ALKOR-Berichte

Monitoring winter spawning activity of Western Baltic cod (Gadus morhua) (2021-25)

Cruise No. AL606

January 22nd – January 30th 2024,
Kiel (Germany) – Kiel (Germany)
Winter cod 2021-25

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1 Cruise Summary

1.1 Summary in English

This cruise was the fourth out of five proposed cruises in the framework of the winter cod 2021-25 cruises of the IMF, which aim to investigate the early winter spawning activity of Western Baltic cod. For this purpose, ichthyoplankton samples and cod samples were taken on a pre-defined station grid. Cod samples were used to investigate maturity stages and condition of adult cod. Plankton samples were analysed with a focus on the occurrence of cod eggs and larvae. The data will be used to identify whether there is a shift towards earlier spawning activities of Western Baltic cod and how spawning activity differs spatially between parts of the Belt Sea.

During the cruise AL606 spawning cod were found in the Kiel Bight, the Mecklenburg Bight, and the Fehmarn Belt. First analyses of BONGO-net samples revealed no occurrence of cod larvae in the sampling area during this year's January cruise 2024. This absence of cod larvae might be a result of the relatively harsh and cold winter of 2023/24 and an associated delay in the maturation and spawning of western Baltic cod compared to the warmer previous years 2021-2023. The observation of fewer larvae of other fish species (e.g., plaice) compared to previous years supports this hypothesis.

However, especially the observation of spawning and post-spawning cod in the Mecklenburg Bight during AL606 provided further evidence for the hypothesised temporal shift in spawning phenology towards an earlier onset than described in the past.

1.2 Zusammenfassung

Diese Fahrt war die vierte von fünf beantragten Fahrten im Rahmen der Winterdorsch 2021-25 Fahrten des IMF, die das Ziel haben die frühe Winterlaichaktivität des westlichen Ostseedorsches zu untersuchen. Zu diesem Zweck wurden Ichthyoplanktonproben und Dorschproben auf einem vorher festgelegten Stationsraster genommen. Die Dorschproben dienen der Untersuchung der Reifestadien und des Zustands der adulten Dorsche. Die Planktonproben wurden insbesondere auf das Vorkommen von Dorscheiern und -larven untersucht. Anhand der Beprobungsdaten sollte festgestellt werden, ob es eine Januar-Laichaktivität des westlichen Ostseedorsches gibt und ob es darüber hinaus räumliche Unterschiede in der Laichaktivität des westlichen Ostseedorsches zwischen den verschiedenen Teilen der Beltsee gibt.

Während der Fahrt AL606 wurden in der Kieler und Mecklenburger Bucht sowie im Fehmarnbelt laichende Dorsche gefunden. Erste Analysen von BONGO-Netzproben ergaben, dass während der diesjährigen Januarfahrt 2024 keine Dorschlarven im Beprobungsgebiet vorkamen. Dieses Fehlen von Dorschlarven könnte auf den relativ strengen und kalten Winter 2023/24 und eine damit verbundene Verzögerung der Reifung und des Laichens des westlichen Ostseedorsches im Vergleich zu den wärmeren Vorjahren 2021-2023 zurückzuführen sein. Die Beobachtung von weniger Larven anderer Fischarten (z.B. Scholle) im Vergleich zu den Vorjahren unterstützt diese Hypothese.

Insbesondere die Beobachtung des laichenden und nachlaichenden Dorsches in der Mecklenburger Bucht während AL606 lieferte jedoch weitere Belege für die angenommene zeitliche Verschiebung der Laichphänologie hin zu einem früheren Beginn als in der Vergangenheit beschrieben.

2 Participants

2.1 Principal Investigators

Table 2.1.1 List of Principal Investigators of the Winter cod cruises 2021-25.

Name	Academic title	Institution
Möllmann, Christian	Prof., Dr. rer. nat.	IMF
Funk, Steffen	Dr. rer. nat.	IMF

2.2 Scientific Party

Table 2.2.1 List of scientific party of cruise AL606

Name	Discipline	Institution
Funk, Steffen, Dr. rer. nat.	Chief scientist; PostDoc	IMF
Klinger, Richard	PhD student	IMF
Ressing, Tobias	Scientific employee	IMF
Heckler, Svenja	MSc student	IMF
Höper, Anton	MSc student	IMF
Mittermayer, Felix, Dr. rer. nat.	Technician	GEOMAR
Klein, Amalia	Student	IMF
Fuchs, Julia	Student	IMF
Rudnick, Hanna	Student	GEOMAR
Schoppenhauer, Ralf	Technician	IMF
Gjeitsund Thorvaldsen, Kjetil, PhD	PostDoc	DTU Aqua
Dahlke, Flemming, Jun. Prof. Dr. rer. nat.	Professor, Scientific employee	IMF

2.3 Participating Institutions

IMF	Institute of Marine Ecosystem and Fisheries Science. University of Hamburg
DTU Aqua	National Institute of Aquatic Resources. Danish Technical University
GEOMAR	GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel

3 Research Program

3.1 Description of the Work Area

The working area of AL606 was located in the Kiel Bight, Little Belt, Great Belt, Fehmarn Belt, and Mecklenburg Bight, which are all part of the Belt Sea (ICES subdivision (SD)22). The Belt Sea is a stratified, brackish-water area (common salinity range: 10 to 25 PSU), which together with the Arkona Sea (SD24) and the Sound (SD23) forms the Western Baltic Sea (WBS) (Fig. 3.1). The Western Baltic Sea is characterized by several shallow obstacles such as the Darss Sill, limiting inflows of water with high salinities from the Kattegat region to the eastern parts of the Baltic Sea. This limited saltwater inflow in combination with river runoffs results in a constant decrease of salinity from the western to the eastern parts of the Baltic Sea. The Belt Sea is microtidal (tidal range: ~ 10 cm) and characterized by wind-induced fluctuations in hydrographic conditions (Leppäranta and Myrberg, 2000; Snoeijs-Leijonmalm and Andrén, 2017). This is caused by changes in inflow of more saline bottom water from the Kattegat and surface outflow of less saline water from the central and southern Baltic Sea through the Danish Straits and the Darss sill. SD22 and SD23 are known as the distributional core area of the Western Baltic cod (*Gadus morhua*) stock. Here, stock mixing with the more easterly distributed Eastern Baltic cod (*Gadus morhua callarias*) is considered negligible (ICES, 2019).

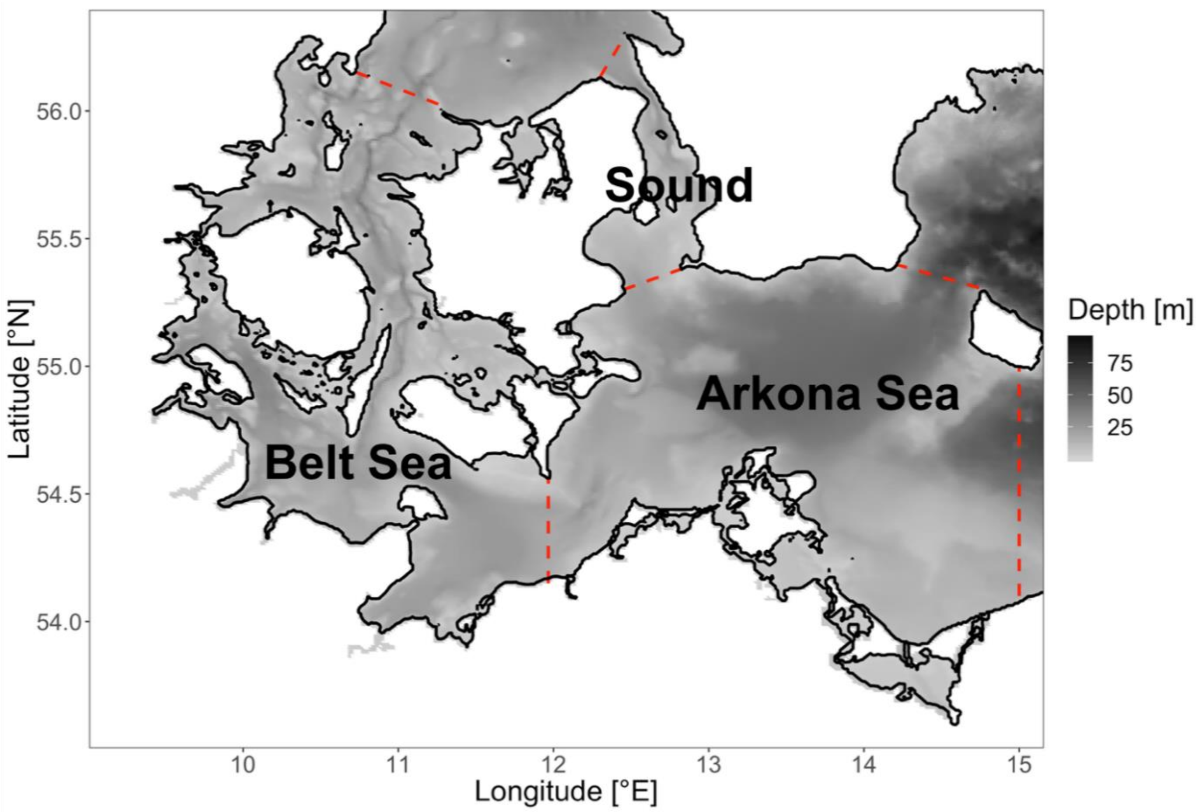

Fig. 3.1. Bathymetry of the Western Baltic sea. Dashed red lines indicate borders between ICES Subdivisions (SD22 – Belt Sea; SD23 – Sound. and SD24 – Arkona Sea). Figure was taken from Funk, 2020.

3.2 Aims of the Cruise

The Western Baltic cod stock (WBC) is currently in distress. This is believed to be linked to the low level of recruitment success over several years. The reasons behind are not yet well understood. There are indications of a (potentially climate-induced) shift in the spawning phenology of the stock, with spawning activity shifting (peak spawning usually occurred in March [Bleil and Oeberst. 1997; Bleil et al., 2009]) to an earlier time period. This has already been observed for other stocks of Atlantic cod as well (e.g., McQueen and Marshall, 2017). The shift probably causes a mismatch situation between the cod larvae and its main prey (zooplankton), which can result in poor larval survival and consequently lower recruitment success. There is an indication that accelerated gonad maturation is already an ongoing process in the study area. Post-spawning cod individuals have been observed more frequently during the Baltic international trawl survey (BITS) conducted in the 1st quarter between the end of February and mid-March each year (pers. comm. U. Krumme, Thuenen Institute of Baltic Sea Fisheries, Rostock). Furthermore. local gillnet fishers located in the harbours of Burgstaaken and Heiligenhafen (Schleswig-Holstein, Germany) observed increasing numbers of spawning cod individuals already in January. Mature fish in spawning stages occur earlier on their traditional spawning grounds near to and within the channels of the Kiel Bight, Mecklenburg Bight, and Fehmarn Belt (pers. comm. S. Funk with local gillnetters). In contrast, former studies indicate that spawning migrations towards these areas occur mainly in February and March (Bleil and Oeberst, 1997; Bleil et al., 2009). Due to its internationally coordinated timing, the official monitoring programme (i.e., Baltic International Trawl Survey [BITS]) will continue to be carried out during the end of February to mid-March and is therefore likely to miss this potentially important early-winter stock dynamics of WBC. The proposed cruises in the framework of winter cod 2021-25 will thus provide important insights into the reproductive ecology of the WBC population, crucial for its sustainable management.

On the one hand, new insights into a potential shift in the spawning phenology of cod in the Western Baltic Sea may provide a better understanding of its recruitment dynamics and the interannual variability of recruitment success. On the other hand, these findings could be used to adapt management measures such as seasonal closures or catch restrictions by taking shifts in the cod spawning season into account.

Therefore, cruise AL606 aimed to:

1. investigate spatial distribution of mature, adult cod inhabiting traditional spawning grounds in the Belt Sea in late January including sampling positions in the channels of the Kiel Bight, Little Belt, Great Belt (i.e., Langeland Belt), Fehmarn Belt, and Mecklenburg Bight.
2. investigate the spatial distribution of cod eggs and larvae in the Belt Sea in late January.

To realize these goals, we defined a station grid of 43 sampling positions, which should be used for zooplankton and especially ichthyoplankton sampling using a BONGO net, including 19 positions in the Kiel Bight, three positions in the Little Belt, two positions in the Great Bel,. three positions in the Fehmarn Belt and 16 positions in the Mecklenburg Bight (Fig. 3.2). This plankton station grid was based on a station grid sampled also during previous winter and spring cruises (including winter cod cruises in 2021 [AL549], 2022 [AL568b], and 2023 [AL585]) of the University of Hamburg. First samplings of these station grid date back to 2016 and have been analysed in cooperation with the Danish Technical University (DTU) in the project FORTORSK.

Data collected and analysed in the framework of FORTORSK can be used as a baseline for comparison of egg and larvae numbers observed in early winter (i.e., January) during the winter cod cruises with those observed during peak spawning periods (February and March of previous years). Furthermore, findings of cod eggs and larvae at several stations of the plankton station grid in previous years prove that at least occasionally cod eggs and larvae can be found at these stations.

In addition, we defined a total number of 13 trawl positions at known spawning grounds in the Belt Sea (Fig. 2), where it was planned to sample cod using a bottom trawl net (TV3/520, the standard net used during the Baltic international trawl surveys). Similar to the previous cruise AL585, it was decided to reduce the total number of trawl hauls for our cruise AL606 to a total of five but using additional angling sampling at hard-structured bottom areas, such as Wrecks and natural reef sides. This decision was made due to the comparably high cod catches resulting from angling during the IMF winter cruises in 2022 and 2023 and the considerably low cod catches obtained from trawling activities during the Baltic international trawl surveys in the study area these years. Furthermore, angling sampling allowed a better area-coverage of the Fehmarn Belt area, where hard structured grounds with rocky reef structures strictly limited our range of activity during standard bottom trawling during previous cruises.

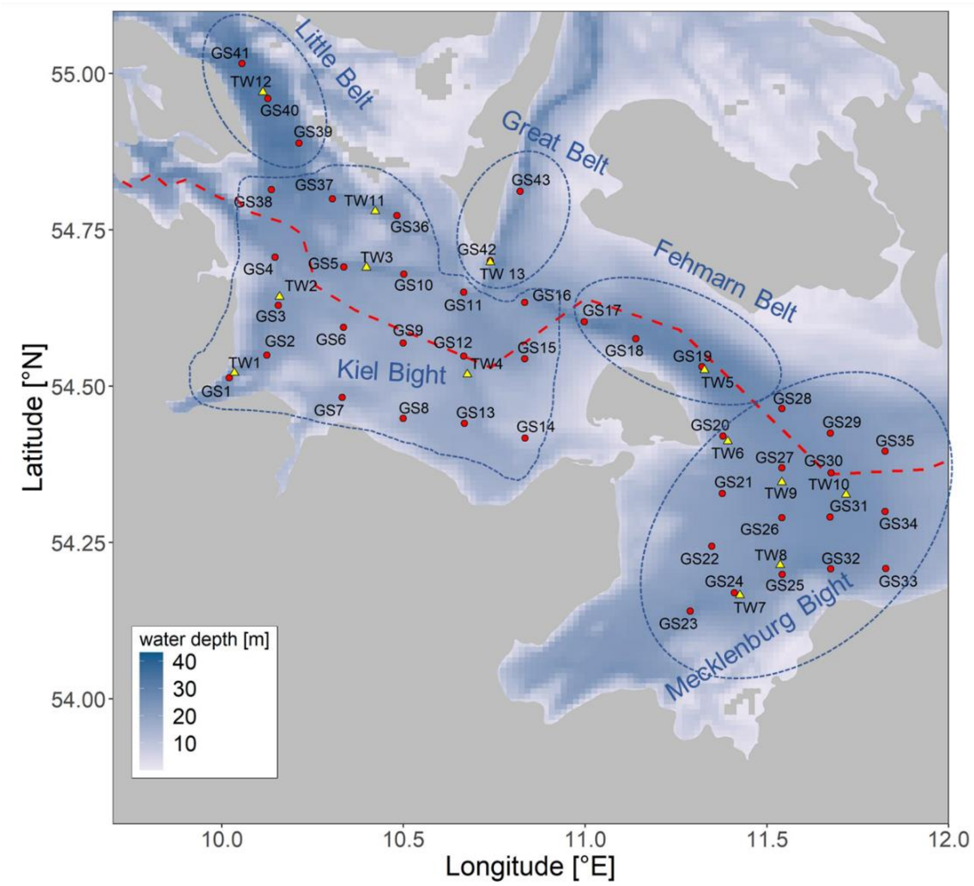

Fig. 3.2 Initially planned zooplankton and trawl fishery stations for the winter cod cruises 2021-25. Red dots indicate CTD and BONGO net stations. Blue triangles indicate trawl and MULTINET stations. Red dashed line depicts EEZ borders and blue circles indicate stations allocated to a specific subregion in the work area. i.e., Kiel Bight. Fehmarn Belt. and Mecklenburg Bight. Great Belt and Little Belt.

3.3 Agenda of the Cruise

It was planned to realize a plankton grid sampling consisting of 43 BONGO net and CTD stations complemented by five trawl hauls and 20 rod and reel fishing stations (i.e., Wrecks). It was decided that MULINET hauls should be conducted only spontaneously if vertical stratification of the water column occurs.

Hydrographic data
Detailed collection of the hydrographic conditions at the working area including fluorescence, oxygen, salinity, pH, and temperature.

Zoo- and ichthyoplankton data
Cod larvae of BONGO net 500 µm should be collected directly out of the samples. and deep frozen at -80°C for subsequent condition analyses in the laboratory. BONGO- and MULTINET-samples should be preserved in formalin for later detailed zoo- and ichthyoplankton community and size composition analyses at the laboratory of the University of Hamburg.

Fishery data
Sampling of the occurring fish fauna at predefined sampling stations at traditional cod spawning grounds including the collection of individual fish data of cod and whiting. In detail it was planned to document full weight, gutted weight liver weight sex maturity stage gonad weight, stomach fullness, and otolith samples, as well as in the case of cod samples of stomachs, liver, and fin clips. The documentation of length and weight data was planned for all other caught fish species.

- Cod stomach samples were taken to supplement the Western Baltic cod stomach data base of the University of Hamburg dating back to 2016 (see Funk et al., 2021).
- Cod fin clips were taken for potential cod stock discrimination analyses using genetics.
- Cod scales and additional fin-clips were taken for an alternative aging study conducted by H. Rudnick and C. Monk (GEOMAR)
- Cod muscle tissue samples were taken for stable isotope analysis.
- Cod otolith samples were taken for subsequent aging.

Responsible marine research and mitigation measures
Measures will be taken according to the “Declaration of responsible research” and the “Code of Conduct for Responsible Marine Research in the Deep and High Seas of the OSPAR Maritime Area”.

Cod catches – “As small as possible, as large as necessary”
Although not listed as endangered species by HELCOM the cod stock in the Western Baltic Sea is currently in a critical state. Fishing pressure should thus be reduced to a necessary minimum. Given the high relevance of the winter cod cruises for gaining important knowledge about spawning behaviour in January of Western Baltic cod, the planned fishery is thus guided by the maxim: keep the cod catches "as small as possible and as large as necessary”. Compared to commercial trawlers, our fishing effort is considered very low. This was also clearly illustrated by the January 2021 cruise where we trawled for a total of 8.5 hours, which was less than the trawl

time of a single average trawler in one day (pers. comm. with local trawl captains by S. Funk). Furthermore, the young fish trawl net we use is smaller than most commercial bottom trawl nets, so the total swept area is much less.

We aim for a total of about 20 cod per 10cm length class per haul in order to enabling statistically valid statements about condition, maturity distribution, sex ratios or nutrition. With an average of 3 length classes that can be expected, considering the current age structure of the stock, this results in a target number of about 60 cod per haul. This would mean a target catch of 780 cod for the whole cruise (when bottom trawling at 13 stations) which highlights that the overall impact can be considered rather negligible. Since trawling efforts of the last years cruises however, yielded only in minor cod catches our fishing impact can be considered even less than in maximum assumed. It can be assumed that only at very few stations this target number of 60 cod will be actually reached. Furthermore, the use of an acoustic net sounder helps to estimate the expected number of fish in the catch during the haul, so that haul times can be shortened in the case of unexpected high number of fish echoes in order to avoid unnecessarily large catches of cod. On the winter cod cruise 2021 we caught a total of 35 cod (which corresponds to the total allowed daily catch of 5 anglers in the Belt Sea). Even those small numbers of individuals already provide valuable and important insights on the early winter spawning activity of cod in the Western Baltic Sea. Moreover, the gained knowledge may result in management adaptations (i.e., time closures of spawning sites for commercial fisheries, or the extension of the closed season to January) which could promote a more sustainable use of the Western Baltic cod stock.

We also used the maxim of keeping our fishing impact low when planning and conducting rod and reel fishery. Here, the haul can be stopped if the target size of 10 animals for a length class is exceeded. The increased focus in recent years away from trawl hauls towards more angling hauls also makes it possible to minimise the bycatch of other non-target species considerably.

4 Narrative of the Cruise

RV ALKOR departed from GEOMAR pier in Kiel on January 22nd at 08:00 am. Due to strong winds from the west of 8 bft with gusts of 9 bft, it was decided to first head for 2 wrecks at the entrance of the Kiel fjord to fish there under land protection. After these fishing stations RV ALKOR headed to GS1 in the Bight of Eckernförde, where the plankton station work started. From the Bight of Eckernförde RV ALKOR headed eastwards across Bight of Hohwacht and the Fehmarn Belt.

On Tuesday, we continued our plankton station work at the GS stations in Mecklenburg Bight. In addition, wrecks were sampled in the southern Mecklenburg Bight.

On Wednesday morning there were again strong winds from the west with 8 bft and gusts up to 10 bft. After an attempt to fish at a reef station off Dahmeshöved (i.e., Schwarzer Grund), which was cancelled due to the strong winds which made angling impossible, RV ALKOR spent the rest of the day close to the coast.

On Thursday morning, 2 trawl hauls were carried out in the southern and central Mecklenburg Bight. Subsequently, the plankton station work at GS16 was resumed.

By early Friday morning, all GS stations had been successfully sampled. In the course of Friday morning, wrecks on the west coast were sampled, with RV ALKOR slowly working its way southwards towards the Bight of Eckernförde. This was followed by a trawl haul in the entrance of the Bight of Eckernförde.

On Saturday station work started with two trawl hauls in the Vejsnæs channel. Subsequently, RV ALKOR headed eastwards to angling stations in the east of the Kiel Bight. After sunset RV ALKOR set again course to the Mecklenburg Bight where station work at AS19 started at Sunday morning, followed by AS20 and AS15. From here RV ALKOR headed to two wreck stations in the Fehmarn Belt AS13 and AS14.

On Monday station work started at AS9 in the northern part of the shooting range Hohwacht Bight, followed by rod and reel fishing at wrecks in north-westerly directions including AS11, and AS 10. In the afternoon, RV ALKOR headed back to Kiel. At 5pm RV ALKOR arrived at the Westshore Pier of the GEOMAR, where the cruise ended.

5 Preliminary Results

5.1 Hydrography

(Steffen Funk and Richard Klinger)

CTD profiles were obtained from a total of 64 sampling stations. In general, we observed a nearly completely vertically mixed water body throughout the working area. Highest salinities with > 20 PSU were observed in the bottom water layers at sampling positions of the Little Belt and from entrance to the Great Belt to central Kiel Bight.

Surface salinities ranged between 13.13 PSU and 20.16 PSU with decreasing surface salinities occurring from west to east within the sampling area. Bottom salinities ranged between 13.88 and more than 20.78 PSU, with lowest salinities observed in the eastern Mecklenburg Bight (Fig. 5.1.1). and highest salinities observed in the entrance of the Great Belt.

In the literature, salinities between 18 to 33 PSU are given as range for neutral egg buoyancy of Western Baltic cod with an optimum of 20-22 PSU (von Westernhagen, 1970; Westerberg, 1994; Nissling and Westin, 1997). Based on this salinity range conditions for cod egg buoyancy and thus conditions for a successful spawning could be found in the northern and central Kiel Bight as well as in the Fehmarn Belt, Great Belt and Little Belt but only partly in the Mecklenburg Bight. Thus, as already mentioned in the last years’ cruise reports (see Funk and Möllmann, 2021, 2022) the question can be raised, if any spawning activity in the central and eastern Mecklenburg Bight (see Figure 5.1.1D) during the survey period would have resulted in successful reproduction.

However, as also already mentioned in the last years’ winter cod cruise report (see Funk and Möllmann, 2021, 2022, 2023) most of the cod egg buoyancy experiments were conducted with cod samples originating from the north-western Belt Sea and information from the Mecklenburg Bight are extremely limited. Since, in the Arkona Basin neutral cod egg buoyancy was already observed at a salinity of 13.7 PSU ± 1.3 PSU (Nissling and Westin, 1997), at least a potential for a lower salinity threshold for neutral egg buoyancy in Western Baltic cod might be considered. Further egg buoyancy experiments (for example in the framework of future winter cod cruises) may shed light on small scale difference in cod egg buoyancy requirements within the Belt Sea, and thus may provide valuable information on how successful observed spawning activities potentially are.

Observed water temperatures ranged between 2.43 °C and 5.46 °C, with highest temperatures observed at bottom water layers in the entrances to the Great and Little Belt and the Bight of Eckernförde. However, at most sampling stations, we observed a completely or nearly completely mixed water column, with temperatures < 4°C even prevailing in bottom water layers.

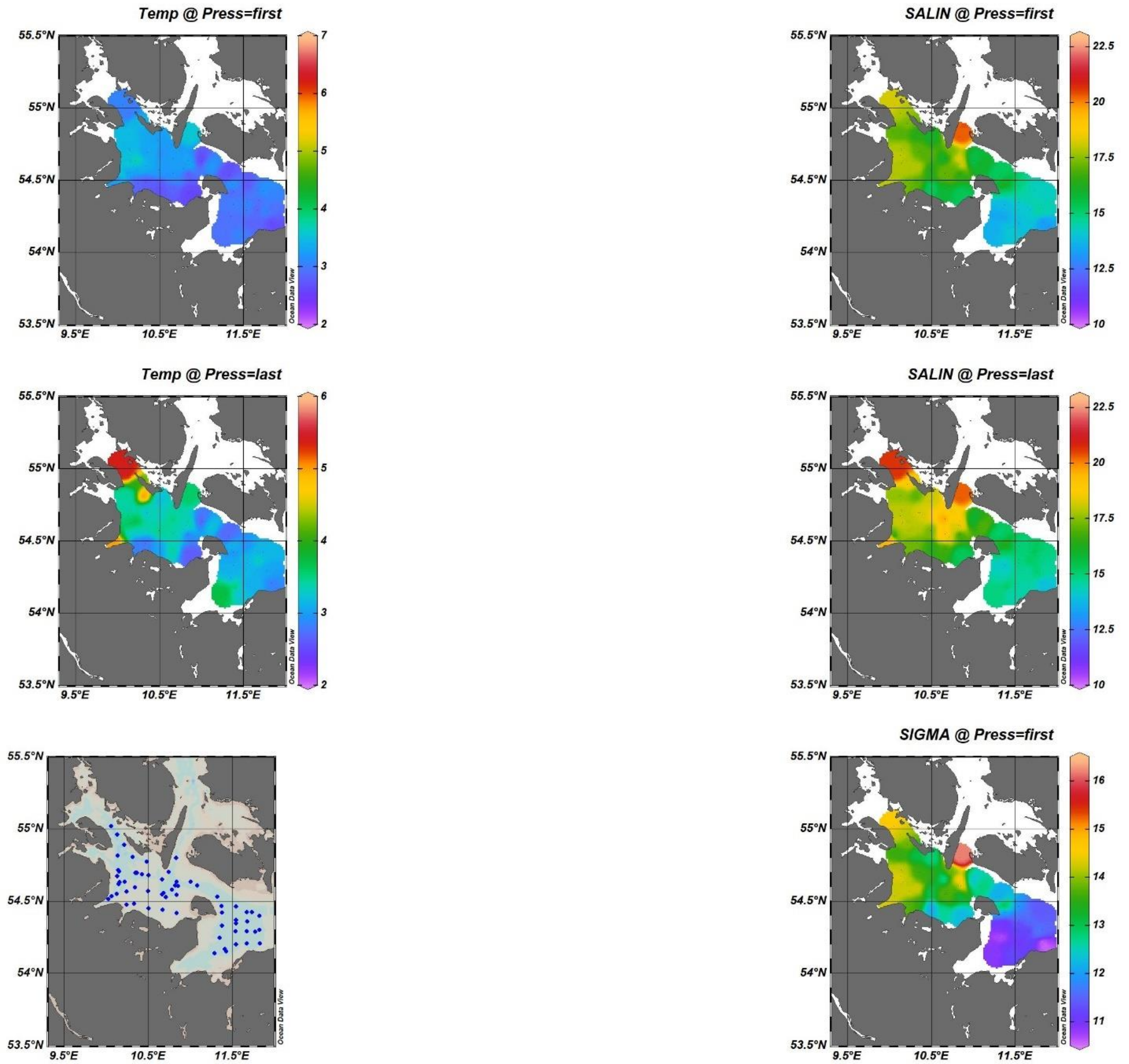

Fig. 5.1.1 Interpolated hydrographic conditions in the Belt Sea in January 2024 obtained from CTD casts (Left top panel: Salinity [PSU] at surface layer; left mid panel: Salinity [PSU] at bottom layer; left bottom panel: Overview of CTD sampling positions; right top panel: Temperature [°C] at surface layer; right mid panel: Temperature [°C] at bottom layer; right bottom panel: dissolved Oxygen [$mg*L^{-1}$] at bottom layer). Graphical visualization was made using the software tool Ocean Data View (Schlitzer, 2018).

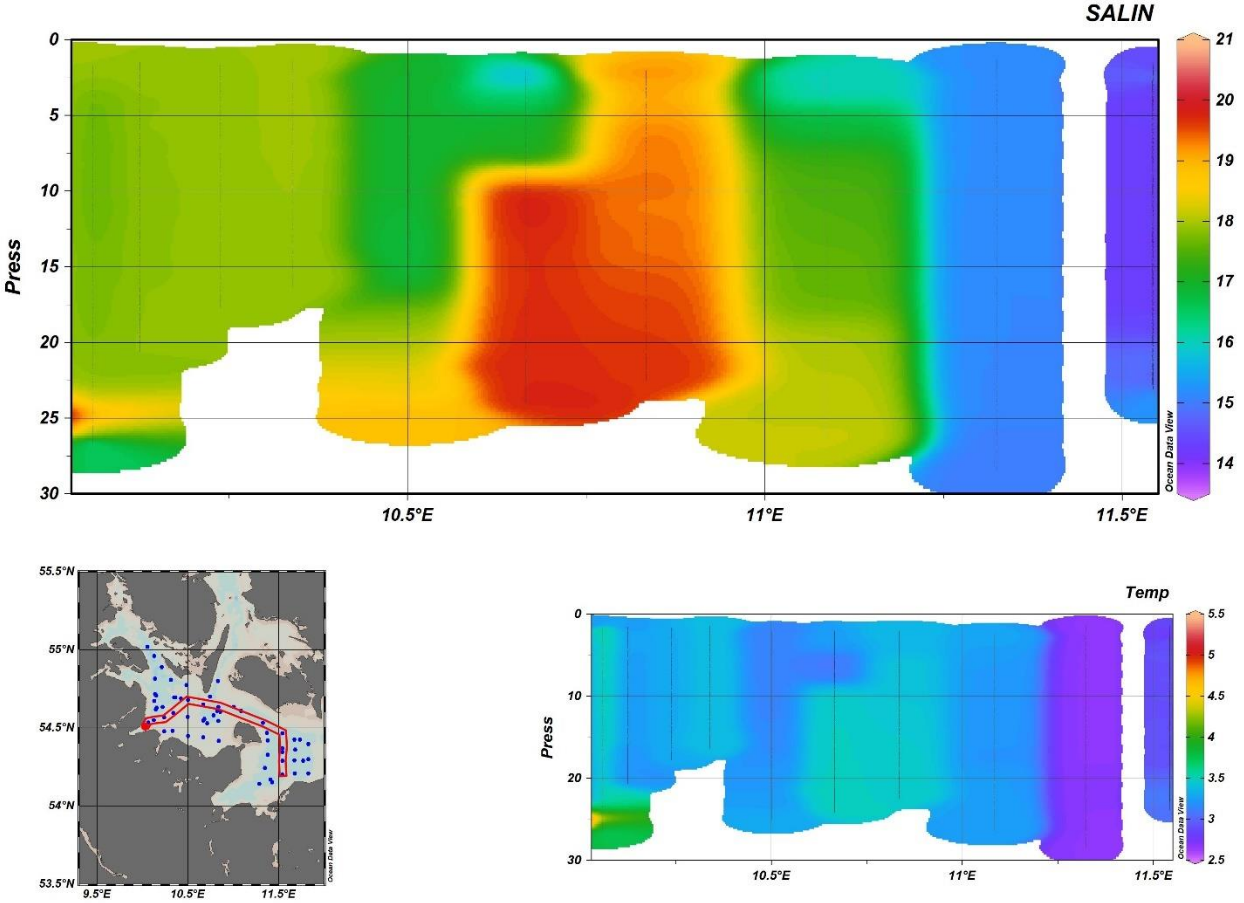

Fig. 5.1.2 Section of interpolated hydrographic conditions over a subsection of CTD casts from the Bight of Eckernförde to the eastern Mecklenburg Bight by longitude (Top panel: Section of salinity [PSU] by depth and longitude; left bottom panel: Overview map displaying selected CTD stations; bottom right panel: Section of temperature [°C] by depth and longitude. Graphical visualization was made using the software tool Ocean Data View (Schlitzer, 2018).

5.2 Fishery

(Steffen Funk)

Angling

A total of 30 rod and reel fishery hauls were conducted in Kiel Bight (n = 17). Fehmarn Belt (n = 3) and Mecklenburg Bight (n = 10) (see Fig. 4.1).

During angling 261 cod individuals were caught with a total wet weight of 152.930 kg. Lengths of cod caught during angling varied between 15 and 68 cm. Catch per unit effort during angling varied between 0 and 8 cod*30 min^{-1}*$angler^{-1}$. Total cod catches per angling station varied between 0 and 42 individuals (Fig. 5.2.1).

It has to be noted that CPUE values resulting from angling sampling have to be seen with caution. On many wreck sites we fished only relatively short time and left quickly when the anglers had several minutes without a cod bite. On two wrecks we caught many small cod of the same size range. To avoid too high catches and thus to minimize our impact we decided to leave these wreck stations. On most wrecks, the first fishes were caught almost immediately after starting fishing and most often cod catches decreased sharply with increasing sampling time.

Furthermore, it has to be noted that zero catches at the wreck stations in the southern Mecklenburg Bight might be biased, since all of these stations were only sampled during strong winds, which may have affected the angling efficiency.

Trawling

During AL606, a total of five trawl hauls were conducted in Kiel Bight (n = 3) and in Mecklenburg Bight (n = 2).

A total of 27 different fish species were recorded in the trawl catches. In total 1458.91 kg of fish had been caught with plaice (*Pleuronectes platessa*) dominating the catch compositions of all four trawl hauls (Tab. 5.2.1). Cod only made a small contribution to the trawl catches. A total of 74 cod with a total weight of 36,082 kg were caught in the trawl catches.

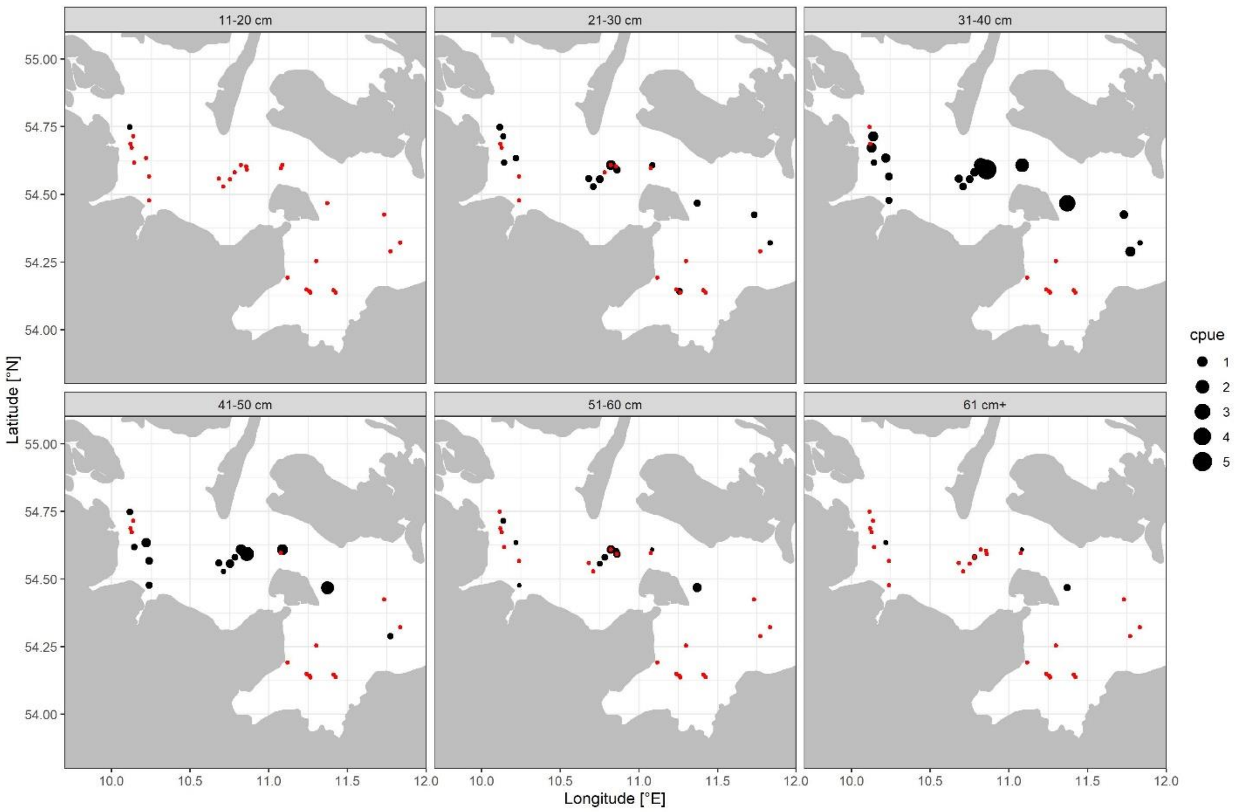

Fig. 5.2.1 Catch per unit effort (CPUE = number of cod caught * 30 min^{-1} * $angler^{-1}$) observed during rod and reel fishing stations at AL606 and per 10 cm-length class of cod (Sizes of dots correspond to CPUE values, red dots denote zero catch).

Table 5.2.1 Total catch obtained from trawl fishing during AL606.

Year	Month	Day	Gear	Station	Haul	Species	Weight [kg]	Numbers
2024	1	25	TV3_520	38-2	1	*Clupea harengus*	2.193	181
2024	1	25	TV3_520	38-2	1	*Sprattus sprattus*	5.412	647
2024	1	25	TV3_520	38-2	1	*Gadus morhua*	1.267	16
2024	1	25	TV3_520	38-2	1	*Merlangius merlngus*	0.656	9
2024	1	25	TV3_520	38-2	1	*Platichthys flesus*	17.54	101
2024	1	25	TV3_520	38-2	1	*Limanda limanda*	17.82	273
2024	1	25	TV3_520	38-2	1	*Pleuronectes platessa*	75.37	1491
2024	1	25	TV3_520	38-2	1	*Myoxocephalus scorpius*	2.554	53
2024	1	25	TV3_520	38-2	1	*Neogobius melanostomus*	0.347	27
2024	1	25	TV3_520	38-2	1	*Callionymus lyra*	0.031	1
2024	1	25	TV3_520	38-2	1	*Agonus cataphractus*	0.019	3
2024	1	25	TV3_520	38-2	1	*Eutrigla gurnadus*	1.02	3
2024	1	25	TV3_520	38-2	1	*Pholis gunellus*	0.008	2
2024	1	25	TV3_520	38-2	1	*Sygnathus sp.*	0.001	2
2024	1	25	TV3_520	38-2	1	*Gasterosteus aculeatus*	0.001	2
2024	1	25	TV3_520	38-2	1	*Pomatoschistus sp.*	0.026	27

2024	1	25	TV3_520	38-2	1	*Lumpenus lampaetraformis*	0.022	4
2024	1	25	TV3_520	38-2	1	*Enchelyopus cimbrius*	0.054	2
2024	1	25	TV3_520	39-2	2	*Clupea harengus*	2.75	219
2024	1	25	TV3_520	39-2	2	*Sprattus sprattus*	8.18	226
2024	1	25	TV3_520	39-2	2	*Gadus morhua*	1.685	14
2024	1	25	TV3_520	39-2	2	*Merlangius merlangus*	0.378	7
2024	1	25	TV3_520	39-2	2	*Enchelyopus cimbrius*	0.294	7
2024	1	25	TV3_520	39-2	2	*Platichthy flesus*	13.13	55
2024	1	25	TV3_520	39-2	2	*Limanda limanda*	22.25	374
2024	1	25	TV3_520	39-2	2	*Pleurnectes platessa*	69.21	1267
2024	1	25	TV3_520	39-2	2	*Arnoglossus laterna*	0.03	2
2024	1	25	TV3_520	39-2	2	*Solea solea*	0.23	4
2024	1	25	TV3_520	39-2	2	*Hippoglossoides platessoides*	0.05	1
2024	1	25	TV3_520	39-2	2	*Myoxocephalus scorpius*	2.086	37
2024	1	25	TV3_520	39-2	2	*Neogobius melanostomus*	0.04	4
2024	1	25	TV3_520	39-2	2	*Agonus cataphractus*	0.052	3
2024	1	25	TV3_520	39-2	2	*Eutrigla gurnardus*	0.087	6
2024	1	25	TV3_520	39-2	2	*Zoarces viviparus*	0.454	63
2024	1	26	TV3_520	61-2	3	*Clupea harengus*	15.506	1886
2024	1	26	TV3_520	61-2	3	*Sprattus sprattus*	11.41	2281
2024	1	26	TV3_520	61-2	3	*Gadus morhua*	1.052	17
2024	1	26	TV3_520	61-2	3	*Merlangius merlangus*	1.121	52
2024	1	26	TV3_520	61-2	3	*Melannogrammus aeglefinus*	0.346	3
2024	1	26	TV3_520	61-2	3	*Platichthys flesus*	7.1	42
2024	1	26	TV3_520	61-2	3	*Limanda limanda*	75.9	1312
2024	1	26	TV3_520	61-2	3	*Pleuronectes platessa*	300.57	3472
2024	1	26	TV3_520	61-2	3	*Myoxocephalus scorpius*	0.929	12
2024	1	26	TV3_520	61-2	3	*Gobius niger*	0.108	13
2024	1	26	TV3_520	61-2	3	*Eutrigla gurnardus*	0.126	2
2024	1	26	TV3_520	61-2	3	*Pomatoschistus sp.*	0.003	1
2024	1	27	TV3_520	62-2	4	*Sprattus sprattus*	0.752	64
2024	1	27	TV3_520	62-2	4	*Gadus morhua*	11.11	6
2024	1	27	TV3_520	62-2	4	*Merlangius merlangus*	1.112	18
2024	1	27	TV3_520	62-2	4	*Enchelyopus cimbrius*	0.02	7
2024	1	27	TV3_520	62-2	4	*Platichthys flesus*	81.07	292
2024	1	27	TV3_520	62-2	4	*Limanda limanda*	95.89	1770
2024	1	27	TV3_520	62-2	4	*Pleuronectes platessa*	183.4	2409
2024	1	27	TV3_520	62-2	4	*Arnoglossus laterna*	0.288	26

2024	1	27	TV3_520	62-2	4	*Solea solea*	4.85	30
2024	1	27	TV3_520	62-2	4	*Hippoglossoides platessoides*	3.23	53
2024	1	27	TV3_520	62-2	4	*Myoxocephalus scorpius*	0.103	2
2024	1	27	TV3_520	62-2	4	*Callionymus lyra*	0.063	2
2024	1	27	TV3_520	62-2	4	*Agonus cataphractus*	0.04	2
2024	1	27	TV3_520	62-2	4	*Eutrigla gurnardus*	0.053	6
2024	1	27	TV3_520	62-2	4	*Zoarces viviparus*	0.032	2
2024	1	27	TV3_520	62-2	4	*Glyptocephalus cynoglossus*	0.213	10
2024	1	27	TV3_520	62-2	4	*Sygnathus sp.*	0.003	7
2024	1	27	TV3_520	63_3	5	*Clupea harengus*	0.011	1
2024	1	27	TV3_520	63_3	5	*Sprattus sprattus*	0.013	1
2024	1	27	TV3_520	63_3	5	*Gadus morhua*	20.968	21
2024	1	27	TV3_520	63_3	5	*Merlangius merlangus*	1.266	21
2024	1	27	TV3_520	63_3	5	*Enchelyopus cimbrius*	0.717	26
2024	1	27	TV3_520	63_3	5	*Platichthys flesus*	132.3	486
2024	1	27	TV3_520	63_3	5	*Limanda limanda*	52.28	467
2024	1	27	TV3_520	63_3	5	*Pleuronectes platessa*	193.54	3301
2024	1	27	TV3_520	63_3	5	*Arnoglossus laterna*	0.493	38
2024	1	27	TV3_520	63_3	5	*Solea solea*	5.98	62
2024	1	27	TV3_520	63_3	5	*Hippoglossoides platessoides*	4.96	78
2024	1	27	TV3_520	63_3	5	*Glyptocephalus cynoglossus*	1.348	16
2024	1	27	TV3_520	63_3	5	*Myoxocephalus scorpius*	1.314	16
2024	1	27	TV3_520	63_3	5	*Neogobius melanostomus*	0.011	1
2024	1	27	TV3_520	63_3	5	*Agonus cataphractus*	0.043	3
2024	1	27	TV3_520	63_3	5	*Zoarces viviparus*	0.033	2
2024	1	27	TV3_520	63_3	5	*Scophthalmus rhombus*	0.441	1
2024	1	27	TV3_520	63_3	5	*Eutrigla gurnardus*	0.946	16
2024	1	27	TV3_520	63_3	5	*Lumpenus lampaetraformis*	0.08	8

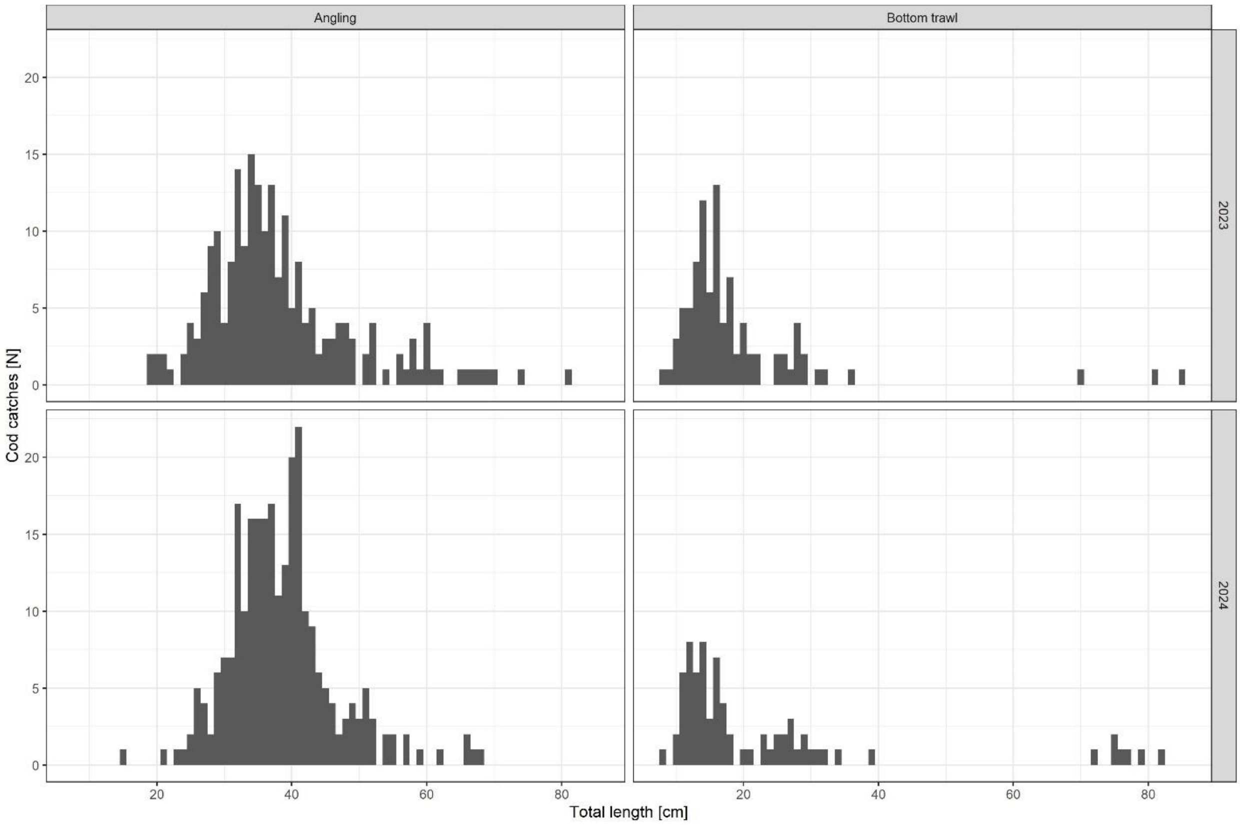

Fig. 5.2.2 Comparison of length distribution of caught cod obtained from rod and reel fishery and bottom trawl fishery at winter cod cruises 2024 (AL606; lower panels) and 2023 (AL585; upper panels). Colours denote sexes of sampled cod (blue = male. green = female, red = unsexed individuals which will be sexed during later analysis in the laboratory of the UHAM).

Catch comparison

Overall, our angling activities can be seen as highly cod selective fishing activities especially when comparing the total catches with those obtained from our trawling activities with the standard BITS trawl TV3/520. During angling we nearly exclusively focussed on artificial reef structures (i.e., wreck sites) with exception of one haul carried out at the natural reef site “Schwarzer Grund” in the Mecklenburg Bight, which however was cancelled due to prevailing bad weather conditions.

The minor cod catches resulting from trawling stand in line with our results from our observation in previous years (AL549, AL585) where we also struggled to catch cod at soft bottom substrates during trawling, while wreck and reef sides yielded comparable good catches in the last two years (AL568b, AL585). In 2022 and 2023 we already hypothesized that soft bottom habitat use of cod might be driven by overall cod density and thus stock biomass. With soft bottom being rather unfavoured habitats for cod (Funk and Möllmann, 2022, 2023). Cod seem to favour structured habitats also during spawning. This is indicated by our catches with several cod males and females in maturity stages from 5 to 7 at wreck and reef sides in 2022, 2023, and this year in 2024. However, whether the eggs are released at these stations or whether the cod migrate to the nearby channels to spawn can only be speculated so far.

Cod aggregations of spawning and late ripening individuals at soft bottom areas in the past might be the result of a spill-over effect, since the space and overall carrying capacity of structures grounds in depths where egg buoyancy can be achieved can be considered rather limited. The results from AL606, with comparable few cod in length > 30 cm being cod at soft bottom substrates during trawling, while cod catches at wreck sites were clearly dominated by individuals > 30 cm, thus emphasizes our hypothesis.

Interestingly, cod < 20 cm were nearly absent in our angling samplings. If this can be related to a size-selectivity caused by used bait sizes or rather to the fact that smaller cod avoided areas inhabited by larger conspecifics to minimise the risk caused by cannibalism, could not be clarified yet, as already stated in Funk and Möllmann (2023). However, occasional catches of cod < 20 cm in this year's cruise and the observations reported in Funk and Möllmann (2023) may prove the hypothesis of a gear-selectivity effect rather unlikely.

Cod condition

Hepatosomatic indices of WBC (calculated as HSI = liver weight [g] *(gutted weight [g])$^{-1}$ *100) sampled in 2024 showed high similarity to those observed in 2023. Furthermore, the HSI values showed only negligible differences between the sampled sub-areas. In general, the HSI values observed in 2024 ranged between 0.52 and 10.15 over all cod length and sub-areas (Fig. 5.2.3).

Fulton indices values (calculated as gutted weight * (length^3)$^{-1}$ *100) observed in 2024 also showed high similarity to those observed in 2023 (Fig. 5.2.4). Observed Fulton condition indices in 2024 ranged between 0.54 and 2.4.

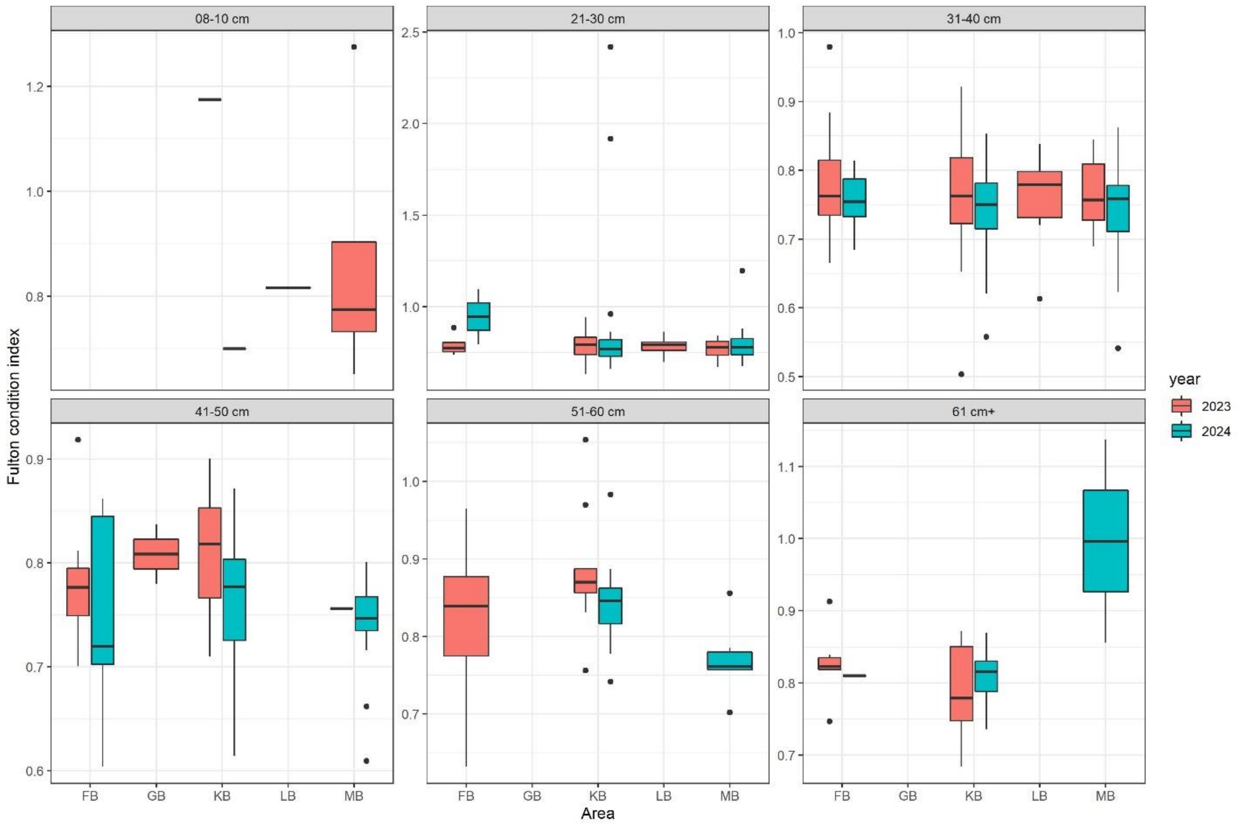

Fig. 5.2.3 Hepatosomatic index of WBC sampled at winter cod cruises 2023 (red; AL585) and 2024 (blue; AL606) per sampling sub-area (FB = Fehmarn Belt. Kiel Bight. MB = Mecklenburg Bight. LB = Little Belt. and GB = Great Belt), and length class.

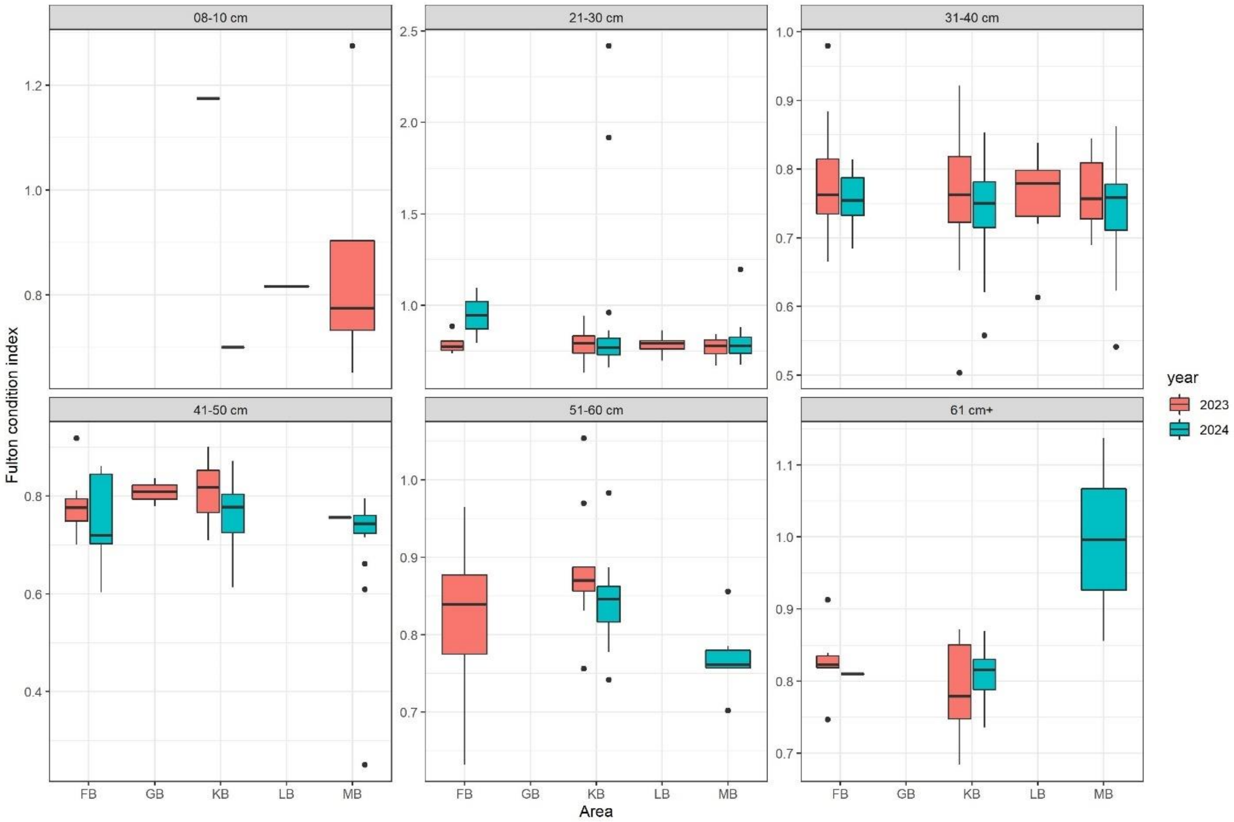

Fig. 5.2.4 Fulton condition index of WBC sampled at winter cod cruises 2023 (red; AL585) and 2024 (blue; AL606) per sampling sub-area (FB = Fehmarn Belt. Kiel Bight. MB = Mecklenburg Bight. LB = Little Belt. and GB = Great Belt), and length class.

Cod maturity stages

All cod staging was based on the guidelines of Tomkiewicz et al, (2002) and the staging routine of the Thuenen Institute of Baltic Sea Fisheries as conducted in the framework of the Baltic international trawl survey.

During AL606 we observed cod in spawning stages (i.e., in maturity stages 5 [= ("early spawning stage"], 6 [= "main spawning stage"], or 7 ["late spawning stage"]) in all sampled sub-areas (Fig. 5.2.5), providing evidence that cod spawning had already started all sampled sub-areas. Furthermore, distribution of maturity stages in January 2024 showed high similarity with those observed in 2023 (Fig. 5.2.5A &B).

Similar to our findings from the previous year, our results indicate that larger females spawn earlier than smaller conspecifics, with relative frequencies of spawning stages increasing with cod length class (Fig. 5.2.5A &B). This result stand in line with findings of Marteinsdóttir and Björnsson (1999) for Icelandic cod who described that larger and older cod tend to arrive earlier at the spawning grounds than their smaller conspecifics.

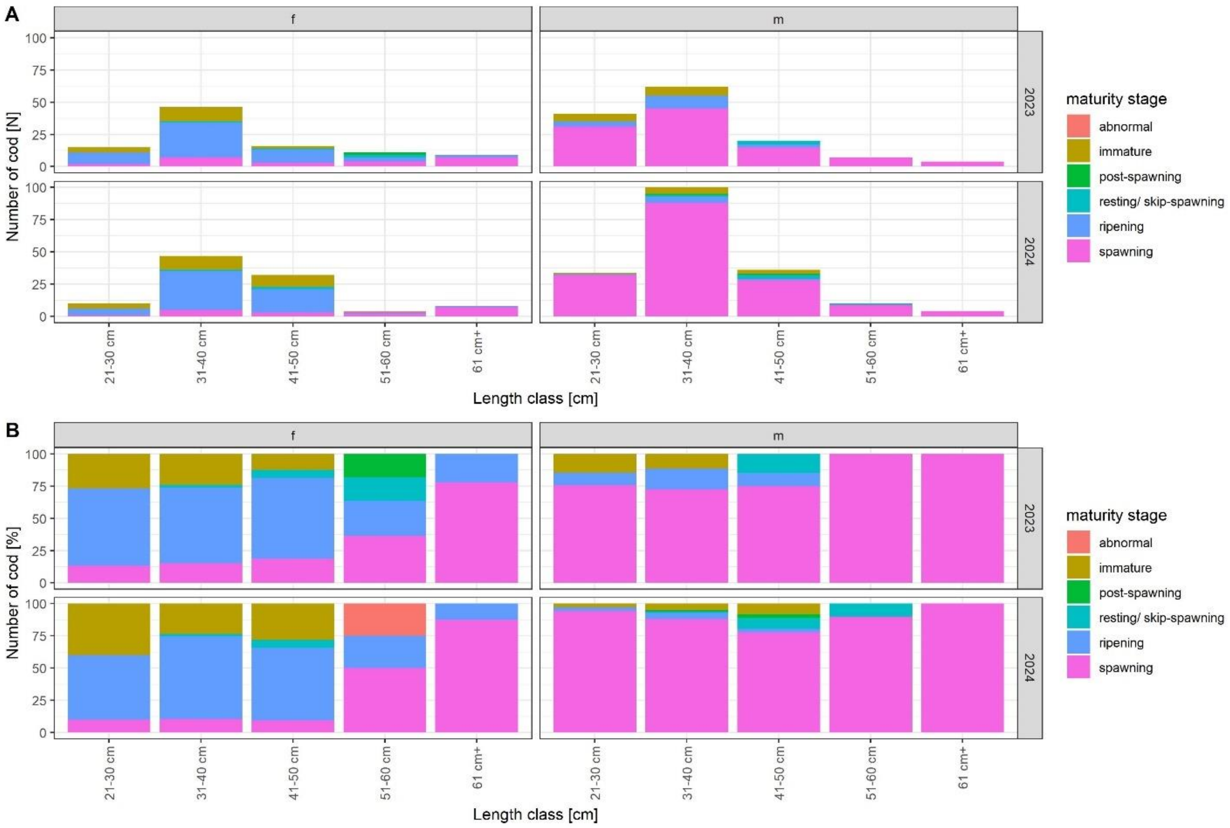

Fig. 5.2.5 Comparison of absolute (A) and relative (B) maturity stage distribution of cod per sex and 10 cm-length class (f = females. m = males) sampled in 2023 (AL585) and 2024 (AL606). Colours denote maturity stages. Note that fish which were not sexed during the cruise have been removed from the plot.

5.3 Ichthyo- and Zooplankton Sampling

(Steffen Funk)

Zoo- and ichthyoplankton samples were obtained from a total of 43 BONGO stations. BONGO net 500 µm samples were also checked directly on board for occurrence of cod larvae by trained scientists (Richard Klinger and Anton Höper). It was planned to pick cod larvae out of the samples and to deep freeze them for later condition and otolith microstructure analysis.

Clupeid larvae were picked out the sample and deep frozen for potential later DNA analysis for stock discrimination. The rest of the plankton samples were conserved in formalin for later species- and size-composition analysis in the laboratory.

<u>Cod larvae</u>

No cod larvae were observed within the BONGO net 500 µm samples during AL606. Thus, the winter cod cruise 2024 was the first winter cod cruise, where no cod larvae could be observed within the sampled Bongo stations. This may indicate that cod spawning activity was shifted towards a later start in 2024, which might be a result of the low temperatures in the winter 2023/24 and a related slow-downed gonadal ripening. However, it has be kept in mind that the total numbers of cod larvae observed in the previous three years have been also low and ranged between 3 and 13 individual cod larvae only. We therefore hope that the cod egg counts from a subsequent analysis of the Bongo net 300 µm samples will provide a better basis for an indication of interannual differences.

However, it was also noticeable that the total egg numbers in the Bongo net samples and the number of larvae of other species such as flatfish were significantly lower in 2024 than in 2023, which may support the hypothesis of a generally delayed onset of spawning activity in the Belt Sea as a result of the prevailing low temperatures in the Belt Sea this winter.

<u>Other fish larvae</u>

While we observed no cod larvae, we, however, observed several larvae from other fish species in the BONGO 500 µm net samples during AL606 (Tab. 5.3.1, Fig. 5.3.2). Similar to our observations during AL585 in January 2023, these other larvae have been mostly flatfish larvae (mostly plaice *Pleuronectes platessa*), and larvae of butterfish (*Pholis gunnellus*). In general, we observed lower numbers of larvae in January 2024 than during the previous January cruise AL585 in 2023. Highest total numbers of larvae were observed in the Kiel Bight and the entrances to the Little and the Great Belt. Fewest number of larvae were observed at stations in the Mecklenburg Bight. Interestingly, we observed more Clupeid larvae in 2024 than in 2023, with total numbers of 42 and 8, respectively.

Table 5.3.1 Observed larvae, fish egg and gelatinous plankton counts from BONGO 500 µm net samples taken during AL606 in January 2024. Note that GS30 was not sampled due to a gear malefaction.

Year	Month	Day	Cruise	Station	Haul	station name	*Gadus morhua*	Clupeid	*Pholis gunnellus*	*Pleuronectes platessa*	*Platichthys flesus*	*Limanda limanda*	*Taurulus bubalis*	other larvae	Cyanea	Ctenophora	Eggs
2024	1	22	AL606	3-2	1	GS1	0	2	1	3	0	0	0	0	1	0	250
2024	1	22	AL606	4-1	2	GS2	0	0	0	2	0	0	0	2	0	0	100
2024	1	22	AL606	5-2	3	GS3	0	3	1	6	0	0	0	0	1	0	300
2024	1	22	AL606	6-1	4	GS6	0	3	1	2	0	0	0	0	0	0	400
2024	1	22	AL606	7-2	5	GS7	0	1	2	0	0	0	0	0	0	0	300
2024	1	22	AL606	8-1	6	GS8	0	2	0	3	0	0	0	0	0	0	90
2024	1	22	AL606	9-2	7	GS13	0	0	0	0	0	0	0	0	0	0	100
2024	1	22	AL606	10-1	8	GS14	0	2	0	3	0	0	0	0	0	0	40
2024	1	22	AL606	11-2	9	GS15	0	0	2	0	0	0	0	0	0	1	20
2024	1	22	AL606	12-1	10	GS17	0	2	0	0	0	0	0	0	0	1	80
2024	1	22	AL606	13-2	11	GS18	0	3	2	6	0	0	4	0	0	0	500
2024	1	22	AL606	14-1	12	GS19	0	2	1	11	0	1	1	0	0	3	300
2024	1	23	AL606	15-2	13	GS20	0	6	3	0	0	1	0	0	0	2	30
2024	1	23	AL606	16-1	14	GS28	0	0	2	2	0	0	0	0	0	1	80
2024	1	23	AL606	17-2	15	GS27	0	0	0	2	0	0	0	0	0	0	30
2024	1	23	AL606	19-1	17	GS29	0	1	1	0	0	0	0	1	0	2	40
2024	1	23	AL606	20-2	18	GS35	0	0	0	0	0	0	0	0	0	7	60
2024	1	23	AL606	21-1	19	GS34	0	2	0	0	0	0	0	1	0	1	12
2024	1	23	AL606	22-2	20	GS33	0	0	1	0	0	0	0	0	0	1	10
2024	1	23	AL606	23-1	21	GS32	0	0	0	3	0	0	0	0	0	6	90
2024	1	23	AL606	24-2	22	GS31	0	1	3	1	0	0	0	2	0	0	30
2024	1	23	AL606	25-1	23	GS26	0	1	1	1	0	0	0	0	0	0	20
2024	1	23	AL606	26-2	24	GS25	0	0	1	3	0	0	0	1	0	6	40
2024	1	23	AL606	27-1	25	GS24	0	1	0	0	0	0	0	0	0	1	10
2024	1	23	AL606	33-2	26	GS23	0	2	0	2	0	0	0	0	0	0	60
2024	1	23	AL606	34-1	27	GS22	0	1	0	0	0	0	0	0	0	0	12
2024	1	23	AL606	36-2	28	GS21	0	7	1	1	0	0	0	3	0	4	50
2024	1	25	AL606	40-4	31	GS43	0	2	0	2	0	1	0	0	0	3	50
2024	1	25	AL606	41-2	33	GS42	0	0	0	0	0	0	0	0	0	2	30
2024	1	25	AL606	42-2	34	GS16	0	6	2	0	0	0	1	2	0	9	90
2024	1	25	AL606	43-1	35	GS11	0	2	5	0	1	0	0	0	0	2	120
2024	1	25	AL606	44-2	36	GS12	0	1	0	1	0	0	0	0	0	7	150
2024	1	25	AL606	45-1	37	GS9	0	0	5	5	0	0	1	1	0	3	100
2024	1	25	AL606	46-2	38	GS10	0	5	4	5	0	0	0	0	0	2	230
2024	1	25	AL606	47-1	39	GS5	0	3	1	12	0	0	0	0	0	4	600
2024	1	25	AL606	48-2	40	GS36	0	3	2	3	0	0	1	1	0	2	280
2024	1	25	AL606	49-1	41	GS37	0	0	2	4	0	1	0	1	1	5	600
2024	1	25	AL606	50-2	42	GS39	0	0	4	4	0	0	0	0	0	3	600

2024	1	26	AL606	51-1	43	GS40	0	0	0	1	0	0	1	0	0	2	200
2024	1	26	AL606	52-2	44	GS41	0	0	2	2	0	0	0	0	0	3	200
2024	1	26	AL606	53-1	45	GS38	0	2	0	0	0	1	0	1	0	3	500
2024	1	26	AL606	54-2	46	GS4	0	0	3	4	0	0	0	0	0	1	200

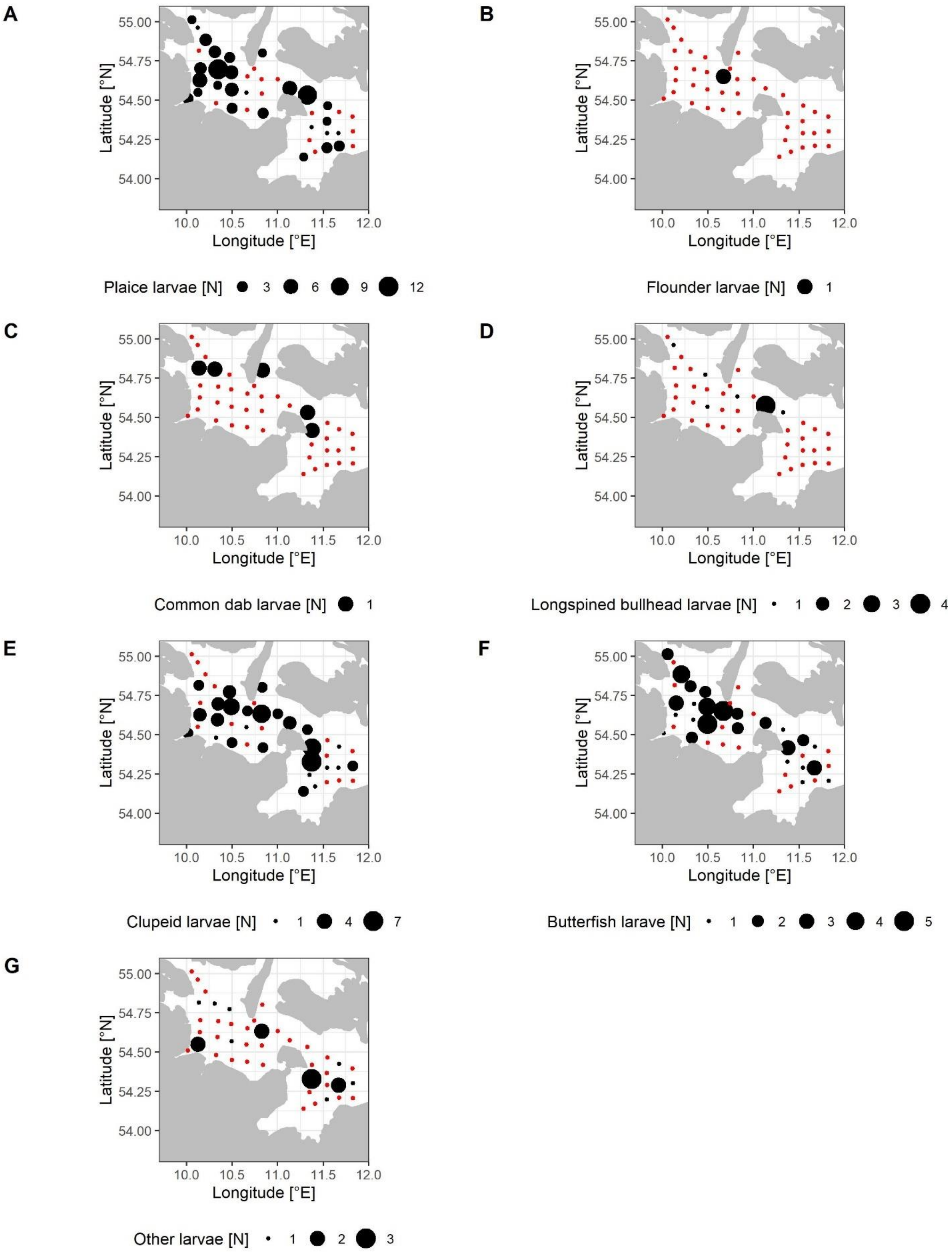

Fig. 5.3.1 Distribution of fish larvae observed in the study area during AL606 in January 2024.

Fish eggs

Number of fish eggs were counted in subsamples and then extrapolated to the total sample of BONGO 500 µm net hauls. Estimated number of observed fish eggs varied between 10 and 600. Maximum observation of fish eggs per station in 2024 was thus much lower than in 2023 where maximum estimated fish egg count was 1500. The distribution of fish eggs showed a clear spatial pattern with highest at stations in the western Kiel Bight and entrance of the Little Belt and a decreasing trend in the number of fish eggs towards the east with exception of the Fehmarn Belt (Fig. 5.3.3).

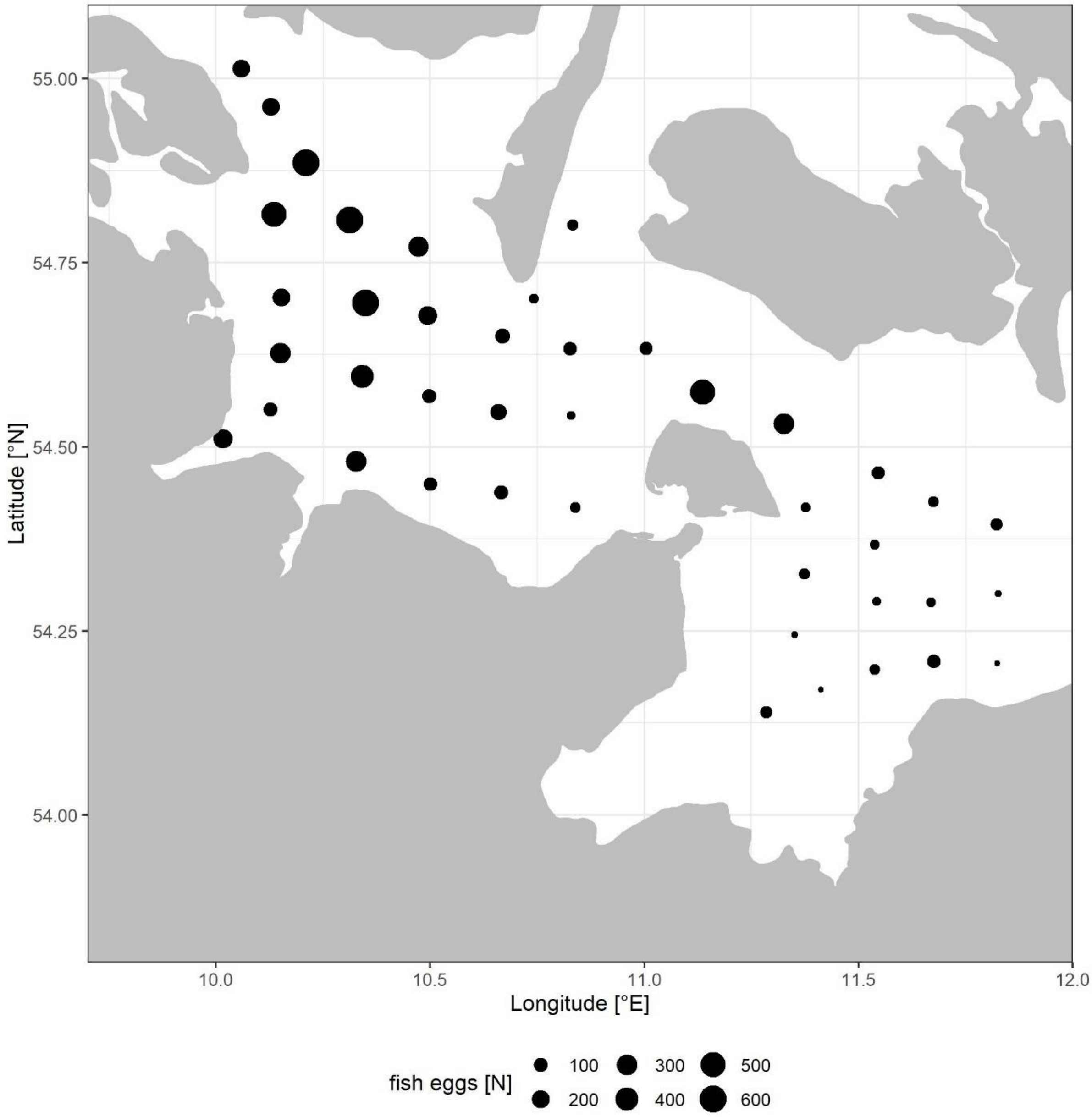

Fig. 5.3.2 Distribution of fish eggs observed in the study area during AL606 in January 2024. Point sizes are related to estimated numbers of fish eggs observed in BONGO 500 µm net hauls. Note that GS30 was not sampled due to a gear malefaction.

Gelatinous plankton

In the 500 µm BONGO nets, which were sorted immediately after the haul, we observed ctenophores (mostly *Mnemiopsis leidyi*) and ephyra-stages of cnidarians (mostly *Cyanea capillata*). Number of ephyra-stage cnidarians per BONGO net varied between 0 and 1. Cnidarians have been exclusively observed in the western Kiel Bight (Fig. 5.3.4).

Number of ctenophores in the Bongo samples varied between 0 and 9, with highest numbers in observed in the central Kiel Bight and eastern Mecklenburg Bight (Fig. 5.3.4). Maximum observations of Ctenophores with 9 individuals per Bongo 500 µm net haul in 2024 were much lower than maximum observations in 2023 with up to 50 individuals per Bongo500 µm net haul.

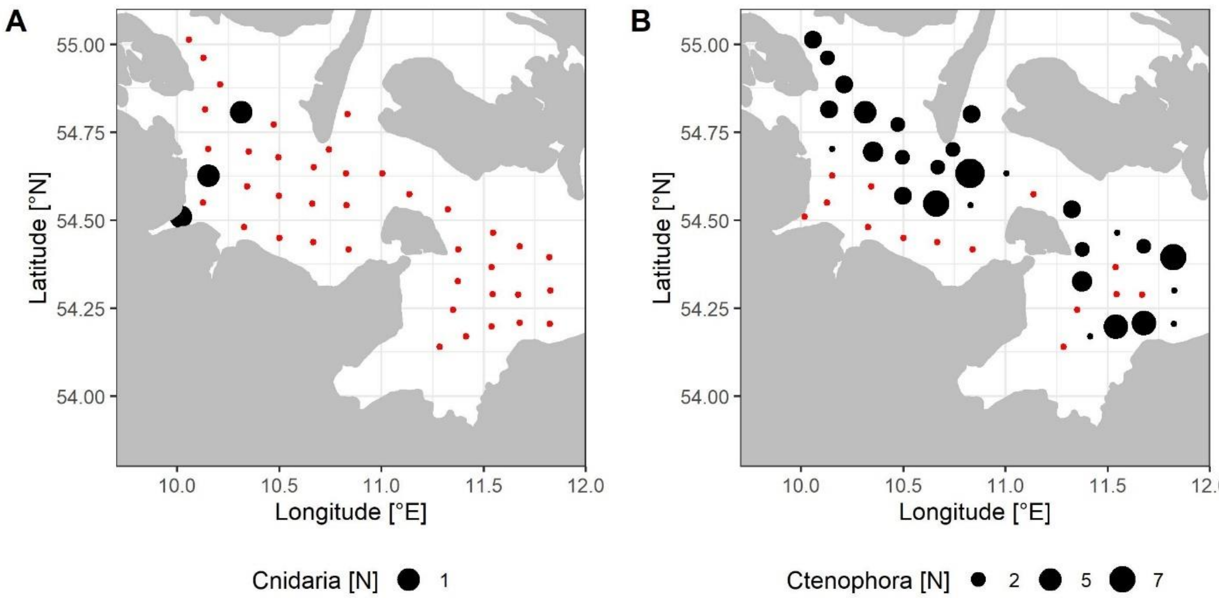

Fig. 5.3.3 Distribution of gelatinous plankton (A: Cnidarians; B: Ctenophores) observed in the study area during AL606 in January 2024. Point sizes are related to numbers of gelatinous plankton observed in 500 µm BONGO net hauls. Red dots denote zero catches (Note that data from station GS26 is missing in the plot).

6 Station List AL606

In total 148 gear deployments were conducted during the cruise AL606. The electronic version of the station list as well as additional cruise data are permanently stored at the field data server of the Institute of Marine Ecosystem and Fisheries Science (IMF) of the University of Hamburg and are available on request. The station log will be uploaded on PANGAEA and will be available most probably latest by January 2025. Furthermore, it is planned to make additional cruise data of AL606 (including catch data and individual fish data of cod, as well as cod stomach content data) publicly available via the public data repository PANGAEA (for further details see also section 7 "Data. Sample Storage and Availability" and Tab. 7.1.1).

6.1 Overall Station List

Table 6.1.1 Station List with all gear deployments during AL606 with CTD = CTD probe, BONGO = BONGO net with 150. 300 and 500 µm nets, FR = rod and reel fishery, BT = Bottom trawl TV3/520, MN_S5 = MULTINET midi, and Depth = water depth..

Station ALKOR	Device operation number	Device Operation Label	Event time	Latitude	Longitude	Depth [m]
AL606_1-1	1	FR	22.01.2024 11:35	54° 28,653' N	010° 14,290' E	19
AL606_1-2	2	CTD	22.01.2024 12:21	54° 28,635' N	010° 14,287' E	19
AL606_2-1	1	FR	22.01.2024 13:01	54° 33,982' N	010° 14,308' E	19
AL606_2-2	2	CTD	22.01.2024 13:37	54° 33,986' N	010° 14,288' E	19
AL606_3-1	1	CTD	22.01.2024 14:34	54° 30,804' N	010° 01,247' E	28
AL606_3-2	2	BONGO	22.01.2024 14:38	54° 30,748' N	010° 01,229' E	28
AL606_4-1	1	BONGO	22.01.2024 15:11	54° 33,120' N	010° 07,771' E	22
AL606_4-2	2	CTD	22.01.2024 15:17	54° 33,007' N	010° 07,518' E	22
AL606_5-1	1	CTD	22.01.2024 15:50	54° 37,780' N	010° 09,307' E	23
AL606_5-2	2	BONGO	22.01.2024 15:54	54° 37,722' N	010° 09,298' E	23
AL606_6-1	1	BONGO	22.01.2024 16:42	54° 35,802' N	010° 20,610' E	19
AL606_6-2	2	CTD	22.01.2024 16:48	54° 35,722' N	010° 20,371' E	17
AL606_7-1	1	CTD	22.01.2024 17:36	54° 28,920' N	010° 19,856' E	20
AL606_7-2	2	BONGO	22.01.2024 17:40	54° 28,888' N	010° 19,787' E	19
AL606_8-1	1	BONGO	22.01.2024 18:26	54° 27,039' N	010° 30,283' E	17
AL606_8-2	2	CTD	22.01.2024 18:32	54° 26,934' N	010° 29,981' E	17
AL606_9-1	1	CTD	22.01.2024 19:14	54° 26,371' N	010° 40,163' E	19
AL606_9-2	2	BONGO	22.01.2024 19:18	54° 26,342' N	010° 40,090' E	19
AL606_10-1	1	BONGO	22.01.2024 20:02	54° 25,102' N	010° 50,427' E	11
AL606_10-2	2	CTD	22.01.2024 20:07	54° 25,031' N	010° 50,261' E	12
AL606_11-1	1	CTD	22.01.2024 21:11	54° 32,680' N	010° 50,059' E	22
AL606_11-2	2	BONGO	22.01.2024 21:16	54° 32,610' N	010° 49,951' E	21
AL606_12-1	1	BONGO	22.01.2024 22:07	54° 38,067' N	011° 00,392' E	19
AL606_12-2	2	CTD	22.01.2024 22:13	54° 37,975' N	011° 00,205' E	19
AL606_13-1	1	CTD	22.01.2024 22:52	54° 34,558' N	011° 08,447' E	28
AL606_13-2	2	BONGO	22.01.2024 22:58	54° 34,536' N	011° 08,435' E	28
AL606_14-1	1	BONGO	22.01.2024 23:45	54° 31,859' N	011° 20,199' E	31
AL606_14-2	2	CTD	22.01.2024 23:57	54° 31,883' N	011° 19,462' E	31
AL606_15-1	1	CTD	23.01.2024 00:45	54° 25,182' N	011° 22,785' E	20

AL606_15-2	2	BONGO	23.01.2024 00:49	54° 25,145' N	011° 22,699' E	20
AL606_16-1	1	BONGO	23.01.2024 01:34	54° 28,003' N	011° 32,939' E	26
AL606_16-2	2	CTD	23.01.2024 01:42	54° 27,863' N	011° 32,560' E	26
AL606_17-1	1	CTD	23.01.2024 02:23	54° 22,143' N	011° 32,563' E	25
AL606_17-2	2	BONGO	23.01.2024 02:26	54° 22,108' N	011° 32,482' E	25
AL606_18-1	1	CTD	23.01.2024 03:10	54° 21,610' N	011° 40,875' E	26
AL606_18-2	2	BONGO	23.01.2024 03:28	54° 21,627' N	011° 40,793' E	26
AL606_19-1	1	BONGO	23.01.2024 03:58	54° 25,587' N	011° 40,659' E	25
AL606_19-2	2	CTD	23.01.2024 04:04	54° 25,517' N	011° 40,421' E	25
AL606_20-1	1	CTD	23.01.2024 04:41	54° 23,822' N	011° 49,493' E	22
AL606_20-2	2	BONGO	23.01.2024 04:45	54° 23,797' N	011° 49,471' E	22
AL606_21-1	1	BONGO	23.01.2024 05:26	54° 18,129' N	011° 49,748' E	23
AL606_21-2	2	CTD	23.01.2024 05:32	54° 18,000' N	011° 49,540' E	23
AL606_22-1	1	CTD	23.01.2024 06:11	54° 12,504' N	011° 49,641' E	21
AL606_22-2	2	BONGO	23.01.2024 06:15	54° 12,461' N	011° 49,602' E	21
AL606_23-1	1	BONGO	23.01.2024 06:56	54° 12,588' N	011° 40,744' E	25
AL606_23-2	2	CTD	23.01.2024 07:02	54° 12,489' N	011° 40,517' E	26
AL606_24-1	1	CTD	23.01.2024 07:41	54° 17,469' N	011° 40,412' E	26
AL606_24-2	2	BONGO	23.01.2024 07:44	54° 17,430' N	011° 40,347' E	26
AL606_25-1	1	BONGO	23.01.2024 08:22	54° 17,420' N	011° 32,756' E	24
AL606_25-2	2	CTD	23.01.2024 08:26	54° 17,408' N	011° 32,535' E	25
AL606_26-1	1	CTD	23.01.2024 09:07	54° 11,948' N	011° 32,592' E	25
AL606_26-2	2	BONGO	23.01.2024 09:11	54° 11,941' N	011° 32,579' E	25
AL606_27-1	1	BONGO	23.01.2024 09:45	54° 10,270' N	011° 24,974' E	24
AL606_27-2	2	CTD	23.01.2024 09:50	54° 10,195' N	011° 24,676' E	24
AL606_28-1	1	FR	23.01.2024 10:37	54° 08,777' N	011° 24,713' E	23
AL606_29-1	1	FR	23.01.2024 11:12	54° 08,239' N	011° 25,491' E	24
AL606_30-1	1	FR	23.01.2024 12:15	54° 08,197' N	011° 15,833' E	22
AL606_31-1	1	FR	23.01.2024 12:42	54° 08,534' N	011° 15,392' E	25
AL606_32-1	1	FR	23.01.2024 13:11	54° 08,923' N	011° 14,335' E	24
AL606_33-1	1	CTD	23.01.2024 13:41	54° 08,444' N	011° 17,300' E	27
AL606_33-2	2	BONGO	23.01.2024 13:45	54° 08,428' N	011° 17,272' E	27
AL606_34-1	1	BONGO	23.01.2024 14:30	54° 14,795' N	011° 21,218' E	22
AL606_34-2	2	CTD	23.01.2024 14:34	54° 14,683' N	011° 20,966' E	22
AL606_35-1	1	FR	23.01.2024 14:51	54° 15,232' N	011° 18,047' E	22
AL606_36-1	1	CTD	23.01.2024 15:42	54° 19,738' N	011° 22,647' E	22
AL606_36-2	2	BONGO	23.01.2024 15:46	54° 19,712' N	011° 22,622' E	22
AL606_37-1	1	FR	24.01.2024 07:12	54° 11,483' N	011° 07,041' E	12
AL606_38-1	1	CTD	25.01.2024 06:48	54° 09,108' N	011° 25,790' E	23
AL606_38-2	2	BT	25.01.2024 06:59	54° 09,081' N	011° 25,535' E	23
AL606_39-1	1	CTD	25.01.2024 09:42	54° 20,721' N	011° 32,570' E	26
AL606_39-2	2	BT	25.01.2024 09:48	54° 20,753' N	011° 32,305' E	25
AL606_40-1	1	CTD	25.01.2024 14:57	54° 47,920' N	010° 49,829' E	43
AL606_40-2	2	BONGO	25.01.2024 15:02	54° 47,921' N	010° 49,826' E	42
AL606_40-3	3	BONGO	25.01.2024 15:17	54° 48,232' N	010° 50,025' E	46
AL606_40-4	4	BONGO	25.01.2024 15:33	54° 48,252' N	010° 49,950' E	40
AL606_41-1	1	BONGO	25.01.2024 16:16	54° 42,101' N	010° 44,677' E	25

AL606_41-2	2	BONGO	25.01.2024 16:23	54° 42,077' N	010° 44,864' E	26
AL606_41-3	3	CTD	25.01.2024 16:29	54° 42,046' N	010° 44,468' E	24
AL606_42-1	1	CTD	25.01.2024 17:06	54° 38,015' N	010° 50,071' E	24
AL606_42-2	2	BONGO	25.01.2024 17:10	54° 38,003' N	010° 49,952' E	24
AL606_43-1	1	BONGO	25.01.2024 17:51	54° 39,079' N	010° 40,336' E	23
AL606_43-2	2	CTD	25.01.2024 17:57	54° 39,031' N	010° 39,939' E	26
AL606_44-1	1	CTD	25.01.2024 18:39	54° 32,857' N	010° 39,953' E	21
AL606_44-2	2	BONGO	25.01.2024 18:43	54° 32,858' N	010° 39,817' E	21
AL606_45-1	1	BONGO	25.01.2024 19:23	54° 34,199' N	010° 30,067' E	20
AL606_45-2	2	CTD	25.01.2024 19:29	54° 34,154' N	010° 29,750' E	20
AL606_46-1	1	CTD	25.01.2024 20:14	54° 40,785' N	010° 30,140' E	26
AL606_46-2	2	BONGO	25.01.2024 20:19	54° 40,734' N	010° 30,009' E	25
AL606_47-1	1	BONGO	25.01.2024 20:56	54° 41,758' N	010° 21,319' E	33
AL606_47-2	2	CTD	25.01.2024 21:04	54° 41,720' N	010° 20,804' E	34
AL606_48-1	1	CTD	25.01.2024 21:52	54° 46,421' N	010° 28,900' E	26
AL606_48-2	2	BONGO	25.01.2024 21:56	54° 46,371' N	010° 28,802' E	26
AL606_49-1	1	BONGO	25.01.2024 22:37	54° 48,517' N	010° 19,161' E	33
AL606_49-2	2	CTD	25.01.2024 22:44	54° 48,449' N	010° 18,671' E	35
AL606_50-1	1	CTD	25.01.2024 23:25	54° 53,413' N	010° 12,723' E	32
AL606_50-2	2	BONGO	25.01.2024 23:30	54° 53,314' N	010° 12,700' E	32
AL606_51-1	1	BONGO	26.01.2024 00:09	54° 57,823' N	010° 07,571' E	35
AL606_51-2	2	CTD	26.01.2024 00:15	54° 57,620' N	010° 07,627' E	35
AL606_52-1	1	CTD	26.01.2024 00:47	55° 01,093' N	010° 03,217' E	36
AL606_52-2	2	BONGO	26.01.2024 00:52	55° 01,029' N	010° 03,281' E	36
AL606_53-1	1	BONGO	26.01.2024 02:08	54° 49,050' N	010° 08,008' E	29
AL606_53-2	2	CTD	26.01.2024 02:15	54° 48,855' N	010° 08,182' E	28
AL606_54-1	1	CTD	26.01.2024 02:59	54° 42,407' N	010° 09,018' E	27
AL606_54-2	2	BONGO	26.01.2024 03:03	54° 42,346' N	010° 09,074' E	27
AL606_55-1	1	FR	26.01.2024 07:30	54° 44,918' N	010° 06,972' E	24
AL606_56-1	1	FR	26.01.2024 08:34	54° 42,902' N	010° 08,235' E	25
AL606_56-2	2	CTD	26.01.2024 09:01	54° 42,900' N	010° 08,237' E	25
AL606_57-1	1	FR	26.01.2024 09:25	54° 41,202' N	010° 07,236' E	17
AL606_58-1	1	FR	26.01.2024 09:48	54° 40,343' N	010° 07,717' E	19
AL606_58-2	2	CTD	26.01.2024 10:15	54° 40,330' N	010° 07,733' E	20
AL606_59-1	1	FR	26.01.2024 10:51	54° 38,028' N	010° 13,166' E	22
AL606_59-2	2	CTD	26.01.2024 11:34	54° 38,013' N	010° 13,203' E	22
AL606_60-1	1	FR	26.01.2024 12:02	54° 37,054' N	010° 08,599' E	21
AL606_60-2	2	CTD	26.01.2024 12:27	54° 37,078' N	010° 08,605' E	23
AL606_61-1	1	CTD	26.01.2024 13:10	54° 32,084' N	010° 03,588' E	28
AL606_61-2	2	BT	26.01.2024 13:16	54° 31,990' N	010° 03,498' E	28
AL606_62-1	1	CTD	27.01.2024 06:56	54° 41,229' N	010° 25,367' E	31
AL606_62-2	2	BT	27.01.2024 07:10	54° 41,140' N	010° 26,381' E	31
AL606_63-1	1	CTD	27.01.2024 08:10	54° 41,672' N	010° 21,614' E	32
AL606_63-2	2	MN_S5	27.01.2024 09:34	54° 41,854' N	010° 18,595' E	31
AL606_63-4	4	BT	27.01.2024 10:40	54° 41,715' N	010° 21,683' E	32
AL606_64-1	1	FR	27.01.2024 14:17	54° 34,853' N	010° 47,026' E	25
AL606_64-2	2	CTD	27.01.2024 14:38	54° 34,845' N	010° 46,998' E	25

AL606_65-1	1	FR	27.01.2024 15:02	54° 36,511' N	010° 49,378' E	22
AL606_66-1	1	FR	27.01.2024 15:46	54° 36,220' N	010° 51,363' E	22
AL606_66-2	2	CTD	27.01.2024 16:49	54° 36,226' N	010° 51,346' E	22
AL606_67-1	1	FR	28.01.2024 06:57	54° 19,303' N	011° 50,000' E	24
AL606_68-1	1	FR	28.01.2024 08:03	54° 17,345' N	011° 46,269' E	26
AL606_68-2	2	CTD	28.01.2024 08:29	54° 17,324' N	011° 46,277' E	26
AL606_69-1	1	FR	28.01.2024 09:27	54° 25,473' N	011° 43,982' E	23
AL606_69-2	2	CTD	28.01.2024 10:01	54° 25,466' N	011° 43,963' E	25
AL606_70-1	1	FR	28.01.2024 11:28	54° 28,059' N	011° 22,270' E	25
AL606_70-2	2	CTD	28.01.2024 13:04	54° 28,037' N	011° 22,260' E	24
AL606_71-1	1	FR	28.01.2024 14:58	54° 35,773' N	011° 04,568' E	32
AL606_72-1	1	FR	28.01.2024 15:35	54° 36,496' N	011° 05,068' E	29
AL606_72-2	2	CTD	28.01.2024 16:22	54° 36,489' N	011° 05,056' E	28
AL606_73-1	1	FR	29.01.2024 06:56	54° 31,722' N	010° 42,570' E	19
AL606_73-2	2	CTD	29.01.2024 07:40	54° 31,715' N	010° 42,601' E	19
AL606_74-1	1	FR	29.01.2024 08:13	54° 33,362' N	010° 45,166' E	24
AL606_75-1	1	FR	29.01.2024 09:05	54° 34,866' N	010° 47,027' E	24
AL606_75-2	2	CTD	29.01.2024 09:35	54° 34,855' N	010° 47,013' E	24
AL606_76-1	1	FR	29.01.2024 10:01	54° 35,509' N	010° 51,588' E	20
AL606_76-2	2	FR	29.01.2024 10:40	54° 35,495' N	010° 51,599' E	21
AL606_77-1	1	FR	29.01.2024 11:27	54° 36,516' N	010° 49,359' E	22
AL606_77-2	2	CTD	29.01.2024 11:39	54° 36,494' N	010° 49,364' E	22
AL606_78-1	1	FR	29.01.2024 12:21	54° 33,499' N	010° 40,915' E	22
AL606_78-2	2	CTD	29.01.2024 12:54	54° 33,495' N	010° 40,909' E	22
AL606_79-1	1	BONGO	29.01.2024 15:00	54° 26,169' N	010° 12,725' E	18

7 Data and Sample Storage and Availability

All data obtained during the cruise have been backed up on the field data server of the IMF of the University of Hamburg. In addition, data have been backed up and stored on different hard drives at different locations. Paper protocols filled out during the cruise were entered electronically and thus already felt under the back-up scheme, applied for the rest of the cruise data (including all cruise meta data such as the output of the onboard DSHIP-System). In addition, paper protocols were also conserved as hard copy at the IMF.

Furthermore, we aim to make all data obtained during the cruise AL606 publicly available. Hydrographic data (CTD) will be submitted to PANGAEA (also planned to be uploaded on the ICES Oceanographic database) within one year from the cruise. Furthermore, it is planned to upload fishery data (including cod single fish data) in the public data repository PANGEA.

Depending on the data set, some of the data (especially including all zooplankton & ichthyoplankton data) are intended for specific publications. In the context of publication these data will be made publicly available. Right after analysing the taken cod stomach samples, stomach data will be added to the cod stomach data base of the IMF and Thuenen-OF.

All plankton samples obtained during the cruise AL606 and preserved in formalin were labelled directly on board using a barcoding scheme and were archived at the IMF. As the case for previous winter cod cruises the analysis of ichthyoplankton and zooplankton data will be coordinated by the WBCF. Please contact the responsible persons for a corresponding data set (see Tab. 7.1.1) if earlier access to the data is desired.

Table 7.1.1 Overview of data, data availability and corresponding contact persons (responsible for the specific data sets).

Data	Database	Available	Free Access	Contact
Hydrography (CTD data)	PANGAEA/ ICES database	Publicly by January 2025, earlier on request	By January 2025	steffen.funk@uni-hamburg.de
Fishery data	PANGAEA	Publicly at time of publishing of the underlying peer-reviewed publication; earlier upon request (see contact)	at time of publishing of the underlying peer-reviewed publication	steffen.funk@uni-hamburg.de
Cod single fish data	PANGAEA	Publicly by January 2025, earlier on request	By January 2025	steffen.funk@uni-hamburg.de
Cod stomach content data	PANGAEA	Publicly at time of publishing of the underlying peer-reviewed publication; earlier upon request (see contact)	at time of publishing of the underlying peer-reviewed publication	steffen.funk@uni-hamburg.de

Ichthyoplankton	PANGAEA	Publicly at time of publishing of the underlying peer-reviewed publication; earlier upon request (see contact)	at time of publishing of the underlying peer-reviewed publication	christian.moellmann@uni-hamburg.de
Zooplankton	PANGAEA	Publicly at time of publishing of the underlying peer-reviewed publication; earlier upon request (see contact)	at time of publishing of the underlying peer-reviewed publication	christian.moellmann@uni-hamburg.de

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10 Abbreviations

BITS – Baltic international trawl survey
DTU – Danish Technical University
ICES – International Council for the Exploration of the Sea
IMF – Institute of Marine Ecosystem and Fisheries Science
UHAM – University of Hamburg
Thuenen-OF – Thuenen Institute of Baltic Sea Fisheries Rostock
WBCF – Western Baltic Cod Forum