surveyor* (OS) operating at 150 kHz with a flat phased-array transducer mounted in the hull of the ship. Since the VMADCP does not have any further built-in sensors, additional data on heading and tilt were obtained from the ship's *Hydrins* system. Data recording was carried out with the TRDI *VmDas* software, version 1.50.19. Characteristic parameters of the device installed on *RV ATAIR* are listed in Table 7.2.

OS 150 kHz	
Blanking Distance [m]	6
Maximum Range [m]	400
Transducer Depth [m]	5
Transducer Angle [°]	-1.6°

Table. 7.2. *Specification of the vessel-mounted Acoustic Doppler Current Profiler (VMADCP) in use during cruise 067I013-1.*

During the cruise the VMADCP was operated in broad-band mode in shallow regions to maximise data quality. It was switched to narrow-band mode when in deeper waters to provide maximum vertical coverage. Furthermore, restrictions issued by the Danish authorities required the use of the narrow-band mode when in Danish waters. Bin sizes were kept constant throughout the cruise to maintain consistency. Depending on the particular survey region, the bottom search threshold was adjusted several times. Detailed parameter settings are listed in Table 7.3. The obtained raw data obtained were processed using the VMADCP-toolbox *OSSI for Matlab*, version 1.9, of the *GEOMAR Helmholtz Centre for Ocean Research Kiel* in Germany. The general settings and procedures follow the recommendations presented by *Firing and Hummon (2010)*.

The data processing yielded datasets of zonal and meridional current velocities distributed across latitude, longitude, time and depth along the ship's track. The processed data were stored in several output files in the native *MATLAB* format (*.mat) at a temporal resolution of 1 minute. Erroneous signals caused by signal reflection at the sea floor were removed in the resulting data files.

Data recording began on 19 July 2022 at 13:16 UTC, following the departure from the initial CTD station. Recording was stopped for the first time on 21 July 2022 at 01:22 UTC, prior to entering the Netherlands' EEZ, due to a missing research permission for these waters. Recording restarted on 21 July at 10:31 UTC and continued until 24 July 2022 at 03:50 UTC, while operating in the British EEZ. Data recording was restarted on 24 July 2022 at 20:56 UTC upon entering the German EEZ. The VMADCP mode was switched to narrow-band mode prior to entering the Danish EEZ on 25 July 2022 at 07:37 UTC. Recording stopped on 31 July 2022 at 13:24 UTC, prior to crossing the Danish 12 nm limit and subsequently entering the port of Skagen in Denmark.

After leaving Skagen, VMADCP data collection resumed on 2 August 2022 at 11:50 UTC after crossing the 12 nm limit of Denmark, continuing until the vessel reached the 12 nm boundary of Sweden 18:10 UTC. Restrictions issued by the Swedish authorities required all underway measurement systems and respective data logging to be switched off while operating within Swedish territorial waters. Furthermore, the vessel was required to approach the two intended stations, GN805 and GN806, which were located within the territorial waters, via the shortest possible route from outside the territorial waters. Transit from station GN805 to GN806 had to occur outside the Swedish territorial limits. Consequently, the data recording was switched off while operating within the territorial waters. After leaving Swedish waters, data recording was started again at 21:27 UTC on 02 August. The VMADCP recording for cruise *067I013*-1 finally ceased on 11 August 2022 at 14:58 UTC upon crossing the 12 nm limit of the UK.

#	Start Date, Time (UTC)	Stop Date, Time (UTC)	Mode of Operation	Bin Size [m]	Number of Bins	Bottom Search [m]
1	19 Jul 2022 13:06	21 Jul 2022 01:22	broadband	4	45	80
2	21 Jul 2022 10:31	24 Jul 2022 03:50	broadband	4	45	80
3	24 Jul 2022 20:56	25 Jul 2022 07:34	broadband	4	45	80
4	25 Jul 2022 07:37	29 Jul 2022 20:13	narrowband	4	60	200
5	29 Jul 2022 20:16	31 Jul 2022 13:24	narrowband	4	120	400
6	02 Aug 2022 11:50	02 Aug 2022 18:10	narrowband	4	120	400
7	02 Aug 2022 21:27	03 Aug 2022 02:57	narrowband	4	120	400
8	03 Aug 2022 02:58	06 Aug 2022 16:48	narrowband	4	120	800
9	06 Aug 2022 17:02	09 Aug 2022 17:54	narrowband	4	120	none
10	09 Aug 2022 17:58	11 Aug 2022 14:58	narrowband	4	120	400

Table. 7.3. *VMADCP settings for different periods and transects of cruise 067I013-1.*

The operation of the VMADCP was documented manually throughout the cruise in a log file. Each time the VMADCP was restarted, a new file was created, and the file counter automatically increased. Configuration setup files were stored alongside the data whenever a change was made to the configuration.

During VMADCP data processing, water-track calibration was performed to determine the phase and the amplitude of the transducer misalignment. The amplitude scale factor and transducer orientation were calculated to minimise the root-mean-square difference between the estimated water velocity over the ground (using GPS navigation) before and after ship accelerations, including major turns as well as stopping on station and getting underway after a station. As the cruise track did not include enough turns for proper analysis, additional turns were performed after leaving a station. The respective adjustments were an amplitude factor of 1.0408 and a misalignment angle amplitude factor and 1.464°.

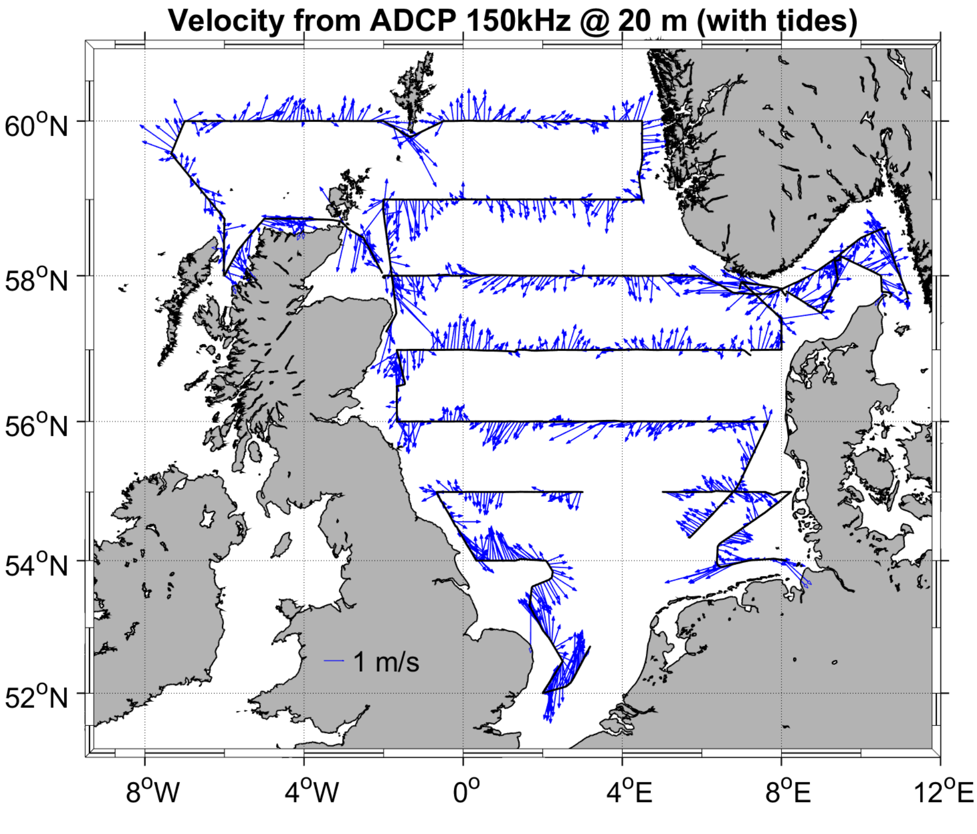

Figure 7.8. *The oceanic flow field at a depth of 20 m as observed with a VMADCP system during cruise 067I013-1, summer 2022. The tidal contribution to the flow field is still included.*

The VMADCP system worked properly during the entire cruise, and the data are expected to be of acceptable quality. However, the VMADCP settings and the resulting data should be considered experimental, since cruise *067I013-1* was one of the first BSH cruises to the North Sea with the vessel's VMADCP system in use. Additional post-cruise quality control and post-processing steps are therefore still necessary to obtain the final dataset and assess its final quality, e.g. a detailed inspection and manual editing of any measurements that appear suspicious. Figure 7.8 shows a first example of the ocean flow field at 20 m as observed during the entire cruise. The tidal contribution is still included.

8. Data Availability and Sample Storage

Further data analysis and interpretation will be carried out together with national and international collaborators in the framework of e.g. BSH's contribution to the international *Working Group on Oceanic Hydrography* (WGOH) hosted by the *International Council for the Explorations of the Seas* (ICES). Data from this cruise will be used for respective assessment reports and reporting in the framework of the *Marine Strategy Framework Directive* (MSFD) of the European Union. The data also serve for validating numerical operational ocean and climate models, for the calibration of satellite-based ocean colour data, hyper-spectral satellite data and downstream products (e.g. Secchi depth, turbidity, fluorescence, chlorophyll-a). In particular, chlorophyll-a data contributes to the EOMAP effort (https://eomap.com).

A cruise summary report (CSR) is available on the SeaDataNet portal, CSR reference number: 21032467; https://csr.seadatanet.org/report/21032467. See also: https://www2.bsh.de/aktdat/dod/fahrtergebnis/2022/20220144.htm

Data related to cruise *067I013-1* is genereally stored at the German Oceanographic Data Service hosted at BSH (DOD, email: dod@bsh.de), DOD reference number: 20220144, https://www.bsh.de/EN/DATA/Climate-and-Sea/Oceanographic_Data_Center/oceanographic_data_center_node.html

Near-realtime CTD data has been submitted and is available for download on the BSH data portal:

Temperature: https://gdi.bsh.de/en/feed/temperature-of-sea-water-2022.xml

Salinity: https://gdi.bsh.de/en/feed/salinity-of-sea-water-2022.xml

Dissolved oxygen: https://gdi.bsh.de/en/feed/dissolved-oxygen-in-sea-water-2022.xml

Fluorescence (chlorophyll): https://gdi.bsh.de/en/feed/chlorophyll-a-in-sea-water-2022.xml

Turbidity: https://gdi.bsh.de/en/feed/turbidity-in-sea-water-2022.xml

Finally processed CTD data has been submitted to DOD and is available at the MUDAB data portal (https://geoportal.bafg.de/MUDABAnwendung/), the mandatory data portal for German governmental agencies. Therein, data of cruise *067I013-1* contribute to the "Bund-Länder Monitoring-Programm" (BLMP/BLMP+). Respective data will be provided via MUDAB to the ICES data portal (https://www.ices.dk/). Also, chlorophyll-a concentrations measured in the home laboratory and Secchi depths are available via the MUDAB database and will be pushed forward to ICES. The following ICES divisions were sampled: IIIa, IVa, IVb, IVc and VIa. The respective ICES ecoregion is the Greater North Sea.

VMADCP data is kept on long-time archives of the BSH's oceanography group as the establishment of an official data storage work flow is in the making through collaboration with the *German Marine Research Alliance* (DAM). Data can be obtained on request from: M22_obs@bsh.de

Data regarding radionuclides has been submitted to the *Integrated Monitoring and Information System for Monitoring Radioactivity in the Environment* (IMIS), also see *BMUV (2024)*.

9. References

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Jeffrey, S. W., and Humphrey, G. F. (1975), New spectrophotometric equation for determining chlorophyll a, b, c_1 and c_2 in higher plants, algae and natural phytoplankton, *Biochem. Physiol. Pflanz.*, 167(2), 194-204, https://doi.org/10.1016/S0015-3796(17)30778-3.

10. Acknowledgments

We would like to express our gratitude to the master of *RV ATAIR*, Ulrich Klüber, and his entire crew for the assistance and great support granted to us during cruise *067I013-1*. We have greatly appreciated the very friendly working environment, the hospitality experienced onboard the vessel, and the very professional and constructive cooperation between the scientific team and the ship's crew. We further thank our colleagues at our home laboratories for assistance in the preparation of the cruise and processing of the cruise-related data. We particularly acknowledge the support of the BSH shipping company *N3* and the respective sections *N32-Vessel Operation* and *N31-Technology and Equipment of Vessels* and the international authorities for granting us permission to undertake this survey in the various national waters.

11. Station List

Station Number	Station Name	Date, Station Begin	Time, Station Begin [UTC]	Latitude, Station Begin	Longitude, Station Begin	Water Depth, Station Begin [m]	Date, Station End	Time, Station End [UTC]	Latitude, Station End	Longitude, Station End	Water Depth, Station End [m]	CTD	Water samples (Niskin)	Secchi Depth	Bottle Salinity	Bottle Water Density	Bottle Chlorophyll-a	Pumped Radionuclide Sampling	Large-volume water sampler	Comment
001	Test CTD/Alte Weser	19-Jul-2022	10:45	53°53.77’N	08°03.87’E	15.2	19-Jul-2022	11:18	53°53.77’N	08°03.87’E	15.8	x								test station, CTD A999X001, no bottle sampling
002	GN003/ELBE1	19-Jul-2022	12:34	54°00.02’N	08°06.40’E	25.2	19-Jul-2022	13:16	54°00.02’N	08°06.41’E	25.6	x	x	x	x		x	x		CTD A001X001
003	GN003A	19-Jul-2022	17:28	54°00.02’N	07°09.84’E	28.0	19-Jul-2022	17:40	54°00.02’N	07°09.84’E	27.7	x	x		x		x	x		CTD A002X001
004	GN007	19-Jul-2022	21:03	53°55.99’N	06°24.81’E	25.2	19-Jul-2022	21:18	53°55.87’N	06°24.36’E	25.2	x	x		x		x	x		CTD A003X001
005	GN025	20-Jul-2022	09:17	55°00.02’N	08°14.90’E	13.2	20-Jul-2022	09:30	55°00.02’N	08°14.90’E	13.2	x	x	x	x		x	x		CTD A004X001
006	GN024/SYLT1	20-Jul-2022	10:49	54°59.96’N	07°59.85’E	15.1	20-Jul-2022	11:02	54°59.96’N	07°59.86’E	15.1	x	x	x	x		x			CTD A005X001
007	GN023	20-Jul-2022	13:16	55°00.00’N	07°35.02’E	25.7	20-Jul-2022	13:34	55°00.00’N	07°35.02’E	25.2	x	x	x	x		x	x		CTD A006X001
008	GN022A	20-Jul-2022	16:15	55°00.00’N	07°00.00’E	33.0	20-Jul-2022	16:31	54°59.99’N	07°00.00’E	33.0	x	x	x	x			x		CTD A007X001
009	GN022	20-Jul-2022	19:47	54°59.98’N	06°15.09’E	43.5	20-Jul-2022	20:01	54°59.98’N	06°15.09’E	44.8	x	x		x	x	x	x		CTD A008X001
010	GN021/AWZW2	21-Jul-2022	01:34	55°00.02’N	05°00.05’E	40.5	21-Jul-2022	01:48	55°00.02’N	05°00.05’E	40.5	x	x		x		x	x		CTD A009X001
011	GN019S	21-Jul-2022	10:24	54°59.95’N	03°00.04’E	25.0	21-Jul-2022	10:59	54°59.95’N	03°00.04‘E	24.5	x	x	x	x					CTD A010X001
012	GN019	21-Jul-2022	15:29	54°59.99’N	01°59.98’E	26.9	21-Jul-2022	15:57	54°59.99’N	01°59.98’E	26.4	x	x	x	x		x	x		CTD A011X001
013	GN018S	21-Jul-2022	17:07	54°59.99’N	01°47.23’E	63.0	21-Jul-2022	20:53	54°59.92’N	01°00.05’E	63.0	x	x		x					CTD A012X001
014	GN018	22-Jul-2022	01:24	54°59.99’N	00°00.04’W	75.0	22-Jul-2022	01:51	54°59.99’N	00°00.04’W	75.0	x	x		x		x	x		CTD A013X001
015	GN018A	22-Jul-2022	04:53	54°59.99’N	00°40.02’W	66.6	22-Jul-2022	05:12	54°59.99’N	00°40.02’W	66.5	x	x	x	x			x		CTD A014X001
016	GN017S	22-Jul-2022	09:44	54°29.96’N	00°09.86’W	62.6	22-Jul-2022	10:06	54°29.96’N	00°09.86‘W	62.5	x	x	x	x	x				CTD A015X001
017	GN017A	22-Jul-2022	14:31	53°59.99’N0	00°20.02’E	52.5	22-Jul-2022	14:46	53°59.99’N	00°20.02’E	52.9	x	x	x	x			x		CTD A016X001
018	GN017	22-Jul-2022	17:47	54°00.02’N0	00°59.96’E	42.6	22-Jul-2022	18:03	54°00.02’N	00°59.96’E	42.5	x	x	x	x		x	x		CTD A017X001
019	GN009S	22-Jul-2022	23:01	54°00.01’N0	02°00.00’E	73.1	22-Jul-2022	23:22	54°00.01’N	02°00.01’E	74.0	x	x		x					CTD A018X001
020	GN016	23-Jul-2022	06:23	53°19.84’N	01°39.94’E	29.2	23-Jul-2022	06:40	53°19.84’N	01°39.94’E	28.9	x	x	x	x		x	x		CTD A019X001
021	GN015B	23-Jul-2022	11:40	52°50.01’N	02°10.06’E	41.0	23-Jul-2022	12:00	52°50.01’N	02°10.07’E	41.7	x	x	x	x	x	x	x		CTD A020X001
022	GN015	23-Jul-2022	15:12	52°29.67’N	02°30.32’E	48.0	23-Jul-2022	15:26	52°29.67’N	02°30.32‘E	47.7	x	x	x	x		x	x		CTD A021X001

Station Number	Station Name	Date, Station Begin	Time, Station Begin [UTC]	Latitude, Station Begin	Longitude, Station Begin	Water Depth, Station Begin [m]	Date, Station End	Time, Station End [UTC]	Latitude, Station End	Longitude, Station End	Water Depth, Station End [m]	CTD	Water samples (Niskin)	Secchi Depth	Bottle Salinity	Bottle Water Density	Bottle Chlorophyll-a	Pumped Radionuclide Sampling	Large-volume water sampler	Comment
023	GN014	23-Jul-2022	19:50	51°59.97'N	01°59.99'E	31.8	23-Jul-2022	20:02	51°59.97'N	01°59.99'E	31.8	x	x		x		x	x		CTD A022X001
024	NEFB	24-Jul-2022	21:13	54°20.35'N	05°41.39'E	41.4	24-Jul-2022	21:25	54°20.35'N	05°41.39'E	41.6	x	x		x					CTD A023X001
025	WBANK	25-Jul-2022	01:11	54°40.02'N	06°15.05'E	40.7	25-Jul-2022	01:31	54°40.02'N	06°15.04'E	40.8	x	x		x					CTD A024X001
026	URST3	25-Jul-2022	05:05	55°00.04'N	06°47.17'E	36.0	25-Jul-2022	05:21	55°00.04'N	06°47.16'E	35.8	x	x	x	x					CTD A025X001
027	GN026	25-Jul-2022	13:43	56°00.03'N	07°40.01'E	28.0	25-Jul-2022	14:00	56°00.03'N	07°40.01'E	28.0	x	x	x	x	x		x		CTD A026X001
028	GN026A	25-Jul-2022	17:08	55°59.99'N	07°00.00'E	36.9	25-Jul-2022	17:26	55°59.99'N	07°00.00'E	35.5	x	x	x	x			x		CTD A027X001
029	GN027	25-Jul-2022	21:46	55°59.98'N	06°00.04'E	48.1	25-Jul-2022	22:13	55°59.98'N	06°00.04'E	49.4	x	x		x		x	x		CTD A028X001
030	GN028	26-Jul-2022	02:54	55°59.94'N	04°59.97'E	44.0	26-Jul-2022	03:30	55°59.94'N	04°59.97'E	43.9	x	x		x		x	x		CTD A029X001
031	GN028S	26-Jul-2022	09:35	55°59.97'N	04°00.14'E	58.0	26-Jul-2022	10:07	55°59.96'N	04°00.13'E	57.8	x	x	x	x					CTD A030X001
032	GN029	26-Jul-2022	14:57	55°59.96'N	03°00.03'E	75.0	26-Jul-2022	15:31	55°59.97'N	03°00.03'E	75.8	x	x		x	x	x	x		CTD A031X001
033	GN030	26-Jul-2022	20:00	56°00.02'N	02°00.08'E	86.5	26-Jul-2022	20:30	56°00.02'N	02°00.07'E	86.9	x	x		x		x	x		CTD A032X001
034	GN031	27-Jul-2022	00:51	55°59.97'N	00°59.98'E	78.2	27-Jul-2022	01:22	55°59.97'N0	00°59.98'E	78.8	x	x		x		x	x		CTD A033X001
035	GN032	27-Jul-2022	05:38	56°00.01'N	00°00.00'W	85.9	27-Jul-2022	06:24	56°00.00'N	00°00.01'W	85.6	x	x	x	x		x	x		CTD A034X001
036	GN033	27-Jul-2022	10:53	56°00.00'N	00°59.96'W	65.4	27-Jul-2022	11:13	56°00.00'N	00°59.96'W	64.4	x	x	x	x	x	x	x		CTD A035X001
037	GN033A	27-Jul-2022	14:14	55°59.98'N	01°40.02'W	68.0	27-Jul-2022	14:37	55°59.98'N	01°40.02'W	67.7	x	x	x	x			x		CTD A036X001
038	GN033S	27-Jul-2022	18:30	56°29.99'N	01°40.14'W	51.6	27-Jul-2022	18:48	56°29.99'N	01°40.14'W	51.2	x	x		x					CTD A037X001
039	GN034A	27-Jul-2022	23:35	56°59.99'N	01°39.90'W	75.9	27-Jul-2022	23:58	56°59.99'N	01°39.90'W	76.1	x	x		x	x		x		CTD A038X001
040	GN034	28-Jul-2022	02:59	56°59.97'N	00°59.94'W	72.1	28-Jul-2022	03:23	56°59.97'N	00°59.93'W	72.7	x	x		x		x	x		CTD A039X001
041	GN034S	28-Jul-2022	08:09	56°59.98'N	00°10.02'E	84.4	28-Jul-2022	08:32	56°59.98'N	00°10.02'E	84.4	x	x	x	x					CTD A040X001
042	GN035	28-Jul-2022	13:29	57°00.02'N	01°20.01'E	99.4	28-Jul-2022	13:54	57°00.02'N	01°20.01'E	99.1	x	x	x	x		x	x		CTD A041X001
043	GN035S	28-Jul-2022	18:25	57°00.01'N	02°24.95'E	81.4	28-Jul-2022	18:51	57°00.01'N	02°24.95'E	80.6	x	x	x	x					CTD A042X001
044	GN036	28-Jul-2022	23:26	56°59.97'N	03°29.95'E	65.0	28-Jul-2022	23:53	56°59.97'N	03°29.95'E	65.3	x	x		x		x	x		CTD A043X001
045	GN037	29-Jul-2022	06:07	56°59.92'N	04°59.98'E	58.5	29-Jul-2022	06:32	56°59.92'N	04°59.97'E	59.5	x	x	x	x		x	x		CTD A044X001
046	GN038	29-Jul-2022	10:49	56°59.98'N	06°00.00'E	52.4	29-Jul-2022	11:13	56°59.98'N	05°59.99'E	52.6	x	x	x	x		x	x		CTD A045X001
047	GN038A	29-Jul-2022	15:31	57°00.00'N	07°00.00'E	33.1	29-Jul-2022	15:50	57°00.00'N	07°00.00'E	33.1	x	x	x	x			x		CTD A046X001
048	GN039	29-Jul-2022	20:17	56°59.99'N	07°59.94'E	33.4	29-Jul-2022	20:31	56°59.99'N	07°59.93'E	33.4	x	x		x	x		x		CTD A047X001

Station Number	Station Name	Date, Station Begin	Time, Station Begin [UTC]	Latitude, Station Begin	Longitude, Station Begin	Water Depth, Station Begin [m]	Date, Station End	Time, Station End [UTC]	Latitude, Station End	Longitude, Station End	Water Depth, Station End [m]	CTD	Water samples (Niskin)	Secchi Depth	Bottle Salinity	Bottle Water Density	Bottle Chlorophyll-a	Pumped Radionuclide Sampling	Large-volume water sampler	Comment
049	GN039S	29-Jul-2022	23:55	57°24.99'N	08°00.01'E	91.8	30-Jul-2022	00:20	57°24.99'N	08°00.01'E	91.0	x	x		x		x			CTD A048X001
050	GN040S	30-Jul-2022	06:09	57°55.06'N	06°59.94'E	362.6	30-Jul-2022	07:23	57°55.05'N	06°59.94'E	362.6	x	x	x	x					CTD A049X001
051	GN040	30-Jul-2022	11:57	57°49.98'N	07°59.93'E	523.8	30-Jul-2022	13:02	57°49.97'N	07°59.93'E	523.9	x	x	x	x	x	x	x		CTD A050X001
052	GN801	30-Jul-2022	17:51	57°29.98'N	09°00.00'E	25.5	30-Jul-2022	18:09	57°29.98'N	09°00.00'E	25.5	x	x	x	x		x	x		CTD A051X001
053	GN802	30-Jul-2022	21:55	57°57.04'N	09°25.08'E	220.0	30-Jul-2022	22:30	57°57.04'N	09°25.08'E	220.0	x	x		x	x	x	x		CTD A052X001
054	GN808	31-Jul-2022	00:40	58°13.00'N	09°20.08'E	679.0	31-Jul-2022	04:19	58°13.02'N	09°20.10'E	679.0	x	x		x		x	x	x	CTD A053X001, 270 L and 333 L samplers
055	GN803	31-Jul-2022	09:29	57°59.99'N	10°30.01'E	126.0	31-Jul-2022	10:13	57°59.99'N	10°30.00'E	126.0	x	x	x	x	x	x	x		CTD A054X001
056	GN804	31-Jul-2022	12:55	57°45.03'N	10°46.06'E	32.0	31-Jul-2022	13:16	57°45.03'N	10°46.07'E	32.0	x	x	x	x	x	x	x		CTD A055X001
057	GN805	02-Aug-2022	09:21	57°39.99'N	11°25.10'E	91.0	02-Aug-2022	10:51	57°39.99'N	11°25.12'E	91.0	x	x	x	x	x	x	x		CTD A056X001
058	GN806	02-Aug-2022	19:42	58°40.18'N	10°47.10'E	91.0	02-Aug-2022	20:18	58°40.17'N	10°47.09'E	91.0	x	x		x	x	x	x		CTD A057X001
059	GN807	04-Aug-2022	00:42	58°29.99'N	09°59.98'E	525.0	03-Aug-2022	01:44	58°29.99'N	09°59.99'E	525.0	x	x		x	x		x		CTD A058X001
060	GN808	03-Aug-2022	06:25	58°13.03'N	09°19.03'E	679.0	03-Aug-2022	07:54	58°13.03'N	09°19.02'E	674.0								x	no CTD cast, only 270 L and 333 L samplers
061	GN041	03-Aug-2022	21:22	58°00.09'N	05°59.82'E	310.0	03-Aug-2022	21:56	58°00.09'N	05°59.83'E	310.0	x	x		x	x	x	x		CTD A059X001
062	GN042	04-Aug-2022	02:05	58°00.00'N	04°59.92'E	127.3	04-Aug-2022	02:26	58°00.00'N	04°59.92'E	127.4	x	x		x		x	x		CTD A060X001
063	GN042S	04-Aug-2022	06:32	57°59.96'N	04°00.09'E	99.4	04-Aug-2022	07:07	57°59.95'N	04°00.08'E	99.5	x	x		x					CTD A061X001
064	GN043	04-Aug-2022	11:01	58°00.02'N	02°59.97'E	77.4	04-Aug-2022	11:28	58°00.02'N	02°59.97'E	77.0	x	x	x	x	x	x	x		CTD A062X001
065	GN044	04-Aug-2022	16:52	57°59.98'N	01°29.99'E	105.0	04-Aug-2022	17:16	57°59.99'N	01°29.99'E	105.0	x	x	x	x		x	x		CTD A063X001
066	GN044S	04-Aug-2022	21:43	57°59.98'N	00°14.95'E	139.1	04-Aug-2022	22:04	57°59.97'N	00°14.95'E	139.0	x	x		x					CTD A064X001
067	GN045	05-Aug-2022	02:45	57°59.98'N	01°00.00'W	113.2	05-Aug-2022	03:06	57°59.99'N	01°00.00'W	114.2	x	x		x		x	x		CTD A065X001
068	GN045A	05-Aug-2022	07:14	58°00.03'N	01°59.96'W	84.1	05-Aug-2022	07:46	58°00.02'N	01°59.98'W	84.2	x	x	x	x	x		x		CTD A066X001

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069	GN045B	05-Aug-2022	15:38	58°30.02'N	02°30.01'W	72.1	05-Aug-2022	15:55	58°30.02'N	02°30.02'W	72.0	x	x	x	x			x		CTD A067X001
070	GN057A	05-Aug-2022	22:19	58°44.99'N	03°59.95'W	77.6	05-Aug-2022	22:44	58°44.99'N	03°59.95'W	78.1	x	x		x			x		CTD A068X001
071	GN056	06-Aug-2022	03:07	58°45.03'N	04°59.92'W	85.5	06-Aug-2022	03:25	58°45.03'N	04°59.92'W	85.5	x	x		x	x	x	x		CTD A069X001
072	GN056C	06-Aug-2022	07:32	58°19.98'N	05°40.02'W	106.3	06-Aug-2022	08:03	58°19.98'N	05°40.01'W	105.9	x	x	x	x			x		CTD A070X001
073	GN064	06-Aug-2022	10:48	58°00.00'N	05°59.98'W	64.5	06-Aug-2022	11:15	57°59.99'N	05°59.98'W	64.5	x	x	x	x		x	x		CTD A071X001
074	GN056B	06-Aug-2022	16:25	58°45.01'N	05°59.91'W	118.4	06-Aug-2022	16:35	58°45.01'N	05°59.91'W	118.7	x	x		x			x		CTD A072X001
075	GN069	06-Aug-2022	21:31	59°09.98'N	06°39.79'W	133.4	06-Aug-2022	21:58	59°09.98'N	06°39.79'W	134.7	x	x		x			x		CTD A073X001
076	GN068	07-Aug-2022	02:29	59°35.03'N	07°20.02'W	1007.2	07-Aug-2022	03:39	59°35.03'N	07°20.02'W	1006.2	x	x		x			x		CTD A074X001
077	GN066	07-Aug-2022	07:03	60°00.03'N	06°59.96'W	448.9	07-Aug-2022	07:58	60°00.02'N	06°59.96'W	448.9	x	x	x	x			x		CTD A075X001
078	GN065	07-Aug-2022	11:32	59°59.98'N	06°00.01'W	1065.0	07-Aug-2022	12:54	59°59.99'N	06°00.00'W	1065.0	x	x	x	x		x	x		CTD A076X001
079	GN055	07-Aug-2022	16:24	60°00.01'N	04°59.98'W	412.0	07-Aug-2022	17:01	60°00.01'N	04°59.99'W	412.0	x	x	x	x		x	x	x	CTD A077X001, 2x 1000 L drums filled with sea-water for home-based sensor calibration
080	GN054S	07-Aug-2022	20:30	60°00.02'N	03°59.94'W	131.8	07-Aug-2022	20:53	60°00.02'N	03°59.95'W	131.7	x	x		x					CTD A078X001
081	GN054	08-Aug-2022	00:28	60°00.01'N	02°59.98'W	104.7	08-Aug-2022	00:53	60°00.01'N	02°59.98'W	105.1	x	x		x		x	x		CTD A079X001
082	GN053B	08-Aug-2022	04:27	59°59.98'N	01°59.93'W	88.3	08-Aug-2022	04:41	59°59.98'N	01°59.94'W	88.3	x	x		x			x		CTD A080X001
083	GN053A	08-Aug-2022	07:31	59°47.84'N	01°19.75'W	128.0	08-Aug-2022	08:03	59°47.85'N	01°19.75'W	128.0	x	x		x	x		x		CTD A081X001
084	GN053	08-Aug-2022	11:39	60°00.02'N	00°29.97'W	124.1	08-Aug-2022	12:10	60°00.02'N	00°29.97'W	123.8	x	x	x	x		x	x		CTD A082X001
085	GN052S	08-Aug-2022	16:42	60°00.02'N	00°45.07'E	127.9	08-Aug-2022	17:01	60°00.02'N	00°45.07'E	128.1	x	x	x	x					CTD A083X001

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086	GN052	08-Aug-2022	21:34	59°59.97'N	02°00.05'E	101.4	08-Aug-2022	21:55	59°59.97'N	02°00.05'E	101.5	x	x		x		x	x		CTD A084X001
087	GN051S	09-Aug-2022	02:50	59°59.99'N	03°15.18'E	264.0	09-Aug-2022	03:15	59°59.99'N	03°15.17'E	264.0	x	x		x					CTD A085X001
088	GN051	09-Aug-2022	07:59	60°00.00'N	04°29.99'E	259.0	09-Aug-2022	08:55	60°00.00'N	04°29.98'E	259.0	x	x	x	x	x	x	x		CTD A086X001
089	GN050S	09-Aug-2022	13:04	59°29.92'N	04°30.02'E	264.0	09-Aug-2022	13:53	59°29.92'N	04°30.01'E	264.0	x	x	x	x					CTD A087X001
090	GN050	09-Aug-2022	17:51	58°59.98'N	04°29.98'E	259.0	09-Aug-2022	18:21	58°59.98'N	04°29.98'E	259.0	x	x	x	x		x	x		CTD A088X001
091	GN049S	09-Aug-2022	21:17	59°00.04'N	03°45.00'E	270.0	09-Aug-2022	21:52	59°00.03'N	03°45.00'E	270.0	x	x		x					CTD A089X001
092	GN049	10-Aug-2022	01:17	59°00.00'N	02°59.98'E	136.3	10-Aug-2022	01:47	59°00.00'N	02°59.98'E	136.5	x	x		x		x	x		CTD A090X001
093	GN048S	10-Aug-2022	05:55	59°00.01'N	02°00.01'E	113.7	10-Aug-2022	06:15	59°00.01'N	02°00.01'E	114.3	x	x	x	x					CTD A091X001
094	GN048	10-Aug-2022	10:20	59°00.00'N	01°00.02'E	125.3	10-Aug-2022	11:16	59°00.00'N	01°00.02'E	124.7	x	x	x	x	x	x	x	x	CTD A092X001, 333 L sampler
095	GN047	10-Aug-2022	15:30	59°00.01'N	00°00.01'W	131.3	10-Aug-2022	15:52	59°00.00'N	00°00.01'W	131.4	x	x	x	x		x	x		CTD A093X001
0096	GN046	10-Aug-2022	21:54	59°00.02'N	01°29.99'W	108.2	10-Aug-2022	22:17	59°00.02'N	01°29.99'W	107.8	x	x		x		x	x		CTD A094X001
0097	GN046A	11-Aug-2022	00:32	59°00.02'N	01°59.99'W	78.7	11-Aug-2022	00:52	59°00.02'N	01°59.99'W	78.4	x	x		x			x		CTD A095X001