ALKOR -Berichte

Bachelor-MARSYS education cruise in the Baltic Sea

Cruise No. AL540

21.07 – 31.07.2020,
Warnemünde (Germany) – Kiel (Germany)
BALTEACH - 1

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2020

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1 Cruise Summary

1.1 Summary in English

This cruise was originally planned as a teaching cruise for bachelor students of the Institute of Marine Ecosystem and Fisheries Sciences (IMF) to learn the most commonly used scientific methods, gears and working procedures of fisheries science and biological oceanography on board of a research vessel.

Due to the current Covid-19 regulations and the resulting restrictions, only 6 scientists were allowed to attend, so the cruise was used to make extensive instructional videos and collect sample material for student project work and module theses.

The main scientific objective was to investigate the distribution patterns of certain fish species such as cod, whiting, sprat and herring in the Kiel Bight, Mecklenburg Bight, Arkona and Bornholm Basin.

Besides fisheries and hydrological surveys, plankton stations were sampled along the cruise track to gain insights into the spatial distribution of zoo- and ichthyoplankton, as well as fish eggs.

All necessary digital educational content could be created and despite persistently bad weather conditions and the resulting changes in the cruise program, sufficient sample and data material could be collected.

1.2 Zusammenfassung

Diese Ausfahrt wurde ursprünglich als Lehrausfahrt für Bachelor-Studenten des Instituts für Marine Ökoystem- und Fischereiwissenschaften (IMF) geplant, um die am häufigsten verwendeten wissenschaftlichen Methoden, Geräte und Arbeitsverfahren der Fischereiwissenschaft sowie der biologischen Ozeanographie an Bord eines Forschungsschiffes kennenzulernen.

Aufgrund der geltenden Covid-19 Bestimmungen und der sich daraus ergebenden Einschränkungen durfte die Ausfahrt nur mit 6 Wissenschaftlern angetreten werden und wurde dazu genutzt, um umfangreiche Lehrvideos zu erstellen, sowie Probenmaterial für Projektarbeiten und Modulabschlussarbeiten zu sammeln. Hauptziel dabei war die Untersuchung der Verteilungsmuster bestimmter Fischarten wie dem Dorsch, Wittling, Sprotten und Heringen in der Kieler Bucht, der Mecklenburger Bucht, des Arkona und des Bornholm Beckens.

Neben der Fischerei und hydrologischen Untersuchungen wurden entlang der Reiseroute Planktonstationen beprobt, um Einblicke in die räumliche Verteilung von Zoo- und Ichthyoplankton und Fischeiern zu gewinnen.

Es konnten alle benötigten digitalen Lehrinhalte erstellt werden und trotz anhaltend schlechten Wetterbedingungen und der dadurch bedingten Änderung des Fahrprogrammes konnte ausreichend Proben- und Datenmaterial gesammelt werden.

2 Participants

2.1 Scientific Party

Name	Discipline	Institution
Nowicki, Margarethe	Chief scientist	IMF
Klinger, Richard	PhD student	IMF
Plonus, René-Marcel	PhD student	IMF
Hornetz, Peter	Scientific Assistant	IMF
Kurbjuweit, Stefanie	Scientific Assistant	IMF
Hirschmann, Sophia Carolin	Scientific Assistant	IMF

2.2 Participating Institutions

IMF Institute of Marine Ecosystem and Fishery Science, University of Hamburg

3 Research Program

3.1 Aims of the Cruise

This cruise was planned as a teaching cruise for MARSYS Bachelor students from the Institute of Marine Ecosystems and Fisheries Science (IMF, University of Hamburg), aiming to train students in different sampling methods of marine ecology and fishery science.

The key characteristic is the integration of oceanographic and biological information to enhance understanding of the spatial distribution of pelagic fish eggs and larvae, phytoplankton and zooplankton abundance patterns as well as fish abundances in dependence of climate change and anthropogenic stressors.

This cruise is designed to train students in sampling methods targeting the different compartments of a marine ecosystem. The methods cover CTD profiles, phyto- and zooplankton samples as well as fishing operations.

Theoretically, all students should be trained in all technical procedures including work on deck, sample preparation, conservation, labelling documentation and storage. Students also receive training in pre-analysing samples and species identification on nearest taxonomic level to get an overview of the biodiversity of the system.

Due to the binding hygiene regulations caused by the Covid-19 Pandemic by the shipping company (Briese), only 6 scientific crew members were allowed to attend the cruise. In addition, due to the effective regulations of the University of Hamburg, no students were able to attend the cruise, as excursions were prohibited.

In order to meet the teaching obligations and the original goals of this cruise, an online field method course was designed under the direction of Dr. Luisa Listmann and in cooperation with Richard Klinger. The contents of this course were to reflect the originally planned teaching cruise in a digital version, aiming to include all steps regarding preparation, conduction and post processing of a scientific cruise.

3.2 Agenda of the Cruise

The cruise had three main general objectives with regard to the scientific training of our students:

1. Provide knowledge and practical skills with regard to the operation of a broad range of different gears needed to sample and investigate the different ecological compartments of a marine ecosystem covering ocean physics, chemistry, particularly plankton, and fish.
2. Provide insights and experiences regarding cruise organization and sampling strategies, producing meaningful estimates of abundance, biomass and rates of selected species or species groups in relation to a stratified marine ecosystem.
3. Provide opportunities to gather relevant data and specimens for bachelor, master and PhD theses.

This cruise program is designed to introduce students of the institute to a scientifically sound practice of standard working procedures on board. As a basis of the teaching procedure, the daily work plan includes a concept of rotation through a range of different subjects. Four different fields of responsibility are determined, in which each student receives individual training, or in a group of 2, to establish a practical knowledge of work on a research vessel. Individual training entails that the students would be introduced to each individual job with the goal to handle everything at a certain point by themselves. Therefore, experienced staff members of the institute lead the teaching process and give guidance throughout the entire process, resulting in gapless mentoring.
With regard to the teaching goals, the online teaching module was created using digital methods such as videotaping and audio recording on board.

Theoretically, the students are lead through the following fields of responsibilities:

I. Gear:
Deploying gears, including the handling of the: voice intercom system, gear software, data documentation and station work coordination. During fishing, for example advanced students are on the bridge to get some insights on how hydroacoustic methods are used for fishery science.

II. Working deck:
Practical work on deck, including: preparing the variety of gears for their use; supporting the crew to manoeuvre the gear in and out of the water.

III. Sampling:
Handle the plankton samples correct until they are labelled, fixed and stored properly. Processing of fish hauls with the trawls, including: coordination of the working procedures as taking adequate subsamples, fish sorting and species identification, length-frequency measurements and determination of sex, maturity as well as otolith preparation, for age determination. These steps add up to apply basic and advanced methods needed for assessment of fish populations.

IV. Lab. coordination:
Including: on one hand the in situ measurement of, for example phytoplankton samples as well as sorting and determination of fish larvae. On the other hand, the students learn the organization of all work procedures in the laboratory, as preparing laboratory utilities, protocol management, cleanliness and accomplish general jobs that keep the work flow organized and efficient.

This scheme was digitally implemented into the module, by the creation of explanatory videos, aiming at the different topics.

3.3 Description of the Working Area

The spatial focus lies on the Western Baltic Sea, Arkona and Bornholm Basin.
This cruise included collecting samples from all major compartments of the ecosystem, from coastal to open waters in a 3-dimensional distribution.

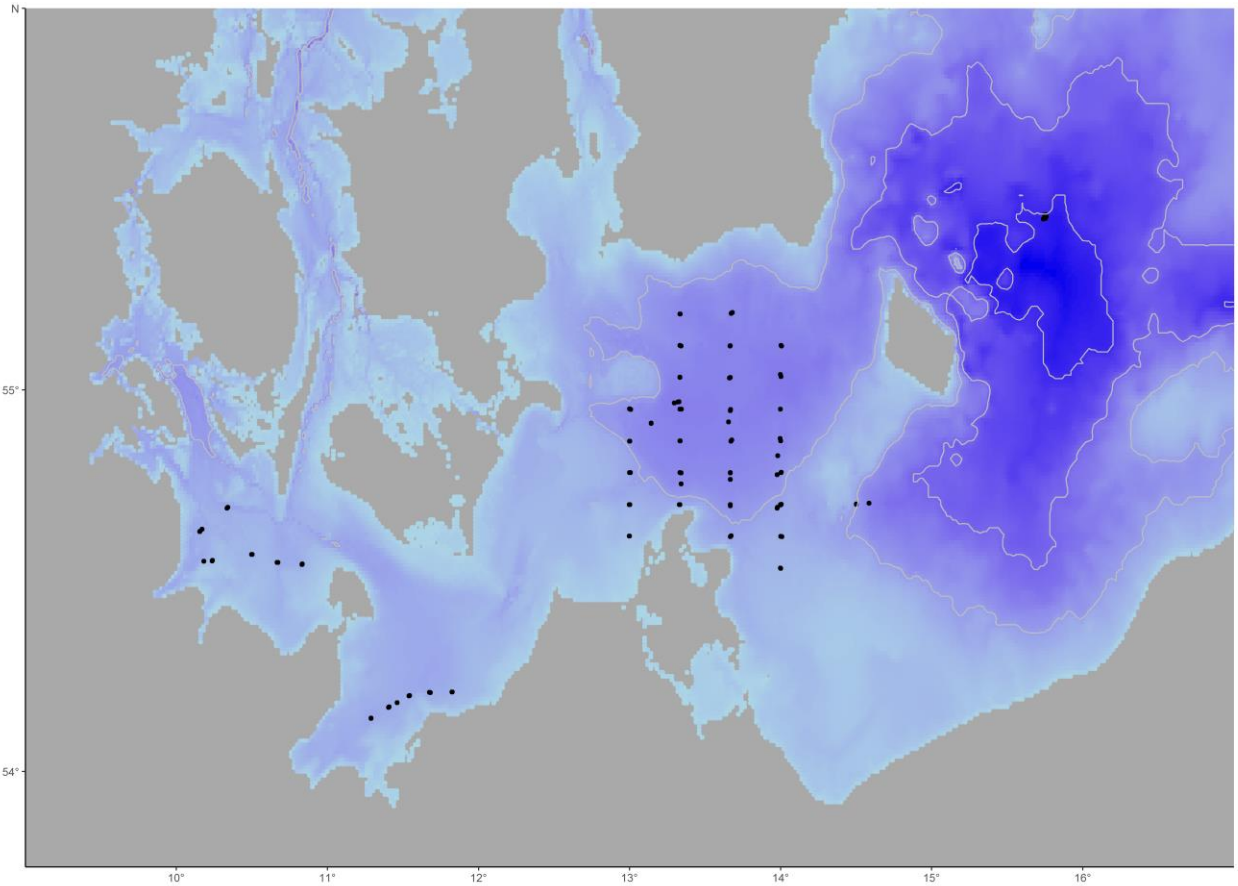

Figure 3.1: Station overview AL540. All realized sample stations are depicted by black dots. Positions per Gear are given in Table 6.1.

Specific investigations included a detailed hydrographic survey (oxygen, salinity, temperature, light intensity, fluorescence), plankton surveys (phyto-, zoo- and ichthyoplankton, with the goal to determine the composition, abundance, vertical and horizontal distribution) and fishery hauls.

The latter served to determine size distributions, maturity status, and length – weight relationships of the three dominant fish species in the system of the Baltic, cod (*Gadus morhua*), herring (*Clupea harengus*) and sprat (*Sprattus sprattus*). Various different samples were obtained for more detailed analyses, stomachs of cod, herring and sprat; otoliths of cod for the determination of the individual age. In addition, along the cruise track, hydroacoustic (echosounder) data were collected continuously for later analysis of fish abundance and distribution.

Most of the samples are of "dual use" in the sense that they are also either used for thesis work or in international cooperation (DTU Aqua).

4 Narrative of the Cruise

RV ALKOR departed from Warnemünde port on 21st of July 2020 at 07:54 am and headed to the first research area in the Mecklenburg Bight (SD22). Over the course of the cruise, fishery hauls, zooplankton hauls with Bongo and Multinet MIDI/MAXI, water sampler as well as CTD hauls were carried out following a large-scale spatial sampling design covering the Mecklenburg Bight (SD22) on 21st of July, the Arkona Basin (SD24) on 22-26th of July, the Bornholm Basin (SD25) on 27th of July and the Kiel Bight (SD22) on 29-30th of July.
In addition, hydroacoustic data obtained with four different echosounder frequencies (38, 70, 120 and 200 kHz) were continuously recorded.
Due to the bad weather conditions on the AL539, parts of the cruise planning had to be adjusted. Stations which were planned on the AL540 were carried out during the AL539 and vice versa.
Unfortunately, the Al540 cruise did not accomplishe all objectives of the original work program. Due to bad weather conditions the fishery stations in the Bornholm Basin could not be accomplished as well as a variety of stations and samplings in the Mecklenburg Bight and Kiel Bight which had to be skipped.
Further, in the Arkona Basin we had to adjust the work program and skip three stations, due to a restricted area (Windpark).

A detailed list of gear deployments (Table 4.1), the station list (Table 6.1), and an overview of first scientific results are provided below.

Table 4.1: Overview of gear deployment. Mesh sizes are given in brackets.

Gear	Total
ADM-CTD vertical	45
Watersampler (Niskin Bottle)	4
CTD with Watersampler	1
Bongo (335µm, 500µm)	39
Multinet MIDI horizontal (300µm)	3
Multinet MIDI horizontal (55µm)	16
Multinet MAXI horizontal (335µm)	8
Pelagic fishery trawl	14
Total	130

5 Preliminary Results

5.1 Cruise Module

(Dr. Luisa Listmann, Richard Klinger, Margarethe Nowicki,
Institute for Marine Ecosystem and Fishery Science, Hamburg University)

The module was structured in a specific way to impart knowledge as close as possible to the planned educational process during the cruise.
This resulted in a structured module, incorporating the following 4 objectives:

1 Creation of a variety of videos, covering all subject areas mentioned under "3.2 Agenda of the Cruise" (defined responsibilities: I-IV), resulting in 12 topics (a-l, mentioned below) with a total of 14 videos (total length: 2,5h), which included added audio explanations.

  a. Tour around the ship; including all labs and important areas
  b. CTD; handling on deck and controls on the computer
  c. Water sampler; handling on deck and controls on the computer
  d. Plankton nets (Bongo, Multi net, WPS, Apstein); handling on deck and controls on the computer
  e. Bongo in detail, gear and sample handling
  f. Multi net in detail, gear and sample handling
  g. Phytoplankton primary production; sample handling and following measurements
  h. Jelly fish, handling jellies caught with plankton catching gears
  i. Fish larvae; sorting and recognizing different species of larvae from bongo samples
  j. Fisheries; usage of a trawl net; catch handling procedure
  k. Sprat and herring; species identification, length measurements and stomach sampling
  l. Cod; single fish analysis

2 A quiz for every video topic, which has to be passed by the students

3 3 recorded lectures (total length: 3h), serving background information with condensed information regarding:

  a. The ecosystem Baltic Sea
  b. Plankton sampling
  c. Fisheries
  d. Gears
  e. Work on a research vessel
  f. Introduction into handling CTD data using Ocean Data View

4 Working with data from recent cruises in groups of 3; resulting in an essay in the style of a scientific publication. Every group had to include hydrographic aspects into their thematic considerations. The following topics were assigned:

  a. Hydrography of the Baltic Sea
  b. Physiological response of phytoplankton communities to temperature changes
  c. Physiological response of phytoplankton communities to salinity changes
  d. Distribution and abundance changes of jelly fish
  e. Distribution and abundance changes of cod eggs

f. Distribution and abundance changes of cod larvae
g. Distribution and abundance changes of zooplankton communities
h. Distribution and abundance changes of pelagic swarm fishes as sprat and herring
i. Distribution and physiological aspects regarding cod

5.2 *Ostreococcus* and virus isolation from the Baltic Sea

(Dr. Luisa Listmann,
Institute for Marine Ecosystem and Fishery Science, Hamburg University)

As part of this ongoing project on the ecological and evolutionary effects of different temperatures and salinities in the Baltic Sea on host-virus dynamics of *Ostreococcus* and its viruses, we aim to answer the following questions: From which regions of the Baltic Sea can we isolate *Ostreococcus* sp. and its associated viruses? And, subsequently, how do the viral dynamics differ between the origins of the hosts and viruses.

To answer these questions, we took surface water samples at 6 stations along the cruise track of AL540. On board, water samples of two size fractions (0.2-2µm and <0.45µm) were collected to isolate picoplankton and viruses, respectively, back in the laboratory at the IMF in Hamburg. The 4 stations were divided into Kiel Bay (1 station), Mecklenburg Bay (1 station), the Arkona Basin (2 station).

From water samples taken on previous cruises (2018 and 2019) we have already successfully isolated 24 new strains of *Ostreococcus* sp.. However, success was mainly restricted to water samples form Spring or Autumn cruises. In line with these previous findings, we were not successful in isolating new *Ostreococcus* sp. this year. Nevertheless, we isolated several other phytoplankton species that will be used for investigations on carbon acquisition in response to environmental change.

In addition, viral isolations of *Ostreococcus* viruses have also been highly successful yielding ca. 60 new viral strains from water samples ranging from the Kiel Bight up to the Bornholm Basin (water samples from cruises in 2018, 2019). Since virus isolations take months and laboratory work has been restricted due to the current Covid-19 situation, we have not yet isolated new virus strains from water samples taken on AL540 but are in the process of doing so. However, first results show, that viruses are present in the water samples collected on board AL540 (example Fig. 5.x). With previous high success rates, we are confident, that also from water samples of the latest cruise, we will successfully isolate new virus strains.

Both virus and host strains from *Ostreococcus* will then be used for investigation of infection dynamics in relation to geographical distribution over the Baltic Sea and environmental change that include temperature and salinity changes.

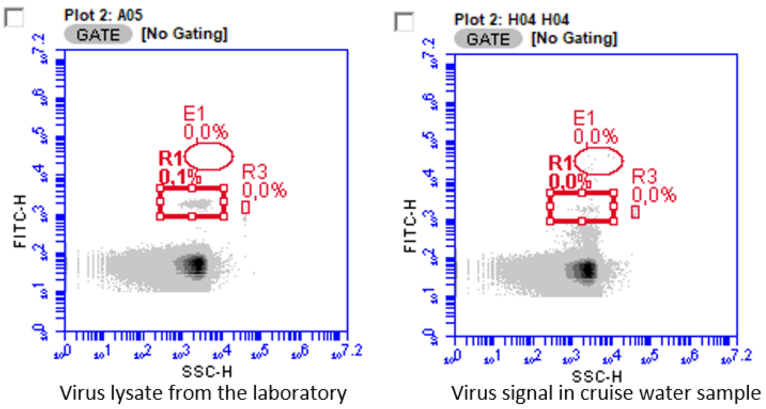

Figure 5.1: Cytometric analysis of a virus lysate after virus isolation (left panel) and concentrated water sample from the cruise (right panel). It shows that in the water sample from the cruise a virus signal is present and isolation success is therefore likely.

5.3 Ichthyo– and zooplankton sampling

(Margarethe Nowicki, Richard Klinger,
Institute for Marine Ecosystem and Fishery Science, Hamburg University)

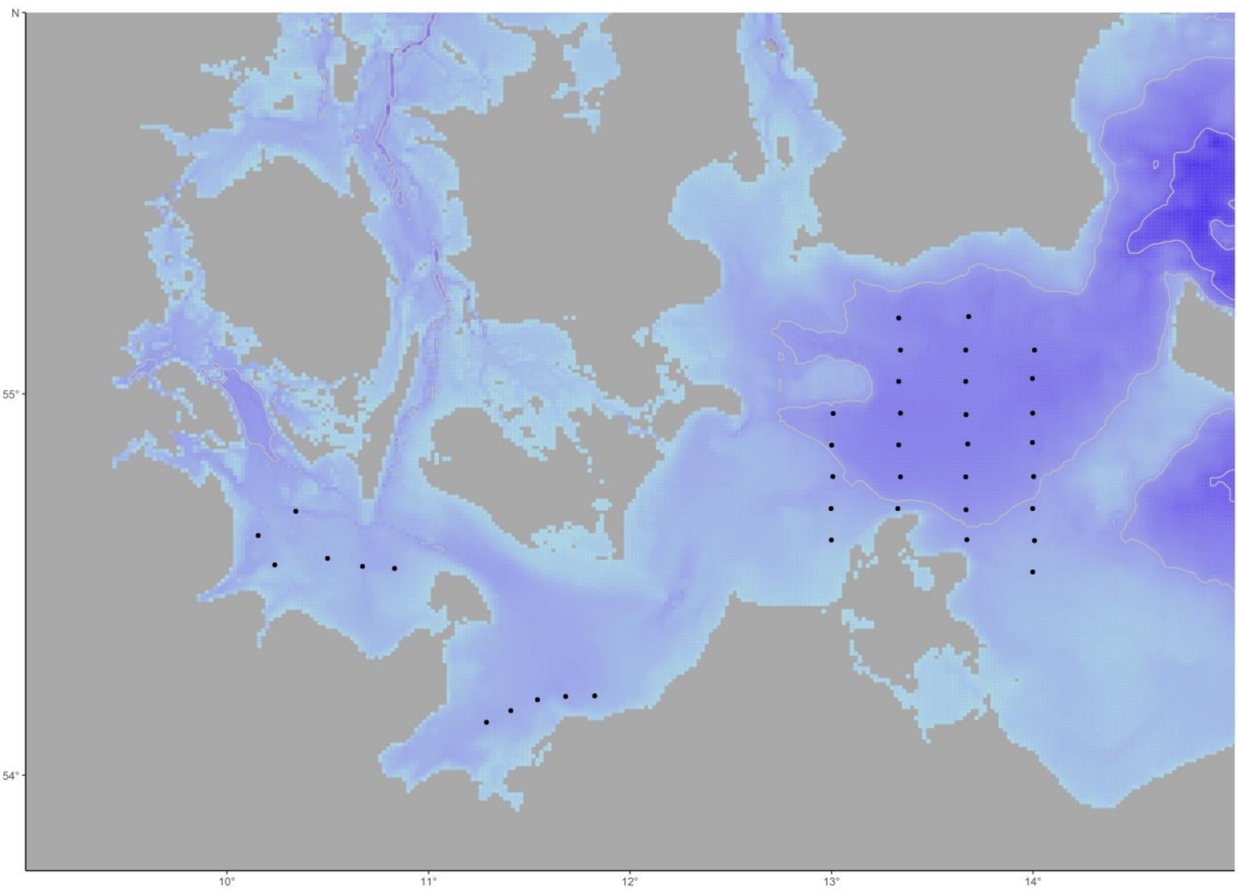

Figure 5.2: Overview of all processed bongo stations during AL540. Black dots represent bongo stations.

Bongo hauls presented in Figure 5.2 covered the Kiel Bight (6 hauls), the south of the Mecklenburg Bight (5 hauls) and the Arkona Basin (28 hauls).
Additionally, three trawled Multinet MIDI hauls (335µm) were performed in the Arkona Basin.
In the Bornholm Basin repeated trawled Multinet MAXI hauls (335 µm) and vertical Multinet MIDI hauls (55µm) over a 24 hour period (July 26th – July 27th) were performed on the north edge of the central deep Bornholm Basin (Station BB16) to investigate diurnally resolved vertical distributions of ichthyo- and zooplankton. From all of the 335 µm Multinet MAXI samples larvae of sprat/herring (Clupeidae; n = 356) and cod (Gadus morhua; n = 254) were picked and conserved at -80°C for subsequent RNA/DNA analyses (collaboration with Dr. Bastian Huwer, DTU Aqua).
Compared to the cruise in July 2019 (AL524; n = 114) cod larvae abundance in the 335 µm Multinet MAXI on in the processed samples increased, the vertical distribution is presented in Figure 5.3.

From all Bongo (500 µm and 335 µm) and Multinet (335 µm) samples gelatinous zooplankton (i.e. jellyfish) were collected and measured.
The vertical distribution of measured jellyfish on the AL540 from the 335 µm Multinet MAXI samples compared to July 2019 (AL524) is shown in Figure 5.4.

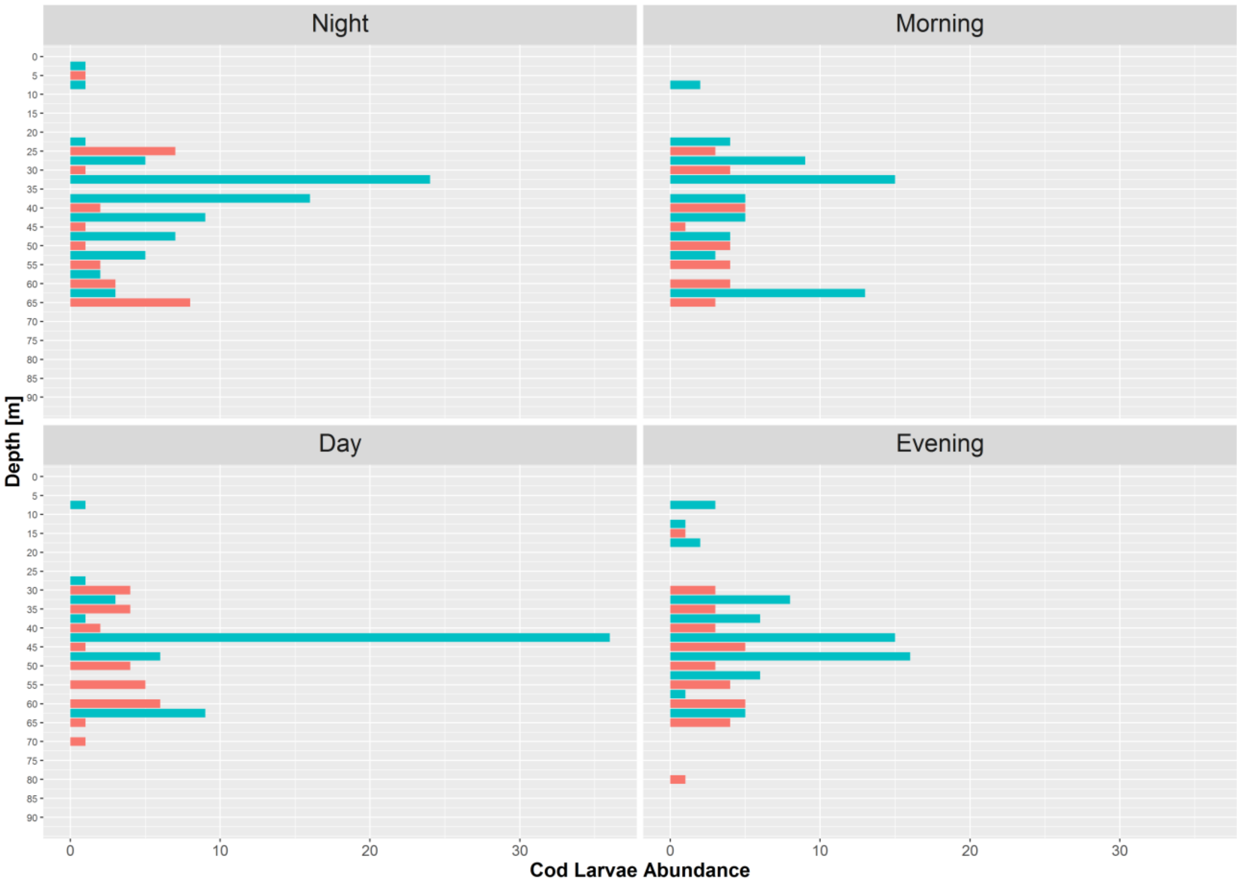

Figure 5.3: Depth distribution of cod (*Gadus morhua*) larvae in 2019 (AL524) in red and 2020 (AL540) in blue observed over a 24 hour period. Abundance as picked larvae from the Multinet samples.

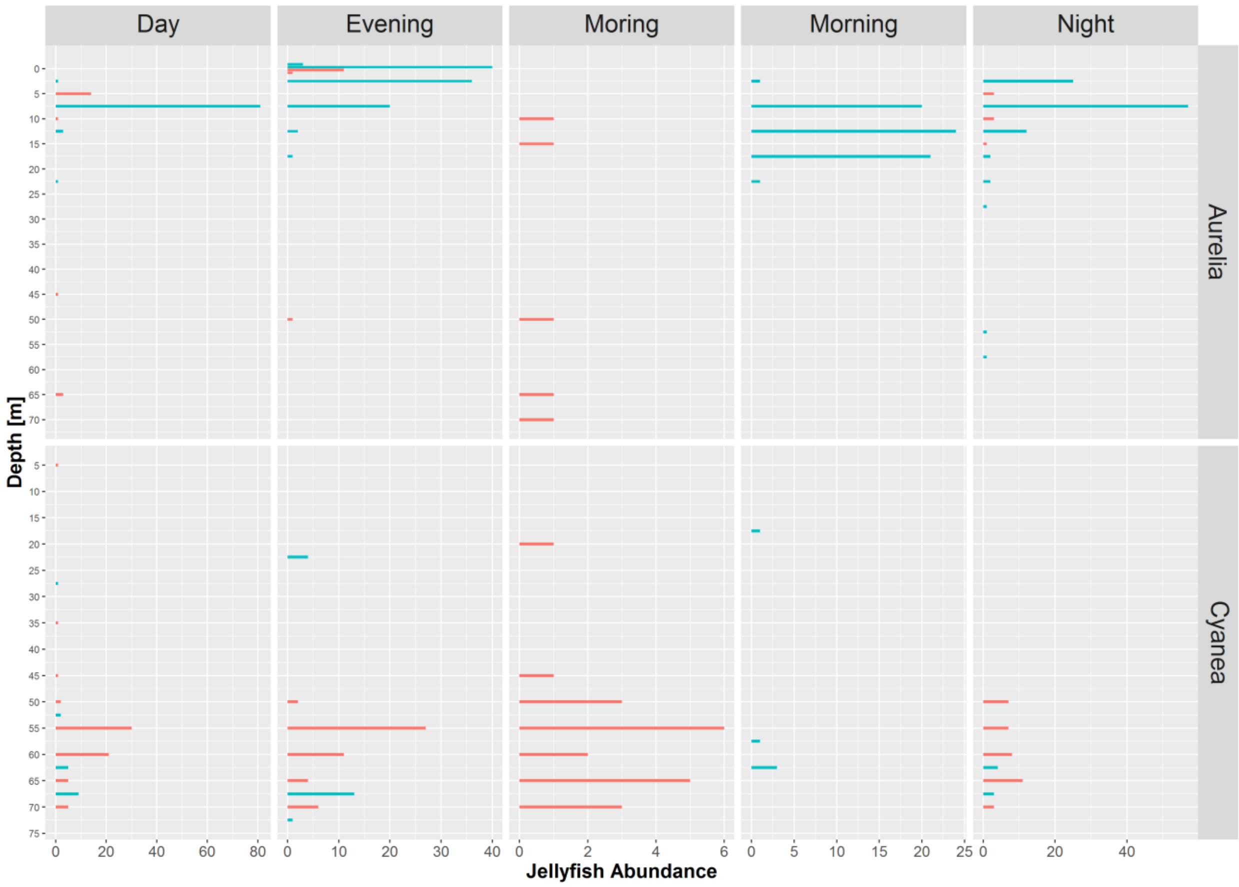

Figure 5.4: Depth distribution of the jellyfisch *Aurelia aurelia* and *Cyanea capillata* in 2019 (AL524) in red and 2020 (AL540) in blue observed over a 24 hour period. Abundance as measured jellyfish from the Multinet samples.

All of the 335 µm Bongo und the 335 µm Multinet samples were also checked for the presence of fish eggs. Following these initial on board steps, all Bongo samples were conserved in 4% buffered formol solution, and will be used for the determination of species composition and abundance of zooplankton and ichthyoplankton.

5.4 Fishery

(Margarethe Nowicki, Richard Klinger,
Institute for Marine Ecosystem and Fishery Science, Hamburg University)

Fishery hauls were conducted in the Kiel Bight (2 hauls), Mecklenburg Bight (1 hauls), Arkona Basin (5 hauls) and Adlergrund (2 hauls).

In parallel to the fishery hauls, hydroacoustic measurements of fish distribution patterns were recorded continuously.
The overall catch composition is shown in Table 5.1.

Table 5.1: Fish catch composition AL540.

Latin name	Common name	n	mass (kg)
Sprattus sprattus	Sprat	28270	340.22
Clupea harengus	Herring	19389	191.89
Merlangius merlangus	Whiting	244	56.01
Gadus morhua	Cod	114	42.78
Pleuronectes platessa	Plaice	68	13.73
Limanda limanda	Dab	33	3.43
Platichthys flesus	Flounder	15	3.96
Myoxocephalus scorpius	Shorthorn Sculpin	12	1.971
Juv. Gadus morhua	Juvenil Cod	10	0.031
Scomber scombrus	Atlantic Mackerel	4	1.81
Juv. Merlangius merlangus	Juvenil Whiting	2	0.013
Scophthalmus maximus	Turbot	1	0.288
Trachinus draco	Greater Weever	1	0.032
Hyperoplus maculatus	Great Sand eel	1	0.024
Ammodytes marinus	Sandlance	1	0.021
Syngnathus rostellatus	Lesser Pipefish	1	0.001
Aurelia aurita	Common Jellyfish		91.95
Cyanea capillata	Lion's mane Jellyfish		1.82
	Total	48166	749,98

For each haul and the entire catch, catch weight and length frequencies of all species were determined. Stomach samples were taken from sprat (30 per 1 cm length class) and herring (30 per 2 cm length class).
For cod, single fish data (length, weight, liver weight, sex and maturity stage) and samples (otoliths and stomach) were obtained for 62 individuals, whereas length, weight, liver weight, sex and maturity stage (without samples taken) were measured for 52 individuals (juveniles are not included).

For whiting, single fish data (length, weight, liver weight, sex and maturity stage) were obtained for 78 individuals, whereas length, weight and sex were measured for the remaining 164 individuals (juveniles are not included).

Relative length frequency distribution of individual sampled cod and whiting are presented in Figure 5.5 and Figure 5.6.

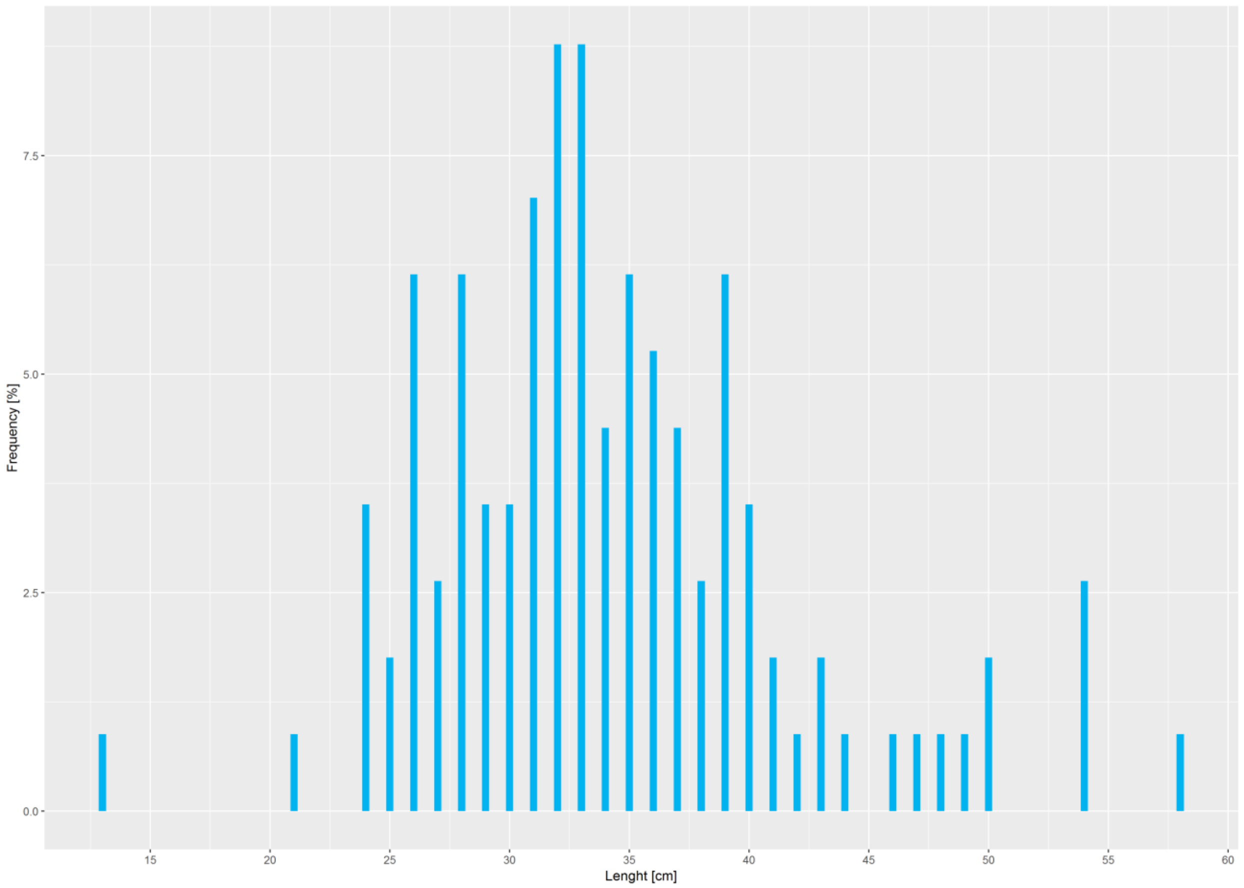

Figure 5.5: Relative length frequency distribution of individual sampled cod (n = 114) during AL540. Frequency is given in percent and length in cm (measurement cm below).

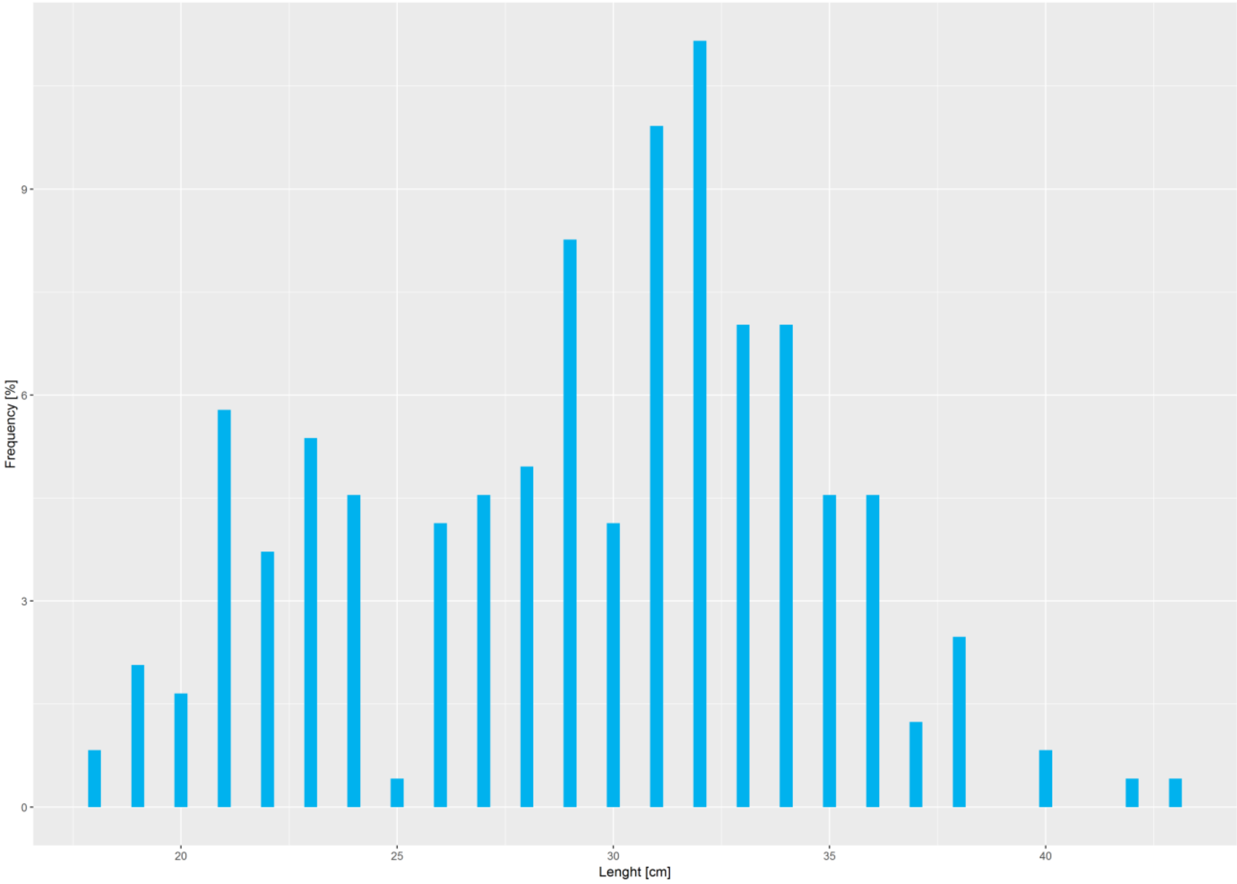

Figure 5.6: Relative length frequency distribution of individual sampled whiting (n = 244) during AL540. Frequency is given in percent and length in cm (measurement cm below).

5.4.1. Stomach samplings

Routine stomach samplings are conducted during the research surveys in cooperation with the Thünen Institute of Baltic Sea Fisheries which focus on the species cod (Gadus morhua), whiting (Merlangius merlangus), flounder (Platichthys flesus) and plaice (Pleuronectes platessa). Aim of the stomach sampling projects starting in 2016 is the investigation of the feeding ecology of key predators in the Baltic Sea, whereby the sampling especially focuses on depth and habitat related patterns in the diet compositions. A year round depth stratified sampling in 2016 revealed depth specific, seasonal and ontogenetic effects in the diet composition of cod in the Western Baltic Sea and provided as a pilot study the basis for the still ongoing depth stratified sampling in the Eastern Baltic Sea. Currently, two master theses (Peter Hornetz, Tobias Reßing) and one PhD thesis (Steffen Funk) are involved in the stomach sampling project.

5.4.2. Preliminary results of single fish cod sampling

Figure 5.7: Comparison of the relative length frequency distribution of individual sampled cod in Bornohlm Basin during AL539 in red and in Arkona Basin during AL540 in blue. Frequency is given in percent and length in cm (measurement cm below).

In order to investigate regional differences within the present cod populations, results from AL539 (mainly Bornholm Basin) are compared to AL540 (mainly Arkona Basin). The following results were evaluated based on the visual inspection, no statistical tests were performed.

The length frequency distribution of individual sampled cod during the AL539 (Bornholm Basin) and during AL540 (Arkona Basin) shows a slight shift of the length distribution towards smaller individuals in the Bornholm Basin (Figure 5.7). However, the mean length of caught fish do not differ clearly between the two areas.

Figure 5.8 shows the condition factor Fulton`s *K* for female and male per length class for the two different areas Arkona and Bornholm Basin. Fulton`s *K* Index is calculated as the somatic weight in g (gutted weight plus liver weight) and the total length in cm (Lambert and Dutil, 1996) and varied between 0.55 and 1.33.
There are no major differences in the condition of individual cod between the sexes, but the condition in the Akrona Basin is slightly higher than in the Bornholm Basin.
These results are consistent with previous observations.

Another PhD thesis (Richard Klinger) focuses on the combination of single fish data gained from various research cruises with results of experimental studies regarding Baltic cod feeding on natural diets in recirculating water systems. This represents a basis of physiological data which will be completed with the stomach content data of the mentioned studies to create a bio-energetic growth model of eastern Baltic cod.

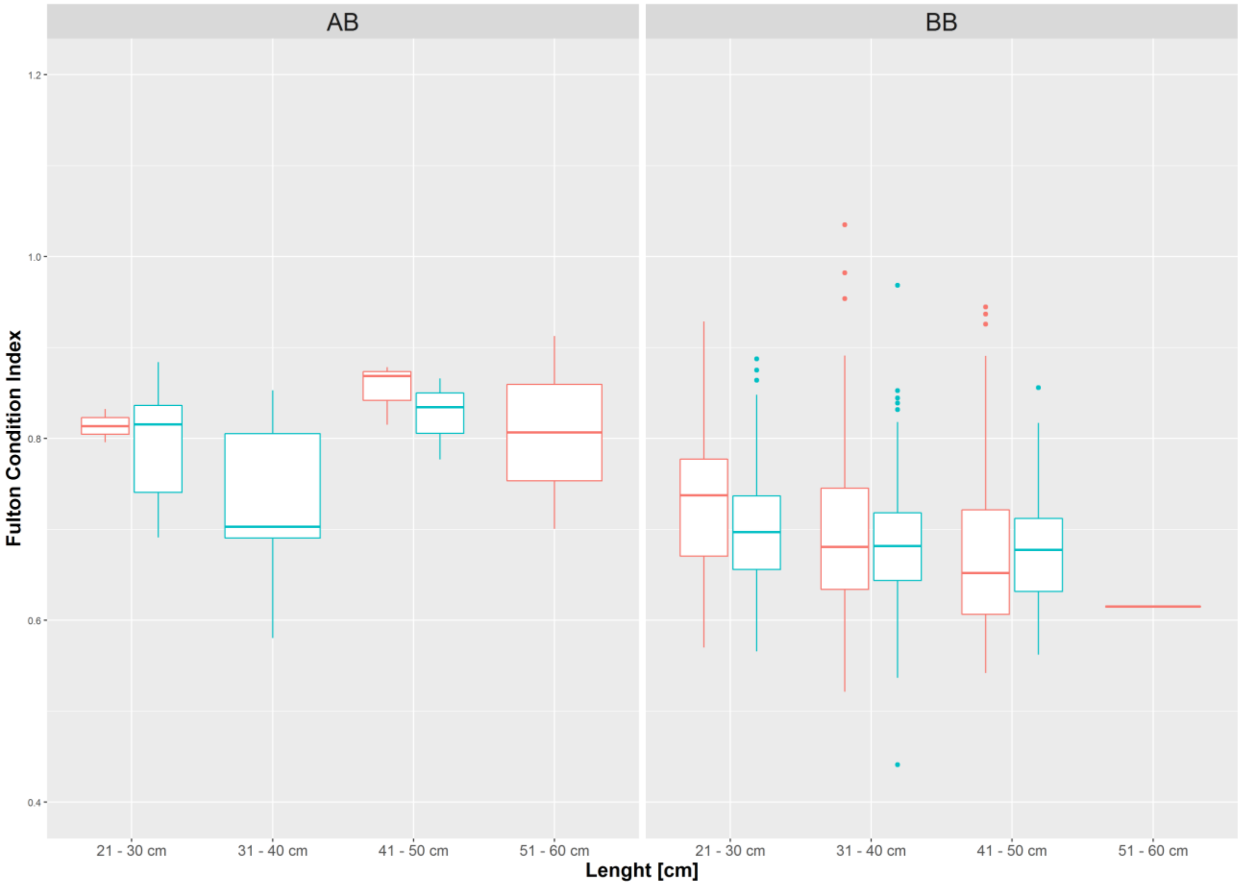

Figure 5.8: Fulton´s K Index of individual sampled cod during the AL539 and AL540. Red boxplots present female and blue boxplots male cod for two different areas; AB = Arkona Basin; BB = Bornholm Basin. Length is given in cm.

As the cruise was conducted during the main spawning season of Eastern Baltic Cod a special interest lies on the distribution of the maturity stages of cod, as an important key species in the Eastern Baltic Sea.

Figure 5.9 show the frequency of grouped maturity stages per 10 cm length class for females and males in each investigated area.
This observation indicates that during the sampling time the main area for spawning cod (maturity stage 5 – 7) was the Bornholm Basin, since maturity stage 5-7 were most frequent in all caught length classes (LC).
Individuals caught in the Akona Basin were mostly either early stages (maturity stage 1 - 2), which means these individuals have never spawned or were in regeneration (maturity stage 8-9), only a few males were at maturity stage 5 -7. Since the Arkona Basin is a mixed zone between the western and eastern part of the Baltic Sea, these results are not unexpected.

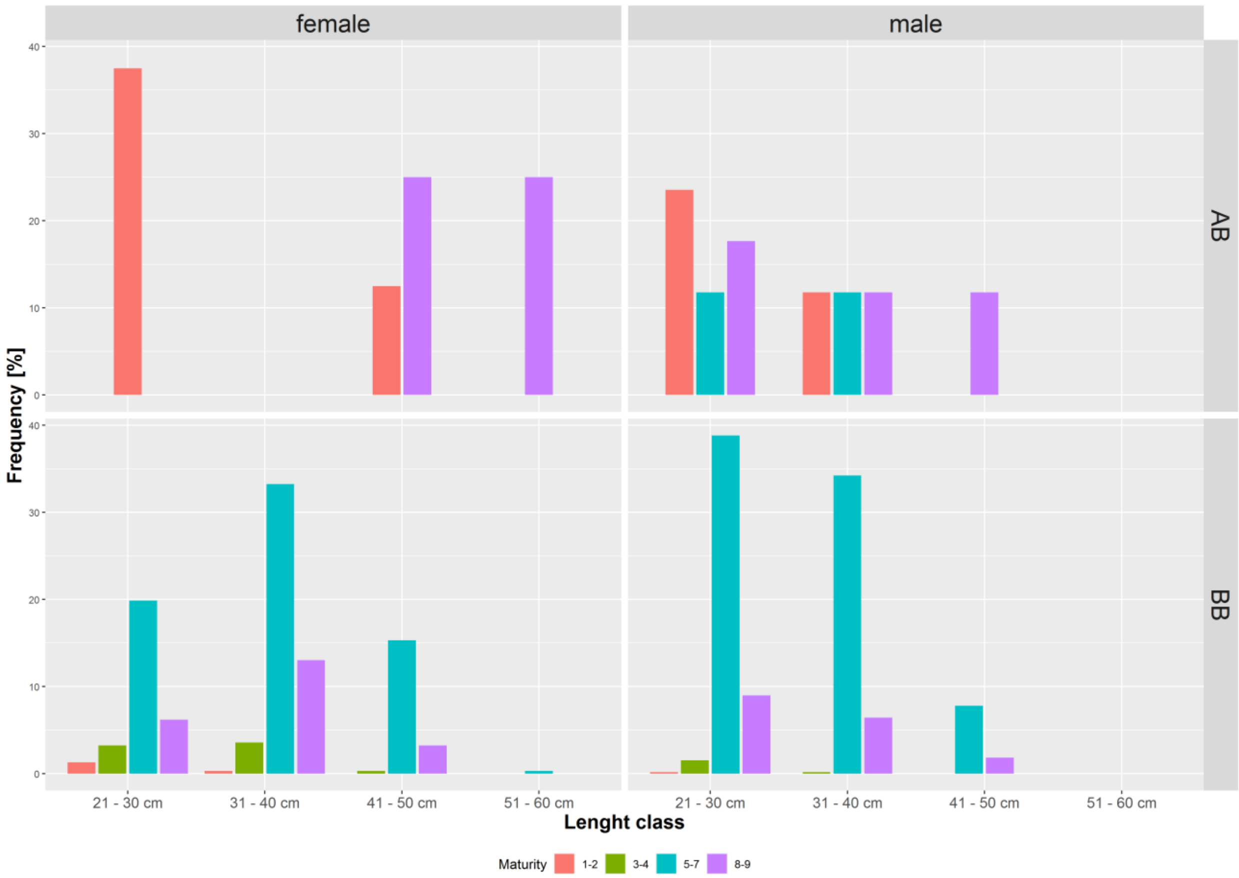

Figure 5.9: Relative frequency distribution in percent of the grouped maturity stages per 10 cm length class of individual sampled cod during AL539 and AL540. Female and male cod in three different areas; AB = Arkona Basin; BB = Bornholm Basin. Red: Maturity stage 1-2 (juvenile and preparation); Green: Maturity stage 3-4 (maturation); Cyan: Maturity stage 5-7 (spawning); Purple: Maturity stage 8-9 (regeneration).

5.5 Hydrography

(Jens-Peter Herrmann,
Institute for Marine Ecosystem and Fishery Science, Hamburg University)

For the description of the hydrography the measured profiles from the two consecutive cruises AL539 and AL540 have been merged in order to get more detailed views on the current situation. The data were validated and finally processed in the software package ODV for the presented isoplots.

5.5.1. From the Kiel Bight to the Bornholm Basin

As expected a strong salinity gradient from west (Kiel Bight) to east (Bornholm Basin) was detected near the surface (Figure 5.10; SALIN). At the surface the salinity ranged from 15 PSU in the western part of the Kiel Bight to 7 PSU in the Bornholm Basin. Near the bottom the salinity was higher with 23 PSU in the west and 15 to 16 PSU in the Arkona as well as in the Bornholm Basin indicating a stratified water column. The temperature distribution (Figure 5.10, Temp) appeared more complex. In the western part as well as in the Bornholm Basin a warm surface layer was identified with decreasing temperatures with depth as is typically for summer situations. In the Arkona Basin we also found warm surface water (17°C) followed by intermediate cold water (10°C to 11°C) and water with around 16°C near the bottom where salinity was highest. This is indicating that warm saline water from a former inflow event at warmer season is still in position. As the oxygen saturation of this water mass is partly depleted down to 60% we argue that it might originate from the year before. In comparison to former years (> 20°C) a relatively lower surface temperatures in 2020 (17°C and less) was noticeable.
The chlorophyll a values (Figure 5.10; ChlA) showed multiple patches in the upper water column along the west-east transect with highest concentrations in the Kiel Bight and the eastern part of the Arkona Basin. These maxima appeared to be somehow linked to the temperature distribution with higher values at higher temperatures.

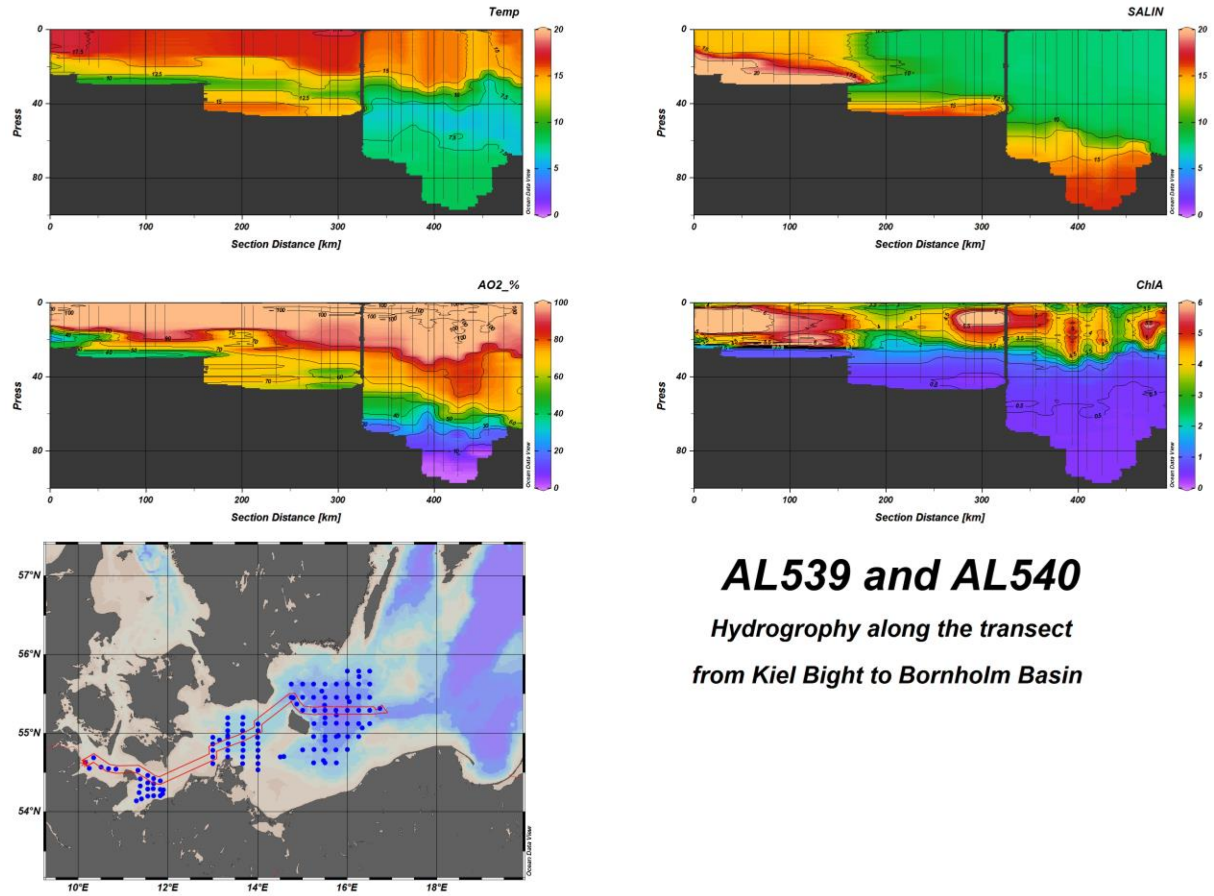

Figure 5.10: Station map and hydrographic isoplots of the cruises AL539 and AL540 along a transect from Kiel Bight to Bornholm Basin.

5.5.2. Arkona Basin

As already described before within the Arkona Basin the hydrography showed differences in comparison to the other areas especially for temperature. The temperature in the western part of the basin seemed to be almost similar over the whole water column (Figure 5.11; Temp) while in the eastern part three different temperature layers were obvious: warm surface water, intermediate cold water and warmer bottom water. The warmer bottom water is also characterized by higher salinity and lower oxygen saturation indicating that this water body seems to be isolated from the surface for a longer time period. Due to the relatively high temperature we speculate that this water mass originated from inflow events from the previous year.

The salinity ranged from 8 to 9 PSU in the upper 40 m of the water column and values between 11 and 18 PSU in the deeper parts (Figure 5.11 and Figure 5.12; SALIN). The oxygen distribution showed a very similar pattern with nearly 100% saturation in the upper water column and decreasing values down to 50% where salinity was highest (Figure 5.11 and Figure 5.12; AO2%). The chlorophyll a data revealed very patchy values within the basin in longitudinal as well as latitudinal direction (Figure 5.11 and Figure 5.12; ChlA) with a minimum in the center of the basin.

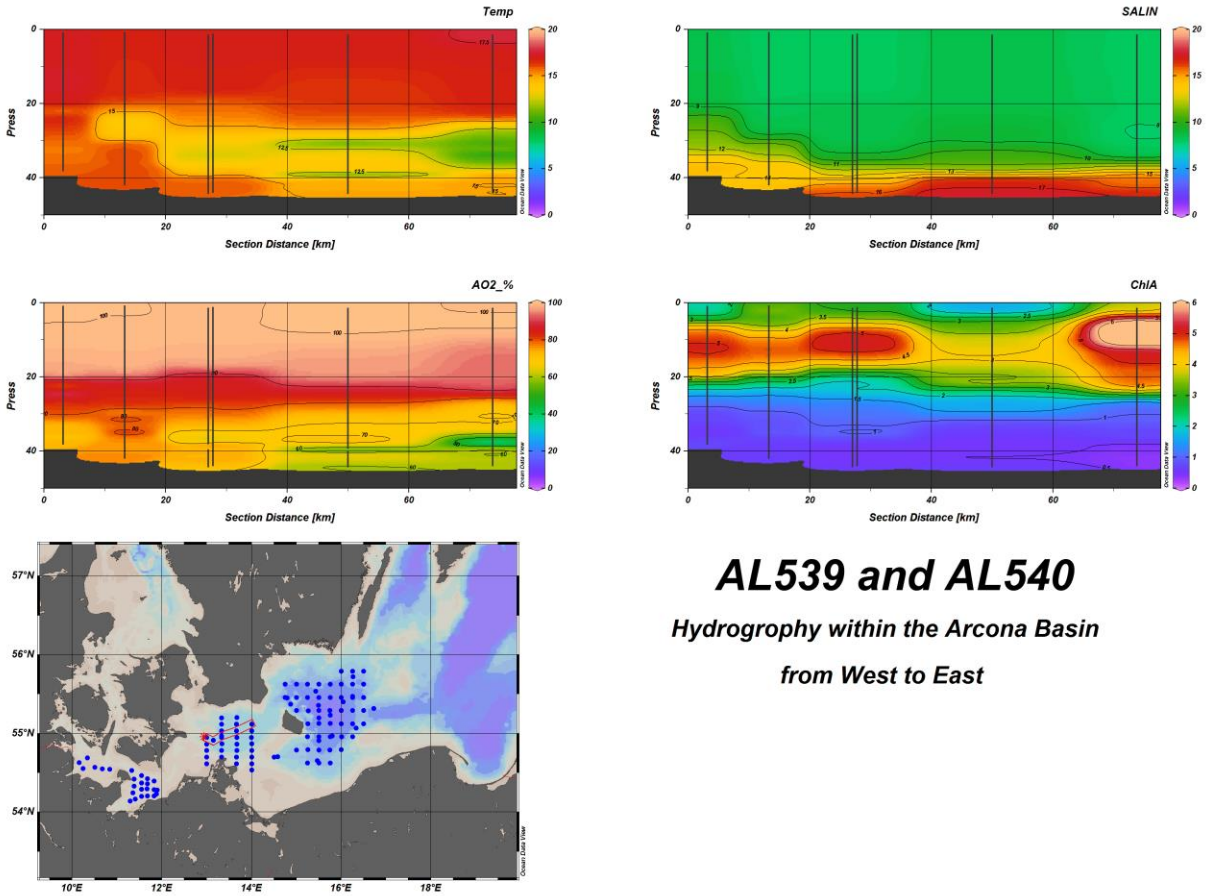

Figure 5.11: Station map and hydrographic isoplots of the cruises AL539 and AL540 along a transect from West to East in the Arkona Basin.

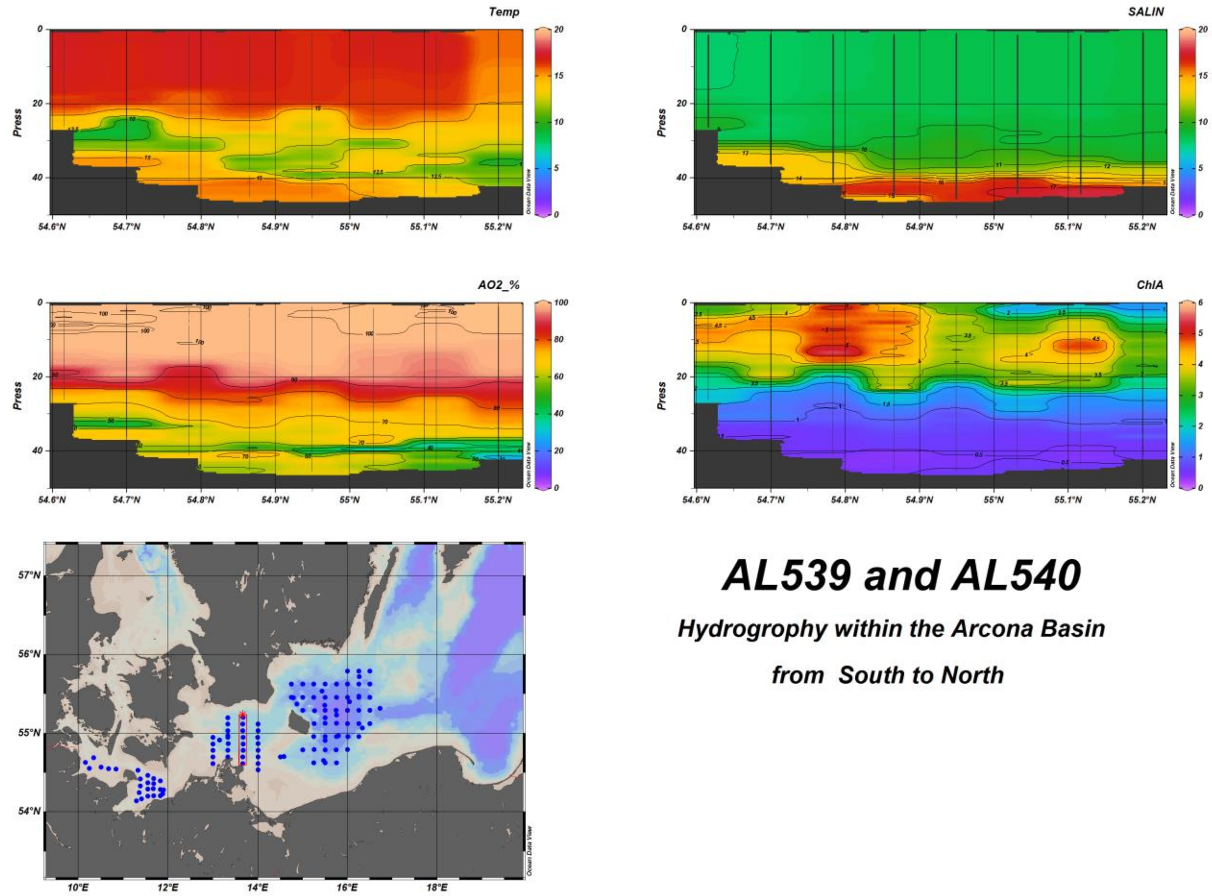

Figure 5.12: Station map and hydrographic isoplots of the cruises AL539 and AL540 along a transect from South to North in the Arkona Basin.

5.5.3. Bornholm Basin

Primarily, the hydrography of the Bornholm Basin is characterized by two water layers: in the upper 60 m of the water column salinities range between 7 to 8 PSU whereas in the water columns below 60m salinities rise up to 16.6 PSU with a relatively steep increase around 65 m depth (halocline) (Figure 5.13 and Figure 5.14; SALIN). Within the upper water layer two different temperature layers are identifiable, a warm top layer down to 30 m with 15 °C to 17 °C and a colder layer below with a minimum of 6°C (Figure 5.13 and Figure 5.14; Temp). In comparison to several former cruises during the same season the temperature at the surface with <17°C was relatively low compared to temperature typically well above 20°C. The temperature below the halocline was very uniform around 8.2 °C.

The oxygen distribution (Figure 5.13 and Figure 5.14; AO2%) resulted in nearly saturated surface water masses along both transects. Between the thermocline and the halocline the oxygen saturation was slightly depleted with lowest values around 60%; indicating together with the low temperature that this water mass contains “winter water” separated from the surface for some time after a thermocline has established in spring. Below the halocline the oxygen saturation is rapidly decreasing with depth and reaches hypoxia (oxygen depletion) at 75m to 80m.
Primary production as indicated by clorophyll a data (Figure 5.13 and Figure 5.14; ChlA) can only be detected in the warm top layer of the water column and showed patchiness as in the Arkona Basin.

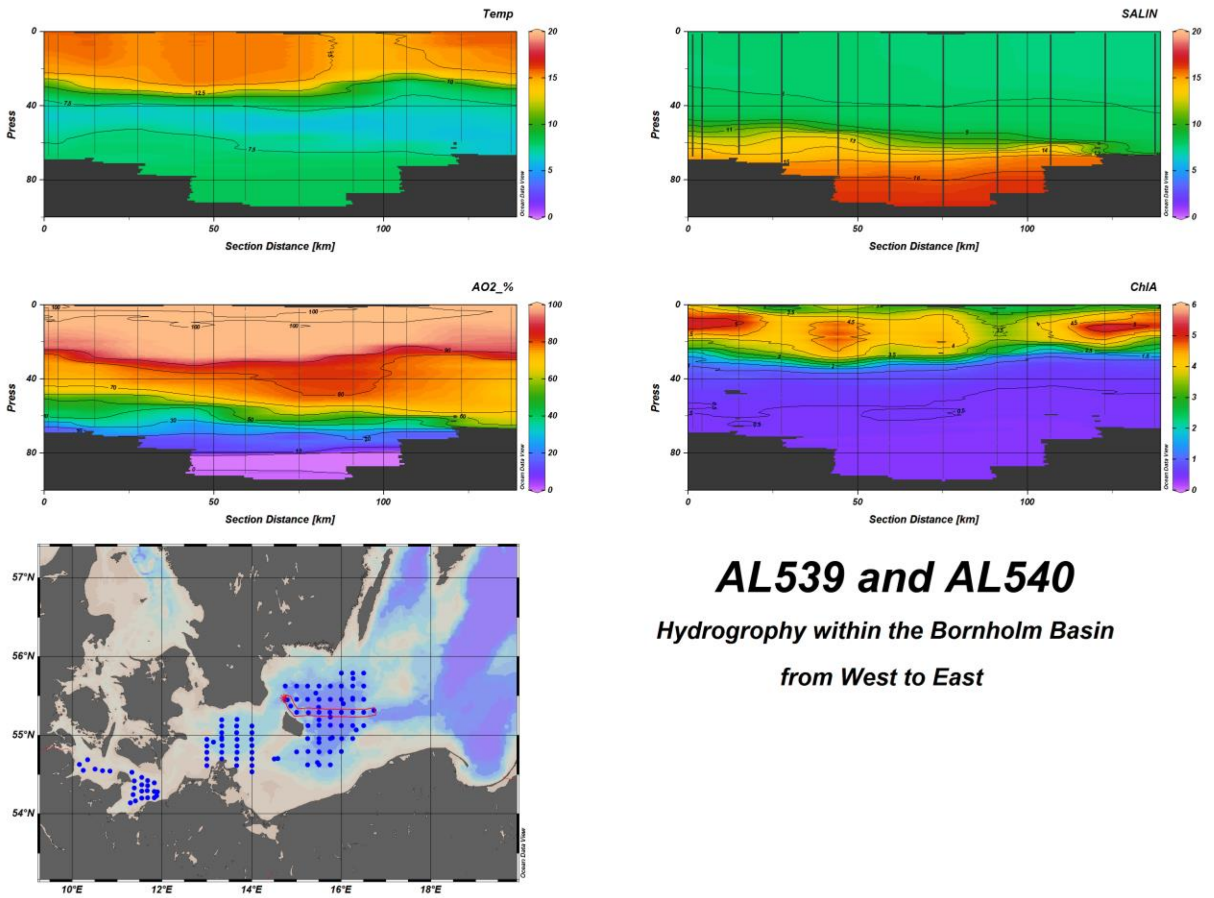

Figure 5.13: Station map and hydrographic isoplots of the cruises AL539 and AL540 along a transect from West to East in the Bornholm Basin.

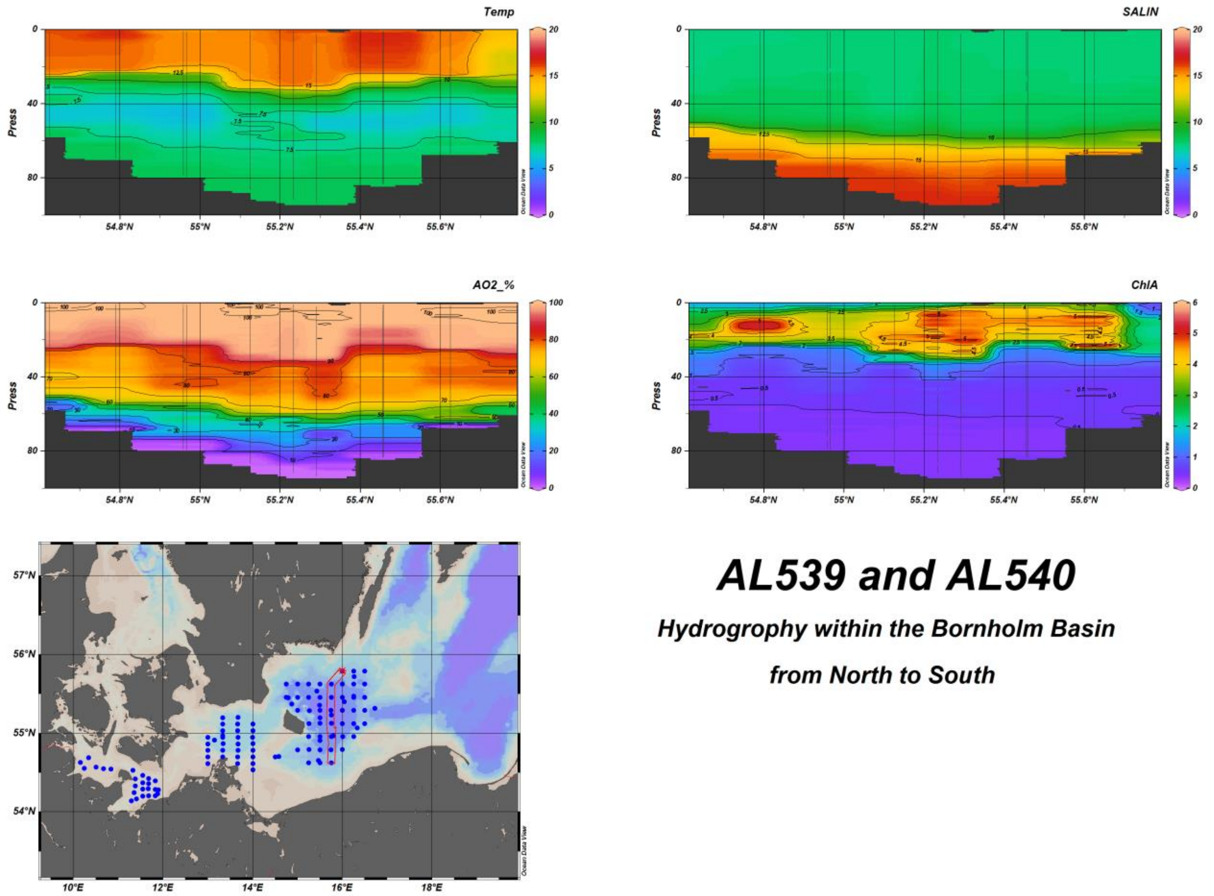

Figure 5.14: Station map and hydrographic isoplots of the cruises AL539 and AL540 along a transect from South to North in the Bornholm Basin.

6 Station List AL540

6.1 Overall Station List

Table 6.1: Start positions for all used gears are given (in actionlog noted as "in water"). For fishing the "Start Fishing" positions are listed.

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/ Recovery
ALKOR	2020		[UTC]	[°N]	[°W]	[m]	
AL540_1-1	21.07.	CTD	07:04	54° 12,518' N	011° 49,578' E	17	
AL540_1-2	21.07.	Bongo	07:10	54° 12,497' N	011° 49,487' E	17	
AL540_2-1	21.07.	Bongo	07:45	54° 12,415' N	011° 40,846' E	21	
AL540_2-2	21.07.	CTD	07:53	54° 12,470' N	011° 40,507' E	22	
AL540_3-1	21.07.	CTD	08:36	54° 11,963' N	011° 32,617' E	21	
AL540_3-2	21.07.	Bongo	08:40	54° 11,891' N	011° 32,418' E	21	
AL540_4-1	21.07.	Fish Net	10:26	54° 10,841' N	011° 27,698' E	20	
AL540_5-1	21.07.	Bongo	11:27	54° 10,161' N	011° 24,501' E	20	
AL540_5-2	21.07.	CTD	11:35	54° 10,098' N	011° 24,303' E	20	
AL540_6-1	21.07.	CTD	12:08	54° 08,411' N	011° 17,282' E	22	
AL540_6-2	21.07.	WS	12:14	54° 08,384' N	011° 17,264' E	22	
AL540_6-3	21.07.	Bongo	12:20	54° 08,374' N	011° 17,247' E	22	
AL540_7-4	22.07.	Bongo	05:54	54° 37,012' N	012° 59,969' E	9	
AL540_7-5	22.07.	CTD	05:59	54° 37,025' N	012° 59,803' E	9	
AL540_8-1	22.07.	CTD	06:34	54° 41,983' N	013° 00,034' E	17	
AL540_8-2	22.07.	Bongo	06:39	54° 41,978' N	012° 59,859' E	17	
AL540_9-1	22.07.	Bongo	07:14	54° 46,990' N	013° 00,347' E	22	
AL540_9-2	22.07.	CTD	07:20	54° 46,992' N	013° 00,018' E	22	
AL540_10-1	22.07.	CTD	07:56	54° 51,970' N	013° 00,115' E	34	
AL540_10-2	22.07.	Bongo	08:02	54° 51,966' N	013° 00,005' E	34	
AL540_11-1	22.07.	Bongo	08:38	54° 56,925' N	013° 00,465' E	36	
AL540_11-2	22.07.	CTD	08:46	54° 57,014' N	012° 59,954' E	36	
AL540_12-1	22.07.	CTD	09:51	54° 54,786' N	013° 08,578' E	40	
AL540_12-2	22.07.	Fish Net	10:00	54° 54,758' N	013° 08,506' E	40	
AL540_13-1	22.07.	CTD	12:32	55° 01,999' N	013° 20,039' E	41	
AL540_13-2	22.07.	WS	12:41	55° 01,994' N	013° 20,004' E	41	
AL540_13-3	22.07.	Bongo	12:46	55° 01,985' N	013° 19,947' E	41	
AL540_14-1	22.07.	Bongo	13:22	55° 06,898' N	013° 20,477' E	36	
AL540_14-2	22.07.	CTD	13:30	55° 06,997' N	013° 19,986' E	35	
AL540_15-1	22.07.	CTD	14:05	55° 11,974' N	013° 20,071' E	38	
AL540_15-2	22.07.	Bongo	14:12	55° 11,952' N	013° 19,949' E	38	
AL540_16-1	23.07.	CTD	05:50	54° 41,987' N	013° 19,983' E	20	
AL540_16-2	23.07.	Bongo	05:56	54° 41,996' N	013° 19,757' E	19	
AL540_16-3	23.07.	Fish Net	06:27	54° 45,254' N	013° 20,419' E	35	
AL540_17-1	23.07.	Bongo	07:36	54° 46,979' N	013° 20,483' E	39	
AL540_17-2	23.07.	CTD	07:45	54° 46,995' N	013° 19,991' E	38	
AL540_18-1	23.07.	CTD	08:19	54° 52,007' N	013° 20,094' E	41	
AL540_18-2	23.07.	Bongo	08:25	54° 51,976' N	013° 19,991' E	41	
AL540_19-1	23.07.	Bongo	08:59	54° 57,003' N	013° 20,549' E	42	
AL540_19-2	23.07.	CTD	09:09	54° 57,002' N	013° 19,983' E	42	

AL540_20-1	23.07.	CTD	10:21	54° 58,162' N	013° 19,572' E	42	
AL540_20-2	23.07.	Fish Net	10:28	54° 58,141' N	013° 19,558' E	42	
AL540_20-3	23.07.	MSN5	12:06	54° 58,112' N	013° 19,182' E	42	
AL540_20-4	23.07.	MSN5	12:33	54° 57,969' N	013° 17,776' E	42	
AL540_21-1	23.07.	Bongo	14:27	55° 01,967' N	013° 39,964' E	42	
AL540_21-2	23.07.	CTD	14:35	55° 01,896' N	013° 39,595' E	42	
AL540_22-1	23.07.	CTD	15:11	55° 06,985' N	013° 40,001' E	41	
AL540_22-2	23.07.	Bongo	15:18	55° 06,901' N	013° 39,939' E	41	
AL540_23-1	23.07.	Bongo	15:57	55° 12,191' N	013° 40,785' E	39	
AL540_23-2	23.07.	CTD	16:06	55° 12,028' N	013° 40,296' E	40	
AL540_24-1	24.07.	CTD	05:59	54° 56,947' N	013° 40,089' E	48	
AL540_24-2	24.07.	Bongo	06:08	54° 56,731' N	013° 40,031' E	48	
AL540_24-3	24.07.	Fish Net	06:52	54° 54,959' N	013° 39,333' E	47	
AL540_25-1	24.07.	Bongo	08:00	54° 52,137' N	013° 40,577' E	46	
AL540_25-2	24.07.	CTD	08:09	54° 51,939' N	013° 40,200' E	46	
AL540_26-1	24.07.	CTD	08:46	54° 47,015' N	013° 40,050' E	43	
AL540_26-2	24.07.	Bongo	08:52	54° 46,954' N	013° 39,971' E	43	
AL540_26-3	24.07.	Fish Net	10:05	54° 45,940' N	013° 40,032' E	42	
AL540_27-1	24.07.	CTD	11:33	54° 41,976' N	013° 39,971' E	38	
AL540_27-2	24.07.	WS	11:41	54° 41,892' N	013° 40,039' E	38	
AL540_27-3	24.07.	Bongo	11:47	54° 41,783' N	013° 40,033' E	37	
AL540_28-1	24.07.	Bongo	12:20	54° 37,084' N	013° 40,314' E	27	
AL540_28-2	24.07.	CTD	12:29	54° 36,944' N	013° 40,020' E	27	
AL540_29-1	25.07.	CTD	05:53	54° 31,967' N	014° 00,026' E	18	
AL540_29-2	25.07.	Bongo	05:57	54° 31,978' N	013° 59,911' E	18	
AL540_30-1	25.07.	Bongo	06:30	54° 36,962' N	014° 00,442' E	22	
AL540_30-2	25.07.	CTD	06:37	54° 36,985' N	014° 00,043' E	23	
AL540_31-1	25.07.	CTD	07:11	54° 41,939' N	014° 00,070' E	24	
AL540_31-2	25.07.	Bongo	07:17	54° 41,955' N	013° 59,886' E	25	
AL540_31-3	25.07.	Fish Net	07:45	54° 41,416' N	013° 58,602' E	26	
AL540_31-4	25.07.	Fish Net	08:30	54° 41,556' N	013° 58,739' E	26	
AL540_31-5	25.07.	Fish Net	09:38	54° 42,030' N	014° 00,230' E	25	
AL540_32-1	25.07.	CTD	10:48	54° 47,034' N	014° 00,193' E	38	
AL540_32-2	25.07.	Bongo	10:54	54° 47,005' N	014° 00,135' E	38	
AL540_32-3	25.07.	MSN5	11:15	54° 46,688' N	013° 58,574' E	39	
AL540_33-1	25.07.	Fish Net	12:02	54° 49,654' N	013° 58,791' E	41	
AL540_34-1	25.07.	Bongo	13:28	54° 52,372' N	013° 59,837' E	42	
AL540_34-2	25.07.	CTD	13:39	54° 52,011' N	014° 00,043' E	43	
AL540_35-1	25.07.	CTD	14:14	54° 56,998' N	013° 59,912' E	47	
AL540_35-2	25.07.	Bongo	14:21	54° 56,971' N	013° 59,927' E	47	
AL540_36-1	25.07.	Bongo	14:58	55° 02,438' N	013° 59,842' E	47	
AL540_36-2	25.07.	CTD	15:10	55° 02,099' N	014° 00,156' E	47	
AL540_37-1	25.07.	CTD	15:44	55° 07,024' N	014° 00,113' E	46	
AL540_37-2	25.07.	Bongo	15:52	55° 06,933' N	014° 00,406' E	46	
AL540_38-1	26.07.	CTD	05:52	54° 42,056' N	014° 30,063' E	36	
AL540_38-2	26.07.	Fish Net	05:58	54° 42,010' N	014° 30,052' E	36	
AL540_39-1	26.07.	CTD	07:56	54° 42,209' N	014° 35,130' E	44	
AL540_39-2	26.07.	Fish Net	08:02	54° 42,192' N	014° 35,125' E	44	
AL540_40-1	26.07.	CTD	22:02	55° 27,305' N	015° 45,087' E	87	
AL540_40-2	26.07.	MSN9	22:25	55° 26,983' N	015° 44,583' E	87	

AL540_40-3	26.07.	MSN9	23:18	55° 26,857' N	015° 44,324' E	87	
AL540_40-4	26.07.	MSN5	23:59	55° 27,553' N	015° 45,132' E	86	vertical
AL540_40-5	27.07.	MSN5	00:19	55° 27,557' N	015° 45,123' E	86	vertical
AL540_40-6	27.07.	MSN5	00:39	55° 27,550' N	015° 45,121' E	86	vertical
AL540_40-7	27.07.	MSN5	00:56	55° 27,555' N	015° 45,121' E	86	vertical
AL540_40-8	27.07.	MSN9	04:10	55° 27,443' N	015° 45,008' E	86	
AL540_40-9	27.07.	MSN9	04:59	55° 27,480' N	015° 45,143' E	86	
AL540_40-10	27.07.	MSN5	05:42	55° 27,518' N	015° 44,984' E	86	vertical
AL540_40-11	27.07.	MSN5	06:02	55° 27,511' N	015° 44,962' E	86	vertical
AL540_40-12	27.07.	MSN5	06:21	55° 27,519' N	015° 44,987' E	86	vertical
AL540_40-13	27.07.	MSN5	06:37	55° 27,499' N	015° 44,965' E	86	vertical
AL540_40-14	27.07.	MSN9	09:59	55° 27,456' N	015° 44,859' E	86	
AL540_40-15	27.07.	MSN9	10:58	55° 27,476' N	015° 44,898' E	86	
AL540_40-16	27.07.	MSN5	11:45	55° 27,505' N	015° 45,014' E	86	vertical
AL540_40-17	27.07.	MSN5	12:06	55° 27,495' N	015° 44,963' E	86	vertical
AL540_40-18	27.07.	MSN5	12:27	55° 27,480' N	015° 45,016' E	86	vertical
AL540_40-19	27.07.	MSN5	12:46	55° 27,490' N	015° 44,941' E	86	vertical
AL540_40-20	27.07.	MSN9	16:10	55° 26,957' N	015° 45,178' E	87	
AL540_40-21	27.07.	MSN9	17:02	55° 27,282' N	015° 45,568' E	87	
AL540_40-22	27.07.	MSN5	18:07	55° 27,479' N	015° 45,050' E	86	vertical
AL540_40-23	27.07.	MSN5	18:28	55° 27,488' N	015° 45,105' E	86	vertical
AL540_40-24	27.07.	MSN5	18:47	55° 27,499' N	015° 45,162' E	86	vertical
AL540_40-25	27.07.	MSN5	19:04	55° 27,512' N	015° 45,197' E	86	vertical
AL540_40-26	27.07.	CTD	19:12	55° 27,500' N	015° 45,208' E	86	
AL540_40-27	27.07.	CTD	19:34	55° 27,532' N	015° 45,272' E	86	
AL540_41-1	29.07.	CTD	06:49	54° 33,221' N	010° 14,292' E	18	
AL540_41-2	29.07.	Bongo	06:56	54° 33,138' N	010° 14,167' E	18	
AL540_41-3	29.07.	Fish Net	07:16	54° 33,089' N	010° 10,860' E	19	
AL540_42-1	29.07.	Bongo	08:57	54° 41,537' N	010° 20,441' E	27	
AL540_42-2	29.07.	CTD	09:04	54° 41,421' N	010° 20,130' E	25	
AL540_43-1	29.07.	CTD	10:05	54° 37,798' N	010° 09,353' E	22	
AL540_43-2	29.07.	Bongo	10:11	54° 37,751' N	010° 09,274' E	22	
AL540_43-3	29.07.	Fish Net	10:25	54° 38,111' N	010° 10,157' E	22	
AL540_44-1	30.07.	CTD	06:24	54° 32,632' N	010° 50,013' E	21	
AL540_44-2	30.07.	WS	06:31	54° 32,594' N	010° 49,985' E	21	
AL540_44-3	30.07.	Bongo	06:35	54° 32,574' N	010° 49,884' E	21	
AL540_45-1	30.07.	Bongo	07:13	54° 32,896' N	010° 40,358' E	21	
AL540_45-2	30.07.	CTD	07:19	54° 32,874' N	010° 39,950' E	20	
AL540_46-1	30.07.	CTD	07:59	54° 34,157' N	010° 30,102' E	19	
AL540_46-2	30.07.	Bongo	08:05	54° 34,124' N	010° 29,871' E	19	

7 Data and Sample Storage and Availability

7.1 Data availability

a) The station list meta data (time, position, gear) will be transferred to the DOD.
b) CTD data will be quality checked and transferred into PANGEA.
c) A cruise summary report (CSR) will be send by the cruise leader to the BSH.
d) The cruise leader confirms the data transfer from a) and b) in his cruise report.
e) The cruise leader will supply detailed information about the analysis of samples and long term storage of the data and samples in his cruise report. Diplomatic mandatory data transfers to visited states will be conducted by the cruise leader.

7.2 Sample availability and storage

a) Samples will be analysed within the IMF teaching modules and student thesis's and stored within the IMF.
b) IMF has its own cruise data base and a certified storage for formalin samples. Frozen samples will be stored in -20°C, -40°C, or -80°C containers at the IMF, which are equipped with an automatic, mobile phone based, alarm system.
c) Samples will be labelled including a barcoding scheme, which is also used for professional archiving of all samples (long-term storage via an external company).

7.3 Data storage

a) Tentative scientific data from this cruise will be
    a. CTD data, light measurements, fluorescence data
    b. Hydroacoustic data (EK 60 & EK 80; 38, 70, 120, 200, 333 kHz)
    c. Fisheries data
    d. Zooplankton data from net samples
b) Paper protocols will be entered in a database continuously during the entire cruise (including daily back up) and conserved as hard copies as well.
c) After quality checks and after their use in publications, data will be submitted to the PANGEA database. The data transfer will be done within three years. Before transfer the data will be stored within the IMF data storage server system (RAID 5 & tape libraries).

8 Acknowledgements

I want to thank the captain Jan Lass and the entire crew of RV ALKOR for their outstanding support throughout the cruise, Richard Klinger for his steadfast support and his assistance and Svend Mees (GEOMAR) for his support in technical equipment for the cruise. A special thanks goes to Dr. Luisa Listmann for her tireless commitment in the preparation and her support in the implementation of the online teaching module. Finally, many thanks go to the scientific cruise participants on AL540 for their enthusiasm and motivation throughout the cruise.

9 References

Lambert, Yvan, and J-D. Dutil, 1997. Condition and energy reserves of Atlantic cod (Gadus morhua) during the collapse of the northern Gulf of St. Lawrence stock. In: Canadian journal of fisheries and aquatic sciences 54.10: 2388-2400.

10 Abbreviations

CTD	Conductivity Temperature Depth probe
WS	Water Sampler (Niskin Bottle)
Bongo	Plankton Net
MSN	Multi opening/closing net (MultiNet)
FishNet	Youngfishtrawl (for pelagic and bottom near use) with a trawl-eye