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Survey Report:

**Herring Recruit and Biological Sampling
Survey**

22 February – 2 March 2009

South-west and south of Ireland

by

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Abstract

The Herring Recruit and Biological Sampling Survey took place from 22 February to 2 March in the area to the south-west and south of Ireland on the Celtic Voyager. The survey was aimed at developing a recruit index for herring. Additionally Information on growth, maturity and sex ratio (biological data) were collected in order to address the requirements of the Data Collection Regulation 1581/2004.

1 Introduction

The purpose of the survey is to develop a recruit index for herring. Additionally the requirements of Module I of the Data Collection Regulation 1581/2004 were addressed. Information on growth, maturity and sex ratio (biological data) were collected for a range of commercially important species. Up-to-date information on these parameters is essential for a good understanding of the state of the stock and its reproductive potential.

Ovary samples were collected to validate visual maturity staging. Samples of hake were taken for genetic analysis and elemental analysis of the otoliths by the University of Bergen. Young cod were collected for elemental analysis of the otoliths by CEFAS (UK). Sepioids were collected for the National Museum of Natural History in The Netherlands. Dab, gurnard, dogfish and juvenile flatfish were collected for GMIT

2 Materials and Methods

2.1 Scientific Personnel

| Name | Service area/Affiliation | Role |
|----------------|--------------------------|---------------------|
| Hans Gerritsen | MI-FSS | Scientist in Charge |
| Sean O'Connor | MI-FSS | Scientist |
| Imelda Hehir | MI-FSS | Scientist |
| Shane Shannon | MI-FSS | Scientist |
| Oliver Wragg | MI-FSS | Scientist |
| Laura Langan | GMIT | Scientist |

2.2 Survey Plan

2.2.1 Area of operation

Ices Divisions VIIb, VIIj and VIIj

2.2.2 Specific operations

Potential towing positions were selected from previous groundfish surveys, inshore stations were selected from a herring pair trawl survey that took place in 2008 and from towing positions provided by Francis Griffin. The main areas where young herring were expected were: Bantry Bay, Kinsale Harbour, Cork Harbour, Dungarvan Bay and Waterford Harbour. Stations were selected with the aim of achieving a good spatial and depth coverage, representative of the survey area. Tows were selected based on these considerations in combination with practical aspects like weather, steaming time etc. Wherever possible, tows were ½ hour in duration and approximately 1.5nm long.

2.3 Equipment and system details and specifications

The fishing gear consisted of a GOV net (V2) with the footrope tied down to one chainlink, no tickler chain. New 37.5m sweeps were used. One spare net was carried.

Headline height and door spread were monitored using Scanmar sensors and a towed hydrophone

Station, catch, sample, length and otolith information was collected using the Electronic Data Capture system.

2.4 Protocols used

2.4.1.1 Sorting

The catch is sorted by species mentioned in Table 1, other species are discarded without weighing. Flatfish and rays are sorted by sex. If necessary, the fish will be sorted into size categories. All sorted samples are weighed, entered into the deckmaster database and labelled.

2.4.1.2 Biological sampling

Otoliths are taken from all species in Table 1 except rays. For all fish that are flagged for otoliths, the sex and maturity stage will be determined and the round weight will be taken.

The sampling targets for the common species are set per station (not per stratum as previously). The sampling target is one per cm per station for abundant species. For species that are not expected in large numbers (cod, monk, sole) 100% of the otoliths will be taken, unless sample sizes are very large. For herring a random sample of 50 fish is taken for otoliths (for this sample the otolith target is 100%) the remaining fish will be entered as a separate category with an otolith target of 0% (measured only).

2.4.1.3 Ovary sampling

Ovary samples are taken for cod, haddock, whiting, hake, plaice and megrim. The sampling targets are five per stage for maturity stages 1, 4, 5 and 6 and ten per stage for maturity stages 2, 3 and 7. In order to spread out the sampling spatially, no more than 2 ovary samples per maturity stage are taken at each station. A photo is taken of each ovary that is sampled.

Ovary samples are taken from the middle of the ovary with capacity solid displacement pipette. These samples will be analysed using whole-mount techniques. A duplicate sample of 100 µl is taken where possible. For spent fish this can be difficult and in these cases a small sample from the ovary lumen is taken with scalpel, noting the exception.

In addition to the pipette samples, a thin slice (<5mm) of the ovary is also preserved in a histology cassette. These cassettes are pre-printed with labels that match the sample numbers on the data sheet. The following one-letter species codes are used: Cod (C); Haddock (H); Whiting (G); Hake (K); Plaice (P); Megrim (M).

2.4.1.4 Other sampling

- Nephrops samples will be recorded using NEMESIS using standard protocol
- Finclips and additional otoliths will be taken from hake
- Cod <35 will be frozen with the otoliths intact
- Sepioids will be preserved in ethanol
- Dab otoliths and gonads will be collected
- Juvenile flatfish will be collected from inshore stations

2.5 Analysis methods

All data extraction and plotting was performed in the R environment

3 Results

3.1 Stations Completed

A total of 37 tows were completed. Four stations were considered invalid and cannot be used to quantify the catch rate as the gear was not performing correctly, however as all of these tows had reasonable catches, sampling took place as normal. Figure 1. shows the station positions.

3.2 Sampling targets

The distribution of the catches is indicated in Figure 2. Small numbers of (mainly small) cod were caught on most hauls in the Celtic Sea. The largest numbers of haddock were caught off the west coast. Herring were caught in small numbers on most hauls in the Celtic Sea and a large amount of herring were caught in Cork Harbour. Hake (mainly small fish) were caught on nearly all hauls. Whiting were absent in many of the deeper hauls.

Figure 3 shows that juvenile herring were mainly caught in Bantry bay, off Kinsale and off the Waterford coast. The largest catch of herring was in Cork Harbour and it consisted mainly of herring of 20cm and over. Table 2 gives the length frequency distributions of the herring catches.

The catch numbers, numbers measured, numbers of biological samples and the numbers of ovary samples are given in Table 3. Overall an estimated 42,632 fish of the target species were caught, nearly half of these were whiting. Herring and haddock were also caught in large numbers. A total of 13,215 fish were measured and 3,116 biological samples were taken (length, weight, sex, maturity, age). A total of 187 ovaries were collected for validation of the maturity stages. Ovary samples were taken from selected species for validation of the macroscopically assigned maturity stages (using histology and image analysis techniques). The targets for these samples were five samples each for maturity stages 1, 4, 5 and 6 and ten samples each for maturity stages 2, 3 and 7 (at the latter stages confusion between immature and mature fish can potentially exist). Ovary samples were taken from cod, haddock, whiting, hake, plaice and megrim.

The sampling targets for biological samples were one fish per cm length class per haul, and all fish for the less common species like cod.. Length distributions of the biological samples taken are as well as length distributions of the catches are shown in Figures 4 and 5.

Table 4. shows a breakdown of the maturity stages in the biological samples. These samples were collected on a length-stratified basis and are therefore not random samples from the population; however they give a reasonable reflection of the maturity stages available at the time of sampling. Of the mature fish, haddock were mostly maturing or ripe, as were whiting. Herring were nearly all immature or spent. Some plaice might have been spent but indistinguishable from immature fish (sampling takes place too late in the season to reliably determine the maturity state of plaice). Megrim and lemon sole were mostly ripe. This suggests that the timing of the survey was good for most of the target species; to distinguish fish that spawn during the current season from those that will not spawn, the gonads of the spawners need to be sufficiently developed to reliably distinguish them from those that will not spawn. Two large female cod were caught which had resting ovaries, suggesting they skipped spawning, both were caught on haul 28.

4 Discussion and Conclusions

4.1 Problems encountered

One day was lost due to mechanical problems. The weather was good throughout the survey and there was no gear damage.

The gear did not perform well in extremely shallow water (5m). Therefore it was not possible to successfully complete some inshore tows. Static gear was encountered in Courtmacsherry bay, preventing trawling in that area.

Acknowledgements

Many thanks to Ciaran Flannigan and the rest of the crew of the Celtic Voyager, the scientific staff and all others involved in this survey.

Appendix 1, Cruise Narrative

| | |
|----------|--|
| 21/02/09 | Mobilised, scientific crew on board for 18:00. Forecast is very good. |
| 22/02/09 | Departed Galway 3:00 am. Completed 5 stations around the Aran Islands. The stbt door fell over on the 3 rd station. Reduced the amount of wire out to 3:1 |
| 23/02/09 | Completed 6 stations west of Kerry, stbt door fell over again on station 9. |
| 24/02/09 | Completed 5 stations in Bantry Bay. Stopped in CTB to collect spare weighing scales. |
| 25/02/09 | During the night an electrical fault occurred in the engine. Most of the day was spent steaming slowly to the nearest anchorage where an engineer could come on board. The problem was fixed in the early evening. |
| 26/02/09 | Completed 5 stations off Waterford. The last tow took place in Waterford harbour in a water depth of around 10m. The gear did not appear to be fishing well and the catch was very small. |
| 27/02/09 | Completed 6 stations west of the Smalls. The gear appeared to be tangled somewhat on the fifth haul; the headline height was less than half of what was expected. |
| 28/02/09 | Completed 5 stations south of Cork. |
| 01/02/09 | Completed 5 stations. Tried Courtmacsherry Bay but could not shoot there because there were too many pots around. Arrived into Cork at 8pm |
| 02/02/09 | Demobilised |

Tables and Figures

Table 1. Species sorted from the catch.

| Code | Species | Sex | Otolith numbers | Otolith target | Ovary samples |
|------|--------------------|-----|-----------------|----------------|---------------|
| COD | Cod | U | 100-149 | 100% | Y |
| HAD | Haddock | U | 150-199 | 1 pcm | Y |
| WHG | Whiting | U | 200-249 | 1 pcm | Y |
| POK | Saithe (coalfish) | U | 250-299 | 1 pcm | |
| MON | Monkfish (white) | U | 300-349 | 100% | |
| WAF | Black bellied monk | U | 350-399 | | |
| MEG | Megrim | M | 400-449 | 1 pcm | Y |
| | | F | 450-499 | | |
| PLE | Plaice | M | 500-549 | 1 pcm | Y |
| | | F | 550-599 | | |
| SOL | Sole | M | 600-649 | 100% | |
| | | F | 650-699 | | |
| HER | Herring | U | 700-749 | 50* | |
| WHB | Blue Whiting | U | 750-749 | 1 pcm | |
| MAC | Mackerel | U | 800-849 | 1 pcm | |
| LEM | Lemon sole | U | 850-899 | 1 pcm | |
| HKE | Hake | U | 900-949 | 1 pcm | Y |
| HOM | Horse Mackerel | U | 950-974 | 1 pcm | |
| DAB | Dab | U | 975-999 | 1 pcm | (Y) |
| BLR | Cuckoo Ray | M | Wkstn | 100% | |
| | | F | number | | |
| CUR | Cuckoo Ray | M | Wkstn | 100% | |
| | | F | number | | |
| SDR | Spotted Ray | M | Wkstn | 100% | |
| | | F | number | | |
| THR | Thornback Ray | M | Wkstn | 100% | |
| | | F | number | | |

* Herring otoliths are be taken from a random sample of 50 fish per station.

Table 2. Length Frequency distributions of the herring catches. Station numbers are printed in bold font. Length is given in cm.

| Area | Aran Islands | | | | Dingle | Bantry Bay | | | | | Waterford coast | | | | | West of Smalls | | | | | South of Cork | | | | | South of Kinsale | | | | | |
|----------|--------------|----|----|-----|--------|------------|----|-----|----|----|-----------------|----|----|----|----|----------------|----|----|-----|----|---------------|-----|----|-----|-----|------------------|----|----|----|-----|---|
| Depth | 42 | 72 | 78 | 107 | 124 | 71 | 61 | 58 | 49 | 43 | 33 | 62 | 72 | 55 | 12 | 81 | 86 | 88 | 104 | 99 | 103 | 106 | 92 | 70 | 20 | 106 | 97 | 92 | 34 | | |
| Len\Stat | 1 | 2 | 3 | 5 | 8 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 37 | | |
| 12.5 | | | | | | | 3 | 3 | | 3 | | | | | 2 | | | | | | | | | | | | | | | | |
| 13.0 | | | | | | | 2 | 15 | | 6 | | | | | 1 | | | | | | | | | | | | | | | | |
| 13.5 | | | | | | | 1 | 15 | 13 | 0 | 3 | | | | 0 | | | | | | | | | | | | | | | | |
| 14.0 | | | | | | | 4 | 56 | 16 | 6 | 8 | | | | 1 | | | | | | | | | | | | | | | 5 | |
| 14.5 | 1 | | | | | | 8 | 85 | 22 | 26 | 8 | | | 1 | 5 | | | | | | | | | | | | | | | 35 | |
| 15.0 | 0 | 2 | | | | | 17 | 68 | 38 | 17 | 23 | 3 | | 0 | 4 | | | | | | | | | | | | | | | 30 | |
| 15.5 | 0 | 1 | | | | | 19 | 121 | 54 | 14 | 36 | 0 | | 4 | 3 | | | | | | | | | | | | | | | 64 | |
| 16.0 | 5 | 0 | | | | | 30 | 85 | 57 | 29 | 36 | 3 | | 8 | 3 | | | | | | | | | | 2 | | | | | 54 | |
| 16.5 | 6 | 0 | 1 | | | | 1 | 22 | 62 | 83 | 29 | 41 | 6 | | 8 | 1 | | | | | | | | 2 | | | | | | 133 | |
| 17.0 | 6 | 0 | | | | | 0 | 16 | 59 | 61 | 17 | 36 | 12 | | 9 | 0 | | | | | | | | 0 | 57 | | | | | 109 | |
| 17.5 | 6 | 1 | | | | | 1 | 10 | 21 | 45 | 9 | 34 | 0 | | 5 | 0 | | | | | | | | 2 | 57 | | | | | 158 | |
| 18.0 | 0 | 0 | | | | | 0 | 2 | 0 | 16 | 9 | 26 | 0 | | 1 | | | | | | | | | 5 | 0 | | | | | 123 | |
| 18.5 | 1 | 0 | | | | | 0 | 3 | 6 | 0 | 0 | 10 | 3 | | 0 | | | | | | | | | 4 | 0 | | | | | 109 | |
| 19.0 | 2 | 0 | | | | | 0 | 1 | 0 | 0 | 0 | 5 | 3 | | 0 | | | | 2 | | | | 4 | 29 | | | | | | 54 | |
| 19.5 | 0 | 1 | | | | | 0 | 0 | 3 | 0 | 0 | 5 | 0 | | 0 | | | 2 | 0 | | | | | 13 | 0 | | | | | 30 | |
| 20.0 | 0 | 1 | | | | | 0 | 0 | 0 | 0 | 0 | 3 | 3 | | 0 | 1 | 1 | 2 | 1 | | | | 27 | 86 | | | | | | 5 | |
| 20.5 | 0 | 0 | | | | | 1 | 0 | 0 | 0 | 0 | 3 | 31 | | 0 | 3 | 1 | 12 | 2 | | 1 | | 40 | 229 | | | | | | 5 | |
| 21.0 | 0 | 0 | | | | | 0 | 0 | 0 | 6 | 0 | 5 | 55 | | 0 | 0 | 5 | 5 | 1 | | 2 | | 71 | 257 | | | 1 | | | 0 | |
| 21.5 | 0 | 0 | | | | | 1 | 0 | 0 | 10 | 0 | 0 | 73 | | 0 | 0 | 6 | 9 | 7 | | 3 | | 69 | 457 | | | 1 | | | 0 | |
| 22.0 | 0 | 0 | | | | | 0 | 1 | 0 | 13 | 0 | 5 | 52 | | 0 | 4 | 4 | 15 | 9 | | 2 | | 49 | 457 | | | 1 | | | 0 | |
| 22.5 | 0 | 0 | | | | | 8 | 6 | 0 | 10 | 0 | 3 | 43 | | 0 | 4 | 12 | 20 | 10 | | 4 | | 3 | 53 | 229 | | | 2 | 1 | 0 | |
| 23.0 | 0 | 0 | | | 1 | | 3 | 10 | 0 | 13 | 0 | 5 | 31 | 1 | 0 | 6 | 9 | 22 | 11 | 3 | 17 | 1 | 5 | 35 | 143 | 5 | 1 | 3 | 0 | 0 | |
| 23.5 | 0 | 0 | | | 1 | | 6 | 15 | 0 | 10 | 6 | | 43 | 0 | 1 | 6 | 19 | 37 | 20 | 0 | 10 | 0 | 8 | 24 | 257 | 2 | 5 | 5 | 0 | 0 | |
| 24.0 | 0 | 0 | | | 2 | | 2 | 5 | 0 | 13 | 6 | | 24 | 1 | | 4 | 9 | 29 | 14 | 1 | 14 | 0 | 7 | 9 | 257 | 7 | 6 | 3 | 0 | 0 | |
| 24.5 | 0 | 0 | | | 6 | | 4 | 7 | 3 | 0 | 20 | | 3 | 0 | | 3 | 6 | 17 | 16 | 0 | 11 | 0 | 7 | 15 | 343 | 9 | 5 | 9 | 0 | 0 | |
| 25.0 | 0 | 0 | | | 7 | | 3 | 1 | 3 | 6 | 23 | | 3 | 0 | | 0 | 3 | 39 | 18 | 1 | 12 | 4 | 8 | 5 | 343 | 11 | 14 | 7 | 5 | 0 | |
| 25.5 | 0 | 0 | | | 11 | | 6 | 2 | 0 | 0 | 14 | | | 0 | | 2 | 9 | 19 | 19 | 0 | 9 | 1 | 14 | 0 | 314 | 11 | 9 | 7 | | 0 | |
| 26.0 | 1 | 0 | | | 8 | | 0 | 1 | 3 | 0 | 17 | | | 1 | | 1 | 6 | 15 | 12 | 0 | 7 | 2 | 7 | 2 | 286 | 10 | 8 | 6 | | 0 | |
| 26.5 | | 1 | | | 13 | | 0 | 2 | | 0 | 14 | | | 1 | | 1 | 6 | 7 | 8 | 0 | 6 | 0 | 9 | 4 | 229 | 7 | 11 | 4 | | 0 | |
| 27.0 | | 0 | | | 9 | | 0 | 1 | | 3 | 9 | | | | | 1 | 1 | 2 | 3 | 3 | 1 | 1 | 4 | 0 | 86 | 1 | 3 | 1 | | 0 | |
| 27.5 | | 1 | | | 13 | | 1 | | | | 6 | | | | | | 2 | 2 | 0 | | 2 | 0 | 0 | 2 | 143 | 6 | 1 | 4 | | 0 | |
| 28.0 | | 0 | | | 4 | | 0 | | | 3 | | | | | | | | 2 | 3 | | 0 | 1 | 1 | | 57 | 1 | 0 | 2 | | 0 | |
| 28.5 | | 0 | | 1 | 3 | | 1 | | | | | | | | | | | 2 | 2 | | 0 | | | | 57 | | 1 | 1 | | 0 | |
| 29.0 | | 1 | | | 1 | | | | | | | | | | | | | | | | 0 | | | | 29 | | | | | 0 | |
| 29.5 | | 1 | | | | | | | | | | | | | | | | | | | 0 | | | | 29 | | | | | 0 | |
| 32.5 | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | 0 |

Table 3. Catch numbers, number of fish measured, numbers sampled for biological parameters (weight, sex, maturity and age; rays were not aged) and numbers of ovary samples taken.

| SPECIES | COMMON NAME | CAUGHT | MEASURED | SAMPLED | OVARIES |
|----------------|--------------------|---------------|-----------------|----------------|----------------|
| COD | Cod | 71 | 71 | 71 | 24 |
| DAB | Dab | 2 028 | 903 | 175 | |
| HAD | Haddock | 7 441 | 2 438 | 443 | 37 |
| HER | Herring | 9 186 | 2 515 | 824 | |
| HKE | Hake | 2 528 | 1 849 | 429 | 24 |
| HOM | Horse Mackerel | 135 | 135 | 70 | |
| LEM | Lemon sole | 222 | 222 | 127 | |
| MAC | Mackerel | 33 | 33 | 23 | |
| MEG | Megrim | 201 | 201 | 142 | 23 |
| MON | White bellied Monk | 19 | 19 | 19 | |
| PLE | Plaice | 335 | 335 | 188 | 39 |
| SDR | Spotted ray | 5 | 5 | 5 | |
| SOL | Black sole | 7 | 7 | 7 | |
| THR | Thornback ray | 3 | 3 | 3 | |
| WAF | White bellied monk | 11 | 11 | 11 | |
| WHB | Blue whiting | 1 993 | 803 | 90 | |
| WHG | Whiting | 18 415 | 3 665 | 489 | 40 |
| TOTAL | | 42 632 | 13 215 | 3 116 | 187 |

Table 4. Biological samples by sex (Female, Male and Unsexed) and maturity state.

| Species | Sex | Immature | Maturing | Ripe | Spent | Total |
|---------|-----|----------|----------|------|-------|-------|
| COD | F | 30 | 5 | 4 | 5 | 44 |
| COD | M | 19 | 3 | 5 | 0 | 27 |
| DAB | F | 3 | 44 | 41 | 4 | 92 |
| DAB | M | 2 | 7 | 60 | 14 | 83 |
| HAD | F | 71 | 84 | 81 | 6 | 242 |
| HAD | M | 26 | 85 | 85 | 1 | 197 |
| HAD | U | 4 | 0 | 0 | 0 | 4 |
| HER | F | 47 | 2 | 5 | 204 | 258 |
| HER | M | 40 | 9 | 2 | 225 | 276 |
| HER | U | 290 | 0 | 0 | 0 | 290 |
| HKE | F | 120 | 7 | 0 | 1 | 128 |
| HKE | M | 119 | 27 | 10 | 0 | 156 |
| HKE | U | 145 | 0 | 0 | 0 | 145 |
| HOM | F | 13 | 2 | 0 | 0 | 15 |
| HOM | M | 7 | 2 | 0 | 0 | 9 |
| HOM | U | 46 | 0 | 0 | 0 | 46 |
| LEM | F | 0 | 37 | 27 | 0 | 64 |
| LEM | M | 1 | 8 | 54 | 0 | 63 |
| MAC | F | 12 | 0 | 1 | 0 | 13 |
| MAC | M | 7 | 1 | 0 | 0 | 8 |
| MAC | U | 2 | 0 | 0 | 0 | 2 |
| MEG | F | 10 | 29 | 58 | 0 | 97 |
| MEG | M | 4 | 19 | 22 | 0 | 45 |
| MON | F | 8 | 0 | 0 | 0 | 8 |
| MON | M | 3 | 0 | 0 | 0 | 3 |
| MON | U | 8 | 0 | 0 | 0 | 8 |
| PLE | F | 34 | 5 | 12 | 63 | 114 |
| PLE | M | 19 | 12 | 40 | 3 | 74 |
| SDR | F | 2 | 1 | 0 | 0 | 3 |
| SDR | M | 1 | 1 | 0 | 0 | 2 |
| SOL | F | 2 | 1 | 3 | 0 | 6 |
| SOL | M | 1 | 0 | 0 | 0 | 1 |
| THR | F | 2 | 0 | 0 | 0 | 2 |
| THR | M | 0 | 1 | 0 | 0 | 1 |
| WAF | F | 4 | 0 | 0 | 0 | 4 |
| WAF | M | 3 | 0 | 0 | 0 | 3 |
| WAF | U | 4 | 0 | 0 | 0 | 4 |
| WHB | F | 23 | 13 | 11 | 0 | 47 |
| WHB | M | 14 | 24 | 5 | 0 | 43 |
| WHG | F | 84 | 84 | 83 | 0 | 251 |
| WHG | M | 51 | 122 | 55 | 0 | 228 |
| WHG | U | 10 | 0 | 0 | 0 | 10 |

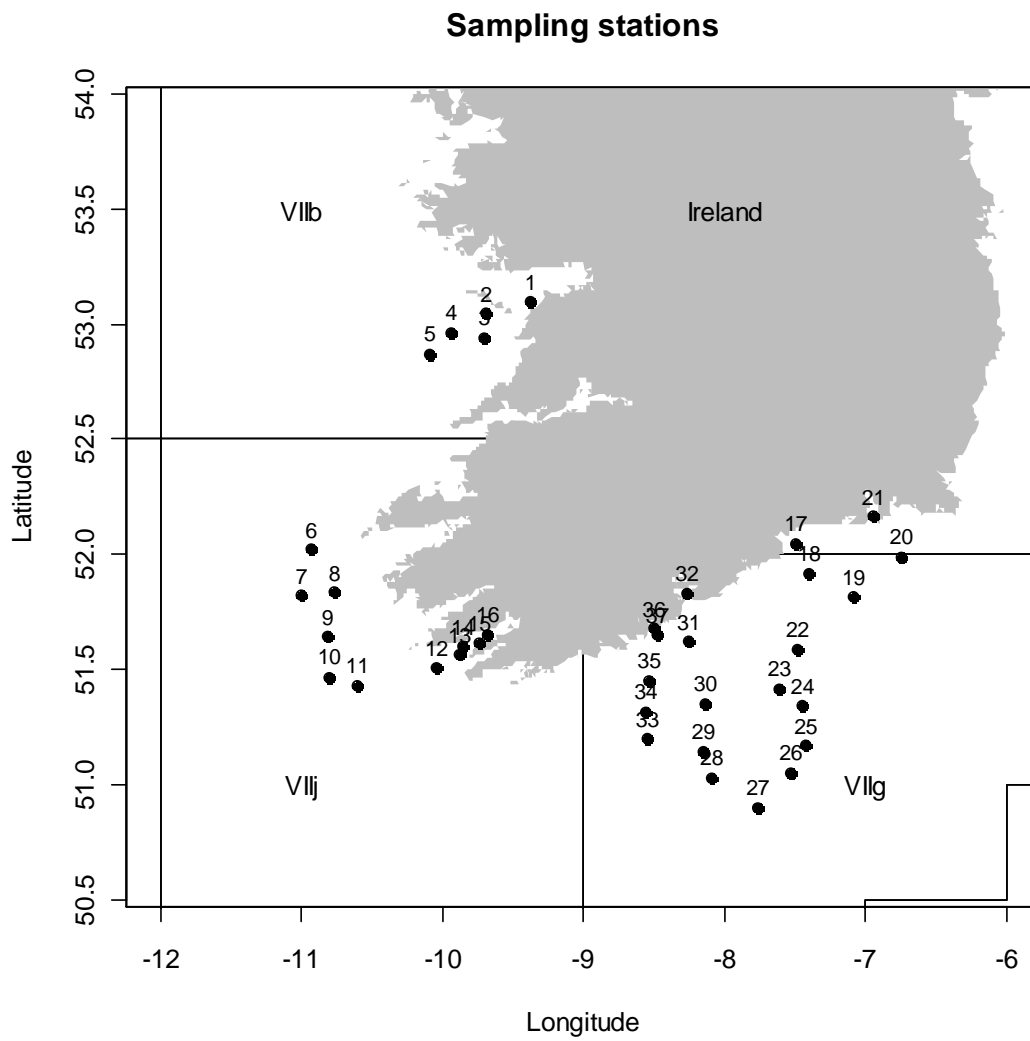


Figure 1. Station positions. The numbers refer to the haul numbers.

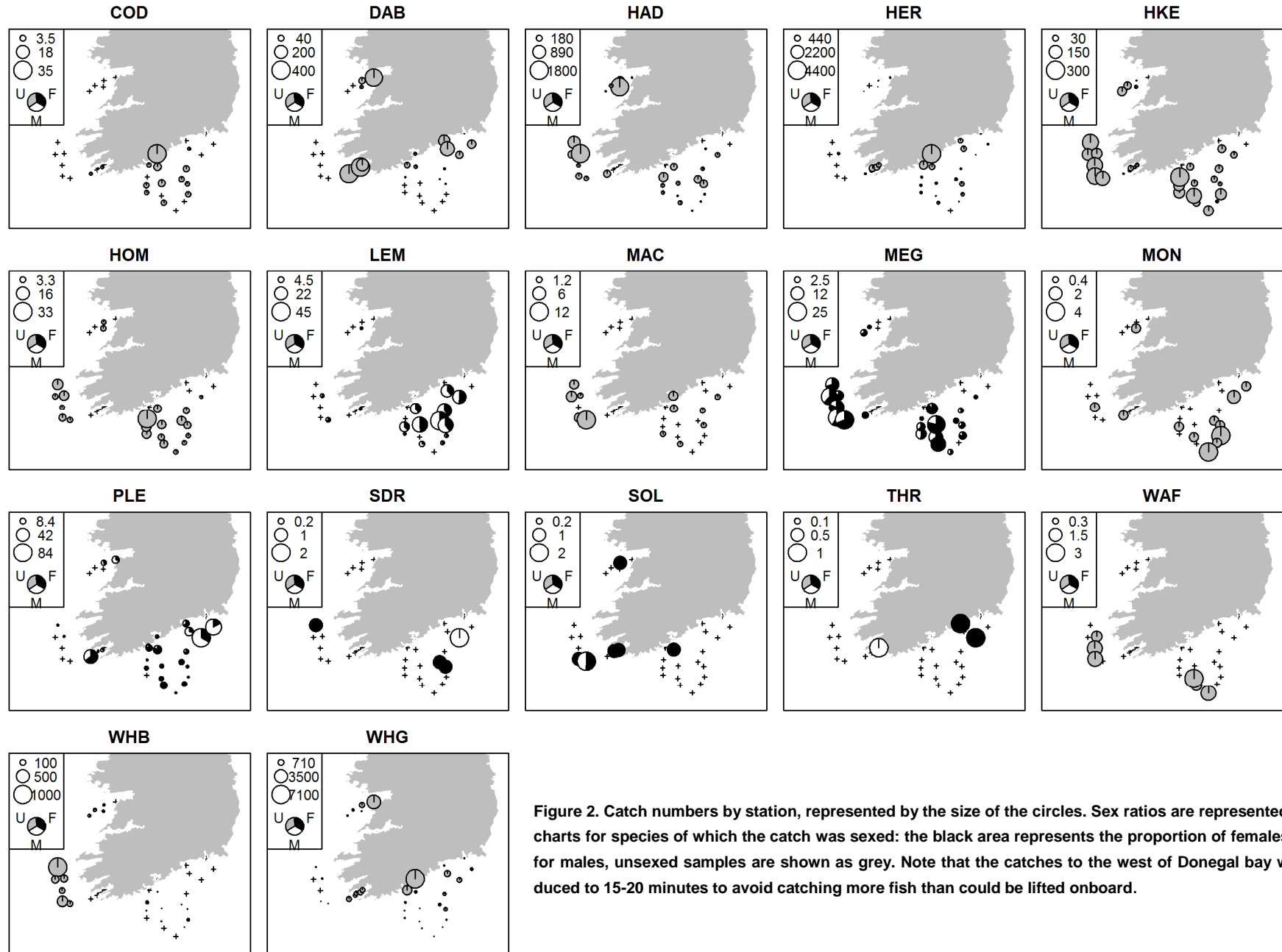


Figure 2. Catch numbers by station, represented by the size of the circles. Sex ratios are represented by pie charts for species of which the catch was sexed: the black area represents the proportion of females, white for males, unsexed samples are shown as grey. Note that the catches to the west of Donegal bay were reduced to 15-20 minutes to avoid catching more fish than could be lifted onboard.

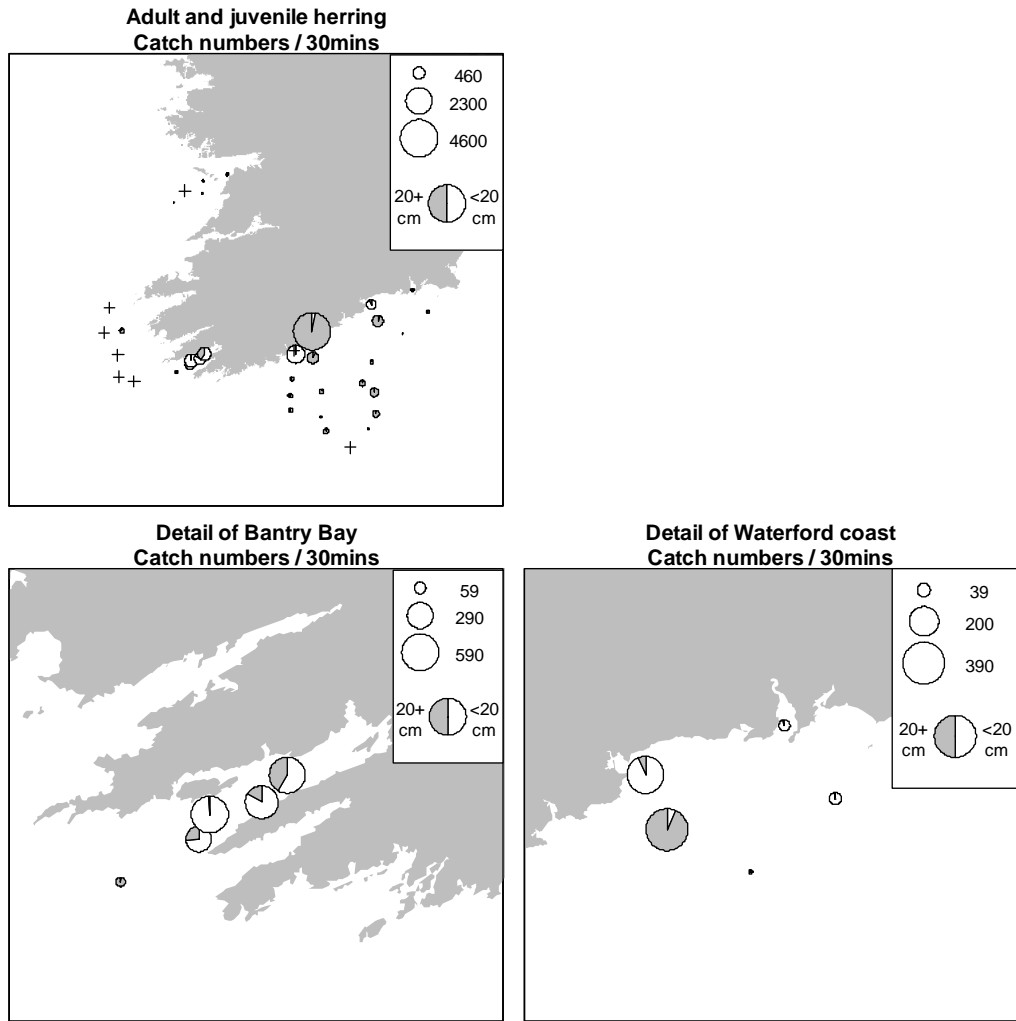


Figure 3. Catch rates of juvenile (<20cm) and adult (20cm+) herring.

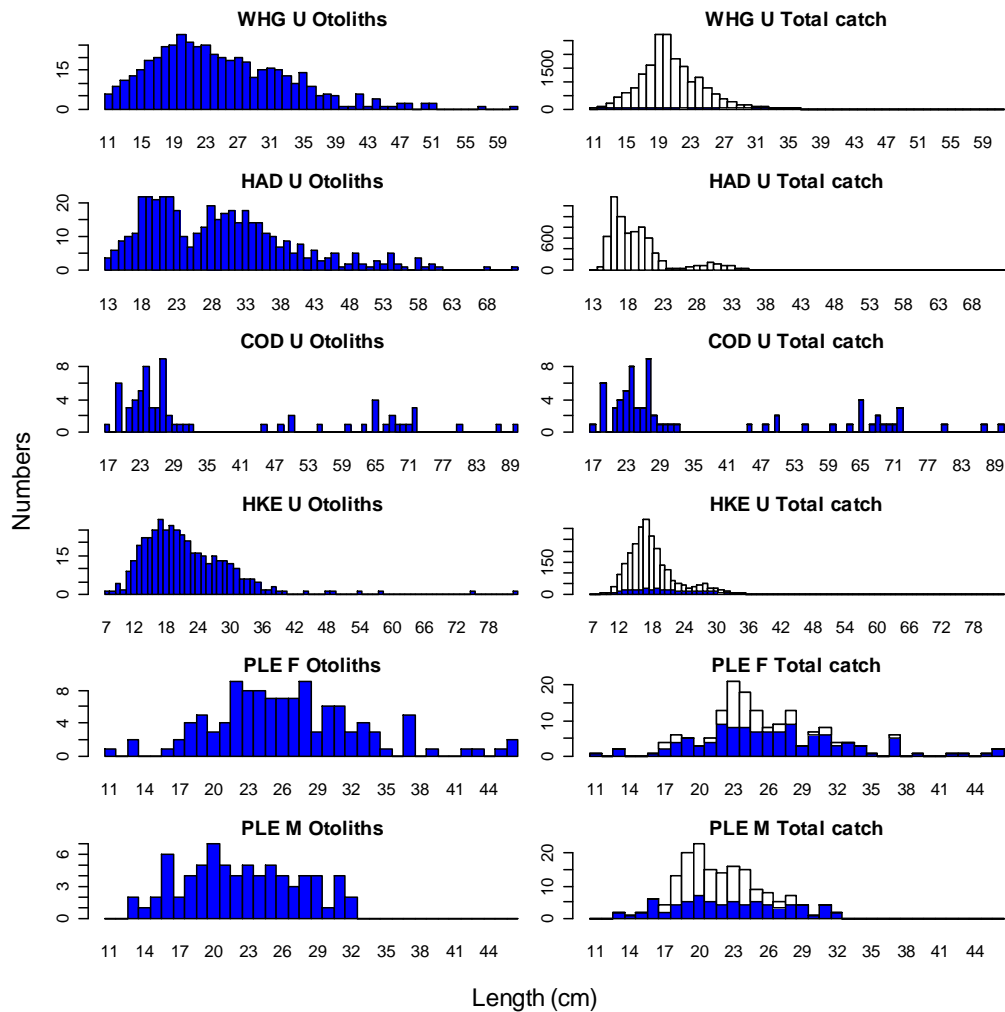


Figure 4. Size frequency of biological samples taken (blue) and total catch (white). The left-hand graphs show only the biological samples, the right-hand graphs show both the total catch and biological samples.

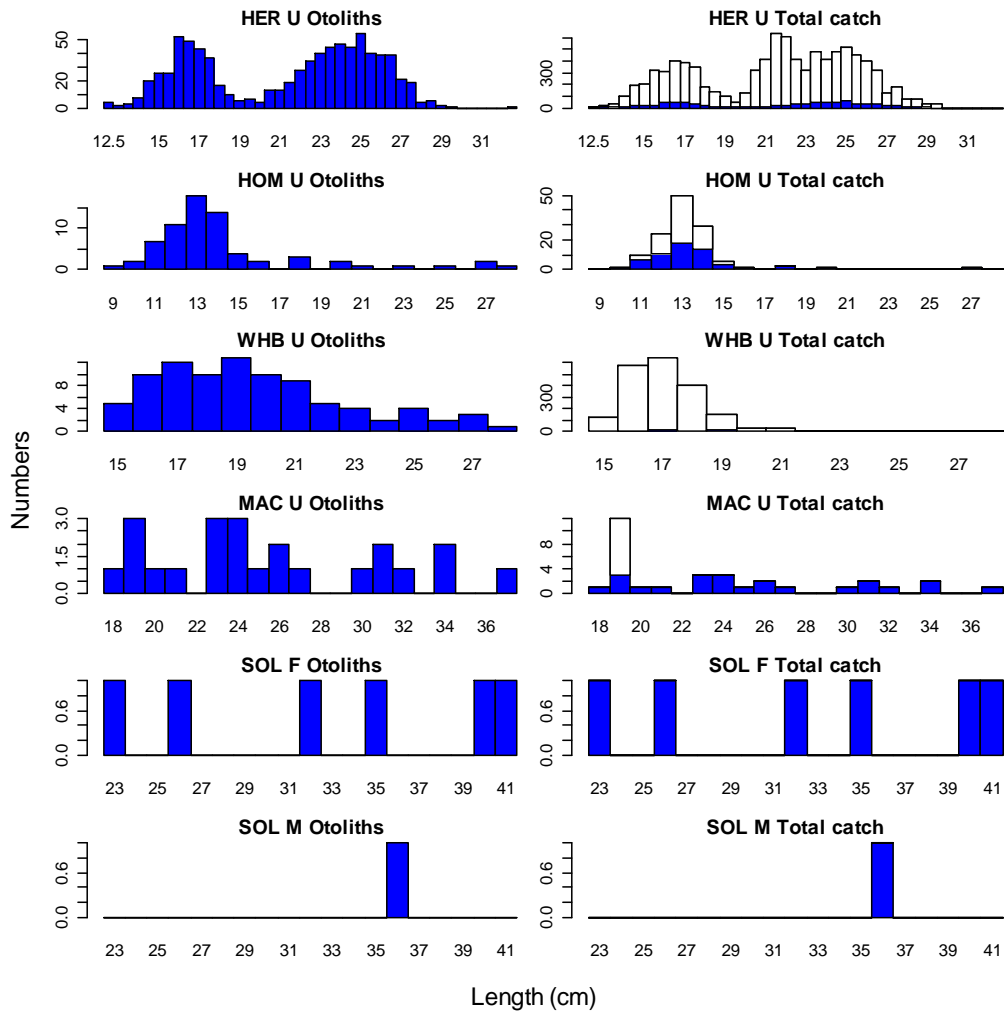


Figure 5. Size frequency of biological samples taken (blue) and total catch (white). The left-hand graphs show only the biological samples, the right-hand graphs show both the total catch and biological samples.