ALKOR–Berichte

Baltic Cod

Cruise No. AL573

14 May – 29 May 2022
Kiel (Germany) – Kiel (Germany)

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1 Cruise Summary

1.1 Summary in English

The cruise AL573 "Baltic Cod" focused on the status of the Eastern Baltic cod stock, along with its prey fields (zooplankton and pelagic fish prey) and hydrographic boundary conditions. The cruise extended a 37yr long-term data series on (eco-)system composition and functioning of the Baltic Sea, with a focus on the deeper basins. The resulting data- and sample sets supported ongoing projects in the Research Unit Marine Evolutionary Ecology at GEOMAR, in particular research within the DFG-funded research training group (RTG) Translational Evolutionary Research /subproject "Fisheries Induced Evolution". International collaborations included (i) artificial fertilization experiments with cod males and females from Bornholm Basin in order to analyze key factors determining their survival and condition (DTU Aqua, Kopenhagen, Denmark, Dr. Sebastian Politis), (ii) sampling and experimentation on phytoplankton-virus and -grazer interactions (Uni HH, Dr. Luisa Listmann) (iii) cod gonad and liver sampling for fecundity and parasite studies (in collaboration with Dr. Jonna Tomkiewicz, DTU Aqua). The cruise focused on the Bornholm Basin as most important remaining spawning area of Baltic cod, but also included the Western Baltic Sea, Arkona Basin, Gdansk Deep, and Stolpe Trench. Zoo- and ichthyoplankton sampling was also conducted in the Western Baltic (Mecklenburg Bight, Arkona Basin) to contribute to spatially resolved recruitment data of Western Baltic cod in the BMBF-DAM funded Project SpaCeParti. Pelagic fisheries hauls were embedded into detailed surveys of hydrological conditions (oxygen, salinity, temperature) of the cruise area and of zooplankton communities (zoo- and ichthyoplankton including jellyfish) to determine the composition and the abundance and vertical and horizontal distribution of species. Subsamples of cod (*Gadus morhua)* and other main fish species were taken to determine stock structure, gonadal maturation, stomach contents, and egg production (sprat and cod), and to sample tissue and otolith samples for individual-level genomic and ecological analyses (cod). Here, we present the following first results (i) cod nutritional condition is not significantly improving, while individual growth rates have significantly decreased in the past 28 years (ii) the size structure of the stock is still not recovering towards larger individuals, with most individuals (>99%) smaller than 50 cm in length and (iii) Eastern Baltic cod possess a high diversity of mitochondrial (mt)DNA haplotypes, suggesting that the stock structure and divergence in to Western and Eastern Baltic cod is recent.

1.2 Deutsche Zusammenfassung

Die Fahrt AL573 "Baltic Cod" konzentrierte sich auf den Zustand des Östlichen Dorschbestands der zentralen Ostsee, zusammen mit seinem Beutefeld (Zooplankton und pelagische Beutefische) und den hydrographischen Randbedingungen. Die Fahrt verlängerte eine 37 Jahre lange Datenreihe über die Zusammensetzung und Funktionsweise des (Öko-)Systems der Ostsee, wobei der Schwerpunkt auf den tieferen Becken lag. Die resultierenden Daten- und Probensätze unterstützten laufende Projekte in der Arbeitsgruppe Marine Evolutionsökologie am GEOMAR, insbesondere die Forschung im Rahmen des DFG-geförderten Graduiertenkollegs (GRK) Translationale Evolutionsforschung / Teilprojekt "Fischereiinduzierte Evolution". Die internationale Zusammenarbeit umfasste (i) künstliche Befruchtungsexperimente mit männlichen und weiblichen Dorschen im Bornholmbecken, um die Schlüsselfaktoren zu analysieren, die ihr Überleben und ihre Kondition bestimmen (DTU Aqua, Kopenhagen, Dänemark, Dr. Sebastian Politis), (ii) Probenahmen und Experimente zu Phytoplankton-Virus- und -Grazer-Interaktionen (Uni HH, Dr. Luisa Listmann), (iii) Dorsch-Gonaden- und Leberproben für Fruchtbarkeits- und Parasitenstudien (in Zusammenarbeit mit Dr. Jonna Tomkiewicz, DTU Aqua). Die Fahrt konzentrierte sich auf das Bornholm-Becken als wichtigstes verbliebenes Laichgebiet des Ostseedorsches, umfasste aber auch die westliche Ostsee, das Arkona-Becken, die Danziger Tiefe und den Stolpe-Graben. Zoo- und Ichthyoplanktonproben wurden auch in der westlichen Ostsee (Mecklenburger Bucht, Arkonabecken) genommen, um im Rahmen des vom BMBF-DAM geförderten Projekts SpaCeParti einen Beitrag zu räumlich aufgelösten Rekrutierungsdaten des westlichen Ostseedorsches zu leisten. Pelagische Fischereihols wurden in eine detaillierte hydrologische Untersuchung des Fahrtgebietes und Zooplanktonuntersuchungen eingebettet, um die Zusammensetzung, die Abundanz sowie die vertikale und horizontale Verteilung der Arten zu bestimmen. Von einzelnen Dorsch- und anderen wichtigen Fischarten wurden Proben entnommen, um die Bestandsstruktur, die Gonadenreifung, den Mageninhalt und die Eiproduktion (Sprotte und Dorsch) zu bestimmen. Zusätzliche Gewebe- und Otolithenproben wurden für genomische und ökologische Analysen auf individueller Ebene beim Dorsch *Gadus morhua* entnommen. In diesem Bericht stellen wir einige erste Ergebnisse vor: (i) der Ernährungszustand des Dorsches hat sich nicht wesentlich verbessert, während die individuellen Wachstumsraten in den letzten 28 Jahren deutlich abgenommen haben, (ii) die Größenstruktur des Bestandes erholt sich immer noch nicht in Richtung größerer Individuen, wobei die meisten Individuen (>99 %) kleiner als 50 cm sind, und (iii) der östliche Ostseedorsch weist eine hohe Vielfalt an mitochondrialen (mt)DNA-Haplotypen auf, was darauf hindeutet, dass die Bestandsstruktur und die jüngste Divergenz zwischen westlichem und östlichem Ostseedorsch erst kürzlich entstanden ist.

2 Participants

2.1. Scientific Party

Name	Function	institute*	leg
Prof. Thorsten Reusch	chief scientist	GEOMAR	entire cruise
Dr. Felix Mittermayer	zooplankton /fisheries (postdoc)	GEOMAR	entire cruise
Dr. Sebastian Politis	zooplankton /fisheries (postdoc)	DTU Aqua	entire cruise
Dr. Luisa Listmann	zoo-phytoplankton (postdoc)	IMF-UHAM	1st leg
Svend Mees	technician	GEOMAR	entire cruise
Hendrik Hampe	technician	GEOMAR	2nd leg
Kwi Young Han	fisheries science (doctoral student)	GEOMAR	entire cruise
Marina Khachaturyan	(fisheries /zooplankton) doctoral student	GEOMAR	entire cruise
Kim Heimberg	zooplankton /fisheries (Msc student)	GEOMAR	entire cruise
Jana Willim	zooplankton /fisheries (Msc student)	GEOMAR	entire cruise
Carolin Meyer	zooplankton /fisheries (Msc student)	GEOMAR	entire cruise
Julius Krebs	zooplankton /fisheries (Msc student)	GEOMAR	entire cruise
Elisabeth Renk	zooplankton /fisheries (Msc student)	GEOMAR	entire cruise
total	13		

*see abbrev Table 2.2.

2.2 Participating Institutions

Abbreviation	Full name
GEOMAR	Helmholtz-Centre for Ocean Research Kiel, Germany
DTU Aqua	Danish Technical University Aqua, Kopenhagen, DK
IMF-UHAM	The Institute of Marine Ecosystem and Fishery Science University of Hamburg

3 Research Program

3.1. Description of the work area

Cruise AL573 was part of a 37-year effort to collect long-term data series on hydrography, zooplankton and fish species composition along the salinity gradient of the Baltic Sea, with an emphasis on the central Baltic Sea. The cruise series is dating back to 1987 by the GEOMAR Helmholtz Centre for Ocean Research (and its predecessors IFM-GEOMAR Kiel and IFM Kiel). The rationale for the specific spatial focus "Bornholm Basin" results from the importance of this area as the only major remaining spawning ground of Eastern Baltic cod. However, the cruise also included the western Baltic Sea, Arkona Basin and Gdansk Deep (Fig. 3.1), thus covering ICES subdivisions (SD) 22, 24, 25, and 26 (Fig. 3.2).

3.2. Aims of cruise AL573

The objective of the cruise was to understand and where possible, quantify the interactions among major pelagic ecosystem components in the Western and central Baltic Sea. The primary components studied were the most abundant fish species in the area, their recruitment dynamics (by collecting ichthyoplankton) and their major prey fields, zooplankton in case of fish larvae, and prey fish in case of adult cod (*Gadus morhua*). These investigations were embedded into climatic forcing impinging on these populations, such as salinity, oxygen supply and temperature.

The cruise integrated oceanographic and biological sampling, permitting a later time series analysis as to how Baltic pelagic food webs and (fish) species across the environmental gradients of the Baltic Sea change in response to both, environmental forcing and human exploitation. Data sets and samples obtained during cruise AL573 are essential for a number of projects, including collaborations with the Technical University of Denmark, National Institute of Aquatic Resources (DTU Aqua), Stockholm University, and the University of Hamburg. Moreover, the cruise contributed to a data set on Western Baltic cod recruitment in the DAM funded SpaCeParti project (with member institutes CAU, GEOMAR and IMF-UHAM).

Fig. 3.1 Cruise track of AL573.

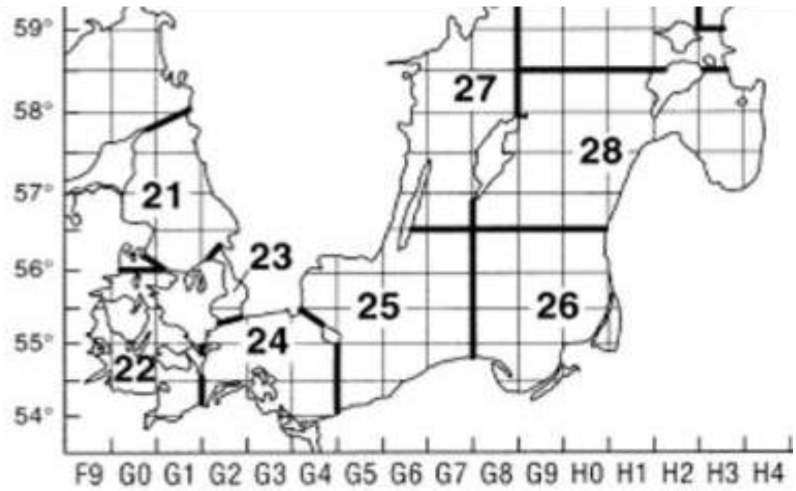

Fig. 3.2 ICES subdivisions in the cruise area (Source: ICES). ICES SD22 corresponds to Kiel Bight = KB, SD24 to Arkona Basin = AB, SD25 to Bornholm Basin = BB and Stolpe Trench = SR, SD26 to Gdansk Deep = GD and Southern Gotland Basin (GB).

3.3. Agenda of the Cruise

Specific investigations during AL573 included (1) a detailed hydrographic survey (oxygen, salinity, temperature) (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 (3) sampling of important food web components including nutrients, seston, phyto-, zoo- (including jellyfish) and ichthyoplankton, (4) benthic (Mecklenburg /Arkona Bight) and pelagic (Bornholm basin) fishery hauls.

Fisheries hauls served to determine size distributions, maturity status, and length – weight relationships of the three dominant fish species in the pelagic system of the Baltic, cod (*Gadus morhua*), herring (*Clupea harengus*) and sprat (*Sprattus sprattus*) as well as flatfishes including flounder (*Plathichthys flesus*). Secondly, various samples for more detailed analyses back on land were obtained, including cod gonads, livers and otoliths, herring and sprat stomachs and whole samples for dietary analyses, and tissue samples of cod, flounder, whiting, plaice 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. Additional work lines carried out in the context of collaborations with external groups included sampling and on-board experiments on photosynthesis and respiration rates of different phytoplankton fractions.

4 Narrative of the Cruise

RV ALKOR was loaded on the days prior to the onset of the cruise. ALKOR then departed from the GEOMAR Westshore pier on 14 May 2022 at 9:00h (all times board time) and headed to the first research area in Kiel Bight (SD22). After covering a station in the Kiel Fjord, first sampling of ichthyo- and zooplankton (plus hydrography) took place in Kiel and Mecklenburg Bight on 15 and 16 May. In the latter, the first 3 fishery hauls were also carried in the framework of the SpaCeParti-project to sample populations of the western cod stock. Of particular importance were the one-year-old cod (<15 cm length), of which we were able to catch a total of 11 individuals. This was followed by the transit to the Arkona Basin (17 and 18 May), where a further 3 fishing hauls were carried out in order to elucidate the composition of cod stocks in this mixing area of western and eastern populations later by genetic analysis.

We then steamed to the permanent station BB23 on 19 May in the central Bornholm Basin, where extensive sampling of various plankton fractions (phytoplankton, meso- and microzooplankton) took place to provide samples for a long-running collaboration with IOW (Dr. Jörg Dutz, Dr. Caroline Paul). Subsequently, a depth-resolved sampling of zooplankton and fish larvae was carried out with the Multinetz Maxi. Samples were collected in 5 m water layers over 24h in 6h intervals with a 335 µm plankton net and immediately counted on board under the stereo-microscope for jellyfish and fish larvae. This was followed by fishing in the central Bornholm Basin area, with low catches as in previous years, , presumably due to the poor oxygen situation at the bottom (>75m water depth <2 mg/L O_2) and low cod abundances.

On 20 May, another research fishery with the pelagic juvenile fish trawl took place in the northern sections of the Bornholm Basin, on 21 May in the southern area. There, at station BB41, only one haul was enough to catch 1200 cod. Thus, as far as the sampling of cod in the core spawning area for the spawning season 2022 is concerned, the target of 300 animals including sampling for otoliths, genomics (finclips) and stable isotopes could be fulfilled. We were also able to catch about 25 animals over 40 cm in length in order to later subject these extreme phenotypes to genomic analysis in combination with age reading.

Among these fish, we also found about 30 spawning-ready males and females, which were used to carry out fertilisation experiments on board (cooperation with DTU Aqua, Sebastian Politis). Gonad samples were also obtained from a partial data set of fish in cooperation with Dr Jonna Tomkiewicz (DTU Aqua, Copenhagen) to perform fertility tests.

Following this, we carried out the first part of the "Bongogrid" (Bongo net and CTD hauls at 45 stations), a quasi-synoptic survey of the zooplankton and fish larval situation in the entire Bornholm Basin on a grid of 10 nm edge length, starting in the evening of 21 May. In addition to the work above, at one station each in Kiel Bight, the Arkona and Bornholm Basin, phytoplankton and marine viruses were sampled in the mixed surface layer using the rosette water sampler (cooperation with Dr. Luisa Listmann, IMF-UHAM) . In the afternoon of May 22, the Bongo grid was interrupted to enter Rönne, Bornholm, for 1.5 days.

ALKOR left Rönne, Bornholm, on 24 May and continued the BONGO Grid to completion until 25 May. Due to bad weather and heavy winds, ALKOR had to seek shelter in Sassnitz, Rügen, for 2 days until we were able to embark again on 28 May. The ALKOR returned to Kiel on 29 May 2022, 1 day ahead of time.

Table 4.1 Overview of all gear deployments during AL573. Mesh sizes of all nets are given in brackets. For location designations are KB=Kiel Bay and Mecklenburg Bay (SD 22), AB=Arkona Basin (SD 24), BB=Bornholm Basin (SD 25), GD=Gdansk Deep (SD 26). Numbers designate the Baltic Sea subdivisions SD.

gear	Kiel Bight	Meck-Bight	Arkona Basin	Bornh-Basin	total
ADM-CTD	11	14	12	49	86
Apstein				3	3
Bongo	10	14	10	47	81
JFT		2	4	6	12
MN-Maxi				8	8
WP2				3	3
WS-CTD	2	1	1	5	9
total	**23**	**31**	**27**	**121**	**202**

5 Preliminary Results

5.1 Ichthyo– and zooplankton sampling

Zooplankton samples were taken along the entire salinity gradient from Kiel Bight to Gotland Basin. The sampling effort west of the Arkona Basin was enhanced for collecting spatially resolved data within the SpaCePari project (DAM funded, "Küstenfischerei, Biodiversität, räumliche Nutzung und Klimawandel") that addresses as one of the major objectives the regionally resolved status of the Western Baltic cod stock.

Another target area was the Bornholm Basin where the "Bongo-Grid" was taken, a quasi-synoptic survey of the entire basin on a grid spanning stations at 10 nm intervals. Bongo- and Baby-Bongo hauls covered Kiel Bight (10 hauls), Mecklenburg Bight (14 hauls), Arkona Basin (10 hauls), and Bornholm Basin including the western part of Stolpe Trench (47 hauls).

In total, identifiable larvae of 9 different species were caught (Table 5.1.). As the most abundant larvae, individuals of sprat (*Sprattus sprattus*; n = 686), flounder (*Plathichthys flesus*; n = 636) and sandeel (n = 19) were picked from the 500 µm bongo-samples and 300 µm Multinet samples and immediately conserved at -80 °C for subsequent RNA/DNA, stable isotope and genetic analyses.

Table 5.1. Overview on fish larvae caught during AL573 in the 500 µm fraction of Bongo nets.

Area	Fish 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

Compared to previous years, a slightly higher number (n = 5) of cod (*Gadus morhua*) larvae was found in the eastern part of the covered area (Bornholm Basin). Both findings are consistent with the continual shift of the spawning period of Eastern Baltic cod stock towards later in the year (i.e, summer). In contrast, we found a total of 52 juvenile cod in the Kiel Bight /Mecklenburg Bight area which is rather similar to the previous year 2021 (N=62).

All zooplankton net catches were checked for the presence of gelatinous zooplankton. Ephyrae (larvae) and small adults of scyphozoan jellyfish (identified on board as lionsmane jellyfish *Cyanea capillata,* potentially low numbers of moon jellyfish *Aurelia aurita*) were present in much higher abundances than in previous years. 119 individuals of, *C. capillata*, were caught, which was only about 20% of the catches in the previous year. In contrast, the invasive comb jelly (Ctenophora) *Mnemiopsis leidyi* remained rare. Here, only 14 individuals in total were caught in deep layers (>50 m depth) of Bornholm basin BB23 during the vertically resolved multinet-hauls, comparable to the previous year (N=5).

After removing fish larvae and jellyfish, all zooplankton catches samples were conserved in 4% buffered formalin solution for later analysis, and are available for the determination of species composition and abundance of zoo- and ichthyoplankton throughout the 37-yr time series. Stations in the eastern part of Stolpe trench and in the Gdansk Deep were sampled with IKS-80 nets instead of Bongo nets to ensure the compatibility of data with a long-term IKS-80 sampling series maintained by the Latvian Fish Resources Agency (LATFRA; Andrei Makarcuks).

At our key central Bornholm Basin station BB23 Multinet MAXI (300 µm, towed, sampling of the water column in 5 m layers) casts were performed over a one-day period on 19/20 May to assess diurnally resolved vertical distributions of ichthyo- and zooplankton. We obtained results of the depth distribution of different species of jellyfish and of the diel vertical migration of fish larvae.

5.2 Pelagic fisheries and the status of Eastern Baltic Cod

5.2.1. General catches and environmental conditions

As oxygen conditions near the bottom were generally low to sustain higher life including fish at water depth >70m, most hauls (except those in Kiel and Mecklenburg Bay) were done within or slightly above the halocline, i.e. in the pelagic zone. Fishery hauls were conducted in Kiel Bight (1 haul), Mecklenburg Bight (3 hauls) Arkona Basin (3 hauls), Bornholm Basin (6 hauls), and Gdansk Deep (3 hauls). The overall catch composition is shown in Table 5.2.1.

species	SD24	SD25	total
flounder	3.95	0.87	4.82
herring	91.8	70.7	162.5
cod	79	434.84	513.84
dab	94.9		94.9
weever	0.14		0.14
sandeel	0.02		0.02
plaice	23.58		23.58
spratt	135.6	737.5	873.1
turbot	1.5		1.5
whiting	71.3		71.3
total	501.79	1243.91	1745.7

Table 5.2.1. Overview on species catch composition, all numbers are kg. SD 24=Mecklenburg Bight, Arkona basin; SD25= Bornholm basin. Single fish measurement and samples were taken for 659 cod and 755 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.

In the Arkona Basin, but also in western parts of the Bornholm Basin, the whiting population seems to further increase in abundance compared to earlier years. Approximately twice the biomass /number of individuals were caught in 2022 compared to 3 yrs before, despite slightly less catch effort. Individualized samples of whiting (otoliths, fin clips for genetic analysis, gonads and livers) were taken from a total of 200 individuals, and of a further 755 were length /weight were recorded. For cod, single fish data (length, weight, sex and maturity stage) and samples (otoliths, fin clips for genetic analysis, gonads and livers) were obtained for 659 individuals in total. These samples will be subjected to a variety of methods later, including age readings (otoliths), parasite investigations (livers), and genetic analyses (finclips). Stable isotope analyses are also being conducted at the moment to reconstruct the trophic level and past prey (i.e. pelagic fish or benthic prey). Length and weight were measured for additional individuals. The condition of animals, assessed as Fulton's K, has not significantly improved compared to previous years, but is also not further declining.

For sprat and herring, detailed stock size structures were recorded for maximally 200 randomly picked individuals per haul. For these zooplanktivorous species, stomach samples (sprat: 10 per 1 cm length class; herring: 20 per 2-cm length class) as well as 2 kg frost samples were taken at each fisheries station.

5.2.2. Cod population structure in the Bornholm basin

In Bornholm Basin, the main remaining spawning area of the Eastern Baltic cod (EBC) stock, the mean standard length of individuals was very small (Figure 5.2.2), and larger individuals >50 cm, which were frequently observed in past decades, were mostly absent from the population. Both of these observations are consistent with temporal trends over past years Fig. 5.2.1.b). In 2021, we even found more individuals in the smallest size class 20-25 com as in previous years (Fig. 5.2.1b) Further analyses, including full genome sequencing of a random samples spanning time points from 1996 until 2021 will address the causes for the dramatic decline in fish size, in particular the hypothesis that ongoing strong size selective fishing "bred" small individuals owing to fisheries induced selection. For the same individuals, we are also conducting stable isotope analyses of muscle tissue to identify the likely food items (benthic invertebrates vs. pelagic fish) in the weeks prior to catch to assess possible correlations among nutritional state and size at maturity of targeted individuals.

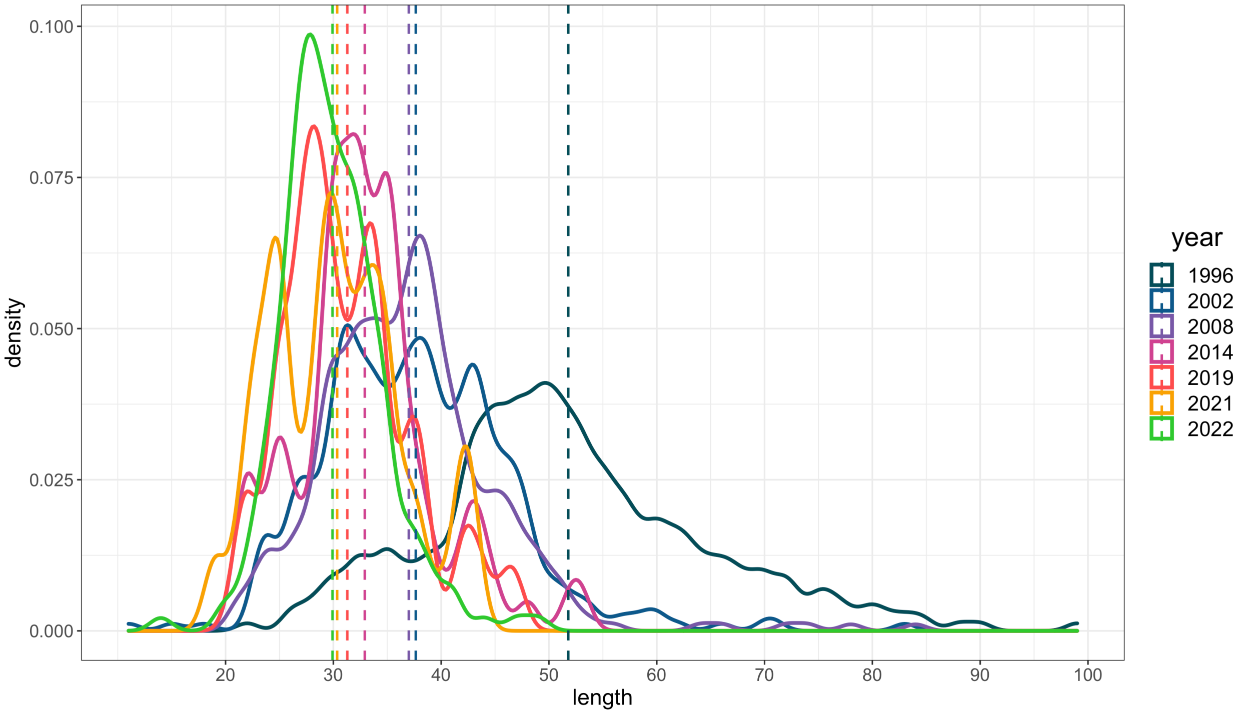

Fig. 5.2.2. Modelled density frequency diagrams of cod individual size distribution since 1996 (in cm standard length) compared to AL573 collected in May 2022. Note that in 2022 <1% of individuals had a standard length of >50 cm. Between 2014 and 2022, the number of individuals >40 cm in length even decreased further.

5.2.3. Temporal changes in growth rate in the Eastern Baltic cod population

One key goal of the past and previous cruises of the 37-yr time series is to detect demographic and conditional changes in the EBC population. One key knowledge gap is to identify the age of the small cod now dominating in the EBC catches. Individuals could be small becáuse they are young, or grow more slowly. Otolith samples from this area cannot be age read using conventional methods, instead, several isotopes in microlayers of otolith sections have to be measured. These novel approaches to ageing Eastern Baltic cod were developed by DTU Aqua (collaboration with Dr. Karin Hussy) and allow, for the first time, to assess whether individuals are small and mature since they grew slowly, or whether they display maturity at an earlier age.

In doing so, we find that indeed, there is a continual decline in modelled growth rate (von Bertalanffy function, Fig. 5.2.3.) between the 1990s and the 2020 years. The next step will be to identify which external factors (i.e. low food supply) or genetic processes (fisheries induced evolution) induced this change.

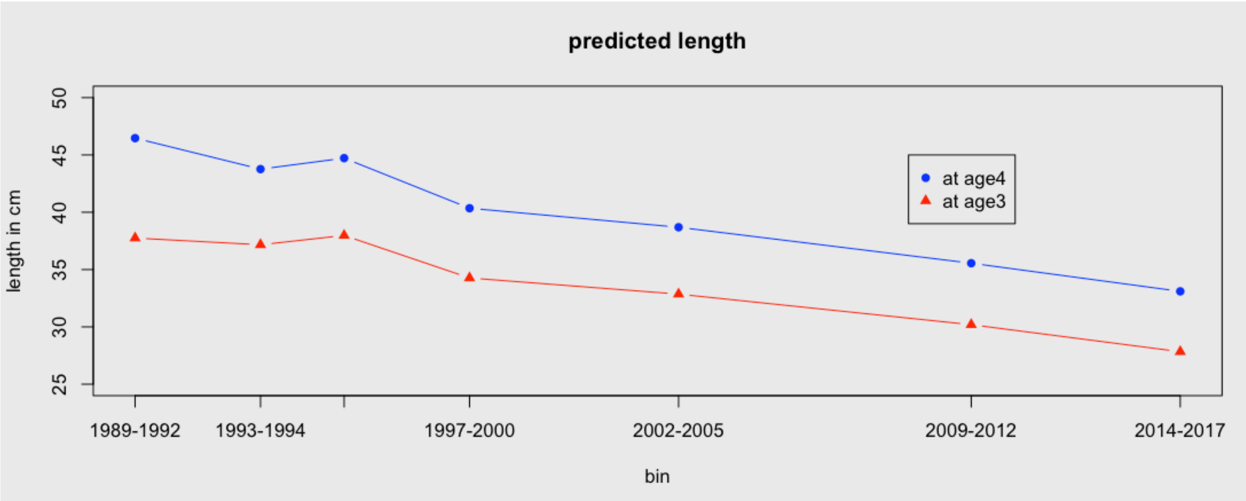

Fig. 5.2.3. Decrease in growth rate in Eastern Baltic cod over 28 years. For five 5-7yr time intervals, back-calculated fish lengths /ages are used to populate von Bertalanffy-functions. The von Bertalanffy Growth Function used for fitting the curve and predicting length at age3 was Lt ~ Linf*(1-exp(-K*(age + t0)) where Lt = Length at age t, L_{inf} = asymptotic length (hypothetical length at infinite age =L∞), age = age from the otolith aging method developed by K. Hüssy, DTU Aqua, K determines how fast L_{inf} can be reached, t0 is hypothetical length at zero age. On the x-axis, year class = (catch year - age). For seven bins, the back-calculated years are divided into 1989-1992, 1993-1994, 1995-1996, 1997-2000, 2002-2005, 2009-2012, 2014-2017 to have equal number of samples (rather than equal time intervals), then the model was fitted for every bin. Unpublished dissertation of Kwi Young Han, DFG-RTG TransEvo.

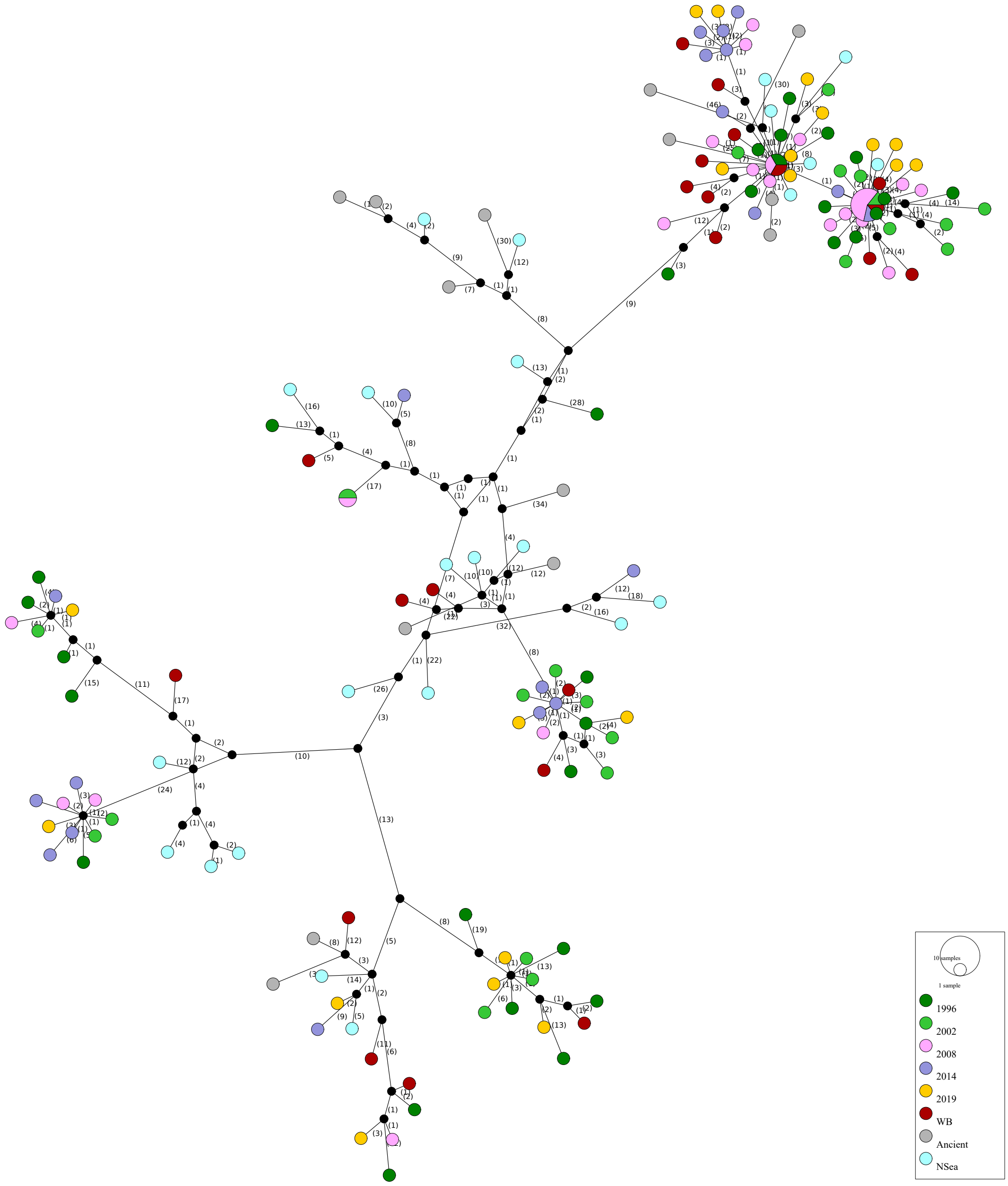

Fig. 5.2.4. Haplotype median-joining network of full mtDNA haplotypes in Eastern Baltic cod. A temporal data set of EBC, as well as other more western populations are combined. Color codes: dark green: EBC 1996; light green: EBC 2002; pink: EBC 2008; lilac: EBC 2014; yellow: EBC 2019). Other populations (red: Western Baltic (WB); grey: Ancient from Haitabu historical site; cyan: North Sea (N Sea)). Black dots represent median consensus sequences in between clusters. Haloptypes of EBC and more western populations are completely intermingled. Mutation steps are shown in brackets. Unpublished Msc thesis of Erika Kokubun, DFG-RTG TransEvo.

5.2.4. Historical population structure of Eastern Baltic cod in the study area

In order to assess potential selection processes within the Eastern Baltic cod stock, it is paramount to test for the historical origin of the distinct Eastern Baltic cod gene pool from the rest of the North Atlantic (including the Western Baltic cod stock). To this end, fin clips obtained from AL573 and from previous cruises were immediately subjected to an analysis of full mitochondrial genomes (mtDNA haplotypes) (Master thesis of Erika Kokubun, GEOMAR). Raw sequence reads were converted to BAM files. Individuals from the 1996-time point which had more than one

sequence run were combined into one single sequence for further analysis, using *samtools* merge. Sequences were then mapped against the Atlantic cod (*Gadus morhua*) reference mitochondrial genome.
To compare the haplotype diversity indices of EBC, three outside Atlantic Cod populations were chosen for comparison: 22 samples from the Western Baltic (WB) (Barth *et al.*, 2019), 24 from the North Sea (NS), and 20 ancient (AN) samples from Haithabu archaeological site. Sequences from WB were obtained from raw reads and had the same mapping and filtering steps as previously done for EB. Samples from NS and AN were treated to be compatible with EBC samples: all reads non-mitochondrial were filtered out with bamtools *split*. Variant calling was performed simultaneously with all populations using GATK *HaplotypeCaller*, and gVCF files were created through GATK. Single nucleotide polymorphism (SNPs) variants were then filtered with *bcftools*.

The resulting distribution of haplotypes indicates that the initial wave of colonizing individuals some 7000 years ago carried the full diversity of North Atlantic mtDNA haplotype diversity. This is apparent in the complete mixing of haplotypes indicative of North Sea, Western Baltic Sea and Eastern Baltic cod stock (Fig. 5.2.4.). Any recent divergence including different spawning times /spawning locations and egg buoyancy traits must thus have evolved relatively quickly, possibly analogous to recent findings of an endemic Baltic flounder species.

5.3 Hydrography

During AL573, CTD profiles were obtained with the ADM-CTD at 86 stations and the rosette water sampler with attached CTD (9 stations). Two additional vertical oxygen profiles were obtained for calibration purposes at the deep central Bornholm Basin station BB23 by determining oxygen concentrations in depth resolved water samples taken with the water sampler using the Winkler method on 18 and 21 May.

Regarding the oxygen conditions, we encountered the typical concentrations in the deeper layers of Bornholm Basin but also Gdansk Deep of 0 ml/l for most of the parts below the halocline in 70-75m depth. Consequently, the fisheries had to be modified and the trawling happened 15-35m above bottom (=pelagic trawls). Owing to these peculiar oxygen conditions, flatfish had to adopt a pelagic life style and were often caught in the free water column, in particular flounder, plaice and dab (Table 5.2.1).

5.4. Cod spawning and fecundity in relation to female condition (Sebastian Politis, Jonna Tomkiewicz & Rikke Bucholtz, DTU Aqua, Denmark)

The objective of this collaboration with Dr. Sebastian Politis (on board) et al. and was a collection of ovaries for fecundity analysis (stereology) and associated individual data in order to relate fecundity to female condition. Furthermore, artificial experiments were conducted from maternal and paternal fishes to relate individual "quality" traits to offspring quality. To do so, female and male cod in running stage (5-7) were stripped to obtain gametes for in vitro fertilizations for onboard experiments investigating offspring quality in relation to parental condition. Main target was cod in SD 25. For each fish successfully stripped (female and male), single fish ID and station were noted. Moreover, length (total and standard), total weight (g), liver weight (g), ovarian weight (g), gutted weight (g), sex and maturity were recorded. A fin clip was preserved in alcohol for genetic analyses. Sperm from each male was weighed and spermatocrit assessed.

In total 22 fertilizations were attempted, whereas 5 batches of viable embryos were produced. Floating embryos were reared in incubators connected to mini RAS units, kept at 6.5°C and ambient salinity of 15 psu. The rearing duration until hatching lasted 17 days. Experiments initiated on board of ALKOR, continued at GEOMAR. Fertilization success was assessed from digital images at the 4-8 cell stage. Dead embryos were enumerated and removed on a daily basis. Embryos were categorized as dead if they turned white and/or sank to the bottom of the incubator. Once hatching was completed, all embryos and larvae within each incubator were counted for hatching success calculations, while larval morphology will be measured from digital images. Larvae with abnormal and/or malformed head, body, yolk-sac or tail regions were classified as deformed. Throughout ontogeny, eggs, embryos and larvae were preserved in RNA later for molecular analyses, where selected biomarkers will be used to characterize offspring quality that possibly can be related to parental condition. Analyses to this end are ongoing. We are currently subjecting hatched larvae to individual parentage assignment analysis.

5.5. Top-Down control of phytoplankton communities measured via modified dilution experiments (Dr. Luisa Listmann, Hamburg University IMF)

As part of a UHAM start-up funding project "PIER" the aim was to answer how do different environmental conditions affect the top-down control of viruses and zooplankton on phytoplankton from the Baltic Sea? To answer this question, surface water samples at four stations along the cruise track of AL573 (Fig. 5.4.1, top left panel) were taken. On board, water samples (pre-filtered at 200µm) were filtered in two steps to yield on the one hand micro-grazer free as well as micro-grazer and virus free fractions. These fractions were then combined with the whole community water sample in dilution series (Fig. 5.4.1. for methodological approach adapted from modified dilution approach) in order to measure the effect of mortality on phytoplankton caused by either zooplankton grazing or viral lysis.

Among the different basins covered by the cruise track we found (via cytometry) four different populations (I-IV) for which we assessed the mortalities separately (Fig. 5.4.2, top left panel). The cell numbers and mortalities measured vary between the different stations and have a tendency to decrease when going from West to East (Fig. 5.4.2, top right and bottom panel). From these first results, we conclude that the environment (i.e. different basins of the Baltic) has an effect on the phytoplankton community and also on the top-down control effects within the phytoplankton communities. However, we do not know at this stage whether the environment has a direct effect on the zooplankton grazing or viral lysis and consequently the cell numbers change, or if the environment affects at the same time both phytoplankton growth and the zooplankton and viruses. Understanding the underlying mechanisms of both top-down and bottom-up control of phytoplankton communities will be part of a future larger project where both experiments and monitoring as well as ecosystem modelling will be combined.

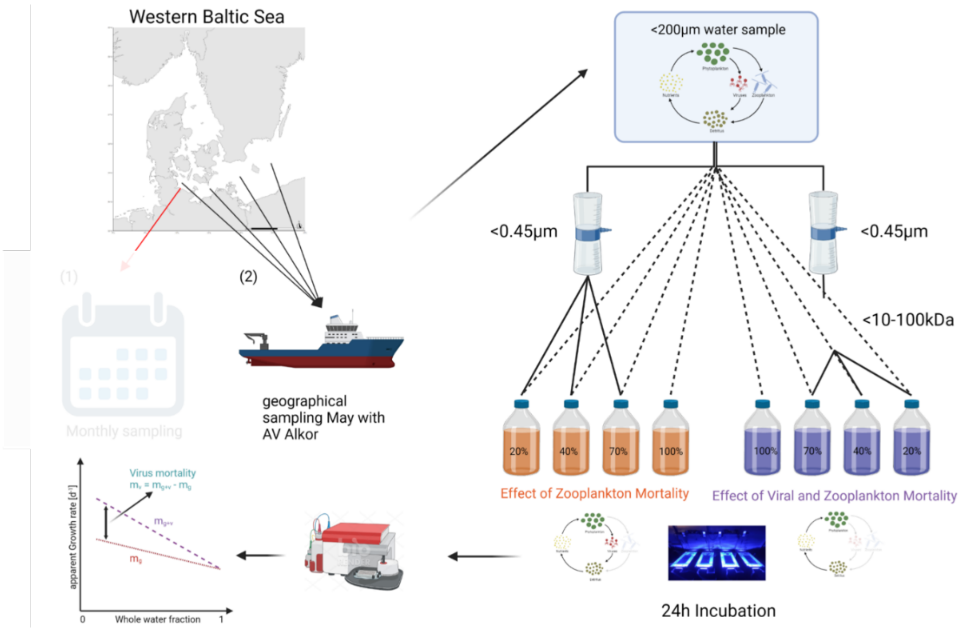

Fig. 5.4.1: Sampling and modified dilution experiment. After sampling, the water was filtered into different size classes (top right panel) and then dilution series were prepared for 24h incubations in plankton wheels (lower right panel). The "incubation samples" were analysed *via* cytometry and apparent growth rates for mortality assessment calculated (lower left panel).

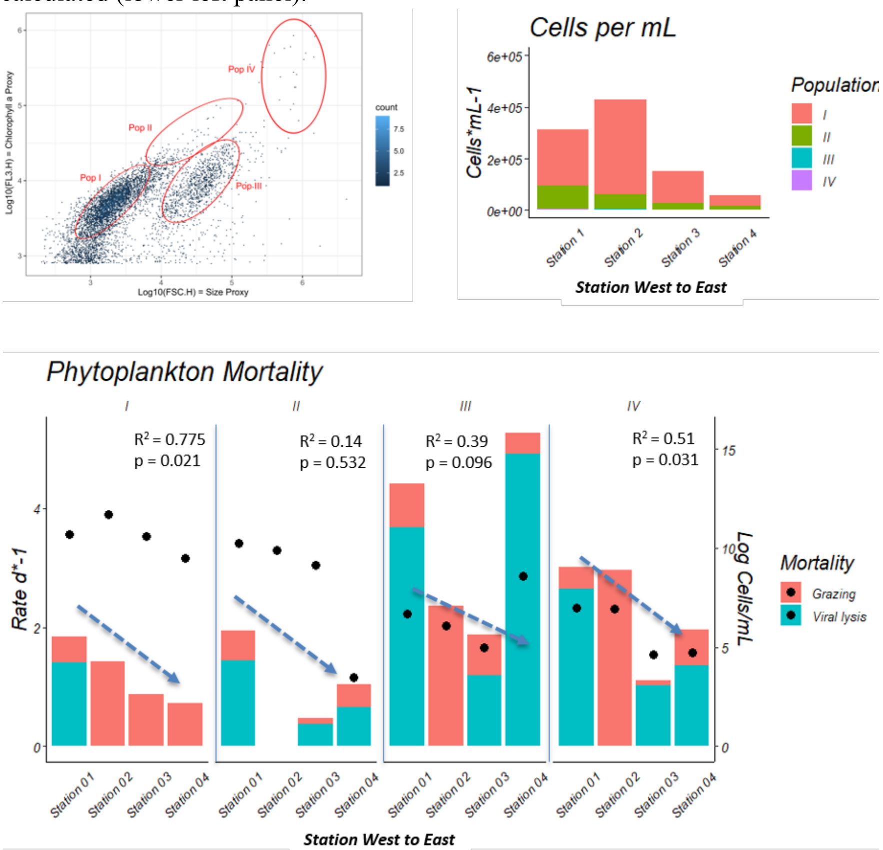

Fig. 5.4.2: Top left panel shows the cytometric fingerprint of the four distinct populations (x-axis=size proxy, y-axis=Chlorophyll proxy). The top right corner shows the change in cell numbers going from West to East. The populations I and II make up the largest proportion of the whole phytoplankton community. The lower panels shows the mortalities caused by either zooplankton grazing (red) or viral lysis (blue). Within all four phytoplankton populations the mortality decreases (blue arrows) when going from West to East.

6 Station List

The list and additional cruise data are also permanently available via the GEOMAR OSIS data portal under the link: https://portal.geomar.de/metadata/leg/show/359912.

Cruise	Event	Gear	Time [UTC]	Lat/Lon	Depth [m]
AL573	1-1	CTD	14.05.22 06:35	54.34158° / 10.17120°	11
AL573	1-2	CTD with rosette watersampler | CTD/Ros	14.05.22 06:46	54.34079° / 10.17122°	13
AL573	2-1	CTD with rosette watersampler | CTD/Ros	14.05.22 07:56	54.48204° / 10.33152°	19
AL573	2-2	CTD	14.05.22 08:08	54.48174° / 10.33165°	19
AL573	2-3	BONGO Netz | BONGO	14.05.22 08:32	54.48135° / 10.33132°	19
AL573	3-1	BONGO Netz | BONGO	14.05.22 09:51	54.51400° / 10.02815°	27
AL573	3-2	CTD	14.05.22 10:03	54.51300° / 10.02087°	27
AL573	4-1	CTD	14.05.22 10:38	54.54960° / 10.12520°	22
AL573	4-2	BONGO Netz | BONGO	14.05.22 10:46	54.54936° / 10.12159°	22
AL573	5-1	BONGO Netz | BONGO	14.05.22 11:24	54.62896° / 10.16062°	22
AL573	5-2	CTD	14.05.22 11:30	54.62954° / 10.15558°	22

AL573	6-1	CTD	14.05.22 12:14	54.59431° / 10.33389°	16
AL573	6-2	BONGO Netz | BONGO	14.05.22 12:17	54.59424° / 10.33307°	16
AL573	7-1	BONGO Netz | BONGO	14.05.22 12:59	54.56970° / 10.50597°	18
AL573	7-2	CTD	14.05.22 13:04	54.56961° / 10.50032°	18
AL573	8-1	CTD	14.05.22 13:45	54.54856° / 10.66640°	20
AL573	8-2	BONGO Netz | BONGO	14.05.22 13:48	54.54863° / 10.66560°	20
AL573	9-1	BONGO Netz | BONGO	14.05.22 14:29	54.54361° / 10.83976°	20
AL573	9-2	CTD	14.05.22 14:34	54.54408° / 10.83429°	21
AL573	10-1	CTD	14.05.22 15:49	54.60260° / 10.99832°	37
AL573	10-2	BONGO Netz | BONGO	14.05.22 15:55	54.60251° / 10.99750°	36
AL573	11-1	BONGO Netz | BONGO	14.05.22 16:42	54.57493° / 11.14965°	27
AL573	11-2	CTD	14.05.22 16:50	54.57603° / 11.14079°	27
AL573	12-1	CTD	14.05.22 17:37	54.53102° / 11.32218°	30
AL573	12-2	BONGO Netz | BONGO	14.05.22 17:42	54.53106° / 11.32127°	30

AL573	13-1	CTD	15.05.22 04:01	54.42020° / 11.37981°	19
AL573	13-2	BONGO Netz | BONGO	15.05.22 04:05	54.41938° / 11.37875°	20
AL573	14-1	BONGO Netz | BONGO	15.05.22 04:39	54.32613° / 11.38318°	21
AL573	14-2	CTD	15.05.22 04:44	54.32819° / 11.37840°	21
AL573	15-1	CTD	15.05.22 05:16	54.24378° / 11.34909°	21
AL573	15-2	BONGO Netz | BONGO	15.05.22 05:20	54.24377° / 11.34797°	21
AL573	16-1	BONGO Netz | BONGO	15.05.22 06:02	54.14083° / 11.29643°	26
AL573	16-2	CTD	15.05.22 06:10	54.14112° / 11.28802°	26
AL573	17-1	CTD	15.05.22 06:43	54.16927° / 11.41042°	23
AL573	17-2	BONGO Netz | BONGO	15.05.22 06:48	54.17010° / 11.41115°	23
AL573	18-1	BONGO Netz | BONGO	15.05.22 07:22	54.19527° / 11.54382°	24
AL573	18-2	CTD	15.05.22 07:27	54.19842° / 11.54326°	24
AL573	19-1	CTD	15.05.22 08:00	54.20808° / 11.67624°	25
AL573	19-2	BONGO Netz | BONGO	15.05.22 08:06	54.20853° / 11.67511°	25

AL573	20-1	BONGO Netz | BONGO	15.05.22 08:38	54.20947° / 11.81710°	21
AL573	20-2	CTD	15.05.22 08:44	54.20897° / 11.82728°	21
AL573	21-1	CTD	15.05.22 09:29	54.29986° / 11.82589°	22
AL573	21-2	BONGO Netz | BONGO	15.05.22 09:34	54.29950° / 11.82337°	23
AL573	22-1	BONGO Netz | BONGO	15.05.22 10:10	54.29169° / 11.68135°	25
AL573	22-2	CTD	15.05.22 10:16	54.29095° / 11.67408°	25
AL573	23-1	CTD	15.05.22 10:51	54.29074° / 11.54297°	24
AL573	23-2	BONGO Netz | BONGO	15.05.22 10:57	54.28983° / 11.54041°	24
AL573	24-1	BONGO Netz | BONGO	15.05.22 11:31	54.37083° / 11.54977°	24
AL573	24-2	CTD	15.05.22 11:38	54.36955° / 11.54149°	24
AL573	25-1	CTD	15.05.22 12:12	54.36164° / 11.67788°	24
AL573	25-2	CTD with rosette watersampler | CTD/Ros	15.05.22 12:18	54.36130° / 11.67702°	25
AL573	25-3	BONGO Netz | BONGO	15.05.22 12:29	54.36047° / 11.67828°	25
AL573	26-1	Jungfischtrawl | JFT	15.05.22 13:27	54.29099° / 11.90732°	19

AL573	27-1	Jungfischtrawl | JFT	15.05.22 14:38	54.26901° / 11.85319°	21
AL573	28-1	CTD	16.05.22 04:01	54.71668° / 12.49114°	18
AL573	28-2	BONGO Netz | BONGO	16.05.22 04:04	54.71685° / 12.49177°	18
AL573	29-1	BONGO Netz | BONGO	16.05.22 05:05	54.73228° / 12.78430°	22
AL573	29-2	CTD	16.05.22 05:11	54.73334° / 12.79046°	22
AL573	30-1	CTD	16.05.22 06:06	54.73282° / 13.04240°	24
AL573	30-2	BONGO Netz | BONGO	16.05.22 06:11	54.73384° / 13.04132°	24
AL573	31-1	BONGO Netz | BONGO	16.05.22 07:17	54.89486° / 13.07575°	44
AL573	31-1	CTD	16.05.22 07:26	54.89089° / 13.08357°	44
AL573	32-1	CTD	16.05.22 08:14	54.95837° / 13.24904°	47
AL573	32-2	BONGO Netz | BONGO	16.05.22 08:19	54.95773° / 13.24955°	47
AL573	33-1	BONGO Netz | BONGO	16.05.22 09:12	54.94046° / 13.48993°	47
AL573	33-2	CTD	16.05.22 09:22	54.94101° / 13.50224°	47
AL573	34-1	CTD	16.05.22 10:26	54.94206° / 13.78230°	47

AL573	34-2	BONGO Netz | BONGO	16.05.22 10:32	54.94242° / 13.78548°	47
AL573	35-1	BONGO Netz | BONGO	16.05.22 11:30	55.01361° / 14.02122°	47
AL573	35-2	CTD	16.05.22 11:39	55.01610° / 14.03151°	47
AL573	35-3	BONGO Netz | BONGO	16.05.22 11:48	55.01587° / 14.03227°	48
AL573	36-1	BONGO Netz | BONGO	16.05.22 12:50	55.11246° / 14.24887°	48
AL573	36-2	CTD	16.05.22 13:00	55.11636° / 14.25683°	48
AL573	37-1	CTD with rosette watersampler | CTD/Ros	17.05.22 05:23	54.95740° / 13.24740°	47
AL573	38-1	CTD	17.05.22 05:58	54.95639° / 13.18745°	45
AL573	39-1	Jungfischtrawl | JFT	17.05.22 06:08	54.95714° / 13.19115°	45
AL573	40-1	Jungfischtrawl | JFT	17.05.22 08:00	54.95641° / 13.19030°	45
AL573	41-1	CTD	17.05.22 11:59	55.00767° / 13.98136°	47
AL573	41-2	Jungfischtrawl | JFT	17.05.22 12:05	55.00792° / 13.98199°	47
AL573	42-1	Jungfischtrawl | JFT	17.05.22 13:46	55.00791° / 13.98891°	47
AL573	43-1	CTD	18.05.22 05:30	55.29179° / 15.74962°	96

AL573	43-2	Apstein net | APSN	18.05.22 05:42	55.29175° / 15.74983°	96
AL573	43-3	Apstein net | APSN	18.05.22 05:57	55.29192° / 15.74996°	96
AL573	43-4	Apstein net | APSN	18.05.22 06:13	55.29186° / 15.74955°	95
AL573	43-5	WP2 Net	18.05.22 06:34	55.29169° / 15.74970°	95
AL573	43-6	WP2 Net	18.05.22 06:46	55.29177° / 15.75009°	95
AL573	43-7	WP2 Net	18.05.22 06:57	55.29170° / 15.75007°	95
AL573	43-8	CTD with rosette watersampler | CTD/Ros	18.05.22 07:13	55.29167° / 15.74966°	95
AL573	43-9	CTD with rosette watersampler | CTD/Ros	18.05.22 07:45	55.29169° / 15.74997°	95
AL573	43-10	BONGO Netz | BONGO	18.05.22 08:03	55.29124° / 15.75065°	95
AL573	43-11	BONGO Netz | BONGO	18.05.22 08:27	55.29180° / 15.74837°	95
AL573	44-1	Jungfischtrawl | JFT	18.05.22 10:05	55.30174° / 15.73785°	95
AL573	45-1	CTD	18.05.22 12:07	55.29479° / 15.50750°	93
AL573	45-2	Jungfischtrawl | JFT	18.05.22 12:17	55.29483° / 15.50868°	93
AL573	46-1	Multinetz MAXI (9Netze) | Multi MAX	19.05.22 04:00	55.29186° / 15.74932°	95

AL573	46-2	Multinetz MAXI (9Netze) | Multi MAX	19.05.22 04:59	55.29138° / 15.74919°	95
AL573	46-3	Multinetz MAXI (9Netze) | Multi MAX	19.05.22 10:01	55.29112° / 15.75002°	95
AL573	46-4	Multinetz MAXI (9Netze) | Multi MAX	19.05.22 11:00	55.29259° / 15.75078°	95
AL573	46-5	Multinetz MAXI (9Netze) | Multi MAX	19.05.22 15:59	55.29263° / 15.75160°	95
AL573	46-6	Multinetz MAXI (9Netze) | Multi MAX	19.05.22 17:02	55.29212° / 15.75130°	95
AL573	46-7	Multinetz MAXI (9Netze) | Multi MAX	19.05.22 22:22	55.29162° / 15.75320°	95
AL573	46-8	Multinetz MAXI (9Netze) | Multi MAX	20.05.22 00:53	55.29385° / 15.74809°	95
AL573	47-1	CTD	20.05.22 06:57	55.45852° / 16.50087°	58
AL573	47-2	Jungfischtrawl | JFT	20.05.22 07:06	55.45863° / 16.50043°	58
AL573	48-1	Jungfischtrawl | JFT	20.05.22 10:00	55.43260° / 16.35215°	66
AL573	49-1	CTD	20.05.22 13:04	55.69599° / 16.16634°	67
AL573	49-2	Jungfischtrawl | JFT	20.05.22 13:12	55.69612° / 16.16469°	67
AL573	50-1	CTD	21.05.22 05:59	54.79469° / 15.23808°	67
AL573	50-2	Jungfischtrawl | JFT	21.05.22 06:09	54.79419° / 15.23742°	67

AL573	51-1	BONGO Netz | BONGO	21.05.22 09:41	54.82888° / 15.20160°	65
AL573	52-1	CTD	21.05.22 13:58	55.45843° / 15.25046°	90
AL573	52-2	BONGO Netz | BONGO	21.05.22 14:10	55.46070° / 15.24732°	89
AL573	53-1	BONGO Netz | BONGO	21.05.22 15:10	55.45905° / 15.51935°	84
AL573	53-2	CTD	21.05.22 15:25	55.45801° / 15.50136°	85
AL573	54-1	CTD	21.05.22 16:21	55.45865° / 15.75068°	85
AL573	54-2	BONGO Netz | BONGO	21.05.22 16:29	55.45630° / 15.75196°	85
AL573	55-1	BONGO Netz | BONGO	21.05.22 17:25	55.46291° / 15.98557°	83
AL573	55-2	CTD	21.05.22 17:39	55.45760° / 15.99982°	83
AL573	56-1	CTD	21.05.22 18:40	55.45849° / 16.24989°	74
AL573	56-2	BONGO Netz | BONGO	21.05.22 18:50	55.45845° / 16.25427°	74
AL573	57-1	BONGO Netz | BONGO	21.05.22 19:50	55.45682° / 16.51309°	57
AL573	57-2	CTD	21.05.22 19:59	55.45858° / 16.50164°	58
AL573	58-1	CTD	21.05.22 21:07	55.62515° / 16.50115°	62

AL573	58-2	BONGO Netz | BONGO	21.05.22 21:15	55.62613° / 16.49817°	62
AL573	59-1	BONGO Netz | BONGO	21.05.22 22:22	55.79088° / 16.51555°	56
AL573	59-2	CTD	21.05.22 22:33	55.79160° / 16.50199°	57
AL573	60-1	CTD	21.05.22 23:33	55.79148° / 16.24981°	60
AL573	60-2	BONGO Netz | BONGO	21.05.22 23:40	55.79157° / 16.24684°	60
AL573	61-1	BONGO Netz | BONGO	22.05.22 00:48	55.78634° / 16.01176°	62
AL573	61-2	CTD	22.05.22 00:59	55.79107° / 16.00068°	62
AL573	62-1	CTD	22.05.22 02:20	55.62513° / 16.24944°	74
AL573	62-2	BONGO Netz | BONGO	22.05.22 02:27	55.62528° / 16.24667°	74
AL573	63-1	BONGO Netz | BONGO	22.05.22 03:25	55.61779° / 16.00491°	74
AL573	63-2	CTD	22.05.22 03:37	55.62559° / 16.00031°	74
AL573	64-1	CTD	22.05.22 04:34	55.62399° / 15.74949°	69
AL573	64-2	BONGO Netz | BONGO	22.05.22 04:40	55.62442° / 15.74901°	69
AL573	65-1	BONGO Netz | BONGO	22.05.22 05:36	55.62528° / 15.51276°	67

AL573	65-2	CTD	22.05.22 05:47	55.62512° / 15.49940°	67
AL573	66-1	CTD	22.05.22 06:43	55.62393° / 15.24958°	72
AL573	66-2	BONGO Netz | BONGO	22.05.22 06:51	55.62445° / 15.24694°	72
AL573	67-1	BONGO Netz | BONGO	22.05.22 07:46	55.62330° / 15.00879°	75
AL573	67-2	CTD	22.05.22 07:54	55.62484° / 14.99902°	75
AL573	68-1	CTD	22.05.22 08:50	55.62488° / 14.74923°	68
AL573	68-2	BONGO Netz | BONGO	22.05.22 08:56	55.62550° / 14.74896°	68
AL573	69-1	BONGO Netz | BONGO	22.05.22 10:01	55.46543° / 14.75355°	69
AL573	69-2	CTD	22.05.22 10:13	55.45800° / 14.75187°	69
AL573	70-1	CTD	24.05.22 10:29	54.79216° / 14.99946°	60
AL573	70-2	BONGO Netz | BONGO	24.05.22 10:37	54.79072° / 15.00280°	60
AL573	71-1	BONGO Netz | BONGO	24.05.22 11:58	54.63014° / 15.24114°	58
AL573	71-2	CTD	24.05.22 12:10	54.62551° / 15.24968°	58
AL573	72-1	CTD	24.05.22 13:04	54.62566° / 15.50051°	63

AL573	72-2	BONGO Netz | BONGO	24.05.22 13:12	54.62487° / 15.50089°	63
AL573	73-1	BONGO Netz | BONGO	24.05.22 14:04	54.62290° / 15.73821°	59
AL573	73-2	CTD	24.05.22 14:14	54.62503° / 15.74998°	59
AL573	74-1	CTD	24.05.22 15:34	54.79178° / 16.00150°	51
AL573	74-2	BONGO Netz | BONGO	24.05.22 15:40	54.79145° / 16.00033°	51
AL573	75-1	BONGO Netz | BONGO	24.05.22 16:33	54.79620° / 15.75922°	71
AL573	75-2	CTD	24.05.22 16:43	54.79198° / 15.75076°	71
AL573	75-3	CTD with rosette watersampler | CTD/Ros	24.05.22 16:54	54.79147° / 15.74981°	71
AL573	76-1	CTD	24.05.22 17:54	54.79326° / 15.50192°	73
AL573	76-2	BONGO Netz | BONGO	24.05.22 18:06	54.79102° / 15.49692°	73
AL573	77-1	BONGO Netz | BONGO	24.05.22 19:00	54.80037° / 15.25425°	67
AL573	77-2	CTD	24.05.22 19:13	54.79129° / 15.24890°	67
AL573	78-1	CTD	24.05.22 20:34	54.95844° / 15.50087°	76
AL573	78-2	BONGO Netz | BONGO	24.05.22 20:41	54.95823° / 15.50142°	76

AL573	79-1	BONGO Netz | BONGO	24.05.22 21:37	54.95808° / 15.73804°	80
AL573	79-2	CTD	24.05.22 21:51	54.95766° / 15.75355°	80
AL573	80-1	CTD	24.05.22 22:49	54.95746° / 15.99920°	73
AL573	80-2	BONGO Netz | BONGO	24.05.22 22:59	54.95597° / 16.00326°	73
AL573	81-1	BONGO Netz | BONGO	24.05.22 23:58	54.95406° / 16.24260°	49
AL573	81-2	CTD	25.05.22 00:09	54.95974° / 16.24987°	49
AL573	82-1	CTD	25.05.22 01:31	55.12510° / 16.50087°	51
AL573	82-2	BONGO Netz | BONGO	25.05.22 01:40	55.12546° / 16.49796°	51
AL573	83-1	BONGO Netz | BONGO	25.05.22 02:34	55.13102° / 16.26472°	77
AL573	83-2	CTD	25.05.22 02:47	55.12509° / 16.25128°	79
AL573	84-1	CTD	25.05.22 03:45	55.12503° / 16.00071°	86
AL573	84-2	BONGO Netz | BONGO	25.05.22 03:53	55.12493° / 16.00036°	86
AL573	85-1	BONGO Netz | BONGO	25.05.22 04:51	55.12900° / 15.76956°	88
AL573	85-2	CTD	25.05.22 05:05	55.12543° / 15.75125°	89

AL573	86-1	CTD	25.05.22 06:05	55.12500° / 15.50084°	67
AL573	86-2	BONGO Netz | BONGO	25.05.22 06:12	55.12483° / 15.50017°	67
AL573	87-1	BONGO Netz | BONGO	25.05.22 07:14	55.28505° / 15.49496°	92
AL573	87-2	CTD	25.05.22 07:27	55.29223° / 15.50071°	92
AL573	88-1	CTD	25.05.22 08:25	55.29169° / 15.75030°	95
AL573	88-2	BONGO Netz | BONGO	25.05.22 08:34	55.29113° / 15.74950°	95
AL573	89-1	BONGO Netz | BONGO	25.05.22 09:49	55.29504° / 16.02457°	87
AL573	89-2	CTD	25.05.22 10:07	55.29192° / 16.00178°	88
AL573	89-3	CTD with rosette watersampler | CTD/Ros	25.05.22 10:16	55.29150° / 16.00108°	88
AL573	90-1	CTD	25.05.22 11:19	55.29109° / 16.24991°	74
AL573	90-2	BONGO Netz | BONGO	25.05.22 11:28	55.29009° / 16.24716°	74
AL573	91-1	BONGO Netz | BONGO	25.05.22 12:33	55.29412° / 16.51075°	63
AL573	91-2	CTD	25.05.22 12:43	55.29130° / 16.49965°	61
AL573	92-1	CTD	25.05.22 13:54	55.35021° / 16.80040°	66

AL573	92-2	BONGO Netz | BONGO	25.05.22 14:01	55.35086° / 16.80050°	66
AL573	93-1	BONGO Netz | BONGO	25.05.22 14:58	55.34910° / 17.06972°	67
AL573	93-2	CTD	25.05.22 15:09	55.34976° / 17.08360°	67
AL573	94-1	CTD	25.05.22 15:51	55.24961° / 17.08395°	83
AL573	94-2	BONGO Netz | BONGO	25.05.22 16:00	55.25008° / 17.08441°	83
AL573	95-1	BONGO Netz | BONGO	25.05.22 17:03	55.23635° / 16.81437°	80
AL573	95-2	CTD	25.05.22 17:14	55.23364° / 16.80065°	79
AL573	96-1	CTD with rosette watersampler | CTD/Ros	25.05.22 19:03	55.10338° / 16.27321°	76
AL573	97-1	CTD	28.05.22 13:54	54.90599° / 13.27667°	45
AL573	97-2	Jungfischtrawl | JFT	28.05.22 14:02	54.90709° / 13.27376°	45

7 Data Availability and Sample Storage

All data are available immediately upon request if not otherwise stated.

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 on board 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/56088 (keyword "AL573").

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 archival and access. 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).

Genetic /genomic data will be submitted to the relevant data archives (Genbank /NCBI) during the process of publication. 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. A data base is currently being set up under the umbrella Mare Data Hub to contain all sample metadata of all zooplankton, fin-clip and other preserved biological samples.

Table 7.1 Overview of data availability and persons responsible for specific data sets of AL573.

Type	Database	Available	Free Access	Contact
Hydrography (CTD data)	ICES database	Publicly by April 2023, earlier on request (see contact e-mail).	yes	Dr. Jan Dierking jdierking@geomar.de
Fishery data and food web sampling data	PANGAEA	Publicly at time of acceptance of the underlying peer-reviewed publication; or via request (see contact e-mail).	yes	Prof. T Reusch treusch@geomar.de
fish individual data (*Gadus morhua*, others)	NCBI /Genbank	Publicly at time of acceptance of the underlying peer-reviewed publication; or via request (see contact e-mail).	yes	Kwi Yong Han khan@geomar.de
Zooplankton metadata	GEOMAR internal /biodiversity storage centre	Publicly at time of acceptance of the underlying peer-reviewed publication; or via request (see contact e-mail).	yes	Dr. Felix Mittermayer fmittermayer@geomar.de
Ichthyoplankton data	PANGAEA	Publicly at time of acceptance of the underlying peer-reviewed publication; or via request (see contact e-mail).	yes	Dr. Catriona Clemmesen cclemmesen@geomar.de
Phytoplankton community sampling	PANGAEA	Inquire with collaboration partner (see contact e-mail).	yes	Dr. Luisa Listmann luisa.listmann@uni-hamburg.de

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