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Cruise Report

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R.V. ALKOR **Cruise No.: AL509**

Compiled by: Prof. Thorsten Reusch

Dates of Cruise: 15.05. – 30.05.2018

Areas of Research: Physical, chemical, biological and fishery oceanography

Port Calls: Riga. Latvia, 22.05.2018

Institute: GEOMAR, RD3 (Marine Ecology, Marine Evolutionary Ecology)

Chief Scientist: Prof. Thorsten Reusch

Number of Scientists: 11 (plus 1 observer)

Projects: EU Horizon 2020 GoJelly, EU BONUS BLUEWEBS, German Science Foundation Collaborative Research Center "Metaorganisms" (CRC1182), US NSF Project "Evolutionary Responses to Global Changes in Salinity and Temperature"

Cruise Report

This cruise report consists of 10 pages including the cover page:

1. Scientific crew

Name	Function	Institute	Leg
Thorsten Reusch	Chief scientist	GEOMAR	Entire cruise
Svend Mees	Technician	GEOMAR	Entire cruise
Henrik Gross	Technician	GEOMAR	Entire cruise
Christian Pawlitzki	MSc student	University of Kiel	Entire cruise
Juanita Diaz	PhD student	Wisconsin University	Entire cruise
Lyndsay Grace Walls	PhD student	GEOMAR	Entire cruise
Lena Porzelt	MSc student	University of Kiel	Entire cruise
Tobias Büring	MSc student	GEOMAR	Entire cruise
Rebecca Piontek	MSc student	GEOMAR	Entire cruise
Erik Francesco Ferrara	MSc student	GEOMAR	Entire cruise
Eva Paulus	BSc student	GEOMAR	Entire cruise
Katarzyna Spich	Observer, Scientist	NMFRI, Gdynia, Polen	Entire cruise
Total per leg	12/12		

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2. 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 AL509 extends a 31-year integrative long-term data series of the central Baltic Sea collected since 1987 by GEOMAR researchers (and their predecessor institutes). The key characteristic of this series is the integration of oceanographic and biological information, to allow the analysis of Baltic pelagic food webs and (fish) species across the environmental gradients of the Baltic Sea, and under changing environmental conditions and human exploitation.
The datasets and samples obtained during cruise AL509 are essential for a number of projects, including the large-scale international projects EU Horizon 2020 GoJelly and BONUS BLUEWEBS, and collaborations with various institutions, including the Technical University of Denmark, National Institute of Aquatic Resources (DTU Aqua) and the University of Wisconsin. The spatial focus lies on the Bornholm Basin as most important spawning area of Baltic cod, but also includes the Western Baltic Sea, Arkona and Gotland Basin and Gdansk Deep (Figure 1), thus covering ICES subdivisions 22, 24, 25, 26 and 28 (Figure 2).

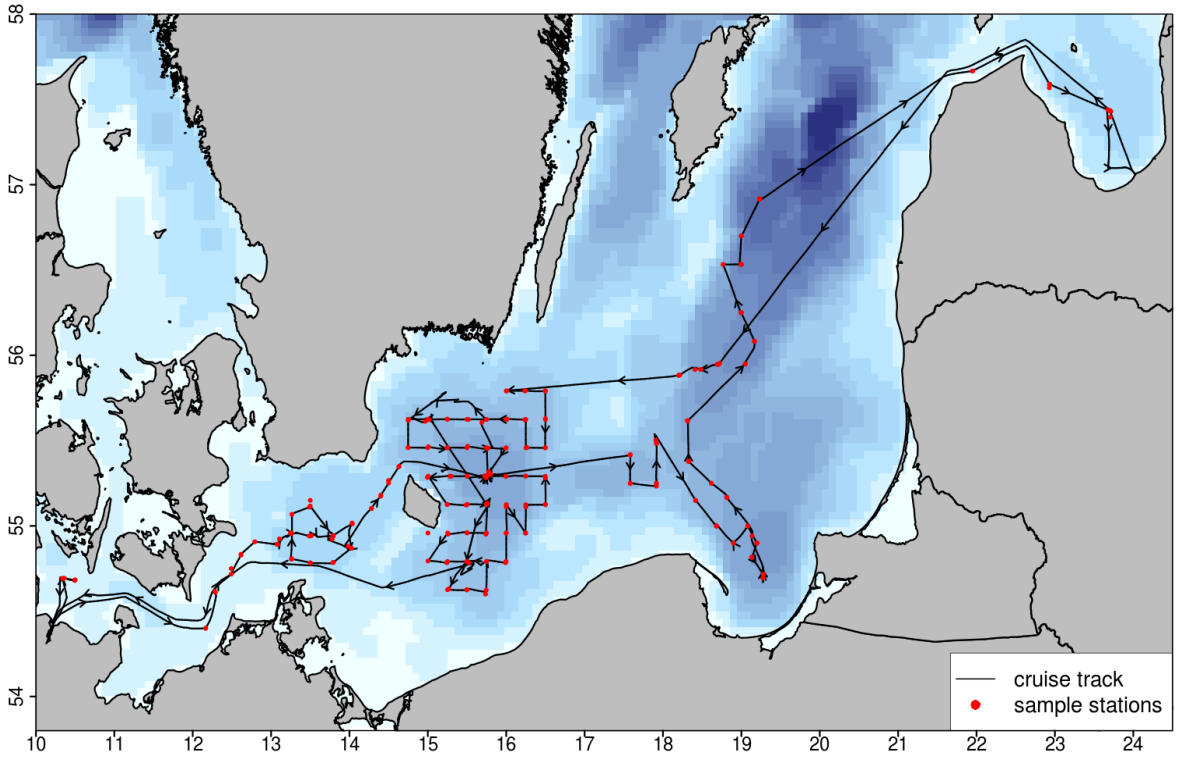

Fig. 1 Cruise track of AL509. Sampling stations are marked by red dots.

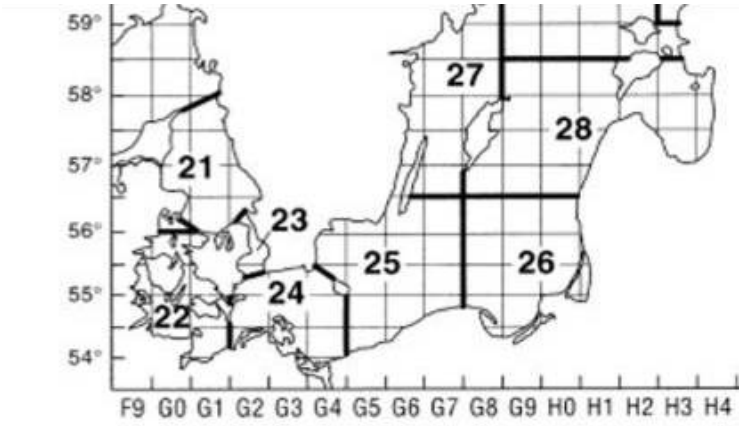

Fig. 2 ICES subdivisions in the Baltic Sea area (Source: ICES). ICES SD22 corresponds to Kiel Bight = KB, SD24 to Arkona Basin = AB, SD25 to Bornholm Basin = BB and Stolpe Trench = SR, SD26 to Gdansk Deep = GD and Southern Gotland Basin (GB). The eastern edge of SD28 is the Gulf of Riga, another subarea visited during this cruise.

Specific investigations during AL509 included a detailed hydrographic survey (oxygen, salinity, temperature, light intensity) (Fig. 3), zoo- and ichthyoplankton surveys (Fig. 3) to determine the composition, abundance, vertical and horizontal distribution and nutritional status of species as well as patterns of plankton phenology, whole food web sampling including nutrients, seston, phyto-, zoo- (including jellyfish), ichthyoplankton , and pelagic fishery hauls (Fig. 4). The latter served firstly 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 were obtained, including cod gonads and stomachs, herring and sprat stomachs and whole samples for dietary analyses, cod otoliths for aging, and tissue samples of cod, flounder, whiting, plaice and other species for genetic and stable isotope analysis. In addition, hydro-acoustic data were collected continuously along the cruise track for later analysis of fish abundance and distribution.

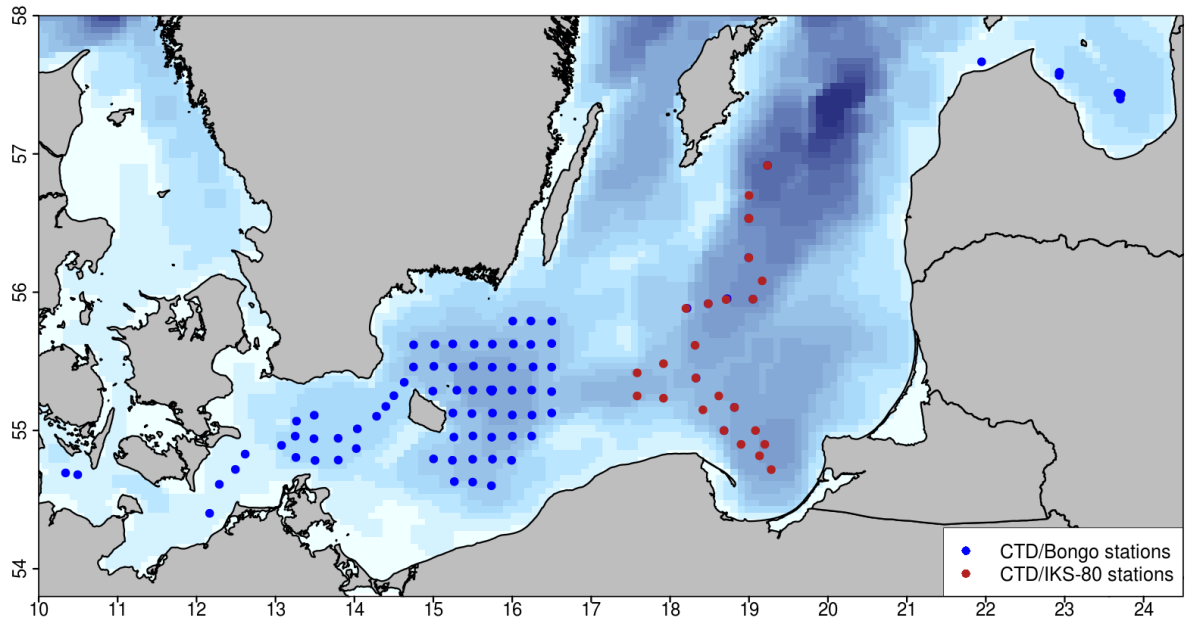

Fig. 3 Plankton sampling (Bongo nets) and CTD stations covered by AL507.

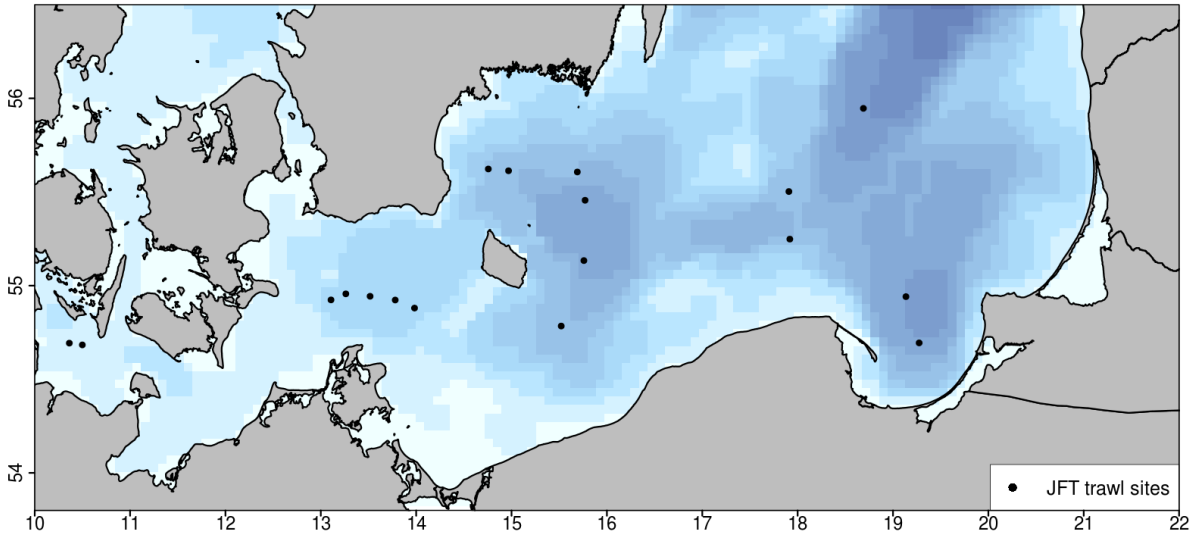

Fig. 4 Pelagic fishery trawl stations covered by AL509 using the JFT trawl net.

3. Narrative of cruise with technical details

RV ALKOR was loaded on the days prior to the onset of the cruise. ALKOR then departed from the GEOMAR west shore pier on 16 May 2018 at 09:00 am (all times board time) and headed to the first research area in the Kiel Bight (SD22). All members of cruise AL509 stayed on board for the complete 16-day leg.

In the following, all work laid out in the original cruise program was accomplished as planned, benefiting from optimum working conditions on board without any equipment problems. Weather over the duration of the cruise made for almost perfect working conditions, with winds rarely exceeding 4 Beaufort, but at the same time, no ship time was lost due to storms.

Specifically, over the course of the cruise, pelagic fishery hauls, zooplankton hauls with Bongo/IKS-80 nets, water sampler, and CTD hauls were carried out following a large-scale spatial sampling design covering Kiel Bight (SD22 on 15.5) Arkona Basin (SD24) on 16 May, Bornholm Basin (SD25) on 17 May, Stolpe Trench (SD25) on 18 May, Gdansk Deep (SD26) on 19 May, and Gotland Basin (SD26/28) on 19-20 and on 24 May, and Gulf of Riga 21/22 May (Figure 1). On the way back, the Bornholm basin was the focal area, with sampling of the Bongo Grid 24-27 May and the major station BB23 on 26-27 May.

In addition, hydroacoustic data obtained with four different echosounder frequencies (38, 70, 120 and 200 kHz) were continuously recorded.

The cruise was interrupted by a harbor day in Riga from 22-23 May to exchange samples with Andrei Makarchouk**,** Latvian Fisheries Research Institute.

In addition to the program above, the central deep station BB23 in Bornholm Basin was intensively sampled on one occasion over 24 hrs between 26 and 27 May including CTD casts, zooplankton sampling with Bongo, Apstein and WP-2 nets, oxygen measurements of water samples obtained with the rosette water sampler and subsequent application of the Winkler method, phytoplankton sampling using the same water samples).

As a special addition to the May cruise program, the cruise section within the Gulf of Riga served to sample the euryhaline copepod species *Eurytemora affinis*. Several dedicated plankton hauls were undertaken for this key species, in collaboration with the University of Wisconsin where this species is invasive in the Great Lakes area.

Table 1 Overview of gear deployment during AL509. Mesh sizes are also given. For location designations (combination of ICES SD and abbreviated name), see Fig. 2. GuR = Gulf of Riga.

Count of area gear	AB	BB	GB	GD	GuR	KB	SR	total
Apstein 50 µm		6						6
Bo/BaBo 150, 300, 500 µm	20	47	6	3	13	2		91
CTD	20	47	11	10	4	2	4	98
IKS80 500 µm			11	10			4	25
trawl JFT 0.5 cm	5	6	1	2		2	2	18
MN-Maxi 300 µm		8						8
MN-Midi 50 µm		8						8
WP2 100 µm		6						6
WP2 200 µm		2						2
Water sampler CTD		3						3
total	**45**	**133**	**29**	**25**	**17**	**6**	**10**	**265**

4. Scientific report and first results

Cruise AL509 accomplished all objectives of the original work program. Specific work lines are described in the following.

4.1 Ichthyo– and zooplankton sampling

Bongo- and Babybongo hauls covered Kiel Bight, Arkona Basin, and Bornholm Basin including the western part of Stolpe Trench (Figure 3, Table 1). Larvae of sprat (*Sprattus sprattus*; n = 503), flounder (*Plathichthys flesus*; n = 301), sculpin (*Myoxocephalus scorpius*, n = 2), and common seasnail (*Liparis liparis*; n = 58) were picked from the 500 µm bongo-samples as well as 300 µm Multinet samples and conserved at -80 °C for subsequent RNA/DNA, stable isotope and genetic analyses. As in April (AL507) no cod (*Gadus morhua*) larvae were found, which is in line with very low abundances observed on our spring cruises in previous years, and with observations over past decades that have shown a temporal shift in the reproductive period and the subsequent occurrence of cod larvae in the Bornholm Basin from spring to summer months.

All of the 500 µm Bongo und the 300 µm Multinet samples were also checked for the presence of gelatinous zooplankton. The jellyfish species *Aurelia aurita*, *Obelia spp.* and the invasive combjelly *Mnemiopsis leidyi* (N=3) were found in unusually low numbers. At the same time adult, small adult *Cyanea capillata* were regularly recovered from the pelagic fishery hauls, in total at least 498 individuals. Following these initial on board steps, all Bongo samples were conserved in 4% buffered formalin solution, and will be used for the determination of species composition and abundance of zooplankton and ichthyoplankton.

Stations in the eastern part of Stolpe trench and the Gdansk Deep and Southern Gotland Basin were covered with IKS-80 instead of Bongo hauls to ensure compatibility of data with a long-term IKS-80 sampling series maintained by the Latvian Fish Resources Agency (LATFRA; Andrei Makarcuks).

Repeated Multinet MAXI (300 µm, towed, sampling of the water column in 5 m layers) and MIDI (50 µm, vertical, sampling of the water column in 10 m layers) casts were done over a 24-hour period on 25-26 May on the central deep Bornholm Basin station BB23

to assess diurnally resolved vertical distributions of ichthyo- and zooplankton. In addition, WP-2 (100 µm, 200 µm) and Apstein (55 µm) nets and the rosette water sampler were deployed to obtain additional samples, including nano- and micro-phytoplankton samples in the context of plankton phenology work (collaboration with Dr. Jörg Dutz, IOW).

4.2 Fishery

Table 2 Fish catch composition during AL509.

For report (example)			
Latin name	Common name	n	mass (kg)
Sprattus sprattus	sprat	71,062	722.8
Gadus morhua	cod	1,031	368.6
Clupea harengus	herring	5,450	258.1
Merlangius merlangus	whiting	145	56.7
Limanda limanda	common dab	135	14.2
Platichthys flesus	flounder	19	3.7
Pleuronectes platessa	plaice	10	1.7
Gaidropsarus vulgaris	three bearded rockling	19	
Zoarces viviparus	eelpout	2	
Ammodytes tobianus	small sandeel	1	
Gasterosteus aculeatus	three-spined stickleback	1	
Rhinonemus cimbrius	four bearded rockling	1	
	Total	**77,876**	**1,426**

Pelagic fishery hauls were conducted in the Kiel Bight (2 hauls), Arkona Basin (4 hauls), Bornholm Basin (6 hauls), Gotland Basin (3 hauls) and Gdansk Deep (2 hauls) (Figure 4). Catches of cod were moderate compared to previous years, but dominated by smaller fish <40 cm. In the Arkona Basin and the Western part of the Bornholm basin, a relatively high number of whitings were caught, consolidating a trends of the expansion of this species into the Baltic proper. It was noteworthy that a number of flatfish (dab and flounder) were caught in the pelagic zones as there was little oxygen remaining in the bottom water layer (Fig. 6). In parallel to the fishery hauls, hydro-acoustic measurements of fish distribution patterns were recorded continuously. The overall catch composition is shown in Table 2.

Fig. 5. Mature female cod with gonads stage 5 from Bornholm basin of only 27 cm in length. Foto T. Reusch

For each haul, catch weight and length frequencies of all species were taken. Stomach samples were taken from sprat (10 per 1 cm length class) and herring (10 per 2 cm length class). For cod, single fish data (length, weight, sex and maturity stage) and samples (otoliths, fin clips for genetic analysis, stomachs and gonads) were obtained for 650 individuals, whereas length and weight were measured for an additional 500 individuals. The low mean size of individuals confirmed observation from recent years that large individuals >45 cm, which were frequently observed in past decades, are now mostly missing from the population. We also frequently observed small (<30cm length) male and female cod that were sexually mature, confirming the general trend towards maturity at much smaller length classes observed throughout the past 20 yrs (Fig. 5).

4.3 Hydrography

CTD profiles from 98 stations were obtained with the ADM-CTD and the HYDROBIOS water sampler with attached CTD (station overview cf. Fig. 3). 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.

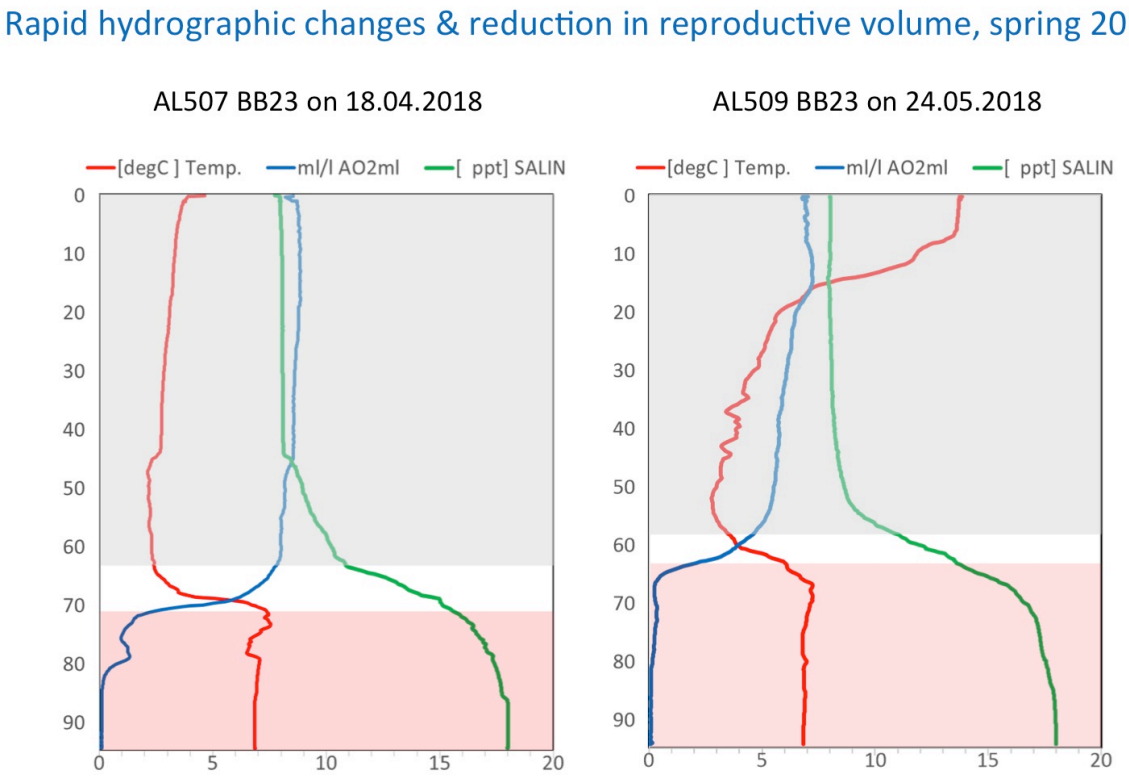

Fig. 6. Comparative hydrography at station BB23 between 18 April and 24 May 2018. red: hypoxic areas with $O_2 < 2mg*L^{-1}$.White layer: reproductive volume of cod, characterized by salinity >11psu and $O_2 > 2mg*L^{-1}$. Note the rapid expansion within only 36 days of the bottom water layer where oxygen is at 0 $mg*L^{-1}$. Profiles prepared by Dr. B. von Dewitz.

Compared to previous years, oxygen concentrations in the deeper layers of Bornholm Basin but also Gdansk Deep showed noticeable declines. Anoxic (0 ml/l) conditions prevailed at depths below of 80 m down to the seafloor, and hypoxic (< 2 ml/l) conditions already prevailed below depths of 64 m, leading to a reduced reproductive volume for cod (see Fig. 6 at BB23). As in April (AL507), the relief from low oxygen conditions provided after the major Baltic inflow event in the winter of 2014/2015 and the subsequent smaller inflow in the winter of 2016/2017 was no longer detectable. Most importantly, the reproductive volume shrank by about 4 vertical meters in a short time interval of only 36 days, highlighting the high oxygen consumption rate of the pelagic water body around the halocline (Fig. 6).
The depth-resolved sampling with the Multi-Nets strikingly demonstrated how compressed life in the water column was during May 2019, with the bulk of the zooplankton biomass between 60 and 70 m (Fig. 7).

Fig. 7. Catches of the Multi-net in 5 m-steps at time intervals of 6 hrs throughout one day at station BB23. Note the pink coloration of Kautex bottles in one distinct depth horizon between 55m and 70 m owing to copepods with lipid droplets containing carotenoids. Below 70 m there is no higher life in the water column (transparent bottles) because oxygen is at 0 mg*L^{-1}. Foto T. Reusch.

4.3 Sampling of the copepod *Eurytemora affinis*

The US funded NSF Project "Evolutionary Responses to Global Changes in Salinity and Temperature" envisions experiments with different populations of the copepod *Eurytemora affinis* obtained along the salinity and temperature gradient of the Baltic Sea, to test these populations for local adaptations to different environmental conditions.

The corresponding objective during cruise AL509 was to obtain samples of *E. affinis* along the cruise track (Figure 1). After efforts failed because *E. affinis* was absent in all plankton samplesfrom the Bay of Gdansk and in Northern Gotland Basin the cruise track for May also included the highly brackish Gulf of Riga (GuR), where several 100s of *E affinis* could be successfully sampled for further population genetic and genomic analyses (collaboration with prof CE Lee).

5. Scientific equipment: instruments and gear

Hydrography:

- ADM-CTD with additional oxygen sensor
- Hydrobios Water Sampler with CTD and oxygen sensor

Zooplankton:
- Baby-Bongo and Bongo-Net (150 µm, 300 µm, 500 µm)
- WP-2 nets (100 µm, 200 µm)
- Apstein net (50 µm)

Ichthyoplankton:
- Bongo net (300 µm and 500 µm)
- Hydrobios Multinet MAXI (300 µm horizontal hauls)
- Hydrobios Multinet MIDI (50 µm vertical hauls)
- IKS-80 (500 µm)

Fish:
- Jungfisch Trawl (pelagic trawl net; 0.5 cm mesh size)

Hydroacoustics:
- 38, 70, 120 and 200 kHz-echosounder EK60

6. Acknowledgements

I want to thank the captain and the entire crew of RV ALKOR for their outstanding support throughout the cruise, Svend Mees for his unwavering support in all technical matters for the cruise, and Burkhard von Dewitz for the compilation of maps for this report. Many thanks to Dr. Jan Dierking for his assistance with cruise planning and preparation, and the scientific personnel and the student assistants of AL509 for their enthusiastic effort and cooperation.

7. Appendix E1: Station list of AL509

Supplied with the report in electronic form as Excel table,
"Appendix_E1_AL509_station_list.xlsx"