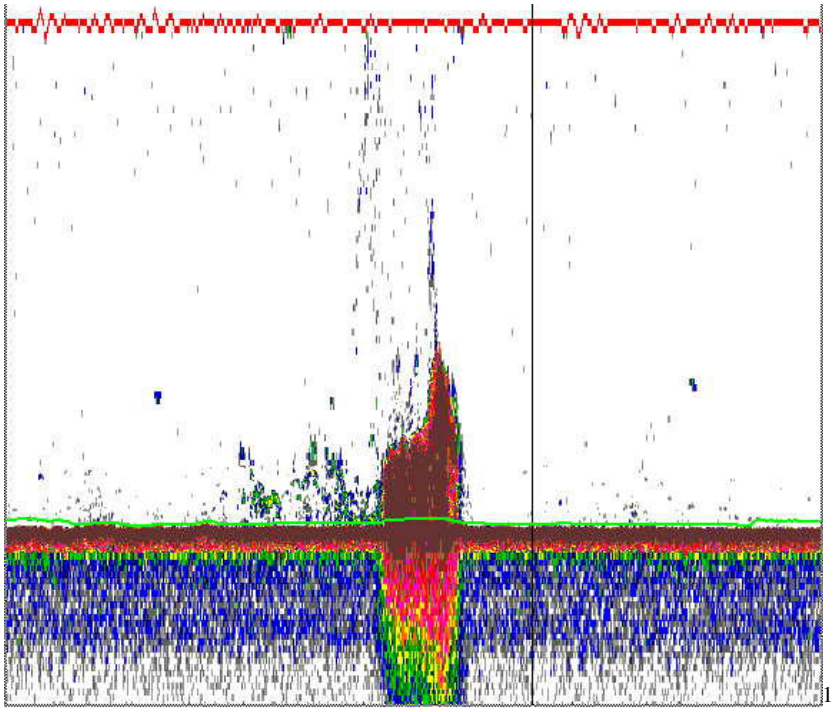
Acoustic Survey Cruise Report

ICES Divisions VIaS and VIIb

 [1]

NORTHWEST HERRING ACOUSTIC SURVEY 2005

6TH - 26TH January

Report by

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Fisheries Science Services, Marine Institute, January 2005

[1] A 45m tall herring echo trace taken off track, southwest of Aranmore Island Co. Donegal

Introduction

The northwest and west coast herring acoustic survey programme was first implemented in 1994. Prior to this a larval survey programme was carried out between 1981 and 1986. The ICES herring working group (HAWG) identified the need for a dedicated herring acoustic survey in this area (Anon, 1993). The stock in this area is composed of a number of spawning components and spawning may extend from September through to March (Molloy *et al*, 2000).

Commercial fishing has targeted the fish during spawning times, no summer matje fishery exists in this area. In VIaS, fishing has traditionally taken place in late December and continues until late February (winter spawners). Traditionally in VIIb, fishing is mainly concentrated on the later months of the year and would be concluded by the early part of the new year (Autumn spawners). The protracted spawning period of herring and the overlap between the two spawning socks in this area (October to February) means that it is difficult to design a survey that covers all spawning fish in one specific survey.

A project is currently underway to describe stock structure and discrimination of herring around Ireland. The results of this project may have implications for the design of this survey and for the stock assessment. However, since 1994, acoustic surveys have been carried out, and currently are the only tuning indices available. The current survey makes up the 11^{th} in the time series. The design and execution of this survey has evolved from summer feeding phase surveys, in the mid 1990s until its present winter spawning state.

Materials and Methods

Area coverage

The areas covered during the winter 2005 survey started to the east of Malin Head (Figure 1) in Co. Donegal (Division VIaS) and extended west and south along the northwestern seaboard covering the main bays and inlets into VIIb.

A parallel transect design was adopted with transects running perpendicular to the coastline and extending up to 30 nmi (nautical miles) offshore. Offshore transects were spaced at 4 nmi. A more intensive area of coverage was carried out within 10 nmi of the coastline, where parallel transects were spaced at 1 and 2 nmi. For bays and inlets encountered a zigzag transect approach was used to optimise coverage. This design was also used to cover the north Mayo and Sligo coastline. In total the combined survey transect length was in the order of 1,350 nmi.

Due to mechanical failure and poor weather conditions the track was broken on several occasions and had to be altered to account for the survey time lost. Long parallel transects extending out to the Stanton Bank (VIaS), up to 65 nmi offshore, were dropped during the revised program. Areas of known herring intensity were further intensified when the latest information from fishermen was taken into consideration (Appendix 2). Also, the track was started from the most southerly position and not from the northeast as originally intended.

Acoustic data Acquisition

Equipment settings for the acoustic equipment were determined before the start of the survey program and were based on established settings employed by FSS on previous surveys. The settings used on the *Celtic Explorer* acoustic array are shown in Table 1.

The acoustic data were collected using the Simrad ER60 scientific echosounder. The Simrad ES-38B (38 KHz) split-beam transducer is mounted within the vessels drop keel and lowered to the working depth of 3m below the vessels hull or 8.8m below the sea surface.

While on the survey track the vessel was cruising using DC twin electric motor propulsion, supplied from 1 main diesel engine, so in effect providing "silent cruising" as compared to normal operations (ICES, 2002). However, it should be noted that during fishing operations normal 2 engine operations were employed to provide sufficient power to tow the net.

Acoustic data were observed and recorded onto the hard-drive of the processing unit using the equipment settings from previous surveys (Table 1). The "RAW files" were logged via a continuous Ethernet connection as "EK5" files to the vessels server and the ER60 hard drive as a backup in the event of data loss. In addition, as a further back up a hard copy was stored on DVD. Sonar Data's Echoview® Echolog (Version 3.2) live viewer was used to display the echogram during data collection to allow the scientists to scroll through echograms noting the locations and depths of fish shoals.

The equipment was monitored continually by a member of the scientific crew. A 15 minute log was taken recording time, position from the vessels GPS and any comments. This log was used to monitor the time spent off track during fishing operations and hydrographic stations plus any general observations.

Calibration of Acoustic equipment

The ER 60 was last calibrated in Dunmanus Bay Co. Cork on the 29th November, 2004 during the Celtic Sea herring acoustic survey (O'Donnell *et al,* 2004). The beam patterns had not been adjusted since this time. When the results from the previous calibration were taken into consideration with the time interval between survey, it was decided that no calibration would be carried out as this would have further reduced our effective area coverage.

The 38 KHz transducer was calibrated in November along with the following frequencies, 18, 120, 200 KHz following the methods described by Foote *et al* (1987). The 18 and 38 KHz frequencies were calibrated using standard target copper spheres (63mm and 60mm respectively). The 120 and 200 KHz frequencies were both calibrated using a 38.1mm tungsten carbide standard target sphere.

Biological Sampling

A single pelagic midwater trawl with the dimensions of 19m in length (LOA) and 6m at the wings ends and a fishing circle of 330 m was employed during the survey (Appendix 2). Mesh size in the wings was 3.3 m through to 2 cm in the cod-end. The net was fished with a vertical mouth opening of approximately 15 m, which was observed using both a cable linked "BEL Reeson" netsonde (50 kHz). The net was fitted with a Scanmar depth sensor. Spread between the trawl doors was monitored using Scanmar distance sensors, all sensors being configured and viewed through a Scanmar Scanbas system.

All components of the catch from the trawl hauls was sorted and weighed; fish and other taxa were identified to species level. Fish samples were divided into species composition by weight. Species other than the herring were weighed as a component of the catch. Length frequency and length weight data were collected for each component of the catch. Length measurements of herring, sprat and pilchard were taken to the nearest 0.5 cm below. Age, length, weight, sex and maturity data were recorded for individual herring within a random 100 fish sample from each trawl haul, where possible. All herring were aged onboard. The appropriate raising factors were calculated and applied to provide length frequency compositions for bulk of each haul.

Decisions to fish on particular echo-traces were largely subjective and an attempt was made to target marks in all areas of concentration not just high density shoals. No bottom trawl gear was used during this survey. However, the small size of the midwater gear used onboard and its manoeuvrability in relation to the vessel power allowed samples at or below 2m from the bottom to be taken in areas of clean ground.

Acoustic data analysis

Acoustic data was backed up every 24 hrs and scrutinised using Sonar data's Echoview® (V 3.2) post processing software for the previous days work Partitioning of data into the above categories was largely subjective and was viewed and agreed upon by 2 scientists experienced in viewing echograms.

The S_a values from each log interval were partitioned into the 4 categories after inspection of the echograms. Categories identified on the basis of trace recognition and trace recognition were as follows:

1. "Definitely herring" echo-traces or traces were identified on the basis of captures of herring from the fishing trawls which had sampled the echo-traces directly, and on large marks which had the characteristics of "definite" herring traces (i.e. very high intensity (red), narrow inverted tear-shaped marks either directly on the bottom or in mid-water and in the case of spawning shoals very dense aggregations in close proximity to the seabed).

2. "Probably herring" were attributed to smaller echo-traces that had not been fished but which had the characteristic of "definite" herring traces.

3. "Herring in a mixture" were attributed to S_A values arising from all fish traces in which herring were thought to be contained, owing to the presence of a proportion of herring within the nearest trawl haul or within a haul which had been carried out on similar echo-traces in similar water depths.

4. "Possibly herring" were attributed to small echo-traces outside areas where fishing was carried out, but which had the characteristics of definite herring traces.

The "EK5" files were imported into Echoview (Version 3.20) for echo post-processing. The echograms were divided into cells using a time/distance grid of 15 minutes. Cells define sets of sample values of an echogram, from which integration variables can be calculated through echo integration. Echo integration was performed by selecting marks or scatter, which belonged to one of the four categories above. Regions were drawn around the various marks and the software calculates S_a values for the selected regions. S_a values were obtained by drawing regions around schools and then defining the regions as one of the four categories. The echograms were analysed at a threshold of -70 dB and where necessary plankton was filtered out by thresholding at –65 dB.

The allocated echo integrator counts (S_a values) from these categories were used to estimate the herring numbers according to the method of Dalen and Nakken (1983).

The following TS/length relationships used were those recommended by the acoustic survey planning group (Anon, 1994):

Herring	TS = 20logL – 71.2 dB per individual (L = length in cm)
Sprat	TS = 20logL – 71.2 dB per individual (L = length in cm)
Mackerel	TS = 20logL – 84.9 dB per individual (L = length in cm)
Horse mackerel	TS = 20logL – 67.5 dB per individual (L = length in cm)

The TS length relationship used for gadoids was a general physoclist relationship (Foote, 1987):

Gadoids TS = 20logL – 67.5 dB per individual (L = length in cm)

The analysis produced density values of numbers and biomass per nautical mile squared for each 15 min log interval. The survey area was stratified into sub-divisions using analysis areas of 0.25° of latitude by 0.5° of longitude (Figures 2,3 and 4). Inshore intertransects were not included in the analysis for the main survey are. Average density values for each area sub-division were then multiplied by the corresponding area. The areas were calculated by using a Lambert Azimuth projection in "Arcinfo" Geographical Information System. Total estimates and age and maturity breakdowns were calculated.

Biomass was calculated from numbers using length-weight relationships determined from the trawl samples taken during the survey for each of the analysis areas.

Herring weight (grams) $= 0.9515 * L^{3.5804}$ (L = length in cm)

Hydrographic data collection

The proposed hydrographic component of the survey was dropped due to the survey time lost. It was decided that CTD stations would be carried out only when spawning herring were encountered. The reasoning behind this being that spawning fish tend to remain in the spawning ground and movement is limited between spawning beds, where hydrographic data would be most beneficial. Non-spawning or spent fish are much more mobile and thus data cannot be directly related to behaviour as with active spawners.

Results

Herring stock size

The estimated stock size from the current survey data was not analysed onboard and so the final TSB and age stratified SSB are pending. However, during this survey the bulk of herring echo traces were categorised as definitely herring and came from large homogeneous schools of fish. These echo traces were positively identified by trawl hauls. Little biomass was attributed to herring occurring mixed with other species or from the probably or possibly herring categories. During the 2004 survey of this area the majority of biomass was assigned from the latter categories and only 3 large echo traces of herring shoals were encountered. During this survey as many as 10 large marks were noted on the survey track and many more were observed within the vacinity. The largest herring echo trace being over 1,600m in length and 30m at the deepest point (Figure 3).

Herring distribution

A total of 11 trawl hauls were carried out over the course of the survey (Figure 1 & Table 2). Of this, all but 2 contained herring and 8 contained over 50% of herring by weight of the catch.

The first herring encountered were in VIIb, on the north Mayo coastline. The fish in this area are though to be composed of mainly late autumn and winter spawners. The 2 shots carried out both yielded herring that were dominated by spent individuals, over 90% in both instances. This would indicate the main spawning events had already taken place within this area and would be consistent with existing knowledge of this component of the stock.

In area VIaS, the first herring encountered were in an area commonly associated with spawning herring catches at this time of the year. The fish were composed of mainly spawning or pre-spawning individuals. The number of spent fish encountered was minimal, indicating the main bulk of spawning had yet to take place.

As we moved north along the north coast, this area was dominated by fish yet to spawn (stage 4-5's dominated). This area is associated with the latest of the winter spawning fish along the northwest coast and this run of fish maybe present until late February or early March. Reports from the fleet working the area suggest that the fish were beginning to appear and no spawning fish had yet been encountered. Waves of fish begin to appear on the grounds and continue for several weeks, the fish spawn and disperse quickly afterwards. Residence time post spawning is thought to be short. This is consistent with finding of previous surveys, existing knowledge of this component of the stock and reports from local fishermen.

Catches from the very east of the survey area yielded a mixture of fish that included immature individuals of the 2004 year class (0 winter rings).

Herring stock composition

Biological samples of herring taken from survey hauls indicate the stock to be composed of ages between 0-10 years (Tables 4 & 5).

Herring encountered along the north Mayo coastline (Figure 1, 3 & Table 2), were found to range in age from 2- 8 years. The dominant year classes from hauls were 3, 4 and 5- winter rings fish respectively.

Herring samples taken from hauls 5 & 6, in the mid northwest were composed of herring between 2-8 years. The dominant year classes being 4 and 3 winter rings respectively

The herring sampled from around Tory Island (haul 7) were the largest by length encountered during the survey. Length measurements ranged between 21-35cm. The dominant year classes being the 4 and 5 year olds respectively.

Fish to the northeast and northwest of Tory Island, namely hauls 8 and 9. These samples were found to contain fish of two distinct size classes. The size range encountered was between 20.5-31cm, with two distinct size classes visible at 22.5cm and 26.5 cm.

Catches from Hauls 10 & 11, around Fanad Head and Lough Swilly were found to contain a percentage of juvenile fish. This was the only time during the survey in which young herring were encountered. This is consistent with findings from previous surveys and indeed Lough Swilly is known to contain juvenile herring which are commonly encountered with sprat at this time of year.

Hydrography

In total 7 CTD stations were carried out (Figure 1) Of these the greatest depth was 92m and the shallowest was 25m, the bulk of stations exceeded 50m in depth. These data have not been examined and so no reports are results as yet.

Discussion

This years survey was dominated by prolonged periods of bad weather and mechanical failure. The survey was broken on 3 occasions due to the effects of weather. As a result the survey track was not carried out in continuity. The original track had to be cut back to allow for the time lost. The planned hydrograhic component of over 54 CTD stations also had to be dropped. Periods of poor weather this is known to affect herring behaviour shoaling, where fish become scattered and dispersed from the grounds. It is not uncommon to see fish taking up to 48 hrs or more to return to the grounds and resume spawning.

The effect was to greatly reduce the planned area coverage. The main hotspots were covered as a priority and to maintain the integrity of the survey time series. The two main areas where covered only when a weather window permitted, so that they could be surveyed without disruption and to minimise the risk of double counting the fish where possible.

The timing of the survey could be said to be successful. The amount of spent fish encountered overall was low and the bulk was found in the south, suggesting the peak spawning period had not been missed. The last of the early spawning component of the stock, found along the north Mayo, was dominated by spent fish. Spawning had taken place, but the fish were still in residence in the area.

Hard and actively spawning fish dominated catches in the north, suggesting that fish were still entering the area to spawn and the bulk of spawning was yet to take place. As the main body of the survey was carried out working from a south to northerly direction, the south to north progression of spawning events was evident over the survey duration.

As the survey progressed north actively spawning fish were encountered. Along the north coast, hard fish (stage 4-5's) were by far the most commonly encountered. This marked an influx of fish or the start of the inward migration of the latest spawning component of the stock. This late component is known to spawn up until the end of February or even early March. Anecdotal evidence from a meeting with fishermen prior to the survey start, pointed to this years season being slightly later than last year by several weeks. This accounted for, it was decided to start in the south and work northwards.

Acknowledgments

We would like to express our thanks and gratitude to Ciaran Flanagan (Captain) and crew of the Celtic Explorer for their good will and professionalism during the survey. We would like to thank all the skippers who provided up to date position information on the whereabouts of herring schools during the survey. We would also like to thank Frankie Griffin (Gear Consultant) for his help and invaluable advice on the fishing gear. Our thanks also goes to Gary Hannon for all his help sampling the catch.

References

Anon. (1994). Report of the planning group for herring surveys. *ICES C.M. 1994/H:3*

Anon (2002) Underwater noise of research vessels. Review and recommendations. 2002. ICES No. 209

Breslin, J.J. (1999). The location & extent of the main herring, *Clupea harengus*, spawning grounds around the Irish Coast. *M.Sc. Thesis*

Dalen, J. and Nakken, O. (1983) "On the application of the echo integration method" *ICES CM 1983/B:19*

Foote, K.G. (1987). Fish target strengths for use in echo integrator surveys. *J. Acoust. Soc. Am.* 82: 981-987

Foote, K.G., Knudsen, H.P., Vestnes, G., MacLennan, D.N. and Simmonds, E.J. (1987). Calibration of acoustic instruments for fish density estimation: a practical guide. *Int. Coun. Explor. Sea. Coop. Res. Rep.* 144: 57 pp

MacLennan, D. N & Simmonds, E. J. 1991. *Fisheries Acoustics*. Chapman Hall, London,England.

O'Donnell, C., Griffin. K., Clarke, M., Lynch. D, Ulgren. J., Goddijn, L., Wall. D., and Mackay, M. (2004). Celtic Sea Herring Acoustic Survey Report, 2004.

O'Donnell, C., Clarke, M. & Dransfeld, L., Review of Irish Acoustic Survey program, 1989-2004. (2005). Irish Fisheries Investigation Series (In press)

List of Participants

FSS

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Frankie Griffin (Fishing gear consultant)
Gary Hannon (Student)

Table 1. Settings for the Simrad ER 60 echosounder, employed during the Northwest and west coast (Divisions VIaS and VIIb) herring acoustic survey, January 2005.

Echo sounder:	Simrad ER 60
Frequency:	38 kHz
Transducer:	ES 38B- Serial
Absorption Coefficient:	0.067 dB/Km (manual)
Pulse length:	1.024 m/s
Bandwidth:	2.425 KHz
Transmitting Power:	2000 W (Max)
Angle Sensitivity:	21.9 dB
2- way beam angle:	-20.6
Gain:	25.98
S_A Correction:	-0.67
3 dB Beam Width:	
Alongship:	6.96°
Athwartship:	7.04°
Max Range:	500m

Table 2. Northwest and west coast (Divisions VIaS and VIIb) herring acoustic survey 2005. Position, water depth, depth of trawling and percentage species composition of fishing hauls.

No.	Date	Lat. N	Lon. W	Bottom m	Target m	Catch t	Herring %	Mackerel %	I. mackerel %	Sprat %
1	14/01/05	54 26.95	09 50.83	101	0-8	0.01	0	0	1	9
2*	15/01/05	54 29.43	09 35.60	95	0-9	1.30	99	1	0	0
3*	15/01/05	54 15.66	09 07.89	28	0-6	0.35	100	0	0	0
4	16/01/05	54 38.15	08 53.42	86	0-25	0.02	0	0	0	13
5*	21/01/05	54 54.04	08 56.90	76	0-20	0.09	100	0	0	0
6*	21/01/05	54 56.02	8 54.66	74	0-45	0.40	100	0	0	0
7*	21/01/05	54 37.72	08 32.90	90	0-17	4.00	74	26	0	0
8*	23/01/05	55 17.77	08 20.02	69	0-30	0.65	99	1	0	0
9*	23/01/05	55 24.77	07 58.64	70	0-7	0.25	100	0	0	0
10	24/01/05	55 22.74	07 40.98	52	0-15	0.01	53	0	0	47
11	24/01/05	55 12.31	07 34.26	21	0-10	0.03	9	0	0	81

*Indicate haul with CTD stations

Table 3. Length Frequency of Herring measured per survey haul in actual numbers of individuals measured. Northwest and west coast (Divisions VIaS and VIIb) herring acoustic survey 2005.

Haul	2	3	4	5	6	7	8	9	10	11
Length (cm)										
11.5										1
12										2
12.5									1	0
13									3	1
13.5									4	1
14									1	0
14.5									3	4
15									1	1
15.5										2
16										2
16.5										1
17										
17.5										
18	1									
18.5										
19										
19.5										
20									1	
20.5									1	
21		1				1	1	2	6	
21.5		1	1			2	4	10	5	
22	1	2		1		4	8	20	5	
22.5	1	4	1	4		4	7	17	3	
23	2	3		2		9	4	10	5	
23.5	2	1	1	1		3	3	7	5	
24	2	7	1			3	2	5	3	
24.5	2	3	1	5		2	4	10	5	
25	9	9	4	6	1	7	6	15	5	
25.5	5	13	7	7	1	4	9	22	6	
26	4	20	12	5	2	11	7	17	4	
26.5	18	16	13	14	8	9	15	37	4	
27	15	14	11	19	14	8	7	17	4	
27.5	16	4	18	16	14	15	6	15	1	
28	8	1	11	12	19	4	8	20	3	
28.5	8	1	10	5	10	4	6	15	1	
29	5		5	3	11	6	1	2		
29.5	1		3		5	2	1	2		
30	1		1		1		1	2		
30.5					1					
31					1					
31.5					2					
32					4	1				
32.5										
33					1					
33.5					2					
34										
34.5					3					
35						1				
Total	101	100	100	100	100	100	100	244	80	15

Table 4. Herring Age length key, determined from survey haul samples. Northwest and west coast (Divisions VIaS and VIIb) herring acoustic survey 2005.

Age	0	1	2	3	4	5	6	7	8	9	10	Grand
(winter rings) Length (cm)												total
11.5	1											1
12	1	2										3
12.5	1	2										3
13	2	3										5
13.5		2										2
14		3										3
14.5		4	1									5
15		1										1
15.5		2										2
16		2										2
16.5		1										1
17												0
17.5												0
18												0
18.5												0
19												0
19.5			1									1
20			1									1
20.5			9									9
21			13									13
21.5			21									21
22			21	3								24
22.5			23	2								25
23			12	4								16
23.5			3	14	1							18
24			1	20	1	1						23
24.5				40	6	1						47
25				46	6							52
25.5				39	23	2	1					65
26				39	51	4	3					97
26.5				23	50	14	3	1				91
27				8	45	33	4					90
27.5					23	33	9	1				66
28					8	19	16	2				45
28.5					1	14	11	4	1			31
29						1	4	5	1	1		11
30						1	1		1			3
30.5									2			2
31						1						1
31.5								1	1	1		2
32						1	1	1	2	1	1	5
32.5												0
33									1			0
33.5								1	1	1	1	2
34												0
34.5										3		0
35									1			1
												0
Total	5	22	106	238	215	125	53	16	10	7	2	790
%	0.63	2.78	13.42	30.13	27.22	15.82	6.71	2.03	1.27	0.89	0.25	100.00

Table 5. Maturity at age as determined from survey haul samples. Northwest and west coast (Divisions VIaS and VIIb) herring acoustic survey 2005.

Maturity Age (winter rings)	1	2	3	4	5	6	7	8	Totals
0	5								5
1	22								22
2	13	57	19	7	3	4		3	106
3		13	25	78	17	44	6	55	238
4		4	8	75	15	61	6	44	213
5		2	4	41	10	34	6	28	125
6			1	25	4	14	1	7	52
7		1	1	7		2		5	16
8				6		1	1	1	9
9				3	2				5
10				1		1			2
Grand Total	**40**	**77**	**58**	**243**	**51**	**161**	**20**	**143**	**793**

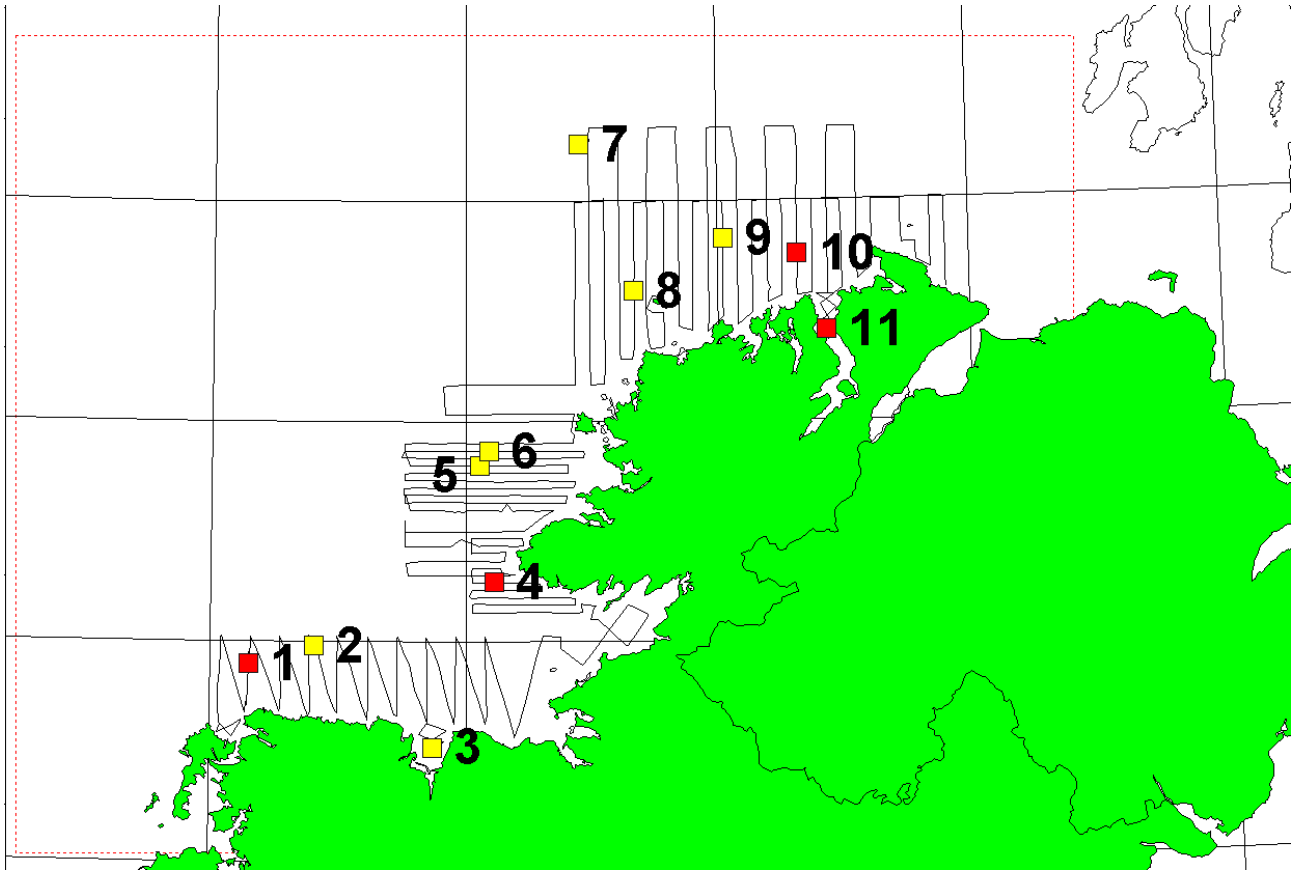

Figure 1. Acoustic cruise track showing survey haul positions (red) and hauls in where at CTD station was carried out post-haul (yellow). Northwest and west coast (Divisions VIaS and VIIb) herring acoustic survey, January 2005.

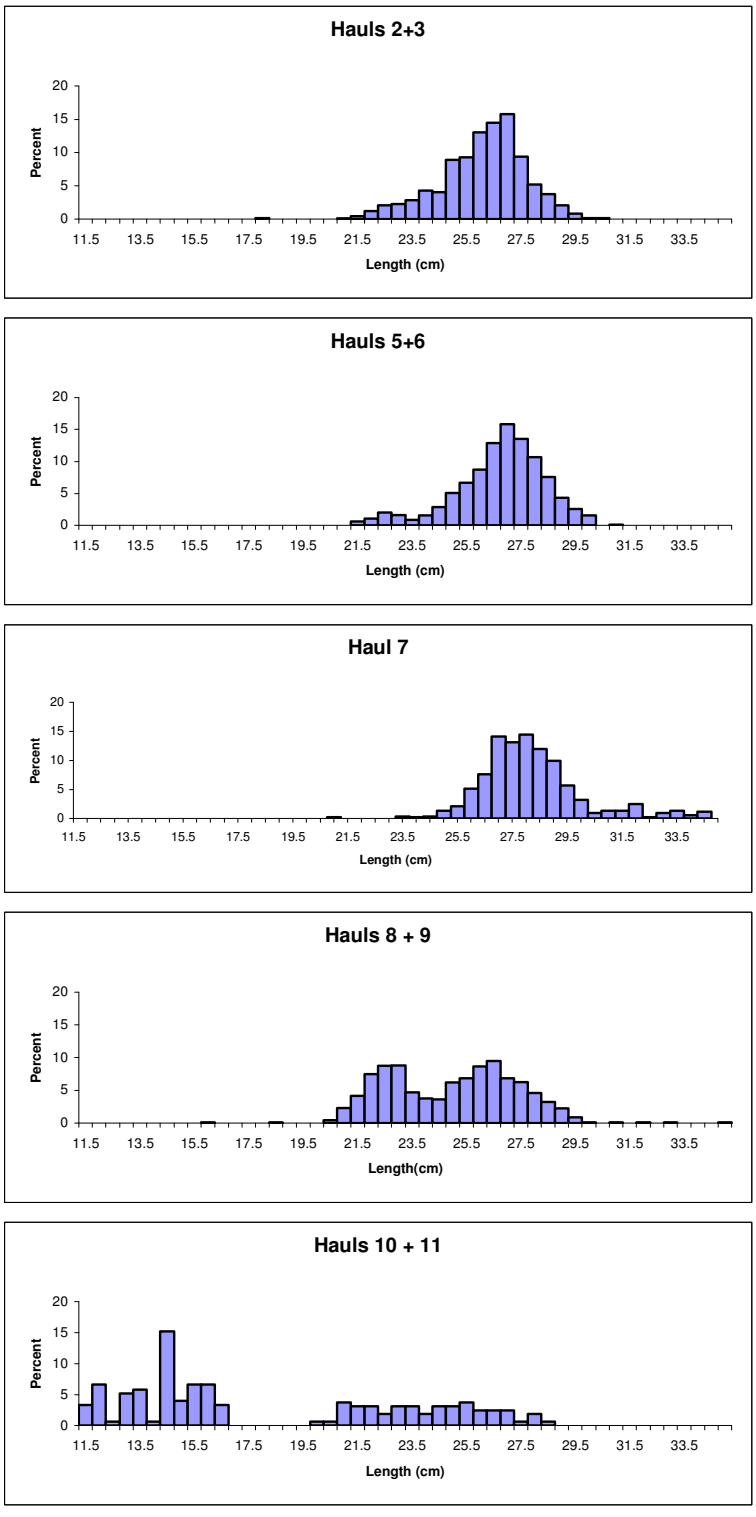

Figure 2. Northwest Herring Acoustic Survey, January 2005. Percentage Length-Frequency graphs for combined hauls.

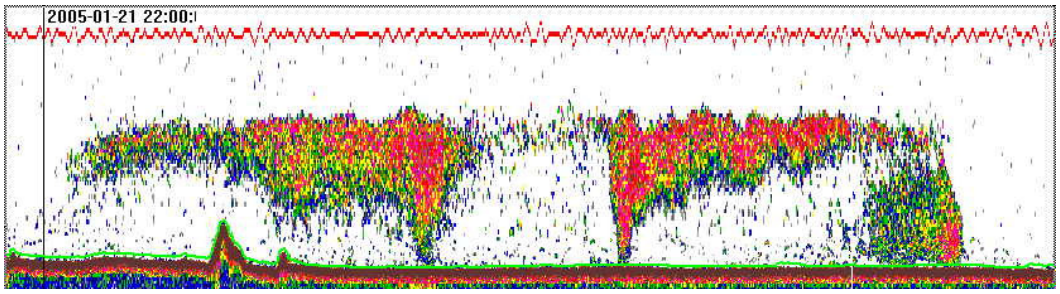

Figure 3. Echogram taken prior to haul 06, this mark was recorded over 1,600m and was 30m at its deepest point. This shot yielded 100% hard herring (stage 4-5).