ALKOR - Berichte

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

Cruise No. AL553

April 15th – April 24th 2021
Kiel (Germany) – Kiel (Germany)
BALTIC APRIL 2021

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1 Cruise Summary

1.1 Summary in English

The multidisciplinary cruise AL553 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. Cruises contributing to this time series are characterized by the integration of biological and oceanographic sampling and observations, to support the analysis of changes in planktonic communities, fish populations and food webs in response to environmental fluctuations and climate change as well as anthropogenic pressures.

The main spatial focus of AL553 lay on the Bornholm Basin (central Baltic Sea), as main spawning area of Baltic cod. Additional work focused on the western Baltic Sea, where processes related to cod spawning and recruitment are important current research questions. The specific investigations included a detailed hydrological survey (oxygen, salinity, temperature) of the entire cruise area, plankton surveys (zoo- and ichthyoplankton including jellyfish) to determine the abundance and the vertical and horizontal distribution of species, and pelagic trawl fishery. The latter served to obtain single fish data (size, weight, organ weights) and a range of different samples (gonads, livers, stomachs, muscle tissue, otoliths) of the fish species cod, whiting, sprat and herring, as well as flatfishes, which provide the foundation for individual-level genetic and ecological analyses back on land. The abundance and distribution of fishes was also assessed continuously over the duration of the cruise with hydroacoustic methods. Additional cruise components included (i) vertically resolved phytoplankton and zooplankton sampling for studies of plankton phenology (collaboration with Dr. Jörg Dutz and Dr. Carolin Paul, Leibniz Institute for Baltic Sea Research Warnemünde, IOW), (ii) 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 (iii) the sampling of blue green algae (genus *Ostreococcus*) and their viruses (collaboration with Dr. Luisa Listmann and Prof. Elisa Schaum, University Hamburg).

Due to Covid-19 related restrictions, AL553 had to take place with only 7 instead of 12 scientist berths. While this led to a reduction in the number of fishing days, all main objectives of the cruise were nevertheless fulfilled. The resulting data- and sample sets support ongoing projects in the Research Unit Marine Evolutionary Ecology at GEOMAR and multiple international collaborations.

1.2 Deutsche Zusammenfassung

Mit der multidisziplinären Fahrt AL553 wurde eine der besten verfügbaren Langzeitdatenreihen ("Baltic Sea integrative long-term data series", 1987 bis heute) über die Zusammensetzung und Funktionsweise der Ökosysteme der tieferen Becken der Ostsee fortgeführt. Ausfahrten im Rahmen dieser Zeitreihe zeichnen sich durch die Integration von biologischen und ozeanographischen Probenahmen und Beobachtungen aus, um so das Verständnis von Veränderungen in planktonischen Gemeinschaften, Fischpopulationen und Nahrungsnetzen in Abhängigkeit von kurzfristigen Schwankungen der Umweltbedingungen und langfristigem Klimawandel, sowie von anthropogenen Einflüssen, zu verbessern.

Der räumliche Schwerpunkt von AL553 lag auf dem Bornholm-Becken (zentrale Ostsee), dem Hauptlaichgebiet des Ostseedorsches. Weitere Arbeiten konzentrierten sich auf die westliche Ostsee, wo Prozesse im Zusammenhang mit dem Fortpflanzungserfolg des Dorsches wichtige aktuelle Forschungsfragen darstellen. Zu den spezifischen Untersuchungen gehörten eine detaillierte hydrologische Aufnahme (Sauerstoff, Salzgehalt, Temperatur) des gesamten Fahrtgebietes, Planktonuntersuchungen (Zoo- und Ichthyoplankton einschließlich Quallen) zur Bestimmung der Abundanz und der vertikalen und horizontalen Verteilung der Arten, sowie pelagische Schleppnetzfischerei. Letztere diente der Gewinnung von Einzelfischdaten (Größe, Gewicht, Organgewichte) und einer Reihe verschiedener Proben (Gonaden, Lebern, Mägen, Muskelgewebe, Otolithen) der Fischarten Dorsch, Wittling, Sprotte und Hering sowie Plattfischen, die die Grundlage für Individuen-basierte genetische und öklogische Analysen zurück an Land bilden. Die Abundanz und Verteilung von Fischen wurde über die gesamte Fahrtdauer mit hydroakustischen Methoden kontinuierlich erfasst. Weitere Bestandteile der Fahrt waren (i) vertikal aufgelöste Phytoplankton- und Zooplanktonprobennahmen zur Untersuchung der Planktonphänologie (Kollaboration mit Dr. Jörg Dutz und Dr. Carolin Paul, Leibniz-Institut für Ostseeforschung Warnemünde, IOW), (ii) die Beprobung von pelagischen Fischen und Planktongemeinschaften zur Untersuchung der Nahrungsökologie planktivorer Fische mit molekularen Metabarcoding-Ansätzen (Kollaboration mit Prof. Monika Winder, Universität Stockholm) und (iii) die Beprobung von Blaualgen (Gattung *Ostreococcus*) und deren Viren (Kollaboration mit Dr. Luisa Listmann und Prof. Elisa Schaum, Universität Hamburg).

Aufgrund von Einschränkungen im Zusammenhang mit Covid-19 musste die Ausfahrt mit sieben statt der normalen Anzahl von 12 Wissenschaftlern durchgeführt werden. Während die Zahl der Fischerei-Tage deswegen reduziert werden musste, wurden dennoch alle Hauptziele der Fahrt erreicht. Die resultierenden Daten- und Probensätze unterstützen laufende Projekte der Forschungseinheit Marine Evolutionsökologie am GEOMAR und mehrere internationale Kooperationen.

2 Participants

2.1 Scientific Party[1]

Name	Discipline	Institution[1]
Dr. Jan Dierking	Marine Evolutionary Ecology (Chief Scientist)	GEOMAR
Hendrik Hampe	Technician	GEOMAR
Dr. Felix Mittermayer	Marine Evolutionary Ecology/Postdoc	GEOMAR
Dr. Elvita Eglite	Marine Evolutionary Ecology/Postdoc	GEOMAR
Alistair Wallace	Biological Oceanography/MSc Student	GEOMAR
Peter Hornetz	Fisheries Science/MSc Student	UHAM - IMF
Anton Hoeper	Fisheries Science /BSc Student	UHAM - IMF

[1]Reduced to seven instead of 12 scientists under Covid-19 regulations.
[2]Abbreviations explained under Section 2.2.

2.2 Participating Institutions

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

3 Research Program

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 anthropogenic changes, and has undergone strong hydrographic and biological shifts in the past decades.

Cruise AL553 extended a 35-year integrative long-term data series of the deep basins of the central Baltic Sea collected since 1987 by the GEOMAR Helmholtz Centre for Ocean Research and its predecessors IFM-GEOMAR Kiel and IFM Kiel. The specific spatial focus lay on the Bornholm Basin as most important spawning area of Baltic cod, but also included the western Baltic Sea (Figure 3.1), thus covering ICES subdivisions (SD) 22 and 25 (Figure 3.2).

The key characteristic of AL553 was the the integration of biological and oceanographic information, to allow the analysis of Baltic pelagic food webs and (fish) species across the Baltic Sea environmental gradient, and – in the context of other time series data - under changing environmental conditions and human exploitation patterns over time. In this context, the datasets and samples obtained during cruise AL553 contribute to numerous projects including the large-scale international project EU Horizon 2020 GoJelly and collaborations with the Technical University of Denmark, National Institute of Aquatic Resources (DTU Aqua), Stockholm University, the Leibniz Institute for Baltic Sea Research Warnemünde (IOW), and the University of Hamburg. Moreover, the cruise delivered samples and first data on western Baltic cod recruitment for the upcoming DAM funded SpaCeParti project (with member institutes Kiel University, GEOMAR and UHAM - IMF).

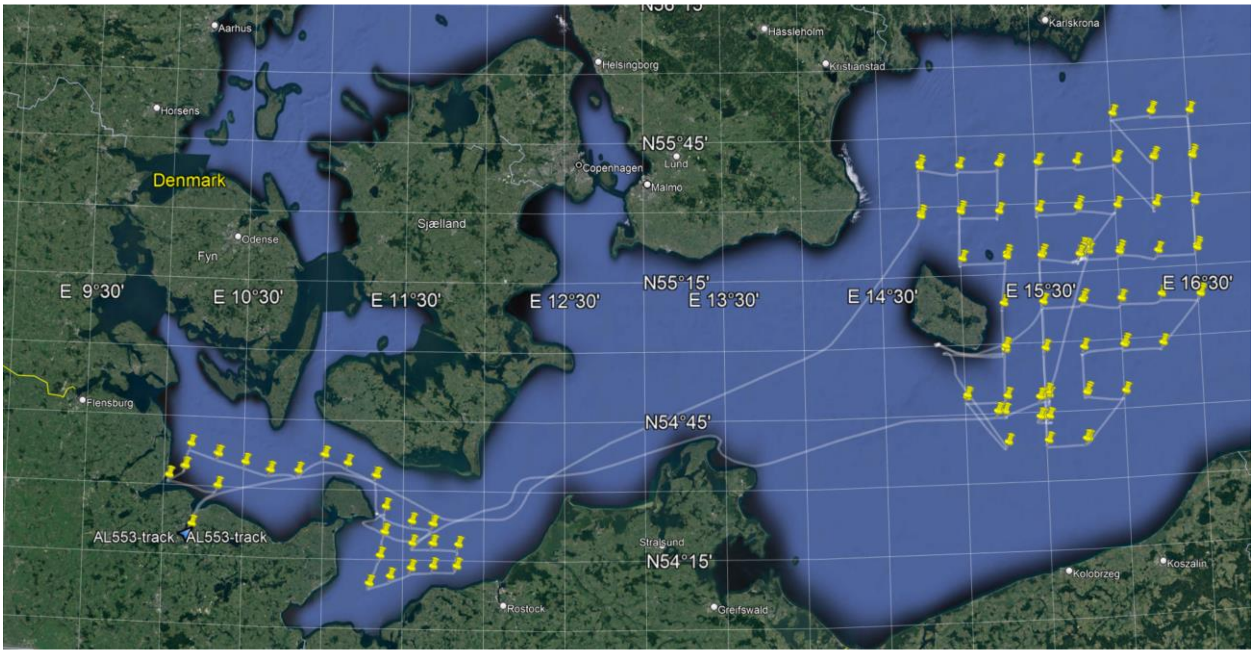

Figure 3.1 Cruise track of AL553, with stations indicated by yellow pins (Map produced in Google Earth).

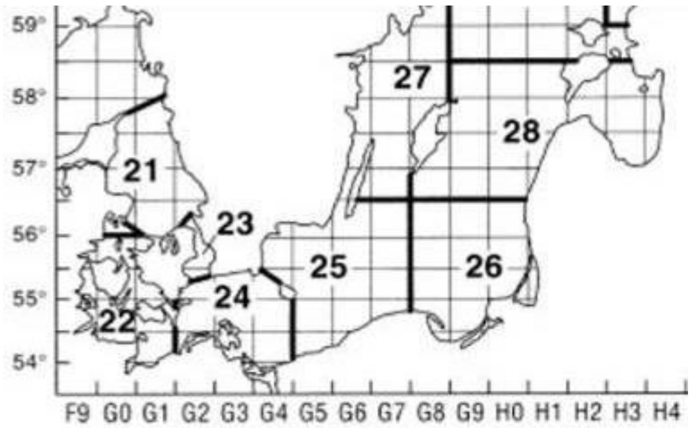

Figure 3.2 ICES subdivisions in the cruise area (Source: ICES). ICES SD22 corresponds to Kiel Bight (KB) and Mecklenburg Bight (MB) in the western Baltic Sea, and SD25 to Bornholm Basin (BB) in the central Baltic Sea, the two geographic areas covered by AL553.

Specific investigations during AL553 included (1) a detailed hydrographic survey (oxygen, salinity, temperature) (72 stations along the cruise track, with a focus on Bornholm Basin and the western Baltic, see Figure 3.1), (2) zoo- and ichthyoplankton surveys to determine the composition, abundance, vertical and horizontal distribution and nutritional status of species as well as patterns of plankton phenology (same 72 stations, Figure 3.1), (3) repeated 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 hauls (3 stations). The latter served firstly to determine size distributions, maturity status and length – weight relationships of the three dominant fish species in the pelagic systems of the central Baltic Sea, cod (*Gadus morhua*), herring (*Clupea harengus*) and sprat (*Sprattus sprattus*).

Secondly, various samples for more detailed analyses back on land were obtained, including cod otoliths, herring and sprat stomachs and whole samples for dietary analyses, and tissue samples of cod, flounder, whiting and other species for genetic and stable isotope analysis. In addition, hydroacoustic data were collected continuously along the cruise track for later analysis of fish abundance and distribution. Finally, additional work in the context of collaborations with external groups were (5) nutrient, phyto- and zooplankton sampling on the central station BB23, (6) sampling of zooplankton and adult planktivorous fishes for the assessment of fish feeding ecology with molecular methods (“metabarcoding”) and (7) sampling of marine microbes and viruses in Bornholm Basin.

4 Narrative of the Cruise[1]

RV ALKOR was loaded by the permanent crew on the days prior to the onset of the cruise. The scientific personnel then boarded on the morning of April 15, 2021 after completing the home quarantine under Covid-19 regulations, and ALKOR departed from the GEOMAR west shore pier at 08:00 am (all times board time).

After covering one station in Kiel Fjord, RV ALKOR transferred to Bornholm Basin (SD 25), where the standard survey grid ("Bongo grid" of 45 stations covered with Bongo net and CTD hauls) started on April 16 at 08:00. Weather conditions were challenging, with a strong standing swell from the northeast and increasing northeasterly winds peaking at force 7-8, requiring an interruption of operations from April 17 2:30 am to April 18 08:00. After resuming work under slightly improved weather conditions, the grid was successfully completed on April 20th. During the grid, sampling for blue green algae (genus *Ostreococcus*) and their viruses in the mixed surface layer was also carried out at four stations (collaboration with Dr. Luisa Listmann, UHAM - IMF), and additional zooplankton samples were taken for the assessment of the feeding ecology of fish larvae and planktivorous fishes with molecular metabarcoding (collaboration with Prof. Monika Winder, Stockholm University).

On April 20, the central deep station BB23 in Bornholm Basin was then 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 for oxygen measurements with the Winkler method for the calibration of oxygen probe measurements. This was followed by the detailed vertically and temporally resolved sampling of plankton communities by towed Multinet MAXI hauls at three time-points over a 24-hour period, covering the water column in 5 m depth layers. On April 21st, the only fisheries day of the cruise was carried out, luckily resulting in good catches (and thus sampling opportunities) of the main target species cod, herring and sprat.

Due to predicted gale force westerly winds in Bornholm Basin for April 22nd onwards, RV ALKOR then transferred back to the western Baltic, where winds (W force 5-7) were more manageable, and concluded the cruise with Bongo net and CTD hauls on the western Baltic Sea station grid on April 22nd – 23rd. Upon completion of the last station, RV ALKOR returned to the GEOMAR Westshore pier on April 23rd at 16:30, where the cruise officially ended on April 24th at 10:00 after a brief visit to the GEOMAR east shore pier to unload equipment and samples.

Table 4.1 Overview of gear deployments during AL553. Mesh sizes of all nets are given in brackets. For location designations (combination of ICES SD and abbreviated name), see Figure 3.2. 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	25 - BB	Total
CTD	12	13	47	72
WS-CTD	1		4	5
Bongo (150, 300, 500 µm)	11	13	49	73
MN Maxi (335 µm)			7	7
Apstein (50 µm)			3	3
WP2 (100µm)			3	3
JFT (0.5 cm)			3	3
Total	24	26	117	166

[1]Cruise under Covid-19 restrictions: the scientific crew size was limited to seven instead of 12, and the seven days prior to the cruise were spent in home quarantine. Moreover, a PCR test was carried out on the day prior to the cruise to ensure that all crew members tested negative for the Corona virus before boarding.

5 Preliminary Results

5.1 Ichthyo– and zooplankton sampling

Bongo net hauls (mesh sizes 150, 335 and 500 µm) covered Kiel Bight (11 hauls), Mecklenburg Bight (13 hauls) and Bornholm Basin (49 hauls) (Table 4.1). Fish larvae and jellyfish 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. Clearly visible is the much higher density of cod larvae in the western areas compared to low numbers in Bornholm Basin. This is generally consistent with low abundances of cod in Bornholm Basin observed on our spring cruises in previous years. It also fits the observation of a long-term, decadal scale shift in the reproductive period and the subsequent occurrence of cod larvae in this area from spring to summer. The high larvae numbers in the west are consistent with peak spawning of western Baltic cod earlier in the year also reported by previous studies.

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).

	Fish						
Area	Sprat	Flounder	Cod	Sculpin	Sandeel	Seasnail	Total
BB	588	417	5	7	2	2	1021
KB	61	111	23	4	9		208
MB	37	108	29	1	8		183
Total	686	636	57	12	19	2	1412

	Jellyfish				
Area	*Aurelia aurita*	*Cyanea capillata*	Hydromedusa	*Mnemiopsis leidyi*	Total
BB		113		3	116
KB	31	4	37	5	77
MB	6	2	2	6	16
Total	37	119	39	14	209

As to jellyfish, ephyrae (larvae) and small adults of scyphozoan jellyfish (*Aurelia aurita* and *Cyanea capillata*) were present in lower abundances (total n over the duration of the cruise = 209) compared to the same period in 2019 (AL521, n = 1550), but much higher than in 2018 (AL491, n = 10). A possible explanation may lie in the intermediate water temperatures in 2021 compared to the same periods in 2019 (warm) and 2018 (cold), and possible effects on the phenology of gelatinous zooplankton. The invasive combjelly *Mnemiopsis leidyi* was present only in low numbers and limited to the western Baltic Sea (n = 14).

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 three time-points over a 24-hour period on April 20 – 21 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 35 m – 75 m with little diurnal vertical variation) and fish larvae (e.g., sprat: mainly depth layers 0 – 30 m, with diurnal migration to the surface layers at night), in line with observations of past 24-hour multinet assessments.

5.2 Fishery

Pelagic fishery hauls were conducted on only one day in Bornholm Basin (3 hauls) (Table 4.1), due to challenging weather conditions during most of the cruise that prevented the deployment of fisheries gear. Catches of cod, herring and sprat occurred in sufficient quantities to conduct systematic sampling and measurements, whereas six other fish species were caught in low numbers (Table 5.2.1.)

Table 5.2.1 Fish catch composition for AL553. Single fish measurement and samples were taken for 172 cod and 23 whiting individuals. For herring and sprat, sub-samples were taken at each station. 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	36494	435.2
Clupea harengus	herring	2126	76.7
Gadus morhua	cod	659	189.8
Merlangius merlangus	whiting	23	4.2
Platichthys flesus	flounder	16	3.9
Alosa fallax	twait shad	3	0.1
Engraulis encrasicolus	anchovy	1	0.0
Rhinonemus cimbrius	four bearded rockling	1	0.1
Pollachius virens	saithe	1	0.1
Summe		39324	710.1

For cod, single fish data (length, weight, sex and maturity stage) and samples (otoliths, fin clips for genetic analysis) were obtained for 172 individuals (see Figure 5.2.2 for illustration). Length and weight were measured for an additional 487 individuals. In Bornholm Basin, the main spawning area of Baltic cod, the mean size of individuals had declined to 30.2 cm from 31.1 cm in 2019 and 32.9 cm in 2018 (Figure 5.2.1), and larger individuals >45 cm, which were frequently observed in past decades, were mostly absent from the population. These observations are consistent with temporal trends over past years, and represent a dramatic difference from size distributions in the 1980s and 1990s, when larger individuals were prevalent in the population.

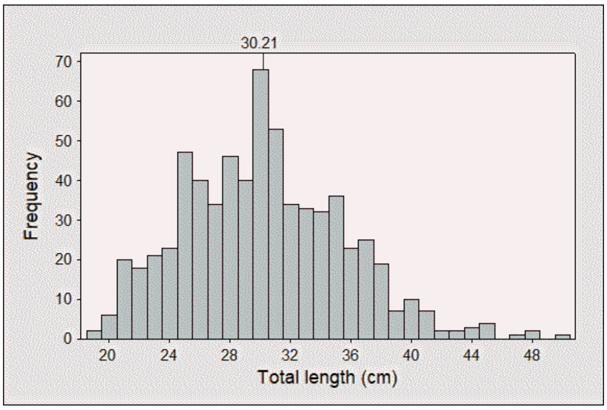

Figure 5.2.1 Length frequency distribution of cod sampled in SD25 during AL553 (n = 659). The mean size of individuals, 30.2 cm, is marked on the x-axis, and compares to 31.1 cm in 2019 and 32.9 cm in 2018.

Figure 5.2.2 Samples (otoliths, fin clips) and measures (total length, weight, gutted weight, liver and gonad weight) were taken from 172 cod individuals (illustrated here for a 38 cm female, maturity stage IV, with full stomach, from Bornholm Basin). Photo: S. Nickel

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.

5.3 Hydrography

CTD profiles were obtained with the ADM-CTD (72 stations) and the HYDROBIOS water sampler with attached CTD (5 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 taken with the water sampler, using the Winkler method.

Regarding the oxygen conditions, we encountered the typical situation in the central Baltic Sea, with hypoxic (< 2 ml/l) to anoxic (0 ml/l) conditions at depths below 70-75 m. Temperatures above the halocline were 4 – 5 °C compared to ~6 °C in 2019 and ~3 °C in 2018 during the same period of the year. On the eastern fringes of Bornholm Basin, salinity above the halocline was much higher than observed in previous years, likely related to upwelling along the basin wall after the long period of strong easterly winds prior and during the cruise. The differences in environmental parameters compared to the same time periods in previous cruises once again unscored the strong potential for fluctuations in environmental conditions from year to year, on top of any long-term changes that are taking place in the Baltic Sea.

5.4 Zooplankton predation by fish larvae in the Baltic Sea assessed with eDNA analysis (Prof. Monika 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 central role in marine food webs, as it controls production of predatory fish and at the same time feeds on zooplankton, with the potential to control 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 AL553 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 station. The stomach content 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. These data are put into perspective with the sample results from previous work (AL521 in 2019), and with the continuous monitoring of zooplankton and fish abundance 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.

5.5 Marine microbes and viruses of the Baltic Sea under climate change (Dr. Luisa Listmann, Prof. Elisa Schaum, Hamburg University, in collaboration with the Research Unit Marine Evolutionary Ecology at GEOMAR)

As part of this project on the ecological and evolutionary effects of different temperatures and salinities in the Baltic Sea on marine microbes and viruses, we aim to answer the following questions: a) From which regions of the Baltic Sea can we isolate blue green algae of the genus *Ostreococcus* and their viruses? b) How do the infection dynamics change in space and time, comparing samples of different cruises over the past years? To answer these questions, we took surface water samples in the Bornholm Basin at four stations along the cruise track of AL553. On board, water samples of all stations were filtered to below 0.45 µm and 2 µm. These samples are now used in the laboratory at the IMF to isolate viruses and picoplankton. To date, we were able to successfully isolate four new strains of *Ostreococcus mediterraneus* from two of the four sampled locations, and are in the process of isolating viruses.

5.6 "Can micro- or mesozooplankton control phytoplankton spring blooms in the Baltic Proper under climate warming?" (DFG Project 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), and dissolved inorganic nutrients were taken from the upper surface layer (1-10 m mix) and at 20 m depth 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 cooperation with the GEOMAR in late April (AL553) and May (AL556) is part of an enhanced monitoring program and will be analysed together with monitoring samplings from IOW cruises in March, early April and May from the same sample station. As microzooplankton is not regularly monitored in this area, the results of the project will give important new insights in the species composition and grazing relationships during spring blooms in the Central Baltic Sea.

5.7 Long-term population dynamics and decadal variation of copepods in the Bornholm Basin (Dr. Jörg Dutz, IOW)

Rationale: Complementary to its regular, seasonal monitoring programme of long-term changes of mesozooplankton in the western and central Baltic Sea since 1978, the IOW has run an additional, high frequency sampling programme (2-3 x month) in the Bornholm Basin since 2014. The goal is to achieve a detailed understanding of the population dynamics and recruitment of key copepod species. The large interannual variation in copepod biomass in the study area can have important implications for the utilization of primary production and the match between trophic levels in the sea. The conditions controlling variability in stock size and timing of the population growth are presently unclear and could reflect the interplay between spring-season weather, timing of seasonal warming and stratification, availability of phytoplankton and important life cycle events in the seasonal recruitment of copepods. In this context, the cruise provides critical data for the understanding of control of the recruitment of populations. It covers the important period between the spring phytoplankton bloom, which occurs usually in March, and the onset of the population growth initiated by associated production pulses of key copepod species.

Preliminary results: The composition of the zooplankton reflected the typical situation for late winter/early spring in the Bornholm Basin. The stocks of the calanoid and cyclopoid copepods were still low (total of 3800 Ind. m^{-3}). The community was dominated by rotifers (16900 Ind. m^{-3}) and Copelata (13300 Ind. m^{-3}), which accounted for 48.6 and 38.2 % of the zooplankton stock, respectively (Figure 5.7.1 a). Both groups were represented by a single species, *Synchaeta* spp. among the rotifers and *Fritillaria borealis* among the Copelata. Cladocera and diverse meroplankton groups were only a minor fraction of the stock. The copepods consisted mainly of nauplii and young copepodite stages, which reflects the burst in production associated with the spring bloom occurring in late March-early April. Two *Acartia* species (*Acartia bifilosa*, *Acartia longiremis*) accounted for the bulk of the calanoid copepods (33 and 44 %, respectively; Fig 5.7.1 b) followed by *Pseudocalanus* spp. (18%). Other species were rare.

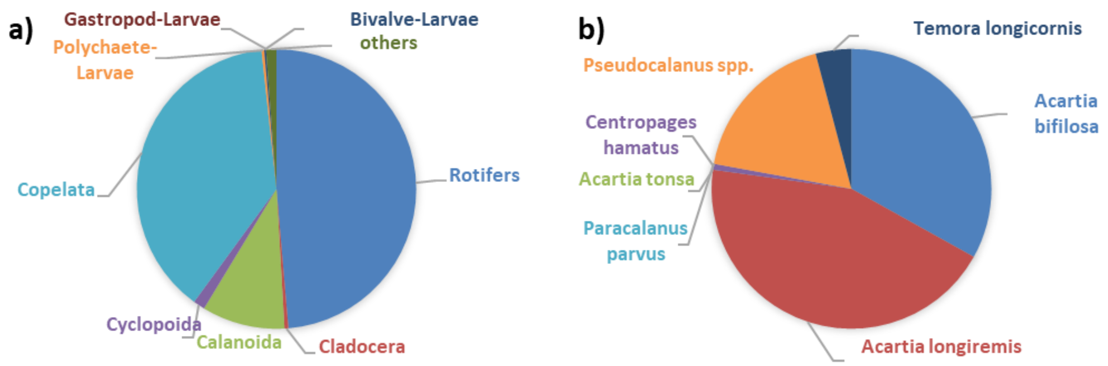

Figure 5.7.1 Composition of the mesozooplankton (a) and calanoid copepods (b) in Bornholm Basin in April 2021.

6 Station List

In total, 166 gear deployments took place during this cruise (see Table 4.1 for an overview, and Table 6.1 for the full station list). The electronic version of the list and additional cruise data are also permanently available via the GEOMAR OSIS data portal under the link: https://portal.geomar.de/metadata/cruise/show/358405 .

Table 6.1 Station list with all 166 gear deployments during of AL553. 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, Bongo, Apstein and WP2 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 degrees decimal minutes format.

Gear	Gear haul nr.	Station nr.	ICES SD	Station	Date	Time	Latitude	Longitude	Depth (m)	Duration (min)
CTD	1	1	22	GKW	4/15/2021	8:10	54°20.420	10°10.270	12	0:05
WS-CTD	1	1	22	GKW	4/15/2021	8:26	54°20.420	10°10.270	12	0:06
Drucktopf	1	2	25	BB01	4/16/2021	7:57	56°26.870	14°44.680	70	
Bongo	1	2	25	BB01	4/16/2021	8:21	55°27.530	14°44.940	70	0:08
CTD	2	2	25	BB01	4/16/2021	8:42	55°27.400	14°44.820	70	0:06
CTD	3	3	25	BB02	4/16/2021	9:58	55°37.450	14°44.990	69	0:05
Bongo	2	3	25	BB02	4/16/2021	10:10	55°37.740	14°44.840	65	0:10
Bongo	3	4	25	BB03	4/16/2021	11:26	55°37.120	15°00.040	76	0:08
CTD	4	4	25	BB03	4/16/2021	11:38	55°37.470	15°00.010	76	
CTD	5	5	25	BB04	4/16/2021	12:48	55°37.590	15°14.980	73	
Bongo	4	5	25	BB04	4/16/2021	12:58	55°37.590	15°15.100	73	0:08
Bongo	5	6	25	BB18	4/16/2021	14:21	55°26.800	15°14.450	92	0:11
CTD	6	6	25	BB18	4/16/2021	14:35	55°27.390	15°14.670	92	0:08
CTD	7	7	25	BB19	4/16/2021	15:37	55°27.390	14°59.930	78	0:06
Bongo	6	7	25	BB19	4/16/2021	15:47	55°27.560	14°59.890	78	0:10
Bongo	7	8	25	BB20	4/16/2021	17:10	55°16.970	14°59.630	72	0:09
CTD	8	8	25	BB20	4/16/2021	17:24	55°17.420	14°59.940	72	0:04
CTD	9	9	25	BB21	4/16/2021	18:34	55°17.500	15°16.830	89	0:06
Bongo	8	9	25	BB21	4/16/2021	18:43	55°17.540	15°16.810	90	0:13
Bongo	9	10	25	BB32	4/16/2021	20:03	55°07.040	15°14.970	62	0:08
CTD	10	10	25	BB32	4/16/2021	20:15	55°07.460	15°15.020	62	0:03
CTD	11	11	25	BB33	4/16/2021	21:23	54°57.530	15°15.090	44	0:03
Bongo	10	11	25	BB33	4/16/2021	21:29	54°57.590	15°15.090	44	0:06

Bongo	11	12	25	BB41	4/16/2021	22:41	54°47.000	15°15.110	67	0:09
CTD	12	12	25	BB41	4/16/2021	22:53	54°47.450	15°15.100	67	0:05
CTD	13	13	25	BB42	4/17/2021	0:06	54°47.520	14°59.890	60	0:05
Bongo	12	13	25	BB42	4/17/2021	0:17	54°47.640	14°59.860	60	0:07
Bongo	13	14	25	BB43	4/17/2021	1:57	54°37.250	15°14.600	59	0:08
CTD	14	14	25	BB43	4/17/2021	2:11	54°37.500	15°14.850	58	0:04
CTD	15	15	25	BB33	4/17/2021	9:17	54°57.480	15°14.950	43	0:05
WS-CTD	2	15	25	BB33	4/17/2021	9:31	54°57.510	15°14.970	44	0:08
Bongo	14	15	25	BB33	4/17/2021	9:45	54°57.600	15°15.020	44	0:07
Bongo	15	15	25	BB33	4/17/2021	10:00	54°57.990	15°15.000	44	0:05
Bongo	16	17	25	BB31	4/18/2021	7:52	55°06.970	15°29.770	67	0:09
CTD	16	17	25	BB31	4/18/2021	8:06	55°07.440	15°29.990	67	0:05
CTD	17	18	25	BB30	4/18/2021	9:05	55°07.450	15°44.810	89	0:08
Bongo	17	18	25	BB30	4/18/2021	9:17	55°07.560	15°44.780	89	0:13
Bongo	18	19	25	BB29	4/18/2021	10:21	55°06.830	15°59.470	86	0:10
CTD	18	19	25	BB29	4/18/2021	10:36	55°07.430	15°59.940	87	0:06
WS-CTD	3	19	25	BB29	4/18/2021	10:47	55°07.470	15°59.870	87	0:13
Bongo	19	20	25	BB28	4/18/2021	11:58	55°07.510	16°14.790	79	0:11
CTD	19	20	25	BB28	4/18/2021	12:13	55°07.950	16°15.260	79	0:06
CTD	20	21	25	BB27	4/18/2021	13:15	55°07.510	16°30.040	51	0:04
Bongo	20	21	25	BB27	4/18/2021	13:23	55°07.590	16°30.110	50	0:07
Bongo	21	22	25	BB37	4/18/2021	14:54	54°57.060	16°14.580	49	0:07
CTD	21	22	25	BB37	4/18/2021	15:04	54°57.450	16°14.880	49	0:05
CTD	22	23	25	BB36	4/18/2021	16:02	54°57.460	15°59.980	73	0:05
Bongo	22	23	25	BB36	4/18/2021	16:11	54°57.510	16°00.040	74	0:11
Bongo	23	24	25	BB35	4/18/2021	17:23	54°56.320	15°44.120	80	0:10
CTD	23	24	25	BB35	4/18/2021	17:37	54°57.340	15°44.170	80	0:05
CTD	24	25	25	BB39	4/18/2021	18:40	54°47.500	15°45.000	71	0:05
Bongo	24	25	25	BB39	4/18/2021	18:48	54°47.510	15°45.050	71	0:09
Bongo	25	26	25	BB38	4/18/2021	19:46	54°47.070	15°59.530	52	0:07
CTD	25	26	25	BB38	4/18/2021	19:56	54°47.400	15°59.830	52	0:04
CTD	26	27	25	BB45	4/18/2021	21:14	54°37.500	15°45.000	60	0:05
Bongo	26	27	25	BB45	4/18/2021	21:22	54°37.550	15°44.950	59	0:07
Bongo	27	28	25	BB44	4/18/2021	22:14	54°37.430	15°30.800	63	0:09
CTD	27	28	25	BB44	4/18/2021	22:27	54°37.500	15°29.940	63	0:05
CTD	28	29	25	BB40	4/18/2021	23:32	54°47.450	15°30.040	73	
Bongo	28	29	25	BB40	4/18/2021	23:42	54°47.490	15°30.030	73	0:09
Bongo	29	30	25	BB34	4/19/2021	0:51	54°56.830	15°30.170	76	0:10
CTD	29	30	25	BB34	4/19/2021	1:05	54°57.440	15°30.160	76	0:07
CTD	30	31	25	BB22	4/19/2021	3:15	55°17.470	15°30.010	93	0:07
Bongo	30	31	25	BB22	4/19/2021	3:26	55°17.530	15°30.040	93	0:11
Bongo	31	32	25	BB23	4/19/2021	4:29	55°16.880	15°44.210	95	0:10
CTD	31	32	25	BB23	4/19/2021	4:44	55°17.470	15°44.790	95	0:08
CTD	32	33	25	BB24	4/19/2021	5:49	55°17.480	16°00.000	88	0:07
Bongo	32	33	25	BB24	4/19/2021	6:00	55°17.590	15°59.960	88	0:12
Bongo	33	34	25	BB25	4/19/2021	7:03	55°16.860	16°14.450	74	0:10
CTD	33	34	25	BB25	4/19/2021	7:17	55°17.430	16°14.910	74	0:05
CTD	34	35	25	BB26	4/19/2021	8:14	55°17.480	16°29.810	61	
Bongo	34	35	25	BB26	4/19/2021	8:22	55°17.490	16°29.810	60	0:09

Bongo	35	36	25	BB13	4/19/2021	9:30	55°26.890	16°29.990	56	0:08
CTD	35	36	25	BB13	4/19/2021	9:41	55°27.480	16°29.970	58	0:04
CTD	36	37	25	BB12	4/19/2021	10:51	55°37.480	16°30.020	62	0:04
WS-CTD	4	37	25	BB12	4/19/2021	11:01	55°37.530	16°29.970	62	0:04
Bongo	36	37	25	BB12	4/19/2021	11:09	55°37.580	16°30.000	62	
Bongo	37	38	25	BB11	4/19/2021	12:15	55°46.870	16°29.880	58	0:07
CTD	37	38	25	BB11	4/19/2021	12:27	55°47.350	16°30.040	57	0:05
CTD	38	39	25	BB09	4/19/2021	13:24	55°47.480	16°14.920	60	0:05
Bongo	38	39	25	BB09	4/19/2021	13:32	55°47.530	16°14.930	60	0:07
Bongo	39	40	25	BB08	4/19/2021	14:35	55°47.090	15°59.650	62	0:08
CTD	39	40	25	BB08	4/19/2021	14:46	55°47.460	15°59.980	62	0:05
CTD	40	41	25	BB10	4/19/2021	16:08	55°37.490	16°14.930	74	0:05
Bongo	40	41	25	BB10	4/19/2021	16:16	55°37.520	16°14.920	73	0:08
Bongo	41	42	25	BB14	4/19/2021	17:30	55°26.950	16°14.820	74	0:10
CTD	41	42	25	BB14	4/19/2021	17:43	55°27.500	16°15.040	74	0:05
CTD	42	43	25	BB07	4/19/2021	19:03	55°37.240	16°00.490	74	0:06
Bongo	42	43	25	BB07	4/19/2021	19:12	55°37.310	16°00.510	74	0:09
Bongo	43	44	25	BB06	4/19/2021	20:16	55°26.920	15°45.070	69	0:08
CTD	43	44	25	BB06	4/19/2021	20:27	55°37.410	15°45.120	67	0:05
CTD	44	45	25	BB05	4/19/2021	21:22	55°37.490	15°30.090	67	0:06
Bongo	44	45	25	BB05	4/19/2021	21:30	55°37.630	15°30.110	67	0:08
Bongo	45	46	25	BB17	4/19/2021	22:40	55°26.980	15°29.430	85	0:10
CTD	45	46	25	BB17	4/19/2021	22:53	55°27.530	15°29.930	85	0:07
CTD	46	47	25	BB16	4/19/2021	23:53	55°27.530	15°44.840	85	0:06
Bongo	46	47	25	BB16	4/20/2021	0:03	55°27.580	15°44.820	85	0:11
Bongo	47	48	25	BB15	4/20/2021	1:07	55°26.970	15°59.840	83	0:11
CTD	47	48	25	BB15	4/20/2021	1:22	55°27.560	16°00.050	83	0:06
MN Maxi	1	49	25	BB23	4/20/2021	7:58	55°17.530	15°44.970	95	
MN Maxi	2	49	25	BB23	4/20/2021	9:02	55°17.430	15°44.880	95	
CTD	48	49	25	BB23	4/20/2021	12:04	55°17.480	15°44.950	95	0:08
Apstein	1	49	25	BB23	4/20/2021	12:15	55°17.490	15°44.990	95	0:16
Apstein	2	49	25	BB23	4/20/2021	12:35	55°17.490	15°44.980	95	0:15
Apstein	3	49	25	BB23	4/20/2021	12:53	55°17.480	15°44.990	95	0:16
WP2 100	1	49	25	BB23	4/20/2021	13:16	55°17.490	15°44.980	95	0:06
WP2 100	2	49	25	BB23	4/20/2021	13:26	55°17.490	15°44.970	95	0:06
WP2 100	3	49	25	BB23	4/20/2021	13:35	55°17.490	15°44.980	95	0:06
Bongo	48	49	25	BB23	4/20/2021	14:13	55°17.510	15°44.940	95	0:12
Bongo	49	49	25	BB23	4/20/2021	14:35	55°17.490	15°44.940	95	0:14
WS-CTD	5	49	25	BB23	4/20/2021	15:02	55°17.490	15°45.030	95	0:11
MN Maxi	3	49	25	BB23	4/20/2021	16:00	55°17.460	15°44.930	95	0:40
MN Maxi	4	49	25	BB23	4/20/2021	17:07	55°17.460	15°44.930	95	0:33
MN Maxi	5	49	25	BB23	4/20/2021	23:28	55°17.420	15°44.640	95	0:41
MN Maxi	6	49	25	BB23	4/21/2021	0:38	55°17.950	15°48.140	95	0:36
MN Maxi	7	49	25	BB23	4/21/2021	1:29	55°17.430	15°44.610	95	0:42
JFT	1	50	25	BB40	4/21/2021	8:08	54°42.740	15°30.630	68	0:30
JFT	2	51	25	BB40	4/21/2021	10:22	54°47.320	15°30.820	73	0:32
JFT	3	52	25	BB43	4/21/2021	12:52	54°44.160	15°14.000	65	0:30
Bongo	50	53	22	GS20	4/22/2021	11:58	54°25.100	11°23.050	19	0:02
CTD	49	53	22	GS20	4/22/2021	12:06	54°25.150	11°22.910	18	0:03

CTD	50	54	22	GS21	4/22/2021	12:45	54°19.720	11°22.550	20	0:03
Bongo	51	54	22	GS21	4/22/2021	12:52	54°19.740	11°22.590	21	0:02
Bongo	52	55	22	GS22	4/22/2021	13:28	54°14.570	11°21.300	20	0:03
CTD	51	55	22	GS22	4/22/2021	13:35	54°14.640	11°20.900	20	0:03
CTD	52	56	22	GS23	4/22/2021	14:17	54°08.580	11°17.130	25	0:04
Bongo	53	56	22	GS23	4/22/2021	14:24	54°08.520	11°16.990	25	0:03
Bongo	54	57	22	GS24	4/22/2021	15:00	54°10.110	11°24.940	23	0:03
CTD	53	57	22	GS24	4/22/2021	15:08	54°10.170	11°24.680	23	0:03
CTD	54	58	22	GS25	4/22/2021	15:42	54°11.990	11°32.540	24	0:03
Bongo	55	58	22	GS25	4/22/2021	15:48	54°11.990	11°32.530	24	0:03
Bongo	56	59	22	GS32	4/22/2021	16:23	54°12.420	11°40.860	24	0:03
CTD	55	59	22	GS32	4/22/2021	16:30	54°12.470	11°40.610	25	0:02
CTD	56	60	22	GS33	4/22/2021	17:04	54°12.520	11°49.420	21	0:02
Bongo	57	60	22	GS33	4/22/2021	17:09	54°12.520	11°49.420	21	0:02
Bongo	58	61	22	GS34	4/22/2021	17:44	54°17.190	11°50.250	22	0:04
CTD	57	61	22	GS34	4/22/2021	17:50	54°17.190	11°99.910	22	0:02
CTD	58	62	22	GS31	4/22/2021	18:32	54°17.430	11°40.570	25	0:03
Bongo	59	62	22	GS31	4/22/2021	18:37	54°17.420	11°40.520	25	0:03
Bongo	60	63	22	GS26	4/22/2021	19:10	54°17.370	11°33.180	24	0:02
CTD	59	63	22	GS26	4/22/2021	19:15	54°17.380	11°32.840	24	0:03
CTD	60	64	22	GS30	4/22/2021	19:57	54°21.650	11°40.630	25	0:03
Bongo	61	64	22	GS30	4/22/2021	20:03	54°21.670	11°40.480	25	0:02
Bongo	62	65	22	GS27	4/22/2021	20:35	54°22.120	11°32.960	24	0:03
CTD	61	65	22	GS27	4/22/2021	20:42	54°22.160	11°32.650	24	0:03
CTD	62	66	22	GS19	4/23/2021	7:59	54°31.870	11°19.290	29	0:04
Bongo	63	66	22	GS19	4/23/2021	8:06	54°31.880	11°19.290	29	0:04
Bongo	64	67	22	GS18	4/23/2021	8:51	54°34.440	11°08.750	27	0:03
CTD	63	67	22	GS18	4/23/2021	8:57	54°34.510	11°08.350	27	0:03
CTD	64	68	22	GS17	4/23/2021	9:36	54°36.190	10°59.950	36	0:03
Bongo	65	68	22	GS17	4/23/2021	9:42	54°36.170	10°59.730	28	0:02
Bongo	66	69	22	GS15	4/23/2021	10:24	54°32.540	10°50.300	20	0:02
CTD	65	69	22	GS15	4/23/2021	10:29	54°32.600	10°49.980	20	0:03
CTD	66	70	22	GS12	4/23/2021	11:24	54°32.620	10°39.520	19	0:02
Bongo	67	70	22	GS12	4/23/2021	11:28	54°32.580	10°39.460	19	0:02
Bongo	68	71	22	GS09	4/23/2021	12:03	54°34.120	10°30.220	18	0:02
CTD	67	71	22	GS09	4/23/2021	12:09	54°34.180	10°29.980	18	0:03
CTD	68	72	22	GS06	4/23/2021	12:52	54°35.700	10°19.990	16	0:03
Bongo	69	72	22	GS06	4/23/2021	13:02	54°35.790	10°19.570	17	0:02
Bongo	70	73	22	GS03	4/23/2021	13:43	54°37.690	10°09.670	22	0:02
CTD	69	73	22	GS03	4/23/2021	13:48	54°37.790	10°09.310	22	0:03
CTD	70	74	22	GS02	4/23/2021	14:21	54°32.950	10°07.540	21	0:03
Bongo	71	74	22	GS02	4/23/2021	14:27	54°32.940	10°07.440	22	0:03
Bongo	72	75	22	GS01	4/23/2021	14:53	54°30.920	10°01.680	27	0:03
CTD	71	75	22	GS01	4/23/2021	14:58	54°30.800	10°01.240	27	0:04
CTD	72	76	22	GS07	4/23/2021	16:06	54°28.940	10°19.850	19	0:03
Bongo	73	76	22	GS07	4/23/2021	16:13	54°28.930	10°19.750	19	0:02

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. In addition, data are stored on different hard drives 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), 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/cruise/show/358405 (keyword "AL553").

We aim to ultimately make all data accumulated during the cruise publicly available. All hydrographic (CTD) data will be submitted to the ICES database within one year from the cruise. Moreover, the KDMT team will assist with the publication of data in the public data repository PANGAEA to provide long-term archiving and access to the data. Depending on the data set, some of the data are intended for specific publications, and will be published openly with 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, and all samples intended for longer-term storage were professionally archived immediately after the cruise. This includes formalin conserved samples for long-term storage, and frozen samples (-20°C and -80°C) currently conserved in freezer rooms at GEOMAR.

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 2022, earlier on request (see contact e-mail).	By April 2022	jdierking@geomar.de
Fishery data, fish and and food web sampling data	PANGAEA	Publicly at time of acceptance of the underlying peer-reviewed publication; alternatively via request (see contact e-mail).		jdierking@geomar.de
Ichthyoplankton data	PANGAEA	See above.		cclemmesen@geomar.de
Hydroacoustic data	PANGAEA	See above.		jdierking@geomar.de
Phytoplankton community sampling		Inquire with collaboration partner (see contact e-mail).		luisa.listmann@uni-hamburg.de
eDNA sampling		Inquire with collaboration partner (see contact e-mail).		monika.winder@su.se

8 Acknowledgements

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9 Appendices

Appendix 9.1 Selected Pictures of Shipboard Operations

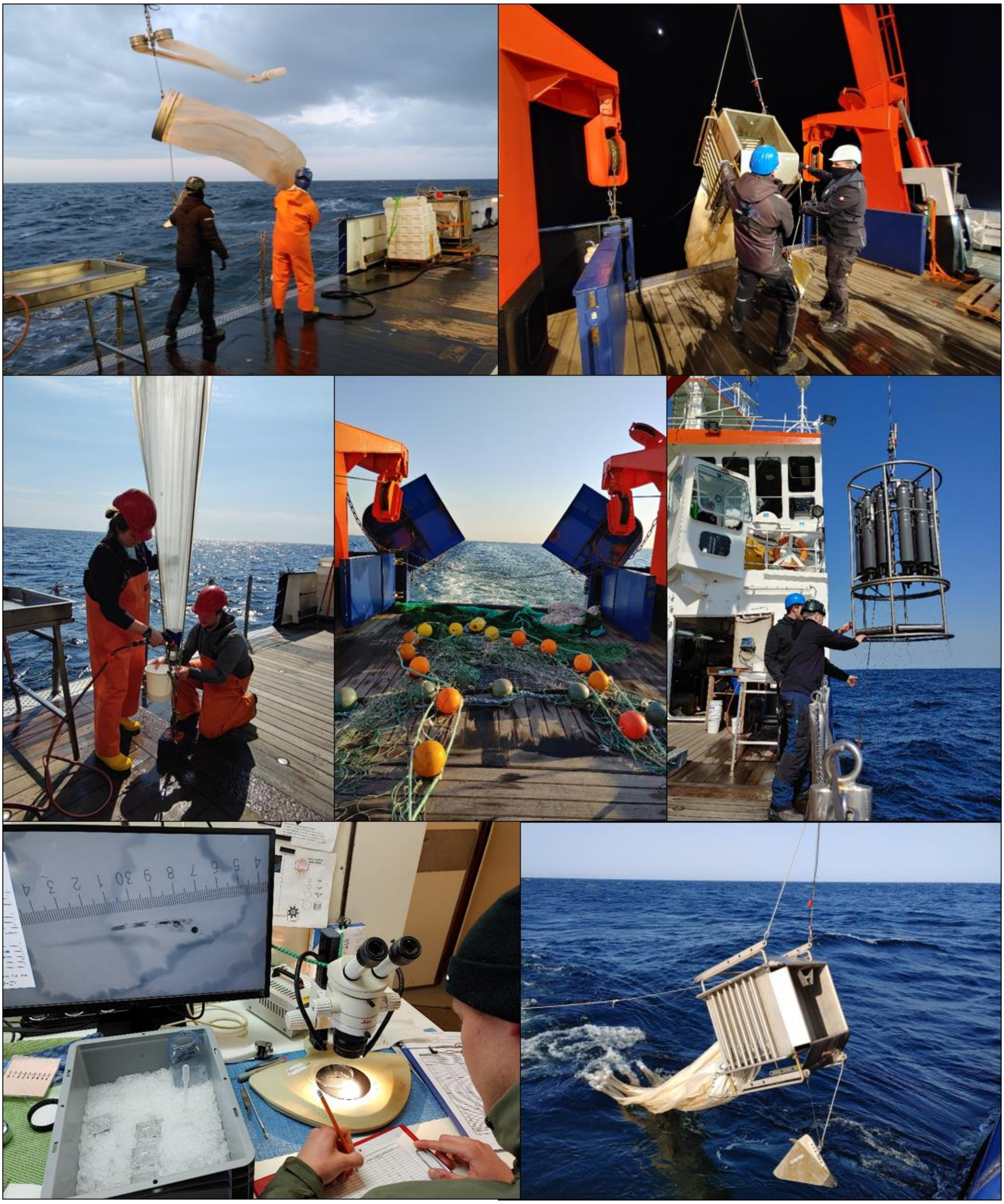

Figure 9.1.1 Impressions of cruise AL553. Top left to right: Bongo net deployment; multinet deployment during 24-hour sampling. Center left to right: Apstein plankton net retrieval; Fishery trawl net waiting for the next deployment; retrieval of the rosette water sampler. Bottom left to right: plankton sorting of the 500 µm net Bongo nets, with a cod larva visible on screen; retrieval of the multinet. Photos: J. Dierking