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The MOSES Sternfahrt Expeditions of the Research Vessels LITTORINA, LUDWIG PRANDTL and MYA II to the Elbe River, Elbe Estuary and German Bight in 2024

Edited by
Ingeborg Bussmann, Eric Achterberg, Holger Brix, Norbert Kamjunke, Björn Raupers and Tina Sanders

with contributions of the participants

HELMHOLTZ

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(Foto: Ingeborg Bussmann, AWI)

Cover: Vorbeifahrt an der schneebedeckten Insel Sylt
(Photo: Ingeborg Bussmann, AWI)

The MOSES Sternfahrt Expeditions of the Research Vessels LITTORINA, LUDWIG PRANDTL and MYA II to the Elbe River, Elbe Estuary and German Bight in 2024

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The MOSES Sternfahrt Expeditions of the Research Vessels *Littorina, Ludwig Prandtl and Mya II* to the Elbe River, Elbe Estuary and German Bight in 2024

Winter flood	January 2023
Binnen Elbe	July and September 2024
Tide Elbe	August 2024
Sternfahrt 12	September 2024
Sylt Transects	January to December 2024

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1. ÜBERBLICK UND EXPEDITIONSVERLAUF

Im Jahr 2024 wurden von der „Hydrologischen Extreme“ Gruppe des MOSES-Konsortiums mehrere Expeditionen durchgeführt, um einen Beitrag zu den im POV-4-Programm der Helmholtz-Gemeinschaft festgelegten Forschungszielen zu leisten. Im Januar 2024 startete ein neues DAM-Projekt „ElbeXtreme“. Basierend auf der seit 2017 aufgebauten MOSES-Infrastruktur zielt ElbeXtreme darauf ab, die Auswirkungen von Extremereignissen wie Sturmfluten, Hitzewellen, Überschwemmungen und Verschmutzungsereignissen auf das Küstenökosystem besser zu verstehen und das Wissen über seine Widerstandsfähigkeit gegenüber dem Klimawandel und anthropogenen Stressoren zu stärken. Durch die Zusammenarbeit mit Interessengruppen wie lokalen Gemeinden, nationalen Behörden und der Industrie zielen MOSES und ElbeXtreme darauf ab, ein umfassendes Informations- und Entscheidungshilfesystem für Politik und Bevölkerung aufzubauen, das die Wissensbasis und die Kompetenz in Bezug auf extreme Ereignisse in der Region verbessert. Ein wichtiges Element in diesem Prozess ist auch die Förderung des Dialogs zwischen Wissenschaft und Politik und die Schaffung eines gemeinsamen Verständnisses für die zukünftigen Herausforderungen im Elbästuar und in der Deutschen Bucht. ElbeXtreme macht verstärkt Gebrauch von der in MOSES aufgebauten Infrastruktur und der Erfahrung der beteiligten Wissenschaftler. Daher fanden die meisten der Fahrten im Jahr 2024 im Rahmen von ElbeXtreme statt. Diese Expeditionen umfassten die Elbe, die Tideelbe und die Deutsche Bucht in der Nordsee. Da im Jahr 2024 zwei reale Hochwasser in der Elbe auftraten, eines im Januar und ein zweites im September, waren die Fahrten im Jahr 2024 Fahrten mit realen Hochwasser-Szenarien.

Das ehrgeizige Fahrtprogramm 2024 war nur durch eine starke Kooperation zwischen den Helmholtz-Partnern und ihren Forschungsschiffen möglich. Dazu gehören das UFZ, Hereon mit der *Ludwig Prandtl*, GEOMAR mit der *Littorina* und das AWI mit der *Mya II*. Darüber hinaus leisteten die Schiffsbesatzungen unschätzbare Unterstützung und zeigten bemerkenswerte Hingabe und Engagement.

Das Jahr 2024 begann mit einem starken Hochwasser an Elbe und Weser. Ein starkes Niederschlagsereignis, das in der deutschen Presse als „Weihnachtshochwasser“ bezeichnet wurde, trat im Winter 2023/24 in verschiedenen nord- und ostdeutschen Gebieten auf und beeinflusste die Abflussmengen in mehreren Wassereinzugsgebieten, vor allem an Elbe und Weser. Am Pegel Neu-Darchau (Elbe) wurde am 04.01.2024 ein maximaler Abfluss von 2471 m^3/s bei einem mittleren Abfluss von 1860 ± 424 m^3/sec für Januar 2024 gemessen. Diese Abflussmenge ist etwa dreimal so hoch wie der mittlere Januarabfluss für die Jahre 2019-2022.

Wie in mehreren vorangegangenen Sitzungen der MOSES „Hydrological Extreme“-Gruppe besprochen, wurde unser „Hochwasserprogramm“ unter dem Label „Stern-11“ in Gang gesetzt. Die Beprobungskampagne begann am 28.12.2023 von den Elbbrücken aus, gefolgt von der Beprobung des Elbästuars mit Schiffsunterstützung der Hamburger Hafenbehörde HPA und der FRS Elbfähre Glückstadt Wischhafen GmbH und endete mit kurzfristigen anberaumten Fahrten mit den Forschungsschiffen *Mya II* (AWI) und *Littorina* (GEOMAR). Diese erste „Hochwasserfahrt“ im Jahr 2024 bot die einzigartige und im Rahmen von MOSES erste Möglichkeit, die Auswirkungen eines extremen Hochwasserereignisses während des Winters zu erforschen, einer Jahreszeit, in der der Abfluss der Flüsse normalerweise niedrig ist.

Im Laufe des Sommers wurden eine Reihe von Standard-Probenahmekampagnen und -fahrten durchgeführt. Im April 2024 fuhr das GEOMAR mit der *Littorina* und beprobte die Probenahmestellen der Januarfahrt erneut. Im Juli und September 2024 wurden zwei weitere Flussbeprobungskampagnen vom UFZ durchgeführt, um die Elbe während einer Sommerperiode mit niedrigem Abfluss (Juli; Q bei Magdeburg war 270 m^3/s) und während eines Sommerhochwassers (September; Q bei Magdeburg war 1.442 m^3/s) zu beproben. In Tesperhude, am Ende der Binnenelbe (vor dem Wehr in Geesthacht), wurde von Hereon eine neue feste Messstation eingerichtet, die ganzjährig Daten liefern wird. Um diese automatisierten Daten zu validieren und zu ergänzen, wurden von September bis Oktober 2024 in Tesperhude zusätzliche Wasserproben genommen. Das Ästuar der Elbe wurde während der jährlichen Fahrt von Hereon im August untersucht. Die Fahrt begann auf der Insel Scharhörn und endete in Hamburg mit einer Fahrt stromaufwärts gegen die Tide. Im September 2024 wurde die zweite gemeinsame Fahrt (Stern 12-2 und 12-3) von GEOMAR, HEREON und AWI durchgeführt. Während dieser Zeit beprobten die beiden Schiffe *Ludwig Prandtl* (HEREON) und *Mya II* (AWI) erneut das Gebiet von der Elbmündung bis zur Deutschen Bucht mit der Endstation Helgoland.

Insgesamt haben die Fahrten und Messungen sehr gut funktioniert und das fast fünfjährige Training und die erlangte Routine in der interinstitutionellen Zusammenarbeit im Rahmen des MOSES-Projekts hat sich als echter Gewinn für die Helmholtz-Küstenforschung erwiesen. Dieser integrative Ansatz zwischen den verschiedenen Helmholtz-Zentren, den Forschern und den Schiffsbesatzungen erwies sich erneut als herausragend in der Küstenforschung.

SUMMARY AND ITINERARY

In 2024, several expeditions were conducted by the MOSES consortium's Hydrological Extremes group in order to contribute to the research objectives outlined in the Helmholtz Association's POV-4 programme. Additionally, in January 2024 a new DAM project was launched called "ElbeXtreme". Based on the MOSES infrastructure build-up since 2017, ElbeXtreme aims to better understand the effects of extreme events such as storm surges, heatwaves, floods and pollution events on the coastal ecosystem and to strengthen the knowledge about its resilience against climate change and anthropogenic stressors. By working together with stakeholders such as local communities, national authorities and industry, MOSES and ElbeXtreme aim at building up a comprehensive information and decision support system for politics and other stakeholders enhancing the knowledgebase and competence with respect to extreme events in the the region. An important element in this process is also to promote the dialogue between science and policy, and to create a common understanding for the future challenges in the Elbe Estuary and the German Bight.

ElbeXtreme makes increased use of the infrastructure built up in MOSES and the experience of the scientists involved. Therefore, most of the cruises in 2024 took place in the context of ElbeXtreme. These expeditions included the Elbe River, the tidal Elbe, and the German Bight in the North Sea. As two flood events occurred in 2024 in the Elbe, one in January and a second in September, the 2024 cruises were real-life-scenario cruises for flood events.

The ambitious cruise programme 2024 was only possible through a strong collaborative effort between the Helmholtz partners and their research vessels. These included UFZ, Hereon with the *Ludwig Prandtl*, GEOMAR with the *Littorina* and AWI with the *Mya II*. Additionally, the ship's crews provided invaluable support, demonstrating remarkable dedication and commitment.

The year 2024 started with the strong flood in the Elbe and Weser rivers. A strong precipitation event, dubbed in the German press as the "Christmas Flood'' occurred in winter 2023/24 in various Northern and Eastern German areas affecting the runoff volume in several watersheds, most notably those of the Elbe and Weser rivers. At the gauge in Neu-Darchau (Elbe) a maximum discharge of 2471 m^3/s was measured on 04.01.2024 with an average discharge of 1860 ± 424 m^3/sec for January 2024. This discharge volume is about three times higher than the average January discharge for the years 2019-2022.

As discussed in several previous meetings of the "Hydroglogical Extremes" group of MOSES our "flood programme" was set into motion under the label "Stern-11". The sampling campaign started on 28.12.2023 from Elbe bridges, followed by sampling the estuarine Elbe with ship support from HPA, the Hamburg Port Authority and the FRS Elbfähre Glückstadt Wischhafen GmbH and ended with short notice cruises with the research vessels *Mya II* (AWI) and *Littorina* (GEOMAR). This first "flood cruise" in 2024 provided the unique and first possibility during the lifetime of MOSES to assess and explore the effects an extreme flood event during winter, a time of the year when the river discharge is normally low.

During the course of the summer, a variety of standard sampling campaings and cruises were performed. In April 2024, GEOMAR sailed with *Littorina* and re-sampled the sampling sites from the January cruise. In July and September 2024, two additional river sampling campaigns, mainly conducted by UFZ, were done to sample the Elbe River during a summer period with

low water discharge (July; Q at Magdeburg was 270 m³/s) and during a summer flood event (September; Q at Magdeburg was 1,442 m³/s). Hereon set up a new fixed monitoring station at Tesperhude, at the end of the freshwater part of the Elbe River (upstream of the weir in Geesthacht), which will contribute with year-round data sets. To validate and complement these automated data, follow-up sampling campaigns were done in Tesperhude from September to October 2024. The estuarine Elbe was investigated during the annual cruise by Hereon in August. The cruise started at Scharhörn Island and ended in Hamburg by sailing upstream against the tide. In September 2024, the second joined cruise (Stern 12-2 and 12-3) was undertaken by GEOMAR, HEREON und AWI. During this time, the two ships *Ludwig Prandtl* (HEREON) and *Mya II* (AWI) again sampled the area from the estuarine Elbe towards the German Bight with the final station Heligoland.

Overall, the cruises and measurements were conducted effectively, and the extensive training and experience gained through inter-institutional collaboration within the MOSES project proved invaluable for Helmholtz coastal science. This integrative approach joining the different Helmholtz centres, researchers and ship crews did once again demonstrate to be outstanding in the field of coastal science.

2. WINTER FLOOD

Outline

A strong precipitation event, dubbed in the German press as the “Christmas Flood“ occurred in winter 2023/24 in various Northern and Eastern German areas affecting the runoff volume in several watersheds, most notably the Elbe and Weser rivers. The winter flood 2023/24 started in the rivers Elbe and Weser. At the gauge in Neu-Darchau (Elbe) a maximum discharge of 2471 m^3/s was measured on 4.1.2024. An average discharge for January 2024 of 1860 ± 424 m^3/sec was determined, which is about three times higher than the average January discharge for the years 2019-2022. At the gauge in Intschede (Weser) a maximum discharge of 2640 m^3/s was measured on 30.12.2023 compared to an average discharge for January 2024 of 1133 ± 525 m^3/s, which is about four times higher than the average January discharges for the years 2019-2022. (Please see Fig. 2.1 and 2.2).

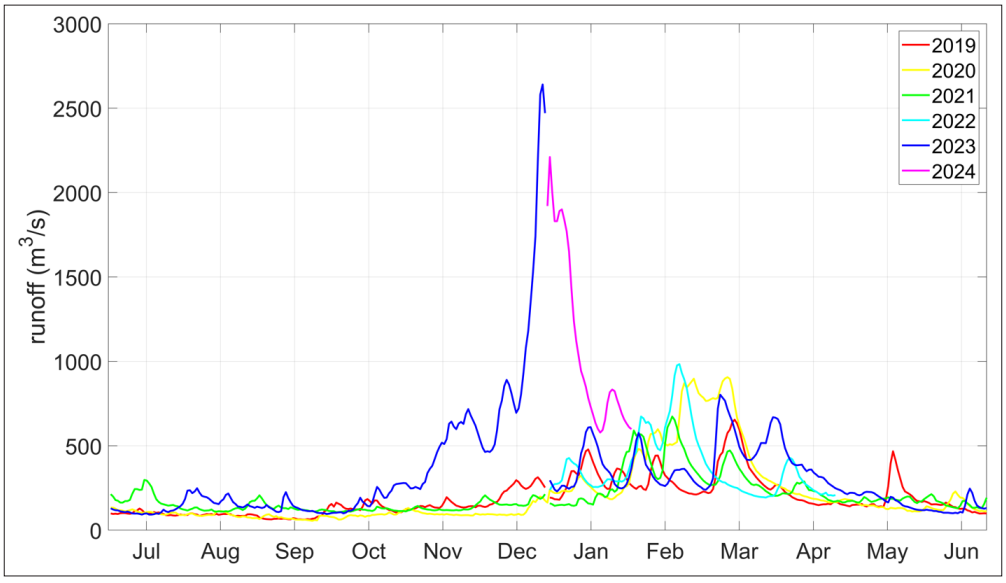

Fig. 2.1. Discharge of the River Weser at Intschede for the period 2019-2024. The flood is indicated by the blue line (end of 2023) and the pink line (beginning of 2024).

In the present study, we assessed whether the “Christmas Flood” event in winter 2023/24 agreed with the passive pipe, pulse-shunt concept of (Raymond et al. 2016)), causing a distinct increase in the export of nutrients and carbon from land to sea during the severe flood events. For that, we performed a longitudinal sampling campaign following a Lagrangian approach along the freshwater River Elbe, the Elbe estuary around Hamburg, and the German Bight. We measured salinity and water temperature, nutrient and chlorophyll concentrations after a period of heavy rain and during the peak of the flood in winter 2023/2024.

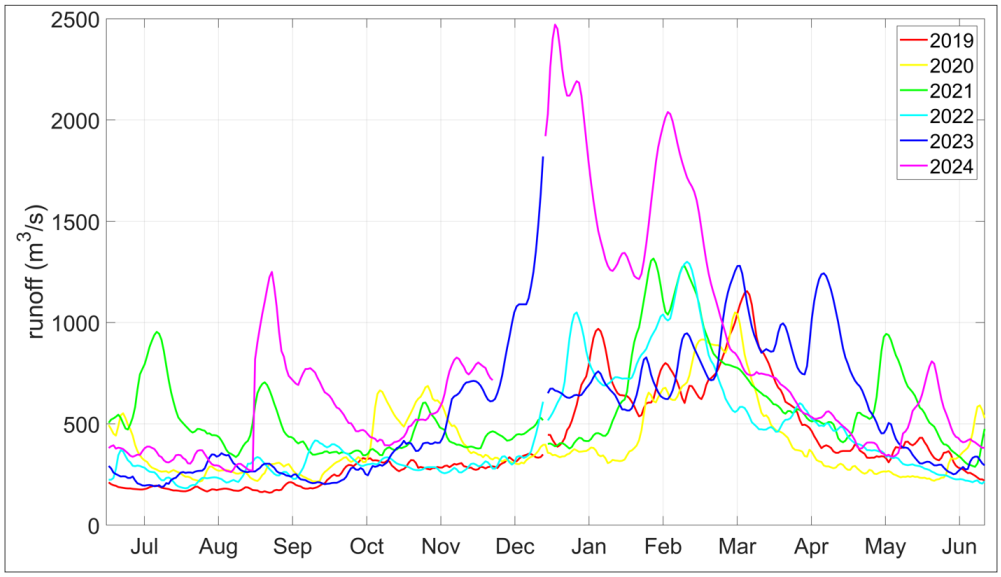

Fig. 2.2: Discharge of the River Elbe at Neu Darchau for the period 2019-2024. The flood is indicated by the blue line (end of 2023) and the pink line (beginning of 2024).

2.1 Winter flood, Binnen Elbe (28.12.2023 – 04.01.2024)

Norbert Kamjunke DE.UFZ

Work at the river

In the freshwater stretch of River Elbe, sampling was performed at eleven sites from bridges in the middle of the river. Sampling started at Bad Schandau (river km 12 according to German kilometer count) on 28 December 2023 and finished in Lauenburg (km 570) on 4 January 2024. It was performed very shortly before the highest water level at the respective sites (few cm or few hours) so that the sampling followed the flood peak on its way downstream.

Water temperature, oxygen saturation, pH, conductivity, and chlorophyll fluorescence were measured using a multiparameter probe (EXO2, YSI). Cooled water samples were transferred to the lab and analyzed the next day. Nutrient and carbon concentrations were measured according to standard protocols, Chlorophyll a concentration was measured by high performance liquid chromatography after calibration with commercial standards (Kamjunke et al. 2021, Tab. 2.1).

Tab. 2.1: Concentrations of chlorophyll a, dissolved nutrients, particulate organic carbon (POC), and total phosphorus (TP) in the freshwater River Elbe

Site	Date	River km	Latitude	Longitude	Chl-a µg L^{-1}	Si µmol L^{-1}	Phosphate µmol L^{-1}	Nitrate µmol L^{-1}	POC µmol L^{-1}	TP µmol L^{-1}
Bad Schandau	28.12.2023	12	50.9221	14.1358	3	174	1.13	316	808	13.32
Dresden	28.12.2023	54.5	51.0572	13.7544	1.79	177	1.13	317	796	9.45
Riesa	29.12.2023	107	51.3106	13.2955	3.61	177	1.23	320	673	11.77
Torgau	29.12.2023	154.5	51.5580	13.0111	3.42	178	1.29	323	711	12.42

Site	Date	River km	Latitude	Longitude	Chl-a µg L^{-1}	Si µmol L^{-1}	Phosphate µmol L^{-1}	Nitrate µmol L^{-1}	POC µmol L^{-1}	TP µmol L^{-1}
Wittenberg	30.12.2023	212	51.8577	12.6513	2.74	183	1.39	324	407	7.94
Roßlau	30.12.2023	258	51.8809	12.2393	2.45	188	1.26	313	308	7.87
Magdeburg	31.12.2023	326.5	52.1371	11.6549	1.65	183	1.58	331	207	5.52
Tangermünde	01.01.2024	388	52.5653	11.9850	1.19	186	1.58	318	158	5.39
Wittenberge	02.01.2024	455	52.9866	11.7251	0.75	202	1.74	301	131	5.06
Dömitz	03.01.2024	506	53.1428	11.2282	1.38	196	1.65	311	113	5.00
Lauenburg	04.01.2024	570.4	53.3665	10.5611	1.81	199	1.68	302	143	4.32

2.2 Winter flood, Tidal Elbe (10.01.2024 – 11.01.2024)

Götz Flöser, Stine Meißner, Leon Schmidt DE. Hereon

Work at the tidal river

Following the UFZ sampling on the riverine part of the Elbe, we wanted to follow up the flood in the port of Hamburg and the Elbe estuary. Unfortunately, both Hereon vessels were in the shipyard and not available. So we contacted the Hamburg Port Authority (HPA), and they offered the *Heinrich Hübbe* which is used for survey cruises in the port of Hamburg (Fig. 2.3). We covered six stations in the port area on 10 January.

Fig. 2.3: Getting on board of the Heinrich Hübbe for sampling on the tidal Elbe in January 2024 (by G. Flöser)

In order to have a station further downstream, we contacted the company that runs the ferries Wischhafen-Glückstadt. They allowed us to take samples from shipboard in mid-stream which we did on the following day, 11 January. Unfortunately we could only take nutrient samples (Tab. 2.2), due to a malfunctioning of the CTD we had on board.

Tab. 2.2: Station list for sampling on the tidal Elbe in January 2024, all at 1 m sampling depth.

Station	datetime (UTC)	Latitude	Longitude	NO^2 (µmol/l)	NO^3 (µmol/l)	Si (µmol/l)	PO4 (µmol/l)	remark
1	10.01.2024 08:24	53.57	9.69	2.304	276.207	86.673	1.757	Wedel
2	10.01.2024 09:02	53.55	9.80	2.346	300.084	65.051	1.858	Blankenese
3	10.01.2024 09:38	53.54	9.91	2.320	304.169	66.568	2.156	Övelgönne
4	10.01.2024 10:00	53.54	9.98	2.270	288.543	72.153	1.877	Elbphilharmonie
5	10.01.2024 10:13	53.53	10.02	2.290	269.951	83.280	1.522	Elbbrücken
6	11.01.2024 09:07	53.80	9.38	2.494	279.520	120.998	1.712	Fähre Glückstadt

2.3 Winter flood, German Bight, *Mya II* (17.01.2024 – 18.01.2024)

Ingeborg Bussmann, Philipp Fischer DE.AWI

Work at sea

As the best date for sampling the flood was still under debate, the *Mya II* came to Heligoland beforehand, picked up the fully equipped Moses-Container on January10 and returned to List, her home port. After following up the salinity development at the station in Cuxhaven, we decided to sail starting on 16 January.

Thus the scientists traveled to List and the *Mya II* started from List to Cuxhaven on 16 January, with all underway systems running, but no water sampling. Two sets of drifters were deployed at the same stations as in August 2023. First group with the drifters #311, #313, #314, #317, was deployed around 16.01.2024 14:21 UTC at approx. position 8.494E; 54.637N; the second group with the drifters #315, #320, #322 was deployed around 16.01.2024 15:07 UTC, at approx. position 8.463E; 53.972N.

On 17January, *Mya* went North, close to the shore with additional water sampling and returned to the port of Büsum.

On 18 January, we continued with our programme, but returned to the port of Heligoland. Heavy weather forced the *Mya* to stay on Heligoland, until 25 January, when she reached the mainland again in Büsum. On 29 January she finally returned to List.

Sensors on board were: pfb_awi_751801, losgatos_awi_3599, ctd_awi_1420 and the Ferrybox of the vessel itself (mya_ii:fb_741202).

Fig. 2.4: Snow covered Mya II with Moses Container in List, Sylt waiting for departure (by I. Bussmann)

Fig. 2.5: Passing the snow-covered island of Sylt (by I. Bussmann)

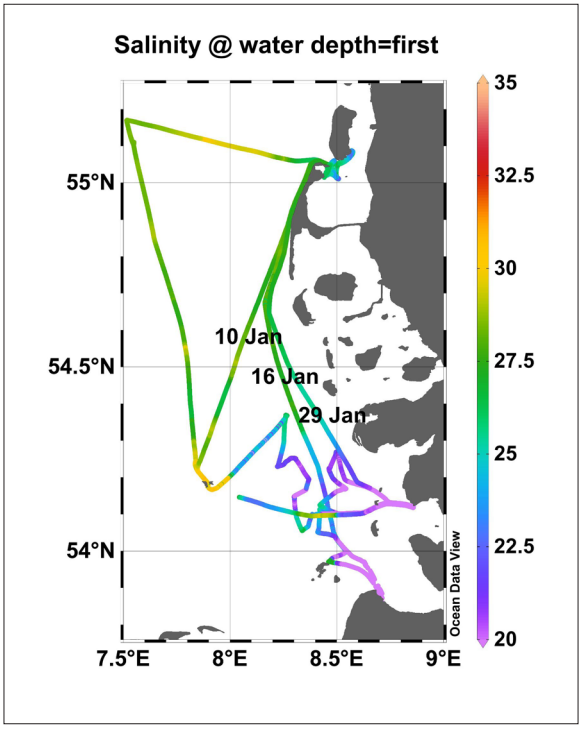

Fig. 2.6: Salinity distribution in the study area, as measured with on-board Ferrybox of Mya II

Tab. 2.3: Station list from German Bight Cruise of *Mya II*. Only surface water samples were taken and analyzed for nutrients, chlorophyll and carbon compounds. Results are published in Pangaea https://doi.pangaea.de/10.1594/PANGAEA.982247.

Station	repetition of	DateTime (UTC)	Latitude (N)	Longitude (E)
M-1	L-8	17.01.2024 08:43	53.9685	8.6310
M-2	L-7	17.01.2024 09:27	54.0370	8.4938
M-3	L-6	17.01.2024 09:57	54.0527	8.4113
M-5		17.01.2024 10:55	54.1007	8.5170
M-6	L-3	17.01.2024 12:10	54.1687	8.5411
M-7		17.01.2024 13:03	54.2251	8.4672
M-8		17.01.2024 13:34	54.269	8.4986
M-9		17.01.2024 15:20	54.1264	8.8192
M-10	L-4	18.01.2024 09:26	54.0995	8.3852
M-11	L-5	18.01.2024 09:58	54.0556	8.3368
M-12		18.01.2024 10:45	54.1458	8.3005
M-13	L-2	18.01.2024 11:29	54.1945	8.3696
M-14		18.01.2024 12:19	54.2500	8.3078
M-15		18.01.2024 13:02	54.2292	8.2235
M-16	L-1	18.01.2024 14:28	54.3679	8.2658

Data management

A combined dataset from all water samples is published in Pangaea https://doi.pangaea.de/10.1594/PANGAEA.982247. Sensor data can be found under the mission of HYDREX_2024_German_Bight_Flood at https://dashboard.awi.de/data-ingest/index.html.#

2.4 Winter Flood, German Bight, *Littorina* (25.01.2024 – 29.01.2024)

Elisa D'Agostino, Riana Braun, Lies Gärtner, Björn Raupers, Lara Schröder, Qiaoguo Tan — DE. GEOMAR

Work at sea

The Scientific cruise L24-01 was the second cruises of two that followed the Elbe flood at the beginning of 2024. For the cruise the ship *Littorina* was equipped with the MOSES container. After first mobilization the ship went from its home port in Kiel through the Nord-Ostsee-Kanal to reach the port of Heligoland as its final destination. On the way sensor data for conductivity, temperature, oxygen, salinity, nitrate, pH and methane were collected. The deployed sensors included EXO1 Multiparameter Sonde, Trios OPUS Nitrate Sensor, AquapHOx Pyroscience pH Sensor, Sunburst Sensors SAMI2-pH, CONTROS HydroC for pCO_2 measurements, and ProOceanus Mini CH4 for methane analysis. In addition to the MOSES container sensors, other instruments were operated in a 400L tank on the deck, which had a continuous supply of surface seawater. The flow rate was adjusted to keep the water residence time low, ensuring that the water inside the tank closely represented the conditions at the sampling location. After

the vessel reached the Island of Heligoland the weather got unfavourable to work with wind speeds above 6 bft and wave heights above 2 m. The ship had to be berthed in port for two days. After the weather calmed down time the crew headed out for their first trip. Sadly, most members of the crew were not able to handle the residual waves after the storm and had to deal with severe sea sickness. The captain and the cruise leader decided to leave the members that were most affected by the sea sickness on Heligoland for recovery. They all went home after they recovered. The remaining crew was not able to handle the planned scientific work for the MOSES container and the additions of discrete sampling. Hence, the cruise leader decided to leave the MOSES container on Heligoland and conducted as many discrete measurements as possible with the remaining crew members. Since most sensors from the MOSES container were also measured by the sensors listed above this decision lead to the least loss in data and the crew was still able to finish the second part of the cruise with as many stations as possible.

As expected, the collected sensor data show a large entry of fresh water for the time before the storm. This is also shown by the data from the Copernicus Marine Service (Fig. 2.7). After the storm the collected data showed values for salinity that were back to normal values.

Samples were collected for methane, dissolved inorganic carbon (DIC), total alkalinity (TA), chlorophyll, and nutrients, including phosphate, nitrate, nitrite, and silicate. Other carbonate system parameters, such as dissolved organic carbon (DOC) and particulate organic carbon (POC) (only for the first station), along with micro-pollutants, trace metals, and environmental DNA (eDNA), were also collected.

The full list of collected samples is provided in Table A.3.1.

Sensors on board were wind_furuno, exo1_geomar_0001, vessel:littorina:course_0001, co2_geomar_0319001, opus_geomar_71f9:nitrate, sami_ph_geomar_p0235

Data management

A combined dataset from all water samples is published in Pangaea https://doi.pangaea.de/10.1594/PANGAEA.982247. Sensor data can be found under the mission of HYDREX_2024_German_Bight_Flood at https://dashboard.awi.de/data-ingest/index.html# as well as at https://osis.geomar.de/app/expeditions/368913/files.

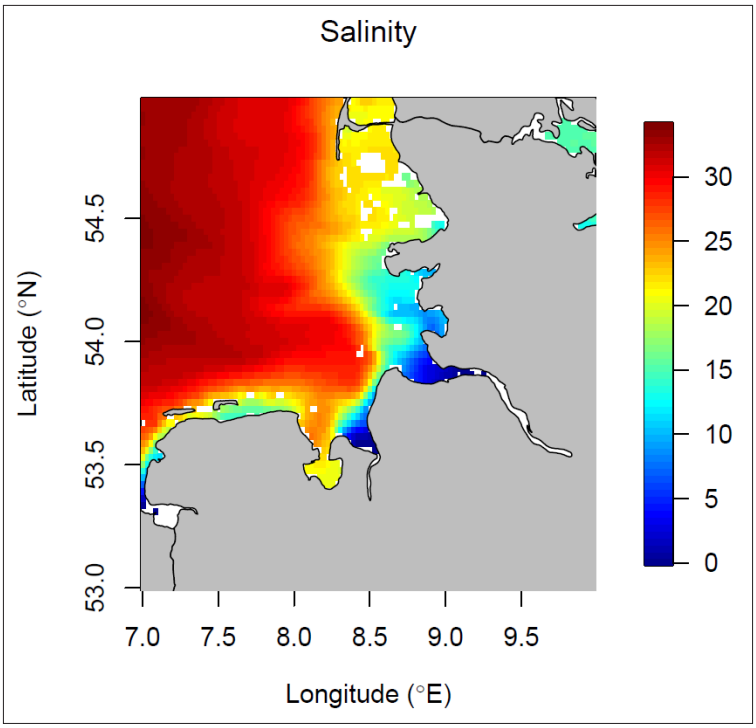

Fig. 2.7: Salinity data taken from the Copernicus Marine Service for 27 January 2024. The high amounts of freshwater intake into the North Sea from the river Elbe are easy to identify with values below 20 psu.

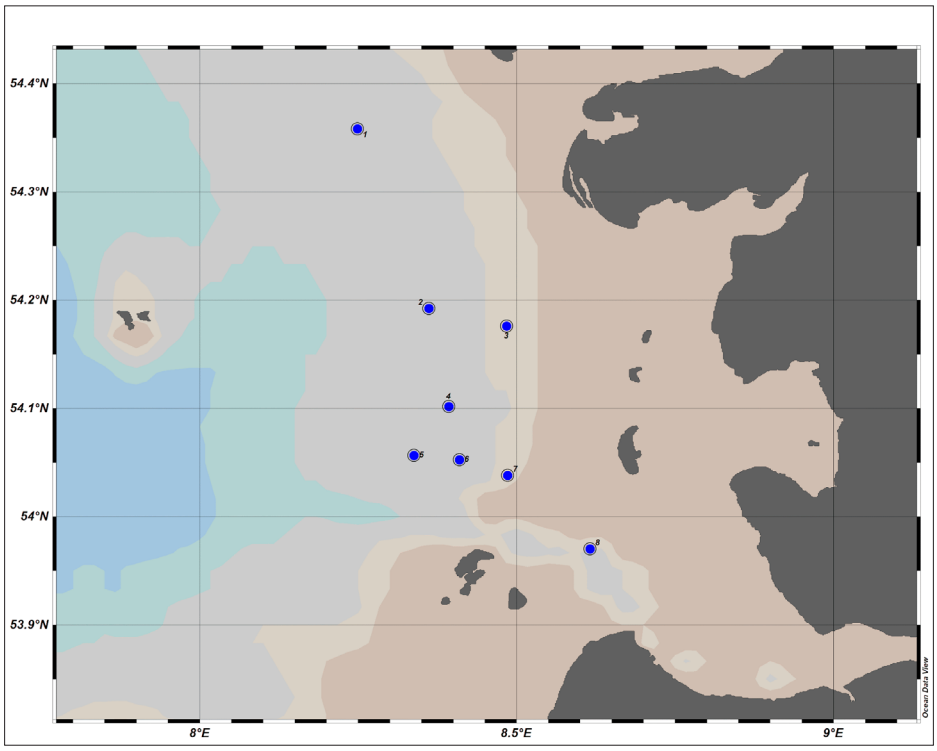

Fig. 2.8: Sampling stations of Littorina Januar cruise (L24-01)

3. SPRING CRUISE, *LITTORINA* (24.04.2024 – 30.04.2024, L24-05)

Eric Achterberg, Elisa D'Agostino, Saranya Jayachandran, Lloyd Reese, Matthias Röckendorf, Xiaohan Yin — DE.GEOMAR

Objectives

As part of the joint survey of the Elbe Estuary and the German Bight, the research vessel *Littorina* (L24-05), departed from Kiel on April 24. Six scientific crew members were on board, heading to Heligoland to begin sampling along the transect. This time, *Littorina* was not equipped with the MOSES container. However, an alternative sensor system was installed in a 400 L tank on board, with a continuous seawater flow of approximately 100 L/min to represent real-time surface water conditions at the specific location. The measurements were recorded continuously throughout the cruise. The onboard sensors included EXO1 Multiparameter Sonde (YSI) for conductivity, water temperature, depth, oxygen saturation, oxygen concentration, pressure, and salinity; OPUS and Trios sensors for nitrate; Vlux AlgaePro and Chelsea Technologies for chlorophyll-a, chlorophyll-b, and turbidity; AquapHOx Pyroscience; SAMI-pH Sunburst Sensors; AQ5 and ANB sensors for water temperature and pH; HydroC CONTROS for pCO_2; and ProOceanus for methane measurements. All sensor measurements were conducted in surface waters (~3 m depth).

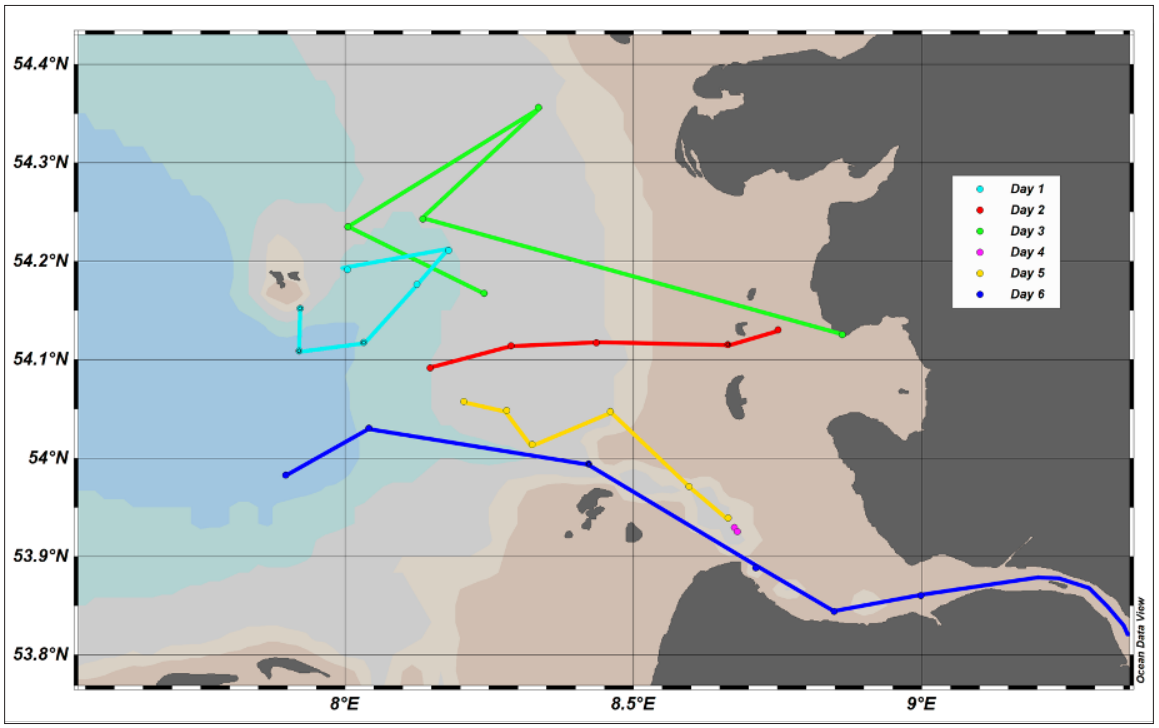

Fig. 3.1: Sampling routes from Day 1 to Day 6 for the Littorina spring cruise

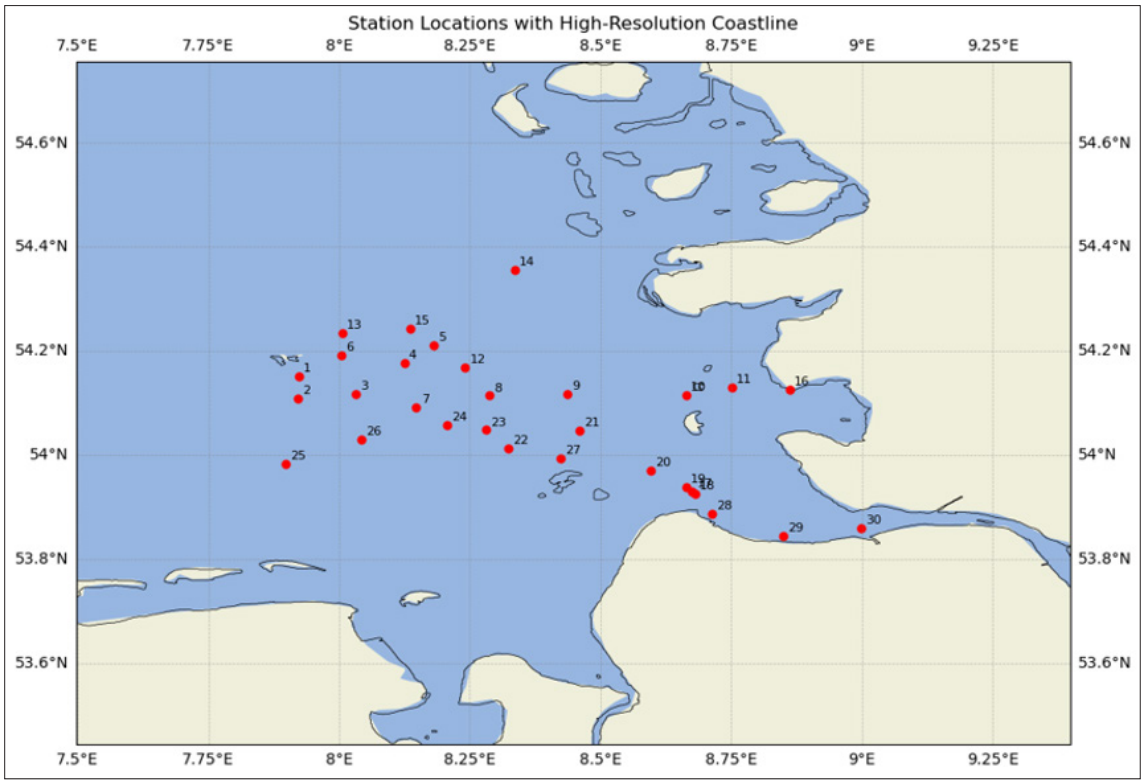

Fig. 3.2: Way points of L24-05

Work at sea

Sampling started on 25 April heading from Heligoland. Over the six-day cruise, samples were collected from 30 stations. The sampling route for each day and waypoints of stations are shown in Figure 3.1 and Figure 3.2, respectively. At most stations, samples were taken at three depths [surface (s), mid (m), and bottom (b)], or two depths (surface and bottom) where the vertical water column profile allowed. A CTD with Rosette was deployed at each station to collect water samples for nutrients (phosphate, silicate, nitrate, nitrite, ammonium), carbonate system parameters (DIC, TA, DOC, POC), dissolved methane, eDNA, plastic leachates, and pharmaceutical compounds, as listed in Table A.3.2. On 28 April (Day 4), the ship was anchored near the northern shoal of the Elbe navigational channel to the northeast of the isle of Neuwerk. For a total of twelve hours, continuous vertical Micro-Structure Shear Sonde (MSS) profiles were taken by scientist from IOW from the aft of the anchored ship to obtain a time series of vertical turbulence, salinity, and temperature throughout an M2 tidal cycle near Cuxhaven. The measurements were complemented by continuous velocity data from an ADCP deployed at the ship's side. The aim of the measurements was to observe processes of enhanced near-shoal mixing in the Elbe estuary which had previously only been simulated with numerical models. As the ship was anchored in the same position for hours, two sets of station sampling were conducted (by CTD and Go-Flo) at the same station – once during high tide and once during low tide.

Samples for trace metals and mercury (including methylmercury) were collected using pre-cleaned Go-Flo bottles. Special precautions were taken to avoid metal contamination. A specific volume of these water samples was filtered inside a laminar flow chamber and subsampled for trace metals (dissolved and particulate), mercury (dissolved and particulate), and methylmercury, as detailed in Table A.3.3.

Additionally, net sampling for microplastics was conducted at selected stations, with details provided in Table A.3.4.

Data management

A combined dataset from all water samples is submitted to Pangaea.

Sensor data can be found at L24-05: https://osis.geomar.de/app/expeditions/368410/files

4. SUMMER CAMPAIGNS

Outline

We performed our routine monitoring along the Binnen Elbe and the Tidal Elbe also in 2024 (July and August). At the end of the Binnen Elbe, in front of the weir in Geesthacht the monitoring station from Hereon is established since 2024. This station was used for additional water sampling to investigate the Elbe in front of the weir with only minor water currents / velocity.

In September 2024 strong rainfall in the Czech Republic resulted in an autumn flood along the Elbe with a discharge of 1720 m³/s in Dresden on 19.09.2024 and of 1442 m³/s in Magdeburg on 22.09.2024. Sampling was done along the Elbe following the peak of the flood and in addition also at the end of the Binnen Elbe in Tesperhude, where the flood was sampled over time (Eulerian approach).

4.1 Binnen Elbe (02.07.2024 – 10.07.2024)

Norbert Kamjunke DE.UFZ

In the freshwater stretch of River Elbe, sampling was performed at eleven sites from bridges in the middle of the river. Sampling started at Bad Schandau (river km 12 according to German kilometer count) on 28 December 2023 and finished in Lauenburg (km 570) on 4 January 2024. It was performed very shortly before the highest water level at the respective sites (few cm or few hours) so that the sampling followed the flood peak on its way downstream.

Water temperature, oxygen saturation, pH, conductivity, and chlorophyll fluorescence were measured using a multiparameter probe (EXO2, YSI). Cooled water samples were transferred to the lab and analyzed the next day. Nutrient and carbon concentrations were measured according to standard protocols, Chlorophyll *a* concentration was measured by high performance liquid chromatography after calibration with commercial standards (Kamjunke et al. 2021, Tab. 4.1).

Work at the river

A longitudinal campaign was performed during summer under conditions of low discharge (Q at Magdeburg 270 m³/s). Sampling was performed from bridges as *Albis* was not available (for sites see Chapter 1.1, Tab. 4.1).

Tab. 4.1: Sampling sites and sensor results from Elbe River sampling in July 2024 for temperature (°C), oxygen concentration (mg/L) and saturation (%), conductivity (µS/cm), pH, Turbidity (NTU) and chlorophyl-a (µg/L)

Date	Site	km	Time	Temp	O2	O2 %	Cond	pH	Turb	Chl a
02.07.2024	Bad Schandau	12.0	07:16	22.2	8.33	97.3	455	8.11	6.35	17.50
02.07.2024	Dresden	54.5	09:00	21.9	10.93	127.0	436	8.72	6.34	34.93
03.07.2024	Meißen	82.2	07:30	20.5	10.07	113.9	454	8.47	7.40	32.26

Date	Site	km	Time	Temp	O2	O2 %	Cond	pH	Turb	Chl a
03.07.2024	Riesa	107.0	08:40	20.6	11.97	135.5	450	8.88	10.31	51.46
04.07.2024	Torgau	154.5	11:45	19.6	12.41	138.1	461	8.96	6.48	51.12
05.07.2024	Wittenberg	212.0	06:30	19.1	11.91	130.3	475	9.01	11.89	63.44
05.07.2024	Roßlau	258.0	07:57	18.6	12.02	130.3	461	9.05	10.56	73.39
05.07.2024	Mulde (B184)	259.0	07:30	19.9	8.04	89.3	614	7.53	1.65	1.12
06.07.2024	Saale (mouth)	290.7	06:00	19.0	8.83	97.4	2887	7.85	8.16	6.16
06.07.2024	Magdeburg left	326.5	08:00	20.1	11.31	127.1	1433	8.63	13.20	62.84
06.07.2024	Magdeburg middle	326.5	08:10	20.1	11.6	130.1	990	8.83	15.08	71.49
06.07.2024	Magdeburg right	326.5	08:15	20.0	12.26	137.1	779	8.94	12.60	84.21
07.07.2024	Tangermünde	388.0	07:45	19.4	12.1	132.6	1168	8.67	12.80	85.20
08.07.2024	Havel (Wehr)	438.0	07:00	20.1	7.7	85.5	763	7.80	2.50	7.11
08.07.2024	Wittenberge	455.0	08:25	20.4	12.9	143.8	1080	8.57	14.50	57.80
09.07.2024	Dömitz	506.0	08:10	21.4	12.8	144.7	1057	8.67	12.40	88.20
10.07.2024	Lauenburg	570.4	09:30	22.6	14.41	167.2	1012	8.71	14.55	76.13

4.2 End of Binnen Elbe, Tesperhude Station (18.09.2024 – 09.10.2024)

Kirstin Dähnke, Irmak Gök, Louise Rewrie, Gesa Schulz, Tina Sanders — DE.Hereon

Objectives

To close the gap between the sampling of the in the freshwater Elbe in July and the sampling in the Tide-Elbe in August additional samples for Greenhouse Gases (CO2, Methan and N2O), Nutrients and SPM were taken at the Tesperhude station. This station is operated by the Helmholtz-Zentrum Hereon since 07/2023 Samples were taken from a by-pass of the Ferrybox for the GHG and by a bucket close to the station for the nutrients. The data will be available in the HCDC database (https://hcdc.hereon.de/campaign_db/#/download).

Tab. 4.2: Station list for sampling at Tesperhude from June to September 2024. Data for Salinity and temperature were taken from Ferrybox Data, discharge data are from Neu-Darchau station, x indicates sample take for later laboratory analysis.

Sample ID	Date	Time [UTC]	Salinity [PSU]	Temperature [°C]	Discharge [m^3/sec]	Nutrients	Greenhouse gases	SPM (C/N)
TE009	18.06.2024		0.41	20.00	480	X	X	X
TE012	24.06.2024		0.48	21.17	411	X	X	X
TE011	27.06.2024		0.48	24.68	413	X	X	X
TE013	02.07.2024		0.45	21.98	379	X	X	X
TE014	04.07.2024	08:40	0.47	19.64	387	X	X	X
TE015	11.07.2024	08:35	0.48	23.20	351	X	X	X
TE029	16.07.2024		0.49	22.68	347	X	X	X
TE016	18.07.2024		0.54	22.52	380	X	X	X
TE017	23.07.2024	08:32	0.46	24.22	359	X	X	X
TE018	25.07.2024	08:14	0.47	22.51	327	X	X	X
TE020	30.07.2024	07:47	0.54	22.27	334	X	X	X
TE021	01.08.2024	08:37	0.52	23.70	348	X	X	X
TE022	06.08.2024		0.51	23.11	305	X	X	X
TE023	08.08.2024	08:15	0.59	23.46	352	X	X	X
TE031	12.08.2024	11:08	0.52	22.87	350	X	X	X
TE025	13.08.2024	08:08	0.51	22.74	331	X	X	X
TE024	22.08.2024	09:40	0.58	21.32	264	X	X	X
TE002	27.08.2024	08:35	0.54	21.29	301	X	X	X
TE027	29.08.2024	08:05	0.51	23.38	284	X	X	X
TE028	03.09.2024	12:15	0.54	22.42	247	X	X	X
TE030	05.09.2024	08:40	0.57	22.99	236	X	X	X
TE032	10.09.2024	08:18	0.59	21.21	229	X	X	X
TE006	12.09.2024	09	0.56	18.40	245	X	X	X
TE007	17.09.2024	08:30	0.69	15.80	274	X	X	X
TE033	19.09.2024	09	0.58	17.20	453	X	X	X
TE034	20.09.2024	09	0.46	17.73	673	X	X	X
TE035	23.09.2024	09:15	0.24	16.90	976	X	X	X
TE036	24.09.2024	14	0.23	17.29	1040	X	X	X
TE037	25.09.2024	13	0.23	17.09	1100	X	X	X
TE038	26.09.2024	11	0.23	17.18	1170	X	X	X
TE039	27.09.2024	12	0.23	16.95	1230	X	X	X
TE040	30.09.2024		0.28	14.83	1030	X	X	X
TE041	01.10.2024		0.29	14.30	911	X	X	X
TE042	02.10.2024	11	0.31	13.96	844	X	X	X
TE043	09.10.2024	08:35	0.38	13.45	691	X	X	X

4.3 Tide Elbe (19.08.2024 – 21.08.2024)

Kirstin Dähnke, Irmak Gök, Louise Rewrie, Tina Sanders, Gesa Schulz DE.Hereon

Work at sea

The Tide-Elbe transect cruises managed by Hereon started in the North Sea near the island of Scharhörn and ended in Oortkaten, behind the port of Hamburg. The Tide-Elbe sampling continued the sampling of the river Elbe. We have used the Hereon Ferrybox in the container on the *Ludwig Prandtl*. We also installed a Picarro system coupled with an equilibrator to measure the greenhouse gases CH4, N2O and CO2 simultaneously. Traditionally, water samples have also been taken for nutrient analysis and nitrogen stable isotopes and Greenhouse Gas samples were taken to prove the online measurements by the picaro system. The data will be available in the HCDC database (https://hcdc.hereon.de/campaign_db/#/download).

Additionally, the Tide Elbe were sampled on 26 and 27 September by the Research Vessel *Heincke* during the Cruise He647. For more information see the Cruise report (Neumann et al. 2024).

Tab. 4.3: Station list of the Tidal-Elbe Cruise in August 2024

ID	Date	Time UTC	Elb-kilometer	Latitude	Longitude	Salinity [PSU]	Temperature [°C]
1270	20.08.2024	11:50	750.3	53.9780	8.3922	31.66	20.79
1271	20.08.2024	12:10	743.8	53.9689	8.4875	29.11	21.29
1272	20.08.2024	12:30	738.0	53.9566	8.5747	27.97	21.33
1273	20.08.2024	12:50	731.7	53.9270	8.6559	24.83	21.62
1274	20.08.2024	13:10	725.4	53.8807	8.7074	23.38	21.58
1275	20.08.2024	13:30	719.8	53.8416	8.7747	22.36	21.62
1276	20.08.2024	13:50	714.5	53.8379	8.8632	19.62	21.58
1277	20.08.2024	14:10	709.2	53.8444	8.9452	16.29	21.68
1278	20.08.2024	14:30	704.2	53.8558	9.0193	13.59	21.75
1279	20.08.2024	14:50	699.2	53.8731	9.0906	11.00	22.02
1280	20.08.2024	15:10	694.4	53.8767	9.1626	9.12	21.92
1281	20.08.2024	15:30	689.8	53.8741	9.2310	7.70	21.93
1282	20.08.2024	15:50	685.8	53.8587	9.2855	6.38	21.94
1283	20.08.2024	16:10	681.6	53.8369	9.3361	4.29	22.08
1284	20.08.2024	16:30	677.3	53.8064	9.3802	2.56	21.95
1285	21.08.2024	06:10	678.8	53.8169	9.3616	3.13	21.58
1286	21.08.2024	06:30	674.6	53.7809	9.3836	1.73	21.64
1287	21.08.2024	06:50	670.2	53.7433	9.4094	1.07	21.72
1288	21.08.2024	07:10	665.5	53.7169	9.4664	0.73	21.95
1289	21.08.2024	07:30	661.1	53.6833	9.4973	0.72	22.11
1290	21.08.2024	07:50	656.5	53.6442	9.5209	0.63	22.23
1291	21.08.2024	08:10	652.0	53.6129	9.5619	0.59	22.29
1292	21.08.2024	08:30	647.2	53.5834	9.6151	0.55	22.39
1293	21.08.2024	08:50	642.1	53.5660	9.6866	0.54	22.48

ID	Date	Time UTC	Elb-kilometer	Latitude	Longitude	Salinity [PSU]	Temperature [°C]
1294	21.08.2024	09:10	637.2	53.5594	9.7598	0.54	22.58
1295	21.08.2024	09:30	632.2	53.5486	9.8317	0.53	22.77
1296	21.08.2024	09:50	627.2	53.5412	9.9061	0.54	22.82
1297	21.08.2024	10:10	622.1	53.5395	9.9809	0.54	22.76
1298	21.08.2024	10:30	617.3	53.5242	10.0472	0.53	22.67
1299	21.08.2024	10:50	612.9	53.4883	10.0514	0.53	22.51
1300	21.08.2024	11:01	610.4	53.4675	10.0630	0.53	22.45

4.4 Autumn flood at the Elbe River (19.09.2024 – 26.09.2024)

Norbert Kamjunke DE.UFZ

Work at the river

Sampling was performed at eleven sites from bridges in the middle of the river and at three tributaries (Tab. 4.4). It was done very shortly before the highest water level at the respective sites (few cm or few hours) so that the sampling followed the flood peak on its way downstream. Discharge at Magdeburg was 1442 m³/s.

Tab. 4.4: Sampling sites and sensor results from Elbe River sampling in September 2024 for temperature (°C), oxygen concentration (mg/L) and saturation (%), conductivity (µS/cm), pH, Turbidity (NTU) and chlorophyl-a (µg/L). Data from the tributaries (Mulde, Saale, Havel) are in italic.

Site	km	Date	Time	Temp	O2	O2%	Cond	pH	Turb	Chl a
Bad Schandau	12	19.09.2024	09:55	16.03	8.63	88.2	294	7.76	43.8	4.07
Dresden	54.5	19.09.2024	11:25	15.97	8.57	87.4	291	7.69	47.45	4.24
Riesa	107	20.09.2024	07:30	15.67	8.7	87.7	297	7.7	35.2	3.65
Torgau	154.5	20.09.2024	08:50	15.92	8.43	85.5	296	7.55	35.11	4.06
Wittenberg	212	21.09.2024	09:00	16.4	8	81.4	305	7.52	16.5	4.1
Roßlau	258	21.09.2024	10:30	16.6	7.13	72.9	303	7.27	11.16	5.21
Mulde (B184)	259.0	21.09.2024	11:20	17.67	8.12	84.9	441.5	7.35	3.07	2.75
Saale (Calbe)	290.7	22.09.2024	07:30	16.4	8.86	91.1	3145	7.76	3.75	1.35
Magdeburg	326.5	22.09.2024	09:10	16.8	7.33	75.2	435	7.63	8.52	4.62
Tangermünde	388	23.09.2024	07:30	16.54	7.38	76.4	432	7.51	9.5	6.43
Havel (Wehr)	438	24.09.2024	07:35	18	9.1	97.7	649	7.82	3.55	19.5
Wittenberge	455	24.09.2024	08:15	17.2	6.99	73.7	453	7.53	4.55	9.57
Dömitz	506	25.09.2024	06:50	16.2	6.64	68.5	458	7.48	2.5	9.42
Lauenburg	570.4	26.09.2024	06:35	16.5	7.41	78	465	7.55	6	10.89

5. STERNFAHRT 12

Objectives

The primary objective of Stern-12 was to enhance the spatial integration of the onboard sensors. To this end, a more systematic grid was implemented, in conjunction with the repetition of the previous fixed stations for water sampling (Fig. 5.1).

The MOSES laboratory container was utilised once more, a choice that proved to be a success. The instruments and, in some cases, the filtration units had been set up in advance. Consequently, the container and associated equipment could be readily transferred between vessels.

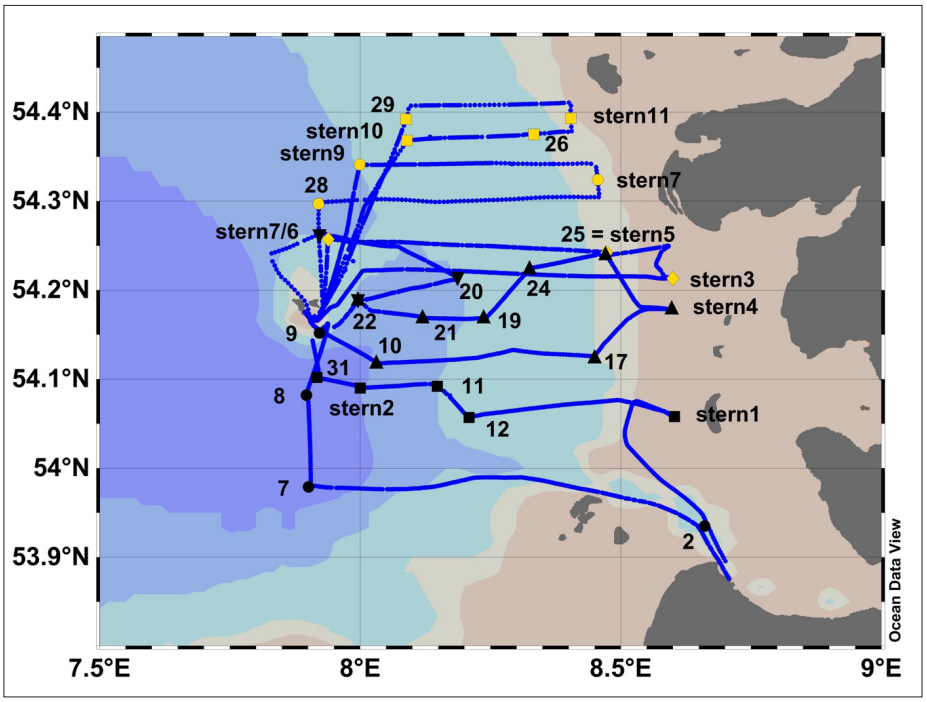

Fig. 5.1: Cruise track for Mya and Ludwig Prandtl in September 2024 for both ships. The black symbols indicate stations covered by Ludwig Prandtl; the yellow symbols indicate stations covered by Mya II.

5.1 Sternfahrt 12-2 (02.09.2024 – 05.09.2024)

Eliza d'Agostino[1], Talea Brinkmann[2], Götz Flöser[3], Saranya Jayachandran[1], Hendrik Rust[3],

[1]DE.GEOMAR
[2]DE.AWI
[3]DE.Hereon

Work at sea

Due to the unanticipated operational problems of Geomar's *Littorina* a week prior to the scheduled cruises, a modification to the original plan was necessary. *Littorina*'s primary function entailed the collection of water samples. Consequently, the personnel (Eliza and Saranya) were rescheduled on board the *Ludwig Prandtl*, and the MOSES container was taken on board and equipped with sampling devices on Monday morning, 02 September on Heligoland.

The *Ludwig Prandtl* proceeded towards Cuxhaven on the first day in order to cover some of the stations from the last MOSES cruise, and also because suspended matter samples were to be taken on that day for a new light scattering instrument, and the samples had to be filtered on land on the same day. The sea water in the container was supplied via the Ferrybox inlet, which leads through the engine room. Thus, water temperature is about 1°C warmer and oxygen concentrations are modified as well (Fig. 5.1). We plan to correct this by comparing with other sensors as best as possible.

For the remainder of the campaign, we followed the rectangular track delineated by Björn Raupers (Geomar), with a daily shift further north. On the final day of the campaign (15 September), the number of stations was reduced to three due to high winds.

Water sampling for TA and CH4 was done at the Ferrybox outlet every hour, independently from the station work.

Details on the station list, the sensors used and locations for data access can be found in Table A.3.6. Analyses of the water samples is in progress and will be published in Pangaea. Data of the underway sensors can be found at the awi.nrt data base with the mission: HYDREX_2024_German_Bight_Stern12-2. The sensor on board were: FerryBox pocket AWI 751801, LosGatos AWI 3K43 000 000 3599, SST_CTD_313_3647.

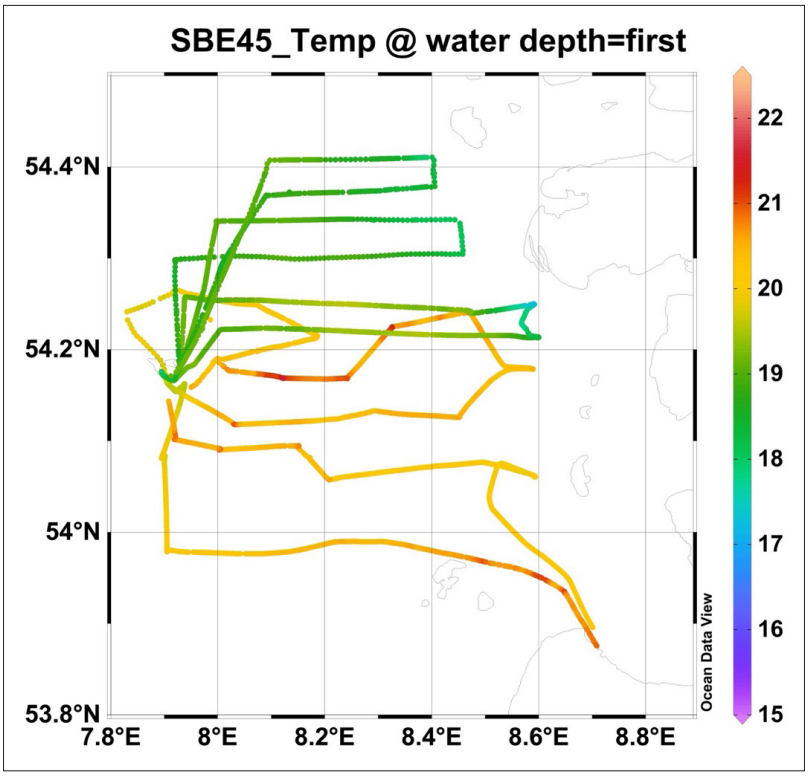

Fig. 5.1: Surface water temperature for Stern 12 in September 2024 for both ships, the temperature difference between the two ships is evident (see text).

5.2 Sternfahrt 12-3 (09.09.2024 – 13.09.2024)

Ragna Bergmann[1], Ingeborg Bussmann[2], Talea Brinkmann[1], Saranya Jayachandran[1], Eliza d'Agostino[1]

[1]DE.GEOMAR
[2]DE.AWI

Work at sea

On 09 September *Mya* arrived on Heligoland and the lab container was installed on board. As on the following day the wind was too strong, we left port on 11 September. Most of the stations had already been covered by the *Ludwig Prandtl* the week before, thus the focus of this cruise was on covering the area with a systematic zig-zag line. We returned to port in the afternoon of 13 September, the container was unloaded and the *Mya* left for Sylt on the next day. Final processing of some water samples was performed in the laboratory of the BAH on Heligoland.

On 9 September, *Mya II* arrived on Heligoland and the laboratory container was installed on board. Due to the persistence of strong winds on the 10 September, we could not leave port. As in the previous lag, the majority of the stations had already been covered by the *Ludwig Prandtl*, the focus of this cruise lag was on covering a wider area with a systematic zig-zag line. The vessel returned to port in the afternoon of 13 September, at which point the container was unloaded. *Mya II* then departed for Sylt the following day. The final processing of a number of water samples was conducted in the laboratory of the BAH on Heligoland.

Water sampling for TA and CH4 was done at the Ferrybox outlet every hour, independently from the station work.

Analyses of the water samples is in progress and will be published in Pangaea. Data of the underway sensors can be found at the awi.nrt data base with the mission: HYDREX_2024_German_Bight_Stern12-3. Details on the station list, can be found in Table A.3.7. Analyses of the water samples is in progress and will be published in Pangaea. Data of the underway sensors can be found at the awi.nrt data base with the mission: HYDREX_2024_German_Bight_Stern12-3. The sensor on board were: FerryBox pocket AWI 751801, LosGatos AWI 3K43 000 000 3599, SST_CTD_1420.

Preliminary results

One of the objectives of the Stern-12 cruise was to cover the study area with a regular cruise track and more systematic zigzagging. The final objective is to integrate the data from the single-line cruise track to achieve aerial coverage. This can easily be achieved with the ODV programme by applying weighted-average gridding. We checked whether the Stern-12 cruise track was different from those of previous cruises. We used the same area (7.5–8.5°E; 53.8–54.7°N) with a salinity range of 20–35 (Fig. 5.2). The statistics option in ODV provides the number of samples and the gridding misfits. The calculated data are shown in Table 5.1.

The root mean square (rms) is particularly useful when working with data that has both positive and negative values, as it highlights the overall magnitude of the deviations, regardless of the sign. As shown in the table, Stern-12 had the lowest RMS, indicating good areal coverage despite a low sample number. In contrast, the merged dataset from all previous cruises (2019–2023, only for the months August and September) has a high sample number but nevertheless has a high RMS. Therefore, we assume that the cruise track of Stern-12 provided good areal coverage of salinity. The estuarine area appears difficult to integrate, as the highest RMS values are observed here for Stern-12, as well as for the other cruises.

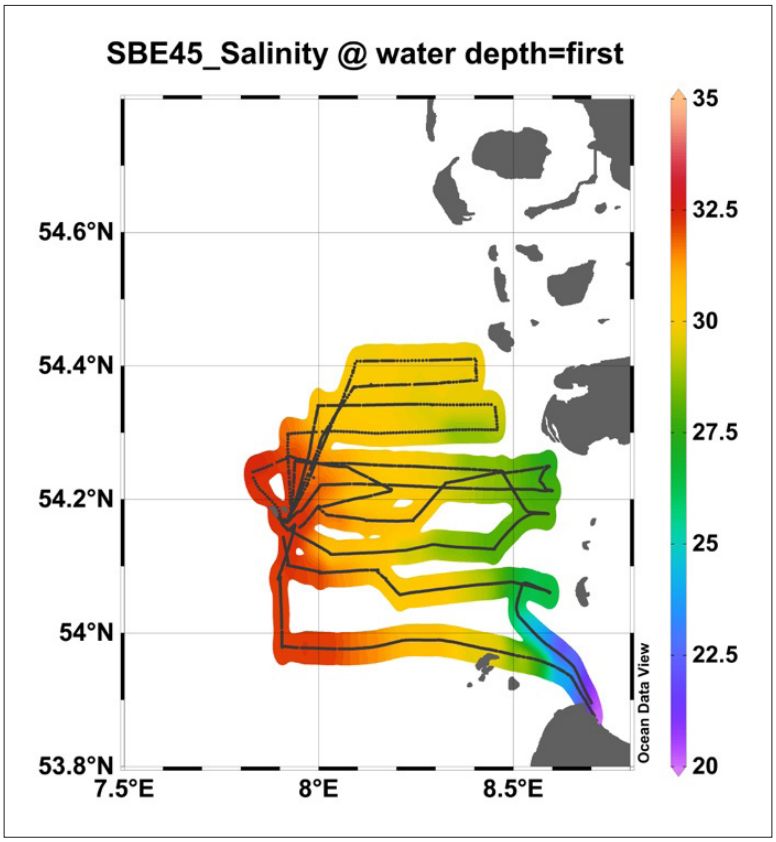

Fig. 5.2: Surface water salinity for Stern 12 in September 2024 for both ships with weighted gridding and the cruise track (in black).

Tab. 5.1: Gridding misfit information obtained by weighted-average gridding for salinity data in the area. The difference between the estimated and measured data is given, along with its mean, root mean square and number of samples.

Cruise	**Mean of estimate – data**	**Root mean square of estimate – data**	**Number of samples**
Stern-5	0.0019	0.70	4819
Stern-9	0.0009	0.47	3433
Stern-10	0.0038	0.53	4396
Stern-12	0.0123	0.35	2377
Stern 3 -10, only Aug-Sept	0.0069	1.40	13170

6. TRANSECT CRUISES WEST OFF SYLT (BUTENDIECK TRANSECTS)

Ingeborg Bussmann, Lasse Sander DE.AWI

Objectives

As a spatial extension of our main research area, the monthly cruises with *Mya II* (if possible, every first Wednesday of the month) were continued in 2024, called Butendiek-Transects. Starting from List (Sylt), these cruises headed towards about 7.5°E to the north-west while the inboard FerryBox continuously measured the basic hydrographic parameters (T, S, pH, O2, chlorophyll, pCO2). We thus hope to be able to assess the influence of the Elbe inflow to the northern German Bight. These trips took place on the following dates: 09.01., 08.02., 07.03., 03.04., 01.05., 04.06., 27.06; 12.08., 03.09., 15.10., 08.11 and 11.12.2024.

In the following figures we compare the monthly means from 2020-2023 with the year 2024, in which a strong flood in the rivers Elbe and Weser occurred in January.

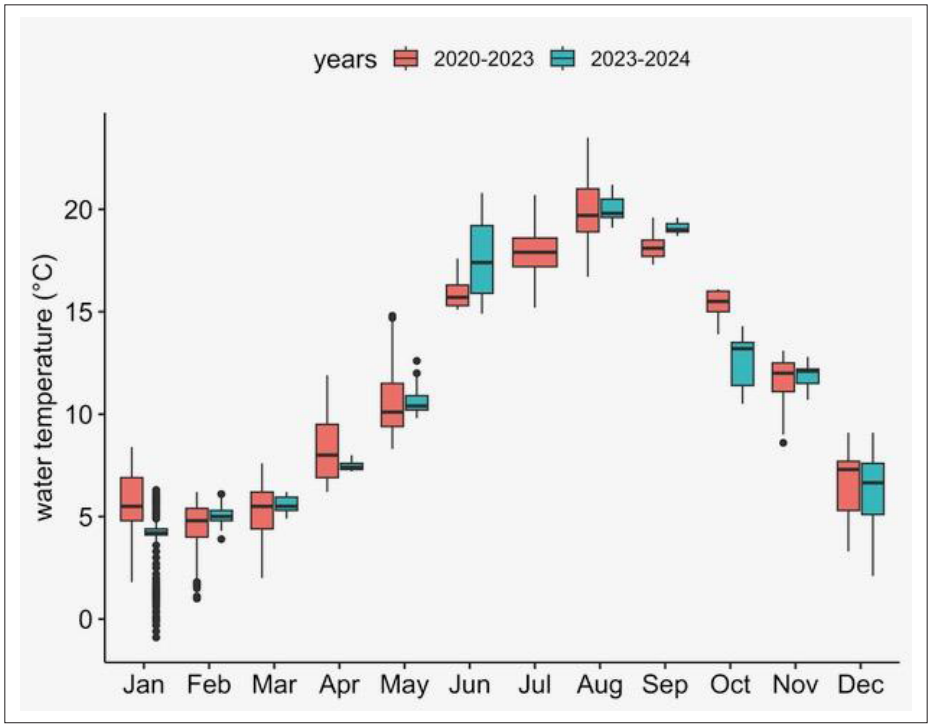

Fig. 6.1: Boxplots for water temperature for the years 2020-2023 (orange) versus the year 2024 (green) for Butendiek Transects off Sylt.

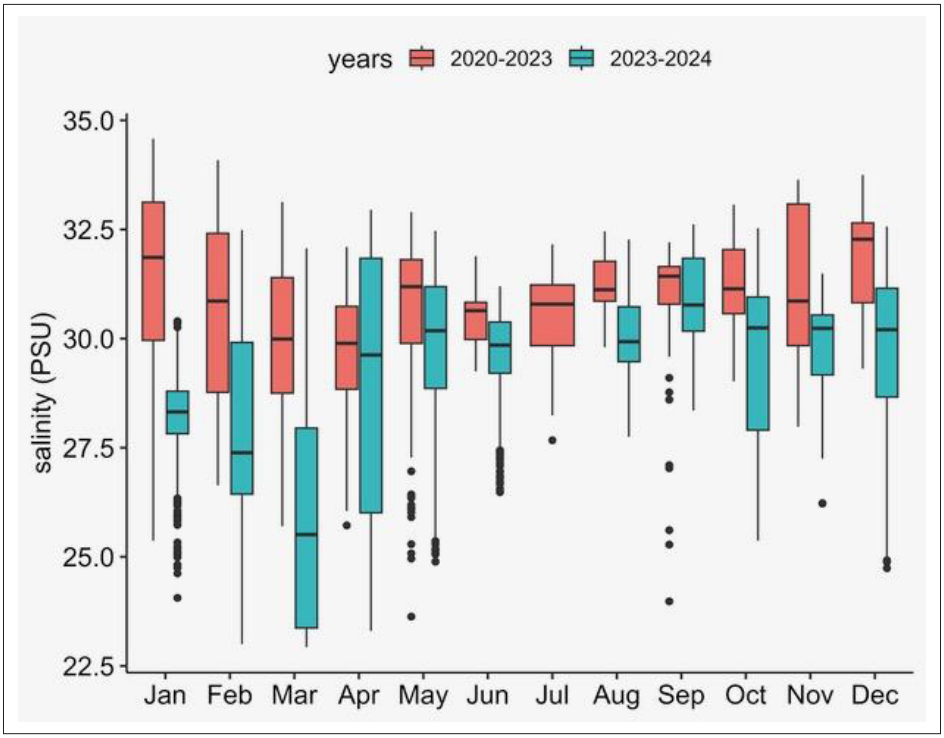

Fig. 6.2: Boxplots for salinity for the years 2020-2023 (orange) versus the year 2024 (green) for Butendiek Transects off Sylt

Preliminary results

From December 2023 to May 2024 the salinity (Fig. 6.2) was significantly lower than in previous years (2020-2023) (ANOVA df=1, F=5807, p<0.001). The lowest salinity was recorded in March with 26.0 ± 2.9 PSU compared to 30.0 ± 1.8 PSU in previous years (Welch df=790 t=33.6, p<0.001=). In April and May salinity was still lower, but the difference was only 1 PSU.

Average monthly temperatures revealed no clear pattern of differences between 2024 and previous years (Fig. 6.1). The data can be found at awi.dship.de and the respective dates.

APPENDIX

A.1 PARTICIPATING INSTITUTES AND RESEARCH VESSELS

A.2 CRUISE PARTICIPANTS

A.3 TABLES FOR STATION LISTS AND SAMPLING OPERATIONS

A.1 PARTICIPATING INSTITUTES

Tab. A.1.1: Participating institutes and their address

Institution	Address
DE.AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven Germany
DE.Geomar	Geomar Helmholtz-Zentrum für Ozeanforschung Kiel Wischhofstraße 1-3 24148 Kiel Germany
DE.Hereon	Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung Max-Planck-Str. 1 21502 Geesthacht Germany
DE.UFZ	Helmholtz Centre for Environmental Research GmbH – UFZ Brückstr. 3a 39114 Magdeburg Germany

Tab. A.1.2: Participating research vessels and campaigns

Ships	Name of Cruise/ Sampling campaign	Start Date	End Date	Name of Chief Scientist
From Bridges	Winter flood, Elbe river	28.12.2023	04.01.2024	Norbert Kamjunke
Heinrich Hübbe	Winter flood, Tidal Elbe	10.01.2024	11.01.2024	Götz Flöser
Mya II	Sternfahrt 11-1	17.01.2024	18.01.2024	Ingeborg Bussmann
Littorina	Sternfahrt 11-2	25.01.2024	29.01.2024	Björn Raupers
Littorina	L24-05	24.04.2024	30.04.2024	Eric Achterberg
From Bridges	Summer drought, Elbe river	02.07.2024	10.07.2024	Norbert Kamjunke
Ludwig Prandtl	Tide-Elbe	19.08.2024	21.08.2024	Tina Sanders
Ludwig Prandtl	Sternfahrt 12-2	02.09.2024	05.09.2024	Götz Flöser
Mya II	Sternfahrt 12-3	09.09.2024	13.09.2024	Ingeborg Bussmann
Tesperhude Station		18.09.2024	09.10.2024	Tina Sanders
From Bridges	Summer flood, Elbe river	19.09.2024	26.09.2024	Norbert Kamjunke

A.2 CRUISE PARTICIPANTS

Name / Last name	Vorname / First name	Institut / Institute	Beruf / Profession	Campaigns
Achterberg	Eric	GEOMAR	Scientist	Spring cruise
Bergmann	Ragna	AWI	Technician	Sternfahrt 12-3
Braun	Riana	GEOMAR	Student	Winter flood, German Bight II
Brinkmann	Talea	AWI	Student	Sternfahrt 12-2, Sternfahrt 12-3
Bussmann	Ingeborg	AWI	Scientist	Winter flood, German Bight I, Sternfahrt 12-3
D'Agostino	Elisa	GEOMAR	Student	Winter flood, German Bight II, Spring cruise, Sternfahrt 12-2, Sternfahrt 12-3
Dähnke	Kirstin	Hereon	Scientist	Tesperhude Station, Tidal Elbe
Fischer	Philipp	AWI	Scientist	Winter flood, German Bight I
Flöser	Götz	Hereon	Scientist	Winter flood, Tidal Elbe, Sternfahrt 12-2
Gärtner	Lies	GEOMAR	Student	Winter flood, German Bight II
Gök	Irmak	Hereon	Student	Tesperhude Station, Tidal Elbe
Jayachandran	Saranya	GEOMAR	Scientist	Spring cruise, Sternfahrt 12-2, Sternfahrt 12-3
Kamjunke	Nobert	UFZ	Scientist	Winter flood, Binnen Elbe, Summer campaign, Binnen Elbe, Autum campaign, Binnen Elbe

Name / Last name	**Vorname / First name**	**Institut / Institute**	**Beruf / Profession**	**Campaigns**
Meißner	Stine	Hereon	Student	Winter flood, Tidal Elbe
Raupers	Björn	GEOMAR	Scientist	Winter flood, German Bight II
Reese,	Lloyd	GEOMAR	Student	Spring cruise
Rewrie	Louise	Hereon	Scientist	Tesperhude Station, Tidal Elbe
Röckendorf	Matthias	GEOMAR	Student	Spring cruise
Rust	Hendrik	Hereon	Technician	Sternfahrt 12-2
Sanders	Tina	Hereon	Scientist	Tesperhude Station, Tidal Elbe

A.3 TABLES FOR STATION LISTS AND SAMPLING OPERATIONS

Tab. A.3.1: Station list of *Littorina* cruise in January 2024

Station ID	Device	Start time	Latitude	Longitude	Total Water depth (m)	Parameters
L-1	CTD	28.01.2024 7:07	54.3582	8.2486	Not recorded	Temperature, Salinity, Density
	Niskin water samplers	28.01.2024 7:07	54.3582	8.2486		CH4, DIC, TA, Chl-a, Nutrients, DOC, Micro pollutants, eDNA, Salinity,
	GoFLO	28.01.2024 7:07	54.3582	8.2486		Trace metals, Mercury and MeHg
L-2	CTD	29.01.2024 9:57	54.1923	8.3614	14	Temperature, Salinity, Density
	Niskin water samplers	29.01.2024 9:57	54.1923	8.3614		CH4, DIC, TA, Chl-a, Nutrients, DOC, Micro pollutants, eDNA, Salinity,
	GoFLO	29.01.2024 9:57	54.1923	8.3614		Trace metals, Mercury and MeHg
L-3	CTD	29.01.2024 10:30	54.1761	8.4839	11.5	Temperature, Salinity, Density
	Niskin water samplers	29.01.2024 10:30	54.1761	8.4839		CH4, DIC, TA, Chl-a, Nutrients, DOC, Micro pollutants, eDNA, Salinity,
	GoFLO	29.012024 10:30	54.176117	8.483883		Trace metals, Mercury and MeHg
L-4	CTD	29.01.2024 11:14	54.101717	8.392917	17	Temperature, Salinity, Density

Station ID	Device	Start time	Latitude	Longitude	Total Water depth (m)	Parameters
	Niskin water samplers	29.01.2024 11:14	54.101717	8.392917		CH4, DIC, TA, Chl-a, Nutrients, DOC, Micro pollutants, eDNA, Salinity,
	GoFLO	29.01.2024 11:14	54.101717	8.392917		Trace metals, Mercury and MeHg
L-5	CTD	29.01.2024 11:44	54.056583	8.337800	17	Temperature, Salinity, Density
	Niskin water samplers	29.01.2024 11:44	54.056583	8.337800		CH4, DIC, TA, Chl-a, Nutrients, DOC, Micro pollutants, eDNA, Salinity,
	GoFLO	29.01.2024 11:44	54.056583	8.337800		Trace metals, Mercury and MeHg
L-6	CTD	29.01.2024 12:04	54.052600	8.409350	17	Temperature, Salinity, Density
	Niskin water samplers	29.01.2024 12:04	54.052600	8.409350		CH4, DIC, TA, Chl-a, Nutrients, DOC, Micro pollutants, eDNA, Salinity,
	GoFLO	29.01.2024 12:04	54.052600	8.409350		Trace metals, Mercury and MeHg
L-7	CTD	29.01.2024 12:26	54.038200	8.485733	10	Temperature, Salinity, Density
	Niskin water samplers	29.01.2024 12:26	54.038200	8.485733		CH4, DIC, TA, Chl-a, Nutrients, DOC, Micro pollutants, eDNA, Salinity,

Station ID	Device	Start time	Latitude	Longitude	Total Water depth (m)	Parameters
	GoFLO	29.01.2024 12:26	54.038200	8.485733		Trace metals, Mercury and MeHg
L-8	CTD	29.01.2024 13:01	53.970533	8.615833	15	Temperature, Salinity, Density
	Niskin water samplers	29.01.2024 13:01	53.970533	8.615833		CH4, DIC, TA, Chl-a, Nutrients, DOC, Micro pollutants, eDNA, Salinity,
	GoFLO	29.01.2024 13:01	53.970533	8.615833		Trace metals, Mercury and MeHg

Tab. A.3.2: Details of CTD rosette operations from the *Littorina* spring cruise L24-05. Different CTD casts are also included. The abbreviations (s, n, and b) indicate surface, mid, and bottom water layers, respectively, for the collected parameters

Station	CTD Cast	Depth (m)	Datetime (UTC)	Latitude	Longitude	Parameters
1	1	total: 49	2024-04-25 05:56	54.1517	7.9229	Nutrients, DOC, DIC/TA (s and m), CH4 (s), Munitions/ Pharmaceuticals (s and b), Microplastics
		47				
		22				
		2				
	2	total: 49	2024-04-25 06:57	54.15194	54.15194	Chlorophyll (s), POC, eDNA
		47				
		22				
		2				
2	1	total: 37	2024-04-25 07:23	54.1086	7.9206	Nutrients, DOC, POC (s), DIC/TA (s and m), CH4 (s), Munitions/ Pharmaceuticals (s and b), Microplastics, Chl (s),
		35				
		20				
		2				
3	1	total: 25	2024-04-25 08:27	54.1172	8.0326	

Station	CTD Cast	Depth (m)	Datetime (UTC)	Latitude	Longitude	Parameters
		23				Nutrients, DOC, POC(s), DIC/TA (s and m), CH4 (s), Munitions/ Pharmaceuticals (s and b), Microplastics, Chl(s)
		13				
		2				
	2	total: 25	2024-04-25 09:17	54.12157	54.12157	eDNA
		23				
		13				
		2				
4	1	total: 23	2024-04-25 10:48	54.1761	8.1248	Nutrients, DOC, POC (s), DIC/TA (s and m), CH4 (s), Munitions/ Pharmaceuticals (s and b), Microplastics, Chl (s),
		21				
		11				
		2				
5	1	total: 18	2024-04-25 12:17	54.2109	8.1804	Nutrients, DOC, POC (s), DIC/TA (s and m), CH4 (s), Munitions/ Pharmaceuticals (s and b), Microplastics, Chl (s),
		16				

Station	CTD Cast	Depth (m)	Datetime (UTC)	Latitude	Longitude	Parameters
		9				
		2				
	2	total: 16	2024-04-25 12:51	54.21592	54.21592	eDNA (s and b)
		14				
		8				
		2				
6	1	total: 14	2024-04-25 14:52	54.1913	8.0049	Nutrients, DOC, POC (s) DIC/TA (s and m), CH4 (s), Munitions/ Pharmaceuticals (s and b), Microplastics, Chl (s),
		12				
		7				
		2				
	2	total: 15	2024-04-25 15:24	5411.7920	759.4743	eDNA
		13				
		2				
7	1	total: 17	2024-04-26 06:23	54.0914	8.1478	

Station	CTD Cast	Depth (m)	Datetime (UTC)	Latitude	Longitude	Parameters
		15				Nutrients, DOC, POC (s), DIC/TA (s and m), CH4 (s), Munitions/ Pharmaceuticals (s and b), Microplastics, Chl (s),
		7				
		2				
	2	total: 17	2024-04-26 07:01	54.09398	54.09398	
		15				
		2				eDNA
8	1	total: 14	2024-04-26 07:38	54.114	8.2884	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eDNA
		12				
		2				
9	1	total: 8	2024-04-26 08:37	54.1168	8.4359	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eDNA
		6				
		2				

Station	CTD Cast	Depth (m)	Datetime (UTC)	Latitude	Longitude	Parameters
10	1	total: 8	2024-04-26 10:09	54.1149	8.6643	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eDNA
		6				
		2				
11	1	total: 16	2024-04-26 11:52	54.1301	8.7513	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eDNA
		12				
		2				
12	1	total: 16	2024-04-27 05:48	54.1674	8.2413	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eNDA
		13				
		2				
13	1	total: 15	2024-04-27 06:45	54.2347	8.0053	

Station	CTD Cast	Depth (m)	Datetime (UTC)	Latitude	Longitude	Parameters
		14				Nutrients, DOC, POC (s), DIC/TA (s and m), CH4 (s), Munitions/ Pharmaceuticals (s and b), Microplastics, Chl (s),
		9				
		2				
	2	total: 15	2024-04-27 07:25	54.23318	54.23318	eDNA (s and b)
		14				
		9				
		2				
14	1	total: 7	2024-04-27 09:41	54.3559	8.3355	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl,
		6				
		2				
15	1	total: 8	2024-04-27 10:39	54.2427	8.1351	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl,
		6				
		2				

Station	CTD Cast	Depth (m)	Datetime (UTC)	Latitude	Longitude	Parameters
16	1	total: 13	2024-04-27 11:27	54.1253	8.8625	Nutrients, DOC, POC (s), DIC/TA (s and m), CH4 (s), Munitions/ Pharmaceutical (s and b), Microplastics, Chl,
		12				
		7				
		2				
	2	total: 13	2024-04-27 12:11	54.22923	54.22923	eDNA
		12				
		7				
		2				
17	1	total:	2024-04-28	53.9294	8.6756	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eDNA
		5.5				
		2				
18	1	Total:	2024-04-28	53.9252	8.6805	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eDNA
		8.5				

Station	CTD Cast	Depth (m)	Datetime (UTC)	Latitude	Longitude	Parameters
		2				
19	1	total: 11	2024-04-29 07:40	53.939	8.6645	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eDNA
		9				
		2				
20	1	total: 9	2024-04-29 08:15	53.9709	8.5968	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl.
		7				
		2				
21	1	total: 9.5	2024-04-29 09:21	54.0471	8.4603	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eDNA
		8				
		2				

Station	CTD Cast	Depth (m)	Datetime (UTC)	Latitude	Longitude	Parameters
22	1	total: 10	2024-04-29 10:24	54.0136	8.3245	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eDNA
		8				
		2				
23	1	total: 13	2024-04-29 10:50	54.0481	8.2808	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eDNA
		11				
		2				
24	1	total: 17	2024-04-29 11:58	54.0571	8.2066	Nutrients, DOC, POC (s), Munitions/ Pharmaceuticals (s and b), Microplastics, Chl (s),
		15				
		8				
		2				
	2	total: 17	2024-04-29 12:36	54.05817	54.05817	DIC/TA (s and m), CH4 (s), eDNA
		15				

Station	CTD Cast	Depth (m)	Datetime (UTC)	Latitude	Longitude	Parameters
		8				
		2				
25	1	total: 32	2024-04-30 05:59	53.9825	7.898	Nutrients, DOC, POC(s), DIC/TA (s and m), CH4 (s), Munitions/ Pharmaceuticals (s and b), Microplastics, Chl(s)
		30				
		16				
		2				
	2	total: 32	2024-04-30 06:22	53.98276	53.98276	eDNA
		30				
		2				
26	1	total: 25	2024-04-30 07:11	54.0303	8.0421	eDNA
		23				
		2				
	2	total: 25	2024-04-30 07:25	54.03138	54.03138	Nutrients, DOC, POC(s), DIC/TA (s and m), CH4 (s), Munitions/ Pharmaceuticals (s and b), Microplastics, Chl(s)
		23				

Station	CTD Cast	Depth (m)	Datetime (UTC)	Latitude	Longitude	Parameters
		13				
		2				
27	1	total: 9	2024-04-30 09:50	53.994	8.4225	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eNDA
		7				
		2				
28	1	total: 12	2024-04-30 11:28	53.8882	8.7128	Nutrients, DOC , POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eNDA
		10				
		2				
29	1	total: 9	2024-04-30 12:13	53.8442	8.8486	Nutrients, DOC, POC (s), DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eNDA
		7				
		2				

Station	CTD Cast	Depth (m)	Datetime (UTC)	Latitude	Longitude	Parameters
30	1	total: 11	2024-04-30 13:28	53.8604	8.9987	Nutrients, DOC, POC (s) DIC/TA, CH4 (s), Munitions/ Pharmaceutical, Microplastics, Chl, eNDA

Tab. A.3.3: Details of Go-Flo operations from *Littorina* spring cruise L24-05. The analyzed parameters include trace metals (TM), total mercury (THg), methylmercury (MeHg), particulate trace metals (particulate TM), and particulate mercury (particulate Hg). Particulate TM is obtained by filtering 150–250 mL of water samples through 0.45 µm PES filters, while particulate Hg is obtained by filtering 200–300 mL of water samples through QF filters.

Station	Depth (m)	Date	Time	Latitude	Longitude	TM, THg, MeHg	Paticulate TM and Hg
1	total: 49	2024-04-25	06:24	54.15171	7.92292		
	47					x	x
	22					x	x
	2					x	x
2	total: 37	2024-04-25	07:40	54.10857	7.92055		
	35					x	x
	20					x	x
	2					x	x
3	total: 25	2024-04-25	08:37	54.11724	8.03261		
	23					x	x
	13					x	x
	2					x	x
4	total: 23	2024-04-25	11:46	54.17613	8.12481		
	21					x	x
	11					x	x
	2					x	x
5	total: 18	2024-04-25	14:04	54.21205	8.1926		
	16					x	x
	9					x	x
	2					x	x
6	total: 14	2024-04-25	15:00	54.19129	8.00492		
	12					x	x

Station	Depth (m)	Date	Time	Latitude	Longitude	TM, THg, MeHg	Paticulate TM and Hg
	7					x	x
	2					x	x
7	total: 17	2024-04-26	06:30	54.09141	8.14776		
	15					x	x
	7					x	x
	2					x	x
8	total: 14	2024-04-26	07:45	54.11404	8.28836		
	12					x	x
	6					x	x
	2					x	x
9	total: 8	2024-04-26	09:07	54.11683	8.43594		
	6					x	x
	2					x	x
10	total: 8	2024-04-26	11:15	54.10915	8.64506		
	6					x	x
	2					x	x
11	total: 16	2024-04-26	12:00	54.13008	8.7513		
	12					x	x
	2					x	x
12	total: 16	2024-04-27	06:00	54.16744	8.24134		
	13					x	x
	2					x	x
13	total: 15	2024-04-27	07:00	54.23472	8.00532		
	14					x	x
	9					x	x

Station	Depth (m)	Date	Time	Latitude	Longitude	TM, THg, MeHg	Paticulate TM and Hg
	2					x	x
14	total: 7	2024-04-27	09:50	54.35592	8.33554		
	6					x	x
	2					x	x
15	total: 8	2024-04-27	10:45	54.24274	8.13507		
	6					x	x
	2					x	x
16	total: 13	2024-04-27	11:35	54.12535	8.86249		
	12					x	x
	7					x	x
	2						
17	Total:	2024-04-28	08:50	53.9294	8.6756		
	5.5					x	x
	2					x	x
18	Total	2024-04-28	13:50	53.9252	8.6805		
	8.5					x	x
	2					x	x
19	total: 11	2024-04-29	07:45	53.93896	8.66446		
	9					x	x
	2					x	x
20	total: 11	2024-04-29	08:05	53.97093	8.59682		
	9					x	x
	2					x	x
21	total: 9.5	2024-04-29	09:27	54.04705	8.46032		
	8					x	x

Station	Depth (m)	Date	Time	Latitude	Longitude	TM, THg, MeHg	Paticulate TM and Hg
	2					x	x
22	total: 10	2024-04-29	10:15	54.01364	8.32447		
	8					x	x
	2					x	x
23	total: 13	2024-04-29	10:56	54.0481	8.28081		
	11					x	x
	2					x	x
24	total: 17	2024-04-29	12:05	54.05712	8.20659		
	15					x	x
	8					x	x
	2					x	x
25	total: 32	2024-04-30	06:08	53.98247	7.89799		
	30					x	x
	16					x	x
	2					x	x
26	total: 25	2024-04-30	07:18	54.0303	8.04206		
	23					x	x
	13					x	x
	2					x	x
27	total: 9	2024-04-30	09:57	53.99404	8.42271		
	7					x	x
	2					x	x
28	total: 12	2024-04-30	11:35	53.88819	8.71283		
	10					x	x
	2					x	x

Station	Depth (m)	Date	Time	Latitude	Longitude	TM, THg, MeHg	Paticulate TM and Hg
29	total: 9	2024-04-30	12:19	53.84422	8.84862		
	7					x	x
	2					x	x
30	total: 11	2024-04-30	13:35	53.86041	8.99867		
	9					x	x
	2					x	x

Tab. A.3.4: Details of net sampling for microplastics from *Littorina* spring cruise L24-05

Station	Net Cast no.	Date	Time START (UTC)	Latitude	Longitude	Time STOP (UTC)	Latitude	Longitude
5	1	2024-04-25	~13:00	54.217188	8.189308	13:16	54.21927	8.175728
	2	2024-04-25	13:21	54.220008	8.171855	13:26	54.212542	8.185578
	3	2024-04-25	13:45	54.224662	8.192567	14:00	54.210135	8.195427
10	1	2024-04-26	10:18	54.114752	8.662398	10:31	54.109868	8.65184
	2	2024-04-26	10:49	54.10887	8.642285	10:55	54.10795	8.637977
	3	2024-04-26	11:08	54.108902	8.637253	11:12	54.10896	8.641963
13	1	2024-04-27	07:31	54.23258	7.998062	07:45	54.237127	8.007828
	2	2024-04-27	07:54	54.240602	8.016153	08:09	54.246147	8.030538
	3	2024-04-27	08:14	54.247627	8.035125	08:30	54.252613	8.052205
16	1	2024-04-27	11:41	54.22244	8.33121	11:45	54.223902	8.33727
	2	2024-04-27	11:50	54.225657	8.338497	11:56	54.222437	8.33632
	3	2024-04-27	12:00	54.223383	8.340285	12:07	54.227475	8.342323

Station	Net Cast no.	Date	Time START (UTC)	Latitude	Longitude	Time STOP (UTC)	Latitude	Longitude
20	1	2024-04-29	08:22	53.97161	8.593923	08:28	53.973187	8.594973
	2	2024-04-29	08:33	53.976928	8.585995	08:38	53.9805	8.57769
	3	2024-04-29	08:45	53.984885	8.568257	08:50	53.9887	8.561373
24	1	2024-04-29	11:19	54.056275	8.229815	11:22	54.056472	8.227182
	2	2024-04-29	11:30	54.057127	8.22076	11:34	54.057165	8.218013
	3	2024-04-29	11:39	54.057063	8.230303	11:49	54.057258	8.20612
26	1	2024-04-30	07:32	54.031152	8.031912	07:42	54.034003	8.036667
	2	2024-04-30	07:48	54.035113	8.038822	07:53	54.036067	8.040587
	3	2024-04-30	08:02	54.037773	8.044513	08:05	54.03842	8.046068
29	1	2024-04-30	12:24	53.84423	8.83958	12:39	53.845278	8.863257
	2	2024-04-30	12:41	53.845453	8.867455	12:56	53.847585	8.893443
	3	2024-04-30	12:59	53.84804	8.897302	13:13	53.85088	8.925458

Tab. A.3.5: Station list for Stern 12-1 with *Ludwig Prandtl.* For POC and Chl the amount of filtered water (ml) is indicated. TM and Hg includes dissolved and particulate material; MeHg only dissolved material. Datetime is UTC time from the start of CTD cast.

Date-time	Latitude	Longitude	Station	eDNA	TA/ DIC	CH4	Nutrients	DOC	POC	Chl	TM	Hg	MeHg	Pharma ceutical	Plastic
02.09.24 09:04	54.152	7.922	9	x (partial)			x	x	1000	1000	250	250	x	x	x
02.09.24 09:48	54.082	7.897	8	-			x	x	1000	1000	250	250	x	x	x
02.09.24 10:53	53.979	7.901	7	x			x	x	1500	1500	250	250	x	x	x
02.09.24 14:26	53.935	8.661	2	x			x	x	1000	1000	500	500	x	x	x
03.09.24 07:46	54.058	8.603	stern1	x	P-7	P-7	x	x	1000	1000	270	250	x	x	x
03.09.24 09:34	54.057	8.209	12	x	P-8	P-8	x	x	1000	1000	300	350	x	x	x
03.09.24 10:01	54.092	8.148	11	x	P-10		x	x	1000	1000	400	400	x	x	
03.09.24 10:46	54.090	8.000	stern2	x	P-11	P-10	x	x	1000	1000	500	500	x	x	x
03.09.24 11:16	54.102	7.917	31	x	P-2		x	x	1000	1000	450	500	x	x	x

Date-time	Latitude	Longitude	Station	eDNA	TA/ DIC	CH4	Nutrients	DOC	POC	Chl	TM	Hg	MeHg	Pharma ceutical	Plastic
04.09.24 06:49	54.118	8.031	10	x	P-13		x	x	1000	1000	500	490	x	x	x
04.09.24 08:23	54.124	8.450	17	x	P-14		x	x	1000	1000			x	x	x
04.09.24 09:02	54.179	8.598	stern4	x	P-15		x	x	500	500	300	300	x	x	x
04.09.24 09:50	54.240	8.471	25	x	P-16		x	x	500	500	300	300	x	x	x
04.09.24 10:33	54.224	8.325	24	x	P-17		x	x	500	500	450	450	x	x	x
04.09.24 11:09	54.169	8.237	19	x	P-18	P-17	x	x	500	500			x	x	x
04.09.24 11:45	54.169	8.120	21	x	P-19		x	x	500	500	350	350	x	x	x
04.09.24 12:26	54.189	7.996	22	x	P-20	P-22	x	x	500	500	400	400	x	x	x
04.09.24 13:02			Tiefe Rinne												
05.09.24 06:08	54.262	7.922	stern7	x	P-21		x	x	1000	1000	550	450	x	x	x

Date-time	Latitude	Longitude	Station	eDNA	TA/ DIC	CH4	Nutrients	DOC	POC	Chl	TM	Hg	MeHg	Pharma ceutical	Plastic
05.09.24 07:29	54.189	7.996	22	x	P-24		x	x	1000	1000	450	450	x	x	
05.09.24 08:24	54.214	8.187	20	x	P-22		x	x	1000	1000	450	450	x	x	x

Tab. A.3.6: Station list for Stern 12-2 with *Mya*. For POC and Chl the amount of filtered water (ml) is indicated.™ and Hg includes dissolved and particulate material; MeHg only dissolved material. Datetime is UTC time from the start of CTD cast. N.s. means no sample was taken.

Date-time	Latitude	Longitude	Station	eDNA	TA/ DIC	CH4	Nutrients	DOC	POC	Chl	TM	Hg	MeHg	Pharma ceutical	Plastic
09.11.24 09:24	54.213	8.600	Stern 3	x	x	x	x	x	300	300	200	200	x	x	
09.11.24 10:34	54.242	8.473	Stern 5	x	x	x	x	x	350	350	250	250	x	x	
09.11.24 13:12	54.257	7.939	Stern 6	x	x	x	x	x	850	850	n.s	n.s		x	
09.12.24 06:59	54.297	7.920	28	x	x	x	x	x	1000	1000	500	500	x	x	
09.12.24 09:30	54.324	8.456	Stern 7	x	x	x	x	x	500	500	400	250	x	x	x
09.12.24 11:35	54.341	7.999	Stern 9	x	x	x	x	x	1000	1000	250	250	x	x	x
13.09.24 07:47	54.368	8.090	Stern 10	x	x	x	x	x	1000	1000	450	450	x	x	x
13.09.24 08:54	54.375	8.333	26	x	x	x	x	x	500	500	350	350	x	x	x
13.09.24 09:25	54.393	8.404	Stern 11	x	x	x	x	x	500	500	300	300	x	x	
13.09.24 10:52	54.392	8.088	29	x	x	x	x	x	500	500	300	350	x	x	x

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