WORKING GROUP ON SURVEYS ON ICHTHYOPLANKTON IN THE NORTH SEA AND ADJACENT SEAS (WGSINS; outputs from 2022 meeting)

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Contents

i Executive summary

The Working Group on Surveys on Ichthyoplankton in the North Sea and adjacent Seas (WGSINS) coordinates several surveys on fish early life stages in the North Sea, Irish Sea and Baltic undertaken for assessment and management purposes. The objectives of WGSINS include review and coordination of these surveys, quality assurance on survey methodology, species identification and provided data and indices, preparation of data for archival as well as identification of additional objectives that can be achieved by the surveys.

The International herring larvae surveys in the North Sea (IHLS) revealed higher larval abundances around the Orkneys, lower abundances in the Buchan and Banks area and large numbers of Downs larvae.

The 2022 North Sea Midwater Ring Net survey (MIK) was faced with numerous challenges (weather, Covid-19 and technical issues) resulting in poor coverage, but data tests showed that the herring 0-ringer index was still reliable, although one of the lowest in the time series.

The Downs recruitment survey (DRS) in April 2022 showed comparable numbers and spatial distribution of herring larvae as in 2021. As sampling should only be done at night, additional survey participation is required. A WGSINS sub-group is planned for 2023 to discuss the way forward with the DRS survey and index calculations.

The Northern Irish Northeastern Larvae survey (NINEL) in November 2021 showed similar spatial distributions as in previous years and relatively high larval abundances.

The 2022 Northern Ireland MIK survey (NI-MIK), targeting different juvenile gadoids, was affected by a change in survey timing and mechanical issues. No juvenile cod were caught and catches of haddock and whiting were low.

The N20 recruitment index of the 2021 Rügen herring larvae survey (RHLS) was more than 10 times higher than the record low value in 2020 and the highest value since 2015, but still below the long-term average.

The Baltic Ichthyoplankton Surveys (BIS) are a series of several individual surveys, providing an SSB estimate and a recruitment index for Eastern Baltic cod. Sample analyses for 2022 are still ongoing, but preliminary data indicate that SSB remains at a similarly low level as in 2018-2021.

In addition to the surveys and target species/stocks mentioned above, WGSINS provides a forum to present and discuss additional work conducted on these surveys and on other, dedicated pilot surveys. A pilot survey aiming to establish a larval recruitment index for North Sea sprat showed promising results but broader area coverage would be an advantage. Another pilot study on recently hatched sandeel larvae analyzed spawning areas and larval drift in the North Sea, which may help to re-define management areas.

Apart from the data needed for the original survey objectives, ichthyoplankton surveys can provide additional information and data products, e.g. on eggs and larvae of non-target species and other organisms like jellyfish and zooplankton as well as marine litter. WGSINS will continue to collect and archive this information which is underrepresented in traditional fishery survey datasets and may thus contribute to the implementation of an ecosystem approach to fisheries management.

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	2022
Reporting year in cycle	1/3
Chair(s)	Bastian Huwer, Denmark
Meeting venue(s) and dates	29 November – 1 December 2022, Belfast, Northern Ireland (13 participants)

1 Survey reviews

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

1.1.1 The IHLS in 2021/2022

Six survey areas were covered within the framework of the International Herring Larval Surveys in the North Sea during the sampling period 2021–2022. 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 and in the southern North Sea (SNS) in December 2021 and January 2022 (Figures 1.1.1 - 1.1.4).

The survey around the Orkneys revealed higher quantities of newly hatched larvae, compared to relatively low numbers in the two preceding years. In the Buchan and the central North Sea, larvae hatched in lower quantities, and concentrated in two areas, while the remaining stations contributed only low numbers of larvae (Figure 1.1.2).

The two surveys in the southern North Sea showed comparable quantities. However, the survey in December was influenced by some hot spots, yielding high numbers of larvae (Figure 1.1.3). This pattern is not uncommon when compared to the survey history, thus all stations were included in further calculations.

As in former years, the abundance of young larvae is high when hatching started in December, but their spatial distribution is limited. With progressing spawning season, also the spatial distribution gets broader (Figure 1.1.4).

No survey was planned for the second half of January 2022. Instead, an additional MIK sampling was scheduled for April 2022 in the German Bight and Skagerrak/Kattegat area. This sampling should shed light on the foraging and recruitment of herring larvae originating from the Downs stock component. This survey is described in section 1.3.

At time of the 2022 WGSINS meeting, the 2022/2023 sampling period is still in progress. The surveys in September were conducted as scheduled. Plankton sorting and larvae length measurements are ongoing. First results on larvae abundance and distribution in the Orkney/Shetland area are shown in Figure 1.1.5.

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	
2021		6651		1413		3282		8899	8764	

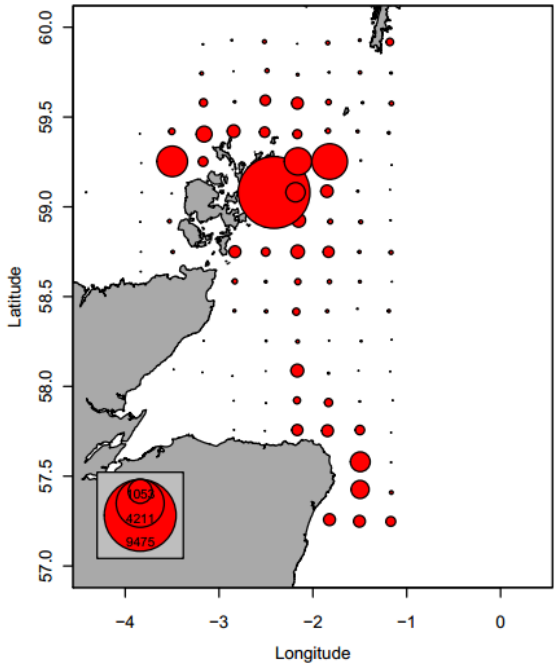

Figure 1.1.1. North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Orkney/Shetlands and northern Buchan area, second half of September 2021 (maximum circle size = 9 475 n/m²).

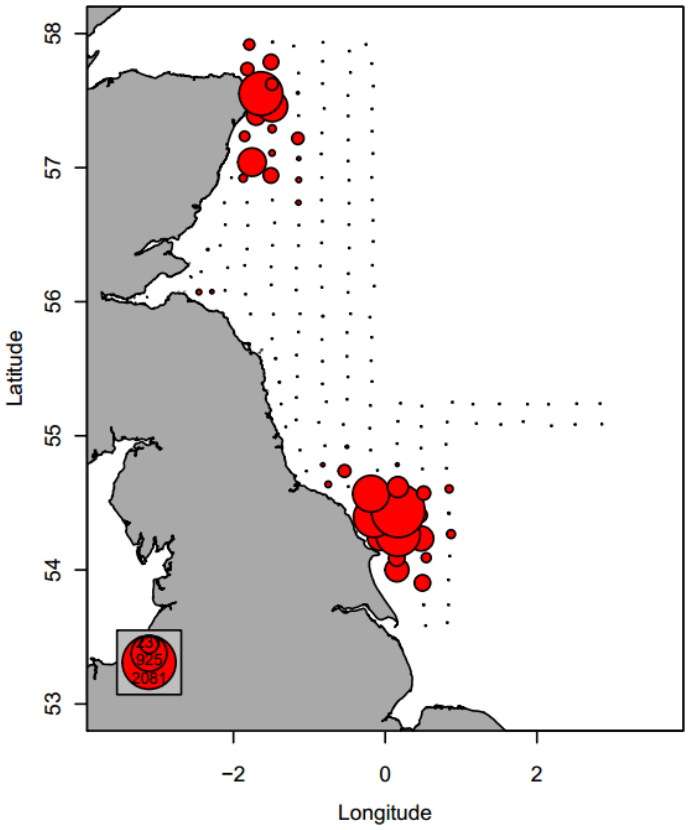

Figure 1.1.2. North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Buchan area and the central North Sea, second half of September 2021 (maximum circle size = 2 081 n/m²).

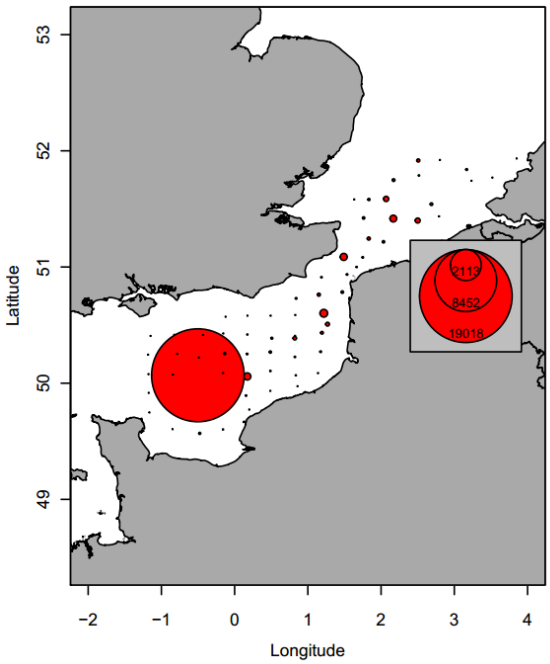

Figure 1.1.3. North Sea herring - Abundance of larvae <11 mm (n/m²) in the Southern North Sea and English Channel, second half of December 2021 (maximum circle size = 19 018 n/m²).

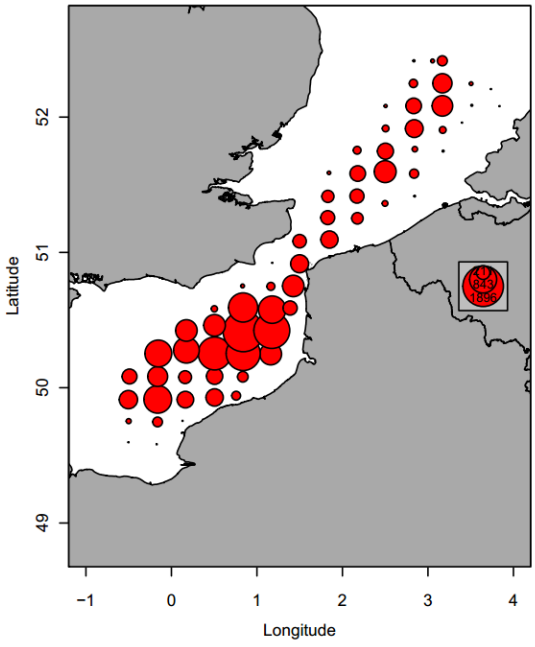

Figure 1.1.4. North Sea herring - Abundance of larvae <11 mm (n/m²) in the Southern North Sea and English Channel, first half of January 2022 (maximum circle size = 1 900n/m²).

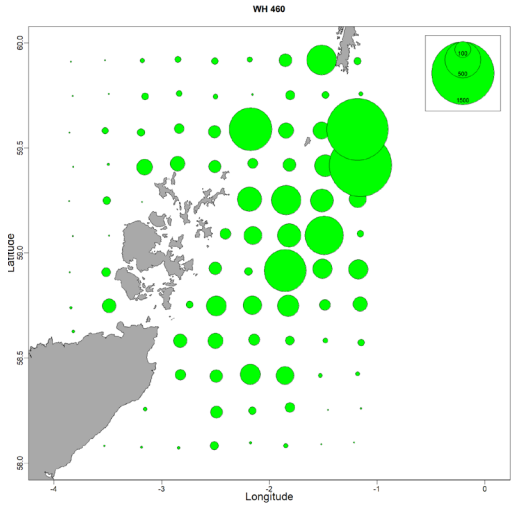

Figure 1.1.5. North Sea herring - Abundance of larvae (all sizes, n/m²) in the Orkney/Shetlands area, second half of September 2022 (maximum circle size = 1 500 n/m²).

1.1.2 Planning of the 2023 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 sheds lights on the recruitment in the Downs stock component and is also scheduled to take place in spring 2023 (see Section 1.2 below).

The plan of the upcoming sampling period is given below.

Table 1.1.2: Areas and periods to be covered during the 2023 IHLS surveys

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

1.2 The North Sea Midwater Ring Net survey (MIK)

1.2.1 Background information

During the International Bottom Trawl Survey in the North Sea in the first quarter of the year (Q1 IBTS), night-time catches are conducted with the MIK net, a fine meshed (1600 μm) 2-m-midwater ring net (ICES 2017) providing abundance estimates for large herring larvae (0-ringers) of the autumn spawning stock components. The total abundance of 0-ringers in the survey area provides the 0-ringer index (also called MIK index), which is used as a recruitment index for the North Sea herring stock.

In addition, the Q1 IBTS also provides a time series of juvenile herring abundance in the North Sea (1-ringer index) which is based on the GOV bottom trawl catches carried out during daytime.

The time series of 0-ringer and 1-ringer indices from the Q1 IBTS survey exist since the 1977 year-class. It has to be borne in mind that the 0-ringer index reflects recruitment in the autumn spawning components, while the 1-ringer index includes both autumn spawning and other components. For more details on these two times series and their utilization in stock assessment, the reader is referred to the reports of the Herring Assessment Working Group (HAWG).

1.2.2 The MIK survey in 2022

The 2022 MIK survey was faced with numerous challenges. Most importantly, very severe weather conditions prevailed throughout most of the survey period. In addition, several cases of Covid-19 on RV Walther Herwig III delayed the German survey for 15 days, and the Scottish survey had to be cancelled after 5 days due to mechanical issues on RV Scotia. Furthermore, minor technical issues also occurred on the Dutch RV Tridens and the Danish RV Dana, resulting in the need to go back to harbor for repairs. All these various issues had severe impacts on the MIK sampling, and only 433 depth-integrated hauls were completed with the MIK-net (Table 1.2.1 and Fig. 1.2.1), which is 250 MIK hauls less than in 2021. For the 2022 MIK 0-ringer index (corresponding to the 2021 year-class), all hauls north of 51° N were used, in total 410 hauls, which is 253 less than in 2020.

As a total of 714 MIK hauls were planned according to the 2022 NSIBTS Q1 program (the target is 4 hauls per ICES rectangle), only approximately 60% of the planned MIK-stations were sampled. However, there has been an increase in the number of MIK hauls throughout the time-series, and the 433 MIK hauls achieved in 2022 are still more hauls than were conducted in the early years of the time-series. Besides, thanks to intensive coordination between participants during the survey and more decent weather in the final part of the survey period, at least 1 MIK haul could be conducted in most ICES rectangles and the majority of rectangles was covered with 2 or more hauls. Nevertheless, 24 rectangles were not covered at all by the MIK sampling, but these were mainly located in the north-western parts of the survey area, which usually only yield low numbers of herring larvae (Fig. 1.2.1). Thus, the majority of the main herring larvae distribution area could be covered.

In order to investigate whether the poor sampling coverage may have had an influence on the 0-ringer index from the 2022 survey, two data tests were conducted. In the first test, the entire 0-ringer index time-series from 1992 to 2021 was re-calculated without the 24 rectangles which were not covered in 2022 and compared to the existing, normal 0-ringer time-series. For most years, the deviances between the two time-series were max. 5% or less, except for one year with a deviance of about 10% (Fig. 1.2.2). Furthermore, when plotting the two time-series together in

the same figure, it became evident that the overall time-series trends were not affected at all and the discrepancy between the two time-series was negligible (Fig. 1.2.3). In the second test, the entire time-series since 1992 was calculated with only 1 and 2 randomly chosen MIK hauls per rectangle, conducting 100 different runs per year (Fig. 1.2.4). For the test with only 1 random MIK haul per rectangle a relatively high variability of the index values was observed (Fig. 1.2.4A), whereas the test with 2 random hauls per rectangle only resulted in a low variability of the index (Fig. 1.2.4B). The overall trends, however, were not seriously affected in both runs. Thus, as the majority of rectangles was covered by at least 2 or more MIK hauls, the impact of the poor MIK sampling coverage during the 2022 survey on the resulting 0-ringer index seems negligible. In summary, despite the encountered issues and low overall number of MIK hauls, it can be assumed that the 2022 MIK survey provides a representative 0-ringer index.

Table 1.2.1: Summary table of the MIK stations sampled during the North Sea Q1 IBTS in 2022

Country	MIK tows planned	MIK tows valid	% stations fished
Denmark	92	54	59
France	106	103	97
Germany	134	17	13
Netherlands	114	100	88
Norway	84	85	101
Scotland	116	28	24
Sweden	53	46	87
SUM	699	433	62

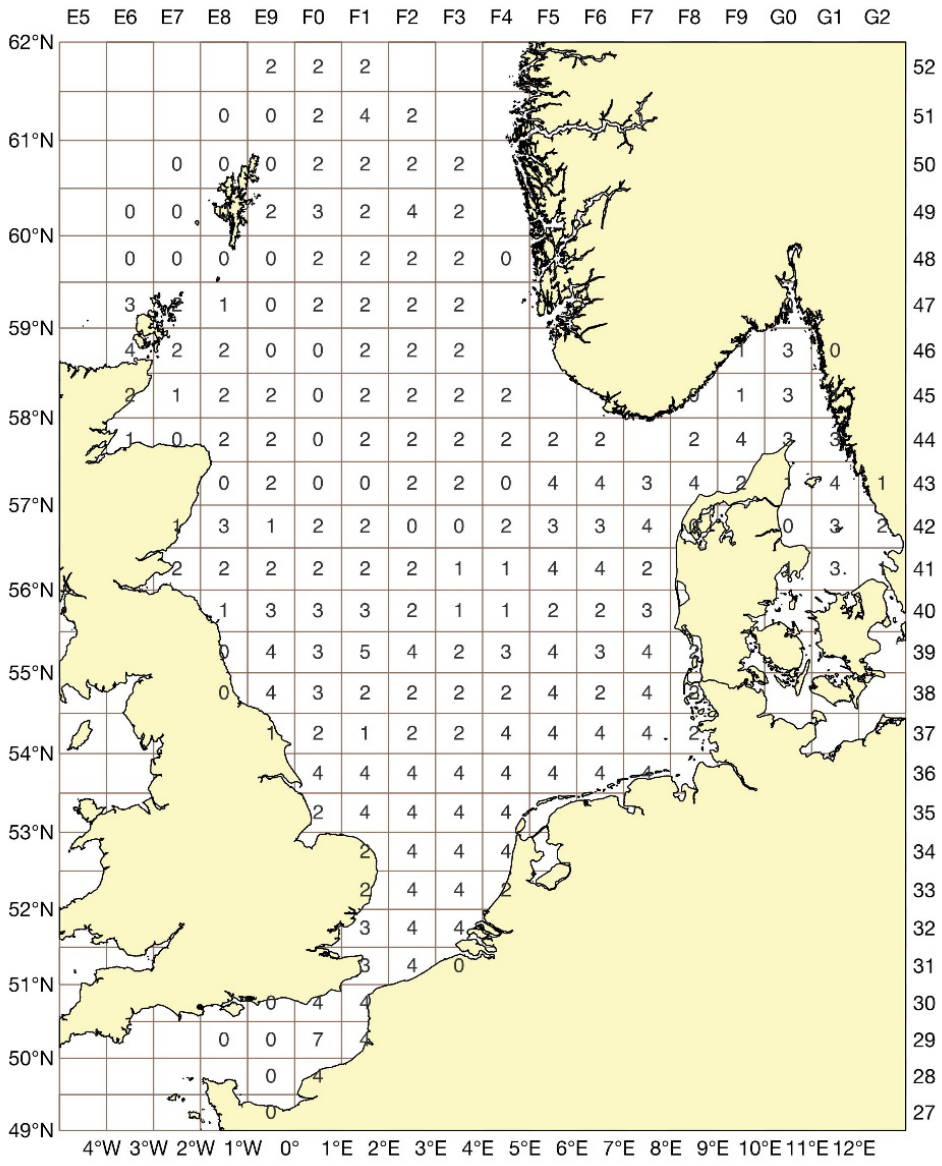

Figure 1.2.1: MIK sampling during IBTS Q1 2022 – numbers of MIK samples per each ICES rectangle.

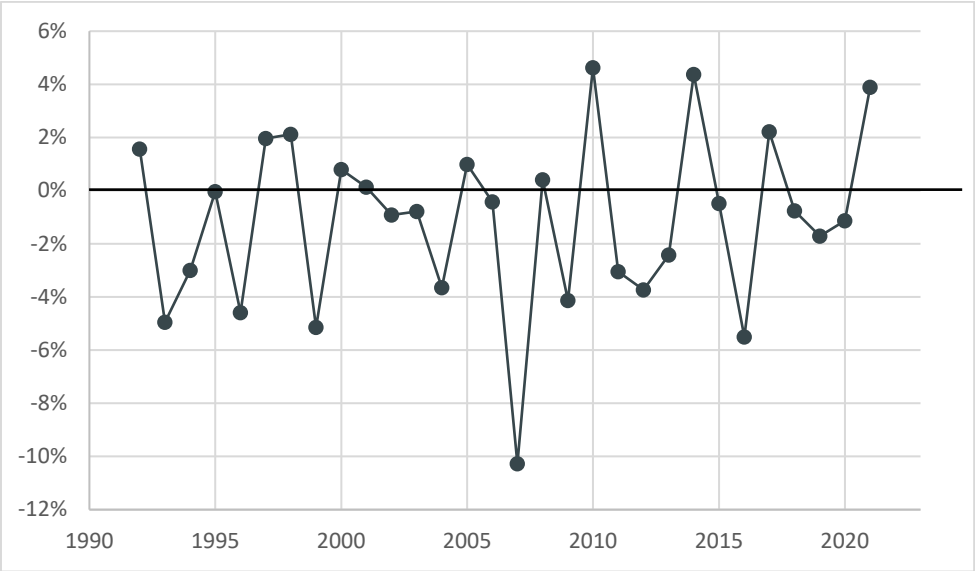

Figure 1.2.2: Test of the impact of unsampled rectangles: Deviance in % if the 24 rectangles that were unsampled in 2022 were also left out in the entire MIK time series

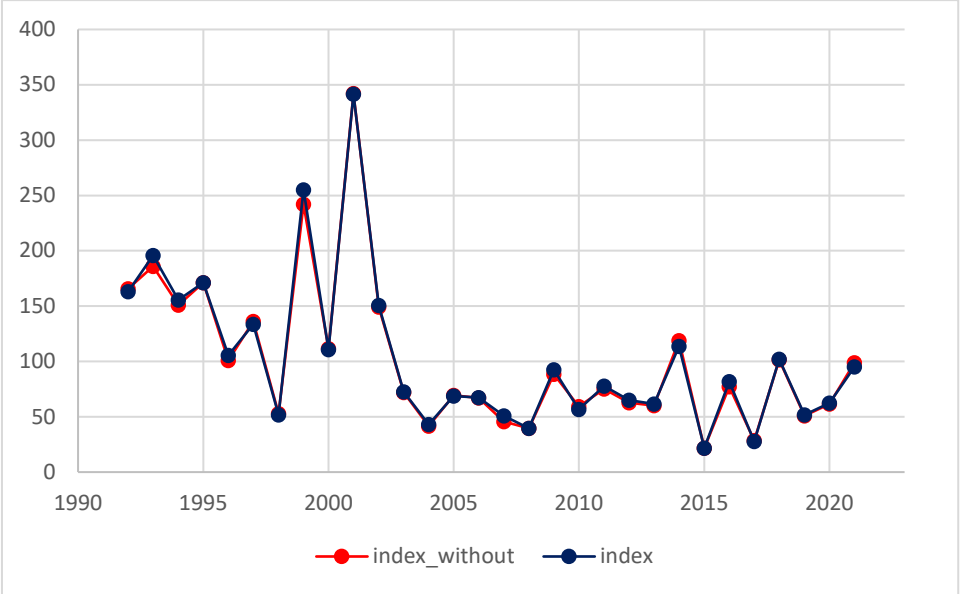

Figure 1.2.3: Test of the impact of unsampled rectangles: MIK time-series with and without the 24 rectangles that were unsampled in 2022.

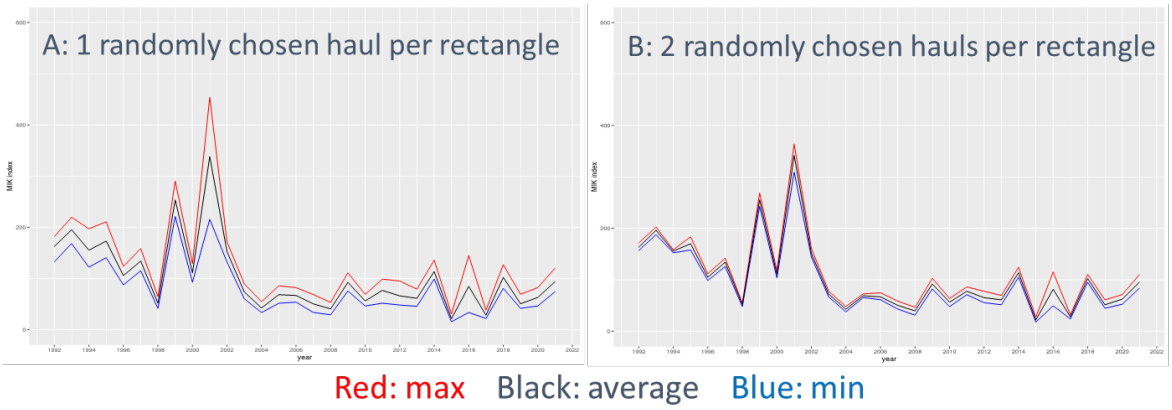

Figure 1.2.4: Test of the impact of few sampled MIK stations per rectangle: Re-calculated MIK time-series since 1992 with A = 1 and B = 2 randomly chosen MIK hauls per rectangle (max, average and min of 100 runs per year)

1.2.3 Herring larvae distribution and abundance

Figure 1.2.5 shows the size distribution of MIK larvae in 2022. Herring larvae measured between 7 and 44 mm standard length (SL). Again, and as in most years, the smallest larvae <12 mm were the most numerous and the larvae between 7 to 11 mm made up almost 50% of the total number of larvae. Larger larvae >18 mm SL were rarer, making up about 10% of all larvae, and were caught in lower densities than last year. An interesting feature in the 2022 length distribution is the peak at 15 mm SL.

Figure 1.2.6 illustrates the spatial distribution of 0-ringers in 2020, 2021 and 2022. In 2022, 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 southeastern and eastern part of the North Sea, the potential nurseries, abundance of large herring larvae was lower than in previous years.

Since 2017, the 0-ringer index (also called MIK index) time series is calculated with a new algorithm, which excludes larvae of Downs origin more rigorously. This is done by excluding the smaller larvae – presumably of Downs origin – from the analyses in certain parts of the survey area. Index values are calculated as described in the MIK manual (ICES 2017 – Note that this new time-series based on the new algorithm only dates back to 1992, and that all French data before 2008 are excluded because of data quality issues). The index from the 2022 survey (corresponding to the 2021 year-class) is 47.8. This is one of the lowest values in the time-series, with only 4 other year-classes being even lower (2003, 2007, 2014 & 2016).

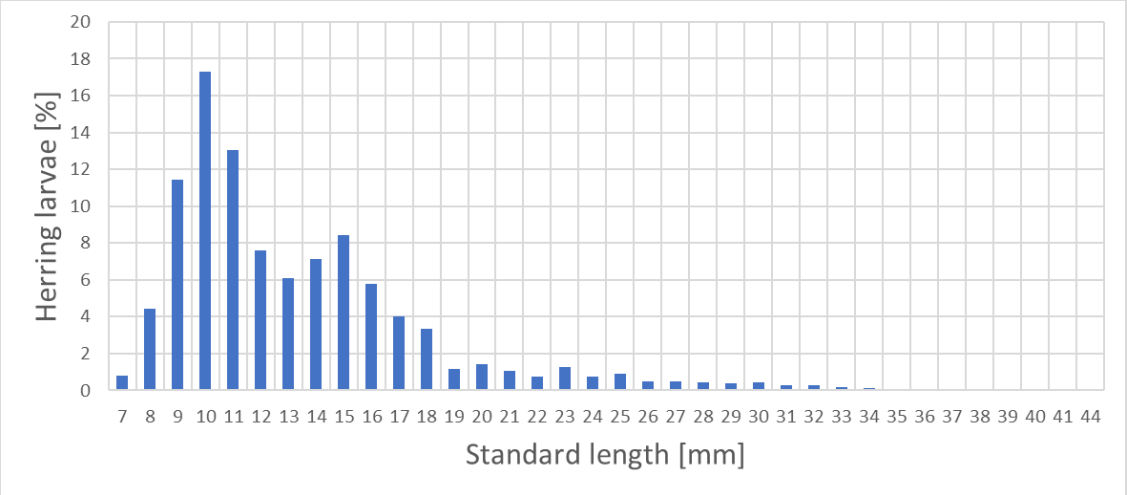

Figure 1.2.5: North Sea herring. Length distribution of all herring larvae caught during the 2022 Q1 IBTS.

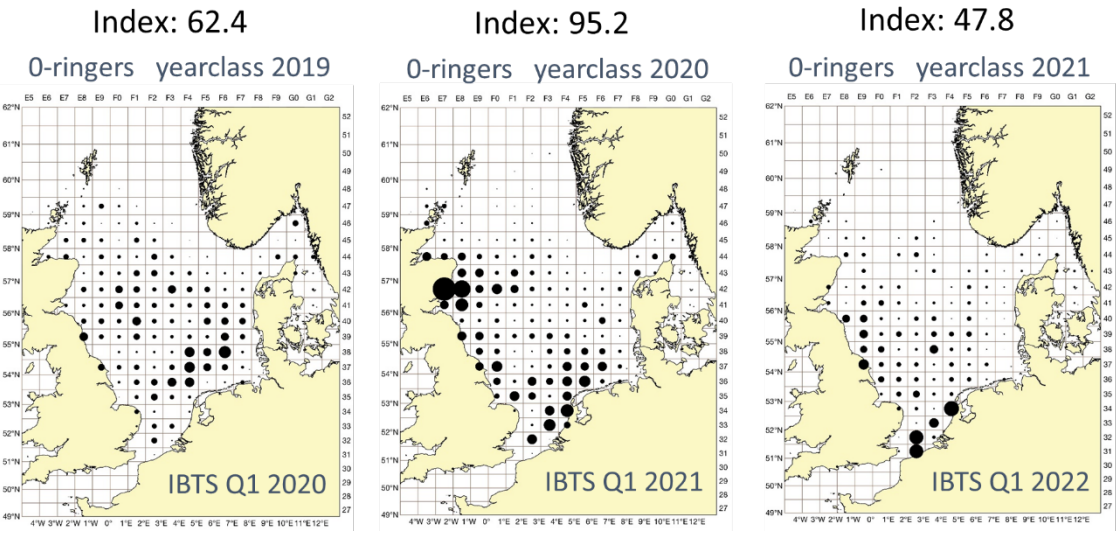

Figure 1.2.6: North Sea herring. Distribution of 0-ringer herring, year classes 2019 – 2021. Density estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in January/February 2020 - 2022. Areas of filled circles illustrate densities in no m-2, the area of the largest circle represents a density of 3.82 m-2. All circles are scaled to the same order of magnitude of the square root transformed densities.

1.2.4 Sardine larvae

As in most recent years, sardine larvae were also found in the 2022 MIK samples. Most sardine larvae occurred in the southern and south-eastern North Sea, as well as in the Skagerrak.

1.2.5 Planning & Coordination of the 2023 MIK sampling during the Q1 IBTS

MIK sampling will be carried out during the night time of the 2023 first quarter IBTS (IBTS Q1). The IBTS Q1 survey coordinator will circulate the survey plan by mid December 2022. MIK

participants are now requested to submit their data directly to the ICES fish eggs and larvae database in due time (i.e. 7 - 10 days) before the HAWG meeting.

1.2.6 The MIKeyM net sampling

Since 2012, eggs are collected along with the MIK sampling using the MIKey M net (MM, ICES, 2018b). In 2022, MM samples were obtained by six of the countries participating in the IBTS 1Q. MM samples were taken with every MIK sample 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.

1.2.7 Planning for the 2023 MIKey M net sampling

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 2023, all institutes are asked to carry out at least two MIKey M 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 or if 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 MIKey M sampling to provide coverage of the Skagerrak area.

1.3 The Downs Recruitment Survey

1.3.1 Survey in 2022

In 2022 the Downs Recruitment Survey (DRS) was carried out following the IBTS-MIK protocol (ICES 2017) as much as possible, but the sampling was carried out both day and night, instead of only at night. Because of the daylight sampling, a blue netting material instead of the usual black fabric is used. Norway was not able to participate in the survey this year. Therefore, the Netherlands was the sole survey participant in 2022.

The survey was conducted from 21 – 29 April, sampling 63 stations in total (Fig 1.3.1)..

On all stations large samples were caught, with high volumes of jellyfish, and all contained larvae. High numbers of sandeel, gadoids and clupeid larvae were found. Of the sampled stations, 17 did not contain herring larvae (Fig. 1.3.1). These stations were mostly on the two northernmost transects and in the northwest corner of the sampling area. Highest numbers of herring larvae were found in the southern North Sea and adjacent to the Frisian Islands. Herring larvae distribution and numbers were comparable to 2021 (Fig. 1.3.2). In 2019 the numbers were much lower and the larvae more westerly distributed (Fig. 1.3.2). 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 1.3.3).

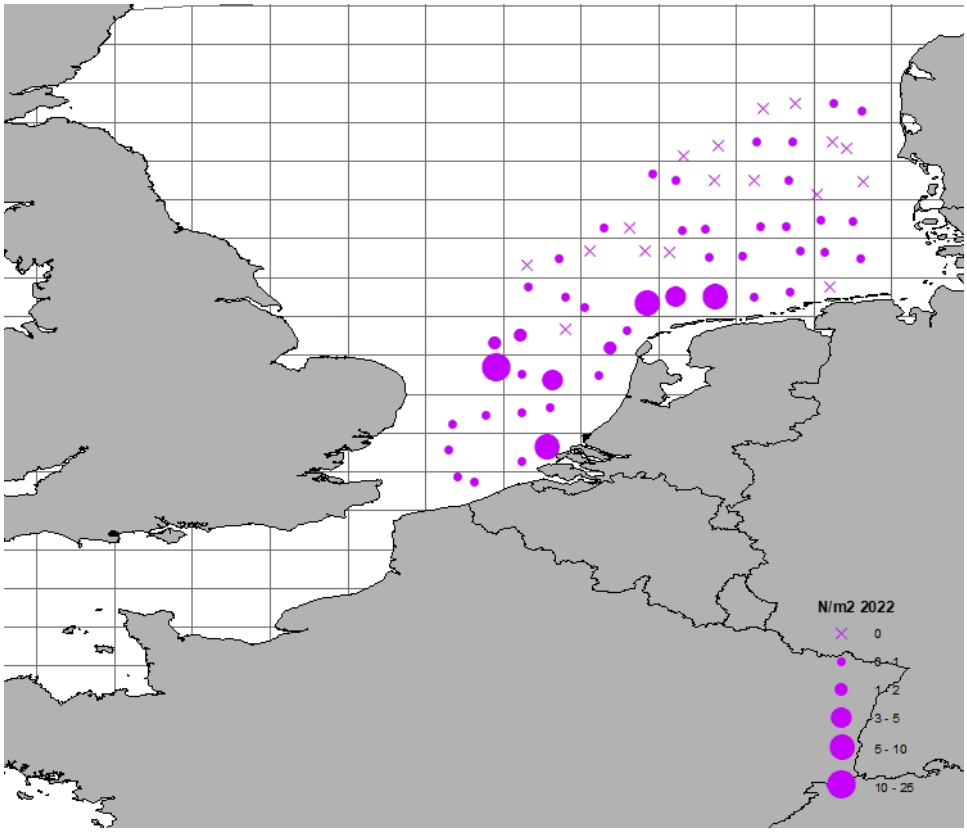

Fig. 1.3.1. Herring larvae distribution by haul from the 2022 DRS.

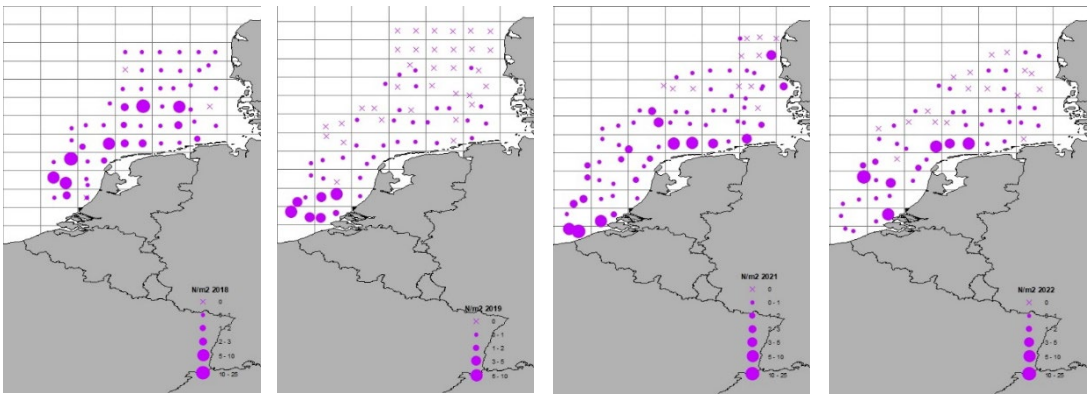

Fig. 1.3.2. Herring larvae distribution for the time series, 2018-2022. (Note: No survey was carried out in 2020.)

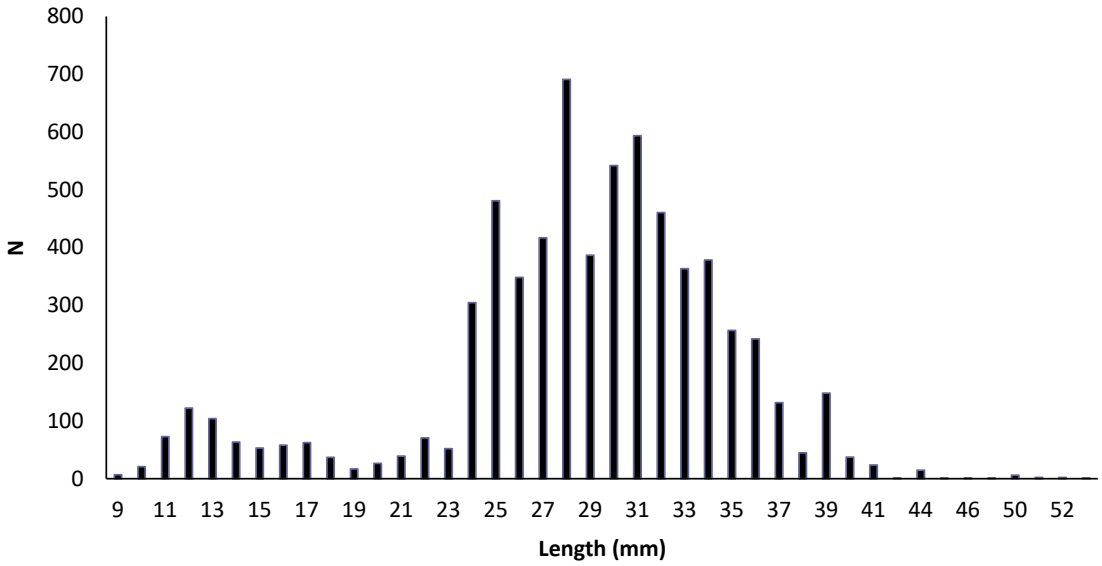

Fig. 1.3.3. Herring larvae length distribution from the 2022 DRS.

1.3.2 Preliminary results on indices calculations

Indices were calculated following the MIK manual (ICES 2017): herring larvae abundance per haul are first raised to numbers per ICES rectangle, and then raised the North Sea MIK subarea (ICES 2017). However, as the DRS only samples parts of the MIK-areas SouthEast (se) and SouthernBight (ch), the index was also calculated raising the rectangle abundances to the actual area sampled (Table 1.3.1). The MIK and DRS indices were summed to a total MIK index (Table 1.3.1).

When using the MIK areas for the calculation the index is 11 to 84% higher compared to using only the area sampled (Table 1.3.1). In most years the DRS index is much higher compared to the MIK index (Table 1.3.1)

Table 1.3.1. DRS and MIK time series from 2018-2022. DRS index is calculated using the MIK areas and using the actual rectangles sampled. Total MIK is the combined MIK and DRS index. (Note: No survey was carried out in 2020.)

Survey year	Year class	DRS index		MIK index	
		DRS (using MIK areas)	DRS (using sampled rectangles)	IBTS-MIK sampling	Total MIK
2018	2017	156.3448808	84.96485884	102.2	258.5448808
2019	2018	27.14121575	20.75566303	51.6	78.74121575
2020	2019			62.4	
2021	2020	191.144775	171.3054805	95.2	286.344775
2022	2021	143.3865136	99.89198396	47.8	191.1865136

1.3.1 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. 1.3.4). Tridens has a portside and a starboard 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, 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 again 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.

This experiment was planned to be conducted again in 2022. However, due to technical issues with Tridens winches, this was postponed to 2023.

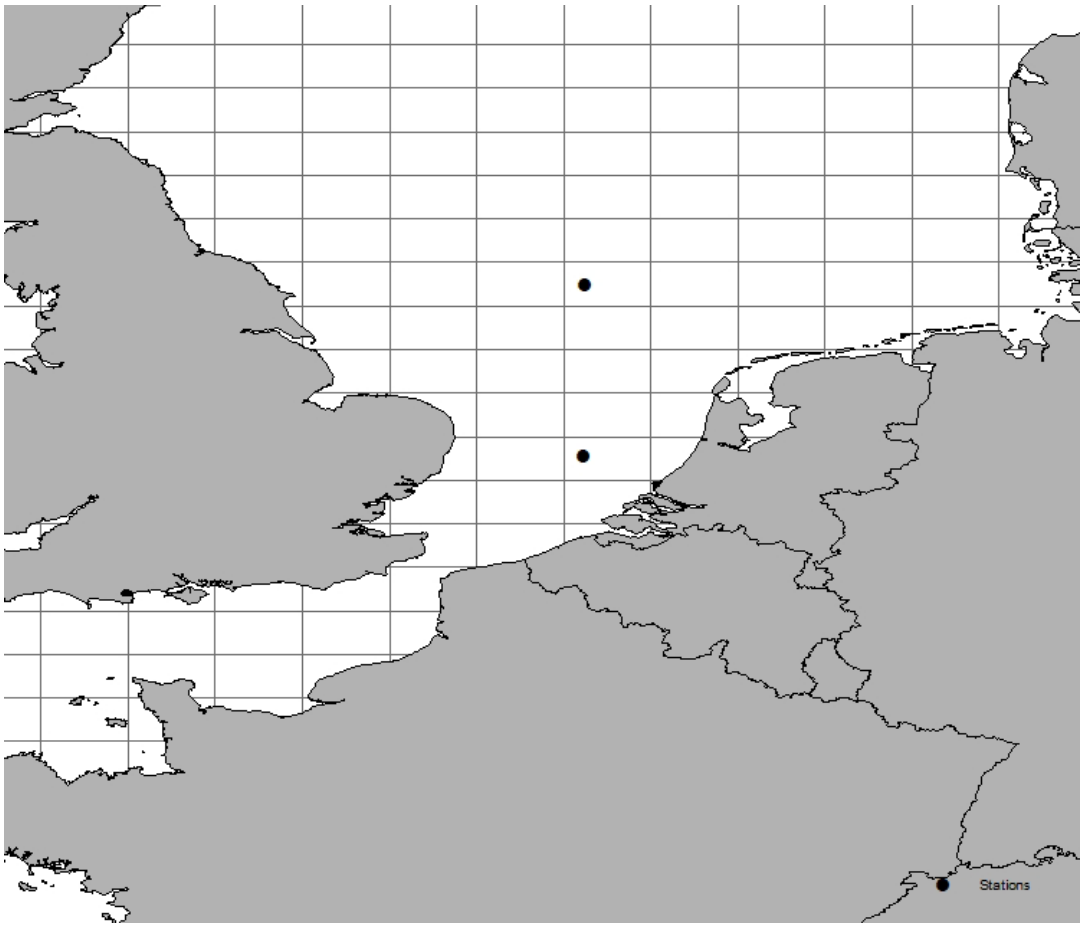

Fig. 1.3.4. Position of stations for comparative sampling with the blue and black midwater ring trawl. The northern station was sampled for 24 hours, the southern station 18 hours.

Preliminary results of the comparative sampling suggest that the MIK catches less herring larvae caught during the day than at night (Fig. 1.3.5). This needs be investigated further when 2023 sampling data is available as well. WGSINS agreed to have a subgroup meeting in summer 2023 to discuss the below points further and agree on the way forward with the DRS.

Points for further data exploration and discussion by the DRS subgroup:

- Combine all 2021 and 2023 results
- Include length frequency plots over comparing day and night time sampling
- Show day and night time on the larvae distribution plots for the 2018 to 2023 sampling
- Agree on the calculation of the DRS index and the total MIK index

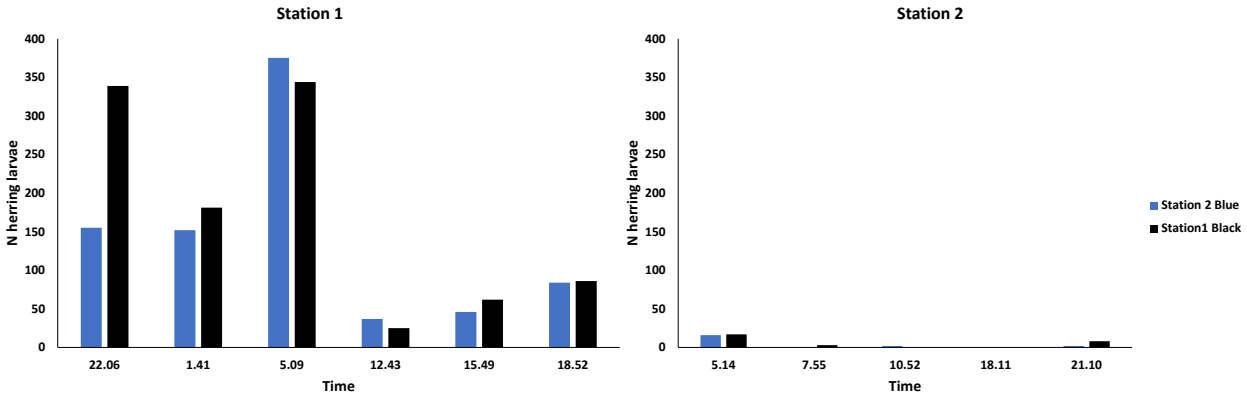

Fig. 1.3.5. Preliminary numbers of herring larvae caught over the day in 2021.

Because the preliminary results suggest that night time catches are much higher at night, WGSINS decided to already advice that the DRS will need to be carried out during night time only. However, with the current survey capacity available it will not be possible to cover the southern North Sea and German Bight when only sampling at night.

1.3.2 Planning for the 2022 survey

The Netherlands will carry out a Downs Recruitment survey from 24 – 28 April 2023. Norway will be requested to again participate in the DRS sampling. At the moment participation of other nations is unsure. After the DRS, the Netherlands is planning to carry out more comparative fishing hauls to investigate the effect of day versus night sampling and the use of a blue net on the catchability of herring larvae.

For the survey in 2024 WGSINS will be seeking for extra survey participation. With the current survey capacity it will not be possible to completely sample the southern North Sea and German Bight when sampling can only be done at night.

1.4 The Northern Irish Herring Larvae Survey (NINEL)

1.4.1 Background information

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).

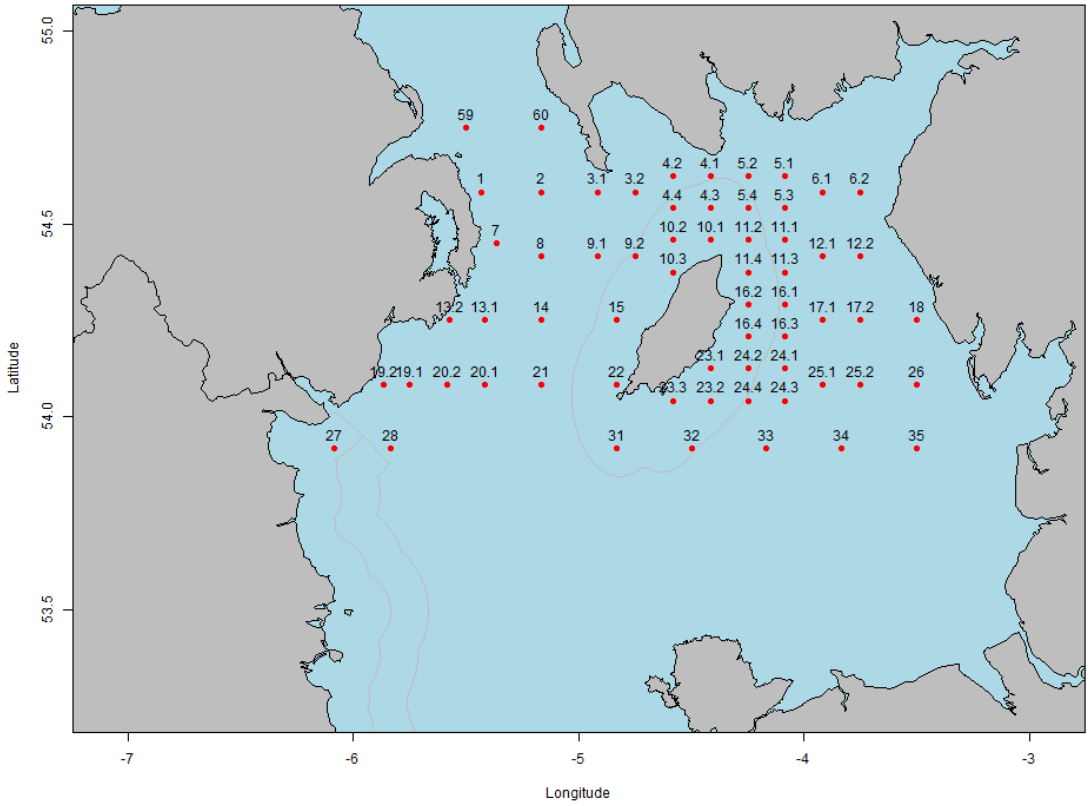

Figure 1.4.1: Station positions for NINEL survey.

1.4.2 Survey Results in 2021

The NINEL survey was completed during 9-13th November with a total of 59 Gulf7 stations sampled. 9605 herring larvae were sorted from samples, with a subsample measured prior to preservation in alcohol. Depth profiles of salinity and temperature were collected at all stations, and remaining plankton samples preserved. Station 27 was not sampled due to permissions not being sought to enter ROI waters.

As in previous years the majority of larvae were captured in the eastern Irish Sea, in the vicinity of the Douglas bank spawning ground (Figure 1.5.2). Larval lengths ranged in size from 5.1 to 18.9 mm, with modal lengths of ~8.0mm in the area of Douglas bank (Figure 1.5.3). The length frequency of larvae suggesting a high mortality rate of larger larvae or sampling occurring close to the beginning of the larvae hatching period. The estimated abundance of larvae, particularly small (<10mm) larvae, was high for the survey.

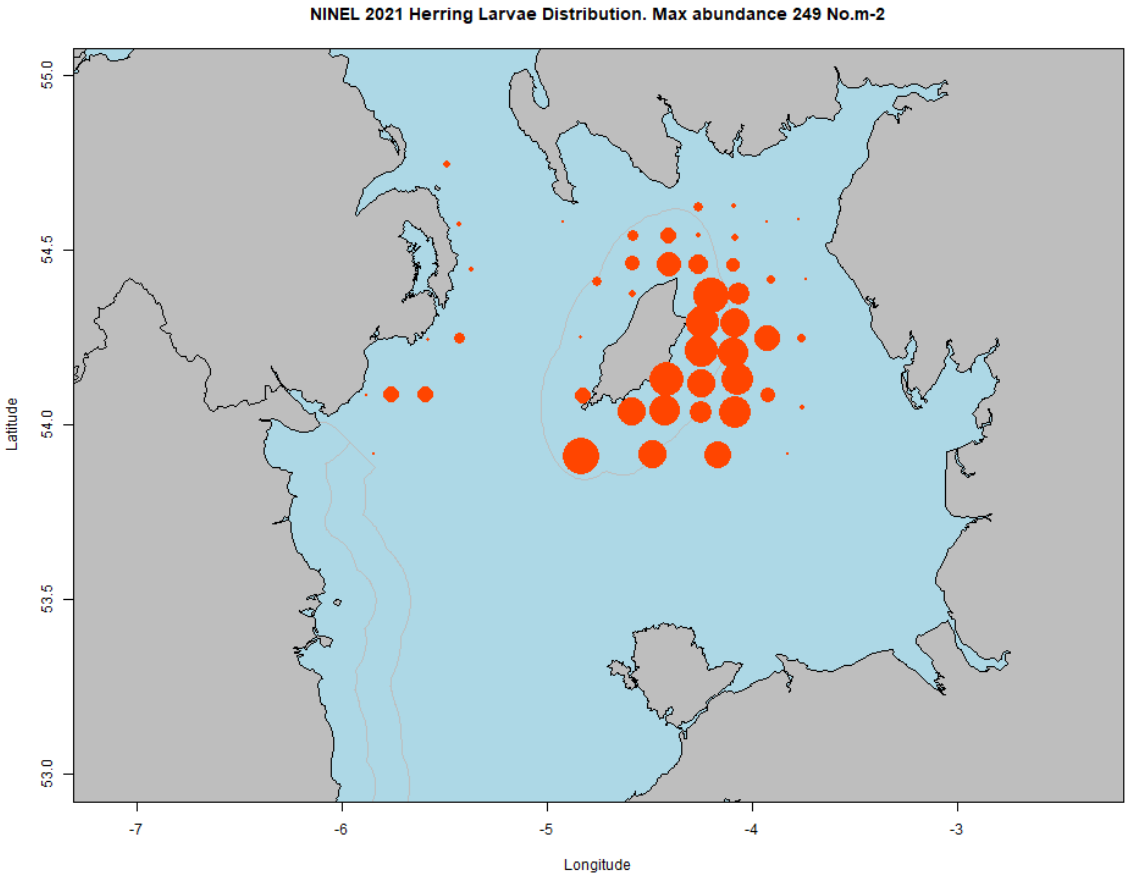

Figure 1.4.2: Abundance of herring larvae captured during 2021 NINEL. Maximum abundance 249 no.m-2.

Figure 1.4.3: Length frequency of larvae removed from Gulf7 samples, total per strata.

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

1.5.1 Background information

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.

1.5.2 Survey Results in 2022

In 2022 the NIMIK survey was forced to depart approximately 2 weeks earlier than initially scheduled due to the RV Corystes being required for a charter. The NIMIK survey is timed to coincide with the pre-settlement stage of juvenile gadoids in the western Irish Sea and this earlier scheduling resulted in a mismatch with this life history stage. In addition to the problems presented by the earlier scheduling of the survey a mechanical fault resulted in the survey ending prematurely. This resulted in poor temporal coverage of the important nursery area and low catches of juvenile gadoids in comparison to previous years (Figures 1.6.1-1.6.2).

No target species of juvenile cod (*Gadus morhua*) where caught, while low catches of haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*) were located predominantly in the western Irish Sea, and north eastern region (Figure 1.6.3).

As well as the 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.

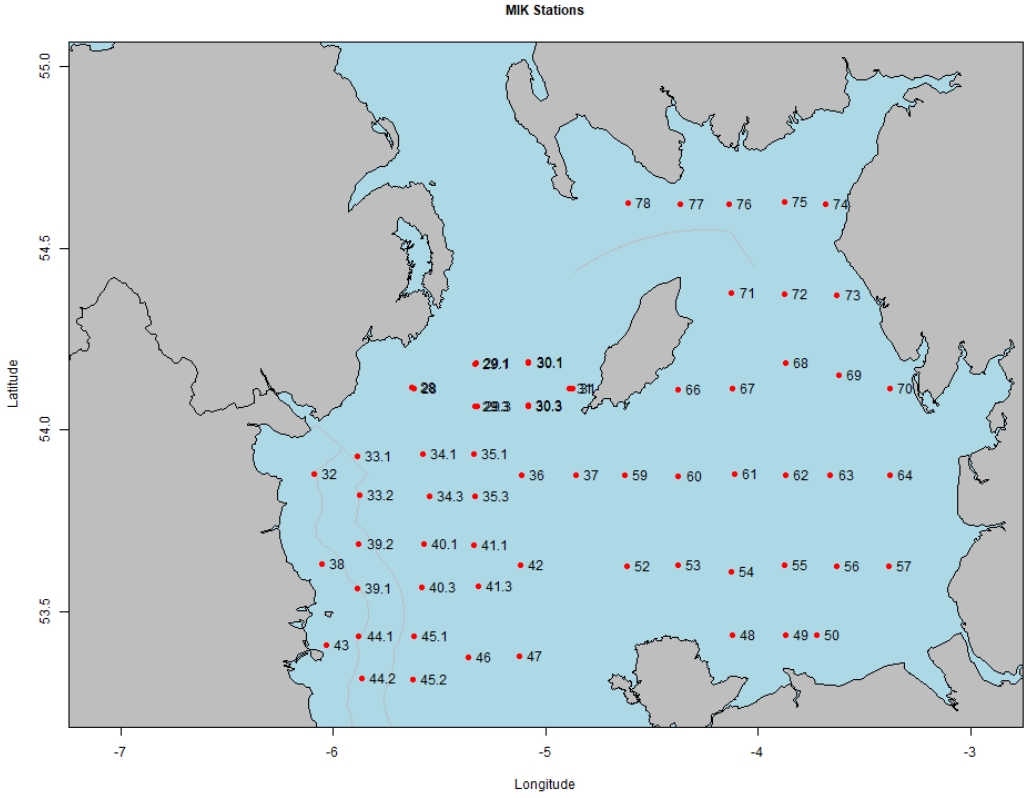

Figure 1.5.1. MIK Station positions during 2022 NIMIK survey.

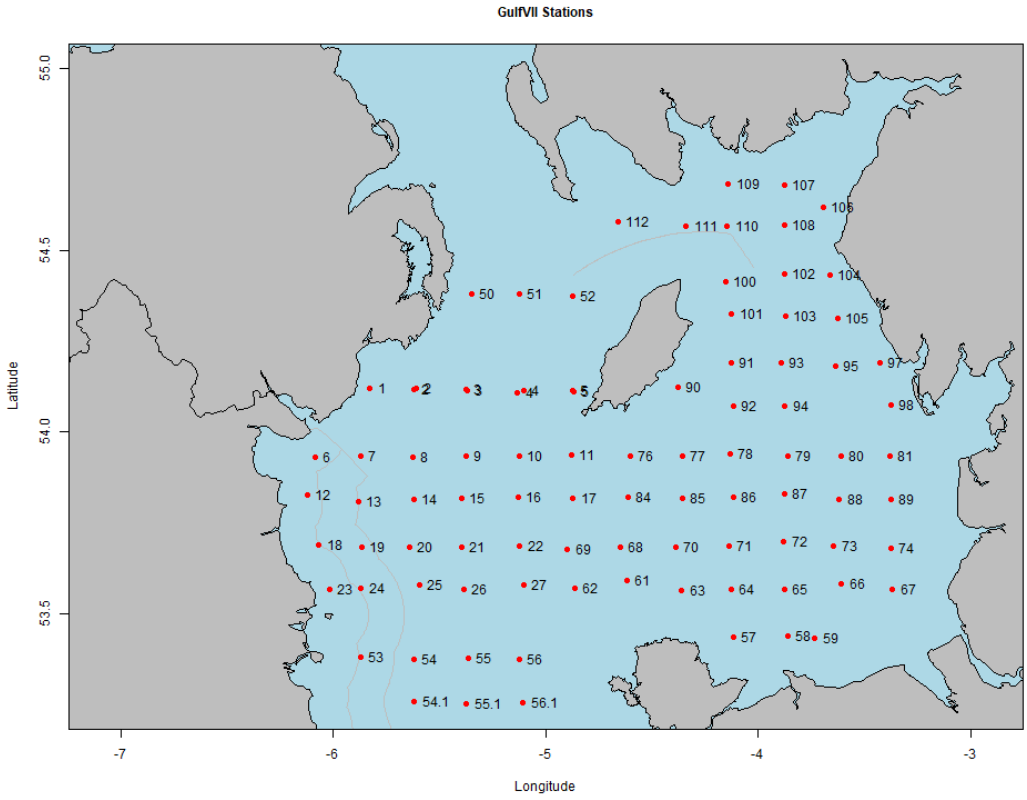

Figure 1.5.2. Gulf7 station positions during 2022 NIMIK survey.

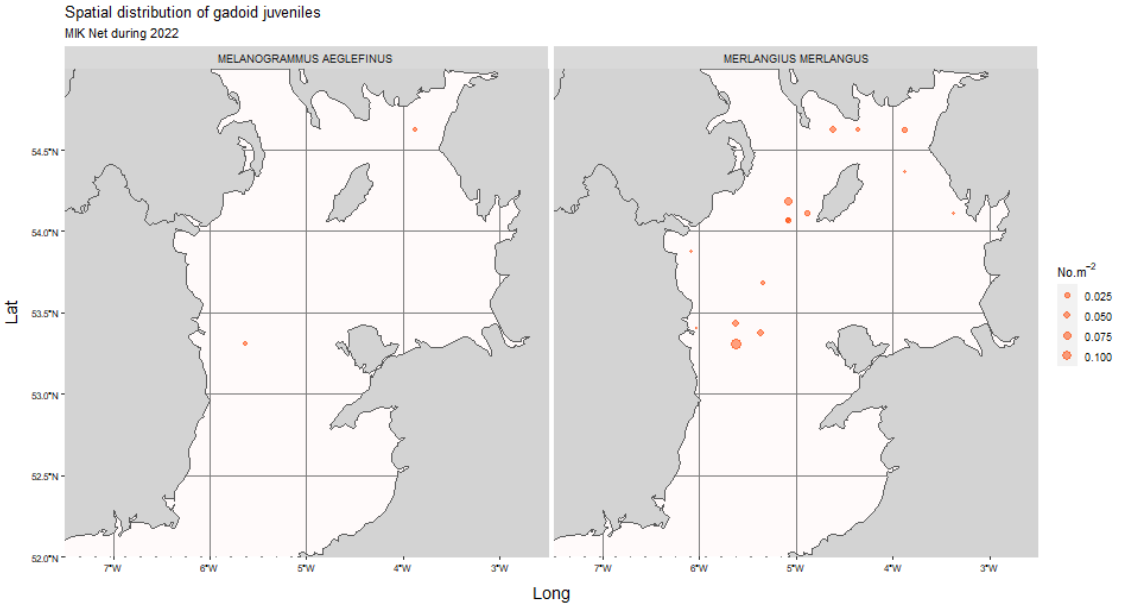

Figure 1.5.3. Spatial abundance (No. m-2) of juvenile gadoids haddock (Melanogrammus aeglefinus) and whiting (Merlangius merlangus).

1.6 The Rügen Herring Larvae Survey (RHLS)

1.6.1 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 has been sampled weekly using ichthyoplankton gear (Bongo-net, mesh size 335 µm) during the main reproduction period from March to June. Due to limited ice cover and changing spawning phenology the survey duration was extended in recent years starting in mid-February. The weekly assessment of the entire sampling area is conducted within two days (detailed description of the survey design can be found 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 ICES Herring Assessment Working Group (HAWG).

The rationale for the *N20* recruitment index is based on strong correlations between the number of larvae reaching a length of 20 mm (TL) in Greifswald Bay and abundance data of juveniles (1-wr and 2-wr fish) 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 (for details see 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.

1.6.2 2021 N20 index

The regular Rügen-Herring Larvae Survey started on March 2nd and continued weekly until June 26th 2021 including a total of 595 stations/hauls. Additional cruises in mid-February (winter control) and November (autumn control) had to be cancelled due to ice cover (Feb.) and vessel problems (Nov.), respectively.

With an estimated product of **2751 million** larvae, the 2021 *N20* recruitment index is more than 10 times higher than that of the record low in 2020 and the highest value since 2015 (Table 1.6.1, Figure 1.6.1).

1.6.3 2021 additional survey observations

According to former observations on the impact of winter SST on spawning phenology and herring early life stage survival (Gröger et al. 2014, Polte et al. 2021), the reasons for the higher N20 index compared to the previous year can be speculated being related to relatively cold February-temperatures, most probably resulting in a comparatively positive spawning phenology

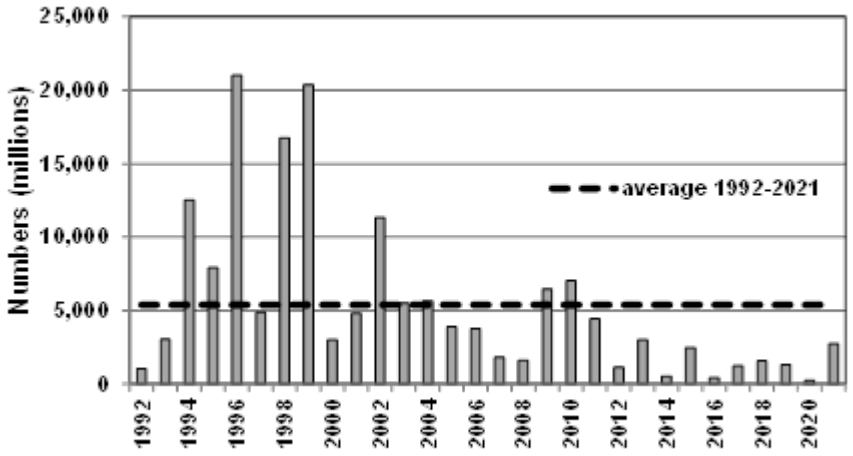

Figure 1.6.1: Validated RHLS time series with N20 index data presented as cumulative value of weekly mean abundance of 20 mm larvae in millions.

Table 1.6.1: 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	2021	2751

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

After multiple years with the record low N20 (2014, 2016, 2020), 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 (R^2= 0.75). The N20 larvae index is correlated with GERAS data including a 1-year lag phase. As GERAS 1-wr data for 2022 are not yet available, the correlation can only include N20 data 1992-2020 correlated to GERAS 1-wr 1993-2021.

1.7 The Baltic Ichthyoplankton Surveys (BIS)

1.7.1 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 marine, steno-haline 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.

1.7.2 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-OF – 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.

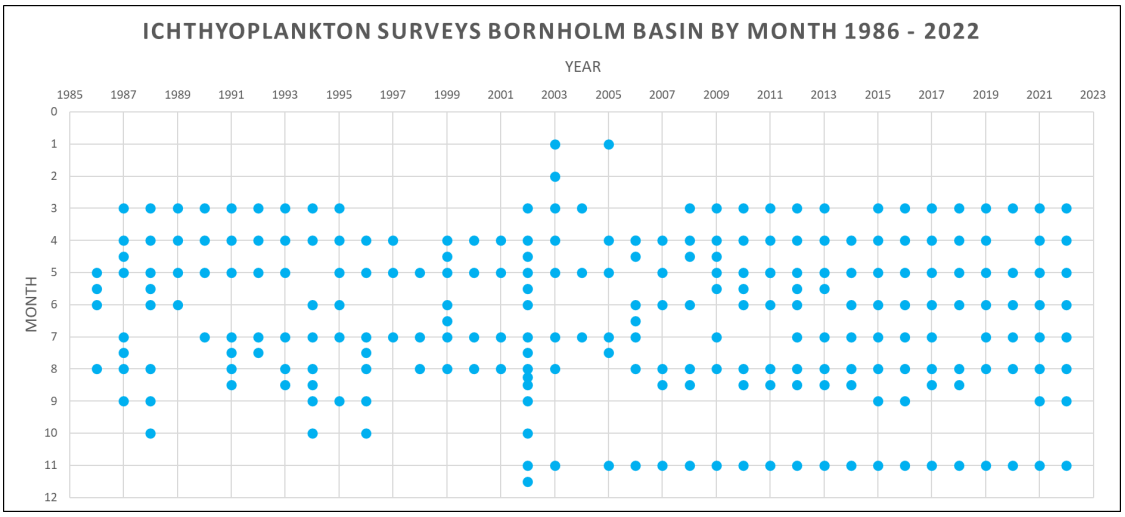

Fig. 1.7.1. Time series of individual BIS surveys by years and months.

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”).

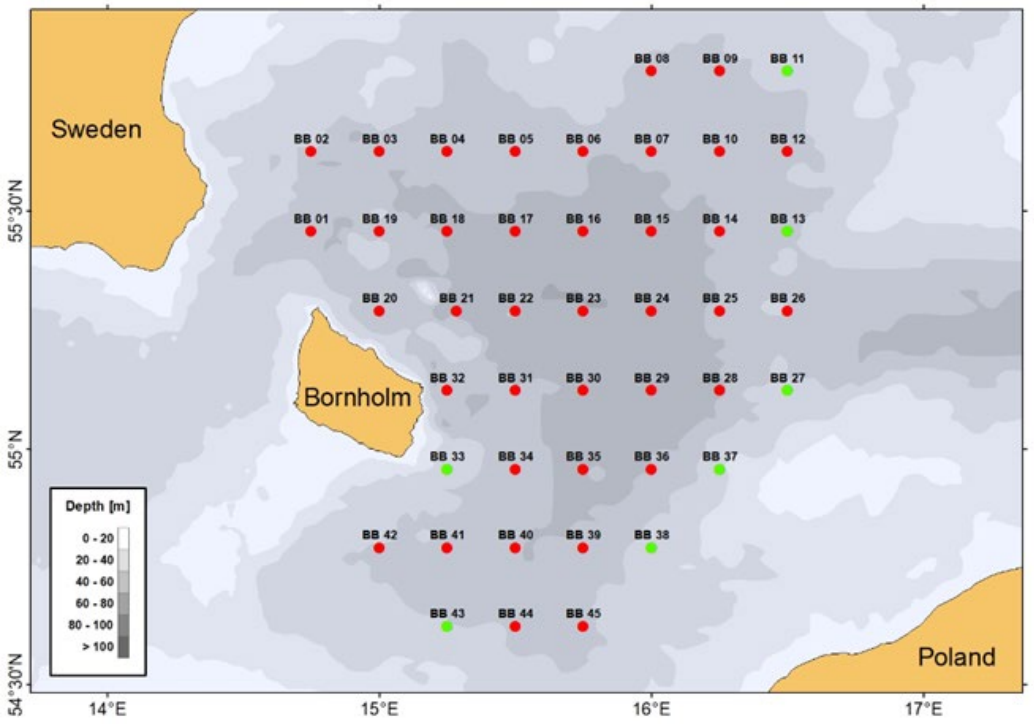

Fig. 1.7.2. The present BIS standard station grid in the Bornholm Basin, consisting of 45 stations. The seven stations shallower than 60 m (green symbols) are excluded from the calculations of average egg abundances used in the AEPM and DEPM.

1.7.3 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.

1.7.4 The Baltic Ichthyoplankton Surveys in 2022

Throughout the 2022 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). The standard grid consisting of 45 stations was conducted on the 8 surveys, amounting to a total of 360 sampled stations in 2022. 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 2022. The final data will be collated and the time-series of stock biomass estimates and larvae indices will be provided to WGBFAS in spring 2023.

Table 1.7.1. Overview of individual BIS surveys conducted in 2022.

Institute	Ship	Cruise Nr	Year	Month	n standard stations conducted	Cruise dates
DTU Aqua	DANA	DANA 02/2022 (BITS 1)	2022	3	42	February 21 - March 10
GEOMAR	ALKOR	AL 571	2022	4	45	April 21 - 30
GEOMAR	ALKOR	AL 573	2022	5	45	May 14 - 30
NMFRI & DTU Aqua	BALTICA	Baltica June 2022	2022	6	45	June 20 - July 01
IMF Hamburg	ALKOR	AL 577	2022	7	45	July 28 - August 08
NMFRI	BALTICA	Baltica August 2022	2022	8	45	August 19 - 29
GEOMAR	ALKOR	AL 580	2022	9	45	August 30 - September 10
DTU Aqua	DANA	DANA 07/2022 (BITS 2)	2022	11	44	November 01 - 18

1.7.5 Planning for the 2023 Baltic Ichthyoplankton Surveys

For the 2023 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 2023. See table 1.7.2 for details.

Table 1.7.2. Overview of individual BIS surveys planned for 2023.

Institute	Ship	Cruise Nr	Year	Month	n standard stations planned	Cruise dates (preliminary)
DTU Aqua	DANA	DANA 02/2023 (BITS 1)	2023	3	45	March 06 - 24
GEOMAR	ALKOR	AL 592	2023	4	45	April 15 - 27
GEOMAR	ALKOR	AL 594	2023	5	45	May 13 - 28
NMFRI & DTU Aqua	BALTICA	Baltica June 2022	2023	6	45	June 15 - 26

IMF Hamburg	ALKOR	AL 598	2023	7	45	July 27 - August 06
NMFRI	BALTICA	Baltica August 2022	2023	8	45	August 15 - 26
GEOMAR	ALKOR	AL 601	2023	9	45	August 30 - September 10
DTU Aqua	DANA	DANA 06/2023 (BITS 2)	2023	11	45	November 06 - 24

2 Pilot surveys & Additional work on existing surveys

2.1 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 also 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 and ecosystem approaches to fisheries management. An analytical assessment for 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 during night-time 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.

By the time of WGSINS 2022, a total of five pilot surveys had been conducted in July/August 2018, 2019 and 2020 and in August/September 2021 and 2022, 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.

During the first 4 years, it became clear that a number of prerequisites for establishing a recruitment index were fulfilled, e.g. that sprat larvae are present in the survey area at the time of the survey and can be caught representatively, spawning activity of sprat is finished before the time of the survey and the MIK sampling can effectively be incorporated into the standard routines of the Q3 IBTS. However, catchability tests between daylight and nighttime have shown that sprat larvae are only caught representatively at night, which is limiting the available time for sampling to approximately 7-8 hours per night. Furthermore, while the main distribution area of sprat larvae seems to be covered by the Danish Q3 IBTS, a better spatial coverage would be desirable. Based on the promising preliminary results from these first 4 years, DTU Aqua decided to continue the pilot survey in 2022.

Table 2.1.1 provides an overview of the sampled stations in the first 5 years of pilot surveys. In 2018 and 2019, 71 and 66 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 89 hauls was conducted on a joint Danish-German survey. In 2022, a total of 63 hauls was conducted by Denmark. Fig. 2.1.1 shows a map of the MIK sampling

stations during the 2022 Q3 IBTS. In addition, Marine Scotland Science also conducted MIK sampling during their Q3 IBTS in 2021 on 51 stations.

Table 2.1.1: Overview of MIK sampling stations conducted during the Q3 IBTS

Year	Denmark	Germany	TOTAL
2018	71	-	71
2019	66	-	66
2020	68	60	128
2021	89 (joint DK/GE survey)		89
2022	63	-	63

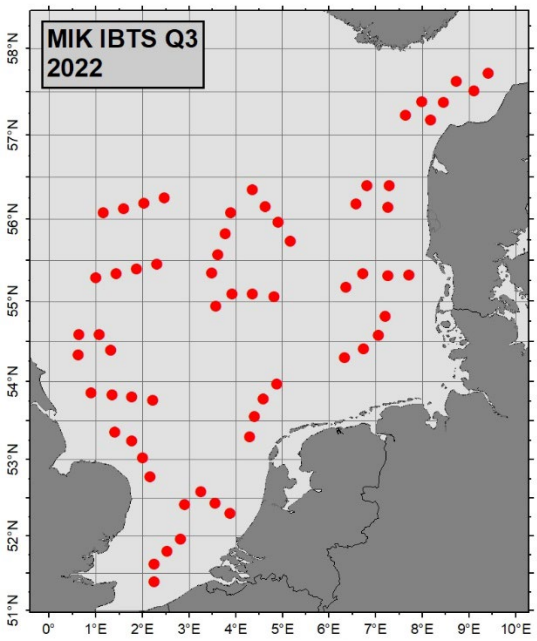

Fig. 2.1.1. MIK sampling stations during the Q3 IBTS in 2022.

The gear in use during the pilot surveys is a MIK net with a ring of two meter in diameter and a mesh size of 1.6 mm. 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 and 2022. 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 five 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. A similar, recurring pattern in the spatial distribution of sprat and sardine larvae could be observed in all 5 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. Catches of sprat larvae in 2022 were the lowest in the five years investigated so far. The MIKeyM samples 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.

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.

At the time of WGSINS 2022, recruitment estimates from the stock assessment were available for the year-classes corresponding to the first 4 years of the pilot survey (2018 - 2021). The first 3 years indicated similar trends in larval abundance and recruitment, while the last year did not fit so well. However, the recruitment estimate for the last year (2021) is so far only based on age 1 sprat catches from the Q1 IBTS and is therefore still very preliminary. Besides, the catches of these age 1 sprat of the 2021 year-class may be underestimated due to the extremely bad weather conditions and other severe difficulties during the 2022 Q1 IBTS (see section 1.2 about the 2022 Q1 MIK survey for details).

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.

Based on the promising results from the first 5 years, DTU Aqua is planning to continue the pilot surveys in 2023. However, 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. In the 2022 survey, mackerel larvae were caught in the northeastern part of the survey area, whereas larger mackerel juveniles (approx. 4-6 cm) were caught in the northwestern area. It could be interesting to investigate further if these juveniles originate from mackerel spawning in the North Sea, or if they were drifted in from the Atlantic. No dedicated funding is presently available to investigate these other species in detail. However, numbers of larvae of other species from the 2018 and 2019 surveys and partly from the 2020 survey were analyzed in the framework of student theses.

2.2 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. Larvae of sandeel and other fish species were sorted from the samples, 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.

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 the spatial distribution of larvae, which only show considerable larval abundances in the immediate vicinity of the known sandeel burying areas. In addition to maps showing the actual larval abundances (see WGSINS report 2021), hot spots of larval occurrence were also analyzed with a spatial GAM model (Fig. 2.1.1). These analyses indicate 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.

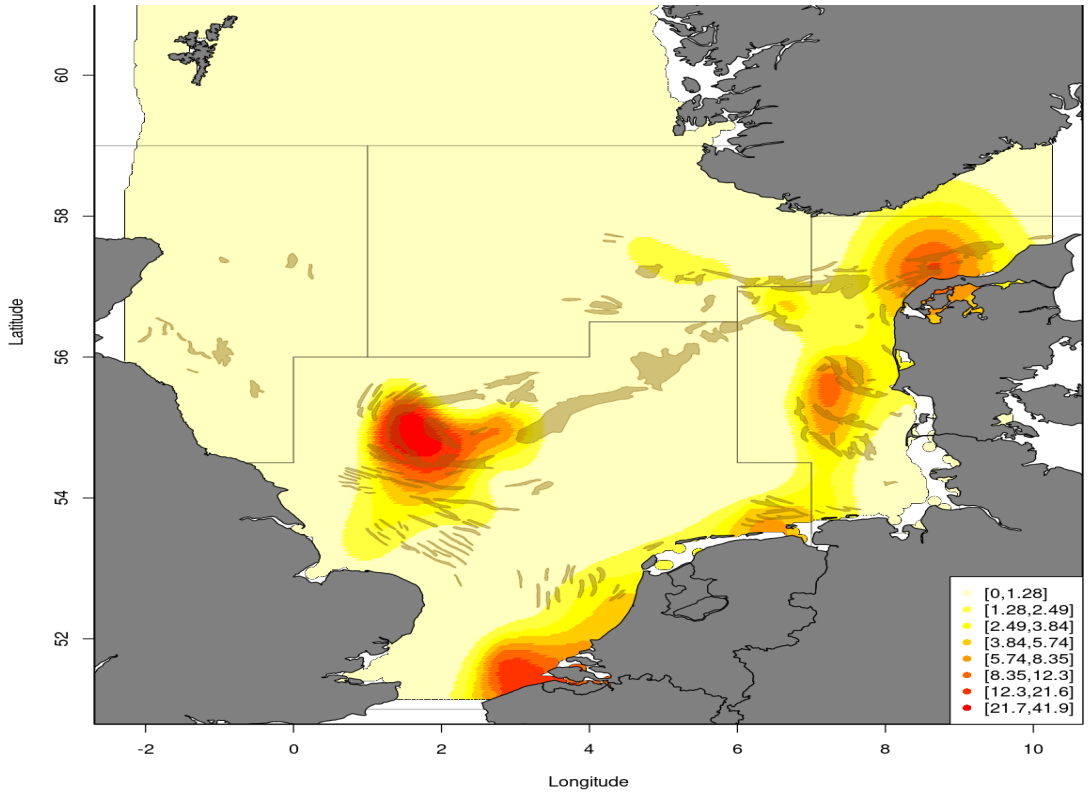

Fig. 2.2.1 Hot spots of recently hatched sandeel larvae from MIKeyM samples based on a spatial GAM model (average for 2015 – 2020, preliminary data). The shaded areas in the background show the known sandeel burying areas (Map produced by Tobias Mildenberger, DTU Aqua).

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 hydrodynamic modelling and by genetic analyses of larvae and adults. Results are expected to be used in stock assessment and management, e.g. to review and potentially re-define the borders of the sandeel management areas in the North Sea.

2.3 Marine Litter sampling during the North Sea Midwater Ring Net survey (Q1 MIK-IBTS)

Marine litter is collected from standard MIK samples taken during the Q1 IBTS (Denmark since 2014, all other nations since 2017). The samples collected up to 2020 have been analyzed in the

project MARLINS (Marine Litter in the water column of the North Sea) coordinated by DTU Aqua and funded by the Danish VELUX Foundation.

In addition, samples from Dutch Downs MIK surveys and Danish Q3 MIK pilot surveys were analyzed in the project. The following samples were analyzed and compiled in a database in the MARLINS project:

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.

For further details, it is referred to previous WGSINS reports, the final MARLINS report and a presentation at the ICES ASC 2021 (Theme Session J: "Advances and challenges in marine litter pollution"). It is further planned to publish results in a relevant scientific journal, e.g. Science of the Total Environment or Marine Pollution Bulletin.

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 down to 100 m, 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.

2.4 Holistic approach to the ichthyoplankton surveys in the North Sea and adjacent waters. Can we define common themes/cross overs between the different surveys?

Currently there are a number of surveys sampling ichthyoplankton in each of the Greater North Sea (including a small part of the Celtic Sea region), Irish Sea and the Baltic Sea (e.g. the Bornholm Basin). The general location and timing of a selection of these surveys are shown in Figure 2.4.1.

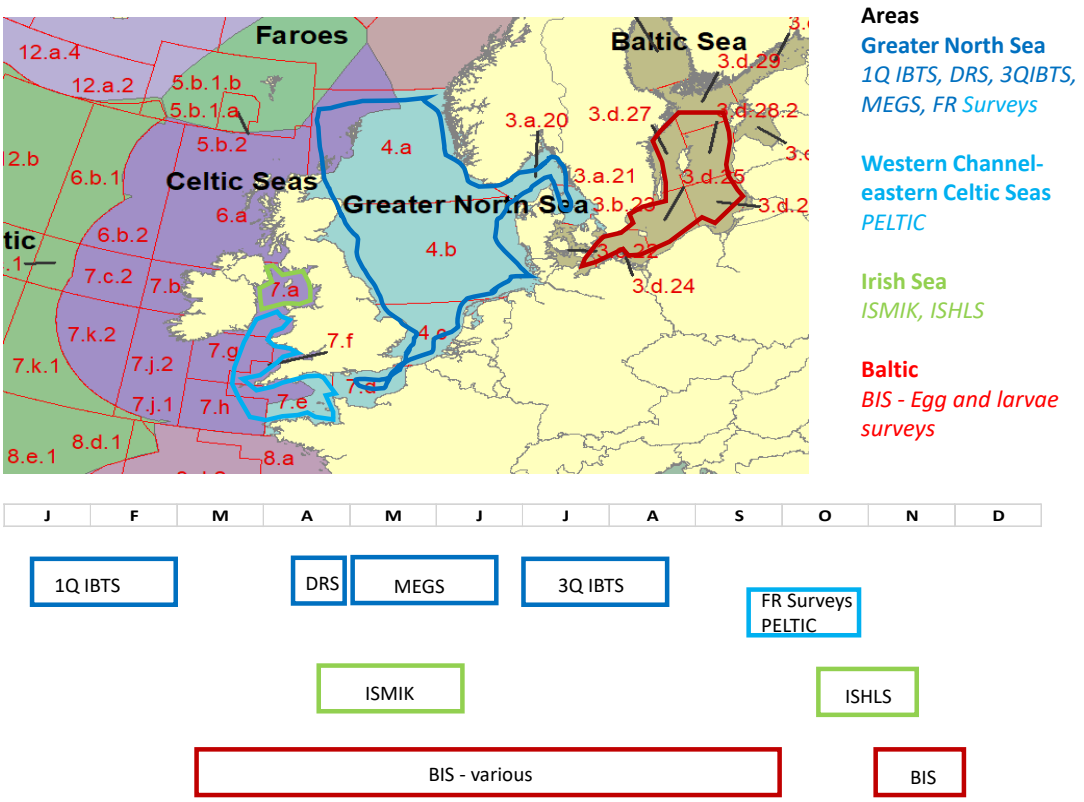

Figure 2.4.1 Current ichthyoplankton surveys in the North Sea and adjacent areas. Upper panel; Geographic location of surveys. Lower panel; Annual survey time slots. Note that there are other surveys which are not shown here.

Each of these surveys generally has one or two target species and whilst other eggs and larvae are also sampled, currently these non-target species are often not reported, identified, or enumerated. A summary of the target species and the eggs and larvae routinely identified and enumerated is given in Table 2.4.1.

Table 2.4.1. Target species and ichthyoplankton identified and enumerated in the surveys given in Figure 2.4.1. 1Q IBTS MIK – 1st Quarter IBTS MIK survey; 1Q IBTS MIKeyM– 1st Quarter IBTS Survey MIKeyM sampling; DRS – Downs Recruitment Survey (MIK); MEGS – North Sea Mackerel Egg Survey; 3Q IBTS MIK – 3rd Quarter IBTS MIK; FR Surveys – French ichthyoplankton surveys in the English Channel; PELTIC – Acoustic survey in the western Channel and Celtic Sea; ISMIK – Irish Sea MIK; ISHLS – Irish Sea Herring larvae survey; BIS – Bornholm Basin ichthyoplankton surveys.

Survey	Target species	Others identified or enumerated	Non-identified
1Q IBTS MIK	Herring	Sprat, sardine, lemon sole	Various
1Q IBTS MIKeyM	Cod, plaice, sandeel	Various eggs	Various eggs
DRS	Herring	Sprat, sardine	Various larvae
MEGS	Mackerel, Horse mackerel		Various eggs and larvae

3Q IBTS MIK	Sprat	Sardine, mackerel	Various larvae
FR Surveys	Sardine		Various eggs
PELTIC	Sprat, sardine		Various larvae
ISMIK	Cod, haddock	Majority of larvae	
ISHLS	Herring		
BIS	Cod, sprat	Herring larvae, eggs & larvae of various other species	

These surveys, when considered together, could provide temporal information on the ichthyoplankton in these regional seas, and if considered together with e.g. the hydrography and/or lower trophic levels e.g. chlorophyll-a or zooplankton, contribute to an ecosystem level assessment of the area. In addition, these data could provide additional ecological data on the dynamics of the early life history of a number of commercially important fish species. This could also include comparisons or investigations of synergies between areas and/or putative stocks.

Besides input to assessments, there is the question, what else can the surveys be used for? What products and information could be delivered? Obvious examples are spatial distribution and ecology of non-target species. Variability in spawning time and hatching areas. In regard to species of interest there is a long list of potential species which include: herring, cod, lemon sole, sprat, haddock, witch, sardine, plaice, ling, anchovy, sole, mackerel and hake.

Using one species as an example, sprat, there is potentially data on larvae distributions from the Celtic Sea, up into the Irish Sea, through the English Channel and into the North Sea. Similarly, with sardine there are larvae data from the Celtic Sea eastward into the North Sea. In the latter case there is a distribution and abundance increase in both adults and larvae over time from the west to the east. In regard to fisheries, currently a fishery and assessment of stock size takes place in the south and west (Biscay and Subarea 7) but as yet does not in the east (Subarea 4).

This section has only considered the on-going vessel-based surveys, however, there are also a number of other data sources that could also be considered within this framework. Of particular interest here are the fixed stations such as the Marine Biological Association station L4 (English Channel; Western Channel Observatory), Helgoland Roads sampling station (Malzahn and Boersma 2007) and the Newcastle sampling station (Dove Marine Laboratory - School of Natural and Environmental Sciences - Newcastle University (ncl.ac.uk)) (all of which have long time-series) and also a number of coastal power station which retain young fish on their cooling water intake screens.

The Working Group will continue to consider the potential 'added' value which can be gleaned from these surveys and how additional data, e.g. by considering combinations of surveys, can be used to inform on pertinent uncertainties in the assessment of specific stocks in the ICES area.

3 Data handling and discussions on various ToRs and other topics

3.1 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 submitters.

Besides archiving the data, the procedures and calculation routines for the MIK index (North Sea Midwater Ring Net survey) are being implemented in the ICES TAF environment. This process is expected to be finished in 2023. Transfer of the IHLS routines into TAF are not finished yet.

Procedures used in the index calculations of the NINEL, NI-MIK and RHLS rely on data which are so far not part of the E+L database (e.g., growth rate per day, mortality rates). These surveys aim to continue archiving their results in the E+L database, but do not aim to implement their index calculation routines in the TAF system. This may change in the long run.

At WGSINS 2022, a number of issues concerning the ICES Eggs and Larvae database was discussed with representatives from the ICES Data Centre. These included questions concerning the template for data submission, the re-submission of new data and replacement of old data, and which columns in the database should be mandatory and optional. It was discussed that some additional columns should be made mandatory. Furthermore, it was suggested to include a third category (besides mandatory and optional) for those columns which are essential for the linking of data and for overwriting of old data during data resubmissions. Columns in this new category should be indicated with a new third colour in the column headers (in addition to the previous red headers for mandatory and green headers for optional data). Furthermore, there was agreement that a "read me" sheet should again be included in the template for the upload of data to the Eggs and Larvae database, which should include detailed explanations of all the columns in the database and their data formats, as well as the colour codes in the column headers. A sub-group was initiated to deal with these issues in more detail and to coordinate between WGSINS, WGALES and the ICES Data Centre (sub-group to meet in January 2023). The sub-group will also deal with final data checks of the Q1 MIK data before these are entirely implemented in the ICES TAF system.

Furthermore, some sections in the fact sheet for the Eggs and Larvae database were identified to be outdated and these will thus be updated in cooperation between selected WGSINS members and the ICES Data center. Participants in the surveys are generally encouraged to update the fact sheets and meta information on the eggs and larvae website whenever needed.

3.2 Additional Data products

Apart from the data needed for the original survey 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 other fish larvae species of the 1Q MIK sampling is requested for at least sardine, lemon sole and eel, while details on sprat, sardine, mackerel, horse mackerel, lemon sole and red mullet larvae are wanted from the 3Q MIK sampling. The Q1 MIK 2022 sampling results were imported into the ICES eggs and larvae database (as far as available). The collection of material for species identification workshops 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 and other planktonic species in the northern Irish Sea (NI-MIK). These were updated with the most recent survey results. Besides, information on jellyfish is available for some of the Danish Q1 and Q3 MIK surveys in the North Sea (Gawinski et al. 2019, Køhler et al. 2022) as well as some of the BIS surveys in the Baltic (e.g. Huwer et al. 2008, Schaber et al. 2011a,b, Jaspers et al. 2018 a,b).

Additional data products from these surveys can also support the implementation of an ecosystem approach to fisheries management through the provision of data on important pelagic components of marine ecosystems (e.g. gelatinous zooplankton, macro plankton). These components are not sampled effectively by traditional fishery survey methods and therefore are underrepresented in many existing survey datasets. Data collected by ichthyoplankton surveys on the distribution and abundance of these ecosystem components can be used to parameterize food web models and support research developing our understanding of the pelagic habitat.

3.3 Species identification

Correct species identification is essential to obtain reliable survey results and indices for use in stock assessments. Most of the surveys coordinated by WGSINS are targeting larvae of different clupeid species, which are co-occurring in the survey areas (herring, sprat and sardine). The correct identification of these species requires specific expertise, including knowledge of certain morphological traits such as the position of the pelvic fins in relation to the pylorus or the number of pre-anal myomeres. Therefore, dedicated larval identification workshops are organized in order to ensure expertise and consistency in species identification. Recent workshops were WKIDCLUP in 2014 (ICES 2014) and WKIDCLUP2 in 2021 (ICES 2022a). Based on the re-assuring results of the most recent workshop identification trials, the potential error caused by misidentification of clupeid larvae can be considered as low or negligible.

Due to the Covid-19 pandemic and related international travel restrictions, WKIDCLUP2 had to be held online. Prior to the workshop, the WebApp SmartDots was adapted to be utilized for

ichthyoplankton identification based on images. Overall, the WebApp SmartDots proved to be very useful for holding such larval identification events. However, while the ICES data centre and the SmartDots team provided excellent support to get WKIDCLUP2 established and conducted, it also became apparent during the workshop that there was room for improvements and to adapt SmartDots (which was originally invented for otolith work) more specifically for identification workshops on fish eggs and larvae.

Therefore, the new egg and larvae module was recently further developed by the SmartDots team, considering the experiences and advice from the WKIDCLUP2 and WKMACHIS workshops (ICES 2022a,b). At WGSINS 2022, SmartDots and the new egg and larvae module was presented by one of the chairs of WGSMART, Julie Olivia Davies (DTU Aqua). There was general agreement that the new module is a considerable improvement, which will make the use of SmartDots in future larval identification workshops even more convenient and user-friendly. In particular the fact that all pictures and software tools needed for the identification are nicely arranged on one screen (i.e. without having to scroll down or switch between pictures or software tools etc.) is regarded as major improvement. Several WGSINS participants agreed to help in the testing of the new module in early 2023, before the module is finally implemented. An online workshop is planned in 2023 to introduce coordinators of identification workshops to the new modules and features of SmartDots.

3.4 Discussions on other topics

Survey manuals: Progress has been made regarding the planned manual for several of the surveys coordinated by WGSINS, based on contributions from various survey coordinators. A draft version of the manual is planned for May 2023. Specific sections to be considered include (1) Description of sampling gears (Gear photos, Mesh sizes etc.), (2) Sorting procedures (species, measurements, preservation) and (3) ID/ keys reference lists. It was discussed if there should be common sections relevant for all included surveys, or separate sections for each survey. Common sections will probably not be feasible due to differences between individual surveys. The final aim is to publish the manual as ICES TIMES publication. It was decided not to include the MIK survey in the manual, as a specific manual already exists for this survey, but that an update of the MIK manual and a conversion from SISP to TIMES format will be required at some point.

Description of WGSINS on the ICES homepage: The information describing the work of WGSINS on the ICES homepage was outdated. A suggestion for a new text was presented by the WGSINS chair Bastian Huwer and discussed, edited and agreed upon by the group. The new WGSINS description text is now updated on the ICES homepage.

Information and discussion concerning WKSIDAC2: “WKSIDAC2 - A Second Workshop on Stock Identification and allocation of catches of herring to stocks” will take place at ICES HQ in Copenhagen, Denmark, 19-22 June 2023. This upcoming workshop was presented by the workshop chair Richard Nash, and options for WGSINS to contribute were discussed. Surveys coordinated by WGSINS could e.g. contribute field samples of yolk sac and early stage larvae for genetic baselines.

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Annex 1: List of participants

Name	Institute	Country	Email
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Note: In addition, the following four guests participated in the meeting:

Alondra Sofia Rodriguez (ICES Scientific officer), Adriana Villamor & Carlos Pinto (ICES Data Centre), Julie Olivia Davies (DTU Aqua, Chair of WGSMART).

Annex 2: Resolutions

2021/FT/EOSG07 The **Working Group on Surveys on Ichthyoplankton in the North Sea and adjacent Seas (WGSINS),** is chaired by Bastian Huwer, Denmark, 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 2022	29 November – 01 December	Belfast, Northern Ireland	Interim report by 7 January 2023 to ACOM/SCICOM	Incoming Chair Bastian Huwer (DK)
Year 2023	28 November – 01 December	Aberdeen, Scotland	Interim report by 1 January 2024 to ACOM/SCICOM	Bastian Huwer (DK)
Year 2024	TBD			

ToR descriptors

ToR	Description	Background	Science plan codes	Duration	Expected Deliverables
a	Planning and execution of North Sea and adjacent seas ichthyoplankton 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,	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 crucial prerequisite for the use of a time series in the assessment.	3.1, 3.2, 5.2	year 1, 2, 3	
c	Update manuals for ichthyoplankton surveys in the North Sea and adjacent seas	Existing manuals should be updated regularly as new information becomes available	3.1	year 3	Updated Times manuals
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	3.3	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 in the ICES eggs and larvae database
g	Assess possibilities for the different ichthyoplankton surveys to supply ecosystem data to support the implementation of an 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.	3.1, 3.3	year 3	Provide an overview of current and potential new data collections, in addition to the target species, and their potential uses for ecosystem management

Note: Please note that ToR g has been added to the resolution.

Summary of the Work Plan

Year 1	Plan and execute the International herring larvae surveys in the North Sea (IHLS), the North Sea Midwater Ring Net survey (MIK), the Downs recruitment survey (DRS), the Northern Irish Northeastern Larvae Survey (NINEL), the Northern Ireland MIK Survey (NI-MIK), the Rügen herring larvae survey (RHLS) and the Baltic Ichthyoplankton Surveys (BIS)
Year 2	Plan and execute the IHLS, the MIK, the DRS, the NINEL, the NI-MIK, the RHLS and the BIS
Year 3	Plan and execute the IHLS, the MIK, the DRS, the NINEL, the NI-MIK, the RHLS and the BIS

Supporting information

Priority	This working group is important for the fisheries advisory process. The different ichthyoplankton surveys in the North Sea and adjacent seas provide important fishery-independent stock and/or recruitment data used in the assessment for herring stocks in the North and Baltic Seas as well as for cod in the Baltic and the Irish Sea, as well as for haddock in the Irish Sea and informs management of whiting in the Irish Sea.
Resource requirements	None.
Participants	The working group is normally attended by 8 – 15 members and guests.
Secretariat facilities	ICES data center
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	HAWG, WGCSE, WGBFAS
Linkages to other committees or groups	EOSG, WGBIOP, IBTSWG, WGALES, WGML, WGZE, DSTSG
Linkages to other organizations	None

Annex 3: Survey Summary Sheets

International Herring Larvae Surveys in the North Sea (IHLS)

Nation:	Vessel:	Dates
Germany	Dana #09-21	20 September – 01 October 2021
Netherlands	Tridens 2	20 September – 29 September 2021
Netherlands	Tridens 2	20 December – 23 December 2021
Germany	WH #452	05 January – 13 January 2022

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 (5m above the bottom) and back to the surface.
Notes from survey (e.g. problems, additional work etc.):	All six survey areas could be sampled as scheduled. The survey around the Orkneys revealed higher quantities of newly hatched larvae, compared to relatively low numbers in the two preceding years. In the Buchan and the central North Sea, newly hatched larvae concentrated in two areas. There are some issues with larvae patchiness in the Downs area. One station yielded > 90% of the total catch in December. However, such a pattern has been seen also in the history of the survey time-series. Thus, all stations were included in further calculations. The estimated larvae abundance indices could 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, 413 plankton samples were taken during the IHLS surveys between September 2021 and January 2022. They contained 118,968 herring larvae.

Stations fished

ICES Divisions	Strat.	Gear	Tows planned	Valid	Add.	Inv.	% stations fished	comments
4a,b	N/A	Gulf	274	274	0	0	100 %	Extra hauls taken when abundance was dense.
7d	N/A	Gulf	141	139	0	0	100 %	Extra hauls taken when abundance was dense.
total	N/A	Gulf	415	413	0	0	100 %	

North Sea Midwater Ring Net survey (MIK)

Nation:	Vessel:	Dates (planned according to Q1 IBTS cruise program)	Comment
Denmark	Dana	26-01 to 13-02	Technical issues – 1 survey day lost
France	Thalassa II	17-01 to 09-02	
Germany	Walther Herwig III	20-01 to 21-02	Covid-19 and weather issues – 19 survey days lost
Netherlands	Tridens 2	24-01 to 25-02	Technical issues – 3 survey days lost
Norway	GO Sars	25-01 to 22-02	
Scotland	Scotia	22-01 to 11-02	Vessel breakdown – 15 survey days lost
Sweden	Svea	19-01 to 04-02	

Cruise	The North Sea Midwater Ring Net survey (MIK) aims to conduct plankton net tows to determine the abundance of late North Sea herring larvae, which is used to provide a recruitment index, the so-called "0-ringer index", for the stock assessment of North Sea herring. 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), a large ring net with a diameter of 2 meters and a mesh size of 1600 µm.
Notes from survey (e.g. problems, additional work etc.):	The 2022 MIK survey was faced with serious challenges due to extremely bad weather conditions throughout most of the survey period, a Covid-19 outbreak onboard of one vessel, breakdown of one vessel as well as technical/mechanical issues on two vessels. This resulted in a severe reduction in the number of survey days and thus also the number of conducted MIK hauls, and a generally poor coverage of the survey area. Of the planned 714 hauls only 433 could be conducted, which is 250 hauls less than in 2021. For the 2022 MIK 0-ringer index (corresponding to the 2021 year-class), all hauls north of 51° N were used, in total 410 hauls, which is 253 less than in 2020. However, thanks to intensive coordination between participants during the survey and more decent weather in the final part of the survey period, at least 1 MIK haul could be conducted in most ICES rectangles and the majority of rectangles was covered with 2 or more hauls. Nevertheless, 24 rectangles were not covered at all by the MIK sampling, but these were mainly located in areas which usually only yield low numbers of herring larvae. Thus, the majority of the main herring larvae distribution area could be covered. In addition, data tests were conducted to investigate whether the poor sampling coverage may have had an influence on the 0-ringer index from the 2022 survey. Based on these tests it can be assumed that the 2022 MIK survey provides a representative 0-ringer index, despite the encountered issues and low overall number of MIK hauls.
Number of fish species recorded and notes on any rare species or unusual catches:	Besides the target species herring, larvae and juvenile stages of various other species were caught, including e.g. lemon sole, crystal goby, sandeel, dab, pearlside, pipefish and gobies. As in previous years, catches of sardine larvae were again observed, specifically in the German Bight area and in the Skagerrak.

Stations fished (aims: to complete 714 MIK tows per year)

Country	Gear	Tows planned	Valid	Add.	Inv.	% stations fished	comments
Denmark	MIK	92	54	0	0	59	
France	MIK	106	103	0	0	97	
Germany	MIK	134	17	0	0	13	
Netherlands	MIK	114	100	0	0	88	
Norway	MIK	84	85	0	0	101	
Scotland	MIK	116	28	0	0	24	
Sweden	MIK	53	46	0	0	87	
TOTAL	MIK	699	433	0	0	62	

Northern Irish Northeastern Larvae Survey (NINEL)

Nation:	UK(NI)	Vessel:	RV Corystes
Survey:	NINEL	Dates:	7- 13th November 2021

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 2021 was completed successfully with a total of 59 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:	9605 larvae were measured (TL mm) and preserved in alcohol.

Northern Ireland MIK Survey (NI-MIK)

Nation:	UK(NI)	Vessel:	RV Corystes
Survey:	NI-MIK	Dates:	10th May – 24thrd May 2022

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 91 Gulf7, 64 MRN2 and 79 WP2 deployments were made.
Number of fish species recorded and notes on any rare species or unusual catches:	Of the target species 31 whiting, 2 haddock were recorded in the MRN2 catches. Larval fish catches in the Gulf7 were dominated by dab (*Limanda limanda*) 2241, clupeiformes (predominantly *Sprattus sprattus*) 1292 and dragonets (*Callionymidae*) 1893. In addition various species of gelatinous zooplankton and crustacea were recorded.

Rügen herring larvae survey (RHLS)

Nation:	Germany	Vessel:	CLUPEA
Survey:	359	Dates:	02.03.-26.06.2021

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 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 (0.6m diameter) of 335 µm mesh, HYDROBIOS-electronic flow-meters
Notes from survey (e.g. problems, additional work etc.):	The Rügen Herring Larvae Survey (RHLS) in the western Baltic (ICES area IIId/SD24) took place during 17 weeks from March (2nd)-June (26th) on FRV "Clupea". In total all 595 stations could be achieved during 51 days at sea. Due to early spawning activity (January) the regular survey was started earlier as in former years, leading to an extended sampling period. During this period, the core program could be fully achieved. However, two additional survey weeks planned as a winter control (February) and autumn control (November) had to be cancelled due to ice cover (Feb.) and vessel repairs (Nov.) respectively. 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.

Table 4.1.2.3.1. Stations fished

ICES Divisions	Strat.	Gear	Towsplanned	Valid	Add.	Inv.	% stations fished	comments
24	N/A	Bongo	595	595			100 %	

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

Baltic Ichthyoplankton Surveys (BIS)

Nation:	Denmark, Poland, Germany	Vessel:	DANA, BALTICA, ALKOR & others
Survey:	BIS-Baltic Ichthyoplankton Surveys	Dates:	Monthly from March-September & November, 2022

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 (0.6 m diameter) of 335 and 500 µm mesh, flowmeters + on some cruises additional other gears, e.g. different types of fishing trawls, Baby-Bongo net (0.2 m 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 2022, a total of 8 individual BIS surveys were conducted in March, April, May, June, July, August, September and November. The 45 station standard grid was sampled on all cruises, amounting to a total of 360 sampled standard stations in 2022.
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 %	