Beatrice Offshore Wind Farm

Pre-construction Baseline Herring Larval Survey- Technical Report

December 2014

Beatrice
Offshore Windfarm Ltd

Project Title/ Location	Beatrice Offshore Wind Farm
Project Reference Number	LF0000005
Date:	12th December 2014

Beatrice Offshore Wind Farm

Herring Larval Survey Results – Technical Report

This document contains proprietary information belonging to Beatrice Offshore Windfarm Ltd and/or affiliated companies and shall be used only for the purpose for which it was supplied. It shall not be copied, reproduced, disclosed or otherwise used, nor shall such information be furnished in whole or in part to third parties, except in accordance with the terms of any agreement under which it was supplied or with the prior consent of Beatrice Offshore Windfarm Ltd and shall be returned upon request.

© Copyright of Beatrice Offshore Windfarm Ltd 2014.

Rev	Prepared By	Sign Off	Checked By	Sign Off	Approved By	Sign Off	Date of Issue
Draft 1.1	AWG		JK				
Draft 1.2	AWG		SJA				03/12/2014
Draft 1.3	AWG		SJA				03/12/2014
Draft 2.1	AWG		SJA				10/12/2014
Final	AWG		SJA				12/12/2014

Table of Contents

1 Executive Summary

This pre-construction Monitoring Report has been prepared by Beatrice Offshore Windfarm Ltd (BOWL) as part of the Project Environmental Monitoring Programme (PEMP) required as part of the Section 36 Consent. This report describes the pre-construction element of condition 27 of the PEMP in relation to herring larvae and will be used to discharge Conditions 34 (requirement for herring surveys) and Condition 12 (Piling Strategy) of BOWL's Section 36 Consent.

The survey methodology was designed in consultation with Marine Scotland Science (MSS) and Marine Scotland Licensing and Operations Team (MS-LOT). 25 stations were sampled every week, weather permitting, for 8 weeks, using a Gulf VII high speed plankton sampler.

A total of 18,544 herring larvae were recorded during the survey. No herring larvae were caught in sampling weeks 1 and 2. Low abundances of herring larvae were observed during weeks 3, 4 and 5 with the largest numbers recorded at the most northerly stations of the survey area. The highest densities of herring occurred in week 7 (38.2% of the total catch) with 96.3% of the total catch recorded in weeks 6, 7 and 8 combined, indicating one distinct spawning period. The back-calculation of larval hatch date and spawning stock indicate the peak spawning period occurs in the first 2 weeks of September, with the highest spawning intensity estimated to be at the end of the first week of September.

The majority of herring larvae caught over the period of the survey were <10mm (78.1%) with over 25% of the total catch being in the size class 7.0 - 7.9 mm. The spatial distribution of larvae by length shows that smaller larvae were caught in the north of the sampling area whereas larger larvae were in the south, indicating that larvae are being transported in a southerly direction from north of the sampling area.

The stations where the highest abundances of larvae were caught were to the north and to the east of the development area. The International Herring Larvae Surveys (IHLS) found comparatively low numbers of herring larvae <10mm (n/m^2) in the vicinity of the BOWL development area in week 7. The highest larval densities recorded by IHLS surveys were found north of the survey area, in and around the Orkneys and Shetlands.

The age back-calculation from length estimates that the mean age for the most prevalent size class (7.0 – 7.9mm) is between 1.53 and 3.28 days. However, no yolk sacs were observed on any herring larvae in the samples and studies have found that absorption of the yolk sac after hatching takes a minimum of 6 days. In order to incorporate the time for yolk sace absorption, the 6 days has been used as a base age, to which the back-calculation age can then be added to. For the larvae size class of 7.0 - 7.9 mm, this results in a mean age of between 7.53 days to 9.28 days.

Hydrodynamic data for the area, derived from the literature, has produced estimates of residual current velocity ranging from 1-2 km/day to 7.0 and 8.6 km/day. Using the residual velocity data, 7.0 - 7.9 mm larvae could travel, in 7.53 to 9.28 days, a minimum of 14 - 18 km up to 60 - 77 km. This suggests that the majority of the larvae caught during the survey have drifted down from the well established spawning grounds in the Orkneys and Shetlands.

2 Introduction

This pre-construction Monitoring Report has been prepared by Beatrice Offshore Windfarm Ltd (BOWL) as part of the Project Environmental Monitoring Programme (PEMP) Section 36 Consent condition (Condition 27).

This report describes the pre-construction element of condition 27 PEMP in relation to herring larvae and will be used to discharge Conditions 34 (requirement for herring surveys) and Condition 12 (Piling Strategy), respectively. This report has been prepared by Brown and May Ltd (BMM).

The report details the findings of the herring larval survey undertaken between the 4th August and 27th September 2014 within the 90 dBht ranges modelled for herring for the BOWL development area.

In line with BOWL's Section 36 Consent, the report addresses the following objectives:

- Collect data comparable with that produced by the ICES International Herring Larvae Surveys (IHLS; ICES, 2008)
- Collect data on the spatial and temporal distribution of herring larvae in the vicinity of the BOWL development area
- Determine the level of spawning activity in and around the BOWL development area.
- Collect data to inform a mitigation strategy for a piling restriction.

The survey methodology (LF000005-REP-147 - BOWL Herring Larval Survey Methodology) was submitted to MSS and MS-LOT in July 2014 for consultation and agreement (Meeting at Marine Scotland, Aberdeen. A. Ford, E. Hatfield 15/07/2014). In line with best practise and in agreement with MSS, the survey was undertaken using a Gulf VII high speed plankton sampler at 25 sampling locations each week for 8 weeks, weather permitting.

A dispensation from MSS, in accordance with the terms of Section 9 of the Sea Fish Conservation Act 1967 and Article 43 of Council Regulation No. 850/98 related to days at sea, was obtained prior to commencement of this survey.

A summary of the Health and Safety performance of the survey is provided in the Appendix (section 9.1).

3 Background

The North Sea herring stock is comprised of four sub-stocks based on areas used for spawning (Figure 3.1), characterised by different spawning times, growth rates, migration routes and recruitment patterns (Dickey-Collas *et al.*, 2010). The sub-stock relevant to the Moray Firth is the Orkney/Shetland stock, which spawns in Shetland/Orkney waters and off the north-east coast of Scotland.

According to Coull *et al.* (1998) the Orkney/Shetland stock spawns between August and September. Herring shoals are considered to arrive at traditional spawning grounds in a series of waves (Lambert, 1987). The physical characteristics of herring spawning grounds are well documented, being characterised by coarse substrates in high energy environments. Due to the substrate specific habitat requirements, spawning grounds are reasonably well defined (Blaxter, 1985; Keltz & Bailey, 2010; Rockmann *et al*., 2011). However, spawning intensity can be highly variable between years.

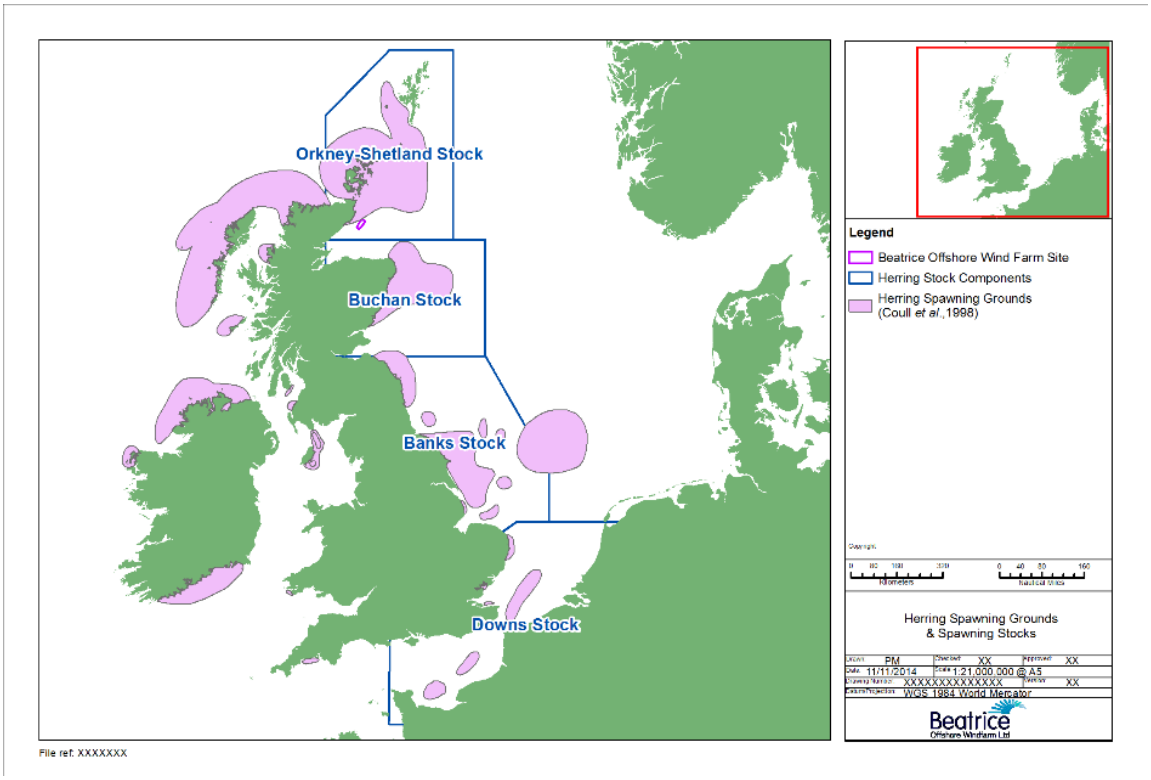

Figure 3.1 Spawning components of North Sea herring stock

North Sea herring are synchronous batch spawners where the females lay mats of benthic sticky eggs directly onto the seabed in areas of coarse sand, gravel, small stones or rocks (Geffen, 2009; Keltz & Bailey, 2010). Herring larvae hatch after approximately three weeks, depending on sea temperature (Hodgson, 1957; Keltz & Bailey, 2010). Newly hatched larvae from the Orkney/Shetland stock are considered to measure between 6 - 8 mm and are dependent on their yolk-sac for 6 - 10 days until the yolk is reabsorbed and the larvae begin to feed on small zooplankton (Blaxter, 1968; Fassler *et al*., 2011; Heath, 1993; Hodgson, 1957).

The distribution of early stage larvae determined from herring larval surveys is used to infer the spatial and temporal coverage of herring spawning grounds in active use (Ellis *et al*., 2012). The IHLS surveys have been regularly undertaken in the North Sea since 1972.

Charts of herring spawning grounds are presented in Ellis *et al*. (2012) and Coull *et al*. (1998). These are the standard references frequenctly used for the assessment of offshore developments impact assessment on fish spawning in UK waters (Figure 3.2). It should be noted that the spatial distribution of larval densities in the North Sea, described in Ellis *et al*. (2010, 2012) is based on a single year of 2008 IHLS survey data for all herring larvae up to 24 mm in length. The data does show lower larval densities in the vicinity of the BOWL development area in comparison to larval abundances recorded to the north and east of the Orkneys and Shetlands.

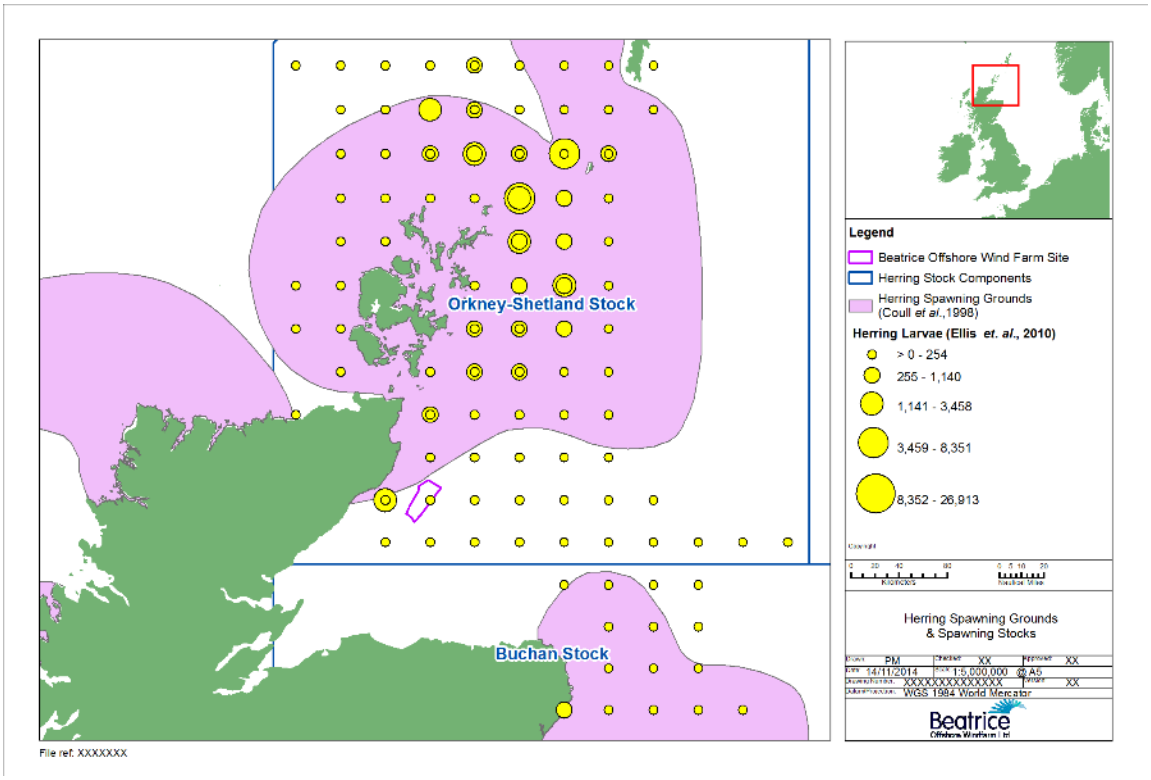

Figure 3.2 Herring spawning grounds presented in Coull *et al*. (1998) and Ellis *et al*. (2010)

Studies examining patterns of larval drift have shown that herring larvae from the Orkney/Shetland stock drift south into nursery grounds in the Moray Firth and east into nursery grounds in the Skagerrak and Kattegat (Figure 3.3, Nichols, 1999). Heath *et al.* (1989) found that herring larvae from a spawning site at Clythness in the Moray Firth had drifted from the spawning grounds at a rate of 1-2 km/day. This is a conservative estimate in comparison to estimates from a recent hydrodynamic study by Guerin *et al*. (2014). As part of the study an overview of the major oceanic and coastal currents in the North-east Atlantic and the North Sea was produced (Figure 3.4), with approximate mid-range estimates of residual current velocity derived from the literature (Baxter *et al*., 2011; UKMMAS, 2014; Turrell *et al*., 1990).

The currents relevant to the BOWL development area are currents 4 (Fair Isle current - West of Orkney) and 5 (Fair Isle current – North Sea) in Figure 3.4, with residual velocities of 7 cm/second and 10 cm /second respectively. This is equivalent to 6.0 km/day (current 4) and 8.6 km/day (current 5).

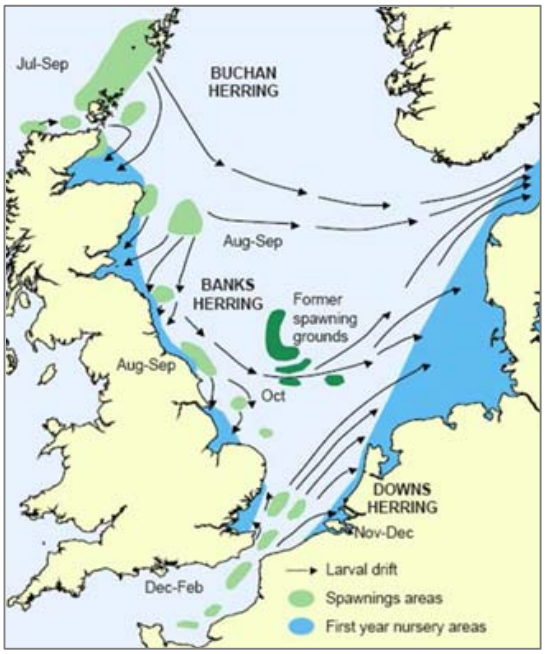

Figure 3.3 The spawning areas and spawning periods of the North Sea autumn spawning sub-populations showing larval drift to nursery grounds (Source: Nichols, 1999)

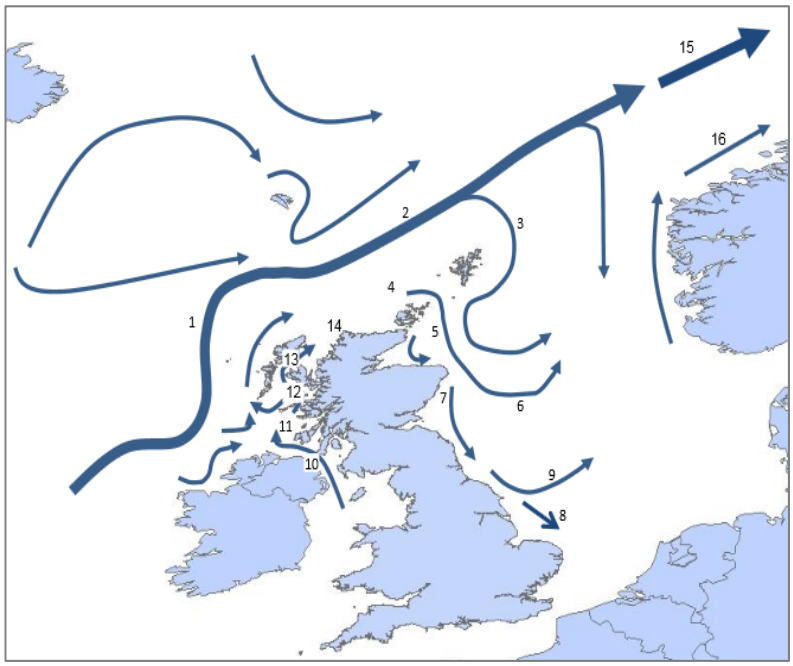

Figure 3.4 Schematic representation of the major oceanic or coastal currents in the North East Atlantic and the North Sea, modified from Baxter *et al*. 2011.

The ICES programme of IHLS surveys in the North Sea has been in operation since 1967. The IHLS surveys are undertaken to provide quantitative estimates of herring larval abundance in order to inform the herring spawning stock biomass assessment (ICES, 2013). Sampling stations are allocated in a 10 by 10 nautical mile grid resulting in 9 smaller grid squares (labelled alphabetically from “a” to “i”) within each ICES rectangle. Further details of survey procedures can be found in the IHLS manual (ICES, 2008). It should be noted that the North Sea IHLS surveys are subject to variable coverage, with some spawning areas undertaken only once per year.

The IHLS surveys only give an indication of herring larval abundance in the first two weeks or last two weeks of September and for the past 20 years data has predominantly been collected from only the last two weeks of September in the Moray Firth. The distribution of herring larvae in recent years (2006-2008) is provided in Schmidt *et al*. (2007, 2008) and Rohlf & Groger (2009). IHLS findings for 2009 – 2013 are given in Figure 3.6 to Figure 3.10. The IHLS data suggest that spawning activity in the Moray Firth is at significantly lower levels than that recorded further north off the Orkneys and Shetlands, where the bulk of spawning of the Buchan stock takes place most years.

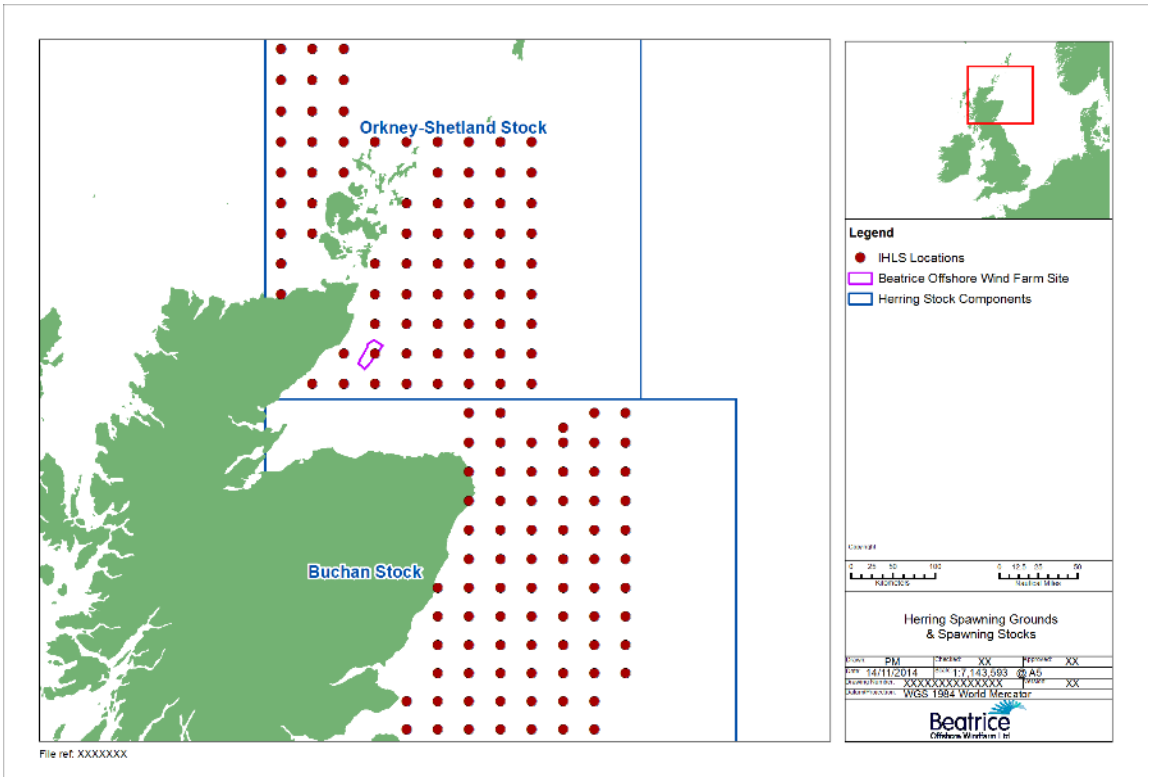

Figure 3.5 IHLS stations in the vicinity of the BOWL development area

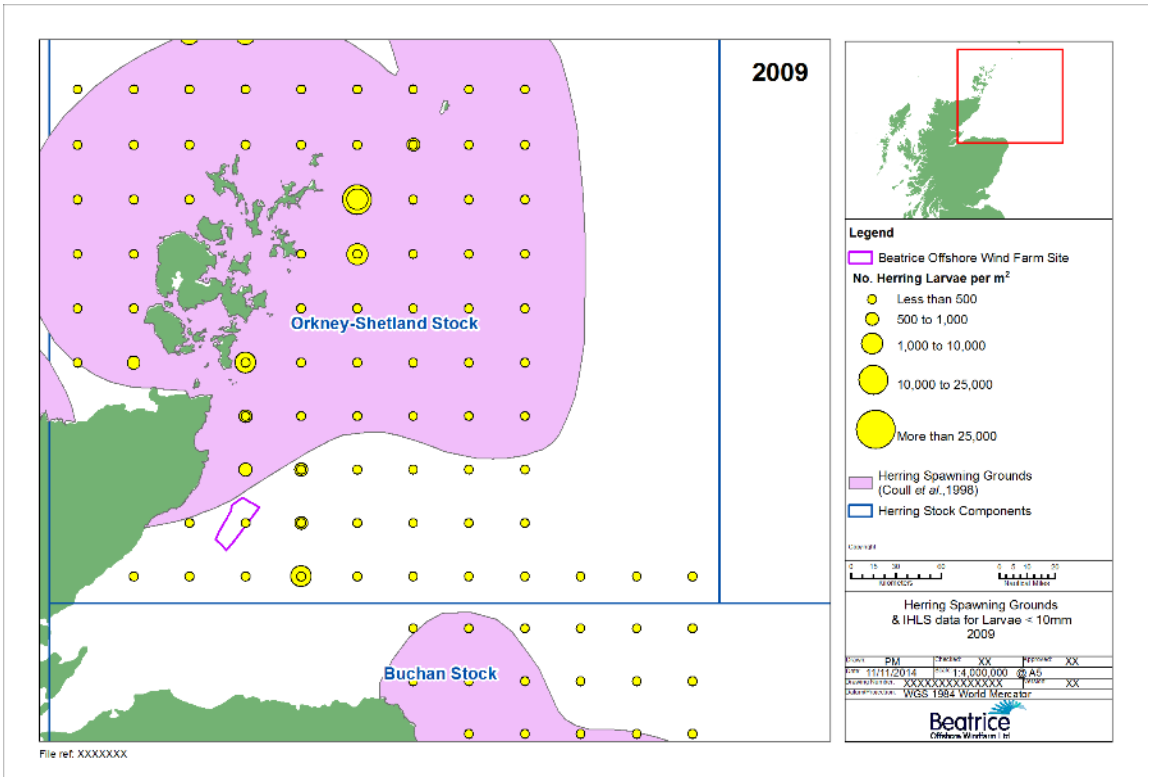

Figure 3.6 IHLS herring larvae (<10mm) abundance (n/m^2) 2009

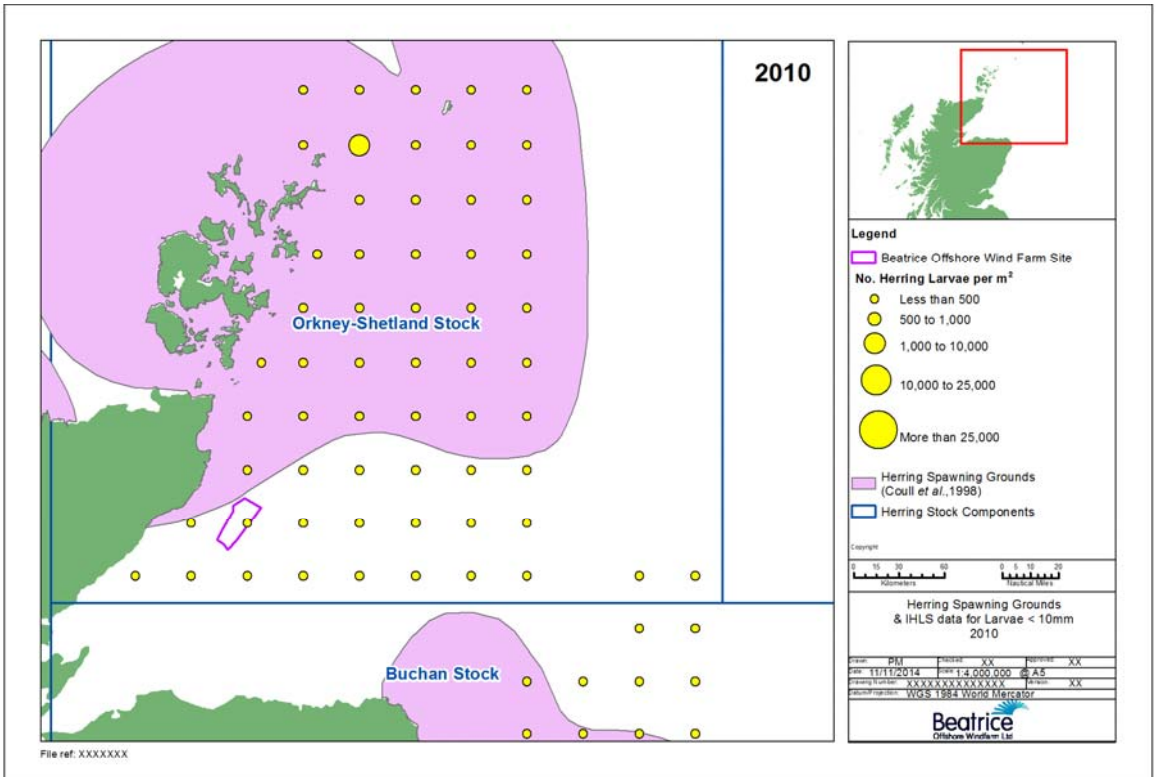

Figure 3.7 IHLS herring larvae (<10mm) abundance (n/m^2) 2010

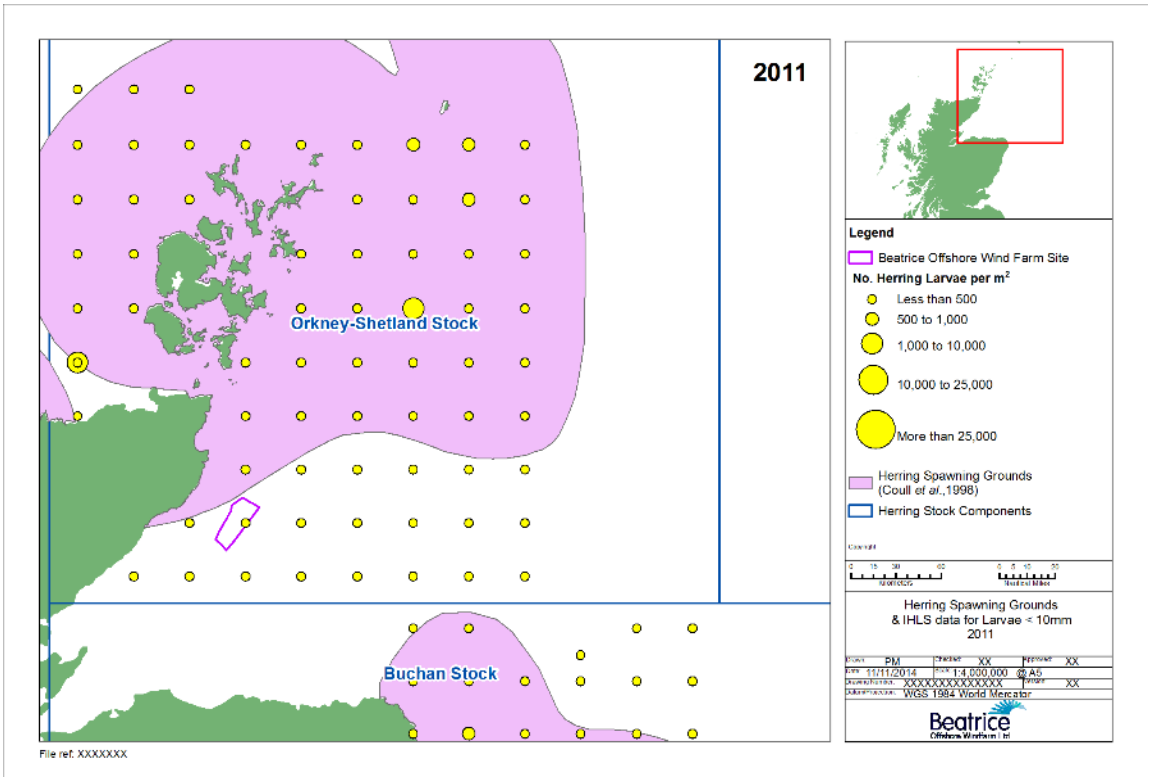

Figure 3.8 IHLS herring larvae (<10mm) abundance (n/m^2) 2011

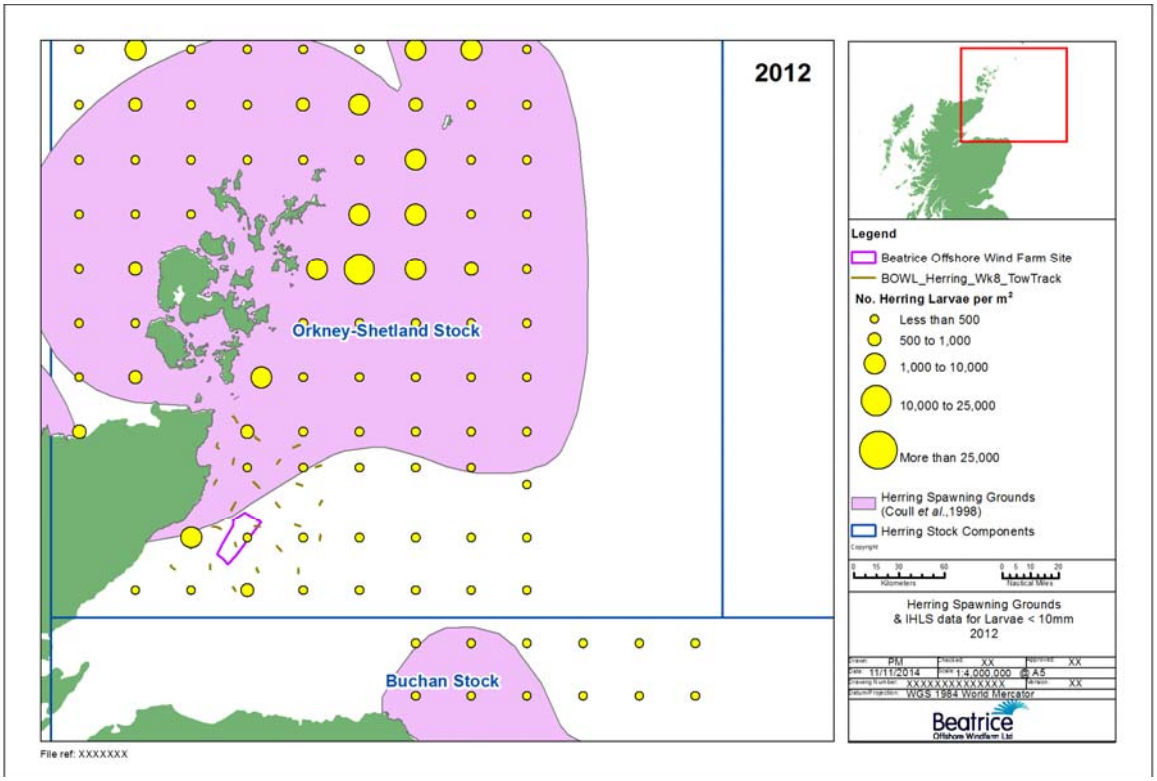

Figure 3.9 IHLS herring larvae (<10mm) abundance (n/m^2) 2012

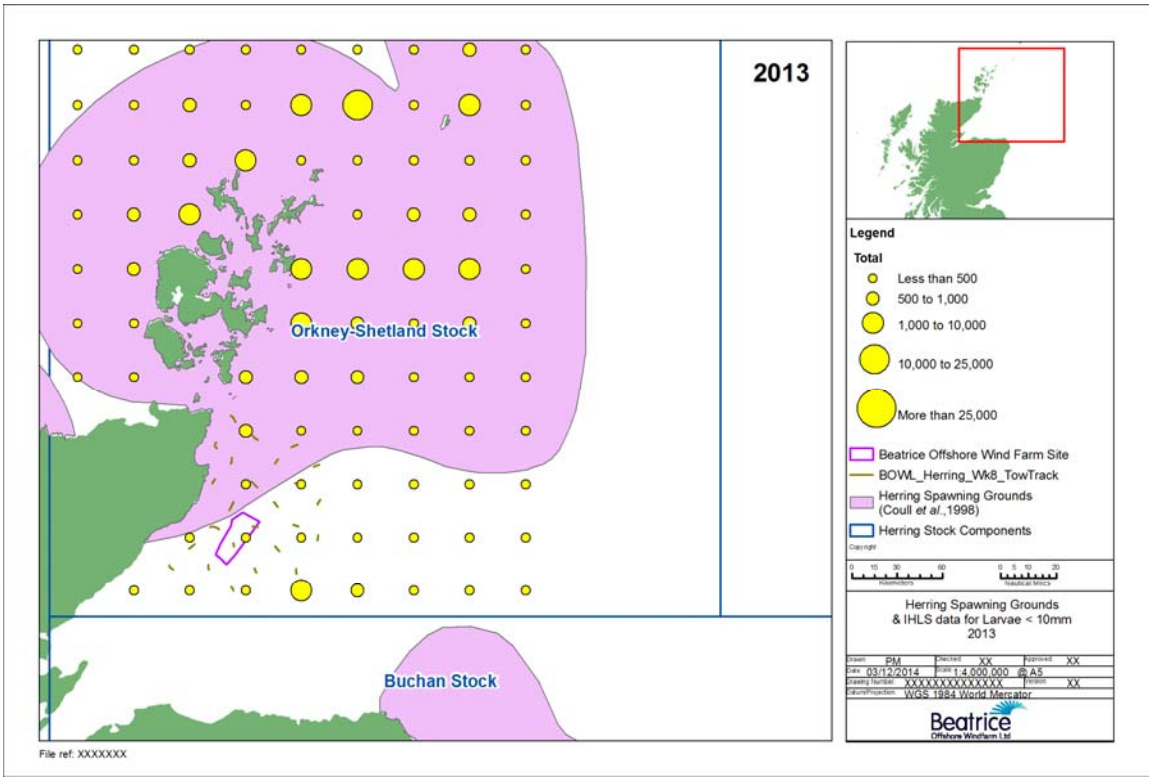

Figure 3.10 IHLS herring larvae (<10mm) abundance (n/m^2) 2013

4 Scope of Works

The scope of works for the herring larval survey are detailed below with the sampling stations illustrated in Figure 4.1. A grid formation was used to provide 25 sampling locations encompassed within the 90 dBht ranges modelled for herring and cross referenced with previous IHLS results and the area defined by Coull *et al.* (1998) as the Moray Firth herring spawning ground.

Accepting weather constraints, the objective was for sampling to be carried out during eight separate trips of four days duration, the first commencing 4th August and continuing until 27th September 2014. A consistent sampling pattern was undertaken with the stations being sampled in the same order each week. A summary of the sampling design is provided below:

- Gulf VII high speed plankton sampler
  - 25 tows per week carried out in the same order for 8 weeks
- Sample analysis
  - Number of individuals by species
  - Length
- Data analysis
  - Sampling effort targeted at producing estimates of various life stages up to 10mm
  - Back calculations from length distributions will be undertaken to approximately determine peak spawning periods

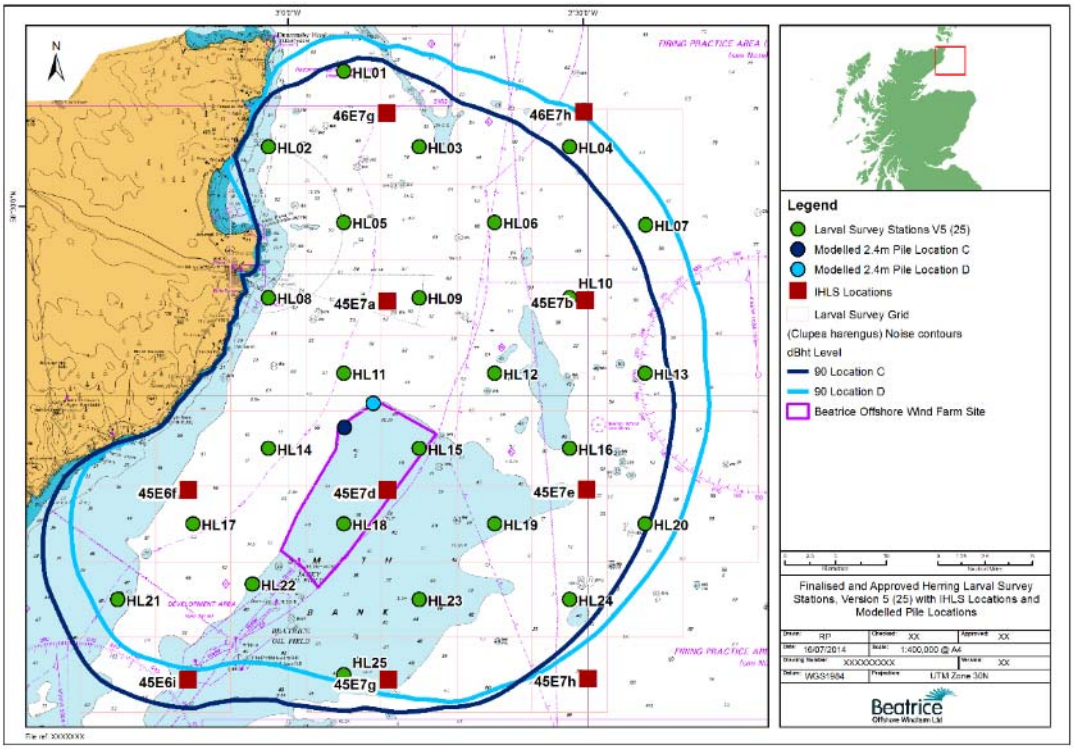

Figure 4.1 Sampling locations

5 Survey Methodology

The survey was undertaken from 4th August to 27th September 2014. A summarised log of events is given in the Appendix (section 9.4).

The survey methodology was designed in consultation with MSS, using the IHLS standard methodology, to ensure adequate coverage of known spawning areas.

A dispensation from MSS, in accordance with the terms of Section 9 of the Sea Fish Conservation Act 1967 and Article 43 of Council Regulation No. 850/98, to fish in Area IVab related to days at sea was obtained prior to commencement of this survey.

5.1 Survey Vessels

Two vessels were chartered for the survey following discussions with Scottish Fishermen's Federation Services Ltd. (SFF). The fishing vessels Antaries (BF27; Figure 5.1) and Pleiades (BF155; Figure 5.2) undertook the sampling on a two week rotation.

5.1.1 Antaries (BF27)

Antaries (Figure 5.1) is a steel hulled, 16.70 metre, Fraserburgh based trawler. The specifications of the vessel are given below in Table 5.1.

Figure 5.1 Survey vessel Antaries

Table 5.1 Antaries vessel specifications

Survey Vessel Specifications	
Length	16.70m
Beam	6.45m
Draft	2.76m
Main engine	Caterpillar 3408-DITA-JW 363KW
GPS	2x Koden KGP-913D
Radar	JRC 5200 series (ARPA) & Koden MD3441
Plotters	Fishmaster Plotter and Trax Plotter
Sounder	Koden CVS8841
Berths	6

5.1.2 Pleiades (BF155)

Pleiades (Figure 5.2) is a steel hulled, 17.50 metre, Fraserburgh based trawler. The specifications of the vessel are given below in Table 5.2.

Figure 5.2 Survey vessel Pleiades

Table 5.2 Pleiades vessel specifications

Survey Vessel Specifications	
Length	17.50m
Beam	6.65m
Draft	3.07m
Main engine	Caterpillar 3408-480HP
GPS	Furuno SC50
Radar	Furuno Navnet Vx2 (ARPA & Ais modules); Furuno
Plotters	Fishmaster Plotter and Trax Plotter
Sounder	JRc-JFC 130
Berths	8

5.2 Sampling Gear

A Gulf VII high speed plankton sampler was used for sampling herring larvae with a plankton net with mesh size of 270µm. The amount of water filtered during each haul was measured using a General Oceanics flowmeter mounted inside the nosecone. An external flowmeter was mounted on the frame of the sampler. The sampler was fitted with a SAIV A/S SD204 probe to record conductivity, temperature and depth (CTD) measurements. An Applied Acoustics transponder was also fitted to give a real time feed of the sampler depth using an Applied Acoustics Portable Acoustics Modem (PAM 35 10). The transducer was deployed below the water surface using an aluminium pole attached to the side of the vessel to allow a clear 'line of sight' between the transducer and transponder.

The specifications of the Gulf VII plankton sampler are given below in Table 5.3. The Gulf VII used during the survey is shown in Figure 5.3.

Table 5.3 Gulf VII plankton sampler specifications

Gulf VII Plankton Sampler Specifications	
Frame size	50cm frame with tail fin
Nose cone	20cm
Scripps type depressor	20kg bronze
Drogue	1 standard form
Net	270 micron
Cod ends	Screw fit type
Flow meter	General Oceanics mechanical flowmeters (internal and external)
Deployment cable	9mm 6x36 IWRC galv rho 1960 grade MBL:5.76t
CTD probe	SAIV- A/S SD204
Transducer Control Box	Applied Acoustics PAM 35-10
Dunker	Applied Acoustics PAM 3 MF 3910
Beacon	Applied Acoustics 1019D

Figure 5.3 BMM Gulf VII plankton sampler

5.3 Sampling Procedure

Accepting weather constraints, sampling was carried out during eight separate trips of four days duration, the first commencing early August and continuing until late September. The 25 sampling locations are given in Figure 4.1. The sampling locations were encompassed within the 90 dBht ranges modelled for herring and cross referenced with previous IHLS results and the area defined by Coull *et al*. (1998) as the Moray Firth herring spawning ground.

At each station the Gulf VII high speed plankton sampler was deployed in a double oblique tow (V-shaped haul through the water column) to 3 - 5m above the sea floor. The standard towing speed was between 4 - 5 knots, directed into the tide. The cable pay out speed when shooting and hauling the sampler was continuous to ensure representative sampling at all depths. The cable pay out speed was such that each 10 metres of the water column was sampled for at least 1 minute.

5.3.1 Positioning and Navigation

The position of the vessel was tracked at all times using a Garmin GPSMap 278 with an EGNOS differential connected to an external Garmin GA30 antenna. Tow start times and positions were taken when the sampler makes contact with the sea surface and tow end times and positions were taken when the sampler returned to the surface. The vessel tracks whilst towing the sampler for each of the eight weeks are illustrated in the Appendix (section 9.6). The start and end times, co-ordinates and duration of each plankton tow are given in the Appendix (section 9.5).

For each station, information was logged on the station number, position, date and time, haul duration, internal and external flowmeter revolutions, bottom and sampler depth, water

bottom temperature and vessel direction of tow. The sampler depth was monitored continuously throughout the tow.

Due to weather constraints, it was was not always possible to undertake sampling at all stations each week. A summary of the number of stations completed each week is given in Table 5.4.

Table 5.4 Summary of Survey Stations Completed

Week	Stations completed	No. stations completed	Reason
1	24, 23, 25, 22, 21, 17, 14. 18, 15, 19, 16, 12, 09, 11, 08, 05, 02, 01, 03, 06, 04, 07, 10, 13, 20	25	
2	18, 15, 09, 08, 02, 01, 04, 10	8	Prolonged adverse weather conditions
3	23, 25, 21, 14, 18, 16, 12, 09, 08, 01, 03, 06, 04, 10.	14	Static gear at station HL02 and adverse weather conditions
4	24, 23, 25, 22, 21, 17, 14, 18, 15, 19, 16, 12, 09, 11, 08, 05, 01, 03, 06, 04, 07	21	Static gear at station HL02 and adverse weather conditions
5	24, 23, 25, 22, 21, 17, 14, 18, 15, 19, 16, 12, 9, 11, 08, 05, 01, 03, 06, 04, 07, 10, 13, 20	24	Time and tidal constraints with slack water at station 01
6	24, 23, 25, 22, 21, 17, 14. 18, 15, 19, 16, 12, 09, 11, 08, 05, 02, 01, 03, 06, 04, 07, 10, 13, 20	25	
7	24, 23, 25, 22, 21, 17, 14. 18, 15, 19, 16, 12, 09, 11, 08, 05, 02, 01, 03, 06, 04, 07, 10, 13, 20	25	
8	24, 23, 25, 22, 21, 17, 14, 18, 15, 19, 16, 12, 09, 11, 08, 05, 02, 03, 01, 06, 04, 07, 10, 13, 20	25	

5.3.2 Sample Retrieval and Preservation

After recovery of the Gulf VII sampler, the front of the sampler was raised to ensure the contents of the net washed down into the cod-end. The cod-end with the initial catch was removed. A second cod end was fitted and the net was very gently washed down with seawater. The sample was retrieved from the cod ends and preserved in screw top jars using 4% borax buffered formalin in seawater. The plankton volume did not exceed 20% of the jar volume on the advice of Marine Scotland and additional jars were used if required.

5.3.3 Sample Analysis

Sample analysis was undertaken by Jacobs Engineering Ltd. Samples were drained and sorted under a low powered microscope. Any fish larvae, post-larvae and juveniles present were removed, measured (total length, mm) and speciated using appropriate keys and literature (e.g. Russell, 1976). A sub sample of 50 individuals was measured if high numbers of a particular species other than herring were encountered.

6 Herring Larval Results

6.1 Herring Abundance and Distribution

The total number of herring larvae and larvae <10mm and ≥10mm caught for each week of the survey is given in Table 6.1. A total of 18,544 herring larvae were recorded during the survey. No herring larvae were caught in sampling weeks 1 and 2. The majority of herring larvae were <10mm (78.1%). The largest number of herring were caught in week 7 (38.2% of the total catch) with 96.3% of the total catch caught in weeks 6, 7 and 8 combined. It should be noted that no herring larvae caught were recorded with a yolk sac.

A total of 46 other fish species were caught during the survey. The number of individuals caught for each bycatch species by sampling week is given in Table 9.4 in the Appendix (section 9.3).

Table 6.1 Number of herring larvae of <10mm and ≥10mm recorded

Week	<10mm	≥10mm	Total
1	-	-	-
2	-	-	-
3	21	61	82
4	13	168	181
5	122	306	428
6	4,993	512	5,505
7	5,896	1,180	7,076
8	3,447	1,825	5,272
Total	14,492	4,052	18,544

As the volume of water filtered was recorded for each tow, herring larvae abundance was calculated using the below formula, which is used for the IHLS surveys (Smith & Richardson, 1977).

Herring larval abundance below a square meter of sea surface at each station were calculated as:

$$n/m^2 = \frac{herring\ larvae\ per\ sample\ (n) * bottom\ depth\ (m)}{Volume\ filtered\ (m^3)}$$

The total herring larvae abundance (n/m^2) for herring larvae <10mm and ≥10mm for each week of the survey is given in Table 6.2. Total herring larvae abundance for each station is given in the Appendix (section 9.1).

Table 6.2 Herring larvae (n/m^2) of <10mm and ≥10mm recorded

Week	<10mm	≥10mm	Total
1	-	-	-
2	-	-	-
3	19.3	54.0	73.4
4	11.5	156.6	168.2
5	97.4	279.9	377.4
6	5,029.3	488.4	5,517.8
7	6,034.7	1,207.9	7,242.6
8	3,683.7	2,139.9	5,823.6
Total	14,876.1	4,326.9	19,202.9

Spatial distribution plots showing the abundance of herring larvae <10mm were produced for every station sampled for each survey week in which herring larvae were recorded (6 out of 8 weeks). No herring larvae were recorded in weeks 1 and 2. The spatial plots for weeks 3 to 8 are given in Figure 6.1 to Figure 6.6. The circle size corresponds to the abundance i.e. larger circles indicate higher abundances.

Low abundances of herring larvae (<10mm) were observed during weeks 3, 4 and 5 with the largest numbers recorded at the most northerly stations of the survey area. Abundance of <10mm herring larvae showed a sharp increase after week 5 with weeks 6, 7 and 8 showing high herring larvae abundance (5,029.3 per m^2, 6,034.7 per m^2 and 3,683.7 per m^2, respectively). The stations with the highest abundances were to the north and to the east of the development area.

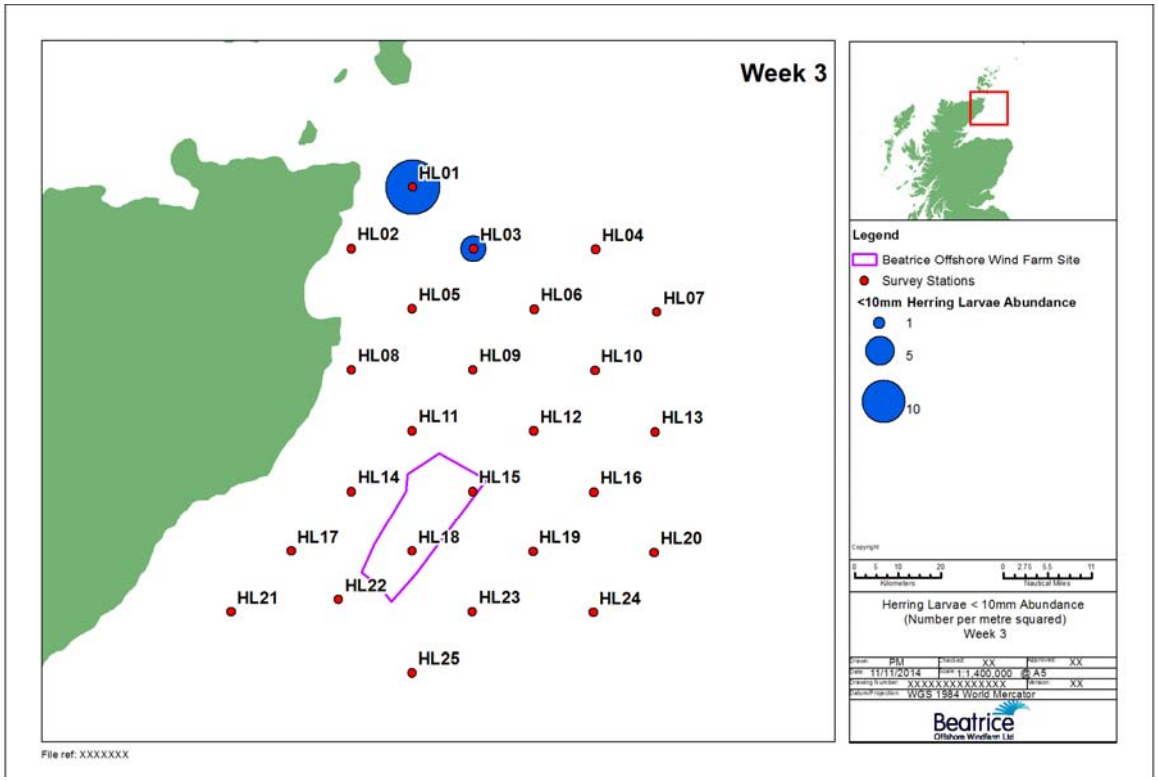

Figure 6.1 Herring larvae abundance (n/m^2) in week 3

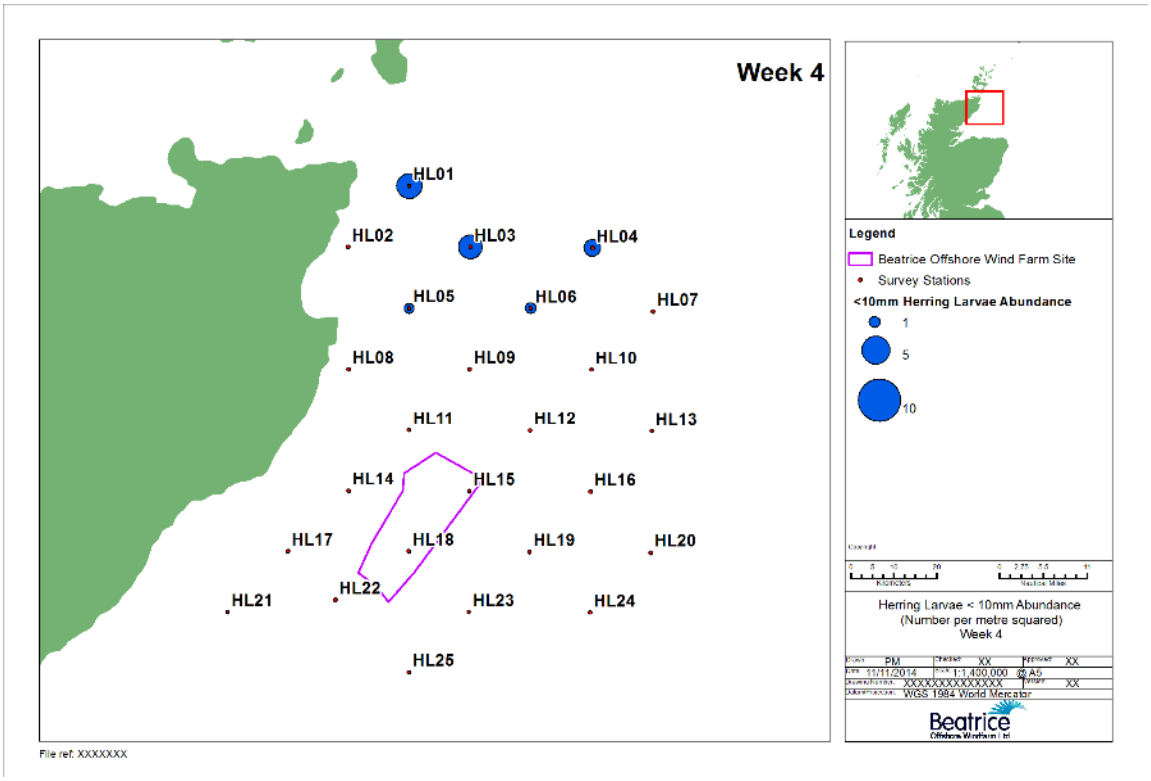

Figure 6.2 Herring larvae abundance (n/m^2) in week 4

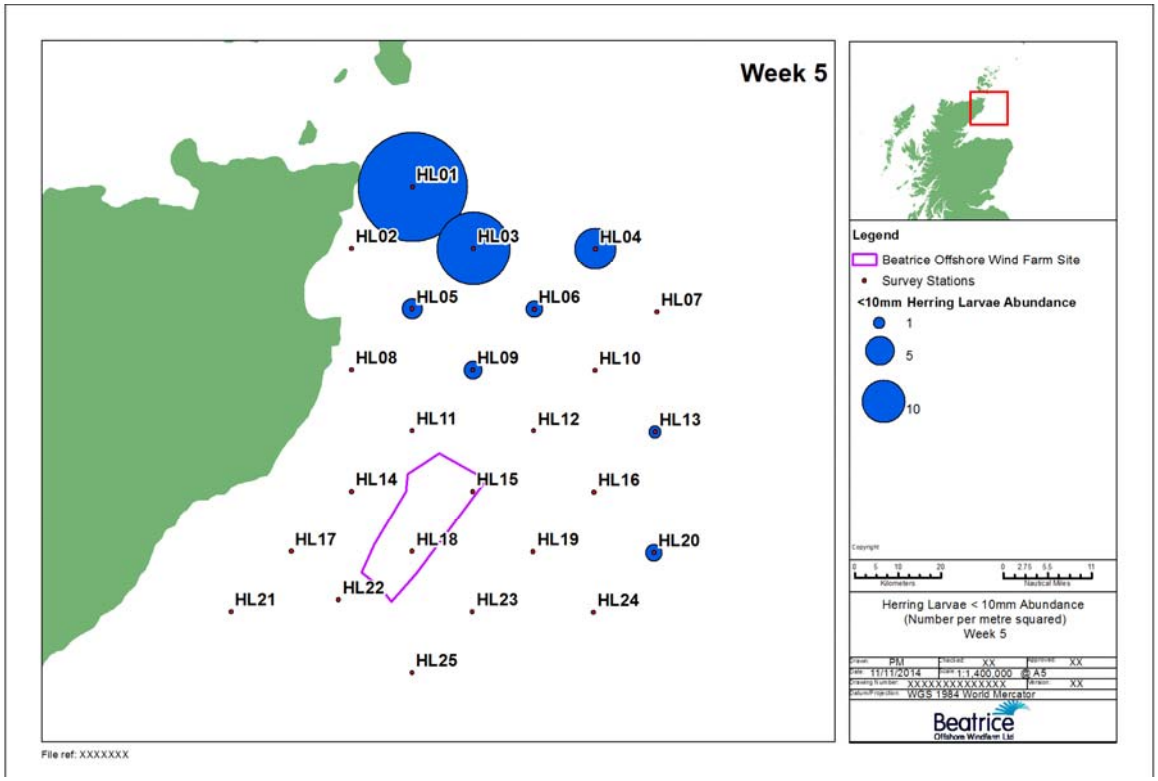

Figure 6.3 Herring larvae abundance (n/m^2) in week 5

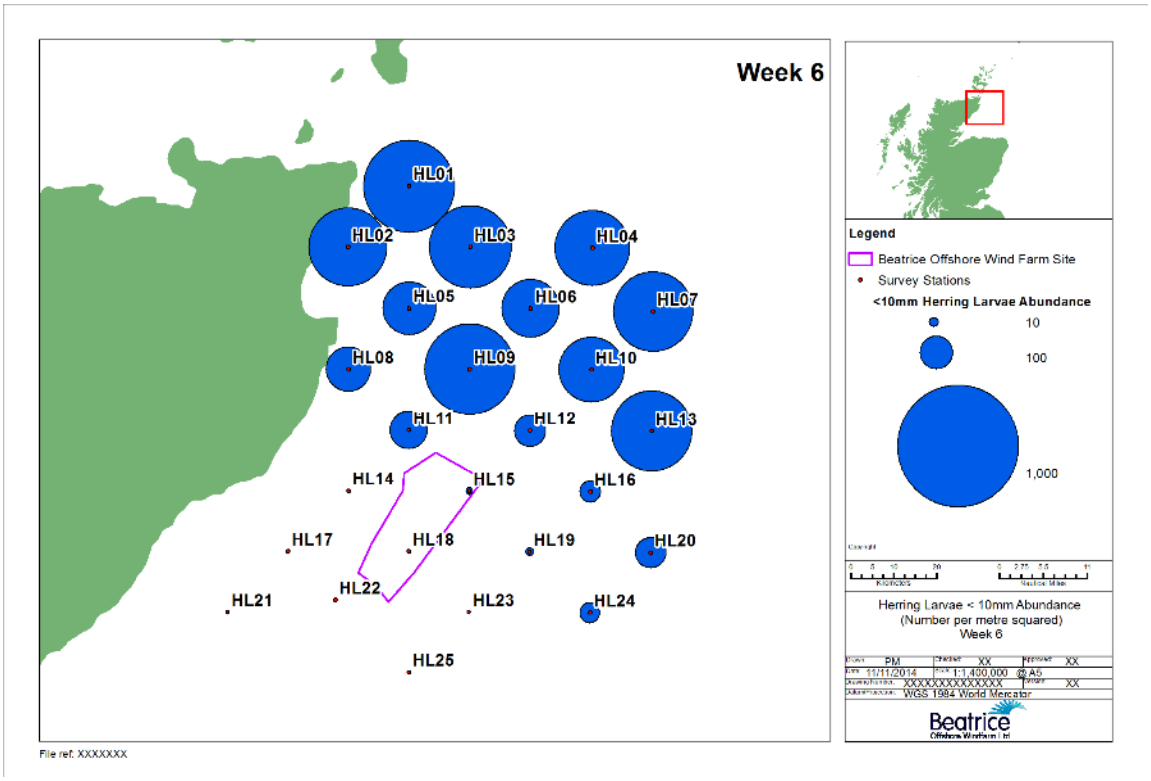

Figure 6.4 Herring larvae abundance (n/m^2) in week 6

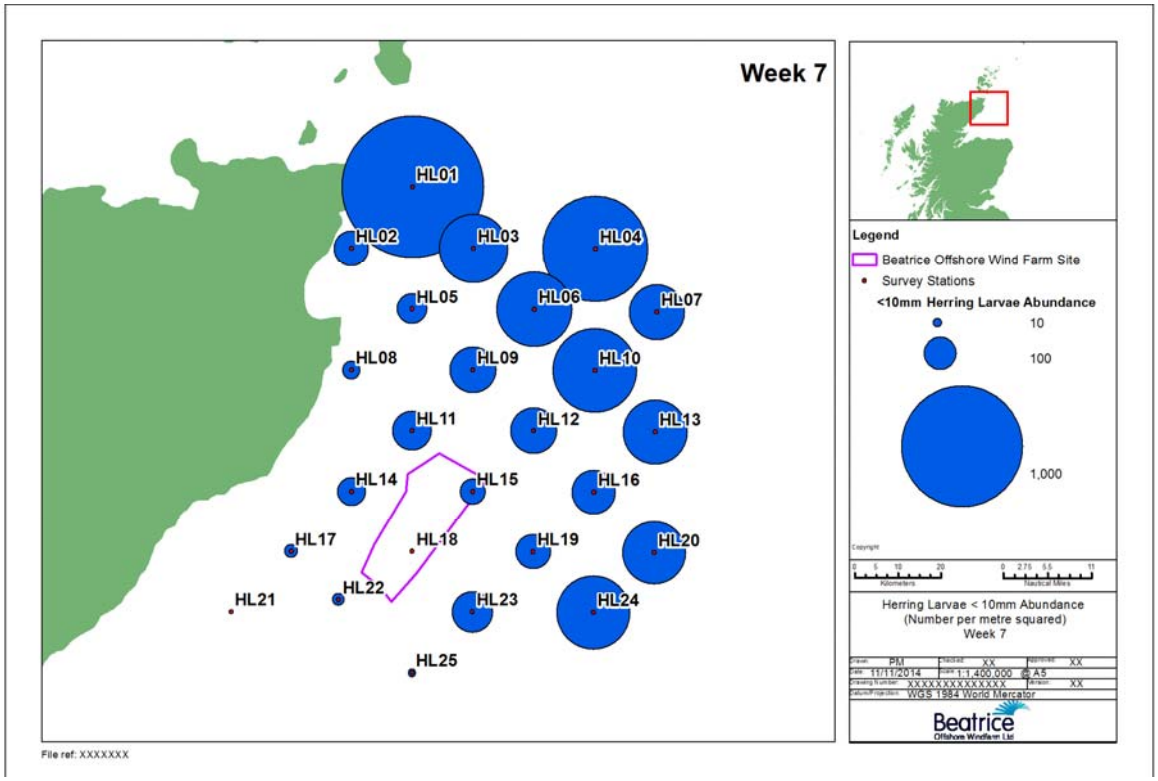

Figure 6.5 Herring larvae abundance (n/m^2) in week 7

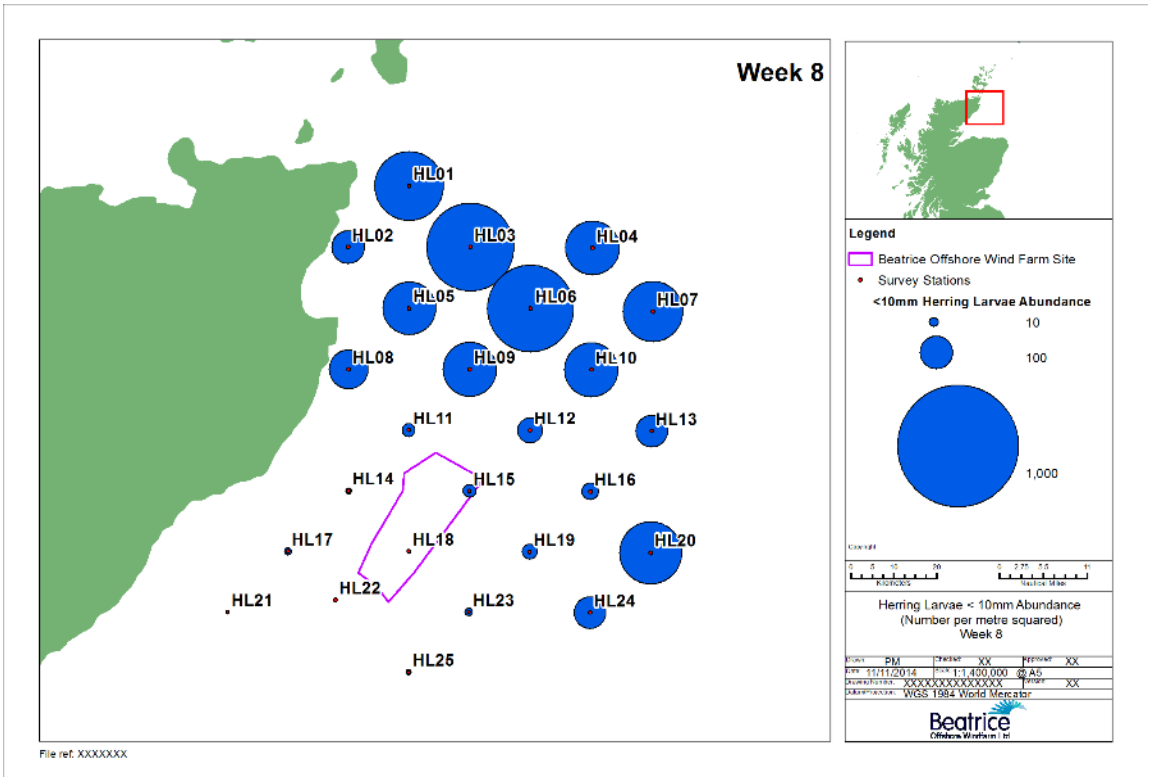

Figure 6.6 Herring larvae abundance (n/m^2) in week 8

6.2 Comparison with IHLS data

In order to compare between data obtained from the IHLS survey and the BOWL survey data, the IHLS abundance data (herring larvae <10mm) was extracted for the same dates surveyed from 2009 to 2012. The 2014 data have not yet been made available from ICES. Whilst there were IHLS data for 2009-2013, after cross-referencing the sampling dates there were only comparable data for 2009 and 2012 in week 7 (Figure 6.7 to Figure 6.10) and for 2009, 2011 and 2013 in week 8 (Figure 6.11 to Figure 6.16). Two sets of charts have been produced for each comparison in order to provide the abundance values in addition to a visual representation of the larval abundance data.

The following IHLS data indicate that comparatively low numbers of herring larvae <10mm (n/m^2) were caught in the vicinity of the BOWL development area in week 7. The larger abundances were recorded north of the survey area, in and around the Orkneys and Shetlands.

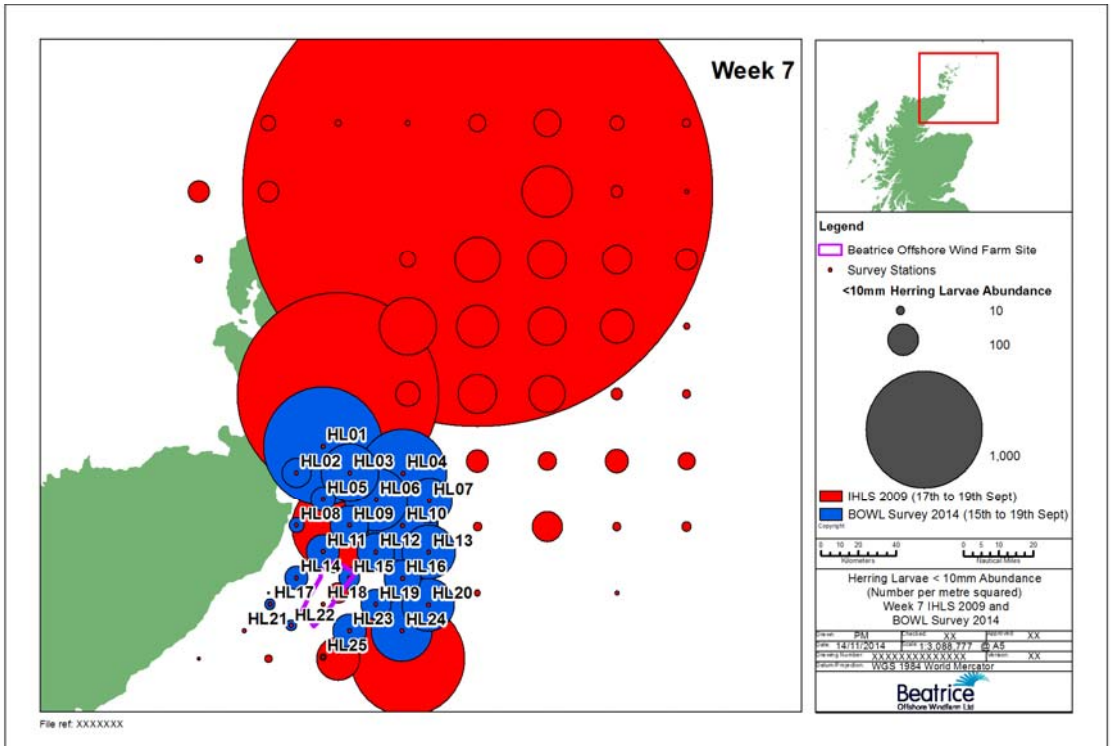

Figure 6.7 Herring larvae abundances recorded during the IHLS 2009 and week 7 of the BOWL 2014 survey for comparable dates

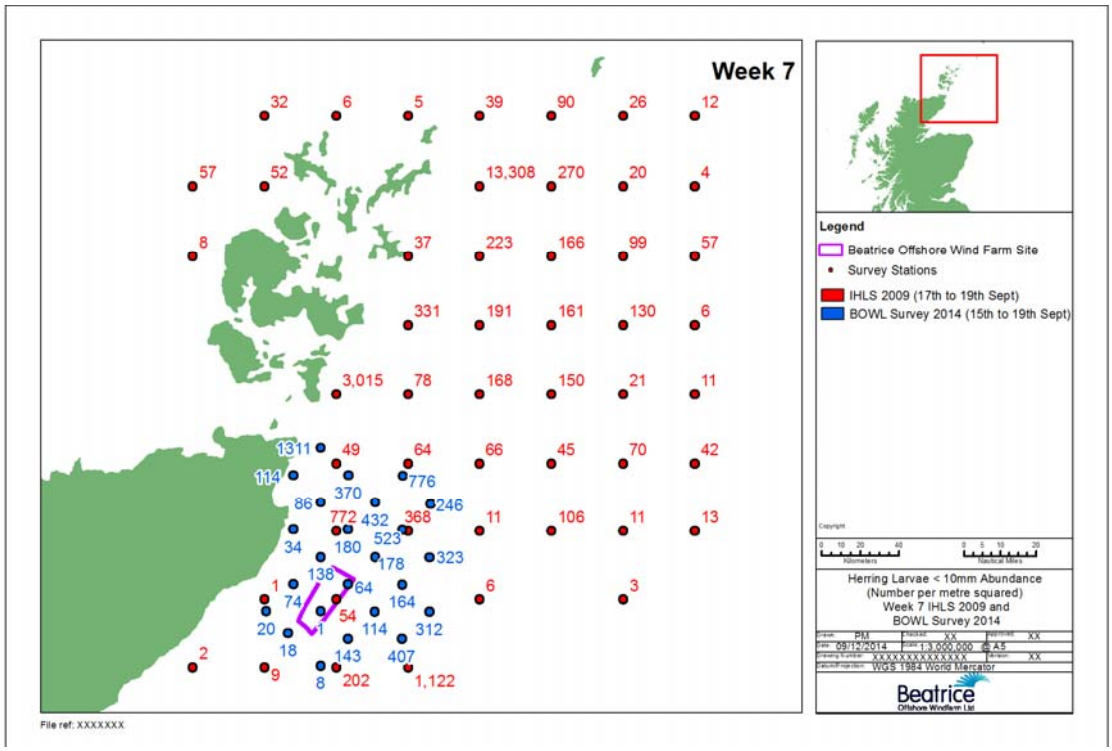

Figure 6.8 Herring larvae abundances recorded during the IHLS 2009 and week 7 of the BOWL 2014 survey for comparable dates (values)

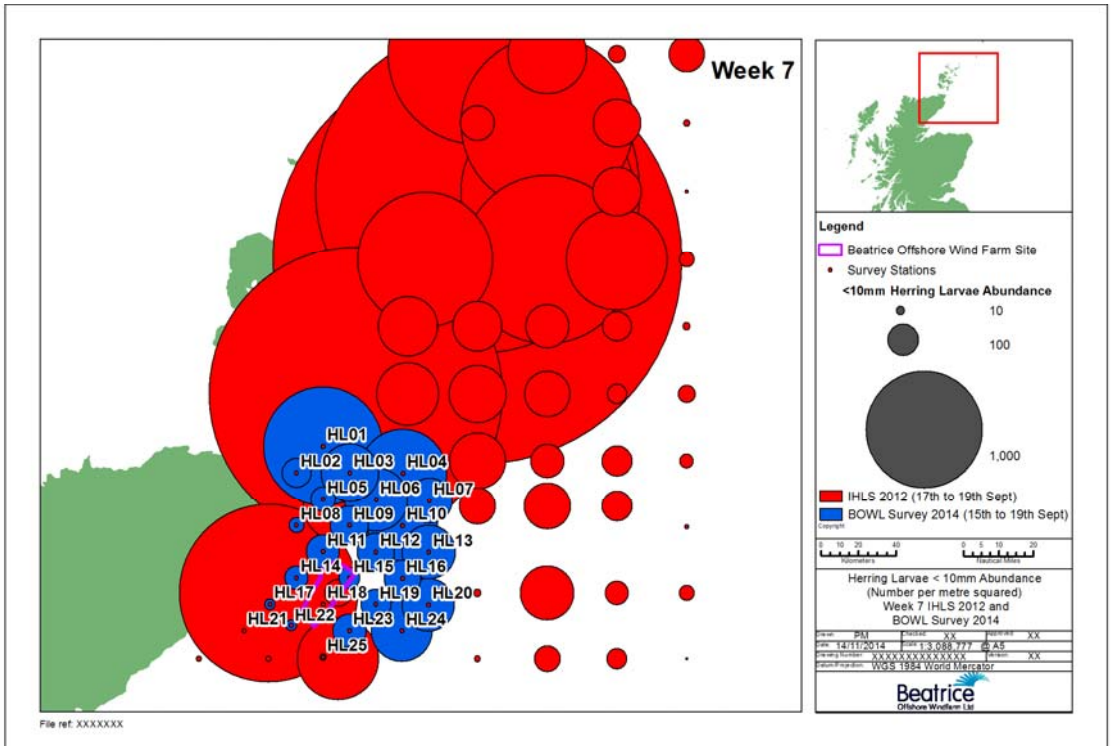

Figure 6.9 Herring larvae abundances recorded during the IHLS 2012 and week 7 of the BOWL 2014 survey for comparable dates

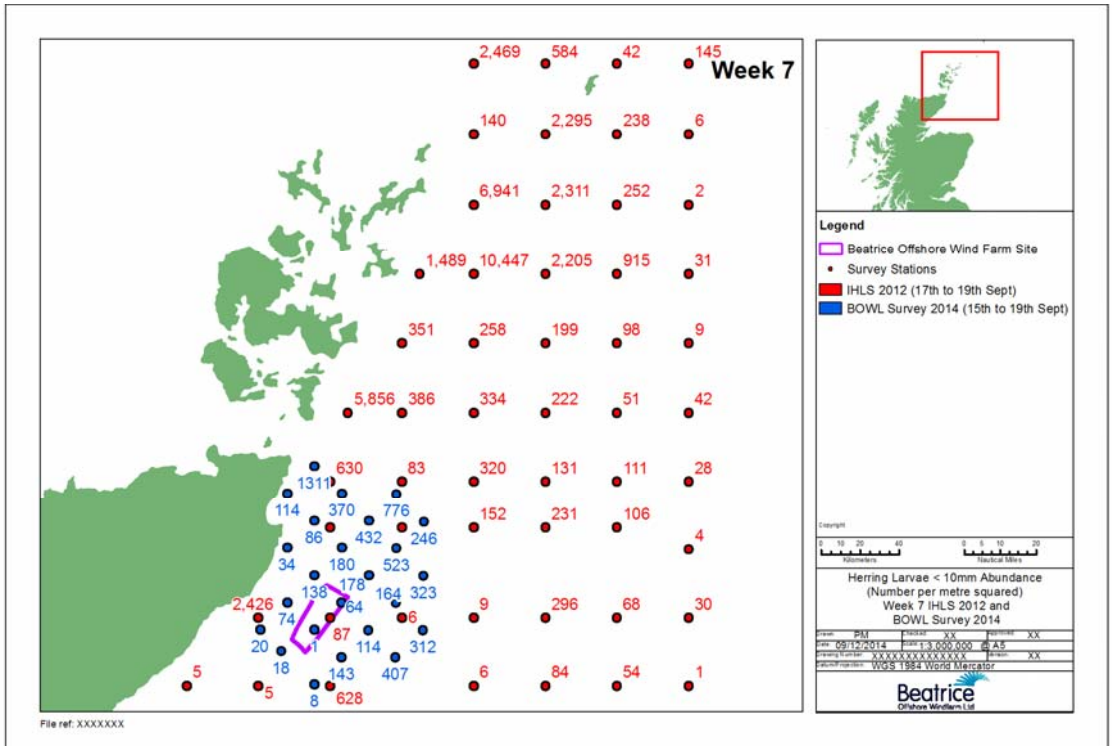

Figure 6.10 Herring larvae abundances recorded during the IHLS 2012 and week 7 of the BOWL 2014 survey for comparable dates (values)

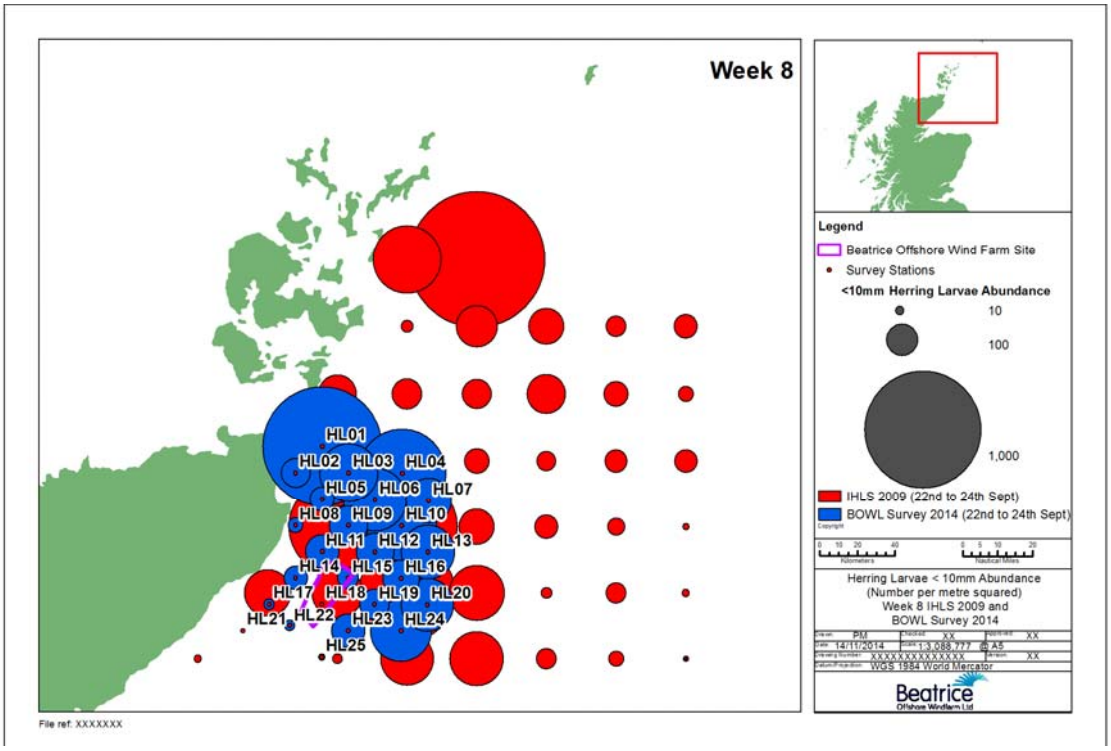

Figure 6.11 Herring larvae abundances recorded during the IHLS 2009 and week 8 of the BOWL 2014 survey for comparable dates

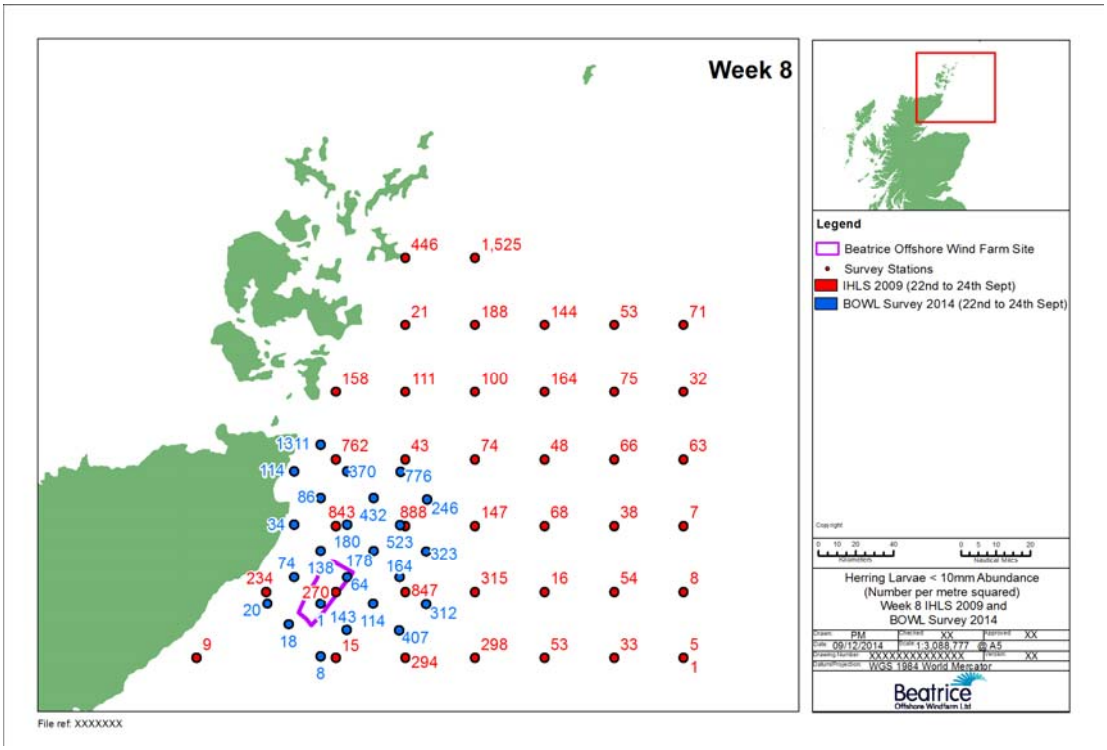

Figure 6.12 Herring larvae abundances recorded during the IHLS 2009 and week 8 of the BOWL 2014 survey for comparable dates (values)

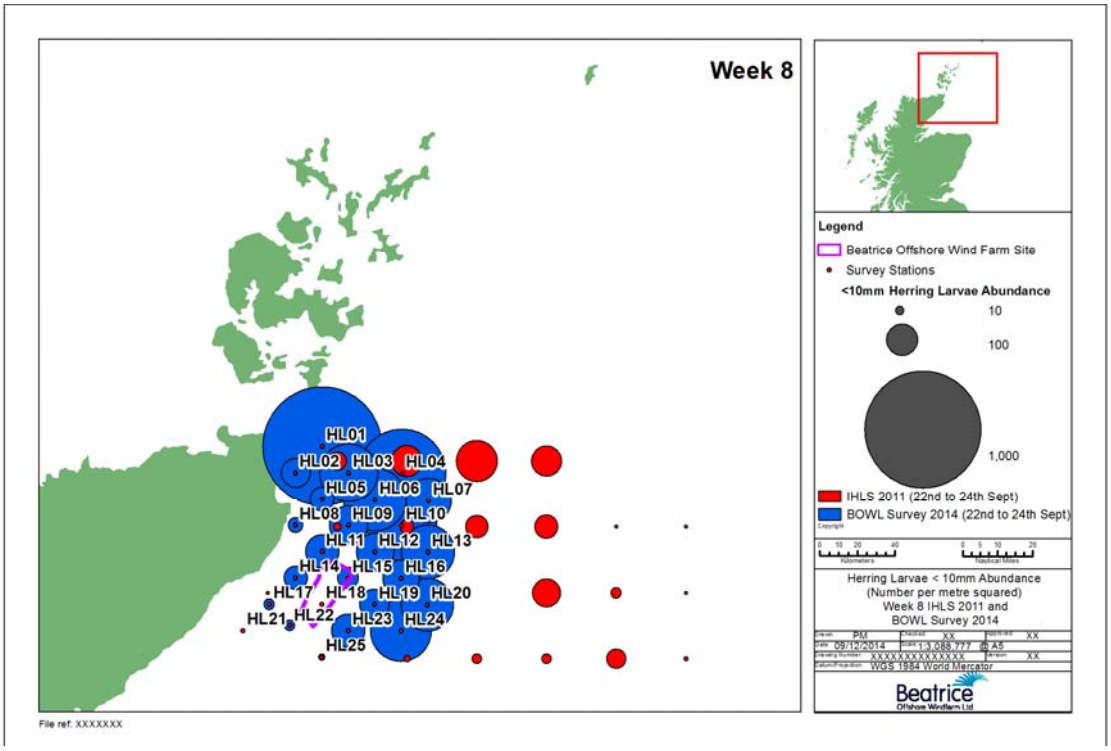

Figure 6.13 Herring larvae abundances recorded during the IHLS 2011 and week 8 of the BOWL 2014 survey for comparable dates

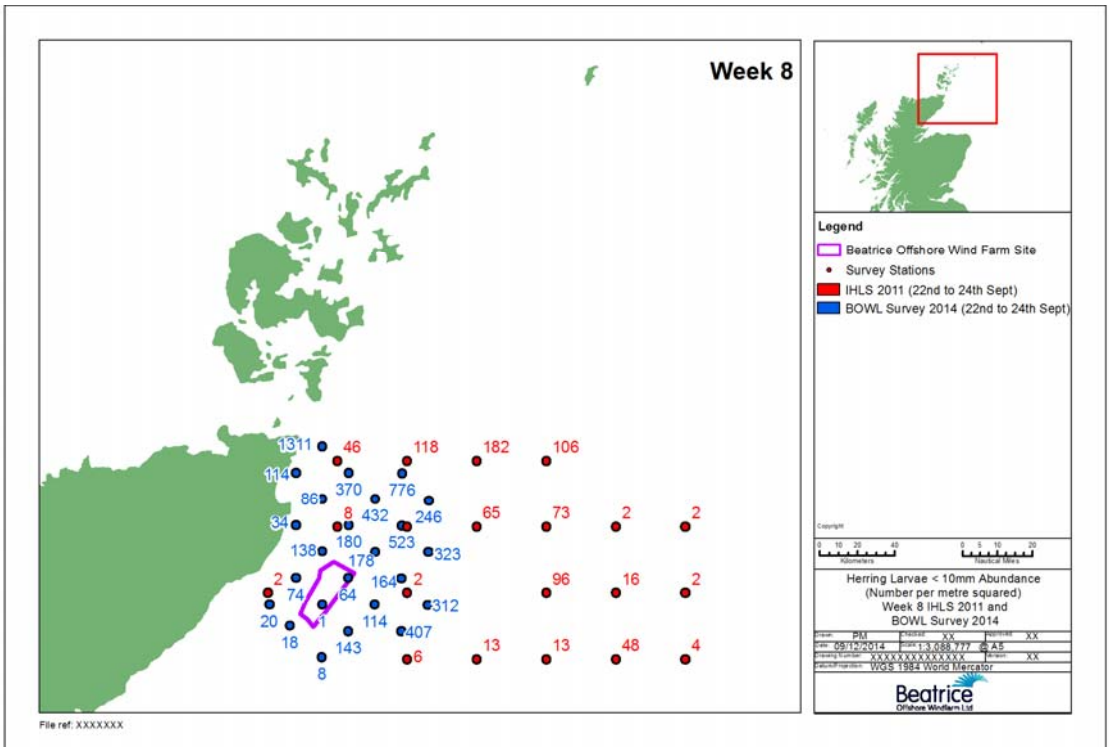

Figure 6.14 Herring larvae abundances recorded during the IHLS 2011 and week 8 of the BOWL 2014 survey for comparable dates (values)

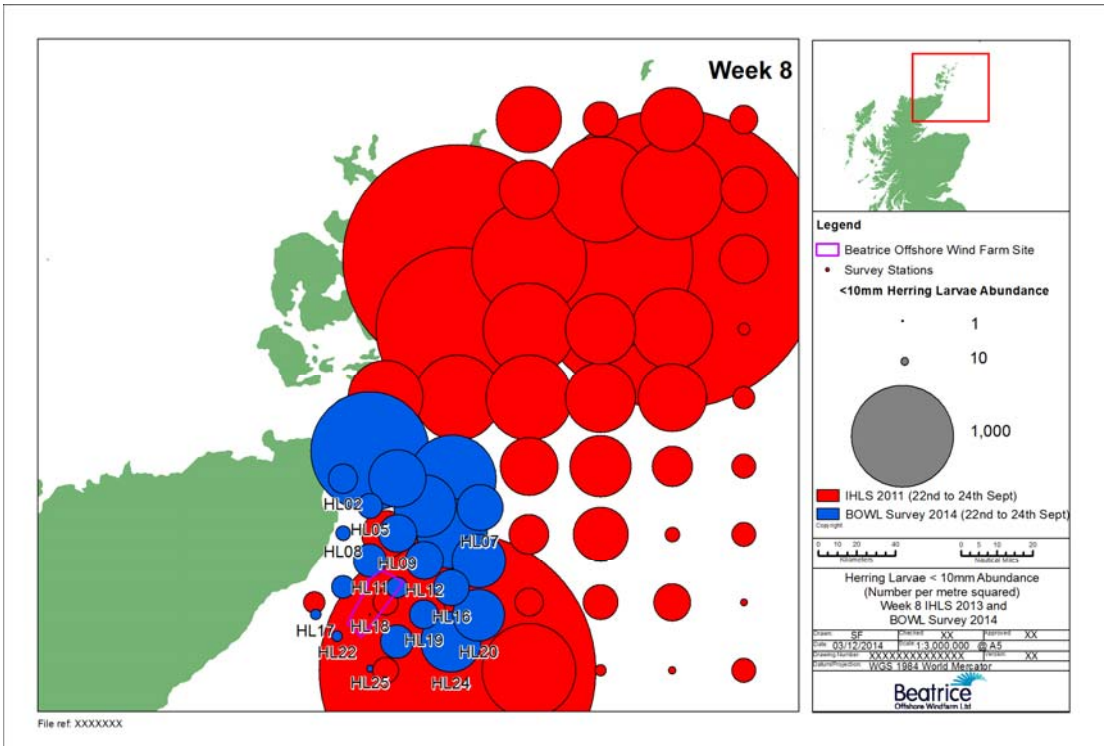

Figure 6.15 Herring larvae abundances recorded during the IHLS 2013 and week 8 of the BOWL 2014 survey for comparable dates

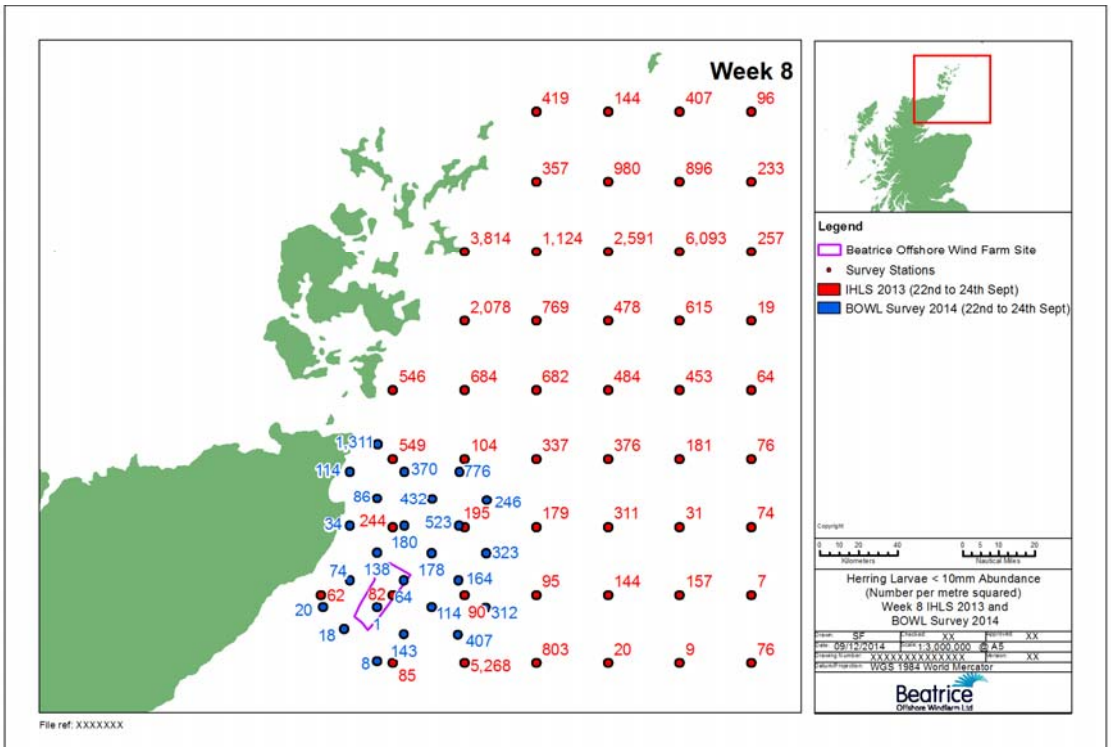

Figure 6.16 Herring larvae abundances recorded during the IHLS 2013 and week 8 of the BOWL 2014 survey for comparable dates (values)

6.3 Herring larvae length distributions

The length distributions of the total number of herring larvae recorded for each sampling week are given in Figure 6.17. The x-axis gives the 1mm length intervals and the y-axis shows the number of individuals caught. The x-axis remains constant for all sampling weeks but the y-axis differs for weeks 6-8 due to the much larger number of individuals recorded.

Figure 6.18 gives the length-frequency of the total number herring larvae recorded during the survey. The majority of herring larvae were <10mm with over 25% of the catch recorded in the length interval 7.0 - 7.9mm.

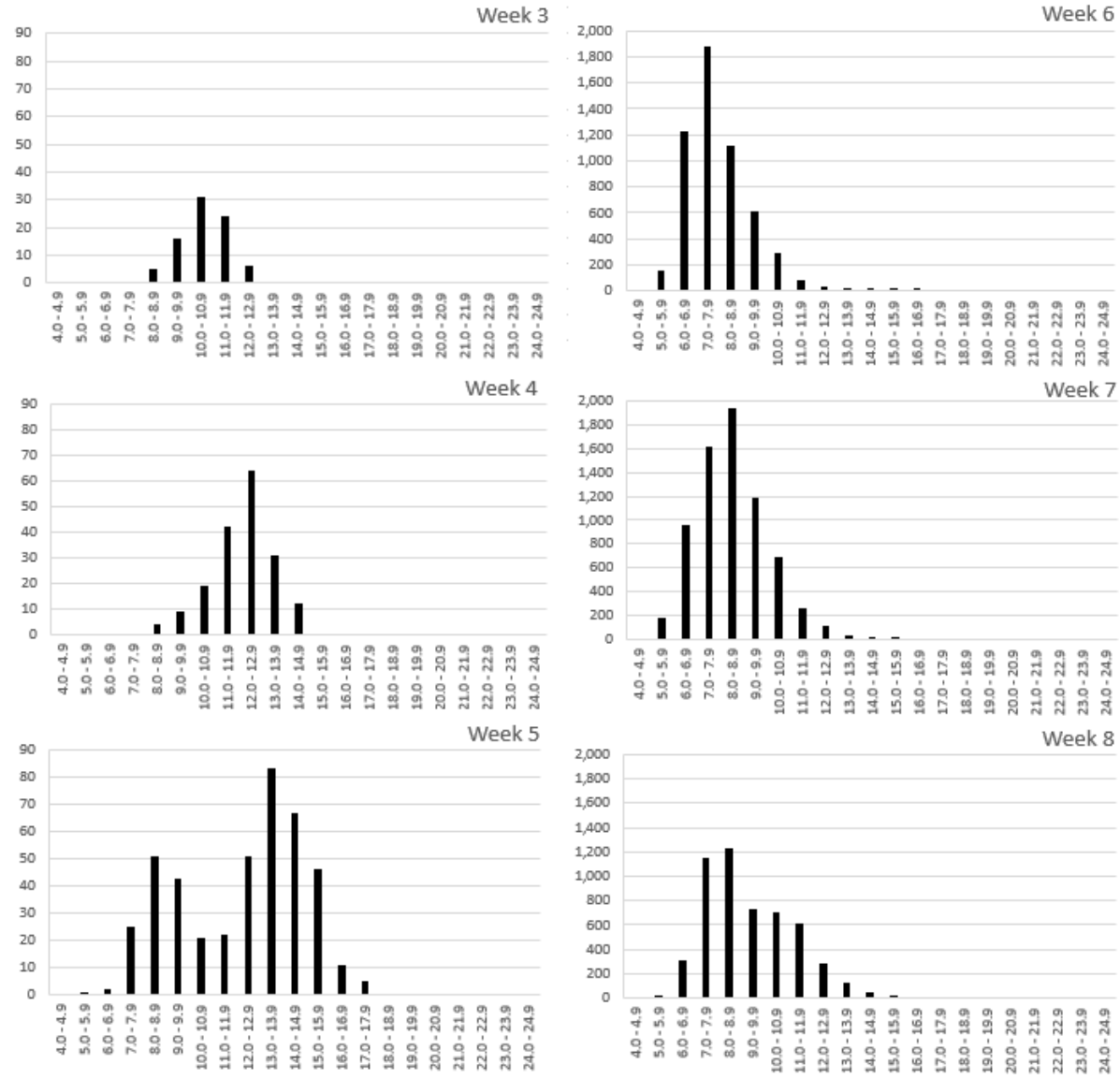

Figure 6.17 Length distributions of the total number of herring larvae recorded in each sampling week

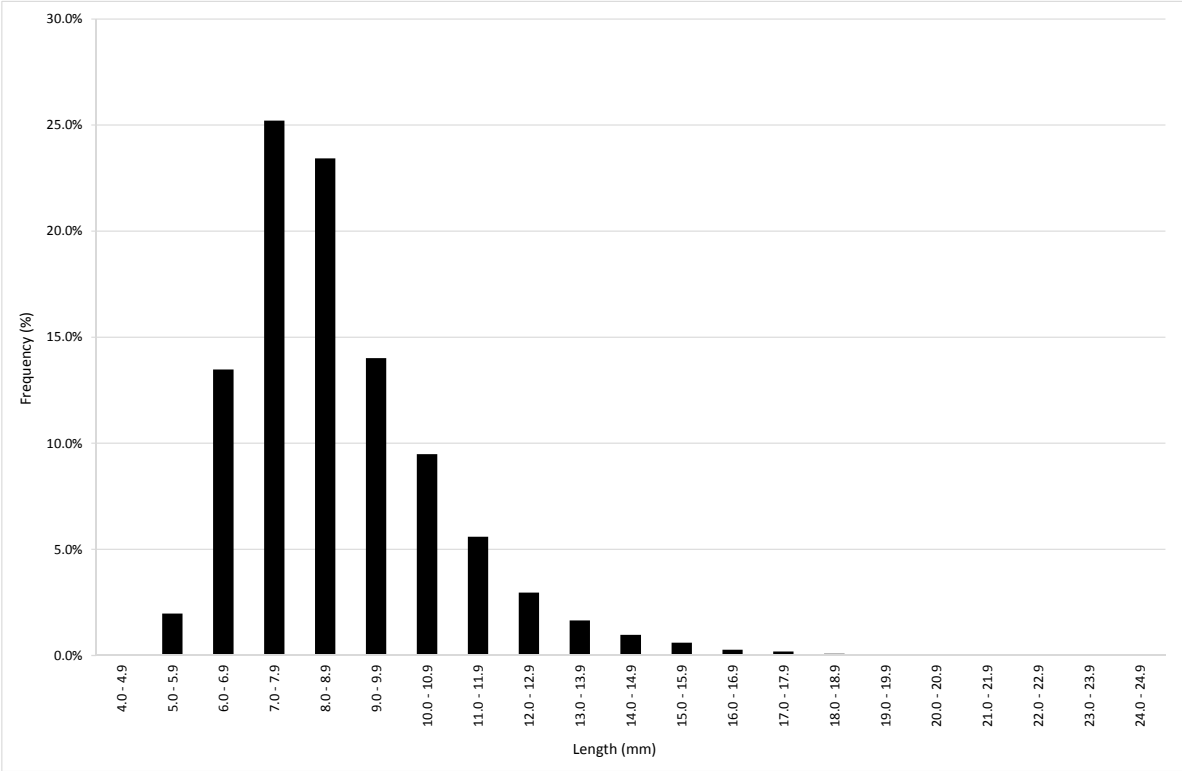

Figure 6.18 Length-frequency plot of total number of herring larvae (mm) recorded

6.4 Spatial distribution of herring larvae by length

Spatial distribution plots showing the abundance of herring larvae in 1 mm size classes have been produced for every station sampled for each survey week in which herring larvae were recorded (6 out of 8 weeks). No herring larvae were recorded in weeks 1 and 2. The spatial plots for weeks 3 to 8 are given in Figure 6.19 to Figure 6.24.The circle size has been standardised and shows only the proportion of each size class recorded at each station.

As shown, there is a general trend of smaller size classes found at the north of the sampling area with larger size classes found in the south. Fish larvae caught in weeks 3 and 4 are predominantly larger with no larvae recorded <8mm. In week 5 a small proportion of 6 – 7mm fish are recorded in the most northerly stations. Week 6 shows a higher proportion of 6-7mm larvae found in the north of the sampling area with larger larvae found in the south. In week 7 and 8, the same general trend is observed as week 6 but there iis a smaller proportion of 6-7mm larvae recorded.

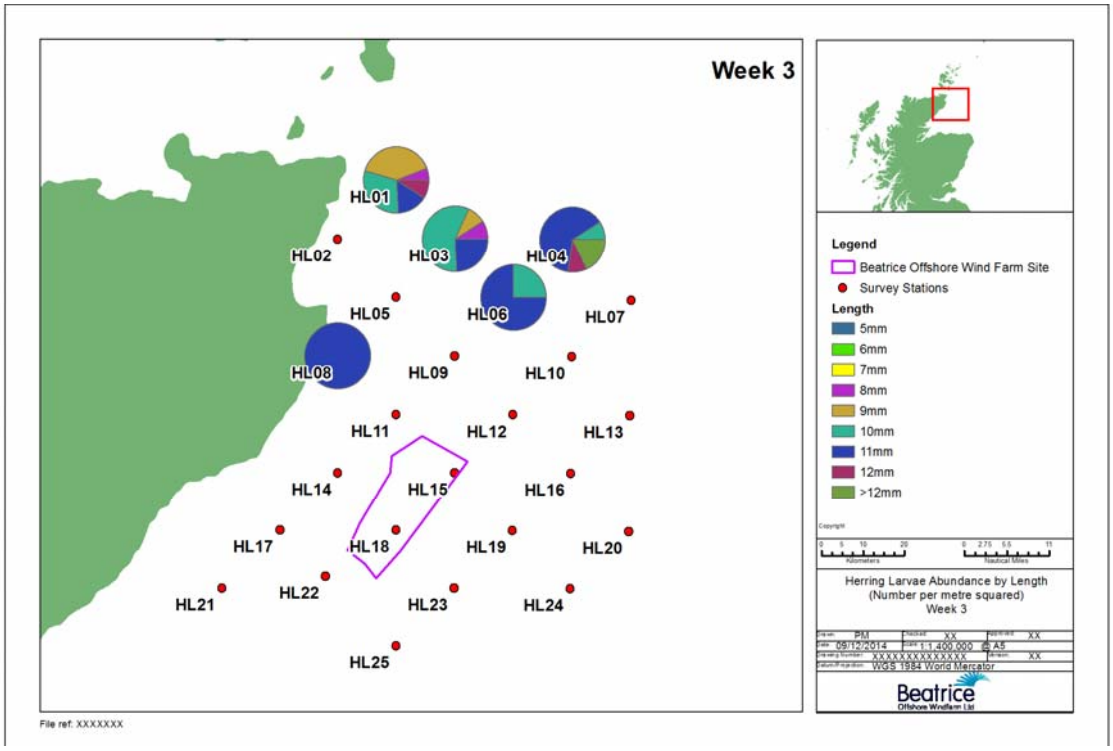

Figure 6.19 Herring larvae length distribution in week 3

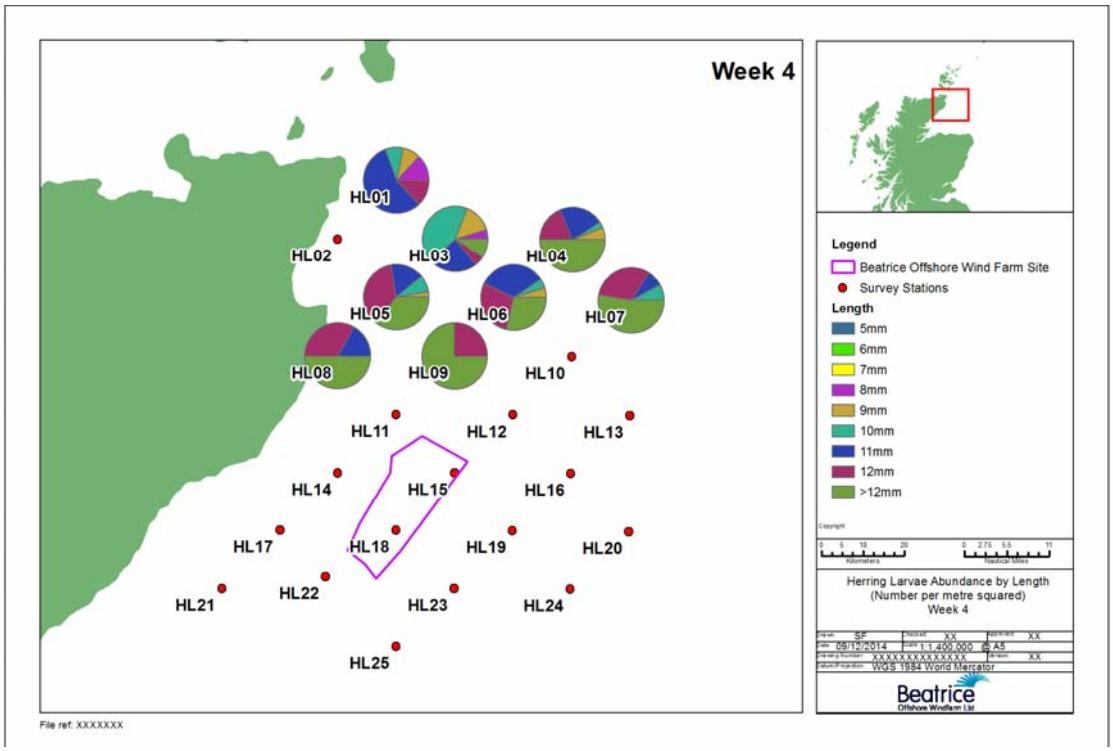

Figure 6.20 Herring larvae length distribution in week 4

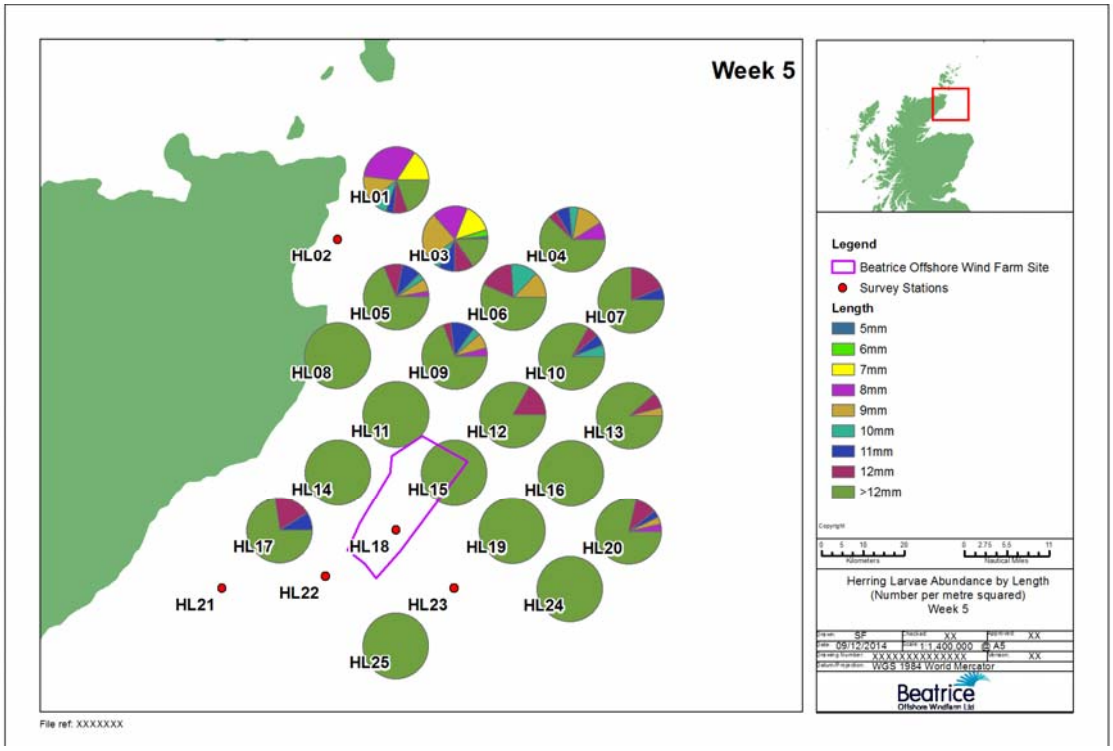

Figure 6.21 Herring larvae length distribution in week 5

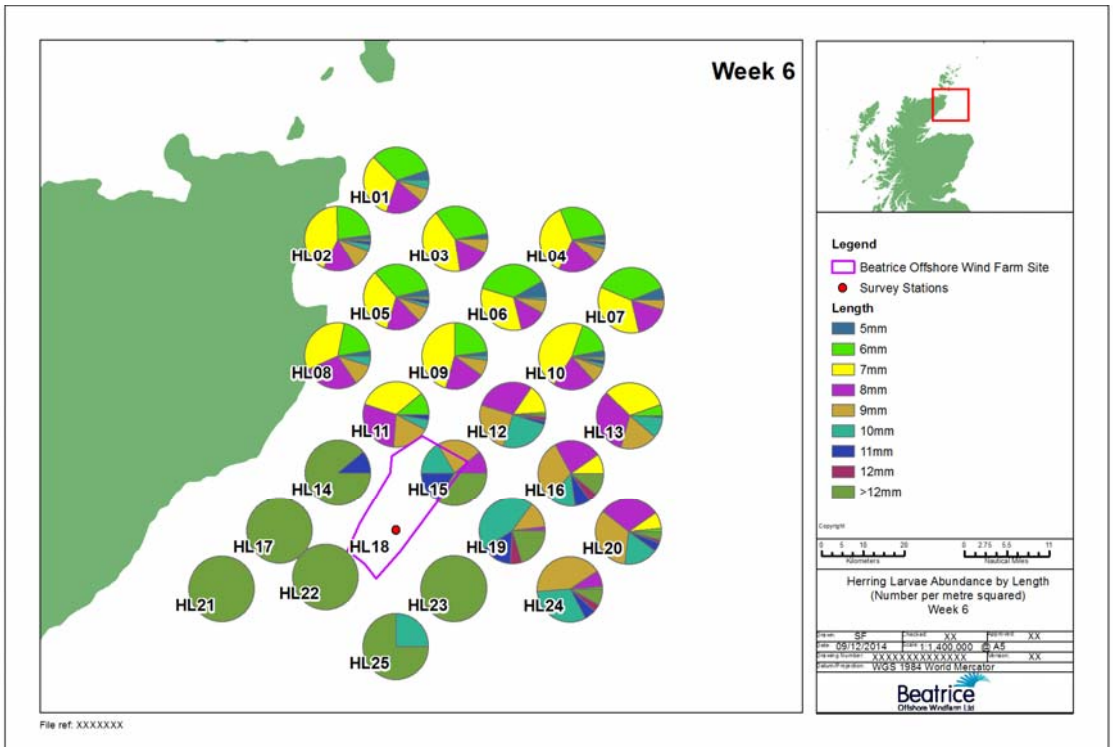

Figure 6.22 Herring larvae length distribution in week 6

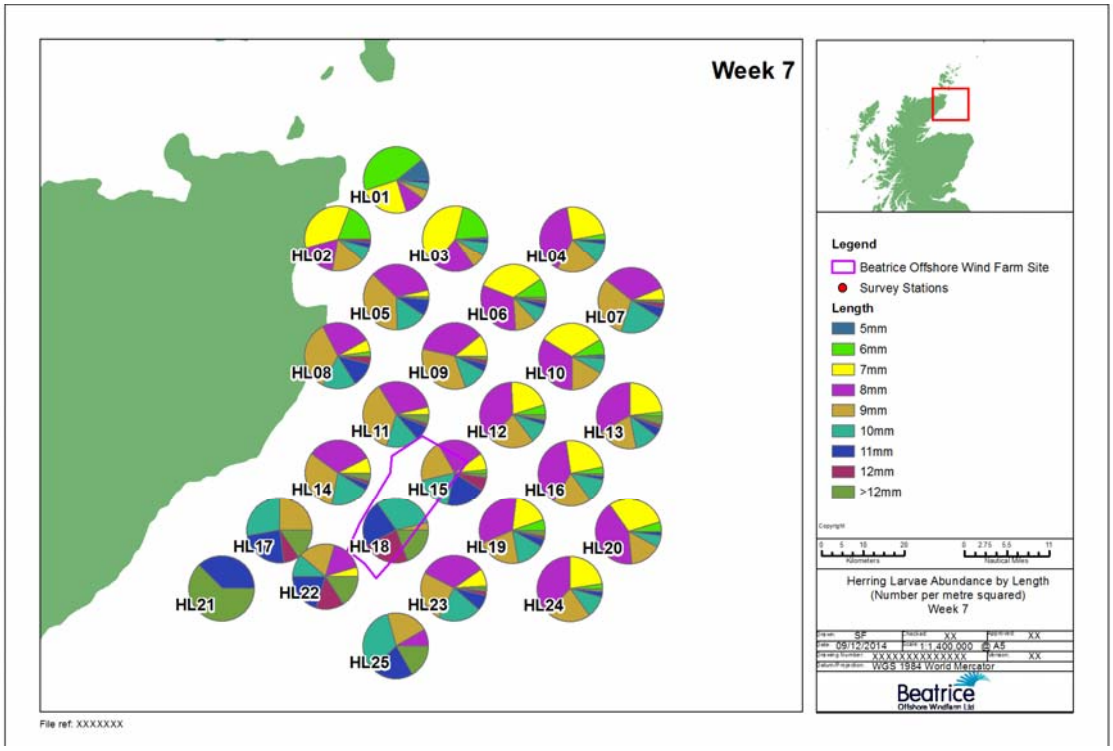

Figure 6.23 Herring larvae length distribution in week 7

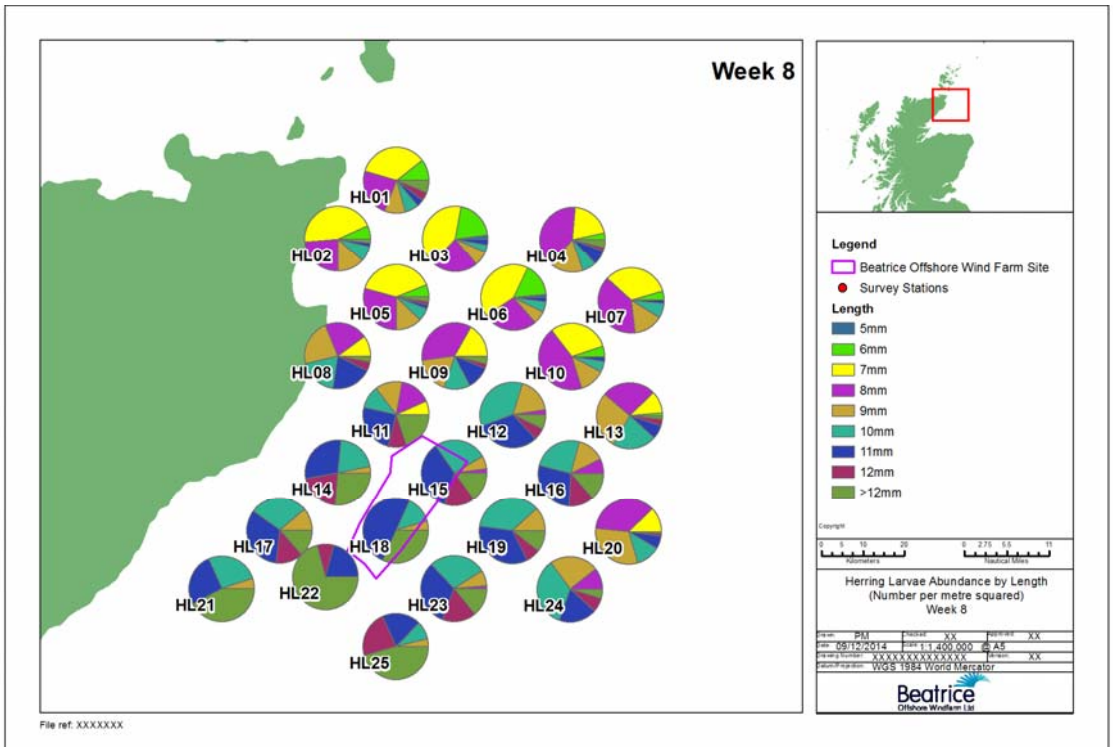

Figure 6.24 Herring larvae length distribution in week 8

6.5 Temperature and Salinity

Salinity (ppt) and temperature (°C) were recorded throughout each tow using a CTD probe on the Gulf VII high speed sampler. Salinity and temperature data were taken from the deepest part of the plankton tow (bottom salinity and temperature) at each station for each survey week and will vary in depth depending on station depth. Surface salinities and temperatures were taken from a standardised 1m depth. Bottom temperature and bottom salinity are used in the IHLS reports and have been spatially plotted for each survey week. Bottom salinity and bottom temperature are shown in the Appendix (section 9.7 and 9.8) in Figure 9.9 to Figure 9.16 and Figure 9.17 to Figure 9.24, respectively.

6.5.1 Salinity

Bottom salinities for the eight survey weeks are shown in Figure 9.9 to Figure 9.16. The range of surface and bottom salinities observed during each week are summarised in Table 6.3.

Surface salinity varied between 34.8 ppt and 35.5 ppt over the eight weeks and bottom salinity ranged between 34.9 and 35.7.

Table 6.3 Surface and bottom salinity range for each survey week

Week	Salinity (ppt)			
	Surface		Bottom	
	Min.	Max.	Min.	Max.
1	34.8	35.1	34.9	35.3
2	35.0	35.1	35.0	35.3
3	35.0	35.2	35.1	35.4
4	35.0	35.3	35.1	35.4
5	35.1	35.3	35.1	35.6
6	35.2	35.4	35.2	35.4
7	35.0	35.5	35.3	35.7
8	35.0	35.5	35.4	35.5

6.5.2 Temperature

Bottom temperatures for the eight survey weeks are shown in Figure 9.17 to Figure 9.24. The range of surface and bottom temperatures observed during each week are summarised in Table 6.4.

Surface temperature varied between 12.8°C and 15.1°C over the eight weeks with the highest temperature observed in week 1. Bottom temperature ranged between 11.9°C and 13.3°C.

Table 6.4 Surface and bottom temperature ranges

Week	Temperature (°C)			
	Surface		Bottom	
	Min.	Max.	Min.	Max.
1	12.8	15.1	11.2	12.8
2	13.0	13.5	11.9	13.1
3	12.9	13.2	12.4	13.1
4	12.9	13.5	12.7	13.1
5	13.0	13.6	11.8	13.2
6	12.9	13.4	12.8	13.2
7	12.8	13.4	11.9	13.2
8	12.8	13.4	12.7	13.3

6.6 Back calculation of spawning date and intensity

Herring larvae <10mm are considered to provide a more accurate refelection of proximity to active spawining grounds. Herring larvae in the Moray Firth have been attributed a hatch size of 6-7mm but can range from 4-10mm (Russel, 1976).

Published values of growth and mortality rates and hatch sizes have been used for this analysis (Dard, 2003; Dickey-Collas *et al*., 2001; Fassler *et al*., 2011; Heath, 1993; Heath *et al*., 1997; Hufnagl & Peck, 2011; ICES, 2009; Johannessen *et al*., 2000; Lazzari & Stevenson, 1992; Munk *et al*., 1986; Payne *et al*., 2013).

It should be noted when using back calculations a study by Geffen (2002) found that “age at hatching determines the hatching length rather than length determining the age at hatching”.

6.6.1 Estimated Ages

Histograms were plotted of the length distribution of herring on each day that herring larvae were caught (Figure 6.25). Ages of herring larvae, in days, were calculated using published values of growth rates and hatch sizes (Dard, 2003; Dickey-Collas *et al*., 2001; Fassler *et al*., 2011; Heath, 1993; Heath *et al*., 1997; Hufnagl & Peck, 2011; ICES, 2009; Johannessen *et al*., 2000; Lazzari & Stevenson, 1992; Munk *et al*., 1986; Payne *et al*., 2013).

Published hatch sizes (here defined as L_0) varied between 6 and 7 mm, while growth rates, *g,* varied between 0.2 and 0.35 mm^{-d}. To reflect the variation in these parameters, ages were estimated using the mean of these values. Additionally, the maximum and minimum possible ages were estimated based on the upper and lower 95% quartiles of the range of published values (Table 6.5, Figure 6.26). Minimum ages were estimated by using a larger hatch size (7 mm) and faster growth rates (0.35 mm^{-d}) while maximum ages were estimated using the small hatch size (6 mm) and slower growth rate (0.2 mm^{-d}). It should be noted that some larvae caught were smaller than published hatch sizes, therefore, as in the literature, these were omitted from the age analysis.

In the literature, studies have found that herring larvae take 6-10 days to absorb the yolk sac after hatching. As no yolk sacs were observed on any of the larvae caught it is proposed that the minimum of 6 days be added to the age back-calculation results. In Table 6.5, the 6 days was added to the mean estimates of herring age.

The mean, lower and upper 95% confidence intervals for the hatch dates of herring larvae

recorded on each day of the survey were plotted (Figure 6.27). The standard approach in the literature (in the absence of data on temperature values experienced by larvae) is to assume linear growth rates for newly hatched larvae, therefore the below formula was applied

$$Age = \frac{L_i - L_0}{g} \qquad (1)$$

where L_i is the measured size of individual i, L_0 the hatch size and g, the growth rate.

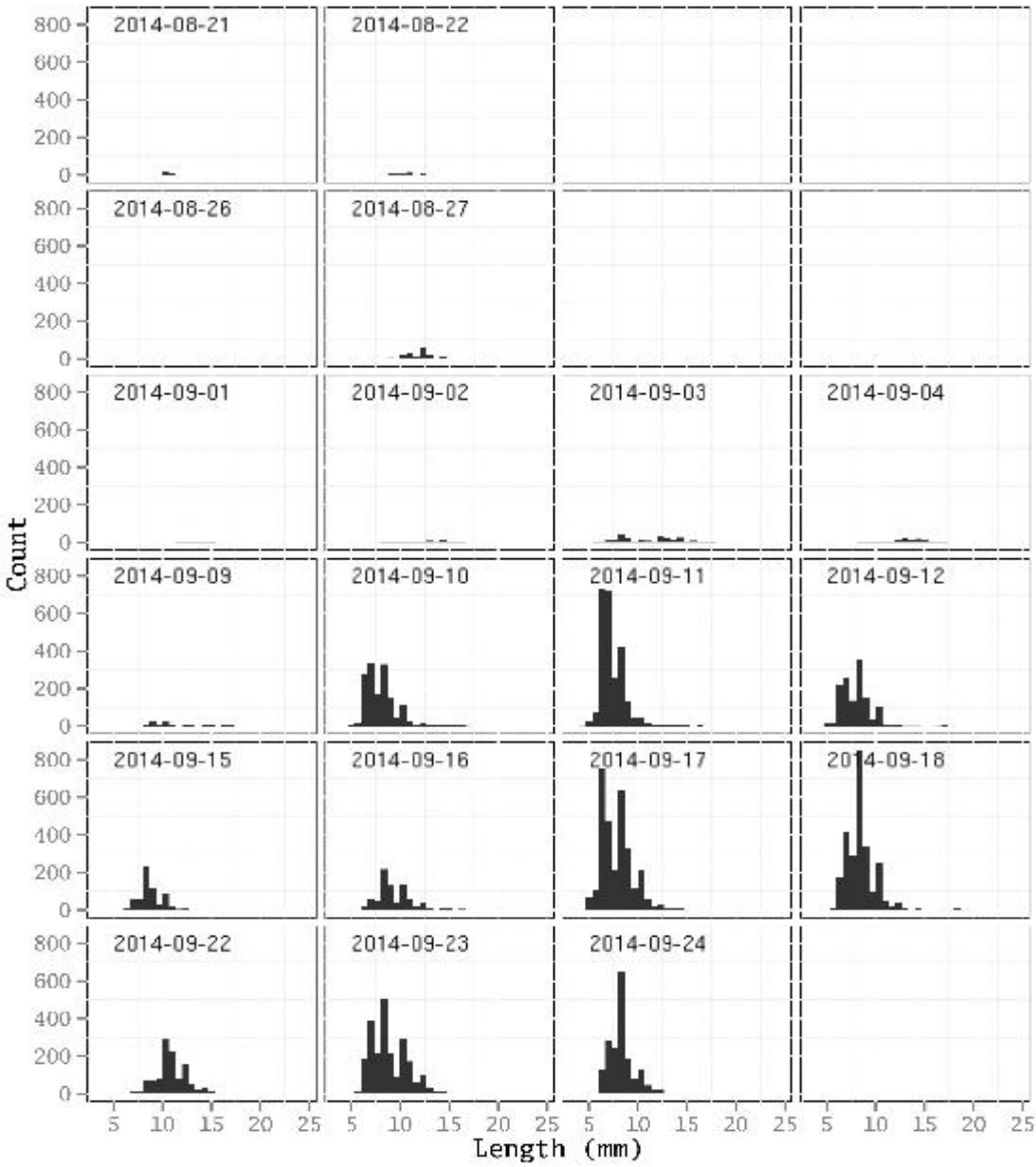

Figure 6.25 Daily histograms of herring larvae size (mm). Each row shows the dates sampled in a sampling week

Table 6.5 Mean, min. and max. estimated ages (in days) for each length of fish encountered in all tows. Min. age is based on the larger hatch size and faster growth rate, while max. age is based on the reverse. Age +6 days is the mean herring larvae age incorporating the absorption time of the yolk sac

Length (mm)	No. larvae	Herring larvae age (days)			
		Mean age	Min. age	Max. age	Age +6 days
4.0	1	-	-	-	-
4.5	7	-	-	-	-
5.0	130	-	-	-	-
5.5	235	-	-	-	-
6.0	1,423	0.12	0	0.89	6.12
6.5	1,076	0.55	0	2.64	6.55
7.0	3,022	1.53	0	4.57	7.53
7.5	1,654	3.28	0.30	6.49	9.28
8.0	3,014	5.22	1.64	8.42	11.22
8.5	1,331	7.27	3.67	10.34	13.27
9.0	1,905	9.32	5.70	12.27	15.32
9.5	694	11.37	7.45	14.19	17.37
10.0	1,204	13.41	9.01	16.14	19.41
10.5	555	15.46	10.56	18.12	21.46
11.0	767	17.51	12.12	20.1	23.51
11.5	269	19.56	13.68	22.53	25.56
12.0	417	21.61	15.24	24.99	27.61
12.5	133	23.65	16.8	27.44	29.65
13.0	211	25.7	18.36	29.9	31.7
13.5	95	27.75	19.92	32.35	33.75
14.0	142	29.80	21.48	34.81	35.8
14.5	38	31.84	23.04	37.26	37.84
15.0	84	33.89	24.60	39.71	39.89
15.5	26	35.94	26.16	42.17	41.94
16.0	40	37.99	27.72	44.62	43.99
16.5	10	40.04	29.28	47.08	46.04
17.0	22	42.08	30.84	49.53	48.08
17.5	12	44.13	32.40	51.99	50.13
18.0	11	46.18	33.95	54.44	52.18
18.5	3	48.23	35.51	56.9	54.23
19.0	7	50.27	37.07	59.35	56.27
20.0	2	54.37	40.14	64.26	60.37
20.5	1	56.42	41.65	66.71	62.42
22.0	2	62.56	46.19	74.08	68.56
24.0	1	70.75	52.24	83.9	76.75

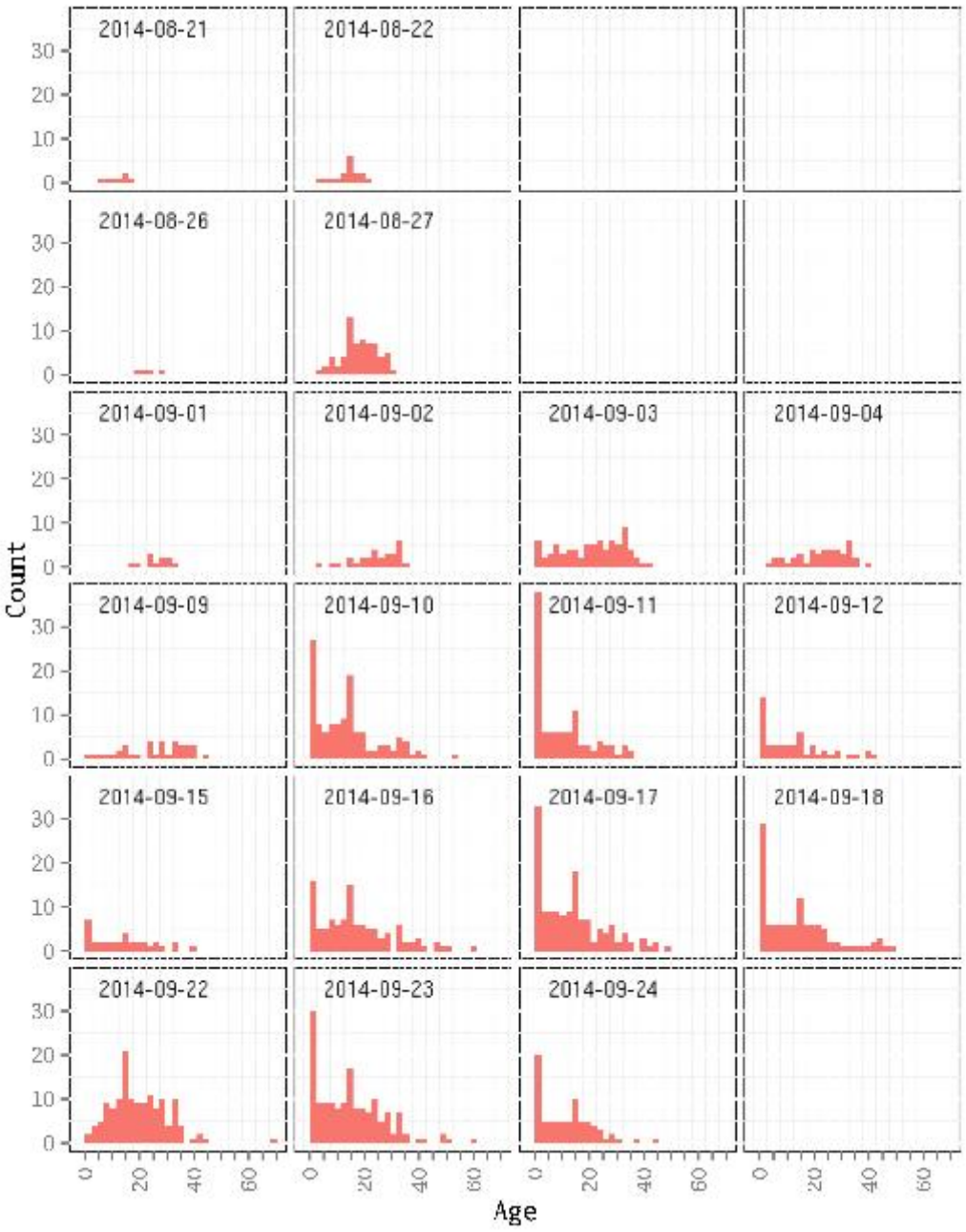

Figure 6.26 Histograms of mean estimated ages (in days) for sampled herring on each day of sampling. Each row indicates the sampling weeks in which herring were caught.

6.6.2 Estimated Hatch Dates

The mean, lower 2.5% and upper 97.5% quartiles of the estimated hatch dates for each size of fish were then calculated and plotted (Figure 6.27). The larvae ages (Table 6.5) were used to back-calculate the hatch dates of the herring larvae from each sample.

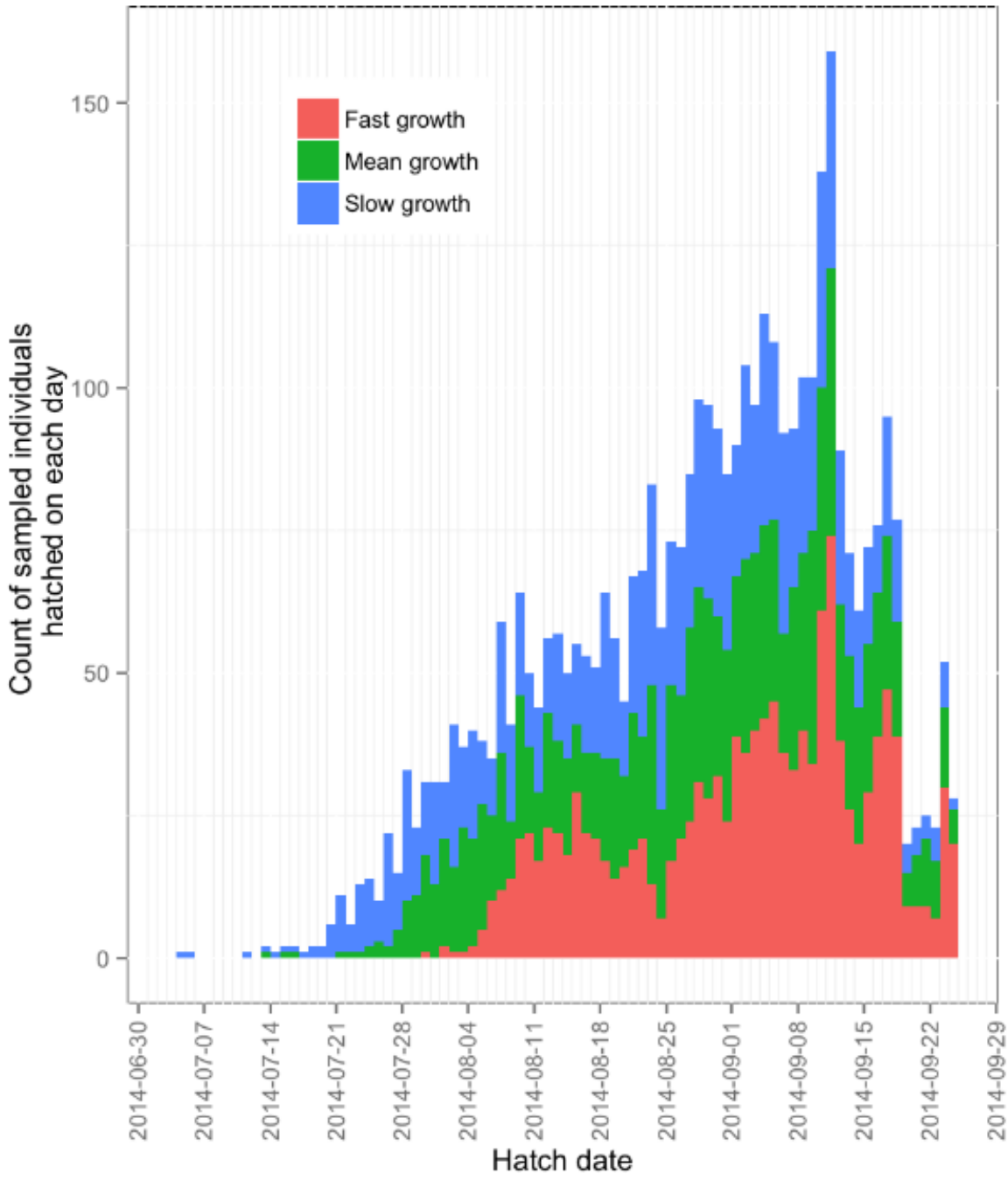

Figure 6.27 Histogram of mean, lower (slow growth) and upper (fast growth) confidence intervals of estimated hatch dates for sampled larvae

6.6.3 *Estimated Spawning Intensity*

Published growth rates were used to back-calculate an estimate of the mean spawning stock at the time of hatching for each hatch-date (Figure 6.28). Larval lengths were aggregated into bins of 0.5 mm for each day and standardised by the number of tows on each day. Spawning intensity was then estimated from the survey dates using the formula

$$P_i = N * e^{(Lt-L0)^{Z/k}} \quad (2)$$

where P_i is the number of larvae hatching on day i, N is the number of larvae in each length category at time t (L_t), L_0 is the hatching size, Z is the mortality rate and k is the growth rate.

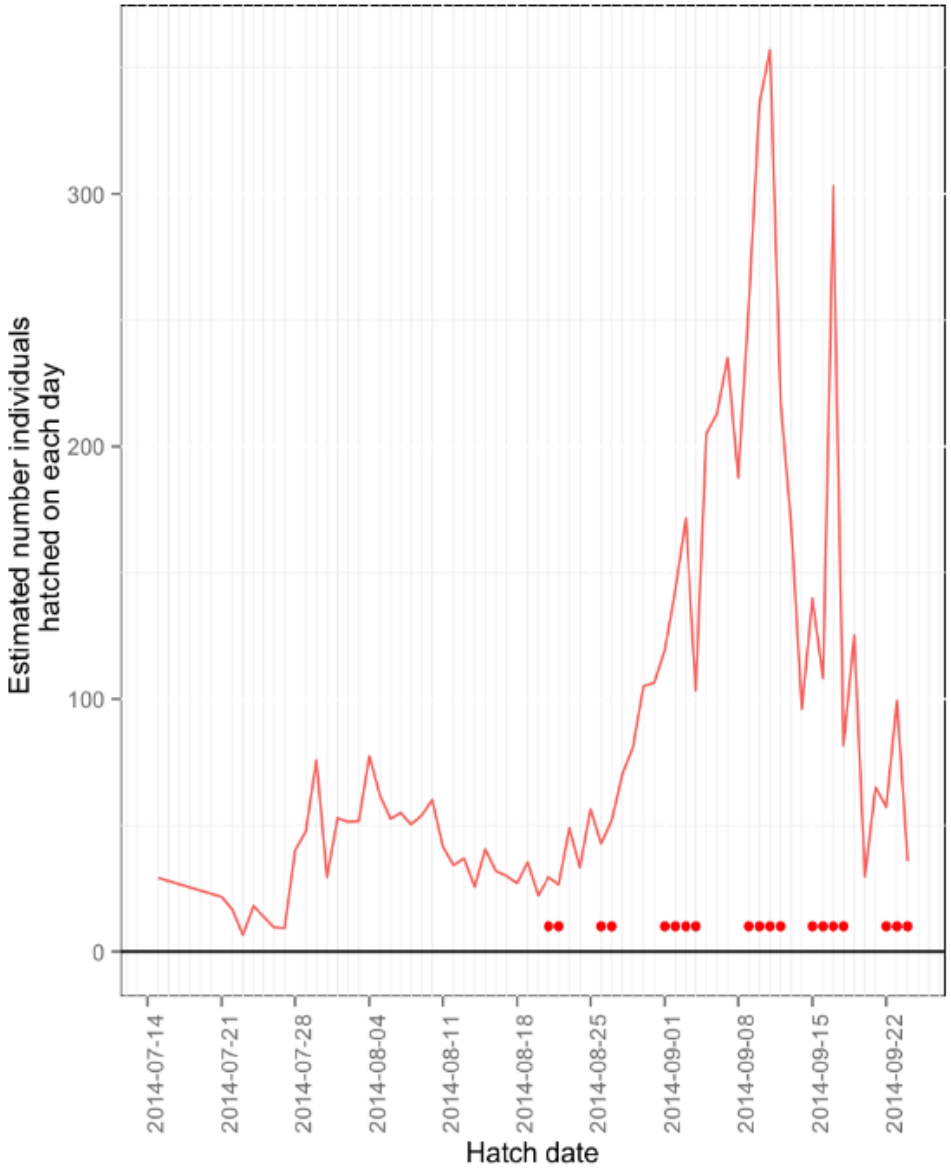

Figure 6.28 Estimated mean spawning intensity (number of hatching larvae). Red dots indicate dates of sampling

7 Conclusion

The survey conducted as part of BOWL's PEMP license conditions is the first of two herring larval surveys, the second of which is to be undertaken in 2015. The results of this survey should however be interpreted in the context of the spatial and temporal variation of environmental factors that may influence patterns of herring spawning.

The IHLS data confirms that herring larvae abundance in the Moray Firth between years is variable. The duration and high definition sampling resolution of the survey design provides robust data that show the temporal duration of herring spawning in the vicinity of the BOWL development area for August and September 2014.

The survey has indicated only one peak spawning period for herring, with larvae abundance showing significantly higher densities within weeks 6, 7 and 8 of the survey. The back-calculation of larval hatch date and spawning stock indicate the peak spawning period occurs in the first 2 weeks of September, with the highest spawning intensity estimated to be at the end of the first week of September. This is supported by the spatial distribution of larvae sizes observed during sampling in week 6.

The majority of herring larvae caught during the survey were <10 mm, with the greatest percentage of larvae between 7.0 mm and 7.9 mm in length. The age back-calculation from length indicates that the mean age for this size is between 1.53 and 3.28 days. However, no yolk sacs were observed on any herring larvae in the samples and this absence of yolk sacs indicate that all of the herring larvae caught would be at least 6 days from hatching. Using the 6 days as a base age, the back-calculation age can then be added to the 6 days resulting in a mean age of 7.0 mm and 7.9 mm larvae between 7.53 days and 9.28 days. Using the residual velocity data, larvae could travel a minimum of 14–18 km using conservative estimates, up to 60-77 km in that time period. This suggests that the majority of the larvae caught may have drifted down from the well established spawning grounds in the Orkneys and Shetlands.

The higher larval densities found in the north of the survey area and the size distribution of larvae recorded during this survey further support the theory that the larvae are transported to the survey area from the main spawning grounds further north in the vicinity of the Orkneys and Shetlands. Similarly, the findings of the IHLS surveys suggest that the highest larval densities occur to the east of the Orkneys and Shetlands.

8 References

Baxter, J.M., Boyd, I.L., Cox, M., Donald, A.E., Malcolm, S.J., Miles, H., Miller, B., Moffat, C.F. (2011). Scotland's Marine Atlas: Information for the national marine plan. Marine Scotland, Edinburgh.

Blaxter, J.H.S. (1985). The herring: A successful species? Can.J.Fish.Aquat.Sci.42 (Suppl.1): 21-30.

Blaxter, J.H.S. (1968). Rearing herring to metamorphosis and beyond. J.Mar.Biol.Ass. UK 48:17-28.

Coull K. A., Johnstone R., and Rogers S.I. (1998). Fisheries Sensitivity Maps in British Waters. UKOOA Ltd.

DARD. (2003). Irish Sea Larval Herring Cruise Report, LF 4503. 4 pp.

Dickey-Collas, M., Nash, R.D.M., Brown, J. (2001). The location of spawning of Irish Sea herring (*Clupea harengus*). J. Mar. Biol. Ass. U.K. 81:713-714.

Dickey-Collas M., Nash R.D.M., Brunel T., van Damme C.J.G., Marshall C.T., Payne M. R., Corten A., Geffen A.J., Peck M.A., Hatfield E.M.C., Hintzen N.T., Enberg K., Kell L.T., & Simmonds E.J. (2010). Lessons learned from stock collapse and recovery of North Sea herring: a review. *ICES Journal of Marine Science* 67, 1875–1886.

Ellis, J.R., Milligan, S., Readdy, L., South, A., Taylor,N., Brown, M. (2010). Mapping spawning and nursery areas of species to be considered in Marine Protected Areas (Marine Conservation Zones). Report No 1: Final Report on development of derived data layers for 40 mobile species considered to be of conservation importance. CEFAS Project Code: MB5301.

Ellis J.R., Milligan S.P., Readdy L., Taylor N. and Brown M.J. (2012). Spawning and nursery grounds of selected fish species in UK waters. *Sci. Ser. Tech. Rep*., Cefas Lowestoft 147, pp. 56.

Fässler S.M.M., Payne M.R., Brunel T. and Dickey-Collas M. (2011). Does larval mortality influence population dynamics? An analysis of North Sea herring (*Clupea harengus*) time series. Fisheries Oceanography 20, 530–543.

Geffen, A.J. (2002) Length of herring larvae in relation to age and hatching order. Journal of Fish Biology 60: 479-485.

Geffen A.J. (2009). Advances in herring biology: from simple to complex, coping with plasticity and adaptability. *ICES Journal of Marine Science* 66, 1688–1695.

Guerin, A.J., Jackson, A.C., Bowyer, P.A., Youngson, A.F. (2014). 'Hydrodynamic models to understand salmon migration in Scotland.' The Crown Estate, 116 pages. ISBN: 978-1-906410-52-0.

Heath, M. (1993). An evaluation and review of the ICES Herring Larval Surveys in the North Sea and adjacent waters. Bull. Mar. Sci., 53(2): 795-817.

Heath, M., Leaver, M., Matthews, A., and Nicoll, N. (1989). Dispersion and feeding of larval herring (*Clupea harengus* L.) in the Moray Firth during September 1985. Estuar. Coast. Shelf Sci. Vol. 28. 549-566.

Hodgson, W.C. (1957). The herring and its fishery. London, Routledge and Kegan Paul.

Hufnagl, M. & Peck, M.A. (2011). Physiological individual-based modelling of larval Atlantic herring (Clupea harengus) foraging and growth: insights on climate-driven life-history scheduling. ICES Journal of Marine Science 68(6): 1170–1188.

ICES (2008). Manual for the International Herring Larvae Surveys South of 62' North. International Council for the Exploration of the Sea, Annex 7: Working Documents to PGHERS, 27pp.

ICES. (2009). Report of the Herring Assessment Working Group for the Area South of 62 N, 17-25 March 2009, ICES Headquarters, Copenhagen. Diane Lindemann. 648 pp

ICES. (2013). Eggs and Larvae Data Fact Sheet, 2013. ICES Data Centre.

Johannessen, A., Blom, G., Folkvord, A. (2000). Differences in growth pattern between spring and autumn spawned herring (*Clupea harengus* L.) larvae. Sarsia 85:461-466.

Keltz, S., Bailey N. (2010). Fish and Shellfish stocks 2010. Marine Scotland, the Scottish Government. ISSN 2044-0359.

Lambert, T. (1987). Duration and intensity of spawning in herring *Clupea harengus* as related to the age structure of the mature population. *Mar. Ecol. Prog. Ser*. 39: 209-200.

Munk, P., Christensen, V., Paulsen, H. (1986). Studies of a larval herring (*Clupea harengus* L.) patch in the Buchan area. II. Growth, mortality and drift of larvae. Dana, vol. 6: 11-24.

Nichols, J. (1999). Saving North Sea Herring. *Based on an article first published in Fishing News 12th February 1999.* Available from: http://www.cefas.defra.gov.uk/publications-and-data/miscellaneous-publications/saving-north-sea-herring.aspx.

Payne, M.R., Stine, D.R., Worsøe, C.L., Munk, P., Mosegaard, H., Nash, R.D.M. (2013). Recruitment decline in North Sea herring is accompanied by reduced larval growth rates. Mar Ecol Prog Ser 489:197-211.

Röckmann C., Dickey-Collas M., Payne M. R., van Hal R. (2011). Realized habitats of early-stage North Sea herring: looking for signals of environmental change. *ICES Journal of Marine Science* 68, 537–546.

Rohlf, N. and Groger, J. (2002). Report of the Herring Larvae Surveys in the North Sea in 2002/2003. International Council for the Exploration of the Sea, CM 2001/ACFM: 12, 10pp.

Rohlf, N. & Groger, J. (2009). Report of the Herring Larvae Surveys in the North Sea in 2008/2009 Working Draft. International Council for the Exploration of the Sea, WD HAWG 2009, 11pp.

Russell, F.S. (1976). The eggs and planktonic stages of British marine fishes, Academic Press, London

Schmidt, J.O., Rohlf, N., Gröger, J.P. (2007). Report of the herring larvae surveys in the North Sea in 2006/2007. Kopenhagen: ICES, WD HAWG 2007, 10 pp

Schmidt, J.O., Rohlf, N., Gröger, J.P. (2008). Report of the herring larvae surveys in the North Sea in 2007/2008. Kopenhagen: ICES, WD HAWG 2008, 10 pp

Smith, P.E. & Richardson, S.L. (1977). Standard technique for pelagic fish egg and larval survey. FAO Fisheries Technical Paper No. 175, 100 pp. FAO, Rome

Turrell, W.R., Henderson E.W., Slesser, G. (1990). Residual transport within the Fair Isle Current observed during the Autumn Circulation Experiment (ACE). Continental Shelf Research 10: 521–543.

UKMMAS. (2010). Charting Progress 2 Feeder Report: Ocean Processes (Ed. Huthnance, J). Produced by Department for Environment Food and Rural Affairs on behalf of the United Kingdom Marine Monitoring and Assessment Strategy. http://chartingprogress.defra.gov.uk/ocean-processes-feeder-report. 279 pp.

9 Appendix

9.1 Health and Safety

9.1.1 Personnel

Brown and May Marine (BMM) staff followed the standard health and safety protocol outlined in the BMM "Offshore Operational Procedures for Surveys using Commercial Fishing Vessels".

All BMM staff have completed a Sea Survival course approved by the Maritime and Coastguard Agency, meeting the requirements laid down in: **STCW 95 Regulation VI/1 para 2.1.1 and STCW Code section A- VI/1** before boarding any vessel conducting works for the company. Employees are also required to have valid medical certificates (ENG1), Safety Awareness, Basic Fire Fighting and Basic First Aid certificates before participating in offshore works.

9.1.2 Vessel Induction

Before boarding the survey team were shown how to safely board and disembark the vessel. Prior to departure the skipper briefed surveyors on the whereabouts of the safety equipment, including the life raft, emergency flares and fire extinguishers, and the location of the emergency muster point. The safe deck areas, man-overboard procedures and emergency alarms were also discussed. The survey team was warned about the possible hazards, such as slippery decks and obstructions whilst aboard. Surveyors were briefed about trawling operations and the need to keep clear of all winches when operational. All hazards were assessed prior to the survey in the BMM health and safety risk assessment.

9.1.3 Daily Safety Checks

The condition of the life jackets, EPIRB's, and life raft were inspected daily. Also checked were the survey team working areas, including the fish room and the wheelhouse to ensure these areas were clear of hazards such as clutter and obstructions.

9.1.4 Post Trip Survey Review

Upon completion of the survey a "Post Trip Survey Review" was filled, see Table 9.1 below.

Table 9.1 Post trip survey review

Project: BOWL Herring Larvae survey 2014	**Vessel:** Pleiades / Antaries
Surveyors: Alex Winrow-Giffin / Richard Preston / Jake Laws	**Skipper:** P. Hepburn / J. Hepburn
Survey Area: Moray Firth	**Total Time at Sea:** 8 weeks
Dates at Sea: 04/08/14 –27/09/14	

	Comments	Actions
Did vessel comply with pre trip safety audits?	Yes (IMCA audits undertaken prior to survey and all items closed out)	N/A
Skipper and crew attitude to safety?	Good – trialled different safety glasses	N/A
Vessel machinery failures?	No	N/A
Safety equipment failures?	None	N/A
Accidents?	No	No
Injuries?	No	NO

9.2 Herring larvae data

The data used to calculate the number of herring larvae below a square meter of water (no./m^2) for each station is given in Table 9.2, with herring larvae abundance (no./m^2) for larvae <10mm and ≥10mm by station and week given in Table 9.3. The first 2 weeks of sampling has been omitted as no herring larvae were caught.

Table 9.2 Herring larvae abundance and volume filtered data by station

Week	Station	Tow duration (mm.ss)	Water depth (m)	Volume filtered (m^3)	No. herring larvae	Herring larvae (no./m^2)
3	HL01	19.34	75.7	74.9	33	33.3
	HL03	20.22	70.6	101.2	33	23.0
	HL04	17.22	72.8	67.3	11	11.9
	HL06	17.23	69.9	66.0	4	4.2
	HL08	17.09	59.1	68.9	1	0.9
	HL09	18.59	64.4	73.1	-	-
	HL10	16.03	72.7	66.4	-	-
	HL12	19.09	59.1	72.3	-	-
	HL14	25.39	79.1	108.8	-	-
	HL16	17.47	55.7	70.3	-	-
	HL18	13.49	41.2	63.8	-	-
	HL21	26.01	59.6	94.7	-	-
	HL23	13.00	44.9	49.0	-	-
	HL25	13.39	45.4	49.2	-	-
4	HL01	24.04	74.5	93.4	23	18.3
	HL03	19.3	69.7	73.6	21	19.9
	HL04	20.04	72.5	73.4	32	31.6
	HL05	16.29	61.7	74.8	36	29.7
	HL06	17.21	70.0	71.8	21	20.5
	HL07	20.45	74.5	76.8	38	36.8
	HL08	15.41	61.9	57.5	6	6.5
	HL09	16.29	63.1	51.2	4	4.9
	HL11	20.11	70.6	71.0	-	-
	HL12	12.23	57.7	44.1	-	-
	HL14	24.30.	82.9	85.3	-	-
	HL15	14.26	52.7	47.9	-	-
	HL16	13.13	58.8	45.4	-	-
	HL17	17.46	63.7	63.5	-	-
	HL18	10.39	43.2	38.9	-	-
	HL19	13.56	54.1	52.3	-	-
	HL21	13.13	56.0	47.1	-	-
	HL22	15.31	54.1	55.4	-	-
	HL23	9.00	43.7	33.6	-	-
	HL24	11.13	57.7	40.2	-	-
	HL25	10.1	41.8	38.9	-	-
5	HL01	19.19	65.3	78.5	102	84.9
	HL03	19.06	65.0	94.7	63	43.2
	HL04	20.31	71.1	73.3	45	43.6
	HL05	17.27	62.3	68.4	32	29.2
	HL06	20.16	67.3	99.3	23	15.6
	HL07	16.01	71.5	56.7	16	20.2
	HL08	14.48	55.9	71.4	9	7.1

Week	Station	Tow duration (mm.ss)	Water depth (m)	Volume filtered (m^3)	No. herring larvae	Herring larvae (no./m^2)
	HL09	18.28	63.0	85.5	26	19.2
	HL10	16.55	70.3	63.8	18	19.8
	HL11	20.27	71.2	63.8	5	5.6
	HL12	16.15	57.0	74.6	6	4.6
	HL13	20.26	75.0	65.9	26	29.6
	HL14	26.55	81.9	115.1	1	0.7
	HL15	12.13	49.0	45.0	2	2.2
	HL16	12.05	54.7	53.4	3	3.1
	HL17	18.14	64.3	85.5	11	8.3
	HL18	9.04	40.0	37.5	-	-
	HL19	12.36	51.7	50.3	6	6.2
	HL20	18.00	64.9	66.7	28	27.2
	HL21	16.36	55.9	79.2	-	-
	HL22	13.36	51.7	45.2	-	-
	HL23	9.24	41.7	28.2	-	-
	HL24	13.3	54.9	43.3	5	6.3
	HL25	9.48	41.7	43.6	1	1.0
6	HL01	18.17	74.5	67.5	589	650.4
	HL02	14.45	52.4	48.2	462	502.2
	HL03	15.25	62.6	55.4	460	519.8
	HL04	20.1	73.7	76.0	464	450.0
	HL05	16.37	61.8	65.7	262	246.5
	HL06	19.38	69.8	77.0	311	281.8
	HL07	24.48	75.2	73.9	479	487.3
	HL08	13.00	55.1	63.0	210	183.6
	HL09	16.19	65.9	58.7	558	626.1
	HL10	20.15	71.3	67.7	335	353.0
	HL11	24.12	71.9	93.2	183	141.2
	HL12	15.28	59.4	71.1	161	134.4
	HL13	22.26	75.6	83.1	616	560.4
	HL14	22.41	80.5	100.4	9	7.2
	HL15	12.35	48.5	49.4	18	17.7
	HL16	14.32	56.7	71.1	91	72.6
	HL17	16.19	63.6	78.3	8	6.5
	HL18	9.35	39.3	34.7	-	-
	HL19	14.26	53.2	49.1	54	58.5
	HL20	19.24	61.3	67.9	137	123.8
	HL21	15.01	56.8	54.3	2	2.1
	HL22	13.45	52.8	57.0	2	1.9
	HL23	11.30	44.8	46.0	4	3.9
	HL24	15.03	54.9	57.1	86	82.7
	HL25	11.02	45.1	42.4	4	4.3
7	HL01	23.33	79.2	87.5	1547	1400.2
	HL02	15.09	65.2	59.4	117	128.4
	HL03	22.08	73.9	79.3	438	408.3
	HL04	19.02	72.0	45.2	560	892.7
	HL05	14.02	62.5	46.7	85	113.9
	HL06	15.42	73.9	70.9	476	495.8
	HL07	19.36	75.9	64.2	296	350.0
	HL08	13.27	54.3	53.0	49	50.2
	HL09	20.49	67.1	75.5	251	223.1

Week	Station	Tow duration (mm.ss)	Water depth (m)	Volume filtered (m^3)	No. herring larvae	Herring larvae (no./m^2)
	HL10	19.14	71.0	68.1	552	575.9
	HL11	18.08	74.9	76.7	200	195.4
	HL12	19.29	60.2	64.8	227	211.0
	HL13	27.07	79.8	91.6	475	413.8
	HL14	27.16	83.0	98.7	122	102.6
	HL15	15.43	50.2	56.0	131	117.4
	HL16	17.07	58.1	64.9	215	192.4
	HL17	19.52	64.1	75.0	91	77.8
	HL18	10.54	42.9	39.2	26	28.4
	HL19	17.59	55.8	64.0	168	146.5
	HL20	18.2	62.0	60.1	332	342.6
	HL21	18.19	58.5	66.2	8	7.1
	HL22	16.50	58.8	56.1	44	46.1
	HL23	12.53	44.8	39.0	186	213.5
	HL24	18.32	57.7	54.6	456	481.9
	HL25	11.48	45.1	38.7	24	28.0
8	HL24	13.07	53.8	46.9	416	477.1
	HL23	12.01	47.6	44.6	105	112.1
	HL25	12.30	45.0	42.3	576	613.0
	HL22	13.26	49.9	51.7	310	299.1
	HL21	16.16	59.1	57.2	258	266.5
	HL17	18.09	64.9	54.1	507	608.2
	HL14	24.18	81.4	94.4	371	320.1
	HL18	10.19	40.6	36.1	227	255.6
	HL15	14.26	50.2	44.7	308	345.6
	HL19	16.34	55.5	69.9	337	267.4
	HL16	15.31	55.5	46.8	45	53.3
	HL12	17.01	56.1	57.4	325	317.7
	HL09	21.19	65.0	76.1	162	138.3
	HL11	22.14	78.1	72.6	103	110.8
	HL08	14.27	56.0	45.4	185	228.1
	HL05	17.39	62.5	49.9	125	156.6
	HL02	15.39	68.0	48.0	45	63.8
	HL03	17.10	66.0	58.7	22	24.8
	HL01	24.33	76.6	59.4	170	219.2
	HL06	15.55	68.6	50.0	287	393.6
	HL04	16.12	74.5	53.3	19	26.5
	HL07	15.09	71.7	49.0	24	35.1
	HL10	16.39	71.4	54.4	78	102.5
	HL13	16.1	70.9	48.4	188	275.2
	HL20	13.16	63.6	44.4	79	113.2

Table 9.3 Herring larvae abundance (no./m^2) for larvae <10mm and ≥10mm by station and week

Week	Station	<10mm	≥10mm	Total
3	HL01	15.2	18.2	33.3
	HL03	4.2	18.8	23.0
	HL04	0.0	11.9	11.9
	HL06	0.0	4.2	4.2
	HL08	0.0	0.9	0.9
4	HL01	4.0	14.4	18.3
	HL03	3.8	16.1	19.9
	HL04	2.0	29.6	31.6
	HL05	0.8	28.9	29.7
	HL06	1.0	19.5	20.5
	HL07	0.0	36.8	36.8
	HL08	0.0	6.5	6.5
	HL09	0.0	4.9	4.9
5	HL01	51.6	33.3	84.9
	HL03	26.1	17.2	43.2
	HL04	9.7	33.9	43.6
	HL05	2.7	26.4	29.2
	HL06	2.0	13.6	15.6
	HL07	0.0	20.2	20.2
	HL08	0.0	7.1	7.1
	HL09	2.2	17.0	19.2
	HL10	0.0	19.8	19.8
	HL11	0.0	5.6	5.6
	HL12	0.0	4.6	4.6
	HL13	1.1	28.4	29.6
	HL14	0.0	0.7	0.7
	HL15	0.0	2.2	2.2
	HL16	0.0	3.1	3.1
	HL17	0.0	8.3	8.3
	HL19	0.0	6.2	6.2
	HL20	1.9	25.3	27.2
	HL24	0.0	6.3	6.3
	HL25	0.0	1.0	1.0
6	HL01	617.3	33.1	650.4
	HL02	470.7	31.5	502.2
	HL03	510.8	9.0	519.8
	HL04	430.6	19.4	450.0
	HL05	232.4	14.1	246.5

Week	Station	<10mm	≥10mm	Total
	HL06	272.8	9.1	281.8
	HL07	477.1	10.2	487.3
	HL08	171.4	12.2	183.6
	HL09	603.6	22.4	626.1
	HL10	334.0	19.0	353.0
	HL11	129.6	11.6	141.2
	HL12	94.4	40.1	134.4
	HL13	491.3	69.1	560.4
	HL14	0.0	7.2	7.2
	HL15	5.9	11.8	17.7
	HL16	46.3	26.3	72.6
	HL17	0.0	6.5	6.5
	HL19	8.7	49.9	58.5
	HL20	90.3	33.4	123.8
	HL21	0.0	2.1	2.1
	HL22	0.0	1.9	1.9
	HL23	0.0	3.9	3.9
	HL24	42.3	40.4	82.7
	HL25	0.0	4.3	4.3
7	HL01	1310.6	89.6	1,400.2
	HL02	114.1	14.3	128.4
	HL03	370.0	38.2	408.3
	HL04	776.3	116.4	892.7
	HL05	85.7	28.1	113.9
	HL06	432.3	63.5	495.8
	HL07	245.9	104.0	350.0
	HL08	33.8	16.4	50.2
	HL09	179.6	43.6	223.1
	HL10	522.7	53.2	575.9
	HL11	137.7	57.6	195.4
	HL12	178.5	32.5	211.0
	HL13	323.2	90.6	413.8
	HL14	74.0	28.6	102.6
	HL15	63.6	53.8	117.4
	HL16	163.7	28.6	192.4
	HL17	19.7	58.1	77.8
	HL18	1.1	27.3	28.4
	HL19	114.3	32.3	146.5
	HL20	311.7	31.0	342.6
	HL21	0.0	7.1	7.1

Week	Station	<10mm	≥10mm	Total
	HL22	17.8	28.3	46.1
	HL23	143.5	70.0	213.5
	HL24	406.9	75.0	481.9
	HL25	8.2	19.8	28.0
8	HL01	378.5	98.6	477.1
	HL02	99.3	12.8	112.1
	HL03	565.1	47.9	613.0
	HL04	239.3	59.8	299.1
	HL05	234.5	32.0	266.5
	HL06	559.0	49.2	608.2
	HL07	289.0	31.1	320.1
	HL08	137.4	118.2	255.6
	HL09	242.4	103.2	345.6
	HL10	245.2	22.2	267.4
	HL11	19.0	34.4	53.3
	HL12	65.5	252.2	317.7
	HL13	92.2	46.1	138.3
	HL14	4.3	106.5	110.8
	HL15	19.7	208.4	228.1
	HL16	33.8	122.8	156.6
	HL17	7.1	56.7	63.8
	HL18	1.1	23.6	24.8
	HL19	27.1	192.1	219.2
	HL20	312.6	80.9	393.6
	HL21	1.4	25.1	26.5
	HL22	0.0	35.1	35.1
	HL23	9.2	93.3	102.5
	HL24	96.6	178.6	275.2
	HL25	4.3	108.9	113.2

9.3 Bycatch data

A total of 46 other fish species were caught during the survey. The number of individuals caught for each species by sampling week is given in Table 9.4 The three most abundant by-catch species were gobies (crystal goby, 2,755 individuals caught; Goby family, 1,797; and Goby sp., 334). Week 3 had the greatest total number of individuals caught.

Table 9.4 Number of individuals for by-catch fish species by sampling week

Common Name	Species	Sampling Week								Grand Total
		1	2	3	4	5	6	7	8	
Crystal goby	*Crystallogobius linearis*	479	59	201	596	617	277	277	249	2,755
Goby family	Gobiidae	135	81	118	224	203	288	451	297	1,797
Goby sp.	*Lebetus* sp.	65	53	37	47	73	59	39	20	393
Smooth sandeel	*Gymnammodytes semisquamatus*	19	24	34	58	79	37	12	6	269
Lemon sole	*Microstomus kitt*	29	11	26	23	61	41	21	19	231
Sandeel	Ammodytidae	38	34	24	6	22	17	9	1	151
Herring family	Clupeidae	0	0	0	6	106	2	31	4	149
Rockling family	*Lotidae sp.*	12	11	10	11	20	20	14	14	112
Dragonet sp.	*Callionymus* sp.	1	9	9	19	18	21	12	7	96
Indet.	INDET	10	5	4	16	23	19	9	6	92
Two-spot clingfish	*Diplecogaster bimaculata*	13	14	8	21	13	6	4	2	81
Sole family	Soleidae	2	1	3	7	32	15	3	14	77
Goldsinny wrasse	*Ctenolabrus rupestris*	0	0	5	10	12	10	12	9	58
Solenette	*Buglossidium luteum*	29	5	3	3	11	0	0	7	58
Sprat	*Sprattus sprattus*	0	6	6	6	6	21	6	3	54
Gurnard family	Triglidae	1	2	2	6	14	10	6	8	49
Transparent goby	*Aphia minuta*	32	5	9	1	0	0	0	1	48
Montagu's seasnail	*Liparis montagui*	5	7	6	5	9	5	6	3	46
Lesser weever	*Echiichthys vipera*	0	3	4	15	6	2	2	0	32
Greater sandeel	*Hyperoplus lanceolatus*	3	1	3	8	8	2	5	1	31
Grey gurnard	*Eutrigla gurnardus*	2	2	4	2	2	2	0	2	16
Scaldfish sp.	*Arnoglossus* sp.	0	0	1	0	2	1	1	5	10
Corkwing wrasse	*Symphodus melops*	2	1	0	4	1	0	0	1	9
Norway bullhead	*Taurulus lilljeborgi*	8	0	0	1	0	0	0	0	9
Norway topknot	*Phrynorhombus norvegicus*	1	3	0	1	1	0	2	0	8
Hake	*Merluccius merluccius*	0	0	0	0	0	5	0	0	5
Blenny sp.	Blenniidae	0	1	0	0	3	0	0	0	4
Whiting	*Merlangius merlangus*	1	0	0	0	1	0	1	1	4

Common Name	Species	Sampling Week								Grand Total
		1	2	3	4	5	6	7	8	
Snake pipefish	*Entelurus aequoreus*	1	0	1	0	0	0	1	0	3
Straight-nosed pipefish	*Nerophis ophiodon*	1	0	0	0	1	0	1	0	3
Nilsson's pipefish	*Syngnathus rostellatus*	0	1	0	0	0	1	0	0	2
Scad	*Trachurus trachurus*	0	0	0	0	0	0	1	1	2
Witch	*Glyptocephalus cynoglossus*	0	0	1	0	0	0	1	0	2
Wrasse family	Labridae	0	0	0	0	1	1	0	0	2
Black goby	*Gobius niger*	0	0	1	0	0	0	0	0	1
Blenny	*Lipophrys pholis*	0	0	1	0	0	0	0	0	1
Brill	*Scophthalmus rhombus*	0	0	1	0	0	0	0	0	1
Clingfish family	Gobiesocidae	0	0	0	1	0	0	0	0	1
Common dragonet	*Callionymus lyra*	0	0	0	0	1	0	0	0	1
Dab	*Limanda limanda*	0	1	0	0	0	0	0	0	1
Greater pipefish	*Syngnathus acus*	0	0	0	0	0	0	1	0	1
Mackerel	*Scomber scombrus*	0	1	0	0	0	0	0	0	1
Reticulated dragonet	*Callionymus reticulatus*	0	0	0	1	0	0	0	0	1
Seasnail family	Liparidae	0	0	0	0	0	0	0	1	1
Tadpole fish	*Raniceps raninus*	0	0	0	1	0	0	0	0	1
Topknot	*Zeugopterus punctatus*	0	0	0	1	0	0	0	0	1
Grand Total		889	341	522	1,100	1,346	862	928	682	6,670

9.4 Log of events

The survey was undertaken from the 4th August to the 27th September 2014, undertaking 25 stations each week for 8 weeks. A summarised log of events is given in Table 9.5

Table 9.5 Summarised log of events

Saturday 2nd August 2014 (Day 1 – Week 1)
BMM surveyors travel from office to Edinburgh
Sunday 3rd August 2014 (Day 2 – Week 1)
BMM surveyors travel from Edinburgh to Fraserburgh
Monday 4th August 2014 (Day 3 – Week 1)
Mobilisation day - Pleiades
Equipment loaded onto vessel (Pleiades) and stowed away
HSE briefing and induction with SSE reps.
Vessel departed Fraserburgh at 1530 hrs (BST) to undertake gear trials outside the harbour
Vessel returned to port at 1730 hrs for G. Hepburn to disembark.
Vessel departed port at 1830 hrs and steamed to survey area.
Overnight at sea
Tuesday 5th August 2014 (Day 4 – Week 1)
Undertook herring larval sampling at stations: 24, 23, 25, 22, 21, 17, 14
Weather: BF 2-5 S-SE, slight to moderate
Overnight at sea
Wednesday 6th August 2014 (Day 5 – Week 1)
Undertook herring larval sampling at stations: 18, 15, 19, 16, 12, 9, 11
Weather: BF 3-4 SE, slight to moderate
Overnight at sea
Thursday 7th August 2014 (Day 6 – Week 1)
Undertook herring larval sampling at stations: 8, 5, 2, 1, 3, 6, 4, 7
Weather: BF 3-4 SE, slight to moderate
Overnight at sea
Friday 8th August 2014 (Day 7 – Week 1)
Undertook herring larval sampling at stations: 10, 13, 20 – week 1 sampling completed
Vessel steamed to Fraserburgh and arrived in port at 1630 hrs
Week 1 samples landed and transported to BMM office
Saturday 9th August 2014 (Day 8 – Week 1)
Non-working day for vessel and crew
Sunday 10th August 2014 (Day 9 – Week 1)
Non-working day for vessel and crew
Monday 11th August 2014 (Day 10 – Week 2)
Standby day in port due to poor weather conditions
Weather forecasts monitored
Tuesday 12th August 2014 (Day 11 – Week 2)
Standby day in port due to poor weather conditions
Weather forecasts monitored
Wednesday 13th August 2-14 (Day 12 – Week 2)

Standby day in port due to poor weather conditions
Weather forecasts monitored
Thursday 14th August 2014 (Day 13 – Week 2)
Standby day in port due to poor weather conditions
Weather forecasts monitored
Vessel departed port at 1930 to steam to survey area
Overnight at sea
Friday 15th August 2014 (Day 14 – Week 2)
Undertook herring larval sampling at stations: 18, 15, 09, 08, 02, 01, 04, 10
Weather: BF 2-5 NW, slight to moderate
Overnight at sea
Saturday 16th August 2014 (Day 15 – Week 2)
Vessel changeover – equipment moved from Pleiades to Antaries
Non-working day for vessel and crew
Sunday 17th August 2014 (Day 16 – Week 2)
Non-working day for vessel and crew
Monday 18th August 2014 (Day 17 – Week 3)
Mobilisation day - Antaries
Equipment loaded onto vessel (Antaries) and stowed away
HSE briefing and induction with SSE reps.
Standby day in port due to poor weather conditions
Tuesday 19th August 2014 (Day 18 – Week 3)
Standby day in port due to poor weather conditions
Weather forecasts monitored
Wednesday 20th August 2014 (Day 19 – Week 3)
Vessel departed Fraserburgh at 0915
Unable to sample due to high persistent swell
Overnight at sea
Thursday 21st August 2014 (Day 20 – Week 3)
Undertook herring larval sampling at stations: 23, 25, 21, 14, 18, 16, 12
Weather: BF3-4 SW – NE, slight to moderate
Overnight at sea
Friday 22nd August 2014 (Day 21 – Week 3)
Undertook herring larval sampling at stations: 09, 08, 01, 03, 06, 04, 10
Weather: BF3 N – NE, slight
Overnight at sea
Saturday 23rd August 2014 (Day 22 – Week 3)
Vessel arrived in Fraserburgh at 0130
Non-working day for vessel and crew
Sunday 24th August 2014 (Day 23 – Week 3)
Non-working day for vessel and crew
Monday 25th August 2014 (Day 24 – Week 4)
Vessel departed Fraserburgh at 0900
Undertook herring larval sampling at stations: 24, 23, 25, 22
Weather: BF 2-4 E, slight

Overnight at sea
Tuesday 26th August 2014 (Day 25 – Week 4)
Undertook herring larval sampling at stations: 21, 17, 14, 18, 15, 19, 16, 12, 09
Weather: BF 2 NE, slight
Overnight at sea
Wednesday 27th August 2014 (Day 26 – Week 4)
Undertook herring larval sampling at stations: 11, 08, 05, 01, 03, 06, 04, 07
Weather: BF 2-4 E, slight to moderate
Vessel steamed to port overnight due to poor forecast for rest of week
Overnight at sea
Thursday 28th August 2014 (Day 27 – Week 4)
Vessel arrived in Fraserburgh at 0600
Weather standby day in port – monitored forecasts
Overnight on vessel
Friday 29th August 2014 (Day 28 – Week 4)
Weather standby day in port
Saturday 30th August 2014 (Day 29 – Week 4)
Vessel changeover – equipment moved from Antaries to Pleiades
Non-working day for vessel and crew
Sunday 31st August 2014 (Day 30 – Week 4)
Non-working day for vessel and crew
Vessel departed Fraserburgh at 2330 and steamed to survey area
Overnight at sea
Monday 1st September 2014 (Day 31 – Week 5)
Undertook herring larval sampling at stations: 24, 23, 25, 22, 21, 17, 14
Weather: BF 2-3 WSW, slight
Overnight at sea
Tuesday 2nd September 2014 (Day 32 – Week 5)
Undertook herring larval sampling at stations: 18, 15, 19, 16, 12, 09, 11
Weather: BF 2-3 SW, slight
Overnight at sea
Wednesday 3rd September 2014 (Day 33 – Week 5)
Undertook herring larval sampling at stations: 08, 05, 01, 03, 06
Weather: BF 2 SW, slight
Overnight at sea
Thursday 4th September 2014 (Day 34 – Week 5)
Undertook herring larval sampling at stations: 04, 07, 10, 13, 20
Weather: BF 2-4 SE, slight to moderate
Overnight at sea
Friday 5th September 2014 (Day 35 – Week 5)
Vessel arrived in port at 0130
Standby day in port
Saturday 6th September 2014 (Day 36 – Week 5)
Non-working day for vessel and crew
Sunday 7th September 2014 (Day 37 – Week 5)

Non-working day for vessel and crew
Monday 8th September 2014 (Day 38 – Week 6)
Weather standby day in port
Vessel departed Fraserburgh at 2200 and steamed overnight to site.
Overnight at sea
Tuesday 9th September 2014 (Day 39 – Week 6)
Undertook herring larval sampling at stations: 24, 23, 25, 22, 21, 17, 14, 18
Weather: BF 2-3 NW - SW, slight
Overnight at sea
Wednesday 10th September 2014 (Day 40 – Week 6)
Undertook herring larval sampling at stations: 15, 19, 16, 12, 09, 11, 08,05
Weather: BF 1-2 S, slight
Overnight at sea
Thursday 11th September 2014 (Day 41 – Week 6)
Undertook herring larval sampling at stations: 02, 01, 03, 06, 04, 07, 10
Weather: BF 1 S, slight
Overnight at sea
Friday 12th September 2014 (Day 42 – Week 6)
Undertook herring larval sampling at stations: 13, 20
Arrive in Fraserburgh at 1615
Weather: BF 1 S, slight
Saturday 13th September 2014 (Day 43 – Week 6)
Vessel changeover – equipment moved from Pleiades to Antaries
Non-working day for vessel and crew
Sunday 14th September 2014 (Day 44 – Week 6)
Non-working day for vessel and crew
Monday 15th September 2014 (Day 45 – Week 7)
Vessel departed Fraserburgh at 1030
Undertook herring larval sampling at stations: 24, 23, 25
Weather: BF 3-4 E/SE, slight or moderate
Overnight at sea
Tuesday 16th September 2014 (Day 46 – Week 7)
Undertook herring larval sampling at stations: 22, 21, 17, 14, 18, 15, 19,16
Weather: BF 3-4 E/SE, slight or moderate
Overnight at sea
Wednesday 17th September 2014 (Day 47 – Week 7)
Undertook herring larval sampling at stations: 12, 09, 11, 08, 05, 02, 01
Weather: BF 2-4 E, slight or moderate
Overnight at sea
Thursday 18th September 2014 (Day 48 – Week 7)
Undertook herring larval sampling at stations: 03, 06, 04, 07, 10, 13, 20
Arrive in Fraserburgh at 2100
Weather: BF 2-4 E/SE, slight or moderate
Friday 19th September 2014 (Day 49 – Week 7)
Non-working day for vessel and crew

Saturday 20th September 2014 (Day 50 – Week 7)
Non-working day for vessel and crew
Sunday 21st September 2014 (Day 51 – Week 7)
Non-working day for vessel and crew
Departed Fraserburgh at 2330
Monday 22nd September 2014 (Day 52 – Week 8)
Undertook herring larval sampling at stations: 24, 23, 25, 22, 21, 17, 14, 18, 15, 19
Weather: BF 1-2 SW, slight
Overnight at sea
Tuesday 23rd September 2014 (Day 53 – Week 8)
Undertook herring larval sampling at stations:16, 12, 09, 11, 08, 05, 02, 03, 01
Weather: BF 2 S to SW, slight
Overnight at sea
Wednesday 24th September 2014 (Day 54 – Week 8)
Undertook herring larval sampling at stations:06, 04, 07, 10, 13, 20
Weather: BF 2-4 NW to WNW, slight to moderate
Arrive Fraserburgh 2100
Thursday 25th September 2014 (Day 55 – Week 8)
Standby day in port
Friday 26th September 2014 (Day 56 – Week 8)
Equipment unloaded from vessel
Meeting the SSE rep
BMM surveyors travel from Fraserburgh to Dunfermline
Saturday 27th September 2014 (Day 57 – Week 8)
BMM surveyors return to office

9.5 Times and Coordinates

The times and coordinates of each Gulf VII plankton tow are given for each survey week in Table 9.6to Table 9.13.

Table 9.6 Week 1 Gulf VII plankton tow times and coordinates

Station	Date	Gulf VII Plankton Tow Start				Gulf VII Plankton Tow End				Duration (mm:ss)
		Time (GMT)	UTM30N		Depth (m)	Time (GMT)	UTM30N		Depth (m)	
			Latitude	Longitude			Latitude	Longitude		
HL01	07/08/2014	11:44:04	58° 37.727	-02° 55.159	81.7	12:00:58	58° 36.799	-02° 53.839	76.4	16:54
HL02		10:22:48	58° 33.780	-03° 01.916	49.9	10:33:46	58° 32.983	-03° 01.866	55.0	10:58
HL03		13:10:03	58° 33.610	-02° 46.830	65.9	13:26:03	58° 32.522	-02° 46.519	70.8	16:00
HL04		16:04:05	58° 33.546	-02° 31.516	74.6	16:22:54	58° 32.194	-02° 31.263	72.7	18:49
HL05		09:04:58	58° 28.592	-02° 54.366	64.8	09:20:41	58° 29.675	-02° 54.324	63.7	15:43
HL06		14:37:19	58° 29.690	-02° 39.227	68.0	14:54:46	58° 28.464	-02° 39.109	64.8	17:27
HL07		17:22:14	58° 29.162	-02° 23.410	74.2	17:42:49	58° 28.041	-02° 25.433	69.4	20:35
HL08		07:25:53	58° 24.660	-03° 02.175	58.4	07:38:11	58° 25.470	-03° 01.954	48.0	12:18
HL09	06/08/2014	15:25:23	58° 25.290	-02° 46.667	64.5	15:42:13	58° 24.081	-02° 46.847	62.4	16:50
HL10	08/08/2014	07:16:31	58° 24.714	-02° 31.540	63.6	07:35:56	58° 26.096	-02° 31.408	72.3	19:25
HL11	06/08/2014	16:46:24	58° 20.910	-02° 54.404	79.8	17:07:58	58° 22.443	-02° 54.042	74.2	21:34
HL12		14:01:37	58° 21.743	-02° 39.009	54.6	14:15:27	58° 20.796	-02° 39.142	57.9	13:50
HL13	08/08/2014	08:48:12	58° 20.445	-02° 24.039	78.7	09:11:57	58° 22.133	-02° 23.792	66.6	23:45
HL14	05/08/2014	17:35:24	58° 17.137	-03° 02.326	82.0	17:58:26	58° 18.464	-03° 00.522	80.4	23:02
HL15	06/08/2014	08:49:17	58° 16.891	-02° 46.790	48.7	09:03:25	58° 17.929	-02° 46.873	53.2	14:08
HL16		12:39:01	58° 17.521	-02° 31.451	55.6	12:51:05	58° 16.679	-02° 31.549	57.3	12:04
HL17	05/08/2014	15:50:54	58° 13.114	-03° 09.774	63.3	16:06:41	58° 13.974	-03° 08.409	66.2	15:47
HL18	06/08/2014	07:25:33	58° 12.817	-02° 54.513	43.2	07:35:19	58° 13.507	-02° 54.268	42.4	09:46
HL19		11:06:42	58° 13.539	-02° 39.040	53.3	11:18:43	58° 12.787	-02° 39.874	52.5	12:01
HL20	08/08/2014	10:50:36	58° 12.713	-02° 24.134	66.9	11:08:24	58° 14.025	-02° 24.008	64.4	17:48
HL21	05/08/2014	14:27:59	58° 09.377	-03° 17.687	53.3	14:41:24	58° 09.106	-03° 15.907	57.3	13:25
HL22		12:52:36	58° 10.456	-03° 03.560	55.3	13:05:47	58° 09.555	-03° 03.577	49.4	13:11
HL23		10:04:59	58° 09.654	-02° 46.411	42.3	10:15:16	58° 08.947	-02° 46.952	42.1	10:17
HL24		08:12:05	58° 08.968	-02° 31.567	55.5	08:28:20	58° 09.572	-02° 33.477	58.3	16:15
HL25		11:22:23	58° 05.370	-02° 54.445	42.6	11:32:03	58° 04.723	-02° 54.558	47.4	09:40

Table 9.7 Week 2 Gulf VII plankton tow times and coordinates

Station	Date	Gulf VII Plankton Tow Start				Gulf VII Plankton Tow End				Duration (mm:ss)
		Time (GMT)	UTM30N		Depth (m)	Time (GMT)	UTM30N		Depth (m)	
			Latitude	Longitude			Latitude	Longitude		
HL01	15/08/2014	14:51:43	58° 36.725	-02° 54.376	77.3	15:22:58	58° 37.246	-02° 54.440	79.2	31:15
HL02		13:13:52	58° 32.531	-03° 01.918	54.0	13:31:15	58° 33.753	-03° 01.888	50.5	17:23
HL04		17:19:58	58° 32.856	-02° 32.365	73.0	17:48:37	58° 34.579	-02° 29.910	76.6	28:39
HL08		11:28:27	58° 24.613	-03° 01.765	60.4	11:46:35	58° 25.848	-03° 01.649	45.5	18:08
HL09		09:43:09	58° 25.636	-02° 46.715	65.6	10:06:40	58° 23.878	-02° 46.737	61.3	23:31
HL10		19:12:36	58° 26.470	-02° 31.126	69.6	19:40:54	58° 24.318	-02° 30.945	66.2	28:18
HL15		07:45:48	58° 17.542	-02° 46.344	50.3	08:03:44	58° 16.327	-02° 46.798	48.7	17:56
HL18		06:22:44	58° 13.573	-02° 54.036	40.5	06:36:44	58° 12.737	-02° 54.875	43.2	14:00

Table 9.8 Week 3 Gulf VII plankton tow times and coordinates

Station	Date	Gulf VII Plankton Tow Start				Gulf VII Plankton Tow End				Duration (mm:ss)
		Time (GMT)	UTM30N		Depth (m)	Time (GMT)	UTM30N		Depth (m)	
			Latitude	Longitude			Latitude	Longitude		
HL01	22/08/2014	12:53:59	58° 36.685	-02° 54.654	79.0	13:13:31	58° 38.151	-02° 54.744	77.3	19:32
HL03		14:14:40	58° 34.382	-02° 47.753	70.0	14:34:03	58° 33.061	-02° 46.697	68.9	19:23
HL04		16:26:19	58° 33.025	-02° 33.096	72.3	16:43:41	58° 32.831	-02° 30.553	74.2	17:22
HL06		15:20:27	58° 30.337	-02° 40.146	69.5	15:37:50	58° 29.252	-02° 38.807	68.6	17:23
HL08		08:43:40	58° 24.574	-03° 01.939	61.6	09:00:50	58° 25.725	-03° 01.597	49.3	17:10
HL09		06:52:11	58° 24.746	-02° 47.103	67.2	07:11:10	58° 25.846	-02° 45.413	60.5	18:59
HL10		18:01:17	58° 25.689	-02° 31.214	73.1	18:17:19	58° 24.535	-02° 31.773	65.5	16:02
HL12	21/08/2014	18:13:11	58° 20.832	-02° 39.879	61.3	18:32:21	58° 21.863	-02° 37.930	56.9	19:10
HL14		13:26:23	58° 17.556	-03° 02.245	81.1	13:52:06	58° 16.403	-02° 59.582	69.2	25:43
HL16		16:46:33	58° 17.409	-02° 33.145	53.0	17:03:35	58° 17.044	-02° 30.862	59.4	17:02
HL18		14:45:01	58° 14.041	-02° 54.661	42.3	14:58:50	58° 13.111	-02° 53.886	41.5	13:49
HL21		11:06:21	58° 08.965	-03° 14.798	63.6	11:32:23	58° 09.764	-03° 17.829	54.9	26:02
HL23		07:35:49	58° 09.087	-02° 46.935	45.1	07:48:53	58° 09.925	-02° 46.087	46.3	13:04
HL25		09:00:45	58° 05.008	-02° 54.343	47.6	09:14:06	58° 05.978	-02° 54.494	53.2	13:21

Table 9.9 Week 4 Gulf VII plankton tow times and coordinates

Station	Date	Gulf VII Plankton Tow Start				Gulf VII Plankton Tow End				Duration (mm:ss)
		Time (GMT)	UTM30N		Depth (m)	Time (GMT)	UTM30N		Depth (m)	
			Latitude	Longitude			Latitude	Longitude		
HL01	27/08/2014	13:42:56	58° 36.924	-02° 54.073	77.6	14:07:01	58° 37.631	-02° 55.957	74.9	24:05
HL03		15:08:07	58° 33.982	-02° 47.734	70.0	15:27:37	58° 32.922	-02° 46.114	61.6	19:30
HL04		17:24:11	58° 33.558	-02° 32.446	74.2	17:44:15	58° 32.482	-02° 30.576	73.1	20:04
HL05		09:58:59	58° 28.389	-02° 55.587	69.7	10:15:33	58° 29.504	-02° 54.966	62.2	16:34
HL06		16:11:25	58° 30.136	-02° 40.816	69.5	16:28:45	58° 29.529	-02° 38.587	68.1	17:20
HL07		18:40:44	58° 30.335	-02° 25.229	76.4	19:01:36	58° 28.910	-02° 24.571	73.7	20:52
HL08		08:59:09	58° 24.530	-03° 01.398	65.0	09:14:49	58° 25.579	-03° 01.130	60.5	15:40
HL09	26/08/2014	16:55:16	58° 25.545	-02° 45.409	60.8	17:11:49	58° 25.210	-02° 47.696	61.2	16:33
HL11	27/08/2014	07:46:16	58° 22.823	-02° 54.013	73.9	08:06:28	58° 21.301	-02° 54.664	76.2	20:12
HL12	26/08/2014	15:48:10	58° 20.462	-02° 38.401	58.3	16:00:33	58° 21.251	-02° 39.411	59.1	12:23
HL14		09:44:30	58° 16.442	-03° 03.569	78.1	10:09:03	58° 17.509	-03° 01.050	81.5	24:33
HL15		12:03:22	58° 16.580	-02° 48.054	52.1	12:17:47	58° 17.320	-02° 46.665	53.0	14:25
HL16		14:40:40	58° 16.529	-02° 31.276	58.5	14:54:10	58° 17.368	-02° 32.245	56.3	13:30
HL17		08:44:14	58° 12.690	-03° 10.263	62.7	09:00:58	58° 13.530	-03° 08.601	64.1	16:44
HL18		11:01:01	58° 13.143	-02° 55.488	42.3	11:11:40	58° 13.250	-02° 53.899	43.2	10:39
HL19		13:10:51	58° 13.197	-02° 40.871	52.7	13:23:48	58° 13.111	-02° 39.034	56.8	12:57
HL21		07:33:48	58° 09.633	-03° 16.525	55.2	07:47:36	58° 08.690	-03° 16.833	56.3	13:48
HL22	25/08/2014	18:09:31	58° 10.522	-03° 02.979	54.6	18:24:03	58° 09.605	-03° 03.917	51.6	14:32
HL23		15:40:55	58° 09.702	-02° 45.884	45.7	15:49:54	58° 09.350	-02° 46.970	43.7	08:59
HL24		14:13:27	58° 08.837	-02° 31.384	57.1	14:24:41	58° 09.498	-02° 32.409	58.9	11:14
HL25		16:45:54	58° 05.963	-02° 54.019	40.4	16:56:03	58° 05.345	-02° 54.799	44.0	10:09

Table 9.10 Week 5 Gulf VII plankton tow times and coordinates

Station	Date	Gulf VII Plankton Tow Start				Gulf VII Plankton Tow End				Duration (mm:ss)
		Time (GMT)	UTM30N		Depth (m)	Time (GMT)	UTM30N		Depth (m)	
			Latitude	Longitude			Latitude	Longitude		
HL01	03/09/2014	13:20:32	58° 37.064	-02° 53.807	75.9	13:39:52	58° 37.648	-02° 56.430	71.9	19:20
HL02		12:15:41	58° 33.996	-03° 01.679	51.6	12:23:40	58° 33.399	-03° 01.818	48.6	07:59
HL03		16:00:17	58° 32.503	-02° 46.423	70.1	16:19:24	58° 33.834	-02° 46.816	67.3	19:07
HL04	04/09/2014	08:19:46	58° 32.471	-02° 31.319	72.7	08:40:16	58° 34.020	-02° 31.575	75.2	20:30
HL05	03/09/2014	09:09:01	58° 29.700	-02° 54.251	62.5	09:25:54	58° 28.442	-02° 54.284	65.7	16:53
HL06		17:21:22	58° 28.905	-02° 39.289	70.5	17:41:38	58° 30.362	-02° 38.437	68.4	20:16
HL07	04/09/2014	09:52:23	58° 29.556	-02° 25.078	75.8	10:08:27	58° 28.712	-02° 23.481	73.7	16:04
HL08	03/09/2014	07:45:05	58° 25.632	-03° 01.477	53.0	07:59:53	58° 24.590	-03° 02.184	58.0	14:48
HL09	02/09/2014	14:45:42	58° 24.519	-02° 46.716	62.2	15:03:14	58° 25.845	-02° 46.578	68.0	17:32
HL10	04/09/2014	13:20:57	58° 26.535	-02° 31.397	68.9	13:37:53	58° 25.295	-02° 31.264	73.1	16:56
HL11	02/09/2014	16:14:53	58° 21.370	-02° 54.243	73.3	16:35:20	58° 22.947	-02° 53.974	74.7	20:27
HL12		13:18:15	58° 20.939	-02° 39.607	60.2	13:34:30	58° 21.881	-02° 38.020	54.7	16:15
HL13	04/09/2014	16:05:41	58° 21.045	-02° 25.135	76.1	16:25:37	58° 21.795	-02° 22.585	64.9	19:56
HL14	01/09/2014	16:59:00	58° 16.683	-03° 02.593	80.5	17:23:55	58° 18.274	-03° 00.527	81.2	24:55
HL15	02/09/2014	09:06:42	58° 17.584	-02° 46.964	51.0	09:18:55	58° 16.652	-02° 46.879	48.0	12:13
HL16		11:48:37	58° 17.608	-02° 31.596	54.7	12:02:32	58° 16.559	-02° 31.627	55.8	13:55
HL17	01/09/2014	15:52:15	58° 12.825	-03° 09.940	62.1	16:10:29	58° 13.893	-03° 08.436	67.0	18:14
HL18	02/09/2014	07:58:12	58° 13.716	-02° 53.604	40.7	08:07:16	58° 13.240	-02° 54.485	41.3	09:04
HL19		10:29:05	58° 13.719	-02° 39.390	51.8	10:41:41	58° 12.753	-02° 39.368	52.4	12:36
HL20	04/09/2014	18:44:17	58° 12.727	-02° 24.342	66.4	19:02:15	58° 14.104	-02° 24.309	63.1	17:58
HL21	01/09/2014	14:34:10	58° 09.007	-03° 17.425	55.4	14:51:49	58° 10.078	-03° 15.946	56.4	17:39
HL22		12:57:56	58° 09.490	-03° 04.139	51.7	13:11:33	58° 10.289	-03° 02.856	53.0	13:37
HL23		10:00:14	58° 09.653	-02° 46.895	41.7	10:09:37	58° 09.014	-02° 46.822	42.2	09:23
HL24		08:25:54	58° 09.721	-02° 31.724	55.5	08:39:06	58° 08.703	-02° 31.791	54.2	13:12
HL25		11:34:57	58° 05.723	-02° 54.822	41.3	11:44:45	58° 05.067	-02° 54.202	45.0	09:48

Table 9.11 Week 6 Gulf VII plankton tow times and coordinates

Station	Date	Gulf VII Plankton Tow Start				Gulf VII Plankton Tow End				Duration (mm:ss)
		Time (GMT)	UTM30N		Depth (m)	Time (GMT)	UTM30N		Depth (m)	
			Latitude	Longitude			Latitude	Longitude		
HL01	11/09/2014	08:47:18	58° 36.620	-02° 53.748	75.8	09:05:36	58° 37.408	-02° 54.994	75.4	18:18
HL02		07:36:40	58° 34.031	-03° 01.448	61.0	07:50:07	58° 32.992	-03° 01.488	59.2	13:27
HL03		10:09:17	58° 32.615	-02° 45.828	59.7	10:24:29	58° 33.319	-02° 47.114	69.0	15:12
HL04		13:30:50	58° 32.553	-02° 31.290	73.1	13:51:00	58° 33.982	-02° 31.778	75.2	20:10
HL05	10/09/2014	17:14:59	58° 29.764	-02° 54.199	61.9	17:31:38	58° 28.593	-02° 54.113	64.6	16:39
HL06	11/09/2014	12:11:21	58° 28.597	-02° 38.880	68.4	12:30:59	58° 29.941	-02° 39.273	69.6	19:38
HL07		15:17:19	58° 28.379	-02° 23.638	74.9	15:41:07	58° 30.225	-02° 24.129	75.5	23:48
HL08	10/09/2014	15:53:50	58° 25.744	-03° 01.557	48.4	16:06:50	58° 24.780	-03° 01.641	62.0	13:00
HL09		13:16:35	58° 24.705	-02° 46.401	63.3	13:33:53	58° 25.911	-02° 47.062	66.4	17:18
HL10	11/09/2014	16:46:28	58° 26.298	-02° 31.284	70.7	17:06:42	58° 24.820	-02° 31.026	64.2	20:14
HL11	10/09/2014	14:44:48	58° 21.302	-02° 53.348	76.6	15:08:36	58° 22.980	-02° 55.016	69.8	23:48
HL12		12:00:58	58° 20.712	-02° 38.854	57.7	12:16:25	58° 21.801	-02° 38.893	54.6	15:27
HL13	12/09/2014	08:13:11	58° 21.919	-02° 24.066	66.6	08:35:38	58° 20.162	-02° 23.981	71.9	22:27
HL14	09/09/2014	16:19:10	58° 17.718	-03° 01.222	79.4	16:41:50	58° 16.384	-03° 03.076	78.9	22:40
HL15	10/09/2014	07:51:02	58° 17.803	-02° 46.518	49.7	08:03:37	58° 16.825	-02° 46.599	46.1	12:35
HL16		10:39:57	58° 16.645	-02° 31.696	57.8	10:54:39	58° 17.705	-02° 31.752	56.0	14:42
HL17	09/09/2014	14:53:03	58° 13.477	-03° 09.105	64.4	15:09:22	58° 12.491	-03° 10.610	62.3	16:19
HL18		17:39:26	58° 13.908	-02° 54.117	39.2	17:48:01	58° 13.299	-02° 54.466	40.0	08:35

Station	Date	Gulf VII Plankton Tow Start				Gulf VII Plankton Tow End				Duration (mm:ss)
		Time (GMT)	UTM30N		Depth (m)	Time (GMT)	UTM30N		Depth (m)	
			Latitude	Longitude			Latitude	Longitude		
HL19	10/09/2014	09:11:34	58° 13.047	-02° 40.441	49.8	09:26:00	58° 13.289	-02° 38.369	54.5	14:26
HL20	12/09/2014	09:50:51	58° 14.257	-02° 24.451	60.7	10:09:15	58° 12.913	-02° 23.933	64.0	18:24
HL21	09/09/2014	13:35:57	58° 08.882	-03° 16.928	57.8	13:51:06	58° 10.095	-03° 16.939	55.2	15:09
HL22		12:07:13	58° 09.300	-03° 03.512	50.0	12:20:29	58° 10.303	-03° 03.578	47.6	13:16
HL23		09:27:30	58° 08.880	-02° 46.990	42.6	09:37:59	58° 09.442	-02° 45.924	44.8	10:29
HL24		07:44:24	58° 09.739	-02° 32.004	54.8	07:59:21	58° 08.676	-02° 31.172	52.7	14:57
HL25		10:45:01	58° 04.765	-02° 54.642	47.9	10:56:03	58° 05.585	-02° 54.756	43.6	11:02

Table 9.12 Week 7 Gulf VII plankton tow times and coordinates

Station	Date	Gulf VII Plankton Tow Start				Gulf VII Plankton Tow End				Duration (mm:ss)
		Time (GMT)	UTM30N		Depth (m)	Time (GMT)	UTM30N		Depth (m)	
			Latitude	Longitude			Latitude	Longitude		
HL01	17/09/2014	18:25:05	58° 36.689	-02° 54.114	76.2	18:48:42	58° 38.167	-02° 53.982	73.1	23:37
HL02		16:49:36	58° 32.262	-03° 01.109	66.4	17:06:44	58° 33.495	-03° 01.710	52.1	17:08
HL03	18/09/2014	07:40:32	58° 32.464	-02° 46.656	75.6	08:02:27	58° 34.098	-02° 46.901	69.7	21:55
HL04		10:18:40	58° 32.550	-02° 33.196	73.7	10:37:37	58° 33.324	-02° 30.998	76.7	18:57
HL05	17/09/2014	15:23:12	58° 28.639	-02° 54.964	66.4	15:37:24	58° 29.676	-02° 55.007	62.7	14:12
HL06	18/09/2014	09:17:10	58° 28.352	-02° 39.488	68.6	09:32:52	58° 29.487	-02° 38.966	70.3	15:42
HL07		11:32:33	58° 29.566	-02° 24.396	72.0	11:51:57	58° 28.289	-02° 23.173	71.4	19:24
HL08	17/09/2014	14:13:59	58° 25.647	-03° 01.491	53.5	14:26:33	58° 24.781	-03° 02.206	57.1	12:34
HL09		10:04:57	58° 25.446	-02° 46.743	67.8	10:24:06	58° 24.050	-02° 47.528	65.8	19:09
HL10	18/09/2014	12:45:21	58° 26.687	-02° 31.306	70.0	13:04:30	58° 25.180	-02° 31.064	72.0	19:09
HL11	17/09/2014	12:45:31	58° 22.272	-02° 54.037	72.0	13:03:40	58° 21.051	-02° 55.162	73.4	18:09
HL12		07:40:37	58° 20.599	-02° 39.160	62.2	07:59:10	58° 21.974	-02° 39.574	57.1	18:33
HL13	18/09/2014	13:56:07	58° 22.141	-02° 24.911	79.8	14:23:00	58° 20.311	-02° 23.267	78.6	26:53
HL14	16/09/2014	12:34:24	58° 18.079	-03° 01.469	80.9	13:01:40	58° 16.166	-03° 02.836	82.6	27:16
HL15		15:23:28	58° 16.624	-02° 47.233	51.6	15:38:11	58° 17.658	-02° 46.519	52.4	14:43
HL16		18:14:36	58° 16.632	-02° 31.914	58.5	18:31:31	58° 17.911	-02° 32.152	54.6	16:55
HL17		10:37:36	58° 13.852	-03° 08.493	65.3	10:56:28	58° 12.643	-03° 09.969	63.9	18:52
HL18		14:15:07	58° 13.111	-02° 54.806	42.9	14:26:01	58° 13.671	-02° 53.745	41.8	10:54
HL19		16:58:14	58° 12.795	-02° 39.464	55.5	17:15:14	58° 14.014	-02° 38.815	53.8	17:00
HL20	18/09/2014	15:33:38	58° 14.204	-02° 25.013	62.5	15:51:22	58° 13.046	-02° 23.786	64.7	17:44
HL21	16/09/2014	08:57:02	58° 09.670	-03° 15.403	59.9	09:14:42	58° 08.777	-03° 17.116	56.0	17:40
HL22		07:37:49	58° 10.310	-03° 03.605	56.9	07:53:40	58° 09.984	-03° 05.689	64.0	15:51
HL23	15/09/2014	17:21:26	58° 09.156	-02° 46.279	46.2	17:33:33	58° 10.008	-02° 46.880	45.1	12:07
HL24		15:16:56	58° 08.603	-02° 31.615	55.7	15:35:01	58° 09.800	-02° 31.831	57.4	18:05
HL25		18:35:39	58° 05.340	-02° 53.954	45.7	18:46:27	58° 05.363	-02° 55.468	45.7	10:48

Table 9.13 Week 8 Gulf VII plankton tow times and coordinates

Station	Date	Gulf VII Plankton Tow Start				Gulf VII Plankton Tow End				Duration (mm:ss)
		Time (GMT)	UTM30N		Depth (m)	Time (GMT)	UTM30N		Depth (m)	
			Latitude	Longitude			Latitude	Longitude		
HL01	23/09/2014	18:07:31	58° 37.807	-02° 55.362	76.3	18:26:00	58° 36.609	-02° 53.649	84.6	18:29
HL02		14:26:05	58° 31.731	-03° 00.220	70.9	14:41:36	58° 32.878	-03° 00.596	75.6	15:31
HL03		16:06:14	58° 34.080	-02° 47.423	70.3	16:23:27	58° 33.278	-02° 45.658	53.2	17:13
HL04	24/09/2014	08:37:26	58° 31.931	-02° 33.663	72.8	08:53:37	58° 32.426	-02° 31.380	73.4	16:11
HL05	23/09/2014	13:36:59	58° 28.834	-02° 55.281	64.4	13:53:17	58° 30.028	-02° 54.867	61.9	16:18
HL06	24/09/2014	07:34:01	58° 29.728	-02° 38.409	66.4	07:48:18	58° 28.897	-02° 39.540	70.6	14:17
HL07		09:48:38	58° 28.289	-02° 25.683	71.1	10:03:34	58° 28.652	-02° 23.644	76.4	14:56
HL08	23/09/2014	12:41:37	58° 25.075	-03° 01.891	58.0	12:56:04	58° 25.988	-03° 00.964	57.1	14:27
HL09		09:59:20	58° 24.422	-02° 45.772	60.5	10:20:39	58° 25.519	-02° 47.884	68.9	21:19
HL10	24/09/2014	11:03:53	58° 24.871	-02° 30.469	69.7	11:20:29	58° 25.236	-02° 32.514	73.9	16:36
HL11	23/09/2014	11:11:42	58° 21.741	-02° 54.262	77.8	11:33:52	58° 20.161	-02° 55.807	75.3	22:10
HL12		08:53:58	58° 20.777	-02° 38.519	55.7	09:10:56	58° 21.713	-02° 39.914	59.7	16:58
HL13	24/09/2014	12:25:46	58° 21.221	-02° 24.316	82.6	12:41:32	58° 22.120	-02° 23.359	67.8	15:46
HL14	22/09/2014	14:48:35	58° 17.006	-03° 02.706	82.3	15:12:20	58° 16.592	-02° 59.499	73.4	23:45
HL15		16:58:40	58° 17.084	-02° 47.564	51.0	17:12:17	58° 16.981	-02° 45.537	49.9	13:37
HL16	23/09/2014	07:37:03	58° 17.424	-02° 33.060	53.0	07:50:34	58° 17.087	-02° 31.120	59.9	13:31
HL17	22/09/2014	13:47:35	58° 12.930	-03° 10.282	64.4	14:05:26	58° 13.799	-03° 08.216	65.5	17:51
HL18		15:58:22	58° 14.002	-02° 54.347	42.6	16:08:03	58° 13.323	-02° 54.077	42.0	09:41
HL19		18:05:32	58° 13.401	-02° 39.504	53.2	18:22:09	58° 12.447	-02° 37.968	54.3	16:37
HL20	24/09/2014	13:50:55	58° 15.540	-02° 24.079	61.1	14:04:12	58° 14.443	-02° 24.200	64.1	13:17
HL21	22/09/2014	12:42:39	58° 08.975	-03° 15.911	60.2	12:58:27	58° 09.838	-03° 17.201	55.7	15:48
HL22		11:22:26	58° 08.939	-03° 03.164	48.5	11:35:54	58° 09.933	-03° 03.339	54.9	13:28
HL23		08:58:58	58° 08.417	-02° 46.174	47.9	09:10:56	58° 09.232	-02° 46.828	44.6	11:58
HL24		07:29:16	58° 08.193	-02° 31.809	52.7	07:42:15	58° 09.200	-02° 31.959	57.4	12:59
HL25		10:12:46	58° 04.952	-02° 54.278	47.4	10:24:18	58° 05.658	-02° 55.122	44.0	11:32

9.6 Tow and Vessel Track charts

The Gulf VII plankton sampler tow locations and vessel tracks for each survey week is shown in Figure 9.1 to Figure 9.8.

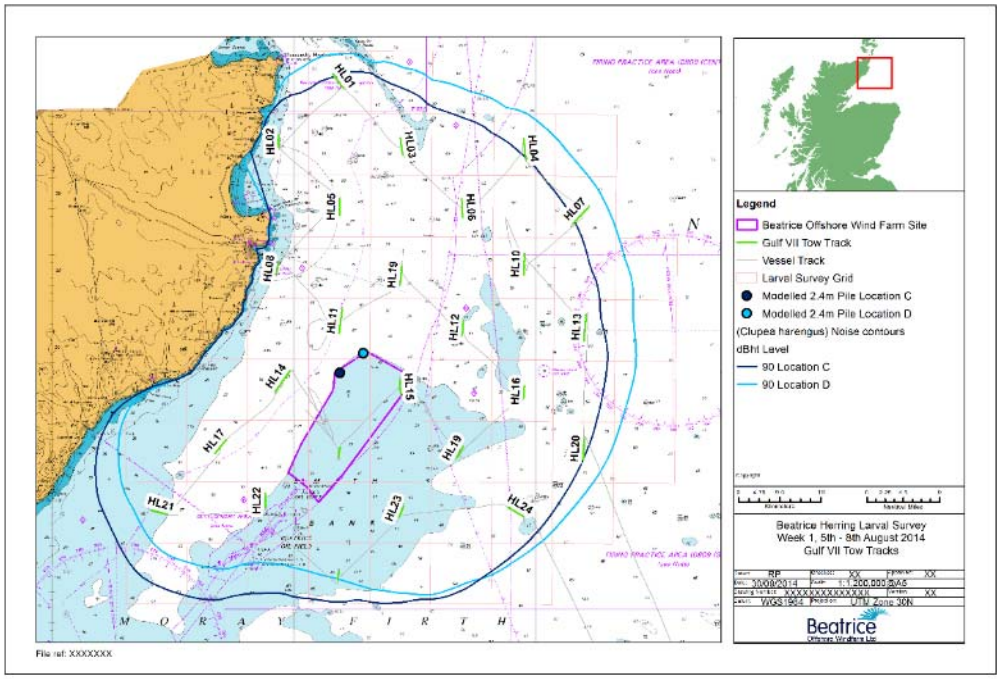

Figure 9.1 Week 1 tow and vessel tracks

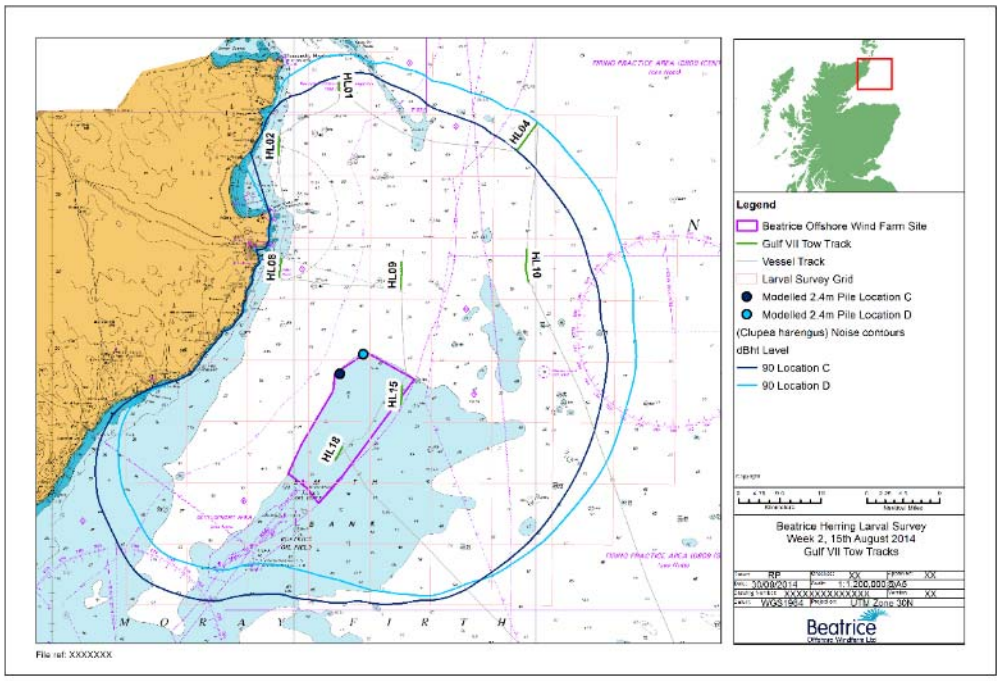

Figure 9.2 Week 2 tow and vessel tracks

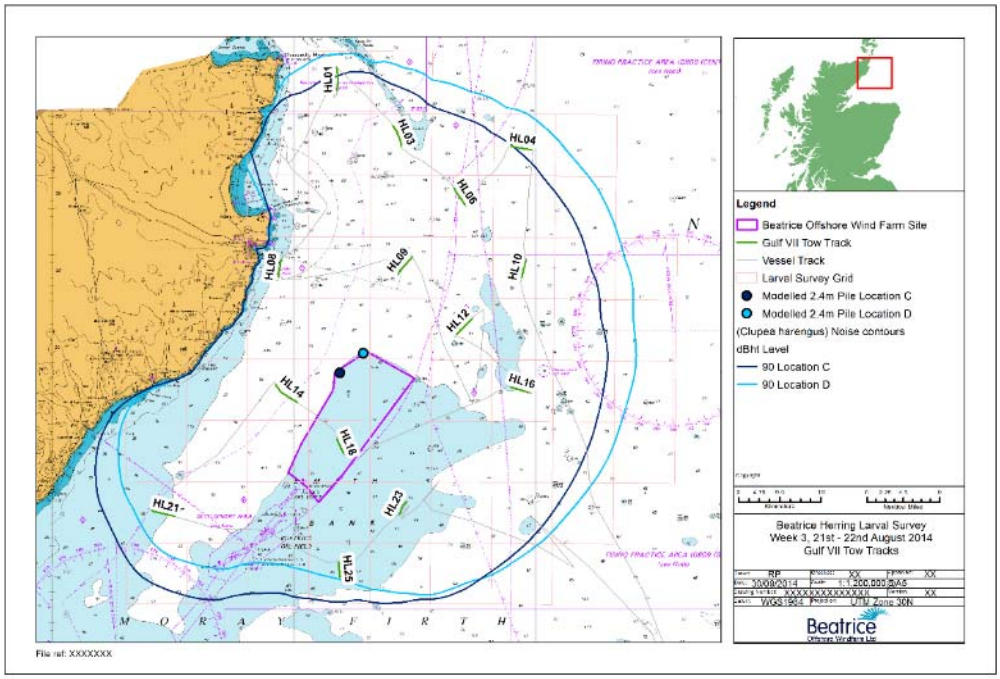

Figure 9.3 Week 3 tow and vessel tracks

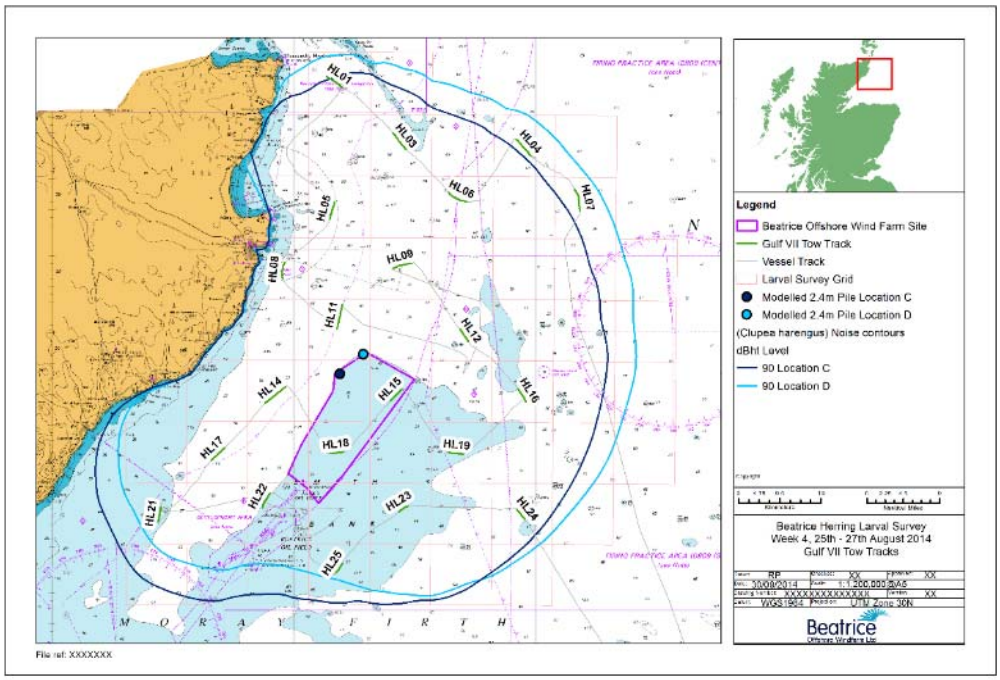

Figure 9.4 Week 4 tow and vessel tracks

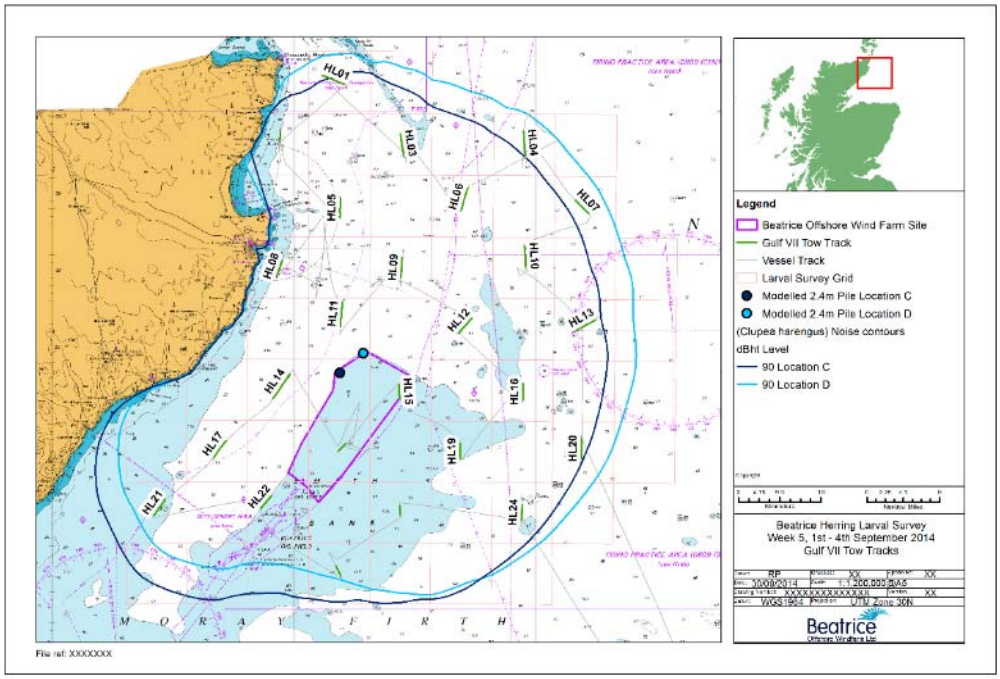

Figure 9.5 Week 5 tow and vessel tracks

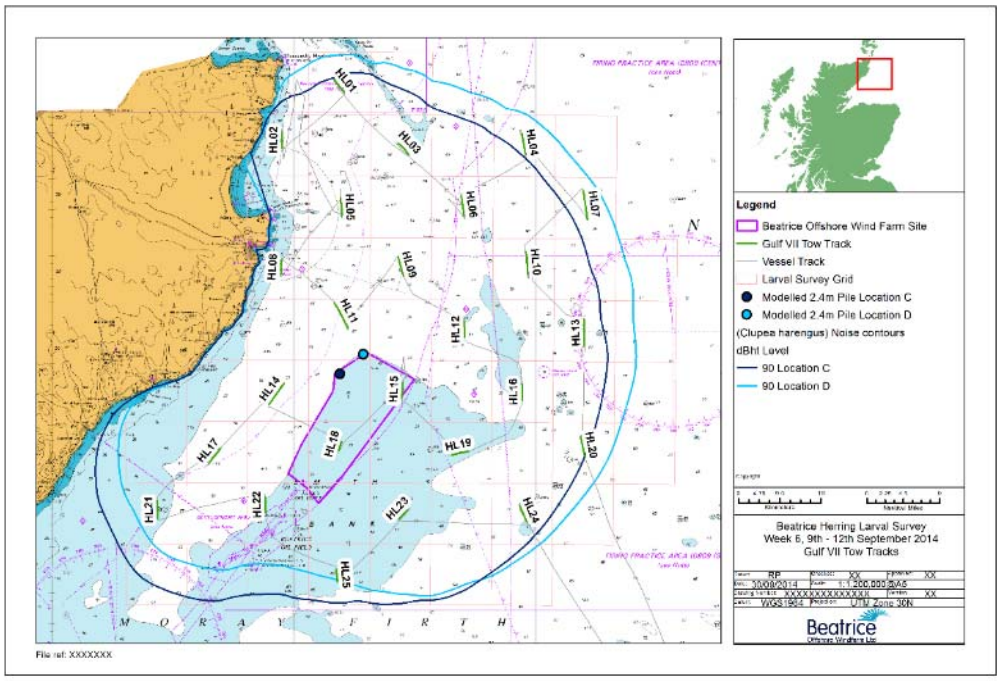

Figure 9.6 Week 6 tow and vessel tracks

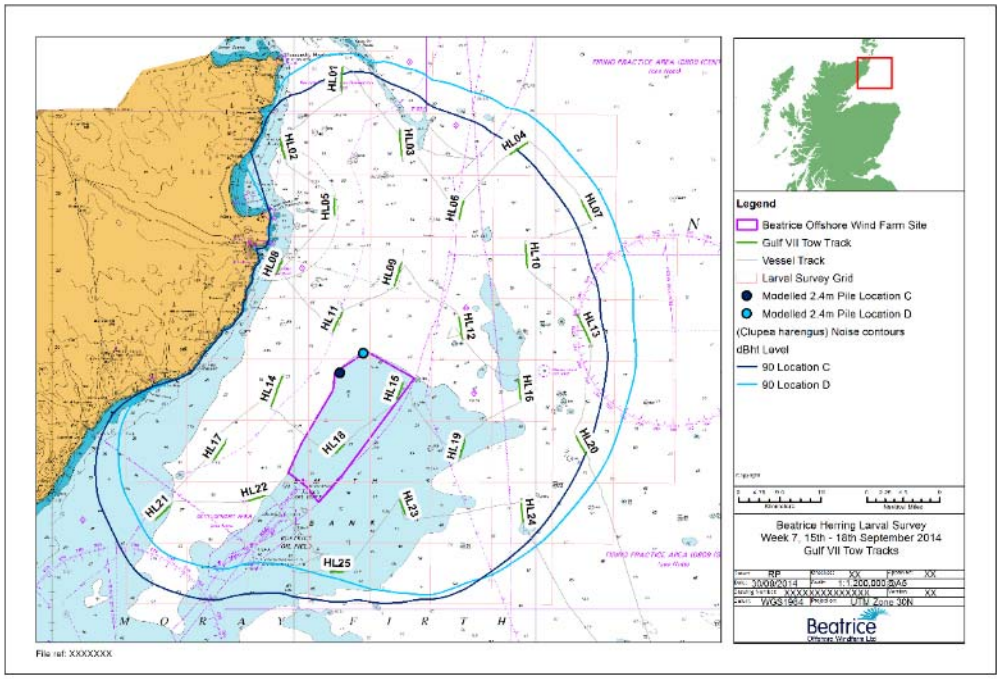

Figure 9.7 Week 7 tow and vessel tracks

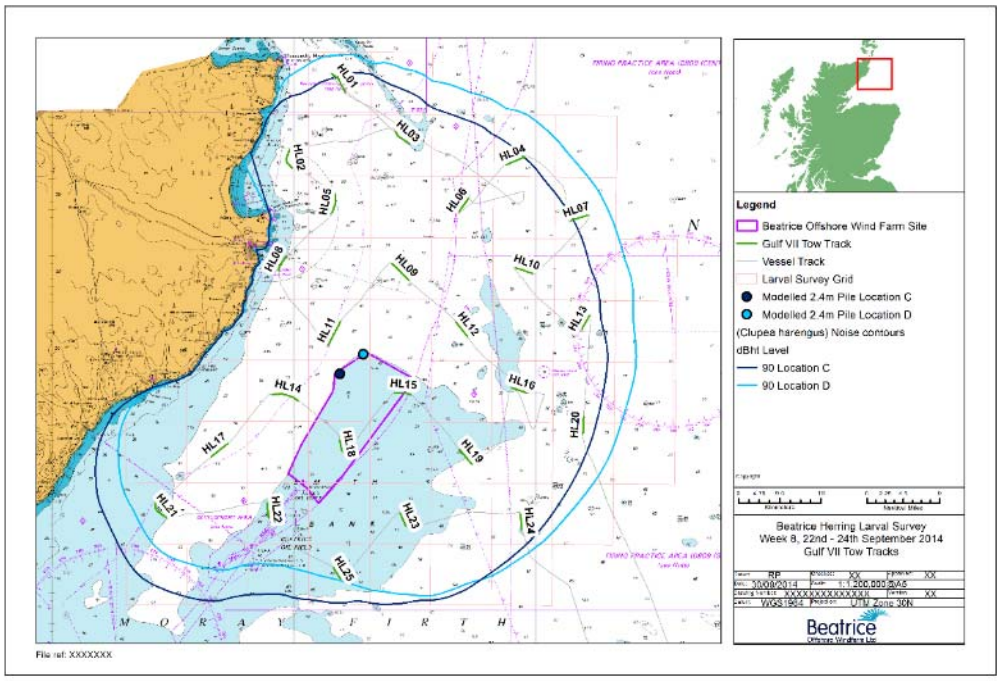

Figure 9.8 Week 8 tow and vessel tracks

9.7 Bottom Salinity

Bottom salinities for the eight survey weeks are shown in Figure 9.9 to Figure 9.16.

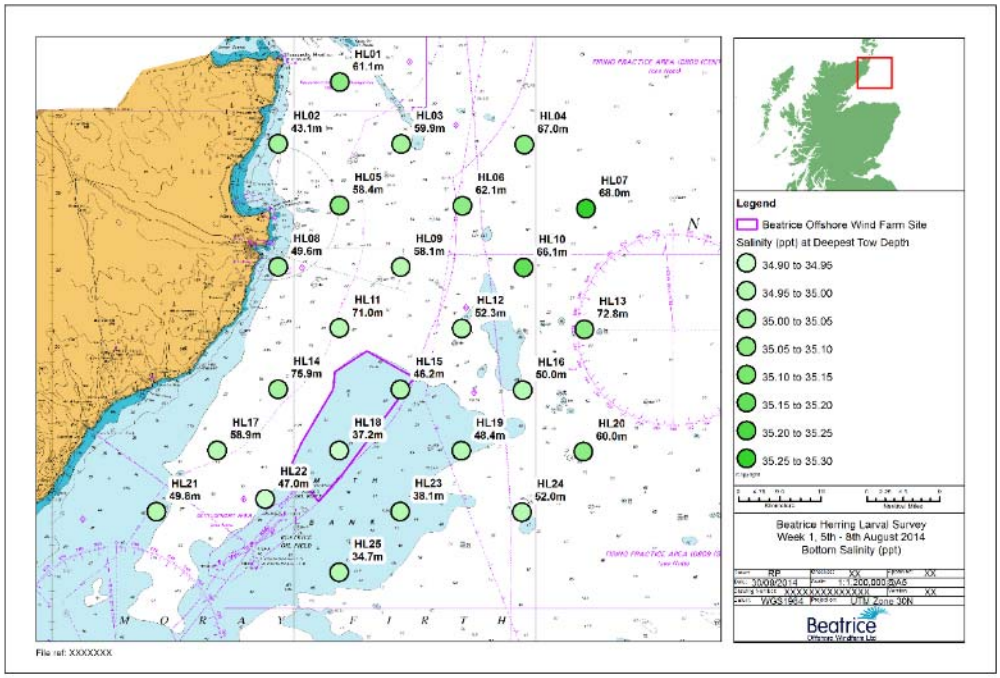

Figure 9.9 Week 1 bottom salinity (ppt)

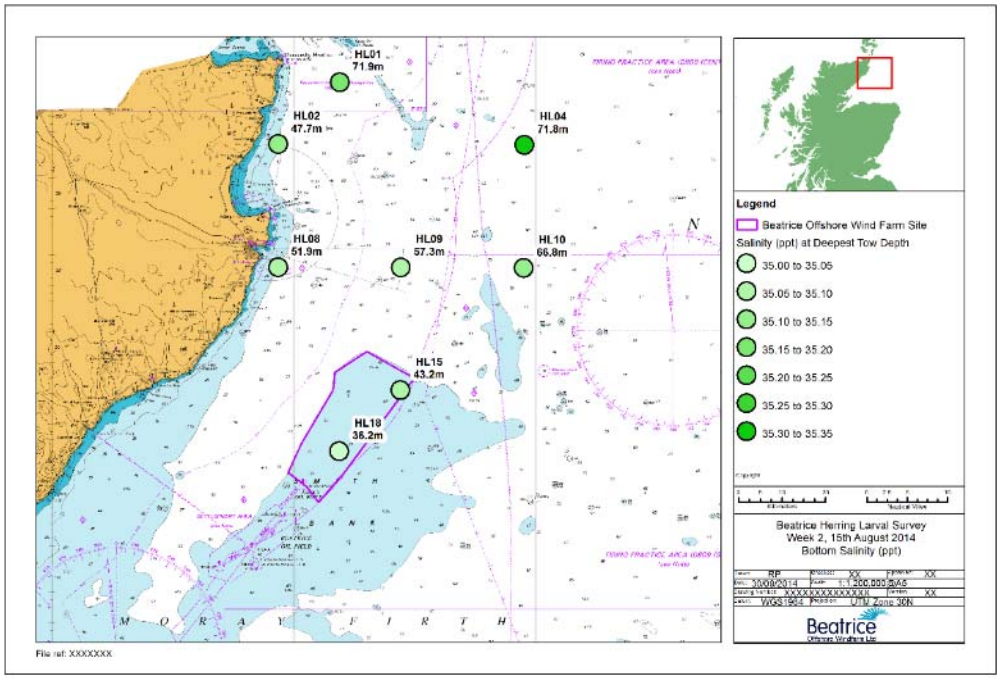

Figure 9.10 Week 2 bottom salinity (ppt)

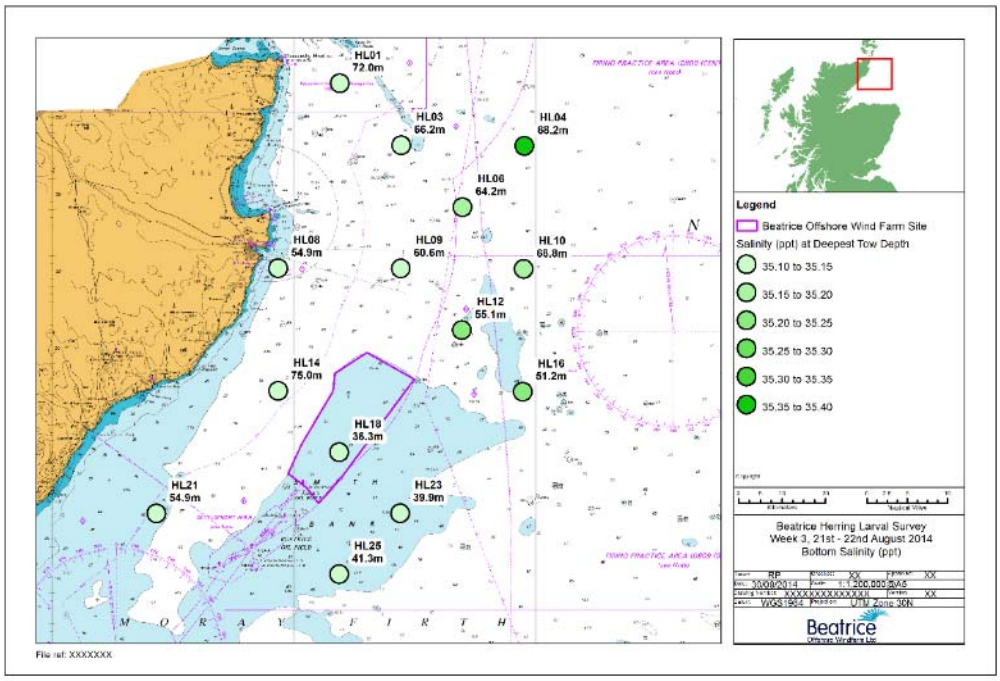

Figure 9.11 Week 3 bottom salinity (ppt)

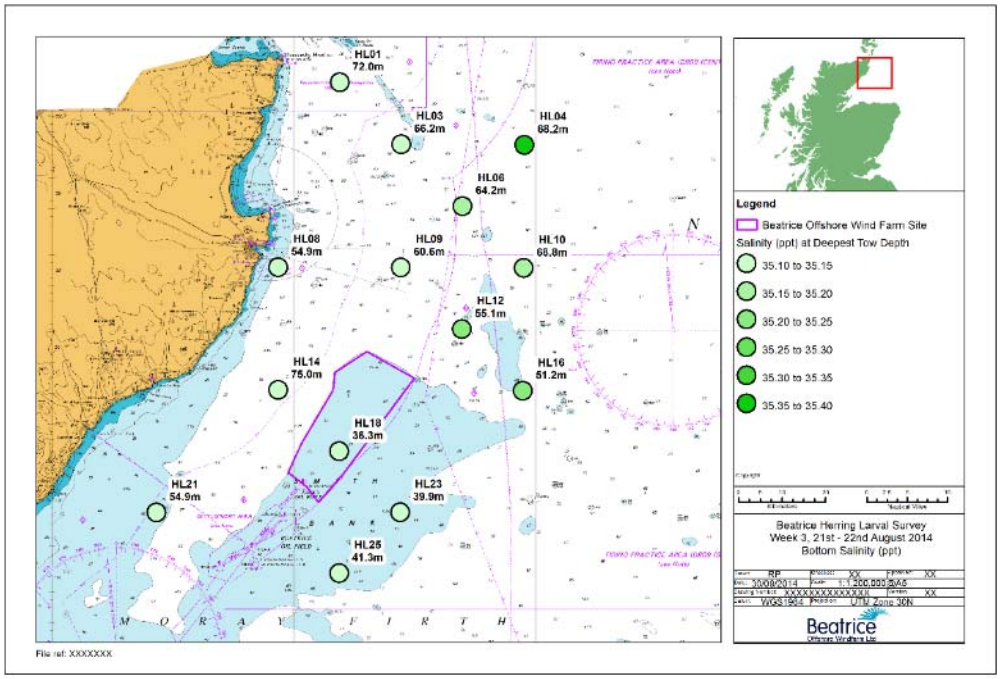

Figure 9.12 Week 4 bottom salinity (ppt)

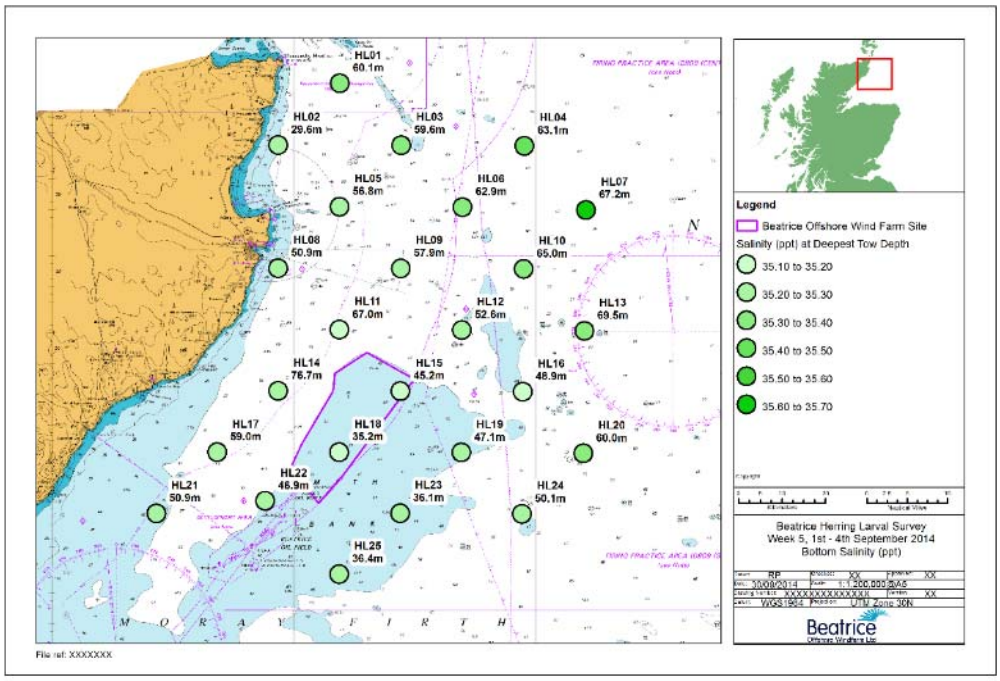

Figure 9.13 Week 5 bottom salinity (ppt)

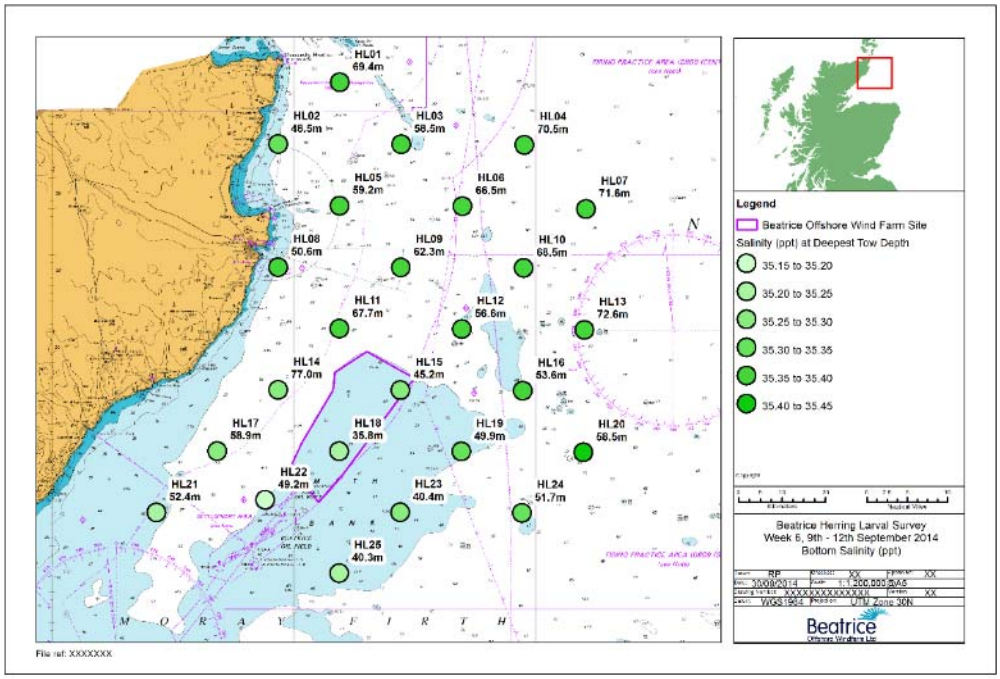

Figure 9.14 Week 6 bottom salinity (ppt)

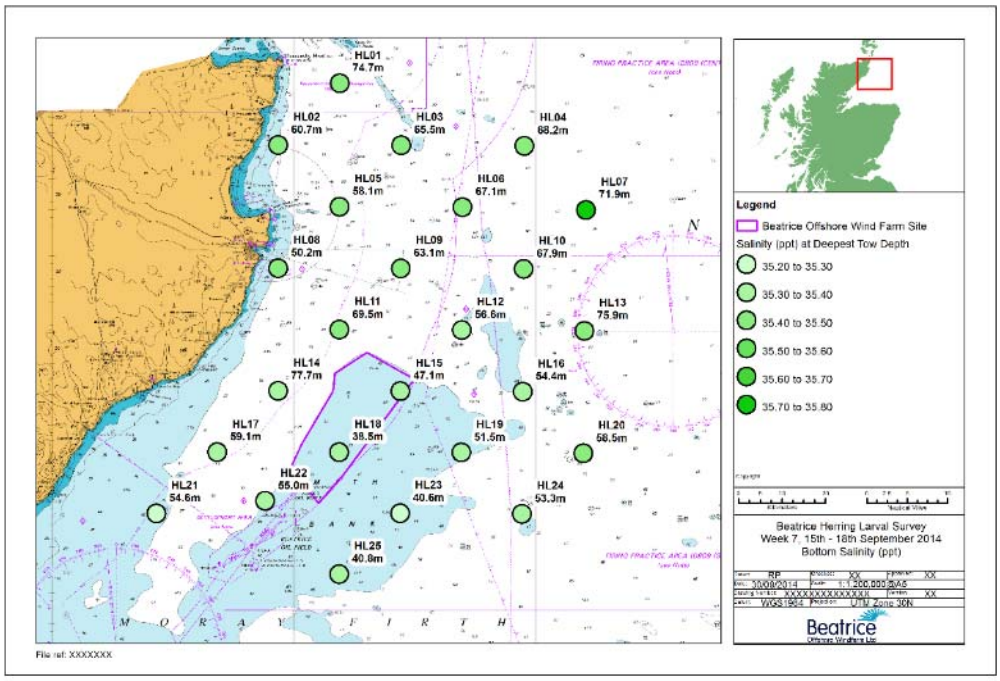

Figure 9.15 Week 7 bottom salinity (ppt)

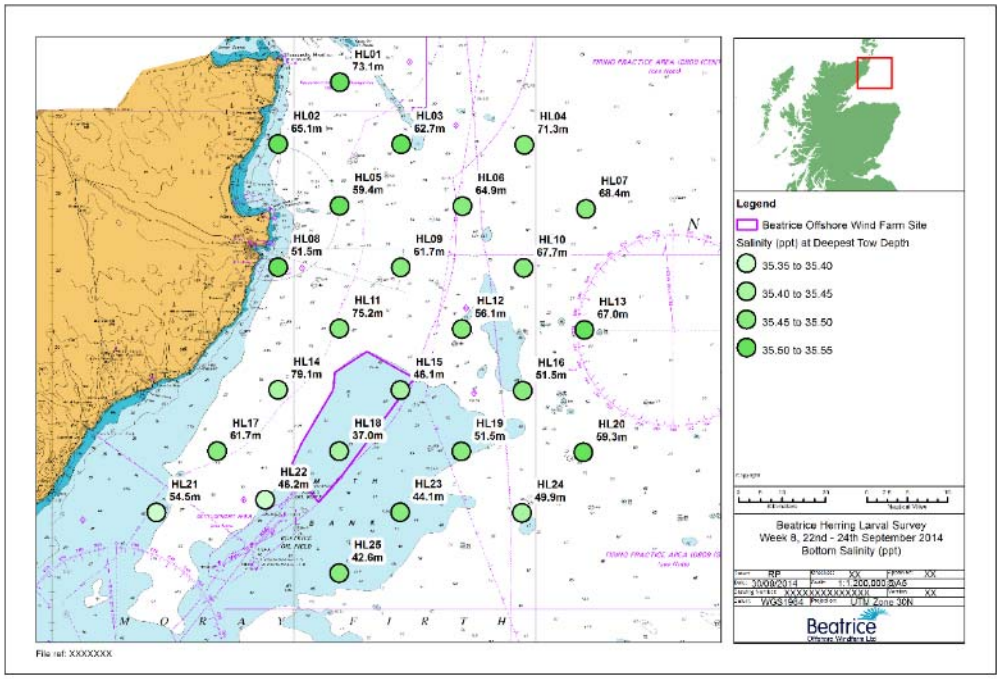

Figure 9.16 Week 8 bottom salinity (ppt)

9.8 Bottom Temperature

Bottom temperatures for the eight survey weeks are shown in Figure 9.17 to Figure 9.24.

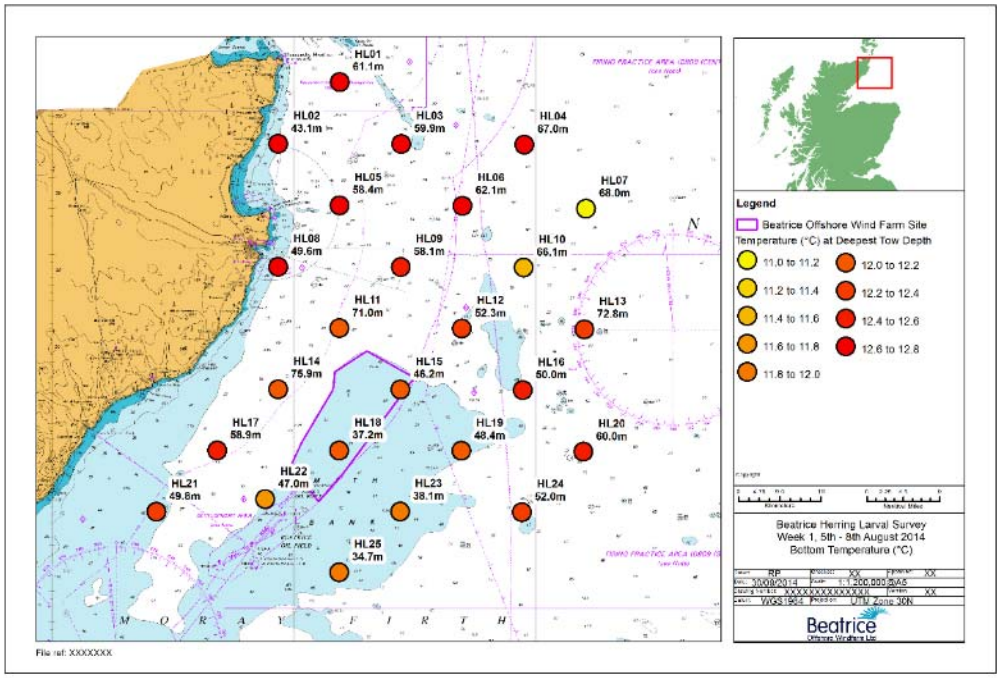

Figure 9.17 Week 1 bottom temperature (°C)

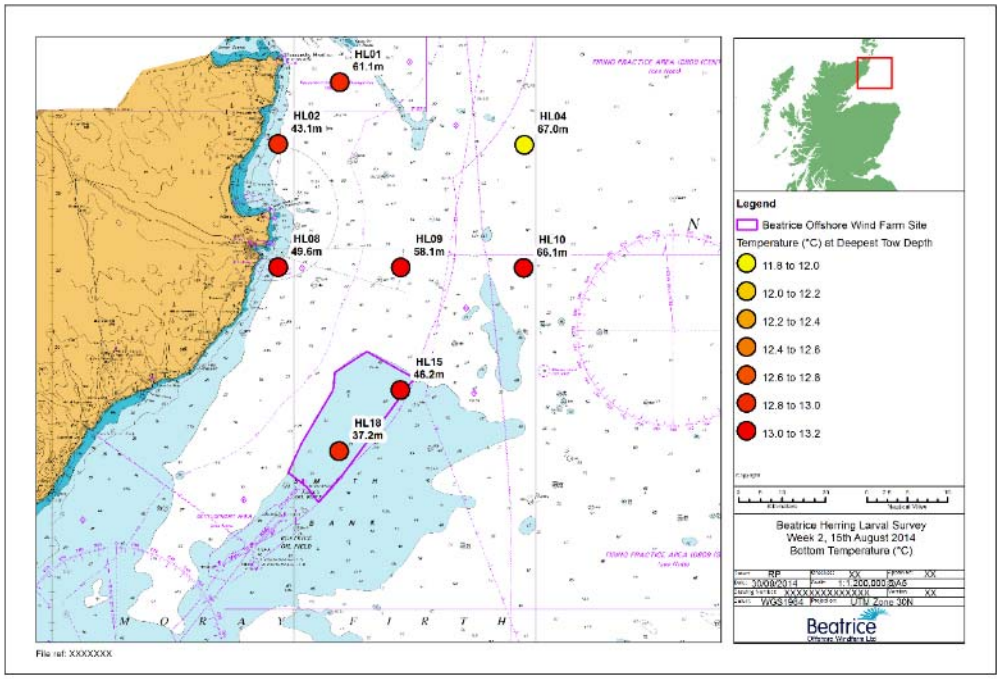

Figure 9.18 Week 2 bottom temperature (°C)

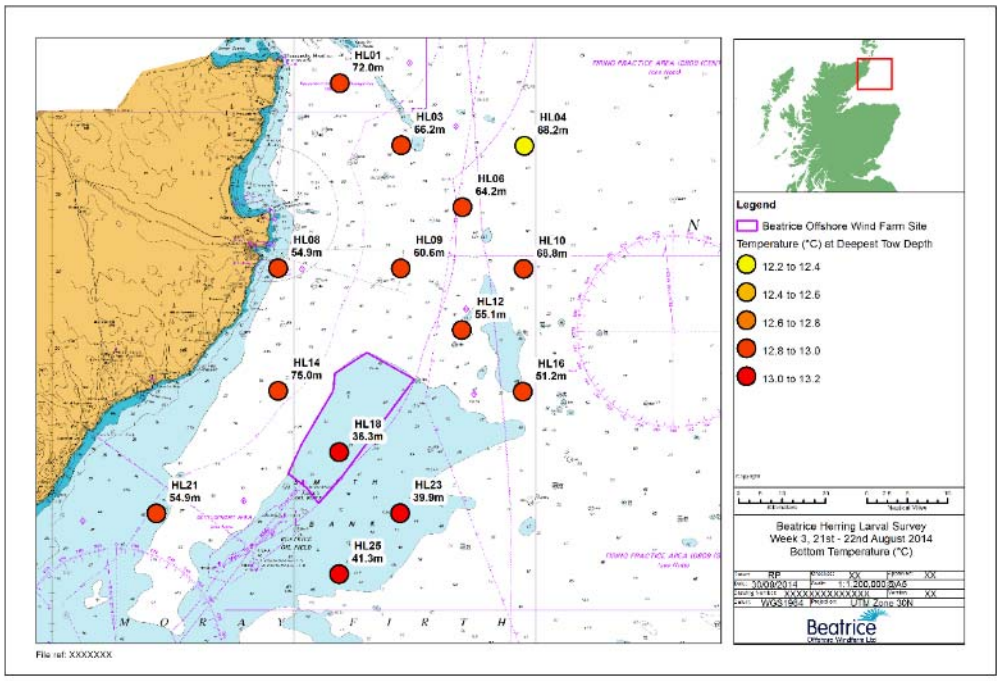

Figure 9.19 Week 3 bottom temperature (°C)

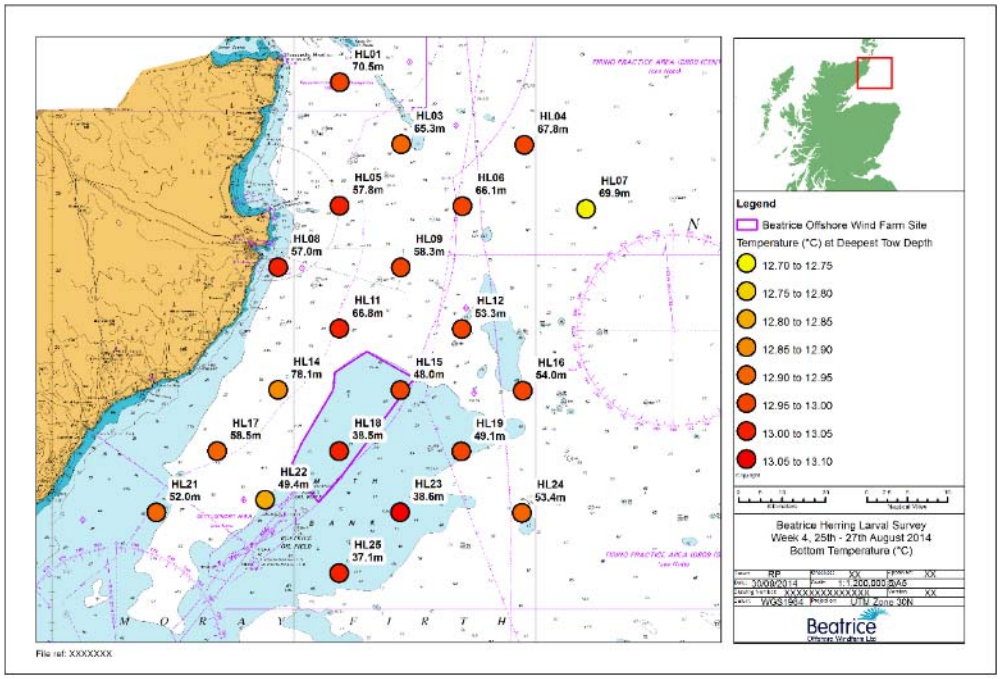

Figure 9.20 Week 4 bottom temperature (°C)

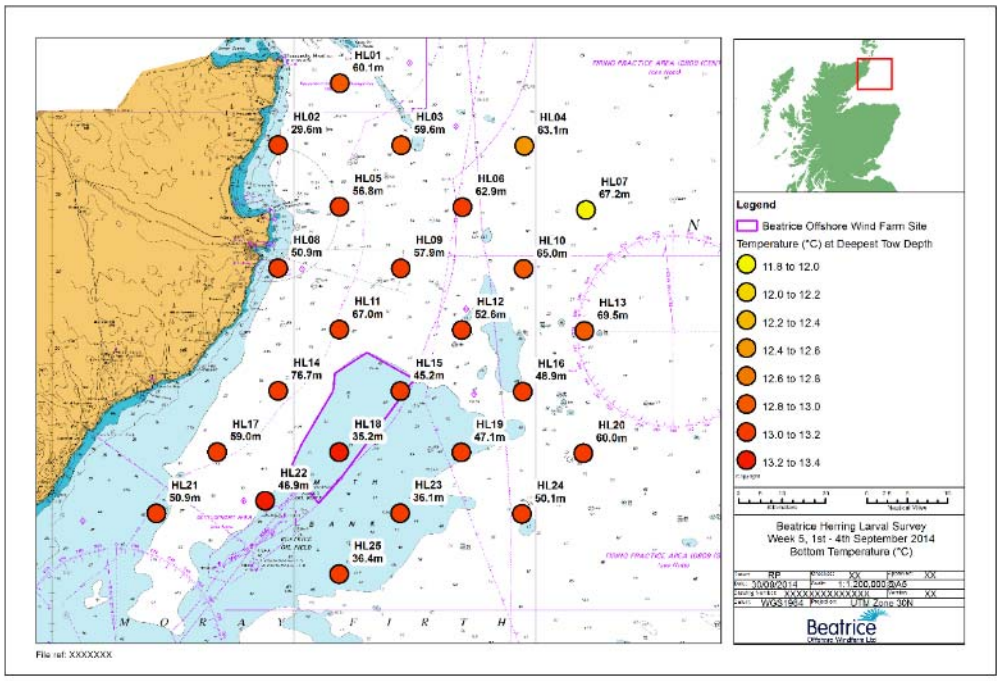

Figure 9.21 Week 5 bottom temperature (°C)

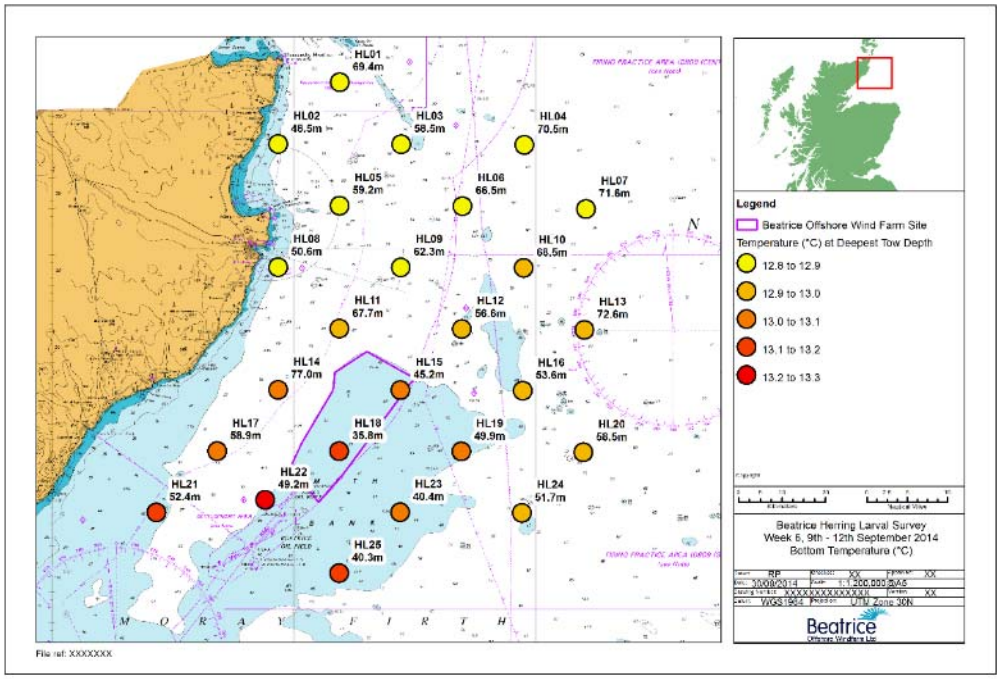

Figure 9.22 Week 6 bottom temperature (°C)

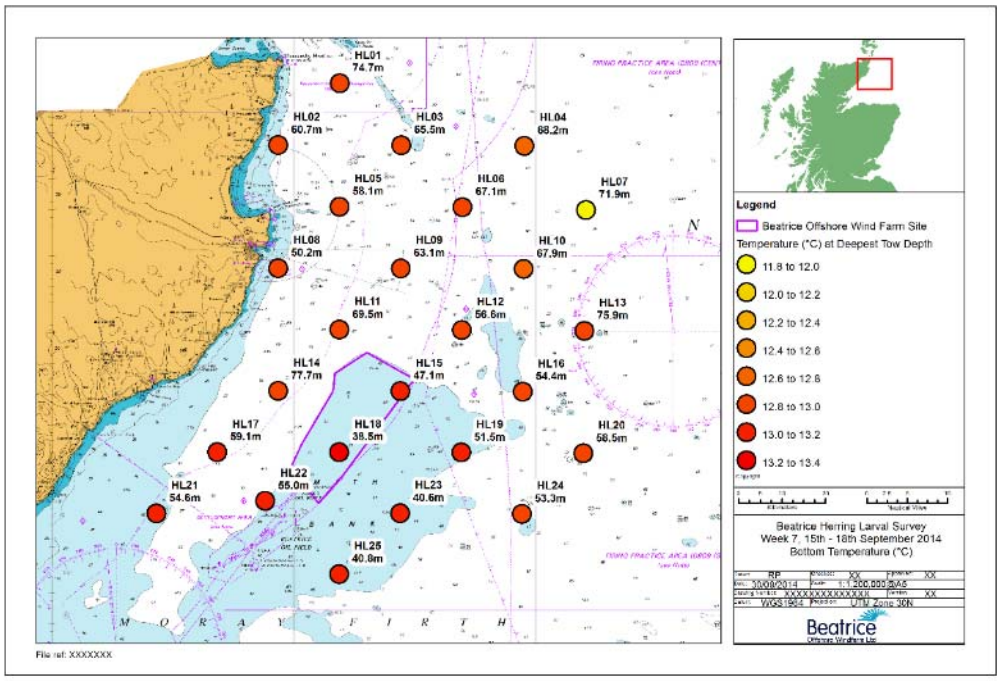

Figure 9.23 Week 7 bottom temperature (°C)

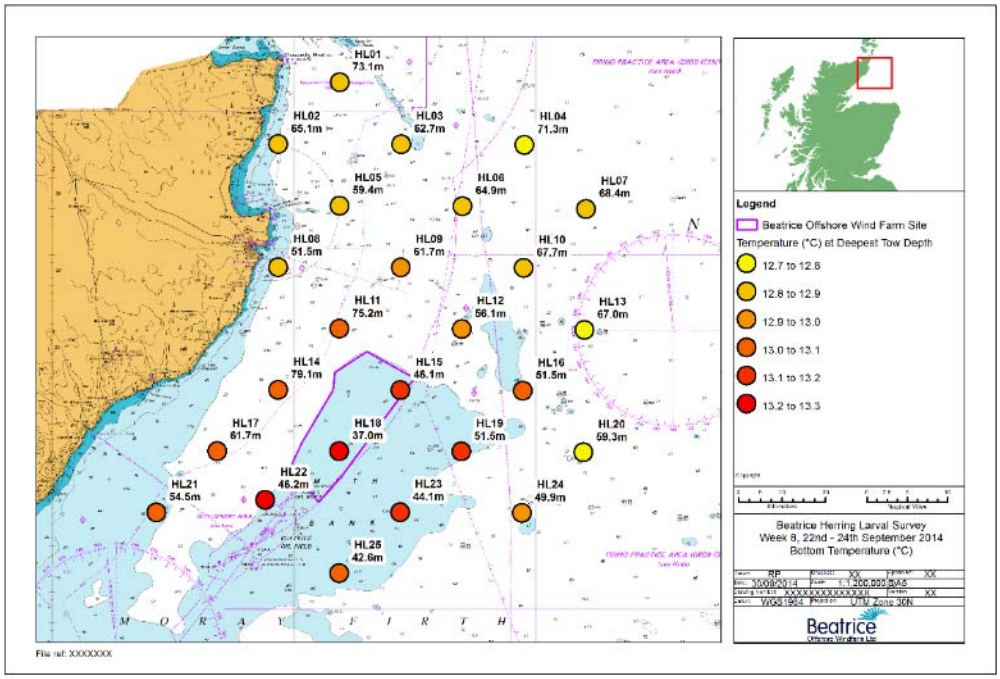

Figure 9.24 Week 8 bottom temperature (°C)

10 ISO Accreditation

Brown & May Marine Ltd. utislises an ISO 9001: 2008, ISO 14001: 2004 and OHSAS 18001: 2007 certified quality management system (certificate number: 11957). This certificate is valid until 22nd July 2017. The certification was issued by ISOQAR Ltd., Alcumus Certification.