

ICES co-ordinated acoustic Survey for Herring and Sprat in the North Sea

RV “Johan Hjort”, 4 – 27 July 2005
Else Torstensen
Institute of Marine Research, Flødevigen
N-4817 His, Norway
else.torstensen@imr.no

1 INTRODUCTION

The Institute of Marine Research carried out an acoustic survey for herring and sprat in the North Sea from the 4th to 27th of July 2005. The survey was part of the ICES co-ordinated herring acoustic survey for the North Sea and adjacent areas planned and co-ordinated by the Planning Group for Herring Surveys (ICES 2005). Five countries cooperate in surveying the North Sea and the Skagerrak for an acoustic abundance estimation of herring and sprat. Data from this survey will be combined with the other surveys to provide a combined age disaggregated abundance index for use in the assessment carried out by the ICES Herring Assessment Working Group (HAWG) to be held in March 2006. This survey has been carried out annually (June-July) since 1984, to provide estimates of adult herring in the North Sea.

Objectives for the survey with RV “Johan Hjort” were:

- a) To conduct an acoustic survey to estimate the abundance and distribution of herring and sprat in the eastern part of the North Sea, between 56°- 62° N, 2°- 6° E.
- b) To obtain samples of herring for biological analysis: including length, weight, age, sex, maturity and Ichthyophonus infection.
- c) To map the general hydrographical regime and monitor the standard profiles: Oksøy – Hanstholm, Hanstholm – Aberdeen, Utsira - Start Point.

2. SURVEY DESCRIPTION AND METHODS

2.1 Personnel

Else Torstensen	(Cruise leader)
Øyvind Torgersen	(Acoustic expert)
Hege Øverbø Hansen	(Technician)
Anne-Liv Johnsen	(Technician)
Jan de Lange (18 – 27 July)	(Technician)
Bente Lundin (18 – 27 July)	(Technician)
Sigmund Myklevoll	(Technician)
Bjørn Vidar Svendsen (4-17 July)	(Technician)
Arild Sæther	(Acoustic operator)

No exchange of staff with other vessels was made.

2.2 Narrative

The RV “Johan Hjort” left Bergen at 1300 UTC on 4 July 2005 and set the course southwards. A call was made in Egersund in the morning 5th July to take onboard samples of herring from commercial landings. “Johan Hjort” proceeded to the Rossfjord, 58°03'96"N 7°00'4"E, for calibration of the acoustic instruments. Like last year the conditions were unfavourable for calibration. Last calibration was made in April. The survey continued eastwards to Kristiansand and commenced with the Oksøy-Hanstholm transect (58° 3'N and 8°5' E) at 2310h. In the morning of 6th July we started the Hanstholm-Aberdeen transect and had a call in Aberdeen on the 8th. The survey continued with east-west transects from south to north between 2° and 6°E. The planned overlap between RV “Johan Hjort” and RV “Dana” around 11 July in the area 42F6-F7, was not realised. The vessel broke off the survey at N59° 47,5' and E2°48,9' and called Stavanger on the 17th at 1600 UTC for change of maritime crew. “Johan Hjort” sailed again on 18 July at 1400 UTC and passed Husøy/Karmøy to get onboard a trawl being repaired. The survey recommenced at 2045 UTC by the eastern station of the Utsira-Start Point hydrographical transect (59° 17' N 4° 50'E). The transect was finalized on the 20 July (0840 UTC) and “Johan Hjort” was back in the position from the 17th, on the 21 July at 1440 UTC (log 9157). The weather conditions were good during the first half of the survey, but the survey suffered by strong wind and rough sea in the period 21-25 July.

A call was made in Lerwick, Shetland on 25 July for a short break. We left in the same afternoon and sailed tracks abt 15 nmi apart, in 49E9 and 50E9. The weather conditions had calmed down and the last two days the weather was good. Finishing the two rectangles on the east coast of Shetland, “Johan Hjort” sailed south to 60°15'N and 02°05E and sailed eastwards and finished the survey area at 60°15'N and 04°35'E. We proceeded to Bergen where “Johan Hjort” docked at 1500 UTC. A total of 3,450 n.mi were sailed, and 72 trawl hauls and 121 CTD-stations were taken. Figure 1 gives the cruise track and locations of trawl hauls and Figure 2 the locations of CTD-stations.

2.3 Survey design

The survey was carried out in systematically parallel east-west transects with about 15n.mi spacing between 2° and 4° E and a spacing of about 30n.mi between 4° and 6°E progressing northwards (ICES 2005).

2.4 Calibration

Calibration was not performed as no calibration conditions were found. The sounders were calibrated in April 2005, with only minor changes. The main settings for the 38 kHz transceiver are given in Table 1.

2.5 Acoustic data collection

The acoustic survey on RV “Johan Hjort” in 2005 was carried out using a SIMRAD ER60 38 kHz sounder and transducer ES38B SK mounted on the drop keel. Acoustic data were collected 24 hours per day. Additional data were collected at 18, 120 and 200 kHz (ES120-7 transducer) but was not used in the present analysis. The mean volume back scattering values (Sv) were integrated over 1 nm intervals from 9-13m (depending on weather conditions and the use of keel) below the surface

to 0,5m above the seabed. The speed of the vessel during the acoustic sampling was 10–11 knots. The acoustic data were archived on tape. The acoustic recordings were scrutinized twice per day using the IMR BEI/SIMRAD BI500 Scientific Post Processing System (The Bergen Echo Integrator) (Foote et al. 1991). No paper records were available.

2.6 Biological data - fishing trawls

Trawling was carried out for supporting the species identifications of acoustic scatters and for biological sampling. For pelagic trawling a “salmon” trawl was used. A Campelen 1800 equipped with a Rock hopper gear, was used for bottom trawling. The pelagic trawl had an 11 mm cod end liner. The bottom trawl hauls were monitored using Scanmar TE40 (wide beam) and distance/depth sensor (A 4693) and Scanmar TE40-2 (PL) (narrow beam) and depth sensor D1200 were used to monitor pelagic trawl hauls. Halfway through the survey we lost the bottom trawl, including gear, one of the doors and the sensors. As we had no spare door for bottom trawling only pelagic trawling was undertaken in the second part of the survey.

The catches were sampled for species composition by weights, and biological samples (length, weight) of the most important species were taken according to the IMR fish-sampling manual (Fotland et.al. 2002). Herring were examined for age, sex, maturity (8 point scale), fat, stomach contents, vertebrae counts (east of 2°00'E) and macroscopic evidence of *Ichthyophonus* infection. If the catch of a target species contained less than 100 specimens, the total catch was sampled. If the catch contained more than 100 specimens, representative samples of about 100 specimens were randomly chosen.

2.7 Hydrographic data

CTD-stations were taken regularly in addition to the four standard hydrographical profiles: Oksøy-Hanstholm, Hanstholm-Aberdeen and Utsira - Start Point

2.8 Data analysis

Data from the echo integrator were averaged per 5 n.mi. The acoustic data were allocated to the following categories: herring, sprat, pelagic fish, demersal fish and plankton. To calculate integrator conversion factors the target strength of clupeids in the mixture were estimated using the following TS/length relationship:

$$TS = 20\log_{10}L - 71.2 \text{ dB}$$

Herring were separated from other recordings by using catch information and characteristics of the recordings. The abundance estimation (Toresen et al 1998) was made by ICES rectangles and summed up for the whole area.

North Sea autumn spawners and Western Baltic spring spawners (WBSS) are mixed during summer in the area covered by RV “Johan Hjort”. No system for workable stock discrimination on individual herring during the survey is available. The proportion of Baltic spring spawners and North Sea autumn spawners by age was calculated by applying the formula $WBSS = ((56,5 - VS(\text{sample})) / (56,5 - 55,8))$ (ICES 1999). All samples were worked up on board. The length-at age and weight-at age were assumed to be the same in the two stocks. The measured proportions of mature fish were applied equally to calculate the maturing part of each age group in both stocks.

3 RESULTS and DISCUSSION

3.1 Acoustic data

3.1.1 Herring

The distribution of sA-values (NASC) assigned to herring along the cruise track, are presented as mean values per 5 n.mi intervals in Figure 3. Herring were distributed along the surveyed area. Unfortunately we were not able to cover the area north to 62° due to loss of time in bad weather. More herring schools were observed than in the last years. Most of them were small and occurred scattered throughout the area, either close to the surface or near bottom. Highest mean densities were measured in the ICES rectangles 44F3, 46F3 and 47F3. Trawling was mainly based on random trawling positions regularly chosen for trawling at the surface, i.e., not based on echo registration. In the “Norwegian” area herring tend to keep close to the surface and may thus be underestimated.

3.2.2 Sprat

No sprat was observed in the target area of the Norwegian survey. A trawl haul on small, strong registration off Aberdeen contained a few numbers of small sprat, in, and just ended the metamorphoses.

3.3 Biological data

A total of 71 valid trawl hauls were carried out, 65 pelagic and 6 bottom hauls (Figure 1, Table 2). Of the pelagic hauls, 62 were carried out with large buoys for fishing at the surface and 3 were mid water hauls. In general 30 min hauls were made. Catch composition per haul is given in Table 3. Herring were present in 46 hauls of which 30 had sample size >20 herring. The length distributions of herring are presented in Table 4. A total of 2,324 fish were length measured and 2,197 fish were aged (winter rings in otoliths). Of the otoliths aged, 54 pairs were unreadable. A low number of herring infected by *Ichthyophonus* was observed (ten herring) which was similar to last years. For the present analysis, 56 hauls taken between 2° and 6°E, are considered. The proportions of mature 2- and 3-ringers were estimated at 43% and 84%, respectively, lower than the proportions estimated in 2004 (78% and 94%). Of the estimated numbers of 1-ringers 9% was classified as maturing. The strong 2000-year class of the North Sea autumn spawner has shown a reduced growth and maturity the last years. As a 4-wr group this year the numbers were thus presented by immature and mature, by 14% and 83% respectively. Where immature herring was classified in older age groups, these were assumed to be mis-interpretation of maturity stages 2 and 3, and were considered as mature in the present analysis.

3.4 Abundance and Biomass estimates

3.4.1 Herring

The geographical distribution of the sA-values assigned to herring, are presented in Figure 3. The bulk of the herring were in general found in the north and central region of the area. Highest concentration was found in the ICES rectangle 44F3 (mean sA = 241). Few good acoustic marks of herring schools were observed and the majority of the trawling positions were, however, regularly

chosen for trawling at surface, i.e. not based on echo registration. Due to the tendency of staying near the surface during daytime, herring may have been underestimated.

Total number of herring was 1,510 million of which 52% was North Sea Autumn Spawners (NSAS). Total biomass of NSAS was estimated to 121,000 tonnes and the spawning stock biomass as 107,000 tonnes. These estimates are lower than the respective biomasses from the Norwegian area last year, 162,000t and 154,000t. Herring of the 2000-year-class was still dominating (4-winter ringers) making 25% of total number and 27% of the spawning stock biomass. The 1- and 2-ringers (2003 and 2002 year class) made about 30% of the number and 17% of the biomass. The total biomass of WBSS was 99,000 tonnes, a small decline since last year.

Table 6 gives the mean length, mean weight, total numbers (millions) and biomass (thousands of tonnes) by age and maturity stage for the North Sea autumn spawners and the Western Baltic spring spawners in the Norwegian target area in July 2005. The mean weight of 1-ringers was more than 40% higher than last year. Also in the elder age groups (5-9+) the mean weights were higher.

3.4.2 Overlap area-Shetland

Three pelagic trawl hauls were taken randomly at surface, PT428-PT430. Herring were caught in the two hauls PT428-429. The estimated abundance (mill) by rectangle, was as follows:

ICES Rect.	Number (mill)
49E9	75.05
50E9	3.51

3.5 Hydrography

A total of 121 CTD-stations were sampled (Figure 2). The horizontal distributions of temperature and salinity at 5m, 50m and at seabed, are shown in Figures 4a-c and 5a-c, respectively. The temperature at surface (5m depth) ranged from 12–14°C in the west to 11–16°C along the Norwegian west coast. Strong northerly winds from the 20th July and onwards, might explain the low temperatures in the northern area during the last week of the survey. A tongue of warmer water was seen at 50 m depth in north. The bottom temperature ranged from <5°C in the north to about 7°C at the level of the Aberdeen-Hanstholm transect, with higher values in the coastal areas. The salinity at 5 m depth was lower than 30‰ along the southern part of the Norwegian west coast and with Atlantic water >35‰ in the central-western part of the area.

The hydrographical data are part of a monitoring program of the IMR and will be analysed and published separately.

4. References

- Fotland, AA., Borge, A., Gjørseter, H. and Mjanger, H. 2002. Manual for sampling of fish and crustaceans. Ver. 3.14. Institute of Marine Research.
- Foote, K.G., Knudsen, H.P., Korneliussen, R.J., Nordbø, P.E. and Røang, K. 1991. Post processing system for echo integrator data. J.Acoust. Soc. Am., 90, 37–47.
- ICES 1999. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1999/ACFM: 12

ICES 2005. Report of the Planning Group for Herring Surveys. ICES CM 2005/G:04, ref D.HAWG

Toresen, R., Gjørseter, H. and de Barros, P. 1998. The acoustic method as used in the abundance estimation of capelin (*Mallotus villosus* Müller) and herring (*Clupea harengus* Linné) in the Barents Sea. *Fisheries Research*, 34: 27–37.

Torstensen, E. 2004. Survey Report, RV “Johan Hjort” 8- 30 July 2004. Institute of Marine Research, Bergen, Norway. www.imr.no

Table 1. RV “Johan Hjort”, survey 2005208. International acoustic survey on herring in the North Sea, 4 – 27 July 2005. Simrad ER60 and analysis settings used.

Tranceiver Menu	38 kHz
Absorption coefficient	9.8 dB/km
Pulse length	1.024 ms
Bandwidth	2.43 kHz
Max power	2000 W
Two-way beam angle	-21.0 dB
3 dB Beam width	7.04/7.02
Calibration details	
TS of sphere	-33.6
Range to sphere in calibration	18.00-23.00 m
Transducer gain	26.94
Log/Navigation Menu	
Speed	Serial from ship's GPS
Operation Menu	
Ping interval	0.0
Display/Printer Menu	
Integration line	n/a
TS colour min.	-60 dB
Sv colour min.	-70 dB

Table 2. RV “Johan Hjort” 4–27 July 2005. Details of trawl stations during the acoustic survey on herring and sprat in the North Sea. PT = Pelagic Trawl, BT = Bottom Trawl.

Trawl haul no	Date	Lat	Lon	Time UTC	Water depth (m)	Trawl depth (m)	Duration (min)	Total catch (kg)
PT364	06.jul	57°45'	8°16' E	0313	439	150	36	13,45
PT365	06.jul	57°22'	8°29' E	0805	32	0	40	36,39
PT366	06.jul	57°00'	7°46' E	1337	44	0	35	72,45
PT367	06.jul	57°00'	6°39' E	1914	57	0	30	350,12
PT368	06.jul	57°00'	5°58' E	2240	54	0	43	36,14
PT369	07.jul	57°00'	5°41' E	0103	52	0	30	38,62
PT370	07.jul	57°01'	4°50' E	0521	62	0	30	16,56
BT371	07.jul	56°59'	2°42' E	1445	73	73	30	136,02
PT372	08.jul	57°00'	0°37' E	0012	91	0	30	191,07
PT373	08.jul	57°00'	0°16' W	0431	80	0	30	31,70
PT374	09.jul	57°09'	1°20' W	1501	76	0	30	28,15
PT375	09.jul	57°11'	0°23' W	2004	82	0	30	14,63
PT376	09.jul	57°12'	0°41' E	2301	85	0	29	138,23
PT377	10.jul	57°14'	2°02' E	0440	86	0	30	1,34
BT378	10.jul	57°14'	3°12' E	0924	63	63	30	49,42
BT379	10.jul	57°14'	5°30' E	1744	52	52	30	23,20
PT380	10.jul	57°19'	5°55' E	2052	77	0	30	52,64
PT381	11.jul	57°29'	5°23' E	0107	83	0	31	45,99
PT382	11.jul	57°31'	4°44' E	0427	78	0	30	11,69
BT383	11.jul	57°45'	2°05' E	1553	86	86	30	283,05
PT384	11.jul	57°46'	3°14' E	2106	61	0	31	24,80
PT385	12.jul	57°47'	4°00' E	0029	80	0	28	96,76
BT386	12.jul	58°01'	3°08' E	0608	86	86	31	90,22
PT387	12.jul	58°16'	4°12' E	1918	139	0	30	94,98
PT388	12.jul	58°16'	5°01' E	2332	303	0	55	135,31
PT389	13.jul	58°16'	5°41' E	0233	332	0	28	28,54
PT390	13.jul	58°45'	5°15' E	0833	211	0	30	13,49
PT391	13.jul	58°45'	4°29' E	1143	239	0	31	263,36
PT392	13.jul	58°45'	4°03' E	1408	279	0	30	209,00
PT393	13.jul	58°31'	2°42' E	2148	101	0	29	297,78
PT394	14.jul	58°39'	2°06' E	0124	95	0	30	63,51
PT395	14.jul	58°47'	3°02' E	0614	112	0	32	36,62
BT396	14.jul	58°47'	3°22' E	0837	100	100	30	45,60
BT397	14.jul	58°46'	3°23' E	1018	103	103	32	-
PT398	15.jul	58°59,6'	3°56,5' E	1409	280	130	31	23,02
PT399	15.jul	59°01'	3°32' E	1711	219	0	25	1500,00
PT400	15.jul	59°02'	2°27' E	2208	120	0	30	1,47
PT401	16.jul	59°15'	2°06' E	0151	120	0	35	161,69
PT402	16.jul	59°31'	2°52' E	0707	121	0	37	26,46
PT403	16.jul	59°31'	3°06' E	1011	223	0	31	38,26
PT404	16.jul	59°32'	4°08' E	1416	273	0	31	195,88
PT405	16.jul	59°44'	4°46' E	1912	248	0	30	411,22
PT406	16.jul	59°47'	4°05' E	2244	274	0	31	62,82
PT407	17.jul	59°47'	3°28' E	0155	253	0	31	58,79
PT408	17.jul	59°46'	2°54' E	0416	111	0	30	5,11
PT409	18.jul	59°17'	4°37' E	2203	277	0	31	101,80
PT410	19.jul	59°17'	3°49' E	0316	268	0	30	21,01
PT411	19.jul	59°16'	3°20' E	0619	159	0	30	221,44
PT412	19.jul	59°17'	1°57' E	1244	121	0	30	3,39
PT413	19.jul	59°17'	1°26' E	1524	104	0	30	3,85
PT414	19.jul	59°16'	0°03' W	2135	136	0	30	3,31

Table 2. Cont.

Trawl haul no	Date	Lat	Lon	Time UTC	Water depth (m)	Trawl depth (m)	Duration (min)	Total catch (kg)
PT415	20.jul	59°16'	0°41' W	50	121	0	31	37,94
PT416	20.jul	59°17'	1°31'W	0448	98	50	30	10,26
PT417	20.jul	59°25'	0°47' W	1327	125	0	38	17,23
PT418	20.jul	59°36'	0°55' E	1938	117	0	30	33,49
PT419	22.jul	60°03'	4°10' E	0719	292	0	30	103,50
PT420	22.jul	60°16'	4°33' E	1157	277	0	32	25,56
PT421	22.jul	60°44'	4°16' E	1704	315	0	34	20,15
PT422	22.jul	60°31'	3°58' E	2113	301	0	30	58,67
PT423	23.jul	60°31'	2°40' E	0355	105	0	31	32,47
PT424	24.jul	61°06'	3°03' E	0357	368	0	30	26,75
PT425	24.jul	61°04'	2°50' E	0918	291	0	31	69,28
PT426	24.jul	61°24'	2°52' E	1522	378	0	30	127,97
PT427	24.jul	61°09'	2°07' E	1955	137	0	30	8,09
PT428	25.jul	60°22'	0°28'W	2049	87	0	30	82,28
PT429	26.jul	60°35'	0°10'W	0116	99	0	30	27,12
PT430	26.jul	60°50'	0°37' W	0449	104	0	30	4,41
PT431	26.jul	60°32'	1°05' E	1126	140	0	31	1,39
PT432	26.jul	60°15'	2°05' E	1629	104	0	30	1,83
PT433	26.jul	60°15'	2°47' E	2111	106	0	29	256,97
PT434	26.jul	60°14'	3°10' E	2350	153	0	30	198,47
PT435	26.jul	60°15'	3°46' E	0320	296	0	30	23,57
PT436	27.jul	60°15'	4°10' E	0533	298	0	29	27,06

Table 3. RV "Johan Hjort" 4 - 27 July 2005. Catch compositions in the trawl hauls (kg).

Trawl station		364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384
ICES rect		44F9	43F8	43F7	43F6	43F5	43F5	43F4	43F2	43F0	43E9	43E8	43E9	43F0	43F2	43F3	43F5	43F5	43F5	44F4	44F2	44F3
Total catch (kg)		13,45	36,39	72,45	350,12	36,14	38,62	16,56	136,02	191,07	31,70	28,15	14,63	138,23	1,34	49,42	23,20	52,64	45,99	11,69	283,05	21,92
Herring	Clupea harengus				0,68	1,32	7,77			108,00	17,50			8,33	0,05			15,60	6,24		215,00	0,35
Sprat	Sprattus sprattus											0,39										
Pilchard	Sardina pilchardus																					
Anchovy	Engraulis encrasicolus																					
Mackerel	Scombrus scombrus		0,49	9,96	330,40	19,77	29,20	15,20		78,00	14,12	0,12	1,64	127,86	1,03	8,64			39,00	10,27	1,92	19,65
Horse mackerel	Tracurus tracurus																					
Norway pout	Trisopterus esmarkii																					
Haddock	Melanogrammus aeglefinus	0,00	0,01					0,00	4,00	0,02	0,01	0,17	0,11	1,00		1,42	3,06	36,03			29,05	0,00
Whiting	Merlangius merlangus		0,13	0,12		0,04		0,01	4,76	0,05	0,01	0,01	0,12	1,00		0,60	0,12		0,00		2,61	0,00
Blue-whiting	Micromesistius poutassou	5,15																				
Saithe	Pollachius virens	2,40																				
Hake	Merluccius merluccius																					
Pollack	Pollachius pollachius																					
Torsk	Brosme brosme																					
Cod	Gadus morhua								3,88												1,26	
Poor cod	Trisopterus minutus																0,72					
Ling	Molva molva																					
Argentine	Argentina sphyraena																					
Sandeels	Ammodytidae spp																					
Gurnard	Trigla spp		2,55	7,40	0,59				1,08							2,02	0,10					3,86
Dab	Limanda limanda								106,00							30,32	3,50					13,68
Plaice	Pleuronectes platessa								2,68							0,27	0,24					10,25
Witch	Glyptocephalus cynoglossus																					
Lemon sole	Microstomus kitt								1,50							0,14	0,11					
Long rough dab	Hippoglossoides platessoides								12,12							6,02	0,42					5,42
Atlantic halibut	Hippoglossus hippoglossus																					
Wolffish	Anarhichas lupus																					
Lumpsucker	Cyclopterus lumpus	0,54																		0,07		
Monkfish	Lophius piscatorius																					
Salmon	Salmon salar												1,70									
Thorny skate	Amblyraja radiata																					
Garpike	Belona belona			0,62		0,74		0,31													0,42	0,61
Norway haddock	Sebastes marinus																					
Jellyfish		5,13	33,20	54,00	18,40	14,26	1,63	0,95		5,00		27,00	11,00		0,17		14,00	0,94	0,60	0,95		1,27
Other		0,22	0,00	0,35	0,05	0,01	0,02	0,09			0,07	0,47	0,06	0,03	0,09			0,07	0,08	0,05		0,04

Table 3. Cont.

Trawl station		385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405
ICES rect		44F4	45F3	45F4	45F5	45F5	46F5	46F4	46F4	46F2	46F2	46F3	46F3	46F3	46F3	47F3	47F2	47F2	48F2	48F3	48F4	48F4
Total catch (kg)		57,12	90,22	94,98	135,31	88,54	13,49	263,36	209,00	297,78	63,47	36,62	45,59	0,00	23,02	1500,16	1,47	161,69	26,46	38,26	195,88	242,83
Herring	Clupea harengus	1,56		16,62	15,36	14,98	8,09		153,00	12,70	0,10	17,03				1460,00		150,20		5,60	18,60	6,06
Sprat	Sprattus sprattus																					
Pilchard	Sardina pilchardus																					
Anchovy	Engraulis encrasicolus																					
Mackerel	Scombrus scombrus	55,50	5,31	38,27	31,15	13,26	4,40	62,50	25,50	280,00	42,50	17,30				40,06		9,94	25,05	31,57	77,00	108,30
Horse mackerel	Tracurus tracurus																					
Norway pout	Trisopterus esmarkii		4,44																			
Haddock	Melanogrammus aeglefinus		14,70	0,03		0,02	0,06	0,01	0,03	0,05	0,41		1,22								0,00	0,04
Whiting	Merlangius merlangus		7,20	0,06	0,27	0,07	0,15	0,06	0,11	0,00	0,35				0,01		0,00				0,06	0,30
Blue-whiting	Micromesistius poutassou				12,90																	
Saithe	Pollachius virens		3,00										32,62		3,38							
Hake	Merluccius merluccius												2,50									
Pollack	Pollachius pollachius												5,53									
Torsk	Brosme brosme																					
Cod	Gadus morhua		0,15											0,75								
Poor cod	Trisopterus minutus																					
Ling	Molva molva																					
Argentine	Argentina sphyraena												0,64				0,03					
Sandeels	Ammodytidae spp																					
Gurnard	Trigla spp		3,24														0,37	0,29	0,21			
Dab	Limanda limanda		43,26																			
Plaice	Pleuronectes platessa		0,93																			
Witch	Glyptocephalus cynoglossus																					
Lemon sole	Microstomus kitt		0,48																			
Long rough dab	Hippoglossoides platessoides		6,17																			
Atlantic halibut	Hippoglossus hippoglossus		1,35																			
Wolffish	Anarhichas lupus																					
Lumpsucker	Cyclopterus lumpus				0,20			0,01							0,99							
Monkfish	Lophius piscatorius																					
Salmon	Salmon salar							0,78														
Thorny skate	Amblyraja radiata																					
Garpike	belona belona				0,53			0,31														
Norway haddock	Sebastes marinus						0,79	200,00	30,00	5,00	20,00	1,84			12,00		1,00	1,00	0,16	0,50	100,00	128,10
Jellyfish				40,00	75,00	60,00																
Other		0,06		0,00	0,10	0,01		0,01	0,05	0,03	0,10	0,45	0,00		6,65	0,10	0,06	0,26	1,04	0,59	0,21	0,02

Table 3. Cont.

Trawl station	ICES rect	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426
		48F4	48F3	48F2	47F4	47F4	47F3	47F1	47F1	47F0	47E9	47E9	47E9	48F0	49F4	49F4	49F4	49F3	49F2	51F3	51F2	51F2
Total catch (kg)		62,82	58,80	5,11	101,80	21,01	221,44	3,39	3,851	3,31	37,94	10,26	17,23	33,49	103,50	25,56	20,15	58,67	32,47	26,75	69,28	127,97
Herring	Clupea harengus	3,53	18,04		21,43	0,11	0,22	0,14				3,73			5,09	0,46		28,86	8,60	0,42	0,17	1,58
Sprat	Sprattus sprattus																					
Pilchard	Sardina pilchardus																					
Anchovy	Engraulis encrasicolus																					
Mackerel	Scombrus scombrus	14,63	35,33	1,70	32,00	0,12	215,00	1,46	1,974	2,45	33,86		6,21	29,27	65,00		6,03	7,05	20,60	11,01	28,00	115,00
Horse mackerel	Tracurus tracurus		0,14															0,43	0,45		8,94	
Norway pout	Trisopterus esmarkii																					
Haddock	Melanogrammus aeglefinus	0,00	0,01			0,01			0,00	0,12	0,00				0,00		0,01			0,01	0,01	0,00
Whiting	Merlangius merlangus	0,00			0,18	0,02			0,00	0,01	0,01	0,37	0,00	0,00	0,09	0,08	0,02	0,10		0,03	0,04	0,02
Blue-whiting	Micromesistius poutassou	24,82			5,66																	
Saithe	Pollachius virens	4,30	2,31																			
Hake	Merluccius merluccius											0,70										
Pollack	Pollachius pollachius																					
Torsk	Brosme brosme																					
Cod	Gadus morhua																					
Poor cod	Trisopterus minutus																					
Ling	Molva molva																					
Argentine	Argentina sphyraena									0,01		0,53										
Sandeels	Ammodytidae spp																					
Gurnard	Trigla spp			0,44									0,00									
Dab	Limanda limanda																					
Plaice	Pleuronectes platessa																					
Witch	Glyptocephalus cynoglossus																					
Lemon sole	Microstomus kitt																					
Long rough dab	Hippoglossoides platessoides																					
Atlantic halibut	Hippoglossus hippoglossus																					
Wolffish	Anarhichas lupus																					
Lumpsucker	Cyclopterus lumpus			2,22		0,23		1,753	0,01				2,11		0,16	0,29	1,59			0,83		0,09
Monkfish	Lophius piscatorius																					
Salmon	Salmon salar																					
Thorny skate	Amblyraja radiata																					
Garpike	Belona belona						0,98		1,59					0,89	0,76					1,22		
Norway haddock	Sebastes marinus																					
Jellyfish		15,00	2,50		42,52	20,00	5,00		0,25	0,61	3,74	4,85	8,61	2,50	32,00	24,42	12,00	21,50	2,79	13,00	32,00	11,00
Other		0,54	0,47	0,75	0,02	0,52	0,24	0,04	0,02	0,11	0,33	0,09	0,30	0,83	0,40	0,31	0,49	0,73	0,04	0,24	0,12	0,27

Table 3. Cont.

Trawl station		427	428	429	430	431	432	433	434	435	436
		51F2	49E9	49F0	50E9	50F1	49F2	49F2	49F3	49F3	49F4
Total catch (kg)		8,04	82,28	27,12	4,41	1,39	1,83	256,97	198,47	23,57	27,06
Herring	<i>Clupea harengus</i>	2,69	21,11	4,45				3,33	0,72	3,94	2,47
Sprat	<i>Sprattus sprattus</i>										
Pilchard	<i>Sardina pilchardus</i>										
Anchovy	<i>Engraulis encrasicolus</i>										
Mackerel	<i>Scombrus scombrus</i>	4,79	55,00	12,90	0,13	0,23		237,78	179,70	4,15	3,10
Horse mackerel	<i>Tracurus tracurus</i>							1,24	9,28		
Norway pout	<i>Trisopterus esmarkii</i>										
Haddock	<i>Melanogrammus aeglefinus</i>										0,01
Whiting	<i>Merlangius merlangus</i>		0,01	0,02					0,01	0,05	0,04
Blue-whiting	<i>Micromesistius poutassou</i>								7,41		
Saithe	<i>Pollachius virens</i>										2,13
Hake	<i>Merluccius merluccius</i>										
Pollack	<i>Pollachius pollachius</i>										
Torsk	<i>Brosme brosme</i>										
Cod	<i>Gadus morhua</i>										
Poor cod	<i>Trisopterus minutus</i>										
Ling	<i>Molva molva</i>										
Argentine	<i>Argentina sphyraena</i>										
Sandeels	<i>Ammodytidae spp</i>										
Gurnard	<i>Trigla spp</i>										
Dab	<i>Limanda limanda</i>										
Plaice	<i>Pleuronectes platessa</i>										
Witch	<i>Glyptocephalus cynoglossus</i>										
Lemon sole	<i>Microstomus kitt</i>										
Long rough dab	<i>Hippoglossoides platessoides</i>										
Atlantic halibut	<i>Hippoglossus hippoglossus</i>										
Wolffish	<i>Anarhichas lupus</i>										
Lumpsucker	<i>Cyclopterus lumpus</i>		0,01		0,78	0,14	0,39	0,67		3,14	
Monkfish	<i>Lophius piscatorius</i>			0,04	0,00	0,28					
Salmon	<i>Salmon salar</i>										
Thorny skate	<i>Amblyraja radiata</i>										
Garpike	<i>belona belona</i>			0,40				0,80			
Norway haddock	<i>Sebastes marinus</i>										
Jellyfish		0,40	2,20	4,07	0,90	0,07	0,04	11,17	1,23	11,50	18,00
Other		0,16	3,95	5,25	2,60	0,67	1,40	1,98	0,11	0,79	1,31

Table 4. RV "Johan Hjort" 4 - 27 July 2005. Herring length (cm) distribution in trawl hauls where sample size > 20 herring.

Trawl st	368	369	372	373	376	380	381	383	385	387	388	389	390	392	393	395	399	401
ICES rect	43F5	43F5	43F0	43E9	43F0	43F5	43F5	44F2	44F4	45F4	45F5	45F5	46F5	46F4	46F2	46F3	47F3	47F2
13,0																		
13,5																		
14,0																		
14,5																		
15,0	2	1																
15,5	4						1											
16,0	18	11				1	4					1						
16,5	9	13					5											
17,0	5	26				1	5											
17,5	1	15				1	6		3									
18,0		19		1	1	4	6		2									
18,5		7	3	1			3		6									
19,0		1	2	4	2	8			4									
19,5		1	1	3		6	5		1									
20,0		3	5	14	2	10	6	2	2			1						
20,5			4	13	2	1	9					1						
21,0			11	11	1	7	10	8	1	1	2	8	5					
21,5			5	7		8	1	2	1	1	6	10	5	3				
22,0		3	5	18	7	10	14	11	1		11	12	5	3	1			1
22,5			8	2	2	12	3	7			8	20	12	9	5			
23,0			1	1	6	10	2	4			7	11	11	12	3		2	1
23,5			6	1	7	7	3	10	1	3	16	11	10	22	7	3		4
24,0			7	6	8	8	2	22		4	3	3	5	4	3	6	1	
24,5			11	2	4		1	7		7	10	8	10	12	11	14	6	6
25,0	1		16	6	15	2	3	20		5	6	6	5	13	13	14	10	17
25,5			2	4	3	2		2		4	3	3	3	4	6	4	2	7
26,0			7	2	5	1			1	8	8	3	2	7	3	13	8	15
26,5			1	2	4			2		12	3	1	2	3	3	12	14	7
27,0			1			1		1		12	7	1	3	3	5	3	13	5
27,5					1					15	3				9	9	14	17
28,0			1	1				1		9	3			3	4	7	11	8
28,5			2		1			1		7	1			1	4	11	8	7
29,0										3	2				2	2	4	
29,5										1	1				4	3	5	4
30,0				1													1	1
30,5														1			1	
31,0																		
31,5													1					
32,0																		
32,5																		
33,0																		
33,5																		
34,0																		
34,5																		
35,0																		
35,5																		
36,0																		
36,5																		
37,0			1															
Total N	40	100	100	100	71	100	89	100	23	91	100	100	79	100	83	101	100	100
mean W(g)	32,9	40,4	106,6	87,2	117,4	127,6	70,1	110,4	68,0	111,7	123,1	96,8	102,4	123,0	153,0	168,6	184,6	178,9
mean L(cm)	16,6	17,7	23,4	22,2	24,1	21,9	20,3	23,9	19,8	26,8	24,6	23,2	23,9	24,5	25,9	26,5	27,2	26,6
mean verteb	-	-	-	-	-	56,02	56,28	56,45	-	56,36	55,89	55,87	55,57	55,59	56,35	56,47	56,20	56,43

Table 4. Cont.

Trawl st	403	404	405	406	407	409	416	419	422	423	428	435
ICES rect	48F3	48F4	48F4	48F5	48F3	47F4	49F3	49F4	49F3	49F2	49E9	49F3
13,0												
13,5												
14,0												
14,5												
15,0												
15,5												
16,0												
16,5												
17,0												
17,5												
18,0												
18,5												
19,0												
19,5												
20,0												
20,5												
21,0												
21,5		4						1				
22,0		2	1			1						
22,5		3		1		6			1			
23,0		8	3	1		15	1	3				
23,5	1	19	5	2		27	5	1	5			
24,0	1	6		1		10	1		2			1
24,5	1	16	3			17	6	4	8			2
25,0	5	13	3	2		11	4	3	11		1	1
25,5	1	7	3		2	1	5	2	8		1	3
26,0	1	6			1	2	2		9		3	2
26,5	2	5	3	2	3	2	1	2	10	1	5	1
27,0	5	3	4		6	5	1		7		9	
27,5	5	4	7	3	8			5	12		5	3
28,0	1	1	2	3	7			6	6	2	9	2
28,5	3	1	2	1	9	2		2	6	1	13	1
29,0	2	1		2	9				3	3	9	1
29,5	3			1	11			2	6	4	11	2
30,0	1		1	1	6	1		1	1	9	12	
30,5				1	5				1	2	3	
31,0					2				1	3	7	2
31,5		1			1				1	2	2	
32,0					1				1		2	
32,5									1	3		
33,0										1		1
33,5											1	
34,0					1						1	
34,5					1							
35,0												
35,5												
36,0												
36,5					1							
37,0												
Total	32	100	37	21	74	100	26	32	100	31	94	22
mean W(g)	174,9	136,2	163,8	168,0	243,8	116,9	143,5	157,4	160,3	277,3	224,6	179,2
mean L(cm)	27,2	24,9	26,1	27,0	29,2	24,5	25,0	26,5	27,0	30,4	29,1	27,7
mean verteb	-	55,63	55,83	56,14	56,29	55,86	-	55,84	56,10	56,19	-	55,82

Table 5. RV "Johan Hjort" 5 - 27 July 2005. Number of otolith pairs read by age-group, length and maturity.

Length cm	1		2		3		4	5	6	7	8	9+	Totalt
	im	mat	im	mat	im	mat	mat	mat	mat	mat	mat	mat	
15	1		1										2
15,5	4		1										5
16	20		13										33
16,5	20		7										27
17	26		11										37
17,5	20		6										26
18	29		4										33
18,5	15		5										20
19	21		1										22
19,5	14	1	2										17
20	35		10										45
20,5	17	1	12	1									31
21	18		35	7			1						61
21,5	6	4	24	10	1		1	1					47
22	21	3	51	13	5		2	4					99
22,5	5	2	37	20	8		8	4					84
23	4	4	27	18	12		18	10	1	1			95
23,5	1	1	38	37	24		33	32	4	1			171
24			14	16	6		19	43	3				101
24,5			14	27	18		31	57	7	3	1		158
25		1	4	19	12		59	83	13	6	2		199
25,5			1	5	1		20	38	12	2			79
26				8	1		29	46	13	1	1		99
26,5				4	2		30	36	13	12	3		100
27				1			19	32	22	15	6	3	98
27,5				5			12	44	21	20	7	1	111
28							6	27	12	24	14	2	86
28,5							6	25	12	19	19	3	85
29								15	11	6	13	2	48
29,5							3	16	14	13	9	5	63
30								7	12	15	2	5	44
30,5									3	7	2	3	18
31							1	1	6	10	1	3	23
31,5							1		3	6		2	12
32										3	1		4
32,5									1	2		1	5
33											1		2
33,5											1		2
34												1	1
34,5									1			1	2
35,5												1	1
36,5											1		1
Totalt	277	17	318	191	90	299	521	184	166	83	31	20	2197

Table 6. RV “Johan Hjort” 4 - 27 July 2005. Herring mean length, mean weight, numbers (millions) and biomass (thousands of tonnes) by age and maturity stages in the herring stocks in the Norwegian survey area.

wr	L _{mean}	W _{mean}	North Sea Autumn Spawners				Western Baltic Spring Spawners			
			No (mill)	%	Biom (10 ³)	%	No (mill)	%	Biom (10 ³)	%
1I	18,8	61,3	92	11,7	6	4,7	114	15,9	7	6,9
1M	22,8	100,9	9	1,1	1	0,7	11	1,6	1	1,1
2I	21,8	84,6	81	10,2	7	5,7	101	14,1	9	8,5
2M	24,1	122,3	62	7,8	8	6,2	74	10,4	9	9,0
3I	24,1	113,4	18	2,2	2	1,6	31	4,3	4	3,5
3M	25,3	161,4	90	11,3	14	11,9	91	12,7	15	14,6
4I	24,6	120,2	28	3,5	3	2,8				
4M	26,5	170,8	172	21,7	29	24,2	123	17,2	21	20,8
5	27,5	193,9	86	10,8	17	13,7	63	8,8	12	12,2
6	28,3	213,1	79	10,0	17	13,9	57	8,0	12	12,1
7	28,7	221,4	47	5,9	10	8,5	31	4,3	7	6,8
8	29,9	243,3	17	2,1	4	3,4	11	1,5	3	2,6
9+	30,9	252,5	12	1,6	3	2,6	8	1,1	2	1,9
Total	24,6	153,1	791	100	121	100	717	100	101	100
Immature	21,4	81,6	219	28	18	15	246	34	19	19
Mature	26,5	180,4	573	72	103	85	471	66	82	81

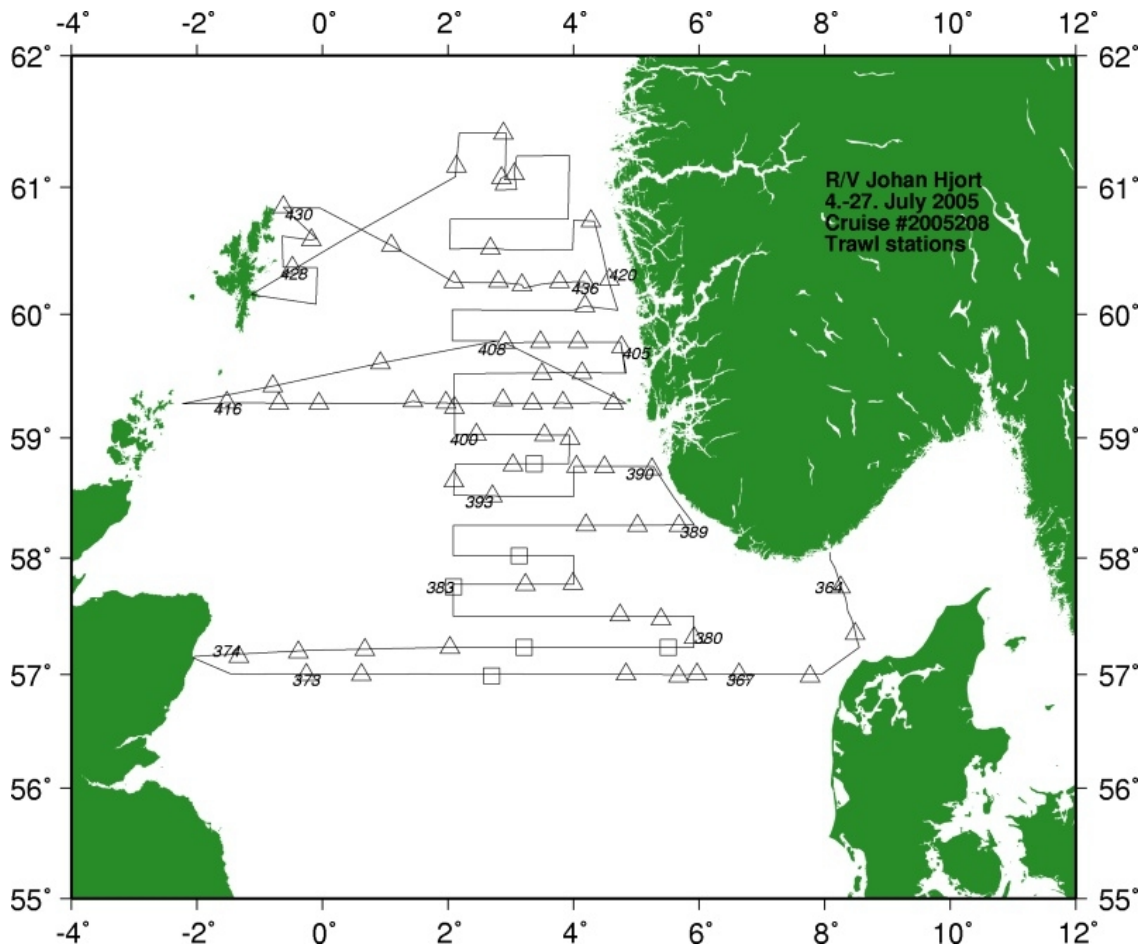


Figure 1. RV “Johan Hjort” 4 - 27 July 2005. Cruise track and fishing trawls undertaken during the acoustic survey.

△ : Pelagic trawl haul, □ : Bottom trawl haul

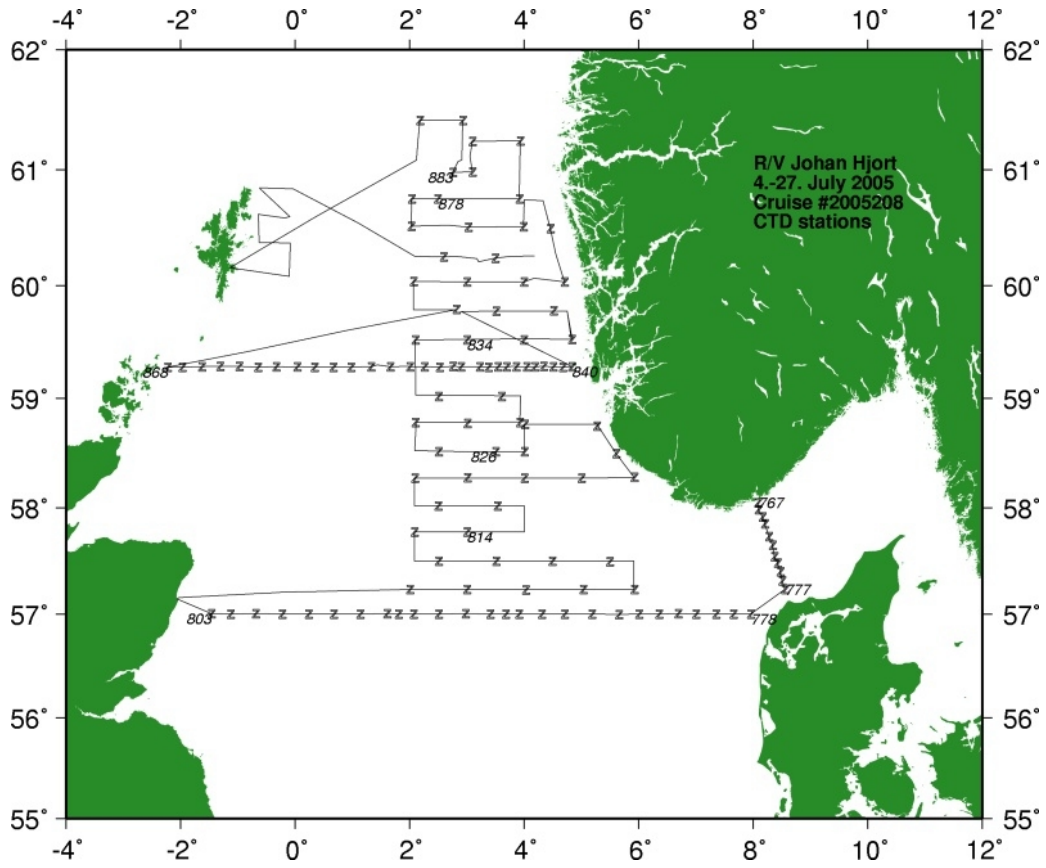


Figure 2. RV “Johan Hjort” 4 - 27 July 2005. Cruise track and CTD-stations undertaken during the acoustic survey.

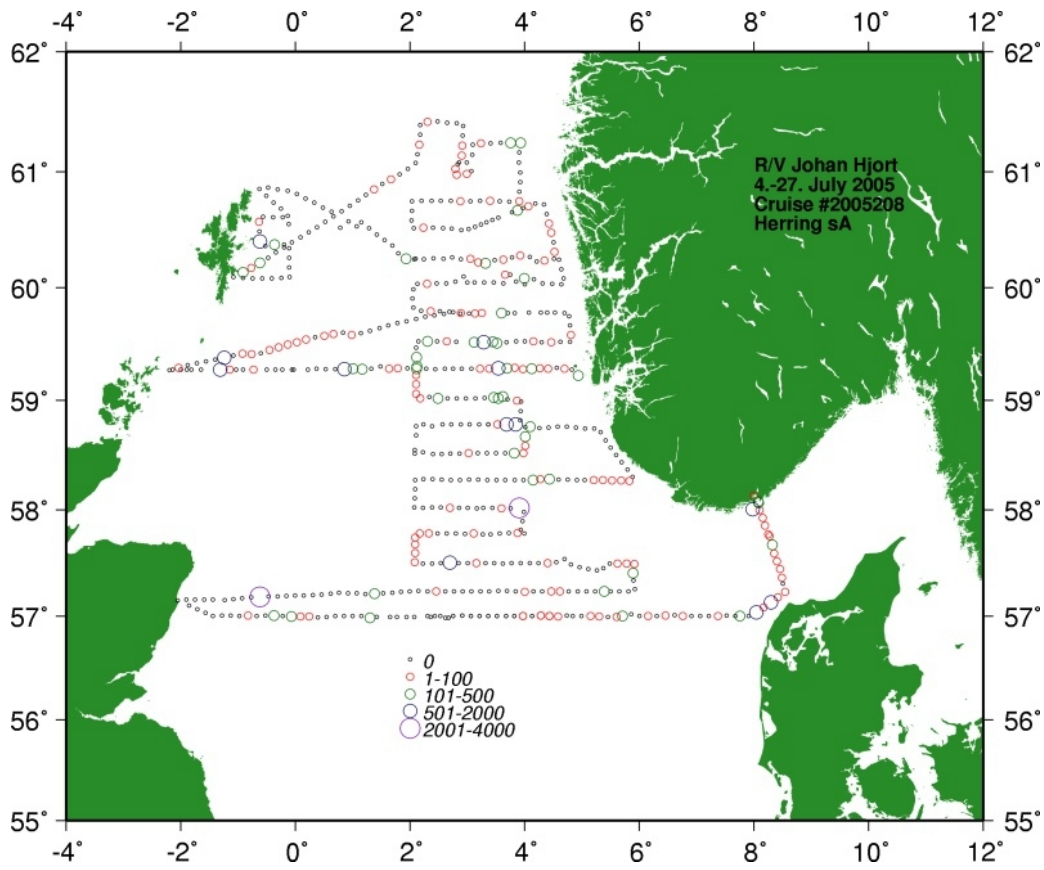


Figure 3. RV “Johan Hjort” 4 - 27 July 2005. Distribution of sA -values attributed to herring per 5 n.mi. along the cruise track.

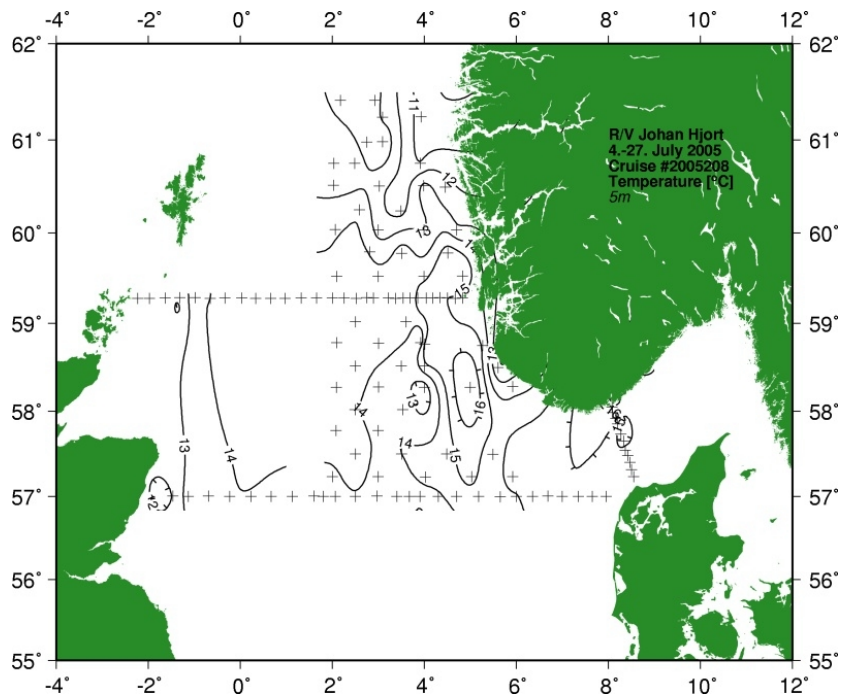


Figure 4a. RV “Johan Hjort” 4 - 27 July 2005. The horizontal distribution of temperature at 5 m.

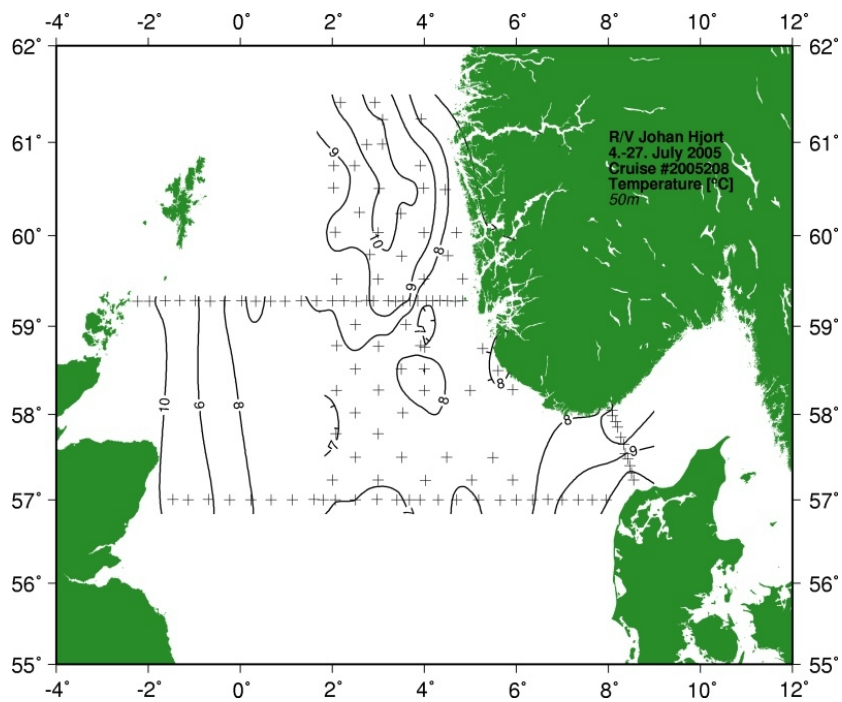


Figure 4b. RV “Johan Hjort” 4- 27 July 2005. The horizontal distribution of temperature at 50m depth.

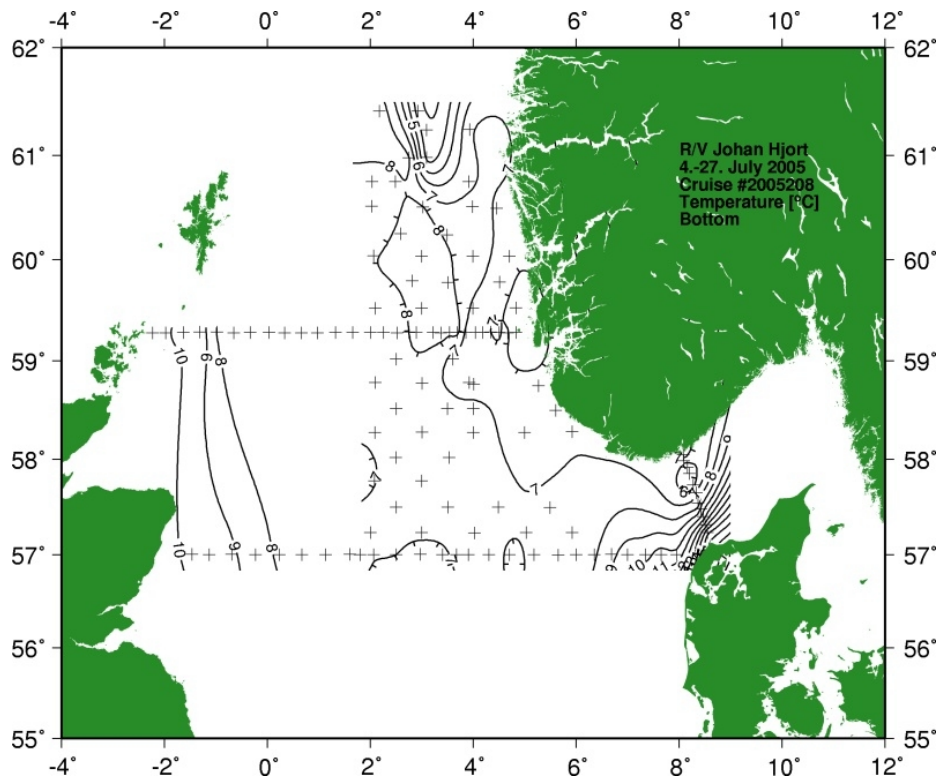


Figure 4c. RV “Johan Hjort” 4 - 27 July 2005. The horizontal distribution of temperature at bottom.

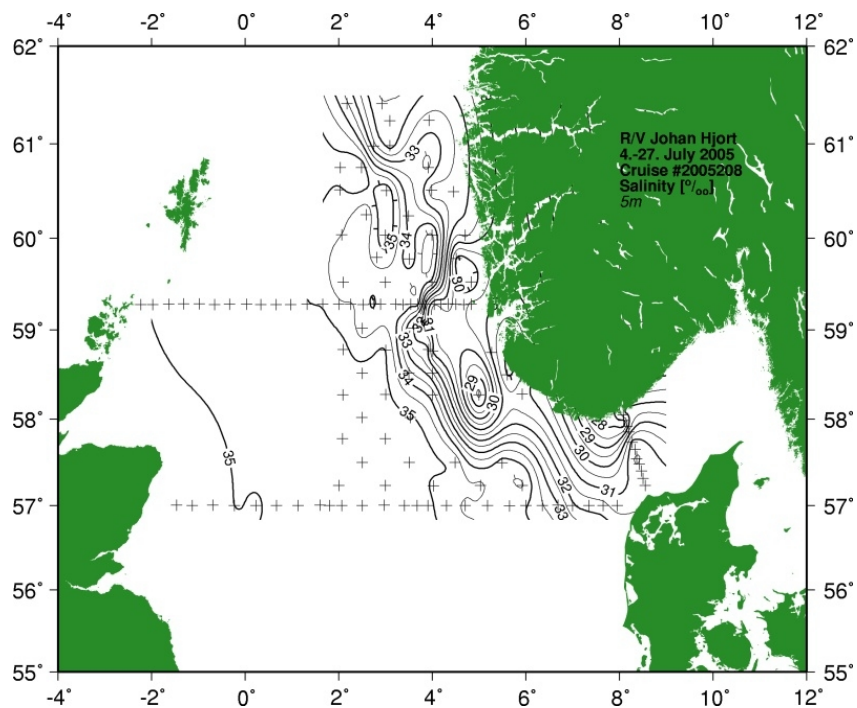


Figure 5a. RV “Johan Hjort” 4 - 27 July 2005. The horizontal distribution of salinity at 5 m.

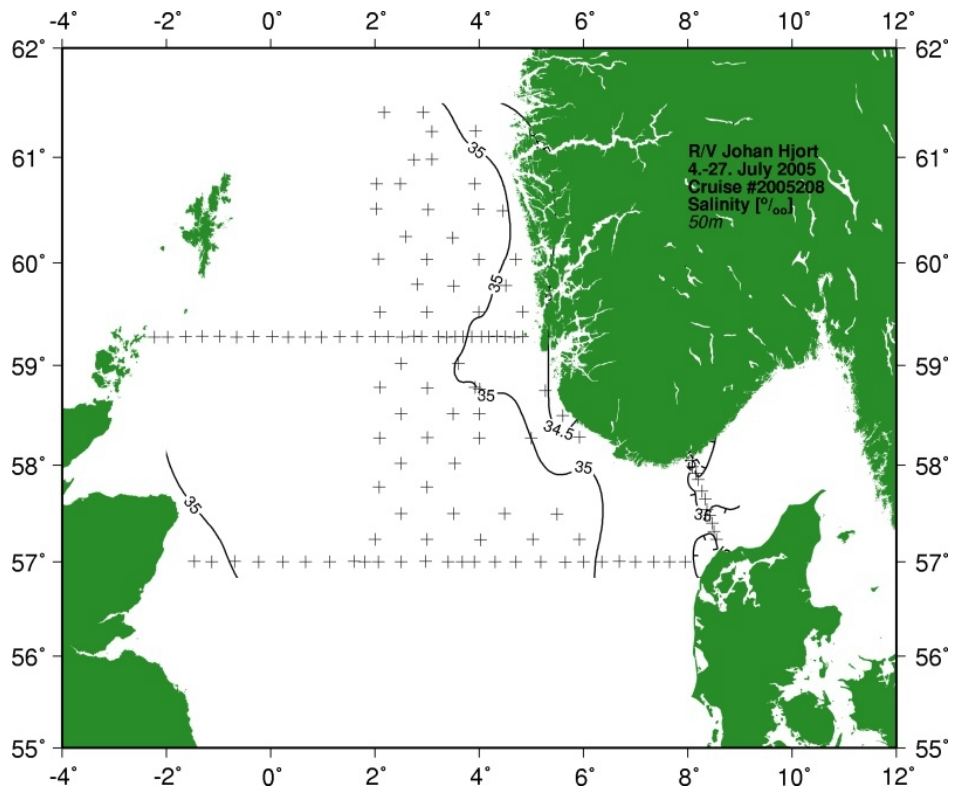


Figure 5b. RV "Johan Hjort" 4 - 27 July 2005. The horizontal distribution of salinity at 50 m depth.

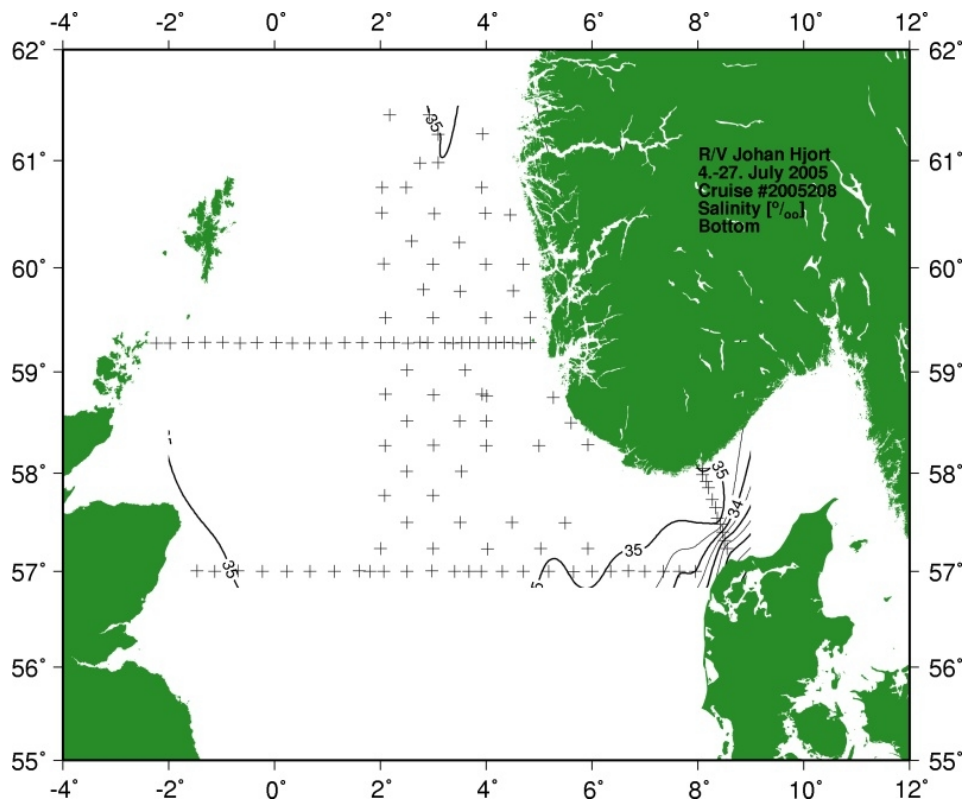


Figure 5c. RV "Johan Hjort" 4 - 27 July 2005. The horizontal distribution of salinity at bottom.

