North Sea hydro acoustic herring survey
Survey report for R/V "TRIDENS"
23 June - 18 July 2014

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- To conduct research with the aim of acquiring knowledge and offering advice on the sustainable management and use of marine and coastal areas.

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1. Introduction

The Dutch Institute for Marine Resources & Ecosystem Studies (IMARES) has been participating in the international North Sea acoustic survey for herring since 1991. Participants in this survey are Scotland, Norway, Germany, Denmark, The Netherlands and Ireland. The survey is part of the EU data collection framework (DCF) and is coordinated by the ICES Working Group for International Pelagic Surveys (WGIPS, formerly PGIPS/PGHERS). The aim of this survey is to provide an abundance estimate of the whole North Sea herring population. This estimate is used as a tuning index by the ICES Herring Assessment Working Group (HAWG) in its assessment of the population size. In this report the results are presented for the survey in the central North Sea, carried out by the Dutch vessel R/V Tridens.

Cruise plan
The survey was split into two periods of 1 and 3 weeks. The first week was used for acoustic equipment calibration in Scapa Flow, Orkneys, Scotland. The executed cruise track and hydrographical positions are presented in Figures 1a and 1b. The actual surveyed transects may differ from the planned transects.

2. Methods

2.1 Scientific Staff

Name	Organisation	Role	Wk 26	Wk 27	Wk 28	Wk 29
Sascha Fässler	IMARES	**Cruise leader & Acoustics**	x	x	x	x
Dirk Burggraaf	IMARES	**Technician & Acoustics**	x	x	x	x
Kees Bakker	IMARES	**Technician & Acoustics**	x			
Daniel Benden	IMARES	**ICT**		x	x	x
Hendrik-Jan Westerink	IMARES	**Fish lab**		x	x	x
Daniel Gallagher	guest	**Fish lab**		x	x	
John Schobben	IMARES	**Fish lab**				x

2.2 Narrative

The first week of the whole 4 week survey period was used for calibration of the acoustic equipment in a sheltered location in the Orkney Islands. Departure from Scheveningen was on Monday 23 June and Tridens steamed up north-west towards the proposed calibration location in Scapa Flow, UK. Arrival in Scapa Flow was in the morning of Wednesday 25th June. Calibration of the acoustic equipment took place during the following 2 days on 25th/26th June and was completed successfully before the vessel

departed again. Conditions at the calibration site were very favourable and good calibration results could be achieved. Tridens then steamed to Aberdeen for an extended weekend break before it left again the following Monday to start conducting the survey.
The survey continued according to the planned transects until Thursday 10th July. Due to bad weather between Wednesday 9th and Thursday 10th July, the towed body housing the echosounder transducers got damaged. In the morning of Thursday 10th July, about 6 hours were lost for repairs (exchanging metal pieces of the towed body, welding on new stabilising weights, and repairing damages to the transducer cable). Therefore, the planned transect coverage had to be compromised in order to reach the end of the transect in time before the agreed weekend stop in Newcastle. After that incident, the survey could be conducted as planned.
During the standard survey protocol, 3 pilot trawls just below the surface aimed at Northeast Atlantic (NEA) mackerel were conducted successfully. The chosen survey setup (1 week calibration/gear trials, followed by 3 weeks of survey transect coverage) proved again to be an optimal solution to complete the transects in good time with adequate possibilities for trawl samples (to guarantee a good survey precision), before the scheduled weekend breaks. Arrival in Scheveningen after the survey was on Thursday 17 July.

Since 2010, cruise leaders keep a weblog during the survey, which can be found at:
http://herringsurvey.blogspot.nl

Deviations from the proposed station grid and material damage
In the morning of 10th July, it was evident that the steal towing cable of the towed body was torn. The towed body was only attached at the transducer data cables and a Dyneema rope which was wound up tight around the capstan on the back deck. The result was that the towed body got closer to the ship than usual and was tight against its starboard side. Waves and swell were smashing it against the boat causing bent metal and fractures in the frame.
All transects were covered as planned, apart from transects 7 and 8 (planned: 56°17'N 2°24'W to 56°17'N 5°45'E and 55°47'N 5°45'E to 55°47'N 1°39'W; covered: 56°17'N 2°24'W to 56°17'N 4°45'E and 55°47'N 4°45'E to 55°47'N 1°39'W). These transects had to be shortened by 30 nmi each in order to compensate for lost time spent repairing damage on the towed body. In addition to the reduced transect mileages, 2 planned CTD stations in ICES rectangles 40F5 and 41 F5 could also not be covered.

Departure and arrival

From	Date	Time (UTC)	To	Date	Time (UTC)
Scheveningen	23-06-2014	10:00	Aberdeen	27-06-2014	03:00
Aberdeen	30-06-2014	13:00	Aberdeen	05-07-2014	00:00
Aberdeen	07-07-2014	07:30	Newcastle	12-07-2014	14:00
Newcastle	14-07-2014	15:00	Scheveningen	17-07-2014	19:00

2.3 Survey design

The actual survey was carried out from 30th June to 17th July 2014, covering an area east of Great Britain from latitude 54°25' to 58°24' North and from longitude 3° West (off the Scottish/English coast) to 5° East between 55°30' and 56°30' North. Following the survey design since 2005, a stratified survey design with random start was applied. Parallel transects along latitudinal lines were used with spacing set at 15 or 30 nmi, depending on expected herring distribution from previous years. Acoustic data from transects running north-south close to the shore (that is parallel to the depth isoclines) were excluded from the dataset. The actual cruise track, trawl and hydrographical station positions are presented in Figure 1.

2.4 Calibration of acoustic equipment

The calibration of the four transducers (38, 120, 200 and 333 kHz) mounted in the towed body was executed in Scapa Flow, Orkneys, UK. Conditions allowed for an optimal and good calibration of the frequencies. Transducer settings of the 38 kHz used for echo-integration during the survey are given in Table 1.

2.5 Acoustic data collection

Data collection
A Simrad 38 kHz split beam transducer was operated in a towed body (type "Shark") 5-6 m under the water surface. Acoustic data were collected with a Simrad EK60 scientific echo sounder and post-processed with the LSSS software to produce acoustic area densities (NASC) at 1 nautical mile intervals. The settings of the EK60 are listed in Table 1. The EK60 received the vessel speed from the ship's GPS. An average survey speed of 10.0 knots was used.
All echoes were recorded with a threshold of -70dB up to a depth of 250 meters below the transducer. A ping rate of 0.6 sec was used during the entire survey. This ping rate has proven most suitable at the depths of 50 - 150 m observed in most of the area covered.
NOTE: As in previous years, electric noise was an issue at the higher frequencies used. The noise mask recordings and present significant problems for multi-frequency data analysis. A solution to this problem would be the use of an acoustic drop keel (presently unavailable on Tridens) to allow a more permanent setup of the acoustic equipment and a shorter cable length.

2.6 Biological data collection

Fishing
The acoustic recordings were verified by fishing with a 2000 mesh pelagic trawl with 20 mm meshes in the cod-end. Fishing was carried out to identify species-composition of major recordings observed on the echo sounder and to obtain biological samples of herring and sprat. In general, after it was decided to make a tow with a pelagic trawl, the vessel turned and fished back on its track line. If the recordings showed schools, a Simrad SD570 sonar was used in order to track schools that were swimming away from the track line. In all hauls, the footrope was very close to the ground with vertical net openings varying from 20 to 30 m (specifications are listed in the PGHERS manual). A Simrad FS20 trawl sonar (vertical and horizontal scan direction) was used to monitor catch performance.

3 pilot trawl stations at the surface targeted at NEA mackerel were conducted during the survey. These were successful and lasted for a standard period of 30 minutes applying a mean towing speed of 5 kts. The towing distance and net dimensions were recorded for each haul and the catch was weighed

(±0.1.kg) onboard. Curved towing was used in order to sample out of the propeller wash. This was monitored with with the trawl sonar showing the propeller wash next to the net. The sampling could be performed without any problems even though the standard pelagic net used is not primarily designed for surface trawling. The conclusion is that R/V Tridens would be suitable to participate as EU representative in the international coordinated ecosystem survey in the Norwegian Sea and adjacent areas (IESSNS; NEA mackerel swept-area survey) if the necessary resources for additional ship time and acquisition of the standardised trawl 'Multpelt 853' were made available.

The swept area biomass indices were estimated from catch weight (C), towing distance (D) and nominal horizontal opening (h) of the trawl as:

$$\text{Swept-area biomass index [kg km}^{-2}\text{]} = \text{C [kg]} \times \text{D}^{-1}\text{ (km)} \times \text{h}^{-1}\text{ (km)}$$

The total biomass index (B) within rectangles of 1° latitude and 2° longitude commonly used during the IESSNS survey was then determined by multiplying the estimate of swept-area biomass with rectangle area.

$$\text{B (Total biomass [kg])} = \text{Swept-area biomass} \times \text{A (km2)}$$

where A is the area of the rectangle.

Comments
Fishing in shallow and rocky area's is an issue. At present it is sometimes not possible to collect samples, i.e. in the Moray Firth area. For the future, we propose to take a bottom trawl with us in addition to the pelagic 2000M net. The GOV net is a suitable net for this purpose. It could be rolled off one of the two net-winches before departure.

During the survey it was often very difficult to fish on the target schools. The main reason is that it is not possible with the omnidirectional sonar currently installed on board Tridens to track the schools after the vessel turns to shoot the net. This affects the quality of the survey and makes collection of representative biological samples more difficult. The sonar is old and has a short range (< 1 Nm). Current performance indicates that signal processing is either faulty or slow, there is no beam stabilisation and the resolution is very low, because even big targets (large schools or even the seabed) cannot be displayed properly. Clearly, this sonar is from the 1990's, it is outdated and there are currently more updated and much sophisticated scientific sonars on the market. We recommend to replace this sonar during the upcoming vessel refit for a low frequency & high resolution sonar which has the typical feature of a longer range (3-4 Nm), for example the scientific sonar 'Simrad SU90'.

Biological samples

- For all fish: Total species weight of the catch
- 150 to 250 specimens for individual length measurement. Depending on the catch weight, a subsample technique is used, based on weights.
- Stratified samples of 5 fish per length class were taken from the 150-250 length measured herring and sprat. The following parameters are sampled from these fish:
- Age of herring and sprat, by means of otolith reading
- Weight
- Gender
- Maturity stage

2.7 Hydrographical data

Hydrographical data were collected at 44 stations, all at fixed locations (Figure 1b). A Seabird CTD device, type SBE 9plus. It had been successfully calibrated in advance by the manufacturer. Conductivity, temperature and depth were measured.

2.8 Optical data

During the survey, video footage was collected using a GoPro Hero3+ camera attached inside the pelagic trawl and at the CDT sonde. The aim of these data was to acquire additional data on fish aggregations entering the trawl and plankton layers observed during CTD casts. This additional data can enhance the echogram scrutinising process to improve allocation of echo recordings to species. As a next step, the video information needs to be better linked with time & depth information.

2.9 Data handling, analysis and presentation

Data analysis
The echograms were scrutinized with Large Scale Survey System (LSSS) software. For each ICES rectangle, species composition and length distribution were determined as the un-weighted mean of all trawl results for this rectangle. From these distributions the mean acoustic backscattering cross-section "sigma" (σ_{bs}) was calculated according to the target strength-length relationships (TS) recommended by the ICES Working Group on International Pelagic Surveys. The TS relationship used to calculate mean acoustic backscattering cross-sections for both herring and sprat was:

$$TS = 20\log_{10}(L) - 71.2$$

The numbers of herring and sprat per ICES rectangle were calculated by dividing the NASC within each rectangle by the overall σ_{bs} in the corresponding rectangle.

The biological samples used for stock structure and biomass calculations were grouped in 3 strata for herring, based on similar length frequency distribution in the area (Figure 2). The numbers per year/maturity class were calculated, based on the age/length key for each stratum. For each separate stratum the mean weight per year/maturity class was then calculated.

3. Results

3.1 Acoustic data results

As in the previous year, the largest herring concentrations were found in the northern part of the Dutch survey area and close to the Devil's Holes (rectangle with highest concentration: 44F0) (Figure 3a). There were no sprat observations in the Dutch survey area this year. However, concentrations of Norway pout, the second most abundant species seen this year, are presented in Figure 3b.

3.2 Trawl data results

Sample ID's used: 2014.5400446 – 2014.5400465

In total, 20 trawl hauls were conducted. Herring was found in 11 hauls in which more than 20 herring samples were taken. The trawl list is presented in Table 2a, the catch weights per haul and species are

presented in Table 2b and the length frequency proportions used in the analysis for herring are presented in Table 2c. Norway pout was observed in 7 trawls. The biological samples contained a total of 824 herring were collected and used for length, age, weight, sex and maturity keys**.** 103 otolith samples were glued on the wrong side into the otolith trays and therefore gave problems for subsequent age reading in the lab. However, the ages from these otoliths fitted within the common age-length pattern, and the relationships between all samples and those with problematic otoliths excluded did not differ from each other.

3.3 Stock estimates

The stock biomass estimate of **herring** found in the Tridens survey area:

Immature	121.1	thousand tonnes
Spawning stock	1155.0	thousand tonnes

The stock biomass estimate of **sprat** found in the Tridens survey area:

Immature	0.0	thousand tonnes
Spawning stock	0.0	thousand tonnes

The total estimated biomass of herring in the survey area covered by R/V Tridens was about 82% higher than in the previous year, when the contribution of mature herring was much lower at 624.5 thousand tonnes. The biomass of immature fish in 2014 was about 56% higher compared to 2013. The most likely explanation for this is that mature herring in the international survey area had a more southern distribution than in previous years.
No sprat was observed in the Tridens survey area this year.

Figure 4 shows the estimated numbers and biomass of herring by ICES rectangle in the area surveyed by R/V Tridens. Table 3 summarizes stock estimates per stratum and Table 4 summarises the sub stock estimates for herring.

3.4 NEA mackerel abundance

The three surface pilot trawl stations conducted during this year's survey corresponded to coverage of three 1° latitude x 2° longitude statistical rectangles, commonly used as sampling unit in the IESSNS survey. The 2000 mesh pelagic trawl used in this survey was not identical to the 'Multpelt 832' standard trawl now commonly used on all vessels during the IESSNS. Particularly, it has a smaller net opening (vertical opening ~21-23m vs Multpelt ~30-35m; horizontal opening ~28-36m vs Multpelt ~60-65m) and is also not designed to trawl tight at the surface (achieved head-rope depth: ~3.5-15m). The biomass estimates derived from the data collected during this herring survey are therefore not directly comparable to the IESSNS estimates. Due to the smaller net opening, they may underestimate mackerel abundances when compared to the numbers reported by the IESSNS. Total NEA mackerel biomass indices for the sampled rectangles are shown in Figure 5.

3.5 Camera observations

GoPro camera pictures were linked with simultaneously collected acoustic data to improve interpretation of acoustic recordings of organisms and potentially sea bed type (Figure 6). With improvement of synchronised metadata information (time, depth, interpretation), these data could be incorporated into acoustic data analyses processes on a routine basis.

Table 1. Simrad EK60 calibration settings used on the 2014 North Sea herring acoustic survey on R/V Tridens.

```
#  Calibration  Version   2.1.0.12
#
#  Date:  25-6-2014
#
#  Comments:
#    38kHz 38.1mmWC 1024us
#
#  Reference Target:
#    TS                  -42.30 dB       Min. Distance         10.00 m
#    TS Deviation          6.0 dB        Max. Distance         12.10 m
#
#  Transducer:  ES38B  Serial No.   30501
#    Frequency           38000 Hz        Beamtype                Split
#    Gain                25.85 dB        Two Way Beam Angle   -20.6 dB
#    Athw. Angle Sens.      21.90        Along. Angle Sens.      21.90
#    Athw. Beam Angle     6.97 deg       Along. Beam Angle    6.89 deg
#    Athw. Offset Angle  -0.04 deg       Along. Offset Angle -0.08 deg
#    SaCorrection        -0.57 dB        Depth                 0.00  m
#
#  Transceiver:  GPT  38 kHz 009072017a3b 2-1 ES38B
#    Pulse Duration       1.024 ms       Sample Interval     0.192   m
#    Power                 2000  W       Receiver Bandwidth   2.43 kHz
#
#  Sounder Type:
#    EK60 Version  2.2.0
#
#  TS Detection:
#    Min. Value          -50.0 dB        Min. Spacing           100 %
#    Max. Beam Comp.       6.0 dB        Min. Echolength         60 %
#    Max. Phase Dev.          3.0        Max. Echolength        180 %
#
#  Environment:
#    Absorption Coeff.   9.3 dB/km       Sound Velocity     1500.9 m/s
#
#  Beam Model results:
#    Transducer Gain    = 25.69 dB       SaCorrection       = -0.66 dB
#    Athw. Beam Angle   = 7.36 deg       Along. Beam Angle  = 7.32 deg
#    Athw. Offset Angle =-0.01 deg       Along. Offset Angle=-0.04 deg
#
#  Data deviation from beam model:
#    RMS =    0.10 dB
#    Max =    0.23 dB  No. =    26  Athw. = -0.3 deg  Along = -0.4 deg
#    Min =   -0.37 dB  No. =    48  Athw. = -4.6 deg  Along = -1.0 deg
#
#  Data deviation from polynomial model:
#    RMS =    0.08 dB
#    Max =    0.32 dB  No. =    27  Athw. = -0.3 deg  Along = -0.2 deg
#    Min =   -0.19 dB  No. =    68  Athw. = -0.9 deg  Along =  0.7 deg
```

Table 2a. Details of the trawl hauls taken on R/V Tridens during the North Sea herring acoustic survey 2014.

haul	day	month	year	hour	minute	haul duration	lat	lon	wind direction	wind force	gear
1	1	7	2014	6	36	42	58.22	-0.24			pelagic trawl
2	1	7	2014	12	18	21	58.2	0.45			pelagic trawl
3	1	7	2014	20	37	65	58.08	1.24			pelagic trawl
4	2	7	2014	6	15	41	58.09	-0.03			pelagic trawl
5	2	7	2014	11	24	60	58.08	-1.09			pelagic trawl
6	3	7	2014	6	7	56	57.45	-2.06			pelagic trawl
7	3	7	2014	14	45	36	57.5	0.16			pelagic trawl
8	3	7	2014	18	59	86	57.52	0.49	338	4	pelagic trawl
9	4	7	2014	9	33	98	57.4	0.39	338	4	pelagic trawl
10	4	7	2014	14	36	58	57.4	-0.1	158	9	pelagic trawl
11	7	7	2014	13	20	61	57.18	-0.27		2	pelagic trawl
12	7	7	2014	19	3	35	57.16	0.57		2	pelagic trawl
13	8	7	2014	9	37	30	56.49	1.08	90	2	pelagic trawl
14	8	7	2014	14	8	66	56.46	0.14	90	1	pelagic trawl
15	9	7	2014	16	32	30	56.17	-0.04	338	2	pelagic trawl
16	10	7	2014	10	5	73	56.16	1.37		7	pelagic trawl
17	14	7	2014	18	49	37	55.17	-1.11	180	2	pelagic trawl
18	15	7	2014	7	52	36	55.17	0.25	113	4	pelagic trawl
19	15	7	2014	11	16	30	55.16	1.05	113	2	pelagic trawl
20	16	7	2014	6	55	131	54.47	-0.14	338	2	pelagic trawl

Table 2b. Trawl catches in kg on R/V Tridens during the North Sea herring acoustic survey 2014.

haul no	date	time UTC	latitude(N)	longitude	E/W	duration min.	herring	N. pout	other gadoids	mackerel	sprat	others
1	01/Jul/14	06.36	58.22	000.24	W	42	12507		10			
2	01/Jul/14	12.18	58.20	000.45	E	21						
3	01/Jul/14	20.37	58.08	001.24	E	65						
4	02/Jul/14	06.15	58.09	000.03	W	41	39	11	0	24		
5	02/Jul/14	11.24	58.08	001.09	W	60		20	46			
6	03/Jul/14	06.07	57.45	002.06	W	56		23	23	16		
7	03/Jul/14	14.45	57.50	000.16	E	36	4620		2	87		0
8	03/Jul/14	18.59	57.52	000.49	E	86	76		1	2		1
9	04/Jul/14	09.33	57.40	000.39	E	98	36			87		
10	04/Jul/14	14.36	57.40	000.10	W	58		14		3		
11	07/Jul/14	13.20	57.18	000.27	W	61		239	5	1		40
12	07/Jul/14	19.03	57.16	000.57	E	35				77		
13	08/Jul/14	09.37	56.49	001.08	E	30				90		
14	08/Jul/14	14.08	56.46	000.14	E	66		24	25			1
15	09/Jul/14	16.32	56.17	000.04	W	30		31	1	1		0
16	10/Jul/14	10.05	56.16	001.37	E	73	34716		82	283		7
17	14/Jul/14	18.49	55.17	001.11	W	37	36		48			
18	15/Jul/14	07.52	55.17	000.25	E	36	2452					
19	15/Jul/14	11.16	55.16	001.05	E	30				59		2
20	16/Jul/14	06.55	54.47	000.14	W	131	2		40	13		22

Table 2c. Length frequency percentage proportions of **herring** by haul caught on R/V Tridens during the North Sea herring acoustic survey 2014.

length/haul-no proportion %	1	2	3	4	7	8	9	16	17	18	20
13.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.4	0.0
17.5	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	1.3	0.8	0.0
18	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	3.5	0.8	0.0
18.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	3.1	3.7
19	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.4	11.9	4.6	18.5
19.5	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.4	10.3	10.8	14.8
20	0.0	0.0	0.0	0.5	0.0	0.5	0.0	0.0	18.3	25.5	29.6
20.5	0.0	0.0	0.0	0.3	0.5	0.2	0.0	1.7	15.7	19.7	18.5
21	0.0	0.0	1.4	0.0	0.3	0.5	0.4	3.0	18.9	19.7	11.1
21.5	0.0	0.0	2.3	0.0	0.3	0.7	1.6	3.4	2.9	9.7	3.7
22	0.0	0.0	3.2	0.5	1.1	1.8	0.8	6.9	5.4	2.7	0.0
22.5	0.3	0.0	3.2	1.3	0.8	1.6	4.3	3.9	1.6	0.4	0.0
23	0.0	0.3	4.6	2.0	1.3	1.4	8.3	5.2	1.3	1.2	0.0
23.5	1.3	0.0	3.2	2.3	1.3	1.4	6.7	2.6	0.0	0.4	0.0
24	1.3	0.3	2.3	2.5	0.8	2.0	9.8	5.6	0.0	0.4	0.0
24.5	1.0	0.0	2.8	3.0	4.3	2.0	11.8	3.0	0.0	0.0	0.0
25	2.6	1.6	6.0	4.0	6.2	9.3	10.6	3.9	0.0	0.0	0.0
25.5	4.1	1.9	7.4	4.8	8.6	7.9	9.8	5.6	0.0	0.0	0.0
26	8.8	7.7	5.6	5.5	9.2	11.3	12.2	9.5	0.0	0.0	0.0
26.5	8.3	7.7	6.0	7.5	8.4	10.2	8.3	9.5	0.0	0.0	0.0
27	11.1	15.5	7.9	10.5	10.5	9.7	7.1	9.1	0.0	0.0	0.0
27.5	11.9	12.0	9.7	17.8	13.5	9.0	2.8	3.4	0.0	0.0	0.0
28	12.7	15.7	6.0	12.3	11.9	9.3	2.4	6.9	0.0	0.0	0.0
28.5	13.7	10.9	9.3	12.5	6.5	8.1	0.4	5.2	0.0	0.0	0.0
29	11.7	10.9	7.9	6.0	7.5	6.8	1.6	4.3	0.0	0.0	0.0
29.5	7.3	7.5	6.9	3.0	3.8	2.3	1.2	3.4	0.0	0.0	0.0
30	3.4	5.6	1.4	2.0	2.2	2.5	0.0	2.2	0.0	0.0	0.0
30.5	0.3	1.3	0.0	1.5	0.5	0.5	0.0	0.4	0.0	0.0	0.0
31	0.0	0.3	0.9	0.5	0.0	0.2	0.0	0.4	0.0	0.0	0.0
31.5	0.3	0.5	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.0
32	0.0	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
32.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
no in sample	386	375	216	400	371	443	254	232	312	259	27

Table 2d. Length frequency percentage proportions of **Northeast Atlantic mackerel** by haul caught at dedicated pilot trawl stations on R/V Tridens during the North Sea herring acoustic survey 2014.

length/haul-no proportion %	12	13	19
21	0.0	0.0	0.0
22	0.9	0.0	0.0
23	0.0	0.0	0.0
24	0.0	0.0	0.0
25	0.0	0.0	0.0
26	0.0	0.0	0.5
27	0.9	1.3	6.2
28	5.1	0.0	14.8
29	13.7	1.3	24.4
30	26.5	5.3	32.5
31	30.8	10.5	8.6
32	16.2	14.5	6.2
33	3.4	9.2	3.3
34	1.7	9.2	1.4
35	0.0	15.8	0.5
36	0.9	17.1	1.4
37	0.0	7.9	0.0
38	0.0	3.9	0.0
39	0.0	3.9	0.0
40	0.0	0.0	0.0
41	0.0	0.0	0.0
no in sample	117	76	209

Table 3. Age/maturity-length keys for herring – Stratum A - C. Tridens, North Sea acoustic survey 2014.

			Stratum A				
Age	Year	Mean Length (cm)	Mean weight (g)	Number (millions)	%	Biomass (1000 tons)	%
0I	2013im			0	0.0	0.000	0.0
0M	2013ad			0	0.0	0.000	0.0
1I	2012im	21.0	78.6	78	1.4	6.138	0.6
1M	2012ad	22.5	96.7	12	0.2	1.120	0.1
2I	2011im	22.0	94.4	108	2.0	10.176	1.1
2M	2011ad	25.0	140.7	1348	24.4	189.583	19.7
3I	2010im	23.5	123.0	4	0.1	0.542	0.1
3M	2010ad	26.7	171.3	1187	21.5	203.391	21.1
4I	2009im			0	0.0	0.000	0.0
4M	2009ad	27.1	182.4	1176	21.3	214.516	22.3
5I	2008im			0	0.0	0.000	0.0
5M	2008ad	28.3	204.4	470	8.5	96.011	10.0
6M	2007	28.6	209.3	724	13.1	151.543	15.7
7M	2006	28.9	210.0	314	5.7	65.867	6.8
8M	2005	30.1	239.7	44	0.8	10.558	1.1
9M	2004	29.9	225.4	24	0.4	5.498	0.6
10M	2003	29.5	235.0	8	0.1	1.791	0.2
11M	2002	29.1	225.7	26	0.5	5.771	0.6
12+	<2002	32.0	0.0	2	0.0	0.000	0.0
Mean		26.9	162.4				
Total				5524	100.0	962.505	100.0
Immature				190	3.4	16.856	1.8
Mature				5334	96.6	945.649	98.2

			Stratum B				
Age	Year	Mean Length (cm)	Mean weight (g)	Number (millions)	%	Biomass (1000 tons)	%
0I	2013im			0	0.0	0.000	0.0
0M	2013ad			0	0.0	0.000	0.0
1I	2012im	20.9	82.0	67	5.3	5.531	2.7
1M	2012ad	21.9	98.4	63	5.0	6.226	3.1
2I	2011im	21.0	93.0	6	0.5	0.593	0.3
2M	2011ad	23.8	130.8	437	34.5	57.172	28.0
3I	2010im			0	0.0	0.000	0.0
3M	2010ad	26.4	168.0	162	12.8	27.202	13.3
4I	2009im			0	0.0	0.000	0.0
4M	2009ad	27.1	191.2	311	24.5	59.414	29.1
5I	2008im			0	0.0	0.000	0.0
5M	2008ad	27.5	197.2	100	7.8	19.631	9.6
6M	2007	29.1	242.8	35	2.8	8.498	4.2
7M	2006	29.5	223.4	68	5.3	15.151	7.4
8M	2005	29.9	233.6	20	1.6	4.599	2.3
9M	2004			0	0.0	0.000	0.0
10M	2003			0	0.0	0.000	0.0
11M	2002			0	0.0	0.000	0.0
12+	<2002			0	0.0	0.000	0.0
Mean		25.7	166.0				
Total				1269	100.0	204.017	100.0
Immature				74	5.8	6.125	3.0
Mature				1195	94.2	197.892	97.0

			Stratum C				
Age	Year	Mean Length (cm)	Mean weight (g)	Number (millions)	%	Biomass (1000 tons)	%
0I	2013im			0	0.0	0.000	0.0
0M	2013ad			0	0.0	0.000	0.0
1I	2012im	20.0	62.7	1382	81.9	86.617	79.0
1M	2012ad	20.7	71.0	107	6.3	7.595	6.9
2I	2011im	20.4	72.5	159	9.4	11.528	10.5
2M	2011ad	22.6	97.6	37	2.2	3.591	3.3
3I	2010im			0	0.0	0.000	0.0
3M	2010ad	22.5	96.0	3	0.2	0.269	0.2
4I	2009im			0	0.0	0.000	0.0
4M	2009ad			0	0.0	0.000	0.0
5I	2008im			0	0.0	0.000	0.0
5M	2008ad			0	0.0	0.000	0.0
6M	2007			0	0.0	0.000	0.0
7M	2006			0	0.0	0.000	0.0
8M	2005			0	0.0	0.000	0.0
9M	2004			0	0.0	0.000	0.0
10M	2003			0	0.0	0.000	0.0
11M	2002			0	0.0	0.000	0.0
12+	<2002			0	0.0	0.000	0.0
Mean		21.2	79.9				
Total				1688	100.0	109.599	100.0
Immature				1541	91.3	98.144	89.5
Mature				147	8.7	11.455	10.5

Table 4. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) **herring** breakdown by age and maturity obtained during the July 2014 North Sea herring acoustic survey on R/V Tridens.

		Total area (all strata summarized)			
Age	Year	Number (millions)	%	Biomass (1000 tons)	%
0I	2013im	0	0.0	0.000	0.0
0M	2013ad	0	0.0	0.000	0.0
1I	2012im	1528	18.0	98.286	7.7
1M	2012ad	182	2.1	14.941	1.2
2I	2011im	273	3.2	22.297	1.7
2M	2011ad	1822	21.5	250.346	19.6
3I	2010im	4	0.1	0.542	0.0
3M	2010ad	1352	15.9	230.862	18.1
4I	2009im	0	0.0	0.000	0.0
4M	2009ad	1487	17.5	273.930	21.5
5I	2008im	0	0.0	0.000	0.0
5M	2008ad	569	6.7	115.641	9.1
6M	2007	759	9.0	160.042	12.5
7M	2006	382	4.5	81.017	6.3
8M	2005	64	0.8	15.157	1.2
9M	2004	24	0.3	5.498	0.4
10M	2003	8	0.1	1.791	0.1
11M	2002	26	0.3	5.771	0.5
12+	<2002	2	0.0	0.000	0.0
Total		8481	100.0	1276.121	100.0
Immature		1805	21.3	121.125	9.5
Mature		6676	78.7	1154.996	90.5

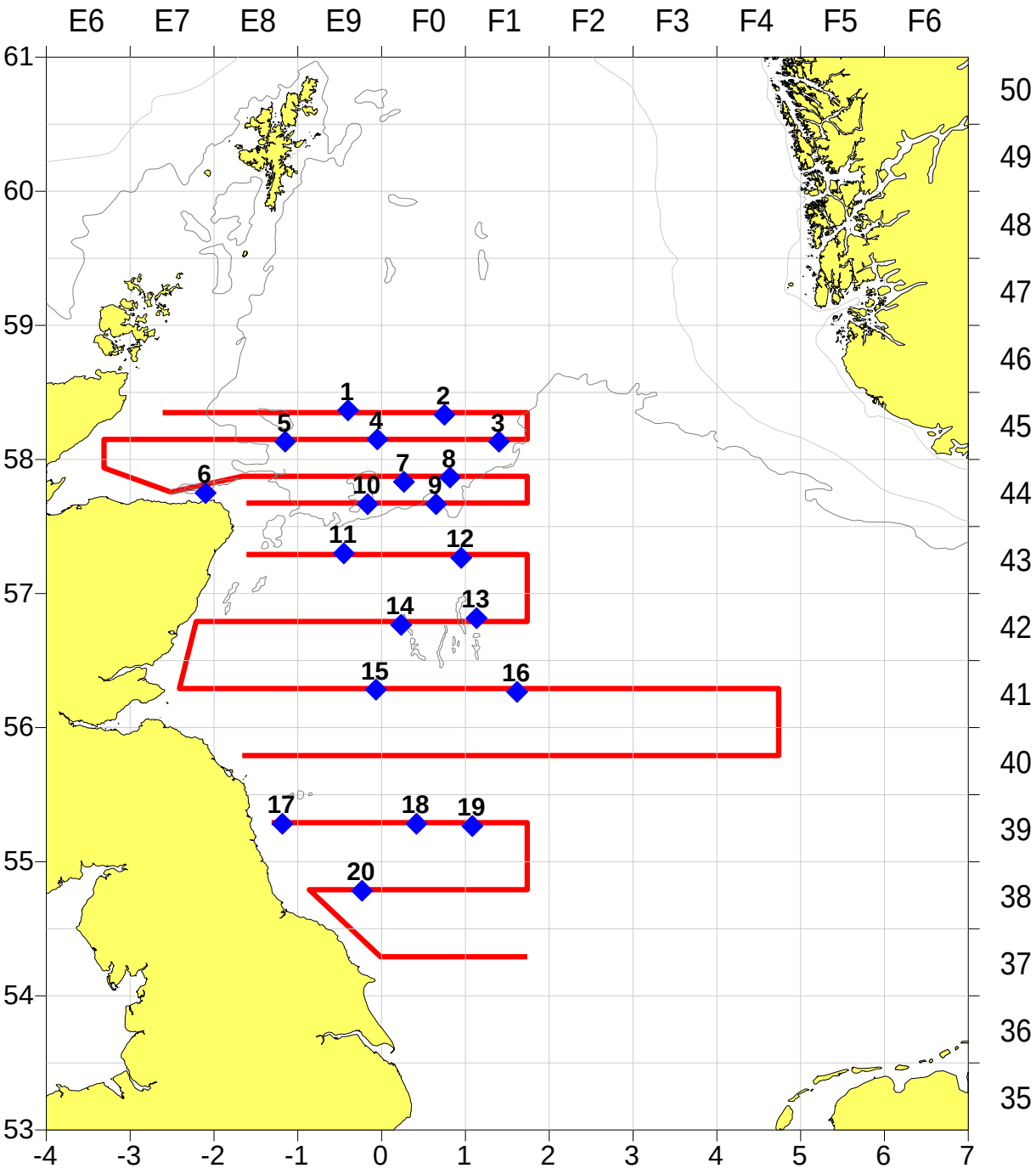


Figure 1a. Map of executed cruise track and positions of trawl stations (blue diamonds with numbers) during the July 2014 North Sea herring acoustic survey on R/V Tridens.

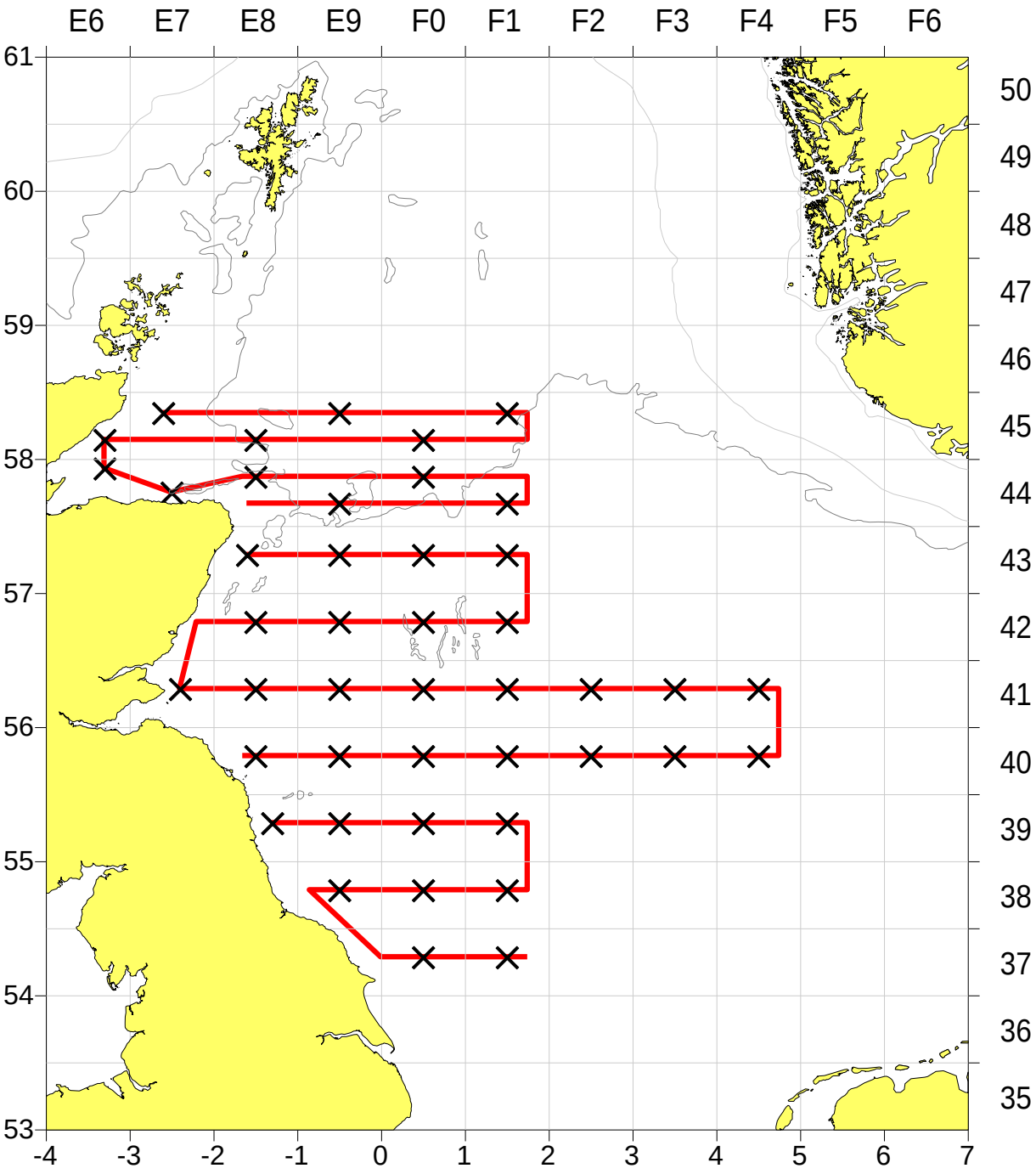


Figure 1b. Map of hydrographical stations (crosses) during the July 2014 North Sea herring acoustic survey on R/V Tridens.

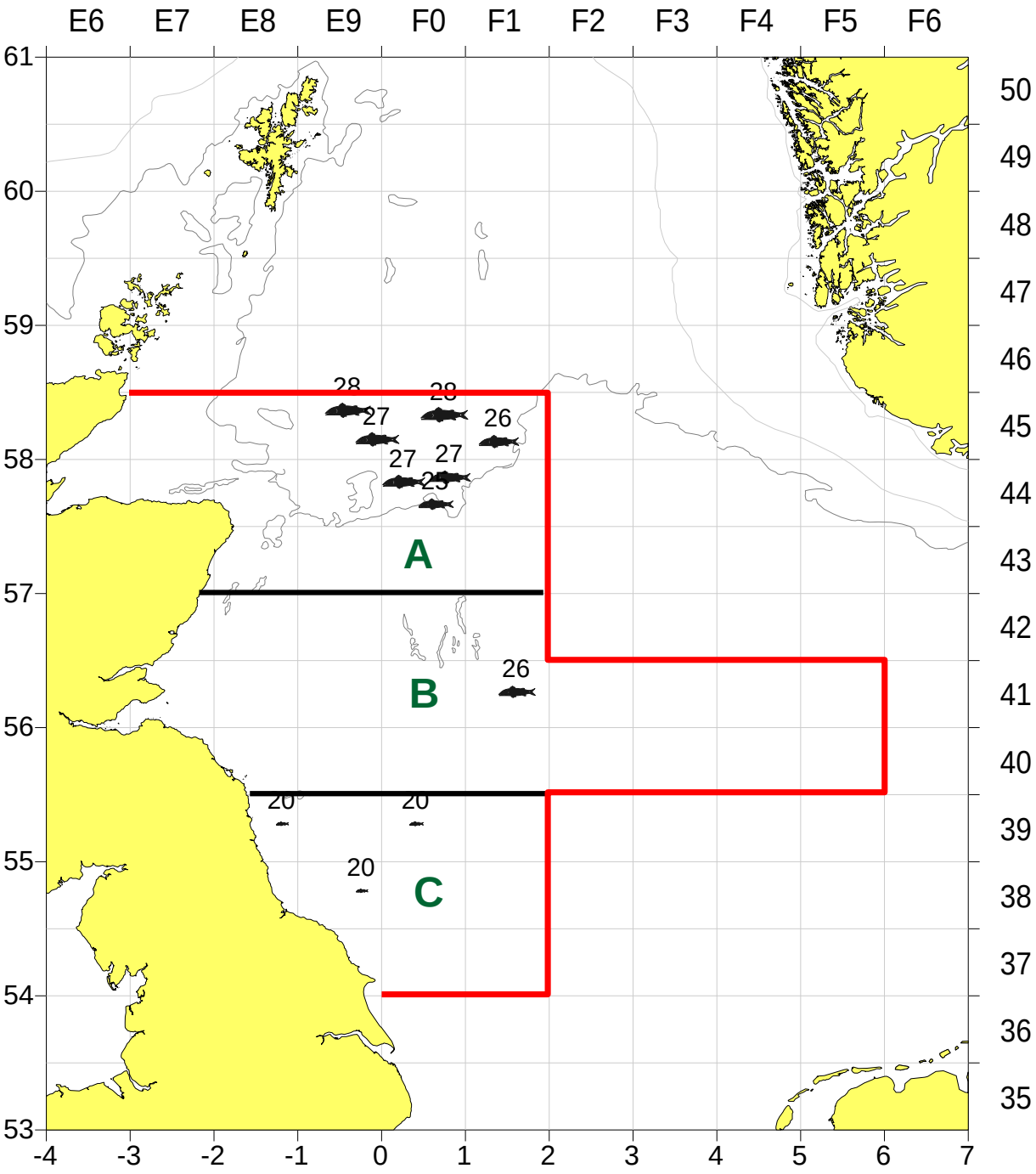


Figure 2. Survey strata used to pool length frequency distributions of **herring** and to raise NASC's by rectangle to numbers and biomass during the July 2014 North Sea herring acoustic survey on R/V Tridens. Size of fish symbols represent relative mean lengths of the species caught in the hauls that contained more than 20 herring.

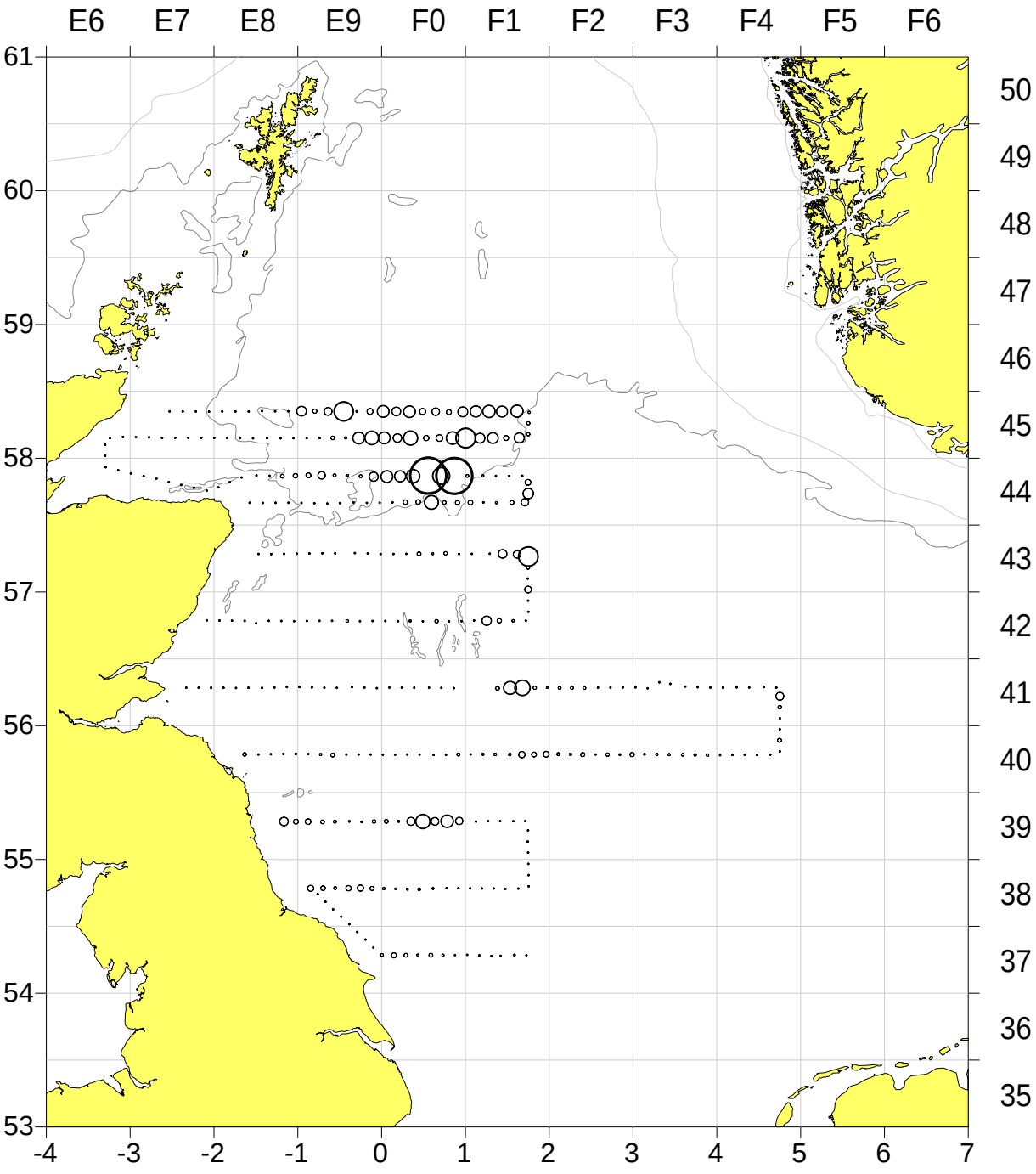


Figure 3a. Post plot showing the distribution of **total herring** NASC's of 5 nm intervals (on a proportional square root scale relative to the maximum value of 9098m^2nmi^{-2}) obtained during the July 2014 North Sea herring acoustic survey on R/V Tridens.

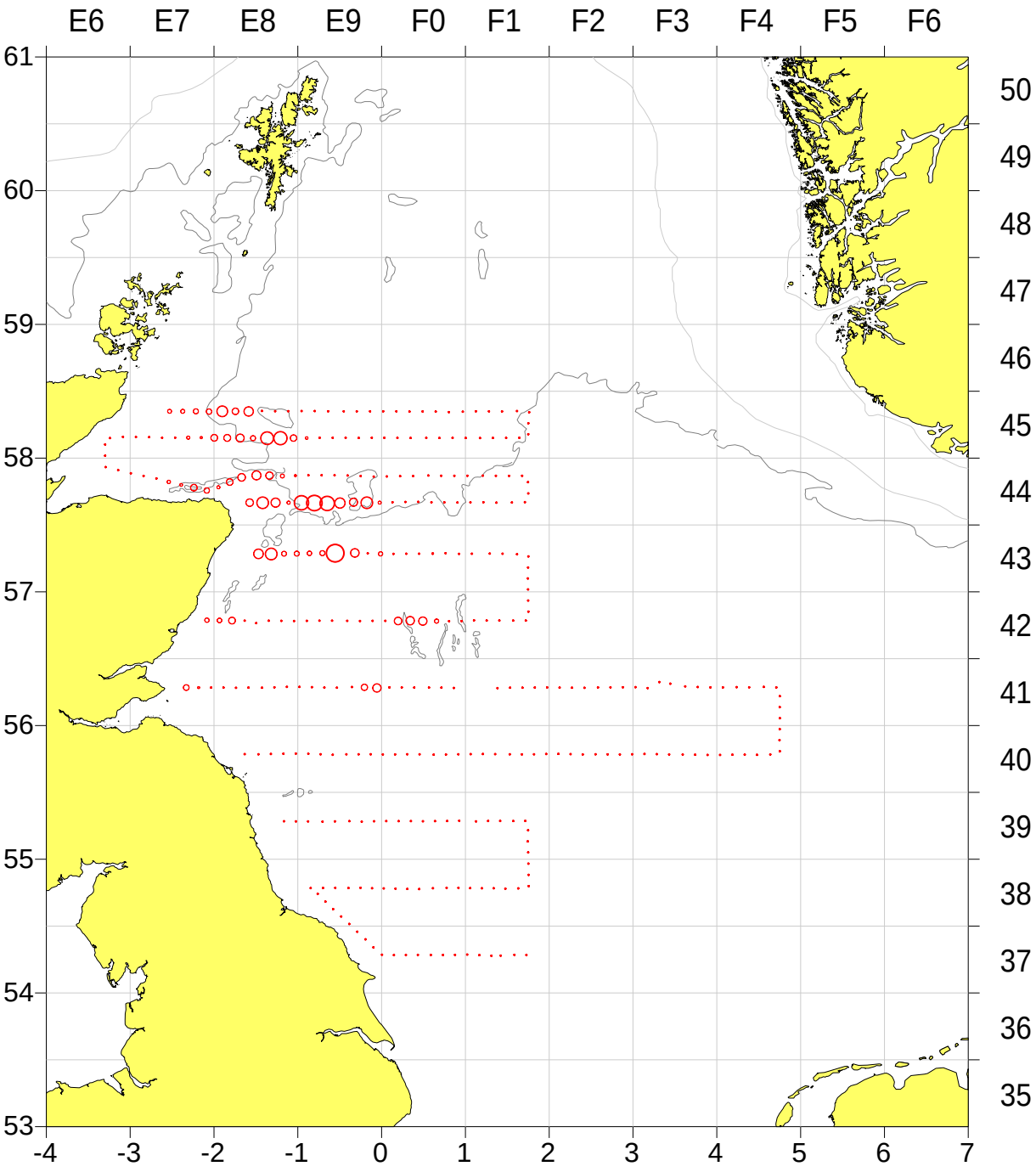


Figure 3b. Post plot showing the distribution of **total Norway pout** NASC's by 5 nm intervals (on a proportional square root scale relative to the largest value observed for herring, 9098m^2nmi^{-2}). Obtained during the July 2014 North Sea herring acoustic survey on R/V Tridens.

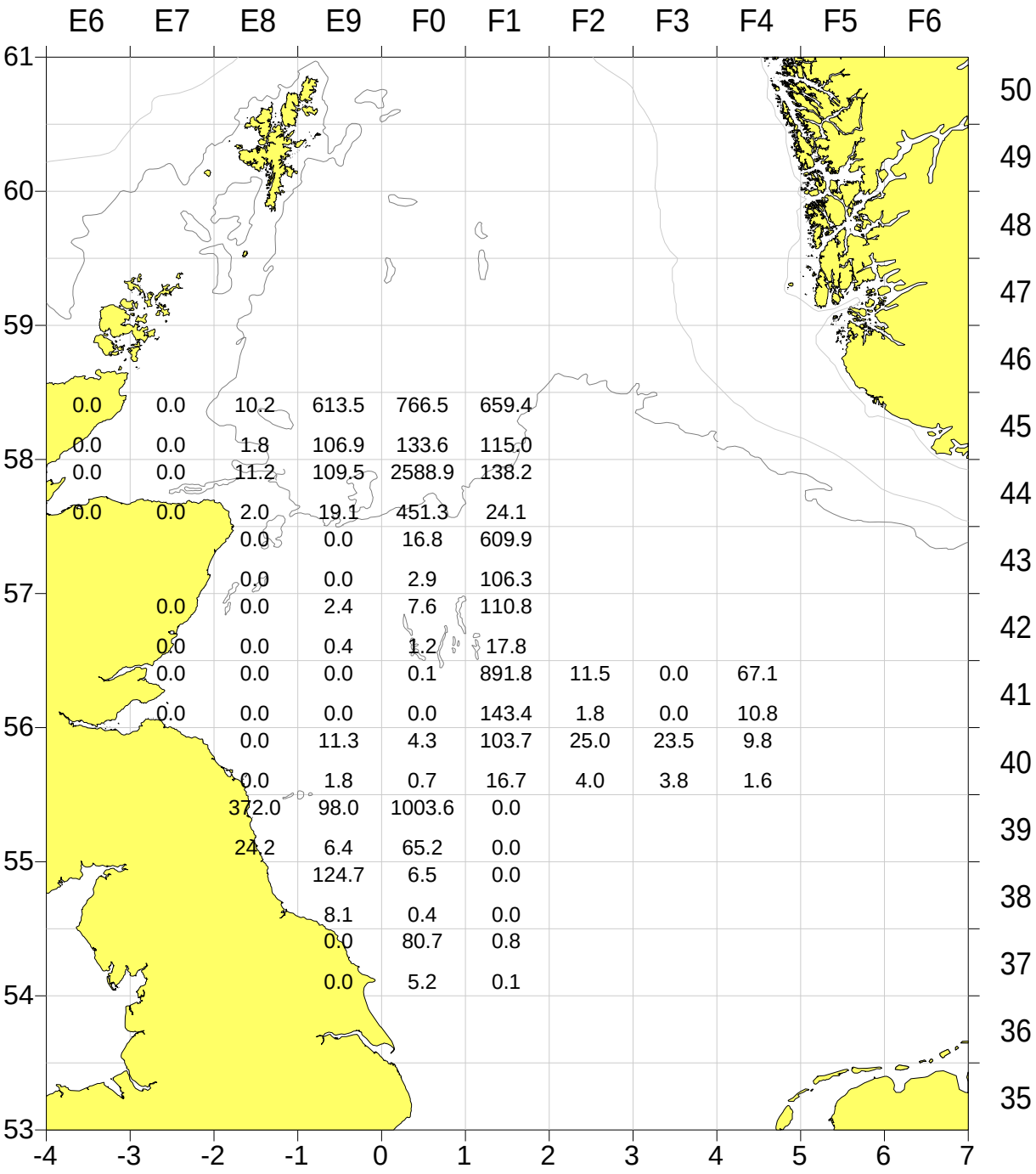


Figure 4. Estimated numbers of **herring** in millions (upper half square) and biomass in thousands of tonnes (lower half of square) by ICES rectangle. Results from the July 2014 North Sea herring acoustic survey on R/V Tridens.

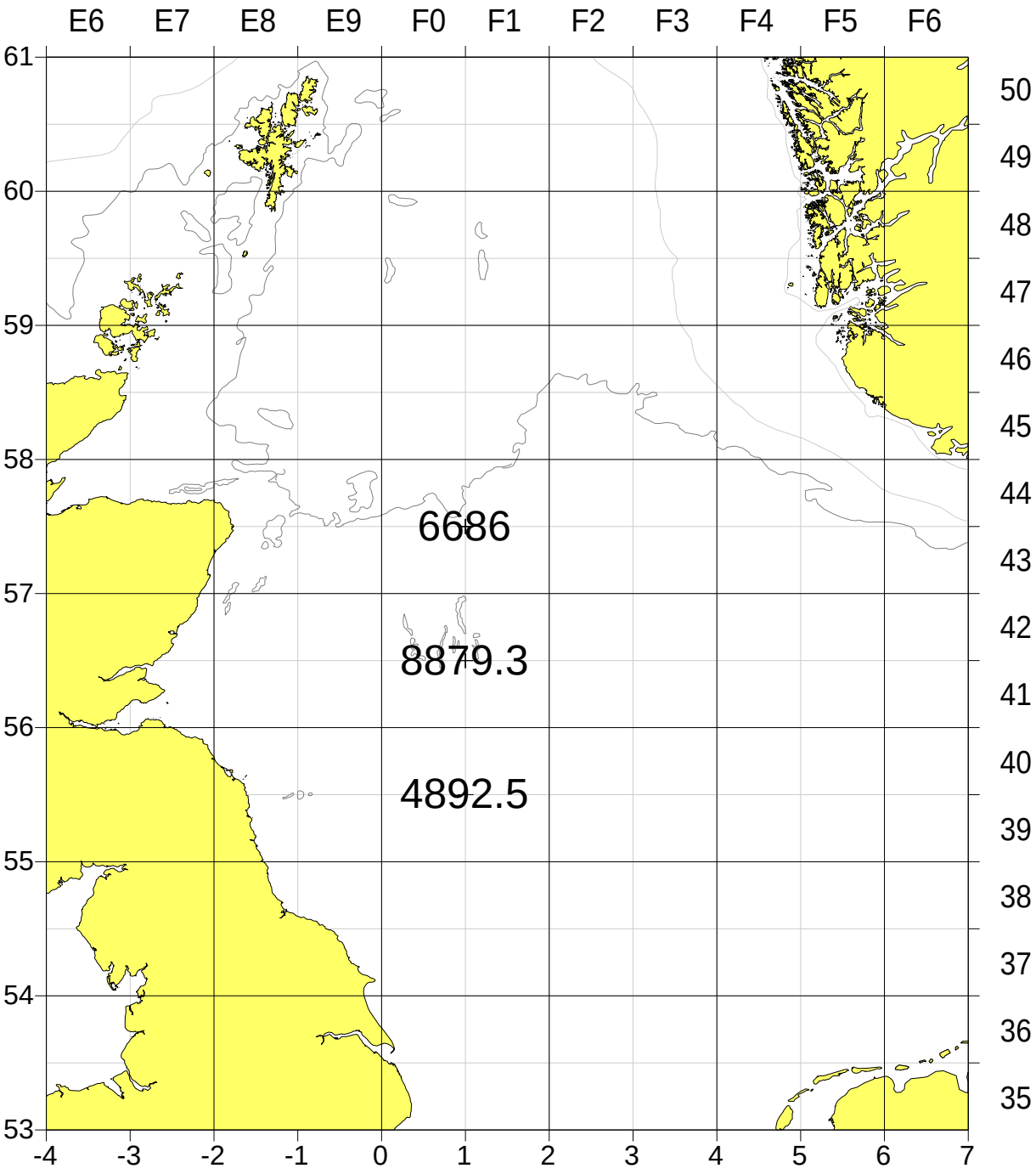


Figure 5. Total biomass index (tonnes) for **Northeast Atlantic mackerel** estimated from three surface pilot trawls conducted within 1° latitude x 2° longitude rectangles during the July 2014 North Sea herring acoustic survey on R/V Tridens.

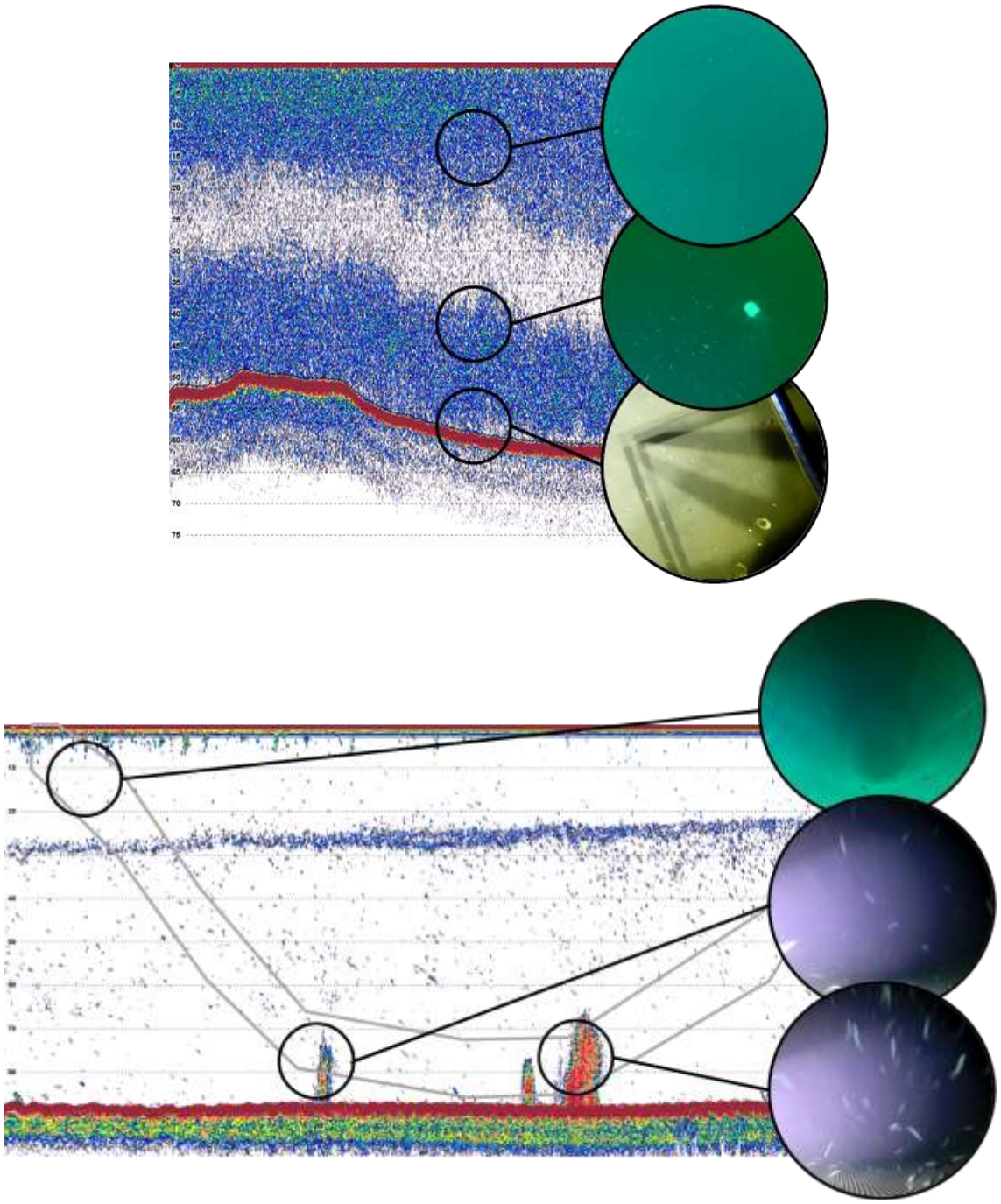


Figure 6. Examples of acoustic-optical data combination to aid echogram interpretation: during CTD casts (top panel) and trawl hauls (bottom panel).

CRUISE SUMMARY REPORT

FOR COLLATING CENTRE USE

Centre: Ref. no:

Is data exchange restricted? ☐ Yes ☐ In part ☐ No

SHIP enter the full name and international radio call sign of the ship from which the data were collected, and indicate the type of ship, for example, research ship; ship of opportunity, naval survey vessel; etc.

Name: TRIDENS Call Sign: PBVO

Type of ship: FISHERIES RESEARCH VESSEL

CRUISE NO./NAME 2014 week 26-29 HERAS (North Sea Herring Acoustic Survey)

CRUISE PERIOD	start (set sail)	23 day	06 month	2014 year	to	18 day	07 month	2014 year

PORT OF DEPARTURE (enter name and country) SCHEVENINGEN, THE NETHERLANDS

PORT OF RETURN (enter name and country) SCHEVENINGEN, THE NETHERLANDS

RESPONSIBLE LABORATORY enter name and address of the laboratory responsible for coordinating the scientific planning of the cruise.

Name: IMARES, Institute for Marine research and Ecosystem studies

Address: P.O. BOX 68
1970 AB IJMUIDEN
HARINGKADE 1

Country: THE NETHERLANDS

CHIEF SCIENTIST(S) enter name and laboratory of the person(s) in charge of the scientific work (chief of mission) during the cruise.

Dr Sascha Fässler, IMARES

OBJECTIVES AND BRIEF NARRATIVE OF CRUISE enter sufficient information about the purpose and nature of the cruise so as to provide the context in which the reported data were collected.

The objective was to carry out an hydro acoustic survey defining the abundance of herring and sprat in the North Sea, in co-operation with the institutes of Norway, Scotland, Denmark, and Germany. Calibration of the echosounder in a sheltered area, preferably at Scapa Flow, Orkneys 58°56′71N - 003°00′57W.
The first week of the whole 4 week survey period was used for calibration of the acoustic equipment in a sheltered location on the Orkney Islands. Departure from Scheveningen was on Monday 23 June and Tridens steamed up north-west towards the proposed calibration location in Scapa Flow, UK. Arrival in Scapa Flow was in the morning of Wednesday 25th June. Calibration of the acoustic equipment took place during the following 2 days on 25th/26th June and was completed before the vessel departed again. Conditions at the calibration site were very favourable and good calibration results could be achieved. Tridens then steamed to Aberdeen for an extended weekend break before it left again the following Monday to start conducting the survey.
The survey continued according the planned transects until Thursday 10th July. Due to bad weather between Wednesday 9th and Thursday 10th July, the towed body housing the echosounder transducers got damaged. In the morning, it was evident that the steal towing cable was torn. The towed body was then only attached at the transducer data cables and a Dyneema rope which was wound up tight around a winch on the back deck. The result was that the towed body got closer to the ship than usual and was tight against its starboard side. Waves and swell were smashing it against the boat causing bent metal and fractures in the frame. In the morning of Thursday 10th July, about 6 hours were lost for repairs (exchanging metal pieces of the towed body, welding on new stabilising weights, and repairing damages to the transducer cable). Therefore, the planned transect coverage had to be compromised (see "Deviations from the proposed station grid") in order to reach the end of the transect in time before the agreed weekend stop in Newcastle. After that incident, the survey could be conducted as planned.
During the standard survey protocol, 3 pilot trawls just below the surface aimed at mackerel were conducted successfully. The chosen survey setup (1 week calibration/gear trials, followed by 3 weeks of survey transect coverage) proved again to be an optimal solution to complete the transects in good time with adequate possibilities for trawl samples (to guarantee a good survey precision), before the scheduled weekend breaks. Arrival in Scheveningen after the survey was on Thursday 17 July with an ETA of 19:00 UTC.
Since 2010, cruise leaders keep a weblog during the survey, which can be found at:
http://herringsurvey.blogspot.nl

PROJECT (IF APPLICABLE) if the cruise is designated as part of a larger scale cooperative project (or expedition or programme), then enter the name of the project, and of the organisation responsible for coordinating the project.
Project name: NHAS - NS Herring Acoustic Survey

Coordinating body: IMARES, Wageningen UR, Institute for Marine Resources and Ecosystem Studies, IJmuiden

PRINCIPAL INVESTIGATORS: Enter the name and address of the Principal Investigators responsible for the data collected on the cruise, and who may be contacted for further information about the data (The letter assigned below against each Principal Investigator is used on pages 2 and 3, under the column heading 'PI', to identify the data sets for which he/she is responsible)

Dr Sascha Fässler, IMARES

MOORINGS, BOTTOM MOUNTED GEAR AND DRIFTING SYSTEMS

PI	APPROXIMATE POSITION		DATA TYPE	DESCRIPTION
see top	LATITUDE	LONGITUDE	enter code(s) from list on	identify, as appropriate, the nature of the instrumentation, the parameters (to be) measured, the number of instruments and
of page	deg min N/S	deg min E/W	cover page	their depths, whether deployed and/or recovered, dates of deployment and/or recovery, and any identifiers given to the site.

MOORINGS, BOTTOM MOUNTED GEAR AND DRIFTING SYSTEMS

PI	APPROXIMATE POSITION			DESCRIPTION
	Station-id	ICES-rectang	latitude longitude	their depths, whether deployed and/or recovered, dates of deployment and/or recovery, and any identifiers given to th site.

SUMMARY OF MEASURED AND SAMPLES TAKEN

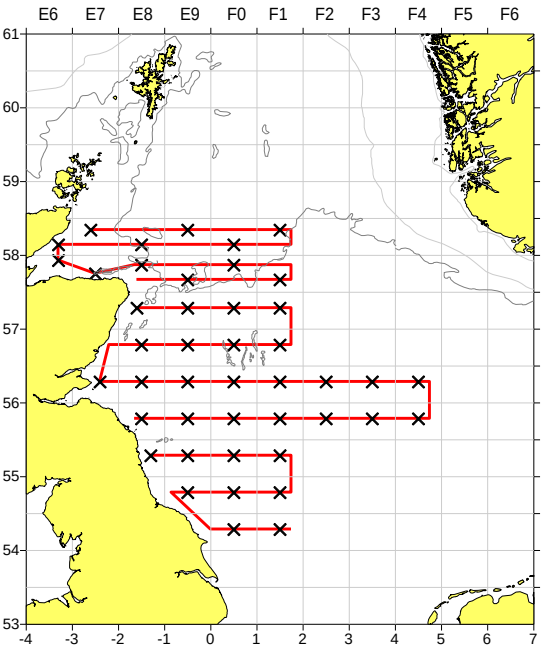
PI	NO	UNITS	DATA TYPE	DESCRIPTION
	3216	kilometres	EK60 Raw	Hydro Acoustic Data
	44	downcasts 500m	CTD	Hydrographical data
	20	pelagic trawls stations	fish data	biological data (number, weight, length, maturity, age)

GENERAL OCEAN AREA(S): Enter the names of the oceans and/or seas in which data were collected during the cruise - please use commonly recognised names (see, for example, International, Hydrographic Bureau Special Publication No. 23, 'Limits of Oceans and Seas')

NORTH SEA

SPECIFIC AREAS: If the cruise activities were concentrated in a specific area(s) of an ocean or sea, then enter a description of the area(s). Such descriptions may include references to local geographic areas, to sea floor features, or to geographic coordinates.

GEOGRAPHIC COVERAGE - INSERT 'X' IN EACH SQUARE IN WHICH DATA WERE COLLECTED



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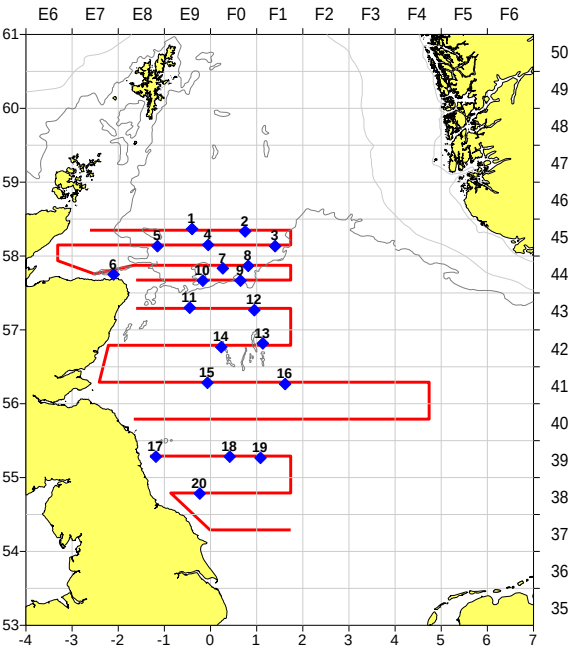

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