End of Cruise report

RV “DANA” - Cruise 05/2023

Herring Acoustic Survey in the North Sea, Kattegat and Skagerrak (HERAS)

24 June – 10 July 2023

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Section for Monitoring and Data

Cruise summary

Total days	16
Days of monitoring	12
Number of nautical miles monitored	1 591nm monitoring track + 160nm for calibration and FLEXUS test + 305nm transit
Number of trawl hauls	31
Number of CTD stations	30
Number of WP2 plankton stations	30
Fish catch in kg	9 751
Number of measured herring	9 548
Number of measured mackerel	3 060
Number of measured sprat	1 837
Number of species recorded	26
Total number of measured fish	17 728
Number of herring frozen for age and stock-split	2 458
Number of sprat frozen for age	530

1 Background

This cruise is part of an international hydro acoustic survey for herring and sprat (HERAS) coordinated by the ICES Working Group of International Pelagic Surveys (WGIPS). The survey is carried out annually by national fisheries institutes from Scotland, Germany, Netherlands, Norway, Ireland and Denmark within the last week of June and the first 3 weeks of July. Geographically it covers most of the continental shelf north of 52°N in the North Sea and to the west of Scotland and Ireland to a northern limit of 62°N. The eastern edge of the survey area is bounded by the Norwegian, Danish, Swedish and German coastline and to the west by the shelf edge at around 200 m depth.
The DTU National Institute of Aquatic Resources (DTU AQUA) has participated in the herring acoustic survey of the North Sea and adjacent waters with the responsibility for surveying the Skagerrak and Kattegat area since 1991. The 2023 cruise with R/V DANA, was conducted in the period June 27 to July 10 2023, while calibration was done during June 24 to June 26 2023.

2 Objectives

The objective of the survey is to provide age aggregated abundance and biomass estimates as well as maturity levels and weight at age for the herring and sprat stocks covered by the survey.
These indices are used in the assessments of sprat and herring stocks carried out in the ICES Herring Assessment Working Group (HAWG) and underpin the management of North Sea herring, Western Baltic Spring Spawning herring, Malin Shelf herring as well as sprat in the North Sea and Skagerrak.
In addition to hydro-acoustic estimates of sprat and herring abundance, the survey also collects information on hydrography and plankton abundance in the survey area to facilitate studies into drivers of herring and sprat abundance and distribution.

The following standard objectives where planned for cruise 05/2023 on Dana:

- Calibration of hydroacoustic equipment used for fisheries acoustic monitoring
- Collect continuous hydro-acoustic measurements along pre-defined transects
- Carry out trawl sampling with bottom and pelagic trawls to verify species and size composition of acoustic registrations
- Collect biological samples of herring and sprat for further analysis of age, stock and maturity composition as well as individual lengths and weights
- Carry out hydrographic sampling along transects (Thermo-Salinograph measurements) and associated with fishing stations (CTD casts) for pelagic habitat description
- Collect plankton samples for water-column integrated dry weight estimates for pelagic habitat description
- Testing manoeuvrability of FLEXUS towed body

3 Survey Description and Results

3.1 Time table

24/6 kl 06:00	Departure from Hirtshals for calibration trip
24/6 kl 09:00	Start test af FLEXUS
24/6 kl 11:00	End test af FLEXUS
24/6 kl 17:00	Arrive at Bornö and start calibration
26/6 kl 20:00	End calibration and depart from Bornö
27/6 kl 06:30	Arrive Hirtshals for crew change
27/6 kl 08:30	Departure Hirtshals for acoustic monitoring part
27/6 kl 22:49	Start monitoring work
02/7 kl 11:15	Pause monitoring due to inclement weather, sheltering in Thyborøn
03/7 kl 23:27	Resume monitoring
09/7 kl 15:00	End monitoring work
10/7 kl 08:00	Arrive Hirtshals - end of trip

All times in DK summertime

3.2 Survey participants

During calibration 24/6– 26/6 2023

Name	Section	Function
Susan Mærsk Lusseau	DTU Aqua, Monitoring Hirtshals	Cruise leader
Ronny Sørensen	DTU Aqua, Monitoring Hirtshals	Technician
Christian Skou Petersen	DTU Aqua, Monitoring Hirtshals	Technician

During acoustic monitoring 27/6 - 10/7-2023

Name	Section	Function
Susan Mærsk Lusseau	DTU Aqua, Monitoring Hirtshals	Cruise leader
Christian Skou Petersen	DTU Aqua, Monitoring Hirtshals	Acoustics, CTD
Gert Holst	DTU Aqua, Monitoring Hirtshals	Acoustics, CTD
Ronny Sørensen	DTU Aqua, Monitoring Hirtshals	Technician
Helle Rasmussen	DTU Aqua, Monitoring Hirtshals	Fish lab, WP2
Stina B. S. Hansen	DTU Aqua, Monitoring Lyngby	Fish lab, WP2
Thomas Møller	DTU Aqua, Monitoring Lyngby	Fish lab, WP2
Mads Bluhm	DTU Aqua, Monitoring Hirtshals	Fish lab, WP2
Maria Jarnum	DTU Aqua, Monitoring Hirtshals	Fish lab, WP2
Rene Erlandsen	DTU Aqua, Monitoring Hirtshals	Fish lab, WP2

3.3 Cruise Narrative

The survey on R/V Dana started on June 24th at 06:00 from Hirtshals heading for Bornö in Gullmar Fjord, Sweden for calibration of the acoustic equipment. On the way manoeuvrability test were carried out with the FLEXUS towed body and the vessel was anchored at Bornö in the Gullmar Fjord, Sweden June 24th by 17:00. The calibration was initiated the same evening and continued until the evening of June 26th when Dana left Bornö. Dana arrived back in Hirtshals June 27th at 06:30 to pick up the crew for the monitoring part.

Dana left Hirtshals at 08:30 again same day and steamed towards the start of the first transect (56° 15.34' N, 08° 00.01' E). Immediately before the start position for the first transect a stop was made in water depths characteristic of the survey area and the CTD was deployed to determine the environmental settings for the EK60. A test the of the pelagic trawl and the associated trawl monitoring sensors was also carried out. Monitoring was started on June 27 at 22.49.

The monitoring was paused at 09:10 on 2/7 due to inclement weather and Dana stopped the survey and went into Thyborøn harbour for shelter. The monitoring was resumed on 3/7 at 23:27 as the weather improved.

The North Sea (strata 151 and 152) was covered during the period June 27 – July 3rd.

The outer Skagerrak (strata 41 and 42) was covered during July 3rd - July 6. The Inner Skagerrak (Strata 31) and Kattegat (Strata 21) was covered in the period July 6 to 9th.

The acoustic integration was ended July 9 at 56° 15.13'N, 011° 27.38'E at 15.00 and Dana arrived back in Hirtshals at 08:00 on July 10 2023.

All primary objectives of the cruise were achieved apart from some transect sections that had to be left uncovered in stratum 21 and 31. In these strata Dana was denied access for the purpose of this survey inside Swedish territorial waters (12 nm boundary) along five transects (Figure 1). This meant a section of strata 21 and 31 was left uncovered towards the Swedish coast (reduction of 47nm).

The planned route also had to be adjusted to take into account navigational hazards and in some cases this resulted in transects being cut shorter than the original plan (reduction of 48nm). Despite this reduction in mileage to the survey it was not enough to make up for the time lost due to inclement weather earlier in the survey. A further reduction in mileage (~20nm) was achieved by removing the second last transect in stratum 21 and joining the two transects on either side directly and treating this as a transect rather than a transit section.

3.4 Calibration

The echosounders were calibrated at Bornö in the Gullmar Fjord, Sweden, between June 24 - June 26 2023. The calibration was performed according to the procedures established for EK60 (Demer et al 2015). This was the second calibration of the year, the previous one just before a cruise to the Norwegian Sea in April. Calibration was successfully carried out on the 38kHz split-beam transducer on both the primary and secondary towed used for integration for abundance estimation. A successful calibration was also carried out on the three hull-mounted split-beam transducers at 18, 38 and 120 kHz with both short and long pulse length (1024 µs and 512µs). Calibrations on 38 and 120kHz were carried out against a 38.1 mm tungsten sphere and the 18kHz against a 63mm Copper sphere. The calibration and setup data for the EK60 38 kHz used during the survey are shown in Table 1.

3.5 Acoustic data collection

The survey track of 1591 nautical miles resulted in 1143 nautical miles of integrated transect track for use in stock size calculation (Figure 1). Data for use in the abundance estimation were recorded using the 38 kHz transducer mounted in a towed paravane running at depths of 4 – 6 m, the depth depending on the sea state and sailing direction relative to the waves, and at a standard ship speed of 9.5 kn. Simultaneously, data from the 120 kHz and 18 kHz echosounders using hull-mounted transducers were also recorded. During trawling operations the paravane was secured on deck and acoustic data was recorded from hull-mounted transducers at 18, 38 and 120 kHz. Data recorded during trawling operations are not included in the abundance estimation process, it is collected to aid echotrace species verification only.
The acoustic data were processed during the survey using the Echoview software to prepare the echograms for further scrutinization and analysis on shore. This included removing interference from surface turbulence, bottom structures and scattering layers from the echogram as well as removing the sections such as trawling and passage between transects (inter-transects) not used in the abundance estimate.

3.6 Biological Data - Trawl Hauls

During the 2023 survey 31 trawl hauls were conducted, 26 with the Fotø pelagic trawl and 5 hauls with the Expo trawl.
The geographical distribution of hauls and details on the hauls are in Figure 2 and Table 2. Catches by species are in Table 3. Length distributions of herring, sprat, mackerel and pilchard by haul are in tables 4 to 7. Maps with catches of main pelagic species including herring and sprat are in Figure 5.

The total catch for the survey was 9.8 tons. Herring was present in 25 hauls with a total catch of 5.37 tons or 55 % of the total catch. Totally 9 548 herring were measured and 2 458 frozen for age and stock splitting analysis back on land. Length distributions of herring per haul are in Table 4 and a map of catches in figure 5.

Sprat were present in 12 hauls with a total catch of 1.21 tons and 12.3 % of the total catch. Totally 1 837 sprat were measured and 530 were frozen for age determination back in the laboratory. Length distributions of sprat per haul are given in table 5 and a map of catches in figure 5.

Mackerel were present in 28 hauls with a total catch of 2.14 ton and 22.0 % of the total catch. A total of 3 060 mackerel were measured. Biomass estimates are not calculated for mackerel from this survey, nor are age readings carried out. Length distributions of mackerel per haul are given in table 6 and a map of catches in figure 5.

Pilchard were present in 10 hauls with a total catch of 176.6 kg and 1.8 % of the total catch. A total of 607 pilchard were measured. Biomass estimates are not routinely calculated for pilchard from this survey and age readings are not carried out. Length distributions of pilchard per haul are given in table 7 and a map of catches in figure 5.

3.7 Zooplankton

A total of 30 WP2 stations were completed. Information on the stations and distribution is given in Table 7 and Figure 4. Dry weight will be measured ashore for each of the three fractions 2000 µm, 1000 µm and 180 µm.

3.8 Hydrography

During the survey 30 CTD stations were completed. Information on the stations and distribution is given in Table 7 and Figure 3. Data from the CTD stations will be uploaded to the ICES hydrography database once quality control checks have been carried out.

3.9 Biomass estimates

Biomass estimates for herring (spring and autumn spawners) and sprat will be produced based on scrutiny of the acoustic integration, catch data and genetic stock split of herring. The estimates will be finalised at the Post Cruise Meeting for the International Acoustic Survey in the North Sea, West of Scotland and Malin Shelf in Bergen, November 2023 and reported in the combined report from the Working Group for International Pelagic Surveys (WGIPS) in Thorshavn in January 2024.

4 References

Demer, D.A, Berger, L., Bernasconi, M., Bethke, E., Boswell, K., Chu, D., Domokos, R., et al. 2015. Calibration of acoustic instruments. ICES Cooperative Research Report. Vol. 326, 133 pp. https://doi.org/10.17895/ices.pub.5494

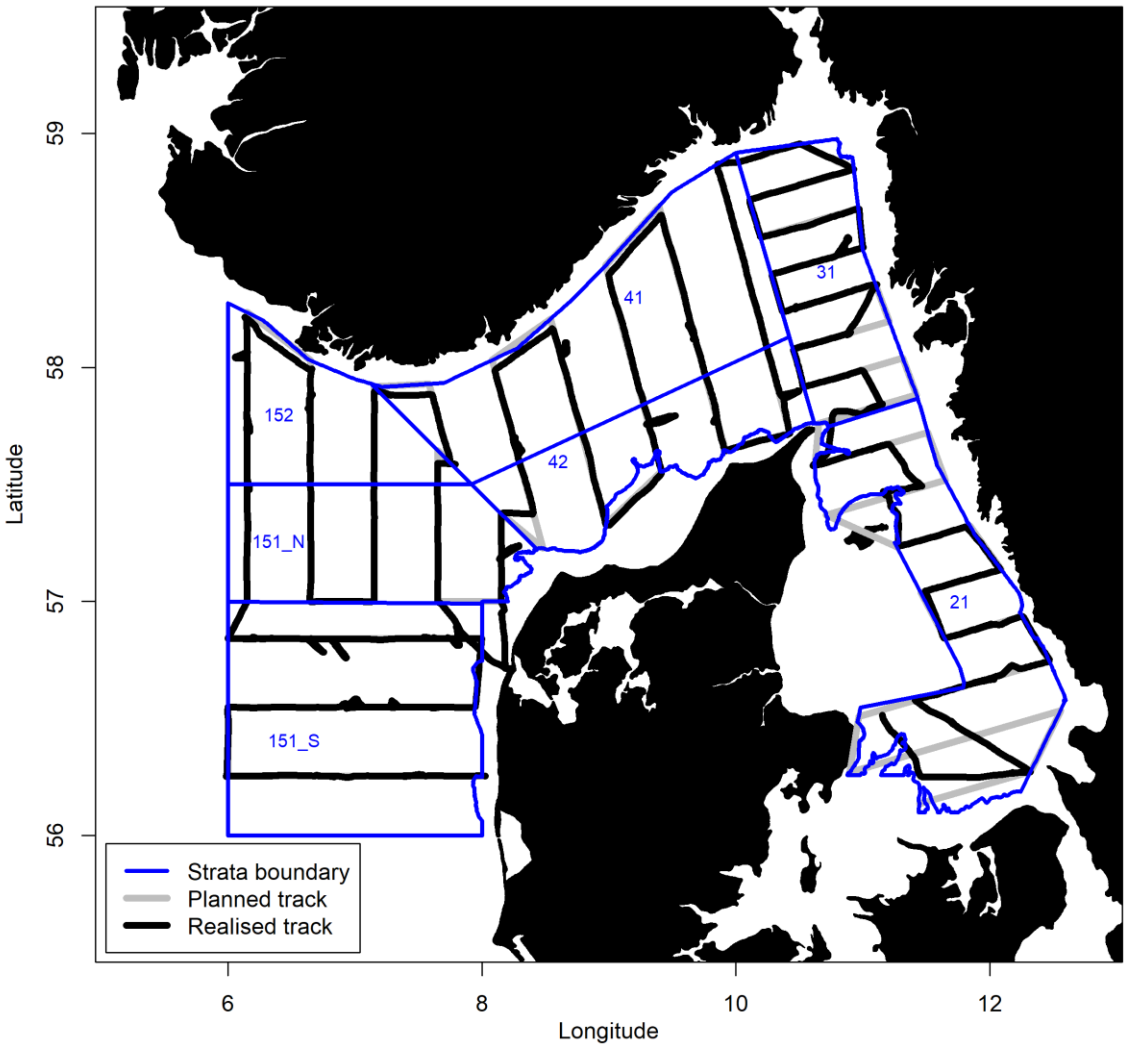

Figure 1. Survey track for the Danish acoustic survey with R/V Dana in June-July 2023. The numbered subareas indicates the strata used in the abundance estimation, the thick grey lines the planned transects for use in the abundance estimation and the thick black line is the actual route sailed.

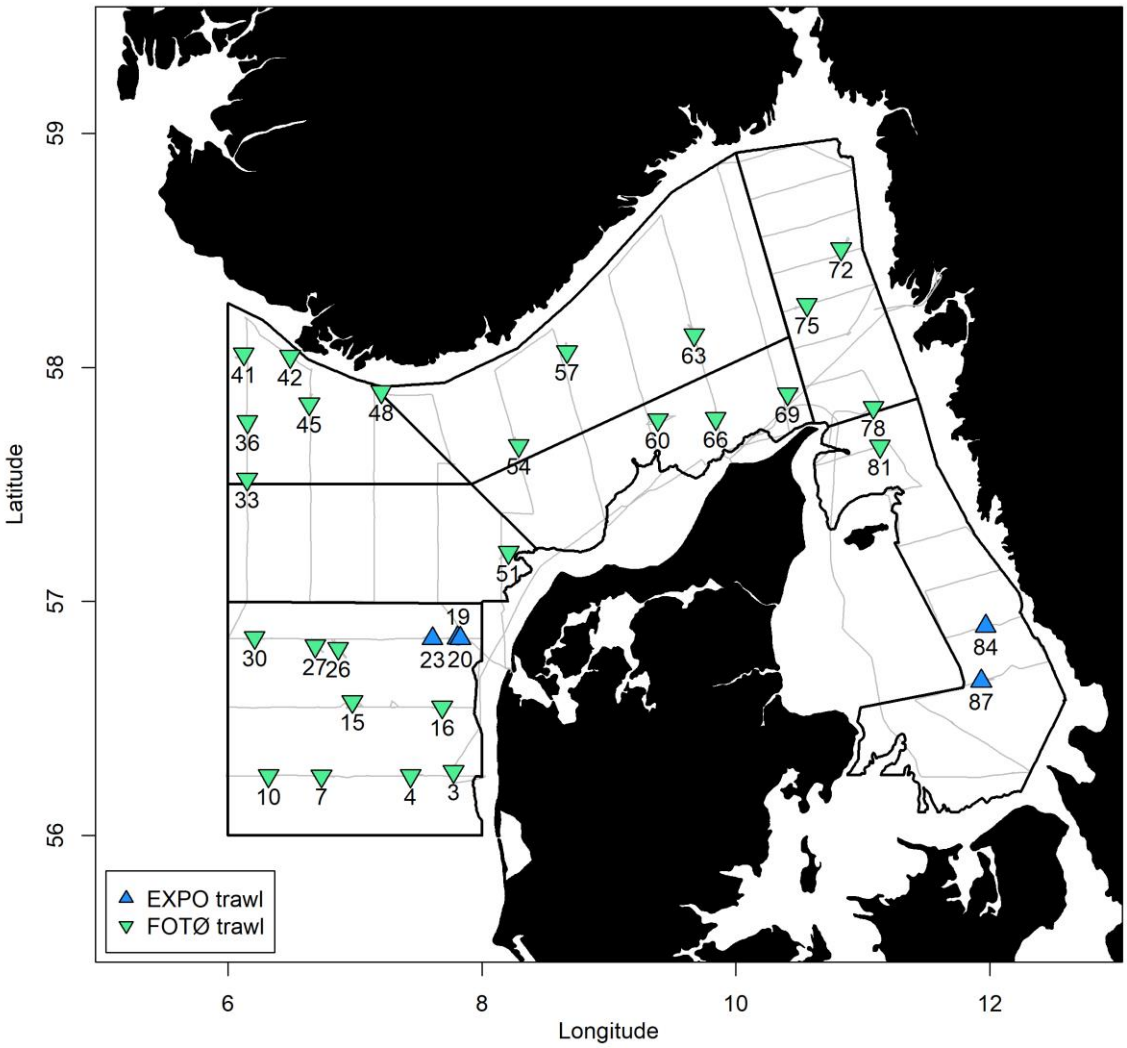

Figure 2. Vessel track and trawl stations during the Danish acoustic survey with R/V Dana in June-July 2023. Green triangles indicate stations with pelagic midwater Fotø trawl and blue triangles indicate locations where the smaller Expo demersal and midwater trawl was used.

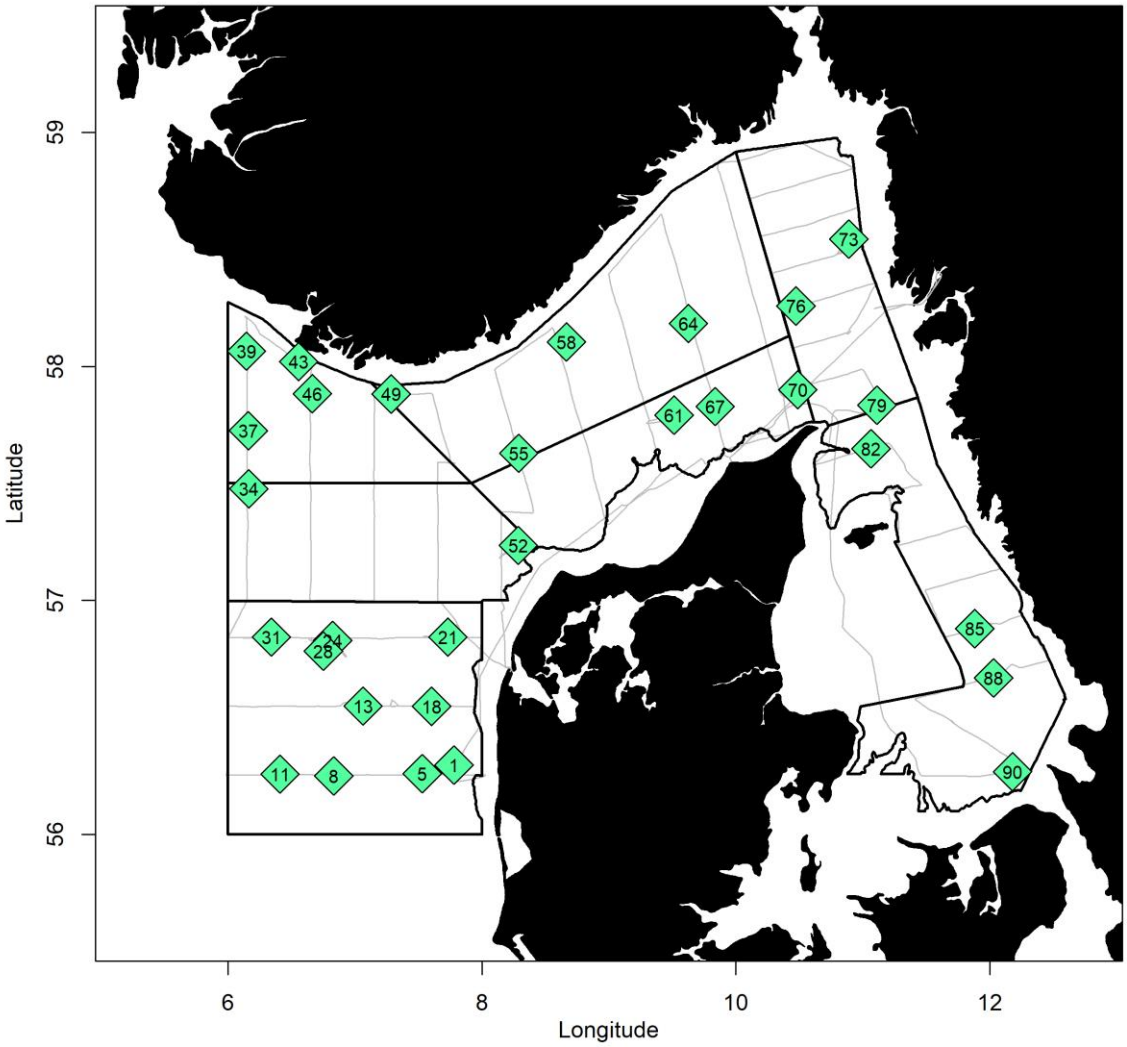

Figure 3. CTD stations during the Danish acoustic survey with R/V Dana in June-July 2023.

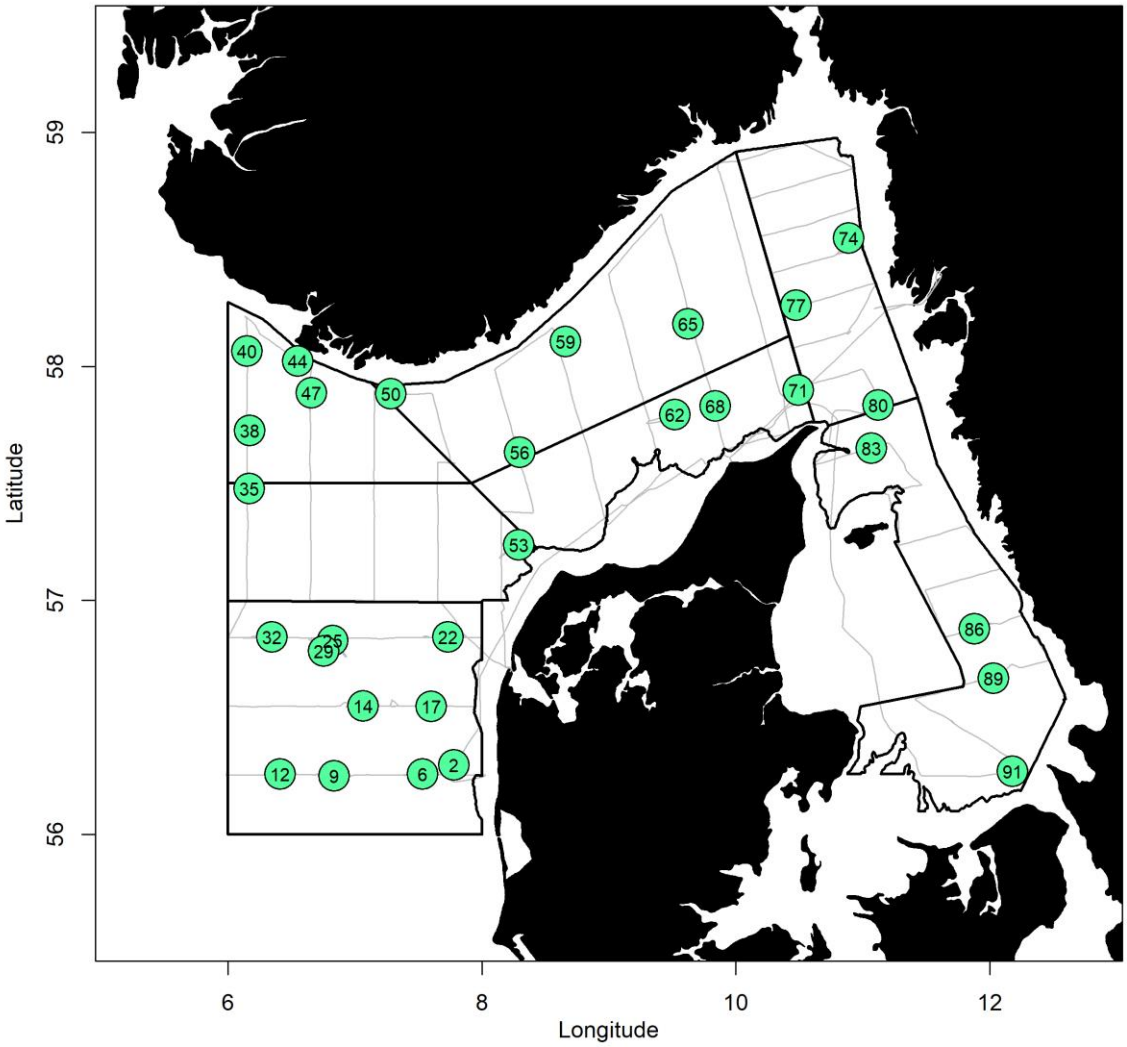

Figure 4. WP2 stations during the Danish acoustic survey with R/V Dana in June-July 2023.

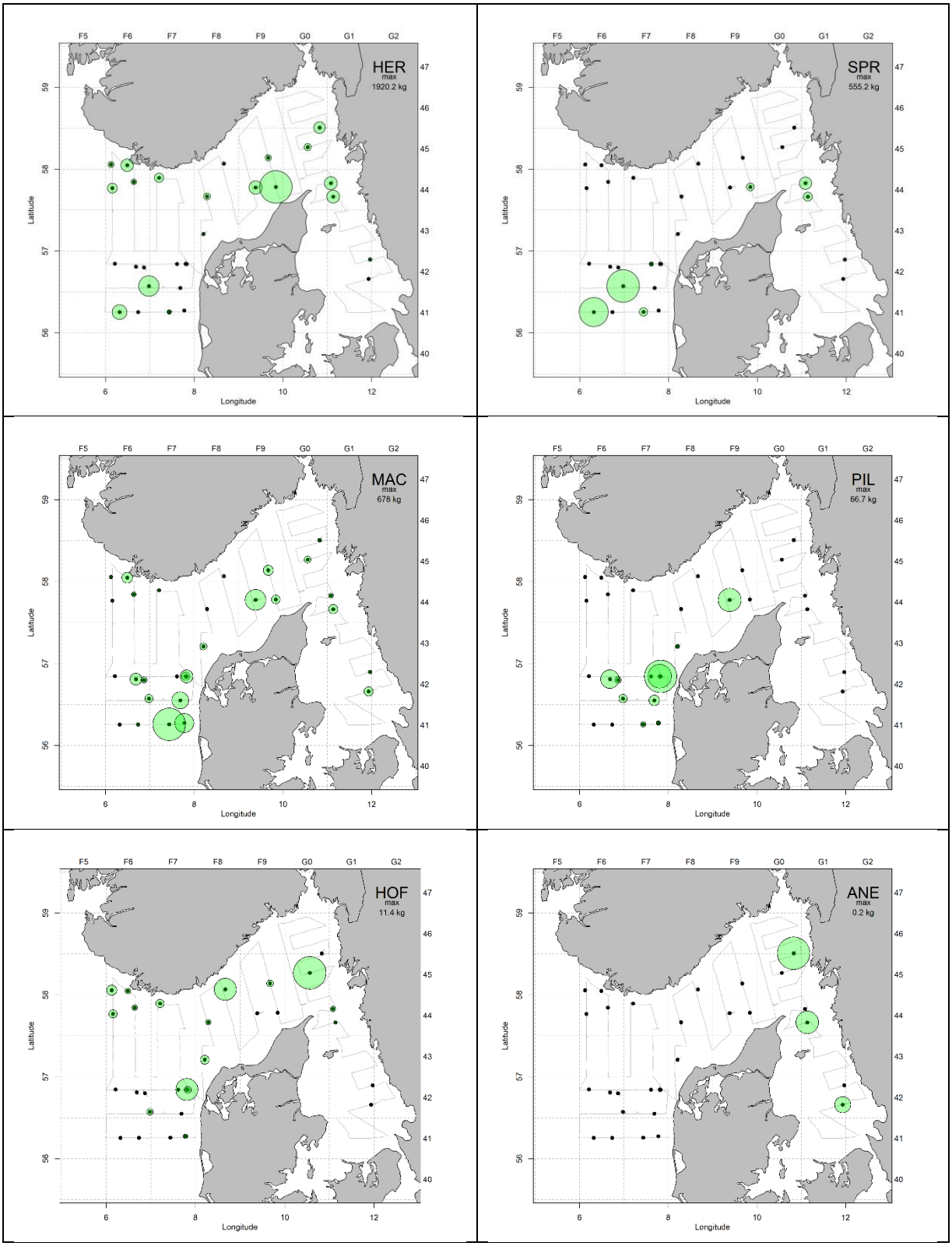

Figure 5. Catches of main pelagic species during the Danish acoustic survey with R/V Dana in June-July 2023. Black circles indicate trawl positions, green circles catches with the size of bubble representing the size of the catch. Catches are **not** to scale between plots, largest catch for each species is annotated on each map.

Table 1: Acoustic instruments and settings used for abundance estimation during HERAS 2023 on R/V Dana. Settings supported by calibration June 2023.

Echo sounder	Simrad EK60
Frequency (kHz)	38
Primary transducer	ES38BP
Transducer installation	Towed body
Transducer depth (m)	4-6
Upper integration limit (m)	7 -9m (3m range exclusion)
Absorption coeff. (dB/km)	6.8
Pulse length (ms)	1.024
Band width (kHz)	2.425
Transmitter power (W)	2000
Ping rate	0.6 in strata 151_S and 21. 1.0 s^{-1} in all other strata
Angle sensitivity (dB)	21.9
2-way beam angle (dB)	-20.5
Sv Transducer gain (dB)	
Ts Transducer gain (dB)	25.48
sA correction (dB)	-0.63
3 dB beam width (dg)	
alongship:	6.91
athw. ship:	6.88
Maximum range (m)	500
Post processing software	Echoview 13.0

Table 2. Trawl station details for the Danish HERAS survey with R/V Dana in June-July 2023.

Station	Date	Time	ICES	Position		Bottom depth	Trawl Direction	Trawling speed	Trawling duration	Trawling distance	Trawl type	Wire length	Headline depth	Trawl opening	Wing distance	Wind speed	Wind direction	Sea state	Total catch	Main catch composition by weight
no.	dd-mm-yy	UTC	Square	Latitude	Longitude	m	deg.	Kn	min.	NM		m	m	m	m	m/s	deg.	bf.	kg	
3	27-06-2023	21:48	41F7	56.16.482 N	007.46.527 E	26.7	191	3.84	30.06667	1.862157	FOTØ	300	0	20.9	32	10.02	298	4	249.998	Mackerel, grey gurnard, clupeids
4	28-06-2023	03:17	41F7	56.15.347 N	007.26.256 E	32.1	80	4.09	30.18333	2.135112	FOTØ	400	6	18	32.2	5.47	277	4	775.004	Mackerel, clupeids
7	28-06-2023	08:30	41F6	56.15.322 N	006.44.125 E	39.4	93	3.68	42.41667	2.54203	FOTØ	215	10	22	29	4.79	200.6	4	23.733	Grey gurnard, mackerel, haddock
10	28-06-2023	12:11	41F6	56.15.340 N	006.19.157 E	44.4	89	3.75	40.26667	2.592857	FOTØ	230	17	20	31	5.75	192.1	2	873.992	Clupeids, grey gurnard
15	28-06-2023	22:38	42F6	56.34.358 N	006.58.727 E	36.7	222	3.77	30.03333	1.882102	FOTØ	300	0	20	31.9	5.2	222	1	1381.001	Clupeids, mackerel
16	29-06-2023	04:20	42F7	56.32.954 N	007.41.187 E	31.7	269	3.46	30.18333	1.796815	FOTØ	270	0	21	30	4.57	202.5	1	245.003	Mackerel, grey gurnard, gadoids, clupeids
19	29-06-2023	10:40	42F7	56.50.689 N	007.48.536 E	29.3	355	4.34	30	2.137891	EXPO	250	3	15	-	5.88	153.3	1	101.837	Mackerel, clupeids, gadoids, garfish
20	29-06-2023	12:27	42F7	56.50.556 N	007.49.761 E	30.4	268	3.8	40.15	2.566756	EXPO	260	3	15	-	8.77	162.9	-	178.889	Mackerel, clupeids, grey gurnard
23	29-06-2023	16:20	42F7	56.50.494 N	007.36.630 E	36.7	269	3.7	30.38333	1.838605	EXPO	360	12	15	-	10.3	189.5	3	43.315	Gadoids, clupeids, grey gurnard
26	29-06-2023	22:00	42F6	56.47.966 N	006.52.004 E	34.5	142	3.94	30.08333	1.971528	FOTØ	300	0	17	-	12.01	294.9	5	31.257	Mackerel, clupeids, grey gurnard
27	30-06-2023	01:26	42F6	56.48.597 N	006.41.237 E	42.9	127	3.84	30.01667	1.930149	FOTØ	300	0	19	-	9.75	297.6	4	116.129	Mackerel, clupeids
30	30-06-2023	05:56	42F6	56.50.796 N	006.12.575 E	49	99	4.38	51.11667	3.318413	FOTØ	270	23	21	29	6.74	271.5	2	434.993	Gadoids, grey gurnard
33	30-06-2023	14:20	44F6	57.31.363 N	006.08.983 E	83.1	171	2.45	32.18333	2.101406	FOTØ	360	41	22	35	7.62	225.1	2	0.000	-
36	30-06-2023	18:05	44F6	57.46.062 N	006.09.128 E	261	176	4.06	30.93333	2.030401	FOTØ	320	0	19.9	28.9	6.97	223.6	3	193.042	Clupeids, lumpfish, mackerel
41	30-06-2023	23:05	45F6	58.03.469 N	006.07.392 E	328.7	247	3.79	30.2	1.902984	FOTØ	300	0	21	29	4.54	157.6	2	113.975	Herring, gadoids,mackerel, krill
42	01-07-2023	03:14	45F6	58.02.809 N	006.29.398 E	372.1	125	3.76	30.11667	1.977443	FOTØ	300	0	23	29	6.22	104.4	2	367.030	Herring, mackerel
45	01-07-2023	07:04	44F6	57.50.680 N	006.38.387 E	352.6	207	3.34	30.13333	1.732521	FOTØ	280	0	21	32	7.09	131.1	2	82.671	Herring, mackerel, spurdog
48	01-07-2023	22:45	44F7	57.53.715 N	007.12.386 E	346.2	106	3.91	30.13333	1.952599	FOTØ	300	0	21	29	12.28	270.8	5	182.999	Herring, mackerel, gadoids, squid
51	03-07-2023	23:19	43F8	57.12.556 N	008.12.582 E	37.2	58	4.62	30.1	2.200916	FOTØ	290	0	25	31	11.12	239.8	5	56.682	Mackerel, clupeids, grey gurnard, garfish
54	04-07-2023	06:48	44F8	57.39.966 N	008.17.340 E	231.6	190	3.88	30.06667	1.80292	FOTØ	290	0	31	30	10.25	238.8	5	90.430	Clupeids, lumpfish
57	04-07-2023	13:53	45F8	58.04.011 N	008.40.183 E	442	182	3.52	30.11667	1.755603	FOTØ	300	0	21	-	13.11	241.4	5	25.001	Clupeids, garfish, lumpfish, mackerel
60	05-07-2023	01:22	44F9	57.46.605 N	009.23.135 E	46	73	5.57	30.08333	2.89221	FOTØ	300	0	25	31.5	12	261	4	641.013	Clupeids, mackerel
63	05-07-2023	13:58	45F9	58.08.305 N	009.40.290 E	530	332	3.76	40.18333	2.57968	FOTØ	300	7	22	-	6.43	111.1	4	152.118	Clupeids, mackerel, lumpfish, spurdog
66	05-07-2023	18:52	44F9	57.46.875 N	009.50.430 E	41.6	192	3.79	35.03333	2.185473	FOTØ	250	16	21	31	8.5	106.9	3	2009.016	Clupeids, mackerel
69	06-07-2023	01:03	44G0	57.53.211 N	010.24.428 E	109.2	77	4.15	30.13333	2.049422	FOTØ	300	0	30	23.9	2.82	104	3	0.000	-
72	07-07-2023	00:18	46G0	58.30.364 N	010.49.711 E	92	46	4.04	30.13333	2.16123	FOTØ	300	0	27	-	12	248.2	6	257.994	Clupeids, mackerel
75	07-07-2023	06:45	45G0	58.16.055 N	010.33.540 E	307	252	3.62	40.06667	2.500845	FOTØ	300	0	15	-	10.87	244	6	157.906	Clupeids, mackerel, lumpfish, garfish
78	07-07-2023	19:34	44G1	57.49.712 N	011.04.981 E	49.1	41	3.73	27.06667	2.004277	FOTØ	225	17	21	30	8.78	252.9	4	428.003	Clupeids, gadoids, mackerel
81	08-07-2023	03:26	44G1	57.39.779 N	011.08.064 E	35.1	251	3.8	30.08333	1.949389	FOTØ	235	14	20	30	8.75	274	4	410.007	Clupeids, mackerel, gadoids
84	08-07-2023	19:04	42G1	56.53.727 N	011.58.009 E	33.1	252	4.04	35.15	2.377665	EXPO	190	14	13	23	1.48	328.7	0	66.711	Spurdog, clupeids, mackerel
87	09-07-2023	02:34	42G1	56.39.633 N	011.55.902 E	30.5	75	3.69	36.55	2.327219	EXPO	170	9	18	21	2.07	54.9	0	61.382	Mackerel, greater weever, gadoids, clupeids

Table 3. Catch composition in trawl hauls for the Danish HERAS survey with R/V Dana in June –July 2023

			Station	**3**	**4**	**7**	**10**	**15**	**16**	**19**	**20**	**23**	**26**	**27**	**30**	**33**	**36**	**41**	**42**
			Stratum	151_S	151_S	151_S	151_S	151_S	151_S	151_S	151_S	151_S	151_S	151_S	151_S	152	152	152	152
			ICES Sq	41F7	41F7	41F6	41F6	42F6	42F7	42F7	42F7	42F7	42F6	42F6	42F6	44F6	44F6	45F6	45F6
			Trawl type	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	EXPO	EXPO	EXPO	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ
			Headline depth	0	6	10	17	0	0	3	3	12	0	0	23	41	0	0	0
			Seabed depth	26.7	32.1	39.4	44.4	36.7	31.7	29.3	30.4	36.7	34.5	42.9	49	83.1	261	328.7	372.1
			Day/Night	Night	Day	Day	Day	Night	Day	Day	Day	Day	Night	Night	Day	Day	Day	Night	Day
% of catches	**Common Name**	**Scientific Name**	**Total catch (kg)**	**249.998**	**775.002**	**23.733**	**873.992**	**1381.001**	**245.003**	**101.837**	**178.889**	**43.315**	**31.257**	**116.129**	**434.993**	**0.000**	**193.042**	**113.975**	**367.030**
55.07	Herring	*Clupea harengus*	5370.224	0.224	37.161		395.424	766.954	0.125		0.240	4.090	2.794	0.244			176.413	66.906	288.320
21.97	Mackerel	*Scomber scombrus*	2142.766	233.705	678.035	8.837		45.408	186.000	44.265	107.003	0.682	24.855	92.374	1.100		2.546	6.434	75.411
12.37	Sprat	*Sprattus sprattus*	1206.399	0.836	38.691		441.363	555.182	0.158			9.281							
4.65	Haddock	*Melanogrammus aeglefinus*	453.556		2.160	0.564			13.910	14.834	1.534	23.160			374.122				
1.81	Pilchard	*Sardina pilchardus*	176.566	1.340	1.800			4.750	7.178	35.214	66.714		2.798	21.742					
1.07	Grey gurnard	*Eutrigla gurnardus*	104.616	7.700	10.820	13.738	35.424	3.070	16.053	1.600	1.946	4.062	0.790	0.486	7.000		0.098		
0.85	Whiting	*Merlangius merlangus*	83.346	0.273	0.006	0.010	0.008	0.270	14.203	0.444		1.948		0.011	51.277			0.012	
0.43	Blue whiting	*Micromesistius poutassou*	42.222															36.902	
0.42	Lumpfish	*Cyclopterus lumpus*	41.105														3.370		0.266
0.41	Spurdog	*Squalus acanthias*	39.543														0.300	0.106	0.909
0.39	Jellyfish	*Scyphozoa*	38.382	4.338	6.329	0.500	1.773	4.851	7.045						1.134		9.560		1.755
0.29	Garfish	*Belone belone*	28.690	0.258				0.486		5.220	0.542						0.756	1.125	0.370
0.06	Greater weever fish	*Trachinus draco*	6.056	0.150														0.132	
0.03	Pollack	*Pollachius pollachius*	3.340																
0.03	Southern shortfin squid	*Illex coindetii*	3.151																
0.03	Invertebrates	*Invertebrata*	2.602																
0.02	Krill	*Euphausiidae*	2.320															2.320	
0.01	Horse mackerel	*Trachurus trachurus*	1.278	0.638										0.400	0.240				
0.01	Northern squid	*Loligo forbesii*	1.164	0.166				0.030					0.020	0.872					
0.01	Plaice	*Pleuronectes platessa*	0.740																
0.01	Cod	*Gadus morhua*	0.734						0.249		0.364				0.121				
0.01	Common dab	*Limanda limanda*	0.609	0.215		0.084			0.082			0.092							
0.01	Saithe	*Pollachius virens*	0.546								0.546								
0.00	Anchovy	*Engraulis encrasicolus*	0.378																
0.00	Lesser flying squid	*Todaropsis eblanae*	0.328																
0.00	Greater sandeel	*Hyperoplus lanceolatus*	0.260							0.260									
0.00	Tub gurnard	*Chelidonichthys lucerna*	0.117	0.117															
0.00	European common squid	*Alloteuthis subulata*	0.049	0.038															
0.00	Pearlside	*Maurolicus muelleri*	0.040															0.038	
100			**9751.127**	**249.998**	**775.002**	**23.733**	**873.992**	**1381.001**	**245.003**	**101.837**	**178.889**	**43.315**	**31.257**	**116.129**	**434.993**	**0.000**	**193.042**	**113.975**	**367.030**

Table 3 (continued).

			Station	45	48	51	54	57	60	63	66	69	72	75	78	81	84	87
			Stratum	152	41	151_N	41	41	42	41	42	42	31	31	31	21	21	21
			ICES Sq	44F6	44F7	43F8	44F8	45F8	44F9	45F9	44F9	44G0	46G0	45G0	44G1	44G1	42G1	42G1
			Trawl type	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	EXPO	EXPO
			Headline depth	0	0	0	0	0	0	7	16	0	0	0	17	14	14	9
			Seabed depth	352.6	346.2	37.2	231.6	442	46	530	41.6	109.2	92	307	49.1	35.1	33.1	30.5
			Day/Night	Day	Night	Night	Day	Day	Night	Day	Day	Night	Night	Day	Day	Day	Day	Day
% of catches	**Common Name**	**Scientific Name**	**Total catch (kg)**	**82.671**	**182.999**	**56.682**	**90.430**	**25.001**	**641.013**	**152.118**	**2009.016**	**0.000**	**257.992**	**157.906**	**428.003**	**410.007**	**66.711**	**61.381**
55.07	Herring	*Clupea harengus*	5370.224	58.564	163.201	18.678	87.016	10.202	328.669	74.228	1920.239		246.515	95.125	302.455	299.604	26.834	
21.97	Mackerel	*Scomber scombrus*	2142.766	16.718	7.008	34.114		4.215	277.493	67.541	49.512		9.682	30.523	17.194	57.780	9.319	55.013
12.37	Sprat	*Sprattus sprattus*	1206.399			0.018					32.360				81.772	43.136	2.886	0.716
4.65	Haddock	*Melanogrammus aeglefinus*	453.556								3.332				17.230	0.012	0.318	2.380
1.81	Pilchard	*Sardina pilchardus*	176.566			1.226			33.804									
1.07	Grey gurnard	*Eutrigla gurnardus*	104.616			1.018					0.270					0.127	0.084	0.330
0.85	Whiting	*Merlangius merlangus*	83.346	0.004	0.001	0.094		0.010		0.034	2.950		0.001	0.012	4.090	7.490	0.110	0.088
0.43	Blue whiting	*Micromesistius poutassou*	42.222		5.320													
0.42	Lumpfish	*Cyclopterus lumpus*	41.105	1.164			3.060	4.810		7.605				20.830				
0.41	Spurdog	*Squalus acanthias*	39.543	5.885	2.755			0.358		2.070							27.160	
0.39	Jellyfish	*Scyphozoa*	38.382										1.098					
0.29	Garfish	*Belone belone*	28.690	0.336	0.768	0.862	0.354	5.230		0.500				11.416	0.326	0.141		
0.06	Greater weever fish	*Trachinus draco*	6.056												1.370	1.604		2.800
0.03	Pollack	*Pollachius pollachius*	3.340												3.340			
0.03	Southern shortfin squid	*Illex coindetii*	3.151		2.385			0.176		0.140	0.094		0.356					
0.03	Invertebrates	*Invertebrata*	2.602		1.555				1.048									
0.02	Krill	*Euphausiidae*	2.320															
0.01	Horse mackerel	*Trachurus trachurus*	1.278															
0.01	Northern squid	*Loligo forbesii*	1.164			0.056									0.020			
0.01	Plaice	*Pleuronectes platessa*	0.740			0.480					0.260							
0.01	Cod	*Gadus morhua*	0.734															
0.01	Common dab	*Limanda limanda*	0.609			0.136												
0.01	Saithe	*Pollachius virens*	0.546															
0.00	Anchovy	*Engraulis encrasicolus*	0.378										0.218			0.106		0.054
0.00	Lesser flying squid	*Todaropsis eblanae*	0.328										0.122		0.206			
0.00	Greater sandeel	*Hyperoplus lanceolatus*	0.260															
0.00	Tub gurnard	*Chelidonichthys lucerna*	0.117															
0.00	European common squid	*Alloteuthis subulata*	0.049		0.004											0.007		
0.00	Pearlside	*Maurolicus muelleri*	0.040		0.002													
100			**9751.127**	**82.671**	**182.999**	**56.682**	**90.430**	**25.001**	**641.013**	**152.118**	**2009.016**	**0.000**	**257.992**	**157.906**	**428.003**	**410.007**	**66.711**	**61.381**

Table 4. Raised length distribution of herring by haul for the Danish HERAS survey with R/V Dana in June-July 2023.

Station	3	4	10	15	16	20	23	26	27	36	41	42	45
Stratum	151_S	151_S	151_S	151_S	151_S	151_S	151_S	151_S	151_S	152	152	152	152
ICES Sq	41F7	41F7	41F6	42F6	42F7	42F7	42F7	42F6	42F6	44F6	45F6	45F6	44F6
Trawl type	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	EXPO	EXPO	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ
Headline depth	0	6	17	0	0	3	12	0	0	0	0	0	0
Seabed depth	27	32	44	37	32	30	37	35	43	261	329	372	353
Day/Night	Night	Day	Day	Night	Day	Day	Day	Night	Night	Day	Night	Day	Day
Total catch (kg)	249.998	775.002	873.992	1381.001	245.003	178.889	43.315	31.257	116.129	193.042	113.975	367.030	82.671
Total weight herring (kg)	0.224	37.161	395.424	766.954	0.125	0.240	4.090	2.794	0.244	176.413	66.906	288.320	58.564
Subsample weight herring (kg)	0.224	10.334	11.860	16.322	0.125	0.240	4.090	2.794	0.244	83.966	41.097	51.698	58.564
9.5													
10	3			47									
10.5	3	7											
11		4		94									
11.5		11		235									
12	2	104	167	470			12						
12.5	1	367	867	2161	2		38						
13	1	514	2634	4746	2		72						
13.5		277	2701	2349			24						
14		151	2501	1598			16						
14.5		147	2467	1081			14						
15		72	2000	1504	2		12						
15.5		90	1400	1363			4						
16		29	1234	2443			3				2		
16.5		22	567	1786							5	11	1
17		4	67	1598			4		1		18	11	1
17.5			100	1786			2		1		29	89	5
18				752			2				41	112	
18.5				658				5	1	2	94	184	11
19	1			611		1		18		2	112	290	16
19.5				235			1	18			140	262	17
20				141				6		2	85	223	13
20.5								1		17	59	184	11
21										2	26	67	7
21.5										6	7	39	18
22	1									23	8	84	39
22.5										23	13	123	48
23										42	15	139	48
23.5										53	8	117	39
24						2				69	7	95	25
24.5										65	16	78	24
25										99	23	190	24
25.5									1	101	18	206	32
26										111	28	190	25
26.5										132	20	67	19
27										130	16	89	22
27.5										97	10	61	18
28										90	15	61	20
28.5										57	5	33	11
29										29	3	6	8
29.5										15	8		5
30										11	2		2
30.5										8	3		
31											2		1
31.5										2		6	
32										2	2		
Number measured	12	500	501	546	6	3	204	48	4	567	514	541	510
Raised number	12	1798	16704	25656	6	3	204	48	4	1191	837	3017	510
Mean length (cm)	12.7	13.4	14.2	15.0	13.5	22.3	13.5	19.3	19.6	25.9	20.9	22.2	23.8

Table 4. continued

Station	48	51	54	57	60	63	66	72	75	78	81	84
Stratum	41	151_N	41	41	42	41	42	31	31	31	21	21
ICES Sq	44F7	43F8	44F8	45F8	44F9	45F9	44F9	46G0	45G0	44G1	44G1	42G1
Trawl type	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	EXPO
Headline depth	0	0	0	0	0	7	16	0	0	17	14	14
Seabed depth	346	37	232	442	46	530	42	92	307	49	35	33
Day/Night	Night	Night	Day	Day	Night	Day	Day	Night	Day	Day	Day	Day
Total catch (kg)	182.999	56.682	90.430	25.001	641.013	152.118	2009.016	257.992	157.906	428.003	410.007	66.711
Total weight herring (kg)	163.201	18.678	87.016	10.202	328.669	74.228	1920.239	246.515	95.125	302.455	299.604	26.834
Subsample weight herring (kg)	41.825	18.678	87.016	10.202	32.327	48.075	12.701	27.792	40.239	21.624	16.068	26.834
9.5										14		
10										28		
10.5												
11												
11.5												
12		1										
12.5		3									19	
13		15					3629				112	
13.5		29					1058				485	
14		27			10		17538			28	858	
14.5		22					13153			28	1622	1
15		46			10		9978	18		42	2051	
15.5		36			10		5292	89		168	2144	2
16		10					3024	257		559	1156	12
16.5		14			20		2721	488		923	727	19
17	8	18			20		2873	452		1189	317	30
17.5	8	27			41		2721	523	2	1315	298	20
18	23	35		2	92		1663	683	24	1007	298	17
18.5	70	45		2	203	3	1210	710	47	573	242	12
19	187	59		6	498	3	1058	834	109	573	149	4
19.5	250	42		13	1098	9	756	585	251	392	56	1
20	332	28		10	1454	28	756	373	246	196	19	
20.5	246	5	2	16	1149	15	454	160	116	56		
21	109	2	1	18	427	43	151	62	87	28		5
21.5	70	1		15	61	73		27	52	14		12
22	121	1	2	14	20	120			66	14	37	18
22.5	117		1	10	31	134		9	87			45
23	82		4	6	10	130	151	9	64	14		45
23.5	101		3	3		76			28	28		31
24	55		4			37		9	24			23
24.5	47		10	2	10	22			28			11
25	43		9	6		20			24			17
25.5	47		13	1		15			9			5
26	43		26	2		17			9			1
26.5	20		37	2		14						6
27	27		73			8			2			
27.5	8		67			3			2			1
28	16		77									
28.5	8		42	1		5						
29			38			2						
29.5			23			2						
30			11			3						
30.5			7									
31			2									
31.5			1									
32												
Number measured	522	466	453	129	508	506	451	596	541	514	568	338
Raised number	2037	466	453	129	5165	781	68186	5287	1279	7189	10591	338
Mean length (cm)	21.3	17.0	27.4	21.5	19.9	22.8	15.2	18.3	20.8	17.6	15.5	21.2

Table 5. Raised length distribution of sprat by haul for the Danish HERAS survey with R/V Dana in June-July 2023.

Station	**3**	**4**	**10**	**15**	**16**	**23**	**51**	**66**	**78**	**81**	**84**	**87**
Stratum	151_S	151_S	151_S	151_S	151_S	151_S	151_N	42	31	21	21	21
ICES Sq	41F7	41F7	41F6	42F6	42F7	42F7	43F8	44F9	44G1	44G1	42G1	42G1
Trawl type	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	EXPO	FOTØ	FOTØ	FOTØ	FOTØ	EXPO	EXPO
Headline depth	0	6	17	0	0	12	0	16	17	14	14	9
Seabed depth	27	32	44	37	32	37	37	42	49	35	33	30.5
Day/Night	Night	Day	Day	Night	Day	Day	Night	Day	Day	Day	Day	Day
Total catch (kg)	249.998	775.002	873.992	1381.001	245.003	43.315	56.682	2009.016	428.003	410.007	66.711	61.381
Total weight sprat (kg)	0.836	38.691	441.363	555.182	0.158	9.281	0.018	32.360	81.772	43.136	2.886	0.716
Subsample weight sprat (kg)	0.836	2.655	3.056	2.720	0.158	3.038	0.018	2.356	2.388	2.790	2.886	0.716
8.5									4			
9									7	2		
9.5	3			4					19	20		
10	23	26	1	59	5	2			47	47		
10.5	33	82	2	89	1	16		5	83	72	2	1
11	17	58	40	69	4	66		6	44	70	14	
11.5	5	26	80	14	2	70		30	21	35	18	
12		12	60	4		39		54	7	11	14	3
12.5		2	20	2		17	1	30	2	3	33	6
13		1	6			8		12		1	40	12
13.5			2			1		4			27	10
14		1	1		1	4		4		1	18	7
14.5						1					8	
15											2	1
Number measured	81	208	212	241	13	224	1	145	234	262	176	40
Raised number	81	3031	30618	49191	13	684	1	1992	8013	4051	176	40
Mean length (cm)	10.5	10.8	11.7	10.6	10.9	11.6	12.5	12.1	10.5	10.7	12.8	13.1

Table 6. Raised length distribution of mackerel by haul for the Danish HERAS survey with R/V Dana in June-July 2023.

Station	3	4	7	15	16	19	20	23	26	27	30	36	41	42	45	48	51	57	60	63	66	72	75	78	81	84	87
Stratum	151_S	151_S	151_S	151_S	151_S	151_S	151_S	151_S	151_S	151_S	151_S	152	152	152	152	41	151_N	41	42	41	42	31	31	31	21	21	21
ICES Sq	41F7	41F7	41F6	42F6	42F7	42F7	42F7	42F7	42F6	42F6	42F6	44F6	45F6	45F6	44F6	44F7	43F8	45F8	44F9	45F9	44F9	46G0	45G0	44G1	44G1	42G1	42G1
Trawl type	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	EXPO	EXPO	EXPO	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	FOTØ	EXPO	EXPO
Headline depth	0	6	10	0	0	3	3	12	0	0	23	0	0	0	0	0	0	0	0	7	16	0	0	17	14	14	9
Seabed depth	26.7	32.1	39.4	36.7	31.7	29.3	30.4	36.7	34.5	42.9	49	261	328.7	372.1	352.6	346.2	37.2	442	46	530	41.6	92	307	49.1	35.1	33.1	30.5
Day/Night	Night	Day	Day	Night	Day	Day	Day	Day	Night	Night	Day	Day	Night	Day	Day	Night	Night	Day	Night	Day	Day	Night	Day	Day	Day	Day	Day
Total catch (kg)	249.998	775.002	23.733	1381.001	245.003	101.837	178.889	43.315	31.257	116.129	434.993	193.042	113.975	367.030	82.671	182.999	56.682	25.001	641.013	152.118	2009.016	257.992	157.906	428.003	410.007	66.711	61.381
Total weight mackerel (kg)	233.705	678.035	8.837	45.408	186.000	44.265	107.003	0.682	24.855	92.374	1.100	2.546	6.434	75.411	16.718	7.008	34.114	4.215	277.493	67.541	49.512	9.682	30.523	17.194	57.780	9.319	55.013
Subsample weight mackerel (kg)	20.680	19.991	8.837	21.169	21.531	15.499	14.250	0.682	17.830	15.442	1.100	2.546	6.434	49.482	16.718	7.008	12.496	4.215	29.634	44.231	28.244	9.682	19.065	17.194	23.186	9.319	14.106
17							8																				
18																											
19	68	475		2	261	3	45		1	6												1			12		
20	723	3697		45	1029	46	293		10	84							22					1		4	22	2	4
21	859	3900	2	154	915	191	638	5	56	395					1		115				11	7	14	44	37	7	27
22	147	712		167	163	103	255	1	43	251					2		167				16	29	83	80	80	31	187
23	23	102		58	33	20	38		14	120			1		3		25		150	2	18	29	88	29	95	21	164
24				28			15		7	24					2		5		243		14	13	38	4	27	9	43
25				6		3			13						1		5		169		2	1	10	5	10	3	12
26			1	4					4	6							3		112		2	1	6	1		1	
27	11	34	3	2			8		11	6			2	2	3			1	37		2	1		1	2		
28	45		4	2	2	3	15	1	10	6				6	2	1	3	1	9		12		2		2	3	
29	23	34	1		4	9	8		8	18	1		1	8			5	2	66	3	11				2		4
30	11			4	5				1	6	1			3				1	94		19						
31			5	2	1	3			7	12	1		2	2	1	2	3	1	187	24	39		2	1		1	
32	11		5	2		6			4	6		1	2	12	6	1		1	159	34	28	1	5		15		4
33	23		5		3				3	6		2		11	6	2		3	103	41	25	2	5	2	10		4
34	34		3		2				1				2	20	5	4		1	37	38	11	1	2	1	7		4
35	11	34	1			6			1			1	2	26	5	1		2	28	17	2				10		16
36	34				3					6		1	1	34	2	4			9	14	2		2		12	1	
37	34				3	6			1		1		2	27	5	1	3	2		5					5		4
38	23		1		1	3							2	20	4	2				14	2	1			7		
39	23		1		2	3						1	2	15	4					3	2		2		5	1	4
40			1		1	3								12	1	2							2		5		
41					2							1		2													
42																				3							
43																											
44																				2							
Number measured	186	265	33	223	176	142	176	7	141	159	4	7	19	130	53	20	130	15	150	130	122	88	162	172	148	80	122
Raised number	2102	8988	33	478	2431	406	1322	7	197	951	4	7	19	198	53	20	355	15	1405	199	214	88	259	172	369	80	476
Mean length (cm)	22.3	20.7	31.0	22.0	20.6	22.5	21.1	22.1	23.9	22.2	31.8	35.6	33.4	35.4	32.4	34.8	22.1	32.2	28.0	33.8	29.0	23.3	23.6	22.3	25.1	23.2	23.5

Table 7. Raised length distribution of pilchard by haul for the Danish HERAS survey with R/V Dana in June-July 2023.

Station	**3**	**4**	**15**	**16**	**19**	**20**	**26**	**27**	**51**	**60**
Stratum	151_S	151_S	151_S	151_S	151_S	151_S	151_S	151_S	151_N	42
ICES Sq	41F7	41F7	42F6	42F7	42F7	42F7	42F6	42F6	43F8	44F9
Trawl type	FOTØ	FOTØ	FOTØ	FOTØ	EXPO	EXPO	FOTØ	FOTØ	FOTØ	FOTØ
Headline depth	0	6	0	0	3	3	0	0	0	0
Seabed depth	26.7	32.1	36.7	31.7	29.3	30.4	34.5	42.9	37.2	46
Day/Night	Night	Day	Night	Day	Day	Day	Night	Night	Night	Night
Total catch (kg)	249.998	775.002	1381.001	245.003	101.837	178.889	31.257	116.129	56.682	641.013
Total weight pilchard (kg)	1.340	1.800	4.750	7.178	35.214	66.714	2.798	21.742	1.226	33.804
Subsample weight pilchard (kg)	1.340	1.800	4.750	7.178	13.364	14.042	2.798	14.892	1.226	14.138
170								1		
180				1		15		9	1	
190			2			14		3		
200		1			3	5	3	3		
210	1	2	1	2	5	20	2	12		
220	1	2	4	6	21	33	3	19		12
230		4	6	5	55	57	3	34	1	24
240	7	3	13	27	87	143	6	58	4	96
250	1	3	10	13	84	162	7	44	4	84
260	1	1	2	4	16	76		6		43
Number measured	11	16	38	58	103	110	24	129	10	108
Raised number	11	16	38	58	271	523	24	188	10	258
Mean length (cm)	23.8	23.2	23.7	23.9	24.0	24.2	23.2	23.3	23.7	24.5

Table 8. CTD station details for the Danish HERAS survey with R/V Dana in June-July 2023.

Stat.	Date	Time	ICES	Position		Bottom depth	Wind speed	Seastate	Associated
no.	dd-mm-yy	UTC	Square	Latitude	Longitude	m	m/s		fishery station
1	27-06-2023	20:58	41F7	56.17.830 N	007.46.820 E	27	8.96	4	3
5	28-06-2023	04:16	41F7	56.15.622 N	007.31.851 E	30	5.62	4	4
8	28-06-2023	09:29	41F6	56.15.043 N	006.50.044 E	39	3.77	4	7
11	28-06-2023	13:10	41F6	56.15.517 N	006.24.632 E	44	5.96	2	10
13	28-06-2023	21:06	42F6	56.32.944 N	007.03.911 E	37	4.01	1	15
18	29-06-2023	05:23	42F7	56.32.893 N	007.36.169 E	34	3.5	1	16
21	29-06-2023	13:30	42F7	56.50.640 N	007.43.941 E	33	8.53	1	19, 20, 23
24	29-06-2023	21:08	42F6	56.49.759 N	006.49.444 E	33	13.27	5	26
28	30-06-2023	02:19	42F6	56.47.049 N	006.45.088 E	40	10.11	4	27
31	30-06-2023	07:10	42F6	56.50.638 N	006.20.544 E	51	5.85	2	30
34	30-06-2023	15:12	43F6	57.28.625 N	006.09.897 E	86	6.16	2	33
37	30-06-2023	18:56	44F6	57.43.510 N	006.09.682 E	263	6.41	3	36
39	30-06-2023	22:09	45F6	58.03.876 N	006.08.822 E	351	4.05	2	41
43	01-07-2023	04:05	45F6	58.01.207 N	006.33.394 E	380	6.31	2	42
46	01-07-2023	08:00	44F6	57.53.017 N	006.39.902 E	362	8.45	2	45
49	01-07-2023	23:37	44F7	57.52.926 N	007.17.102 E	395	12.98	5	48
52	04-07-2023	00:10	43F8	57.14.119 N	008.17.240 E	36	9.53	5	51
55	04-07-2023	07:41	44F8	57.37.727 N	008.17.415 E	207	8.38	5	54
58	04-07-2023	14:44	45F8	58.06.257 N	008.39.916 E	426	12.56	5	57
61	05-07-2023	02:16	44F9	57.47.537 N	009.30.832 E	39	11.89	4	60
64	05-07-2023	14:56	45F9	58.10.990 N	009.37.536 E	572	7.54	4	63
67	05-07-2023	19:47	44F9	57.49.702 N	009.50.258 E	48	8.42	3	66
70	06-07-2023	01:53	44G0	57.53.998 N	010.29.253 E	23	5.58	3	69
73	07-07-2023	01:11	46G0	58.32.620 N	010.53.387 E	78	11.05	6	72
76	07-07-2023	07:47	45G0	58.15.472 N	010.28.376 E	331	11.74	6	75
79	07-07-2023	20:33	44G1	57.50.068 N	011.06.702 E	49	7.91	4	78
82	08-07-2023	04:15	44G1	57.38.913 N	011.03.927 E	34	7.32	4	81
85	08-07-2023	19:59	42G1	56.52.810 N	011.52.856 E	31	0.61	0	84
88	09-07-2023	03:37	42G2	56.40.169 N	012.01.799 E	36	1.54	0	87
90	09-07-2023	11:50	41G2	56.16.125 N	012.10.686 E	30	2.81	0	-

Table 9. WP2 station details for the Danish acoustic survey with R/V Dana in June-July 2023.

Stat.	Date	Time	ICES	Position		Bottom depth	Wind speed	Seastate
no.	dd-mm-yy	UTC	Square	Latitude	Longitude	m	m/s	
2	27-06-2023	21:08	41F7	56.17.850 N	007.46.850 E	27	11.59	4
6	28-06-2023	04:31	41F7	56.15.509 N	007.31.972 E	30	5.92	4
9	28-06-2023	09:41	41F6	56.15.001 N	006.50.166 E	39	4.31	4
12	28-06-2023	13:21	41F6	56.15.498 N	006.24.628 E	44	5.69	2
14	28-06-2023	21:15	42F6	56.32.968 N	007.03.892 E	37	4.38	1
17	29-06-2023	05:18	42F7	56.32.888 N	007.36.156 E	34	3.55	1
22	29-06-2023	13:43	42F7	56.50.653 N	007.43.886 E	33	9.67	1
25	29-06-2023	21:19	42F6	56.49.709 N	006.49.604 E	33	10.79	5
29	30-06-2023	02:29	42F6	56.47.056 N	006.45.175 E	40	9.24	4
32	30-06-2023	07:22	42F6	56.50.600 N	006.20.745 E	51	5.62	2
35	30-06-2023	15:23	43F6	57.28.640 N	006.10.040 E	86	5.81	2
38	30-06-2023	19:22	44F6	57.43.568 N	006.10.232 E	263	6.11	3
40	30-06-2023	22:32	45F6	58.03.862 N	006.09.074 E	351	4.18	2
44	01-07-2023	04:27	45F6	58.01.289 N	006.33.074 E	380	5.83	2
47	01-07-2023	08:26	44F6	57.53.171 N	006.39.379 E	362	8.07	2
50	01-07-2023	23:58	44F7	57.52.957 N	007.17.046 E	395	13.46	5
53	04-07-2023	00:20	43F8	57.14.258 N	008.17.466 E	36	10.45	5
56	04-07-2023	08:00	44F8	57.37.930 N	008.17.790 E	207	9.64	5
59	04-07-2023	15:02	45F8	58.06.302 N	008.39.584 E	426	11.92	5
62	05-07-2023	02:26	44F9	57.47.621 N	009.31.240 E	39	12.26	4
65	05-07-2023	15:13	45F9	58.10.891 N	009.37.405 E	572	6.57	4
68	05-07-2023	19:59	44F9	57.49.798 N	009.50.298 E	48	9.89	3
71	06-07-2023	02:07	44G0	57.53.917 N	010.29.567 E	23	5.85	3
74	07-07-2023	01:22	46G0	58.32.900 N	010.53.333 E	78	12.87	6
77	07-07-2023	08:07	45G0	58.15.612 N	010.28.437 E	331	10.82	6
80	07-07-2023	20:44	44G1	57.50.012 N	011.07.170 E	49	8.48	4
83	08-07-2023	04:24	44G1	57.39.005 N	011.03.967 E	34	6.8	4
86	08-07-2023	20:10	42G1	56.52.778 N	011.52.778 E	31	0.63	0
89	09-07-2023	03:47	42G2	56.40.080 N	012.01.811 E	36	1.87	0
91	09-07-2023	12:01	41G2	56.16.182 N	012.10.692 E	30	2.73	0

The 2023 ICES Coordinated Acoustic Survey in the Skagerrak and Kattegat, the North Sea, West of Scotland and the Malin Shelf area

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Six surveys were carried out during late June and July covering most of the continental shelf in the North Sea, West of Scotland and the Malin Shelf. The surveys are presented here as a summary in the report of the ICES Working Group of International Pelagic Surveys (WGIPS), and component survey reports are available individually on request. The global estimates of herring and sprat from these surveys are reported here. The global survey results provide spatial distributions of herring and sprat and total abundance by number and biomass at age as well as mean weight and fraction mature at age.

The estimate of North Sea Autumn Spawning herring spawning stock biomass is slightly lower than the previous year at 1.89 million tonnes (2022: 1.96 million tonnes) despite an increase in the number of mature fish from 10 348 million fish in 2022 to 11 069 million fish in 2023.

The 2023 estimate of Western Baltic Spring Spawning herring 3+ group is 45 000 tonnes and 319 million fish. Compared to the 2022 estimates of 77 000 tonnes and 483 million fish, this equals a further decrease of 42% in biomass and is yet again the lowest estimate in the time series.

The West of Scotland herring estimate (6.a.N) of SSB in 2023 is 144 000 tonnes and 943 million individuals, which is a ~19% decrease in biomass and a ~10% decrease in abundance compared to the 177 000 tonnes and 1052 million herring estimate found in this area in 2022.

The 2023 SSB estimate for the entire Malin Shelf area (6.a and 7.b, c combined) is 167 000 tonnes and 1 158 million individuals. This is 28% lower than the 2022 SSB estimate (233 000 tonnes) and 20 % lower than the 2022 abundance estimate (1 442 million herring). There were again low numbers of herring found in the northernmost strata (to the north of Scotland and east as far as the 4°W line) in 2023, which is similar to recent years. Mature herring were distributed mostly in deeper and cooler areas (>150m deep) in 2023, to the south west of Barra between the 56°N and 57°N degree lines, and also in an area south of St. Kilda in deep water. There were more immature herring found in 2023, particularly to the north of Lough Swilly where there was good evidence of 0-wr and 1-wr herring. There were also 0-wr herring found in the Minch in 2023.

For consistency, the survey results continue to be presented separately for sprat in the North Sea and Skagerrak-Kattegat in this report, although these two stocks were combined in a benchmark in 2018 (ICES, 2018).

The total abundance of North Sea sprat age 1+ (Subarea 4) in 2023 was estimated at 73 402 million individuals and the biomass at 707 000 tonnes (Table 5.10). This is around the same level as the previous year, and above the long-term average of the time series (44% in terms of abundance and 50% for biomass). The stock is dominated by 1-year-old sprat (55% in biomass). The estimate of 0-group sprat, which only

occasionally is observed in the HERAS survey, was 6% in numbers and 1% in biomass compared with the totals.

In Div. 3.a, the sprat age 1+ abundance in 2023 was estimated at 280 million individuals and the biomass at 3 345 tonnes. This is the lowest estimate of the time series in terms of biomass, and well below the long-term average both in terms of abundance (84% below) and biomass (86% below). The estimate is dominated by 1-year-old sprat.

1 Introduction

Six surveys were carried out during late June and July covering most of the continental shelf north of 52°N in the North Sea and to the west of Scotland and Ireland to a northern limit of 62°N. The eastern edge of the survey area was bounded by the Norwegian, Danish, Swedish and German coastline and to the west by the shelf edge at around 200 m depth. Individual survey reports from participants are available on request from the nation responsible. The vessels, areas and dates of cruises are given in Table 5.1 and in Figure 5.1.

Table 5.1. Vessels, areas, and cruise dates during the 2023 herring acoustic surveys.

Vessel	Period	Contributing to Stocks	Strata
Celtic Explorer (IE) EIGB	01 - 20 July	WoS, MSHAS (6.a.N and 6.a.S)	2, 3, 4, 5, 6
Scotia (GB-SCT) MXHR6	28 June – 20 July	MSHAS, WoS, NSAS, Sprat NS	1, 91 (north of 58°30'N), 111, 121
Johan Hjort (NO) LDGJ	1 – 18 July	NSAS, WBSS, Sprat NS	11, 141
Tridens (NL) PBVO	27 June - 19 July	NSAS, Sprat NS	81, 91 (south of 58°30'N), 101, 131
Solea (DE) DBFH	1 July – 12 (19) July	NSAS, Sprat NS	51, 61, 71, (131)
Dana (DK) OXBH	27 June – 10 July	NSAS, WBSS, Sprat NS, Sprat 3.a	21, 31, 41, 42, 151, 152

2 Methods

Survey design and acoustic data collection

The acoustic surveys were carried out and analysed in accordance with the ICES survey manual for International Pelagic Surveys (ICES, 2015) using Simrad EK60 and EK80 echosounders with transducers mounted either on the hull, drop keel or in towed bodies. Only data gathered at 38 kHz was used for the analysis. Data collected at other frequencies was used for target discrimination. Echo integration and further data analyses were carried out using either LSSS (Large Scale Survey System; Korneliussen et al., 2006) or Echoview (Echoview Software Pty Ltd, Hobart, Australia).

The survey is designed to be analysed using StoX (Johnsen et al., 2019) with a set of strata surveyed through a grid of evenly spaced parallel transects. The survey area is divided into 23 strata with a randomized starting point for the grid of transects in each stratum and with transects running perpendicular to lines of bathymetry where possible (Figures 5.1 and 5.2). The planned transect spacing in the (parallel transect) strata ranges from 10 to 30 nautical miles (n.mi.) (Table 5.18). The relative effort (and therefore the transect spacing) in each stratum was determined based on the mean abundance and variance in each of the strata during surveys in the most recent 10 years prior to the new overall survey design being implemented (2005 – 2015), and the strata had been classed as high, medium, and low effort (ICES, 2016).

In 2022 a change was made to the survey design by splitting stratum 151 into a northern and a southern part. In the southern part (below 57°N) transects were changed from running in a North - South direction parallel to the Danish coast to running perpendicular to the coast and parallel to the transects in stratum 71 to the south instead. Mixed aggregations of small herring and other juvenile fish tend to concentrate towards the coast in this area, and the change in design/transect orientation is more appropriate in this situation. Additionally, the change mitigates potential bias introduced in the analysis caused by increasing amounts of mixing of WBSS and NSAS from south to north. In the southern part of stratum 151 (151_S) there is little mixing, and the herring is nearly all NSAS. In the northern part (151_N) the proportion of WBSS in catches can be very high, and WBSS is consistently present in this part of stratum 151 (Figure 5.21).

A total of 9 715 n.mi of acoustic transects covered during the survey were used in the acoustic analysis. achieving good coverage of most of the survey area. Due to a loss of survey time through initial delays and a required premature termination of the survey, stratum 131 covered by Germany had to be omitted, but was covered by RV “Tridens” instead of RV “Solea”. Thus, full coverage of that stratum was achieved. The coverage of stratum 81 by the Netherlands was adapted due to time constraints and navigational restrictions due to wind farms. In the far south of the stratum the bathymetry did not allow sailing and fishing. The modifications and adaptions allowed full and even coverage in all strata.

Scrutiny of acoustic data

In the Dutch, Irish, Norwegian, and Scottish cruises, covering strata 1, 2, 3, 4, 5, 6, 11, 81, 91, 101, 111, 121 and 141, scrutiny of hydroacoustic data during post-processing is conducted to individual species level and species-specific NASC values are uploaded to the ICES database[1]. In strata 21, 31, 41, 42, 51, 61, 71, 131, 151, 152, covered by the German and Danish cruises, clupeids usually do not occur in single species schools but in mixed aggregations and schools that are comparatively clearly distinguishable from other schooling fishes. Post-processing of hydroacoustic data is therefore based on an aggregated CLU category consisting of a mix (in variable proportions) of clupeids herring (HER) and sprat (SPR) as well as on some occasions also anchovy (ANE) and sardines (PIL). Occasionally, spatially restricted occurrences of “clean” schools of herring, sprat or sardine are observed. Then, species-specific categories are allocated to the corresponding acoustic registrations. In cases of mixed targeted catches of clupeids together with other species (horse mackerel, mackerel, various gadoids etc.) a combined MIX category is allocated to the respective echoes. Depending on regional observations and catch composition, clupeid species can therefore also be included in

the MIX category. The allocation of spatially limited but partly significant observations and catches of clupeids e.g. sardines and anchovies to a species-specific or a combined category is followed to avoid overestimating the contribution of these species in the total stratum by including them in the CLU category.

The composition of both the CLU and MIX categories in the Danish and German cruises can vary according to catch compositions in trawl hauls conducted on the corresponding transects. All disaggregation steps of mixed acoustic categories to individual species in the German and Danish data are conducted using a Split-NASC process in the StoX software, where all categories employed are clearly defined (Table 5.20). In 2023, the aggregated CLU as well as the MIX category was allocated to both German and Danish data. The disaggregated and species-specific NASC values from the Split-NASC process attributed to herring and sprat etc. are used in subsequent processes in the overall analysis.

For the Split-NASC processes as well as for further analyses of disaggregated data (stock estimates), the following target strengths were used for clupeids (ICES, 2015):

Herring, sprat, sardine, anchovy $TS = 20 \log L - 71.2$ dB

Stock splitting

Stock splitting was conducted using genetic analysis in several parts of the survey area (See section 5 for details). For the genetic analysis, Single Nucleotide Polymorphism (SNP) panels were used including diagnostic markers to discriminate known populations (Bekkevold et al., 2022; Farrell et al., 2022; Han et al., 2020). Laboratories has developed their individual SNP panel consisting of diagnostic markers to specifically identify populations of interest in that specific region, i.e. there is no need to include markers discriminating central Baltic herring in the Malin Shelf area. However, the development of individual panels was conducted in close collaboration between laboratories. This also accounts for the establishment of reference baselines. Several reference samples that would be of interest for multiple laboratories have been exchanged. This ensures that all laboratories use identical baselines to identify known populations. However, the newly identified population of spring-spawning herring in the North Sea is so far only included in the genetic baseline used in the Norwegian survey area. Thus, herring from this population are either assigned as Norwegian spring spawners or Western Baltic spring spawners in the Danish survey area, using the Danish baseline (ICES, 2024). Nevertheless, this would not influence the survey indices since all three populations would be assigned to the western Baltic herring stock based on mimicking the otolith microstructure method (Table 5.21).

Data analysis

The 2023 disaggregated biological and acoustic data were uploaded to the ICES Acoustic trawl surveys database[1] held at the ICES data centre, and the data was analysed using the StoX analysis software (v. 3.6.2; Johnsen et al., 2019).

Acoustic and biological data were combined to provide an overall global estimate. Estimates of numbers-at-age, maturity stage and mean weights-at-age were calculated by individual survey stratum (Figure 5.1). The data were combined to provide estimates of the North Sea Autumn Spawning herring, Western Baltic Spring Spawning herring, West of Scotland (6.a.N) herring and Malin Shelf herring stocks (6.a./7. b, c) as well as sprat in the North Sea and 3.a.

1 https://www.ices.dk/ data/data-portals/Pages/acoustic.aspx

North Sea Autumn Spawning herring (NSAS)

Includes all herring encountered in the North Sea between 4°W and 2°E and south of 56°N [56.5°N between 2-6°E] (strata 71, 81, 91, 101, 111, 121 in Figure 5.1). East of 2°E and north of 56°N [56.5°N between 2-6°E], in strata 11, 21, 31, 41, 42, 141, 151_N, 151_S and 152, herring is split into North Sea Autumn Spawning herring and Western Baltic Spring Spawning herring (Figure 5.1) based on genetic analysis (See more details in section 5).

Western Baltic Spring Spawning herring (WBSS)

The allocation to the Western Baltic Spring Spawning herring stock is limited by the geographical boundaries of strata 11, 21, 31, 41, 42, 141, 151_N, 151_S and 152. Stock splitting is only applied within these strata (Figure 5.1). Individual biological assignments of WBSS herring are based on genetic analyses (see details in section 5).

Malin Shelf Herring (MSH)

Includes all herring in the stock complex located in ICES areas 6.a and 7.b, c. The survey area is bounded in the west and north by the 200m depth contour, in the south by the 53.5°N latitude, and in the east by the 4°W longitude (strata 1 - 6 in Figure 5.1). The survey targets herring of 6.a.N and 6.a.S spawning origin in mixed feeding aggregations on the Malin Shelf. HAWG recommended to WGIPS in 2021 that the results of the EASME project (Farrell et al., 2021) on stock splitting be considered in future analysis and planning of the summer survey in 6.a.N and 6.a.S (also known as the Malin Shelf Herring Acoustic Survey, or MSHAS). The genetic split results were accepted at ICES WKNSCS benchmark on 6a herring in 2022 (ICES, 2023a) and therefore 6.a.N and 6.a.S stocks are now assessed separately. Split indices for 6.a.N and 6.a.S stocks based on genetic analysis are now also produced from the MSHAS survey results. To maintain consistency with previous years, overall results for the MSHAS survey based on area are still presented here, and the split results for the 2014 – 2023 MSHAS surveys into the relevant stocks are documented in a working document to WGIPS 2024 (O'Malley and O'Connell, 2024). These results are generated using the method described in a working document to the WKNSCS benchmark (ICES, 2023a). The differentiation between 6.a herring and North Sea herring across the 4°W line of longitude is purely based on geography.

West of Scotland herring (6.a.N)

This is a now historic subset of the Malin Shelf herring abundance and biomass estimate based on geographical location (strata 1 - 4 in Figure 5.1). All herring recorded north of the 56°N line of latitude are reported as West of Scotland (6.a.N). This distinction is kept to maintain a comparable time series of abundance of mixed stocks of herring to the West of Scotland. The area North of the 56°N line of latitude has been covered annually since 1991 whereas the extended area to include all of 6.a and 7.b and c (MSHAS index) has been covered annually since 2008.

North Sea and Div. 3a sprat

The sprat benchmark in November 2018 (ICES, 2018) decided that sprat in these two areas should be assessed as one stock going forward. In this survey report, the results are still presented separately for these two areas for consistency. The indices should be summed for use in the sprat assessment.

All sprat recorded in the North Sea geographical area (ICES Subarea 4) are included in the North Sea sprat survey estimate, including the northern parts (strata 141, 91, 111 and 121), where low but recurring registrations of sprat have been observed in the preceding years (Figure 5.1). Furthermore, sprat in the Moray Firth (stratum 101) are also included in the survey estimate of North Sea sprat.

Sprat in Div. 3.a: All sprat in strata 21, 31, 41 and 42 are included in this index.

The border between ICES Div. 3.a and Subarea 4 was revised in 2015. The new border has been used for index calculation since 2015, but prior to this the old border was used to delineate the stocks.

The survey strata used for the analysis are shown in Figure 5.1. The area and transects covered during the national acoustic surveys are given in Figure 5.2, and magnitudes of acoustic herring and sprat detections (NASC, Nautical Area Scattering Coefficients) for 5 n.mi. intervals are given in Figures 5.3 and 5.4, respectively. The survey provides numbers at age, mean length as well as weight at age and maturity at age for the different herring and sprat stocks (North Sea Autumn Spawning herring, Western Baltic Spring Spawning herring, West of Scotland herring, Malin Shelf herring, sprat in the North Sea and sprat in Div. 3.a), and the time series of these are given in Figures 5.5-5.10. The time series of biomass/abundance for the four herring stocks (North Sea Autumn Spawning herring, Western Baltic Spring Spawning herring, West of Scotland and Malin Shelf herring) are given in Tables 5.6–5.9 and illustrated in Figures 5.11-5.14, respectively. The time series of biomass and abundance for sprat in the North Sea and in Div. 3.a are given in Tables 5.11 and 5.13 and Figures 5.9, 5.10, 5.15 and 5.16 respectively. In each of the figures 5.11-5.16, a 3-year running mean is included to show the general trend more clearly.

Herring to the east of 4°W

The NASC values attributed to herring throughout the HERAS survey are shown in Figure 5.3. As in previous years, the largest aggregations of adult herring east of 4°W were concentrated in the areas to the east of the Shetland Isles, between 2°W and 2°E and app. 58°N - 61.5°N (Figures 5.3 & 5.17). Adult herring were also distributed in the Norwegian Trench into the deeper parts of Skagerrak. Juvenile herring were primarily in the usual distribution in the shallower south and eastern parts of the North Sea and in the Skagerrak and Kattegat (Figure 5.18).

The estimate of **North Sea** Autumn Spawning herring spawning stock biomass (SSB) has decreased by 4% from 1.96 million tonnes in 2022 to 1.89 million tonnes this year (Table 5.6, Figure 5.11). The abundance of mature fish has increased from 10 348 million in 2022 to 11 069 million in 2023 (Table 5.2). The mean weight of mature fish is 10% lower than last year at 170.3g, and the decrease in biomass of mature fish can be attributed to this change in condition of individual fish. The strong 2012 and 2013 year classes are both in the 9+ group now and no longer contributing significantly to the stock. The ages 1 - 4 winter rings (wr) make up the majority of the stock now. It should be noted that several year classes from 2014 onwards are well below the average level since 2010 (and the long-term average). The 2016 year class (6-wr in 2023) is particularly weak with abundance at only 49% of the average level since 2010. The abundance of immature fish in the stock has increased by 116% from 19 780 million in 2022 to 42 775 million this year. This is due to a large number of age 1-wr in the survey this year. The estimate for this age group is associated with high uncertainty in the survey though, so the impact of this increase on future stock development is still uncertain.

Maturities for all ages were comparable to the long-term average with 67% maturity for 2-wr, 97% maturity of 3-wr, 99% or higher maturity for all ages 4-wr and above (Table 5.2). Since 2015, actual observed maturities are reported for all age groups. Prior to 2015 maturity was fixed at 100% for ages above 4-wr.

The 2023 estimate of **Western Baltic** Spring Spawning herring 3+ group is 45 000 tonnes and 319 million herring (Table 5.3). This is a 42% decrease in biomass (34% decrease in abundance) compared to 2022 and represents the lowest estimate in the time series, well below the average from 2009 to the present (2009 – 2022; 690 million herring). In comparison, the 2017 estimate was the highest level observed since 2008 (1 353 million) and was comparable to the stock size prior to the low levels observed after 2008 (Table 5.8). In 2022 the fish of age 2-wr was the single largest component of the stock (32% of overall abundance) (Table 5.7, Figure 5.6). In 2023 this year class, now at 3-wr still account for 21% of the total stock. The single largest age component in 2023 however was 1-wr fish that accounted for 35% in contrast to the almost complete lack of 1 winter ring fish in both 2021 and 2022. The numbers of older herring (3+ group) accounted for 49% of the

total stock in 2023. This is a decrease from 2022, where the 3+ group accounted for 69% of the total stock but still a higher contribution than was observed in the period 2009 to 2020 where the 3+ group on average accounted for only 37% of the stock. The average weight of WBSS herring was 28% lower in 2023 (100g) compared to 2022 (138g). This poorer condition was observed over all age classes apart from age 1- and 4-wr where there was an increase in average weight of 14 and 9% respectively.

Herring to the west of 4°W

The **Malin Shelf** (6.a and 7.b, c) herring estimate of SSB in 2023 is 167 200 tonnes and 1 158 million individuals (Table 5.5), is a decrease compared to the 233 400 tonnes and 1 442 million individual herring found in 2022. The estimate is the 5th lowest estimate in the time series (2008-2023) (Table 5.9, Figure 5.14). In 2023, 70% of the total biomass (TSB) and 85% of the SSB was observed north of 56°N (the geographic area that forms the historic **West of Scotland** (6.a.N) index). Herring were distributed in more areas in 2023 compared to 2022, with mature herring found mostly in deep areas south west of Barra, west of the Hebrides (south of St. Kilda) and young immature fish found north of Lough Swilly (Malin Head area). The **West of Scotland** (6.a.N) herring estimate of SSB is 144 000 tonnes and 943.5 million individuals (Table 5.4) is a decrease compared to the 177 000 tonnes and 1052 million herring estimate in 2022. The time-series of indices of abundance per age class for West of Scotland herring are provided in Table 5.8. The estimates since 2016 are still the lowest in the time series. The distribution of herring schools was broadly similar to 2022 except that herring were found in more areas and in more hauls (Figure 5.3). There were some good herring marks found to the south of St. Kilda in 2023, tight to the bottom in deep areas, but generally less than found historically in this area.

Immature herring were found north of Lough Swilly to the north west of Malin Head, in higher numbers than 2022, similar to years immediately prior to 2022 (Figure 5.18). There were some immature herring distributed to the west of the Outer Hebrides in low numbers also. Adult herring were mainly found in deeper, cooler water to the south west of Barra and west of the Outer Hebrides (Figure 5.17). Most of the herring in Stratum 1 to the north of Scotland were found in the north east of the stratum near the 4°W line. Herring has in the past been found in high densities to the east of the 4°W line to the north of Scotland in association with a specific bathymetric feature and the occurrence of these herring west of the line in some years has the ability to strongly influence the annual estimate of abundance of the Malin Shelf/West of Scotland estimates. This has not been the case for the last number of years. Relatively large schools for the strata are usually seen in the north east of the strata along the 4°W line. In 2023 there were some evidence of increased herring abundance east of the 4°W line, more than in recent years.

The Malin Shelf survey estimate was dominated by 2-, 3- and 4- winter ringers, making up 75% of the total abundance and 76% of the total biomass. Immature herring made up 24% of the total biomass (Table 5.5). Age disaggregated survey abundance indices for Malin Shelf herring since 2008 are given in Table 5.9.

Sprat in the North Sea and Div. 3.a

In the North Sea, sprat were observed in strata 51, 61, 71, 81, 131, 151_S, and 151_N (Table 5.17). Highest sprat densities were measured in the southeastern part (below 56.5° N) of the survey area (strata 51, 131, and 71) (Figure 5.4). The southern limit of the surveyed area is at 52° N. There is no indication that the southern limit of the sprat stock distribution has been reached; it is likely that sprat distribution extends further south into the English Channel.

The sprat distribution in the North Sea and Div. 3.a in terms of abundance and biomass per stratum is shown in Table 5.17. The NASC values attributed to sprat in the survey are shown in Figure 5.4. The age 0 indices are not used in the stock assessment for sprat.

The total abundance of sprat 1+ in the North Sea (Subarea 4) in 2023 was estimated at 73 402 million individuals and the biomass at 707 000 tonnes (Table 5.10). This is above the long-term average of the time series in terms of both abundance (44%) and biomass (50%). Compared to the 2022 estimate, abundance and biomass are 7% lower and 0.3% higher, respectively (Table 5.11, Figure 5.9). The 1+ estimate was dominated by 1-year-old sprat (55% of biomass), and 89% of the sprat were found to be mature (Table 5.10).

An age-disaggregated time-series of abundance and biomass of sprat in the North Sea (ICES Subarea 4), as obtained from the acoustic survey, is given in Table 5.11.

In Div. 3.a, sprat in stratum 21 (Kattegat) and 31 (Skagerrak) dominated the estimate (97% of the abundance and 96% of the biomass), but sprat were also found in stratum 42 of the Skagerrak area (comprising strata 31, 41, 42). In some years (2013 and 2018), sprat has exclusively been found in the Kattegat. The age 1+ abundance was estimated at 280 million individuals, 33% lower than the 417 million individuals in 2022 (Tables 5.12-13). The biomass was 36% lower than in 2022, at 3 345 tonnes. 1-year-old sprat dominate the stock (64% in numbers and 53% in biomass). The age-disaggregated time-series of sprat abundance and biomass in Div. 3.a are given in Table 5.13 and Figure 5.10.

5 Quality considerations

The 2023 HERAS global survey estimates of abundance were calculated using StoX (Johnsen et al., 2019) version 3.6.2 with Rstox Framework 3.6.2, with input files (ICES XML format) generated via the ICES Acoustic database[2]. Version 3.6.2 is comparable with version 3.5.2 used for the 2022 survey estimates. The delivery of disaggregated acoustic and biological data to the group continues to be considered an improvement to the survey analysis as it allows a level of transparency and discussion on data collection and standardisation issues not readily achieved before.

The 2023 survey covered all planned strata, and survey effort, timing and coverage were largely comparable to previous years. Due to temporal and other (see below) restrictions, the stratum area of stratum 81 had to be reduced by cutting the southern part of the stratum off (at ca. 54°30 N) and reducing the total stratum area by 34%. The non-issuing of permits by Swedish authorities for some parts of Swedish territorial waters required shortening some transects in coastal areas of strata 21 and 31 (Skagerrak/Kattegat). This was accounted for by a corresponding reduction of the stratum area in the analysis by 8% and 15% respectively. Despite these modifications, all main aggregations of herring are considered to have been sampled sufficiently.

Some parts of stratum 81 covered by the Netherlands are not accessible anymore due to the building of wind farms requiring a slight modification in transect orientation. Additionally, the southern part of stratum 81 in some areas does not allow sailing and pelagic fishing due to topographical constraints. As these restrictions are pertaining it may be necessary to consider a permanent modification to this stratum in the future. The modifications carried out this year are typical for this stratum and are not thought to have a significant effect to the overall results.

Stock containment

In previous years, herring was observed in the most northern HERAS transects, suggesting that North Sea herring may be distributed further north than the area covered by the HERAS survey. The amount is not currently considered significant, and as in previous years, the northward extension of herring appeared to be largely contained within the survey strata covered in 2023. Other surveys covering the area north of the HERAS area have also detected small amounts of herring in recent years, and genetic sampling of herring in the Norwegian Sea surveys in May and July has also confirmed the presence of NSAS herring north of 62°N.

To ensure containment of North Sea herring in the northern part of the HERAS survey we suggest using data from summer surveys covering the most northern part of the North Sea and areas further north. In particular, the Norwegian acoustic saithe survey (NORACU) where the first part co-occurs with the Norwegian part of HERAS, and the second part covers the area between 59-62°N and 1°W to 2°E. NORACU allocate herring for the acoustics, but since herring is not the target species there are no targeted hauls. The trawl hauls targeting saithe though occasionally have good samples of herring, and this survey thus can be used to add an exploratory stratum north of the northern boundary of if the HERAS to monitor the containments (or lack thereof) of North Sea herring. In 2023, NORACU had seven bottom tows at the margin of or north of the HERAS survey area, whereof five had very small herring catches (less than ten kg).

Generally, good containment of the adult stock was achieved in the Malin Shelf area in 2023. However, herring was observed straddling the 4°W line in 2023, particularly just to the east side of the line between strata 1 and strata 121 (Figure 5.3). This is an ongoing issue that is observed to some degree in most years.

2 https://www.ices.dk/data/data-portals/Pages/acoustic.aspx

This year, herring acoustic echo-traces showed some unusual patterns with occasional near-surface vertical distribution. This raised concerns about some potential underestimation due to limited echosounder coverage issues (blind zones) near the surface and potential increased avoidance problems. The survey coincided with an unusual marine heatwave, resulting in significantly warmer surface waters above the seasonal thermocline. This may have caused a sharper mixed layer interface and a shallower thermocline depth, potentially affecting herring vertical distribution and zooplankton availability. The near-surface herring distribution was confirmed by sonar observations onboard FRV "Tridens" when possible, followed by extra scrutiny of the upper echograms during analysis. Other survey groups (Scotland and Norway) also corroborated these observations and carefully inspected the surface observations. A preliminary analysis showed that the interpretations and the outcomes are in agreement between Scottish and Dutch group. We are confident in the accurate identification of "surface herring" and in the corresponding inclusion in the analysis.

Stock splitting

Since 2021 a common genetic analysis method has been applied for stock splitting, replacing the two traditional methods of otolith microstructure and shape (used in strata 21, 31, 41, 42, 151, 152) or vertebrae counts (used in stratum 11 and 141). The advantage of genetic data is a more fine-scale discrimination down to the population level compared to the previously used methods. The results of the genetic analysis revealed that several populations that were previously not considered occur in the survey area. In total, 9 different herring populations have been identified (Figure 5.21). Aside from the 3 identified with previous methods (NSAS, Downs (included in NSAS indices) and WBSS), the genetic method also identified herring from several adjacent populations in the survey area: WBSS Skagerrak herring (WBSS-SK) which can be discriminated from other WBSS herring, Norwegian Spring Spawning (NSS) herring, spring spawning herring from the North Sea (SSNS), Central Baltic herring (CBH), Baltic Autumn Spawning (BAS) herring, and North Atlantic summer/autumn spawning herring (NASS) comprising Icelandic Summer Spawning herring, Norwegian Autumn Spawning herring and Faroes Autumn Spawning herring (ICES, 2024). This increased resolution of stock discrimination at individual level provides challenges to the index calculation and warrants a larger discussion with the assessment working group (HAWG) for the way forward. In terms of consistency in the calculation of the indices for NSAS and WBSS, individuals were only assigned to either the NSAS or WBSS herring stock as was done previously. Their assignments to either stock was based on the genetic result, and where this indicated a different stock than NSAS or WBSS, the assignment was mapped to how the previously used splitting methods would have assigned them (Table 5.21). So, in strata 11 and 141, where the vertebrae counts were previously used, NSS, SSNS and WBSS Skagerrak herring would be mapped to NSAS, whereas in strata 21, 31, 41, 42, 151 and 152, where the otolith microstructure method was used, these would be mapped to WBSS and so forth following linkages in table 5.21. This allows us to provide estimates of abundance for NSAS and WBSS herring that are comparable to previous years and therefore compatible with the time series. We do however now have firm evidence that these indices contain several more herring stocks than previously considered in the splitting process and need to discuss a way forward. The indices used for NSAS and WBSS are "contaminated" by other stocks, however we cannot estimate by how much each year going back in time, or how variable this has been between years. There is likely a high inter-annual variability in mixing proportion both due to the migratory behavior of herring in these areas and also to differences in year class strength between the different stocks in the mix.

It should be noted that the amount of the newly identified spring-spawning herring in the North Sea in strata 11 and 141 is surprisingly high. SSNS herring account for up to 25% within a haul. Retrospective comparison with previous years shows that the amount has continuously increased since 2019 when genetic assignments was used for the first time. Further investigations are needed to explore the origin of this population and the potential consequences for the survey estimate. For example, if the internal consistency of the survey estimate will be influenced by the occurrence of a strong year class of a different population.

In addition, herring outside the stock splitting area for NSAS and WBSS are assumed to be 100% NSAS herring. Small scale investigations over recent years have indicated that other stocks may be encountered in these areas, albeit in relatively small numbers. A recent study identified Norwegian Spring Spawning herring (NSS) in the survey area by using length-at-age differences between NSAS and NSS (WD Annex 18, ICES, 2023b). The study indicated that some individual catches contained up to as much as 25% of NSS herring. The applied method is very conservative and most likely underestimating the amount of NSS herring present in the northern part of the HERAS survey area. We recommend that genetic analysis also be applied in other strata to quantify potential mixing with other stocks and that Norwegian Spring Spawning herring should be considered in a future splitting scenario.

Occasionally, Germany has also conducted analysis of otoliths to deduct stock origin of herring in strata 51, 61, 71 and 131. Only very small amounts of spring spawning herring have been found during this exercise (2 in 2015, 1 in 2016, 3 in 2017, 1 each in 2018, 2019 and 2020, most in strata 71 or bordering it). These are suspected to be from local spring spawning populations in the adjacent Ringkøbing Fjord, but this has not been genetically verified. Historically splitting has not been carried out in these strata, and given the very small amount of spring spawning herring detected since the start of this investigation in 2015, no splitting of the acoustic abundances is conducted in the southern area.

Malin Shelf (6.a/7.b, c) splitting: A benchmark for the herring stocks contained in 6.a, 7.b, c was held in 2022 (ICES, 2023a). A split index for the survey back to 2014 using results from the EASME project (Farrell et al., 2021) was accepted at the benchmark. Methods used to split the MSHAS index using genetics were published in Farrell et al. (2022). The splitting of the herring found on the MSHAS relies on continued maintenance of baseline spawning data from the individual 6.a.N and 6.a.S stocks, but also from other stocks known to be in the MSHAS area during the survey. For instance, there are spring spawning herring and other herring of unknown origin known to be in the MSHAS area during the summer and although these are accounted for in the split index of the MSHAS, there is a lot of uncertainty around the life history of these smaller stocks and how vulnerable they are to fishing or environmental pressures.

Survey uncertainty

The use of the StoX software for survey abundance estimation, concurrent availability of disaggregated survey data, and application of a transect-based approach allows for an estimate of survey uncertainty. With the development of automatic routines, CVs have been estimated for abundance at age in each stratum. Results are shown for the period 2017-2020 for the NSAS and WBSS herring estimates in Figure 5.19 and 5.20, respectively. Overall, there is consistency in CV estimates since 2017 for both NSAS and WBSS herring. Since 2021 the procedure has not yet been realised in the new version of StoX due to a bug during the impute function when using genetic stock identification. The survey group is in close contact with the StoX developers that this bug will be fixed in the next StoX version (release planned in early 2024). The survey group anticipates CVs to be estimated again in 2024 and forward for these stocks also.

The CV on the estimate for the Malin Shelf survey in 2023 was 0.41. This is slightly lower than the 2022 estimate of 0.51, but still higher than in recent years. The increased distribution of herring overall in the survey area, and herring found in more hauls and on more transects was most likely the cause of the slightly improved CV estimate compared to 2022. There has been an increase in the juvenile/immature herring occurring in the trawls in the Malin Shelf area in recent years, particularly in the southern area, this were evident again in 2023. However, because of the expected distribution of juvenile/immature herring in mostly shallow inshore areas at this time of the year, they are not considered reliably estimated with this survey design.

Biological sampling

More biological samples were obtained in the Malin Shelf survey area in 2023. The stock was more widely distributed in terms of area compared to 2022 with increased numbers of echotraces. Conditions were good on the survey and there was adequate trawling effort, however samples were only obtained in the deeper, cooler areas where herring were found in high concentrations acoustically. In strata 1 a ground trawl has been used for the last number of years to secure samples particularly in the area north west of The Butt of Lewis. In this area herring are often only found tight to the seabed. There were samples obtained in all the relevant strata, including genetic sampling which was used for stock splitting a requirement after the 6.a benchmark (ICES, 2023a). Overall, trawling in 2023 provided good confidence in school recognition and supporting biological data for age stratified abundance estimation of herring in most strata. However, there were still relatively low numbers of hauls in some strata. With the continued low stock size in recent years in the Malin Shelf area it has been difficult to secure catches in some years, potentially affecting the accuracy of the stock composition estimates for West of Scotland and Malin Shelf herring.

The biological sampling strategy (how many individual fish of the target species are measured and aged and how they are selected) is not standardised amongst participants in the HERAS survey, mainly due to historical differences in analysis methods used to work up the partial results from each area. The strategies vary, with some collecting a fixed total number of fish from the catch to sample for age, maturity and stock ID, for others a fixed number of fish from each length class are sampled (either the same across the length distribution, or further stratified by length class with a larger number (but still pre-determined) selected from the larger lengths to resolve the age structure better (see Table 5.19 for an overview of sampling strategies used in HERAS).

There is concern that biological sampling effort in some strata is inadequate to satisfy the increasing demands on the survey to provide results for an increasing number of sub-categories with the increased focus on stock splitting using genetic results.

We suggest a review of the different strategies used and that an analysis is carried out in the survey group to determine the effect of the different strategies on the accuracy and precision of the final results (the abundance indices delivered to the assessment procedure for the stocks). Furthermore, it should be explored what the optimal sampling strategy and level is, given the present situation, but also what is needed with the increased demand for splitting the survey results in the near future.

A workshop with the nations participating in the HERAS survey has been put on hold due to lack of resources. The survey group hope the work can be taken up again in the near future.

Scrutiny of acoustic data

In the Dutch, Irish, Norwegian, and Scottish survey, scrutiny of hydroacoustic data during post-processing is taken to species level. Based on scattering characteristics of echo-traces as well as catch composition of corresponding targeted trawl hauls, a robust allocation of e.g. herring and sprat to echoes originating from detected fish schools and aggregations is feasible. The acoustic categories HER (herring) and SPR (sprat) are therefore allocated to these echo-traces and corresponding NASC values are exported from integration results.

The group recommend mixed-species acoustic categories should only be used when there is no other alternative, i.e. when species level scrutiny is not possible due to herring and sprat occurring in truly inseparable mixed aggregations with other species. In general, it is recommended to scrutinize to the highest resolution where possible and to improve species allocation to mixed aggregations through more directed trawling on aggregations.

In the German and Danish survey area, clupeids mostly occur in mixed schools of “typical” appearance that based on hydroacoustic characteristics and corresponding catch composition from trawl hauls rarely allow allocation of a single species category to echo-traces. However, clupeid schools in the area are comparatively

clearly distinguishable, and an allocation of a general aggregated CLU (clupeid) category is typically feasible. Where clupeids are found in aggregations with other species, a category of MIX is assigned in the post-processing, the precise mix of species being determined from the composition of relevant trawl hauls. In 2023, the MIX category was allocated in the German acoustic data due to some hauls on distinct aggregations containing notable numbers of a species other than clupeids assumed to contribute to the measured backscatter (horse mackerel, *Trachurus trachurus*). In the Danish acoustic data, the MIX category was applied due to partly high species diversity in catch samples with notable contributions of other than the target species and the expectable contribution of those fishes to the echo registrations recorded. This is partly expected to result from different trawl gear employed as well as the areas visited. In general, this approach followed in the adjacent Danish and German survey areas with a high degree of mixed aggregations is considered to give a robust estimate of the disaggregated, species-specific and spatially explicit NASC distribution of both target and non-target species in the corresponding strata. In 2023 one of the strata in the German survey area had to be covered by the participating Dutch vessel. There, to harmonize post-processing and scrutiny of acoustic data with the adjacent German (and Danish) strata, no scrutiny to species level was conducted, but schools were reported as an aggregated CLU category as would have been the case with the German vessel covering that stratum. Accordingly, while the acoustic and biological data was sampled by the Dutch vessel, post-processing and evaluation of the data from stratum 131 were conducted following the German "mixed CLU schools" approach.

The allocations of trawl hauls to acoustic samples used for the split-NASC processes are documented in the final StoX project. The allocation of aggregated categories to acoustic data as well as the splitNASC project results (disaggregated categories are shown in Fig. 5.22.

The potential concern introduced by the near-surface occurrence of herring (see above) and an observed increase in the contribution of backscatter originating from other species in some strata, predominantly gadoid groups (Haddock and Whiting) did not pose a significant challenge, and we are confident in the accurate identification of species from the acoustic recordings.

Maturity

Since the 2015 survey no assumptions have been made about expected full maturity above a certain age, and those actually observed in the surveys are reported in this report. In the past (prior to 2015), fish 5-wr or older were all assumed mature by definition in the reported result from the HERAS survey. This is a decision that should be made in the assessment working group for each assessment, as the underlying data should be collected and reported as actually observed.

From 2017 the proportion mature at age of WBSS is not reported. Due to the timing of the survey in relation to the spawning time of this spring spawning stock, it would be erroneous to calculate SSB based on observations since first-time spawners might not have started their maturation development (switch from immature to mature) at this time of the year.

6 Further improvements to survey

1) Efforts to further standardise the HERAS survey should continue.
    a. Assess the various biological sampling strategies used in the survey by different laboratories and develop a commonly agreed strategy to achieve adequate resolution of stock, age and maturity composition
2) Strive to continue monitoring of stock containment to the north of stratum 111. This informs whether it should become necessary to expand the survey area further north.
3) Monitor sardine and anchovy occurrence and distribution in the survey area and provide corresponding information in the combined survey report.
4) Continued extensive check of the national data incl. check of compliance with the ICES acoustic trawl database format requirements should be performed prior to the post-cruise meetings. This includes also thorough checks of the reporting format for e.g. age: All ages for herring must be provided in winter rings to be used by the assessment working group.
5) Further work to incorporate genetic sampling and analysis of herring throughout the HERAS area to facilitate splitting the survey estimates into the component stocks using a commonly agreed set of techniques and procedures. This includes the evaluation of NSAS/WBSS stock splitting but also mixing with other herring stocks. This will require extra resources from national laboratories and possibly a series of workshops to agree on methods for collecting and analysing genetics as well as agreements on sampling levels needed to achieve adequate precision.
6) The coverage of strata 152 by Denmark and 141 by Norway should be temporally synchronized to ensure that western Baltic spring-spawning herring are fully monitored during their feeding migrations. A lack of synchrony could result in issues with stock containment by missing the fish in both strata or by double detections. This is best accomplished by ensuring coverage of these strata between 25 June – 2 July each year.

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Tables and Figures

Table 5.2. North Sea Autumn Spawning herring: Total numbers (millions) and biomass (thousands of tonnes) in the area surveyed in the acoustic surveys June - July 2023. Mean weights, mean length and fraction mature by age (winter ring).

Age (ring)	Numbers	Biomass	Maturity	Weight(g)	Length (cm)
0	31 408	96	0.00	3.1	7.7
1	11 189	456	0.07	40.7	17.0
2	2 703	300	0.67	111.1	23.4
3	3 335	542	0.97	162.4	26.3
4	2 295	450	0.99	196.1	27.9
5	1 387	280	1.00	201.6	28.0
6	466	96	1.00	206.9	28.5
7	377	83	0.99	220.8	28.7
8	298	72	1.00	239.7	29.5
9+	385	96	1.00	249.3	29.8
Immature	42 775	585		13.7	10.3
Mature	11 069	1 885		170.3	26.1
Total	53 844	2 471	0.21	45.9	13.6

Table 5.3. Western Baltic spring spawning herring: Total numbers (millions) and biomass (thousands of tonnes) in the area surveyed in the acoustic surveys June-July 2023. Numbers. biomass. mean weight and mean length by age (winter ring).

Age (ring)	Numbers	Biomass	Weight (g)	Length (cm)
0	0	0		
1	229	11	46.0	17.8
2	98	9	87.9	22.3
3	133	15	115.4	24.1
4	76	11	149.1	26.0
5	42	7	162.7	27.0
6	28	5	169.8	27.5
7	25	4	174.3	27.6
8+	15	3	192.2	28.2
3+	319	45	142.5	25.7
Total	645	65	100.0	22.4

Table 5.4. Autumn spawning West of Scotland herring: Total numbers (millions) and biomass (thousands of tonnes) in the area surveyed in the acoustic surveys June-July 2023. Mean weights. mean lengths and fraction mature by age (winter ring).

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	43.2	0.2		3.7	8.3
1	3.5	0.2		64.8	20.2
2	283.1	32.5	0.7	114.8	23.9
3	214.5	31.4	1.0	146.4	25.5
4	308.9	50.1	1.0	162.3	26.5
5	153.7	26.5	1.0	172.6	27.2
6	35.3	6.0	1.0	169.0	26.9
7	17.3	3.4	1.0	199.2	28.7
8	6.5	1.1	1.0	175.6	28.1
9+	6.9	1.3	1.0	182.8	28.0
Immature	131.2	9.0		69.0	18.2
Mature	943.5	144.0		152.6	26.0
Total	1075.1	153.2	0.9	142.5	25.0

Table 5.5. Malin Shelf herring (6.a./7. b. c): Total numbers (millions) and biomass (thousands of tonnes) in the area surveyed in the acoustic surveys June-July 2023. Mean weights. mean lengths and fraction mature by age (winter ring).

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	43.2	0.2		3.7	8.3
1	219.3	15.1		68.7	20.2
2	783.4	80.1	0.5	102.2	22.8
3	229.5	33.1	0.9	144.3	25.4
4	320.9	51.7	1.0	161.1	26.4
5	154.3	26.6	1.0	172.5	27.1
6	35.4	6.0	1.0	169.0	26.9
7	17.3	3.4	1.0	199.2	28.7
8	6.5	1.1	1.0	175.6	28.1
9+	6.9	1.3	1.0	182.8	28.0
Immature	660.3	51.6		78.2	20.6
Mature	1158.1	167.2		144.4	25.4
Total	1820.8	218.9	0.6	120.2	23.7

Table 5.6. North Sea Autumn Spawning herring: Numbers (millions) at age (winter rings) and spawning stock biomass (SSB) from acoustic surveys 1986–2023. For 1986 the estimates are the sum of those from the Div. 4.a summer survey. the Div. 4.b autumn survey. and the Div. 4.c. 7.d winter survey. The 1987 to 2023 estimates are from summer surveys in Div. 4.a-c and 3.a excluding estimates of Western Baltic Spring Spawning herring. For 1999 and 2000. the Kattegat was excluded from the results because it was not surveyed. Prior to 2008 there is no information on 0-ringers.

Year / Age (ring)	0	1	2	3	4	5	6	7	8	9+	Total	SSB ('000t)
1986		1 639	3 206	1 637	833	135	36	24	6	8	7 542	942
1987		13 736	4 303	955	657	368	77	38	11	20	20 165	817
1988		6 431	4 202	1 732	528	349	174	43	23	14	13 496	897
1989		6 333	3 726	3 751	1 612	488	281	120	44	22	16 377	1 637
1990		6 249	2 971	3 530	3 370	1 349	395	211	134	43	18 262	2 174
1991		3 182	2 834	1 501	2 102	1 984	748	262	112	56	12 781	1 874
1992		6 351	4 179	1 633	1 397	1 510	1 311	474	155	163	17 173	1 545
1993		10 399	3 710	1 855	909	795	788	546	178	116	19 326	1 216
1994		3 646	3 280	957	429	363	321	238	220	132	13 003	1 035
1995		4 202	3 799	2 056	656	272	175	135	110	84	11 220	1 082
1996		6 198	4 557	2 824	1 087	311	99	83	133	206	18 786	1 446
1997		9 416	6 363	3 287	1 696	692	259	79	78	158	22 028	1 780
1998		4 449	5 747	2 520	1 625	982	445	170	45	121	16 104	1 792
1999		5 087	3 078	4 725	1 116	506	314	139	54	87	15 107	1 534
2000		24 735	2 922	2 156	3 139	1 006	483	266	120	97	34 928	1 833
2001		6 837	12 290	3 083	1 462	1 676	450	170	98	59	26 124	2 622
2002		23 055	4 875	8 220	1 390	795	1 031	244	121	150	39 881	2 948
2003		9 829	18 949	3 081	4 189	675	495	568	146	178	38 110	2 999
2004		5 183	3 415	9 191	2 167	2 590	317	328	342	186	23 722	2 584
2005		3 113	1 890	3 436	5 609	1 211	1 172	140	127	107	16 805	1 868
2006		6 823	3 772	1 997	2 098	4 175	618	562	84	70	20 199	2 130
2007		6 261	2 750	1 848	898	806	1 323	243	152	65	14 346	1 203
2008	6 869	3 714	2 853	1 709	1 485	809	712	1 749	185	270	20 355	1 784
2009	13 554	4 655	5 632	2 553	1 023	1 077	674	638	1 142	578	31 526	2 591
2010	12 227	14 577	4 237	4 216	2 453	1 246	1 332	688	1 110	1 619	43 705	3 027
2011	2 530	10 119	4 166	2 534	2 173	1 016	651	688	440	1 207	25 524	2 431
2012	2 936	7 437	4 718	4 067	1 738	1 209	593	247	218	478	23 641	2 269
2013	17 786	6 388	2 683	3 031	2 895	1 546	849	464	250	592	36 484	2 261
2014	34 864	11 634	4 918	2 827	2 939	1 791	1 236	669	211	250	61 339	2 610
2015	386	6 714	9 495	2 831	1 591	1 549	926	520	275	221	24 508	2 280
2016	20 314	9 034	12 011	5 832	1 273	822	909	395	220	146	51 686	2 648
2017	14 259	3 054	1 761	6 095	3 142	787	365	298	153	140	30 055	1 943
2018	7 480	9 938	4 254	1 692	5 150	2 440	719	529	293	111	32 606	2 337
2019	4 573	10 146	1 303	2 345	1 212	3 506	1 657	395	252	172	25 560	1 919
2020	7 178	7 130	2 736	1 156	1 371	1 674	1 666	504	164	188	23 766	1 717
2021	17 500	5 196	2 803	1 800	773	877	915	1 021	388	208	31 481	1 501

2022	14 746	3 711	3 814	3 043	1 743	822	662	718	619	249	30 127	1 963
2023	31 408	11 189	2 703	3 335	2 295	1 387	466	377	298	385	53 844	1 885

Table 5.7. Western Baltic Spring Spawning herring: Numbers (millions) at age (winter rings) from acoustic surveys 1992 to 2023. The 1999 survey was incomplete due to the lack of participation by RV "Dana".

Year/Age (ring)	1	2	3	4	5	6	7	8+	Total	3+ group
1992	277	2 092	1 799	1 593	556	197	122	20	10 509	4 287
1993	103	2 768	1 274	598	434	154	63	13	5 779	2 536
1994	5	413	935	501	239	186	62	34	3 339	1 957
1995	2 199	1 887	1 022	1 270	255	174	39	21	6 867	2 781
1996	1 091	1 005	247	141	119	37	20	13	2 673	577
1997	128	715	787	166	67	69	80	77	2 088	1 245
1998	138	1 682	901	282	111	51	31	53	3 248	1 428
1999	1 367	1 143	523	135	28	3	2	1	3 201	691
2000	1 509	1 891	674	364	186	56	7	10	4 696	1 295
2001	66	641	452	153	96	38	23	12	1 481	774
2002	3 346	1 576	1 392	524	88	40	18	19	7 002	2 081
2003	1 833	1 110	395	323	103	25	12	5	3 807	864
2004	1 668	930	726	307	184	72	22	18	3 926	1 328
2005	2 687	1 342	464	201	103	84	37	21	4 939	910
2006	2 081	2 217	1 780	490	180	27	10	0.1	6 791	2 487
2007	3 918	3 621	933	499	154	34	26	14	9 200	1 661
2008	5 852	1 160	843	333	274	176	45	44	8 839	1 715
2009	565	398	205	161	82	85	39	65	1 602	638
2010	999	511	254	115	65	24	28	34	2 030	519
2011	2 980	473	259	163	70	53	22	46	4 067	614
2012	1 018	1 081	236	87	76	33	14	60	2 605	505
2013	49	627	525	53	30	12	8	15	1 319	643
2014	513	415	176	248	28	37	26	42	1 798	556
2015	1 949	1 244	446	224	171	82	89	115	4 322	1 127
2016	425	255	381	99	40	40	12	28	1 483	600
2017	696	424	661	401	94	53	52	92	2 474	1 353
2018	106	224	271	175	169	50	35	44	1 075	745
2019	418	591	315	109	67	52	19	13	1 585	574
2020	815	274	225	180	74	77	64	46	1 764	667
2021	26	245	275	203	52	49	22	39	911	639
2022	45	246	129	124	100	58	36	37	774	483
2023	229	98	133	76	42	28	25	15	645	319

Table 5.8. West of Scotland herring: Numbers (millions) at age (winter rings) and SSB (thousands of tonnes) from acoustic surveys 1993 to 2023. In 1997 the survey was carried out one month early in June as opposed to July when all the other surveys were carried out. A revision of the period 1991 to 2007 was carried out in 2010 and is incorporated in this table (Hatfield and Simmonds. 2010).

Year/Age (ring)	1	2	3	4	5	6	7	8	9+	SSB:
1993	2	579	690	689	565	900	296	158	161	845
1994	494	542	608	286	307	268	407	174	132	534
1995	441	1 103	473	450	153	187	169	237	202	452
1996	41	576	803	329	95	61	77	78	115	370
1997	792	642	286	167	66	50	16	29	24	175
1998	1 222	795	667	471	179	79	28	14	37	376
1999	534	322	1 388	432	308	139	87	28	35	460
2000	448	316	337	900	393	248	200	95	65	445
2001	313	1 062	218	173	438	133	103	52	35	359
2002	425	436	1 437	200	162	424	152	68	60	549
2003	439	1 039	933	1 472	181	129	347	114	75	739
2004	564	275	760	442	577	56	62	82	76	396
2005	50	243	230	423	245	153	13	39	27	223
2006	112	835	388	285	582	415	227	22	59	472
2007	0	126	294	203	145	347	243	164	32	299
2008	48	233	912	669	340	272	721	366	264	788
2009	346	187	264	430	374	219	187	500	456	579
2010	425	489	398	150	143	95	63	48	188	253
2011	22	185	733	451	204	220	199	113	263	458
2012	792	179	729	471	241	107	107	56	105	375
2013	0	137	320	600	162	69	61	24	37	256
2014	1 031	243	218	469	519	143	30	19	11	272
2015	0	122	325	650	378	442	83	23	2	387
2016	0	30	108	88	112	79	62	6	1	88
2017	0	22	324	144	97	109	44	18	5	139
2018	964	323	92	331	153	51	72	27	13	152
2019	3	50	77	41	137	86	14	16	20	76
2020	657	579	274	150	83	178	38	13	10	158
2021	61	511	282	97	54	41	80	26	23	147
2022	2	230	378	276	121	52	24	30	5	177
2023	4	283	215	309	154	35	17	6	7	144

Table 5.9. Malin Shelf acoustic survey (6.a./7. b. c): Numbers (millions) at age (winter rings) and SSB (thousands of tonnes) from acoustic survey time series 2008-2023. This table has been revised in 2015. details can be found in Lusseau et al.. 2015.

Year/Age (ring)	1	2	3	4	5	6	7	8	9+	SSB:
2008	50	267	996	720	363	331	744	386	274	845
2009	773	265	274	444	380	225	193	500	456	592
2010	133	375	374	242	173	146	102	100	297	370
2011	63	257	900	485	213	228	205	113	264	498
2012	796	548	832	517	249	115	111	57	105	434
2013	0	209	434	672	195	71	61	29	37	284
2014	1 012	278	242	502	534	148	33	19	13	280
2015	0	212	397	747	423	476	90	24	2	430
2016	0	30	108	88	112	79	62	6	1	88
2017	0	25	339	155	106	110	47	13	5	145
2018	1 289	447	106	343	153	52	72	27	13	159
2019	24	231	225	123	169	95	14	17	21	128
2020	1 175	1 226	609	235	110	209	42	18	10	226
2021	227	1 808	711	177	81	48	83	27	23	278
2022	232	316	543	362	162	63	29	40	5	233
2023	219	783	229	321	154	35	17	6	7	167

Table 5.10. Sprat in the North Sea (ICES Subarea 4): Abundance. biomass. mean weight and mean length by age and maturity (i = immature. m = mature) from the summer 2023 North Sea acoustic survey (HERAS).

Age	Abundance (million)	Biomass (1000 t)	Mean weight (g)	Mean length (cm)
0i	4 792	10	2.1	6.6
1i	7 644	45	5.9	9.2
1m	40 303	343	8.5	10.4
2i	400	3	8.5	10.4
2m	18 085	222	12.2	11.6
3i	0	0	-	-
3m	5 955	80	13.4	11.9
4m	1 015	14	13.1	12
Immature	12 844	59	4.6	8.3
Mature	65 357	658	9.9	10.8
Total	78 201	717	9.0	10.4

Table 5.11. Sprat in the North Sea (ICES Subarea 4): Time-series of abundance and biomass as obtained from the summer North Sea acoustic survey (HERAS) time series 2000-2023. The surveyed area has expanded over the years. Only figures from 2004 and onwards are broadly comparable. In 2003, information on sprat abundance is available from one nation only.

	Abundance (million)					Biomass (1000 t)				
Year/Age	0	1	2	3+	Sum	0	1	2	3+	Sum
2023	4 792	47 947	18 485	6 970	**78 201**	10	388	225	94	**717**
2022	23 317	59 961	16 067	2 861	**102 206**	45	493	175	37	**750**
2021	1 345	46 595	6 793	1 467	**56 200**	4	315	82	20	**420**
2020	12 869	34 717	17 505	1 963	**67 055**	13	278	208	32	**531**
2019	574	93 503	26 512	4 410	**124 999**	0	413	393	74	**880**
2018	3 409	107 083	9 061	588	**120 141**	1	717	106	10	**834**
2017	2 941	38 124	3 518	1 374	**45 956**	2	280	48	24	**354**
2016	24 792	58 599	33 318	7 880	**124 588**	24	500	453	141	**1118**
2015	198	26 241	22 474	9 799	**58 711**	0	239	312	161	**712**
2014	5 828	58 405	20 164	3 823	**88 219**	9	429	228	62	**728**
2013	454	9 332	6 273	1 600	**17 660**	2	71	74	25	**172**
2012	7 807	21 912	12 541	3 205	**45 466**	27	177	150	55	**409**
2011	0	26 536	13 660	2 430	**42 625**	0	212	188	44	**444**
2010	1 991	19 492	13 743	798	**36 023**	22	163	177	14	**376**
2009	0	47 520	16 488	1 183	**65 191**	0	346	189	21	**556**
2008	0	17 165	7 410	549	**25 125**	0	161	101	9	**271**
2007	0	37 250	5 513	1 869	**44 631**	0	258	66	29	**353**
2006*	0	21 862	19 916	760	**42 537**	0	159	265	12	**436**
2005*	0	69 798	2 526	350	**72 674**	0	475	33	6	**513**
2004*	17 401	28 940	5 312	367	**52 019**	19	267	73	6	**366**
2003*	0	25 294	3 983	338	**29 615**	0	198	61	6	**266**
2002	0	15 769	3 687	207	**19 664**	0	167	55	4	**226**
2001	0	12 639	1 812	110	**14 561**	0	97	24	2	**122**
2000	0	11 569	6 407	180	**18 156**	0	100	92	3	**196**

*** re-calculated using FishFrame (https://www.ices.dk/data/data-portals/Pages/RDB-FishFrame.aspx)**

Table 5.12. Sprat in ICES Div. 3.a: Abundance. biomass. mean weight and length by age and maturity from the summer 2023 North Sea acoustic survey (HERAS).

Age	Abundance (million)	Biomass (tonnes)	Mean weight (g)	Mean length (cm)
0i	0	0	-	-
0m	0	0	-	-
1i	26.5	220	8.3	9.7
1m	151.5	1567	10.3	10.6
2i	6.7	74	11.0	10.7
2m	49.8	707	14.2	11.9
3m+	45.2	778	17.2	12.8
Immature	33.2	294	8.8	9.9
Mature	246.5	3051	12.3	11.3
Total	279.7	3345	11.9	11.1

Table 5.13. Sprat in ICES Div. 3.a: Time-series of sprat abundance and biomass as obtained from the summer North Sea acoustic survey (HERAS) time series 2006-2023

	Abundance (million)					Biomass (1000 t)				
Year/Age	0	1	2	3+	Sum	0	1	2	3+	Sum
2023	0.0	178.0	56.5	45.2	**279.7**	0.0	1.8	0.8	0.8	**3.3**
2022	0.0	262.6	132.7	21.2	**416.5**	0.0	2.9	2.0	0.4	**5.3**
2021	0.0	323.2	258.0	42.0	**623.2**	0.0	2.6	2.9	0.8	**6.2**
2020	3.5	3698.2	488.1	92.1	**4 281.9**	0.0	31.7	6.5	1.6	**39.9**
2019	0.7	271.5	1 508.0	865.1	**2 645.3**	0.0	2.7	19.8	16.0	**38.4**
2018	98.2	2 096.9	1 051.6	191.0	**3 437.7**	0.3	17.7	11.7	3.7	**33.4**
2017	0.0	10.9	146.3	90.5	**247.7**	0.0	0.1	2.3	1.7	**4.1**
2016	0.0	5.4	671.2	280.0	**956.5**	0.0	0.0	8.7	4.8	**13.5**
2015	0.3	840.8	202.0	342.6	**1 385.8**	0.0	9.6	2.7	6.2	**18.5**
2014	29.6	614.5	109.8	159.4	**913.3**	0.1	4.8	1.8	3.4	**10.1**
2013	1.4	14.5	68.8	448.6	**533.3**	0.0	0.2	1.2	9.6	**10.9**
2012	0.3	123.9	290.1	1 488.0	**1 902.3**	0.0	1.2	5.0	31.4	**37.6**
2011	0.0	45.4	546.9	981.9	**1 574.2**	0.0	0.5	9.1	17.8	**27.5**
2010	0.0	836.1	343.8	376.3	**1 556.2**	0.0	7.3	4.9	6.4	**18.6**
2009	0.0	169.5	432.4	1 631.9	**2 233.8**	0.0	1.8	6.5	28.3	**36.6**
2008	0.0	23.0	457.8	291.2	**772.0**	0.0	0.2	6.3	5.8	**12.3**
2007	0.0	5 611.9	323.9	382.9	**6 318.7**	0.0	47.9	3.8	6.5	**58.2**
2006	86.0	61.3	1 451.9	653.0	**2 252.2**	0.3	0.6	21.2	11.5	**33.6**

Table 5.14. North Sea Autumn Spawning herring: Total abundance. biomass. mean weight and percent mature (in numbers) by stratum. last year and present survey. Stratum numbers correspond to numbering in Figure 5.1.

	2022				2023			
Strat.	Abundance (mill)	Biomass (kt)	Mean weight (g)	Pro-portion mature	Abundance (mill)	Biomass (kt)	Mean weight (g)	Pro-portion mature
11	556	135	242.4	0.96	879	183	208.1	0.99
21	292	6	21.7	0.01	103	5	51.2	0.27
31	436	23	52.7	0.03	351	15	42.9	0.03
41	572	73	128.3	0.72	169	16	93.9	0.40
42	910	36	39.1	0.02	980	32	32.9	0.02
51	6 382	31	4.9	0.00	16 124	49	3.0	0.00
61	2 647	11	4.1	0.00	11 282	31	2.8	0.00
71	3 127	18	5.8	0.00	2 840	22	7.8	0.00
81	9	0	54.5	0.22	3 067	185	60.4	0.25
91	3 058	516	168.9	0.89	3 152	459	145.6	0.79
101	0	0	-	-	23	1	39.0	0.00
111	4 773	981	205.5	0.98	6 022	1 054	175.0	0.91
121	608	130	214.1	1.00	999	177	177.7	0.97
131	0	0	-	-	4 931	87	17.6	0.01
141	2 829	232	81.9	0.29	1 285	102	79.4	0.18
151_N	180	24	133.9	0.77	234	8	34.4	0.02
151_S	3 224	44	13.8	0.00	1 278	33	25.4	0.00
152	526	70	132.5	0.71	124	12	95.4	0.44

Table 5.15. Western Baltic Spring Spawning herring: Total abundance. biomass. and mean weight by stratum. Stratum numbers correspond to numbering in Figure 5.1.

	2022			2023		
Stratum	Abundance (mill)	Biomass (kt)	Mean weight (g)	Abundance (mill)	Biomass (kt)	Mean weight (g)
11	93.0	18.6	200.2	73.4	14.1	192.5
21	23.4	1.2	52.1	26.7	1.7	65.5
31	84.2	7.0	83.3	84.1	4.5	53.2
41	215.9	25.1	116.3	160.0	15.2	95.0
42	12.0	1.1	91.4	77.9	4.5	57.4
141	238.1	39.9	167.4	101.6	14.4	141.4
151_N	17.4	2.5	145.3	19.8	1.0	52.6
151_S	5.6	0.1	22.5	25.6	1.0	39.5
152	84.0	11.2	133.3	76.1	8.1	106.3

Table 5.16. Malin shelf and West of Scotland (6.a.N) herring: Total abundance. biomass. mean weight. and percent mature by stratum. Stratum numbers correspond to numbering in Figure 5.1. The 6.a.N herring geographic subset is comprised of strata marked with *.

	2022				2023			
Stratum	Abun-dance (mill)	Bio-mass (kt)	Mean weight (g)	Proportion mature	Abun-dance (mill)	Bio-mass (kt)	Mean weigh t (g)	Proportion mature
1*	61.5	12.2	198.3	0.9	78.0	13.8	177.4	1
2*	0	0	0	0.9	43.2	0.2	3.7	0.0
3*	695.6	113.9	163.8	0.9	540.8	82.3	152.2	0.9
4*	389.4	62.1	159.4	1	413.1	56.8	137.5	0.9
5	646.9	70	108.2	0.6	745.8	65.8	88.2	0.3
6	0	0	0	0	0.0	0.0	0.0	0.0

Table 5.17. Sprat in the North Sea and Div. 3.a: Total abundance. biomass. mean weight. and percent mature by stratum. Stratum numbers correspond to numbering in Figure 5.1.

		2022				2023			
ICES area	Stratum	Abundance (mill)	Biomass (t)	Mean Weight (g)	% Mature	Abundance (mill)	Biomass (t)	Mean Weight (g)	% Mature
Div. 3.a	21	405	5 069	12.5	98	105	1 523	14.5	94
	31	0	0	-	-	166	1 685	10.2	83
	41	0	0	-	-	0	0	-	-
	42	11	146	13.3	1	9	136	15.5	100
North Sea	11	0	0	-	-	0	0	-	-
	51	63 332	401 417	6.3	45	50 292	383 713	7.6	76
	61	12 248	86 542	7.1	61	3 768	35 977	9.5	97
	71	8 155	73 998	9.1	92	5 172	55 414	10.7	99
	81	15 459	162 184	10.5	89	530	8 348	15.8	100
	91	64	451	7.0	70	0	0	-	-
	101	42	359	8.5	1	0	0	-	-
	111	0	0	-	-	0	0	-	-
	121	0	0	-	-	0	0	-	-
	131	0	0	-	-	13 037	163 367	12.5	98
	141	740	625	0.8	0	0	0	-	-
	151_N	0	0	-	-	23	305	13.5	100
	151_S	2 166	25 233	11.6	100	2 678	34 919	13	97
	152	0	0	-	-	0	0	-	-

Table 5.18. Length of track used in analysis. number of fish ages used in estimates and transect spacing for each stratum in the 2022 and 2023 survey. Number of ages cannot be summed for all strata to give total number of ages for the survey as haul information may have been used in more than one stratum. * zig zag. ** Stratum 131 was not covered in 2022.

	2022				2023			
Stratum	Total transect length (nmi.)	Herring ages	Sprat ages	Transect spacing (nmi.)	Total transect length (nmi.)	Herring ages	Sprat ages	Transect spacing (nmi.)
1	415	156	-	15	455	149	-	20
2	150	0	-	*	130	21	-	*
3	270	101	-	15	285	202	-	17
4	265	100	-	15	235	304	-	17
5	380	227	-	10	385	151	-	15
6	205	0	-	15	195	-	-	18
11	920	808	0	15	925	1085	0	16
51	565	476	572	25	575	736	780	25
61	230	384	388	23	210	260	110	24
71	285	400	332	17.5	285	964	420	18
81	470	29	146	*	295	66	68	*
91	1550	399	12	15	1600	743	2	16
101	90	0	21	15	110	0	0	11
111	705	1046	0	15	805	1889	0	16
121	415	96	0	15	415	105	0	16
131	**	**	**	**	595	168	122	31
141	1230	574	30	15	1215	424	0	16
21	245	490	378	13	180	203	186	14
31	150	417	0	10	150	322	70	11
41	160	560	0	17.5	175	596	-	18
42	75	209	70	17.5	85	154	59	17
151_N	150	194	0	15	120	90	1	17
151_S	185	139	205	17.5	195	244	271	18
152	115	238	0	15	95	814	0	17

Table 5.19. Biological sampling of trawl hauls in the HERAS survey by country and species.

Country	Species	Full biological sample	Length and weight	Total
GB-SCT	Herring	2 per 1/2 cm class below 22 cm. 5 per 1/2 cm class from 22 1/2-27 1/2 cm and ten per 1/2 cm class for 28 cm and above	400-500	400-500
GB-SCT	Sprat	5 per 1/2 cm length group from the pool that are length measured	150	150
NL	Herring	5 per 1/2 cm length group from the pool that are length measured	350	350
NL	Sprat	5 per 1/2 cm length group from the pool that are length measured	250	250
IE	Herring	100 random fish aged. length. weight. sex. maturity and genetic sample. Additional 100 random fish for length and weight only. Length frequency only continued until 60 individuals is reached in one length class.	200 (length and weight). Up to 600 lengths	~600
IE	Sprat	100 random fish for length and weight. Length frequency only continued until 60 individuals is reached in one length class.	100 (length and weight) 200-300 lengths	200-300
DE	Herring	10 fish per ½ cm length group per stratum from length frequency measurements. Sampling from length measurements continued until length group sample is full.	>750 (all strata combined)	Catches allowing. a sample of at least 200 fish is measured (length frequency) per haul
DE	Sprat	10 fish per ½ cm length group per stratum from length frequency measurements. Sampling from length measurements continued until length group sample is full.	>750 (all strata combined)	Catches allowing. a sample of at least 200 fish is measured (length frequency) per haul
DK	Herring	3 per ½ cm length group up to 16cm. 6 per ½ cm length group from 16.5 – 19cm and 10 per 1/2cm length group for 19.5 and above from the pool that are length measured.	450-500	450-500
DK	Sprat	10 per ½ cm length group from the pool that are length measured	200	200
NO	Herring	50. random	50. random	100
NO	Sprat	30. random	70. random	100

Table 5.20. Defining acoustic categories uploaded to ICES database by Denmark and Germany in 2023. The table shows the category name used in the ICES Database. which acoustic (split) categories and associated species are contained in these mixed categories. and the TS relationship used to split the NASC where a and m refer to the values in the standard formula: TS = m* log L – a. where L is length in cm.

Acoustic category in database	Country	Name in StoX project	AcousticSplit category	Species name	Aphia code	(a) dB	(m)
CLU	DE. DK	CLU	HER	*Clupea harengus*	126417	-71.2	20
			SPR	*Sprattus sprattus*	126425	-71.2	20
			PIL	*Sardina Pilchardus*	126421	-71.2	20
			ANE	*Engraulis encrasicolus*	126426	-71.2	20
MIX	DK. DE	MIX	HER	*Clupea harengus*	126417	-71.2	20
			SPR	*Sprattus sprattus*	126425	-71.2	20
			PIL	*Sardina Pilchardus*	126421	-71.2	20
			ANE	*Engraulis encrasicolus*	126426	-71.2	20
			HAD	*Melanogrammus aeglefinus*	126437	-67.5	20
			HOM	*Trachurus trachurus*	126822	-67.5	20
			POL	*Pollachius pollachius*	126440	-67.5	20
			WHG	*Merlangius merlangus*	126438	-67.5	20

Table 5.21. Assignment of herring populations to either North Sea Autumn Spawning herring (NSAS) or Western Baltic Spring Spawning (WBSS) herring based on genetic analysis. mean vertebral counts. or otolith microstructure.

Genetics	*ICES stock code*	*Vertebral counts*	*Otolith microstructure*
North Sea autumn spawners (NSAS)	her-47d3	NSAS	NSAS (autumn)
Downs	her-4c7d	NSAS	NSAS (winter)
Western Baltic spring spawners (WBSS)	her-3a22	WBSS	WBSS (spring)
Western Baltic spring spawners Skagerrak	her-3a	NSAS	WBSS (spring)
North Sea spring spawners (SSNS)	her-4ab	NSAS	WBSS (spring)
Norwegian spring spawners (NSS)	her-noss	NSAS	WBSS (spring)
Northeast Atlantic summer/autumn spawners (NASS)	her-vasu	NSAS	NSAS (autumn)
Baltic Autumn spawners (BAS)	her-riga	WBSS	NSAS (autumn)
Central Baltic spring spawners	her-2532-gor	WBSS	WBSS (spring)

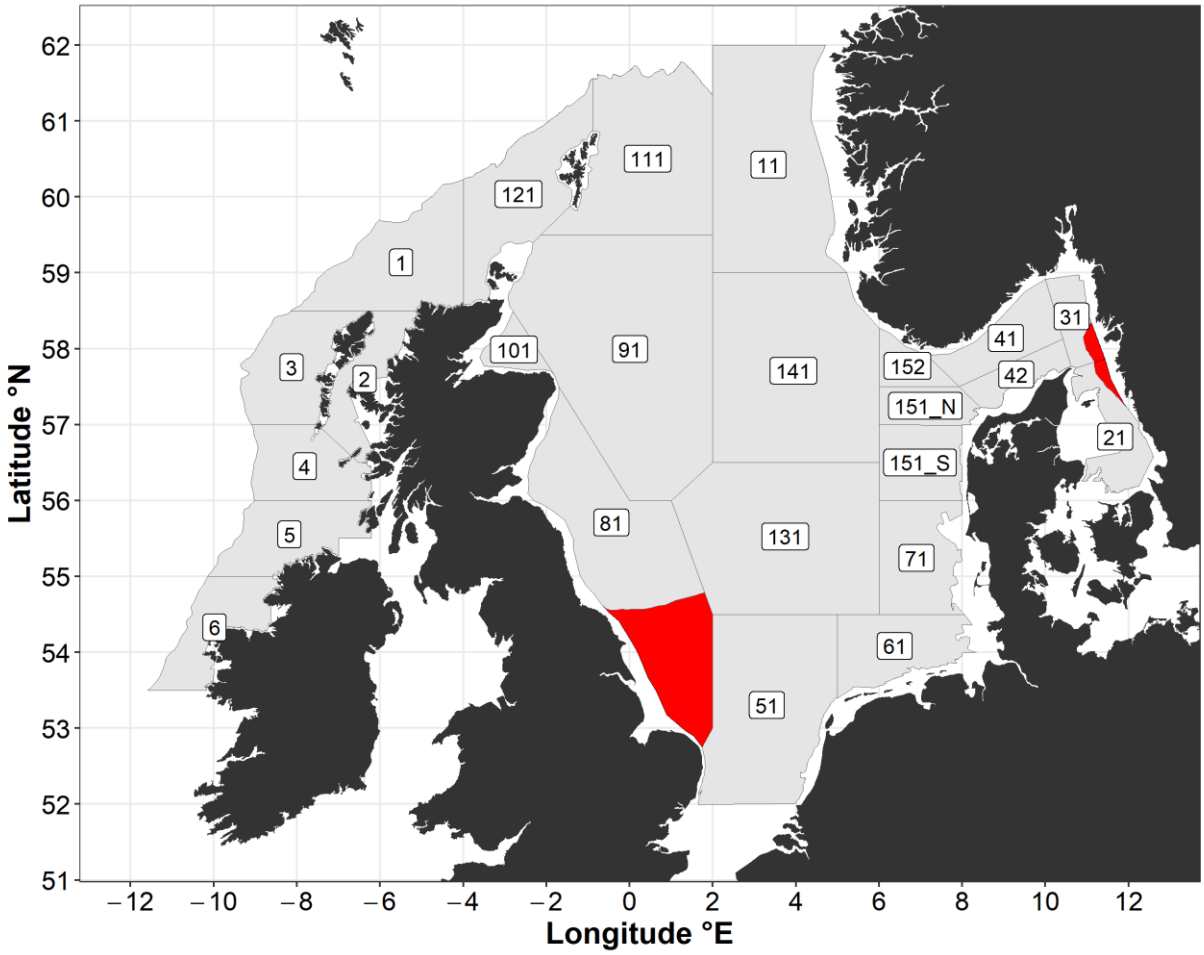


Figure 5.1. Strata used in the HERAS survey 2023. Red shaded areas were planned but could not be covered due to various restrictions. This led to the reduction of the total stratum area by 34% (S81), 15% (S31) and 8% (S21) in the analysis.

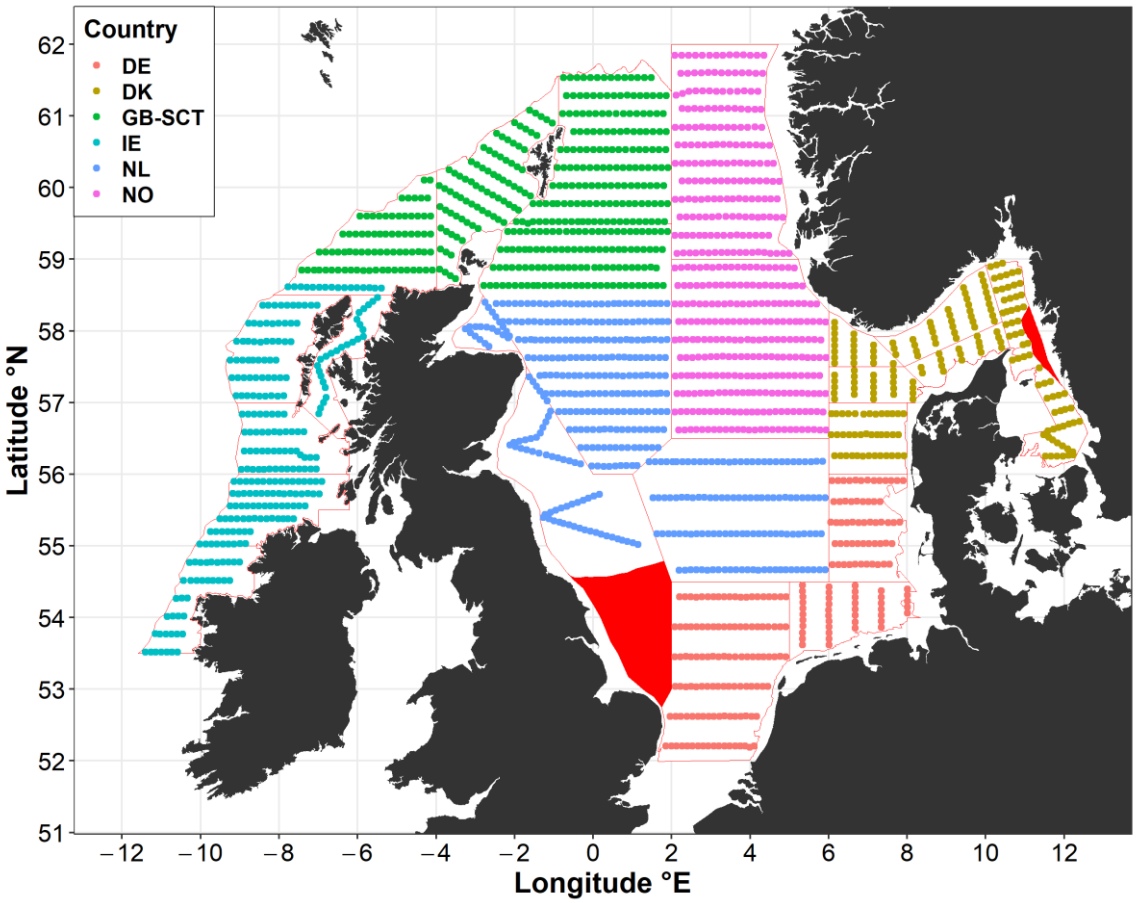


Figure 5.2. Survey area coverage in the 2023 HERAS survey and individual vessel tracks by nation. Red shaded areas were planned but not covered.

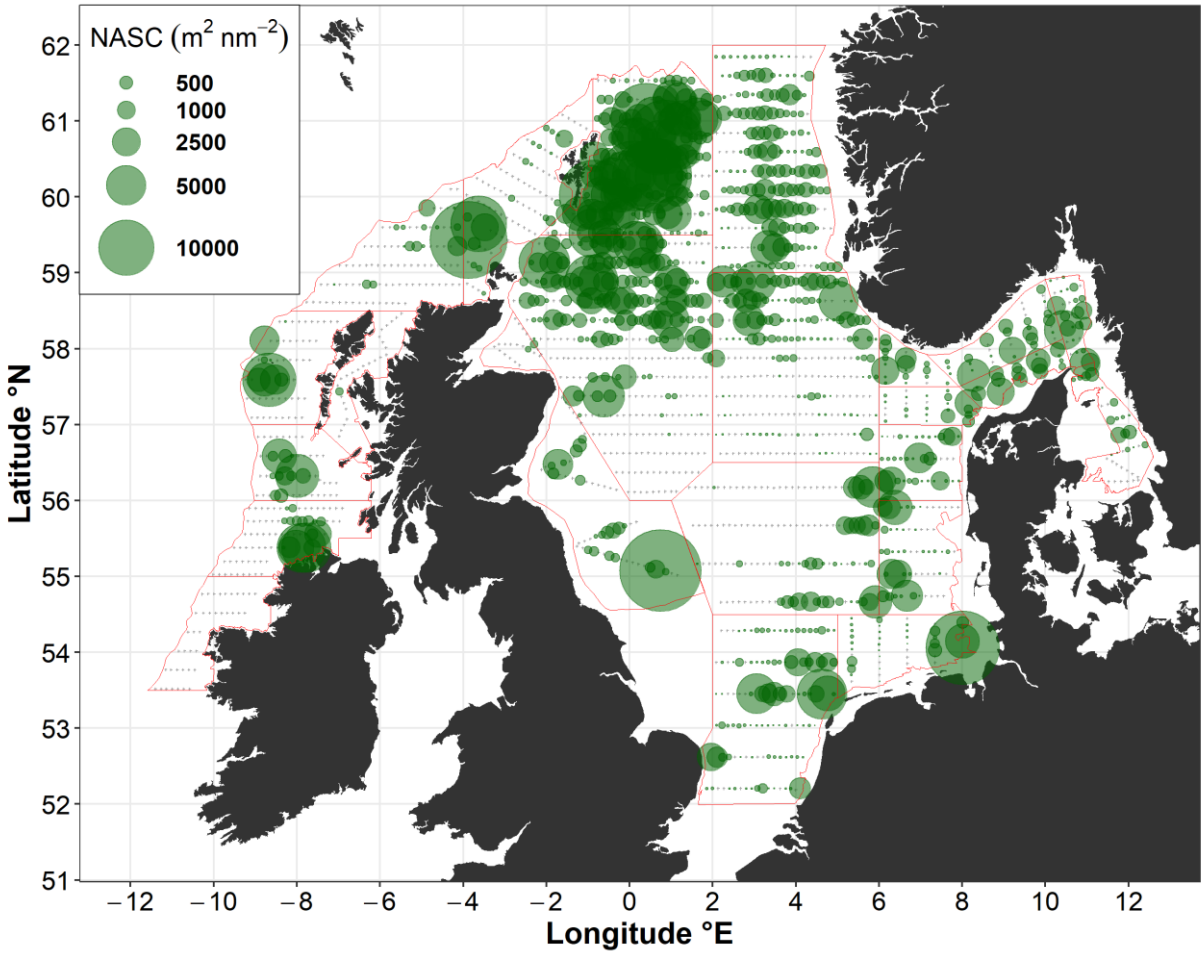


Figure 5.3. Distribution of NASC attributed to herring in the 2023 HERAS survey. Acoustic intervals represented by light grey dots. with green circles representing size and location of herring aggregations. NASC values are resampled at 5 n.mi. intervals along the cruise track. The red lines indicate stratum boundaries.

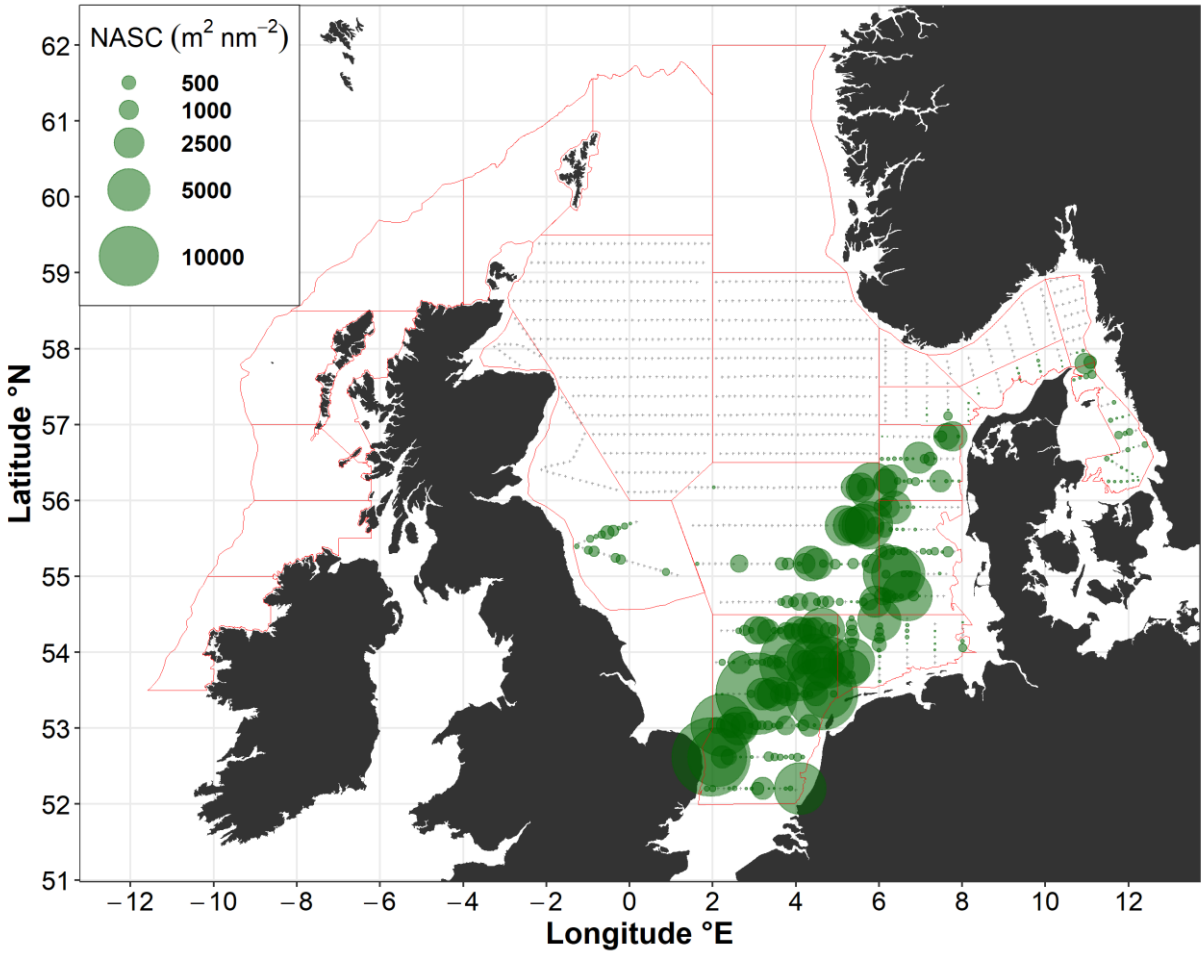


Figure 5.4. Distribution of NASC attributed to sprat in the 2023 HERAS survey. Acoustic intervals represented by light grey dots. with green circles representing size and location of herring aggregations. NASC values are resampled at 5 n.mi. intervals along the cruise track. The red lines indicate stratum boundaries.

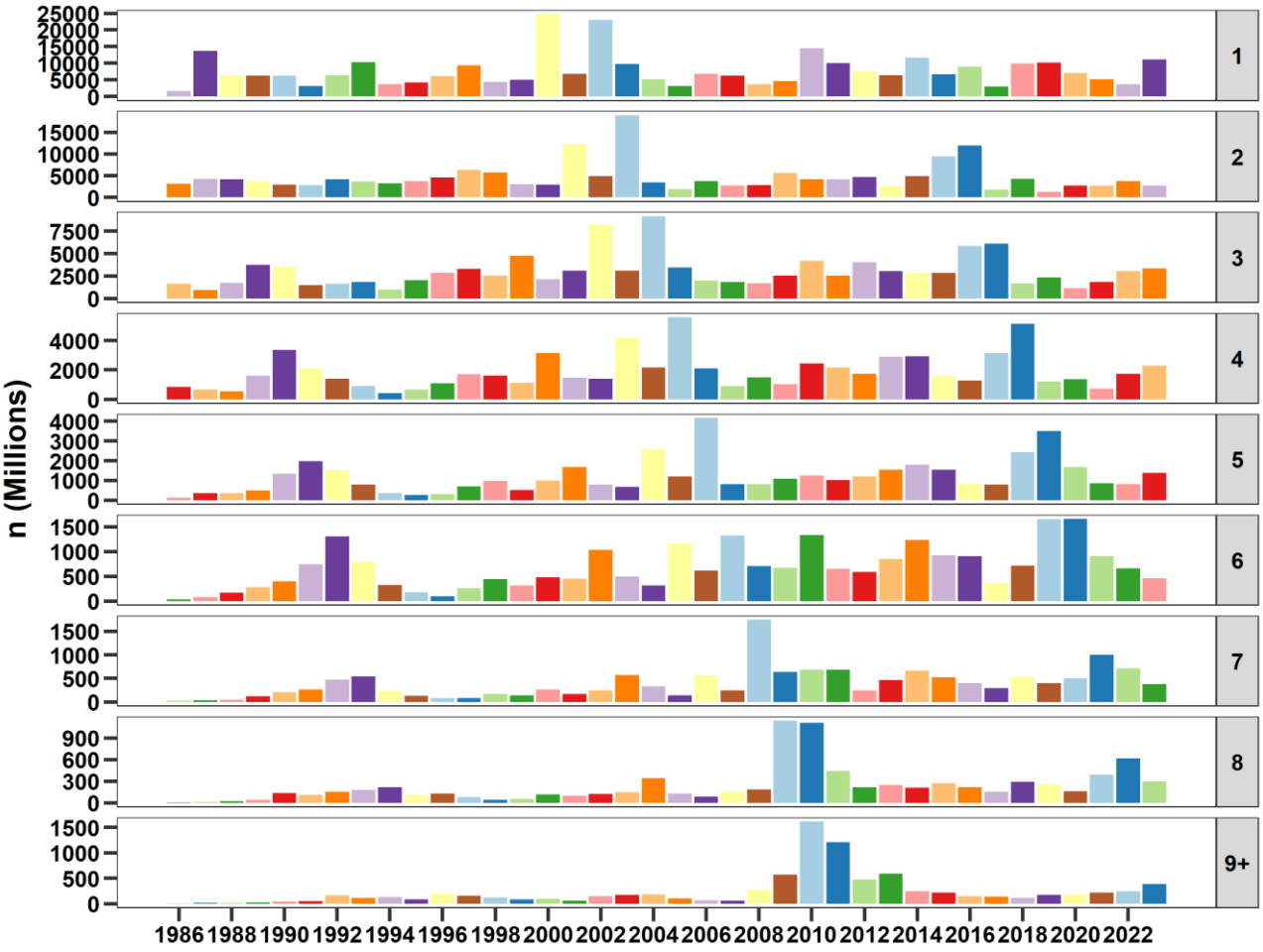


Figure 5.5. North Sea Autumn Spawning herring: HERAS indices (millions) by age (winter rings. panels) and year from the acoustic surveys 1986-2023. Note diverging scales of abundance between ages.

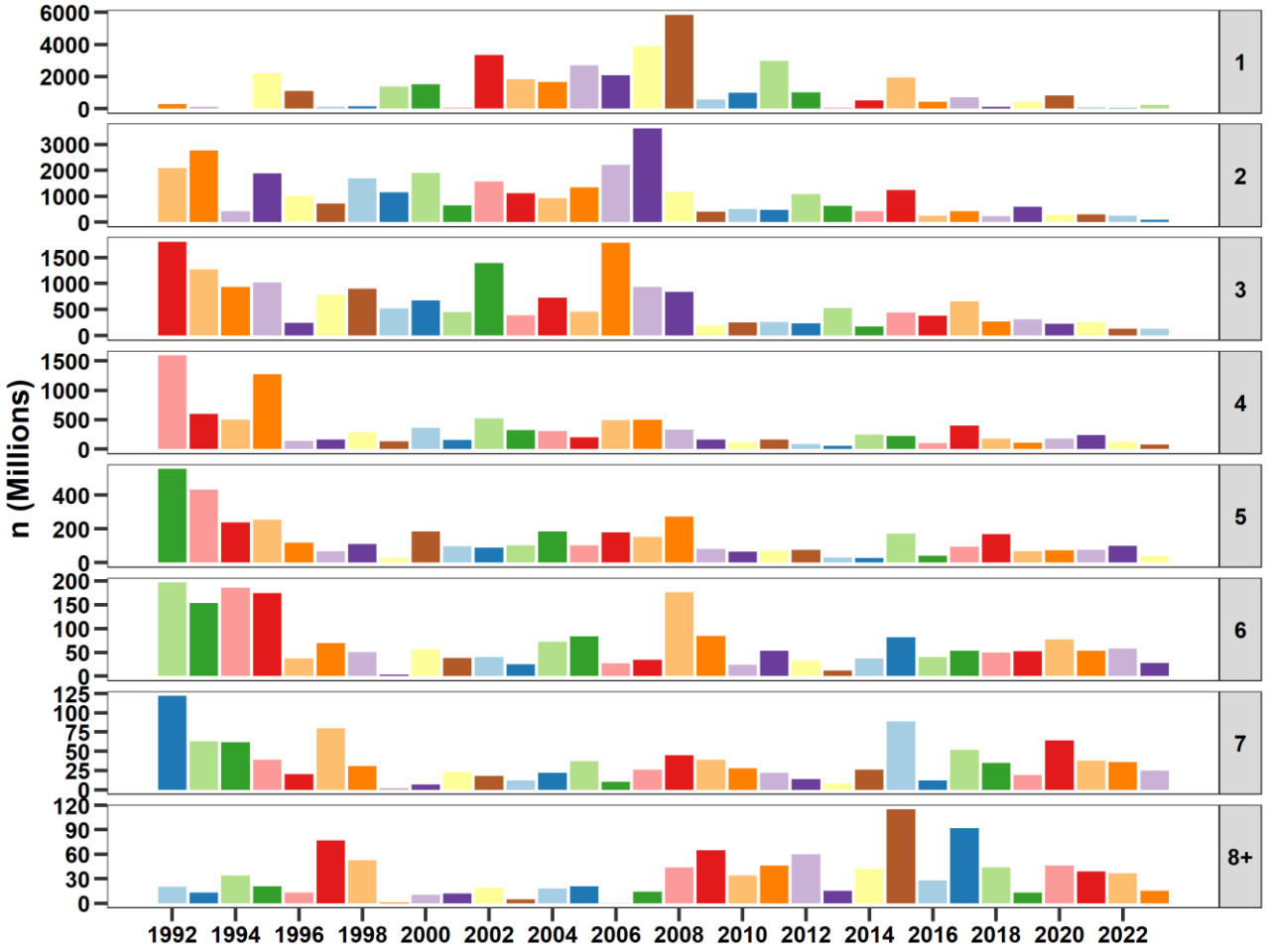


Figure 5.6. Western Baltic Spring Spawning herring: HERAS indices (millions) by age (winter rings. panels) and year from the acoustic surveys 1992-2023. Note diverging scales of abundance between ages.

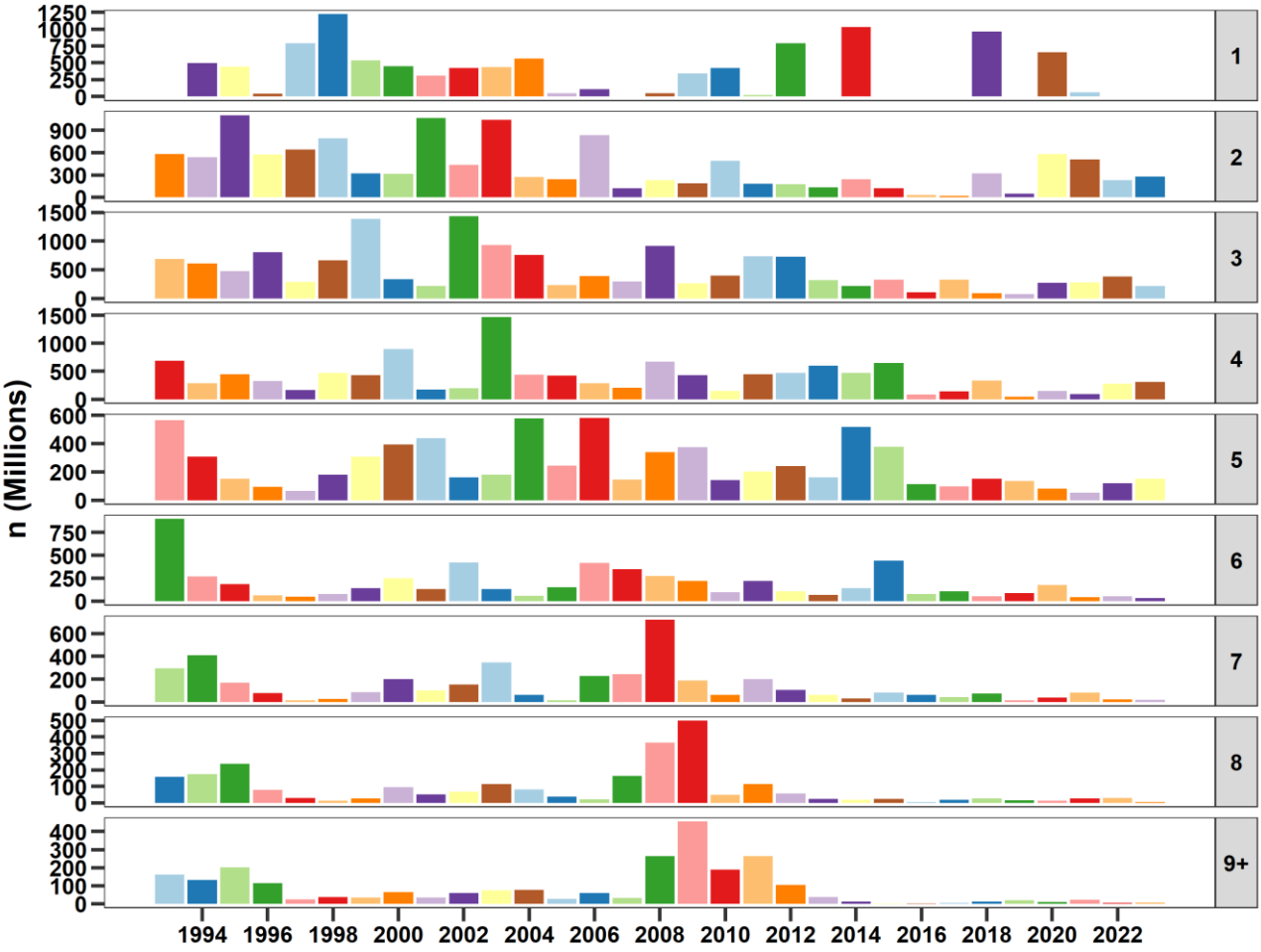


Figure 5.7. West of Scotland (6.a.N) herring: HERAS indices (millions) by age (winter rings. panels) and year from the acoustic surveys 1993-2023.

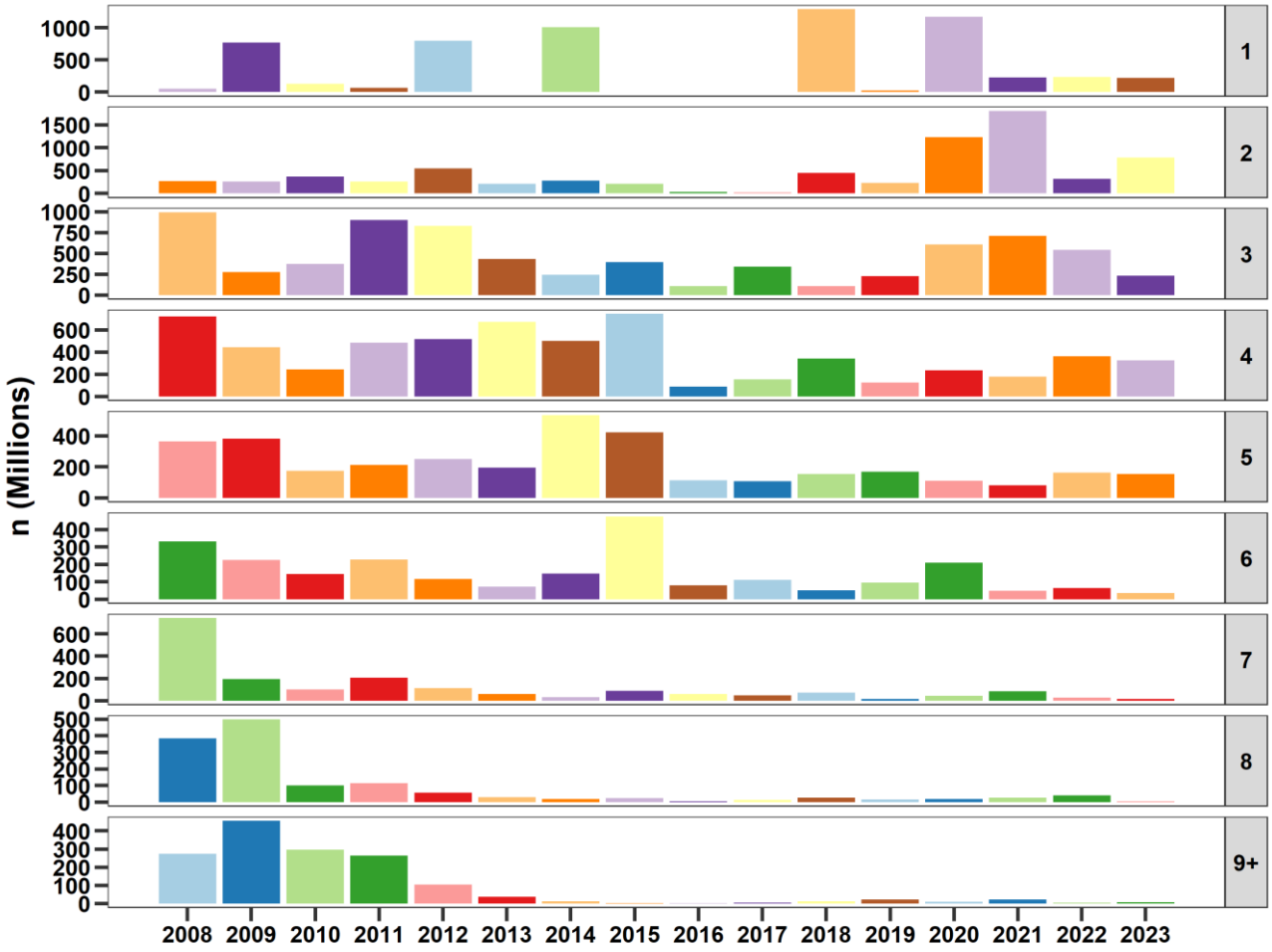


Figure 5.8. Malin Shelf Herring (6.a./7. b. c): HERAS indices (millions) by age (winter rings. panels) and year from the acoustic surveys 2008-2023.

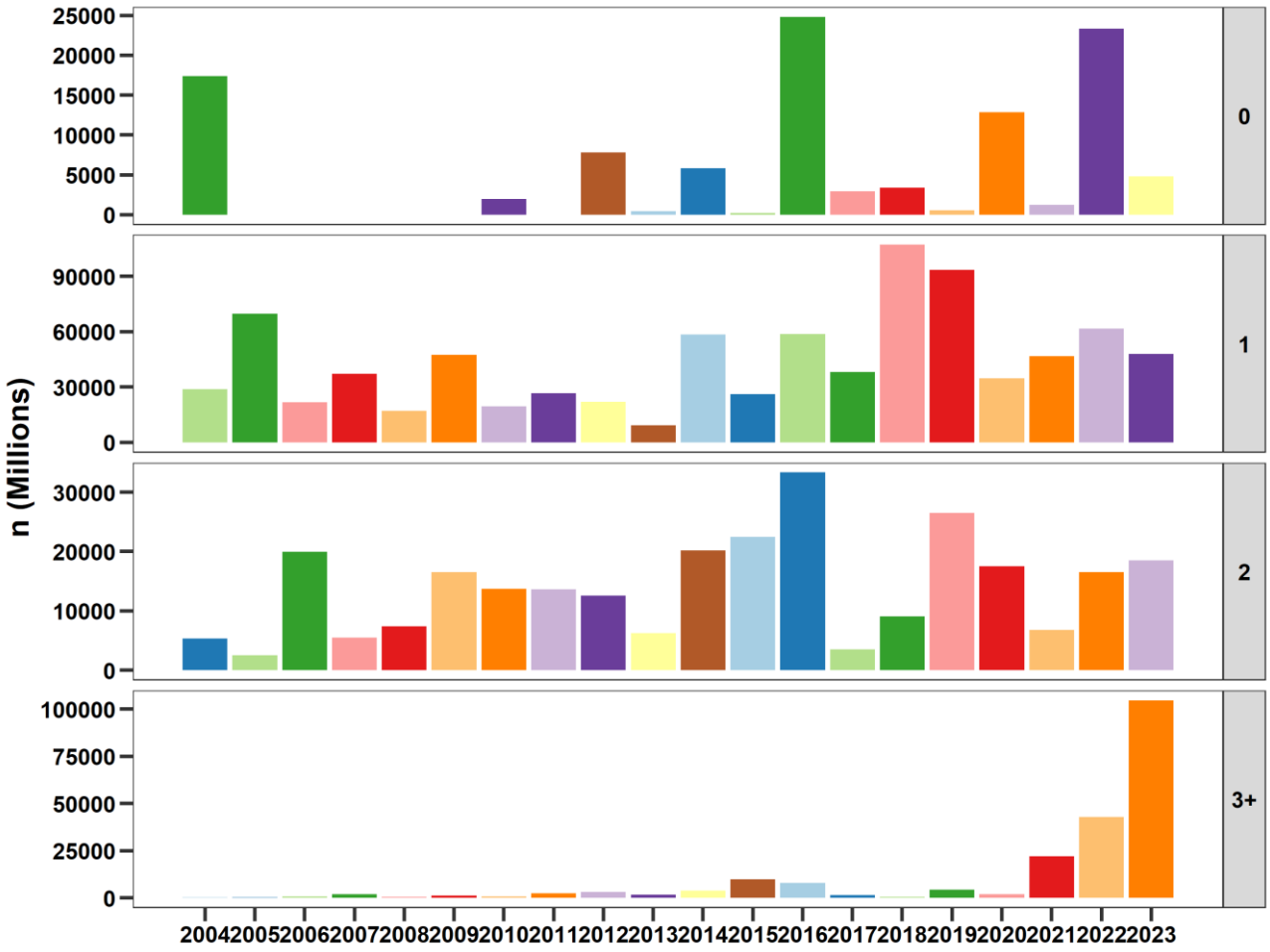


Figure 5.9. North Sea Sprat (ICES Subarea 4): HERAS indices (millions) by age (winter rings. panels) and year from the acoustic surveys 2004-2023. Note diverging scales of abundance between ages.

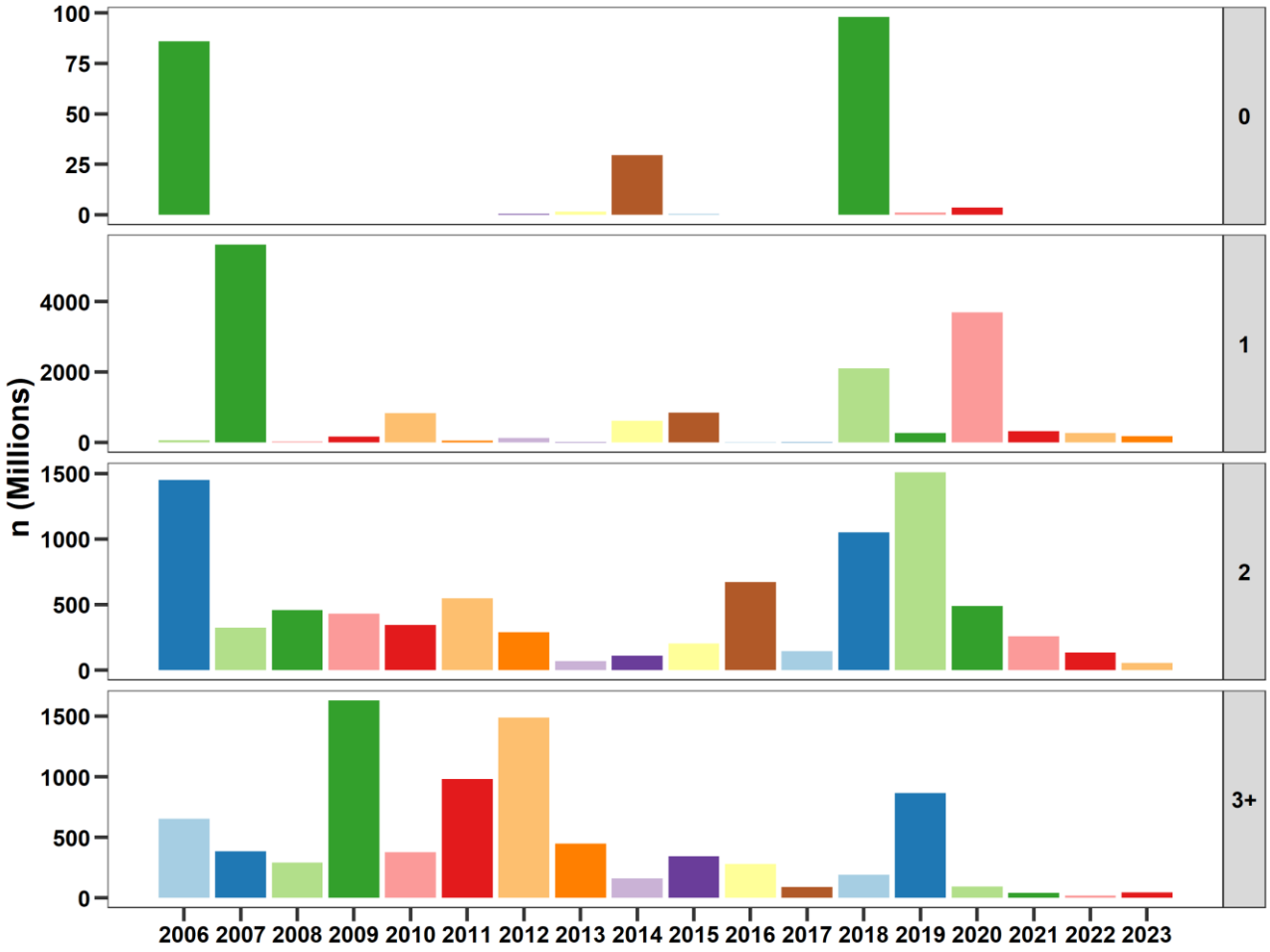
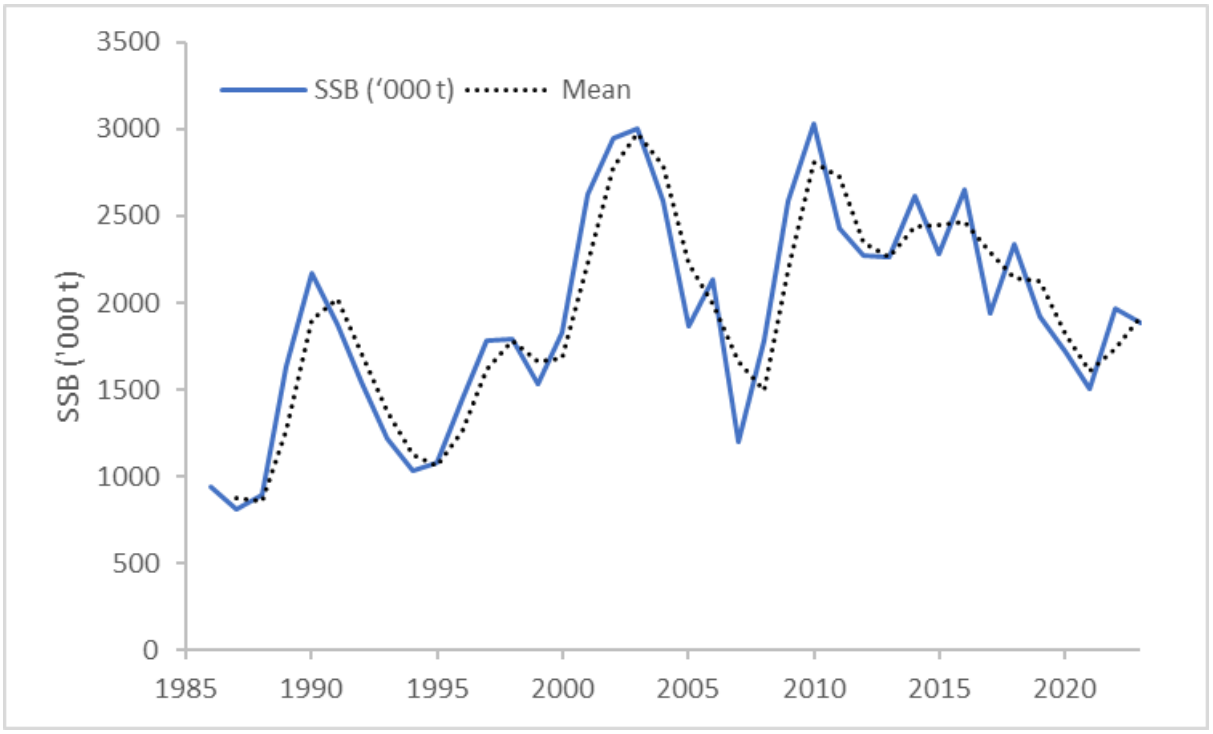


Figure 5.10. Sprat in Div. 3.a: HERAS indices (millions) by age (winter rings. panels) and year from the acoustic surveys 2006-2023. Note diverging scales of abundance between ages.

(a)



(b)

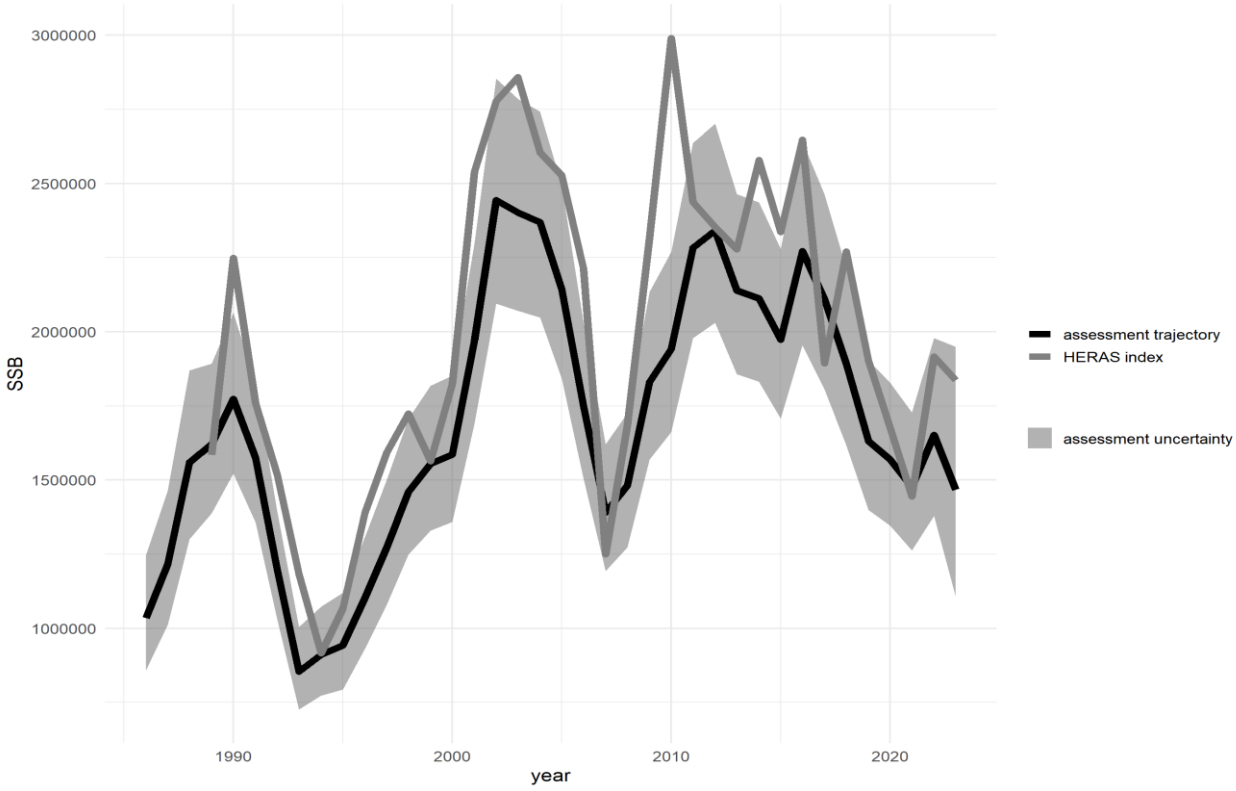


Figure 5.11. North Sea Autumn Spawning Herring: (a) Time series of SSB for the period 1986 – 2023 with two year running mean. (b) Comparison of the HERAS index for 1986 – 2023 with the 2023 NSAS herring assessment (HAWG 2023).

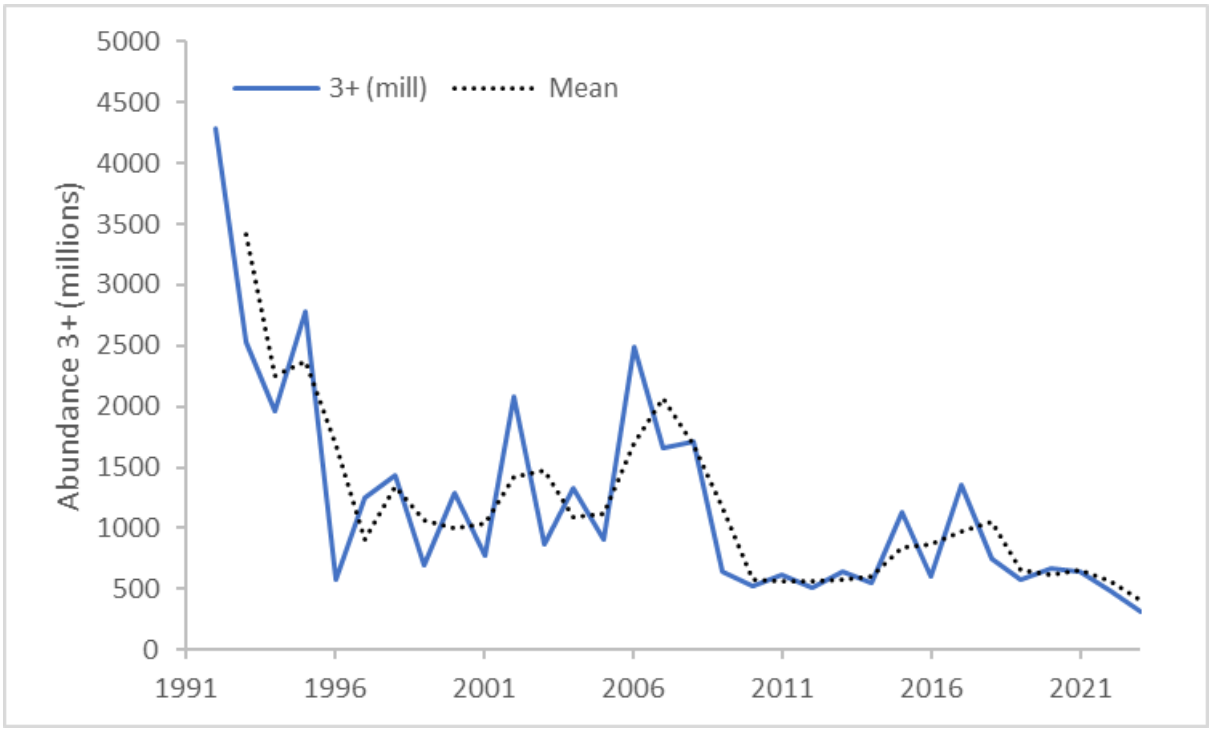


Figure 5.12. Western Baltic spring spawning herring: Time series of 3+ abundance with two year running mean.

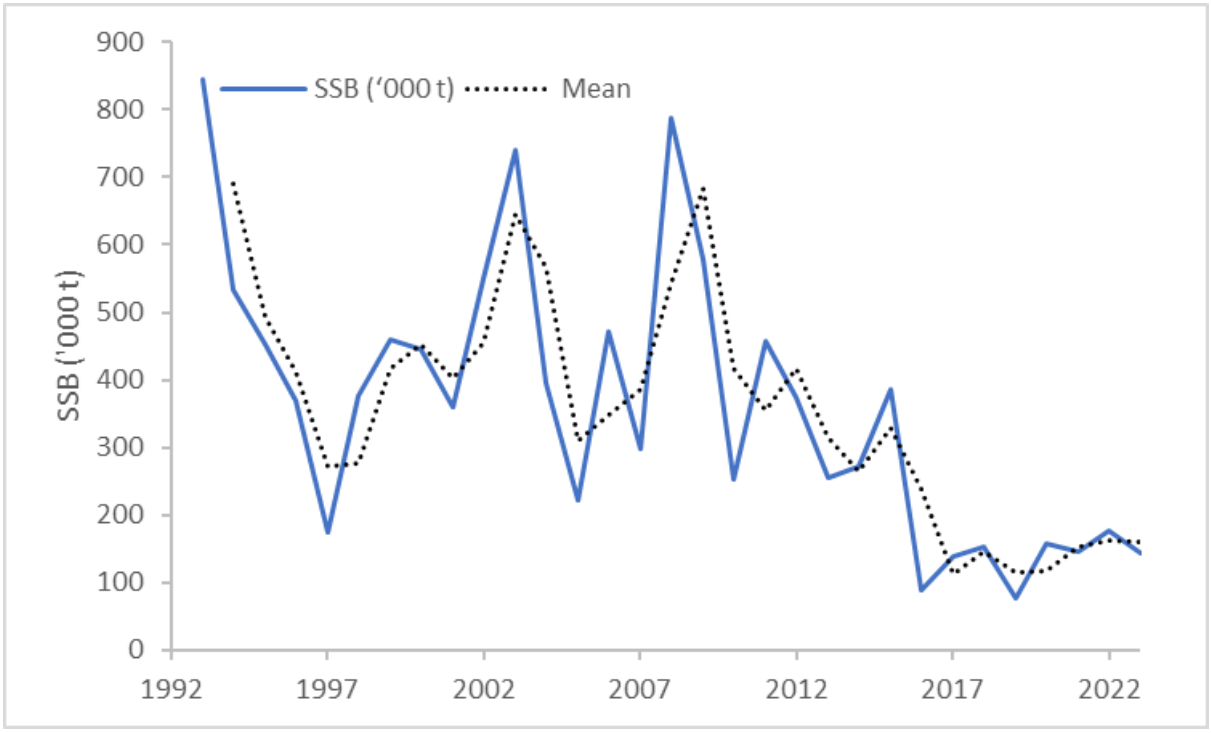


Figure 5.13. West of Scotland herring (geographical subset of Malin Shelf herring): Time series with two year running mean.

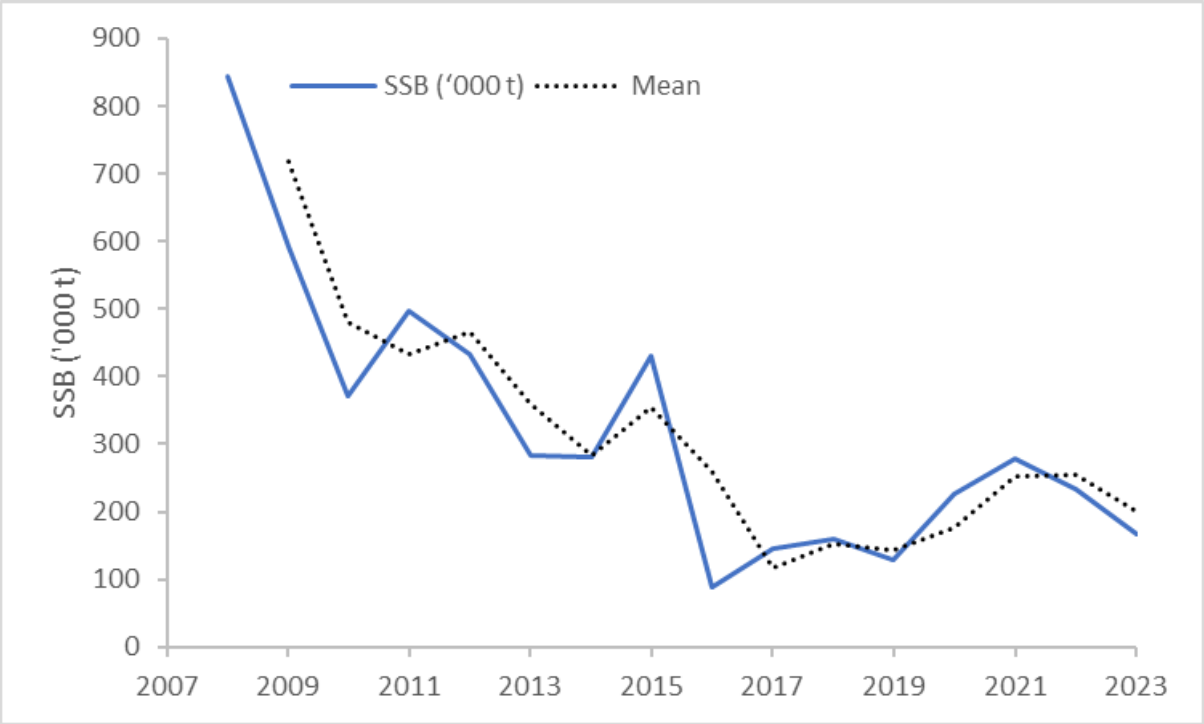


Figure 5.14. Malin Shelf herring: Time series of SSB with two year running mean.

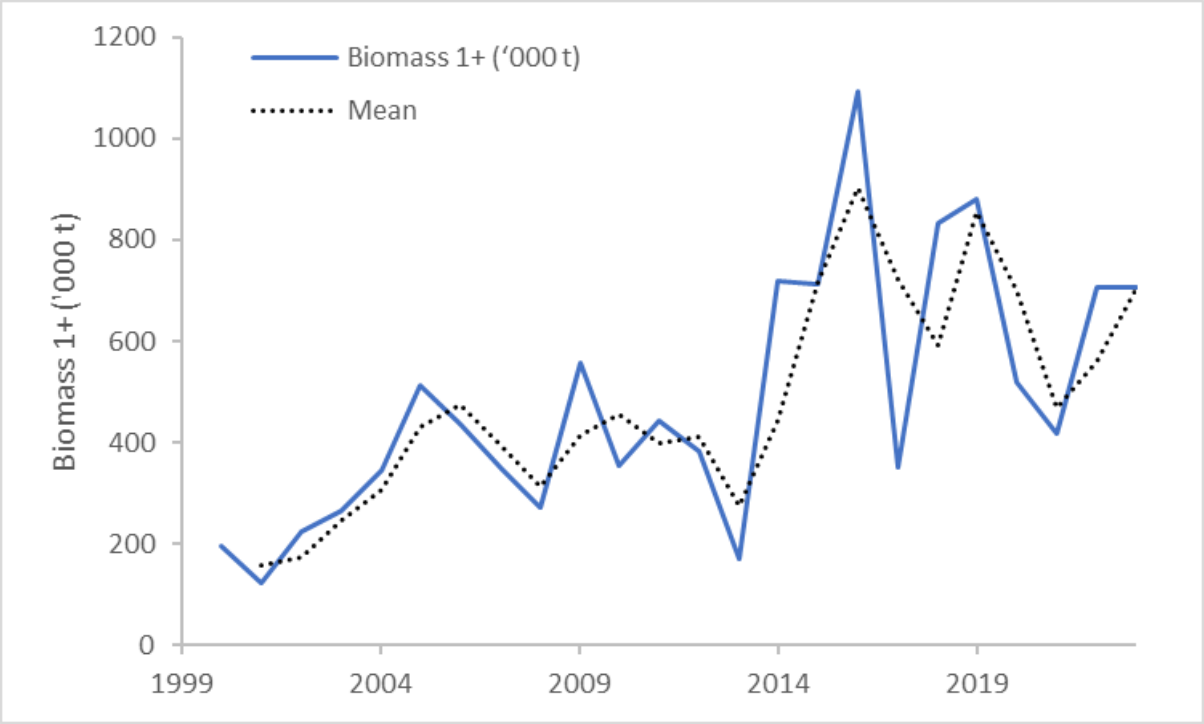


Figure 5.15. North Sea sprat (ICES Subarea 4): Time series of 1+ biomass with two year running mean.

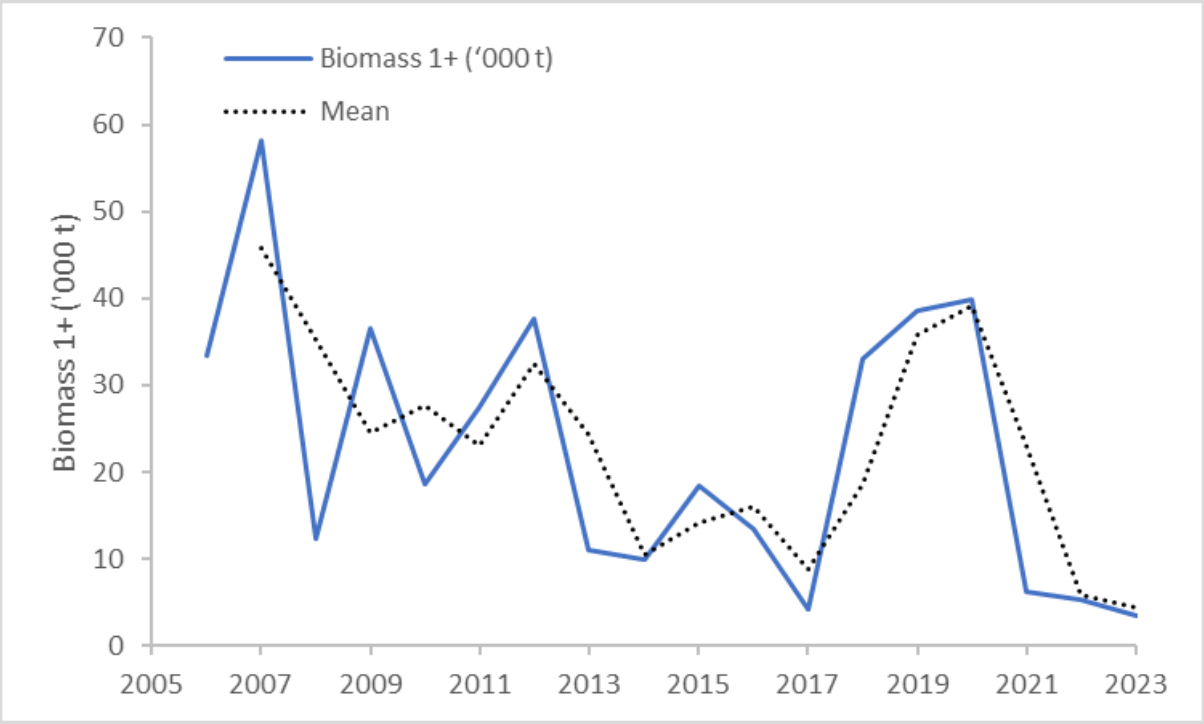


Figure 5.16. Sprat in Div. 3.a: Time series of 1+ biomass SSB with two year running mean.

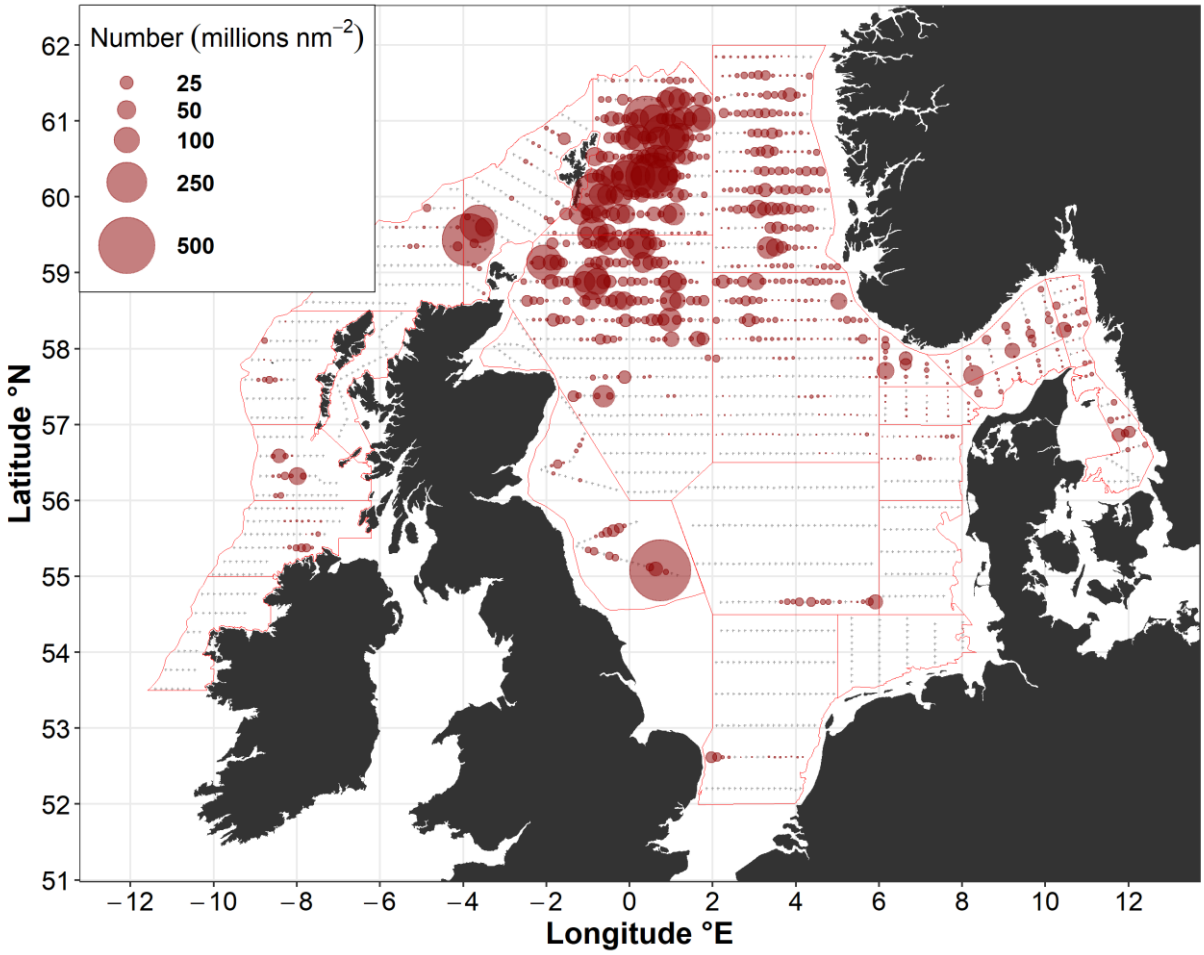


Figure 5.17. Distribution of NASC attributed to mature herring in HERAS 2023. Acoustic intervals represented by light grey dots with red bubbles representing size and location of herring aggregations. NASC values are resampled at 5 n.mi. intervals along the cruise track and split into mature and immature within each stratum following the proportion of mature herring in the stratum. The red lines show the strata system.

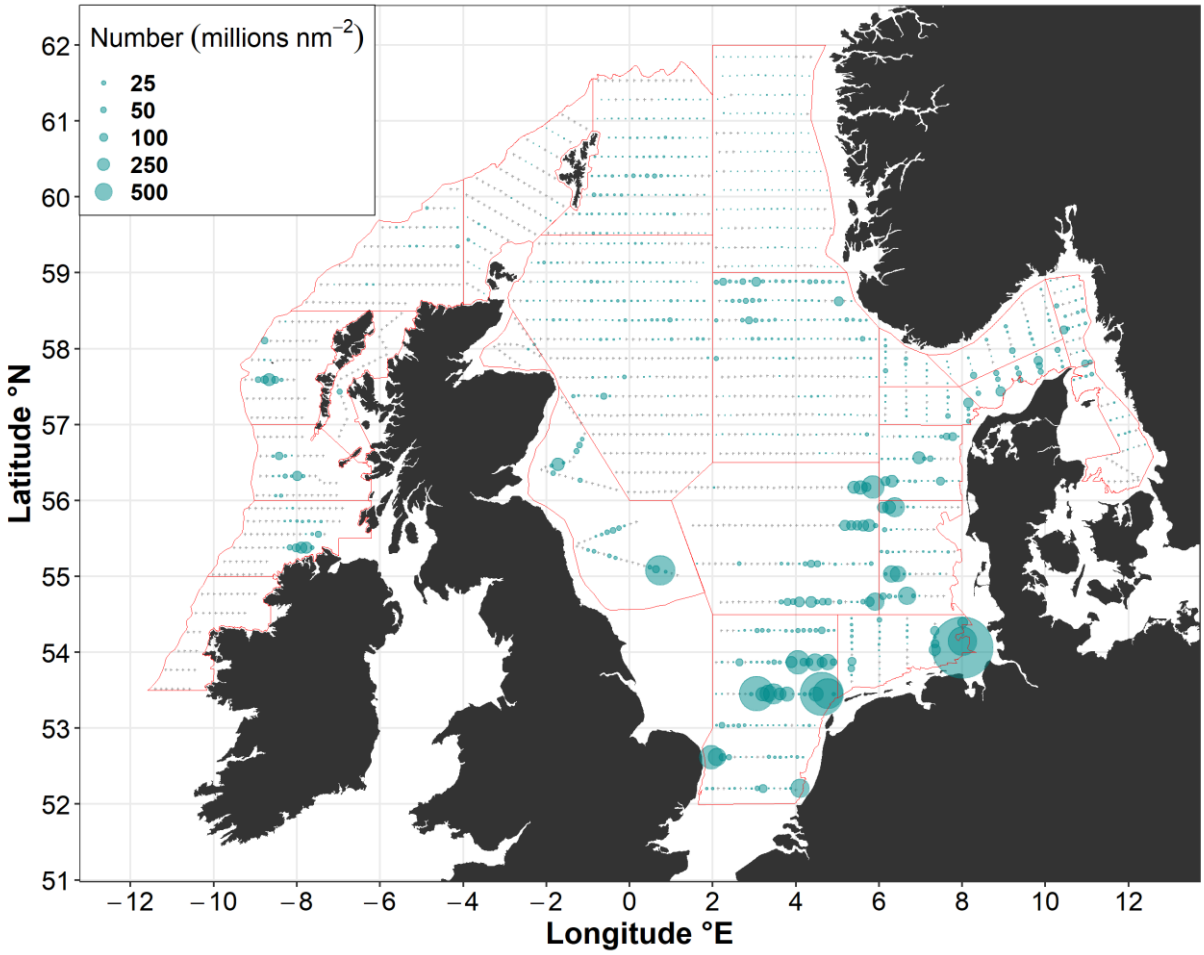


Figure 5.18. Distribution of NASC attributed to immature herring in HERAS 2023. Acoustic intervals represented by light grey dots with red bubbles representing size and location of herring aggregations. NASC values are resampled at 5 n.mi. intervals along the cruise track and split into mature and immature within each stratum following the proportion of mature herring in the stratum. The red lines show the strata system.

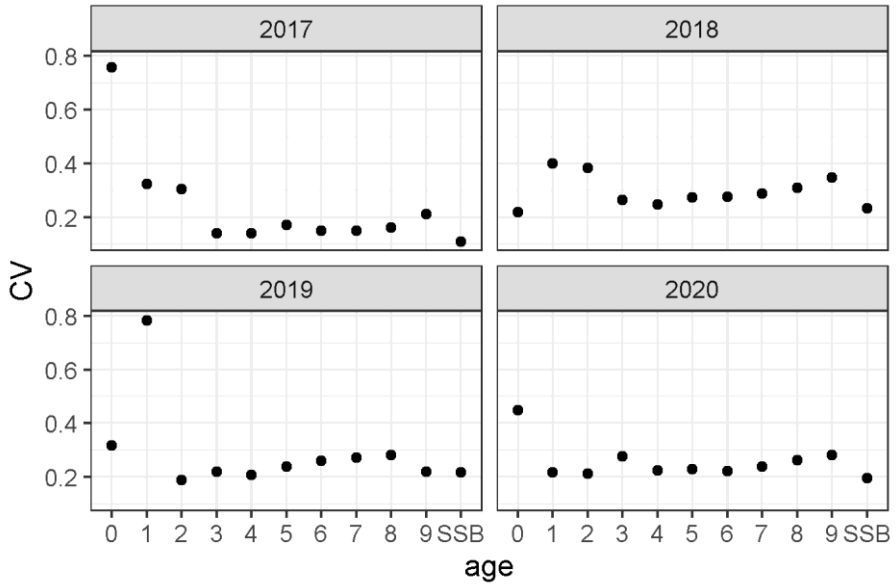


Figure 5.19. NSAS herring Coefficient of Variation (CV) for abundance at age and SSB as estimated using bootstrapping results from StoX. Data are shown for the 2017-2020 period for comparison.

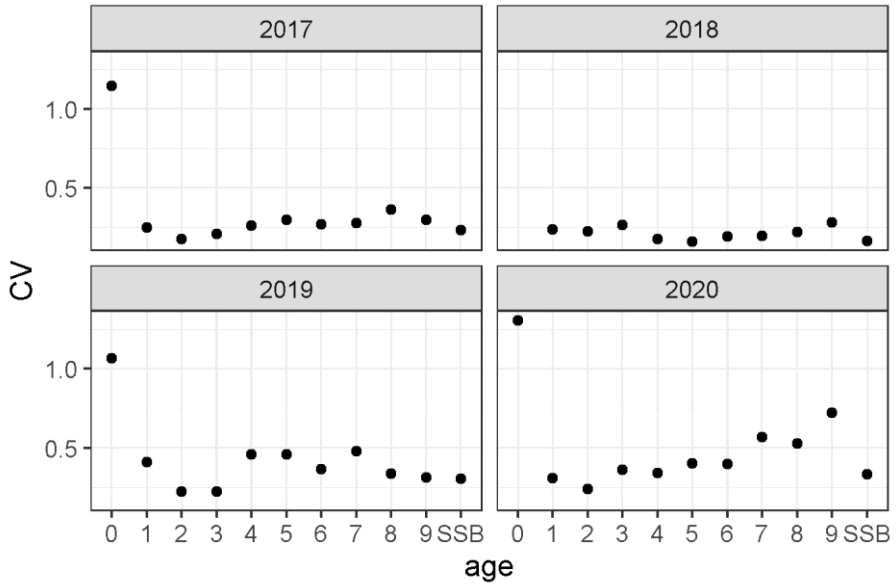


Figure 5.20. WBSS herring Coefficient of Variation (CV) for abundance at age and SSB as estimated using bootstrapping results from StoX. Data are shown for the 2017-2020 period for comparison.

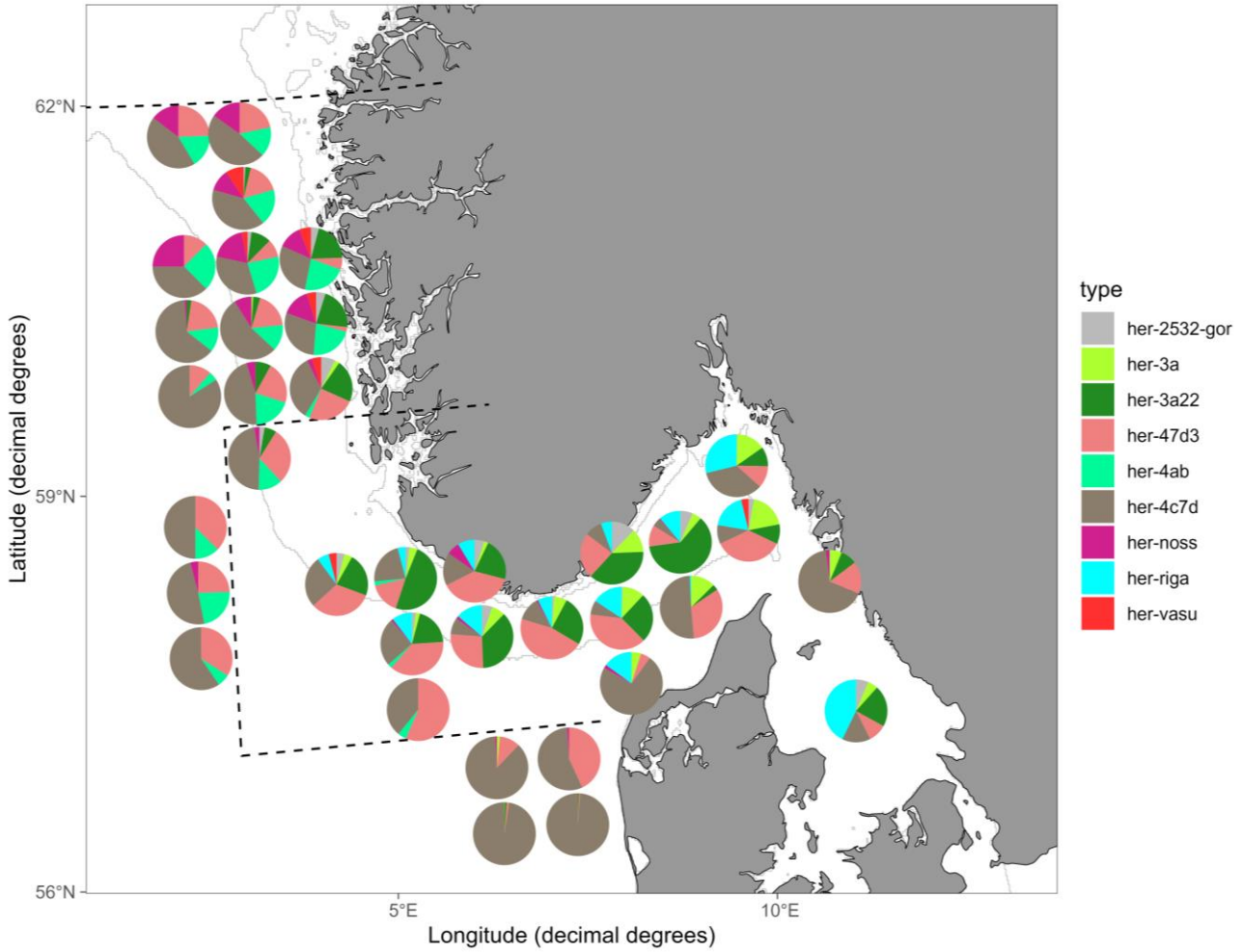


Figure 5.21. Results of genetic analyses (Single Nucleotide Polymorphism panels; Bekkevold et at. 2022; Farrell et al. 2021; Han et al. 2020) for stock splitting. The analysis was conducted in areas where previously North Sea Autumn Spawning (NSAS = her-47d3. and Downs = her-4c7d) and Western Baltic Spring Spawning (WBSS = her-3a22) herring had been identified using otolith microstructure and vertebrae counts. Aside from 3 populations identified with the previous methods (NSAS. Downs –included in NSAS indices-. and WBSS). the genetic method also identified herring from several adjacent populations in the survey area: WBSS Skagerrak herring (her-3a). CBH – Central Baltic herring (her-2532-gor). SSNS – Spring spawners from the North Sea (her-4ab). BAS – Baltic Autumn Spawning herring (her-riga). NSS – Norwegian Spring Spawning herring (her-noss). ISSH – Icelandic Summer Spawning herring (her-vasu).