HORIZON NUCLEAR POWER

WYLFA NEWYDD

ENERGY WORKING FOR BRITAIN

Wylfa Newydd Project

6.4.86 ES Volume D - WNDA Development App D13-4 - Fish Surveys Report

PINS Reference Number: EN010007

Application Reference Number: 6.4.86

June 2018

Revision 1.0

Regulation Number: 5(2)(a)

Planning Act 2008
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Horizon Internal DCRM Number: WN0902-JAC-PAC-APP-00166

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Wylfa Newydd Project

Horizon Nuclear Power Wylfa Limited

Fish Survey Report

60PO8007/AQE/REP/003 | 4

26 May 2017

WN03.01.01-S5-PAC-REP-00021

JACOBS

Wylfa Newydd Project

Project no:	60PO8032
Document title:	Fish Survey Report
Document No.:	60PO8007/AQE/REP/003
Revision:	4
Date:	26 May 2017
Client name:	Horizon Nuclear Power Wylfa Limited
Client no:	WN03.01.01-S5-PAC-REP-00021
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Document history and status

Revision	Date	Description	By	Review	Approved
1	01/01/2014	Fish Survey Report (2010 – 2013 data)	MD, CT, EC	MR	RB
2	01/02/2015	Fish Survey Report (2010 – 2014 data)	MD, CT, EC, HY	MR	RB
3	04/04/2016	Fish Survey Report (2010 – 2015 data)	FP	JB	RB
4	26/05/2017	Fish Survey Report- preparation for submission as appendix to ES.	HY	RW	RB

Contents

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Executive Summary

Jacobs UK Limited (Jacobs) was commissioned by Horizon Nuclear Power Wylfa Limited (Horizon) to undertake a full marine ecological survey programme within the vicinity of the proposed new Nuclear Power Station (the Wylfa Newydd Power Station) on north Anglesey. This report summarises the fish surveys that took place between spring (April) 2010 and autumn (November) 2015.

Baseline fish surveys were carried out with the aim of assessing the prevailing environmental and ecological conditions and to enable assessments of the predicted impacts of the Wylfa Newydd Power Station within the final Environmental Statement. The fish survey programme used a multi-method approach to characterise fish communities from a variety of habitats. In total, the baseline surveys reported here have recorded 111 fish to genus or species level.

Ichthyoplankton (fish larvae) sampling was completed at seven sites along the north Anglesey coast. The greatest abundance of larvae was observed in April and May following the spring spawning of various species. The ichthyoplankton samples were dominated by sandeel (Ammodytidae) and consisted mainly of inshore species such as gobies (Gobiidae) and flatfish (Pleuronectidae).

The ichthyoplankton samples did not contain significantly high numbers of the commercially exploited species whiting and cod; however, numbers of Clupeidae (represent mainly by sprat) represented approximately 11% of the larvae collected. The data suggest the presence of low intensity sandeel spawning grounds inshore within the Wylfa Newydd Development Area, compared to high intensity area identified offshore and in the eastern Irish Sea. Inshore abundances of other dominant ichthyoplankton species (i.e. sprat, dab and dragonets) were also much lower than those reported for the eastern Irish Sea and further offshore.

Intertidal surveys used seine nets to sample fish from 11 sandy and mixed-substrate beaches between Traeth Mawr near Holyhead in the west and Traeth Bychen in the east. Fish traps sampled fish from two rocky bays along the north coast (Porth-y-pistyll and Porth Wen). Diving surveys helped to fill knowledge gaps for the rocky coastline between intertidal sampling areas. Clupeids, sandeel and plaice dominated samples in spring and into summer with sand smelt dominating in autumn. Winter samples generated very few fish in all years, a result attributed to the moderately exposed nature of the coast and colder water temperatures in the shallower, intertidal waters.

The intertidal survey programme has confirmed the presence of inshore nursery areas for sandeel and plaice. For plaice, these are primarily located up to 24 km east of the Wylfa Newydd Development Area, with abundances declining markedly further towards the west. Sandeel nursery areas appear to be affiliated with sandy bays along the north coast of Anglesey and therefore represent a more patchy distribution. The east coast sites recorded higher abundances of juvenile clupeids and plaice, whereas sites further west supported greater numbers of sand smelt. Porth-y-pistyll and certain areas of Cemaes Bay supported notable numbers of clupeids and reasonably high numbers of sand smelt; however, these areas were not found to be particularly important nursery areas for sandeel, and there was a distinct absence of plaice and other flatfish species from these sites. Western Cemlyn Bay also recorded reasonably high numbers of sand smelt but was not an important nursery area for sandeel.

Dive surveys in the vicinity of the cooling water outfall of the Existing Power Station demonstrated there was no major negative impact on the nearshore fish populations of the north Anglesey coast. If any impact occurred, it remained localised to within a few hundred metres of the outfall. The results and further observations from surveys in 2011 and 2012 confirm that the discharge attracts mullet and bass and might attract greater numbers of gobies and juvenile gadoids to the general area to feed.

Subtidal surveys were completed at five sites along the north Anglesey coast. Subtidal trawl data, along with published literature and evidence from other fish surveys has been used to characterise subtidal fish communities. Whiting and dab were the most abundant species and dominated the subtidal fish community. Even though fish species such as herring, sandeel, plaice and dab are considered key species characterising wider fish communities along the north coast of Anglesey, they are not considered to represent key species of the subtidal fish communities within the Wylfa Newydd Development Area and Disposal Site. Herring, however,

is likely to be a key species characterising fish communities at the Disposal Site considering its wider distribution, abundance and behaviour.

Whiting is considered to represent a significant component of subtidal fish communities within the Wylfa Newydd Development Area and Disposal Site whilst cod remains a notable though not dominant species characterising fish communities within and around these areas. It is expected that fish communities at the Disposal Site would be dominated by pelagic species such as sprat and herring; bentho-pelagic species such as poor cod, whiting and other gadoids species; and demersal species such as lesser-spotted dogfish, common dragonet and perhaps species such as pogge.

The subtidal reference site SF01 in Red Wharf Bay is located within a Natura 2000 site (Menai Strait and Conwy Bay Special Area of Conservation (SAC)) and consistently yielded the highest numbers of fish in terms of abundance and species richness. There was a clear difference in community composition between that recorded at Red Wharf Bay (SF01) and all other sites (SF02-SF05). These spatial differences were largely caused by variations in the abundance of whiting, dab and poor cod, rather than the community as a whole. No clear temporal distinction was seen between the catch by either season or year.

The only shellfish species of commercial or conservational importance recorded during subtidal surveys was the native oyster *Ostrea edulis*, but in very low abudnance. Scallops, crabs and whelks represent the commercial species that were recorded in the highest abundances, their distribution reflecting known commercial grounds around the north coast of Anglesey. Shellfish abundance was reasonably low within the vicinity of the Wylfa Newydd Development Area, increasing out towards known commercial fishing grounds along the north-east coast of Anglesey.

Atlantic salmon, Twaite and Allis shad, sea lamprey, smelt, European eel, hake and Corbin's sandeel may be present in the waters around the north Anglesey coast in low numbers throughout the year or during peak migratory periods. To date, none of these species have been recorded during annual sampling or during the sampling carried out by Bangor University. A single river lamprey was recorded from the Existing Power Station cooling water intake.

Atlantic halibut, cod, haddock, tope, spurdog, bull huss/nurse hound, blonde ray and thornback ray have all been recorded from fish surveys and are listed in the International Union for the Conservation of Nature (IUCN) Red List as 'near threatened' or 'vulnerable'.

1. Introduction

1.1 Overview

Horizon Nuclear Power Wylfa Limited (hereafter referred to as Horizon) is currently planning to develop a new Nuclear Power Station on Anglesey as identified in the *National Policy Statement for Nuclear Power Generation (EN-6)* (Department of Energy and Climate Change, 2011). The Wylfa Newydd Project (the Project) comprises the proposed new Nuclear Power Station, including the reactors, associated plant and ancillary structures and features, together with all of the development needed to support its delivery, such as highway improvements, worker accommodation and specialist training facilities. It also includes the licenced Disposal Site at Holyhead North (IS043). The Project will require a number of applications to be made under different legislation to different regulators. As a Nationally Significant Infrastructure Project under the *Planning Act 2008*, the construction and operation must be authorised by a Development Consent Order. A separate application for a Marine Licence for marine construction works and marine dredging and disposals is also required under the *Marine and Coastal Access Act 2009*.

Jacobs UK Limited (Jacobs) was commissioned by Horizon to undertake a full ecological survey programme within the vicinity of the proposed new Nuclear Power Station on Anglesey (the Wylfa Newydd Power Station). This report details the findings of the fish survey programme carried out between 2010 and 2015. To inform the baseline assessment, a desk-based review of existing data sources was also carried out. Where appropriate, this information has been presented to provide further support to the baseline description of fish and shellfish populations around the north Anglesey coast and within the wider eastern Irish Sea. Collectively, the information contained within this report has been used to inform the various applications, assessments and permits that will be submitted for approval to construct and operate the Wylfa Newydd Power Station and Associated Development[1].

This report uses a number of technical terms and abbreviations. Key terms are capitalised and explained with their acronyms within the text. References to legislation are to that legislation as in force at the time of the publication of this report.

1.2 The Project

The Project includes the Wylfa Newydd Power Station and Associated Development. The Wylfa Newydd Power Station includes two UK Advanced Boiling Water Reactors to be supplied by Hitachi-GE Nuclear Energy Limited, associated plant and Ancillary Structures and features. In addition to the reactors, development on the Power Station Site would include steam turbines, control and service buildings, operational plant, radioactive waste storage buildings, Ancillary Structures, offices and coastal developments. The coastal developments would include a Cooling Water System and breakwater, and a Marine Off-Loading Facility.

1.3 Site Description

1.3.1 Wylfa Newydd Development Area

The Wylfa Newydd Development Area (the indicative areas of land and sea, including the Power Station Site, the Wylfa NPS Site[2] and the surrounding areas that would be used for the construction and operation of the Power Station) covers an area of approximately 380 ha (Figure 1.1). It is bounded to the north by the coast and the existing Magnox Power Station (the Existing Power Station). To the east, it is separated from Cemaes by a narrow corridor of agricultural land. The A5025 and residential properties define part of the south-east boundary, with a small parcel of land spanning the road to the north-east of Tregele. To the south and west, the Wylfa Newydd Development Area abuts agricultural land, and to the west it adjoins the coastal hinterland.

[1] Development needed to support delivery of the Wylfa Newydd Power Station is referred to as Associated Development. This includes highway improvements along the A5025, Park and Ride Facilities for construction workers, Logistics Centre, Temporary Workers' Accommodation, Specialist Training Facilities, Horizon's Visitor Centre and Media Briefing Facilities.

[2] The site identified on Anglesey by the *National Policy Statement for Nuclear Power Generation (EN-6)* as potentially suitable for the deployment of a new Nuclear Power Station.

The Wylfa Newydd Development Area includes the headland south of Mynydd y Wylfa candidate Wildlife Site. There are two designated sites for nature conservation within the Wylfa Newydd Development Area: the Tre'r Gof Site of Special Scientific Interest (SSSI) and the Anglesey Terns/Morwenoliaid Ynys Môn Special Protection Area. There is also a candidate Special Area of Conservation (cSAC) that has been submitted to the European Commission, but not formally adopted (North Anglesey Marine/Gogledd Môn Forol cSAC). The Wylfa Newydd Development Area is within 1 km of the Cae Gwyn SSSI and Cemlyn Bay Special Area of Conservation (SAC) and SSSI[3].

The open coast location of north Anglesey is characterised by strong tidal flows (>1.5 m s^{-1}) and a seabed that slopes steeply to a depth of approximately 25m to 30 m. The substrata are comprised of a mix of bedrock, boulders and cobbles and sediments including gravel and sands in variable proportions. The sublittoral coastline around north Anglesey comprises a diverse habitat assemblage characteristic of a moderately exposed, western UK, rocky coastline and dominated by macrophytic algae.

1.3.2 The Holyhead North Disposal Site

The licensed Disposal Site at Holyhead North (IS043) is situated approximately 4 km off the west coast of South Stack, Anglesey, at its closest point, within the Irish Sea. The Holyhead North Disposal Site is rectangular, measuring around 6.5 km in length and 4.4 km in width, oriented along a roughly north-south axis (Figure 1.2). The area of the site is approximately 28.6 km^2. The southern and northern sections of the Disposal Site's eastern boundary are approximately 9 km and 10 km, respectively, from the exit of Holyhead Harbour, whilst the north-west corner is approximately 15 km distant.

Before 2017, the Holyhead North Disposal Site represented the northern half of the Holyhead Deep (IS040) Disposal Site; however, in 2017 it was designated a Disposal Site in its own right. The site IS040 was heavily active for several decades, receiving regular disposal events, which in recent years have largely comprised maintenance dredging from Stena Line Ports. Capital dredging is required for construction of the Wylfa Newydd Project, and it is proposed that excavated material be disposed at the Holyhead North Disposal Site. The southern half of the historical Holyhead Deep Disposal Site was awarded an Agreement for Lease by the Crown Estate for the development of a marine tidal energy array called Deep Green Utility.

1.4 Study Aims and Objectives

This study aims to provide a detailed baseline description of fish and shellfish populations present along the north Anglesey coast and within the wider eastern Irish Sea with particular consideration to the Holyhead North Disposal Site (herein referred to as 'the Disposal Site').

The original scope of the survey programme in 2010 was developed in consultation with the Centre of Fisheries and Aquaculture Science (Cefas). Subsequent changes have been agreed in consultation with Natural Resources Wales (NRW) (previously known as Countryside Council for Wales).

Outlined within this report are the results of all marine fish survey work undertaken to date by Jacobs as well as relevant data from literature. A final overall discussion of baseline fisheries information is provided in Section 5, which includes consideration of all life stages of fish considered present within intertidal and subtidal waters around the coast of Anglesey. Where appropriate, reference is provided to corresponding technical appendices throughout this document.

The objective is to provide the context within which the predicted effects of the construction and operation of the Wylfa Newydd Project on fish and shellfish populations will be assessed. Furthermore, it will be used to give the context within which possible changes in fish and shellfish populations can be assessed and monitored following construction and operation of the Wylfa Newydd Project. This information is required to inform the various applications, assessments and permits required to construct and operate the Wylfa Newydd Power Station and Associated Development.

[3] Note that the format of names for designated and conservation sites are consistent with JNCC guidance.

1.5 Study Area

The survey study area covered coastal and offshore waters around north Anglesey, extending up to 15 km to the west, 25 km to the east and 5 km north of the Wylfa Newydd Development Area. Early modelling of the Wylfa Newydd Cooling Water discharge indicated a 5 km radius covers the area where potential significant effects may occur. Updated hydrodynamic modelling has confirmed this delineation is still appropriate. Survey effort was concentrated within this area to provide a more detailed temporal and spatial baseline description of fish and shellfish populations.

The study area for the desk-based literature review considered existing data and information relevant to the survey study area as well as the wider eastern Irish Sea. The purpose of this information was to validate the findings of the fish survey programme and to provide ecological context to these findings at the appropriate spatial scale (e.g. spawning, population and stock distribution).

1.6 Fish Surveys

A multi-method survey technique was adopted for the fish surveys to facilitate sampling from this mosaic of habitats and environmental conditions present along the north Anglesey coast. Surveys were designed to assess both spatial and temporal variations in larval, juvenile and adult fish communities within the inshore and offshore waters north of Anglesey. To provide an understanding of fish spawning and recruitment patterns, ichthyoplankton surveys were carried out monthly from May 2010 to September 2014; the results and discussion of this data are presented in Section 2.

To provide an understanding of inshore fish communities, intertidal fish surveys were carried out on a quarterly basis between spring (April) 2010 and autumn (November) 2015. Diver fish surveys were also carried out in the summer of 2010 to assess sublittoral fish communities of the north Anglesey coast. Further anecdotal data was obtained during diver surveys in 2011 and 2012. It should be noted that the Existing Power Station was in operation at the time of sampling. Sites were therefore selected with increasing distance from the cooling water outfall to determine any gradients in community composition or diversity caused by the thermal discharge. A number of sites were determined to be beyond the likely detectable influence from the cooling water discharge (approximately 3 – 5 km). The results and discussion of the findings of these surveys can be found in Section 3.

Offshore fish communities were sampled during subtidal fish surveys carried out on a quarterly basis between spring (April) 2010 and autumn (November) 2014; the results and discussion of this data are presented in Section 4.

1.7 Literature Review

To inform this baseline assessment of fish communities, a desk-based review of existing data sources was carried out. This included data relating to ichthyoplankton, juvenile and adult fish as well as shellfish. Commercial fisheries information has also been included to provide further evidence of abundance and distribution patterns of fish and shellfish populations as well as their social and commercial importance to the Isle of Anglesey. The data sources used to inform this baseline report are described in Table 1.1.

Table 1.1: Data sources used to inform fish and shellfish ecology baseline.

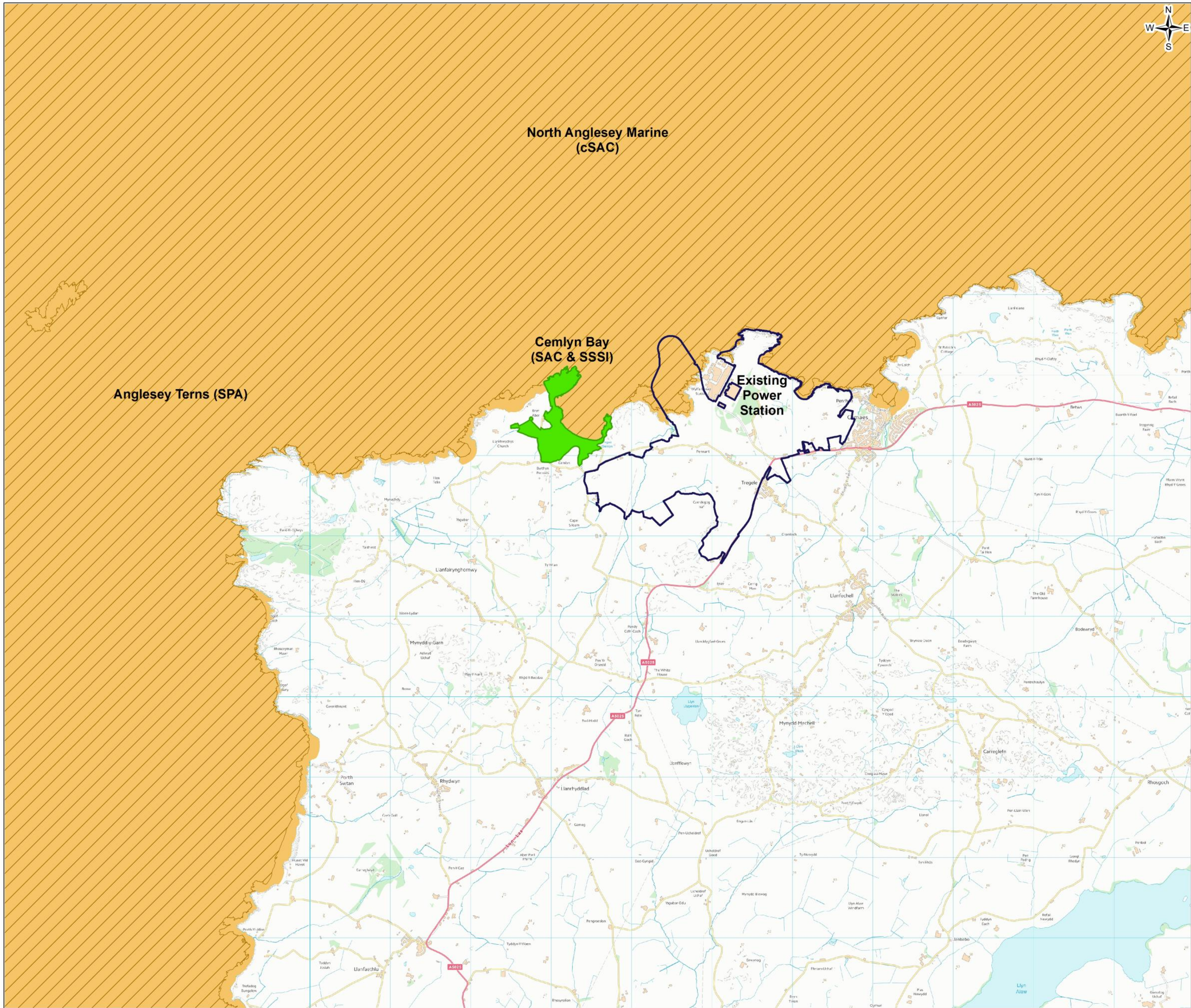
Source	Data/publication details	Summary
Spawning and nursery grounds of selected fish species in UK waters.	Ellis *et al*. (2012)	Spatial data highlighting the spawning and nursery grounds of key commercial species in UK waters.
Irish Beam Trawl Surveys	Parker-Humphreys (2004)	Distribution and relative abundance of demersal fishes from beam trawl surveys in the Irish Sea (ICES division VIIa) 1993 – 2001.

Source	Data/publication details	Summary
Impingement Monitoring Data	Spencer (1990)	Published results from a two-year study of impingement at the Existing Power Station between September 1985 and September 1987.
Impingement and Entrainment Monitoring Data	Jacobs (2016a) (Application Reference Number: 6.4.92)	Unpublished survey data from a 16-month monitoring programme (March 2011 to July 2012) carried out at the Existing Power Station.
UK Sea Fisheries Statistics 2014	MMO (2014)	UK Sea Fisheries Statistics 2014 provides a broad picture of the UK fishing industry and its operations.
Fishmap Môn Project	Fishmap Môn (2014)	Findings of a collaborative pilot project between NRW and recreational and commercial fishermen in north Wales.

FIGURE 1-1

Legend

- Wylfa Newydd Development Area
- The North Anglesey Marine/Gogledd Môn Forol cSAC
- Bae Cemlyn/Cemlyn Bay SAC and SSSI
- Anglesey Terns/Morwenoliaid Ynys Môn SPA



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	AUG 17	Initial Issue	HT	CT	EC	RB

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

WYLFA NEWYDD DEVELOPMENT AREA
AND DESIGNATED MARINE AND
COASTAL CONSERVATION SITES

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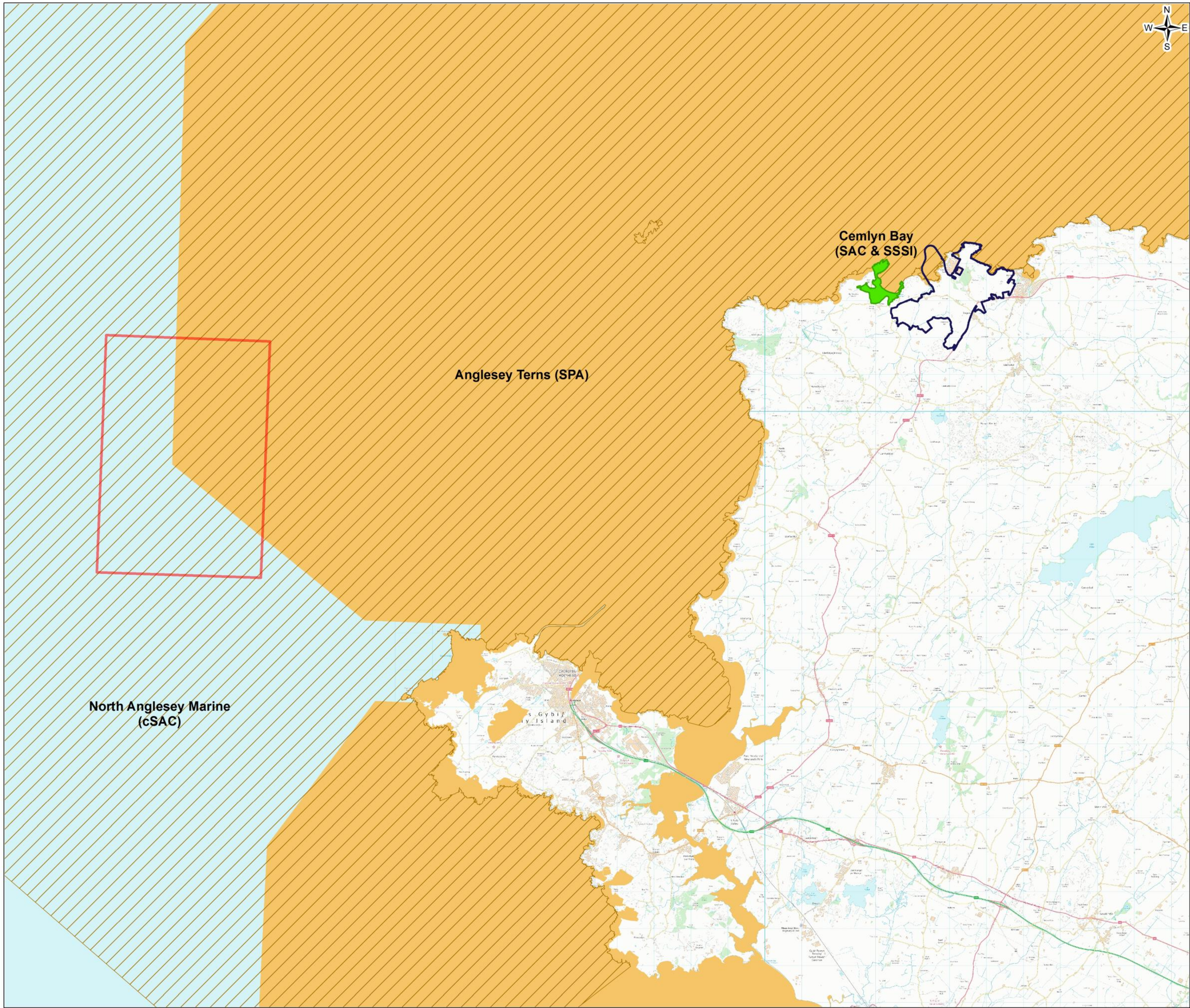

FIGURE 1-2

Legend

- Wylfa Newydd Development Area
- Disposal Site
- The North Anglesey Marine/Gogledd Môn Forol cSAC
- Bae Cemlyn/Cemlyn Bay SAC and SSSI
- Anglesey Terns/Morwenoliaid Ynys Môn SPA

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	AUG 17	Initial Issue	HT	CT	EC	RB

Client

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Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

DISPOSAL SITE

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2. Ichthyoplankton Communities

2.1 Methodology

Ichthyoplankton communities were sampled from 2010 to 2014 to provide data on early life stages, including larval fish and eggs. During the first full year of sampling (May 2010 to April 2011), surveys were carried out monthly to encompass the entire seasonal variation in ichthyoplankton abundance.

Samples were initially collected at five sites (see Figure 2.1 and Appendix A.1 for site locations). These included:

- sites 1 and 3 were located farthest from the Wylfa Newydd Development Area, approximately 5 km to the east and west, respectively;
- site 4 was located approximately 4 km offshore to the north of Wylfa Head; and
- sites 2 and 5 which were located inshore, up to approximately 1 km and 2 km north of the Wylfa Newydd Development Area, respectively.

In May 2011, site 6, which was located immediately to the west of the Power Station Site (in the area of the cooling water intake of the Existing Power Station), was added to the programme. Due to the large tidal excursion, samples were collected during a range of different tidal states including flood and ebb tides and at slack water.

Analysis of data from the first year of sampling (May 2010 to April 2011) showed very low numbers of ichthyoplankton in the tow samples during the winter, and therefore sampling was reduced to a single random tide at sites 1 to 5 in November 2011 and January 2012 whilst no sampling was carried out in December 2011. To ensure sufficient data were obtained, sampling on both flood and ebb tides continued at site 6 in November 2011 and January 2012. At sites 1 to 5, sampling on both states of tide resumed in February 2012 until April 2012.

The addition of data from the second year of sampling (May 2011 – April 2012) showed no statistically significant differences between ichthyoplankton communities at different sites or different tidal states (see Jacobs, 2011a). Based on this evidence and the scale of the tidal excursion along the north Anglesey coast, it was decided that from April 2012 sampling would cease at sites 1 to 3: the furthest sites east and west of Wylfa Head, respectively. Between May 2012 and October 2013, sampling continued on a single random tide at sites 2, 4 and 5 along a north/south axis from the Wylfa Newydd Development Area, whilst sampling at site 6 continued on both flood and ebb tides.

The composition of ichthyoplankton communities at site 4 and site 5 demonstrated a very high degree of similarity; therefore, from the February 2014, it was considered reasonable, after nearly three years of data collection, to cease sampling at site 5. An additional site (site 7) was added to the 2014 programme to provide data on the ichthyoplankton community approximately 0.5 km to the west of Porth-y-pistyll. From the February 2014 sampling period, all sites (2, 4, 6 and 7) were sampled on a single random tide.

No sampling was carried out between November and January inclusive in 2012/2013 and 2013/2014 owing to the very low numbers of ichthyoplankton previously observed during winter months. The full survey programme, including sampling dates, can be found in Appendix A.

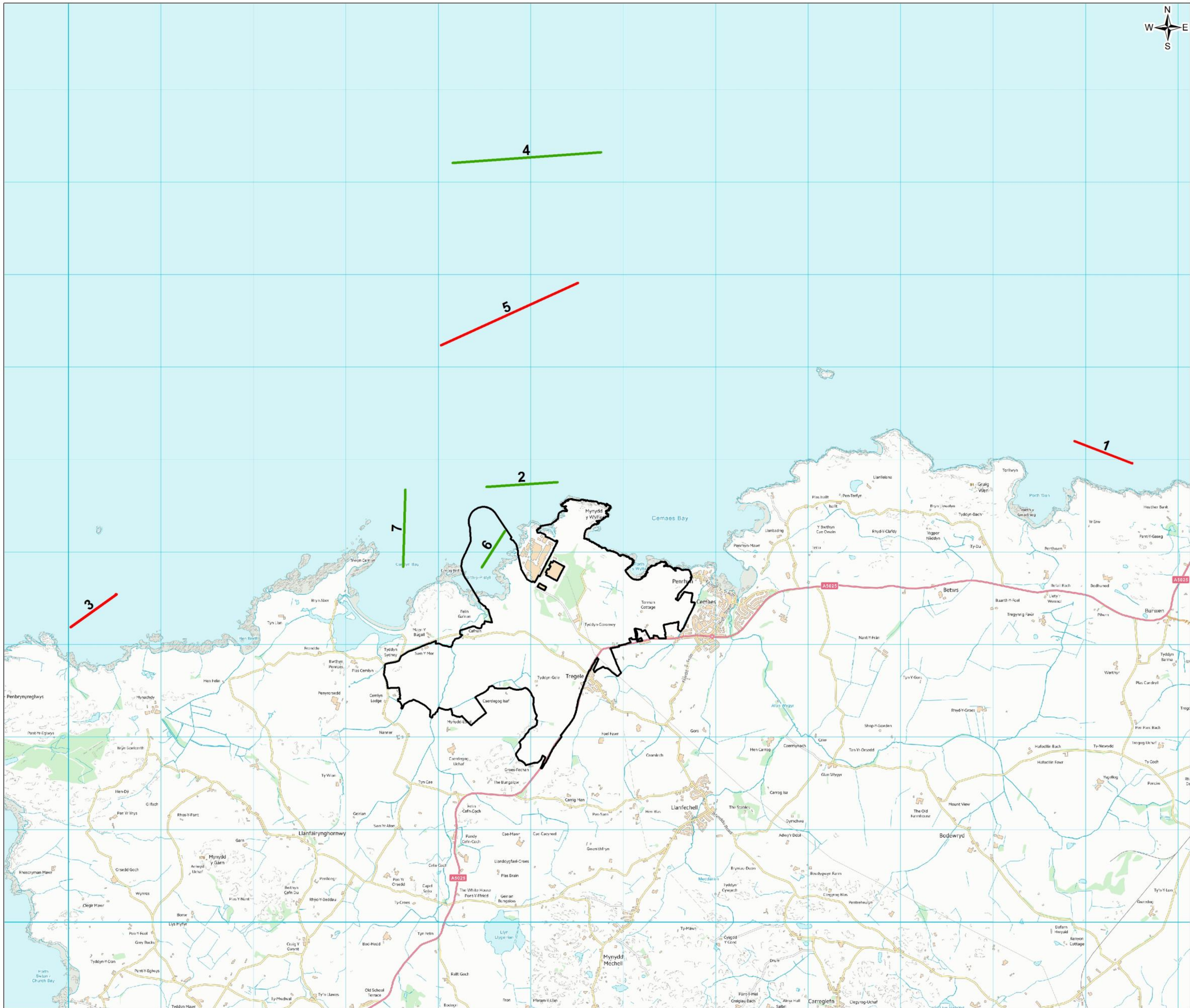

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FIGURE 2-1

Legend

- Wylfa Newydd Development Area
- Inactive Sites in 2014
- Active Sites in 2014

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Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

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WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

ICHTHYOPLANKTON SURVEY SITES

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Ichthyoplankton surveys were carried out on the vessel 'SeeKat C' operating from Amlwch Port. Ichthyoplankton samples were collected using a high-speed plankton sampler, the Gulf™ sampler. This sampler has been used extensively by Cefas and is regarded as one of the most effective methods of collecting ichthyoplankton (S. Milligan, Cefas, pers. comm.).

The Gulf™ plankton sampler consisted of a two metre long, 275 µm mesh net housed in a steel frame (Figure 2.2). Fins at the back of the frame and a depressor weight at the front aid stability during towing. A nose cone fitted to the front of the frame contains a calibrated flowmeter General Oceanics (G.O. Environmental, Model 2030) enabling the volume of water filtered through the net to be calculated.

A pressure sensor (YSI, 600 XLM) was mounted on the sampler frame to measure towing depth, temperature and salinity. Before deployment, the flowmeter reading was recorded. The sampler was then deployed on a winch over the stern of the vessel and lowered into the water.

The sampler was towed in an undulating pattern by adjusting the length of winch cable. The depth sensor measured the sampler's profile and a Global Positioning System (GPS) (Garmin GPS76) was used to record the start and end points of each tow, including the route taken. The sampler was towed for approximately 10 minutes at around 3.5 knots through the water.

On retrieval of the sampler, the end flowmeter reading was recorded on the trawl log sheets and the cod-end removed. The catch was transferred to a sealable container and labelled with date, time, site name, tidal state and replicate number. Samples were fixed in 4% formalin upon reaching the shore.

Three replicate tows were collected at each site and on both the ebb and flood tide where the sampling programme dictated both tides should be sampled. It was considered that each replicate tow sampled a different body of water, owing to the strong currents in the area.

Figure 2.2 : Deploying the Gulf™ plankton sampler over the stern of the SeeKat C.

2.1.1 Sample Processing

In the laboratory, fish larvae were picked from the samples under a stereomicroscope (Leica, S6E) before being identified, counted and measured to the nearest 0.5 mm. Identification of fish larvae was intended to be taken to the lowest taxonomic level possible (i.e. species level). In some cases, loss of key identification features in fragile specimens and/or size prevented certainty in speciation and therefore identification of some specimens was taken to family level only. In addition, a combination of poor specimen condition and the general difficulty in identifying juvenile fish prevented identification to family level. In these instances, individuals were classified as bony fish (osteichthyes indeterminate). Fish eggs were also picked from each plankton sample and counted.

2.1.2 Data Analysis

Numbers of fish and eggs recorded within each tow were divided by the volume of water sampled (number per m^3) and extrapolated to numbers per 10^6 m^3 of water abstracted. This standardisation allows direct comparison of data between sites, replicates, sampling months and sampling years. To compare to published literature, which typically reported per m^2, abundance estimates per m^3 have been divided by the mean sample depth.

The statistical analysis of ichthyoplankton data was carried out using PRIMER 6™ (Clarke and Gorley, 2006). In contrast to univariate analyses, which concentrate complex ecological data into a single metric, multivariate analysis compares differences between all taxa and their relative abundances between samples and sites. The analysis therefore allows identification of samples/sites with similar/dissimilar communities. Further explanation of the statistical terms and methods used is provided in Appendix B.

Over the sampling programme, poor weather resulted in sampling being postponed until the following month on five sampling occasions (see Figure A.1, Appendix A). In all cases, the delay was no more than four days into the following month. For the purpose of data analysis, all surveys have been reported based on the month in which they were intended to have been sampled. For statistical analysis of temporal and seasonal differences, where sampling had been postponed into the subsequent month and this month represented a different season for example, from February (winter) to March (spring), the data generated was considered representative of the season in which they were collected, in this example spring. The February 2014 sampling period was the only recorded instance where the survey was delayed and the subsequent sampling month represented a different season.

2.2 Results

2.2.1 Overall

Between May 2010 and September 2014, a total of 10,160 fish were recorded from filtering 35,685 m^3 of seawater through Gulf sampling nets, representing 52 distinct taxa (Table 2.1). The taxa list was covered by 24 taxonomic families, of which the most diverse representation was given by flatfish (Pleuronectidae, n = 6), the cod family (Gadidae, n = 5) and sandeel (Ammodytidae, n = 4). Samples were dominated by individuals from the family Ammodytidae, which accounted for the highest proportion (n = 4,124, 41%), followed by Pleuronectidae (n = 1,191, 12%), Clupeidae (n = 1,064, 11%) and Gobiidae (n = 633, 6%).

Table 2.1 : Taxa recorded in ichthyoplankton tows from May 2010 to September 2014 and the total abundance over the whole survey period. Taxa that could not be identified to species level are shown in bold. Those entries with * denote taxa that were not included in calculation of total taxa richness.

Common name	Scientific name	Numbers
Sandeel family	**Ammodytidae***	3,672
Sprat	*Sprattus sprattus*	812
Dab	*Limanda limanda*	722
Goby family	**Gobiidae**	613
Dragonet family	**Callionymidae***	454
Long-spined sea scorpion	*Taurulus bubalis*	339
Right-eyed flatfish family	**Pleuronectidae***	298
Lesser sandeel	*Ammodytes tobianus*	283
Tompot blenny	*Parablennius gattorugine*	279

Common name	Scientific name	Numbers
Herring family	**Clupeidae***	218
Corkwing wrasse	*Symphodus melops*	175
Solenette	*Buglossidium luteum*	155
Raitt's sandeel	*Ammodytes marinus*	137
Flounder	*Platichthys flesus*	130
Sole family	**Soleidae***	122
Butterfish	*Pholis gunnellus*	119
Montagu's seasnail	*Liparis montagui*	92
Common dragonet	*Callionymus lyra*	85
Whiting	*Merlangius merlangus*	84
Pogge	*Agonus cataphractus*	79
Cod family	**Gadidae***	64
Two-spotted clingfish	*Diplecogaster bimaculata*	61
Common seasnail	*Liparis liparis*	58
Shanny	*Lipophrys pholis*	51
Dover sole	*Solea solea*	39
Scorpionfish family	**Cottidae***	38
Plaice	*Pleuronectes platessa*	37
Nilsson's pipefish	*Syngnathus rostellatus*	34
Herring	*Clupea harengus*	30
Seasnail family	**Liparidae***	30
Greater sandeel	*Hyperoplus lanceolatus*	28
Yarrell's blenny	*Chirolophis ascanii*	26
Wrasse family	**Labridae***	24
Short-spined sea scorpion	*Myoxocephalus scorpius*	19
Transparent goby	*Aphia minuta*	16
Ling/Rockling family	**Lotidae family**	16
Scaldfish	*Arnoglossus laterna*	14
Reticulated dragonet	*Callionymus reticulatus*	14
Lesser weever	*Echiichthys vipera*	10
Blenny family	**Blenniidae***	9
Gurnard family	**Triglidae***	7
Snake pipefish	*Entelurus aequoreus*	6
Goldsinny wrasse	*Ctenolabrus rupestris*	5
Smooth sandeel	*Gymnammodytes semisquamatus*	4
Ballan wrasse	*Labrus bergylta*	4

Common name	Scientific name	Numbers
Pilchard	*Sardina pilchardus*	4
Crystal goby	*Crystallogobius linearis*	3
Mackerel	*Scomber scombrus*	3
Lemon sole	*Microstomus kitt*	2
Norwegian topknot	*Phrynorhombus norvegicus*	2
Pollack	*Pollachius pollachius*	2
Bib	*Trisopterus luscus*	2
Left-eyed flounder family	**Bothidae***	1
Bass	*Dicentrarchus labrax*	1
Cod	*Gadus morhua*	1
Clingfish family	**Gobiesocidae***	1
Long rough dab	*Hippoglossoides platessoides*	1
Atlantic halibut	*Hippoglossus hippoglossus*	1
Goby species	*Lebetus* sp.	1
Norway bullhead	*Micrenophrys lilljeborgii*	1
Thickback sole	*Microchirus variegatus*	1
Brill	*Scophthalmus rhombus*	1
Greater pipefish	*Syngnathus acus*	1
Poor cod	*Trisopterus minutus*	1
Topknot	*Zeugopterus punctatus*	1

A number of specimens were only identified to family level, for example, whilst the presence of four species of sandeel was recorded, many specimens could only be recorded as Ammodytidae (see above). In addition, over the entire sampling programme, 617 individuals were categorised as bony fish (Osteichthyes indet.). It is possible that specimens identified to family level and Osteichthyes indet. represented entries already recorded; therefore, these groups were not included in the distinct-taxa-richness calculation where they could already represent another entry. The only exceptions were the inclusion of Lotidae (rockling and lings) and Triglidae (gurnards), as speciation of individuals belonging to either family is not possible owing to the absence of sufficient published literature.

The family Gobiidae was included because, although species such as transparent gobies (*Aphia minuta*), diminutive/Guillet's goby (*Lebetus* sp.) and crystal goby (*Crystallogobius linearis*) are easily identified, even at a small size, species belonging to the genera *Gobius* spp. and *Pomatoschistus* spp. are difficult to separate. Those individuals recorded as Gobiidae are believed to represent species belonging to these two genera alone. It is considered that the true taxa richness could be noticeably higher than 52, as these three families contain several species commonly found off the west coast of the UK; therefore, taxa richness estimates can be considered minimum values.

Taxa richness peaked during the spring months of April and May in all sampling years, with the total number of discrete taxa ranging from 12 (May 2012) to 24 (April 2012). The lowest taxa richness was recorded during the autumn and winter months (September to February), with a seasonal maximum of seven discrete taxa recorded in September 2013. Ichthyoplankton were absent on a number of sampling occasions; however, there were only two instances where ichthyoplankton were absent for the entire sampling month (November 2010 and 2011).

The total number of discrete taxa observed at each site over the whole survey programme ranged from 20 at site 7 to 41 at site 4. The highest number of discrete taxa recorded in a single sampling occasion was observed in April 2011 at site 5 (n = 13).

2.2.2 Spatial Variation

Of the 52 distinct taxa recorded over the survey programme, 14 taxa were found at all seven sites. The four most abundant taxa groups (Ammodytidae, Pleuronectidae, Clupeidae and Gobiidae) were recorded at all sites, and only where taxa were low in overall abundance were there notable differences in presence or absence at individual sites. Of the 52 taxa recorded, 25 were all recorded at sites 1 to 6. These values do not take into account differences in the frequency of sampling at each site, which varied considerably (see Section 2.1). Poor cod (*Trisopterus minutus*) was new to the taxa list in 2014, with an individual recorded at site 4 in June.

The highest ichthyoplankton abundance (averaged for all replicate samples per month and adjusted to numbers per 10^6 m^3) over the 47 months of sampling was observed at site 1 in February 2012 (approximately 2.6 x 10^6 individuals per 10^6 m^3) (Figure 2.3). Peaks in ichthyoplankton abundance were also observed at sites 4 and 5 during March and April 2011 (1.8 and 2.3 x 10^6 individuals per 10^6 m^3respectively) (Figure 2.4). Lower abundances were observed at sites 2 and 3, where numbers did not exceed 950,000 individuals per 10^6 m^3 at any point during the sampling programme. The highest peak in abundance at site 6 was in the February 2014 sampling occasion, with 974,000 individuals per 10^6 m^3 recorded (Figure 2.4). A maximum of 1.4 x 10^6 m^3 individuals were recorded at site 7 in March 2014 (Figure 2.5).

Over the whole sampling period, the abundance of ichthyoplankton followed a similar seasonal pattern, with the highest abundances occurring from February to May and the lowest from October to January. The timing of peak abundance has differed between years and sites. In 2011 and 2013, peak abundance was recorded in March at the majority of sites. In 2012, peak abundance occurred in February at sites 1 and 6 but in April at sites 2, 3 and 5 (peak abundance at site 4 was recorded in March). In 2014, peak abundance was recorded in March at site 7.

A two-way crossed ANOSIM test found considerable similarity between the communities at the sites (Global R = 0.015, $p<0.05$) despite lower abundances of common taxa such as Ammodytidae, Gobiidae and Clupeidae at sites 6 and 7.

A two-way crossed ANOSIM test between tides across all sites found that there was no significant difference between samples taken at ebb, flood or slack tide (Global R = 0.002, $p > 0.05$) (see Table C1, Appendix C).

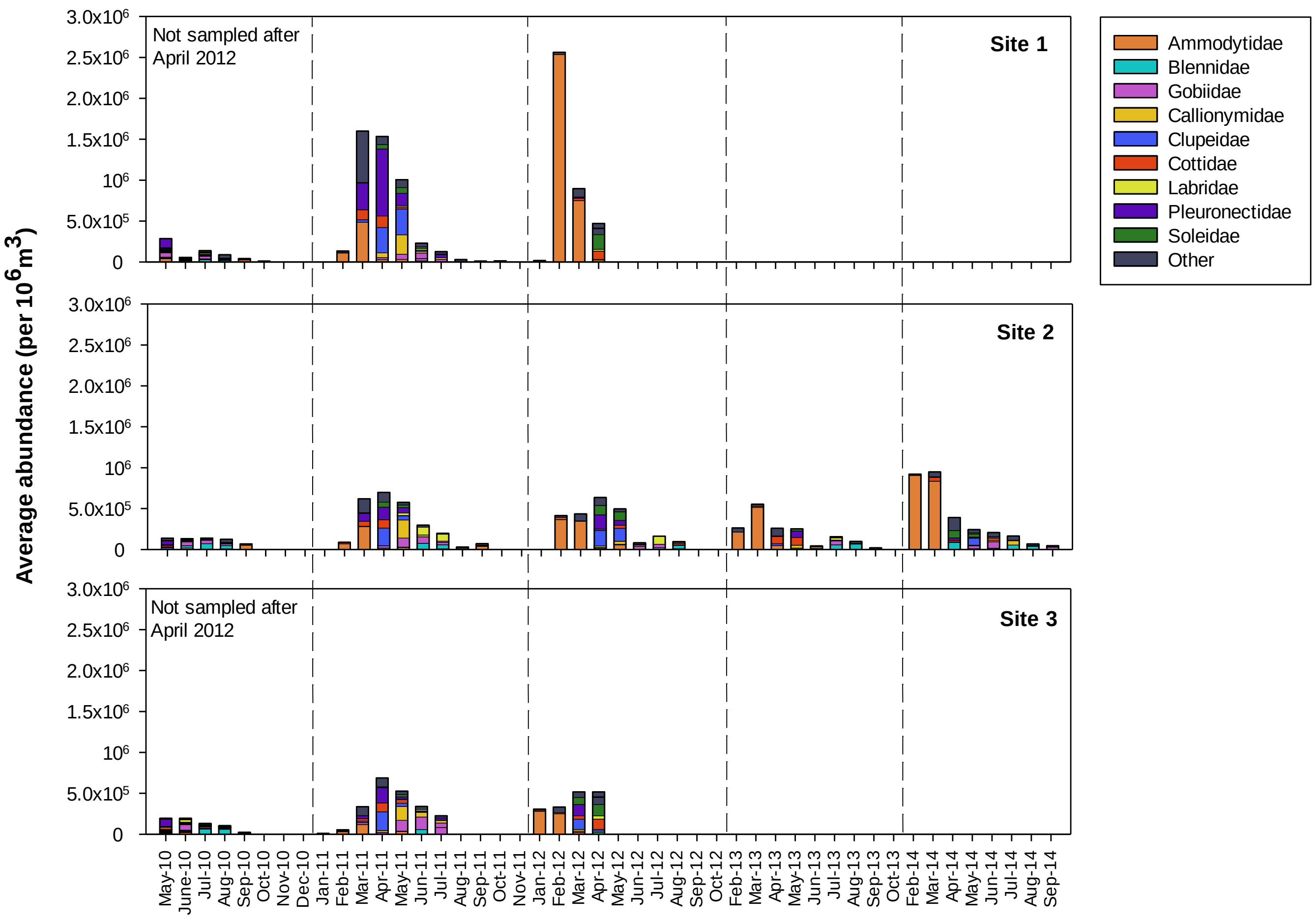


Figure 2.3 : Ichthyoplankton abundances (adjusted for average abundance per 10^6 m^3 of water filtered) from the north coast of Anglesey at sites 1-3 between May 2010 and September 2014. The nine most abundant families are shown. 'Other' group comprises the following families: Gobiesocidae, Syngnathidae, Gadidae, Liparidae, Pholidae, Bothidae, Triglidae, Scophthalmidae, Scombridae, Moronidae, Trachinidae and also includes 'Osteichthyes indet.'

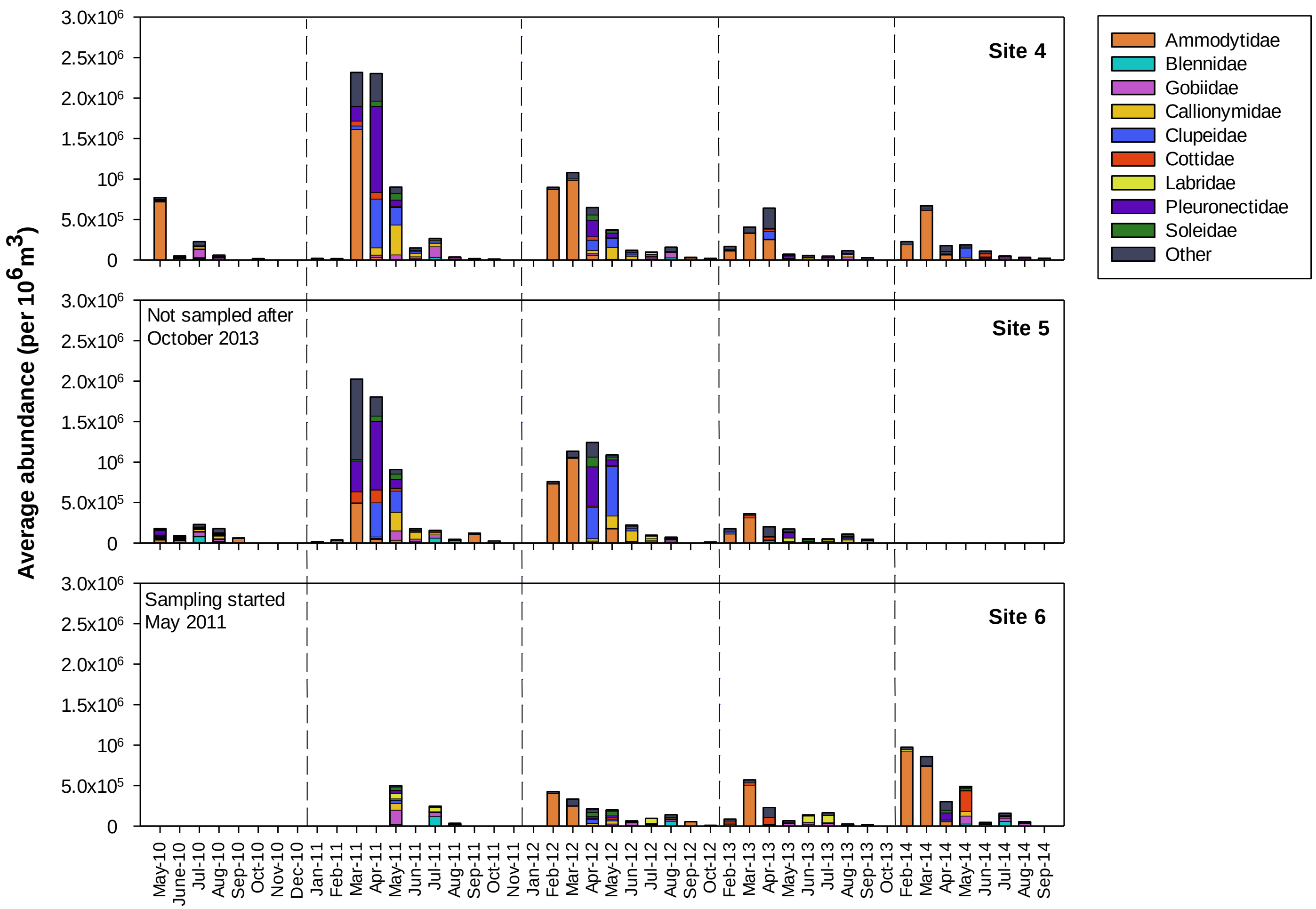


Figure 2.4 : Ichthyoplankton abundances (adjusted for average abundance per 10^6 m^3 of water filtered) from the north coast of Anglesey at sites 4-6 between May 2010 and September 2014. The nine most abundant families are shown. 'Other' group comprises the following families: Gobiesocidae, Syngnathidae, Gadidae, Liparidae, Pholidae, Bothidae, Triglidae, Scophthalmidae, Scombridae, Moronidae, Trachinidae and also includes 'Osteichthyes indet.'

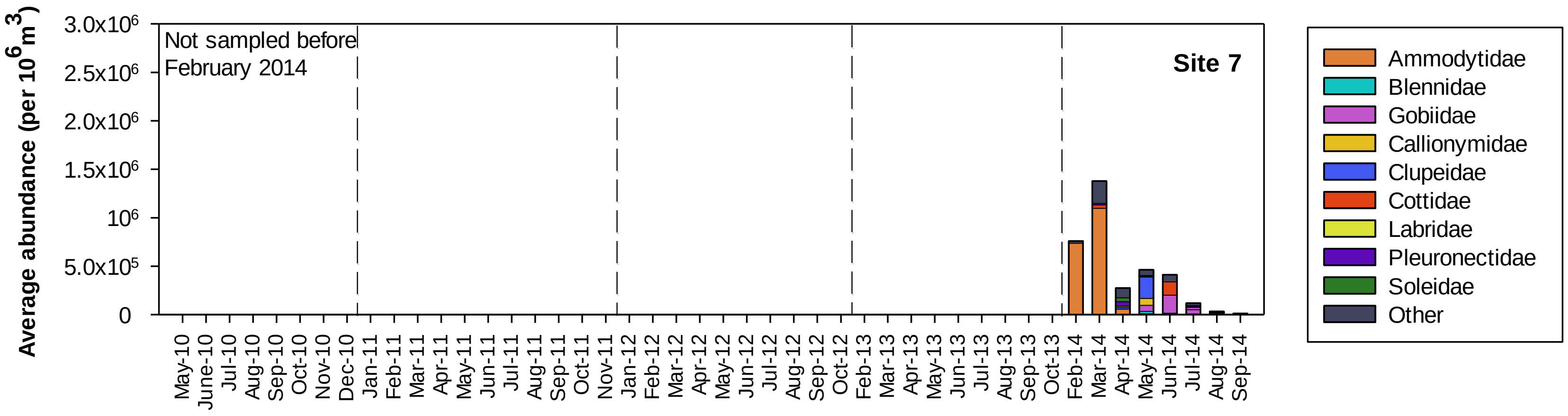


Figure 2.5 : Ichthyoplankton abundances (adjusted for average abundance per 10^6 m^3 of water filtered) from the north coast of Anglesey at site 7 between February 2014 and September 2014. The nine most abundant families are shown. 'Other' group comprises the following families: Gobiesocidae, Syngnathidae, Gadidae, Liparidae, Pholidae, Bothidae, Triglidae, Scophthalmidae, Scombridae, Moronidae, Trachinidae and also includes 'Osteichthyes indet.'

2.2.3 Temporal Variation

Over the entire survey programme, sandeel (Ammodytidae) was the only taxa recorded in every season. Although Clupeidae represented the third most abundant taxon, they were not recorded during the autumn months, with the exception of three individuals recorded in September 2011. Pleuronectidae represented the second most abundant taxon; however, abundances represented a strong seasonal cycle and, with the exception of 16 individuals recorded in May 2013, the presence of this taxon was limited to the spring months only.

A two-way crossed ANOSIM carried out on the families indicated considerable similarity in the ichthyoplankton communities sampled between years (Global R = 0.137, P<0.05). In contrast, the ANOSIM testing between seasons resulted in an intermediate Global R value (R = 0.491, P<0.05), which indicated notable differences in the ichthyoplankton community over the seasons (Table C3, Appendix C). The greatest difference was observed between spring and autumn (R = 0.572, P<0.05), whilst summer and autumn seasons were found to be the most similar in community composition (R = 0.292, P<0.05).

The results of the above ANOSIM test were illustrated through a multi-dimensional scaling (MDS) plot, which showed grouping of samples into their seasonal components and a transition between seasons throughout the year (Figure 2.6). Spring and summer samples were relatively tightly clustered, indicating that samples from different years demonstrated similar taxa assemblages. Autumn samples, however, demonstrated a more dispersive pattern, with taxa assemblages showing similarities to summer samples in some years (2013 and 2014) and winter samples in other years (2010, 2011 and 2012). Winter samples were also relatively dispersed.

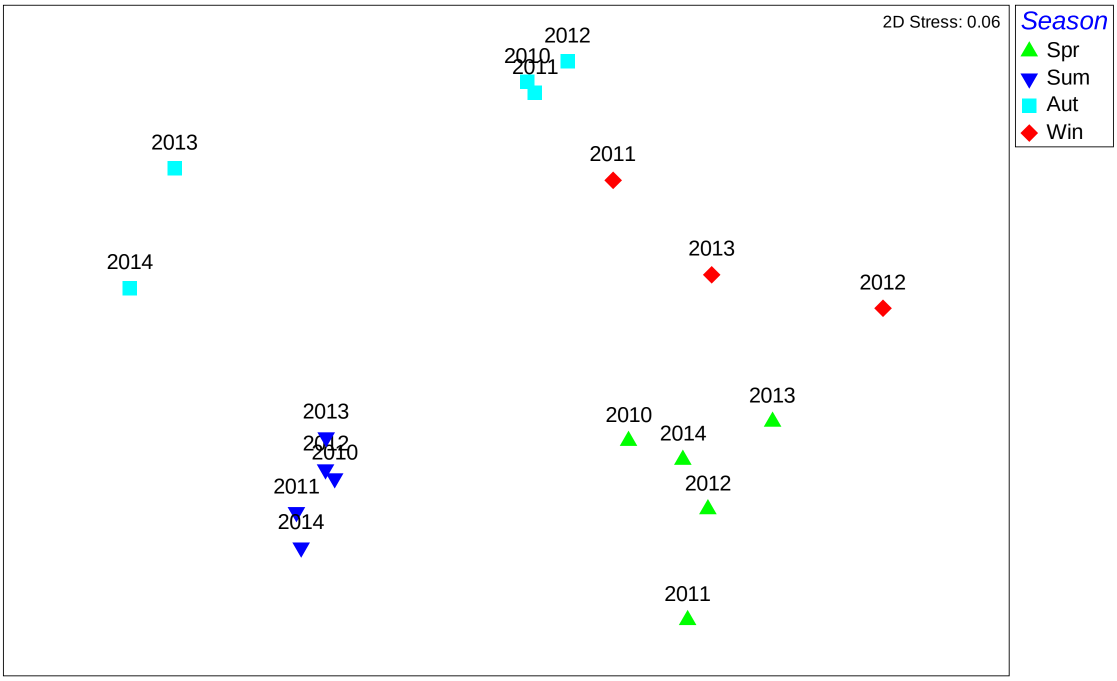


Figure 2.6 : A two-dimensional MDS plot of ichthyoplankton data (square root transformed) sampled from north Anglesey between February and September in 2010, 2011, 2012, 2013 and 2014, with season as a factor. Samples collected between October and January inclusive were omitted from the plot owing to the low abundances observed during these sampling months. Note that the winter 2014 data point is missing, as this survey was delayed until March and has therefore been classified as a spring data point.

SIMPER analysis indicated that differences between seasons and years appeared to be the result of changes in the abundances of common taxa, as opposed to a significant change in assemblage composition (Table E4 and Table C5, Appendix C). The difference in abundances of Ammodytidae, contributed to the highest proportion of dissimilarity between all year combinations and nearly all season combinations. The only exception was found when comparing summer to autumn, in which case Gobiidae were found to contribute the most to dissimilarity.

The other main families contributing to dissimilarity were Pleuronectidae, Blenniidae and Cottidae. These families were dominated by dab, tompot blenny (*Parablennius gattorugine*) and long-spined sea scorpion (*Taurulus bubalis*), respectively.

SIMPER analysis of autumn samples (September) indicated that ichthyoplankton communities recorded in 2013 and 2014 were characterised by an unusually low abundance of Ammodytidae and a high abundance of Blenniidae, Syngnathidae and Gobiidae (Table C5, Appendix C). A comparison between winter samples indicated that variation between sampling years was primarily driven by the abundance of Ammodytidae. Bubble plots superimposed onto the MDS plot (Figure 2.7) demonstrated the fluctuations in abundance of sandeel (Ammodytidae), right-eyed flatfish (Pleuronectidae), blennies (Blenniidae) and pipefish (Syngnathidae) across seasons and the dissimilarities between years.

Total ichthyoplankton abundance recorded between 2010 and 2014 peaked during late winter and early spring (February – April) (see Section 2.2.2). Peak abundances during February and March were dominated by sandeel larvae, which represented between 44% – 97% of the total abundance in each sampling year. From late spring (May), sandeel abundance generally decreased and the fish community showed a higher diversity as other families such as Clupeidae and Pleuronectidae contributed more to total abundance, respectively. Fish diversity remained low throughout the autumn and winter months, but sandeel again dominated samples representing between 31% – 96% of total abundance.

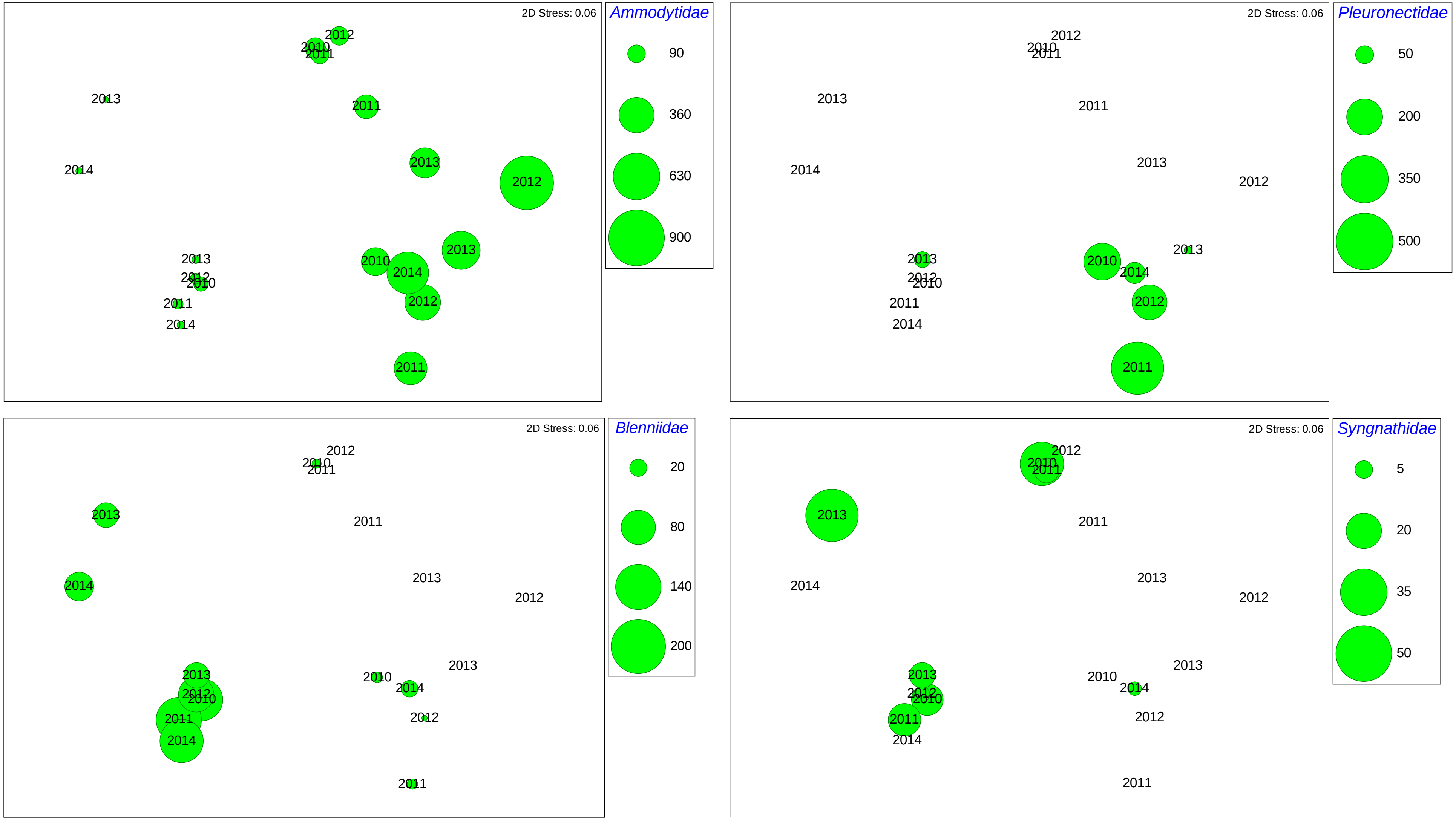


Figure 2.7 : MDS of the aggregated abundance of Ammodytidae, Pleuronectidae, Blenniidae and Syngnathidae using seasons as a factor and labelled by year. Note that the abundance shown (per 10^6 m^3) is square root transformed.

2.2.4 Species of Conservation and Commercial Importance

Several species of conservation importance have been recorded during the ichthyoplankton survey programme. These include the following species which are listed under Section 7 of the *Environment (Wales) Act 2016*:

- Raitt's sandeel (*Ammodytes marinus*);
- plaice (*Pleuronectes platessa*);
- herring (*Clupea harengus*);
- mackerel (*Scomber scombrus*);
- cod (*Gadus morhua*);
- Dover sole (*Solea solea*); and
- whiting (*Merlangius merlangus*).

Of these seven species, five occurred in significant numbers over the survey programme and their abundances are presented in Figure 2.8. Raitt's sandeel are shown in the context of the sandeel family due to difficulties in identification of larval sandeel (either owing to loss of key identification features in fragile specimens or where the small size precludes certainty in speciation); a number of sandeel identified to family level could potentially be Raitt's sandeel. Sandeel represented the most abundant taxa of interest (and overall) in all sampling years with total extrapolated catches ranging from 45,001 per 10^6 m^3 of water sampled in 2010 to 1,593,874 per 10^6 m^3 in 2014. Sandeel was the only species to be recorded in every season.

Whiting represented the second most abundant taxa of interest with annual extrapolated catches ranging from 1,576 per 10^6 m^3 in 2010 to 59,829 per 10^6 m^3 in 2011. The majority of whiting were recorded during the spring (April – May). However, whiting ranked 19th in terms of its contribution to the total abundance of ichthyoplankton recorded between 2010 and 2014 (see Table 2.1).

Annual extrapolated numbers of herring varied during the sampling programme with catches ranging from 1,906 per 10^6 m^3 in 2012 to 16,050 per 10^6 m^3; herring ranked 29th in terms of its contribution to overall abundance, although individuals recorded as Clupeidae only (ranked 10th) could have also been this species. The majority of herring were recorded in winter or early spring (December to April) during 2010 to 2013 (Figure 2.8). No herring were recorded in 2014.

Plaice were recorded between March and May in all sampling years and were most frequently recorded in April. The maximum extrapolated abundance recorded during a single sampling month was observed in April 2011 (29,301 per 10^6 m^3 of water sampled). The presence of Dover sole was limited to May, with May 2012 representing the highest monthly extrapolated catch of Dover sole (23,563 per 10^6 m^3 of water sampled). Dover sole were absent from the sampling programme in 2010. Plaice and sole ranked 27th and 25th, respectively, in terms of its contribution to overall ichthyoplankton abundances recorded, although a number of individuals were recorded to family level only, and therefore the contribution of these taxa to overall abundance could well be greater.

Of the remaining taxa of interest, there was only a single record of cod (June 2012) and three records of mackerel (April and June 2012) during the entire survey programme.

Several other taxa found in the survey are uncommon or rarely recorded in Welsh waters, including long rough dab, Norwegian topknot (*Phrynorhombus norvegicus*), Norway bullhead (*Micrenophrys lilljeborgii*) and diminutive/Guillet's goby. The Atlantic halibut (*Hippoglossus hippoglossus*) is also considered rare in Welsh waters due to over exploitation and is listed as 'endangered' in the IUCN (International Union for the Conservation of Nature) Red Data List. These taxa were not recorded on more than one sampling occasion during the entire sampling programme.

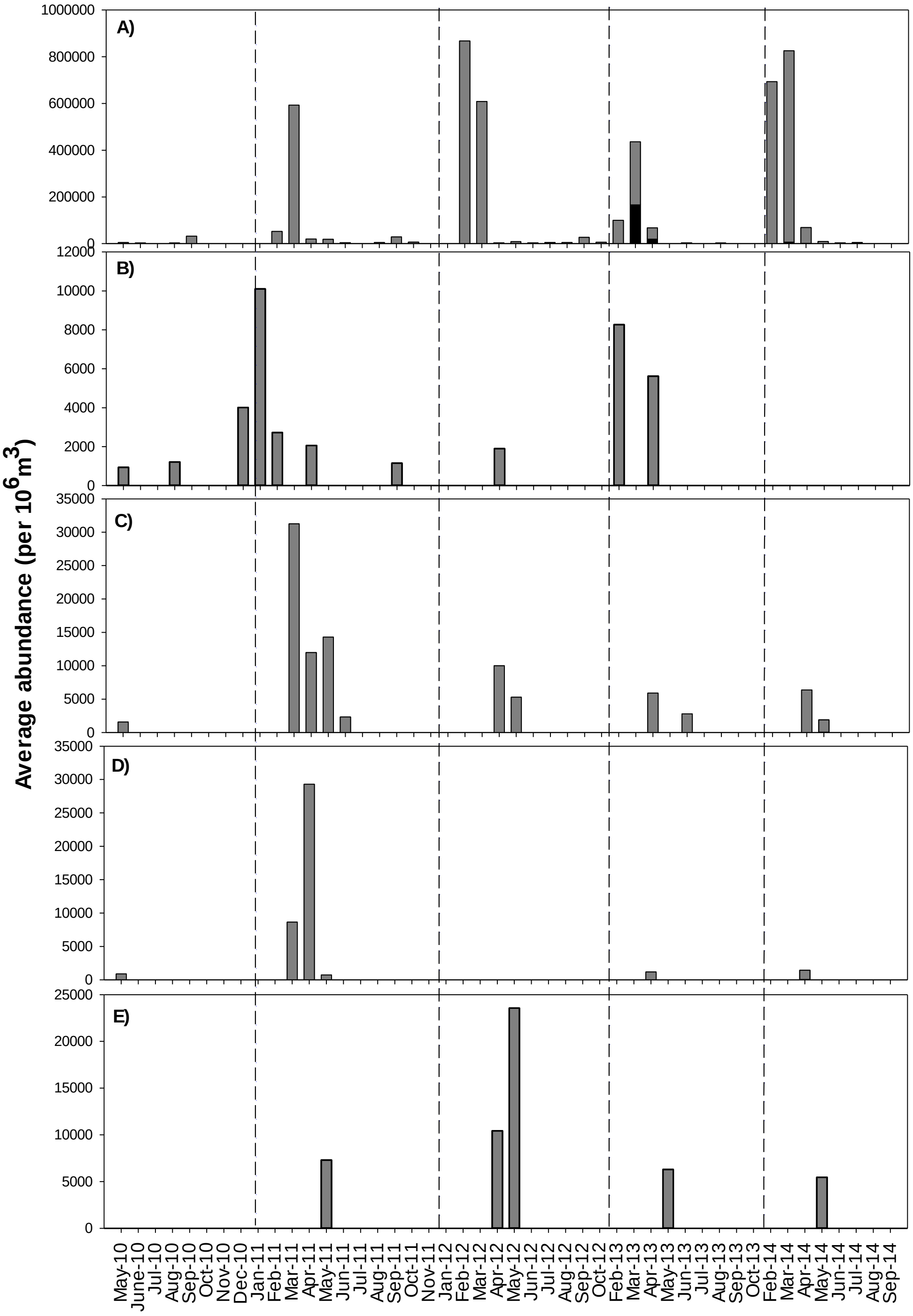


Figure 2.8 : Average abundance per month for all sites for taxa of conservation importance: A) Raitt's sandeel shown in black as a component of all Ammodytidae; B) herring; C) whiting; D) plaice; and E) Dover sole. Note the difference in scale on the y-axis.

2.2.5 Egg abundance

The average egg abundance between May 2010 and September 2014 showed a similar pattern of abundance at all sites, with a peak in spring months followed by a decrease in abundance into summer and then very low numbers in autumn and winter (Figure 2.9). Peak abundance occurred during May in 2011 and March in 2012 and 2013. In 2014, peak egg abundance was observed in April. In 2011 and 2013, a secondary smaller peak was observed, occurring in September and July respectively. Average egg abundance at site 2 was slightly higher than at other sites whilst egg abundance at site 4 was slightly lower than the other sites. Sites 6 and 7, which were in close proximity to one another, demonstrated very similar egg abundances. Despite small differences between sites, the main influence on egg abundance was clearly seasonal and the observed pattern corresponded with recorded abundances of fish larvae (Figure 2.3 to Figure 2.5).

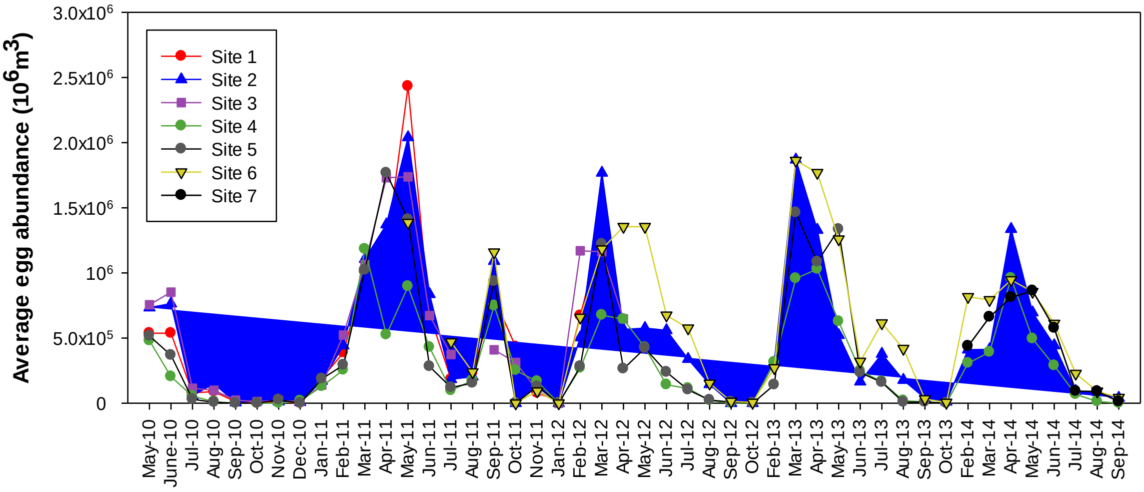


Figure 2.9 : Average egg abundance (per 10^6 m^3 of seawater sampled) at each site between May 2010 and September 2014.

2.3 Comparison to Published Literature

In 2012, Cefas published updated maps outlining species-specific spawning distributions in waters surrounding the British Isles (Ellis *et al*., 2012). These maps have been created using data collected during numerous national and internationally co-ordinated ichthyoplankton surveys and provide valuable information on ichthyoplankton abundance and distribution in the Irish Sea.

Those surveys relevant to the study area include the Irish Sea plankton surveys, which were carried out annually between 1982 and 1989 (Nichols *et al*., 1993), as well as in 1995 and 2000 (Fox *et al*., 1997 and Bunn and Fox, 2004, respectively). Dedicated plankton surveys in the eastern Irish Sea were also carried out in 2000, 2001 and 2003 (Bunn *et al*., 2004).

Figure 2.10 to Figure 2.14 demonstrate that the north coast of Anglesey, and westwards towards the Disposal Site, is characterised by low intensity spawning for species such as plaice, whiting, Dover sole and sandeel as well as other taxa not graphically presented including cod and mackerel (Ellis *et al*., 2012). High intensity spawning grounds for Dover sole, cod and sandeel are however located to the east of the Isle of Anglesey, in Liverpool Bay, and north towards the Isle of Man (Ellis *et al*., 2012). High intensity spawning grounds for plaice occur in the east and north-east Irish Sea, including the area around the north coast of Anglesey (Figure 2.10).

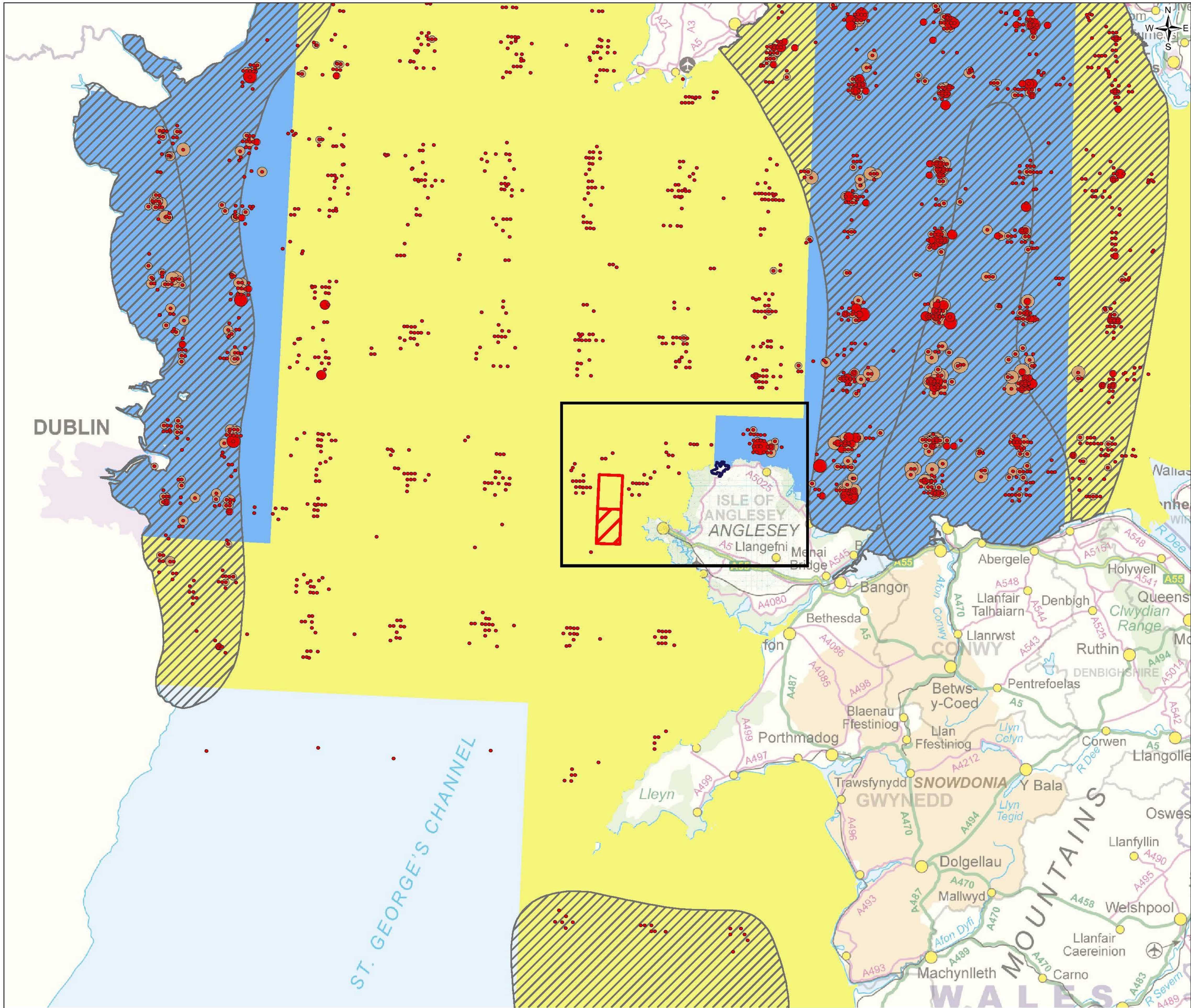


FIGURE 2-10

Legend

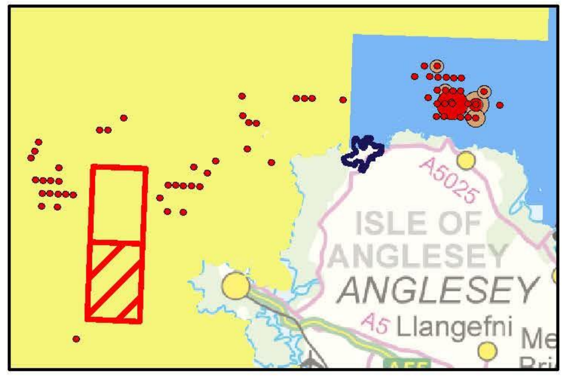
- Wylfa Newydd Development Area
- Holyhead Deep North (The Disposal Site)
- Holyhead Deep South
- Plaice spawning grounds 1998
- Plaice spawning grounds 2010: high intensity
- Plaice spawning grounds 2010: low intensity

Larvae (per m^2)

- 0 - 2.9
- 3.0 - 10.9
- 11.0 - 20.9
- 21.0 - 47.9
- 48.0 - 97.9

Eggs (per m^2)

- 0.0- 7.9
- 8.0- 27.9
- 28.0 - 62.9
- 63.0- 125.9
- 126.0 - 280.9



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	AUG 17	Initial Issue	RM	HY	EC	RB

Client: HORIZON NUCLEAR POWER

Project: WYLFA NEWYDD PROJECT ENVIRONMENTAL STATEMENT

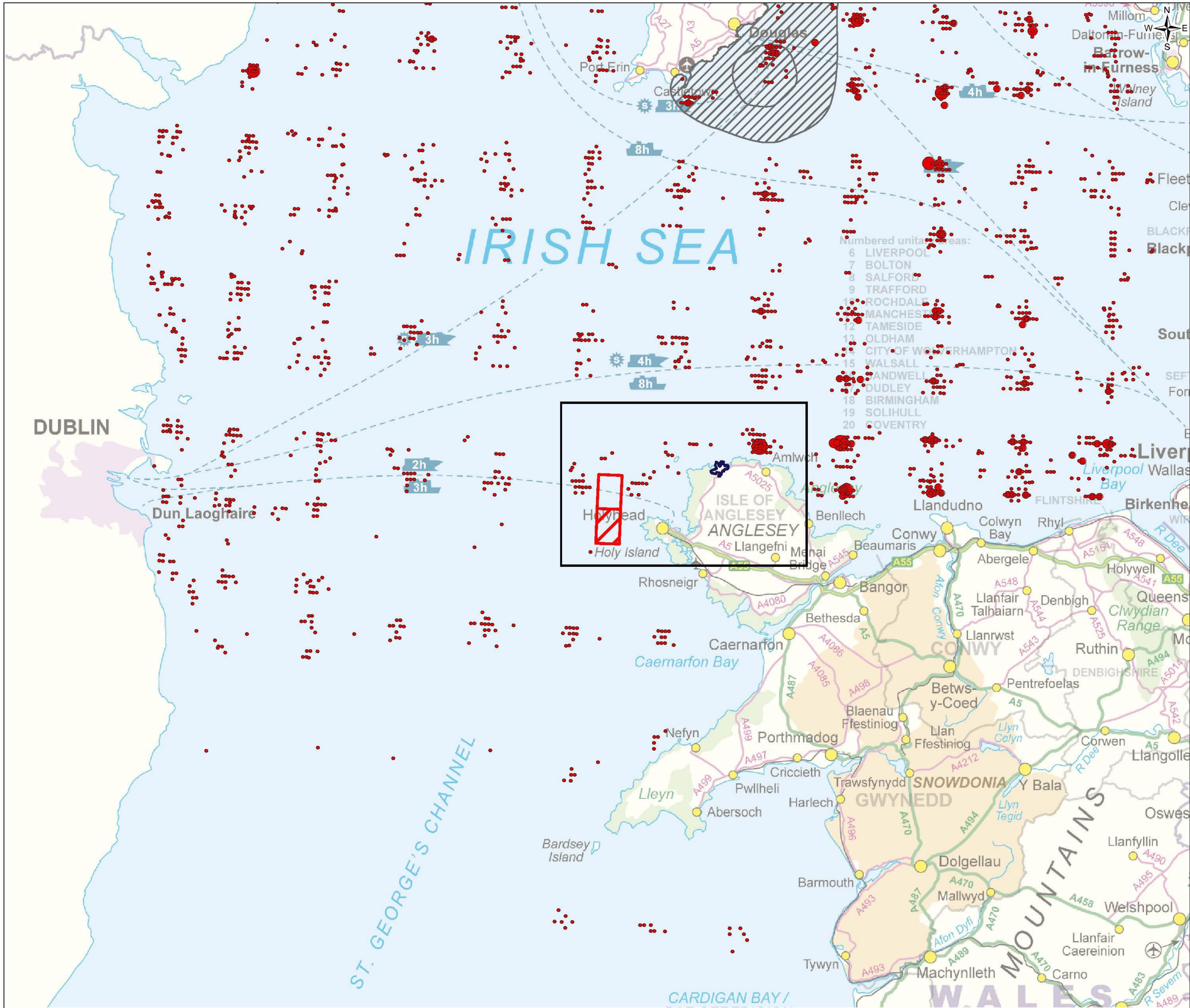
Drawing Title: SPAWNING GROUNDS OF PLAICE IN THE IRISH SEA

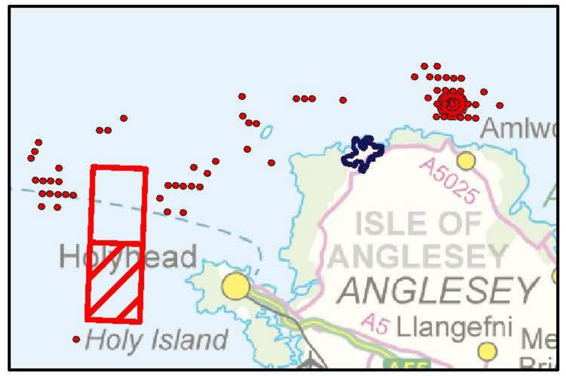
Scale @ A3: 1:700,000 DO NOT SCALE

Jacobs No.: 60PO8077

Client No.:

Drawing No.: 60PO8077_DCO_APP_2_10





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0 5 10 20 30 40 50 Kilometers

FIGURE 2-11

Legend

- Wylfa Newydd Development Area
- Holyhead Deep North (The Disposal Site)
- Holyhead Deep South
- Herring spawning grounds 1998

Larvae (per m^2)

- 0.0 - 0.59
- 0.6 - 2.9
- 3.0 - 5.9
- 6.0 - 12.9
- 13.0 - 32.0

Note - no egg data present for Herring in the Irish Sea

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	AUG 17	Initial Issue	RM	HY	EC	RB

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

SPAWNING GROUNDS OF HERRING IN THE IRISH SEA

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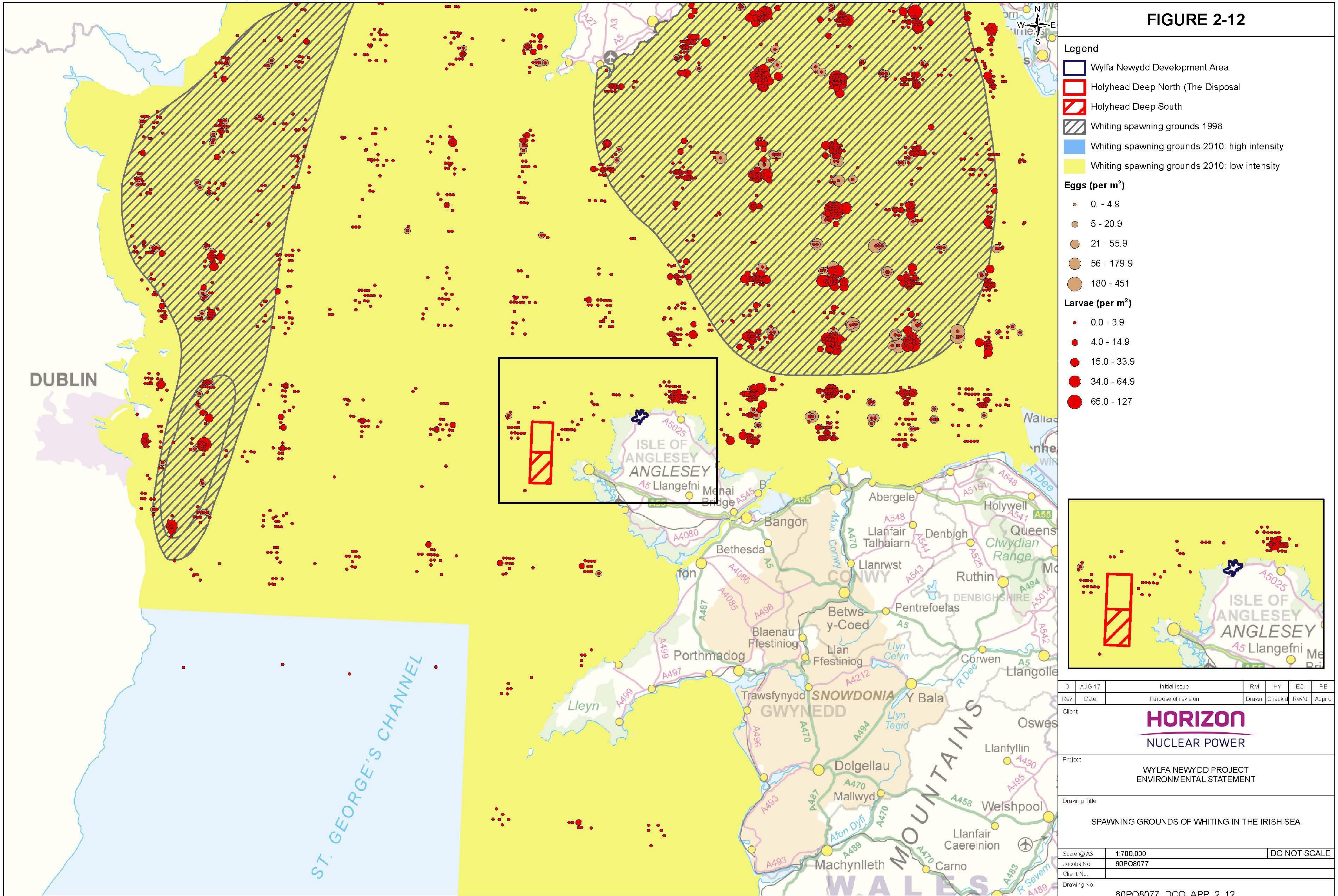

FIGURE 2-12

Legend

- Wylfa Newydd Development Area
- Holyhead Deep North (The Disposal
- Holyhead Deep South
- Whiting spawning grounds 1998
- Whiting spawning grounds 2010: high intensity
- Whiting spawning grounds 2010: low intensity

Eggs (per m^2)

- 0. - 4.9
- 5 - 20.9
- 21 - 55.9
- 56 - 179.9
- 180 - 451

Larvae (per m^2)

- 0.0 - 3.9
- 4.0 - 14.9
- 15.0 - 33.9
- 34.0 - 64.9
- 65.0 - 127

0 5 10 20 30 40 50 Kilometers

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
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Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

SPAWNING GROUNDS OF WHITING IN THE IRISH SEA

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Drawing No.	60PO8077_DCO_APP_2_12	

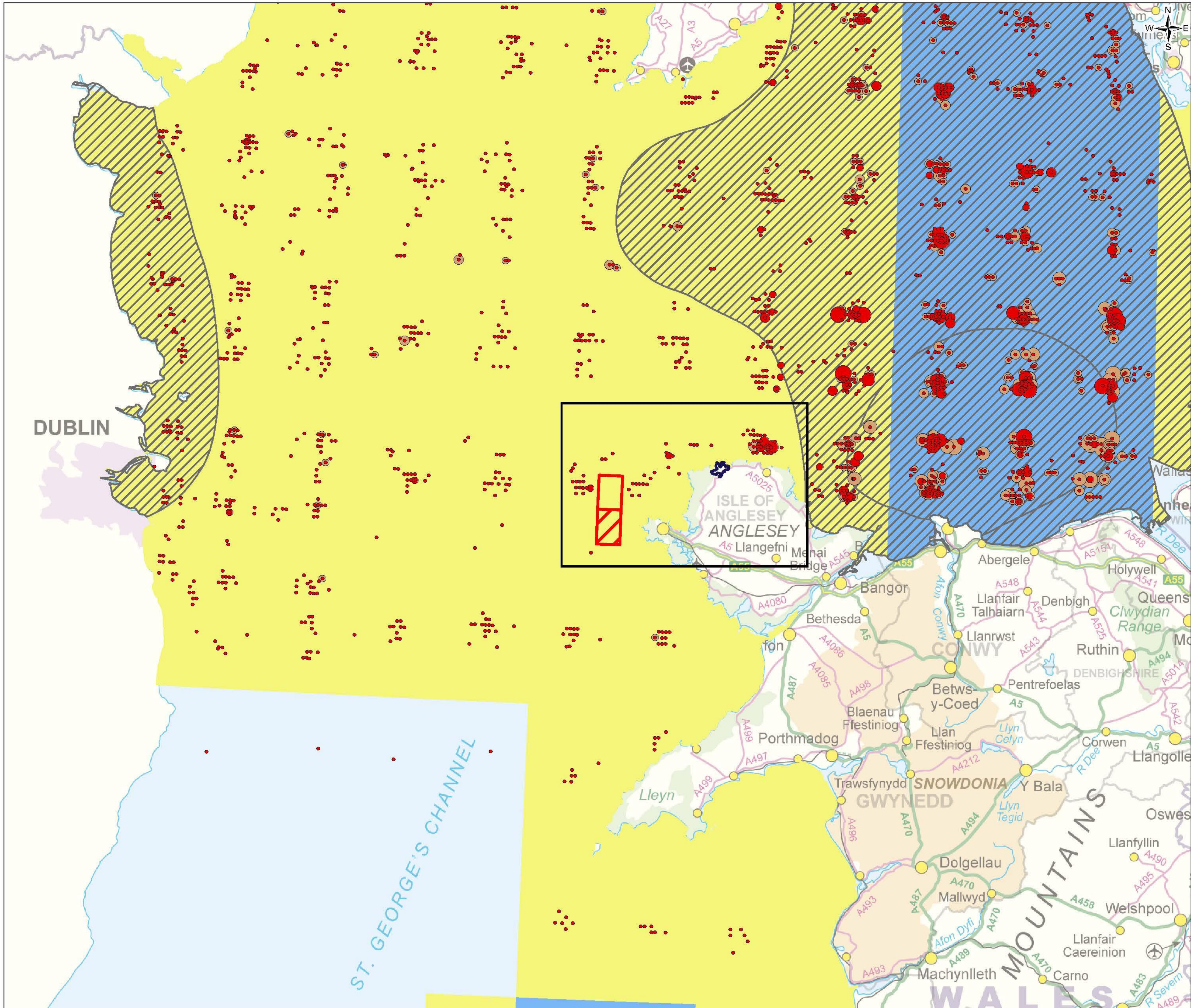

FIGURE 2-13

Legend

- Wylfa Newydd Development Area
- Holyhead Deep North (The Disposal Site)
- Holyhead Deep South
- Sole spawning grounds 1998
- Sole spawning grounds 2010: high intensity
- Sole spawning grounds 2010: low intensity

Larvae (per m^2)

- 0.0 - 0.79
- 0.80 - 2.99
- 3.0 - 5.9
- 6.0 - 11.9
- 12.0 - 33.0

Eggs (per m^2)

- 0.0 - 4.9
- 5.0 - 13.9
- 14.0 - 29.9
- 30.0 - 54.9
- 55.0 - 123.0

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	AUG 17	Initial Issue	RM	HY	EC	RB

Client: HORIZON NUCLEAR POWER

Project: WYLFA NEWYDD PROJECT ENVIRONMENTAL STATEMENT

Drawing Title: SPAWNING GROUNDS OF SOLE IN THE IRISH SEA

Scale @ A3: 1:700,000 — DO NOT SCALE

Jacobs No.: 60PO8077

Client No.:

Drawing No.: 60PO8077_DCO_APP_2_13

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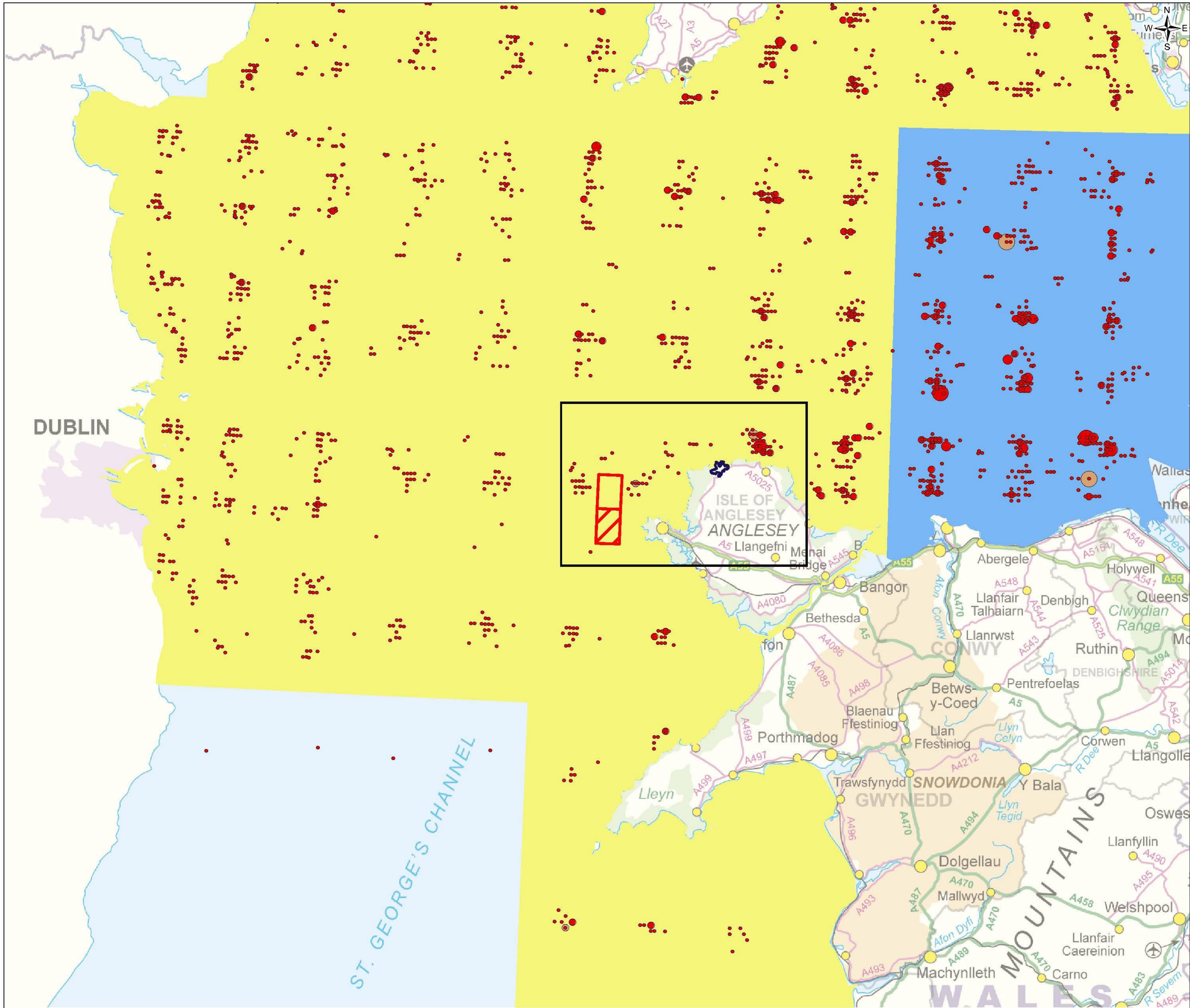
0 5 10 20 30 40 50 Kilometers

FIGURE 2-14



Legend

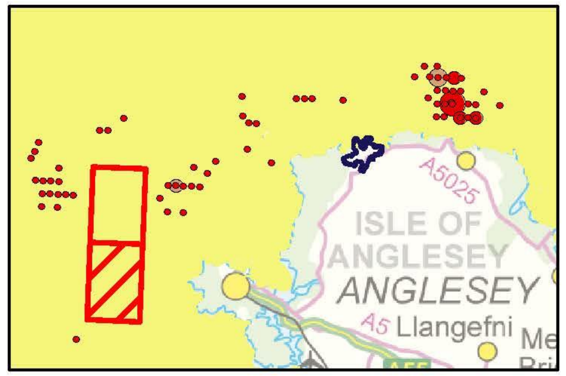
- Wylfa Newydd Development Area
- Holyhead Deep North (The Disposal Site)
- Holyhead Deep South
- Sandeel spawning grounds 1998
- Sandeel spawning grounds 2010: high intensity
- Sandeel spawning grounds 2010: low intensity

Larvae (per m^2)

- 0.0 - 5.9
- 6.0 - 24.9
- 25 - 54.9
- 55 - 149.9
- 150- 300.9

Eggs (per m^2)

- 0.00 - 0.24
- 0.25 - 0.49
- 0.50 - 0.99
- 1.00 - 9.99
- 10.00 -15.5



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0	AUG 17	Initial Issue	RM	HY	EC	RB

Client: HORIZON NUCLEAR POWER

Project: WYLFA NEWYDD PROJECT ENVIRONMENTAL STATEMENT

Drawing Title: SPAWNING GROUNDS OF SANDEEL IN THE IRISH SEA

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Ellis *et al*. (2012) reports densities of fish larvae (numbers per m^2) from sampling stations throughout the Irish Sea. Average larval densities of plaice, sandeel, herring, Dover sole and whiting reported by Ellis *et al*. (2012) from the sampling station closest to the Wylfa Newydd Development Area and the Disposal Site are presented in Table 2.2. Data reported for the north-east coast of Anglesey have been derived from a sampling station located approximately 5 km to the east of the Wylfa Newydd Development Area. Data reported for the north-west coast of Anglesey have been derived from a number of sampling stations located to the west of Wylfa Newydd Development Area but east of the Disposal Site.

For comparison, the range of larval densities recorded during ichthyoplankton surveys during the corresponding survey period (February - June) are also presented. These values have been derived by multiplying numbers per m^3 by the average depth sampled to yield numbers per m^2.

Table 2.2: The mean (± standard deviation) larval densities (no. per m^2) reported by Ellis *et al*. (2012) off the north-east, north-west coast of Anglesey (within the vicinity of the Disposal Site). Larval densities recorded during ichthyoplankton surveys carried out by Jacobs between 2010 and 2014 during the corresponding survey period (February - June) are also presented (see Section 2.2). Numbers in brackets represent the range of densities recorded in a single tow (minimum to maximum).

Species	North-east coast of Anglesey (Ellis *et al*., 2012)	North coast of Anglesey (Jacobs surveys)	North-west coast of Anglesey (vicinity of the Holyhead Deep Disposal Site) (Ellis *et al*., 2012)
Plaice	2.12 ± 10.95 (0 – 71.21)	<0.01 ± <0.01 (0 – 0.08)	0.04 ± 0.23 (0 – 1.21)
Sandeel	3.45 ± 13.00 (0 – 83.72)	0.94 ± 1.80 (0 – 15.15)	0.16 ± 0.34 (0 – 1.21)
Herring	0.87 ± 3.68 (0 – 22.24)	<0.01 ± 0.02 (0 – 0.28)	0.02 ± 0.07 (0 – 0.36)
Dover sole	0.43 ± 1.31 (0 - 6.21)	0.01 ± 0.04 (0 – 0.49)	0.09 ± 0.40 (0 – 2.12)
Whiting	2.11 ± 8.98 (0 – 57.86)	0.01 ± 0.03 (0 – 0.31)	0.08 ± 0.25 (0 – 1.05)

Despite high densities of ichthyoplankton larvae recorded to the north-east of the study area (Ellis *et al*., 2012), larval densities within the vicinity of the Wylfa Newydd Development Area have been found to be very low (Section 2.2).

According to Ellis *et al*. (2012), the Wylfa Newydd Development Area is encompassed within an area of high intensity spawning for plaice (Figure 2.10); however, ichthyoplankton surveys found mean larval densities within this area (<0.01 larvae per m^2) were four orders of magnitude lower than the mean density recorded immediately to the north-east in 2002 (2.12 larvae per m^2). This suggests a possible shift in the distribution of plaice spawning grounds, with high intensity spawning no longer extending westwards to encompass the Wylfa Newydd Development Area. The data reported by Ellis *et al*. (2012) are in some cases up to 19 years older than the data collected during ichthyoplankton surveys carried out within the Wylfa Newydd Development Area between 2010 and 2014. Consequently, the results presented within this report, which were obtained at a higher temporal and spatial resolution than that reported by Ellis *et al*. (2012), are considered to provide a more accurate indication of spawning intensity within Wylfa Newydd Development Area.

Mean densities of herring and whiting within the Wylfa Newydd Development Area were found to be up to two orders of magnitude lower than that reported by Ellis *et al*. (2012) immediately to the north-east. Similarly, densities of Dover sole larvae were also found to be an order of magnitude lower. This provides further support to the conclusion that the north Anglesey coastline is not an area of high intensity spawning for whiting and Dover sole (Figure 2.12 and Figure 2.13). Ellis *et al*. (2012) did not classify densities of herring larvae within the Irish Sea, although it is evident from Figure 2.11 that the highest levels of spawning occur in the eastern Irish Sea.

Although the maximum density of sandeel larvae within the Wylfa Newydd Development Area was found to be the same order of magnitude as that reported by Ellis *et al*. (2012) for the area immediately adjacent to the north-east, the mean density of sandeel larvae was an order of magnitude lower. This demonstrates that the low intensity spawning area for sandeel along the north coast of Anglesey, as classified by Ellis *et al*. (2012) (Figure 2.14), has remained consistent.

To the north-west of Anglesey and within the vicinity of the Disposal Site, mean densities of sandeel larvae are much lower than those reported to the north-east and within the Wylfa Newydd Development Area, although of the same order of magnitude. On the other hand, densities of plaice, herring, whiting and Dover sole larvae are slightly higher than that observed within the Wylfa Newydd Development Area, although remain much lower than those reported along the north-east coast of Anglesey (Ellis *et al*., 2012).

The area to the north-west of Anglesey, including the Disposal Site, is not classified as a high intensity spawning area for any of the species examined by Ellis *et al*. (2012), including those presented in Figure 2.10 to Figure 2.14.

Although sprat, dab, gobies and dragonets (Callionymidae) are known to be dominant components of the ichthyoplankton assemblage within the eastern Irish Sea, Ellis *et al*. (2012) did not assess the distribution of spawning for these species. Nonetheless, drawing on other published literature, comparisons can be made between the data presented in Section 2.2, and inferences made with regards to possible densities within the vicinity of the Disposal Site.

In the eastern Irish Sea, egg abundances have been found to be dominated by sprat, with the highest abundances occurring in shallower, generally coastal waters (Fox *et al*., 1997). The dominance of this species from ichthyoplankton surveys within the vicinity of the Wylfa Newydd Development Area (max abundance of 3.72 larvae per m^2 recorded at site 3 in May 2012) is therefore unsurprising, although larvae are known to disperse quickly becoming widespread throughout the Irish Sea. The mean abundance of sprat larvae recorded within the vicinity of the Wylfa Newydd Development Area during the entire sampling programme was 0.07 ± 0.29 larvae per m^2. During the late spring, densities of sprat larvae within the vicinity of the disposal are likely to range from 0.10 to 54.90 larvae per 10^2 (Bunn and Fox, 2004).

During the spring plankton surveys carried out in the Irish Sea in 2000 (Bunn and Fox, 2004), larval communities were found to be dominated by dab with peak densities occurring off Ireland and in Liverpool Bay. In 1997, peak densities of 2,070.2 larvae per m^2 were recorded in Cardigan Bay in April (Fox *et al*., 1997). Whilst evidently abundant around the north coast of Anglesey, coastal densities are typically much lower; the maximum density recorded during Jacobs' ichthyoplankton surveys was 0.98 larvae per m^2, observed at site 2 in April 2012. Comparatively low densities of dab larvae have been recorded to the north-west of the Wylfa Newydd Development Area and within the vicinity of the Disposal Site (Bunn and Fox, 2004). This pattern demonstrates the planktonic movement and dispersal of dab larvae from the west and south-west to north Anglesey during the spring months.

Callionymidae (dragonets) larvae was the second most common species recorded during spring plankton surveys carried out in the Irish Sea in 2000 with abundances reaching 301 larvae per m^2 (Bunn and Fox, 2004). The highest densities recorded within the Wylfa Newydd Development Area were 1.1 larvae per m^2. During the late spring, densities of dragonet larvae within the vicinity of the Disposal Site are likely to range from 0.10 to 55.00 larvae per 10^2 (Bunn and Fox, 2004).

Gobiidae represents a large group of fish common in inshore waters. Offshore densities are therefore typically low; densities within the vicinity the Disposal Site have not been found to exceed 0.1 larvae per m^2 (Bunn and Fox, 2004).

2.4 Discussion of Ichthyoplankton Communities

Ichthyoplankton surveys provide an opportunity to sample those species whose adult ecology, behaviour and habitat preferences mean that they are unlikely to be captured using conventional sampling techniques. For example, topknot (*Zeugopterus punctatus*), Norwegian topknot, tompot blenny, Montagu's seasnail (*Liparis montagui*) and shanny (*Lipophrys pholis*) were all recorded during ichthyoplankton surveys, yet adult life stages of these species are normally associated with rocky areas which are not suitable for trawling or seine netting. In addition, species such as the topknot and Norwegian topknot are well camouflaged and able to cling to rocks, enabling them to remain undetected among hard substrata. It is thought that both these species are possibly more widely distributed around the rocky coastline of north Anglesey than other survey data indicate but are generally under-recorded (MarLIN, 2014). Other species recorded in the ichthyoplankton surveys, including the Yarrell's blenny (*Chirolophis ascanii*), are also indicative of the rocky habitats encountered along the north Anglesey coast but were recorded infrequently during other surveys (see Section 3 and 4).

Entrainment surveys carried out on-site at the Existing Power Station between March 2011 and July 2012 also provide a useful means of sampling ichthyoplankton within inshore areas (Jacobs, 2016a, Application Reference Number: 6.4.92). Although it is acknowledged that this sampling methodology may provide a biased picture of ichthyoplankton communities, targeting those species utilising habitats within the immediate vicinity of the Existing Power Station and that are susceptible to entrainment, they provide valuable data, which can be used to supplement data collected within the wider study area. A number of species were recorded in the entrainment surveys but were absent from ichthyoplankton surveys. These included fifteen-spined stickleback (*Spinachia spinachia*), worm pipefish (*Nerophis lumbriciformis*), garfish (*Belone belone*), butterfly blenny (*Blennius ocellaris*), grey gurnard (*Eutrigla gurnardus*), Eckstrom's topknot (*Zeugopterus regius*) and a number of goby species. These species are all considered common to the ecoregion, with a number recorded during surveys targeting juvenile and adult life stages (see Section 3 and 4). A table showing the presence/absence of all fish species recorded during the fish survey programme, including those recorded in the ichthyoplankton and entrainment surveys, is presented in Appendix D.

The survey area covers an exposed part of the Anglesey coastline typified by transient coastal features such as fronts and upwelling as well as strong tidal currents. Meroplanktonic (spending part of their lifecycle in the plankton) larvae spawned within shallow coastal waters can therefore be transported long distances and account for the presence of species such as the greater pipefish (*Syngnathus acus*) and topknot at site 4, the most offshore of all the sites sampled. Both of these species are more commonly found inshore, and topknot is considered a littoral benthic species.

Single records of both Norway bullhead and cod occurred at sites 6 and 2, respectively. Neither species was recorded in entrainment surveys at the Existing Power Station (Jacobs, 2016a, Application Reference Number: 6.4.92). Norway bullhead has not been recorded in Welsh waters previously (Kay and Dipper, 2009) but have been recorded off the coast of the Isle of Man (Wheeler, 1969). Adult cod are not uncommon to the survey area, but they are not known to spawn inshore along the Anglesey coast. The presence of very low numbers of cod larvae was possibly the result of spring storms and strong currents transporting individuals from spawning sites located in the eastern Irish Sea, south-west coast of the Isle of Man and off the Irish coast (Armstrong *et al.*, 2001). In any case, the north coast of Anglesey and the majority of the Irish Sea is characterised by low intensity spawning for cod (Ellis *et al*., 2012); therefore, it is unsurprising that low abundances were observed during ichthyoplankton surveys carried out within the vicinity of the Power Station Site.

Most of the taxa recorded were typical of the north-west coast of Wales, the exception to this were the single records of a long rough dab, Atlantic halibut and the Norway bullhead. The Atlantic halibut is considered rare in Welsh waters due to over exploitation and is listed as 'endangered' in the IUCN Red Data List. This species was only recorded on one sampling occasion in April 2012.

The absence or very low numbers of some common fish species, such as sand smelt (*Atherina presbyter*), as well as rays and sharks that were recorded using the other fish survey techniques (see Sections 3.1, 3.2 and 4.1), is not surprising. Sand smelt prefer to spawn close inshore where seaweed or seagrass is present. Their sticky eggs adhere to plants until hatching, at which time the young sand smelt continue to reside in very shallow water. Sand smelt larvae were not recorded within entrainment samples, suggesting an absence of these habitats within the vicinity of the intake of the Existing Power Station. The majority of fish species caught in ichthyoplankton (tow and entrainment) surveys were all broadcast spawners, some possibly releasing many thousands of eggs into the water column during each spawning event. By contrast, sharks and rays exhibit a different life strategy, some species being ovoviviparous (eggs are hatched within the body of the parent) and others depositing a small number of egg sacs. The intertidal survey recorded plaice as the fourth most abundant species over the entire survey duration (Section 3); however, larval plaice numbers were low in both the ichthyoplankton and entrainment surveys. As per the report by Cefas (Ellis *et al.*, 2012), the present study area is located to the west of a large, productive spawning ground for plaice, and is considered to fall outside of the area believed to be characterised by high intensity spawning.

Difficulty in identifying many of the small larvae may have resulted in several species being overlooked. Larval gobies, gadoids and clupeids are particularly difficult to speciate, which is reflected by the high numbers of individuals recorded to family level only. The family Gobiidae contained approximately 6% of all the fish found and 6% of those recorded as 'Osteichthyes indet.'. Thus, although some widespread fish species such as sand and common gobies were not found in the ichthyoplankton surveys, it is thought likely that they were represented by their respective family.

In 2014, an additional site located approximately 400 m to the west of Porth-y-pistyll was added to the survey programme (site 7). This site is in relatively close proximity to sites 2 and 6. Analysis of all data collected to date identified a statistically significant, albeit weak, difference between sites. Further investigation identified that communities found at site 6 were significantly different to all other sites except site 7. A one-way SIMPER analysis found this relationship was characterised by consistent but variable abundances of common species rather than differences in the abundance of less common species (see Table C.2, Appendix C). Abundance of corkwing wrasse at site 6 for example was found to be consistently higher than all other sites, whilst the abundance of long-spined sea scorpions and sprat were lower. Sites 6 and 7 were the most sheltered inshore sites and it could be expected that the localised hydrographic regime is quite different from that experienced at those sites further offshore. The presence of bass larvae at site 6 (the only site to record bass) is not surprising given the proximity of populations of bass along the north and west coasts of Wales and in the Irish Sea.

The presence of one or two individuals from a single species is not necessarily as important as identifying the taxa which typify and dominate the survey region. The highly significant seasonal differences were clearly illustrated by distinct peaks in abundance in late winter/early spring and richness in late spring. During February, larval fish abundances were predominately made up from five taxa or less in any single replicate and heavily dominated by sandeel (Ammodytidae). Entrainment surveys reflected a similar seasonal pattern in species assemblages (Jacobs, 2016a, Application Reference Number: 6.4.92). The sandeel accounted for more than 64% of the individuals recorded in ichthyoplankton surveys during this period; however, by April the larval community was greatly enriched by the influx of a variety of fish taxa, and whilst sandeel were still present, their numbers fell noticeably. At this time, the community was dominated by high numbers of clupeids, specifically sprat, and dab (Figure 2.3, Figure 2.4 and Figure 2.5). With the onset of summer, the community was initially dominated by dragonets and clingfish, and later in the season by gobies. By late summer, fish abundances had fallen by an order of magnitude, and the following four months (October - January) yielded very low numbers of fish, if any.

Sandeel, sprat, dab, gobies and dragonets (Callionymidae) clearly have a dominant role in the community assemblages within the vicinity of the Wylfa Newydd Development Area. Of these taxa, Ellis *et al*. (2012) only examined the distribution of sandeel spawning in the Irish Sea (Figure 2.14). High intensity spawning grounds were identified in the eastern Irish Sea; however, lower densities were recorded inshore within the Wylfa Newydd Development Area, which is unsurprising, as this taxon (particularly Raitt's sandeel) is known to spawn predominately offshore (Bunn and Fox, 2004). With the exception of perhaps gobies, inshore abundances of all of the remaining species listed above are much lower than that reported for the eastern Irish Sea and further offshore. The Disposal Site may be characterised by slightly higher abundances of certain species to that observed within the Wylfa Newydd Development Area, although these are likely to remain much lower than abundances recorded in the eastern Irish Sea. Furthermore, given the rapid dispersion of larvae, peak abundances at the Disposal Site are only likely to occur for a short period, coinciding with the timing of peak spawning.

Larval densities presented in Section 2.2 of this report are more or less consistent with values reported by Ellis *et al.* (2012) for the corresponding area, despite there being up to 19 years between data collection. This comparison gives confidence in the validity of data presented by Ellis *et al*. (2012) for the area surrounding the Disposal Site.

Trends in the overall abundance and dominance of taxa were repeated each year and, though there were slight changes in presence and/or abundance of the key taxa, the general pattern remained the same (see Section 2.2.3). This showed a variety of key taxa dominating the populations at various times throughout late winter, spring and summer before numbers fell dramatically in the autumn. As would be expected, this pattern corresponded well with trends in egg numbers, with peak abundances of eggs followed by peaks in larvae.

Peak egg abundance typically occurs between March and May and is thought to be largely driven by the spawning of sandeel, sprat and dab. In 2011, a distinct secondary peak in egg abundance was observed at all sites in September. A secondary peak was also observed in July 2013 but to a lesser extent and only at the inshore sites (site 2 and 6).

It is not known what triggered the September peak in 2011, though it is considered that the availability of a good food supply would have been necessary to initiate the spawning. Sandeel such as *Ammodytes tobianus* have been reported as having two spawning periods in spring and summer (Dipper, 2001) or spring and autumn (Fishbase, 2014). Despite high egg abundances being recorded at most sites in September 2011, the larvae results were still comparatively low; however, a small increase in sandeel numbers was recorded at sites 1, 2, 4 and 5. Unlike the previous years, the egg abundances in 2012, 2013 and 2014 did not fall as sharply, instead showing a more gradual fall, particularly at sites 6 and 7. It is speculated again that food availability may have also allowed a more prolonged spawning period in these years.

3. Intertidal Fish Communities

3.1 Seine net and Potting Surveys

3.1.1 Methodology

Intertidal surveys were carried out on a quarterly basis between spring (April) 2010 and autumn (November) 2015 to provide an understanding of seasonal variations in the abundance and diversity of inshore fish communities.

Samples were collected at thirteen sites (see

Figure 3.1 and Appendix A.2 for site locations). These included:

- sites IF01 and IF02 located up to 15 km west of the Wylfa Newydd Development Area;
- sites IF11 and IF12 located up to 24 km to the east;
- sites IF03, IF04, IF10 and IF13 located to the west of Wylfa Head some 1.2 km – 2.2 km from the Wylfa Newydd Development Area within Cemlyn Bay;
- sites IF05, IF06, IF07 and IF09 located to the east of Wylfa Head within Cemaes Bay; and
- site IF08 located in a rocky bay (Porth Wen) some 1.5 km – 2.6 km east of the Wylfa Newydd Development Area.

Initially, only sites IF01 to IF10 were sampled in 2010, with sites IF11, IF12 and IF13 added to the sampling programme in 2011. The full survey programme, including sampling dates, can be found in Appendix A.

Sites were selected to include both beach and rocky shore sites. Due to the large tidal range, sites were visited during different tidal states depending on site access. Owing to the rocky nature of the near-shore environment along the north coast of Anglesey, a multi-method approach to surveying the intertidal fish communities was adopted, including the use of seine netting and fish traps as well as diver surveys (see Section 3.2). Ground conditions and site access largely determined which method was used at each site, with rocky outcrops or limited site access preventing the use of seine nets.

Seine netting was carried out at sites all sites with the exception of IF04 and IF08 (

Figure 3.1). Three replicate net samples were taken at each site with the exception of April 2010, when only two were taken owing to time restrictions on the initial survey. A seine net 45 m long and 3 m deep with a mesh size of 20 mm (wings) and 5 mm (centre panel) was set in an arc from the shore, hauled in and the catch processed (Figure 3.2). Intertidal fish surveys were carried out with written consent from the Welsh Government to use survey nets with under-sized mesh.

Owing to the presence of many rocky outcrops within Porth-y-pistyll, only one suitable site for seine netting was identified (IF13). Consequently, traps were also deployed in Porth-y-pistyll bay (IF04) and at site IF08 (Porth Wen) to provide additional information on fish communities and mobile shellfish (e.g. lobster) associated with rocky habitats. Traps were deployed at these sites, left for 24 hours, and then retrieved. Traps were baited and set close to the low-water mark in strings of five with the traps 5 m apart. The traps were modified with a micro-mesh outer covering (Figure 3.3), and the method used followed the guidelines set out by the Joint Nature Conservation Committee (Wilding *et al.*, 2001).

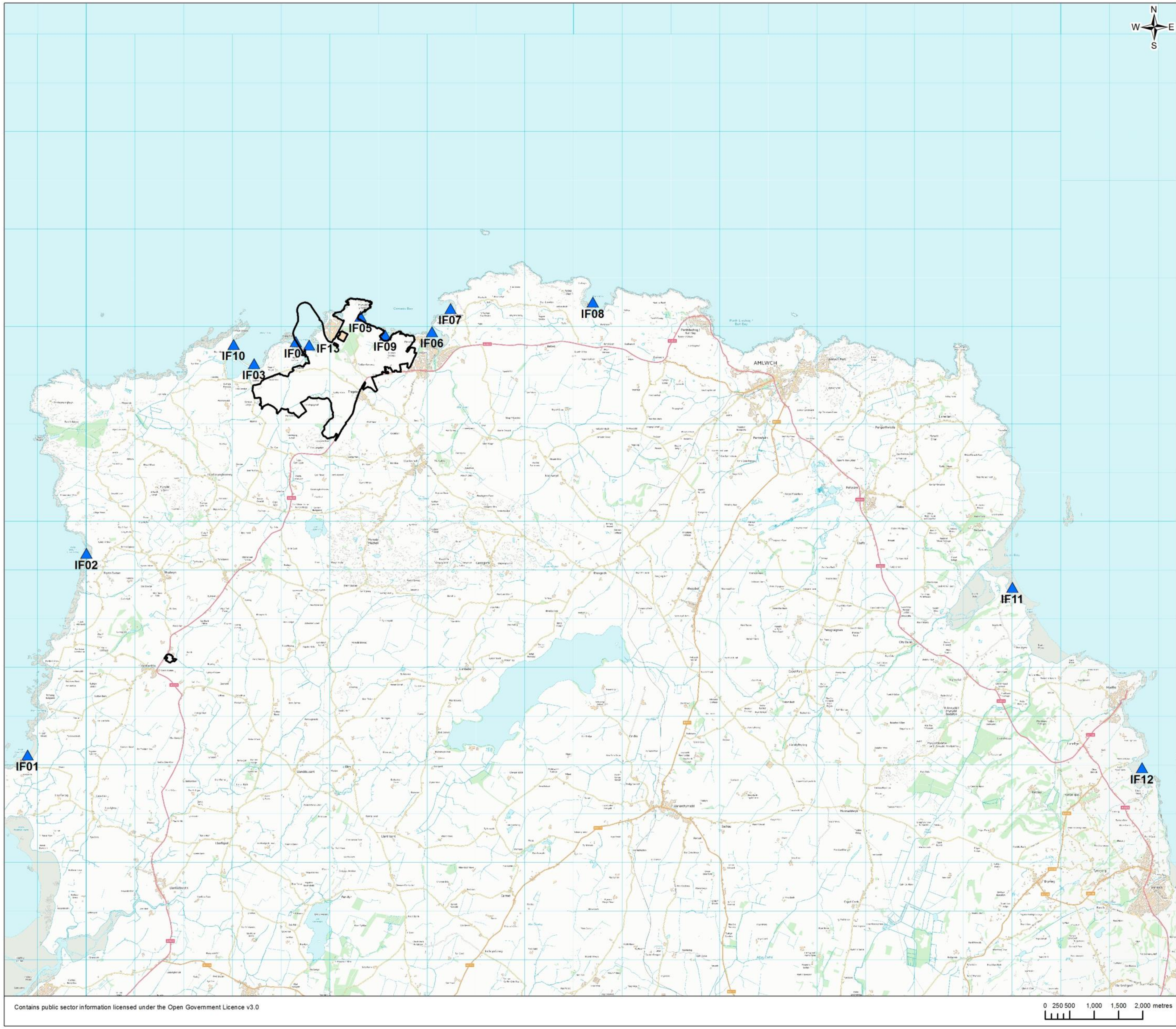

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FIGURE 3-1

Legend

- Wylfa Newydd Development Area
- Intertidal fish sites

0	JUN 17	Initial Issue	VG	HY	EC	RB
Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

INTERTIDAL FISH SURVEY SITES

Scale @ A3	1:75,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		
Drawing No.	60PO8077_DCO_APP_03_01	

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Figure 3.2 : Setting the seine net using the boat to deploy one end (left) and people on the shore to hold the other end (right) in Cemaes Bay.

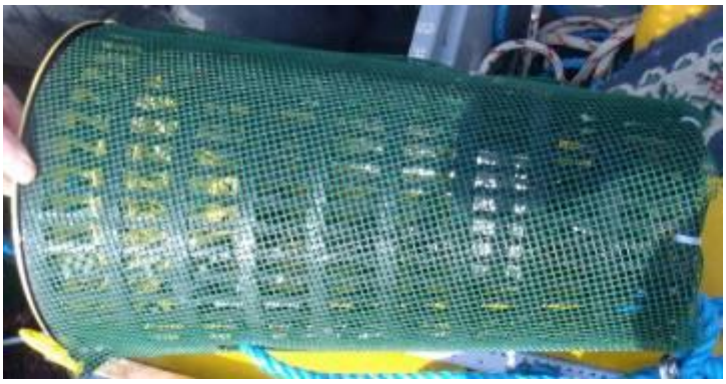

Figure 3.3 : Traps used during the intertidal surveys.

3.1.1.1 Sample processing

All organisms were transferred to a covered container of seawater as quickly as possible. Upon collection, the catch from all three samples was sorted and processed at each site. All fish specimens were identified to the lowest taxonomic resolution possible, measured to the nearest 5 mm (standard length) size class and enumerated. Where identification of a specimen was ambiguous, identification keys such as Maitland and Herdson (2009) were used and photographs of key features (e.g. fin ray counts, fin alignment and scale counts) taken for later confirmation. Occasionally, smaller specimens (particularly gobies and lesser sandeel) were retained for identification at the laboratory. Any shellfish were enumerated only. Once processed, all organisms were returned to the water.

3.1.1.2 Data analysis

To assess seasonal and spatial trends, the intertidal fish sites were grouped into four distinct geographic 'areas' (Table 3.1) in relation to Wylfa Head. The typology of the intertidal sites within each group was broadly similar allowing direct comparison. Sites were also aggregated based on 'bed type' and 'exposure' (Table 3.2).

Multivariate statistical analysis of intertidal fish data was carried out using PRIMER 6™ (Clarke and Gorley, 2006). In contrast to univariate analyses, which concentrate complex ecological data into a single metric, multivariate analysis compares differences between all taxa and their relative abundances between samples and sites. The analysis therefore allows identification of samples/sites with similar/dissimilar communities. Further explanation of the statistical terms methods used is provided in Appendix B.

Table 3.1: Sites grouped based on 'area' for analysis. See

Figure 3.1 for site locations.

Location	Sites	Dominant typology
Western sites	IF01, IF02	Sand and pebble beaches
Cemlyn (west)	IF03, IF10, IF13	Pebble/sand and rocky beaches
Cemaes (east)	IF05, IF06, IF07, IF09	Pebble/sand and rocky beaches
Eastern sites	IF11, IF12	Sand beaches

Table 3.2 : Sites grouped based on 'bed type' and 'exposure' for analysis. See

Figure 3.1 for site locations.

Site	Bed type	Exposure
IF01	Sandy rocky beaches	Exposed
IF02	Sandy rocky beaches	Exposed
IF03	Sandy pebble beaches	Moderately exposed
IF05	Sandy beach	Sheltered
IF06	Sandy beach	Moderately exposed
IF07	Sandy rocky beaches	Exposed
IF09	Sandy beach	Sheltered
IF10	Sandy pebble beaches	Sheltered
IF11	Sandy beach	Sheltered
IF12	Sandy beach	Sheltered
IF13	Rocky beach	Moderately exposed

3.1.1.2.1 Feeding guilds

All fish taxa recorded were assigned to one of five feeding guilds, dependent on the principal food type of adult fish (see Appendix E). Feeding guilds can be used to identify changes in abundance of species linked to seasonal availability of food and sites where a particular food source may be abundant.

3.1.2 Results

3.1.2.1 Overall

Between spring 2010 and autumn 2015, a total of 60,337 intertidal fish were caught in the seine nets and traps, representing at least 45 taxa (excluding entries to family or genus level only) (Table 3.3). Of the total, 60,292 fish were caught in seine nets, with five taxa making up 97.97% of the individuals caught: clupeids (45.92%); sandeel[4] (19.83%); sand smelt (18.67%); plaice (11.30%); and gobies (*Pomatoschistus* spp.) (2.24%). Prior to summer 2013, clupeids only made up approximately 10% of the total catch, but large catches of herring at sites IF09, IF11 and IF12 in summer 2013 and 2015 more than doubled the percentage contribution of this family.

[4] Unless otherwise specified subsequent reference in this section to sandeel refers to species belonging to the *Ammodytes* genus only.

Table 3.3 : The total abundance of fish taxa recorded in intertidal surveys (seine net and fish traps) from April 2010 to November 2015. Taxa that could not be identified to species level are shown in bold.

Common name	Species name	Abundance in seine nets	Abundance in fish traps
Herring family	**Clupeidae**	17,225	-
Sandeel genus[5]	***Ammodytes* spp.**	11,958	-
Sand smelt	*Atherina presbyter*	11,258	-
Herring	*Clupea harengus*	7,779	-
Plaice	*Pleuronectes platessa*	6,767	-
Sprat	*Sprattus sprattus*	2,665	-
Goby genus	***Pomatoschistus* spp.**	711	-
Sand goby	*Pomatoschistus minutus*	595	-
Greater sandeel	*Hyperoplus lanceolatus*	188	-
Turbot	*Psetta maxima*	171	-
Golden grey mullet	*Liza aurata*	168	-
Lesser weever	*Echiichthys vipera*	152	-
Flounder	*Platichthys flesus*	126	-
Fifteen-spined stickleback	*Spinachia spinachia*	123	-
Brill	*Scophthalmus rhombus*	37	-
Mullet family	**Mugilidae**	36	-
Pollack	*Pollachius pollachius*	33	-
Painted goby	*Pomatoschistus pictus*	27	-
Long-spined sea scorpion	*Taurulus bubalis*	19	7
Common goby	*Pomatoschistus microps*	20	-
Bass	*Dicentrarchus labrax*	20	-
Garfish	*Belone belone*	18	-
Sea trout	*Salmo trutta*	16	-
Five-bearded rockling	*Ciliata mustela*	10	6
Thick-lipped grey mullet	*Chelon labrosus*	15	-
Greater pipefish	*Syngnathus acus*	14	-
Two-spot goby	*Gobiusculus flavescens*	14	-
Pilchard	*Sardina pilchardus*	13	-
Thin-lipped grey mullet	*Liza ramada*	12	-
Dab	*Limanda limanda*	10	-
Rock goby	*Gobius paganellus*	-	10
Grey gurnard	*Eutrigla gurnardus*	9	-
Lesser-spotted dogfish	*Scyliorhinus canicula*	1	7
Three-spined stickleback	*Gasterosteus aculeatus*	7	-
Corkwing wrasse	*Symphodus melops*	6	-

[5] It was not possible to speciate the genus *Ammodytes* spp. in the field; however, individuals checked in the lab confirmed the presence of both *A. tobianus* and *A. marinus*.

Common name	Species name	Abundance in seine nets	Abundance in fish traps
Three-bearded rockling	*Gaidropsarus vulgaris*	-	6
Cod	*Gadus morhua*	4	-
Whiting	*Merlangius merlangus*	3	1
Pogge	*Agonus cataphractus*	2	1
Short-spined sea scorpion	*Myoxocephalus scorpius*	2	-
Transparent goby	*Aphia minuta*	2	-
Cod family	**Gadidae**	2	-
Sole family	**Soleidae**	2	-
Tompot blenny	*Parablennius gattorugine*	-	2
Bull huss	*Scyliorhinus stellaris*	-	2
Poor cod	*Trisopterus minutus*	-	2
Dragonet genus	***Callionymus* spp.**	1	-
Ballan wrasse	*Labrus bergylta*	1	-
Common dragonet	*Callionymus lyra*	1	-
Rockling family	**Lotidae**	1	-
Shanny	*Lipophrys pholis*	1	-
Goldsinny wrasse	*Ctenolabrus rupestris*	-	1

Between spring 2010 and autumn 2015, a total of 45 fish representing 11 species were caught in the fish traps. Of these, five species were unique to the fish traps (being absent from the seine nets). These included tompot blenny, rock goby (*Gobius paganellus*), three-bearded rockling (*Gaidropsarus vulgaris*), lesser-spotted dogfish and bull huss (*Scyliorhinus stellaris*). The tompot blenny, three-bearded rockling and rock goby would not be expected to be caught in seine nets owing to their preference for rocky habitats. The dogfish and bull huss are also not to be expected in seine nets and are more commonly found in subtidal areas but may have been attracted to the traps owing to the presence of bait.

The fish-trap data are considered to be qualitative only and, as such, were not included in any statistical analyses. Nevertheless, this survey methodology proved useful in identifying the presence of both fish and shellfish species associated with rocky intertidal habitats. Results are discussed further in Section 3.1.2.3.1.

3.1.2.2 Temporal variation

The average number of fish caught per net and the number of species caught per survey varied noticeably between seasons and from year-to-year (Figure 3.4). From the 22 surveys between spring 2010 and autumn 2015, the highest catch per net was recorded in summer 2015 with an average of 520 fish per net: a result mainly owing to large numbers of fish caught at sites IF11, IF12, IF07 and IF09, particularly clupeids, plaice and sand smelt.

In nearly all years, the highest catches per net occurred in the summer season. The general seasonal pattern was of an increase in abundance with the onset of spring, peaking in summer before dropping through autumn into winter. The only exception was observed in 2012 where the average fish abundance per net decreased between spring and summer.

As water temperatures fell in autumn and winter months, average numbers of fish per net and the number of species per survey typically decreased. The lowest numbers of fish per net were generally recorded during the winter surveys with an average of nine fish per net in winter 2011, 21 fish per net in winter 2012 and just one and four fish per net in winter 2013 and winter 2014, respectively. The highest numbers of species were recorded during the summer in all years except 2014 and 2015, where number of species per survey peaked in autumn.

Plaice and sand smelt were the only two taxa that were recorded during every intertidal seine netting survey carried out between April 2010 and November 2015. A further 11 taxa were recorded in every season but not necessarily in all sampling years and included: flounder (*Platichthys flesus*), turbot (*Scopthalmus maximus*), lesser weever (*Echiichthys vipera*), long-spined sea scorpion, fifteen-spined stickleback, bass (*Dicentrarchus labrax*), two-spot goby (*Gobiusculus flavescens*), clupeids, sandeel, brill (*Scophthalmus rhombus*) and gobies.

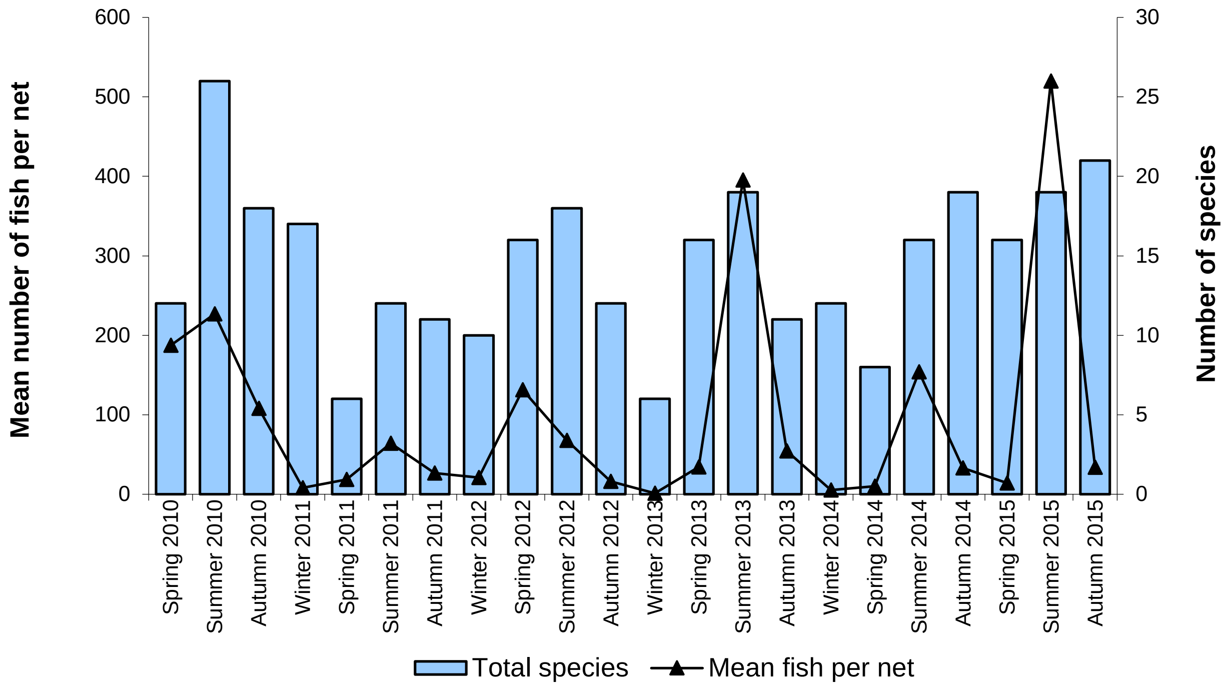

Figure 3.4: Mean number of fish per seine net and total number of species recorded per season from spring 2010 to autumn 2015.

A two-way crossed ANOSIM across all sampling years indicated that significant differences in the intertidal fish communities existed between seasons across all years (R=0.424, p<0.001), although these were not clearly separated as evidenced by the moderate R-value. Pairwise ANOSIM tests showed that the main differences occurred between spring and all other seasons. All the R-values were moderate to low, indicating some overlap in the community composition characterising each season, particularly between successive seasons (Table 3.4).

Table 3.4 : ANOSIM pairwise comparisons between seasons for intertidal seine net data from sampling sites around the north Anglesey coast, spring 2010 to autumn 2015. Statistically significant results at p<0.05 are marked with **.

Pairwise comparison	R-value	Significance, p
Spring, winter	0.538	0.001**
Spring, autumn	0.527	0.001**
Spring, summer	0.481	0.001**
Summer, autumn	0.446	0.001**
Summer, winter	0.431	0.001**
Autumn, winter	0.088	0.027**

SIMPER analysis (see Appendix F) showed that differences between seasons were largely due to changing abundances of the four dominant taxa (sandeel, plaice, clupeids and sand smelt) as opposed to species presence/absence differences. In spring, large numbers of sandeel and plaice contributed heavily to the community assemblages with clupeids and sand smelt also becoming abundant in the summer. Autumn was characterised by a dominance of sand smelt and lower abundances of sandeel, clupeids and plaice. Sand smelt remained present in winter (albeit in lower abundances) during the winter months as did plaice and clupeids. Low but persistent abundance of grey mullet and fifteen-spined stickleback also characterised intertidal fish communities in the winter.

Temporal patterns in species composition are illustrated in Figure 3.5 showing the greatest separation between the spring and autumn/winter samples. Two-dimensional bubble plots for the most abundant taxa are also presented; the larger the bubble, the higher the number of individuals sampled. These species were present in samples from all seasons but showed marked fluctuations in abundance. The sudden emergence of clupeids during summer 2015 is evident (Figure 3.5).

Figure 3.5: 2-D MDS plots of intertidal fish communities with the abundance of five taxa overlaid as bubble plots. The sixth plot is included for reference of seasonal data points. Data has been averaged across the years to present a single data point per season and year. Note variable scales on the plots.

3.1.2.3 Spatial variation

Overall the highest abundance of fish within intertidal areas was recorded on the north-east coast of Anglesey at sites IF11 and IF12 with the average number across the whole sampling programme (April 2010 to November 2015)[6] exceeding 150 fish per seine net (Figure 3.6). Conversely, the lowest abundances of fish within intertidal areas were recorded on the north-west coast of Anglesey (IF01 and IF02); here average abundances did not exceed 50 fish per net. The mean abundance of fish observed at intervening sites along the north coast of Anglesey ranged from 36 fish per net at IF10 (west of Wylfa Head) to 88 fish per net at IF13 in Porth-y-pistyll. Typically fish catches in Porth-y-pistyll were low, particularly during the spring and autumn (<10 fish per net). The relatively high average value is driven by elevated catches of sand smelt in summer 2014 (611 fish per net); removal of this uncharacteristically high catch reduces the average abundance to 50 fish per net.

Despite apparent spatial differences in the average abundance of fish utilising intertidal habitats along the north Anglesey coastline, a univariate Kruskal-Wallis one-way ANOVA on ranks using surveys as replicates, found no significant difference between the thirteen sites sampled ($H = 4.592$, $p = 0.917$). This result is likely to be an artefact of seasonal variations in the abundance of fish recorded at each site throughout the sampling programme (Figure 3.6). The greatest variability in catches was seen at sites on the north-east coast of Anglesey with the highest standard deviation (i.e. variability in mean number of fish per net) observed at site IF11 (±3,029 fish per net). Conversely, the lowest standard deviation was seen on the north-west coast of Anglesey at site IF02 (±127 fish per net).

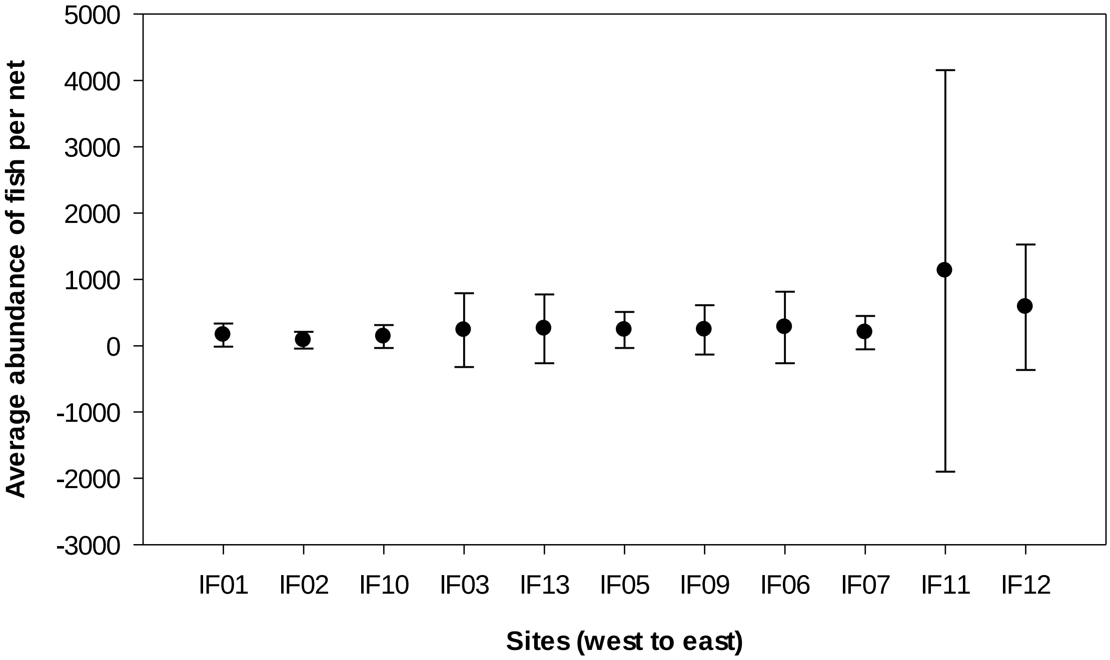

Figure 3.6 : The mean abundance (± standard deviation) of fish recorded per net at each site during the 22 surveys carried out between April 2010 and November 2015.

The average abundance of those taxa most commonly recorded during the sampling programme are presented in Figure 3.7 for each sampling site. The site furthest east (IF12) was characterised by high abundances of plaice and Clupeidae (average of 83 and 68 individuals recorded per net, respectively). Westward at site IF11, clupeids were even more dominant with an average of 304 fish recorded per net, although as already identified, the majority of individuals were caught in later years (2013 onwards). Fish communities at site IF11 were also

[6] I.e. the total number of fish recorded at each site between April 2010 and November 2015, divided by the total number of seine nets shot.

characterised by moderate abundances of sandeel and plaice; average abundances (31 sandeel and 18 plaice per net) represented the third and second highest values recorded across all sites sampled, respectively.

East to west gradients in species abundance were evident along the north coast of Anglesey. Clupeids remained prevalent but declined in abundance with distance westwards. Mean abundances at sites farthest west, IF01 and IF02, were low (0.42 and 0.31 clupeids per net, respectively). Although sandeel remained abundant in Cemaes Bay at sites IF06 and IF07 (51 and 16 fish per net, respectively), abundances declined markedly between west Cemaes Bay (IF09) and Porth-y-pistyll (IF13), with an average of less than five sandeel per net recorded within this area. Further west, elevated sandeel abundances (average of >25 fish per net) were evident but only at isolated sites including IF03 (east Cemlyn Bay) and IF01 which is located some 15 km from the Wylfa Newydd Development Area. A re-emergence of plaice was also evident at the sites furthest west (IF01 and IF02) but abundances remained low (average of four and two fish per net) compared to those observed at sites farthest east (IF11 and IF12).

Sand smelt abundances were low at the most eastern sites (an average of less than four fish per net) but increased westwards from site IF09 located in west Cemaes Bay (average of 20 fish per net). This highest average abundance was observed at site IF13 in Porth-y-pistyll (57 fish per net); despite this, overall abundances of fish recorded at this site were low. Sand smelt remained prevalent at sites further west, with average abundances ranging from 14 to 20 fish per net.

All other taxa were recorded in comparatively low abundances (≤ nine fish per net) at all sampling sites. Gobies were however notably present at sites IF10 and IF09. Flatfish species such as turbot, brill and flounder were also present at sites on the north-east (IF11 and IF12) and north-west (IF01 and IF02) coast of Anglesey. There was a distinct absence of flatfish, including plaice, turbot, brill, dab (*Limanda limanda*) and Soleidae at intervening sites along the north coast Anglesey, particularly in Porth-y-pistyll (IF13) and on the eastern side of Wylfa Head (IF05). Turbot was recorded in west Cemaes Bay at sites IF06 and IF11 but often in low (single) abundance.

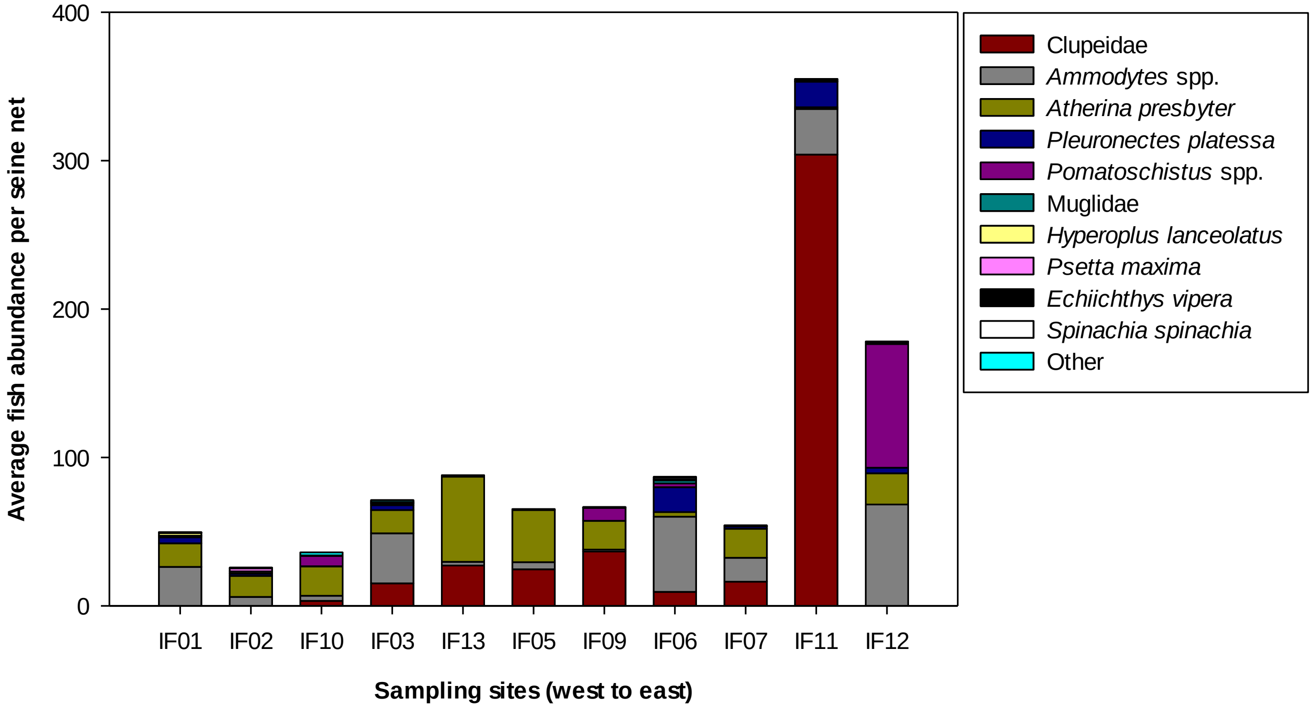

Figure 3.7 : Average abundance of the dominant fish taxa recorded per seine net at each site between April 2010 and November 2015.

When considering the community assemblage and abundances of individual taxa, a one-way ANOSIM identified statistically significant differences between sampling sites (Global R = 0.147, p = 0.001), although the low R-value suggests a high degree of overlap. The largest differences were generally observed between sites located some distance from each other. For example, the biggest difference was found between site IF10 in Cemlyn Lagoon and both sites IF12 (R = 0.412, p = 0.001) and IF02 (R = 0.365, p = 0.01), located approximately 21 km and 10 km away to the east and west, respectively. Smaller, albeit significant, differences were observed between sites located in relatively close proximity to one another such as IF06 vs. IF05 (R = 0.350, p = 0.001) and IF09 (R = 0.339, p = 0.001) which are all located in Cemaes Bay

One-way SIMPER analysis (see Appendix F) showed that spatial differences were driven by the variable abundance of taxa common to the north coast of Anglesey. Unsurprisingly, differences between the far eastern site (IF12) and site IF10 in Cemlyn Bay was driven by a higher abundance of sand smelt, gobies, grey mullet and fifteen-spined stickleback in Cemlyn Bay but a lower abundance of plaice, sandeel and clupeids. These species collectively accounted for 90.2% of the dissimilarity between intertidal fish communities recorded at these two sites. Differences between site IF02 on the west coast of north Anglesey and site IF10 were characterised by the same patterns as well as an absence of turbot, brill and greater sandeel (*Hyperoplus lanceolatus*) in Cemlyn Bay.

The average abundance of those taxa most commonly recorded at sites located within Cemaes Bay (IF05, IF09, IF06 and IF07) are visually presented in Figure 3.8. One-way SIMPER analysis found differences between site IF06 and both IF05 and IF09 were driven by a lower abundance of sand smelt and clupeids at site IF06 but a higher abundance of plaice and sandeel. These four taxa cumulatively accounted for 76.2% (IF06 vs. IF05) and 73.1% (IF06 vs. IF09) of the dissimilarity between intertidal fish communities recorded between these site combinations.

No statistically significant difference was identified between IF07 (eastern region of the bay) vs. IF05 and IF09 (western region of the bay), nor between IF05 and IF09 which were immediately adjacent to one another (at p = 0.05). Whilst a statistically significant difference was identified between IF07 vs. IF06, the low R-value suggests differences were small (R = 0.134, p = 0.04), being primarily driven by variable abundances of sandeel, sand smelt and plaice.

Differences in intertidal fish communities recorded at sites in Cemlyn Bay which for the purpose of this analysis includes Porth-y-pistyll (IF10, IF03 and IF13) were not found to be statistically significant at p = 0.05.

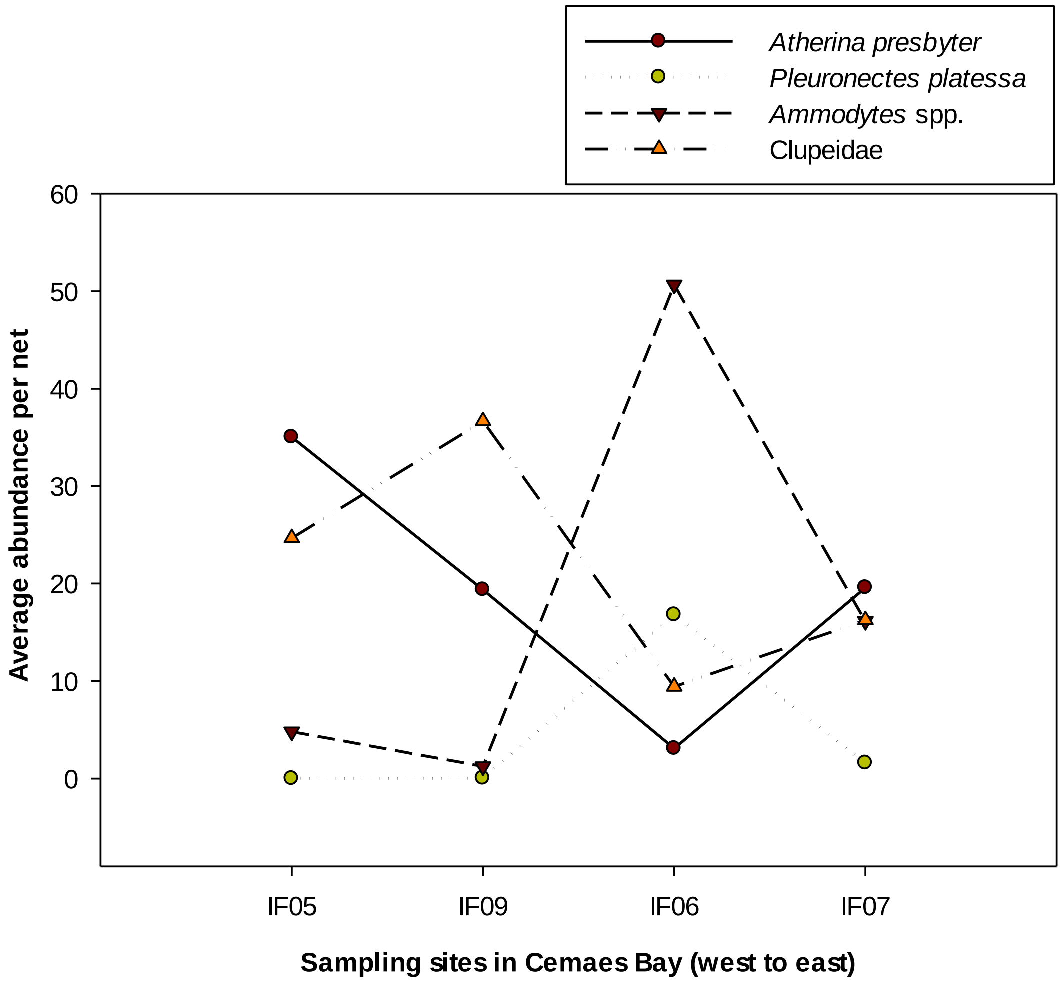

Figure 3.8 : The average abundance (per net) of four taxa driving dissimilarity between sites located in Cemaes Bay.

The prevailing wind direction is south-west and therefore sites on the north-west coast of Anglesey are considered to be extremely exposed whilst those sites along the north-east coast are relatively sheltered. Although the intervening area along the north coast of Anglesey is generally considered reasonably sheltered, small-scale variations in exposure, do occur with the eastern margins of bays and inlets being more exposed than western margins which are typically located in the lee of headlands.

To explore whether differences in exposure could be driving spatial difference in intertidal fish communities, a one-way ANOSIM was carried out using ‘exposure’ as a factor. Overall, there was no statistical difference in intertidal fish communities observed at sites characterised by different exposure conditions (Global R = -0.004, p = 0.604). However, when each bay was considered in isolation, differences between sites in Cemaes Bay (site: IF05 and IF09 - ‘sheltered’; IF06 – ‘moderately exposed’; and IF07 – ‘exposed’) were found to be statistically significant (Global R = 0.165, p = 0.001). The greatest difference was identified between sheltered and moderately exposed sites (R = 0.311 and p = 0.001); this was followed by moderately exposed and exposed sites (R = 0.134, p = 0.006) (Figure 3.9). The species driving dissimilarity between these sites are outlined above. No significant difference was identified between sheltered and exposed sites in Cemaes Bay (at p = 0.05).

The absence of any statistical difference between sites in Cemlyn Bay suggests that despite localised differences in exposure, (site: IF10 – 'sheltered'; and IF03 and IF13 – 'moderately exposed'), the species compliment identified in Porth-y-pistyll is comparable to that recorded in sheltered rocky habitats in the western area of the bay.

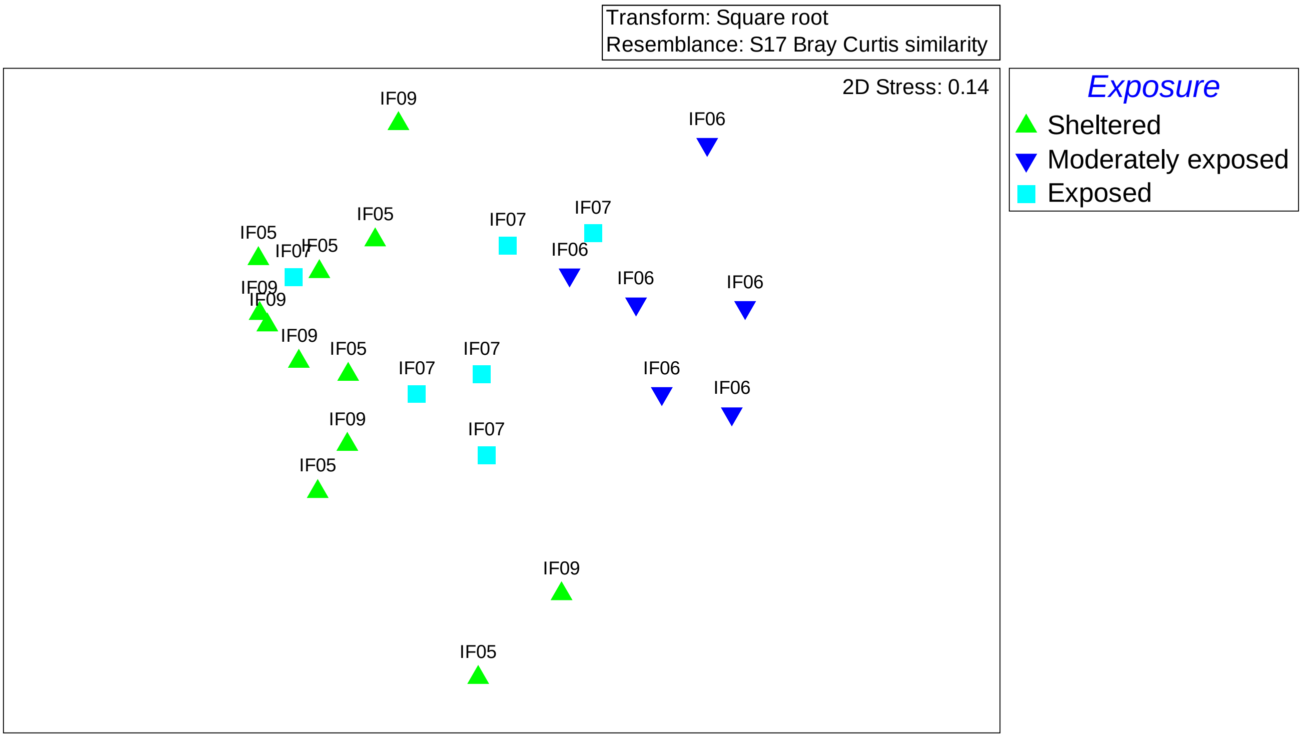

Figure 3.9 : 2D MDS plot showing the seperation of sampling sites in Cemaes Bay (IF05, IF06, IF07 and IF09) based on exposure. Note data has been averaged per site and sampling year.

Another factor that is likely to influence the species compliment present in different areas is substrate type. The eastern sites are made up of long stretches of homogenous, shallow, sandy beaches. It appeared that sandeel, clupeids, lesser weever and flatfish demonstrate a preference for these habitats which are likely to provide suitable nursery grounds for these taxa.

The western sites (IF01 and IF02) are more akin to the habitats at Cemlyn (IF03 and IF10) and Cemaes (IF05, IF06, IF07 and IF09), with coarser substrata and rocky outcrops in the close vicinity, along with expanses of exposed sands. These sites had a greater number of taxa, with fish associated with soft, mixed and hard substrata, coincident with the more varied habitats in these areas. For example, lesser weever and flatfish species, including plaice, flounder and turbot were prevalent on the wide sandy beach at Cemaes (IF06), whilst the steeper, pebbly beaches to east and west favoured schooling species such as sprat and sandeel. The site at IF10 in Cemlyn is a small, pebbly beach between rocky, intertidal areas that were dominated by weed growth: it had an extensive sandy seabed and was close to the entrance to the saline lagoon. Over the survey period, a number of different taxa were caught here, though mostly in low numbers, including pollack, corkwing wrasse, golden mullet (*Liza aurata*), three- and fifteen-spined stickleback, whiting, herring, sand smelt and sandeel. The algal stands offer suitable habitat for the sticklebacks, as does the proximity of brackish water, whilst sandy habitats provide suitable grounds for taxa such as sandeel and sand smelt.

Although site IF13 in Porth-y-pistyll was the rockiest and deepest site sampled with the seine net with no extensive, adjacent, sandy area, the species compliment was broadly similar to that observed at other rocky sites. The only species recorded during seine netting in Porth-y-pistyll that was not recorded elsewhere was shanny. This is typically a cryptic species affiliated with crevices within rock and is therefore not easily sampled using seine netting. Fish traps situated in adjacent areas of Porth-y-pistyll (IF04) and Porth Wen (IF08) were intended to help determine further fish species present within shallow rocky habitats; these results have been discussed in Section 3.1.2.3.1.

Despite apparent differences between intertidal fish communities sampled over different substrates; a one-way ANOSIM using ‘bed type’ as a factor, found no statistically significant difference between sites (Global R = -0.001, p = 0.493). Many of the survey sites had sandy substrates over which the fish were sampled. Even sites with shingle banks (IF03, IF09) or with partially rocky shores (IF02, IF05 and IF07) still had extensive sandy areas from mid-tide level downward. Although Porth-y-pistyll lacks extensive shallow sandy substrates, sandy muds and muddy sands are known to be present with the outer bay within the sublittoral zone (Jacobs, 2014, Application Reference Number: 6.4.85). This may in part explain the absence of significant differences between sites considering substrate type alone.

3.1.2.3.1 Fish traps

The fish traps deployed at sites IF04 (Porth-y-pistyll) and IF08 (Porth Wen) sampled rocky habitats just below the low-tide mark at each site. Fish species recorded from the two sites are presented in Table 3.5 below.

Over half the species present within traps (six of the 11 species) were also recorded in seine nets (see Table 3.3), primarily at sites characterised by coarse substrates such as IF03 in west Cemlyn Bay. Other taxa recorded in the traps including whiting, long-spined sea scorpion and lesser-spotted dogfish were also recorded in seine nets at more sandy sites (e.g. IF09). This further demonstrates that the heterogeneous nature of habitats along the north-coast of Anglesey, with sandy substrata and rocky outcrops in close vicinity, supporting a broadly similar but mixed community assemblage characterised by species typically associated with both substrates.

The two sampling techniques (seine netting and fish traps) identified species which are taxonomically and ecologically very similar but which occupy slightly different depths. For example, a single shanny was recorded from seine netting in Porth-y-pistyll whilst a tompot blenny was recorded from traps in Porth Wen. Both species belong to the taxonomic family Blenniidae and are known to be associated with rocky inshore habitats. Shanny is typically found higher up the shore in rockpools or hiding under stones and seaweed and therefore the record of this species from seine netting is unsurprising. Tompot blennies however, are typically found at slightly deeper depths generally residing between vegetation and boulders at extreme lower water, outside of the area surveyed by seine netting. This demonstrates the importance of a multi-method approach to sampling intertidal habitats.

It is interesting to note that four of the taxa which were only recorded in fish traps were also observed during dive surveys including goldsinny wrasse, poor cod, tompot blenny and rock goby (see Section 3.2.2). This provides evidence to suggest that these species are widespread along the north-Anglesey coastline being present in both rocky bays and headlands exhibiting a range of exposure conditions.

Fish traps are also a useful method of sampling large mobile shellfish such as European lobster (*Homarus gammarus*), which was identified in both Porth-y-pistyll and Porth Wen. Over the entire sampling period, this species was recorded a total of 29 times; abundances at the two sites were reasonably consistent. Abundances per string of traps did not exceed four on any given sampling occasion.

Table 3.5 : Presence (grey cells) and absence (clear cells) of fish species recorded in fish traps at two sites along the north Anglesey coast between spring 2010 and autumn 2015.

Common name	Species name	IF04, Porth-y-pistyll	IF08, Porth Wen
Three-bearded rockling	*Gaidropsarus vulgaris*	(shaded)	(shaded)
Five-bearded rockling	*Ciliata mustela*	(shaded)	(shaded)
Bull huss	*Scyliorhinus stellaris*	(shaded)	
Goldsinny wrasse	*Ctenolabrus rupestris*	(shaded)	
Lesser-spotted dogfish	*Scyliorhinus canicula*	(shaded)	(shaded)

Common name	Species name	IF04, Porth-y-pistyll	IF08, Porth Wen
Long-spined sea scorpion	*Taurulus bubalis*		
Pogge	*Agonus cataphractus*		
Poor cod	*Trisopterus minutus*		
Rock goby	*Gobius paganellus*		
Tompot blenny	*Parablennius gattorugine*		
Whiting	*Merlangius merlangus*		

3.1.2.4 Temporal vs. spatial variation

To compare spatial and seasonal patterns in the overall abundance of intertidal fish along the north coast of Anglesey, survey sites have been grouped into four broad areas described in Section 3.1.1.2. The average numbers of fish sampled per seine net set at each of the four regions during the whole sampling period (spring 2010 to autumn 2015) are shown in Figure 3.10. Catches were generally highest in spring and summer across all areas except for Cemlyn Bay, which showed higher catches in autumn compared with spring. This was driven by the presence of uncharacteristically high abundances of sand smelt during the autumn season at site IF03 in 2010 (562 fish per net) and IF13 in 2015 (149 fish per net).

The highest average catch per net was at IF11 and IF12 (eastern sites) in summer 2015 with an average of 2,222 of fish per net, largely attributed to high numbers of clupeids (specifically herring). These sites are located up to 24 km to the east of the Wylfa Newydd Development Area. In winter, the catches were relatively low in all sampling regions before the arrival of spring saw a distinct increase in fish recorded, particularly at Cemaes Bay and the eastern and western sites. Temporal vs. spatial patterns for the four most abundant taxa are described in more detail in the following sections.

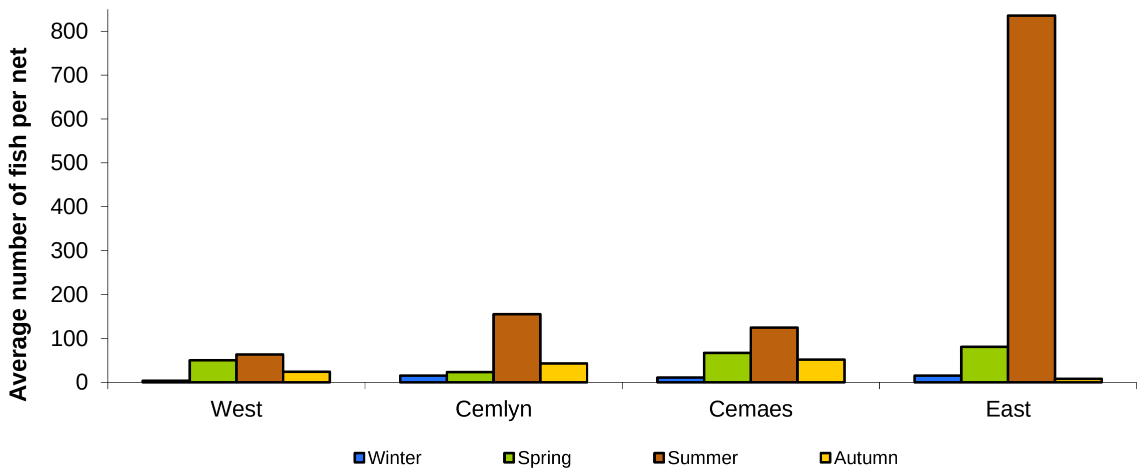

Figure 3.10 : Mean number of fish sampled per seine net in each of the four survey areas around north Anglesey between spring 2010 and autumn 2015.

3.1.2.5 Comparisons of fish community age structure

3.1.2.5.1 Sandeel

Sandeel numbers peaked in spring, often remaining high into summer when many small individuals (<50 mm) were recruited to the population (Figure 3.11). Figure 3.11 below illustrates the lower frequencies recorded during the autumn and winter months when overall catches were low (<400 recorded in both autumn and winter between 2010 and 2015). Two cohorts appear to be present in the summer samples, whereas in spring the length-frequency distribution appears to be approximately unimodal. The spring 2012 survey was delayed by six weeks owing to incessant, inclement weather and thus would have allowed more time for growth of the juvenile sandeel.

Length frequencies of sandeel recorded at each site during spring and summer are presented in Figure 3.12 to investigate whether size classes were distributed uniformly along the north coast of Anglesey. Across all sites, the majority of sandeel recorded in the spring ranged from 55 mm to 80 mm, representing between 47% and 96% of the total number measured at each site between 2010 and 2015. Despite this, subtle variations in the distribution of sandeel size classes were evident along the north coast of Anglesey during the period of peak abundance (spring and summer).

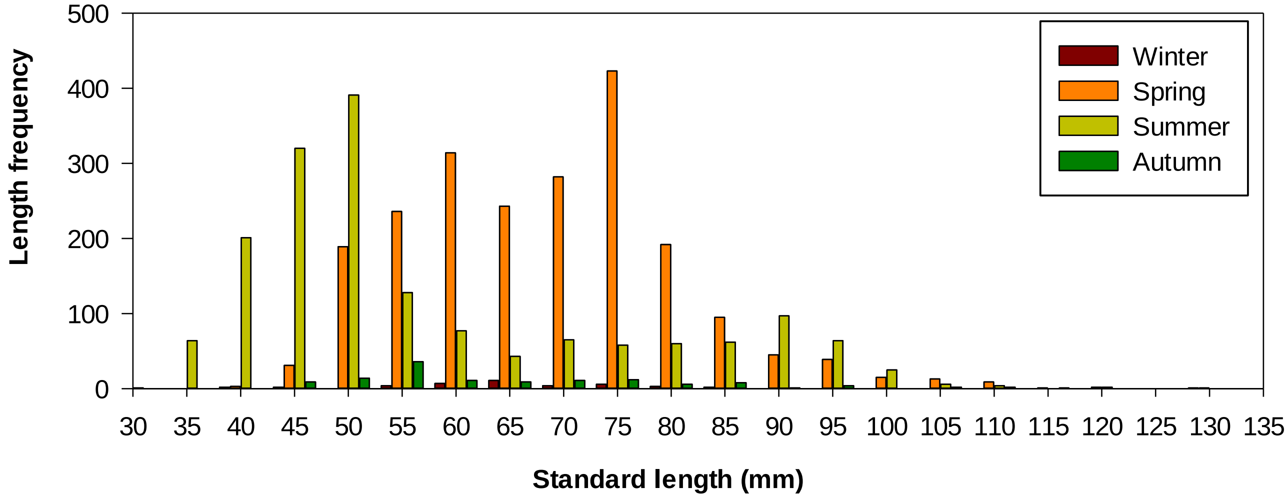

Figure 3.11 : Length frequency of sandeel sampled from the north Anglesey coast between spring 2010 and autumn 2015. Frequencies are based on the first 50 individuals measured from each sample and do not indicate the total numbers recorded.

In spring, adolescent sandeel measuring 75 mm to 130 mm dominated catches at sites farthest east, representing 57% and 55% of the total number measured at IF11 and IF12, respectively. Adolescent sandeel also dominated catches at sites in eastern Cemaes Bay (IF06 and IF07), although higher overall abundances were also driven by an increased prevalence of small juveniles measuring 45 mm to 70 mm.

Moderate to high spring catches recorded at sites IF02 and IF01 farthest west (13 and 65 sandeel per net, respectively), and site IF03 in Cemlyn Bay (30 sandeel per net) were dominated by smaller size classes (<70 mm) which accounted for 64%, 77% and 85% of total measured sandeel catches, respectively. Spring catches at the remaining sites in Cemlyn Bay (IF10 and IF13) and eastern Cemaes Bay (IF05 and IF09) were generally characterised by fewer, larger sandeel with an increased abundance of smaller sandeel at IF09. At these sites, abundances did not exceed 11 fish per net.

Overall, abundances of sandeel declined in summer, the prevalence of juveniles (30 – 50 mm) increased at nearly all sites. The exceptions were site IF02 to the west and site IF13 in Porth-y-pistyll where catches remained extremely low (one individual per net), being comprised solely of a few adolescent sandeel (55 mm – 80 mm).

The highest sandeel catch in summer occurred at site IF03 in Cemlyn Bay (90 fish per net) and site IF11 to the east (80 fish per net). Generally, catches at sites farthest east (IF11 and IF12) and to a lesser extent site IF03, exhibited a bimodal distribution indicating the presence of two cohorts (30 mm – 60 mm and 75 mm – 100 mm). Lower abundances at sites within Cemaes Bay (≤20 fish per net) were dominated by juvenile sandeel measuring <60 mm SL; these smaller size classes represented between 75% (IF09) and 98% (IF05) of the total number of fish measured. In eastern Cemlyn Bay (IF10), however, extremely low abundances (< one individual pet net) were dominated by even smaller sandeel (<55 mm). Moderate abundances at sites farthest west (IF01 and IF02) comprised a range of size classes, demonstrating a unimodal length frequency distribution.

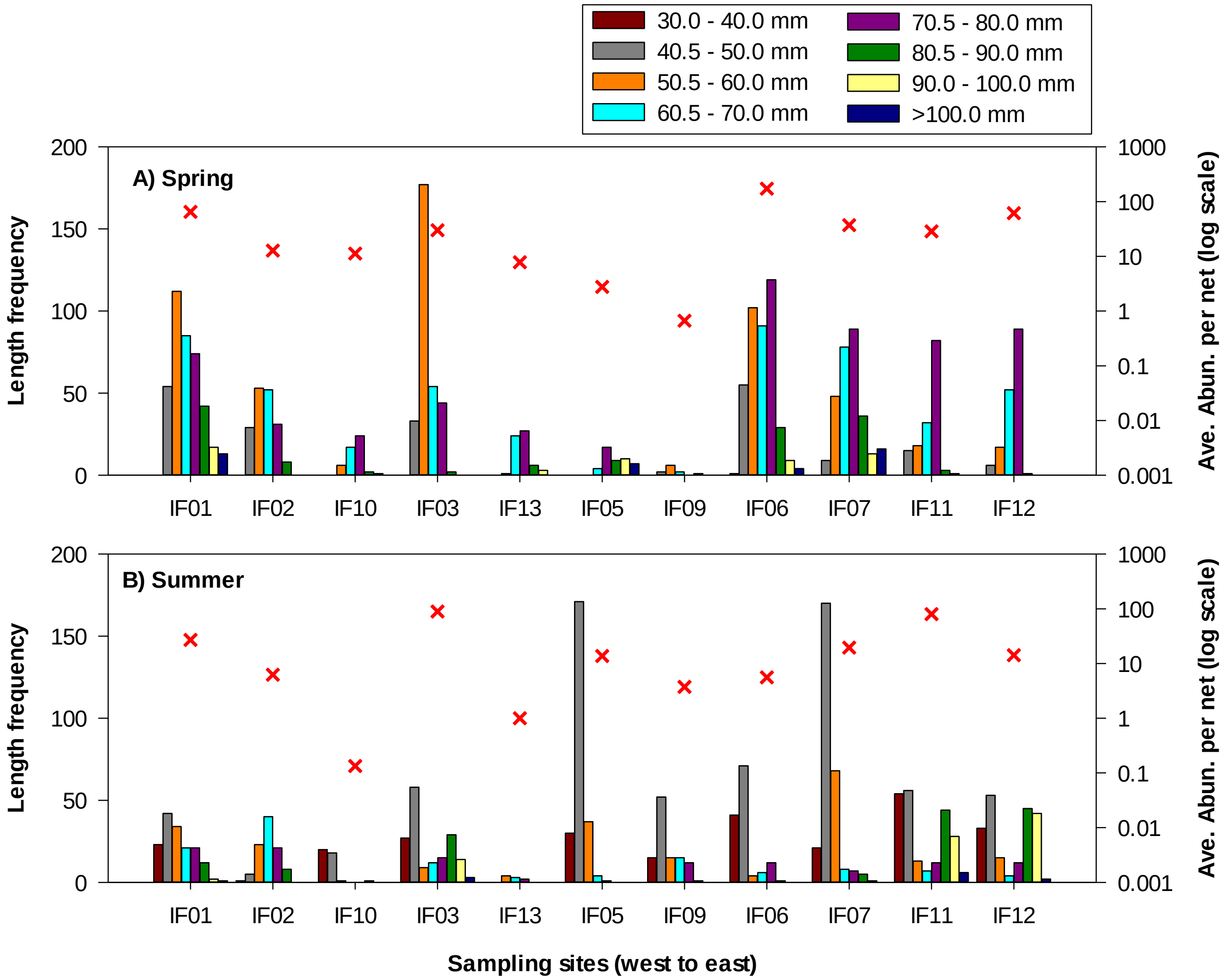

Figure 3.12 : Length-frequency distribution of sandeel sampled from the north Anglesey coast in A) spring (March to May) and B) summer (June to August) between 2010 and 2015. Frequencies are based on the first 50 individuals measured from each sample and do not indicate the total numbers recorded. Average abundances at each site corrected for sampling effort (per net) are presented as red crosses.

3.1.2.5.2 Sand smelt

In spring, the abundance of sand smelt in intertidal waters around north Anglesey was low and fish were centred around the 75 mm – 90 mm size range (Figure 3.13). A new cohort between 35 mm and 50 mm (age class 0+) appeared during the summer each year. The 1+ age class could also be identified at around 95 mm with a possible further age class (2+) at 115 mm – 120 mm. By autumn, the 0+ age class was dominated by fish of 60 mm – 70 mm. Growth slowed over the winter months with the same age class being largely represented by individuals between 65 mm – 80 mm. Few sand smelt were caught during the winter with older fish most likely moving into deeper waters not sampled by the seine net.

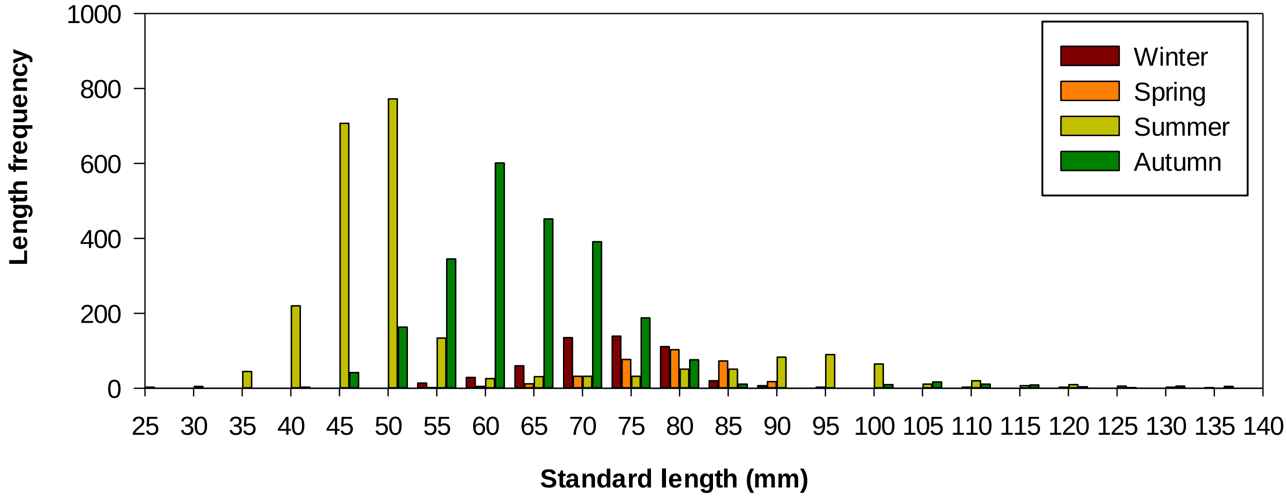

Figure 3.13 : Length frequency of sand smelt sampled from the north Anglesey coast between spring 2010 and autumn 2015. Frequencies are based on the first 50 individuals measured from each sample and do not indicate the total numbers recorded.

Figure 3.14 below illustrates the length frequencies of sand smelt recorded at each sites during the period of peak abundance in summer and autumn. Summer catches at all sites were characterised by the arrival of a new cohort of sand smelt measuring <50 mm (0+ group); their contribution to total measured catches of sand smelt ranged from 90% (IF11) to 67% (IF07). This size class dominated high catches at site IF13 in Porth-y-pistyll (average of 162.6 sand smelt per net) representing 77% of the total measured catch of sand smelt.

The length frequency of sand smelt at all sites exhibited a bimodal distribution during the summer, indicating the presence of additional, less numerous age classes measuring between 55 mm and 145 mm. These fish are likely to represent adolescent (0+ group) and adult sand smelt (1+ and 2+ group). Adult sand smelt (>85 mm) were found to be particularly prevalent at sites IF05, IF09, IF06 and IF07 in Cemaes Bay, representing between 23% and 15% of those measured at each of these sites between 2010 and 2015.

By autumn, very few sand smelt were recorded at sites farthest east (IF11 and IF12) and site IF02 to the east with total average abundances per net ranging from 0.3 and 3.4. At all remaining sites, sand smelt measuring 55 mm to 70 mm dominated catches, representing between 66% (IF13) and 84% (IF10) of the total number measured. Abundances of sand smelt measuring 75 mm – 80 mm (adolescents) persisted at site IF01 and those located in Cemaes Bay (IF05, IF09, IF06 and IF07), but very few adults were recorded at any of the sites along the north coast of Anglesey during this season.

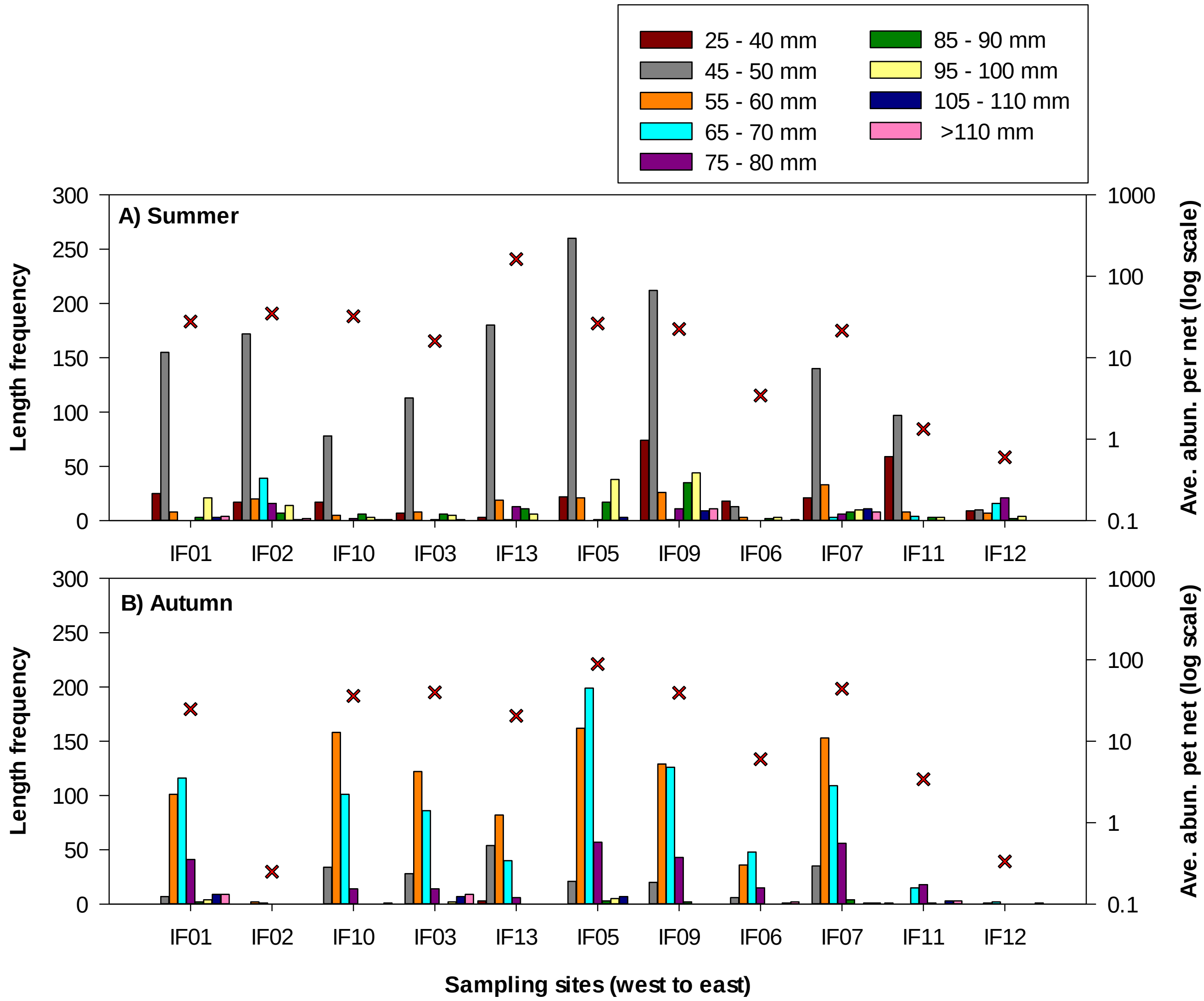

Figure 3.14 : Length-frequency distribution of sand smelt sampled from the north Anglesey coast in A) spring (March to May) and B) summer (June to August) between 2010 and 2015. Frequencies are based on the first 50 individuals measured from each sample and do not indicate the total numbers recorded. Average abundances at each site corrected for sampling effort (per net) are presented as red crosses.

3.1.2.5.3 Plaice

Juvenile (0+ group) plaice first appeared in the samples each year during the spring surveys, most frequently between 20 mm – 40 mm although in low abundance (Figure 3.15). Plaice larvae begin to metamorphose and settle out during April. By summer, it is evident that large numbers of 0+ plaice had settled in intertidal areas along the north coast of Anglesey. The number of plaice dropped rapidly in autumn and winter months, a result of natural mortality and migration to deeper waters as sea temperatures fall in shallow intertidal areas.

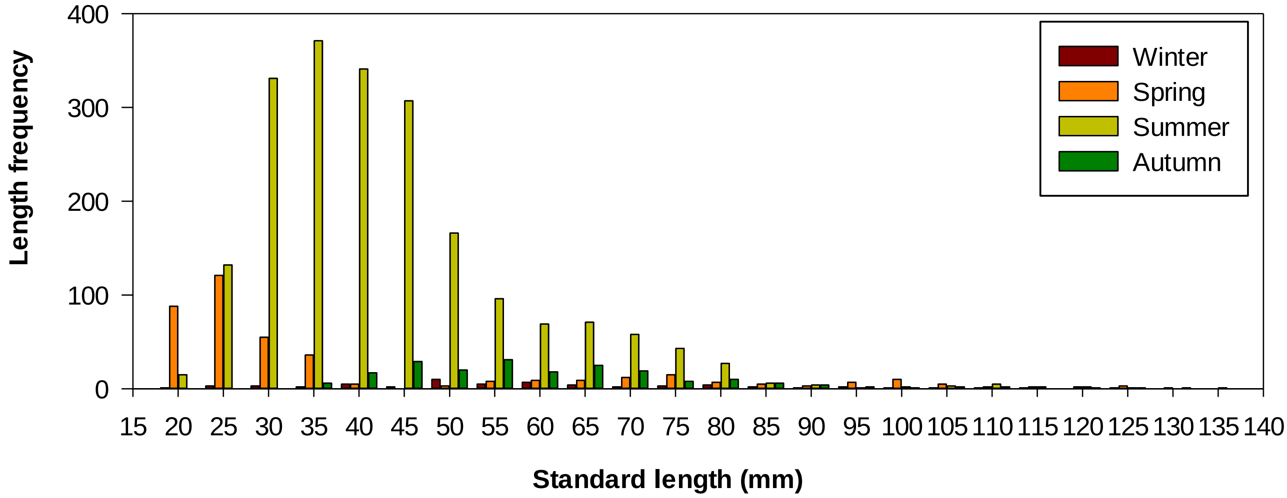

Figure 3.15 : Length frequency of plaice sampled from the north Anglesey coast between spring 2010 and autumn 2015. Frequencies are based on the first 50 individuals measured from each sample and do not indicate the total numbers recorded.

The length frequency of summer catches of plaice recorded at each site between 2010 and 2015 is presented in Figure 3.16. High catches at sites farthest east (IF11 and IF12) and site IF06 in eastern Cemaes Bay (53 to 194 fish per net) were dominated by plaice measuring 30 mm to 55 mm. Plaice of this size collectively represented between 68% (IF12) and 71% (IF11) of the total number plaice measured at these sites between 2010 and 2015. Although overall, catches of plaice at sites IF09 and IF07 in Cemaes Bay were low (<5 fish per net), plaice measuring between 30 mm and 55 mm remained dominant, representing 82% and 100% of individuals measured at these sites, respectively. Comparatively few 1+ group plaice (60 mm – 85 mm) were recorded at eastern sites. Conversely, sites further west (IF01, IF02) were characterised by a lower abundance of 0+ group plaice (<60 mm) and an increased proportion of 1+ group, the latter representing 67% and 33% of the total number measured, respectively.

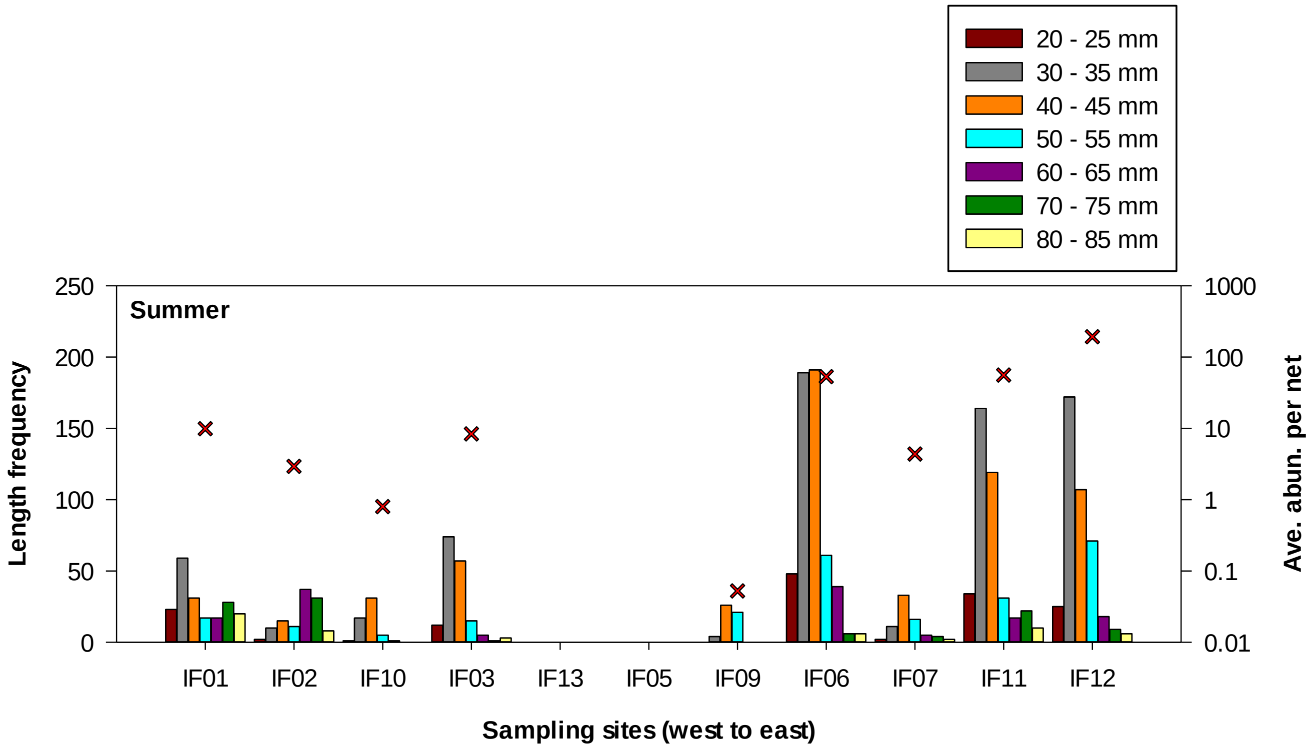

Figure 3.16 : Length-frequency distribution of plaice sampled from the north Anglesey coast in summer (June to August) between 2010 and 2015. Frequencies are based on the first 50 individuals measured from each sample and do not indicate the total numbers recorded. Average abundances at each site corrected for sampling effort (per net) are presented as red crosses.

3.1.2.5.4 Clupeids

Juvenile 0+ clupeids (herring, sprat and pilchard) first appeared in the samples each year during the spring surveys, most frequently between 35 mm – 50 mm standard length. Recruitment to intertidal habitats was found to peak in summer (Figure 3.17). There was no clear progression in cohort growth but rather a fall in abundance from summer to autumn, suggesting that larger fish moved away from the sampling areas as they grew, with mostly smaller individuals remaining by autumn; larger fish were sampled only rarely.

The length frequency of clupeids sampled at each site during the summer between 2010 and 2015 is presented in Figure 3.18. Aside from lower overall abundance at site IF06 in Cemaes Bay and sites farther west (IF01 and IF02) there is very little spatial variation in the size of clupeids observed at sampling sites along the north coast of Anglesey. Individuals measuring 35 – 50 mm, representing 82% to 96% of all clupeids measured at each site between 2010 and 2015. Slightly larger 0+ group clupeids measuring 55 – 60 mm were most prevalent at sites farthest east (IF11 and IF12) whilst increased abundances of individuals measuring 25 - 30 mm were observed at some sites in Cemlyn Bay (IF03 and IF13).

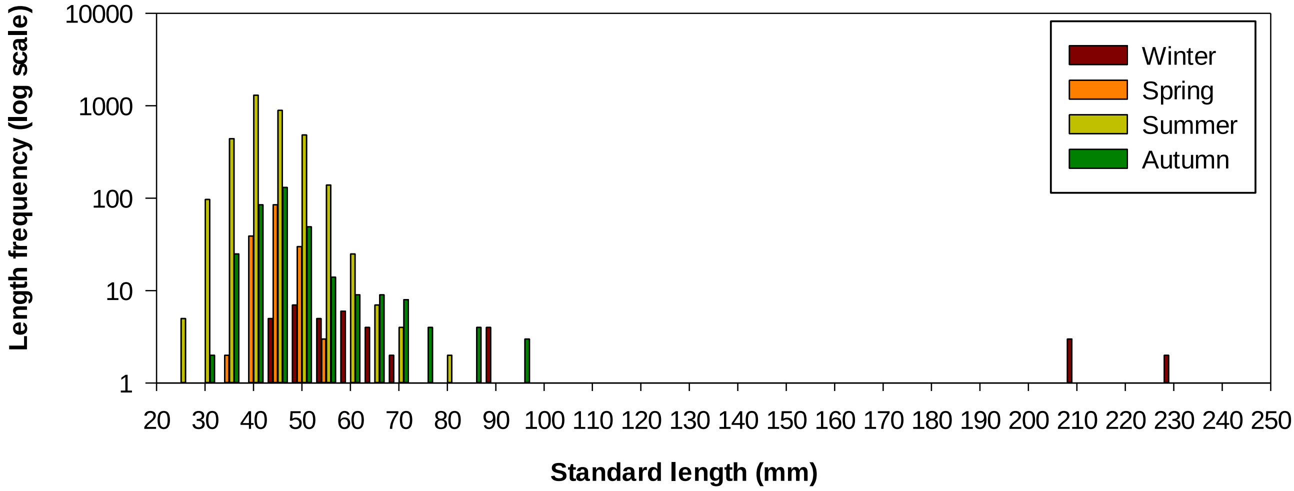

Figure 3.17 : Length-frequency of clupeids (herring, sprat and pilchard) sampled from the north Anglesey coast between spring 2010 and autumn 2015. For presentational purposes, the length frequency is presented on a log scale. Frequencies are based on the first 50 individuals measured from each sample and do not indicate the total numbers recorded.

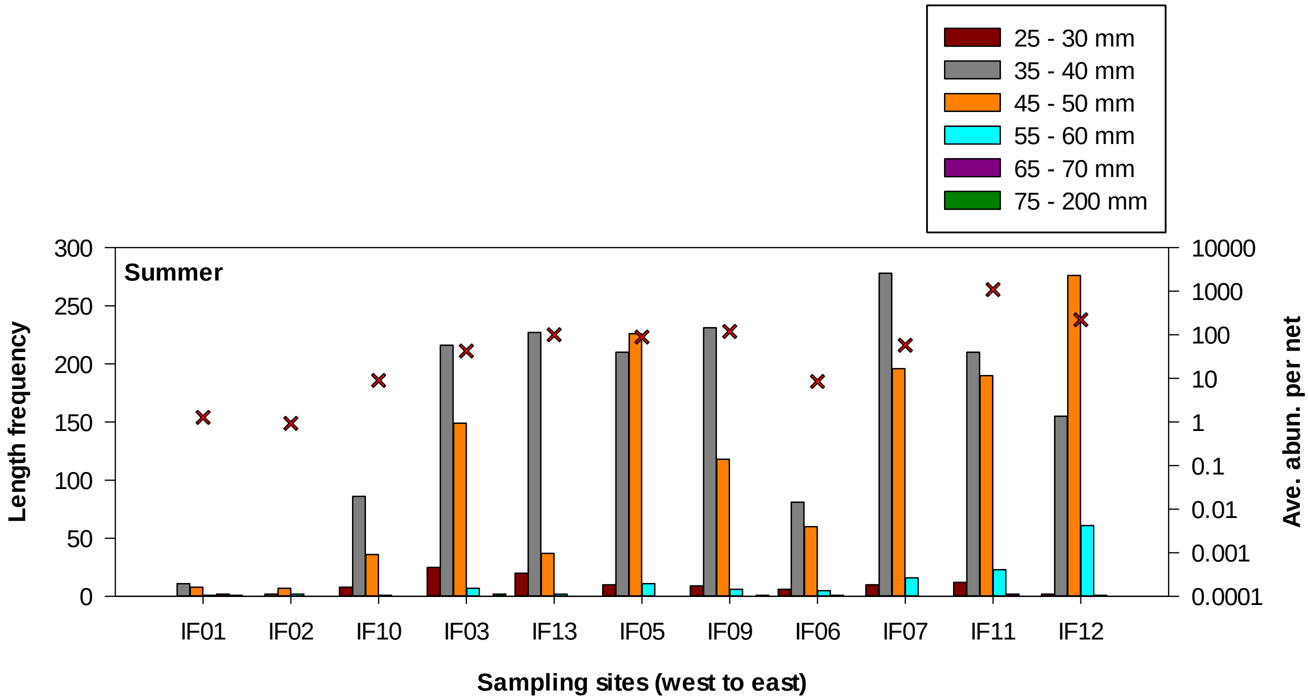

Figure 3.18 : Length-frequency distribution of Clupeidae (sprat, herring and pilchard) sampled from the north Anglesey coast in summer (June to August) between 2010 and 2015. Frequencies are based on the first 50 individuals measured from each sample and do not indicate the total numbers recorded. Average abundances at each site corrected for sampling effort (per net) are presented as red crosses.

3.1.2.6 Species of conservation and commercial importance

Between 2010 and 2015, a total of 16 sea trout was recorded. Most of the individuals were recorded at Cemaes, sites IF05, IF06 and IF07, although two were recorded at site IF13 in the Cemlyn area. The smolts were recorded in the size range 135 mm to 205 mm standard length; however, in spring 2010 a single specimen was 255 mm, and in summer 2010 and 2015, parr, measuring 45 mm and 70 mm respectively, were recorded. The sea trout is listed in in Section 7 of the *Environment (Wales) Act 2016*.

Over the whole survey period, a further five fish taxa were recorded that are listed in the Section 7 list of ‘species of principal importance for conservation of biological diversity in Wales’: these were herring, plaice, cod, whiting and the sandeel (specifically Raitt’s sandeel). Herring, plaice and sandeel constituted the highest abundances in the present survey programme.

The bull huss is not listed as a Section 7 species but is listed by the IUCN as ‘Near Threatened’ throughout its range in western Europe. The main threat is from over-exploitation by commercial fishing methods. This species was recorded in low abundance (n = 2) in intertidal areas between 2010 and 2015.

3.1.2.7 Feeding guilds

Analysis by feeding guild classification showed the intertidal fish communities at the survey sites were largely dominated by the continuous presence of zooplankton feeders throughout the year (e.g. sandeel, sand smelt and clupeids) (Figure 3.19). In most seasons, the zooplankton feeders constituted over 70% of the community in each season. The next largest group, in terms of composition, was the benthic feeders (e.g. plaice and common goby (*Pomatoschistus microps*)), which showed peaks in most summers, mainly owing to the settlement of newly metamorphosed juvenile plaice, for example in summer 2012. Benthic feeders also appeared to peak again in some winter and autumn seasons (e.g. winter 2013 and autumn 2014) but could be attributed to lower overall catches giving more resident demersal species a greater influence over percentage composition, as opposed to actual increases in number. The benthic feeders comprised the largest numbers of fish taxa followed by the zooplanktivorous and piscivorous groups respectively.

Over the course of the study period, most of the sampling areas displayed approximately similar ratios of feeding guilds (Figure 3.20), the main contributor being zooplankton feeders (on average >70%). There were occasional exceptions to this when higher proportions of benthic or piscivorous feeders were recorded, such as plaice or turbot respectively. Piscivores were generally low in abundance (<3%); however, in 2012 and 2014, the western sites showed an increased percentage contribution, predominantly comprised of juvenile turbot (<75 mm) with lower numbers of brill. Indeed, in 2014, there was an apparent increase in piscivores across all areas and this was mainly attributable to higher numbers of turbot at selected sites.

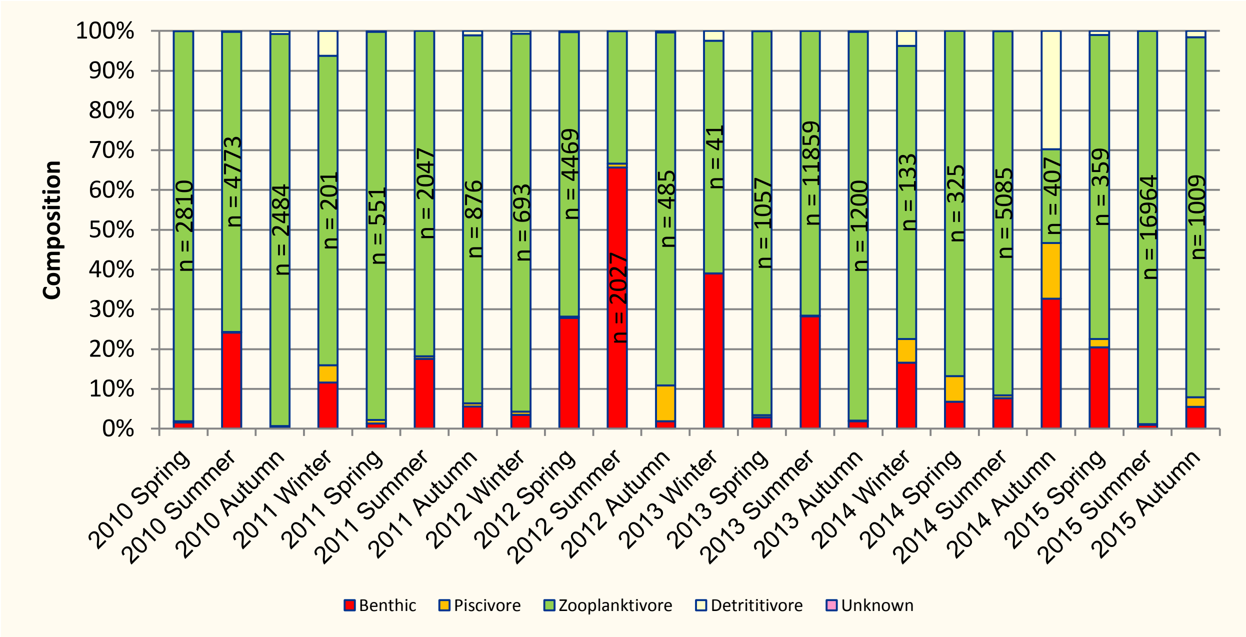

Figure 3.19: Seasonal feeding guild composition of fish recorded during intertidal seine netting at various locations along the north Anglesey coast between spring 2010 and autumn 2015. Data labels reflect total number of fish caught. Sampling was not carried out in winter 2010 and 2015.

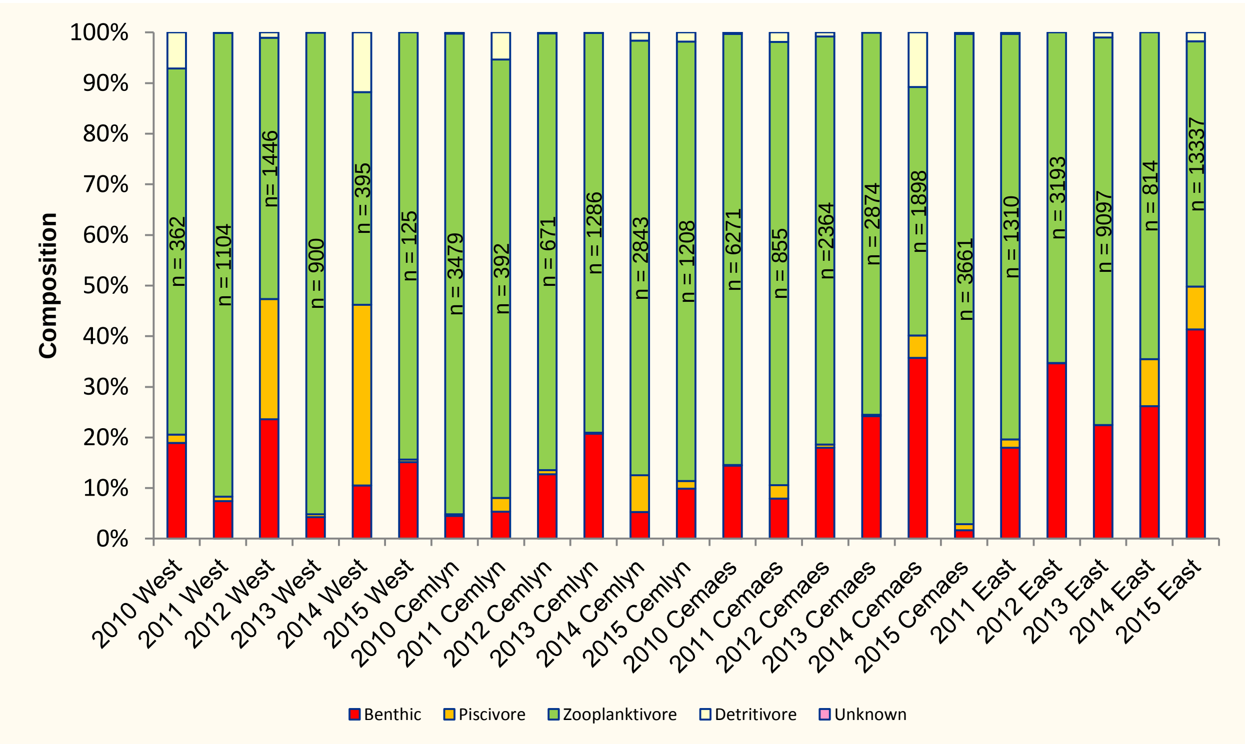

Figure 3.20: Feeding guild composition of fish recorded during intertidal seine netting in the four spatial areas around the north coast of Anglesey between spring 2010 and autumn 2015. Data labels reflect total number of fish caught.

3.2 Diver Surveys

3.2.1 Methodology

Diver fish surveys were carried out in the summer of 2010 to assess sublittoral fish communities along the north Anglesey coast. Surveys were scheduled for eight days over late July and early August 2010; sampling dates can be found in Appendix A.

Fourteen sampling sites were selected encompassing westerly and north-westerly facing bays and exposed headlands (see Figure 3.21 and Appendix A for site locations); these included:

- three immediately to the west of the Existing Power Station outfall (Outfall A, Outfall B and DV2);
- four were located to the east of the outfall around Wylfa Head (DV4, DV6, DV7 and DV8);
- five approximately 3 km – 5 km from the Wylfa Newydd Development Area, around Llanbadrig and Llanlleiana Heads which demonstrate similar tidal exposure to Wylfa Head sites (DV9A, DV9B, DV11, DV12A and DV12B); and
- two sites around Point Lynas (DV5 and DV16).

The location of some sites was changed during the survey to best meet the conditions on site.

Historical temperature profiles suggested that at periods of slack water (approx. 300 m from the outfall), a difference of 2°C or more can exist between depths of 8 m below the surface and the seabed at 17 m (Wimpol, 1985). Further away from the outfall (approx. 1 km), this difference was less apparent.

Based on the likelihood of encountering (a) different habitats at different depths and (b) a temperature differential between depths (albeit for potentially short periods of time), it was planned to survey two depths at each location. These depths were expected to be at 8 m – 10 m and 15 m – 16 m below chart datum. Surveying using a visual census technique at depths shallower than this (i.e. within the infralittoral zone) was considered impractical owing to the density of kelp (*Laminaria hyperborea*) along the shore that would have impeded the vision of the surveyors and prevented accurate count data.

Shallower depths encompassed the lower infralittoral and upper circalittoral zone below the kelp forest where temperatures were likely to be higher. The lower depth range was well within the circalittoral zone where algae are not present. For reasons of health and safety, diving was limited to 20 m maximum depth below sea level; this also permitted a longer dive time (approx. one hour) per survey. Appropriate depths were determined on site and corrected to chart datum.

3.2.1.1 Transects and replicates

At each site, fish communities were surveyed over 2 x 30 m belt transects. Each transect was 3 - 4 m wide depending on visibility. Divers surveyed 1.5 - 2 m to either the left or the right side of the transect line. Each dive was planned to take 50 minutes with a maximum time of 60 minutes. Five minutes were taken to survey each 10 m of seabed.

3.2.1.2 Number of sites

The dive team consisted of four divers and was able to survey up to four sites per day, tides and weather permitting. In total, seven dive days were completed providing data from 13 stations. Site DV12A was not sampled owing to poor visibility.

Station = dive locations at set distances from the outfall

Site = any dive conducted by a buddy pair at a specified depth at a station

Transect = 2 x 30 m belt

The first dives completed were conducted to allow the divers to familiarise themselves with the methods; data from these dives were not included in the final analysis.

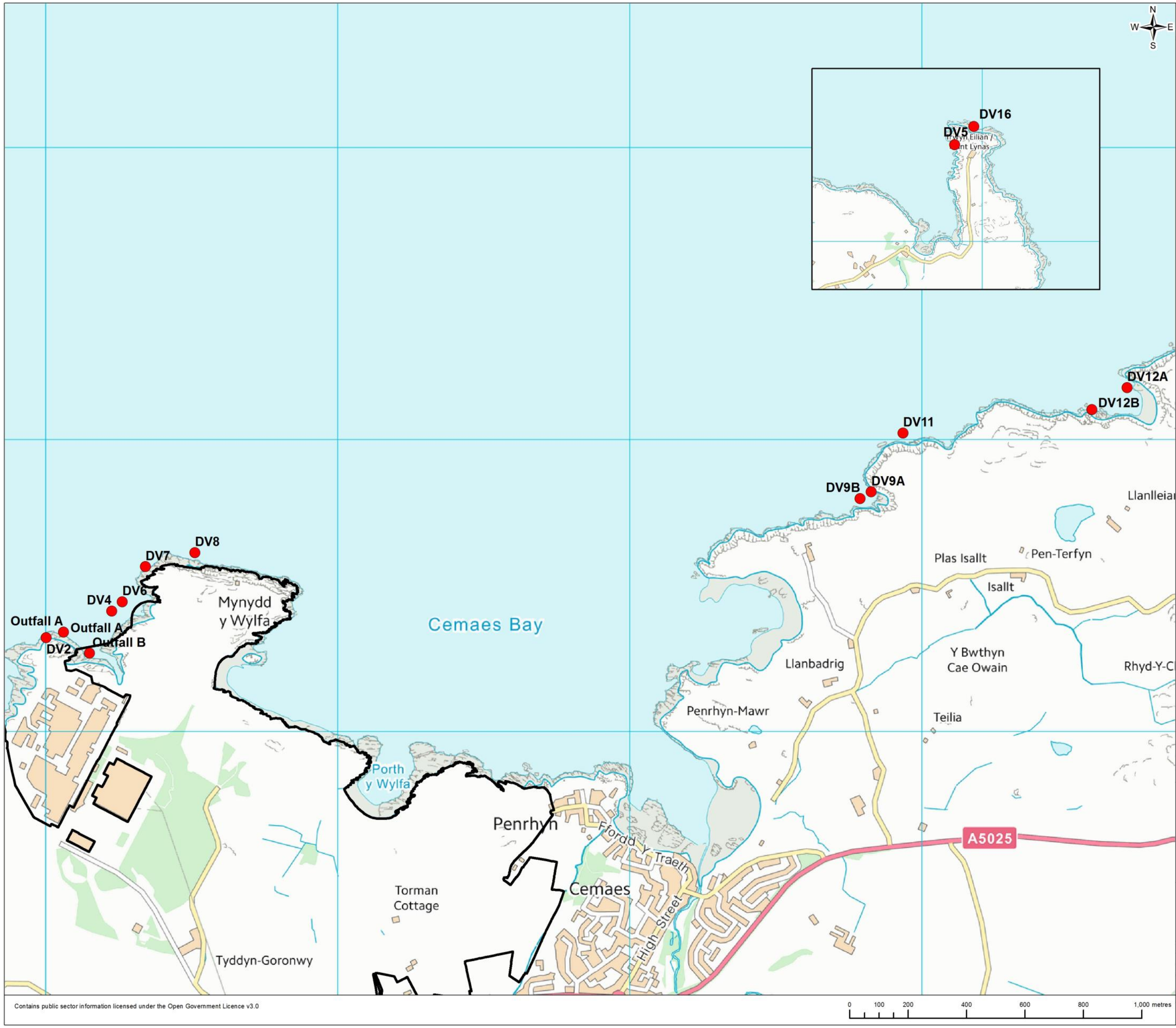

FIGURE 3-21

Legend

- Wylfa Newydd Development Area
- Dive sites

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	JUN 17	Initial Issue	VG	HY	EC	RB

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

DIVER SURVEY SITES (FISH)

Scale @ A3	1:12,500	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		
Drawing No.	60PO8077_DCO_APP_03_21	

3.2.1.3 Data analysis

It was intended to obtain two replicate transects per site and survey station; however, data were not always obtained from each site and station, nor for the complete 30 m transect, owing to currents, visibility or available time.

To permit a robust statistical analysis of data, only those sites for which sufficient data were obtained have been included. These are clearly outlined in the subsequent section. Data analysis was performed using PRIMER 6™ (Clarke and Gorley, 2006).

3.2.2 Results

3.2.2.1 Overall

In total, 23 survey dives were conducted: 14 shallow dives (<12 m) and nine deep dives (>12 m). A summary of dive site data, including dates, surveyors, visibility, distance from outfall and position can be found in Appendix F.

In total, 24 fish taxa were recorded (Table 3.6). Not all taxa could be determined to species level owing to difficulties identifying certain species, e.g. common and reticulated dragonets (*Callionymus lyra* and *C. reticulatus* – unless they were males in breeding colours) and gobies of the genus *Pomatoschistus*.

The fish taxa identified belonged to 11 taxonomic families. Of these, goby (Gobiidae) was most diverse with representatives of five different species as well as the genus *Pomatoschistus* spp. All species identified are known to be common to the north coast of Anglesey. The leopard-spotted goby (*Thorogobius ephippiatus*) was recorded in moderate abundances (n = 62) despite being a crypto-benthic species.

Five species of wrasse (Labridae) were recorded including goldsinny (*Ctenolabrus rupestris*), ballan (*Labrus bergylta*) and corkwing wrasse (*Symphodus melops*), which are all considered common to north European waters. Less common species such as rock cook (*Centrolabrus exoletus*) and cuckoo wrasse (*Labrus mixtus*) were also recorded in lower abundances (n = 5 and 1, respectively). Two species belonging to the cod family (Gadidae) were recorded including poor cod, which was one of the most common taxa identified (n = 203), and pollack which was recorded in much lower abundance (n = 4).

All remaining taxonomic families included just one positively identified species with additional individuals recorded to a higher taxonomic level (genus or family) in some cases (e.g. *Callionymus* spp. and codling). Of these, dragonets (including reticulated dragonet and *Callionymus* spp.) and tompot blenny were the most commonly recorded (n = 98 and 24, respectively).

Table 3.6 : Total abundance of fish taxa identified during diver fish surveys along the north Anglesey coast. Taxa that could not be identified to species level are shown in bold.

Common name	Scientific name	Total abundance
Gobies	***Pomatoschistus* spp.**	1,166
Poor cod	*Trisopterus minutus*	203
Goldsinny wrasse	*Ctenolabrus rupestris*	128
Dragonets	***Callionymus* spp.**	90
Two-spotted goby	*Gobiusculus flavescens*	69
Leopard-spotted goby	*Thorogobius ephippiatus*	62
Tompot blenny	*Parablennius gattorugine*	24
Ballan wrasse	*Labrus bergylta*	20

Common name	Scientific name	Total abundance
Rock goby	*Gobius paganellus*	17
Long-spined sea scorpion	*Taurulus bubalis*	11
Reticulated dragonet	*Callionymus reticulatus*	11
Corkwing wrasse	*Symphodus melops*	8
Rock cook wrasse	*Centrolabrus exoletus*	5
Pollack	*Pollachius pollachius*	4
Butterfish	*Pholis gunnellus*	3
Lesser-spotted dogfish	*Scyliorhinus canicula*	3
Topknot	*Zeugopterus punctatus*	2
Cuckoo wrasse	*Labrus mixtus*	1
Black goby	*Gobius niger*	1
Transparent/crystal goby	*Aphia minuta/Crystallogobius linearis*	1
Bass	*Dicentrarchus labrax*	1
Fifteen-spined stickleback	*Spinachia spinachia*	1
Conger eel	*Conger conger*	1
Cod	*Gadus morhua*	1

3.2.2.2 Spatial variation

Figure 3.22 presents the total abundance of the each taxonomic family recorded at each of the 13 sites sampled. The highest numbers of fish overall were recorded from both near the outfall of the Existing Power Station and far to the east at Point Lynas (DV5). Total fish numbers at these sites were very high (300 - 500 individuals) and related to the high numbers of gobies at these sites. High abundances observed at DV5 were also due to the many small post-larval fry recorded (approx. 220 individuals); it was not possible to identify these fish to species level *in situ*.

Gobies were recorded at all sites; *Pomatoschistus* spp., two-spotted goby and leopard-spotted goby were most common at sites around Wylfa Head. A single goby considered either a transparent or crystal goby was also recorded here at site DV4.

Wrasse were recorded at all sites except the site immediately adjacent to the outfall (Outfall A). Wrasse were generally more common around Wylfa Head, although reasonably high numbers of goldsinny wrasse (n = 46) were recorded at site DV11 near Llanbadrig Head.

Those taxa identified in low abundance (1> n ≤5) where generally recorded at multiple sites. For example, lesser-spotted dogfish were recorded at three sites, two around Wylfa Head (DV2 and DV7) and DV16 at Port Lynas. Butterfish were recorded at sites DV8 and DV11 around Llanbadrig and Llanlleiana Head. The single occurrences of cuckoo wrasse, black goby (*Gobius niger*) and conger eel (*Conger conger*) were recorded at sites around Wylfa Head; this is likely due to the concentration of sampling sites here increasing the likelihood of recording less common or cryptic species. A single fifteen-spined stickleback was however recorded at DV9A; this species is considered to be abundant and widely distributed along the north coast of Anglesey.

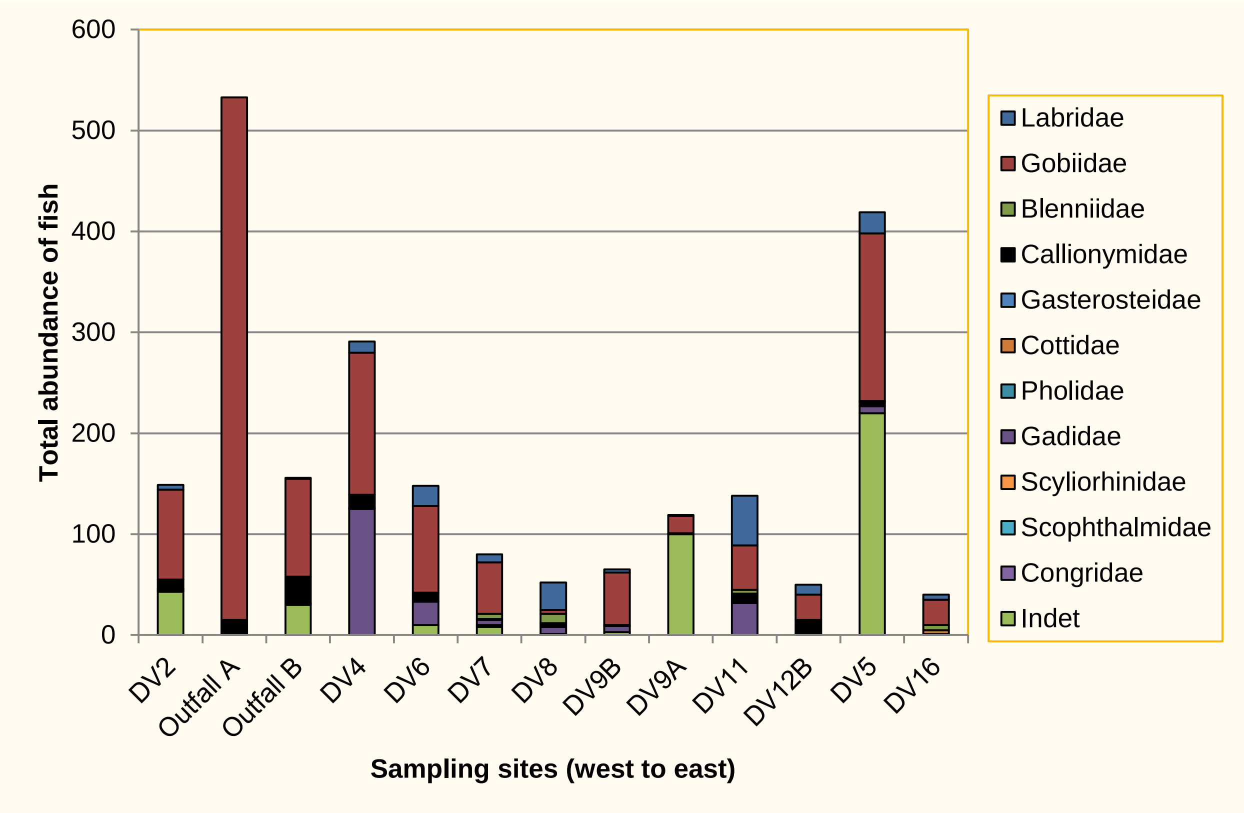

Figure 3.22 : Total abundance of fish recorded at each site during dive surveys in 2010. Note: data has not been corrected for sampling effort.

To determine whether fish community abundance and composition exhibited statistically significant spatial differences, multivariate analysis using PRIMER 6™ was performed. Not all stations could be included in this analysis owing to imbalances in sample replication (e.g. differences in the number of sites, transects and replicate 10 m samples taken). Those stations assessed included DV2, DV5, DV6, DV7, DV8, DV11 and DV16[7]. These stations were distributed along the north coast of Anglesey from Wylfa Head to Port Lynas and were considered sufficient to determine potential spatial patterns in fish communities associated with steep rocky habitats.

Before investigating whether there were any statistically significant differences between stations, the possible effects of 'site' (i.e. depth) were first explored. A one-way ANOSIM on non-aggregated data (all stations and sites as replicates), found that sampling depth had a statistically significant influence on fish communities at $p < 0.05$ (Global $R = 0.102$, $p = 0.023$). Differences are visually presented in Figure 3.23. The relatively low Global R value suggests a high degree of overlap in the community composition identified at each site.

A one-way SIMPER identified that shallow water sites were characterised by a higher abundance of gobies (*Pomatoschistus* spp. and two-spotted goby), long-spined sea scorpion and fish fry (indeterminates) but a lower abundance of goldsinny wrasse, poor cod, and leopard-spotted goby. Collectively these taxa accounted for 68% of the dissimilarity between sites across all stations. Complete statistical outputs can be found in Appendix F.

Differences between stations were tested using a two-way crossed ANOSIM, which accounted for differences between sites. Although overall a statistically significant difference was found between stations (Global $R = 0.469$, $p = 0.001$), pairwise tests did not identify statistically significant differences between particular sites at $p = 0.05$.

To investigate whether 'exposure' (e.g. headland vs. bay) influenced fish communities, a one-way ANOSIM was performed. Data was averaged for the two sites at each station to remove the effect of depth. There was no

[7] Corrections were made to very small imbalances in sample replication for DV06 and DV08.

statistical difference between the fish communities observed at rocky habitats characterised by different exposure conditions (Global R = 0.407, p = 0.570).

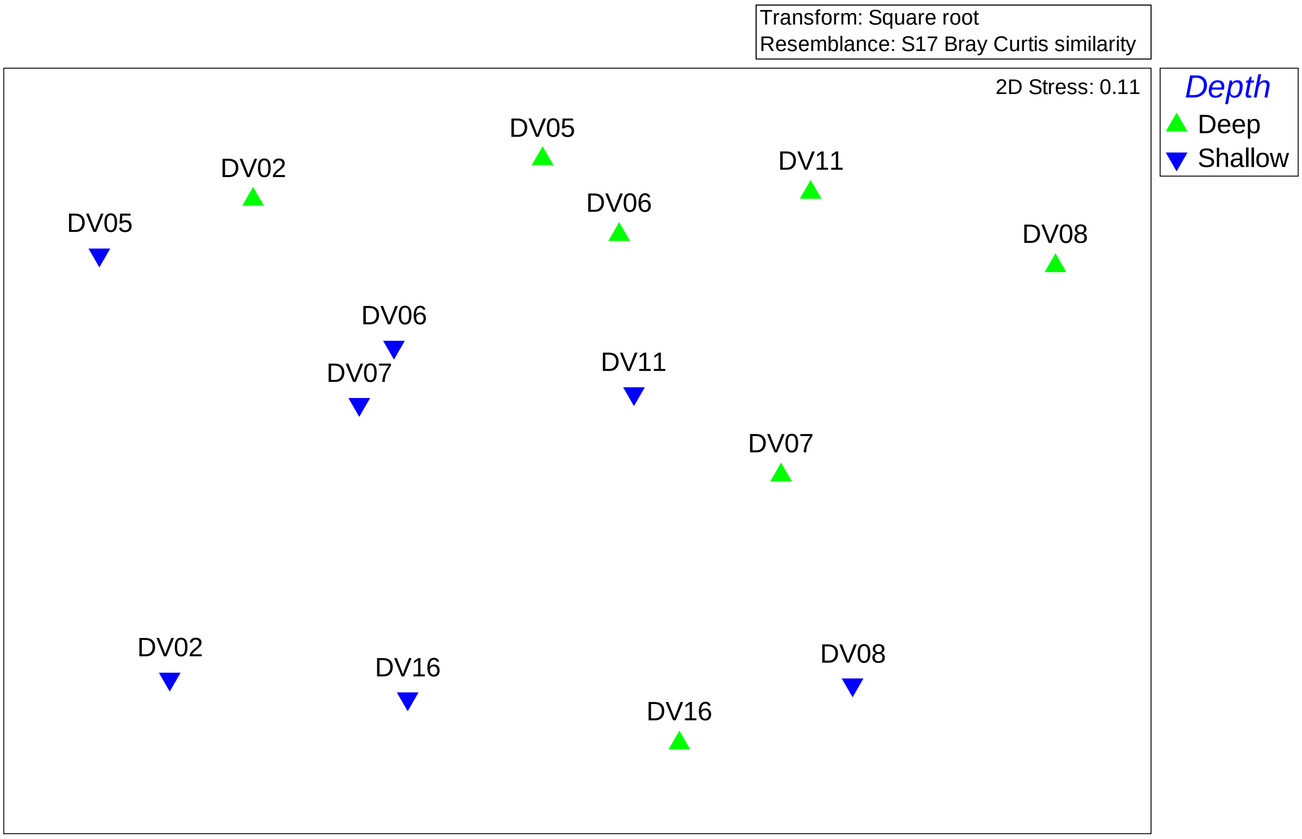

Figure 3.23 : 2D-MDS plot showing differences in the fish communities observed during dive surveys between different stations and sites.

3.2.2.3 Diversity indices

Diversity indices were calculated for each site. Species richness (d) is a measure of the number of species present, making some allowance for the number of individuals, whilst Pielou's evenness (J) is a measure of how evenly the individuals are distributed among the species. The Shannon diversity score (H'loge) provides a measure of species diversity in that its value is increased either by the addition of more unique species or by having a greater species evenness.

A one-way ANOVA identified no significant difference in species richness observed at the 13 sampling sites examined above (F = 1.984, p = 0.114). Pielou's evenness did however exhibit significant differences (F = 6.302, p = <0.001). Multiple pairwise comparisons (Holm-Sidak method) found this result was primarily driven by differences between sites DV02 and DV05, which exhibit lower mean evenness (0.498 and 0.486, respectively), than sites DV07, DV08 and DV16 (range: 0.842 – 0.880). Higher evenness indicates a relatively equal distribution of abundance among taxa; differences are likely to be driven by the dominance of *Pomatoschistus* spp. and fish fry at both DV2 and DV5. Consequently, there was a significant difference in species diversity identified between sites (F = 3.226, p = 0.021), although multiple pairwise comparisons did not identify statistically significant differences between particular stations at p = 0.05.

No significant difference in diversity scores between shallow vs deep transects were identified (species richness: F = 0.725, p = 0.402; Pielou's evenness: F = 0.005, p = 0.946; Shannon diversity: F = 0.402, p = 0.531) with the highest diversities occurring in both sheltered bays and exposed headlands.

3.2.2.4 Subsequent observations

Further transect surveys around the outfall were conducted in 2011 and 2012 using *in situ* diver recording techniques, but these used different methods and concentrated on recording the epi-benthic flora and fauna in greater detail (Jacobs, 2016c, Application Reference Number: 6.4.87). During these surveys, records were made of fish observed, though as fish were not the main objective of the surveys, the records were not as quantitative as those presented above. Despite this, the attraction of the outfall for large numbers of fish was apparent. Divers observed bass shoaling within 30 m – 100 m of the discharge point (Figure 3.24); large grey mullet were also observed, but could not be identified to species level in the turbulent water. The presence of bass in the outfall channel has been well known for several decades, but the dive records provide further evidence of high abundance close to the discharge point of the Existing Power Station.

Figure 3.24: Video still of bass from a survey transect within 40 m – 50 m of the cooling water outfall at the Existing Power Station, July 2012.

3.3 Discussion of Intertidal Fish Communities

The compliment of fish species recorded during the 2010 – 2015 sampling programme were all considered to be within their biogeographical range, and therefore their presence in intertidal areas along the north coast of Anglesey was not unexpected. Clupeids (mainly herring and sprats) were the most abundant taxa recorded in seine nets (27,682), followed by sandeel (*Ammodytes* spp.) (11,958), sand smelt (11,258) and plaice (6,812).

Intertidal fish communities along the north coast of Anglesey exhibited both seasonal and spatial variability. The seasonal pattern in fish abundance is closely linked to changes in seawater temperatures. Fish are generally residing within the intertidal areas during the warmer months where there is abundant availability of prey, and moving into the deeper subtidal waters for shelter during the colder autumn and winter months. The pattern of peak abundance of fish in intertidal areas during the summer was consistent throughout the sampling period.

Overall, higher abundances of fish were found to be using intertidal areas on the north-east coast of Anglesey; this is likely to be owing to the proximity of sampling sites to known spawning and nursery grounds in the eastern Irish Sea (Ellis *et al*., 2012). The lowest abundances of fish were observed along the north-west coast of Anglesey with a clear gradient of overall fish abundance evident along the intervening coastline from east to west. Species-specific variations in abundance and distribution were however evident; these are believed to be linked to life history characteristics and habitat preferences.

Juvenile sandeel were found to utilise intertidal habitats throughout the spring and summer months. During the winter, sandeel stop feeding, burrow 20 cm – 40 cm into the sand and effectively hibernate. The lack of sandeel in autumn and winter samples is most likely due to this form of hibernation rather than migration.

The abundance and size of sandeel utilising intertidal areas during the spring and summer varied considerably between sampling sites. Relatively high abundances were recorded at sites both farthest east and west;

however, catches to the east were dominated by larger adolescent sandeel (60 mm – 80 mm) whilst an increased proportion of small adolescents (40.5 mm – 60.0 mm) were also observed at sites farthest west. Smaller adolescents increased in abundance during the summer at the majority of sites, although larger adolescent sandeel remained prevalent at sites farthest east. A number of intertidal sites did not appear to be particularly important nursery areas for sandeel; these included Porth-y-pistyll (IF13), areas of Cemaes Bay (IF09) and western Cemlyn Bay (IF10).

Sandeel are a key constituent of marine food chains and are prey to both fish and birds alike. Located at Cemlyn Lagoon, on the north coast of Anglesey, is one of the most important tern nesting sites in Wales. This nesting site contains large populations of Arctic, Sandwich and common terns, all of which feed on sandeel. The peak abundance of sandeel coincides well with the tern-breeding season as it does with several other marine bird species found in the local area (Jacobs, 2011b; Jacobs, 2012).

Similar to the pattern seen with sandeel, the plaice appeared to move offshore in the autumn and, with the exception of a few individuals, were not recorded in any significant numbers until spring. Although the greatest numbers of plaice were recorded in summer, the smallest fish were found in spring with many individuals less than 30 mm in length. The highest abundances were recorded at sites IF11 and IF12, which are located at the western edge of a recognised plaice nursery area in Conwy Bay and Liverpool Bay (Figure 3.7). Further west along the north Anglesey coast the number of juvenile plaice recorded in intertidal areas declined rapidly, although lower abundances were recorded at sites farthest west (IF01 and IF02). There was a distinct absence of plaice (and other flatfish species) at certain sites including Porth-y-pistyll and west Cemaes Bay (IF05); this was considered to be linked to substrate type.

Clupeids also peaked in abundance during the summer within the intertidal habitats. Higher numbers of juveniles were recorded at the east coast sites (IF11 and IF12) as well in Porth-y-pistyll (IF13) and certain areas of Cemaes Bay (IF09), indicating a preference for these more sheltered sites. Although present in summer catches prior to 2013, average abundances increased markedly during this season in subsequent sampling years with the significant abundances recorded in 2015 and to a lesser extent 2013.

Widespread increases in sprat stock have been observed during the sampling period. Annual acoustic surveys carried out in the Celtic Sea each October found a year-on-year increase (with a small decline in 2014) in sprat biomass, from 5,493 tonnes in 2008 to 83,779 tonnes in 2015 (ICES, 2016). Landings of sprat within the Celtic Seas (ICES Subdivision 7.g-k) have shown an increasing trend since the year 2001, and total landings from divisions 6 and 7 in 2012, 2013 and 2015 were the highest since 2003, with the 2012 – 2015 average (11,887 tonnes) nearly double the 2004 – 2011 average (6,726 tonnes) (ICES, 2016).

Recruitment success and migration of marine fish is known to be influenced strongly by sea temperature. The optimal temperature for sprat growth is believed to be around 17.5°C (Frisk *et al*., 2015). It is likely that, among other factors, the generally warmer summertime sea temperatures during 2012 – 2014 increased recruitment success for this species, resulting in higher numbers of juvenile fish within intertidal areas.

Sand smelt were recorded in seine nets predominately during the latter part of the year in the summer through to winter. The presence of adults within intertidal areas during the summer suggests that sand smelt are utilising inshore areas for spawning. Sand smelt are demersal spawners, known to deposit eggs on seaweeds attached to rocky substrates (Bamber *et al*., 1985). It is therefore unsurprising that the highest abundances of this species were observed in Porth-y-pistyll where such habitats are prevalent.

The emergence of a cohort measuring 35 mm – 50 mm suggests that intertidal areas are also being used as nursery grounds. Sand smelt exhibit extremely high growth rates during their first year of life, and therefore it is possible to track the growth of the new cohort through the seasons as well as distinguish between different age groups. The new cohort was seen to reside within the population until the following summer, showing as 1+ group individuals. Very few sand smelt measuring greater than 100 mm standard length were observed in seine nets; this suggests movement of adult individuals to deeper waters away from the sampling area. This is also likely to explain lower overall abundances during the winter.

Sand smelt was recorded at all sampling sites during the sampling period, being particularly abundant in Cemaes Bay, western Cemlyn Bay and at sites further west (IF01 and IF02). This suggests that suitable habitats for spawning and nurseries are widespread along the north coast of Anglesey.

Cod and whiting were recorded in low numbers over the survey period (one and three fish in 2010 and 2015 respectively). Furthermore, no Dover sole were recorded in any of the inshore fish surveys. This is perhaps surprising given that the inshore areas of north Anglesey are classified as nursery areas for these species, particularly whiting and Dover sole. This suggests that the spatial resolution of data presented by Ellis *et al*. (2012) is perhaps not sufficient to accurately reflect the distribution of nursery grounds close inshore around the Isle of Anglesey.

Dab was regularly recorded in large numbers on the eastern offshore subtidal survey site SF1 (see Section 4). In contrast with the other flatfish species, this was the least abundant in the intertidal surveys (n=10) despite the productive nurseries at IF11 and IF12 being relatively close to the trawl sampling site SF01.

Sea trout were recorded on several occasions in Cemaes Bay. The sea trout is listed in Section 7 of the *Environment (Wales) Act 2016*. Sea trout migrates from spawning and juvenile grounds in freshwater as smolt to the marine environment. Sea trout may spend up to three years in the sea, preying on abundant food sources (such as marine crustaceans and worms, sandeel, sand smelt, sprat and goby species) prior to returning to their homing rivers to spawn. The general size of individuals recorded during these surveys (135 mm – 255 mm) suggests local recruitment to the marine environment. There is a sea trout run in the Afon Wygyr that flows into Cemaes Bay (Cefas, 2010); however, given the migratory nature of sea trout, these specimens may also be from adjoining river systems. Cemaes Bay is the only sampling site that experiences a considerable freshwater input. In summer 2010, very heavy rainfall coincided with the survey, giving rise to noticeable, turbid, freshwater mixing with the sea. It is considered that this high rainfall resulted in the unusual presence of a sea trout parr (45 mm) in the bay; the parr appeared in good condition and was returned at the point of capture.

The presence of smolt throughout the sites around Cemaes Bay each year suggests the habitats within the bay provide a suitable feeding area and/or migratory route for the fish as they head out to sea. The record of smolt from IF13 in Porth-y-pistyll close to the proposed new Cooling Water intake confirms they use intertidal habitats further along the coast than those just limited to within Cemaes Bay.

In addition to sea trout, five other Section 7 species were recorded. These were cod, whiting, herring, plaice and sandeel. Many of the sandeel recorded were not identified to species level in the field owing to the difficulty associated with viewing the required anatomical features on such small individuals; however, those speciated in the laboratory confirmed the presence of both *Ammodytes marinus* and *A. tobianus*, the former being listed under Section 7. As well as *Ammodytes* spp., large numbers of both plaice and herring were recorded in the spring and summer months. The importance of the shallow intertidal area as a nursery ground to these species is clear from the high numbers recorded, although as demonstrated, the presence of these species is not ubiquitous along the coastline.

The intertidal sampling sites demonstrated a range of aspects in relation to prevailing weather conditions, but despite this, ‘exposure’ failed to account statistically for spatial variations in the abundance and assemblage of fish using intertidal areas along the north coast of Anglesey. However, when Cemaes Bay was considered in isolation, a statistically significant difference was observed between sites characterised by different exposure conditions, being driven by variable abundance of common taxa such as sand smelt, clupeids and sandeel at ‘moderately exposed’ and ‘sheltered’ sites. The absence of any statistical difference between sites in Cemlyn Bay (including Porth-y-pistyll) is unsurprising given the complex typography along this region of the coastline, with a variety of exposure conditions present at a range of spatial scales.

Intuitively, it is thought that ‘bed type’ (i.e. substrate) is likely to govern, in part, the species compliment observed in intertidal areas. However, differences in the intertidal fish communities recorded along the north coast of Anglesey were not found to be statistically attributable to ‘bed type’. This is perhaps unsurprising as seine netting is not well suited to rocky habitats, and therefore, despite differences in the surrounding dominant bed type, sampling sites would have preferentially selected gentle-sloping areas characterised by muds/sands and gravels.

The limitations of seine netting were acknowledged within the sampling programme with additional fish traps and dive surveys carried out to target rocky habitats specifically. The merit of this approach was demonstrated with an additional six and eight species recorded from fish trap and diver surveys, respectively. Species unique to the fish traps included bull huss and three-bearded rockling. Conversely, those unique to diver surveys included leopard-spotted goby, reticulated dragonet, rock cook wrasse, butterfish (*Pholis gunnellus*), topknot, cuckoo wrasse, black goby and conger eel. Four species were found in both fish trap and diver surveys: goldsinny wrasse, poor cod, tompot blenny and rock goby. The absence of all these species within seine nets is unsurprising, as they are known to be affiliated with rocky and/or deeper habitats.

The European lobster was also recorded on a number of occasions with the fish traps demonstrating the value of intertidal areas to shellfish species. Further consideration has been given to shellfish communities in Section 4. Although fish traps were deployed in a limited number of areas, it is reasonable to conclude that the species recorded at Porth-y-pistyll and Porth Wen are unlikely to be unique to these bays. Being common and widely distributed, the species recorded in traps are likely to be present all around the north coast of Anglesey in association with rocky habitats characterising areas of exposed coastline, rocky bays and marginal areas of the larger sandy bays.

Results from diver surveys indicated there was little difference in the marine reef fish species around the outfall of the Existing Power Station compared with the rest of the coast. The main differences observed were the higher numbers of gobies, poor cod and other juvenile gadoids (as well as the large numbers of bass and mullet observed in 2012) within 300 m of the outfall compared with other sites. Bass is a Lusitanian species, often attracted to warmer waters, so their presence in the outfall channel is not surprising; many coastal power stations in the UK have bass nursery areas designated around their outfalls (e.g. Bradwell, Kingsnorth, Fawley, Heysham, Aberthaw and Pembroke). The higher numbers of gobies and juvenile fish around the outfall at the Existing Power Station might also play a role in attracting the bass to feed on them and/or on further food items discharged following entrainment through the station’s Cooling Water System.

The warmer water and constant currents in this area most likely provide a suitable habitat for feeding and increased growth (Langford, 1990). High numbers (albeit lower than at the outfall) of gobies and juveniles at site DV5 (around Port Lynas) suggest that the outfall site is not entirely unique in this respect; strong tidal currents at Point Lynas may also play a role providing a productive feeding area for fish. The other bays surveyed away from the outfall (Llanbadrig, Llanlliana and Point Lynas) all had the same north-west-facing aspect and were also very silted, so they should be considered characteristic of this coastline. All these bays had very similar fish communities.

The results of the three survey techniques (seine netting, fish traps and diver surveys) demonstrate the importance of adopting a multi-method approach to characterise intertidal fish communities from a variety of habitats. Impingement surveys carried out on-site at the Existing Power Station between March 2011 and July 2012 also provide a useful means of sampling juveniles and adults within inshore areas (Jacobs, 2016a, Application Reference Number: 6.4.92). Although it is acknowledged that this sampling methodology may provide a biased picture of fish communities, targeting those species utilising habitats within the immediate vicinity of the Power Station and that are susceptible to impingement, they provide valuable data, which can be used to supplement data collected within the wider study area. A table showing the presence/absence of all fish species recorded during the fish survey programme, including those recorded in the intertidal and impingement surveys, is presented in Appendix D.

Of all the taxa recorded during intertidal fish surveys (seine, fish traps and diving), only two have not been recorded on-site at the Existing Power Station; these include black goby and topknot. Conversely, examination of the impingement species list shows that, of the taxa expected to reside in intertidal areas, nearly all have been reported during either the seine, fish trap and/or diver fish surveys. The only exceptions are seasnails (Liparidae), which are commonly found among rocks, pipefish species, including Nilsson’s (*Syngnathus rostellatus*), and snake (*Entelurus aequoreus*), which are typically associated with seaweeds. The high level of consistency between the impingement and intertidal fish datasets confirms that, despite differences in temporal and spatial resolution, both sufficiently characterise the compliment of intertidal fish species present along the north coast of Anglesey.

Overall, the data suggest that spatial differences in the core intertidal fish communities around the north Anglesey coast were considerable, being driven primarily by proximity of sites to spawning and nursery grounds in the eastern Irish Sea (Ellis *et al*., 2012). Variations in the intertidal fish communities within large bays are likely to be attributed, in part, to differences in exposure conditions (as demonstrated by Cemaes Bay). Although substrate type is likely to play a contributing role in determining intertidal fish communities along the north coast of Anglesey, in isolation it was not found to represent a significant driver of statistical differences. Therefore, whilst the presence of large sandy bays interspersed with rocky coastline gives the impression of significant differences in habitat type along the north coast of Anglesey, the relative consistency in which rocky outcrops are found adjacent to sandy substrates suggests that this region of coastline supports a broadly consistent intertidal fish community.

The survey programme has confirmed the presence of inshore nursery areas for sandeel and plaice, and to a lesser extent sand smelt. For plaice, this is primarily located up to 24 km east of the Wylfa Newydd Development Area, with abundances declining markedly further towards the east. Sandeel nursery areas appear to be affiliated with sandy bays along the north coast of Anglesey and therefore represent a more patchy distribution. Nursery areas of sand smelt also exhibit a patchy distribution, being associated with vegetated rocky areas.

Other species recorded that are commercially exploited include brill, turbot, pollack (*Pollachius pollachius*) and bass. The reasonable abundance of juvenile brill (n=37) and particularly turbot (n=171) at the sites farthest east located up to 15 km from the Wylfa Newydd Development Area, shows the role of these intertidal habitats as nurseries.

Analysis of the feeding guilds showed that the majority of the fish caught each season during intertidal fish surveys was made up of zooplanktivorous feeders such as sandeel, sand smelt and clupeids. The exception to this was summer 2012, which was dominated by benthic feeders (contributing nearly 70%), mostly plaice. The plaice showed a distinct increase in abundance in 2012 and 2013 when compared with 2010 and 2011, with more than 1,000 recorded in each of the spring and summer sampling occasions in 2012 and more than 2,000 in summer 2013; only 224 were recorded in summer 2014 and 145 in 2015.

Over the entire survey duration, a total of 19 taxa exhibited a benthic feeding strategy compared with 11 zooplanktivorous, 12 piscivorous and three detrivorous taxa. The spatial data showed a similar trend with a numerical dominance of zooplanktivorous taxa followed by benthic feeders in all survey areas (Figure 3.20). The percentage composition of detritivores and piscivores varied both seasonally and annually, though these were largely minor constituents of the community (Figure 3.19). A notable exception occurred on the western sites in 2012 with more than 20% composed by piscivores, consisting mainly of turbot with some brill.

This survey work has, over five years, added to the understanding of the fish community using the shallow, intertidal zones around north Anglesey. For the most part, species were represented by juveniles (e.g. plaice, herring, sprat) or small-bodied species (e.g. sandeel, gobies, pogge, stickleback); however, a few large adult fish were caught (e.g. mullet and bass). The fish traps and dive surveys to sample fish in different habitats supplemented the seine netting. It should be noted that these surveys are part of the much wider fish study, described in other sections, using several techniques to sample further species and life stages. These results have been discussed collectively in Section 5.

4. Subtidal Fish and Shellfish Communities

4.1 Methodology

Subtidal surveys were carried out on a quarterly basis between spring (April) 2010 and autumn (November) 2014 to identify temporal and spatial variations in subtidal fish and shellfish communities.

Samples were collected at five sites (see Figure 4.1 and Appendix A for site locations). These included:

- site SF01 was located some 25 km to the east of Wylfa Head, just north of Red Wharf Bay;
- sites SF02 and SF03 were located 2 km to the east (north of Cemaes Bay) and north-west of Wylfa Head, respectively;
- site SF04 was located 5 km to the north-east of Point Lynas; and
- site SF05 approximately 10 km to the south of The Skerries in Church Bay.

Site locations were informed by detailed analysis of side-scan sonar data (Titan, 2010) and examination of Admiralty Charts. From autumn 2013, it was not possible to obtain fishing dispensation for site SF01 due to its location within a European Marine Site (Menai Strait and Conwy Bay SAC). For this reason, no trawling was carried out at this site for the remainder of the survey programme (November 2013 – November 2014). Sites SF04 and SF05 were added to the sampling programme in autumn 2013. The proximity of SF02 to the shore prevented otter trawling; beam trawling was carried out at this site only. The full survey programme, including sampling dates, can be found in Appendix A.

Otter trawling was used to collect quantitative data of demersal species and some pelagic species. The otter trawl consisted of a cone-shaped net comprising of four panels, closed by a cod-end. The trawl was kept open horizontally by two otter boards, and the mouth of the trawl was framed by a headline with floats to open the trawl vertically. A weighted ground rope equipped with rubber discs was used to shield the lower margin of the net mouth from ground damage. The otter net deployed was a small, scientific trawl with a 4 mm cod-end mesh. Trawling was undertaken at 2.5 – 3.5 knots over the ground for 10 – 15 minutes.

Beam trawls are used for sampling demersal species, targeting demersal fish and shellfish. The beam trawl deployed was a standard, scientific beam trawl consisting of a 1.8 m – 2.0 m metal beam with two triangular shoes fitted (one to each end) that act as runners, forming an aperture 1.7 m – 2.0 m wide and approximately 0.5 m high. The net was 4.5 m long with a 10 mm mesh and a 5 mm knotless cod-end. Trawling was undertaken at approximately two knots over the fishing ground for 10 minutes.

The positional track of each trawl was recorded using GPS in WGS84 datum.

Throughout the survey area, the seabed is characterised predominantly by hard substrate with areas of rough ground filled with cobbles and boulders. Consequently, owing to the risk of damage to trawling equipment and the risk to health and safety of vessel and crew, trawling was not always possible at all the desired locations. Five replicates were obtained from each site with each trawl type, although prevailing weather conditions and/or other unpredictable factors during the surveys sometimes prevented all five replicates from being obtained, or prevented a site from being sampled altogether.

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FIGURE 4-1

Legend

- Wylfa Newydd Development Area
- Beam Trawls
- Otter Trawls

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	JUN 17	Initial Issue	VG	HY	EC	RB

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

SUBTIDAL FISH SURVEY SITES

Scale @ A3	1:85,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		
Drawing No.	60PO8077_DCO_APP_04_01	

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4.1.1 Sample processing

All organisms were transferred to a covered container of seawater as quickly as possible. The catch was sorted and processed at each site upon collection of all replicate samples. All fish were identified to the lowest taxonomic resolution possible, enumerated and measured to the nearest 5 mm (standard length) size class. Where identification of a specimen was ambiguous, identification keys such as Maitland and Herdson (2009) were used and photographs of key features (e.g. fin ray counts, fin alignment and scale counts) taken for later confirmation. Occasionally, smaller specimens (particularly gobies and lesser sandeel) were retained for identification at the laboratory. Shellfish were enumerated only. Once processed, all organisms were returned to the water.

4.1.2 Data analysis

4.1.2.1 Catch per unit effort (CPUE)

Otter and beam trawl catch data were collated for each survey between spring 2010 and autumn 2014. Trawls were carried out for approximately 10 minutes each, although the length of each trawl varied owing to differences in the sea bed type and/or tidal currents. However, the proximity of SF02 to the shore prevented trawls of much greater than seven minutes. The length of each individual trawl track was used to calculate the number of each fish species sampled per 100 m trawled for otter trawls and the number of each species sampled per 100 m^2 trawled for beam trawls; this provided relative abundances to compare each trawl known as ‘catch per unit effort’ (CPUE).

The statistical analysis of subtidal fish data was carried out using PRIMER 6™ (Clarke and Gorley, 2006). Owing to the different fishing efficiencies of each net type, otter trawl catches were only ever compared with other otter trawl catches, and likewise for beam trawls. Comparisons of the temporal and spatial datasets were carried out using the mean CPUE values. Further explanation of the statistical terms methods used is provided in Appendix B.

4.1.2.2 Feeding guilds

Feeding guilds were used to determine the ecological behaviours and feeding types of the fish species recorded from the subtidal trawls; these are outlined in further detail in Appendix E.

4.2 Results

4.2.1 Overall

Between spring 2010 and autumn 2014, 68,233 fish were caught in the subtidal fish surveys in otter and beam trawls. A minimum taxa richness of 75 was recorded from all the subtidal trawls (otter and beam). However, certain taxa groups could represent several species found in the trawls; therefore, the actual number of species may be higher (Table 4.1).Large fluctuations were seen in the total number of taxa caught in a survey season, from S = 16 in November 2014 to S = 38 in August 2013, and between sites (S = 4 to S = 27) over the various sampling occasions.

The 2014-survey programme recorded three species not previously found during the trawling: fifteen-spined stickleback, Norwegian topknot and sand smelt. In recent years (2014 and 2015), sand smelt has been recorded in large numbers from the intertidal fishing programme around the north coast of Anglesey (see Section 3.1).

Six species of fish were recorded in all seasons and years: common dragonet, dab, lesser-spotted dogfish (*Scyliorhinus canicula*), plaice, poor cod and whiting. Up until summer 2014, cod had been recorded from every survey period; however, no individuals were found in summer or autumn 2014. The most abundant species were dab and whiting, which represented approximately 47% and 33% respectively of all catch during the survey programme.

Table 4.1 : The total abundance of each fish taxa recorded from subtidal surveys (beam and otter trawls combined) from April 2010 to November 2014. Taxa that could not be identified to species level are shown in bold.

Common name	Species name	Abundance in subtidal trawls
Dab	*Limanda limanda*	31,622
Whiting	*Merlangius merlangus*	22,518
Lesser-spotted dogfish	*Scyliorhinus canicula*	2,653
Plaice	*Pleuronectes platessa*	2,296
Sprat	*Sprattus sprattus*	2,241
Poor cod	*Trisopterus minutus*	1,905
Common dragonet	*Callionymus lyra*	1,125
Herring	*Clupea harengus*	990
Pogge	*Agonus cataphractus*	310
Bib	*Trisopterus luscus*	261
Red gurnard	*Chelidonichthys cuculus*	237
Thornback ray	*Raja clavata*	207
Cod	*Gadus morhua*	187
Greater sandeel	*Hyperoplus lanceolatus*	174
Sand goby	*Pomatoschistus minutus*	149
Gobiidae	**Gobiidae**	148
Lesser weever	*Echiichthys vipera*	108
Starry smoothhound	*Mustelus asterias*	99
Spotted ray	*Raja montagui*	72
Seasnail family	**Liparidae**	71
Cod family	**Gadidae**	63
Grey gurnard	*Eutrigla gurnardus*	60
Greater pipefish	*Syngnathus acus*	57
Lesser sandeel	*Ammodytes tobianus*	54
Lozano's goby	*Pomatoschistus lozanoi*	51
Painted goby	*Pomatoschistus pictus*	39
Haddock	*Melanogrammus aeglefinus*	38
Bull Huss	*Scyliorhinus stellaris*	36
Transparent goby	*Aphia minuta*	34
Five-bearded rockling	*Ciliata mustela*	32
Sandeel genus[8]	***Ammodytes* spp.**	32

[8] It was not possible to speciate the genus *Ammodytes* spp. in the field; however, individuals checked in the lab confirmed the presence of both *A. tobianus* and *A. marinus*.

Common name	Species name	Abundance in subtidal trawls
Blonde ray	*Raja brachyura*	28
Scaldfish	*Arnoglossus laterna*	28
Mackerel	*Scomber scombrus*	26
Tub gurnard	*Chelidonichthys lucernus*	25
Thickback sole	*Microchirus variegatus*	22
Flounder	*Platichthys flesus*	19
Herring family	**Clupeidae**	18
Dover sole	*Solea solea*	15
Reticulated dragonet	*Callionymus reticulatus*	13
John Dory	*Zeus faber*	13
Long-spined sea scorpion	*Taurulus bubalis*	13
Smooth hound	*Mustelus mustelus*	13
Sand smelt	*Atherina presbyter*	11
Solenette	*Buglossidium luteum*	11
Lemon sole	*Microstomus kitt*	9
Brill	*Scophthalmus rhombus*	8
Short-spined sea scorpion	*Myoxocephalus scorpius*	8
Megrim	*Lepidorhombus whiffiagonis*	7
Short-snouted seahorse	*Hippocampus hippocampus*	7
Worm pipefish	*Nerophis lumbriciformis*	7
Butterfish	*Pholis gunnellus*	6
Anglerfish	*Lophius piscatorius*	5
Lumpsucker	*Cyclopterus lumpus*	4
Nilsson's pipefish	*Syngnathus rostellatus*	4
Bass	*Dicentrarchus labrax*	3
Common goby	*Pomatoschistus microps*	3
Common stingray	*Dasyatis pastinaca*	3
Indeterminate	**-**	3
Three-bearded rockling	*Gaidropsarus vulgaris*	2
Clingfish	***Gobiesocidae* spp.**	2
Goldsinny wrasse	*Ctenolabrus rupestris*	2
Montagu's seasnail	*Liparis montagui*	2
Pollack	*Pollachius pollachius*	2

Common name	Species name	Abundance in subtidal trawls
Tope	*Galeorhinus galeus*	2
Spurdog	*Squalus acanthias*	2
Fifteen-spined stickleback	*Spinachia spinachia*	1
Two-spotted clingfish	*Diplecogaster bimaculata*	1
Common seasnail	*Liparis liparis*	1
Corkwing wrasse	*Symphodus melops*	1
Norwegian topknot	*Phrynorhombus norvegicus*	1
Scad/Horse mackerel	*Trachurus trachurus*	1
Sea scorpion family	**Cottidae**	1
Small eyed ray	*Raja microocellata*	1
Snake pipefish	*Entelurus aequoreus*	1
Striped red mullet	*Mullus surmeletus*	1
Tadpole fish	*Raniceps raninus*	1
Topknot	*Zeugopterus punctatus*	1
Turbot	*Psetta maxima*	1
Blue Whiting	*Micromesistius poutassou*	1

4.2.2 Trawl type

In total, 54 fish taxa were recorded from beam trawls over the study period, while 62 were taken by otter trawls; 43 taxa were common to both trawl types. Not surprisingly, the beam trawl catches were characterised by benthic species living in close association with the seabed, such as flatfish, rays, rocklings and clingfish (*Gobiesocidae* spp.). The otter trawl sampled a greater diversity of pelagic species, such as sprat and herring, and demersal species such as whiting, haddock and cod.

4.2.3 Temporal variation

In 2011, 2013 and 2014, the number of fish taxa showed an increase over the course of the year until autumn, when the number fell (Figure 4.2). During 2010, the highest number of taxa was recorded in autumn (n = 31). In 2011, 2013 and 2014, the highest number of taxa was in summer, whilst in 2012 the highest taxa number was recorded in spring. The lowest number of taxa over the whole survey was recorded in autumn 2014 (n = 16).

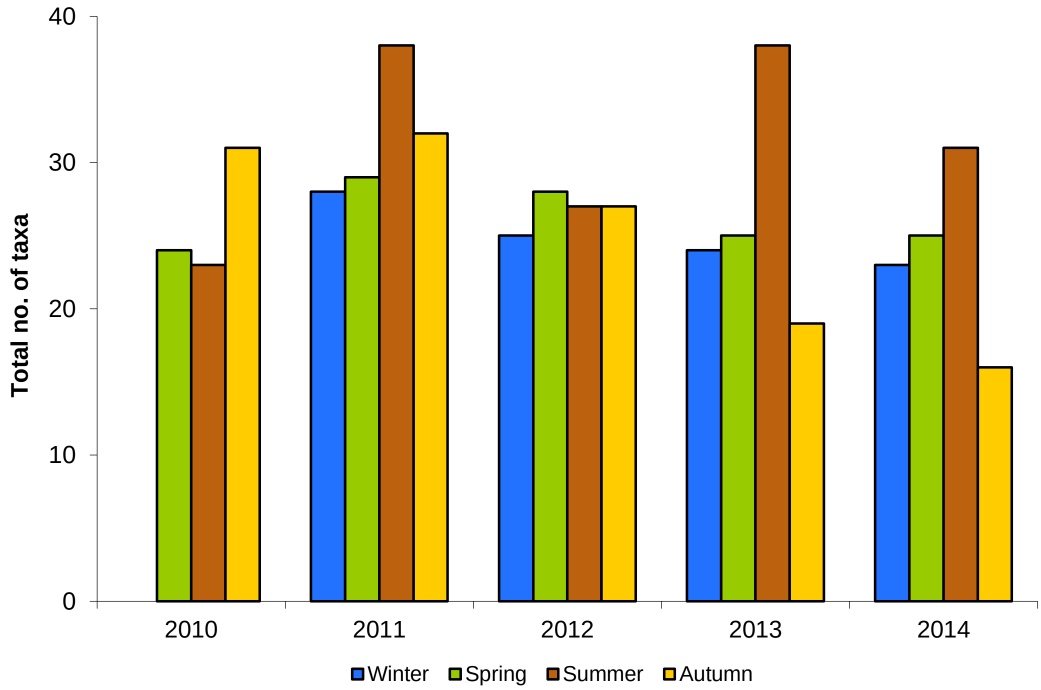

Figure 4.2 : Number of taxa recorded in each sampling season between spring 2010 and autumn 2014.

For the years 2012 and 2013, the total annual abundances were comparable (n = 17,014 and 16,339 respectively), though in 2011 fish abundance was noticeably higher (n = 26,705). The removal of SF01 from the programme clearly affected the overall numbers of fish caught, with consistently low catches recorded throughout 2014.

In terms of total fish abundance, 2011 and 2012 showed peak abundances in the spring sampling period (n = 11,169 and 9,832 respectively) (Figure 4.3); however, in 2010 peak abundance was recorded in autumn (n = 3,076) and in 2013 and 2014 during the summer (n = 10,203 and n = 981 respectively). Low fish numbers were generally recorded in autumn and winter periods, the major exception being November 2011 (n = 7,640).

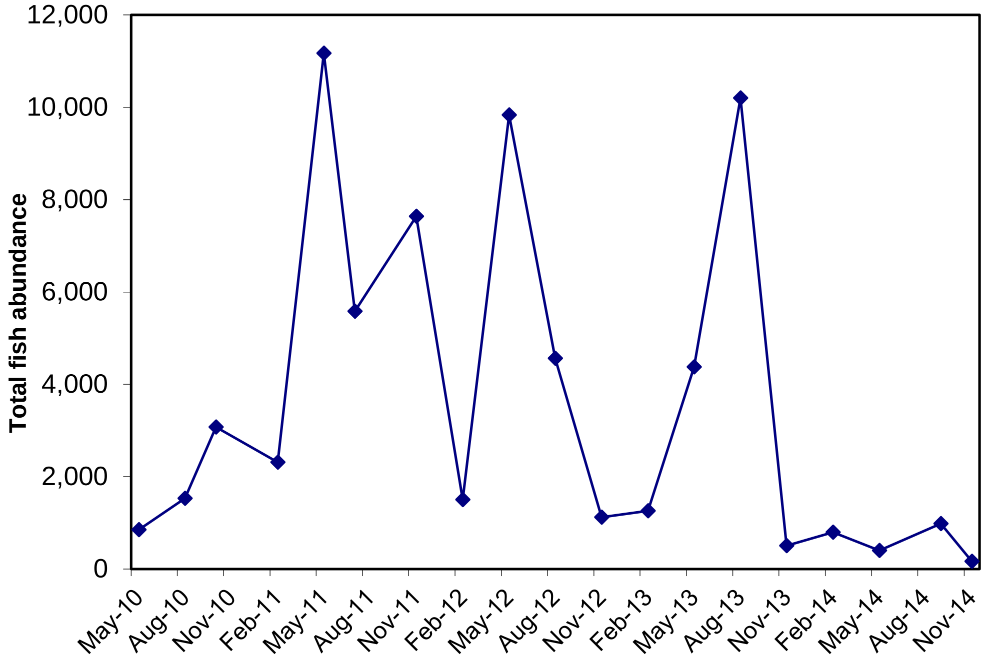

Figure 4.3 : Total numbers of fish caught by beam and otter trawl between spring 2010 and autumn 2014.

Total CPUE values recorded at each site for both beam and otter trawls showed no clear seasonal patterns between 2010 and 2014 (Figure 4.4). Similarly, there was no evident seasonal pattern in CPUE over the survey area as a whole. However, for both trawling techniques CPUE was considerably higher at SF01 (Red Wharf Bay) than at other sites, sometimes by over an order of magnitude. Otter CPUE values were also consistently higher than beam CPUE at all sites during all survey periods, except SF03 (Wylfa Head) in February 2012 when CPUE was low for both trawl types. It is evident that statistical differences between seasons overall are not being driven by a consistent pattern of dominant taxa.

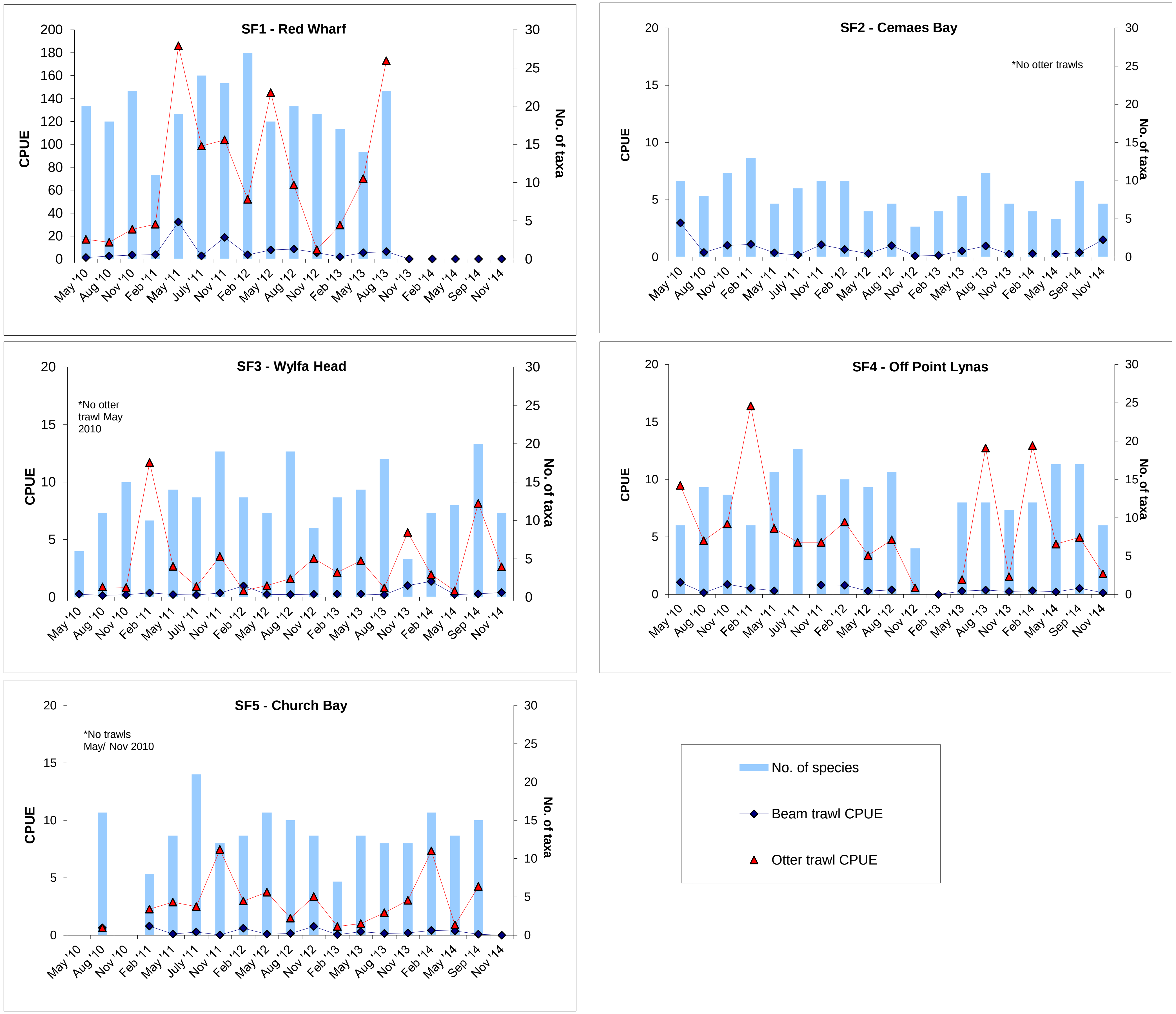

Figure 4.4 : Catch per unit effort (CPUE) for otter (▲) and beam trawls (♦) and the number of taxa recorded (blue bar) at each site between spring (May) 2010 and autumn (Nov) 2014. Note that the CPUE scale is an order of magnitude larger at SF01.

An analysis of the beam and otter trawl data (CPUE) using two-way crossed ANOSIM identified a statistically significant difference in fish assemblage observed between seasons across all sites (beam trawls, Global R = 0.107, p = 0.013; otter trawls, Global R = 0.136, p = 0.001). The low Global R-values however indicated that, despite this, there was considerable overlap in species assemblages observed during each season. MDS plots of the data, showing strong overlapping of all the seasons, provide further evidence of this (Figure 4.5). The stress value of the seasonal MDS plot is not small (0.23), indicating that the two-dimensional ordination could be useful at a high level, but too much reliance should not be placed in the detail of the plot.

The removal of SF01 from the survey programme in 2014 gave a notable reduction in fish abundance. For this reason, a two-way crossed ANOSIM using 'year' and 'site' as factors was carried out on the beam and otter trawl data. No significant difference in catch composition was identified between years (across all sites) (beam trawls, R=0.032, p>0.05; otter trawls, R=0.023, p>0.05). This indicated that the cease in trawling at SF01 did not result in a notably different catch composition over the remainder of the programme.

The CPUE of the six most abundant taxa (whiting, dab, plaice, sprat, lesser-spotted dogfish and herring) did not show clear temporal trends in catch over the survey period (spring 2010 to autumn 2014) (Figure 4.6). However, prior to 2014, plaice, dab and lesser-spotted dogfish all recorded the highest catch in spring, the exception being for dab in 2013 when the highest numbers were recorded in summer. In 2014, the highest catch of plaice was recorded in winter and lesser-spotted dogfish in summer; catches of dab were low across all seasons, although this is likely to be because no samples were obtained from SF01 during this year.

In 2010, 2012 and 2013, the highest CPUE of sprat and herring were seen in the winter/spring. Herring exhibited a similar seasonal pattern, but the abundance of sprat in this year was found to be greatest in the autumn. In 2014, peak abundance of herring and sprat occurred later in the year, in summer and autumn respectively. The maximum catch of whiting in any given year varied considerably, with all seasons except spring recording the highest CPUE in any given sampling year. It is therefore evident that within subtidal fish communities, seasonal shifts in peak abundance, most likely in response to temperature and prey availability cues, occur.

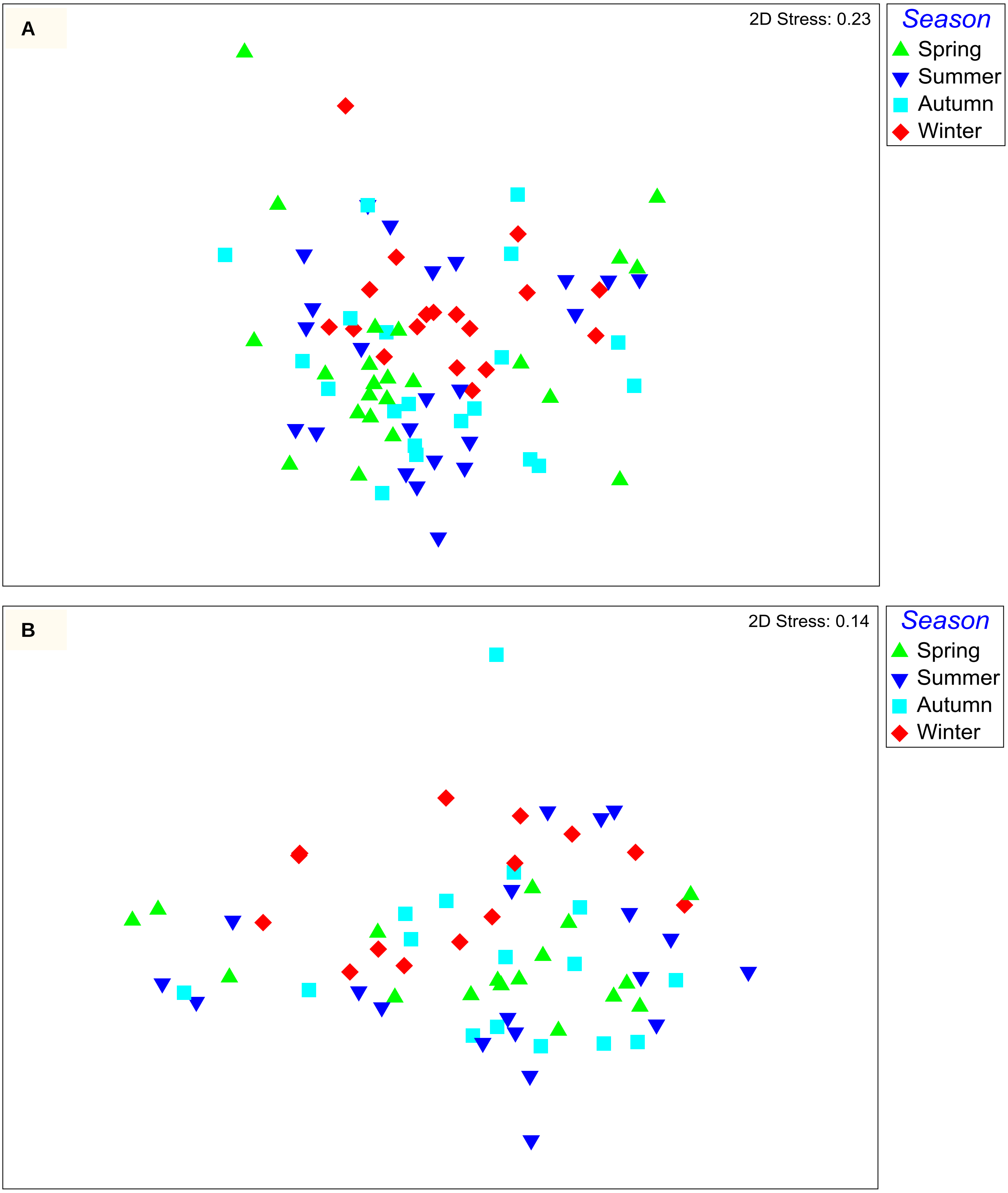

Figure 4.5: Two-dimensional MDS plots for the subtidal fish communities sampled by beam trawl (A) and otter trawl (B), off north Anglesey between spring 2010 and autumn 2014 with seasons as factors. To allow a clear pictorial representation using an MDS plot, two sampling occasions (SF04, summer 2011 and SF04, autumn 2012) were removed from the beam trawl analyses. The absence of any fish caught at these sites during these sampling occasions skewed the data, forcing all other samples together.

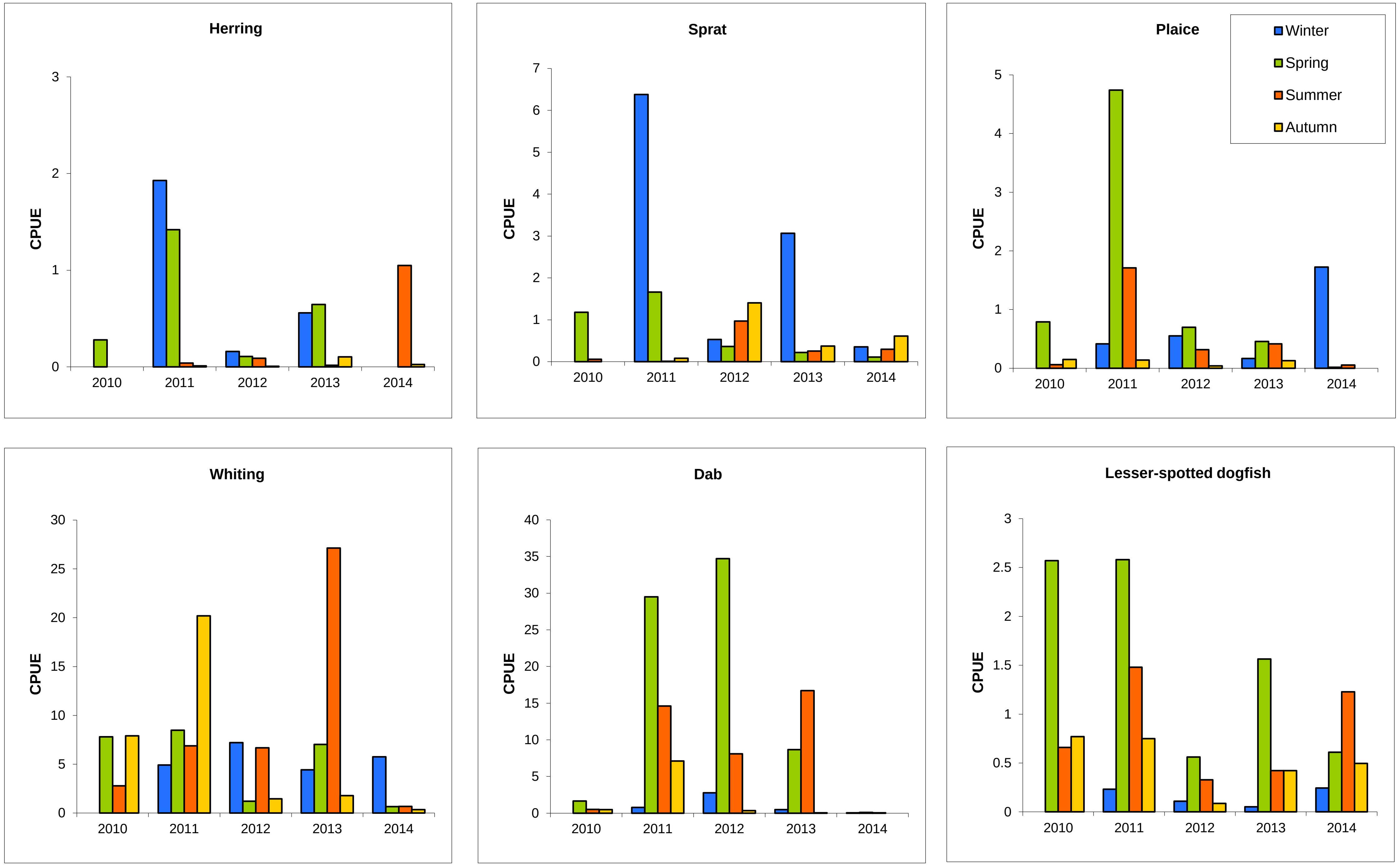

Figure 4.6 : Catch per unit effort (CPUE) of the six most abundant taxa in each sampling season off the north Anglesey coast using otter trawling. Note that whiting and dab have greater y-axis values.

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4.2.4 Spatial variation

A two-way ANOSIM test indicated statistically significant differences in the abundance and community composition of fish recorded in beam trawl catches (CPUE) between sites (across all seasons) (Global R = 0.300, p = 0.001). Otter trawl catches exhibited a similar result (Global R = 0.519, p = 0.001), although the higher Global-R value suggests a greater degree of spatial separation.

Pairwise comparisons from beam and otter trawls showed that overall statistical differences were primarily driven by differences between site SF01 (Red Wharf Bay) and all other sites (Table 4.2). This is highlighted by the MDS plots (Figure 4.7A and Figure 4.7B), which showed clustering of SF01 to one side of the plot and some overlapping between the other sites. Pairwise comparisons from the otter trawls also showed reasonable differences between the SF04 community and each of SF03 (off Wylfa Head) and SF05 (The Skerries in Church Bay) (Table 4.2), whilst a strong similarity (differences not statistically significant at p = 0.05) was apparent between the community at SF03 and SF05. In contrast, small statistically significant differences were observed between beam trawl data from sites SF03 and SF05 as well as SF04 and SF05.

Table 4.2 : ANOSIM pairwise comparisons between CPUE data for beam and otter trawls at each site. R values and p (significance) are shown. No otter trawling was carried out at SF02. Statistically significant results at p<0.05 are marked with **.

Site comparison	Beam		Otter	
	R-value	Significance, p	R-value	Significance, p
SF01, SF02	0.752	0.001**	-	-
SF01, SF03	0.741	0.001**	0.773	0.001**
SF01, SF04	0.546	0.001**	0.783	0.001**
SF01, SF05	0.698	0.001**	0.847	0.001**
SF02, SF03	0.079	0.15	-	-
SF02, SF04	0.012	0.42	-	-
SF02, SF05	0.152	0.06	-	-
SF03, SF04	-0.004	0.49	0.372	0.003**
SF03, SF05	0.188	0.02**	0.075	0.21
SF04, SF05	0.191	0.02**	0.541	0.001**

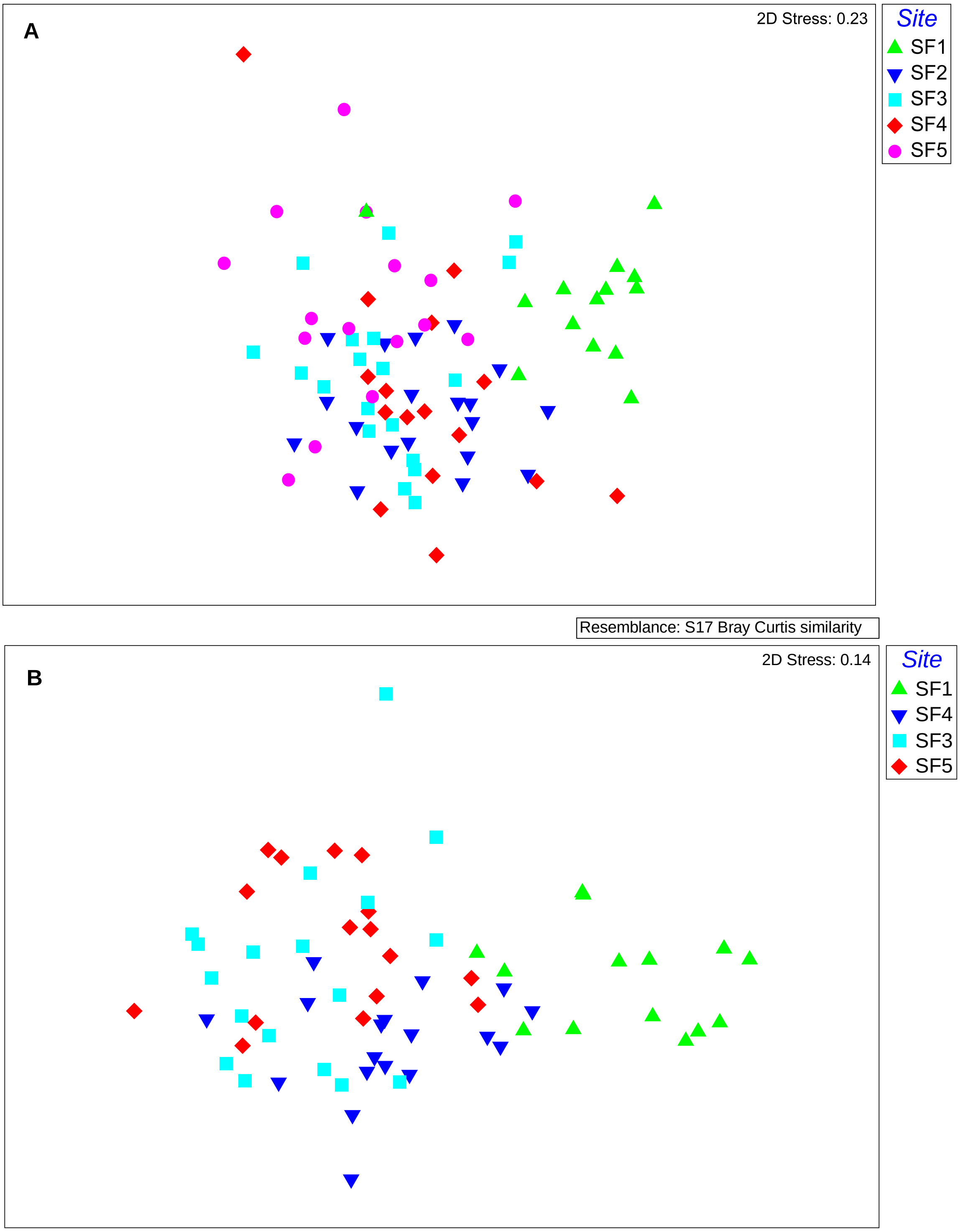


Figure 4.7 : Two-dimensional MDS plots for the subtidal fish communities sampled by beam trawl (A) and otter trawl (B) off north Anglesey between spring 2010 and autumn 2014 with sites as factors.

Beam and otter trawl data for each site underwent SIMPER analysis (see Appendix B) to identify those species which characterised the communities at each site, and also to determine those species which caused the differences described above.

A two-way SIMPER analysis of beam trawl data showed that differences between site SF01 and all other sites were driven by a higher abundance of dab, whiting, common dragonet and plaice but a lower abundance of poor cod at SF01. Cumulatively, these taxa accounted for between 79% and 80% of dissimilarity between these sites. Differences between SF03 off Wylfa Head and SF05 to the west in Church Bay were driven by a higher abundance of whiting, poor cod and lesser-spotted dogfish at SF03 but a lower abundance of sandeel, dab and plaice. Cumulatively, these taxa accounted for 59% of the dissimilarity between beam trawl catches at these two sites. The lower abundance of poor cod, common dragonet and dab at site SF05 compared to SF04 accounted for 37% of the dissimilarity between these two sites, with the higher abundance of whiting at SF05 contributing a further 13%.

As might be expected, whiting featured more heavily in otter trawls compared to the beam trawls. The higher abundances of whiting, dab and sprat observed at SF01 in Red Wharf Bay were responsible for driving statistical differences, accounting for up to 87% of dissimilarity between this and all other sites. Differences between SF04 and each of SF03 and SF05 were driven by a higher abundance of whiting, poor cod and lesser-spotted dogfish but a lower abundance of sprat at site SF04. Cumulatively, these taxa accounted for 75% and 76% of dissimilarity between SF04 and each of SF03 and SF05, respectively.

4.2.5 Dominant species

4.2.5.1 Dab

Throughout the study period, dab represented approximately 47% of all fish caught in terms of abundance, with a total of 31,622 individuals recorded. More than 75% of the dab caught were from otter trawling, and almost 99% recorded from SF01 in Red Wharf Bay.

Analysis of the CPUE data demonstrated the strong contribution of otter trawling to dab recorded (Figure 4.8). The influence of SF01 on dab catch is highlighted by the plots, the absence of any notable catch in 2014 being linked to the absence of trawling at this site.

From the length-frequency data for dab, SF01 showed two clear cohorts in spring, this being also observed at SF05 farthest east, although a much smaller cohort was observed at the latter site (Figure 4.9). Although many more dab were caught at SF01 than the other sites, these were rarely below 50 mm, in contrast to the other sites which recorded a much greater percentage of dab below 50 mm in length, particularly SF05. The paucity of numbers recorded from the remaining sites did not provide reliable conclusions on cohort presence of dab.

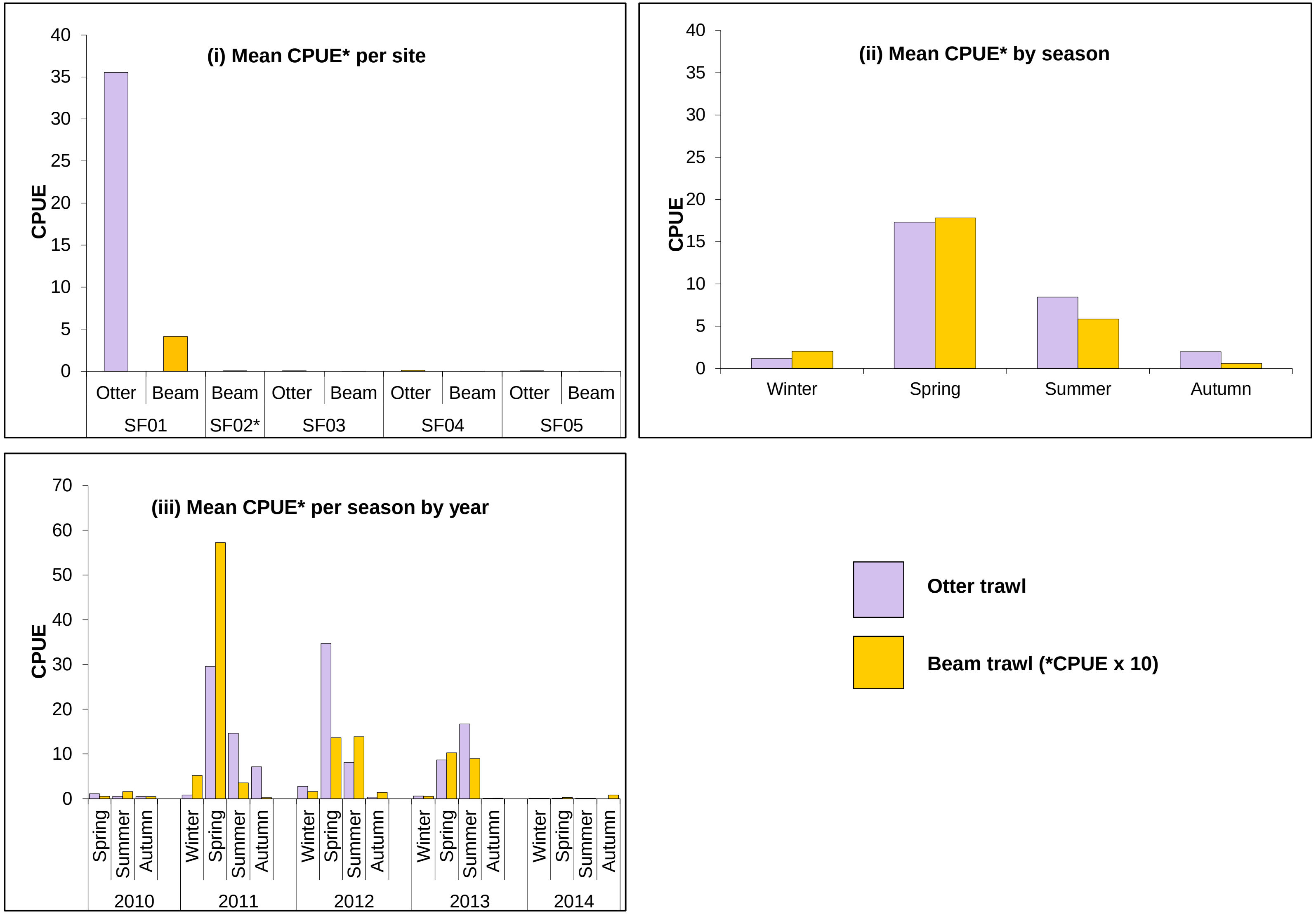


Figure 4.8 : Mean CPUE of dab from spring 2010 to autumn 2014: i) at different sampling sites, ii) in different seasons and iii) in different seasons and years. * Note beam trawl CPUE is x 10. Note that no sampling was carried out at SF01, one of the most productive sites for dab, in 2014.

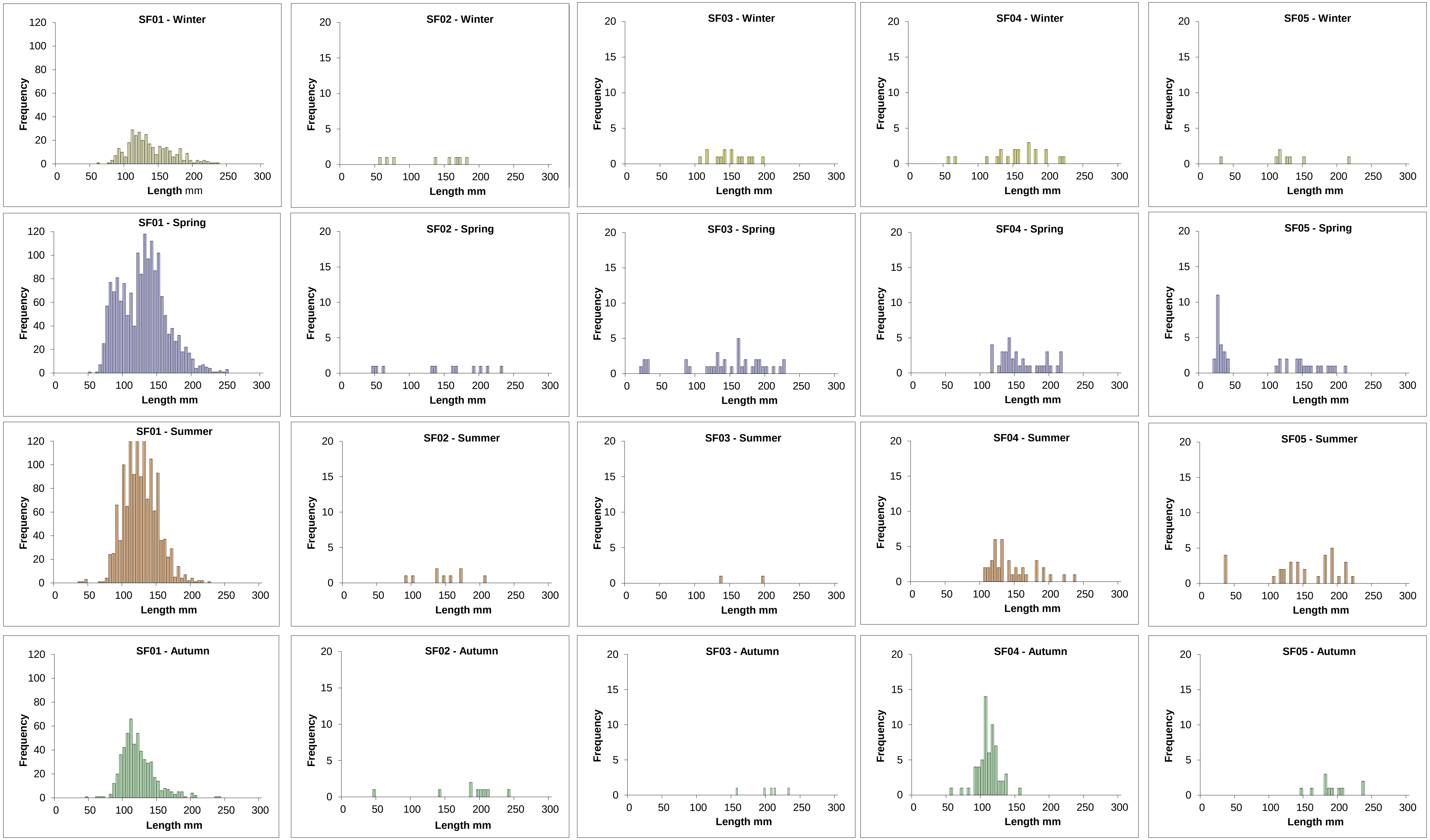


Figure 4.9 : Length-frequency for dab caught at each site pooled over the study period (spring 2010 to autumn 2014). The y-axes values differ for SF01 to accommodate the consistently greater catches.

4.2.5.2 Whiting

Throughout the study period, whiting represented 33% of all fish caught with a total of 22,518 individuals recorded; approximately 95% of these from otter trawls. Prior to 2014, the majority (>88%) of all whiting caught in the otter trawls were from SF01 while for beam trawls, >75% of all whiting were taken at SF01; these patterns being reflected in the CPUE for both trawl methods (Figure 4.10).

Seasonal patterns in whiting showed a large variation in catch, year-on-year. The highest mean CPUE for any one season was recorded in summer 2013 and, overall, the summer sampling periods recorded the highest mean CPUE. Unlike the otter trawling, the mean CPUE for the beam trawling was highest during the winter sampling. In 2014, the winter sampling data was generally comparable with previous years, yet the remainder of 2014 showed considerably lower values for otter trawls, specifically, but also, to a lesser extent, for beam trawls, when compared to the seasons of previous years. This is however, again likely to be because no sampling was carried out at SF01 in 2014.

Length-frequency data for whiting showed two cohorts in summer and autumn at SF01 in Red Wharf Bay (Figure 4.11). The scarcity of whiting caught at SF02 in Cemaes Bay (not graphically presented) and, to a lesser extent, SF03 off Wylfa Head precluded suitable length-frequency analysis; however, two cohorts can be seen in autumn at SF03 and, like SF05, some recruitment of juveniles was observed in spring and summer. In 2014, the highest whiting CPUE was recorded at SF04 off point Lynas; a similar number of cohorts in each season was seen at this site compared to SF01, though these were over a greater size range. Similarities between SF04 and SF01 are unsurprising given their proximity to one another on the north-east coast of Anglesey.

Between the sites, there was a discernible difference in length range of whiting: almost all individuals measured at SF01 were in the size range 50 - 250 mm, whereas many whiting were over 250 mm at both SF04 to the north and SF05, with some also below 50 mm at the latter site.

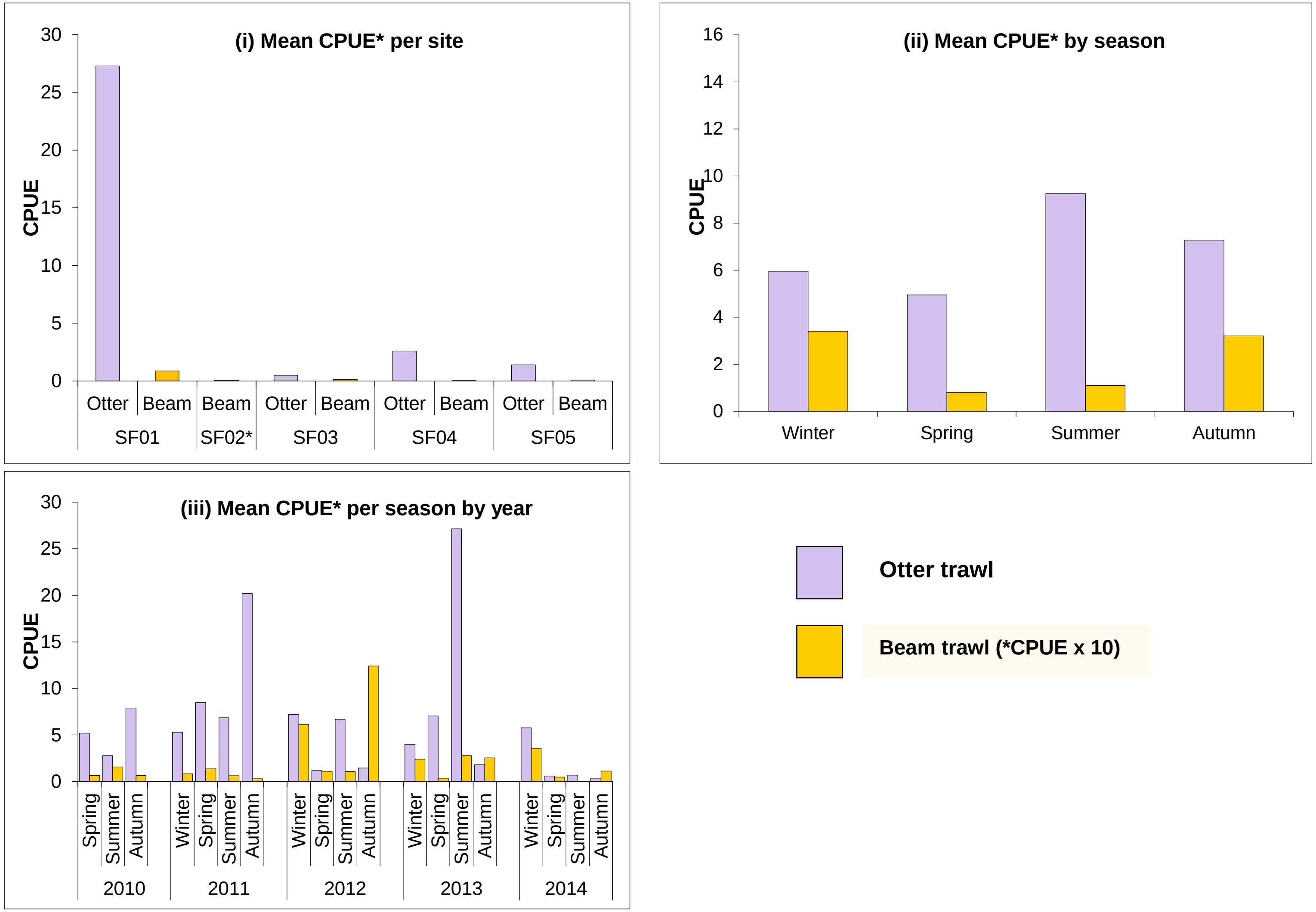


Figure 4.10 : Mean CPUE of fish caught off the north Anglesey coast from spring 2010 to autumn 2014: i) per site, ii) by season and iii) per season by year. * Note beam trawl CPUE is x 10. Note that no sampling was carried out at SF01, one of the most productive sites for whiting, in 2014.

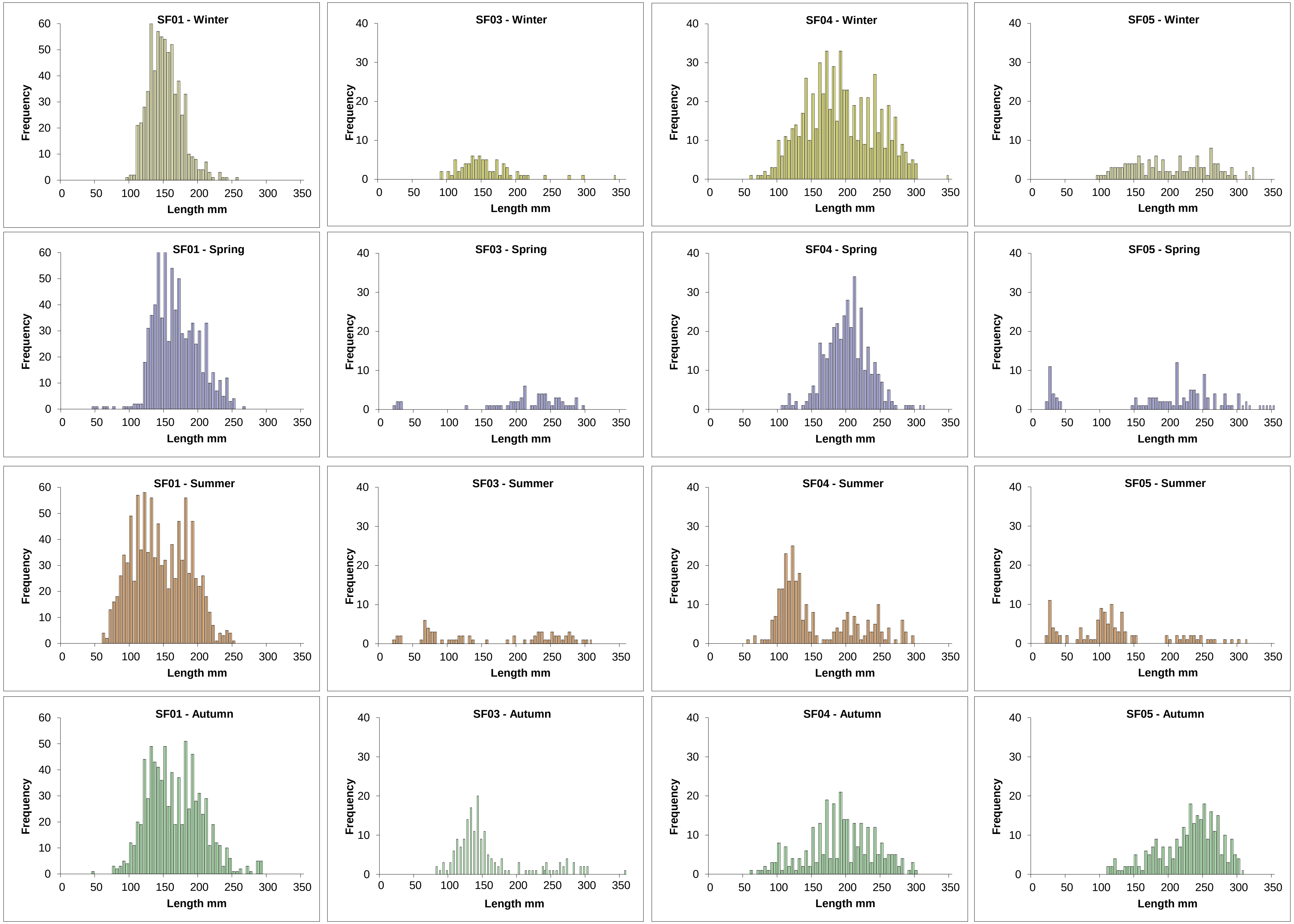


Figure 4.11 : Length-frequency for whiting caught at each site pooled over the study period (spring 2010 to autumn 2014). The y-axis values differ for SF01 to accommodate the consistently greater catches.

4.2.6 Feeding guild

Over the survey programme, benthic feeders largely dominated the catch from the beam trawl with values often exceeding 60% of the total catch (Figure 4.12). However, in autumn 2012 and 2013 along with winter 2013 and 2014, the proportion of piscivorous species was greater, this as a result of the high abundance of whiting.

Species such as dab, poor cod, common dragonet, pogge (*Agonus cataphractus*) and bib (*Trisopterus luscus*), contributed heavily to the beam catch; all are benthic feeders (see Figure 4.12). Zooplankton feeders such as sprat and sandeel consistently represented less than 10% of the feeding community from beam trawl catches.

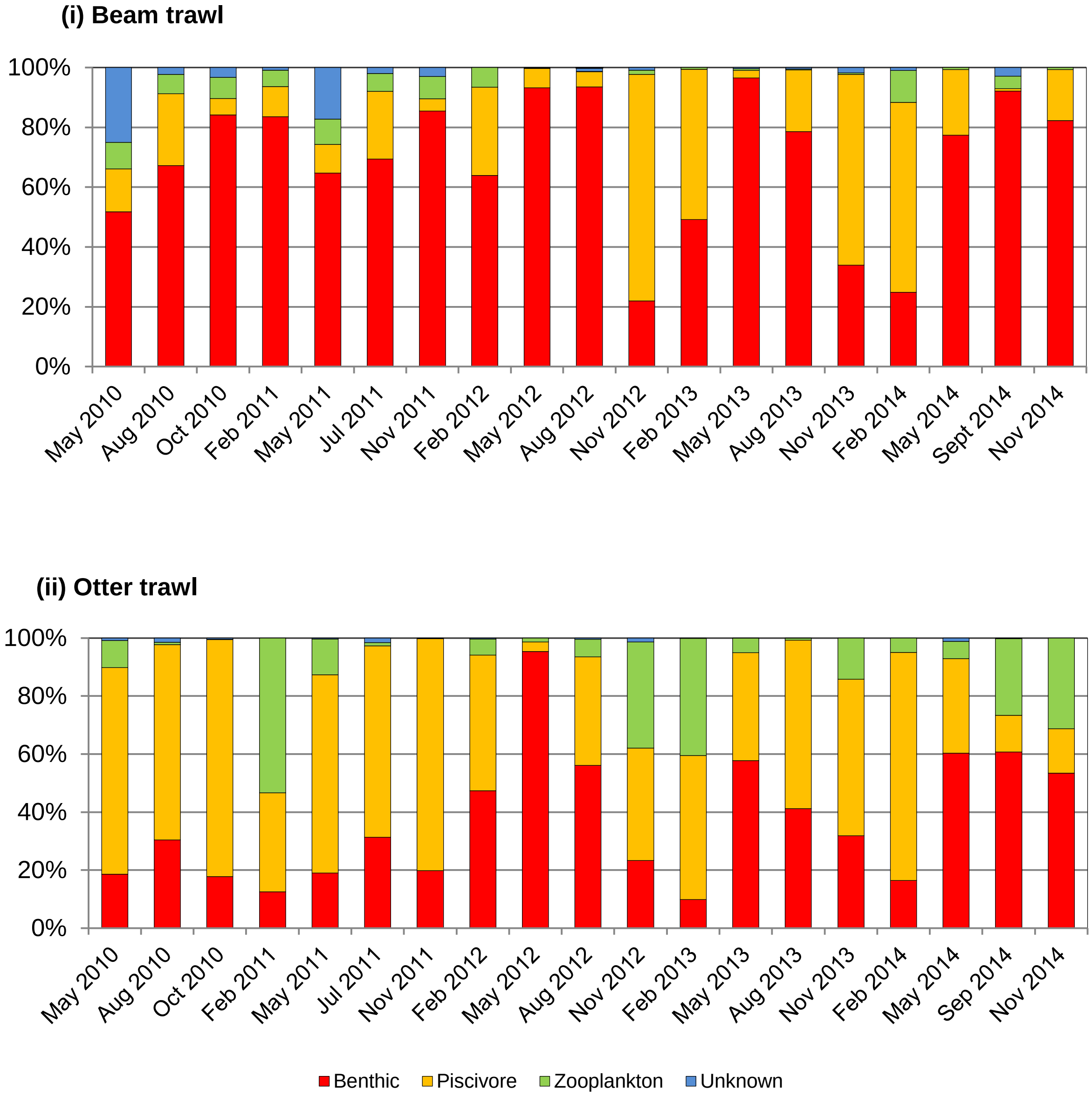


Figure 4.12 : Seasonal feeding guild composition of fish caught during beam (i) and otter (ii) trawling off the north Anglesey coast from spring 2010 to autumn 2014. See Appendix E for details on guilds.

Throughout most of 2010 and 2011, piscivores was the dominant feeding guild in otter trawl catches, with dominance primarily related to numbers of whiting. However, in winter 2011 zooplankton feeders, primarily sprat, made up the dominant feeding guild. These zooplankton feeders also made up a noticeable proportion of the catch in November 2012 and February 2013, and were the second most dominant guild after benthic feeders, in summer and autumn 2014. During 2012, 2013 and 2014, benthic feeders generally represented a higher proportion of catches than was recorded in the previous two years (Figure 4.12), a pattern evidently driven by the numbers of dab caught. However, in 2014 the benthic feeders caught were largely composed of poor cod, plaice and lesser-spotted dogfish.

During the study period, no consistent seasonal pattern was evident in the feeding guild proportions in either beam or otter trawl catches.

4.2.7 Shellfish

A number of shellfish species were recorded in beam trawls including queen scallop (*Aequipecten opercularis*), king scallop (*Pecten maximus*), prawns (*Palaemon serratus*), shrimps (all other superfamilies within the infraorder Caridea), edible crabs (*Cancer pagurus*), 'other crab species' and whelks (Figure 4.13). Shellfish were not specifically targeted by trawling and therefore the following data should be considered semi-quantitative, providing an indication of spatial patterns of abundance.

Overall, shrimp was the most abundant shellfish caught during subtidal beam trawl surveys, with 4,734 individuals recorded from beam trawls between April 2010 and November 2014. This was followed by 'other crabs' (n = 649), queen scallop (n = 459), prawns (n = 144) and whelk (n = 117). Comparatively few edible crab (n = 41) and king scallops (n = 7) were recorded during the survey programme.

Shellfish CPUE per 100 m^2 at each of the five sampling sites is presented in Figure 4.13. The highest CPUE of shrimp (1.15 per 100 m^2) was recorded at site SF03, located offshore, north-west of Wylfa Head. Comparatively high catches were reported at the sites further east (0.72 – 0.99 per 100 m^2) whilst the lowest CPUE was recorded at site SF05, located 10 km to the south of The Skerries in Church Bay. The majority of queen scallops sampled were taken from SF04 located 5 km to the north-east of Point Lynas; CPUE at all other sites was low (≤0.02 per 100 m^2). King scallops were only recorded at site SF01 and SF02 located to the east of the Wylfa Newydd Development Area, albeit in low abundances (CPUE<0.01 per 100 m^2).

Edible crab was recorded at all sites, with the highest CPUE recorded at SF03 (0.01 per 100 m^2). Other crab species were recorded in higher abundances with the highest CPUE value of 0.02 per 100 m^2 recorded at both SF01 and SF02. The highest CPUE for whelk was recorded at SF01 (0.07 per 100 m^2). Wider abundances of crab are likely to be higher than those indicated from the survey results owing to their preference for rocky habitats, which are not targeted by beam trawling.

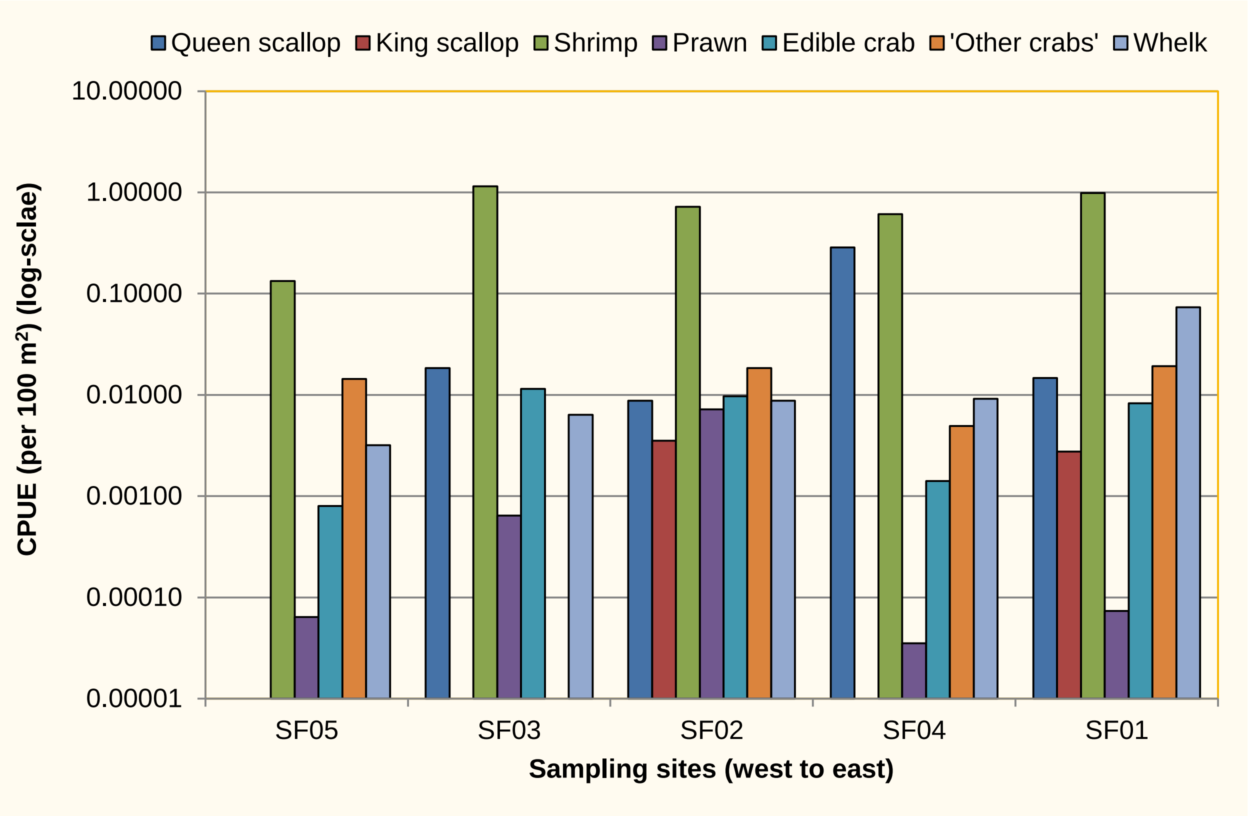


Figure 4.13 : Average CPUE (per 100m²) of seven invertebrate taxa recorded in beam trawl samples at five sites between April 2010 and November 2014. Note the y-axis is on a log-scale.

4.2.8 Species of conservation and commercial importance

Several species were recorded in the trawls that are represented on the Section 7 list of principal importance in Wales under the *Environment (Wales) Act 2016*. These species were spurdog (*Squalus acanthias*), tope (*Galeorhinus galeus*), cod, whiting, Dover sole, plaice, herring, scad/horse mackerel (*Trachurus trachurus*), mackerel, anglerfish (*Lophius piscatorius*), Raitt's sandeel, blonde ray (*Raja brachyura*) and the thornback ray (*Raja clavata*). Many of these were recorded infrequently; however, throughout the programme whiting and, to a lesser degree, plaice and herring made up a regular and notable proportion of the catch.

Of the elasmobranchs, by far the most commonly caught of those species listed on Section 7 were thornback rays, these being recorded from every survey period except autumn 2013, although in reasonably low abundances.

The UK Biodiversity Action Plan 'UK BAP Grouped Commercial Plan' features species of national commercial importance, and although mackerel and Dover sole are both listed, only cod, whiting, herring and plaice were caught in any reasonable numbers over the survey programme, whiting being by far the most numerous. No clear patterns in catch were seen for the gadoids (cod and whiting); however, the CPUE of herring was notably greater in winter and spring, whilst plaice consistently recorded the highest annual catch during the spring (Figure 4.6)

As demonstrated in Section 4.2.7, the highest abundances of commercial shellfish including scallop and, to a lesser extent, whelk were observed to the north-east of the Wylfa Newydd Development Area (SF01 and SF04). The only shellfish species of conservation importance (listed under Section 7) recorded during the subtidal sampling programme was native oyster, *Ostrea edulis.* Only 12 individuals were recorded between 2010 and 2014, occurring at sites to the north (SF02 and SF03) and north-east (SF04) of the Wylfa Newydd Development Area.

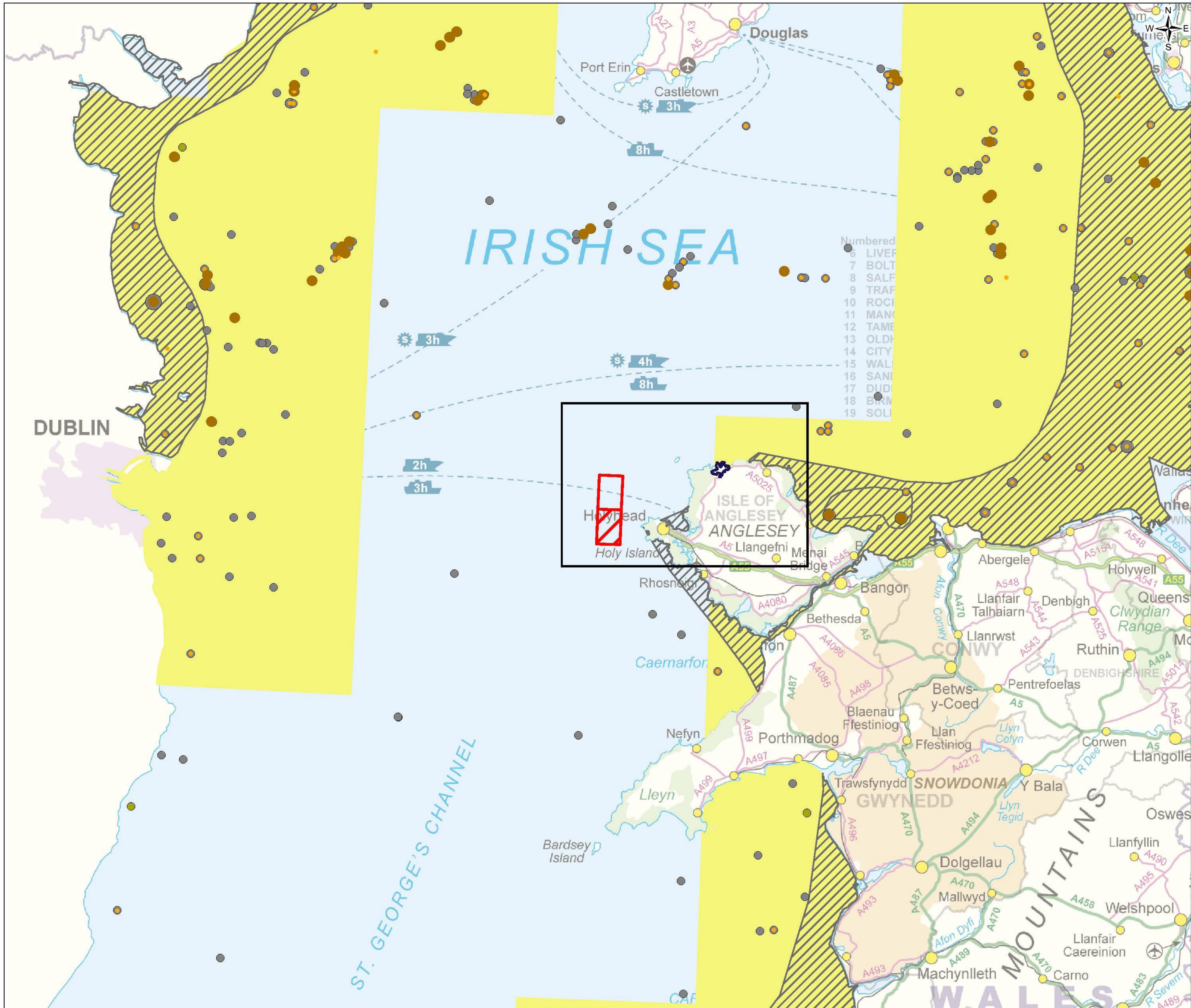
4.3 Comparison to Published Literature

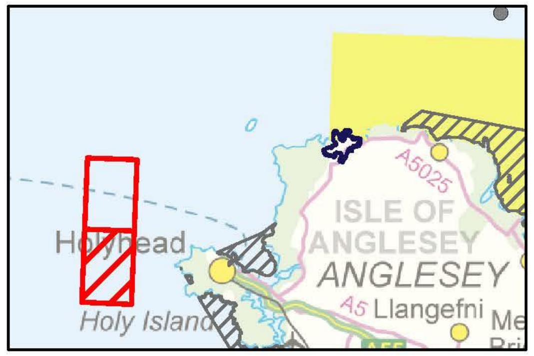
4.3.1 Distribution of inshore nursery areas, Ellis *et al*. (2012)

Ellis *et al*. (2012) provide a spatial description of the nursery grounds around the UK for species of commercial and/or conservation importance including cod, Dover sole, whiting, plaice, herring and sandeel. Of the species examined, all except herring are known to use inshore areas around North Anglesey as nursery grounds, although for sandeel and plaice, this area and the wider eastern Irish Sea is only classified as a low intensity nursery (Ellis *et al*. (2012). Inshore areas around north Anglesey and the south-eastern Irish Sea are, however, classified as a high intensity nursery area for whiting and Dover sole according to Ellis *et al*. (2012). These figures have been discussed in further detail within the subsequent section.

Figure 4.14 to Figure 4.17 outlines the location of nursery grounds for plaice, herring, whiting and Dover sole.

FIGURE 4-14





Legend

- Wylfa Newydd Development Area
- Holyhead Deep North (The Disposal Site)
- Holyhead Deep South
- Plaice nursery grounds 1998
- Plaice nursery grounds 2010: high intensity
- Plaice nursery grounds 2010: low intensity

Presence

- Presence in 1 or more tows at each station
- Present in over 50% of tows at each station
- Present in over 70% of tows at each station

Maximum catch rate

- 0 - 70.9
- 71.0 - 234.9
- 235.0 - 588.9
- 589.0 - 1166.9
- 1167.0 - 3533

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	AUG 17	Initial Issue	RM	HY	EC	RB

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

NURSERY GROUNDS OF PLAICE IN THE IRISH SEA

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Client No.		

Drawing No.

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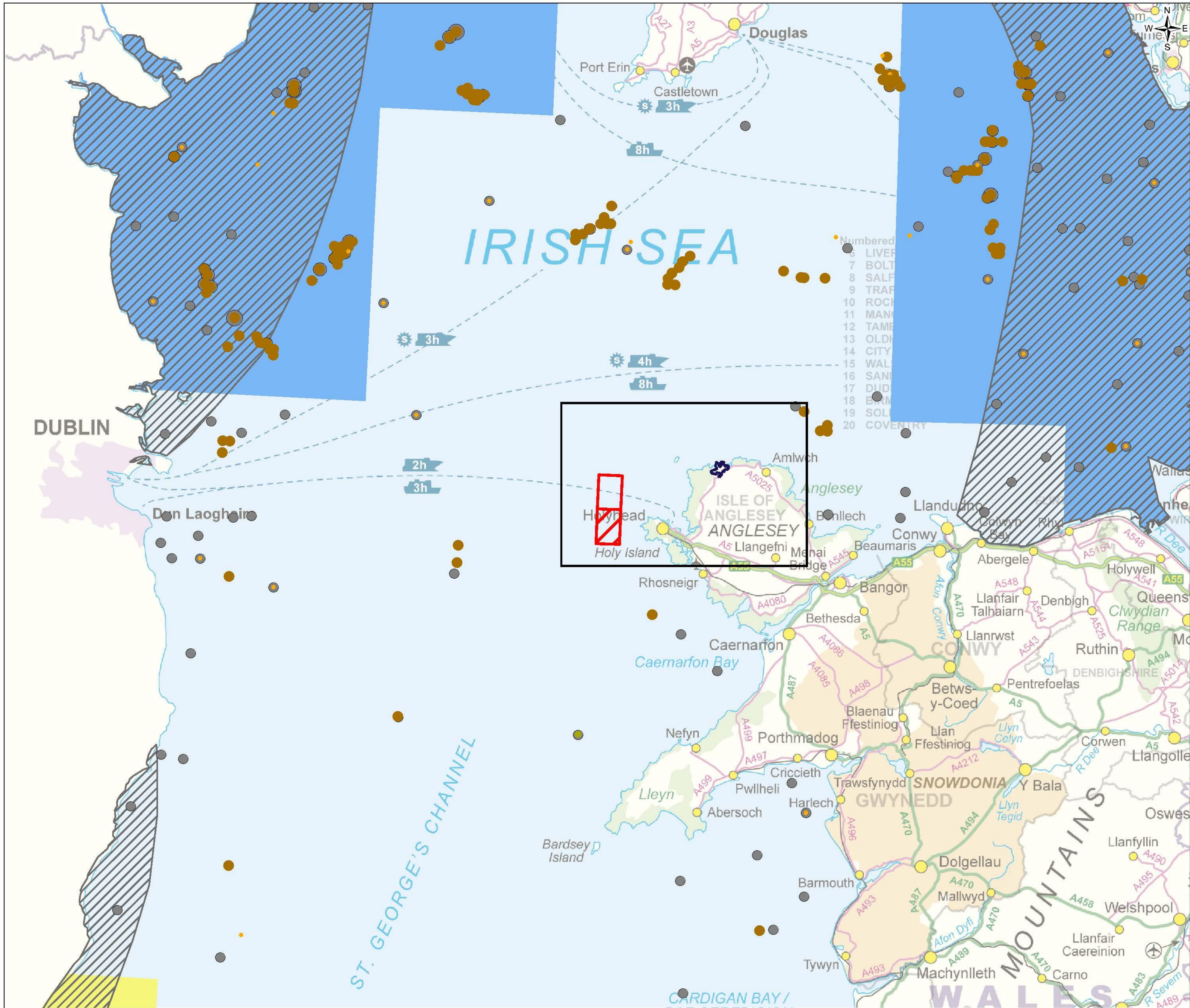

FIGURE 4-15

Legend

- Wylfa Newydd Development Area
- Holyhead Deep North (The Disposal Site)
- Holyhead Deep South
- Herring nursery grounds 1998
- Herring nursery grounds 2010: high intensity
- Herring nursery grounds 2010: low intensity

Presence

- Presence in 1 or more tows at each station
- Present in over 50% of tows at each station
- Present in over 70% of tows at each station

Maximum Catch Rate

- 0 - 18138.9
- 18139.0 - 48984.9
- 48985.0 - 105838.9
- 105839.0 - 241090.9
- 241091.0 - 503868.9

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	AUG 17	Initial Issue	RM	HY	EC	RB

Client: HORIZON NUCLEAR POWER

Project: WYLFA NEWYDD PROJECT ENVIRONMENTAL STATEMENT

Drawing Title: NURSERY GROUNDS OF HERRING IN THE IRISH SEA

Scale @ A3	1:700,000	DO NOT SCALE
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Client No.		
Drawing No.	60PO8077_DCO_APP_4_15	

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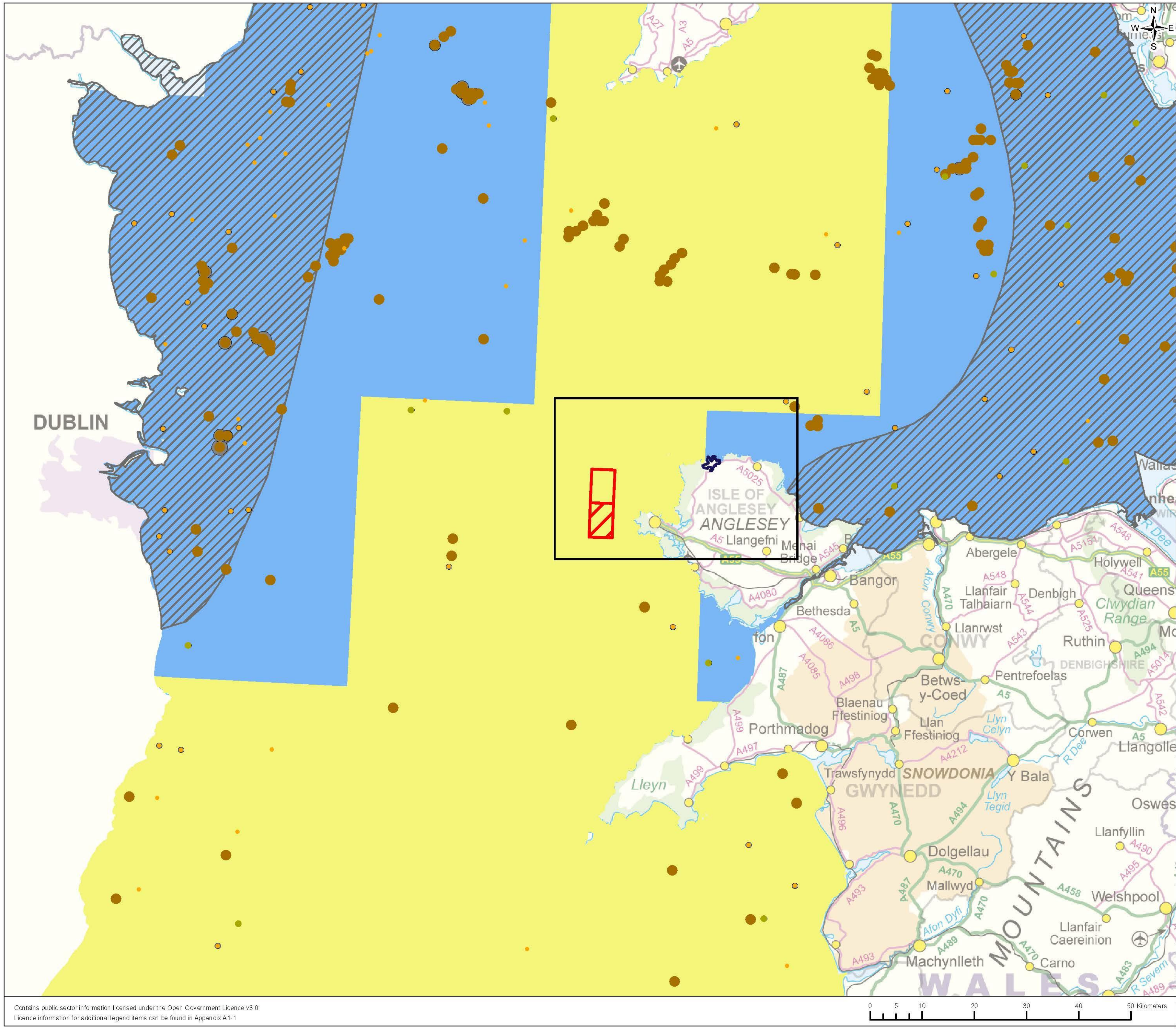
0 5 10 20 30 40 50 Kilometers

FIGURE 4-16



Legend

- Wylfa Newydd Development Area
- Holyhead Deep North (The Disposal Site)
- Holyhead Deep South
- Whiting nusery grounds 1998
- Whiting nursery grounds 2010: high intensity
- Whiting nursery grounds 2010: low intensity

Presence

- Presence in 1 or more tows at each station
- Present in over 50% of tows at each station
- Present in over 70% of tows at each station

Maximum catch rate

- 2.0 - 26936.9
- 26937.0 - 81347.9
- 81348.0- 164816.9
- 164817.0 - 428918.9
- 428919.0 - 849495.0

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	AUG 17	Initial Issue	RM	HY	EC	RB

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

NURSERY GROUNDS OF WHITING IN THE IRISH SEA

Scale @ A3	1:700,000	DO NOT SCALE
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Client No.		
Drawing No.	60PO8077_DCO_APP_4_16	

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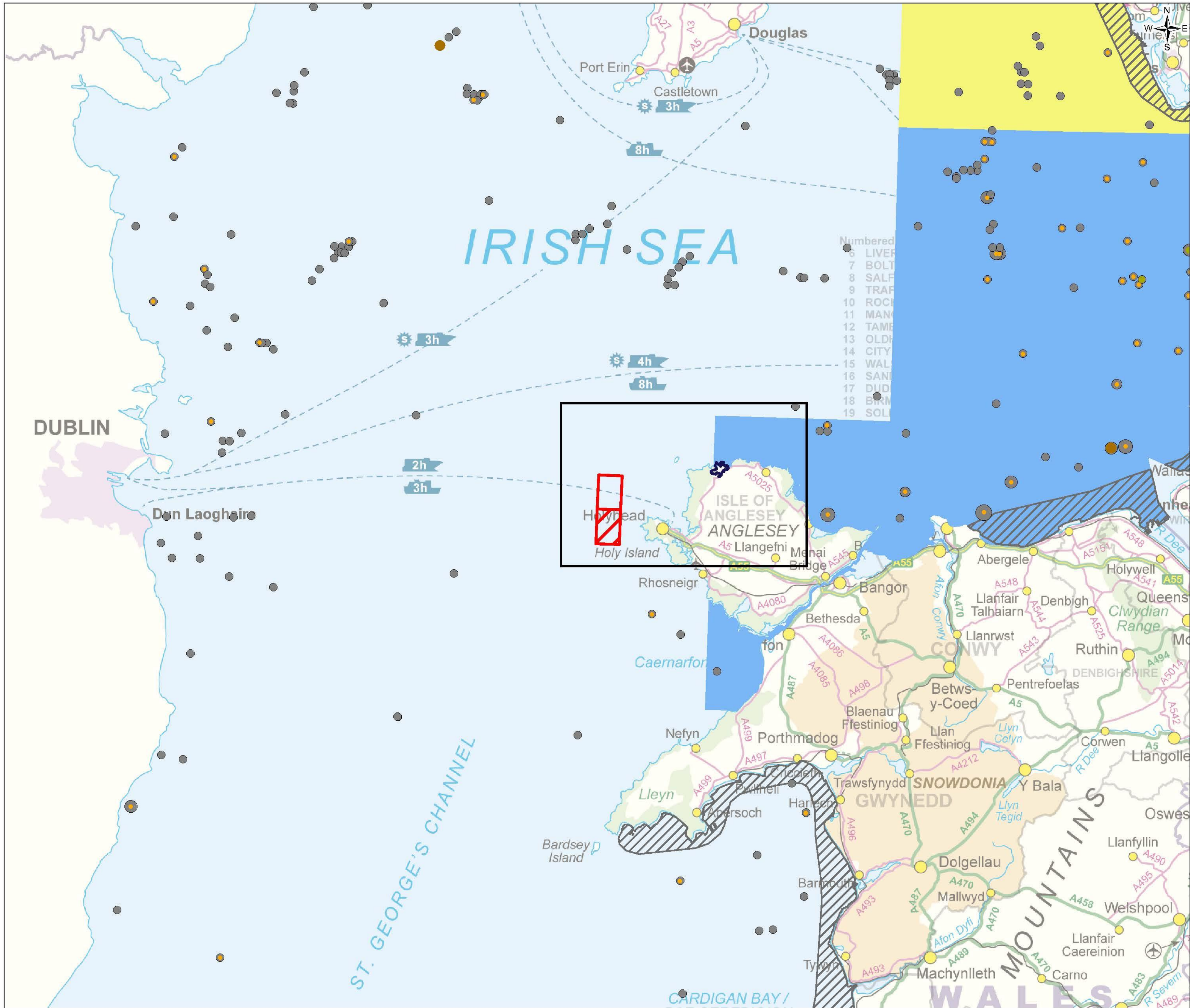
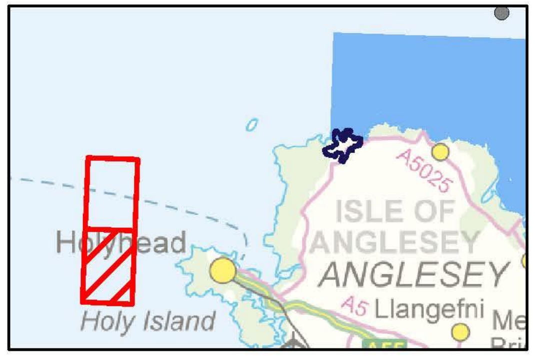
FIGURE 4-17





Legend

- Wylfa Newydd Development Area
- Holyhead Deep North (The Disposal Site)
- Holyhead Deep South
- Sole nursery grounds 1998
- Sole nursery grounds 2010: high intensity
- Sole nursery grounds 2010: low intensity

Presence

- Presence in 1 or more tows at each station
- Present in over 50% of tows at each station
- Present in over 70% of tows at each station

Maximum catch rate

- 0 - 14.9
- 15.0 - 40.9
- 41.0 - 106.9
- 107.0- 230.9
- 231.0 - 462.0

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	AUG 17	Initial Issue	RM	HY	EC	RB

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

NURSERY GROUNDS OF DOVER SOLE IN THE IRISH SEA

Scale @ A3	1:700,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		
Drawing No.	60PO8077_DCO_APP_4_17	

4.3.2 Irish Sea beam and otter trawl data, Centre for Environment, Fisheries and Aquaculture Science (Cefas) (Parker-Humphreys, 2004; Armstrong *et al*., 2013)

A number of survey programmes have been undertaken in the Irish Sea to assess the abundance and species composition of pelagic and demersal fish communities, the results of which have been published. This information can be used in conjunction with results derived from subtidal surveys reported in Section 4.2.1 to further characterise subtidal fish communities around the north coast of Anglesey and within the wider sea area.

Between 1993 and 2001, Cefas carried out beam trawling in the Irish Sea (ICES division VIIa) (Parker-Humphreys, 2004). Amongst the sites surveyed, three were in proximity of Anglesey: one south of Holy Island, one north of Red Wharf Bay and one off Point Lynas. Annual roundfish surveys using a combination of semi-pelagic trawling or otter trawling were also carried out between 2004 and 2010 as part of a collaborative project between the fishing industry and Cefas (Armstrong *et al*., 2013).

Parker-Humphreys (2004) recorded more than 100 species of marine fish across the Irish Sea between 1993 and 2001 whilst Armstrong *et al*. (2013) identified 56 species. The species that contributed to the top 90% of all fish sampled during each study are presented in Table 4.3 and Table 4.4. Comparative results from the subtidal surveys carried out by Jacobs between April 2010 and November 2014 have also been presented.

Table 4.3 : A comparison between the dominant demersal fish species sampled (in terms of percentage contribution to overall abundance) by Parker-Humphreys (2004) in the Irish Sea between 1993 and 2001 and the results of Jacobs subtidal fish surveys (beam trawls) carried out between 2010 and 2014. Only those species which contributed to 90% of the overall abundance of fish sampled are presented.

Parker-Humphreys (2004)- Irish Sea		Jacobs beam trawl surveys- north coast of Anglesey	
Species	**Percentage contribution to total abundance**	**Species**	**Percentage contribution to total abundance**
Dab	28.0%	Dab	62.2%
Plaice	16.6%	Whiting	10.3%
Solenette	11.7%	Poor cod	5.1%
Common dragonet	7.6%	Common dragonet	4.9%
Poor cod	7.0%	Plaice	4.4%
Whiting	4.4%	Lesser-spotted dogfish	3.0%
Dover sole	4.3%	Pogge	1.3%
Grey gurnard	3.0%	Sand goby	1.0%

Parker Humphreys (2004) found dab and plaice to be the most numerically dominant demersal fish species in the Irish Sea representing 28.0% and 16.6% of all fish sampled between 1993 and 2001, respectively (Table 4.3). Catches of both species were confined to coastal waters along the east coast of Ireland and within the eastern Irish Sea (Parker-Humphreys, 2004). The results of beam trawl surveys along the north coast of Anglesey between 2010 and 2014 were consistent with the findings of Parker-Humphreys (2004); the higher percentage contribution of dab (62.2%) at SF01 being indicative of known nursery grounds located in Red Wharf Bay within the vicinity of this site. The highest catches of plaice overall were also observed at SF01 although the lower percentage contribution of this species (4.4%) suggests that juvenile and adult plaice are not utilising coastal waters around the north coast of Anglesey in any significant abundance compared to populations elsewhere.

Dab are largely absent from the central Irish Sea and plaice has only been recorded in low abundances between 1993 and 2001 (<50 fish per site) (Parker-Humphreys, 2004). Consideration of this and the comparatively low catches of dab and plaice at sites located westwards of Red Wharf Bay suggest that these species are unlikely to form an important component of demersal fish assemblages within the vicinity of the Disposal Site.

Within the wider Irish Sea, plaice and dab have also been found to dominate otter trawl catches, contributing 33.4% and 19.8% to the total abundance recorded (Armstrong *et al*., 2013). This demonstrates the importance of the wider Irish Sea for these two species. Comparative catches of these two species during Jacobs surveys mirror patterns observed from beam trawling (Table 4.3 and Table 4.4), the explanation of which also remains consistent.

The relative contribution to overall abundance of common dragonet and poor cod was reasonably consistent across the two studies (Table 4.3). Poor cod are widely distributed throughout the central Irish Sea with common dragonet abundant in the eastern Irish Sea and in coastal waters around north Wales (Parker-Humphreys, 2004). Consequently, both species are likely to be key components of demersal fish assemblages within the vicinity of the Disposal Site.

The contribution of whiting to total beam trawl catches along the north coast of Anglesey was over double that reported by Parker-Humphreys (2004) (Table 4.3). Whiting are present throughout the Irish Sea, being particularly abundant in coastal waters known to be high intensity nursery grounds off the east coast of Ireland and in the eastern Irish Sea (Ellis *et al*., 2012). The results of the beam trawling sampling programme carried out around the north coast of Anglesey between 2010 and 2014 (described in more detail in Section 4.2.4) confirmed the importance of this area as a nursery ground for whiting. However, the low catches reported at SF02 (and in otter trawls at SF03), suggests that inshore waters within the vicinity of Wylfa Newydd Development Area are less important than areas farther east and west. Nursery grounds for whiting are known to extend offshore to water depths of up to 460 m (Ellis *et al*., 2012). Owing to the proximity of the Disposal Site to known nursery grounds, it is likely that whiting is a common component of demersal fish assemblages within this area.

As expected, whiting was recorded in much higher abundances in otter trawls (Table 4.4) compared with beam trawling (Table 4.3). Whiting were found to be particularly dominant inshore around the north coast of Anglesey (as determined by Jacobs otter trawl surveys) compared to populations within the wider Irish Sea.

The remaining demersal species known to dominate beam trawl catches within the Irish Sea varied between the two studies with lesser-spotted dogfish, pogge and sand goby (*Pomatoschistus minutus*) common around the north coast of Anglesey (Table 4.3). Despite being abundant elsewhere in the Irish Sea, very few solenette (*Buglossidium luteum*), Dover sole and grey gurnard were recorded in beam trawls around the north coast of Anglesey between 2010 and 2014, with the abundance of each species only representing 0.1% of total catches.

The results of the present study brings into question the classification of inshore coastal waters around the north coast of Anglesey as a high intensity nursery ground for Dover sole (Ellis *et al*., 2012). Historically, primary Dover sole nurseries have been found off the north Wales coast at Rhyl, in Morecambe Bay and in the Solway Firth (Riley *et al*., 1986). The original nursery ground proposed by Coull *et al*. (1998) did not include the north coast of Anglesey, and its subsequent inclusion by Ellis *et al*. (2012) was acknowledged as intending to incorporate what are considered to be “secondary nursery grounds”. In any case, the low abundance of Dover sole in both beam and otter trawls provides strong evidence to suggest that inshore coastal waters within the vicinity of the Wylfa Newydd Development Area is not an important primary or secondary nursery ground for Dover sole. This is corroborated by the findings of Rogers (1994) which demonstrated that juvenile Dover sole do not disperse greatly from primary nursery grounds (unlike plaice), preferring to remain on inshore nursery grounds until after their first winter. This suggests that Dover sole is unlikely to represent a key component of demersal fish assemblages within the vicinity of the Disposal Site.

Armstrong *et al*. (2013) found grey gurnard, herring and flounder to be a reasonably important component of subtidal fish communities. However, inshore around the north coast of Anglesey, a slightly different species complement dominated catches. Jacobs’ otter trawl surveys found lesser-spotted dogfish, sprat (*Sprattus sprattus*) and poor cod to be reasonably prevalent. These differences between the two studies is not unexpected; around the British Isles, lesser-spotted dogfish are known to be more common in waters <150 m deep, although they are found up to depths of 300 m (Ellis *et al*., 2005). This species utilise shallow coastal waters for feeding and spawning (Ellis and Shackley, 1997). Poor cod are also known to be a common component of coastal fish communities, utilising inshore areas as nursery grounds and feeding further offshore (Rogers *et al*., 1998).

In recent years, the abundance of sprat, a Lusitanian clupeid species, has increased in the Irish Sea. Biomass determined by annual acoustic surveys carried out during September was predicted to be 367,100 tonnes in 2014, which represented the second highest in the time series (1994 – 2014), the highest being recorded in 2002 (405,100 tonnes) (ICES, 2016). Disparity between the two studies is likely to reflect the timing of sampling with subtidal otter trawl surveys around the coast of Anglesey capturing a period of good recruitment (e.g. 2014).

Considering the water depth at the Disposal Site, lesser-spotted dogfish, sprat, herring, grey gurnard and poor cod are all expected to be present in this area, although in much lower abundances than that observed inshore within coastal waters around the north coast of Anglesey and wider Irish Sea.

Table 4.4 : A comparison between the dominant demersal and pelagic fish species sampled (in terms of abundance) by Armstrong *et al*. (2013) in the Irish Sea in 2010 and the results of Jacobs subtidal fish surveys (otter trawls) carried out between 2010 and 2014. Only those species making up at least 90% of the total abundance of fish sampled are presented.

Armstrong *et al*. (2013)		Jacobs otter trawl surveys	
Species	**Percentage contribution to total abundance**	**Species**	**Percentage contribution to total abundance**
Plaice	33.4%	Dab	43.2%
Dab	19.8%	Whiting	37.5%
Whiting	15.9%	Lesser-spotted dogfish	4.1%
Grey gurnard	8.4%	Sprat	3.9%
Herring	7.3%	Plaice	3.2%
Flounder	5.2%	Poor cod	2.3%

It is important to note that sandeel species represented 0.24% of the overall abundance of fish recorded from beam trawl surveys in the Irish Sea between 1993 and 2003 (Parker-Humphreys, 2004). These individuals sampled equated to 0.004 tonnes. As expected, this taxon was not recorded in semi-pelagic otter trawls (Armstrong *et al*., 2013). The Disposal Site is characterised by the presence of hard rocky substrates, and therefore, whilst sandeel may venture into the area, they are unlikely to form a significant or permanent component of fish assemblages.

4.3.3 Impingement monitoring data, Existing Power Station (Spencer, 1990)

Spencer (1990) reported 66 species from an impingement-monitoring programme at the Existing Power Station between September 1985 and September 1987. The most common species sampled was sprat, sand smelt, poor cod and dragonet with abundances varying both seasonally and annually. Lesser-spotted dogfish represented the last proportion of total biomass, although catches were dominated by fish <30 cm, with much larger specimens caught only occasionally. These results have been discussed further within Section 5.

4.3.4 Commercial fishing and landings data, Irish Sea (Marine Management Organisation, 2015; FishMap Môn, 2014)

The broad range of seabed and resulting habitats found along the Anglesey coastline support diverse fish and shellfish assemblages with various species being commercially exploited by local fishermen (NRW, 2010). The distribution and intensity of commercial fishing activity provides further evidence of the distribution and abundance of certain fish and shellfish species in coastal waters around Anglesey.

The inshore fleet on Anglesey employs mainly static gear such as bottom set gill nets to target demersal finfish, and pots to target lobster, crab, prawn and whelk (NRW, 2010). Light beam and otter trawling occurs inshore to the north-east of Anglesey in Red Wharf Bay and Liverpool Bay as well as off the south-west coast of Holyhead. Beyond approximately 2 km from the coastline, king and queen scallop are targeted by dredging and beyond 11 km, heavy commercial beam and otter trawling occurs (NRW, 2010).

Shellfish including king scallop, queen scallop, whelk (*Buccinum undatum*) and lobster (*Homarus gammarus*) and crabs are by far the most important commercial species constituting the main resources for many fishermen operating on the island (Walmsley and Pawson, 2007). On average, scallops accounted for over 70.0% of total landings at Cemaes, Amlwch and Holyhead (2,658 tonnes) between 2010 and 2014. Whelk and lobster for a further 28.5% (1,081 tonnes), 0.5% (17 tonnes), respectively (MMO, 2015).

Haddock, skates and rays represented the most important finfish although collectively, these only accounted for on average 0.5% of total landings between 2010 and 2014, with plaice and Dover sole each contributing a further 0.1%. Other species known to be landed include: anglerfish, cod, brill, Norway lobster, common prawns, turbot, gurnards, lemon sole, whiting, megrim, dab, lesser-spotted dogfish, pollack, conger eel, common ling, octopus, bib, bass, squid, mackerel, saithe and flounder. On average, each of these species accounted for less than 0.1% (≤ 1 tonne) of landings between 2010 and 2014.

Table 4.5 : Key species landed into Holyhead, Cemaes Bay and Amlwch, average from 2010 - 2014 by all vessels (MMO, 2015). All remaining taxa represented less than 0.1% to total average catches.

Taxa	Live weight landed (tonnes)	% total
Scallop	2,658	70.0%
Whelk	1,081	28.5%
Lobster	17	0.5%
Haddock	10	0.3%
Skates and rays	8	0.2%
Crab	7	0.2%
Plaice	4	0.1%
Dover sole	3	0.1%

Comparison to landings from ICES rectangle 35E5 which encompasses the coastal waters around Anglesey, including the Wylfa Newydd Development Area and Disposal Site, suggests that the majority of landings into Holyhead, Cemaes Bay and Amlwch are derived from fishing areas further afield. For example, only 23% and 63% of annual scallop and whelk landings into the Isle of Anglesey were caught within ICES rectangle 35E5. In addition, landings of haddock into the Isle of Anglesey (10 tonnes on average between 2010 and 2014) were found to be entirely caught in waters further offshore outside of ICES rectangle 35E5.

Table 4.6 : Key species landed from ICES rectangle 35E5, average from 2010-2014 by all UK vessels (MMO, 2015).

Taxa	Live weight landed (tonnes)	% total
Whelk	693	49.7%
Scallop	677	48.4%
Lobster	15	1.1%
Crab	6	0.4%
Plaice	2	0.1%
Dover sole	1	0.1%

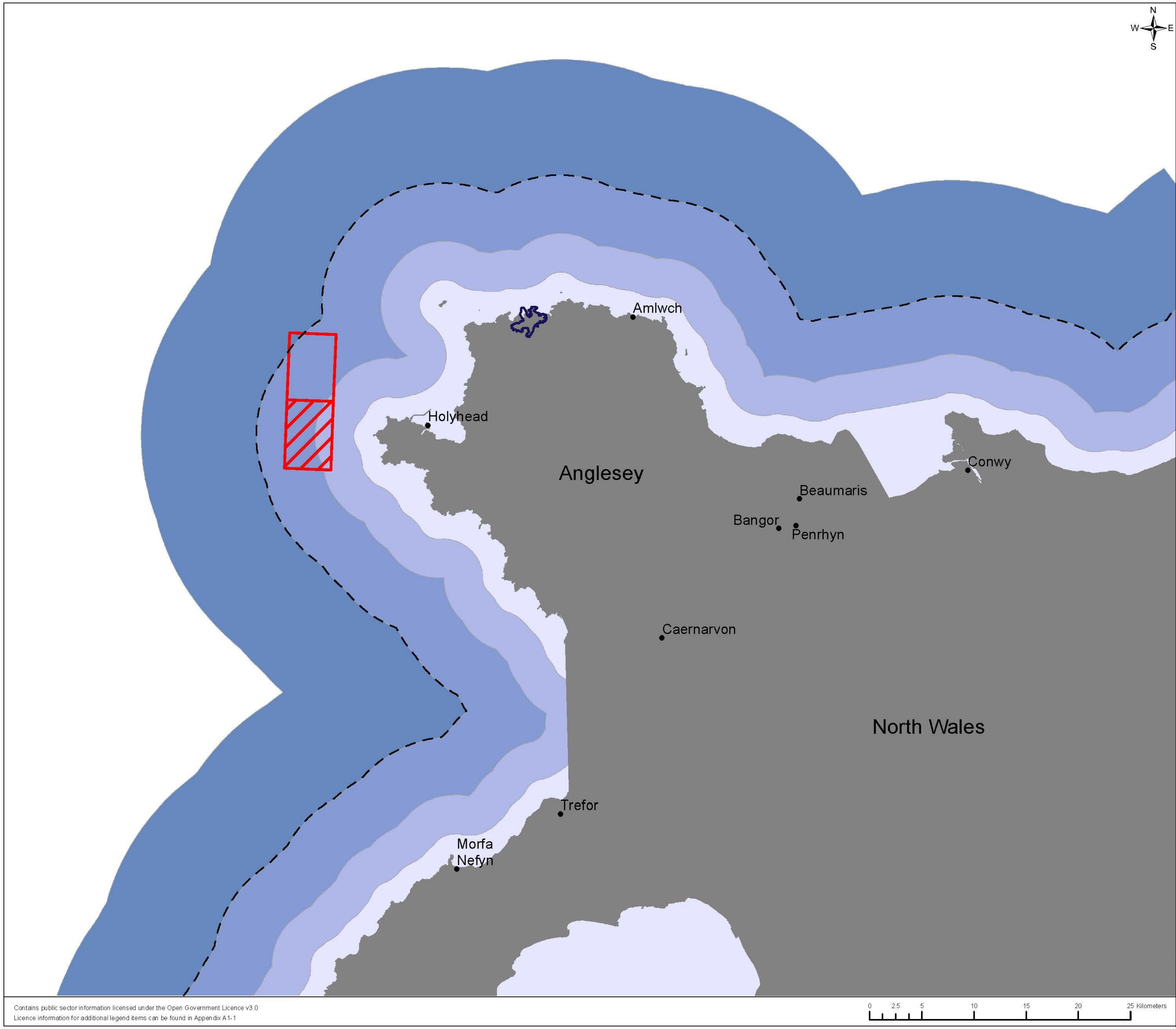
Comparison of these fishing statistics confirms that the coastal waters around the north coast of Anglesey do not support significant abundances of commercial finfish species, with fishing activities for these species primarily occurring further offshore.

Although commercial shellfish fisheries operate around the coast of Anglesey (Figure 4.19, Figure 4.20 and Figure 4.21), a large proportion of landings into ports on the island (Holyhead, Cemaes and Amlwch) are caught further afield. For scallop, this is likely to be due to the presence of an exclusion zone 1 nm (1.9 km) from the coast, which prohibits scallop dredging inshore; this includes the Wylfa Newydd Development Area and surrounding coastal waters (Figure 4.18). Additional restrictions prevent vessels over 12 m in length from fishing within 6 nm (11.1 km) of the shore. The Disposal Site is located outside of 1 nm but largely within 6 nm; despite this Figure 4.19 and Figure 4.20 shows that no commercial fishing for scallops is operating in or around the Disposal Site.

Within the coastal waters around north-east Anglesey, it is clear that king scallops are targeted infrequently with a large proportion of the commercial fishery occurring outside the 6 nm zone. Slightly higher intensity dredging occurs east of Amlwch within the 6 nm limit by vessels <12 m long (Figure 4.19). Queen scallops are almost exclusively fished outside 6 nm, again infrequently off north-eastern Anglesey (Figure 4.20). Commercial potting for whelks, lobster and crab is known to occur both within the Wylfa Newydd Development Area and the Disposal Site although the intensity is considered to be low (<2 pots lifted and dropped per hectare per day). Furthermore the area of commercial potting activity encompassed by the Wylfa Newydd Development Area and Disposal Site is small representing small percentage of wider fishing grounds.

The disparity between the fishing statistics presented in Table 4.5 and Table 4.6 for commercial shellfish taxa suggests that whilst productive, local populations (i.e. within ICES rectangle 35E5) are perhaps not as large as populations within the wider eastern Irish Sea (e.g. scallop fishery in Cardigan Bay).

FIGURE 4-18



Legend

- Wylfa Newydd Development Area
- 6 nautical mile limit
- Holyhead Deep North (The Disposal Site)
- Holyhead Deep South
- Port town

Scallop fishing Wales order 2005

- MHW -1nm
- 1nm - 3nm
- 3nm - 6nm
- 6nm - 12nm

0	AUG 17	Initial Issue	RM	HY	EC	RB
Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

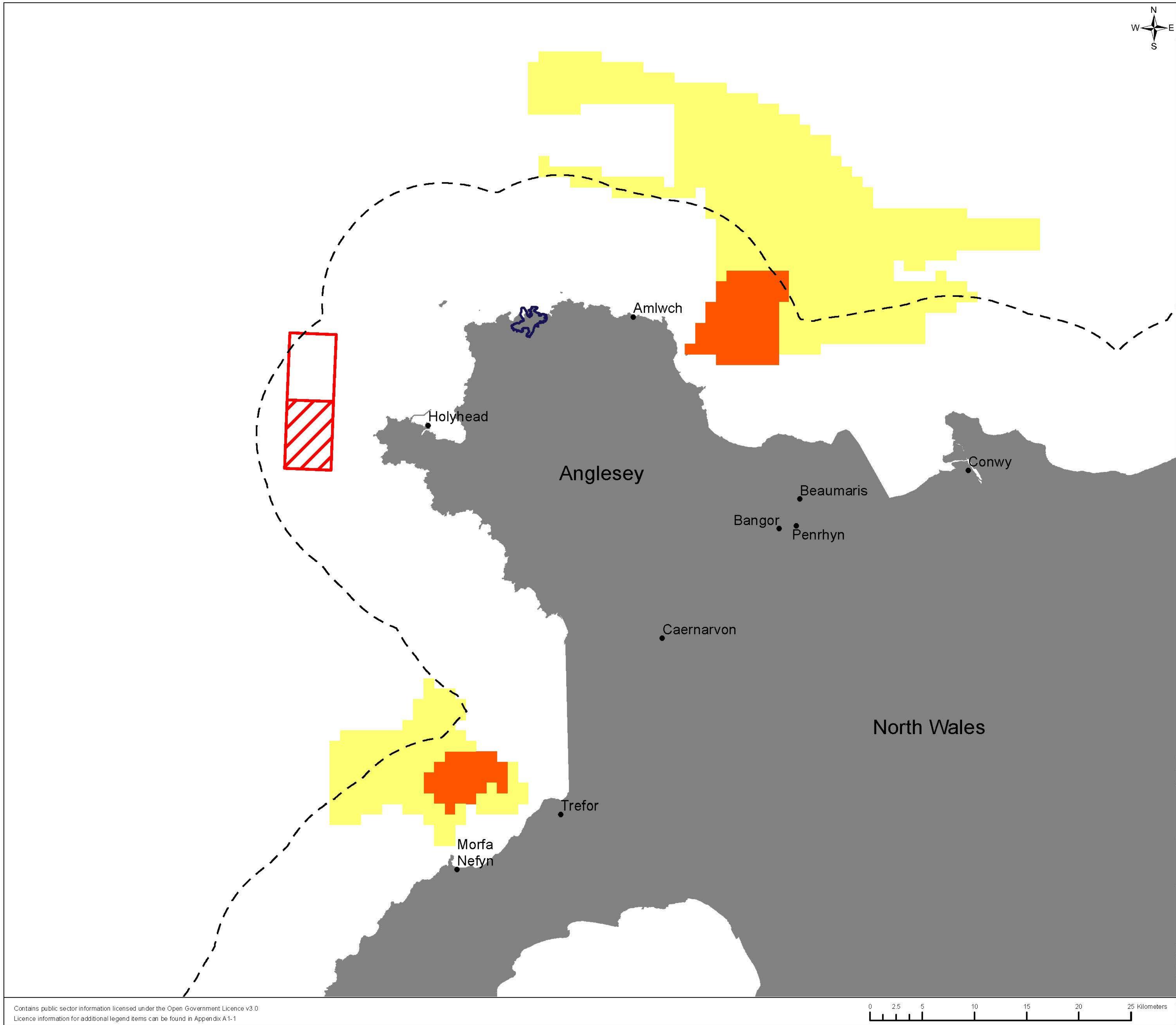
SCALLOP NO TAKE ZONE

Scale @ A3	1:350,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		

Drawing No.

60PO8077_DCO_APP_4_18

FIGURE 4-19



Legend

- Wylfa Newydd Development Area
- 6 nautical mile limit
- Holyhead Deep North (The Disposal Site)
- Holyhead Deep South
- Port town

King Scallop dredging intensity

(Number of times area fished per year)

- Level 1 (<0.8)
- Level 2 (0.8-3)

Rev	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	AUG 17	Initial Issue	RM	HY	EC	RB

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

KING SCALLOP COMMERCIAL FISHING AREAS

Scale @ A3	1:350,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		
Drawing No.	60PO8077_DCO_APP_4_19	

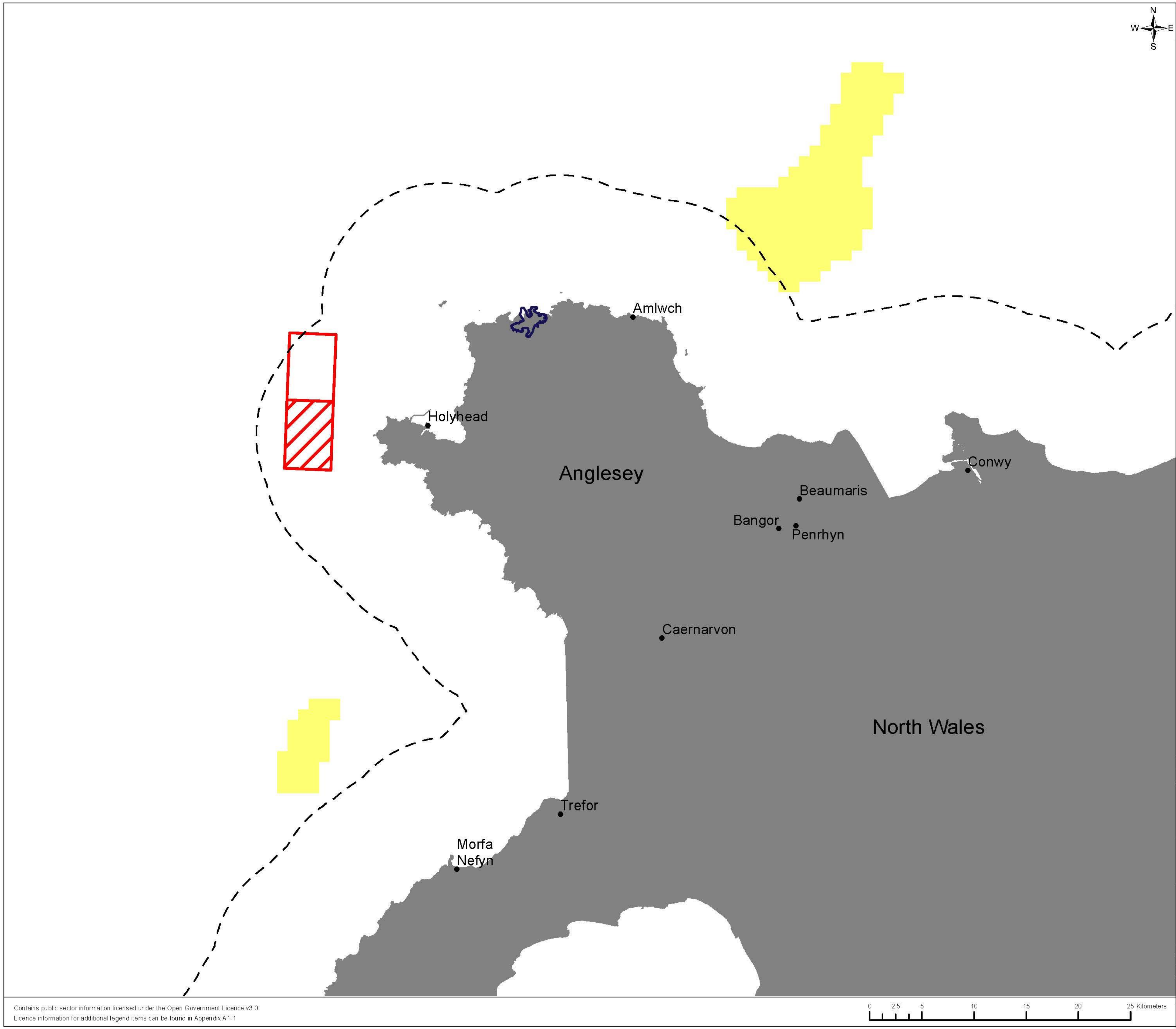


FIGURE 4-20

Legend

- Wylfa Newydd Development Area
- 6 nautical mile limit
- Holyhead Deep North (The Disposal
- Holyhead Deep South
- Port town

Queen Scallop dredging intensity

(Number of times area fished per

- Level 1 (<1.35)

0	AUG 17	Initial Issue	RM	HY	EC	RB
Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

QUEEN SCALLOP COMMERCIAL FISHING AREAS

Scale @ A3	1:350,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		
Drawing No.	60PO8077_DCO_APP_4_20	

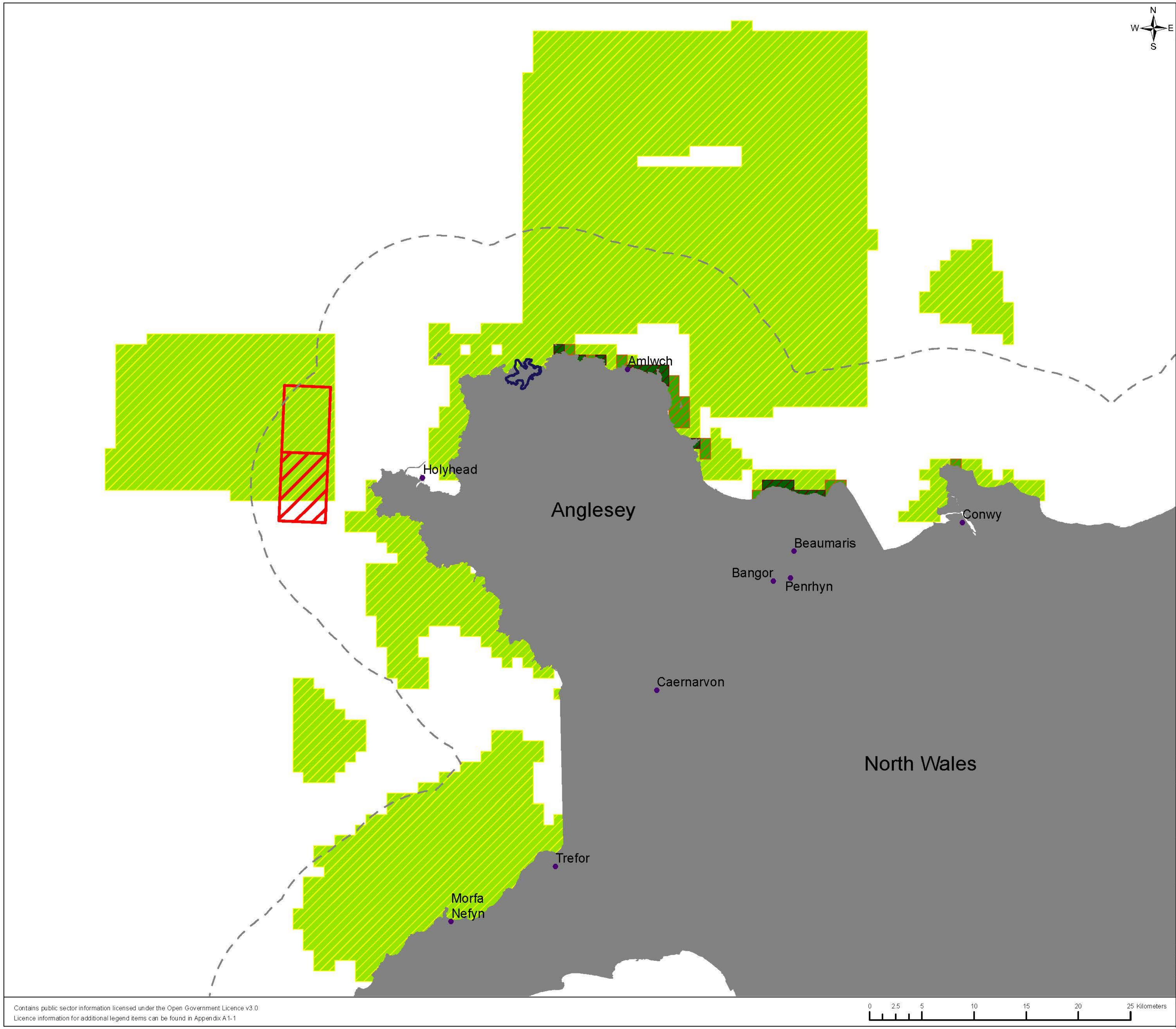


FIGURE 4-21

Legend

- Wylfa Newydd Development Area
- 6 nautical mile limit
- Port town
- Holyhead Deep North (The Disposal Site)
- Holyhead Deep South

Commercial potting intensity (lobster & crab)

(number of pots lifted and dropped/ha/day)

- Level 1 (<2)
- Level 2 (2-5)
- Level 3 (>5)

Commercial potting intensity (whelks)

(number of pots lifted and dropped/ha/day)

- Level 1 (<2)
- Level 2 (2-5)
- Level 3 (>5)

Rev	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	AUG 17	Initial Issue	RM	HY	EC	RB

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

WHELK, LOBSTER AND CRAB COMMERCIAL POTTING AREAS

Scale @ A3	1:350,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		
Drawing No.	60PO8077_DCO_APP_4_21	

4.4 Discussion of Subtidal Fish and Shellfish Communities

The subtidal fish programme covers almost five years of consecutive trawling surveys along the north coastline of Anglesey. Over this period, 75 discrete fish taxa have been recorded and approximately 68,000 individuals caught. Cefas surveys in the wider Irish Sea recorded more than 105 species of fish (Parker-Humphrey, 2004; Armstrong *et al*., 2013). The results of the Cefas survey suggest that around 60% of all species recorded in the Irish Sea have also been found along the relatively shallow coastline of north Anglesey, during this baseline study.

The trawling surveys at SF02, 03 and 05 are considered to be the first dedicated scientific surveys to have been conducted along the inshore north Anglesey coastline, though scientific trawling has been carried out at SF01 (Red Wharf Bay) on the north-east coast and further offshore at SF04 (off Point Lynas). The rocky nature of the seabed makes trawling challenging around Wylfa Head and this area is not commercially fished with any towed gears. Despite the inherent difficulties of fishing the rough ground, the five trawling sites identified have generally allowed trawling to take place, providing an insight to the fish assemblages present in this region.

By the end of 2014, this survey had been carried out on 19 separate sampling occasions, covering the seasons from spring 2010 to autumn 2014. Despite this timescale, new species to the subtidal fish survey and even to the wider fish survey programme (i.e. intertidal, ichthyoplankton, diving and entrainment surveys) were still being recorded toward the end of the survey programme. For example, in 2014, three fish species caught were new to the subtidal survey programme: the fifteen-spined stickleback, sand smelt and Norwegian topknot. These species have all been recorded on other fish surveys although the latter is particularly uncommon.

Sand smelt make up a high proportion of the intertidal catch each year and, although the sand smelt is associated with very shallow waters, it is rather surprising that it has not been recorded before on the trawling surveys or by Cefas surveys (Parker-Humphrey, 2004; Armstrong *et al*., 2013). The prior absence of what is considered a ubiquitous and abundant species in these waters, clearly demonstrates the importance of using a wide range of fish surveying methods, ensuring that the varied fish assemblages around north Anglesey are all targeted. Similarly, using two different trawls allowed both benthic and demersal fish assemblages to be targeted, the otter trawl even catching a number of pelagic species (e.g. herring and sprat). The beam trawl catches were usually dominated by benthic feeders such as poor cod, common dragonet and, at least prior to 2014, significant numbers of dab. This contrasted considerably with the dominance of piscivores, principally whiting, in most of the otter trawls. Targeting of these groups was further highlighted, as many fish were only recorded using one of the trawling techniques: 16% of all taxa caught by the beam trawl (n=54) and 30% of the total taxa caught by the otter trawl (n=62).

Despite the marked reduction in overall dab numbers during the 2014 survey, clearly a consequence of dropping site SF01, a dominance of benthic feeders was seen in the beam trawls and, more notably, in the otter trawls; the latter method historically recording a higher proportion of piscivorous feeders in most sampling periods. Observed changes in the dominant feeding guilds sampled by otter trawling in 2014 were primarily driven by a decline in whiting although again, this is likely to be due to the absence of data from SF01.

Comparison of the trawling sites showed that SF01 was particularly diverse: of the 14 sampling occasions at SF01 (this site was not trawled from autumn 2013 to the end of 2014) half recorded 20 taxa or more. By contrast, only one other site (SF05- south of The Skerries in Church Bay) recorded more than 20 taxa although this only occurred on only one sampling occasion (summer 2011). Despite the comparative taxa richness of SF01, during 2014 when no trawling was carried out at this site, the combined taxa richness of the other sites was generally comparable season-on-season to previous years. Statistical analysis of the beam and otter trawl data by ANOSIM showed clear differences between the SF01 fish community and all other fishing sites, these being primarily driven by the differing abundances of dab (specifically with the beam trawl) and whiting with the demersal fishing gear. The only other notable dissimilarity identified was between beam trawl catches from SF05, SF03 and SF04, this principally being a result of whiting and poor cod abundances.

The site SF01 lies partly within an SAC and experiences little in the way of commercial trawling, though fishing for research purposes has been carried out by Bangor University. From the examination of benthic invertebrate fauna collected at the fish survey sites, it is believed that the seabed at SF01 is considerably more heterogeneous than the other sites, with large clumps of upright fauna (e.g. the octocoral *Alcyonium digitatum*) often being present in the trawls. Fish and their juveniles to shelter from currents or predators can potentially use upright structures. Auster *et al.* (1997) and Tupper and Boutilier (1995) showed that juvenile cod are more likely to avoid predation in structurally complex habitats, leading to better rates of survival. However, though a number of studies have found a positive correlation between increase in structural complexity and fish species diversity (e.g. Carpenter *et al.*, 1982), this is less clear for fish abundance (Carpenter *et al.*, 1982; Roberts and Ormond, 1987). From the analyses carried out in this survey, the identified differences between sites were largely based on abundances of common species rather than different fish assemblages (Section 4.2.4).

Other major environmental differences noted at the survey sites include their varying exposure to prevailing winds and the degree of water current experienced. Anglesey is well known for its strong tides, and along the north coast, the current regularly exceeds four knots. Currents, though strong, are less so at SF01 and SF04, and unlike the other sites SF01 is also relatively sheltered from the prevailing south-westerly winds. Whilst, in contrast to SF01, the site at Church Bay (SF05) has the greatest level of exposure to the prevailing winds, the exposure and shallow depth of the site (<20 m) no doubt giving rise to a much more dynamic environment on the seabed than seen at SF01. However, despite the perceived differences in the physical environment at the sites, the fish communities were generally similar, the key exceptions being SF01 and to a much lesser extent SF04.

Nevertheless, a close look at the data revealed that certain species were only recorded from one or two sites throughout the survey programme. For example, lemon sole (*Microstomus kitt*) were recorded each year from 2010 to 2013 but only from SF04, three-bearded rockling only from SF03, whilst scaldfish (*Arnoglossus laterna*) were found most years but only at SF01 and SF04.

Ellis *et al*. (2012) classified inshore coastal waters around the north coast of Anglesey as a high intensity nursery ground for Dover sole. Subtidal trawl surveys along with published literature and evidence from other fish surveys (see Section 3) has demonstrated this not to be the case. Consequently, Dover sole, which is of both conservational and commercial importance, is not considered a key species characterising fish communities along the north coast of Anglesey, including the Wylfa Newydd Development Area and Disposal Site.

Cod is a boreal species that has exhibited a detectable shift in distribution to more northerly and deeper waters as far back as the 1920s (Drinkwater, 2006). Consequently, abundances at its southern most distribution have demonstrated a notable decline. Relatively few cod were recorded in subtidal surveys around the north coast of Anglesey between 2010 and 2014 (0.3% of overall otter and beam trawl catches), a result consistent with the findings of Armstrong *et al*. (2013) (cod contributed only 0.6% to the overall abundance of fish recorded from pelagic trawl surveys in 2010). It is therefore questionable whether juvenile cod are using inshore coastal waters around the north coast of Anglesey in sufficient abundance to warrant its classification as a low intensity nursery grounds as defined by Ellis *et al*. (2012). Irrespective of this, cod, which is of both conservational and commercial importance, remains a notable although not dominant species characterising fish communities within and around the Wylfa Newydd Development Area and Disposal Site.

The highest abundances of herring within the subtidal surveys was recorded to the east in Red Wharf Bay and off Point Lynas, as well as to the west, at SF05 (south of The Skerries in Church Bay); at intervening sites around Wylfa Head, abundances were lower. The distribution of this pelagic species is likely to be linked to the prevalence of strong tidal current around Wylfa Head, with juveniles in particular, preferring to remain further inshore in the more sheltered inlets and bays (see Section 4). Therefore whilst herring, which is of both conservational and commercial importance, is considered a key species characterising wider fish communities along the north coast of Anglesey (particularly to the east and inshore), it is not considered to represent a key species characterising subtidal fish communities within the Wylfa Newydd Development Area. Considering the presence of herring in Church Bay, the behaviour of this species (e.g. shoaling and highly migratory) and its wider abundance within the Irish Sea (Armstrong *et al*., 2013), it is likely to be a key species characterising fish communities at the Disposal Site.

Overall, sandeel abundance within subtidal areas (as determined by beam trawling) was low; individuals were recorded most often and in the highest abundance at site SF05. This bentho-pelagic species prefers to bury into sediments where the weight fraction of the fine particles silt/clay and very fine sand (particles<0.09mm) is less than 10% (Wright *et al*., 2000). Their presence along the north-west coast of Anglesey is therefore unsurprising given the prevalence of large sandy bays. The comparatively low and sporadic abundance of sandeel at all other subtidal sites suggests that substrates in these regions are not suitable or extensive enough to support significant populations. Sandeel has however been recorded in significant abundance within intertidal areas but only at selected sites (e.g. Red Wharf Bay, Cemaes Bay, site IF03 in Cemlyn Bay and sites farthest west), with distribution likely being driven by substrate type (see Section 4). Whilst sandeel is undoubtedly a key species characterising wider fish communities along the north coast of Anglesey (particularly inshore within sandy bay and inlets), owing to the presence of hard rocky substrates, it is not considered to represent a key species characterising subtidal fish communities within the Wylfa Newydd Development Area and the Disposal Site.

The area encompassing site SF01 (Red Wharf Bay) has long been considered an important nursery ground for dab, plaice and whiting, with known spawning of dab and plaice occurring off Great Orme Head, 15 km to the north-east of Red Wharf Bay (Macer, 1967; Bolle *et al.*, 1994; Ellis *et al.*, 2012). This nursery ground explains the high quantities of fish caught at SF01, the majority of which constituted juveniles.

The prevalence of plaice in subtidal trawls at site SF01 and within the intertidal seine nets at sites IF11 and IF12 confirms the presence of a low intensity nursery ground in the eastern Irish Sea (Ellis *et al*., 2012). However, the marked decline in abundance at intertidal and subtidal sites further west of Red Wharf Bay, suggests that this area delineates the westward boundary of these nursery grounds. Abundances were comparatively low at all other intertidal and subtidal sites, especially around Wylfa Head and the adjoining coastline (i.e. in and around the Wylfa Newydd Development Area) which is to be expected as this area is characterised by hard rocky substrates not suitable for use as plaice nursery grounds. Therefore whilst plaice, which is of both conservational and commercial importance, is considered a key species characterising wider fish communities along the north coast of Anglesey (particularly in the large shallow sandy bays), it is not considered to represent a key species characterising subtidal fish communities within the Wylfa Newydd Development Area and Disposal Site.

Overall, subtidal fish communities around the north coast of Anglesey are dominated by whiting and dab; the former being of commercial importance. Observations of the whiting and dab length-frequency data found differences in the population structure of these species between sites and seasons. Whiting spawn between February and June, with peak spawning in February to March (Cefas, 2009), as temperatures begin to rise. Growth in whiting is highly variable, particularly in their first year where growth is especially fast. Within the first year, whiting may grow up to 250 mm (mean length 180-190 mm) in the central Irish Sea. Growth then slows to approximately 50 mm per year until seven years of age when growth slows considerably further. First-spawning most frequently occurs during year two, once the fish are above 200 mm in length (Bowers, 1954).

Two clear cohorts of whiting were recorded from SF01 during summer in the approximate ranges 50 to 150 mm and 150 to 220 mm (considered 0+ and 1+ age respectively). It is thought that those less than 150 mm represent recent recruits to the nursery, possibly after migration from spawning areas to the west. The site SF05 was the only site to record individuals less than 50 mm in reasonable numbers (spring and summer survey periods) and it is thought that these recently settled individuals may form the nursery recruits at the more sheltered SF01.

Habitat selection in young whiting has been observed in the literature with younger fish preferring shallower sites with a perceived migration to deeper waters of larger fish. Anecdotal evidence exists of the movement of smaller fish offshore from September onward (Bowers, 1954). Indeed, the length-frequency distributions of the whiting sampled throughout the study period show clear habitat selection by fish of different age classes (Figure 4.11). Juvenile 0+ whiting appear to be resident year-round at site SF01, whilst the majority of larger fish, over 220 mm, frequented sites SF04 and SF05; the whiting at the latter site consisted of approximately half the population in this size category.

The general presence of comparatively large whiting at SF05 appears to contradict the accepted idea that larger individuals prefer deeper water. Although clear that the high seasonal CPUE values in spring to autumn were driven by SF01 catch, the winter CPUE for 2014 (otter and beam) was comparable to previous winter seasons and notably greater than both 2011 and 2013. This highlights the important contribution of SF04 and SF05 to the whiting catch: both these sites recording whiting in reasonably high numbers.

Multiple cohorts of dab were only visible during spring and then only observed at SF01 and SF05. The limited numbers of dab caught elsewhere during the survey programme prevented any meaningful interpretation of their size range. The two cohorts seen in spring at SF01 could represent the year classes 0+ and 1+ whilst the small size (<50 mm) of those dab recorded at SF05 in spring indicates the presence of recently settled individuals. As seen with whiting, the presence of recently settled dab at SF05 indicated that this site's exposure to the prevailing wind may be the result of ichthyoplanktonic movement from higher-intensity spawning areas in the Irish Sea (e.g. Cardigan Bay). These newly settled individuals may eventually form part of the nursery at SF01, supplemented by those dab migrating from known spawning areas to the north-east of Anglesey (e.g. Liverpool Bay (Fox *et al.*, 1997)). In 2014, the drop in dab catch was particularly noticeable with dab abundances at the remaining sites (SF02-05) often in single figures, yet again highlighting the contribution of SF01 in previous years.

Knowing the influence SF01 has had on fish abundance and richness historically (Figure 4.4 and Figure 4.4), it might be expected that the fish data from 2014 would show clear differences between other years, yet this was not found to be the case. Instead, a considerable overlap in catch composition was observed between each year (Section 4.2.3). Similarly, a strong overlap in fish composition recorded from the beam and otter trawling was shown between seasons, indicating only very minor differences in the seasonal composition. With the exception of a few species, such as tope, the fish caught did not appear wholly seasonal instead being largely resident all year round; however, trends in population abundance of several species did show some seasonal patterns. The highest numbers of dab, plaice and lesser-spotted dogfish were in the spring and, though high numbers of dab were recorded in summer 2013, these were considerably less than those recorded in spring 2011 and 2012 were. It is possible that the prolonged winter weather in 2013 may have delayed the spawning of dab in early spring, giving rise to the higher CPUE during summer 2013, as during the course of the programme dab numbers were generally highest in spring and lowest in autumn and winter. Dab are known to migrate seasonally between spawning and feeding grounds (Rijnsdorp *et al.*, 1992), and it is, therefore, not unexpected to see a regular drop in numbers as autumn approaches.

Whiting patterns were less clear, as might be expected from a more mobile species, with each season recording the highest annual catch at least once over the five years. The catch of whiting in summer 2013 yielded the highest seasonal CPUE across all years, and it is thought that 2013 may have represented a good year for this species. Furthermore, the whiting CPUE in autumn 2013 was higher than autumn 2012 even though no trawling was carried out at SF01. The patterns of whiting abundance over the survey programme emphasise well the often stochastic variability in fish populations and therefore catch composition.

Whiting is clearly a key species characterising wider fish communities along the north coast of Anglesey, particularly in Red Wharf Bay and to the west in Church Bay; abundances however, were much lower in the intervening subtidal areas. Nonetheless, due to the highly mobile nature of this species (being bentho-pelagic and migratory), whiting is considered to represent a significant component of subtidal fish communities within the Wylfa Newydd Development Area and Disposal Site. Given the overwhelming dominance of dab in Red Wharf Bay, this species is a key component of subtidal fish communities within this area; however, the extremely low abundances observed elsewhere along the coastline suggests that dab does not represent a key component of subtidal fish communities within the wider area, including the Wylfa Newydd Development Area and Disposal Site.

Whilst no dedicated fish surveys were carried out within the immediate vicinity of the Disposal Site, inferences can be made drawing upon survey results within the wider area, published literature and an understanding of the movement and habitat preferences of difference fish species. With this in mind, it is expected that fish communities in the Disposal Site would be dominated by pelagic species such as sprat and herring; bentho-pelagic species such as poor cod, whiting and other gadoids species; and demersal species such as lesser-spotted dogfish, common dragonet and perhaps species such as pogge. Those species, which are highly unlikely to be present in significant abundance, include flatfish species (e.g. dab, plaice and Dover sole) and sandeel. This is primarily owing to the presence of hard rocky substrates at the Disposal Site, which is not a preferred habitat type for these species.

The only shellfish species of commercial or conservational importance recorded during subtidal surveys the native oyster *Ostrea edulis*; however, only 12 individuals were recorded from the 19 surveys undertaken.

Scallops, crabs and whelks represent the commercial species that were recorded in the highest abundances; their distribution reflecting known commercial grounds around the north coast of Anglesey.

5. Overall Discussion

Fish species assemblages recorded along the north coast of Anglesey using the different survey methods (i.e. gulf sampling, seine netting, potting, diver surveys and trawling) were found to exhibit a number of similarities. Whilst only a single species (long-spined sea scorpion) was recorded in all seven survey methods, a further six and 20 were recorded in six and five of the survey methods, respectively (see Appendix D). Despite this, there were important differences which highlighted the value of using a multi-method approach to characterise fish communities. This is particularly true for regions of coastline such as the north coast of Anglesey, which is characterised by a diverse and complex range of abiotic conditions (e.g. exposure, substrate and hydrodynamics) capable of supporting a multitude of species.

Table 5.1 shows the five most abundant taxa recorded from each of the five sampling methodologies employed, providing a high-level overview of the key species characterising the different habitats along the north coast of Anglesey. Evidently, coastal waters are important for larval sandeel and sprat, with intertidal areas providing nurseries for juvenile sandeel and clupeids (including sprat and herring). Open coastal waters are also important for the dispersion of larval dab, with subtidal areas being utilised as nursery grounds for metamorphosed juveniles. Nursery grounds for herring and plaice were identified both inshore (within intertidal seine netting surveys) and offshore (within subtidal trawl surveys).

Inshore rocky habitats are clearly important for gobies, scorpionfish, rockling, wrasse and dragonets, with gobies and dragonets also representing an important component of ichthyoplankton assemblages. Gadoids, notably poor cod were found to utilise inshore rocky coastal areas whilst whiting were important in subtidal areas. Finally, lesser-spotted dogfish evidently move between inshore and offshore habitats, being recorded in intertidal areas from potting and within subtidal trawls.

Table 5.1 : Top five most abundant taxa recorded from each sampling methodology. Note that an equal abundance of long-spined sea scorpion and lesser-spotted dogfish (n = 7) as well as five-bearded rockling and three-bearded rockling (n = 6) were recorded in intertidal potting surveys.

Ichthyoplankton	Intertidal- seine netting	Intertidal- potting	Intertidal- diver surveys	Subtidal
Sandeel	Clupeidae	Rock goby	Gobiidae	Dab
Sprat	Sandeel	Long-spined sea scorpion	Poor cod	Whiting
Dab	Sand smelt	Lesser-spotted dogfish	Goldsinny wrasse	Lesser-spotted dogfish
Gobiidae	Herring	Five-bearded rockling	Callionymidae	Herring
Callionymidae	Plaice	Three-bearded rockling	Two-spotted goby	Plaice

Ichthyoplankton, intertidal seine netting and subtidal surveys all exhibited considerable natural temporal and spatial variations in the overall abundance of fish, as well as the relative abundance of dominant species. Although potting and diver surveys provided important additional information relating to fish assemblages associated specifically with rocky areas of coastline, owing to the limited resolution of these datasets, very little can be inferred regarding temporal and spatial variability in the abundance and distribution of taxa associated solely with these habitats.

Temporal patterns in ichthyoplankton abundance were found to be highly seasonal. The greatest abundances are observed between February and September; for the remainder of the year the numbers of eggs and larvae are extremely low. Peak abundance is driven by the spawning patterns of the dominant taxa. Sandeel were one of the first taxa to spawn in the year with larval abundance peaking in February. By April, numbers significantly declined whilst sprat, dab, scorpionfish larvae became prevalent. In the summer, dragonets were also recorded.

Fish abundance in intertidal areas generally peaked in the summer and autumn months. In each of the winter seasons, many of the juvenile fish either had left intertidal areas or, as in the case of sandeel, were hibernating. Consequently, the catch recorded decreased sharply, often yielding only low numbers of sand smelt. Despite this, the sheltered bays appeared to continue to be important feeding areas for larger individuals, with several large herring and mullet occasionally recorded from shallow waters (<0.5 m).

Total CPUE values recorded at each site for both beam and otter trawls showed no clear seasonal patterns between 2010 and 2014. Even considering the most abundant species individually (dab and whiting) did not identify clear and consistent seasonal patterns in abundance and distribution. In general, the recruitment of dab to nursery areas was observed during the spring and summer, mainly at site SF01 (Red Wharf Bay) and to a lesser extent SF04 (off Port Lynas) and SF05 (farthest west). Whiting were prevalent throughout the year although two cohorts where observed in summer and autumn at SF01 and to a lesser extent SF04.

The eastern Irish Sea is recognised as an important spawning area for a number of fish species including plaice, Dover sole, sandeel, dab, whiting, dragonet, gobies and herring. It is also an important nursery area for plaice, whiting, dab and Dover sole. Sampling sites along the north-east coast of Anglesey have confirmed the importance of these areas, exhibiting high catches of the species listed above. Consequently, overall catches at these sites were generally much higher than that observed at sites further west, although moderate abundances were also recorded at subtidal site SF05 located south of The Skerries in Church Bay.

To the west of Red Wharf Bay, the distribution and abundance of ichthyoplankton is considered to be driven by hydrodynamic conditions aiding dispersal of eggs and larvae from high intensity spawning grounds in the east. Densities observed inshore in and around the vicinity of the Wylfa Newydd Development Area were found to be much lower than densities reported by Ellis *et al*. (2012). This suggests that spawning predominantly occurs offshore, which is true for dominant taxa such as sandeel. Similarly, dispersion is likely to be driven by the strong tidal currents characteristic of the area, which may transport eggs and larvae away from coastal areas. This is likely to explain why Ellis *et al*. (2012) reported slightly higher densities of certain species such as plaice, herring, Dover sole and whiting at sites within the vicinity of the Disposal Site (which is located further offshore) compared to values recorded within the vicinity of the Wylfa Newydd Development Area (see Section 2.2).

The abundance and distribution of fish species within intertidal and subtidal areas is likely to driven by proximity to spawning and nursery grounds, hydrodynamic conditions as well as exposure and substrate type. A key feature that was broadly consistent across all both intertidal and subtidal surveys was a comparatively lower abundance of fish in and around the Wylfa Newydd Development Area. Within intertidal areas there was a notable absence of flatfish and a lower abundance of sandeel; these species exhibit a preference for shallow sandy habitats present to the east within Red Wharf Bay, Cemaes Bay and at sites farthest west some 15 km from the Wylfa Newydd Development Area. Trawling off Wylfa Head also identified relatively low abundances of fish compared to other sites, with a distinctly low abundance of sandeel and flatfish (e.g. plaice and dab). It is evident that this region of coastline is characterised by hydrodynamic and substrate conditions that are not well suited to supporting significant populations of these species.

Although overall abundances were found to be low, intertidal catches within the Wylfa Newydd Development Area were characterised by the presence of sand smelt and clupeids. Sand smelt utilise rocky vegetated intertidal habitats as spawning, feeding and nursery grounds; the demersal nature of spawning means this species is not prevalent in ichthyoplankton samples. Clupeids utilise inshore areas for feeding and nursery grounds; this species did not appear to be affiliated with a particular set of conditions, occurring at a range of sites.

Subtidal catches within the Wylfa Newydd Development Area where characterised by the presence of whiting, poor cod, lesser-spotted dogfish and sprat. Whilst few sand smelt were recorded in subtidal surveys, it was found to be the second most abundant species impinged at the Existing Power Station between March 2011 and July 2012, with both large juveniles and adults present in catches (Jacobs, 2016a, Application Reference Number: 6.4.92). It is therefore evident that whilst this species is prevalent along the north coast of Anglesey, the distribution of all life stages is predominately limited to waters close inshore. Sand smelt is of neither commercial nor conservational importance.

Impingement data from the Existing Power Station is considered to provide a good indication of the abundance and complement of fish species present within the vicinity of the Wylfa Newydd Power Station as the intake is located off Wylfa Head. Sprat, whiting and herring were ranked the first, third and fourth most abundant species impinged between March 2011 and July 2012 (Jacobs, 2016a, Application Reference Number: 6.4.92) which shows good agreement to subtidal trawl data. Total annual impingement catches at the Existing Power Station were considered to be low when compared to other coastal power stations; this provides further support to the conclusion that fish abundances within the vicinity of the Wylfa Newydd Development Area are low compared to fish populations elsewhere in the Irish Sea (e.g. eastern Irish Sea)

Ellis *et al*. (2012) suggests that the Wylfa Newydd Development Area is encompassed within an area of high intensity spawning for plaice as well as a high intensity nursery area for Dover sole and whiting. Comparison to results presented within Sections 2, 3, and 4 of this report, which were sampled at a much higher spatial and temporal resolution, disputes a number of these classifications. Whilst relatively abundant within Cemaes Bay, plaice was distinctly absent from the intertidal areas in Porth-y-pistyll with further low abundances recorded in adjacent subtidal areas. Similarly, only 35 plaice were recorded from impingement surveys at the Existing Power Station (Jacobs, 2016a, Application Reference Number: 6.4.92). Whilst plaice is recognised as a key component of fish assemblages along the coastline of north Anglesey with specific areas important for spawning and nursery of juveniles, plaice is not considered to be an important component of fish assemblages within the Wylfa Newydd Development specifically.

Catches of Dover sole were relatively low throughout the survey area and from all fish surveys, with impingement surveys from the Existing Power Station also only yielding two individuals from 55 surveys carried out over the 16-month monitoring period (Jacobs, 2016a). This casts significant doubt on the importance of the north coast of Anglesey as a nursery area for this species. Given the prevalence and abundance of whiting throughout the survey area (in subtidal areas), it is however agreed that the north coast of Anglesey (including the Wylfa Newydd Development Area) is a high intensity nursery ground for this species.

Aside from the current fish survey programme, the most recent surveys of the fish populations at the Existing Power Station were carried out more than 20 years ago by Spencer (1990) who monitored the impingement of fish on the cooling water screens at the Existing Power Station. Of the 66 species reported by Spencer (1990), all but three have been observed during the survey work to date. The absence of Atlantic salmon, hake (*Merluccius merluccius*) and Corbin’s sandeel (*Hyperoplus immaculatus*) can be explained by either their rarity or their specific habitat preferences. Spencer (1990) only recorded salmon and hake on a single occasion during 68 sampling occasions. Armstrong *et al*. (2013) recorded salmon and hake in the wider Irish Sea in 2010 but in reasonably low abundances (three and 83, respectively). Parker-Humpreys (2004) only recorded 117 Corbin’s sandeel in the Irish Sea between 1993 and 2001 Corbin’s sandeel is rarely recorded in Welsh waters (Kay and Dipper, 2009) and was the only species of the five sandeel species known to frequent British waters not recorded during this fish survey programme.

Some of the species recorded in the present study were rarities normally associated with deeper, offshore waters: e.g. boarfish (*Capros aper*), subtidal fish survey autumn 2012; Atlantic halibut, ichthyoplankton survey spring 2012; and the pearlside (*Maurolicus muelleri*), impingement surveys (see Jacobs, 2016a, Application Reference Number: 6.4.92). The boarfish and pearlside were sampled following periods of windy weather, possibly suggesting they had been forced into shallower waters during storms. Other species such as the Norwegian topknot and long rough dab are rarely recorded, while no records for Welsh waters exist for the Norway bullhead, the nearest records being from the Isle of Man (Wheeler, 1969; Kay and Dipper, 2009). Thirty-eight species of fish have been recorded from Jacobs’ fish and impingement surveys that were not listed by Spencer (1990). Most of these species are at the centre of their bio-geographical ranges, and their presence in the samples reflects the value of using a multi-method approach to provide a comprehensive picture of the local fish assemblages.

Within the vicinity of the Disposal Site, Dover sole, sandeel, plaice and dab are unlikely to constitute key components of the fish assemblages due to the prevalence of hard rocky substrates in the area. Considering the distance to known spawning and nursery grounds in the eastern Irish Sea as well as the abundance and distribution of fish along the wider north coast of Anglesey (derived from dedicated surveys and published literature), species such as whiting, poor cod, common dragonet, lesser-spotted dogfish, sprat, herring, grey gurnard and other elasmobranchs are all likely to be present.

Shellfish abundance within beam trawls and potting exhibited a similar pattern to fish catches, being reasonably low within the vicinity of the Wylfa Newydd Development Area and increasing out towards known commercial fishing grounds along the north-east coast of Anglesey. Although commercial fishing activities are prevalent within both the Wylfa Newydd Development Area and Disposal Site, intensity is recognised as being low (FishMap Môn, 2014).

5.1 Species of Conservation Importance

Potts and Swaby (1995) noted that river lamprey (*Lampetra fluviatilis*) and sea lamprey (*Petromyzon marinus*) have been reported from north Wales' waters. River lamprey and sea lamprey are listed under Section 7 of the *Environment (Wales) Act 2016* and are also listed on Annex II and V of the EU Habitats and Species Directive and Appendix III of the Bern Convention. Sea lampreys undergo marine migrations and are found in rivers on all coastlines bordering the Irish Sea. To date, only a single river lamprey has been sampled from the Existing Power Station cooling water intake (Jacobs, 2016a, Application Reference Number: 6.4.92), while no sea lampreys have been recorded.

The species listed below may be present in the waters around the north Anglesey coast in low numbers throughout the year or during peak migratory periods. To date, none of these species have been recorded during annual sampling or during the sampling carried out by Bangor University.

The Atlantic salmon is known to migrate through the Irish Sea and enter river systems on both the north Welsh, eastern Irish and north-west English coastlines. The Atlantic salmon is an *Environment (Wales) Act 2016* Section 7 and UK BAP priority species, and is listed on Annex II and V of the EU Habitats and Species Directive. Atlantic salmon have not yet been recorded in any of the baseline surveys, but Spencer (1990) recorded a single specimen during the impingement surveys on the site of the Existing Power Station. A single individual was also observed in Cemlyn Bay in 2005 (Cofnod, 2015).

Twaite (*Alosa fallax*) and Allis shad (*Alosa alosa*) are also *Environment (Wales) Act 2016* Section 7 and UK BAP priority species listed on Annex II and V of the EU Habitats and Species Directive and Appendix III of the Bern Convention but have not been recorded during the survey programme.

It is not known whether smelt, another *Environment (Wales) Act 2016* Section 7 species, frequent the waters off Anglesey, but the nearest spawning population is at the River Conwy, less than 50 km south-east of Anglesey on the north Wales coast (CMACS, 2006).

European eel are known from freshwater habitat adjacent to the marine habitats at Cemaes and Cemlyn and undergo migration between freshwater and marine habitats. Although not previously recorded within the 2010 – 2015 marine fish sampling programme, eel would be expected to be present within the intertidal and subtidal marine environment at certain times of year, as migrating adults and juveniles. European eel are listed on Section 7 of the *Environment (Wales) Act 2016*, receive protection relating to recruitment, exploitation and maintaining migratory corridors under the *Eel (England and Wales) Regulations 2010* and are considered critically endangered on the IUCN Red List.

5.1.1 International Union for the Conservation of Nature Red List

The IUCN Red List cites species assessments ranging from 'least concern' to 'extinct'. 'Least concern' means there is no evidence to suggest a species is in decline over its known range. Of the species recorded in the present programme, several are listed as 'near threatened' (close to qualifying for threatened categories in the near future) or 'vulnerable' (faces a high risk of extinction in the wild):

- Atlantic halibut – endangered;
- cod – vulnerable;
- haddock – vulnerable;
- basking shark – vulnerable;
- tope – vulnerable;
- spurdog – vulnerable;
- bull huss/nurse hound – near threatened;
- blonde ray – near threatened; and
- thornback ray – near threatened.

6. Conclusions

Ichthyoplankton communities

Many of the fish species recorded in the ichthyoplankton surveys were found in one or more of the other fish surveys (intertidal, subtidal and/or diving); however, ichthyoplankton tows recorded a number of species that were not recorded during dive, intertidal or subtidal trawl surveys. This highlights the importance of this technique in sampling the full spectrum of species present. The results of the ichthyoplankton surveys also demonstrated that the area is a spawning ground for many inshore species through the distinct peaks in abundance of taxa including gobies, dragonets, scorpionfish, blennies and wrasse. It also indicates that sandeels spawn in this area as is evidenced by the strong peaks in their larval abundance during both spring and autumn.

Sandeel, sprat, dab, gobies and dragonets clearly have a dominant role in the ichthyoplankton community assemblages within the vicinity of the Wylfa Newydd Development Area. However, with the exception of perhaps gobies, inshore abundances of all the species listed above are much lower than those reported for the eastern Irish Sea and further offshore. Specifically for sandeel, this is indicative of low intensity spawning grounds inshore within the Wylfa Newydd Development Area, compared to high intensity area identified offshore and in the eastern Irish Sea. The Disposal Site may be characterised by slightly higher abundances of certain species to those observed within the Wylfa Newydd Development Area, although these are likely to remain much lower than abundances recorded in the eastern Irish Sea.

The ichthyoplankton survey provided a useful technique for identifying many of the fish species that use this area. This exposed region of north Anglesey contains an ichthyoplankton community that does not vary to any significant degree within the survey area but exhibits clear temporal changes. The seasonal variation in community is largely driven by a few key taxa (i.e. sandeels, gobies, dab, dragonets and sprat), these exhibiting spawning events at slightly different times throughout the year. Trends in the overall abundance and dominance of taxa were repeated each year and, though there were slight changes in presence and/or abundance of the key taxa, the general pattern remained the same. Peak egg abundance typically occurs between March and May and is thought to be largely driven by the spawning of sandeel, sprat and dab. The community is characteristic of this region and environment; however, the strong ocean and wind-driven currents in this region, coupled within the open nature of the coastline, occasionally results in the presence of species not normally associated with this part of Wales (e.g. Norway bullhead).

Intertidal fish communities

The fish species recorded during the 2010 – 2015 sampling programme were all considered to be within their biogeographical range. Zooplanktivorous feeders such as clupeids (mainly herring and sprats), sandeel and sand smelt were the most abundant taxa recorded in seine nets, followed by plaice. Overall, the data suggest that spatial differences in the core intertidal fish communities around the north Anglesey coast were considerable, being driven primarily by proximity of sites to spawning and nursery grounds in the eastern Irish Sea.

Overall, higher abundances of fish were found to be using intertidal areas on the north-east coast of Anglesey; this is likely to be owing to the proximity of sampling sites to known spawning and nursery grounds in the eastern Irish Sea. The lowest abundances of fish were observed along the north-west coast of Anglesey with a clear gradient of overall fish abundance evident along the intervening coastline from east to west. The east coast sites recorded higher abundances of juvenile clupeids and plaice, whereas sites further west supported greater numbers of sand smelt. Porth-y-pistyll and certain areas of Cemaes Bay supported notable numbers of clupeids and reasonably high numbers of sand smelt; however, these areas were not found to be particularly important nursery areas for sandeel and there was a distinct absence of plaice and other flatfish species from these sites. Western Cemlyn Bay also recorded reasonably high numbers of sand smelt but was not an important nursery area for sandeel.

The survey programme has confirmed the presence of inshore nursery areas for sandeel and plaice. For plaice, these are primarily located up to 24 km east of the Wylfa Newydd Development Area, with abundances declining markedly further towards the west. Sandeel nursery areas appear to be affiliated with sandy bays along the north coast of Anglesey and therefore represent a more patchy distribution.

Temporal changes in the fish assemblages generally followed similar trends, with recruitment occurring in spring and early summer followed by emigration from the intertidal during winter, a seasonal relationship that follows the rise and fall in water temperature. The exception to this was juvenile sand smelt, which showed clear recruitment in the summer and tended to reside in the shallow waters year round.

The intertidal fish data provide good evidence that the intertidal areas along the northern coastline of Anglesey are populated by a variety of species, many providing food sources for other local fauna, including seabirds and marine mammals. The intertidal fish communities were largely dominated by sandeel in the spring and summer (with plaice forming a significant fraction at the eastern sites) and sand smelt in the autumn and winter.

The cooling water outfall of the Existing Power Station did not appear to have any major negative impact on the nearshore fish populations of the north Anglesey coast. If any impact was present, it remained localised to within a few hundred metres of the outfall. The results and further observations from surveys in 2011 and 2012 confirm that the discharge attracts mullet and bass and might attract greater numbers of gobies and juvenile gadoids to the general area to feed.

Subtidal fish communities

This element of the fish survey programme has shown that the subtidal waters off the north coast of Anglesey contain a diverse fish assemblage, with over 70 discrete fish taxa recorded since the trawling surveys began. Feeding guild composition of the fish community was dominated, as might be expected, by benthic and piscivorous feeders; these guilds in turn were dominated by just a few species: dab and lesser-spotted dogfish dominated the former guild, and whiting was the principal piscivore.

The heterogeneity of the rocky coastline provides an array of complex habitats allowing a rich and, at times, abundant fish community to thrive. The shelter on the east coast of the island creates a suitable nursery ground for juvenile dab, whiting and plaice, as evidenced from the number and size range of the individuals caught in this area. However, from the length-frequency data collected, recruitment of post-larval and juvenile dab and whiting from the Irish Sea also occurs (but to a lesser extent) at the western-most site (Church Bay). Whether they then migrate south or north along the coastline is unclear, as recognised nursery grounds exist both on the south-west and north-east coast of Anglesey.

Subtidal trawl data along with published literature and evidence from other fish surveys have demonstrated that fish species such as herring, sandeel, plaice and dab are considered key species characterising wider fish communities along the north coast of Anglesey. However, these species are not considered to represent key components of the subtidal fish communities within the Wylfa Newydd Development Area and Disposal Site. Herring, however, is likely to be a key species characterising fish communities at the Disposal Site considering its wider distribution, abundance and behaviour.

Whiting is considered to represent a significant component of subtidal fish communities within the Wylfa Newydd Development Area and Disposal Site whilst cod remains a notable though not dominant species characterising fish communities within and around these areas. It is expected that fish communities at the Disposal Site would be dominated by pelagic species such as sprat and herring; bentho-pelagic species such as poor cod, whiting and other gadoids species; and demersal species such as lesser-spotted dogfish, common dragonet and perhaps species such as pogge.

The reference site SF01 in Red Wharf Bay is located within a Natura 2000 site (Menai Strait and Conwy Bay SAC) and consistently yielded the highest numbers of fish in terms of abundance and species richness. From autumn 2013, trawling dispensation was not obtained for this site; thereafter, trawling was restricted to the remaining four sites (SF02-SF05). However, despite this change to the programme and the consequent drop in overall fish abundance in 2014, analysis of the fish data using ANOSIM found a considerable overlap in the fish community between all years. Similarly, on a seasonal timescale, no substantial differences in the communities were identified suggesting that communities present are similar and also generally consistent over time. The exception to this was SF01, which showed clear differences between the other sites in the fish community but as a result of large abundances of the ubiquitous taxa, as opposed to the overall composition of the fish population.

Invariably, the stochastic nature of fishing (fish movements, tidal strengths, weather and sea conditions) creates peaks and troughs in the data, as observed in this survey with species such as sprat and herring, yet the overall picture given by this work is that of a diverse and consistent subtidal fish community that essentially characterises this region of the Anglesey coastline. The relatively similar communities identified spatially, between four of the five sites, along with clear overlaps on a temporal scale, suggest that the data, covering almost five years of surveys, have established a robust baseline.

The only shellfish species of commercial or conservational importance recorded during subtidal surveys was the native oyster *Ostrea edulis*, but in very low abundance. Scallops, crabs and whelks represent the commercial species that were recorded in the highest abundances, their distribution reflecting known commercial grounds around the north coast of Anglesey. Shellfish abundance was reasonably low within the vicinity of the Wylfa Newydd Development Area, increasing out towards known commercial fishing grounds along the north-east coast of Anglesey.

Species of conservation importance

Atlantic salmon, Twaite and Allis shad, sea lamprey, smelt, European eel, hake and Corbin's sandeel may be present in the waters around the north Anglesey coast in low numbers throughout the year or during peak migratory periods. To date, none of these species have been recorded during annual sampling or during the sampling carried out by Bangor University. A single river lamprey has been recorded from the Existing Power Station cooling water intake.

Atlantic halibut, cod, haddock, tope, spurdog, bull huss/nurse hound, blonde ray and thornback ray have all been recorded from fish surveys and are listed in the IUCN Red List as 'near threatened' or 'vulnerable'.

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Appendix A. Fish Survey Programme

A.1 Ichthyoplankton

Table A.1: Latitude and longitude of the start and end of each transect carried out at the seven ichthyoplankton survey sites.

Site	Start latitude, longitude	End latitude, longitude
1	N53° 25.645, W004° 23.314	N53° 25.769N, W004° 23.788
2	N53° 25.492, W004° 28.826	N53° 25.314N, W004° 29.225
3	N53° 24.529, W004° 33.053	N53° 24.454N, W004° 33.386
4	N53° 27.170, W004° 28.996	N53° 27 170N, W004° 29.762
5	N53° 26.383, W004° 29.591	N53° 26.610N, W004° 28.999
6	N53° 25.091, W004° 29.478	N53° 24.832N, W004° 29.506
7	N53º 24.904, W004º 30.300	N53º 25.354N, W004º 30.306

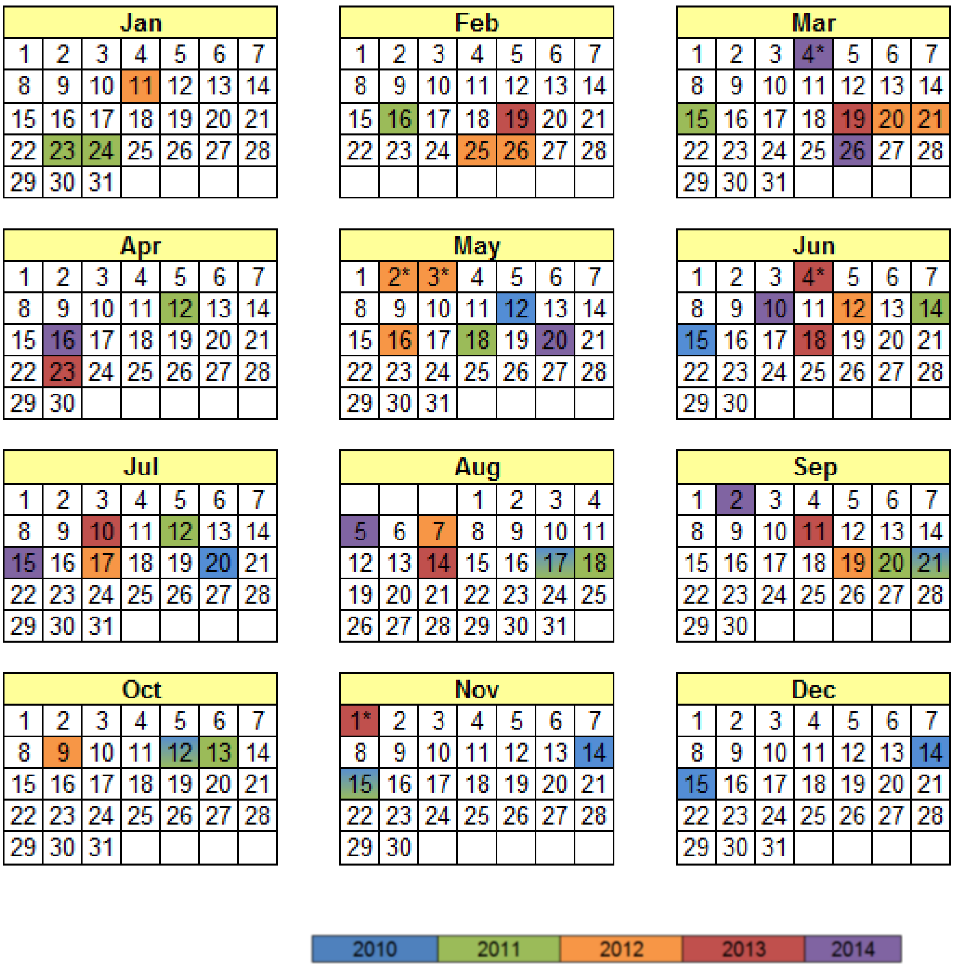

Figure A.1 : Ichthyoplankton survey dates. Dates marked with an asterisk (*) represent surveys that were delayed due to weather (April 2012, May 2013, October 2013 and February 2014).

A.2 Intertidal Fish

Table A.1 : Location (latitude and longitude) of the thirteen intertidal fish sampling sites.

Site name	Site code	Sampling strategy	Latitude, longitude
Porth Tywyn-Mawr	IF01	Seine net	N53° 20.300, W004° 34.000
Porth Swtan	IF02	Seine net	N53° 22.400, W004° 33.400
Cemlyn Bay (east)	IF03	Seine net	N53° 24.600, W004° 30.400
Porth-y-pistyll	IF04	Seine net	N53° 24.800, W004° 29.500
Porth y Ogof	IF05	Fish traps	N53° 24.940, W004° 28.020
Cemaes Bay	IF06	Seine net	N53° 24.910, W004° 27.103
Llanbadrig Bay	IF07	Seine net	N53° 25.300, W004° 26.800
Porth Wen	IF08	Fish traps	N53° 25.300, W004° 24.200
Porth y Wylfa	IF09	Seine net	N53° 24.940, W004° 28.060
Cemlyn Bay (west)	IF10	Seine net	N53° 24.780, W004° 30.825
Traeth Lligwy	IF11	Seine net	N53° 22.390, W004° 16.188
Traeth Buchan	IF12	Seine net	N53° 20.381, W004° 13.802
Porth-y-pistyll	IF13	Seine net	N53° 24.799, W004° 29.427

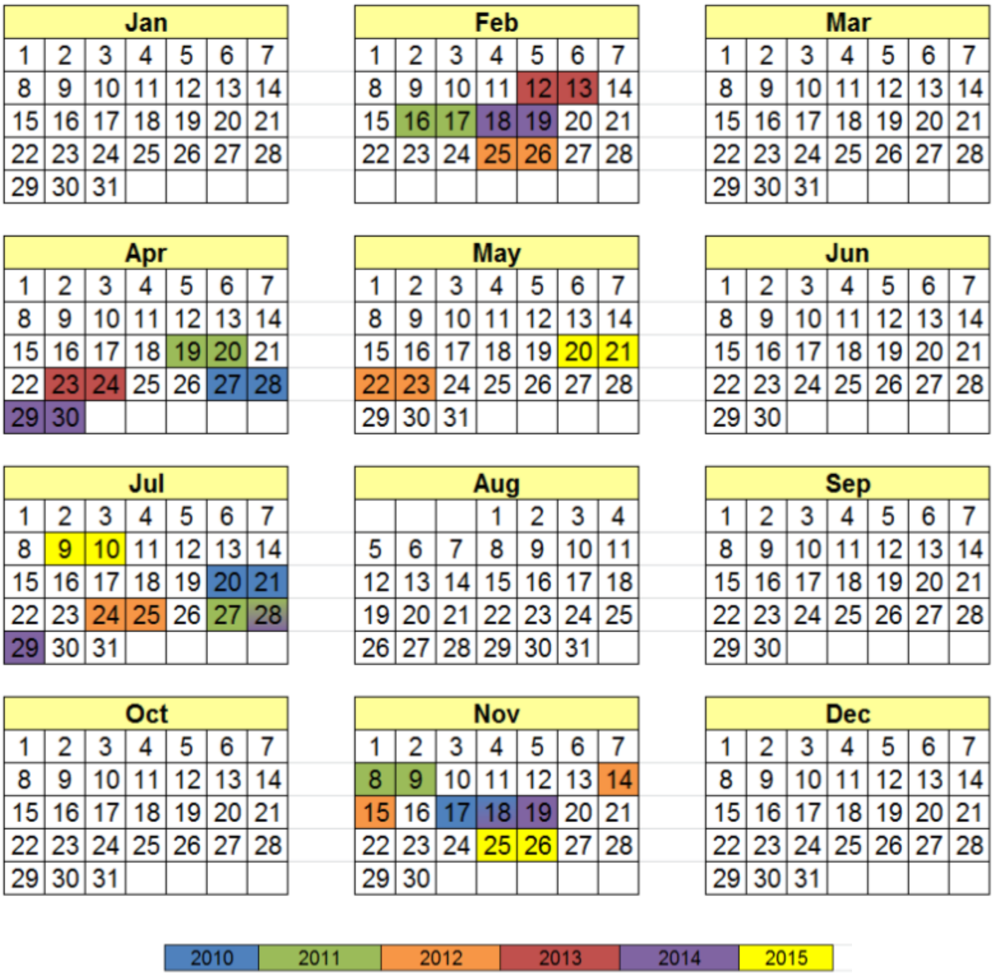

Figure A.2 : Intertidal fish survey dates from 2010 to 2015.

A.3 Diver Surveys

Table A.2 : Summary of sites dived, positions, underwater visibility (vis.) and distance from outfall.

Site	Surveyors	Date	Time	Lat.	Long.	Comments	Visibility (m)	Dist. from outfall (km)
DV04 deep	LM & JE	29/07/10	14:00	N 53 25.230	W004 28.880	No data collected - wrong habitat (sediment) >1 m visibility	2	0.2
DV04 shallow	MD &BW	29/07/10	14:02	SE from deep site	SE from deep site	Data collected, 2 m visibility	2	0.2
DV06 deep	LM & JE	29/07/10	16:58	N53 25.271	W004 28.840	Rock at 13 m - divers moved away from shot as started on a wreck, moved to 53deg 25.283, 004deg 28.391 @ 17:30. Limited data collected	1-2	0.28
DV06 shallow	MD & BW	29/07/10	17:02	N53 25.250	W004 28.830	Data collected	1-2	0.28
DV04 deep	MD & BW	30/07/10	09:27	N53 25.242	W004 28.867	Data collected	1-2	0.2

Site	Surveyors	Date	Time	Lat.	Long.	Comments	Visibil-ity (m)	Dist. from outfall (km)
DV06 deep	HG & JE	30/07/10	09:30	N53 25.260	W004 28.835	Very silted only 1 transect completed	1-1.5	0.28
DV08 deep	MD & BW	30/07/10	12:12	N53 25.271	W004 28.615	Data collected - current started throughout dive	2	0.64
DV08 shallow	HG & JE	30/07/10	12:13	Inshore of deep site	Inshore of deep site	Data collected - current started throughout dive	1-2	0.64
DV11 shallow	HG & JE	31/07/10	12:57	N53 25.615	W004 25.413	Data collected	2	3.2
DV11 deep	MD & BW	31/07/10	12:54	N53 25.615	W004 25.413	Data collected	1-2	3.2
DV12A shallow (X)	HG & JE	31/07/10	15:46	N53 25.729	W004 25.754	No data collected - very silted >1 m visibility (East side of bay)	1	3.9
DV12B shallow (Y)	MD & BW	31/07/10	15:41	N53 25.676	W004 25.861	Data collected (West side of bay)	2	3.9
DV11 shallow	MD & BW	01/08/10	13:26	N53 25.621	W004 26.442	Data collected	2	3.2
DV11 deep	HG & JE	01/08/10	13:28	N53 25.621	W004 26.442	Data collected	2	3.2
DV09B shallow	MD & BW	01/08/10	16:20	N53 25.511	W004 26.534	Divers inshore of this mark - data collected	1-2	2.9
DV09A shallow	HG & JE	01/08/10	16:21	N53 25.511	W004 26.534	Divers in at this mark - data collected	1-2	2.9
Outfall B shallow	HG & JE	02/08/10	15:51	N53 25.210	W004 28.939	Data collected. Strong current present	1.5	0.14
Outfall A shallow	MD & BW	02/08/10	15:52	N53 25.207	W004 28.892	No data collected - current too strong from outfall.	2	0.25
DV04 shallow	HG & JE	02/08/10	18:06	N53 25.223	W004 28.886	Limited data collected	2	0.2
Outfall A shallow	MD & BW	02/08/10	17:58	N53 25.267	W004 28.881	Data collected	2	0.25
DV04 deep	LM & JE	29/07/10	14:00	N 53 25.230	W004 28.880	No data collected - wrong habitat (sediment) >1 m visibility	2	0.2
DV16 deep	HG & JE	03/08/10	09:05	N53 25.123	W004 17.420	Data collected	3	13.6
DV16 shallow	LM & BW	03/08/10	09:08	N53 25.110	W004 17.426	Data collected	3	13.6
DV05 deep	LM & BW	03/08/10	12:00	N53 24.930	W004 17.540	Data collected (shot was 5-6 m east of this position)	2	13.3
DV05 shallow	HG & JE	03/08/10	12:03	No Position - Inshore of deep site	No Position - Inshore of deep site	Data collected	1-2	13.3
DV02 shallow	MD & BW	06/08/10	12:40	N53 25.203	W004 29.067	Data collected	3-4	0.32
DV02 deep	LM & JE	06/08/10	12:40	N53 25.266	W004 29.070	Data collected	2-3	0.32
DV07	LM & JE	06/08/10	09:35	N53 25.326	W004 28.768	Data collected	3	0.44

Site	Surveyors	Date	Time	Lat.	Long.	Comments	Visibil-ity (m)	Dist. from outfall (km)
shallow								
DV07 deep	MD & BW	06/08/10	09:30	N53 25.338	W004 28.781	Data collected	4-5	0.44

A.4 Subtidal

Table A.3 : The number of replicate trawls, and the location (latitude and longitude) of the start and end of each transect carried out at the five subtidal fish sites.

Location name	Site name	Replicates		Start latitude, longitude	End latitude, longitude
		Otter	Beam		
Red Wharf Bay	SF01	3-5	3-5	N53 22.241, W004° 13.590	N53° 21.156, W004° 12.455
Cemaes Bay	SF02	0	3-5	N53 25.612, W004° 27.260	N53° 25.448. W004° 27.751
Wylfa Head	SF03	3-5	3-5	N53 26.033, W004° 29.338	N53° 25.712. W004° 30.410
Point Lynas	SF04	3-5	3-5	N53 29.168, W004° 17.232	N53° 28.796. W004° 14.547
Church Bay	SF05	3-5	3-5	N53 22.661, W004° 35.815	N53° 22.017. W004° 35.792

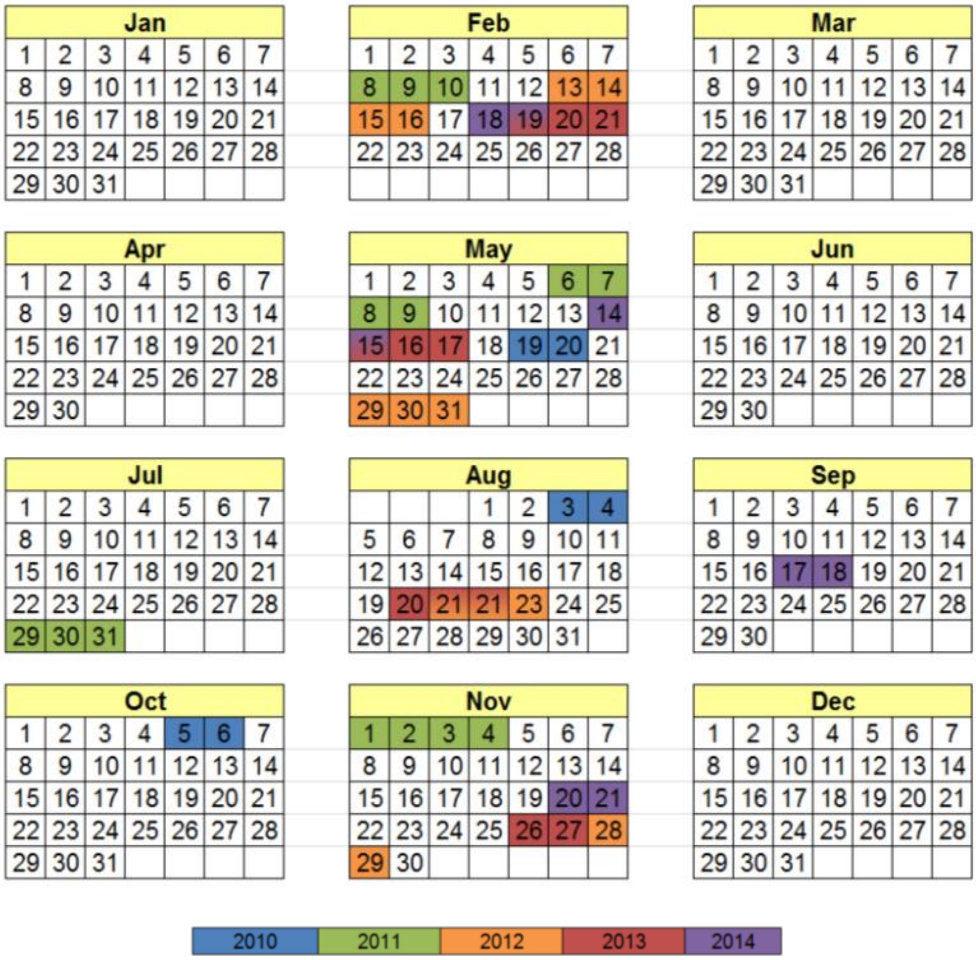

Figure A.3 : Subtidal fish survey dates from 2010 to 2014.

Appendix B. Statistical Glossary and Methodologies

B.1 Multivariate Statistical Analysis (PRIMER)

Plymouth Routines In Multivariate Ecological Research (PRIMER) (www.primer-e.com) is a program designed to analyse datasets where samples contain several variables. The following descriptions of the various procedures and tests used for the data analysis are all summaries of the full descriptions provided in the PRIMER manual (Clarke and Warwick, 2001). The full manual should be consulted for detailed descriptions of each test undertaken.

B.1.1 Transformation of Data

Data transformation is used to remove the weighting of common or rare species within a sample when undertaking statistical analysis. The type of transformation used depends on the biological (not statistical) questions being asked of a dataset and whether a broad or specific approach is required. The more severe the transformation, the broader the answer as all species become more equal, thus giving a greater weighting to species with low abundances.

B.1.2 Bray-Curtis Similarity

Before many of the analyses can be undertaken in PRIMER, a similarity matrix must be constructed. This creates a matrix containing a value for every pairwise (between species) comparison possible between the samples. The higher the value, the more similar the comparison is. This matrix is used for comparison of samples in subsequent statistical tests. PRIMER uses the Bray-Curtis coefficient (S) which is particularly common in ecological analyses.

B.1.3 ANOSIM

Analysis of Similarity (ANOSIM) tests are a form of hypothesis testing for differences between pre-defined groups e.g. sites/times of sampling. ANOSIM tests can be applied to multivariate datasets and are not restricted to balanced designs i.e. equal numbers of replicate samples within sites, or treatments, or both.

ANOSIM tests provide two results: R-values and p-values. Of these two values, R is often the most useful to use for interpreting the data as it is not affected by the number of replicates but by actual differences between the two or more groups of data. On the other hand, p is always influenced by the sample size and might mask confidence in the results obtained from smaller datasets.

R-values lie between -1 and 1. $R = 1$ only when all replicates within groups are more similar to one another than any replicates from different groups. $R = 0$ when similarities between all replicates, regardless of groupings, are the same on average. R-values well below zero suggest greater similarities between replicates from different groups than within groups and may indicate errors in the labelling of samples.

B.1.4 Multi-Dimensional Scaling

MDS plots provide a visual representation of the relationships between samples and can be useful for data interpretation. The Bray-Curtis similarity matrix described above can be used to create a MDS plot of the sample similarities. Samples with greater similarities are placed closer to one another with more dissimilar samples placed further away.

The usefulness of the plots is indicated by a stress value. If stress values in a 2-D plot are too high, a 3-D plot can be generated which might provide a better representation as there is more dimensional space in which to plot the samples and their relative distances to each other. Stress values should be considered as follows:

- <0.05 – excellent representation of the relationships between the data;
- 0.05< s <0.1– good plot with little prospect of a misleading interpretation;

- 0.1< s <0.2– potentially useful although for values toward the upper end of this range too much emphasis should not be placed on the detail of the plot;
- 0.2< s <0.3– treat these points with scepticism and consider plots at higher dimensions; and
- >0.3 – the points are close to random. Consider plots at higher dimensions.

B.1.5 CLUSTER ANALYSIS

Cluster analysis is designed to find natural groups or ‘clusters’ of samples within the main dataset, again based on a Bray-Curtis similarity matrix. Each cluster is successively linked to the next most similar sample or cluster until a tree diagram (dendrogram) is completed with all samples finally forming a single cluster (the whole tree).

Cluster analysis is particularly useful for determining groups of sites with distinct ecological communities. This does not imply that the species themselves are necessarily different, since patterns of abundance may also play a role in determining similarities. Dendrograms can be used to compliment MDS plots or, when stress values are too high in MDS plots, they might prove a useful substitute to show clusters of samples.

B.1.6 SIMPER ANALYSIS

When differences have been detected between groups of samples, Similarity Percentage (SIMPER) tests can be used to determine the individual species that contribute to the differences between groups of samples and the similarities between samples within a group. The SIMPER test identifies species that typify a group and/or potentially an environmental condition or impact.

B.2 Ichthyoplankton Analysis

The statistical analysis of ichthyoplankton data used a multivariate approach, where each taxon was treated as a separate variable, enabling an assessment of complex patterns within large-scale datasets. Multivariate statistical tests were performed using PRIMER-E^{TM} (Clarke and Gorley, 2006) and following the methods of Clarke and Warwick (2001).

To assess potential differences, a two-way crossed ANOSIM (analysis of similarity) was used to test for *a priori* (pre-defined) differences, assessing temporal effects in the structure of the community between sites and tidal state (flood and ebb). This approach can be viewed as a non-parametric version of a multivariate Analysis of Variance (ANOVA) (Clarke and Gorley, 2006). The ANOSIM was carried out on a square root transformed Bray-Curtis matrix, with 999 permutations, using season (spring, summer, autumn, winter), sites and tide as factors. Square root transformation was used to down-weight the influence of several highly abundant species, enabling the presence of rarer taxa to have a stronger influence on the statistical tests.

Where a Global R value of >0.2 was found using ANOSIM, a Similarity Percentage (SIMPER) test was then used to investigate which taxa were driving dissimilarities between these groups. The test ranks, in order of importance, each taxon by calculating their overall percentage contribution to the average dissimilarity between each group.

To further investigate and visualise differences in communities across factors (seasons, sites, tides), non-metric MDS (50 restarts, Kruskal fit) was carried out on the square root transformed Bray-Curtis resemblance matrix. MDS constructs a pictorial representation of the samples whose distances reflect statistically tested ‘true’ differences between the samples. Put simply, the closer a sample is to another sample on the MDS plot, the more similar the samples are to each other. For more information on statistical analysis, see Appendix B.

Following the first year of sampling (May 2010 to April 2011) it was identified that ichthyoplankton abundance during the winter months was extremely low, with 71% of all samples collected between October and January found to contain no fish larvae, and the remaining samples rarely having more than a single individual. Samples containing a very low abundance of ichthyoplankton, or those where larvae are absent altogether, can have a notable effect on the visual representation of data (MDS) and the assessment of statistical differences between factors (ANOSIM between sites, replicates, seasons, years). To reduce the effect of these samples, data collected between October and January inclusive were omitted prior to PRIMER analysis. Furthermore, a ‘dummy variable’ of one was added to every sample within the resemblance matrix, thereby forcing two samples with no content to be 100% similar (as they share the dummy variable). This aims to further dampen the behaviour of joint absences where samples are denuded for the same reason (i.e. ichthyoplankton abundance is low).

A preliminary assessment of species-assemblage data identified temporal variations in the taxonomic classification of certain taxa. Although damage to specimens may be a contributing factor, this pattern is believed to occur in response to variations in the size of larvae throughout the year and the subsequent ease of identification at specific times of the year. For example, a key taxonomic feature of species belonging to the Callionymidae family (dragonets) is the presence of preopercular spines; however, these are generally absent from larvae less than 6 mm (standard length) (Russell, 1976). Smaller individuals sampled earlier in the year are therefore typically recorded as Callionymidae, whilst larger individuals (>6 mm) caught later in the year and exhibiting preopercular spines are generally speciated. If these variations in taxonomic resolution were retained within the dataset during statistical analysis, they could infer false temporal patterns in species assemblages and distort comparisons between factors such as seasons and sampling years. To permit accurate statistical analysis, all taxa were grouped to family level.

The group ‘osteichthyes indeterminate’ was also removed from the dataset prior to analysis in PRIMER, as this group is likely to contain multiple taxa which may also exhibit different spatial, temporal and seasonal patterns in abundance. This being the case, inclusion could distort differences between factors making it difficult to identify statistical trends. The multivariate analyses were carried out using all replicates from all sites, including sites sampled on different tidal states.

B.3 Intertidal Fish Analysis

Analysis of the intertidal fish community composition was carried out using multivariate statistics on the PRIMER-E™ software package (Clarke and Gorley, 2006) and following the methods of Clarke and Warwick (2001). The multivariate analysis compared differences between all species and their relative abundances between samples and sites. It also provides graphical representation of samples and sites with similar communities.

A reduced taxa list used for the Bray-Curtis matrix resulted in several entries being amalgamated, e.g. the species *Pomatoschistus pictus*, *P. microps* and *P. minutus* were grouped under *Pomatoschistus* spp., and sprat, herring and pilchard (*Sardina pilchardus*) were grouped as Clupeidae. Other broad entries were removed for greater clarity where only one or two individuals existed which likely belonged to species already listed, e.g. the entry ‘Gadidae’ consisting of just two recorded individuals was removed to allow the distinction between cod, pollack, whiting, etc. to be analysed. The taxa list was thereby reduced to only those taxa which could be confirmed as clearly separate entries, i.e. they did not represent a group that could potentially have been included in another entry such as genus or family.

To assess potential differences between sites and seasons, a two-way, crossed ANOSIM was used to test for *a priori* differences, and for assessing spatial and temporal effects in the structure of the communities between sites and seasons. This approach can be viewed as a non-parametric version of a multivariate ANOVA (Clarke and Gorley, 2006). The ANOSIM was carried out on a square root-transformed Bray-Curtis matrix using season (spring, summer, autumn, winter) and geographic location (as detailed in) as factors. Transformations of data were investigated to down-weight the influence of several highly abundant species, but these bore no influence on the results.

Where ANOSIM found that significant differences occurred, a SIMPER test was used to investigate which individual species were driving the dissimilarity between these groups. To illustrate any differences, an MDS was carried out on the square root-transformed Bray-Curtis matrix.

B.4 Subtidal Fish Analysis

Analysis of the subtidal fish community composition was carried out using multivariate statistics on the PRIMER-E™ software package (Clarke and Gorley, 2006) and following the methods of Clarke and Warwick (2001). The multivariate analysis compared differences between all species and their relative abundances between samples and sites. It also provides graphical representation of samples and sites with similar communities.

Owing to the different fishing efficiencies of each net type, otter trawl catches were only ever compared with other otter trawl catches, and likewise for beam trawls. Comparisons of the temporal and spatial datasets were carried out in the PRIMER™ software package using the mean CPUE values.

A reduced taxa list for the Bray-Curtis matrix resulted in several entries being removed to allow greater clarity: clupeid indet., flatfish juv. indet., gadoid indet. and Gobiidae indet. Records for these groups were generally low in number and, as they all covered several species already listed in the taxa, they were removed. During the survey programme, Raitt's sandeel (*Ammodytes marinus*) was confirmed from the catch in 2011 and 2014; however, due to the difficulty in determining the difference between this species and the congeneric *A. tobianus*, previous years' analyses had grouped these sandeel under *Ammodytes* spp. This was continued for the 2014 analyses.

Appendix C. Results of Ichthyoplankton Statistics

Table C.1 : Results of two-way crossed ANOSIM test between ichthyoplankton samples at all sites and all tides.

Groups	R	p-value
Global R = 0.015, p = 0.004		
Site 1, Site 2	0.023	0.055
Site 1, Site 3	0	0.433
Site 1, Site 4	0.01	0.211
Site 1, Site 5	0.017	0.092
Site 1, Site 6	0.045	0.003
Site 1, Site 7	-0.042	0.85
Site 2, Site 3	-0.015	0.85
Site 2, Site 4	0.006	0.195
Site 2, Site 5	0.005	0.272
Site 2, Site 6	0.035	0.003
Site 2, Site 7	-0.029	0.74
Site 3, Site 4	-0.007	0.688
Site 3, Site 5	-0.004	0.318
Site 3, Site 6	0.032	0.012
Site 3, Site 7	-0.017	0.633
Site 4, Site 5	-0.004	0.687
Site 4, Site 6	0.031	0.002
Site 4, Site 7	-0.048	0.903
Site 5, Site 6	0.059	0.001
Site 5, Site 7	-0.01	0.554
Site 6, Site 7	0.02	0.245
Global R = 0.002, *p* = 0.351		
As *p* is >0.05, pairwise values are not reported.		

Table C.2 : Results of the SIMPER analysis showing all taxa contributing to the first 50% of dissimilarity within ichthyoplankton assemblages between significant sites. Average abundance is fourth root transformed abundance (per 10^6 m^3).

Groups: Site 1 & 6	Average dissimilarity = 87.65					
	Group 1	Group 6				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. %	Cum. %
Ammodytidae	269.89	154.48	22.03	0.83	25.14	25.14
Gobiidae	80.45	72.95	9.23	0.70	10.53	35.66
Pleuronectidae	154.81	25.04	7.19	0.65	8.20	43.86
Blenniidae	32.61	45.74	6.75	0.47	7.70	51.56
Groups: Site 2 & 6	Average dissimilarity = 85.27					
	Group 2	Group 6				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. %	Cum. %

Ammodytidae	186.45	154.48	21.47	0.85	25.17	25.17
Gobiidae	86.21	72.95	10.33	0.72	12.12	37.29
Blenniidae	66.35	45.74	9.38	0.58	11.00	48.29
Labridae	45.00	55.95	7.21	0.58	8.46	56.75
Groups: Site 3 & 6	Average dissimilarity = 85.28					
	Group 3	Group 6				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. %	Cum. %
Ammodytidae	144.20	154.48	19.27	0.80	22.59	22.59
Gobiidae	122.17	72.95	11.72	0.82	13.74	36.34
Blenniidae	76.41	45.74	9.55	0.62	11.20	47.54
Cottidae	83.95	41.63	7.28	0.65	8.53	56.07
Groups: Site 4 & 6	Average dissimilarity = 87.66					
	Group 4	Group 6				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Species	Av. Abund.
Ammodytidae	235.62	154.48	23.36	0.85	26.65	26.65
Gobiidae	78.59	72.95	10.77	0.70	12.29	38.93
Clupeidae	102.83	38.79	7.88	0.60	8.99	47.92
Blenniidae	29.01	45.74	6.85	0.47	7.82	55.74
Groups: Site 5 & 6	Average dissimilarity = 86.20					
	Group 5	Group 6				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Species	Av. Abund.
Ammodytidae	219.51	154.48	21.77	0.86	25.26	25.26
Gobiidae	70.08	72.95	8.54	0.72	9.90	35.16
Clupeidae	126.50	38.79	7.48	0.68	8.67	43.83
Callionymidae	90.91	31.11	7.42	0.64	8.61	52.45

Table C.3 : Results of two-way crossed ANOSIM test between ichthyoplankton samples for all years and seasons.

Groups	R	p-value
Global R = 0.137, p = 0.001		
2010, 2011	0.17	0.001
2010, 2012	0.086	0.001
2010, 2013	0.192	0.001
2010, 2014	0.045	0.062
2011, 2012	0.115	0.001
2011, 2013	0.288	0.001
2011, 2014	0.172	0.001
2012, 2013	0.109	0.001
2012, 2014	0.034	0.022
2013, 2014	0.078	0.002
Global R = 0.491, p = 0.001		
Spring, Summer	0.546	0.001

Groups	R	p-value
Spring, Autumn	0.674	0.001
Spring, Winter	0.473	0.001
Summer, Autumn	0.319	0.001
Summer, Winter	0.458	0.001
Autumn, Winter	0389	0.001

Table C.4 : Results of the SIMPER analysis showing all taxa contributing to the first 50% of dissimilarity within ichthyoplankton assemblages between sampling years. Average abundance is fourth root transformed abundance (per 10^6 m^3).

Groups: 2010 & 2011				Average dissimilarity = 85.11		
	Group 2010	Group 2011				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. %	Cum. %
Ammodytidae	100.81	159.76	15.15	0.70	17.80	17.80
Gobiidae	100.11	117.10	11.99	0.79	14.09	31.89
Blenniidae	77.56	54.88	9.48	0.63	11.14	43.04
Callionymidae	36.26	111.97	7.64	0.71	8.97	52.01
Groups: 2010 & 2012				Average dissimilarity = 86.03		
	Group 2010	Group 2012				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. %	Cum. %
Ammodytidae	100.81	354.95	27.04	0.98	31.43	31.43
Gobiidae	100.11	46.40	9.14	0.74	10.63	42.06
Blenniidae	77.56	21.81	7.31	0.61	8.50	50.55
Groups: 2011 & 2012				Average dissimilarity = 83.97		
	Group 2011	Group 2012				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib. %	Cum. %
Ammodytidae	159.76	354.95	23.20	0.89	27.63	27.63
Clupeidae	132.74	105.87	8.05	0.79	9.59	37.22
Gobiidae	117.10	46.40	7.77	0.73	9.26	46.48
Pleuronectidae	159.93	90.26	7.59	0.77	9.04	55.52
Groups: 2010 & 2013				Average dissimilarity = 87.73		
	Group 2010	Group 2013				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Ammodytidae	100.81	147.80	19.52	0.82	22.25	22.25
Gobiidae	100.11	43.80	12.24	0.77	13.95	36.20
Blenniidae	77.56	27.39	10.23	0.63	11.67	47.86
Cottidae	21.17	71.59	7.37	0.59	8.40	56.27
Groups: 2011 & 2013				Average dissimilarity = 87.75		
	Group 2011	Group 2013				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Ammodytidae	159.76	147.80	17.08	0.78	19.47	19.47
Gobiidae	117.10	43.80	9.89	0.74	11.27	30.74
Cottidae	94.05	71.59	7.91	0.65	9.01	39.75

Callionymidae	111.97	23.61	7.81	0.64	8.91	48.65
Groups: 2012 & 2013				Average dissimilarity = 85.56		
	Group 2012	Group 2013				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Ammodytidae	354.95	147.80	28.12	1.00	32.86	32.86
Cottidae	55.79	71.59	7.09	0.67	8.29	41.15
Clupeidae	105.87	27.25	6.84	0.67	7.99	49.14
Gobiidae	46.40	43.80	6.38	0.59	7.45	56.60
Groups: 2010 & 2014				Average dissimilarity = 83.59		
	Group 2010	Group 2014				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Ammodytidae	100.81	260.13	21.60	0.88	25.85	25.85
Gobiidae	100.11	91.69	12.08	0.82	14.45	40.30
Blenniidae	77.56	64.35	10.68	0.69	12.78	53.08
Groups: 2011 & 2014				Average dissimilarity = 84.21		
	Group 2011	Group 2014				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Ammodytidae	159.76	260.13	18.82	0.82	22.35	22.35
Gobiidae	117.10	91.69	10.43	0.75	12.38	34.74
Blenniidae	54.88	64.35	8.44	0.57	10.02	44.76
Clupeidae	132.74	78.18	8.20	0.71	9.74	54.50
Groups: 2012 & 2014				Average dissimilarity = 81.48		
	Group 2012	Group 2014				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Ammodytidae	354.95	260.13	26.38	1.03	32.38	32.38
Clupeidae	105.87	78.18	7.88	0.74	9.67	42.05
Gobiidae	46.40	91.69	7.75	0.70	9.51	51.56
Groups: 2013 & 2014				Average dissimilarity = 86.69		
	Group 2013	Group 2014				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Ammodytidae	147.80	260.13	23.00	0.91	26.53	26.53
Gobiidae	43.80	91.69	10.35	0.71	11.94	38.47
Blenniidae	27.39	64.35	9.11	0.57	10.50	48.98
Clupeidae	27.25	78.18	6.83	0.58	7.88	56.86

Table C.5 : Results of the SIMPER analysis showing all taxa contributing to the first 50% of dissimilarity within ichthyoplankton assemblages between seasons. Average abundance is fourth root transformed abundance (per 10^6 m^3).

Groups: Spring & Summer				Average dissimilarity = 89.68		
	Group Spring	Group Summer				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Ammodytidae	366.55	34.35	20.49	0.93	22.85	22.85
Pleuronectidae	232.20	7.30	10.12	0.93	11.29	34.14

Clupeidae	203.14	26.93	9.31	0.93	10.38	44.52
Gobiidae	79.45	130.74	7.77	0.96	8.67	53.19
Groups: Spring & Autumn				Average dissimilarity = 92.24		
	Group Spring	Group Autumn				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Ammodytidae	366.55	82.20	25.94	0.94	28.12	28.12
Pleuronectidae	232.20	0.00	12.46	0.90	13.51	41.62
Clupeidae	203.14	4.04	11.25	0.88	12.20	53.82
Groups: Summer & Autumn				Average dissimilarity = 93.68		
	Group Summer	Group Autumn				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Gobiidae	130.74	10.21	19.34	0.93	20.65	20.65
Blenniidae	107.73	13.72	17.51	0.78	18.69	39.34
Ammodytidae	34.35	82.20	16.19	0.68	17.28	56.62
Groups: Spring & Winter				Average dissimilarity = 76.66		
	Group Spring	Group Winter				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Ammodytidae	366.55	486.55	24.16	1.15	31.52	31.52
Pleuronectidae	232.20	0.00	9.97	0.91	13.00	44.52
Clupeidae	203.14	18.96	9.21	0.90	12.01	56.53
Groups: Summer & Winter				Average dissimilarity = 94.09		
	Group Summer	Group Winter				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Ammodytidae	34.35	486.55	39.22	1.41	41.68	41.68
Gobiidae	130.74	5.99	12.40	0.87	13.18	54.86
Groups: Autumn & Winter				Average dissimilarity = 84.93		
	Group Autumn	Group Winter				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Ammodytidae	82.20	486.55	58.73	1.73	69.14	69.14

Appendix D. Presence/Absence of fish taxa

Table D.1 : Presence/absence of fish taxa recorded from the seine nets, fish traps, diver surveys, subtidal, impingement, entrainment and ichthyoplankton surveys between 2010 and 2015. Those species only identified to family level are in bold.

Latin name	Common name	Seine nets	Fish traps	Diver surveys	Subtidal	Impingement	Entrainment	Ichthyoplankton
Taurulus bubalis	Long-spined sea scorpion							
Agonus cataphractus	Pogge							
Aphia minuta	Transparent goby							
Ctenolabrus rupestris	Goldsinny wrasse							
Merlangius merlangus	Whiting							
Pollachius pollachius	Pollack							
Symphodus melops	Corkwing wrasse							
Callionymus lyra	Common dragonet							
Callionymus reticulatus	Reticulated dragonet							
Ciliata mustela	Five-bearded rockling							
Clupea harengus	Herring							
Dicentrarchus labrax	Bass							
Echiichthys vipera	Lesser weever							
Gadus morhua	Cod							
Labrus bergylta	Ballan wrasse							
Limanda limanda	Dab							
Myoxocephalus scorpius	Short-spined sea scorpion							
Parablennius gattorugine	Tompot blenny							
Pholis gunnellus	Butterfish							
Platichthys flesus	Flounder							
Pleuronectes platessa	Plaice							
Scyliorhinus canicula	Lesser-spotted dogfish							
Spinachia spinachia	Fifteen-spined stickleback							
Sprattus sprattus	Sprat							
Syngnathus acus	Greater pipefish							
Trisopterus minutus	Poor cod							
Clupeidae	**Herring family**							
Ammodytes tobianus	Lesser sandeel							
Arnoglossus laterna	Scaldfish							
Buglossidium luteum	Solenette							
Entelurus aequoreus	Snake pipefish							
Eutrigla gurnardus	Grey gurnard							
Gobius paganellus	Rock goby							
Gobiusculus flavescens	Two-spotted goby							
Hyperoplus lanceolatus	Greater sandeel							
Liparis montagui	Montagu's sea snail							
Lipophrys pholis	Shanny							
Pomatoschistus microps	Common goby							
Pomatoschistus minutus	Sand goby							
Scophthalmus rhombus	Brill							
Solea solea	Dover sole							

Latin name	**Common name**	**Seine nets**	**Fish traps**	**Diver surveys**	**Subtidal**	**Impingement**	**Entrainment**	**Ichthyoplankton**
Syngnathus rostellatus	Nilsson's pipefish				■	■	■	■
***Callionymus* spp.**	**Dragonet genus**	■		■		■	■	
Gadidae	**Cod family**	■				■	■	■
Pomatoschistus spp.	Goby genus	■		■		■	■	
***Ammodytes* spp.**	**Sandeel genus**	■			■	■	■	
Blenniidae	**Blenny family**				■	■	■	■
Gobiidae	Goby family				■	■	■	■
Liparidae	**Sea snail family**				■	■	■	■
Ammodytes marinus	Raitt's sandeel				■		■	■
Atherina presbyter	Sand smelt	■			■	■		
Cyclopterus lumpus	Lumpsucker				■	■	■	
Diplecogaster bimaculata	Two-spotted clingfish				■		■	■
Gaidropsarus vulgaris	Three-bearded rockling		■		■	■		
Liparis liparis	Striped sea snail					■	■	■
Microchirus variegatus	Thickback sole				■		■	■
Phrynorhombus norvegicus	Norwegian topknot				■		■	■
Scyliorhinus stellaris	Bull huss		■		■	■		
Trisopterus luscus	Bib				■	■		■
Zeugopterus punctatus	Topknot			■	■			■
Lotidae	**Rockling family**	■					■	■
Soleidae	**Sole family**	■					■	■
Labridae	**Wrasse family**					■	■	■
Cottidae	**Sea scorpion family**					■	■	■
Triglidae	**Gurnard family**					■	■	■
Belone belone	Garfish	■					■	
Centrolabrus exoletus	Rock cook wrasse			■		■		
Chelidonichthys cuculus	Red gurnard				■	■		
Chelon labrosus	Thick-lipped grey mullet	■				■		
Chirolophis ascanii	Yarrell's blenny						■	■
Conger conger	Conger eel			■		■		
Gasterosteus aculeatus	Three-spined stickleback	■				■		
Gymnammodytes semisquamatus	Smooth sandeel						■	■
Labrus mixtus	Cuckoo wrasse			■		■		
Liza aurata	Golden grey mullet	■				■		
Melanogrammus aeglefinus	Haddock				■	■		
Microstomus kitt	Lemon sole				■	■		■
Nerophis lumbriciformis	Worm pipefish				■		■	
Pomatoschistus pictus	Painted goby	■			■			
Raja clavata	Thornback ray				■	■		
Raja montagui	Spotted ray				■	■		
Raniceps raninus	Tadpole fish				■	■		
Sardina pilchardus	Pilchard	■						■
Scomber scombrus	Mackerel				■			■
Thorogobius ephippiatus	Leopard-spotted goby			■		■		
Trachurus trachurus	Scad/horse mackerel				■	■		
Zeus faber	John Dory				■	■		

Latin name	Common name	Seine nets	Fish traps	Diver surveys	Subtidal	Impingement	Entrainment	Ichthyoplankton
Mugilidae	**Mullet family**							
Pleuronectidae	**Right-sided flatfish family**							
Syngnathidae	**Pipefish family**							
Indeterminate	Indeterminate							
Blennius ocellaris	Butterfly blenny							
Callionymus maculatus	Spotted dragonet							
Ciliata septentrionalis	Northern rockling							
Crystallogobius linearis	Crystal goby							
Gobius niger	Black goby							
Hippoglossoides platessoides	Long rough dab							
Hippoglossus hippoglossus	Atlantic halibut							
Lampetra fluviatilis	River lamprey							
Liza ramada	Thin-lipped grey mullet							
Maurolicus muelleri	Pearlside							
Micrenophrys lilljeborgii	Norway bullhead							
Molva molva	Ling							
Pollachius virens	Saithe							
Psetta maxima	Turbot							
Salmo trutta	Sea trout							
Zeugopterus regius	Eckstrom's topknot							
***Scyliorhinus* sp.**	**Dogfish genus**							
Trisopterus sp.	Poor cod genus							
Gobiesocidae	**Clingfish family**							
Ammodytidae	**Sandeel family**							
Callionymidae	**Dragonet family**							
Lebetus sp.	Goby species							
Bothidae	**Left-eyed flounder family**							
Scophthalmidae	**Topknot family**							
Capros aper	Boarfish							
Chelidonichthys lucernus	Tub gurnard							
Galeorhinus galeus	Tope							
Gobiesocidae spp.	Clingfish							
Lepidorhombus whiffiagonis	Megrim							
Lophius piscatorius	Anglerfish							
Micromesistius poutassou	Blue whiting							
Mullus surmeletus	Red mullet							
Mustelus asterias	Starry smooth hound							
Mustelus mustelus	Smooth hound							
Pomatoschistus lozanoi	Lozano's goby							
Raja brachyura	Blonde ray							
Raja microocellata	Small-eyed ray							
Squalus acanthias	Spurdog							
Dasyatis pastinaca	Common stingray							

Appendix E. Feeding Guilds Explained

Table G.1 : Feeding guilds of fish (Elliott *et al.*, 2007).

Guild	Description	Example species
Zooplankton (**Z**)	Species feeding on zooplankton	Sprat, herring, lesser sandeel, pipefish, goby spp.
Benthovores (**B**)	Species feeding principally on benthic organisms	Flounder, pogge, wrasse spp., goby spp., dab
Piscivores (**P**)	Species feeding on other fish species	Bass, cod, whiting, brill, turbot
Detritivores (**D**)	Species feeding on detritus	All mullet species
Omnivores (**O**)	Species feeding on a range of food types	

Appendix F. Results of Intertidal Survey Statistics

Table F.1 : Results of the two-way crossed SIMPER analysis (factors were 'Season' and 'Year') showing all taxa contributing to similarities within intertidal fish communities between seasons. Average abundance is square root transformed.

Group Spring			Average similarity: 33.88		
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib.%	Cum.%
Ammodytes spp.	5.07	27.51	1.24	81.20	81.20
Pleuronectes platessa	1.25	3.25	0.39	9.61	90.81
Group Summer			Average similarity: 40.23		
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib.%	Cum.%
Clupeidae	6.83	13.74	0.80	34.15	34.15
Atherina presbyter	3.15	10.83	0.69	26.91	61.06
Ammodytes spp.	2.97	7.73	1.09	19.22	80.28
Pleuronectes platessa	3.05	5.18	0.61	12.87	93.16
Group Autumn			Average similarity: 37.77		
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib.%	Cum.%
Atherina presbyter	4.11	28.81	1.31	76.29	76.29
Clupeidae	0.76	2.48	0.42	6.58	82.86
Ammodytes spp.	0.42	2.14	0.26	5.66	88.52
Pleuronectes platessa		0.56	1.80	0.33	4.76
Group Winter			Average similarity: 33.44		
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib.%	Cum.%
Atherina presbyter	2.09	25.50	1.16	76.24	76.24
Pleuronectes platessa	0.44	1.83	0.28	5.48	81.73
Clupeidae	0.30	1.36	0.18	4.06	85.79
Mugilidae	0.28	1.32	0.26	3.96	89.74
Spinachia spinachia	0.11	1.17	0.29	3.50	93.25

Table F.2 : Results of the two-way crossed SIMPER analysis (factors were 'Season' and 'Year') showing all taxa contributing to dissimilarities within intertidal fish communities between seasons. Average abundance is square root transformed.

Groups Spring & Summer				Average dissimilarity = 79.32		
	Group Spring	Group Summer				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Clupeidae	0.34	6.83	23.54	1.01	29.68	29.68
Ammodytes spp.	5.07	2.97	15.51	1.12	19.55	49.23
Atherina presbyter	0.64	3.15	12.98	0.79	16.37	65.59
Pleuronectes platessa	1.25	3.05	11.63	0.91	14.67	80.26
Pomatoschistus spp.	0.11	1.07	4.35	0.49	5.49	85.75
Psetta maxima	0.23	0.21	1.60	0.61	2.02	87.77
Platichthys flesus	0.27	0.21	1.37	0.66	1.73	89.50
Spinachia spinachia	0.03	0.24	1.16	0.33	1.46	90.96

Groups Spring & Autumn				Average dissimilarity = 84.02		
	Group Spring	Group Autumn				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Ammodytes spp.	5.07	0.42	26.07	1.31	31.03	31.03
Atherina presbyter	0.64	4.11	25.56	1.30	30.42	61.45
Pleuronectes platessa	1.25	0.56	8.66	0.83	10.31	71.76
Clupeidae	0.34	0.76	6.29	0.67	7.48	79.24
Psetta maxima	0.23	0.31	3.72	0.50	4.43	83.67
Mugilidae	0.11	0.44	3.30	0.56	3.92	87.59
Platichthys flesus	0.27	0.15	2.37	0.55	2.82	90.41
Groups Summer & Autumn				Average dissimilarity = 77.02		
	Group Summer	Group Autumn				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Atherina presbyter	3.15	4.11	19.79	1.26	25.70	25.70
Clupeidae	6.83	0.76	18.86	0.96	24.49	50.18
Pleuronectes platessa	3.05	0.56	11.01	0.88	14.30	64.48
Ammodytes spp.	2.97	0.42	9.95	1.02	12.92	77.40
Pomatoschistus spp.	1.07	0.12	4.17	0.52	5.41	82.81
Psetta maxima	0.21	0.31	2.24	0.48	2.91	85.73
Mugilidae	0.13	0.44	1.97	0.59	2.56	88.29
Spinachia spinachia	0.24	0.16	1.38	0.44	1.79	90.08
Groups Spring & Winter			Average dissimilarity = 87.06			
	Group Spring	Group Winter				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Ammodytes spp.	5.07	0.33	32.95	1.57	37.85	37.85
Atherina presbyter	0.64	2.09	18.94	1.09	21.76	59.60
Pleuronectes platessa	1.25	0.44	10.76	0.88	12.36	71.96
Clupeidae	0.34	0.30	6.84	0.61	7.86	79.82
Mugilidae	0.11	0.28	3.16	0.56	3.63	83.45
Psetta maxima	0.23	0.09	3.16	0.45	3.63	87.08
Platichthys flesus	0.27	0.08	2.58	0.51	2.96	90.04
Groups Summer & Winter			Average dissimilarity = 78.09			
	Group Summer	Group Winter				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Atherina presbyter	3.15	2.09	20.91	1.14	26.78	26.78
Clupeidae	6.83	0.30	14.70	0.86	18.83	45.61
Pleuronectes platessa	3.05	0.44	13.42	0.92	17.19	62.79
Ammodytes spp.	2.97	0.33	10.92	1.05	13.98	76.78
Pomatoschistus spp.	1.07	0.08	4.42	0.51	5.66	82.44
Hyperoplus lanceolatus	0.26	0.00	2.01	0.31	2.57	85.02
Mugilidae	0.13	0.28	1.93	0.61	2.48	87.49

Psetta maxima	0.21	0.09	1.88	0.56	2.41	89.90
Scophthalmus rhombus	0.16	0.13	1.81	0.68	2.31	92.22
Groups Autumn & Winter			Average dissimilarity = 68.81			
	Group Autumn	Group Winter				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Atherina presbyter	4.11	2.09	25.72	1.31	37.38	37.38
Pleuronectes platessa	0.56	0.44	7.25	0.83	10.54	47.92
Ammodytes spp.	0.42	0.33	6.64	0.63	9.65	57.57
Clupeidae	0.76	0.30	5.89	0.59	8.56	66.13
Mugilidae	0.44	0.28	5.39	0.69	7.83	73.96
Psetta maxima	0.31	0.09	5.13	0.54	7.46	81.42
Spinachia spinachia	0.16	0.11	2.26	0.53	3.29	84.71
Platichthys flesus	0.15	0.08	1.99	0.54	2.89	87.60
Scophthalmus rhombus	0.01	0.13	1.97	0.33	2.86	90.46

Table F.3 : Results of the one-way SIMPER analysis (factors was 'Site') showing all taxa contributing to dissimilarities within intertidal fish communities between sites. Average abundance is square root transformed.

Groups IF01 & IF02			Average dissimilarity = 72.47			
	Group IF1	Group IF2				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	3.46	1.73	19.69	1.1	27.17	27.17
Atherina presbyter	2.73	1.85	19.3	1.11	26.64	53.8
Pleuronectes platessa	1.63	0.85	7.86	1.32	10.84	64.64
Psetta maxima	0.49	1.13	7.3	0.86	10.07	74.72
Clupeidae	0.37	0.36	3.36	0.7	4.63	79.35
Mugilidae	0.15	0.33	3.2	0.55	4.42	83.76
Hyperoplus lanceolatus	0.41	0.33	2.95	0.43	4.07	87.83
Scophthalmus rhombus	0.14	0.33	2.95	0.56	4.07	91.9
Groups IF01 & IF03			Average dissimilarity = 73.00			
	Group IF1	Group IF3				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	3.46	2.91	20.24	1.09	27.73	27.73
Atherina presbyter	2.73	2.42	17.02	1.11	23.32	51.05
Pleuronectes platessa	1.63	1.18	8.75	1.32	11.98	63.03
Clupeidae	0.37	2.09	8.62	0.84	11.81	74.84
Pomatoschistus spp.	0.39	0.49	3.37	0.74	4.61	79.45
Psetta maxima	0.49	0.03	2.95	0.88	4.04	83.5
Echiichthys vipera	0.15	0.38	1.66	0.82	2.27	85.76
Mugilidae	0.15	0.09	1.63	0.4	2.23	88
Hyperoplus lanceolatus	0.41	0.04	1.6	0.34	2.19	90.19

Groups IF02 & IF03			Average dissimilarity = 80.43			
	Group IF2	Group IF3				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	1.73	2.91	17.82	1.05	22.16	22.16
Atherina presbyter	1.85	2.42	17.02	1.1	21.17	43.33
Clupeidae	0.36	2.09	9.74	0.85	12.11	55.44
Psetta maxima	1.13	0.03	8.8	0.78	10.94	66.38
Pleuronectes platessa	0.85	1.18	7.87	1.04	9.78	76.16
Mugilidae	0.33	0.09	3.41	0.53	4.24	80.4
Scophthalmus rhombus	0.33	0	2.69	0.45	3.35	83.75
Spinachia spinachia	0.13	0.27	2.44	0.44	3.04	86.78
Pomatoschistus spp.	0	0.49	2.4	0.65	2.99	89.77
Hyperoplus lanceolatus	0.33	0.04	1.96	0.33	2.43	92.2
Groups IF01 & IF05			Average dissimilarity = 77.03			
	Group IF1	Group IF5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	2.73	4.6	24.33	1.29	31.58	31.58
Ammodytes spp.	3.46	1.32	17.72	1	23.01	54.59
Clupeidae	0.37	2.79	11.81	0.66	15.33	69.91
Pleuronectes platessa	1.63	0	8.46	1.48	10.98	80.9
Psetta maxima	0.49	0	2.97	0.9	3.86	84.75
Pomatoschistus spp.	0.39	0	1.87	0.43	2.43	87.18
Mugilidae	0.15	0.14	1.76	0.5	2.28	89.46
Hyperoplus lanceolatus	0.41	0.12	1.66	0.35	2.16	91.62
Groups IF02 & IF05			Average dissimilarity = 83.09			
	Group IF2	Group IF5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	1.85	4.6	28.51	1.29	34.31	34.31
Ammodytes spp.	1.73	1.32	13.45	0.92	16.19	50.5
Clupeidae	0.36	2.79	13.24	0.67	15.94	66.44
Psetta maxima	1.13	0	8.78	0.8	10.57	77.01
Pleuronectes platessa	0.85	0	5.26	0.93	6.33	83.34
Mugilidae	0.33	0.14	3.45	0.58	4.15	87.49
Spinachia spinachia	0.13	0.15	2.74	0.48	3.3	90.79
Groups IF03 & IF05			Average dissimilarity = 77.11			
	Group IF3	Group IF5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	2.42	4.6	25.4	1.25	32.94	32.94
Clupeidae	2.09	2.79	16.35	0.87	21.2	54.14

Ammodytes spp.	2.91	1.32	15.2	0.93	19.72	73.86
Pleuronectes platessa	1.18	0	5.63	0.73	7.3	81.16
Spinachia spinachia	0.27	0.15	2.3	0.57	2.99	84.14
Pomatoschistus spp.	0.49	0	2.24	0.63	2.9	87.04
Mugilidae	0.09	0.14	1.76	0.49	2.29	89.33
Echiichthys vipera	0.38	0	1.43	0.67	1.85	91.18
Groups IF01 & IF06			Average dissimilarity = 70.01			
	Group IF1	Group IF6				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	3.46	3.42	19.26	1.02	27.52	27.52
Atherina presbyter	2.73	1.23	14.08	1.03	20.11	47.63
Pleuronectes platessa	1.63	3.01	11.79	1.08	16.85	64.47
Clupeidae	0.37	1.18	5.09	0.72	7.27	71.74
Platichthys flesus	0.13	0.76	3.48	0.89	4.97	76.71
Mugilidae	0.15	0.68	3.41	0.57	4.88	81.59
Pomatoschistus spp.	0.39	0.6	3.29	0.65	4.7	86.29
Psetta maxima	0.49	0.48	2.84	0.94	4.05	90.35
Groups IF02 & IF06			Average dissimilarity = 76.71			
	Group IF2	Group IF6				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	1.73	3.42	16.25	0.9	21.18	21.18
Pleuronectes platessa	0.85	3.01	13.94	1.06	18.17	39.35
Atherina presbyter	1.85	1.23	13.66	0.99	17.81	57.17
Psetta maxima	1.13	0.48	7.11	0.8	9.27	66.44
Clupeidae	0.36	1.18	5.64	0.73	7.35	73.79
Mugilidae	0.33	0.68	4.76	0.66	6.21	80
Platichthys flesus	0.04	0.76	4.03	0.86	5.26	85.26
Scophthalmus rhombus	0.33	0.21	2.89	0.6	3.77	89.02
Pomatoschistus spp.	0	0.6	2.18	0.48	2.85	91.87
Groups IF03 & IF06			Average dissimilarity = 76.03			
	Group IF3	Group IF6				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	2.91	3.42	17.38	0.94	22.86	22.86
Pleuronectes platessa	1.18	3.01	13.94	1.06	18.34	41.2
Atherina presbyter	2.42	1.23	12.26	0.99	16.12	57.32
Clupeidae	2.09	1.18	9.89	0.91	13.01	70.33
Platichthys flesus	0.22	0.76	3.82	0.84	5.02	75.35
Mugilidae	0.09	0.68	3.5	0.55	4.6	79.95
Pomatoschistus spp.	0.49	0.6	3.46	0.76	4.56	84.5
Psetta maxima	0.03	0.48	2.6	0.81	3.42	87.92

Echiichthys vipera	0.38	0.33	2.37	0.73	3.12	91.04
Groups IF05 & IF06			Average dissimilarity = 82.67			
	Group IF5	Group IF6				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	4.6	1.23	21.71	1.14	26.27	26.27
Pleuronectes platessa	0	3.01	14.59	1.08	17.65	43.92
Ammodytes spp.	1.32	3.42	13.75	0.79	16.64	60.55
Clupeidae	2.79	1.18	12.94	0.74	15.65	76.2
Platichthys flesus	0	0.76	3.78	0.83	4.57	80.77
Mugilidae	0.14	0.68	3.52	0.59	4.26	85.03
Psetta maxima	0	0.48	2.6	0.82	3.15	88.18
Pomatoschistus spp.	0	0.6	2.06	0.48	2.49	90.67
Groups IF01 & IF07			Average dissimilarity = 68.22			
	Group IF1	Group IF7				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	3.46	2.87	19.78	1.07	29	29
Atherina presbyter	2.73	3.3	18.8	1.16	27.56	56.55
Clupeidae	0.37	1.78	7.9	0.59	11.58	68.13
Pleuronectes platessa	1.63	0.82	7.89	1.39	11.57	79.7
Psetta maxima	0.49	0.03	2.72	0.93	3.99	83.69
Pomatoschistus spp.	0.39	0.25	2.71	0.66	3.97	87.65
Mugilidae	0.15	0.21	1.69	0.55	2.48	90.14
Groups IF02 & IF07			Average dissimilarity = 77.70			
	Group IF2	Group IF7				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	1.85	3.3	22.44	1.16	28.89	28.89
Ammodytes spp.	1.73	2.87	18.14	1	23.34	52.23
Clupeidae	0.36	1.78	8.89	0.61	11.44	63.67
Psetta maxima	1.13	0.03	7.95	0.82	10.23	73.9
Pleuronectes platessa	0.85	0.82	7.02	1.03	9.04	82.94
Mugilidae	0.33	0.21	3.15	0.61	4.06	86.99
Scophthalmus rhombus	0.33	0.08	2.62	0.52	3.38	90.37
Groups IF03 & IF07			Average dissimilarity = 71.71			
	Group IF3	Group IF7				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	2.91	2.87	18.94	1.01	26.42	26.42
Atherina presbyter	2.42	3.3	18.81	1.06	26.23	52.65
Clupeidae	2.09	1.78	12.62	0.86	17.59	70.24
Pleuronectes platessa	1.18	0.82	7.38	0.92	10.29	80.53

Pomatoschistus spp.	0.49	0.25	2.84	0.81	3.95	84.49
Mugilidae	0.09	0.21	1.66	0.56	2.32	86.8
Spinachia spinachia	0.27	0.08	1.47	0.54	2.05	88.85
Echiichthys vipera	0.38	0	1.36	0.68	1.9	90.75
Groups IF05 & IF07			Average dissimilarity = 71.31			
	Group IF5	Group IF7				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	4.6	3.3	25.08	1.28	35.17	35.17
Ammodytes spp.	1.32	2.87	15.99	0.9	22.42	57.59
Clupeidae	2.79	1.78	15.75	0.79	22.09	79.68
Pleuronectes platessa	0	0.82	4.97	0.68	6.98	86.66
Mugilidae	0.14	0.21	1.64	0.71	2.3	88.96
Spinachia spinachia	0.15	0.08	1.64	0.49	2.3	91.26
Groups IF06 & IF07			Average dissimilarity = 74.06			
	Group IF6	Group IF7				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	3.42	2.87	17.95	0.94	24.24	24.24
Atherina presbyter	1.23	3.3	15.65	0.97	21.13	45.36
Pleuronectes platessa	3.01	0.82	12.96	1.11	17.5	62.87
Clupeidae	1.18	1.78	9.39	0.69	12.68	75.55
Platichthys flesus	0.76	0.06	3.5	0.87	4.73	80.28
Mugilidae	0.68	0.21	3.31	0.6	4.48	84.75
Pomatoschistus spp.	0.6	0.25	2.84	0.66	3.83	88.59
Psetta maxima	0.48	0.03	2.44	0.86	3.29	91.88
Groups IF01 & IF10			Average dissimilarity = 75.86			
	Group IF1	Group IF10				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	2.73	3.59	19.93	1.28	26.27	26.27
Ammodytes spp.	3.46	0.77	17.87	0.95	23.55	49.83
Pleuronectes platessa	1.63	0.21	7.91	1.46	10.43	60.25
Clupeidae	0.37	1.07	5.88	0.76	7.74	68
Pomatoschistus spp.	0.39	1	5.8	0.53	7.64	75.64
Psetta maxima	0.49	0	2.89	0.97	3.81	79.45
Mugilidae	0.15	0.32	2.57	0.62	3.39	82.84
Spinachia spinachia	0	0.51	2.44	0.55	3.22	86.06
Platichthys flesus	0.13	0.17	1.59	0.62	2.1	88.16
Pollachius pollachius	0	0.27	1.45	0.52	1.91	90.07
Groups IF02 & IF10			Average dissimilarity = 84.19			
	Group IF2	Group IF10				

Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	1.85	3.59	24.85	1.34	29.52	29.52
Ammodytes spp.	1.73	0.77	13.66	0.81	16.22	45.74
Psetta maxima	1.13	0	8.47	0.85	10.06	55.8
Clupeidae	0.36	1.07	6.59	0.78	7.83	63.63
Pomatoschistus spp.	0	1	5.29	0.43	6.28	69.91
Pleuronectes platessa	0.85	0.21	5.26	1.01	6.24	76.16
Mugilidae	0.33	0.32	4.02	0.7	4.77	80.93
Spinachia spinachia	0.13	0.51	3.63	0.59	4.32	85.25
Scophthalmus rhombus	0.33	0	2.56	0.49	3.04	88.29
Hyperoplus lanceolatus	0.33	0	1.72	0.3	2.05	90.33
Groups IF03 & IF10			Average dissimilarity = 75.64			
	Group IF3	Group IF10				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	2.42	3.59	19.98	1.14	26.41	26.41
Ammodytes spp.	2.91	0.77	14.9	0.82	19.7	46.11
Clupeidae	2.09	1.07	10.84	0.96	14.33	60.45
Pomatoschistus spp.	0.49	1	5.99	0.53	7.92	68.37
Pleuronectes platessa	1.18	0.21	5.82	0.82	7.69	76.06
Spinachia spinachia	0.27	0.51	3.26	0.69	4.32	80.38
Mugilidae	0.09	0.32	2.6	0.6	3.44	83.81
Platichthys flesus	0.22	0.17	1.85	0.62	2.44	86.26
Pollachius pollachius	0.09	0.27	1.72	0.58	2.27	88.53
Echiichthys vipera	0.38	0	1.42	0.69	1.87	90.4
Groups IF05 & IF10			Average dissimilarity = 71.83			
	Group IF5	Group IF10				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	4.6	3.59	26.22	1.37	36.51	36.51
Clupeidae	2.79	1.07	14.27	0.78	19.87	56.38
Ammodytes spp.	1.32	0.77	10.19	0.66	14.18	70.56
Pomatoschistus spp.	0	1	4.94	0.42	6.88	77.44
Spinachia spinachia	0.15	0.51	3.42	0.7	4.77	82.21
Mugilidae	0.14	0.32	2.66	0.71	3.71	85.92
Pollachius pollachius	0.1	0.27	1.76	0.59	2.45	88.36
Dicentrarchus labrax	0.05	0.17	1.49	0.45	2.08	90.44
Groups IF06 & IF10			Average dissimilarity = 79.61			
	Group IF6	Group IF10				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	1.23	3.59	16.55	1.02	20.79	20.79

Pleuronectes platessa	3.01	0.21	13.9	1.09	17.45	38.25
Ammodytes spp.	3.42	0.77	13.82	0.74	17.36	55.6
Clupeidae	1.18	1.07	7.46	0.83	9.38	64.98
Pomatoschistus spp.	0.6	1	5.76	0.53	7.24	72.21
Mugilidae	0.68	0.32	4.01	0.67	5.04	77.26
Platichthys flesus	0.76	0.17	3.81	0.92	4.78	82.04
Psetta maxima	0.48	0	2.56	0.86	3.21	85.25
Spinachia spinachia	0.06	0.51	2.46	0.57	3.09	88.34
Echiichthys vipera	0.33	0	1.57	0.5	1.98	90.32
Groups IF07 & IF10			Average dissimilarity = 70.80			
	Group IF7	Group IF10				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	3.3	3.59	19.83	1.19	28.01	28.01
Ammodytes spp.	2.87	0.77	16.28	0.87	23	51.01
Clupeidae	1.78	1.07	10.35	0.74	14.62	65.63
Pomatoschistus spp.	0.25	1	5.25	0.49	7.41	73.04
Pleuronectes platessa	0.82	0.21	5.13	0.76	7.24	80.28
Spinachia spinachia	0.08	0.51	2.69	0.62	3.79	84.08
Mugilidae	0.21	0.32	2.49	0.76	3.52	87.59
Pollachius pollachius	0.03	0.27	1.55	0.56	2.19	89.79
Platichthys flesus	0.06	0.17	1.28	0.52	1.8	91.59
Groups IF01 & IF09			Average dissimilarity = 76.78			
	Group IF1	Group IF9				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	2.73	3.31	20.18	1.27	26.28	26.28
Ammodytes spp.	3.46	0.72	17.61	0.95	22.94	49.22
Clupeidae	0.37	3.24	13.77	0.72	17.94	67.15
Pleuronectes platessa	1.63	0.06	8.54	1.47	11.13	78.28
Pomatoschistus spp.	0.39	0.69	3.91	0.46	5.09	83.37
Psetta maxima	0.49	0	3.13	0.92	4.08	87.45
Mugilidae	0.15	0.14	1.64	0.45	2.14	89.59
Hyperoplus lanceolatus	0.41	0.07	1.62	0.34	2.11	91.7
Groups IF02 & IF09			Average dissimilarity = 83.37			
	Group IF2	Group IF9				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	1.85	3.31	23.75	1.34	28.48	28.48
Clupeidae	0.36	3.24	15.63	0.75	18.75	47.24
Ammodytes spp.	1.73	0.72	12.83	0.88	15.39	62.62
Psetta maxima	1.13	0	9.34	0.81	11.21	73.83
Pleuronectes platessa	0.85	0.06	5.52	0.95	6.62	80.45

Mugilidae	0.33	0.14	3.54	0.55	4.25	84.7
Scophthalmus rhombus	0.33	0	2.85	0.47	3.42	88.12
Spinachia spinachia	0.13	0.18	2.41	0.44	2.89	91.01
Groups IF03 & IF09			Average dissimilarity = 75.71			
	Group IF3	Group IF9				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	2.42	3.31	20.34	1.24	26.87	26.87
Clupeidae	2.09	3.24	18.35	0.94	24.23	51.1
Ammodytes spp.	2.91	0.72	14.46	0.86	19.1	70.2
Pleuronectes platessa	1.18	0.06	6.06	0.76	8	78.21
Pomatoschistus spp.	0.49	0.69	4.29	0.51	5.66	83.87
Spinachia spinachia	0.27	0.18	2.08	0.62	2.74	86.61
Mugilidae	0.09	0.14	1.65	0.45	2.17	88.78
Echiichthys vipera	0.38	0	1.49	0.67	1.96	90.75
Groups IF05 & IF09			Average dissimilarity = 69.48			
	Group IF5	Group IF9				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	4.6	3.31	27.13	1.29	39.05	39.05
Clupeidae	2.79	3.24	21.5	0.91	30.94	69.99
Ammodytes spp.	1.32	0.72	9.3	0.73	13.38	83.37
Spinachia spinachia	0.15	0.18	2.27	0.57	3.26	86.64
Pomatoschistus spp.	0	0.69	2.22	0.27	3.19	89.83
Mugilidae	0.14	0.14	1.72	0.61	2.48	92.31
Groups IF06 & IF09			Average dissimilarity = 81.55			
	Group IF6	Group IF9				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	1.23	3.31	16.75	1.13	20.54	20.54
Pleuronectes platessa	3.01	0.06	14.99	1.09	18.37	38.91
Clupeidae	1.18	3.24	14.93	0.8	18.31	57.22
Ammodytes spp.	3.42	0.72	12.95	0.75	15.88	73.11
Pomatoschistus spp.	0.6	0.69	3.97	0.47	4.87	77.98
Platichthys flesus	0.76	0	3.96	0.83	4.86	82.84
Mugilidae	0.68	0.14	3.59	0.57	4.4	87.24
Psetta maxima	0.48	0	2.74	0.83	3.36	90.59
Groups IF07 & IF09			Average dissimilarity = 71.00			
	Group IF7	Group IF9				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	3.3	3.31	21	1.18	29.57	29.57
Clupeidae	1.78	3.24	17.54	0.85	24.7	54.28

Ammodytes spp.	2.87	0.72	15.69	0.85	22.1	76.37
Pleuronectes platessa	0.82	0.06	5.34	0.71	7.52	83.89
Pomatoschistus spp.	0.25	0.69	3.46	0.43	4.88	88.77
Mugilidae	0.21	0.14	1.63	0.72	2.29	91.06
Groups IF10 & IF09			Average dissimilarity = 70.69			
	Group IF10	Group IF9				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	3.59	3.31	22.01	1.29	31.14	31.14
Clupeidae	1.07	3.24	16.31	0.85	23.07	54.21
Ammodytes spp.	0.77	0.72	8.57	0.57	12.13	66.34
Pomatoschistus spp.	1	0.69	6.94	0.51	9.82	76.15
Spinachia spinachia	0.51	0.18	3.28	0.7	4.63	80.79
Mugilidae	0.32	0.14	2.69	0.67	3.81	84.6
Pollachius pollachius	0.27	0.08	1.8	0.57	2.55	87.14
Dicentrarchus labrax	0.17	0.06	1.5	0.47	2.12	89.26
Taurulus bubalis	0.23	0.03	1.42	0.46	2.01	91.27
Groups IF01 & IF11			Average dissimilarity = 73.64			
	Group IF1	Group IF11				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	3.46	3.35	19.83	1.11	26.92	26.92
Atherina presbyter	2.73	0.61	14.8	0.9	20.1	47.03
Clupeidae	0.37	7.17	13.56	0.61	18.42	65.45
Pleuronectes platessa	1.63	2.5	10.54	1.15	14.32	79.77
Pomatoschistus spp.	0.39	0.31	3.21	0.57	4.36	84.13
Psetta maxima	0.49	0.2	3.05	0.84	4.14	88.27
Echiichthys vipera	0.15	0.51	2.27	0.61	3.08	91.35
Groups IF02 & IF11			Average dissimilarity = 79.19			
	Group IF2	Group IF11				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	1.73	3.35	17.8	1.08	22.47	22.47
Clupeidae	0.36	7.17	14.52	0.62	18.34	40.81
Atherina presbyter	1.85	0.61	11.35	0.76	14.33	55.14
Pleuronectes platessa	0.85	2.5	11.29	1.02	14.25	69.39
Psetta maxima	1.13	0.2	8.29	0.75	10.47	79.85
Mugilidae	0.33	0	2.84	0.44	3.58	83.44
Scophthalmus rhombus	0.33	0.03	2.66	0.45	3.36	86.8
Platichthys flesus	0.04	0.39	2.41	0.73	3.05	89.84
Echiichthys vipera	0.05	0.51	2.37	0.55	3	92.84

Groups IF03 & IF11			Average dissimilarity = 76.84			
	Group IF3	Group IF11				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	2.91	3.35	18.94	1.08	24.65	24.65
Clupeidae	2.09	7.17	18.24	0.82	23.73	48.38
Atherina presbyter	2.42	0.61	12.2	0.88	15.88	64.26
Pleuronectes platessa	1.18	2.5	11.42	0.98	14.87	79.12
Pomatoschistus spp.	0.49	0.31	3.47	0.57	4.52	83.64
Echiichthys vipera	0.38	0.51	2.91	0.72	3.79	87.43
Platichthys flesus	0.22	0.39	2.54	0.74	3.3	90.74
Groups IF05 & IF11			Average dissimilarity = 84.72			
	Group IF5	Group IF11				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	4.6	0.61	23.99	1.08	28.31	28.31
Clupeidae	2.79	7.17	20.94	0.81	24.72	53.03
Ammodytes spp.	1.32	3.35	15.84	0.99	18.69	71.72
Pleuronectes platessa	0	2.5	10.6	0.9	12.51	84.23
Platichthys flesus	0	0.39	2.24	0.68	2.65	86.88
Pomatoschistus spp.	0	0.31	2.2	0.37	2.6	89.48
Echiichthys vipera	0	0.51	2.06	0.5	2.44	91.91
Groups IF06 & IF11			Average dissimilarity = 74.26			
	Group IF6	Group IF11				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	3.42	3.35	17.58	0.98	23.67	23.67
Clupeidae	1.18	7.17	14.82	0.68	19.96	43.62
Pleuronectes platessa	3.01	2.5	14.56	1.1	19.61	63.23
Atherina presbyter	1.23	0.61	8.65	0.75	11.65	74.88
Platichthys flesus	0.76	0.39	3.71	0.85	4.99	79.88
Pomatoschistus spp.	0.6	0.31	3.34	0.58	4.5	84.37
Mugilidae	0.68	0	3.02	0.49	4.07	88.44
Echiichthys vipera	0.33	0.51	2.9	0.68	3.9	92.35
Groups IF07 & IF11			Average dissimilarity = 76.38			
	Group IF7	Group IF11				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	2.87	3.35	18.47	1.02	24.18	24.18
Atherina presbyter	3.3	0.61	17.71	0.92	23.19	47.36
Clupeidae	1.78	7.17	17.69	0.75	23.17	70.53

Pleuronectes platessa	0.82	2.5	10.46	0.98	13.7	84.23
Pomatoschistus spp.	0.25	0.31	2.72	0.54	3.56	87.79
Platichthys flesus	0.06	0.39	2.08	0.73	2.72	90.52
Groups IF10 & IF11			Average dissimilarity = 84.54			
	Group IF10	Group IF11				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	3.59	0.61	19.69	1.03	23.29	23.29
Ammodytes spp.	0.77	3.35	16.25	0.93	19.22	42.52
Clupeidae	1.07	7.17	16.06	0.72	19	61.52
Pleuronectes platessa	0.21	2.5	10.26	0.93	12.13	73.65
Pomatoschistus spp.	1	0.31	5.74	0.5	6.79	80.44
Platichthys flesus	0.17	0.39	2.56	0.8	3.02	83.47
Spinachia spinachia	0.51	0	2.49	0.53	2.95	86.41
Mugilidae	0.32	0	2.11	0.53	2.49	88.91
Echiichthys vipera	0	0.51	2.04	0.51	2.41	91.32
Groups IF09 & IF11			Average dissimilarity = 83.91			
	Group IF9	Group IF11				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Clupeidae	3.24	7.17	23.39	0.9	27.88	27.88
Atherina presbyter	3.31	0.61	18.84	1.06	22.45	50.32
Ammodytes spp.	0.72	3.35	15.62	0.95	18.62	68.94
Pleuronectes platessa	0.06	2.5	11.03	0.93	13.15	82.09
Pomatoschistus spp.	0.69	0.31	4.22	0.45	5.03	87.12
Platichthys flesus	0	0.39	2.36	0.71	2.82	89.94
Echiichthys vipera	0	0.51	2.15	0.5	2.57	92.5
Groups IF01 & IF12			Average dissimilarity = 75.10			
	Group IF1	Group IF12				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	3.46	3.1	18.71	1.02	24.92	24.92
Pleuronectes platessa	1.63	5.56	16.22	1.2	21.6	46.52
Atherina presbyter	2.73	0.87	14.7	0.88	19.58	66.09
Clupeidae	0.37	4.51	12.71	0.75	16.93	83.02
Pomatoschistus spp.	0.39	0.46	3.06	0.61	4.08	87.1
Psetta maxima	0.49	0.09	2.7	0.81	3.59	90.69
Groups IF02 & IF12			Average dissimilarity = 79.79			
	Group IF2	Group IF12				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%

Pleuronectes platessa	0.85	5.56	17.98	1.15	22.54	22.54
Ammodytes spp.	1.73	3.1	16.48	0.96	20.66	43.2
Clupeidae	0.36	4.51	13.84	0.76	17.35	60.55
Atherina presbyter	1.85	0.87	11.3	0.71	14.16	74.71
Psetta maxima	1.13	0.09	7.76	0.74	9.72	84.44
Mugilidae	0.33	0.16	3.16	0.52	3.96	88.39
Scophthalmus rhombus	0.33	0.09	2.52	0.45	3.16	91.55
Groups IF03 & IF12			Average dissimilarity = 77.20			
	Group IF3	Group IF12				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ammodytes spp.	2.91	3.1	17.71	0.97	22.94	22.94
Pleuronectes platessa	1.18	5.56	17.24	1.07	22.34	45.27
Clupeidae	2.09	4.51	16.46	0.94	21.32	66.59
Atherina presbyter	2.42	0.87	12.45	0.85	16.13	82.72
Pomatoschistus spp.	0.49	0.46	3.27	0.7	4.23	86.95
Mugilidae	0.09	0.16	1.62	0.43	2.1	89.06
Echiichthys vipera	0.38	0.25	1.62	0.78	2.1	91.15
Groups IF05 & IF12			Average dissimilarity = 83.74			
	Group IF5	Group IF12				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	4.6	0.87	23.01	1.04	27.47	27.47
Clupeidae	2.79	4.51	18.96	0.89	22.65	50.12
Pleuronectes platessa	0	5.56	17.44	1.05	20.83	70.95
Ammodytes spp.	1.32	3.1	14.71	0.87	17.56	88.52
Pomatoschistus spp.	0	0.46	1.93	0.45	2.3	90.82
Groups IF06 & IF12			Average dissimilarity = 75.32			
	Group IF6	Group IF12				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Pleuronectes platessa	3.01	5.56	18.81	1.28	24.97	24.97
Ammodytes spp.	3.42	3.1	16.59	0.89	22.03	47
Clupeidae	1.18	4.51	13.58	0.81	18.04	65.04
Atherina presbyter	1.23	0.87	9.27	0.74	12.31	77.35
Platichthys flesus	0.76	0.12	3.37	0.76	4.47	81.83
Mugilidae	0.68	0.16	3.23	0.55	4.29	86.12
Pomatoschistus spp.	0.6	0.46	3.2	0.64	4.25	90.37
Groups IF07 & IF12			Average dissimilarity = 76.49			
	Group IF7	Group IF12				
Species	Av.Abund		Av.Diss	Diss/SD	Contrib%	Cum.%

		Av.Abund				
Atherina presbyter	3.3	0.87	17.54	0.91	22.93	22.93
Ammodytes spp.	2.87	3.1	17.39	0.92	22.73	45.66
Pleuronectes platessa	0.82	5.56	16.37	1.09	21.4	67.06
Clupeidae	1.78	4.51	16.09	0.86	21.03	88.09
Pomatoschistus spp.	0.25	0.46	2.66	0.64	3.48	91.56
Groups IF10 & IF12			Average dissimilarity = 85.54			
	Group IF10	Group IF12				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	3.59	0.87	19.5	1.02	22.8	22.8
Pleuronectes platessa	0.21	5.56	17.04	1.07	19.93	42.73
Ammodytes spp.	0.77	3.1	15.47	0.85	18.09	60.81
Clupeidae	1.07	4.51	14.75	0.86	17.24	78.06
Pomatoschistus spp.	1	0.46	5.62	0.51	6.56	84.62
Mugilidae	0.32	0.16	2.43	0.62	2.85	87.47
Spinachia spinachia	0.51	0	2.34	0.52	2.73	90.2
Groups IF09 & IF12			Average dissimilarity = 83.26			
	Group IF9	Group IF12				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Clupeidae	3.24	4.51	21.05	0.96	25.28	25.28
Atherina presbyter	3.31	0.87	18.49	1.02	22.21	47.49
Pleuronectes platessa	0.06	5.56	18.07	1.08	21.7	69.19
Ammodytes spp.	0.72	3.1	14.47	0.82	17.38	86.57
Pomatoschistus spp.	0.69	0.46	3.83	0.46	4.6	91.17
Groups IF11 & IF12			Average dissimilarity = 73.74			
	Group IF11	Group IF12				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Clupeidae	7.17	4.51	20.66	0.87	28.01	28.01
Pleuronectes platessa	2.5	5.56	18.15	1.15	24.61	52.62
Ammodytes spp.	3.35	3.1	16.67	0.92	22.61	75.23
Atherina presbyter	0.61	0.87	7.06	0.57	9.58	84.8
Pomatoschistus spp.	0.31	0.46	3.25	0.51	4.4	89.21
Echiichthys vipera	0.51	0.25	2.18	0.56	2.95	92.16
Groups IF01 & IF13			Average dissimilarity = 75.52			
	Group IF1	Group IF13				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	2.73	5.28	23.7	1.41	31.39	31.39

Ammodytes spp.	3.46	0.87	17.5	0.99	23.17	54.56
Clupeidae	0.37	2.53	9.36	0.71	12.39	66.95
Pleuronectes platessa	1.63	0	8.59	1.49	11.37	78.32
Mugilidae	0.15	0.44	3.4	0.75	4.5	82.82
Psetta maxima	0.49	0	3.02	0.91	4	86.82
Pomatoschistus spp.	0.39	0	1.9	0.43	2.51	89.33
Hyperoplus lanceolatus	0.41	0	1.41	0.3	1.87	91.2
Groups IF02 & IF13			Average dissimilarity = 81.48			
	Group IF2	Group IF13				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	1.85	5.28	28.69	1.55	35.21	35.21
Ammodytes spp.	1.73	0.87	13.01	0.93	15.97	51.18
Clupeidae	0.36	2.53	10.31	0.72	12.65	63.83
Psetta maxima	1.13	0	8.98	0.8	11.02	74.85
Pleuronectes platessa	0.85	0	5.35	0.93	6.57	81.42
Mugilidae	0.33	0.44	4.81	0.81	5.9	87.31
Scophthalmus rhombus	0.33	0	2.74	0.46	3.36	90.67
Groups IF03 & IF13			Average dissimilarity = 75.87			
	Group IF3	Group IF13				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	2.42	5.28	24.75	1.4	32.62	32.62
Ammodytes spp.	2.91	0.87	14.81	0.92	19.52	52.14
Clupeidae	2.09	2.53	14.16	0.96	18.67	70.81
Pleuronectes platessa	1.18	0	5.72	0.72	7.53	78.34
Mugilidae	0.09	0.44	3.58	0.74	4.72	83.07
Pomatoschistus spp.	0.49	0	2.27	0.63	3	86.06
Spinachia spinachia	0.27	0.23	1.97	0.65	2.59	88.65
Salmo trutta	0	0.12	1.47	0.25	1.94	90.6
Groups IF05 & IF13			Average dissimilarity = 66.94			
	Group IF5	Group IF13				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	4.6	5.28	29.2	1.37	43.62	43.62
Clupeidae	2.79	2.53	17.06	0.83	25.48	69.1
Ammodytes spp.	1.32	0.87	10.04	0.8	15	84.1
Mugilidae	0.14	0.44	3.41	0.76	5.09	89.2
Spinachia spinachia	0.15	0.23	2.2	0.58	3.29	92.49
Groups IF06 & IF13			Average dissimilarity = 80.63			
	Group IF6	Group IF13				

Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	1.23	5.28	21.18	1.26	26.27	26.27
Pleuronectes platessa	3.01	0	14.78	1.09	18.34	44.6
Ammodytes spp.	3.42	0.87	13.39	0.78	16.6	61.21
Clupeidae	1.18	2.53	10.68	0.8	13.25	74.45
Mugilidae	0.68	0.44	4.52	0.73	5.61	80.06
Platichthys flesus	0.76	0	3.84	0.83	4.76	84.82
Psetta maxima	0.48	0	2.65	0.82	3.28	88.1
Pomatoschistus spp.	0.6	0	2.08	0.47	2.58	90.68
Groups IF07 & IF13			Average dissimilarity = 69.46			
	Group IF7	Group IF13				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	3.3	5.28	24.14	1.34	34.76	34.76
Ammodytes spp.	2.87	0.87	15.78	0.89	22.71	57.47
Clupeidae	1.78	2.53	13.63	0.81	19.62	77.09
Pleuronectes platessa	0.82	0	5.06	0.67	7.29	84.38
Mugilidae	0.21	0.44	3.07	0.78	4.42	88.8
Salmo trutta	0.09	0.12	1.67	0.34	2.41	91.21
Groups IF10 & IF13			Average dissimilarity = 69.23			
	Group IF10	Group IF13				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	3.59	5.28	24.99	1.44	36.1	36.1
Clupeidae	1.07	2.53	11.85	0.86	17.11	53.21
Ammodytes spp.	0.77	0.87	9.68	0.64	13.99	67.2
Pomatoschistus spp.	1	0	5.01	0.42	7.24	74.44
Mugilidae	0.32	0.44	3.86	0.88	5.57	80.01
Spinachia spinachia	0.51	0.23	3.13	0.69	4.52	84.53
Pollachius pollachius	0.27	0.07	1.67	0.55	2.41	86.94
Salmo trutta	0	0.12	1.34	0.27	1.93	88.87
Dicentrarchus labrax	0.17	0	1.24	0.4	1.8	90.67
Groups IF09 & IF13			Average dissimilarity = 68.01			
	Group IF9	Group IF13				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	3.31	5.28	26.11	1.37	38.39	38.39
Clupeidae	3.24	2.53	19.56	0.93	28.76	67.15
Ammodytes spp.	0.72	0.87	8.72	0.74	12.82	79.97
Mugilidae	0.14	0.44	3.7	0.78	5.44	85.41
Pomatoschistus spp.	0.69	0	2.23	0.27	3.28	88.69
Spinachia spinachia	0.18	0.23	1.83	0.7	2.7	91.39

Groups IF11 & IF13			Average dissimilarity = 84.30			
	Group IF11	Group IF13				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	0.61	5.28	24.1	1.25	28.58	28.58
Clupeidae	7.17	2.53	18.7	0.8	22.19	50.77
Ammodytes spp.	3.35	0.87	15.37	0.98	18.23	69
Pleuronectes platessa	2.5	0	10.75	0.91	12.75	81.75
Mugilidae	0	0.44	3.31	0.68	3.93	85.68
Platichthys flesus	0.39	0	2.28	0.7	2.7	88.38
Pomatoschistus spp.	0.31	0	2.23	0.39	2.64	91.02
Groups IF12 & IF13			Average dissimilarity = 83.10			
	Group IF12	Group IF13				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Atherina presbyter	0.87	5.28	23.29	1.2	28.02	28.02
Pleuronectes platessa	5.56	0	17.63	1.05	21.22	49.24
Clupeidae	4.51	2.53	17.08	0.9	20.56	69.8
Ammodytes spp.	3.1	0.87	14.08	0.85	16.94	86.74
Mugilidae	0.16	0.44	3.25	0.7	3.92	90.65

Table F.4 : Summary of sites dived, positions, underwater visibility (vis.) and distance from outfall.

Site	Surveyors	Date	Time	Lat.	Long.	Comments	Visibil-ity (m)	Dist. from outfall (km)
DV04 deep	LM & JE	29/07/10	14:00	N 53 25.230	W004 28.880	No data collected - wrong habitat (sediment) >1 m visibility	2	0.2
DV04 shallow	MD &BW	29/07/10	14:02	SE from deep site	SE from deep site	Data collected, 2 m visibility	2	0.2
DV06 deep	LM & JE	29/07/10	16:58	N53 25.271	W004 28.840	Rock at 13 m - divers moved away from shot as started on a wreck, moved to 53deg 25.283, 004deg 28.391 @ 17:30. Limited data collected	1-2	0.28
DV06 shallow	MD & BW	29/07/10	17:02	N53 25.250	W004 28.830	Data collected	1-2	0.28
DV04 deep	MD & BW	30/07/10	09:27	N53 25.242	W004 28.867	Data collected	1-2	0.2
DV06 deep	HG & JE	30/07/10	09:30	N53 25.260	W004 28.835	Very silted only 1 transect completed	1-1.5	0.28
DV08 deep	MD & BW	30/07/10	12:12	N53 25.271	W004 28.615	Data collected - current started throughout dive	2	0.64

Site	Surveyors	Date	Time	Lat.	Long.	Comments	Visibil-ity (m)	Dist. from outfall (km)
DV08 shallow	HG & JE	30/07/10	12:13	Inshore of deep site	Inshore of deep site	Data collected - current started throughout dive	1-2	0.64
DV11 shallow	HG & JE	31/07/10	12:57	N53 25.615	W004 25.413	Data collected	2	3.2
DV11 deep	MD & BW	31/07/10	12:54	N53 25.615	W004 25.413	Data collected	1-2	3.2
DV12A shallow (X)	HG & JE	31/07/10	15:46	N53 25.729	W004 25.754	No data collected - very silted >1 m visibility (East side of bay)	1	3.9
DV12B shallow (Y)	MD & BW	31/07/10	15:41	N53 25.676	W004 25.861	Data collected (West side of bay)	2	3.9
DV11 shallow	MD & BW	01/08/10	13:26	N53 25.621	W004 26.442	Data collected	2	3.2
DV11 deep	HG & JE	01/08/10	13:28	N53 25.621	W004 26.442	Data collected	2	3.2
DV09B shallow	MD & BW	01/08/10	16:20	N53 25.511	W004 26.534	Divers inshore of this mark - data collected	1-2	2.9
DV09A shallow	HG & JE	01/08/10	16:21	N53 25.511	W004 26.534	Divers in at this mark - data collected	1-2	2.9
Outfall B shallow	HG & JE	02/08/10	15:51	N53 25.210	W004 28.939	Data collected. Strong current present	1.5	0.14
Outfall A shallow	MD & BW	02/08/10	15:52	N53 25.207	W004 28.892	No data collected - current too strong from outfall.	2	0.25
DV04 shallow	HG & JE	02/08/10	18:06	N53 25.223	W004 28.886	Limited data collected	2	0.2
Outfall A shallow	MD & BW	02/08/10	17:58	N53 25.267	W004 28.881	Data collected	2	0.25
DV04 deep	LM & JE	29/07/10	14:00	N 53 25.230	W004 28.880	No data collected - wrong habitat (sediment) >1 m visibility	2	0.2
DV16 deep	HG & JE	03/08/10	09:05	N53 25.123	W004 17.420	Data collected	3	13.6
DV16 shallow	LM & BW	03/08/10	09:08	N53 25.110	W004 17.426	Data collected	3	13.6
DV05 deep	LM & BW	03/08/10	12:00	N53 24.930	W004 17.540	Data collected (shot was 5-6 m east of this position)	2	13.3
DV05 shallow	HG & JE	03/08/10	12:03	No Position - Inshore of deep site	No Position - Inshore of deep site	Data collected	1-2	13.3
DV02 shallow	MD & BW	06/08/10	12:40	N53 25.203	W004 29.067	Data collected	3-4	0.32
DV02 deep	LM & JE	06/08/10	12:40	N53 25.266	W004 29.070	Data collected	2-3	0.32
DV07 shallow	LM & JE	06/08/10	09:35	N53 25.326	W004 28.768	Data collected	3	0.44
DV07 deep	MD & BW	06/08/10	09:30	N53 25.338	W004 28.781	Data collected	4-5	0.44

Table F.5 : Results of the one-way SIMPER analysis (factors were 'Sites') showing all taxa contributing to 90% dissimilarities within fish communities observed during dive surveys. Abundance is square root transformed.

Groups Deep & Shallow				Average dissimilarity = 68.52		
	Group Deep	Group Shallow				
Species	Av. Abund.	Av. Abund.	Av. Diss.	Diss/SD	Contrib.%	Cum.%
Pomatoschistus spp.	2.59	2.83	12.63	1.37	18.43	18.43
Goldsinny wrasse	2.11	0.73	8.60	1.25	12.56	30.98
Indeterminate	0.60	1.56	6.86	0.60	10.01	41.00
Poor cod	1.50	0.20	6.73	1.12	9.82	50.82
Two-spotted goby	0.21	1.15	5.83	0.73	8.51	59.33
Leopard-spotted goby	1.01	0.96	5.07	1.14	7.40	66.73
Tompot blenny	0.70	0.59	4.11	1.01	6.00	72.73
Callionymus spp.	0.66	0.32	3.62	0.87	5.28	78.01
Ballan wrasse	0.27	0.46	3.05	0.65	4.45	82.46
Rock goby	0.44	0.24	2.47	0.85	3.61	86.06
Long-spined sea scorpion	0.17	0.27	2.12	0.59	3.10	89.16
Lesser-spotted dogfish	0.21	0.00	1.38	0.47	2.01	91.17

Appendix G. Results of Subtidal Survey Statistics

Table E.1: Results of the two-way crossed SIMPER analysis (factors were 'Season' and 'Site') on beam trawl data showing all taxa contributing to similarities within subtidal fish communities between seasons. Average abundance is log (x+1) transformed.

Group SF1			Average similarity: 32.23		
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib.%	Cum.%
Dab	4.13	19.45	0.92	60.37	60.37
Whiting	0.86	5.57	0.74	17.27	77.64
Dragonet (common)	0.47	2.51	0.80	7.78	85.42
Plaice	0.33	2.39	1.26	7.43	92.84
Group SF2			Average similarity: 30.99		
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib.%	Cum.%
Lesser-spotted dogfish	0.16	11.45	0.71	36.94	36.94
Poor cod	0.20	7.48	0.71	24.12	61.06
Whiting	0.06	2.90	0.67	9.35	70.41
Dragonet (common)	0.04	2.50	0.74	8.08	78.49
Dab	0.04	1.94	0.90	6.27	84.76
Plaice	0.03	1.74	0.59	5.61	90.36
Lesser-spotted dogfish	0.16	11.45	0.71	36.94	36.94
Group SF3			Average similarity: 29.60		
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib.%	Cum.%
Poor cod	0.08	10.12	0.73	34.18	34.18
Lesser-spotted dogfish	0.05	8.34	0.84	28.19	62.37
Whiting	0.12	3.20	0.61	10.82	73.19
Pogge	0.02	1.82	0.49	6.13	79.32
Dab	0.01	1.01	0.43	3.40	82.72
Sprat	0.02	0.94	0.37	3.18	85.91
Plaice	0.01	0.86	0.49	2.92	88.83
Bib	0.01	0.81	0.44	2.75	91.57
Group SF4			Average similarity: 24.11		
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib.%	Cum.%
Poor cod	0.14	9.30	0.74	38.59	38.59
Dragonet (common)	0.09	3.66	0.82	15.19	53.78
Whiting	0.04	3.38	0.67	14.03	67.81
Lesser-spotted dogfish	0.03	2.62	0.45	10.88	78.70
Seasnail	0.05	1.30	0.34	5.39	84.08
Dab	0.03	1.12	0.29	4.63	88.71
Pogge	0.05	1.05	0.68	4.35	93.06
Group SF5			Average similarity: 21.66		
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib.%	Cum.%
Lesser-spotted dogfish	0.03	3.46	0.38	15.98	15.98

Lesser weever	0.01	3.26	0.67	15.07	31.05
Whiting	0.09	3.25	0.53	14.99	46.04
Dab	0.02	2.97	0.56	13.73	59.77
Plaice	0.02	2.31	0.64	10.66	70.43
Poor cod	0.02	1.75	0.44	8.06	78.49
Bib	0.01	1.23	0.35	5.68	84.17
Pogge	0.01	0.86	0.39	3.97	88.14
Lesser sandeel	0.03	0.71	0.41	3.26	91.40

Table E.2: Results of the two-way crossed SIMPER analysis (factors were 'Season' and 'Site') on otter trawl data showing all taxa contributing to similarities within subtidal fish communities between seasons. Average abundance is log (x+1) transformed.

Group SF1			Average similarity: 42.56		
Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib.%**	**Cum.%**
Whiting	2.59	15.28	1.18	34.44	34.44
Lesser-spotted dogfish	0.85	12.39	1.58	27.93	62.37
Poor cod	0.97	10.70	1.16	24.12	86.49
Red gurnard	0.18	1.66	0.79	3.73	90.23
Group SF4			**Average similarity: 44.36**		
Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib.%**	**Cum.%**
Whiting	2.59	15.28	1.18	34.44	34.44
Lesser-spotted dogfish	0.85	12.39	1.58	27.93	62.37
Poor cod	0.97	10.70	1.16	24.12	86.49
Red gurnard	0.18	1.66	0.79	3.73	90.23
Group SF3			**Average similarity: 31.68**		
Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib.%**	**Cum.%**
Lesser-spotted dogfish	0.52	12.53	1.02	39.56	39.56
Sprat	1.05	7.08	0.74	22.36	61.92
Whiting	0.49	5.32	1.58	16.78	78.70
Poor cod	0.30	3.56	0.56	11.23	89.94
Dab	0.05	0.36	0.52	1.14	91.08
Group SF5			**Average similarity: 30.26**		
Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib.%**	**Cum.%**
Whiting	1.40	13.54	1.34	44.76	44.76
Lesser-spotted dogfish	0.27	7.02	0.64	23.20	67.96
Plaice	0.14	2.35	1.00	7.77	75.73
Sprat	0.32	1.95	0.61	6.45	82.17
Dab	0.06	1.24	1.04	4.11	86.28
Herring	0.23	1.05	0.49	3.47	89.75
Greater sandeel	0.20	0.97	0.45	3.22	92.96