WORKING GROUP ON SURVEYS ON ICHTHYOPLANKTON IN THE NORTH SEA AND ADJACENT SEAS (WGSINS; outputs from 2021 meeting)

VOLUME 4 | ISSUE 27

ICES SCIENTIFIC REPORTS

RAPPORTS
SCIENTIFIQUES DU CIEM

ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
CIEM COUSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

ISSN number: 2618-1371

ICES Scientific Reports

Volume 4 | Issue 27

WORKING GROUP ON SURVEYS ON ICHTHYOPLANKTON IN THE NORTH SEA AND ADJACENT SEAS (WGSINS; outputs from 2021 meeting)

Recommended format for purpose of citation:

ICES. 2022. Working Group on Surveys on Ichthyoplankton in the North Sea and adjacent Seas (WGSINS; outputs from 2021 meeting)

ICES Scientific Reports. 4:27. 47pp. http://doi.org/10.17895/ices.pub.19420232

Editors

Norbert Rohlf

Authors

Norbert Rohlf • Cindy van Damme • Hannah Holah • Matthias Kloppmann • Malin Werner
Annegret Finke • Bastian Huwer • Christophe Loots • Carolina Giraldo • Steven Beggs • Hannes Höffle
Richard Nash

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

Contents

i Executive summary

The Working Group on Surveys on Ichthyoplankton in the North Sea and adjacent Seas (WGSINS) carries out surveys on early life stages of North Sea, Baltic and Irish Sea fishes. The objectives of WGSINS described in this report include review and coordination of ichthyoplankton surveys undertaken for assessment purposes, preparation of data for archival, documentation to provide quality assurance on species identification, and identification of additional objectives that can be achieved within the existing survey designs.

The international herring larvae surveys in the North Sea (IHLS) revealed low numbers of newly hatched larvae around the Orkneys in autumn 2020. In the Buchan and Banks, larvae hatched in larger quantities, but concentrated in only two dense areas. As in recent years, large numbers of herring larvae were found at the Downs herring spawning sites.

The Midwater Ring Net (MIK) sampling during the first quarter international bottom trawl survey in 2021 (Q1 IBTS) reported higher abundance of foraging herring larvae, compared to 2020. However, at the potential nurseries in the eastern part of the North Sea, abundances of larger herring larvae were lower than last year.

The Rügen herring larvae survey (RHLS) considers the major spawning areas of western Baltic spring spawning herring, but there is still no substantial recruitment in the area.

The Northern Irish Herring Larvae survey monitored the vast majority of larvae in the eastern Irish Sea, in the vicinity of the Douglas bank and north of the Isla of Man. In contrast to the previous year, larvae were also detected in the vicinity of the Mourne spawning ground, along the Irish coast.

The Northern Irish MIK survey resumed in 2021 after missing 2020 due to Covid-19 restrictions. Target species juvenile gadoids cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*) were located predominantly in the western Irish Sea. Additional MIK hauls indicated higher abundances of juvenile gadoids north of the study area, which will be monitored in future years to ensure that the main distribution of juvenile gadoids is surveyed.

The Downs recruitment survey (DRS) resumed after a pause in 2020 due to Covid-19 measures. In 2021, highest numbers of herring larvae were observed at the southern-most stations, just above the Wadden Sea isles. Results were comparable to 2018. In 2019, the numbers were much lower and the larvae more westerly distributed.

The individual Baltic Ichthyoplankton Surveys (BIS) are distributed over the spawning season of the main target species Eastern Baltic cod. Sample analyses are still ongoing. 2021 preliminary data indicate that the egg-based stock biomass remains at a low level as in 2018-2020.

A four-year pilot study tries to establish a sprat recruitment index for the North Sea. Survey results are promising, but broader area coverage is necessary. Another pilot study investigated the distribution and abundance of small, recently hatched sandeel larvae. High larval abundances were found at Dogger Bank and Horns Reef, indicating that these are major spawning areas.

Results of marine litter in the North Sea MIK surveys are available for 2017-2020 and sampling was continued in 2021.

WGSINS will continue to collect and archive information on co-occurring fish larvae to establish time-series as a basis for further analyses of species distribution.

ii Expert group information

Expert group name	Working Group on Surveys on Ichthyoplankton in the North Sea and adjacent Seas (WGSINS)
Expert group cycle	Multiannual
Year cycle started	2019
Reporting year in cycle	3/3
Chair	Norbert Rohlf, Germany
Meeting venue(s) and dates	30 November - 02 December 2021, online meeting (12 participants)

1 Survey reviews

1.1 The International Herring Larvae Surveys in the North Sea (IHLS)

The IHLS in 2020/2021

Six survey areas were covered within the framework of the International Herring Larval Surveys in the North Sea during the sampling period 2020-2021. They monitored the abundance and distribution of newly hatched herring larvae in the Orkney/Shetlands area, in the Buchan area and the central North Sea (CNS) in September. Surveys in the southern North Sea (SNS) were conducted in December 2020 and January 2021 (Figures 1.1.1 - 1.1.4).

The survey around the Orkneys revealed relatively low numbers of newly hatched larvae, in line with the estimate last year. In the Buchan and the central North Sea, larvae hatched in larger quantities, but were concentrated in two dense areas, while the remaining stations contributed only low numbers of larvae (Fig 1.1.2).

The two surveys in the southern North Sea showed a peak in abundance in January. In recent years, this peak was most often observed in December. However, the overall distribution of larvae and thus the main spawning area used by herring is not obviously different from preceding years. The abundance of young larvae is high when hatching started in December, but their spatial distribution is limited. With progressing spawning season the spatial distribution gets broader.

No survey was planned for the second half of January 2021. Instead, an additional MIK sampling was undertaken in March/April 2021 in the German Bight and Skagerrak/Kattegat area. This sampling should shade light on the foraging and recruitment of herring larvae originating from the Downs stock component. This survey is described in section 1.2.

At time of the WGSINS meeting, the 2021/2022 campaign is still running. The surveys in September were conducted as scheduled, but no results are available yet. Plankton sorting and larvae length measurements are ongoing.

During the most recent benchmark of the North Sea herring assessment (ICES, WKPELA 2018a), it was decided to use the Larvae Abundance Index (LAI, Tab. 1.1.1) as direct input into the assessment model and to resolve spatial stock dynamics inside the model.

Table 1.1.1: Herring Larvae Abundance Time-Series (LAI) of larvae <10 mm long (<11 mm for the SNS), by standard sampling area and time periods. The numbers of larvae are expressed as mean numbers per ICES rectangle * 10^9

	Orkney/ Shetland		Buchan		Central North Sea			Southern North Sea		
Period/ Year	1-15 Sep.	16-30 Sep.	1-15 Sep.	16-30 Sep.	1-15 Sep.	16-30 Sep.	1-15 Oct.	16-31 Dec.	1-15 Jan.	16-31 Jan.
1972	1133	4583	30		165	88	134	2	46	
1973	2029	822	3	4	492	830	1213			1
1974	758	421	101	284	81		1184		10	
1975	371	50	312			90	77	1	2	
1976	545	81		1	64	108			3	
1977	1133	221	124	32	520	262	89	1		
1978	3047	50		162	1406	81	269	33	3	
1979	2882	2362	197	10	662	131	507		111	89
1980	3534	720	21	1	317	188	9	247	129	40
1981	3667	277	3	12	903	235	119	1456		70
1982	2353	1116	340	257	86	64	1077	710	275	54
1983	2579	812	3647	768	1459	281	63	71	243	58
1984	1795	1912	2327	1853	688	2404	824	523	185	39
1985	5632	3432	2521	1812	130	13039	1794	1851	407	38
1986	3529	1842	3278	341	1611	6112	188	780	123	18
1987	7409	1848	2551	670	799	4927	1992	934	297	146
1988	7538	8832	6812	5248	5533	3808	1960	1679	162	112
1989	11477	5725	5879	692	1442	5010	2364	1514	2120	512
1990		10144	4590	2045	19955	1239	975	2552	1204	
1991	1021	2397		2032	4823	2110	1249	4400	873	
1992	189	4917		822	10	165	163	176	1616	
1993		66		174		685	85	1358	1103	
1994	26	1179				1464	44	537	595	
1995		8688					43	74	230	164
1996		809		184		564		337	675	691
1997		3611		23				9374	918	355

1998		8528		1490	205	66		1522	953	170
1999		4064		185		134	181	804	1260	344
2000		3352	28	83		376		7346	338	106
2001		11918		164		1604		971	5531	909
2002		6669		1038			3291	2008	260	925
2003		3199		2263		12018	3277	12048	3109	1116
2004		7055		3884		5545		7055	2052	4175
2005		3380		1364		5614		498	3999	4822
2006	6311	2312		280		2259		10858	2700	2106
2007		1753		1304		291		4443	2439	3854
2008	4978	6875		533		11201		8426	2317	4008
2009		7543		4629		4219		15295	14712	1689
2010		2362		1493		2317		7493	13230	8073
2011		3831		2839		17766		5461	6160	1215
2012		19552		5856		517		22768	11103	3285
2013		21282		8618		7354		5	9314	2957
2014		6604		5033		1149				1851
2015		9631		3496		3424		2011	1200	645
2016				3872		3288		20710	1442	1545
2017				5833		3965		10553	5880	
2018		102		1740		1509		1140		
2019	2488		5654	3794		10605		14082	5258	
2020		3208		3418		7663		4077	9704	

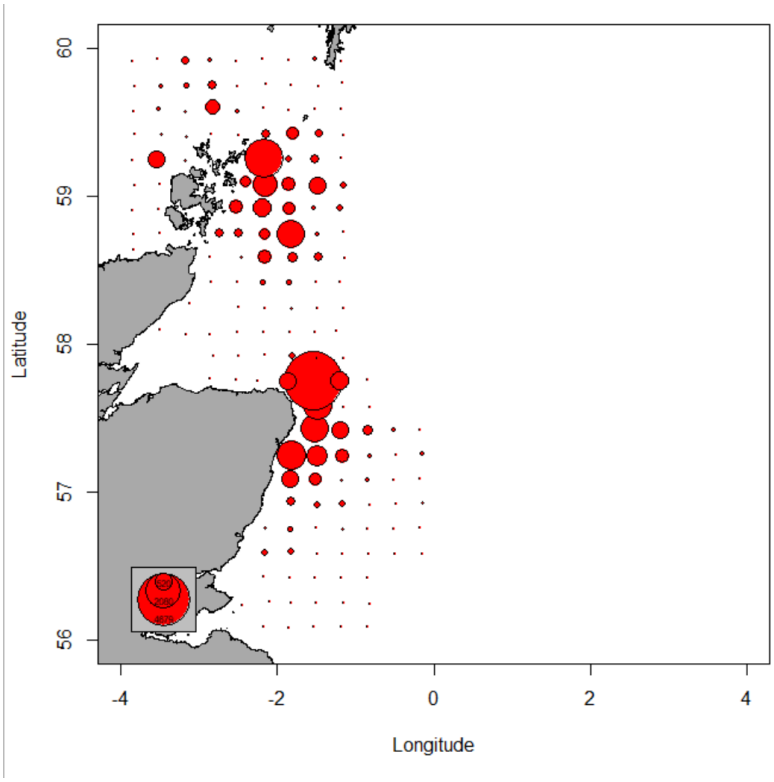

Figure 1.1.1: North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Orkney/Shetlands and Buchan area, second half of September 2020 (maximum circle size = 4700 n/m²).

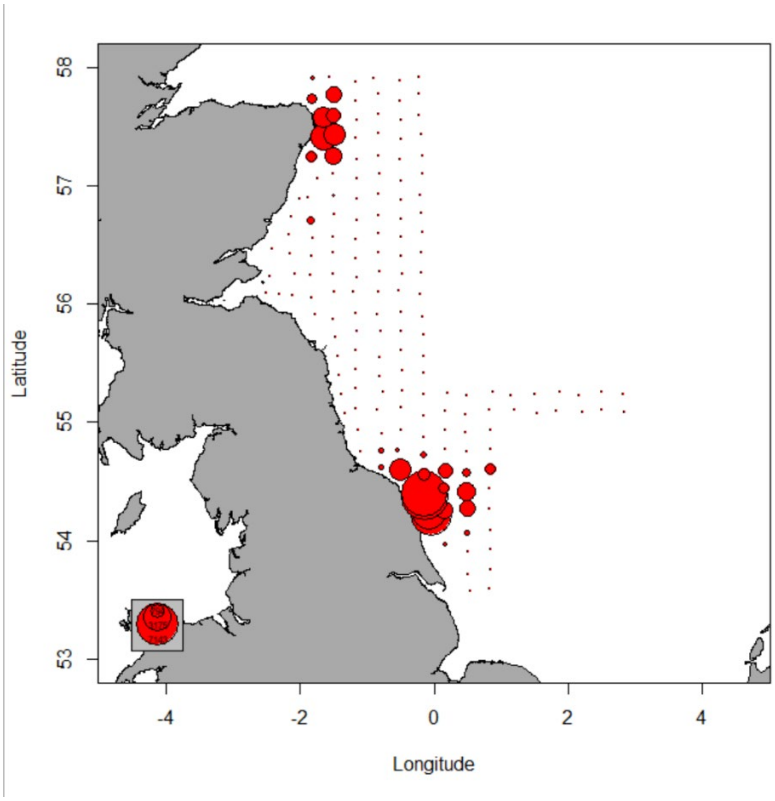

Figure 1.1.2: North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Buchan and central North Sea area, second half of September 2020 (maximum circle size = 7100 n/m²).

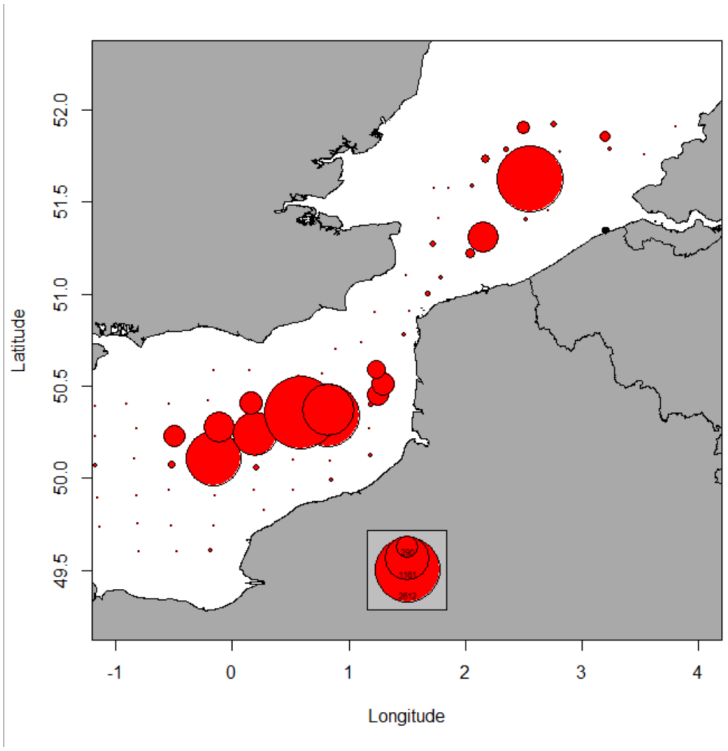

Figure 1.1.3: North Sea herring - Abundance of larvae < 11 mm (n/m²) in the Southern North Sea and English Channel, second half of December 2020 (maximum circle size = 2600 n/m²).

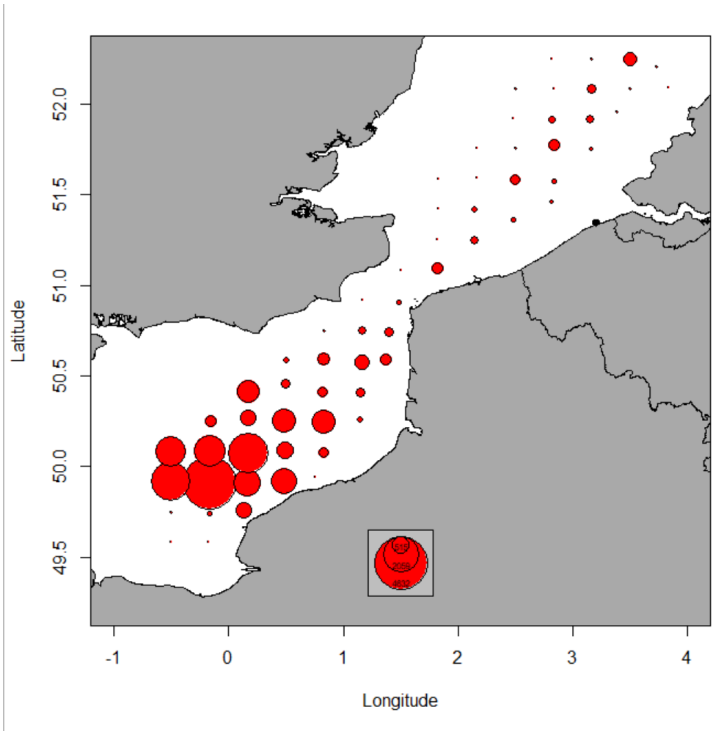

Figure1.1.4: North Sea herring - Abundance of larvae < 11 mm (n/m²) in the Southern North Sea and English Channel, first half of January 2021 (maximum circle size = 4600 n/m²).

Planning of the 2022 IHLS surveys

The IHLS surveys give information about herring larvae hatching success and larvae abundance on the main spawning grounds of North Sea autumn spawning herring. They also inform about the relative contribution of the different spawning components to the whole stock. In general, on four different spawning areas, two (Orkney/Shetlands and Buchan) or three (Banks and Downs) sampling periods are needed monitoring the full spawning activity. This condition hasn't been met since the mid of the 1990s, when several participants left the larvae surveys and continued with acoustic surveys thereafter. Nowadays, only the Netherlands and Germany participate in the IHLS and it is only possible to cover some sets out of the 10.

Instead of the survey in the southern North Sea in the 2nd half of January, an additional MIK-Survey, following foraging Downs herring larvae, was introduced and conducted since 2018. This additional survey shades lights into the recruitment of the Downs stock component and is also scheduled to take place in spring 2022 (see Section 1.2 below).

The plan of the upcoming campaign is given below.

Table 1.1.2: Areas and periods to be covered during the 2022 IHLS surveys

Area / Period	01.-15.09.	16.-30.09.	01.-15.10.
Orkney/Shetlands	None	FRG	
Buchan	None	NL / FRG	
Central	None	NL	None
Area/Period	**16.-31.12.**	**01.-15.01.**	**16.-31.01.**
Southern North Sea	NL	FRG	None

1.2 The Downs Recruitment Survey

1.2.1 Survey in 2021

In 2021, the Downs Recruitment Survey (DRS) was carried out following the IBTS-MIK protocol as much as possible, but the sampling was carried out both day and night, instead of only at night. Both Netherlands and Norway participated in the survey. Because of the day sampling a blue midwater ring trawl is used (see Chapter 1.2.2).

In total 69 stations were sampled, Norway sampled 10 stations and Netherlands 59 (Fig 1.2.1). All hauls were valid. Netherlands sampled from 19 - 23 April, Norway sampled 20 - 21 April.

On all stations large samples were caught, with high volumes of jellyfish, and high numbers of sandeel and clupeid larvae. Of all stations sampled 11 did not contain herring larvae (Fig 1.2.2). These stations were on the two most northern transects and in the northwest corner of the sampling area. Highest numbers of herring larvae were found in the southern stations and just above the Wadden Sea isles.

Herring larvae distribution and numbers were comparably to 2018 (Fig. 1.2.3). In 2019 the numbers were much lower and the larvae more westerly distributed (Fig. 1.2.3). In 2020 no survey was carried out due to Covid-19 measures.

Length distributions of the herring larvae in the DRS was the same in 2021 compared to 2018 and 2019 (Fig 1.2.4).

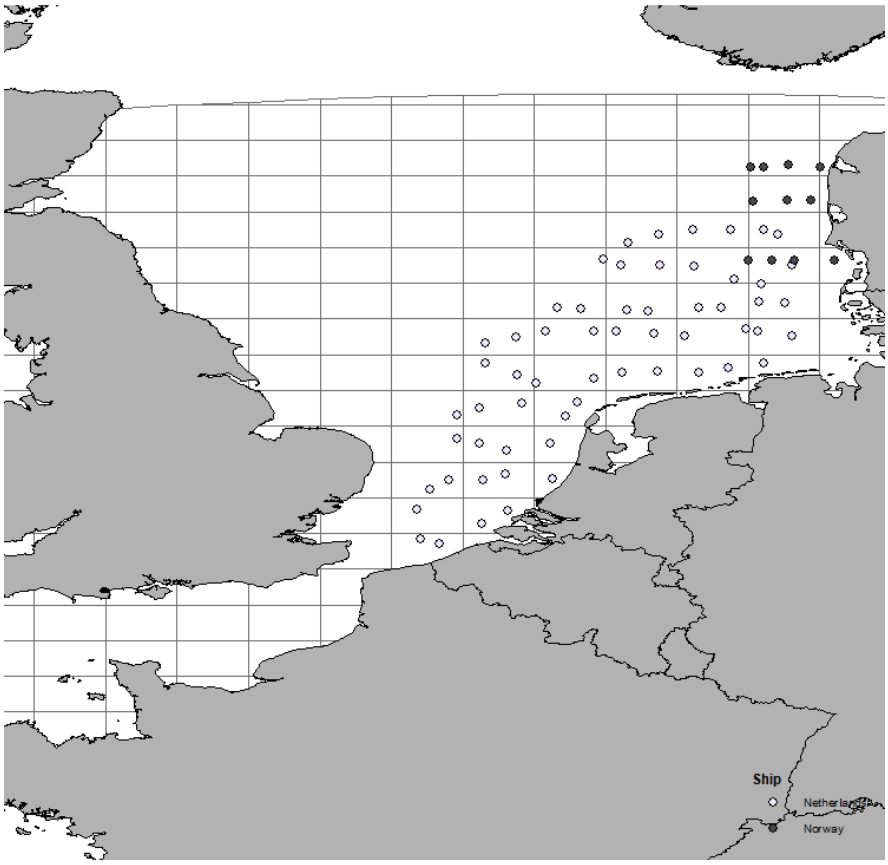

Figure 1.2.1. Sampled stations by country during the 2021 DRS (○ Netherlands; ● Norway).

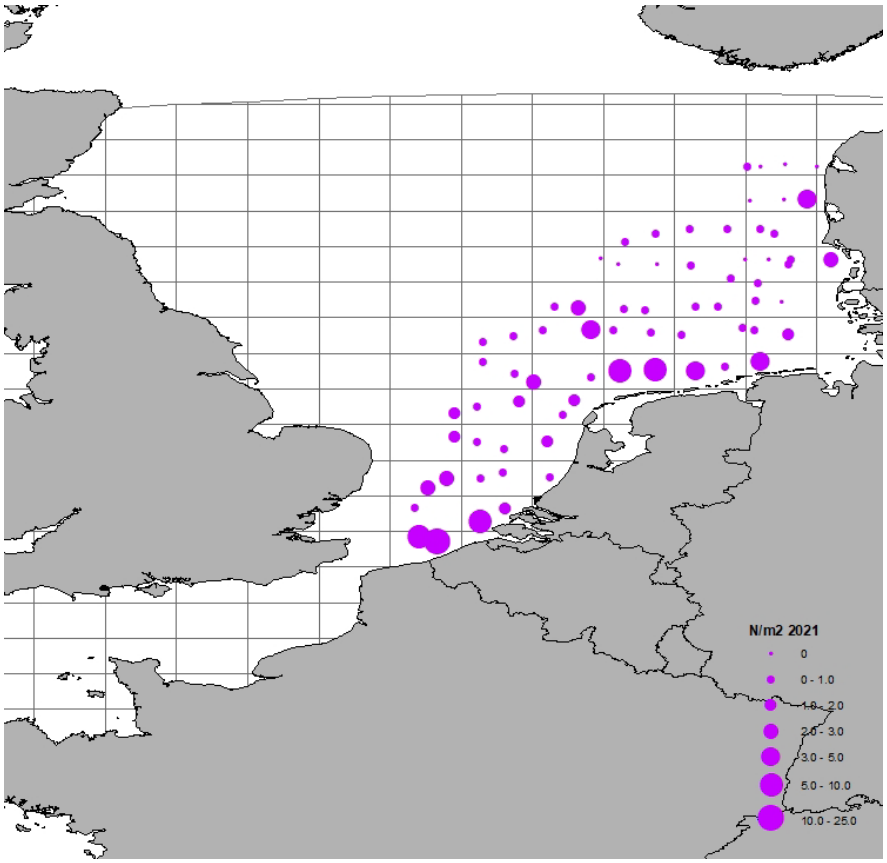

Figure 1.2.2. Herring larvae distribution by haul from the 2021 DRS.

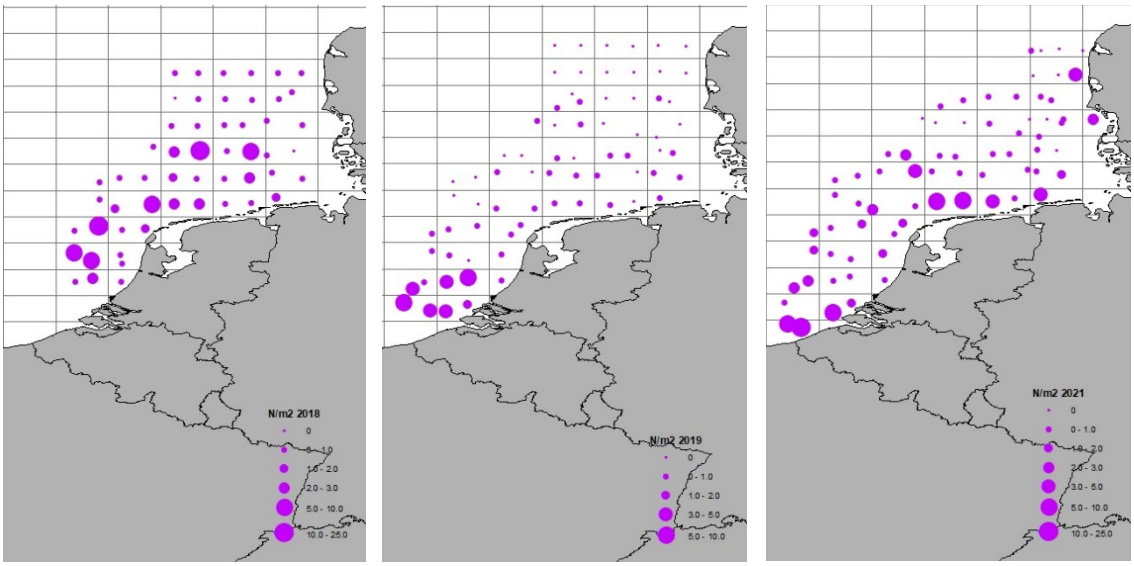

Figure 1.2.3. Herring larvae distribution for the time series, 2018-2021. (Note: No survey was carried out in 2020.)

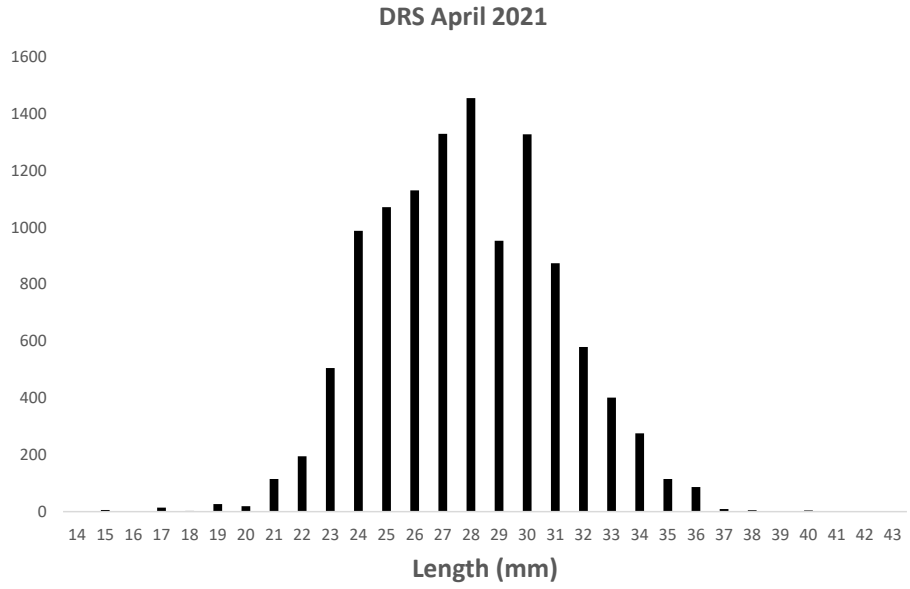

Figure 1.2.4. Herring larvae length distribution from the 2021 DRS.

1.2.2 Comparative sampling

Because sampling is done during day and night a blue midwater ring trawl was used. It was expected that a blue net would be less visible during day time compared to a black net, and this would reduce the chance of larvae trying to escape the net. It was however recommended to carry out comparative sampling with both nets and to check for differences in catchability during day and night.

In 2021 before the survey, the Netherlands carried out 3 days of comparative sampling. At one station sampling was carried out for 24 hours and at a second station for 18 hours (Fig. 1.2.5). RV Tridens has a portside and starboard side winch for the midwater ring trawl. At the start a haul was carried out with the blue ring trawl on portside. When the haul was finished, the vessel steamed back to the starting position. A second haul was carried out with the black ring trawl on starboard side, the starting position and direction of hauling was exactly the same as for the first haul. Again, the vessel steamed back to the starting position, and a haul was carried out with the blue ring trawl from the same starting point and sampling in the same direction. This was continued for 24 and 18 hours at the two stations. After 12 hours the blue and black net were swapped on the winches, in order to investigate any effect of the vessel's rudder on the sampling. At the first station 36 hauls (18 blue and 18 black), and at the second station 30 hauls were carried out. Like during the survey the samples were large, containing many jellyfish and sandeel and clupeid larvae. Because of this samples are still being worked up. Preliminary results seem to suggest there was no difference in herring larvae numbers between the nets or between day and night. Also, no differences were seen in the number of jellyfishes caught, but there seemed to be higher numbers of sandeel larvae in day time compared to night time.

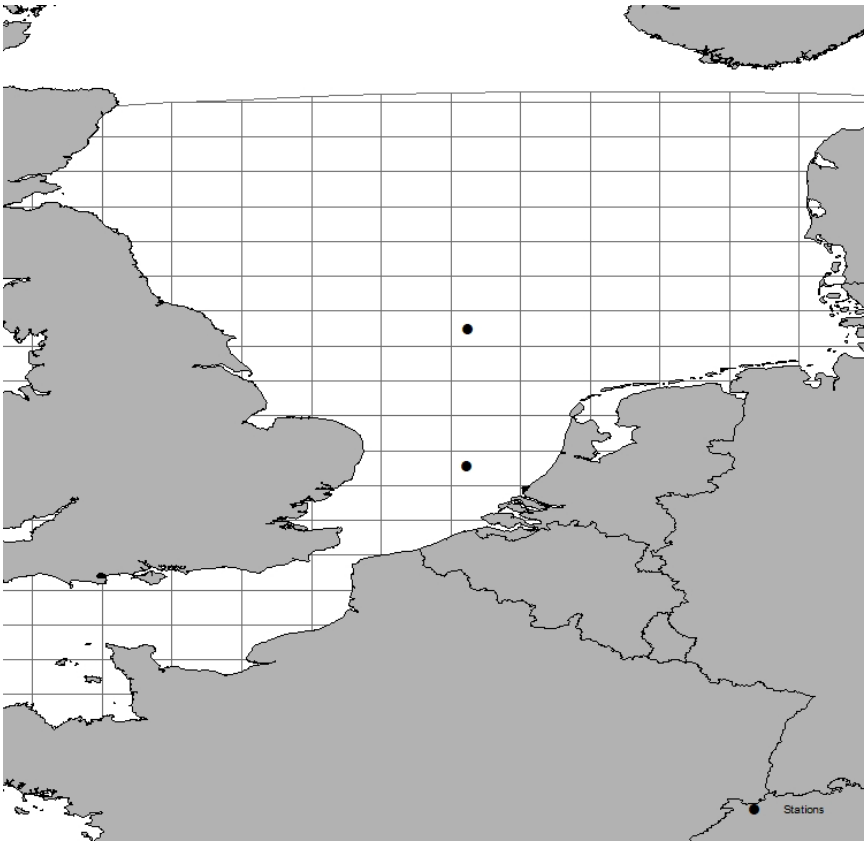

Fig. 1.2.5. Position of stations for comparative sampling with the blue and black midwater ring trawl. The northern station was sampled for 24 hours, the southern station 18 hours.

1.2.3 Planning for the 2022 survey

The Netherlands will carry out a Downs Recruitment survey from 25 - 29 April. Norway will be requested to again participate in the DRS sampling. At the moment participation of other nations is unsure.

Prior to the DRS, the Netherlands plan to carry out more comparative fishing hauls, investigating the effect of day versus night sampling and the use of a blue net on the catchability of herring larvae.

1.3 The MIK sampling during the International Bottom Trawl Survey (IBTS-Q1)

MIK Results of the 2021 survey

Besides providing the time series of 1-ringer herring abundance indices in the North Sea from GOV catches carried out during day-time, the International Bottom Trawl Survey (IBTS) also provides abundance estimates for large herring larvae (0-ringers) of the autumn spawning stock components. The estimates come from night time catches with a 2 m midwater ring-net trawl (MIK, ICES 2017). The total abundance of 0-ringers in the survey area is used as a recruitment index for the North Sea herring stock.

This year, 683 depth-integrated hauls (Table 1.3.1) were completed with the MIK-net, which is 117 MIK hauls more than in 2020. For the index, all hauls north of 51° N were used, in total 663 hauls, 111 more than in 2020. Due to severe weather during the second week of February, some participants could not take their stations, but these gaps could be successfully filled by other participants. Coverage of the survey area was good, mostly achieving the desired 4 hauls per ICES rectangle.

Table 1.3.1: Summary table of the MIK stations sampled during the North Sea IBTS Q1 in 2019

Country	Tows planned	Valid	% stations fished
DE	134	144	107
DK	92	92	100
FR	106	107	100
NL	114	90	79
NO	90	90	100
SW	55	55	100
UK-SCO	116	105	91
sum	706	683	97

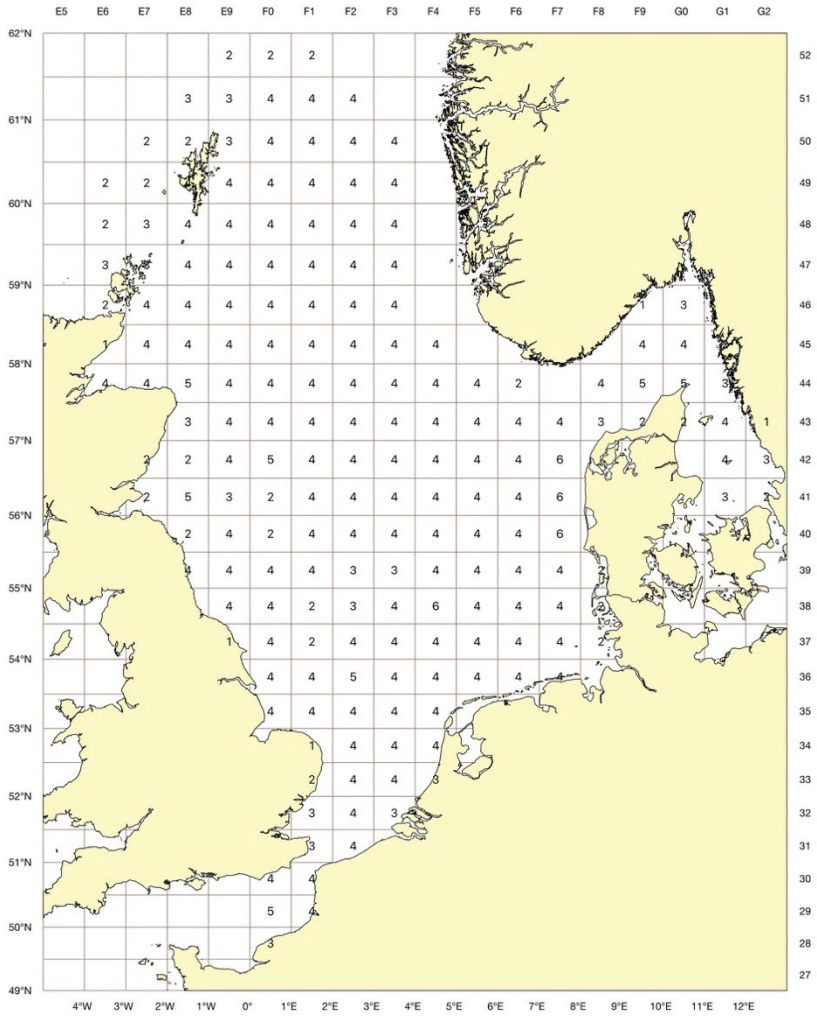

Figure 1.3.1: MIK sampling during IBTS Q1 2021 – numbers of MIK samples per each ICES rectangle.

Herring larvae distribution and abundance

Larvae measured between 7 and 41 mm standard length (SL). Again, and as in most years, the smallest larvae < 12 mm were the most numerous (Figure 1.3.3). Larger larvae >18 mm SL were rarer but were caught in higher densities than last year (Figure 1.3.4). The smallest larvae were chiefly caught in 7.d and in the Southern Bight. The large larvae appeared in moderate to high quantities in both, the central western and southern parts of the North Sea. In the south-eastern and eastern part of the North Sea, the potential nurseries, abundance of large herring larvae was lower than last year.

The newly proposed calculation routine was applied to the MIK herring larvae data time series from 1992 onwards, where because of data quality issues all French data before 2008 are excluded. The 2021 index is 95.2.

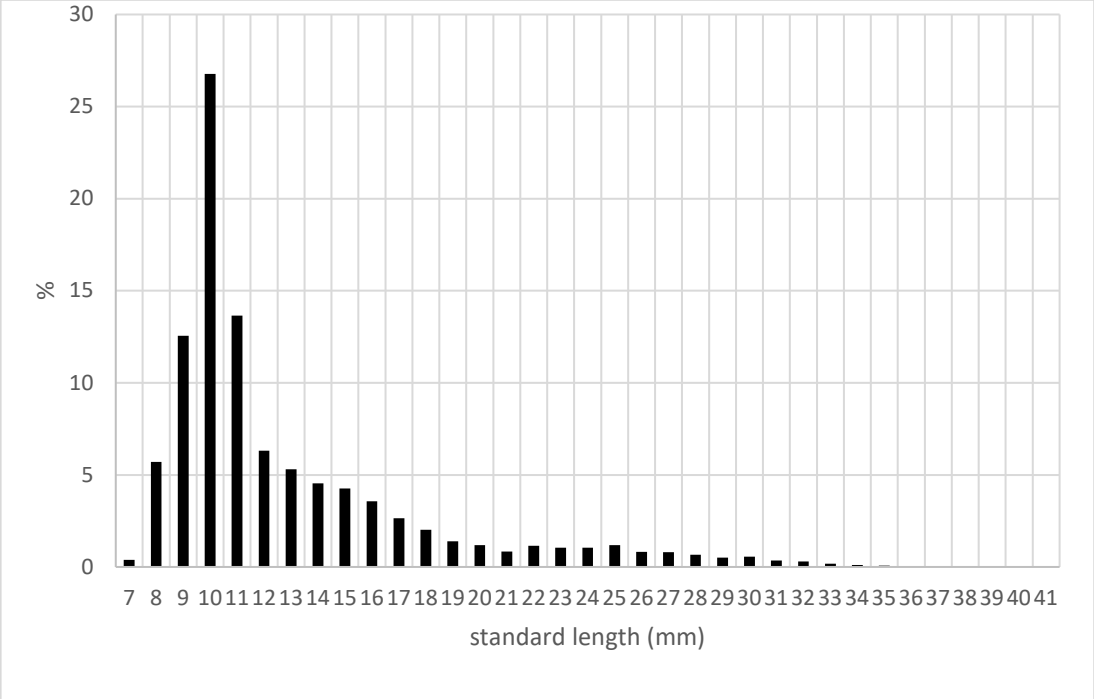

Figure 1.3.3: North Sea herring. Length distribution of all herring larvae caught during the 2021 Q1 IBTS.

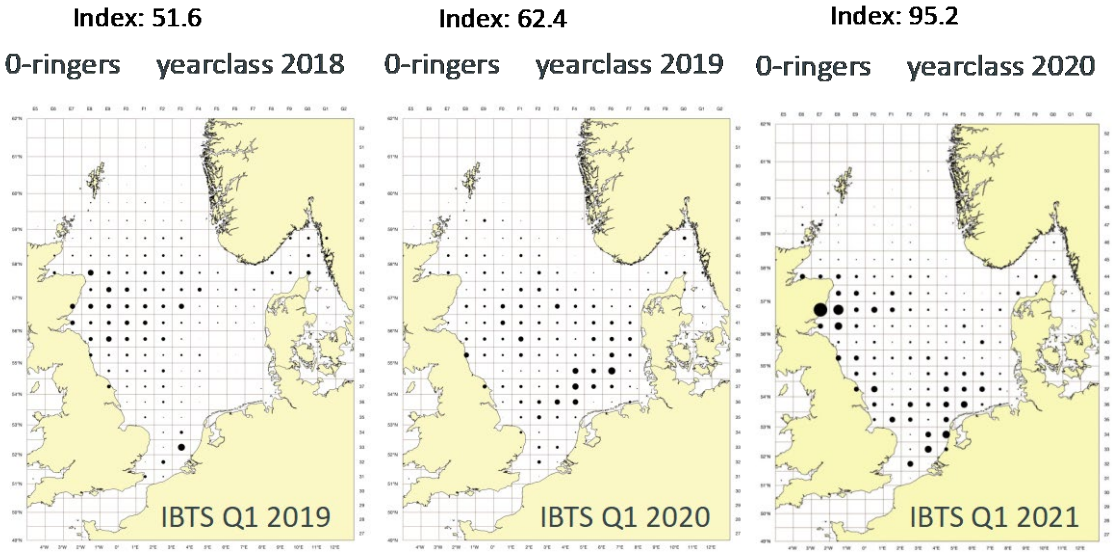

Figure 1.3.4: North Sea herring. Distribution of 0-ringer herring, year classes 2018 – 2020. Density estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in January/February 2019 - 2021. Areas of filled circles illustrate densities in no m^{-2}, the area of the largest circle represents a density of 3.83 m^{-2}. All circles are scaled to the same order of magnitude of the square root transformed densities.

Sardine larvae

As in most recent years, many sardine larvae were found in the samples. With an abundance of 7.9 * 109, sardine larvae made up 8.3 % of herring larvae abundance in the entire North Sea, Channel and Kattegat/Skagerrak. Most sardine larvae occurred in the southern and south-eastern North Sea, and in the Skagerrak (Figure 1.3.5). Sardine larvae were only recorded in small amounts in the Kattegat and west of Scotland area, which is in line with the observations last year.

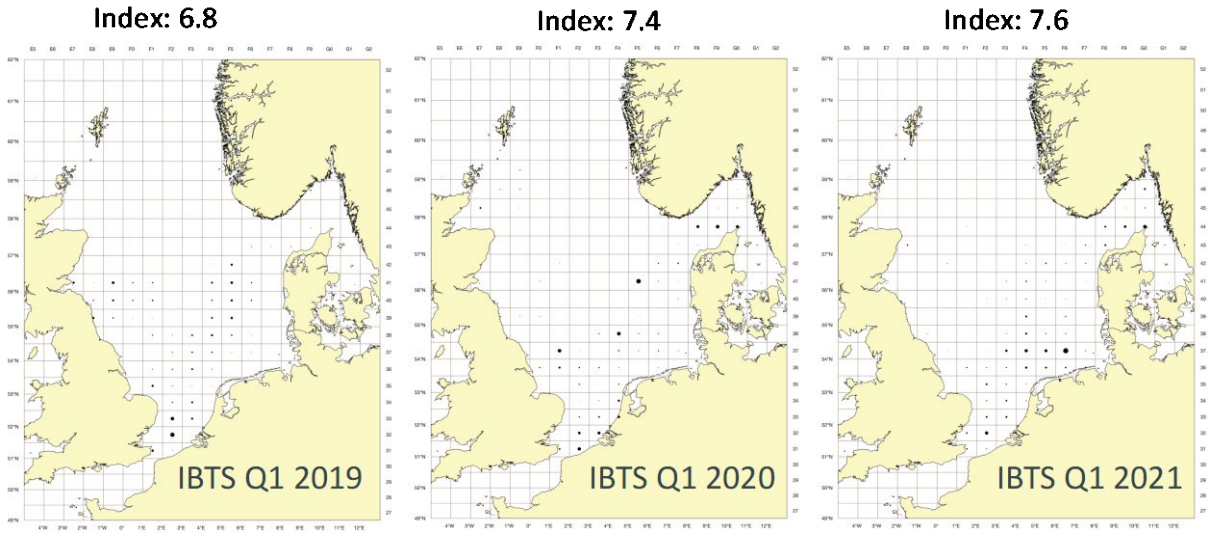

Figure 1.3.5: Distribution of sardine larvae by rectangle from MIK sampling during the Q1 IBTS 2019-2021. Areas of filled circles illustrate densities in no m^{-2}, the area of the largest circle represents a density of 0.30 m^{-2}. All circles are scaled to the same order of magnitude of the square root transformed densities.

Coordination of the 2022 MIK sampling during Q1 IBTS

MIK sampling will be carried out during the night time of the 2022 first quarter IBTS (IBTS Q1). The IBTS Q1 survey coordinator will circulate the survey plan by mid December 2021. MIK participants are now requested to submit their data directly to the ICES fish egg and larvae database in due time (i.e. 7 - 10 days) before the HAWG meeting.

The MIKeyM net sampling

Since 2012, eggs are collected along with the MIK sampling using the MIKeyM net (MM, ICES, 2018b). In 2021, MM samples were obtained by six of the countries participating in the IBTS 1Q. MM samples were taken with every MIK samples when possible. The status of sample analyses varied between institutes, ranging from fish eggs identified where possible, staged and measured to still needs to be sorted.

Planning for the 2022 survey

As in previous years, MM net sampling is planned to be carried out along-side MIK sampling during the first quarter IBTS in the North Sea. For 2022, all institutes are asked to carry out at least two MIKeyM net hauls (1 with every MIK haul) in each ICES statistical rectangle. However, there is no requirement for these samples to be worked up this year. The intention is to retain a reservoir of samples that can be used if interesting questions arise concerning egg and larvae distributions in the North Sea and Skagerrak in 2022 or there is a need for an uninterrupted time

series of egg or larvae data. These samples should be stored at the respective institutes. Those institutes with sufficient resources will work up their samples and inform the rest of the group as to what they have done. The intention, as in previous years, is that every other haul per rectangle should be worked up according to the MM manual. The remaining plankton can then be discarded. All samples that are not sorted for fish eggs and larvae shall be stored at the respective institutes. In addition, the WG will consider a suitable time frame for retaining these samples for future analyses.
Sweden will be requested to undertake MIKeyM sampling to provide coverage of the Skagerrak area.

1.4 The Western Baltic Rügen Herring Larvae Survey (RHLS)

The RHLS

The waters of Greifswald Bay (ICES area 24) are considered a major spawning area of Western Baltic spring spawning (WBSS) herring. The German Thünen Institute of Baltic Sea Fisheries (TI-OF), Rostock, and its predecessor monitors the density of herring larvae as a vector of recruitment success since 1977 within the framework of the Rügen Herring Larvae Survey (RHLS). It delivers a unique high-resolution dataset on the herring larvae ecology in the Western Baltic, both temporally and spatially. Onboard the research vessel CLUPEA, a sampling grid including 35 stations is sampled weekly using ichthyoplankton gear (Bongo-net, mesh size 335 μm) during the main reproduction period from March to June. The weekly assessment of the entire sampling area is conducted within two days (detailed description of the survey design in Oeberst *et al*. 2009, Polte 2013). The collected data provide an important baseline for detailed investigations of spawning and recruitment ecology of WBSS herring spawning components. As a fishery-independent indicator of stock development, the recruitment index is incorporated into the assessment of the western Baltic spring spawners at the ICES Herring Assessment Working Group (HAWG).

The rationale for the *N20* recruitment index is based on strong correlations between the amounts of larvae reaching a length of 20 mm (TL) in Greifswald Bay and abundance data of juveniles (1-wr and 2-wr fish, wr: winter ring in otoliths) as determined by the German autumn hydro-acoustic survey (GERAS) in the Arkona and Belt Seas.

This correlation supports the underlying hypotheses that i) major variability of natural mortality occurs at early life stages before larvae reach a total length of 20 mm and ii) larval herring production in Greifswald Bay is an adequate proxy for annual recruitment strength of the WBSS herring stock.

The *N20* recruitment index is calculated every year based on data obtained from the RHLS. This is done by estimating weekly growth of larvae for seasonal temperature change and taking the sum of larvae reaching 20 mm by every survey week until the end of the investigation period. On the spatial scale, the 35 sampling stations are assigned to 5 strata and mean values of stations for each stratum are extrapolated to the strata area (Oeberst *et al.* 2009).

Calculation procedures have been externally reviewed in 2006 and 2011. Consequently, the survey design was refined in 2007. Accordingly, a recalculated index for the time series from 1992 onwards is used by HAWG since 2008 as 0-group recruitment index for the assessment of Western Baltic Spring Spawning herring.

2020 N20 index

The regular Rügen herring larvae survey started on March 2nd and was conducted until June 26th, over a 17-week period.

With an estimated product of 239 million larvae, the 2020 *N20* recruitment index is a historic low in the entire time series. It is just half of the so far all-time low observed in 2016 (Table 1.4.1, Figure 1.4.1). This underlines the decreasing trend of larval production observed in the system during the past two decades.

2020 additional survey observations

Additionally, on two dates in February (start Feb 26th) and November (start Nov 11th), control surveys should test the occurrence of winter and autumn larvae, respectively. But the February survey had to cancelled due to Covid-19 restrictions. However, using a 1550 µm CalCofi net beside the standard Bongo net in the first weeks of the regular survey (Polte *et al.* 2017), the presence of foraging, older larvae in the system was investigated. Otolith microstructure analysis on post-flexion larvae caught during March 2020 revealed very limited numbers of larvae that hatched during the previous autumn and winter period (Finke, personal communication 2021). In November 2020, only few larvae were found in Greifswald Bay. However, scientific gill net sampling for spawning fish during November 2020 (Nov 16th) resulted in > 50% of adult herring at maturity stage ≥ 5 (8-point scale). Accordingly, a certain amount of autumn/winter spawning evidently takes place, but currently without major contributions to larvae abundance in winter and early spring.

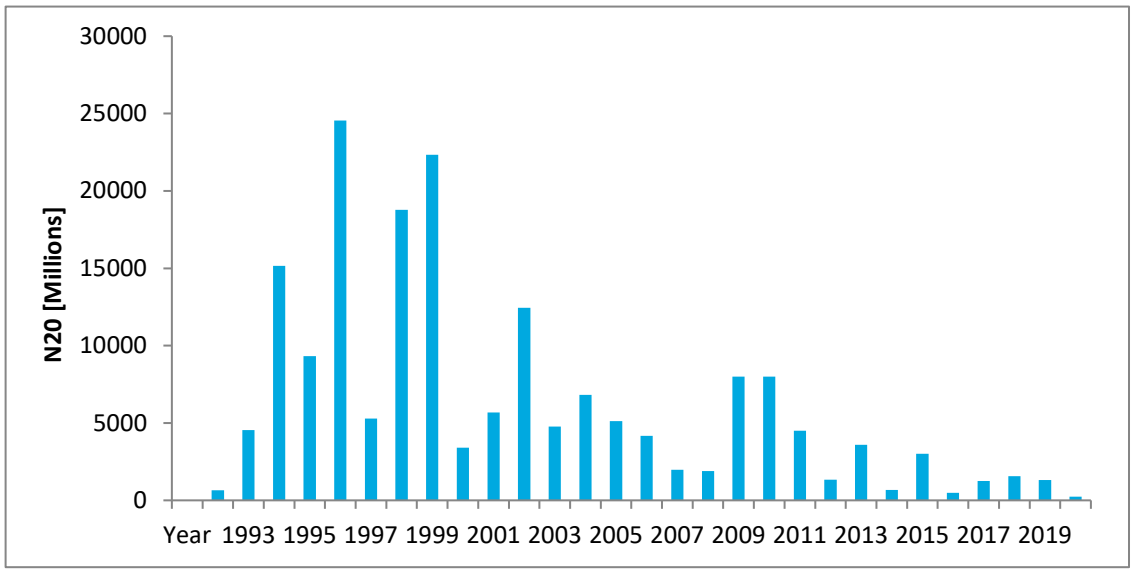

Figure 1.4.1: Validated RHLS time series with N20 index data presented as cumulative value of weekly mean abundance of 20 mm larvae in millions.

Table 1.4.1: N20 larval herring index for spring spawning herring of the Western Baltic Sea (WBSS).

Year	N20		Year	N20
1992	1060		2007	1829
1993	3044		2008	1622
1994	12515		2009	6464
1995	7930		2010	7037
1996	21012		2011	4444
1997	4872		2012	1140
1998	16743		2013	3021
1999	20364		2014	539
2000	3026		2015	2478
2001	4845		2016	442
2002	11324		2017	1247
2003	5507		2018	1563
2004	5640		2019	1317
2005	3887		2020	239
2006	3774			

Revision of the relation between N20 and GERAS 1-wr herring after years with low larvae production

After multiple years with a record low *N20* (2014, 2016), the relation with the 1-group juveniles as monitored by the German hydroacoustic survey (GERAS) was re-evaluated to see if recent years with extremely low larvae production are reflected in the abundance of 1-wr juveniles on the scale of the western Baltic Sea. The results reveal an unchanged and strong correlation between *N20* and GERAS 1-wr juveniles, with the record low years (including 2020) not providing any outliers. In fact, the extremely low *N20* years resulted in correspondingly low GERAS indices for the 1-wr juveniles (Fig.1.4.2).

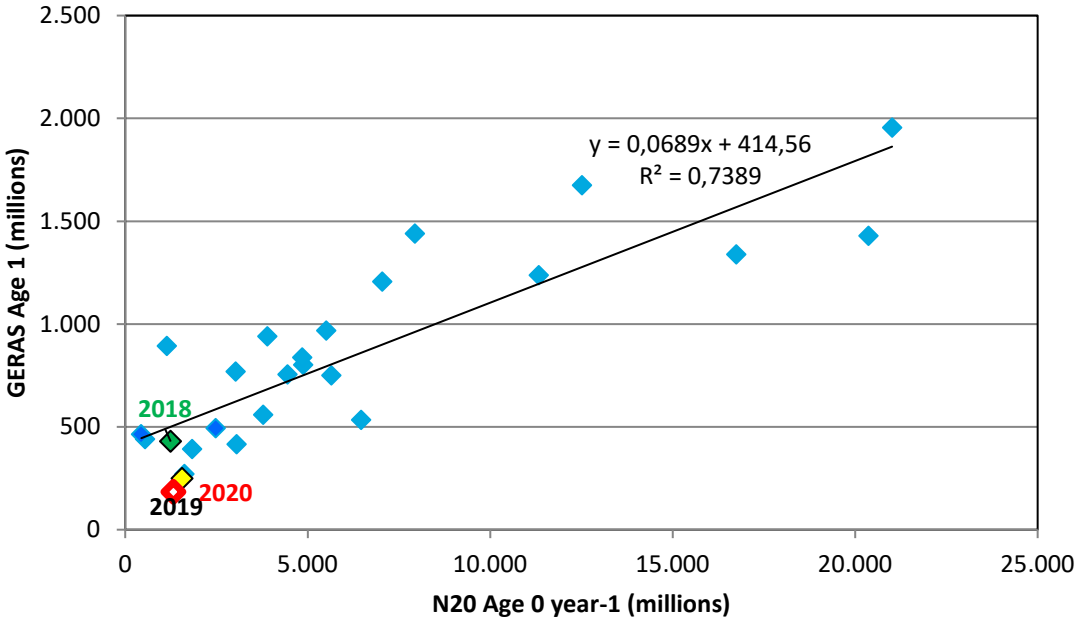

Figure 1.4.2: Correlation of N20 larvae index (1993-2019) with the 1-wr herring from GERAS (1994-2020). Note: The one-year lag phase between indices. E.g. the exceptionally low N20 year 2020 is represented by the GERAS 1-wr index 2021.

1.5 The Northern Irish Herring Larvae Survey (NINEL)

Herring larvae surveys of the northern Irish Sea (ICES area 7aN) have been carried out by the Agri-Food and Biosciences Institute (AFBI), formerly the Department of Agriculture and Rural Development for Northern Ireland (DARD), in November each year since 1993. The surveys are conducted on-board the RV "Corystes" since 2005 and prior to that on the smaller RV "Lough Foyle". Sampling is carried out on a systematic grid of stations covering the spawning grounds and surrounding regions throughout the north Irish Sea (Figure 1.5.1). Larvae are sampled using a Gulf7 high-speed plankton sampler with 280 µm net and on-board Valeport Midas+ CTD. Mean catch-rates (nos.m^{-2}) are calculated over stations and strata to give area specific indices of abundance. Larval production rates and birth-date distributions are computed based on the mean density of larvae by length class. A growth rate of 0.35 mm per day and instantaneous mortality of 0.14 per day are assumed based on estimates made in 1993–1997. The index has been historically used as an indicator of spawning-stock biomass (SSB) in the assessment of Irish Sea herring by the ICES Herring Assessment Working Group (HAWG). The assessment of this stock was benchmarked in 2012 and issues concerning the survey raised. Specifically the survey index exhibited a diverging trend in SSB from that observed in Irish Sea herring acoustic surveys, not indicating the increasing SSB confirmed from all the repeated acoustic surveys (ICES, 2012).

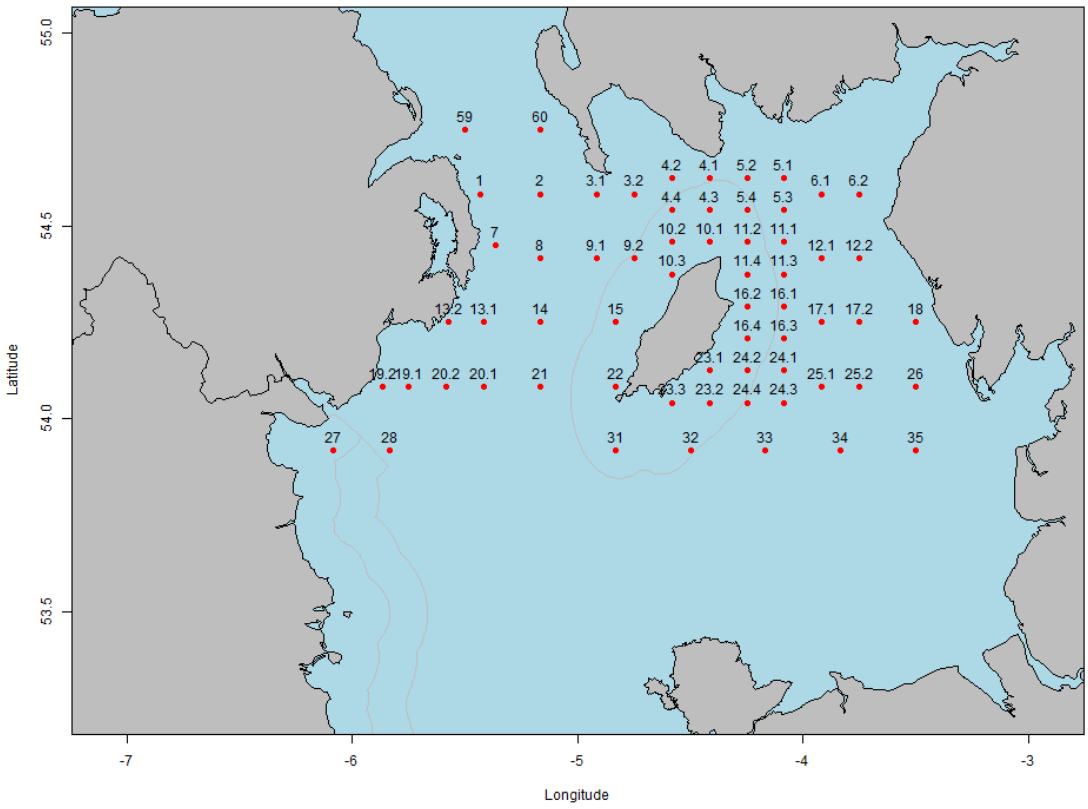

Figure 1.5.1: Station positions for north Irish Sea herring larvae survey (NINEL).

Survey Results in 2020

The NINEL survey was completed during 9-15th November with a total of 62 Gulf7 stations sampled. 2999 larvae were sorted from samples and measured prior to preservation. Depth profiles of salinity and temperature were collected at all stations, and remaining plankton samples preserved.

As in previous years the vast majority of larvae were captured in the eastern Irish Sea, in the vicinity of the Douglas bank spawning ground, and to the north of the Isle of Man (Figure 1.5.2). Larvae were also detected in the vicinity of the Mourne spawning ground, along the Irish coast. Larval lengths ranged in size from 5.8 to 22.2 mm, with a bimodal length distribution in some strata (Figure 1.5.3).

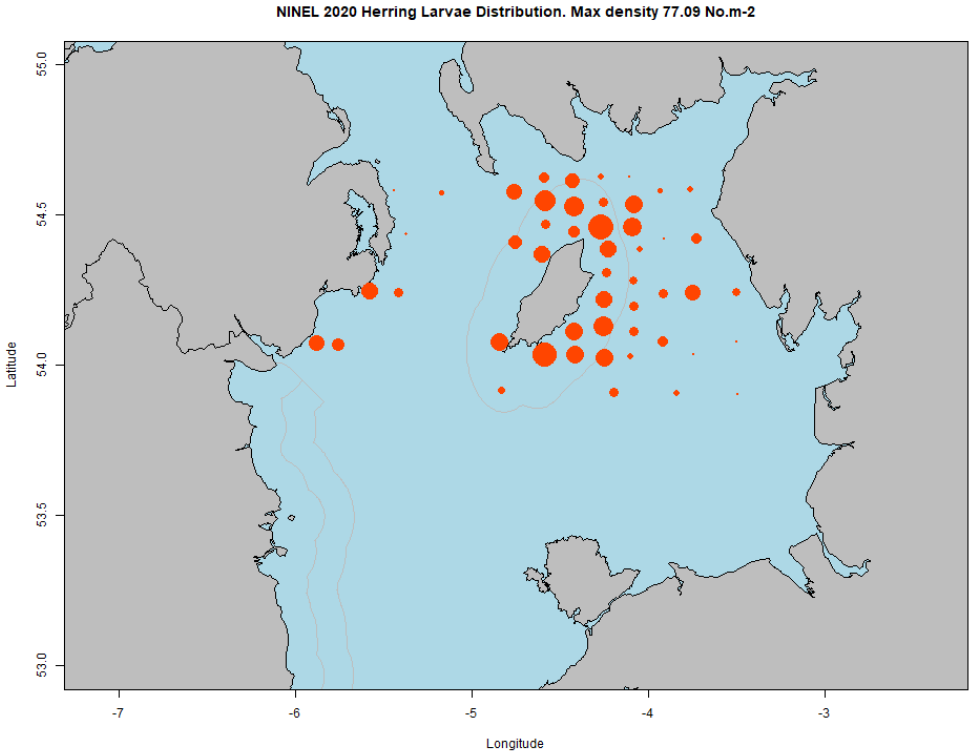

Figure 1.5.2: Distribution of herring larvae captured during 2020 north Irish Sea herring larvae survey (NINEL) using Gulf7. Maximum density 77.09 no.m^{-2}.

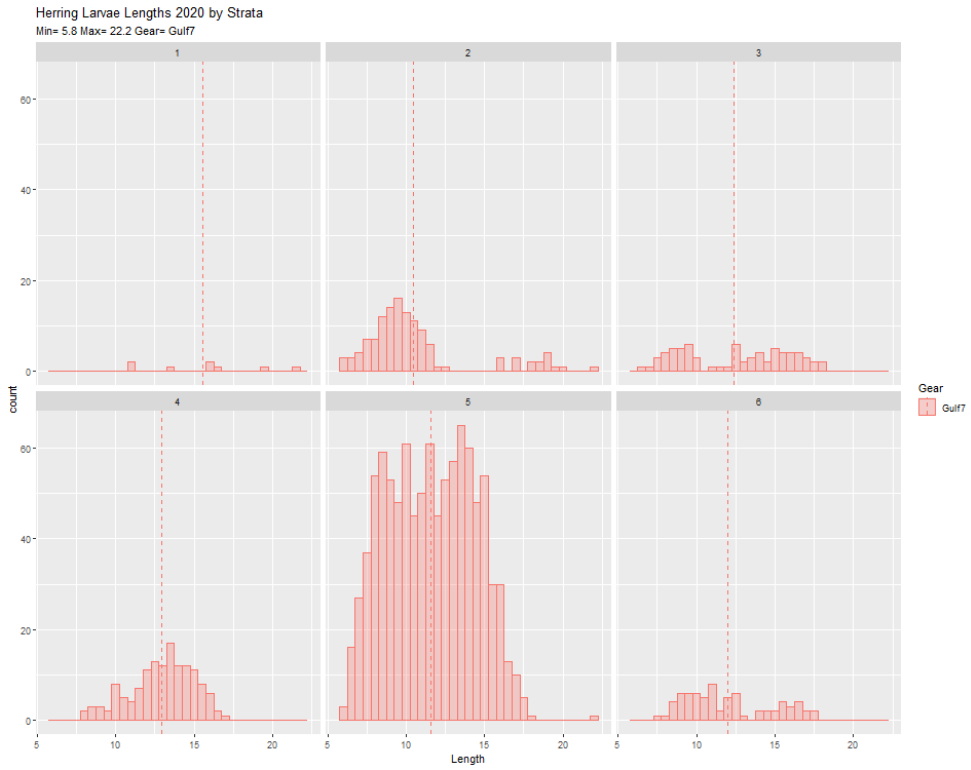

Figure 1.5.3: Length frequency of larvae removed from Gulf7 samples, total per strata.

1.6 The UK (Northern Irish) MIK Survey (NIMIK)

The survey previously used a modified Methot-Isaacs-Kidd frame trawl to target pelagic juvenile gadoids (whiting, cod, haddock) in the Irish Sea between 1993 - 2018. The modified Methot-Isaacs-Kidd frame was replaced with a 2m midwater ring net in 2019 (ICES 2017). The survey is a stratified design and takes place in May and June during the period prior to settlement of gadoid juveniles. Indices are calculated as the arithmetic mean of the numbers per unit sea area (no.m^{-2}). The MIK net is deployed during the hours of darkness (max. 30 mins$\pm$ hr sunset). During daylight hours a Gulf7 high speed plankton sampler with on-board Valeport Midas+ CTD is deployed. Density and distribution data on larval fish, zooplankton and water structure properties (SST, salinity, chlorophyll *a*) are recorded. While the main objective of the survey is to provide recruitment information on gadoids, the survey provides the opportunity and tools to collect valuable information on the wider ecosystem. For example, data collected on the survey has provided the basis for the development of a 20+ year time-series of gelatinous zooplankton abundance in the Irish Sea. Since 2018 a standard WP2 frame with side floats for neuston sampling (333 μm mesh size) has been deployed for the study of marine micro plastics at a number of the Gulf7 stations.

The NIMIK survey resumed in 2021 after missing 2020 due to Covid-19 restrictions. A total of 90 MIK, 118 Gulf7 and 55 WP2 stations were successfully completed. These provided comprehensive coverage of the north Irish Sea (Figures 1.6.1-1.6.2).

Target species juvenile gadoids cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*) were located predominantly in the western Irish Sea, with a number of whiting also sampled in the north eastern region (Figure 1.6.3). Evidence for higher abundances of juveniles in the north western region of the study area was investigated with a number of additional MIK hauls (1a-1b). These catches suggested that there were high abundances of juvenile gadoids north of the study area, in a region of deeper water. This distribution of juvenile gadoids will be monitored in future years to ensure that the survey continues to capture their main distribution.

As well as the 3 target gadoid species, catches of all fish, crustacea, and gelatinous zooplankton were recorded to species level were possible, while zooplankton samples were preserved for future lab analysis. WP2 samples were preserved in alcohol for analysis of marine micro plastics.

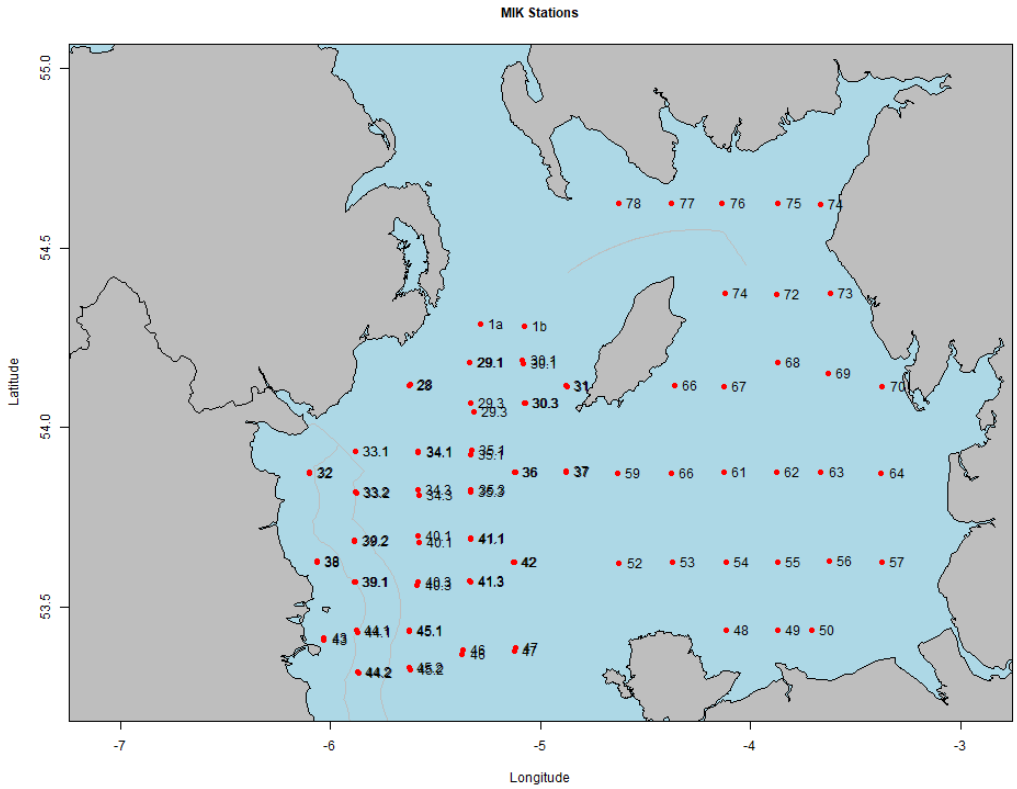

Figure 1.6.1. MIK Station positions during 2021 NIMIK survey.

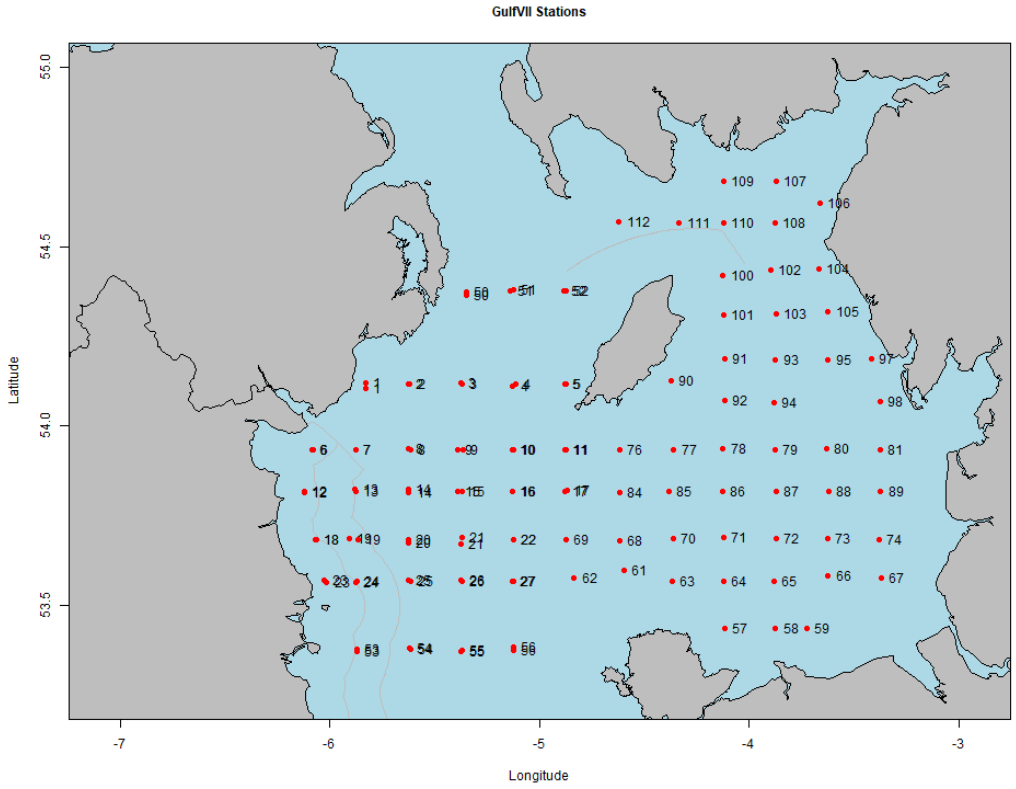

Figure 1.6.2. Gulf7 station positions during 2021 NIMIK survey.

Figure 1.6.3. Spatial abundance (no. m-2) of juvenile gadoids cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and whiting *(Merlangius merlangus*).

1.7 The Baltic Ichthyoplankton Surveys (BIS)

Background information about ichthyoplankton surveys in the Baltic

Ichthyoplankton surveys in the Baltic have a long tradition, dating back to egg studies by Hensen & Apstein as early as the late 1800s and early 1900s. Starting in 1904, Ehrenbaum & Strodtmann have conducted more or less regular egg and larvae surveys for several years, followed by the surveys of Kändler, Mielck & Künne in the 1920s and 1930s as well as a series of surveys by Grauman, Bagge & Müller in the 1970s and early 1980s (e.g. Bagge *et al.* 1994). Already in these early days of ichthyoplankton surveys in the Baltic, there has been particular focus on the Bornholm Basin, located between Sweden, Poland and east of the Danish island Bornholm. The importance of this area for Baltic fish stocks, in particular cod and sprat, is related to the unique hydrographic situation in the Baltic and the resulting limitations for the survival of fish eggs and larvae.

Reproductive success of the Eastern Baltic cod stock is closely linked to these unique hydrographic conditions (review by Köster *et al.* 2017), which are restricting the main spawning grounds to deeper areas, i.e. the Bornholm Basin (BB) just east of Bornholm as well as the Gdansk Deep (GD) and the Gotland Basin (GB) further east. However, due to oxygen deficiencies in the GD and GB in recent decades, successful spawning of Baltic cod is largely restricted to the Bornholm Basin in recent years.

Presently, Eastern Baltic cod is spawning from approx. March to November, which is the longest reported spawning period of any cod stock. This extremely protracted spawning season can be interpreted as a risk-spreading strategy to cope with the highly variable environmental conditions in the Baltic and the related inter-annual as well as seasonal differences in the survival chances of eggs and larvae.

General information about the present time series of Baltic Ichthyoplankton Surveys (BIS)

The present time series of Baltic Ichthyoplankton Surveys (BIS) was initiated in 1986 by the "Institut für Meereskunde" (IfM, Institute of Marine Sciences, now GEOMAR) in Kiel, Germany and has been running ever since. The extremely protracted spawning season of Eastern Baltic cod makes it necessary to conduct several surveys throughout the year in order to obtain a reliable picture of the seasonal egg production and larval abundances. As this requires considerable vessel time, personnel and resources, several institutes joined forces to cover the spawning season with several surveys per year.

Presently, the following partners are involved in the BIS:

1. DTU Aqua – National Institute of Aquatic Resources, Kgs. Lyngby, Denmark
2. NMFRI – National Marine Fisheries Research Institute, Gdynia, Poland
3. GEOMAR – Helmholtz Centre for Ocean Research Kiel, Germany
4. IMF – Institute of Marine Ecosystem and Fishery Science, Hamburg University, Germany
5. TI-OSF – Thünen Institute of Baltic Sea Fisheries, Rostock, Germany
6. BIOR – Institute of Food safety, Animal health and Environment, Riga, Latvia

The time-series of individual BIS surveys by month is shown in Fig. 1.7.1. In the earlier part of the time-series the seasonal coverage is somewhat variable, as the surveys relied largely on funding via running research projects as well as partly on national funding sources. Nevertheless, it

was possible to maintain a continuous survey time-series since 1986. In the most recent period since 2008 the seasonal coverage has been very good, with all years covered by 7 to 9 surveys, except for 2020 when only 6 surveys could be conducted due to the Covid-19 pandemic. During this recent period the surveys were usually conducted in March, April, May, June, July and/or August and November, in some years even with 2 surveys in August (early and late) as well as some years with additional surveys in September.

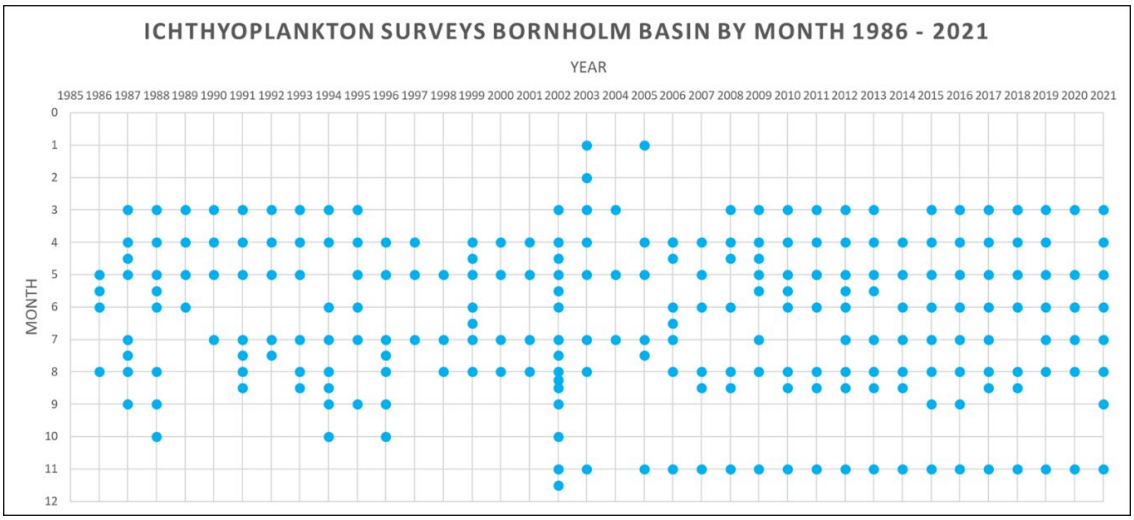

Fig. 1.7.1. Time series of individual BIS surveys by years and months.

As mentioned above, oxygen conditions in the eastern spawning grounds (GD and GB) have deteriorated over the past decades and spawning is therefore largely restricted to the Bornholm Basin. Thus, the present BIS are focusing on the Bornholm Basin. However, some additional information about egg and larval abundances in the GD and GB is also collected every year, in order to detect potential future changes in the utilization of these spawning grounds.

In the beginning of the survey series from 1986 - 1989, only the central BB was covered by a station grid consisting of 20 stations, which was extended to 30 stations from 1990 - 1993. Since 1994, the standard station grid is consisting of 45 stations (Fig. 1.7.2). On some cruises additional stations are covered, e.g. in the Slupsk Furrow or at the basin edges.

On each station ichthyoplankton is sampled with a Bongo net (Ø 60 cm, nets length 320 cm, mesh sizes 335 and 500 µm). The gear is further equipped with a V-fin depressor, a depth sensor and flowmeters. On most surveys, an additional Baby-Bongo net (Ø 20 cm, net length 200 cm, mesh size 150 µm) is attached above the Bongo net in order to collect additional samples of smaller zooplankton size fractions. The gear is deployed at 3 knots ship speed in a double-oblique haul from the surface to 3 m above the sea floor, measured from the lower edge of the Bongo ring. Samples are preserved in 4% formaldehyde-sea water solution for later analysis on land. In addition, profiles of the ambient hydrographic conditions are obtained by CTD casts. Furthermore, adult cod are sampled on selected cruises by trawl fishery to obtain information on fecundity, sex ratios and maturity ogives which are needed for egg production methods and stock biomass estimates (see also next section “Utilization of BIS results in research and stock assessment”).

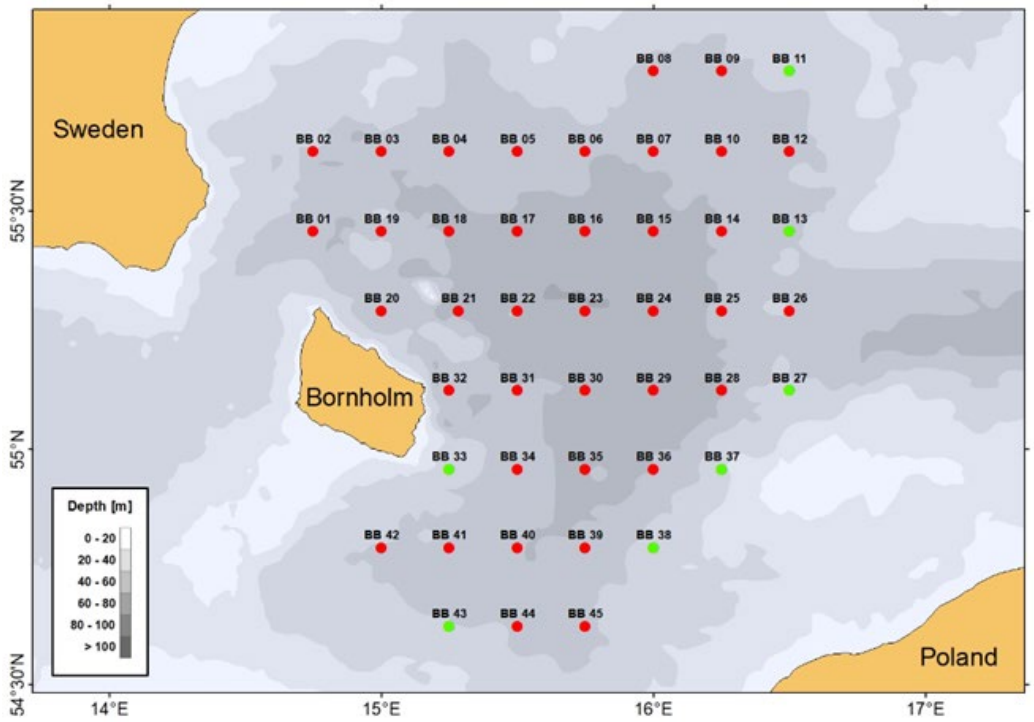

Fig. 1.7.2. The present BIS standard station grid in the Bornholm Basin, consisting of 45 stations. The seven stations shallower than 60 m (green symbols) are excluded from the calculations of average egg abundances used in the AEPM and DEPM.

Utilization of BIS results in research and stock assessment

The BIS surveys have been used for a multitude of scientific research purposes in various projects, including studies on ichthyoplankton ecology and the recruitment dynamics of Baltic cod and sprat. Besides, SSB estimates based on egg production methods for Baltic cod and sprat have been developed, but despite providing promising results these methods had previously not been implemented into the stock assessment.

However, due to increasing issues with the stock assessment of Eastern Baltic cod in the late 2000s and early 2010s, the ideas of fishery independent stock biomass estimates based on egg production have been revived and were implemented in the assessment of Eastern Baltic cod since the benchmark assessment in 2019. Thus, the BIS is now providing input data for annual (AEPM) and daily (DEPM) egg production methods, which are used to provide a time-series of Eastern Baltic cod stock biomass estimates (1986 - present) to WGBFAS.

Besides, the BIS is providing a recruitment index to WGBFAS, based on average larval abundances during the summer months (June - August, time-series 1987 - present). This recruitment index provides an early indication of year-class strength, while the BITS bottom trawl surveys are not catching the new incoming year-classes representatively until age 2. Both the egg-based stock estimates and the larvae index are used as relative trends in stock dynamics to tune the assessment models.

The Baltic Ichthyoplankton Surveys in 2021

Throughout the 2021 spawning season of Eastern Baltic cod, a total of 8 individual BIS surveys were conducted in March, April, May, June, July, August, September and November (see table 1.7.1 for details). All 45 standard grid stations were conducted on all 8 surveys, amounting to a total of 360 sampled stations in 2021. Furthermore, several additional stations outside the standard grid were sampled on some of the surveys. The sample analyses were still ongoing at the time of WGSINS 2021. Preliminary data indicate that the egg-based stock biomass estimate for 2021 remains on a similarly low level as in the years 2018 - 2020, but that a slightly higher larval index than in 2020 may be expected. The final data will be collated and the time-series of stock biomass estimates and larvae indices will be provided to WGBFAS in spring 2022.

Table 1.7.1. Overview of individual BIS surveys conducted in 2021.

Institute	Ship	Cruise Nr	Year	Month	Standard stations conducted
DTU Aqua	DANA	DANA 02/2021 (BITS 1)	2021	3	45
GEOMAR	ALKOR	AL 553	2021	4	45
GEOMAR	ALKOR	AL 556	2021	5	45
NMFRI & DTU	BALTICA	Baltica June 2021	2021	6	45
IMF Hamburg	ALKOR	AL 560	2021	7	45
NMFRI	BALTICA	Baltica August 2021	2021	8	45
GEOMAR	ALKOR	AL 563	2021	9	45
DTU Aqua	DANA	DANA 10/2021 (BITS 2)	2021	11	45

Planning for the 2022 Baltic Ichthyoplankton Surveys

For the 2022 spawning season of Eastern Baltic cod, a total of 8 individual BIS surveys are planned in March, April May, June, July, August, September and November. On each of these surveys, it is planned to cover the 45 standard grid stations, amounting to a total of 360 planned stations for 2022. See table 1.7.2 for details.

Table 1.7.2. Overview of individual BIS surveys planned for 2022.

Institute	Ship	Cruise Nr	Year	Month	Standard stations planned
DTU Aqua	DANA	DANA 02/2022 (BITS 1)	2022	3	45
GEOMAR	ALKOR	AL 571	2022	4	45
GEOMAR	ALKOR	AL 573	2022	5	45
NMFRI & DTU	BALTICA	Baltica June 2022	2022	6	45
IMF Hamburg	ALKOR	AL 577	2022	7	45
NMFRI	BALTICA	Baltica August 2022	2022	8	45

GEOMAR	ALKOR	AL 580	2022	9	45
DTU Aqua	DANA	DANA 07/2022 (BITS 2)	2022	11	45

1.8 A pilot survey on the feasibility of establishing a sprat recruitment index based on larval sampling during Q3 IBTS surveys

Sprat is a short-lived species, and the sprat stock in the North Sea is dominated by young fish. Thus, the size of the stock is to a large degree driven by the recruiting year class, and catches are mainly composed of 1-year old fish (up to 80%). Sprat is an important forage fish and represents a major food source for many other fish species as well as sea birds and mammals. It is therefore a highly relevant species in multispecies approaches to fisheries management. An analytical assessment of sprat was established some years ago, however the availability & quality of data for the assessment are relatively poor and the assessment of and advice for the North Sea sprat stock needs to be improved. There is presently no information available on young-of-the-year (0-group) sprat for possible use in short-term forecasts or for use in the stock assessment model. However, such information could potentially be very useful, in particular because sprat is a short-lived species that matures early.

The aim of the present study is - by conducting a series of pilot surveys - to evaluate the feasibility of establishing a sprat recruitment index based on larval sampling on the Q3 IBTS surveys and to contribute generally to a better understanding of the biology, ecology and distribution of the North Sea sprat stock. Thus, the basic idea is to follow similar procedures as the MIK herring larvae surveys during the Q1 IBTS. These surveys are targeting relatively large larvae (2 to 3 cm) and the abundance of these has shown to relate to later recruitment to the stock, thus providing a recruitment index for autumn spawning herring in the North Sea.

The specific aims of the sprat larvae pilot surveys are to investigate whether:

- sprat larvae can be caught in appropriate numbers with a MIK net during nighttime on the Q3 IBTS
- main spawning activity of sprat is finished well before the time of the survey
- there are significant differences in catchability during daylight vs. nighttime hours
- the MIK sampling can effectively be incorporated into the standard routines during Q3 IBTS
- the sampling can cover the relevant areas of major sprat larvae occurrence
- sampled larvae can be expected representative for the entire year-class
- sampled larvae are of sizes for which the following mortality is relatively constant and that abundances thus provide a reliable recruitment index

By the time of WGSINS 2021, a total of four pilot surveys had been conducted in July/August 2018, 2019 and 2020 and in August/September 2021, targeting sprat larvae with a MIK net. The surveys were conducted by DTU Aqua, Denmark, in 2018 and 2019 in the framework of the project "BEBRIS - Maintaining a sustainable sprat fishery in the North Sea" and in 2020 and 2021 in the follow-up project "PELA – Pelagic species". Sampling was conducted during nighttime on the Q3 IBTS. Besides, the Thünen Institute of Sea Fisheries in Bremerhaven, Germany contributed to the sampling in 2020 and 2021. In 2018 and 2019, 66 and 61 valid standard hauls (plus several additional hauls for gear tests etc.) were conducted, respectively. In 2020, a total of 128 hauls was conducted (68 by Denmark and 60 by Germany). In 2021, a total of 82 hauls was conducted on a joint Danish-German survey. In addition, Marine Scotland Science also conducted

MIK sampling during their Q3 IBTS in 2021 on 51 stations. Marine Scotland Science is planning to analyze these samples in the end of 2021, and results of relevant stations may be included in the other 2021 data.

The gear in use during the two pilot surveys in 2018 and 2019 was a MIK net with a ring of two-meter diameter. During the first hauls in the 2018 survey, a net with a mesh size of 1.6 mm was used. However, as there were many relatively small larvae in the first samples, the mesh size was changed to 1.0 mm during the remainder of the 2018 survey and the same 1.0 mm mesh size was also used during the 2019 survey. In order to be directly comparable with the additional samples collected by the Thünen Institute, a mesh size of 1.6 mm was used in 2020 and 2021 (which is also the standard mesh size on the Q1 MIK-IBTS herring larvae surveys). In addition, a small MIKeyM net (20 cm Ø, 500 µm mesh size) was attached to the MIK ring on the Danish surveys in 2018 - 2020. This was done to test if there still are eggs and/or very small larvae in the area during the time of the Q3 IBTS surveys, which would indicate that the seasonal spawning activity has not finished yet. The gear was equipped with a depth sensor and was deployed in a double-oblique haul from the surface to 5 meter above the sea-floor (measured from the lower end of the MIK ring). Fishing speed was 3 knots through the water, and the wire was paid out at a speed of 25 meters per minute (= 0.4 ms-1) and retrieved at 15 meters per minute (= 0.25 ms-1). Both the MIK and the MIKeyM were equipped with flowmeters to record the volume of filtered water.

With very few exceptions, clupeid larvae were found on all sampling stations in the four years investigated, and abundances were generally relatively high, with many stations yielding several hundreds of larvae. However, in all years the clupeid larvae not only contained sprat but also sardine larvae in high abundances. Fig. 1.8.1 shows average sprat and sardine distributions per ICES square for the years 2018 - 2020. Even though the sample analyses for the 2021 survey are still ongoing, it can already be concluded that a similar, recurring pattern in the spatial distribution of sprat and sardine larvae could be observed in all 4 years, with sprat larvae mainly occurring in the northern part of the study area while sardine larvae were most abundant in the south. This shows that careful identification procedures to species level are mandatory.

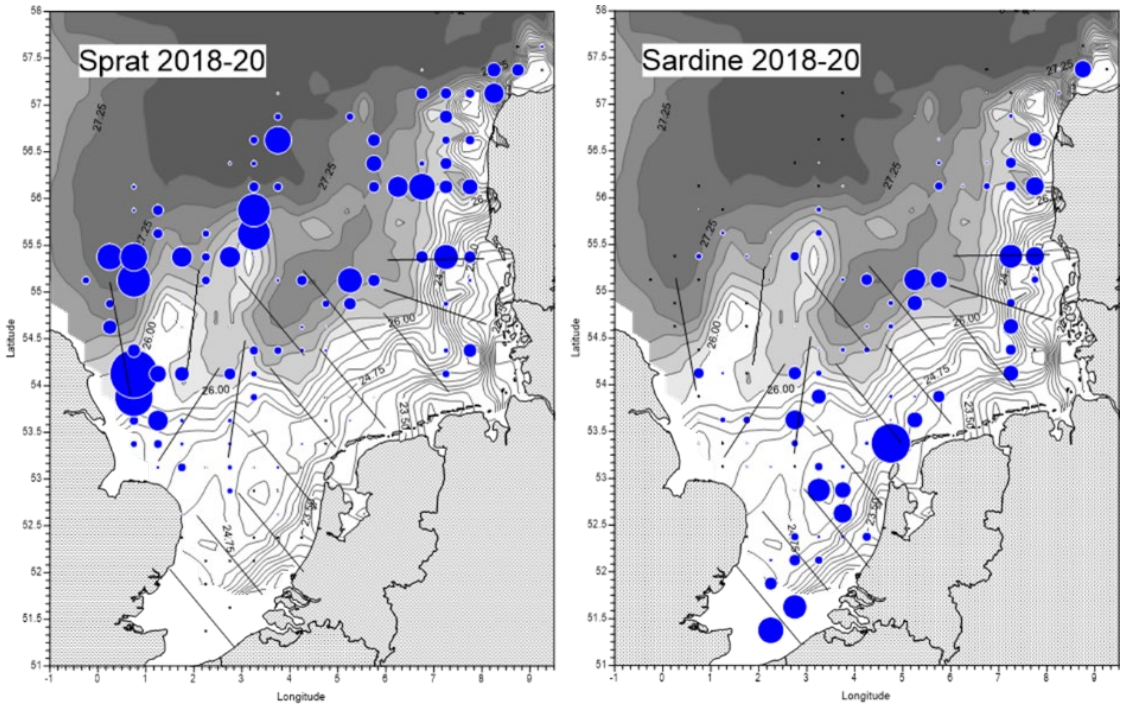

Fig. 1.8.1 Average abundance and distribution of sprat and sardine larvae per ICES square for the years 2018 - 2020. Grey contours show average density in the study area (2018 - 2020).

The samples collected with the MIKeyM nets contained relatively little sample material, and many samples could thus be checked for the presence of eggs directly during the surveys. These analyses did not suggest any catches of sprat eggs, indicating that sprat spawning activity had been finished and larvae had hatched well before the time of the surveys, and that the surveys are thus covering the total larval production. That was also the reason for omitting the MIKeyM net in 2021.

Tests conducted in 2018 (and repeated in 2021) revealed that there is a significant difference in catchability between day and night hauls, with considerably lower numbers of clupeid larvae caught during daylight hours than during darkness. Thus, larval sampling will have to be restricted to the period of complete darkness, and while the MIK sampling can be incorporated into the standard routines during the Q3 IBTS, this limits the time available for larvae sampling to approximately seven to eight hours per night. This means that a regular sprat larvae survey during the Q3 IBTS would profit from international collaboration to achieve a sufficient spatial coverage of the relevant areas.

The larvae had a broad size range from approx. 6 mm to juvenile fish of 4 - 5 cm with very similar size frequency distributions for the two species sprat and sardine, but the majority of larvae were in a size range between 12 and 20 mm. This means that the sprat larvae caught during the Q3 IBTS are below the target size of the herring larvae of North Sea autumn spawners during the Q1 surveys, but above the size range of the Downs herring larvae. Therefore, there may still be relatively high between-year variability in mortality, and a link between larval abundances and later recruitment may not yet be fully established for these size ranges. On the other hand, sprat larvae are generally smaller than herring larvae at any given developmental stage. Thus, the larvae in the observed size range may actually already indicate recruitment. At the time of WGSINS 2021, recruitment estimates from the stock assessment were available for the first 3 years of the pilot survey (2018 - 2020), and preliminary analyses indicated similar trends and a correlation between larval abundance and recruitment. However, the recruitment estimate for the last year (2020) is so far only based on age 1 sprat catches from the Q1 IBTS and is therefore still very preliminary. Thus, it still requires more reliable recruitment estimates, further analyses

and a longer time-series to make a final judgement if the larvae survey can provide an early recruitment index.

Nevertheless, the 4 years of pilot surveys illustrate that this kind of larvae survey during nighttime of the Q3 IBTS has the potential to provide larval abundance estimates and potentially a recruitment index for North Sea sprat. However, additional surveys will be necessary to provide further yearly observations and more data for the modelling of recruitment patterns. Despite the promising results from the first 4 years, it is presently unclear if DTU Aqua will be able to continue the pilot surveys in 2022 due to the lack of a follow-up project, but it is planned to investigate options to prolong the time-series. In any case, a better area coverage than obtainable by the Danish survey with RV DANA alone would be advisable, and other nations participating in the Q3 IBTS are encouraged to contribute to these pilot surveys.

It is noteworthy that in addition to sprat and sardine, a number of larvae of other fish species were caught in the MIK. The more abundant species were mackerel, horse mackerel, sandeel, gurnards and lemon sole, scaldfish and other flatfishes, as well as several non-commercial species, e.g. gobies, crystal goby, rocklings, pipefish, dragonets and greater weever. In addition, a limited number of larger gadoid larvae and/or pelagic juveniles were caught. Concerning mackerel larvae, there was a tendency of higher catches in the northern part of the sampling area, whereas horse mackerel dominated in the southern part. The larvae of other species from the 2018 and 2019 surveys were analyzed in the framework of a master thesis at DTU Aqua, and results were presented at the ICES ASC 2021.

1.9 Investigations on recently hatched sandeel larvae in MIKeyM samples collected during the Q1 MIK-IBTS surveys

Several sandeel species are found in the North Sea, with Raitt's sandeel (*Ammodytes marinus*) being by far the most common. Being a major prey for predatory fish, seabirds and mammals, this species is one of the most important forage fish in the North Sea and is also supporting one of the largest single species fisheries in that area. Due to its high ecological and economical importance, a relatively large body of research exists about the species, covering various aspects. However, there is only limited knowledge about the spawning ecology, which may be due to the unique life cycle. From late summer to autumn, the adults and newly recruited juveniles are burying into the sediment where they are overwintering for several months, utilizing specific areas with suitable sediment. Spawning is also taking place in these areas during winter, when the adults are briefly leaving the sediment to deposit demersal eggs on or in the sediment. Thus, the eggs are more or less impossible to sample, and knowledge about the occurrence and intensity of spawning activity in the different sandeel areas is largely lacking.

The project PELA, which is conducted by DTU Aqua from 2019 - 2022, is aiming to close this knowledge gap by mapping the spatial distribution and abundance of recently hatched larvae as an indicator for spawning activity. The analyses are making use of samples collected with a so called "MIKeyM net", a small ring net with a diameter of 20 cm and a mesh size of 335 µm, which is attached to the larger MIK ring on the annual herring larvae surveys which are conducted at nighttime during the Q1 IBTS. The use of this additional MIKeyM net was introduced some years ago by ICES WGEGGS2, with the aim to obtain information on the occurrence and distribution of cod and plaice eggs. However, it was noticed that the samples also contained very small sandeel larvae, which gave rise to the present study.

The PELA project is aiming to analyze MIKeyM samples for a 6-year period from 2015 - 2020, which includes years with contrasting recruitment (2015 and 2017 very poor, 2016 exceptionally

high, 2019 very good recruitment). The analyses are aiming to include all available samples from Denmark, Germany, Norway, the Netherlands and France, as these nations are covering the main sandeel habitats during their Q1 IBTS. The sample analyses were planned to start in spring 2020, but had to be postponed to September 2020 due to the Covid-19 pandemic. The samples from the other nations were transported to DTU Aqua for analysis, and larvae of sandeel and other fish species were sorted from the samples and counted, and sandeel larvae were scanned and length measurements conducted with an image analysis system. An exception are the French samples, which are anyhow regularly analyzed by Ifremer via zooscan or zoocam, and for which the sandeel larvae data are provided to DTU Aqua. By the time of WGSINS 2021, all available samples had been analyzed, but data analyses were still ongoing. However, some preliminary results for 2015 - 2020 could be presented during WGSINS 2021.

These preliminary results show that the majority of sandeel larvae in the samples are only about 5 to 6 mm. As the hatch size of *A. marinus* is approx. 5.5 mm, the sampled larvae can be considered to have hatched very recently, i.e. they have not drifted very far and should indeed provide an indication for spawning areas. This is also supported by maps of the spatial distribution of larvae, which only show considerable larval abundances in the immediate vicinity of the known sandeel burying areas (Fig. 1.9.1). However, there are spatial differences in the utilization of burying areas, as certain areas are frequently used for spawning while other areas are apparently not regularly used. High larval abundances were usually found in the Dogger Bank area as well as in the Horns Reef area west of Denmark, indicating that these are major spawning areas. In contrast, in the central area at "Elbow Spit" no or at least only few larvae were found, which indicates that this is an area of minor importance for spawning. Furthermore, the data show clear differences in larval abundance between years.

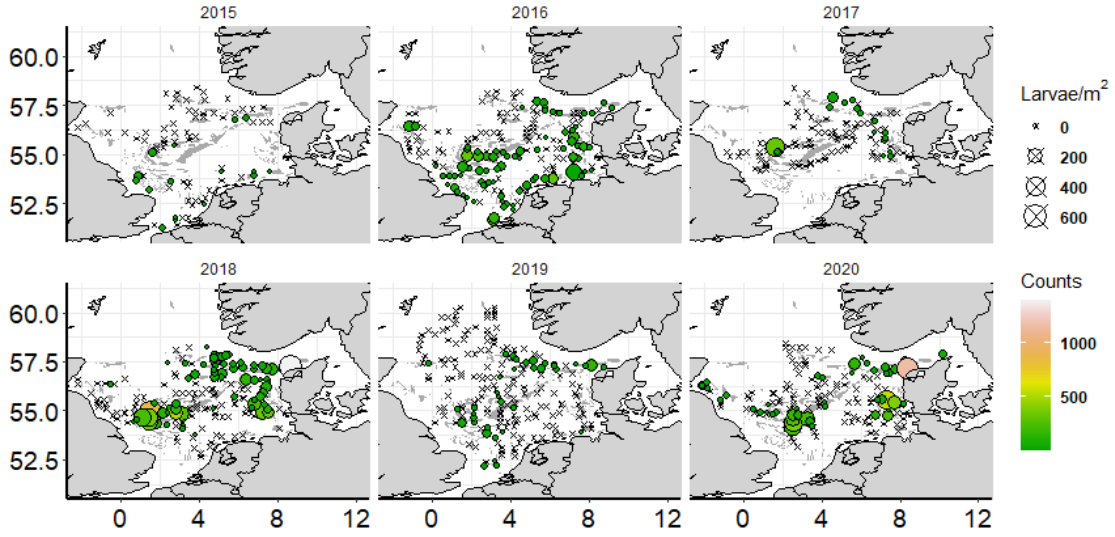

Fig. 1.9.1 Spatial occurrence and abundance of recently hatched sandeel larvae from MIKeyM samples in 2015 - 2020 (preliminary data). The grey areas in the background show the known sandeel burying areas.

The aims of the further data analyses are to investigate in more detail which of the adult burying areas are actually used for spawning, if the area utilization is consistent between years or if there are inter-annual differences, and if there are differences in larval abundance between years. Besides, by comparing these larvae results with results from dredge surveys aiming at the buried adults and juveniles, it is planned to investigate if the sandeel are utilizing different areas for overwintering, spawning and foraging, and how they are moving between different areas

throughout the year. In addition, it is planned to utilize data on sediment samples from the dredge surveys to analyze if the sandeel prefer different sediment types for overwintering and for spawning. Furthermore, as the burying areas are located in different management areas, another aim is to gather more information if sandeel in a specific management area are also reproducing and recruiting in that area, or if they are migrating from other management areas. This will be supported by genetic analyses of larvae and adults, and potentially also by hydrodynamic modelling. Finally, it is also planned to investigate if there is any connection between larval abundance and recruitment or stock size.

1.10 Marine Litter sampling during the Q1 MIK-IBTS and other MIK surveys

DTU AQUA - Denmark has been collecting data of marine litter from standard MIK samples taken during the Q1 IBTS from 2014 - 2016, and first results were presented at the WGEGGS2 meeting 2016 in Hamburg, Germany. Given the information on spatial distribution and composition of different litter types that may be obtained from these litter samples, the group agreed that this additional sampling was worthwhile, and from 2017 all nations participating in the Q1 IBTS contribute to this effort. For this purpose and in order to standardize methodology, a manual and a MIK litter protocol sheet were developed and distributed to the MIK survey participants. As all nations are participating, the spatial coverage is basically identical with the MIK coverage, i.e. the entire North Sea, Skagerrak and Kattegat. Marine litter was sorted from the MIK samples, classified in different categories and the litter items were collected in plastic bags by station and taken ashore for more detailed analyses. Preliminary results of the 2017 MIK litter sampling were presented at the 2017 WGEGGS2 in Boulogne-sur-Mer and the 2018 WGEGGS2 in Ijmuiden. Further in-depth sample and data analyses were initially hampered by a lack of funding. However, in summer 2018 DTU Aqua was able to obtain funding for detailed analyses by the Danish VELUX Foundation in the project MARLINS (Marine Litter in the water column of the North Sea). This project and updated preliminary results were presented at WGSINS 2019.

The MARLINS project was supposed to be running from fall 2018 to fall 2020, aiming to analyze all available MIK litter samples from 2014 - 2020, i.e. both from the Q1 MIK-IBTS herring larvae surveys, the recently implemented Dutch MIK Downs recruitment surveys and the Danish MIK pilot surveys for sprat larvae during the Q3 IBTS. Until early spring 2020, the project was well on track, and it was planned to present more or less final project results at WGSINS 2020. However, due to the Covid-19 pandemic, the analyses were unfortunately considerably delayed. This was due to a lock-down in Denmark and the closing of labs at DTU during spring/summer 2020, difficulties to ship the 2020 samples from several other survey participants to DTU Aqua, and various other issues. Therefore, no updated results could be presented at WGSINS 2020, and only a short update on this Covid-19 related delay was given. Fortunately, the VELUX Foundation was very understanding with regards to the unprecedented challenges caused by the Covid-19 pandemic, and agreed to extend the MARLINS project period until fall 2021. The project ended in the end of October 2021, and final project results were presented at WGSINS 2021.

All litter sample analyses planned in the project description were conducted, except for samples from the Dutch Downs Survey in 2020 as this survey was cancelled due to Covid-19. This means that samples from the following MIK surveys were analyzed and compiled in a database:

(1) Q1 MIK Denmark 2014 - 2016

(2) Q1 MIK All nations 2017 - 2020

(3) Dutch Downs MIK 2018 & 2019

(4) Danish Q3 sprat pilot surveys 2018 - 2020

The final database includes data from a total of 2988 sampling stations and detailed information for 2356 individual litter items.

The following results focus on the Q1 MIK surveys in 2017 - 2020, as these provided the most comprehensive spatial coverage. Data analyses showed that on average, 98% of the litter items were some kind of plastic material, and the following 4 litter categories made up 95% of all litter items: (1) monofilaments, (2) plastic films, (3) plastic pieces and (4) synthetic rope. Furthermore, the composition of litter items from the Q1 MIK surveys in 2017 - 2020 was very similar in each of the 4 investigated years. Fig. 1.10.1 shows the proportions of the different litter categories for all 4 years combined as well as for each individual year.

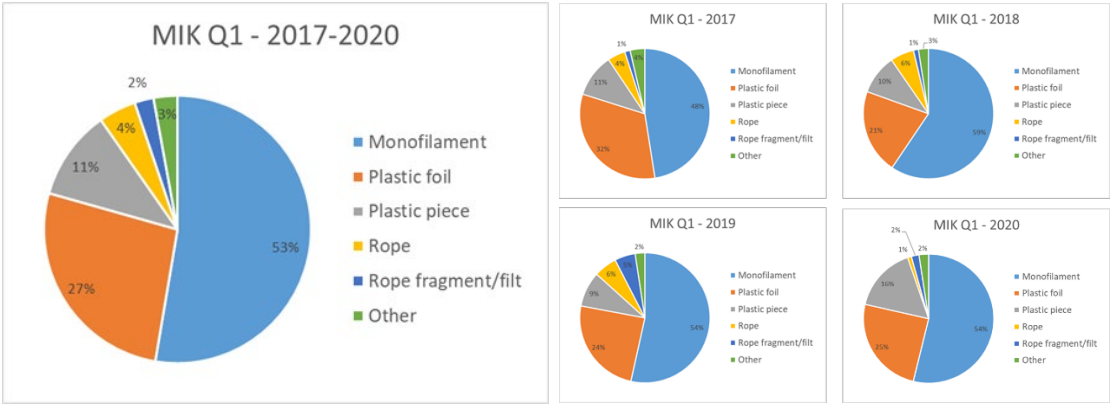

Fig. 1.10.1. Proportions of the different litter categories for all 4 years combined (left) as well as for each individual year (right).

The spatial distribution of litter items showed that there was only little litter in the northern part of the study area, while there were higher abundances in the southern and eastern parts, with hotspots in the south in the English Channel and in the east along the west coast of Denmark and Sweden. This fits to results from beach litter monitoring, which have identified the west coast of Denmark and Sweden as "sink areas" for marine litter. In most cases it was difficult to identify specific litter sources, as it was often only small fragments of larger items that were found in the samples. In some cases, however, the colour or printed labels (e.g. wrapping foils from candy bars) could indicate potential sources. A large part of the most abundant litter category "monofilaments" does very likely originate from "dolly ropes", based on their typical colours (orange, blue and black) and their characteristic diameter. This was further corroborated by comparison of the plastic material of a subsample of monofilaments from the samples with known dolly ropes. This was done via Raman spectroscopy, and the results showed that both samples and known dolly ropes were made of PE, which provided further confirmation that the majority of monofilaments in the field samples indeed originated from "Dolly ropes". In addition, connectivity between potential source and sink areas were analyzed by drift modelling exercises.

The results from the MARLINS project were presented at the ICES ASC 2021 in Theme Session J: "Advances and challenges in marine litter pollution". It is further planned to publish the results in a relevant scientific journal, e.g. Science of the Total Environment or Marine Pollution Bulletin. So far, there is no additional funding available to continue the detailed MIK litter analyses from 2021 onwards. However, in contrast to many other studies on marine litter which are usually based on either beach surveys, bottom trawling or sampling in surface waters, the MIK net is sampling the entire water column, filtering large volumes of water. Besides, the MIK survey covers a large area and the amount of litter can be quantified as flowmeter data are available anyhow, whereas many other marine litter studies are spatially restricted and qualitative or semi-quantitative. Furthermore, the sampling of marine litter from MIK samples does not

require any additional vessel time. Thus, the MIK survey can provide unique and valuable data on the occurrence, distribution and abundance of free-floating marine litter in the entire North Sea area, as well as indications of potential sources and transport pathways. Therefore, WGSINS agreed that it is worthwhile to continue the MIK litter sampling in the future, and to investigate options for the future funding of the MIK litter analyses.

2 Data handling

2.1 ICES eggs and larvae database

For most of the surveys routinely dealt with in WGSINS, the ICES egg and larvae database (E+L, http://ices.dk/data/data-portals/Pages/Eggs-and-larvae.aspx) is the tool to store information

about larvae abundance per station and relevant haul information. Upload of annual survey results is in the responsibility of the national data submitter.

Besides archiving the data, the procedures and calculation routines for the MIK index are meanwhile part of the TAF environment. Transfer of the IHLS routines into TAF are not finished yet.

Procedures used in the Rügen and the northern Irish survey index calculation rely on data which are so far not part of the E+L database (e.g., growth rate per day, mortality rates). These surveys will continue archiving their results in the E+L, but actually not their calculation routines. This may change in the long run.

Participants in the surveys are encouraged to update the fact sheets and meta information on the eggs and larvae website whenever needed.

2.2 Additional Data products

Apart from the data needed for the original surveys objectives (e.g., calculating indices for assessment purposes), Ichthyoplankton surveys can provide additional information on e.g. the spatial and temporal distribution of other fish eggs and larvae, co-occurring in the catches. For some of these species, this will be the only source of information about their planktonic phase, because they are not of high commercial value and thus not part of any dedicated survey program.

Additional sampling and sorting of fish larvae (other than herring), was continued in the MIK surveys. Analyses of fish larvae of the 1Q IBTS/MIK sampling is requested for at least lemon sole, sardine and sandeel, while details on sprat, sardine, mackerel, horse mackerel, lemon sole and red mullet larvae are wanted from the 3Q sampling. The Q1 MIK 2021 sampling results were imported into the ICES eggs and larvae database. The collection of material for species identification will be continued.

Additional data products are also available with regards to the marine litter monitoring in some of the MIK surveys and on the distribution of jellyfish in the northern Irish Sea (NIMIK). These were updated with the most recent survey results.

2.3 Species identification

A dedicated workshop on the identification of clupeid fish larvae was planned to take place in Bremerhaven in August/September 2021 (WKIDCLUP2, 30.08.- 03.09.21). Due to Covid-19 pandemic related international travel restrictions, the workshop had to be held online.

The majority of the time at the workshop was spent identifying fish larvae. Prior to the workshop, the WebApp SmartDots was adapted to be utilized for ichthyoplankton identification based on images. The results from the identification trials were analysed in the traditional way using modified Excel tables built by Guus Eltink. For the two reading cycles in 2021, 120 fish

larvae were used in each. Overall agreement during the first round was 72.5 %, 81 % for herring larvae, for sprat 56 %, for sardine 67 % and for anchovy 72 %. During the second round, overall agreement increased to 81.7 %, 85 % in herring, 83 % in sprat, 69 % in sardine, 82 % in anchovy and 94 % in non-clupeids.

Subsequent analysis of the myotome counts, which was also facilitated through the SmartDots WebApp during all larvae reading events, showed that particularly in those specimens that showed low agreement in correct identification, variation of counts was high.

Overall, the WebApp SmartDots proved to be very useful for holding such events like WKIDCLUP2. Once all images of larvae were available, it was rather easy to upload them to the SmartDots server. During the workshop, and also through feedback of the participants, it was apparent that no one had serious problems nor problems at all with annotating the images. Support through ICES and the SmartDots team was again excellent.

The only species for which larvae abundance indices are currently used in the assessment is herring. Two of those surveys are conducted in the North Sea, the third in the Baltic. Based on the re-assuring results of the workshop identification trials, the potential error caused by misidentification of the larvae can be considered as low or negligible for all of these surveys.

3 References

Bagge O. & Thurow, F. (1994). The Baltic cod stock: fluctuations and possible causes. - ICES mar. Sci. Symp., 198: 254-268.

Gawinski C., Huwer B., Munk P., Jaspers C. (2019) Biodiversity of gelatinous macrozooplankton: Quantitative assessment of data and distribution patterns in the southern and central North Sea during August 2018. Data in brief 25, Article Number: 104186. doi: 10.1016/j.dib.2019.104186.Geffen AJ, Albretsen J, Huwer B, Nash RDM (2021). Lemon sole *Microstomus kitt* in the northern North Sea: a multidisciplinary approach to the early life-history dynamics. J Fish Biol. 2021; 99:569–580. https://doi.org/10.1111/jfb.14745

ICES (2012). Report of the Benchmark Workshop on Pelagic Stocks (WKPELA 2012), 13–17 February 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:47. 572 pp.

ICES (2017). Manual for the Midwater Ring Net sampling during IBTS Q1. Series of ICES Survey Protocols SISP 2. 25 pp. http://doi.org/10.17895/ices.pub.3434

ICES (2018a). Report of the Benchmark Workshop on Pelagic Stocks (WKPELA 2018), 12–16 February 2018, ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:32. 313pp.

ICES (2018b). Manual for egg survey for winter spawning fish in the North Sea. Series of ICES Survey Protocols SISP 13. 19 pp. http://doi.org/10.17895/ices.pub.5225

ICES (2019). Report of the Working Group 2 on cod and plaice egg surveys in the North Sea (WGEGGS2). 3 - 7 December. IJmuiden, The Netherlands. ICES CM 2018/EOSG:09. 37 pp.

ICES (2020). ICES Working Group on Surveys on Ichthyoplankton in the North Sea and adjacent Seas (WGSINS; outputs from 2019 meeting). ICES Scientific Reports. 2:17. 33 pp. http://doi.org/10.17895/ices.pub.5969

Köster F.W., Huwer B., Hinrichsen H-H., *et al.* (2017). Eastern Baltic cod recruitment revisited—dynamics and impacting factors, *ICES Journal of Marine Science*, Volume 74, Issue 1, January-February 2017, Pages 3–19, https://doi.org/10.1093/icesjms/fsw172

Köster F.W., Huwer B., Kraus G., Diekmann R., Eero M., Makarchouk A., Örey S., Dierking J., Margonski P., Herrmann J.-P., Tomkiewicz J., Oesterwind D., Kotterba P., Haslob H., Voss R., Reusch T.B.H. (2020). Egg production methods applied to Eastern Baltic cod provide indices of spawning stock dynamics. Fisheries Research 227: 105553 (published online). doi: 10.1016/j.fishres.2020.105553

Oeberst R. Klenz B., Gröhsler T., Dickey-Collas M., Nash R.M., Zimmermann C. (2009). When is the year class strength determined in Western Baltic herring? ICES Journal of Marine Science, 66: 1667-1672.

Polte P. (2013) Ruegen herring larvae survey and N20 larval index. In: ICES 2013, Report of the Benchmark Workshop on Pelagic Stocks (WKPELA), 4-8 February 2013, Copenhagen, Denmark. ICES CM 2013/ACOM: 4, 449-456

Polte P, Kotterba P, Moll D, Nordheim L von (2017). Ontogenetic loops in habitat use highlight the importance of littoral habitats for early life-stages of oceanic fishes in temperate waters. Scientific Reports 7:42709, DOI:10.1038/srep42709

Rossel, S., Barco, A., Kloppmann, M., Martinez Arbizu, P., Huwer, B., Knebelsberger, T. (2021). Rapid species level identification by proteome fingerprinting using MALDI-TOF MS. Journal of Proteomics 231. https://doi.org/10.1016/j.jprot.2020.103993

Annex 1: List of participants

Name	Institute	Country (of institute)	Email
Norbert Rohlf	Thünen-Institute of Sea Fisheries, Herwigstrasse 31, 27572 Bremerhaven	Germany	norbert.rohlf@thuenen.de
Cindy van Damme	Wageningen Marine Research, Haringkade 1, 1976 CP IJmuiden	The Netherlands	cindy.vandamme@wur.nl
Hannah Holah	Marine Scotland Science, 375 Victoria Road, Aberdeen, AB11 9DS	United Kingdom	hannah.holah@gov.scot
Matthias Kloppmann	Thünen-Institute of Sea Fisheries, Herwigstrasse 31, 27572 Bremerhaven	Germany	matthias.kloppmann@thuenen.de
Malin Werner	Swedish University of Agricultural Sciences, SLU Aqua, Turistgatan 5, 453 30 Lysekil	Sweden	malin.werner@slu.se
Annegret Finke	Thünen-Institute of Baltic Sea Fisheries, Alter Hafen Süd 2, 18060 Rostock	Germany	annegret.finke@thuenen.de
Bastian Huwer	Technical University of Denmark, DTU Aqua - National Institute of Aquatic Resources, Kemitorvet, Building 202, 2800 Kgs. Lyngby	Denmark	bhu@aqua.dtu.dk
Christophe Loots	IFREMER, 150 Quai Gambetta. 62200 Boulogne sur Mer, France	France	christophe.Loots@ifremer.fr
Carolina Giraldo	IFREMER, 150 Quai Gambetta. 62200 Boulogne sur Mer, France	France	carolina.Giraldo@ifremer.fr
Steven Beggs	AFBI, 18 Newforge Lane, Belfast, BT9 5PX, Northern Ireland	UK, Northern Ireland	steven.Beggs@afbini.gov.uk
Hannes Höffle	Havforskningsinstituttet, Avdeling Tromsø, Postboks 6606 Langnes, 9296 Tromsø, Norway	Norway	hannes.hoffle@hi.no
Richard Nash	Centre for Environment, Fisheries and Aquaculture Science (Cefas)	UK England	richard.nash@cefas.co.uk

Annex 2: Resolutions

2018/MA2/EOSG09 The **Working Group on Surveys on Ichthyoplankton in the North Sea and adjacent Seas (WGSINS),** chaired by Norbert Rohlf, Germany, and will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2019	22 – 25 October	Bremerhaven, Germany	Interim report by 15 December 2019	
Year 2020	01 – 04 December	By Correspondence/Webex	Interim report by 15 January 2021	
Year 2021	30.11. – 02.12.2021	By Correspondence/Webex	Final report by 15 January 2022	

ToR descriptors

ToR	Description	Background	Science plan codes	Duration	Expected Deliverables
a	Planning and execution of North Sea and adjacent seas ichthyplankton surveys used for assessment and management purposes	Ichthyoplankton surveys in the North Sea and adjacent Seas deliver abundance data of early life history stages for fish SSB and/or recruitment for assessment of several fish stocks.	3.1, 3.2, 5.2	year 1, 2, 3	Survey Plan
b	Provide quality assurance of the survey indices time series to assessment working groups	Consistency in generation of data is a cruicial prerequisite for the use of a time series in the assessment.	3.1, 3.2, 5.2	year 1, 2, 3	
c	Prepare a manual for ichthyoplankton surveys in the North Sea and adjacent seas	A manual that describes the standard procedures of ichthyoplankton surveys and their necessary adaptations to the survey specific objectives needs to be in place and reviewed regularly.	3.1, 3.2	year 3	SISP manual on standards in ichthyoplankton surveys
d	Provide quality assurance of ichthyoplankton identification, including molecular methods	The accurate identification of ichthyoplankton and the developmental stages is crucial for species specific abundance estimates.	3.1, 3.2	year 1, 2, 3	

e	Standardization of sampling and sample processing procedures	Standards of sampling and sample processing procedures need to be optimized w.r.t. efficiency	3.1	year 1, 2, 3	
f	Prepare data for archiving in the ICES eggs and larvae database	WGSINS data need to be prepared and uploaded to the ICES eggs and larvae database by each institute	3.2	year 1, 2, 3	Updated dataset om the ICES egg and larval databse
g	Assess possibilities for the different ichthyoplankton surveys to supply data for the implementation of ecosystem approach to fisheries management	Ichthyoplankton surveys are able to provide additional data than needed for the original survey objectives. The acquisition of additional data has to be assessed w.r.t. feasibility of new survey objectives.	3.1, 3.3	year 1, year 2, year 3	Review any additional objectives that are proposed for the different ichthyoplankton surveys in the North Sea and adjacent seas.

Summary of the Work Plan

Year 1	Plan and execute the International Herring Larvae Survey (IHLS), the Rügen Herring Larvae Survey (RHLS), the Baltic Ichthyoplankton Survey (BIS), MIK Surveys in the North Sea (MIK), the Northern Ireland Method Isaacs Kidd Survey (NIMIK), and the Irish Sea Herring Larvae Survey (ISHLS)
Year 2	Plan and execute the IHLS, the RHLS, the BIS, the MIK, the NIMIK, ISHLS
Year 3	Plan and execute the IHLS, the RHLS, the BIS, the MIK, the NIMIK, ISHLS

Annex 3: Survey Summary Sheets

Germany – Rügen herring larvae survey (RHLS)

Nation:	Germany	Vessel:	CLUPEA
Survey:	334	Dates:	02.03. – 26.06.2020

Cruise	Target herring population is the Western Baltic spring-spawning herring. The main aim is to monitor the spawning activity and larval production in a major spawning area, the Greifswald Bay as an indicator of reproductive success in the coastal Baltic Sea. Target data are a high-resolution spatial and temporal records of the larval abundance (35 stations/week) during the entire spawning period as well as hydrographic data (temperature, salinity and oxygen). Weekly mean abundance of larva is summarized in an annual index value (N20) expressing the sum of larvae reaching a critical length of 20 mm total length by the end of the reproduction season. The collected data are stored nationally and in the ICES Fish Eggs and Larvae dataset.
Gear details:	Bongo net (0.6 m diameter) of 335 µm mesh, HYDROBIOS-electronic flowmeters
Notes from survey (e.g. problems, additional work etc.):	The Rügen Herring Larvae Survey (RHLS) in the western Baltic (ICES area 3d/24) took place during 17 weeks from March-June. Additionally, in February and November control survey were planned to investigate the density of winter and autumn spawned larvae respectively, however, the February control was cancelled due to Covid-19. Also survey week 3 (16. + 17.03.20) was cancelled. In total 574 stations were achieved of the 595 planned stations, including the autumn sampling. On each station a vertical CTD-profile was taken (T, Sal, DO2, turbidity, Chl-a fluorescence). Vertical Zooplankton samples (55µm, 200µm) were taken weekly on a grid of 5 stations throughout the Bay.
Number of fish species recorded and notes on any rare species or unusual catches:	Samples are processed for herring larvae exclusively. Remaining samples are stored for potential future processing of other species. Zooplankton samples (55 µm + 200 µm mesh) are taken on 5 stations/week.

Stations sampled

ICES Divisions	Strat.	Gear	Tows planned	Valid	Add.	Inv.	% stations fished	comments
24	N/A	Bongo	595	574 (total) 538 (for *N20*)	36	50	97 % 91 %	

Strat: strata; Add: Additional tows; inv: Invalid

UK(NI) NIMIK – Irish Sea MIK Net survey

Nation:	UK(NI)	Vessel:	RV Corystes
Survey:	NIMIK	Dates:	17th May – 3rd June 2021

Cruise	MIK net surveys of the Irish Sea (ICES area 7aN) have been carried out by the Agri-Food and Biosciences Institute (AFBI), formerly the Department of Agriculture and Rural Development for Northern Ireland (DARD), in the spring/early summer each year since 1993. The surveys have been carried out onboard the RV "Corystes" since 2005, and prior to that on the smaller RV "Lough Foyle". Sampling is carried out on a systematic grid of stations covering the main nursery ground of juvenile gadoids (cod (*Gadus morhua)*, whiting (*Merlangius merlangus*) and haddock (*Melanogrammus aeglefinus*) in the western Irish Sea. From 2006 additional sampling in the eastern Irish Sea has also taken place. While the MIK net is deployed during the hours of darkness (30±mins) a GULFVII high speed plankton sampler is deployed during the day to sample zooplankton and ichthyoplankton. Catches of cod, haddock and whiting from the MIK net survey are reported to WGCSE. Since 2018 Neuston sampling for marine litter (micro/macro) have been included in the survey.
Gear details:	GulfVII high-speed plankton sampler fitted with 280µm/425µm mesh net dependent on clogging. A Valeport MIDAS+CTD system is fitted providing flow rates of internal and external Valeport model 002 current meters with 50mm diameter impellers, depth, temperature and salinity profiles. A Seabird SBE19plus CTD is also carried recording depth, temperature, salinity and fluorescence. Between 1993-2018 a 5m^2 modified Isaacs Kidd trawl was deployed. In 2019 a 2 metre diameter midwater ring net replaced this gear. Scanmar sensors are fitted to the MIK frame to provide depth and monitor deployment. A General Oceanics mechanical standard flowmeter records internal flow rates. From 2018 a WP2 net with side floats for neuston sampling fitted with 333µm mesh and internal flowmeter (General Oceanics mechanical standard) has been deployed at GULFVII stations.
Notes from survey (e.g. problems, additional work etc.):	A total of 118 Gulf7, 90 MRN2 and 55 WP2 deployments were made.
Number of fish species recorded and notes on any rare species or unusual catches:	Of the target species 684 whiting, 99 haddock and 59 cod were recorded in the MRN2 catches. Larval fish catches in the Gulf7 were dominated by dab (*Limanda limanda*) 3790, clupeiformes (predominantly *Sprattus sprattus*) 2947 and dragonets (*Callionymidae*) 2689. In addition various species of gelatinous zooplankton and crustacea were recorded.

North Sea Quarter 1 IBTS-MIK (IBTS1Q)

Nation:	Vessel:	Dates
Germany	Walther Herwig III	25 January – 26 February 2021
France	Thalassa II	15 January – 7 February 2021
Netherlands	Tridens 2	25 January – 26 February 2021
Sweden	Svea	19 January – 5 February 2021
Scotland	Scotia	23 January – 12 February 2021
Norway	GO Sars	7 February – 3 March 2021
Denmark	Dana	2 – 19 February 2021

Cruise	North Sea MIK survey aims to conduct plankton net tows with a 2 m ring trawl to determine the abundance of late North Sea herring larvae. Work is carried out at night time during the Q1 IBTS
Gear details:	Night time plankton catches are carried out with the standard midwater ring net (MIK).
Notes from survey (e.g. problems, additional work etc.):	This year, 683 depth-integrated hauls were completed with the MIK-net, which is 117 MIK hauls more than in 2020. For the index, all hauls north of 51° N were used, in total 663 hauls, 111 more than in 2020. Due to severe weather during the second week of February, some participants could not take their stations, but these gaps could be successfully filled by other participants. Coverage of the survey area was good, mostly achieving the desired 4 hauls per ICES rectangle.
Number of fish species recorded and notes on any rare species or unusual catches:	Again, above-average catches of sardine larvae were found specifically in the German Bight area, and in the Skagerrak.

Stations fished (aims: to complete 707 MIK tows per year)

ICES Divisions	Strat.	Gear	Tows planned	Valid	Add.	Inv.	% stations fished	comments
3a	N/A	MIK	55	55	0	0	100 %	
4	N/A	MIK	632	608	0	0	96 %	
7d	N/A	MIK	20	20	0	0	100%	
total	N/A	MIK	707	683	0	0	97 %	

UK(NI) NINEL – Irish Sea Herring larvae survey

Nation:	UK(NI)	Vessel:	RV Corystes
Survey:	NINEL	Dates:	8- 14 November 2020

Cruise	Herring larvae surveys of the northern Irish Sea (ICES area 7aN) have been carried out by the Agri-Food and Biosciences Institute (AFBI), formerly the Department of Agriculture and Rural Development for Northern Ireland (DARD), in November each year since 1993. The surveys have been carried out onboard the RV "Corystes" since 2005, and prior to that on the smaller RV "Lough Foyle". Sampling is carried out on a systematic grid of stations covering the spawning grounds and surrounding regions in the NE and NW Irish Sea. Mean catch-rates (nos.m-2) are calculated over stations to give separate indices of abundance for the NE and NW Irish Sea. Larval production rates (standardized to a larva of 6 mm), and birth-date distributions, are computed based on the mean density of larvae by length class. A growth rate of 0.35 mm day-1 and instantaneous mortality of 0.14 day-1 are assumed based on estimates made in 1993–1997.
Gear details:	Sampling is conducted using a Gulf7 high-speed plankton sampler fitted with 280µm mesh net. A Valeport MIDAS+CTD system is fitted providing flow rates of internal and external Valeport model 002 current meters with 50mm diameter impellers, depth, temperature and salinity profiles. A Seabird SBE19plus CTD is also carried recording depth, temperature, salinity and fluorescence.
Notes from survey (e.g. problems, additional work etc.):	The survey in 2020 was completed successfully with a total of 62 Gulf7 stations sampled. Depth profiles of salinity and temperature were collected at all stations, and zooplankton samples preserved in 4% formalin.
Number of fish species recorded and notes on any rare species or unusual catches:	2999 larvae were measured (TL mm) and preserved in alcohol.

International Herring Larvae Surveys (IHLS)

Nation:	Vessel:	Dates
Germany	WH #439	14 September – 28 September 2020
Netherlands	Tridens 2	15 September – 24 September 2020
Netherlands	Tridens 2	14 December – 17 December 2020
Germany	WH #442	05 January – 11 January 2021

Cruise	North Sea IHLS monitor the abundance and distribution of newly hatched herring larvae at the main spawning grounds of autumn spawning herring along the Scottish and English coast in September and on the Downs spawning ground in the English Channel in December and January.
Gear details:	Gulf-type high speed plankton sampler catches are taken during day and night time. Mesh size of the net is 280 microns. The sampler is equipped with a CTD for measurements of actual sampler depth, salinity and temperature profiles as well as internal and external flowmeters determining the filtered water volume. Samples are taken in a V-shape manner, e.g. from the sea surface down to near the seabed (5 m above the bottom) and back to the surface.
Notes from survey (e.g. problems, additional work etc.):	All four surveys could be conducted as scheduled. The Orkney area revealed relatively low numbers of larvae. In the Buchan and the central North Sea, larvae hatched in larger quantities, but concentrated in only two dense areas. However, the overall distribution of larvae and thus the main spawning area used by herring was not obviously different from preceding years. The estimated larvae abundance indices should be used in the assessment of North Sea autumn spawning herring.
Number of fish species recorded and notes on any rare species or unusual catches:	In total, 475 plankton samples were taken during the IHLS surveys in September 2020 and January 2021. They contained 136,127 herring larvae.

Stations fished

ICES Divisions	Strat.	Gear	Tows planned	Valid	Add.	Inv.	% stations fished	comments
4a,b	N/A	Gulf	320	332	0	0	100 %	Extra hauls taken when abundance was dense
7d	N/A	Gulf	143	143	0	0	100 %	
total	N/A	Gulf	463	475	0	0	100 %	

Denmark, Poland, Germany – Baltic Ichthyoplankton Surveys (BIS)

Nation:	Denmark, Poland, Germany	Vessel:	DANA, BALTICA, ALKOR & others
Survey:	BIS-Baltic Ichthyoplankton Surveys	Dates:	Monthly from March-September & November, 2021

Cruise	The Baltic Ichthyoplankton Surveys (BIS) are an annual series of individual surveys conducted by several participating institutes from Denmark, Poland and Germany. The surveys aim to cover the main spawning area of the target species, Eastern Baltic cod (EBC), throughout its spawning season, i.e. individual surveys cover a standard grid of 45 Bongo net stations and are usually conducted in March, April, May, June, July, August and November, in some years also in September. The surveys provide a stock biomass estimate for EBC based on egg abundances and a recruitment index based on larval abundances. In addition, the surveys provide information on eggs and larvae of several other species, including sprat, herring and flounder. On some cruises, Bongo net hauls are also conducted on additional stations to supplement the standard grid, and sometimes also vertically resolved Multinet sampling is conducted. Besides, most surveys are multidisciplinary and also include sampling of adult fish (e.g. for fecundity estimates needed for egg production methods) and zooplankton (e.g. as prey for larvae) as well as hydrographic measurements. The collected data are stored in national databases, and the time series of egg based stock biomass estimates and recruitment indices for EBC are updated every year and provided to WGBFAS for use in the stock assessment of EBC.
Gear details:	Bongo net (0.6m diameter) of 335 and 500 µm mesh, flowmeters + on some cruises additional other gears, e.g. different types of fishing trawls, Baby-Bongo net (0.2m diameter) of 150 µm mesh, WP-2 net (100 µm mesh), Multinet (335 µm mesh)
Notes from survey (e.g. problems, additional work etc.):	In 2021, a total of 8 individual BIS surveys were conducted in March, April, May, June, July, August, September and November. The entire 45 station standard grid was sampled on all cruises, amounting to a total of 360 sampled standard stations in 2021.
Number of fish species recorded and notes on any rare species or unusual catches:	In addition to cod as the target species, eggs and larvae of several other species are caught. Depending on the sampling month, abundant species include sprat, herring, flounder, plaice, sandeel and gobies. Additional species occur at relatively low abundances, including e.g. rockling, sea snail, turbot and sculpin. In addition, various species of gelatinous plankton were recorded.

Stations fished

ICES Divisions	Strat.	Gear	Tows planned	Valid	Add.	Inv.	% stations fished	comments
25	N/A	Bongo	360	360	Several	0	100 %	