ALKOR-Berichte

Long-term monitoring of biodiversity changes and their functional consequences in the pelagic ecosystems of the central Baltic Sea

Cruise No. AL571

April 21th – April 30th 2022
Kiel (Germany) – Kiel (Germany)
BALTIC APRIL 2022

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GEOMAR Helmholtz Centre for Ocean Research Kiel

2024

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1 Cruise Summary

1.1 Summary in English

The multidisciplinary cruise AL571 extended the “Baltic Sea Integrative Long-term Data Series”, constituting one of the best available time series (1987 to the present) on ecosystem composition and functioning of the deeper basins of the Baltic Sea. This time series is characterized by the integration of biological and oceanographic data, and thus provides the foundation for assessments of recent rapid changes in planktonic communities, fish populations and food webs in response to anthropogenic pressures as well as climate change.

The specific work during AL571 included depth-resolved hydrographic measurements (temperature, salinity, oxygen concentrations), water and plankton sampling and pelagic fishery trawls carried out on standardized station grids in the central (Bornholm Basin, ICES subdivision 25) and western (Kiel and Mecklenburg Bight, ICES subdivision 22) Baltic Sea. The resulting data- and sample sets support ongoing projects in the Research Unit Marine Evolutionary Ecology at GEOMAR and multiple national and international collaborations, including the “Winter cod 2021-2025” program in the BMBF funded DAM project SpaCeParti, for which short status updates and preliminary results are presented in this report.

All planned stations and cruise objectives were successfully covered, benefiting from mostly good weather conditions and the flawless performance of all gear.

1.2 Deutsche Zusammenfassung

Mit der multidisziplinären Fahrt AL571 wurde die "Baltic Sea Integrative Long-term Data Series" erweitert, die eine der besten verfügbaren Zeitreihen (1987 bis heute) über die Arten-Zusammensetzung und Funktionsweise der Ökosysteme der tieferen Becken der Ostsee darstellt. Diese Zeitreihe zeichnet sich durch die Integration biologischer und ozeanographischer Daten aus, und bildet so die Grundlage für ein verbessertes Verständnis der rapiden Veränderungen in Planktongemeinschaften, Fischpopulationen und Nahrungsnetzen in Reaktion auf anthropogene Einflüsse und den Klimawandel über die letzten Dekaden.

Die spezifischen Arbeiten während der AL571 umfassten tiefenaufgelöste hydrographische Messungen (Temperatur, Salzgehalt, Sauerstoffkonzentration), Wasser- und Planktonprobennahmen und pelagische Forschungsfischerei, die auf standardisierten Stationsgrids in der zentralen (Bornholm-Becken, ICES-Subdivision 25) und westlichen (Kieler und Mecklenburger Bucht, ICES-Subdivision 22) Ostsee durchgeführt wurden. Die daraus resultierenden Daten- und Probensätze unterstützen laufende Projekte in der Forschungseinheit Marine Evolutionsökologie am GEOMAR und mehrere nationale und internationale Kooperationen, darunter das Programm "Winterdorsch 2021-2025" im BMBF-geförderten DAM-Projekt SpaCeParti, zu dem in diesem Bericht kurze Status-Updates und vorläufige Ergebnisse vorgestellt werden.

Alle geplanten Stationen und Fahrtziele wurden erfolgreich abgedeckt, begünstigt durch überwiegend gute Wetterbedingungen und die hervorragenden Arbeitsbedingungen an Bord.

2 Participants

2.1 Principal investigators

Name	Institution
Jan Dierking, Dr.	GEOMAR
Thorsten Reusch, Prof.	GEOMAR

2.2 Scientific Party

Name and title	Discipline	Institution
Jan Dierking, Dr.	Marine ecology and evolution, Chief scientist	GEOMAR
Hendrik Hampe	Technician	GEOMAR
David Needham, Dr.	Microbial ecology and evolution	GEOMAR
Femke Thoben, BSc	Marine ecology	GEOMAR
Erika Endo Kokubun, BSc	Marine ecology	GEOMAR
Helen Lichtenstein, BSc	Marine ecology	GEOMAR
Jasmin Hütt, BSc	Marine ecology	GEOMAR
Marvin Lehmann, BSc	Marine ecology	GEOMAR
hanna Rudnick	Marine ecology	GEOMAR
Timo Jensen, MSc	Biotechnology	CAU
Svenja Heckler, BSc	Fish ecology	UHAM-IMF
Anton Hoeper, BSc	Fish ecology	UHAM-IMF

2.3 Participating Institutions

Abbreviation	Full name
GEOMAR	Helmholtz-Centre for Ocean Research Kiel, Germany
CAU	Christian-Albrechts-Universität zu Kiel, Germany
UHAM – IMF	Hamburg University – Institute of Marine Ecosystem and Fishery Science, Germany

3 Research Program

3.1 Description of Work Area

The Baltic Sea is comparatively speaking species poor, yet it provides enormous ecosystems services to the Baltic nations. At the same time, it is one of the systems most affected by the combination of global (including climate) and local (including fishing) anthropogenic pressures, and has undergone strong hydrographic and biological shifts in the past decades.

The specific spatial foci of cruise AL571 lay on the Bornholm Basin (ICES subdivision (SD) 25) as last remaining spawning area of eastern Baltic cod, and Kiel and Mecklenburg Bight (ICES SD22) as essential habitat and spawning area of western Baltic cod (Fig. 3.1).

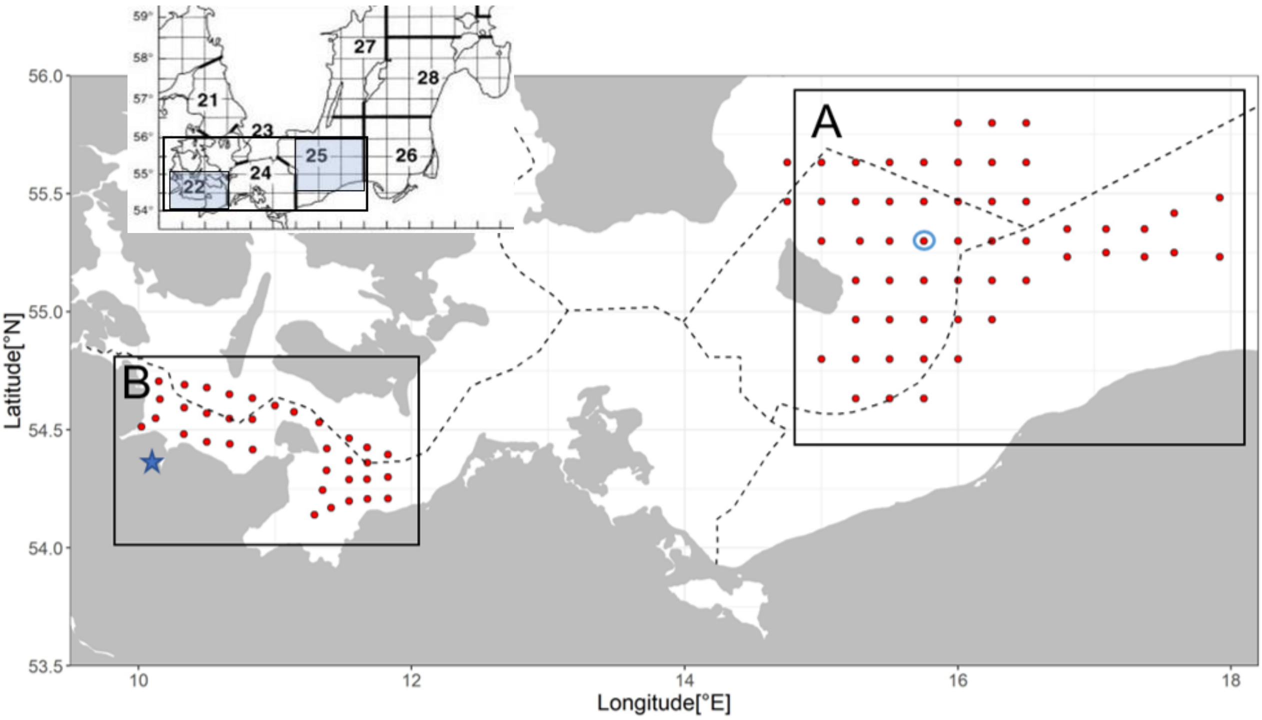

Fig. 3.1 Station grid covered during cruise AL571 with the two focus areas (A) Bornholm Basin, ICES subdivision 25, with the central station BB23 marked by blue circle, and (B) Kiel Bight and Mecklenburg Bight, ICES subdivision 22. The map inlay gives an overview of ICES SDs in the cruise area (source: ICES). Blue star: Kiel, Germany, start and end harbor of the cruise.

3.2 Aims of the cruise

The overarching scientific aim of cruise AL571 was to contribute to the understanding of biological changes in the structure and functioning of planktonic communities, fish populations and food webs of the western and central Baltic Sea in response to anthropogenic pressures as well as climate change. For this purpose, the main cruise objective was to generate biological and oceanographic data and samples to extend the 36-year “Baltic Sea Integrative Long-term Data Series (BILTS)” of the deeper basins of the central Baltic Sea. This series has been collected since 1987 by the GEOMAR Helmholtz Centre for Ocean Research and its predecessors, and provides the foundation for assessments of biological and environmental changes over time.

BILTS and AL571 datasets and samples support ongoing projects in the Research Unit Marine Evolutionary Ecology at GEOMAR, including the DFG-funded research training group (RTG) Translational Evolutionary Research/subproject "Fisheries Induced Evolution", and national and international collaborations, including (i) the “Winter cod 2021-2025” sub-project on cod recruitment in the Deutsche Allianz Meeresforschung (DAM) project SpaCeParti, (ii) the Baltic Ichthyoplankton Survey (BIS) and resulting applications in stock assessments (coordinated by Dr. Bastian Huwer, DTU-Aqua, Denmark), (iiv) water sampling and filtration for a research line on microbial (eukaryotes, bacteria, archaea) diversity and ecology (collaboration with Dr. David Needham, GEOMAR), (iv) the sampling of pelagic fishes and plankton communities to study the feeding ecology of planktivorous fishes with molecular metabarcoding approaches (collaboration with Prof. Monika Winder, Stockholm University), and (v) the vertically resolved phytoplankton and zooplankton sampling for studies of plankton phenology in central Bornholm Basin (collaboration with Dr. Jörg Dutz and Dr. Carolin Paul, Leibniz Institute for Baltic Sea Research Warnemünde, IOW).

3.3 Agenda of the Cruise

The key characteristic of AL571 was the integration of biological and oceanographic information with meso-scale spatial resolution on the two station grids in the central and western Baltic Sea, leading to a total of 206 gear deployments during 83 stations covered during the cruise. Specific investigations included detailed surveys of (1) hydrographic conditions (oxygen, salinity, temperature) and (2) zoo- and ichthyoplankton communities covering 83 stations, with a focus on Bornholm Basin and the western Baltic Sea (Fig. 3.1, Table 3.1), (3) vertically resolved multinet sampling of the deep station BB23 in central Bornholm Basin over a 24-hour period, to assess the diel vertical migration of zooplankton, and (4) pelagic fishery trawls at five stations in the central and southern Bornholm Basin, complemented by the continuous collection of hydroacoustic data along the cruise track for later analysis of fish abundance and distribution. Additional work in the context of collaborations with external groups were (5) sampling of microbial communities throughout the cruise area, (6) sampling of zooplankton and adult planktivorous fishes for the assessment of fish feeding ecology with molecular methods and (7) phyto- and zooplankton sampling on the central station BB23.

Table 3.1 Overview of gear deployments during AL571. Mesh sizes of all nets are given in brackets. Area designations represent combinations of ICES SD (see Fig 3.1) and abbreviated name; KB = Kiel Bight, MB = Mecklenburg Bight, AB = Arkona Basin, BB = Bornholm Basin. Abbreviations: CTD = probe measuring salinity, temperature, oxygen concentration and depth. WS-CTD = Rosette water sampler coupled with CTD probe. MN Maxi = large multinet. JFT = "Jungfischtrawl", pelagic trawl net with cod end mesh size of 0.5 cm.

	Area				
Gear	22 - KB	22 - MB	24 - AB	25 - BB	Total
CTD	19	17	2	45	83
WS-CTD	5		2	9	16
Bongo (150, 300, 500 µm)	18	18		48	84
MN Maxi (335 µm)				8	8
Apstein (50 µm)				3	3
WP2 (100µm)				3	3
WP2 (200µm)				4	4
JFT (0.5 cm)				5	5
Grand Total	42	35	4	125	206

4 Narrative of the Cruise

RV ALKOR was loaded and all scientific equipment was prepared on the days prior to the onset of the cruise, and the scientific personnel with negative PCR tests for Covid-19 (6 persons) boarded on April 20th already. Because of inconclusive PCR tests for the remaining scientific crew, RV ALKOR then departed from the GEOMAR west shore pier on April 21st at 08:00 am (all times board time, CET) with only half of the scientific personnel on board.

After covering one station in Kiel Fjord, Bongo and CTD station work on the "West cod" standard survey grid (SD22) (CTD and Bongo net hauls) commenced. The cruise was interrupted from April 21st 20:00 to April 22nd 6:30 to pick up the remaining scientific crew (now with negative test results) in Kiel. Afterwards, work on the western grid was continued in 24-hour shift work and completed on the morning of April 23rd. Following a transit to Bornholm Basin (SD 25), Bongo and CTD station work resumed on the Bornholm Basin standard survey grid ("Bongo grid" of 45 stations) on April 23rd at 16:12. Due to rising swell from the northeast and increasing northeasterly winds force 7-8, operations were interrupted from April 24 3:00 to April 25 6:30, with an overnight stop in Rönne (Bornholm) harbor. The grid was then successfully completed under much improved weather conditions on the morning of April 27th. Throughout the cruise, additional water sampling for the study of microbial communities was carried out at 16 stations along the cruise track.

On April 27th, the central deep station BB23 in Bornholm Basin was intensively sampled, including CTD casts, zooplankton sampling with Bongo, Apstein and WP-2 nets, and rosette water sampler hauls to collect phytoplankton, nutrient and water samples. The latter were used on board for oxygen measurements with the Winkler method for the calibration of oxygen probe measurements. BB23 work then continued with the detailed vertically and temporally resolved sampling of plankton communities by towed Multinet MAXI hauls at four time-points over a 24-hour period, covering the water column in 5 m depth layers ("BB23 24-hour station"). The cruise work was completed with five fisheries trawls on April 28st and the morning of April 29th, resulting in good catches (and thus sampling opportunities) of the main target species cod, herring and sprat.

After completion of the last station on April 29th at 10:00, RV ALKOR started the transit to Kiel, where the cruise ended at GEOMAR Westshore pier on April 30th at 07:54.

5 Preliminary Results

5.1 Ichthyo– and Zooplankton Sampling

(Dr. J. Dierking)

Bongo net hauls (mesh sizes 150, 335 and 500 µm) covered Kiel Bight (18 hauls), Mecklenburg Bight (18 hauls) and Bornholm Basin (48 hauls) (Fig. 3.1, Table 3.1). Fish larvae (n_{total} = 1210) and jellyfish (n_{total} = 828) from the 500 µm nets were counted (Table 5.1.1) and measured immediately on board, and conserved at -80 °C for subsequent RNA/DNA, stable isotope and genetic analyses. Cod larvae were present regularly in the catches in the western Baltic Sea (n = 72) but were absent in the Bornholm Basin, consistent with peak spawning of cod in late winter/early spring in the west, but only later in the year in the east. The geographic distribution of cod larvae catches in Kiel and Mecklenburg Bight is shown in Fig. 5.1.1. These data will be integrated with output of partner cruises covering the period January to March in the western Baltic Sea in the context of the "Winter cod 2021-2025" program (DAM project SpaCeParti), to quantify spawning intensity over the entire potential spawning period (also see Section 5.4).

Table 5.1.1 Catches of fish larvae (upper panel) and jellyfish (lower panel) in Bongo net hauls (500 µm mesh size) in Bornholm Basin (BB), Kiel Bight (KB) and Mecklenburg Bight (MB). The actual number of clupeid and flatfish larvae is higher than counts listed here, since a maximum of 10 larvae per species and haul are counted and conserved. The jellyfish *Rhizostoma* spec. is listed in parentheses, as the taxonomic identification needs to be confirmed.

Fish

Area	Clupeid	Flatfish	Cod	Goby	Sand eel	Long-spined bullhead	Shorthorn sculpin	Striped seasnail	Total
BB	437	337			2		4	14	794
KB	51	122	39		10	2	4		228
MB	43	103	33	1	6		2		188
Total	531	562	72	1	18	2	10	14	1210

Jellyfish

Area	*Aurelia aurita*	*Cyanea capillata*	*Mnemiopsis leidyi*	Hydro-medusae	(*Rhizostoma* spec.?)	Total
BB	10	141		9	14	174
KB	28	138	28	91		285

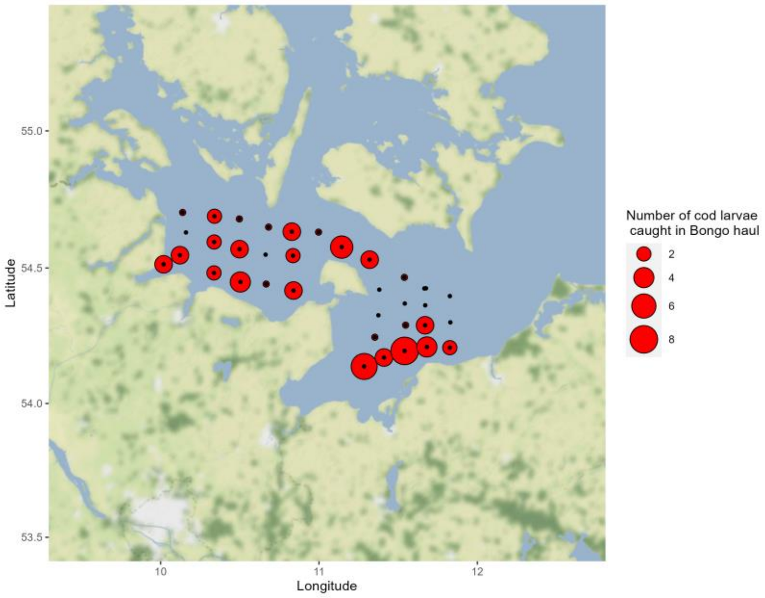

Fig. 5.1.1 Geographic distribution of cod larvae catches on the western Baltic Sea station grid.

As to jellyfish, ephyrae (larvae) and small adults of scyphozoan jellyfish (*Aurelia aurita* and *Cyanea capillata*) were present in higher abundances (total n over the duration of the cruise = 376) compared to the same period in 2021 (AL553, n = 209). Comparisons with the same period in 2019 (AL521, n = 1550) and 2018 (AL491, n = 10) highlights the major variability among years. The invasive combjelly *Mnemiopsis leidyi* was present only in low numbers and limited to the western Baltic Sea (n = 28).

Following the initial sorting steps on board, all remaining Bongo samples were conserved in formalin, and are available for the determination of species composition and abundance of zoo- and ichthyoplankton.

Repeated multinet MAXI (335 µm mesh size, towed, sampling of the water column in 5 m layers) casts were done at four time-points over a 24-hour period on April 27 - 28 on the central deep Bornholm Basin station BB23, to assess diurnally resolved vertical distributions of ichthyo-and zooplankton. A notable pattern here was the different depth distribution of jellyfish (mainly in the depth layers 40 m – 75 m) and fish larvae (mainly in the depth layers 2.5 – 25 m) (Fig. 5.1.2).

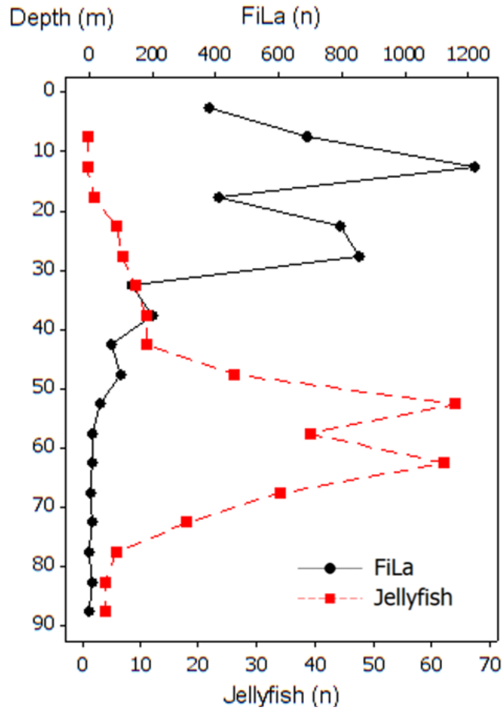

Fig. 5.1.2 Depth distribution of fish larvae and scyphozoan jellyfish at station BB23 in central Bornholm Basin, based on depth resolved multinet MAXI (mesh size 335 µm) catches over a 24-hour period on April 27 – 28.
Values represent combined counts of flatfish and clupeid larvae and combined counts of *A. aurita* and *C. capillata*, respectively, aggregated per 5 m depth layer over the entire 24-hour period. Abbreviations: FiLa = fish larvae.

5.2 Fishery

(Dr. J. Dierking)

Five pelagic fishery hauls were conducted on April 28-29 in Bornholm Basin (Table 3.1). Nine species were present in the catch, with sufficient quantities of cod, herring and sprat to conduct systematic sampling and measurements (Table 5.2.1.).

For cod, single fish data (length, weight, sex and maturity stage) and samples (otoliths, fin clips for genetic analysis) were obtained for 206 individuals from Bornholm Basin (see Fig. 5.2.2 for illustration). Length and weight were measured for an additional 345 individuals. The mean total length of individuals in the catches was 30.9 cm, similar to values in 2021 (30.2 cm), 2019 (31.1 cm) and 2018 (32.9 cm) (Fig. 5.2.1). Larger individuals >45 cm were rare, and the largest cod had a total length of 50.0 cm. These observations represent a dramatic difference from size distributions in the 1980s and 1990s, when larger individuals were prevalent in the population and mean sizes were substantially larger. For detailed information regarding declining sizes over time, also see the cruise report for AL573 (https://doi.org/10.3289/CR_AL573).

For sprat and herring, stomach samples (sprat: 20 per 1 cm length class; herring: 20 per 2 cm length class) as well as 2 kg frost samples were taken at each station.

Table 5.2.1 Fish catch composition for AL571. Single fish measurement and samples were taken for 206 cod and 12 whiting individuals. For herring and sprat, length-weight distributions based on sub-samples of 200 individuals were taken at each station, and stomach and whole fish samples were taken. For flatfishes and all other species, measurements and fin clips of all individuals were taken.

Latin name	Common name	n	Mass (kg)
Sprattus sprattus	sprat	52648	560.0
Clupea harengus	herring	1280	50.9
Gadus morhua	cod	778	223.6
Merlangius merlangus	whiting	12	2.7
Platichthys flesus	flounder	22	4.2
Alosa fallax	twait shad	15	0.4
Engraulis encrasicolus	anchovy	11	0.1
Gasterosteus aculeatus	three-spined stickleback	10	0.0
Trachurus trachurus	Atlantic horse mackerel	1	0.0
Total		54777	842.1

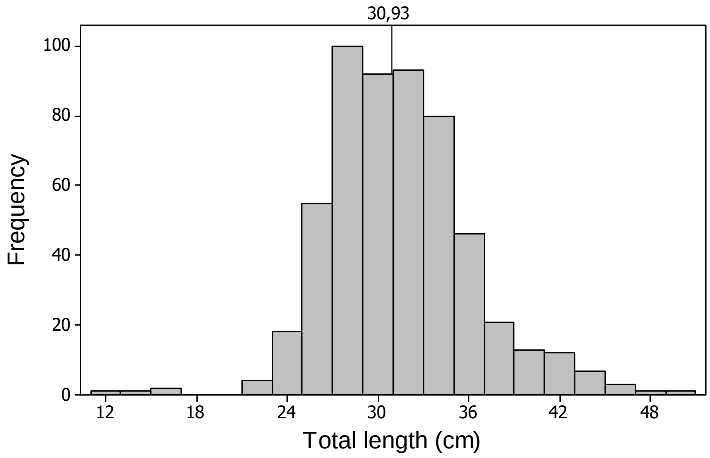

Fig. 5.2.1 Length frequency distribution of cod sampled in SD25 during AL571 (n = 659). The mean size of individuals, 30.9 cm, is marked on the x-axis, and compares to 30.2 cm in 2021, 31.1 cm in 2019 and 32.9 cm in 2018.

Fig. 5.2.2 Samples (otoliths, fin clips) and measures (total length, weight, gutted weight, liver and gonad weight) were taken from 206 cod individuals (illustrated here for a 38 cm female, maturity stage IV, with full stomach, from Bornholm Basin). Photo: S. Nickel

5.3 Hydrography

(Dr. J. Dierking, Dr. F. Mittermayer, H.-H. Hinrichsen)

CTD profiles were obtained with an ADM-CTD (83 stations) and a HYDROBIOS water sampler with attached CTD (16 stations). One additional vertical oxygen profile was obtained for calibration purposes at the deep central Bornholm Basin station BB23, by determining oxygen concentrations of depth-resolved water samples using the Winkler method.

Observed oxygen condition in the central Baltic Sea reflected the typical situation also observed in previous years, with hypoxic (< 2 ml/l) to anoxic (0 ml/l) conditions at depths below 65-75 m. Profiles of oxygen, salinity and temperature along a transect from the southwestern to the northeastern Bornholm Basin highlight the strong vertical structuring, with more saline, warmer, oxygen poor water in deep water layers, and well mixed, oxygenated, less saline and colder water above the halocline (Fig. 5.3.1), which reflects the typical situation in Bornholm Basin past years in the absence of major inflow events of North Sea water.

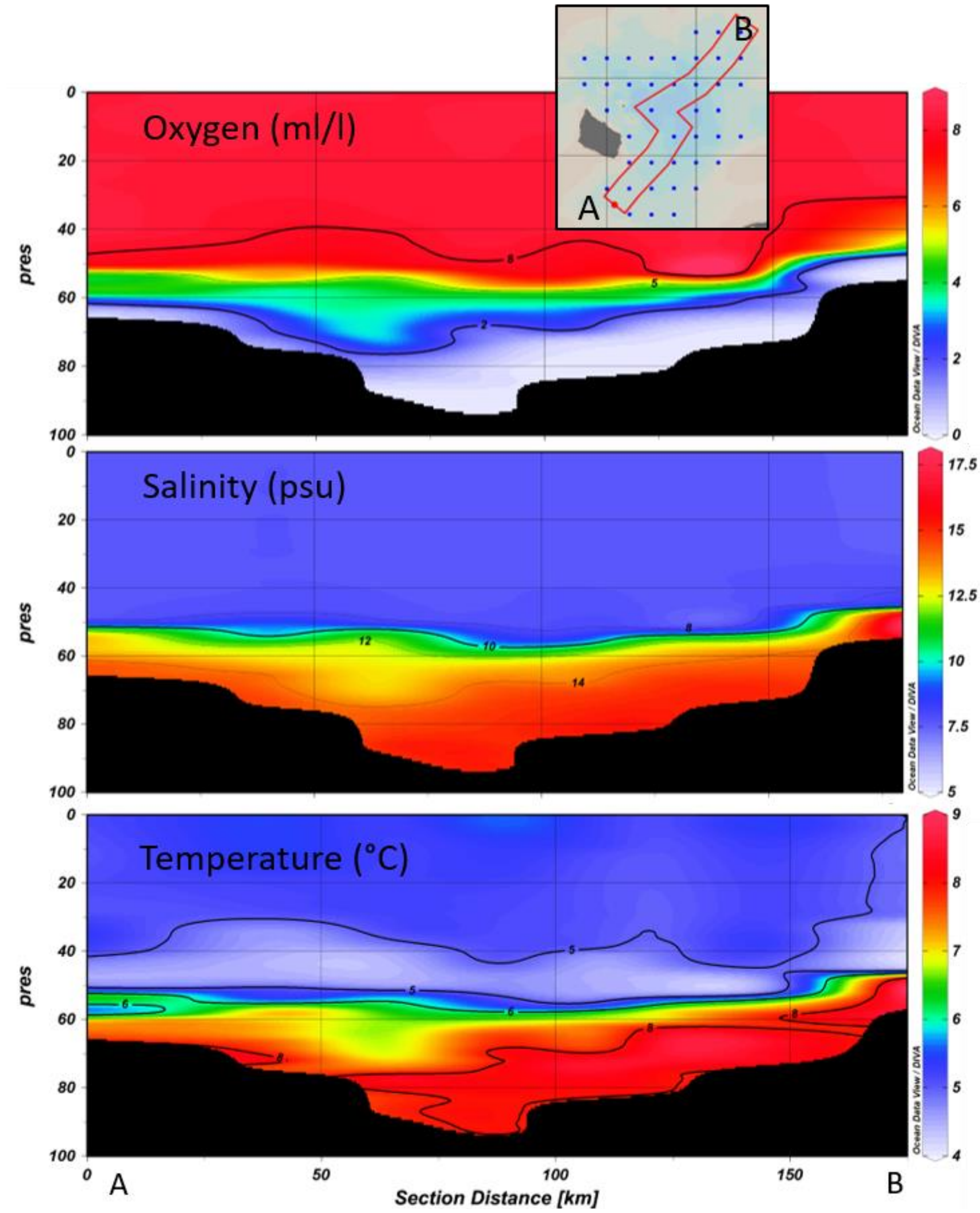

Fig. 5.3.1 Vertically resolved oxygen, salinity and temperature sections across Bornholm Basin. Values between the sampling stations are interpolated. Insert: station grid in Bornholm Basin showing the positioning of the section.

5.4 Investigation of the Spawning Ecology of Western Baltic Cod

(Dr. S. Funk, Prof. C. Möllmann, IMF, University of Hamburg, in collaboration with the Research Unit Marine Evolutionary Ecology at GEOMAR and the Danish partners DTU-Aqua and Aarhus University, in the framework of the "Winter cod 2021-25" cruise program (GPF 21-2_041) and the BMBF funded DAM project SpaCeParti)

The "Winter cod 2021-25" cruise program investigates the spawning ecology of Western Baltic cod. For this purpose, ichthyoplankton samples were taken with Bong nets on the western Baltic Sea station grid (Fig. 3.1). Cod larvae were picked out of the 500 µm nets and deep frozen on -80°C for later otolith age-readings, stomach content analyses and DNA-RNA-condition analyses. Samples from the 300 µm net were conserved in formalin for later sorting and counting of (cod) larvae and eggs.

Information on the occurrence of cod egg and larvae will be used to support drift modelling for the identification of active spawning grounds in the Framework of the project SpaCeParti (Coastal Fishery, Biodiversity, Spatial Use and Climate Change: A Participative Approach to navigate the Western Baltic Sea into a Sustainable Future, funded by BMBF, Grant no. 03F0914). In this context, cruise AL571 complements cruises conducted in January to March 2022 by the University of Hamburg and in May 2022 by GEOMAR, specifically:

AL568b (24.01.2022 – 01.02.2022, Chief Scientist: Dr. Steffen Funk)
AL568c (08.02.2022 – 10.02.2022, Chief Scientist: MSc. Richard Klinger)
AL568d (11.02.2022 – 13.02.2022, Chief Scientist: Dr. Steffen Funk)
AL569 (02.03.2022 – 11.03.2022, Chief Scientist: Dr. Luisa Listmann)
AL 573 (14.05.2022 – 30.05.2022, Chief Scientist: Prof. Dr. Thorsten H.B. Reusch)

5.5 Contribution to the Baltic Ichthyoplankton Survey (BIS) and Resulting Applications in Stock Assessments

(Dr. B. Huwer, DTU Aqua, in the framework of the ICES Working Groups on Surveys on Ichthyoplankton in the North Sea and Adjacent Seas (WGSINS) and on Baltic Fisheries Assessments (WGBFAS))

The Baltic Ichthyoplankton Survey (BIS) represents a long-standing international effort of partners from Denmark (DTU-Aqua), Poland (National Marin Fisheries Research Institute, NMFRI) and Germany (GEOMAR; University of Hamburg IMF) to cover the entire protracted spawning season (March to November) of the eastern Baltic cod stock with cruise-based surveys of eggs and larvae (Fig. 5.5.1). This partner network covers the Bornholm Basin with meso-scale resolution using identical Bongo nets on the same standardized 45-station grid (Fig. 3.1).

The data on cod egg and larval abundances from the ichthyoplankton survey conducted during cruise AL571 (Table 5.1.1) represent one of eight complementary data sets spanning the months March to November in 2022, jointly constituting the BIS and supporting resulting applications in stock assessment. Specifically, the BIS data sets have been used to support fishery independent cod biomass estimates based on egg production in the stock assessment of eastern Baltic cod since 2019. This includes input data for annual (AEPM) and daily (DEPM) egg production methods, which are used to provide a time series of Eastern Baltic cod stock biomass estimates (1986-present) to the ICES WGBFAS. Moreover, the BIS is providing

WGBFAS with a recruitment index based on average larval abundances, as early indication of year-class strength.

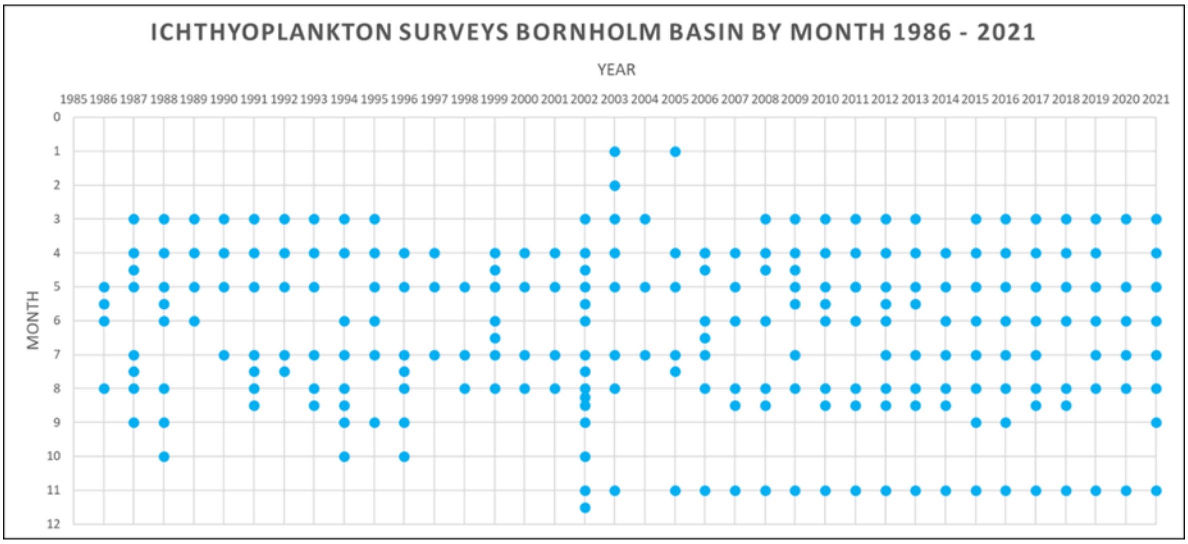

Fig. 5.5.1 Time series of existing individual BIS surveys by years and months. Note: 8 cruises for 2022, including AL571 covering the month of April, not yet incorporated. Figure provided by Dr. Bastian Huwer, BIS coordinator)

5.6 Microbial Diversity and Ecology

(Dr. D. Needham, Helmholtz Young Investigator group Leader at GEOMAR, in collaboration with the Research Unit Marine Evolutionary Ecology at GEOMAR)

Rationale: The microbial diversity and ecology research line aims to 1) examine the diversity and abundance of the entire microbial community (eukaryotes, bacteria, and archaea) across the Baltic Sea, 2) apply cultivation techniques aimed at the numerically dominant taxa present from deep waters, 3) preserve samples for single cell genomic analyses, and 4) conduct experiments to examine how bacterial and archaeal communities respond to organic materials provided from different phytoplankton species. For this purpose, depth-resolved microbial community sampling was performed with the rosette water sampler at 17 sampling locations, led on board by Prof. Needham. Ultimately, the dataset will contribute to large-scale seasonal microbial community structure data sets currently being assembled at GEOMAR and elsewhere. All of the microbial sampling was done in accordance with the DAM CREATE (Concepts for reducing the effects of anthropogenic pressures and uses on marine ecosystems and on biodiversity) mission.

Preliminary results: Preliminary data are available for aims 1) and 2). While samples for water from the surface layer (1 m), mid-water layer (just below thermocline), and deep layer (just above the seafloor) are available, so far the focus has been on the deep samples. The data revealed the dominance of Bacteroidia, Nitrososphaeria archaea, and Proteobacteria (Fig 5.6.1 a), groups that also dominate the deep global ocean. Subsequently, efforts to grow these organisms in the lab have been successful for the Nitrososphaeria archaea, which are carbon fixing ammonia oxidizers. While relatives of Nitrososphaeria archaea have been previously isolated elsewhere, typically, Nitrososphaeria archaea in culture show preference for temperatures that are warmer than the in-situ temperatures in their natural environment.

However, at least one of the strains isolated during cruise AL571 grows better at 10 °C and thus much closer to the temperatures experienced in their natural habitat (4 °C – 6 °C) than the usual cultivation temperatures for Nitrosophaeria (22 °C – 25 °C) (Fig 5.6.1 b). This observation is so far unique for a Nitrosophaeria strain culture in the laboratory, and may allow us to further exploit this strain when studying the traits involved in cold-adaptation in Nitrososphaeria archaea.

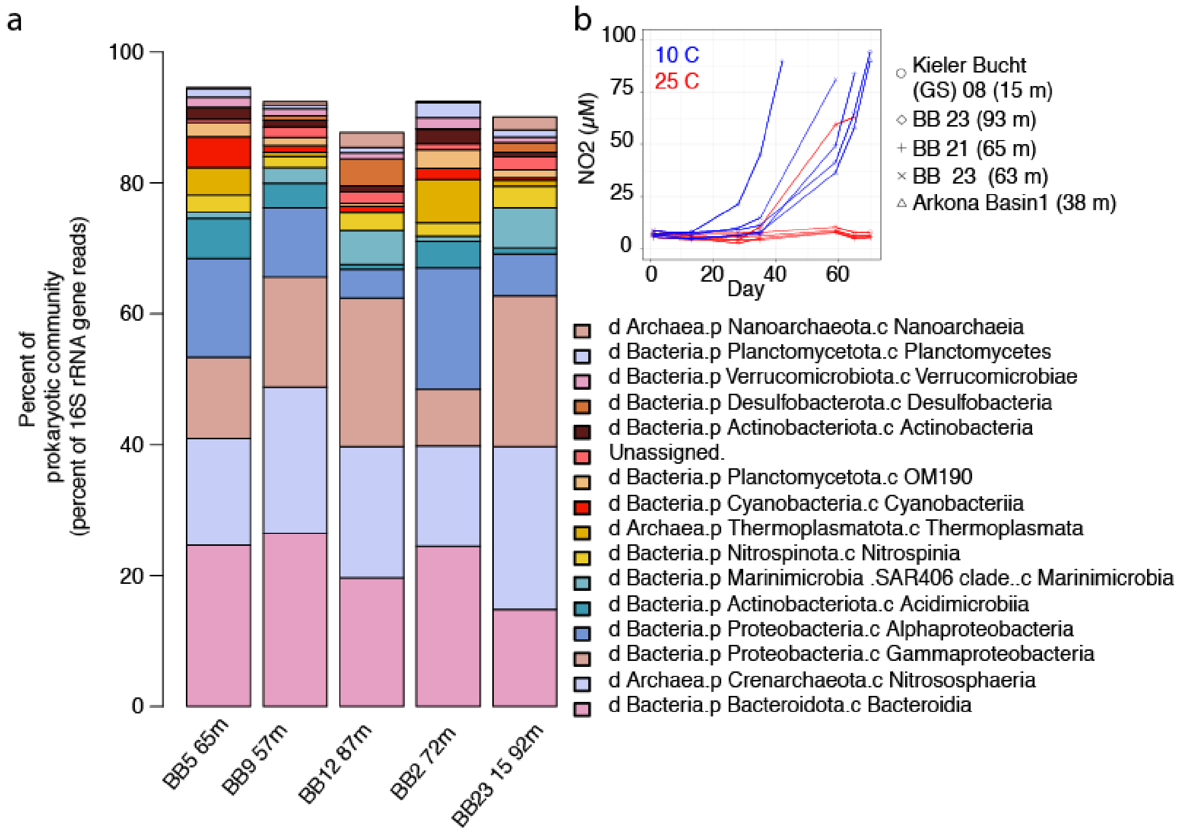

Fig. 5.6.1 a) Prokaryotic community composition for a subset of deep water samples collected during AL571. b) Growth of ammonium oxidizing Nitrososphaeria archaea enriched from a variety of samples from mid-water and deep samples indicating growth at 10 °C and not 25 °C, which differs from other reported Nitrososphaeria archaea temperature preferences.

5.7 Zooplankton Predation by Fish Larvae in the Baltic Sea Assessed With eDNA Analysis

(Prof. M. Winder, Stockholm University, in collaboration with the Research Unit Marine Evolutionary Ecology at GEOMAR)

This research project based at Stockholm University aims to study ecosystem-wide species interactions in the Baltic Sea. By applying DNA metabarcoding to field collected specimens we want to increase our understanding of the ecological niches and trophic positioning of species, and answer the question "*who eats whom?*", with a particular focus on planktivorous fishes. This group plays a central role in marine food web, as it has the potential to control both the production of predatory fish (via bottom-up effects) and zooplankton (via top-down effects from predation), thus affecting algal blooms. Yet, feeding interactions between planktivorous fishes and zooplankton are not well studied across spatial and temporal scales for key species.

In this study, we use zooplankton and fish samples collected during the cruise AL571 from different stations in the Bornholm Basin. Fish were caught by trawl net and immediately dissected and preserved frozen; in addition, zooplankton samples were taken at each of the trawl locations. The stomach contents of sprat and herring, the dominating planktivorous fish species at the time of the sampling, and prey availability (zooplankton samples) will be identified using microscopy. Data will then be put into the perspective of the similar data sets from previous cruises (AL521 in 2019 and AL553 in 2021) and of continuous zooplankton and fish abundance monitoring data available over the last 10-15 years. The results of this study are expected to guide ecosystem management for sustainable fisheries and ecosystem health. The work is currently ongoing, with a MSc student analyzing the samples.

5.8 Long-term Population Dynamics and Decadal Variation of Copepods in the Bornholm Basin

(Dr. Jörg Dutz, IOW, in collaboration with the Research Unit Marine Evolutionary Ecology at GEOMAR)

Rationale: The IOW runs a regular time series of the seasonal, long-term variation in composition and stock size of mesozooplankton in the western and central Baltic Sea since the year 1983. An additional time series of high temporal resolution with regular sampling of 12-16 times/year was initiated in 2014 in order to resolve the population dynamics of key copepod species and provide a mechanistic background for their long-term variation in the Bornholm Basin. The cruises in April (AL 571) and May (AL 573) by GEOMAR contribute to this sampling programme and particularly close an important gap in the knowledge of the spring development of zooplankton in the central Baltic Sea. For this purpose, regular, triplicate sampling is conducted with an Apstein net of 55 µm and a WP-2 net of 100 µm mesh size to study the dynamics of nauplius and copepodite stages, respectively. The conditions controlling the temporal variability and stock sizes are incompletely understood and likely reflect the interplay between spring-season weather, availability of phytoplankton and important life cycle events in the seasonal recruitment of copepods.

Preliminary results: The analysis of the Apstein and WP-2 samples taken in April 2022 has been initiated, but first results are still pending. The 55 µm Apstein net samples specifically aim at resolving the stage composition of the nauplius stages of Temora longicornis, Centropages hamatus, Pseudocalanus acuspes and the genus Acartia, which is very time consuming. In addition, the abundance of the rotifer Synchaeta is largely underestimated by the ‘traditional’ monitoring mesh size of 100 µm and the Apstein net sampling is expected to provide considerably better estimates, particularly with regard to the young, early stages, which potentially are important in the control of the post-spring bloom dynamics of the phytoplankton. The analysis of the WP-2 samples, in contrast, focuses on the dynamics of the copepodite stages of these key copepods. After completion of April 2022 analyses, results will be assessed in the context of May 2022 (AL573) and IOW monitoring cruises.

5.9 "Can Micro- or Mesozooplankton Control Phytoplankton Spring Blooms in the Baltic Proper Under Climate Warming?"

(Dr. Carolin Paul; Institute for Baltic Sea Research Warnemuende, IOW)

For the DFG-projekt "Can micro- or mesozooplankton control phytoplankton spring blooms in the Baltic Proper under climate warming?", water samples for phytoplankton and microzooplankton species composition (Lugol iodine fixed) were taken from the upper surface layer (1-10 m mix) in Bornholm Basin. The aim of this project is to find out whether recent changes in the phytoplankton community composition of the Baltic Proper in spring are a result of warming-induced changes in grazing by meso-and microzooplankton. The sampling in late April (AL571) and May (AL573) contributes to the enhanced monitoring program of IOW (also see Section 5.8) and will be analysed together with IOW cruise data covering March, early April and May 2022 at the same sample station (IOW TF0213, near grid station BB23). As microzooplankton is not regularly monitored in this area, the results of the project will provide new insights regarding the species composition and grazing relationships during spring blooms in the Central Baltic Sea.

Preliminary results on phytoplankton and microzooplankton composition: The microzooplankton ciliate composition was dominated by Strombids/Strobilids in late April and May 2022. However, composition differed between size-classes and diversity (Fig. 5.8.1, A and B). In April, Strombids/Strobilids of the size classes 30-50 µm and 55-80 µm dominated the ciliates, with about 80% of total biomass. The remaining biomass consisted mainly of Strombids/Strobilids 20-30µm and *Laboea strobila* (Fig. 5.9.1 A). The phytoplankton mainly consisted of the mixotrophic ciliate *Mesodinium rubrum* and the dinoflagellate *Peridiniella catenata*. In contrast, by May, the large ciliates mostly disappeared and 99% of total ciliate biomass consisted of smaller Strombids/Strobilids with a size of 20-30µm (Fig. 5.9.1 B). The phytoplankton was dominated by the mixotrophic ciliate *Mesodinium rubrum*, but also by small phytoplankton taxa/groups (cryptophytes, flagellates, Gymnodinales, Prymnesiales), whereas the dinoflagellate *Peridiniella catenata* nearly disappeared.

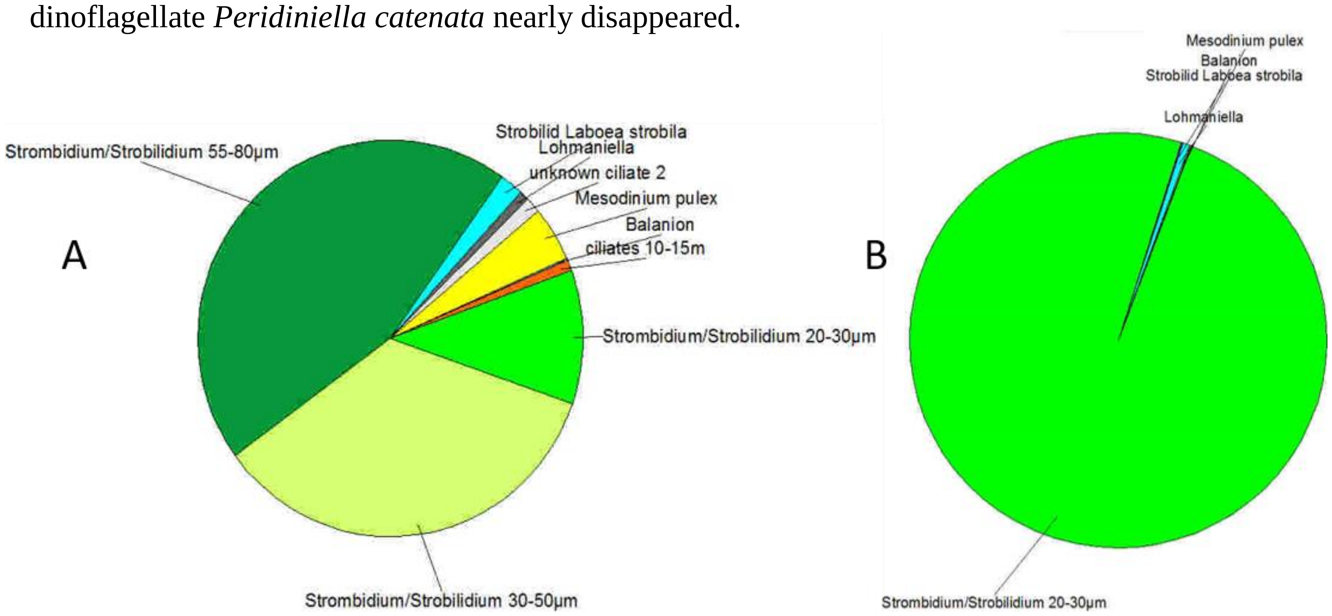

Fig. 5.9.1 Composition of the mesozooplankton community (% of biomass) in central Bornholm Basin on A) April 22, 2022 (AL571) and B) May 18, 2022 (AL573).

6 Station list AL571

Gear	Gear nr	Station nr	Station name	ICES Sub-division	Date	Time (board time)	Latitude (decimal degrees)	Longitude (decimal degrees)	Depth (m)	Duration (min)
CTD	1	1	GKW	22 - KB	21.04.2022	08:15	54.33983	10.17017	12	00:30
WS-CTD	1	1	GKW	22 - KB	21.04.2022	08:30	54.34017	10.16983	12	00:15
CTD	2	2	GS01	22 - KB	21.04.2022	10:25	54.51317	10.01983	27	00:13
WS-CTD	2	2	GS01	22 - KB	21.04.2022	10:38	54.51367	10.01967	27	00:07
Bongo	1	2	GS01	22 - KB	21.04.2022	10:56	54.51317	10.01983	27	00:04
Bongo	2	3	GS02	22 - KB	21.04.2022	11:41	54.54700	10.12200	22	00:09
CTD	3	3	GS02	22 - KB	21.04.2022	12:36	54.54850	10.12250	22	00:03
CTD	4	4	GS03	22 - KB	21.04.2022	13:16	54.63033	10.15467	22	00:02
Bongo	3	4	GS03	22 - KB	21.04.2022	13:21	54.63033	10.16000	22	00:04
Bongo	4	5	GS04	22 - KB	21.04.2022	13:58	54.70333	10.13883	21	00:03
CTD	5	5	GS04	22 - KB	21.04.2022	14:05	54.70617	10.14533	24	00:01
CTD	6	6	GS05	22 - KB	21.04.2022	14:47	54.68850	10.33500	24	00:03
Bongo	5	6	GS05	22 - KB	21.04.2022	14:52	54.68950	10.34000	24	00:04
Bongo	6	7	GS10	22 - KB	21.04.2022	15:28	54.67967	10.49717	25	00:03
CTD	7	7	GS10	22 - KB	21.04.2022	15:34	54.68033	10.49867	25	00:02
CTD	8	8	GS09	22 - KB	21.04.2022	16:20	54.56917	10.49983	18	00:03
Bongo	7	8	GS09	22 - KB	21.04.2022	16:27	54.56917	10.49850	18	00:03
WS-CTD	3	8	GS09	22 - KB	21.04.2022	16:28	54.57217	10.49367	18	00:07
Bongo	8	9	GS06	22 - KB	21.04.2022	17:45	54.59533	10.33783	17	00:02
CTD	9	9	GS06	22 - KB	21.04.2022	17:49	54.59550	10.33450	17	00:04
CTD	10	10	GS07	22 - KB	21.04.2022	18:40	54.48117	10.33183	19	00:03
Bongo	9	10	GS07	22 - KB	21.04.2022	18:46	54.48200	10.33683	19	00:02
CTD	11	11	GS08	22 - KB	22.04.2022	08:22	54.44833	10.49900	17	00:01
Bongo	10	11	GS08	22 - KB	22.04.2022	08:27	54.44867	10.50333	17	00:02
WS-CTD	4	11	GS08	22 - KB	22.04.2022	08:35	54.44983	10.50333	17	00:05
Bongo	11	12	GS13	22 - KB	22.04.2022	09:16	54.44117	10.66633	18	00:02
CTD	12	12	GS13	22 - KB	22.04.2022	09:20	54.44150	10.66867	18	00:04
CTD	13	13	GS14	22 - KB	22.04.2022	10:04	54.41633	10.83533	11	00:01
Bongo	12	13	GS14	22 - KB	22.04.2022	10:11	54.41733	10.83900	12	00:02
Bongo	13	14	GS12	22 - KB	22.04.2022	11:08	54.54900	10.66267	20	00:02
CTD	14	14	GS12	22 - KB	22.04.2022	11:11	54.53983	10.66417	20	00:03
CTD	15	15	GS11	22 - KB	22.04.2022	11:59	54.54883	10.66517	25	00:03
Bongo	14	15	GS11	22 - KB	22.04.2022	12:04	54.64983	10.68167	26	00:03
Bongo	15	16	GS16	22 - KB	22.04.2022	12:43	54.63317	10.82850	22	00:04
CTD	16	16	GS16	22 - KB	22.04.2022	12:49	54.63317	10.82867	22	00:04
CTD	17	17	GS15	22 - KB	22.04.2022	13:28	54.54533	10.83267	22	00:03
Bongo	16	17	GS15	22 - KB	22.04.2022	13:34	54.54550	10.83600	22	00:03
WS-CTD	5	17	GS15	22 - KB	22.04.2022	13:35	54.54550	10.83750	22	00:07
Bongo	17	18	GS17	22 - KB	22.04.2022	14:38	54.63150	10.99717	21	00:05
CTD	18	18	GS17	22 - KB	22.04.2022	14:45	54.63167	10.99883	19	00:03
CTD	19	19	GS18	22 - KB	22.04.2022	15:27	54.57667	10.13717	26	00:06
Bongo	18	19	GS18	22 - KB	22.04.2022	15:34	54.57667	11.14333	27	00:07

Bongo	19	20	GS19	22 - MB	22.04.2022	16:22	54.53067	11.31983	30	00:04
CTD	20	20	GS19	22 - MB	22.04.2022	16:29	54.53150	11.32050	30	00:03
CTD	21	21	GS20	22 - MB	22.04.2022	17:16	54.41917	11.37750	20	00:02
Bongo	20	21	GS20	22 - MB	22.04.2022	17:21	54.42050	11.38083	19	00:02
Bongo	21	22	GS21	22 - MB	22.04.2022	18:00	54.32617	11.37500	21	00:02
CTD	22	22	GS21	22 - MB	22.04.2022	18:05	54.32800	11.37617	21	00:02
CTD	23	23	GS22	22 - MB	22.04.2022	18:39	54.24467	11.34833	21	00:02
Bongo	22	23	GS22	22 - MB	22.04.2022	18:44	54.24533	11.35267	21	00:03
Bongo	23	24	GS23	22 - MB	22.04.2022	19:31	54.13717	11.28533	26	00:03
CTD	24	24	GS23	22 - MB	22.04.2022	19:36	54.13967	11.28700	26	00:03
CTD	25	25	GS24	22 - MB	22.04.2022	20:15	54.17000	11.40983	23	00:02
Bongo	24	25	GS24	22 - MB	22.04.2022	20:19	54.17033	11.41050	23	00:03
Bongo	25	26	GS25	22 - MB	22.04.2022	20:55	54.19467	11.54083	24	00:03
CTD	26	26	GS25	22 - MB	22.04.2022	21:02	54.19917	11.54250	24	00:01
CTD	27	27	GS32	22 - MB	22.04.2022	21:41	54.20867	11.67533	25	00:02
Bongo	26	27	GS32	22 - MB	22.04.2022	21:45	54.20933	11.68100	25	00:03
Bongo	27	28	GS33	22 - MB	22.04.2022	22:25	54.20667	11.82600	20	00:03
CTD	28	28	GS33	22 - MB	22.04.2022	22:31	54.20867	11.82733	20	00:01
CTD	29	29	GS34	22 - MB	22.04.2022	23:36	54.30000	11.82450	23	00:01
Bongo	28	29	GS34	22 - MB	22.04.2022	23:39	54.30017	11.82950	23	00:03
Bongo	29	30	GS31	22 - MB	23.04.2022	00:20	54.28933	11.66983	25	00:05
CTD	30	30	GS31	22 - MB	23.04.2022	00:25	54.29100	11.67067	25	00:05
CTD	31	31	GS26	22 - MB	23.04.2022	00:59	54.29017	11.54150	24	00:03
Bongo	30	31	GS26	22 - MB	23.04.2022	01:04	54.28983	11.54700	24	00:03
Bongo	31	32	GS27	22 - MB	23.04.2022	01:39	54.36950	11.54167	24	00:04
CTD	32	32	GS27	22 - MB	23.04.2022	01:45	54.36950	11.54167	24	00:03
CTD	33	33	GS28	22 - MB	23.04.2022	02:27	54.45500	11.53833	24	00:03
Bongo	32	33	GS28	22 - MB	23.04.2022	02:32	54.46567	11.53917	25	00:04
Bongo	33	34	GS29	22 - MB	23.04.2022	03:09	54.42500	11.66533	24	00:04
CTD	34	34	GS29	22 - MB	23.04.2022	03:14	54.42483	11.67233	24	00:03
Bongo	34	34	GS29	22 - MB	23.04.2022	03:24	54.42550	11.67550	24	00:04
Bongo	35	35	GS30	22 - MB	23.04.2022	03:56	54.36283	11.67083	25	00:03
CTD	35	35	GS30	22 - MB	23.04.2022	04:00	54.36133	11.67700	25	00:03
CTD	36	36	GS35	22 - MB	23.04.2022	04:43	54.39650	11.82450	21	00:02
Bongo	36	36	GS35	22 - MB	23.04.2022	04:47	54.39683	11.82650	21	00:03
CTD	37	37	ArkB1	24 - AB	23.04.2022	10:28	54.76467	13.33017	40	00:03
WS-CTD	6	37	ArkB1	24 - AB	23.04.2022	10:35	54.76483	13.33033	40	00:14
CTD	38	38	ArkB2	24 - AB	23.04.2022	13:36	54.95250	14.21900	41	00:04
WS-CTD	7	38	ArkB2	24 - AB	23.04.2022	13:37	54.95317	14.22850	41	00:07
CTD	39	39	BB42	25 - BB	23.04.2022	16:18	54.79100	15.00000	60	00:05
Bongo	37	39	BB42	25 - BB	23.04.2022	16:25	54.79200	15.00000	60	00:07
Bongo	38	40	BB41	25 - BB	23.04.2022	17:23	54.78517	15.24133	67	00:07
CTD	40	40	BB41	25 - BB	23.04.2022	17:34	54.79100	15.24817	67	00:05
CTD	41	41	BB43	25 - BB	23.04.2022	18:36	54.62833	15.25333	59	00:05
WS-CTD	8	41	BB43	25 - BB	23.04.2022	18:41	54.63067	15.25417	59	00:16
Bongo	39	41	BB43	25 - BB	23.04.2022	18:59	54.62950	15.25283	59	00:07
Bongo	40	42	BB44	25 - BB	23.04.2022	19:55	54.61683	15.48867	62	00:09
CTD	42	42	BB44	25 - BB	23.04.2022	20:07	54.62483	15.50000	63	00:06
CTD	43	43	BB40	25 - BB	23.04.2022	21:17	54.79233	15.50050	72	00:08

Bongo	41	43	BB40	25 - BB	23.04.2022	21:26	54.79333	15.50017	65	00:09
Bongo	42	44	BB34	25 - BB	23.04.2022	22:31	54.94917	15.49033	68	00:12
CTD	44	44	BB34	25 - BB	23.04.2022	22:46	54.95750	15.49983	74	00:05
CTD	45	45	BB31	25 - BB	24.04.2022	00:04	55.12483	15.49900	67	00:06
Bongo	43	45	BB31	25 - BB	24.04.2022	00:13	55.12533	15.49983	67	00:08
Bongo	44	46	BB32	25 - BB	24.04.2022	01:16	55.11983	15.25033	61	00:07
CTD	46	46	BB32	25 - BB	24.04.2022	01:25	55.12533	15.26650	62	00:05
CTD	47	47	BB33	25 - BB	24.04.2022	02:32	55.95817	15.25150	44	00:04
Bongo	45	47	BB33	25 - BB	24.04.2022	02:39	54.95867	15.25617	43	00:05
Bongo	46	47	BB33	25 - BB	24.04.2022	03:00	54.96067	15.25683	44	00:05
CTD	48	48	BB01	25 - BB	25.04.2022	08:59	55.45867	14.75083	67	00:05
Bongo	47	48	BB01	25 - BB	25.04.2022	09:07	55.45950	14.75250	63	00:10
Bongo	48	49	BB02	25 - BB	25.04.2022	10:10	55.61400	14.75033	66	00:10
CTD	49	49	BB02	25 - BB	25.04.2022	10:22	55.62383	14.74983	66	00:05
WS-CTD	9	49	BB02	25 - BB	25.04.2022	10:26	55.62450	14.74933	65	00:09
CTD	50	50	BB03	25 - BB	25.04.2022	11:34	55.62467	14.99900	74	00:05
Bongo	49	50	BB03	25 - BB	25.04.2022	11:42	55.62533	15.01483	69	00:10
Bongo	50	51	BB04	25 - BB	25.04.2022	12:38	55.62683	15.24250	72	00:09
CTD	51	51	BB04	25 - BB	25.04.2022	12:48	55.62583	15.24417	72	00:06
CTD	52	52	BB05	25 - BB	25.04.2022	13:47	55.62450	15.49983	67	00:07
Bongo	51	52	BB05	25 - BB	25.04.2022	13:55	55.62583	15.50817	67	00:07
WS-CTD	10	53	BB05	25 - BB	25.04.2022	13:58	55.62917	15.51167	67	00:10
Bongo	52	53	BB06	25 - BB	25.04.2022	14:59	55.62400	15.73667	68	00:09
CTD	53	53	BB06	25 - BB	25.04.2022	15:09	55.62483	15.74683	68	00:07
CTD	54	54	BB06	25 - BB	25.04.2022	16:06	55.62500	16.00000	74	00:06
Bongo	53	54	BB07	25 - BB	25.04.2022	16:14	55.62483	15.99717	74	00:09
Bongo	54	55	BB08	25 - BB	25.04.2022	17:15	55.78250	16.00083	62	00:08
CTD	55	55	BB08	25 - BB	25.04.2022	17:26	55.79083	16.25000	62	00:04
CTD	56	56	BB09	25 - BB	25.04.2022	18:13	55.79250	16.26217	60	00:05
Bongo	55	56	BB09	25 - BB	25.04.2022	18:19	55.79200	16.26367	59	00:07
WS-CTD	11	56	BB09	25 - BB	25.04.2022	18:30	55.79117	16.48567	60	00:08
Bongo	56	57	BB11	25 - BB	25.04.2022	19:21	55.79050	16.50000	57	00:08
CTD	57	57	BB11	25 - BB	25.04.2022	19:32	55.62500	16.51567	56	00:04
CTD	58	58	BB12	25 - BB	25.04.2022	20:34	55.62467	16.48333	62	00:06
Bongo	57	58	BB12	25 - BB	25.04.2022	20:41	55.62450	16.25100	62	00:09
Bongo	58	59	BB10	25 - BB	25.04.2022	21:34	55.62550	16.24950	74	00:13
CTD	59	59	BB10	25 - BB	25.04.2022	21:51	55.45683	16.49917	74	00:05
CTD	60	60	BB13	25 - BB	25.04.2022	23:14	55.45667	16.48600	5	00:04
Bongo	59	60	BB13	25 - BB	25.04.2022	23:20	55.45683	16.24917	58	00:07
Bongo	60	61	BB14	25 - BB	26.04.2022	00:12	55.45683	16.24917	74	00:11
CTD	61	61	BB14	25 - BB	26.04.2022	00:26	55.45917	16.24867	74	00:06
CTD	62	62	BB15	25 - BB	26.04.2022	01:24	55.45850	15.99933	82	00:07
Bongo	61	62	BB15	25 - BB	26.04.2022	01:33	55.45767	15.97967	82	00:12
Bongo	62	6	BB16	25 - BB	26.04.2022	02:28	55.45883	15.75400	85	00:12
CTD	63	63	BB16	25 - BB	26.04.2022	02:42	55.45800	15.75200	85	00:08
CTD	64	64	BB17	25 - BB	26.04.2022	03:42	55.45767	15.50050	85	00:07
Bongo	63	64	BB17	25 - BB	26.04.2022	03:50	55.45783	15.49917	85	00:11
Bongo	64	65	BB18	25 - BB	26.04.2022	04:46	55.45817	15.25367	89	00:12
CTD	65	65	BB18	25 - BB	26.04.2022	05:00	55.45817	15.25233	90	00:08

CTD	66	66	BB19	25 - BB	26.04.2022	06:12	55.45883	15.00033	78	00:06
Bongo	65	66	BB19	25 - BB	26.04.2022	06:18	55.45767	15.00550	78	00:12
Bongo	66	67	BB20	25 - BB	26.04.2022	07:20	55.30117	14.99900	72	00:10
CTD	67	67	BB20	25 - BB	26.04.2022	07:32	55.29217	15.00100	72	00:06
CTD	68	68	BB21	25 - BB	26.04.2022	08:35	55.29183	15.28450	88	00:05
WS-CTD	12	68	BB21	25 - BB	26.04.2022	08:45	55.29133	15.28383	88	00:10
Bongo	67	68	BB21	25 - BB	26.04.2022	08:58	55.29167	15.28500	89	00:13
Bongo	68	69	BB22	25 - BB	26.04.2022	09:47	55.29150	15.49567	92	00:12
CTD	69	69	BB22	25 - BB	26.04.2022	10:02	55.28450	15.49917	93	00:06
CTD	70	70	BB23	25 - BB	26.04.2022	10:58	55.29117	15.75067	95	00:07
Bongo	69	70	BB23	25 - BB	26.04.2022	11:06	55.29100	15.77050	95	00:14
Bongo	70	71	BB24	25 - BB	26.04.2022	12:02	55.29200	16.00350	89	00:14
CTD	71	71	BB24	25 - BB	26.04.2022	12:18	55.29117	16.00383	88	00:08
CTD	72	72	BB25	25 - BB	26.04.2022	13:17	55.29100	16.24900	74	00:06
WS-CTD	13	72	BB25	25 - BB	26.04.2022	13:25	55.29117	16.26567	74	00:11
Bongo	71	72	BB25	25 - BB	26.04.2022	13:38	55.29233	16.25000	73	00:10
Bongo	72	73	BB26	25 - BB	26.04.2022	14:33	55.30550	16.49983	63	00:08
CTD	73	73	BB26	25 - BB	26.04.2022	14:44	55.29200	16.50000	61	00:07
CTD	74	74	BB27	25 - BB	26.04.2022	15:46	55.12500	16.48333	51	00:04
Bongo	73	74	BB27	25 - BB	26.04.2022	15:51	55.12450	16.48950	50	00:07
Bongo	74	75	BB28	25 - BB	26.04.2022	16:43	55.12633	16.25400	77	00:10
CTD	75	75	BB28	25 - BB	26.04.2022	16:56	55.12533	16.25050	79	00:05
CTD	76	76	BB29	25 - BB	26.04.2022	17:53	55.12517	16.00000	86	00:06
Bongo	75	76	BB29	25 - BB	26.04.2022	18:00	55.12450	15.99933	86	00:11
Bongo	76	77	BB36	25 - BB	26.04.2022	19:03	54.96917	16.00033	75	00:11
CTD	77	77	BB36	25 - BB	26.04.2022	19:18	54.95900	16.00017	73	00:05
WS-CTD	14	77	BB36	25 - BB	26.04.2022	19:25	54.95800	15.99917	73	00:08
CTD	78	78	BB37	25 - BB	26.04.2022	20:26	54.95833	16.24950	49	00:04
Bongo	77	78	BB37	25 - BB	26.04.2022	20:32	54.95717	16.24200	49	00:06
Bongo	78	79	BB38	25 - BB	26.04.2022	21:49	54.79650	16.00150	51	00:08
CTD	79	79	BB38	25 - BB	26.04.2022	22:00	54.79150	15.99967	51	00:04
CTD	80	80	BB45	25 - BB	26.04.2022	23:23	54.62483	15.75017	59	00:04
Bongo	79	80	BB45	25 - BB	26.04.2022	23:28	54.62650	15.74983	59	00:09
Bongo	80	81	BB39	25 - BB	27.04.2022	00:30	54.78500	15.74933	71	00:10
CTD	81	81	BB39	25 - BB	27.04.2022	00:43	54.79433	15.73383	71	00:06
CTD	82	82	BB35	25 - BB	27.04.2022	01:47	54.95833	15.75150	80	00:07
Bongo	81	82	BB35	25 - BB	27.04.2022	01:56	54.95900	15.74750	80	00:11
Bongo	82	83	BB30	25 - BB	27.04.2022	02:58	55.11050	15.74933	89	00:13
CTD	83	83	BB30	25 - BB	27.04.2022	03:15	55.12383	15.74983	89	00:07
MN-Maxi	1	84	BB23	25 - BB	27.04.2022	08:05	55.29167	15.74800	95	
MN-Maxi	2	84	BB23	25 - BB	27.04.2022	09:14	55.29167	15.74733	95	
WS-CTD	15	84	BB23	25 - BB	27.04.2022	10:12	55.29133	15.74867	95	00:12
WS-CTD	16	84	BB23	25 - BB	27.04.2022	11:37	55.29133	15.74900	95	00:07
Apstein	1	84	BB23	25 - BB	27.04.2022	12:12	55.29133	15.74917	95	00:17
Apstein	2	84	BB23	25 - BB	27.04.2022	12:32	55.29150	15.74933	95	00:15
Apstein	3	84	BB23	25 - BB	27.04.2022	12:48	55.29150	15.74917	95	00:15
WP2-100	1	84	BB23	25 - BB	27.04.2022	13:09	55.29167	15.74950	95	00:08
WP2-100	2	84	BB23	25 - BB	27.04.2022	13:19	55.29150	15.74917	95	00:08
WP2-100	3	84	BB23	25 - BB	27.04.2022	13:30	55.29150	15.74900	95	00:07

MN-Maxi	3	84	BB23	25 - BB	27.04.2022	13:59	55.29167	15.74983	95	00:43
MN-Maxi	4	84	BB23	25 - BB	27.04.2022	15:13	55.29150	15.74983	95	00:45
WP2-200	1	84	BB23	25 - BB	27.04.2022	16:29	55.29117	15.74867	95	00:10
WP2-200	2	84	BB23	25 - BB	27.04.2022	16:40	55.29133	15.74867	95	00:07
WP2-200	3	84	BB23	25 - BB	27.04.2022	16:49	55.29150	15.74867	95	00:07
WP2-200	4	84	BB23	25 - BB	27.04.2022	16:57	55.29167	15.74883	95	00:07
MN-Maxi	5	84	BB23	25 - BB	27.04.2022	10:01	55.29150	15.74733	95	10:39
MN-Maxi	6	84	BB23	25 - BB	27.04.2022	21:14	55.29150	15.74967	95	00:36
Bongo	83	84	BB23	25 - BB	27.04.2022	22:29	55.29167	15.76883	95	00:15
Bongo	84	84	BB23	25 - BB	27.04.2022	23:00	55.29167	15.76883	95	00:15
MN-Maxi	7	84	BB23	25 - BB	28.04.2022	02:00	55.29150	15.74983	95	00:37
MN-Maxi	8	84	BB23	25 - BB	28.04.2022	03:06	55.29200	15.74833	95	00:34
JFT	1	85	BB23	25 - BB	28.04.2022	08:26	55.29583	15.75150	95	00:30
JFT	2	86	BB25	25 - BB	28.04.2022	10:47	55.28983	16.27217	75	00:30
JFT	3	87	BB36	25 - BB	28.04.2022	14:00	54.95183	15.98183	72	00:30
JFT	4	88	BB39	25 - BB	28.04.2022	15:41	54.85183	15.87400	95	00:30
JFT	5	89	BB41	25 - BB	29.04.2022	08:19	54.78633	15.14417	65	00:29

Notes: Gear abbreviations: CTD = probe measuring salinity, temperature, oxygen concentration and depth. WS-CTD = Rosette water sampler coupled with CTD probe. MN-Maxi = large multinet. MN-Maxi (mesh size 300 µm), Bongo (150, 335 and 500 µm), Apstein (50 µm) and WP2 (100, 200 µm) represent different plankton nets. JFT = “Jungfischtrawl”, pelagic trawl net with cod end mesh size of 0.5 cm. Times refer to “board time”, representing Central European Time (CET). Latitude and longitude are given in decimal degrees. The electronic version of this list is permanently available via the GEOMAR OSIS data portal under the link: https://portal.geomar.de/metadata/leg/show/359858 .

7 Data and Sample Storage and Availability

All data obtained during the cruise have been backed up on a GEOMAR virtual drive that is backed up daily. Additional backup copies of all data are stored on different hard drives stored in different locations. Paper protocols filled out during the cruise were entered electronically continuously throughout the cruise, and thus fall under the electronic back-up scheme, but have also been conserved as hard copies to resolve possible data entry errors later on if needed.

All cruise meta-data – including output of the onboard DSHIP-System - have been entered in the GEOMAR Ocean Science Information System (OSIS) (https://portal.geomar.de/osis), managed by the Kiel Data Management Team (KDMT) and intended for permanent archiving of such data. The data are freely available via the link https://portal.geomar.de/metadata/leg/show/359858 (keyword “AL571”).

All hydrographic (CTD) data will be submitted to the ICES database (https://www.ices.dk/data/) within one year from the cruise. Moreover, the KDMT team will assist with the publication of data in the public data repository PANGAEA (https://www.pangaea.de). Depending on the data set, some of the data are intended for specific publications, and will be published openly in Pangaea only after the appearance of the underlying peer-review article. In these cases, please contact the person responsible for the data in case earlier access to the data is desired (Table 7.1).

All samples obtained during the cruise were labelled on board with a barcoding scheme, allowing for clear identification and connectivity to the station and sample metadata. The samples intended for long-term storage were then professionally archived immediately after the cruise in the GEOMAR Biosample Information System (BIS) by the GEOMAR Biosample management team. This included the formalin conserved zooplankton samples, otoliths (conserved dried at room temperature) and frozen samples (-20°C and -80°C). These samples are stored in designated, monitored storage areas and freezers. All labelling, archiving and storage was conducted according the "SOP Biosample management for samples from expeditions and cruises at GEOMAR - How to pre sample cruise/expedition biosamples to generate FAIR and Nagoya compliant entries in the GEOMAR biosample management system BIS", DOI: https://zenodo.org/record/7003999#.YwcM4efgphE .

Table 7.1 Overview of data availability and persons responsible for specific data sets.

Type	Database	Available	Free Access	Contact
Hydrography (CTD data)	ICES database	Publicly by April 2023, earlier on request (see contact e-mail).	By April 2023	jdierking@geomar.de
Fishery data, fish and and food web sampling data	OSIS; PANGAEA	Publicly at time of acceptance of the underlying peer-reviewed publication; earlier via request (see contact e-mail).		jdierking@geomar.de
Ichthyo- and zooplankton data	OSIS; PANGAEA	See above.		fmittermayer@geomar.de
Hydroacoustic data	OSIS; PANGAEA	See above.		jdierking@geomar.de
Microbial community sampling samples		Inquire with collaboration partner (see contact e-mail).		Dr. David Needham, GEOMAR, dneedham@geomar.de
Phytoplankton samples		Inquire with collaboration partner (see contact e-mail).		Dr. Jörg Dutz, IOW, joerg.dutz@io-warnemuende.de

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9 **Appendix -** Selected Pictures of Shipboard Operations

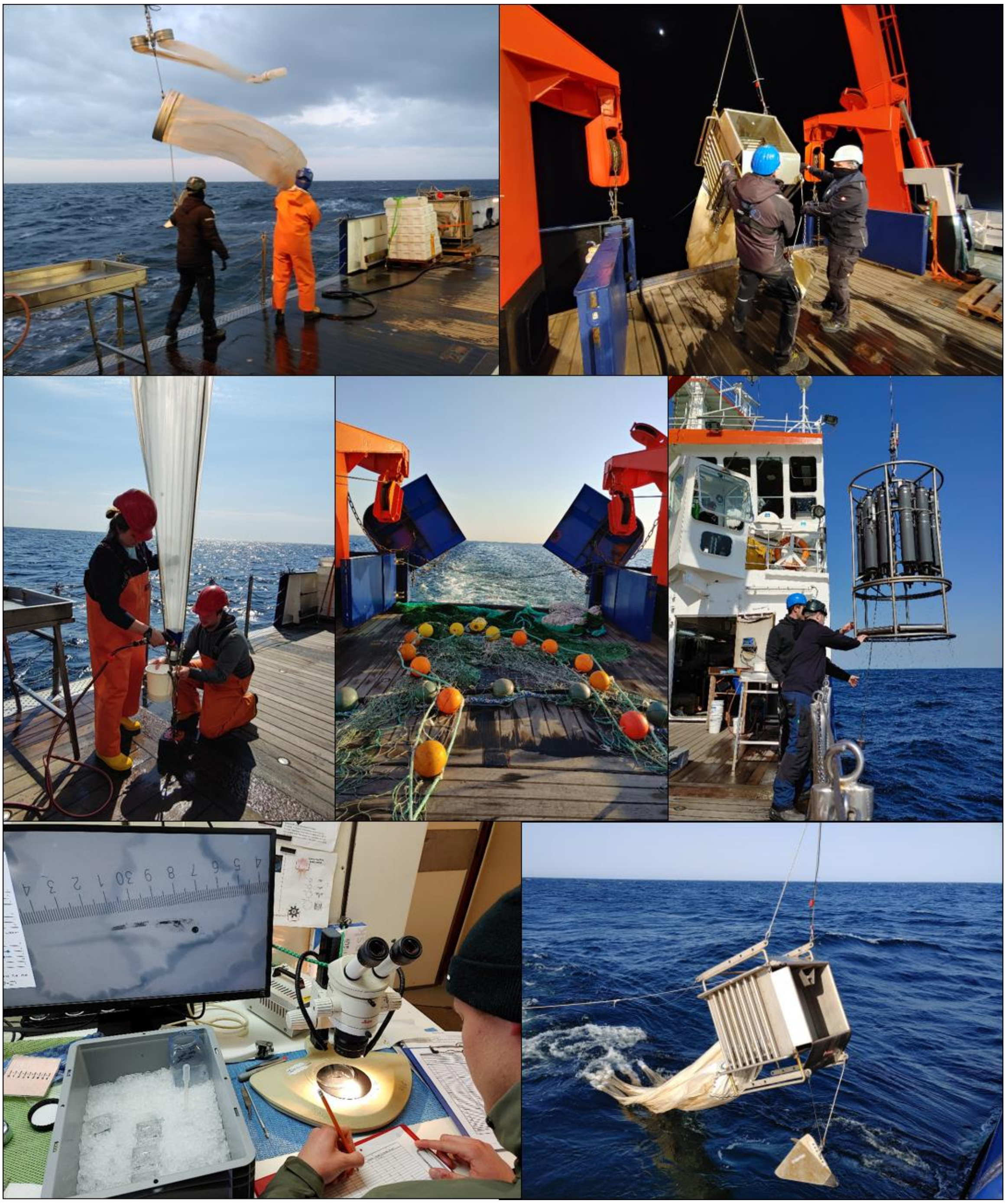

Fig. 9.1 Representative impressions of Baltic Sea Integrative Long-Term Monitoring Cruises. Top left to right: Bongo net deployment; multinet deployment during 24-hour sampling. Center left to right: Apstein plankton net retrieval; Fishery trawl net waiting for the next deployment; retrieval of the rosette water sampler. Bottom left to right: plankton sorting of the 500 µm net Bongo nets, with a cod larva visible on screen; retrieval of the multinet. Photos: J. Dierking