European Offshore Wind Deployment Centre
Environmental Statement

Appendix 9.1: Marine Ecology, Intertidal Ecology, Sediment and Water Quality Baseline Technical Report

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the
INSTITUTE
of
ESTUARINE
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THE UNIVERSITY OF HULL
Institute of Estuarine and Coastal Studies (IECS)

European Offshore Wind Deployment Centre (EOWDC)

Marine Ecology, Intertidal Ecology and Sediment and Water Quality

Baseline Technical Report

Report to Aberdeen Offshore Wind Farm Limited
(AOWFL)

Institute of Estuarine and Coastal Studies
University of Hull

5th May 2011

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Aberdeen Offshore Wind Farm Ltd (AOWFL)

European Offshore Wind Deployment Centre (EOWDC)
Marine Ecology, Intertidal Ecology and Sediment and Water Quality
Baseline Technical Report

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Reference No: ZBB772-F-2011

For and on behalf of the Institute of Estuarine and Coastal Studies	
Approved by:	Nick Cutts
Signed:	
Position:	Deputy Director
Date:	5th May 2011

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MARINE ECOLOGY, INTERTIDAL ECOLOGY AND SEDIMENT AND WATER QUALITY

1 The Institute of Estuarine and Coastal Studies (IECS) at the University of Hull was commissioned by Aberdeen Offshore Wind Farm Limited (AOWFL) to undertake the Baseline Technical report for the proposed European Offshore Wind Deployment Centre (EOWDC).

2 The present report focuses on marine ecology baseline information and presents an update of the literature review carried out by Titan Ltd (TES, 2008a) which was based on a previous turbine layout. The Titan Ltd report included analysis of sediment and water quality, benthic ecology, natural fish and shellfish species. This information has been incorporated with the results of the benthic sampling and analysis programme undertaken by the Centre for Marine and Coastal Studies Limited (CMACS Ltd) in September 2010 and additional data from Marine Scotland Science.

1. Information for the Non-Technical Summary

3 The proposed EOWDC area (i.e. the area inside the development lease boundary) shows physical, chemical and biological characteristics resembling those of the surroundings. There is general agreement between scientific literature and survey results.

4 Well-washed fine sandy sediments are present in the site in the vicinity of the proposed EOWDC. A gradient in sediment characteristics has been observed with a decrease in mud and organic content in sediments at inshore, shallower stations. This is as expected given the higher degree of sediment re-suspension caused by tidal movements, wave action and coastal currents in these areas.

5 Contaminant levels measured in sediments during the benthic survey did not raise any concerns, predominantly being below detection limits (organic compounds such as polycyclic aromatic hydrocarbons, polychlorinated biphenyls, organotin compounds), or below international benchmarks indicating potential adverse biological effects in aquatic systems (as for heavy metals). The sediment contamination in the site is in line with the background contamination levels reported for the North Eastern Atlantic zone.

6 The water quality in the Aberdeen area is generally good given the presence of a large sewage outfall for trade and domestic effluent. This is confirmed by the information on the quality of nearby bathing waters for the past few years.

7 The intertidal areas in Aberdeen Bay are mostly represented by sandy shores with moderate exposure to wave action, wind and tidal streams. The intertidal benthic fauna is dominated by mobile crustaceans (such as haustorid amphipods). These habitats may provide feeding grounds to fish species using the adjacent sublittoral areas.

8 The sublittoral benthic community is dominated by polychaetes (mainly *Notomastus latericeus)* and bivalves (mainly *Nucula nitidosa* and *Tellina fabula*). Ophiuridae are also characteristic of the surveyed benthic assemblages, particularly at offshore stations. Depth and distance offshore highly affects benthic assemblages. Assemblages (and biotopes) present within the proposed EOWDC area are consistent with those found further offshore where the benthic community strongly resembles the JNCC biotope SS.SSA.CMuSa.AalbNuc (*Abra alba* and *N. nitidosa* in

circalittoral muddy sand or slightly mixed sediment). At inshore sites sparser benthic assemblages occur, matching well with the biotope SS.SSA.IFiSa.NcirBat (*Nephtys* cirrosa and *Bathyporeia* spp. in infralittoral sand). This latter biotope, however, is not present within the proposed EOWDC area, where only the biotope SS.SSA.CMuSa.AalbNuc occurs. The biotopes SS.SSA.CMuSa and SS.SSA.IFiSa are considered as a priority habitat under the UK BAP designation (sublittoral sands and gravels). The UK Habitat Action Plan aims to ensure that the best examples of sublittoral sand and gravel habitats are protected from the adverse effects human activities, such as wind farm development. However this is also the most common habitat found below the level of the lowest low tide around the coast of the United Kingdom, and is not uncommon in the wider Aberdeen Bay area, hence is not considered to have an especially high ecological importance at the local scale.

9 The invertebrate epibenthic fauna in the site is sparse and is composed of brittle stars, brown shrimp and swimming crabs. The most common fish species are flatfish such as dab and plaice, particularly in inshore stations. Hooknose and whiting are also abundant. Fishing grounds are located farther offshore or northwards with respect to the proposed development area. No specific spawning or nursery grounds are reported in the proposed EOWDC area, although areas with these roles have been identified at a larger spatial scale. The epibenthic survey carried out in the proposed EOWDC site seems to confirm the absence of spawning grounds. A high abundance of juvenile flatfish (plaice and dab) has been recorded in inshore stations, suggesting their use as a nursery. However, it is likely that similar nursery grounds extend over a wider area along the Scottish coast.

10 A number of sites designated for conservation interest (SAC, SPA, Ramsar sites, SSSI and NNR) occur along the coast in the Aberdeen area. However, the proposed EOWDC area and the surroundings do not fall within a designated statutory conservation area and no designated species are present within them, as confirmed by the survey results. There is the possibility that migration routes of Atlantic salmon and sea trout cross the proposed EOWDC site, having the species important spawning areas in the nearby rivers (e.g. River Dee). These species are discussed in detail within the salmon and sea trout assessment for the proposed EOWDC, although there is a notable lack of knowledge on how these salmonids migrate and behave along the east coast of Scotland.

2. Introduction

11 The proposed EOWDC site is a wind farm and deployment centre located approximately between 2 and 4.5 km east of Blackdog, off the Aberdeenshire coast. The project is expected to comprise 11 wind turbines between 4 and 10 MW. An Ocean Laboratory for meteorological and other environmental monitoring is proposed and would be subjected to a separate consent application. The lease boundary for development will cover up to 20 km^2 between northern Aberdeen and Balmedie and this area will be referred to in this document as the "proposed EOWDC area" (green area in Figure 1). Where in text there is discussion regarding the wider area where the proposed development will fall (e.g. lease boundary and its surroundings) this will be referenced as the "proposed EOWDC site".

12 Offshore wind farm developments are listed under Annex II of the Environmental Impact Assessment Directive (97/11/EC) as "installations for the harnessing of wind power for energy production (wind farms)" and, as such, an Environmental Impact Assessment (EIA) must be carried out in support of any application for development consent. Whilst the proposed EOWDC area is outside any designated statutory conservation areas, there are a number of European Directive designated sites nearby and these should be taken into account in any assessment of potential impacts.

13 Assessing the impact of offshore wind farm developments on marine habitats and species must account for the natural variability within marine ecosystems (e.g. resulting from extreme weather conditions, storms, smothering following natural sediment movement, changes in predator/prey populations) so that distinction between natural and anthropogenically induced change can be made (Hiscock *et al.*, 2002).

14 This section provides baseline data for the physical and chemical properties of the sediment (particle size and persistent contaminants), the macrofaunal communities living within the sediment (infauna) and those species living at the sediment/water column interface (epifauna). Information available from the literature has been integrated with data obtained during benthic and epibenthic surveys carried out in the proposed EOWDC site. These data were collected in order to characterise the benthic ecology in the proposed EOWDC area and its surroundings. The data will also provide a baseline for the assessment of both direct and indirect (e.g. sedimentation) impacts of the scheme in the wider area during future monitoring. A review of existing information on the water quality and nature conservation status in the area is also provided in this section.

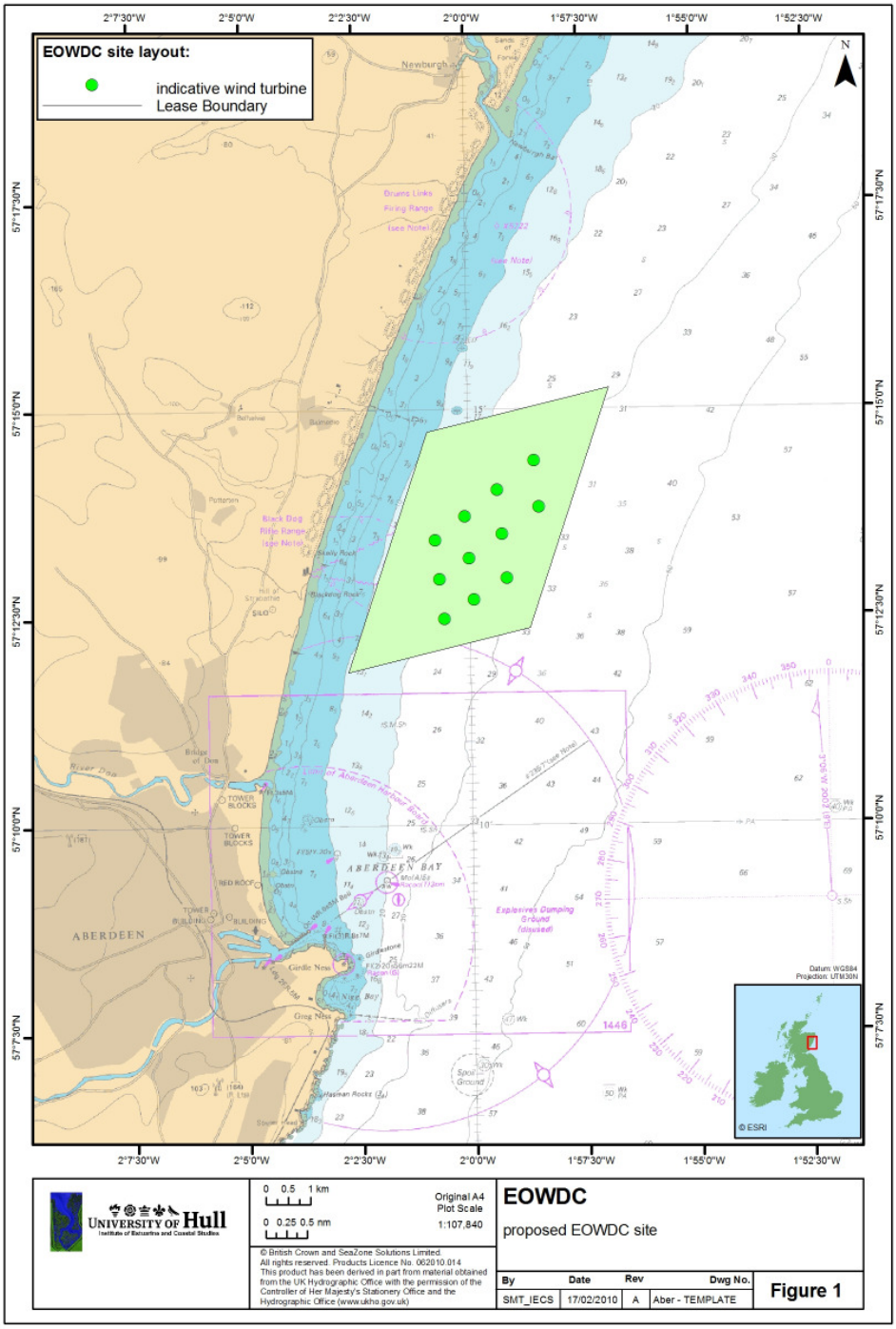


Figure 1. Proposed EOWDC site location in Aberdeen Bay. The wider area where the proposed development will fall is referred to as the proposed EOWDC site, whereas the lease boundary for development is referred to as the proposed EOWDC area (green area in figure).

2.1. METHODOLOGY CONSULTATION

15 Responses to the Request for Scoping Opinion 2010 which were relevant to marine ecology aspects were received from following organisations:

- Sue Lawrence, Area Officer – City of Aberdeen and Aberdeenshire Central, Scottish Natural Heritage (10/09/29);
- Robert Forbes, Senior Planning Enforcement Officer, Aberdeen City Council (10/09/23);
- Nicola Abrams, Senior Planning Officer, Scottish Environmental Protection Agency (10/09/24);
- Fiona Thompson, Marine Scotland (10/12/15)
- Fiona Thompson, Marine Scotland (Scoping Opinion, and Consultee comments therein, in particular comments from Scottish Natural Heritage, Scottish Environmental Protection Agency, Marine Scotland, Association of Salmon Fishery Boards) (11/02/24)

16 A previous Request for Scoping Opinion was submitted in 2005 when the project was a commercial wind farm and responses relevant to marine ecology were received from:

- James C McKie, Fisheries Research Services (FRS) (05/07/06)
- Ron MacDonald, Area manager, Scottish Natural Heritage (05/08/02)

17 The above responses raised main concerns regarding UK BAP priority species, migratory fishes, and elasmobranchs. These aspects were then taken into account when compiling the baseline technical report and main concerns regarding the impact assessment were also addressed in the EIA report and in the Environmental Statement (ES) chapter.

18 Prior to the benthic sampling and analysis programme (CMACS Ltd, 2010), a Method Statement was provided by Vattenfall and agreed with statutory consultees. These documents are listed below:

- Titan Environmental Survey (TES) Ltd (2008b). Marine Benthic Sampling Proposal. Report CS0208/D1/V2. April 2008
- GoBe (2010). Review of proposed Benthic Ecology Sampling
- EOWDC (2010). European Offshore Wind Deployment Centre: Proposed Benthic Sampling Strategy ver. 2.

2.2. KEY GUIDANCE DOCUMENTS

- Canadian Council of Ministers of the Environment (CCME) (2001). Canadian sediment quality guidelines for the protection of aquatic life. Summary tables. Updated in Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

- CEFAS (2004). Offshore wind farms: Guidance note for Environmental Impact Assessment in respect of FEPA and CPA requirements. Version 2. Prepared by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) on behalf of the Marine Consents Unit (MCEU). 45pp

- English Nature (2001). Wind farm development and nature conservation. Publication by English Nature, Royal Society for the Protection of Birds, World Wildlife Fund UK & British Wind Energy Association. Goldaming: WWF-UK.

- JNCC (Joint Nature Conservation Committee) (2009). Species pages for 2007 UK BAP priority species. http://www.jncc.gov.uk/_speciespages/437.pdf

- JNCC (2008). UK Biodiversity Action Plan; Priority Habitat Descriptions. BRIG (ed. Ant Maddock) 2008.

- OSPAR (2006). OSPAR Agreement 2005-2006. Agreement on Background Concentrations for Contaminants in Seawater, Biota and Sediment. OSPAR Commission, London. Revised by ASMO 2006 (ASMO 2006 Summary Record (ASMO 06/12/1) § 5.38

- OSPAR (2004). Draft background document on problems and benefits associated with the development of offshore windmill farms (OWF). Annex 1. Report BDC/03/4/2-E

- Scottish Natural Heritage (2004). Marine renewable energy and the natural heritage: an overview and policy statement. Policy Statement No. 04/01.

- Scottish Natural Heritage (2010). Renewable energy and the natural heritage. Ref No. 2010/02.

2.3. DATA INFORMATION AND SOURCES

19 This section lists the sources of data used to describe the baseline environment within and around the proposed EOWDC area.

- Heath M.R., Adams R.D., Brown F., Dunn J., Fraser S., Hay S.J., Kelly M.C., Macdonald E.M., Robertson M.R., Robinson S. and Wilson C. (1999). Plankton monitoring off the east coast of Scotland in 1997 and 1998. Fisheries Research Services Report, No */99

- SEA 5 Environmental report, September 2004, Department of Trade and Industry http://www.offshore-sea.org.uk/site/scripts/book_info.php?consultationID=5&bookID=6

- Fisheries Research Services (FRS) survey (2006). Data from Video survey, assessment of the level of contaminants and epifauna trawls in Aberdeen Bay.

- ICES (2006). Cooperative Research Report No 281: Zooplankton monitoring results in the ICES area, Summary Status Report 2004/2005, Sept. 2006, pp.19-21.

- EMU Ltd (2007) Geophysical and seabed habitat assessment of the proposed Aberdeen Offshore Wind Farm. Report to Aberdeen Renewable Energy Group and Amec Wind Energy Ltd. Report No: 07/J/1/02/1136/0716.

- Titan Environmental Survey (TES) Ltd (2008a) Marine Ecology – Review of Baseline Information. Report CS0208/R2/V2. May 2008.
- Centre for Marine and Coastal Studies Ltd (CMACS Ltd) (2011) Benthic Survey Technical Report Ref: J3154 Field Report v3. February 2011.
- British Crown and SeaZone Solutions Limited, Product Licence No. 062010.014
- OSIRIS Projects Ltd (2010). Report: Aberdeen offshore wind farm. Geophysical survey. December 2010. Volume 2a, b
- European Offshore Wind Deployment Centre (EOWDC) (2010). Request for an Environmental Impact Assessment (EIA). Scoping Opinion. August 2010.
- Marine Scotland Science survey (2010). Trawl and video data from benthic survey in Aberdeen Bay.

3. Baseline Description

20 A literature review was carried out in 2008 by Titan Environmental Survey (TES) Ltd. describing the North Sea environment and the area around Aberdeen Bay, including references to previous studies (TES, 2008a). The majority of information used to compile the literature review in the present document has come from the TES report (2008a). This information has then been integrated with the results of benthic and epibenthic surveys carried out in the proposed EOWDC site, in order to provide an updated picture of the benthic ecology in the area. In order to characterise the area for the purposes of the EIA only a single faunal sample has been analysed. If the site is consented it is AOWFL's intention to analyse the remaining two samples for the purposes of statistically robust BACI (Before-after Control Impact) type analysis ie pre and post construction comparison.

3.1. General Remarks on the Ecology of the Region

21 This section reports on the general characteristics of the marine ecology in the wider area. The spatial scale that will be chosen to discuss the ecology is the area covered in the Strategic Eenvironmental Assessment 5[1] (Figure 2), where the proposed EOWDC is located.

22 The North Sea is a complex and productive ecosystem, which supports important populations of benthic animals, fish, seabirds and marine mammals. Pelagic and benthic communities are interlinked in more or less tightly coupled food webs which, together with the abiotic environment, make up marine ecosystems.These ecosystems are dynamic and influenced by a range of biological, physical and chemical factors operating over different spatial and temporal scales.

23 Climatic and hydrographic variability, in particular the extent of Atlantic inflow, are important ecological determinants in the North Sea area, particularly affecting the character and extent of plankton communities. In recent years, spring and autumn phytoplankton blooms in the Area SEA 5 have become more evident, with primary production increasing throughout the year. Oceanographic conditions also influence the transport of zooplankton, fish larvae and cephalopods with direct consequences for associated predator populations.

24 Fish spawning areas are found throughout the Area SEA 5, with the juvenile stages of many commercial fish species remaining within coastal nursery areas for a year or two before moving offshore. Offshore areas are characterised by fish communities dominated by haddock (*Melanogrammus aeglefinus*), whiting (*Merlangius merlangus*) and cod (*Gadus morhua*). Migratory species such as herring (*Clupea harengus*) and mackerel (*Scomber scombrus*) are also found although their distribution is seasonal. Diadromous species such as Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*), sea lamprey (*Petromyzon marinus*) and European eel (*Anguilla anguilla*) are present, with coastal rivers supporting important populations. Sandeels (*Ammodytes* spp.), a key prey item for a number of seabird and marine mammal species, are distributed throughout the area and are closely associated with well-oxygenated, medium to coarse sand. Important *Nephrops* stocks are found on a range of muddy-sand

[1] In 1999, the Department of Trade and Industry's (DTI) commenced a Strategic Environmental Assessment (SEA) process for offshore energy with a sequence of sectoral SEAs of the implications of further licensing of the UKCS for oil and gas exploration and production. The main focus of SEA 5 was the potential further licensing for oil and gas exploration of offshore areas of the UK Continental Shelf (UKCS) to the east of the Scottish mainland, Orkney and Shetland.

sediments. Benthic communities are intrinsically linked to the physical nature and characteristics of the substratum. As such, the offshore communities are spatially distributed over the area, with distinct species assemblages being associated with particular substratum types. In particular sedentary species with high abundance and biomass dominate in the sheltered coastal areas, whereas exposed beaches have lower diversity, abundance and biomass. Dense populations of intertidal benthos found in many of the sheltered inner firths and estuaries also support important fish and waterbird populations.

25 Key predators include seabirds with colonies along the east coast of Scotland that have been given protected status under the EU "Birds" Directive as Special Protected Areas (SPAs) for the species breeding there, and the number they support. Marine mammals including harbour porpoise (*Phocoena phocoena*), harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*) are frequently sighted along the north east coast of Scotland, and white-beaked dolphin (*Lagenorhynchus albirostris*) and minke whale (*Balaenoptera acutorostrata*) are present further offshore (particularly during summer). Bottlenose dolphins (*Tursiops truncatus*) are regularly sighted within Aberdeen day with a peak occurrence during the winter and spring months (November-May), when they can be observed almost daily feeding at Aberdeen Harbour.

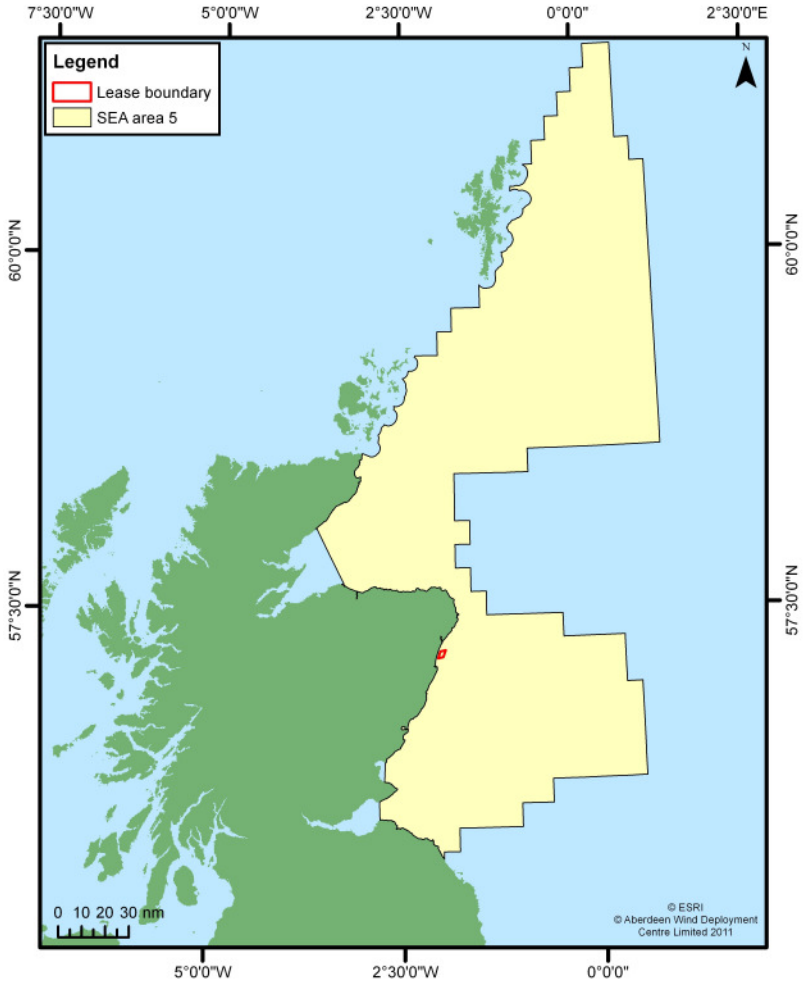


Figure 2. Location of the Strategic Environmental Assessment (SEA) 5 Areaand the proposed EOWDC lease boundary.

3.2. SEDIMENT AND WATER QUALITY

3.2.1. Sediment characteristics and contamination

26 This section reports on the information available on sediment characteristics and contamination for the proposed EOWDC site and the wider Area SEA 5 where it will fall, as gathered from background data and the benthic surveys undertaken by CMACS Ltd in 2010.

3.2.1.1. BACKGROUND INFORMATION

27 The sediments of the Area SEA 5 consist predominantly of sands, sandy gravels and gravel (Figure 3). Gravel and sandy gravel generally occur in nearshore areas where there are very strong tidal and wave driven currents, particularly around Shetland and Orkney. Large mobile sandwaves and sandbanks are also present. Muddy sediments are restricted to deeper waters and very sheltered coastal areas in the Area SEA 5.

28 According tho the broad scale map of seabed sediment distribution in the Area SEA 5 (Figure 3), the sediments off Aberdeen Bay consist predominantly of sand and slightly gravelly sand. Recent surveys carried out in the Aberdeen Bay area confirmed these data:

- A geophysical survey carried out in 2007 by EMU Ltd for AOWFL including swath bathymetry, side scan sonar imaging, shallow seismic profiling, Acoustic Ground Discrimination System (AGDS) and the collection of sediment samples for processing, confirmed the proposed EOWDC site to be dominated by muddy sand with small patches of glacial material towards the shore, and finer sediment features in places with occasional patches of shell fragments in others (EMU Ltd, 2007).

- A geophysical survey carried out in 2010 by OSIRIS Projects for AOWFL, including detailed bathymetric information, seismic profiling and information on magnetic anomalies in/on the seabed, confirmed that in the proposed EOWDC site sediments are mostly fine silty sand, frequently shelly, with localised patches of coarser grained sediments towards the shore (outside the proposed EOWDC lease area) (OSIRIS Projects Ltd, 2010).

29 The main factors affecting water quality and marine organisms are contaminant levels (organic pollutants and metals) and levels of suspended sediments. If present in sufficient concentrations, contaminants may have the potential to disturb biological processes through a variety of mechanisms. These include increased toxicity, mutagenicity, interference with reproductive physiology and availability of food and nutrients.

30 In general, riverine and atmospheric transport accounts for the largest inputs of contaminants to the north-east Atlantic and North Sea. However, transport, shipping, military activities and offshore industries, including oil and gas production, all have the potential to make significant contributions (OSPAR, 2000).

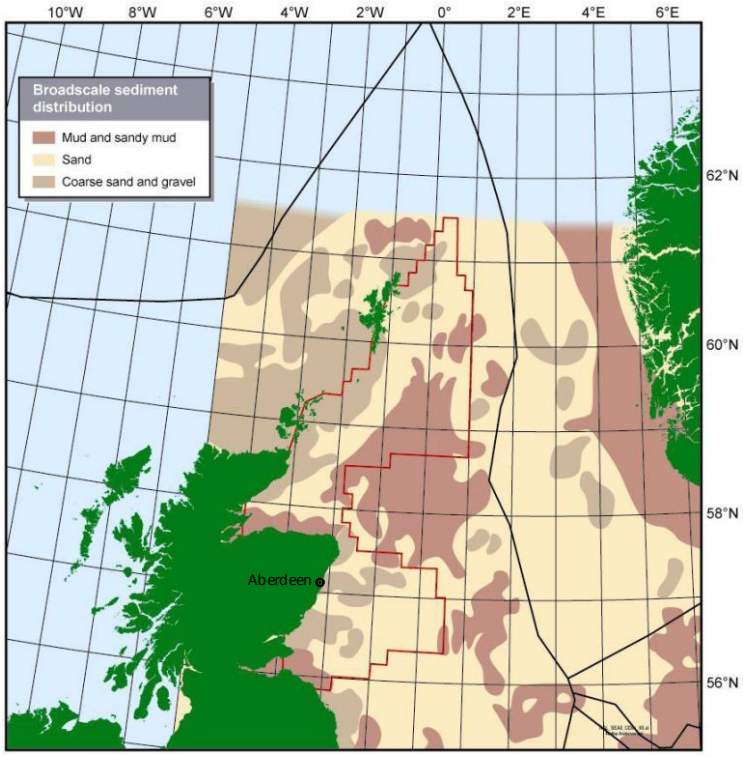


Figure 3. Broadscale seabed sediment distribution in the Area SEA 5. Source: OSPAR 2000.

31 FRS carried out a survey in April 2006 to assess the level of contaminants in the sediments in Aberdeen Bay, with sampling locations falling within the proposed EOWDC site (Appendix 5.1). The data collected during this survey were provided by FRS**,** and were taken into account to integrate the background information on the sediment contamination in the proposed EOWDC site.

32 Maximum Polycyclic Aromatic Hydrocarbons concentrations (total PAH) of 1732.2 µg/kg dry weight were found at station 11ABZ06 inside the proposed EOWDC area (Appendix 5.1). This concentration can be compared to the background reference concentrations (BCRs), background concentrations[2] (BCs) and provisional background assessment criteria[3] (BAC) provided by OSPAR (OSPAR, 2006). Except for Phenanthrene, Anthracene and Pyrene concentrations at station 11ABZ2006 (which are 5, 8 and 6 times higher than OSPAR's BACs, respectively), the level of PAHs in the sediments in Aberdeen Bay in 2006 can be considered to be near or below background concentrations.

33 In terms of metal concentrations in the sediments of Aberdeen Bay, the average values measured across all sampling sites during the FRS 2006 survey are given in

[2] "Background concentrations" (BCs) are assessment tools intended to represent the concentrations of certain hazardous substances that would be expected in the North-East Atlantic if certain industrial developments had not happened. (OSPAR Agreement 2005-6)

[3] "Background assessment criteria" (BACs) are statistical tools defined in relation to the background concentrations (BCs), which enable testing of whether mean observed concentrations can be considered to be near background concentrations. (OSPAR Agreement 2005-6)

Table 1. Cd concentration was always below detection limits (BDL), as well as Hg concentration (except for station 13ABZ2006) (Table 1, Appendix 5.1). All average concentrations were below OSPAR Background Concentrations (BCs), i.e. those expected in the North-east Atlantic if certain industrial developments had not happened. The results of the FRS 2006 survey also showed that the distribution of metals was rather uniform in the samples analysed (Appendix 5.1).

Table 1. Average metal concentrations (mg/kg dry weight) for all sites from FRS survey (Source: FRS, 2006) and relative Background Concentration BC (OSPAR, 2006).

Metal	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
FRS 2006 survey	4.717	BDL*	15.693	3.081	0.079	7.385	7.146	21.716
BC	15	0.2	60	20	0.05	30	25	90

*BDL=Below Detection limits

34 Sediment contamination by PAHs, PCBs and heavy metals was also measured during the benthic survey carried out in the proposed EOWDC site by CMACS Ltd in 2010. The main results are provided in the section below.

3.2.1.2. INFORMATION TAKEN FROM CMACS LTD SURVEY 2010

35 In October 2010, CMACS Ltd undertook benthic environmental surveys in the proposed EOWDC area and in the surrounding marine environment. Sediment samples were collected from 14 stations (6 in and 8 outside the proposed EOWDC area) by means of grab sampling (see Figure 1 in Appendix 5.3 for sampling stations location). Sediment subsamples were analysed for particle size (PSA), total organic carbon, and contamination levels. Further details on the sampling and laboratory methodologies, the data analysis and the raw data are provided in the CMACS Ltd Technical Report (Appendix 5.3).

36 The sediments were homogeneous across the proposed EOWDC area and around it, being generally well sorted (i.e. composed of similar particle sizes in each sample). Fine sand was the dominant sediment type in the area, with medium sand also being present at stations 1, 2, 6, 7, 13 and 14. A silt/clay fraction was also detected at some stations (Figure 4).

37 Spatial distribution of sediment types was related to the variation in depth and distance offshore (with depth and distance from the shore being closely related). The inshore stations (2, 13 and 14, all located outside the proposed EOWDC area) were characterised by well-washed sand with low mud content, as a result of tidal movements, wave action and coastal currents re-suspending sediments in shallower, inshore areas, thus preventing the settlement of finer particles. A lower organic content was also recorded at these inshore stations compared to the others.

38 When comparing the other stations, no major differences were detected in particle size composition between those outside and inside the proposed EOWDC area. Fine-medium sandy bottoms, with a silt/clay fraction and a higher organic content characterised these stations.

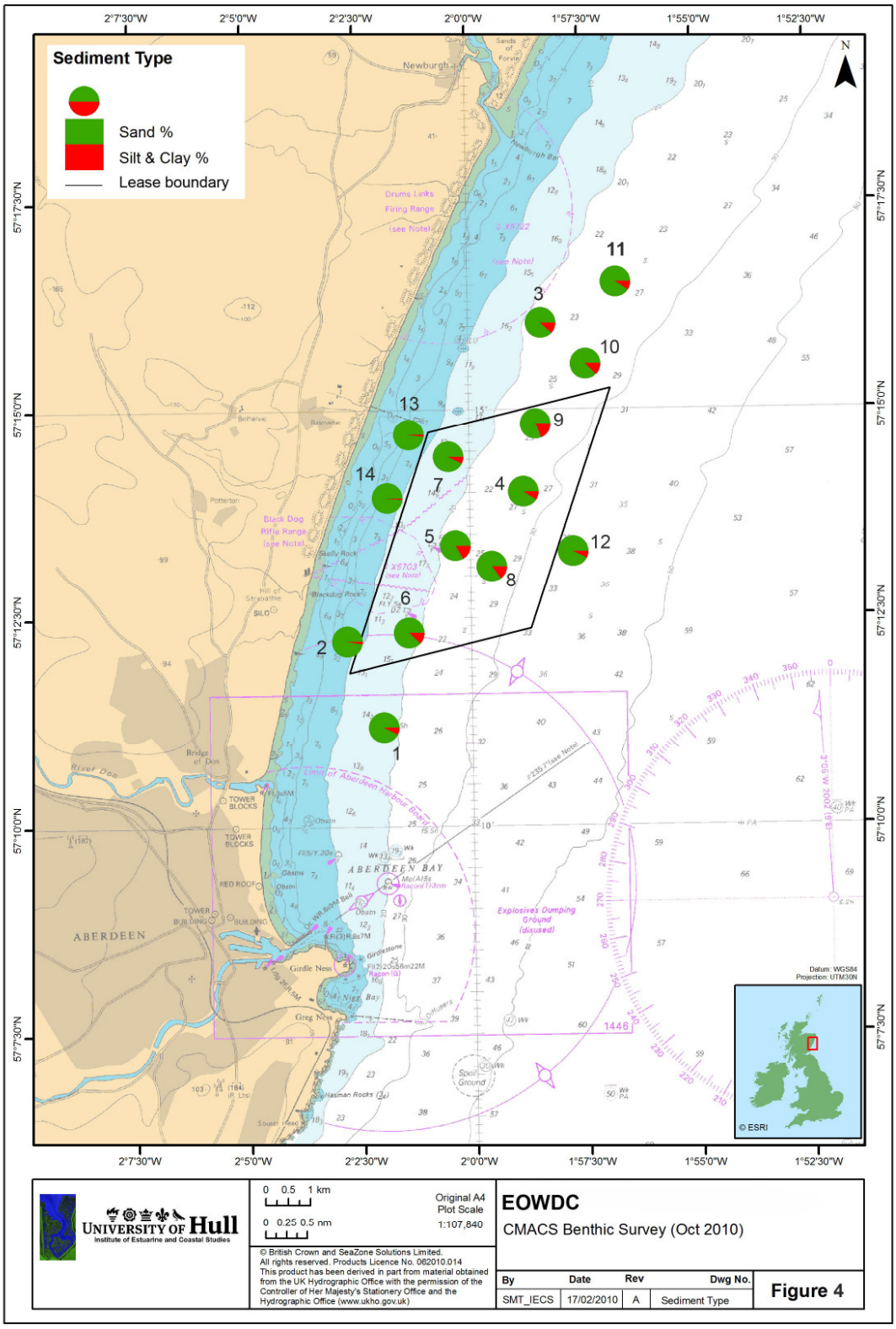


Figure 4. Geographical distribution of sand and silt/clay content across the proposed EOWDC site (stations are numbered as from CMACS Ltd Technical Report, Appendix 5.3). Map drawn by IECS based on CMACS Ltd 2010 data.

39 Mean concentrations of all PAH[4] and PCB[5] compounds were below the detection limits of 0.1 mg kg^{-1} and 0.01 µg kg^{-1}, respectively. Also concentrations of tributyl tin and other organotin compounds were all below detection levels (< 0.02 mg kg^{-1}) in all samples. For certain PAM compounds their detection limit exceeded the Interim Sediment Quality Guidelines levels (ISQG) and the Probable Effects Levels (PEL) given by CCME (2001) (see CMACS Ltd Technical Report for details, Appendix 5.3).

40 Mean concentrations of heavy metals, including cadmium, chromium, copper, lead, mercury, nickel and zinc were below the ISQG and PEL values. Arsenic concentrations exceed the ISQG of 7.24 mg kg^{-1}, but only at station 11 (7.6 mg kg^{-1}) (Appendix 5.3). However, this value is well below the PEL value for this contaminant, and, following dilution and dispersion, upon disturbance should not cause any pollution problems. Heavy metal concentrations were similarly distributed throughout the area although levels of zinc were slightly lower at station 13 than in the other stations (Appendix 5.3).

3.2.2. Water quality

41 This section reports on the background information available on water quality in the area of the proposed EOWDC site.

42 Sewage discharges are associated with coastal communities along the Area SEA 5 coastal margin, ranging in size from <100 to >100,000 population equivalent. The population equivalent and the sensitivity of waters receiving the discharges determine the level of treatment required. With regard to sewage sludge, which is left over from the treatment process, UK legislation now prohibits the disposal of sewage sludge to sea (DTI, 2004a).

43 The Ythan Estuary and lower River Don are designated as Sensitive Areas on account of eutrophication (possibly due to run-off from agricultural land), none of the east Scottish, Orkney and Shetland coasts are classified as such. Estuarine and coastal waters formerly identified as *Less Sensitive Areas* (*High Natural Dispersion Areas* under the transposing regulations) have now all been revoked (after Defra website[6]).

44 Various Bathing Waters and Shellfish Production Waters have been designated on the east coast of Scotland, north of Aberdeen. The Bathing Waters Directive (76/160/EEC) requires the monitoring of microbial indicators of faecal contamination (faecal coliform, total coliform and faecal streptococci) during the bathing season. Forty of Scotland's 60 identified Bathing Waters are located in the Area of SEA 5 and in 2003 monitoring by SEPA classified all 40 as "excellent" (i.e. meeting the Directive's guideline quality standards) or "good" (i.e. meeting the Directive's mandatory quality standards) (DTI, 2004a).

45 Overall, the water quality in the vicinity of Aberdeen is generally good, despite the presence of a large sewage outfall for trade and domestic effluent. Two main bathing waters have been identified near the proposed EOWDC site: Aberdeen –

[4] Polycyclic aromatic hydrocarbon, one of a class of chemical compounds, organic pollutants

[5] Polychlorinated biphenyls are a class of organic compounds

[6] http://www.defra.gov.uk/environment/quality/water/waterquality/sewage/sensarea/sensareas-summary.htm

Ballroom/Footdee and Balmedie Country Park Beach. The water quality of these bathing waters has been generally good for the past few years (source: Marine Conservation Society - http://www.goodbeachguide.co.uk).

3.2.3. Conclusions

46 The results of the sediment grab surveys carried out by CMACS Ltd in 2010 (Appendix 5.3) confirmed the presence of well-washed fine sandy bottoms in the proposed EOWDC area and its surroundings. A spatial pattern of increasing mud and organic content in bottom surface sediments was observed with increasing depth and distance offshore. This would be expected given the higher degree of sediment re-suspension in shallower, inshore areas, due to tidal movements, wave action and coastal currents preventing the settlement of finer particles.

47 As indicated by previous studies (e.g. the FRS benthic survey in 2006 (Appendix 5.1)), the sediment contamination in the proposed EOWDC site is in line with the background contamination levels provided for the North-eastern Atlantic area (OSPAR, 2000). Contaminant levels measured in sediments during the 2010 CMACS Ltd benthic survey (Appendix 5.3) confirm that there are no elements of concern in the area. Concentrations of the contaminants present are either below detection limits (as for PAH, PCB and organotin compounds) or below international benchmarks (ISQG and PEL) indicating potential adverse biological effects in aquatic systems (as for heavy metals).

48 The water quality in the Aberdeen area is generally good, despite the presence of a large sewage outfall for trade and domestic effluent. This is confirmed by the information on the quality of nearby bathing waters for the past few years which is generally good (Marine Conservation Society - http://www.goodbeachguide.co.uk).

Summary of sediment characteristics, contamination and water quality

Overall, the composition of the sediments is homogeneous across the survey area. The sediments at the inshore stations within the study area are characterised by fine well-sorted sands, whereas sediments further offshore and in deeper water are composed of very fine muddy sands.

The concentration of contaminants is below the Probable Effects Level (PEL) throughout the area for all contaminants measured. Arsenic is marginally above the Interim Sediment Quality Guidelines level (ISQG) but still below the PEL. All hydrocarbons, organotin and PCB concentrations are below the limit of detection.

The water quality in the Aberdeen area is generally good, as confirmed also by the information on the quality of nearby bathing waters for the past few years.

3.3. INTERTIDAL BENTHIC ECOLOGY

49 This section addresses the background information available on the intertidal benthic assemblages present along the north east coast of Scotland in general and in Aberdeen Bay in particular.

3.3.1. Background information

50 Most of the shores of the east Scottish mainland are moderately exposed to wave action, having a northerly or north-easterly orientation and the complex shore geology has created a high diversity of intertidal habitats. Sandy beaches are more prominent on the north-east coast of Scotland (Rattray Head and north of Aberdeen), south of Montrose (Lunan Bay) and south of the Firth of Tay (Tentsmuir, West Sands). The intertidal substratum in the Aberdeen Bay is also mostly sandy, with rocky platforms and boulders/loose rock southwards of Aberdeen (River Dee) and northwards of the Ythan Estuary. Also the sandy foreshore from Aberdeen to the Ythan Estuary is interrupted by a few rock platforms around Blackdog Rock, whereas the shores from Duncansby Head to Coldingham Bay are predominantly rocky.

3.3.1.1. SEDIMENTARY SHORES

51 The intertidal fauna on the east Scottish sandy beaches can be generally described as follows (Stephen, 1930; Eleftheriou and McIntyre, 1976; Eleftheriou and Robertson, 1988):

- the upper foreshore is inhabited mainly by the crustaceans *Talitrus saltator* and *Bathyporeia pilosa*;
- the middle and lower reaches have a fauna of crustaceans such as *Eurydice pulchra*, *Haustorius arenarius*, *Bathyporeia pelagica* and *B. sarsi*, along with the polychaetes *Paraonis fulgens*, *Eteone longa*, *Ophelia rathkei* and *Scolelepis(Scolepepis) squamata*;
- the lower foreshore is inhabited by polychaetes (*Spio filicornis*, *Nephtys cirrosa*, *Spiophanes bombyx* and *Lanice conchilega*), crustaceans (*Bathyporeia elegans*, *B. guilliamsoniana*, *Pontocrates altamarinus*, *Pontocrates arenarius, Atylus swammerdami* and *Monopseudocuma gilsoni*) and bivalves (*Angulus tenuis* and *Donax vittatus*).

52 Besides these general characteristics, some differences occur in the faunal composition of sandy beaches according to the degree of exposure to wind and wave action (Eleftheriou and Nicholson, 1975; Eleftheriou and McIntyre, 1976; Eleftheriou and Robertson, 1988). Extreme exposure, in fact, limits species richness by eliminating or restricting the sedentary forms of many bivalves and polychaetes, favouring in turn the presence of a fragile fauna of crustaceans. In turn, intertidal assemblages in sheltered beaches are generally dominated by sedentary species with high abundance and biomass.

53 A moderate degree of exposure to wave action, wind and tidal streams characterises most of the open coast beaches of Eastern Scotland, due to their easterly and north-easterly orientation. This type of beaches is generally short, steep and consists of medium sand and their intertidal fauna is restricted to 9-26 species and includes very few sedentary forms (Eleftheriou and Robertson, 1988). It is generally dominated by

fast swimming crustaceans such as the haustorid (*H. arenarius* and *B. pelagica*) and oedicerotid amphipods (*Pontocrates* spp.) and also cirolanid isopods (*E. pulchra*), whose overall abundance and biomass are low (Eleftheriou and Robertson, 1988). A local study carried out in Nigg Bay, to the south of the River Dee, confirmed the dominance of haustorid amphipods (*H. arenarius*) (Hart, 1971). This study highlighted also a dominance of the spionid polychaete *Scolepis cirratulus*in this beach, another species typical of exposed intertidal sandflats.

54 More sheltered beaches along the Scottish east coast are found at the inner part of firths, and are protected by headlands or by sandbanks. Tentsmuir and St. Andrews in Fife are some examples. They are generally flat or gently undulating, with fine sandy sediments, and their fauna consists of 24-48 species of which a high percentage are sedentary forms present in high abundance and biomass (Eleftheriou and Robertson, 1988). The intertidal fauna, in fact, is dominated by bivalves such as *Angulus tenuis* and *D. vittatus*, the polychaetes *N. cirrosa, S. filicornis, S. (Scolelepis) squamata* and the cumaceans *Bodotria pulchella* and *Cumopsis goodsir*. In those beaches with a flattish profile and a high retention of seawater there may be some evidence of an incursion of subtidal species well into the intertidal, such as *Tellina fabula*, as well as the amphipod *B. guilliamsoniana*, mysids, the polychaete *Nephtys hombergii* and several cumaceans (Eleftheriou and Robertson, 1988).

3.3.1.2. ROCKY SHORES

55 The littoral rocky shoreline extends sublittorally as outcrops of bedrock of variable extent and size. On vertical surfaces barnacles and limpets replace fucoid algae as the dominant organisms. The communities of plants and animals occurring on hard substrata between the tidal extremes are dependent on a combination of factors: wave exposure, shore topography, geology and geographical location. However, it should be noted that important stretches of hard substrata on the east coast are either only partially surveyed, or, in some cases, there is no information available.

56 The macroalgae of the rocky outcrops of north-eastern Scotland were studied by Wilkinson (1979) who found 80 species not previously recorded from the area. The first British record of the brown algae *Sorapion kjellmanii* was also recorded from this area, as reported by Bennett and McLeod (1998). Early records by Jack (1890) provided information on the marine algae of the rocky shores in the vicinity of Arbroath.

57 In the early 20th century, the distribution of fucoid algae was described for the Ugie (Peterhead), the Ythan (Newburgh), the Don (Aberdeen) and the Dee (Aberdeen) estuaries (Chater, 1927). The Ugie and the Don were similar in that they were both small estuaries supporting an abundance of the fucoid alga *Fucus ceranoides*. Much of the Ythan consisted of muddy shores but where rock occurred it supported a variety of fucoids. A range of fucoid algae also characterised the lower part of the Dee estuary but only *F. ceranoides*, which can tolerate reduced salinity, penetrated the estuary beyond Victoria Bridge, Aberdeen. The Don was then heavily polluted by effluent from a paper mill, but since the installation of a biological treatment plant, water quality has much improved and the estuary was declared a Local Nature Reserve in 1993 (Bennett and McLeod, 1998). The paper mill has now closed.

58 A large number of common and widespread intertidal faunal species are found on the rocky shores along the east coast of Scotland. Chitons (*Lepidochitona* and *Acanthochitona*), gastropods such as *Nucella lapillus, Patella aspera, P. vulgata, Margarites helicinus*, and several species of *Littorina* and nudibranchs (*Onchidoris spp., Archidoris, Facelina, Aeolidia*) are present on these habitats. A large gastropod

fauna including *Ansates pellucida*, several species of *Lacuna* and some pyramidellids have been also recorded, in association with *Fucus* fronds and laminarian stipes (Eleftheriou *et al.,* 2004).

3.3.2. Conclusions

59 The intertidal substratum in Aberdeen Bay is mostly sandy and moderately exposed to wave action, wind and tidal streams. Hence, an intertidal assemblage typical of moderately exposed beaches, as described above, is likely to be found along the shores possibly affected by the proposed EOWDC development. The dominant species in it (errant amphipods and spionid polychaetes) are adapted to living in a highly perturbed environment, and general unspoilt conditions are reported for most of the coast in the area (Bennett and McLeod, 1998). Hence, although the available data are dated, it is considered unlikely that the intertidal fauna has significantly changed since the data were collected.

60 Sandy intertidal habitats may also function as feeding grounds for the juveniles of many fish species (e.g. plaice *Pleuronectes platessa*; Gibson, 1973; Kuipers, 1977), hence supporting the populations of the adjacent sublittoral areas.

Summary of Intertidal Benthic Community

The open coast beaches of east Scotland are generally moderately exposed to wave action, wind and tidal streams, and the complex shore geology has created a high diversity of intertidal habitats. Sandy beaches are more prominent, although rocky shores are also present along the coast.

In the Aberdeen area, sandy shores are present, with an intertidal fauna being generally dominated by mobile crustaceans (such as haustorid amphipods) and showing a lower diversity, abundance and biomass than more sheltered sandy beaches (such as those at St. Andrews), where sedentary species dominate on richer assemblages.

3.4. SUBLITTORAL BENTHIC ECOLOGY

61 This section reports on the information available on sublittoral benthic fauna for the proposed EOWDC site and the wider area (North Sea and Area SEA 5), as gathered from background data and the CMACS Ltd 2010 benthic survey (Appendix 5.3).

3.4.1. Background information

62 In spite of the fact that the North Sea has been one of the most studied marine environments in the world, historically most investigations have concerned fish populations. As a result there was relatively little information available about the benthic fauna up until 30 years ago, particularly with regard to the northern North Sea (TES, 2008a). The need for further investigations covering the northern and central areas of the North Sea was widely acknowledged (Kingston and Rachor, 1982). Recently this gap has been partly filled by intensive small-scale surveys required for oil and gas exploration in the area. A Working Group on North Sea Benthos was established in 1981 by the International Council for the Exploration of the Sea (ICES). The Working Group organised a survey of the North Sea benthos, which was completed in early 1986. Wide-ranging benthic surveys (Basford and Eleftheriou, 1988; Eleftheriou and Basford, 1989; Basford *et al*., 1989, 1990, 1993; Künitzer *et al*., 1992), as well as epifaunal surveys (Dyer *et al*., 1982, 1983; Jennings *et al*., 1999; Zulhke, 2001) have also been undertaken, providing a database for the description of the benthic fauna of the entire North Sea. A thorough literature review for the Aberdeen Bay area was carried out in 2008 by TES Ltd, describing the North Sea environment and the area around Aberdeen Bay, including references to previous studies, and little new information has become available since its release (TES, 2008a).

63 At the North Sea scale, Künitzer *et al*. (1992) describe a division of the infauna between northern and southern assemblages occurring along the 70 m depth contour. Assemblages were further separated by the 30, 50 m and 100 m depth contour as well as by the sediment type. Cold water species did not occur further south than the northern edge of the Dogger Bank, which corresponds to the 50 m depth contour, whereas warm water species were not found north of the 100 m depth contour. The factors structuring species distributions and assemblages seemed to be temperature, the influence of different water masses (e.g. nutrient rich Atlantic water), the type of sediment and the food supply to the benthos. Much of the primary productivity in the northern North Sea is associated with the input of nutrient rich water from the North Atlantic and this has an effect on the benthic community structure in the northern part of the North Sea. At a North Sea scale, assemblages of other benthic groups such as the meiofauna (Huys *et al.,* 1992) and the epifauna (Dyer *et al.,* 1983; Frauenheim *et al.,* 1989) are structured and grouped within similar spatial patterns as the macrobenthic infauna assemblages.

64 The major division in macro-zoobenthic assemblages between the deeper northern and the shallower southern North Sea was confirmed by the findings of recent macrobenthic infaunal and environmental data from various sources, published by ICES in 2007 (Rees *et al.,* 2007). Separation of assemblages occurred along the Frisian Front at around 30 m depth and at the northern lower slope margin of the Dogger Bank (at a depth between 50 and 70 m). The influence of Atlantic inflow was again highlighted to be an important factor in structuring northern communities. General trends of increasing diversity and density are correlated with increasing latitude and depth.

65 Changes in community structure along the British coast between 1986 and 2000 were also described by Rees *et al*. (2007). A general trend of decreasing species richness was observed with a parallel increase in species abundance. Rees *et al.* (2007) suggest that increased abundances of cold-temperate species, such as the small polychaete *Paramphinome jeffreysii* and the interface-feeding *Myriochele* spp., north of the 50 m contour line could be an indication of the influence of colder northern water masses.

66 Within Aberdeen Bay, Stephen (1933, 1934) reported on a group of samples from around Aberdeen (20 – 40 m depth) and a transect of eight stations extending offshore in a south-easterly direction to the 100 m contour. The above stations, along with another fifteen dispersed widely throughout this sub-division of Area SEA 5, were considered to be from a community characterised by the presence of *Ophiura affinis* and *Echinocyamus pusillus*. Stephen (1933, 1934) concluded that there was large-scale geographic similarity in the offshore fauna and that it was less abundant than the inshore fauna. Stephen (1933, 1934) also noted a sub-community off the north-east coast of Aberdeenshire. Here large numbers of broken *Sabellaria* tubes (species of high nature conservation importance), probably originating from the masses growing near Rattray Head, formed the substratum for a community characterised by the molluscs *Astarte compressa, Cardium fasciatum, Venus ovata* and *Leda (*now *Nuculana) minuta*, and the polychaetes *Glycera lapidum* and *Ophelia limacina*.

67 At a later date, McIntyre (1958) described the benthos of the east coast fishing grounds with reference to surveys of St. Andrews and Aberdeen Bays. He found the fauna to be dominated by lamellibranchs and polychaetes together with the bivalves *A. alba, T. fabula, Nucula turgida* and *Ensis* sp. In addition the polychaetes *L. conchilega, Sigalion mathildae, Notomastus latericeus* and *Nephtys* spp. were dominant in both bays. Aberdeen Bay had a quantitatively richer fauna than St. Andrews Bay. The poorer offshore fauna was dominated by *A. alba* at St. Andrews and by *N. turgida* in Aberdeen Bay.

68 According to the results of a drop down video survey undertaken in 2007 by EMU Ltd for AOWFL, two main biotopes were described in the proposed EOWDC area, namely SS.SSa.CMuSa and SS.SSa.CCS. Tide-swept circalittoral coarse sand, gravel and shingle (SS.SCS.CCS) is a habitat occurring generally at depths of over 15-20 m and is typical of tidal channels of marine inlets, along exposed coasts and offshore. As with shallower coarse sediments, this biotope is characterised by robust infaunal polychaetes, mobile crustacea and bivalves. Circalittoral non-cohesive muddy sands (SS.SSa.CMuSa) is a biotope characterised by a silt content of the substratum typically ranging from 5% to 20%. This biotope is generally found in water depths of over 15-20 m and supports animal-dominated communities characterised by a wide variety of polychaetes, bivalves and echinoderms.

69 The proposed EOWDC site is located between two main estuarine areas: the Ythan Estuary, northwards, and the River Dee estuary, southwards. The invertebrate fauna of the Dee estuary was studied by Eleftheriou (1964). As might be expected, the maximum densities of marine, estuarine and freshwater species were found at the mouth, middle and head of the estuary respectively. The Ythan Estuary is a small meso-tidal bar-built estuary (Davidson *et al*., 1991) lying approximately half way between Peterhead and Aberdeen on the east coast of Scotland. It is a well-understood small-scale ecosystem (Raffaelli, 1992) and has been the subject of many studies based at the Culterty Field Station of the University of Aberdeen. At the mouth of the Ythan the sediments are sandy with stones and mussel beds and with occasional patches of muddy sand. In the middle reaches of the estuary the

sediments are muddy sand becoming finer further into the inner estuary (Baird and Milne, 1981). The faunal community is well studied with the amphipod *Corophium volutator*, the gastropod mollusc *Hydrobia ulvae*, the polychaete *Hediste diversicolor* and the bivalve *Macoma balthica* being widely distributed. Species such as the cockle *Cerastoderma edule*, the gastropod *Littorina littorea,* the shore crab *Carcinus maenas* and the mussel *Mytilus edulis* exhibit more localised distributions (Bennett and McLeod, 1998). Increasing weed cover (*Enteromorpha intestinalis*) led to increases in the the abundance of the opportunistic polychaete species *Capitella capitata* in the 1980s. Also local populations of less common species occur in the Ythan, such as the annelid *Lumbriculus variegatus*, the very local mollusc *Hydrobia ventrosa* and the very rare marine midge *Halocladius braunsi* (Scottish Natural Heritage, http://www.snh.org.uk/pdfs/publications/nnr/ForvieNNRTheReserveStory.pdf).

70 Also, rocky platforms and boulders/loose rock occur to the south of Aberdeen (River Dee) and to the north of the Ythan Estuary, with the littoral rocky shoreline extending sublittorally as outcrops of bedrock of variable extent and size. The invertebrate fauna associated with these habitats is described in Section 3.3. Intertidal Benthic Ecology of the present document.

3.4.2. Information taken from CMACS Ltd Survey 2010

71 The CMACS Ltd benthic grab survey was conducted in October 2010, using a standard weighted Day grab with a 0.1 m^2 sample area for all sediment sampling. Fourteen stations were visited in total, 6 in (and 8 outside) the proposed EOWDC area (see Figure 1 in Appendix 5.3 for sampling stations location). Macrofaunal analysis was carried out at the CMACS Ltd laboratory in the Isle of Man which participates in the National Marine Biology Analytical Quality Control Scheme. Further details on the sampling and laboratory methodologies, the data analysis and the raw data are provided in the CMACS Ltd Technical Report (Appendix 5.3). Additional analyses carried out by IECS on CMACS Ltd benthic data are provided in Appendix 5.4.

72 A total of 70 species was recorded from the survey area as a whole. The key dominant species (making up 85% of total abundance in the area) are reported in Table 2.

73 The mean number of species recorded across the sites was 18.3 (ranging from 10 to 32), whereas abundance values ranged from 17 to 145 individuals/0.1 m^{-2} (with an average value of 60.43 individuals/0.1 m^{-2}) (Appendices 5.3 and 5.4).

74 In general, the greatest number of species and abundances were recorded from the deeper stations in the proposed EOWDC site. This is likely to be due to the increasing depth and distance from the shore and the fact that there was a relatively high proportion of silt/clay present at these stations. This is supported by the data collected from stations 4, 8 and 9 which are located in the proposed EOWDC area (Figure 4). These stations have the highest number of taxa and are all in waters deeper than 27 m. When considering stations outside the proposed EOWDC area, this pattern was less evident, as, for example, stations at depths between 28 and 31 m showed either high (station 10) or low (station 3 and 11) number of taxa.

75 The species diversity (measured by the Shannon-Wiener diversity index H'(log_2) and the Pielou's evenness index (J') varied throughout the area with some of the shallower stations (such as station 1) having a more varied species composition and

some of the deeper stations (e.g. station 8) being more dominated by large numbers of a single species (as indicated by the lower values of the evenness index) (Appendix 5.4). The values of these indices across the stations, together with the relatively low abundance ratio, indicate a general even spread of the individuals between the species, suggesting that the communities are not dominated by one or very few species.

76 The dominant faunal groups found were polychaetes (Annelida), crustaceans and the molluscs (Appendix 5.3). The dominant species of polychaetes were *N. latericeus*, *S. bombyx*, *Galathowenia oculata*, *Pholoe baltica*, *N. cirrosa* and *Nephtys assimilis*. The most abundant molluscs were the bivalves *N. nitidosa*, *T. fabula*, *Kurtiella bidentata* and *A. alba*. The most abundant crustaceans were the amphipods, such as *Bathyporeia guilliamsoniana* and *Ampelisca brevicornis*. Other groups accounted for less than 7% of the total faunal abundance.

77 The most abundant species across the survey area as a whole was the annelid worm *N. latericeus* (243 individuals being found across 12 out of the 14 stations). *N. latericeus* is a polychaete (bristle worm) with a wide distribution across the North Sea and is generally thought to be found in low numbers. It is thought to inhabit sediment with a mud content of 0-50%, preferring sediments with a mud content of 10-30% (Warwick and Davies, 1977). This species is found across the survey area (Appendix 5.3), particularly in relatively deep locations. The stations where *N. latericeus* was particularly prevalent are all deeper than 25 m.

78 The second most common taxa at the proposed EOWDC site were juvenile brittle stars from the Ophiuridae family (Appendix 5.4). It is likely that these are *Ophiura ophiura*, but small juveniles are often difficult to identify to species level. The distribution of this taxon shows that these are more abundant towards the south of the lease boundary, stations 5, 6 and 9 having the highest numbers of juvenile Ophiuridae. These sites were all classed as muddy sand, suggesting the juvenile brittle stars have an affinity for muddier sediment types.

79 The third most abundant species was *N. nitidosa* (Appendix 5.4), which is a bivalve mollusc found throughout the North East Atlantic and European coastal waters. *N. nitidosa* shows a similar distribution to *N. latericeus*, being present at higher abundances in deeper waters. However, when compared with *N. latericeus* individual numbers per station were considerably lower.

80 The forth most abundant species was *T. fabula* (Appendix 5.4), which is a small burrowing bivalve commonly found in most coastal areas and occurring in a wide range of sediments. The distribution of *T. fabula* shows that it was absent from the closest inshore stations but appears to be present throughout the rest of the survey area, showing overall higher abundances outside the proposed EOWDC area. Although *T. fabula* was the third most abundant species, individual numbers are low and do not exceed 12 at any stations.

Table 2. Key infaunal species (top 85% abundance) for the survey area as a whole (CMACS Ltd Benthic Survey 2010).

Species	Taxonomic group	Ranked abundance
Notomastus latericeus	Polychaeta	1
Ophiuridae juv.**	Echinodermata	2
Nucula nitidosa	Bivalvia	3
Tellina fabula	Bivalvia	4
Spiophanes bombyx	Polychaeta	5
Galathowenia oculata	Polychaeta	6
Acrocnida brachiata	Echinodermata	7
Pholoe baltica	Polychaeta	8
Kurtiella bidentata	Bivalvia	9
Abra alba	Bivalvia	10
Nephtys cirrosa	Polychaeta	11
Nephtys assimilis	Polychaeta	12
Amphiura filiformis	Echinodermata	13
Nephtys sp. juv.	Polychaeta	14
Chamelea striatula	Bivalvia	15
Amphiuradae sp. juv.	Echinodermata	16
Bathyporeia guilliamsoniana	Amphipoda	17
Thyasira flexuosa	Bivalvia	18
Diastylis bradyi	Cumacea	19

**Ophiuridae juv. include Ophiuridae juv and *Ophiura* sp. Juv

81 The multivariate analysis carried out on the species abundance data highlighted the presence of two distinct groups of stations showing different benthic assemblages (Appendices 5.3 and 5.4). All the stations in the proposed EOWDC area (stations 4-9) and 5 of the stations outside it (stations 1, 3, 10-12) (Group A) showed benthic assemblages characterised by higher species richness and abundance than the rest of stations (stations 2, 13 and 14; Group B), located inshore, outside the proposed EOWDC area. Dominant species in stations from the Group A are the polychaete *N. latericeus*, followed by the bivalves *N. nitidosa* and *T. fabula* and brittle star of the family Ophiuridae. In turn, the polychaete *N. cirrosa* and amphipods dominated the benthic assemblage in stations from Group B, though with very low abundances if compared to the values recorded in the other group. The patterns in the species distribution and communities observed were found to be highly related to sedimentary and depth parameters (mainly median grain size, % sand, % silt/clay and depth, as indicated by the BIOENV analysis). Such a correlation between sediment types and depth is likely to reflect the difference between shore positions.

82 The infaunal communities are clearly strongly influenced by the depth and distance offshore (these two being indistinguishable on this open coast). The above results (combining faunal and sediment data) allowed the identification of two major biotopes in the survey area (Appendices 5.3 and 5.4). The biotope SS.SSA.CMuSa.AalbNuc (*A. alba* and *N. nitidosa* in circalittoral muddy sand or slightly mixed sediment) occurred at the majority of stations (these are the stations included in Group A defined by the multivariate analysis presented above). The biotope SS.SSA.IFiSa.NcirBat (*N. cirrosa* and *Bathyporeia* spp. in infralittoral sand) occurred at the inshore stations (these are the stations included in Group B defined by the

multivariate analysis presented above) where a much lower silt/clay content was detected (being predominantly fine-medium sands).

3.4.3. Conclusions

116 The proposed EOWDC area supports a benthic infaunal community similar to that occurring in the surrounding environment. There are no major differences in the community characteristics (species richness, abundance and diversity) or the taxonomic structure between the stations inside and outside the proposed EOWDC area (when considering similar depth conditions).

117 Overall, the benthic faunal characteristics in the area reflect those reported in the literature for Aberdeen Bay, with particular regard to the study by McIntyre (1958). Benthic infauna is quantitatively dominated by polychaetes (Annelida), such as *N. latericeus*, and the bivalves *N. nitidosa* and *T. fabula*. Ophiuridae are also characteristic of the surveyed benthic assemblages, particularly at offshore stations. This is consistent with previous findings of Stephen (1933, 1934) regarding the Aberdeen Bay area.

118 Most of the surveyed area is characterised by circalittoral non-cohesive muddy sands supporting animal-dominated communities characterised by a wide variety of polychaetes, bivalves and echinoderms, partly confirming the biotope analysis carried out in 2007 by EMU Ltd. In particular, the dominant benthic community strongly resembles the JNCC biotope SS.SSA.CMuSa.AalbNuc (*A. alba* and *N. nitidosa* in circalittoral muddy sand or slightly mixed sediment).

119 Although the previous biotope analysis (EMU Ltd., 2007) also described the presence of tide-swept circalittoral coarse sand, gravel and shingle (SS.SCS.CCS) in a small patch within the proposed EOWDC area, this biotope was not identified during the CMACS Ltd benthic survey in 2010. However, it should be noted that biotope analysis by EMU Ltd 2007 was based on geophysical data only. An additional biotope was described by CMACS Ltd study at inshore sites (outside of the proposed EOWDC area) not explored in 2007. These sites are characterised by finer sands, with sparser benthic assemblages matching well with the biotope SS.SSA.IFiSa.NcirBat (*N. cirrosa* and *Bathyporeia* spp. in infralittoral sand).

120 The differentiation between the benthic assemblages in the area is clearly strongly influenced by the depth and distance offshore, with the assemblage/biotope in the proposed EOWDC area being consistent with those found at stations located outside the lease boundary at a greater distance offshore.

Summary of Infaunal Community and Biotope Mapping

Species richness, abundance and diversity are variable across the site. These biological parameters are somewhat higher at deeper offshore stations than inshore ones. Numbers of species and abundance are somewhat lower outside the proposed EOWDC area; however, Shannon-Weiner diversity remains similar.

Two types of communities occur across the proposed EOWDC site, mainly reflecting sedimentary and depth characteristics. A community with a low number of species and abundance is present at inshore shallow stations with fine-medium, well-washed, sandy sediments. This community is characterised by the polychaete *N. cirrosa* and amphipods. A community with a relatively high number of species and abundance occurs at the offshore stations (including those present in the proposed EOWDC area), where the sediments are generally classified as muddy sand. The most abundant species in this community are the polychaete *N. latericeus*, the bivalves *N. nitidosa* and *T. fabula* and brittle stars of the family Ophiuridae.

These two communities can be characterised by two major biotopes: SS.SSA.CMuSa.AalbNuc (*A. alba* and *N. nitidosa* in circalittoral muddy sand or slightly mixed sediment) and SS.SSA.IFiSa.NcirBat (*N. cirrosa* and *Bathyporeia* spp. in infralittoral sand).

3.5. EPIBENTHIC FAUNA AND FISHERY ECOLOGY

121 This section reports on the information available on epibenthic invertebrate and fish fauna for the proposed EOWDC site and the wider area (North Sea and Area SEA 5), as gathered from background data and the epibenthic surveys carried out in the area in 2010 by CMACS Ltd (specifically for this project) and Marine Scotland Science (MSS, not for this project).

3.5.1. Background information

3.5.1.1. EPIBENTHIC INVERTEBRATES

122 Dyer *et al.* (1982) mapped the abundances of the most common or locally abundant epifauna species in the North Sea. Seven of these occurred in Area SEA 5: the echinoderms *Echinus acutus* and *Asterias rubens*, the polychaete *Hyalinoecia tubicola*, the red sea pen *Pennatula phosporea*, Dead Men's Fingers *Alcyonium digitatum*, the Norway Lobster *Nephrops norvegicus* and the bryozoan *Flustra foliacea*.

123 In Aberdeen Bay, Stephen (1933, 1934) reported on a group of samples from around Aberdeen (20 – 40 m depth) and a transect of eight stations extending offshore in a south-easterly direction to the 100 m contour. The above stations, along with another fifteen dispersed widely throughout this sub-division of Area SEA 5, were considered to be from a community characterised by the presence of *Ophiura affinis* and *Echinocyamus pusillus*. Stephen (1933, 1934) concluded that there was large-scale geographic similarity in the offshore fauna and that it was less abundant than the inshore fauna. Stephen (1933, 1934) also noted a sub-community off the north-east coast of Aberdeenshire. Here large numbers of broken *Sabellaria* tubes (species of high nature conservation importance), probably originating from the masses growing near Rattray Head, formed a substratum for a community characterised by the molluscs *A. compressa, C. fasciatum, V. ovata* and *N. minuta*, and the polychaetes *G. lapidum* and *O. limacina*.

3.5.1.2. SPAWNING AND NURSERY GROUNDS

124 The offshore area around Aberdeen is reported as a spawning ground for many commercially important species. The juvenile stages of many of these species remain within coastal nursery areas for a year or two before moving offshore. The offshore areas are characterised by fish communities dominated by haddock, whiting and cod, with saithe (*Pollachius virens*) and Norway pout (*Trisopterus esmarki*) being associated with deeper waters. Lemon sole (*Microstomus kitt*) are distributed throughout the central and northern North Sea and are pelagic spawners (February to June, with peak spawning period between April and May; Coull *et al.*, 1998). Little is known about this species' spawning habitats, and it is thought the lemon sole spawns throughout its range (CEFAS, 2001).

125 According to broad scale maps of fishery sensitivity areas in British waters, spawning grounds of herring, lemon sole and sandeel *Ammodytes marinus*, and nursery areas for lemon sole, sprat *Sprattus sprattus*, saithe, plaice and sandeel are present in the area where the proposed EOWDC site is located (Coull *et al.*, 1998 – see Appendix 5.2).

126 These maps have been updated for some species with more recent larval and juvenile data obtained from ichthyoplankton and groundfish surveys (CEFAS, 2010). The updated maps seem to confirm the spawning of sandeel in the area, while highlighting also the presence of nursery areas of herring, whereas a minor importance as spawning or nursery grounds was highlighted for plaice in the area (no updated data were available for lemon sole, sprat and saithe). Sandeel and herring play a key role in the North Sea food web. Sitting in a mid-trophic position, they are major predators of zooplankton and the principal prey of many top predators such as Atlantic salmon and sea trout. Sandeel eggs are demersal, and are laid in sticky clumps on sandy subratrata from November to February (Coull *et al.*, 1998). On hatching, the larvae become planktonic, resulting in a potentially wide distribution (CEFAS, 2001). Herring is a migratory species and is found throughout the area, although its distribution is seasonal.

127 The above mentioned maps represent very broad scale distributions and do not take into account the different suitability of habitats for the species within the highlighted areas. Sandeel, for example, is closely associated with well-oxygenated, medium to coarse sand, hence its distribution will be limited to this suitable habitat (not detected in the proposed EOWDC area, where fine to very fine sandy sediments occur). In addition, spawning grounds are dynamic features of fish life history and are rarely fixed in one location from year to year. Although some fish species exhibit the same broad patterns of distribution from one year or season to the next, others show a large degree of variability. For sediment spawners, not all suitable sediment areas might be used in every year and areas used will depend on the size of the spawning stock. Also the locations of nursery areas can change from year to year depending on factors such as water temperature or the availability of food. It is therefore difficult to define the limits of nurseries precisely. The maps provided in Appendix 5.2 as well as those provided by CEFAS (2010) must therefore be considered an indication of the likely positions of juvenile and egg concentrations, representing the widest known distribution rather than a definitive description of the limits of all spawning and nursery grounds.

128 No specific information has been found in the literature on the use of the proposed EOWDC site as a fish nursery or spawning ground. However, an indication that no specific spawning or nursery grounds are present within the site came from the Marine Scotland Licensing Operations Team in its scoping response (2010).

3.5.1.3. MIGRATORY SPECIES

129 There are several species that migrate between fresh and salt waters (diadromous species) in the North Sea, such as Atlantic salmon, sea trout, sea lamprey, river lamprey (*Lampetra fluviatilis*), European eel, twaite shad (*Alosa fallax*), allis shad (*Alosa alosa*) and sparling (*Osmerus eperlanus*) (Barne *et al.*, 1996; DTI, 2004b).

130 Atlantic salmon, anadromous sea trout and European eel, in particular, may use the coastal areas of Scotland for feeding and migration and are of high economic and / or conservation value (see Section 3.6. Nature Conservation Status). However the knowledge on the migration routes of these species along the east coast of Scotland is rather scarce and uncertain (Malcom *et al.*, 2010). Further details on this issue are provided in the salmon and sea trout assessment for the proposed EOWDC.

3.6.1.4. NON-COMMERCIAL FISH SPECIES

131 The numbers of exploited and non-exploited fish species from coastal areas of Area SEA 5 were estimated by Swaby and Potts in 1993 (in Swaby and Potts, 1996,

1997a, b, c). Information on the distribution and abundance of non-commercial species comes from records made during routine groundfish surveys, landings data, historical records as well as scientific studies. The most abundant species found in near-surface surveys in areas from Aberdeen to off Shetland were rocklings (Gadidae), members of the herring family (Clupeidae) and three-spined sticklebacks (*Gasterosteus aculeatus)* (Swaby and Potts, 1996).

3.5.1.5. CEPHALOPODS

132 Cephalopods are important elements in food webs and interact with commercial fisheries of finfish. Evidence exists that fishing pressure has changed ecological conditions and shifts in community structure have occurred with cephalopod stocks slowly replacing predatory fish stocks (Caddy and Rodhouse, 1998). Their commercial significance to world fisheries is relatively recent but is increasing (Boyle and Pierce, 1994). According to Stephen (1944) frequently occurring cephalopod species in the North Sea include *Eledone cirrhosa*, *Sepiola atlantica*, *Sepiola pfefferi*, *Sepietta oweniana*, *Rossia macrosoma*, *Rossia glaucopis*, *Sepia officinalis*, *Loligo vulgaris*, *Loligo forbesi*, *Alloteuthis subulata*, *Illex coindetii*, *Todaropsis eblanae* and *Todarodes sagittatus.* Infrequently occurring species are *Bathypolypus arcticus*, *Benthoctopus piscatorum*, *Sepietta neglecta*, *Sepia elegans*, *Onychoteuthis banksi*, *Architeuthis monachus*, *Architeuthis harveyi*, *Sthenoteuthis caroli* and *Brachioteuthis riisei.* The main commercial species in Scottish waters is the long-finned squid *L. forbesi* (Boyle and Pierce, 1994; Pierce *et al.*, 1994a, b, 1998). Since 1995, annual UK landings of loliginid squid have ranged between 1600 and 3200 tonnes, making the UK the second most important fishery nation for loligonid squid within the ICES region after France. Figure 5 shows the total squid landings for Area SEA 5 in 1998. Although squid are caught off the Aberdeen coast, this area is not the most important in terms of Area SEA 5 as a whole.

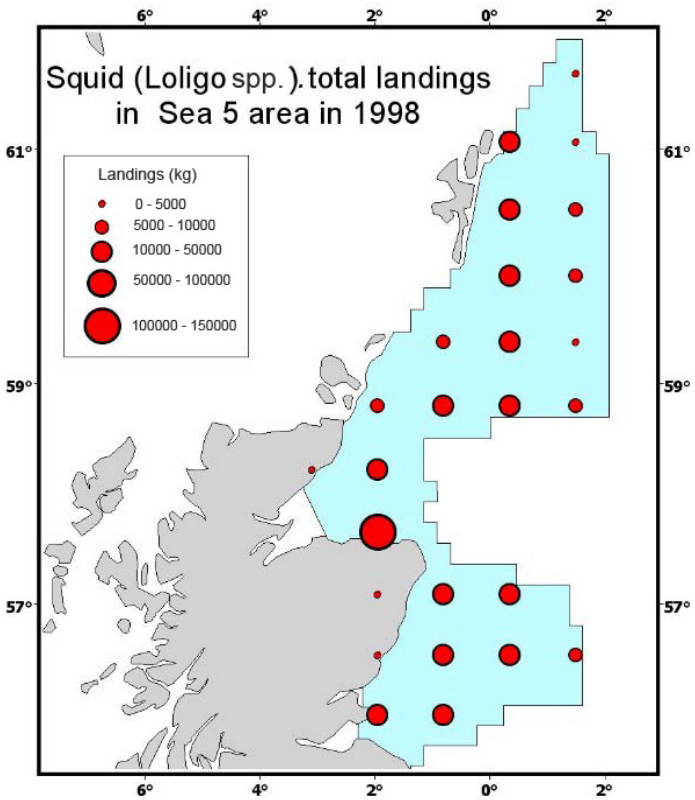


Figure 5. Squid total landings in Area SEA 5 in 1998. Source: Stowasser *et al.* (2004).

3.5.1.6. ELASMOBRANCHS

133 Elasmobranchs are cartilaginous fish that share life history characteristics which make them vulnerable to over fishing (e.g. slow growing, late maturity, low fecundity), meaning that once depleted, populations take a long time to recover.

134 Several elasmobranchs species (sharks, skates and rays) occur in the Scottish waters. According to the results of the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) groundfish surveys, spiny dogfish *Squalus acanthias* and starry ray *Amblyraja radiata* are frequently found in the North Sea, as well as lesser-spotted dogfish *Scyliorhinus canicula* and cuckoo ray *Leucoraja naevus* (Ellis *et al.*, 2005). Other less frequent species are tope *Galeorhinus galeus*, smoothound *Mustelus asterias,* spotted ray *Raja montagui*, common skate *Dipturus batis*, sandy ray *Leucoraja circularis*, shagreen ray *Leucoraja fullonica*, thornback ray *Raja clavata* (Ellis *et al.*, 2005). Many of these species have depleted populations, with the common skate being nearly extirpated from the UK waters (Fowler *et al.*, 2004). As a result many species of sharks and rays are on the OSPAR list of Threatened and Declining Species due to their removal as both target and non-target species of fishery (Scottish Government, 2011). These species are found mainly off the north-west coast of Scotland (e.g. spiny dogfish, shagreen ray, thornback ray, spotted ray) (Scottish Government, 2011), where their main nursery areas are located (CEFAS, 2010). Hence a significant occurrence of these species in the shallow area where the proposed EOWDC site is located is unlikely.

135 Porbeagle sharks (*Lamna nasus*) are also found throughout the North Atlantic, with the largest population in UK waters found to the north of Scotland. Recorded sightings of porbeagle sharks within the North Sea have generally occurred offshore in the central North Sea, between May and September (Weir, 2001).

136 The Basking shark, *Cetorhinus maximus,* is the world's second largest fish species, with a circum-global distribution in warm-temperate to boreal seas. Sightings data indicate that this species is common along the west coast of the UK as far north as the Shetland Islands, and is infrequently recorded off the east coast of the UK mainland (Figure, 6). According to TES (2008a) a basking shark was reported during a boat survey close to the proposed EOWDC area on the 16th November 2007. A survey carried out by Travers *et al.*, 2008, also in 2007, did not record any basking sharks in Aberdeen Bay and it may be that the TES sighting was an unusual and isolated event.

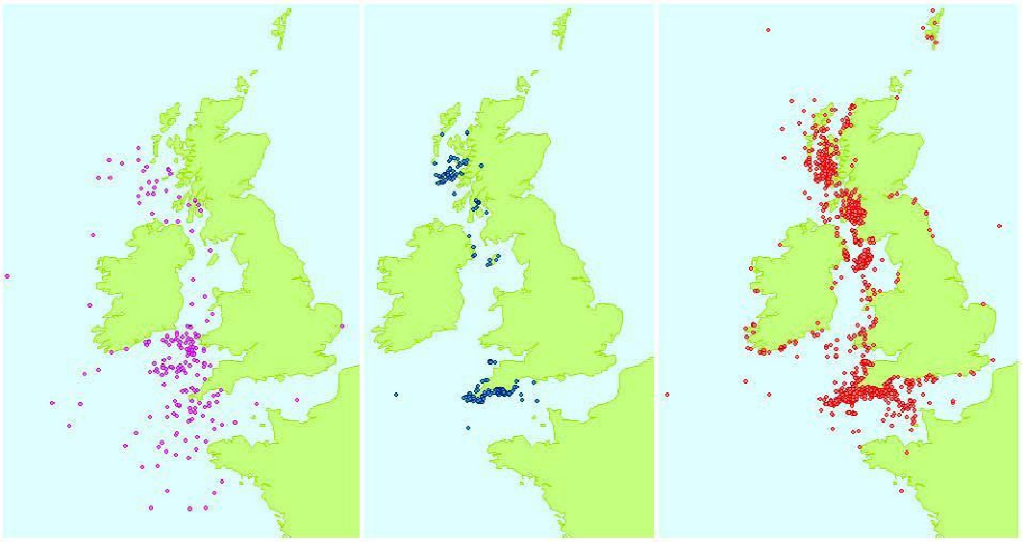


Figure 6. Distributions of basking sharks on the European continental shelf, determined using three independent methods: pink, tag geolocations; blue, scientific surveys; red, public sightings. Survey and sightings data from CEBS partners. Source: Basking shark population assessment research project – Report produced by CEFAS on behalf of the Global Wildlife Division, Defra.

3.5.2. Information taken from CMACS Ltd and MSS Epibenthic Surveys 2010

137 Epifaunal benthic surveys were undertaken in October 2010 in the proposed EOWDC area and in the surrounding marine environment by the CMACS Ltd (Appendix 5.3). Additional benthic survey data, collected in the same year (in September), were presented by MSS and these have been analysed by IECS (Appendix 5.5) and the results integrated with the CMACS Ltd survey results. In both cases, data were obtained by the combination of video camera surveys and epibenthic trawls in the area.

138 The CMACS Ltd epibenthic survey programme comprised 15 underwater camera stations (6 in the proposed EOWDC area, and 9 outside it, as a reference) and 10 stations which were sampled using a 2 m scientific beam trawl (4 stations inside and 6 outside the proposed EOWDC area). Further details on the CMACS Ltd epibenthic survey methods and data analysis are provided in Appendix 5.3.

139 The MSS survey was carried out in Aberdeen Bay at 14 video camera stations and at 7 stations sampled by means of Agassiz trawl net. Most of the stations were located in the area where CMACS Ltd survey took place, except for stations TV 42, TV 43, TV44, ABAG4 and ABAG5, located 1 to 5 km further offshore (see Appendix 5.5 for station locations). Further details on the MSS epibenthic survey and on the data analysis (carried out by IECS on MSS data) are provided in Appendix 5.5.

140 The main results obtained from the CMACS Ltd and MSS 2010 surveys (detailed in Appendices 5.3, 5.4, and 5.5) are presented here and compared to the data obtained during a previous epibenthic survey carried out in 2006 (April 7th) in Aberdeen Bay by FRS[7] (Table 3).

[7]The 2006 FRS survey consisted of 3 epifaunal trawls (between 12 and 25 m of depth) with video footage being obtained during the same survey. The raw data were provided by FRS in 2006, during the first consultation round.

Table 3. Species from Aberdeen Bay caught in epifaunal trawls during 2006 survey. Source: FRS, 2006.

	Haul 1	**Haul 2**	**Haul 3**
Haul duration, min	20	20	23
Start and end coordinates	57°12.690N 2°00.320W 57°11.800N 2°00.740W	57°11.970N 2°01.430W 57°11.070N 2°00.980W	57°11.170N 2°02.660W 57°12.230N 2°02.380W
Depth, m	25	19	12
Species:			
Common dab	13	13	2
Long rough dab	1	3	/
Plaice	26	29	10
Flounder	1	0	1
Pandalus	1	0	1
Asterias	17	8	0
Echinoderm	2	3	1
Brittle stars	180	50	20
Dead mens fingers	0	1	0
Pipefish	0	1	4

141 A fairly uniform seabed was observed in the proposed EOWDC area during CMACS Ltd and MSS 2010 surveys and no sensitive habitats were observed during the camera surveys. The sediments were mainly composed of fine sand, silt/clay and shell fragments, and sand ripples on the sea bed were noticeable. The observed sediment characteristics were consistent with the results of sediment analysis (Section 3.2. Sediment and Water Quality). No seaweed was recorded at these stations. The epifauna was sparse, with only brittle stars being seen regularly in high numbers. Also some fish species, mostly plaice and common dab (*Limanda limanda*), were detected.

142 During the MSS survey, deeper areas farther offshore (1 to 5 km far from the proposed EOWDC area) were also explored in addition to the shallow areas surveyed by both MSS and CMACS. These deeper sites comprised areas of mixed sediments including coarse sediments, stones, pebbles and boulders with silt/clay particles. Relatively slow current speeds and lower water turbidity were also recorded at these stations. A more diverse and abundant epifauna was recorded with the common starfish *Asterias rubens*, the bryozoan *Flustra foliacea* and dead man's fingers *Alcyonium digitatum* occurring in large numbers at these stations. Attached epifaunal species (anemones, bryozoans, sponges) were also notable on the video footage.

143 The trawl surveys carried out in the area in 2010 by CMACS Ltd and MSS gave similar results on the overall structure of epifauna assemblages. It is of note that similar sampling methods were employed in all surveys. Specific differences may be ascribed to the different timing of sampling (September for the MSS survey, late October for the CMACS Ltd survey) and to the different areas explored during the two surveys (with the MSS survey also covering offshore areas).

144 Brittle stars were always present as a quantitatively important taxon in the invertebrate epifaunal community of the studied site (Appendices 5.3 and 5.5). These organisms are typical of sandy and muddy sandy sea beds from the shallow sublittoral through to 200 m depth. The common starfish was also found in the area. It is common and widespread throughout British coastal waters and occurs in most

sublittoral zones, particularly on soft sediments. These results confirmed the observations carried out previously by FRS in the Aberdeen area in 2006 (Table 3).

145 The brown shrimp *Crangon crangon* dominated the epifaunal invertebrate assemblage in the CMACS Ltd catches (late October 2010), whereas it was not detected in the MSS catches (September 2010), where brittle stars dominated the epifaunal assemblage (Figure 7). Although *C. crangon* is common in shallow coastal waters, its abundance is highly seasonal in these areas (Campos and van der Veer, 2008). Larger catches are usually obtained in autumn, when *C. crangon* is generally present in large numbers in the shallower fishing grounds near the coast. Peak autumn landings in recent years have proven to extend later in the autumn season (Campos and van der Veer, 2008) hence higher abundances of the species are expected in late October than in September.

146 In late October 2010 (CMACS Ltd survey), high abundances of the swimming crab *Liocarcinus holsatus* were also recorded in the area (Figure 7). This is a common species which is found throughout in the North Sea. Its high abundance in the CMACS Ltd samples can be related to the presence and abundance of the brown shrimp in the area in late October since this species is the principle food source for swimming crabs.

147 The distribution of invertebrate epifauna across the site was clearly related to depth and distance from shore. Some correlations between species distribution and sediment type were also suggested by the results. Higher numbers of brittle stars, for example, were associated with muddy areas although there were some muddy areas where brittle stars abundance was low. *C. crangon* also showed an apparent correlation with softer sediment types and in general, a higher number of taxa was also detected at deeper stations than in the shallower, inshore stations (CMACS Ltd survey 2010, Appendix 5.3).

148 In terms of fish fauna, the dominant species in the area were always two flatfish species, the common dab and plaice, with these two species being found throughout the entire survey site in 2006 (FRS survey, Table 3) and in 2010 (CMACS Ltd and MSS surveys, Appendices 5.3, 5.4, and 5.5, Figure 8). These are common species around the UK coastline, usually found within a few meters to about 100 m water depth. The majority of individuals from these commercial species were caught as juveniles below the legal landing size.

149 Hooknose *Agonus cataphractus* was also abundant in the survey area in both 2010 surveys (Figure 8). This is a small, non commercial species that is common around UK coastal areas, particularly on sandy seabeds.

150 Other abundant species included Norway pout, which was particularly abundant in the September 2010 catches (MSS survey), and whiting, which was more abundant in late October (CMACS Ltd survey). Both species showed a high degree of temporal variability.

151 As well as dab, plaice and whiting, other species of commercial fish included sprat, haddock, witch (*Glyptocephalus cynoglossus*), bib (*Trisopterus luscus*) and grey gurnard (*Eutrigla gurnardus*).

152 Sandeels were also present in the catches, in particular in late October, although low abundances were detected during the 2010 CMACS Ltd survey in the area (43 individuals overall, mainly at shallower inshore stations).

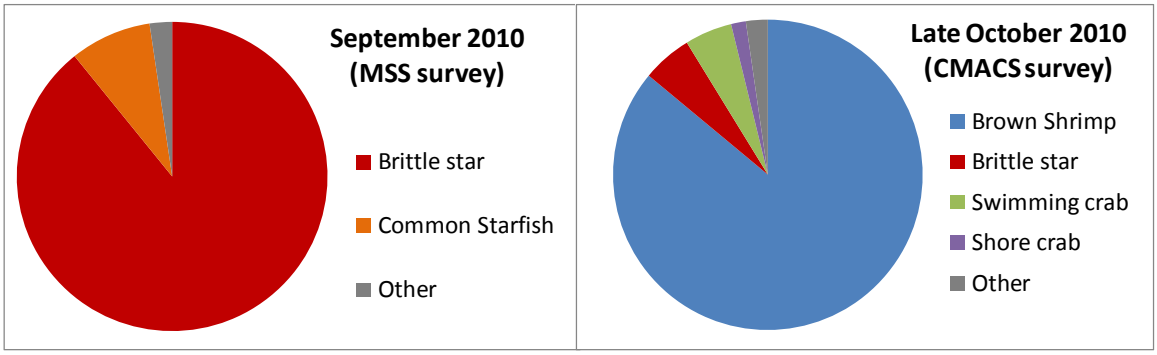


Figure 7. Composition (% abundance) of the invertebrate epifauna assemblages in the study area based on the two surveys carried out in 2010.

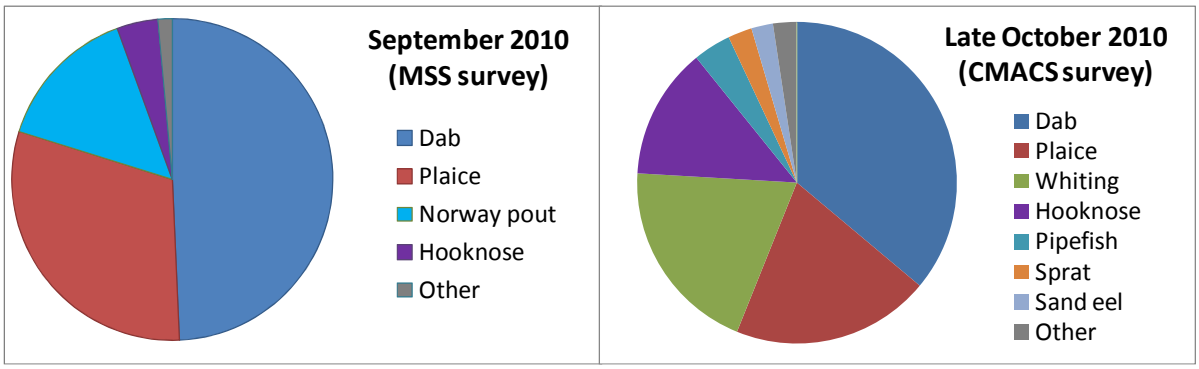


Figure 8. Composition (% abundance) of the fish assemblages in the study area based on the two surveys carried out in 2010.

153 The distribution of fish fauna across the site (the 2010 CMACS Ltd and MSS surveys) seemed related to depth and/or distance from shore. In general, higher numbers of fish taxa occurred at the more inshore locations, this pattern being contrary to that detected for epifaunal and infaunal assemblages. Dab and plaice, in particular, were recorded with higher numbers at the shallower, inshore stations, whereas hooknose and whiting were more abundant in deeper waters. Differences among fish assemblages were particularly evident when comparing offshore stations (station 8 of the 2010 CMACS Ltd survey and station ABAG4 of the 2010 MSS survey) with the inshore stations. Lower abundances of flatfish and brittle stars characterised the offshore areas, and this can be related mainly to the greater depth and distance from the shore.

3.5.3. Conclusions

154 Overall, the epibenthic invertebrate fauna in the area is sparse and composed of brittle stars, brown shrimp and swimming crabs (the latter two species being mainly represented later in the autumn period). The most common fish species are flatfish, such as dab and plaice, particularly at inshore areas. Hooknose and whiting are also abundant. These survey findings confirm what is reported in the literature.

155 According to large scale mapping, the proposed EOWDC area appears to fall within nursery and spawning grounds of several fish species which are either of commercial interest (such as flatfish) or may constitute important feeding resources for other fish predators (e.g. sandeel and herring). However, no specific spawning and nursery grounds are known to exist in the proposed area (MS-LOT reference in Scoping response 2010).

156 The low abundance of sandeels recorded during the surveys in the proposed EOWDC area and its surroundings seems to support the absence of a spawning ground for the species in the area. During autumn and winter, sandeels usually lie dormant, buried in the sediment, hence bottom trawl surveys carried out in these periods should have provided good estimates of the abundance of local populations (Greenstreet *et al*., 2010). The observed low abundances of sandeels could possibly be ascribed to a preference of the species towards coarser sandy bottoms (Dickey-Collas *et al*., 2010), not present in the proposed EOWDC area. Sandeel is also a key prey species for Atlantic salmon and sea trout, which have important spawning areas in nearby rivers (e.g. River Dee). The low abundance of sandeels in the proposed EOWDC area suggests the area is not an important feeding ground for these predator species.

157 The epibenthic survey in the area recorded high abundances of juveniles of flatfish species. The inshore, shallower coastal areas are likely to serve as nursery grounds for flatfish (mainly plaice and dab) extending over a wider area along the Scottish coast (Appendix 5.2).

158 The coastal waters in the Aberdeen Bay, where the proposed EOWDC area is situated, are likely also to be used as migratory routes by the Atlantic salmon and the sea trout, which have important spawning areas in nearby rivers (e.g. Rivers Dee and Esk). This is discussed within the salmon and sea trout assessment for the proposed EOWDC.

159 Other relevant commercial fish species (e.g. whiting, cod, Norway pout), although present in the proposed EOWDC area, are associated mainly with deeper waters. It therefore seems unlikely that the proposed EOWDC development will raise concerns regarding their distribution. The same is considered valid for other species of interest, for example basking sharks or squids.

160 The only elasmobranch recorded during the 2010 epibenthic surveys in the proposed EOWDC site was the cuckoo ray, but its presence was occasional in the catches.

Summary of Epifaunal and Fish Community

The invertebrate epifaunal community includes brittle stars, brown shrimp and swimming crabs (the latter two species being mainly represented later in the autumn period).

The most common fish species are dab and plaice which were recorded at all stations in relatively high numbers. The distribution of these flatfish species, found mainly at juvenile stages, suggests the presence of nursery grounds in the shallow inshore areas.

Hooknose is also abundant, as well as whiting (particularly in October). Sandeel is present in the area, although in low numbers.

The distribution pattern for whiting and hooknose shows an increase in individuals with increasing depth and distance from the shore. This is not the case for dab and plaice which are recorded in high numbers near the shore.

3.6. NATURE CONSERVATION STATUS

161 Several sites designated for conservation interest are present in the general area of Aberdeen. These are:

- Special Areas of Conservation (SACs), i.e. strictly protected sites designated under the EC Habitats Directive (92/43/EEC).
- Special Protection Areas (SPAs), i.e. strictly protected sites classified for rare and vulnerable birds, and for regularly occurring migratory species, in accordance with Article 4 of the EC Birds Directive (79/409/EEC).
- Ramsar sites, i.e. wetlands of international importance designated under the Ramsar Convention.
- Sites of Special Scientific Interest (SSSIs), i.e. sites that, within the UK, are nationally important for plants, animals or geological or physiographical features, and are protected by law.
- National Nature Reserves (NNR), declared by Scottish Natural Heritage as a selection of the very best parts of UK SSSIs.

162 A list of these sites and the species and habitats they have been designated for is provided in Table 4. None of the above mentioned sites falls within the proposed EOWDC area, the closest designated sites being at a distance of 5 to 7 km from it (Table 4).

163 A range of national and international designation acts, plans and directives (e.g. the Wildlife and Countryside Act 1981, the UK Biodiversity Action Plan (UK BAP), the OSPAR Initial List of Threatened and/or Declining Species and Habitats, the European Habitats Directive, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)) identify conservation priority habitats and species which are under threat because of their rarity and/or rate of decline, and, as such, need protection.

164 According to these designations and to the information gathered from the recently published Scotland's Marine Atlas (Scottish Government, 2011) several benthic organisms of conservation significance occur in the inshore and shelf subtidal areas along Scottish coasts (e.g. the bivalve molluscs *Arctica islandica* and *Atrina fragilis,* the reef forming species *Sabellaria spinulosa* and *Modiolus modiolus*). None of these species are present in or close to the proposed EOWDC area, as confirmed also by the benthic surveys carried out in the site (CMACS Ltd and MSS surveys 2010).

165 As regards fish, Table 5 provides the list of designated species possibly occurring along the coast of east Scotland and reports their likelihood of occurrence in the proposed EOWDC site, according to the information gathered from literature and from the results of the epibenthic surveys carried out by CMACS Ltd and MSS in 2010.

166 Many of the inshore habitats in the Aberdeen area are reported as important nursery and spawning grounds of species like herring and sandeels, which constitute important feeding resources for other fish and bird species of conservation interest (e.g. Atlantic salmon and trout). However, according to the epibenthic surveys

carried out in the area and to the information gathered in Section 3.5 epibenthic Fauna and Fishery Ecology, sandeel occurs in the proposed EOWDC site but in low numbers and it is unlikely to be an important food source for salmonids in this area. In turn, herring has not been recorded in the proposed EOWDC site during the epibenthic surveys in 2010, and its spawning grounds are likely to be located further offshore.

167 Cod and whiting have been recorded in the proposed EOWDC site during the epibenthic surveys in 2010. However, cod was present in very low numbers, occurring only in the MSS survey 2010, and both species, although present in the proposed EOWDC area, are associated mainly with deeper waters. Plaice was also present in the 2010 epibenthic catches from the proposed EOWDC site, with higher numbers at the shallower, inshore stations.

168 Migration routes of Atlantic salmon and sea trout might cross the proposed EOWDC site, having the species important spawning areas in the nearby rivers (particularly in the River Dee) (see salmon and sea trout assessment for proposed EOWDCfor details.) Indirect impacts on these migratory species might also lead to an indirect impact on the River Dee SAC populations of freshwater pearl mussel (*Margaritifera margaritifera*). This is a rare and threatened species, being one of primary reasons for the selection of the River Dee SAC, and highly dependent on the presence of Atlantic salmon and sea trout as hosts for their larvae.

169 Other migratory fish, which move from seas to freshwater habitats to spawn and which could occur in the area include the sparling (Osmerus eperlanus) (or European smelt) and the common sturgeon (Acipenser sturio). The sparling is of conservation importance and is included in the UK Biodiversity Action Plan Species List, whilst the common sturgeon is critically endangered, included on the IUCN Red List and on Schedule 5 of the Wildlife & Countryside Act, Annexes II & V of the EU Habitats Directive and Appendix II of the Bern Convention, as well as on the UKBAP Priority Species List.

170 However, although once relatively widespread in rivers around Scotland, the breeding status of the sparling is now extremely restricted in Scottish rivers (Cree, Forth and Tay), and the common sturgeon is not known to have bred in Britain.

171 As such, whilst the occasional occurrence of these species in waters in Aberdeen Bay cannot be ruled out (although available data would not suggest a presence), it is considered unlikely that the proposed EOWDC would have any significant impact on these two species and therefore they have been scoped out of further assessment.

172 As already mentioned (Section 3.5. Epibenthic Fauna and Fishery Ecology), elasmobranch species occur mainly off the north-west coast of Scotland or farther offshore than the proposed EOWDC site. No significant records in the proposed EOWDC site are reported. The only elasmobranch occasionally recorded during the epibenthic surveys 2010 in the proposed EOWDC site is the cuckoo ray. In contrast to the elasmobranchs reported in Table 5, this is a smaller, rapidly growing and more fecund species for which a stable or increasing population abundance is reported (Fowler *et al.,* 2004).

173 Priority habitats have also been recognised under the UK BAP, being considered of particular importance for biodiversity conservation. Together with the habitats created by the reef forming species *S. spinulosa* and *M. modiolus*, other habitats such as native oyster (*Ostrea edulis*), blue mussel (*M. edulis*) and eelgrass (*Zostera marina* and *Nanozostera noltii*) beds occur frequently in the intertidal and subtidal

areas along the coasts of Scotland. However, these habitats occur mostly on the west coast of Scotland, and none of them is present in in Aberdeen Bay (Scottish Governement, 2011). This was also confirmed by the benthic surveys carried out in the proposed EOWDC site (CMACS Ltd and MSS surveys 2010).

174 The dominant substratum found in the proposed EOWDC site matches well with the UK BAP habitat "sublittoral sands and gravels". This habitat is described as well sorted medium and fine sands on exposed coasts subjected to frequent wave action and variable tidal currents are typified by errant polychaetes such as *N. cirrosa* and isopods such as *Bathyporeia* spp (common in full salinity areas of many estuaries) (JNCC, 2008). Illustrative Level 4 biotopes for this habitat are SS.SSa.CMuSa (Circalittoral muddy sand) and SS.SSa.IFiSa (Infralittoral fine sand), as those found in the proposed EOWDC site. The UK Habitat Action Plan aims to ensure that the best examples of sublittoral sand and gravel habitats are protected from the adverse effects of fishing, dredging, aggregate extraction and other activities such as wind farm development. Therefore, where wind farms are proposed, their development should respect, and where possible further, the objectives and targets for priority habitats and species listed in the UK Biodiversity Action Plan. However, it must be noted that sublittoral sand and gravel sediments are the most common habitats found below the level of the lowest low tide around the coast of the United Kingdom. The biotope SS.SSA.CMuSa.AalbNuc is not uncommon in the wider Aberdeen Bay area, and although *A. alba* is a common food source for *Asterias rubens* and different species of demersal fish (MarLIN), it is not considered to have an especially high ecological importance at the local scale.

Table 4. Designated sites in a range up to 150 km from the proposed EOWDC development.

Designation	Site (approx. distance from the proposed EOWDC)	Designated for
SAC	River Dee (7.5 km)	Atlantic salmon, freshwater pearl mussel and otter
	Sands of Forvie (7.2 km)	Embryonic shifting dunes, shifting dunes along the shorelines with *Ammophilia arenaria*, decalcified fixed dunes with *Empetrum nigrum*, humid dune slacks
	Buchan Ness to Collieston (12.2 km)	Vegetated sea cliffs
	Garron Point (30 km	Narrow-mouthed whorl snail *Vertigo angustior*
	Moray Firth (150 km)	Bottlenose dolphin, sandbanks which all the times are covered by seawater
SPA	Ythan Estuary, Sands of Forvie and Meikle Loch (7.2 km)	Breeding population of common tern; breeding population of little tern; breeding population of sandwich tern; Wintering population of pink-footed goose; regularly supporting at least 20,000 waterfowl of which the notable components are redshank, lapwing, eider and pink-footed goose
	Buchan Ness to Collieston (9.5 km)	Regularly supporting at least 20,000 seabirds of which the notable components are guillemot, kittiwake, herring gull, shag and fulmar
	Loch of Skene (21 km)	Over wintering area for greylag goose and whooper swan, breeding population of tufted duck, supporting waterfowl assemblages of which the notable components are wintering goldeneye, goosander, common gull
	Fowlsheugh (31.1 km)	Breeding population of guillemot; breeding population of kittiwake; regularly supporting at least 20,000 waterfowl of which the notable components are razorbill, herring gull, fulmar, guillemot and kittiwake
	Loch of Strathbeg (47.6 km)	Sandwich tern, supporting waterfowl assemblages of which the notable components are pink-footed goose, greylag goose, teal and goldeneye
	Troup, Pennan and Lion's Heads (74.3 km)	Supporting seabird assemblages of which the notable components are fulmar, kittiwake, guillemot, herring gull and razorbill

Designation	Site (approx. distance from the proposed EOWDC)	Designated for
	Forth Islands (124.4 km)	Gannet, shag, lesser black-backed gull, roseate tern, Arctic tern, common tern, Sandwich tern, puffin; supporting seabird assemblages of which the notable components are cormoranyt, herring gull , kittiwake, razorbill and guillemot
Ramsar sites	Ythan Estuary, Sands of Forvie and Meikle Loch (7.2 km)	Aggregation of breeding sandwich tern, aggregation of non-breeding pink-footed goose and waterfowl assemblage
National Nature Reserve	Forvie (7.2 km)	Sand dune, foreshore, estuarine, spit, dune heath, slacks, rough pasture and cliffs habitat
SSSI	Foveran Links (4.8 km)	Sand dune, coastal geomorphology, vegetation assemblages, migrating birds, large moulting and passage flocks of seaduck and divers occurring off-shore, nesting site for the little tern
	Corby, Lily and Bishops lochs (6.7 km)	Non-breeding graylag goose; mesotrophic loch, aquatic vegetation, wetland sites
	Sands of Forvie and Ythan Estuary (7.2 km)	Non-breeding population of pink-footed goose, breeding populations of Sandwich tern, common tern, eider, breeding bird assemblage; sand dune; coastal geomorphology
	Nigg Bay (10 km)	Quaternary geomorphology
	Collieston to Whinnyford (15 km)	Seabird colony; breeding: kittiwake, guillemot, razorbill, fulmar, shag; maritime cliff; dalradian geology
	Meikle Loch and Kippet Hills (17 km)	Non-breeding: Greylag goose, pink-footed goose, teal; quaternary geomorphology
	Bullers of Buchan (25 km)	Seabird colony; breeding: kittiwake, guillemot; maritime cliff; coastal geomorphology

Table 5. Fish species designations possibly occurring along the east coast of Scotland.

Taxon Group	Species	OSPAR	Habitats Directive	EC Cites	IUCN Red list	UK BAP 2007*	SNH**	Wildlife and Countryside Act 1981	occurrence in the proposed EOWDC site
bony fish	*Alosa alosa*	x	x			x	x	x	Unlikely
bony fish	*Alosa fallax*		x			x	x	x	Unlikely
bony fish	*Ammodytes marinus*					x	x		Yes
bony fish	*Ammodytes tobianus*						x		Yes
bony fish	*Anguilla anguilla*	x			x	x	x		Unlikely
bony fish	*Clupea harengus*					x	x		Likely
bony fish	*Gadus morhua*	x			x	x	x		Yes
bony fish	*Merlangius merlangus*					x	x		Yes
bony fish	*Osmerus eperlanus*					x	x		Unlikely
bony fish	*Pleuronectes platessa*					x	x		Yes
bony fish	*Salmo salar*	x	x			x	x		Likely
bony fish	*Salmo trutta*					x			Likely
bony fish	*Solea solea*					x			Unlikely
elasmobranch	*Amblyraja radiata*				x				Unlikely
elasmobranch	*Cetorhinus maximus*	x		x	x	x	x	x	Unlikely
elasmobranch	*Squalus acanthias*	x			x	x			Unlikely
elasmobranch	*Dipturus batis*	x			x	x	x		Unlikely
elasmobranch	*Galeorhinus galeus*				x	x			Unlikely
elasmobranch	*Raja montagui*	x							Unlikely
elasmobranch	*Leucoraja circularis*				x	x			Unlikely
elasmobranch	*Raja clavata*	x					x		Unlikely
elasmobranch	*Lamna nasus*	x			x	x			Unlikely

* taxon designations that are assessed as "least concern" using the IUCN classification are excluded. **Scottish Biodiversity List, http://www.snh.gov.uk/protecting-scotlands-nature/biodiversity-scotland/scottish-biodiversity-list/

3.6.1. Conclusions

175 Several sites designated for conservation interest (SAC, SPA, Ramsar sites, SSSI and NNR) occur along the coast in the Aberdeen area, but none of the designated areas coincide with the proposed EOWDC site.

176 The species designated under national and international legislation have been considered and are not thought to occur within the proposed EOWDC area (at least not in significant numbers). This is mainly due to the habitat preferences of the different species which locate them far from the proposed EOWDC area (e.g. further offshore or within estuarine areas). However, the possibility of migration routes of Atlantic salmon and sea trout crossing the proposed EOWDC site needs to be taken into account, the species having important spawning areas in the nearby rivers.

177 Many of the inshore habitats in the Aberdeen Bay area are reported as important nursery and spawning grounds of species like herring and sandeel, which constitute important feeding resources for other fish and bird species of conservation interest (e.g. Atlantic salmon and sea trout). According to the epibenthic surveys carried out in the proposed EOWDC site and to the information gathered in Section 3.5. Epibenthic Fauna and Fishery Ecology, sandeel is not present at high densities and is unlikely to be an important food source for salmonids in this area.

178 The dominant substratum found in the proposed EOWDC site corresponds to the UK BAP habitat “sublittoral sands and gravels”, well illustrated by the biotopes SS.SSa.CMuSa (Circalittoral muddy sand) and SS.SSa.IFiSa (Infralittoral fine sand).

Summary of Nature Conservation Status

Several sites designated for conservation interest (SAC, SPA, Ramsar sites, SSSI and NNR) occur along the coast in the Aberdeen area.

According to the knowledge on the distribution of nationally and internationally designated species, and following the results of the surveys carried out in the area, none of the designated species occur in the proposed EOWDC area or in its surroundings. The presence of migration routes of salmonids in the area is discussed in the salmon and sea trout assessment for the proposed EOWDC.

The dominat substratum found in the proposed EOWDC site corresponds to the UK BAP habitat “sublittoral sands and gravels”, well illustrated by the biotopes SS.SSa.CMuSa (Circalittoral muddy sand) and SS.SSa.IFiSa (Infralittoral fine sand).

4. Summary

179 This document provides the baseline information on the marine ecology of the proposed EOWDC area in Aberdeen Bay. Information from the available literature was integrated with the results from benthic and epibenthic surveys carried out within the proposed EOWDC area and in the surroundings. A combination of camera (15 stations), grab (14stations) and trawl (10 stations) sampling was undertaken by CMACS Ltd for OSIRIS Projects Ltd on behalf of AOWFL in October 2010. Additional benthic survey data were provided by FRS (survey carried out in April 2006) and MSS (survey carried out in September 2010), and information on sediments was available from EMU Ltd (2007) and OSIRIS Projects Ltd (2010) work.

180 According to a geophysical survey carried out by EMU Ltd for AOWFL, the seabed sediments in the proposed EOWDC site are dominated by muddy sand with small patches of glacial material towards the shore, and finer sediment features in places with occasional patches of shell fragments in others. The sediment analysis carried out by CMACS Ltd in 2010 complemented these results, showing a homogeneous composition of the sediments in the area, with a common pattern of variation following the gradient of depth and distance from the shore. At inshore stations, medium-fine well-sorted sands dominate, whereas sediments farther offshore and at deeper sites are dominated be fine-very fine muddy sands.

181 According to the CMACS Ltd 2010 survey results, there are no contaminants in the sediments showing concentrations above the Probable Effect Level (PEL) and all hydrocarbons, organotin and PCB concentrations were below detectable limits. Among heavy metals, only Arsenic was marginally above the Interim Sediment Quality Guidelines (ISQG) level but still below the PEL. Overall, the sediment contamination in the area is in line with the background contamination levels reported for the North-eastern Atlantic area.

182 The intertidal substratum in the area is mainly composed of sandy shores. The intertidal macrofauna is dominated by haustorid amphipods (*H. arenarius* and *B. pelagica*) and in some cases the spionid polychaete *S. cirratulus*, whereas sedentary species are less abundant, in agreement with the moderate exposure of the shores.

183 The sublittoral benthic survey results showed that the infaunal community changed mainly along the gradient of depth/distance offshore. The infaunal community at inshore shallower stations was characterised by low number of species and abundance, and was dominated by the polychaete *N. cirrosa* and amphipods. A relatively high number of species and abundance was detected at the stations farther offshore, where the most abundant species were the polychaetes *N. latericeus*, the bivalves *N. nitidosa* and *T. fabula* and brittle stars *Ophiura* sp. These two communities characterise two major biotopes: SS.SSA.CMuSa.AalbNuc (offshore) and SS.SSA.IFiSa.NcirBat (inshore). The Level 4 biotopes SS.SSA.CMuSa and SS.SSA.IFiSa are considered as a priority habitat under the UK BAP designation (sublittoral sands and gravels).

184 The invertebrate epifaunal community present in the proposed EOWDC site is sparse and composed mainly of brittle stars, brown shrimp and swimming crabs (the latter two species being mainly represented later in the autumn period). The most common fish species were dab, plaice, whiting and hooknose, recorded at all stations in relatively high numbers. The distribution pattern for whiting and hooknose showed an increase in abundance with increasing depth and distance from the shore, whereas dab and plaice were recorded with higher numbers near the shore. The latter species, in particular, were present in the area mainly as juveniles, suggesting

the presence of nursery grounds for these flatfish along this part of the Scottish coast.

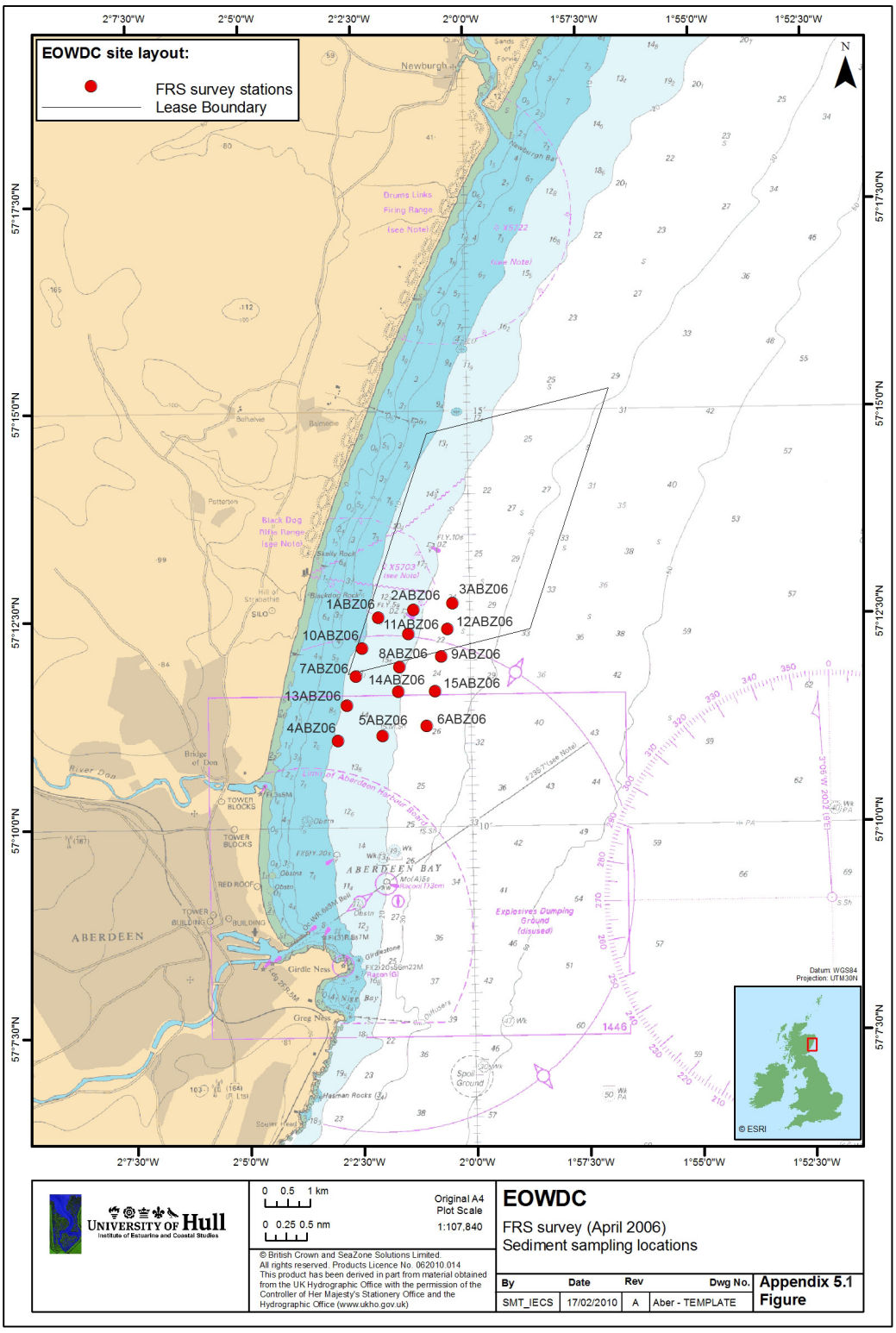
185 Although extensive spawning grounds for several species are known to be present along the east coast of Scotland, no specific spawning grounds are reported in the proposed EOWDC site. This seems to have been confirmed, e.g. for sandeel and herring, by the results of the epibenthic survey, which showed no significant abundances of the species in the trawl catches. This could also be explained by the preference of these species for coarser bottom sediments than those present in the proposed EOWDC site.

186 The wider east coast around Aberdeen displays a wide variety of habitats. Some of them are rare in a national and/or international context, or support important bird colonies, hence being designated as areas for conservational interest (SAC, SPA, Ramsar sites NNR and SSSI). However, no such areas are present within the proposed EOWDC area and in the close vicinity. Furthermore, designated species and habitats (except for the above mentioned UK BAP habitat sublittoral sands and gravels) have not been found in the site. No main conservation concerns have been identified for the area. However, the possibility that migration routes of Atlantic salmon and sea trout cross the proposed EOWDC site must be taken into account. A separate assessment of Atlantic salmon and sea trout has been undertaken.

5. Appendices

APPENDIX 5.1.

FRS BENTHIC SURVEY 2006 – LOCATION OF STATIONS AND RAW DATA



Sampling locations of the benthic survey carried out by FRS in 2006 (map drawn by IECS, based on FRS 2006 survey stations location).

Sediment contamination in Aberdeen Bay (FRS survey 2006) – PAH compounds.
All concentration values expressed in µg/kg dry weight. Latitude and longitude are expressed in degrees and decimals of degrees (WGS 84).

	1ABZ06	2ABZ06	3ABZ06	4ABZ06	5ABZ06	6ABZ06	7ABZ06	8ABZ06	9ABZ06	10ABZ06	11ABZ06	12ABZ06	13ABZ06	14ABZ06	15ABZ06
Latitude	57.2086	57.2100	57.2113	57.1840	57.1849	57.1868	57.1969	57.1986	57.2006	57.2024	57.2052	57.2061	57.1911	57.1938	57.1937
Longitude	-2.0340	-2.0210	-2.0064	-2.0495	-2.0330	-2.0166	-2.0425	-2.0263	-2.0108	-2.0401	-2.0228	-2.0084	-2.0460	-2.0269	-2.0133
Date Time	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06
Date Time	13:03:44	14:21:52	14:29:44	13:36:16	13:55:34	14:55:38	13:20:16	14:10:00	14:41:30	13:15:18	14:16:14	14:34:48	13:28:32	14:04:20	14:49:22
Depth (m)	13	18.0	24	6	17.0	24.0	11.0	18	24.0	11.0	18.0	24.0	10.0	18.0	24.0
Naphthalene		0.9			4.5	1.0	0.4		4.5	TR	10.3	3.4	0.5	1.8	0.9
Phenanthrene		9.0			42.9	8.4	2.2		37.8	0.4	153.4	14.6	1.8	11.7	3.4
Anthracene		2.4			10.6	1.8	0.7		8.8	ND	38.1	4.2	0.4	3.5	0.8
Fluoranthene		12.0			51.4	9.2	4.9		55.9	0.7	141.1	22.2	2.9	13.6	5.6
Pyrene		10.6			46.1	9.0	4.6		50.7	0.6	141.9	20.4	2.9	13.1	5.1
Benz[a]anthracene		5.5			25.9	4.2	2.7		29.1	0.4	62.0	10.2	1.5	6.4	2.9
Chrysene + Triphenylene		5.9			26.8	4.7	2.9		29.9	0.5	62.5	10.3	1.7	6.8	3.3
Benzofluoranthene		17.6			68.2	14.7	8.6		80.2	2.3	130.6	30.6	6.8	19.3	11.8
Benzo[a]pyrene		7.5			29.9	5.9	3.5		36.6	0.7	73.1	13.7	2.3	8.2	4.2
Indenopyrene		7.5			25.4	6.6	3.9		32.6	1.3	52.5	13.8	3.4	8.7	5.5
Benzoperylene		6.1			21.2	5.6	3.1		26.6	1.1	47.8	11.4	2.8	7.3	4.4
Acenaphthylene		0.2			0.4	0.3	TR		0.5	ND	0.3	0.2	ND	TR	TR
Acenaphthene		1.0			4.6	0.9	0.2		3.7	ND	32.9	2.4	0.2	1.7	0.3
Fluorene		1.1			5.2	1.0	0.2		3.6	TR	18.2	1.9	0.2	1.5	0.4
Dibenz[a,h]anthracene		1.20			4.50	1.00	0.60		5.60	0.20	9.00	2.30	0.50	1.40	0.80
TOTAL PAH		185.3			802.1	159.6	85.9		850.5	20.1	1732.2	360.9	68.3	223.6	116.4

ND, Not detected; TR, Trace.

Sediment contamination in Aberdeen Bay (FRS survey 2006) – Heavy metals.
All concentration values expressed in mg/kg dry weight. Latitude and longitude are expressed in degrees and decimals of degrees (WGS 84).

	1ABZ06	2ABZ06	3ABZ06	4ABZ06	5ABZ06	6ABZ06	7ABZ06	8ABZ06	9ABZ06	10ABZ06	11ABZ06	12ABZ06	13ABZ06	14ABZ06	15ABZ06
Latitude	57.2086	57.2100	57.2113	57.1840	57.1849	57.1868	57.1969	57.1986	57.2006	57.2024	57.2052	57.2061	57.1911	57.1938	57.1937
Longitude	-2.0340	-2.0210	-2.0064	-2.0495	-2.0330	-2.0166	-2.0425	-2.0263	-2.0108	-2.0401	-2.0228	-2.0084	-2.0460	-2.0269	-2.0133
Date Time	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06	7/4/06
Date Time	13:03:44	14:21:52	14:29:44	13:36:16	13:55:34	14:55:38	13:20:16	14:10:00	14:41:30	13:15:18	14:16:14	14:34:48	13:28:32	14:04:20	14:49:22
Depth (m)	13	18.0	24	6	17.0	24.0	11.0	18	24.0	11.0	18.0	24.0	10.0	18.0	24.0
As	4.27	4.41	5.04	4.16	5.02	6.06	4.44	4.38	4.81	4.22	4.83	4.84	4.32	5.02	4.95
Cd	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cr	14.09	15.01	20.72	13.80	16.85	13.86	14.42	14.85	18.29	16.97	19.98	16.28	14.18	12.62	13.47
Cu	2.01	2.88	4.58	2.22	3.68	3.25	2.04	3.11	4.17	2.54	3.81	3.78	2.64	2.75	2.74
Hg	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.08	BDL	BDL
Ni	5.85	7.32	10.08	6.68	8.04	7.17	5.83	7.53	9.38	5.83	8.89	8.68	5.97	6.82	6.69
Pb	5.46	6.72	10.22	6.14	8.10	7.52	5.56	7.12	8.84	5.80	8.39	8.63	5.92	6.42	6.32
Zn	20.65	22.27	29.39	23.28	22.69	20.69	16.04	20.95	26.96	16.58	24.87	25.47	17.19	19.57	19.13

BDL, Below Detection Limits.

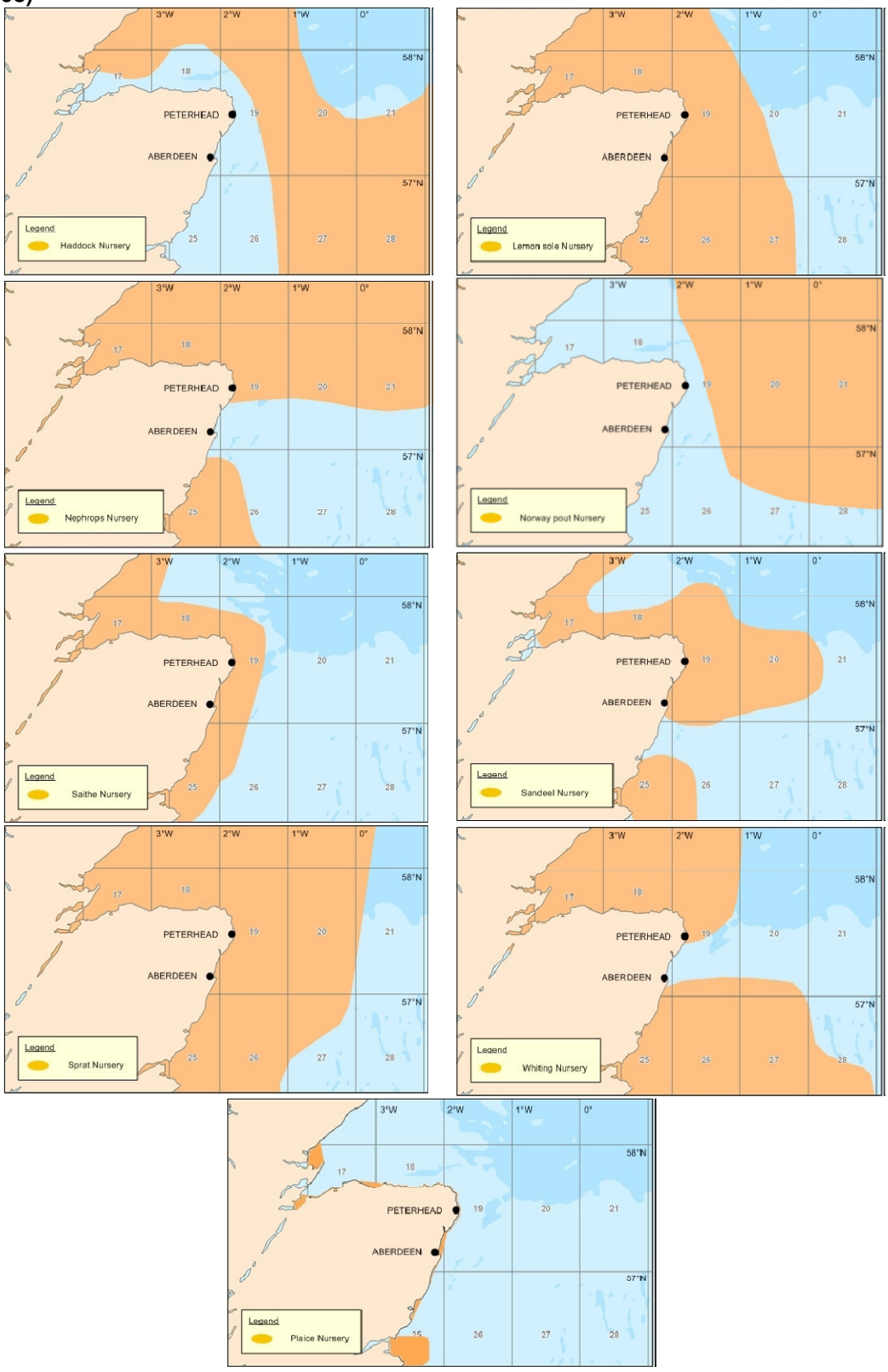
APPENDIX 5.2.

NURSERY AND SPAWNING GROUNDS

Broad nursery and spawning areas of fish and *Nephrops* are presented for the area off north-east Scotland, as from Coull *et al*. (1998).

Fish and *Nephrops* spawning grounds off north-east Scotland. Source: Coull *et al.* (1998)

Fish and *Nephrops* nursery grounds off north-east Scotland. Source: Coull et al. (1998)



APPENDIX 5.3.

CMACS LTD BENTHIC SURVEY 2010 – TECHNICAL REPORT V3 (FEB. 2011)

APPENDIX 5.4.

INTEGRATIVE ANALYSES CARRIED OUT BY IECS ON CMACS LTD 2010 BENTHIC DATA

5.4.1. Introduction

1 Additional analyses were carried out by IECS on the benthic data obtained during the CMACS Ltd survey in 2010, in order to update and integrate results of the CMACS Ltd Technical Report (Appendix 5.3).

5.4.2. Additional data analysis

2 Measured values and descriptive statistics for primary and derived biological parameters were calculated by IECS both for the survey area as a whole and for individual stations. The following biological parameters were calculated using PRIMER v. 6 (Plymouth Routines in Marine Ecological Research):

- The total number of species (S) at each station and for the survey area as a whole;
- Total abundance (A) of organisms expressed as individuals / 0.1 m^{-2} at each station;
- Abundance ratio (A/S) which gives an indication of the level of dominance of particular species within a community. Low values indicate a low number of organisms spread between a large number of species whereas high values indicate few species each with a large number of individuals (i.e. the community is dominated by very few species occurring at high abundances);
- Shannon-Wiener diversity (H'(log_2)), incorporating both species richness and evenness (a measure of the distribution of the individuals between the species):

  $$\mathbf{H' = - \sum p_i \log_2 p_i}$$

  Where,
  p_i = proportion of individuals in the *i*th species = n_i / N
  n_i = number of individuals of the *i*th species in the sample
  N = total number of individuals

  High values of H' indicate high diversity. Differences in the absolute values of the index obtained here with respect to those reported in the CMACS Ltd Technical Report (Appendix 5.2) likely arise from a different basis for the logarithm used in the H' index calculation (not specified in the CMACS Ltd Technical Report).
- Pielous Evenness index (J') gives a measure of the relative abundance of each species:

  $$\mathbf{J' = H' / \log_2 S.}$$

  Low values (close to zero) indicate that a community is dominated by one or few species and indicate low diversity. Communities where there is an even spread of the individuals between the species (J' values approaching 1) are considered to be diverse.

3 Description of the biological communities for individual stations and for the survey area as a whole was carried out by ranking the species in terms of their abundance, percentage contribution to the community (% dominance) and cumulative percent dominance.

4 Multivariate techniques allowing comparison of communities based on their component species and their relative importance in terms of abundance were also applied to faunal data. In order to complement multivariate analyses carried out by CMACS Ltd (namely cluster and MDS analyses, see Appendix 5.3) BIOENV was used to determine relationships between environmental and biological parameters in order to identify the combination of environmental variables best relating to community structure patterns. This procedure allows the calculation of rank correlations between the Euclidean distances of samples based on environmental variables and benthic community dissimilarity.

5.4.3. Results

5 The biological parameters for benthic fauna were variable, as demonstrated by the coefficient of variation values, ranging from 9.2 to 70.3% across the survey site, reflecting the variable and possibly mobile or frequently disturbed nature of the sediments (Table 1).

6 The number of species ranged from 10 at station 14 to 32 at station 12 with between 20 and 30 species being recorded from stations 4, 5, 8, 9 and 10 (Figure 1). The mean number of species recorded across the site is 18.3. Abundance values ranged from 17 individuals / 0.1 m^{-2} at station 14 to 145 individuals / 0.1 m^{-2} at station 8, with an average value of 60.43 individuals/0.1 m^{-2} (Figure 2).

7 Shannon-Weiner diversity (H'(log_2)) was highest at station 10 (H'=3.7) with diversity being greater than 3 at the majority of stations (Figure 3). Pielou's evenness (J') values ranged from 0.65 at station 8 to 0.95 at station 14 and all values were greater than 0.7 (Figure 4). These values, together with relatively low abundance ratio (A/S, Figure 5) indicate an even spread of the individuals between the species and that the communities are not dominated by one or very few species.

8 A total of 70 species were recorded from the survey area as a whole, most of them recorded in low numbers (Table 2). The top 85% abundance of the community was composed of 19 species and was dominated by the polychaete *N. latericeus* (85% frequency of occurrence) and brittle stars of the family Ophiuridae (93% frequency of occurrence, including juvenile individuals from the family Ophiuridae and from the genus *Ophiura*) which together accounted for 42% of the total benthic abundance (Table 2) and were present in abundances ranging from 1 to 46 individuals / 0.1 m^2. Other species present in notable abundances included the bivalves *N. nitidosa*, *T. fabula*, and the polychaetes *S. bombyx* and *G. oculata* (Table 2).

Table 1. Descriptive statistics for the biological parameters across the area as a whole (IECS analysis of data collected during CMACS Ltd Benthic Survey 2010).

	S	A	J'	H' (log_2)	A/S
Mean	18.29	60.43	0.83	3.33	2.96
Standard Error	1.83	11.36	0.02	0.08	0.32
Standard Deviation	6.84	42.49	0.08	0.31	1.20
Minimum	10.00	17.00	0.65	2.97	1.58
Maximum	32.00	145.00	0.95	3.76	5.58
%Coefficient of Variation	37.43	70.32	9.72	9.17	40.36

*S=Number of species; A= abundance; J' = Pielous evenness; H' (log_2) = Shannon-Weiner diversity; A/S = abundance ratio

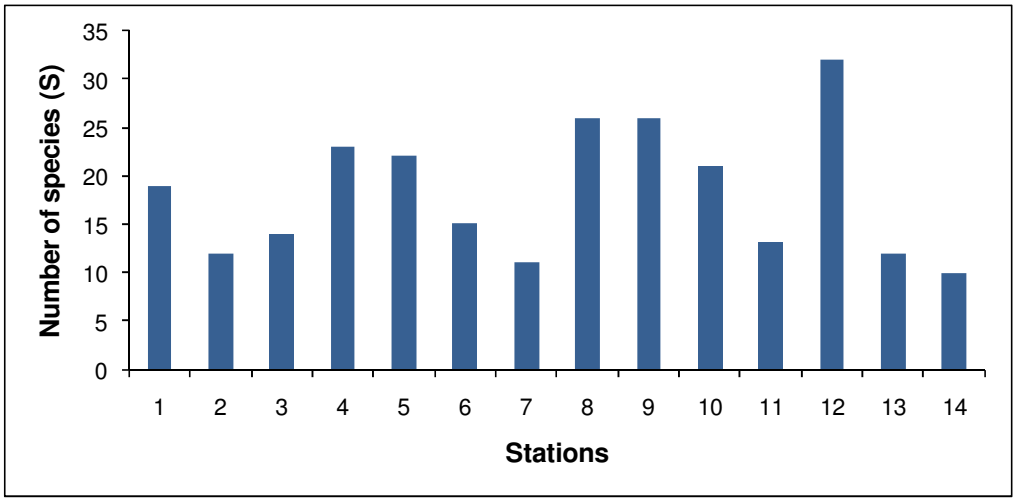


Figure 1. Number of species recorded from each sampling station across the site (IECS analysis of data collected during the CMACS Ltd Benthic Survey 2010; see Fig. 1 in Appendix 5.3 for station numbering).

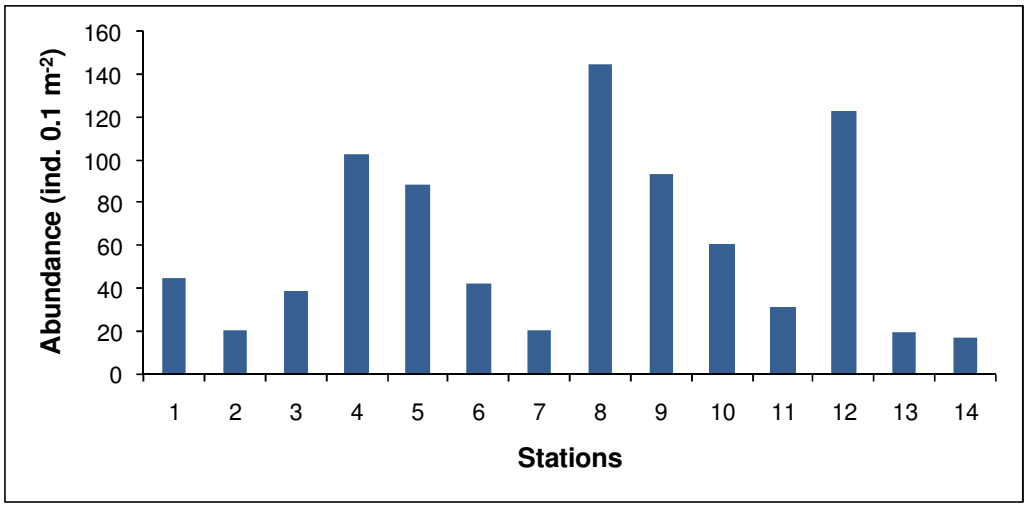


Figure 2. Abundance of individuals (A, individuals/0.1 m^{-2}) recorded from each sampling station across the site (IECS analysis of data collected during the CMACS Ltd Benthic Survey 2010; see Fig. 1 in Appendix 5.3 for station numbering).

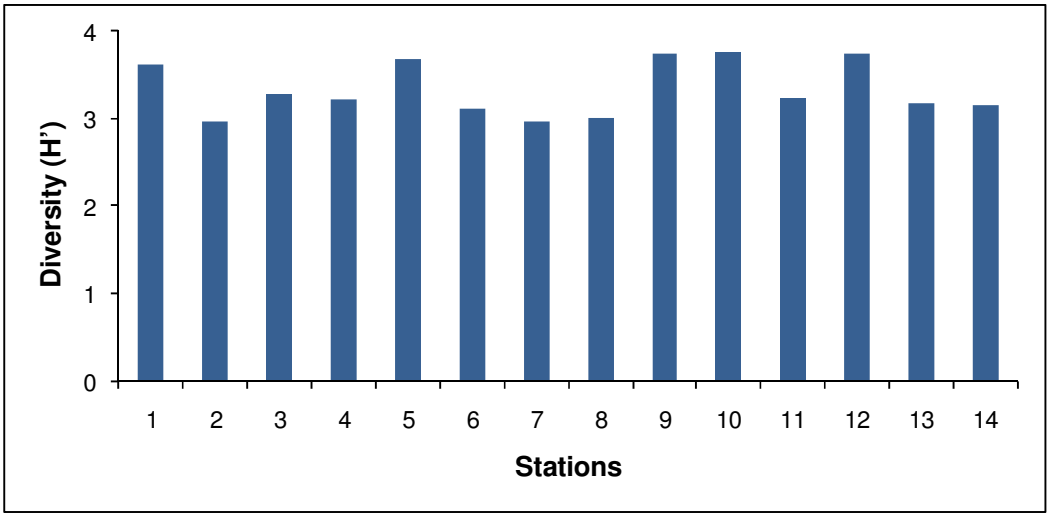


Figure 3. Shannon Weiner diversity (H'(log_2)) index for each sampling station across the site (IECS analysis of data collected during the CMACS Ltd Benthic Survey 2010; see Fig. 1 in Appendix 5.3 for station numbering).

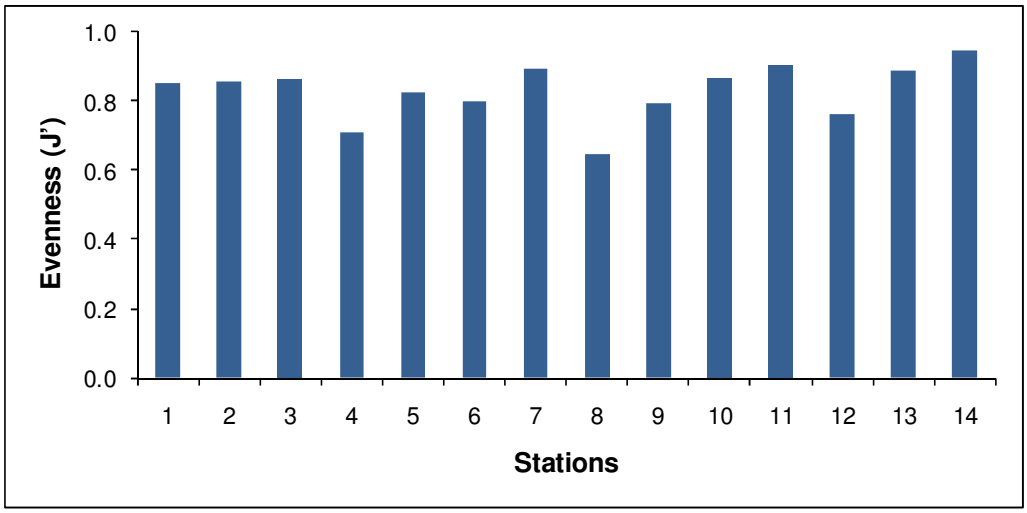


Figure 4. Pielou's evenness (J') for each sampling station across the site (IECS analysis of data collected during CMACS Ltd Benthic Survey 2010; see Fig. 1 in Appendix 5.3 for station numbering).

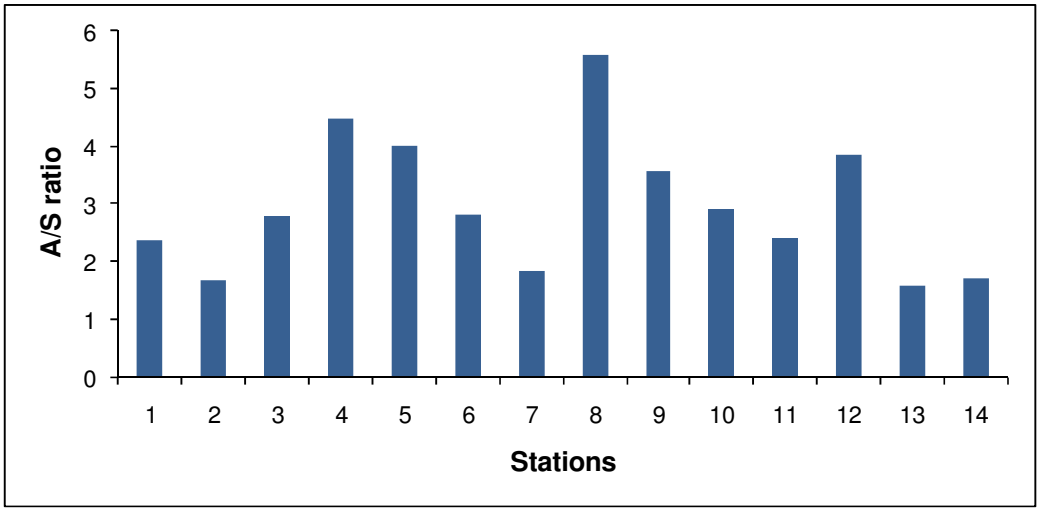


Figure 5. Abundance ratio (A/S) for each sampling station across the site (IECS analysis of data collected during CMACS Ltd Benthic Survey 2010; see Fig. 1 in Appendix 5.3 for station numbering).

Table 2. Abundance and dominance of the key (top 85%) infaunal species for the survey area as a whole (IECS analysis of data collected during CMACS Ltd Benthic Survey 2010).

Species	Taxonomic group	Total A*	% Dom*	Cum %*	FO %*
Notomastus latericeus	Polychaeta	243	28.7	28.7	85.7
Ophiuridae juv.**	Echinodermata	109	12.9	41.6	92.9
Nucula nitidosa	Bivalvia	67	7.9	49.5	92.9
Tellina fabula	Bivalvia	63	7.4	56.9	78.6
Spiophanes bombyx	Polychaeta	34	4.0	60.9	71.4
Galathowenia oculata	Polychaeta	27	3.2	64.1	50.0
Acrocnida brachiata	Echinodermata	23	2.7	66.8	57.1
Pholoe baltica	Polychaeta	22	2.6	69.4	50.0
Kurtiella bidentata	Bivalvia	15	1.8	71.2	57.1
Abra alba	Bivalvia	15	1.8	73.0	42.9
Nephtys cirrosa	Polychaeta	15	1.8	74.7	28.6
Nephtys assimilis	Polychaeta	14	1.7	76.4	64.3
Amphiura filiformis	Echinodermata	14	1.7	78.0	28.6
Nephtys sp. juv.	Polychaeta	11	1.3	79.3	42.9
Chamelea striatula	Bivalvia	11	1.3	80.6	42.9
Amphiuradae sp. juv.	Echinodermata	11	1.3	81.9	14.3
Bathyporeia guilliamsoniana	Amphipoda	10	1.2	83.1	28.6
Thyasira flexuosa	Bivalvia	8	0.9	84.1	35.7
Diastylis bradyi	Cumacea	7	0.8	84.9	42.9

*Total A – sum abundance values for all stations, % Dom – dominance, Cum % - cumulative %, FO % - frequency of occurrence

**Ophiuridae juv. – this contains Ophiuridae juv and *Ophiura* sp. Juv (these two taxa were analysed separately in the CMACS Ltd Technical Report, Appendix 5.3).

9 The two groupings of stations identified by the multivariate analyses carried out by CMACS Ltd (Appendix 5.3) were interpreted in the light of the assemblage species richness and of the main species contributing to the similarity within the two groups. For the purpose of clarity, stations 2, 13 and 14 were named “group B”, whereas the other stations were named “group A” (see Figures 17 and 18 in Appendix 5.3).

10 The richest community in terms of number of species and abundance was in group A, including 11 stations. The most impoverished community, in terms of the number of species and abundance, was in group B.

Table 3. Characteristic taxa within each cluster and frequency of occurrence across the proposed EOWDC site. Top 21 species in terms of abundance presented for group A, for group B all species included (IECS analysis on data from the CMACS Ltd Benthic Survey 2010).

Group A	Total Ab.	% Dom	FO %		Group B	Total Ab.	% Dom	FO %
Notomastus latericeus	241	30.5	91		*Nephtys cirrosa*	14	24.6	100
Nucula nitidosa	65	8.2	100		*Pontocrates altamarinus*	6	10.5	100
Tellina fabula	63	8.0	100		*Bathyporeia guilliamsoniana*	6	10.5	67
Ophiuridae juv.	58	7.3	91		*Bathyporeia elegans*	5	8.8	67
Ophiura sp. juv.	48	6.1	91		*Donax vittatus*	3	5.3	100
Spiophanes bombyx	33	4.2	82		Ophiuridae juv.	3	5.3	67
Galathowenia oculata	27	3.4	64		*Notomastus latericeus*	2	3.5	67
Acrocnida brachiata	23	2.9	73		*Pontocrates arenarius*	2	3.5	67
Pholoe baltica	22	2.8	64		*Nucula nitidosa*	2	3.5	67
Kurtiella bidentata	14	1.8	64		*Eteone longa/flava* (agg.)	2	3.5	33
Abra alba	14	1.8	45		*Nephtys assimilis*	1	1.8	33
Amphiura filiformis	14	1.8	36		*Nephtys hombergii*	1	1.8	33
Nephtys assimilis	13	1.6	73		*Spiophanes bombyx*	1	1.8	33
Nephtys sp. juv.	11	1.4	55		*Diplocirrus glaucus*	1	1.8	33
Chamelea striatula	11	1.4	55		*Atylus falcatus*	1	1.8	33
Amphiuradae juv.	11	1.4	18		*Iphinoe trispinosa*	1	1.8	33
Thyasira flexuosa	8	1.0	45		*Diastylis bradyi*	1	1.8	33
Ampelisca brevicornis	7	0.9	36		*Crangon allmanni*	1	1.8	33
Magelona johnstoni	7	0.9	27		*Kurtiella bidentata*	1	1.8	33
Ophiura ophiura	7	0.9	27		*Abra alba*	1	1.8	33
Scoloplos armiger	6	0.8	45		*Abra prismatica*	1	1.8	33

11 Stations of group A are located farther from the shore and characterised by fine muddy sand. This group contains 64 species, and the top 21 species in

terms of abundance. Predominant species of this group are the polychaete *N. latericeus*, which contributed over 30% into community, followed by the bivalves *N. nitidosa* and *T. fabula* and brittle stars of the family Ophiuridae (Table 3).

12 Stations of group B are located inshore and are characterised by fine-medium well-washed sand. This group is poor in terms of number of species (with a total number of species of 22) and abundance (Table 3). The most abundant taxa in this group is the polychaete *N. cirrosa* and amphipods, although still these taxa were recorded in very low numbers (Table 3).

13 The BIOENV test (based on all sediment physical parameters) indicated that the highest correlation between physical parameters and the species assemblages (r= 0.766) was with median mm grain size, % sand, % silt/clay and depth. Therefore, the patterns in the species distribution and communities appear to best relate to sedimentary and depth parameters.

14 The above results allowed the identification of two major biotopes in the survey area, as detailed in Appendix 5.3. According to the biotope descriptions provided in the CMACS Ltd Technical Report, these two biotopes are: SS.SSA.CMuSa.AalbNuc (*A. alba* and *N. nitidosa* in circalittoral muddy sand or slightly mixed sediment) and SS.SSA.IFiSa.NcirBat (*N. cirrosa* and *Bathyporeia* spp. in infralittoral sand) (an error in the legend of the biotope mapping in Figure 19 of the CMACS Ltd Technical Report was found, hence the amended map is provided in Figure 6 below).

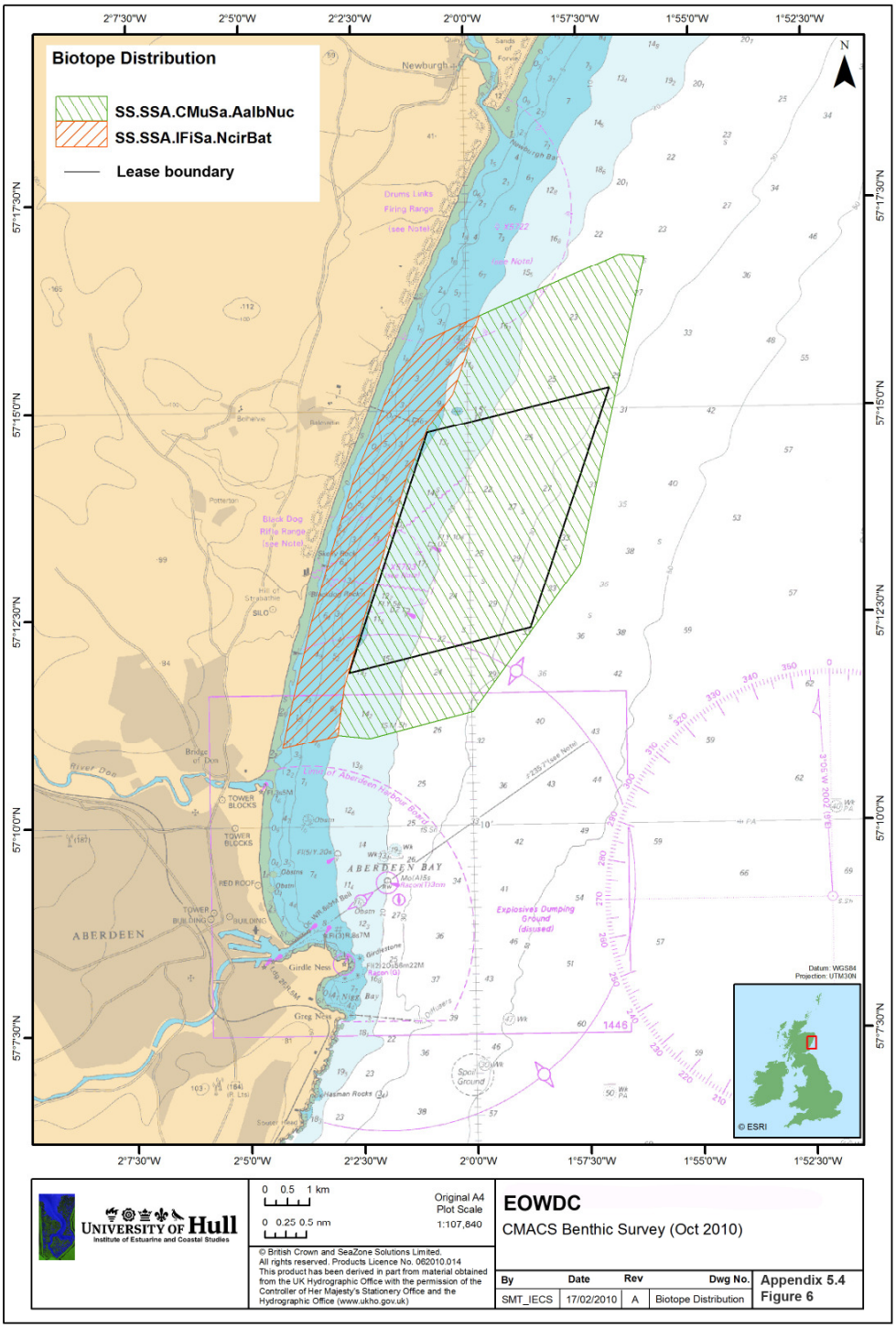


Figure 6. Biotope map showing the estimated extent of the two biotopes present (modified and redrawn from the CMACS Ltd Tecnical Report, Appendix 5.3).

APPENDIX 5.5.

MSS EPIBENTHIC SURVEY

The detailed methods and results of the epibenthic survey carried out by MSS in 2010 in the proposed EOWDC site are presented.

The data were provided by MSS and analysed by IECS.

5.5.1. Field sampling

1 MSS carried out an epibenthic survey in Aberdeen Bay in September 2010 on the FRV Alba Na Mara. Both data from video camera surveys and epibenthic trawls were obtained.

2 The TV tows were taken at 14 stations and trawl samples were taken from 7 locations. Most of the stations were located inshore, except for 6 stations (TV41, TV42, TV43, TV44, ABAG4 and ABAG5), which were located farther offshore (Figure 1).

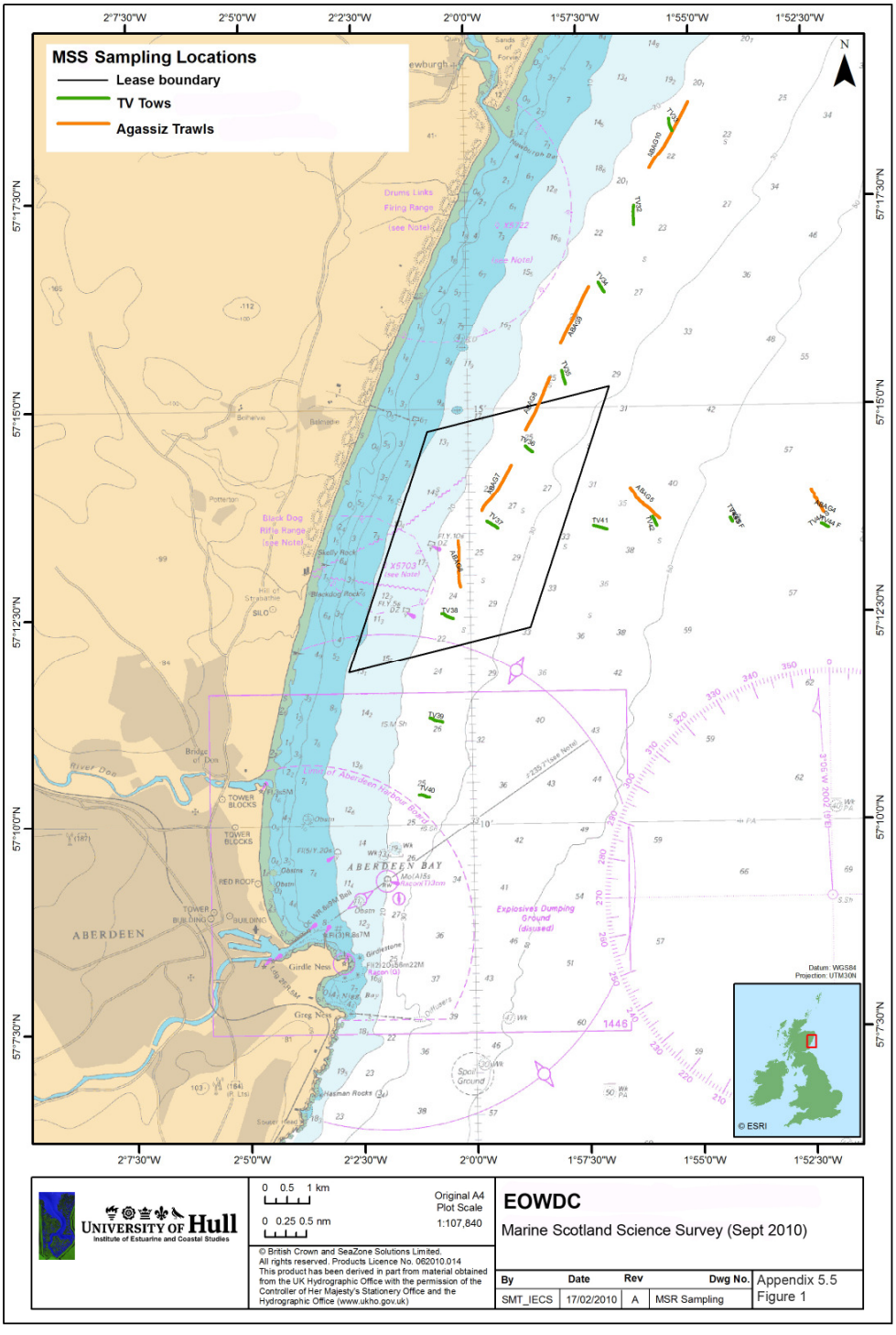


Figure 1. Trawl and video stations (MSS survey 2010).

3 The seabed video-footage was collected using a drop-frame TV system with video and digital still capabilities. The drop-frame was deployed with an armoured cable over the stern of the vessel typically steaming ahead at 1 knot into the tide or wind, whichever was the strongest. Once the drop-frame had reached the sea bed, a tow of typically ten to forty minutes duration was completed and the device then retrieved. The drop-frame was positioned approximately 1 m above the sea bed to ensure the best focal range for the digital camera. Vertical positioning of the drop frame is gauged by the deployment of a steel weight off the base of the drop frame which should only touch the sea bed surface. During deployment, a written record of macrobenthos, litter and sea bed type was recorded on an appropriate datasheet every minute. Digital stills were also recorded at approximately 1 minute intervals. Arc View was used to record the locations of the drop-frame TV and of the digital stills recorded during the tow. The video-footage was recorded directly onto DVD and the digital stills downloaded from the camera after the recovery of the drop-frame onto the vessel.

4 Epibenthic sampling was carried out by means of 2 m Agassiz trawl. It was deployed over the stern of the vessel while steaming ahead at between 1 and 2 knots. The Agassiz trawl was lowered to the seabed at a speed of up to 50 m per second. Once the Agassiz trawl had reached the sea bed, a tow of typically ten minutes duration was completed and then the Agassiz trawl was retrieved. The data on trawl position, vessel speed, towing direction and water depth were recorded using a datasheet and directly into Arc View. Once on deck, all animals were removed from the cod end and belly of the net and then transferred to the vessel's fish house for processing. All animals caught were identified, sorted and counted immediately on board the vessel. Non-biological material was thrown overboard during sorting.

5.5.2. Data analysis

MSS survey data were analysed by IECS.

5 Measured values and descriptive statistics for primary and derived biological parameters were presented both for the survey area as a whole and for individual stations. The following biological parameters were calculated using PRIMER v. 6 (Plymouth Routines in Marine Ecological Research):

- The total number of species (S) at each station and for survey area as a whole;
- Total abundance (A) of organisms expressed as individuals / 0.1 m^{-2} at each station;
- Shannon-Wiener diversity ($H'(\log_2)$), incorporating both species richness and evenness (a measure of the distribution of the individuals between the species).

  $$\mathbf{H' = - \sum p_i \log_2 p_i}$$

  Where,
  p_i = proportion of individuals in the ith species = n_i / N
  n_i = number of individuals of the ith species in the sample
  N = total number of individuals

  High values indicate high diversity.

- Pielou's Evenness index (J') gives a measure of the relative abundance of each species:

  $J' = H' / \log_2 S$.

  Low values (close to zero) indicate that a community is dominated by one or few species and indicate low diversity. Communities where there is an even spread of the individuals between the species (J' values approaching 1) are considered to be diverse.

6 Description of the biological communities for individual stations and for the survey area as a whole was carried out by ranking the species in terms of their abundance.

7 Multivariate techniques were also applied, allowing comparison of communities based on their component species and their relative importance in terms of abundance. Such techniques enable the interpretation of large data sets as a whole rather than examination of different components individually. Calculation of the Bray-Curtis similarity coefficient gives the percentage similarity between each pair of samples (i.e. all samples are compared with each other) and can be plotted in the form of a dendrogram, or an ordination plot (using Multi Dimensional Scaling) so that groups of samples with distinct community structures can be identified.

8 Multivariate analysis was carried out on the trawl data using the PRIMER v6.0 program to determine difference in epifaunal community structure between sample stations, particularly between those inside and outside the proposed EOWDC area. Sample data were fourth-root transformed prior to analysis, to reduce the effect of dominant species. A multi-dimensional scaling (MDS) diagram was generated to visualize the similarity among sites.

5.5.3. Results

9 The detailed results from the video analysis are presented in Appendix 5.6. The video footage from the inshore stations (TV32 to TV40) showed very similar characteristics of the sea bed. At all videos from these sites, the high current speed, large amount of organic matters and significant amount of silt/clay content was recorded. Due to the high sediment load, a very poor diversity of epifauna was observed. Brittle stars *Ophiura* sp. were observed in high numbers, but it was difficult to enumerate them using the video footage due to the poor visibility. Some fish species, mostly plaice and common dab were also detected. Sediments were mainly composed of fine sand, silt/clay and shell fragments. Sand ripples on the sea bed were also noticeable. No seaweed was recorded at these stations.

10 The sediments at stations TV41 and TV42 were very similar to those described above, but with greater content of shell fragments. Current speed at these stations was somewhat slower, and sand ripples were very noticeable. Species of brittle stars and common starfish *Asterias rubens* were recorded on the sea bed.

11 Mixed types of sediments were recorded further offshore (stations TV43 and TV44), with coarse sediments, stones, pebbles and boulders with silt/clay particles detected at these stations (Appendix 5.6). A relatively slow current

speed was present and the water was clear. Common starfish, bryozoans *Flustra foliacea* and dead man's fingers *Alcyonium digitatun* were present in large numbers at these stations. Attached epifaunal species (anemones, bryozoans, sponges) were also notable on the video footage (Appendix 5.6).

12 In total 14 species of fish, 7 species of decapods and 8 species of other invertebrates were recorded in trawl samples (raw data are provided in Appendix 5.7).

13 Fish accounted for 30% of the overall abundance in the trawl catches, with the predominant species being common dab *Limanda limanda* and plaice *Pleuronectes platessa* (Figure 2). These species were recorded in particularly high numbers (total of 823 and 510 individuals respectively) at the inshore stations (Appendix 5.7). Norway pout *Trisopterus esmarki* was also abundant, but only at station ABAG10 (240 individuals) (Appendix 5.7). Other species were recorded with lower abundances.

14 Crustacea accounted just for 1% of the overall abundance in the trawls catches, with the predominant species being harbour crab *Liocarcinus depurator* and circular crab *Atelecyclus rotundatus* (Figure 2).

15 Sixty-nine percent of the overall trawl catch abundance was accounted for by other invertebrate species, with brittle stars being the predominant taxon (Figure 2).

16 Low numbers of fish species and abundance were generally recorded at the offshore stations, although decapods occurred with a higher number of species and abundance in these areas (particularly at station ABAG4) (Figures 3 and 4). At inshore stations large numbers of brittle stars and common starfish were present (Figure 4, Appendix 5.7). The largest number of common starfish was recorded at the furthest offshore station ABAG4, and was also observed from the video analysis for this station. Higher species diversity and evenness values were found at offshore stations ABAG5 and ABAG4, as well as at station ABAG10 (Figures 5 and 6).

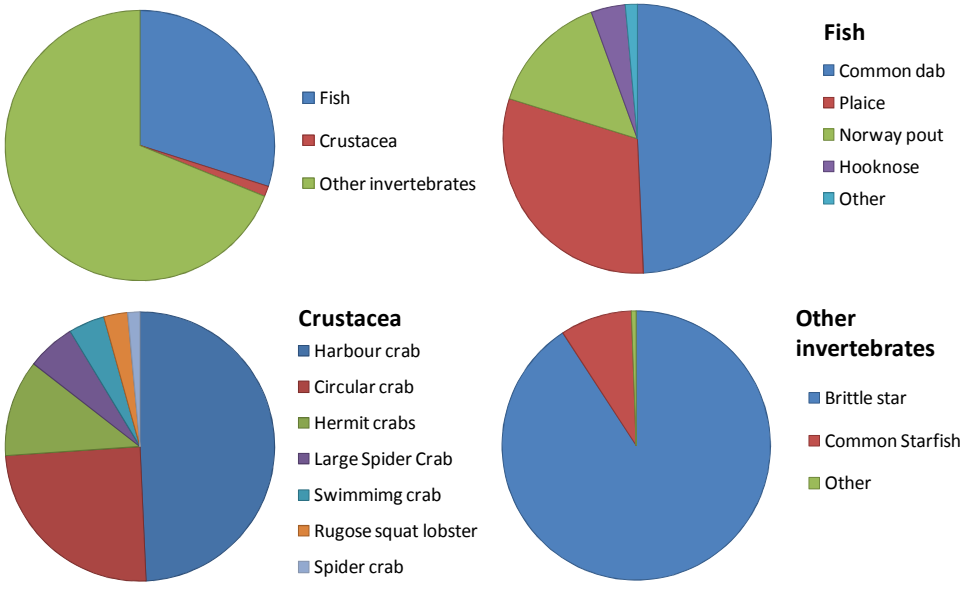


Figure 2. Overall composition (% abundance) of the epibenthic trawl catches carried out by Marine Scotland Science (September 2010).

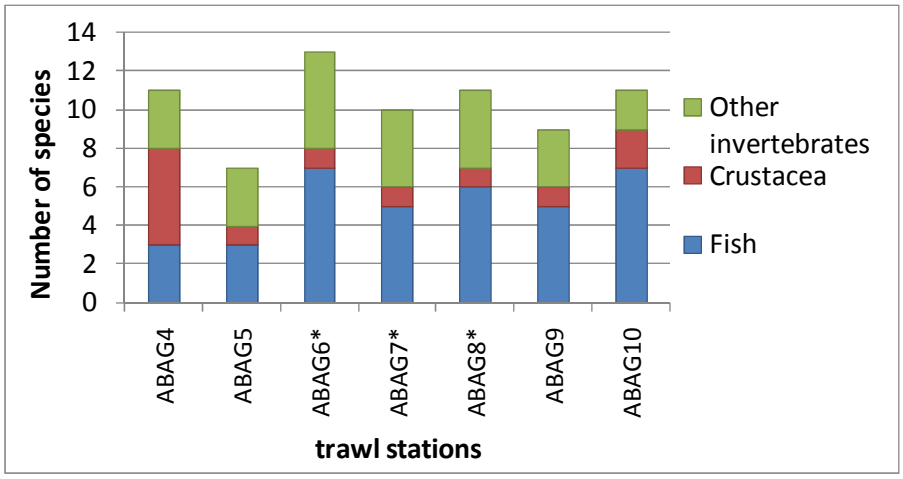


Figure 3. Number of species in the epibenthic trawl catches carried out by MSS (September 2010) at the 7 stations in Aberdeen Bay (asterisks indicate trawls inside the proposed EOWDC area).

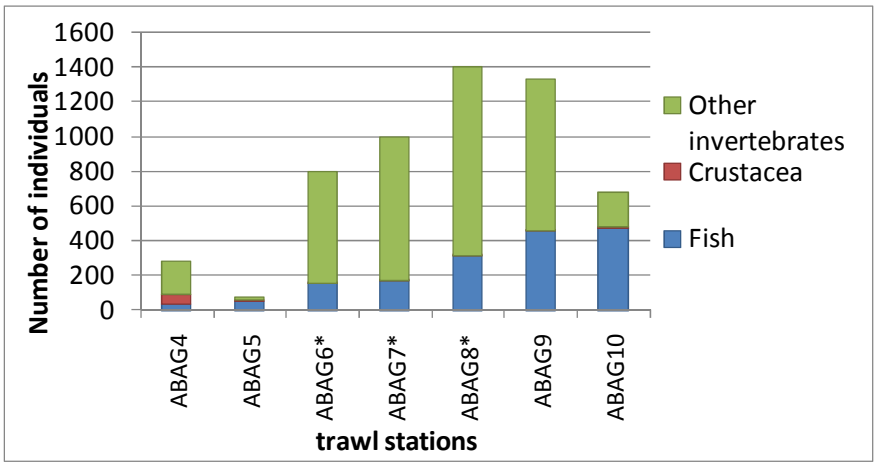


Figure 4. Total abundance in the epibenthic trawl catches carried out by MSS (September 2010) at the 7 stations in Aberdeen Bay (asterisks indicate trawls inside the proposed EOWDC area).

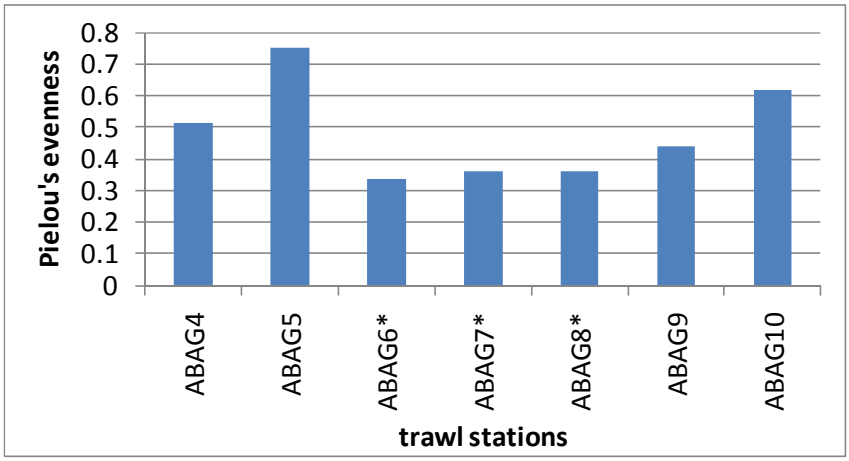


Figure 5. Pielou's evenness index measured on the epibenthic trawl catches carried out by MSS (September 2010) at the 7 stations in Aberdeen Bay (asterisks indicate trawls inside the proposed EOWDC area).

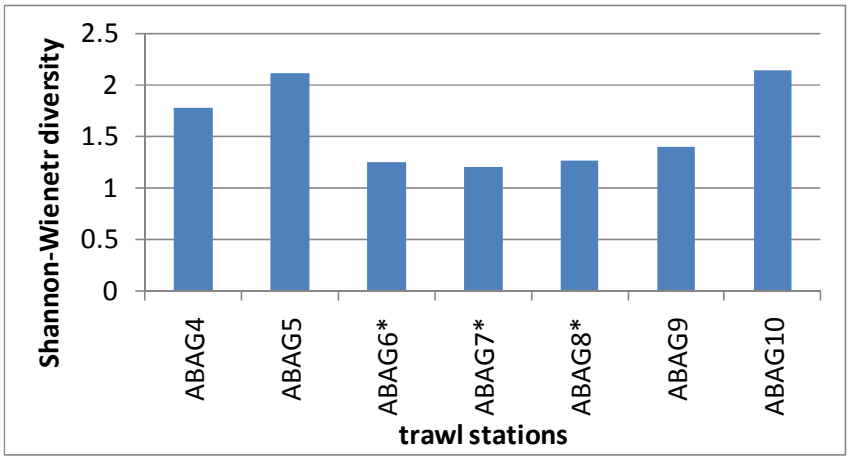


Figure 6. Pielou's evenness index measured on the epibenthic trawl catches carried out by MSS (September 2010) at the 7 stations in Aberdeen Bay (asterisks indicate trawls inside the proposed EOWDC area).

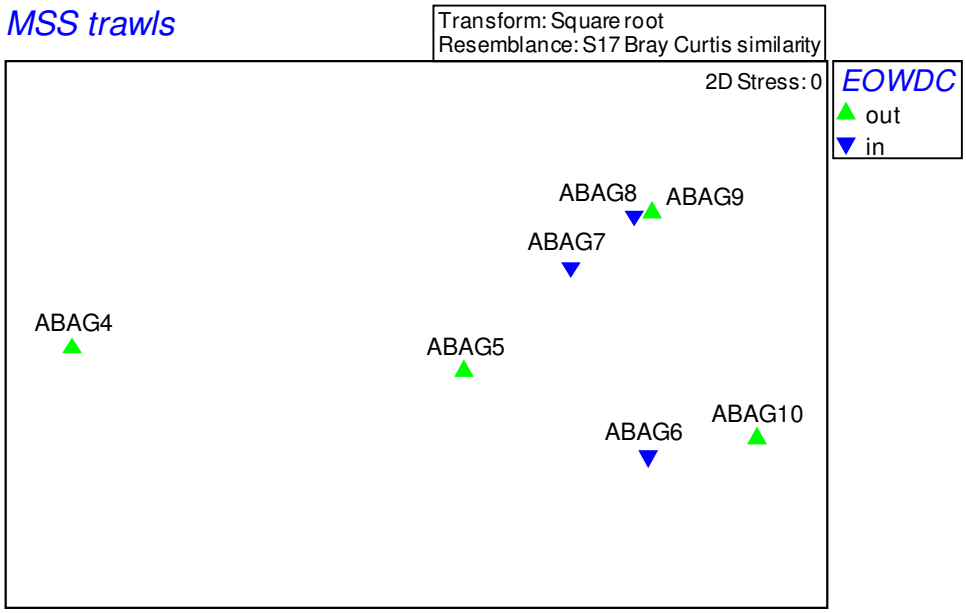


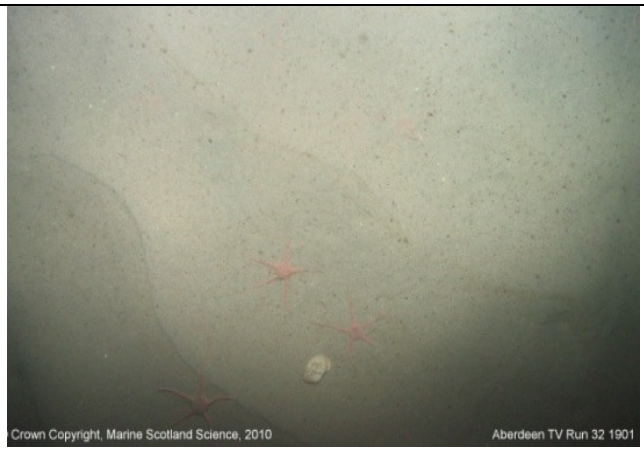
Figure 7. MDS plot (√√ transformed) based on the species abundance composition at each station (distinguished by their location inside or outside the proposed EOWDC area) (MSS epibenthic survey 2010).

17 The Multi Dimensional Scaling (MDS) diagram, representing similarities among stations according to the structure of epibenthic assemblages (in terms of species abundance) is shown in Figure 7. No major differences were detected between stations located inside the proposed EOWDC area, and those outside. In turn, station ABAG4, located farther offshore (Figure 1), showed an epibenthic assemblage well distinguished from the assemblage in the other stations. This result was mainly ascribed to the higher abundance of hooknose, harbour and circular crabs, and of common starfish present at the station, as well as to a lower abundance of flatfishes (common dab and plaice) and brittle stars compared to the other stations, and this can be related to the differences in depth and distance from the shore.

APPENDIX 5.6.

MSS EPIBENTHIC SURVEY 2010 – ANALYSIS OF VIDEO RUNS

VIDEO NO.	**TV32: 15/09/2010**
Duration (mins)	10
Summary	High current speed, large amount of Suspended Organic Solids. *Ophiura* sp. present, but hard to see them on the video footage due to muddy water. Some shell material and dead shells on the sea bed. Sand ripples, fine muddy sand, no weed
Real time	
17.19	*Asterias rubens* x 1
17.19	Plaice
17.21 17.26	*Asterias rubens* x 5
17.26	Plaice or dab x 1
17.27	*Asterias rubens* x 1
17.27	Plaice or dab x 1
17.28	Plaice or dab x 1; *Asterias rubens* x 1



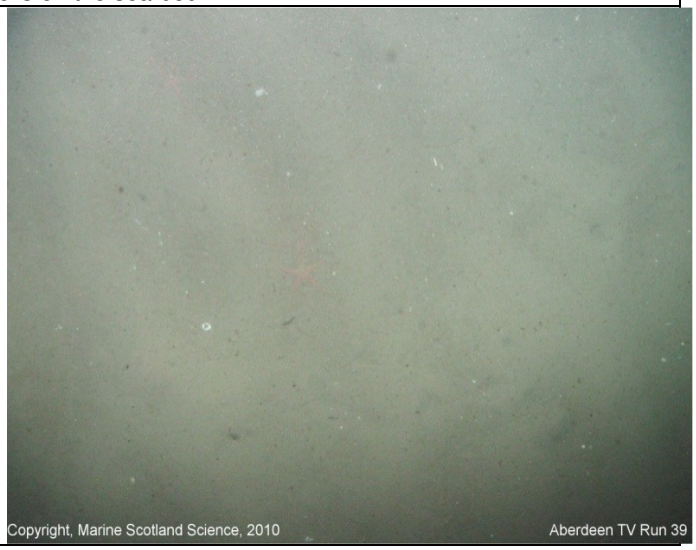
VIDEO NO.	**TV33: 15/09/2010**
Duration (mins)	10
Summary	High current speed, large amount of Suspended Organic Solids. Camera jumps, very bad visibility. Sediments are as described above.
Real time	
17.47	Plaice x 1
17.47	Pisces indet. x 1
17.48	*Asterias rubens* x1
17.50	Plaice or dab x 2
17.53	*Ophiura* sp. x 6
17.54	Plaice or dab x 1
17.55	Plaice or dab x 1

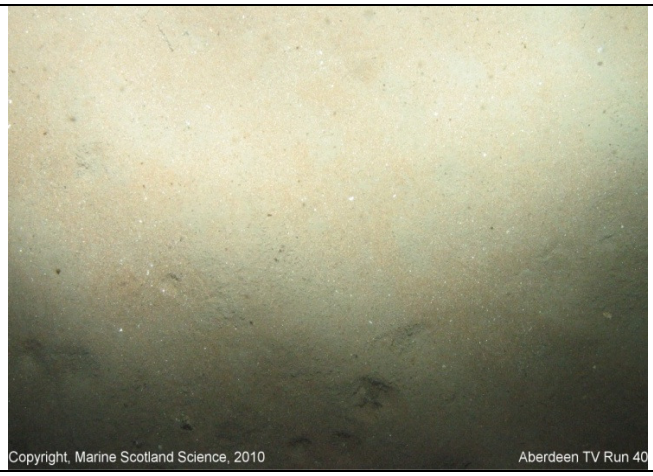
VIDEO NO.	**TV34: 16/09/2010**
Duration (mins)	10
Summary	High current speed. Sediments are as described in video 32.
Real time	
7.24 7.25	*Asterias rubens* x 4
7.26	Plaice or dab x 1
7.28	Crustacea indet.
7.29	*Asterias rubens* x 3
7.30	Plaice x 1
7.31	*Asterias rubens* x 2

VIDEO NO.	**TV35: 16/09/2010**
Duration (mins)	10
Summary	High current speed. Sediments are as described in video 32.
Real time	
7.47	Common dab x 1
7.49	*Asterias rubens* x 1
7.49	Plaice x 1
7.49	*Asterias rubens* x 1
7.50	Plaice x 2
7.50 7.51	Plaice or dab x 2
7.51	*Asterias rubens* x 1
7.51	Plaice x 1
7.51	Common dab x 1
7.53	*Asterias rubens* x 2
7.54	Common dab x 1
7.54	*Asterias rubens* x 3
7.55	Common dab x 2
7.56	See weed?
7.56	*Asterias rubens* x 1

VIDEO NO.	**TV36: 16/09/2010**
Duration (mins)	10
Summary	High current speed. Sediments are as described in video 32.
Real time	
8.12	*Asterias rubens* x 1
8.13	Plaice or dab x 1
8.13	*Asterias rubens* x 1
8.14	Plaice or dab x 1
8.15	*Asterias rubens* x 1
8.16	Empty razor shells
8.18	Plaice or dab x 1
8.20	*Asterias rubens* x 3
8.20	*Solea solea* x 1
8.21	*Asterias rubens* x 1
8.21	Plaice or dab x 1
8.21	*Asterias rubens* x 1
8.21	Plaice or dab x 1

VIDEO NO.	**TV37: 16/09/2010**
Duration (mins)	10
Summary	High current speed, large amount of Suspended Organic Solids. *Ophiura* sp., *Asterias rubens* and *Flustra folicea* spread widely, but not clear on the video footage due to very muddy water. Some shell material and dead shells on the sea bed. Sand ripples, fine muddy sand, no weed.
Real time	
8.39	Crustacea indet.
8.39	*Asterias rubens* x 1
8.39	*Flustra foliacea*
8.40	Common dab x 1
8.40	Plaice or dab x 1
8.40	*Asterias rubens* x 1
8.41	Plaice or dab x 1
8.41	Common dab x 1
8.42	*Asterias rubens* x 4
8.42	Common dab x 1
8.42 8.43	*Asterias rubens* x 3
8.43	Crustacea indet.
8.43	Pipe fish
8.43 8.44	*Asterias rubens* x 2
8.44	Razor shells x 1
8.44 8.46	*Asterias rubens* x 5
8.46	Common dab x 1
8.47	*Asterias rubens* x 1
8.47	Razor shells x 1
8.48	*Asterias rubens* x 1

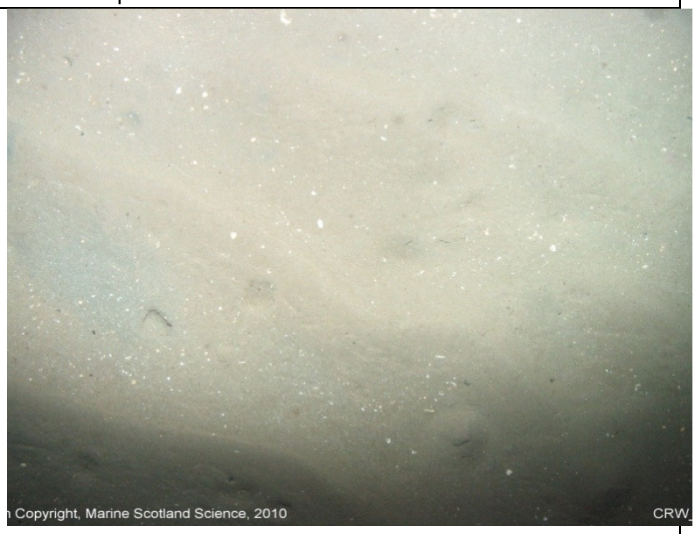
VIDEO NO. Duration (mins)	**TV38: 16/09/2010** 10	
Summary	Large amount of Suspended Organic Solids. Water is very muddy. Silt/clay type sediment on the surface, some burrows are visible. Some shell material and dead shells on the sea bed.	
Real time		
9.04	Common dab x 2	
9.06 9.08	*Asterias rubens* x 7	
9.08	Common dab x 1	
9.09	*Asterias rubens* x 2	
9.12	Asterias rubens x 1; Razor shells x 1	
9.14	*Asterias rubens* x 2	
9.14	Echinodermata indet.	
VIDEO NO. Duration (mins)	**TV39: 16/09/2010** 10	
Summary	Large amount of Suspended Organic Solids. Water is very muddy. Silt/clay presented on the sediments surface, fine sand sediments, sand ripples. Some shell material and dead shells on the sea bed.	
Real time		
9.31	Common dab x 1	
9.32	Plaice or dab x 3	
9.34	Pisces indet. x 1	
9.34 9.36	*Asterias rubens* x 5	
9.36	Plaice or dab x 1	
9.38	Razor shells x 1	
9.38	Plaice or dab x 1	
9.39	Ohiuroidea spp.	
9.39	*Asterias rubens* x 1	

VIDEO NO. Duration (mins)	**TV40: 16/09/2010** 8	
Summary	Large amount of Suspended Organic Solids. Water is very muddy. Silt/clay type sediment on the surface, fine sand sediments. Some shell material and dead shells on the sea bed.	
Real time		
9.55	*Asterias rubens* x 1; Whelk (Buccinum sp.)	
9.56	*Asterias rubens* x 1	
9.56	Decapoda indet.	
9.57	Common cockle?	
10.01	*Asterias rubens* x 1	
10.02	Crustacea indet.	

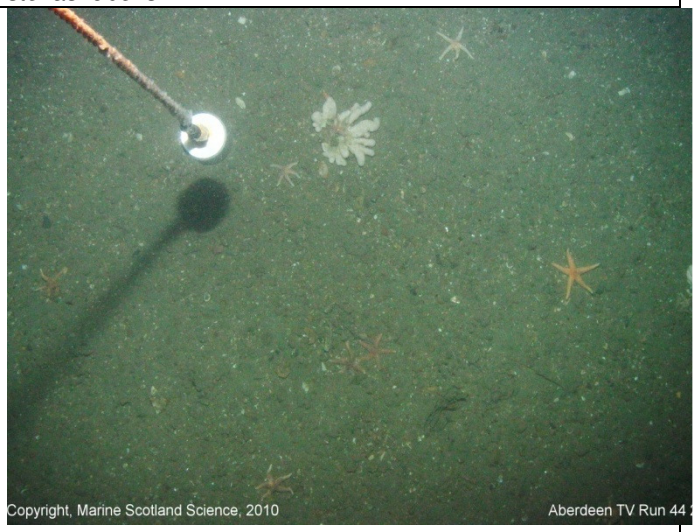
VIDEO NO. Duration (mins)	**TV41: 16/09/2010** 10	
Summary	Very similar sediments as above, large amount of Suspended Organic Solids. Silt/clay and fine sand on the sediment surface. Some shell material and dead shells on the sea bed. Species of *Ophiura* sp. and *Asterias rubens* present on the surface.	
Real time		
11.02	Ohiura sp.	
11.03	Gastropod x 1	
11.03 11.05	*Asterias rubens* x 5	
11.08	Razor shells x 1	
11.08	Sea urchin?	
11.09	*Asterias rubens* x 1	
11.10	*Ohiura* sp.	
11.10 11.12	*Asterias rubens* x 5	
11.12	*Ohiura* sp. X 2	

VIDEO NO. Duration (mins)	**TV42: 16/09/2010** 10
Summary	The sediment is mostly the same type as described above, but slightly darker in colour. Relatively slow current speed.

Real time	
11.23	*Asterias rubens* x1; Decapoda indet. x 1
11.24	*Asterias rubens* x5
11.25	Crustacea? x 1
11.25	Whelk (Buccinum)
11.25	*Asterias rubens* x 2
11.27	*Flustra foliacea* x 1
11.27	*Asterias rubens* x 1
11.27	*Ohiura* sp. x 1
11.27	*Asterias rubens* x 1
11.28	*Flustra foliacea* x 1
11.28	*Asterias rubens* x 6
11.29	*Flustra foliacea* x 1
11.30	*Asterias rubens* x 1
11.30	Sponge?
11.31	*Asterias rubens* x 1
11.31	*Ohiura* sp. x 1
11.31 11.33	*Asterias rubens* x 6



VIDEO NO. Duration (mins)	**TV43: 16/09/2010** 10
Summary	Mostly coarse sediments, stones, pebbles and boulders presented. Silt/clay particles covering coarse sediments. Relatively slow current speed, some attached epifauna present (Anemones, bryozoans, sponges), large amount of corals (*Alcyonium digitatun*) and sea stars.
Real time	
11.46	*Alcyonium digitatun* x 2
11.46	*Alcyonium digitatun* x 2; Echinodermata? x 1
11.46 11.48	*Asterias rubens* x12; *Alcyonium digitatun* x10; *Flustra foliacea* x 2; Actiniaria indet.x 1
11.48 11.51	*Asterias rubens* x 21; *Alcyonium digitatun* x 19; *Flustra foliacea* x 1; Crustacea indet. x 3; Whelk x 1;
11.51 11.55	*Asterias rubens* x 23; *Alcyonium digitatun* x 43; *Flustra foliacea* x 14?

VIDEO NO. Duration (mins)	**TV44: 16/09/2010** 10	
Summary	Coarse sediments, pebbles and stones, mixed types of sediments. Moderate currents speed, some attached epifauna recorded (Anemones, bryozoans), large amount of sea stars *Asterias rubens*.	
Real time		
12.12 12.17	*Asterias rubens* x 137; *Alcyonium digitatun* x 10; *Flustra foliacea* x 4; *Ohiura* sp. x 1; Decapoda indet. x 2; *Cancer pagurus* x 1;	
12.18 12.19	*Asterias rubens* x 50; *Alcyonium digitatun* x 7; *Flustra foliacea* x 3	
12.20	*Asterias rubens* x 41; *Alcyonium digitatun* x 11; *Flustra foliacea* x7	
12.21	Pectinidae spp. x 1	

APPENDIX 5.7.

MSS EPIBENTHIC TRAWL SURVEY 2010 – RAW DATA

Epifaunal composition from trawl survey (MSS survey 2010).

Common Name	Species name	ABAG4	ABAG5	ABAG6	ABAG7	ABAG8	ABAG9	ABAG10	Totals
Fish									
Common dab	*Limanda limanda*	4	20	80	90	211	331	87	823
Plaice	*Pleuronectes platessa*		31	60	70	92	123	134	510
Norway pout	*Trisopterus esmarki*					2	2	240	244
Hooknose	*Agonus cataphractus*	34	5	11	12	5	2		69
Long rough dab	*Hippoglossoides platessoides*						2	5	7
Flounder	*Platichthys flesus*			1				4	5
Cod	*Gadus morhua*					1		2	3
Greater pipefish	*Syngnathus acus*			1	1				2
Red Gurnard	*Aspitrigla cuculus*					2			2
Whiting	*Merlangius merlangus*			1					1
Cuckoo Ray	*Raja naevus*			1					1
Dragonet	*Callionymus lyra*	1							1
Long spined scorpionfish	*Paracentropogon longispinis*				1				1
Long-spined Bullhead	*Taurulus bubalis*							1	1
Crustacea species									
Harbour crab	*Liocarcinus depurator*	30				1		3	34
Circular crab	*Atelecyclus rotundatus*	17							17
Hermit crabs	*Pagarus* sp.	2		2				4	8
Large Spider Crab	*Inachus* sp.	4							4
Swimming crab	*Necora puber*		2		1				3
Rugose squat lobster	*Munida rugosa*	2							2
Spider crab	*Macropodia deflexa*						1		1
Other species									
Brittle star	*Ophiura albida*		2		780	1040	850		2672
Brittle star	Ophiuroida			619				200	819

Common Name	Species name	ABAG4	ABAG5	ABAG6	ABAG7	ABAG8	ABAG9	ABAG10	Totals
Common Starfish	*Asterias rubens*	183	13	16	42	52	24	3	333
Common heart urchin	*Echinocardium cordatum*		1	5	4	1	2		13
Sea urchin	*Psammechinus miliaris*	4							4
Astrapecten	*Astropecten polyacanthus*			1	1	1			3
Whelk	*Neptunea* sp.	1							1
Sea mouse	*Aphrodite aculeata*			1					1

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