40MW LEWIS WAVE ARRAY: ENVIRONMENTAL STATEMENT

VOLUME 3 OF 3: TECHNICAL APPENDICES

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Scoping Opinion

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The Scottish Government

Lewis Wave Power Oyster Wave Energy Convertor Array, North West Coast Lewis

Scoping Opinion

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SCOPING OPINION FOR THE PROPOSED SECTION 36 APPLICATION FOR LEWIS WAVE POWER OYSTER WAVE ENERGY CONVERTOR ARRAY, NORTH WEST COAST LEWIS

1. Introduction

I refer to your email of 20th May 2011 requesting a scoping opinion under the Electricity Works (Environmental Impact Assessment) (Scotland) (EIA) Regulations 2000 enclosing a scoping report.

Any proposal to construct or operate an offshore power generation scheme with a capacity in **excess of 1 megawatt** requires Scottish Ministers' consent under section 36 of the Electricity Act 1989.

Schedule 9 of the Act places on the developer a duty to "have regard to the desirability of preserving the natural beauty of the countryside, of conserving flora, fauna and geological and physiological features of special interest and of protecting sites, buildings and objects of architectural, historic or archaeological interest". In addition, the developer is required to give consideration to the Scottish Planning Policy on Renewable Energy other relevant Policy and National Policy Planning Guidance, Planning Advice Notes, the relevant planning authority's Development Plans and any relevant supplementary guidance.

Under the Electricity Works (Environmental Impact Assessment)(Scotland)(EIA) Regulations 2000, Scottish Ministers are required to consider whether any proposal for an offshore device is likely to have a significant effect on the environment. Scottish Ministers have considered your request for an opinion on the proposed content of the Environmental Statement (ES) in accordance with regulations and in formulating this opinion Scottish Ministers have consulted with the relevant organisations.

Please note that the EIA process is vital in generating an understanding of the biological and physical processes that operate in the area and that may be impacted by the proposed project. We would however state that references made within the scoping document with regard to the significance of impacts should not prejudice the outcome of the EIA process.

It is important that any devices to exploit renewable energy sources should be accompanied by a robust assessment of its environmental impacts. The assessment should also consider how any negative environmental impacts could be avoided or minimised, through the use of mitigating technologies or regulatory safeguards, so that the quality and diversity of Scotland's wildlife and natural features are maintained or enhanced. Scottish Ministers welcome the commitment given in the report that the EIA process will identify mitigation measures in order to avoid, minimise or reduce any adverse impacts. Marine Scotland Licensing Operations Team (MS-LOT) would suggest that the range of options considered should be informed by the EIA process in order that these objectives can be achieved. Consultation with the relevant nature conservation agencies is essential and it is advised that this is undertaken as appropriate.

2. Aim of this Scoping Opinion

Scottish Ministers are obliged under the EIA regulations to respond to requests from developers for a scoping opinion on outline design proposals.

The purpose of this document is to provide advice and guidance to developers which have been collated from expert consultees whom the Scottish Government (SG) has consulted. It should provide clear advice from consultees and enable developers to address the issues they have identified and address these in the EIA process and the ES associated with the application for section 36 consent.

3. Description of development

From your submitted information it is understood that Lewis Wave Power is proposing to develop a commercial wave farm located along the North West coast of Lewis. The wave farm would consists of up to 40 x 1 MW 'Oyster 3' wave energy convertors which would be deployed within two lease areas at the site. The total generating capacity of the development would be 40 MW.

4. Land Use Planning

The Scottish Government's planning policies are set out in the National Planning Framework, Scottish Planning Policy, Designing Places and Circulars.

The National Planning Framework is the Scottish Government's Strategy for Scotland's long term spatial development.

Scottish Planning Policy (SPP) is a statement of Scottish Government policy on land use planning and contains:

- the Scottish Government's view of the purpose of planning,
- the core principles for the operation of the system and the objectives for key parts of the system,
- statutory guidance on sustainable development and planning under Section 3E of the Planning etc. (Scotland) Act 2006,
- concise subject planning policies, including the implications for development planning and development management, and
- the Scottish Government's expectations of the intended outcomes of the planning system.

Other land use planning documents which may be relevant to this proposal include:

- PAN 45: 2002 Renewable Energy Technologies
- PAN 50: Controlling the Environmental Effects of Surface Mineral Workings
- PAN 51: Planning, Environmental Protection and Regulation
- PAN 58: Environmental Impact Assessment
- PAN 60: Planning for Natural Heritage
- PAN 62: Radio Telecommunications
- PAN 68: Design Statements
- PAN 69: Planning and Building Standards Advice on Flooding
- PAN 75: Planning for Transport
- PAN 79: Water and Drainage
- Marine Guidance Note 371 (M)

- The Highland Structure Plan
- West Highland and Islands Local Plan (WHILP).

5. Natural Heritage

Scottish Natural Heritage (SNH) has produced a service level statement (SLS) for renewable energy consultation. This statement provides information regarding the level of input that can be expected from SNH at various stages of the EIA process. Annex A of the SLS details a list of references, which should be fully considered as part of the EIA process. A copy of the SLS and other vital information can be found on the renewable energy section of their website – www.snh.org.uk

6. General Issues

Economic Benefit

The concept of economic benefit as a material consideration is explicitly confirmed in the consolidated SPP. This fits with the priority of the Scottish Government to grow the Scottish economy and, more particularly, with our published policy statement "Securing a Renewable Future: Scotland's Renewable Energy", and the subsequent reports from the Forum for Renewables Development Scotland (FREDS), all of which highlight the manufacturing potential of the renewables sector. The application should include relevant economic information connected with the project, including the potential number of jobs, and economic activity associated with the procurement, construction operation and decommissioning of the development.

7. Contents of the Environmental Statement (ES)

Format

Developers should be aware that the ES should also be submitted in a user-friendly PDF format which can be placed on the Scottish Government website. A description of the methodology used in assessing all impacts should be included.

It is considered good practice to set out within the ES the qualifications and experience of all those involved in collating, assessing or presenting technical information.

Non Technical Summary.

This should be written in simple non-technical terms to describe the various options for the proposed development and the mitigation measures against the potential adverse impacts which could result. Within an ES it is important that all mitigating measures should be:

- clearly stated;
- fully described with accuracy;
- assessed for their environmental effects;
- assessed for their effectiveness;
- their implementation should be fully described;
- how commitments will be monitored; and
- if necessary, how they relate to any consents or conditions.

Given that the layout and design are still developing and evolving, the exact nature of the work that is needed to inform the EIA may vary depending on the design choices. The EIA must address this uncertainty so that there is a clear explanation of the potential impact of each of the different scenarios. It should be noted that any changes produced after the ES is

submitted may result in the requirement of further environmental assessment and public consultation if deemed to be significant by the licensing authority.

Baseline Assessment and Mitigation

Refer to Annex 1 for consultee comments on specific baseline assessment and mitigation.

8. Archaeology and Cultural Heritage

General Principles

The ES should address the predicted impacts on the historic environment and describe the mitigation proposed to avoid or reduce impacts to a level where they are not significant. Historic environment issues should be taken into consideration from the start of the site selection process and as part of the alternatives considered.

National policy for the historic environment is set out in:

- Scottish Planning Policy *Planning and the Historic Environment* at: http://www.scotland.gov.uk/topics/built-environment/planning/National-planning-policy/themes/historic
- The Scottish Historic Environment Policy (SHEP) sets out Scottish Ministers strategic policies for the historic environment and can be found at: http://www.historic-scotland.gov.uk/index/heritage/policy/shep.htm

Amongst other things, SPP paragraph 110–112, Historic Environment, stresses that scheduled monuments should be preserved *in situ* and within an appropriate setting and states that developments must be managed carefully to preserve listed buildings and their settings to retain and enhance any special architectural or historic features of interest. Consequently, both direct impacts on the resource itself and indirect impact on its setting must be addressed in any EIA undertaken for this proposed development. Further information on setting can be found in the following document: Managing Change in the Historic Environment http://www.historic-scotland.gov.uk/managing-change-consultation-setting.pdf.

Historic Scotland recommend that you engage a suitably qualified archaeological/historic environment consultants to advise on, and undertake, the detailed assessment of impacts on the historic environment and advise on appropriate mitigation strategies.

Baseline Information

Information on the location of all archaeological/historic sites held in the National Monuments Record of Scotland, including the locations and, where appropriate, the extent of scheduled monuments, listed buildings and gardens and designed landscapes can be obtained from www.PASTMAP.org.uk

Data on scheduled monuments, listed buildings and properties in the care of Scottish Ministers can also be downloaded from Historic Scotland's Spatial Data Warehouse at http://data.historic-scotland.gov.uk/. For any further information on those data sets and for spatial information on gardens and designed landscapes and World Heritage Sites which are not currently included in Historic Scotland's Spatial Data Warehouse please contact hsgimanager@scotland.gsi.gov.uk. Historic Scotland are also available to provide any further information on all such sites.

9. Navigation

The ES should include the following details on the possible impact on navigation for both commercial and recreational craft.

- Collision Risk
- Navigational Safety
- Risk Management and Emergency response
- Marking and lighting of Tidal Site and information to mariners
- Effect on small craft navigational and communication equipment
- Weather and risk to recreational craft which lose power and are drifting
- In adverse conditions
- Evaluation of likely squeeze of small craft into routes of larger
- Commercial vessels.
- Visual intrusion and noise

10. Ecology, Biodiversity and Nature Conservation

Refer to Annex 1 for comments from advisors on ecology, biodiversity and nature conservation.

Species

The ES should show that the applicants have taken account of the relevant wildlife legislation and guidance, namely

- Marine (Scotland) Act 2010
- Council Directives on The Conservation of Natural Habitats and of Wild Flora and Fauna
- Conservation of Wild Birds (commonly known as the Habitats and Birds Directives)
- Wildlife & Countryside Act 1981
- Wildlife and Natural Environment (Scotland) Act 2011
- Nature Conservation (Scotland) Act 2004
- Protection of Badgers Act 1992
- 1994 Conservation Regulations
- Scottish Executive Interim Guidance on European Protected Species
- Development Sites and the Planning System and the Scottish Biodiversity Strategy and associated Implementation Plans

In terms of the SG Interim Guidance, applicants must give serious consideration to/recognition of meeting the three fundamental tests set out in this Guidance. **It may be worthwhile for applicants to give consideration to this immediately after the completion of the scoping exercise.**

It needs to be categorically established which species are present on and near the site, and where, <u>before</u> the application is considered for consent. The presence of protected species such as Schedule 1 Birds or European Protected Species must be included and considered as part of the application process, not as an issue which can be considered at a later stage. Any consent given without due consideration to these species may breach European Directives with the possibility of consequential delays or the project being halted by the EC. Likewise the presence of species on Schedules 5 (animals) and 8 (plants) of the Wildlife & Countryside Act 1981 should be considered where there is a potential need for a licence under Section 16 of that Act.

11. Water Environment

Developers are strongly advised to consult with the Scottish Environment Protection Agency (SEPA), at an early stage. SEPA are the regulatory body responsible for the implementation of the Controlled Activities Regulations (CAR), to identify if a CAR licence is necessary and clarify the extent of the information required by SEPA to fully assess any licence application.

All applications (including those made prior to 1 April 2006) made to Scottish Ministers for consent under section 36 of the Electricity Act 1989 to construct and operate a electricity generating station are required to comply with new legislation. In this regard MS-LOT will be advised by SEPA and will have regard to this advice in considering any consent under section 36 of the Electricity Act 1989.

SEPA produces a series of Pollution Prevention Guidelines (PPG), several of which should be fully utilised in preparation of an ES and during project development. These include SEPA's guidance note PPG6: Working at Construction and Demolition Sites, PPG5: Works in, near or liable to affect Watercourses, PPG2 Above ground storage tanks, and others, all of which are available on SEPA's website at http://www.sepa.org.uk/about_us/publications/guidance/ppgs.aspx. SEPA would look to see specific principles contained within PPG notes to be incorporated within mitigation measures identified within the ES rather than general reference to adherence to the notes.

Prevention and clean-up measures should also be considered for each of the following stages of the development;

- Construction.
- Operation.
- Decommissioning.

Construction contractors may be unaware of the potential for impacts such as those listed below but, when proper consultation with the local fishery board is encouraged at an early stage, many of these issues can be averted or overcome.

- increases in silt and sediment loads resulting from construction works.
- point source pollution incidents during construction.
- obstruction to upstream and downstream migration both during and after construction.
- disturbance of spawning beds during construction - timing of works is critical.
- drainage issues.
- sea bed and land contamination

The ES should identify location of, and protective/mitigation measures in relation to, all private water supplies within the catchments impacted by the scheme, including modifications to site design and layout.

Developers should also be aware of available CIRIA guidance on the control of water pollution from construction sites and environmental good practice (www.ciria.org). Design guidance is also available on river crossings and migratory fish (SE consultation paper, 2000) at http://www.scotland.gov.uk/consultations/transport/rcmf-00.asp.

12. Other Material Issues

Traffic Management

The ES should provide information relating to the preferred route options for delivering equipment etc. via the trunk road network. The EIA should also address access issues, particularly those impacting upon the trunk road network; in particular, potential stress points at junctions, approach roads, borrow pits, bridges, site compound and batching areas etc.

Where potential environmental impacts have been fully investigated but found to be of little or no significance, it is sufficient to validate that part of the assessment by stating in the report:

- the work has been undertaken, e.g. transport assessment;
- what this has shown i.e. what impact if any has been identified, and
- why it is not significant.

13. General ES Issues

In the application for consent the applicant should confirm whether any proposals made within the ES, e.g. for construction methods, mitigation, or decommissioning, form part of the application for consent.

Consultation

Developers should be aware that the ES should also be submitted in a user-friendly PDF format which can be placed on the SG website. Developers are asked to issue ES directly to consultees. Consultee address lists can be obtained from MS LOT who will also advise on the number of hardcopies required for onward distribution.

Where the developer has provided Scottish Ministers with an ES, the developer must publish their proposals in accordance with part 4 of the Environmental Impact Assessment (Scotland) Regulations 2000. Information and guidance, including the specific details of the adverts to be placed in the press, can be obtained from MS LOT; ms.marinelicensing@scotland.gsi.gov.uk

Gaelic Language

Where s36 applications are located in areas where Gaelic is spoken, developers are encouraged to adopt best practice by publicising the project details in both English and Gaelic.

Ordinance Survey (OS) Mapping Records

Developers are requested at application stage to submit a detailed OS plan showing the site boundary and all turbines, access tracks and onshore supporting infrastructure in a format compatible with the SG's Spatial Data Management Environment (SDME), along with appropriate metadata. The SDME is based around Oracle RDBMS and ESRI ArcSDE and all incoming data should be supplied in ESRI shape file format. The SDME also contains a metadata recording system based on the ISO template within ESRI ArcCatalog (agreed standard used by the SG); all metadata should be provided in this format.

Difficulties in Compiling Additional Information

Developers are encouraged to outline their experiences or practical difficulties encountered when collating/recording additional information supporting the application. An explanation of any necessary information not included in the ES should be provided, complete with an indication of when an addendum will be submitted.

Application and ES

A developer checklist is enclosed with this opinion to assist developers in consideration and collation of the relevant ES information to support their application. In advance of publicising the application, developers should be aware this checklist will be used by the licensing authority in consideration of formal applications.

Consent Timescale and Application Quality

In December 2007, Scottish Ministers announced an aspirational target to process new section 36 applications within a 9 month period, provided a Public Local Inquiry (PLI) is not held. This scoping opinion is specifically designed to improve the quality of advice provided to developers and thus reduce the risk of additional information being requested and subject to further publicity and consultation cycles.

Developers are advised to consider all aspects of this scoping opinion when preparing a formal application to reduce the need to submit further information in support of your application. The consultee comments presented in this opinion are designed to offer an opportunity to consider all material issues relating to the development proposals.

In assessing the quality and suitability of applications, the licensing authority will use the enclosed checklist and scoping opinion in assessment of the application. Developers are encouraged to seek advice on the contents of ES prior to applications being submitted, although this process does not involve a full analysis of the proposals. In the event of an application being void of essential information, the licensing authority reserve the right not to accept the application. Developers are advised not to publicise applications in the local or national press, until their application has been accepted by the licensing authority.

Judicial review

All cases may be subject to judicial review. A judicial review statement should be made available to the public.

Signed

Andrew Sutherland

12/10/2011

Authorised by the Scottish Ministers to sign in that behalf

Enclosed - Developer Application Checklist

Annex 1

Consultee Comments Relating to Lewis Wave Power Oyster Array, North West Coast Lewis

The following organisations provided a scoping opinion in relation to the Lewis Wave Power Oyster Array, North West Coast Lewis

Statutory Consultees

Comhairle nan Eilean Siar (Western Isles) Planning Authority
Scottish Environmental Protection Agency
Scottish Natural Heritage

Non Statutory Consultees

British Telecom (Radio Network Protection Team)
Chamber of Shipping
Civil Aviation Authority
Crown Estate
Defence Infrastructure Organisation
Health and Safety Executive
Historic Scotland
Inshore Fishery Groups
Joint Radio Company
Marine Scotland
Maritime and Coastguard Agency
National Air Traffic Services
Northern Lighthouse Board
Royal Yachting Association
Royal Society for the Protection of Birds
Scottish Canoe Association
Scottish Government Planning
Surfers Against Sewage
Transport Scotland

Local Authority - Comhairle nan Eilean Siar (Western Isles) Planning Authority

Physical Environment

1.1 The main issue identified which is addressed in part in the Scoping Report is the impact of installations on existing coastal processes and the effect of this on soft sandy coasts and till cliffs, for example, increased coastal erosion. Modelling should be considered to ensure installations are situated as sympathetically as possible in relation to the potential for increased coastal erosion.

1.2 A baseline should be made of the current state of coastal erosion adjacent to the proposed sites. The work carried out by HR Wallingford during 1995 for the Minch Project may help inform such a study. This is described in the report Survey of Coastal Erosion in the Western Isles, Report EX 3155, HR Wallingford.

Commercial Fisheries

2.1 From a fisheries perspective although the Lewis Wave Power Scoping Report indicates low fishing effort this is based on Vessel Monitoring System information between 2005 and 2007. This highlights fishing effort of over 15m vessels only with most effort in the area undertaken by under 10m vessels. Local information indicates up to 8 static gear vessels working this area through the summer months. The development will materially affect the extent of this fishing.

2.2 The data gathering exercise indicated in the Scoping Report and used to inform the impact assessment appears reasonable with targeted consultation with local stakeholders and the utilisation of a Fisheries Liaison Officer to interact with fishing stakeholders.

Traffic and Transport

3.1 Traffic and vehicular issues have the potential to be significant and to that effect information is required within an EIA on the following:

a) the effect of the project on the existing roads network;
b) any proposed access arrangements;
c) transportation of materials to sites during the construction phase;
d) details of any significant changes to traffic flows; and
e) details of a proposed management arrangements in terms of traffic and transport issues.

Archaeology and Cultural Heritage

4.1 The Comhairle welcome's the inclusion of a dedicated chapter to assess the potential impact of any development proposal upon the cultural heritage resource.

4.2 On page 77, the Scoping Report notes that the assessment will consider "both direct and indirect (largely visual) effects" on both terrestrial and submerged archaeological monuments/features and deposits and also listed buildings. Each broad category of impact is commented on as below. Guidance outlining the requirements of the Western Isles Archaeology Service is also included:

Potential direct (physical) impacts to the cultural heritage resource

4.3 The main agencies of direct (i.e. physical) impact have been discussed within the scoping report. The impact on archaeological remains and deposits are summarised below:

- Onshore works up to c4,000m^2
- Drilling of pipelines/preparation of ground
- Possible disturbance of seabed and potential submerged remains
- Changes in coastal processes
- Changes in hydrological conditions
- Junction widening

4.4 In addition, it is also important to consider the following direct impacts:

- Machinery movement onto site
- construction of temporary site compound comprising a lay down area and possibly an additional marshalling area
- hardstanding for site welfare / office facility
- site landscaping
- decommissioning

Each of these stages of work clearly has the potential to impact on or destroy archaeological features or deposits. The assessment and Environmental Statement should consider the impact of each of these activities (if applicable) on the identified and potential cultural heritage resource.

Assessment requirements

4.5 In order to establish the archaeological potential of the application site, to establish the significance of any archaeological remains within the proposed development site and the impact of the development, the applicant should be required to undertake a targeted programme of assessment. All stages of assessment should be undertaken prior to determination and incorporated into the required Environmental Statement. The scoping report identifies that the applicant will commission an archaeological desk-based assessment of relevant existing cultural heritage data to be augmented by a walkover survey of the site. This walkover survey should pay particular attention to the construction impact of the proposed development. Whilst the scope of this assessment should be broadly as set out 5.6.3 of the Scoping Report, it should also include an assessment of the impact upon any coastal sites which may be affected through the perceived changes in coastal processes, it is important that all phases of assessment, including the desk-based assessment, are undertaken in line with an agreed project design or method statement. A specific project brief for each stage of the assessment can be requested from the Comhairle's Archaeology Service once the parameters of the development are agreed.

4.6 Much of the proposed survey area has been assessed through the Coastal Zone Assessment programme, this identified a huge number of sites. This was completed in 1997 so out of date and not complete. The archaeological consultant should liaise with SCAPE directly for any additional advice or information they may hold.

4.7 In addition the CZA recorded changes in the geomorphology along this coastal stretch of North West Lewis, this should also be assessed for any impact for changes in coastal processes, not to provide detailed evidence of the geomorphology but rather to allow the effective analysis and assessment of the erosion regimes to address any site specific issues that may impact on the visibility, preservation and management of sites in the survey area. Assessment should also be made of specific archaeological landscape impacts, for example the prehistoric ritual landscape around Ballantrushal and not just specific individual monuments. This work will hopefully help to refine the areas requiring further archaeological evaluation.

4.8 North West Lewis is extremely important to the consideration of the late Quaternary environment of Scotland as an area which was positioned outwith the maximum extent of the Devensian Ice Sheet 18,000 years ago and has the rare evidence of raised beaches of the Outer Hebrides.

4.9 Upon completion, a copy of the archaeological desk-based assessment should be provided to the Comhairle's Archaeology Service for comment prior to being included within the EIA. Subject to the archaeological potential of the application site, further stages of assessment, including geophysical survey and intrusive evaluation (by trial trenching) and palaeoenvironmental sampling may be required, where appropriate. All phases of assessment and evaluation should also be undertaken prior to determination and incorporated within the applicant's Environmental Statement.

Potential indirect (visual) impacts to the cultural heritage resource

4.10 The Scoping Report notes that a development of this form and scale has potential to indirectly (largely visually) impact cultural heritage features some distance from the proposal. In order to enable an informed assessment of the potential visual impact to cultural heritage receptors, the desk-based assessment should also seek to identify the most sensitive cultural heritage assets (not just scheduled monuments and listed buildings but also non designated features/monuments of national importance) and the historic landscape character within the agreed study area. Once these features are identified, and subject to their relationship with relevant Zone of Theoretical Visibility (ZTV) data, consideration should be given to including these sites within the scope of the detailed visual assessment exercise, using wireframe and / or photomontage simulations.

4.11 The Historic Landscape Assessment for the Outer Hebrides has been completed contrary to what has been written in the Scoping Report and is available for consultation.

4.12 Once the initial desk-based assessment is complete the Comhairle's Archaeology Service should be consulted in order to agree specific locations for visual simulations (photomontage or wireframe) for inclusion within the Environmental Statement.

Mitigation

4.13 Appropriate mitigation advice can be made only once the results of all stages of assessment are available for consideration and details of the development agreed. In the event that significant archaeological remains are identified, appropriate mitigation works may be recommended. These could comprise one or more of the following:

- the abandonment or re-location of specific elements of the scheme;
- full archaeological excavation of impacted areas prior to construction commencing in a defined area.

4.14 Where less significant archaeological remains are revealed, these areas may be dealt with by a condition requiring one or more of the following:

- a programme of archaeological strip and record mitigation prior to construction commencing in that area;
- an archaeological watching brief during groundworks on the least significant archaeological remains;
- topographic survey of archaeological earthworks impacted by the proposal.

4.15 Please feel free to get in touch with the Comhairle's Archaeology Service to discuss the information required for the EIA.

Onshore Noise

5.1 The Scoping Report makes reference to onshore noise and the applicant's willingness to carry out additional monitoring if necessary which is welcomed. Noise from land based construction is likely to be addressed through normal planning conditions with significant effects not expected.

Socio- Economics

6.1 The proposal shows a large search area, which will presumably narrow, down to a precise deployment site. It would be useful for the application to clarify the proposals for the unused portion of the search area e.g. reverting to The Crown Estate to become available to other developers through future leasing rounds.

6.2 While the Scoping Report refers to the creation of Scottish jobs during construction, an evaluation of direct jobs created in the local community should be provided with any proposals to support the development of local expertise where it does not already exist in the community. The EIA should seek to indicate any planned commitments towards local fabrication, research and monitoring in connection with the project.

6.3 The Scoping Report refers to a Socio Economic Assessment, which will support the EIA. One of the topics to be covered by the Socio Economic Assessment is energy supplied by the development. The assessment may wish to consider any impacts arising from any decisions to use of an Outer Hebrides Energy Supply Company.

6.4 As lead partner in the 'ISLEPACT' project, the Comhairle is committed to reducing carbon emissions in the Outer Hebrides by 20% by 2020 and innovative schemes like the one proposed could assist in driving the delivery of this objective.

6.5 In general, the socio-economic assessment should break down the variety of benefits to and impacts within the local economy as well as wider impacts outwith the Outer Hebrides.

General/Consultation Strategy

7.1 The Outer Hebrides Coastal Marine Partnership (www.coasthebrides.co.uk) should be added to the list of consultees.

7.2 As Elected Members (local Councillors) may make a planning decision based on the proposals it would be more appropriate to simply consult Comhairle nan Eilean Siar rather that including local councillors on the consultee list.

7.3 It is noted that the Scoping Report is not site specific about the onshore requirements. Without that detail it is difficult to give any meaningful comment on this aspect of the proposal as part of the Comhairle's Scoping Opinion. The EIA should however be clear on the site(s) selected, the detail of the works proposed and any mitigation proposals put forward.

Scottish Environmental Protection Agency

Thank you for consulting SEPA on the scoping opinion for the above development proposal by way of your email which we received on 27 May 2011. We would welcome meeting with the applicant at an early stage to discuss any of the issues raised in this letter. Overall we consider that the scoping report addresses most of our issues however they should check that they have included all the issues discussed within this letter. In particular we consider that the following key issues should be addressed in the EIA process:

- Impacts upon the water environment both onshore and offshore including existing Scottish Water sewage discharges from local villages
- Pollution prevention measures
- Management of waste peat should deep peat be encountered

Please note that all of the issues below should be addressed in the Environmental Statement (ES), but due to the fluid nature of the proposals there may be opportunities for several of these to be scoped out of detailed consideration. The justification for this approach in relation to specific issues should be set out within the ES.

We have produced SEPA Planning Guidance Note LUPS 17 *Marine development and marine aquaculture planning guidance* which may be helpful to the applicant. In addition we have referred to SEPA Planning Guidance Note LUPS GU4 *Planning Guidance on windfarm developments* as this contains guidance which is relevant to some of the onshore elements of the proposals.

1. Scope of the ES for marine developments

1.1 From the information submitted we understand the development will include both onshore and offshore components. As such, the development will be subject to a range of different consenting regimes. We would encourage you to consider producing a single ES which covers all aspects of the proposed development. This will enable a full assessment of the potential effects of the development as a whole, rather than assessing certain details of the development individually.

2. Water Framework Directive and River Basin Management Planning

2.1 The ES should identify if the impacts of the proposal are likely to lead to deterioration of the water environment or present opportunities for improving the water environment. The determining authority should take this into account in considering the application, as, in order to meet the requirements of the Water Framework Directive (200/60/EC), Marine Scotland is designated “responsible authorities” by the Water Environment and Water Services (Designation of Responsible Authorities and Functions) Order 2006. Responsible authorities must carry out their statutory functions in a manner that secures compliance with the objectives of the Directive (i) preventing deterioration and (ii) promoting improvements in the water environment in order that all water bodies achieve “good” ecological status by 2015.

2.2 All coastal water out to three nautical miles seaward from the Scottish territorial baseline falls under the Directive which requires them to be considered in terms of their chemical, ecological and hydromorphological status. In particular the Gallan Head to Butt of Lewis water body should be assessed.

2.3 In order to assist both applicants and determining authorities, we have made information available on our website. River Basin Management Plans have been

prepared to support the successful implementation of the Directive and include measures set against individual water bodies which require to be implemented if "good" status is to be achieved. The GIS interactive map (complete with user guide) or the River Basin Management Plan data download function, both available on the River Basin Management Plan section of our website, should be used in assessing any development proposal. The map enables a search for individual water bodies by grid reference, place name or postcode. The data download tool allows water body information to be filtered by planning authority. Both the map and data download tool hold data sheets relating to each individual water body. The water body data sheets set out the water body's ecological status, any pressures upon it, measures set up to resolve any issues and targets for any improvement needed. As responsible authorities, determining authorities should promote measures already agreed in respect of relevant water bodies as well as considering other opportunities for the proposals in question to contribute to Directive objectives. SEPA's planning and river basin planning staff will be happy to discuss any suggestions put forward.

2.4 We note that there are several existing Scottish Water sewage discharges which the development may impact upon depending on the exact location of the proposals. The applicant should consult Scottish Water to assess whether the proposals will affect these existing discharges.

3. Site layout and nature of construction for marine developments

3.1 The ES should contain plans giving detailed information on the site layout, including details of all onshore and offshore components such as access tracks, buildings, cabling and marine devices for each phase of the development. These plans should be supported by a statement detailing the development, as well as reasons for the choice of site and design of the development. We note the variability on your construction methods so depending on the types and scale of construction the information below may be required.

4. Land reclamation and construction (if proposed)

4.1 A site plan and cross sections showing the location of all the engineering activities, including temporary works, in the marine environment will be required. Depending upon the scale and nature of the works, there may be a need to carry out hydrodynamic modelling to predict the impacts of construction activities on water quality, as well as coastal processes in the longer term. If large scale works are proposed then any potential impacts from suspended sediment should be compared to natural background levels and water quality standards (eg Shellfish Waters Directive). Any proposed mitigation should also be detailed in the ES.

5. Seabed preparation for device and foundation installation

5.1 The ES should include information on the quantities of material to be dredged, a description of the substrate type/habitats and species, as well as the dredging method. Although by its nature dredging is a destructive activity, adverse effects can be minimised (e.g. timing, dredging technique). If large scale works are proposed then any potential impacts from suspended sediment should be compared to natural background levels and water quality standards (e.g. Shellfish Waters Directive).

5.2 Information describing measures to minimise impacts (e.g. from suspended solids) should also be provided. Depending upon the scale of the works and neighbouring sensitivities, there may be a need to carry out hydrodynamic modelling to predict the impacts on water quality during construction and coastal processes in the longer

term. Options for the subsequent disposal and beneficial reuse of the material should be submitted.

6. Marine renewables

6.1 Plans should be included in the ES showing the array of the devices, cabling routes and associated onshore infrastructure.

6.2 Background information that will help inform the ES process is available from European Marine Energy Centre (EMEC) which you may already be aware of due to your recent testing there. The EMEC has produced guidelines to assist developers in considering the range and scale of impacts that may result from the testing of devices. These guidelines are available at www.emec.org.uk/index.asp. Generally, if this standard industry guidance is followed for scoping, preparing and undertaking EIA for marine renewables, then we are likely to be satisfied with the standard of assessment.

6.3 There may be a need to address the cumulative effects of devices/arrays on coastal processes depending upon array density and location with respect to existing renewable and coastal developments.

6.4 The combined footprint area of the devices and associated works and zones of modified hydrodynamics should be put into context of the area of the adjacent RBMP water body.

7. Onshore engineering activities in the water environment

7.1 In order to meet the objectives of the Water Framework Directive, the on shore components of the development should be designed wherever possible to avoid engineering activities in the water environment. The water environment includes burns, rivers, lochs, wetlands, groundwater and reservoirs. We prefer the water environment to be left in its natural state, with engineering activities such as culverts, bridges, watercourse diversions, bank modifications or dams avoided wherever possible. Where watercourse crossings are required, bridging solutions or bottomless or arched culverts which do not affect the bed and banks of the watercourse should be used. If the proposed engineering works are likely to exacerbate flood risk, then a flood risk assessment should be submitted in support of the application and we should be consulted.

7.2 Scottish Planning Policy states “Culverts are a frequent cause of local flooding, particularly if the design or maintenance is inadequate. Watercourses should not be culverted as part of a new development unless there is no practical alternative and existing culverts should be opened whenever possible. If culverts are unavoidable, they should be designed to maintain or improve existing flow conditions and aquatic life. A culvert may be acceptable as part of a scheme to manage flood risk or where it is used to carry a watercourse under a road or railway” (Paragraph 211). Applications should be determined in line with this planning policy.

7.3 A site survey of existing water features and a map of the location of all proposed engineering activities in the water environment should be included in the ES or planning submission. A systematic table detailing the justification for the activity and how any adverse impact will be mitigated should also be included. The table should be accompanied by a photograph of each affected water body along with its dimensions. Justification for the location of any proposed activity is a key issue for us to assess at the planning stage. The detailed design of engineered structures in the

water environment will be considered under regulations administered by us. Where flood risk may be an issue, this will need to be addressed at the planning stage.

7.4 Further guidance on the design and implementation of crossings can be found in our Construction of River Crossings Good Practice Guide. Best practice guidance is also available within the water engineering section of our website.

8. Disruption to peatlands

8.1 If there are peatland or mire systems present, the ES or planning submission should demonstrate how the layout and design of the proposal, including any associated borrow pits, hard standing and roads, avoid impact on such areas where possible. For areas where avoidance is impossible details of how impact is minimised and mitigated should be provided, including a detailed map of peat depth for all construction elements that affect peatland habitats. The peat depth survey should include details of the basic peatland characteristics. Peatland impacts that should be considered include those from waste management, drainage, dewatering, excavation and pollution.

8.2 By adopting an approach of minimising disruption to peatland, the volume of excavated peat can be minimised and the commonly experienced difficulties in dealing with surplus peat waste reduced. The generation of surplus peat waste is a difficult area which needs to be addressed from the outset given the limited scope for re-use. Landscaping with waste peat (or soil) may not be of ecological benefit and consequently a waste management exemption may not apply, and the position regarding disposal of waste peat within borrow pits can be very difficult. Early discussion of proposals with us is essential, and an overall approach of minimisation of peatland disruption should be adopted.

9. Disposal of waste peat to borrow pits

9.1 The disposal of surplus peat waste to borrow pits is not encouraged as experience has shown that peat used as cover can suffer from significant drying and oxidation, and that peat redeposited at depth can lose structure and create a hazard when the stability of the material deteriorates. This creates a risk to people who may enter such areas or through the possibility of peat slide and we are aware that barbed-wire fencing has been erected around some sites in response to such risks.

9.2 There are important waste management implications of measures to deal with surplus peat. Peat disposed at depth must be considered in the context of waste being landfilled, and may not be consentable under our regulatory regimes. It is therefore essential that the scope for minimising the extraction of peat is explored and alternative options identified that minimise risk in terms of carbon release, human health and environmental impact. It is also important to discuss options with us at an early stage.

10. Peat slide risk

10.1 Protection of development in relation to unstable land including landslides or landslip is not generally an area within our expertise or remit. This is a matter for the planning and building standards authorities and civil engineers, who will need to consider whether or not a detailed assessment of the risks of peat slide arising from the development should also be undertaken, what it should involve, and the extent to which the peat stability report should influence the layout of the proposals and the outline construction method statement.

10.2 Our main interest relates to the consequences of a peat-slide or bog burst which can result in severe environmental damage including the pollution of the surrounding area. The risk of this occurring should form part of any peat stability report. Guidance on preparing a peat stability report can be found on the Scottish Government website.

11. Wetland ecology (including groundwater dependent terrestrial ecosystems)

11.1 A Phase 1 habitat survey should be carried out for the whole site and the guidance 'A Functional Wetland Typology for Scotland' (currently available for free download on the SNIFFER website) used to help identify all wetland areas. National Vegetation Classification should be carried out for any wetlands identified. Results of these findings should be included in the ES, including appropriate maps with the location of infrastructure clearly marked.

11.2 Generally the layout of the site should be designed to avoid impacts on all wetlands. Peatland (active blanket bog in particular) should be avoided. If impacts on wetlands are likely then details of appropriate mitigation measures are required

11.3 Groundwater dependent terrestrial ecosystems are specifically protected under the Water Framework Directive. The results of the National Vegetation Classification survey and Appendix 2 of our Planning guidance on windfarm developments (which could also be used in this instance) can be used to identify if wetlands are groundwater dependent terrestrial ecosystems. If any groundwater dependent terrestrial ecosystems are located within a radius of (i) 100m from roads, tracks and trenches or (ii) 250m from borrow pits and foundations the likely impact of these features will require further assessment. This assessment should be carried out whether or not the features in (i) and (ii) occur within or outwith the site boundary in order that micrositing and small changes to site layout do not necessitate further National Vegetation Classification work being carried out during unfavourable weather conditions. The results of this assessment and measures that will be taken to ensure the proposals do not have an unacceptable impact should be included in the ES

11.4 Infrastructure that is within 100m or 250m and likely to have an unacceptable impact on groundwater dependent terrestrial ecosystems identified as highly sensitive (in Appendix 2 of our Planning Guidance on windfarm developments which may be useful in this instance) should be reconsidered. Further detailed studies will be required if infrastructure remains within the buffer zones.

12. Groundwater

12.1 Roads, foundations and other construction works associated with developments can disrupt groundwater flow and impact on groundwater abstractions. To address this risk a list of groundwater abstractions sources both within and outwith the site boundary, within a radius of i)100 m from roads, tracks and trenches and ii) 250 m from borrow pits and foundations) should be provided. Further details can be found in our Planning guidance on windfarm developments which may be helpful given your onshore elements.

12.2 If groundwater abstractions are identified within the 100m and 250 m radii from development infrastructure, then either the applicant should ensure that the route or location of engineering operations avoid this buffer area or further information and investigations will be required to show that impacts on abstractions are acceptable.

13. Offshore water abstractions and discharges

13.1 Sensitive water uses, such as bathing waters and shellfish growing waters, and associated potential impacts should be assessed. The proximity to existing discharges and designated areas (ie estuarine abstractions and cooling water discharges), should also be assessed.

13.2 We also recommend the ES should assess risks of introduction of marine non-native species and we encourage the developer to draw up a protocol or method statement to remove the risk of introducing marine non-natives into this area either during the development of this project or during the construction, operational, maintenance or decommissioning phases of the project. Given that the accidental introduction of marine non-native has been highlighted as a risk for water body degradation we recommend that controls should be included for marine non-native species in line with Water Framework and Marine Strategy Framework Directive objectives. An example of guidance that may be drawn upon is the non-natives advice produced by the Oil & Gas industry www.ogp.org.uk/pubs/436.pdf.

14. Onshore water abstraction

14.1 Where water abstraction is proposed we request that the ES, or planning submission, details if a public or private source will be used. If a private source is to be used the information below should be included. Whilst we regulate water abstractions under The Water Environment (Controlled Activities) (Scotland) Regulations 2011 we require the following information to determine if the abstraction is feasible in this location:

- Source eg ground water or surface water;
- Location eg grid ref and description of site;
- Volume eg quantity of water to be extracted;
- Timing of abstraction e.g. will there be a continuous abstraction;
- Nature of abstraction e.g. sump or impoundment;
- Proposed operating regime e.g. details of abstraction limits and hands off flow;
- Survey of existing water environment including any existing water features; and
- Impacts of the proposed abstraction upon the surrounding water environment.

14.2 If other development projects are present or proposed within the same water catchment then we advise that the applicant considers whether the cumulative impact upon the water environment needs to be assessed. The ES or planning submission should also contain a justification for the approach taken.

15. Timing and duration of project

15.1 All submissions should include information on likely timing and duration of the project, possible long-term locational and/or operational impacts and short-term construction impacts.

16. Borrow pits

16.1 Detailed investigations in relation to the need for and impact of such facilities should be contained in the ES or planning submission. Where borrow pits are proposed, information should be provided regarding their location, size and nature including the depth of the borrow pit floor and the final reinstated profile. The impact of such facilities (including dust, blasting and impact on water) should be appraised as part of the overall impact of the scheme. Information should cover, in relation to water, at

least the information set out in PAN 50 Controlling the environmental effects of surface mineral workings (Paragraph 53) and, where relevant, in relation to groundwater (Paragraph 52).

16.2 Details of the proposed depth of the excavation compared to the actual topography, the proposed restoration profile, proposed drainage and settlement traps, turf and overburden removal and storage for reinstatement should be submitted. The reinstatement of borrow pits can raise significant waste management issues and it is essential that any proposals are discussed with our regulatory teams as part of the development of the scheme to ensure that such proposals are feasible in terms of cost and regulatory requirements.

17. Air quality

17.1 The local authority is the responsible authority for local air quality management under the Environment Act 1995, however we recommend that this development proposal is assessed alongside other developments that are also likely to contribute to an increase in road traffic. This increase will exacerbate local air pollution and noise issues, particularly at busy junctions and controlled crossing points. Consideration should therefore be given to the cumulative impact of all development in the local area in the ES or supporting information. Further guidance regarding these issues is provided in NSCA guidance (2006) entitled Development Control: Planning for Air Quality.

17.2 Excavation works, particularly through drilling and blasting, may cause nuisance to adjacent land users due to the generation of dust and noise. Comments from the local authority environmental health officers should be sought on the potential nuisance to adjacent land users during the construction and decommissioning phases of the project.

18. Construction Environmental Management Document (CEMD) and pollution prevention

18.1 One of our key interests in relation to major developments is pollution prevention measures during the periods of construction, operation, maintenance, demolition and restoration. The construction phase includes construction of access roads and any other site infrastructure.

18.2 We advise that the applicant, through the EIA process or planning submission, should systematically identify all aspects of site work that might impact upon the environment, potential pollution risks associated with the proposals and identify the principles of preventative measures and mitigation. This will establish a robust Project Environmental Management Process (PEMP) for large scale (e.g. Major and Environmental Impact Assessment Projects (EIA). A draft Schedule of Mitigation should be produced as part of this process. This should cover all the mitigation measures identified to avoid or minimise environmental effects. Details of the specific issues that we expect to be addressed are available on the Pollution Prevention and Environmental Management section of our website.

18.3 A key issue for us is the timing of works. Therefore, the Schedule of Mitigation should include a timetable of works that takes into account all environmental sensitivities, such as fish spawning, which have been raised by SEPA, SNH or other stakeholders. Timing should also be planned to avoid construction of roads, dewatering of pits and other potentially polluting activities during periods of high rainfall. We can provide

useful information such as rainfall and hydrological data through our Access to Information Team.

18.4 A Construction Environmental Management Document (CEMD) is a key management tool to implement the Schedule of Mitigation. We recommend that the principles of the CEMD are set out in the ES drawing together and outlining all the environmental constraints and commitments, proposed pollution prevention measures and mitigation as identified in the ES.

18.5 The CEMD should form the basis of more detailed site specific Construction Environmental Management Plans (CEMPs) which along with detailed method statements may be required by planning condition or, in certain cases, through environmental regulation. This approach provides a useful link between the principles of development which need to be outlined at the early stages of the project and the method statements which are usually produced following award of contract (just before development commences).

18.6 We recommend that the detailed CEMD is submitted for approval to the determining authority at least two months prior to the proposed commencement (or relevant phase) of development to order to provide consultees with sufficient time to assess the information. This document should incorporate detailed pollution prevention and mitigation measures for all construction elements potentially capable of giving rise to pollution during all phases of construction, reinstatement after construction and final site decommissioning. This document should also include any site specific CEMPs and Construction Method Statements provided by the contractor as required by the determining authority and statutory consultees. The CEMD and CEMP do not negate the need for various licences and consents, e.g. CAR and PPS, if required. The requirements from the obtained licences and consents should be included within the final CEMPs.

19. Flood Risk

19.1 The onshore components of the development should be assessed for flood risk from all sources in line with Scottish Planning Policy (Paragraphs 196-211). Further information and advice can be sought from your Local Authority technical or engineering services department, Scottish Water and from our website. Our Indicative River & Coastal Flood Map (Scotland) is also available to view online. If a flood risk is identified then a flood risk assessment (FRA) should be carried out following the guidance set out in the Annex to the SEPA Planning Authority flood risk protocol. Our Technical flood risk guidance for stakeholders outlines the information we require to be submitted as part of a FRA, and methodologies that may be appropriate for hydrological and hydraulic modelling. Further guidance on assessing flood risk and planning advice can be found at our website.

20. Marine ecological interests

20.1 A baseline assessment of existing intertidal and subtidal habitats and species should be submitted. This should include any UK Biodiversity Action Plan habitats and species (eg maerl, sea pens, eel grass, horse mussels). Additional information on the UK Biodiversity Action Plan is available at: http://jncc.defra.gov.uk/default.aspx?page=5155. Developers will then be able to ascertain if they are required to supplement or quantify the available data with in-field surveys.

20.2 We also recommend information be submitted detailing how the development will contribute to sustainable development. Opportunities to enhance marine habitats in line with Water Framework Directive and The Nature Conservation (Scotland) Act 2004 objectives and Scottish Planning Policy guidance should be explored. Examples may include coastal realignment, the incorporation of naturalistic features in the design of shoreline works, or planting with salt tolerant species. These could be used as examples of best practice and demonstration sites under SEPA's Habitat Enhancement Initiative (HEI).

20.3 During the construction phase, it is important that good working practice is adopted and that habitat damage is kept to a minimum and within defined acceptable parameters. These should be controlled through an environmental management plan.

20.4 Advice on designated sites and European Protected Species should be sought from SNH. For marine and transitional Special Areas of Conservation (SAC) and Special Protected Areas (SPA), these are WFD Protected Areas. Therefore, their objectives are also RBMP objectives. In this case, SNH may contact us for input on the consultation.

21. Coastal Processes

21.1 The wave resource modelling should assess the effect that the array of devices will have upon the wave regime and nearshore processes and the effects that any changes may have upon the habitats/species (e.g. Modiolus beds) that they support.

21.2 Developers will then be able to ascertain if they are required to supplement or quantify the available data with in-field surveys and what mitigation measures are required.

22. Regulatory advice

22.1 Details of regulatory requirements and good practice advice for the applicant can be found on our website at www.sepa.org.uk/planning.aspx. If you are unable to find the advice you need for a specific regulatory matter, please contact a member of the operations team in your local SEPA office at James Square, James Street, Stornoway HS1 2QN Tel: 01851 706477.

Scottish Natural Heritage

Thank you for the recent consultation requesting our advice on the proposal for a 40MW wave array located on the north west coast of Lewis.

Natural heritage interests to be considered

In principle, we support the development of marine renewable energy devices where sensitively designed and sited – as set out in SNH Policy Statement 04/01. For this wave energy proposal, we highlight the key natural heritage interests which we consider should be scoped into the Environmental Impact Assessment (EIA). We provide our full advice on these interests in Appendix A, organised into those aspects which we consider apply to the development in general; those relevant to its offshore elements; and those relevant to the onshore works.

As part of our scoping advice we include the range of interests and potential impacts that may need to be considered in relation to the requirements of Regulation 61 of the Conservation of Habitats and Species Regulations 2010 and regulation 48 of the Conservation (Natural Habitats, &c.) Regulations 1994 as amended – now commonly referred to as Habitats Regulations Appraisal (HRA) (please note we are currently seeking legal advice over the application of the 2010 Regulations to reserved matters in Scotland e.g. Section 36 of the Electricity Act). We provide more detail on the legislative requirements for European sites in Appendix B. We also provide our advice on HRA tailored to the potential impacts of the proposed wave array in Appendix D for Special Protection Areas and Appendix E for Special Areas of Conservation.

General comments

The scoping report provides details on the proposed 40MW wave energy array by Lewis Wave Power Ltd. The proposed development will deploy 40 x Oyster Wave Energy Convertors (WEC) with an installed capacity of 1MW each. One application would cover the following phased installation:

- Phase 1: three devices (installed 2013),
- Phase 2: seven devices (installed 2014),
- Phase 3: fifteen devices (installed 2015), and
- Phase 4: fifteen devices (installed 2016).

At this early stage in the process, and as described in the scoping report, it is not possible for the applicant to be definitive about the details of their project. As a result, the scoping advice we present in this response also has to be less tailored on some aspects of the project which have yet to be fully detailed.

We recommend that the applicant submits an interim report after the first year of survey work to Marine Scotland and SNH. Based on the results of this interim report, a second year of survey work may be required. We also recommend that the applicant provides an initial Environmental Mitigation and Monitoring Plan (EMMP) as part of the Environmental Statement (ES), taking into consideration monitoring work from EMEC. The proposed EMMP should provide details on the various monitoring studies to be undertaken and, importantly, schedule sufficient time between each phase in order to accurately monitor any potential impacts (both positive and negative).

The scoping report provides little information on the onshore element of the proposal, including cabling, directional drilling, powerhouse(s), transformers, substation, access tracks,

maintenance base/facility, and grid connection. The onshore works may have further implications with regard to HRA.

At this early stage in the process, and with detail lacking on both the onshore and off-shore elements, we consider that the conclusions drawn in section 6 and table 6.1 of the scoping report, regarding which potential impacts are scoped in or out of the EIA, will need to be reassessed once further detailed project information is provided. We recommend that as further project details are developed these are forwarded to all stakeholders and MS LOT to provide an opportunity for the scoping opinion to be updated.

Further information and advice

Answers to the scoping questions outlined in section 8.1 of the scoping report can be found in Appendices A, D and E.

We can provide further advice on natural heritage interests, at appropriate stages, as work is undertaken by the applicant in support of their formal submission. We would be grateful if you could copy us into the formal scoping opinion in due course. However, we note that due to the scoping report having omissions in relation to key aspects of the development proposals there may be a necessity for SNH to provide further formal advice and for Marine Scotland to issue scoping addendum(s). In the meantime, if further information or advice is required in respect of this scoping advice then please contact me in the first instance: chris.eastham@snh.gov.uk or 01292 261392.

APPENDIX A

ADVICE ON NATURAL HERITAGE INTERESTS TO BE SCOPED INTO ENVIRONMENTAL IMPACT ASSESSMENT

Our scoping advice is organised into those aspects we consider apply to the development in general; those relevant to offshore elements; and those relevant to the onshore works.

GENERAL ADVICE

ai. Project Planning & Phases of Development
aii. Landscape & Visual
aiii. Fisheries
aiv. Designated Sites & Species Protection

ai. Project Planning & Phases of Development

Project Planning

We recommend that the applicant's Environmental Statement (ES) contains an outline of the main alternatives they studied with an explanation of the reasons for their final choice of site, taking into account environmental effects. Further advice is provided in PAN 58 – Environmental Impact Assessment, in SNH's Environmental Assessment Handbook, and in the draft Marine Renewable Licensing Manual.

Rochdale Envelope

We note that Lewis Wave Power Ltd propose to take a Rochdale Envelope approach during the EIA. With this approach the maximum extent of development proposal is assessed, so that the scheme is then designed within these maximum parameters i.e. an assessment of a potential worst-case scenario. If this approach is to be used then we highlight that it would need to apply to both offshore and onshore elements together i.e. what is the maximum extent of onshore / associated development that is required to support the maximum number of wave devices?

Project details

Section 1.3 provides details on the project components including site layout and phasing, device design and installation, and onshore elements. As options are currently being kept open with regard to project design, so our scoping advice has to be kept general. We would welcome ongoing dialogue with the applicant and the consenting authority as this project progresses in order to discuss how they are addressing environmental interests, and to provide more focused advice with regard to the finalised project details.

Coastal geomorphology should be considered when identifying cable / directional drilling routes (please see bv. Hydrodynamic Processes & Coastal Geomorphology).

Grid connection

The report identifies that the options for export cable route, substation and grid connection, are currently under consideration.

We would welcome an invitation to be engaged in discussing potential route options to assist in identifying environmental sensitivities/mitigation at the earliest opportunity.

Phases of Development

In their Environmental Impact Assessment for this proposal (to be reported in the ES), the applicant should address the following phases of wave farm development:

Installation & construction

The ES should include details on proposed installation and construction methods including information on project management – contractor arrangements, 'chain of command', roles and responsibilities of key staff – and timetabling – the phasing / sequencing of proposed works – especially if this has been identified as a mitigation measure for environmental, navigational or other effects. Information should also be included on the proposed installation equipment, vessels used and intended delivery routes and port facilities.

Operation & maintenance (O&M)

The ES should include details on operation and maintenance activities (as discussed in the scoping report, section 1.3.3) and an assessment of any impacts that could arise – considering any potential environmental, navigational and/or other effects. We note that the annual scheduled maintenance for each individual device is anticipated to be approximately 2 weeks per year. For the proposed 40 devices this may result in 80 weeks of scheduled maintenance. Further details should be provided on how this maintenance will be carried out together with an assessment of any potential impacts.

Repowering

The applicant does not discuss repowering in their scoping report and does not indicate the anticipated design life of any of the elements to be placed offshore: devices, pipes and cabling. The applicant will need to consider all aspects of repowering and address this issue in their ES.
It is important to be clear what repowering entails and whether there is to be any relocation of subsea infrastructure or alteration of the wave array layout. Any alterations to the locations of offshore elements for repowering may require further baseline characterisation and assessment to that previously carried out at application submission stage.

Decommissioning

Decommissioning is discussed in section 1.3.4 of the scoping report. We recommend that any potential impacts are assessed in the ES.

aii. Landscape & Visual

The following advice is offered to clarify the approach and methodology presented in the scoping report. We are in the process of reviewing both our own guidance and that commissioned by others in order to draw up a list of recommendations for carrying out seascape, landscape and visual assessment in Scotland in relation to marine renewables.

Baseline environment

Fieldwork is a fundamental part of EIA. The Seascape and Landscape Character Assessment needs to examine both the regional and local coastal landscapes and seascape. While SNH's Scottish seascape (Scott et al. 2005) report is a helpful reference we emphasise that it is a strategic assessment, a 'nationwide' look at the coast, with general descriptions of seascape character types. These were tested against a specific, set theoretical windfarm scenario to explore issues of sensitivity and visibility. Furthermore, in

this study fieldwork was not a major part of the assessment process, which was limited to a strategic desk-based approach. Thus, the seascape units are of only limited use in appraising actual development proposals and need refinement in order to examine the impacts of a specific proposal.

Field work is required to do this, and we recommend that the applicant uses the coastal character methodology developed for aquaculture capacity studies. This approach identifies areas of consistent seascape character with strong integrity, like a specific bay or stretch of coast. We recommend that these local coastal character areas are defined at a scale comparable to the existing LCAs and will be informed by them and field work. The Beaches of Scotland series may also be helpful in this regard – these regional reports offer a quantified description of many aspects of Scotland's coastline and are available from SNH publications (see The Beaches of Lewis and Harris, SNH 1970, reprinted 2004). Fieldwork and desk study will refine the broad characterisation of the 'low rocky island coast' (Scott et al. 2005), revealing the more varied character of the West Lewis coast.

EIA Methodology

We recommend that Chartered Landscape Architects, preferably a team of at least two, should carry out the landscape and visual impact assessment.

The described approach uses the accepted good practice outlined in 'Guidelines for Landscape and Visual Impact Assessment' (LI-IEMA, 2002). The assessment process for coastline, landscape and seascape is essentially the same, although each area has its own specific characteristics, as well as other shared characteristics. It is important to consider the key elements that are specific to each environment, whether land-based or marine. It is these that differ, not the method of character assessment.

Although the techniques and methods developed to evaluate seascapes are helpful, (such as SNH's seascapes work, quoted in the scoping report) it needs to be critically assessed. This is because of Scotland's specific coastal conditions and qualities, but also because the report findings relate to offshore windfarm development. While our knowledge of the likely impacts of the new wave technology is limited, some of the principles developed in relation to the siting and design of aquaculture may be relevant. With this in mind we refer the applicants to SNH guidance on '*Marine Aquaculture and the Landscape*'.

Essentially, a coastal landscape assessment clearly related both 'seawards' and 'landwards' is required. Once the baseline is established, judgements on sensitivity and impacts can then be made. Establishing the relationship of landscape character to seascape character (and vice versa) is fundamental to the assessment. Important elements to consider include the contrast of form, pattern, texture and colours between the landscape and sea; and the effects of the development's form, pattern, texture and colours within this.

Visibility and Zones of theoretical visibility

In assessing visibility, reference should be made to SNH's guidance on the Visual Representation of Windfarms (December 2007). Although the VRW guidance relates to onshore windfarms, this gives practical guidelines on the preparation, presentation and application of visibility maps, viewpoints and visualisations.

The configuration of the wave array will be noticeable, as the eye is attracted to groups or patterns. Therefore, as the horizontal extent of the sea is a strong compositional attribute in views looking out offshore from land, it will be important to assess the wave array within a 'wider view', or panorama.

Viewpoint Selection and Assessment

Viewpoints should be selected in negotiation with MS LOT and statutory consultees, principally the Local Planning Authority and SNH. Viewpoints selected by the planning authority may include additional residences and public buildings, as local authorities have other interests in addition to those of SNH. Initially lengthy, the viewpoint list is likely to be shortened as viewpoints that best illustrate the most significant likely impacts, or help the most with design iteration, become obvious.

Public consultation on viewpoint selection is recommended. The selection of viewpoints and the direction of views selected should be based on the identification of potentially sensitive receptors (people, places and activities) and potentially significant views, locations or landscapes, taking into account the likely impacts of the wave array.

The choice of **all** viewpoints should be informed by the cumulative ZTV as well as the individual ZTV. Although it is possible to add supplementary viewpoints as part of a cumulative VIA, it is preferable to use all or some of the same viewpoints for both the individual and cumulative VIA.

View type

Viewpoints should be selected in order to show:

a) Areas of high landscape or scenic value; both designated and non designated. For example NSA's, AGLV's, GDL's, search areas for wild land, tourist routes and local amenity spaces;
b) A full representation of views from a range of distances, aspects, landscape character types and visual receptors; to include coastal views looking out to the coast and back, as well as across water to opposing shores
c) All aspects of the proposed development, i.e. illustrate it "in the round" to help in the design development and assessment processes. This will also enable assessment of a range of light conditions e.g. side-lit, back-lit and front-lit;
d) Visual composition. For example focussed or panoramic views, simple or complex;
e) The variety of images that the wave array will present from coastal areas as well as important coastal hilltops and landmarks including, for example, where the whole array is visible as well as places where partial views occur;
f) A range of distances;
g) A range of elevations;
h) Sequential along specific routes;
i) The full range of different types of views, e.g. popular hilltops, footpaths and other recreational routes, key transport routes (on and offshore where relevant), minor roads where the array will be the focus of the view, settlements, cultural and recreational foci, and so on;

Viewer Type

j) The full range of receptor groups, e.g. residential, work, road users and other travellers, walkers, other recreational users, etc.;
k) Various modes of movement. For example those moving through the landscape, across ferry and popular recreational sailing routes, or stationary

In addition to representative viewpoints, it is important to consider viewpoints that are already important vantage points within the landscape, for example local visitor attractions, scenic routes, or places with cultural landscape associations.

The developer should be aware that further or alternative viewpoints may need to be considered throughout the VIA process.

The local planning authority may have additional considerations regarding viewpoint selection. Elevated viewpoints, for example those on coastal walks and hilltops are particularly useful in exploring the layout and design. Precise adjustment of the viewpoint location should be made to avoid underestimation of the visual effect by, for example, the judicious positioning of screening objects.

The precise location of the viewpoint (including 12 figure OS grid reference and a brief description), viewpoint height (mAOD), nature of view (width of view in degrees and bearing of key foci within view) and conditions of assessment should be given. This should give details of the orientation to and distance from the proposed development, date, time of day and weather conditions and visual range, when the photographs were taken and the assessment made. It is helpful if a small insert map (based on a 1:50000 OS base map) showing the viewpoint's detailed location and direction is given alongside each visualisation.

All viewpoint information should be presented in a table and cross-referred to a ZTV map on which all of the numbered viewpoints are plotted.

The characteristics visible from each viewpoint that are sensitive development on the seasurface should be described and assessed, particularly in relation to changes the development would cause. Factors such as season, weather, air clarity, movement, orientation to prevailing winds, in relation to the viewer, and any screening elements may be relevant. The design and layout of the wave array, as it would appear from each viewpoint, should also be described and assessed.

Details of the types of receptors, and an assessment of their sensitivity, should be included.

Cumulative Impacts

Cumulative SLVIA should be carried out with reference to the current SNH guidance on cumulative effects (2005), though please be aware that this guidance is currently being updated. Whether it follows the draft guidance or not, the reasoning behind judgements should be made clear. This is because there is more than one type of cumulative impact and their assessment quickly becomes complicated.

Potential Mitigation and Monitoring

The applicant should clearly articulate their design process in the ES – a summary and analysis of the iterations leading to the final choice of wave array layout, and why this is the optimal design in respect of landscape and seascape, balancing the various other constraints.

aiii. Fisheries

Fishing industry liaison / consultation

We agree with the scoping report that close liaison with the local fishing industry is important. In addition to the Scottish Fishermen's Federation, major fishing associations, the Association of Salmon Fishery Boards and the relevant government departments, we recommend consultation with the relevant Inshore Fisheries Group (IFG). IFGs are currently being established around Scotland and, while they do not function as fishermens' associations in representing fishing interests per se, they endeavour to comprise representation from all vessels fishing in the inshore area, including those that are not part of

a major association (small independent fishers) and those that are not based locally (i.e. east coast vessels that also operate on the west coast, and vice versa). As such, they can act as a useful contact point for consultations and we welcome their inclusion on the stakeholder group list.

We note that geo-referenced data on inshore fishing activity and catch is very limited because (a) shellfish fisheries are largely unregulated and require very little catch reporting, and (b) many of the vessels in the inshore area are <15m long so are not required to have satellite vessel monitoring systems (VMS). Therefore, consultation with the IFGs is likely to be helpful in establishing the importance of the fishery resources within an area and the likely extent of displacement of fishing activity.

Data sources & survey design for fish and shellfish

Marine Scotland Science is the primary source for information on commercial fish and shellfish in Scottish waters. For spawning information, the applicant should also be aware of Ellis et al (2010).

The desk-based study (mentioned in section 4.6.3) should not only consider the importance of the species themselves, but also: a) the importance of the habitat type and local area for these species, b) the importance of these species to other components of the natural heritage e.g: feeding seabirds), and c) the vulnerability and sensitivity of these species to the identified potential impacts.

We note that only diadromous fish are considered in the discussion on migration routes (page 58). The applicant should be aware that other (fully marine) fish and shellfish also exhibit migratory behaviour (mostly seasonal). Logic suggests that the geographical range of their migration is less restricted than diadromous species and therefore less vulnerable to potential impacts. Nevertheless the potential physical/noise barrier effects are worthy of consideration.

Spawning and nursery grounds are not spatially or temporally fixed, potentially moving according to the conditions of the substrate, seabed habitats, climate and hydrodynamic regimes. Marine Scotland Science and CEFAS should be able to advise on the most appropriate data sources relating to spawning and nursery grounds, and whether any additional surveys are required. They should also be contacted to discuss mitigation measures if there is any overlap between the development site and the location of spawning events/nursery grounds.

The impacts of underwater noise on the spawning behaviour of fish is a potential concern, and should be considered with regard to installation and operation of the array. It should be noted that different species of fish have differing sensitivities to underwater noise, and this should be considered in the EIA.

The applicant should assess the environmental effects of displacing (and potentially concentrating) fishing effort to other areas. The potential of the development area to provide a refuge for particular species, potentially increasing biomass, with potential benefits to adjacent fishing grounds should also be considered.

The applicant proposes to scope out change in abundance of targeted species. However, depending on (a) the prior intensity of fishing at the site and (b) the vulnerability and sensitivity of the species to negative effects associated with construction and operation of the array, there could be positive and/or negative impacts on local fish and shellfish populations. We recommend that the ES identifies a monitoring scheme which would identify any changes to the local populations pre, during and post construction.

Habitat associations for commercial fish/shellfish species

Many fish and shellfish have strong associations with particular habitats or substrate types, sometimes varying for different life-history stages of a species. Consequently, particular sectors of the Scottish fishing industry are also closely associated with particular substrate types. The information below does not cover all species or fisheries but may help (a) focus liaison with the fishing industry, and (b) indicate some of the key commercial species which may be impacted by particular developments.

Muddy sediments in Scottish inshore waters are the favoured habitat of Scottish langoustine (Nephrops norvegicus), also known as prawns or Norway lobster, inhabiting burrows in the mud. The Nephrops fishery is the most valuable inshore fishery in Scotland being exploited using trawlers (all coasts) and static gear (mostly west coast).

Sand and gravel substrates are often fished for scallops (Pecten maximus and Aquepecten opercularis). Other commercial bivalves such as cockles, razors (Ensis spp.) and surf clams also favour sandy substrates, but are mostly exploited very close to shore. Skates and rays (elasmobranchs) and sandeels are also often associated with sandier substrates and are of conservation concern.

Fish and shellfish to consider

In the section above we provided advice on the association between certain habitats and species, which may be used as a guide to help identify some of the key species that may be present within the proposed site. In determining species to consider within the EIA, we recommend that in addition to the UK Biodiversity Action Plan (BAP) the applicant includes the OSPAR Threatened and Declining and the Scottish Priority Marine Features (PMF) list as part of the criteria. These include some commercial species of fish, and for some the juvenile life stages.

Of the crustaceans, crawfish (Palinurus elephas), which has commercial value, is on the PMF list and is predominantly found on bedrock and boulder habitats. When considering shellfish, other species besides crustaceans should be considered, except where they are covered in the benthic ecology section.

aiv). Designated Sites & Species Protection

Marine Protected Areas

The Marine (Scotland) Act 2010 and the UK Marine and Coastal Access Act 2009 include new powers and duties to designate Marine Protected Areas (MPAs) as part of a range of measures to manage and protect our seas for current and future generations.

The guidance document by Scottish Government includes a draft list of Priority Marine Features for which MPAs may be an appropriate mechanism. SNH and JNCC are currently reviewing the lists of marine biodiversity and geodiversity features in order to help identify habitats and species for which MPAs could make a contribution to their conservation.

The MPA process is likely to be running on a parallel timescale to the applicant's project development and its formal consenting. The applicant should liaise with Marine Scotland over this aspect and we will seek to keep them informed as to our own input to the progress of MPAs, where this is relevant.

Natura sites

Appendix B provides advice on the legislative requirements for these sites; please see Appendix D and Appendix E respectively for advice with regard to the proposal's potential impacts on Special Protection Areas and Special Areas of Conservation.

Sites of Special Scientific Interest (SSSIs)

As discussed in the covering letter and above in section ai, the location and extent of onshore infrastructure is currently unconfirmed. Loch Dalbeg SSSI, notified as a mesotriphic loch, is the only SSSI within the area of search. However, at present we are unable to advise whether this will require further consideration. We note that further information on SSSIs is available from our website with information on particular sites being available on our Sitelink.

ADVICE IN RESPECT OF OFFSHORE ELEMENTS

We provide our advice below relating to the potential impacts from the offshore elements of wave array infrastructure on various natural heritage interests:

bi. Benthic Ecology
bii. Ornithology
biii. Marine Mammals & Basking Shark
biv. Fish of Conservation Concern
bv. Hydrodynamic processes & Coastal geomorphology

bi. Benthic Ecology

Studies, Methods and Assessment

The scoping report references the regional locational guidance published by Marine Scotland Science in 2010 which describes the predominant seabed characteristic as being infralittoral coarse sediment and provides a broad overview of the benthic features in the West of Lewis Area of Search (section 4.2.1). These are typical of an exposed high energy environment. There are records of horse mussel beds (*Modioulus modioulus*) within the Area of Search MNCR (via the NBN). Sensitive habitats such as *modiolus* beds are potentially at risk from a variety of impacts associated with installation, operation, maintenance and decommissioning, all of which are broadly identified in the scoping report (section 4.2.2).

Survey methodology is not discussed in the scoping report. We recommend that benthic ecology survey methodologies are submitted to MS and SNH for comment, and should include the proposed development area including the zone of influence in order to make an accurate assessment of any potential impacts to benthic ecology. The applicant should check for Annex 1 habitats, and/or Marine Priority Features during survey work as well as any BAP habitats and species. They may find it helpful to undertake early analysis of their survey data in case this indicates that survey methods need to be revised and / or that further detailed surveys are required. Consideration should also be given to future seabed monitoring during the 4 phases of the proposed development.

The ES should identify and where possible seek to mitigate any significant negative impacts on any protected habitats and species identified. In a high energy, exposed shallow water environment the principal impacts on benthic habitat are likely to be related to direct physical disturbance – e.g. abrasion of seabed and loss of habitat. We recommend that potential impacts due to suspended sediment and smothering are not scoped out at this stage (see section 4.2.3) as there may be protected habitats (e.g. *modiouls* beds) that are sensitive to this type of impact.

The scoping report highlights that site preparation works will require a degree of kelp removal, gulley infilling and 'small scale' rock removal (page 13). The ES should quantify this work and place it in context. Further information should be provided on the anti-foulants and hydraulic fluids to be used, together with an assessment of environmental risks and potential impacts.

We recommend that the ES presents clear information on, and identification of, the main biotopes found on-site. The biotope/habitat map should be used by the applicant to inform their finalised array layout, taking account of likely impacts from pipelines on benthic ecology.

bii. Ornithology

In Appendix B we provide overall advice on the Habitats & Birds Directives and the process of Habitats Regulations Appraisal (HRA) that will consider potential impacts to the qualifying bird species of Special Protection Areas (SPA). In Appendix D we provide initial tailored advice that addresses the potential impacts of the proposed wave array on SPA bird species which may be affected by this development.

In Appendix D, we are only able to provide advice on HRA in respect of existing SPAs. We note that there is work underway across the UK to designate marine SPAs. This is to ensure a comprehensive network of SPAs across Europe, which will provide protection for all bird species across their life cycle stages. Further information on this programme of work is provided on the Scottish Government website.

Further work is ongoing to investigate the possibility of marine SPAs for:

- Inshore aggregations of non-breeding waterbirds; and
- Offshore aggregations of seabirds.

This work is in addition to the extensions to existing seabird SPAs in 2009.

Detailed ornithological comments

The scoping report identifies a number of designated sites in close proximity to the Area of Search (table 4.1), but provides no reasoning for the scoping in of only these sites. Furthermore, the scoping report states that there are no designated sites within the Area of Search (section 4.1.1). However, as shown on figure 4.1, the Lewis Peatlands SPA & Ramsar site and the Ness and Bravas SPA are within the Area of Search. Please see Appendix D for further discussion of SPA qualifying interests and our advice in this regard.

We have provided comments on the methodology for the shore-based vantage point survey for birds and marine mammals which commenced in September 2010. We would welcome the opportunity to provide comment on an interim report of the survey work after one year.

Please note that the Area of Search in the scoping report covers a larger area than the Potential Areas of Interest in Figure 1 of the Monitoring Protocol which we provided comments on. We recommend that vantage point surveys should cover the development footprint and an appropriate buffer. If this is different to the Potential Areas of Search shown in Figure 1 of the Monitoring Protocol, then additional vantage points will be required.

As noted in our response dated the 20 October 2010, for a demonstration array we recommend that a minimum of one year of pre-construction baseline survey may be sufficient. However, if the results of the first year of survey work demonstrate that the site

may be important for birds we may advise that a second year of survey work would be necessary. Note that for a commercial array we recommend that a minimum of 2 years baseline survey data are collected in order to accurately characterise the use of the site by natural heritage features. This is also allows the level of inter-annual variation to be assessed at the site. However, if it can be *strongly demonstrated* that either the proposed development is sufficiently environmentally benign or that the proposed development site is of a very low environmental sensitivity then 1 year of baseline survey effort *may* be sufficient. An interim report would be required to make this judgement.

We welcome the proposal to undertake breeding bird surveys and intertidal walkover surveys. These would help to inform the assessment of potential disturbance and habitat loss from onshore construction.

We are pleased that the bird survey work from the Siadar Wave Energy Project EIA is being used for the proposed Lewis wave array. This information will provide a useful context to the on-going survey work.

In addition to the key issues listed in section 4.4.2, we recommend that loss of breeding habitat is also included. At present the size of the on-shore footprint of the proposal is unclear, and the level of potential disturbance during construction, operation and maintenance and decommissioning is not known. This should be carefully assessed as part of the EIA.

Monitoring data gathered for the Oyster 1 and 2 testing at EMEC should be used to inform the assessment of potential impacts for the proposed wave array.

biii. Marine Mammals & Basking Shark

Please see Appendix B for the detail of the legislative requirements that apply to SAC interests, and Appendix C for those relating to cetaceans – whales, dolphins and porpoises – which are European protected species (EPS). Appendix E provides our advice on HRA, tailored to the Lewis wave array, for marine mammals which are an SAC qualifying interest.

We highlight the sharp fall there has been in the UK population of harbour (common) seals and note that the applicant will need to consider this in their EIA. The harbour seal Potential Biological Removal (PBR) for the Outer Hebrides management area is 54 (not taking into consider the number of licences issued to shoot harbour seals to protect fisheries and salmon farms). PBR refers to the number of individuals that may safely be taken from a population without adversely effecting overall numbers in addition to normal mortality.

Survey methods and data analysis

We provided comments on the proposed shore based vantage point surveys for marine mammals, basking sharks and birds on the 20th October 2010. We recommend that the applicant submits an interim report to MS and SNH after the completion of one year of survey work.

Potential impacts to marine mammals

The survey results should be used to inform the likelihood of disturbance to cetaceans during the various phases of the proposal. The ES should provide information on the acoustic properties of any 'significant underwater noise' generating activities (such as piling, drilling, cardox detonations, vessel deployment, device operation, etc) and the frequency and duration at which these will occur. The ES should also provide appropriate mitigation measures to avoid any potential impacts. Information regarding potential mitigation

measures is available in the Guidelines for Minimising Acoustic Disturbance to Marine Mammals from Acoustic Surveys, JNCC (2004). We would be happy to advise further on potential mitigation depending on results of survey and modelling work.

Noise in the marine environment is an important cause of behavioural disturbance in cetaceans which use acoustics to navigate, locate prey and maintain social contact. Marine noise produced during installation, operation, maintenance and decommissioning could potentially interfere with these signals through masking of communication calls, or disruption of foraging clues. We recommend that the potential impacts on marine mammals from noise are carefully assessed in the ES. The noise monitoring data for the Oyster 2 array gathered at EMEC should be compared with the modelled noise analysis (see the ES for the Oyster 2 deployment at EMEC) and used to inform the ES for the proposed deployment.

There are a number of grey seal haulouts within and in close proximity to the Area of Search; the islands and skerries off the Butt of Lewis, Dell Rock and Outer Loch Roag regularly have small numbers of grey seals hauled out on them (1-20). The area is likely to be used less frequently by harbour seals although there are known haulouts in Loch Roag and in Broadbay (east Lewis). Seals are known to travel substantial distances while foraging for food, utilise the whole water column and are inquisitive animals. It is therefore probable that both seal species commonly found in the Outer Hebrides may be found within or in close proximity to the proposed development.

Please note that certain haulout sites have been identified for protection under Section 117 of the Marine (Scotland) Act 2010 as detailed in the Scottish Government consultation. Under the Marine (Scotland) Act 2010 it is an offence to harass seals at designated haulout sites, and we recommend that any works that may cause potential disturbance to seal haulouts is considered in the ES.

Harbour seals are currently vulnerable to any impacts which could lead to their further population decline or prevent their recovery. We highlight, therefore, the report by SMRU on the preliminary findings of investigations in to the causes of the recent number of "corkscrew" injuries to seals. The injuries are consistent with the seals being drawn through a ducted propeller such as a Kort nozzle or some types of Azimuth thrusters. Such systems are common to a wide range of ships including tugs, self propelled barges and rigs, various types of offshore support vessels and research boats. Such systems may be used on the installation and maintenance vessels.

Basking sharks are likely to use the area for passage and/or feeding. Basking sharks have full protection from intentional or reckless disturbance in Scottish waters (up to 12 miles offshore) under the section 6 of the Nature Conservation Act (Scotland) 2004. Basking sharks are known to be sensitive to sound (e.g. boat engine noise) and the risks of disturbance are similar to those of marine mammals, i.e. physical and marine noise related disturbance. Establishing the distribution and usage by basking sharks will be critical in determining the likelihood and significance of the array leading to any substantial loss of foraging habitat (potentially due to noise). The applicant should contact MS as licensing authority if disturbance to basking sharks is considered likely.

As raised generally, and in respect of other interests, we will be able to consider the potential effects of the proposed development on marine mammals and basking shark in more detail once the proposal is further progressed.

biv. Fish of Conservation Concern

Fish species to consider

We are in agreement with the fish species of conservation concern listed in section 4.6.1. For migratory fish of conservation concern we provide the following advice:

Adult Atlantic salmon – Marine Scotland Science has published a report reviewing the migratory routes and behaviour of Atlantic salmon. We recommend that the applicant considers potential impacts on Atlantic salmon populations. Atlantic salmon is a host species for freshwater pearl mussels, and so this species would also need to be considered in the ES.

Post smolt Atlantic salmon which migrate in the upper layers of the water column, making use of dominant marine currents. Whilst many smolts use the near-shore areas during the commencement of their marine migratory phase, little is known about the migratory routes of fish from individual rivers.

European eel which is a conservation priority due to a 95% drop in its population over the last 20 years; it is considered by ICES to merit emergency action and is listed as 'critically endangered' on the IUCN Red list. Very little is known about their migration pathways – either as juveniles or adults. The report from Marine Scotland Science reviews the data available in relation to European eel migration routes and behaviour.

Sea trout which support a number of fisheries in Scotland. Many of these fisheries have undergone significant declines in the last 25 years and this was a primary reason for the addition of the species to the UKBAP priority list. The report from Marine Scotland Science reviews the data available in relation to sea trout migration routes and behaviour.

What potential impacts need to be considered?

Installation impacts

Noise will be produced during the installation. We need to know what levels of noise production can be expected and, using published literature, decide what impact, if any, this will have on fish movements through the area. In this regard the recent review commissioned by SNH may be helpful: it considers the current state of knowledge with regard to the potential impacts of noise, associated with marine renewable energy, on Atlantic salmon, sea trout and European eel.

Operational noise

Once the devices are installed and operational, there is the potential for the development to generate noise over the longer term. It is unclear what levels of noise will be generated and what impact this may have on fish. Noise monitoring work undertaken at EMEC may help to address this.

On-shore impacts

Once we have further information regarding the on-shore proposals we will be able to provide advice on any potential impacts to freshwater species and habitats.

Electromagnetic effects (EMF)

As no electricity generation or electrical cabling will occur in the marine environment this potential impact can be scoped out.

The above impacts (excluding EMF) should also be considered in terms of cumulative and incombination impacts. They should also be considered for the different life stages of the species concerned.

bv. Hydrodynamic Processes & Coastal Geomorphology

The only designated geological site in the area is the North-west coast of Lewis Geological Conservation Review (GCR) site26. The proposals should try to avoid the key GCR locations (listed on page 6 of the site document).

Our own key concerns relate to the associated development – the directional drilling, cabling and land-based infrastructure. While there are no details yet in this regard, we highlight that the location and design of these elements need careful thought and planning, and we strongly recommend that expert advice is sought from an experienced coastal geomorphologist.

ADVICE IN RESPECT OF ONSHORE ELEMENTS

We provide our advice below relating to the potential impacts from the onshore elements of wave array infrastructure on various natural heritage interests:

ci. Habitats
cii. Ornithology
ciii. Mammals
civ. Reptiles & Amphibians
cv. Fish of Conservation Concern
cvi. Hydrology & Hydrogeology

As discussed in the covering letter, we highlight that project details are not yet finalised and therefore there is a lack of information regarding the onshore elements of this proposal. Once the proposal is further progressed and these details are available, then we will be able to refine and focus our general advice below.

ci. Habitats

Habitat survey work will be required in respect of cable and grid connection routes, as well as for construction of any onshore substation and other infrastructure. This should also cover intertidal habitats.
Further information on designated sites is available from SNH's sitelink. Appendix B provides an overview of the legislative requirements relating to SPAs and SACs, while further information on SSSIs can be obtained from our website.

cii. Ornithology

The location of all elements of onshore infrastructure will need to be considered in respect of potential impacts to bird species, including species which are a qualifying interest of SPAs. We are also pleased that birds of high conservation interests, such as the corncrake, will be carefully considered.

ciii. Mammals

The location of all elements of onshore infrastructure will need to be considered in respect of potential impacts to mammals. Survey work will be required for any mammal species likely to occur in locations where onshore works are proposed. Appendix C provides advice on the legislation that relates to otters and bats, both of which are European protected species (EPS). In Appendix B we provide overall advice on the Habitats and Birds Directives and the process of Habitats Regulations Appraisal (HRA) that will consider potential impacts to otter as a qualifying interest of Special Areas of Conservation (SAC). In Appendix D we provide initial tailored advice that addresses the impacts of the onshore elements of the proposal wave array where otter is a qualifying interest of SACs.

Whilst otters are generally regarded as a freshwater/terrestrial species, in the Outer Hebrides an important part of their lifestyle is spent in or near the marine environment. Most of the coastline of NW Lewis is considered likely to have otters present. Survey work should also cover suitable habitats in the marine environment. Information on survey methodologies and mitigation for otters is available in the SNH publication "Otters and Development".

civ. Reptiles & Amphibians

The location of all elements of onshore infrastructure will need to be considered in respect of reptiles and amphibians. Please note that the only native herp on Lewis is the slow worm, and in the area where the proposal is there. Frogs and toads have been released on Lewis in recent years.

cv. Fish of Conservation Concern

The applicant may need to consider the fish species which are qualifying interests of SACs e.g. Atlantic salmon and other non SAC qualifying interest fish e.g. European eel in their EIA and HRA, dependent upon the proposed locations for onshore works and whether there is any connectivity, or possible effect, on these watercourses.

cvi. Hydrology & Hydrogeology

The applicant should contact SEPA in the first instance for advice on hydrological and hydrogeological aspects. If any freshwater SACs require consideration – which depends upon the proposed location of onshore infrastructure – then we can provide further advice.

APPENDIX B

HABITATS & BIRDS DIRECTIVES, & HABITATS REGULATIONS

The two most influential pieces of European legislation relating to nature conservation are the Habitats and Birds Directives. The 'Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora' was adopted in 1992 and is commonly known as the Habitats Directive. It complements and amends (for classified SPAs) Directive 2009/147/EC of the European Parliament and of the Council on the conservation of wild birds (this is the codified version of Directive 79/409/EEC as amended), commonly known as the Birds Directive.

The Birds Directive protects all wild birds, their nests, eggs and habitats within the European Community. It gives EU member states the power and responsibility to classify Special Protection Areas (SPAs) to protect birds which are rare or vulnerable in Europe as well as all migratory birds which are regular visitors.

The Habitats Directive builds on the Birds Directive by protecting natural habitats and other species of wild plants and animals. Together with the Birds Directive, it underpins a European network of protected areas known as Natura 2000 comprising SPAs classified under the Birds Directive and Special Areas of Conservation (SACs) designated under the Habitats Directive.

The Habitats Directive is transposed into domestic law in Scotland by the 'Conservation (Natural Habitats, &c.) Regulations 1994' which came into force on 30 October 1994 – usually called simply the **Habitats Regulations**. For all onshore elements that may be consented through the Town and Country Planning system these amended Habitats Regulations will apply. Certain provisions of The Conservation of Habitats and Species Regulations 2010, as amended (the "2010 Habitats Regulations") apply to Natura sites in Scotland where they may be affected by activities consented under section 36 or section 37 of the Electricity Act 1989.

Habitats Regulations Appraisal

Where a plan or project could affect a Natura site, both the 1994 and 2010 Regulations require the competent authority – the authority with the power to undertake or grant consent, permission or other authorisation for the plan or project in question – to:

- determine whether the proposal is directly connected with or necessary to site management for conservation; and, if not,
- determine whether the proposal is likely to have a significant effect on the site either individually or in combination with other plans or projects; and, if so, then
- make an appropriate assessment of the implications (of the proposal) for the site in view of that site's conservation objectives.

This process is now commonly referred to as Habitats Regulations Appraisal (HRA). HRA applies to any plan or project which has the potential to affect the qualifying interests of a Natura site, even when those interests may be at some distance from that site.

The competent authority, with advice from SNH, decides whether an appropriate assessment is necessary and carries it out if so. It is the applicant who is usually required to provide the information to inform the assessment. Appropriate assessment focuses exclusively on the qualifying interests of the Natura site affected and their conservation objectives. A plan or project can only be consented if it can be ascertained that it will not

adversely affect the integrity of a Natura site (subject to no alternatives and imperative reasons of overriding public interest).

Further Information and Advice on HRA

In this scoping response we provide tailored advice for HRA in respect of birds that are qualifying interests of SPAs, and for the various qualifying interests of terrestrial and marine SACs in the area.

- Appendix D – SNH Advice on Habitats Regulations Appraisal for SPAs
- Appendix E – SNH Advice on Habitats Regulations Appraisal for SACs

In respect of this, further information on the qualifying interests and the conservation objectives for each relevant Natura site is available from SNH's Sitelink database.

For further advice on the HRA process please see SNH's website, including the leaflet on "Natura sites and the Habitats Regulations" which provides a helpful summary. Some of the key concepts are explained in the European Commission's guidance on Article 6 of the Habitats Directive. Revised guidance updating the Scottish Office Circular 6/1995 on the implementation of the Habitats and Birds Directive in Scotland was produced in June 2000. This sets out current Government policy relating to Natura sites. Please note that SNH is seeking advice on the full scope of interaction between the 1994 Regulations as amended and the 2010 Regulations and therefore certain technical changes may be ended to the above. However they will not alter the underlying principals or main actions.

APPENDIX C

EUROPEAN PROTECTED SPECIES

Certain species are listed on Annex IV of the Habitats Directive as species of European Community interest and in need of strict protection. The protective measures required are outlined in Articles 12 to 16 of the Directive. The species listed on Annex IV whose natural range includes any area in the UK are called 'European protected species'.

SNH is the statutory nature conservation body who provides advice on EPS in respect of the Habitats Regulations in Scotland, including Scottish Territorial Waters. A summary of the legal requirements for EPS is as follows:

The Conservation (Natural Habitats, &c.) Regulations 1994 as amended. (Known as the 'Habitats Regulations'.)

Protection of certain wild animals

39. (1) It is an offence –

(a) deliberately or recklessly to capture, injure or kill a wild animal of a European protected species;

(b) deliberately or recklessly –

i. to harass a wild animal or group of wild animals of a European protected species;
ii. to disturb such an animal while it is occupying a structure or place which it uses for shelter or protection;
iii. to disturb such an animal while it is rearing or otherwise caring for its young;
iv. to obstruct access to a breeding site or resting place of such an animal, or otherwise to deny the animal use of the breeding site or resting place;
v. to disturb such an animal in a manner that is, or in circumstances which are, likely to significantly affect the local distribution or abundance of the species to which it belongs;
vi. disturb such an animal in a manner that is, or in circumstances which are, likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young; or
vii. to disturb such an animal while it is migrating or hibernating;

(c) deliberately or recklessly to take or destroy the eggs of such an animal; or

(d) to damage or destroy a breeding site or resting place of such an animal.

(2) Subject to the provisions of this Part, it is an offence to deliberately or recklessly disturb any dolphin, porpoise or whale (cetacean).

Scottish Government has also provided guidance on the 2007 amendments addressing EPS – *Explanatory guidance for species related activities*.

EPS Licences

Licences may be given authorising activities that could affect EPS which would otherwise be illegal under the Habitats Regulations. For Scottish territorial waters these licences will be issued either by Marine Scotland or by SNH depending on the reason for the licence request. Please note that Marine Scotland are now responsible for issuing licences for cetaceans, and SNH will be responsible for issuing licences for otters. Licences are only issued under very strict conditions as set out in regulations 44 and 45 of the Habitats Regulations.

As highlighted in Scottish Government Interim Guidance, three tests must be satisfied before the licensing authority can issue a licence under Regulation 44(2) of the Conservation (Natural Habitats &c.) Regulations 1994 (as amended) to permit otherwise prohibited acts. An application for a licence will fail unless all of the three tests are satisfied. The three tests involve the following considerations:

Test 1 - The licence application must demonstrably relate to one of the purposes specified in Regulation 44(2) (as amended). For development proposals, the relevant purpose is likely to be Regulation 44(2)(e) for which MS/SNH are currently the licensing authority, depending if it is onshore or offshore activity. This regulation states that licences may be granted only for the purpose of "preserving public health or public safety or other imperative reasons of overriding public interest including those of a social or economic nature and beneficial consequences of primary importance for the environment."

Test 2 - Regulation 44(3)(a) states that a licence may not be granted unless the licensing authority is satisfied "that there is no satisfactory alternative".

Test 3 - Regulation 44(3)(b) states that a licence cannot be issued unless the licensing authority is satisfied that the action proposed "will not be detrimental to the maintenance of the population of the species concerned at a favourable conservation status in their natural range" (The licensing authority will, however, seek the expert advice of SNH on this matter).

Consideration of European protected species must be included as part of the application process, not as an issue to be dealt with at a later stage. Any consent given without due consideration to these species is likely to breach European Directives with the possibility of consequential delays or the project being halted by the EC.

APPENDIX D

WEST COAST LEWIS WAVE ARRAY: HABITATS REGULATIONS APPRAISAL – SPECIAL PROTECTION AREAS

Introduction

In the following advice for HRA we set out the three steps that need to be considered in order to determine whether or not the proposed wave array, comprising oyster devices is likely to have a significant effect on qualifying interests of SPAs, and any possible adverse impact on site integrity – Appendix B provides more detail on the legislative framework. It is the competent authority (Scottish Ministers devolved to Marine Scotland) who will carry out the HRA, based on our advice and using information and data collated by the developer.

Under HRA, the potential impacts of the wave array will need to be considered alone and in combination with other plans and projects. It may also need to be considered in combination with the other wave and tidal renewable energy developments and with other types of industry and activity in the region.

Special Protection Areas for inclusion in HRA

At this early stage of the process we do not have full details on the development being proposed or finalised locations of all elements of infrastructure. We have provided comments on the shore-based vantage point survey methodology, and we welcome the opportunity to review this work after one year. Once this information and review has been provided, we will be able to provide further information on which SPAs should be included in the HRA. Prior to this, we recommend using the meta-data on seabird foraging ranges available from the Birdlife International database (http://seabird.wikispaces.com/) to determine which qualifying species from which sites are included. For some seabird species, the meta-data is such that it allows the use of cumulative frequency plots to determine the foraging range at which 95% of the population will be included. If these data are not available, or of poor quality, then we recommend using the mean of the species maximum foraging range. Although this will initially produce a long list of SPAs, this will be refined through an iterative process as the results of survey work are presented by developers, and as species sensitivity to potential impacts from the proposal are defined.

Further information on SPAs, including their conservation objectives, is available from http://www.snh.org.uk/snhi/

Advice for HRA in respect of SPA qualifying interests

We provide advice on the legislative requirement for HRA in Appendix B. The steps of the process are as follows and our advice is tailored to consideration of the wave array:

Step 1: Is the proposal directly connected with or necessary for the conservation management of the SPAs?

The wave array is not directly connected with or necessary for the conservation management of any of the SPAs listed above.

Step 2: Is the proposal likely to have a significant effect on the qualifying interests of the SPAs either alone or in combination with other plans or projects?

This step acts as a screening stage: it removes from the HRA those proposals (plans or projects) which clearly have no connectivity to SPA qualifying interests or where it is very

obvious that the proposal will not undermine the conservation objectives for these interests, despite a connection. When this screening step is undertaken at an early stage in the development process, it usually means that it takes the form of a desk-based appraisal. We advise that this is kept broad so that potentially significant impacts are not missed out, or discounted too early, in any HRA (or EIA).

The SPA bird interests being considered in respect of wave energy developments are wideranging – many seabirds make long foraging trips, especially during the breeding season. This means that wave energy proposals may be 'connected to' SPAs even at great distances. Although connectivity is thus established the fact that the proposal is located further away from the designated sites means that direct impacts are less likely on qualifying species while they are within the SPA.

Expert agreement over species sensitivity should help to identify those SPA qualifying interests for which the conservation objectives are unlikely to be undermined by wave energy developments, despite any possible connection (e.g. SPA qualifiers which are recorded within a proposed wave site but where their flight behaviour and / or foraging ecology means that the wave energy development will not have a likely significant effect).

Determination of 'likely significant effect' is not just a record of presence or absence of bird species at a wave development site, but also involves a judgement as to whether any of the SPA conservation objectives might be undermined. Such judgement is based on a simple consideration of the importance of the area in question for the relevant species. Complex data analysis should not be required at this stage. For example; how many birds have been recorded? What are they using the area for? Is this the only area that they can use for this particular activity? Understanding the behavioural ecology of the species, and the characteristics and context of the proposed wave development site, will help in determining whether there are likely significant effects.

There are three possible conclusions for this step of HRA:

- The likely impacts are such that there is clear potential for the conservation objectives to be undermined – conclude likely significant effect.
- The likely impacts are so minimal (either because the affected area is not of sufficient value for the birds concerned or because the risk to them is so small) that the conservation objectives will not be undermined – conclude no likely significant effect.
- There is doubt about the scale of the likely impacts in terms of the conservation objectives – conclude likely significant effect.

Step 3: Can it be ascertained that the proposal will not adversely affect the integrity of the SPA, either alone or in combination with other plans or projects?

This stage of HRA is termed appropriate assessment, and it is undertaken by the competent authority based on information supplied by the developer, with advice provided by SNH. Appropriate assessment considers the implications of the proposed development for the conservation objectives of the qualifying interests for which a likely significant effect has been determined. These conservation objectives follow a standard format requiring protection of the qualifying bird interests and protection of the habitat in the SPA which supports them.

Conservation objectives for SPA bird species

To ensure that site integrity is maintained by:

i) Avoiding deterioration of the habitats of the qualifying species.
(ii) Avoiding significant disturbance to the qualifying species.
To ensure for the qualifying species that the following are maintained in the long term:
(iii) Population of the bird species as a viable component of the SPA.
(iv) Distribution of the bird species within the SPA.
(v) Distribution and extent of habitats supporting the species.
(vi) Structure, function and supporting processes of habitats supporting the species.
repeat of (ii) No significant disturbance of the species.

It is important to recognise that the conservation objectives primarily offer site-based protection and that some of them will not directly apply to species when they are outwith the boundaries of the SPA. This is particularly true of objectives (i), (v) and (vi) which relate to the supporting habitats within the SPA.

Objective (iii) however – maintenance of the population of the bird species as a viable component of the SPA – will be relevant in most cases because:

- It encompasses direct impacts to the species, such as significant disturbance to qualifying bird interests when they are outwith the SPA.

- It addresses indirect impacts such as the degradation or loss of supporting habitats which are outwith the SPA but which help to maintain the population of the bird species of the SPA in the long-term.

Finally, in rare circumstances, it is possible that factors / events outside site boundaries may have the capacity to affect the long term distribution of bird species within the SPA – see objective (iv).

Issues to consider under appropriate assessment

The **key question** in any appropriate assessment for the wave array is whether it can be ascertained that this proposal, alone or in combination, will not adversely affect the population of any qualifying bird species as a viable component of the SPAs under consideration.

Ongoing Liaison

We will continue to review our advice on HRA as the proposal progresses, as survey work and analyses are undertaken, and when construction methods, location of infrastructure, and other aspects of the proposal have been finalised.

APPENDIX E

WEST COAST LEWIS WAVE ARRAY: HRA ADVICE– SPECIAL AREAS OF CONSERVATION

Introduction

In the following advice for Habitats Regulations Appraisal (HRA) we set out the three steps that need to be considered in order to determine whether or not the wave array is likely to have a significant effect on the qualifying interests of Special Areas of Conservation, and any possible adverse impact on the site integrity of SACs – Appendix B provides more detail on the legislative framework. It is the competent authority (most likely Marine Scotland) who will carry out the HRA, based on our advice and using information and data collated by the developer.

Under HRA, the potential impacts of the wave array will need to be considered alone and in combination with other plans and projects. It needs to be considered in combination with the other wave and tidal renewable energy developments and with other types of industry and activity in the region.

Special Areas of Conservation for Inclusion in HRA

We recommend that the following SACs are addressed in relation to HRA:

- **North Rona SAC** designated for its population of grey seals.
- **Monach Islands SAC** designated for its population of grey seals.
- **Langavat SAC** designated for its Atlantic salmon.
- **Lewis Peatlands SAC** designated for its population of otters

Depending on the location of on-shore works, we also recommend the following SAC is addressed in relation to HRA:

- **Lewis Peatlands SAC** designated for its blanket bog, wet heathland with cross-leaved heath, depressions in peat substrates, clear-water lakes or lochs with aquatic vegetation and poor to moderate nutrient levels, and acid peat-stained lakes and ponds.

We have considered other SACs and included only those that we consider relevant i.e. where there may be connectivity between the wave array proposal and the SAC. We confirm that we have considered the harbour seals of Ascrib, Islay and Dunvegan SAC, and that we do not identify that there would be any connectivity between the designated site and the offshore elements of the proposed wave farm. In general, harbour seals forage within 40 – 50km of their haul out sites, and prefer sheltered waters, so there is no reason to suppose that seals from this SAC would be found at the proposed wave farm site.

Once we have been provided with further information on the location of the on-shore works, we will be able to provide further information on whether the proposal will have a likely significant effect (step 2 below) on the qualifying habitats of the Lewis Peatlands SAC.

HRA should address all elements of the wave array proposal – onshore works as well as offshore elements. However, at this early stage in the process we do not have full details on the development being proposed or finalised locations of all elements of infrastructure. In particular there is limited information on the onshore works, and we cannot provide focused advice for HRA in respect of this until further details are submitted.

Further information on SACs is available from http://www.snh.org.uk/snhi/.

SNH advice for HRA in respect of Special Areas of Conservation

We provide advice on the legislative requirement for HRA in Appendix B. The steps of the process are as follows; our advice is tailored to consideration of the wave array:

Step 1: Is the proposal directly connected with or necessary for the conservation management of the SACs?

The proposed wave array is not directly connected with or necessary for the conservation management of any of the SACs listed above.

Step 2: Is the proposal likely to have a significant effect on the qualifying interests of the SACs either alone or in combination with other plans or projects?

This step acts as a screening stage: it removes from the HRA those proposals which clearly have no connectivity to SAC qualifying interests or where it is very obvious that the proposal will not undermine the conservation objectives for these interests, despite a connection. When this screening step is undertaken at an early stage in the development process, it usually means that it takes the form of a desk-based appraisal.

While a desk-based review is helpful for this screening step, this part of the HRA will only be fully completed when the wave array proposal has been further progressed – when survey work and analyses have been completed, and when the location of / construction and installation methods for wave array infrastructure, including onshore elements, has been finalised.

There are three possible conclusions to this step of HRA:

a) The likely impacts are such that there is clear potential for the conservation objectives to be undermined – conclude likely significant effect.
b) The likely impacts are so minimal that the conservation objectives will not be undermined – conclude no likely significant effect.
c) There is doubt about the scale of the likely impacts in terms of the conservation objectives – conclude likely significant effect.

However, we are not yet in a position to present a definite conclusion for this step, so we provide a **summary of our current advice** in respect of SAC interests:

Grey seals of North Rona SAC and Monach Islands SAC. The wave array is located at approximately 75km from the North Rona SAC and 105km from the Monach Islands SAC, and is therefore within the foraging range (100+km) of grey seals from these SACs. Installation, boat movements, piling and other construction activity may give rise to disturbance. There may also be impacts to the prey species of seals – either from the placement of infrastructure or due to noise. We advise that there is potential for the proposal to have likely significant effects on grey seals and we discuss below (under step 3) the issues that we think need to be considered.

Summary of our current advice: likely significant effect, so impacts (including cumulative) will need to be considered in appropriate assessment (see step 3).

Atlantic salmon of Langavat SAC. The proposed wave array may be located within the migratory pathways of Atlantic salmon from this designated site. Construction and operational noise/vibration may give rise to disturbance of Atlantic salmon. We advise that

there is potential for the proposal to have likely significant effects on Atlantic salmon and we discuss below (under step 3) the issues that we think need to be considered.

Summary of our current advice: likely significant effect due to the potential disturbance to migrating Atlantic salmon, so impacts (including cumulative) will need to be considered in appropriate assessment (see step 3).

Otters of Lewis Peatlands SAC. The potential options for cabling and onshore works are within the home range (10-20km) of otters from this designated site. Boat movements, cable-laying, piling, directional drilling and other construction activity may also give rise to the disturbance of otters. And there may be impacts to their prey species – either from the placement of infrastructure or due to noise. We advise that there is potential for the proposal to have likely significant effects on otters and we discuss below (under step 3) the issues that we think need to be considered.

Summary of our current advice: likely significant effect, so impacts (including cumulative) will need to be considered in appropriate assessment (see step 3).

Step 3: Can it be ascertained that the proposal will not adversely affect the integrity of the SAC, either alone or in combination with other plans or projects?

This stage of HRA is termed **appropriate assessment**, and it is undertaken by the competent authority based on information supplied by the developer, with advice provided by SNH. Appropriate assessment considers the implications of the proposed development for the **conservation objectives** of the qualifying interests for which a likely significant effect has been determined. We discuss this below for each of the qualifying interests listed above.

North Rona SAC and Monach Islands SAC: advice on grey seals.

The **conservation objectives** for grey seals are: (i) to avoid deterioration of the habitats of this species or (ii) significant disturbance to the seals, thus ensuring that the integrity of each SAC is maintained and that it makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features.

And to ensure for grey seals that the following are maintained in the long term:

(iii) Population of grey seals as a viable component of each site.
(iv) Distribution of grey seals within each site.
(v) Distribution and extent of habitats supporting grey seals.
(vi) Structure, function and supporting processes of habitats supporting grey seals.
repeat of (ii) No significant disturbance of grey seals.

For grey seals, it is probably conservation objective (iii) that has most relevance – population of the species as a viable component of each SAC. The proposal is far enough away from these SACs for there not to be direct impacts, or disturbance, to the seals while they are within the SACs. However, there may be occasions when the seals forage far enough from the SAC to come into contact with the proposed wave array.

We advise that noise impact assessment is likely to be an important part of assessing any disturbance to grey seals while they are outwith the SACs, including their potential displacement from feeding grounds and other supporting habitats. We highlight that the proposal may have impacts on the prey species of seals, an issue which will also need to be considered.

While we consider that the installation phase may give rise to the greatest risk of disturbance, potential impacts during the operational (including maintenance) phase of the proposal will also need to be considered, as well as any repowering and decommissioning work.

Langavat SAC: advice of Atlantic salmon.

The SAC conservation objectives for Atlantic salmon are: (i) to avoid deterioration of the habitats of the qualifying species or (ii) significant disturbance to them, thus ensuring that the integrity of the SAC is maintained and that they make an appropriate contribution to achieving favourable conservation status for the qualifying species.

And to ensure for the qualifying species that the following are maintained in the long term:

(iii) Population of the species, including range of genetic types for salmon, as a viable component of the SACs.
(iv) Distribution of the species within sites.
(v) Distribution and extent of habitats supporting each species.
(vi) Structure, function and supporting processes of habitats supporting each species.
repeat of (ii) No significant disturbance of the species.

The key question in any appropriate assessment for the wave array is whether it can be ascertained that this proposal, alone or in-combination, will not adversely affect the population of the qualifying species as a viable component of the Langavat SAC.

Information to support the application should consider all aspects of the proposal with the potential to affect the conservation objectives of the site and, through this, ascertain whether or not the integrity of the site will be adversely affected.

We advise that a noise/vibration impact assessment is likely to be an important part of assessing any disturbance to Atlantic salmon while they are outwith the SAC. Further information on the installation, operation, maintenance and decommissioning of the array and on-shore works is required to assess whether there will be any direct disturbance to Atlantic salmon.

Lewis Peatlands SAC: advice on otters.

The conservation objectives for the otter population in this SAC are the same as those we have listed above for grey seals.

Based on these conservation objectives the following questions need to be addressed in an appropriate assessment of potential impacts of the proposal on the otter population of the Lewis Peatlands SAC:

i. Will the proposal cause significant disturbance to otters while they are outwith the SAC such that the viability of this SAC population will be affected?

ii. Will the proposal affect the viability of the SAC population of otters in any way?

Further information on cabling and on-shore infrastructure is required to assess whether there will be any direct disturbance to otters, including their potential displacement from foraging grounds and other supporting habitats.

Ongoing Liaison

We will continue to review our advice on HRA as the proposal progresses, as survey work and analyses are undertaken, and when construction methods, location of infrastructure, and other aspects of the proposal have been finalised.

British Telecom (Radio Network Protection Team)

British Telecom (Radio Network Protection Team) had no comments to make on the scoping report.

Chamber of Shipping

The Chamber of Shipping welcomes the opportunity to comment on the Scoping Report for the West Coast Lewis Wave Array.

The issue of navigational safety is likely to be significant and we are satisfied that the developers have covered all the potential impacts under Section 5.3 “Shipping and Navigation”. We support the developers’ proposal to undertake a navigational review and a Preliminary Hazard Analysis as part of the navigational risk assessment.

We have no further comments to make at this stage but please do not hesitate to contact me should you require further input from the Chamber.

Civil Aviation Authority

Civil Aviation Authority had no comments to make on the scoping report.

Crown Estate

The Crown Estate had no comments to make on the scoping report.

Defence Infrastructure Organisation

The MOD has no objections at this stage. Please continue to consult us on further developments.

Health and Safety Executive

Environmental Impact Assessments are concerned with projects which are likely to have significant effects on the environment. HSE's principal concern is the health and safety of people affected by work activities. HSE cannot usefully comment on what information should be included in the environmental statement of the proposed development. However, the environmental statements should not include measures which would conflict with the requirements of the Health and Safety at Work etc Act 1974 and it's relevant statutory provisions.

Historic Scotland

Thank you for your letter dated 27 May 2011 requesting comments / information on the above project. We have treated this as a request for information on the potential scope of an Environmental Impact Assessment (EIA) under the relevant regulations which might be required for this development. The comments in this letter relate to our statutory remit for scheduled monuments and their settings, category A listed buildings and their settings, gardens and designed landscapes appearing in the Inventory and designated wreck sites (Protection of Wrecks Act 1973). In this case, our advice also includes matters relating to marine archaeology out-with the scope of the terrestrial planning system.
The scoping comments below relate to the potential impacts from both the onshore and offshore works associated with the proposal, in relation to both the marine and terrestrial assets within our statutory remit. Please also seek information and advice from the relevant Council's Conservation and Archaeological Service if you have not already done so.

<u>The Proposed Development</u>

I understand the proposed wave energy development shall consist of 40 wave energy convertors located off the West coast of the Isle of Lewis. Two pipelines shall link the wave energy convertors to an onshore powerhouse and transformers. The proposed onshore powerhouse shall accommodate an area of approximately 4,000 sqm. The precise location of the wave converters is yet to be determined, as is the location of the onshore aspects of the proposal. The proposed converters shall be located in 8 – 15m water depth, they shall protrude approx 3m above the sea surface and shall be at least 10m apart. It is anticipated that the offshore element of the proposal will lead to a total cumulative development area of 2 km along the coastline.

<u>Marine Assets - Potential Impacts</u>

In relation to the submitted search area of the proposed offshore wave array, I can confirm that there are no designations within our statutory remit located within this identified area. I can also confirm that there are no such designations within the immediate vicinity of the proposed wave array search area.

We recommend that the potential direct and indirect impacts on any undesignated wrecks and other archaeological sites, within the search area or in the vicinity of it, be assessed with appropriate involvement of archaeological expertise and in consultation with the Council Archaeological Service. We welcome that archaeological analysis of the geotechnical and geophysical surveys shall be undertaken, as this shall assist with identifying whether any such remains are likely to survive within the area zoned for development. We would highlight the positive contribution that EIA related surveys can make to enhancing our knowledge and in this regard it would be very helpful if the results of all archaeological assessments could be archived through the Royal Commission on the Ancient and Historical Monuments of Scotland.

Please see guidelines set down in '*Historic Environment Guidance for the Offshore Renewable Energy Sector*' (Cowrie 2007) and '*Offshore Geotechnical Investigations and Historic Environment Analysis*' (Cowrie 2011). In terms of submerged prehistoric remains, we would also refer the applicant to '*The scope of Strategic Environmental Assessment of North Sea Area SEA7 with regard to prehistoric and early historic archaeological remains*' (CR Wickham-Jones & S Dawson, March 2006).

Terrestrial Assets - Potential Direct Impacts

The following nationally important assets are identified with the Scoping Report as being within the proposed search area:

- Cnoc na Moine,burial cairn,Dalmore (Index no. 5402)
- Loch Raoinavat,stone circle (Index no. 5344)
- Teampull Eoin, chapel, graveyard & settlement, Port Mhór Bragar, Lewis (Index no. 3926)
- Allt na Muilne,horizontal water-mills,Bragar (Index no. 5412)
- Arnol, blackhouses no. 39 and no. 42 and associated croft houses (Index no. 90022)
- Dun Borve,broch (Index no. 1669)
- Teampull nan Cro'Naombh,chapel 410m WNW of Galson (Index no. 3945)
- Loch Baravat,dun,North Galson (Index no. 5454)
- Dun Mara,dun (Index no. 5352)
- Teampull Pheadair,church,Swainbost (Index no. 5359)
- Carnan a'Ghrodhair,souterrain (Index no. 5395)

Any works within a scheduled monument require the prior written consent of Scottish Ministers, obtained through Historic Scotland in the form of Scheduled Monument Consent. Without wishing to prejudge the final decision of Scottish Ministers it is unlikely that we would recommend that consent be granted for any works that impacted upon any scheduled archaeological deposits. Development should therefore be carefully designed to avoid the scheduled areas.

Further comments in relation to potential direct impacts on terrestrial assets shall be provided upon receipt of specific location details.

Terrestrial Assets - Impact on Setting

In relation to the search areas provided, I can confirm that there are terrestrial assets which maybe subject to an indirect impact as a result of both the proposed onshore and offshore works. These are listed below:

Scheduled Monuments

- Luchruban, Prehistoric and Monastic Settlements (Index no. 5878)
- Teampull Pheadair, Church, Swainbost (Index no. 5359)
- Teampull nan Cro' Naombh, Chapel 410m WNW of Galson (Index no. 3945)
- Teampull Pheadair, Chapel and Settlement, Shader (Index no. 5341)
- Teampull Eoin, Chapel, Graveyard and Settlement, Port Mhór Bragar, Lewis (Index no. 3926)
- Cnoc na Moine, Burial Cairn, Dalmore (Index no. 5402)
- Loch Raoinavat, Stone Circle (Index no. 5344)
- Clach an Trushal, Standing Stone, Ballantrushal (Index no. 1661)
- Arnol, blackhouses no. 39 and no. 42 and associated croft houses (Index no. 90022)
- Dun Borve,broch (Index no. 1669)
- Dun Mara,dun (Index no. 5352)

Any ES to be produced for this development should consider impacts upon these assets and any others in the wider area which may experience significant impacts. It would be helpful if such an analysis contained appropriate visualisations such as photomontage and wireframe

views of the development in relation to the sites and their settings, illustrating views both towards and from the proposed development.

Given the scale of the onshore elements of these proposals, depending on where they are placed, there is a potential that they could have significant impacts on the settings of some of the scheduled monuments both within and nearby the search area. It is possible that Historic Scotland could object were these developments to have a significant detrimental impact on a monument's, or a number of monuments', settings. Further comments shall be provided upon receipt of details of the specific design and location of the onshore elements of the proposal.

We welcome that a Zone of Theoretical Visibility (ZTV) analysis is to be applied to the proposal. This shall provide a basis for assessing the potential impacts on the setting of surrounding assets.

Inshore Fishery Group

The proposed area is fished by a fleet of up to 8 local under 10m static gear vessels fishing mainly for lobster (but also velvets seasonally) in the shallower areas under 20m and lobster and brown crab in waters between 20-50m. This is a locally important fishery.

Most of this fleet are based out of Carloway and Loch Roag. The developer should meet with the local fishermen to discuss their concerns.

Joint Radio Company

JRC has no concerns in respect of this development.

Maritime Coastguard Agency

Thank you for your email dated 27 May 2011. We have now had an opportunity to review the Scoping Opinion Report, provided by Lewis Wave Power Ltd for the proposed West Coast of Lewis Wave Array project, and would comment as follows:

The Environmental Statement should supply detail on the possible the impact on navigational issues for both Commercial and Recreational craft, viz.

- Collision Risk
- Navigational Safety
- Visual intrusion and noise
- Risk Management and Emergency response
- Marking and lighting of site and information to mariners
- Effect on small craft navigational and communication equipment
- The risk to drifting recreational craft in adverse weather or tidal conditions

Although the anticipated traffic density is low, a Navigational Risk Assessment will need to be submitted in accordance with MGN 371 (and 372) and the DTI/DfT/MCA Methodology for Assessing Wind farms, as appropriate to this development.

Particular attention should be paid to cabling routes and burial depth for which a Burial Protection Index study should be completed and, subject to the traffic volumes, an anchor penetration study may be necessary.

Reference should be made to any Marine Environmental High Risk Areas (MEHRAS) established on adjacent coastlines.

Cumulative and in combination effects require careful consideration.

Casualty information from the MAIB and RNLI would also be good data sources, in establishing the risk profile for the area.

Navigational marking for array devices should be referred to the General Lighthouse Authority, in this case Northern Lighthouse Board, and the UK Hydrographic Office.

The shipping and navigation study should include radar and manual observations in addition to AIS data to ensure vessels of less than 300gt are captured.

The offshore human environment should also include recreational and other sport activities.

Particular consideration will need to be given to the implications of the site size and location on SAR resources and Emergency Response & Co-operation Plans (ERCOP).

Particular consideration will need to be given to third party approval of the devices and associated mooring arrangements.

Scoping Questions

Have all regulatory requirements that the project should be taking into account been identified? *Yes*

Do the studies proposed for assessment of effects on the physical environment look appropriate and complete? *Risk assessment techniques should be based on the principles of ALARP.*

Are you aware of any proposed developments or activities with which the proposed Oyster development may interact to result in cumulative effects? *No*

Have the most likely and significant effects been identified through this analysis? *Yes*

Are there any others that should be considered for inclusion in the full assessment process and if so why? *Risk to shipping from rogue devices to be carefully considered due to low freeboard and shape.*

Does the list of proposal consultees reflect the range of stakeholders that should be considered as consultees for this project? *Yes, subject to traffic study/preliminary hazard analysis outcomes*

Are there any other key sources of environmental information that should be consulted?

1. *MAIB and RNLI information*
2. *Crown Estates MARS system*
3. *UK Hydrographic Publications*
4. *DECC Marine traffic database at www.maritimedata.co.uk*

Marine Scotland

Marine Scotland notes that the candidate device for the site, Oyster 3, will be informed by sea trials of the Oyster 2 device at the European Marine Energy Centre (EMEC). Without specific device dynamics of the proposed device to be installed at the Lewis site Marine Scotland is unable to provide detailed feedback on the predicted environmental issues at the site. As a result, the scoping report is limited by the lack of information about the design of the device that will be used at the site and the installation methods to be undertaken during installation of Oyster 3.

Identification of the key issues and sensitivities at the proposed site is welcome however there is little or no description of the measures that will be undertaken to reduce, prevent and where possible offset, significant adverse impacts on the environment as a result of the proposed works. The difficulties in gathering the information required to underpin the EIA are not discussed within the document. These should be given due consideration when it comes to collecting the information that will be necessary to produce the Environmental Statement (ES).

Section 1.3.2 focuses on the installation of the devices and changes in the seabed morphology and substrate should be considered as a result of site preparation and device installation. Habitat loss and variations in hydrographic flow may influence sediment transportation around and adjacent to the devices thus affecting the morphology and benthic habitat of the sea bed. Clearance of the existing seabed of vegetation could have a potentially significant effect however appropriate survey data will establish the likely significance of any clearance. Geotechnical survey work to asses site suitability for device deployment could potentially have a significant impact on the environment but the level of impact will depend on the vessels used, survey methods adopted, frequency of activity, seasonal timing and interactions with other activities of the geotechnical survey work.

Marine Scotland notes that removal of rock is a possibility as part of the installation process. More information on this would be welcome as the removal of rock and infilling of gullies has the potential to impact on the seabed habitat as well as noise sensitive species. The method by which the rock may be removed also requires clarification. Will explosives be used for example? Noise associated with site preparation, installation, operation and decommissioning will also be an issue for noise sensitive species.

Where directional drilling is proposed the developer should note that whilst this process can recover the majority of drill cuttings some will still be released during the break through phase into the marine environment along with any associated chemicals.

In section 3.1 the developer states that a model has been developed ‘for the east coast of Lewis’ to predict the wave resource available. Marine Scotland queries whether this should in fact state west coast of Lewis and also what was the domain of the model? Did the model solely output significant wave height and average period? Further information on the wave spectra would be welcome. Based on these predicted wave conditions, what is the theoretical power yield from the Oyster devices and would this be susceptible to change with the varying wave conditions and elevations in tidal water? The statement about the diverse range of wave climates and lack of data highlights the need for detailed measurements. The proposed deployment of an ADCP to measure wave conditions is welcomed.

Figures are provided for tidal currents and ranges at the Butt of Lewis however the source of these figures is not provided. Marine Scotland would welcome confirmation as to whether these figures are derived from a model or from measurements taken from within the development area. The reason for the data collection undertaken at Cárlabahaigh pier and

subsequent comparison with onsite data outwith the area of search is not clear. Was this undertaken to compare the veracity of the onsite data and if so, there is likely to be a degree of discrepancy between the data due to the different locations and depths. Results from these measurements should be presented within the ES.

The scoping report states that "storm waves are the dominant force in terms of sediment movement, transporting it mainly southwards along the stretch of coastline where the area of search is located." Marine Scotland disagrees with this statement and notes that the referenced paper by Barne *et al.* 1997 states, under section 2.4.1 Sediment Transport: Description, "Tidal currents in the regions are generally weak and net sediment transport offshore is generally northwards, determined by residual currents." The statement in the scoping report should be corrected. Marine Scotland recommends that a more rigorous section on sediment transport is provided with a wider evidence base.

Whilst there is little sediment transport within this region, with sediments generally well confined to small coastal sub-cells, there is some onshore transport of coarse sediments. Marine Scotland broadly agrees that this issue can be scoped out of the EIA however we recommend giving a greater level of consideration to this area before simply scoping it out of the EIA. The reasons provided for doing so are weak and are dependent on the outcome of survey work (e.g. multibeam) which has not yet been undertaken. Further justification should be provided, along with a wider evidence base, in addition to what is detailed in the scoping report. Table 6.1, specifically sections on 'Marine physical processes and geomorphology', and 'Benthic ecology', should be amended to reflect this.

No reference is made to the spatial data held and made freely available by Marine Scotland Science on the Marine Scotland Interactive website. This information may provide support or regional context for the information recorded in section 3.2 of the scoping document.

The scoping report, section 4.2.1, cites the paper by Gubbay (1998) where she refers to large, local populations of relatively few species. Some examples of these species should be provided. Physical disturbances to the benthic environment must also consider any alterations to the wave / current speeds and directions brought about by installation of the devices. Changes may create scour effects and result in the removal or relocation of softer sediments observed in gullies between the bedrock and boulders. Marine Scotland does not agree that smothering is an effect 'unlikely to be significant at the proposed site' and should not be discounted in the proposed EIA. Animal adaptations to high energy environments do not necessarily make them immune to short or long term burial and this will depend on the species impacted by the effects of smothering. The data table does not discuss the possibility of further acoustic surveys being undertaken over the lease area. Are future surveys of this type proposed by the developer? Additionally, the seabed and benthic habitat could be smothered by drill cuttings breaking through into the marine environment as well as through hypothetical rock removal.

Section 4.6 adequately identifies the main fish and shellfish species that utilise the area of search. Although none of the species identified are unique to the area, the development may pose a significant risk to these species by virtue of physical disturbance, noise and vibrations from construction or loss of habitat from the arrays footprint. Marine Scotland agrees that the potential for impacts from this development would be within scope and should be considered as part of the EIA.

The developer should be made aware that the fisheries sensitivity maps that have used Coull *et al.* (1998) data, were produced as broad scale (indicative) distributions and that more detailed site specific maps should be available through Marine Scotland Science. If the developer wishes to obtain such information they should contact Marine Scotland Licensing Operations team in the first instance.

To avoid disturbance during the construction of the devices, two periods of the year have been classified as sensitive for commercial species due to the presence of nursery and spawning grounds Davies *et al* (2010) . These are between January - April and August - September. Activities that could cause disturbance within these areas should be avoided at these times.

Fishing activity by the over 15 m fleet is well represented by the VMS data with further data available through the aforementioned Marine Scotland Science paper 'Regional Locational Guidance (Saltire Prize Projects)', Davies *et al*. (2010). Marine Scotland notes that the developer has identified the inshore fleet (less than 15 m, non-VMS) as a data gap. The commercial value of this fleet has been over looked in terms of its importance to the local communities. The scoping report foresees the impact on the low numbers of vessels using the area to be minor. However, if these vessels were to be excluded from fishing grounds within the lease area there may be few opportunities for these fishermen to be displaced elsewhere due to a lack of available and / or suitable fishing grounds which are not already being exploited by other local fishermen.

Potential displacement of fishing activity results in additional costs to fisherman including increased fuel costs associated with having to either travel to alternative fishing grounds further afield or detouring around site on transit to these grounds. This should be taken into account by the developer who should investigate whether the fishery can absorb this additional cost and still maintain its viability. The developer should consult with local fishermen and a possible point of contact is the Inshore Fisheries Group coordinator for the Outer Hebrides.

The effects of displacement should also be considered in terms of increased congestion at piers and pontoons. Although the numbers of vessels that use these facilities may be low, if they were excluded from using these piers during construction, operation etc of the wave array it may be difficult to relocate vessels and the associated onshore infrastructure elsewhere which may have impact on communities in the area.

The applicant may wish to refer to the Marine Renewable Licensing Manual, currently in draft format, for further guidance and information. Marine Scotland would welcome the opportunity to review any proposed survey methodology and provide comments and advice as required.

National Air Traffic Services

The proposed development has been examined from a technical safeguarding aspect and does not conflict with our safeguarding criteria. Accordingly, NATS (En Route) Limited has no safeguarding objections to this proposal.

Northern Lighthouse Board

Please find our response to Environmental Scoping Report sent by Lewis Wave Power Ltd regarding the intention to deploy an Oyster 2 wave energy converter array within two distinct areas on the west coast of the Isle of Lewis, Western Isles, Scotland.

We would advise that as per previous correspondence with Aquamarine Power regarding the deployment of the Oyster device, there is no requirement to install navigational lighting on the device as this would be difficult to maintain and ineffective due to the operating characteristics of the device. We would however require the upper section of each device to be painted yellow to improve its visual conspicuity.

We anticipate that the various stages of development will be marked by buoyage, based on the guidance within IALA Recommendation O-139 and commensurate with the volume of traffic and degree of risk to navigation safety. We will provide more detailed guidance once the array deployment plans are clarified and navigational Risk Assessment provided in accordance with MGN-371.

We would expect that each device would incorporate a monitoring capability, capable of detecting catastrophic failure of the device. In the event of any component(s) becoming detached and which are not in negative buoyancy shall be communicated to the MCA to ensure the mariner is informed immediately.

We would advise that Navigation Warnings should be promulgated before commencement of any installation, operation, maintenance and decommissioning periods relating to the device. We would also require that the UKHO be notified of the position of each site in order that Admiralty Chart BA-2720 can be correctly updated.

With regard to the consultation and the scope of the assessment, we would only comment on that part relating to Shipping and Navigational Safety contained within section 5 of the consultation document. We agree that Notice(s) to Mariners, Radio Navigation Warning and publication in appropriate bulletins will be required stating the nature and timescale of any works carried out in the marine environment relating to this project.

We would advise that any marking and lighting recommendations will be made in a formal response through the Marine (Scotland) Act 2010: Part 4 consultation process.

It may be necessary to mark the landfall site of the export cable routes depending on the location chosen after the OFTO process has been completed. All navigational marking and lighting of the site or its associated marine infrastructure will require the Statutory Sanction of the Northern Lighthouse Board prior to deployment.

We would also welcome and encourage engagement with any other Offshore Renewable Energy Developers in order to work together to minimise the cumulative impact of site development in the vicinity.

Royal Yachting Association

The Royal Yachting Association Scotland (RYA Scotland) is established to promote the sport of sailing and power boating in Scotland and is recognised by Sport Scotland as the governing body for all forms of recreational and competitive boating in Scotland. RYA Scotland represents dinghy and yacht racing, motor and sail cruising, RIBs and sports boats, windsurfing, inland cruising and personal watercraft and is recognised by the Scottish Government, the Crown Estate, Local Authorities and other non-governmental organisations in Scotland as being the primary consultative body for the activities it represents. RYA Scotland was a founding member of the Scottish Boating Alliance.

RYA Scotland acts as the Royal Yachting Association (RYA) Council for Scotland and the two organisations work closely together on all aspects of their activities. The RYA is the UK and internationally recognised governing body for all forms of recreational and competitive boating in the UK. The RYA currently has more than 100,000 personal and family members across the UK, the majority of whom go afloat for purely recreational non-competitive pleasure on coastal and inland waters. There are an estimated further 500,000 boat owners nationally who are members of over 1,500 RYA affiliated clubs and class associations. The RYA sets and maintains a recognised standard for recreational boat training through a network of over 2,200 RYA Recognised Training Centres in 20 countries. On average, approximately 160,000 people a year complete RYA training courses.

Over 150 RYA affiliated clubs, 120 RYA Recognised Training Centres, 1,900 RYA qualified instructors and over 5,500 RYA individual and family members are based in Scotland.

The RYA and the British Marine Federation have also developed The Green Blue programme to minimise the environmental impact of recreational boating; a programme that is directly supported in Scotland.

You will no doubt be aware of the '*RYA Position Statement on Offshore Renewable Energy Developments*'. The RYA's concerns regarding recreational boating and offshore energy devices are included in this statement. We are currently considering revising this document to take greater account of the particular issues relating to wave devices.

In summary the RYA's concerns with offshore energy developments and recreational boating relate to:

- Navigational safety
    1. Collision risk, particularly in adverse weather conditions
    2. Risk management and emergency response, for example in response to units breaking free in a storm
    3. Marking and lighting
    4. Weather
- Location
    1. Loss of cruising routes
    2. Squeeze into commercial routes
    3. Effect on sailing and racing areas
    4. Cumulative effects
    5. Visual intrusion and noise
- End of life
    1. Dereliction
    2. Decommissioning
- Consultation

These are detailed in our position statement, referenced above.

Some of these points are not relevant in the present case. As is pointed out in section 3.1 of the report, the RYA UK Coastal Atlas of Recreational Boating marks this area as being only lightly used. However, contrary to the impression given in the document, some recreational vessels do follow a route to the west of Lewis. Such vessels will be likely to keep well offshore to avoid what is often a dangerous lee shore and are thus unlikely to enter the area proposed for the Oyster devices. Moreover only experienced sailors are likely to attempt the route west of Lewis. There is thus no need to carry out a survey of the number of recreational vessels passing through this area.

We restrict ourselves to commenting on those parts of the report in which we have particular expertise, namely questions 4 and 5.

The studies proposed for the assessment of effects on those parts of the human environment related to recreational boating look appropriate. In good conditions, the devices will pose no hazard to a competent skipper. However, the Navigational Risk Assessment needs to consider the worst case scenario for recreational, and fishing, vessels, which, due to the water depth, are those most likely to enter the wave farm area through force majeure, e.g. caused by deteriorating weather, poor visibility or equipment breakdown. Many NRAs adopt a matrix approach for considering the risk and severity of incidents. However, these can underestimate the significance of rare but severe incidents, e.g. involving loss of life. Section 5.14 of the *Guidelines for Ecological Impact Assessment in Britain and Ireland: Marine and Coastal* (http://www.ieem.net/ecia.asp) published by the Institute of Ecology and Environmental Management and approved by the relevant authorities in the UK and the Republic of Ireland states that 'The reason for including a confidence level category of 'extremely unlikely' is that some effects may be very improbable, but extremely serious should they occur and hence merit contingency planning. Where doubt exists as to which of two categories of probability best fits the level of professional confidence, the more precautionary level should be cited.'. These comments also apply to the wider EIA process of which Ecological Impact Assessment forms a part. As the nearest lifeboat is based at Stornoway, contingency planning will be particularly important.

IAIA Recommendation 0-139 Marking of Man Made Offshore Structures was largely based on the Northern Lighthouse Board experience with fishfarms and at EMEC and there does not appear to be any real precedent anywhere in the world for marking such schemes. As several large wave farms are being proposed for the waters round Scotland, it is important that general guidelines are developed speedily to avoid the evolution of purely local solutions for marking and lighting. As this is one of the first developments of this size and type in UK waters, we feel that it is important that a precautionary approach should be taken to marking and lighting and would be keen to be involved in discussions in this respect. The *International Regulations for Preventing Collisions at Sea* of the International Maritime Organization may provide a useful basis for discussion. We will work with RYA (Hamble) on this matter as it raises important matters of principle that have implications elsewhere in the UK. It is important that skippers of vessels are aware of the boundaries of hazards so that an appropriate passage plan can be produced to meet the requirements of Regulation 34 - Safe navigation and avoidance of dangerous situations of *SOIAS V*. The boundaries of the actual arrays will need to be marked on charts. With an increasing use of electronic charts, there is a danger that skippers may be using charts that have not been updated or that do not contain the relevant information. *Notices to Mariners* may not reach all relevant vessels, particularly those from abroad. Moreover, the widespread use of electronic position finding can result in erroneous positions, for example when there is an equipment or power failure particularly in conditions of adverse visibility. Regrettably not all skippers follow RYA advice to also use traditional methods of navigation. However, this is a general point that applies to all developments in the sea.

As is mentioned in the report, there are likely to be cumulative effects with the Siadar wave energy project, particularly as the project description notes that: *'Besides its function to generate electricity from the Atlantic waves, it is expected that this structure will help to develop small boat, commercial and leisure craft facilities in Siadar Bay*'. That statement leads on to my final point which is that there can be useful synergies between the development of marine renewables and the development of recreational boating with its contribution to local economies. For example, infrastructure improvements necessary for the construction or maintenance phases may potentially benefit recreational craft. It is unclear whether the water inshore of the devices will be much calmer than in the open sea and thus a possible place of refuge in adverse weather conditions.

I hope that the above information proves useful. RYA Scotland members will be happy to provide any further information relating to their activities that is required in the preparation of the Environmental Statement.

A copy of the Position Statement is included in Annex 3. of this scoping opinion.

Royal Society for the Protection of Birds

Thank you for consulting RSPB Scotland over the scoping request for Lewis Wave Power Ltd's proposals to the west of the Isle of Lewis. We have had some very brief initial discussions with the applicant and were aware that development of this site was being considered and welcome the opportunity to comment.

Marine renewables are emerging technologies and we acknowledge the input that has gone into producing this document. As an organisation we have commented on similar schemes in Orkney (including proposals from Aquamarine for Oyster devices) and Argyll, as well as the nPower Wavegen proposal in north Lewis, the site for which overlaps with this scheme.

Wave-powered devices are likely to cause some disturbance to birds and other wildlife during construction, maintenance and decommissioning. However, impacts related to construction activities are likely to be minimised where pile driving is not required.

Marine renewables also have the potential to change environmental processes indirectly around the devices, which in turn may alter habitat assemblages. Disturbance could have deleterious impacts on the foraging efficiency of some bird species, however there is the possibility that the reverse may also be true, as some species could profit from an increase in food availability through changes in water flows.

RSPB Scotland is also aware that the area is utilised by several species of cetaceans and other marine animals. Before and after monitoring of species such as basking shark would be encouraged to instruct the industry generally and inform decision-making on any future extensions to this site in particular.

Potential impact on landfall locations is perhaps of greatest concern. Bragar Bay is one of the few areas of machair on Lewis where local people still undertake strip arable cropping: not only should potential impacts on crofting operations be considered but this site is also a biodiversity 'honey pot' with machair, great yellow bumblebees, corncrakes, otters and a natural lagoon. The applicant should be aware of infringing on such sensitive natural sites when undertaking work on land and seek to mitigate adverse impacts arising from his proposed activity.

Machair is a globally restricted habitat, listed on Annex 1 of the EU Habitats Directive and primarily occurring in west Scotland. In addition to Bragar, a larger open area of machair occurs at Barvas and Brue. It develops under an exceptional blend of physical factors in addition to human and livestock influences, but is formed primarily by blown and deposited sand. It can be very sensitive to disturbance, for example by vehicles. Monitoring should take place to assess machair habitats and sand movements before and after implementation of these devices.

We note the comment in the section "Wave Resource". A model developed by Aquamarine Power for the east coast of Lewis predicts that over a 12 year period the average maximum significant wave height of for the area is 7.7m and waves occur at intervals of 7.38 seconds..... "

It should however be remembered that the area proposed here is on the more exposed Atlantic Ocean, west side of Lewis, where physical conditions are likely to be more extreme, rather than the sheltered eastern side.

RSPB Scotland understands that sediment transport in the area may be an issue. This has been raised previously through public consultations on potential marine renewables developments on the west coast and is being looked at by SNH and CnES (S. Angus and D.Muir pers comm). It should be noted that the development and maintenance of machair habitats are linked closely to sediment transportation. This may contradict the statement in the report of:

"Effects on sediment transport: Due to the relatively low levels of sediment transport thought to occur within the area of search, the substrate (mostly hard substrates with limited sediment) and the proposed alignment of devices (non barrier forming) along the coastline, it is likely that installation and operation of a wave array off the coastline of Lewis will have little or no effect on sediment transport and distribution within the area. Therefore this issue has been scoped out of the EIA (see Table 6.1)."

We would therefore like to see some further consideration of sediment transport, or further evidence to show that sediment transport related environmental effects would be unlikely to be significant.

Otters. Page 36 of 106 states "A walkover survey in October 2010 identified fresh otter spraint under the pedestrian bridge over Abhainn Bhuirgh (NB 408,572). Otter records are also presented on the NBN gateway website (submitted by the Mammal records from Britain from the Atlas of Mammals (1993) and the Scotland Otter Survey Database). It is therefore likely that otters are present in the wider area of search."

Otters are frequent around the coast and can regularly be seen at Shawbost, Bragar, Arnol, Brue, Barvas and Balantruseil/Siadar. As such, full otter surveys will be required, perhaps utilising historical knowledge from other planning applications such as Lewis Wind Power and Wavegen, as well as dedicated searches.

Red throated divers, in particular, utilise the sea areas mentioned in the document. These birds form part of the Lewis Peatlands SPA assemblage, breeding on inland moorlands but feeding in the sea, and any potential impacts upon these birds will require thorough assessment. The pattern of movement of birds was established in dedicated diver surveys in relation to the Lewis Wind Power proposal in 2003. It may be possible to use this as baseline information for future project-specific studies.

Tern colonies: Arctic terns, and occasionally little terns, breed on the coast in the survey area. Particularly notable colonies can be found at Brue and Barvas, though colonies have

been established at times at a number of other coastal locations. RSPB Scotland holds datasets relating to many of these colonies and would be willing to supply these on request for a nominal charge to cover our costs.

Black guillemot: The document notes a nesting count of 92 between Geodha Chaol to Geodha Ruadh in table 2. This is a very high count of this species and RSPB would suggest that these data be reviewed.

Overall, a monitoring programme should be established on site to measure any changes in biodiversity that may occur. RSPB Scotland would be grateful for further consultation on any application which may come forward.

Scottish Canoe Association

The Scottish Canoe Association (SCA) has concerns relating to this proposed wave array.

Page 81 of the scoping report says "possibly sea kayaking would be displaced during construction, operation & decommissioning." This proposal has the potential to be a major safety hazard to sea kayakers who will continue to paddle this stretch of coastline at all times. Serious consideration will need to be given as to which side of the devices small boats like kayaks would be expected to take. On an exposed stretch of coast like this it would be far preferable to paddle between the shore & the wave devices, rather than being forced onto the seaward side.

We also have concerns over the design of any landfall infrastructure, especially if this was to restrict access in any way or impact on tidal flows. Also, from a surf kayak point of view we are concerned that this proposal could impact on the quality of surf beaches along this stretch of coast.

We would therefore expect the EIA to address these issues.

Scottish Government Planning

In terms of national planning policy, I am content that reference is made to the consolidated Scottish Planning Policy (SPP) and the National Planning Framework 2.

I am also content that reference is made to the relevant Development Plan policy, namely the Western Isles Structure Plan 2003 and the Western Isles Local Plan 2008, and that it is noted that the first Local Development Plan under the Planning etc (Scotland) Act 2006 is currently being prepared. The Council's Proposed LDP is expected to be published at the end of this year.

Section 2.3 should make clear that statutory planning control under the Town and Country Planning (Scotland) Act 1997 and associated legislation extends to the mean low water mark of ordinary spring tides, and to marine fish farming, but that the Marine (Scotland) Act 2010 extends up to the mean high water mark. It should also be noted that although the terrestrial planning system and the marine planning system are legally and functionally separate, they overlap in the inter-tidal area.

Surfers Against Sewage

Introduction

Surfers Against Sewage (SAS) have been invited by Lewis Wave Power to comment on the Scoping Report prepared in relation to the proposed 40MW wave farm off the west coast of Lewis. SAS have been effectively representing recreational water users in the UK since 1990. SAS's campaign remit has expanded from safeguarding public health with the successful Sewage & Sickness campaigns, to encompassing surfing resource and recreation protection with the popular Protect Our Waves campaigns. SAS have been an integral stakeholder in several offshore renewable proposals over the last 7 years.

SAS Offshore Renewable Energy Position Statement

SAS believe that climate change poses a major threat to recreational water users, the marine environment and the global environment as a whole, and agrees that action needs to be taken to combat it. SAS also believe that offshore renewable energy has the potential to help solve climate change, but are concerned that future development has the potential to cause negative impacts on surfing resources and recreation, and negative impacts on the social and economic benefits that surfing contributes to both the surfing and wider communities. SAS strive to protect surfing breaks from unacceptable levels of environmental impact and will work with, and where necessary against, governmental regulators and agencies, NGOs and developers to ensure surfing breaks get the protection they deserve.

SAS's Concerns Relating To Surfing Waves

Waves are naturally occurring features of the environment. Waves that are suitable for surfing only exist where the wave climate and seabed morphology combine to form sufficiently progressively breaking waves of sufficient height and power. Although most of the Scottish coast has some kind of surfable waves and is surfed on a regular basis, the quality of the waves hitting the coast varies enormously.

SAS [1, 2], Marine Scotland [3] and the Scottish Government [4] have summarised the surfing conditions along Scotland's west coast including the Isle of Lewis. The surfing breaks are of very high quality, high consistency and very low popularity in terms of the number of regular surfers. Prevailing winds are westerly and the coast of Lewis receives sufficient swell from the Atlantic Ocean that even sheltered spots are surfed. The breaks are a mixture of reef and beach breaks.

More specifically, there are a number of locations along Lewis coast where breaking waves are surfed. Notable locations are identified in SAS [2] and include those known as Tolsta, Port of Ness, Europie, Barvas, Bus Stop, Bragar, Dalbeg, Dalmore, Cliff, Mangersta, Scarasta; a number of these breaks are located within the area of search in Figure 1-2 of the Scoping Report (at page 10). The Scottish Government [5] identify the west coast of Lewis as a prime location for surfing while Sport Scotland [6] notes that "Scotland's environment provides conditions of international quality for…surfing off Thurso and the Western Isles".

SAS [1] estimate that there are approximately 300,000 recreational water users in Scotland while Marine Scotland [3] estimate that there are approximately 53,000 surfers (aged above 16 years) in Scotland and the Borders. There is little data about the socio-economic value of surfing. Based on 2007 data, Marine Scotland [3] estimate that surfing contributes £16.4m per annum to the Scottish economy, noting "high quality waves located in remote areas could bring economic benefits to a rural area through travel, accommodation and subsidence

expenditure of visiting surfers". It should be noted that, according to UK Marine Monitoring and Assessment Strategy (UKMMAS) [7] "the economic value of the UK surf industry…is growing each year with the increasing popularity of the sport".

Wave energy converters (WECs), such as those proposed for installation at Lewis, whether individually or in arrays, can change the environment in which they operate. WECs can affect surfing resources by changing:

- Wave climate (e.g. height, period, direction, harmonics).
- Seabed geomorphology (e.g. bathymetry).
- Wave form (e.g. section length, peel angle).

The potential impacts of WECs on surfing waves and recreation are not unknown and ongoing research indicates that the impacts could have significant adverse effects on surfing resources and associated recreational and socio-economic activities. For example, reporting from an industry perspective, Neumann [8] identified the modification of surf as a potentially conflicting use posing a non-technological barrier to generating energy from waves, noting "a common concern of the surfing community is that wave energy farms will destroy the swell conditions for this popular sport".

Studies informing the impacts of WECs on wave climate have, to date, been largely based on numerical modelling of reduced downstream wave height (and wave energy) in relation to WECs' wave energy reflection, absorption and transmission characteristics. Studies of WECs have been made for a number of locations in UK waters including southwest England, south Wales and the Orkney Islands, and for other locations including Portugal. Numerical modelling predicts downstream wave height changes caused by WECs by using wave transmission and/or absorption rates to represent a proposed or hypothetical array's influence on the passing wave energy.

Wave height reductions appear to be largest immediately downstream of WECs irrespective of the modelled scenario (i.e. the combination of factors such as the array, transmission / absorption rate and wave climate). Halcrow [9] predicted maximum wave height reductions above 20% for the Wave Hub project off the north coast of Cornwall, and Venugopal and Smith [10] predicted maximum wave height reductions between 13% and 69% for a linear array of five sea bed mounted WECs at a site off the western shore of the Orkney Islands. While wave height reductions do not appear to progressively drop off with distance downstream of WECs, the proximity of the WECs to an impact receptor (such as surfing breaks) has a bearing on an impact's significance. In addition, based on their predictions of downstream wave height reductions, Venugopal and Smith [10] show how they can significantly reduce downstream wave height and change downstream sediment transport patterns such that beach erosion and/or deposition can occur. In summary, independent research establishes that wave farm development has the potential to negatively affect surfing resources which, by implication, means that wave farm development has the potential to negatively affect surfing recreation and socio-economic activities.

The Scottish Government has long recognised that the natural environment and publicly accessible open space contributes positively to recreational and sporting activities including surfing. Former Scottish Planning Policy (SPP) 11 [11] states:

"Scotland's outdoors presents outstanding opportunities to participate in a range of sport and recreation activities. Resources such as rivers, lochs, hills, crags and paths support activities as diverse as fishing, mountain biking, horse riding, surfing, canoeing, rock climbing and snowboarding…In assessing development proposals which may affect such

facilities and resources, sport and recreation interests should be fully considered and planning authorities should consult with sport and recreation interests."

Current Scottish Planning Policy [12] states:

"Rural areas provide a wide range of outdoor recreation opportunities, many of which are closely linked to the quality of the environment. Planning authorities should support, protect and enhance open space and opportunities for sport and recreation."

Review of the Lewis Wave Farm Development Scoping Report

In relation to scoping the environmental impact assessment in relation to surfing resources and recreation and associated socio-economic benefits, SAS's review of the Scoping Report establishes that the Scoping Report provides very little, if any detail, on the baseline conditions, potential impacts and potential cumulative effects on surfing. This is of concern to SAS because the importance of surfing in Lewis is referred to in a number of documents published by SAS and various organisations within the Scottish Government, and the potential impacts of WECs on surfing are established by previous impact assessments and research.

Under sections on the Existing Environment (i.e. baseline conditions), there is no reference to waves and the shoreline bathymetry providing surfing resources under section 3.1.1 on Marine Physical Processes and Geomorphology (at page 22), little reference to surfing recreation under Section 5.8.1 (at page 80) on Recreation and Tourism, and no reference to surfing contributing to the socio-economy under section 3.9.1 on Socio-economics (at page 81).

Under sections on the Identification of Key Issues and Sensitivities (i.e. impacts) and Table 6.1 on Key Potential Effects (at pages 85 to 89), there is no identification of either direct or indirect impacts on surfing resources under section 3.1.2 on Marine Physical Processes and Geomorphology (at page 23), on surfing recreation under Section 5.8.2 (at page 81) on Recreation and Tourism, and the socio-economy where it is influenced by surfing-related jobs, income, etc under section 3.9.2 on Socio-economics (at page 82).

Under Section 5.10 on Cumulative Effects (at page 83) and Table 6.1 on Key Potential Effects (at pages 85 to 89), there is no identification of either additive or interactive effects on surfing resources, surfing recreation and the socio-economic benefits of surfing.

Given that the Scoping Report contains very little baseline formation, does not identify impacts and does not identify potential additive and interactive cumulative effects in relation to surfing resources and recreation, SAS believes that it is insufficient to inform the EIA process and Marine Scotland's scoping opinion in accordance with the requirements of, for example, Regulation 7 (2) (b) of the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000 (as amended), which states that a request for a scoping opinion shall be accompanied by "a brief description of the nature and purpose of the proposed development and of its possible effects on the environment". Accordingly, SAS requests that Marine Scotland gives notice to the developer that further information is required in relation to surfing and other nearshore recreation to inform the scoping opinion.

SAS Responses to the Scoping Questions

The developer has requested responses to the scoping questions posed under Section 8.1 of the Scoping Report (at page 98). SAS's responses are presented below.

Q1. Have all relevant regulatory requirements for the proposed project been identified? A1. SAS have no comment to make in relation to this question.

No. It is not clear how, if at all, the "potential for stakeholder and team engagement" identified in Figure 3.8 (at page 12) is aligned with the stakeholder engagement strategy identified in Chapter 9. Nevertheless, SAS would like to participate in the optioneering process associated with identifying acceptable options for the proposed wave farm development.

Q2. Do the studies proposed for assessment of effects on the physical environment look appropriate and complete?

A2. No. SAS are concerned that, despite the development's potential for far-field effects on wave climate identified under Section 3.1.2 (at page 23) and published research showing that WECs can change wave climates and bathymetry at surfing breaks, the scoping report does not propose studies for assessing impacts on surfing resources under Section 3.1.3 (at pages 23 and 24). In addition, SAS are concerned that the studies proposed under Section 3.1.3 (at pages 23 and 24) appear to be focused on the developer's requirements (i.e. "to inform device siting and array layout") rather than assessing impacts on the environment. SAS recommend that the studies are undertaken in accordance with the recommendations made in Part 4 of SAS's Guidance on environmental impact assessment of offshore renewable energy development on surfing resources and recreation [2].

Q3. Do the studies proposed for assessment of effects on the biological environment look appropriate and complete?

A3. SAS have no comment to make in relation to this question.

Q4. Do the studies proposed for assessment of effects on the human environment look appropriate and complete?

A4. No. SAS are concerned that, despite the presence of the surfing breaks identified in Section 5.8.1 at page 80), the impacts identified at Section 5.8.2 (at page 81) do not identify potential impacts on surfing recreation (i.e. "Existing marine recreational activities (likely only to be recreational boating / fishing, and possibly sea kayaking) would be displaced during construction, operation and decommissioning of the array").

SAS are also concerned that, despite the SAS are concerned that, despite Marine Scotland [3] noting "high quality waves located in remote areas could bring economic benefits to a rural area through travel, accommodation and subsidence expenditure of visiting surfers", the impacts identified at Section 5.9.2 (at page 82) do not identify potential indirect impacts on surfing related socio-economic benefits associated with impacts on surfing resources and recreation.
In addition, SAS are concerned that the studies proposed under Sections 5.8.3 (at page 81) and 5.9.3 (at page 82) are not transparent on how they will be used for assessing impacts on surfing recreation and the associated benefits surfing has on the local socio-economy. SAS recommend that the studies are undertaken in accordance with the recommendations made in Part 4 of SAS's Guidance on environmental impact assessment of offshore renewable energy development on surfing resources and recreation [2].

Q5. Are you aware of any proposed developments or activities with which the proposed Oyster development might interact to result in cumulative effects?

A5. SAS have no comment to make in relation to this question.

Q6. Have the most likely and significant effects been identified through this analysis? Are there any others that should be considered for inclusion in the full assessment process and if so why?

A6. No. Under Table 6.1 on marine physical processes and geomorphology (at page 85), potential significant effects are identified on hydrodynamics and seabed morphology but are scoped out for sediment transfer. Despite the acknowledgement in Section 3.1.2 that the development could have device-scale, near-field and far-field effects on wave climate and seabed morphology, SAS believe that Table 6.1 does not identify the types of effects that could arise (e.g. reduced wave height, changed wave direction, etc) to be addressed by the EIA process. Accordingly, the scoping report is too generic and, therefore, fails to be transparent on how, if at all, the EIA process will assess impacts on particular aspects of the environment directly associated with marine physical processes and geomorphology, including surfing resources.

Also, under Table 6.1 on tourism and recreation (at page 89), potential significant effects are identified on disturbance to recreational activity. For the reasons given in our response to Q4, SAS believe that Table 6.1 does not identify the types of effects that could arise (e.g. changes to surfing recreation including sport as a result of changes to surfing resources) to be addressed by the EIA process. Accordingly, the scoping report is too generic and, therefore, fails to be transparent on how, if at all, the EIA process will assess impacts on particular aspects of the environment directly associated with tourism and recreation, including surfing recreation.

Finally, Table 6.1 does not identify any cumulative effects. Given that the potential for cumulative effects is not scoped in this table or in Section 5.10 on Cumulative Effects (at page 83), this means that the scoping report does not identify any potential cumulative effects in relation to the proposed development.

Overall, SAS believe that the information on potential key issues is insufficient to inform the scoping stage of the EIA process and Marine Scotland's scoping opinion in accordance with the requirements of, for example, Regulation 7 (2) (b) of the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000 (as amended), which states that a request for a scoping opinion shall be accompanied by "a brief description of the nature and purpose of the proposed development and of its possible effects on the environment". Accordingly, SAS request that further information on potential key issues is required in relation to surfing to inform the scoping stage of the EIA process and Marine Scotland's scoping opinion. In addition, SAS recommend that the assessment of impacts on surfing receptors (resources and recreation) is undertaken in accordance with the recommendations made in Part 4 of SAS's Guidance on environmental impact assessment of offshore renewable energy development on surfing resources and recreation [2].

Q7. Does the proposed list of consultees reflect the range of stakeholders that should be considered for this project?

A7. No. SAS and the Scottish Surfing Federation (SSF) are not included in the consultee list (Table 7.2 at pages 96 and 97). SAS also welcome the inclusion of British Surfing Association (BSA), but it should be noted that as of 2010 the BSA has been succeeded by Surfing GB as the national governing body for surfing.

The Scottish Government has long recognised the importance of consultation in relation to development that may affect recreation and sport. For example, former Scottish Planning Policy (SPP) 11 [10] states:

“In assessing development proposals which may affect such facilities and resources, sport and recreation interests should be fully considered and planning authorities should consult with sport and recreation interests. Depending on the nature of the proposal this could include sports clubs, community groups, Non Governmental Organisations, governing bodies of sport, the local sports council, land managers and the appropriate local authority service.”

Q8. Are there any other sources of key environmental information which should be consulted?

A8. Yes. The information source identified in Section 5.8.1 (at page 80) is insufficient to inform the EIA process in relation to surfing resources and surfing recreation and tourism. SAS recommend that the approach for gathering data and information n relation to surfing resources and recreation is undertaken in accordance with the recommendations made in Part 4 of SAS’s Guidance on environmental impact assessment of offshore renewable energy development on surfing resources and recreation [2]. Data sources include, but should not be limited to, SAS [1], SAS [2], Marine Scotland [3], Scottish Government [4], Scottish Government [5], Sport Scotland [6] and UKMMAS [7].

Conclusions

SAS are fully in favour of offshore renewable energy development, including the development of wave farms, but the priority must always be that such development takes place without significantly impacting on surfing resources and recreation. Independent research suggests that WECs have the potential for significant adverse impacts on the natural features that create surfing breaks (i.e. wave climate and bathymetry) and that, indirectly, support the social and economic benefits associated with surfing.

SAS’s review of the Scoping Report identifies that it contains very little baseline formation, does not identify impacts and does not identify potential additive and interactive cumulative effects in relation to surfing resources and recreation. Accordingly, SAS believes that it is insufficient to inform the EIA process and Marine Scotland’s scoping opinion and requests that Marine Scotland gives notice to the developer that further information is required in relation to surfing resources and recreation.

SAS have responded to the scoping questions raised in the Scoping Report. SAS’s responses identify that the Scoping Report and EIA process is insufficient in a number of matters relating to surfing resources and recreation.

SAS [2] have produced a comprehensive guidance document aimed at developers of offshore renewable energy. This document promotes the surfing community as an important stakeholder to offshore renewable energy development and promotes best practice within the EIA process. If used effectively, this guidance could expedite the consent process for the proposed development in relation to surfing resources and recreation.

Yours sincerely

Andy Cummins
SAS Campaigns Director
Cc: Mr Noble, Scottish Surfing Federation Chairman & Mr Thompson, Surfing GB Director.

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Transport Scotland

I refer to your email of 27 May 2011 and the accompanying report the comments of the Trunk Road and Bus Operations Directorate (TRBOD) are as follows.

The proposed development represents an intensification of the use of this site, however the percentage increase in traffic on the trunk road is such that the proposed development is likely to have no impact on the trunk road network. On this basis TRBOD have no comment to make.

Annex 2. Marine Scotland scoping comments in relation to information requirements on diadromous fish of freshwater fisheries interest

Offshore renewable developments have the potential to directly and indirectly impact diadromous fish of freshwater fisheries interest including Atlantic salmon, anadromous brown trout (sea trout) and European eel. These species use the coastal areas around Scotland for feeding and migration and are of high economic and / or conservation value. As such they should be considered during the EIA process. Developers should also note that offshore renewable projects have the potential to impact on fish populations at substantial distances from the development site.

In the case of Atlantic salmon information will be required to assess whether there is likely to be any significant effect of developments on rivers which are classified as Special Areas of Conservation (SAC's) for Atlantic salmon under the Habitats Directive. Where there is the potential for significant impact then sufficient information will be required to allow Marine Scotland to carry out an Appropriate Assessment.

In order that Marine Scotland is able to assess the potential impacts of marine renewable devices on diadromous fish and meet legislative requirements the developer should consider the site location (including proximity to sensitive areas), type of device, and the design of any array plus installation methodology. Specifically we request that developers provide information in the following areas:

1. Identify use of the proposed development area by diadromous fish (salmon, sea trout and eels)

a. Which species use the area? Is this for feeding or migration?
b. At what times of year are the areas used?
c. In the case of salmon and sea trout what is the origin / destination of fish using the area?

2. Identify the behaviour of fish in the area

a. What swimming depths do the fish utilise
b. Is there a tendency to swim on or offshore

3. Assess the potential impacts of deployed devices on diadromous fish during deployment, operation and decommissioning phases. Potential impacts could include:

a. Strike
b. Avoidance (including exclusion from particular rivers and subsequent impacts on local populations)
c. Disorientation that could potentially affect behaviour, susceptibility to predation or by-catch, or ability to locate normal feeding grounds or river of origin
d. Delayed migration

4. Consider the potential for cumulative impacts if there are multiple deployments in an area.

5. Assess 1-4 above to determine likely risk.

a. If there are insufficient data to determine use of the development area, these should be obtained
b. If there are insufficient data on the origin / destination of fish using the area then these should be obtained

c. Where it is not possible to obtain site specific data, the developer should make a convincing argument why this is the case and apply appropriate expert judgement based on published information.

6. If there is any remaining doubt as to the potential impacts of a particular development, then the developer should recommend a scientifically robust monitoring strategy to assess any impacts either on stocks as a whole, or on particular rivers as necessary.

Marine Scotland Science has completed a review of migratory routes for Atlantic salmon, sea trout and eels relevant to Scotland. The review is available from http://www.scotland.gov.uk/Resource/Doc/295194/0111162.pdf. This will assist the developers in identifying what pre-existing information is available and what supplementary site specific data will be required.

Annex 3. RYA Positional Statement

THE RYA'S POSITION ON OFFSHORE ENERGY DEVELOPMENTS

DECEMBER 2009

The RYA has taken an active role in policy making that affects boat users and has been the voice of recreational boating for over a century. We represent our 100, 000 personal members and over 1500 affiliated clubs representing approximately 400, 000 boating enthusiasts and administer training standards at over 2000 recognised teaching establishments. Research conducted by the RYA, BMF, MCA, RNLI and Sunsail in 2006 showed there were approximately 3.5 million participants in boating-related watersports in the UK. The BMF estimates the total turnover of the UK leisure and small commercial marine industry in 2005/6 was £2.8 billion. Of this, the 'value added contribution' which is the principal measure of national economic benefit was £1.04 billion (37.6% turnover). The industry employs 35,000 people across 4300 different businesses.

RYA represents users of inland and coastal:

- Cruising and racing sailing and motor boats
- Sailing dinghies and day boats
- Windsurfers
- Personal watercraft

The RYA supports the UK Government's and evolved administrations' efforts to promote renewable energy[1]. We note that it is Government policy that wind farms should not be consented where they would pose unacceptable risks to navigational safety after mitigation measures have been adopted[2]. Our primary purpose in engaging in the consultation regarding the development of offshore energy developments is to secure navigational safety and to ensure that recreational boating interests are not adversely affected. The RYA has made objections to some of the proposed developments on grounds explained in this document. As more issues have come to light, we have reviewed our position on offshore energy development. We recognise that some marine renewable schemes may provide opportunities to benefit recreational sailors, e.g. active breakwater types of power generation can provide areas of sheltered water.

This position paper sets out our concerns from a general perspective and should enable developers to more accurately take account of recreational boating concerns in their environmental impact assessments.

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[1] The UK Renewable Energy Strategy 2009. HM Government

[2] Draft National Policy Statement for Renewable Energy Infrastructure (EN-3) DECC. November 2009. Note that this NPS will be a relevant planning consideration even though marine planning is a devolved issue in Scotland and Northern Ireland and in some cases Wales.

In summary the concerns of recreational boating and offshore energy developments relate to:

1. Navigational safety
    a. Collision risk
    b. Risk management and emergency response
    c. Marking and lighting
    d. Effect on small craft navigational and communication equipment
    e. Weather

2. Location
    a. Loss of cruising routes
    b. Squeeze into commercial routes
    c. Effect on sailing and racing areas
    d. Cumulative effects
    e. Visual intrusion and noise

3. End of life
    a. Dereliction
    b. Decommissioning

4. Consultation

The MCA has developed guidance for assessing the navigational impact of offshore renewable energy installations, this should be utilised in addition to the information contained here[3].

1. Navigational Safety

Prior to leaving the shore, mariners make a passage plan and make assessments based on weather, tides and the environmental conditions. Offshore developments become an additional navigational hazard to the mariner. However, if sited sensitively, well designed and managed effectively these developments can satisfy the safety issues of concern to recreational boating.

Construction of the first offshore wind farm, North Hoyle, was completed in 2004. Since that time, Scroby Sands was completed in 2004, Kentish Flats in 2005, Barrow in 2006, Burbo Bank in 2007, Lynn in 2008 and Inner Dowsing in 2008. A further seven are currently under construction and seven more are consented and awaiting a start date. There have been no reported incidents involving recreational craft and offshore wind farms in these five years of operation around the UK coast.

Collision risk

The RYA believes that poorly designed wind farm developments could pose a risk of rotor blade collision with recreational craft. Wave and tidal developments and the sub-surface structures and scour protection associated with wind turbines could similarly pose a threat of underwater collision. The danger that moving rotor blades or other parts of the mechanisms pose is the reason for concern. Navigating around static hazards is part of sailing and only in

[3] (MGN 371 ***"Offshore Renewable Energy Installations (OREIs) - Guidance on UK Navigational Practice, Safety and Emergency Response Issues.",*** MGN 372 ***"Offshore Renewable Energy Installations (OREIs): Guidance to Mariners Operating in the Vicinity of UK OREIs".***

rare situations, such as in narrow channels with strong tidal flows, do static installations pose a threat.

The RYA believes that the threat to recreational yachts can be minimised by specifying

1. a minimum rotor height clearance above mean high water springs of 22 metres
2. a minimum underwater clearance of 3.5 m below mean low water springs

The RYA has developed its position on clearance height and depth on the available data. Firstly an estimation of the air draught of the national fleet of yachts around the UK was established in the knowledge that these types of yachts may be found in all UK waters, these data are taken from the Royal Ocean Racing Club (RORC) Rating Office's database. For more detail see the final section on *Developing RYA policy on minimum clearance height and depth*.

Risk management and emergency response

Risk management provisions should be formulated from the results of a site specific risk assessment that accounts for recreational craft. Recreational craft can be generalised as 'small craft' which are defined by the MCA as those craft under 24m in length. This distinction is important when it comes to equipment and other requirements for small and large craft. Guidance was developed in 2005 to outline the requirements for assessing the navigation impacts of offshore wind farms[4] .

For recreational craft, such an assessment should take into account the following parameters:

- The number, size and type of local vessels
- The number, size and type of national vessels
- Annual events that are not covered in a short term monitoring
- Wave height and sea state conditions
- Monitoring should be carried out during the high season
- A range of possible incidences

Any risk assessment should recognise that it is a theoretical process and that utilising historical data on the number of incidents reported to HM Coastguard from the area with no hazards in place may not adequately represent the situation with 30-300 installations in situ. It should also be recognised that not all incidents are reported to the Coastguard; generally only those that represent life threatening situations are reported. However, since commercial offshore wind farms have now been deployed in UK waters for five years, this experience should be fed into any risk assessment to provide an accurate and realistic predicted level of risk and enable a proportionate and practical set of measures to be put in place to address any unacceptable risk.

In order to effectively manage the risk of a vessel in distress drifting towards an installation, there needs to be an effective *Emergency Response System* in place. This will require the ability to shut down the moving parts, such as the turbines, when an emergency call is reported. In some cases, where traffic is high, a stand-by safety vessel may be required.

[4] Guidance on the Assessment of the Impact of Offshore Wind Farms: Methodology for Assessing the Marine Navigational Safety Risks of Offshore Wind Farms. 2005. DTI.

Safety Zones

The RYA's opinion remains that the creation of safety zones around wind turbines or other installations that exclude small craft on a wholesale basis are likely to be unnecessary, impracticable and disproportionate. In our view, such a restriction on the small craft's right of navigation is not justifiable in terms of safety and there is little possibility of enforcing such zones. In some locations, it may actually increase risk of collision as small craft may be pushed into the lanes of larger vessels or may have to make extended voyages.

European standards are now being established where small craft, under 24m, are exempt from any operational safety zones. The German Government was the first to recognise the negative implications of imposing safety zones on small craft and has exempted small craft from such zones. In principle the RYA has no objection to the creation of *advisory or precautionary zones* but such zones must be designed and implemented on a case-by-case basis and with due respect to the right of navigation. The RYA believes that the purpose of any *advisory or precautionary zones* should be to warn vessels to navigate with particular caution but they should not permanently restrict navigation or exclude recreational vessels. Wave and tidal technology is varied and is now the unknown factor when considering navigational safety impact. Nevertheless when these do not have moving parts within keel depth, their status as a hazard is in principle no different from that of a reef or other natural obstruction.

The RYA does, however, foresee occasions when it may be prudent to impose short-term temporary restrictions, for example during engineering, maintenance or construction works. Such temporary restrictions should be promulgated through Notices to Mariners. Many vessels visit the UK from continental Europe and this should be taken account of in any communication.

Cables and anchoring

A further issue relating to risk management is that of cables and anchoring. In most cases, small craft will not anchor within an offshore energy 'farm'. However, in emergency situations this may be the only way of securing a drifting vessel to ensure no damage is done. To secure the safety of navigation, cables should be buried to a sufficient depth to avoid being uncovered. This should take into account shifting sediments on the seabed.

Marking and lighting

As offshore renewable energy installations become more common in UK waters, the requirements for marking and lighting the sites should be consistent. This has been achieved for offshore wind and should be replicated for wave and tidal devices. Much work has been done in this field and guidance supported by RYA is available from Trinity House or the Northern Lighthouse Board as appropriate. For wind farms, as a minimum each turbine should be clearly marked in high visibility yellow paint to a height of 12 m, low level lighting should allow the turbine number to be read from a 'safe' distance, corners of the wind farms should be marked and any other points or routes through the wind farm marked accordingly. Wave and tidal developments vary dramatically in their design and the marking and lighting of these installations will need to be developed carefully. Wave power units that lie low in the water and that may move within an area of water, such as Pelamis, will be particularly hazardous to small boats and effective marking and lighting will be essential.

The RYA supports the guidance issued by the relevant light house boards on these issues and works with them to identify site specific issues that may occur.

Effect on small craft navigational and communication equipment

All craft larger than a dinghy will have some form of navigational equipment on board. The most common will be a magnetic compass. Large quantities of steel, cabling and the transmission of electrical power may produce interference with the magnetic compass. Studies have shown that the effect on systems such as GPS, VHF and mobile phones from wind farms is negligible. However, there is a demonstrated effect on radar systems which reduces the visibility of small craft to search and rescue vessels as well as to each other and larger commercial vessels. This causes concern when large wind farm developments are sited close to commercial shipping lanes and obstruct small craft routes avoiding these commercial routes or at the confluence of routes.

Problems may be found with small craft navigational equipment, which is not as powerful as commercial varieties, when we start consider installations further offshore. Antennae are likely to be lower and less powerful than many larger commercial vessels.

Any proposed development should account for the effect on small craft navigation and communication equipment in detail

Weather

Local weather conditions should also be examined in the risk assessment and measures taken to reduce the effects of poor weather conditions, low visibility and fog should be included in the risk management plan. Installations may need to have fog horns attached for low visibility conditions.

2. Location

The location of offshore energy installations is going to be crucial to navigational safety as well as potential loss of amenity for recreational craft. It should also be noted that commercial routes and shipping lanes do not represent those routes taken by small recreational craft. Whilst these routes will vary, the RYA, has collated these routes into the *UK Coastal Atlas of Recreational Boating* which is available from the RYA and which details cruising routes, sailing areas and racing areas as well as the location of marinas, RYA affiliated clubs and recognised training centres. This document should be consulted when considering the location of offshore energy developments and when writing an environmental statement.

Recreational routes, general sailing and racing areas must be accounted for when examining the impacts of wind farm developments.

Loss of cruising routes

When examining the routes and location of turbines it is important to recognise that sailing boats behave differently to power driven craft in that their actual line of travel may zigzag across the ultimate direction of travel as they are dependant on the wind direction. The coastal atlas should be consulted as well as any other available information to inform the siting of the developments and individual installations and the potential provision of navigation routes through the larger sites.

Along many stretches of coast, recreational craft may need to seek shelter in poor weather. Sheltered harbours and anchorages and routes to these harbours of refuge should be protected. These are identified as essential routes in the Coastal Atlas.

The loss of routes will also lead to an increased distance of travel. This has environmental implications for powered craft and safety implications for all craft. Some routes, typically narrow channels or strong tidal flows, may already be hazardous at times to navigate through and adding hazards in these areas may seriously compromise navigational safety. There are also safety issues with the creation of turbulence and wind shadowing in confined areas where craft may be moving slowly and gusty turbulent conditions may create problems.

Squeeze into commercial routes

Recreational routes differ from commercial routes as recreational craft essentially aim to keep out of the major commercial navigation routes by travelling in the shallower adjacent waters or taking other routes entirely. As a result, examining commercial routes alone will not enable the safe positioning of OREIs, recreational boating must also be accounted for. This may require routes through large developments to be identified or inshore routes for smaller craft to be safeguarded. The cumulative impact of all marine developments is becoming increasingly important when assessing these issues of squeeze.

Effect on sailing and racing areas

Most of the general day sailing and racing areas are close to the shore and in the more sheltered waters. The Strategic Environmental Assessment for Round 3 offshore wind development[5] recognises the busy inshore areas and states that the majority of offshore wind development should be beyond 12nm. European standards are again being set by Netherlands and Germany who have excluded any development within 12nm from the shore in order to retain 'open space' for its amenity and recreational value. Recreational activity is important to the health and wellbeing of the community as well as economic support for the local coastal economies. Retaining the undisturbed remoteness of some waters will be important in terms of its wilderness and amenity value.

In certain confined areas and areas heavily used for sail racing, the effects of wind turbines in terms of turbulence and shadowing on craft should be taken into account.

Any interference in wind speed and/ or turbulence created by a wind farm in a racing area would create a significant negative impact on the event site and diminish its value.

Cumulative effects

Of increasing concern with the planned number of developments is the need to assess each development in its wider surroundings. The *cumulative effects* of offshore energy installations on navigation routes will be increasingly significant. Existing navigation routes affected by other proposed development sites will need to be accounted for, rather than only current routes.

[5] Offshore Energy Strategic Environmental Assessment: Post consultation report. June 2009. DECC.

3. End of Life

Dereliction

Whilst we would hope that these installations remain economically viable for the lifetime of the structures, the RYA would support measures taken by Government to secure the financial implications of removing the structures, prior to consents been given. This will ensure that after the installation ceases electricity production for whatever reason, derelict structures that are not marked or lit and remain a hazard to navigation and anchoring are not found in UK waters.

Decommissioning

Equally, any decommissioning plan needs to ensure that the structures are completely removed. Any parts of the structure remaining after the commercial operation of the installation may pose a hazard to navigation and should be avoided. However, we recognise that secondary uses may be identified for these structures once energy generation ceases. If structures are to remain in the water, navigational safety must be taken into account and structures should be appropriately marked and lit.

4. Consultation

Consultation with the RYA should be through the Headquarters in Hamble and the Scottish, Welsh and Northern Irish offices who can coordinate wider consultation with their regional environmental coordinators, the clubs and individual membership and if needed, help to coordinate stakeholder meetings.

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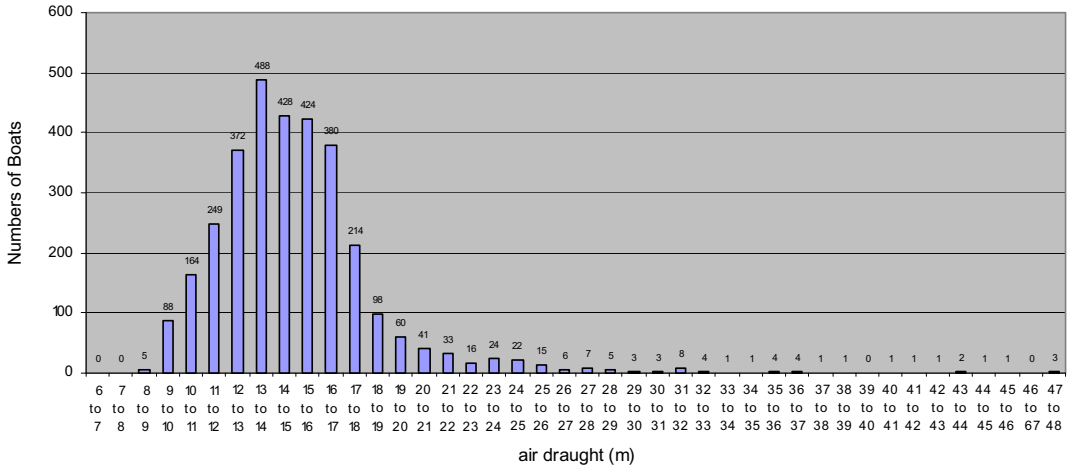
Original document December 2005, revised December 2009

Development of the RYA policy on minimum clearance height and depth

The RYA has developed its position on clearance height and depth on the available data. Firstly an estimation of the air draught of the national fleet of yachts around the UK was established with the knowledge that these types of yachts may be found in all UK waters, this data is taken from the Royal Ocean Racing Club (RORC) Rating Office's database. Although there are other rating systems in use, the RORC system is widely accepted and applied worldwide. Rating is a technical handicapping process that enables adjustments to be made to yacht racing results so as to allow a wide range of different boats to be raced on equal terms. The boats contained in the database are mainly cruisers and yachts. Many yachts taking place in club races are registered with the RORC Rating Office. The RYA believes this data, containing 3179 records, is a good representation of the type of yacht to be found sailing around the shores of the UK. Although the total number of yachts around the UK has not been quantified, this database represents 6% of the total number of boats owned in the UK, estimated at 564,000 (BMF, 2003).

'Air draught' as presented here is the distance from the waterline to the top of the mast structure. This is based on the 'p' measurement, boom to top of mast, in the rating system (RORC, 2003). Two metres have been added for the distance from the boom to the water surface, which is a conservative estimate for the larger vessels. It should be noted that masthead equipment and instrumentation has not been included in the calculation of air draught, although it will also add a further half to one metre to the air draught of a yacht. Loss of this equipment may produce failure in communication from the yacht although not structural failure to the yacht.

Figure 1: Graph showing the air draught in metres of the boats within the IRC fleet (sample size=3179)



Looking at the above data in the form of percentage of the UK boating fleet, we can see the percentage of recreational yachts at risk from different rotor clearance heights. Figure 2, shows that a clearance height of 14 metres above sea level will put 57% of the national fleet at risk from rotor height collision. Reducing this to 18 metres above sea level, substantially reduces this percentage, however it still leaves 12% of the national fleet at risk from rotor height collision. This is still an unacceptable level of risk to the yachts found in UK waters. A clearance of 22 metres has been shown to be possible in engineering terms, which would put 4 % of the national fleet at risk, a more acceptable level of risk in the view of the RYA. As a matter of common observation, larger yachts over 18 metres in length (see Figure 3), representative of this 4% group are more likely to be run by highly experienced crews and skippers. The datum of mean high water springs (MHWS) is taken as the clearance datum rather than mean sea level and then factoring in a site specific wave height parameter. However, wave height should be examined in the risk assessment at each site. It should be

noted that 22 m above MHWS has already been specified as a minimum clearance height in several of the wind farms consented in the first round of consents and is therefore a feasible, cost-effective option for developers.
It should also be noted that while this is currently an acceptable level of clearance, yachts are increasing in size and future developments may require a greater clearance height.

Figure 2: Graph showing the percentage of boats in the IRC fleet with different air draught shown in metres (sample size = 3179)

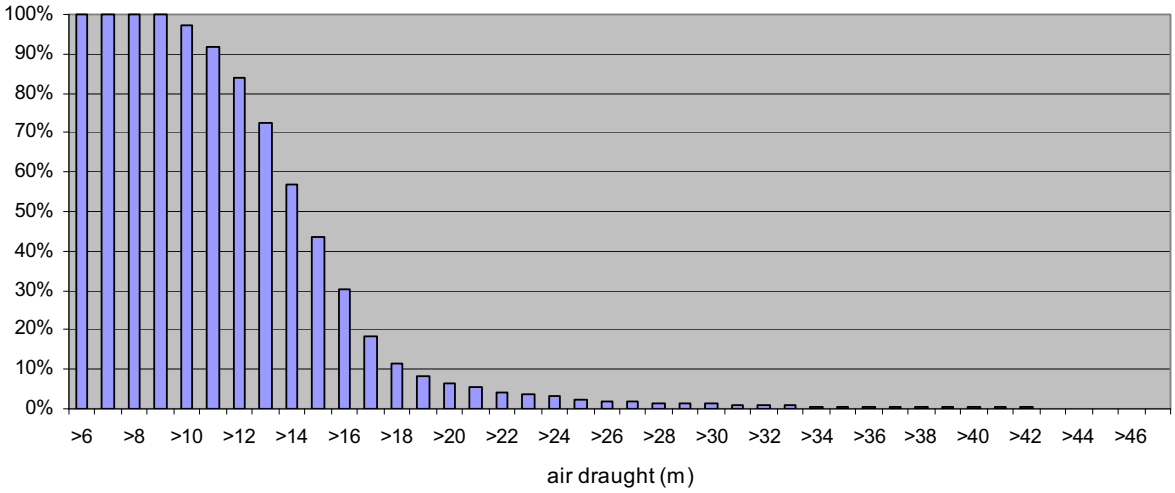
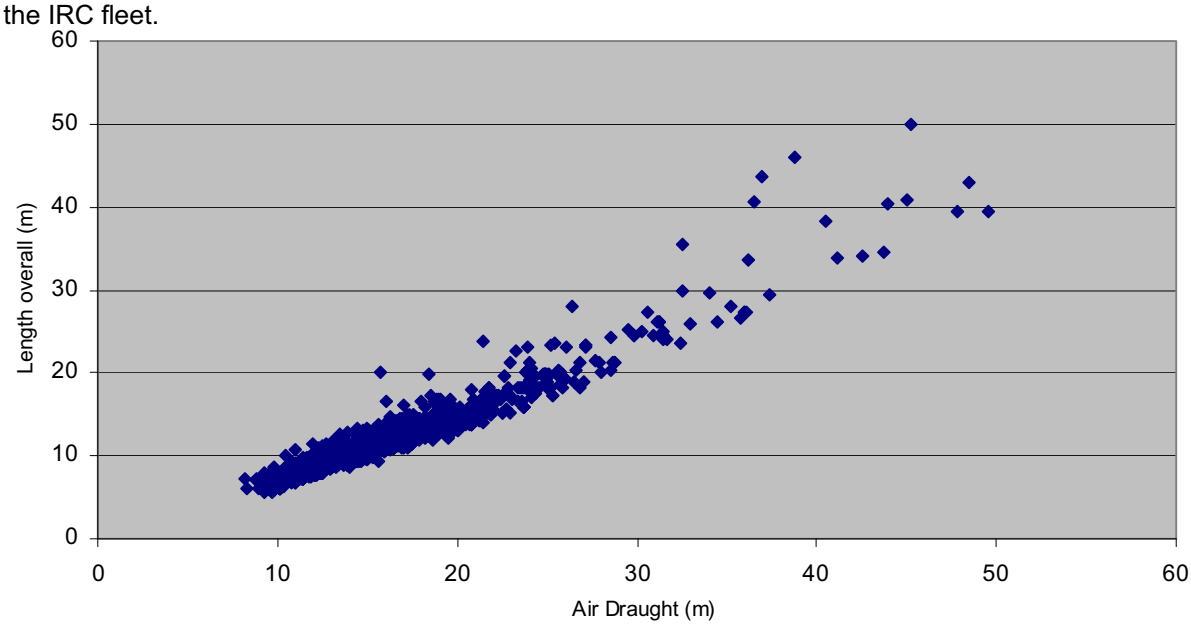
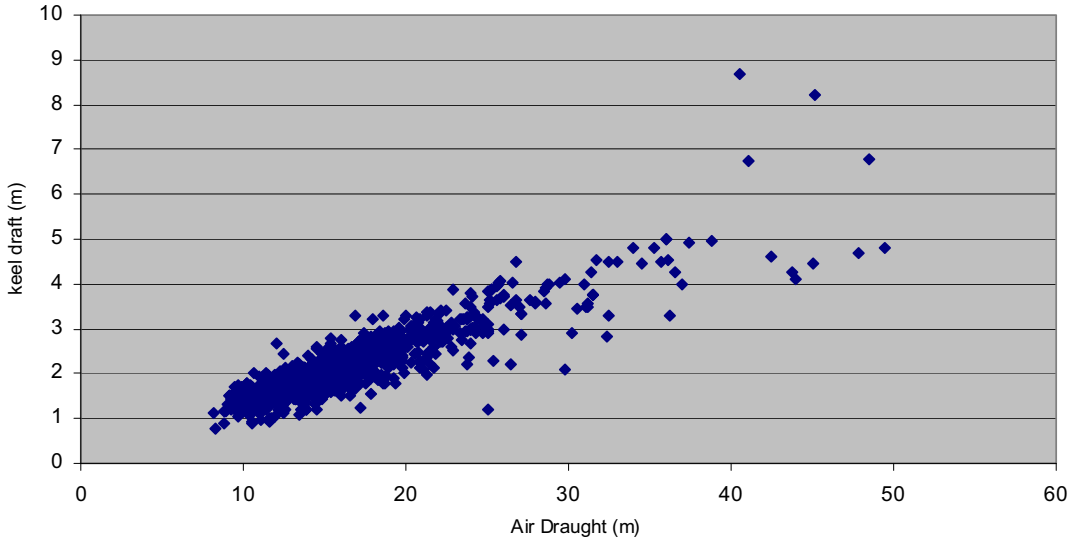


Figure 3: Graph showing the relationship of Length Over All (LOA) in metres and air draught in metres of the IRC fleet.



Additional data is provided showing the relationship between air draught and the depth of water required for clearance below the vessel's keel (Figure 4). Figure 4 shows that a depth of 3.5 metres corresponds to an air clearance of 22m above MHWS which is relevant for subsurface wave and tidal developments.

Figure 4: Graph showing the relationship of water draft in metres and air draught in metres of the IRC fleet.



References

RORC (Royal Ocean Racing Club). 2003. IRC/IRM Yearbook. London

BMF (British Marine Federation). 2003. *Marine Leisure Industry European Overview*. Egham, Surrey.

Annex 4. Developer Application And Environmental Statement Checklist

DEVELOPER APPLICATION AND ENVIRONMENTAL STATEMENT CHECKLIST

	Enclosed
1. Developer cover letter and fee cheque	□
2. Copies of ES and associated OS maps	□
3. Copies of Non Technical Summary	□
4. Confidential Bird Annexes	□
5. Draft Adverts	□
6. E Data – CDs, PDFs and SHAPE files	□

Environmental Statement	Enclosed	ES Reference (Section & Page No.)
7. Development Description	□	
8. Planning Policies, Guidance and Agreements	□	
9. Economic Benefits	□	
10. Site Selection and Alternatives	□	
11. Baseline Assessment data – air emissions	□	
12. Design, Landscape and Visual Amenity	□	
13. Construction and Operations (outline methods)	□	
14. Archaeology	□	
15. Designated Sites	□	
16. Habitat Management	□	
17. Species, Plants and Animals	□	
18. Water Environment	□	
19. Sub-tidal benthic ecology	□	
20. Hydrology	□	
21. Waste	□	
22. Noise	□	
23. Traffic Management	□	
24. Navigation	□	
25. Cumulative Impacts	□	
26. Other Issues	□	

N.B. Developers are encouraged to use this checklist when progressing towards application stage and formulating their Environmental Statements. The checklist will also be used by officials when considering acceptance of formal applications. Developers should not publicise applications in the local or national press, until their application has been checked and accepted by officials.

Appendix 3.1

Scottish Natural Heritage responses to Habitats Regulations Appraisal correspondence

Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad

Marc Murray
Aquamarine Power
Elder House
24 Elder Street
Edinburgh
EH1 3DX

Your ref: Lewis Wave Array Year 1 Bird Survey Technical report - NRP

Our ref:
CNS/REN/WAVE/AQUAMARINE POWER LEWIS WAVE ARRAY/CDM110606

Date: 23 January 2012

By email only

Dear Mr Murray,

LEWIS WAVE ARRAY: ADVICE ON YEAR 1 BIRD SURVEY RESULTS AND REQUIREMENTS FOR HABITATS REGULATIONS APPRAISAL

Thank you for your email of 19 December 2011 requesting comments on the Aquamarine Power Limited (APL) year 1 bird survey results and requirements for Habitats Regulations Appraisal.

The Natural Research Projects Limited (NRP) report entitled *'Lewis Wave Array Year 1 bird surveys technical report', 'Lewis Wave Array Ornithology, Provisional Conclusions of Year 1 Survey Results'* and Royal Haskoning letter *'Lewis Wave Development - requirement for HRA'* were circulated to Scottish Natural Heritage and Marine Scotland Science for review. These documents were also discussed in a meeting held by teleconference on 19 December 2011 attended by APL, NRP, Royal Haskoning and SNH staff.

We have now reviewed these documents and offer the following comments:

<u>Year 1 bird surveys – Technical report and provisional conclusions</u>

1) The technical ornithology report is of high quality and we broadly agree with the main conclusions reached, specifically:

   - Non-breeding red-throated divers, great northern divers and eiders are the bird interests that require most consideration. All three occur in number which meet or exceed 1% of the respective regional wintering estimates.

   - Non-breeding red-throated diver numbers were unexpectedly high, based on aerial survey data available for the west coast of the Outer Hebrides. We agree with the assertion that it is unlikely that the birds recorded in the winter months are breeding on the Lewis Peatlands SPA.

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2) In addition to these conclusions, we make the following observations:

- The proposed development zone coincides strongly with the observed distribution of all three species requiring consideration and is further from the shore than the Orkney Oyster deployment at EMEC. It is likely even taking into account distance correction, the bird data is likely to be lower quality than that collected in Orkney.

- For all three species, alternative lines of evidence that the distribution and abundance are likely to be consistent from year to year are currently anecdotal.

- The proposed vantage point watch schedule was not fully met due to weather constraints.

- In estimating bird density using distance based methods, the implications of the confounding effect of recording across an ecological gradient (water depth and distance from the shore) have not been considered. In normal circumstances, vantage points from shore fail to meet the uniformity assumption of the distance method as birds are not randomly distributed with respect to the observer. We acknowledge that tackling this confounding effect is challenging. We would therefore welcome details of any approaches considered by NRP to address this issue.

3) We recommend that continuation of survey work until September 2012 to capture two years of baseline data. Taking into consideration the above observations, further data collection would be advantageous to provide a better baseline for post-construction monitoring and a more robust and informed decision making process.

<u>Requirements for Habitats Regulations Appraisal</u>

The letter entitled *'Lewis Wave Development - requirement for HRA'* prepared by Royal Haskoning summarises further information regarding the proposal and provides summaries of available survey information to inform the potential impact of the development on the qualifying features of Natura sites. Qualifying species outlined the letter are discussed in turn below:

- <u>Birds (Lewis Peatlands SPA)</u>: Our recommendations for bird species are provided above. At this interim stage, these data suggest no likely significant effect on breeding red-throated divers, a qualifying feature of Lewis Peatlands SPA. Full evaluation and advice regarding all bird species, including relevant SPA qualifying bird features will be made on submission of the report at the end of the second year of vantage point data collection.

- <u>Grey seals (North Rona and Monach Isles SACs)</u>: We welcome the summary provided and request that the first year survey report for marine mammals is provided to allow us to fully evaluate the data and provide detailed advice for marine mammals, including qualifying seal features of SACs.

- <u>Atlantic salmon (Langavat SAC):</u> The revised proposal is for a much reduced development area, which would be located approximately 25 km from the sea loch at the end of which is the Langavat SAC. Taking the length of the sea loch into account, the development would be approximately 40 km from the Langavat SAC. At such distance, it could be expected that disturbance arising from installation, operation and decommissioning of the array would be unlikely to have a significant effect on the Langavat SAC, and an HRA would not be required.

- Otters (Lewis Peatlands SAC): We received the otter report relating to the onshore components of the development on 20 December 2012. Our advice regarding otters and the onshore infrastructure will soon be provided in a separate response.

We hope these comments are helpful. Please contact me if you have any queries (tracey.begg@snh.gov.uk or 01870 620238).

Yours faithfully,

TRACEY BEGG
Marine Renewable Energy Casework Adviser

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All of nature for all of Scotland
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Marc Murray
Aquamarine Power
Elder House
24 Elder Street
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EH1 3DX

Your ref: Lewis Wave Array: Extended Phase 1 Habitat and Otter Survey report

Our ref:
CNS/REN/WAVE/AQUAMARINE POWER LEWIS WAVE ARRAY/GEN110679

Date: 25 January 2012

By email only

Dear Mr Murray,

LEWIS WAVE ARRAY: ADVICE ON EXTENDED PHASE 1 HABITAT AND OTTER SURVEY REPORT

Thank you for your email of 19 December 2011 requesting comments on the Aquamarine Power Limited (APL) extended phase 1 habitat and otter survey report.

Royal Haskoning (RH) was commissioned by APL to conduct an EIA for the proposed wave array development, including the on-shore elements. These on-shore elements consist of a hydro-electric power station and associated curtilage, estimated to have a footprint of 10,000m^2. This will be sited somewhere within the study area, the precise location to be determined by a number of parameters.

The RH report entitled *'Lewis Wave array: Extended Phase 1 Habitat and Otter Survey report'* was circulated to Scottish Natural Heritage and Marine Scotland Science for review. This document was also discussed in a meeting held by teleconference on 19 December 2011 attended by APL, RH, Natural Research Projects Limited and SNH staff. The report includes:

- An extended phase 1 habitat survey
- An otter survey
- Recommendations for siting of the onshore station

We have now reviewed this document and offer the following comments:

1) <u>General Comments</u>

- We welcome the consideration that has been given to onshore elements at an early stage of project development and the detailed information the report provides.

- The recommended siting of the on-shore electricity sub-station appears appropriate with regard to the terrestrial natural heritage features in the area of search. The ES should consider the options for the siting of the station and be able to justify the selection of the eventual site, using this report as a basis.

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2) Extended phase 1 habitat survey

- We welcome the report recommendations for habitats, notably that the final location of the station should not be within a groundwater dependent terrestrial ecosystem type e.g. blanket bog, wet heath.

- We agree with the recommendation that a terrestrial invasive species survey is not required. We advise that an aquatic invasive species survey is also not required.

- The area of search is undesignated and does not have any significant connectivity with the Lewis Peatlands SAC/SPA or Ness and Barvas SPA nearby.

- The species list within the report does not contain any record of plant species of conservation concern/interest that may be affected by the proposal. We recommend the ES takes account of BAP priority habitats objectives as part of the decision making process in the final site selection of the sub-station.

- We can provide advice about the selection of appropriate plant species for any remedial landscaping (planting) post-construction.

3) Otters

- The otter survey represents a fair reflection of the way in which otters are using the area. The report shows the presence of otters in the vicinity of the 2 main water courses within the area of search.

- The preferred development site is over 200m from the coast, over 360 metres from the Lambol Burn and over 760 metres from Allt Fisgro. We advise that the proposed works are unlikely to require an European Protected Species (EPS) licence unless the development site is moved within a 50 metre buffer of these areas.

- We consider the current range of mitigation measures to be appropriate for this development. We can advise further when specific details are available regarding the development.

- The coastal hinterland and the 2 water courses may form part of the navigational route used by otters between the Lewis Peatlands SAC (for which otters are a qualifying feature) and the sea. We would advise that with mitigation in place, as outlined in the report, there is minimal risk to the otter population of the SAC. We would therefore advise there is no requirement for a Habitats Regulations Appraisal, based on the current proposal. Should the development site move to within 50m these water courses, we can provide further advice regarding appropriate mitigation.

- The report correctly recognises that the baseline situation may change before construction works begin. We note there is no indication of the proposed period of ground works. Prior to construction starting, a smaller scale otter survey should be undertaken. This should encompass the proposed construction footprint plus a 50m buffer zone around it (200m buffer along any water course/coastal area) to determine current use by otters at the time of construction. Although otters can breed at any time of the year, females of the otter population of the Outer Hebrides usually give birth in late spring (April-May) and cubs tend to stay in the natal den for up to 3 months afterwards. To comply with EPS legislation, it will be critical for the survey to identify any active/potential natal dens in the vicinity of the development at that time.

4) Reptiles and amphibians

The report asks for advice regarding potential impacts on reptiles and amphibians. We advise that there is little potential for impact on reptiles or amphibians. Slow worms are the only protected reptile known to occur in the terrestrial environment of the Outer Hebrides. No records of slow worms are known from the north west coast of Lewis. Habitat types in the area of search are largely unsuitable for this species.

We hope these comments are helpful. Please contact me if you have any queries (tracey.begg@snh.gov.uk or 01870 620238).

Yours faithfully,

TRACEY BEGG
Marine Renewable Energy Casework Adviser

Scottish Natural Heritage
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All of nature for all of Scotland
Nàdar air fad airson Alba air fad

Jen Trendall
Haskoning UK Ltd
10 Bernard Street
Leith
Edinburgh
EH6 6PP

By email only

Your ref: Lewis Wave Array Marine Mammal Survey Year 1 report

Our ref:
CNS/REN/WAVE/AQUAMARINE POWER LEWIS WAVE ARRAY/GEN111317

Date: 17 February 2012

Dear Jen,

LEWIS WAVE ARRAY: ADVICE ON YEAR 1 MARINE MAMMAL MONITORING RESULTS AND REQUIREMENTS FOR HABITATS REGULATIONS APPRAISAL

Thank you for your email of 25 January 2012 requesting comments on the Aquamarine Power Limited (APL) year 1 marine mammal survey results and requirements for Habitats Regulations Appraisal.

The Royal Haskoning (RH) report entitled *'Lewis Wave Array Marine Mammal Survey Year 1* and Royal Haskoning letter *'Lewis Wave Development - requirement for HRA'* were circulated to Scottish Natural Heritage and Marine Scotland Science for review. These documents were also discussed in a meeting held by teleconference on 19 December 2011 attended by APL, NRP, Royal Haskoning and SNH staff.

We have now reviewed these documents and offer the following comments:

<u>Marine mammal year 1 surveys report</u>

1) The marine mammal year 1 report is well written and the outlined methodology has been followed diligently, conditions permitting. We agree with the observation that the frequency of marine mammals (seals and cetaceans) and basking shark sightings are relatively low.

   While the methodology and data are well presented, there is limited analysis and discussion to ascribe the relative importance of the areas of search for marine mammals and basking sharks in the regional context. We recommend that future reports and the Environmental Statement (ES) should include a literature review and other data sources, including the unpublished grey seal telemetry data review cited in the RH HRA letter, and any relevant data available from other developments to place the results in context. Current data from Hebrides Whale and Dolphin Trust (HWDT) may be available to enhance future data analyses and inform the ES.

2) Additionally, we make the following observations:

   - The proposed vantage point (VP) watch schedule was not fully met due to weather constraints.

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- A significant proportion (approximately 70%) of the total observation effort was during sea state 3 or 4 when confidence of detection and identification become more challenging, particularly since the area of search extends to over 1 km from the shore-based VPs.

- For seals, there is an association between detection and proximity, with the majority of records within 0.5km of a VP. This is likely a function of sea state, distance and other factors impacting on detection rates.

- The report states that both SACs are over 150km from the study area. This is incorrect. North Rona is 83Km to the NNE of the nearest VP (Mealabost) and the Monach islands are 108Km to the SW of the nearest VP (Labost).

- The closest breeding colony to the study area is Gaisker (not the Sound of Harris) which regularly produces over 1000 pups per annum. Gaisker is WSW of Scarp, 55Km to the SW of Labost.

3) We recommend that continuation of survey work until September 2012 to capture two years of baseline data. Taking into consideration the above observations, further data collection would be advantageous to provide a better baseline for post-construction monitoring and a more robust and informed decision making process.

<u>Requirements for Habitats Regulations Appraisal</u>

The letter entitled *'Lewis Wave Development - requirement for HRA'* prepared by Royal Haskoning summarises further information regarding the proposal and provides summaries of available survey information to inform the potential impact of the development on the qualifying features of Natura sites. With the exception of seals, advice regarding qualifying species was provided in our previous response to the year 1 bird report on 23 January 2012.

Our recommendations for seals are provided above. At this interim stage, these data suggest no likely significant effect on breeding grey seals, qualifying features of North Rona and Monach Isles SACs. Full evaluation and advice regarding grey seals will be made on submission of the report at the end of the second year of VP data collection.

We hope these comments are helpful. Please contact me if you have any queries (tracey.begg@snh.gov.uk or 01870 620238).

Yours faithfully,

TRACEY BEGG
Marine Renewable Energy Casework Adviser

Appendix 5.1

Project footprint calculations (offshore)

APPENDIX 5.1 Calculations for the offshore footprint area of the development

Table A5.1 Explanation of calculations for the area of disturbance or project footprint in the offshore environment

Parameter	Explanation of Minimum Area	Explanation of Maximum Area
WEC and gap fillers under each WEC	If the gap fillers are made of wire cages filled with rocks it is possible that the gap filler of each WEC will have vertical sides. The seabed take in this scenario will be the area surrounding the pile under the WEC flap which would be approximately 26m long (with the smallest scenario device to be deployed at Lewis) and 5m wide. Therefore 26 x5m = 130 m^2 If the devices are this size then 50 devices will be installed. Therefore 130 x 50 = **6,500m^2**	The gap fillers could be made of accopodes which will have a natural side slope of about 30° resulting in a truncated rectangular pyramid (See Figure A5.1 Below). The height of the gap filler is required to be 4.3m therefore if the natural slope of the materials used will be 30° the following equation can be used to calculate the width of the gap filler. 4.3/Tan30°= 7.45 The width of the gap filler required to be at 4.3m height will be 5m and therefore the entire width of the gap filler will be 7.45+5+7.45=19.9m (see Figure A5.1). The total maximum length of each gap filler will be the maximum length of the final WEC device to be installed (33m) with the addition of 7.5m at each end to allow for the natural slope of the accropode gap fillers therefore 33 + 7.45 + 7.45 = 47.9 The total maximum area of each gap filler will be 19.9 x 47.9 = **953.21m^2** If the WECs and therefore the gap fillers are 33m in length there will be a maximum of 40 and therefore the total area of seabed take in this scenario is **38128.4m^2**. However the likely buildable scenario that would result in the maximum seabed take is if the WECs were 26m long (see Chapter 5 Project description) in which case each gap filler would be: 19.9 x (26+7.45+7.45)=**813.91m^2** With this smaller size WEC 50 gap fillers would be used. Therefore: 813.91 x 50 =**40,695.5m^2**

WECs pipeline	The WEC devices may be connected directly to the Common Pipeline under the landing platform (See Project description and Landing platform calculations below). Therefore under this scenario there will be no seabed take as a result of the WEC pipelines.	The Maximum potential distance from any WEC to the Common Pipeline is likely to be 50m, The maximum number of WECs likely to be deployed is 50 and the maximum area that will be cleared around each WEC pipeline is 10m. Therefore: 50 x 50 x10 = **25000m^2**
Common Pipeline	The Common pipeline will be a minimum of 2000m in length with a 10m wide construction corridor. Therefore 2000 x 10 = **20000m^2**	The Maximum length of the common pipeline is predicted to be 3500m (if the common pipeline is built in sections, WEC to WEC) with a 10m wide construction corridor. Therefore 3500x10= **35000m^2**
Common to Shore Pipelines	Realistically the minimum length of these pipelines would be about 700m and the minimum number would be 2 this is multiplied by 10m construction footprint for most of the distance apart from a 20m construction footprint for 100 in the intertidal zone. Therefore 2 x ((600m x 10) + (100 x 20)) = **16000m^2**	It is difficult to define the maximum area of disturbance/ Footprint for common to shore pipelines as the eventual configuration will be largely determined as the project evolves. Therefore an extremely cautious calculation has been made for this element of the project. The maximum distance from the likely common landing point to the furthest WEC is 2.3km (Figure 5.2 in Chapter 5 Project description). The following calculation allows for 4 of the Shore pipelines corridors to be this length and have said that the other 4 based on worst case scenario would 1km. All this is multiplied by 10m for the construction corridor over all but 100m of the length of each; the remaining 100m will have a 20m construction corridor through the surf zone. Therefore Area = (4x ((2300 x 10) +(100 x 20)) + (4 x (900 x 10) + (100 x 20))= **144,000m^2**
Landing platforms	Landing platforms are likely to be approximately 10m by 10m for a minimum of 40 WECs and therefore 10 x 10 x 40 = **4000m^2**	Taking a very precautious approach the landing platforms may be up to 20m wide by 10m long for a maximum of 50 WECs and therefore the total area occupied by these structures will be. 10 x 20 x 50 = **10000m^2**
Monopiles	Monopiles are 5m in diameter and the minimum number would be 40 and so the area would be Pi × (2.5 x 2.5) x 40 = **785.40m^2**	Monopiles are 5m in diameter and the maximum number would be 50 and so the area would be Pi × (2.5 x 2.5) x 40 = **981.75m^2**
Manifold to connect the WEC to the Common pipeline	The preferred scenario is to incorporate the connection of the WEC pipeline with the Common pipeline within the Landing platform structure. If this Scenario is achieved there will be no footprint in this element.	If it is not possible to incorporate the WEC and Common pipeline connection within the landing platform a manifold structure will be needed to make this connection. The manifold will be 6m by 6m and the maximum number will be 50 and therefore 6 x 6 x50= 1800**m^2**
Manifold to connect the Common pipeline to the shore pipeline	A manifold structure will be used to connect the Common pipelines with the Shore pipelines these will be 10m by 10m the minimum number that will be required is two. Therefore 10m × 10m x 2 = **200m^2**	A manifold structure will be used to connect the Common pipelines with the Shore pipelines these will be 10m by 10m the minimum number that will be required is two. Therefore 10m × 10m x 8 = 8**00m^2**

Mooring Anchors	Up eight mooring anchors will be installed around each WEC (minimum of 40 WECs). The anchor plate of each mooring anchor is composed of three arms. The plate is approximately 1m by 1m (although the entirety of this area is not occupied by the anchor but these dimensions are used as a precaution to allow for excess disturbance. Therefore 1 x 1 x 8 x 40= **320m^2**	Up eight mooring anchors will be installed around each WEC (up to 50 WECs). The anchor plate of each mooring anchor is composed of three arms. The plate is approximately 1m by 1m (although the entirety of this area is not occupied by the anchor but these dimensions are used as a precaution to allow for excess disturbance. Therefore 1 x 1 x 8 x 50= **400m^2**
Jack up barge footprint	It is estimated that the jack up barge will have a footprint of approximately 20m^2 (the footprint of Seacore's Excalibur). It is thought that the Jack up barge will deploy its legs once per pile drilling operation and therefore if the minimum number of WECs are installed: 20m^2 x 40 = **800m^2**	It is estimated that the jack up barge will have a footprint of approximately 20m^2 (the footprint of Seacore's Excalibur). However to allow for the potential that a different Jack up vessel is used a cautious estimate of 40m2 is used in this calculation. It is thought that the Jack up barge will deploy its legs once per pile drilling operation and therefore if the maximum number of WECs are installed: 40m^2 x 40 = **2000m^2**
Total	**46520**	**259696**

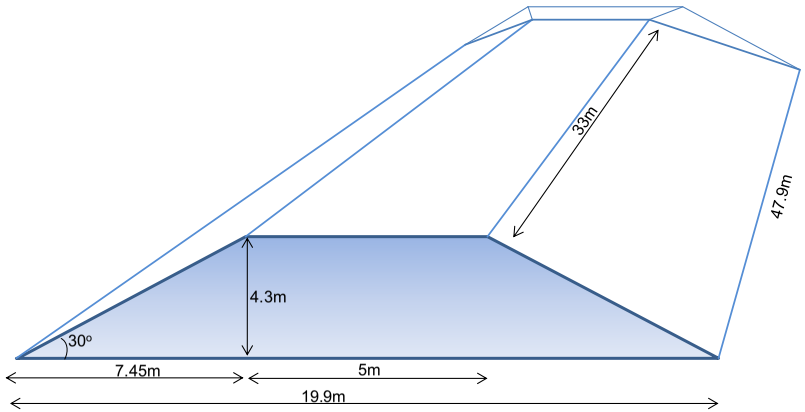

Figure A15.1 Schematic showing the maximum dimensions of the gap fillers

Appendix 5.2

Excavated material calculations

APPENDIX 5.2 Calculations of the amount of material to be extracted by the offshore elements of the proposed development

Table A5.2 Explanation of calculations for the volume of excavated rock (Table		
Parameter	**Explanation of Minimum volume (m^3)**	**Explanation of Maximum volume (m^3)**
Monopile sockets	Monopiles are 5m in diameter and will be installed to a depth of 15m. The minimum number of monopoles will be 40 and so the excavated volume would be Pi × (2.5 x 2.5) x 15 x 40= **11781m^3**	Monopiles are 5m in diameter and will be installed to a depth of 15m. The maximum number would be 50. Therefore the excavated volume would be Pi × (2.5 x 2.5) x 15 x 50 = **14726m^3**
Mooring anchors	There are will be eight mooring anchors per WEC, each mooring anchor consist of 3 pins 50mm in diameter and 1500mm long. The minimum number of WECs will be 40 and therefore the total excavated material would be Pi × (0.025 x 0.025) x 1.5 x 3x 8 x 40= **2.83m^3**	There are will be eight mooring anchors per WEC, each mooring anchor consist of 3 pins 50mm in diameter and 1500mm long. The maximum number of WECs will be 50 and therefore the total excavated material would be Pi × (0.025 x 0.025) x 1.5 x 3 x 8 x 50= **3.53m^3**
Stabilisation anchors	It is anticipated that a stabilisation anchor will be needed for every 50m of pipeline. The minimum conceivable distance of pipeline will be 3400m and therefore 3400 ÷ 50 = 68 Small rock anchors are 25mm in diameter and 500mm long and up to six will be used at each of the 68 stabilisation anchors and therefore the volume of one is calculated using the following equation. Pi × (0.0125 x 0.0125) x 0.5 x 6 x 68= **0.1m^3**	It is anticipated that a stabilisation anchor will be needed for every 50m of pipeline. However it may be necessary to include more than this and so as a precaution these calculations will assume on stabilisation anchor every 25m. The maximum possible distance of pipeline will be 19600m and therefore 19600 ÷ 25 = 784 Small rock anchors are 25mm in diameter and 500mm long and up to six will be used at each of the 784 stabilisation anchors and therefore the volume of one is calculated using the following equation. Pi × (0.0125 x 0.0125) x 0.5 x 6 x 784= **1.15m^3**
Landing Platform / manifold Anchors	The landing platforms may need as little as eight large rock anchors to attach them to the seabed. The minimum anticipated number of landing platforms is 40. The minimum number manifolds will be 2 each requiring 16 large rock anchors therefore the minimum number of large rock anchors used in landing platforms and manifolds is: (8 x 40) + (2 x 16) = 352 Large Rock anchors are 0.05m in diameter and will be buried to a depth of 1.5m therefore the extracted material will be Pi × (0.025 x 0.025) x 1.5 x 352 = **1.04m^3**	The landing platforms may need up to 20 large rock anchors to attach them to the seabed. The maximum anticipated number of landing platforms is 50. The maximum number of large manifolds will be 8 each requiring 16 large rock anchors therefore the maximum number of large rock anchors required for landing platforms and manifolds is: (20 x 50) + (16 x 8) = 1128 Large Rock anchors are 0.05m in diameter and will be buried to a depth of 1.5m therefore the extracted material will be Pi × (0.025 x 0.025) x 1.5 x 1128 = **3.32m^3**

Table A5.2 Explanation of calculations for the volume of excavated rock (Table		
Parameter	**Explanation of Minimum volume (m^3)**	**Explanation of Maximum volume (m^3)**
HDD drilling		It is estimated the HDD bore holes will be drilled from 8 different points along the seabed. The distances of the bore holes are estimated to be a maximum of 1.5km, 1km, 0.7km, 0.7km, 0.8km, 1.2km, 1.2km and 0.7km in length. The diameter of the pipe as 0.9metres, but scaled up as the hole drilled will be larger than the pipe. The Total maximum amount of drilled material is calculated to be = **10127m^3**
Total with Surface Laid installation of Shore pipelines	**10214.14**	**12770.73**
Total with HDD installation of Shore pipelines		**22897**

Appendix 5.3

Project footprint calculations (onshore)

APPENDIX 5.3 Calculations for the onshore footprint of the proposed development

Table A5.3 Explanation of calculations for the area of disturbance or project footprint in the onshore environment

Parameter	Explanation of Minimum Area	Explanation of Maximum Area
Onshore pipeline Trench Area	The minimum distance from the common landing area to the hydroelectric station is 160m this is multiplied by a 20m as a construction corridor. Therefore 160 x 20 **= 320m^2**	The maximum distance from the common landing area to the hydroelectric station is 430m this is multiplied by a 20m construction area for 4 pipelines and the distance of 200m is used for the other 4 pipelines. Therefore (430 x 20 x 4) + (300 x 20 x 4) = **58400m^2**
Hydro-electric power plant compound	The hydro electric power plant compound will be **10,000m^2**	The hydro electric power plant compound will be **10,000m^2**
Temporary construction area	The Temporary construction area will be **6,000m^2**	The Temporary construction area will be **6,000m^2**
Access road construction/widening	The minimum area that is likely to be disturbed by the construction and widening of the access track will be approximately 7000m^2	The area that will be disturbed by the construction and widening of the access track will be **10707m^2.** This is a very cautious calculation as this value includes the area already occupied by the existing road and track (See Figure 5.2 in Chapter 5 Project description)
Shore access track	At a minimum one shore access track will be required which will be constructed from the hydro electric power plant to the shore. This track will be a minimum of 160km long and will have a construction footprint of approximately 10m width. therefore 160 x 10 = **1,600m**	Up to a maximum of 460 shore access track may be required (one track of 160 to go to the common landing point or drilling rig platform and a second track of up to 300m in length to provide access to a second landing point or drilling rig platform) each track will have a construction area of approximately 10m width. therefore (160 x 10) + (300 x 10) = **4600m^2**
Drilling rig Platform	The drilling rig platform will be an area 30m by 30m and there will be a minimum of 1 platform 30 x 30= **900m^2**	The drilling rig platform will be an area 30m by 30m and there will be a minimum of 1 platform 30 x 30 x 2= 180**0m^2**
Total with Surface laid Option	**31507**	**89707**
Total with HDD Option	**32407**	**91507**

Appendix 7.1

Site investigation survey report

Aspect Land & Hydrographic Surveys

Chartered Surveyors

Aspect Land & Hydrographic Surveys

Thornhouse Business Centre
Ballot Road, Irvine, Ayrshire KA12 0HW
Tel: 01294 313 399 Fax: 01294 313 389
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Web: www.aspectsurveys.com

SITE INVESTIGATION SURVEYS

SIADAR TO BRAGAR

ISLE OF LEWIS

SCOTLAND

FINAL REPORT

A4655

19th October 2010

COMPILED: C. D. Thomson
APPROVED: G. J. Campbell

Client:

Aquamarine Power Ltd
10 Saint Andrew Square
Edinburgh
Scotland
EH2 2AF

AQUAMARINE POWER

RICS · The Hydrographic Society UK · ICES · Achilles · Scottish Association for Marine Science · ISO 9001:2008 Registered Firm

Aspect
Land & Hydrographic Surveys
Chartered Surveyors

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6. Sub Bottom Profiling
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10. Personnel
11. Conclusions
12. Recommendations

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B. Horizontal and Vertical Positioning system precision
C. Multibeam Echosounder Calibration
D. Data Processing Procedures
E. Standard Disclaimer

1. Introduction

On the instructions of Aquamarine Power Ltd, multibeam bathymetric and sub bottom profiling surveys were conducted on the west coast of the Isle of Lewis between 18th August and 2nd September 2010.

The survey was to inform planning for the development of a wave energy project in the area.

The programme of events was as follows:

Mobilise to site	16-17 Aug 10
Tide gauge established at Carloway Pier	17 Aug 10
MBES and SBP Area 3 (Coastal Sensor)	18 Aug 10
MBES and SBP Area 4 (Remote Sensor)	18 Aug 10
MBES and SBP Area 3 (Coastal Sensor)	19 Aug 10
MBES and SBP Area 4 and 2 (Remote Sensor)	19 Aug 10
MBES and SBP area 2 (Remote Sensor)	20 Aug 10
Surveying Suspended due to Adverse Weather	20 Aug 10
MBES and SBP area 2 (Remote Sensor)	31 Aug 10
MBES and SBP Transit Lines (Remote Sensor)	1 Sep 10
MBES and SBP Transit Lines (Remote Sensor)	2 Sep 10
Demobilise	3 Sep 10
Processing and Deliverable Preparation	23 Aug – 14 Sep 10
Initial Presentation of Deliverables	6 Sep 10

Weather and sea conditions throughout the survey did not interfere with the quality of data but storm force 10 winds and subsequent heavy swells did force surveying to be suspended between 20th August & 31st August 2010. No survey operations were conducted during periods of unsuitable weather.

The survey was conducted using two vessels, Remote Sensor and Coastal Sensor. These vessels were based at Bragar throughout the works and launched and recovered daily as there were no suitable berthing facilities in the vicinity. This enabled the vessels to be on site in short order to commence surveys and make the most of available weather windows in this area which presents significant challenges due to powerful predominant Atlantic swells. The slipway at Bragar is in good condition and offers safe launch and recovery facilities in all but extreme low spring tides.

2. Description of Site / Geomorphology

The survey area stretches from approximately 13km to the south of the Butt of Lewis along the coast to Bragar in the south.

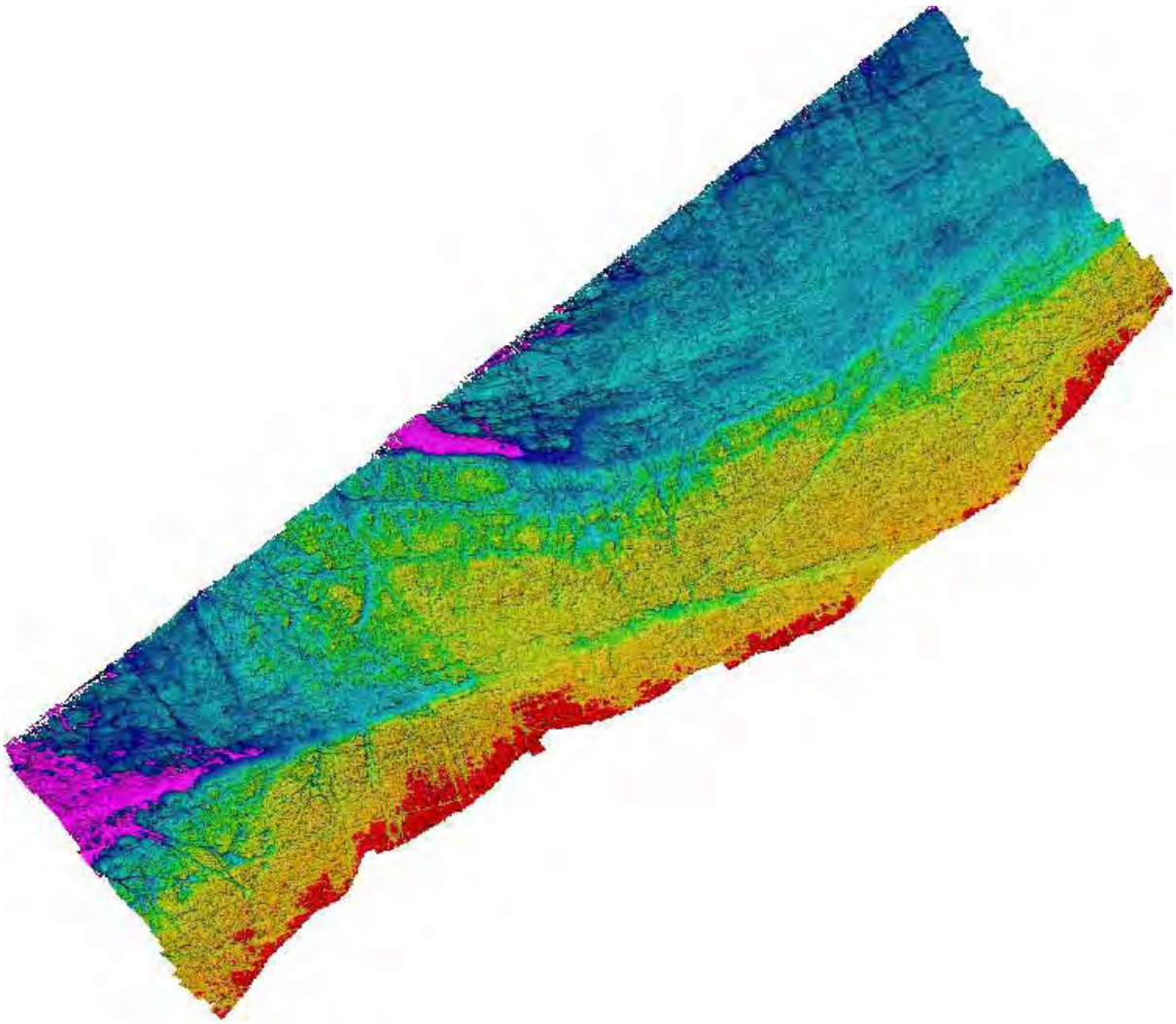
Published geological maps show that onshore bedrock comprises undifferentiated Lewisian gneiss of Pre-Cambrian age. These high grade metamorphic rocks have undergone a complex deformation history and are of widely variable composition.

Zones of associated rocks also occur within the gneiss and these include metadiorite, metatonalite, other metasedimentary and metavolcaniclastic rocks, granites and amphibolites. The general trend of these zones is northeast-southwest, i.e. roughly parallel to the current shoreline.

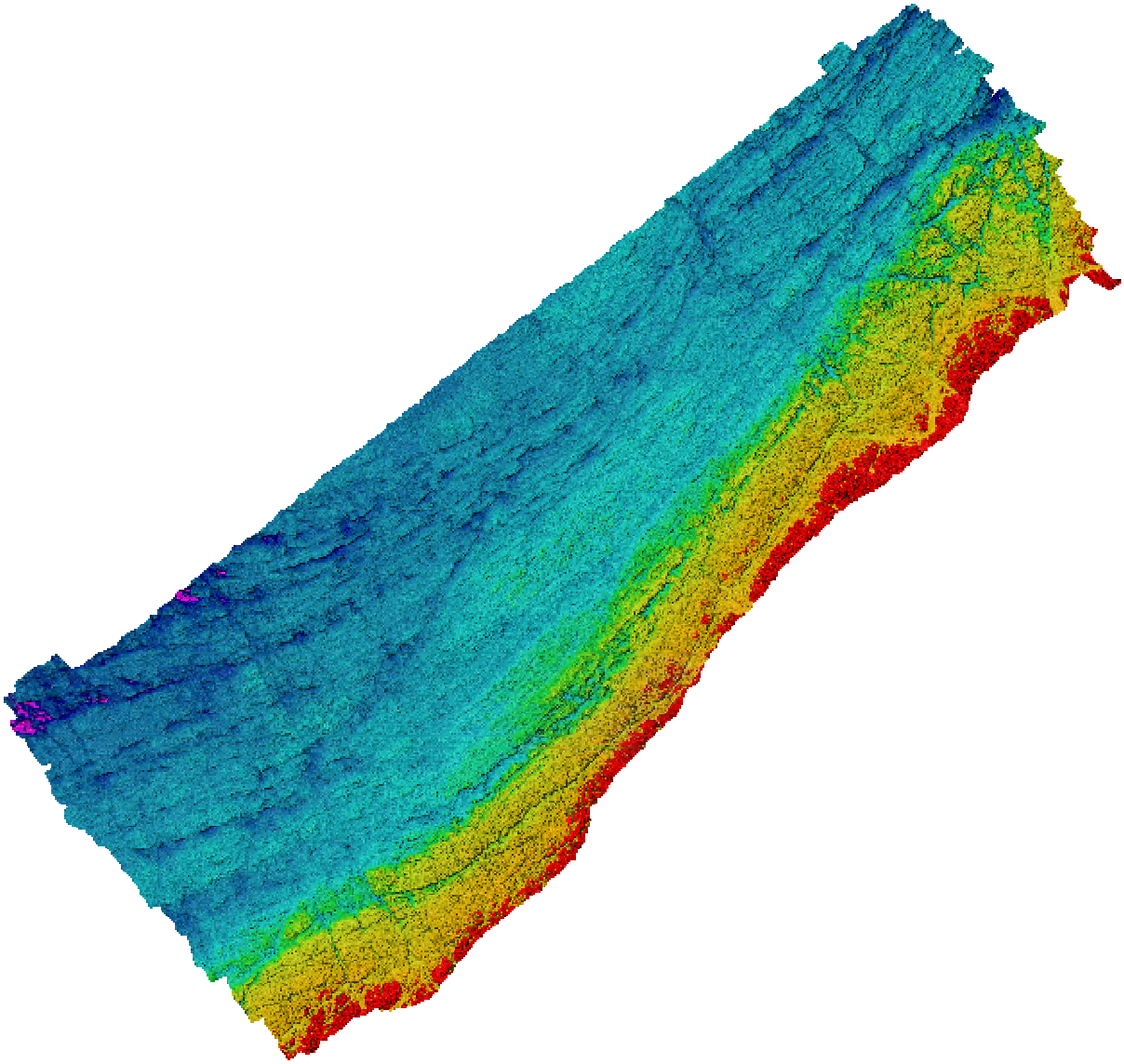
In general it can be expected that the main fabric in the gneiss will be dominated by foliation or banding. This strikes northeast-southwest which is the regional trend in this part of Lewis, i.e. parallel to the zones of rock outlined above. This main foliation fabric is cross cut by later faulting and jointing. All of these features are visible in the rocks that outcrop on the seabed in the areas surveyed.

The coastline is characteristically rugged and rocky with some areas of steep gravel beaches. The seabed is rugged and dominated by rocky outcrops. This rock is covered in places by thin coverings of gravel and sand particularly in the crevasses between shallower bare rock platforms.

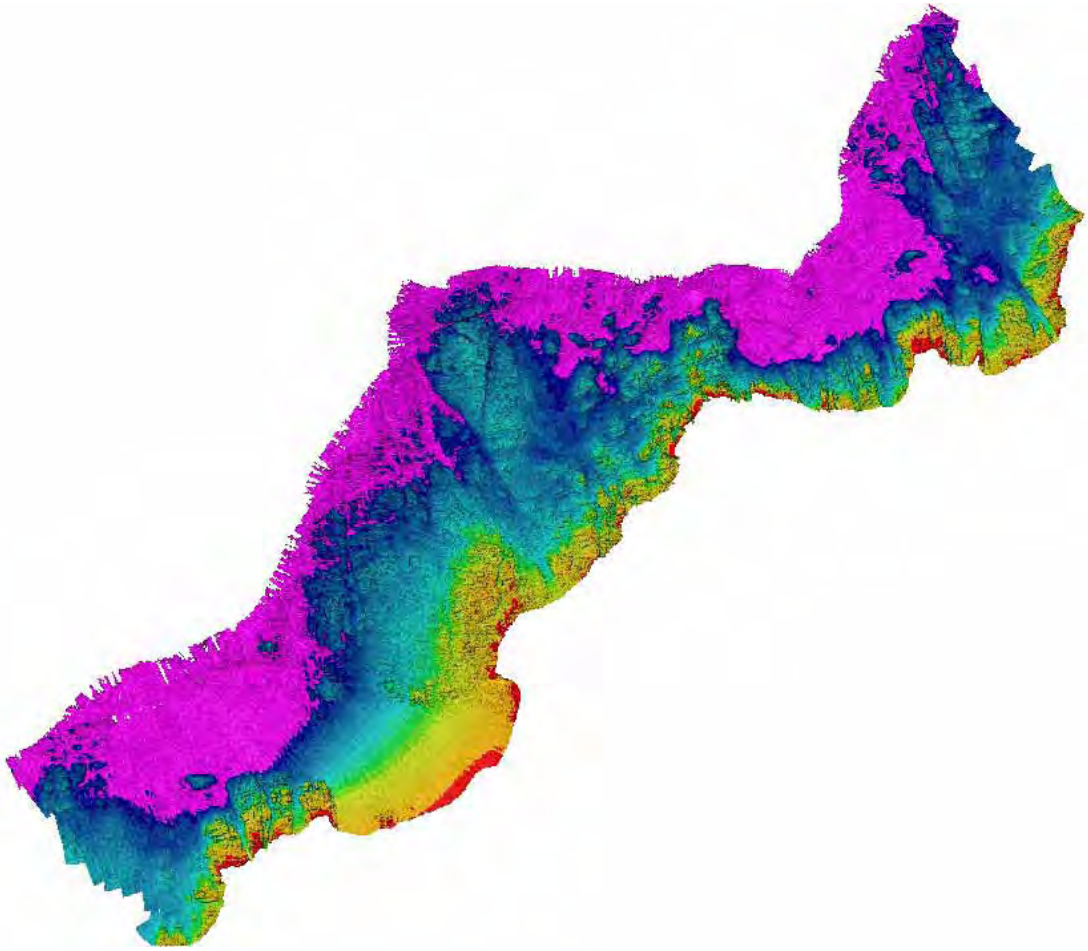
The graphics below depict the morphology of the areas. In these graphics magenta shows areas deeper than 20m CD and red highlights areas shallower than 8m CD. The only significant area of sand in the survey was towards the south of Area 2 in the bay at Shawbost.



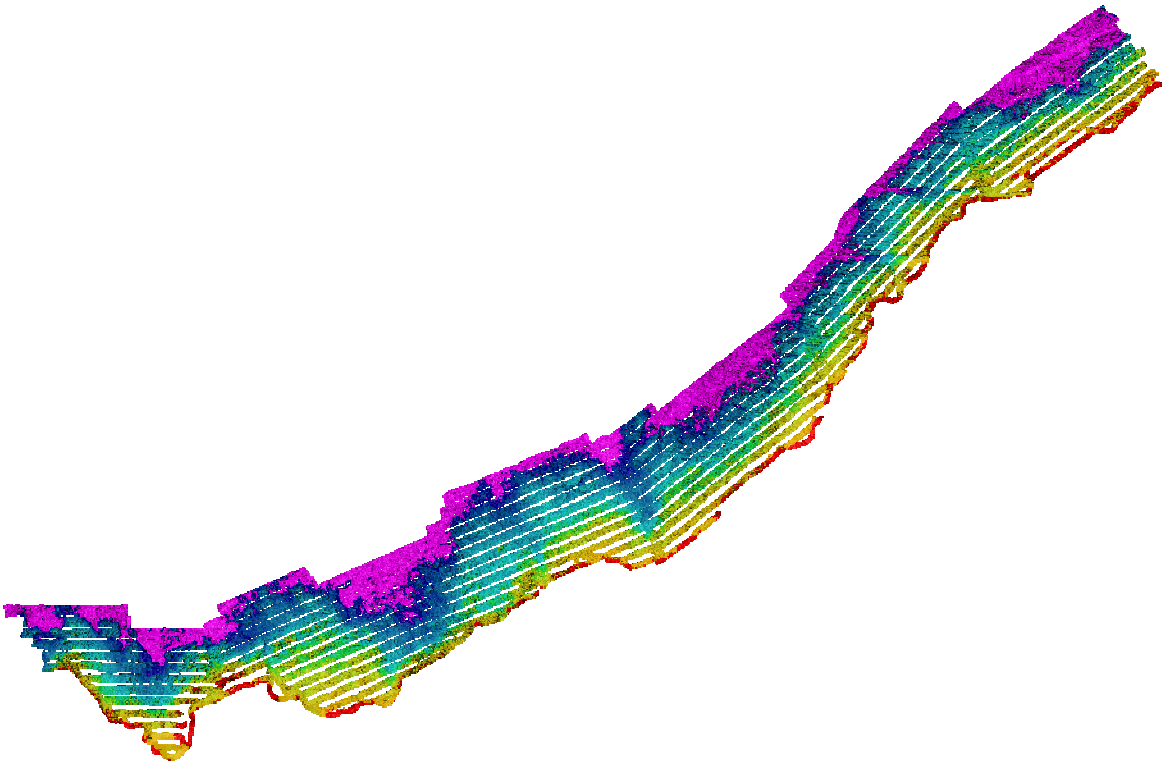
Area 3



Area 4



Area 2



Transit Area

3. Scope

The survey aimed to identify sites suitable for the deployment of wave energy devices. Even during the most benign weather during the conduct of the survey the high energy nature of this coastal environment was clearly evident with 2-3m rolling swells being almost constant throughout. Due to the high energy of this coast the majority of the seabed is characteristically rock. With the exception of a few larger patches of sandy or gravelly sediment any sediment evident in the area is only present in the cracks, faults and fissures between the metamorphosed rock making up the majority of the seabed.

This area was surveyed using the following sensors:

- Multibeam Echosounder to provide a high quality bathymetric model.
- Sub Bottom Profiler to provide an assessment sediment overburden.

4. Geodesy & Datum

Both Horizontal and Vertical control throughout the survey was established using RTK GPS. Trimble VRS Now network corrections were used throughout.

The horizontal datum used is OSGB36 (OSTN02 ™).

OSTN02™ defines OSGB36 National Grid in conjunction with the National GPS Network. In this respect OSTN02™ can be considered error free (not including any GPS positional errors). The agreement between OSTN02™ and the old triangulation network stations (down to 3rd order) is 0.1m rms.

The Vertical Datum used for all bathymetric data is Chart Datum. Chart Datum at Carloway (the nearest quoted port in Admiralty Tide Tables) is 2.20m below Ordnance Datum.

5. Bathymetric Survey

Bathymetric surveys were carried out over the area using two vessels. One of these utilised a Kongsberg EM3002 Multibeam Echosounder (MBES) and the other an R2Sonic 2024 MBES. Both of these are high resolution swathe echosounders with dynamically focussed beams.

These MBES are high-resolution seabed mapping and inspection systems meeting the most demanding standards for survey precision.

Two of our vessels were mobilised to Lewis and utilised for the data gathering, *Remote Sensor* an 8m catamaran and *Coastal Sensor* a 6.2m Cabin RIB which are designed and perfectly adapted for shallow water MBES surveys.

The EM3002 was controlled using Kongsberg SIS software online and data distributed from this to Hypack's Hysweep acquisition program. The R2Sonic was controlled through their Sonic Control software and data distributed to Hypack's Hysweep software.

SIS was used for the following aspects of the data gathering process:

- Control of the beam forming and steering both in transmit and receive modes
- Application of Sound Velocity in real time to allow for beam steering at the array face and ray tracing in the water column

The EM3002 system forms 254 discrete beams from a 130º x 1.5° pitch stabilised swathe. With these swathe characteristics 100% insonification of the seabed is achievable at vessel speeds of up to 10 knots in shallow water. Survey speeds during this work however did not exceed 5 knots due to the shallow nature and proximity of navigational hazards.

The R2Sonic is a 160° x 0.5° swathe. During survey operations the swathe width was limited to 130° in order to maintain maximum survey accuracy and to minimise noise in the outer beams. Again with this system 100% coverage of the seabed was achieved at speeds up to 10 knots but survey speeds were limited to no more than 5 knots to maintain accuracy and minimise noise.

Across track coverage of up to four times depth is possible with these systems.

Data was gathered with a planned insonification of 200% in Areas 2, 3 and 4. This allows online and post survey quality assurance checks to be carried out reliably. These were found in all cases to confirm the calibration values that were applied to the system.

In the Transit area between Areas 2 and 3 a line spacing of 100m was carried out resulting in less than 100% coverage of the seabed.

Essential motion compensation for the EM3002 MBES system was achieved using the Seatex MRU5 and for the R2Sonic with Coda Octopus F185R+. Both of these systems performed well throughout the survey. This data was thoroughly examined during the processing of the MBES data and no editing was required.

The MBES system was corrected for sound velocity using an online SV probe at the transducer face thereby allowing the system to electronically form and steer the beams accordingly to allow for refraction in the water column.

Additionally sound velocity dips were taken prior to commencing sounding and at intervals thereafter when the online sensor indicated that there was a difference exceeding $1ms^{-1}$ between the last SV cast and the current sound velocity at the transducer face. The full SV cast was used to correct for beam ray tracing.

Data gathering was done in Hypack and this system was then also used to post-process in the HySweep software. This allowed utilisation of RTK height for correction of the tidal variation during the data gathering phase. This system is used to process data and to form the x, y, z gridded product.

Details of data processing procedures are at Annex D.

6. Sub Bottom Profiling

An Edgetech 3100P (SB-216S Body) Sub Bottom Profiler was used for this survey. This sensor operates at either 2-10kHz, 2-12kHz or 2-16kHz frequency bands. The system was operated in its medium frequency mode (2-12kHz) which was found to achieve the best results in this shallow water environment.

Figure 6

The FM pulse is linearly swept over the full spectrum frequency range of 2-12kHz for 20 milliseconds. The towed body was secured alongside the survey vessel in order to maximise the distance between transducer and seabed, thereby optimising the possible penetration of the sub seabed before the first multiple of the seabed return.

Figure 7

Survey lines were run concurrently with the multibeam survey and line spacing is therefore a function of the depth of water for Areas 2, 3 and 4. In the transit areas the line spacing is 100m.

The offset between the SBP transducer reference point and the GPS antenna used for positioning was accurately measured in the field and applied in the Edgetech Discover software that was used to gather the Sub Bottom data.

Care was taken to tune the sub bottom profiler system so as to ensure its performance over the range of depths in this survey and over the varying seabed types.

Areas 2, 3 & 4 - General Geology Underlying The Adjacent Land Onshore

Areas 3 & 4

In these areas the main foliation\banding fabric is visible and can be seen trending northeast-southwest, i.e. roughly parallel to the shoreline. It is particularly clear in the deeper water offshore (blue).

Both areas are cross cut by joints which can be seen where the bedrock has been preferential weathered and eroded, and relatively straight, narrow channels have been cut into the rock surface. The dominant trend of the joints is northwest-southeast, i.e. normal to the shoreline, however joints in other orientations occur. A selection of joints is highlighted on the figures to show their general trend and orientation.

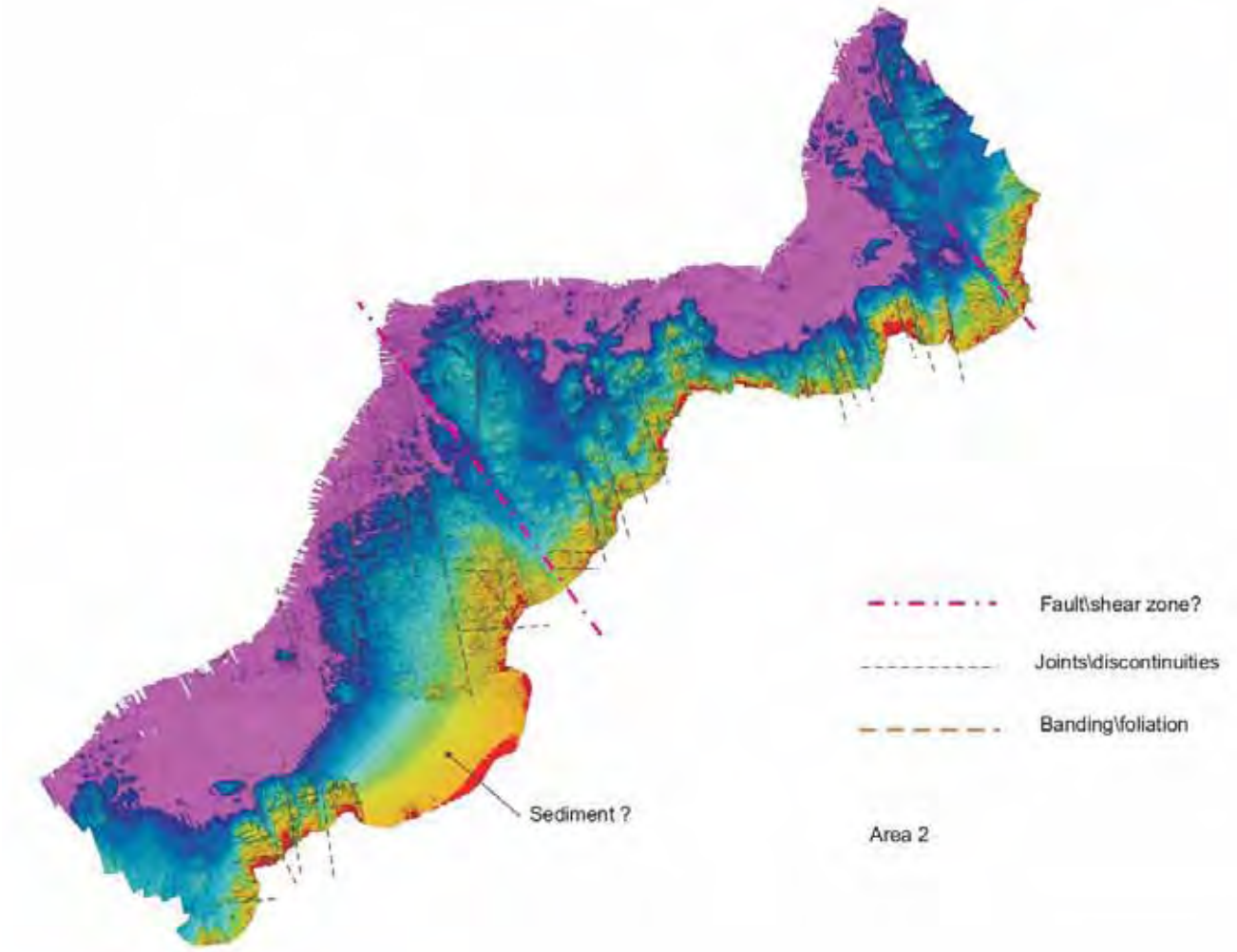
In Area 3 a distinct linear feature can be seen trending ENE-WSW across the area. This probably represents a fault zone or shear zone that has been preferentially weathered and eroded. At the extreme southwestern end of the area, a deep channel has been eroded into bedrock at the southwestern end of this feature. Another linear feature can be seen trending northeast-southwest across Areas 3 and 4; this too probably represents a fault zone or shear zone cutting across the dominant foliation fabric.

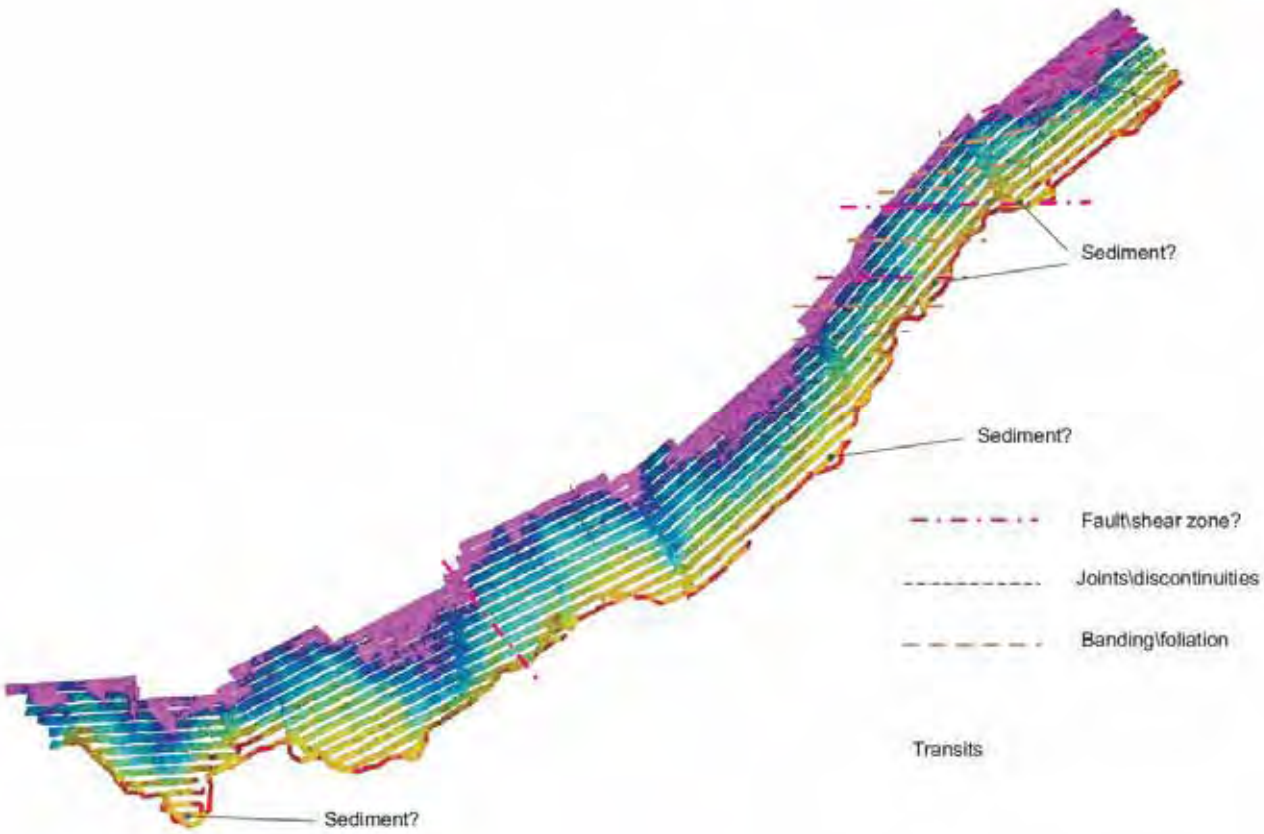
Transits (Area between Areas 2 and 3)

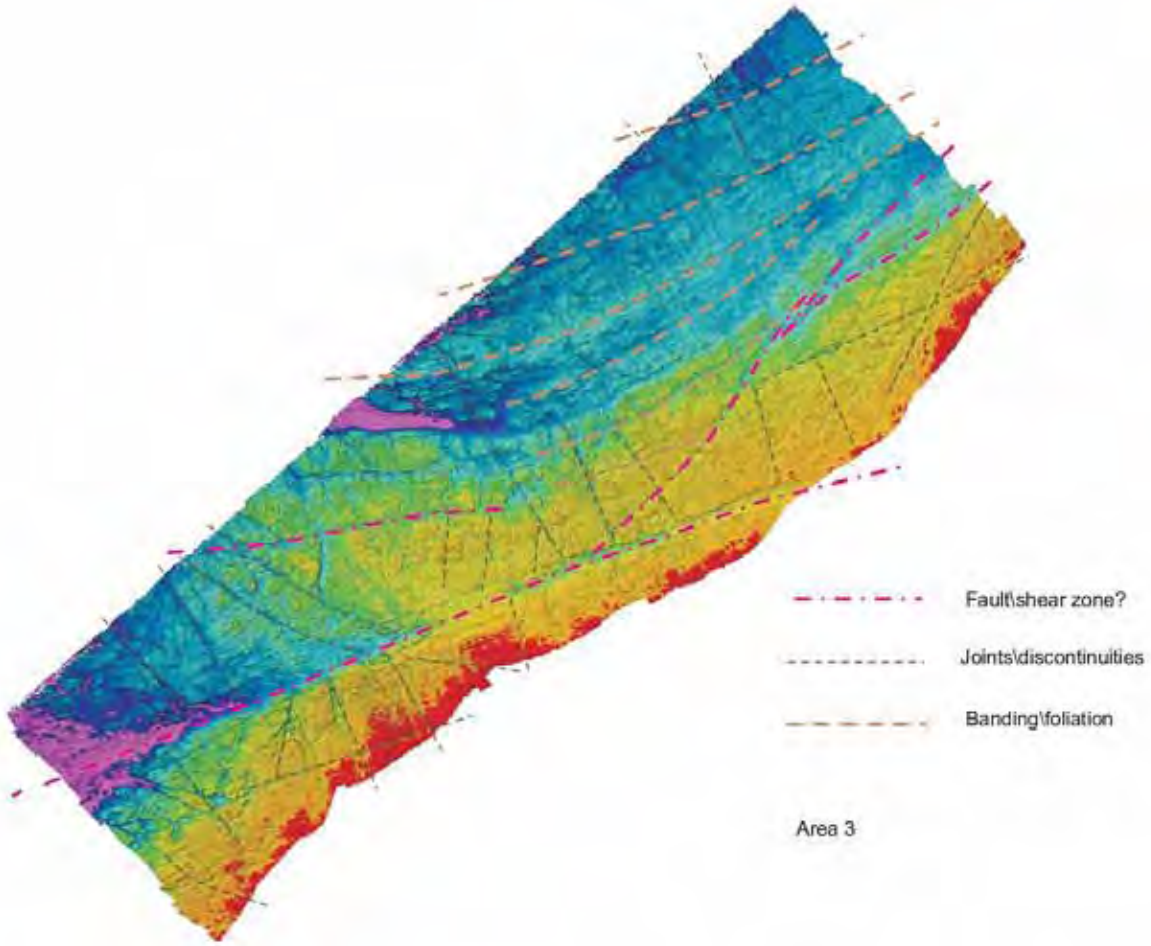
The distinct linear feature (fault zone\shear zone) visible at the southwestern end of Area 3 extends into this area as shown. Also at the northern end of the area the foliation fabric can be seen in the rock and in this area it strikes east-west – at the extreme northeastern end of the area it may be swinging into a more ENE-WSW orientation similar to Areas 3 and 4 to the north. At a number of locations more prominent, wider linear features can be seen trending east-west and these probably represent fault zones or shear zones that have been preferentially weathered and eroded. In places these features appear to be infilled with recent sediment (SAND). At its southwestern end (near Area 2) bedrock is exposed over the sea bed however a strong foliation fabric is not visible as is the case in Areas 3 and 4. It is possible that bedrock in this area (and Area 2) is different from that further to the northeast and it is composed predominantly of igneous type rocks (granites, amphibolites etc).

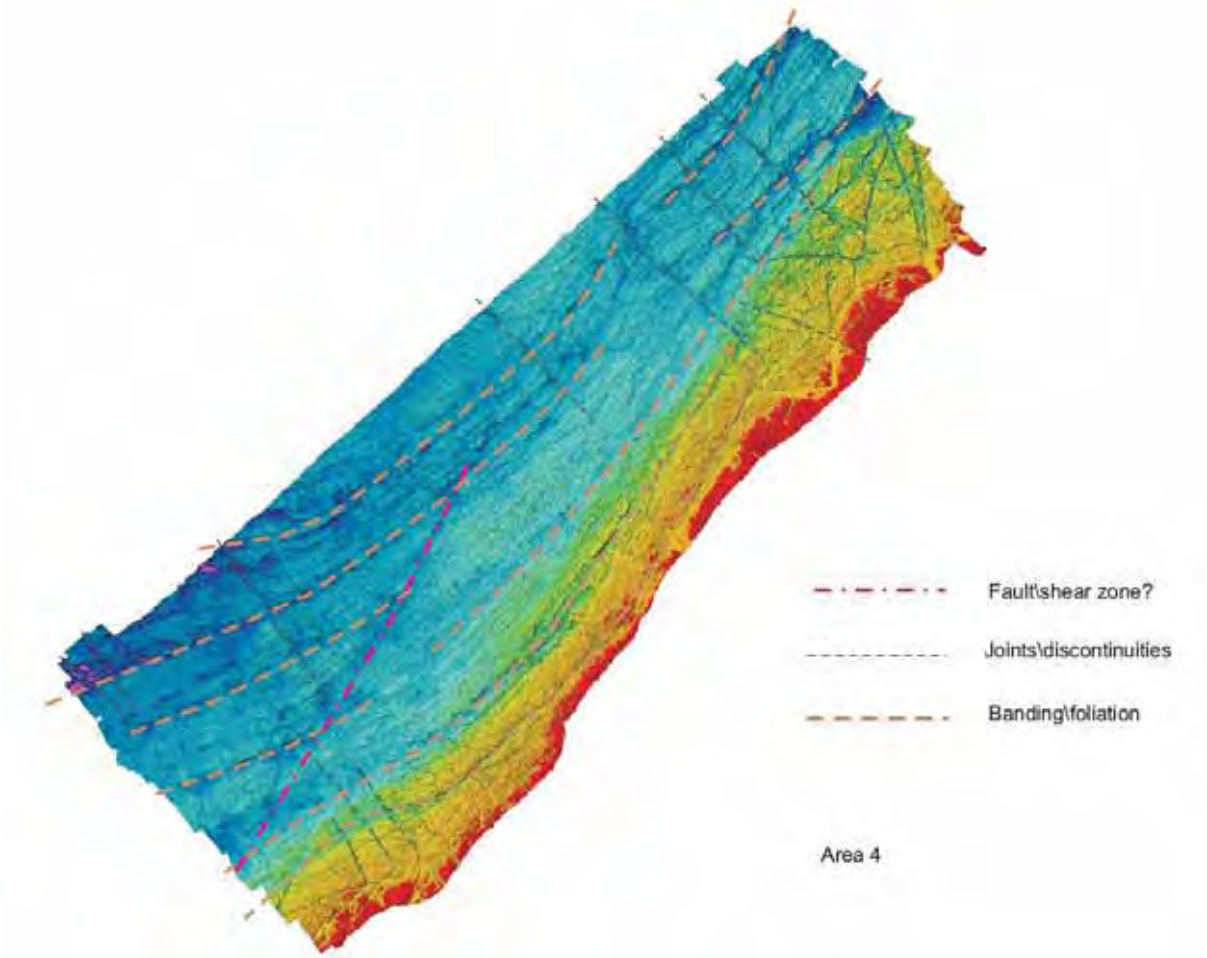
Area 2

The foliation\banding fabric is much less obvious in this area however jointing can be seen as indicated, with the dominant trend of the joints striking NNW-SSE, though again as in Areas 3 and 4 joints in other orientations occur. At a number of locations more prominent, wider linear features can be seen trending northwest-southeast and these probably represent fault zones or shear zones that have been preferentially weathered and eroded.
The rock surface (characterised by grooves and channels preferentially eroded along discontinuity planes) cannot be seen in the area indicated on the figure and it is likely that bedrock is covered by sediment (SAND) at this location.

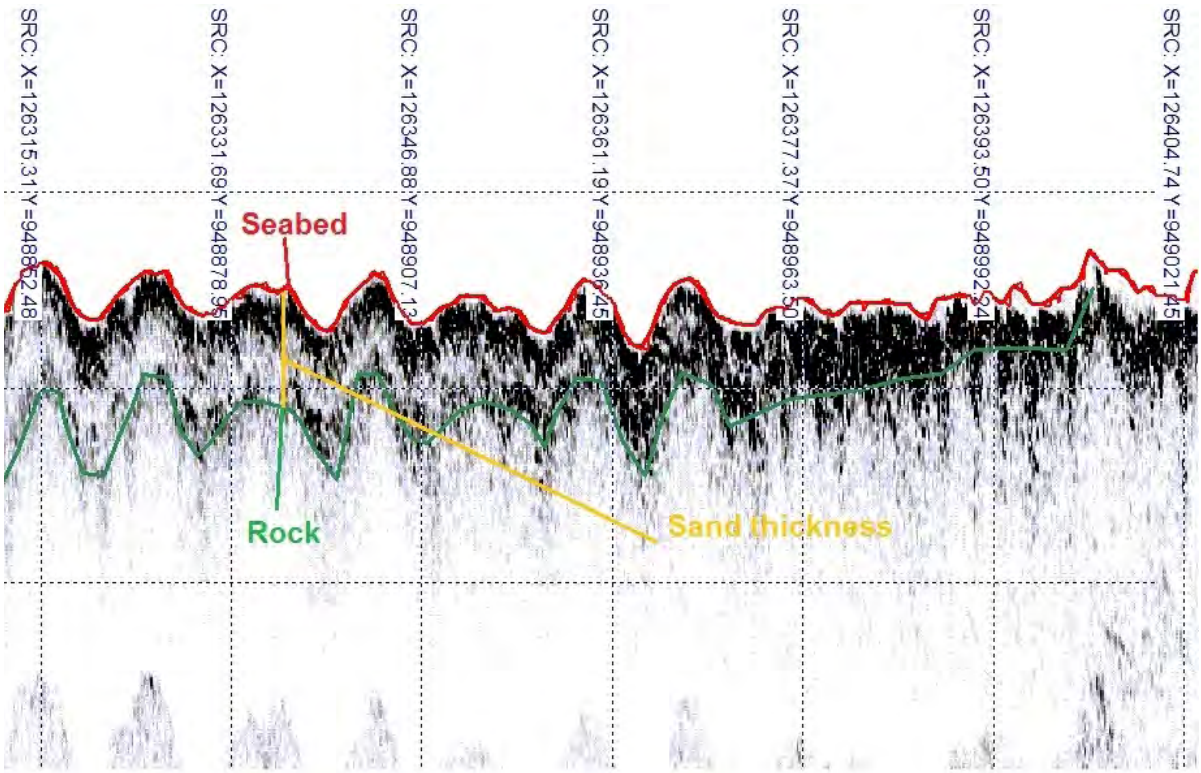



Sediment?
Sediment?
Fault\shear zone?
Joints\discontinuities
Banding\foliation
Transits
Sediment?

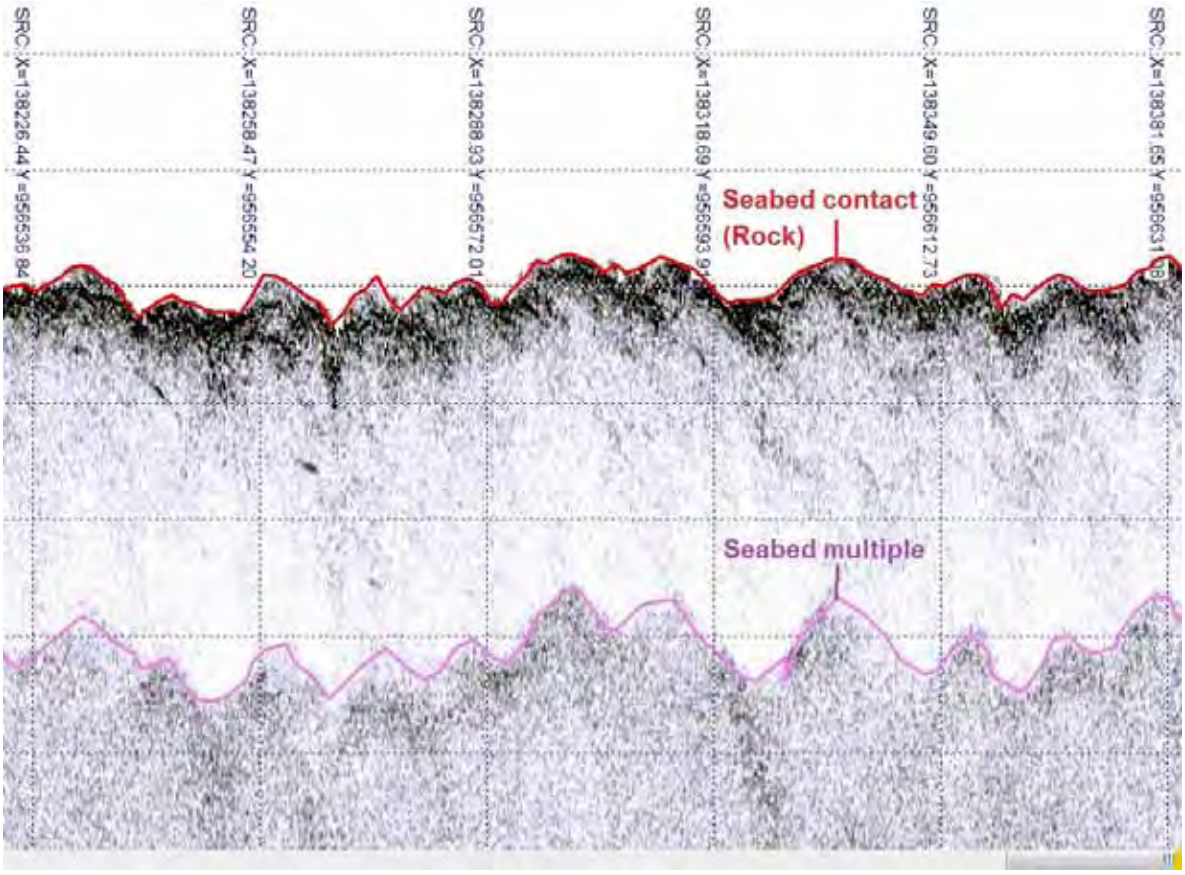

Fault\shear zone?
Joints\discontinuities
Banding\foliation
Area 3



The graphics below show examples of the seabed types encountered during the survey.



Seabed penetration in excess of 3.0m through SAND.



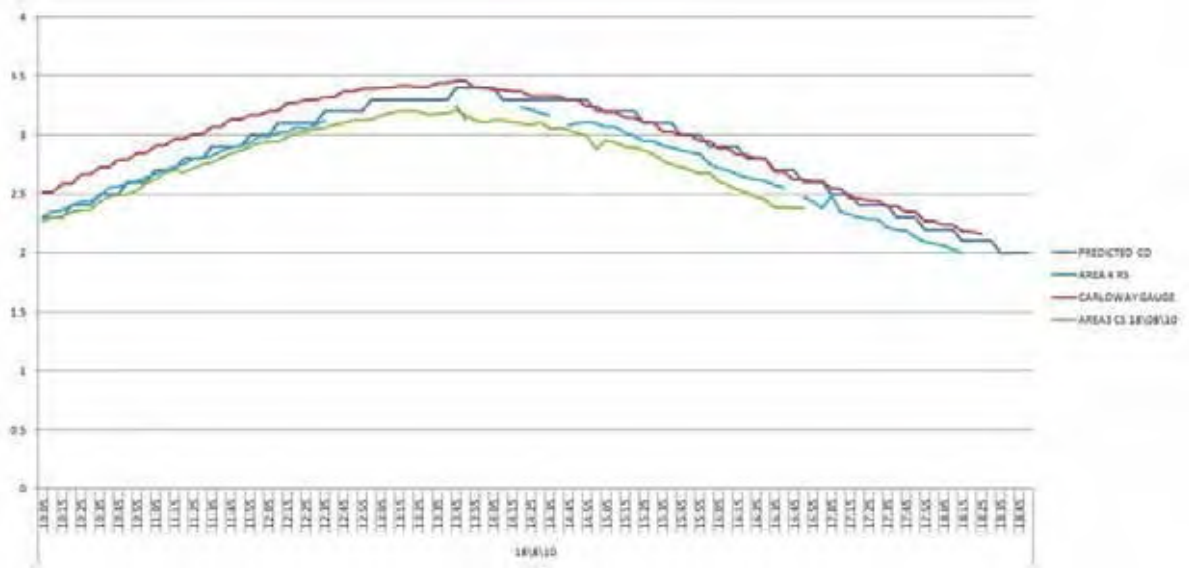
Hard seabed contact (ROCK) with multiple reflector

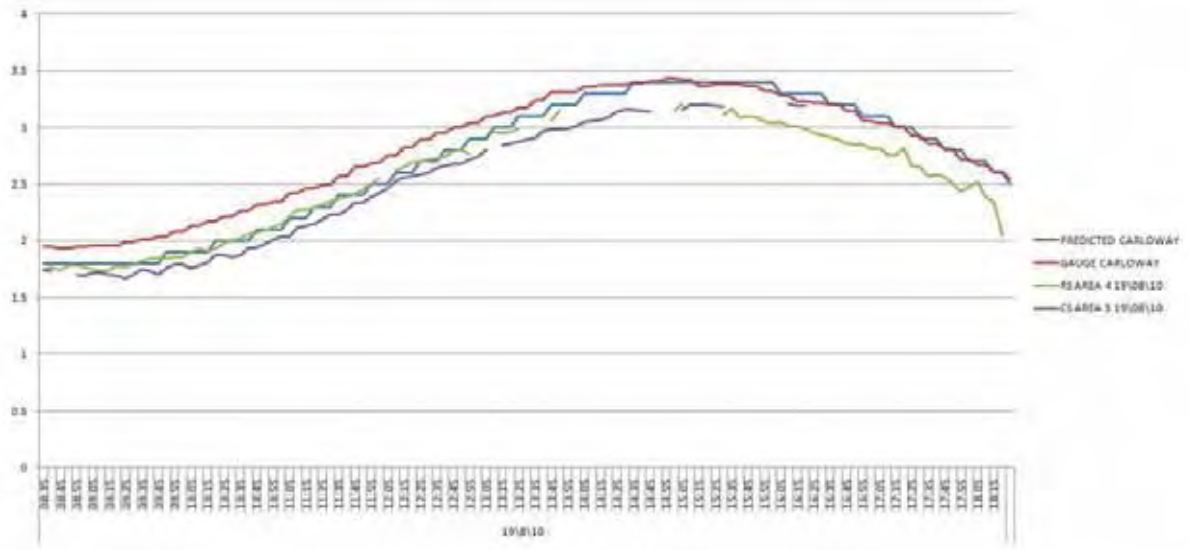
The sub bottom interpretation is an informed opinion and should therefore be used with caution until some further diver or ROV investigation can be undertaken to verify the nature of the sub seabed more confidently.

7. Tidal Height Measurement

A Valeport Tidemaster direct pressure recording tidegauge was deployed at Carloway pier 17 Aug 10. Data was gathered using this gauge over a period of 36 hours and this has been compared to tidal data gathered on site during survey operations. This gauge was not referred accurately to datum at Carloway and therefore has only been used to assess time and range differences in the tide at the survey site in comparison to that at Carloway.

The graphics below show broadly that the range and time appears similar at the sites as at Carloway. There may however be a shift in the OD/CD offset but assessment of this would require longer period tidal observations at the site and comparison with locally established control in that area.





8. Vessel

The vessels used for the hydrographic survey were Aspect Surveys, Remote Sensor, an 8m catamaran of fibreglass construction and Coastal Sensor a 6.2m cabin RIB. Both vessels are certified Cat III by the Maritime and Coastguard Agency for work up to 20nm offshore.

The ease of launch and recovery, good transit speeds and manoeuvrability of these vessel ideally suited it to survey these waters. The vessels were launched and recovered daily at Bragar to minimise transit time and maximise time on site.

REMOTE SENSOR

COASTAL SENSOR

9. Survey Standards

The Hydrographic surveys of Areas 2, 3 and 4 are considered complete to International Hydrographic Organisation Special Order standard, with a Full Sea Floor Search being achieved as per IHO publication S44, Table 1.

The survey of the Transit areas is considered incomplete to modern standards due to the wide line spacing and lack of 100% insonification of the seabed.

10. Personnel

The following personnel were involved during the survey:

Hydrographic Data Gathering

NAME	POSITION
G.J. Campbell	Party Chief
C. Thomson	Surveyor
G.T. Campbell	Surveyor
C. Stephenson	Surveyor

11. Conclusions

The data-gathering portion of the survey progressed smoothly and good quality useable data was gathered from all deployed sensors.

The MBES survey shows clearly the rocky nature of the seabed over the majority of the site and is being used to focus attention on the processing of the sub bottom information to the isolated areas where sand lenses may be present.

The sub bottom survey shows that most of the area is characterised by rock outcropping or rock near to the surface of the seabed overlain by either sand or gravel.

Annex A to
A4655
Dated 15 Sep 10

Drawing Register

Title	Content
Area 2_MBES_PDF	PDF files of multibeam bathymetry (Area 2)
A4655_2_Bathy_Final.dwg	AutoCAD file of multibeam survey (Area 2)
A4655_2_Final_0_5m.XYZ	XYZ file at 0.5m grid intervals (Area 2)
A4655_2_Final.Scene	Fledermaus Viewing File (Area 2)
A4655_2_Final.SD	Fledermaus Viewing File (Area 2)
Area 3_MBES_PDF	PDF files of multibeam bathymetry (Area 3)
A4655_3_Bathy_Final.dwg	AutoCAD file of multibeam survey (Area 3)
A4655_3_Final_0_5m.XYZ	XYZ file at 0.5m grid intervals (Area 3)
A4655_3_Final.Scene	Fledermaus Viewing File (Area 3)
A4655_3_Final.SD	Fledermaus Viewing File (Area 3)
Area 4_MBES_PDF	PDF files of multibeam bathymetry (Area 4)
A4655_4_Bathy_Final.dwg	AutoCAD file of multibeam survey (Area 4)
A4655_4_Final_0_5m.XYZ	XYZ file at 0.5m grid intervals (Area 4)
A4655_4_Final.Scene	Fledermaus Viewing File (Area 4)
A4655_4_Final.SD	Fledermaus Viewing File (Area 4)
Transit Area_MBES_PDF	PDF files of multibeam bathymetry (Transit Area)
A4655_Transit_Bathy_Final.dwg	AutoCAD file of multibeam survey (Transit Area)
A4655_Transit_Final_0_5m.XYZ	XYZ file at 0.5m grid intervals (Transit Area)
A4655_Transit_Final.Scene	Fledermaus Viewing File (Transit Area)
A4655_Transit_Final.SD	Fledermaus Viewing File (Transit Area)
A4655_Area 2_SBP.dwg	AutoCAD file of geophysical survey (Area 2)
A4655_Area 2_CD.jpg	JPEG image of geophysical survey (Area 2)
Area_2_SBP_Images	Folder containing geophysical data imagery (Area 2)
A4655_Area 3_SBP.dwg	AutoCAD file of geophysical survey (Area 3)
A4655_Area 3_CD.jpg	JPEG image of geophysical survey (Area 3)
Area_3_SBP_Images	Folder containing geophysical data imagery (Area 3)
A4655_Area 4_SBP.dwg	AutoCAD file of geophysical survey (Area 4)
A4655_Area 4_CD.jpg	JPEG image of geophysical survey (Area 4)
Area_4_SBP_Images	Folder containing geophysical data imagery (Area 4)
A4655_Transit Area_SBP.dwg	AutoCAD file of geophysical survey (Transit Area)
A4655_Transit Area Image_CD.jpg	JPEG image of geophysical survey (Transit Area)
A4655_Transit Area_SBP_Images	Folder containing geophysical data imagery (Transit Area)

Annex B to
A4655
Dated 15 Sep 10

Horizontal & Vertical Positioning System Precision

TRIMBLE MS860 Geodetic grade GPS Receiver and Heading system, and the CODA Octopus F185R+ Inertially aided system both using RTK corrections.

	HORIZONTAL ACCURACY	VERTICAL ACCURACY
REAL TIME KINEMATIC	±10mm + 1ppm RMS	±20mm + 1ppm RMS

All horizontal positions in the survey are referred to National Grid Coordinates OSGB36 (OSTN02™).

The published Chart Datum value at Carloway (2.20m below Ordnance Datum) has been applied to the hydrographic data surveyed at Siadar and Bragar.

Multibeam Echosounder Calibration

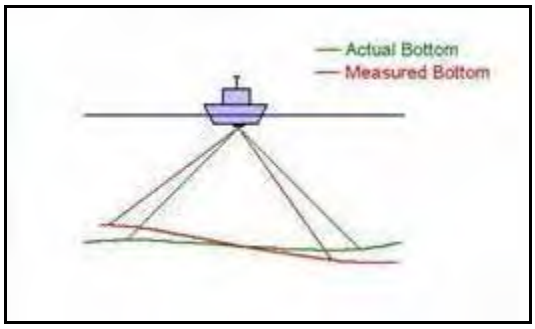
Patch tests are tests which are performed after initial equipment installation, and periodically thereafter as well as if sensors are modified, to quantify any residual biases from the initial system alignment.

During this calibration series, four separate tests must be performed to determine residual alignment biases for:

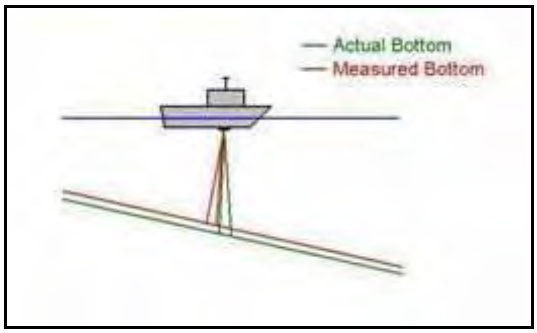
- Roll offset
- Position Time Delay (Latency)
- Pitch Offset
- Yaw (Heading) Offset

Errors relating to Multibeam

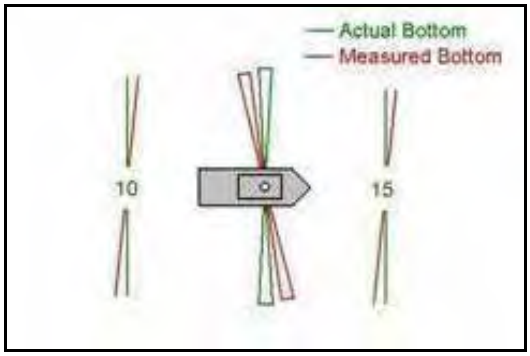
Roll: Sonar and Motion Reference Unit (MRU) alignment relative to vertical.
Can cause large depth and position errors at outer beams.



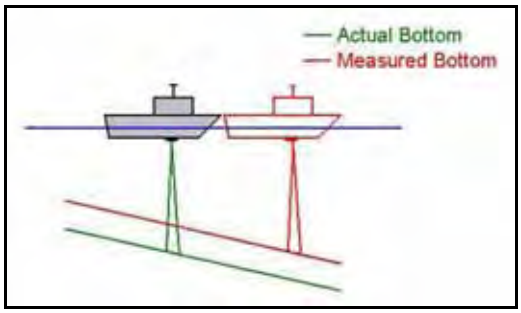
Pitch: Sonar and MRU alignment relative to vertical.
Can cause depth and position errors across the swath.



Yaw (Heading): Sonar and MRU alignment relative to vertical
Can cause depth and position errors across the swath.



Latency: The delay between position and fix transmission.
Will cause positional errors.
Error is independent of multibeam system.

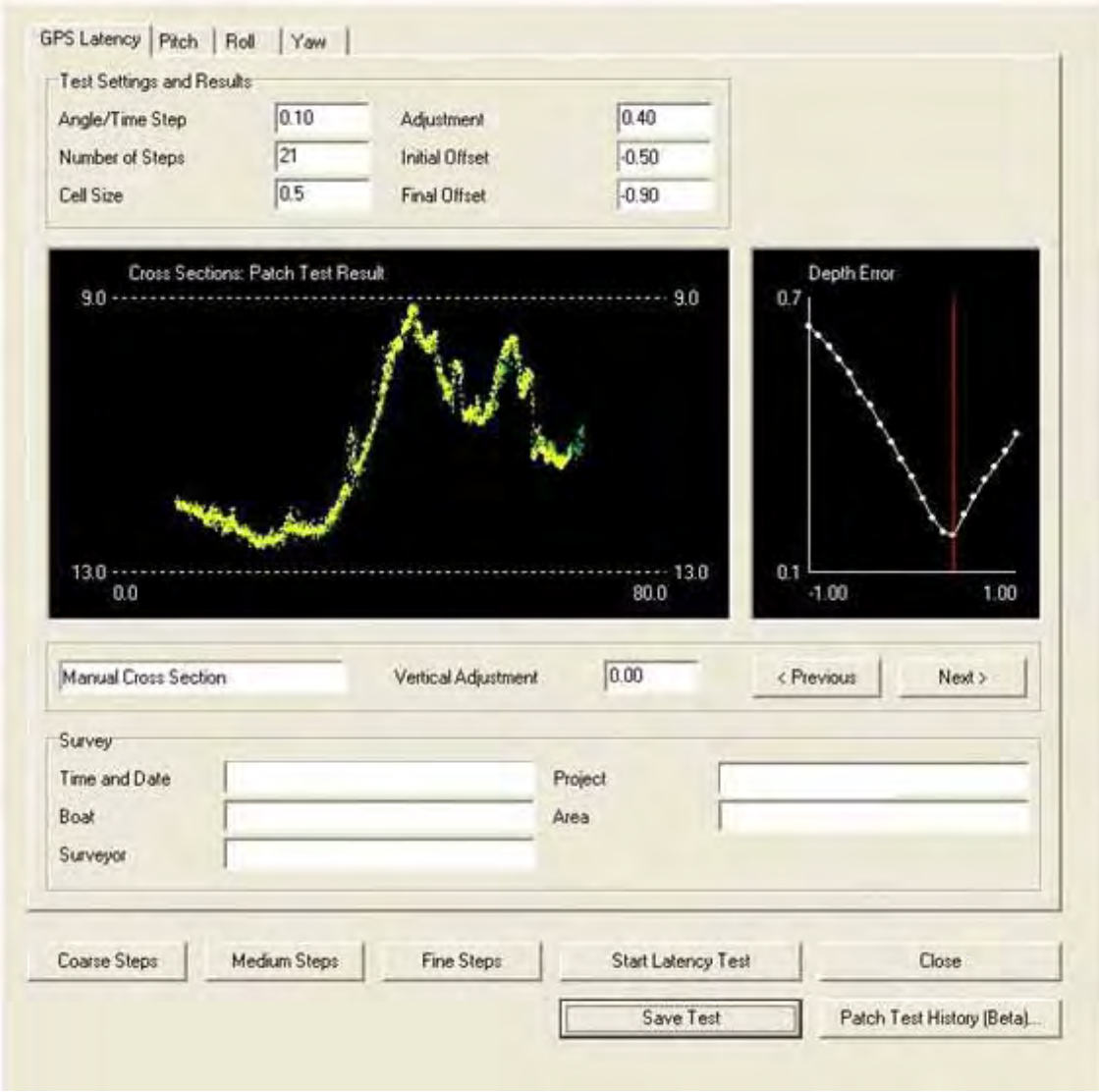


Calibration

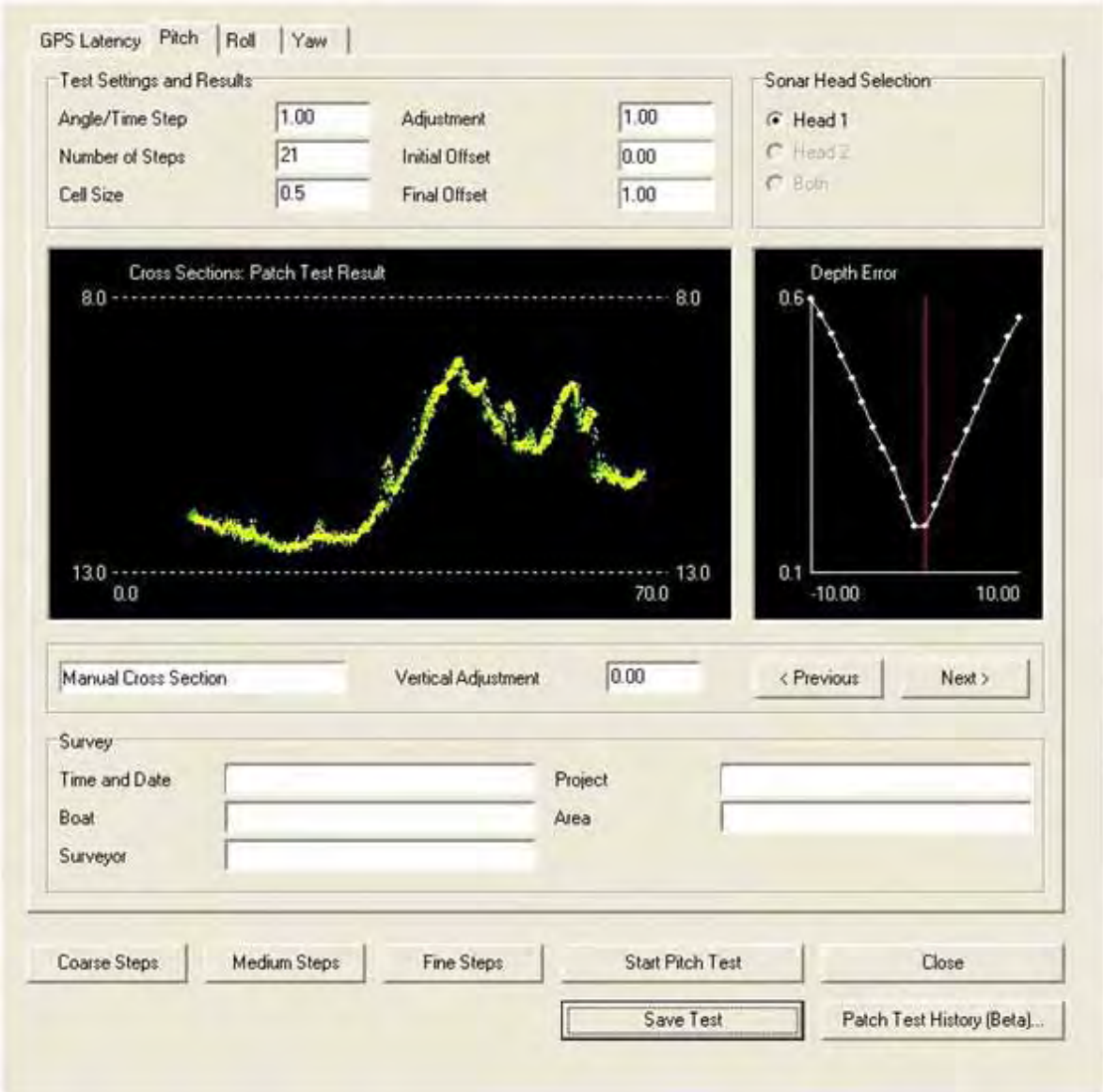
Patch Testing was performed on 18 August 10.

The calibration details are as follows:

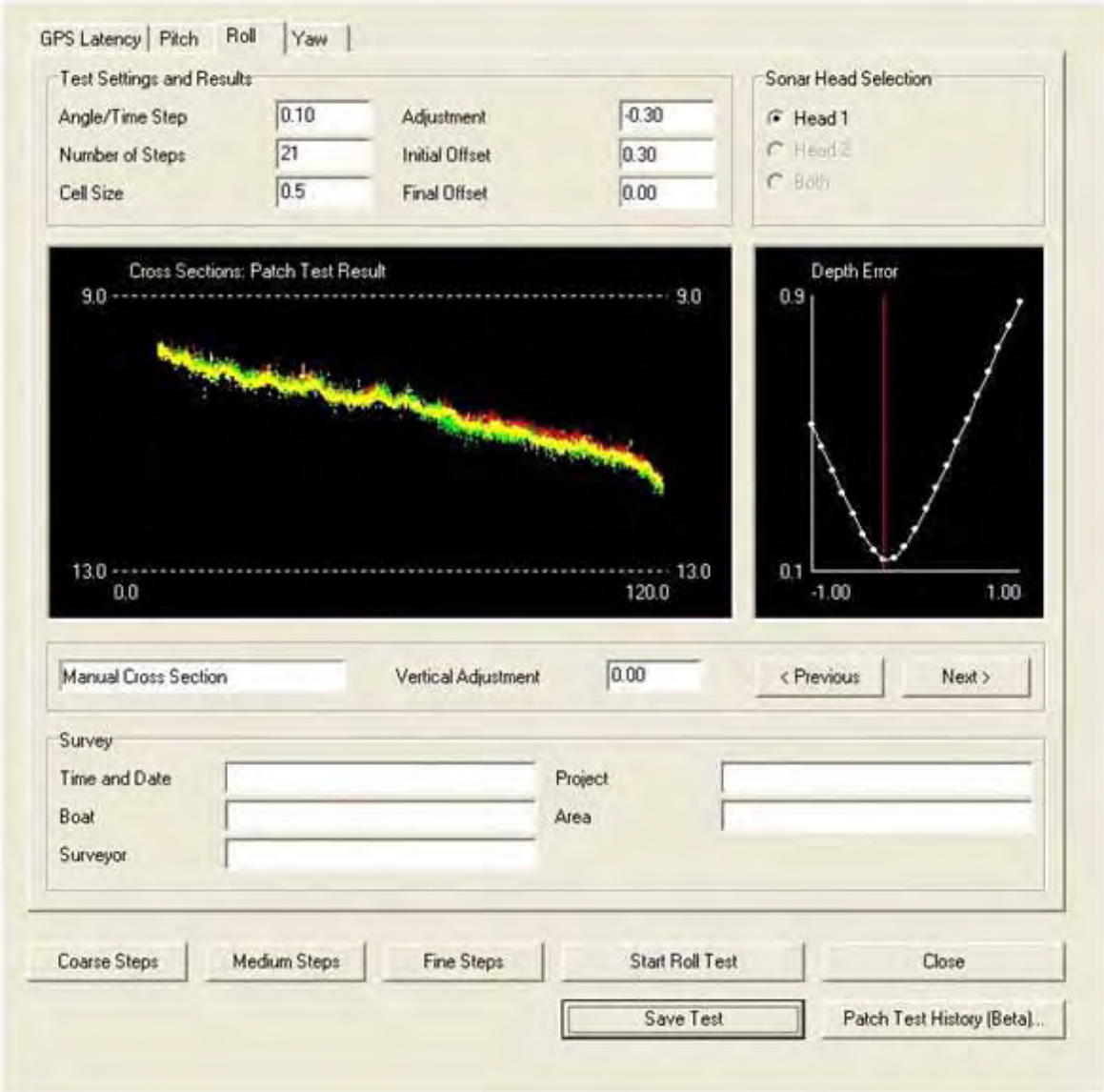
GPS Latency - 18/08/2010



Pitch - 18/08/2010



Roll - 18/08/2010



Yaw - 18/08/2010

Annex D to
A4655
Dated 15 Sep 10

Data Processing Procedures

Bathymetric Data

Multibeam Processing Stages

EM3002 - Kongsberg SIS software was used to control the MBES system during the data gathering phase. Data was simultaneously logged in Kongsberg SIS and HYPACK HYSWEEP software to ensure data redundancy were a computer to fail.

R2Sonic 2024 – The Sonic 2024 was controlled via the Sonic Control 2000 program. Data was logged in Hypack during the data gathering phase.

After data gathering all data was post processed in HYPACK MBMax where the following stages of processing were undertaken:

- Navigation data was processed.
- Motion Sensor data was examined and edited as required.
- Automatic filtering of the data was carried out.
- Individual lines of MBES sounding data were manually edited.
- Processed files were loaded into Fledermaus visualisation and editing software and fully quality assured before being unloaded back to Hypack.
- The data was gridded at an appropriate post spacing for the scale of plot requested by the client. This was exported to AutoCAD for presentation.
- The data was contoured at 1m intervals in Hypack and exported to AutoCAD.
- X,Y, Z, files at 0.5m post spacing were generated and exported in Hypack. These higher density data files will be rendered to the client in ASCII X,Y,Z format.

Data was then transferred to Fledermaus for quality control and preparation of 3D visualisations.

Sub Bottom Profiler Data

The SEG-Y data gathered by the Edgetech 3100P 2-10KHz sub bottom profiler was processed in Chesapeake SonarWiz.MAP software. The following stages were undertaken:

- SEG-Y data was imported to the software.
- The Gain and Time Variable Gain settings were adjusted to ensure that the best possible picture of the sub bottom data was available to the user.

- Each individual horizon was digitised including:
  - Surface
  - Sediment horizon 1
  - Sediment Horizon 2
  - Isolated Reflectors - Point Hyperbolae sonar returns within the sediment
  - Rockhead / Glacial Till

- Each horizon was referenced to the Multibeam Bathymetry to ensure a coherent record.

- Individual horizons were exported to McCarthy Taylor Systems LSS (3D modelling software) where it was gridded, contoured and prepared for export to AutoCAD.

- Drawing files prepared in AutoCAD to represent the deliverables requested by the client.

- SEG-Y data was saved to DVD as requested and rendered to the client.

Annex E to
A4655
Dated 15 Sep 10

Standard Disclaimer

1. All client-supplied data is taken on trust as being accurate and correct, and the sub contractor cannot be held responsible for the quality and accuracy of that data set.

2. Geophysical interpretation of bathymetry and sonar is based on an informed opinion of the supplied data, and is subject to inherent errors outwith the control of the interpretational geophysicist, which include but are not limited to GPS positioning errors, navigation busts, data quality, assumed speed velocity sediment profiles in the absence of Geotechnical data, sub bottom profile pulse width, and induced scaling errors therein associated with seismic signature. Seabed geomorphology and sub seabed geology should be further investigated by visual or intrusive methods.

3. The limits of this survey are defined by the data set; outwith the survey limits are not covered at any level by the sub contractor.

4. The data is accurate at the time of data acquisition, the sub contractor cannot be held responsible for environmental changes, and the client by accepting this report accepts that the environment of the seabed is subject to continuous change, that items of debris, hard contacts etc. may move, appear, be relocated or removed, thickness of surficial sediment change out with the knowledge of the sub contractor and they will not be held responsible for such actions at any level.

Appendix 7.2

Met Ocean data

Hebridean Marine Energy Futures
Lews Castle College
Stornoway
Isle of Lewis
HS2 0XR
Tel. 01851 770 325

Waverider buoy report for three months period covering October-December 2011

31 January 2012

1. Locations of Waverider buoys

There are currently three Datawell Waverider buoys deployed off the Isle of Lewis. The exact locations are shown in figure 1 and WGS84 coordinates are 58°22.500'N 007°02.580'W, 58°30.000'N 006°43.500'W and 58°25.752'N 006°54.798'W for Waverider buoy 2 (Roag), buoy 1 (Siadar) and buoy 3 (Bragar) respectively.

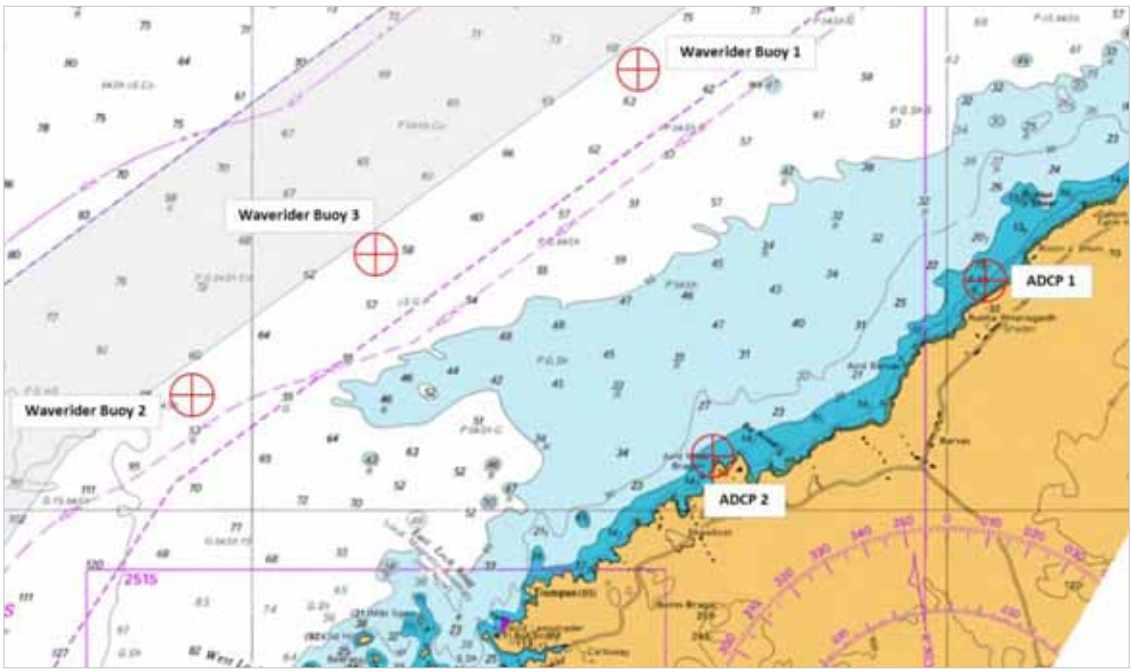


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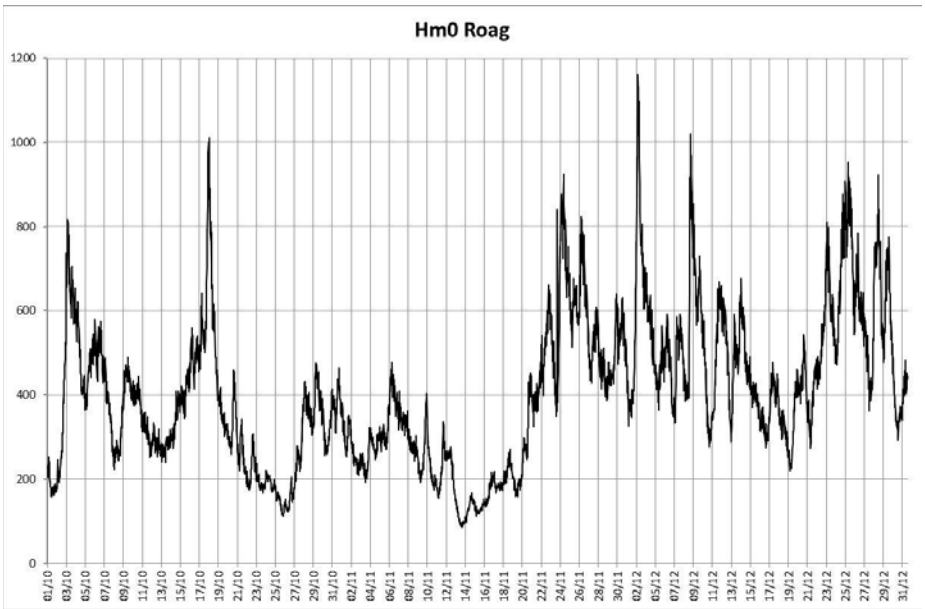
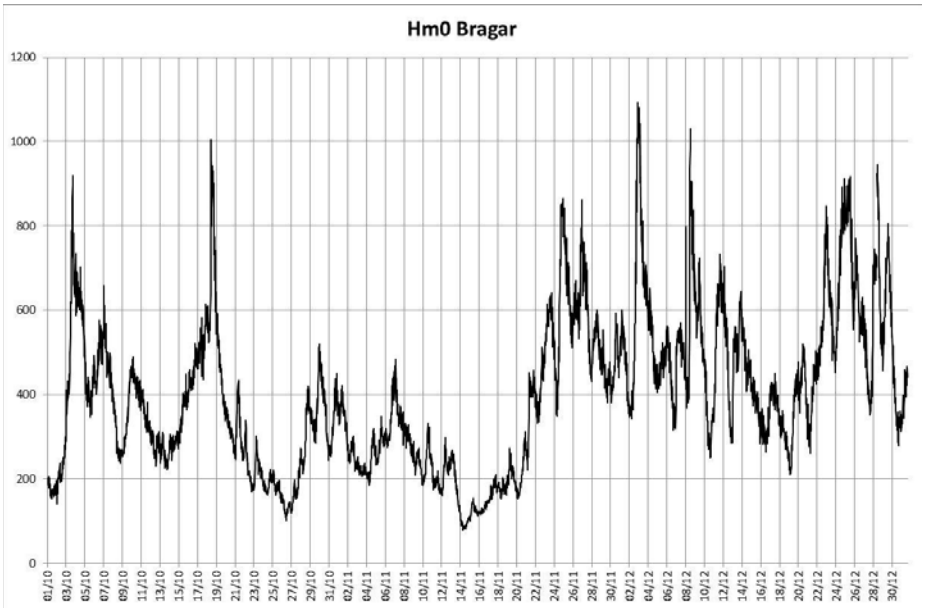
Figure 1 – Locations of Datawell Waverider buoys off Lewis

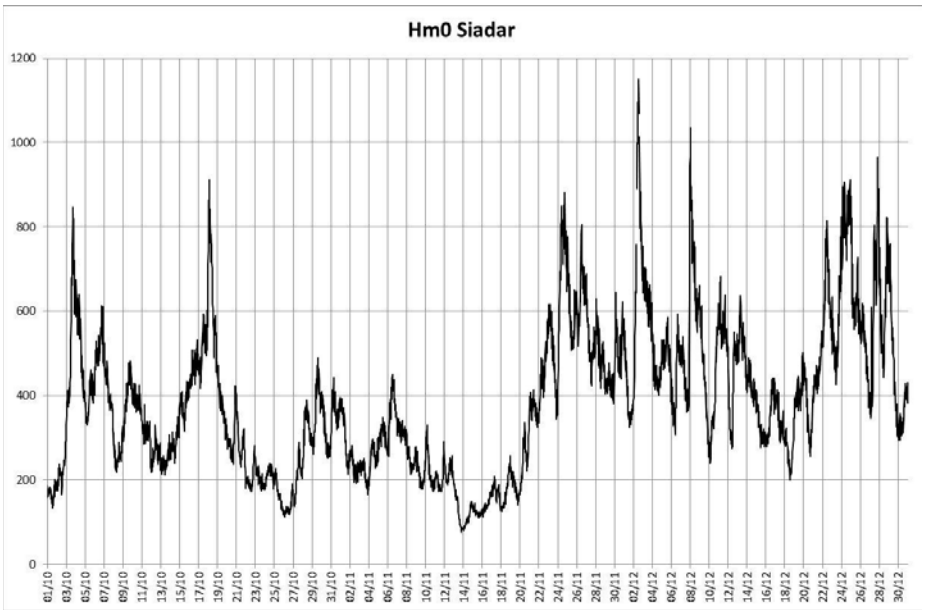
The graphs on the following pages show the significant wave heights, maximum wave heights, peak direction and peak periods for the period from October to December 2011. The data has been processed and cleaned on a high level only at this stage, and in particular peak values for the wave heights should be treated with caution. Poor signal quality was occasionally observed during storm events and this was likely caused by steep and collapsing waves. In some instances the recorded wave heights under those circumstances were in excess of 25m and a more detailed quality check is required before this values should be taken as real. The data shown below has been through a first pass processing were values that appeared to be distorted due to poor signal reception have been filtered out.

Acknowledgement of the Hebridean Marine Energy Futures project, a collaborative research and knowledge exchange activity led by UHI Lews Castle College with Aquamarine Power as industry lead partner and Voith Hydro Wavegen, Pelamis Wave Power, E.ON, Scottish Power Renewables, Universities of Edinburgh, Strathclyde and Heriot Watt and also UHI-SAMS and ERI, is to be made when using this data. Unless confirmed otherwise, permission is currently only granted for the wave data to be used in direct support of the activities of project partners.

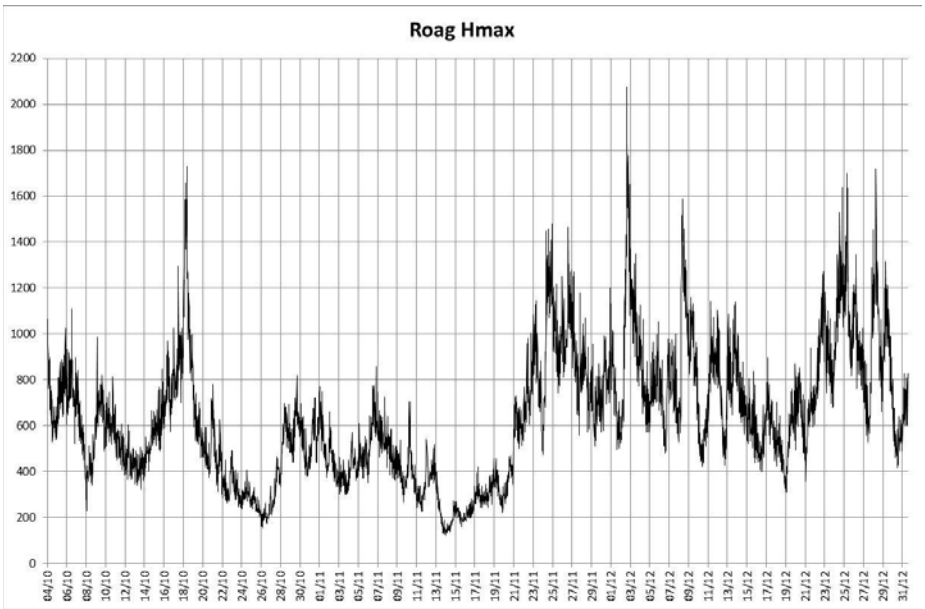
Significant wave height in centimetres

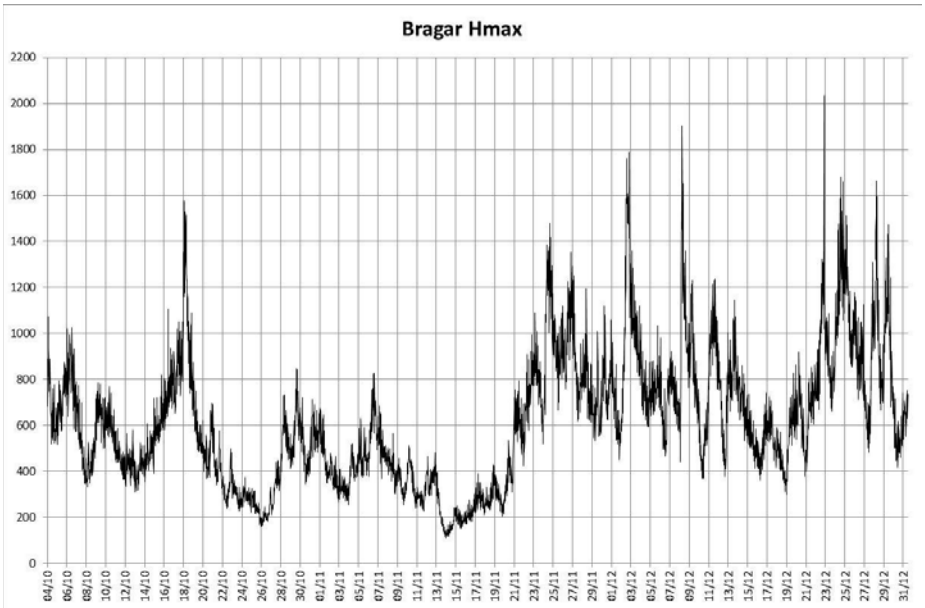


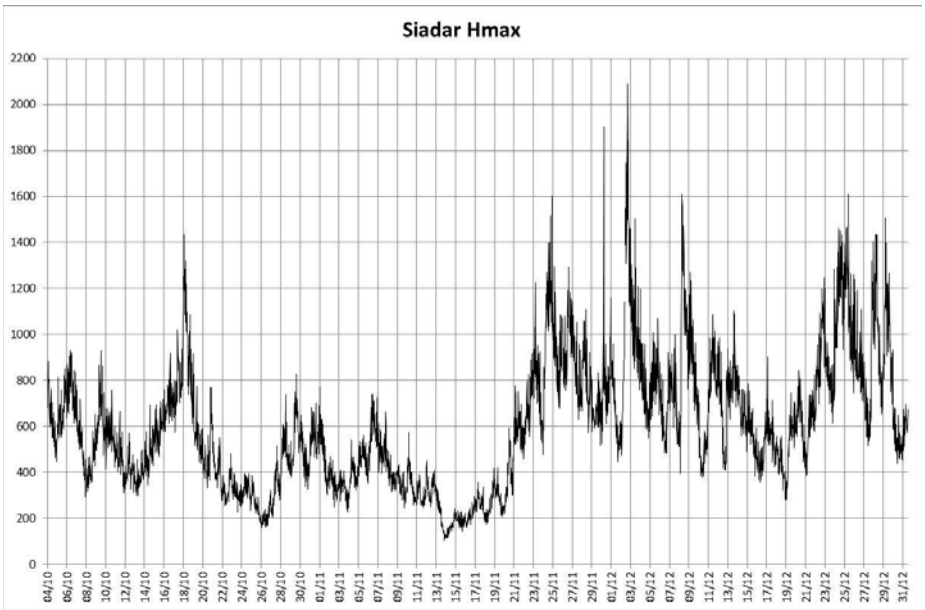




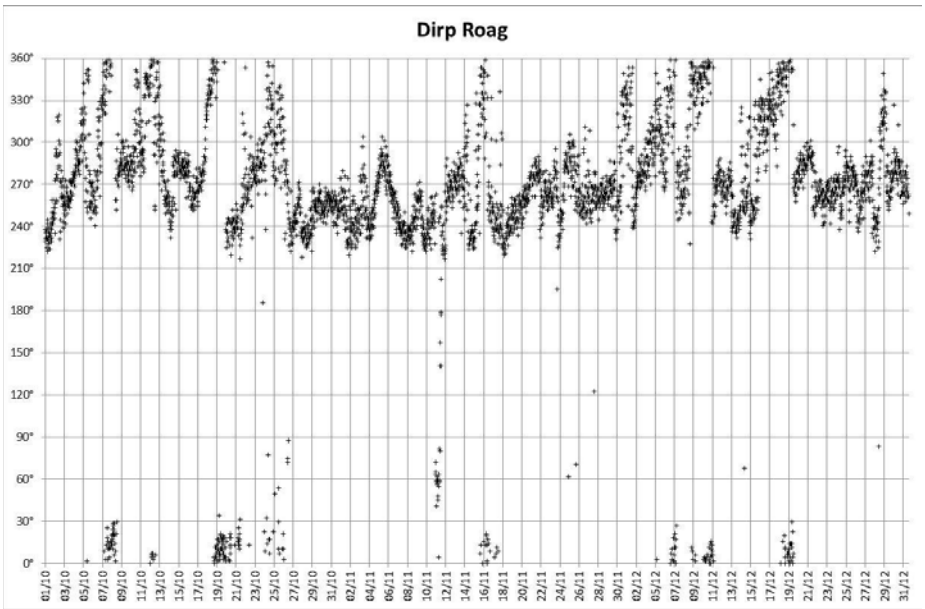
Maximum wave height in centimetres

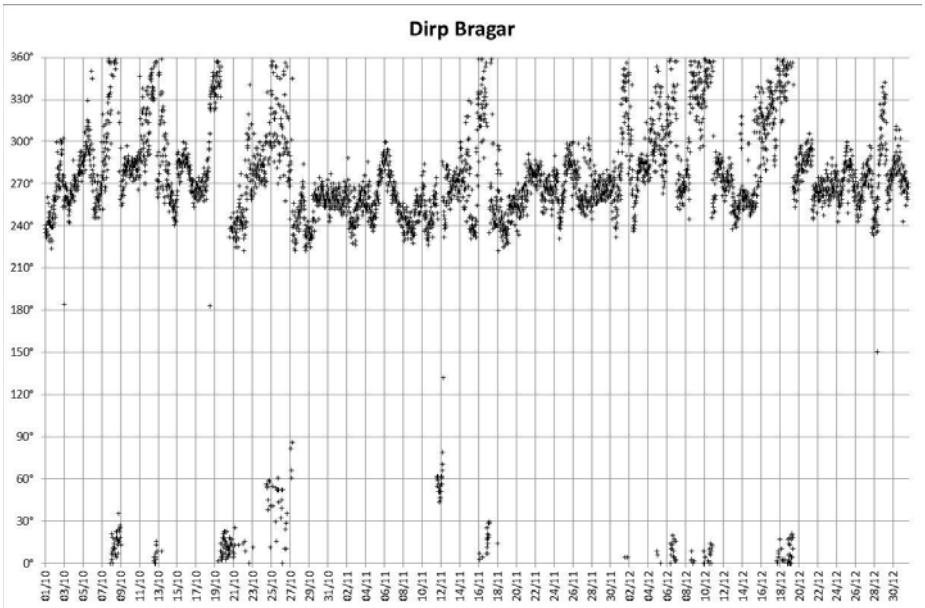


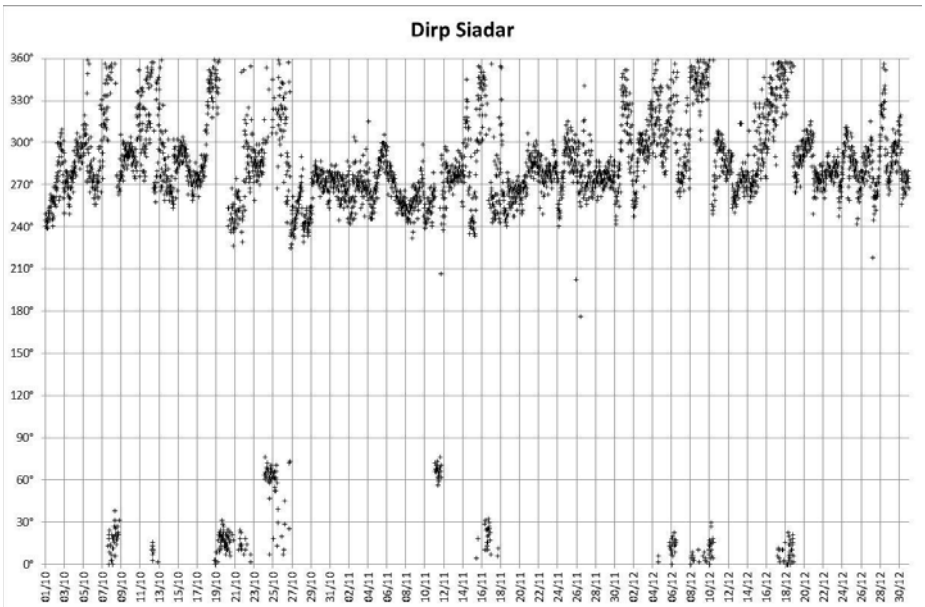




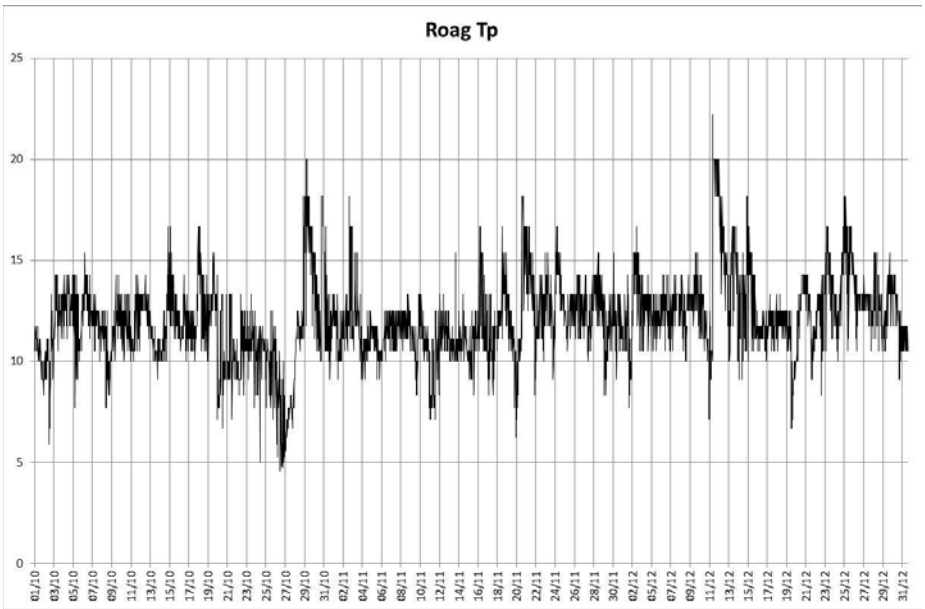
Peak direction (true north)

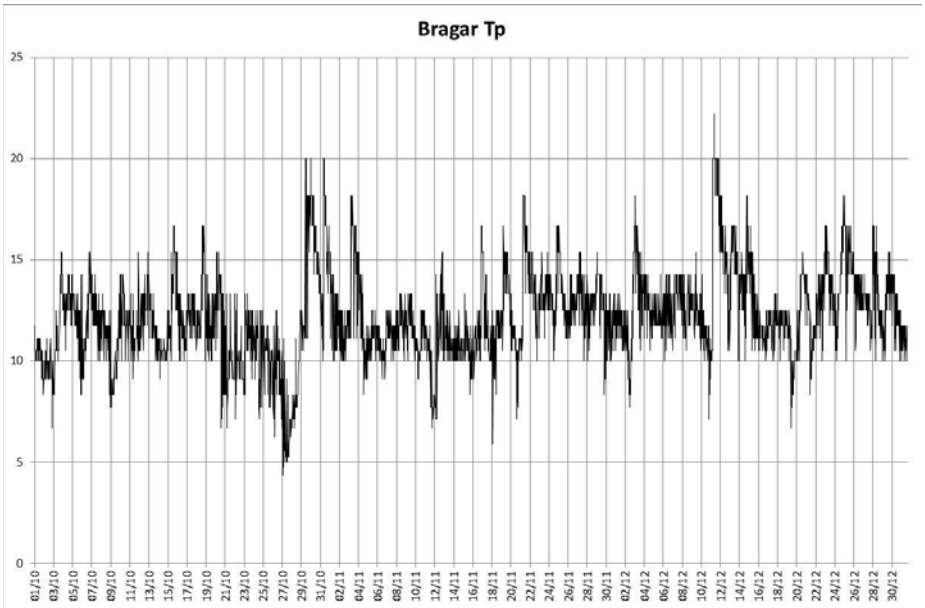


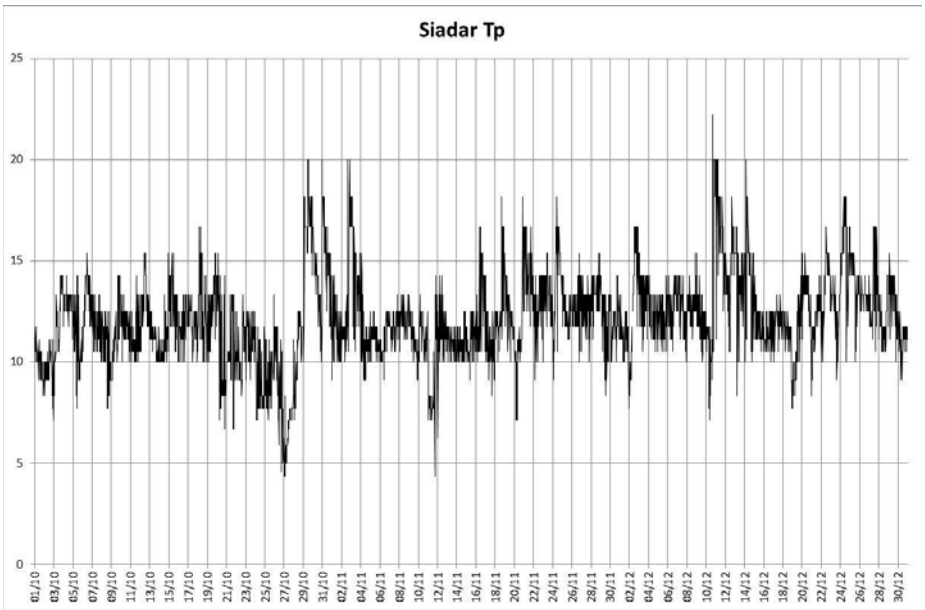




Peak Period in seconds







Appendix 7.3

Coastal geomorphology and physical environment survey report

Lewis Wave Array: Coastal Geomorphology and Physical Environment

Lewis Wave Power Limited

October 2011
Final Report
9W2153

A COMPANY OF

ROYAL HASKONING

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Document title	Lewis Wave Array: Coastal Geomorphology and Physical Environment
Document short title	Lewis Coastal Geomorphology
Status	Final Report
Date	October 2011
Project number	9W2153
Client	Lewis Wave Power Limited
Reference	9W2153/Glasgow/303437
Version	1

Drafted by	Julian Carolan	
Checked by	Jen Trendall	
Date/initials check	24/10/11…….	…….
Approved by	Frank Fortune	
Date/initials approval	28/10/11…….	…….

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1 INTRODUCTION

Lewis Wave Power Limited, a wholly owned subsidiary of Aquamarine Power, intends to develop a demonstration wave energy conversion array off the north-west coast of Lewis. Royal Haskoning has been commissioned by Aquamarine Power to assist in applications for consent and as part of this support is conducting an Environmental Impact Assessment (EIA) for the proposed development

All place names within this document are taken from Ordnance survey maps, either 1:25000 scale or 1:10000.

1.1 The proposed development

The intention is to deploy 40 Aquamarine's oyster devices which will be attached to the seabed in the waters between 10m and 20m in depth. The Oyster wave power technology, which captures energy from near shore waves and converts it into clean sustainable electricity requires a certain amount of onshore infrastructure. The oyster devices will pump water, via a high pressure undersea pipeline, to the onshore powerhouse. The water will be returned to the devices via a low pressure return pipeline. The on shore powerhouse will contain one or more Power Take Off (PTO) units, generator equipment, a header tank and a storage/site office area. The proposed location of the Powerhouse is in an undeveloped area of land to the north of the village of Siadar.

1.2 Objectives of report

Royal Haskoning has been commissioned by Aquamarine Wave Power Limited to undertake a coastal geomorphology walkover survey. This report assesses the current morphological regime at the site prior to a preliminary identification of opportunities and constraints (technical and environment), based on an Expert Geomorphological Assessment (EGA). The EGA is further supported by a desk based review of currently available data relating to physical processes.

2 STUDY AREA AND PHYSICAL PROCESSES

2.1 Study area

The study area is located on the north-west Lewis coast (**See Figure 2.1**) and includes the intertidal and supra-tidal environments. The site is bound to the south by Mol Eire shingle beach and prominent headland, and to the north by the prominent headland at Melbost.

2.2 Physical environment and processes

2.2.1 Geology

The geological sequence along the coastal study area is relatively simple, comprising Pre-Cambrian Lewisian gneiss mostly of the metamorphic type. These high grade metamorphic rocks have undergone a complex deformation history and are of widely variable composition. Within the general uniformity of the geological conditions, however, a number of significant variations do occur, and frequently these variations are reflected in the resultant coastal landforms.

Some small igneous intrusions are picked out locally as zones of weakness by marine or sub-aerial processes, but the main lines of weakness, followed by many of the sea lochs and inlets, are structural lines of dislocation or crushing. On the smaller scale, factors such as variations in dip angles and the occurrence and density of joint planes exert important local influences on coastal evolution, especially on the cliff morphology.

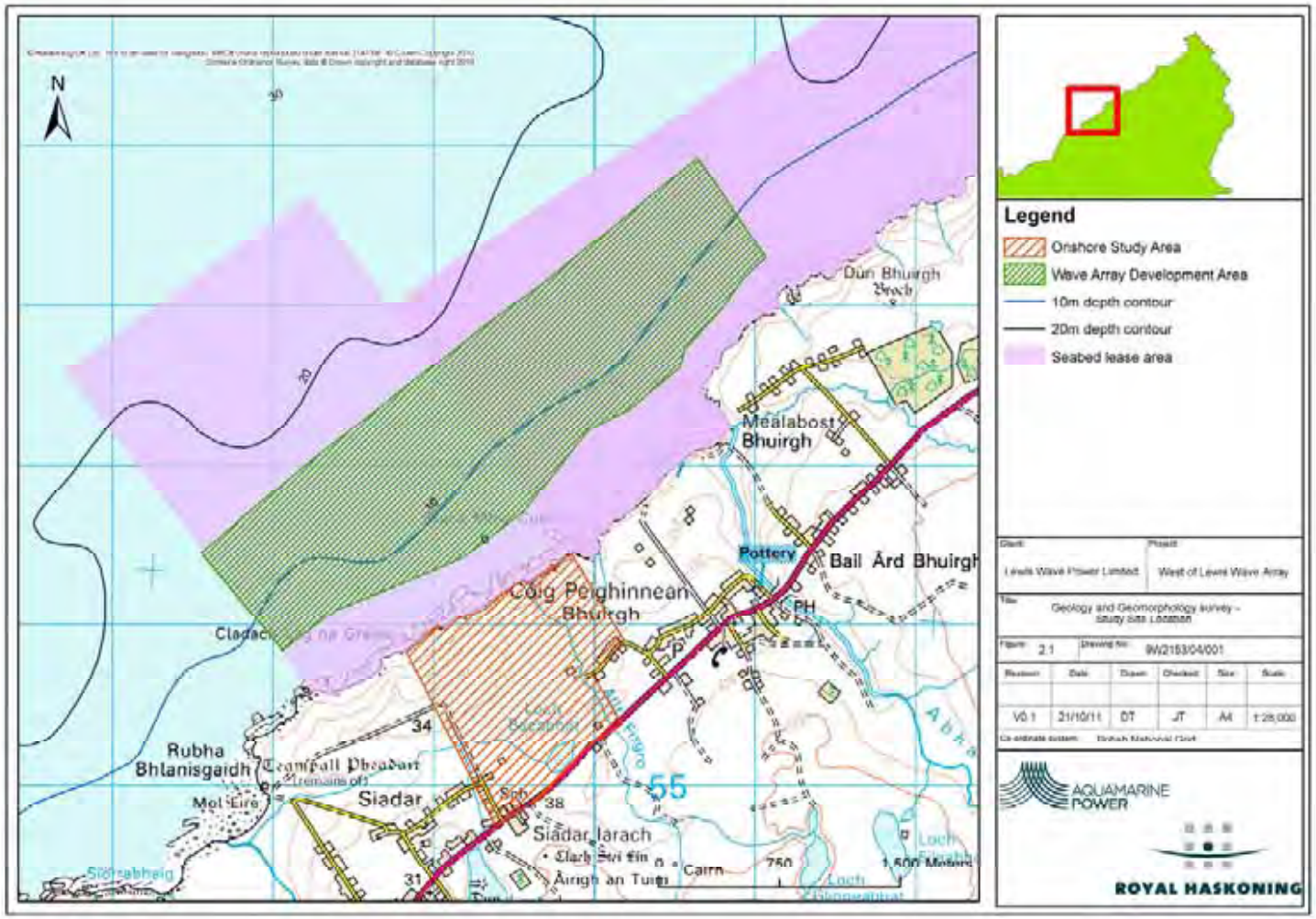
There are no areas designated for their geological importance within the area of search and only one (located to the north, at the Butt of Lewis) approximately 20km to the north..

2.2.2 Geomorphology

The geomorphology of the study area is characterised as subdued topography typical of northern Lewis. The northern part of the island consists of a vast tabular plateau at an altitude of between 80 and 140m above sea level. This plateau, broken in places by low residual hills such as Beinn Mholach and Muirneag, is tilted slightly towards the west, and almost always terminates sharply at the coast in cliffs, of variable height.

On the northern plateau, the mainland ice-sheet achieved little in the way of erosion other than limited scouring, though deposited till of variable thicknesses. In some areas, such as around Swanibost, the till is thick and has been cut into sea cliffs. Elsewhere, the effect on the bedrock plateau has been much less, and in places pockets of weathered rock have been neither removed nor buried under till. In North Harris the most important glacial effects were wrought by local glaciers rather than the mainland ice-sheet. Glacial deposits typically consist largely of sand and gravel, which have therefore been important in terms of supplying materials for beach morphology.

Figure 2.1 **Study site location.**



2.2.3 Waves

Exposure to a severe wind and wave climate characterises north-west Lewis. The nature of the Western Isles means that they are exposed to long fetch for wave generation` in practically every direction, with the exception of eastern sector.

A wave model developed by Aquamarine Power for the east coast of Lewis predicts that over a 12 year period the average maximum significant wave height of for the area is 7.7m and waves occur at intervals of 7.38 seconds. The predicted summer (March 21st to September 21st) maximum significant wave heights are 5.26m occurring at intervals of 6.68 seconds. The model also predicts the waves will on average most frequently occur from the west north-westerly direction (294° +95°/-42°) and in the summer will be from more westerly direction (286°+101°/-34°). The irregular coastline of Lewis results in a diverse range of local wave climates, and most available data refers to open sea conditions rather than localised wave conditions.

2.2.4 Tides and tidal currents

The tidal range is consistent along the west coast, ranging from 3.26 m during springs to 1.43 m during neaps. Tidal currents are consistent and of a relatively low magnitude along the west coast ranging from 0.13 m/s during neaps to 0.36 m/s during springs with little seasonal variability. Net sediment transport offshore is generally northwards, determined by residual currents although numerous local eddies modify this broad pattern.

2.2.5 Seabed and Bathymetry

Submarine contours exert a major control on the convergence and divergence of wave fronts, and in the movement of sediment landwards from the offshore. For the most part the submarine contours parallel the coastline (see **Figure 2.1**) although the offshore gradient is spatially very variable (HR Wallingford 2004). From the Mean Low Water Spring (MLWS) mark the seabed across much of the survey area slopes relatively steeply to the 10m depth contour, and then slopes more gradually down to 20m depth; between 0.5 km – 1.5 km offshore.

Where deep water approaches close inshore cliffs are actively forming. The lack of sand beaches in southeast Lewis is partly explained by the gradient of the inshore zone. What little information is available from bathymetric charts indicate that the floor is comprised of predominantly rock. The seabed and intertidal areas are typically rugged in nature and dominated by rocky outcrops of Lewisian gneiss. This rock is overlain within the intertidal in places by thin coverings of gravel and sand particularly in crevasses between shallower bare rock platforms. The rock surface is characterised by grooves and channels preferentially eroded along discontinuity planes.

2.2.6 Sediment Transport

Sandy material within the intertidal is likely to have originated from glacial deposits. Off the west coast of Lewis, where the ground is of rock, any glacial deposits which may have existed have already been swept clear above wave base, so that the nourishment

of the beaches is confined to the products of present marine erosion and fluvial supply (HR Wallingford 2004).

Erosion of the gneiss bedrock is slow and provides little material for the beaches of this region, most of which is derived from shell fragments moved onshore by waves. There is little longshore sediment transport within the study area with sediment movement generally confined to small coastal sub-cells, though there is expected to be some onshore transport of coarse sediments during high magnitude low frequency (HMLF) events such as storms.

3 SITE VISIT

A brief overview of the regional and local processes driving the evolution of the study area has been detailed in the preceding section (**See Section 2.2**). The purpose of the site visit was to ascertain to what degree the various external forcing parameters where controlling the evolution of this section of coastline and to note any observational evidence present within the field. It was further anticipated that the walkover survey would help direct future survey and assessment effort and address issues and concerns as identified within the Formal Scoping Opinion.

The site visit took place to coincide with low spring tide on the 2nd September, 2011 and was attended by Dr Julian Carolan and Mr David Tarrant. The site visit involved a walkover survey to note geomorphological features and make potential judgement on reasons for features/change in the system. This included consideration of intertidal platform, shingle beaches, exposed and eroding Quaternary cliffs and where watercourses discharged into the open sea. Rain persisted for much of the day, however there were no restrictions to the completion of the walkover survey.

The location of key survey points discussed herein is presented in **Figure 3.1**.

The following sections present observational notes and supporting photography for key locations within the study site (red points in **Figure 3.1**).

Plate 3.1 presents the view to the north along the coast from Point 2 to the headland at Mol Eire (Point 5). The beach extends about 400m, with an intertidal zone of approximately 10m (20m wide at its maximum point). Till outcrops at the southwest end of beach, where an actively eroding cliff (<1.5m) backs the beach.

Figure 3.1 **Key survey locations discussed.**

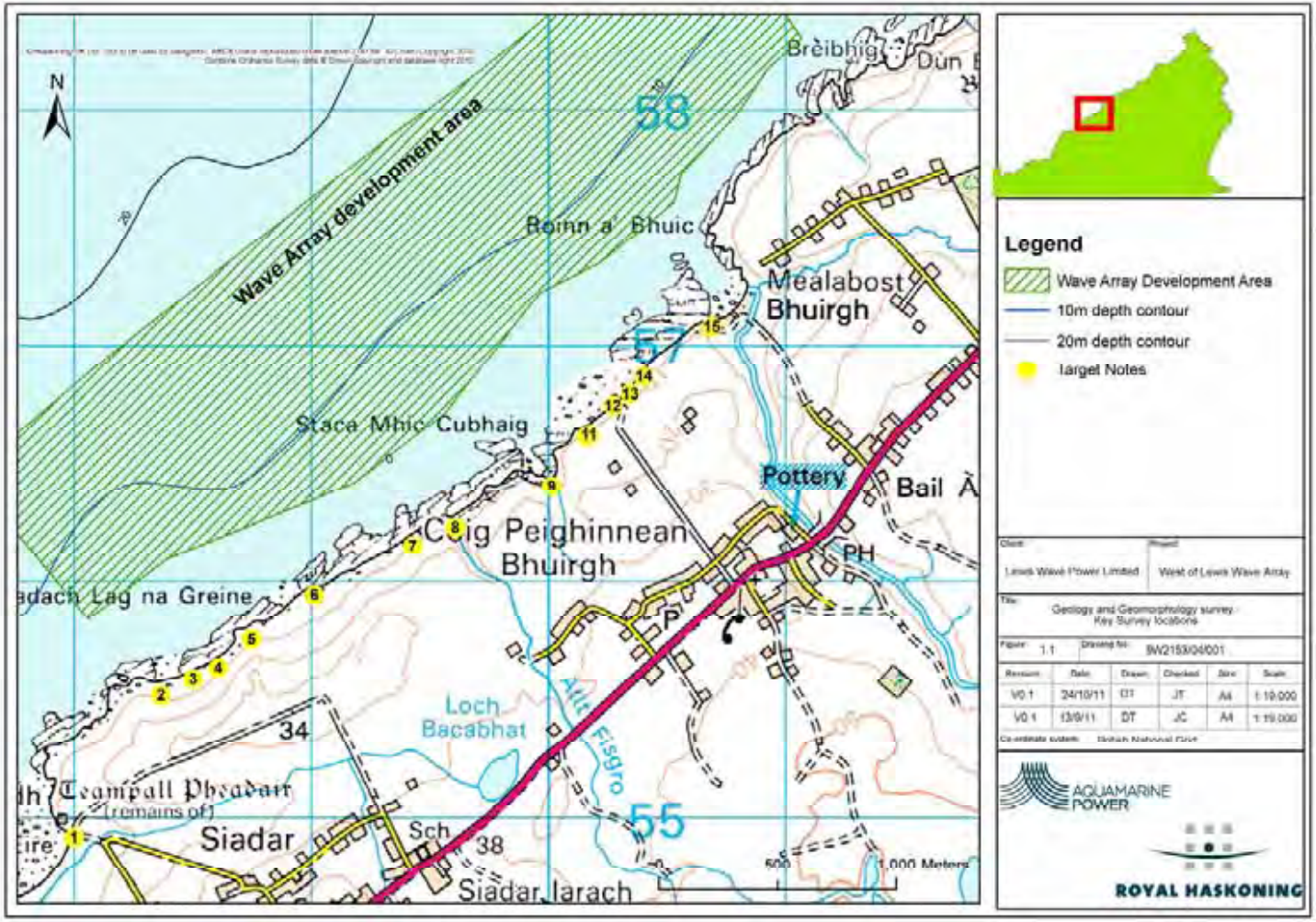


Plate 3.1 Looking north from Point 2 along the beach north from the Mol Eire headland

The beach planform (the shape or layout when viewed from above) is controlled by the general absence of outcropping intertidal bedrock, with the exception of the presence of a distinct intertidal outcrop to the north (see **Plate 3.1**). The outcropping bedrock slows the retreat of the shoreline at this location and influences beach planform to the north. Where waves incident from the south and west break within close proximity to the shoreline, higher energy incident on this section of the coast has resulted in a back-stepped beach planform on the northern extent of the beach (see **Plate 3.2**). This is evidenced by the beach being significantly eroded further landward than the southern section.

The beach material consists mainly of shingle with some interstitial sand and gravel immediately fronting areas of active cliff erosion. Active marine erosion of the low Quaternary cliffs (approx 1-2m overlying exposed bedrock) to the south is evidenced, with the degree of erosion decreasing toward the north corresponding to a decrease in Quaternary cliff height.

The exposed nature of the beach means that incident waves are competent to move large clasts (<25cm). Despite the wave strength, however, some large (>50cm) angular boulders litter the shore. These boulders are not being actively transported within the intertidal, and probably represent storm deposits or lag till derived clasts eroded from the Quaternary cliffs.

Plate 3.2 presents the back-stepped beach to the upper centre of **Plate 3.1**. This section of shingle beach (between Point 4 and Point 5) extends for approximately 300m and displays a distinct curved planform controlled by the headland to the north and an area of outcropping intertidal bedrock to the south (see **Plate 3.1**).

Plate 3.2 Curved headlock controlled shingle beach north of Point 3

Plate 3.3 Well-rounded shingle clasts on lower foreshore to the north of Point 3

The beach is characterised by kelp detritus on the lower foreshore which is reworked by wave and tidal process to form a distinct berm crest of detritus which attains an elevation of 1-2m. Approximately two thirds of the way up the beach the overlying detritus is absent. From this point northwards the shingle berm crest increases in elevation and angle to the north, indicative of an increased south to north energy gradient along the coastal cell.

The next section of the coastline, from north of the headland at Point 5 to Point 8, in planform represents a series of headland controlled shingle beaches. The headland controlled shingle beaches vary in length from <100m to >500m and are characterised by a variety of shingle clast sizes dependant upon each beach's respective orientation and degree of protection afforded by outcropping intertidal bedrock. In most instances the beach itself extends between 20-25m from the berm crest of seaward limit of shingle where it overlies the bedrock platform.

Plate 3.4 presents the view northward from the low tide line immediately downdrift of the headland to the south at Point 5. The view is toward the headland at Point 6 (see **Figure 2.1**).

Plate 3.4 Distinct zonation of shingle beach at Point 5

Along this stretch of coastline (between Point 5 and Point 6) the beach material consists mainly of shingle with occasional bands of pebbles and cobbles in the lee of headlands (see **Plate 3.4**) and in a spatially constrained bad (not exceeding 2m) along the lower foreshore. The exposed nature of the beach and high energy gradients are evidenced in shingle clast sizes along and across the beach. Despite the apparent available wave energy some large (>50cm) sub-angular boulders litter the shore. As with the presence of other large boulders noted previously, these boulders are not being actively transported within the intertidal, and probably represent a lag storm deposit or remain as

a lag deposit from the former erosion of the Quaternary cliffs which at one time would have extended much further seaward than at present.

Plate 3.5 presents the mid- to upper-foreshore shingle beach and berm crest of a typical shingle beach at Point 6. Shingle clasts along the lower foreshore are well rounded due to prolonged abrasion indicative of active and persistent transport within the intertidal zone. Clast sizes typically vary from 5-10cm. Close to the berm crest (a nearly horizontal plateau on the beach face or backshore, formed by the deposition of beach material by wave action) clast size increases to 10-20cm with a corresponding change in clast shape from sub- to well-rounded on the lower foreshore to more well-rounded plate shape clasts (see **Plate 3.5**).

Plate 3.5 Clast orientation on shingle beach, Point 6

The beach maintains an angle of between 10-15 degrees and a near constant berm crest height of ~5-6m for approximately two thirds of its length. The shingle displays a subtle variation in colour between the lower and mid-foreshore clasts and the upper to mid-foreshore clasts (see **Plate 3.4**), with the lower clast being predominantly of a light grey colour. The upper beach clasts display a distinct brown colouration. The colour variance may be attributable to the degree of sub-aerial exposure and stability within the environment resulting in a more brown (oxidised) appearance to the upper foreshore shingle. Although the berm crest forms an important element in the morphology of the beach, it appears to be a relict feature and relatively immobile, and may be associated with differing marine conditions or sea-level to those currently observed within the study area.

These series of shingle beaches terminate upon a series of bedrock headlands which continue for approximately 1,000m to the west of Point 9. **Plate 3.6** presents the view

from the west of Point 9 to the south over the series of headland and intertidal bedrock dominated shingle beaches. To the north from Point 10 and Point 11 (see **Plate 3.7**) the coastline is dominated by a series of headlands which protrude in the marine environment and constrain sediment movement. Most sediment transport along the coastline is dominated by off- to onshore as evidenced by the presence of pocket shingle beaches

Plate 3.6 Series of headland and intertidal bedrock dominated shingle beaches, Point 8

Plate 3.7 Series of pocket shingle beaches to the north, Point 9

Plate 3.8 Exposed intertidal platform, shingle beach and partially eroding cliffs, Point 11

The marked change in the nature of the coastal geomorphology from Point 10 northwards is presented in **Plate 3.8**. This change is characterised from one dominated by bedrock headlands and pocket beaches to a more open coastal planform. This section of the coastline is broadly characterised by a wide intertidal platform or variable relief (up to 2m in places) which is overlain by a shingle beach and backed by bedrock promontories and active Quaternary cliffs.

From north of Point 11 the shingle beach is supported to the south by a bedrock cliff which increases in height to the north and is increasingly overlain by a covering of Quaternary materials. Where bedrock is present within the mid- to upper-intertidal (as in mid-way up the beach in **Plate 3.8**) the beach width markedly decreases. Furthermore, the beaches are not backed by a significant berm crest indicating that outcropping bedrock within the intertidal interferes the wave regime and sediment transport to such an extent that the beach profile does not adopt an equilibrium planform in cross section. Along this section of the coastline mean clast size typically decreases towards the low water mark indicating that the back beach is relatively stable and that the active transport zone is seaward of the mid-foreshore.

The shingle beach displays a sharp transition with the intertidal platform (**Plate 3.9**) at Point 13. The intertidal platform is characterised by an irregular topography in the range of approximately plus or minus1m change for every 5m on the horizontal plane (i.e. ground level), though spatially this may increase at certain locations on the platform.

Plate 3.9 Looking north from Point 13 across bedrock platform to active Quaternary cliffs

Till displays an undulating topography to the back beach along the coastline from Point 11 to Point 14 (see Plate 3.9). Active marine erosion of the cliffs is evident over the entire coastal unit (Point 11 -14) with exposed cliff height decreasing towards the north (Point 14). Small (<2m) intertidal bedrock pinnacles outcrop at discrete locations along this coastal unit (see **Plate 3.10**). Where they occur they provide a degree of protection

to active cliff erosion. There is a strong correlation between the presence of outcrops in the intertidal and decreased rates of coastal erosion, which are repeated along the entire study area. This is evidenced by the presence of angular to sub-angular clasts which is likely to be the main source of sediment for the upper beach.

The quantity of material smaller than large shingle (<5cm) is spatially limited to a small band exposed at low tide along the boundary between the mid-foreshore and lower-foreshore bedrock boundary change. It should be noted that the extent of coarse sand and gravel will vary with weather and wave conditions.

The intertidal platform extends from the boundary of the shingle beach, which it overlies, to the low water mark, approximately 100-200m**.** The platform is typically swept clean of fine-grained material as a consequence of the high energy environment. **Plate 3.11** presents a band of coarse grained sand and gravel with occasional shell fragments located within a topographical depression on the bedrock platform.

Plate 3.10 View south from Point 13 looking south across intertidal platform

Plate 3.11 Relatively fine-grained sediment transport in bathymetric depressions at Point 13

Toward the northern extent of this coastal unit extensive Quaternary deposits (5-6m high) form an active cliff (see **Plate 3.12**). The Quaternary deposits are characterised by inter-bedded gravels (>2mm) and till which are likely to be the main source of sediment to the upper-foreshore beach.

To the north of Point 14 (see **Plate 3.13**) the southern part of the shingle beach is supported by a small headland of outcropping strata. The shingle displays a diffuse boundary with the intertidal sandy beach to the north and in places along the beach; fragments of the underlying bedrock platform protrude through the mixed clast, though sand dominated, foreshore. The sandy foreshore, though limited in spatial extent is devoid of any wave induced morphological features (i.e. ripples), indicating a relatively high energy environment. Under such energy it is most likely that the sand on this section of the coastline is ephemeral in nature and overlies the bedrock platform.

North of Point 15 the coastal geomorphology is dominated by a large concave sweeping shingle beach (see **Plate 3.14**). The upper berm crest displays a near uniform topography indicating that it is well above active marine process, except, probably, storm process. The intertidal displays two distinct detritus lines indicative of the upper levels of typical marine processes, which are well below the shingle beach berm crest.

Plate 3.12 Active Quaternary cliffs at Point 14

Plate 3.13 Point 15 looking south over mixed clast foreshore and outcropping intertidal bedrock

Plate 3.14 Point 15 looking north across curved planform shingle beach

4 SUMMARY AND CONCLUSIONS

4.1 Summary

The entire coastline is characterised as very high energy with a distinct south to north wave-driven littoral drift. This is observed in coastal geomorphogy along the coast particularly in the headland controlled and small pocket beaches which display a marked increase in beach berm crest to the north and a corresponding increase in mean clast size, suggestive of an increase in energy to the north as south-westerly incident waves break around headlands and set up a wave-driven littoral drift to the north.

Although strong tidal streams run in both directions around the Butt of Lewis, the residual direction of drift is northwards. This trend is also observed within the study area and is confirmed by the asymmetry of shingle beaches which display a tendency for maximum accumulation to the north. However, it should be noted that there is possibly, as a consequence of wind generated waves incident from the northwest, a tendency for the accumulation of fine-grained clasts to the south of open expanses of coastline. Alternatively these deposits may result from the deposition resulting from wave breaking around southern headlands.

The quantity of material smaller than large shingle (<5cm) is spatially limited to a small band exposed at low tide along the boundary between the mid-foreshore and lower-foreshore bedrock boundary change. It should be noted that the extent of coarse sand and gravel will vary with weather and wave conditions.

Shingle size ranges from 10->50cm diameter. Shingle beaches display a marked sedimentological transition between lower intertidal rounded to well-rounded clasts to large plate like clasts in the upper berm crests. The shingle beaches display a marked transition in colour between the lower shoreface and upper shoreface sediments. This is indicative of an active transport zone on the lower beach face and a relatively stable mid- to upper beachface which is only active under low frequency high magnitude storm events. Beach angles are typically greater than 10 degrees, indicating high energy reflective beaches. This is supported with the lack of any fine (sand to pebble) material in the intertidal.

Where large clasts (>50cm) are present within the lower intertidal they provide a large degree of stability to the lower beach face by way of creating a complex topography and inducing wave breaking and energy dissipation. Although exposure to the west and southwest is extreme, deep water does not extend close into the beach. This is particularly evident at low tide where a wide gently sloping intertidal platform extends for approximately 200-400m to the low water mark.

It should be noted that the erosion of the Quaternary cliffs has resulted in the accumulation of substantial lag deposits which are typically of variable size and differentiated from the marine derived component by way of their clast shape, with the more rounded clasts being reworked within the marine and intertidal environments.

HR Wallingford (2004) noted that numerous beaches ‘appear to be a shingle-built features…..on closer examination, to be composed very largely of angular and sub-angular boulders, with only occasional cobbles and pebbles thrown up by storm waves’.

Therefore, much of the material present within the intertidal may possibly represent a lag eroded deposit of Quaternary material which exerts an important influence on the subsequent evolution of the contemporary beaches by functioning as a discrete source of material.

Where bedrock is present within the intertidal, as outcropping from the seafloor, it exerts a major control on the coastal geomorphology via breaking of incident wave energy. This is observed along the coastline in numerous places where there are Quaternary deposits. Where the Quaternary deposits are fronted by outcropping bedrock they are provided a degree of protection from the incident wave energy. Where they are absent there is a notable erosion of the Quaternary cliffs.

Essentially the energy gradients along these beaches are so large that it would be difficult to establish cause and effect of any associated sedimentological changes associated with the proposed development. Wave energy devices are known to result in a reduction in wave energy within the lee of the device. However, due to the distance of the devices from the shore any associated wave wake effects would be considered to be low due to the prevalent high energy regime.

4.2 Conclusion

In conclusion an approach to future assessment to inform the EIA should adopt an approach to assessment that is proportionate to the potential environmental effect/impact. The key question would therefore be; are there any sensitive receptors along this coastline that warrant detailed assessment.

In terms of coastal geomorphology and physical processes (waves, tides and sediment transport patterns) sensitive receptors may be considered as, but not limited to:

1. Soft sedimentary coasts
2. Ecologically sensitive areas of the coastline
3. Designated habitats
4. Designated coastal sedimentary features (e.g. dunes)

In light of the evidence gathered from this walkover survey, and supported by conclusions drawn within the Intertidal Survey (Royal Haskoning, 2011), it can be concluded that there are no sensitive receptors within the proposed development footprint in terms of coastal geomorphology and physical processes.

The main impacts on the marine environment as a consequence of the proposed development are associated with wave energy change as a result of the device, foundation scour and sedimentary impacts, hydraulic pipes and their potential to alter coastal processes, and landfall infrastructure at the shoreline having a negative impact upon features of coastal geology and geomorphology.

In the absence of any specific wave and tidal energy guidance, any future works should be guided by the existing Collaborative Offshore Wind Research Into the Environment (COWRIE, 2009) guidance which sets out the key questions for establishing the requirement for assessment and, if required, numerical modelling:

1. Are there any sensitive receptors?
2. What information do we need to assess impacts on these?
3. Can information be practicably and efficiently provided by existing knowledge and available field data without the need for numerical modelling?
4. If no, can numerical models represent the processes involved sufficiently to provide the required information?
5. If yes, can sufficient field data be obtained the adequately calibrate and validate the model to provide confidence in results?

6. Does the regulating authority agree with the proposed approach?

REFERENCES

COWRIE (2009). Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment: Best Practice Guide.

HR Wallingford (2004). The beaches of Lewis and Harris. Special report to Scottish Natural Heritage.

Royal Haskoning (2011). Lewis Wave Array Intertidal Survey

Appendix 8.1

Raw data from peat depth survey

APPENDIX 8.1 Raw data from peat depth survey

Lewis Wave Array Peat Depth Survey

Field Form

Date: 8th February 2012

Time of survey start: 10:30

Time of Survey end: 16:30

Weather: Very windy, overcast, intermittent rain

Priority samples – 8th February 2012

	Sample Point		Actual location of sample					
Name	**Lat**	**Long**	**Lat**	**Long**	**WP no.**	**Peat Depth**	**Photo no**	**Notes**
A1	138852	955837	38844	55787	007	7	110	Granular soil, fairly dry
A2	138899	955844	38912	55830	008	30	111,112	Wet, soggy, though also areas of rock with thin soil
A3	138903	955898	38960	55872	010	2	113	Very thin soil, rocky though waterlogged areas nearby
A4	138999	955969	39026	55928	014	25	-	Very waterlogged, fibrous peat
A5	138999	955908	39017	55916	011	90	114	Heavily waterlogged, drainage area
A6	138999	955857	As per indicated	As per indicated	-	124	115 - 117	Peat layer over 1m deep
A7	139100	955988	Not taken as point located on rocky foreshore					
A8	139100	955931	As per indicated	As per indicated	-	30	119	Saturated with standing water
A9	139100	955869	As per indicated	As per indicated	-	26	118	Wet peat, adjacent to wet flush with sphagnum moss present
A10	139200	956048	Not taken as point located on rocky foreshore					
A11	139200	955974	As per indicated	As per indicated	-	60	124	Drier peat, raised area
A12	139200	955900	As per indicated	As per indicated	-	127	-	Fairly fry area with grassland on upper slopes
A13	139300	956100	39289	56057	016	10	127 - 129	Edge of eroding area at rocky foreshore, small humus layer
A14	139300	956000	As per indicated	As per indicated	-	90	-	Dry grassland with flushes
A15	139300	955900	As per indicated	As per indicated	-	90	125,126	Very firm peat adjacent to old peat cutting areas
A16	139400	956001	As per indicated	As per indicated	-	51	135	Firm but wet peat with fibrous top mass
A17	139400	956166	Not sampled – rocky foreshore?					
A18	139400	956100	As per	As per	-	42	136 -	Dryish, layer of humus

	Sample Point		Actual location of sample					
Name	Lat	Long	Lat	Long	WP no.	Peat Depth	Photo no	Notes
			indicated	indicated			138	overlying soil
A19	139378	955935	As per indicated	As per indicated	-	50	150	Same as A24
A21	139465	956209	39493	56184	019	27	-	Boggy and waterlogged, at edge of shore
A22	139437	956100	As per indicated	As per indicated	-	158	146 - 147	Evidence of peat cutting operations – very 'woody' upper layer
A23	139434	955951	As per indicated	As per indicated	-	60	148	Top layers looked relatively recent/lost of plant material and clearish water when pressed
A24	139462	955907	As per indicated	As per indicated	-	74	149	Top couple of cm black, then organic brown wet layer
A25	139400	955874	As per indicated	As per indicated	-	90	151	Top 20cm rooty and dark, below layer lighter brown
A26	139322	955838	As per indicated	As per indicated	-	58	152	More vegetation established on surface, dark brown peaty upper layer
A27	139277	955800	As per indicated	As per indicated	-	75	153	Very rooty/fibrous top peat layer (top 20cm)
A28	139214	955749	As per indicated	As per indicated	-	48	154	Black top 5cm, very wet and light brown below this layer
A29	139160	955704	As per indicated	As per indicated	-	80	155	Dense vegetation cover and root mass, wet brown coloured peat below
A30	139100	955667	As per indicated	As per indicated	-	28	156	Hard ???? encountered, waterlogged
A31	139023	955620	As per indicated	As per indicated	-	39	157	Dense vegetation layer, soggy ???
A32	138969	955587	As per indicated	As per indicated	-	21	161	Very fibrous upper layers, wet
A33	138999	955584	As per indicated	As per indicated	-	38	158,159	Very fibrous upper layers, wet
A34	139012	955546	As per	As per	-	10	160	Dry, compact peat

	Sample Point		Actual location of sample					
Name	Lat	Long	Lat	Long	WP no.	Peat Depth	Photo no	Notes
			indicated	indicated				
A35	139064	955505	As per indicated	As per indicated	-	8	162	Earthworm, quite soil-like, stones at shallow depth
A36	139093	955451	As per indicated	As per indicated	-	29	163	Vegetated, wet peat, smell when dug
A37	139122	955393	As per indicated	As per indicated	-	34	164	Grasses and mineral soil, no peat
A38	139166	955303	As per indicated	As per indicated	-	14	165	Peat layer, dark and moist but not a lot of water when squeezed
A39	139180	955250	As per indicated	As per indicated	-	60	166	West of road, in very boggy area
A40	139190	955255	As per indicated	As per indicated	-	300+	167	East side of road next to burn, very wet, standing water
A41	139196	955246	As per indicated	As per indicated	-	300+	168	East side of road next to burn, very wet, standing water
A43	139242	955149	As per indicated	As per indicated	-	300+	170,171	East side of road next to burn, very wet, standing water
A44	139268	955100	As per indicated	As per indicated	-	250	172	East side of road next to burn, very wet, standing water
A45	139292	955052	As per indicated	As per indicated	-	22	173	Vegetated at edge of track
A46	139085	955448	As per indicated	As per indicated	-	36		Directly next to track
A47	139112	955388	As per indicated	As per indicated	-	27		Dry area, beside stone wall
A48	139155	955300	As per indicated	As per indicated	-	27	175	Drier area on slope of hill
A49	139183	955242	As per indicated	As per indicated	-	170		Directly next to burn
A50	139231	955146	As per indicated	As per indicated	-	300		West of track in existing boggy area/drain
A51	139256	955094	As per indicated	As per indicated	-	280	174	West of track in existing boggy area/drain

EXTRAs – 8th February 2012

Name	Lat	Long	WP no.	Peat Depth (cm)	Photo number	Notes
021	139483	956109	021	220	139, 140,141,142,143,144,145	Peat cutting cliff, deep peat
A42	139214	955198		+300		Most places more than 2m to east of track in +3.0m peat
017	39326	55983			130,131,132,133,134	peat cutting with 5cm upper vegetation, 20cm deep fibrous, next 60-70 cm visible compacted and fine with no visible roots/vegetation

Sample Stations If Time Allows – 9th February 2012

	Target Sample Locations		Actual sample Locations				
Name	**Lat**	**Long**	**Lat**	**Long**	**WP no.**	**Peat Depth**	**Notes**
B1	139274	955103	-	-	-	-	Not surveyed
B2	139259	955124	-	-	-	-	Not surveyed
B3	139251	955152	-	-	-	-	Not surveyed
B4	139225	955196	-	-	-	-	Not surveyed
B5	139205	955248	-	-	-	-	Not surveyed
B6	139195	955260	-	-	-	-	Not surveyed
B7	139172	955305	-	-	-	-	Not surveyed
B8	139127	955396	-	-	-	-	Not surveyed
B9	139099	955455	-	-	-	-	Not surveyed
B10	139107	955426	-	-	-	-	Not surveyed
B11	139148	955341	-	-	-	-	Not surveyed
B12	139033	955526	-	-	-	-	Not surveyed
B13	138987	955585	-	-	-	-	Not surveyed
B14	139065	955643	-	-	-	-	Not surveyed
B15	139139	955689	-	-	-	-	Not surveyed
B16	139250	955778	-	-	-	-	Not surveyed
B17	139357	955890	As per indicated	As per indicated	- photo 300	43	Grass and moss, damp underfoot
B18	139417	955923	As per indicated	As per indicated	- photo 182	80	Lower vegetation cover/mosses, next to old peat cutting area
B19	139329	955943	As per indicated	As per indicated	- photo 301,302	77	Grass, moss, wet underfoot, next to old peat cutting area (photo 302 shows)
B20	139388	955972	As per indicated	As per indicated	- photo 185	46	Longer grasses, boggy
B21	139280	955912	As per indicated	As per indicated	- photo 303	82	Grass with mosses

B22	139243	955954	-	-	-	-	Not surveyed
B23	139348	956064	-	-	-	-	Not surveyed
B24	139250	956049	-	-	-	-	Not surveyed
B25	139150	955952	-	-	-	-	Not surveyed
B26	139048	955941	-	-	-	-	Not surveyed
B27	139283	955071	-	-	-	-	Not surveyed
B28	139306	955022	-	-	-	-	Not surveyed
B29	139191	955731	-	-	-	-	Not surveyed
B30	138949	955897	-	-	-	-	Not surveyed

Date: 9th February 2012

Survey start: 09:15

Survey end: 15:30

Dry, no wind, bright with high cloud. Rain overnight.

New Sample stations

WPT	Lat	Lon	Peat depth (cm)	Photo no.	Notes
N12	39381	55848	72	176	Heather and mosses on peat
N13	39428	55874	61	177	As N12
N14	39459	55893	76	178	As N12
				179	Photo taken looking north at distinct area of old peat cutting
N15	39469	55897	93	180	As N12, right next to gate
N03	39432	55894	82	181	Boggier ground than N12
N08	39445	55932	63	183	As B18
N10	39404	55958	82	184	As B18, but adjacent to flush
N02	39415	55984	20	186	Long grass, dry underfoot
N01	39383	55983	44	187	Low vegetation, firm, lichens etc, old peat cutting adjacent
N16	39357	55942	31	188	Wetter underfoot than N01, less vegetation cover
N17	39364	55917	45	189	Longer grass vegetation, mosses, quire wet underfoot
N11	39388	55910	76	190	As N17, think hit bedrock with probe
N18	39413	55904	86	191,192	Next to old peat cutting, very think grass growth
N19	39417	55888	94	193	Mosses, wet underfoot, adjacent to flush
N20	39442	55884	42	194	Next to fence, sphagnum moss present
N21	39404	55865	60	195	Next to fence, grass and sphagnum moss, wet underfoot
N22	39391	55892	85	196	Dry underfoot, mosses and grass
N23	39380	55879	82	197	Mosses, grass, heather mix
N24	39362	55931	49	198	Dryish, moss/grass mixed vegetation cover
N25	39399	55941	87	199	Dry, firm ground, lichens and moss, grass
N26	39418	55968	51	200	Wet, moss/heather mix
N27	39417	56055	77	201,202	Dry, heather/moss mix, old peat cutting visible

N28	39442	56123	168	203,204,205,206	Near existing peat cutting
				207,208	View north, photos show 'bulge' in topography
N29	39467	56137	154	209,210,211,212, 213	Peat cutting area
N30	39441	56142	26	214	Coastal fringe area, grass and boulders
N31	39415	56117	38	215,216	Boggy coastal grassland
N32	39420	56093	48	217	Grass, near interface with peat area/mound
N33	39428	56075	58	218	Peat area, but bedrock hit quite quickly
N34	39399	56034	65	219	Grass, moss, dry old peat cutting
N35	39379	56011	42	220	Boggy, long grass
N36	39350	55997	143	221	Peat cutting evident, wet mosses
N37	39342	56025	89	222	Long grass
N38	39351	56050	35	223,224,225	Very boggy, standing water with Hydrocarbon sheen present, long grasses
N39	39368	56073	50	226	Grasses, not wet
N40	39387	56058	55	227	Grass, dry
N41	39371	56039	62	228,229	Grass, boggy, hydrocarbons present on surface waters
N42	39323	56019	194	230,231	Grass, peat cutting nearby
N43	39320	56033	115	232,233	Grass, moss, next to old peat cutting
N44	39314	56050	32	234,235	Saturated area, black
				236	Picture taken of 'white' grass, submerged – unclear why had turned white but was visible in many standing water areas
N45	39288	56028	40	237,238	Grass, some wet areas, black upper sediment
N46	39261	56018	187	239	Bulge of peat next to shore
N47	39247	56038	2	240	Right on foreshore, many boulders present
N48	39268	55985	63	241	Dry, grassy peatland, very dark upper layers
N49	39284	55955	82	242	As N48, lichens now present (hard 'layer' encountered when probing)
N50	39299	55931	68	243,244	As N49
N51	39263	55929	45	245	As N49
N52	39246	55952	39	246	More grasses, wetter underfoot
N53	39231	55977	81	247	Drier grass and moss cover, some bare surface peat present
N54	39218	56006	2	248	Foreshore, boulders and grass

N55	39180	55992	2	249,250,251,252	Edge of shore delineated, photos show eroding shoreline and soil horizon
N56	39220	55939	94	253	Moss and grass cover, dry underfoot
N57	39232	55915	99	254	Firmer ground than N56, drier with mix of grass and mosses
N58	39182	55936	25	255,256,257	Grassy plain
N59	39146	55972	2	258,259	Edge of foreshore, boulders
N60	39122	55957	0	260,261,262,263	Rocks and boulders
N61	39142	55931	69	264	Grass, wet underfoot
N62	39164	55898	61	265	Grass, drier than N61
N63	39135	55885	32	266,267	Next to fence high up in site
N64	39117	55906	22	268	Grassy area, dry underfoot
N65	39064	55930	2	269,270,271	Photos showing rock/boulder foreshore
N66	39075	55904	26	272	Mid-drainage/standing water area – strong rotting smell
N67	39087	55886	27	273	Probe hit rock, very wet and boggy
N68	39059	55862	84	274	Dry grassland, higher than surrounding areas where wetter conditions
N69	39047	55887	26	275	Boggier grassland, wet underfoot
N70	39032	55932	0	276,277,278,279, 280	Rocky foreshore, photos demonstrate
N71	39014	55888	85	281,282	Grass, damp – photo of drain to north
N72	39030	55862	74	283	Long grass, very wet underfoot
N73	38974	55850	110	284,285	Next to drainage channel
N74	38930	55849	0	286,287,288	Rocky shoreline, wet
N75	39309	55854	50	289	Dry heather/moss/lichen area
N76	39358	55832	50	290	Acid grassland next to new fence at top of site boundary, dry underfoot
N77	39341	55853	76	291	Grass and mosses, dry underfoot
N78	39322	55867	83	292,293	Dry heather, mossy growth
N79	39306	55888	53	294	Dry grassland/heather
N80	39303	55911	70	295	Dry grassland/heather, sloping
N81	39319	55916	80	296	Dry grassland/heather, sloping
N82	39327	55900	79	297	Dry grassland/heather, sloping
N83	39341	55880	46	298	Wet underfoot, sphagnum moss present

N84	39362	55867	55	299	Grass and moss, damp underfoot
N85	39249	55889	58	304	Grass, moss, dry
N86	39250	55870	40	305	Wet grass, moss, spongy underfoot
N87	39269	55852	38	306	Much direr than N86, firm underfoot, lichens present
N88	39287	55834	70	307	Firm, some bare areas
N89	39301	55822	55	308	Firm underfoot, longer grasses, next to old peat cutting
N90	39319	55806	61	309,310	Next to new fence at top of site
N91	39334	55817	84	311	Next to fencepost, grasses
N92	39291	55783	55	312	Grass, dry but very wet surrounding areas
N93	39257	55816	55	313	Very dry, heather, flushes present either side
N94	39237	55840	41	314	Still dry, not as much as N93, probe hit bedrock
N95	39216	55868	55	315	Dry, firm underfoot, heather vegetation
N96	39208	55815	35	316	Dry, firm underfoot, heather vegetation
N97	39226	55793	72	317,318	Mossy but dry underfoot
N98	39243	55776	33	319	Dry but adjacent to wet flush with long grasses, wet underfoot
N99	39259	55759	37	320	Next to new fence at site boundary, dry underfoot but wet patches around
N100	39259	55759	31	321	Heather and moss/grass, small wet patch next to fence, wet underfoot

9th February 2012

Hydrology target notes

WPT	Lat	Lon	Peat depth (cm)	Photo no.	Notes
H1	39192	55706	-	322,323,324,325	Larger area of sphagnum moss/water logged area, feeds flush going down slope to boggy area at shoreline
H2	39143	55673	-	326,327	As above
H3	39073	55632	-	328,329,330	As above, but areas more numerous, all way from this point to gate where track turns is wet, black upper layers and hydrocarbons present

Photo 204 – View of peat land facing south east, near an area of existing peat cutting

Photo 207 – View north, showing undulating topography

Photo 216 – Boggy coastal grassland

Photo 231 – Peat cutting

Photo 278 – Rocky foreshore

Photo 331 - Lambol Burn upstream of river crossing

Photo 332 – Lambol Burn upstream of river crossing

Photo 334 - Lambol Burn upstream of river crossing

Appendix 9.1

Benthic habitat survey report

Isle of Lewis Benthic Ecology Drop-down Video Survey

Envision Mapping Ltd.

October 2011

Prepared for		**Lewis Wave Power Ltd. (Aquamarine Ltd.)**		
Title		Isle of Lewis Benthic Ecology: Drop-down Video Survey		
Abstract				
Contract reference:		2011-1012-Aquamarine – Lewis		
Report identification:		2011-1012- JFS-Isle of Lewis Benthic Ecology Drop-down Video Survey Report		
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Prepared by Envision Mapping Ltd. 6 Stephenson House Horsley Business Centre Horsley, Newcastle upon Tyne Northumberland NE15 0NY United Kingdom T:+44 (0)1661 854 250 F:+44 (0)1661 854 361				
NOTES:				

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A. Introduction

A1. Background and Purpose

Lewis Wave Power Ltd. (LWP) (a wholly owned subsidiary of Aquamarine Power Ltd.) is seeking to develop a wave energy demonstration array off the west coast of the Isle of Lewis. As a first stage of the Environmental Impact Assessment (EIA) for the project, LWP commissioned Royal Haskoning Ltd. to produce an Environmental Scoping Report (Lewis Wave Power Ltd., 2011) to facilitate the identification and assessment of the potential environmental impacts associated with the project. The Scoping Report identified further studies required to fulfil EIA requirements (Institute of Ecology and Environmental Management, 2010; Scottish Natural Heritage, 2009), including a site-specific benthic survey using drop-down/towed video. The survey reported on here formed this field-based benthic component. Its purpose was to provide site-specific benthic data to inform an assessment of impact of the proposed development. The key objectives were to:

- Determine the distribution and abundance of marine habitats and communities within the study areas;
- Determine the substrate type at all locations sampled;
- Identify habitats or species of conservation importance.

A2. Contractors

The benthic video survey was carried out by Envision Mapping Ltd. (Envision), using a vessel supplied by SeaTrek (www.seatrek.co.uk) (*MV LochLann* – Figure 1.).

Figure 1. Survey Vessel: SeaTrek's MV Lochlann

A3. Site

The work took place at off the north western coast of the Isle of Lewis within the 'Area of Search' for which the Crown Estate granted Aquamarine Ltd. with a seabed lease in May 2011 (Figure 2.) It focussed on two sites defined as the 'Benthic Survey Areas' in the 'Invitation to Tender' produced by Aquamarine Power Ltd. The sites are both located off the north western coast of the Isle of Lewis near the settlements of Labost (Figure 3.) and Siadar (Figure 44.). As neighbouring sites together, they stretch approximately 30km along the coast.. An additional area, adjoining the northern boundary of the Siadar site, was also surveyed after mid-survey instructions received from Aquamarine Power Ltd. (see Figure 66.).

The local coastline is predominantly cliffs up to 30m in height, with several small cobble or sand beaches interspersed with exposed Lewisian gneiss bedrock. The maximum depth of the survey areas is approximately 28m. The survey port was Loch Miabhaig, located approximately 10km to the south of the study area.

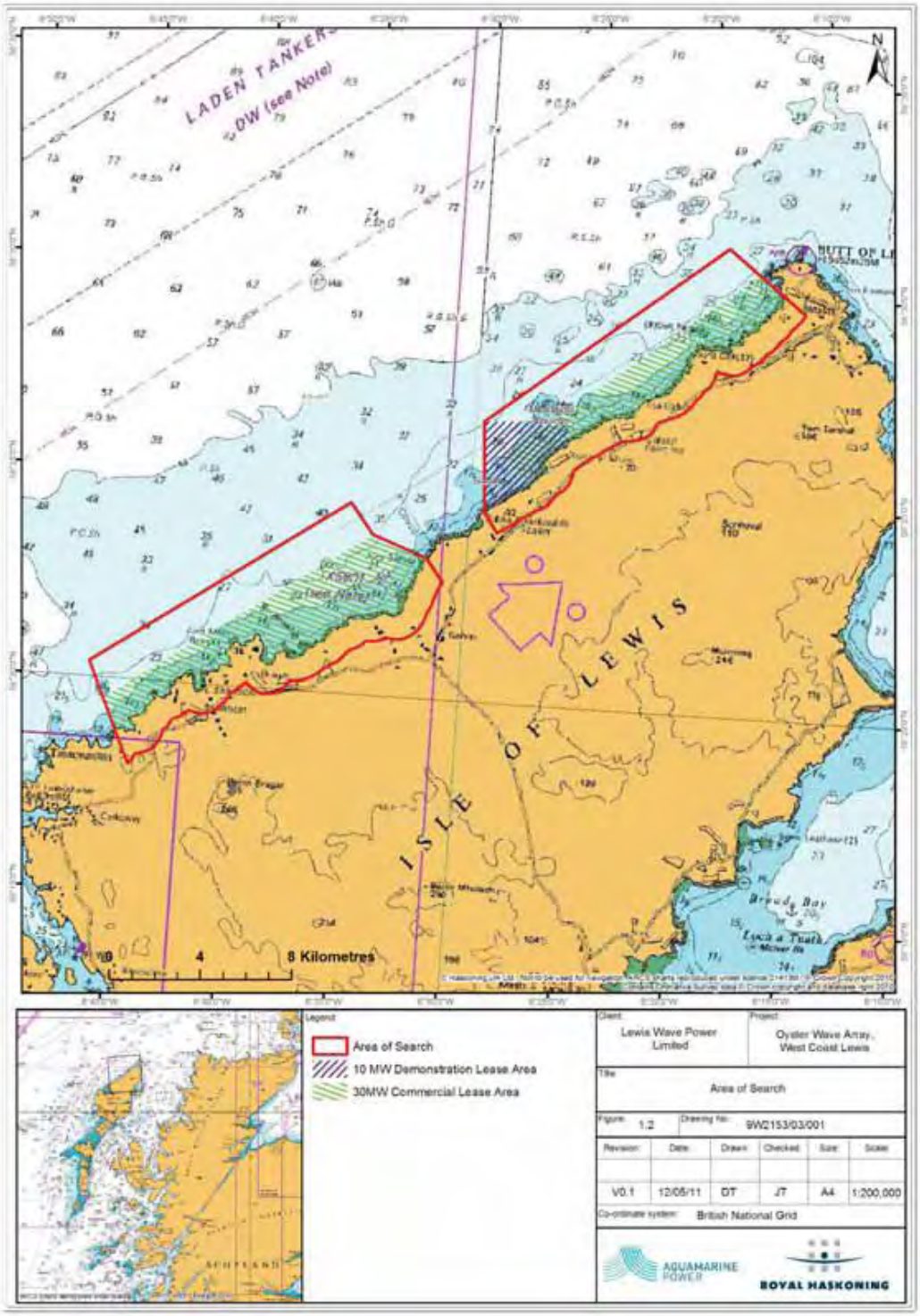


Figure 2. Lewis Wave Power (Aquamarine Ltd.) 'Area of Search' (from Lewis Wave power Ltd., 2011)

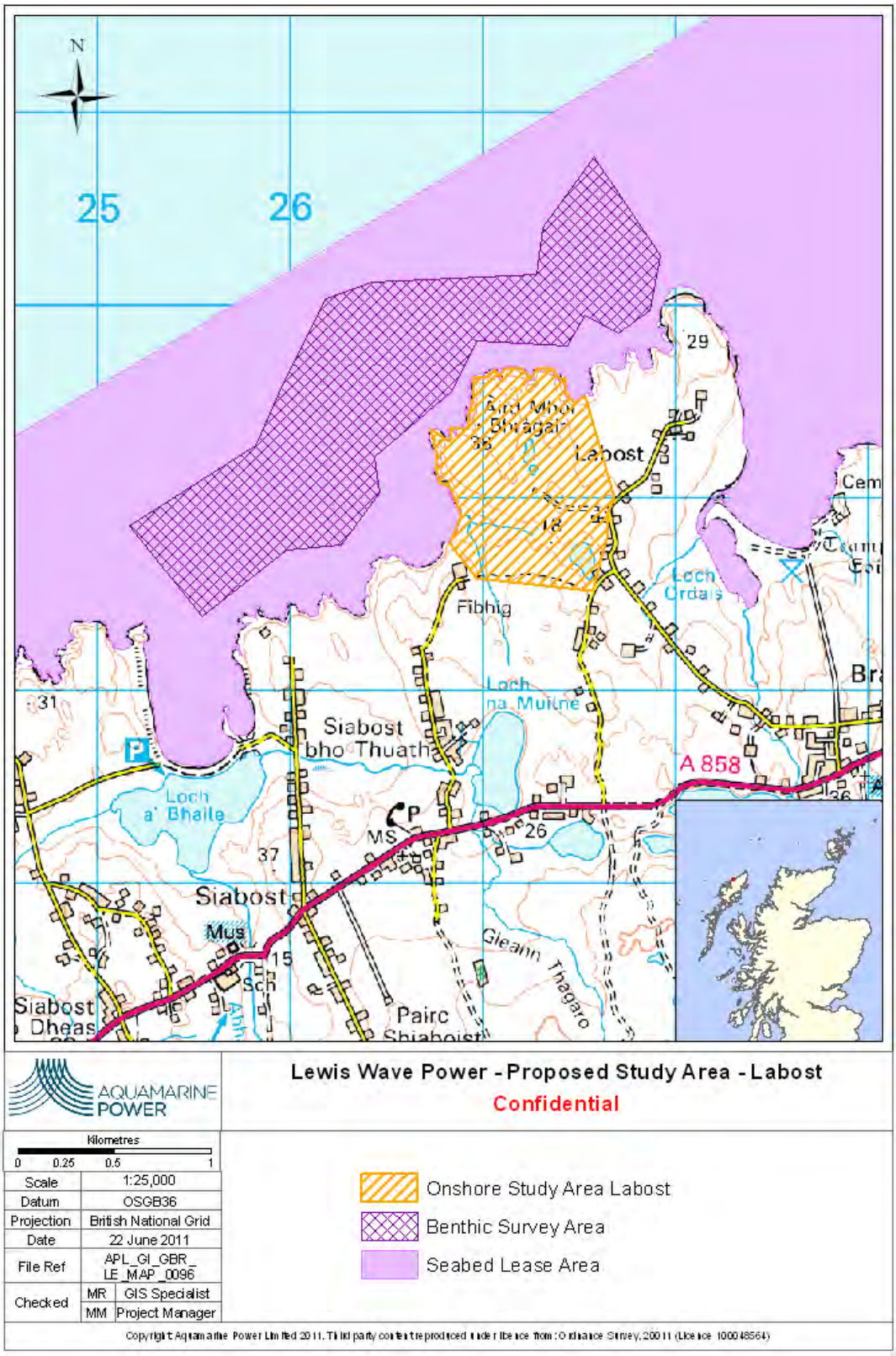


Figure 3. The Labost Benthic Survey Area

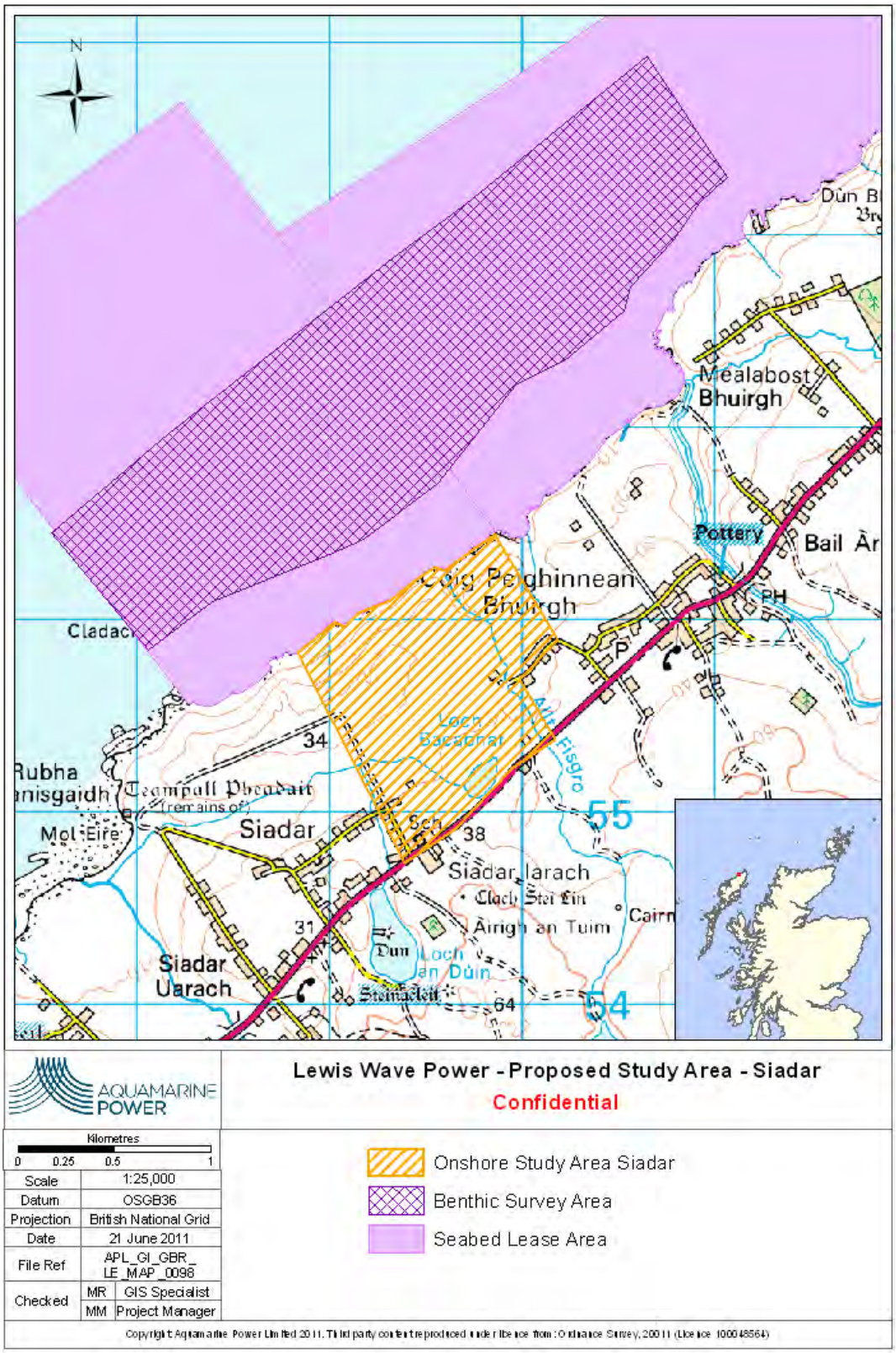


Figure 4. The Siadar Benthic Survey Area

B. Methodology

B1. Sampling Strategy

A field sampling strategy had been drawn up and approved by Aquamarine Ltd. prior to the start of the survey. Transects running roughly perpendicular to the shoreline (from shallow to deep water) were drawn up and video drop positions were marked along these transects for each of the survey areas (Figures 5 and 6). The transects were approximately equidistant over the sites, 7 at the Labost site and 9 at the Siadar site. Four video drops were carried out along each transect, thus amounting to 28 in total for the Labost site and 36 at the Siadar site. A further 4 transects (16 video drops) (see Figure 6) were carried out after instructions to extend the Siadar survey northwards.

B2. Field Survey

The survey took place over the period 23rd - 30th August 2011. Sampling began on 24th August at the north end of the original Siadar study area, working southwards from one transect to the next. Video drops were carried out along the transects from east to west with the prevailing wind and current conditions. On Day 2 (25th August) the field work began at the southern boundary of the Labost site, moving north, again working with the wind (which had moved round to southerly - Force 2), and surface currents. After a change of survey plans in accordance with Aquamarine's instructions, Envision concentrated on completing and extending the northern (Siadar) site. However, by the end of Saturday 27th August, the whole of both the Labost and Siadar survey areas and four additional transects, adjoining the northern boundary of the Siadar site, had been completed. Fortunately, the sea conditions had remained favourable during this time, although sea work ceased at around 3.15pm on Saturday 27th as the wind had moved round to the NW, Force 5, and was due to pick up to Force 7-8 later. Conditions were not suitable to go to sea on Sunday 28th (NW Force 7-8). Interestingly, the underwater visibility was relatively good on the first survey day (7m+), but it subsequently became poor (approximately only about 2m), due to a sharp rise in the presence of phytoplankton.

As explained in the Envision proposal document, the use of short camera 'drops' was favoured over longer 'tows', because of the rugged terrain and the risk of snagging. A small robust camera system, consisting of a small, high-resolution CCTV bullet camera (the footage of which can be recorded and viewed on the surface) was used. This is a sturdy camera system that can withstand the rugged conditions encountered. It was deployed at the specific positions marked along the transect lines running across the survey areas.

Each video drop was numbered and recorded using a Sony DV tape recorder, for subsequent analysis, and the position and time at the start and end of each deployment were logged. The positions were recorded using a differentially corrected GPS (dGPS) system (with a published accuracy of ≤ 1m). These were displayed on the video. Depths were also noted for each video drop.

The survey team stayed on site for the remainder of the proposed survey time (until 30th August) in the hope of the weather calming sufficiently to continue with additional transects to the north of the original Siadar survey area. However, this did not transpire and so no further survey work was carried out. Some of the video already captured was reviewed during the 'no-sea' period, to check that the footage already obtained during the low visibility conditions was suitable for analysis.

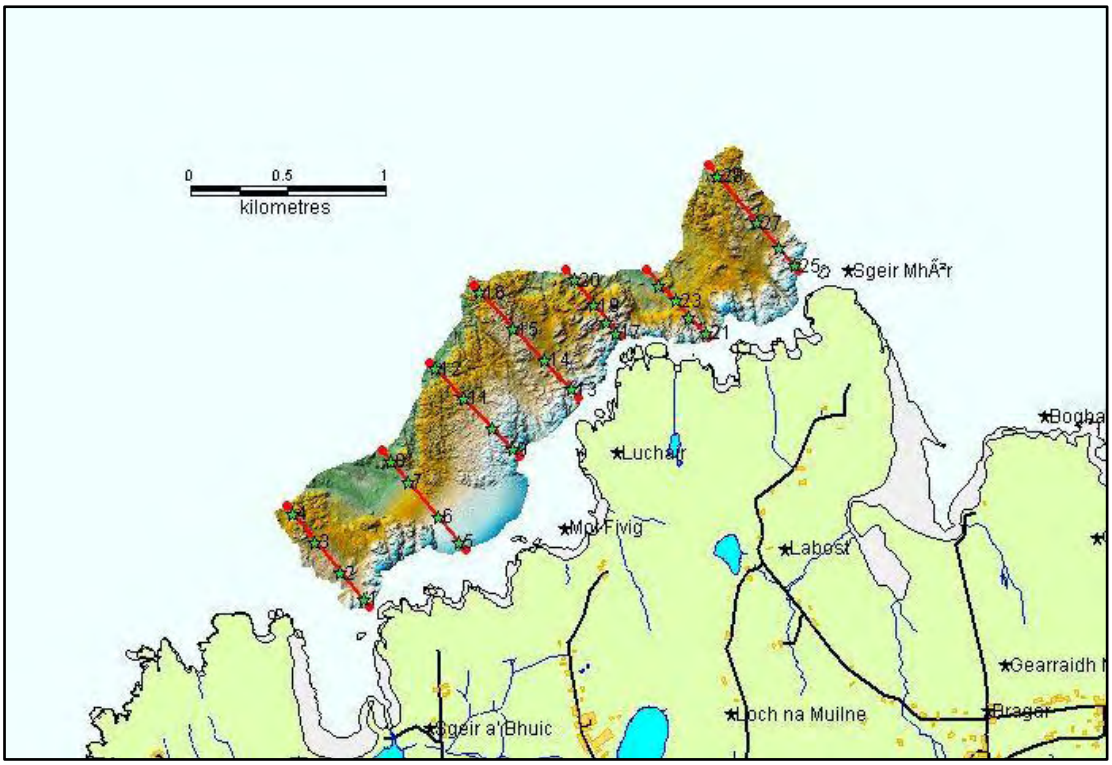


Figure 5. The Labost Benthic Survey Area showing agreed transect lines and video drop positions.

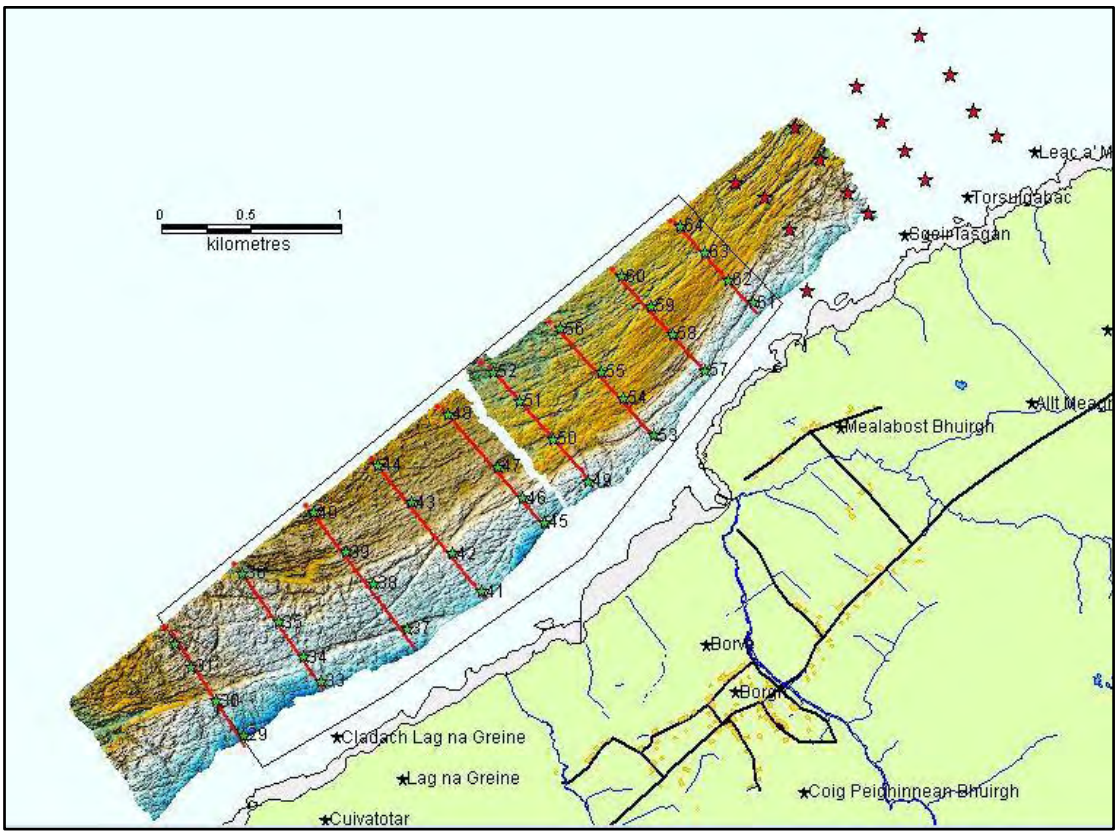


Figure 6. The Siadar *Benthic Survey Area showing agreed transect lines and video drop positions. (The red stars represent the positions of the video drops carried out in addition to those originally planned).*

B3. Video analysis

The video clips that had been recorded on the digital tapes were transferred to an external hard drive (a) as a form of back-up and (b) for analysis using video processing software.

During analysis, each video clip was observed several times: firstly to get an overview of the sample site; secondly to obtain substrate data; thirdly to obtain species data and fourthly, to take frame grabs to illustrate particular features. Initially, a brief written description of each of the 80 sample sites was given. Substrate and species data obtained from the video clips were then entered into an Excel™ spreadsheet based on a 'Data Entry Spreadsheet' produced by the JNCC for biotope analysis. Once this process was completed, it was then possible to allocate biotopes to each of the sample (video drop) sites. This was done using the 'Marine Habitat Classification v. 04.05' (Connor et al., 2004). Frame grabs were obtained from the video to illustrate the different biotopes present. Where biota could not be identified to species (e.g. because they would need to be collected and closely examined to be certain, such as for the sponges, or where only a glimpse of them was available on the video) then they were assigned a higher taxonomic category within which they are definitely contained. It was not possible to be certain about the precise identity of some of the encrusting fauna (e.g. Cirripedes, Serpulids and Spirorbids) because of their small size and, in many cases, much of the foliose red algae could not be distinguished because of the density with which they grew.

C. Results

In the following description of the Benthic Survey Areas, the additional transects that were carried out to the north of the Siadar site have been included as part of the Siadar Survey Area.

C1. Drifting

It is to be noted that the video clips recorded at the 'drop-down' sample sites are not 'point' samples. Instead, they are 'line' samples due to the drift of the survey vessel while the video camera was deployed. The extent of the drift (and therefore the ground covered during the recording of each video clip) is indicated in Figure 7 and Figure 88. This was dependent on the prevailing tidal and surface current conditions.

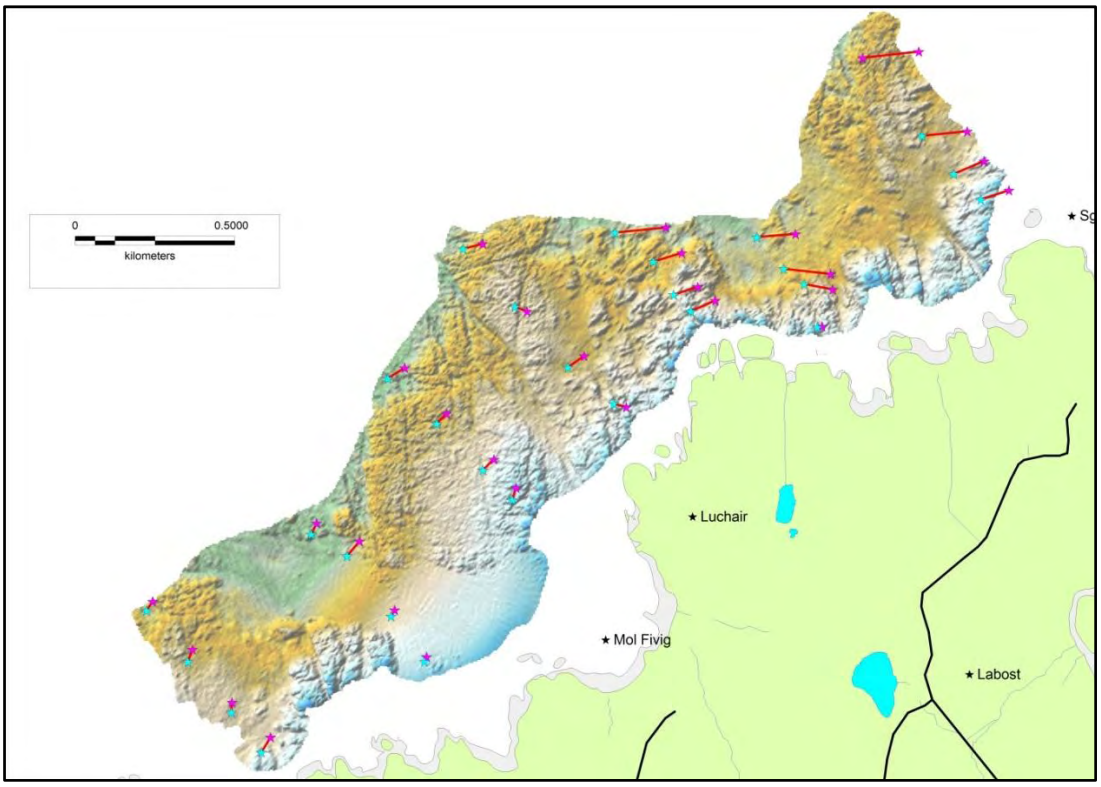


Figure 7. The extent of the drift of the research vessel that occurred during the recording of each of the video clips at the Labost Benthic Survey Area. (Blue stars are the start point and red the end point).

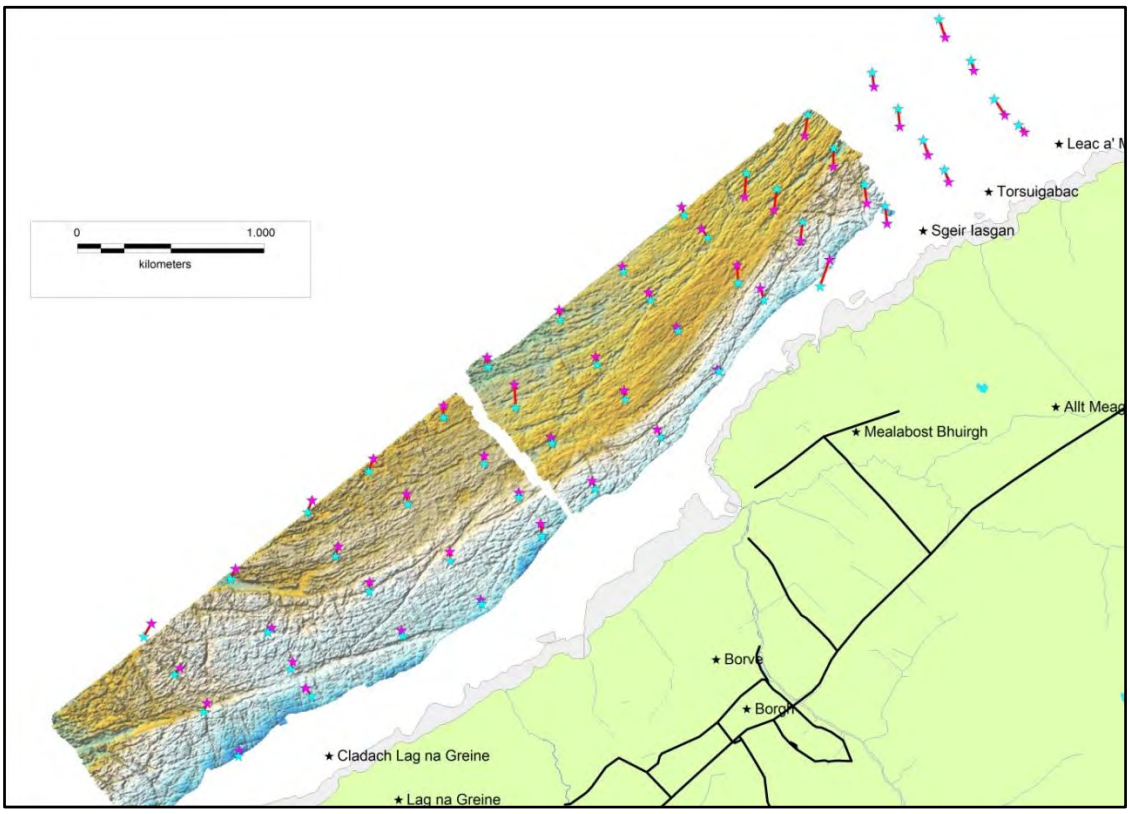


Figure 8. The extent of the drift of the research vessel that occurred during the recording of each of the video clips at the Siadar Benthic Survey Area. (Blue stars are the start point and red the end point).

C2. Benthic characteristics

C2.1. Preliminary inspection of Video clips

Preliminary inspection of the video captured, showed that the two sites largely contain the same elements of substrate and biota. The substrate type consists mainly of rugged bedrock, with areas of boulder and/or cobble tending to occur along the fault lines described by Aspect Land and Hydrographic Surveys (2010) and with patches of gravel and coarse sand tending to be close inshore. The biota consists predominantly of *Laminaria hyperborea* kelp forest, and also kelp park, where the kelp plants are relatively short, as is typical of exposed to very exposed, shallow water (infralittoral) areas. The kelp forest plants are heavily covered in epi-biota, primarily red algae (e.g. *Membranoptera alata; Ptilota plumosa*; *Phycodrys rubens* and encrusting corallines) but also some ascidians (e.g. *Botryllus schlosseri*), and sponges (e.g. *Halichondria panicea*). Foliose red algae were the dominant community in the more offshore (deeper) parts of the Labost area. *Echinus esculentus* urchins occur throughout, tending to be in greater numbers in the deeper areas where the kelp is less dense or absent. *Ophiothrix fragilis* and *Ophiocomina nigra* brittlestars are common in patches amongst the boulders and cobble, again in the deeper areas.

C2.2. Physical and Biological Data

The physical and biological data obtained from the video clip samples is given in Appendix 1.

a) Substrate

A wide range of substrate types was found to be present within the two survey areas as a whole, including coarse sand, gravel, pebble, cobble, boulder and bedrock (Figure 9.). However, the dominant substrate type recorded at both the Labost and the Siadar sites was rugged bedrock. Areas of boulder and cobble occurred towards the north end of the Labost site and, on the Siadar site, boulder, cobble and gravel occur in patches, probably occurring where they have gathered as a result of wave action, such as in gullies and along the fault lines identified by Aspect (2010).

Coarse sand was the finest sediment observed; fine sands and muds were not a feature of the study site. Coarse sand was found in a channel of sediment (off Mol Fivig in the Labost survey area), and also relatively close inshore (off Sgeir lasgan and Torsuigabac in the Siadar survey area).

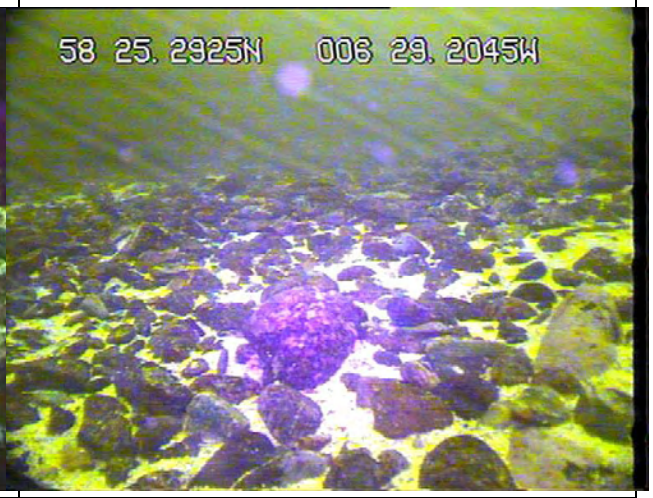
Sand – Video drop 65	Gravel – Video drop 40
Pebble and Cobble – Video drop 42	**Cobble and Sand – Video drop 36**
	
Boulder on rock – Video drop 24	**Bedrock – Video drop 8**

Figure 9. *The different types of substrate present.*

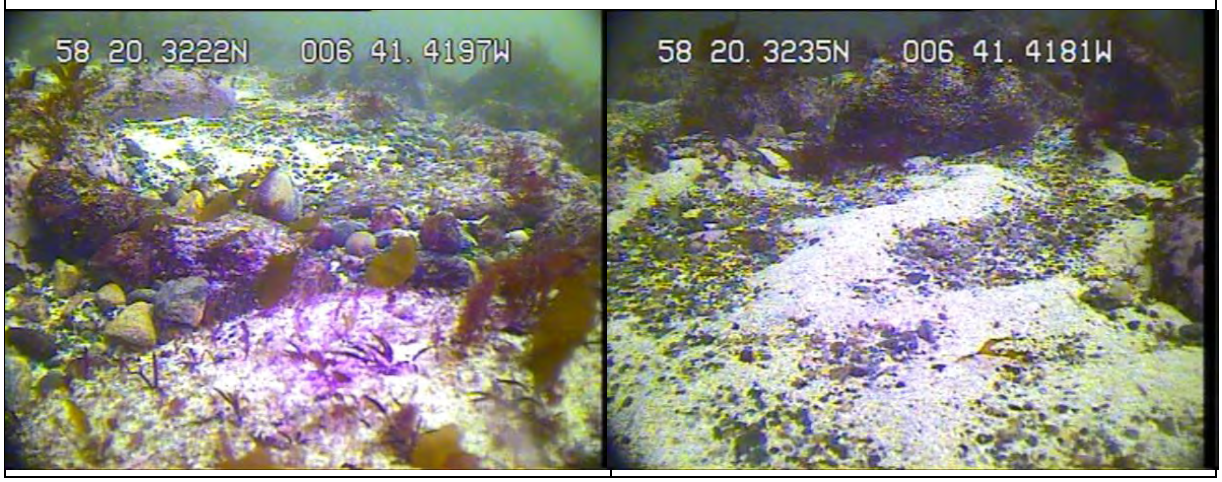
b) Biota

In all, 51 different taxa were recognised from the video footage, with 46 recorded from Labost and 44 from Siadar. The species component from the two sites was very similar, with a 76.5% overlap between the two. Some of the species not found in both sites were very mobile, such as fish and crabs and hence are probably equally likely to occur in both areas. However, others may be restricted to their particular areas because of certain environmental conditions. The brittlestar, *Ophiothrix fragilis,* for instance, was recorded (at 2 sample sites) only in the Labost survey area, in places which were deeper than any occurring at the Siadar site.

c) Biotopes

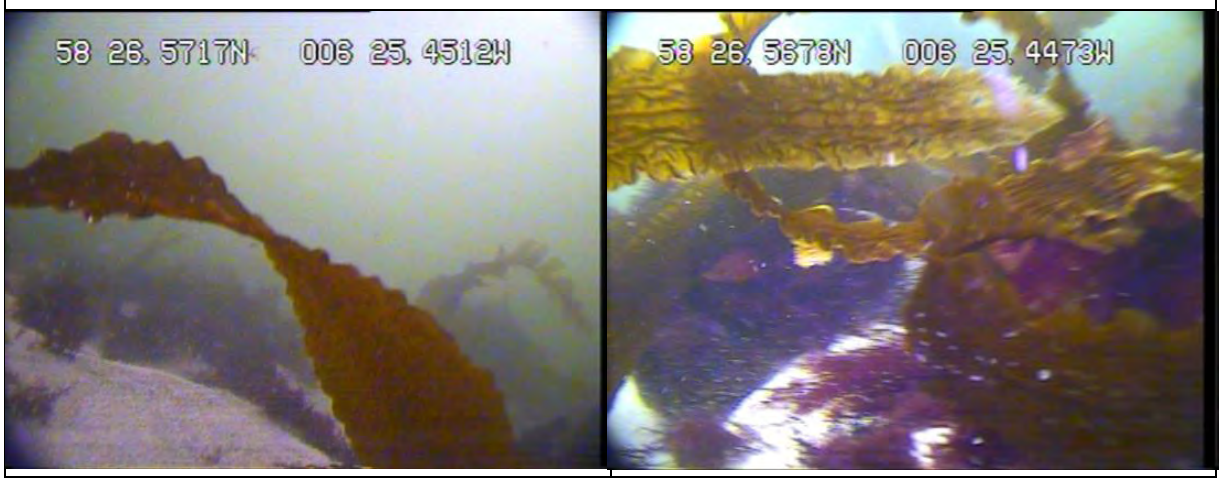
In all, eight different biotopes were noted for the two survey areas (Figure 10.).

SS.SCS - Sublittoral coarse sediment (unstable cobbles and pebbles, gravels and coarse sands)

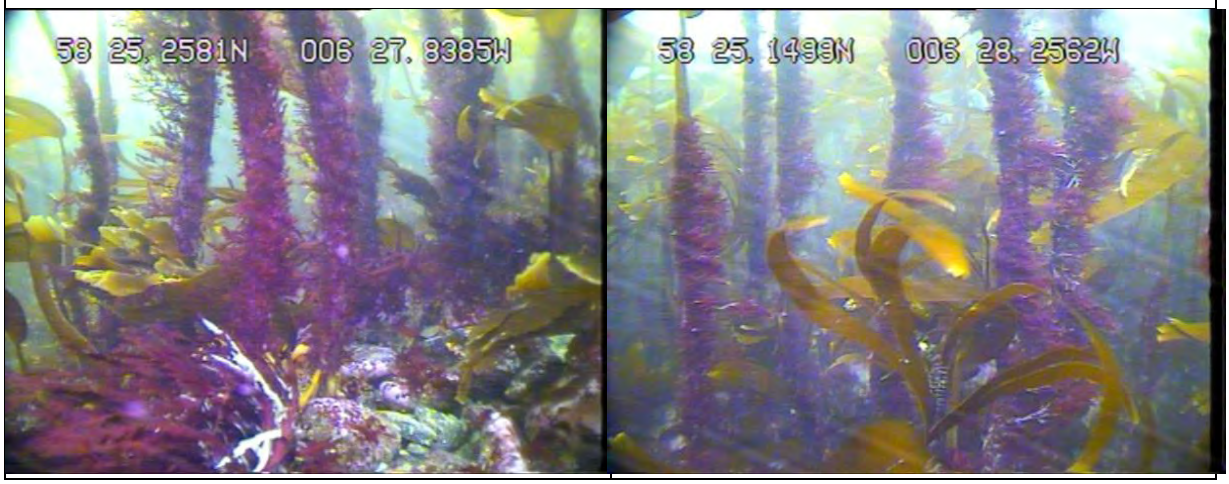


SS.SCS.ICS - Infralittoral coarse sediment

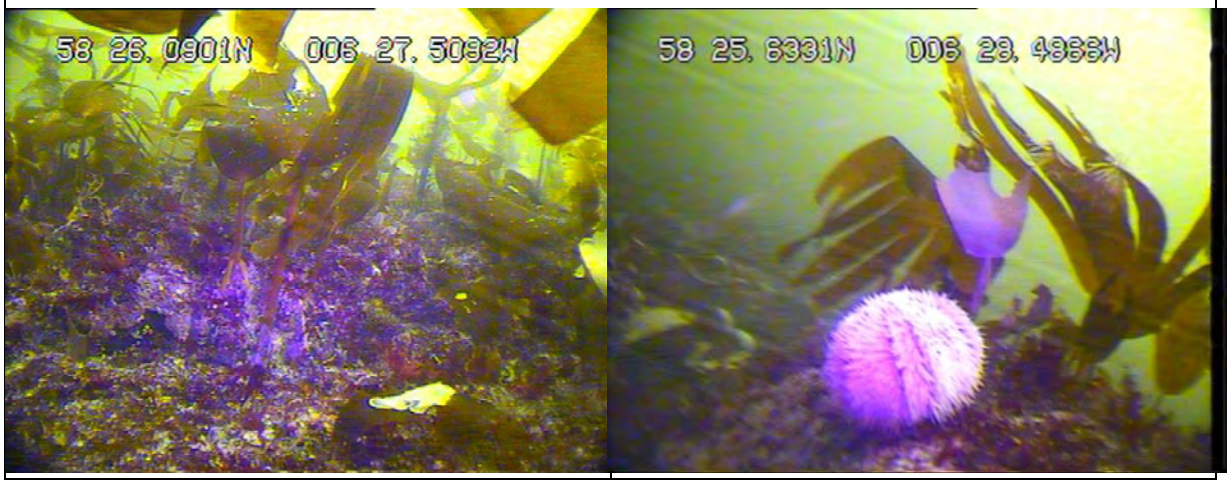
SS.SMp.KSwSS.LsacR.Sa - *Laminaria saccharina* and filamentous red algae on infralittoral sand



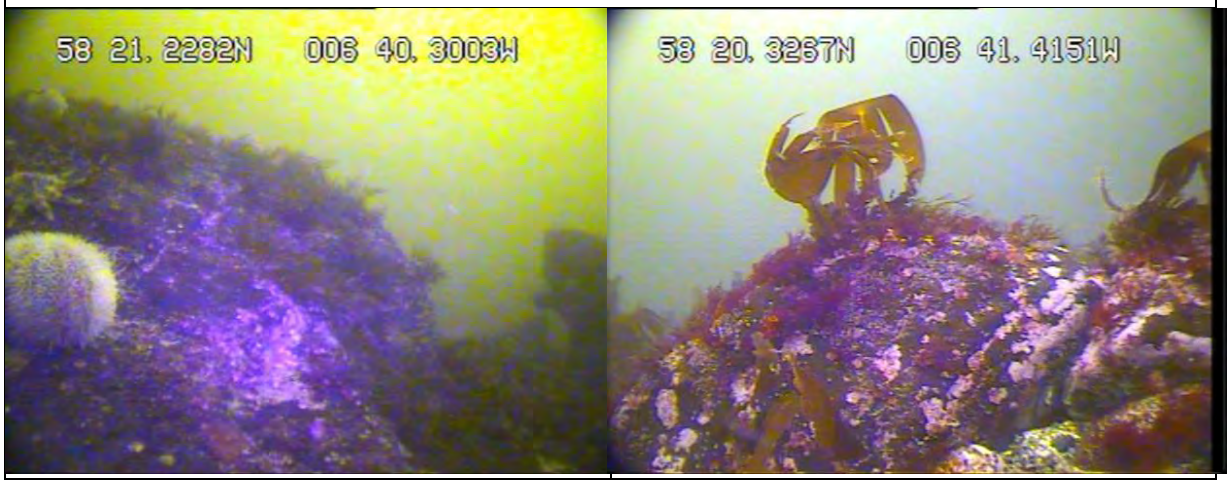
IR.HIR.KFaR.LhypR.Ft - *Laminaria hyperborea* forest with dense foliose red seaweeds on exposed, upper infralittoral rock



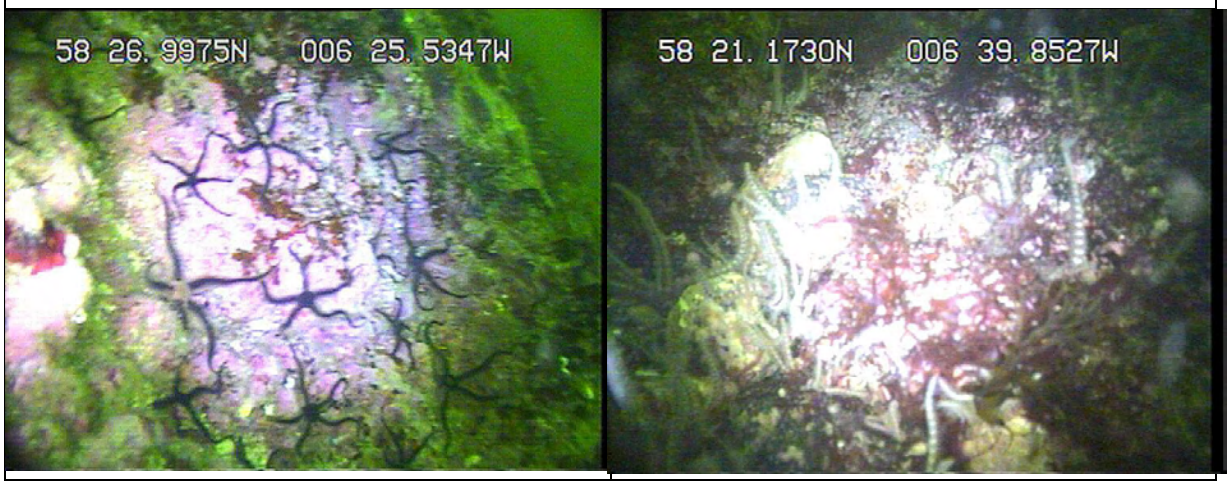
IR.HIR.KFaR.LhypR.Pk - *Laminaria hyperborea* park with dense foliose red seaweeds on exposed, lower infralittoral rock



IR.HIR.KFaR.FoR - Foliose red seaweeds on exposed, lower infralittoral rock



CR.MCR.EcCr.FaAlCr.Bri - Brittlestars on faunal and algal encrusted, exposed to moderately wave-exposed, circalittoral rock



CR.MCR.EcCr - Echinoderms and crustose communities

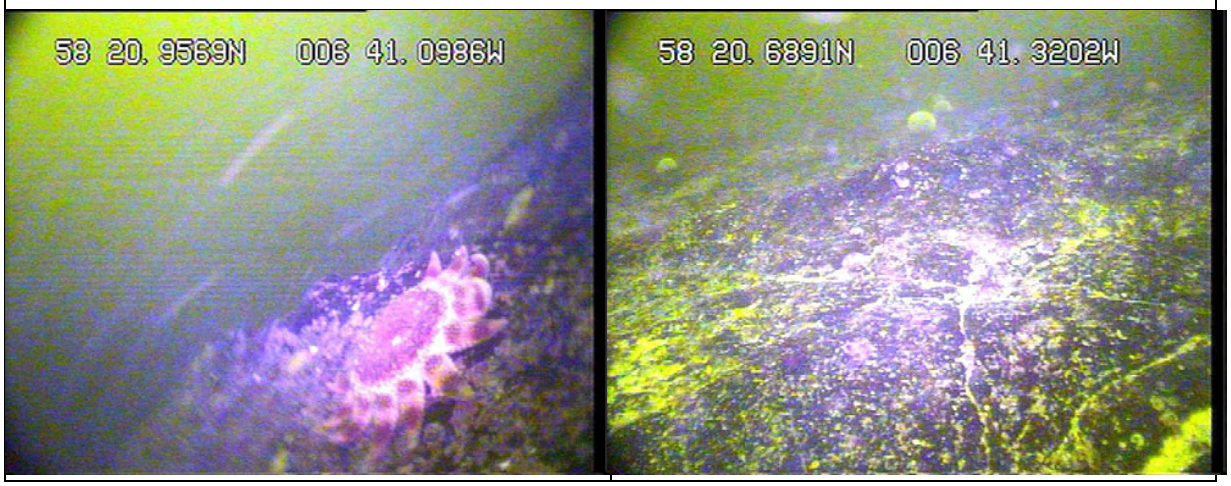


Figure 10. *Frame grab images of the 8 different biotopes that were recorded during the survey*

The distribution of these biotopes is presented in Figure 11 and Figure 12.

There appears to be some inshore/offshore pattern to the distribution of the biotopes. There is a relatively consistent change in the types of biotopes present across both of the survey areas (from onshore to offshore). Those that contain more sand, gravel and cobble tend to occur in the shallower areas close to the shore, whereas those with predominantly foliose red algae, and those with predominantly encrusting biota and echinoderms occur on the outer, offshore edges. Kelp forest and kelp park occur on the 'middle ground' between.

The data clearly show that the kelp *Laminaria hyperborea* biotopes dominate in the survey area (Table 1). Taking into account the 'mixed biotope' records, kelp forest (IR.HIR.KFaR.LhypR.Ft) was recorded at 43 sample sites and kelp park (IR.HIR.KFaR.LhypR.Pk) at 24. Together these amount to 67/90 = 74.5% of the total biotope records.

However, while the two survey areas contain a similar number of different biotopes (or mixtures of biotopes) (Table 1.), there are distinct differences in biotope compliments between the two areas. The Labost survey area contains foliose red algae (IR.HIR.KFaR.FoR) and encrusting biota with echinoderms (CR.MCR.EcCr) biotopes whereas these were not recorded at Siadar. On the other hand, kelp forest is much more prevalent at Siadar. The Labost survey area extends into deeper water than does the Siadar site. The deepest point recorded at Siadar is 21.1m whereas there were 9 video samples taken below this depth (21.2m to 24.5m) at Labost. This is likely to have some bearing on the types of biotopes present at the two sites.

JNCC Biotope Code	Labost	Siadar	Total
SS.SCS.ICS	2	0	**2**
SS.SMp.KSwSS.LsacR.Sa/IR.HIR.KFaR.LhypR.Ft/SS.SCS.ICS	0	1	**1**
IR.HIR.KFaR.LhypR.Pk/SS.SCS	1	1	**2**
IR.HIR.KFaR.LhypR.Ft/SS.SCS.ICS	0	6	**6**
IR.HIR.KFaR.LhypR.Ft	7	29	**36**
IR.HIR.KFaR.LhypR.Pk	8	14	**22**
IR.HIR.KFaR.FoR	6	0	**6**
CR.MCR.EcCr.FaAlCr.Bri	2	1	**3**
CR.MCR.EcCr	2	0	**2**
Total	**28**	**52**	**80**
Number of Types of Biotope	**7**	**6**	

Table 1. The occurrence of biotopes, or 'mixed biotopes' in the different survey areas.

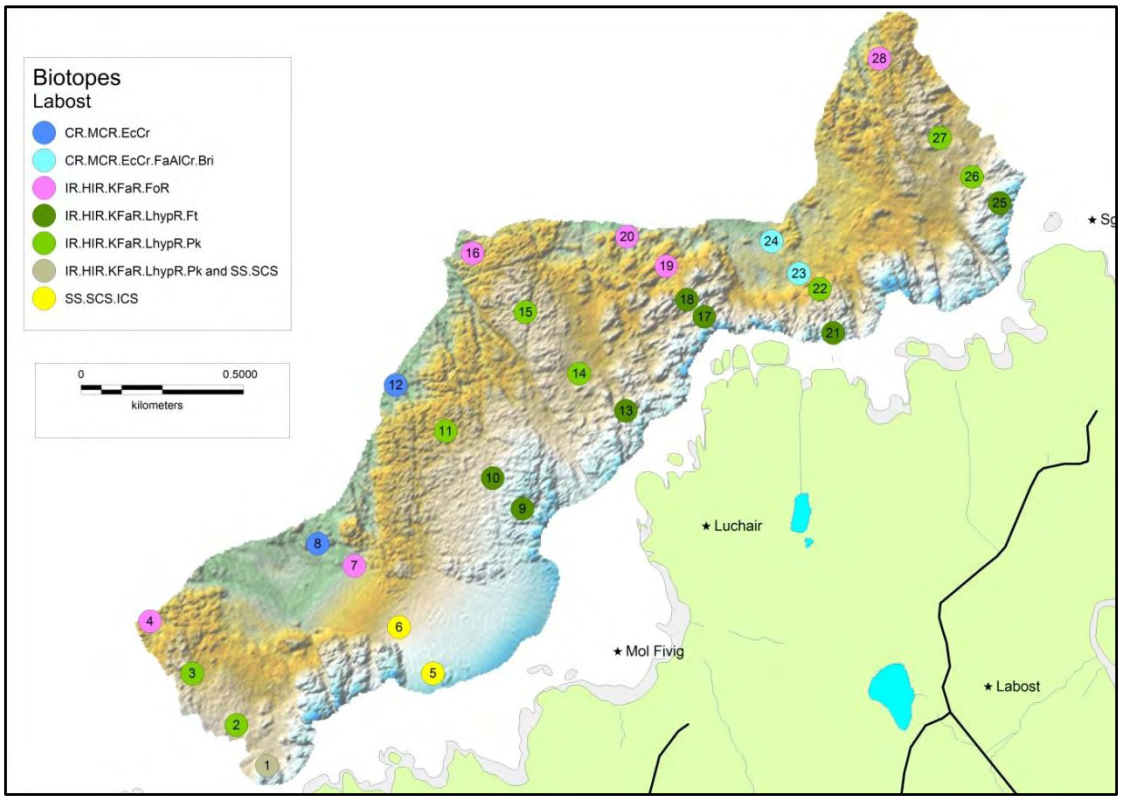


Figure 11. ***The distribution of the different biotopes recorded at the Labost Benthic Survey Area.***

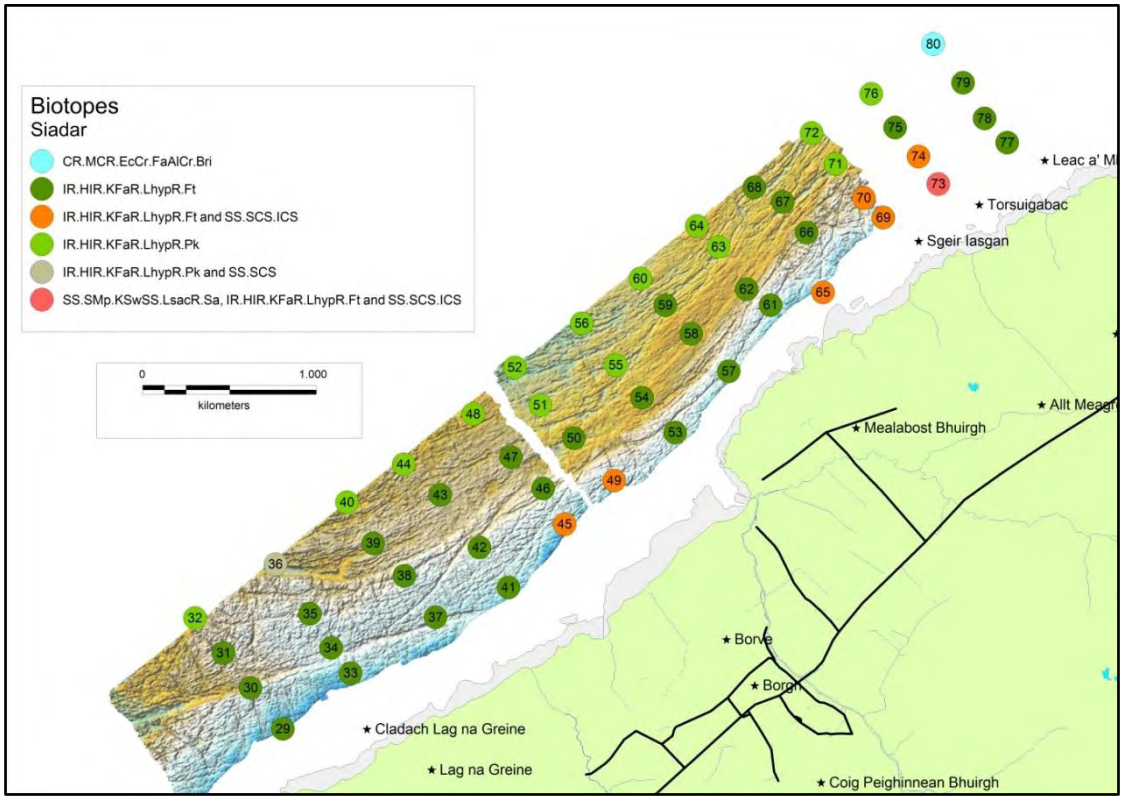


Figure 12. ***The distribution of the different biotopes recorded at the Siadar Benthic Survey Area (including the 16 extra sample sites – see Figure 66).***

D. Discussion

This video survey of the benthic ecology of the specified study areas off the north western coast of the Isle of Lewis forms a component of Aquamarine Ltd.'s EIA process. It provides a 'close-up, *in-situ*' view of the benthic survey areas concerned.

D1. Substrate

The substrate types present in the survey areas are characteristic of a more exposed site, consisting predominantly of rugged bedrock. Boulder and cobble tend to occur in patches overlying bedrock or mixed with pebble and gravel in gullies and on other low-lying areas of rock. Coarse sand tends to be restricted to the inshore areas and was apparently mobile, occurring in ripples and with no obvious fauna associated with it. No substrate finer than coarse sand was observed. These findings are in contradiction to the suggestion by Harrald et al. (2010) that this whole 'Area of Search' may be classed as BAP Habitat (see JNCC, 2010c) 'Sublittoral sands and gravels'. However, the Envision observations do concur with those of Aspect (2010) and with the YouTube video footage collected by Marine Scotland as reported in Lewis Wave Power Ltd. (2011).

D2. Biota

The Envision survey provides data on the distribution and abundance of the marine habitats present. There is good evidence that the dominant habitat consists of the kelp *Laminaria hyperborea*. This occurs either as 'forest' where the plants are tall and densely- growing, or as 'park' where the plants are much smaller and much less dense. The differences tend to be dependent on depth, with forest changing to park at roughly 18m depth. The kelp forest, in particular, supports diverse communities of red foliose algae and encrusting biota such as ascideans, bryozoans, sponges and coralline algae.

The biotopes tend to change with distance from shore, with coarse sands and gravel occurring close inshore being replaced by kelp forest, then kelp park (both mainly on either bedrock or boulder/cobble) and then, in the deeper bedrock areas off the Labost survey area, by foliose red algal communities and finally encrusting biotas with echinoderms.

The video footage obtained for the outermost parts of the Labost survey area reflects the account detailed in the information already gathered for the site (Lewis Wave Power Ltd., 2011, section 4.2.1). This showed communities of limited diversity typical of high energy environments containing sponges and echinoderms, such as *Echinus esculentus*, and *Ophiothrix fragilis*.

It is to be noted that this survey was carried out during the late summer, at a time when many of the fine red algae and encrusting species, such as ascidians and bryozoans are at their most abundant. Seasonal changes in some of the characteristic biota are to be expected.

D3. Habitats and Species of Conservation Importance

Scottish Natural Heritage has recently been undertaking a review of marine habitats and species to identify those considered to be of greatest marine nature conservation importance in Scottish Territorial waters – referred to as 'Priority Marine Features'. This has resulted in the production of a draft list of Priority Marine Features (SNH, 2011). Since this list will be used to support the advice that SNH gives on marine biodiversity, playing a role in the delivery of new marine planning and licensing systems set out in the Marine (Scotland) Act (2010), it is probably the most relevant document for assessing habitats and species of conservation importance within the study site.

None of the species recorded during the present survey is considered a 'Priority Marine Species' (see SNH, 2011). However, one of the biotopes identified as occurring within the study area is listed in the draft list of Priority Marine Features: 'Kelp and seaweed communities on sublittoral sediment' (SS.SMp.KSwSS). This was identified as '*Laminaria saccharina* and filamentous red algae on infralittoral sand' (SS.SMp.KSwSS.LsacR.Sa) and was present in the area, to the north of the Siadar survey area, that was part of the additional fieldwork (video drop sample 73). This formed a small part of a 'mixed biotope' site together with '*Laminaria hyperborea* forest with dense foliose red seaweeds on exposed, upper infralittoral rock' (IR.HIR.KFaR.LhypR.Ft) and 'Infralittoral coarse sediment' (SS.SCS.ICS). This biotope is not specifically mentioned in the UK BAP Habitats list (JNCC, 2010c).

UK BAP Species and Habitats lists have also been referred to as a benchmark to identify features of conservation importance. UK Priority species and habitats are those that have been identified as being the most threatened and requiring conservation action under the UK Biodiversity Action Plan (UK BAP) (JNCC, 2010a).

None of the UK BAP Species (JNCC, 2010b) has been recorded within either of the benthic survey areas. However, one of the habitats, 'Subtidal sands and gravels' (SS.SCS), found to occur within the Labost and the Siadar survey areas on 11 occasions (Table 1.), is listed on the UK BAP Habitats list (see JNCC, 2010c).

Horse mussel (*Modiolus modiolus)* beds, which are included both in the SNH list of Priority Marine Features (SNH, 2011) and as a UK BAP Priority Habitat (JNCC, 2010c), have been reported to occur both within and near to the Benthic Survey Areas (Harrald *et al*., 2010). However, this species was not observed from the video footage obtained during the present survey. The Horse mussel beds included in the BAP Habitat and Priority Marine Features lists occur in the circalittoral zone. Precise locations of the reported sightings are unclear but it would appear from the information given in Harrald *et al.* (2010) that they are close inshore in the shallow sublittoral (infralittoral) zone. They may not, therefore, be of particular conservation importance.

E. Conclusion

The drop-down video survey carried out by Envision Mapping Ltd. in the Labost and Siadar 'Benthic Survey Areas', (including 16 additional sample points to the north of the Siadar area) has given evidence that the benthic ecology of the area is robust. The dominant substrate within both of the survey areas is rugged bedrock, consistent with a high-energy marine environment. The dominant habitat at both sites consists of the kelp *Laminaria hyperborea* - either as kelp forest (in particular, at Siadar) or as kelp park. Kelp habitat commonly occurs on moderately to very exposed open coast around Scotland (MarLIn, 2007) and contains a diverse community of foliose red algae and encrusting biota.

None of the species observed from the video footage obtained is included on the SNH Priority Marine Features, or on the UK BAP species lists. One biotope, '*Laminaria saccharina* and filamentous red algae on infralittoral sand' (SS.SMp.KSwSS.LsacR.Sa), recorded at one video drop sample site, to the north of the Siadar area, is included on the SNH Priority Marine Features, and one habitat 'Sublittoral sands and gravels' which was found to occur within both the Labost and Siadar survey areas, is included on the UK BAP habitat list.

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Appendix 10.1

Lewis Wave Array Year 1 bird survey technical report

LEWIS WAVE ARRAY

YEAR 1 BIRD SURVEYS TECHNICAL REPORT

Natural Research Projects Ltd

November 2011

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Introduction

1. This document reports the results of on-going ornithological studies from north-west Lewis conducted to give baseline data to inform the EIA of Lewis Wave Power's proposed Oyster device wave power development (Fig 1). It covers the period from late September 2010, when regular observations began, to the end of September 2011.

2. This report covers the marine areas and adjacent coastlines within 2 km of the three vantage points (VPs), one situated at Labost and, two further north at Siadar and Mealabost together covering a continuous section of coast approximately 8km. Within these areas lies the proposed location of the proposed tidal demonstration project (Fig 3. The report also covers breeding birds surveys undertaken in 2011 at two small areas immediately inland from the coast at Siadar and Labost, where shore infrastructure associated with the development is currently proposed (Siadar, Fig 2) or might be proposed in the future (Labost, Fig 3).

Survey scope and aims

3. Marine wave energy developments are a novel technology and at present there are no commercial scale developments operating in the UK. At the time of commencing surveys there was no official guidance on the ornithological survey work that is considered necessary to inform the assessment of effects. Recently however draft guidance has been produced by SNH (Jackson and Whitfield 2011) and the recommendations in this were followed. There are also useful parallels that can be drawn with recent survey work undertaken for the Sound of Islay Demonstration Tidal Array (also by NRP) to inform EIA and monitoring. This project received consent in April 2011.

4. This survey programme covers birds, marine mammals and basking shark, the same approach that was successively used for baseline studies at the Sound of Islay. The survey programme draws heavily from the Sound of Islay work programme but has been modified to take account of local circumstances, differences in the species interests and in light of practical lessons learnt from the Islay study.

5. Although the results for marine mammals and basking shark are reported separately (LWA marine mammal and basking shark year-1 report), the survey methods for these mammals and sharks is also described here, alongside the methods for birds, because the survey programme was designed to collect information for these groups as a single exercise.

6. The aim of the baseline survey work is to collect quantitative and qualitative information to serve two purposes. These are:

- To characterise baseline conditions and inform the assessment of impacts for the Environmental Statement; and
- To establish baseline conditions against which results of future (post-consent) monitoring studies can be compared.

To a large extent the same baseline information can serve both these functions, although not in all cases.

7. The information collected by the surveys includes:

- Identification of species present;
- Estimation of absolute or relative numbers of each species (as appropriate for the species concerned);
- Mapping distribution of each species' activity;
- Recording of seasonal changes in species occurrence;
- Identifying the life-cycle stages and behavioural activities that a species undertakes in the study area.

Survey design and study area

8. The study area is located on the NW coast of Lewis and has an open and very exposed aspect. The study area includes the two distinct marine areas identified by Lewis Wave Power as having the best potential for initial deployment of wave generation devices (Fig 1). The study area is therefore split into two parts approximately 10 km apart, each focussing on one of the potential deployment areas. The more southerly part is centred on the Labost headland (Fig 2, Photo 1). The more northerly part stretches from the crofting townships of Siadar to Mealabost (Fig 3, Photos 2, 3 and 4).

9. Pilot work undertaken in September 2010 showed that the sites lend themself to shore-based survey methods. Shore-based methods were chosen in preference to boat-based or aerial methods because, where practical, they have significant advantages in terms of the quality and quantity of data collected, organisational logistics and generally lower costs. The pilot work showed that under reasonable conditions (sea state 4 or less) and, with the aid of a x25 spotting scope mounted on a tripod, it is practical to detect and identify birds and marine mammals up to at least 2 km from the coast. This distance comfortably allows the proposed development sites to be included. Beyond this detection and identification of animals becomes increasingly difficult. For this practical reason it was considered that the seaward extent of the study area should be 2km from the coast. Nevertheless, any scarce species, including all cetaceans, which were detected beyond that 2km limit were also recorded.

10. The marine extent of the study area includes the potential development area plus a surrounding buffer area (Fig 1). The width of the buffer in front and behind the development sites varies somewhat according to distance of the development site from the shore and local depth of water. The buffer includes all the area between the proposed development sites and the coast; a strip about 0.3 to 0.6 km wide. Parallel to the coast it extends in both directions for about 2 km beyond the proposed development sites.

11. At the Labost part of the study area the suitable depth range for Oyster devices lies between approximately 0.3 and 1.0 km from the shore. Therefore, the buffer, in this part of the site, extends for approximately 1km seaward beyond the proposed development area. At the Siadar/Mealabost part of the site the suitable

depth range for Oyster devices lies between approximately 0.6 and 1.2 km from the shore. Therefore, the buffer in this part of the site extends for approximately 0.8 km seaward, beyond the proposed development area.

Survey methods

12. Information on birds, marine mammals and basking shark using the marine parts of the study area was collected through a programme of vantage point (VP) watches. Information on birds using the coast was collected by periodic walkover surveys.

13. Information was routinely collected during VP watches on all marine mammal species, basking shark and all species of seabird, raptor, wader, wildfowl and heron. Some species were only recorded during certain VP survey activities (see below) but scarce species were recorded whenever seen, irrespective of survey activity. Scarce species included all cetacean species, basking shark, all diver species, and raptor species listed on Annex 1 of the EU Birds Directive.

14. Some common wildfowl and duck species of relatively low conservation importance were regularly present but in very small numbers and therefore recording them could potentially take up a disproportionate of amount of VP watch time. Therefore, during VP watches these species were recorded only if the flock size was greater than four birds. These species were oystercatcher, redshank, turnstone, curlew, golden plover, lapwing, greylag goose, mallard, teal, wigeon and red-breasted merganser. These species were always recorded in walkover surveys irrespective of flock size.

15. The vast majority of survey work in Year 1 was undertaken by Tristan ap Rheinallt. Digger Jackson, Lauren Jackson and Simon Pinder also undertook some surveys in July and August 2011.

Vantage point watches

16. Watches are undertaken from three VP locations, Labost (LA), Siadar (SI) and Mealabost (ME). These VPs were carefully selected to give optimal views of the areas of interest and provide adequate height (>10 m above sea level) for observations (Table 2, Figs 2 and 3, Photos 1, 2 and 4).

17. The target effort for each VP is 12 hours of watching per month (typically 4 x 3-hour sessions) spread over 4 days each month. Watches from the VPs are scheduled so that, as far as is practical, each month's sampling effort is evenly distributed with respect to the tidal cycle (six periods per ebb-flood cycle) and day light hours.

18. The experience of the first year of survey work has shown that weather and sea conditions are a major constraint to collecting VP data at the site and prevented the target hours being achieved in some months. When this occurs the shortfall is made up in the following month, if conditions allow.

19. The monthly programme of survey work from the VPs provides repeated information on the numbers, activity and fine-scale distribution of animals using the study area. VP watch sessions normally last for three hours and consist of short bouts of three separate activities, namely:

- Marine mammal watches (MMW);
- Snapshot scans (SSS); and
- Flying bird watches (FBW).

20. A three-hour VP watch typically comprises 2x snap-shot scans (one at the start and the other at the end of the period, total of 45-50 minutes), 7x marine mammal watches (total 105 minutes) and 5x flying bird watches (total 25 minutes).

21. VP watch data on birds were primarily collected during the SSS and FBW sessions. In addition records of scarce birds and Annex 1 species were collected during the MMW sessions.

22. The weather and sea conditions during a VP are recorded at the start of the watch and periodically through the watch if conditions change. The details recorded are wind force (Beaufort scale), wind direction, precipitation, visibility, sea state and extent and severity of sun glare.

23. VP watches are not undertaken in conditions greater than sea state 4 or in continuous heavy rain or when visibility is <2km.

24. The six tidal periods used in planning watches are based on equal portions (one sixth) of the tidal cycle (high tide to high tide). This means that each period is of approximately two hours duration, the exact time depending on the actual length of the tidal cycle. Periods 1 to 3 cover the ebb part of the cycle; Period 1 commences at high tide and Period 3 ends at low tide. Periods 4 to 6 cover the flow part of the cycle starting at low tide and ending at high tide. The start and end times of tidal periods were calculated from tide tables for Carloway, Lewis.

Marine mammal watches

25. Marine mammal watches are for fixed periods of 15-minute. They aim to measure the activity of marine mammals and basking shark using the survey area during each the period and because they are designed to measure a rate of occurrence, their duration is fixed. The following details are recorded for all marine mammals and basking sharks seen: time, species, age/size, group size, activity when first seen, location and travel direction.

26. An animal's location is recorded in terms of a compass bearing (measured using compass binoculars) and an angle of declination from the VP. Trigonometry is later used to calculate the grid reference of locations from these field measurements and the height above sea level of VPs.

27. The angle of declination is measured using a digital level attached to a spotting scope firmly mounted on a tripod fitted with a levelling head (Photo 5). The digital level measures angles to a precision of 0.05 degrees. The angle of declination of the horizon is also measured to provide a consistent reference.

28. Within each 15-min watch individual marine mammals (or groups) are given a sequential reference number to allow multiple records of the same individual (or group) to be distinguished from records of different individuals. The survey recording form also has space for the observer to record in detail any additional information they consider to be worth recording, e.g. comments on an animal's behaviour.

Snapshot scans

29. Snapshot scans (SSS) primarily aim to measure the instantaneous distribution of birds using survey areas. Cetaceans and basking shark are also searched for and recorded. A scan takes about 45 minutes to complete, depending on how many birds are present. Snap-shot scans are only conducted in conditions of sea state 4 or below. Flying birds passing through the survey areas, except those actively searching for food are ignored during SSS. SSS are undertaken by systematically searching the arc of the search area from one side to other using a combination of telescope and binoculars, going sufficiently slowly so as to reduce the likelihood overlooking actively diving birds or cetaceans because they are underwater (dives by birds typically last <1 minute).

30. The following details are recorded for birds, cetaceans and basking sharks seen during SSS: species, age/size, group size, behaviour, activity when first seen, location and travel direction. The locations of animals on the sea are recorded as described under MMW above.

31. Successive SSSs within a session are always in different tidal periods (these last slightly over 2 hours) and are separated by a period of at least an hour to reduce pseudo replication of records. Two SSS are completed in each 3-hour VP session.

Flying bird watches

32. Flying bird watches (FBW) are periods of exactly five minutes in which the number of flying birds passing a notional line straight out from the VP are recorded. These watches aim to quantifying the rate of seabird passage over the study area. The species, age, distance band and direction of travel are recorded. Any cetaceans or basking shark seen in the five-minute period are also recorded, in the same way as during MMW and SSS.

33. FBWs are conducted approximately every 40 minutes during each VP sessions; this means that approximately sixty 5-minute watches are completed each month.

34. The position of flying birds is recorded using distance zones from the shore as detailed in Table 1:

Vessel activity

35. All ships and boats within 2 km of the shore seen during the course VP survey work are recorded. The type of vessel, its distance zone from the shore (as defined for birds in FBW), activity and direction of travel are recorded. The vessel's name and registration code are also recorded if they are discernible.

Walkover surveys

Bi-monthly surveys of coastal sections

36. The coastline adjacent to the survey areas (Figs 2 and 3) was walked approximately bi-monthly through the year. These walkover surveys had two main aims: to count the numbers of waders and wildfowl using the coast on passage or to overwinter, and to record breeding birds in particular seabirds, waders and any

scarce species of high conservation value . Particular attention was paid to sections of cliff suitable for nesting raptors, and areas suitable for feeding shorebirds and geese.

37. Walkover visits were made October, December, February, April, June and August.

Breeding birds at 'inland' site

38. In late April and early June, i.e. the peak of the breeding season, the two small 'inland' areas around the proposed shore installation at Siadar and the potential shore site at Labost were surveyed for breeding and non-breeding birds using the conventional moorland bird survey method (Figs 2 and 3, Photo 2). This involved walking transects across the sites that took the observer to within 100 m of all parts and recording the location and behaviour of birds seen on large scale field maps (approximately 1:10,000 scale, enlarged from OS 1:25,000 map) using standard British Trust for Ornithology notation.

39. Incidental observations of scarce birds or notable flocks of other birds were also recorded during the breeding season during all fieldwork visits to the sites.

Data Analysis

Correction and presentation of Snapshot Scan data

40. The survey areas were defined as extending out to 2km from the coast at the VP locations. During SSS field observations it was not always possible to tell if birds seen on the sea were within 2km of a VP or a little beyond this. Therefore, observers took a cautious approach by recording any birds seen that might have been just beyond 2km survey area. Later the actual distance for each record was calculated using trigonometry from the angle measurements. Any records that were clearly well beyond 2km were not used in the seasonal analyses of abundance, density calculations or on the abundance and distribution maps. The calculated distances are subject to small errors associated with measurement, sea swell and tide state. To err on the side of caution all records with a calculated distance below 2250m were included rather than using a threshold exactly 2km.

41. The SSS data are summarised according to five seasons as follows: spring, April to June; summer, July and August; autumn, September and October; and early winter, November and December and late winter, January to March. The spring period broadly corresponds to the main part of the breeding season for most bird species and covers the period when most seabird species are most closely tied to breeding colonies. The summer period overlaps the breeding season of seabird species, but to a varying extent. Many seabird species depart from breeding colonies during July. Gannet, puffin and Manx shearwater are notable exceptions and these typically depart from their breeding colonies later, in August or September.

42. For the autumn season the data set includes observations from both September 2010 and September 2011, but for the other seasons, data from only one year were available.

43. For regularly occurring species, the mean density of birds using the survey areas was calculated for each season.

Distance Detection Correction

44. It is apparent from the SSS data that birds on the sea were subject to a bias in detection related to distance from the VP, especially smaller species such as auks. This bias was mostly caused by the swell component of the sea-state which could cause birds at distance to be out of view for much of the time. This bias was corrected using the method described below to improve the accuracy of estimates of the mean numbers and densities of birds present in the survey areas during each season.

45. The basis of the correction factors applied was the relative change in density (birds seen per unit area) in a series of 250m wide distance bands out from the VPs. Data from the three VPs was pooled. To prevent the potentially confounding issues of distance detection bias and habitat selection (some species show preference/avoidance for sea areas related to distance from the shore or water depth) the examination of distance detection bias was restricted to records within 500m of the shore. This restriction effectively overcame the confounding issue of distance-from-shore habitat selection effects but at the cost of a reduced sample size. To compensate data for similar species were pooled into species groups. The species groups examined were: diver species, shag & cormorant, gulls/terns/shearwaters and auks & eider duck.

46. Records for shag and black guillemot from the Labost VP were also excluded from the analysis to calculate correction factors. This was because these two species bred in small numbers close to this VP and birds there spent a disproportionate amount of time on the water in the 0-250 and 250-500m distance bands loafing below the breeding sites. If these records were included it would have caused a serious bias in the correction factors for these two species.

47. The density of birds in each distance category was compared and correction factors derived relative to the closest distance category (Table 3). As expected, for all species groups (except gannet) there were lower apparent densities in the distance bands furthest from the VP and this was most marked for the groups with smaller, less obvious species. It was also apparent that densities in the closest distance bands were very similar suggesting that these had detection rates at or close to 100% and therefore no correction was required for these distance bands.

48. Correction factors were only applied to records involving less than four individuals on the basis that larger flocks of birds were more easily detected. Whereas this group size cut off is arbitrary, in practice the only species affected is eider duck, a species that usually occurred in obvious flocks of more than four individuals which were unlikely to be overlooked. All SSS records of divers, shag, cormorant, puffin, common guillemot and black guillemot (<500m from colony) were of less than four individuals, and only five records of razorbill (16%) involved four or more individuals.

49. The analysed results for the SSS records are presented in a single table for each species (Tables 15–31). These detail the results for each of the five defined season from each VP, and for the three VPs combined. The information in these tables refers only to birds seen on the sea, or in the case of some species that forage on the wing (e.g. gannet, gulls, terns, skuas, shearwaters, petrels) birds that were clearly actively foraging when seen and were thus definitely using the study areas. Seven parameters are given in the tables. These are explained below.

50. *'Effort (No. of SSS)'*, this is the number of snapshot scans completed each season at each VP. For the three VP combined, this value is the sum of the values for individual VPs.

51. *'% zero counts'*, is the percentage of snapshot scans in the season in which the species was not recorded. This value was not calculated for the three VPs combined.

52. *'Maximum count'*, is the maximum number of individuals recorded in any single snapshot scan during that season from a VP. This figure is uncorrected. For the three VP combined, this value is simply the sum of the maximum values from each VP, even though these may have occurred on different dates.

53. *'Mean count uncorrected'*, is the mean of the number of individuals recorded from all SSS sessions during that season from a VP. This figure is also uncorrected. For the three VPs combined, this value is the sum of the means for the individual VPs.

54. *'Standard deviation of mean'*, is the standard deviation of the mean of individuals recorded from all SSS sessions during that season from a VP. For the three VPs combined, this value is the sum of the standard deviations for the individual VPs. The standard variations give an indication of the magnitude of the variation of the counts from a VP in a given season. In most cases the variation is large due to combination of the mobile nature of seabirds and the small size of the study areas.

55. '*Mean (corrected)*', is the mean of the number of individuals corrected for distance detection bias recorded from all SSS sessions during that season from a VP. For the three VPs combined, this value is the sum of the corrected means for the individual VPs. The corrected mean count gives the best indication of the numbers of individuals typically present in the individual study areas and the combined area during each season

56. 'Density bird/km^2 (corrected)', is the mean corrected count but expressed as a density. This was calculated by dividing the mean corrected count by the area of sea visible from each VP out to 2km. The mean density figures are useful for comparing the relative importance of the study areas with the published results on seabird densities at sea (specifically, Pollock *et al*. 2000)

57. Distribution maps (Figs 4 – 23) show the locations of birds recorded on the sea or actively feeding for common species. The purpose of these maps is to visually show any patterns in distribution that might be relevant to the proposed development. The dot sizes vary according to the number of birds recorded. The maps do not account for any under recording in the parts of the study areas furthest from the VPs and thus give a somewhat biased picture, especially for auk species. The likely extent of this bias can be judged from the correction factors (Table 3) and should be borne in mind the interpreting the maps. No account is made in the maps for the small amount of potential overlap (about 300m) between the semi circles of coverage from the Siadar and Mealabost VPs (Fig 1).

Analyses and presentation of Flying Bird Watch data

58. For regularly occurring seabird species, the FBW data were used to calculate the mean number of individuals of each species flying through over the study area per (daylight) hour during each month (Tables 14).

59. The numbers of birds recorded as flying either approximately NE or SW (i.e. parallel to the coast) was also examined to provide evidence of any net passage along the Lewis coast.

60. The relative frequency of the number of flying birds seen in each distance band was not examined. Data on the distance of flying birds from the shore are available should this information become pertinent in the future.

61. Compared to birds on the sea, flying birds were easy to detect and it is not thought that the FBW data are significantly affected by any distance detection bias. The only likely exception to this is the FBW data for storm petrel, a very small, dark species that habitually flies close to the sea surface. However even this species is quite easily detected in good survey conditions up to at least 2km away using a telescope.

Regional population context

62. For most species the regional breeding population is defined as all birds breeding in the SNH Natural Heritage Zone 3 (NHZ 3), the Western Isles (Outer Hebrides). Regional population sizes are taken from the Seabird 2000 census (Mitchell *et al* 2004). The units used to express seabird population sizes vary between species in accordance with Mitchell *et al.* (2004) and include: pairs, individuals, apparently occupied nests (AONs) apparently occupied territories (AOTs) and apparently occupied sites (AOSs) For gannet the regional population is taken to also include birds breeding on both the North Rona and Sula Sgeir SPA and Sule Skerry and Sule Stack SPA These islands lie just inside the boundary of NHZ 3. For Manx shearwater the regional population is taken to also include birds breeding on Rum SPA.

Results

Survey effort

63. The VP survey effort was approximately equal at each of the three VPs and spread across 78 days (Table 4).

64. The target number of VP watches was achieved in the majority of months through the year, except for the first survey month (September 2010) due not starting surveys until the last week of the month (Tables 6–8). In some months there was a small shortfall in the target effort achieved, however surveyors were often able to entirely or partly make good a shortfall in the following month. The survey sites are very exposed and sea conditions were often unsuitable for survey work (i.e. sea-state >4). Lack of days in a month with suitable survey conditions was the main reason for any VP effort shortfalls. Logistical problems caused by vehicle and CalMac ferry breakdown were a contributory reason to the shortfall in July 2010.

65. Whenever possible, VP survey work was targeted for times when there were conditions with a sea-state 3 or below (Tables 9-10). Overall 76% of VP watches were conducted in sea-state 3 or below. The remaining 24% were conducted in sea-state 4 (Table 9-10).

66. The VP survey work over the year was evenly distributed with respect to tide cycle.

67. Walkover surveys of the coast sections were completed bi-monthly as planned, in October, December, February, April, June and August (Table 5). Breeding bird territories were mapped on the April and June visits.

68. Breeding bird surveys of the two small 'inland' areas at Labost and Siadar, (i.e. the areas where shore development infrastructure is possible) were also conducted on 22 April and 4 & 6 June 2011.

Species accounts

Divers

69. Four species of diver were recorded during the year. Great northern (Photo 6) and red-throated divers were recorded in all months and were by far the commonest species, but the number of red-throated diver records was approximately half (48%) that for great northern diver. Black-throated divers were scarce and white-billed diver was recorded on one occasion only.

70. Great northern, red and black-throated diver are all listed on Annex 1 of the EU Birds Directive (European Parliament and Council 2010) and all four diver species are listed on Schedule 1 of Wildlife and Countryside Act. White-billed diver is an IUCN red list species with a globally Near Threatened status.

Red-throated diver

71. Red-throated diver is listed on Annex 1 of the EU Birds Directive (European Parliament and Council 2010) . Based on the mean maximum foraging distance estimate for red-throated diver of 12.2km (Birdlife International 2011a), red-throated divers from the Lewis Peatlands SPA (80 pairs, 2-5km SW of survey areas) (JNCC 2011b) could potentially use the survey areas for feeding. The north-western boundary of the Lewis Peatlands SPA runs roughly parallel to the NW Lewis coastline and the estimated breeding population of 80 pairs comprises 9% of the UK breeding population (JNCC 2011b). Within this area many red-throated divers breed on peatland lochs toward the eastern side of the island and forage in the more sheltered coastal waters to east of the Isle of Lewis. Fewer breed on the western side of the SPA and these are likely to forage along the NW Lewis coast (Stirling & Hulka 2003).

72. Red-throated divers were recorded in all months with the highest totals recorded in the four months, December-March (Table 13,median: 42 birds, range: 33-52) a period when birds from local breeding populations are unlikely to be present (Wernham *et al*. 2002).

73. SSS maximum monthly counts of red-throated diver were highest in early winter (13 birds) and late winter (15 birds). By contrast the sum of maximum counts across all three VPs during the autumn and summer was only two birds for each period (Table 15). Red-throated divers were seen on a greater proportion of scans in the Siadar (29%) and Mealabost (23%) survey areas compared to the Labost (7%) survey area (Table 15). The majority of birds (58%) were recorded from the Siadar VP with fewer (36%) at the Mealabost VP and only 6% of records from the Labost VP.

74. The average corrected seasonal density of red-throated divers was 1.5 birds/km^2, with the highest density recorded in late winter (Jan-Mar) at 4.4 birds/km^2. (Table 15)

75. In general the majority of red-throated divers recorded on the sea were distributed in a wide band parallel to, and less than 1.3km from the coast (Fig. 5).

76. Red-throated divers were recorded on FBW in all months except for May and July (Table 14). Numbers were consistent but low, typically three or four birds seen each month. Two thirds of birds were flying SE and one third in a NE direction. In addition, 68 flying red-throated divers were recorded during SSS and MMW sessions. These records had a similar spread through the year to FBW and an almost identical proportion of birds flying in NE and SW directions.

77. The scarcity of red-throated divers seen during SSS and FBW during spring and summer periods suggests that the study areas are of low importance as feeding areas for locally breeding birds, including those breeding on the Lewis Peatlands SPA.

78. Red-throated divers on the sea were seldom recorded during the walkover surveys (Table 32 and 34); they were only seen in Coast Sections 12 and 13 (close to Mealabost), and the maximum number present was 4 individuals.

Great northern diver

79. Great northern diver (Photo 6) is listed on Annex 1 of the EU Birds Directive (European Parliament and Council 2010). There is no great-northern diver breeding population in British Isles and the majority of birds using Scottish coasts are likely to be from breeding grounds in Iceland, Greenland or possibly Canada (Wernham *et al*. 2002).

80. Great northern divers were recorded in all months but were most numerous from early winter to the middle of the spring period (Nov-May), with monthly totals in this period varying between 26 and 90 birds. Monthly counts for June through to September were much lower (3-13 birds) (Table 13).

81. On average great northern divers were seen on 39%, 58% and 63% of scans at Labost, Siadar and Mealabost VPs respectively. Each of the two more northerly survey areas at Siadar and Mealabost had just over twice as many SSS records as the survey area at Labost. SSS maximum monthly counts of birds on the sea were during the early and late winter and spring (20, 20 and 22 birds respectively). In both the summer and autumn, maximum monthly counts totalled four birds (Table 16).

82. The average corrected seasonal density of great northern divers, was 6.1 birds/km^2 with the highest densities in the early winter (Nov-Dec, 7.7 birds/km^2), late winter (Jan-Mar, 11.8 birds/km^2) and spring (Apr-Jun, 8.4birds/km^2) (Table 16).

83. In general great northern divers on the sea were most frequently recorded in a wide band parallel to, and less than 1km from the shoreline (Fig. 6 and 7). This was particularly evident within the adjacent Siadar and Mealabost survey areas.

84. Great northern diver monthly totals for FBWs were very low; between one and three birds. In some months, widely scattered through the year, no birds were recorded. In addition to FBW survey records; there were 40 sightings of great northern divers in flight recorded during SSS and MMW sessions. Two thirds of all great northern divers recorded in flight were moving northward and a third southward.

85. Small numbers of great northern diver were regularly recorded on the sea within approximately 500m of the coast during the walkover surveys (Table 32 and 34). The greatest total number seen on any single survey was 7 individuals in the Labost sections and 14 in the Siadar/Mealabost sections.

Black-throated diver

86. A single black-throated diver diving on the sea on the 15th November and another flying NE on the 20th November were the only records.

White-billed diver

87. A single immature white-billed diver was seen on the sea with great northern divers 2.9km from the Labost VP on the 19th November 2010.

88. White-billed diver is a rare winter visitor and passage migrant to the NW coast of Scotland.

Shearwaters and petrels

89. Four species of the procellariiformes order (shearwaters and petrels) were recorded during surveys, namely fulmar, Manx shearwater, sooty shearwater and European storm petrel. Of these all but sooty shearwater has substantial breeding populations in western Scotland, including the world's largest colony of Manx shearwater on Rum and of fulmar on St Kilda.

90. European storm petrel is listed on Annex 1 of the EU Birds Directive (European Parliament and Council 2010).

91. Sooty shearwater is an IUCN red list species with a globally Near Threatened status.

Fulmar

92. Based on a mean maximum foraging distance for fulmar of 311km (Birdlife International 2011a) and the distance by sea between the survey areas and designated sites that have fulmar as a qualifying interest, fulmar from 17 SPAs could theoretically be foraging in the survey areas. Fulmar at all these 17 SPAs are categorised as part of internationally important seabird assemblages. These are, in order of increasing distance from the survey areas; Flannan Isles (47km, 4730 pairs), Handa (65km, 3500 pairs), North Rona and Sula Sgeir (66km, 11,500 pairs), The Shiant Isles (75km, 6,820 pairs), Cape Wrath (77km, 2300 pairs), St Kilda (113km, 62,800 pairs) North Caithness Cliffs (140km, 14,700) Hoy (171km, 35,000 pairs Mingulay and Berneray (182km, 10,450 pairs), Rousay (198km, 1240 pairs), West Westray (207km 1,400 pairs), East Caithness Cliffs (217km, 15,000 pairs) Calf of Eday (218km, 1955 pairs), Copinsay (220km, 1615 pairs), Fair Isle (290km, 35,210 pairs), Foula (300km, 46,800 pairs) Troup, Pennan and Lion`s Heads (306km, 4400 pairs) (JNCC 2011b). The Seabird 2000 survey recorded 64 apparently occupied sites along the coast within the Labost survey area and 17,500 apparently occupied sites on the Isle of Lewis as whole. The Western Isles regional breeding population of Fulmar is estimated at 118,073 apparently occupied sites (Mitchell *et al* 2004).

93. Fulmars were recorded in all survey months except September and October 2010. Monthly counts varied between months. Generally, fulmar numbers were highest in late winter and early spring (Jan-Apr, median: 266 birds, range: 136-355) and lower during late spring, summer and early autumn (May-Sep, median: 110 birds, range: 31-182) (Table 13). The number of fulmar recorded on the sea during SSS scans were approximately half those recorded flying through the survey areas during FBWs.

94. Fulmars were recorded on 20% of scans during SSS surveys. However at the Labost VP during the spring period (Apr-Jun) fulmar were recorded during 91% of scans, reflecting the presence of breeding birds close to the Labost VP (Tables 17).

95. SSS maximum monthly counts of fulmars were much higher during the late winter than in any other season with a maximum count of 105 birds recorded during this period. Compared with this, early winter and spring maximum counts were approximately a third of this figure (33 and 28 birds respectively) and during the summer and autumn fulmars were infrequently recorded on the sea. (Table X.

96. The averaged seasonal density of fulmars on the water was 5.8 birds/km^2 with a maximum density of 16.4 birds/km^2 in late winter (Jan-Mar). The average density of 7.7 birds/km^2 in spring (Apr-Jun) was also relatively high compared with other seasons. (Table 17).

97. Just under half (48%) of fulmars recorded during SSS surveys were single birds. with a further 44% in small groups of between 2-10 birds. Occasional groups of between 10 and 48 fulmar were also recorded.

98. Out of a total of 606 fulmar records during SSS surveys 538 (89%) were seen from the southern Labost VP with only 65 and 3 birds recorded at Siadar and Mealabost VPs. In the Labost survey area birds were recorded at a range up approximately 1.5km with the highest number of records in a SW-NE band approx 200-500m from the coastline (Fig.8). The relatively few records from the Siadar and Mealabost survey areas showed no clear distributional pattern (Fig.9).

99. Fulmars accounted for 14% of birds seen during FBWs. They were recorded in all months except September and November 2010. Monthly count totals were varied with no clear seasonal pattern. The number of fulmars passing VPs was highest during mid-winter (Jan) with an average of 44 birds/hour and late winter-spring (Mar-Jun, average: 32.3 birds/hour, SD=5.7). Summer (Jul-Aug) rates were approximately half this with an average of 18.4 birds/hour. No birds were recorded passing VPs during autumn 2010 (Sept-Oct) and the rate in September 2011 was low (4.2 birds/hour)(Table 14).

100. Just under half (45%) of fulmars during FBW surveys were flying in a generally SW direction, a quarter (25%) of birds were heading generally NE, and 30% had a varying flight direction.

101. Moderate numbers of fulmars were regularly recorded using the coast in the walkover surveys (Table 32 and 34). The maximum counts outwith the breeding season were 108 birds in the Labost sections and 7 birds in the Siadar/Mealabost sections.

102. Small numbers of fulmars were recorded breeding on cliffs along the coast. There 54 pairs breeding in the Labost sections, mainly in Sections 16 and 4, and 9 pairs breeding in the Siadar/Mealabost sections, all in Section 9 (Table 33 and 35).

Sooty shearwater

103. Sooty shearwater is an IUCN red list species with a globally Near Threatened status (Birdlife International 2011b). They breed on sub-Antarctic islands in the Southern Ocean, migrating to the temperate zones during its non-breeding season (the boreal summer). It is only present in significant numbers in European waters during (and just prior to) its southern passage (mainly in Aug-Oct) (Birdlife International 2004).

104. Sooty shearwaters were recorded in survey area in summer and early autumn (Jul-Sep 2011) with 73 of a total of 84 recorded in September (Table 13).

105. Sooty shearwaters were only recorded on the sea during SSS surveys in September 2011 with 28 birds seen on the 15th comprising a flock of 16 birds and three smaller groups of 5, 5 and 2 birds.

106. Sooty shearwaters were recorded flying during both FBW surveys (15 birds) and during MMW surveys (41 birds). Flying sooty shearwaters recorded during these two surveys were either single birds (62%) or birds flying in small groups of 2-8 birds (38%). The rate of sooty shearwaters passing VPs per hour was low and restricted to the summer and early autumn with a maximum rate of 2.0 birds/hour in September 2011 (Table 14).

107. Two thirds of birds recorded in flight on FBW and MMW survey were heading SW and one third heading NE.

Manx shearwater

108. Based on the mean maximum foraging distance of 196km (Birdlife International 2011a), Manx shearwaters from two designated sites that have this species as a qualifying interest could theoretically be foraging in the survey area. These are St Kilda (113km, 5,000 pairs), and Rum (164km, 61,000 pairs) (JNCC 2011b). No non-designated breeding sites were recorded within the Western Isles region during Seabird 2000 surveys (JNCC 2004).

109. Manx shearwater is a summer visitor to Scotland and was recorded between April and September with counts generally increasing during this period and peaking in September 2011 (Table 13).

110. Manx shearwaters were recorded on the sea during SSS surveys during the summer and autumn (Jul-Sept). Only one bird was recorded in July, 20 of 21 birds recorded during August were a single feeding flock and the maximum count of 241 birds in September largely comprised a single flock of 190 birds on the water.

111. Manx shearwaters were recorded passing over the study areas on FBW surveys between March and September). The rate of birds passing VPs per hour was highest in June and July with a monthly average of 14 birds/hour. Rates were slightly lower in the autumn (Aug, 9.7 bird/hour, October, 11.2 birds/hour) and very low in spring (Apr-May, < 3 birds/hour) (Table 14).

112. Equal numbers of birds were recorded flying in a general southerly direction (S or SW) compared with a generally northerly direction (N or NE).

113. Just over half (51%) the Manx shearwaters flew past singularly with most other birds in groups of 2-10 (47%). Four flocks of between 10 and 20 birds were recorded.

Storm petrel

114. European storm petrel is listed on Annex 1 of the EU Birds Directive (European Parliament and Council 2010). Based on a mean maximum foraging distance for storm petrel of 100km (Ratcliffe, Phillips & Gubbay 2000) storm petrels from two SPAs have this species as a qualifying interest could theoretically be foraging in the survey area . These are North Rona and Sula Sgeir (66km, 1000 pairs) and Priest Island (Summer Isles) (78km, 2,200 pairs) (JNCC 2011b). Additionally the Seabird 2000 survey recorded breeding storm petrels at Eilean Mor, Flannan Isles, 52km to the west of the Labost VP (7 apparently occupied sites), and at Shillay 73km SW of the Labost survey area (328 apparently occupied sites) (JNCC 2004).

115. A total of 106 storm petrels were recorded during all surveys with nearly all recorded in July (101 birds) and just five birds in August (Table 13).

116. During the summer months (Jul-Aug) storm petrels were recorded on 20% of SSSs, and these records totalled of 50 birds. All but three of these actively searching for food on the wing. The maximum number present in summer period was 18 birds, but the mean number present was only 1.8 birds (Table 19).

117. Two thirds of storm petrels (32 birds, 64%) seen on SSS surveys were recorded in the Siadar survey area. The location of storm petrel sightings showed no clear distributional pattern. (Figs. 10 and 11).

118. Eighteen records (60%) were single birds, seven (23%) were groups of two birds together and the remaining five (17%) were groups of three or four birds.

119. A total of 38 storm petrels were recorded during FBW surveys with all but one bird seen in July.

120. Half of the storm petrels recorded in flight during FBWs had no specific direction, and varied during their course. Of the remaining birds, 15 (39%) passed in a generally NE direction and four (11%) in a SW direction.

Gannet

121. Based on a mean maximum foraging distance for gannet (Photo 7) of 309km (Birdlife International 2011a) and the distance by sea between the survey sites and designated sites that have gannet as a qualifying interest, gannets from four SPAs could theoretically be foraging in the survey area (JNCC 2011b) . These are, in order of increasing distance from the study areas, North Rona and Sula Sgeir (66km, 10,400 pairs), St Kilda (113km, 50,050 pairs), Sule Skerry and Sule Stack (118km, 5900 pairs), and Fair Isle (290km, 1166 pairs). In addition the Seabird 2000 survey recorded 1244 apparently occupied nests at Roareim, a component of the Flannan Islands and lying 56km to the west of the Labost survey site.

122. Gannets were recorded in all survey months although numbers seen during much of the winter period (Nov-Feb) were very low (median 4.5, range: 2-7 birds). Generally numbers increased gradually from March to a maximum of 800 birds in August (Table 13). The numbers of gannets recorded during SSS scans, either on the water (85%) or actively searching for food (15%), were low compared with numbers recorded passing through the survey areas during FBWs.

123. Gannets were recorded on 11% of SSS scans overall rising to 18% of scans during the spring and summer periods (Apr-Aug). Numbers recorded in the winter periods were very low. SSS maximum monthly counts were highest during the spring and summer (the breeding season) and in the autumn, however the overall mean values for each of these periods was still low at between one and two birds Table 20).

124. The averaged seasonal density for gannets on the water/hunting was 0.7 birds/km^2 with no single season exceeding a density of 2.0 birds/km^2 (Table 20).

125. Most gannets were recorded singly on SSS surveys (86% of total counts) with a further 10% of records in small groups of 2-3 birds. The maximum group size recorded during SSS surveys was 25 birds.

126. Similar numbers of gannets were recorded at Labost (47% of SSS records) and Siadar (40% of SSS records) survey areas. Fewer were recorded from the Mealabost VP (13% of SSS records). Birds were widely distributed through the three survey areas with no clear distributional pattern (Figs.12 and 13).

127. Gannets accounted for 31% of birds seen during FBWs. They were recorded in all months but were scarce during the winter. The number of gannets passing VPs was generally highest during late spring, summer and autumn (Jun-Oct) with a maximum of 306 birds per hour in September 2010. Other monthly rates in this period were less than half this figure and with the exception of a low figure in July were between 61 and 110 birds per hour (Tables 14).

128. Three quarters (75%) of all gannets recorded during FBW were flying either NE or N with the remaining 25% flying SW or S. During August when nearly 800 birds were recorded, 97% of these were heading NE or N.

Cormorant and shag

Cormorant

129. No cormorants were recorded breeding within the survey sites during Seabird 2000 surveys. Two small non-designated breeding colonies totalling 21 apparently occupied nests were recorded on two adjacent islands 15km to the SW of the Labost survey area during Seabird 2000'. These colonies are within the mean maximum foraging range estimate of 31.7km for cormorant. No other cormorant breeding colonies were recorded during Seabird 200' surveys within 50km of the survey areas; 50 km is the maximum recorded foraging range for this species. (Birdlife International 2011a; JNCC 2004). The Western Isles cormorant breeding population was (445 apparently occupied nests, Mitchell *et al*. 2004).

130. Cormorants were recorded in very low numbers in all months except April, May and September (2011) No more than 4 birds were recorded during any one month (Table 13). Most birds were recorded flying with equal numbers heading SW and NE

131. SSS monthly counts of birds on the sea only totalled 8 birds throughout the year.

132. Cormorants seen flying over the survey areas during FBW sessions did not exceed three birds in any month, equivalent to an average rate of well below 1 bird per hour.

133. Small numbers of cormorant were regularly recorded on the sea or roosting on rocks within approximately 500m of the coast during the walkover surveys (Table 32 and 34). The greatest total number seen on any single survey was 7 individuals in the Labost sections and 8 in the Siadar/Mealabost sections.

134. No cormorants were recorded breeding in the walkover sections.

Shag

135. The distance from any of the survey areas to the nearest designated site that has shag (Photo 8) as a qualifying interest is greater than the maximum known foraging distance estimate for shag of 20km (Birdlife International 2011a). Therefore, it is very unlikely that the shags seen in the study areas are from designated sites with shag as a qualifying interest.

136. The location of the survey areas are within the maximum known foraging range (20 km) (Birdlife International 2011a) of *ca.* 600 pairs of shags from numerous small non-designated colonies along the W coast of Lewis (JNCC 2004) . This includes one colony of 10 pairs at Labost on the cliffs below the VP there. The

Western Isles regional breeding population of shag is estimated at 2,661 apparently occupied nests (Mitchell *et al* 2004).

137. Shags were recorded in all months with the highest number of birds recorded in the autumn and early winter and the lowest in April. (Table 13).

138. SSS maximum monthly counts of shag were highest in autumn (38 birds) and early winter (33 birds). Maximum counts in summer and late winter were approximately half this, 16 and 17 birds respectively (Table 21).

139. The average density of shags on the sea was highest during the autumn (Sep-Oct, 15.6 birds/km^2) and early winter (Nov-Dec, 11.9 birds/km^2) and lowest during the spring (Apr-Jun, 1.8 birds/km^2)(Table 21).

140. SSS records of shag were spread amongst the three VPs fairly equally with 34%, 39% and 28% of birds recorded at Labost, Siadar and Mealabost VPs respectively. Shags were recorded on the sea on average on two thirds of all SSS scans.

141. Most shags were recorded on the sea singularly (87% of records). Otherwise birds were in small groups of up to 4 birds (12% of records) or rarely larger groups of up to 11 birds.

142. Shags mainly were recorded in a band parallel to, and *ca*. 0-600m from the shorelines of the study areas (Figs. 14 and 15).

143. Shags flying over the survey sites accounted for 3% of all birds recorded on FBWs. They were recorded on FBWs in all months. Numbers were generally low and monthly rates varied between 10 and 36 birds per hour. On average 5.4 (SD=2.1) birds per hour flew past VPs with the highest figures in January and February (8.3 and 8.6 birds per hour respectively (Table 14). Nearly all shags on FBW were flying alone. The numbers of flights NE and the number south west were approximately equal suggesting that the majority were local movements of birds re-distributing between feeding areas or moving between these and roost sites.

144. Small numbers of shag were regularly recorded on the sea or roosting on rocks within approximately 500m of the coast during the walkover surveys (Table 32 and 34). The greatest total number seen on any single survey was 12 individuals in the Labost sections and 11 in the Siadar/Mealabost sections.

145. Shags were recorded breeding only in the Labost walkover survey sections (Table 33). The exact number could not be determined because the nest sites were out of view from the cliff tops (for example in small caves), however judging from the numbers of adults birds seen in the vicinity there were approximately five pairs present in 2011.

Herons

Grey heron

146. Single grey herons were recorded on four occasions. Sightings were all in the late autumn/winter (Oct-Feb) with three records at the Mealabost VP and one at Siadar.

Swans and geese

147. Two species of swan and five species of geese were recorded during survey work. Barnacle goose was the most commonly recorded migrant goose species

comprising just under half of all geese recorded. Pink-footed geese comprised just under a quarter of goose records with greylag and Greenland white-fronted geese accounting for 8% and 6% of all geese recorded.

148. Whooper swan, barnacle goose, Greenland white-fronted goose are listed on Annex 1 of the EU Birds Directive (European Parliament and Council 2010). Barnacle goose is listed on Annex 1 of the EU Birds Directive (European Parliament and Council 2010). Greylag goose is listed on Annex II/2 of the EU Birds Directive (European Parliament and Council 2010.)

149. Approximately a fifth of all goose records (17%) were not identified to species. It is most likely that these were either pink-footed, Greenland white-fronted or greylag geese.

Whooper swan

150. Whooper swan is listed on Annex 1 of the EU Birds Directive (European Parliament and Council 2010).

151. Three groups of flying whooper swans were recorded on two dates, one in spring the other in autumn. On 8th October 2010 12 birds were seen flying SW past the Mealabost VP, and on 15th March 2011 55 birds were seen well out to sea and additional six birds were recorded from the Labost VP flying north.

152. The whooper swans seen were actively migrating flocks either coming from or going to Iceland.

153. Whooper swan was occasionally recorded during walkover surveys using freshwater lochs. The greatest total was six birds, split between Sections 1 and 3 (Table 32). Up to two mute swans were also seen in these sections.

Pink-footed goose

154. Pink-footed goose is listed on Annex II/2 of the EU Birds Directive (European Parliament and Council 2010). A total of 511 pink-footed geese were recorded during October 2010 (14% of total birds recorded) and April/May 2011 (86% of total birds). All birds were recorded flying. Spring records were from 18th April and 12th May and comprised groups of 400 and 40 birds respectively both flying NW. Autumn records were from 11th October; a group of 24 birds flying south, and 12th October; two birds flying SW.

155. The flocks of pink-footed geese seen in autumn and spring were actively migrating flocks either coming from or going to Iceland.

Greenland white-fronted goose

156. Greenland white-fronted goose is listed on Annex 1 of the EU Birds Directive (European Parliament and Council 2010). A total of 157 Greenland white-fronted geese were recorded. All records were from two dates in October 2010 and all birds were flying in a generally southerly direction. Birds were recorded in approximately equal numbers from each of the three VPs. Apart from one record of a single bird, the size of the four other groups seen was 11, 30, 55 and 60 birds.

157. The flocks of Greenland white-fronted geese seen in autumn were actively migrating flocks arriving in Scotland from Iceland.

Greylag goose

158. Flocks of migrating greylag geese were recorded during the late autumn/early winter (Oct-Nov, 118 birds) and early spring (Apr, 80 birds). During the autumn one bird and a group of seven birds were recorded flying in a southerly direction on 13th and 14th October respectively, and on 23rd November three groups of between 30 and 40 birds were recorded flying NE. During the spring 80 greylag geese were seen flying N on the 20th April. These flocks of greylag geese seen in autumn and spring were all flying high over the sea and were most likely actively migrating flocks either coming from or going to Iceland.

159. This species also breeds and overwinters locally in moderate numbers. These birds sometimes seen using and overflying the croftland near VPs however they were not recorded during the VP watches because they were not over the sea and the walkover surveys were a more effective means of recording them.

160. Greylag geese were commonly recorded on pastures and wetlands in all 13 coast sections during walkover surveys (Table 32 and 34). Greylag geese were recorded throughout the year but especially in the winter. The highest totals were 129 birds in the Labost sections and (coincidentally) 129 birds in the Siadar and Mealabost sections.

161. Nine breeding pairs of greylag geese, most with broods, were recorded in the 'inland' survey section at Siadar on Loch Bacabhat (Table 35).

Barnacle goose

162. Barnacle goose is listed on Annex 1 of the EU Birds Directive (European Parliament and Council 2010). Barnacle geese were almost exclusively recorded during October 2010 with a monthly total of 1156 birds. The only other records were of five birds seen in September 2010. With the exception of two groups of 15 and 55 birds all birds were recorded in flight, nearly all (98%) were flying past in a SW direction and most (96%) were recorded from the southern Labost VP.

163. Just under a third (32%) of flying Barnacle geese were seen in small groups of up to 10 birds, with all but one of the remaining records (65%) of birds in groups of between 10 and 100. One large flock of 200 birds was recorded.

164. The flocks of barnacle geese seen in autumn were actively migrating flocks arriving in Scotland from Iceland.

Brent goose

165. Two pale-bellied brent geese were seen on the coastal walkover surveys along the Siadar/Mealabost sections in October (Table 34).

Unidentified geese

166. A total of 418 unidentified geese were recorded during SSS, FBW and MMW surveys from all three VPs. Three quarters (318 birds) of these were seen in October the remaining 100 in April. Most unidentified geese were recorded flying except for a group of 75 seen on the sea from the Labost VP. These geese were mostly likely to have been either pink-footed geese, Greenland white-fronted geese or greylag geese.

Ducks

167. Twelve species of duck were recorded during survey work. Of these eider was the only commonly occurring species using the sea.

168. The less common duck species seen during VP watches were represented either by a records of a few small flocks totalling between 10 and 100 birds (common scoter, long-tailed duck, mallard, red-breasted merganser, scaup, and teal) or isolated records totalling less than 10 birds (gadwall, pintail, pochard, tufted duck and wigeon).

169. Several common species of ducks were also recorded on the coastal walkover surveys during the autumn and winter. Peak counts for the Labost sections were 4 shelduck, 59 wigeon, 6 teal, 16 mallard, 4 eider and 13 red-breasted merganser (Table 32). Peak counts for the Siadar/Mealabost sections were 115 wigeon, 17 teal, 49 mallard and 80 eider (Table 34).

170. Common scoter is listed on Annex 1 of the EU Birds Directive (European Parliament and Council 2010).

171. Common scoter and eider are on the Birds of Conservation Concern Red-list (Eaton *et al*. 2009).

Wigeon

172. Ten wigeon seen from the Labost VP flying SW on 13th October 2010 and two birds recorded from the Mealabost VP flying SW on 18th August 2011 were the only records during VP watches.

Gadwall

173. A single gadwall seen from the Labost VP, flying SE on 11th October was the only record.

Teal

174. VP watch records of teal comprised two flocks recorded during the late autumn/early winter (Oct-Nov). Eleven birds flew NE past the Mealabost VP on the 8th October 2010 and 25 birds flew NE past the Siadar VP on the 23rd November 2010.

Mallard

175. A total of 24 mallard were mainly recorded in VP watches during the late autumn and winter (Oct and Dec/Jan, 11 birds). Other records were a single bird seen during a FBW at Mealabost on 3rd May and an incidental record of 12 birds feeding in a bay near the Mealabost VP.

Pintail

176. A single pintail seen from the Siadar VP during a MMW on the 11th October 2010 was the only record.

Pochard

177. A single record of five pochard flying NE past the Mealabost VP with a flock of 25 scaup on 8th October 2010 was the only record.

Tufted duck

178. Two small flocks of tufted duck were recorded during VP watches; one of seven birds at Siadar the other of three birds at Labost flying SW on the 11th October 2010 were the only records.

Scaup

179. Scaup records during VP watches were restricted to October except for a single record of 2 birds flying NE on the 15th February. A total of 72 birds were recorded although it is likely that 22 birds recorded at twice at different times on one date were the same birds making the actual total 50 birds. Scaup were recorded at all three VPs and all birds seen were flying.

Eider

180. The distance from any of the Survey areas to the nearest designated site that has eider as a qualifying interest is greater than the current maximum foraging range estimate of 100km for eider (Birdlife International 2011a). Therefore no impacts of the development on designated sites with eider as a qualifying interest are predicted.

181. Eiders were recorded during VP watches from late autumn (Oct) to late winter (Mar), with no records during spring and early summer (Apr-Jul).Monthly totals showed an increase from 10 birds in October to a maximum of 474 birds in December a decrease in January and February to 173 birds followed by an increase in March to 421 birds, similar to that recorded in December (Table 13).

182. Eiders seen on the sea during SSS counts comprised most (92%) of the total number of eiders recorded. Records of eider during SSS surveys were restricted to the winter (Nov-Mar).with similar maximum counts of 166 and 182 birds in the early and late winter periods respectively (Table 22). On average eider were recorded on 52% of scans during SSS surveys during the winter period (Table 22). Eider were recorded as single birds (18% of records), or in groups of different sizes up to 90 birds. The majority of eider were recorded either from the central Siadar (44% of SSS birds) (53% of SSS birds) with only 49 birds (3%) recorded from the Labost VP. Generally eider were distributed in a band parallel to, and approximately 0-800m from the shoreline (Figs. 16 and 17).

183. The averaged seasonal density of eiders on the water was 12.3 birds/km^2 with peak densities in early winter (Nov-Dec, 23.6 birds/km^2) and late winter (Jan-Mar, 37.6 birds/km^2)(Table 22).

184. Eiders were recorded during FBW surveys in low numbers in late autumn/early winter (Oct-Nov) and during late winter (Jan-Mar) with an additional single bird in September 2011. The maximum monthly count of eiders during FBW surveys was 19 birds in March. Two thirds of FBW sightings were from the central Siadar VP (29 birds) and a third from the southern Labost VP (16 birds) with only 6 records of flying birds from the northern Mealabost VP. During the main period when eider were recorded (Oct-Mar) an average of 1.7 birds/hour passed VPs with a maximum of 3.8 birds/hour in March (Table 14). Two thirds (65%) of eider were recorded flying SW compared with under a quarter (20%) flying NE. The remaining birds were recorded flying in varying directions.

Long-tailed duck

185. A total of 17 long-tailed duck were recorded during VP watches: all were seen in the late autumn and early winter (Oct-Dec) from the Labost (4 birds) or the

Mealabost VPs(13 birds). All birds were recorded in flight with the majority (59%) heading SW.

Common scoter

186. The distance from any of the survey areas to the nearest designated site that have common scoter as a qualifying interest is greater than the common scoter maximum foraging distance of 200km (Birdlife International 2011a). Therefore, it is not likely that birds seen using the survey areas during the breeding season are from designated sites with common scoter as a qualifying interest

187. During VP watches a total of 21 common scoter were recorded in mid/late winter (Dec-Feb, 11 birds), spring (Apr-Jun, 5 birds) and late summer (Aug, 5 birds) with no records during autumn or early winter (Sep-Nov) 2010 or in September 2011 (Table13). More common scoter were recorded at the central Siadar survey area (11 birds) compared with the Mealabost (8 birds) or Labost (2 birds) survey areas. Half (11 birds) of the total common scoter recorded were flying, nine moving SW and two NE. There was no seasonal pattern to the direction of flight. Three common scoter were recorded foraging; 2 two together in the Siadar survey area and 1 in Mealabost survey area.

Red-breasted merganser

188. A total of 12 red-breasted mergansers were recorded during VP watches. Except for 4 birds seen on the water during September all were either single birds or in groups of two and recorded in flying past VPs during FBWs. Red-breasted mergansers were recorded on FBW surveys during the late autumn and early winter (Oct and Dec, 3 birds), early spring (Apr, 2 birds) and early summer (Jul, 1 bird)

Raptors

189. Six species of raptor were recording during surveys flying over the survey sites and nearby coastlines. No raptor species bred in the survey areas.

190. White-tailed eagle, peregrine and merlin are listed on Annex 1 of the EU Birds Directive (European Parliament and Council 2010), and are on Schedule 1 of the Wildlife and Countryside Act (as amended).

White-tailed eagle

191. A single immature white-tailed eagle was seen flying NE on 22 April 2011 over coast Section 6 during a walkover survey.

Sparrowhawk

192. A sparrowhawk flying SW past the Labost VP during a SSS survey on the 29th December 2010 was the only record.

Buzzard

193. A total of five buzzards were seen during VP watches; one in December 2010, one in April and three during September 2011, were the only records. All birds where flight direction was recorded (4 birds) were flying NE.

Kestrel

194. A kestrel flying SW past the Labost VP during a FBW on the 15th March 2011 was the only record during VP watches.

Merlin

195. Merlin was recorded on eight occasions (9 birds in total) during VP watches. Just over half of these records (5 birds) were during the early/mid-winter period (Nov-Jan). The rest were in early spring (Apr-May, 2 birds), early summer (Jul, one bird), and early autumn (Sep, 1 bird). Seven records involved single birds and one two birds.

196. A single merlin was occasionally seen hunting in autumn and winter in the coastal walkover surveys (Table 32 and 34).

Peregrine

197. Peregrine was recorded on 3 occasions during VP watches survey work.

198. Peregrine was occasionally seen hunting during the coastal walkover surveys (Table 32 and 34). There was no evidence that peregrine bred in any of the coastal sections, though the cliffs at Labost appeared broadly suitable.

Waders

199. Sixteen species of waders were recorded during VP survey work. Of these golden plover, knot and oystercatcher were the most commonly recorded but even the total numbers of these birds were small; ca. 150 for golden plover and ca. 100 for the others. Less common waders were represented by either a few small flocks totalling between 10 and 100 birds (curlew, dunlin, purple sandpiper, sanderling, turnstone and whimbrel) or isolated records totalling less than 10 birds (bar-tailed and black-tailed godwit, common sandpiper, greenshank, grey plover, lapwing and ringed plover).

200. Small numbers of non-breeding knot, whimbrel, curlew, purple sandpiper, turnstone and sanderling were recorded in autumn, winter and spring during the coastal walkover surveys though in no case could the numbers present be considered to be of particular importance (Tables 32 and 34).

Oystercatcher

201. A total of 115 oystercatchers were recorded during VP watches. Birds were recorded in all months except September and January. Monthly totals were lowest during most of the winter Nov-Feb with numbers not exceeding five birds in any of these months. Numbers were slightly higher in March (10 birds) and April (15 birds) but low again in May (4 birds). Peak counts were for July (33 birds) and August (30 birds). Just under half (46%) of records were from the Labost VP with fewer birds recorded at the Siadar VP (30%) and at Mealabost (24%).

202. Most oystercatchers (71 birds, 62%) were recorded during FBW surveys flying. Of these just over half (53%) were single birds, approximately a third (30%) groups of two, and the remainder (17%) seen in in groups of 3-5 birds. More oystercatchers flew in a southerly (59% of FBW birds) rather than northerly direction (38%) but there was no clear seasonal pattern.

203. Oystercatchers were one of the commonest shoreline waders using the coastal sections. They were recorded throughout the year and in all survey sections.

Peak numbers (non-breeding) were 100 birds in the Labost sections, mainly in Sections 1 and 6 (Table 32), and 67 birds in the Siadar/Mealabost sections, mainly in Section 11 (Table 34).

204. Oystercatchers were also recorded breeding in small numbers (7 pairs) in the Labost sections, all in Section 4 (Table 31).

Ringed plover

205. Three summer records ringed plovers seen from Labost; one on the 26th July and two on the 13th August were the only sightings seen during VP watches.

206. Ringed plover were one of the commonest shoreline waders using the coastal sections. They were recorded throughout the year and in most survey sections. Peak numbers (non-breeding) were 121 birds in the Labost sections, mainly in Sections 1 and 6 (Table 32), and 13 birds in the Siadar/Mealabost sections (Table 34).

207. Ringed plover were also recorded breeding in small numbers. There were 3 pairs in the Labost sections, all in Sections 3 and 4, and one pair in the Siadar/Mealabost sections, in Section 9. (Table 33 and 35 and Fig x)

Golden plover

208. Golden plover is listed on Annex 1 of the EU Birds Directive (European Parliament and Council 2010) .Golden plovers were recorded during early winter (Nov), early spring (Mar-Apr) and summer (Jul-Aug). The highest monthly count was in April (96 birds) and November (26 birds). Other monthly totals did not exceed 15 birds. Golden plovers were not recorded during the autumn (Sep-Oct), mid to late winter (Dec-Feb) and only one bird was recorded during the late spring (May-Jun).A fifth of golden plover were recorded as single birds, just under half (47%) were seen in groups of 2-10 and a third in groups of between 12 and 35. Just under two thirds of flying golden plover (61%) were recorded heading SW with all but one of these records occurring during the late winter spring and summer (Mar-Aug) period. A third of flying birds were heading NE. These records were scattered throughout the year (Apr, Aug and Nov).

209. Golden plover were commonly recorded during the coastal walkover surveys, especially the autumn, winter and spring (Table 32 and 34). Most birds at these times were likely to be birds from the Icelandic breeding population. Peak numbers were 221 birds in the Labost sections and 112 birds in the Siadar/Mealabost sections.

210. A few golden plover were seen in June, the peak of the breeding season, (Table 33) in the 'inland' survey area at Labost (Section 4 inland). Although these birds were not breeding within the survey area (they were feeding) it is likely that they were part of the local breeding population, perhaps including birds breeding on the Lewis Peatlands SPA, where this species is a qualifying interest. Additionally eight birds (non-breeding) were recorded on land 100m from the Siadar VP on 25th July.

Grey plover

211. Grey plovers were recorded on three occasions (5 birds in total) between late September and mid-October during VP watches flying past the VPs.

Lapwing

212. A single lapwing flying SW on 24th December past the Siadar VP was the only record during VP watches.

213. Small numbers of lapwing were occasionally recorded on the coastal walkover sections outwith the breeding season (Tables 32 and 34). Peak numbers were 44 in the Labost sections and 20 in the Siadar/Mealabost sections. These birds were likely to be from the Lewis breeding population.

214. Small numbers of lapwing were also recorded breeding in the two 'inland' surveys areas; 2 pairs at Labost and five pairs at Siadar (Tables 31 and 33).

Knot

215. A total of 91 knot was recorded during FBW surveys. With the exception of 2 birds seen flying SW on 29th September 2010, all sightings during VP watches were during August 2011 and seen from either Siadar or Mealabost VPs. All but two of knot recorded during August were flying NE.

Sanderling

216. A total of 26 sanderlings in three small flocks, seen in the late summer (19th and 22nd August) from the Mealabost VP were the only records from the VP watches.

Purple sandpiper

217. A total of 65 purple sandpipers were recorded although it is likely that two flocks of 22 birds seen on 27th and 29th December at Labost were the same birds. Most purple sandpipers (58 birds) were recorded during the early winter (Nov-Dec) with the remaining 7 records in late March. All but one record of five birds at Mealabost were seen from the Labost VP.

Dunlin

218. Dunlin was recorded on three occasions on surveys during late spring and summer. Single birds were recorded flying NE and SW on 22nd June and 27th July respectively. On 22nd August a flock of 10 birds was seen flying SW during a MMW from the Mealabost VP. On 27th July 20 birds were noted as an incidental record feeding in the bay close to the Mealabost VP.

219. Non-breeding dunlin were commonly recorded on shorelines during the coastal walkover surveys, especially the August and October (Table 32 and 34). Most birds at these times were likely to be birds from the Icelandic breeding population. Peak numbers were 125 birds in the Labost sections, mainly in Sections 1 and 6, and 36 birds in the Siadar/Mealabost sections, mainly in Section 7.

220. Approximately three pairs of dunlin were recorded breeding in the 'inland' survey area at Siadar (Table 33 and Fig 25). These breeding dunlins are of the *Schinzii* race, which is listed on Annex 1 of the EU Birds Directive

Black-tailed godwit

221. Single records of black-tailed godwit were made during MMW from the Mealabost VP. One was seen flying SW on 28th March and another, also flying SW, on 19th August.

Bar-tailed godwit

222. One bar-tailed godwit was recorded during MMW from the Mealabost VP flying SW on 1st September. This was the only record.

Snipe

223. Two pairs of snipe bred, one in the Labost 'inland' area and one in the Siadar 'inland' area. (Tables 31 and 33 and Figs x and y).

Whimbrel

224. A total of 53 whimbrel were recorded mainly during MMW and FBW surveys. Most whimbrels (49 birds) were recorded during the spring (Apr-Jun) with just four birds seen in late summer (Aug). All whimbrel were recorded in flight with approximately half of these recorded as single birds and the other half as small flocks of up to eight birds. All birds were likely to be migrants from the Icelandic breeding population. During the spring just under two thirds (57%) of birds flew SE and a just under a third (32%) flew NE. During August the four birds recorded flew S or SE.

Curlew

225. Curlews were recorded from mid-winter (Dec) to late summer (Aug) during VP watches. All birds were flying past VPs and involved one or two birds except in January when 26 birds were recorded. These comprised a flock of 11 flying NE on the 22nd, and flocks of 10 and 5 flying SW on the 27th. Overall similar numbers of birds were flying northerly and southerly directions.

226. Two pairs of breeding curlew were recorded in June, one pair in Section 7 and one pair in the 'inland' survey area at Siadar.

Greenshank

227. One greenshank on 25th July flying NE during a FBW at the Siadar VP was the only record during VP watches.

Redshank

228. No flocks of >5 redshank were recorded during the VP watches though singles and smaller flocks were regularly seen.

229. Redshank was commonly recorded in small numbers during the coastal walkover surveys, especially the autumn, winter and spring (Table 32 and 34). Most birds at these times were likely to be birds from the Icelandic breeding population. Peak numbers were eight birds in the Labost sections and 59 birds in the Siadar/Mealabost sections.

230. Small numbers of redshank were also recorded breeding in the two 'inland' surveys areas; three pairs at Labost and approximately 8 pairs at Siadar (Tables 31 and 33, Figs 24 and 25).

Common sandpiper

231. One common sandpiper was recorded from the Labost VP flying NE on the 27th July. This was the only record during VP watches.

232. One pair of common sandpipers bred in coast section 11.

Turnstone

233. A total of 16 turnstone in small flocks (<10) were recorded in late summer/early autumn (Aug-Sept) and in November. They were seen in roughly equal numbers from each of the three VPs. The eight turnstones seen in November flew

NE, those in August and September flew both north and southward in roughly equal numbers.

Skuas

234. Two species of skua were recorded in small numbers, namely Arctic skua and great skua. Both these species are summer visitors and breed locally in small numbers.

235. Arctic skua is on the Birds of Conservation Concern Red-list (Eaton *et al*. 2009).

Arctic skua

236. Arctic skua is a qualifying interest for the adjacent Lewis Peatlands Ramsar Site with 70 apparently occupied territories at the time of designation and representing an average of 3.2% of the UK population (Eaton *et al*. 2009; JNCC 2011a). No other designated site lie within a radius from the surveys equalling the maximum foraging range estimate for Arctic skua of 100km (Birdlife International 2011a). [Note, Arctic skua is not a qualifying species for the Lewis Peatlands SPA.]

237. The Western Isles regional breeding population of Arctic skua is estimated at 156 apparently occupied territories (Mitchell *et al*. 2004).

238. Only three Arctic skuas were recorded during the year, one in May and two in October. This suggests that the study areas are of low importance for foraging by locally breeding birds, including those breeding on the Lewis Peatlands Ramsar Site.

Great skua

239. Great skuas breed on moorland inland of the survey sites. There are just over 100 pairs breeding within a radius from the three survey sites equivalent to the great skua mean maximum foraging distance of 42.3km (Birdlife International 2011a; JNCC 2004). The Western Isles regional breeding population of great skua is estimated at 345 apparently occupied territories (Mitchell *et al* 2004).

240. Monthly counts of great skua were small (1-8 birds) and, with the exception of a single bird in October, were only recorded in spring and summer months (Apr-Aug). All but four from the total of 29 birds were recorded on FBW surveys.

241. Approximately two thirds (61%) of the great skuas seen were recorded from the Siadar VP, and a quarter (26%) from the Labost VP. Only two birds were recorded from the Mealabost VP.

Gulls

242. Eight species of gull were recorded during VP survey work during the year with herring gull the commonest comprising 8% of all birds seen and 47% of all gull records. Great black-backed gull (25% of gull records), common gull (15% of gull records) and kittiwake (8% of gull records) were the next most frequently recorded species. Lesser black-backed (3% of gull records) and black-headed gull (1% of gull records) were relative uncommon. Glaucous gull, Iceland gull and Bonaparte's gull were scarce with five, six and one bird respectively seen during the year.

243. Herring gull is on the Birds of Conservation Concern Red-list (Eaton et al. 2009).

Black-headed gull

244. The distance from any of the survey areas to the nearest designated site that has black-headed gull as a qualifying interest is greater than the maximum foraging distance estimate of 70km (Thaxter *et al*. in prep.). Therefore, it is not likely that birds seen using the survey areas during the breeding season are from designated sites with back-headed gull as a qualifying interest.

245. Black-headed gull breeding sites are patchily distributed in Lewis with inland colonies totalling *ca*. 300 pairs situated at Loch Stiapavat, (*ca*. 10km NE of the Mealabost) and at Garynahine (*ca*. 20km S of the Labost). The Western Isles regional breeding population of black-headed gull is estimated at 1012 apparently occupied nests (Mitchell *et al*. 2004).

246. Black-headed gulls were scarce throughout most of year at all VPs with April (19 records) and May (7 records) the only monthly counts exceeding two birds (Table 13).

247. Black-headed gull records on the sea during SSS surveys were uncommon with nine birds in April and two birds in May the only sightings.

248. FBW surveys accounted for the majority (66%) of black-headed gull records. Numbers were nonetheless low with a maximum of 10 birds in April and five birds in June constituting over two thirds (68%) of the FBW records. For other survey months black-headed gulls were either not recorded flying or had total counts below two birds. Approximately two thirds of black-headed gulls (62%) recorded during FBW surveys were flying SW, the rest (38%) were flying NE.

249. Black-headed gulls were commonly recorded in the walkover surveys throughout the year (Tables 32 and 34). The peak totals of non-breeding birds were 53 birds for the Labost sections and 76 birds for the Siadar/Mealabost sections.

250. Black-headed gulls were also recorded breeding in moderate numbers in the coastal walkover sections (see '*Breeding gull colonies'* section below).

Common gull

251. The distance from any of the three survey areas to the nearest designated site that has common gull as a qualifying interest is greater than the current maximum foraging distance estimate for this species of 50km (Thaxter *et al.* in prep.). Therefore, it is not likely that birds seen using the survey areas during the breeding season are from designated sites with common gull as a qualifying interest.

252. Common gull has a widespread breeding distribution across Lewis. Based on Seabird 2000 surveys, the potential foraging ranges of approximately 326 breeding pairs could include the survey areas. The Western Isles regional breeding population of common gull is estimated at 1,707 apparently occupied nests (Mitchell *et al*. 2004).

253. Overall, common gulls were recorded in all months with a distinct maximum of 190 birds in April constituting 40% of all birds recorded. They were also commonly recorded in May July and October with monthly totals of 54, 62 and 47 respectively (Table 13).

254. On average common gulls were seen on only *ca.* 7% of scans from the three VPs SSS maximum monthly counts of common gull were highest during the spring (85 birds) with a maximum count of half this figure during the summer. Maximum counts during the autumn and winter were consistently low. (< 7 birds) (Table 23).

255. The averaged seasonal corrected density for common gull was 2.4 birds/km^2 with a maximum density of 8.1 birds/km^2 in the spring (Apr-Jun) (Table 23).

256. Common gulls were recorded in all months during FBW. The highest hourly rates were in May, July and October with 9.0, 6.8 and 8.1 birds respectively. The average rates were lowest during September (2010), January and August, with less than two birds passing per hour in these months (Tables 14)

257. Just under twice the number of common gulls recorded during FBW flew in a SW direction (59%) compared to those flying generally NE (36%). The reasons for this discrepancy were unclear, but may be associated with local roosting behaviour.

258. Common gulls were commonly recorded in the walkover surveys throughout the year (Tables 32 and 34). The peak totals of non-breeding birds were 53 birds for the Labost sections and 91 birds for the Siadar/Mealabost sections.

259. Common gulls were also recorded breeding in moderate numbers in the coastal walkover sections (see '*Breeding gull colonies'* section below).

Lesser black-backed gull

260. The distance from any of the three survey areas to the nearest designated site that has lesser black-backed gull as a qualifying interest is greater than the current maximum foraging distance estimate for this species of 134.6km (Thaxter *et al.* in prep.). Therefore, it is not likely that birds seen using the survey areas during the breeding season are from designated sites with lesser black-backed gull as a qualifying interest.

261. Lesser black-backed gull is a widespread breeding bird in Lewis. The Seabird 2000 survey recorded 400 apparently occupied, lesser black-backed gull nests within a radius from the survey areas, equivalent to the mean maximum foraging range estimate of this species (JNCC 2004). The Western Isles regional breeding population of lesser black-backed gull is estimated at 552 apparently occupied nests (Mitchell *et al*. 2004).

262. Lesser black-backed gulls are summer migrants to the Western Isles and were not recorded from November to February. In March five birds were recorded followed by a sharp increase in April and lower numbers through the summer (Table 13).

263. Lesser black-backed gulls were recorded on only 3% of SSS scans; they were only recorded on the sea in April (24 birds) and July (9 birds) (Table 24). Birds were most frequently seen on the sea singularly (50% of SSS records). Occasionally groups of up to 10 birds were recorded.

264. The averaged seasonal density of lesser black-backed gull recorded by SSS surveys was 0.3 birds/km^2 with a seasonal maximum density of 1.0 birds/km^2 in spring (Apr-Jun) (Table 24).

265. SSS records were restricted to the Labost (39% of records) and Siadar (60% of records) survey areas. Birds on the sea were most frequently seen within 400m of the coastline.

266. Lesser black-backed gull records for FBW showed a peak in spring with 19 birds in both April and May and 18 in June (Table 14). During April, May and June there were an average of 3.8, 5.7 and 3.6 lesser black-backed gulls passing per hour respectively (Table 14). There was little difference in the proportion of lesser black-backed gulls flying flight SW (45%) compared with those flying NE (48%).

267. Lesser black-backed gulls were recorded breeding in small numbers in the coastal walkover sections (see '*Breeding gull colonies*' section below).

Herring gull

268. The distance from any of the three survey areas to the nearest designated site that has herring gull as a qualifying interest is greater than the maximum foraging distance estimate of 100km for this species (Thaxter *et al*. in prep.). Therefore, it is not likely that birds seen using the survey areas during the breeding season are from designated sites with herring gull as a qualifying interest.

269. Herring gull is a widespread breeding bird along the coasts of Lewis. The mean maximum foraging range for herring gull is estimated to be 45km (Thaxter *et al*. in prep.). Results from Seabird 2000 survey show there are 831 herring gull pairs whose foraging range is potentially likely to include some or all of three survey (JNCC 2004). The Western Isles regional breeding population of herring gull is estimated at 2,665 apparently occupied nests (Mitchell *et al*. 2004).

270. Herring gull was recorded in all seasons in widely varying numbers. Generally the highest monthly counts were during the winter and early spring (Nov-Apr, median: 177 birds, range: 136-311) and the lowest counts in late spring, late summer and autumn (May, Jun, Aug-Oct, median: 25 birds, range: 8-36 (Table 13).

271. SSS maximum monthly counts of herring gull were highest during late winter (118 birds) Maximum counts for early winter, spring and summer were much lower, approximately between a quarter and a half of the late winter figure The lowest maximum count total was during the autumn (7 birds). On average herring gulls were recorded on just over a quarter (28%) of scans during SSS surveys (Table25).

272. The average seasonal corrected density for herring gull was 6.6 birds/km^2 with a maximum density of 17.4 birds/km^2 in the late winter (Jan-Mar) (Table 25)

273. Eighty-five percent of herring gull sightings on the sea were either of single birds (46%) or small groups of 2-10 birds (39%). The remainder were of flocks of up to 110 birds. The majority (65%) of herring gull seen during SSS were in the Labost survey area.

274. Herring gull, recorded on the sea, was generally distributed in a band 100-600m from the main shoreline with occasional records at *ca.*1km from the nearest shoreline (Figs. 18 and 19).

275. The averaged seasonal density for herring gull was 6.6 birds/km^2 with a maximum density of 17.4 birds/km^2 in the late winter (Jan-Mar) (Table 25)

276. Herring gull was recorded in all months on FBWs. On average there were 11.1 birds passing per hour, with the highest rates during the mid and late winter (Dec: 22.1birds/hour, Jan 31.5 birds/hour and Feb: 20.6 birds/hour) and the lowest rate of 0 7 birds/hour in August (Table 14).

277. During both the autumn and mid-winter to spring there were two to three times more birds flying generally SE compared to NW.

278. Herring gull was commonly recorded in the walkover surveys throughout the year (Tables 32 and 34). The peak totals of non-breeding birds were 129 birds for the Labost sections and 20 birds for the Siadar/Mealabost sections.

279. Herring gull was also recorded breeding in moderate numbers in the coastal walkover sections (see '*Breeding gull colonies'* section below).

Great black-backed gull

280. The distance from any of the three survey areas to the nearest designated site that has great black-backed gull as a qualifying interest is greater than the maximum foraging distance estimate of 40km for this species (Fenny & Walls 2009;

Ratcliffe *et al*. 2000). Therefore, it is not likely that birds seen using the survey areas during the breeding season are from designated sites with great black-backed gull as a qualifying interest.

281. Great black-backed gulls breed in small numbers around the Lewis coast. During the Seabird 2000 surveys one apparently occupied nest was recorded in the survey areas; at Labost. Based on Seabird 2000 surveys, the potential foraging ranges of approximately 200 breeding pairs could include the survey areas (JNCC 2004). The Western Isles regional breeding population of great blacked-gull is estimated at 2,007 apparently occupied nests (Mitchell *et al*. 2004).

282. Great black-backed gull was recorded in all seasons in widely varying numbers Monthly totals were highest in December (259 birds, 44% of records) and declined in late winter and early spring (Feb-April),and then remained low through the mid-spring and summer period (April-August) (Table 13).

283. Great black backed gull was recorded on approximately a third (32%) of SSS scans (Table X).

284. On SSS surveys, great black-backed gull was recorded on the sea in all months, but numbers varied widely through the year. SSS maximum monthly counts of great black-backed gulls were highest in late winter (45 birds) Maximum monthly count totals for other seasons were much lower and similar to each other ranging from 7 birds in the spring to 12 birds in early winter (Table 26).

285. The averaged seasonal corrected density of great black-backed gull recorded by SSS surveys was 3 birds/km^2 with a maximum density of 5.8 birds/km^2 in late winter (Jan-Mar) (Table 26).

286. Nearly all sightings of great black-backed gull on the sea were either of single birds (73%) or two birds together (21%). A single flock of 39 birds in March was exceptional.

287. Great black-backed gull SSS records were distributed approximately equally between the adjacent Labost and Siadar survey areas (42% and 47% respectively) with only 10% of records from the northern Mealabost survey area. They were generally distributed in a band 100-500m from the shoreline.

288. Great black-backed gull accounted for 7% of birds seen during FBWs. They were recorded on FBWs in all months. The average number of birds passing per hour was highest in December and January (55.3 and 40.5 birds/hour respectively). Between March and November figures were below 7 birds/hour with particularly low monthly averages (< 1bird per hour) from June to September (Table 14).

289. The majority of great black-backed gulls recorded during FBWs were flying SW (81%) compared with 13% flying NE suggesting a net movement of southward during the winter months.

290. Great black-backed gull was commonly recorded in the walkover surveys throughout the year (Tables 32 and 34). The peak totals of non-breeding birds were 225 birds for the Labost sections and 25 birds for the Siadar/Mealabost sections.

291. Great black-backed gull was also recorded breeding in small numbers in the coastal walkover sections (see '*Breeding gull colonies'* section below).

Kittiwake

292. The survey areas are beyond the mean maximum foraging distance of kittiwake (66km) (Birdlife International 2011a) for designated sites that have kittiwake as a qualifying interest. Therefore, it is not likely that birds seen using the survey

areas during the breeding season are from designated sites with kittiwake as a qualifying interest.

293. Kittiwake was not recorded breeding along any of the coast within the survey areas during Seabird 2000 surveys. Small to moderate size colonies (median: 62 apparently occupied nests, range 7-663) totalling just under 2,962 apparently occupied nests were recorded on the Lewis coast within a radius from the survey areas equivalent to the mean maximum foraging range estimate of 66km for kittiwake. The Western Isles regional breeding population of kittiwake is estimated at 21,152 apparently occupied nests (Mitchell *et al*. 2004).

294. Kittiwake was recorded in all months except January. Records were infrequent in other winter months with only one bird recorded in December and three in February. Monthly peaks occurred in March, June and September 2011(37, 49 and 55 birds respectively) (Table 13).

295. Kittiwake was rarely recorded on the sea during SSS surveys with one bird in March and two birds in August, September 2010 and September 2011. A flock of 22 birds in September 2011 was the only other record during SSS surveys.

296. Kittiwake was recorded in all months except January during FBW surveys. The average number of kittiwakes recorded flying past VPs was 9.8 birds/hour in June, *7.2* birds/hour in March and between 5 and 7 birds/hour in October and November 2010 and September 2011. An average of less than one bird per hour was recorded passing during December to February (Table 14).

Other gulls

297. Glaucous gulls were recorded on three occasions; a single record in March and two single records in December and May.

298. Iceland gulls were recorded occasionally with 3 records in January and single records in September (2010), October and February.

299. A single immature Bonaparte's gull, a vagrant from North America, over summered on the coast at Siadar.

Breeding gull colonies

300. A mixed gull colony at Labost (Section 4) held 25 of herring gull, 8 pairs of lesser-black-backed gull and 2 pairs of great-black-backed gull. In the Labost 'inland' survey area centred on Lochan Dubh there was a small colony of 5 pairs of black-headed gulls and 4 pairs of common gulls. (Table 32).

301. In the Siadar 'inland' survey area there was a mixed colony of breeding gulls on the N shore of Loch Bacabhat comprising approximately 50 pairs of common gulls, 30 pairs of herring gulls and 10 pairs of lesser-black-backed gulls (Table 35 and Fig 25).

Terns

302. Two species of tern were recorded in small numbers; Arctic tern and common tern. Both these species are summer visitors and breed on Lewis.

303. All tern species are listed on Annex 1 of the EU Birds Directive (European Parliament and Council 2010).

Common tern

304. Common tern was recorded on two consecutive dates in July 2011. On the 26th five were recorded NE and on the 27th a single bird flying SW.

Arctic tern

305. The distance from any of the survey areas to the nearest designated site that has Arctic tern as a qualifying interest is greater than the maximum foraging range estimate of 20.6km Arctic tern (Birdlife International 2011a). Therefore, it is not likely that birds seen using the survey areas during the breeding season are from designated sites with Arctic tern as a qualifying interest.

306. Breeding Arctic terns were recorded during Seabird 2000 at three locations along NW Lewis coastline; two pairs at Bragar within the Labost survey area, 129 pairs at Barvas midway between and *ca.* 5 km from Labost and Siadar survey areas respectively, and 10 pairs at Aird Dell 6km NE of the Mealabost survey area. The Western Isles regional breeding population of Arctic tern is estimated at 4,146 pairs (Mitchell *et al* 2004).

307. Arctic tern records were confined to the period between May and September 2011. With the July contributing over half (59%) of all survey records. It is likely that records from May to July involve locally breeding birds (Table 13).

308. During the spring and summer period (Apr-Aug) Arctic tern was recorded on 14% of scans during SSS surveys (Table 27. All birds recorded during SSS surveys were actively foraging. Records were confined to eight birds in June and 59 birds in July).

309. The average seasonal corrected density of birds recorded using the study areas during SSS surveys in spring (Apr-Jun) was 0.4 birds/km^2 and in summer (Jul-Aug) was 5.1birds/km^2 (Table 27).

310. The majority of Arctic terns (82%) recorded during SSS surveys were foraging singularly or in groups of two with the remainder in small groups of between three and seven birds.

311. Most Arctic terns were recorded within the central Siadar survey area (31 birds) with slightly fewer at Mealabost (26 birds) and only 10 birds at the southern Labost survey area. Birds foraging at the Siadar and Mealabost survey areas were generally recorded at between *ca.* 500m and 1.5km from the shoreline. The relatively few records at Labost were generally closer to the shore at *ca.*300-500m.

312. Monthly totals of Arctic terns recorded during FBW surveys increased incrementally May to July and then decreased in August and September. The average rate of Arctic terns flying past VPs ranged from 0.3 birds per hour in August to 9.5 birds per hour in July (Tables 14).

313. Approximately equal proportions of Arctic terns recorded on FBWs were flying NE, SW or in a variable direction.

314. No Arctic terns were recorded breeding along the coasts adjacent to the survey areas in 2011, or on the small ‘inland areas’ surveyed for breeding birds at Labost and Siadar.

Auks

315. Five species of auk were recorded: common guillemot (Photo 9), razorbill (Photo 9), black guillemot (Photo 10), little auk and puffin (Table 13). Excluding the

rarely recorded little auk, all auk species were scarce during January and February and commonest between April and July. Black guillemot was the only species present in all months although there were only single records from January and February. Common guillemot records were restricted to period between April and October. Compared with guillemot, razorbill was recorded earlier in the year with a few birds in the late winter period between January and March. Puffin records were largely restricted to the period between April and July with only single birds recorded outside this period. Little auk records were restricted five birds seen during the winter.

316. Razorbill and common guillemot can be difficult to distinguish at distance and 31% of records were categorised as either guillemot or razorbill. These birds were assigned to either razorbill or guillemot counts based on the relative proportion of these species recorded overall. This was done separately for birds seen on the water and birds seen in flight.

Common guillemot

317. Based on the mean maximum foraging distance estimate for common guillemot (Photo 9) of 60.6km (Birdlife International 2011a), the only guillemots from a designated site that could theoretically use the survey areas during the breeding season are those from the Flannan Isles SPA (21,930 individuals, JNCC 2011b). The Flannan Islands are located 53km west of the Labost survey area.

318. The survey areas are also within the mean maximum foraging range of several small non-designated common guillemot colonies totalling 1500 individuals, (*ca.* 1000 pairs) along the coast of Lewis (JNCC 2004). The Western Isles regional breeding population of common guillemot is estimated at 120,594 individuals (Mitchell et al. 2004) corresponding to 80,798 pairs.

319. Common guillemot on the sea was recorded infrequently and in low numbers during SSS sessions, with birds seen during only *ca.* 10% of scans from the three VPs (Table 28). Guillemot on the sea was typically seen alone or in small groups (median: 1, range 1-4 birds).

320. SSS records of common guillemot were restricted to the summer and autumn periods, with maximum counts of 17 birds in autumn and 10 in summer (Table 28). Birds were most frequently seen at the southernmost VP with 68% of all SSS sightings from Labost; 23%, from Siadar and 10% from Mealabost.

321. On average the density of guillemot recorded on the sea during SSS surveys, corrected to account for fall off in detectability with distance from the VP and the proportion of unidentified auks likely to be common guillemots (see above) was 1.3 bird/km^2. The highest density recorded was during the autumn (Sep-Oct, 3.6 bird/km^2). Densities during other season were less than 2 birds/km^2 (Table 28).

322. Common guillemot sightings during the FBWs were restricted to the spring, summer and early autumn (May-Sep) with a total of 88 records, the majority of these (72%) were recorded in July. The average number of guillemots passing VPs was highest in June (12.6 birds/hour). In the other months where guillemots were recorded the rate of passing birds was much lower (<3 birds/hour) (Table 14). The majority of guillemots (83%) seen in FBW sessions were flying NE with only five birds seen flying SW.

Razorbill

323. The distance from any of the three survey areas to the nearest designated site that has razorbill (Photo 9), as a qualifying interest is greater than the mean

maximum foraging distance estimate for razorbill of 31km (Birdlife International 2011a). Razorbill are a qualifying interest for the Flannan Isles SPA (3,160 individuals, JNCC 2011b), 53km to west of the Labost survey area which is close to the current maximum foraging distance estimate of 51km for this species. Based on this, it is unlikely that razorbills occurring in the study areas during the breeding season (i.e. when birds are attending colonies) originate from designated sites. The survey areas are within the mean maximum razorbill foraging range of several small non-designated razorbill colonies (total of 240 individuals, *ca.* 160 pairs) located along the Lewis coast (JNCC 2004). The Western Isles regional breeding population of razorbill is estimated at an estimated 25,081 pairs based on the 37,434 individuals recorded in the Seabird 2000 colony counts (Mitchell *et al*. 2004).

324. The number of razorbills recorded during all survey work was over seven times greater than for common guillemot with most records of birds in flight. Compared with guillemot, razorbill was recorded through more of the year with August November and December the only months with no records. As with guillemot, the highest counts were in July (Table 13).

325. SSS counts of razorbill on the sea were relatively low. On average razorbill was seen on only *ca.* 10% of SSS scans (Table 29) The highest monthly count across the study area (i.e. the sum of maximum counts from each VP) was 20 birds in the late winter period. Maximum counts during the spring and summer period did not exceed 11 birds. Very few birds were seen the early winter (Oct-Dec) period. (Table 29). The mean SSS counts were approximately 90% lower than the maximum counts. Razorbill on the sea was most commonly in groups of two birds (median: 2, range: 1-7). Similar numbers of birds were recorded on the sea from each of the three VPs and records were widely scattered through across survey areas (Figs. 20 and 21)

326. Densities of razorbill recorded on the sea during SSS sessions and corrected to account for fall off in detectability with distance from the VP and the proportion of unidentified auks likely to be razorbills, were highest during the autumn, (Sept-Oct, 7.3/km^2), late winter (Jan-Mar, 3.7 birds/km^2) and spring (Apr-Jun, 4.9 birds/km^2). Densities were lower during the summer (Jul-Aug, 0.4 birds/km^2) and early winter (Nov-Dec, 0.6 birds/km^2) (Table 14).

327. Razorbill was recorded frequently during FBW sessions between March and July with numbers increasing to a maximum in June (458 birds, 56% of the total FBW records) declining to 60 (7%) birds in July. From late summer to the end of the winter period (Aug-Feb) sightings were scarce with no monthly total exceeding 5 birds.

328. The actual numbers of razorbill flying over the study areas during FBW are estimated to be approximately 50% higher than the figures above after adding the records of 'unidentified large auk species' likely to have been razorbill, (based on the ratio of birds identified to species level). After accounting for the unidentified large auks, during the peak period of May and June estimated averages of 55.2 and 91.6 birds/hour respectively passed over the survey area.

329. Nearly all razorbill (97%) seen during FBW sessions were flying NE. Of these, 44% were recorded from the most northerly VP at Mealabost, 37% from the central VP at Siadar and only 18% passing the most southerly VP at Labost.

Black guillemot

330. The distance from any of the three survey areas to the nearest designated site that has black guillemot (Photo 10), as a qualifying interest is greater than the maximum foraging distance estimate for black guillemot of 55km (Birdlife

International 2011a). Therefore, it is unlikely that birds seen in the surveys areas were from designated sites.

331. Black guillemot has previously been recorded breeding close to the survey area. Ninety two individuals were recorded close to suitable nesting habitat during the national Seabird 2000 surveys along the coast approximately 2km NE of the Labost survey area(JNCC 2004). The Western Isles regional breeding population of black guillemot was counted at 4577 pre-breeding individuals during the Seabird 2000 surveys corresponding to an estimated 2289 pairs (Mitchell *et al*. 2004).

332. Black guillemot was detected during SSS sessions throughout the year with peak counts of 51 birds in spring period. Overall maximum counts for early and late winter period were 14 and 20 birds respectively. The lowest maximum count was for the autumn period (4 birds) (Table 30). On average the species was recorded on 35% of scans during SSS surveys (Table 30).

333. Densities of black guillemots recorded on the sea during SSS surveys and corrected to account for fall off in detectability with distance from the VP were highest in spring (Apr-Jun, 17.5 birds/km^2), slightly lower in early winter (Nov-Dec, 11.3 birds/km^2) and summer (July-Aug, 9.6 birds/km^2) and lowest in late winter (Jan-Mar, 2.2 birds/km^2) and autumn (Sep-Oct, 0.7 birds/km^2) (Table 30).

334. Black guillemots on the sea were most commonly seen alone (76% of records) or in small groups of less than 10 birds (21% of records). The largest group seen was 28 birds close to the breeding colony at Labost. Numbers seen were much higher at the Labost VP with 69% of all SSS sightings from this VP, reflecting the presence of the small breeding colony close to the VP there (see below).

335. Records of black guillemot seen on the sea from Labost VP were clustered within *ca.* 500m and to the N and NW of the VP reflecting the behaviour of the nearby breeding birds to loiter around and display on the water close to the breeding colony there (Fig 22). Records from the VPs at Siadar and Mealabost showed an approximately even distribution across the study areas (Fig 23).

336. Black guillemot was recorded during FBWs infrequently with the monthly total only exceeding 10 birds in June and July. They were most frequently observed flying during July, when on average 6.2 birds/hour flew past the VPs (Table 14). The relatively high flight activity in June and July is likely to be associated with birds provisioning young.

337. Approximately 20 pairs of black guillemot bred on the cliffs of the Labost headland (Section 4). This count is approximate as the nests are not visible; it is based on the maximum numbers (divided by two) of adults seen early in the morning in the breeding season on the sea and rocks close to the suitable nesting habitat. No other sections coast sections appeared to have suitable nesting habitat for this species.

Little auk

338. A total of five little auk were recorded, four during the early winter (Nov-Dec) and one in February. All sightings were of flying birds.

Puffin

339. Based on the mean maximum foraging distance estimate for puffin of 62.2km (Birdlife International 2011a) only puffins from a designated site that are likely to use the survey areas during the breeding season are those from the Flannan Isles SPA (4,400 pairs, JNCC 2011b). The Flannan Islands are located 53km west of the

Labost survey area, and this is the closest known breeding site to the survey areas. The Western Isles regional breeding population of puffin is estimated at 234,666 apparently occupied burrows (Mitchell *et al*. 2004).

340. Puffin was recorded infrequently overall with most sightings in May, June and July (18, 10 and 49 birds respectively). From August through the winter to May only five birds were recorded (Table 13).

341. On average puffin was seen on only *ca.* 3% of scans during SSS surveys (Table 31). Puffins were recorded on the sea in the study areas in small numbers only and infrequently during SSS sessions. The maximum seasonal counts occurred in the spring (Apr-Jun, 8 birds) (Table 31).

342. The average density (based on the mean of the five seasonal periods) of puffins recorded on the sea during SSS surveys, corrected to account for fall off in detectability with distance from the VP, was 0.4 birds/km^2 with the highest density during the spring (Apr-Jun, 1.4 birds/km^2) and the lowest (Table 31). The majority (67%) of puffins recorded on the sea were seen from the Labost VP.

343. Puffin on the sea was most commonly seen singly or occasionally in groups of two or three birds.

344. Puffin was only recorded during FBW sessions between May and July with 46 of a total of 64 birds (71%) recorded in July. During May, June and July an average of 3.9, 1.0 and 14.2 birds per hour respectively passed during FBW surveys (Tables 14). All puffin seen during FBW sessions were flying approximately NE. It is not known if these birds were from breeding colonies or were non-breeding birds. There are a number of colonies on this heading, for example, Sula Sgeir (74km), North Rona (83km) or Handa (76km), all of which are within the maximum known foraging range for puffin of 200km (Birdlife International 2011a).

Other land birds

Corncrake

345. A total of four calling (presumed breeding) male corncrakes were recorded during the walkover surveys in June, in Sections 6, 7 and 11. The croft land along the NW Lewis coastline holds numerous pairs of corncrake. This is an uncommon species with a UK breeding distribution now almost restricted to NW Scotland.

346. Corncrake is on Annex 1 of EU Birds Directive, Schedule 1 of Wildlife and Countryside Act and is on the Birds of Conservation Concern Red-list. It is also a UK Biodiversity Action Plan species.

Starling

347. Starling was commonly recorded in the walkover surveys throughout the year (Tables 32 and 34). The peak totals of non-breeding birds were 130 birds for the Labost sections and 230 birds for the Siadar/Mealabost sections.

348. Starling is on the Birds of Conservation Concern Red-list and is a UK Biodiversity Action Plan species. However, it is a very common species of croft land throughout the Western Isles.

Twite

349. A non-breeding flock of 25 twites was recorded in Section 6 during the October walkover surveys.

350. Twite is on the Birds of Conservation Concern Red-list and is a UK Biodiversity Action Plan species. However, it is a common species on coastal croftland throughout the Western Isles.

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LEWIS WAVE ARRAY

YEAR 1 BIRD SURVEYS TECHNICAL REPORT photographs, tables and maps

Natural Research Projects Ltd

November 2011

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Photographs

Photo 1. View south-west from vantage point on cliff top at Labost on a calm day with a heavy swell in February 2011. (*Copyright Tristan Ap Rheinallt*).

Photo 2. View north west from close to Siadar vantage point, July 2011. The grassland area in mid-ground shows western part of the proposd shore development area. (*Copyright Digger Jackson*)

Photo 3. Shore at Siadar. This is typical of much of the coastline between Siadar and Mealabost. (*Copyright Digger Jackson*)

Photo 4. View from Mealabost (c. 300m SW of vantage point) looking south-west towards Siadar. (*Copyright Digger Jackson*)

Photo 5. Spotting scope mounted on levelling head and fitted with digital level instrument. (*Copyright Digger Jackson*)

Photo 6. Great northern diver in summer plumage. Moderate numbers of this species occurred in the study sites outside the breeding season, and a few immature birds over-summered . (*Copyright Digger Jackson*)

Photo 7. Moderate numbers of gannets were recorded flying over, and on occasions foraging in, the survey areas. (*Copyright Digger Jackson*)

Photo 8. Small numbers of shag occurred in the study areas throughout the year and a few pairs bred at the Labost headland. (*Copyright Digger Jackson*)

Photo 9. Small numbers of razorbill and common guillemot used the surveys areas for feeding. (*Copyright Digger Jackson*)

Photo 10 Small numbers of black guillemot use the study areas through the year for feeding and about 20 pairs bred at the Labost headland. (*Copyright Digger Jackson*)

Tables

Table 1. Distance zones used for flying bird watch (FBW) records.

Distance zone	**Definition** (distance from shore)
A	<100m
B	100-300m
C	300-750m
D	750-2000m
E	2000-5000km (except for scarce species, birds in this distance are not recorded)
S	Shore (birds over shore and cliffs, i.e. not over the sea proper)
L	Land (birds flying inland of coast)

Table 2. Details of vantage points.

VP name	**Easting**	**Northing**	**Ht. above sea level (m)**
Labost	27049	49641	25
Siadar	38748	55663	19
Mealabost	40974	57811	13

Table 3. Correction factors derived to correct for under detection of birds on the sea.

Bird group	Distance category (m)						
	0-500	500-750	750-1000	1000-1250	1250-1500	1500-1750	1750-2000
Auk and diving ducks	1	1	1.7	2	4	8	16
Divers	1	1	1	1	2	4	6
Gannet	1	1	1	1	1	1	1
Shag & cormorant	1	1	1	1.5	2	4	6
Gulls/terns/shearwaters	1	1	1.6	2.4	3	4	4

Table 4. Dates on which VP watches were undertaken.

Month	Dates with VP watches	Total days
Sept 2010	27, 28, 29	3
Oct 2010	8, 11, 12, 13, 14, 25	6
Nov 2010	13, 15, 19, 20, 22, 23, 25, 29	8
Dec 2010	13, 14, 24, 27, 28, 29, 30, 31	8
Jan 2011	17, 19, 22, 27, 29	5
Feb 2011	7, 10, 12, 14, 15, 22	6
Mar 2011	5, 10, 12, 14, 15, 22, 24	7
Apr 2011	14, 15, 18, 20, 21, 26, 28	7
May 2011	3, 4, 12, 31	4
Jun 2011	6, 8, 20, 22, 27, 28	6
Jul 2011	25, 26, 27	3
Aug 2011	12, 13, 14, 16, 17, 18, 19, 22, 23	9
Sep 2011	1, 5, 15, 16, 29, 30	6
Total		78

Table 5. Dates on which walkover surveys were undertaken.

Month	Survey dates
Oct 2010	16
Dec 2010	14, 23
Feb 2011	12, 24
Apr 2011	22
Jun 2011	4, 6
Aug 2011	14, 15, 16

Table 6. The number of snapshot scans (SSS) completed each month at each VP.

Month	VP			Total
	LA	ME	SI	
Sept 2010	5	5	5	15
Oct 2010	6	8	8	22
Nov 2010	8	8	6	22
Dec 2010	8	6	6	20
Jan 2011	4	6	8	18
Feb 2011	6	6	8	20
Mar 2011	8	8	8	24
Apr 2011	8	8	8	24
May 2011	6	4	6	16
Jun 2011	8	8	8	24
Jul 2011	7	6	7	20
Aug 2011	9	12	9	30
Sep 2011	8	8	8	24
Yr1 total	91	93	95	279
%	33%	33%	34%	100%

Table 7. The number of 5-minute flying bird watches (FBW) completed each month at each VP.

Month	VP			Total
	LA	ME	SI	
Sept 2010	5	5	5	15
Oct 2010	15	20	20	55
Nov 2010	20	20	15	55
Dec 2010	20	16	15	51
Jan 2011	10	15	20	45
Feb 2011	15	15	20	50
Mar 2011	20	20	20	60
Apr 2011	20	20	20	60
May 2011	15	10	15	40
Jun 2011	20	20	20	60
Jul 2011	13	12	14	39
Aug 2011	27	33	25	85
Sep 2011	20	20	20	60
Yr1 total	220	226	229	675
%	33%	33%	34%	100%

Table 8. The number of 15-minute marine mammal watches (MMW) completed each month at each VP.

Month	VP			Total
	LA	ME	SI	
Sept 2010	10	10	10	30
Oct 2010	21	28	28	77
Nov 2010	28	28	21	77
Dec 2010	28	23	20	71
Jan 2011	14	21	27	62
Feb 2011	21	21	28	70
Mar 2011	28	28	28	84
Apr 2011	28	28	27	83
May 2011	21	14	20	55
Jun 2011	28	28	27	83
Jul 2011	22	18	16	56
Aug 2011	34	45	41	120
Sep 2011	28	28	28	84
Yr1 total	311	320	321	952
%	33%	34%	34%	100%

Table 9. The number of snapshot scans (SSS) completed each month in different sea-state conditions. Data are for all three VPs combined.

Month	Sea-state				Total
	1	2	3	4	
Sept 2010	1	1	11	2	15
Oct 2010	6	4	4	8	22
Nov 2010	1	3	13	5	22
Dec 2010	0	10	8	2	20
Jan 2011	2	0	12	4	18
Feb 2011	0	5	13	2	20
Mar 2011	0	1	11	12	24
Apr 2011	0	4	12	8	24
May 2011	1	1	9	5	16
Jun 2011	0	2	9	13	24
Jul 2011	0	17	3	0	20
Aug 2011	0	10	16	4	30
Sep 2011	3	12	7	2	24
Year1 total	14	70	128	67	279
%	5%	25%	46%	24%	100%

Table 10. The number of 5-minute flying bird watches (FBW) completed each month in different sea-state conditions. Data are for all three VPs combined.

Month	Sea-state				Total
	1	2	3	4	
Sept 2010	1	1	10	3	15
Oct 2010	14	11	12	18	55
Nov 2010	0	10	35	10	55
Dec 2010	0	26	20	5	51
Jan 2011	5	0	30	10	45
Feb 2011	0	11	36	3	50
Mar 2011	0	2	29	29	60
Apr 2011	0	3	32	25	60
May 2011	1	1	27	11	40
Jun 2011	0	2	25	33	60
Jul 2011	3	28	8	0	39
Aug 2011	0	30	40	15	85
Sep 2011	5	33	22	0	60
Yr1 total	29	158	326	162	675
%	4%	23%	48%	24%	100%

Table 11. The number of 15-minute marine mammal watches (MMW) completed each month in different sea-state conditions. Data are for all three VPs combined.

Month	Sea-state				Total
	1	2	3	4	
Sept 2010	1	2	21	6	30
Oct 2010	18	17	16	26	77
Nov 2010	0	14	49	14	77
Dec 2010	0	37	27	7	71
Jan 2011	7	0	41	14	62
Feb 2011	0	16	48	6	70
Mar 2011	0	4	40	40	84
Apr 2011	0	8	42	33	83
May 2011	1	2	37	15	55
Jun 2011	0	4	33	46	83
Jul 2011	8	38	10	0	56
Aug 2011	0	38	59	23	120
Sep 2011	8	46	29	1	84
Yr1 total	43	226	452	231	952
%	5%	24%	47%	24%	100%

Table 12. The number of VP snapshot scans (SSS) undertaken in each part of the tide cycle period each month. The tidal cycle is divided into six equal parts (each of approximately two hours) with the start of Period 1 corresponding to high tide and the start of Period 3 to low tide

Month	Tide Period						Total
	1	2	3	4	5	6	
Sept 2010	4	4	3	1	1	2	15
Oct 2010	7	2	4	3	2	4	22
Nov 2010	4	5	5	4	2	2	22
Dec 2010	4	5	0	2	5	4	20
Jan 2011	3	3	3	4	3	2	18
Feb 2011	4	4	4	3	2	3	20
Mar 2011	5	2	5	4	3	5	24
Apr 2011	2	6	4	5	4	3	24
May 2011	3	4	4	2	0	3	16
Jun 2011	3	3	4	5	4	5	24
Jul 2011	3	4	4	3	4	2	20
Aug 2011	6	5	5	2	6	6	30
Sep 2011	5	4	5	4	4	2	24
Total	53	51	50	42	40	43	279
% of total	19.0%	18.3%	17.9%	15.1%	14.3%	15.4%	100%

Table 13. Combined monthly totals of birds recorded during 'Snapshot Scans' (SSS) and 'Flying Bird Watches' (FBW) during vantage point watches at Labost, Siadar, and Mealabost, between September 2010 and September 2011. For scarce species, the totals include incidental records of birds recorded during 'Marine Mammal Watches' (MMW). Blank cells indicate no records in that month.

Species	2010				2011								
	9	10	11	12	1	2	3	4	5	6	7	8	9
Red-throated diver	1	16	14	52	41	33	43	3	2	13	3	8	14
Black-throated diver			2										
Great northern diver	1	26	65	90	52	37	84	76	41	13	3	11	6
White-billed diver			1										
Fulmar			112	86	355	136	249	283	110	182	68	145	31
Sooty shearwater											3	8	73
Manx shearwater	2							8	9	70	47	100	297
Storm petrel											101	5	
Gannet	413	291	7	4	2	5	33	119	131	375	127	798	431
Cormorant		4	4	3	1	2	1			1	1	3	
Shag	65	113	105	107	67	93	74	18	36	28	38	60	47
Grey heron		1	1	1		1							
Whooper swan		12					61						
Pink-footed goose		71						400	40				
Greenland white-fronted goose		157											
Greylag goose		8	110					80					
Barnacle goose		1156											5
Unidentified goose species		318						100					
Wigeon		10										2	
Gadwall		6											
Teal		11	25										
Mallard		5		1	5				1				
Pintail		9											
Pochard		5											
Tufted duck		10											
Scaup		70				2							
Eider		10	211	474	321	173	421					13	10
Long-tailed duck		15	1	1									
Common scoter				7	2	2		2	2	1		5	
Red-breasted merganser		3		2				2			1		4
Oystercatcher		3	5	2		2	10	15	4	11	33	30	
Ringed plover											1	2	
Golden plover			26				12	96	1		8	13	
Grey plover	1	4											
Lapwing													1
Knot	2											89	
Sanderling												26	

Species	2010				2011								
	9	10	11	12	1	2	3	4	5	6	7	8	9
Purple sandpiper			14	44			7						
Dunlin										1	1	10	
Black-tailed godwit								1				1	
Bar-tailed godwit													1
Whimbrel								16	28	5		4	
Curlew				1	26	2	1	1	1	1	1	2	
Greenshank											1		
Common sandpiper											1		
Turnstone			8									5	3
Arctic skua		2							1				
Great skua		1						6	3	4	8	7	
Black-headed gull		2	1				1	19	7	2			1
Common gull	2	53	34	15	6	18	19	190	54	11	62	7	12
Lesser black-backed gull		1					5	43	19	18	9	1	1
Herring gull	8	25	136	117	311	201	153	203	36	25	210	8	11
Iceland gull	1	1			3	1							
Glaucous gull				2			1		2				
Great black-backed gull	5	27	48	259	164	102	70	21	27	7	31	4	6
Kittiwake	7	31	27	1		3	37	4	12	49	8	12	55
Common tern											6		
Arctic tern									7	26	90	2	28
Common Guillemot	1	1						1	10	63	14	1	28
Razorbill		6			2	8	57	88	187	461	64		20
Common Guillemot/razorbill			5			4	28	145	122	128			14
Black guillemot		6	29	9	1	1	28	74	100	64	128	16	1
Little auk			3	1		1							
Puffin						1		2	18	10	49		2
Unidentified auk species	8	10											

Table 14. The total number of flying seabirds and mean number of flying seabirds seen passing per hour each month during 5-minute Flying Bird Watch (FBW) sessions in the survey areas, Sept 10 to Sept 11. (Seabird species with <10 FBW records and all non-seabird species are not shown).

Species	Measure	2010				2011								
		Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Red-throated diver	Total	0	6	1	3	3	4	4	3	0	4	0	3	4
	Mean p/h	0.0	1.3	0.2	0.7	0.8	1.0	0.8	0.6	0.0	0.8	0.0	0.4	0.8
Great northern diver	Total	0	0	3	1	1	0	0	1	0	3	0	0	1
	Mean p/h	0.0	0.0	0.7	0.2	0.3	0.0	0.0	0.2	0.0	0.6	0.0	0.0	0.2
Fulmar	Total	0	0	51	67	165	48	167	199	88	148	55	141	21
	Mean p/h	0.0	0.0	11.1	15.8	44.0	11.5	33.4	39.8	26.4	29.6	16.9	19.9	4.2
Sooty shearwater	Total	0	0	0	0	0	0	0	0	0	0	3	2	10
	Mean p/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.3	2.0
Manx shearwater	Total	2	0	0	0	0	0	0	8	9	70	46	69	56
	Mean p/h	1.6	0.0	0.0	0.0	0.0	0.0	0.0	1.6	2.7	14.0	14.2	9.7	11.2
Storm petrel	Total	0	0	0	0	0	0	0	0	0	0	37	1	0
	Mean p/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.4	0.1	0.0
Gannet	Total	382	278	7	4	2	5	31	118	110	356	105	782	383
	Mean p/h	305.6	60.7	1.5	0.9	0.5	1.2	6.2	23.6	33.0	71.2	32.3	110.4	76.6
Cormorant	Total	0	0	3	2	1	1	1	0	0	1	0	3	0
	Mean p/h	0.0	0.0	0.7	0.5	0.3	0.2	0.2	0.0	0.0	0.2	0.0	0.4	0.0
Shag	Total	9	22	34	23	31	36	32	10	20	21	10	21	22
	Mean p/h	7.2	4.8	7.4	5.4	8.3	8.6	6.4	2.0	6.0	4.2	3.1	3.0	4.4
Eider	Total	0	10	8	0	2	9	19	0	0	0	0	0	1
	Mean p/h	0.0	2.2	1.7	0.0	0.5	2.2	3.8	0.0	0.0	0.0	0.0	0.0	0.2
Great skua	Total	0	0	0	0	0	0	0	4	3	2	7	7	0
	Mean p/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.9	0.4	2.2	1.0	0.0
Black-headed gull	Total	0	2	1	0	0	0	1	10	5	2	0	0	1
	Mean p/h	0.0	0.4	0.2	0.0	0.0	0.0	0.2	2.0	1.5	0.4	0.0	0.0	0.2
Common gull	Total	2	37	22	11	5	18	19	28	30	11	22	7	12
	Mean p/h	1.6	8.1	4.8	2.6	1.3	4.3	3.8	5.6	9.0	2.2	6.8	1.0	2.4
Lesser black-backed gull	Total	0	1	0	0	0	0	5	19	19	18	0	1	1
	Mean p/h	0.0	0.2	0.0	0.0	0.0	0.0	1.0	3.8	5.7	3.6	0.0	0.1	0.2

Species	Measure	2010				2011								
		Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Herring gull	Total	5	19	69	94	118	86	62	57	30	25	21	5	11
	Mean p/h	4.0	4.1	15.1	22.1	31.5	20.6	12.4	11.4	9.0	5.0	6.5	0.7	2.2
Great black-backed gull	Total	0	10	20	235	152	79	15	7	23	5	2	1	4
	Mean p/h	0.0	2.2	4.4	55.3	40.5	19.0	3.0	1.4	6.9	1.0	0.6	0.1	0.8
Kittiwake	Total	5	31	25	1	0	3	36	4	12	49	8	10	31
	Mean p/h	4.0	6.8	5.5	0.2	0.0	0.7	7.2	0.8	3.6	9.8	2.5	1.4	6.2
Arctic tern	Total	0	0	0	0	0	0	0	0	7	18	31	2	11
	Mean p/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	3.6	9.5	0.3	2.2
Guillemot	Total	1	0	0	0	0	0	0	1	7	63	4	1	11
	Mean p/h	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2.1	12.6	1.2	0.1	2.2
Razorbill	Total	0	6	0	0	1	4	28	78	184	458	60	0	5
	Mean p/h	0.0	1.3	0.0	0.0	0.3	1.0	5.6	15.6	55.2	91.6	18.5	0.0	1.0
Guillemot/Razorbill	Total	0	0	3	0	0	2	28	145	116	128	0	0	10
	Mean p/h	0.0	0.0	0.7	0.0	0.0	0.5	5.6	29.0	34.8	25.6	0.0	0.0	2.0
Black guillemot	Total	0	1	0	2	0	0	1	2	4	7	20	1	0
	Mean p/h	0.0	0.2	0.0	0.5	0.0	0.0	0.2	0.4	1.2	1.4	6.2	0.1	0.0
Puffin	Total	0	0	0	0	0	0	0	0	13	5	46	0	0
	Mean p/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	1.0	14.2	0.0	0.0

Table 15. Numbers of **red-throated diver** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011.

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	100	81	83	100	100
	Max count	0	1	2	0	0
	Mean count	0.0	0.2	0.2	0.0	0.0
	Std Dev	0.0	0.4	0.5	0.0	0.0
	Mean (corrected)	0.0	0.7	0.3	0.0	0.0
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	86	71	35	100	94
	Max count	1	7	7	0	1
	Mean count	0.1	0.8	1.4	0.0	0.1
	Std Dev	0.4	1.9	1.8	0.0	0.2
	Mean (corrected)	0.2	0.8	1.9	0.0	0.1
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	95	33	33	100	94
	Max count	1	5	6	0	1
	Mean count	0.0	1.8	2.0	0.0	0.1
	Std Dev	0.2	1.8	2.1	0.0	0.3
	Mean (corrected)	0.3	2.9	2.6	0.0	0.3
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	2	13	15	0	2
	Sum of mean count	0.2	2.7	3.7	0.0	0.1
	Sum of Std Dev	0.6	4.1	4.5	0.0	0.5
	Sum of mean (corrected)	0.5	4.4	4.8	0.0	0.3
	Density birds/km^2 (corrected)	0.4	2.4	4.4	0.0	0.2

Table 16. Numbers of **great northern diver** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011.

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	100	38	6	59	100
	Max count	0	4	6	5	0
	Mean count	0.0	1.5	2.2	0.7	0.0
	Std Dev	0.0	1.4	1.5	1.2	0.0
	Mean (corrected)	0.0	3.0	5.3	1.3	0.0
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	67	7	10	30	72
	Max count	3	9	5	7	3
	Mean count	0.6	3.2	2.5	2.3	0.4
	Std Dev	0.9	2.8	1.7	2.1	0.8
	Mean (corrected)	1.3	4.2	3.9	3.4	0.4
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	86	0	21	41	63
	Max count	1	7	9	10	1
	Mean count	0.1	3.0	3.3	2.3	0.4
	Std Dev	0.4	1.9	3.3	2.6	0.5
	Mean (corrected)	0.8	6.5	4.5	4.7	0.9
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	4	20	20	22	4
	Sum of mean count	0.7	7.7	8.0	5.2	0.8
	Sum of Std Dev	1.3	6.0	6.5	5.9	1.3
	Sum of mean (corrected)	2.0	13.7	13.7	9.4	1.3
	Density birds/km^2 (corrected)	1.8	7.7	11.8	8.4	0.9

Table 17. Numbers of **fulmar** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011.

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	95	63	28	9	75
	Max count	10	33	64	23	4
	Mean count	0.5	5.0	17.2	5.8	0.6
	Std Dev	2.3	8.8	19.0	5.4	1.3
	Mean (corrected)	0.5	5.4	18.1	7.3	0.7
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	100	100	95	95	94
	Max count	0	0	1	1	1
	Mean count	0.0	0.0	0.1	0.1	0.1
	Std Dev	0.0	0.0	0.2	0.2	0.2
	Mean (corrected)	0.0	0.0	0.1	0.2	0.1
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	100	100	83	82	88
	Max count	0	0	40	4	2
	Mean count	0.0	0.0	2.1	0.5	0.2
	Std Dev	0.0	0.0	8.2	1.2	0.5
	Mean (corrected)	0.0	0.0	2.7	1.0	0.6
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	10	33	105	28	7
	Sum of mean count	0.5	5.0	19.3	6.3	0.9
	Sum of Std Dev	2.3	8.8	27.4	6.8	2.0
	Sum of mean (corrected)	0.5	5.4	20.9	8.4	1.5
	Density birds/km^2 (corrected)	0.4	3.6	16.4	7.7	1.0

Table 18. Numbers of **Manx shearwater** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011.

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	89	100	100	100	100
	Max count	211	0	0	0	0
	Mean count	12.7	0.0	0.0	0.0	0.0
	Std Dev	48.5	0.0	0.0	0.0	0.0
	Mean (corrected)	12.7	0.0	0.0	0.0	0.0
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	100	100	100	100	89
	Max count	0	0	0	0	1
	Mean count	0.0	0.0	0.0	0.0	0.1
	Std Dev	0.0	0.0	0.0	0.0	0.3
	Mean (corrected)	0.0	0.0	0.0	0.0	0.4
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	100	100	100	100	100
	Max count	0	0	0	0	0
	Mean count	0.0	0.0	0.0	0.0	0.0
	Std Dev	0.0	0.0	0.0	0.0	0.0
	Mean (corrected)	0.0	0.0	0.0	0.0	0.0
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	211	0	0	0	1
	Sum of mean count	12.7	0.0	0.0	0.0	0.1
	Sum of Std Dev	48.5	0.0	0.0	0.0	0.3
	Sum of mean (corrected)	12.7	0.0	0.0	0.0	0.4
	Density birds/km^2 (corrected)	10.1	0.0	0.0	0.0	0.3

Table 19. Numbers of **storm petrel** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011.

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	100	100	100	100	88
	Max count	0	0	0	0	2
	Mean count	0.0	0.0	0.0	0.0	0.2
	Std Dev	0.0	0.0	0.0	0.0	0.5
	Mean (corrected)	0.0	0.0	0.0	0.0	0.2
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	100	100	100	100	78
	Max count	0	0	0	0	7
	Mean count	0.0	0.0	0.0	0.0	0.7
	Std Dev	0.0	0.0	0.0	0.0	1.8
	Mean (corrected)	0.0	0.0	0.0	0.0	0.7
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	100	100	100	100	75
	Max count	0	0	0	0	9
	Mean count	0.0	0.0	0.0	0.0	0.9
	Std Dev	0.0	0.0	0.0	0.0	2.4
	Mean (corrected)	0.0	0.0	0.0	0.0	0.9
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	0	0	0	0	18
	Sum of mean count	0.0	0.0	0.0	0.0	1.8
	Sum of Std Dev	0.0	0.0	0.0	0.0	4.8
	Sum of mean (corrected)	0.0	0.0	0.0	0.0	1.8
	Density birds/km^2 (corrected)	0.0	0.0	0.0	0.0	1.3

Table 20. Numbers of **gannet** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011.

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	63	100	100	59	75
	Max count	4	0	0	9	10
	Mean count	0.8	0.0	0.0	1.2	0.9
	Std Dev	1.4	0.0	0.0	2.2	2.5
	Mean (corrected)	0.8	0.0	0.0	1.2	0.9
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	90	100	95	90	100
	Max count	3	0	1	2	0
	Mean count	0.2	0.0	0.1	0.2	0.0
	Std Dev	0.8	0.0	0.2	0.5	0.0
	Mean (corrected)	0.2	0.0	0.1	0.2	0.0
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	90	100	96	82	88
	Max count	3	0	1	7	1
	Mean count	0.3	0.0	0.0	0.5	0.1
	Std Dev	0.9	0.0	0.2	1.5	0.3
	Mean (corrected)	0.3	0.0	0.0	0.5	0.1
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	10	0	2	18	11
	Sum of mean count	1.3	0.0	0.1	1.9	1.0
	Sum of Std Dev	3.0	0.0	0.4	4.2	2.8
	Sum of mean (corrected)	1.3	0.0	0.1	1.9	1.0
	Density birds/km^2 (corrected)	1.1	0.0	0.1	1.7	0.7

Table 21. Numbers of **shag** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011.

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	11	13	44	50	19
	Max count	14	7	4	6	7
	Mean count	3.1	2.9	1.0	0.9	2.4
	Std Dev	3.2	2.4	1.3	1.4	2.2
	Mean (corrected)	4.9	5.0	1.3	1.3	3.5
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	29	7	25	75	61
	Max count	10	10	6	1	7
	Mean count	2.4	3.4	1.7	0.3	0.8
	Std Dev	2.6	2.7	1.7	0.4	1.7
	Mean (corrected)	5.3	5.1	1.9	0.3	1.1
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	29	0	4	73	63
	Max count	14	16	7	2	2
	Mean count	2.6	4.1	3.4	0.3	0.6
	Std Dev	3.6	4.0	1.8	0.6	0.8
	Mean (corrected)	6.6	8.8	5.9	0.4	0.8
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	38	33	17	9	16
	Sum of mean count	8.1	10.4	6.1	1.4	3.7
	Sum of Std Dev	9.4	9.1	4.8	2.4	4.6
	Sum of mean (corrected)	16.8	18.9	9.1	2.0	5.4
	Density birds/km^2 (corrected)	14.3	10.8	8.5	1.8	3.7

Table 22. Numbers of **eider** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011.

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	100	75	72	100	100
	Max count	0	1	10	0	0
	Mean count	0.0	0.3	1.8	0.0	0.0
	Std Dev	0.0	0.4	3.4	0.0	0.0
	Mean (corrected)	0.0	1.8	1.9	0.0	0.0
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	100	43	30	100	100
	Max count	0	92	121	0	0
	Mean count	0.0	28.1	20.6	0.0	0.0
	Std Dev	0.0	34.7	31.4	0.0	0.0
	Mean (corrected)	0.0	28.1	20.7	0.0	0.0
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	100	58	13	100	100
	Max count	0	73	51	0	0
	Mean count	0.0	11.8	17.9	0.0	0.0
	Std Dev	0.0	21.6	14.8	0.0	0.0
	Mean (corrected)	0.0	11.8	18.7	0.0	0.0
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	0	166	182	0	0
	Sum of mean count	0.0	40.1	40.3	0.0	0.0
	Sum of Std Dev	0.0	56.7	49.6	0.0	0.0
	Sum of mean (corrected)	0.0	41.8	41.4	0.0	0.0
	Density birds/km^2 (corrected)	0.0	23.6	37.6	0.0	0.0

Table 23. Numbers of **common gull** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011.

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	100	75	100	100	100
	Max count	0	4	0	0	0
	Mean count	0.0	0.5	0.0	0.0	0.0
	Std Dev	0.0	1.1	0.0	0.0	0.0
	Mean (corrected)	0.0	0.9	0.0	0.0	0.0
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	86	93	95	90	94
	Max count	4	2	1	9	40
	Mean count	0.4	0.1	0.1	0.8	2.2
	Std Dev	1.2	0.5	0.2	2.5	9.4
	Mean (corrected)	0.9	0.3	0.1	1.0	2.2
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	95	83	100	77	100
	Max count	1	1	0	76	0
	Mean count	0.0	0.2	0.0	7.5	0.0
	Std Dev	0.2	0.4	0.0	19.2	0.0
	Mean (corrected)	0.2	0.5	0.0	8.0	0.0
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	5	7	1	85	40
	Sum of mean count	0.5	0.8	0.1	8.3	2.2
	Sum of Std Dev	1.4	2.0	0.2	21.7	9.4
	Sum of mean (corrected)	1.1	1.7	0.1	8.9	2.2
	Density birds/km^2 (corrected)	0.9	1.1	0.0	8.1	1.7

Table 24. Numbers of **lesser black-backed gull** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011.

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	100	100	100	95	75
	Max count	0	0	0	4	6
	Mean count	0.0	0.0	0.0	0.2	0.6
	Std Dev	0.0	0.0	0.0	0.9	1.5
	Mean (corrected)	0.0	0.0	0.0	0.2	0.6
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	100	100	100	100	100
	Max count	0	0	0	0	0
	Mean count	0.0	0.0	0.0	0.0	0.0
	Std Dev	0.0	0.0	0.0	0.0	0.0
	Mean (corrected)	0.0	0.0	0.0	0.0	0.0
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	100	100	100	91	100
	Max count	0	0	0	10	0
	Mean count	0.0	0.0	0.0	0.9	0.0
	Std Dev	0.0	0.0	0.0	2.9	0.0
	Mean (corrected)	0.0	0.0	0.0	0.9	0.0
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	0	0	0	14	6
	Sum of mean count	0.0	0.0	0.0	1.1	0.6
	Sum of Std Dev	0.0	0.0	0.0	3.8	1.5
	Sum of mean (corrected)	0.0	0.0	0.0	1.1	0.6
	Density birds/km^2 (corrected)	0.0	0.0	0.0	1.0	0.4

Table 25. Numbers of **herring gull** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011.

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	84	50	17	82	50
	Max count	2	36	70	4	40
	Mean count	0.2	3.5	15.8	0.5	11.6
	Standard Deviation	0.5	8.9	17.3	1.2	14.3
	Mean (corrected)	0.5	4.0	15.8	0.6	11.7
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	95	71	70	95	100
	Max count	3	10	18	2	0
	Mean count	0.1	1.6	1.6	0.1	0.0
	Std Dev	0.7	3.2	4.1	0.4	0.0
	Mean (corrected)	0.1	2.1	1.8	0.3	0.0
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	95	50	54	91	81
	Max count	2	2	30	24	2
	Mean count	0.1	0.6	3.5	1.3	0.3
	Std Dev	0.4	0.7	6.9	5.2	0.7
	Mean (corrected)	0.2	1.1	4.0	1.3	0.8
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	7	48	118	30	42
	Sum of mean count	0.4	5.7	20.8	1.9	11.9
	Sum of Std Dev	1.6	12.8	28.4	6.8	15.0
	Sum of mean (corrected)	0.8	7.2	21.6	2.2	12.5
	Density birds/km^2 (corrected)	0.7	4.5	17.4	2.0	8.4

Table 26. Numbers of **great black-backed gull** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	63	31	61	68	56
	Max count	2	6	4	5	4
	Mean count	0.5	1.6	0.8	0.8	1.2
	Std Dev	0.7	1.7	1.3	1.4	1.6
	Mean (corrected)	0.9	3.0	1.5	1.2	1.3
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	90	57	80	100	78
	Max count	2	3	2	0	1
	Mean count	0.1	0.6	0.3	0.0	0.2
	Std Dev	0.5	0.9	0.7	0.0	0.4
	Mean (corrected)	0.2	1.1	0.5	0.0	0.3
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	71	42	46	95	75
	Max count	4	3	39	2	3
	Mean count	0.4	1.0	2.8	0.1	0.6
	Std Dev	0.9	1.1	7.8	0.4	1.1
	Mean (corrected)	1.3	2.1	4.3	0.4	0.9
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	8	12	45	7	8
	Sum of mean count	1.0	3.3	3.9	0.9	2.0
	Sum of Std Dev	2.1	3.8	9.8	1.9	3.1
	Sum of mean (corrected)	2.5	6.2	6.2	1.6	2.5
	Density birds/km^2 (corrected)	2.1	3.7	5.8	1.4	1.7

Table 27. Numbers of **Arctic tern** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011.

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	100	100	100	95	81
	Max count	0	0	0	1	5
	Mean count	0.0	0.0	0.0	0.0	0.6
	Std Dev	0.0	0.0	0.0	0.2	1.4
	Mean (corrected)	0.0	0.0	0.0	0.1	0.9
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	100	100	100	95	72
	Max count	0	0	0	7	6
	Mean count	0.0	0.0	0.0	0.4	1.0
	Std Dev	0.0	0.0	0.0	1.6	2.1
	Mean (corrected)	0.0	0.0	0.0	0.4	2.1
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	100	100	100	100	75
	Max count	0	0	0	0	17
	Mean count	0.0	0.0	0.0	0.0	1.9
	Std Dev	0.0	0.0	0.0	0.0	4.5
	Mean (corrected)	0.0	0.0	0.0	0.0	4.5
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	0	0	0	8	28
	Sum of mean count	0.0	0.0	0.0	0.4	3.4
	Sum of Std Dev	0.0	0.0	0.0	1.8	8.0
	Sum of mean (corrected)	0.0	0.0	0.0	0.5	7.4
	Density birds/km^2 (corrected)	0.0	0.0	0.0	0.4	5.1

Table 28. Numbers of **common guillemot** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011. (Auks that were not specifically identified as razorbill or guillemot were assigned to either razorbill or guillemot counts based on the relative proportion of these species recorded overall. Those assigned to guillemot are included here)

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	74	100	100	91	94
	Max count	5.0	0.0	0.0	2.0	2.0
	Mean count	0.8	0.0	0.0	0.2	0.1
	Std Dev	1.6	0.0	0.0	0.5	0.5
	Mean (corrected)	3.3	0.0	0.0	0.9	0.2
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	81	93	95	95	100
	Max count	1.0	0.3	0.5	1.0	0.0
	Mean count	0.1	0.0	0.0	0.1	0.0
	Std Dev	0.3	0.1	0.1	0.2	0.0
	Mean (corrected)	0.6	0.1	0.1	0.8	0.0
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	81	92	100	95	94
	Max count	1.0	0.3	0.0	0.3	1.0
	Mean count	0.1	0.0	0.0	0.0	0.1
	Std Dev	0.3	0.1	0.0	0.1	0.3
	Mean (corrected)	0.5	0.3	0.0	0.2	1.0
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	7.0	0.5	0.5	3.3	3.0
	Sum of mean count	1.0	0.0	0.0	0.2	0.2
	Sum of Std Dev	2.2	0.1	0.1	0.8	0.8
	Sum of mean (corrected)	4.4	0.4	0.1	1.9	1.2
	Density birds/km^2 (corrected)	3.6	0.2	0.0	1.7	0.8

Table 29. Numbers of **razorbill** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011. (Auks that were not specifically identified as razorbill or guillemot were assigned to either razorbill or guillemot counts based on the relative proportion of these species recorded overall. Those assigned to razorbill are included here)

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	84	100	78	73	94
	Max count	4.0	0.0	2.0	3.7	1.0
	Mean count	0.5	0.0	0.4	0.5	0.1
	Std Dev	1.3	0.0	0.8	1.0	0.3
	Mean (corrected)	2.5	0.0	2.4	3.9	0.1
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	86	93	85	85	94
	Max count	3.0	0.7	5.0	2.0	2.0
	Mean count	0.2	0.1	0.5	0.2	0.1
	Std Dev	0.7	0.2	1.3	0.5	0.5
	Mean (corrected)	2.3	0.2	0.6	0.7	0.4
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	86	92	92	91	100
	Max count	2.7	0.7	13.0	5.0	0.0
	Mean count	0.3	0.1	0.8	0.3	0.0
	Std Dev	0.7	0.2	2.9	1.1	0.0
	Mean (corrected)	3.8	1.0	1.4	0.8	0.0
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	9.7	1.5	20.0	10.7	3.0
	Sum of mean count	1.0	0.1	1.7	0.9	0.2
	Sum of Std Dev	2.7	0.4	4.9	2.6	0.7
	Sum of mean (corrected)	8.6	1.2	4.4	5.3	0.5
	Density birds/km^2 (corrected)	7.3	0.6	3.7	4.9	0.4

Table 30. Numbers of **black guillemot** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011.

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	100	69	61	5	13
	Max count	0	7	13	38	23
	Mean count	0.0	0.7	1.4	7.8	3.4
	Std Dev	0.0	1.7	3.2	9.6	4.4
	Mean (corrected)	0.0	5.1	2.5	12.7	9.6
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	90	71	85	25	61
	Max count	3	11	1	4	12
	Mean count	0.2	1.4	0.2	1.4	1.7
	Std Dev	0.7	3.1	0.4	1.1	3.2
	Mean (corrected)	0.5	9.4	0.4	3.2	2.8
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	90	75	100	73	63
	Max count	1	2	0	9	3
	Mean count	0.1	0.3	0.0	1.2	0.6
	Std Dev	0.3	0.7	0.0	2.5	0.9
	Mean (corrected)	0.3	4.7	0.0	3.4	1.6
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	4	20	14	51	28
	Sum of mean count	0.3	2.4	1.6	10.4	5.7
	Sum of Std Dev	1.0	5.5	3.6	13.2	8.4
	Sum of mean (corrected)	0.8	19.2	2.9	19.3	14.0
	Density birds/km^2 (corrected)	0.7	11.3	2.2	17.5	9.6

Table 31. Numbers of **puffin** seen from each VP during snapshot scans (SSS), Sept 2010 to Sept 2011.

VP	Measure	Autumn (Sep &Oct 2010, Sep 2011)	Early winter (Nov & Dec 2010)	Late winter (Jan – Mar 2011)	Spring (Apr – Jun 2011)	Summer (Jul & Aug 2011)
Labost	Effort (No. SSS)	19	16	18	22	16
	% zero counts	95	100	100	82	94
	Max count	2	0	0	5	1
	Mean count	0.1	0.0	0.0	0.4	0.1
	Std Dev	0.5	0.0	0.0	1.1	0.3
	Mean (corrected)	0.2	0.0	0.0	1.3	1.0
Melbost	Effort (No. SSS)	21	14	20	20	18
	% zero counts	100	100	100	95	100
	Max count	0	0	0	2	0
	Mean count	0.0	0.0	0.0	0.1	0.0
	Std Dev	0.0	0.0	0.0	0.4	0.0
	Mean (corrected)	0.0	0.0	0.0	0.1	0.0
Siadar	Effort (No. SSS)	21	12	24	22	16
	% zero counts	100	100	96	95	100
	Max count	0	0	1	1	0
	Mean count	0.0	0.0	0.0	0.0	0.0
	Std Dev	0.0	0.0	0.2	0.2	0.0
	Mean (corrected)	0.0	0.0	0.0	0.1	0.0
Combined	Effort (No. SSS)	61	42	62	64	50
	Sum of max count	2	0	1	8	1
	Sum of mean count	0.1	0.0	0.0	0.6	0.1
	Sum of Std Dev	0.5	0.0	0.2	1.8	0.3
	Sum of mean (corrected)	0.2	0.0	0.0	1.5	1.0
	Density birds/km^2 (corrected)	0.2	0.0	0.0	1.4	0.7

Table 32. The maximum and mean numbers of a species recorded in each coastal walkover section of the **Labost** survey area from October 2010 to August 2011. Actively breeding birds are excluded as these are reported in Table 30. Means and percentages are rounded to nearest integer. "n.a." indicates not appropriate.

Species	Measure	Survey section						Total
		1	2	3	4	5	6	
Great northern diver	% visits seen	33%	17%	33%	17%	50%	83%	83%
	Maximum count	2	1	1	1	1	2	7
	Mean, when present	2	1	1	1	1	1	3
Fulmar	% visits seen	0%	17%	67%	67%	33%	0%	67%
	Maximum count	0	7	21	82	7	0	108
	Mean, when present	n.a.	7	14	44	7	n.a.	63
Cormorant	% visits seen	67%	0%	50%	0%	33%	33%	100%
	Maximum count	3	0	1	0	3	1	7
	Mean, when present	3	n.a.	1	n.a.	2	1	3
Shag	% visits seen	33%	50%	33%	100%	33%	33%	100%
	Maximum count	2	1	1	10	3	2	12
	Mean, when present	2	1	1	6	2	2	9
Grey heron	% visits seen	0%	0%	17%	17%	17%	17%	50%
	Maximum count	0	0	1	2	1	3	3
	Mean, when present	n.a.	n.a.	1	2	1	3	2
Mute swan	% visits seen	17%	0%	0%	0%	0%	17%	33%
	Maximum count	1	0	0	0	0	2	2
	Mean, when present	1	n.a.	n.a.	n.a.	n.a.	2	2
Whooper swan	% visits seen	50%	0%	0%	0%	0%	17%	50%
	Maximum count	3	0	0	0	0	3	6
	Mean, when present	2	n.a.	n.a.	n.a.	n.a.	3	3
Greylag goose	% visits seen	100%	17%	67%	17%	33%	83%	100%
	Maximum count	110	10	75	2	17	28	129
	Mean, when present	33	10	21	2	11	17	67
Shelduck	% visits seen	0%	0%	0%	0%	0%	50%	50%
	Maximum count	0	0	0	0	0	4	4
	Mean, when present	n.a.	n.a.	n.a.	n.a.	n.a.	3	3
Wigeon	% visits seen	17%	0%	0%	0%	0%	50%	50%
	Maximum count	19	0	0	0	0	40	59
	Mean, when present	19	n.a.	n.a.	n.a.	n.a.	26	32
Teal	% visits seen	0%	0%	0%	17%	0%	50%	67%
	Maximum count	0	0	0	2	0	6	6
	Mean, when present	n.a.	n.a.	n.a.	2	n.a.	3	3
Mallard	% visits seen	100%	0%	0%	17%	0%	67%	100%
	Maximum count	10	0	0	1	0	9	16
	Mean, when present	6	n.a.	n.a.	1	n.a.	4	9
Eider	% visits seen	0%	0%	0%	0%	0%	17%	17%

	Maximum count	0	0	0	0	0	4	4
	Mean, when present	n.a.	n.a.	n.a.	n.a.	n.a.	4	4
Red-br. merganser	% visits seen	0%	0%	0%	0%	0%	83%	83%
	Maximum count	0	0	0	0	0	13	13
	Mean, when present	n.a.	n.a.	n.a.	n.a.	n.a.	7	7
Buzzard	% visits seen	17%	17%	17%	17%	0%	33%	67%
	Maximum count	1	1	1	2	0	1	3
	Mean, when present	1	1	1	2	n.a.	1	2
Merlin	% visits seen	0%	17%	0%	17%	17%	17%	33%
	Maximum count	0	1	0	1	1	1	2
	Mean, when present	n.a.	1	n.a.	1	1	1	2
Peregrine	% visits seen	17%	0%	0%	0%	0%	0%	17%
	Maximum count	1	0	0	0	0	0	1
	Mean, when present	1	n.a.	n.a.	n.a.	n.a.	n.a.	1
Oystercatcher	% visits seen	83%	50%	50%	33%	50%	100%	100%
	Maximum count	63	8	3	8	14	37	100
	Mean, when present	19	5	2	7	7	13	39
Ringed plover	% visits seen	100%	0%	0%	0%	17%	100%	100%
	Maximum count	85	0	0	0	7	54	121
	Mean, when present	23	n.a.	n.a.	n.a.	7	32	56
Golden plover	% visits seen	33%	33%	0%	17%	50%	17%	100%
	Maximum count	175	220	0	6	6	6	221
	Mean, when present	98	111	n.a.	6	4	6	73
Lapwing	% visits seen	17%	17%	17%	0%	0%	33%	83%
	Maximum count	44	1	1	0	0	22	44
	Mean, when present	44	1	1	n.a.	n.a.	15	15
Knot	% visits seen	0%	0%	0%	0%	0%	17%	17%
	Maximum count	0	0	0	0	0	19	19
	Mean, when present	n.a.	n.a.	n.a.	n.a.	n.a.	19	19
Sanderling	% visits seen	33%	0%	0%	0%	0%	67%	67%
	Maximum count	18	0	0	0	0	5	19
	Mean, when present	15	n.a.	n.a.	n.a.	n.a.	3	10
Purple sandpiper	% visits seen	33%	0%	0%	0%	17%	0%	33%
	Maximum count	4	0	0	0	9	0	13
	Mean, when present	3	n.a.	n.a.	n.a.	9	n.a.	8
Dunlin	% visits seen	50%	0%	0%	0%	0%	83%	83%
	Maximum count	40	0	0	0	0	85	125
	Mean, when present	15	n.a.	n.a.	n.a.	n.a.	33	42
Snipe	% visits seen	17%	0%	17%	0%	0%	0%	33%
	Maximum count	1	0	1	0	0	0	1
	Mean, when present	1	n.a.	1	n.a.	n.a.	n.a.	1
Whimbrel	% visits seen	0%	0%	0%	0%	17%	17%	17%
	Maximum count	0	0	0	0	1	4	5

	Mean, when present	n.a.	n.a.	n.a.	n.a.	1	4	5
Curlew	% visits seen	0%	0%	17%	33%	50%	83%	83%
	Maximum count	0	0	1	1	5	19	24
	Mean, when present	n.a.	n.a.	1	1	4	6	9
Redshank	% visits seen	83%	0%	17%	0%	0%	100%	100%
	Maximum count	3	0	1	0	0	5	8
	Mean, when present	2	n.a.	1	n.a.	n.a.	3	5
Greenshank	% visits seen	0%	0%	0%	0%	0%	17%	17%
	Maximum count	0	0	0	0	0	1	1
	Mean, when present	n.a.	n.a.	n.a.	n.a.	n.a.	1	1
Turnstone	% visits seen	50%	0%	0%	0%	0%	83%	83%
	Maximum count	14	0	0	0	0	8	17
	Mean, when present	5	n.a.	n.a.	n.a.	n.a.	4	7
Black-headed gull	% visits seen	33%	0%	17%	17%	0%	33%	33%
	Maximum count	18	0	5	1	0	26	44
	Mean, when present	11	n.a.	5	1	n.a.	25	39
Common gull	% visits seen	33%	0%	0%	0%	0%	67%	83%
	Maximum count	35	0	0	0	0	18	53
	Mean, when present	22	n.a.	n.a.	n.a.	n.a.	10	17
Herring gull	% visits seen	50%	17%	33%	67%	17%	17%	83%
	Maximum count	48	15	36	24	17	6	129
	Mean, when present	19	15	20	14	17	6	38
Great black-backed gull	% visits seen	0%	33%	17%	17%	17%	17%	50%
	Maximum count	0	83	7	4	70	68	225
	Mean, when present	n.a.	47	7	4	70	68	81
Arctic tern	% visits seen	17%	17%	0%	0%	0%	17%	17%
	Maximum count	1	1	0	0	0	3	5
	Mean, when present	1	1	n.a.	n.a.	n.a.	3	5
Black guillemot	% visits seen	33%	0%	0%	17%	17%	0%	50%
	Maximum count	1	0	0	9	1	0	9
	Mean, when present	1	n.a.	n.a.	9	1	n.a.	4
Rock dove	% visits seen	0%	0%	0%	17%	0%	0%	17%
	Maximum count	0	0	0	26	0	0	26
	Mean, when present	n.a.	n.a.	n.a.	26	n.a.	n.a.	26
Starling	% visits seen	0%	17%	0%	0%	0%	50%	50%
	Maximum count	0	100	0	0	0	90	130
	Mean, when present	n.a.	100	n.a.	n.a.	n.a.	60	93
Twite	% visits seen	0%	0%	0%	0%	0%	17%	17%
	Maximum count	0	0	0	0	0	25	25
	Mean, when present	n.a.	n.a.	n.a.	n.a.	n.a.	25	25

Table 33. The number of breeding bird recorded in the **Labost** count sections in April-June 2011. The numbers indicated pairs/territories unless stated otherwise.

Species	**Survey section**						
	1	**2**	**3**	**4**	**4 inland area**	**5**	**6**
Shag	0	0	0	*ca.* 5	0	0	0
Fulmar	0	1	16	34	0	3	0
Corncrake	0	0	0	0	0	0	2
Great black-backed gull	0	0	1	2	0	0	0
Herring gull	0	0	0	25	0	0	0
Lesser black-backed gull	0	0	0	8	0	0	0
Black-headed gull	0	0	0	0	5	0	0
Common Gull	0	0	0	0	4	0	0
Black guillemot	0	0	0	ca. 20	0	0	0
Lapwing	0	3	0	3	2	0	0
Golden plover (not breeding)	0	0	0	0	15 birds	0	0
Ringed plover	0	0	1	1	1	0	0
Oystercatcher	0	0	0	7	0	0	0
Greenshank (not breeding)	0	0	0	0	1 bird	0	0
Redshank	0	1	0	0	3	0	0
Snipe	0	0	0	0	1	0	0

Table 34. The maximum and mean numbers of a species recorded in each coastal walkover section of the Siadar/Mealabost survey area from October 2010 to August 2011. Actively breeding birds are excluded as these are reported in Table 32. Means and percentages are rounded to nearest integer. "n.a." indicates not appropriate.

Species	Measure	Survey section							Total
		7	8	9	10	11	12	13	
Red-throated diver	% visits seen	0%	0%	0%	0%	0%	17%	17%	17%
	Maximum count	0	0	0	0	0	1	3	4
	Mean, when present	n.a.	n.a.	n.a.	n.a.	n.a.	1	3	4
Great northern diver	% visits seen	50%	33%	17%	50%	17%	33%	50%	83%
	Maximum count	2	4	4	3	1	5	2	14
	Mean, when present	1	3	4	2	1	4	1	7
Fulmar	% visits seen	0%	0%	0%	33%	17%	33%	0%	33%
	Maximum count	0	0	0	5	1	1	0	7
	Mean, when present	n.a.	n.a.	n.a.	3	1	1	n.a.	5
Cormorant	% visits seen	33%	17%	17%	33%	17%	17%	0%	50%
	Maximum count	3	1	1	3	1	3	0	8
	Mean, when present	2	1	1	3	1	3	n.a.	5
Shag	% visits seen	17%	17%	17%	50%	17%	50%	50%	50%
	Maximum count	1	1	1	3	1	5	1	11
	Mean, when present	1	1	1	3	1	3	1	8
Grey heron	% visits seen	67%	0%	0%	33%	17%	0%	0%	67%
	Maximum count	1	0	0	1	1	0	0	2
	Mean, when present	1	n.a.	n.a.	1	1	n.a.	n.a.	2
Greylag goose	% visits seen	67%	50%	17%	50%	17%	50%	33%	83%
	Maximum count	52	60	6	30	14	30	39	129
	Mean, when present	27	26	6	24	14	22	27	79
Wigeon	% visits seen	50%	0%	0%	0%	0%	17%	0%	50%
	Maximum count	110	0	0	0	0	5	0	115
	Mean, when present	52	n.a.	n.a.	n.a.	n.a.	5	n.a.	53
Teal	% visits seen	67%	0%	0%	0%	17%	0%	0%	67%
	Maximum count	16	0	0	0	1	0	0	17
	Mean, when present	12	n.a.	n.a.	n.a.	1	n.a.	n.a.	12
Mallard	% visits seen	100%	17%	0%	33%	83%	0%	0%	100%
	Maximum count	24	5	0	8	15	0	0	49
	Mean, when present	17	5	n.a.	5	10	n.a.	n.a.	28
Eider	% visits seen	17%	17%	33%	0%	0%	0%	17%	33%
	Maximum count	35	1	4	0	0	0	75	80
	Mean, when present	35	1	3	n.a.	n.a.	n.a.	75	59
Buzzard	% visits seen	0%	0%	0%	0%	0%	17%	0%	17%
	Maximum count	0	0	0	0	0	1	0	1
	Mean, when present	n.a.	n.a.	n.a.	n.a.	n.a.	1	n.a.	1
Peregrine	% visits seen	0%	0%	0%	0%	17%	0%	0%	17%

	Maximum count	0	0	0	0	1	0	0	1
	Mean, when present	n.a.	n.a.	n.a.	n.a.	1	n.a.	n.a.	1
Oystercatcher	% visits seen	83%	67%	50%	100%	67%	33%	50%	100%
	Maximum count	16	4	10	9	24	2	16	67
	Mean, when present	8	3	8	4	16	2	8	32
Ringed plover	% visits seen	17%	0%	0%	50%	67%	0%	0%	83%
	Maximum count	3	0	0	6	8	0	0	13
	Mean, when present	3	n.a.	n.a.	4	4	n.a.	n.a.	6
Golden plover	% visits seen	17%	33%	17%	33%	17%	17%	0%	50%
	Maximum count	36	7	6	31	32	5	0	112
	Mean, when present	36	5	6	18	32	5	n.a.	41
Lapwing	% visits seen	17%	0%	0%	17%	0%	0%	0%	33%
	Maximum count	20	0	0	1	0	0	0	20
	Mean, when present	20	n.a.	n.a.	1	n.a.	n.a.	n.a.	11
Knot	% visits seen	0%	0%	0%	0%	17%	0%	0%	17%
	Maximum count	0	0	0	0	5	0	0	5
	Mean, when present	n.a.	n.a.	n.a.	n.a.	5	n.a.	n.a.	5
Sanderling	% visits seen	33%	0%	0%	0%	0%	0%	0%	33%
	Maximum count	1	0	0	0	0	0	0	1
	Mean, when present	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1
Purple sandpiper	% visits seen	33%	0%	0%	0%	0%	0%	0%	33%
	Maximum count	19	0	0	0	0	0	0	19
	Mean, when present	14	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	14
Dunlin	% visits seen	50%	0%	0%	33%	33%	0%	0%	50%
	Maximum count	33	0	0	6	9	0	0	36
	Mean, when present	12	n.a.	n.a.	5	6	n.a.	n.a.	19
Snipe	% visits seen	33%	17%	0%	17%	0%	33%	33%	50%
	Maximum count	8	2	0	1	0	2	2	10
	Mean, when present	6	2	n.a.	1	n.a.	2	2	7
Whimbrel	% visits seen	33%	17%	0%	50%	0%	0%	33%	50%
	Maximum count	4	6	0	6	0	0	2	10
	Mean, when present	3	6	n.a.	3	n.a.	n.a.	2	7
Curlew	% visits seen	100%	33%	50%	50%	50%	17%	33%	100%
	Maximum count	26	4	1	3	8	1	2	35
	Mean, when present	7	3	1	2	7	1	2	14
Redshank	% visits seen	83%	33%	0%	50%	67%	33%	33%	100%
	Maximum count	49	2	0	6	4	1	14	59
	Mean, when present	18	2	n.a.	3	2	1	8	21
Greenshank	% visits seen	0%	0%	0%	0%	17%	0%	0%	17%
	Maximum count	0	0	0	0	1	0	0	1
	Mean, when present	n.a.	n.a.	n.a.	n.a.	1	n.a.	n.a.	1
Turnstone	% visits seen	83%	0%	17%	17%	33%	0%	0%	83%
	Maximum count	8	0	10	15	10	0	0	36

	Mean, when present	5	n.a.	10	15	7	n.a.	n.a.	13
Black-headed gull	% visits seen	17%	17%	17%	17%	33%	33%	0%	33%
	Maximum count	9	14	9	9	30	5	0	76
	Mean, when present	9	14	9	9	18	4	n.a.	42
Bonaparte's gull	% visits seen	0%	0%	0%	0%	50%	0%	0%	50%
	Maximum count	0	0	0	0	1	0	0	1
	Mean, when present	n.a.	n.a.	n.a.	n.a.	1	n.a.	n.a.	1
Common gull	% visits seen	50%	0%	0%	33%	50%	17%	17%	67%
	Maximum count	46	0	0	10	26	39	3	91
	Mean, when present	27	n.a.	n.a.	9	17	39	3	48
Herring gull	% visits seen	50%	17%	17%	0%	33%	0%	0%	67%
	Maximum count	19	4	4	0	4	0	0	20
	Mean, when present	16	4	4	n.a.	4	n.a.	n.a.	16
Great black-backed gull	% visits seen	33%	0%	17%	0%	0%	17%	0%	33%
	Maximum count	19	0	3	0	0	3	0	25
	Mean, when present	11	n.a.	3	n.a.	n.a.	3	n.a.	14
Arctic tern	% visits seen	0%	0%	17%	0%	0%	17%	0%	17%
	Maximum count	0	0	1	0	0	1	0	2
	Mean, when present	n.a.	n.a.	1	n.a.	n.a.	1	n.a.	2
Starling	% visits seen	50%	0%	0%	17%	33%	17%	0%	50%
	Maximum count	120	0	0	45	100	70	0	230
	Mean, when present	72	n.a.	n.a.	45	73	70	n.a.	158

Table 35. The number of breeding bird recorded in the Siadar to Mealabost count sections in April-June 2011. The numbers indicated are pairs/territories unless stated otherwise.

Species	**Survey section**							
	7	**8**	**9**	**9 inland area**	**10**	**11**	**12**	**13**
Fulmar	0	0	9	0	0	0	0	0
Greylag goose	0	0	0	9	0	0	0	0
Mallard	0	0	0	1	0	0	0	0
Teal	0	0	0	1	0	0	0	0
Corncrake	1	0	0	0	0	1	0	0
Common gull	10	0	0	50	0	1	0	0
Herring gull	0	0	0	30	0	0	0	0
Lesser black-b. gull	0	0	0	10	0	0	0	0
Lapwing	0	0	0	5	0	0	0	0
Ringed plover	0	0	1	0	0	0	0	0
Dunlin	0	0	0	3	0	0	0	0
Curlew	1	0	0	1	0	0	0	0
Redshank	3	0	0	ca. 8	0	0	0	0
Common sandpiper	0	0	0	0	0	1	0	0
Snipe	0	0	0	1	0	0	0	0

Maps (Figures)

Fig 1. Location of study area

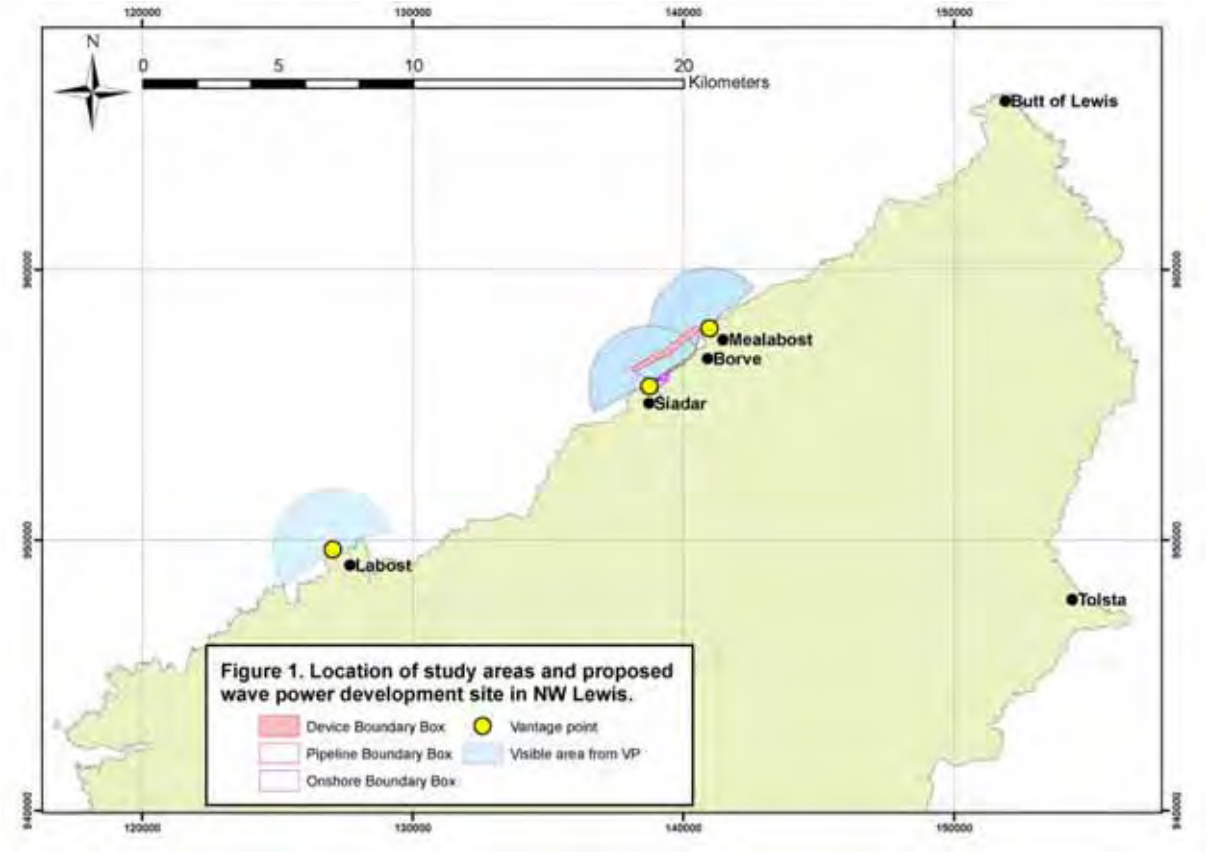


Fig 2. Labost survey area and coastal walkover

Fig 3. Siadar and Mealabost survey areas and coastal walkover (change title)

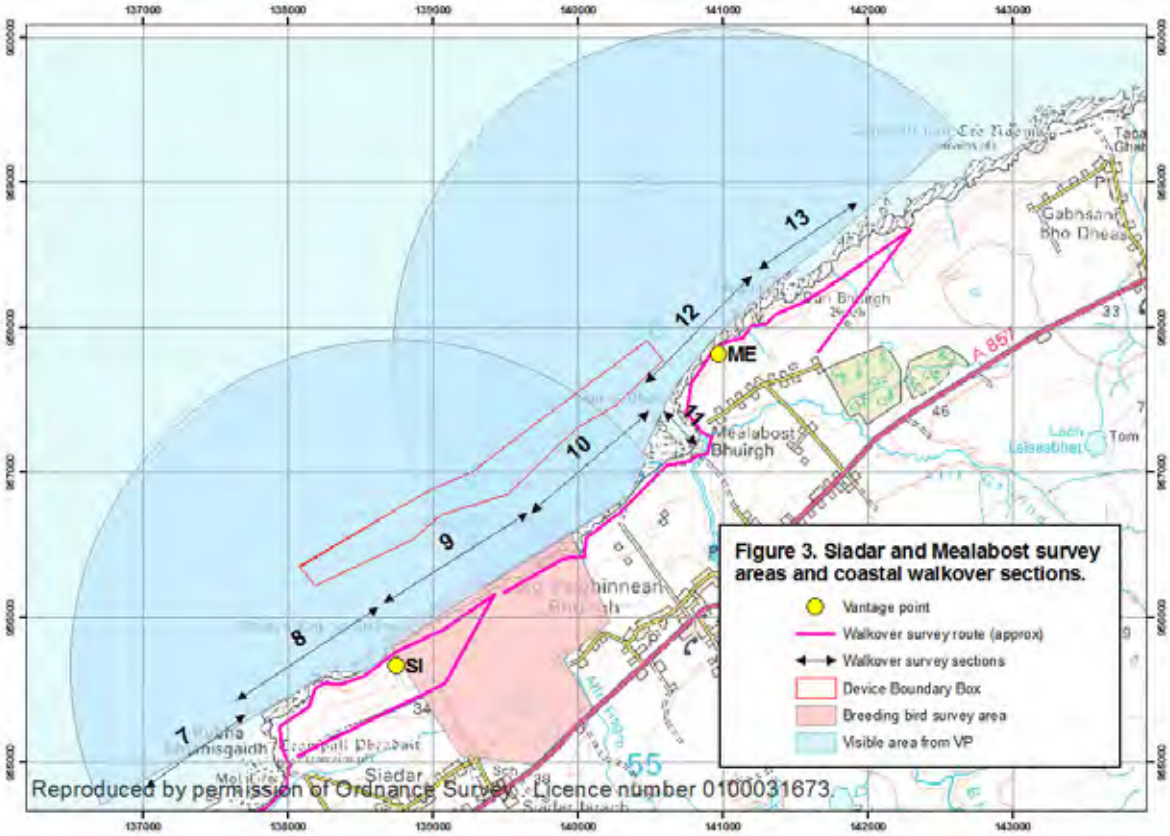


Fig 4. Red-throated diver - LA

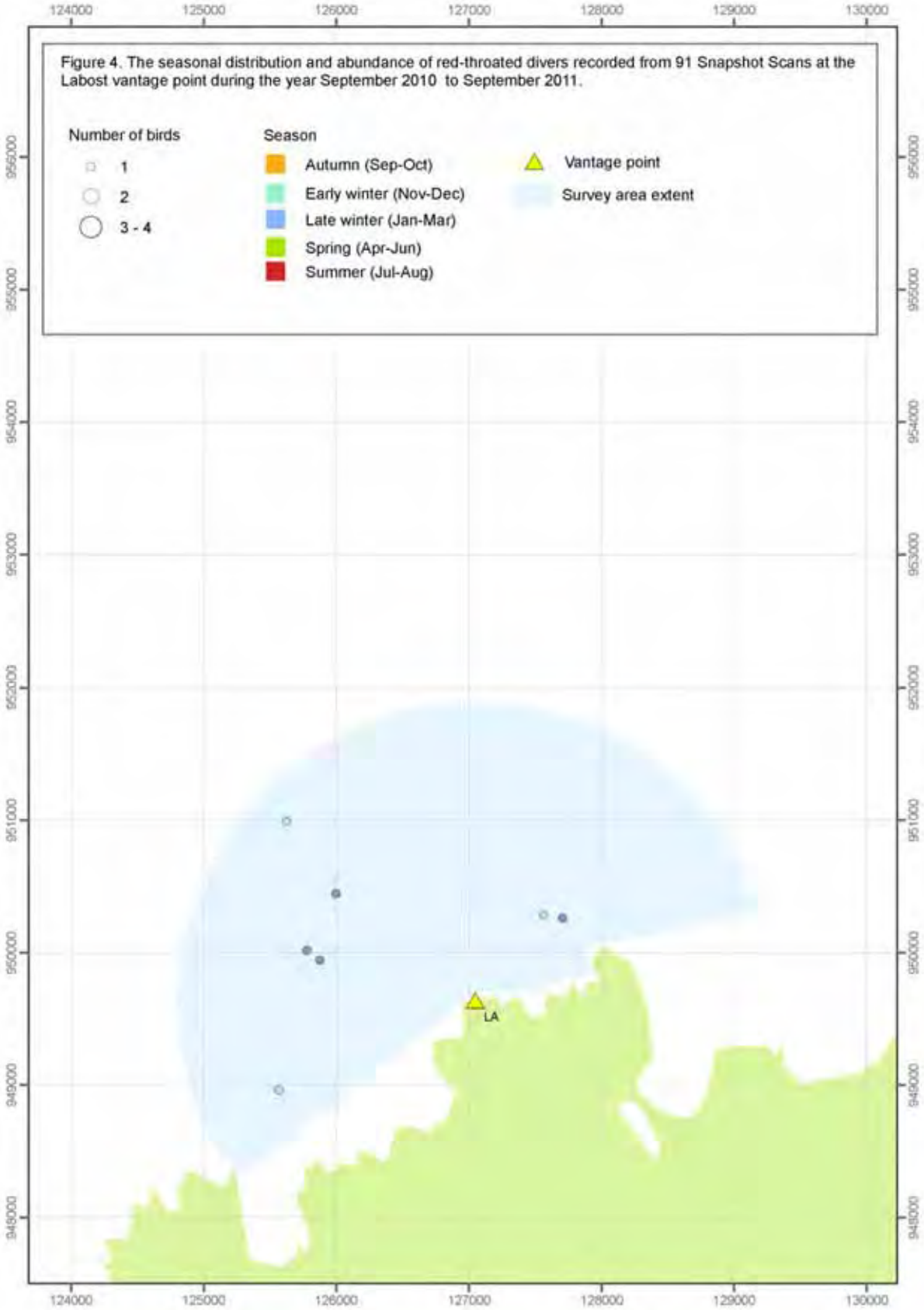


Fig 5. Red-throated diver – SI and ME

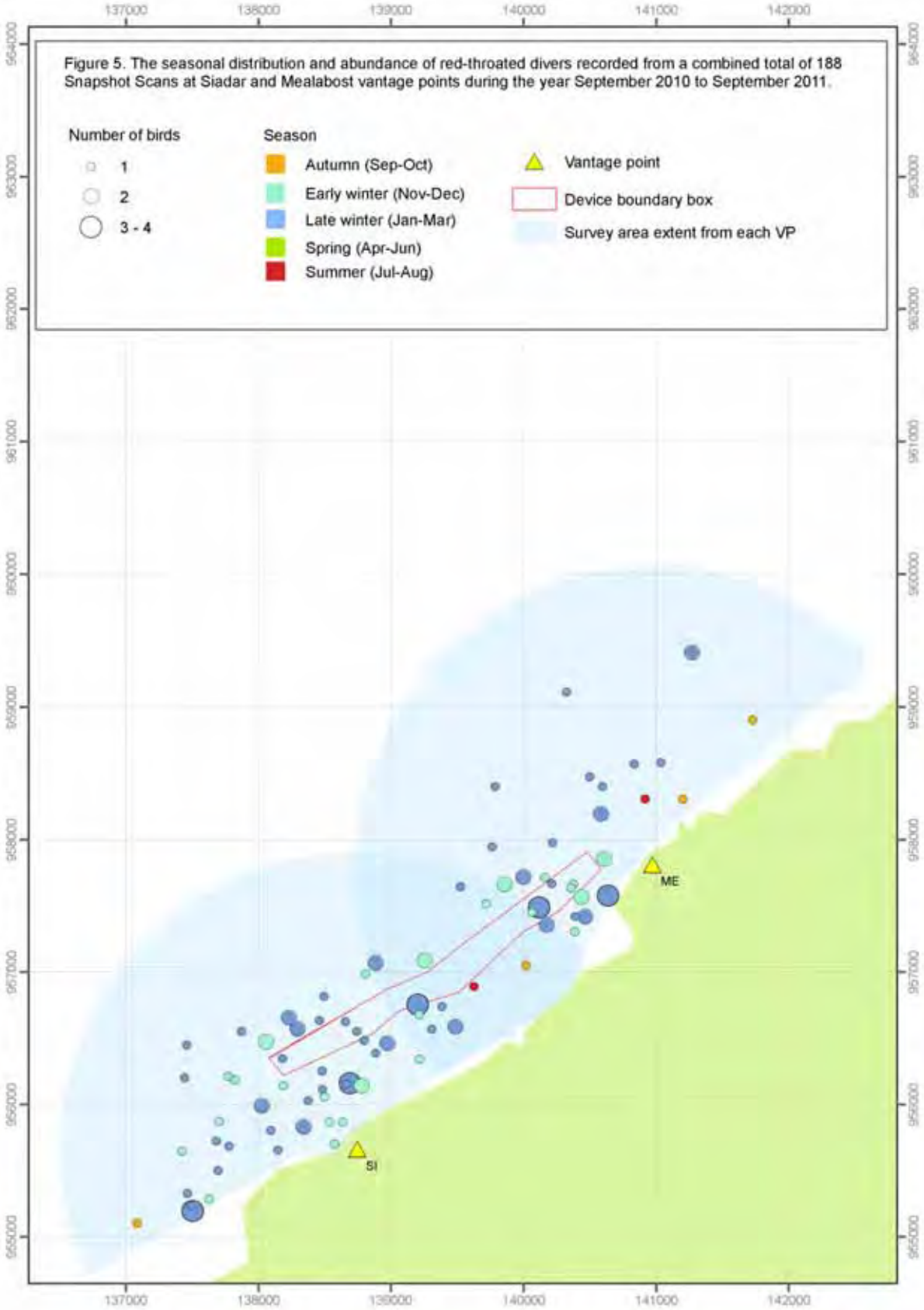


Fig 6. Great northern diver - LA

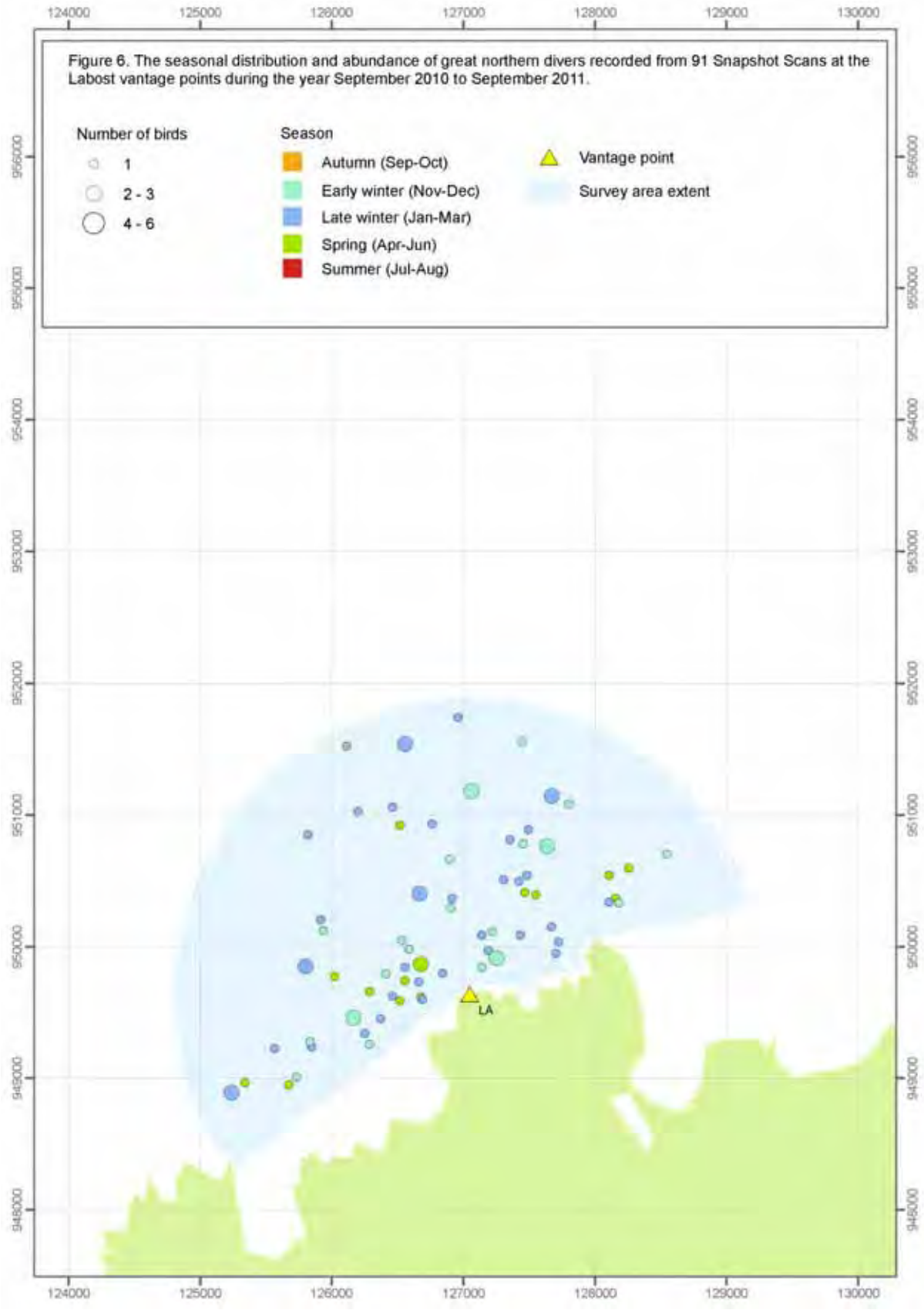


Fig 7. Great northern diver – SA and ME

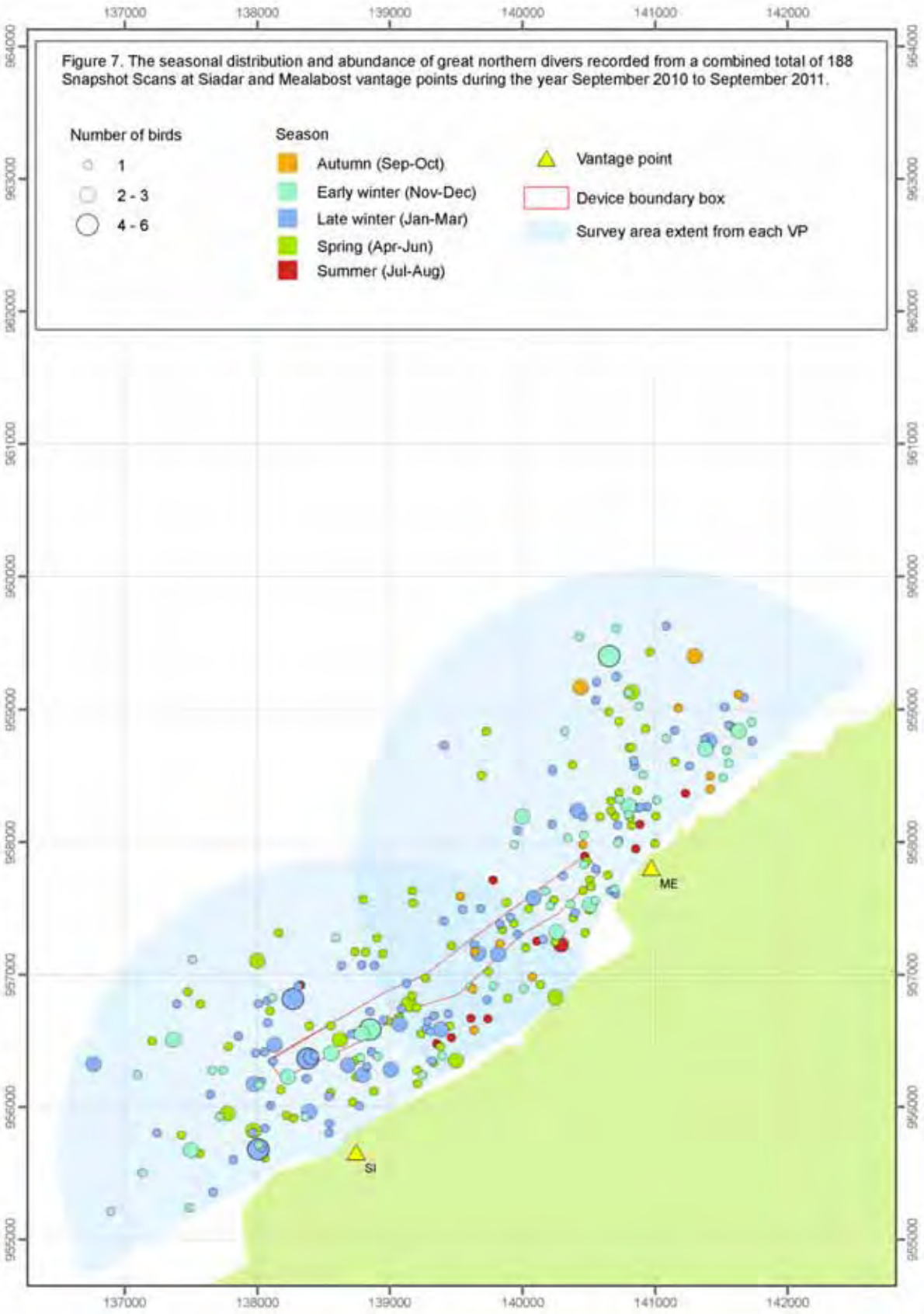


Fig 8. Fulmar - LA

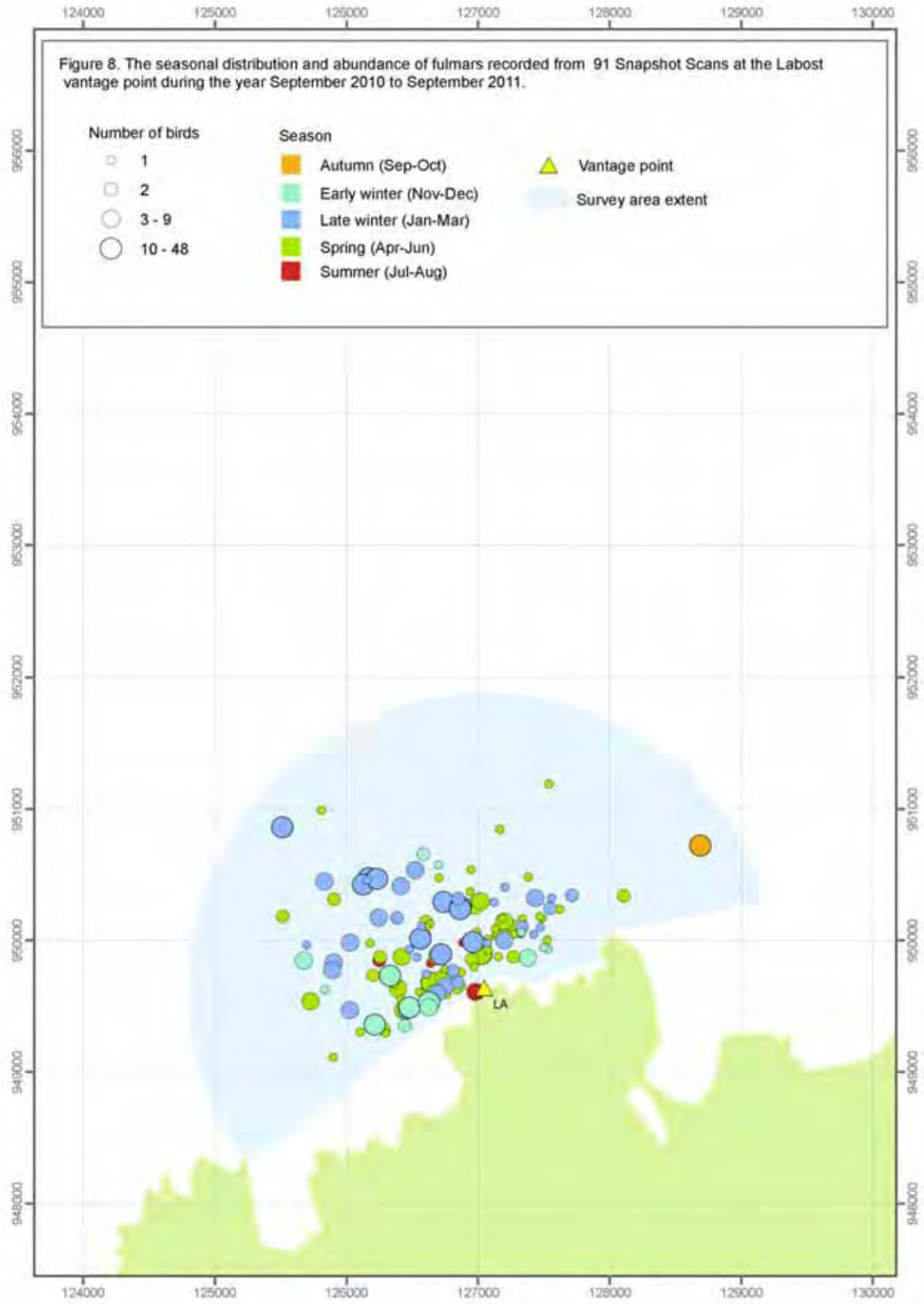


Fig 9. Fulmar – SI and ME

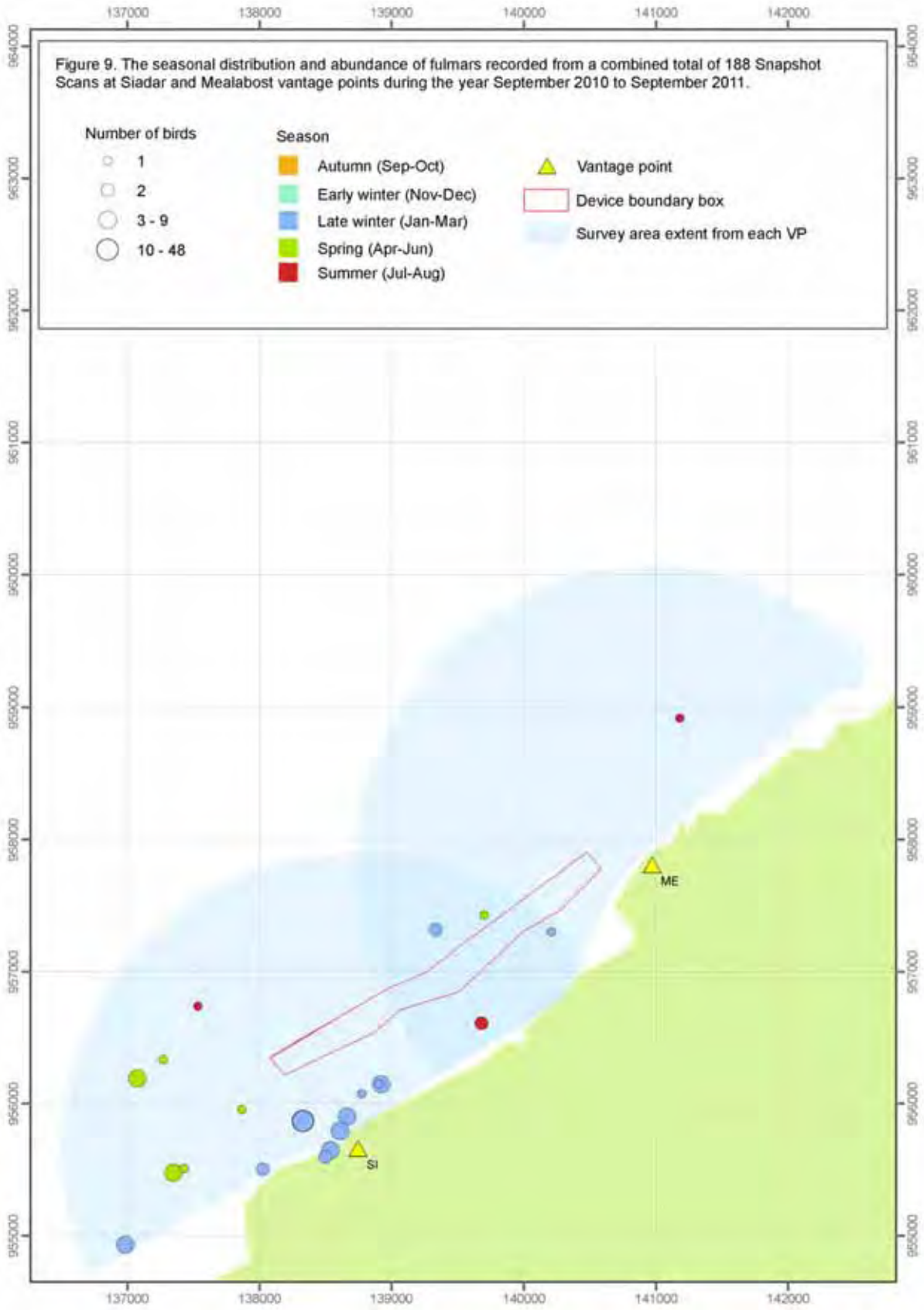


Fig 10. Storm petrel - LA

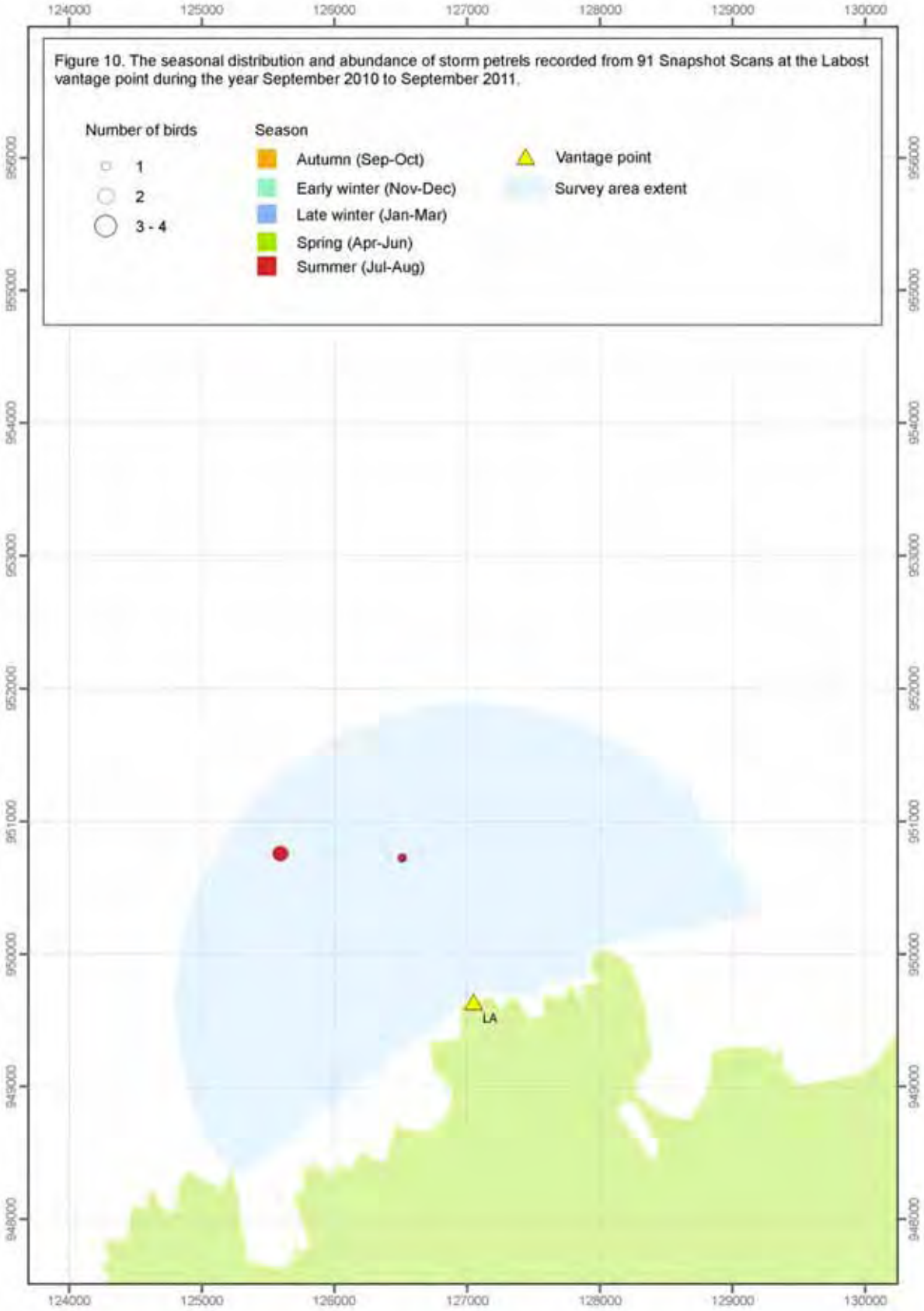


Fig 11. Storm petrel – SI and ME

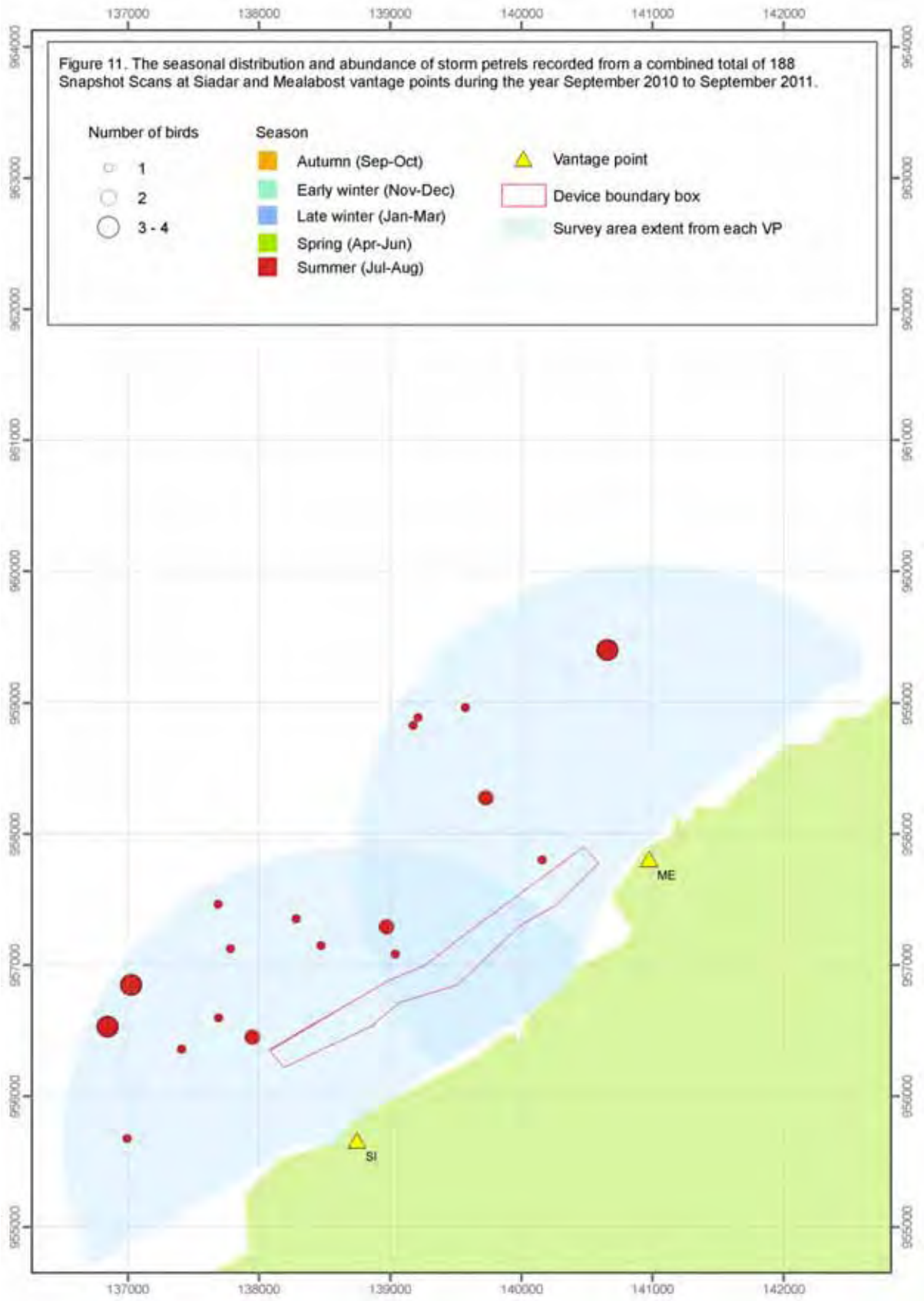


Fig 12. Gannet - LA

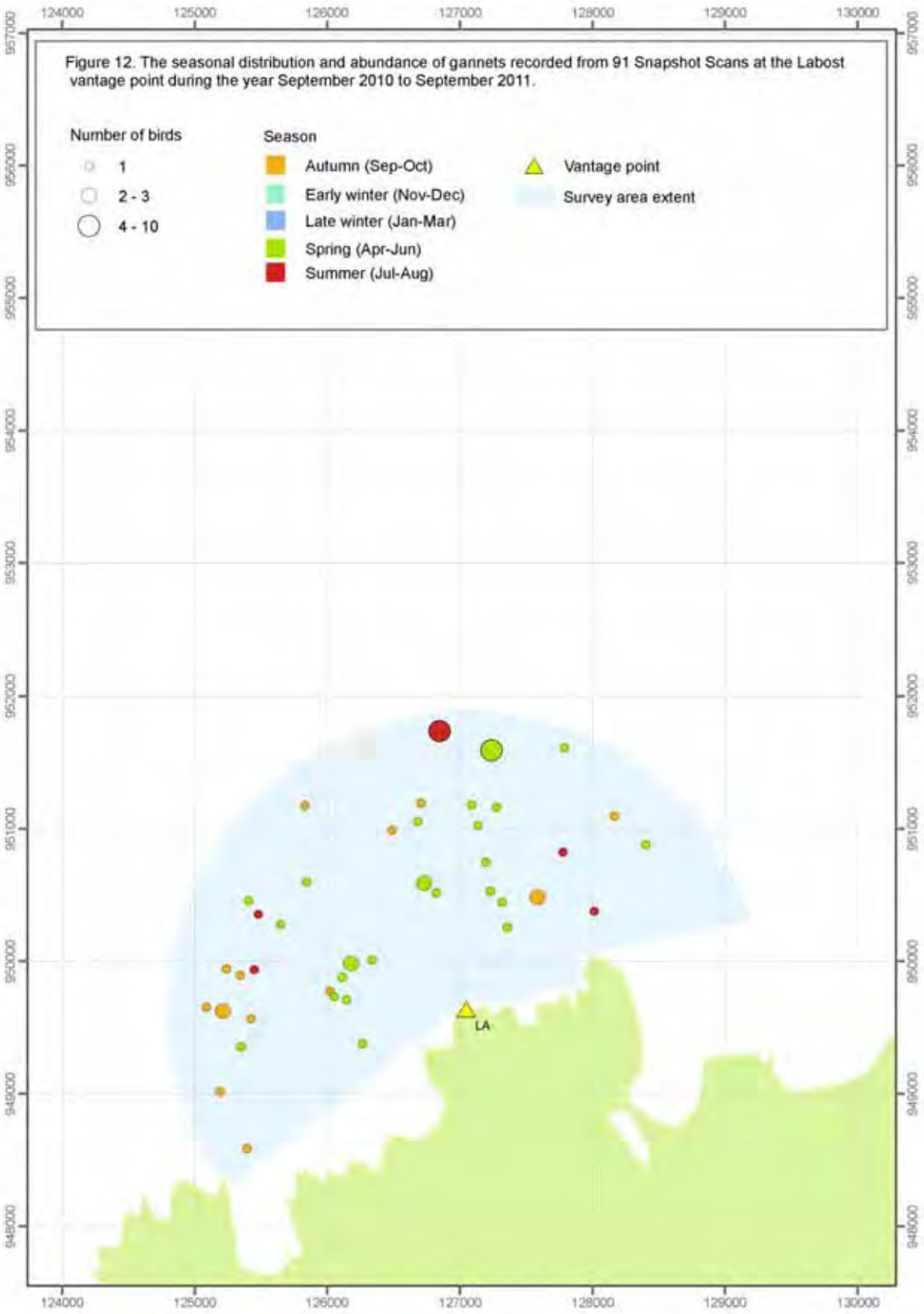


Fig 13. Gannet – SI and ME

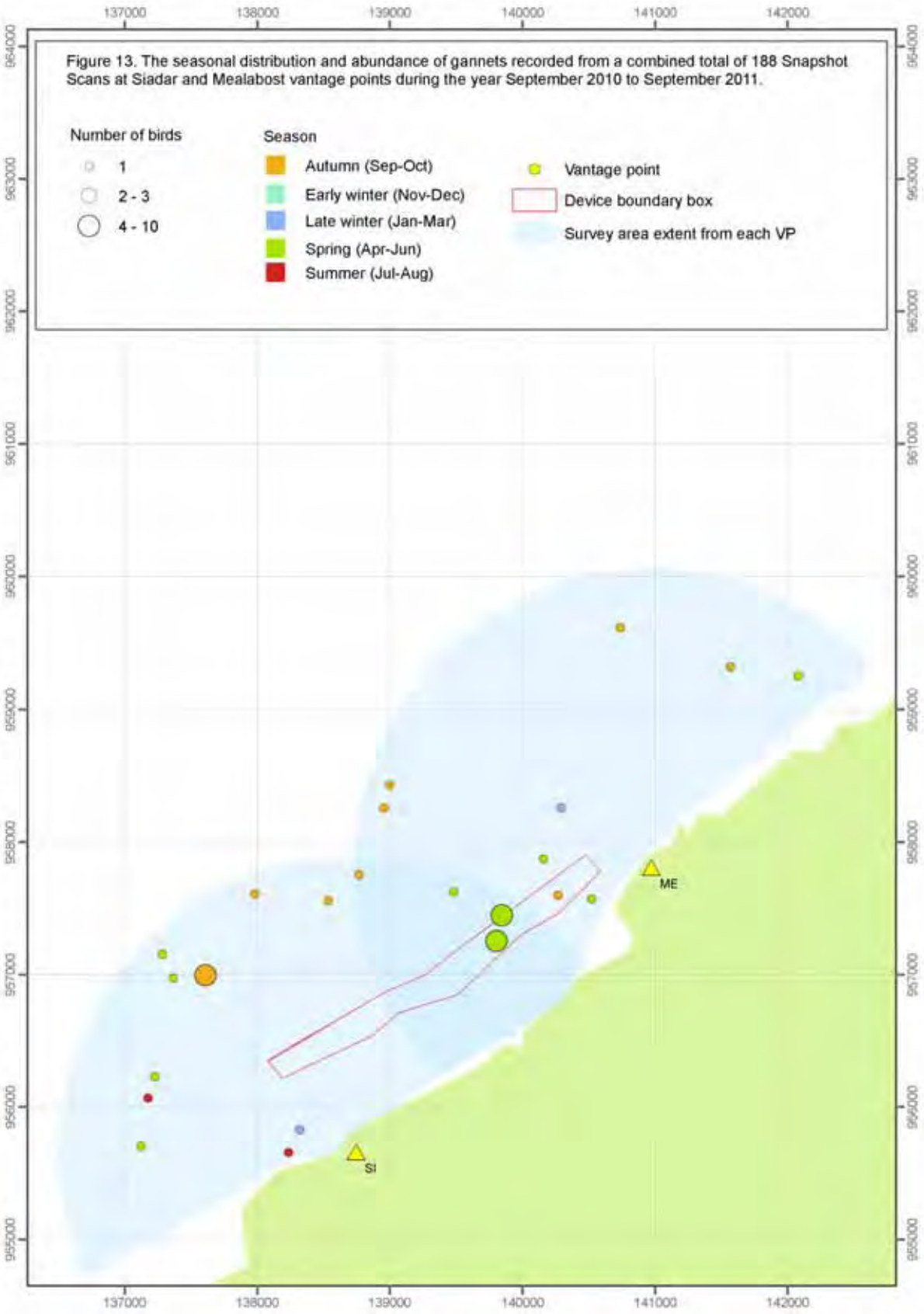


Fig 14. Shag - LA

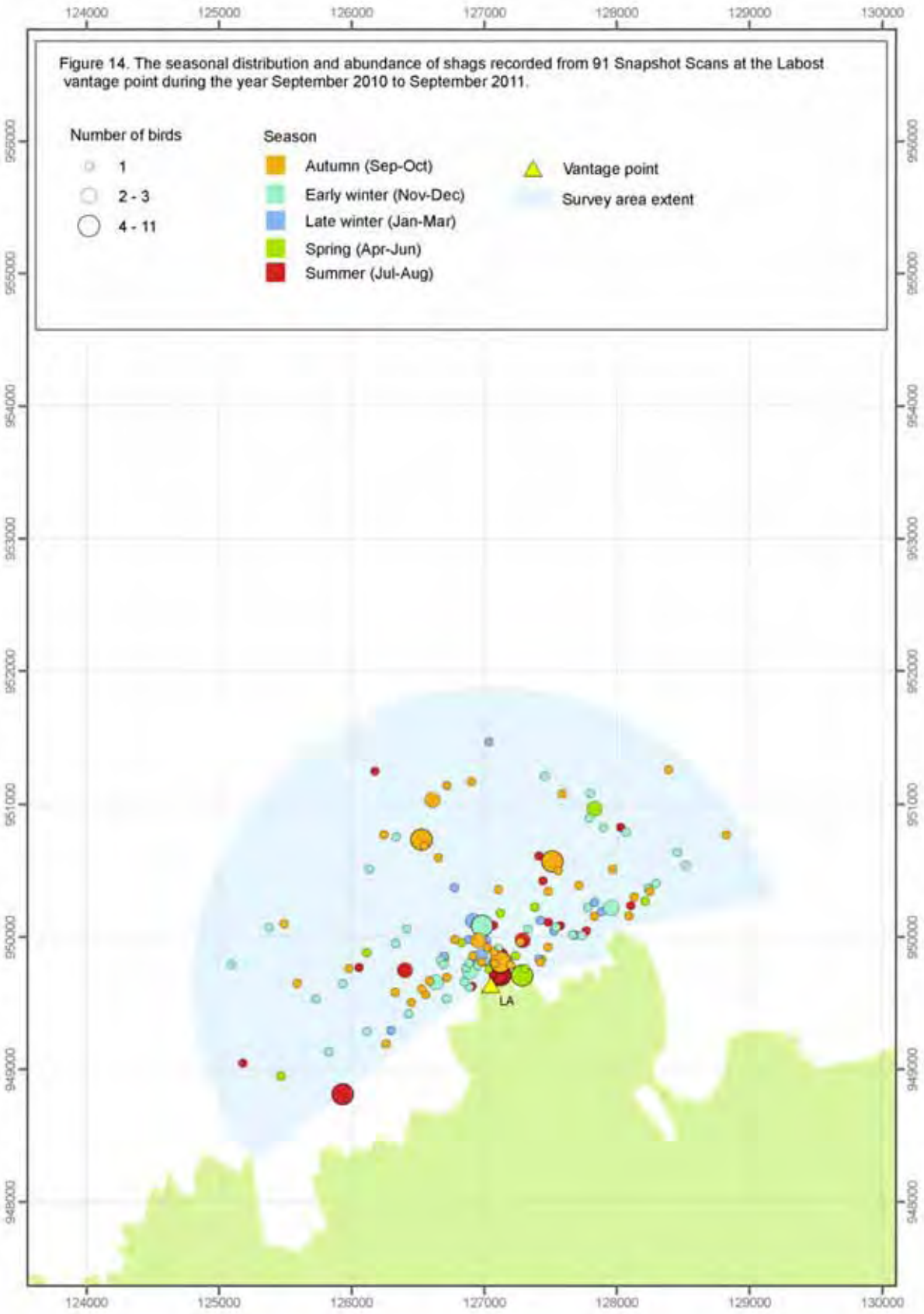


Fig 15. Shag – SI and ME

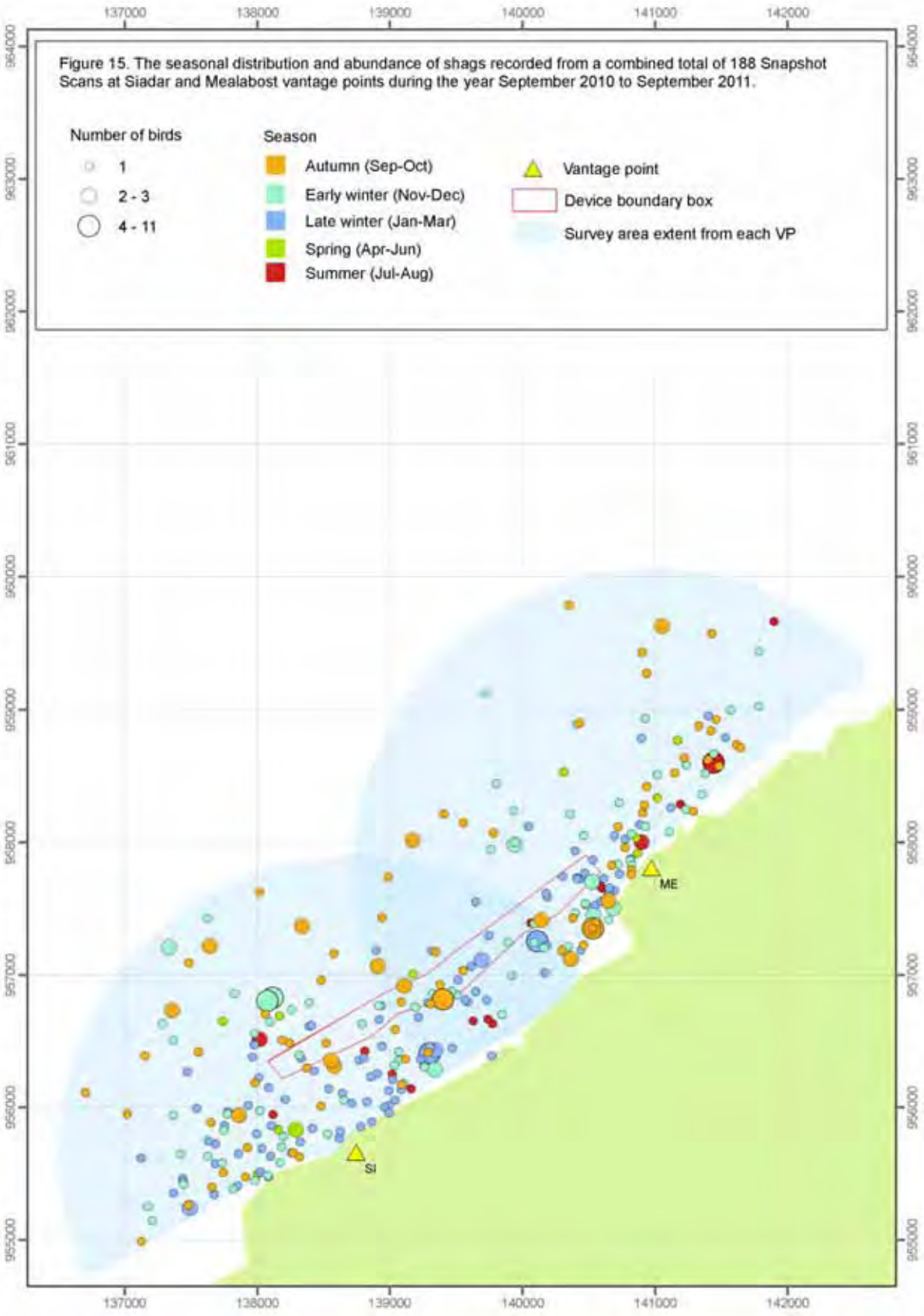


Fig 16. Eider - LA

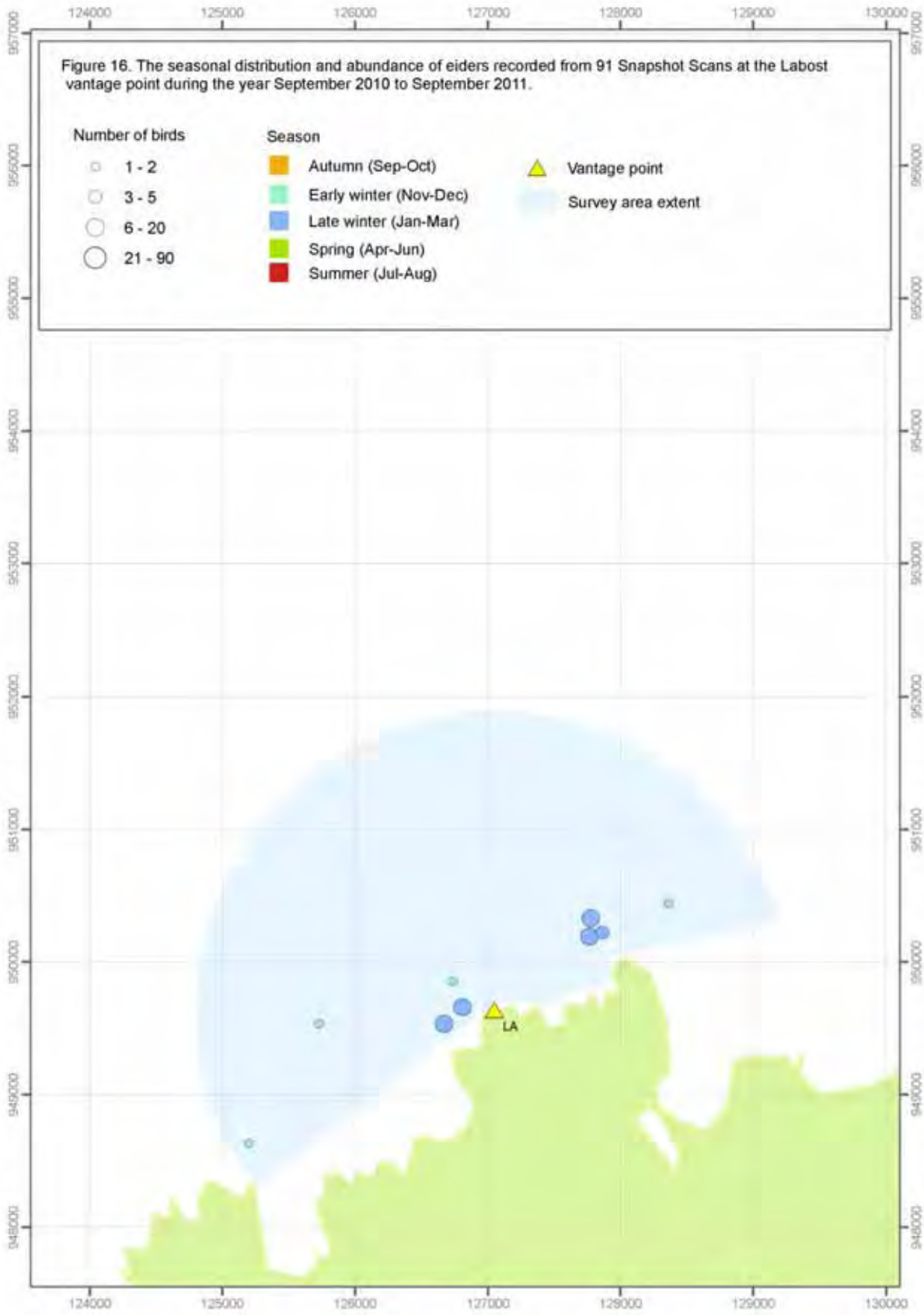


Fig 17. Eider – SI and ME

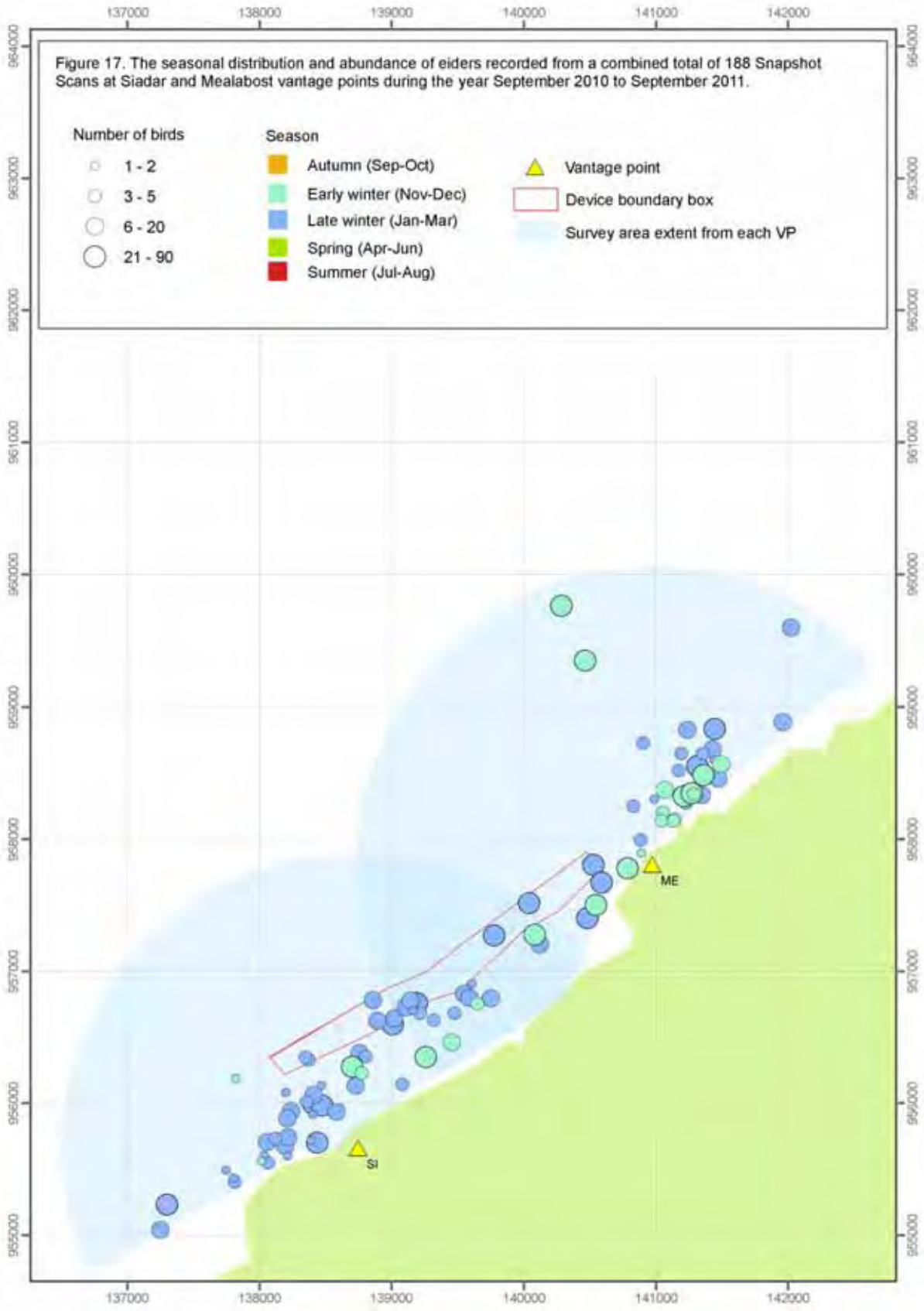


Fig 18. Herring gull - LA

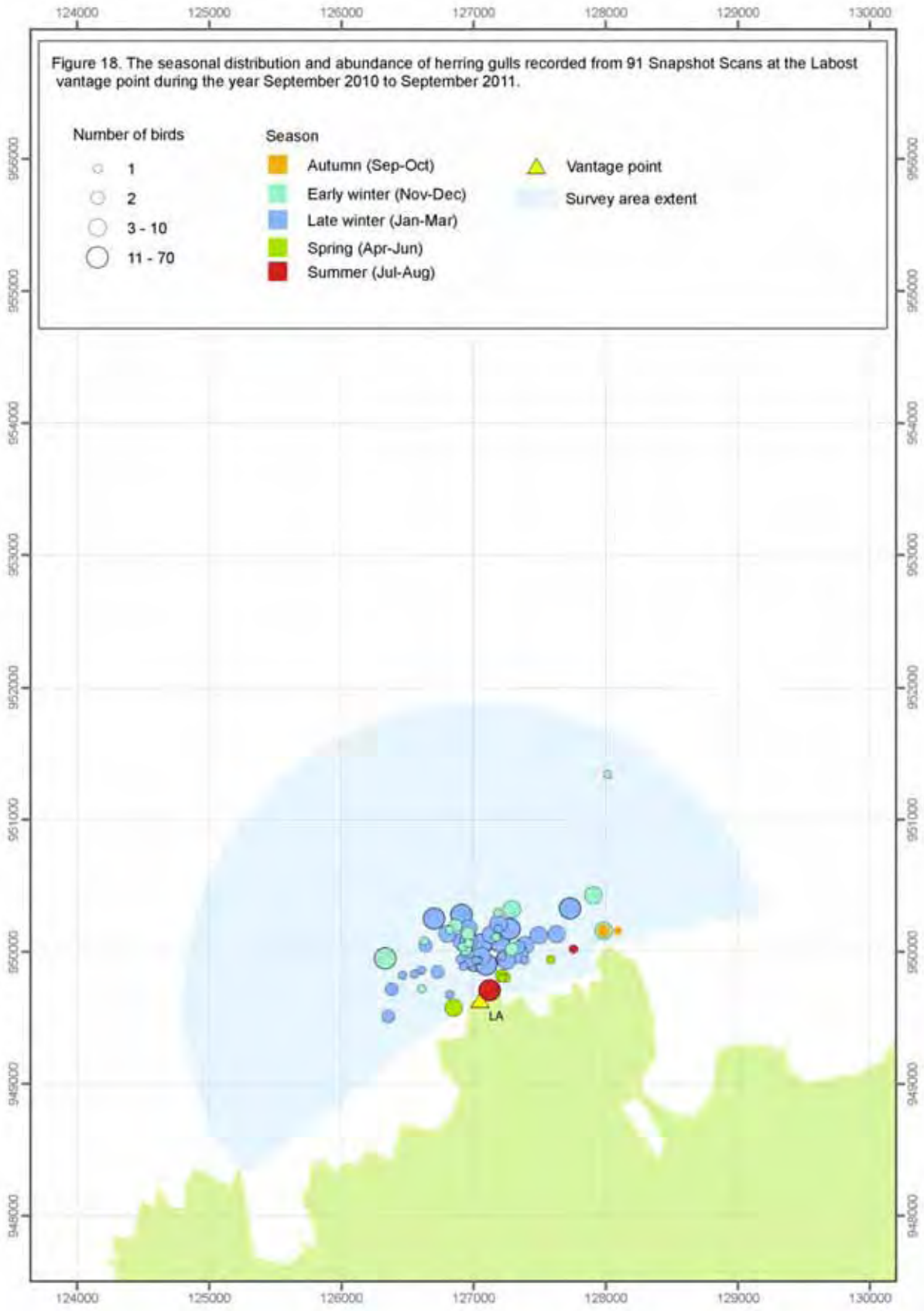


Fig 19. Herring gull – SI and ME

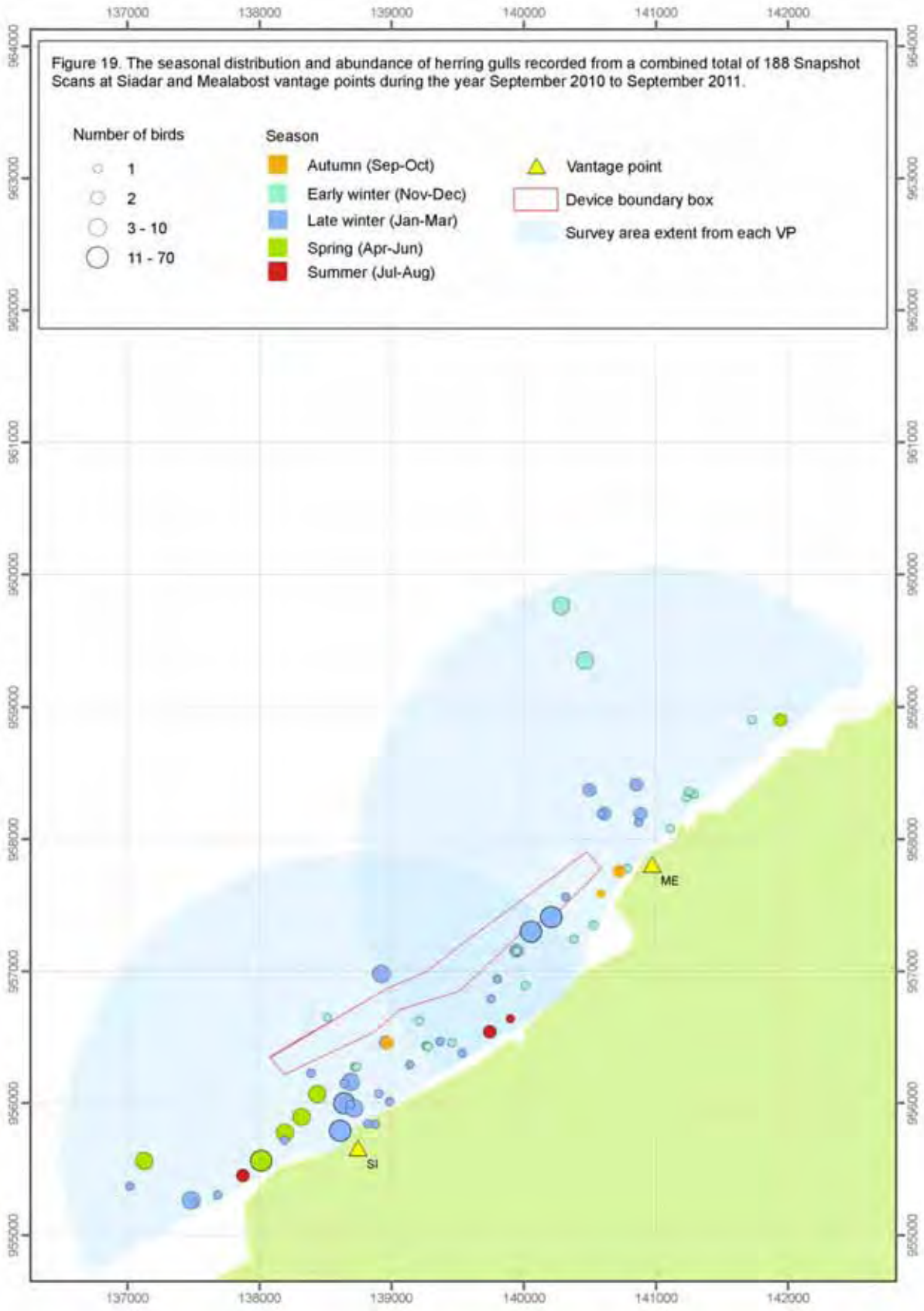


Fig 20. Razorbill - LA

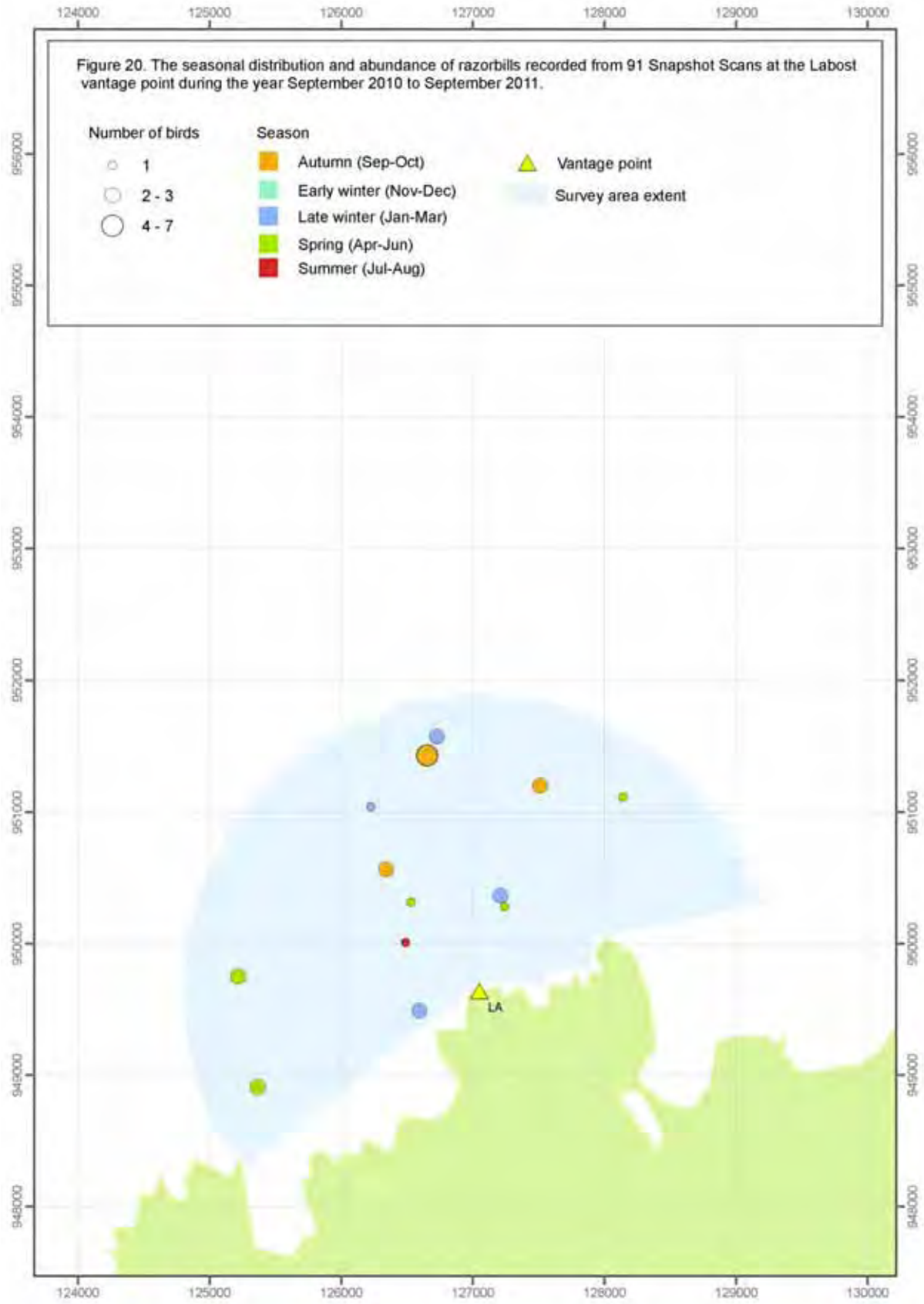


Fig 21. Razorbill – SI and ME

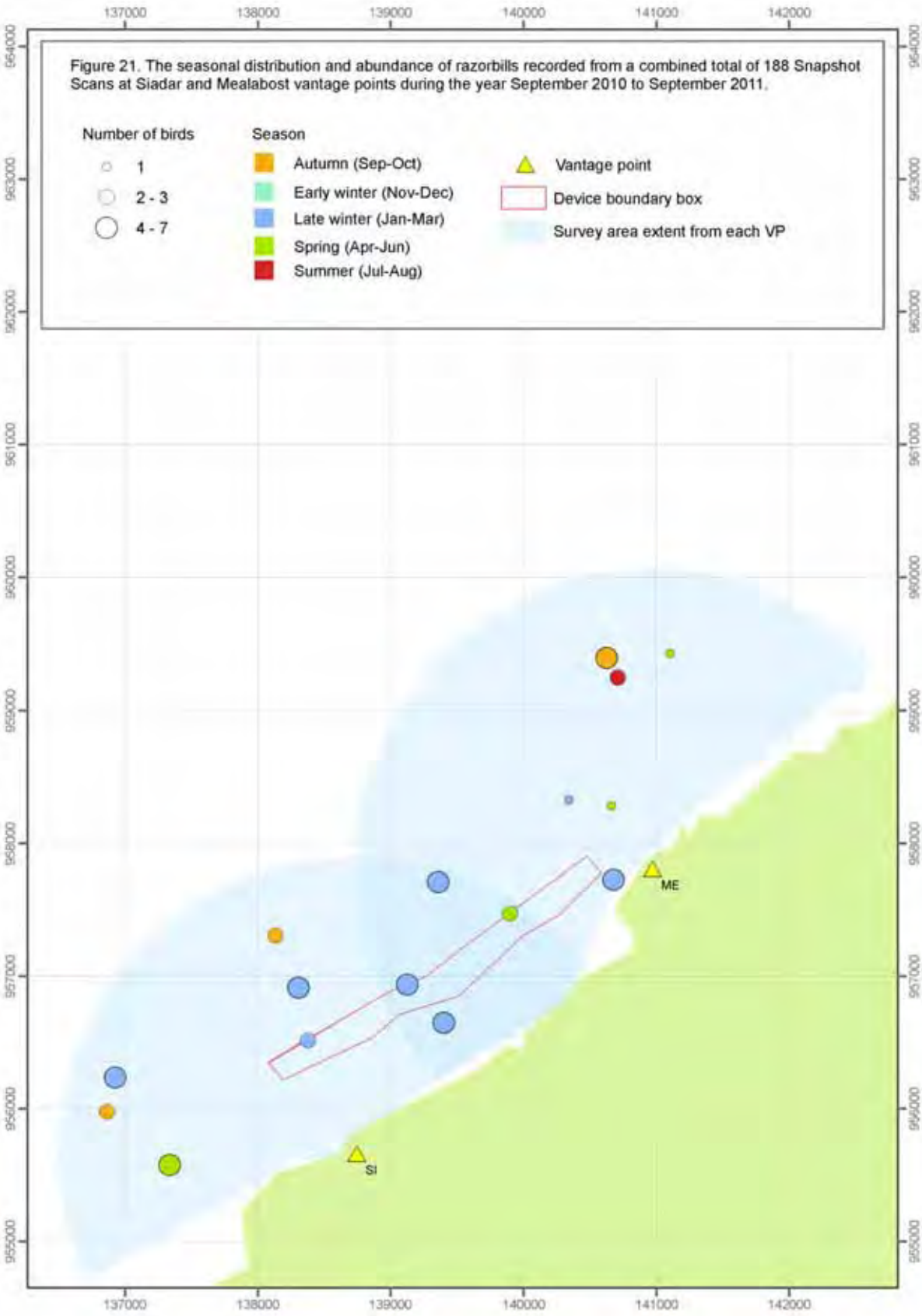


Fig 22. Black guillemot - LA

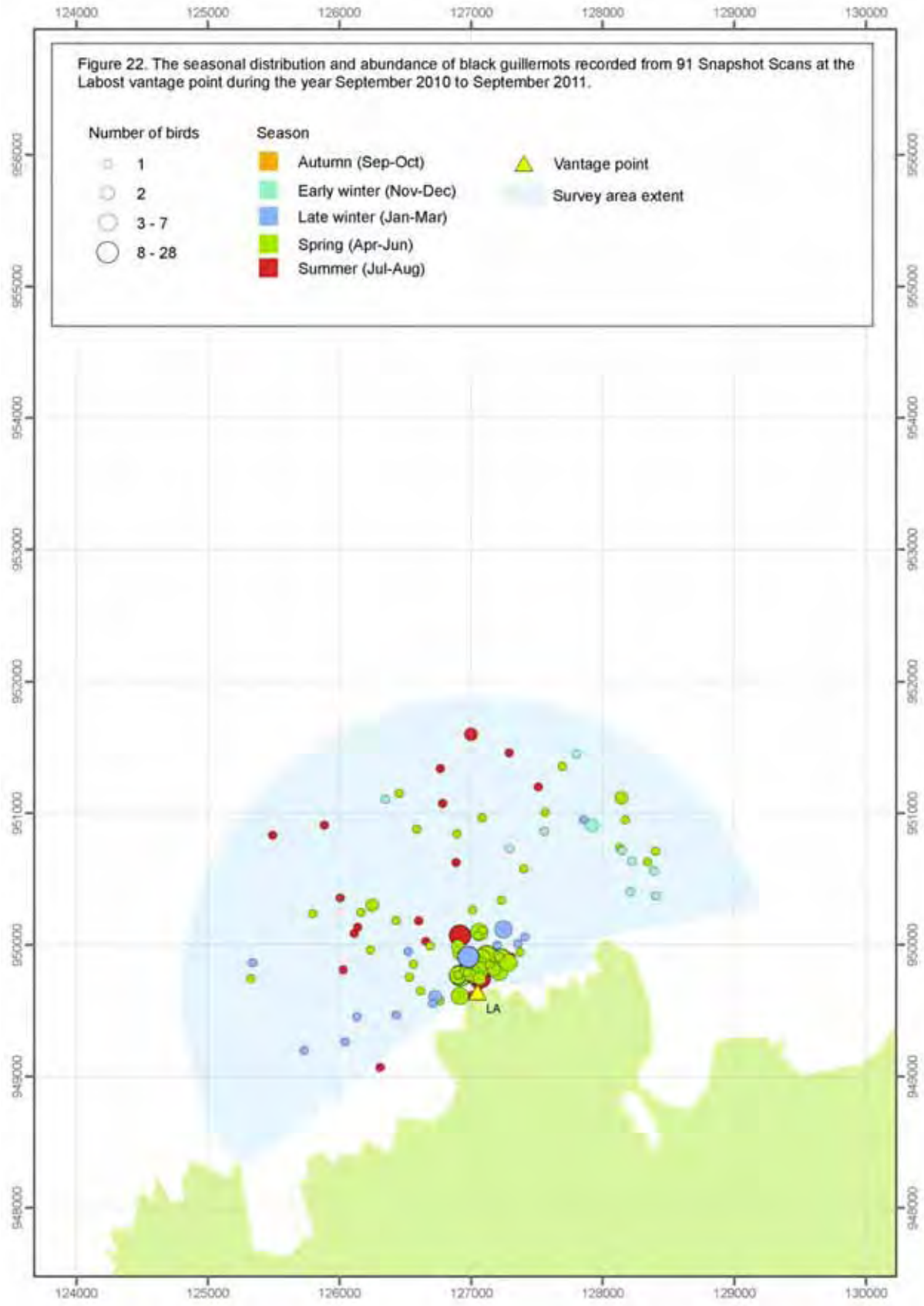


Fig 23. Black guillemot – SI and ME

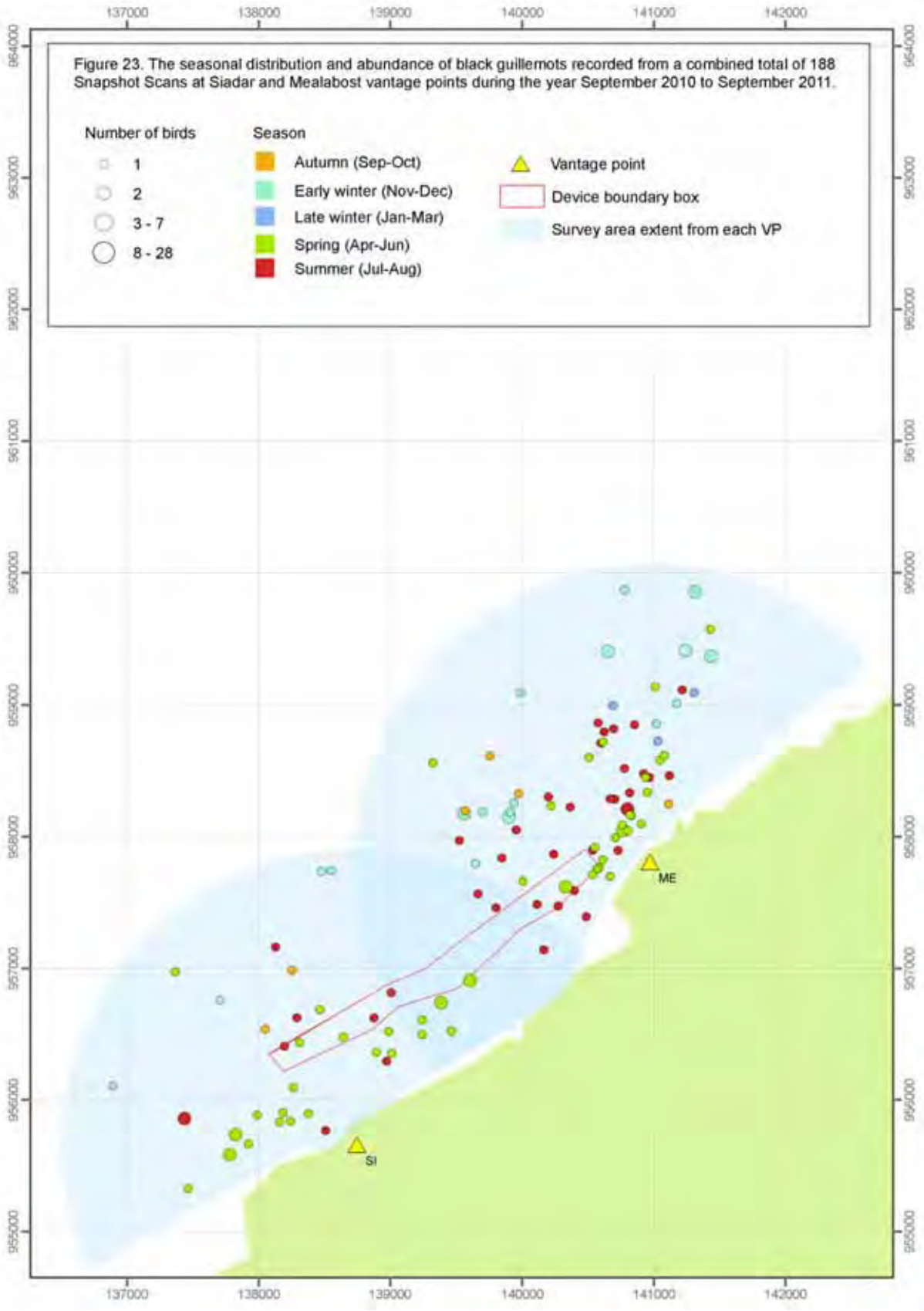


Fig 24 Distribution of breeding 2011 breeding birds territories at the Labost 'inland' survey area

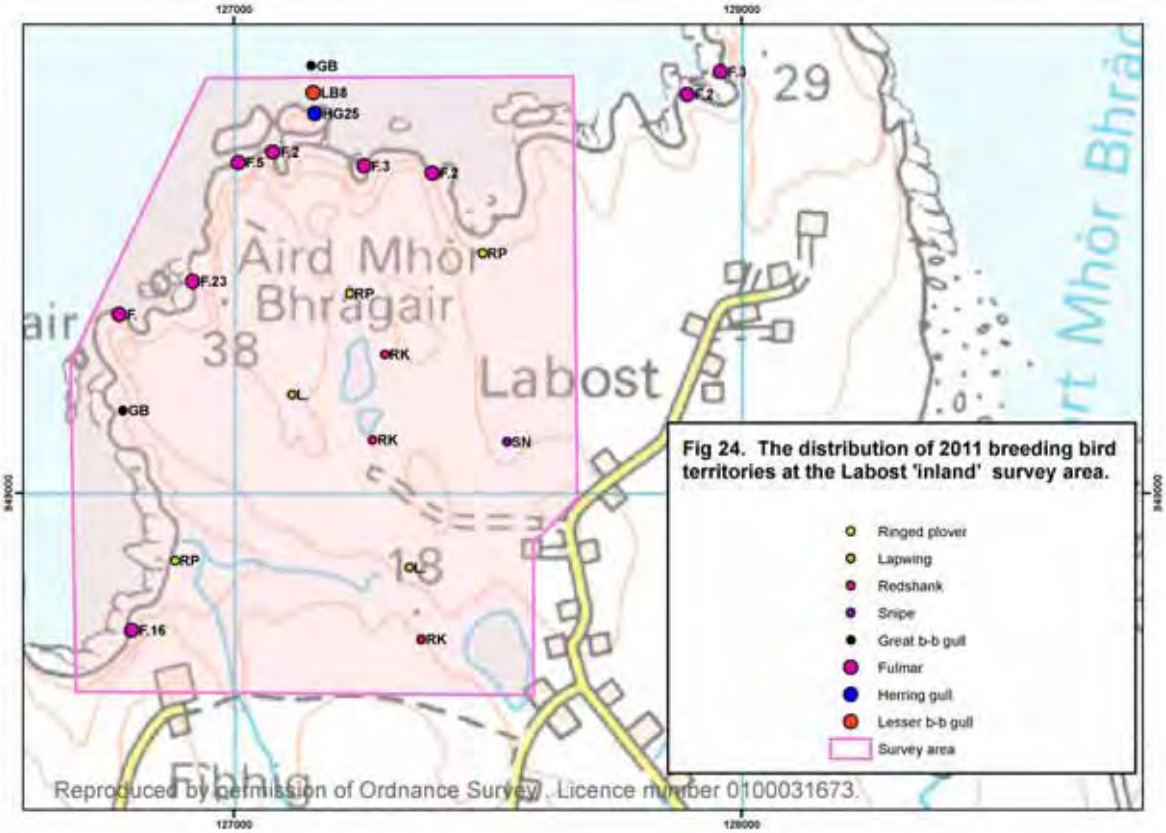
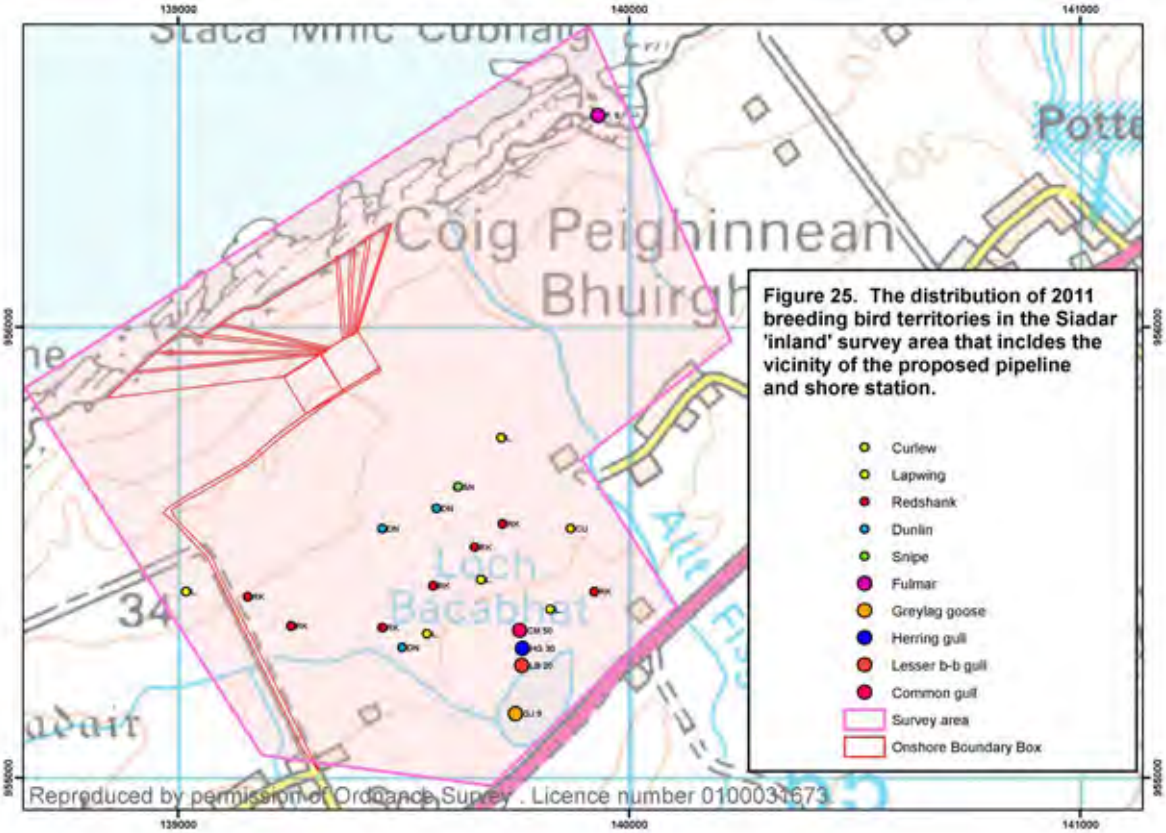


Fig. 25 The distribution of 2011 breeding bird territories in the Siadar 'inland' survey area



Appendix 11.1

Year 1 marine mammals and basking shark survey report

Aquamarine Lewis Wave Array

Marine Mammal Survey, Year 1

25 January 2012

9W2153

ROYAL HASKONING
Enhancing Society

ROYAL HASKONING
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1. INTRODUCTION

1. Aquamarine has obtained a lease from the Crown Estate on the west coast of Lewis, Scotland to develop an array of their Oyster 2 wave energy convertors (WECs).

2. To support the Environmental Impact Assessment for the proposed project, a series of vantage point surveys have been ongoing since September 2010 to collect spatial and temporal data on site usage for marine mammals and birds. The aims of this work are:

   - To characterise baseline conditions and inform the assessment of impacts for the Environmental Statement
   - To establish baseline conditions against which results of future (post-consent) monitoring studies can be compared.

3. This report outlines the results of the marine mammal data collection up to September 2011.

1.1 Study area

4. The survey area is located on the NW coast of Lewis and has an open and very exposed aspect to the northwest. The survey area was designed to encompass two potential development areas.

5. Two vantage points are situated within the preferred development area, at Siadar and Mealabost. A further, single, vantage point is situated to the south at Labost, an area within the lease boundary which also potential for development.

6. Figure 1.1 shows the location of the vantage points (VP) and the associated visible area for each VP.

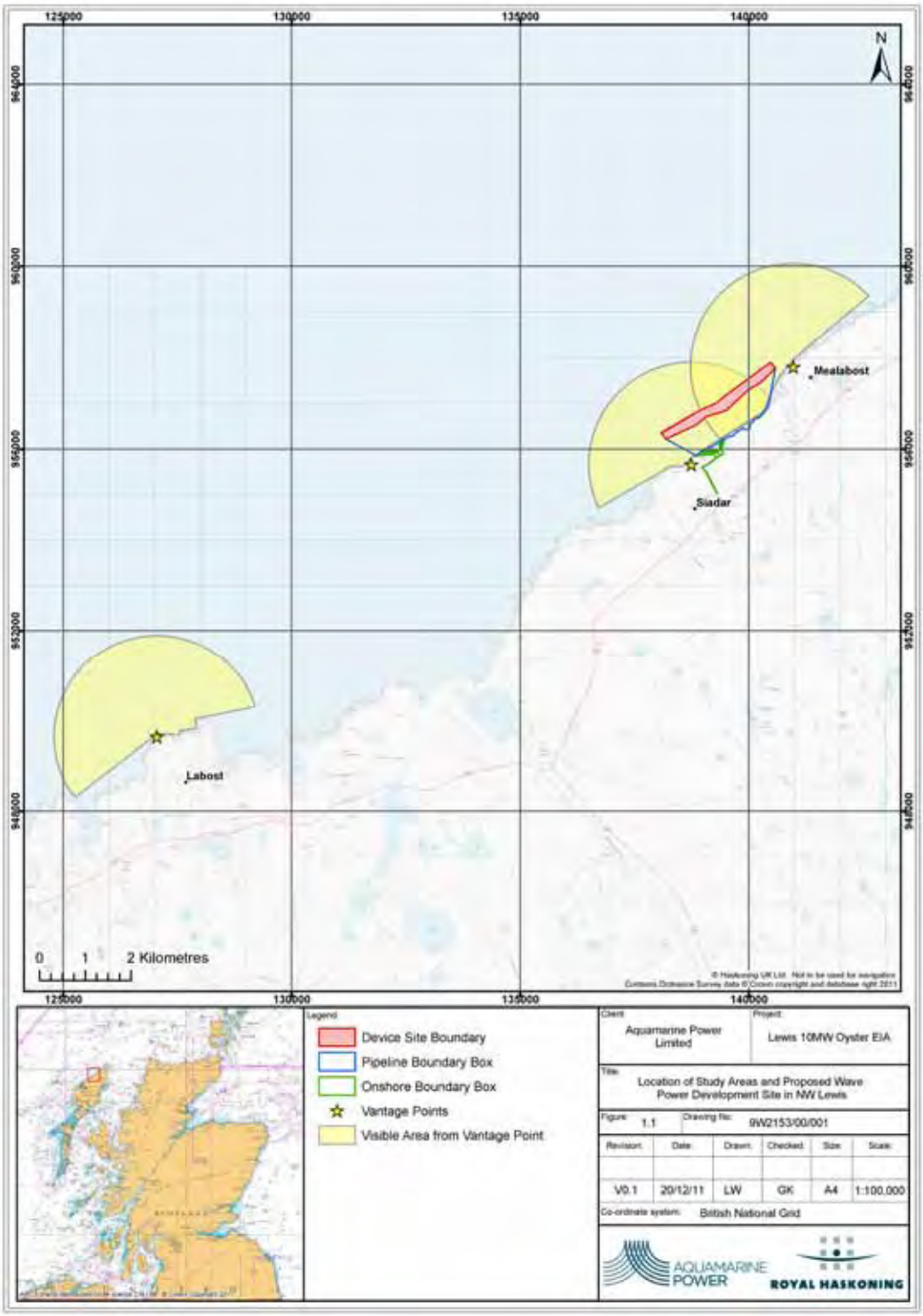


Figure 1.1: Survey area

2. METHODOLOGY

2.1 Survey design

7. Pilot work undertaken by NRP Ltd in September 2010 showed that the site lends itself to shore-based survey methods. Shore-based methods were chosen in preference to boat-based or aerial methods because, where practical, they have significant advantages in terms of the quality and quantity of data collected, logistics, and have generally lower costs. The VP locations were carefully selected during pilot work to give optimal views of the areas of interest and adequate height (>10 m above sea level).

8. The pilot work showed that under reasonable conditions (sea state 4 or less) and with the aid of a x25 spotting scope mounted on a tripod, it is practical to detect and identify marine mammals from the VPs. Cetacean species were recorded up to approximately 9 km from the VPs, however the confidence in species identification decreases with distance, especially beyond 2 km. Seals and basking shark were recorded within 2.5 km of the VPs.

9. At the Labost part of the study area the suitable depth range for Oyster devices lies between approximately 0.3 and 1.0 km from the shore. At the Siadar/ Mealabost part of the site the suitable depth range for Oyster devices lies between approximately 0.6 and 1.2 km from the shore.

10. Data were routinely collected for all marine mammal species and basking shark during each of the VP methods. [1]

11. The VP watch programme is designed to give equal sampling effort across tidal cycle (6 periods per cycle) and day light hours. The six tidal periods used in planning when to undertake watches are based on equal portions (one sixth) of the tidal cycle (high tide to high tide). This means that each period is approximately two hours duration, the exact time depending on the actual length of the tidal cycle. Periods 1 to 3 cover the ebb part of the cycle; Period 1 commences at high tide and Period 3 ends at low tide. Periods 4 to 6 cover the flood part of the cycle starting at low tide and ending at high tide. The start and end times of tidal periods were calculated from tide tables at Carloway (Lewis).

12. The target effort for each VP is 12 hours of watching per month (typically composed of four 3-hour sessions) spread over 4 days each month. Watches from the VPs are scheduled so that, as far as is practical, each month's sampling effort is evenly distributed with respect tidal cycle (six periods per ebb-flow cycle) and day light hours.

13. Experience gained from the first year of survey work has shown that weather and sea conditions are a major constraint to collecting VP data at the site, and

[1] D. Jackson (2011, unpublished). Lewis Wave Array, Birds Technical Report, November 2011

thus have prevented the target hours being achieved in some months. When this occurs the shortfall is made up in the following month, if conditions allow[1].

14. The monthly programme of survey work from the VPs provides repeated information on the numbers, activity and fine-scale distribution of animals using the study area. VP watches normally last for three hours and consist of short bouts of three separate activities, with each three hour VP watch typically comprising:

- 2 snap-shot scans (one at the start and the other at the end of the period, total of 45 - 50 minutes);
- 7 marine mammal watches (total 105 minutes); and
- 5 flying bird watches (total 25 minutes).

15. The weather and sea conditions prevailing during a VP survey are recorded at the start of the watch and then periodically through the watch if conditions change. The details recorded are wind force (Beaufort scale), wind direction, precipitation, visibility, sea state and the extent and severity of sun glare.

16. VP watches are not undertaken in poor conditions, for example, greater than sea state 4, continuous heavy rain or when visibility is less than 2 km.

2.2 Snap-shot scans

17. Snap-shot scans (SSS) aim to measure the instantaneous distribution of birds, cetaceans and basking sharks using the sound. Scans take about 15-25 minutes to complete, depending on how many birds are present. Snap-shot scans are only conducted in conditions of sea state 4 or below (over the majority of the visible area). SSS are undertaken by systematically searching the arc of the search area from one side to other, going sufficiently slowly so as to reduce the likelihood overlooking actively diving marine mammals (or birds), while those animals are underwater.

18. The following details are recorded during SSS:

- Species;
- Age/ size;
- Group size;
- Behaviour / activity when first seen;
- Location; and
- Travel direction.

19. The location of animals on the sea is recorded as described under MMW above. The survey recording form also has space for the observer to record additional comments, such as further details on an animal's behaviour.

20. Successive SSSs within a VP session are always in different tidal periods (these last slightly over 2 hours) and are separated by a period of at least an hour to reduce the issue of pseudo replication. Normally two SSS are completed in each 3-hour VP session.

2.3 Marine Mammal Watches

21. Marine Mammal Watches (MMW) are fixed periods of 15 minute dedicated observations for marine mammals and basking sharks. These aim to measure the activity of marine mammals and basking sharks using the survey area or passing through the area during each the period. These watches are designed to measure a rate of occurrence, and therefore are of fixed duration. The following details are recorded for all marine mammals and basking sharks: time; species; age/size; group size; behavioural activity when first seen; location; and travel direction.

22. An animal's location is recorded in terms of a compass bearing (measured using compass binoculars) and an angle of declination from the VP. Trigonometry is later used to calculate the grid reference of locations from these field measurements and the height above sea level of VPs.

23. The angle of declination is measured using a digital level attached to a spotting scope firmly mounted on a tripod fitted with a levelling head. The digital level measures angles to a precision of 0.05 degrees. The angle of declination of the horizon is also measured to provide a consistent reference.

24. Within each 15 minute watch individual marine mammals (or groups) are given a sequential reference number to allow easy identification of multiple records of the same individual. The survey recording form also has space for the observer to record in detail any additional information they consider to be worth recording, e.g. comments on an animal's behaviour.

2.4 Flying Bird Watches

25. Flying Bird Watches (FBW) were undertaken for five minutes in which the number of flying birds are recorded. In addition, any cetaceans or basking shark seen in the five-minute period are also recorded

2.5 Data Analysis

26. A spreadsheet of all marine mammal data collected by NRP Ltd from September 2010 to September 2011 was provided to Royal Haskoning for analysis. Due to the low level of marine mammal sightings it was deemed appropriate to undertake descriptive analysis of the data only at this stage.

27. Records from all observation types (FBW, MMW and SSS) were grouped together since marine mammals were recorded during each method. Numbers are made comparable by correcting per hour of survey effort.

28. Where the same individual(s) are recorded during multiple sightings on the same day, repeat sightings are removed from the graphs to avoid over estimating the number of animals shown per hour of effort.

29. Investigation of the data was undertaken to investigate:

    - Total numbers of sightings per species;
    - Effort corrected sightings rates;
    - Seasonal variation in abundance; and
    - Behaviour.
    - Distribution

30. The location of each sighting has been presented in distribution maps.

3. RESULTS

3.1 Survey Effort

31. The number of days per month, during which vantage point surveys were completed is shown in Figure 3.1.

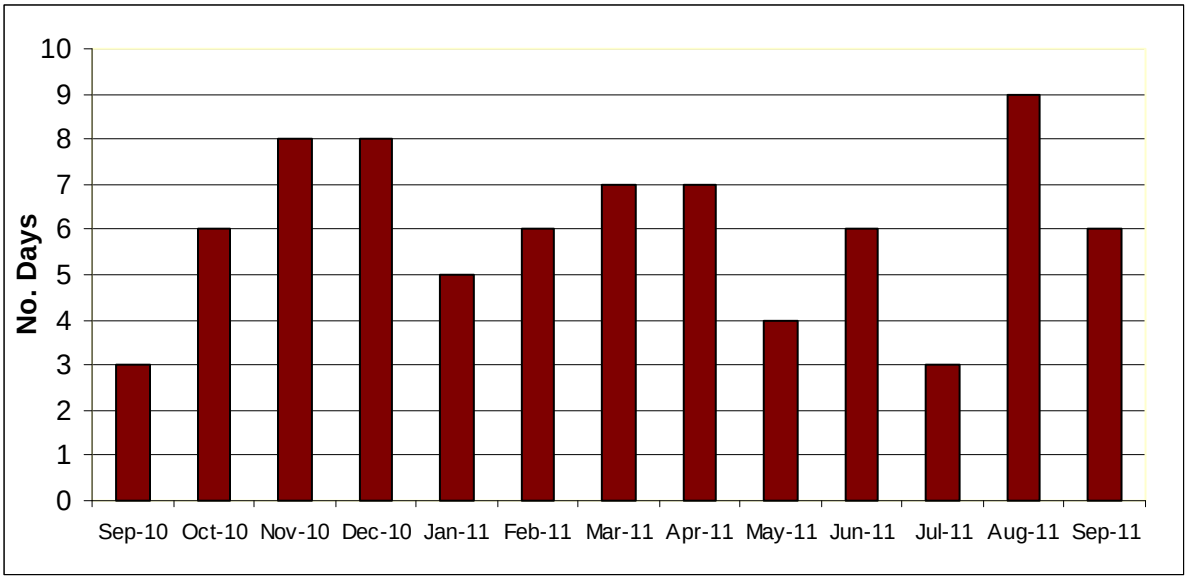


Figure 3.1: Number of survey days per month

32. Tables 3.1, 3.2 and 3.3 provide a break down of the number of snapshot surveys, marine mammal watches and flying bird watches, respectively, completed per month at each of the vantage points.

Table 3.1: The number of snapshot scans (SSS) completed each month at each VP.

	VP			
Month	**LA**	**ME**	**SI**	**Total**
Sep 2010	5	5	5	15
Oct 2010	6	8	8	22
Nov 2010	8	8	6	22
Dec 2010	8	6	6	20
Jan 2011	4	6	8	18
Feb 2011	6	6	8	20
Mar 2011	8	8	8	24
Apr 2011	8	8	8	24
May 2011	6	4	6	16
Jun 2011	8	8	8	24
Jul 2011	7	6	7	20
Aug 2011	9	12	9	30
Sep 2011	8	8	8	24
Year 1 Total	**91**	**93**	**95**	**279**
%	**33%**	**33%**	**34%**	**100%**

Table 3.2: The number of 15-minute marine mammal watches (MMW) completed each month at each VP.

	VP			
Month	**LA**	**ME**	**SI**	**Total**
Sep 2010	10	10	10	30
Oct 2010	21	28	28	77
Nov 2010	28	28	21	77
Dec 2010	28	23	20	71
Jan 2011	14	21	27	62
Feb 2011	21	21	28	70
Mar 2011	28	28	28	84
Apr 2011	28	28	27	83
May 2011	21	14	20	55
Jun 2011	28	28	27	83
Jul 2011	22	18	16	56
Aug 2011	34	45	41	120
Sep 2011	28	28	28	84
Year 1 Total	**311**	**320**	**321**	**952**
%	**33%**	**34%**	**34%**	**100%**

Table 3.3: The number of 5-minute flying bird watches (FBW) completed each month at each VP.

	VP			
Month	**LA**	**ME**	**SI**	**Total**
Sep 2010	5	5	5	15
Oct 2010	15	20	20	55
Nov 2010	20	20	15	55
Dec 2010	20	16	15	51
Jan 2011	10	15	20	45
Feb 2011	15	15	20	50
Mar 2011	20	20	20	60
Apr 2011	20	20	20	60
May 2011	15	10	15	40
Jun 2011	20	20	20	60
Jul 2011	13	12	14	39
Aug 2011	27	33	25	85
Sep 2011	20	20	20	60
Year 1 Total	**220**	**226**	**229**	**675**
%	**33%**	**33%**	**34%**	**100%**

33. Tables 3.4, 3.5 and 3.6 provide a break down of the number of snapshot surveys, marine mammal watches and flying bird watches, respectively,

completed per month during different sea states. No surveys were undertaken during a sea state greater than 4.

Table 3.4: The number of snapshot scans (SSS) completed each month in different sea state conditions. Data are for all three VPs combined.

	Sea state			
Month	**1**	**2**	**3**	**4**
Sep 2010	1	1	11	2
Oct 2010	6	4	4	8
Nov 2010	1	3	13	5
Dec 2010	0	10	8	2
Jan 2011	2	0	12	4
Feb 2011	0	5	13	2
Mar 2011	0	1	11	12
Apr 2011	0	4	12	8
May 2011	1	1	9	5
Jun 2011	0	2	9	13
Jul 2011	0	17	3	0
Aug 2011	0	10	16	4
Sep 2011	3	12	7	2
Year 1 Total	**14**	**70**	**128**	**67**
%	**5%**	**25%**	**46%**	**24%**

Table 3.5: The number of 15-minute marine mammal watches (MMW) completed each month in different sea state conditions. Data are for all three VPs combined.

	Sea state			
Month	**1**	**2**	**3**	**4**
Sep 2010	1	2	21	6
Oct 2010	18	17	16	26
Nov 2010	0	14	49	14
Dec 2010	0	37	27	7
Jan 2011	7	0	41	14
Feb 2011	0	16	48	6
Mar 2011	0	4	40	40
Apr 2011	0	8	42	33
May 2011	1	2	37	15
Jun 2011	0	4	33	46
Jul 2011	8	38	10	0
Aug 2011	0	38	59	23
Sep 2011	8	46	29	1
Year 1 Total	**43**	**226**	**452**	**231**
%	**5%**	**24%**	**47%**	**24%**

Table 3.6: The number of 5-minute flying bird watches (FBW) completed each month in different sea state conditions. Data are for all three VPs combined.

	Sea state			
Month	**1**	**2**	**3**	**4**
Sep 2010	1	1	10	3
Oct 2010	14	11	12	18
Nov 2010	0	10	35	10
Dec 2010	0	26	20	5
Jan 2011	5	0	30	10
Feb 2011	0	11	36	3
Mar 2011	0	2	29	29
Apr 2011	0	3	32	25
May 2011	1	1	27	11
Jun 2011	0	2	25	33
Jul 2011	3	28	8	0
Aug 2011	0	30	40	15
Sep 2011	5	33	22	0
Year 1 Total	**29**	**158**	**326**	**162**
%	**4%**	**23%**	**48%**	**24%**

3.2 Species Records

34. The following results report all sightings of individuals and groups of marine mammals, both within the 2km extent of the study area, and beyond. The following species were recorded during Year 1:

- Common dolphin;
- Harbour porpoise;
- Risso's dolphin;
- Unidentified dolphin species;
- Minke whale;
- Grey seal;
- Unidentified seal species; and
- Basking shark

35. Figure 3.2 shows the number of species recorded at each vantage point per hour of survey effort

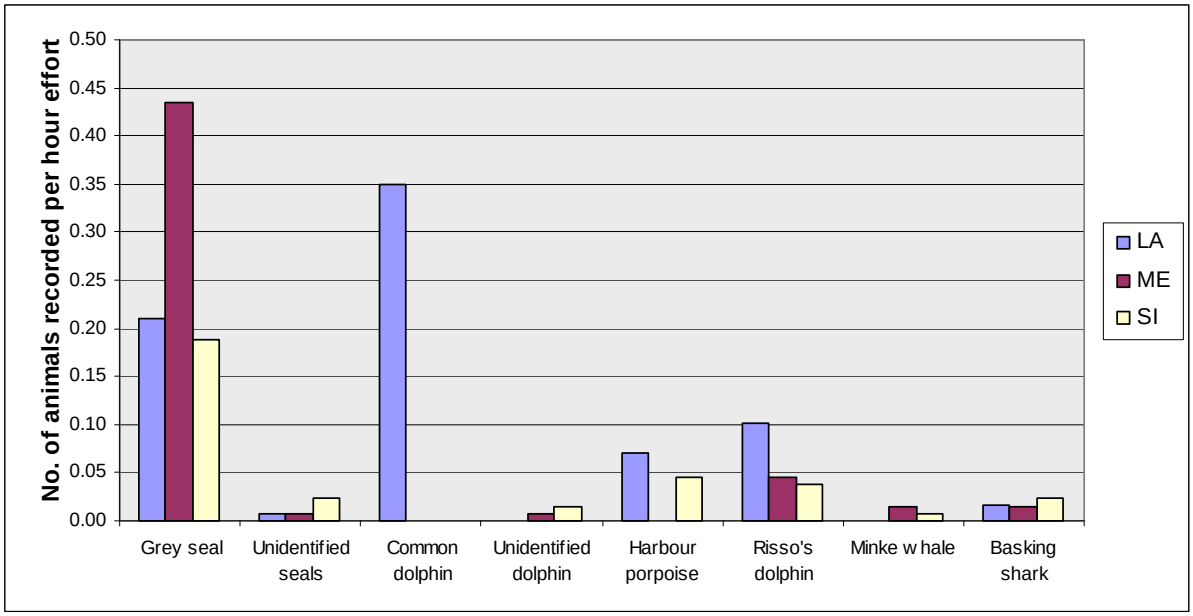


Figure 3.2: No of each species recorded per hour of effort at each vantage point.

3.3 Cetaceans

36. Pods of up to approximately 20 common dolphins were recorded infrequently. A pod of 15 common dolphins was recorded nine times during one VP watch on the 27th July 2011. Pods of approximately 10 and 20 common dolphin were also recorded on 11th and 13th of October 2010, respectively.

37. Harbour porpoise was recorded on six occasions, either as individuals or in small pods of up to three animals.

38. Risso's dolphin was recorded as individuals and in pods of up to six animals during 11 sightings events. A pod of six was recorded at the Mealabost site and a pod of five at Siadar. Pods were recorded on three separate days at the Labost site. It is not known whether an individual Risso's dolphin was from a pod of five animals recorded on the same day in August and so it is assumed that they are different in order to be most precautionary.

39. Two sightings of unidentified dolphin were recorded at 1.5 km and beyond 2 km from the vantage point. (Figure 3.3)

40. Minke whales were seen on two occasions. These were estimated to be at around 1.5 km and 9 km from the vantage point (Figure 3.1). A large splash seen ca 4km off shore was mostly likely to be a breaching minke whale but the animal's identification could not be confirmed.

3.3.2 Distribution

41. The majority of cetacean sightings were made from the LA vantage point (Figure 3.3) compared to the northern vantage points of ME and SI (Figure 3.4). Risso's dolphin, common dolphin and harbour porpoise were all recorded in greater abundance at the Labost site (Figure 3.3).

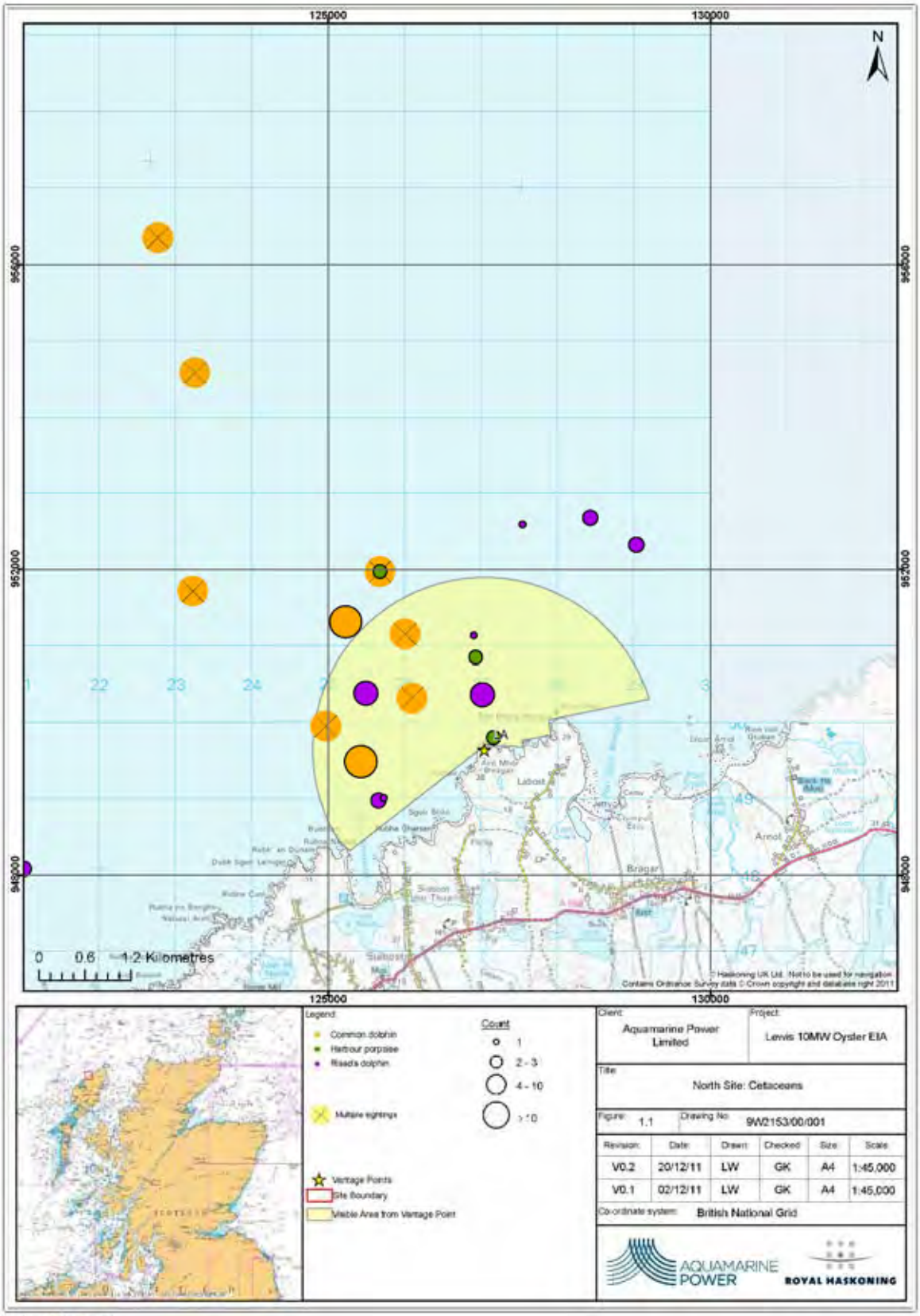
42. There were no sightings of common dolphin made from the ME and SI vantage points. However, the unidentified dolphins seen off Siadar VP may have been this species.

43. Figure 3.3 shows where multiple sightings were recorded of the same individual.

44. Harbour porpoise sightings were approximately evenly spread between the north (SI and ME vantage points) and the south sites (LA vantage point). (Figures 3.3 and 3.4)

45. Slightly more sightings of Risso's dolphin were recorded at the south site (LA vantage point compared to the north site (SI and ME vantage points). (Figures 3.3 and 3.4)

46. Figure 3.4 shows the location of the two sightings of unidentified dolphin species.



Source info: NRP Year 1 data

Figure 3.3: Distribution of cetacean sightings at the south site (LA vantage point)

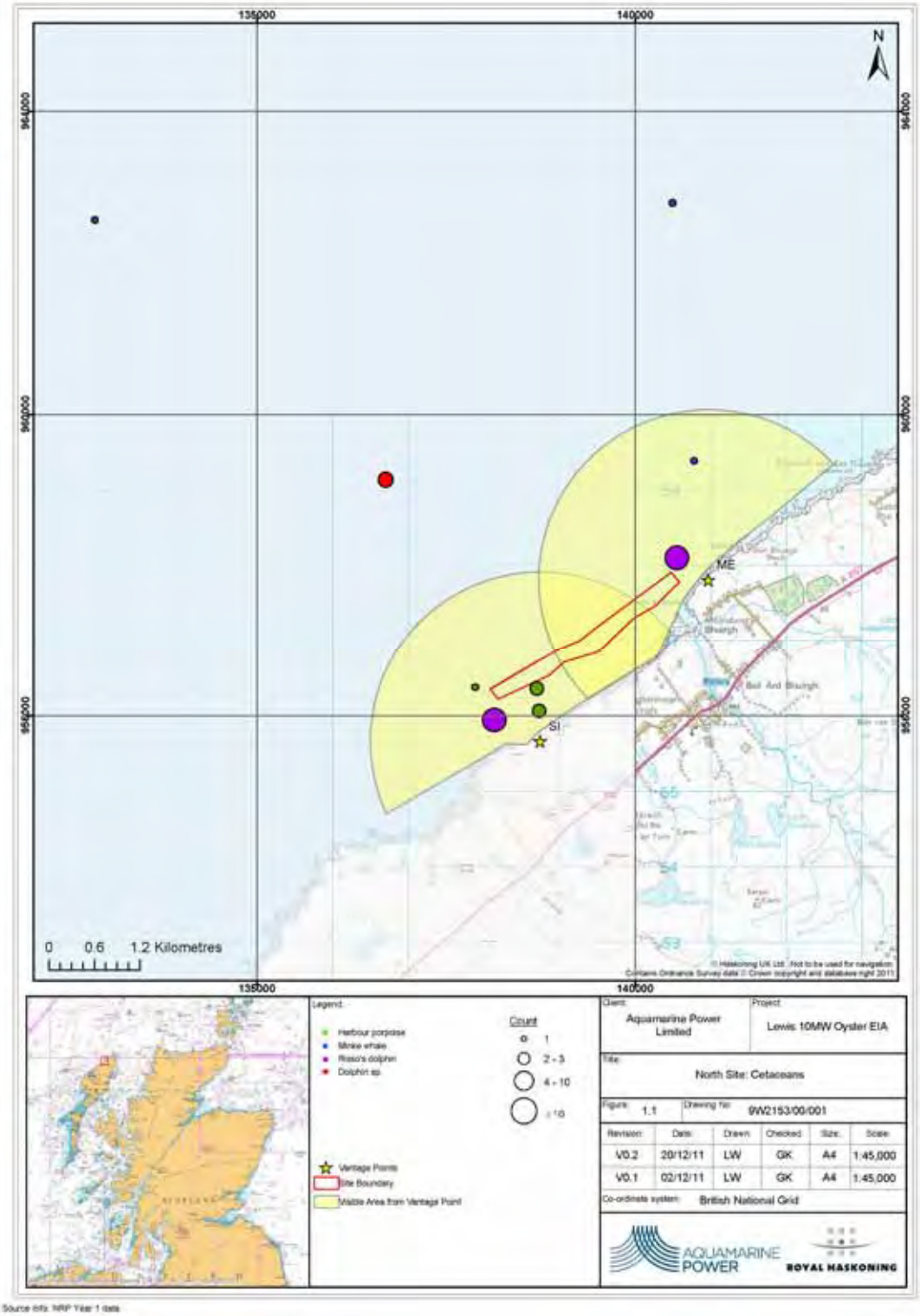


Figure 3.4: Distribution of cetacean sightings at the north site (SI and ME vantage points)

3.3.3 Seasonal Variation

47. Due to the low number of sightings for cetacean species it is difficult to determine any real trends in seasonal variation. Figure 3.5 shows the sighting

rate per hour of survey effort for each species throughout the year. Possible crude patterns include:

- Common dolphins were recorded on two days in October 2010 and on one day in July 2011.
- Harbour porpoise were recorded in groups of one to three. There was one sighting per month in September, November, March and August. In December two sightings were recorded, one at Labost and one at Siadar;
- Figure 3.5 shows a relatively consistent number of Risso's dolphins per hour of survey effort from March to August, except for an absence of sightings in April.
- Minke whale were recorded in October, April and June; and
- Unidentified dolphin sightings were recorded in October 2010 and August 2011.

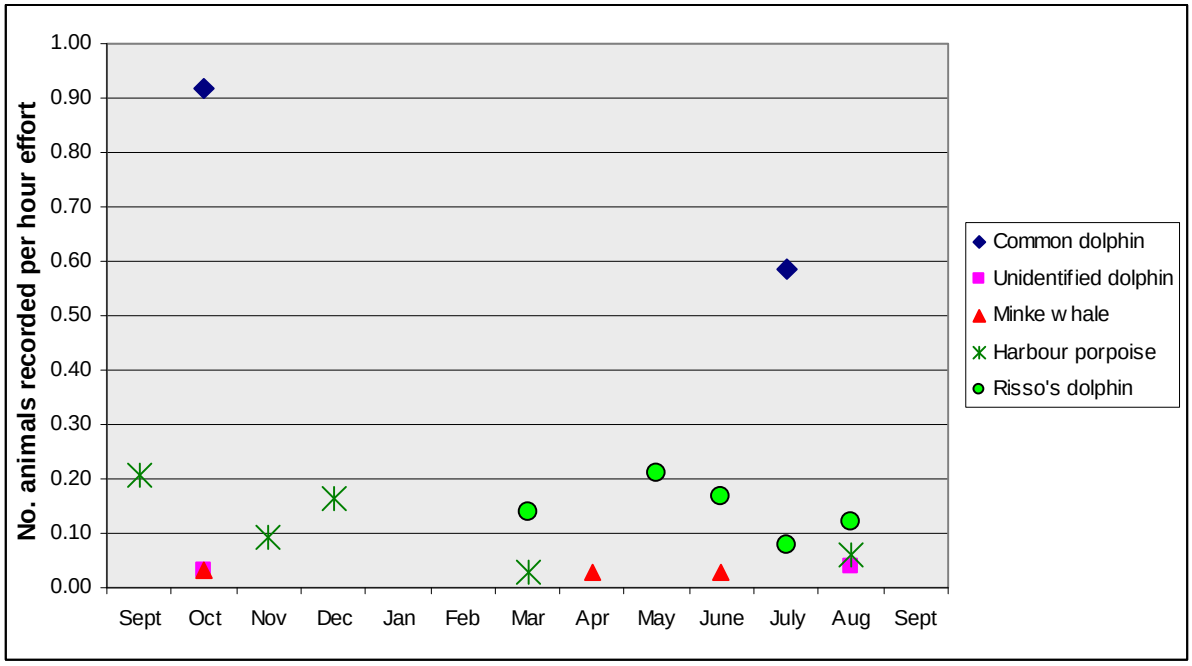


Figure 3.5: No of cetacean animals recorded per hour of effort by month

3.3.4 Behaviour

48. Common dolphins were recorded feeding and swimming at high speed at the Labost site. The group of 15 dolphins present on the 27 July were watched feeding (in association with gannets) over a wider area (Figure 3.3) over a period of around 2 hours)

49. Harbour porpoise were recorded swimming at slow, normal, and fast speed. Slow travel may indicate feeding activity.

50. Unidentified dolphins were recorded swimming at normal and fast speeds.

51. Risso's dolphins were predominantly recorded swimming at slow speed, but were also seen swimming at normal speed. Apparent feeding activity was suspected at the Labost site.

52. The two confirmed sightings of minke whale were during normal swimming and in both cases the animals appeared to be transiting through the site. There was no evidence of feeding as far as could be ascertained from the VP. An uncertain sighting of a possible minke breaching was also recorded.

3.4 Seals

53. Grey seal are the most frequently recorded marine mammal species in the study area (Figure 1.1). No harbour seals were recorded. A small number (5) of unidentified seals were recorded (Figure 3.2) but it is most likely that these were grey seals.

3.4.2 Distribution

54. Grey seals were recorded frequently across the site with greatest numbers recorded at the Mealabost site (Figure 3.6).

55. The majority of the sightings from both ME and SI vantage points were within 0.5km of the vantage point (Figure 3.6). This pattern may be partly caused by a bias towards greater detection rates of seals close to VPs; however seals were detected and identified to species level up to 1.7km from VPs.

56. Figure 3.7 shows the seal sightings at the Labost site. The majority records were of seals relatively close to the vantage point but sightings were also recorded up to around 1.7km from the vantage point.

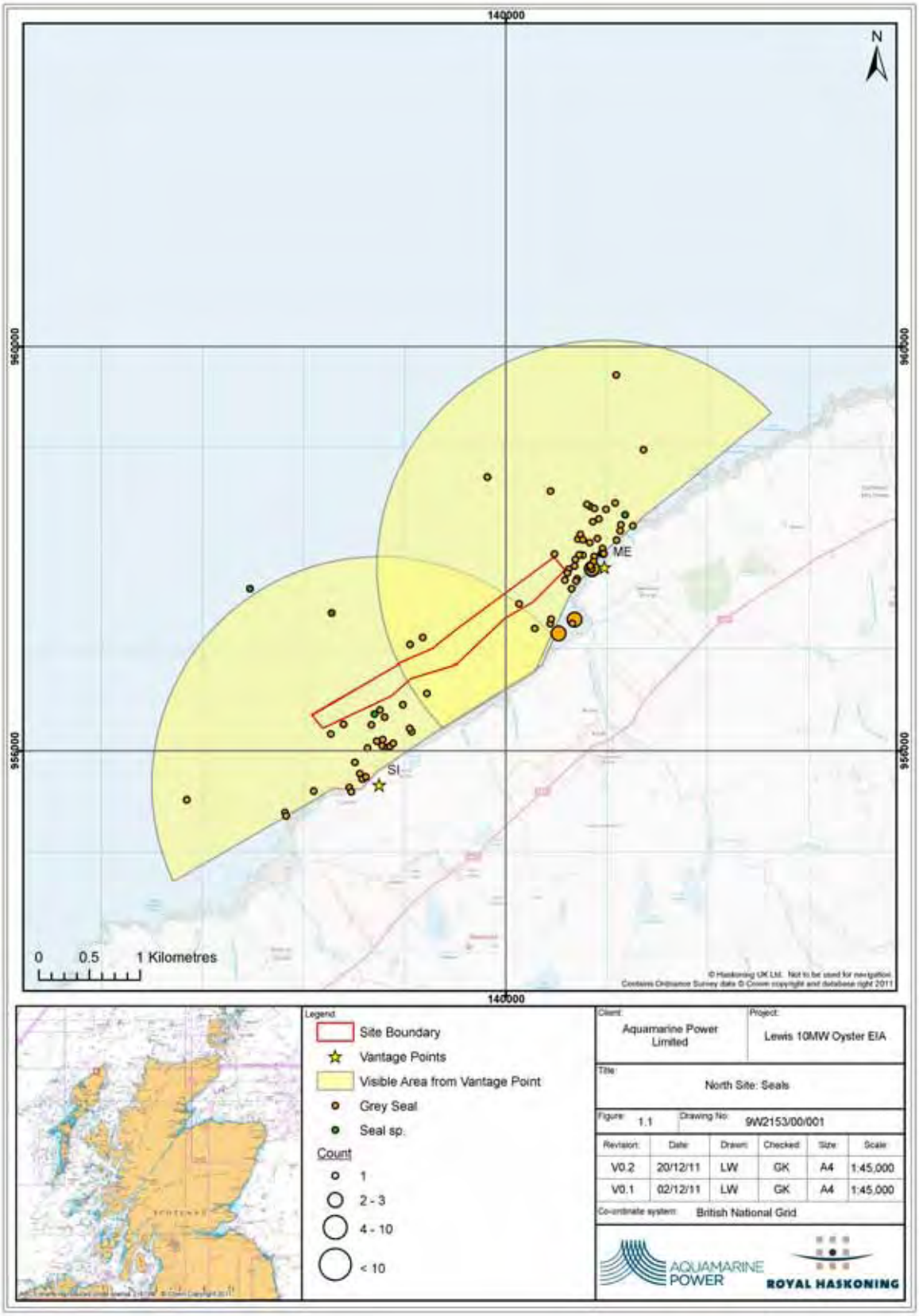


Figure 3.6: Distribution of seal sightings at the north site (SI and ME vantage points)

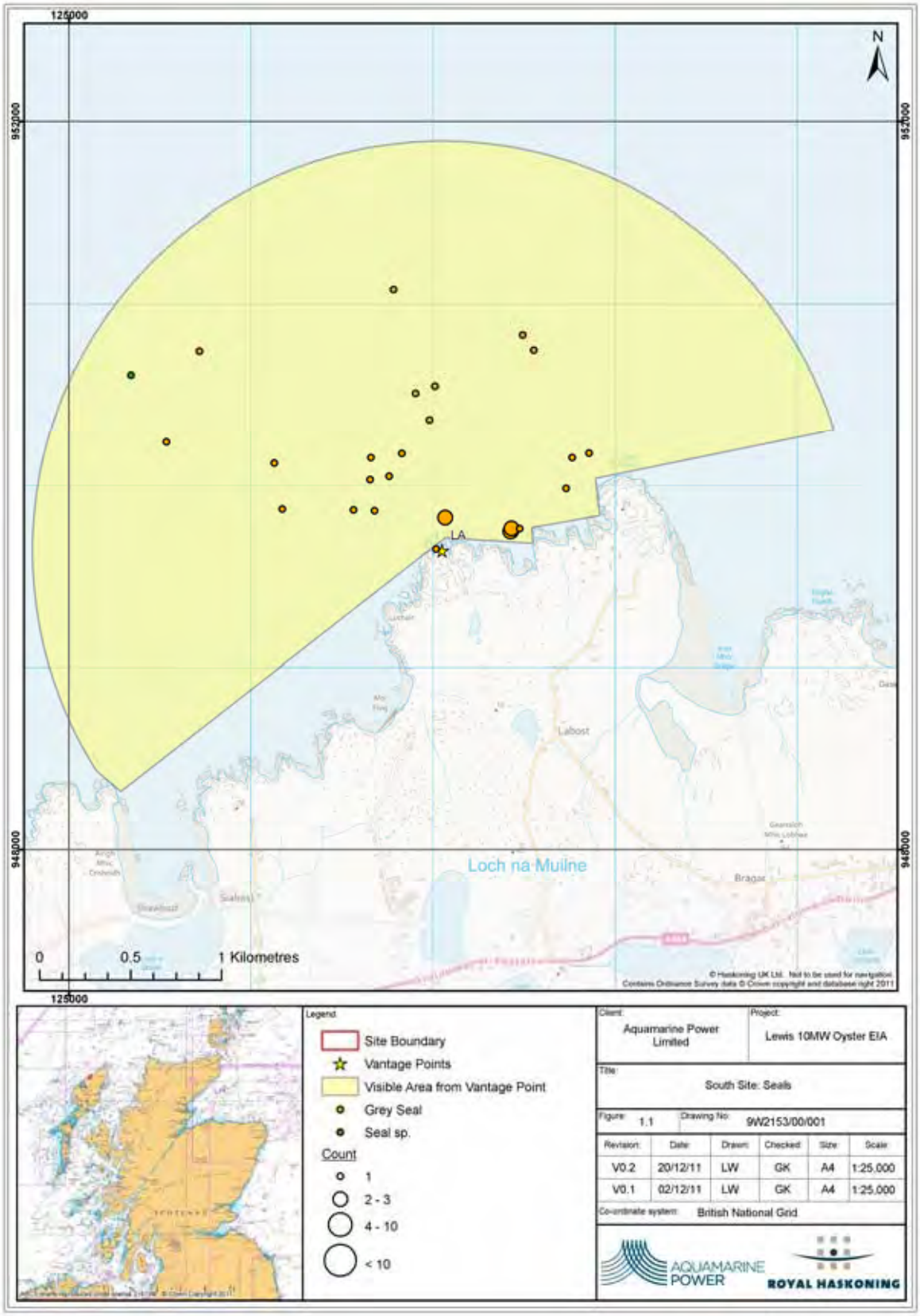


Figure 3.7: Distribution of seal sightings at the south site (LA vantage point)

3.4.3 Seasonal Variation

57. Grey seals were recorded relatively consistently through out the year, except for a dip in numbers recorded in January and February, and May and June 2011. (Figure 3.8).

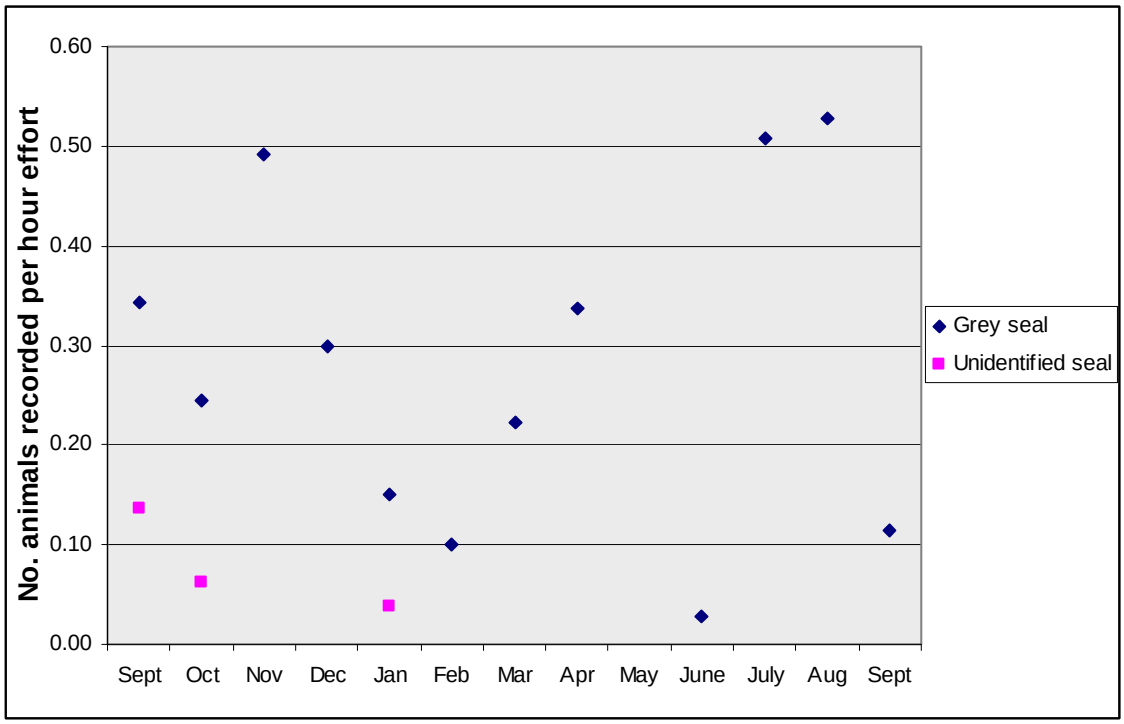


Figure 3.8: Total number of seals recorded per hour of effort by month

3.4.4 Behaviour

58. Figure 3.9 shows the number of seals exhibiting the different types of behaviour recorded. 'Bottling' (resting with the head held vertically above the surface) and 'bobbing' (resting with the head in a horizontal position) were the dominant behaviours recorded.

59. No haul out sites were recorded within the study area.

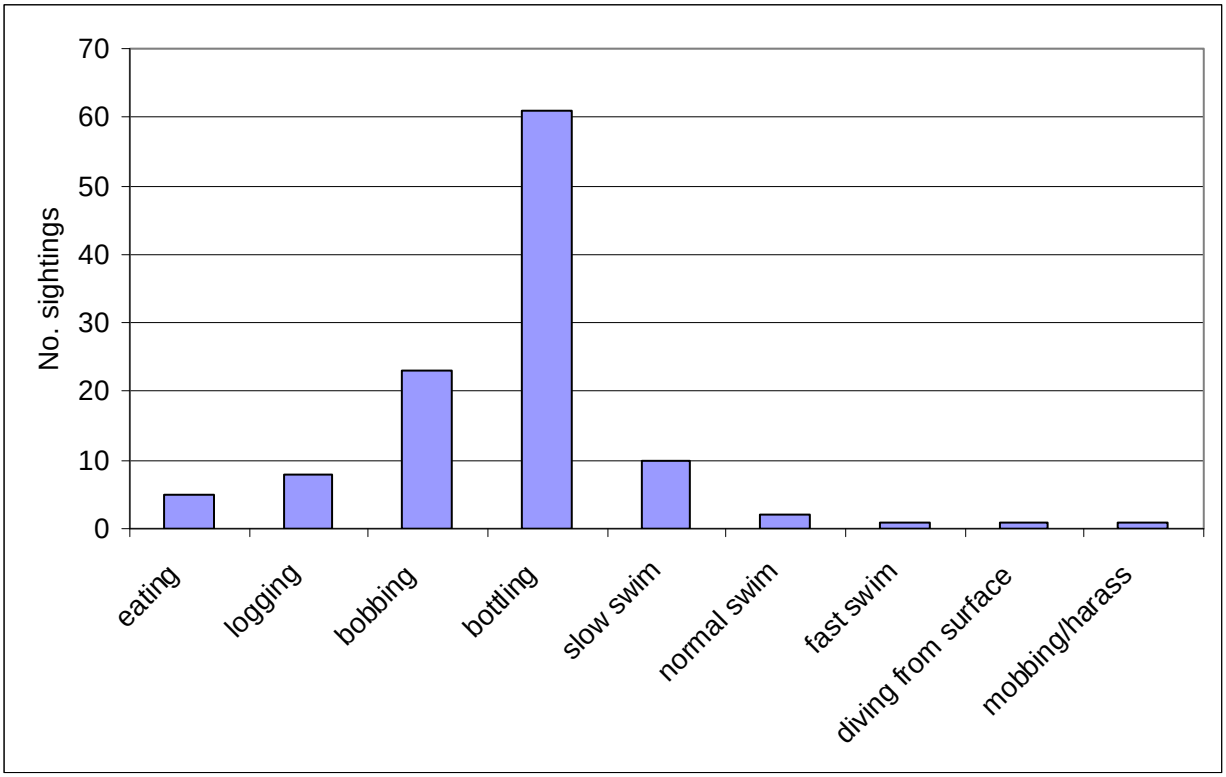


Figure 3.9: Behaviour of grey seals

3.5 Basking Sharks

60. Single basking sharks were recorded on six days from May to August 2011 (Figure 3.2). On three of these days a basking shark was recorded twice within a short period and in all cases the observer considered extremely likely that the two sightings were of the same individual.

3.5.2 Distribution

61. Basking sharks were recorded at each of the vantage points (Figure 3.10 and 3.11). Figures 3.10 and 3.11 show where the same individual was recorded twice (multiple sightings).

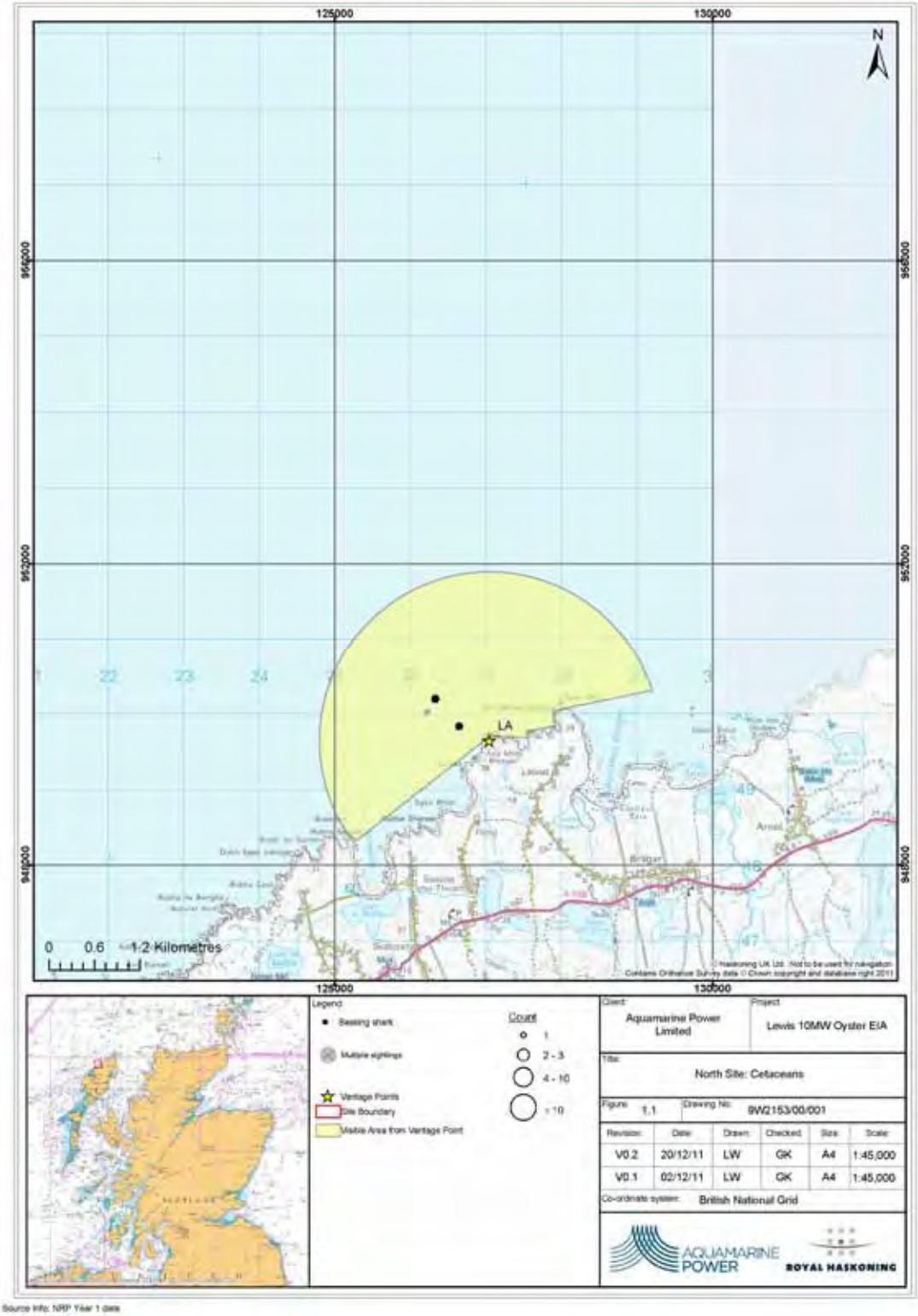
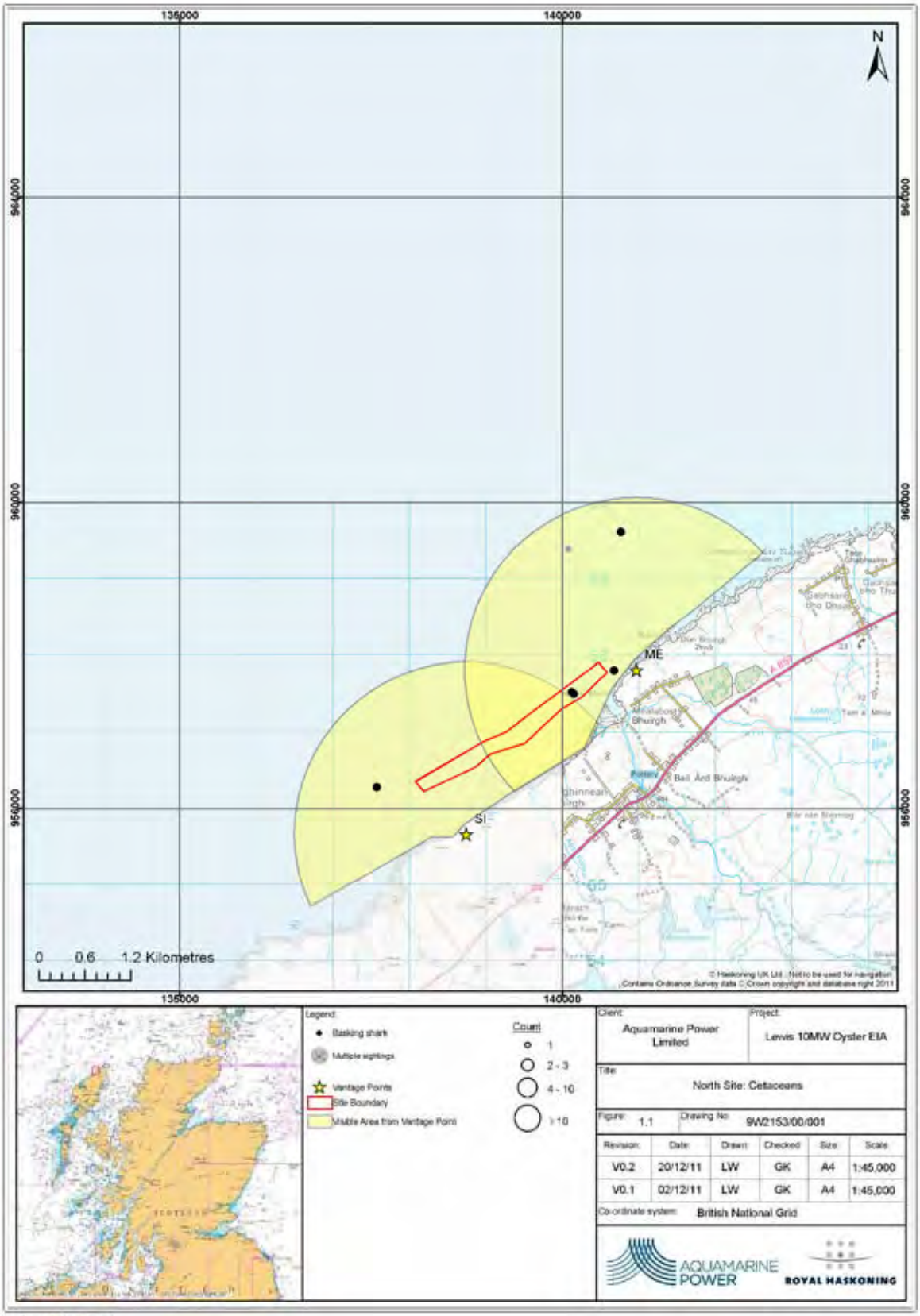


Figure 3.10: Distribution of basking shark sightings at the south site (LA vantage point)



Source info: NRP Year 1 data

Figure 3.11: Distribution of basking shark sightings at the north site (ME and SI vantage points)

3.5.3 Seasonal Variation

62. Figure 3.12 shows the basking shark sightings rate per minute of survey effort throughout the year. Most basking sharks were recorded in the summer of 2011.

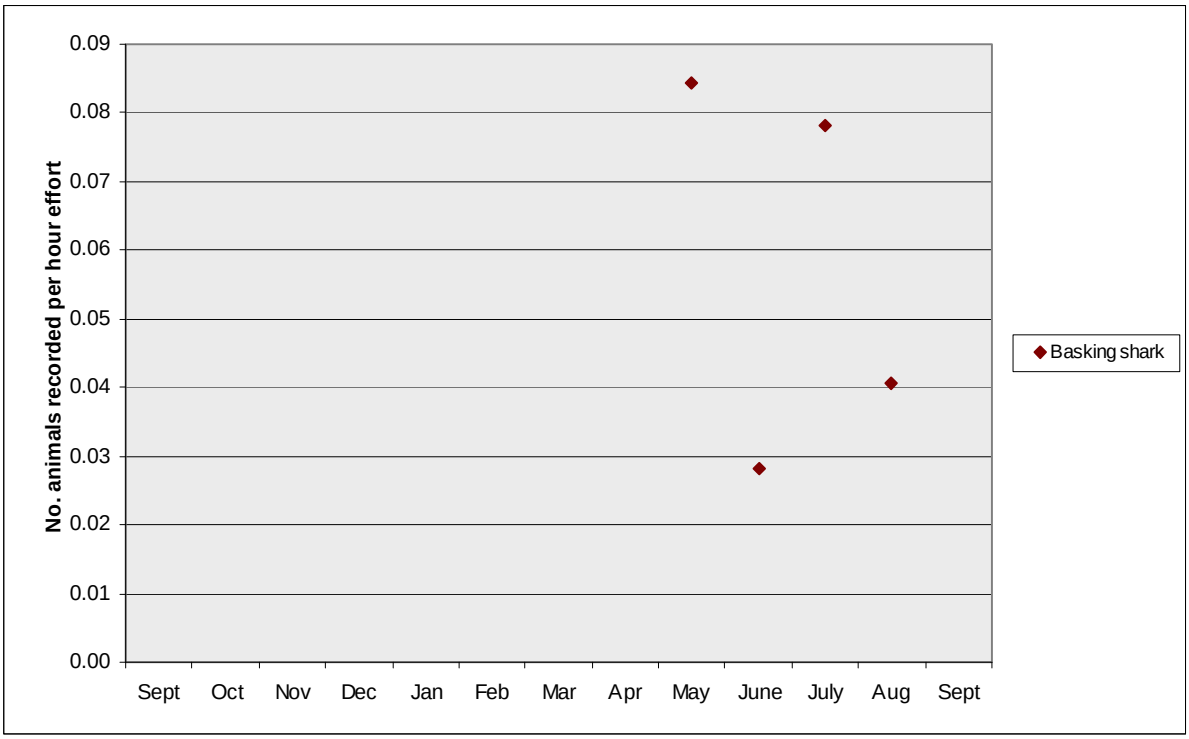


Figure 3.12: No of basking sharks recorded per hour of effort by month

3.5.4 Behaviour

63. Basking sharks were recorded swimming at slow and normal speeds. Feeding behaviour was recorded during four of the eight sightings.

4. DISCUSSION

64. The most commonly recorded species was grey seal. Grey seal is an Annex II (Habitats Directive) species that is a primary reason for site selection of the North Rona SAC[2] and the Monach Islands SAC[3]. Both of these sites are just over 150 km from the study area. Records of seal behaviour show no evidence of the survey areas being of used for haul out or breeding behaviour. No clear seasonal variation in seal use of the site was detected.

65. Grey seals breed during the autumn months (September – November) in the Western Isles when they come ashore to pup. The closest breeding colonies to the study area are in the Sound of Harris.

66. Cetaceans were recorded occasionally. Most species were recorded in spring and summer except for harbour porpoise which were recorded throughout all seasons.

67. The findings of this study are in keeping those for marine mammals and basking shark in the Outer Hebrides by Faber Maunsell and Metoc, 2007[4], in summary:

- Most minke whale sightings off Scotland occur between May and September;
- The greatest density of Risso's dolphin sightings is the shelf waters off north-west Scotland and particularly around the Inner and Outer Hebrides; and
- Faber Maunsell and Metoc, 2007 report that common dolphins are frequently seen in the Sea of the Hebrides in the warmer months. It could therefore be expected that they are likely to be also frequently seen on the Atlantic side of Lewis.

=o=o=o=

[2] http://jncc.defra.gov.uk/protectedsites/sacselection/sac.asp?EUCode=UK0012696
[3] http://jncc.defra.gov.uk/protectedsites/sacselection/sac.asp?EUCode=UK0012694
[4] Faber Mausell and Metoc (2007). Scottish Marine Renewables SEA, Environmental Report Section C SEA Assessment: Chapter C9: Marine Mammals. *Scottish Executive, March 2007*

Appendix 11.2

Underwater noise impact study

KONGSBERG

Underwater noise impact study in support of the Oyster Wave Energy Project, Isle of Lewis

Doc ref: **250121-TR-0005-V1**
Section: Technical Report
Date: 31 January 2012
Issue A
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APPROVALS

250121-TR-0005-V1

Underwater noise impact study in support of the Oyster Wave Energy Project, Isle of Lewis

Prepared by: PDWard ..... **Date:** 31 January 2012
Peter Ward – Underwater acoustics consultant

Approved by: ..... **Date:** 31 January 2012
Keith Clubley – Manager, Maritime Projects
(Commercial Point of Contact)

Rev	Reason	Date
1	Original	31 January 2012

EXECUTIVE SUMMARY

This report has been prepared by Kongsberg Maritime Ltd for Aquamarine Power Ltd. The report provides an assessment of the potential impact of underwater sound of an Oyster wave energy development on marine life found off the north-west coast of the Isle of Lewis, Outer Hebrides. The underwater sound arises during the installation, operation and decommissioning stages of the Lewis Wave Power Development. The main sources of noise have been identified as foundation socket drilling; the Oyster Wave Energy Converters (WEC) in operational mode; the tools used for decommissioning; and the vessels used during each stages identified above. Specific sound source characteristics for drilling were based on measurements of drilling noise acquired at the EMEC wave site, Billia Croo, Orkney during summer 2011. These were combined with background noise measurements made off the Isle of Lewis during the same period. Vessel noise was based on generic noise levels arising from vessels similar to those expected to be used in the development. There was no specific data for noise from operational WECs: synthesised data was based on a modified drilling noise spectrum. It is understood that when conditions permit, in-the-field measurements of operational noise will be made and an update to this report will be published.

Reports currently under commission by Aquamarine Power Ltd on the marine biology relevant to the Lewis Wave Power development area have identified a number of species that could potentially be impacted by the project. Of the marine mammals, these are common dolphin, harbour porpoise; minke whale; harbour seal and grey seal. Several species of fish have also been identified, specifically Atlantic salmon, European eel, herring and sea trout. Remaining species of fish have, for the purpose of this report, been sub-divided into two groups those being hearing specialists and those being hearing generalists.

Acoustic propagation modelling was undertaken using site-specific data relating to the bathymetry, oceanography and geo-acoustics of the Atlantic coast of the Isle of Lewis. Acoustic impact modelling was subsequently carried out using both weighted and unweighted impact criteria in order to determine the ranges over which acoustic impacts might arise on various target species of marine life.

Based on unweighted criteria, it was found that fatality, hearing damage, Level B – Harassment and Low Level Behavioural impacts are unlikely to occur when any of the species of interest are exposed to any of the single noise sources identified above. Using weighted criteria, derived specifically using the dB_{ht} technique, it was found that neither Strong nor Mild behavioural reactions are likely to be seen in Atlantic salmon, European eel, sea trout and hearing generalist fish when they are exposed to drilling or operational noise while mild behavioural reactions out to a maximum distance of 5 m may be seen in herring and other hearing-specialist fish when they are exposed to vessel noise. Odontocetes may show Mild Avoidance to operational noise out to 101 m while mysticetes show Mild Avoidance reactions to vessel noise and drilling noise up to 1.7 km and 112 m respectively.

Using a simple model to represent the transit of an animal through the proposed Lewis Wave Power Development area, the Sound Exposure Level (SEL) metric was used to determine the build-up of acoustic dose when an animal is exposed to a single source over a period of time. It was found that neither permanent nor temporary hearing damage (Permanent Threshold Shift (PTS) or Temporary Threshold Shift (TTS)) would be likely to arise on cetaceans or pinnipeds. No impact criteria using this metric were available for fish and invertebrates. Aversive behaviour could arise on the harbour porpoise after an exposure duration of 70 seconds.

The cumulative impact of adjacent multiple sources was determined for a number of indicative installation and operation scenarios. It was found that even when a total of 50 WECs are in operation at the end of year 4, for marine mammals, neither the Level B – Harassment nor the Low Level Behavioural impact criteria are exceeded. When installation

noise is included it was found that the Low Level Behavioural impact criterion was met at a distance of 1 m from the installation site.

When determining impacts from multiple sources based on weighted criteria, specifically the dB_{ht}, it was found that Strong Avoidance and Mild Avoidance are unlikely to arise in any of the target species considered, while the Mild Avoidance criterion is met only for odontocetes and mysticetes over distances varying between 60 m and 300 m.

Using the SEL metric, it was found that neither PTS nor TTS would arise in any of the marine mammal groupings when exposed to operational noise from multiple Oyster WECs. Aversive Behavioural reactions are likely to be seen in the harbour porpoise after an exposure duration of 8 seconds when exposed to the noise arising from each of the operation and installation scenarios considered.

GLOSSARY

Abbreviation	Definition
Ann	Annex
App	Appendix
BAP	Biodiversity Action Plan
BC	Bern Convention
BGS	British Geological Society
CITES	Convention on International Trade in Endangered Species
CR	Critically Endangered – IUCN conservation status
dB	Decibel
dB(A)	A-weighted decibel
DD	Data Deficient – IUCN conservation status
EMEC	European Marine Energy Centre
EN	Endangered – IUCN conservation status
EPS	European Protected Species
ES	Environmental Study
EU	European Union
Hab Dir	Habitats Directive
HESS	High Energy Seismic Survey
ht	Hearing threshold
Hz	Hertz
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
km	Kilometre
LC	Least Concern – IUCN conservation status
log	Logarithm
m	Metre
MP	Management Plan
MV	Merchant Vessel
MW	Mega-Watt
N	Newton
NE	Not Evaluated – IUCN conservation status
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NT	Near Threatened – IUCN conservation status
OSPAR	Oslo and Paris Conventions
Pa	Pascal
PMF	Priority Marine Feature
PTS	Permanent Threshold Shift
r	range
RAM	Rapid Acoustic Model
RL	Received Level
RMS	Root-mean-square
SEL	Sound Exposure Level
SL	Source Level
SPL	Sound Pressure Level
TL	Transmission Loss
TTS	Temporary Threshold Shift
UKHO	United Kingdom Hydrographic Office
VU	Vulnerable – IUCN conservation status
World Ocean Atlas	World Ocean Atlas

1. INTRODUCTION

Lewis Wave Power has an Agreement for Lease (AfL) from The Crown Estate on a region of the seabed off the north-west coast of Isle of Lewis, Outer Hebrides in order to develop a wave farm using Aquamarine Power's Oyster wave power technology. The latest generation device is the Oyster 800 which is in the process of being installed for performance assessment at the EMEC range, Billia Croo, Orkney. On satisfactory completion of the testing phase at Billia Croo, it is proposed to install up to 50 such wave devices off the Isle of Lewis. The location of the AfL in which the devices are proposed to be installed is shown in Figure 1.1.

Figure 1.1: Location of Agreement for Lease area, Isle of Lewis, Outer Hebrides

The construction of an offshore wave array requires the execution of a number of tasks that generate underwater noise. These include but are not restricted to underwater construction/anchoring in order to provide secure foundations for each wave device, as well as associated shipping movements. Each of the tasks generates levels of underwater noise and the noise has the potential to impact on marine life.

As part of the consenting process mandated by the regulatory authorities, it is necessary for the developer to produce an Environmental Impact Assessment including any specialist

technical studies. As a consequence of this requirement, this report, prepared by Kongsberg Maritime Ltd for Aquamarine Power Ltd, provides an assessment of the impact of underwater sound on marine life found in the Lewis Wave Power development area.

The report provides a brief overview of the stages involved in the installation, operation and decommissioning stages at the Lewis Wave Power development area. The noise generating activities are reviewed and the noise source characteristics are discussed in terms of their source level and frequency spectra using data, as far as possible, from the peer-reviewed literature.

Subsequently acoustic modelling was undertaken using a suite of computer programs to investigate the underwater noise propagating along a set of transects radiating from the Lewis Wave Power Development area. The programs themselves are based on mature and rigorous scientific methodologies that have been reviewed extensively in the international literature over a number of years. It is considered of fundamental importance that acoustic modelling is not based on "in-house" solutions using non peer-reviewed techniques as this could compromise the developer in the event that the environmental impact assessment documents become subject to scrutiny.

Studies currently under commission by Aquamarine Power Ltd have identified a number of species of marine animals that are local to the area. Of the mammals, these include the cetacean species: common dolphin; harbour porpoise; Risso's dolphin and minke whale; while pinniped species are the grey seal and harbour seal. Numerous species of fish have been identified and it is noted whether they are hearing specialists or hearing generalists with the difference between the two types being related to the relative sensitivity of the fish to underwater noise. It is noted that the cetaceans are all listed on the European Protected Species List (JNCC 2004), additionally, the harbour seal, grey seal, harbour porpoise and Atlantic salmon are Annex II species under the Habitats Directive[1] and thus all require protection from human activities.

Data are presented using underwater noise impact assessment metrics for generic species of marine animal, with impact zones calculated based on proposed criteria from various studies. The metrics themselves consist of unweighted metrics for fatality and physical injury through to the M-weighting metrics used to quantify audiological damage. Behavioural impacts are assessed using both unweighted metrics and the dB_{ht} technique. It is worth noting that currently these criteria have had little or no validation under open water conditions. Auditory injury data from controlled tests with a few captive animals have been used as the basis for developing the auditory injury criteria. Observations of behavioural avoidance with concurrent acoustic measurements are sparse, and hence the behavioural avoidance criteria must be considered speculative. The current study makes no judgement as to the validity of the impact criteria, but applies the metrics to the predicted noise levels in order to determine the range over which the effect arises.

The impacts relating to single sources operating in isolation are determined. Subsequently, cumulative impacts are assessed where multiple sources are operating and for which, the impact zones from adjacent sources may overlap.

[1] Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora, known as the Habitats Directive was adopted in 1992. The Directive is the means by which the European Union meets its obligations under the Bern Convention.

2. DESCRIPTION OF UNDERWATER NOISE AND ASSESSMENT METRICS

2.1 Introduction

Studies by Thomsen *et al.* (2006) and Southall *et al.* (2007) for example, provide detailed reviews of the metrics used to measure and assess the impact of underwater noise in the marine environment. A detailed review has not therefore been provided here, although a brief overview is provided to assist the reader.

Southall *et al*. (2007) classifies underwater sounds according to their periodicity. These are: single pulses such as an explosion or an airgun discharge; multiple pulses such as a series of piledriving strikes; and nonpulses This last class represents the sounds generated from sources that are used in connection with the Lewis Wave Power development and consists of drilling noise, vessel noise and operation noise from the Oyser WECs. In each case however, sound may be defined as the periodic disturbance in pressure from some equilibrium value. The unit of pressure is given in Pascals (Pa) or Newton per square metre (N/m^2). The measurements however cover a very wide range of pressure values, typically from 1×10^{-3} Pa for the hearing threshold value of a human diver at 1 kHz to 1×10^{7} Pa for the sound of a lightening strike on the sea surface. For convenience therefore, sound levels are expressed in decibels (dB) relative to a fixed reference pressure commonly 1 μPa for measurements made underwater.

2.2 Peak Sound Level

For transient pressure pulses such as an explosion or a single discharge of an airgun, the peak sound level is the maximum absolute value of the instantaneous sound pressure recorded over a given time interval. Hence:

Peak Level (zero-to-peak) = $20 \times \log_{10} (P_{peak} / P_{ref})$ eqn. 2-1

When the pulse has approximately equal positive and negative parts to the waveform, the peak-to-peak level is often quoted and this is equal to twice the peak level or 6 dB higher.

2.3 RMS Sound Pressure Level

The Root-Mean-Square (RMS) Sound Pressure Level (SPL) is used to quantify noise of a continuous nature. Underwater sound sources of this type include shipping, sonar transmissions, drilling or cutting operations, or background sea noise. The RMS Sound Pressure level is the mean square pressure level measured over a given time interval (t), and hence represents a measure of the average sound pressure level over that time. It is expressed as:

RMS Sound Pressure Level = $20 \times \log_{10} (P_{RMS}/P_{ref})$ eqn. 2-2

Where RMS Sound Pressure Levels are used to quantify the noise from transients, the time period over which the measurements are averaged must be quoted as the RMS value will vary with the averaging time period. Where the noise is continuous, as in the examples given above, the time period over which measurements are taken is not relevant as the measurement will give the same result regardless of the period over which the measurements are averaged.

2.4 Sound Exposure Level

The problems associated with the time period over which the Sound Pressure Levels are averaged, as highlighted above, can be overcome by describing a transient pressure wave in terms of the Sound Exposure Level (SEL). The Sound Exposure Level is the time integral of the square pressure over a time window long enough to include the entire pressure-time history. The Sound Exposure Level is therefore the sum of the acoustic energy over a measurement period, and effectively takes account of both the level of the sound, and the

duration over which the sound is present in the acoustic environment. Sound Exposure (SE) is defined by the equation:

$$SE = \int_0^T p^2(t)dt \qquad \text{eqn. 2-3}$$

where *P* is the acoustic pressure in Pascals, *T* is the duration of the sound in seconds and *t* is time. The Sound Exposure is a measure of the acoustic energy and therefore has units of Pascal squared seconds (Pa^2-s).

To express the Sound Exposure as a logarithmic decibel, it is compared with a reference acoustic energy level of 1 μPa^2.s. The Sound Exposure Level (SEL) is then defined by:

$$SEL = 10\log_{10}\int_0^T \frac{p^2(t)dt}{P_{ref}^2} \qquad \text{eqn. 2-4}$$

Where a sound time period is less than a second the RMS Sound Pressure Level will be greater than the Sound Exposure Level. For signals of greater than 1 second, the Sound Exposure Level will be greater than the RMS Sound Pressure Level where:

$$SEL = SPL + 10\log_{10} T \qquad \text{eqn. 2-5}$$

2.5 Cumulative Sound Exposure Level

Where multiple transient pressure wave events occur, the total or cumulative Sound Exposure Level from multiple events can be calculated by summing the Sound Exposure Level from a number of individual events. The events themselves may be separated in time or space or both. For instance, the events could be consecutive from foundation drilling at adjacent sites or concurrent from operational Oysters at neighbouring sites.

2.6 Source Level

The source level (SL) is the apparent strength of a sound source at a reference distance, usually 1 m, from the source. For example, a source may be quoted as having a source Sound Pressure Level of 180 dB re.1μPa @ 1 m. In practise the parameters of the source are rarely measured at such a close range, and the source level is inferred by back-propagating the noise from a number of far field measurements

2.7 Received Level

The Received level (RL) is the strength of the acoustic field at a given depth and range relative to the source. As the sound varies with range, it is important to state the range at which the measurement has been taken or the estimate has been made.

2.8 Transmission Loss

The transmission loss (TL) represents the loss in intensity or pressure of the acoustic field strength as the sound propagates from source to receptor. In general terms the transmission loss is given by:

$$TL = N\log(r) + \alpha r \qquad \text{eqn. 2-6}$$

where r is the range from the source, N is a factor for attenuation due to geometric spreading, and α (in $dB.km^{-1}$) is a factor for the absorption of sound in water. Hence, the received sound level at a range r from a source is given by:

$$RL = SL - TL \qquad \text{eqn. 2-7}$$

which can be written in the form :

$$RL = SL - N\log(r) - \alpha r \qquad \text{eqn. 2-8}$$

3. CRITERIA FOR ASSESSING IMPACTS UPON MARINE FAUNA

3.1 Introduction

This section of the report describes the assessment criteria proposed by various investigators to assess the impact of underwater sound upon species of interest to the Lewis Wave Power development area. These criteria may be used to estimate impact zones about the sound sources using the results from underwater sound propagation modelling.

It should be noted that in many cases these criteria have had little or no validation under open water conditions. Auditory injury data from controlled tests with a few captive animals have been used as the basis for developing the auditory injury criteria. Observations of behavioural avoidance with concurrent acoustic measurements are sparse, and hence the behavioural avoidance criteria are speculative. No judgement is made here or throughout the subsequent calculations of mitigation zones regarding the merits or shortfalls of each approach.

3.2 Species of interest to Lewis Wave Power development area

3.2.1 Introduction

Previous studies commissioned by the developer have identified a number of species of fish and marine mammals present in and around the Lewis Wave Power development area being potentially susceptible to acoustic disturbance. This section provides an overview of the sensitivity of the species to underwater sound as far as is known and also notes their conservation status according to the Red List of the International Union for Conservation of Nature (IUCN)[2] and the presence of any other legislation covering their environmental sensitivity or denoting a relevant management plan.

3.2.2 Fish

From an acoustic perspective, fish may be classed as a hearing specialist or a hearing generalist based on the definition of the terms introduced by Fay and Popper (1997). The difference between the two categories is based on a comparison of the relative sensitivity of the fish to underwater sound and this in turn is related to the internal physiology of the fish. Hearing generalists tend not to have a swimbladder and these fish species have relatively poor hearing. By contrast, a number of fish species do possess a swimbladder. This gas-filled sac performs several different functions such as acting as a float which gives the fish buoyancy, as a lung and as a sound-producing organ. In addition, the swim bladder can enhance the hearing capability of the fish species through the amplification of underwater sound although this alone, would not necessarily make a swimbladder fish a hearing specialist. For some species (e. g. herring) there is a connection between the inner ear and the swim bladder and it is this feature which leads to them being classed as "hearing specialists". Fish termed "hearing specialists" are therefore more sensitive to underwater noise. Subsequently, there is the potential for such species of fish to be more susceptible to acoustic impacts than "hearing generalist" fish.

Table 3.1 lists a number of species of fish found in and around the Lewis Wave Power Development, their conservation status and whether they are classed as "hearing generalists" or "hearing specialists".

[2] The IUCN Red List of Threatened Species™ 2011, http://www.iucn.org/about/work/programmes/species/red_list/index.cfm. Accessed September 2011. (CR - Critically Endangered, EN – Endangered, VU – Vulnerable, NT - Near Threatened, LC - Least Concern, DD - Data Deficient, NE - Not Evaluated).

Fish	Legislation / environmental sensitivity or management plan[3]	Hearing ability
Atlantic salmon (*Salmo salar*)	Ann II Hab Dir, BAP, PMF, OSPAR, IUCN LC	Generalist
Basking shark *(Cetorhinus maximus)*	WC, IUCN VU	Generalist
European Eel (*Anguilla anguilla*)	BAP, PMF, OSPAR,, IUCN CR, EU MP	Specialist
Herring (*Clupea harengus*)	BAP, IUCN LC, EU MP	Specialist
Sea trout (*Salmo trutta trutta*)	BAP, IUCN LC	Generalist

Table 3.1: Fish species found in and around the Lewis Wave Development area

3.2.3 Marine mammals

A number of species of cetacean are regularly found in and around the Lewis Wave Power Development area. Table 3.2 lists the species especially of note: they include both odontocetes and mysticetes. Cetaceans make extensive use of underwater sound and have hearing that is highly tuned for the undersea environment (Richardson *et al*. 1995). Their susceptibility to impacts arising through the introduction of man-made noise into the marine environment is subsequently well-documented.

Common or harbour and grey seals are the only pinniped species native to the Lewis Wave Power Development area. Although seals are classed as marine mammals they spend considerable periods of time on land. As a consequence, seals are known to hear very well in-air as well as underwater. When diving or swimming, they may be susceptible to impacts arising from high levels of underwater sound. Equally, when on land, they may be liable to impacts arising through the emission of sound in-air such as construction noise.

The conservation status of the marine mammals found in the Lewis Wave Development area is also included in Table 3.2.

Mammals	Conservation Status
Cetacea	
Common dolphin (*Delphinus delphis*)	IUCN Least Concern, Annex IV of Habitats Directive, EPS
Harbour porpoise (*Phocoena phocoena*)	IUCN Least Concern, Annex IV of Habitats Directive, EPS
Risso's dolphin (*Grampus griseus*)	IUCN Least Concern, Annex IV of Habitats Directive, EPS
Minke whale (*Balaenoptera acutorostrata*)	IUCN Least Concern, Annex IV of Habitats Directive, EPS
Pinnipedia	
Common or Harbour seal (*Phoca vitulina*)	IUCN Least Concern, Annex II of Habitats Directive
Grey seal (*Halichoerus grypus*)	IUCN Least Concern, Annex II of Habitats Directive

Table 3.3: Marine mammal species found in the Lewis Wave Development area

3.3 Acoustic impact criteria

3.3.1 Introduction

The degree to which a given species might be affected by underwater sound emissions depends on a number of factors, these being the sensitivity of the species or individual to the sound, the level of sound on the receptor, its frequency content and the duration of the sound.

[3] Ann II Hab Dir – Annex II Habitats Directive (1992), BAP – UK Biodiversity Action Plan (1994), PMF – Priority Marine Feature in Scottish waters, OSPAR – OSPAR Convention (1992), BC App II, III – Bern Convention Appendix II, Appendix III, CITES App II (1963), EU MP – European Union Management Plan, WC – UK Wildlife and Countryside Act (1981)

This section of the report describes briefly the assessment criteria proposed by various investigators to assess the impact of underwater sound upon species of interest to the Lewis Wave Power Development area. These criteria are then used to estimate impact zones about the underwater noise sources using the results from underwater sound propagation modelling.

3.3.2 Lethality

High levels of underwater sound can be lethal to marine life. Yelverton *et al.* (1975) carried out a number of studies on various species of fish and terrestrial mammals and demonstrated that mortality rates were related to body mass of the subject and the magnitude of the impulsive wave. The work indicates that there are levels below which a sound would cease to be lethal to a creature of a certain weight. It is shown that the upper limit for No-Injury ranges from 26 Pa s for rats (0.2 kg) to 210 Pa s for sheep (45 kg). While these impulse levels may not cause swim bladder rupture or kidney and liver damage that may be seen after lethal doses of sound, there still may be considerable tissue damage to susceptible organs such as the lungs, gastro-intestinal tract or eyes. Any mortality or direct physical injury from the noise and vibration generated by a particular sound source is associated with very high peak pressure or impulse levels. Typically, these effects would be associated with blasting operations or in the immediate vicinity of an impact piling operation where the pile is being driven into the seabed, and is therefore in direct contact with water allowing efficient sound radiation. It has been observed that at high exposure levels, such as those typical of underwater explosive operations or offshore impact piling (pile driving) operations, fatality may occur in species of fish and marine mammal where the incident peak to peak sound level exceeds 240 dB re. 1 μPa. It is noted that the likelihood of fatality increases with level above 240 dB re. 1 μPa, and as the time period of the exposure increases.

3.3.3 Physical injury

Physical injury refers to damage of the soft tissues such as the eyes, liver and kidneys. While the damage is not sufficient to kill the animal immediately, they may nevertheless be so disabled that mortality arises as a result. This level of injury has been seen to occur where peak to peak levels exceed 220 dB re. 1μPa (Rawlins (1974), Hill (1978), Goertner (1982), Richardson *et al.* (1995), Cudahy and Parvin (2001), Hastings and Popper (2005)).

The US National Marine Fisheries Services (NMFS) propose non-injury limits for pinnipeds of 190 dB re. 1μPa and for cetaceans of 180 dB re. 1μPa [4].

3.3.4 Auditory damage

At lower sound pressure levels, permanent and temporary hearing loss may occur when marine animals are constrained within a high level sound environment for prolonged periods. Permanent hearing loss results from the death of the sensory hair cells of the inner ear. This gives rise to a permanent increase in threshold sensitivity over the affected frequencies and is known as Permanent Threshold Shift (PTS). Temporary hearing loss is an injury that is recoverable over a period of time ranging from minutes to days or even weeks and this is known as Temporary Threshold Shift (TTS).

More specifically, Southall *et al*. (2007) discussed auditory damage in cetaceans and pinnipeds and noted that this was dependant on the relative hearing sensitivity of each group. A number of groupings were proposed based on similarity of hearing capability and acoustic impact criteria were developed using metrics weighted according to the hearing characteristics of each group. Low-frequency hearing cetaceans, denoted by M_{lf}, consist of mysticetes or baleen whales including, of interest to this report, the minke whale. For these species, hearing sensitivity has been based on behavioural responses observed in open

[4] This was based on findings at the High-Energy Seismic Workshop held at Pepperdine University in 1997 as updated by the NMFS' Acoustics Workshop held in Silver Spring, MD in 1999.

waters. Mid- and high-frequency hearing cetaceans, denoted by M_{mf} and M_{hf} respectively are all odontocetes or toothed whales. The mid-frequency cetaceans include the common dolphin and Risso's dolphin while the high-frequency cetacean group includes the harbour porpoise. The grouping consisting of pinnipeds in water, including both the harbour and grey seal, is denoted by M_{pw}.

Studies reviewed in Southall *et al.* (2007) indicated that hearing damage can occur following either a single exposure to a loud sound or else from multiple exposures of lower level sound. In the first case, the threshold is given by the unweighted peak sound pressure level while in the second case the threshold is given by the SEL indicating a build-up of energy over a period of time and weighted according to the animal's hearing sensitivity. Using the peak level metrics, the onset of PTS is set at 230 dB re 1 μPa (Peak) for cetaceans and 218 dB re 1 μPa (Peak) for pinnipeds while the thresholds for the onset of TTS are 224 dB re 1 μPa (Peak) and 212 dB re 1 μPa (Peak) for cetaceans and pinnipeds respectively. Alternatively, using energy based metrics, the corresponding thresholds for the onset of PTS are 215 dB re 1μPa^2.s SEL M-Weighted and 203 dB re 1 μPa^2.s SEL M-Weighted for cetaceans and pinnipeds while the corresponding thresholds for TTS are 195 dB re 1 μPa^2.s SEL M-Weighted and 183 dB re 1 μPa^2.s SEL M-Weighted respectively.

In a series of controlled experiments, Lucke *et al*. (2009) exposed a harbour porpoise to seismic airgun sounds. It was discovered that TTS was found to occur at a received level of 199.7 dB re 1 μPa peak-to-peak (193.7 dB re 1 μPa zero-to-peak) and an SEL of 164.3 dB re 1 μPa^2.s. The results indicated that harbour porpoises appeared to be particularly sensitive to underwater noise with the onset of TTS being some 24 dB lower than the threshold proposed by Southall *et al*. (2007).

3.3.5 Behavioural reactions – unweighted metrics

At still lower sound pressure levels, it has been observed that fish and marine mammals may exhibit changes in their normal behaviour. These changes range from a startle reaction to the sound, a cessation of their current activities (e.g. feeding, nursing, breeding) or the animals may leave the area for a period of time.

A number of researchers (Terhune *et al.* (2002), Fjälling *et al.* (2005), Yurk and Trites (2000)) have noted levels of sound necessary to deter harbour seals (*Phoca vitulina*) and grey seals (*Haliochoerus grypus*) from predation on fish stocks. Acoustic harassment devices (AHDs) with source levels of between 191 to 195 dB re 1 μPa @ 1 m were used to determine the response of marine animals to these devices. Behavioural avoidance responses were observed out to ranges of between 100 m and 2.9 km from the sound source. While monitoring common dolphin (*Delphinus delphis*) before, during and after a seismic survey in the Irish Sea, Goold (1996) observed an avoidance reaction in the area, from 1 to 2 km from the survey vessel. Lucke *et al.* (2009) observed that harbour porpoises shows signs of aversive behaviour when exposed to peak to peak levels of 174 dB re 1 μPa and an SEL of 145 dB re 1 μPa^2.s.

Analysis of behavioural responses coupled with measurements of sound levels at receptor locations has led to the development of impact criteria for assessing the significance of behavioural impacts. These fall into two groups making use of unweighted metrics - where the thresholds do not take into account the hearing sensitivity of the target species; and weighted metrics – where sensitivity is allowed for.

Behavioural thresholds using unweighted metrics consist of:

- Level B Harassment (defined by the 1994 amendment to the US Federal law Marine Mammal Protection Act of 1972) states that sound has "*the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild*". This threshold has been set at 160 dB re 1 μPa (RMS) (NMFS 1997);

- Low Level Disturbance where the threshold has been set at 140 dB re 1 μPa (RMS) (NMFS 1997).

3.3.6 Behavioural reactions – weighted metrics (dB_{ht})

Behavioural thresholds using weighted metrics are based on the dB_{ht} methodology. The dB_{ht} technique is based on a comparison of the frequency spectrum of the noise being considered with the hearing threshold of the target species. This is illustrated in Figure 3.1 which shows the frequency spectrum for a noise source and the hearing sensitivity curve for a fish – hearing generalist. The difference between the two curves gives the apparent loudness of the noise source as perceived by the fish. The propagation loss data (computed using the acoustic modelling undertaken and discussed in Section 5) is applied to the apparent loudness of the sources for each species. Subsequently, the range at which sound pressure level has fallen to the threshold for each behavioural impact may be easily determined.

The level by which the impact is measured may be thought of as a dB scale where the species' hearing threshold is used as the reference unit and this is analogous to the dB(A) scale used for rating the behavioural effects of sound on humans. It is noted that the response from a species tends to be probabilistic in nature, e.g. for a given sound pressure level on a receptor, one individual from a species may react whereas another individual may not. Two impact levels are commonly used:

i. 90 dB_{ht}(species) represents a level which will cause a significant avoidance reaction by most individuals;

ii. 75 dB_{ht}(species) represents a level which will cause a milder avoidance response occurs in a majority of individuals;

Using the thresholds above, ranges from the sound source may be determined at which each of the impact criteria are met.

It is noted that the dB_{ht} technique may be applied to any species for which a hearing threshold curve is available. Hence it is valid for both marine mammals and fish. However, it is understood that the technique has not been validated by either rigorous peer-review or experimental study.

3.4 Summary of acoustic impact thresholds

The criteria used to assess the significance of the acoustic impact on the pinnipeds and fish in the Lewis Wave Power Development area are summarised in Table 3.3 below. The species for which the impact applies is noted where possible. Due to lack of research data, specific impact criteria for fish are restricted to lethality; and to the 90 dB_{ht} and 75 dB_{ht} thresholds.

3.5 Conclusion

A number of species of marine fauna that are found in and around the Lewis Wave Power development area are known to be sensitive to sound emitted underwater. It is further noted that many of these species are legally protected under various guidelines, agreements and directives. Therefore, it is important to provide a rigorous methodology for quantifying the potential risk that the animals face following exposure to sound. This was addressed using the M-weighting and dB_{ht} methodologies and has been applied to underwater noise data in the ensuing sections.

Exposure limit	Effect	Study
240 dB re 1 µPa (Peak)	Lethality	Yelverton and Richmond (1981)
230 dB re 1 µPa (Peak)	PTS Auditory injury onset in cetaceans	Southall *et al.* (2007)
218 dB re 1 µPa (Peak)	PTS Auditory injury onset in pinnipeds	Southall *et al.* (2007)
215 dB re.1µPa^{2}s SEL M-Weighted	PTS Auditory injury onset in cetaceans	Southall *et al.* (2007)
203 dB re.1µPa^{2}s SEL M-Weighted	PTS Auditory injury onset in pinnipeds	Southall *et al.* (2007)
224 dB re 1 µPa (Peak)	TTS onset in cetaceans	Southall *et al.* (2007)
212 dB re 1 µPa (Peak)	TTS onset in pinnipeds	Southall *et al.* (2007)
193.7 dB re 1 µPa (Peak)	TTS onset in harbour porpoise	Lucke *et al*. (2009)
195 dB re.1µPa^{2}s SEL M-Weighted	TTS onset in cetaceans	Southall *et al.* (2007)
183 dB re.1µPa^{2}s SEL M-Weighted	TTS onset in pinnipeds	Southall *et al.* (2007)
164.3 dB re 1 µPa^{2}s SEL	TTS onset in harbour porpoise	Lucke *et al*. (2009)
190 dB re 1 µPa (RMS)	Auditory injury criteria – pinnipeds	NMFS, (1995)
180 dB re 1 µPa (RMS)	Auditory injury criteria – cetaceans	NMFS, (1995)
174 dB re 1 µPa pk-pk	Aversive behavioural reaction in harbour porpoise	Lucke *et al*. (2009)
145 dB re 1 µPa^{2}s SEL	Aversive behavioural reaction in harbour porpoise	Lucke *et al*. (2009)
160 dB re 1 µPa (RMS)	Behavioural disturbance, Level B - Harassment in cetaceans and pinnipeds	NMFS, (1995)
140 dB re 1 µPa (RMS)	Low level disturbance in cetaceans and pinnipeds	HESS (1999)
90 dB_{ht} above species specific hearing threshold	Strong behavioural reaction	Nedwell *et al.* (2005)
75 dB_{ht} above species specific hearing threshold	Mild behavioural reaction	Nedwell *et al.* (2005)

Table 3.3: Summary of underwater noise impact criteria for cetacean, pinniped and fish species.

4. SOUND SOURCE CHARACTERISTICS

4.1 Introduction

A number of tasks associated with the installation, operation and decommissioning stages in the Lewis Wave Power development area involve the generation of underwater noise.

The installation stage consists of preparing the seabed in the development area and placing the Oyster Wave Energy Converter (WEC) in position. The Oyster is secured to the seabed through a pin-pile which is grouted into position in a foundation socket drilled into the seabed. Following installation, the Oyster WECs are expected to remain in operation for 20 years followed by a decommissioning programme.

The noise has the potential to impact on species of marine fauna resident or transiting through the region. As part of the process of quantifying the acoustic impacts arising, it is necessary to first define and characterise, as far as possible, the nature of each noise source in terms of its source level and frequency content. This section discusses the noise characteristics using equipment-specific data where possible or publicly available generic data where specific data does not exist.

4.2 Construction noise

The Oyster wave device is secured to the seabed using a monopile grouted into a foundation socket previously drilled into the seabed.

Two noise sources have thus been identified as being predominant during the installation stage: foundation socket drilling and the support vessel on which the Oyster WEC and supporting infrastructure are transported to the site. Specific details of the vessels to be used during installation were not available therefore generic noise parameters for vessel noise were assumed using publicly available data.

4.2.1 Vessel noise

It is understood that vessels fitted with heavy lifting gear and drilling rigs will be deployed in the Lewis Wave Power Development area. Specific data relating to the underwater noise radiated by the vessels is currently not available. In order to be able to provide an indicative assessment of the acoustic impact from vessel noise it is necessary to use instead an alternative data set which is representative of the noise generated by the vessels in connection with the Lewis Wave Power Development.

Noise from shipping is a major contributor to the overall noise in a given sea area due principally to the large numbers of ships present, their wide distribution and their mobility. Sound levels and frequency characteristics are related approximately to ship size and speed however, even amongst vessels of similar classes, there is considerable variation.

Vessel noise is a combination of narrowband sounds at specific frequencies and broadband sounds with energy spread over a range of frequencies. The narrowband sound or tonal components arise from the propeller blade rate, engine cylinder firing and crankshaft rotation. Typical frequencies for these components lie in the range 10 - 100 Hz. Broadband noise can be attributed to propeller cavitation and flow noise and may extend up to 100 kHz peaking in the range 50-150 Hz (Ross 1987).

A review of shipping noise for small vessels is summarised in Table 4.1 below. This includes tugs, crew boats and other vessels with outboard motors as well as larger vessels associated with the offshore renewables industry *(*Richardson *et al.* 1995, Thomsen et al. 2006*)*. It is noted that source levels are given as both broadband levels and where appropriate, spectral levels measured over a given bandwidth.

Sources	Freq (Hz)		dB re 1μPa at 1 m	
Small ship (55 m-85 m long)		Broadband	180	Broadband noise levels lie in range 170-180 dB re 1μPa
Windfarm service vessel	250	1/3 octave	160	
Windfarm service vessel	2000	1/3 octave	150	
MS Sparton 25m long	37	tonal	166	Tug pulling empty barge
Arctic Fox	1000	1/3 octave	170	Tug pulling loaded barge
Arctic Fox	1000	1/3 octave	164	Tug pulling empty barge
Arctic Fox	5000	1/3 octave	161	Tug pulling loaded barge
Arctic Fox	5000	1/3 octave	145	Tug pulling empty barge
Twin diesel 34 m long	630	1/3 octave	159	
Trawlers	100	1/3 octave	158	Same level 100, 125, 160, 200, 250 Hz
Imperial Adgo 16 m long	90	tonal	156	Crewboat, 2nd harmonic of prop blade rate
Outboard drive	630	1/3 octave	156	Same level 400, 500, 630, 800 Hz
MV Sequel	250-1000		151	Fishing boat 7 kt
Zodiac	6300	1/3 oct	152	Outboard engine

Table 4.1: Source levels of underwater noise for various class of vessel reviewed by Richardson *et al.* (1995)

It must be noted that the actual broadband source levels may be somewhat greater than those indicated in the table because the data above does not span all the frequencies over which vessel noise is generated.

The table includes data on noise levels measured over a number of specific 1/3 octaves as well as data measured as broadband. Strictly, this makes comparison between each of the datasets presented above somewhat difficult. The table indicates that broadband source levels lie in the range 170-180 dB re 1 μPa at 1 m. It will also be seen that tonal noise levels can vary between 145 dB re 1 μPa at 1 m and 170 dB re 1 μPa at 1 m depending on vessel size and engine loading. The table shows specific 1/3 octave band levels for a number of different frequency bands for tugs pulling both empty barges and loaded barges. Clearly, the noise levels are greater when the engine is pulling loaded barges. The mean noise level for a tug pulling an empty barge is given as 158 dB re 1 μPa at 1 m, increasing to 163 dB re 1 μPa at 1 m when the tug pulls a loaded barge.

Frequency spectra for a number of classes of vessels are included in Figure 4.1. This shows 1/3 octave band levels for a 34 m diesel boat, a trawler, a supertanker, a tug/barge and the service vessel[5] which is of similar size to the vessels that may be used in the Lewis Wave Power Development area. The measurements were made over a frequency range of 10 Hz to 10 kHz. It will be seen that for a given 1/3 octave band, there is a spread of source levels for each vessel of typically 30-40 dB once again, indicating the considerable variability in vessel noise with ship size. The frequencies at which peak levels arise, increase as vessel size decreases and it will be seen that for the supertanker the peak level is at 16 Hz while for the tug and 34 m diesel-engine vessel, the peak levels are found around 500-600 Hz. Generally, therefore, it might be expected that the vessel noise impacts more on fish with their relative sensitivity to low frequency sound, than on pinnipeds and cetaceans whose hearing is most sensitive at frequencies around 10 kHz and 20 kHz respectively.

Figure 4.1 indicates that there is no high-frequency noise data at frequencies above 10 kHz. This represents a considerable shortfall in the published data particularly with regards to assessing the noise impact on marine species that are known to be responsive to sound at

[5] Pipeline Construction Equipment and Noise Source Levels - Sakhalin Energy, http://www.sakhalinenergy.com, accessed Feb 24, 2009

such frequencies. To address this issue for this study, the noise levels for each vessel have been extrapolated to 160 kHz however, the uncertainty in these projected figures is unquantifiable.

From the frequency spectra given in Figure 4.1, broadband source levels are estimated for each of the vessels considered and these are listed in Table 4.2. On the basis that the tug/barge is the noisiest type of vessel likely to be used in connection with the Lewis Wave Power Development project, source level data for the tug/barge was taken forward and used in the analysis subsequently discussed in this report.

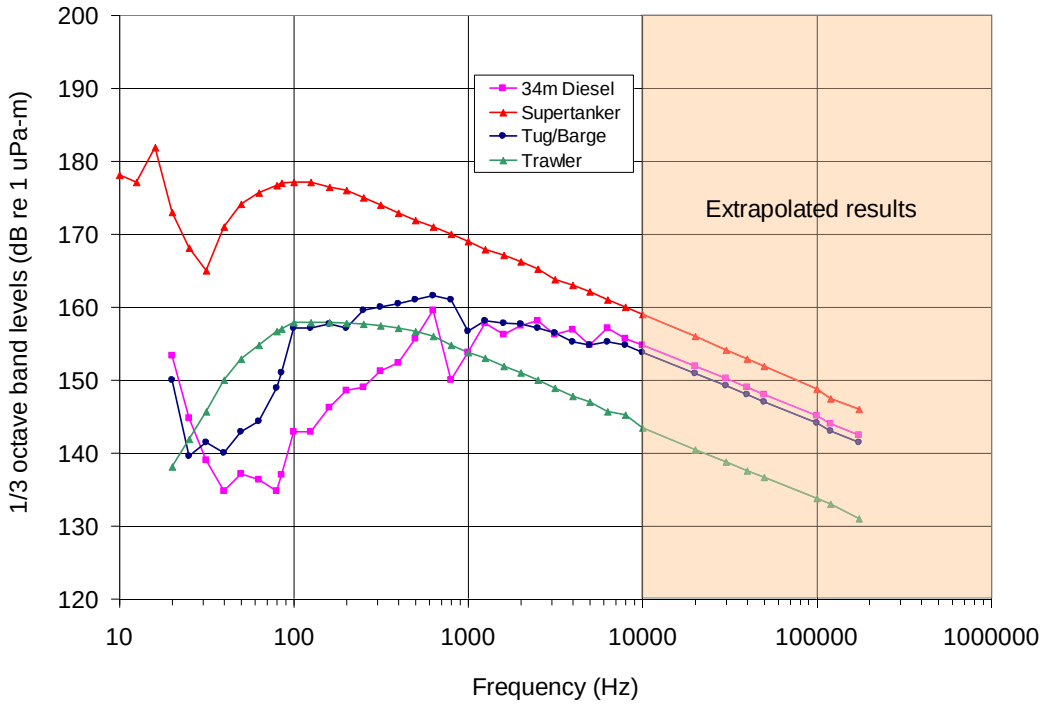

Figure 4.1: Estimated 1/3 octave band source levels of underwater noise for various classes of vessel (Brueggeman *et al.* (1992a), (1992b); Cybulski (1977), Malme *et al.* (1989), Richardson and Malme (1993)).

Vessel type	Broadband Source Sound Pressure Level (dB re 1 µPa at 1 m)
Trawler	169
34 m diesel	168
Supertanker	189
Tug/barge	172

Table 4.2: Estimated broadband source levels for various classes of vessel

4.2.2 Drilling noise

Noise is generated during drilling principally through the grinding motion of the drill bit on the surrounding rocks. The level of noise created is dependent therefore on the degree to which the seabed rock is consolidated; a soft clay will produce lower levels of sound compared to that generated by a granite layer. It is known that sediment coverage of the seabed in the Lewis Wave Power Development area is variable; consisting of mainly exposed bedrock with occasional patches of gravely sand overlain with cobbles and boulders (Moore and Roberts 2011) so it is expected that considerable levels of sound may arise.

Sound generated at the drill head is likely to be transmitted into the water through two mechanisms. The first is where the noise is transmitted from the drill bit-sediment interface and into the surrounding seabed layers before becoming refracted back into the water column while the second is where vibrations travel up the drill shaft and then become transmitted into the water.

Foundation sockets for the Oyster 800 project were drilled at the European Marine Energy Centre (EMEC) Wave test site, Billia Croo, Orkney during summer 2011. The drilling equipment used was Seacore's Teredo 40 reverse circulation, large diameter drill rig[6]. This was equipped with a 4.25 m diameter drill bit, dressed with tungsten carbide roller cutters that ground away at the rock interface. Measurements recorded during the drilling of the socket for Oyster 801 indicated that the total underwater noise levels (defined as the sum of background noise and drilling noise) were 153.8±12.1 dB re 1 μPa at 1 m (Kongsberg 2011a).

By way of comparison, McCauley (1998) provided examples of noise levels recorded from an oil drilling rig in the Timor Sea. During drilling, the highest noise levels measured were around 115-117 dB re 1μPa at distances of 405 m and 125 m from the rig. This indicates a broadband source level of around 125.5 dB re 1 μPa at 1 m. The main difference in total noise between the two reports could be attributed to the nature of the seabed rock that was being drilled in the Timor Sea. Intuitively, it would be expected that underwater drilling noise gives rise to higher levels when drilling through harder rocks. However, no discussion of subsea bedrock type was made in the McCauley paper so further comparisons in noise levels between Timor Sea and Billia Croo are nugatory.

It is not clear whether the underwater noise as recorded by McCauley (1998) was due entirely to the action of the drill bit on the seabed rock. It is understood that additional noise may be introduced into the water through supporting equipment on the drilling rig via the rig superstructure. There is however, insufficient data available in McCauley (1998) to allow for any quantitative partitioning of the noise levels between each noise generating mechanism.

During the measurement activity at Billia Croo, underwater background noise in the absence of drilling was recorded. In the subsequent data processing, the noise due to drilling only was extracted from the total noise dataset and this was added to the background noise spectrum recorded at Isle of Lewis during August 2011 (Kongsberg 2011). The total noise spectrum used for the analysis discussed in this report is shown in Figure 4.2 while corresponding 1/3 octave band levels for each are given in Appendix A.

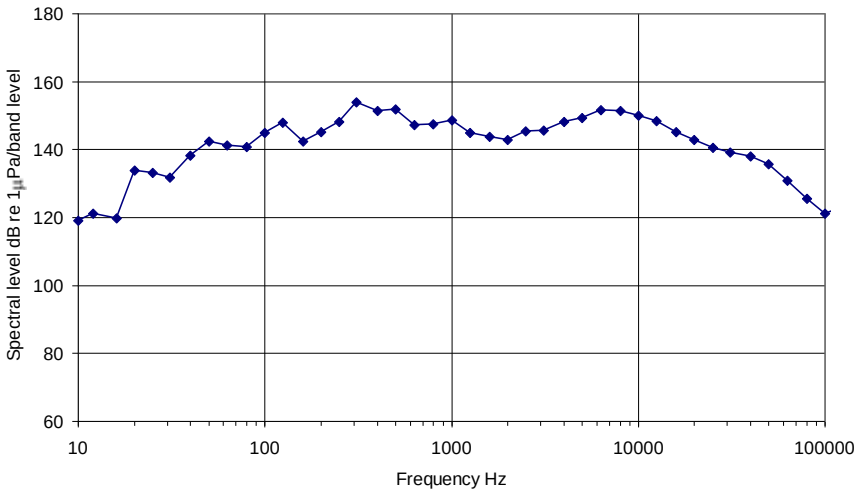

Figure 4.2: Source spectrum of drilling noise

[6] See http://www.seacore.com/downloads/pdf/t40

4.3 Operational noise

It was anticipated that underwater operational noise data from the Oyster 800 installed at the EMEC wave test site would be available in time for the analysis undertaken in this report. Due to the fact that the device has not been fully commissioned and operating by the time this report was written, this was not possible hence it has been necessary to source alternative data[7].

It is speculated that the Oyster WEC is likely to have low operation noise levels. Anecdotal evidence from divers working on the EMEC range suggest that the highest levels of noise arising may be attributed to the noise of the hydraulic fluid running through the pipelines. In order to complete the acoustic assessment, it was decided to generate a synthetic spectrum based loosely on drilling noise with its overall noise level reduced by an arbitrary 3 dB. The frequency spectrum for this is given in Figure 4.3.

There is no data on the vertical or azimuthal directivity of the operational noise. It is assumed therefore that source sound levels are independent of bearing about the Oyster devices.

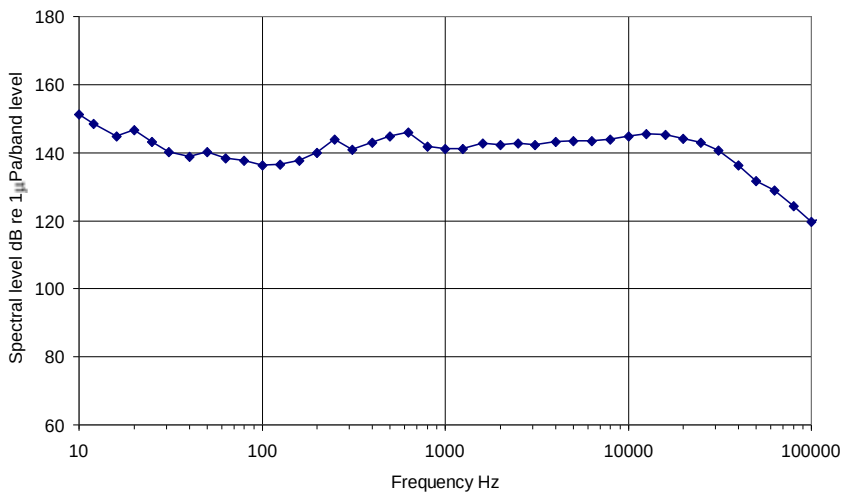

Figure 4.3: Source spectrum in third octaves of operational noise

4.4 Decommissioning noise

It is estimated that the Lewis Wave Power Development will have an operational lifetime of 20-25 years. After this, a decision will be made to decommission (or re-power) the site. During the decommissioning programme, it is likely that the Oyster wave devices will be lifted off the seabed using a crane or hoist then towed back to port as they are buoyant. Any structures remaining below the water line will be cut off level with the seabed. The foundation grouting is likely to remain in place.

Only two sources of noise have been identified from this notional decommissioning programme: cutting noise and vessel noise. Since decommissioning of an Oyster development has not taken place yet there is no data currently available on cutting noise from the large scale tools likely to be used for this operation therefore no acoustic impact assessment of this is possible. In the event that cutting noise is as loud as drilling noise, then the spatial extent of cutting noise is likely to be the same as for drilling noise. In the

[7] It is anticipated that underwater measurements of operational noise will be made during Spring or Summer 2012 and an update to this report will subsequently be issued.

absence of any suitable data, it is proposed that drilling noise will be a suitable proxy for cutting noise. Tug-type vessels are likely to be used to tow the barges to and from the site. Information on source levels and frequency spectra is given in Section 5.2.

4.5 Background noise

Underwater background noise levels within the Lewis Wave Power Development area were recorded during August 2011 (Kongsberg 2011b). Kongsberg-developed seabed recorders were located at two sites (denoted by RUNES-5 and RUNES-6 - see Figure 4.4) over a two-week period. Background noise was sampled for 2 minutes every 30 minutes over a broadband frequency range of 20 Hz to 250 kHz. Subsequent data processing revealed that the background noise level at RUNES-5 was 119 ± 6 dB re 1 μPa while that at RUNES-6 was 117 ± 4 dB re 1 μPa. Such levels are consistent with measurements made in shallow coastal waters around the UK (Nedwell *et al*. 2003). The difference in noise levels at the two sites is not considered to be significant.

A comprehensive discussion of underwater background noise at the Isle of Lewis sites is given in the ensuing deployment report (Kongsberg 2011).

Figure 4.4: Map showing positions of measurement locations

4.6 Summary of noise sources

Although there is extensive literature on shipping noise in general, specific details of noise levels for the types of vessels that are expected to be used on the Lewis Wave Power project are not currently available. It may be assumed that a tug type vessel is used to provide the parameters that characterise the vessel noise, hence the broadband source level should be taken as 172 dB re 1 μPa at 1 m. Drilling noise is based on measurements made at the EMEC wave site during summer 2011 and uplifted by taking into account the background underwater noise measurements made off the Isle of Lewis during summer 2011. Operational noise is based on synthetic data. When actual operational noise data becomes available, an update to this report will be issued.

5. SOUND PROPAGATION MODELLING

5.1 Introduction

In order to assess the impact of underwater sound on marine life, it is necessary to model its propagation from the source to a point in the far field. For accuracy, the process invariably requires the use of sophisticated modelling techniques and site-specific data. This section discusses the acoustic models used and the geoacoustic and oceanographic data required as input parameters for the models.

5.2 Underwater acoustic propagation models

A very simple approach to modelling underwater propagation is to consider simple geometrical spreading laws given by

$$TL = N \log_{10}(r) \qquad \text{eqn. 5.1}$$

where TL is the propagation loss in dB, N is a constant: 20 for spherical spreading and 10 for cylindrical spreading; and r is the distance in metres from the source to the receptor.

When sound propagates uniformly in all directions, spherical spreading applies. When the propagation of sound is constrained by the water surface and the seabed, then cylindrical spreading is most applicable (see e.g. Urick 1983). Although computing the propagation loss in this way is very quick, the biggest drawback is that it fails entirely to take into account the influence of both the environment and of signal frequency on the propagation of sound and hence the propagation loss may be under- or over-estimated, often by a considerable amount. The solution to this is to make use of more sophisticated modelling techniques and these are described briefly below.

The calculation of propagated, underwater sound fields is based on a solution to the Helmholtz equation having appropriate boundary conditions (see e.g. Brekhovskikh and Lysanov 1991). The boundary conditions used and the modelling regime to be considered logically lead to one or other solution to the Helmholtz equation and this has given rise to a number of classes of models that employ similar techniques. The models are based on ray theory, normal mode, parabolic equation and full-field techniques (Buckingham 1992, Etter 2003). Each set of solutions are valid and computationally efficient over a limited frequency, depth and range regime. For instance, ray theory is most suited to short range and high frequency scenarios while normal mode and parabolic equation are applied to long range and low frequency models. Full-field models are applicable to many scenarios but are often computationally intensive and require a large level of user-experience to ensure that the mathematical iterative processes have reached convergence (Jensen *et al.* 2000).

In general the models operate at narrow-band frequencies and do not therefore easily lend themselves to applications involving broadband sound sources and assessment metrics such as peak level and Sound Exposure Level. To cover the broad range of frequencies of interest to the current study, it is acceptable however to use more than one type of model. At low frequencies, the propagation modelling relies on the fully range-dependent parabolic equation model RAM (Collins 1993). At high frequencies, RAM becomes too cumbersome to use so a ray-trace model is used instead. The switchover frequency is dependent on the wavelength of the signal and the water depth in which the source is located. When the water depth reaches approximately 8 wavelengths (the wavelength of sound is equal to c_w/f where c_w is the sound speed in water and f is the frequency of the propagating signal); then it becomes more computationally efficient to use an alternative modelling technique. The Lewis Wave Power development region is a shallow water site with water depths varying between 2m and 60 m along propagation paths radiating from the survey regions. For these shallow water depths, the changeover frequency occurs around 500 Hz. Subsequently, the ray-trace model Bellhop was used.

As the sound propagates with range through the water, generally it loses energy. There are a number of mechanisms by which this happens. Urick (1983) provides a detailed explanation of these and an overview is given as follows. The first mechanism is due to spreading over range and is a process whereby acoustic energy is converted into heat which is subsequently dissipated in the ocean. The second is due to the interaction of the sound wave with various dissolved salts in the water. This is proportional to the frequency of the propagating signal and the associated losses become considerable at frequencies in excess of 100 kHz. The third mechanism involves reflection and refraction of acoustic energy at the water/seabed interface. The means by which this is modelled starts with the depiction of the water and seabed layers in an idealised representation given below.

Both computer models make use of a shallow water depth- and range-dependent layer overlying two lossy, fluid layers representing the seabed sediment and the underlying basement. This is shown schematically in Figure 5.1 below. It is noted that the classic 3-layer acoustic model as represented in RAM and Bellhop assumes a basement rock that is semi-infinite in thickness. The data that is used to parameterise each layer is discussed below.

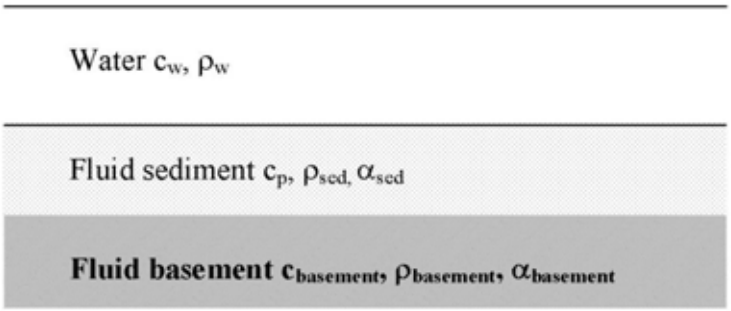

Figure 5.1: Schematic of acoustic model

It is noted that the modelling techniques relied upon by both RAM and Bellhop, are based on mature and rigorous scientific methodologies that have been reviewed extensively in the international literature over a number of years. It is considered of fundamental importance that acoustic modelling is not based on "in-house" solutions using non peer-reviewed techniques as this could compromise the developer in the event that the environmental impact assessment documents become subject to scrutiny. Such techniques (reviewed in Kongsberg 2010) rely on simple geometrical spreading arguments or empirical techniques and fail to incorporate the complex mechanisms required to explain fully how underwater sound propagates through the environment.

5.3 Sound propagation transects

Water depth data was taken from the bathymetry database ETOP01 (Amante and Eakins 2009). This is a database of water depths having global coverage and a resolution of 1 min of arc - corresponding to a spatial separation of around 1.8 km around the Isle of Lewis.

The nominal centre of the Lewis Wave Power Development area is located at 58°25.74'N 006°28.9'W in a water depth of 12 m and some 800 m offshore. Water depth data was taken along a total of 24 transects radiating from the nominal centre thus giving an azimuthal separation of each transect of 15° (see Figure 5.2).

The lengths of the transects were nominally 10 km but these were limited by the Isle of Lewis for those that lay on bearings from approximately 45° through to 135°. For these transects, the water depth falls to zero at a range of approximately 2 km. All other transects are located in open water where the water depth increases to around 60 m at 10 km range.

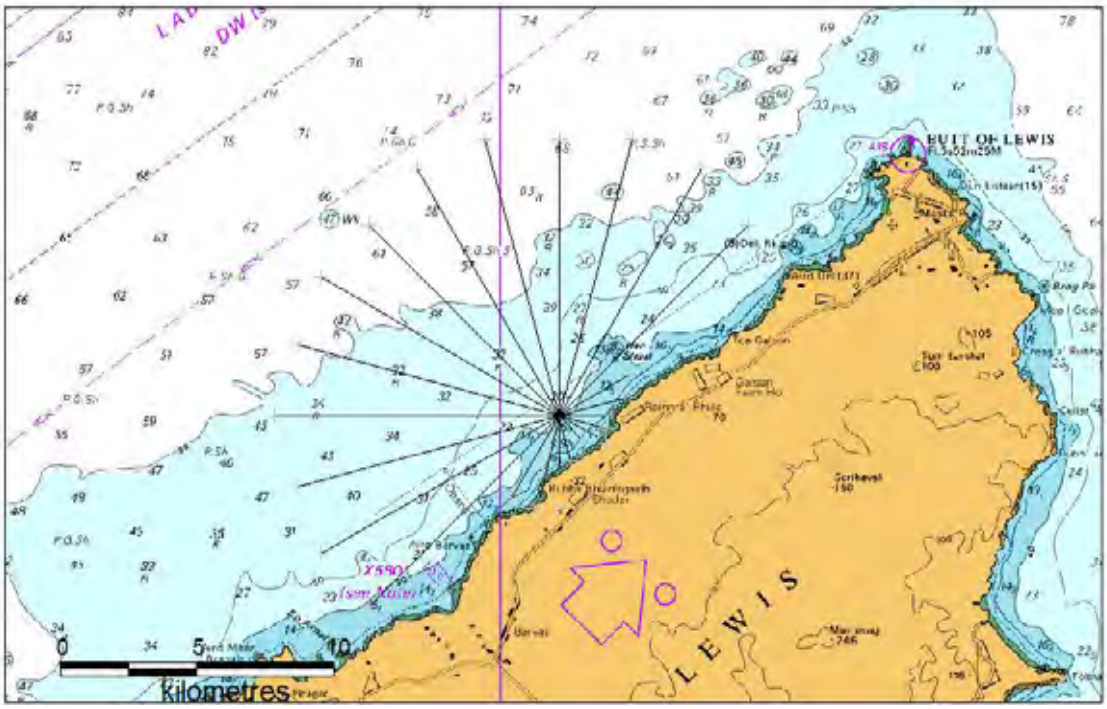

Figure 6.2: Location of acoustic propagation modelling transects in the Lewis Wave Power development area

5.4 Oceanographic data

Oceanographic data was obtained through the World Ocean Atlas (WOA 2009). This consists of gridded monthly samples of temperature, salinity and depth and from which sound speed profiles relevant to the Lewis Wave Power development area may be reconstructed.

Due to weather constraints, it is expected that both the construction and decommissioning phases will take place between spring and autumn while the Oyster devices are likely to be in operation all year round. From an oceanographic perspective, over the course of a year the sound speed profile in the relatively shallow waters of the UK undergoes a marked change in characteristics. During the winter months, the sound speed tends to increase uniformly with depth leading to an upwardly refracting profile by the month of February. During late spring and early summer, increased solar heating of the topmost layers causes an increase in the sound speed over the topmost 10-20 m below which the seasonal thermocline gives rise to a downwardly refracting profile. This leads to the creation of a surface duct that tends to channel acoustic energy emitted from shallow sources while below this, the energy tends to be directed towards the seabed. As the surface waters cool down and become well-mixed due to the autumnal storms, the surface duct is lost and the profile tends to become increasingly upwardly refracting once again.

In order to adequately characterise the environment yet keep the number of acoustic runs to a realistic limit, acoustic propagation modelling was undertaken using the February and August sound speed profiles as these two months are most likely to give rise to the maximum and minimum propagating conditions.

Sound speed profiles for the Lewis Wave Power development area are shown in Figure 6.3. It will be seen that the February sound speed increases with increasing water depth. This gives a profile that is upwardly refracting throughout the water column down to the seabed. The August profile shows a weak downwardly refracting profile to a depth of about 30 m followed by the seasonal thermocline down to the seabed. For this profile, there is a tendency for underwater sound to be generally directed towards the sea surface. Given

these two profiles, longer range acoustic propagation is more likely to occur during winter than during summer.

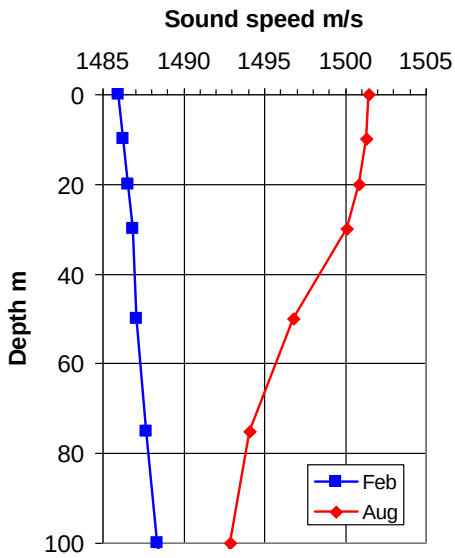

Figure 6.3: Representative sound speed profiles offshore Isle of Lewis for February (representing winter) and August (representing summer)

5.5 Geo-acoustic parameters

Surveys undertaken in the area (Aspect 2010) determined that a wide range of substrate types was found to be present, including coarse sand, gravel, pebble, cobble, boulder and bedrock. However, the dominant substrate type recorded was rugged bedrock with areas of boulder and cobble occurring on the Siadar site and coarse sand being found relatively close inshore (off Sgeir lasgan and Torsuigabac in the Siadar survey area). Additional data is provided by Moore and Roberts (2011) where it is indicated the seabed consists of uneven bedrock with patchy areas of boulders and cobbles on thin layers of coarse sand. Hamilton (1963, 1970, 1972) provides advice on seabed sediment parameters. From this, sound speed and attenuation data was obtained and the data is summarised in Table 6.2.

Layer	Compressional wave velocity Vp m/s	Density kg/m^3	Attenuation dB/m/kHz	Thickness m
Terrigenous sand	1647	2000	0.459	5
Metamorphic basement	5548	2745	0.094	-∞

Table 5.2: Sediment parameters for acoustic models

5.6 Sound modelling parameters

Due to the limitations of the acoustic propagation techniques (Etter 2003), it is necessary to assume that the sources are equivalent to acoustic points, for which discrete source depths were required. Typically for the purposes of acoustic propagation in a water channel, the acoustic centre of a vessel is assumed to lie at a water depth of 6 m; the acoustic centre of the Oyster WEC is assumed to be half the water depth – where this is based on the approximate location of the hydraulic modules (Lewis Scoping report 2011); and drilling noise is assumed to originate on the seabed.

The input parameters for the acoustic propagation modelling as discussed in this section are summarised in Table 5.3.

Parameter	Vessel	Drilling	Operational
Source depth m	6	11	6
Frequency Hz	20, 25, 31, 40, 50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1k, 1.25k, 1.6k, 2k, 2.5k, 3.15k, 4k, 5k, 6.3k, 8k, 10k, 12.5k, 16k, 20k, 25k, 800, 31.5k, 63k, 80k, 100k, 125k, 160k, 200k		
Winter	✓	✓	✓
Summer	✓	✓	✓

Table 5.3: Source parameters for acoustic model inputs

6. PROPAGATION MODELLING RESULTS

6.1 Introduction

This section of the report describes the acoustic propagation modelling undertaken in Section 5 to predict the unweighted sound levels with range.

6.2 Drilling noise

Underwater drilling tends to be a low noise level operation at least compared with other activities. In a relatively noisy environment such as the Lewis Wave Power Development area where background noise levels are fairly high (in the range 113 – 121 dB re 1 μPa - see Section 4), it may be assumed that the drilling noise will propagate over only short distances before it falls below background noise levels. There are two further loss-inducing mechanisms which bear discussion. In a shallow water channel, the lowest frequencies arising from a sound source contribute nothing to the overall SPL in the water column. The cut-off frequency in a water channel is related to the water depth and the wavelength of a given signal (Urick 1983). Using data relevant to the Lewis Wave Power Development area, it may be shown that the cut-off frequency is around 130 Hz, that is, energy with a frequency less than 130 Hz will become absorbed into the seabed and will not contribute to the sound levels in the water. In addition, the highest frequencies become rapidly attenuated with distance due to the absorptive properties of the salts dissolved in the seawater. Urick (1983) shows that at frequencies above 100 kHz, the losses become considerable. The significance of these two properties, taken in conjunction with the source spectrum shown in Figure 4.2, means that propagated SPLs are likely to be low. This is supported by the results discussed below.

Drilling noise was modelled as a function of range using oceanographic conditions for the months of both February and August. In each case, the source is located on the seabed at a depth of 12 m. The SPL thus plotted is given as the maximum value though the water column at each range. Figure 6.1 shows the modelled SPL using oceanographic conditions for both months and it will be seen that there is a steady decrease in sound pressure level with increasing range. The SPL falls to background noise levels (113 dB re 1 μPa) at a range of approximately 2 km. It is noted that there is very little difference between the results for February and August. This is attributed to the fact that because the water is so shallow, substantial levels of acoustic energy become absorbed into the seabed before the environment has any chance of further influencing the distribution of sound. The effect of water depth on the propagation of sound may be explored further. Figure 6.2 shows a contour plot of sound level as a function of depth and range using February oceanographic conditions and along the transect having a bearing of 285°. From Figure 5.2, it is noted that this transect lies approximately perpendicular to the coastline and thus points directly out to sea. It will be seen that over the entire water column, the SPL has fallen to background noise levels at a range of around 0.7 km. There is a tendency for the sound to become channelled at mid-water depth: at the water surface the sound levels start low, increase with depth then fall off again as the seabed is reached. This is slightly clearer in Figure 6.3 which shows the contour plot as function of depth and range along the transect having a bearing of 105° - this being the one that radiates from the Oyster to the coastline. It will be seen that as the sound propagates up the slope towards the coastline, the overall sound pressure in the water column rapidly decreases. The SPL has fallen to 140 dB re 1 μPa at around 0.2 km, 130 dB re 1 μPa is reached at 0.6 km and the background level is attained at around 1.2 km. The channelling at mid-water depth is also evident.

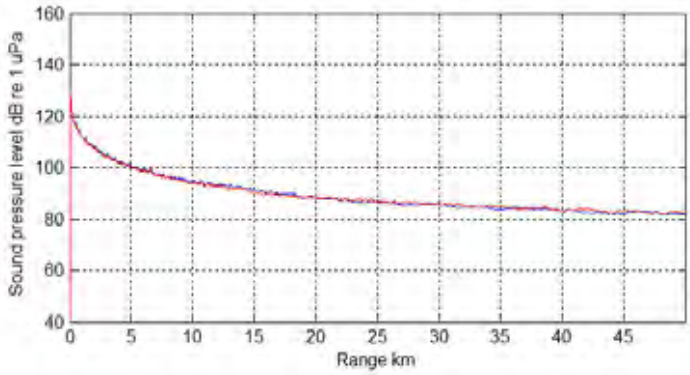

Figure 6.1: Drilling noise as a function of range for the months of February (blue) and August (red)

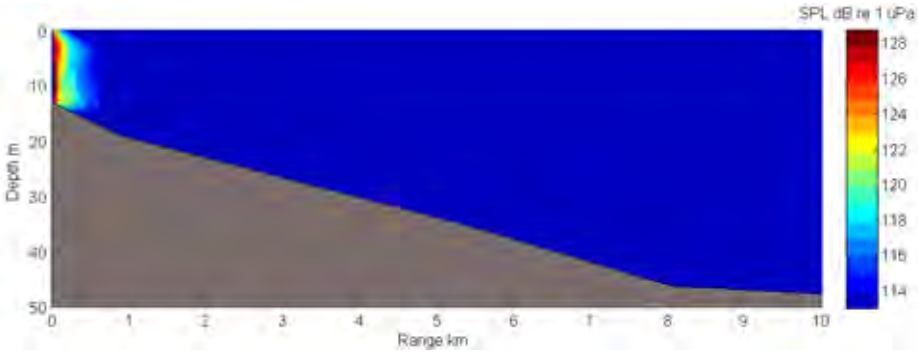

Figure 6.2: Drilling noise as a function of range and depth along the transect at a bearing of 285° for the month of February (note the part coloured grey indicates the seabed)

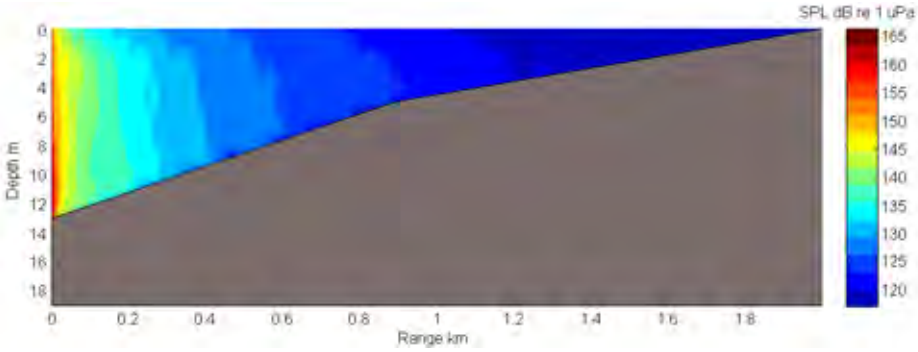

Figure 6.3: Drilling noise as a function of range and depth along the transect at a bearing of 105° for the month of February

6.3 Operational noise

Figure 6.4 shows operational noise as a function of range modelled using oceanographic and climatological conditions for the months of February and August. It is noted that noise levels fall fairly uniformly with increasing range. Further, it will be seen that there is no significant difference between SPLs predicted using oceanographic conditions for the two months. The reasons for this have been discussed in the previous section.

Operational Oyster WECs are expected to give rise to slightly lower levels of underwater noise compared with drilling activities. The background noise levels in the Lewis Wave Power Development area are variable, lying in the range 113 – 121 dB re 1 μPa, and therefore have the potential to drown out the operational noise from time to time even at relatively short distances from the Oyster WECs. Figure 6.4 indicates that when background levels are at their highest, operational noise may fall to background levels as close as 0.05

km from the Oysters. This distance may increase to 0.25 km when background noise levels are at their lowest. It is worth mentioning that low background noise levels are associated with low wave activity with the result that the Oyster WECs will also be emitting lower operational noise levels.

Figure 6.5 shows SPL as a function of depth and range along the transect having a bearing of 285° computed using oceanographic conditions for the month of February. It is seen that very little energy is propagated beyond a distance of 0.5 km before background noise levels are attained. Along the transect heading upslope and in-shore (Figure 6.6), the energy is seen to be rapidly stripped out of the water column as it interacts increasingly with the seabed. Apart from a shadow zone over the first metre or so, acoustic energy is distributed throughout the water column.

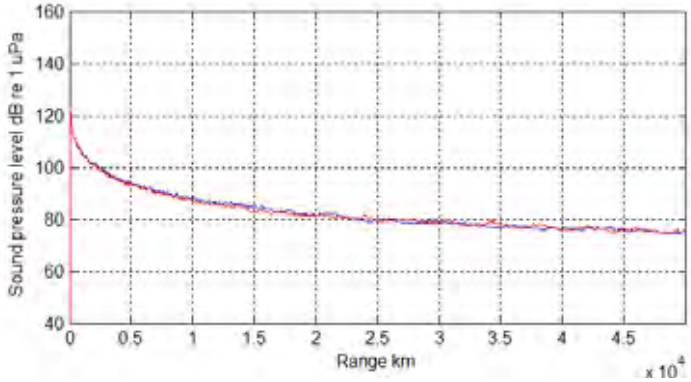

Figure 6.4: Drilling noise as a function of range for the months of February (blue) and August (red)

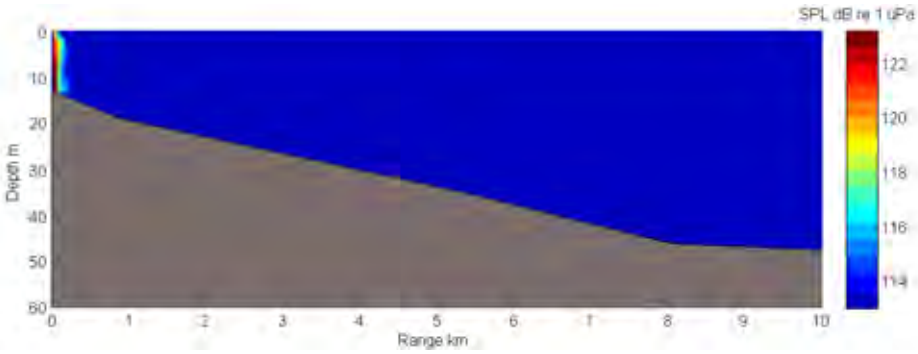

Figure 6.5: Operational noise as a function of range and depth along the transect at a bearing of 285° for the month of February

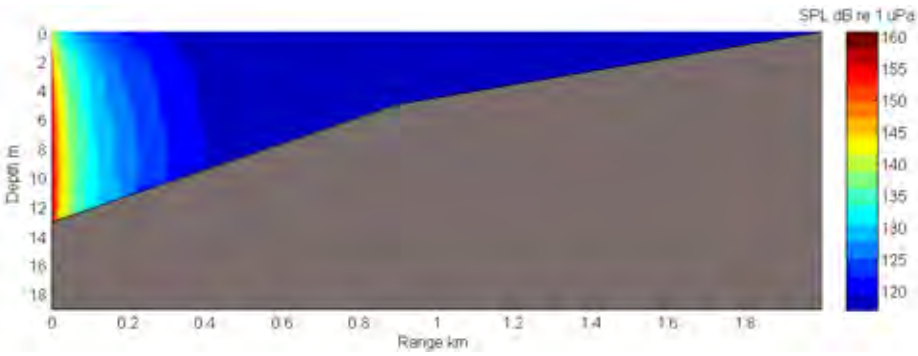

Figure 6.6: Operational noise as a function of range and depth along the transect at a bearing of 105° for the month of February

6.4 Vessel noise

Figure 6.7 indicates that in both February and August, vessel noise (based on the tug/barge noise level data presented in Section 5.2) remains audible out to ranges of 8.7 km to 9.7 km depending on the prevailing levels of background noise. The contour plot shown in Figure 6.8 shows that along those transects that are heading into deeper water offshore (see Figure 6.2), the sound energy tends to propagate at mid-water depths while for those transects heading in-shore into progressively shallower water, as illustrated in Figure 6.9, the sound energy is rapidly absorbed into the seabed, falling to background levels over a distance of 1.1 km.

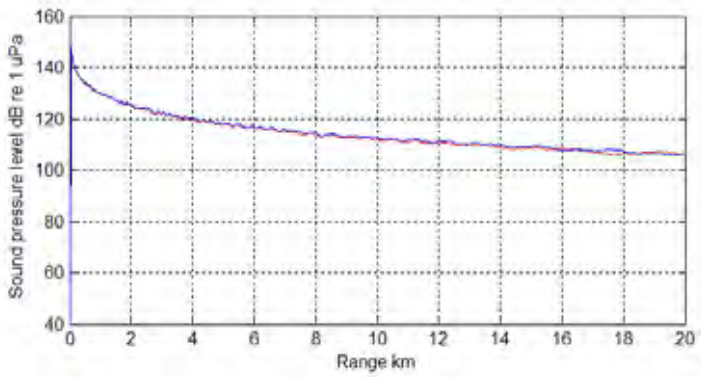

Figure 6.7: Vessel noise as a function of range for the month of February (blue) and August (red)

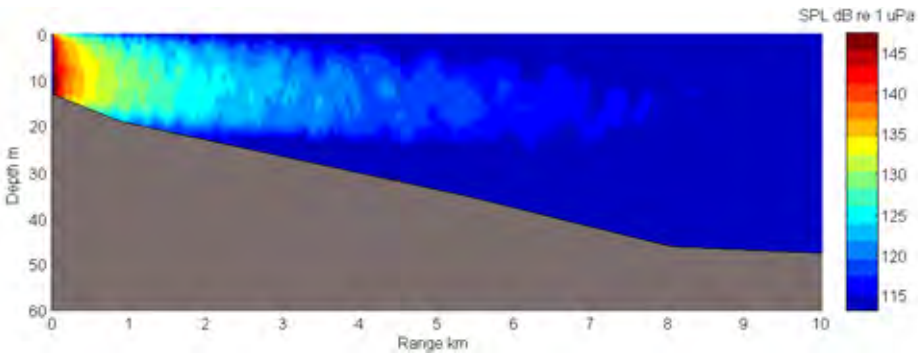

Figure 6.8: Vessel noise as a function of range and depth along the transect at a bearing of 285° for the month of February

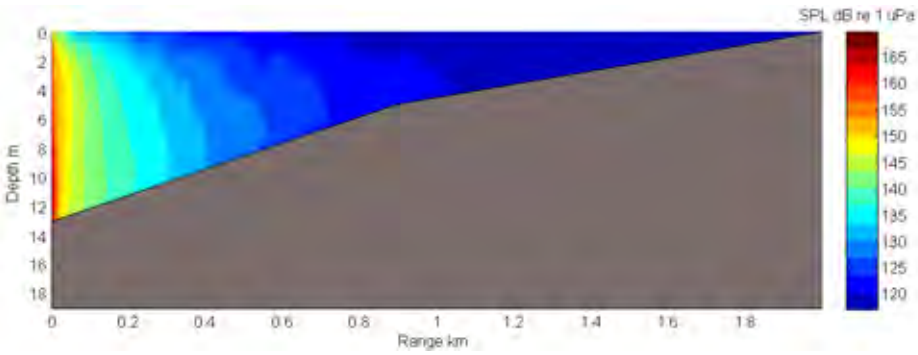

Figure 6.9: Vessel noise as a function of range and depth along the transect at a bearing of 105° for the month of February

6.5 Summary of acoustic modelling

The results from the acoustic propagation modelling show that as a result of the high background noise levels and the generally low source levels for each of the noise-making activities associated with the Lewis Wave Power Development, man-made noise will tend to propagate over relatively short distances before becoming masked by the background. The variation lies between 0.05 km and 9.7 km depending on the particular noise source and the particular background noise level considered. There is seen to be very little dependence on propagation ability due to time of the year. This is attributed to the very shallow water in which the Oyster WECs are installed.

The unweighted SPLs computed for each of the noise sources discussed above may be used to determine likely impacts on sensitive species of marine life identified in Section 3.

7. ACOUSTIC IMPACT ANALYSIS - SINGLE SOURCE

7.1 Introduction

The levels of underwater noise generated during installation, operational and decommissioning activities in the Lewis Wave Power Development area, are used here to estimate impact zones for a number of target marine species *viz.* odontocetes; mysticetes; pinnipeds; hearing-generalist fish; and hearing-specialist fish. A discussion of the ranges for each impact is given below.

7.2 Lethal injury range

The source levels for vessel, drilling, operational and cutting noise (based on drilling noise – see Section 4.4) are all considerably below the levels at which lethal injury to species of marine mammal and fish might occur (established at 240 dB re. 1 μPa). It is therefore considered unlikely that any marine animals will be killed as a consequence of the underwater noise from any of the activities undertaken for the Lewis Wave Power project.

7.3 Hearing damage injury range

Both PTS and TTS have the potential to arise on an animal when either the SPL peak level or the SEL dosage is exceeded. In the first case, peak source levels associated with vessel, drilling and operational activities are below the levels at which hearing damage from the underwater noise might occur (established at 230 dB re. 1μPa and 224 dB re. 1μPa for the onset of PTS and TTS for cetaceans and 218 dB re. 1μPa and 212 dB re. 1μPa for the onset of PTS and TTS for pinnipeds). Even taking into account the more conservative criteria proposed by Lucke *et al*. (2009) for harbour porpoises (193.7 dB re 1 μPa) and those put forward by the US NMFS (1995), whereby auditory injury may occur to pinnipeds and cetaceans following prolonged exposure to underwater sound at levels at or above 190 dB re. 1 μPa and 180 dB re. 1 μPa respectively, the source levels associated with vessel, drilling and operational activities were sufficiently low such that the impact criteria were not exceeded.

The use of SEL as an impact criterion requires an understanding of the build-up of an acoustic dose on an animal as it is exposed to a noise source over a period of time. This may be explored by developing a scenario whereby an animal moves through a region where various noise sources are in operation and determining the time it takes for the SEL on the animal to build up to a level such that the PTS and TTS impact criteria are met (Theobald 2009).

The model assumes an animal enters the Lewis Wave Power Development area from offshore and approaches an Oyster WEC no closer than a distance of 20 m, then swims due north-east on a constant bearing at a speed of 5 m/s. Given this scenario, neither the PTS nor TTS impact criteria are met for any of the cetacean or pinniped species. In addition, the Lucke *et al*. (2009) TTS impact criterion for harbour porpoises (164.3 dB re 1 $\mu Pa^2 s$ SEL unweighted) is not met. Similarly, none of the PTS and TTS impact criteria are met given alternative scenarios where the animal approaches to within 10 m and 5 m of the WEC. When the transit speed of the animal is reduced to 2 m/s, the TTS impact criterion for harbour porpoise is met after an exposure time of 12 minutes. Changing the scenario to one of an animal approaching the drilling site while adjacent WECs are operational does not lead to a substantially different result.

It is noted that these scenarios are for illustrative purposes only. The study of animal behavioural response to sound stimuli is known to be fraught with difficulties: Southall *et al*. (2007) observes that responses elicited are hugely context-driven and very variable.

It is further noted that hearing damage criteria for fish and invertebrates have not been developed hence it is not possible to assess the impact of noise on these species.

7.4 Behavioural avoidance ranges

This part of the assessment is concerned with comparison of predicted underwater noise levels from each of the activities associated with the Lewis Wave Power Development with threshold levels for various criteria relating to behavioural impacts. The criteria considered will be the Level B – Harassment, Low level behavioural and the dB_{ht}.

7.4.1 Unweighted behavioural impacts

The first impact criterion to be considered is the Level B – Harassment of 160 dB re 1 μPa (rms) (NMFS 1995). This is an unweighted metric that does not require the application of an M-weighted filter representing the hearing functionality of the target species. When this threshold is applied to the propagation data, it will be seen that the source levels associated with drilling and operational activities are below the threshold at which Level B – Harassment might occur. It is unlikely therefore that marine animals will suffer Harassment from the noise arising from either noise source. For vessel noise, the Level B criterion may be met when marine animals are within 7 m of the largest vessels likely to be used in the Lewis Wave Power Development.

Low-level behaviour is delineated by the unweighted 140 dB threshold limit. The source level associated with drilling, being 141 dB re 1 μPa, is just sufficient for the criterion to be met at a distance of 1 m from the source. However, the source level for operational noise at 135 dB re 1 μPa, is below the threshold at which behavioural reactions might arise. When marine mammals are exposed to vessel noise, Low-level behavioural changes may be seen at distances up to 150 m during both February and August.

When using the SEL as a metric and the model scenario discussed earlier, the Aversive Behaviour criterion for the harbour porpoise (145 dB re 1μPa^2s SEL as proposed by Lucke *et al*. (2009)) is met after a time of 70 seconds.

7.4.2 Weighted behavioural impacts

The behavioural impact model is based on the dB_{ht} technique where the frequency spectrum of the source noise is compared with the hearing threshold of the target species. The overall difference between the two curves gives the apparent loudness of the vessel as perceived by the target species. The apparent loudness in dB_{ht} of each noise source as perceived by each of the target species is given in Table 7.1. The propagation loss data (computed using the acoustic modelling undertaken and as discussed in Section 6) is applied to the apparent loudness of the sources for each species. Subsequently, the range at which sound pressure level has fallen to the threshold for each behavioural impact may be easily determined. Two behavioural impact criteria have been considered: 90 dB_{ht} and 75 dB_{ht} corresponding to strong avoidance reactions and mild avoidance reactions respectively. These are applied to the generic groupings: mysticetes; odontocetes; pinnipeds; hearing-specialist fish and hearing-generalist fish. In addition the analysis has been applied to the specific fish species: Atlantic salmon, basking shark, European eel, sea trout and herring. The herring is classed as a hearing-specialist while the basking shark is assumed to be a hearing-generalist[8] as they have no swimbladder so for the purposes of the subsequent analysis, the impact analysis for the herring will be based on the hearing-specialist and that for the shark will be based on the hearing-generalist.

Tables 7.2, 7.3, 7.4 and 7.5 show that no behavioural reactions are likely to be seen in Atlantic salmon, European eel, sea trout and hearing generalist fish respectively when they are exposed to drilling or operational noise while mild behavioural reactions out to a

[8] Audiograms for the basking shark are not available hence the precise hearing capability of the shark is not known. It is noted that the basking shark does not have a swimbladder so it is assumed to be a hearing-generalist. However, the fish may be more sensitive to particle displacement and hence uses pressure variation as a means of prey detection.

maximum distance of 5 m may be seen when they are exposed to vessel noise. It is noted that these groupings are the most insensitive of all species to the man-made noises that may be made in connection with the Lewis Wave Power Development.

For hearing specialist fish (Table 7.6), only vessel noise is sufficiently loud to elicit a strong behavioural reaction and then only out to a distance of 8 m. Mild behavioural reactions may be seen out to a maximum distance of around 73 m, 4 m and 1 m when exposed to vessel, drilling and operational noise respectively.

Pinnipeds are relatively insensitive to all man-made noises considered in this analysis (Table 7.7). The maximum distance out to which a strong behavioural reaction may be seen is 9 m when the animal is exposed to vessel noise. Similarly, mild behavioural reactions may be seen out to a maximum distance of 58 m when exposed to the same source.

Cetaceans are likely to be the most sensitive of all species considered to the man-made noises associated with the Lewis Wave Power Development. Odontocetes such as the harbour porpoise and common dolphin may show signs of strong behavioural reactions out to 47 m from vessels (Table 7.8) while for mysticetes such as minke whales, the distance increases to 208 m (Table 7.9). Mild behavioural reactions in the odontocetes and mysticetes may be seen at distances up to 300 m and 1700 m respectively from vessels. Both groupings are less sensitive to drilling noise and operational noise with the maximum ranges out to which strong behavioural avoidance and mild behavioural avoidance reactions may be seen is 18 m and 115 m respectively.

A summary of the behavioural impact ranges for each of the target species when exposed to each noise source is given in Tables 7.2 to 7.9.

	Apparent loudness dB_{ht}		
	Drilling	Operational	Vessel
Mysticete	113.1	107.9	128.0
Odontocete	113.3	112.3	121.1
Pinniped	99.7	95.0	107.8
Fish – hearing-specialist	83.1	76.4	102.9
Fish – hearing-generalist	60.3	55.0	84.2
Atlantic salmon	55.2	58.2	78.5
European eel	51.5	45.9	76.3
Sea trout	40.7	33.8	61.5

Table 7.1: Apparent loudness of noise sources as perceived by target species

		Strong avoidance ($90\ dB_{ht}$)	**Mild avoidance ($75\ dB_{ht}$)**
Feb	Vessel	<1 m	2 m
	Drilling	<1 m	<1 m
	Operational	<1 m	<1 m
Aug	Vessel	<1 m	2 m
	Drilling	<1 m	<1 m
	Operational	<1 m	<1 m

Table 7.2: Behavioural impact ranges for Atlantic salmon

		Strong avoidance (90 dB_{ht})	Mild avoidance (75 dB_{ht})
Feb	Vessel	<1 m	1 m
	Drilling	<1 m	<1 m
	Operational	<1 m	<1 m
Aug	Vessel	<1 m	1 m
	Drilling	<1 m	<1 m
	Operational	<1 m	<1 m

Table 7.3: Behavioural impact ranges for European eel

		Strong avoidance (90 dB_{ht})	Mild avoidance (75 dB_{ht})
Feb	Vessel	<1 m	<1 m
	Drilling	<1 m	<1 m
	Operational	<1 m	<1 m
Aug	Vessel	<1 m	<1 m
	Drilling	<1 m	<1 m
	Operational	<1 m	<1 m

Table 7.4: Behavioural impact ranges for sea trout

		Strong avoidance (90 dB_{ht})	Mild avoidance (75 dB_{ht})
Feb	Vessel	<1 m	5 m
	Drilling	<1 m	<1 m
	Operational	<1 m	<1 m
Aug	Vessel	<1 m	5 m
	Drilling	<1 m	<1 m
	Operational	<1 m	<1 m

Table 7.5: Behavioural impact ranges for hearing-generalist fish

		Strong avoidance (90 dB_{ht})	Mild avoidance (75 dB_{ht})
Feb	Vessel	8 m	73 m
	Drilling	<1 m	4 m
	Operational	<1 m	1 m
Aug	Vessel	8 m	73 m
	Drilling	<1 m	4 m
	Operational	<1 m	1 m

Table 7.6: Behavioural impact ranges for hearing-specialist fish

		Strong avoidance (90 dB_{ht})	Mild avoidance (75 dB_{ht})
Feb	Vessel	9 m	58 m
	Drilling	3 m	21 m
	Operational	2 m	12 m
Aug	Vessel	9 m	58 m
	Drilling	3 m	21 m
	Operational	2 m	12 m

Table 7.7: Behavioural impact ranges for pinnipeds

		Strong avoidance (90 dB_{ht})	Mild avoidance (75 dB_{ht})
Feb	Vessel	47 m	300 m
	Drilling	18 m	115 m
	Operational	16 m	101 m
Aug	Vessel	47 m	290 m
	Drilling	18 m	115 m
	Operational	16 m	101 m

Table 7.8: Behavioural impact ranges for odontocetes

		Strong avoidance (90 dB_{ht})	Mild avoidance (75 dB_{ht})
Feb	Vessel	208 m	1700 m
	Drilling	17 m	112 m
	Operational	9 m	59 m
Aug	Vessel	190 m	1520 m
	Drilling	17 m	112 m
	Operational	9 m	59 m

Table 7.9: Behavioural impact ranges for mysticetes

8. ACOUSTIC IMPACT ANALYSIS - MULTIPLE SOURCES

8.1 Introduction

Cumulative impact assessment in the context of this report refers to the acoustic impacts arising on a marine species when it is exposed to multiple sound sources operating concurrently. An assessment of cumulative impacts covered a number of construction scenarios taking into account the proposed phased approach to the installation and interaction of neighbouring Oyster wave devices.

The range over which cumulative effects become apparent depend on the apparent source level of the impacting noise as well as the ease or otherwise over which the sound propagates. If the radius of any given impact zone is less than the Oyster wave device spacing, then cumulative impacts are less likely to warrant close scrutiny. From the preceding analysis it is likely therefore that physical injury and deafness zones will not give rise to cumulative effects, while behavioural impacts may well do so.

Lewis Wave Power plans to install between 40 (1MW) and 50 (800kW) Oyster WECs over a period of 4 to 6 years. A notional installation schedule based on 50 1MW WECs and a construction period of 5 years is given by:

Phase 1 in 2014 consisting of an initial deployment of 3 x 1 MW Oysters;

Phase 2 in 2015 consisting of a further deployment of 7 x 1 MW Oysters;

Phase 3 in 2016 consisting of a further deployment of 15 x 1 MW Oysters;

Phase 4 in 2017 consisting of a further deployment of 15 x 1 MW Oysters.

Phase 5 in 2018 consisting of a final deployment of 10 x 1 MW Oysters.

The first installation will take place at the southern-most end of the development and work will proceed in a north-easterly direction. It is expected that each phase will become operational before the next installation takes place. The multiple-source scenarios considered in this analysis is therefore given as follows:

1. Installation noise for 1 Oyster WEC;
2. Operational noise for 3 x 1 MW Oyster WECs;
3. Operational noise for 3 x 1 MW Oyster WECs + Installation noise for 1 Oyster WEC;
4. Operational noise for 10 x 1 MW Oyster WECs;
5. Operational noise for 10 x 1 MW Oyster WECs + Installation noise for 1 Oyster WEC;
6. Operational noise for 25 x 1 MW Oyster WECs;
7. Operational noise for 25 x 1 MW Oyster WECs + Installation noise for 1 Oyster WEC;
8. Operational noise for 40 x1 MW Oyster WECs
9. Operational noise for 40 x 1 MW Oyster WECs + Installation noise for 1 Oyster WEC;
10. Operational noise for all 50 x1 MW Oyster WECs
11. Decommissioning noise

The scenarios and the potential cumulative impacts arising are discussed below.

8.2 Cumulative installation noise

The latest client advice with regards to preparing the site for the installation of the Oyster WECs indicates that foundation socket drilling is likely to occur at only one WEC location at a time. Multiple drilling sites are therefore not likely to arise so any cumulative impacts from

drilling will not occur. The analysis discussed in Section 7 indicates that vessel noise may give rise to Low-level behavioural reactions up to 150 m from the vessel. This is based on noise levels being emitted by the vessel when the engine is operating under under full-load conditions. It is expected that once any vessel involved in the installation process is on-site, the engine speed will be reduced and the noise levels generated by the vessel will fall accordingly.

8.3 Cumulative operational noise and installation noise

Phase 1 consists of 3 Oyster WECs. The minimum Oyster spacing is 20 m but in practice this is likely to be greater due to localised seabed bathymetry and could be as great as 50 - 60 m. For two adjacent WECs, the separation defines the distance over which cumulative impacts might occur. The single source impact analysis discussed in Section 7 indicates that the WECs generate insufficient levels of operational noise to give rise to any impacts based on unweighted metrics. The analysis shows that when using unweighted metrics to quantify the cumulative acoustic impact from 3, 10, 25, 40 and 50 operational WECs, the impact threshold for Low-level behavioural reaction is not exceeded.

When the cumulative effect of installation drilling is included, there is found to be a small increase in underwater noise levels over and above those generated by the operational WECs alone. The resulting cumulative SPLs are such that the Low-level behavioural threshold criterion is met over a distance of 1 m only from each installation site.

A similar effect arises when considering weighted metrics such as the dB_{ht}. For single sources, Section 7 indicates that Strong Aversion behavioural reactions observed in odontocetes and mysticetes following exposure to operational or installation noise might arise at distances up to 18 m – which is less than the minimum WEC separation of 20 m. Hence cumulative impacts are unlikely to occur. By contrast, the distances over which the Mild Avoidance criterion is met for odontocetes and mysticetes when exposed to a single source at 115 m is somewhat greater than the minimum WEC spacing hence cumulative effects must be considered. The distances over which this condition is met for each of the operation and installation scenarios outlined above are given in Table 8.1. For pinnipeds, the cumulative Mild Avoidance criterion for exposure to operational noise is not met and may only be exceeded if the animal remains less than 1 m from the site during installation.

	Odontocetes	Mysticetes
3 operational WECs	110 m	60 m
3 operational WECs + 1 installation	150 m	120 m
10 operational WECs	170 m	75 m
10 operational WECs + 1 installation	250 m	140 m
25 operational WECs	260 m	80 m
25 operational WECs + 1 installation	280 m	170 m
40 operational WECs	300 m	100 m
40 operational WECs + 1 installation	300 m	180 m
50 operational WECs	310 m	110 m

Table 8.1: Mild Avoidance impact ranges for construction and installation scenarios

While hearing damage such as PTS or TTS arising from single high SPL transients is unlikely to occur, hearing damage also has the potential to arise when the cumulative dosage of underwater sound builds up over a period of time. Using the simple model introduced in Section 7 whereby an animal swims through the Lewis Wave Power Development area at a speed of 5 m/s, it is found that the PTS impact criterion based on the SEL metric (Southall *et al*. 2007) is not likely to be met for either the cetacean hearing groups (215 dB re 1 μPa^2s M-weighted) or the pinnipeds (203 dB re 1 μPa^2s M-weighted). Neither the TTS impact

criterion based on Southall *et al.* (2007) for cetaceans and pinnipeds, nor the more precautionary TTS impact criterion for harbour porpoise as proposed by Lucke *et al.* (2009) will be met. By contrast, the threshold for Aversive Behaviour (145 dB re 1 μPa^2s - based on Lucke *et al.* 2009) as observed in the harbour porpoise will be met after an exposure duration of 8 seconds for each of the operation and installation scenarios considered above. It needs to be emphasised however, that this limiting time over which the Aversive Impact criterion is met is only relevant for the particular source/receptor scenario model considered.

8.4 Decommissioning noise

For the purpose of the analysis discussed in this report, and in the absence of any noise data relevant to decommissioning activities, the cumulative impact of decommissioning noise together with operational noise is assumed to be the same as that for operational noise only and as discussed in Section 8.5 above. Decommissioning activities are assumed to generate noise levels similar to those generated during foundation drilling. Decommissioning noise at one site at a time is therefore assumed to introduce no additional underwater noise to the environment over and above the noise generated from 50 Oyster WECs in operational mode.

9. SUMMARY AND CONCLUSIONS

This report provides an assessment of the impact of underwater noise generated during the installation, operation and decommissioning of the Oyster WECs in the Lewis Wave Power development area. The main sources of noise have been identified as foundation socket drilling for the monopiles; the Oyster WECs in operational mode; the tools used for decommissioning; and the vessels used during each stages identified above.

The acoustic propagation modelling has been carried out using computer programmes based on rigorous mathematical models and peer-reviewed techniques combined with high temporal and spatial resolution site-specific data relating to the bathymetry, oceanography and geoacoustics of the development area. Acoustic impact modelling draws on both the M-weighting and dB_{ht} criteria and ranges to each impact have been determined.

It is found that there was no significant difference in sound propagation using input modelling parameters for winter conditions against using those for summer conditions. This was attributed to the extreme shallow water environment in which the Oyster WECs are likely to be located.

Sound source characteristics for drilling were based on measurements of drilling noise acquired at the EMEC wave site, Billia Croo during summer 2011. These were combined with background noise measurements made off the Isle of Lewis during the same period. Specific data on the sound characteristics emitted by the vessels likely to be used in the development do not exist. In order to be able to carry out the assessment, generic values of vessel source levels and frequency spectra were obtained from the published literature and used as proxy data erring wherever possible, on the precautionary side so as not to under-estimate the resulting ranges over which each impact criterion is met. Source data for operational Oyster WECs was based on a modified drilling noise spectrum. It is understood that when conditions permit, in-the-field measurements will be made and an update to this report will be published.

It is demonstrated that transient sound levels from single noise sources such as foundation drilling, Oyster operation and vessel movements are not likely to give rise to fatality or hearing damage i.e. either PTS or TTS. Similarly, source levels associated with drilling or operational noise are below the threshold at which both Level B – Harassment and Low Level Behavioural impacts might occur. For vessel noise the Level B criterion may be met when marine animals are within 7 m of the largest vessels likely to be used in the Lewis Wave Power development while Low Level Behavioural impacts might occur up to a maximum of 150 m.

Using the dB_{ht} technique, it is shown that neither Strong nor Mild behavioural reactions are likely to be seen in Atlantic salmon, European eel, sea trout and hearing generalist fish when they are exposed to drilling or operational noise, while mild behavioural reactions out to a maximum distance of 5 m may be seen in hearing generalist fish when they are exposed to vessel noise. Pinnipeds show Mild Avoidance reactions up to 58 m from vessels and up to 12 m from individual Oyster WECs. Odontocetes such as the common dolphin and harbour porpoise show Strong Avoidance to operational noise out to a distance of 16 m and Mild Avoidance to 101 m. Mysticetes such as the minke show Strong Avoidance to vessel noise and drilling noise of 208 m and 17 m respectively and Mild Avoidance to each noise source up to 1.7 km and 112 m respectively.

The SEL metric was used to assess the impact of acoustic dose using a simple model involving an animal swimming through the Lewis Wave Power Development area with a closest point of approach to an Oyster WEC of 20 m. Based on the impact criteria proposed by Southall *et al.* (2007), it was found that none of the marine mammal species considered were likely to develop PTS or TTS as a result of exposure to underwater sound. Even using the more precautionary TTS impact criterion for harbour porpoises developed by Lucke *et al.* (2009), temporary hearing damage would not arise. For the simple model considered, the

Aversive Behaviour criterion (Lucke *et al.* 2009) would however be met after an exposure of 70 seconds.

When adjacent noise sources have an acoustic footprint larger than the spacing between individual Oyster WECs then cumulative effects may arise. For this scenario, the impact of multiple noise sources was assessed using various construction and operation scenarios. A phased approach to installing the WECs will be followed. It was found that even when a total of 50 WECs are in operation at the end of year 5, for marine mammals neither the Level B – Harassment nor the Low Level Behavioural impact criteria are exceeded. When the effect of the noise arising from one installation site is included it was found that the Low Level Behavioural impact criterion was met at a distance of 1 m from the installation site.

No impact criteria based on unweighted metrics for behavioural responses seen in fish are available hence no assessment was possible. Using the dB_{ht} criterion, Strong Avoidance and Mild Avoidance are unlikely in any of the target species considered, while the Mild Avoidance criterion is met only for odontocetes and mysticetes over distances varying between 60 m and 300 m.

Using the SEL metric, it was found that neither PTS nor TTS would arise in any of the cetacean or pinnipeds groupings (as defined by Southall *et al.* 2007) when exposed to multiple Oyster WECs. In addition the TTS impact criterion for harbour porpoise (as proposed by Lucke *et al.* 2009) will not be met. Aversive behavioural reactions are likely to be seen in the harbour porpoise after an exposure duration of 8 seconds when exposed to the noise arising from each of the operation and installation scenarios considered.

It was noted that the exposure times using the SEL metric were based on one simple model representing the transit of an animal on an idealised route through the Lewis Wave Power development area. Alternative transit scenarios are likely to generate a different set of exposure times. The model used in the analysis was for illustrative purposes only.

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A Appendix A

Third octave frequency band levels for underwater drilling spectrum.

Frequency Hz	Pressure spectral level dB re 1 μPa^2/band level
10	119.1
12	121.2
16	119.9
20	133.9
25	133.1
31	131.8
40	138.2
50	142.4
63	141.3
80	140.7
100	144.9
125	147.8
160	142.5
200	145.2
250	148.2
310	154.0
400	151.5
500	151.8
630	147.2
800	147.4
1000	148.6
1250	144.8
1600	143.8
2000	142.9
2500	145.3
3100	145.7
4000	148.1
5000	149.2
6300	151.6
8000	151.5
10000	149.9
12500	148.3
16000	145.2
20000	142.9
25000	140.5
31000	139.1
40000	138.0
50000	135.6
63000	130.8
80000	125.5
100000	121.1
125000	123.0
160000	129.4
200000	135.6

B Appendix B

Third octave frequency band levels for Oyster WEC operational noise.

Frequency Hz	Pressure spectral level dB re 1 μPa^2/band level
10	151.2
12	148.4
16	144.8
20	146.6
25	143.0
31	140.2
40	138.9
50	140.1
63	138.3
80	137.5
100	136.2
125	136.5
160	137.6
200	139.9
250	143.8
310	140.8
400	143.0
500	144.8
630	145.8
800	141.8
1000	141.2
1250	141.0
1600	142.7
2000	142.2
2500	142.7
3100	142.3
4000	143.2
5000	143.4
6300	143.4
8000	143.8
10000	144.7
12500	145.4
16000	145.1
20000	144.1
25000	142.9
31000	140.5
40000	136.2
50000	131.6
63000	129.0
80000	124.3
100000	119.7
125000	121.0
160000	125.5
200000	130.0

Appendix 12.1

International Council for Exploration of the Sea (ICES) landings data for the Regional Study Area

APPENDIX 12.1 Species landings by weight form the RSA

Table A12.1 contains a complete list of all recorded species landed from the Regional Study Area between 2005 and 2010. Live weight of landings by species and year is also displayed. The Table is arranged by total landings throughout all years in descending order.

Table A12.1 All landings by species and year from ICES Rectangle 45E3 Between the years 2005-2010. Data source: Marine Scotland

		Years 2005-2010						
Common Name	Scientific Name	2005	2006	2007	2008	2009	2010	Total
Mackerel	*Scomber scombrus*	0.18	2941.56	2412.53	380.05	0.41		**5734.73**
Nephrops (Norway Lobster)	*Nephrops norvegicus*	656.95	915.66	863.86	782.37	511.72	424.00	**4154.56**
Crabs (C.P.Mixed Sexes)	*Cancer pagurus*	625.55	722.88	629.86	399.11	615.71	623.93	**3617.04**
Crabs - Velvet (Swim)	*Necora puber*	53.06	63.72	64.90	51.99	70.66	57.50	**361.84**
Scallops	*Pecten maximus*	107.96	87.29	24.60	74.46	80.07	30.78	**405.15**
Herring	*Clupea harengus*	0	1.05	153.38	0	0	0	**154.43**
Lobsters	*Homarus gammarus*	15.23	25.31	24.21	18.66	21.29	20.29	**124.99**
Spurdog	*Squalus acanthias*	16.11	22.06	12.88	1.75	3.18	0.17	**56.16**
Other or mixed Demersal	*Osteichthyes*	14.85	8.48	10.58	9.10	5.38	5.64	**54.03**
Green Crab	*Carcinus maenas*	2.62	4.60	2.62	4.37	5.46	3.60	**23.27**
Megrim	*Lepidorhombus spp*	9.85	9.61	4.89	2.83	0.80	0.81	**28.78**
Monks or Anglers	*Lophiidae*	9.87	7.11	4.09	1.19	0.36	0.31	**22.92**
Skates and Rays	*Raja spp*	8.74	4.22	2.10	1.87	1.09	0.65	**18.66**
Witch	*Glyptocephalus cynoglossus*	2.02	2.65	2.63	2.57	0.23	0.93	**11.03**
Haddock	*Melanogrammus aeglefinus*	26.8	0.96	1.49	3.11	0.25	0.45	**33.06**
Whiting	*'Merlangius merlangus*	0.94	0.55	1.26	2.36	0.29		**5.39**
Cod	*Gadus morhua*	1.86	0.74	2.06	1.06	0.03	0.02	**5.79**
Unidentified Dogfish	*Squalidae, Scyliorhinidae*	0.88	3.24		0.42			**4.54**

Pollack	*Pollachius pollachius*	1.34	0.12	0.58	1.13	0.05	1.68	**4.90**
Hake	*Merluccius merluccius*	2.44	1.36	0.57	1.09	0.21	0.13	**5.80**
Crawfish	*Palinurus spp*	0.64	0.20	0.31	1.01	0.33	1.15	**3.65**
Ling	*Molva molva*	0.69	0.58	0.30	0.42	0.01	0.52	**2.52**
Blue Whiting	*Micromesistius poutassou*	0	0	1.63	0	0	0	**1.63**
Sprats	*Sprattus sprattus*	0.48		1.50				**1.98**
Squid	*Loligo spp*	2.86	0.51	0.17	0.13	0.28	0.14	**4.09**
Thornback Ray	*Raja clavata*	0				1.01	0.01	**1.01**
Albacore	*Thunnus alalunga*	0	0.90					**0.90**
Lemon Sole	*Microstomus kitt*	0.03	0.14	0.36	0.12	0.13	0.02	**0.79**
Razor Clam	*Solen spp*	16.27	0.19	0.14	0.17	0.17	0.04	**16.98**
Plaice	*Pleuronectes platessa*	1.86	0.17	0.13	0.12		0.20	**2.48**
Gurnards - Grey	*Eutrigla gurnardus*	0				0.48		**0.48**
Other Flatfish	*Pleuronectiformes*	0.08	0.15	0.08	0.00	0.09	0.03	**0.43**
John Dory	*Zeus faber*	0.38	0.18	0.03	0.13	0.01		**0.71**
Unid DS Squal Sharks & Dogfish	*Squalidae*	0				0.20		**0.20**
Cuckoo Ray	*Leucoraja naevus (previously Raja)*	0				0.17		**0.17**
Catfish	*Parauchenoglanis macrostoma*	0			0.12			**0.12**
Brown Shrimps	*Crangon crangon*	0				0.03	0.09	**0.12**
Eels	*Conger conger*	0.02	0.04	0.02	0.02	0.02		**0.12**
Saithe	*Pollachius virens*	0			0.02		0.06	**0.08**
Turbot	*Psetta maxima*	0.06	0.02	0.01	0.02	0.00	0.03	**0.13**
Portuguese Dogfish (Shark)	*Centroscymnus coelolepis*	0		0.07				**0.07**
Halibut - Greenland	*Reinhardtius hippoglossoides*	0	0.05					**0.05**

Whelks	*Buccinum undatum*	0				0.03		**0.03**
Roes		0		0.01				**0.01**
Common Prawns	*Palaemon serratus*						0.01	**0.01**
Shrimps - Pink (Northern prawn)	*Pandalus borealis*	0		0.01		0.01		**0.01**
Shrimps - Other	*Penaeus spp*					0.01		**0.01**
Mixed Crabs	*Brachyura*						0.00	**0.00**
Conger Eels	*Conger conger*	0.21						**0.21**

Appendix 12.2

Fish and shellfish species present within the wider region

APPENDIX 12.2 Fish and shellfish species present within the wider region

Table A12.2 contains a list of species known to occur throughout the wider region (West Coast of Scotland) on the basis of fisheries landings data and the findings of the Marine Renewables SEA (Faber Maunsell, 2007).

Table A12.2 Shellfish and finfish species potentially present within the Study Areas and adjacent waters. Data Source: Faber Maunsell

Shellfish	Fish	Fish	Elasmobranches and Anadromous fish
Crustaceans	Cod *Gadus morhua*	Sea bream *Spondyliosoma cantharus*	Elasmobranches
Lobster *Homarus gammarus**	Ling *Molva molva*	Bass *Dicentrarchus labrax*	Spurdog (Squalus acanthias)
Nephrops *Nephrops norvegicus*	Whiting *Merlangius merlangus*	Hake *Merluccius merluccius*	Lesser spotted dogfish (Scyliorhinus canicula)
Squat lobster *Galathea squamifera*	Mackerel *Scomber scombrus*	Gurnards *Triglidae spp*	Basking shark (Cetorhinus maximus)
Crawfish *Palinurus elephas*	Sandeels *Ammodytes spp.*	Dab *Limanda limanda*	Porbeagle (Lamna nasus)
Edible crab *Cancer pagurus* *¤	Sprat *Sprattus sprattus*	Turbot *Psetta maxima*	Tope(Galeorhinus galeus)
Green crab *Carcinus maenas*	Pollack *Pollachius pollachius*	Dover sole *Solea solea*	Thornback Ray (Raja clavata)
Velvet crab *Necora puber* *	Plaice *Pleuronectes platessa*	Lemon sole *Microstomus kitt*	Common skate (Dipturus batis)
Spider crab *Maja verrucosa*	Saithe *Pollachius virens*	Megrim *Lepidorhombus whiffiagonis*	Anadromous Fish
Brown shrimp *Crangon crangon*	Haddock *Melanogrammus aeglefinus*	Conger eel *Conger conger*	Salmon (Salmo salar)
Molluscs	Norway pout *Trisopterus esmarkii*	Herring Clupea harengus	Sea trout (Salmo trutta)
King scallop *Pecten maximus*¤	Flounder *Platichthys flesus*	Atlantic halibut *Hippoglossus hippoglossus*	sea lamprey Petromyzon marinus
Queen scallop *Aequipecten opercularis*	Monkfish (angler) *Lophius piscatorius*	Red gurnard *Aspitrigla cuculus*	river lamprey Lampetra fluviatilis
Razor clam *Ensis ensis*	Witch *Glyptocephalus cynoglossus*	Brill *Scophthalmus rhombus*	allis shad Alosa fallax

Table A12.2 Shellfish and finfish species potentially present within the Study Areas and adjacent waters. Data Source: Faber Maunsell			
Shellfish	Fish	Fish	Elasmobranches and Anadromous fish
Horse mussel *Modiolus modiolus*	Striped red mullet *Mullus surmuletus*	Long rough dab *Hippoglossoides platessoides*	
Mussel *Mytilus edulis*¤	John dory *Zeus faber*		
Cockle *Cerastoderma edule*			
Native oyster *Ostrea edulis*			
Squid *Loligo spp.*			
Whelk *Buccinum undatum*			
Common periwinkle *Littorina littorea*			
Spiny Lobster Palinurus elephas			

Appendix 12.3

Complete list of species likely to be present within the Regional Study Area

APPENDIX 12.3 Complete list of species likely to be present within the RSA

Table A12.3 contains a list of all important species in terms of:

- Commercial value;
- Sensitivity (those that have nursery and/ or spawning grounds in the vicinity of the proposed development); and
- Local importance (species that have been identified as locally important by the local fishing industry).

Table A12.3 Species list of all species that may be present within the RSA

Common name	Scientific Name	Common name	Scientific Name
Pelagic		Lemon Sole	*Microstomus kitt*
Blue Whitting	*Micromesistius poutassou*	Thornback Ray	*Raja clavata*
Saithe	*Pollachius virens*	Spotted ray	*Raja montagui*
Norway Pout	*Trisopterus esmarkii*	Sandeel	*Ammodytes spp*
European Hake	*Merluccius merluccius*	Ling	*Molva molva*
Salmon	*Salmo salar*	River Lamprey	*Lampetra fluviatilis*
Sea trout	*Salmo trutta*	Spurdog	*Squalus acanthias*
Haddock	*Melanogrammus aeglefinus*	Sea Lamprey	*Petromyzon marinus*
Herring	*Clupea harengus*	**Shell Fish**	
Mackerel	*Scomber scombrus*	Nephrops (Norway Lobster)	*Nephrops norvegicus*
Sprat	*Sprattus sprattus*	Velvet Swimming Crab	*Necora puber*
Tope	*Galeorhinus galeus*	Brown Crab	*Cancer pagurus*
Whiting	*Merlangius merlangus*	Scallops	*Pecten Maximus*
Demersal		Lobsters	*Homarus gammarus*
Common skate	*Dipturus batis*	European Spiny lobster	*Palinurus elephas*
European eel	*Anguilla anguilla*	Green Crab	*Carcinus maenas*
Cod	*Gadus morhua*		

Note that this species list is further refined in Table 12.8 within Chapter 12 of the ES to include only species that are likely to be commonly found within the LSA.

Appendix 13.1

Extended phase 1 habitat and otter survey report

Lewis Wave Array: Extended Phase 1 Habitat and Otter Survey Report

Lewis Wave Power Limited	
22 September 2011	
Final Report	
9W2153	

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1 INTRODUCTION

Lewis Wave Power Limited, a wholly owned subsidiary of Aquamarine Power Limited, intends to develop a demonstration wave energy conversion array off the north-west coast of Lewis, Scotland. Royal Haskoning have been commissioned by Lewis Wave Power Limited to assist in applications for consent and as part of this support are conducting an Environmental Impact Assessment (EIA) for the proposed development. This document reports on the Extended Phase 1 habitat survey conducted by Royal Haskoning which will be used to inform the EIA.

All place names within this document are taken from Ordnance Survey maps, either 1:25000 scale or 1:10000.

1.1 The proposed development

The proposed development is a 40MW Oyster wavefarm which will consist of a number of Aquamarine Power's Oyster wave energy convertors attached to the seabed in the waters between 10metre (m) and 15m in depth. Oyster technology, which captures energy from near shore waves and converts it into clean sustainable electricity requires onshore infrastructure to be installed as part of the development. The oyster devices will pump water, via a high pressure undersea pipeline, to the onshore hydro-electric power station. The water will be returned to the devices via a low pressure return pipeline. The onshore powerhouse will contain one or more Power Take Off (PTO) unit, generator equipment, a header tank and a storage/site office area. The detailed layout and design of the hydro-electric power station has not been finalised at the time of writing, however, as an indication of scale, the expected footprint of the site which will accommodate the hydro-electri power station, a vehicle turning area and parking will be approximately 10,000m^2..

The proposed location of the hydro-electric power station is in an area of land to the north of the village of Siadar in north west Lewis (see Figure 1.1). The final location of the hydro-electric powers station will be determined by a number of parameters, including the findings of the Extended Phase 1 Habitat Survey, but will be located within the study area illustrated in Figure 1.1.

1.2 Objectives

The objectives of the survey were to:

- Identify the habitat of each parcel of land within the study area (Figure 1.1);
- Digitally map all habitats as per standard Phase 1 habitat symbols and colours (JNCC, 2010); and
- Provide target notes of each habitat, including characterising, rare, protected and non-native species encountered.

Figure 1.1 Location of the study area for onshore works for the phase 1 habitat survey.

This survey was completed in conjunction with an intertidal survey of coastal areas adjacent to the development site (Royal Haskoning, 2011).

1.3 Conditions of Survey

The survey was completed by two experienced Royal Haskoning ecologists during the 30th and 31st of August 2011 with a final additionally walkover completed on the 2nd of September 2011. Weather was variable throughout the survey period ranging from strong north westerly winds with heavy rain during the morning of the 30th to calm dry periods on the 31st. The conditions did not inhibit the surveyors. Access was unrestricted throughout the study area.

2 METHODOLOGY

Standard methods were used as described in Joint Nature Conservation Committee (JNCC) Phase 1 Handbook for Habitat Survey (2010).

Each parcel of land throughout the survey area was systematically visited by the surveyors and the vegetation was mapped on to an Ordnance Survey map at a scale of 1:10,000 by hand in the field and then digitised using ArcGIS 9.3. Global Positioning System (GPS) waypoints were recorded at each target note position, and digital photographs were taken to visually illustrate the study area. The final habitat map was electronically colour coded in GIS with standard symbols and colours (JNCC 2010) to illustrate the dominant species codes, and annotated with target notes, detailing the species and communities found in each parcel. As a guide to the importance of habitats, the standard colour coding is arranged so that the brighter or more intricate the colour, the greater the value of the habitat. Species were identified using standard references books, including Fields Studies Council (1998), Rose (1991) Sterry (1997) and Fitter (1995).

Species not in flower were identified by other plant characteristics such as leaf, form and arrangement, however there is the potential for some perennial plants, (particularly spring flowering plants), to have already died back and no longer be apparent.

To assist accurate notation of peat hag and standing water, Google Earth aerial imagery was geo-referenced to the digital ordnance survey map, and cross referenced with the hand-drawn maps from the field and GPS waypoints.

3 RESULTS

3.1 Main Findings

A map identifying the habitat of each parcel of land is presented in Figure 3.1. An accompanying description is provided below in the form of selected target notes. A full list of all target notes as recorded by the surveyors when in the field can be found in Appendix A: Target notes.

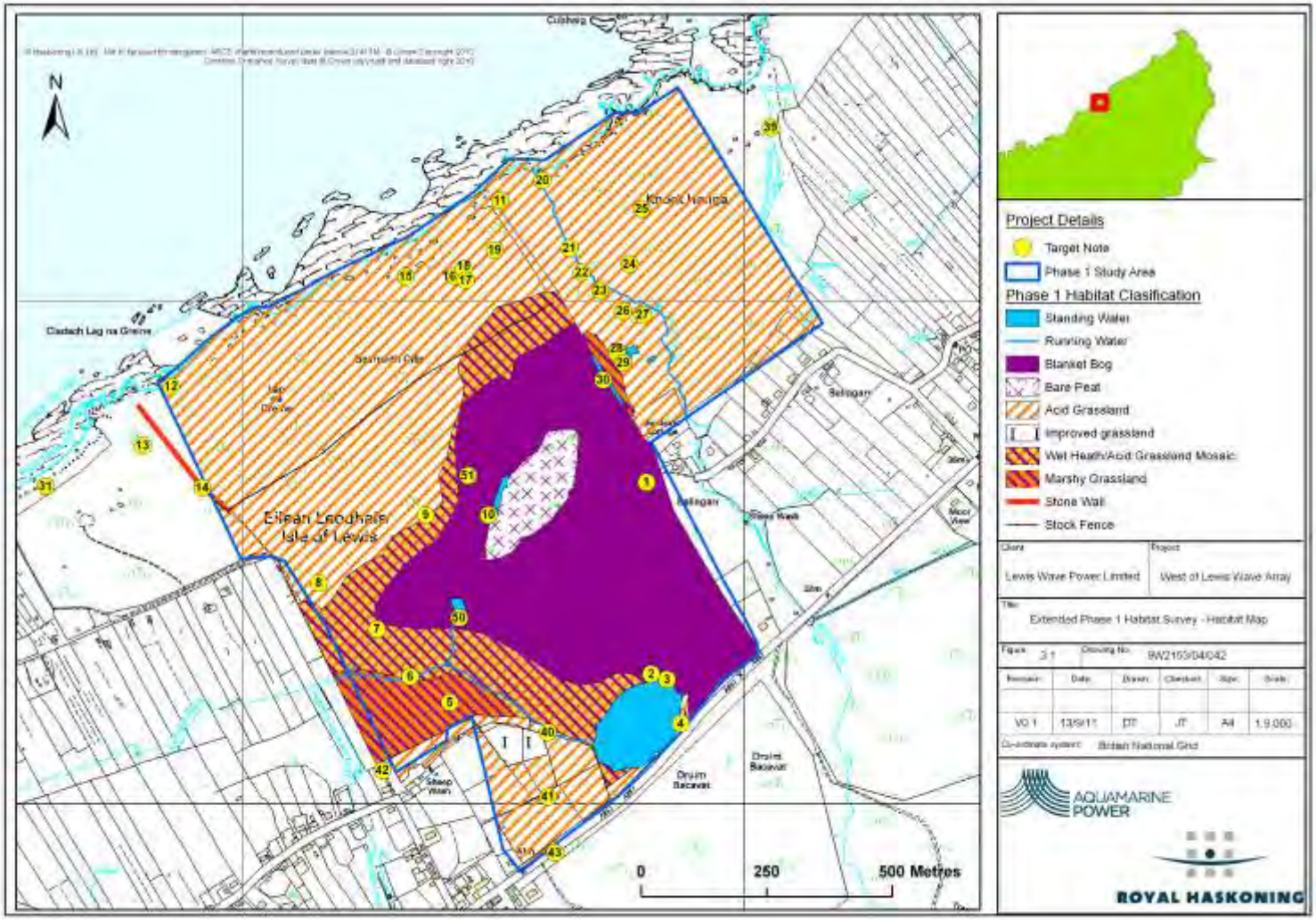

Figure 3.1 Phase 1 Habitat Map. Land parcel categories assigned in accordance with the Handbook for phase 1 habitat survey (JNCC, 2010).

A summary of the terrestrial ecology of the proposed study areas is described below, with two main habitat types across the proposed study area: the wetter blanket bog, wet heath and marshy grassland communities to the south and east, and the dryer acid grassland communities on the coastal fridge and hilltop.

Blanket bog, marshy grassland and wet heath communities

Much of the southern part of the study area consists of a complex mix of blanket bog marshy grassland, exposed peat hag, and wet heath/acid grassland mosaic, with gradual transition between these habitats across the site. This area is very wet and spongy underfoot indicating the water table is at or close to the surface. Standing water is present, particularly in areas of peat gullying and erosion. Some areas of erosion are classed as active blanket bog, showing signs of re-generation, and supporting a significant area of vegetation that is normally peat forming. A large expanse of eroded peat hag (mapped as bare peat) was present within the site, with limited vegetation of ling heather and deer grass. Extensive sheep footprints were present across the bare peat indicating that grazing activities occur in this area, up to the stock fence which is present at the top of a ridge line (Figure 3.1).

A peaty dystrophic lochan is also present within this section of the study area, which flows via the Lambol Burn west to the sea. Evidence of historic (regenerated) and current (stacked) peat cutting is also present within this area.

The habitat complexity found during the survey is considerable with many different habitats encountered in a small area. The map in Figure 3.1 therefore shows the most dominant habitat classifications with further details of species present and features of interest (including wet bog pools and hollows) discussed in the target notes.

At the southern end of the study area there is a fenced off field complex which is slightly higher in altitude than the surrounding land and is dryer. This fenced area supports a series of small fields of acid and improved grassland. The lower fields in this area are however also very wet, especially near the Lombol burn.

Acid grassland communities

In the northern part of the study area the ground rises steadily uphill away from the sea to a height of about 30m before decreasing in altitude towards wetter blanket bog habitat described above. This area is predominantly species rich acid grassland with some heath species also present, including ling heather, bell heather marsh lousewort, bog cotton and bog asphodel (in small numbers). As more than 75% of the habitat is acid grassland that is the classification assigned to this area in the Map (Figure 3.1). The seaward facing slope is exposed to strong winds off the Atlantic, and the vegetation is noticeably short and stout, with ericoids present as a low carpet layer understory beneath the grasses. Maritime indicator species present in the coastal fringe, include thrift *Armeria maritima*, suggesting coastal grassland is present, and merges into the acid grassland habitat as the terrain rises up from the shore.

Remains of historic “lazybeds” are present in the coastal margin, running down the slope towards the sea and lying perpendicular to the shore. This further suggests this area is well drained having been used historically for agriculture. The lazybeds area (marked as Lag na Greine on Figure 3.1 is not used for grazing, as a stock fence running parallel to the coastline prevents access by grazing animals. The restricted grazing in this area may contribute to species richness of the acid grassland community.

A narrow burn, the Allt Fisgro is set into a v shaped valley of varying steepness in the east of the study area, and flows north to the sea. The surrounding acid grassland is wetter than that to the south-west, and pools with both sphagnum or potomogeton species are present in this area.

Further detail is contained in the target notes below, the positions of which are illustrated in the map in Figure 3.1. The notes describe the study area and are arranged by location within the study area, in a clockwise direction, starting from the Ballagarr on the north eastern side.

3.2 Target notes

Target note 1

The description recorded at this Target Note (TN) encompasses a large area (approximately 250m^2) around the location shown in Figure 3.1.

The area is mostly blanket bog (Plate 1) with eroded peat gullies (Plate 2) and limited vegetation (mainly ericoids and lichens). Also present is wet heath with patches of bell heather and dense sphagnum moss is present in small pools of water.

Well defined wet hollows and puddles are present (Plate 1) and the ground is also spongy underfoot elsewhere, with peat hag and wet heath occurring side by side. The species present include: ling heather *Calluna vulgaris*, deer grass *Trichophorum cespitosum,* reindeer lichen *Cladonia portentosa*, sphagnum moss in wet pools, bog cotton *Eriophorum angustifolium*, red and green cushion forming sphagnums, common tormentil *Potentilla erecta*, *Cladonia* spp, bell heather *Erica cinerea*, prostrate juniper *Juniperus communis* ssp. *nana*, purple moor grass *Molina caerulea* and occasional patches of *Juncus acutiflora* and *Juncus effusus*.

Sheep and goose faces area present indicating the land is grazed and used by geese.

Plate 1. Sphagnum moss, blanket bog	Plate 2. Eroded peat showing signs of regeneration and standing water making up blanket bog

Target note 2
Flat blanket bog/wet heath habitat, surrounding Loch Bacabhat (Plate 3), which is very sodden, to the point that the surveyors feet start to sink (Plate 4) and it is presumed that, in this location there is a very high water table. Species present include: common haircap moss *Polytrichum commune*, sphagnum mosses, prostrate juniper, heath rush *Juncus squarrosus*, ling heather, common tormentil, Yorkshire fog *Holcus lanatus*, and round-leaved sundew *Drosera rotundifolia*.

Plate 3. Looking south toward Loch Bacabhat	Plate 4. Illustration of the water level within the blanket bog.

Target note 3 (loch)
A view of Loch Bacabhat from the north can be seen in Plate 3. Water flows into the Loch via a culvert on SE side. Patches of soft rush are present around the loch, both in and out of the water. The water is very dark (Black) presumably due to the peat content. Species present around the loch include daisy, sharp-flowered rush and buttercup species *Ranunculus spp*.

Target note 4
On the eastern side of the loch (Figure 3.1) is an area of acid grassland containing: Yorkshire fog, sharp-flowered rush, common ragwort *Senecio jacobaea*, common silverweed *Argentina anserina*, spear thistle *Cirsium vulgare*, soft rush, ribwort plantain *Plantago lanceolata*, yellow rattle *Rhinanthus minor*, creeping bent *Agrostis stolonifera*, and devil's-bit scabious *Succisa pratensis*.

Clumps of marsh marigold *Caltha palustris* are also present around the edge of the loch, while a large patch (Approximately 30m by 10m) of dense pondweed *Potamogeton* exists on the eastern side of the loch.

Target note 40
On the dryer ground in the south western corner of the study area a network of fences create enclosures which are presumed to be used for grazing. Most of the enclosures contain semi improved acid grasslands with ragwort, bent, soft rush and autumn hawkbit *Leontodon autumnalis*. The area is, however, still quite marshy (in keeping with the habitats identified in previous TNs), especially the lower enclosures to the north and east, where small patches of soft rush are present in the vicinity of the Lambol burn.

Target note 41
On higher ground to the south of TN40 the enclosures are considered further improved than those at TN40 (described above). Species present here include: autumn hawkbit, dock *Rumex crispus*., thistles, and soft rush. It is dryer here than at TN40, although still wet to the northwest, with soft rush and buttercups present in the wetter sections. There were 20+ geese in this enclosure at the time of survey.

Further target notes recorded in the vicinity of TN 41 (39, 42 and 43) can be found in Appendix A.

Target note 5
At this TN there exists a large patch of marshy grassland between two higher areas of land to the north-west and south east. Species present include soft rush, Yorkshire fog, and common tormentil. The terrain is very hummocky and between hummocks it is very wet. This habitat supports many species including: white clover *Trifolium repens*, bog cotton, several species of grass including: crested dogs tail *Cynosurus cristatus* and creeping bent. Pondweed, common lousewort *Pedicularis sylvatica*, and a number of buttercup species are also present.

Target note 6
The Lambol Burn runs through the study area at this location. It is a very narrow burn cutting through peat, with steep sides/banks. The banks surrounding the burn support a wet heath/acid grassland complex. The watercourse is completely shaded by grasses in some places and its course is not always easy to detect.

Note – No signs of otters were found within this section of the study area, including along this watercourse. However slides and spraints were located at mouth of the Lambol Burn, 1km downstream (Figure 4.1)

Target note 50
To the north of the Lambol Burn a network of small pools was present (Figure 3.1). These may desiccate during dry periods, but as at the time of survey they have clear margins it is likely that they are present for much of the year. There are clear outflows from the ponds which converge and form a small water course that in turn joins the main Lambol Burn. The land surrounding this water course supports soft rush, ling, heather and bog cotton.

Target note 7
To the north of TN6 the ground rises towards a ridge and becomes drier as a result. The habitat changes to grassland, with many species of grass forming large hummocks. Between the hummocks the ground remains very wet underfoot with small pockets of water forming in the surveyor's footprints. Grass species include: crested dogs tail, *Agrostis sp*, soft rush, heath rush, sedge species, Yorkshire fog and autumn hawkbit. Dryer ground exits further up the side of the ridge as there is better drainage in this area.

Target note 8
Further north of TN7 the ground continues its rise towards the ridge and small outcrops of exposed rock are present. The ground continues to become drier as the land rises. All grasses found in TN7 continue to be present as well as a species of dog lichen *Peltigera* sp. (Plate 5).

Plate 5. Dog lichen *Peltigera* sp. found at Target note 8

Target note 9
Heading northeast from TN8 the ground descends towards areas of exposed peat hag (Plate 6). As the ground gets lower the habitat underfoot becomes wetter again, with deer grass, bog cotton and sphagnum on wet heath/blanket bog present.

Target note 51
A small area of peat cutting exists at this location. The cutting is fairly recent, but has not yet been piled so as to dry (Plate 7).

Target note 10
On the lower ground to the north east of TN9, peat hags are interspersed with areas of standing water (Plate 8). This area contains a significant sized patch of bare peat (Figure 3.1) with eroded sides and limited re-colonisation of vegetation (Plate 9). Small quantities of sedge are present in peat, sedge and ling heather tops the hags.

Plate 6. Descending from target note 9 north east toward areas of exposed peat

Plate 7. Area of peat cutting showing re-generation of the peat

Plate 8. Standing water surrounding peat hags.	Plate 9. Gullies surrounding peat hags. Significant pare exposed peat, with sheep footprints.

The north western part of the study area is higher (approximately 15m) then the area to the south, through which the Lambol burn runs. This higher ground is in the form of a ridge that runs south west to north east, parallel to the coast. The apex of the ridge is delineated by a stock fence, which is illustrated in Figure 3.1, and the northern side of the ridge slopes down to the sea. The ridge is less pronounced in the north east than in the south west and slopes downward toward a burn at TN20.

Target note 14

An old dry stone wall, almost completely covered in vegetation (mostly grasses), is present on the western boundary of the study area (Figure 3.1).

Target note 12

The north western boundary of the study area is coastal margin which consist of small crumbling cliffs interspersed with sloping vegetated banks. This target note describes the land starting at the cliffs and moving uphill away from cliffs. Erosion of the coastal fringe is evident here and cobbles and pebbles on the shore extend right up to terrestrial habitats. The ground is firm underfoot and species present include: daisy, autumn hawkbit, Yorkshire fog, ribwort plantain, creeping buttercup *Ranunculus repens* common mouse ear *Cerastium fontanum*, buck horn plantain *Plantago coronopus*, purple clover, thrift, devil's-bit scabious, heath rush, common tormentil, birds-foot trefoil *lotus corniculatus*, bog asphodel *Narthecium ossifragum* and a carpet of small wind clipped ling heather plants.

The vegetation at TN12 is classed as acid grassland, however some wet heath species are also present. Patches of heathland were identified across the side of the ridge; however these did not make comprise more than 25% of the vegetation and therefore are not present in the map (Figure 3.1). The species present include: bog cotton, common lousewort, sharp flowered rush.

Linear marks running east to west that exist in this area were confirmed by the archaeological survey (Headland Archaeology) to be historic lazybeds. Patches of common haircap moss, wavy-hair grass *Deschampsia flexuosa*, bumble bee on devil's-bit scabious, sedge indet, bell heather, and lichens were present as well as goose faeces.

As the land slopes down towards the small burn at TN20 the wider habitat classification is acid grassland (Plate 10), however, small pools which contain sphagnum (Plate 11), eroded peat gullies and exposed peat hags (Plate 12) are also present. At several locations vegetated historic peat cuttings were also present (Plate 13). Details of target notes (TN15- TN19) in this area can be found in appendix A.

Plate 10. Acid grass land on down slope toward coastal margin	Plate 11. Small pool (TN18) with sphagnum moss on the down slope leading to the coastal margin
Plate 12. eroded dry peat gullies close to Allt Fisgro down slope leading to the coastal margin (TN19)	Plate 13. Peat cuttings (TN16) in the acid grass land on the downward slope towards the sea.

Target note 20

A small burn bisects the north eastern part of the study area. The burn itself is within a deep v-shaped gulley with steep sides of exposed rock and areas of grass. The burn cuts through the bedrock to the sea shore via a gorge of boulders and cobbles (Plates 14 and 15). At the mouth of the burn it opens out and flows through a cobble and boulder field, with very shallow water trickling between and under the rocks, even despite recent heavy rainfall. Species present include: thrift and sea campion growing on the bedrock. Kelp stipes have been cast up the stream by the sea. Numerous gullies exist, some suitable for otter shelter, however, there are no signs of otter couches or layups at this TN location. Sheep footprints are present and pieces of fleece can be seen attached to peat banks.

Near to the mouth of the burn otter spraint is present on rocks on the right hand bank see section 4.3 for more details.

Plate 14. Mouth of the burn cuts through bedrock and boulders on the shore	Plate 15.Small gorge created by the burn cutting through the bedrock

Target note 21
Upstream from the location of TN 20 the burn is narrow and peat stained. It is likely that the restricted access at the mouth of the stream would provide an impassable barrier to salmonids.

Species present at TN 21 include: bracken *Pteridium aquilinum* (small patches, not enough to be classified as an area of habitat), marsh marigold, hard fern *Blechnum spicant*, liverworts, thistle, ling heather, bent, lichens on rocks, devil's-bit scabious.

Upstream the burn narrows and the banks of the riparian corridor are not as steep or as high as they are downstream of this point (Plate 16).

Plate 16. burn undercut with narrow riparian corridor

The stream is undercut providing potential cover for otters.
A number of target notes regarding otter signs were recorded along the burn see section 4.3 ,Otters, for details.

Target note 24
Heath grassland habitat complex is present at this TN location, with a carpet of ling heather, bog cotton, sedge species, and devil's-bit scabious. The area is grazed by sheep and is predominantly dry underfoot: Common tormentil, Yorkshire fog, wavyhair

grass, sharp flowered rush, perennial ryegrass *Lolium perenne*, crested dogs tail, ribwort plantain and yellow rattle also exist here.

Target note 25
A wet hollow approximately 3m^2, with sphagnum and sedges, bog cotton is present at this TN.

Target note 26
Several wet pools on the left hand bank of the burn sit amongst a drier heath/grassland complex. Sphagnum and sedges are also identified here.

Target note 27
A large pool on the left hand bank of the burn is present at this location containing *Potamogeton sp*., sphagnum mosses, horsetails and bog cotton (Plate 17).

Target note 30
A long pool 100m by 4m is observed located in a vegetated gully at this TN. The pool leads to a track running up to nearby houses (Plate 18).

Plate 17. Small pond with potomogeton (TN 27).	Plate 18. long pool located at target note 30.

4 CONCLUSIONS

4.1 Habitats

The study area contains a complex habitat matrix incorporating blanket bog, bare peat, marshy grassland, acid grassland wet heath/acid grassland mosaic, lochs, and occasional areas of temporary and permanent standing water. Two main streams cut across the study area one, the Lambol burn, in the south west, and a second, the Alt Fisgro in the north east. The topography of the land centres around a ridge in the north and west of the study area with a shallow valley of very wet habitats to the south east.

Features of interest include the peat hags in the middle of the proposed study area and the blanket bog which is a fragile ground water dependant ecosystem covering most of the southeast part of the study area.

4.2 Protected Habitats and species

There are no Special Areas of Conservation (SAC), Sites of Special Scientific Interest (SSSI) or National or Local Natures Reserves (NNR and LNR respectively) within the study area. The Lewis Peatlands Special Protection Area (SPA) and Ramsar site is located approximately 1.3km inland from the study area and the Lewis Peatland SAC, which has otters listed as a qualifying feature is located approximately 2.5km inland of the study area.

Of the terrestrial habitats listed under Annex I of the EU Habitats Directive, those present within the study area include: blanket bog, European dry heaths, northern Atlantic wet heaths with *Erica tetralix* and *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*).

4.2.1 Biodiversity Action Plans

The Western Isles Local Biodiversity Action Plan (BAP) has prepared plans for several habitats and species, none of which are likely to be affected by the proposed development due to their geographical location or habitat requirements. The UK BAP has Habitat Action Plans (HAPs) (for 'Blanket Bog, and 'Upland Heath') which are of relevance to the proposed development.

Table 4.1 lists the relevant National Biodiversity Action Plan Habitats and Species (excluding birds).

Table 4.1 Habitats and Species for which action plans have been prepared within the National Biodiversity Action Plans that have been identified as potentially relevant to the study area.

National BAP species	National BAP habitats
Otter *Lutra lutra* Juniper *Juniperus communis*	Blanket bog Upland heath

4.2.2 Western Isles Species Priority List

The Western Isles Species Priority List identifies several priority animals and plants which may be encountered along the north-west Lewis coastline, including otter, Scottish scurvy grass *Cochlearia scotica*, juniper *Juniperus communis* and several eyebright *Euphrasia spp* species.

The prostrate form of juniper, *Juniperus communis* ssp *nana*, was recorded in an isolated location within the study area as part of the blanket bog community. No other vascular plants from the Western Isles Priority List were recorded during the Extended Phase 1 Habitat Survey.

Evidence of otter was restricted to the watercourses, and the presence of sources of shelter was limited within the proposed study area.

4.2.3 Ground water dependant terrestrial ecosystems (GWDTEs)

Following the guidance 'A Functional Wetland Typology for Scotland' (Sniffer, 2009) ground water dependant terrestrial ecosystems could be seen to dominate the south east of the study area, where peat bog, marshy grassland and wet heath/acid grassland mosaic habitats were present. The area surrounding the Allt Fisgro watercourse was also identified as containing historic peat cuttings, with several small ponds also present, although these features were individually too small to map (Target Note 25 and 26).

4.2.4 Summary of habitats within the study area

Table 4.2 provides a summary of the habitats found within the study area along with information regarding their importance with regard to UK BAP plans and their dependence on ground water.

Table 4.2. Summary of habitats within the study area and associated relevant information.

Community type	Phase 1 classification (JNCC, 2010)	EC Habitats Directive (JNCC, undated)[1]	UKBAP (Brig 2008)	Groundwater Dependant Terrestrial Ecosystem (SEPA 2010)
Blanket Bog/Mire Communities	Blanket bog, Modified Bog	7130 Blanket bogs	UK BAP Priority habitat	*no*
Marshy grassland/ rush and pasture	Marshy grassland	6410 Molina meadows on calcareous, peaty of clayey-silt-laden soils (Molina caerulae).	N/A	*yes*
Dry Heath communities	dry dwarf shrub heath, acid dry heath	4030 European dry heaths	Priority UK BAP habitat	no
Wet Heath communities	Wet heath	4010 Northern Atlantic wet heaths with *Erica tetralix*	Priority UK BAP habitat	*yes*
Acid Grassland communities	Semi improved acid Grassland, coastal grassland	N/A	N/A	no

4.3 Otter

The European otter *Lutra lutra* is a semi-aquatic mammal, which is common around the freshwater and coastal areas of Scotland. UK Populations are internationally important, especially since their widespread decline across much of their western European range (JNCC, 2004). Populations in coastal areas utilise shallow, inshore marine areas for feeding and require fresh water for bathing and terrestrial areas for resting and breeding

[1] http://jncc.defra.gov.uk/page-1523

holts (JNCC, 2004). Where otters live in coastal areas (particularly in Scotland) they tend to have a largely diurnal habit, live in group territories, and have home ranges below 5km (Kruuk, 1996). The Western Isles provide an important stronghold for otters in the British Isles (Barne *et al*., 1997), and the otter is a qualifying feature of the nearby Lewis Peatland SAC (located approximately 2.5km inland of the study area).

Otters are a European Protected Species (EPS) and are fully protected under the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended in Scotland).

It is an offence to deliberately or recklessly:

- capture, injure or kill an otter;
- harass an otter or group of otters;
- disturb an otter in a holt or any other structure or place it uses for shelter or protection;
- disturb an otter while it is rearing or otherwise caring for its young;
- obstruct access to a holt or other structure or place otters use for shelter or protection or to otherwise deny the animal use of that place;
- disturb an otter in a manner that is, or in circumstances which are, likely to significantly affect the local distribution or abundance of the species;
- disturb an otter in a manner that is, or in circumstances which are, likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young.

The Conservation (Natural Habitats, &c.) Amendment (Scotland) Regulations 2007 enhanced this protection such that, in summary, it is now illegal to:

- deliberately or recklessly kill, injure or take (capture) an otter
- deliberately or recklessly disturb or harass an otter; or
- damage, destroy or obstruct access to a breeding site or resting place of an otter (i.e an otter shelter) (note that this does not need to be deliberate or reckless to constitute an offence).

Otters are also a UK and local Biodiversity Action Plan (BAP) species. Thus, otter shelters are legally protected whether or not an otter is present. If otter shelters are located within 30m or, breeding area within 200m of potential development, a European Protected Species licence must be applied for from the Scottish Government.

The survey methodology used conformed to SNH guidance (Scottish Wildlife Series: Otters and Development) and was designed to inspect potential resting site locations (i.e. burn banks, exposed peat faces or rock piles) throughout the core survey area.

A number of otter signs were recorded within the study area and in the surrounding region (Figure 4.1). These signs centred on the burn located in the north eastern part of the study area (Figure 3.1). Spraint was located near the mouth of the burn at TN20 (Plate 19) and again further upstream on the same burn at TN22 (Plate 20 details in Appendix A). Further upstream, at TN23, two small isolated possible covered lie ups were recorded (Plate 21) close to the stream. Evidence was found of flattened vegetation under overhanging grasses and turf, once in a natural hollow, and once also behind a pothole. No tunnels were present, and the surrounding watercourse and undercut peat hag was investigated but no further resting sites or signs of otter were recorded. No spraint was found at either potential resting site and therefore the

evidence for these locations being lie ups is not conclusive. No evidence of breeding was found within the surveyed area.

The evidence recorded gives a strong indication that one or more otters use this water course on a regular basis and may travel the entire length of it, either in search of food or as a corridor to travel throughout the area, possibly into the Lewis Peatlands SAC, for which otters are listed as a qualifying feature. Evidence of marine crustacean was noted in the otter spraints, indicating that the burns may be used by animals accessing the coast to feed.

Several spraints (Plate 22) and slides were located downstream of the study area, near the mouth of the Lambol burn, which flows through the study area. It should be assumed that otters travel up this watercourse to Loch Barabhat, as well as possibly beyond to the pool systems within the nearby moorland and SAC.

While carrying out the intertidal survey (Royal Haskoning, 2011), a number of otter spraints and fresh anal jelly were found near the mouth of the Abhainn Bhuirgh and the Allt Grunndal burns approximately 1km north of the Phase 1 habitat study area. These burns were visited on the 31st of August and again on the 2nd of September. By the second visit the water level in both had risen considerably although there had not been large quantities of precipitation. These two burns are considerably wider than the two which travel through the study area.

The otter signs detailed above, coupled with the relatively undisturbed environment on the west coast of Lewis, indicate that otter territories may encompass the study area, however suitable habitat was centred on the watercourses. Freshwater sources are important to local otters for washing fur, and provision of other habitat requirements and it is considered likely that otters may use the streams within the study area as passages to the nearby Lewis Peatlands SAC.

Figure 4.1 Location of Otter Signs

Plate 19 Otter spraint found at TN 20.	Plate 20 Location of the spraint on rock in middle of burn (Allt Fisgro).
Plate 21 Possible lie up near to burn TN23.	Plate 22 spraints on stone under bridge and slide near mouth of Lambol Burn.

4.4 Other fauna of note

Pinnipeds

Pinnipeds found within Scottish waters are protected by a range of national and international obligations. On the 1st February 2011 it became an offence to kill, injure or take a seal at any time of year except to alleviate suffering or where a licence has been issued to do so by Marine Scotland under Part 6 of the Marine (Scotland) Act 2010. Furthermore under the same act it will also be an offence to intentionally or recklessly harass seals at significant haul-out sites under the Marine (Scotland) Act 2010. The Sea Mammal Research Unit (SMRU) are currently working on defining significant seal haul-outs based on their aerial seal counts, there will be a period of consultation before significant haul-outs are designated. Grey seals (*Halichoerus grypus*) and common seals (*Phoca vitulina*) are protected under Annex 1 and 2 of the Bonn Convention, and Annex II, IV and V of the Council Directive 92/43/EC on the Conservation of Natural Habitats and of Wild Fauna and Flora, Annex IV (the 'Habitats Directive'). They are also listed under Conservation Regulations Schedule 3 of the Conservation (Natural Habitats and c) Regulations 1994. Common seals are also classed as a UK Biodiversity Action Plan (BAP) species.

During the survey, a grey seal was observed milling close to the shore near to the study area during the survey on the 2nd of September (TN31 on Figure 3.1 and Appendix A).

This sighting will be considered within the marine mammal assessment work for this project.

Birds

The following species were recorded during the Phase 1 survey: Oyster catcher *Haematopus ostralegus*, herring gull *Larus argentatus*, curlew *Numenius arquata*, gannet *Morus bassanus* and great black back gull *Larus marinus*. No evidence of breeding birds was noted within the study area: however the survey was completed late in the breeding bird season.

No designated species from the Lewis Peatlands SPA (golden eagle *Aquila chrysaetos,* merlin *Falco columbarius*, red-throated diver *Gavia stellata*, black-throated diver *Gavia arctica* and greenshank *Tringa nebularia*) were recorded during the extended Phase 1 habitat survey.

4.5 Invasive species

The study area was assessed for presence of terrestrial invasive species giant hogweed *Heracleum mantegazzianum*, Japanese knotweed *Fallopia japonica*, Himalayan balsam *Impatiens glandulifera* and rhododendron spp during the Phase 1 Habitat survey. No terrestrial invasive species were present on the site.

No assessment was made of aquatic invasive species.

5 RECOMMENDATIONS

5.1 Habitats

1) It is recommended that the final location of the hydro-electric powers station should not be within any of the groundwater dependant terrestrial ecosystems, in particular blanket bog, marshy grasslands and wet heath acid grassland mosaic. Construction activities within these habitats will require detailed consultation with SEPA and further vegetation surveys may be required.

The **preferred location** of the hydro-electric power station within the study area, from an ecological perspective would be on the higher ground and coastal ground in the north west of the study area to the east of target note 14 (Figure 3.1). These findings will be used as part of the selection criteria for the final location.

2) If the hydro-electric power station is to be located within one of the groundwater dependent ecosystems an NVC survey may be required. SNH and SEPA will need to be consulted for confirmation on this matter;

3) A ‘no build’ buffer of 50m should be placed either side of the two burns within the study area, in order to prevent impacts on otters;

4) A terrestrial invasive species survey is not required for the study area;

5) An aquatic invasive species survey was not completed during the Phase 1 Habitat Survey. Advice should be sought from SNH as to whether one is required, however, this is thought to be unlikely;

6) Any landscape planting schemes should aim to improve the existing value of the study area through increasing the species diversity. The use of species of local provenance is recommended;

7) If there are any impacts on stone walls during the works, the stone should be retained in-situ and replaced on completion;

8) During construction, good working practices and following published SEPA site management protocols should eliminate risk from oil, chemicals and other harmful materials. Construction areas should be left in a safe condition during periods of inactivity, with chemicals and construction materials stored safely, with appropriate bunding, in accordance with SEPA's Pollution Prevention and Chemical Guidelines (PPG2 - Above ground oil storage tanks, and PPG5 – Works in, near or liable to affect watercourses);

5.2 Otters

9) Construction activities should maintain a strict footprint of works, and construction vehicles and equipment should not be active on, or stored by, the coastline for longer than is essential. It is appreciated equipment may need to be located on the shore at times but if equipment is not required to be stored on the coastline for operational purposes, then it should be stored further up the hill if possible. This will minimise disturbance to the shore;

10) Any temporarily exposed open pipe system should be capped in such a way as to prevent otters gaining access at the end of each working day;

11) Open trenches should have a ramp constructed in at least one place, especially if water filled, to provide an escape route;

12) Any otter casualties occurring during construction should be retained and SNH should be notified;

13) Construction work will be undertaken during agreed daylight working hours. Where artificial light is required, lights should be directed away from the coastal area and watercourses to allow otters to migrate through the area undisturbed.

14) Although no resting sites of otters have been identified in the vicinity of the proposed development site, there remains the potential for the baseline situation to change before construction works commence. Prior to the commencement of operations an otter survey should be undertaken, within the proposed footprint of construction plus a 200 m buffer zone around it, to determine current use at the time of construction (otters may increase their use of the site in the interim period between the current survey and the commencement of construction). A European Protected Species (EPS) Licence is not currently anticipated however this will be reconsidered once the preconstruction otter survey has been undertaken;

15) All otter mitigation measures for the site will be agreed with SNH prior to construction and will be detailed within the Environmental Statement for the proposed development;

16) It may be necessary to install otter fencing around the construction area;

17) Further information and advice is available from SNH Otters and Development[2], Nature Conservation and Roads: advice in relation to otters (2001), by A Grogan, C Philcox and D Macdonald, and the Design Manual for Roads and Bridges (DMRB)3;

18) Construction should adhere to The Scottish Wildlife Series publication 'Otters and Development'.

5.3 Other fauna

19) Advice should be sought from SNH regarding potential for reptiles and amphibians. In the scoping opinion collated by marine Scotland for the proposed development SNH comment that "The location of all elements of onshore infrastructure will need to be considered in respect of reptiles and amphibians". Consultation with SNH will clarify what this will include.

20) The sightings of grey seal should be added to the marine mammal baseline.

[2] http://www.snh.org.uk/publications/on-line/wildlife/otters/default.asp

[3] http://www.dft.gov.uk/ha/standards/dmrb/index.htm

6 SPECIES LIST

Common name	Scientific Name
Creeping bent	*Agrostis stolonifera*
Common silverweed	*Argentina anserine*
Thrift	*Armeria maritima*
Hard fern	*Blechnum spicant*
Buck horn plantain	*Plantago coronopus*
Ling heather	*Calluna vulgaris*
Marsh marigold	*Caltha palustris*
Common mouse ear	*Cerastium fontanum*
Spear thistle	*Cirsium vulgare*
Lichen	*Cladonia sp.*
Lichen	*Cladonia portentosa*
Crested dogs tail	*Cynosurus cristatus*
Wavy hair grass	*Deschampsia flexuosa*
Round-leaved sundew	*Drosera rotundifolia.*
Bell heather	*Erica cinerea*
Bog cotton	*Eriophorum angustifolium*
Fushia	*Fushia spp*
Yorkshire fog	*holcus lanatus*
Sharp-flowered rush	*Juncus acutiflorus*
Soft rush	*Juncus effusus*
Heath hush	*Juncus squarrosus*
Prostrate juniper	*Juniperus communis ssp nana*
Autumn hawkbit	*Leontodon autumnalis*
Perennial ryegrass	*Lolium perenne*
Bird's-foot trefoil	*Lotus corniculatus*
Purple moor grass	*Molina caerulea*
Deer grass	*Trichophorum cespitosum*
Crab eye lichen	*Ochrolechia parella*
Common lousewort	*Pedicularis sylvatica*
dog lichen species	*Peltigera sp*
Ribwort plantain	*Plantago lanceolata*
Greater plantain	*Plantago major*
Sea plantain	*Plantago maritima*
Common haircap moss	*Polytrichum commune*
Pond weed Potamogeton	Potamogeton spp
Common tormentil	*Potentilla erecta*
Bracken	*Pteridium aquilinum*
Sea ivory	*Ramalina siliquosa*
Creeping buttercup	*Ranunculus repens*
Yellow rattle	*Rhinanthus minor*

Dock species	*Rumex crispus*
Common ragwort	*Senecio jacobaea*
Sea campian	*Silene maritima*
Devil's-bit scabious	*Succisa pratensis*
White clover	*Trifolium repens*
common orange lichen	*Xanthoria parietina*

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APPENDIX A. COMPLETE LIST OF TARGET NOTES WITH DETAILS

Target Note	Grid Ref (NB)		description	Phase 1 habitat classification	Value	Photos (N)=north (E)=West etc
	Long	Lat				
1	39804	55639	**Blanket bog with eroded gullies** limited vegetation (mainly ericoids and lichens). Wet heath with patches of bell heather, dense sphagnum moss in pools, sheep faeces, goose faeces. Very wet hollows and puddles but spongy underfoot elsewhere. Blanket bog, peat hag and wet heath: Ling heather *Calluna vulgaris*, deer grass *Trichophorum cespitosum*, reindeer lichen *Cladonia portentosa.* Sphagnum moss in wet pools, bog cotton *Eriophorum angustifolium,* sphagnums in pools, and red and green cushion forming sphagnums, common tormentil *Potentilla erecta*, *Cladonia spp*, bell heather *Erica cinerea*, prostrate juniper *Juniperus communis ssp nana,* purple moor grass *Molina caerulea*, Limited rush patches of *Juncus acutiflora* and *Juncus effusus*	Blanket bog	High	Pentax 570-577 Olympus 264-278
2	39813	55257	**Flat blanket bog/wet heath habitat surrounding pond**. Very boggy- sinking. High water table throughout: common haircap moss *Polytrichum commune*, sphagnum mosses, prostrate juniper, heath hush *Juncus squarrosus*, ling heather, common tormentil, Yorkshire fog *holcus lanatus*, Round-leaved sundew *Drosera rotundifolia.*	Blanket bog	High	Pentax 578-586 Olympus 279-282

Target Note	Grid Ref (NB)		description	Phase 1 habitat classification	Value	Photos (N)=north (E)=West etc
	Long	Lat				
3	39845	55247	**Loch Bacabhat** Soft rush in and out of the water. Very dark (Black) water, Daisy, sharp-flowered rush, buttercup species *Ranunculus spp*. Culvert inflow on SE side.		High	Olympus 283-286
4			**East side of Pond** Grassland: Yorkshore fog, sharp-flowered rush, common ragwort *Senecio jacobaea*, common silverweed, *Argentina anserine*, spear thistle *Cirsium vulgare*, soft rush, Ribwort plantain *Plantago lanceolata*, yellow rattle *Rhinanthus minor*, creeping bent *Agrostis stolonifera*, devil's-bit scabious *Succisa pratensis* In pond: Clumps of marsh marigold *Caltha palustris* around the edge. A large patch of the eastern side of the pond contains dense pondweed *Potamogeton.* Wet poached smelly area in SW corner	Acid Grassland		Pentax 583-584 585-586 geese flying overhead
5	39412	55201	**Fairly large patch of marshy grassland** between two areas of higher parts. soft rush, Yorkshire fog, common tormentil, Very hummocky and wet between hummocks: white clover *Trifolium repens*, bog cotton, several species of grass including: crested dogs tail *Cynosurus cristatus*, creeping bent, pondweed, common lousewort *Pedicularis sylvatica*, buttercup species.	Marshy grassland		
6			**Lambol Burn** that runs through Study area: Very narrow cutting through peat, with steep sides bank on wet heath/acid grassland complex Note – signs of otters not found within study area on this	wet heath/acid grassland mosaic running water	High	

Target Note	Grid Ref (NB)		description	Phase 1 habitat classification	Value	Photos (N)=north (E)=West etc
	Long	Lat				
			watercourse, however slide and spraints located at mouth of burn 1km down stream			
7	39267 39224	55347 55386	**Dryer ground and grassland** Many species of grass forming large hummocks: Crested dogs tail, *Agrostis sp*, soft rush, heath rush, sedge indet, yorkshire fog, autumn hawkbit *Leontodon autumnalis*, Dryer ground exists on side of hill as there is better drainage in this area.	Acid grassland		
8	39151	55439	Rise with some exposed rock All grasses found in TN7, and a dog lichen species *Peltigera sp.*	Acid grassland		Olympus 287-288
9	39364	55574	Habitat getting wetter underfoot, with Deer grass, bog cotton and sphagnum on wet heath/blanket bog	Transition between wet heath/acid grassland mosaic and blanket bog	high	Olympus 289-291 (N)
10	39524	5540	**Pools and Hags** Significant areas of bare peat with eroded sides and limited recolonisation of vegetation. limited sedge in peat, sedge and ling heather on hags.	Blanket bog and bare peat	high	Pentax 587, 588 Olympus 29
11	39513	56200	Cliff top margin illustrated on Map	Acid grassland		Olympus 294(S) 295(E) 296 (W)
12	38856	55829	**Coastal Margin** (Moving uphill away from cliff). Erosion of	Coastal		Olympus 331

Target Note	Grid Ref (NB)		description	Phase 1 habitat classification	Value	Photos (N)=north (E)=West etc
	Long	Lat				
			the coastal fringe evident. Cobbles and pebbles on the shore extend right up to the terrestrial area, firm ground underfoot. Species include: Daisy, autumn hawkbit, Yorkshire fog, ribwort plantain, creeping buttercup *Ranunculus repens* common mouse ear *Cerastium fontanum*, buck horn plantain *Plantago coronopus*, purple clover, thrift *Armeria maritima*, devil's-bit scabious, heath rush, common tormentil, small carpeted ling (wind clipped), birds-foot trefoil *lotus corniculatus*, bog asphodel *Narthecium ossifragum*. Ground classed as acid grassland, however some heath species present. Heath habitat increasing and decreasing across the across the hillside but not greater than 25% of the vegetation. Cont'd bog cotton, common lousewort, sharp flowered rush within acid grassland matrix. Cont'd Linear marks E-W on ground, suspected historical farming strips/lazybeds. Patches of common haircap moss, wavy-hair grass *Deschampsia flexuosa*, goose faeces, bumble bee on devil's-bit scabious, sedge indet, bell heather, reindeer lichen.	grassland on maritime fringe, leading to acid grassland		Olympus 333-336
13	38800	55712	Few patches of localised sphagnum moss. Marsh figwort v.maurow wet flush in hollow, damp, marsh	Wet flush		Olympus 334

Target Note	Grid Ref (NB)		description	Phase 1 habitat classification	Value	Photos (N)=north (E)=West etc
	Long	Lat				
			marigold, common Tormentil and heath rush.			
14	38919	55628	**Stone wall boundary** Wall covered in vegetation			Olympus 336 337-340 surrounding area
15	39325	56049	**Eroded peat gulley-un-vegetated.**			Olympus 341-342
16	39422	56049	Vegetated area that appears to have been used for peat cutting historically.			Olympus 343
17	39440	56063	Sphagnum in wet pool in historic peat cutting		high	Olympus 344
18	39440	56063	Sphagnum in wet pool in historic peat cutting. $2m^2$		high	Olympus 345
19	39502	56101	**Exposed peat hags surrounded by heath grassland** complex. Numerous small pools also present.		high	Olympus 346-450
20	39596	56239	**Stream** Otter spraint present on rocks by mouth of stream on the right hand bank. River in deep V-shaped gulley with steep sides of exposed rock and areas of grass. The stream cuts through the bedrock on shore in a gorge of boulders and cobbles. Species present include: thrift and sea campion growing on the bedrock, kelp stipes have been cast up the stream. Numerous gullies exist some suitable for otter shelter however there are no signs of couches or layups at this TN. Sheep footprints are present and pieces of fleece can be seen attached to peat banks.	Otter spraint	High	Olympus 351-353 Olympus 354 moving up stream

Target Note	Grid Ref (NB)		description	Phase 1 habitat classification	Value	Photos (N)=north (E)=West etc
	Long	Lat				
21	39651	56105	**Up stream from last TN** Species present: bracken (small patches, not enough to be classified as habitat), marsh marigold, hard fern *Blechnum spicant*, liverworts, thistle, ling heather, bent, lichens on rocks, devil's-bit scabious. The steam is quite narrow and peat stained and has some salmonid potential. No impassable barriers were noted on the stream within the study area. The mouth of the stream opens out and is dominated by cobble and boulder, with shallow water Upstream of this point there is a narrowing and the banks of the riparian corridor are not as steep or as high as they are downstream of this point. The stream is quite undercut providing potential cover for otters.		High	355
22	39675	56057	Otter spraint on rock in middle of stream potential resting site behind concrete water culvert close by, where tunnel has been made through vegetation by mammal to space behind. No spraint found, but very close to those in the stream		high	Olympus 356, 357
23	39712	56021	**Potential lie up** in bank, tunnel through vegetation, but no spraints. 3 m from stream		high	Olympus 358, 359
24			**Heath grassland complex**, with carpet of ling, bog cotton, sedge species, devil's-bit scabious. Grazed by sheep and predominantly dry underfoot: Common tormentil, yorkshire			

Target Note	Grid Ref (NB)		description	Phase 1 habitat classification	Value	Photos (N)=north (E)=West etc
	Long	Lat				
			fog, wavyhair grass, sharp flowered rush, perennial ryegrass *Lolium perenne*, crested dogs tail, ribwort plantain, yellow rattle.			
25	39770	56073	Wet hollow, with sphagnums and sedges, bog cotton. Hollow approximately 3m2		high	
26	39758	55980	Several wet pools on LHB amongst dryer heath/grassland complex. Sphagnums and 3 leaved sedge		high	
27	39797	55972	LHB large pool with *Potamogeton sp*., sphagnums, horsetail and bog cotton		high	Olympus 360 361
28	39745	55897	As TN 27		high	
29	39758	55877	As TN 27		high	
30	39718	55843	Long pool 100mx4m in vegetated gully – leads to track running up to houses		high	Olympus 362
31	38607	55631	Adult grey seal 50m offshore		Add to marine mammal records	
39	40052	56345	**Marshy grassland at southern boundary of field where stream runs through**. Buttercup, soft rush, common tormentil			
40			**Semi Improved grassland** with ragwort, bent, soft rush quite marshy, Autumn hawkbit			
41			More improved then TN40. Autumn hawkbit, dock *Rumex crispus*., thistles, soft rush. Dryer then 40, though north west corner wetter with soft rush and buttercups. 20+ geese in a field			

Target Note	Grid Ref (NB)		description	Phase 1 habitat classification	Value	Photos (N)=north (E)=West etc
	Long	Lat				
42	39278	55066	Tall ruderal, with dock, silverweed, creeping buttercup, thistle, nettle and grasses. Small area next to track west of houses.			
43	39622	54902	Road verge slopes down away from main road to enclosed fields strip about 15m wide. Ling heather, tall thistles, grasses, creeping bent, dandelions, greater plantain *Plantago major*, ribwort plantain, ragwort, silverweed, fushia bushes.			
50	39431	55370	Network of small pools with clear outflow that joins the main Lambol Burn. Surrounding is soft rush, ling, bog cotton		high	Pentax 621 (n) 622 (w) 623 (e) 624 outflow 626-627 pool
51	39449	55652	Small area of peat cutting		high	Pentax 628-630 (n)
Additional Information						
			Lower reaches/ mouth of the Lombol Burn (outside of study area). Otter spraint present	N/A	high	SLR 1,2,3 Shore, 4 hole under bridge, 5 Upstream, 6-7 Downstream, 8.9 Otter spraint, 10 Bridge on left

Target Note	Grid Ref (NB)		description	Phase 1 habitat classification	Value	Photos (N)=north (E)=West etc
	Long	Lat				
						side of beach
	37800	54900	Lambol burn road crossing near Mol Eire Otter spraint and slide on North side of bridge	N/A	high	SLR 624,627
	39276	55768	Fishing vessel hauling a fleet of creels approximately 1km offshore	N/A	N/A	
	40798	57351	Creeling (fishing) vessel SY873 possibly the same as the one above. 3 Crew hauling a large fleet of creels possibly up to 50 in Bay 300m from the shore line. Once the fleet were hauled they kept gear onboard and headed north west	N/A	N/A	
	40867	57094	Old otter spriant on left hand bank of the Abhainn Bhuirgh, just down stream of foot bridge		high	Pentax 638-639 640 upstream 641 down Stream

Appendix 13.2

Intertidal survey report

Lewis Wave Array: Intertidal Survey Report

22 September 2011

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1 INTRODUCTION

Lewis Wave Power Limited, a wholly owned subsidiary of Aquamarine Power Limited, intends to develop a wave energy array off the north-west coast of the Isle of Lewis. Royal Haskoning have been commissioned by Lewis Wave Power to assist in applications for consent and as part of this support are conducting an Environmental Impact Assessment (EIA) for the Development. This document reports on the Intertidal survey conducted by Royal Haskoning which will be used to inform the EIA.

1.1 The development

The intention is to deploy a number or Aquamarine Power's oyster devices which will be attached to the seabed in the nearshore waters (between 10metres (m) and 20m in depth) off the northwest coast of Lewis. The Oyster wave power technology captures energy from nearshore waves and converts it into clean sustainable electricity. Between 40 and 50 Oyster devices will be deployed in a roughly linear formation that will run roughly parallel to the coastline and will produce up to 40MW of electrical power.

The location of the wave array is to the north west of the village of Siadar and to the west of the settlement of Mealabost (Figure 1.1). As the oyster devices will extract energy from the waves there is potential for the array to affect the hydrodynamic regime experienced by the intertidal environment immediately inshore of the array. To assess the possible implications of this to the intertidal communities, an intertidal survey was conducted to establish an environmental baseline. This document reports on the results of that survey, makes a number of recommendations on methods for better understanding the impacts that the wave array may have on the intertidal environment and recommends ways in which these impacts can be minimised.

1.2 Objectives

The objectives of the survey were to:

- Identify the habitats and communities present within the survey area (Figure 1.1);
- Digitally illustrate the location of biotopes present within the survey area boundaries, and
- Provide target notes of each biotope, including characterising, rare, protected and non-native species encountered.

This survey was completed in conjunction with an extended Phase 1 survey (Royal Haskoning, 2011a) which was conducted over the area for proposed onshore works inland of the intertidal survey between Siadar and Còig Peighinnean Bhuirgh (Figure 1.1).

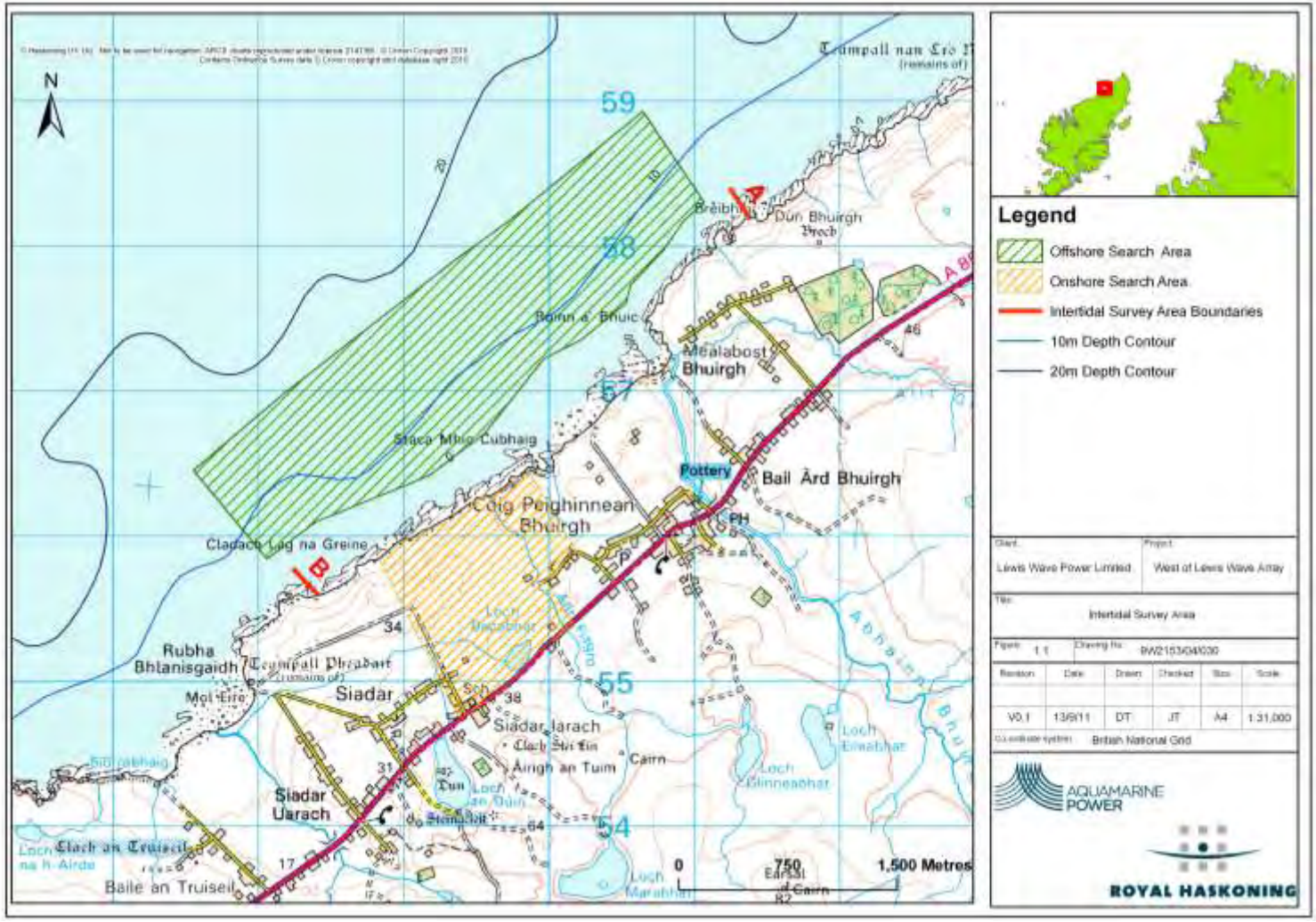


Figure 1.1 Location of the area of search for the intertidal survey.

1.3 Conditions during survey

The survey was completed by two experienced Royal Haskoning ecologists during low water spring tides on the 30th and 31st of August. Weather was variable throughout the survey period ranging from strong north westerly winds with heavy rain to calm dry periods. Weather conditions did not inhibit the surveyors. Sea state on the 30th calmed from a 5 in the morning to a 3 in the afternoon and then further calmed on the 31st to a 2. Breaking waves impeded survey particularly in the more exposed areas and during the morning of the 30th making access to some of the intertidal impossible. The survey was conducted from a safe location the top of the cliff at this time. Access due to landowner issues was unrestricted throughout the survey period. Tidal conditions during the survey are shown in Table 1.1

Table 1.1 Tidal conditions experienced during the intertidal survey

	Low water		High water	
	Time (BST)	Height (m)	Time	Height
30th	14:38	0.47	20:29	5.36
31st	15:18	0.41	21:09	5.31

2 METHODOLOGY

The survey was completed on foot, using a number of methods and techniques, based upon those specified in the Countryside Council for Wales (CCW) report 'CCW Handbook for marine intertidal Phase 1 mapping' (Wyn *et al.*, 2000) and the 'Marine Nature Conservation Review: Rationale and methods' (Hiscock, 1996).

Target notes were recorded and photos taken wherever a change in either the biological zonation or physiological conditions appeared to occur. A hand held Garmin Global Positioning System (GPS) was used to provide positioning data for each target note which were then mapped using ArcGIS 9.3 after the survey was completed.

3 RESULTS

3.1 Main Findings

19 target notes within the study area were recorded during the intertidal survey. The study area was extended beyond the original survey boundary to provide a record of the shore beyond where any potential impact will occur (Figure 3.1).

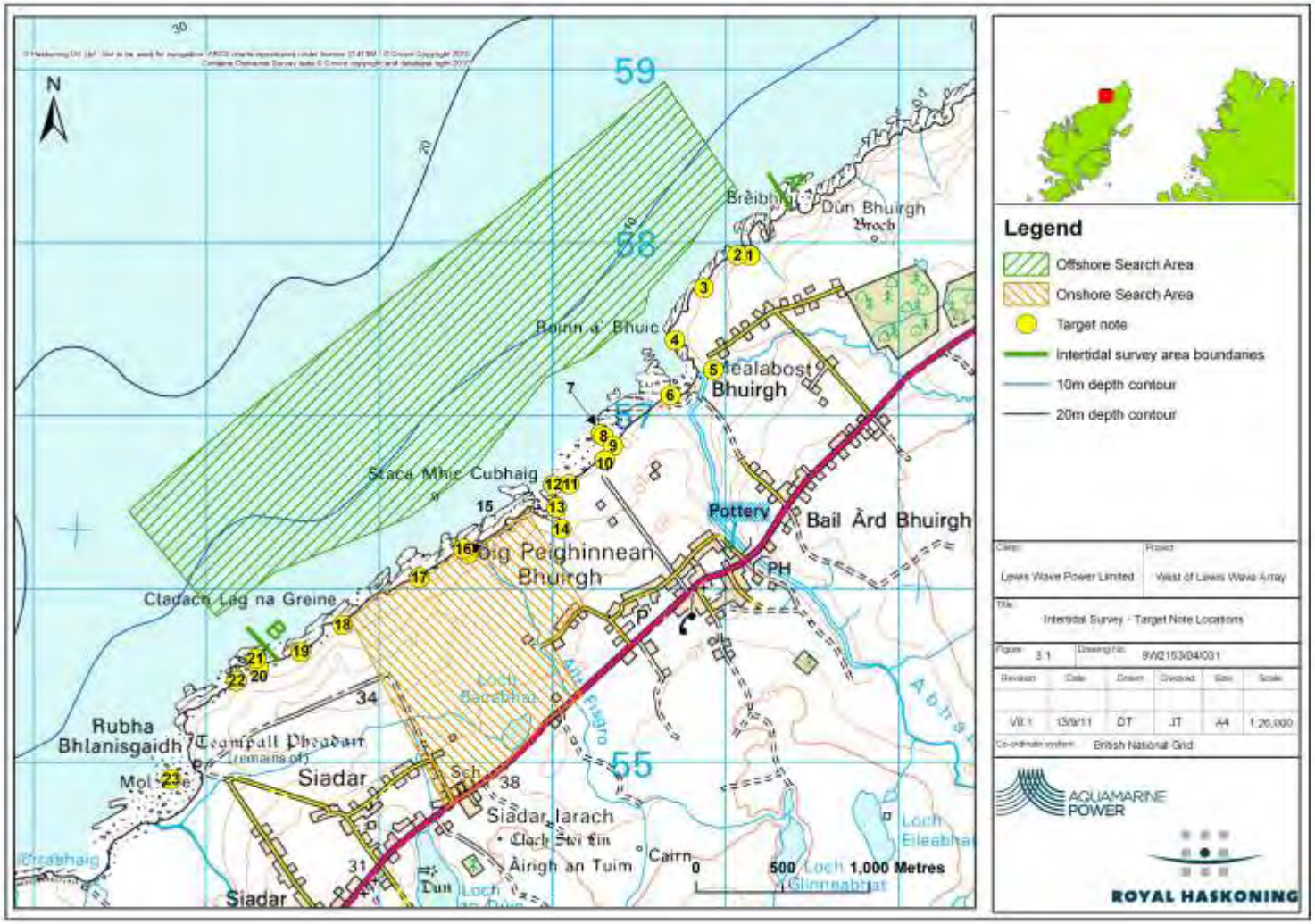


Figure 3.1 Target note locations for the intertidal survey.

The intertidal zone, within the study area, was composed of a mixture of substrates ranging from solid bedrock in the more exposed locations through to cobbles and sand in sheltered bays. The most common substrate however was a mixture of boulders and bedrock.

3.2 Biotope mapping

16 different biotopes were recorded over the 23 different target notes (Table 3.1). The number of biotopes recorded within each target note was not limited to a single biotope at that location and many of the target notes encompass more than one biotope. The location of biotopes recorded during the survey are displayed in Figure 3.2a and 3.2b

Table 3.1 Biotopes recorded during the intertidal survey

Biotope	Description	Target Note locations identified
IR.MIR.KR.Ldig.Bo	*Laminaria digitata* and under-boulder fauna on sublittoral fringe boulders	7,12,20
IR.MIR.KR.Ldig.Ldig	*Laminaria digitata* on moderately exposed sublittoral fringe bedrock	4
LR.FLR.Lic	Lichens or small green algae on supralittoral and littoral fringe rock	1,18,20,21
LR.FLR.Lic.Ver.Ver	*Verrucaria maura* on very exposed to very sheltered upper littoral fringe rock	11
LR.FLR.Rkp.Cor	Coralline crust-dominated shallow eulittoral rockpools	16
LR.FLR.Rkp.Cor.Cor	Coralline crusts and *Corallina officinalis* in shallow eulittoral rockpools	21
LR.FLR.Rkp.G	Green seaweeds (*Enteromorpha* spp. and *Cladophora* spp.) in shallow upper shore rockpools	3
LR.HLR.MusB.MytB	*Mytilus edulis* and barnacles on very exposed eulittoral rock	2,3
LR.HLR.MusB.Sem.Sem	*Semibalanus balanoides, Patella vulgata* and *Littorina* spp. on exposed to moderately exposed or vertical sheltered eulittoral rock	9,18,19
LR.MLR.BF	Barnacles and fucoids on moderately exposed shores	8
LR.MLR.BF.Fser.R (north side of bay)	*Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock	6
LR.MLR.BF.FvesB	*Fucus vesiculosus* and barnacle mosaics on moderately exposed mid eulittoral rock	23
LR.MLR.BF.PelB	*Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock	13
LS.LCS.Sh	Shingle (pebble) and gravel shores	15, 17,6
LS.LMx on the south side of the bay	Littoral mixed sediment	6
LS.LSa.St	Strandline	6

3.3 Target notes

All target notes recorded during the survey are provided below, along with photos to help illustrate the findings. The positioning of each target note (TN) is displayed it Figure 3.1 above. Further details on each TN can be found in Appendix A.

Target note 1
The survey started near to the northern-most extent of the survey boundary. This area was categorised by high wave exposure, and the shore could not be accessed safely due to steep cliffs on the small bedrock headlands, with large waves breaking high up the shore. Rocky gullies filled with boulders were present here (Plate 1) and little flora and fauna was visible in the intertidal. The spray zone appeared to be dominated by large lichens (Plate 2) including sea ivory *Ramalina siliquosa.*

Plate 1. Rocky gullies filled with boulders. Waves breaking on protruding bedrock	Plate 2. Spray zone at TN1 and TN2. Dominated by lichens.

Target note 2
Further south the shore was safely accessed, but due to breaking waves only the uppershore could be surveyed. Small gastropods were abundant in the intertidal zone here, thought to be the rough periwinkle *Littorina saxatilis*, however large waves prevented identification. Patches of channeled wrack *Pelvetia canaliculata* were evident and small limpets *Patella.sp*. were also present. Other species included the green seaweed *Cladophora rupestris*, coralline algae, encrusting red algae, as well as small common mussels *Mytilus edulis,* present in tight clumps along with spiral wrack *Fucus spiralis* on the mid and lower shore.

Target note 3
Exposed bedrock with little fauna and flora dominated this area (Plate 3). A rock pool (Plate 4) at TN3 contained: limpets, spiral wrack, the sea cauliflower *Leathesia difformis,* coralline algae, barnacle *Cirripedia sp*., common periwinkle *Littorina littorea*, rough periwinkle *Littorina saxatilis*, tar lichen *Verrucaria maura*, unidentified red seaweed *Ceramium* indet., gut weed *Ulva intestinalis* on boulders, as well as other filamentous green and red seaweeds.

A few metres further south along the shore spiral wrack and toothed wrack *Fucus serratus* were encountered deep within a rock pool. On high areas of exposed rock on the lower shore, common mussels were present in discrete large clumps. Also present

on the lower shore was purple laver weed *Porphyra umbilicalis* and the beadlet anemone *Actinia equina*.

Plate 3. Exposed rock, looking south fromTN3	Plate 4. Rock pool at TN3

Target note 4

On the northern side of Roinn a Bhuic the rock was very fragmented with outcrops protruding from the shore (Plate 5). Large to small boulders were also encountered here. This area was generally very rugged with numerous rock pools (Plate 6).

The upper shore contained rook pools with abundant gut weed, and few other fauna and flora. The mid shore and lower shore supported the following species: occasional spiral wrack which was abundant in patches, barnacles which were common, small clumps of channelled wrack, occasional limpets, oar weed *Laminaria digitata*, sea-oak *Halidrys siliquosa,* red seaweed *Polysiphonia sp.*, sea cauliflower*, C.rupestris*, encrusting red algae, beadlet anemone, coralline red algae and the green seaweed *Ceramium sp*.

Plate 5. Rocky outcrops as boulder filled gully	Plate 6. Rock pools in the upper shore at TN 4

Target note 6

TN 6 was located in the bay between the Sgeir nan Sgarbh and the Roinn a Bhuic (Plate 9 and Figure 3.1). Here the strandline was composed of decaying oar weed and Furbelows *Saccorhiza polyschides* (Plate 7).

In the lower/midshore (Plate 8) of the bay, along an old ruined slipway, the following species were recorded: *C. rupestris*, limpets, common mussel, barnacles, the crustose

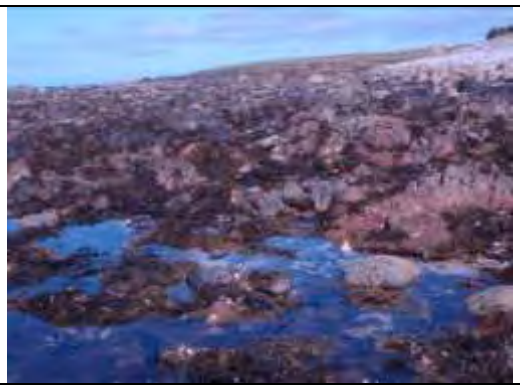
red algae *Hildenbrandia rubra*, the red seaweed *Polysiphonia lanosa*, knotted wrack *Ascophyllum nodosum*, the red seaweed *Heterosiphonia plumosa* common periwinkle, spiral wrack, bladder wrack *Fucus vesiculosus*, false Irish moss *Mastocarpus stellatus*, sea lettuce *Ulva lactuca,* coralline algae, beadlet anemone, dog whelk *Nucella lapillus*. The flat top shell *Gibbula umbilicalis*, and flat periwinkle *Littorina obtusata* were found in a rock wall to the south of the slipway, which is probably a manmade structure built to protect the slipway (Plate 10).

Plate 7. Strandline composed of kelp.	Plate 8. Lower shore at TN5
Plate 9. Overview of bay	Plate 10. Old ruined slipway in southern part of the bay

The substrate at TN6 was composed of boulders, cobbles and pebbles and on the lower/mid shore these sat in a sandy matrix. There were also patches of open sand in the southern part of the bay, in particularly near the old slipway at southern extent of the bay (Plate 10). Littorinds and patellids were much larger here than on the open coast to the north.

A low shore rock pool on south side of the bay contained: toothed wrack, oarweed, sea oak *Halidrys siliquosa*, the red epiphytic seaweed *Polysiphonia lanosa*, knotted wrack, the bryozoan or seamat *Electra pilosa*, The red seaweed *Membranoptera alata*, common periwinkle (very large), limpets, carrageen *Chondrus crispus*, coralline algae, red seweed, *Plocamium cartilagineum*, *C.rupestris*, beadlet anemone*, Heterosiphonia plumosa*, knotted wrack, breadcrumb sponge *Halichondria panacea*, dulse *Palmaria palmata*, unidentified sponges (mostly orange), grey top shell *Gibbula cineraria*, butterfish *Pholis gunnellus* and common shore crab *Carcinus maenas*.

Target note 7, 8 and 9 (lower, mid and Upper shore)
Target notes 7, 8 and 9 are described together as they represent different shore heights at one locations (Figure 3.1). On the low shore (TN7) approximately 400m south of TN6, a much less rugose environment was encountered than at previous TNs. The shore is composed of boulders with less rocky outcrops than previously. Species present include: *C.rupestris*, c*arrageen*, dulse, painted top shell *Calliostoma zizyphinum,* hermit crab *Pagurus bernhardus*, oarweed (which dominates the very low shore (Plate 11)), toothed wrack, breadcrumb sponge, tube worm *Spirobis spirobis*, coralline algae, beadlet anemone, grey top shell, dahlia anemone *Urticina felina* (found in deep rock pool) and pepper dulse.

	
Plate 11. Very low shore dominated by oarweed	Plate 12. The upper shore at TN 9

In the midshore on the same stretch of coast line (TN8) species present included: false Irish moss, carrageen, brown seaweed *Bifurcaria bifurcata,* coralline algae, limpets, toothed wrack, common periwinkle, rough periwinkle, peeper dulse, flat top shell, *Ceramium. sp,* knotted wrack*, P.lanosa,* hermit crab and the sea hare *Aplysia punctata.*

On the upper shore at TN9 species present included: sea oak, common periwinkle, limpet, barnacles, dog whelk, toothed wrack, spiral wrack and bladder wrack, flat periwinkle.

There were two strandlines at this location separated by an area of clean boulders. The upper strandline was thin and the lower was much thicker.

Target Note 11, 12 and 13
Further south in a small bay the upper shore was dominated by tar lichen, barnacles, common periwinkle, rough periwinkle and the lichen *Xanthoria parietina*.

On the lower shore of the bay the substrate was mainly boulders with isolated outcrops. species found here included: oar weed (Plate 13), toothed wrack, furbelows, pepper dulse, blue rayed limpet *Helcion pellucidum,* breadcrumb sponge, carageen, *C. rupestris*, shanny *Lipophrys pholis* (Plate 14), *Membranoptera altata*, grey top shell, beadlet anemone, unidentified chiton, star ascidian *Botryllus schlosseri*, various unidentified sponges *porifera indet,* common starfish *Asterias rubens,* and the laver spire shell *hydrobia sp.*

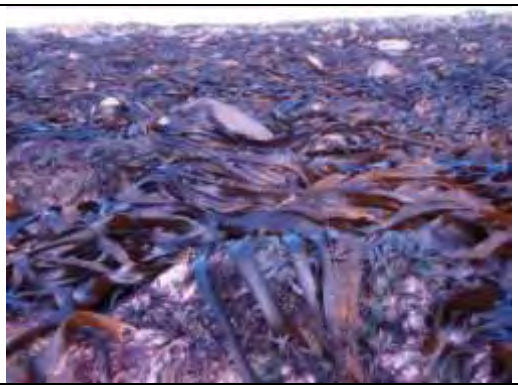


Plate 13. Lower shore dominated by oarweed	Plate 14. Shanny

The substrate in the and around the bay consisted of boulders and small rocky outcrops backed by shingle in the upper shore. Rock pools were numerous at all levels on the shore. Species present in the rock pools include: limpets, barnacles, common periwinkle, tar lichen, occasional channelled wrack, common beadlet anemones, *Cladophora rupestris*, carrageen and false Irish moss.

Target note 14

A small fast flowing shallow water course of very peaty dark water enters the bay at this location (Plate 15 and 16). The bed of this burn is composed of cobbles and pebbles.

Plate 15. Fast flowing shallow watercourse looking downstream	Plate 16. Fast flowing shallow watercourse looking upstream

Target note 15 and 16

South of the small bay the upper shore substrate was composed of shingle and boulders (Plate 17 and 18) on the easy angled bedrock (TN15). In the mid and lower shore boulders and small outcrops were present. Looking north and south from this location the shore was composed of small rocky promontories no more than 30m long and 50m apart which were interspersed with small embayments.

Mid shore rock pools (TN16) were common on the large expanse of intertidal area at this TN. The species present here included: The sea cauliflower, *M.alata* , false Irish moss, toothed wrack, unidentified filamentous brown algae, sugar kelp *Saccorhiza latissima* , beadlet anemone, grey top shell, dog whelk, limpet, barnacle, bladder wrack, flat periwinkle, *C.rupestris*, gut weed, *Ceramium sp*, sea oak, *Hildenbrandia rubra*

(sommerfelt), unidentified sponges, encrusting algae *Lithophyllum incrustans*, and unidentified intertidal black lichens.

Plate 17. Upper shore looking south	Plate 18. Overview of shore looking north

Target note 17
Further south again the upper shore was found to support common periwinkle and rough periwinkle. The mid shore area was generally more rugged than at TN16 with frequent rock outcrops, up to 2m high, running in bands across the area from NE to SW. On the lower shore small inlets were present between bedrock rather than a network of pools. There shore here was less algal dominated than at TN16 more mobile boulders, cobbles and pebbles.

Target note 18
The shingle upper shore stops at this point and terrestrial vegetation merges with outcropping bedrock. Vegetation present included: sea ivory, sea plantain *Plantago maritima*, *X. parietina,* sea rocket *Cakile maritima,* crab eye lichen *Ochrolechia parella* and tar lichen.

The mid/lower shore was much less algal dominated than at the previous (Plate 19) TN17, greater amounts of bare rock existed here. The bedrock is steep with deep gullies running through it (Plate 20). Species present included: abundant limpets, dog whelk, beadlet anemone, barnacles, gut weed, mussels (small clumps in sheltered areas), and common periwinkle (large). On the lower shore toothed wrack and beadlet anemone were present.

Plate 19. Shore less algal dominated than previously see plate 13	Plate 20. Steep bedrock with deep gullies

Targets 19

Near to the southernmost boundary of the survey area the shore is gently sloping and mostly composed of bedrock, of which outcrops are generally less than 1m high. The top of the outcrops are bare rock whilst the bottom of the outcrops and gullies were dominated by fucoids. In the upper shore a few isolated rockpools were present containing limpets, common mussel, common periwinkle, and rough periwinkle. The intertidal zone at this point is backed by shingle.

Target note 20 and 21

To the south of the survey area shingle on the upper shore gives way to bedrock which supports: sea campian *Silene maritima*, thrift, sea plantain and many species of lichen.

On the lower shore the following species were present: oarweed, dulse, unidentified coralline algae, breadcrumb sponge (Plate 21), flat top shell, beadlet anemone, carrageen, toothed wrack, limpet, blue rayed limpet, *E.pilosa*, furbellows, dahlia anemone, hermit crab, star ascidian, common starfish, unidentified chitons, gutweed, edible crab *Cancer pagurus*, brittle star *Ophiothrix fragilis*, gut weed, common shore crab, velvet swimming crab *Necora puber*, rag worm *Hediste diversicolor*, unidentified polychaetes, occasional small limpets, unidentified amphipods, pepper dulse, false Irish moss, carageen, crab indet (possibly a *Xantho.sp*) strawberry anemone *Actinia fragacea*, squat lobster *Galathea squamifera*, shanny, bloody Henry starfish *Henricia oculata* (Plate 22), and dog whelk.

Plate 21. Breadcrumb sponge *Halichondria panacea*	Plate 22. bloody henry starfish *Henricia* and grey top shell *Gibbula cinerea*
Plate 23. large discarded winch	Plate 24. further discarded machinery, rock outcrops and rock pools

On the mid shore near to TN20 a large old winch (Plate 23) and other old abandoned machinery parts (Plate 24) were present. Rock outcrops and small rock pools were encountered here and within the rock pools were found: sea cauliflower, spiral wrack knotted wrack, coral weed *Corallina officinalis* and sea oak. Barnacles dominate the bedrock with 90% coverage and: limpets, dogwhelks and beadlet anemones were also present. The upper shore supported: channelled wrack, gut weed (in rock pool) and tar lichen.

Target note 22

Further south at TN22 the shore became much steeper (Plate 25) as it rounds a small headland (Figure 3.1). The shore at this location exhibits compressed width of biological zonation, although the zones are still evident.

To the south of this target note the shore opens up again and becomes flatter (Plate 26) with wider biological zones.

Plate 25. Steeper shore with narrow intertidal area	Plate 26. Further south of TN22 the shore widens again

Target note 23

The Bay at Mol Eire, to the south of the study area, was surveyed on the 2nd of August because it was atypical of the surrounding area. The north side of bay, in the upper/mid shore, was composed of medium sized boulders. The shore was gently sloping with some exposed bedrock. The fauna was dominated by grazing species including common periwinkle and limpets, while also present were: barnacles, *L. incrustans,* channelled wrack and unidentified amphipods which were abundant in places. In a rock pool on the mid shore, coral weed, channelled wrack sea oak, dog whelk, *L. incrustans*, toothed wrack, bladder wrack, filamentous brown algae, false Irish moss, *C. rupestris*, common periwinkle, gut weed and flat periwinkle were all present,

In the mid to lower shore the same species as above were present, but in addition knotted wrack, carrageen and the sea cauliflower were recorded.

Biotopes recorded from target notes

Figures 3.2a and 3.2b show the distribution of the biotopes recorded within the study area.

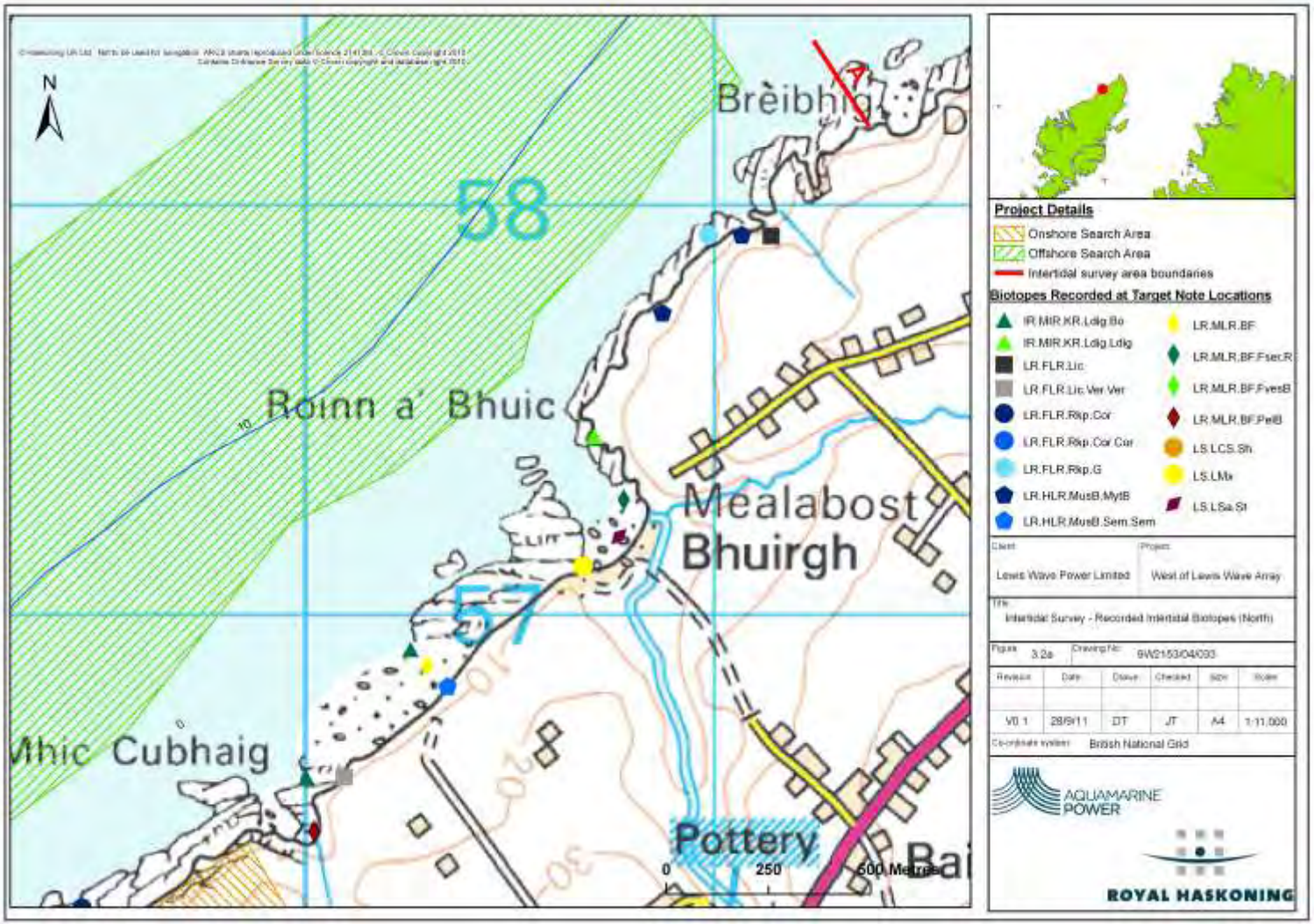


Figure 3.2a. Biotopes recorded in the intertidal survey

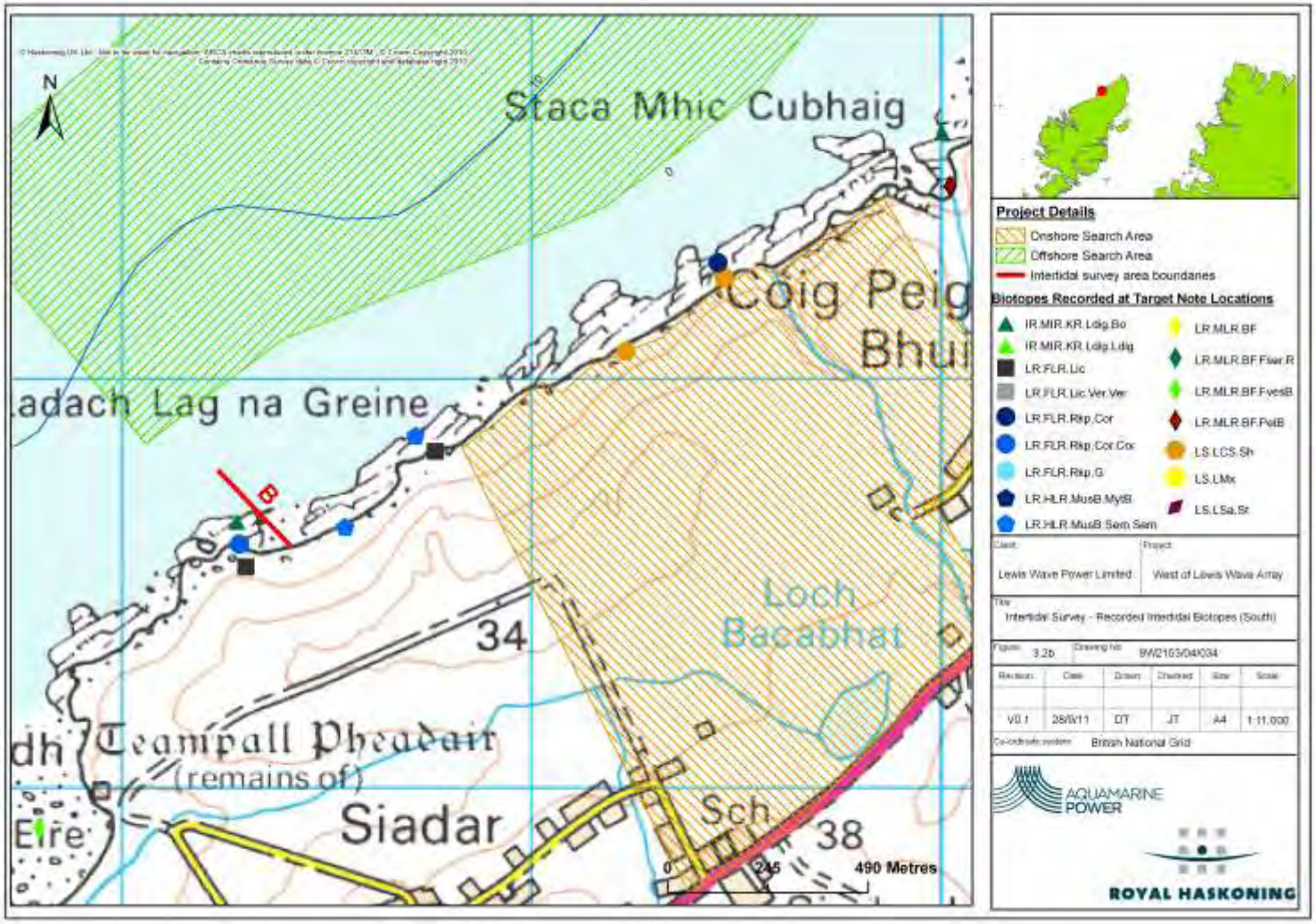


Figure 3.2b. Biotopes recorded in the intertidal survey

4 DISCUSSION

The level of exposure appears to dictate the floral and faunal distribution within the survey area. The northern most part of the survey area (Figure 3.2a), which is particularly exposed, exhibited low species diversity supporting only species that are robust and can survive high energy environments, such as mussels and barnacles. The fucoids present in this location were found to be short and stout in morphology, an adaptation to the high level of exposure. A large spray zone was also present here in which the tar lichen dominated and during the survey waves spray was reaching the top of the cliff within 2 hours of low water spring tide. This extremely high energy environment was encountered in the north of the study area and at two small exposed headlands one at target note 18 and one to the south of the survey area at target note 22 (Figure 3.1)

In more sheltered areas boulders were present between areas of bedrock and here algal communities were dominant with kelps dominating the low shore and fucoids the mid shore. This type of medium exposure environment makes up the majority of the study area which exhibits high species diversity.

In the bay at TN6 (Figure 3.1) a more sheltered habitat was found. Here sand and gravel had built up between the boulders, in contrast to the rest of the survey area. This location supported the only example of the biotope LS.LMx (Littoral mixed sediment) within the survey area.

There is potential for a decrease in wave energy to occur during operation of the Development, but given the complex nature of the shore and already highly exposed environment, it is unlikely this will lead to any significant change in intertidal communities.

5 RECOMENDATIONS

A well defined construction footprint should be maintained throughout construction activities, to minimise disturbance to the shore.

During construction, good working practices and SEPA protocols should eliminate risk of exposure to oil, chemicals and other harmful materials. Construction areas should be left in a safe condition during periods of inactivity, with chemicals and construction materials stored safely, with appropriate bunding, in accordance with SEPA's Pollution Prevention and Chemical Guidelines (PPG2 - Above ground oil storage tanks, and PPG5 – Works in, near or liable to affect watercourses).

Material removed from the intertidal habitat should be stored and replaced within the same intertidal zone following any construction and installation works associated with the pipelines.

6 SPECIES LIST

All common names are sourced from the marine life information network (MarLIN) website (marlin, undated)

Common name	Scientific Name
Identified to species	
Sea hare	*Aplysia punctata*
Beadlet anemone	*Actinia equina*
Common starfish	*Asterias rubens*
Strawberry anemone	Actinia fragacea
Thrift	*Armeria maritima*
Knotted wrack	*Ascophyllum nodosum*
brown seaweed	Bifurcaria bifurcata
Star ascidian	*Botryllus schlosseri*
Sea rocket	*Cakile maritima*
Painted top shell	*Calliostoma zizyphinum*
Edible crab	*Cancer pagarus*
Coral weed	*Corallina officinalis*
common shore crab	*Carcinus maenas*
Carrageen	*Chondrus crispus*
Green seaweed	*Cladophora rupestris*
Seamat bryozoan	*Electra pilosa*
Toothed wrack	*Fucus serratus*
bladder wrack	*Fucus vesiculosus*
squat lobster	*Galathea squamifera*
Grey top shell	*Gibbula cinerea*
Flat top shell	*Gibbula umbilicalis*
Sea Oak	*Halidrys siliquosa*
Bloody Henry starfish	*Henricia oculata*
Ragworm	*Hediste diversicolor*
Blue rayed limpet	*Helcion pellucidum*
Red seaweed	*Heterosiphonia plumosa*
Sommerfelt	*Hildenbrandia rubra*
Oarweed	*Laminaria digitata*
Encrusting coralline alga	*Lithophyllum incrustans*
The sea cauliflower	*Leathesia difformis*
Shanny	*Lipophrys pholis*
Common periwinkle	*Littorina littorea*
Common flat periwinkle	*Littorina obtusata*
Rough periwinkle	*Littorina saxatilis*
False Irish moss	*Mastocarpus stellatus*
red seaweed	*Membranoptera alata*
Common mussel	*Mytilus edulis*
Velvet swimming crab	*Necora puber*
Dog whelk	*Nucella lapillus*
Crab eye lichen	*Ochrolechia parella*
Common brittle star	*Ophiothrix fragilis*
Pepper dulse	*Osmundea pinnatifida*
Hermit crab	*Pagurus bernhardus*
Dulse	*Palmaria palmata*
Common limpet	*Patella vulgata*
Channelled wrack	*Pelvetia canaliculata*

butterfish	*Pholis gunnellus*
Sea Plantain	*Plantago maritima*
Red seaweed	*Plocamium cartilagineum*
Red seaweed	*Polysiphonia spp*
Red seaweed	*Polysiphonia lanosa*
Purple laver	*Porphyra umbilicalis*
Sea ivory	*Ramalina siliquosa*
Sugar kelp	*Saccharina latissima*
Fur Bellows	*Saccorhiza polyschides*
Sea campian	*Silene maritima*
A tubeworm	*Spirorbis spirorbis*
Gutweed	*Ulva Intestinalis*
Sea lettuce	*Ulva lactuca*
Delia anemone	*Urticina felina,*
Tar lichen	*Verrucaria maura*
Common orange lichen	*Xanthoria parietina*
Lower taxonomic resolution	
Barnacles	*Cirripedia*
Limpets	*Patella* (likely to be vulgata and/or vulgata or patella ulyssiponensis)
Chiton	*Polyplacophora*
Sponges	Poriferea
Laver spire shells	*Hydrobia sp*
Red filamentous seaweeds	*Ceramium sp*
Coralline seaweeds	*corallinaceae*
Amphipods	*Amphiopoda*
Coralline algae	*Coralinacea*

7 REFERENCES

Hiscock, K (ed.) (1996). *Marine Nature Conservation Review: rational and methods*. Coasts and seas of the United Kingdom. MNCR Series. Joint Nature Conservation Committee, Peterborough.

Wyn, G, Brazier, P and McMath, A J (2000). *CCW handbook for marine intertidal Phase 1 survey and mapping.* CCW Marine Sciences Report: 00/06/01.

MarLIN, undated. Website, available at: http://www.marlin.ac.uk/

APPENDIX A FULL DETAILS OF EACH TARGET NOTE

(S) = Super abundant, (A) = Abundant, (C) = Common, (F) = Frequent, (O) = Occasional and (R) = Rare

Location (Target note)	Description	Target note	Notes	Biotope	Photos (N)=north (E)=West etc
NB 41141 57923 (**1**)	Northern extent of intertidal Survey	Rocky Gullies filled with boulders, very exposed and little flora and fauna visible in the intertidal. The spray zone appeared to be dominated by large lichens including sea ivory *Ramalina siliquosa.*	Could not access the intertidal as waves were too large. Similar intertidal environment appeared to continue north.	LR.FLR.Lic	Pentax 551 and 552 Olympus 219 and 220
NB 41069 57926 (**2**)	South of the first target note where the rocky shore could be safely accessed.	Small Gastrpods abundant thought to be rough periwinkle *Littorina saxatilis*. Patches of channeled wrack *Pelvetia canaliculata* (R), Small limpets *Patella*. sp., the green seaweed *Cladophora rupestris*, coralline algae, encrusting red algae. Small common mussels *Mytilus edulis* in tight clumps and spiral wrack *Fucus spiralis* lower on the shore.	Mid and lower shore not accessible due to high wave action and timing of low tide. Most of the flora and Fauna was in rock pools.	LR.HLR.MusB. MytB	Olympus 223, 224 (*F. spiralis*).
NB 40875 57736 (**3**)	Large rock pool between the northern extent of the survey area and Roinn a Bhuic	The rock pool contained: Limpets, spiral wrack, The sea cauliflower *Leathesia difformis,* coralline algae, Barnacle sp., common periwinkle *Littorina littorea*, rough periwinkle *Littorina saxatilis*, Tar lichen *Verrucaria maura*, unidentified red seaweed *Ceramium* indet., Gut weed *Ulva intestinalis* on boulders and other filamentous green and red seaweeds.	Access could only be gained to the mid and upper shore. Where large quantities of foam had settled out on the rocks a brown scrum covered the	LR.FLR.Rkp.G	Pentax 553(N) 554(W) 555(S) Pentax 554 Filamentous Green and Red seaweeds.

Location (Target note)	Description	Target note	Notes	Biotope	Photos (N)=north (E)=West etc
		A few meters further south along the shore the fauna consisted of found: Spiral wrack, and toothed wrack *Fucus serratus* deep within the rockpool. On high areas of exposed rock on the lower shore common mussels were present in discrete large clumps. Also present on the lower shore was purple laver weed *Porphyra umbilicalis* and the beadlet anemone *Actinia equina*.	rocks making it very slippery underfoot.	LR.HLR.MusB.MytB	Olympus 225 (*F.spiralis*). Olympus 226-229 mid to lower shore
NB 40708 57434 (**4**)	Northern side of Roinn a Bhuic. Very fragmented rocky with lots of rock outcrop and large to small boulders. Highly rugose with numerous rock pools	Upper shore contains rookpools with abundant gut weed, but not much else. Mid shore and into the lowershore: Spiral wrack (O (A) in patches)). Barnacles (C), Small channelled wrack, Limpets (O), Oar weed *Laminaria digitata*, *Halidrys siliquosa*, Red seaweed *Polysiphonia* indet., sea cauliflower, *C.rupestris*, encrusting red algae, beadlet anemone, coralline red algae, *Ceramium* indet.		IR.MIR.KR.Ldig.Ldig	Olympus 230(W) 231 (S) Olympus 232 Rock arch on north side of Bay
NB 409719 55243 (**5**)		Several otter spriant and anal jelly under bridge on the Alt Brunde stream			Pentax 632-634
NB 40681 57117 (**6**)	Bay between the Sgeir nan Sgarbh and the	Strandline composed of decaying Oar weed and *Saccorhiza polyschides.*	Zonation in this bay is not as clear as other parts along	LS.LSa.St	Pentax 557-560 overview of bay and

Location (Target note)	Description	Target note	Notes	Biotope	Photos (N)=north (E)=West etc
	Roinn a Bhuic	In the lower/Midshore: *C. rupestris*, limpets common mussel, barnacles, the crustose red algae *Hildenbrandia rubra*, the red seaweed *Polysiphonia lanosa*, knotted wrack *Ascophyllum nodosum*, the red seaweed *Heterosiphonia plumose*, common periwinkle, spiral wrack and bladder wrack *Fucus vesiculosus*, false Irish moss *Mastocarpus stellatus*, sea lettuce *Ulva lactuca,* coralline algae, beadlet anemone, dog whelk *Nucella lapillus*. The flat top shell *Gibbula umbilicalis*, and flat periwinkle *Littorina obtusata* were found in the rock wall to the south of the slipway which is probably a man made structure built to protect the slipway. Substrate: Boulders cobbles and pebbles a sandy matrix exists in patches on the lower/mid shore. There are also patches of open sand in the in the southern part of the bay particularly near the old slipway at southern extent of the bay (Plate 10). Littorinds and Petellids are much larger here than on the open coast to the north. A low shore rockpool on south side of the bay contained: toothed wrack, oarweed, sea oak *Halidrys siliquosa*, the red epiphytic seaweed *Polysiphonia lanosa*, knotted wrack, the bryozoan or seamat *Electra pilosa*, The red seaweed *Membranoptera alata*, common periwinkle (very	the coast. The Alt Burgh stream is very peaty which makes the inshore water in the Bay very dark. Very large littorinids and very few crustaceans.	LR.MLR.BF.Fser.R (north side of bay) LS.LMx on the south side of the bay	hinterland Olympus 234 strandline 235(N) 236 (W) 237 (S), 238 close up of mid shore. Olympus 239 (W), 240(S), 241 the shore. 248 along the boundary between boulders and sand.

Location (Target note)	Description	Target note	Notes	Biotope	Photos (N)=north (E)=West etc
		large), limpets, carrageen *Chondrus crispus*, coralline algae, red seweed, *Plocamium cartilagineum*. *C.rupestris*, beadlet anemone, *Heterosiphonia plumosa*, Christmas tree seaweed, Knotted wrack, breadcrumb sponge *Halichondria panacea*, Palmaria, porifera indet (orange), grey top shell *Gibbula cineraria*, butterfish *Pholis gunnellus* and common shore crab Carcinus maenas.		LR.MLR.BF.Fser.R	
NB 40277 56891 (**7**)	Approximately 400m South of the bay see above	The lower shore is much less rugose here and is composed of boulders with less rocky outcrops than previously. Species present include: *C.rupestris*, carrageen, dulse *Palmaria palmata*, painted top shell *Calliostoma zizyphinum,* hermit crab *Pagurus bernhardus*, oarweed, toothed wrack, breadcrumb sponge, tube worm *Spirobis spirobis*, coralline algae, beadlet anemone, grey top shell, delia anemone *Urticina felina* in deep rock pool and pepper dulse.		IR.MIR.KR.Ldig.Bo	Olympus 249
NB 40296 56879 (**8**)	Mid shore inland of previous	Species present: False Irish moss, carageen, brown seaweed *Bifurcaria bifurcata,* coralline algae, limpets, toothed wrack, common periwinkle, rough periwinkle peeper dulse, flat top shell, *Ceramium. sp,* knotted wrack*, P.linosa,* hermit crab and the sea hare *Aplysia punctata**.***		LR.MLR.BF	
NB 40350 56824	Upper shore from previous two WP	Species present include. Sea oak, common periwinkle, limpet, barnacles indet, dog whelk, toothed wrack, spiral wrack and bladderwrack, flat	There are two strandlines here, the upper is thin then	LR.HLR.MusB.Sem.Sem	Olympus 252 (N), 253 and 254 abundant

Location (Target note)	Description	Target note	Notes	Biotope	Photos (N)=north (E)=West etc
(**9**)		periwinkle and an unidentified feathery brown seaweed.	below this is an area of clean boulders and below that is larger strandline.		Periwinkles
NB 40302 56742 (**10**)	Two observes in PP scanning the sea with binoculars from a makeshift hide	At this point there are two strandlines on the shore the higher one is more dense. The shore is composed of large mobile boulders.	Further individual on the beach below the observers collecting unidentified objects from the beach, Suspected winkles		
NB 40097 56603 (**11**)	Upper shore near a small bay	Tar lichen, barnacles. Common periwinkle, rough periwinkle and *Xanthoria parietina.*		LR.FLR.Lic.Ver.Ver	
NB 40005 56600 (**12**)	Lower shore of second small bay	Substrate: mainly boulders with isolated outcrops. Species include: Oar weed, toothed wrack, *Saccorhiza polyschides* dulse, blue rayed limpet *Helcion pellucidum,* breadcrumb sponge, carageen, *C.rupestris*, shanny *Lipophrys pholis, M.altata*, grey top shell, beadlet anemone, unidentified chiton, star ascidian *Botryllus schlosseri*, various unidentified sponges *porifera indet,* common starfish *Asterias rubens,* laver spire shell *hydrobia sp.*		IR.MIR.KR.Ldig.Bo	Pentax 561-564 Shanny Olympus 255-260
NB 40024 56470 (**13**)	Small Bay	Substarte: Boulders and small rocky outcrops backed by shingle in the upper shore. Rock pools are numerous at all levels on the shore. Species present include: limpets, barnacles, common periwinkle, tar lichen, channelled wrack(O), beadlet anemone (C), *C.rupestris*, carrageen, false Irish	Upperstrand line narrow and located near the top of the shingle	LR.MLR.BF.PelB	Olympus 261

Location (Target note)	Description	Target note	Notes	Biotope	Photos (N)=north (E)=West etc
		moss.			
NB 40051 56344 (**14**)	Stream 3	Small fast flowing shallow water course, very peaty dark water and a stony base. No spraint apparent.	Add to otter notes		Olympus 262 (W) 263 (E) Pentax 565 through to 569 start facing north and rotating round through west to south
WP 503 NB 39513 56200 (**15**)	Uppershore	Substrate: shingle and boulders on the upppershore with easy angled bedrock in the mid and lower shore, with boulders and small outcrops. Looking north and south the shore is composed of small rocky promontories interspersed with small embayments no more than 50m apart and 30m deep (not water depth)		LS.LCS.Sh	Olympus 294(S) 295(E) 296 (W)
WP 504 NB 39486 56229 (**16**)	Mid shore rockpools	Species include: The sea cauliflower, *M.alata* , false Irish moss, toothed wrack, unidentified filamentous brown algae, *Saccorhiza polyschides* , beadlet anemone, grey top shell, dog whelk, limpet, barnacle, bladder wrack, flat periwinkle, *C.rupestris*, gut weed, *Ceramium sp*, sea oak, sommerfelt, unidentified sponges, encrusting algae *Lithophyllum incrustans*, indentified intertidal black lichen.	Large network of rock pools	LR.FLR.Rkp.Cor	Olympus 297-302

Location (Target note)	Description	Target note	Notes	Biotope	Photos (N)=north (E)=West etc
WP 505 NB 39233 56065 (**17**)		Uppershore: Common periwinkle, Rough periwinkle, Mid shore: Area generally more rugose than TN16 with frequent rock outcrops up to 2m high running in bands across the area from NE to SW Lower shore: Small inlets between bedrock rather than a network of pools. Less algal dominated than at TN16 more mobile boulders, cobbles and pebbles.	Upper shore rock pools filled with Ulva intestinalis,	LS.LCS.Sh	Olympus 303 (W) 304 (S) 305
WP 506 NB 38788 55791 (**18**)		The shingle upper shore is broken here at a small headland and terrestrial vegetation merges with outcropping bedrock. Vegetation present include: Sea ivory, Sea plantain *Plantago maritima*, *X.parietina,* Sea rocket *Cakile maritima,* Crab eye lichen *Ochrolechia parella* leading to Tar lichen. Mid/lower shore: Much less algal dominated than at previous TN 17, greater amounts of bare rock. The bedrock is steep with deep gullies running through it. Species present include: Limpets (A) dog whelk, beadlet anemone, barnacles (C), gut weed, common mussels (small clumps in sheltered areas), common periwinkle (large). Lower shore: Toothed wrack and beadlet anemone.		LR.FLR.Lic LR.HLR.MusB. Sem.Sem	
WP 507 NB 38547 55637 (**19**)	Very slight wide bay	Shore is gently sloping and mostly composed of bedrock of which outcrops are generally less than 1m high. The top of the outcrops have bare rock whilst the bottom of the outcrops and gullies are dominated by	Large amounts of kelp thrown up on the shore,	LR.HLR.MusB. Sem.Sem	Olympus 306-307

Location (Target note)	Description	Target note	Notes	Biotope	Photos (N)=north (E)=West etc
		fucoids. Uppershore: some rockpools Limpets (C), Common mussel (O), common periwinkle, and rough periwinkle. The intertidal is backed by shingle.			
WP 508 NB 38305 55539 (**20**)	Southern edge of footprint	Shingle on the uppershore gives way to bedrock which supports: Sea campian *Silene maritima*, thrift, sea plantain and many species of lichen. Lower shore: Oarweed, dulse, unidentified coralline algae, breadcrumb sponge, flat top shell, beadlet anemone, carageen, toothed wrack, limpet, blue rayed limpet, *E.pilosa*, Saccorhiza polyschides, Delia anemone, hermit crab, star ascidian, common starfish, chitons indet, gutweed, edible crab *Cancer pagurus*, *Ophiothrix fragilis* brittle star indet, gut weed, common shore grab, velvet swimming crab *Necora puber*, Hediste diversicolor, polychaetes indet, patella (small (R)) unidentified amphipods. Pepper dulse, false irish moss, carageen, crab indet (xantho) strawberry anemone *Actinia fragacea*, squat lobster *Galathea squamifera*, shanny, *Henricia occulata* and dog whelk.	WP taken in upper shore, lower shore survey conducted down the shore from this WP	LR.FLR.Lic IR.MIR.KR.Ldig.Bo	Olympus 308 - 328 320-323 shanny 328 bloody Henry starfish
WP 509 NB 382 (**21**)	Mid shore from previous. Old winch and machinery in the upper shore	Rock outcrops with small rockpools in the rockpools are: The sea cauliflower, spiral wrack knotted wrack, coral weed *Corallina officinalis*, sea oak, barnacles dominate the bedrock with 90% coverage, limpets, dogwhelks and beadlet		LR.FLR.Rkp.Cor.Cor	Olympus 329-230

Location (Target note)	Description	Target note	Notes	Biotope	Photos (N)=north (E)=West etc
		anenomes Upper shore: channelled wrack, gut weed (in rock pool), tar lichen.		LR.FLR.Lic	
WP 510 NB 38176 55469 (**22**)	Southern edge of survey area.	Steep shore that exhibits compressed width of biological zonation, but they are still evident.	To the south the angle of the shore decreases and looks similar to previous WP		
NB 37800 54900 (**23**)	Mol Eire Bay (outside of study area)	North side of Bay in the upper/mid shore: Substrate dominated by medium sized boulder easy angled shore with some exposed bedrock. Dominated by the grazers species include: channelled wrack, dog whelk, barnacles, common periwinkle, *L. incrustans,* unidentified amphiopods (A), in rock pool in the mid shore, coral weed, sea oak, *L. incrustans* toothed wrack, bladder wrack, filamentous brown algae, false irish moss, *C.rupestris*, gut weed, flat periwinkle. Mid/lower shore: same species as above but also knotted wrack, carrageen, the sea cauliflower.		LR.MLR.BF.FvesB	SLR 2 photos of the mid shore, 1 (N) 1 (S)

S) Super abundant (A) Abundant (C) common (F) frequent (O) occasional (R) rare. Note no quantative data was recorded and therefore the SACFOR scale has been applied subjectively by the surveyors

Conditions

30/08/2011 Intertidal survey of the northern part of the footprint.

Arrived on site 10am. Weather at the start of survey: Fresh North westerly wind (gusting up to 20mph) with rain heavy at times. Overcast with low cloud. Rain cleared gradually over the day and from 12:30 onwards sunshine was interspersed with cloud. Sea state 3-4

31/08/2011 slight breeze from the west, overcast with occasional sunny spells. Sea state greatly reduce 1-2

=O=O=

Appendix 14.1

Seascape Landscape and Visual Impact Assessment figures

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AQUAMARINE POWER

Core Path

Wider Path Network

Lewis Wave Power Limited
40MW Oyster Wave Array

Core Paths Plan

0 1 : 50,000 1 km

Fig 14.1

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AQUAMARINE POWER

Local Coastal Character

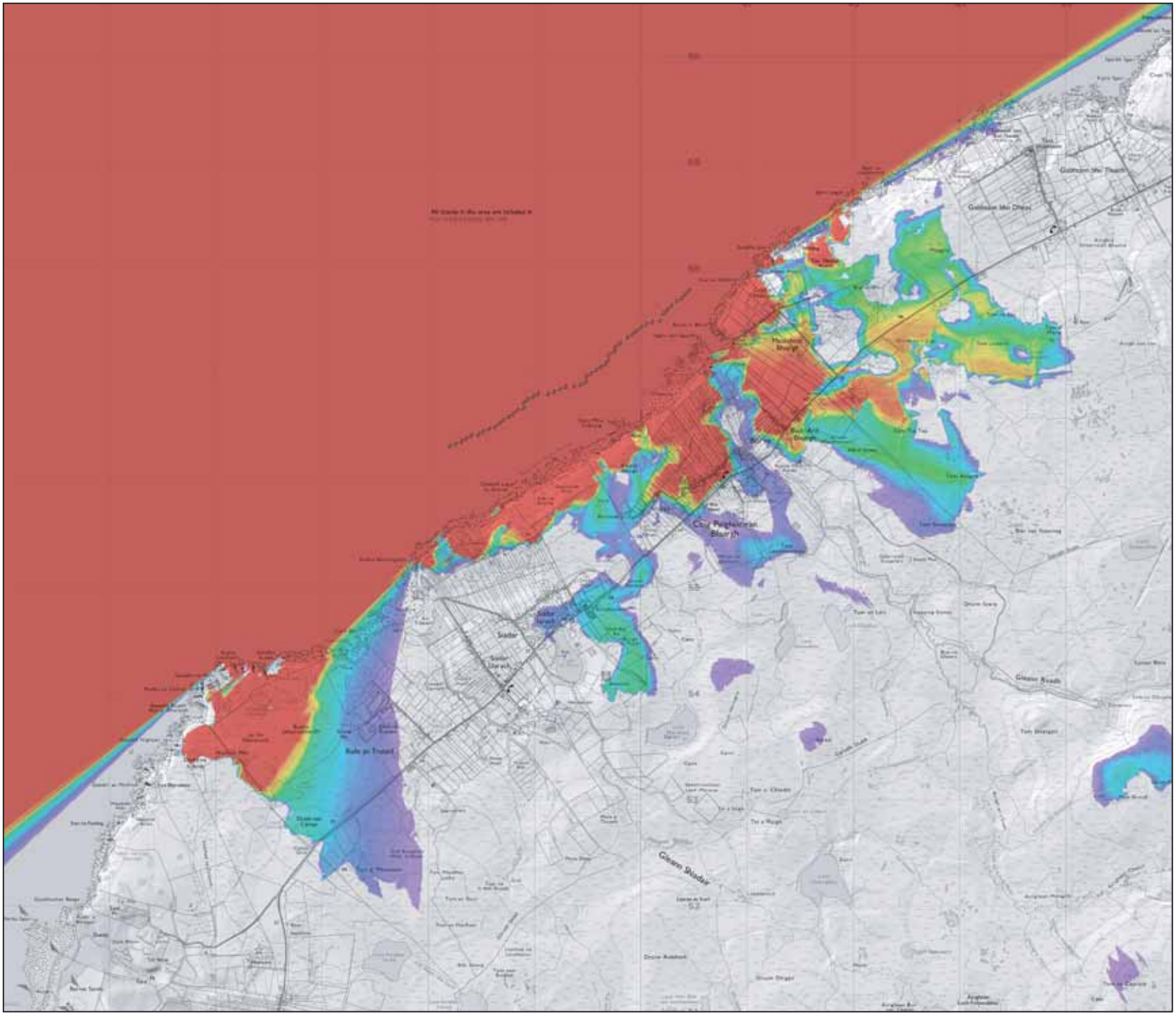
- Gabhsann to Mealabost
- Mealabost to Rubha na Caillich
- Oyster devices
- Onshore development

Lewis Wave Power Limited
40MW Oyster Wave Array

Local Coastal Character

0 — 1 : 50,000 — 1 km

Fig 14.2



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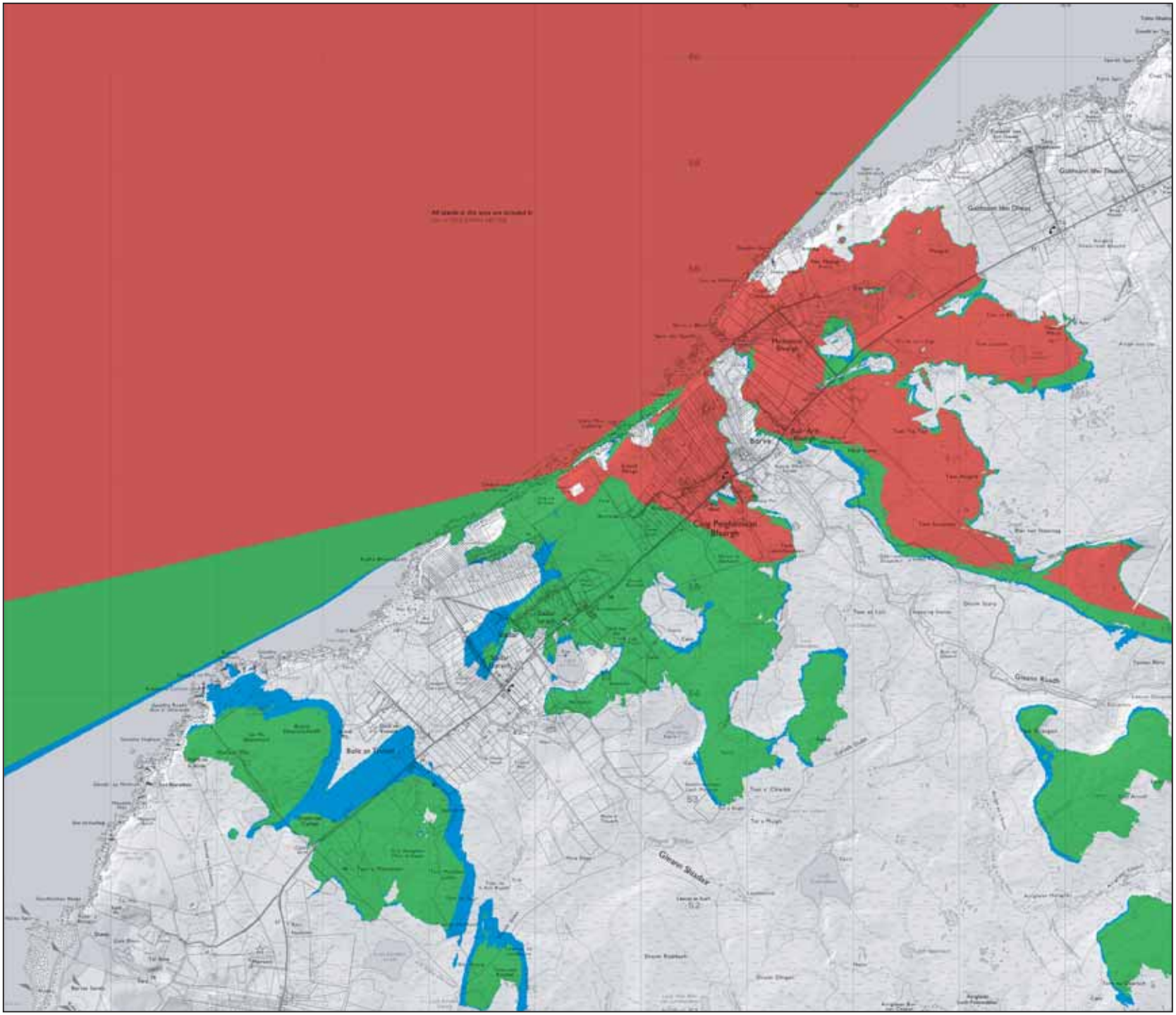
AQUAMARINE POWER

Lewis Wave Power Limited
40MW Oyster Wave Array

Zone of Theoretical Visibility (ZTV)
Offshore Oyster Devices

0 1 km

Fig 14.3



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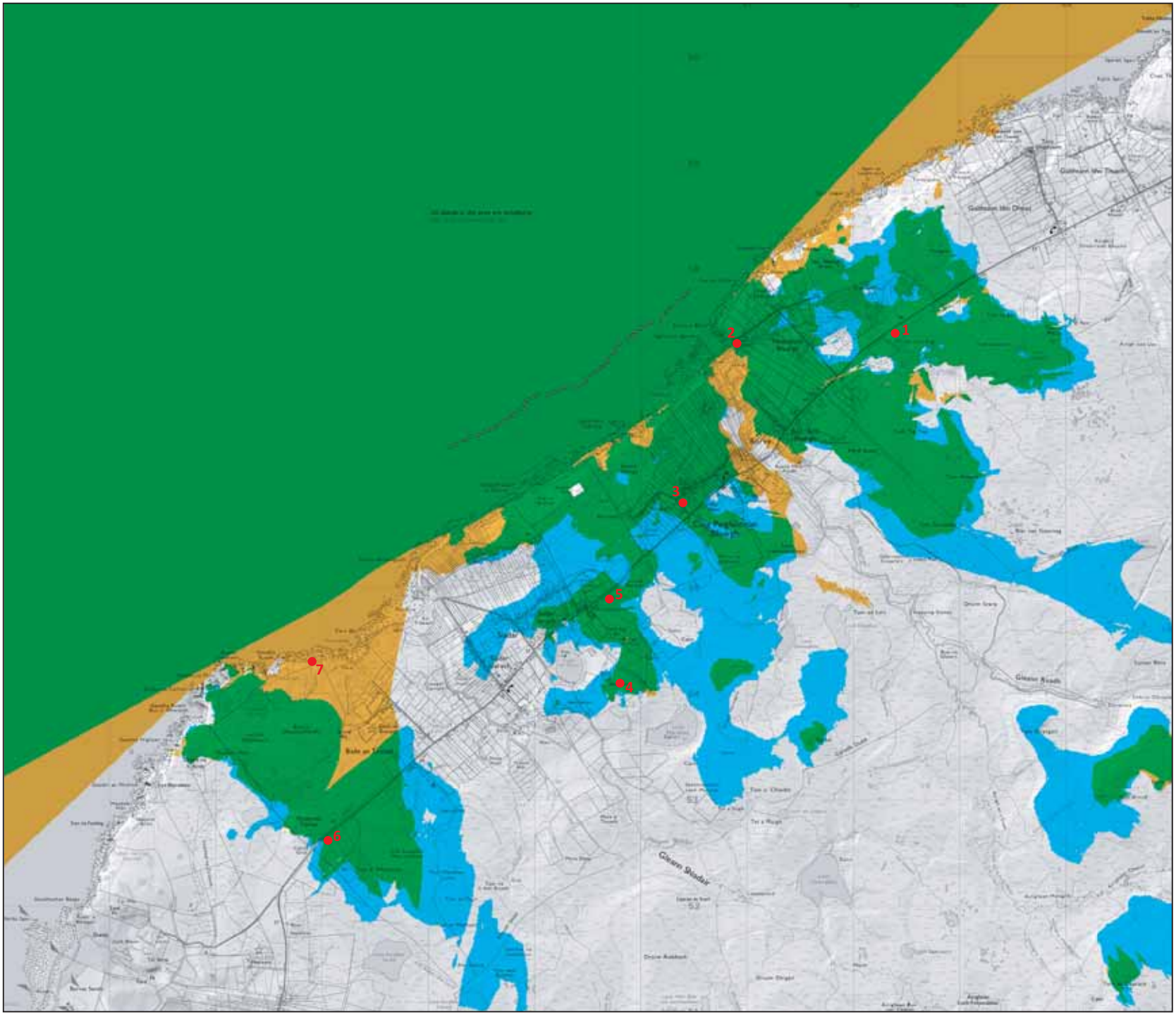
AQUAMARINE POWER

Lewis Wave Power Limited
40MW Oyster Wave Array

Zone of Theoretical Visibility (ZTV)
Onshore development

0 1 km

Fig 14.4



Assessment Viewpoints

- 1 A857 NW Mealabost
- 2 Car park for coastal walk, Mealabost
- 3 Borve
- 4 Steincleit Stone Circle
- 5 A857 Siadar
- 6 A857 south-west of Baile an Truiseil
- 7 Coastal edge to the south-west of the proposal

ZTV

- Onshore buildings visible
- Offshore Oyster devices visible
- Both onshore and offshore components visible

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Lewis Wave Power Limited
40MW Oyster Wave Array

Combined ZTV for Offshore and Onshore development

0 1 km

Fig 14.5

Viewpoint 1 - A857 NW Mealabost - Fig 14.6

Viewpoint 1 - A857 NW Mealabost - Fig 14.6a

Viewpoint 2 - Car park for coastal walk, Mealabost - Fig 14.7

Viewpoint 2 - Car park for coastal walk, Mealabost - Fig 14.7a

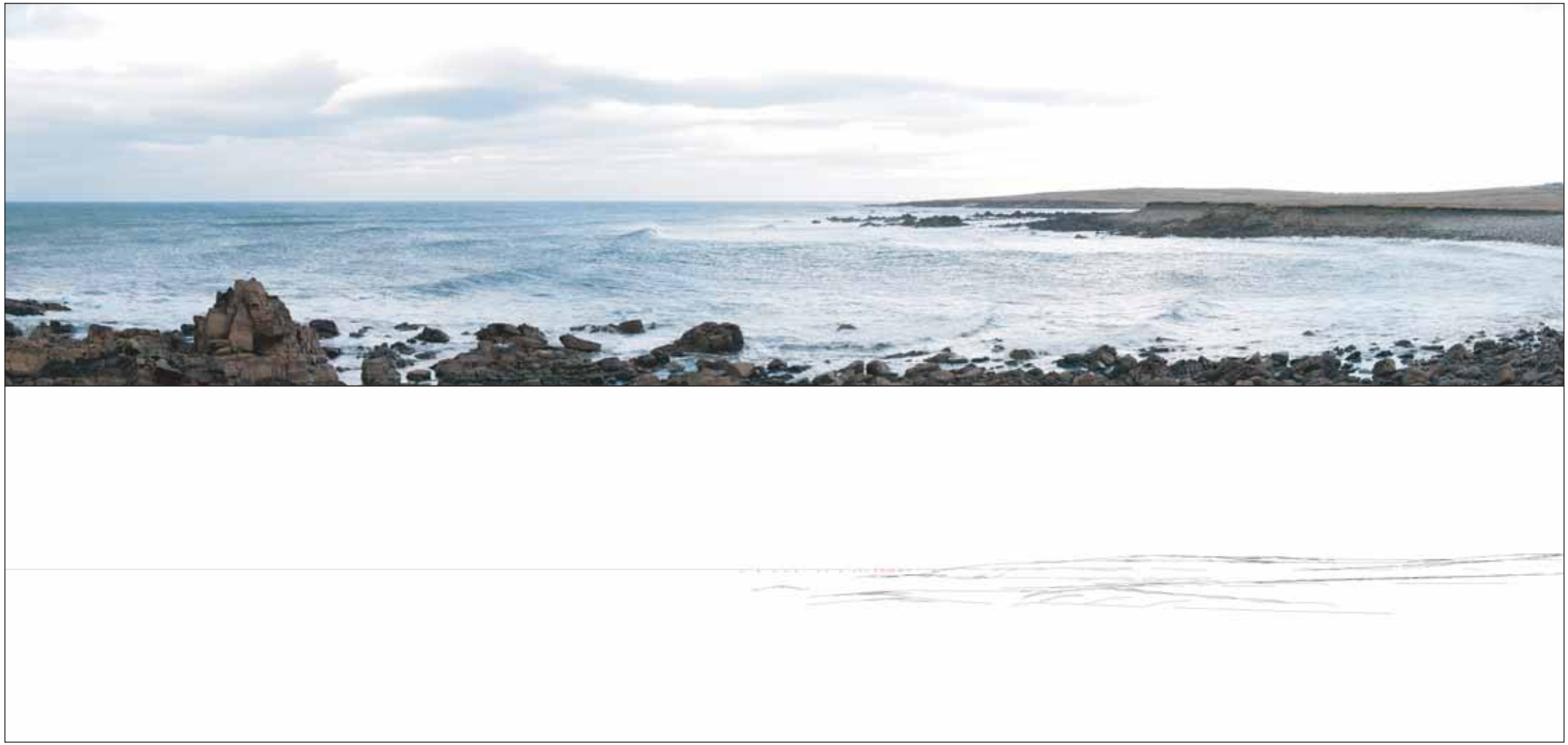
Viewpoint 3 - Borve - Fig 14.8

Viewpoint 4 - Steincleit Stone Circle - Fig 14.9

Viewpoint 5 - A857 Siadar - Fig 14.10

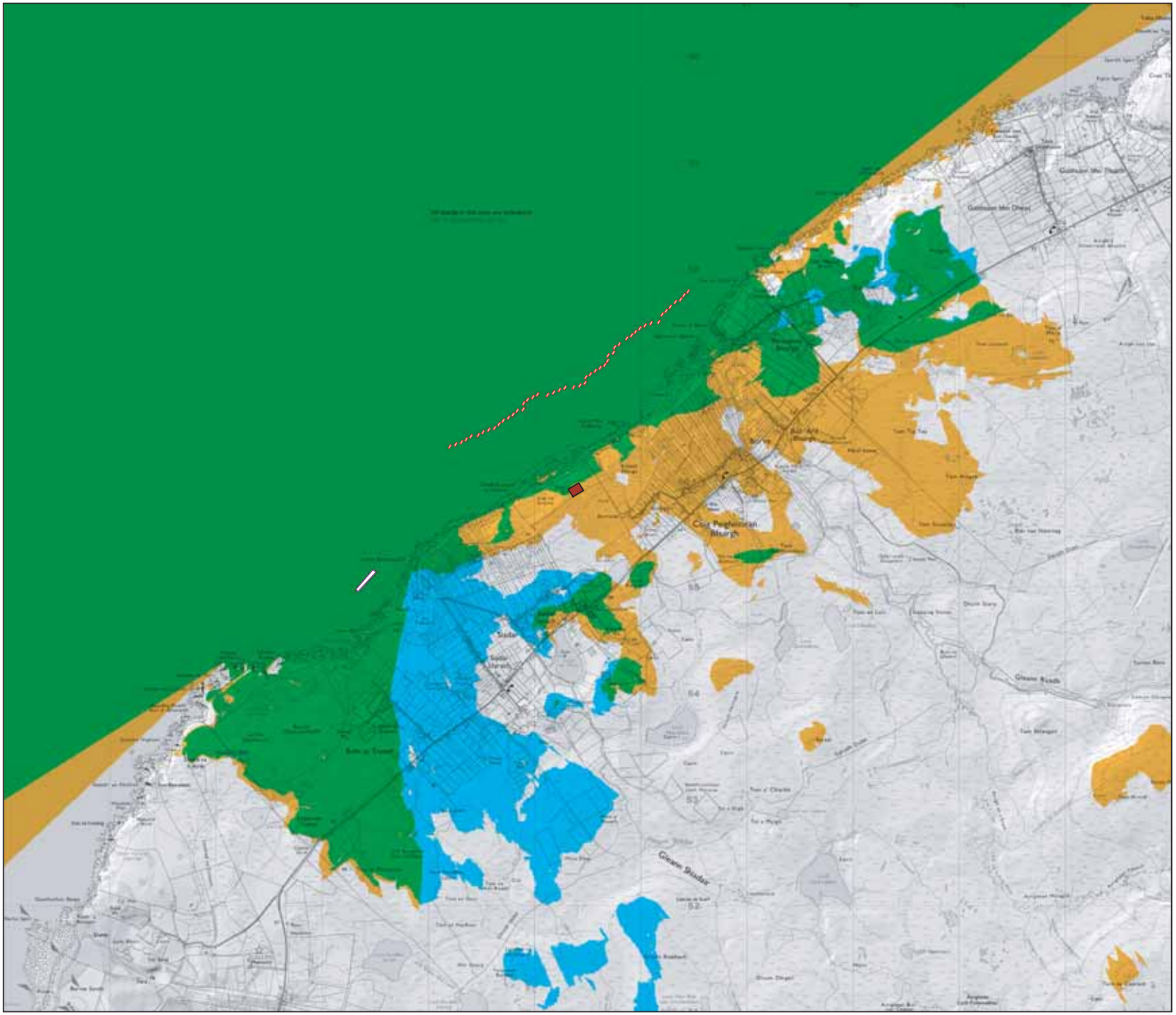
Viewpoint 5 - A857 Siadar - Fig 14.10a

Viewpoint 6 - A857 south-west of Baile an Truiseil - Fig 14.11



Viewpoint 7 - Coastal edge to the south-west of the proposal - Fig 14.12

Viewpoint 7 - Coastal edge to the south-west of the proposal - Fig 14.12a



AQUAMARINE POWER

Oyster devices

Onshore development

Consented 4MW Siadar Wave Energy Development breakwater structure

ZTV

4MW Siadar Wave Energy Development breakwater visible

40MW Lewis Wave Array onshore and offshore development visible

Both consented 4MW Siadar Wave Energy breakwater and 40MW Lewis Wave Array development visible

Lewis Wave Power Limited
40MW Oyster Wave Array

Cumulative Zone of Theoretical Visibility (ZTV)

0 1 km

Fig 14.13

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Siadar breakwater structure

Viewpoint 7 - Cumulative visualisation consented 4MW Siadar Wave Energy Project and 40MW Lewis Wave Array - Fig 14.14

Appendix 15.1

Navigational Risk Assessment

Navigation Risk Assessment
West Lewis
Oyster Wave Array
(Technical Note)

Prepared by:	Anatec Ltd.
On behalf of:	Lewis Wave Power Ltd
Date:	22 February 2012
Revision No.:	00
Ref.:	A2740-NRA-01

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This study has been carried out by Anatec Ltd on behalf of Lewis Wave Power Ltd. The assessment represents Anatec's best judgment based on the information available at the time of preparation. Any use which a third party makes of this report is the responsibility of such third party. Anatec accepts no responsibility for damages suffered as a result of decisions made or actions taken in reliance on information contained in this report.

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1. Introduction

1.1 Background

Anatec Ltd (Anatec) has been commissioned by Lewis Wave Power to carry out the shipping and navigation risk assessment of the North West Lewis Wave Array (hereafter referred to as the Project, and WLWA in figures) located on the northwest coast of the Isle of Lewis.

This document presents information on the proposed development relative to the baseline navigational activity and features in the area. Following this, an assessment of the impact of the proposed development on shipping and navigation is presented.

1.2 Objectives

The main aims of this study were as follows:

- Identify the key navigational features of the area including sea room, water depth, navigational aids, port / harbour locations and metocean characteristics.

- Collect and analyse vessel activity data in the vicinity of the Project to characterise all the different vessel types using the area, both locally-based vessels and transiting vessels from further afield.

- Review the historical maritime incidents that have occurred in the area in recent years and the Search and Rescue resources in the area which may be called upon in the event of a maritime incident.

- Assess the impact on navigation and maritime risk associated with the Project (including the different phases, such as installation and operation). This stage included a Hazard Review Workshop involving a cross-section of local stakeholders.

- Assess the potential cumulative and in-combination impacts on vessels of proposed, nearby developments/activities.

- Review the available measures to mitigate the navigational risks associated with the project

1.3 Methodology

The assessment methodology principally followed the Department of Energy and Climate Change (DECC) Risk Assessment Methodology (Ref. i) and the Maritime and Coastguard Agency's (MCA) Marine Guidance Notice 371 (MGN 371) (Ref. ii). (The DECC guidance was originally developed for offshore wind farms but most of it is relevant to other offshore renewable energy installations (OREIs). The MCA guidance has been specifically altered to make relevant to other OREIs). The DECC guidance requires a submission that is proportionate to the scale of the development and the magnitude of the risks. A development in an area where the potential risks are lower, or a small scale development, might only require a submission based on a:

- Hazard list
- Navigation risk assessment based on qualitative techniques such as "expert judgement"
- Search and rescue overview, to agreed MCA requirements
- Emergency response overview, to agreed MCA requirements
- Risk Control List.

1.4 Abbreviations

The following abbreviations are used in this report:

AIS	-	Automatic Identification System
ALARP	-	As Low as Reasonably Practicable
ALB	-	All-weather Lifeboat
BTA	-	British Tug owners Association
CA	-	Cruising Association
CRT	-	Coastguard Rescue Teams
DW	-	Deep Water
EMEC	-	European Marine Energy Centre
ETV	-	Emergency Towing Vessels
GPS	-	Global Positioning Systems
HDD	-	Horizontal Directional Drilling
ICES	-	International Council for Exploration of the Sea
IMO	-	International Maritime Organisation
LAT	-	Lowest Astronomical Tide
MAIB	-	Marine Accident Investigation Branch
MCA	-	Maritime and Coastguard Agency
MGN	-	Marine Guidance Note
MLWS	-	Mean Low Water Springs
MMO	-	Marine Management Organisation
MMSI	-	Maritime Mobile Service Identity
MRCC	-	Maritime Rescue Co-ordination Centres
MSL	-	Mean Sea Level
NLB	-	Northern Lighthouse Board
NM	-	Nautical Miles (1nm ≡ 1,852 metres)
PLN	-	Port Letter Number
RNLI	-	Royal National Lifeboat Institution
RYA	-	Royal Yachting Association
SAR	-	Search and Rescue
SOLAS	-	Safety of Life at Sea
UKCS	-	United Kingdom Continental Shelf
UKHO	-	United Kingdom Hydrographic Office
VHF	-	Very High Frequency
WEC	-	Wave Energy Converter

2. Project Overview

2.1 Location Overview

The Project is located on the west coast of the Isle of Lewis and will have a planned operational life of 20 years. There will be up to 50 Oyster devices in an 'array'.

General and detailed chart overviews of the Project are presented in Figure 2.1 and Figure 2.2, respectively.

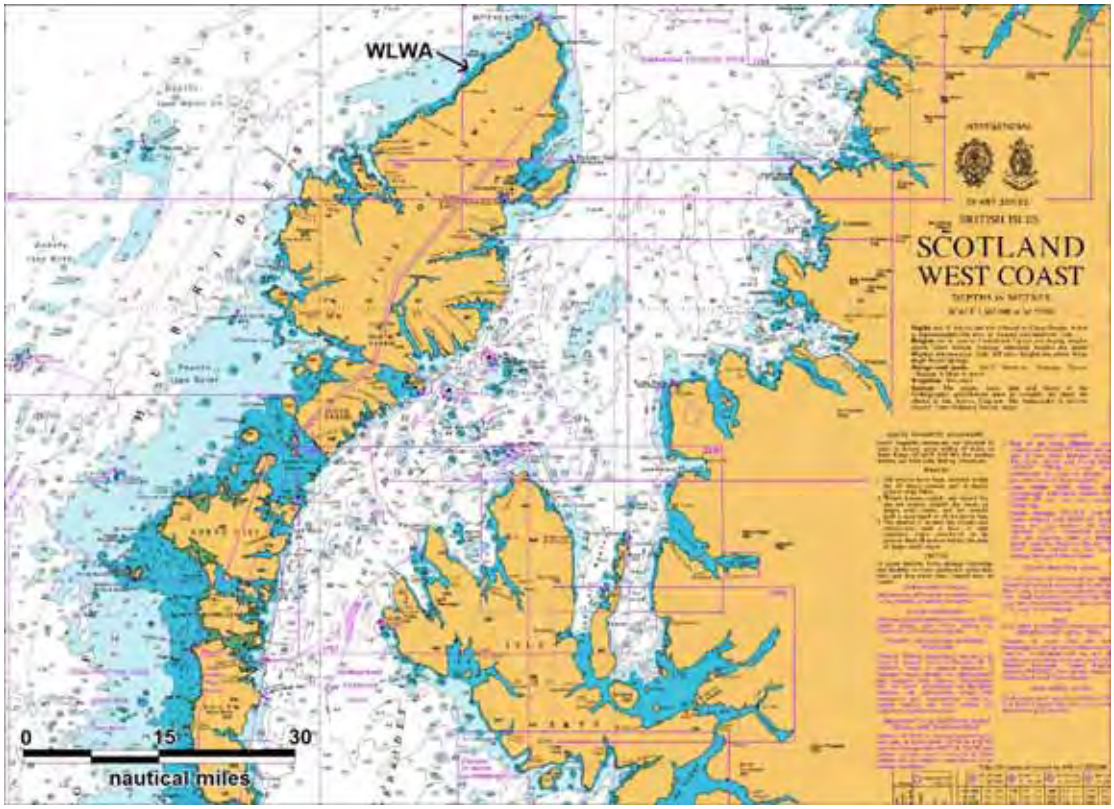


Figure 2.1 General Chart Overview of the Project

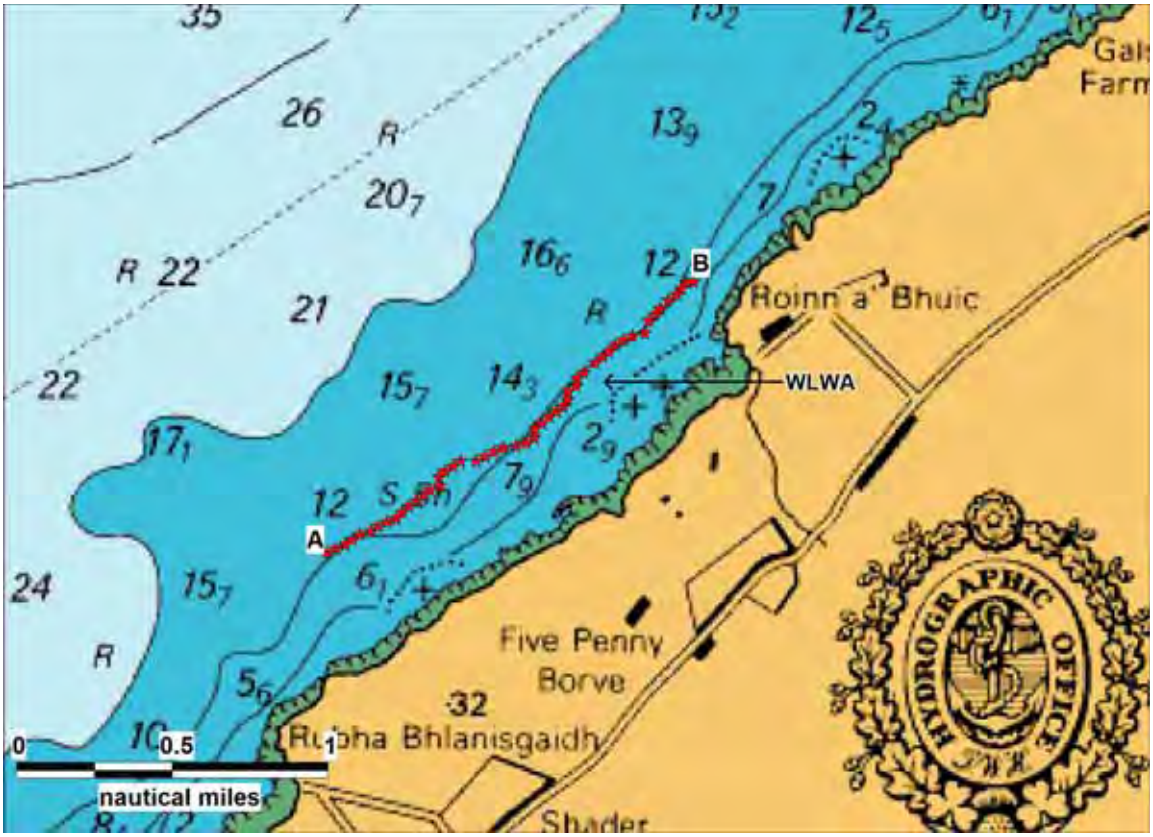


Figure 2.2 Detailed Chart of the Project

2.2 Device Layout

Details from the Environmental Scoping Report (Ref: iii) state that the devices are located approximately 300m to 750m from the shore of the North West coast of Lewis. The devices will lie parallel with the coastline of about 3km in length and a maximum of 50m in width. Devices will be sited based on bathymetry and therefore will not be located in a straight line. From the MLWS mark, the seabed across much of the Project area slopes relatively deeply to the 10m depth contour, and then slopes more gradually down to 20m. Between 0.5km – 1.5km offshore, water depth varies between 13m and 15m.

The geographical co-ordinates of the extremities of the Project are presented in Table 2.1.

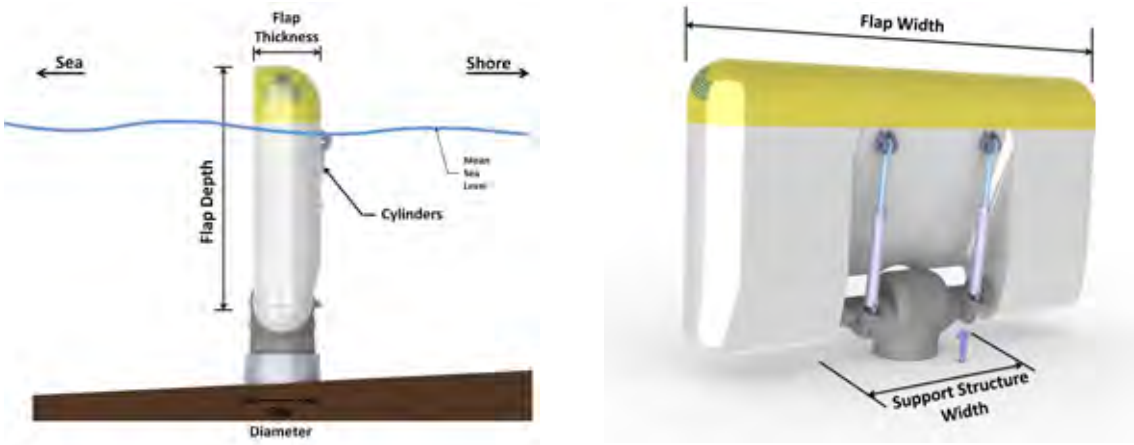
Table 2.1 Corners of West Lewis Wave Array (WGS 84)

Location	Geographical Co-ordinates	
Name	Latitude	Longitude
A	58° 25' 01.20" N	006° 29' 01.61" W
B	58° 25' 53.57" N	006° 26' 46.98" W

2.3 Oyster Devices

In total, the Project will consist of up to 50 Oyster wave energy converters (WECs). The layout is planned to consist of Oyster 800 devices. The Oyster device is currently undergoing commercial demonstration trials at Billia Croo (EMEC test site) in Orkney and information from these trials will inform the final design of the Oyster 800.

Figure 2.3 presents the design of an Oyster 800.



Side View **Back View**

Figure 2.3 Design of the Oyster 800 Device

Devices will be installed on the seabed and partially submerged in operation, with the upper 3m of the devices protruding above the water level (relative to MSL). There will be a minimum separation between devices of at least 10m, with a minimum of 20m separation proposed perpendicular to the devices to aid maintenance activities and ensure safe work vessel passage between each Oyster device. The final navigational markings will be agreed with the Northern Lighthouse Board (NLB). Previous Oyster devices were designed with the top section of the devices and the edges of the ends painted yellow to improve visual conspicuousness, and it is anticipated that the markings for the Lewis Wave Array will be similar, subject to the agreement of the NLB. There will also be an Aquamarine Power logo in blue to aid identification and each device will be given a unique identifier number..

In addition to the top section of devices being painted yellow, NLB would consider marking the Project site using two shore posts with lights at each end of the array. Buoys will most likely be too hard to maintain on station and not a lot of inshore fishing activity occurs. The layout will be reviewed once the final layout is confirmed and local consultation may be undertaken.

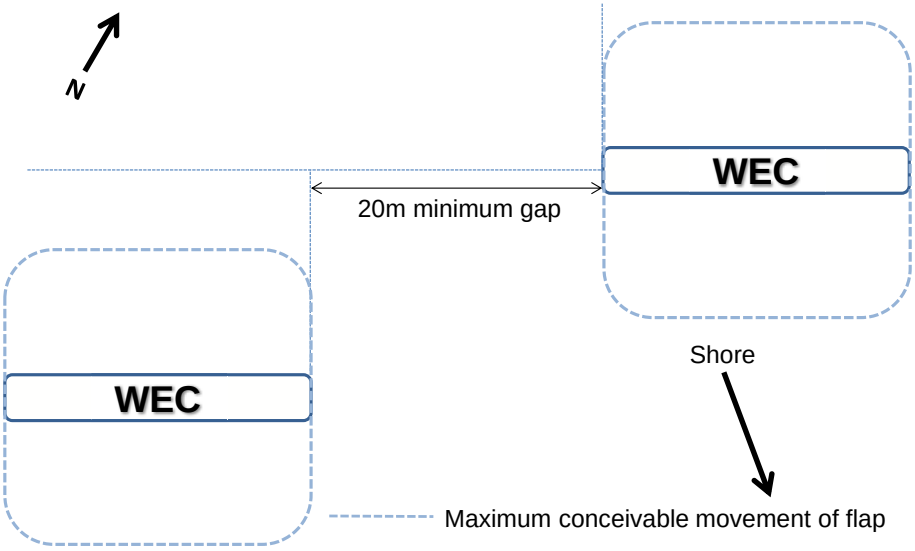


Figure 2.4 Overview of Spacing Between WEC Devices

2.4 Device Installation

Prior to the installation of devices, it may be required that the seabed be prepared in the form of kelp removal, filling in gullies and a small amount of rock removal.

Each device will be towed to site from a local port. The nearest large port is Stornoway, with smaller ports in the area including Bhaltos, Carloway, Miabhaig and Beárnaraigh (Kirkibost). It is a possibility that devices may be moored at a sheltered 'storage area' on the west coast of Lewis (Loch Roag) near to site, prior to installation.

Devices will sit on pre-installed monopoles which will be drilled and grouted into the rock seabed. The monopoles will provide a secure and level base for the WECs on the seabed at spproximately 13m MSL water depth.

To ensure that maximum energy is extracted from the waves, the area below the WECs will be filled by 'gap fillers'. These will take the form of wire cages or bags filled with rocks, or will be made of concrete accropodes. The gap fillers will be placed around the monopile and under the bottom of each Oyster flap after the WEC is attached to the monopile.

Vessels considered likely to be involved in installation are presented in Table 2.2.

Table 2.2 Vessel Requirements

Activity	Vessel Type	Days on Site (per WEC)
Pipeline preparation and Installation	Tug	3
	2 x Multi-cat	Multi-cat A – 20 Multi-cat B - 3

Activity	Vessel Type	Days on Site (per WEC)
	Dive boat	20
Piling Operations	Jack up barge	14 (for 3 piles)
	Tug	3
Device Installation	Tug	3
	2 x Multi-cat	Multi-cat A – 20 Multi-cat B - 3
	Dive boat	20
Installation of Latching Anchors	Multi-cat	20
	Dive boat	20

2.5 Pipelines

Two pipelines will form a closed loop mains water system, linking the devices to the onshore powerhouse, as shown in Figure 2.5.

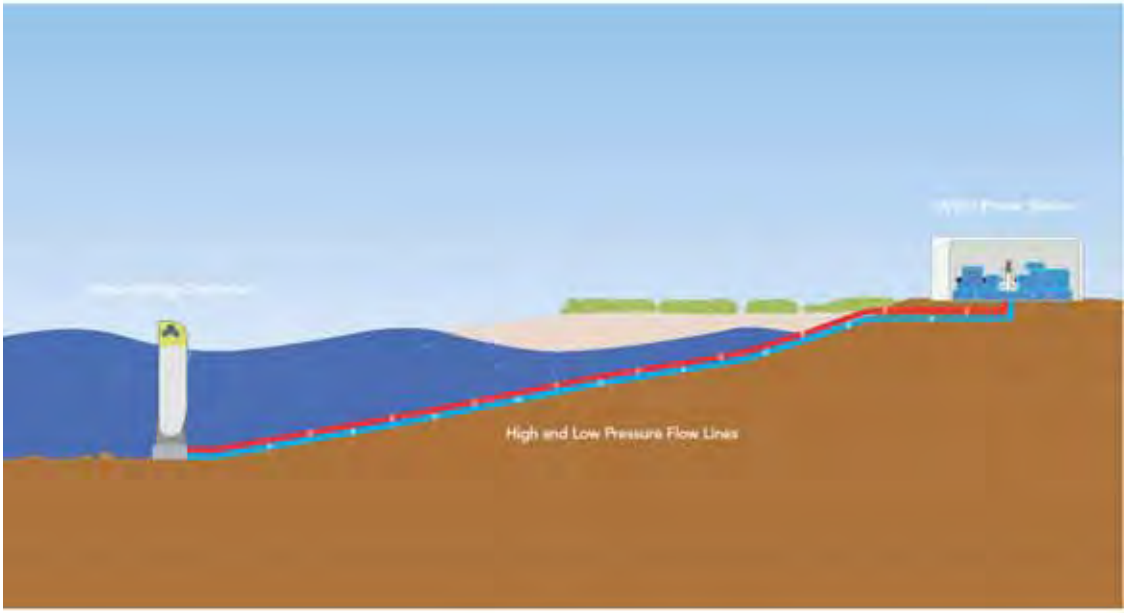


Figure 2.5 Oyster 800 Schematic

The common pipelines (Figure 2.6) will each measure a maximum of 0.9m in diameter. Each common pipeline will run the length of the array and is likely to be a maximum distance of 3.5km in length. The common pipeline will be installed in sections that join each WEC to the previous WEC. Each section will be secured at both ends under the landing platforms and will have an additional substation anchor point mid-way along the section. Stabilisation anchors will consist of a collar surrounding the pipeline which will be pinned to the seabed using rock anchors. A grout bag may be positioned under the pipeline which will be held in place by the rock anchors.

At up to eight separate locations the common pipelines will be connected to shore pipelines which will transport the hydraulic fluid to the shore. The shore pipelines will also consist of one high and one low pressure pipeline and will be installed using one of two options:

- The pipes will either be surface laid i.e. attached to the seabed using stabilisation anchors; or
- The pipes will be installed under the existing bedrock using horizontal directional drilling (HDD).

Alternatively, a mixture of the two installation methods will be used.

2.5.1 Surface Laid Pipelines

The configuration of the pipelines is yet to be finalised. The description below is based on a buildable scenario that would result in the worst case amount of pipeline being installed. Up to eight shore pipelines will connect the common pipeline to either a common landing area or between two and eight separate landing areas. Each shore pipeline will consist of pipes, one high pressure and one low pressure, each of which will be 0.9m in diameter and will be between 700m and 2400m long. The shore pipelines will be secured to the seabed using stabilisation anchors positioned at regular intervals of approximately 50m.

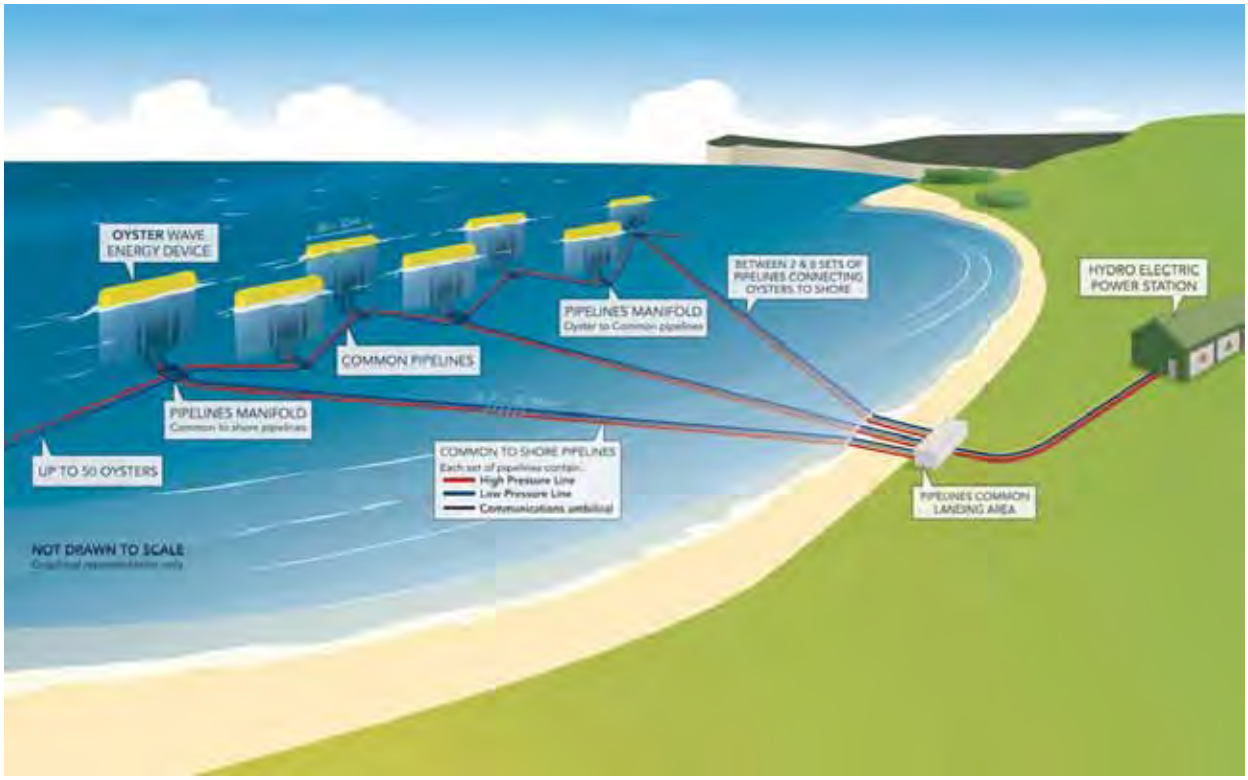


Figure 2.6 Oyster Schematic Plan View

2.5.2 Directionally Drilled Pipelines

Shore pipelines may be installed using a HDD method. The boreholes through which the pipes will be pulled will be drilled from either one of two onshore locations or from an offshore location using a jack up rig. If the boreholes are drilled from an onshore location several boreholes will be drilled from one or possibly two separate areas each up to 30m by 30m located within the onshore pipeline installation area. A maximum of 32 (16 for high pressure pipelines and 16 for low pressure pipelines) boreholes may be required to connect the common pipeline to the shore. From the point of breakthrough at the seabed the pipelines would be surface laid as described above.

2.6 Foundations

Foundations will be monopile for each device with no latching pile. Piles will be up to 5m diameter piles and up to 15m in length. The monopile sockets will be drilled from a jack-up barge and then a steel pile will be inserted into the socket and this will be grouted into place.

2.7 Installation/Operation & Decommissioning Phases

The installation of the devices will be phased over a period of 4 to 6 years with installation of the first phase of 3MWs commencing in summer 2014. The expected installation schedule for all phases is:

- Phase 1 – 3MW – installation starts in 2014
- Phase 2 – 7MW – installation starts in 2015
- Phase 3 – 15MW – installation starts in 2016
- Phase 4 – 15MW – installation starts in 2017

Estimates on support vessels required during installation are presented in Section 2.4. These vessels will be on and off site for a period of approximately two months depending on the phasing of pipeline preparation and installation in relation to the rest of the installation schedule.

During maintenance, a dive boat will be on site 10 days every six months per Oyster device. Once every five years, a multi-cat vessel will be required for an extended 20 day maintenance period. Decommissioning requirements will be the similar to those for device installation.

3. Data Sources

3.1 Introduction

This section summarises the main data sources used in assessing the existing environment and baseline shipping relative to the Project. The main data sources used in this assessment are listed below:

- Automatic Identification System (AIS) data (Summer and Winter 2010/11);
- Vessel recordings taken during coastal visual bird and marine mammal surveys to the west of Lewis;
- Fishing Surveillance (Satellite 2005-09 and Over flight 2005-09);
- Maritime Incident Data (Royal National Lifeboat Institute (RNLI) 2001-10 and Maritime Accident Investigation Branch (MAIB) 2001-10);
- UK Admiralty Charts; and
- Admiralty Sailing Directions NP 66.

A description of each is provided in the following sections.

3.2 AIS

3.2.1 Carriage Requirements

Regulation 19 of Safety of Life at Sea (SOLAS) Chapter V - Carriage requirements for ship-borne navigational systems and equipment - sets out navigational equipment to be carried on board ships according to ship type. In 2000, IMO adopted a new requirement (as part of a revised new chapter V) for ships to carry AIS. AIS is a system by which ships automatically send data concerning their position, Maritime Mobile Service Identity (MMSI), etc., on two individual Very High Frequency (VHF) channels to the shore and other vessels at very frequent intervals.

The regulation requires AIS to be fitted aboard all ships engaged on international voyages of 300 gross tonnage and upwards, cargo ships of 500 gross tonnage and upwards not engaged on international voyages and passenger ships irrespective of size built on or after 1st July 2002. It also applies to ships engaged on international voyages constructed before 1st July 2002, according to the following timetable:

- all passenger ships, not later than 1st July 2003;
- tankers, not later than the first survey for safety equipment on or after 1st July 2003;
- ships, other than passenger ships and tankers, of 50,000 gross tonnage and upwards, not later than 1st July 2004.

An amendment adopted by the Diplomatic Conference on Maritime Security in December 2002 states that ships, other than passenger ships and tankers, of 300 gross tonnage and

upwards but less than 50,000 gross tonnage, will be required to fit AIS not later than the first safety equipment survey after 1st July 2004 or by 31st December 2004, whichever occurs earlier. Ships fitted with AIS shall maintain AIS in operation at all times except where international agreements, rules or standards provide for the protection of navigational information.

The regulation requires that AIS shall:

- provide information - including the ship's identity, type, position, course, speed, navigational status and other safety-related information - automatically to appropriately equipped shore stations, other ships and aircraft;
- receive automatically such information from similarly fitted ships; and monitor and track such ships; and
- exchange data with shore-based facilities.

AIS employs the principle of using a ship's speed and manoeuvring status as a means of governing information update rates and ensuring the appropriate levels of positional accuracy for ship tracking. The different information types, identified as "static", "dynamic" or "voyage related" are valid for different time periods and thus require a different update rate. Information included in the various message types is summarised in the following tables below.

Table 3.1 AIS Information per Message Type

Static	Dynamic	Voyage related
MMSI	Position (Lat/Long)	Draught
IMO Number	Time	Hazardous Cargo (type)
Call Sign	Course over ground	Destination
Name	Speed over ground	ETA
Length and Beam	Heading	Route Plan
Type of Ship	Navigational Status	
Type of Nav Sensor	Rate of Turn	

Table 3.2 Class A AIS Broadcasting Rate

Static	Reporting Interval
Ship at anchor	3 min
Ship 0-14 knots	12 sec
Ship 0-14 knots changing course	4 sec
Ship 14-23 knots	6 sec
Ship 14-23 knots changing course	2 sec
Ship >23 knots	3 sec
Ship >23 knots changing course	2 sec

Class B AIS is a less expensive system which may be used voluntarily by smaller, non-SOLAS vessels. The data broadcast is slightly reduced but it still contains the main information that is required for collision risk management.

Class B messages are broadcast every 30 seconds, depending on the vessels speed. When the vessel is travelling < 3 knots the update rate is every 3 minutes, and when static or at anchor there is an update rate of 6 minutes. The table below summarises the broadcast information.

Table 3.3 Class B AIS Information

Static	**Dynamic**
MMSI	Position (Lat/Long)
Name	Time
Length and Beam	Course over ground
Type of Ship	Speed over ground
	Heading

3.2.2 Use of AIS systems by Smaller Vessels

Fishing vessels 45m in length and over are already required to carry AIS. AIS is not mandatory for recreational craft.

Directive 2009/17/EC of the European Parliament and of the council of April 23 2009 amended Directive 2002/59/EC. One of the main amendments made related to the use of AIS on fishing vessels, which is addressed through the insertion of Article 6a:

Use of automatic identification systems (AIS) by fishing vessels.

Any fishing vessel with an overall length of more than 15 metres and flying the flag of a Member State and registered in the Community, or operating in the internal waters or territorial sea of a Member State, or landing its catch in the port of a Member State shall, in accordance with the timetable set out in Annex II, part I (3), be fitted with an AIS (Class A) which meets the performance standards drawn up by the IMO.

Fishing vessels equipped with AIS shall maintain it in operation at all times. In exceptional circumstances, AIS may be switched off where the master considers this necessary in the interest of the safety or security of his vessel.

The timetable set out in Annex II, part 1(3) is as follows:

Fishing vessels with a length of more than 15 metres overall are subject to the carrying requirement laid down in Article 6a according to the following timetable:

- fishing vessels of overall length 24 metres and upwards but less than 45 metres: not later than 31 May 2012,
- fishing vessels of overall length 18 metres and upwards but less than 24 metres: not later than 31 May 2013,
- fishing vessels of overall length exceeding 15 metres but less than 18 metres: not later than 31 May 2014.

New built fishing vessels of overall length exceeding 15 metres are subject to the carrying requirement laid down in Article 6a as from 30 November 2010.'

Beyond this it is noted from a number of surveys Anatec has been carrying out on the United Kingdom Continental Shelf (UKCS) that the number of fishing vessels using AIS has increased significantly over the last two years.

3.2.3 AIS Limitations

AIS is a passive system and will therefore not track vessels that:

- Do not carry AIS (not mandatory for smaller fishing vessels <45m in length and recreational craft);

- Has turned their AIS transmitter off; and
- Has a failed AIS transmitter.

In addition broadcasting inaccurate information is often suggested as a potential failing of AIS that could lead to confusion in terms of collision risk management.

It is noted that significant numbers of smaller vessels are electing to install AIS as good practice. Recent surveys have shown significant numbers of <45m fishing vessels carrying AIS and discussions with RYA indicate that around 10% of their members are now using AIS.

3.3 Coastal Surveys (Visual)

Bird and marine mammal surveys were carried out from 3 viewpoints along the north west coast of Lewis, during which vessels passing within 2nm of the viewpoint were recorded. Vessels tracked during the coastal survey are presented in Section 8.

3.4 Fishing VMS and Over flight data

Data on fishing vessel sightings were obtained from Marine Management Organisation (MMO), who ensure the fishing industry's compliance with UK, EU and international fisheries laws through the deployment of patrol vessels, surveillance aircraft and the sea fisheries inspectorate. Each patrol logs the positions and details of all fishing vessels (UK and non-UK) within the Rectangle being patrolled. Data were obtained for the five-year period 2005 to 2009. Section 9.2.2 presents the sightings data analysis.

Fishing satellite vessel monitoring is also carried out by the MMO as part of the sea fisheries enforcement programme, to track the positions of fishing vessels in UK waters. This data is presented for 2009. Satellite data was also provided by Marine Scotland Compliance, for the years 2006-09. Data was analysed in Section 9.2.3.

3.5 Recreational Data

The Royal Yacht Association (RYA), supported by the Cruising Association (CA), who represent the interests of cruising sailors and motor-boaters worldwide, have identified recreational cruising routes, general sailing and racing areas for UK waters. This work was based on extensive consultation and qualitative data collection from RYA and CA members, through the organisations' specialist and regional committees and through the RYA affiliated clubs. The consultation was also sent to berth holder associations and marinas. The results of this work were published in Sharing The Wind (Ref. iv) and updated GIS layers published in the Coastal Atlas (Ref. v). Data from 2010 has been used for this study.

3.6 Maritime Incident data

All UK commercial vessels are required to report accidents to MAIB. Non-UK vessels do not have to report unless they are in a UK port or are in 12 mile territorial waters and carrying passengers to a UK port. There are no requirements for non-commercial recreational craft to report accidents to MAIB. The locations accidents, injuries and hazardous incidents reported to MAIB within 10nm of the wave array boundary for the last ten years between January 2001 and December 2010 have been analysed in Section 11.2.

Data on RNLI lifeboat responses within 10nm of the Project in the ten-year period between 2001 and 2010 have been analysed in Section 11.3.

3.7 UK Admiralty Charts

Admiralty charts are nautical charts issued by the United Kingdom Hydrographic Office (UKHO) and are subject to Crown Copyright. The charts have been used to consider approaches and entrances to port and harbours in the area. The charts also include data on depths (chart datum), coastline, buoyage, land and underwater contour lines, seabed composition (for anchoring), hazards, tidal information ("tidal diamonds"), traffic separation schemes, lights, and in short anything which could assist navigation in this area to ensure it is fully considered within this regional work. The following are the main charts used in this study:

- 2635 – *Scotland West Coast*
- 2720 – *Flannan Isles to Sule Skerry*

3.8 Admiralty Sailing Directions

The United Kingdom Hydrographic Office (UKHO) publication, Admiralty Sailing Directions – West Coast of Scotland Pilot NP 66, covering the west coast of Scotland from Mull of Galloway to Cape Wrath including the Hebrides and off-lying islands was used to summarise features in the vicinity of the Project.

4. Navigational Features

This section presents an overview of the baseline navigational features in the vicinity of the Project. Figure 4.1 presents the main navigational features in the vicinity of the Project.

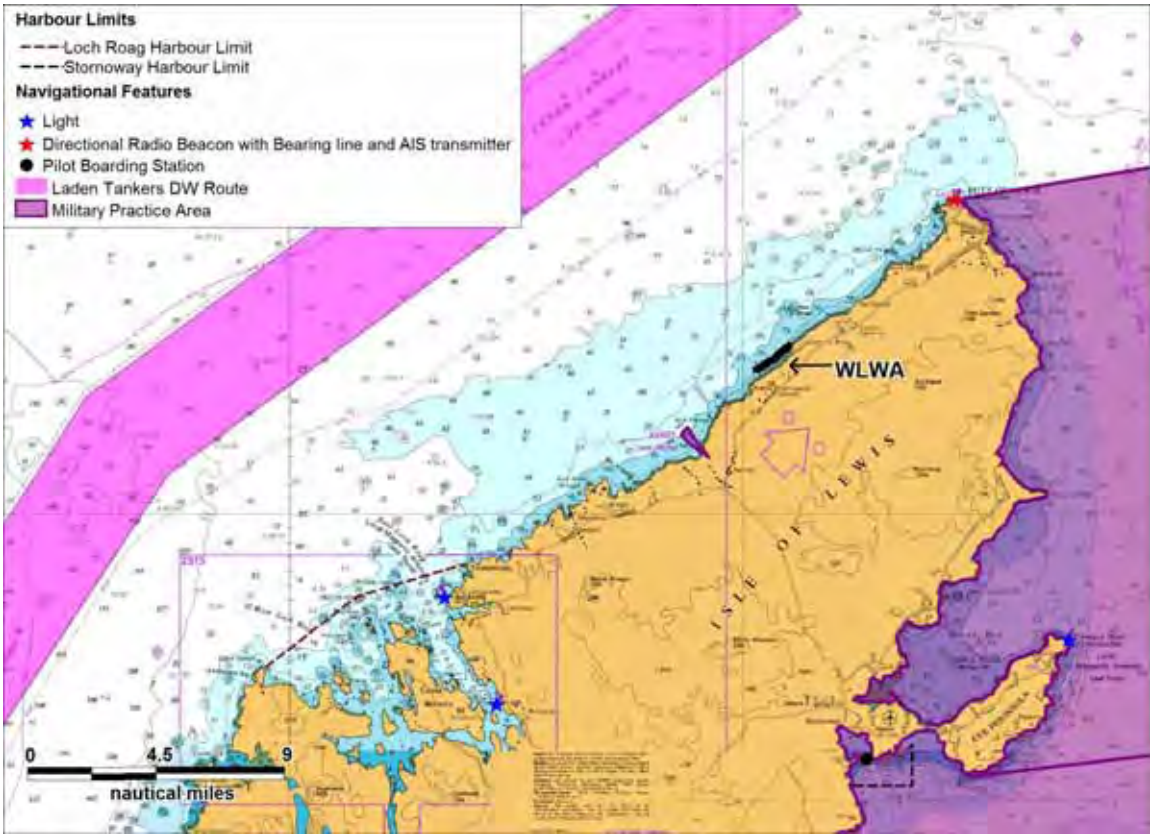


Figure 4.1 Overview of Navigational Features in proximity to the Project

The proposed Oyster wave array is approximately 7nm southeast of the IMO recommended West of Hebrides Deep Water (DW) Route for deep draught vessels and laden tankers. There is a military practice area on the east coast of Lewis. There are no restrictions placed on mariners transiting the area at any time.

Loch Roag Harbour Area, approximately 12nm to the southwest of the Project, is a statutory harbour area which includes all waters within seaward limits. All craft of more than 24m registered length must advise the harbour authority (Comhairle nan Eilean Siar) of their intended arrival and destination within the loch.

Stornoway Harbour, on the east side of Lewis, is the most important harbour in the Hebrides, serving a large fishing industry and being the main terminal for vehicular ferries from Ullapool. Pilotage is not compulsory but a pilot is advisable with 24 hours' notice, day and night on request to the Harbour Master, to board vessels off Arnish Point Light.

There are no noted areas of unexploded ordinance or shipwrecks in the vicinity of the Project. due to the nature of the bathymetry in the development area there is limited potential for residual artifacts or debris from wrecks to be trapped in the fissures of the bedrock.

5. Metocean Data

5.1 Introduction

This section presents the Metocean statistics in the vicinity of the Project.

According to the Admiralty Sailing Directions (Ref: vi) the climate of the region is greatly affected by the high degree of exposure to winds from the north and west and the hilly terrain to the east. Gales and rough seas are frequent in winter, with winds reaching storm or hurricane force on occasions.

There is abundant rainfall across the area. The climate is generally mild and snow is infrequent. Fog and thunderstorms are uncommon. Visibility is often good, although the average humidity and cloud cover are high.

5.2 Wind

Winds are variable in both direction and speed in all seasons due to the frequent mobile depressions that affect the area. In the late winter and early spring, east to northeast winds may persist for several days when a high cell becomes established over northwest Europe.

The area is exposed to the Atlantic and subject to Atlantic depressions, gales and storms. This results in a prevailing system of constantly recurring bad weather.

5.3 Tide

Admiralty Chart 2720 Tidal Diamond D, approximately 15nm north-north-east of the Project, specifies that tides move in a west to east-south-east direction on the flood and an east to west direction on the ebb.

During the west-going stream an eddy sets northeast along the coast. There is almost certainly violent turbulence off the point where the eddy meets the main stream, but factual information is not available.

Tidal levels for Little Bernera, approximately 15nm south-west of the Project, are presented in Table 5.1.

Table 5.1 Tidal Levels above LAT at Little Bernera

Tidal Level	Height Above Chart Datum (m)
Mean High Water Springs (MHWS)	4.3
Mean High Water Neaps (MHWN)	3.1
Mean Sea Level (MSL) (approx.)	2.4
Mean Low Water Neaps (MLWN)	1.6
Mean Low Water Springs (MLWS)	0.5

5.4 Wave

Wave data (Ref: vii) for the period from October to December 2011 was obtained from a Waverider buoy located at the position shown in Figure 5.1.

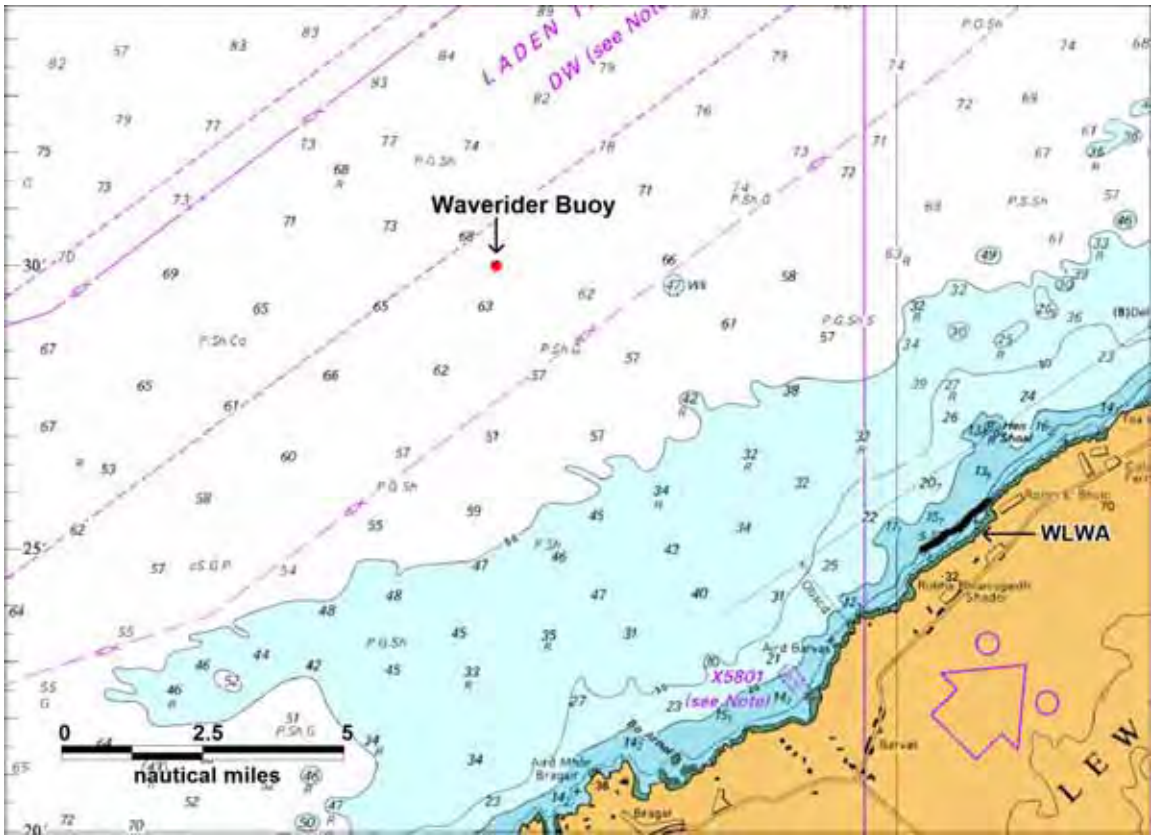


Figure 5.1 Location of Waverider Buoy

Graphs of significant wave height, maximum wave height, peak direction and peak period are presented in Figure 5.2 to Figure 5.5, respectively.

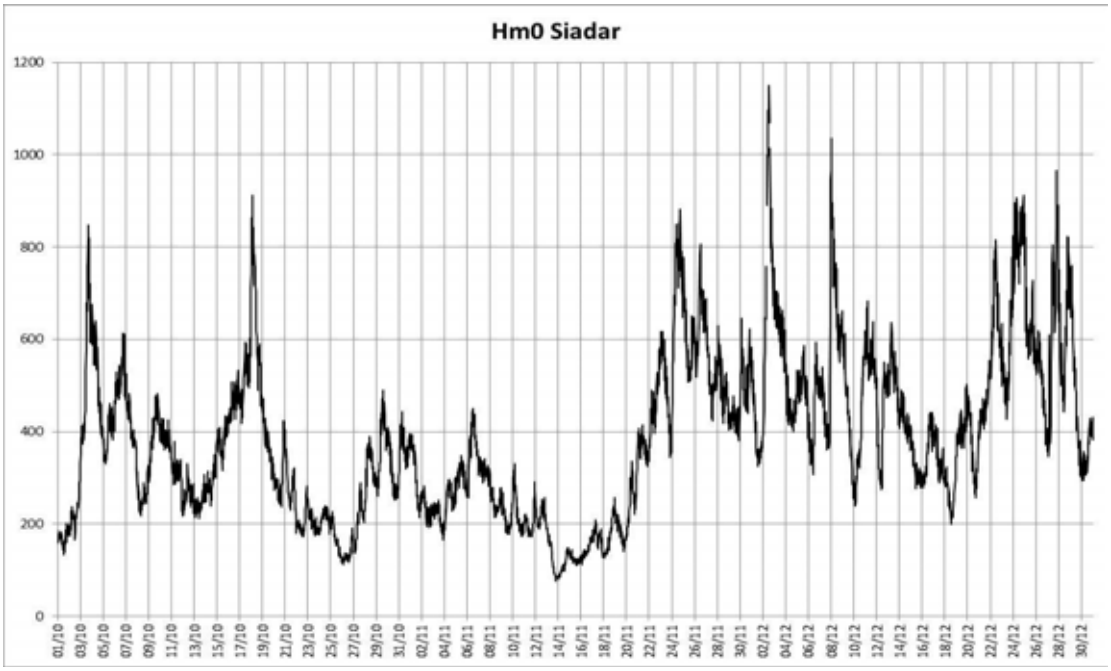


Figure 5.2 Significant Wave Height

Significant wave height ranged from approximately 1m to 11.5m.

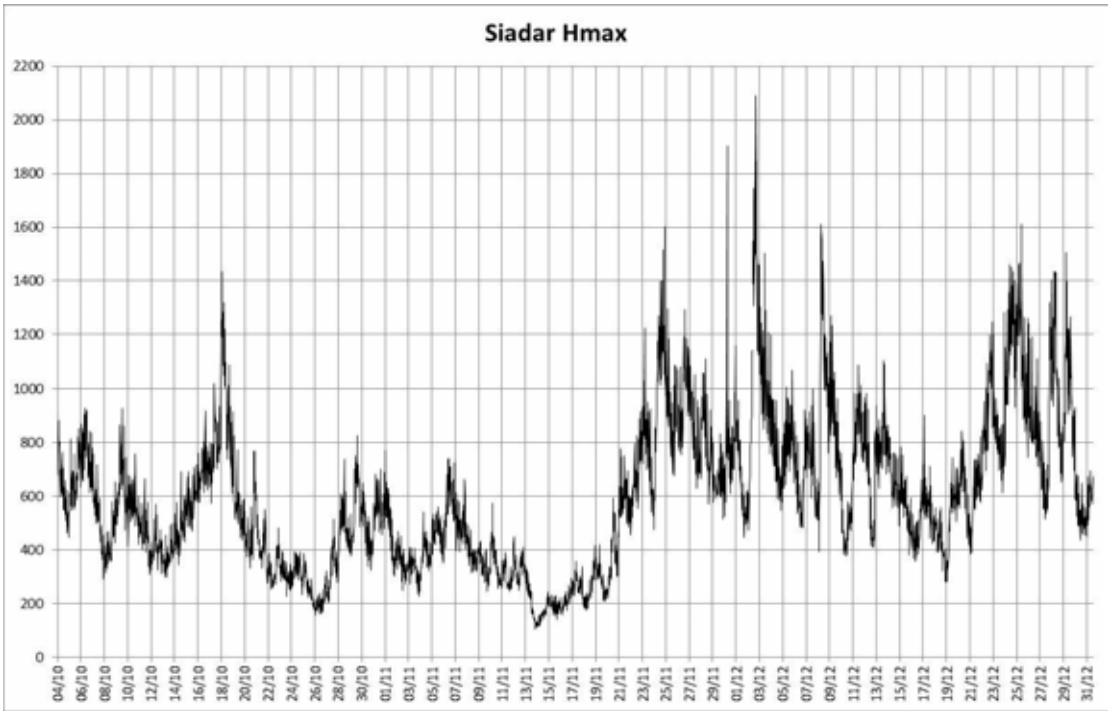


Figure 5.3 Maximum Wave Height

Maximum wave height ranged from approximately 1m to 21m.

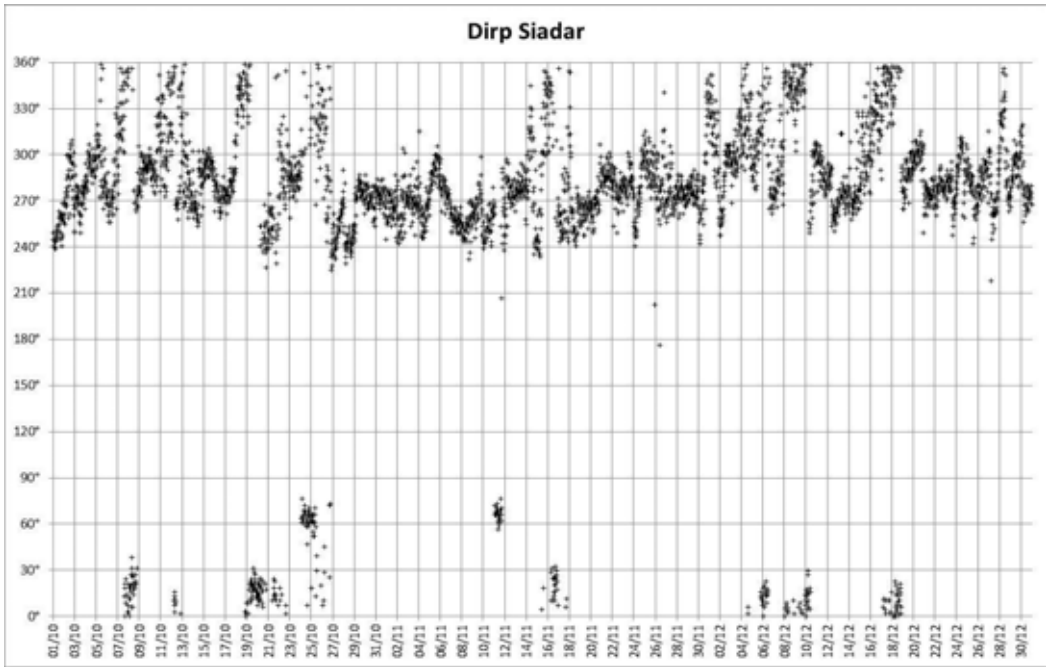


Figure 5.4 Peak Direction

Peak wave direction was southwest to north.

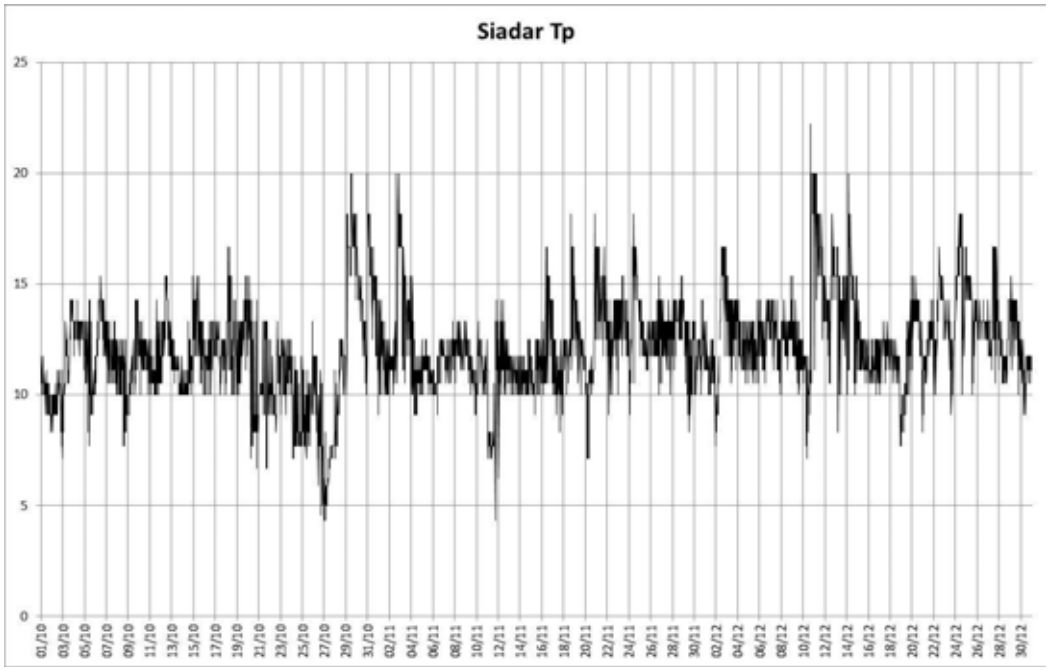


Figure 5.5 Peak Period

6. Stakeholder Consultation

6.1 Introduction

Widespread consultation on the Project was carried out with local and national stakeholders during preparation of the Navigational Risk Assessment.

This involved the following organisations representing the different users / stakeholders:

- Local Inshore Fishermen – consulted during local stakeholder meetings as well as fishing representation at Hazard Workshop
- Marine Scotland (Stornoway)
- Maritime & Coastguard Agency (Navigational safety branch in Southampton and local MCA in Stornoway)
- RNLI – Stornoway
- Local Port Authorities (Stornoway Port Authority and Comhairle nan Eilean Siar responsible for Loch Roag)
- RYA
- Scottish Canoe Association
- Northern Lighthouse Board

6.2 Summary of Stakeholder Comments

The following table summarises the main points raised during consultation.

Table 6.1 Summary of Main Consultation Comments

Consultee	Main Comments
Maritime & Coastguard Agency	Questioned how device is moored and expected to perform in severe weather. Concerns on a device breaking free and presenting a hazard to shipping. Array will bring lee shore closer, but shipping well away from the site. Asked if devices will have identification marks. Questioned if devices will show up on small vessel radar. Asked how devices would be monitored and if shutdown was possible.
RNLI	Respond to very few incidents in this area in general. Response would be from Stornoway and time to site would depend on prevailing conditions. Could take in order of 1.5hrs.
Scottish Canoe Association	Proposal has potential to be a major safety hazard to sea kayakers.

Consultee	Main Comments
RYA	Area only lightly used, no need to carry out a survey of vessels using this area. Vessels likely to keep well offshore given that it is a dangerous lee shore. Only very experienced sailors likely to attempt to route to West of Lewis. A precautionary approach should be taken to lighting and marking. Marking of site will be important with boundaries marked on charts
Northern Lighthouse Board	Upper section of devices should be painted yellow to improve visual conspicuity. Shore posts with lights at both ends of the site. Monitoring of devices to detect catastrophic failure. Promulgation of navigational warnings.
Inshore Fisheries Group	Loss of fishing grounds (inshore potting) Loss of gear with equipment and surface laid pipelines.

7. AIS Data Analysis

7.1 Introduction

This section presents analysis of AIS tracking data of vessels which pass within 5nm of the proposed Project. Appendix B presents details of vessels which pass within a wider 15nm area of the Project. The following periods of data have been used:

- 28 days winter 2011 (February-March)
- 28 days summer 2011 (July-August)

These periods are analysed in Section 7.2. This was validated with longer-term AIS data from the periods:

- 28 days summer 2010 (June-July)
- 28 days winter 2010 (October/November/December)

These periods are discussed in Section 7.3.

7.2 5nm Traffic Analysis – 2011

More detailed plots of the vessels passing within 5nm of the proposed Project during each of the 28 day survey periods in 2011 are presented in Figure 7.1 to Figure 7.10.

Type, length and draught information broadcast on AIS has been checked against literature and in some cases updated to provide greater definition.

In total there were 23 different vessels, making a total of 49 unique tracks over the 56 days passing within 5nm. The number of vessels varied between the winter and summer periods, with 10 during winter compared to 13 in summer 2011.

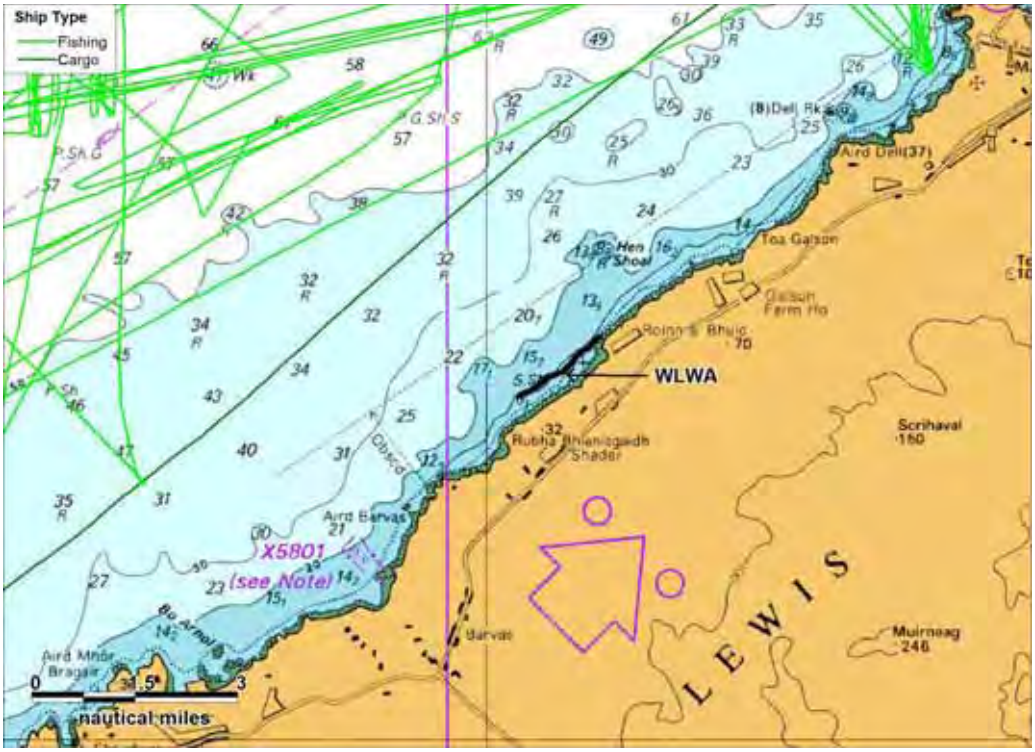


Figure 7.1 Winter 2011 AIS Data

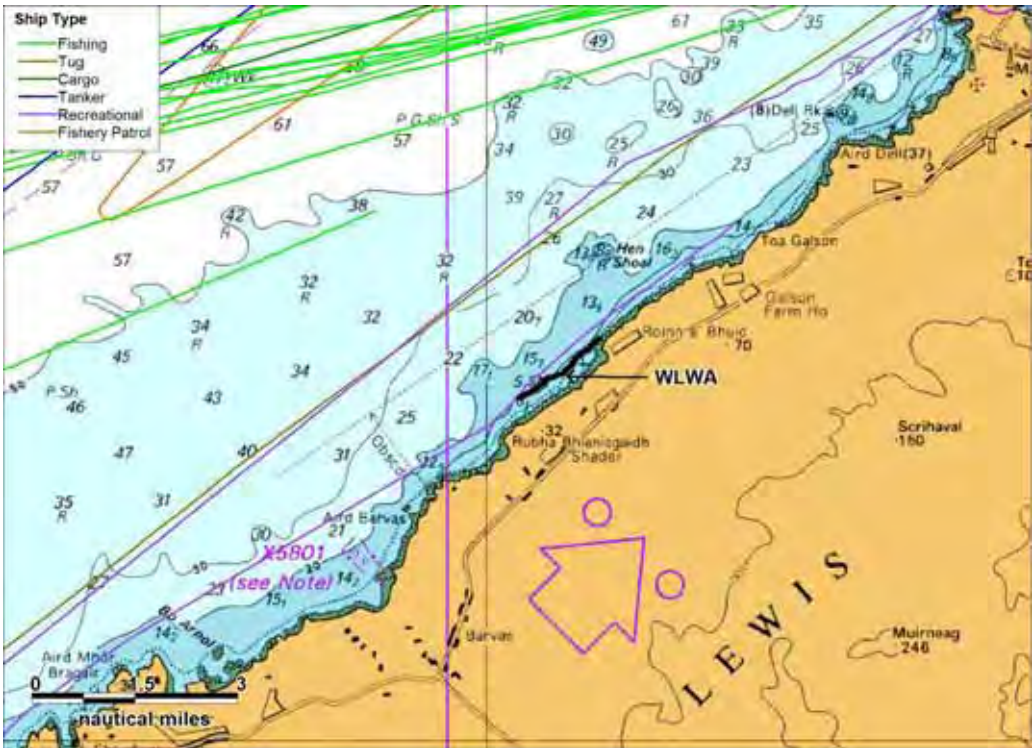


Figure 7.2 Summer 2011 AIS Data

The tug workboat, *Tie Venture III*, passed approximately 1.7nm to the northwest of the site. Larger fishing vessels were active further offshore, with the closest passing vessel at approximately 3.5nm northwest of the Project. Additional information on fishing vessels tracked on AIS is presented in Section 9.3. Two recreational vessels passed within close proximity of the Project, this is discussed in Section 10.3.

The vessel type distribution over the two survey periods is presented in Figure 7.3.

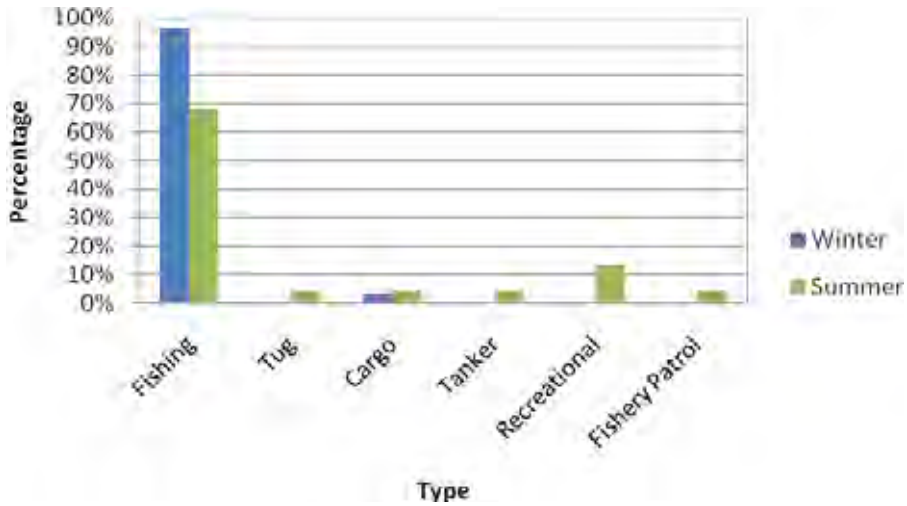


Figure 7.3 AIS Survey Vessel Type Distribution within 5nm (Winter and Summer 2011)

A combined plot of the transiting traffic by length is presented in Figure 7.4

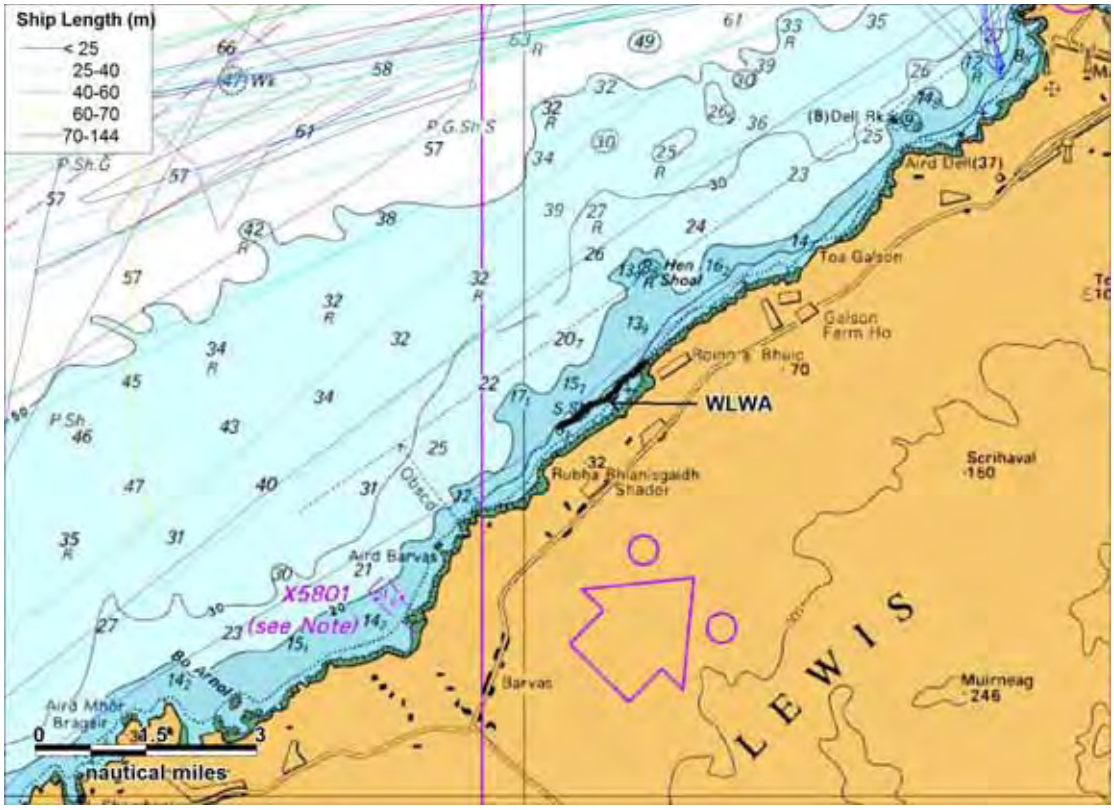


Figure 7.4 Combined Tracks by Length (Winter and Summer 2011)

The length distribution of vessels within 5nm is presented in Figure 7.5.

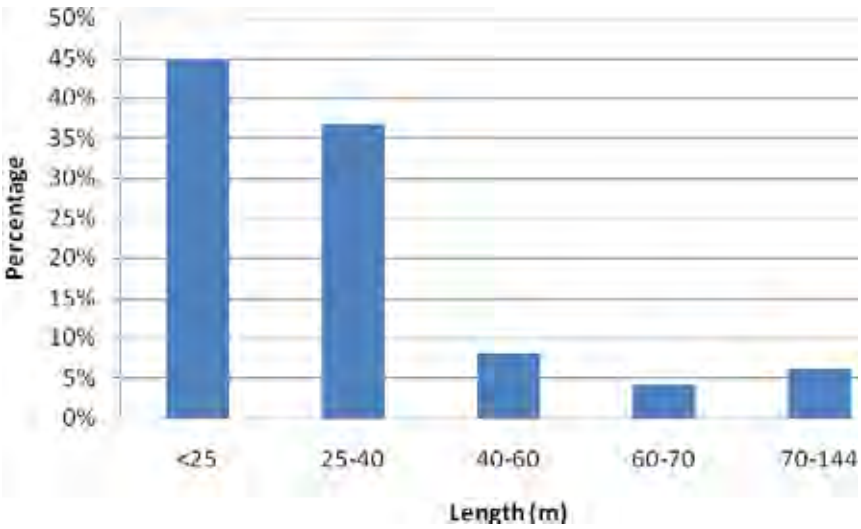


Figure 7.5 Length Distribution within 5nm (Winter and Summer 2011)

A combined plot of the transiting traffic by draught is presented in Figure 7.6.

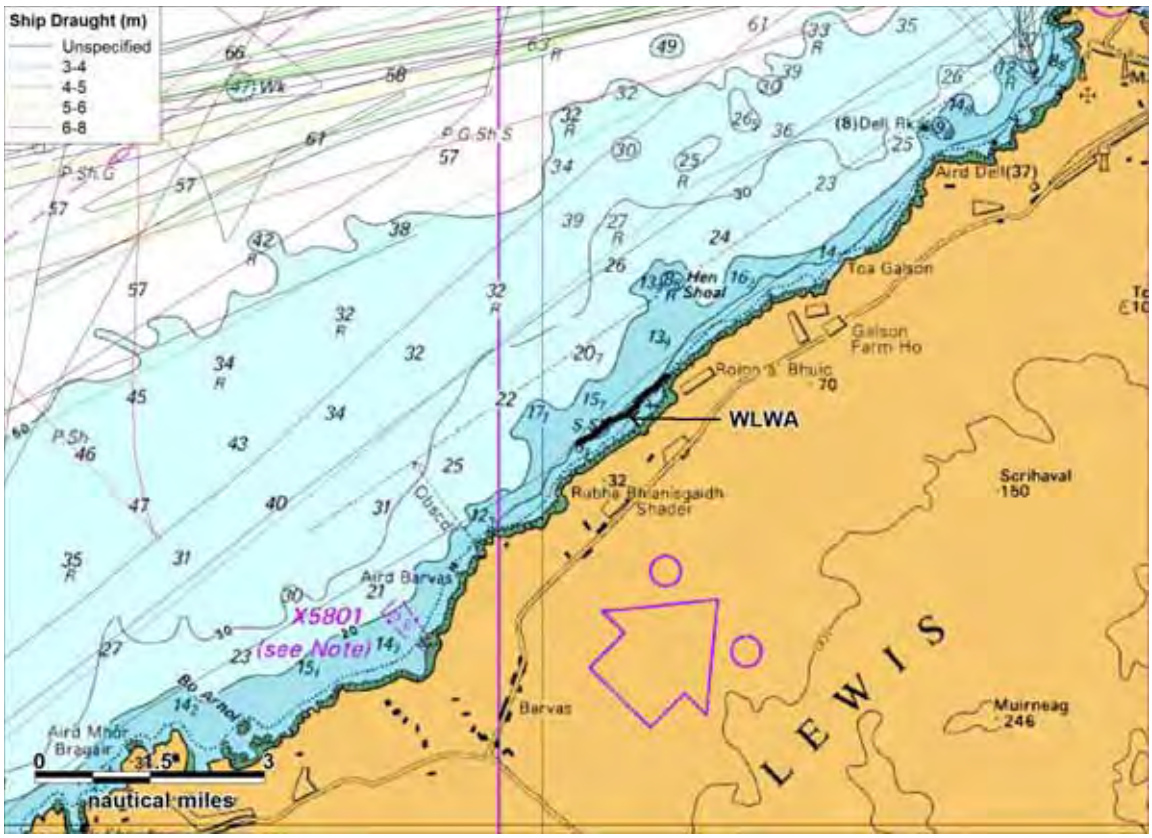


Figure 7.6 Combined Tracks by Draught (Winter and Summer 2011)

The draught distribution of vessels within 5nm is presented in Figure 7.7, however, it should be noted that 69% were unspecified (mostly fishing vessels).

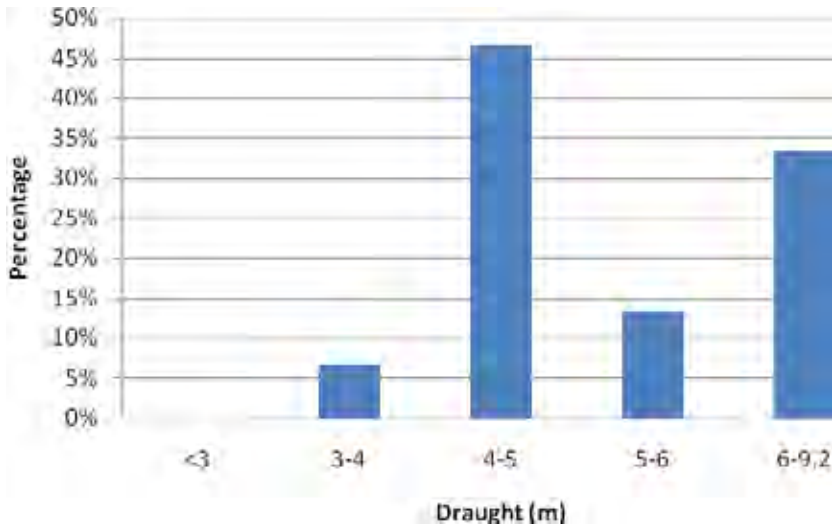


Figure 7.7 Draught Distribution within 5nm (Winter and Summer 2011)

The average draught of vessel was 5.5m. The deepest draught vessel was the fishing vessel *Paula*, presented in Figure 7.8, with a draught of 8m, which transited approximately 5nm northwest of the Project en route to fishing grounds.

Figure 7.8 Deepest Draught Vessel, *Paula*

The tracks colour-coded by direction are presented in Figure 7.9.

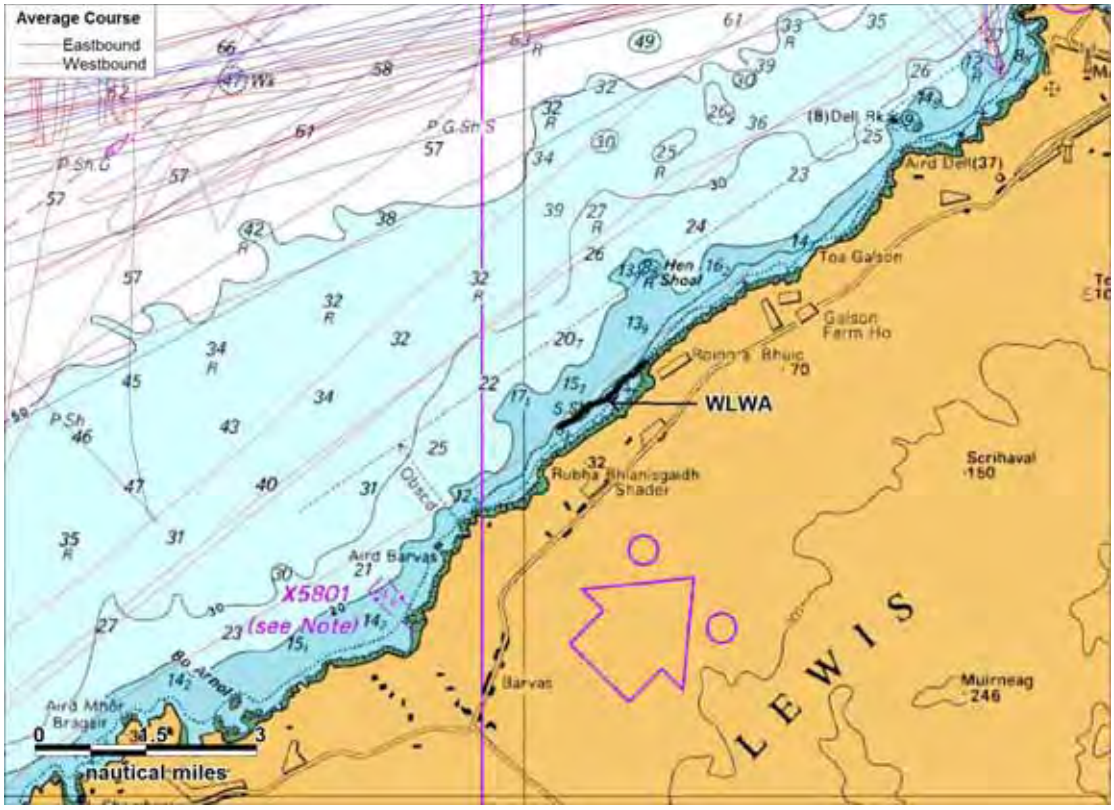


Figure 7.9 Combined Tracks by Average Course (Winter and Summer 2011)

43% of vessels were travelling eastbound compared to 57% westbound.

The main destinations (excluding unspecified) broadcast within 5nm of the Project are presented in Figure 7.10. 67% of vessels did not broadcast a destination. These were mainly fishing vessels.

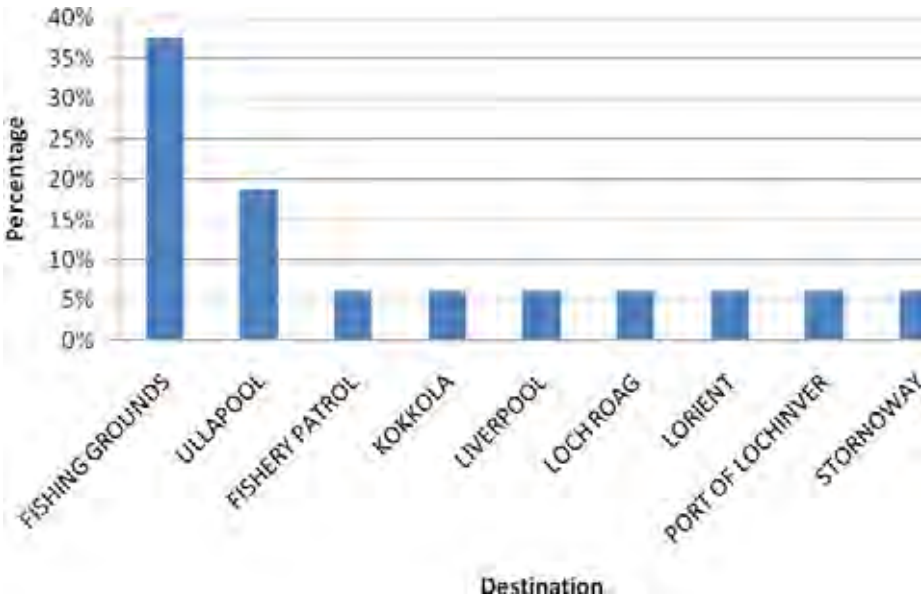


Figure 7.10 Main Destinations for Vessels within 5nm (Winter and Summer 2011)

Details on vessels tracked more than once within 5nm are presented in Table 7.1. In total, 23 different vessels were recorded within 5nm of the Project, making a total of 49 transits over the 56 day period.

Table 7.1 Vessels tracked more than once within 5nm of the Project (56 Days 2011)

Name	Type	Destinations	Length (m)	Draughts (m)	Transits
Heather K	Fishing	--	16.9	--	8
Our Hazel	Fishing	--	20	--	7
Polaris 2	Fishing	--	25	--	6
Marigold INS241	Fishing	--	24	--	3
Cuca	Fishing	--	38	4.4	2
Jiminy	Fishing	Ullapool	35	4	2
Julien Coleou	Fishing	Stornoway / Lorient	30	4.5	2
Lochlann	Pleasure Craft	--	12	--	2
Paula	Fishing	Fishing Grounds	60	8	2
Viking Monarch	Fishing	--	40	--	2

7.3 5nm Traffic Analysis – 2010

More detailed plots of the vessels passing within 5nm of the proposed Project during each of the 28 day survey periods in 2010 are presented in Figure 7.11 to Figure 7.20.

Type, length and draught information broadcast on AIS has been checked against literature and in some cases updated to provide greater definition.

In total there were 15 unique vessels, making 63 tracks over the 56 days.

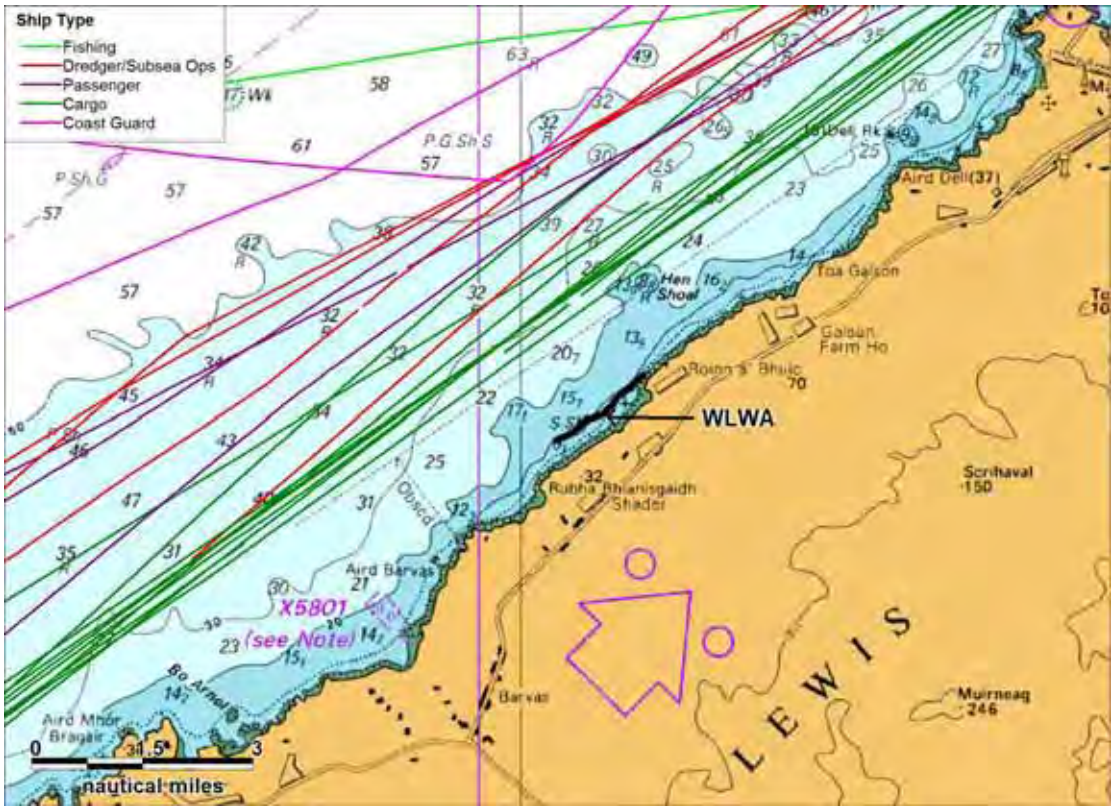


Figure 7.11 Summer 2010 AIS Data

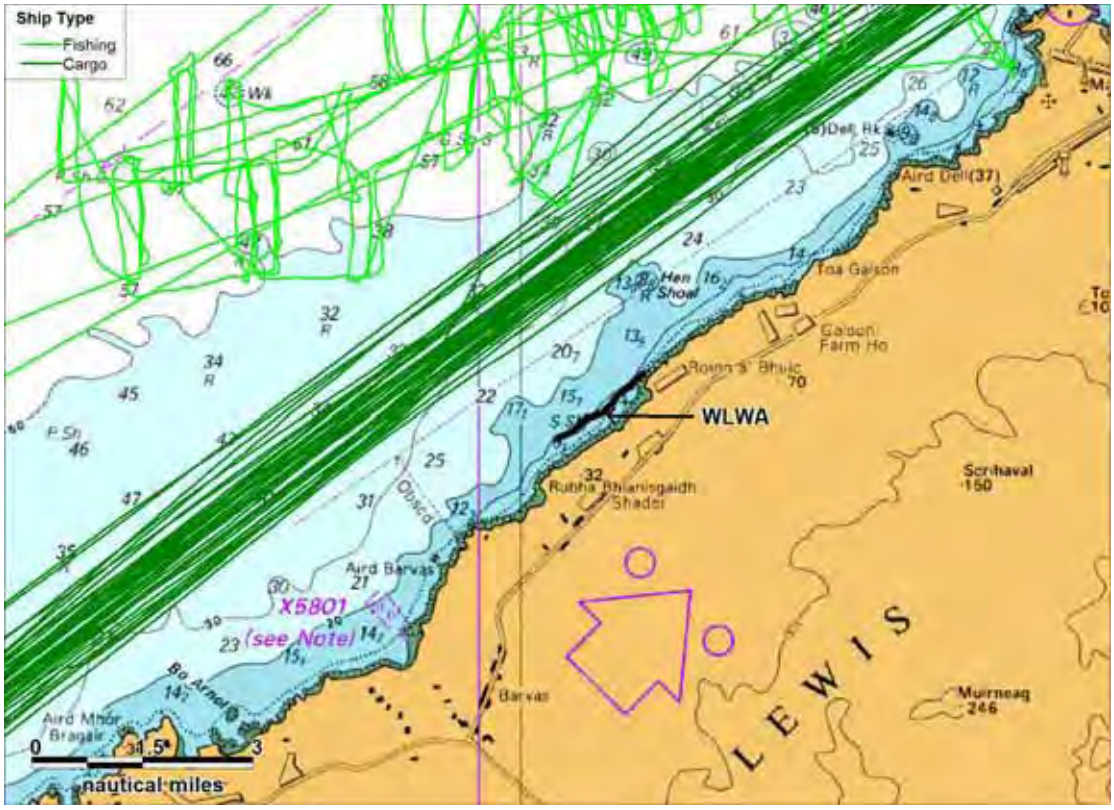


Figure 7.12 Winter 2010 AIS Data

The vessel type distribution within 5nm of the Project during the summer and winter survey periods is presented in Figure 7.13.

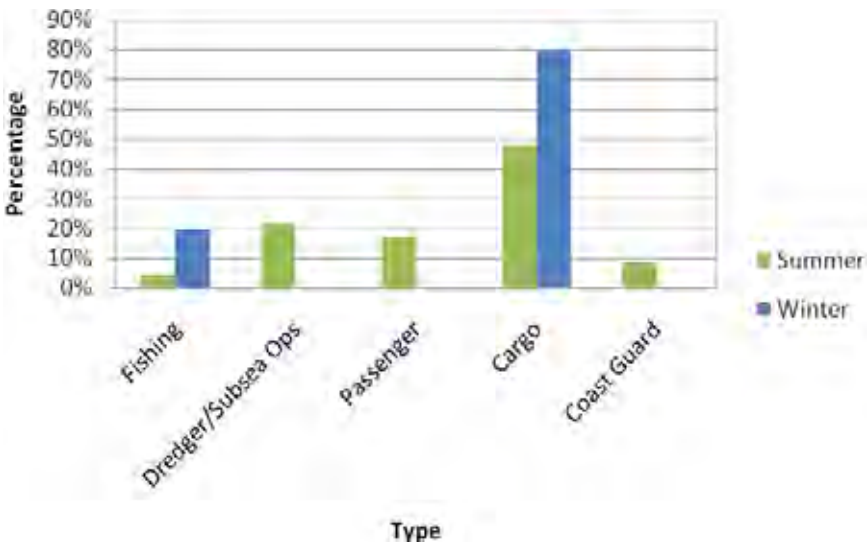


Figure 7.13 AIS Survey Vessel Type Distribution – 5nm (Summer and Winter 2010)

A combined plot of the transiting traffic by length is presented in Figure 7.14.

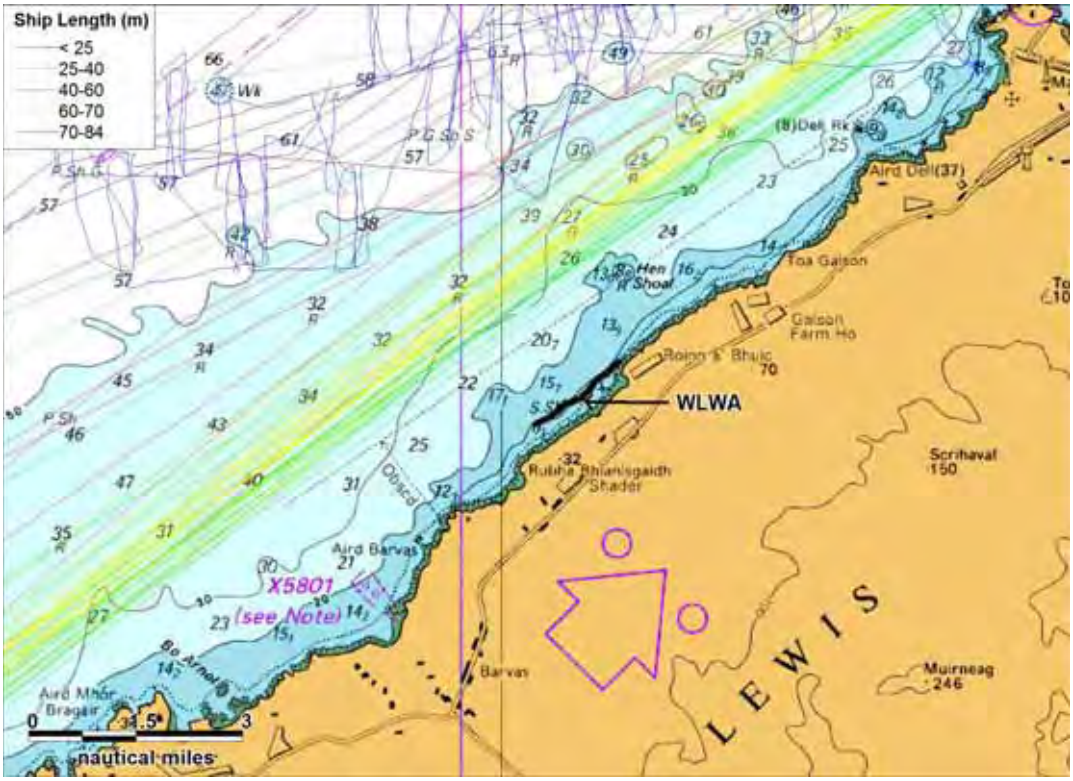


Figure 7.14 Combined Tracks by Length (Summer and Winter 2010)

The length distribution of vessels within 5nm is presented in Figure 7.15.

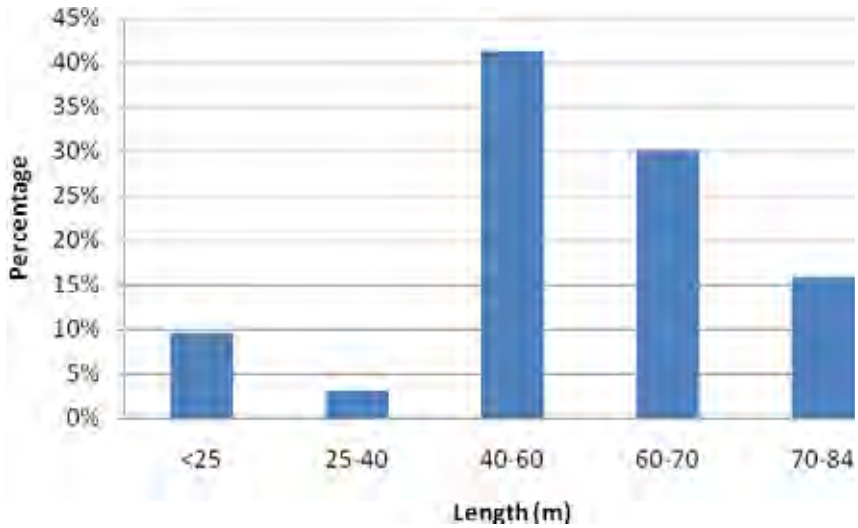


Figure 7.15 Length Distribution within 5nm (Summer and Winter 2010)

The average length was 56m and the longest vessel at 84m was the fishery patrol vessel, *Hirta*, broadcasting its destination as "On Patrol".

A combined plot of the transiting traffic by draught is presented in Figure 7.16.

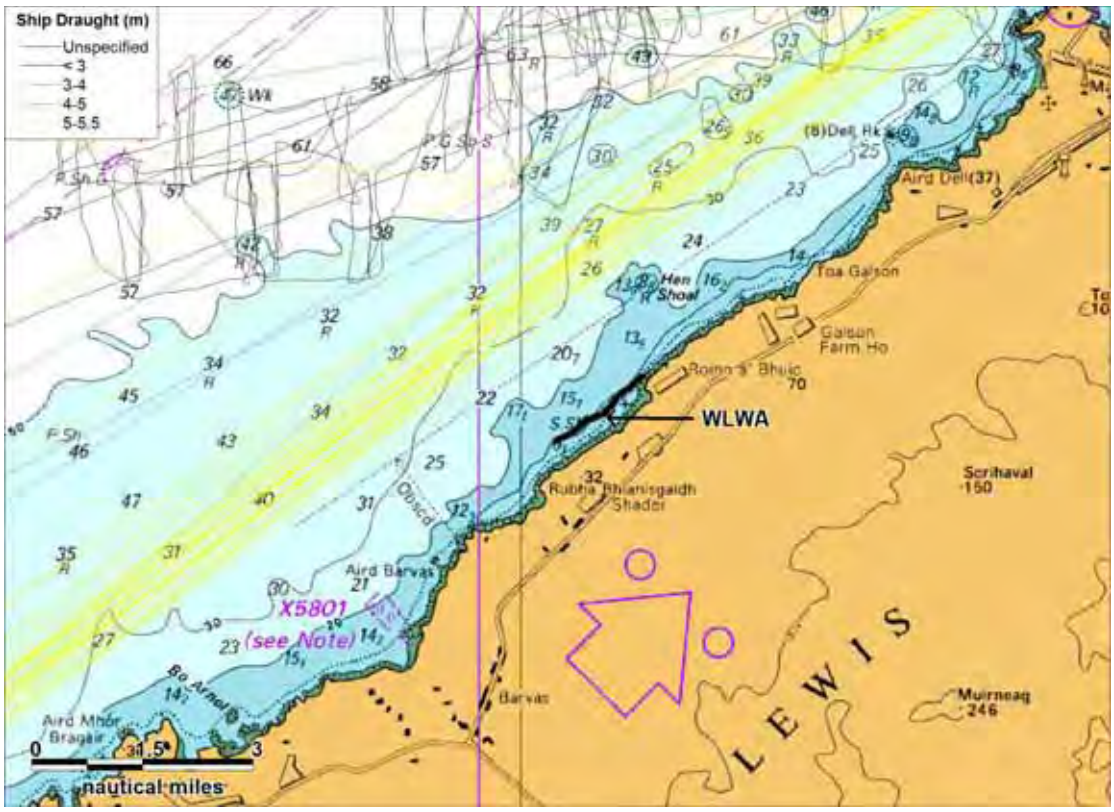


Figure 7.16 Combined Tracks by Draught (Summer and Winter 2010)

The draught distribution (excluding 10% unspecified) of vessels within 5nm is presented in Figure 7.17.

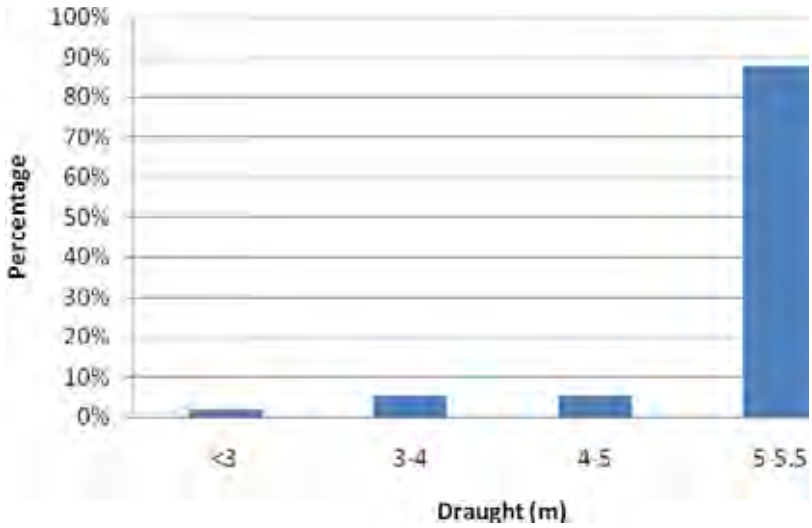


Figure 7.17 Draught Distribution within 5nm (Summer and Winter 2010)

The average draught was 5m. The deepest draught vessels, both with draughts of 5.5m, were the fishery patrol vessel *Hirta*, which was on patrol, and the fish carrier *Ronja Viking*, presented in Figure 7.18, which made a number of transits between the west coast of Scotland (e.g. Lochinver & Mallaig) and Lewis.

Figure 7.18 Deepest Draught Vessel, *Ronja Viking*

The tracks colour-coded by direction are presented in Figure 7.19.

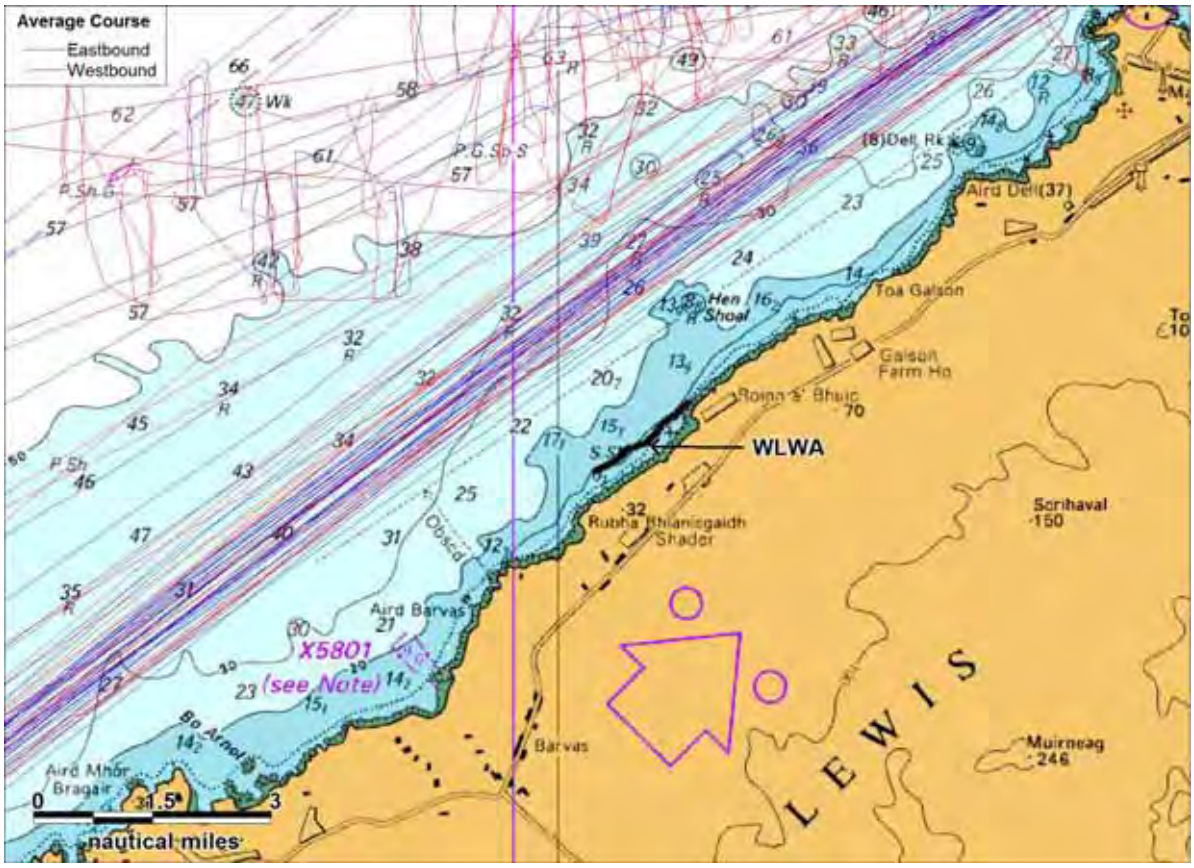


Figure 7.19 Combined Tracks by Average Course (Summer and Winter 2010)

48% of vessels were heading eastbound compared to 52% heading westbound.

The main destinations (excluding unspecified) broadcast by the vessels tracked within 5nm of the Project are summarised in Figure 7.20. 14% of vessels did not broadcast a destination. These were mainly fishing vessels.

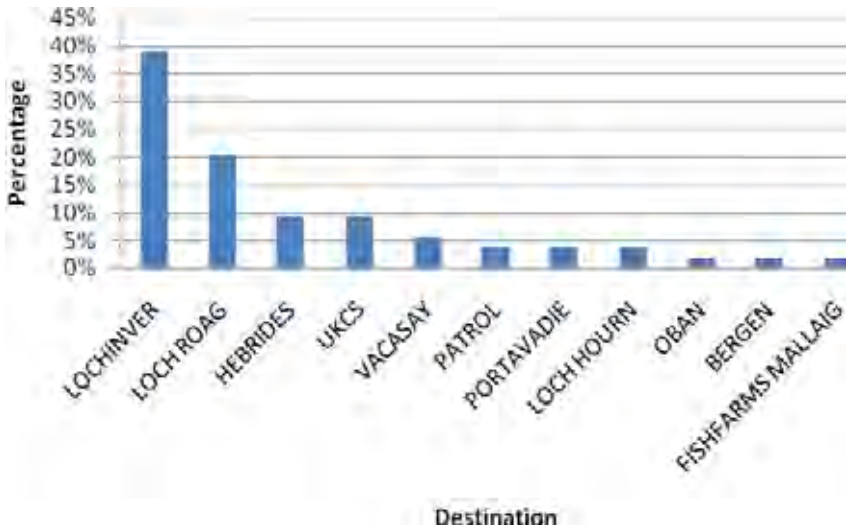


Figure 7.20 Main Destinations for Vessels within 5nm (Summer and Winter 2010)

Details on vessels tracked more than once within 5nm are presented in Table 7.2.

Table 7.2 Vessels tracked more than once within 5nm of the Project (56 Days 2010)

Name	Type	Destinations	Length (m)	Draughts (m)	Transits
Oydrott	Cargo	Lochinver / Loch Roag	60	5	19
Ronja Viking	Cargo	Hebrides / Lochinver / Loch Roag / Portavadie / Vacasay	57	5.5	19
Our Hazel	Fishing	--	20	--	6
Vigilant	Dredger / Subsea Ops	--	72	5.2 / 5.3	5
Hebridean Princess	Passenger	--	72	3	2
Hirta	Coastguard	On Patrol	84	5.5	2
Ronja Pioneer	Cargo	Loch Hourn	57	5.1	2

In total, 15 different vessels were recorded within 5nm of the Project, making a total of 63 transits.

8. Coastal Surveys (Visual)

Vessels were also recorded during coastal surveys of the site (bird and marine mammal watch). Visual observations were made (using naked eye, binoculars and telescope) from 3 viewing points (VPs) along the north west coast of Lewis. Figure 8.1 presents the locations of the VPs, Saidair (SA), Mealabost (ME) and Labost (LA),

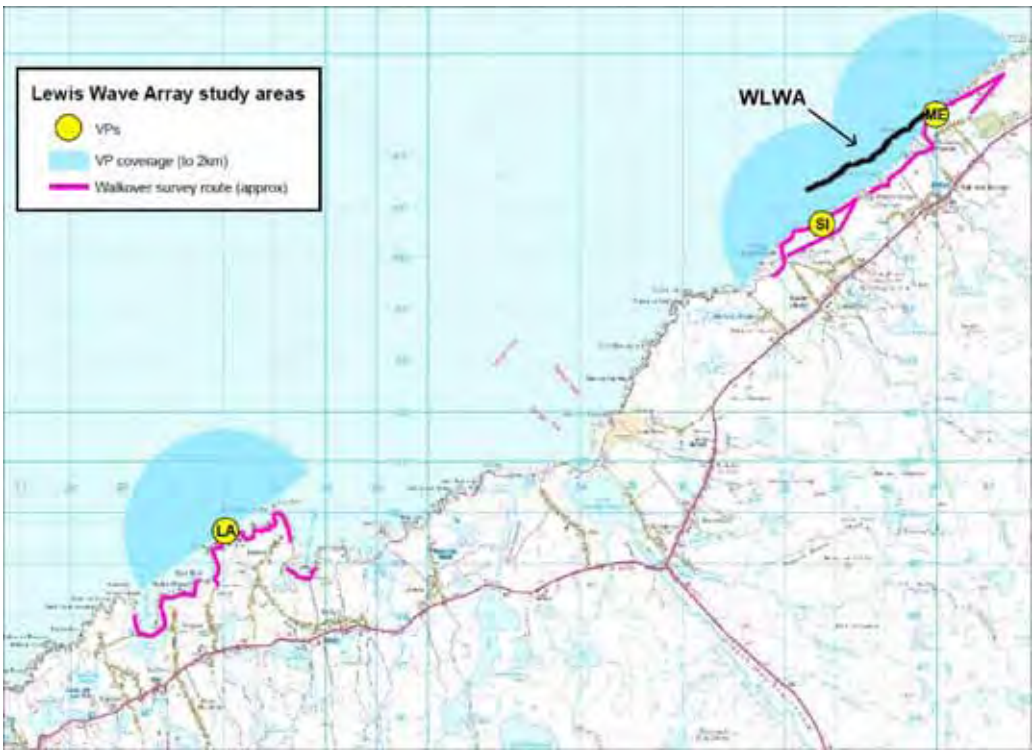


Figure 8.1 Locations of Viewpoints used in Coastal Surveys

A total of 407 hours were spent surveying at the 3 VPs; 137 hours at Saidair, 136 hours at Mealabost and 134 hours at Labost. For the purposes of vessel sightings, it was not necessary to distinguish between the types of survey undertaken. In total, 137 survey sessions during which passing vessels were recorded were spent at the 3 VPs; 46 at Saidair, 47 at Mealabost and 44 at Labost. These were carried out over a period of just over 12 months, from September 2010 to September 2011. Surveys were undertaken approximately 4 times per month at each VP, for 3 hours each session and only in good visibility and when sea state was <4.

Figure 8.2 shows the vessel type distribution of vessels sighted from the 3 viewpoints during the coastal surveys, while Figure 8.3 presents the vessel type distribution with distance from shore.

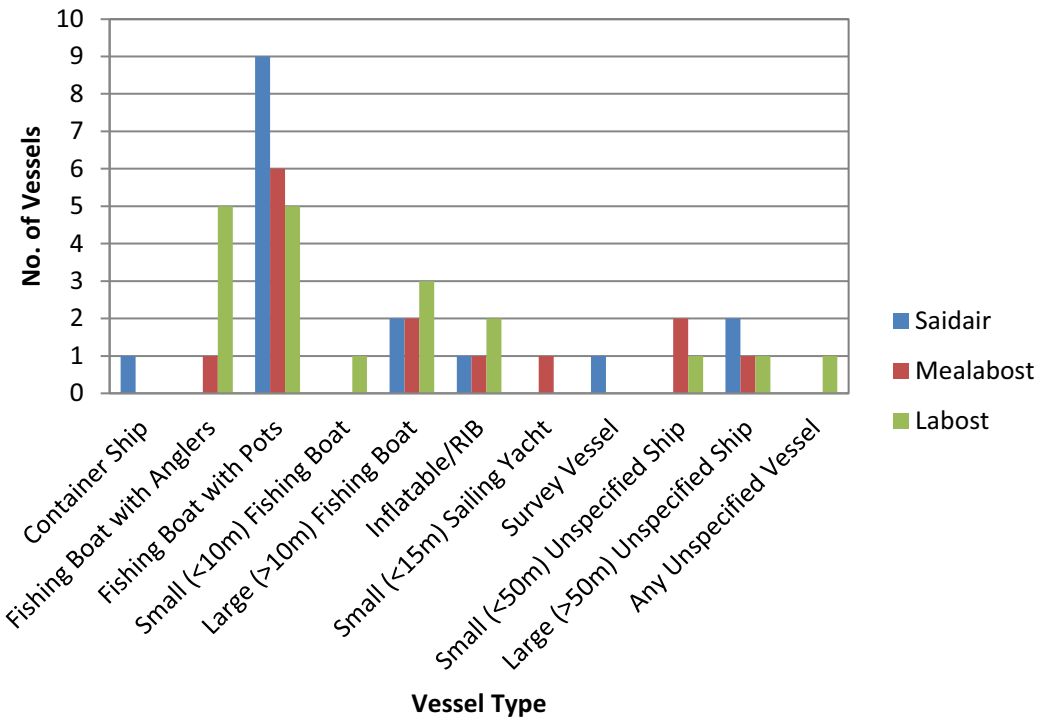


Figure 8.2 Vessel Type Distribution from each VP during Coastal Surveys

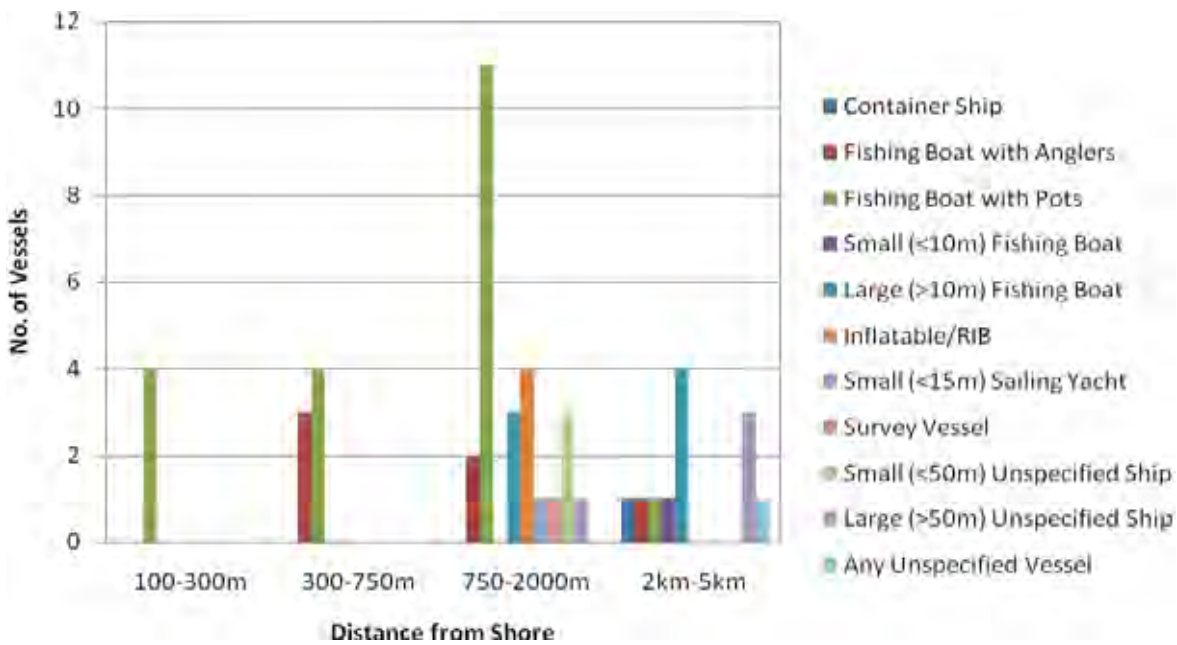


Figure 8.3 Vessel Type Distribution with Distance from Shore

In general, these surveys show that there is little activity close to the shore within the vicinity of the Project, with all of the vessels tracked within 750m being potters and anglers.

Further information on the potters sighted has been gathered and is presented in Table 8.1.

Table 8.1 Potters tracked within 750m of Shore during Coastal Surveys

Name	Registration	Port	Length (m)	Sightings
Carlsbay	SY873	Stornoway	9.95	13
Jacamar II	SY16	Stornoway	9.66	2
Night Owl	KY454	Kirkcaldy	7.7	2
Keristum	SY76	Stornoway	17.76	1
Serene	SY6	Stornoway	7.25	1

9. Fishing Vessel Activity Analysis

9.1 Introduction

This section reviews the fishing vessel activity at the proposed development area based on the latest available surveillance (sightings and satellite data), AIS recordings and consultation on the local fishing activity. Fishing vessels sighted during the coastal surveys are discussed in Section 8.

9.2 Surveillance Data Overview

9.2.1 Geographical Division

Fisheries statistics in the UK are reported by ICES statistical Rectangles and Subsquares. The Project is located within ICES Rectangle 45E3 Subsquare 2 (45E3/2), as shown in Figure 9.1. The Subsquare area is approximately 236nm^2 (810km^2). The four closest Subsquares have been analysed as part of the baseline fishing assessment. Data was obtained for the five-year period 2005 to 2009.

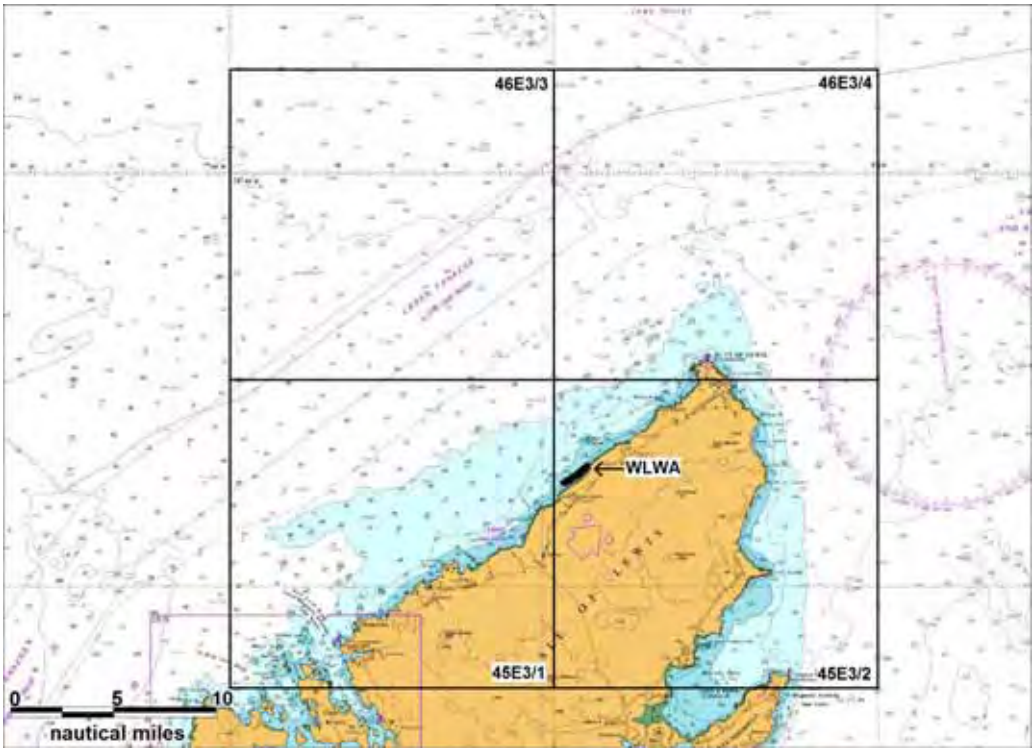


Figure 9.1 ICES Subsquares encompassing the Project

9.2.2 Sightings Data

Data on fishing vessel sightings were obtained from Marine Scotland Compliance who monitor the fishing industry in Scottish waters through the deployment of patrol vessels and surveillance aircraft.

Each patrol logs the positions and details of fishing vessels within the Rectangle being patrolled. All vessels are logged, irrespective of size, provided they can be identified by their Port Letter Number (PLN).

The numbers of fishing vessel sightings, surveillance patrols and hence average sightings per patrol within each ICES Subsquare encompassing the Project in the five-year period 2005-09 are presented in Table 9.1 and Figure 9.2.

Table 9.1 Average Sightings per Patrol (2005-09)

ICES Subsquare	Sightings	Patrols	Sightings per Patrol
45E3/1	37	150	0.25
45E3/2	190	472	0.40
46E3/3	160	445	0.36
46E3/4	243	545	0.44

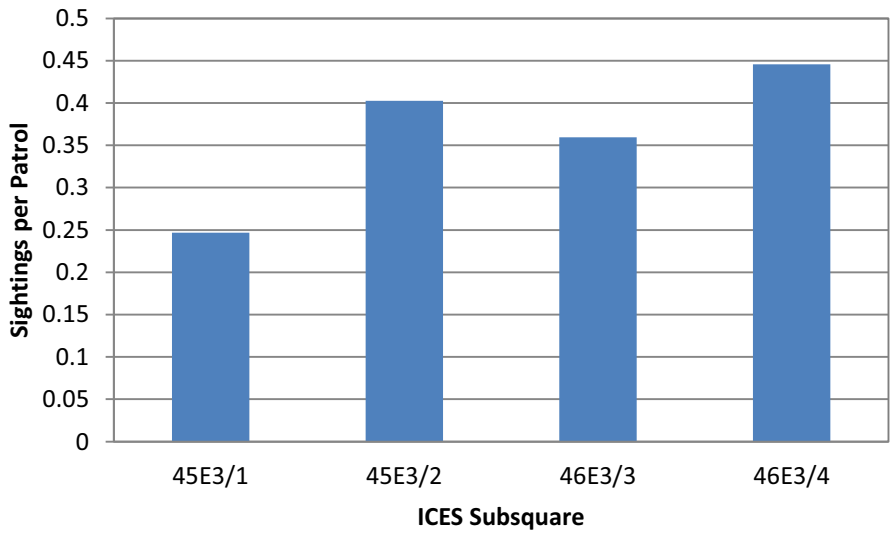


Figure 9.2 Average Fishing Vessel Sightings per Surveillance Patrol (2005-09)

All the Subsquares had a low sightings density. Subsquare 45E3/2, which contains the Project, had an average of approximately one fishing vessel sighting per two patrols. The majority of these were on the east coast of Lewis.

The sightings data were imported into a GIS for mapping and analysis. A plot of the vessel sighting locations, colour-coded by gear type is presented in Figure 9.3. The vessel sighted closest to the Project area was approximately 1.5nm north west of the location. This vessel was a Norwegian Pelagic Stern Trawler which was observed to be steaming.

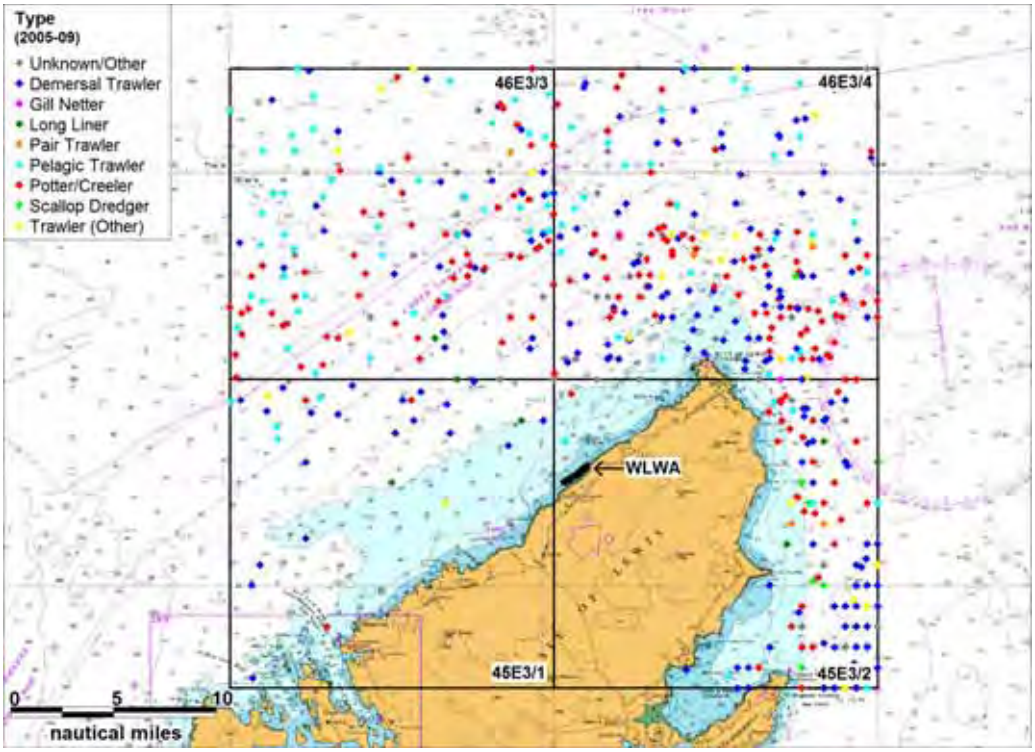


Figure 9.3 Fishing Vessel Sighting Locations (2005-09)

The main fishing type overall was demersal trawler (38%) followed by potter/creeler (29%).

Fishing vessels colour-coded by nationality are presented in Figure 9.4.

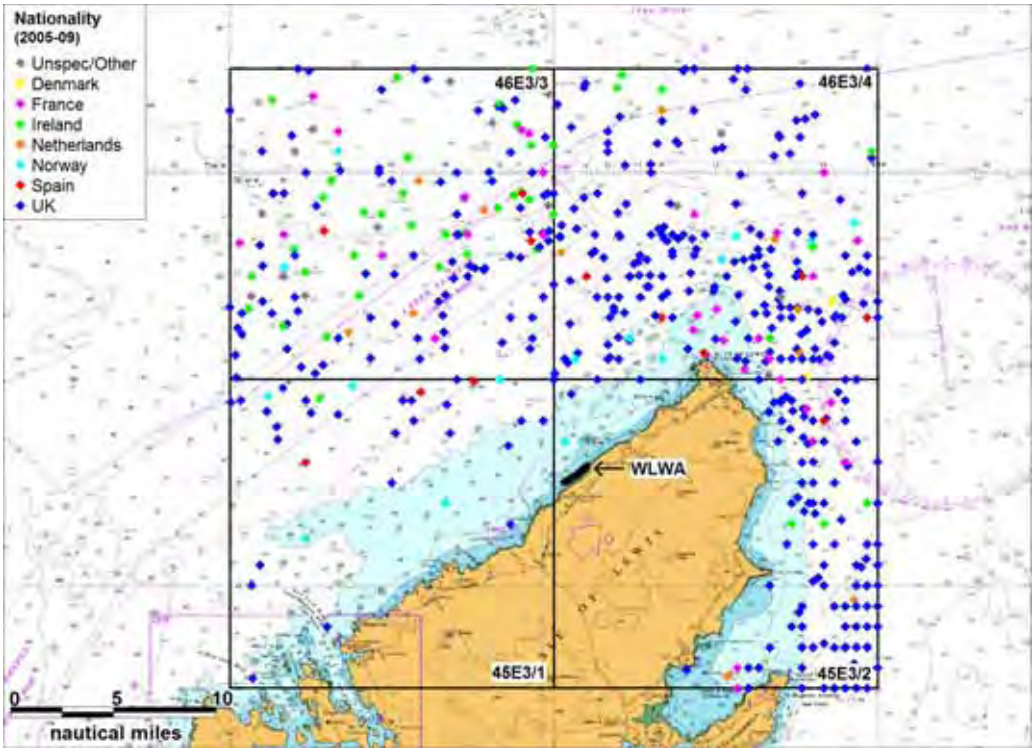


Figure 9.4 Fishing Vessel Sightings by Nationality (2005-09)

The vast majority of fishing vessels were UK-registered (76%).

The fishing vessels colour-coded by activity when sighted are presented in Figure 9.5.

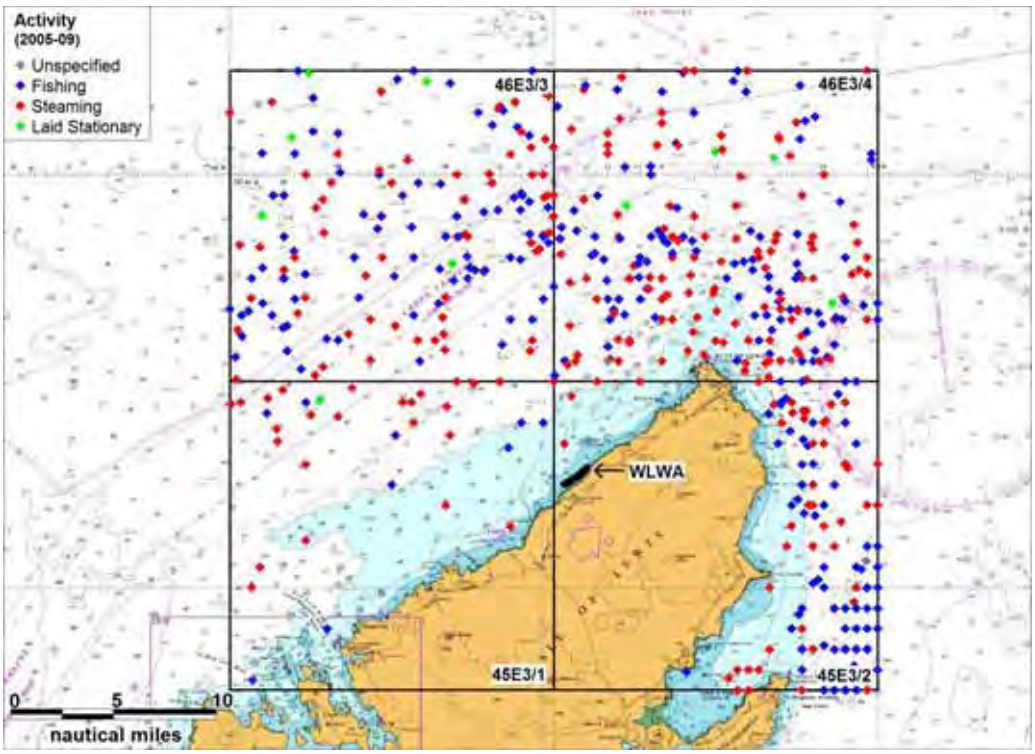


Figure 9.5 Fishing Vessel Sightings by Activity (2005-09)

52% of vessels sighted were engaged in fishing, i.e., gear deployed, 45% were steaming (transiting to/from fishing grounds), and 2% were laid stationary (vessels at anchor or pair vessels whose partner vessel is taking the catch whilst the other stands by).

9.2.3 Satellite Data

The Marine Management Organisation (MMO) operate a satellite-based Vessel Monitoring System (VMS). The VMS is used, as part of the sea fisheries enforcement programme, to track the positions of fishing vessels of 15m length and over in UK waters. It is also used to track all UK registered fishing vessels globally.

Vessel position reports are typically received every 2 hours. The data covers all EC countries within British Fisheries Limits and certain Third Countries, e.g., Norway and Faeroes. Vessels used exclusively for aquaculture and operating exclusively within baselines are exempt.

The latest VMS data available in GIS format is for the year 2009 and includes UK and foreign vessels. Figure 9.6 and Figure 9.7 present this data colour coded by nationality and speed, respectively.

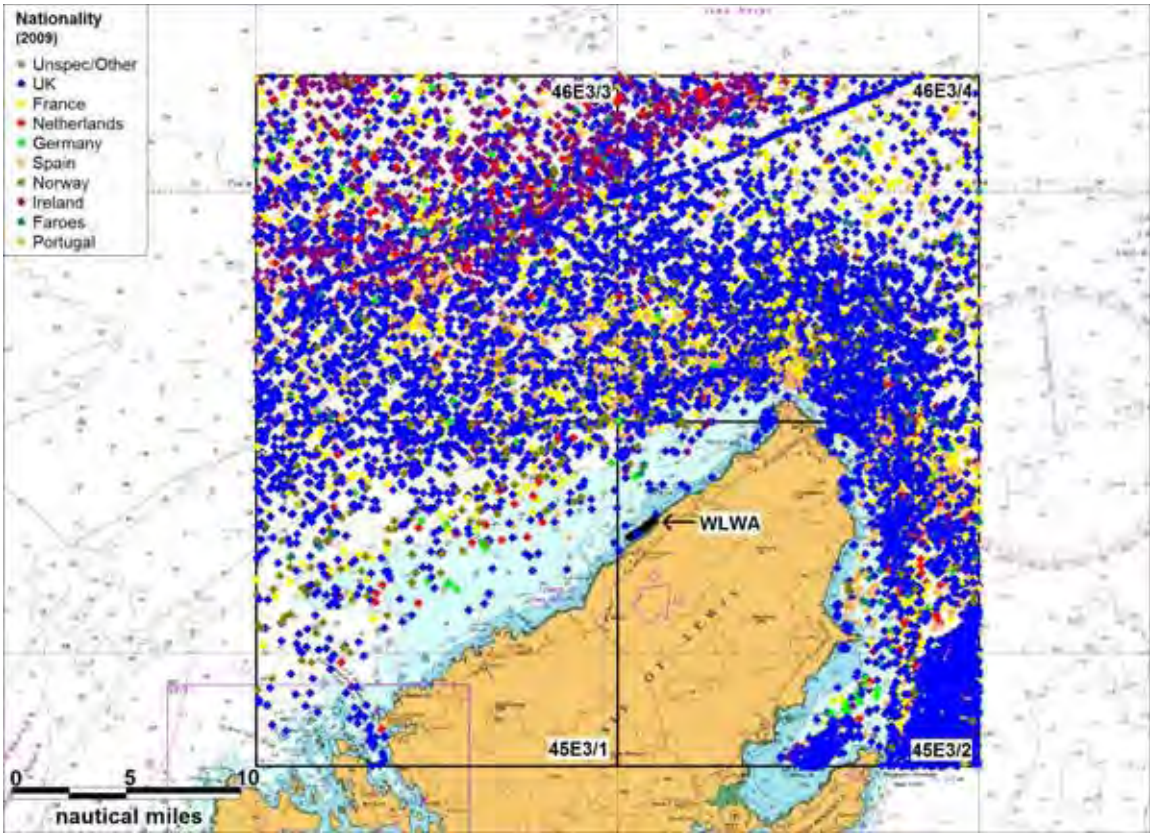


Figure 9.6 Fishing Vessel Satellite Positions by Nationality (2009)

As with the sightings data, the majority of fishing vessels tracked on VMS were UK-registered (61%). All 5 vessel positons within 1nm of the Project were UK registered.

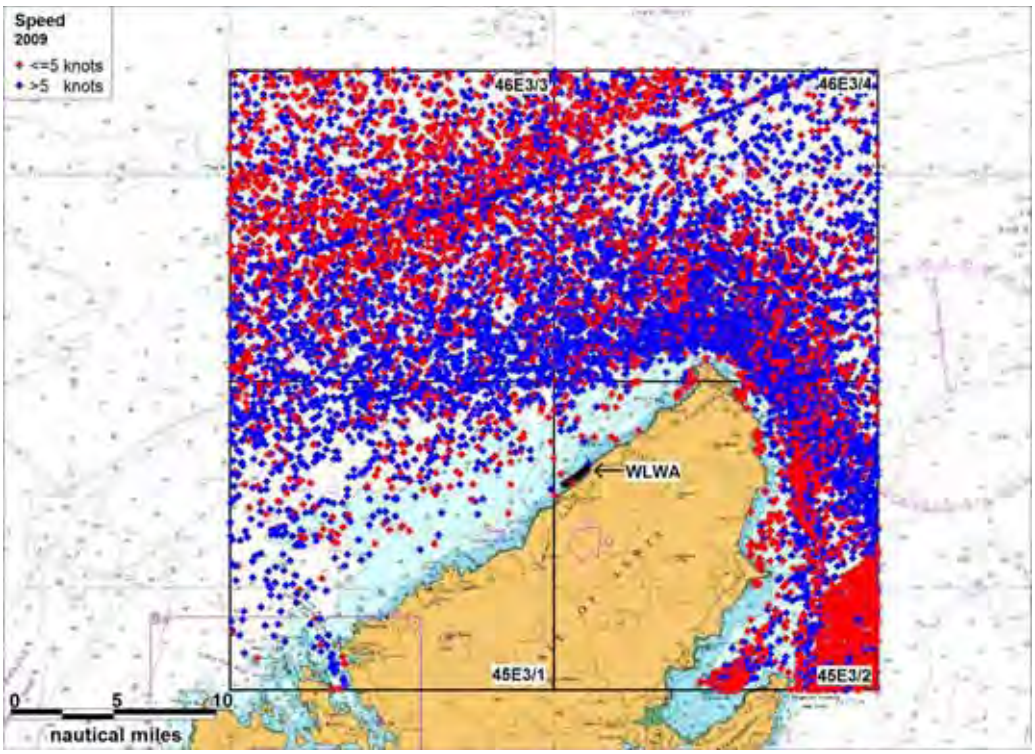


Figure 9.7 Fishing Vessel Satellite Positions by Speed (2009)

52% of vessels were travelling at greater than 5 knots and hence likely to be steaming on passage as opposed to fishing. Vessels tracked within 1nm of the Project were both steaming and fishing.

Data provided by Marine Scotland Compliance in digital image format (2006-09) was used to provide information regarding gear type for 2009, as it provided more comprehensive information concerning the different gear types. Plots were also presented for 2006-08 to verify the 2009 data. The images were georeferenced within a GIS to allow the data to be plotted relative to the Project site. These plots include only UK administered vessels. It should be noted that the MMO data includes one fishing vessel position within the Project which is not represented by the Marine Scotland Compliance data. This was a vessel with an unspecified gear type. Plots of the vessel positions colour coded by gear type are presented in Figure 9.8 to Figure 9.11.

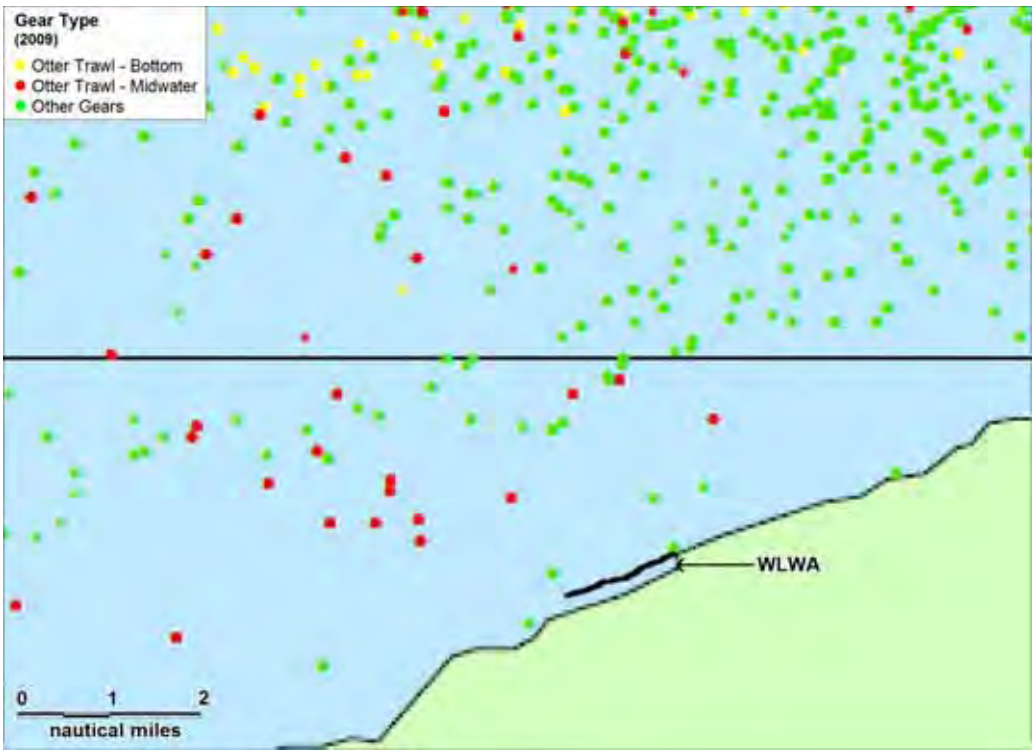


Figure 9.8 Fishing Vessel Satellite Positions by Gear Type (2009)

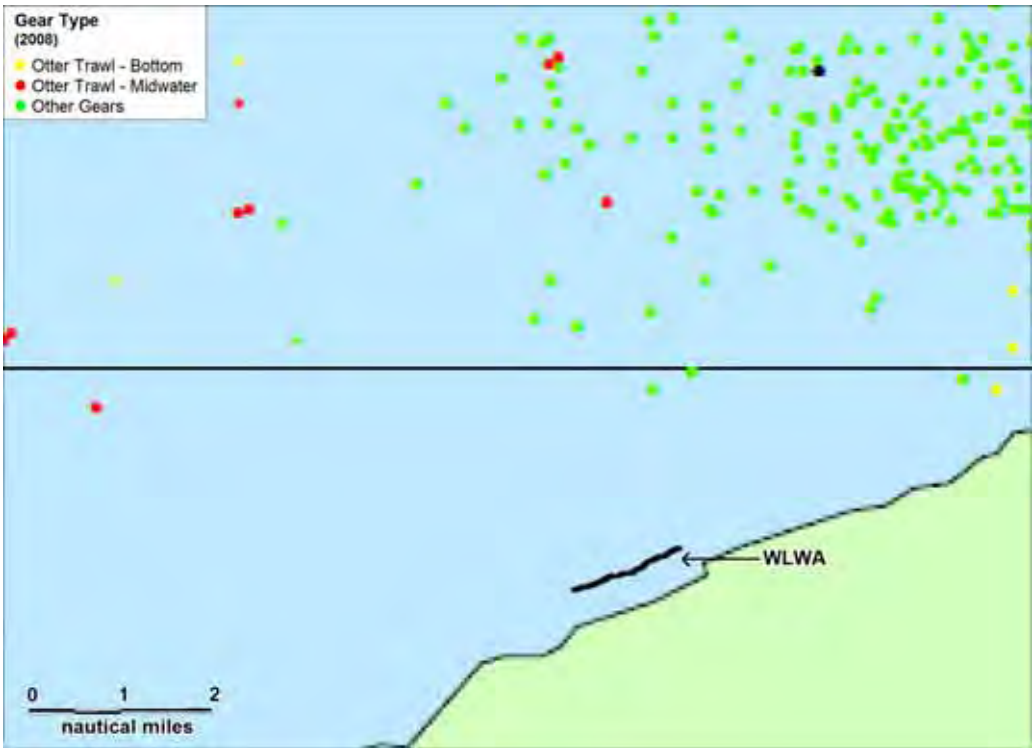


Figure 9.9 Fishing Vessel Satellite Positions by Gear Type (2008)

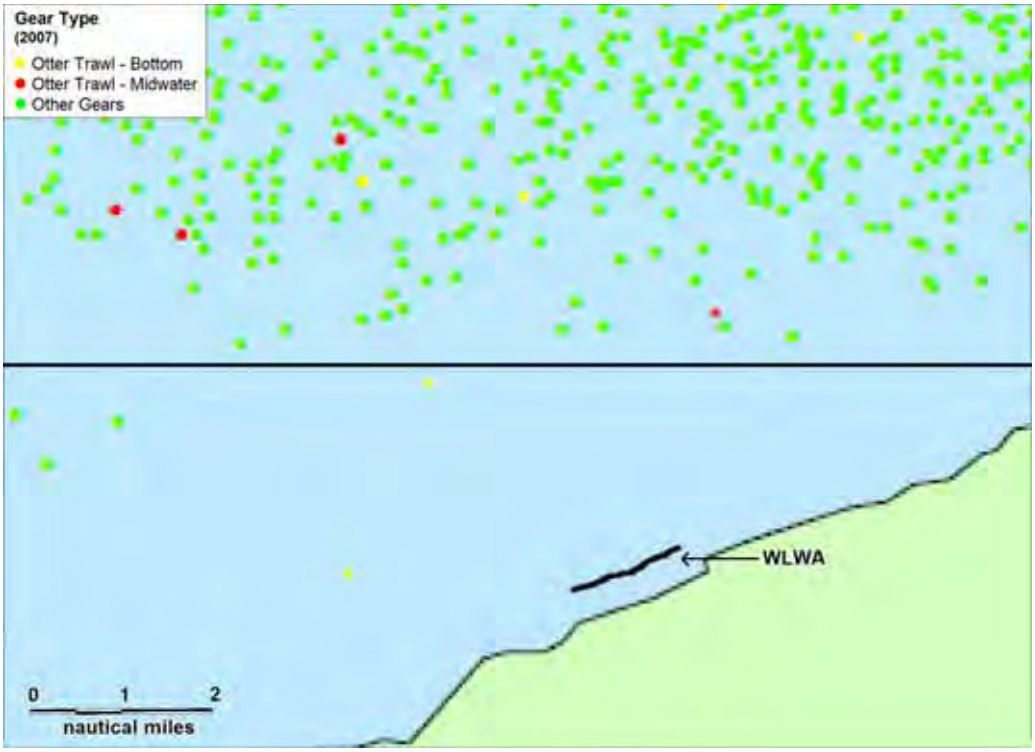


Figure 9.10 Fishing Vessel Satellite Positions by Gear Type (2007)

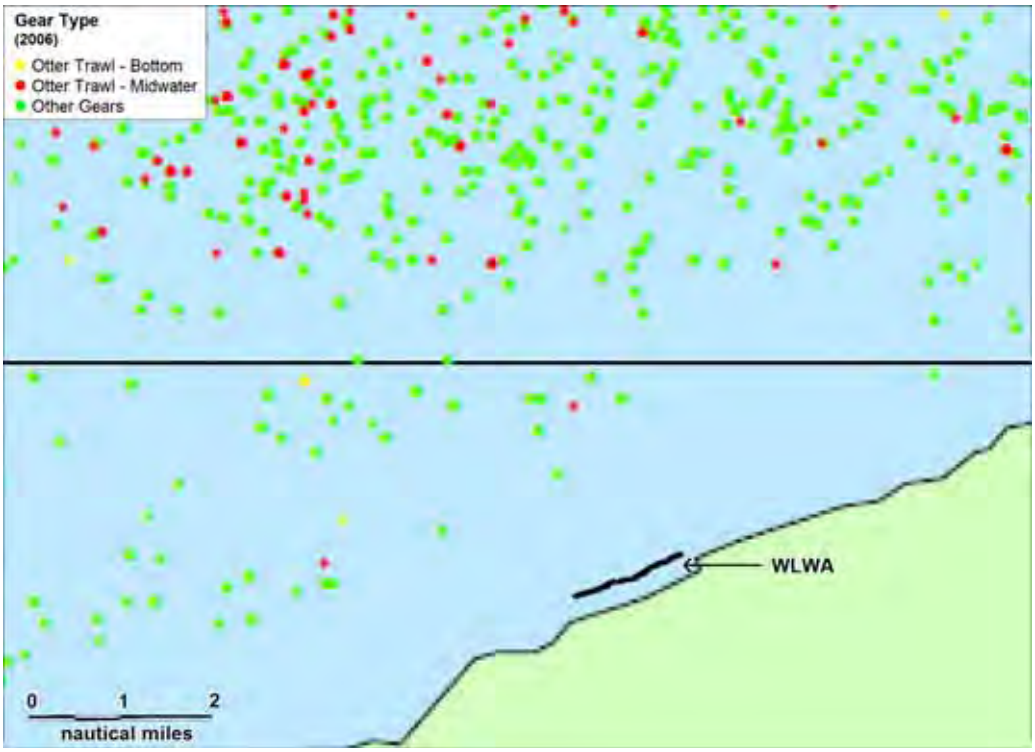


Figure 9.11 Fishing Vessel Satellite Positions by Gear Type (2006)

It is not possible to interrogate the Marine Scotland Compliance images in a GIS but the general pattern appears similar to the 2009 data, although with fewer positions closer to the Project.

9.3 AIS Data

All the fishing vessel tracks recorded during the combined 2011 survey period (56 days summer and winter 2011) are presented in Figure 9.12.

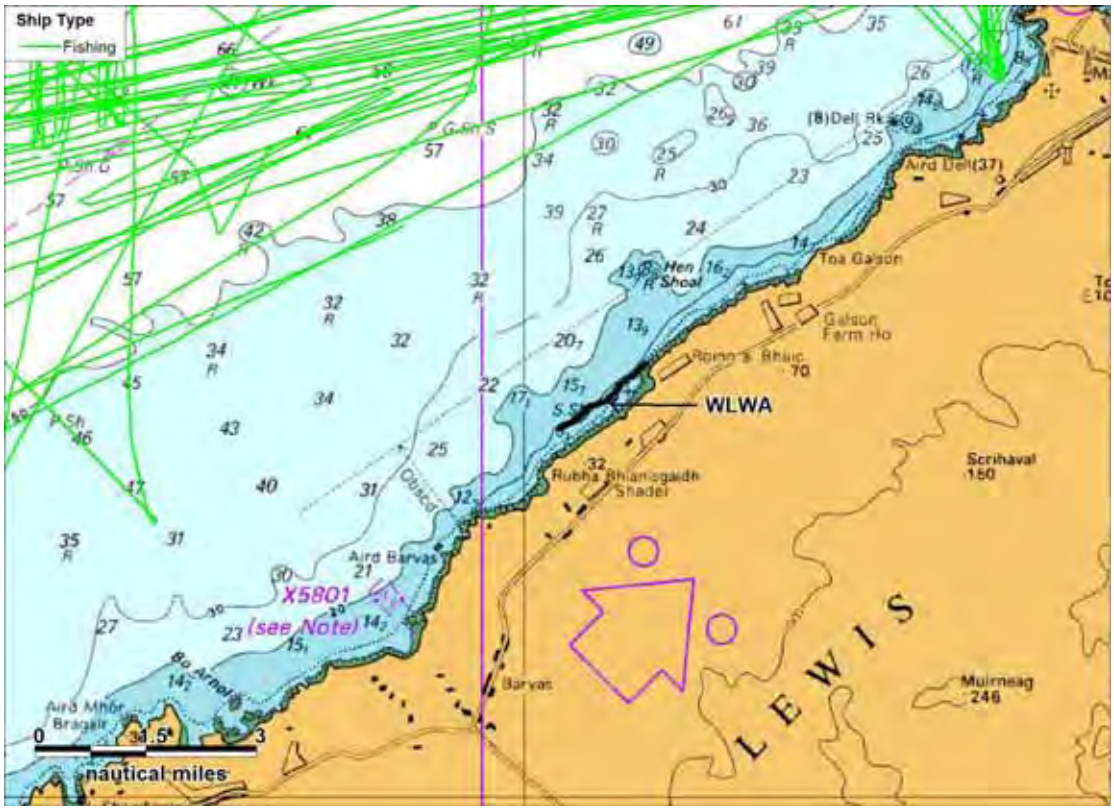


Figure 9.12 Fishing Vessels Tracked on AIS (Summer and Winter 2011)

In total, sixteen different fishing vessels were tracked within 5nm of the Project. These are presented in Table 9.2. It can be seen from this that trawlers operate much further offshore in this area with potting being the main fishing activity taking place in and around the site.

Table 9.2 Fishing Vessels tracked within 5nm of the Project (56 Days 2011)

Name	Destinations	Length (m)	Draughts (m)	Transits
Heather K	--	16.9	--	8
Our Hazel	--	20	--	7
Polaris 2				6
Marigold	--	24	--	3
Cuca	--	38	4.4	2
Jiminy	Ullapool	35	4	2

Name	Destinations	Length (m)	Draughts (m)	Transits
Julien Coleou	Stornoway / Lorient	30	4.5	2
Paula	--	60	8	2
Viking Monarch	--	40	--	2
Atlantic Challenge	--	15	--	1
Ayr Dawn	Ullapool	32	--	1
Mar Blanco	--	40	5	1
Norlantean K508	--	30	--	1
Ocean Way	--	27	--	1
O Genita	Port of Lochinver	33	4	1
Venture II	--	27	6.5	1

Images of Heather K, Our Hazel, Polaris 2 and Marigold INS241, the vessels tracked most frequently, are presented in Figure 9.13 to Figure 9.16.

Figure 9.13 Fishing Vessel *Heather K*

Figure 9.14 Fishing Vessel *Our Hazel*

Figure 9.15 Fishing Vessel *Polaris 2*

Figure 9.16 Fishing Vessel *Marigold*

10. Recreational Vessel Activity Analysis

10.1 Introduction

This section reviews recreational vessel activity at the Project based on the available desktop information as well as feedback from RYA during the scoping stage of the project. .

10.2 RYA Data

The RYA, supported by the Cruising Association, have identified recreational cruising routes, general sailing and racing areas in the UK. This work was based on extensive consultation and qualitative data collection from RYA and Cruising Association members, through the organisations' specialist and regional committees and through the RYA affiliated clubs. The consultation was also sent to berth holder associations and marinas.

The results of this work were published in Sharing the Wind and updated GIS layers published in the Coastal Atlas.

A summary plot of the recreational sailing activity and facilities identified in the vicinity of the Project is presented in Figure 10.1.

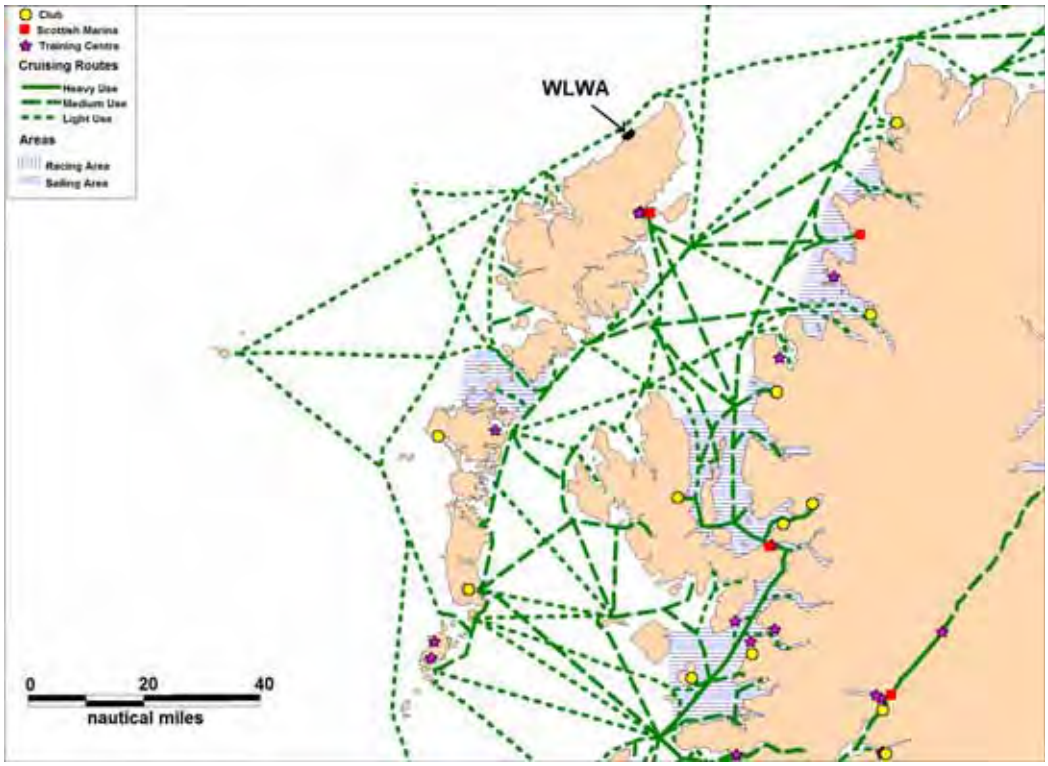


Figure 10.1 Recreational Information for North East Scotland Strategic Area

Based on the RYA published data, the Project does not fall within any Racing or Sailing Areas. In terms of facilities, the nearest marina and training centre is at Stornoway. The closest club is the Loch Clash Boat Club at Kinlochbervie.

A light use cruising route follows the coast of Lewis, passing the Project at a distance of approximately 1.5nm, i.e. following the same route as observed to be used by the cargo and fishing vessels which take the more coastal route.

10.3 AIS Data

All the recreational vessel tracks recorded during the combined 2010 and 2011 survey period (112 days 2010 and 2011) are presented in Figure 10.2.

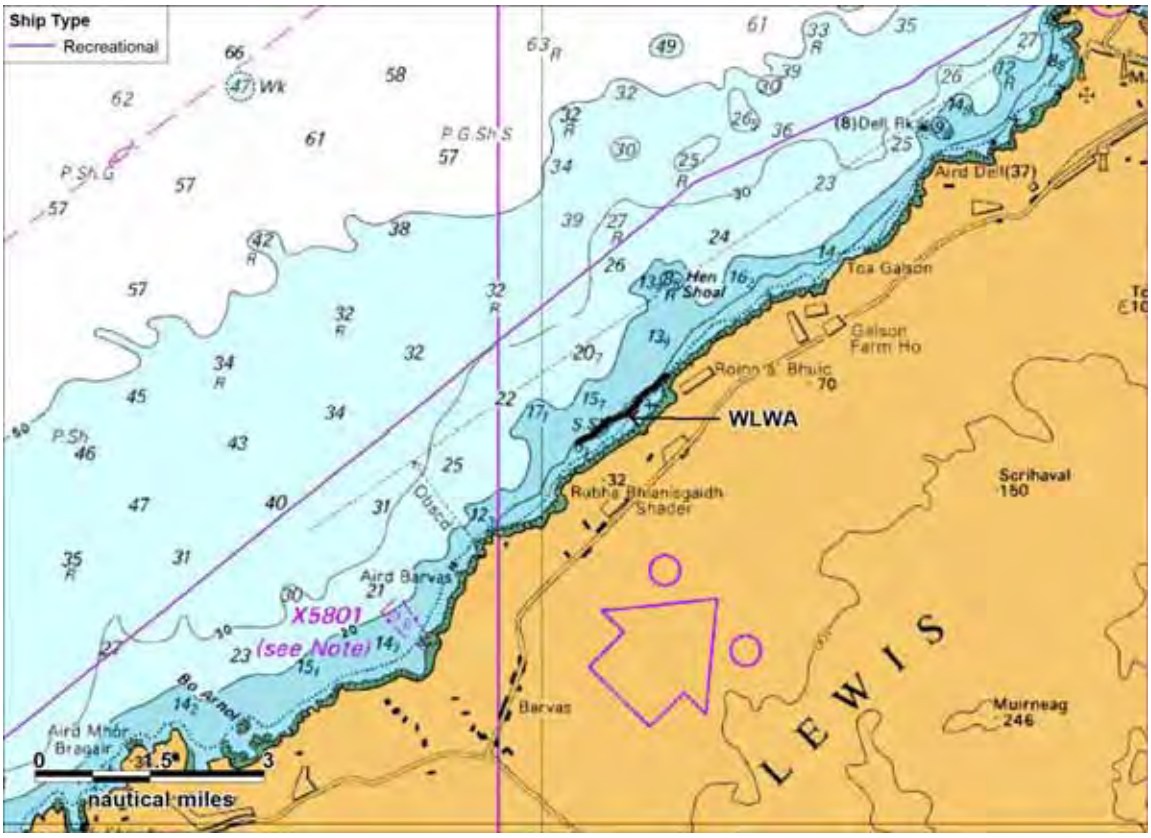


Figure 10.2 Recreational Vessels Tracked on AIS (Summer and Winter 2011)

The sailing vessel *Northern Spirit* passed approximately 1.7nm from the Project.

Further details of these vessels are presented in Table 10.1.

Table 10.1 Recreational Vessels tracked within 5nm of the Project (56 Days 2011)

Name	Destinations	Length (m)	Draughts (m)	Transits
Northern Spirit	'Cruising'	37	3.2	1

An image of *Northern Spirit* is presented in Figure 10.3.

Figure 10.3 Sailing Vessel *Northern Spirit*

11. Review of Historical Maritime Incidents

11.1 Introduction

This section reviews maritime incidents that have occurred in the vicinity of the Project over the last 10 years.

The analysis is intended to provide a general indication as to whether the area of the proposed development is currently low or high risk area in terms of maritime incidents. If it was found to be a particular high risk area for incidents, this may indicate that the development could exacerbate the existing maritime safety risks in the area.

Data from the following sources has been analysed:

- Marine Accident Investigation Branch (MAIB)
- Royal National Lifeboat Institution (RNLI)

(It is noted that a number of incidents were recorded by both sources.)

11.2 MAIB

All UK-flagged commercial vessels are required to report accidents to MAIB. Non-UK flagged vessels do not have to report unless they are within a UK port/harbour or within UK 12 mile territorial waters and carrying passengers to or from a UK port (including those in inland waterways). However, the MAIB will record details of significant accidents of which they are notified by bodies such as the Coastguard, or by monitoring news and other information sources for relevant accidents. The Maritime and Coastguard Agency, harbour authorities and inland waterway authorities also have a duty to report accidents to MAIB.

The locations[1] of accidents, injuries and hazardous incidents reported to MAIB within 10nm of the Project area boundary between January 2001 and December 2010 are presented in Figure 11.1, colour-coded by type.

[1] MAIB aim for 97% accuracy in reporting the locations of incidents.

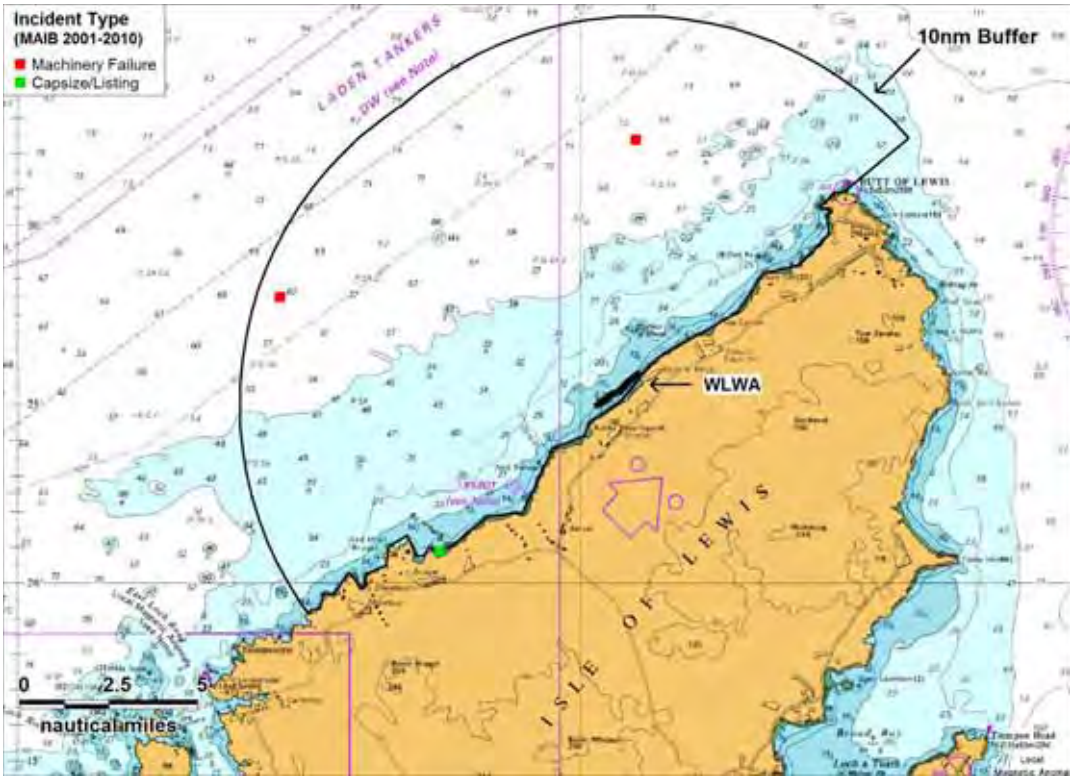


Figure 11.1 MAIB Incident Locations by Type within 10nm of the Project (2001 – 2010)

A total of 3 incidents were reported in the area within 10nm of the Project, corresponding to one incident approximately every 3-4 years. Details of these incidents are presented below:

- On 10th November 2004 an unspecified vessel suffered Machinery Failure.
- On 11th May 2006 a stern trawler encountered Machinery Failure.
- On 04th June 2007 an open boat Capsized / Listed.

The closest incident to the site occurred approximately 6nm south west of the area when a father and son launched an open canoe into the sea off the beach. Neither had any experience of canoeing. The canoe was reported to the coastguard as upturned and in the surf a short while later. The coastguard immediately scrambled a helicopter and launched a lifeboat to the area. Six local coastguard rescue teams ware also tasked.

11.3 RNLI

Data on RNLI lifeboat responses within 10nm of the Project in the ten-year period between 2001 and 2010 have been analysed. There were a total of 2 unique incidents (excluding hoaxes and false alarms), i.e., an average of 1 incident every 5 years.

Cross-referencing by date, description and location, it was identified that 1 of the RNLI incidents was also logged by MAIB. This was the incident which occurred in June 2007, although the dates logged differ by one day.

Figure 11.2 presents the geographical location of incidents colour-coded by casualty type.

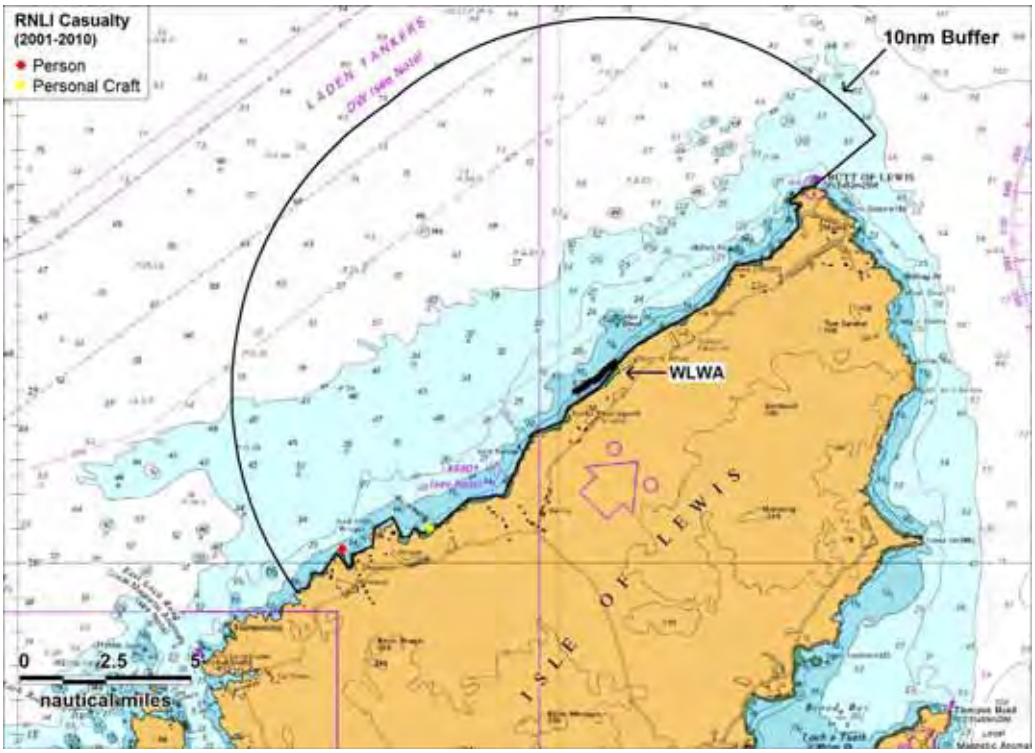


Figure 11.2 RNLI Incidents by Casualty Type within 10nm of the Project (2001 -2010)

One person and one personal craft were involved in incidents. Details of the incidents are presented below:

- On 05th June 2007 a personal craft suffered a Leak / Swamping and Stornoway ALB responded to the incident.
- On 13th February 2008 a person went missing and the incident was responded to by Stornoway ALB.

12. Search and Rescue

12.1 Introduction

This section summarises the Search and Rescue resources in the region and the issues being considered in relation to the design of the Project. (A detailed review of the historical incidents in the area, including RNLI launches, has been presented in Section 11.)

12.2 SAR Resources

12.2.1 SAR Helicopters

A review of the assets in the area of the Project indicated that the closest SAR helicopter base is located at Stornoway, operated by Her Majesty's Coastguard (HMCG), approximately 13nm to the SSE of the Project. This base has Sikorsky S92 helicopters with speeds of 145mph.

Up to 22 persons can be carried, however this is dependent on weather conditions and the distance of the incident from the helicopter's operating base.

Figure 12.1 SAR Helicopter Bases relative to the Project Area

12.2.2 RNLI Lifeboats

The Royal National Lifeboat Institution maintains a fleet of over 400 lifeboats of various types at 235 stations round the coast of the UK and Ireland.
The RNLI stations in the vicinity of the proposed Project are presented in Figure 12.2.

Figure 12.2 RNLI Bases closest to the Project Area

From the RNLI incident review presented in Section 11.3 it was identified that it would normally be Stornoway RNLI responding to an incident in the vicinity of the Project.

Crew and lifeboats are available on a 24-hour basis throughout the year. Stornoway RNLI, located 13nm south-south-east of the Project over land and approximately 40nm by sea, use the Severn class lifeboat, *Tom Sanderson.* The Severn class lifeboat has a speed of 25 knots, range of 250nm and can operate in all weather. All-weather lifeboats are fitted with the latest in navigation, location and communication equipment, including electronic chart plotter, VHF radio with direction finder, radar and global positioning systems (GPS).

Based on the distance between Stornoway RNLI and the Project, and the speed of the lifeboat, there could be a lifeboat on site at the Project within approximately 96 minutes, plus the time taken to respond to the incident.

The RNLI recently approved the placement of a new lifeboat station at Leverburgh on the Isle of Harris, 42nm SW of the Project over land and approximately 54nm by sea. A Mersey class all-weather lifeboat will operate here on a trial basis for a minimum of 12 months starting next year. The Mersey class lifeboat has a speed of 17 knots, range of 14nm and can operate in all weather.

12.2.3 Overview Coastguard Stations

HM Coastguard is responsible for requesting and tasking SAR resources made available by other authorities and for co-ordinating the subsequent SAR operations (unless they fall within military jurisdiction).

HM Coastguard co-ordinates SAR through its network of 18 Maritime Rescue Co-ordination Centres (MRCC). A corps of over 3100 volunteer Auxiliary Coastguards around the UK coast form over 400 local Coastguard Rescue Teams (CRT) involved in coastal rescue, searches and surveillance.

All of the MCA's operations, including SAR, are divided into three geographical regions. The East of England Region covers the East and South Coasts of England from the Scottish border down to the Dorset/Devon border. The Wales and West of England Region extends from Devon and Cornwall to cover the coast of Wales, North West England and the Moray Firth. The Scotland and Northern Ireland Region covers the remainder of the UK coastline including the Western Isles, Orkney and Shetland.

Each region is divided into six districts with Maritime Rescue Co-ordination Centre (MRCC), which co-ordinate the Search and Rescue response for maritime and coastal emergencies within each district's boundaries.

The Project area lies within the Scotland and Northern Ireland Region with the nearest rescue coordination centre being Stornoway MRCC.

12.2.4 Proposed Changes to Coastguard Stations

MCA published a consultation document in December 2010 (Ref. viii) in order to modernise HM Coastguard. The main part of the document proposes the reduction in the number of Maritime Rescue Co-ordination (MRCC) stations around the UK coastline.

Revised plans were released by the UK Government, (Ref. ix) mid-way through 2011 with a second consultation period from 14th July 2011 to 6th October 2011. Under the revised proposals the MCA intends to:

- Establish a single 24 hour Maritime Operations Centre (MOC) based in the Southampton/Portsmouth area with 96 operational coastguards. The MOC will act as a national strategic centre to manage Coastguard operations across the entire UK network as well as co-ordinating incidents on a day to day basis. The MOC will also generate a maritime picture using information from a variety of sources;

- Dover will be configured to act as a stand-by MOC for contingency purposes. Dover would have 28 staff and would retain its responsibilities for the Channel Navigation Information Service (CNIS);

- In addition to the MOC and Dover, there will be eight further put in centres, Maritime Rescue Sub-Centres (MRCS), all of which would be connected to the national

network and the MOC. All would be open 24 hours a day with a total staffing of 23 in each. These would be based at the following stations:

- MRSC Aberdeen
- MRSC Shetland
- MRSC Stornoway
- MRSC Belfast
- MRSC Holyhead
- MRSC Milford Haven
- MRSC Falmouth
- MRSC Humber

*NB: The station at London will be retained unchanged.

12.2.5 Effect of Changes to Coastguard Stations on the Project

The Project currently lies within the Scotland and Northern Ireland region with the nearest rescue coordination centre being MRSC Stornoway. MRSC Stornoway will remain open 24hrs.

12.2.6 Salvage

MCA charters four Emergency Towing Vessels (ETVs) to provide emergency towing cover in winter months in the four areas adjudged to pose the highest risk of a marine accident: the Dover Strait, the Minches, the Western Approaches and the Fair Isle Channel.

The Minches tug is within range of the Project, although response times would depend upon their exact location at the time. The contract for these ETVs was due to end in September 2011 but has been extended by the MCA for a further three months. At the time of writing (February 2012) there is not currently any further information about these contracts. It is expected that information will soon be made available relating to longer-term arrangements to fund the ETVs.

Each MRCC also holds a comprehensive database of harbour tugs available locally. Procedures are also in place with Brokers and Lloyd's Casualty Reporting Service to quickly obtain information on towing vessels that may be able to respond to an incident.

MCA has an agreement with the British Tug-owners Association (BTA) for emergency chartering arrangements for harbour tugs. The agreement covers activation, contractual arrangements, liabilities and operational procedures, should MCA request assistance from any local harbour tug as part of the response to an incident.

12.2.7 SAR Liaison

Developers will require to consult and liaise with the local RNLI stations and the Coastguard about the devices to be deployed and provide any further information requested to assist SAR efforts. This should include:

- Precise location details
- Device details and illustrations
- Information on the buoyancy of device parts
- Emergency contact details.

13. Hazard and Risk Review

13.1 Introduction

This section reviews the navigational hazards associated with the Project based on the baseline data analysis, stakeholder consultation and discussions at the Hazard Review Workshop held for the project.

13.2 Hazard Identification

A Hazard Review Workshop was held at the MCA's Control Centre in Stornoway on 15th December 2011, attended by local maritime stakeholders, as outlined in as outlined in Table 13.1. It is noted that in addition to the workshop consultation has also been carried out with the MCA in Southampton as well as the RNLI on Stornoway, the Northern Lighthouse Board and local inshore fishermen.

Table 13.1 Hazard Review Workshop Attendees

Person	Organisation	Position
Kenny Morrison	Comhairle nan Eilean Siar	Assistant Harbour Master
Roddy Jardine	Comhairle nan Eilean Siar	Harbour Master
Donald Morrison	Marine Scotland	Senior Fishery Officer
Torquil Macleod	Stornoway Port Authority	Harbour Master
Duncan MacInnes	Outer Hebrides Inshore Fisheries Group	Coordinator
Marc Murray	Senior Site Developer	Aquamarine Power
Jamie Ralston	Maritime & Coastguard Agency	RCCM
Alasdair MacDonald	Anatec Ltd	Senior Risk Analyst

The key maritime hazards associated with the array were identified and associated scenarios prioritised by risk level. Within each hazard scenario, local and transiting vessel types were considered separately to ensure the risk review and control/mitigation options were specific to each.

The following list of main navigational hazards were reviewed:

OPERATION:

- Unauthorised mooring to structure and/or deliberate damage to device
- Recreational vessel (e.g. yacht and/or angling boat) collides with structure
- Anchor interaction with wave device or cable/pipelines
- Transiting vessel (powered) collision with wave device or partially constructed device
- Transiting vessel (drifting) collision with wave device

- Access to structure in an emergency situation
- Fishing vessel collision with wave device
- Man overboard in site under normal operations
- Loss of Oyster device or part of device
- Workboat collision with structure
- Fishing gear interaction with wave device or cable/pipelines

INSTALLATION / MAINTENANCE / DECOMMISSIONING:

- Transiting vessel collision with working vessel
- Local vessel collision with working vessel
- Diver in difficulty at site
- Working vessel in difficulties due to conditions e.g. Jack-Up during installation

The hazards were recorded systematically using Anatec's Hazard Management software.

The ranking of the risks associated with the various hazards was carried out based on the discussion at the workshop, together with the baseline data analysis and other consultation. A risk matrix was used based on the frequency and consequence categories shown below.

Table 13.2 Frequency Bands

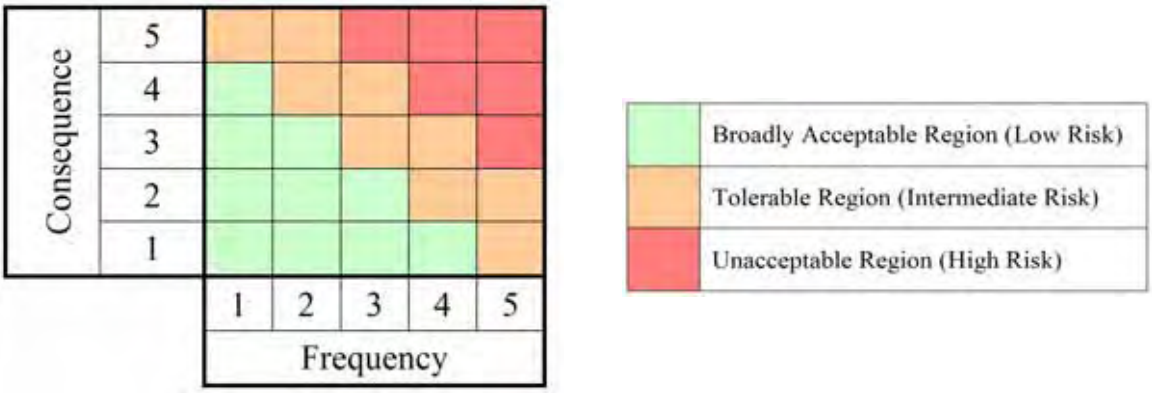
Rank	Description	Definition
1	Negligible	< 1 occurrence per 10,000 years
2	Extremely Unlikely	1 per 100 to 10,000 years
3	Remote	1 per 10 to 100 years
4	Reasonably Probable	1 per 1 to 10 years
5	Frequent	Yearly

Table 13.3 Consequence Bands

Rank	Description	Definition			
		People	Property	Environment	Business
1	Negligible	No injury	<£10k	<£10k	<10k
2	Minor	Slight injury(s)	£10k-£100k	Tier 1 Local assistance required	£10k-£100k
3	Moderate	Multiple moderate or single serious injury	£100k-£1M	Tier 2 Limited external assistance required	£100k-£1M Local publicity
4	Serious	serious injury or single fatality	£1M-£10M	Tier 2 Regional assistance required	£1M-£10M National publicity
5	Major	More than 1 fatality	>£10M	Tier 3 National assistance required	>£10M International publicity

The four consequence scores were averaged and multiplied by the frequency to obtain an overall ranking (or score) ranking which determined the hazard's position within the risk matrix shown below.

Table 13.4 Risk Matrix



As well as ranking the hazard by expected risk, based on the estimated frequency versus consequence, the worst case risk was also ranked in order to capture scenarios with a particularly high worst case risk. An example of the methodology and the full set of results are presented in Appendix A.

13.3 Risk Rankings

The final hazard log contained 15 navigational hazards with the following overall breakdown by tolerability region.

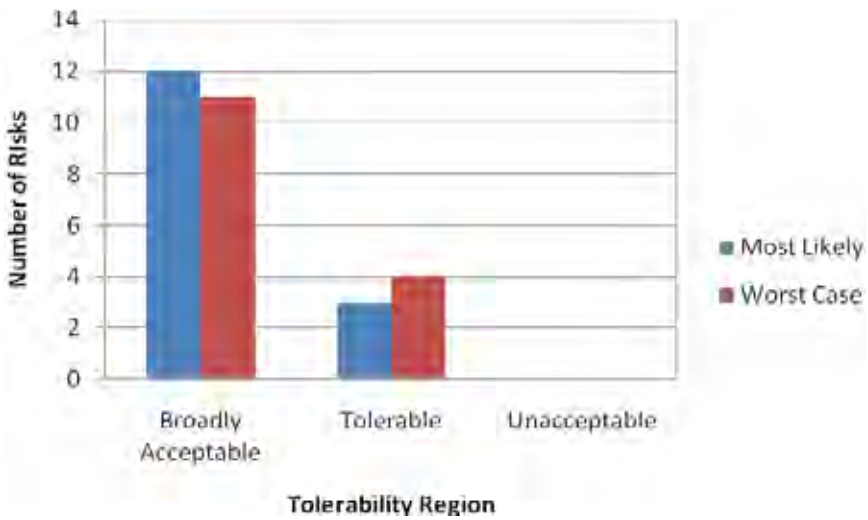


Figure 13.1 Hazard Ranking Results

A total of three risks were ranked within the Tolerable (As Low as Reasonably Practicable, ALARP) region based on the probable outcome whilst four were ranked as Tolerable (ALARP) based on the worst case outcome.

The hazards ranked as tolerable based on probable outcome were:

- Working vessel in difficulties due to conditions e.g. Jack-Up during installation (Construction).
- Workboat collision with structure (Operational phase);
- Fishing gear interaction with wave device or cable/pipelines (Operational phase).

Another key hazard discussed extensively at the workshop and consultation meetings which mertis further review is the potential loss of a wave device during severe weather.

Full details of the logged and ranked hazards (including phase of operation, causes, frequency and consequences ranking and potential risk control/mitigation measures) are recorded in the Hazard Log (Appendix A).

Details on the mitigation measures proposed for the different phases of the project presented in Section 14.

Based on the results of the workshop and the fact that it is a relatively small scale development with limited shipping in close proximity to the site a qualitative review of the key hazards / impacts has been carried out.

13.4 Review of Key Hazards

This section presents a discussion of the key hazards and issues raised during consultation.

This section considers the hazards associated with loss of station of a device or part of a device, fishing gear interaction with subsea equipment, as well as the highest risk hazard identified which was the Jack-Up installation vessel getting into difficulties during the construction phase.

13.4.1 Installation Vessel e.g. Jack-Up in Difficulty

One of the key hazards identified at the Hazard workshop was the Jack-Up involved in the construction phase getting into difficulty in severe weather. The location on the North West Coast of Lewis is very exposed and high winds and swells can occur even in the Summer months.

The nearest realistic refuge is in Loch Roag and it would take a self propelled Jack-Up barge in the order of 40 minutes to reach shelter from the location. If tug assistance was required then this would take in the order of 1.5hrs assuming a tug makes 5-6 knots.

In order to reduce this risk to a tolerable level, the Jack-Up selected should have operating limits well within the potential worst case conditions predicted in the proposed months for

installation. In addition allowable weather limits and procedures for down manning or forecasting for vessel to go to sheltered waters should be established in the event of severe weather being forecast.

13.4.2 Loss of Wave Device

Loss of a device or part of a device was raised as a concern during consultation and at the Hazard Review Workshop. This could present a hazard to local vessels as well as potentially the larger vessels (e.g. passing tankers) using the Deep Water Route to the West of the site in certain conditions.

In order to minimise the risk of a device being lost, the devices will be installed using foundation piles with all equipment being designed and certified for the local conditions West of Lewis.

The Oyster technology is currently being tested at the EMEC Billia Croo site in Orkney. The performance of the devices is being monitored during this testing and any necessary adjustments / improvements will be made prior to deployment on the west coast of Lewis.

A ‘deploy and monitor’ strategy is being used at the Project. The devices will be installed in phases over several summer seasons from 2014 onwards. This will limit the consequences of any initial problems.

If, in the unlikely worst case scenario instance that the Oyster flap broke free from its foundation pile it would almost certainly be under extreme storm conditions where the storm surge would play a much bigger role than tidal currents. The most likely result would be that it would end up on the shore, but the location would be dependent on the size and direction of the waves and storm duration etc.

If the storm was very short lived then there would be the possibility that the flap could break free from its foundation pile and then when the waves died down and tidal currents took over the Oyster flap could end up somewhere else other than the beach. This situation is very unlikely to occur.

It is noted that the devices inherent protection in high energy waves is that it is pushed under the water.

The Oyster flap to be installed at Lewis will be made out of Fibre Reinforced Polymer (FRP) which is not be visible on a small vessel radar, but as it is made of FRP, it will not present a significant risk to shipping.

In terms of being aware that a device has broken free, all Oyster devices will have continuous monitoring back to shore through a Control and Instrumentation (C&I) system – i.e. a direct connection between the shore and each device through a dedicated umbilical cord providing real time data. In the unlikely instance that a device were to break free then all communication would cease. If this occurred during a period of poor visibility or during the

hours of darkness then Lewis Wave Power Ltd could not be sure that the flap has broken free. However, the Emergency Response Cooperation Plan (ERCoP) will have the provision to alert the Coastguard that there is a risk that a device has broken free from its foundations in order for navigational safety warnings to be issued to shipping in the area.

13.4.3 Anchor or Fishing Gear Interaction

There is a risk of anchor or fishing gear interaction with the Oyster devices, inter-array cabling and cables to shore. These risks are discussed below along with appropriate mitigation.

Anchor Interaction

No vessels were observed to be anchoring in the immediate vicinity of the Project over the 112 days of AIS survey as well as during the visual surveys. The Admiralty Sailing Directions (Ref: v) mentions anchorages in the area as between Tiumpan (58°18’20N, 6°48’20W) and Aird Mhor Braigair, 5 miles east-north-east, where there are several small bays which might afford shelter for small vessels during offshore winds. Local knowledge is required for this. Loch Shawbost (58°20’20N, 6°41’50W) is open and has a sandy bottom, but its sides dry out, leaving an area of only 1 cable in width for anchoring. The bay between Aird Dell (58°28.70”N, 6°20’00W) and the southwest extremity of Butt of Lewis 2.25nm northeast offers anchorage with fairly good holding ground. Several fishing vessels were observed to be anchoring here.

Fishing Gear Interaction

As reviewed in Section 9, trawling occurs further off the West coast of Lewis, with potting being the main fishing activity taking place in and around the proposed site.

There is the risk of fishing gear (creels) getting washed into and entangled in amongst devices and cables/pipelines. This would most likely result in loss of gear as opposed to presenting a risk to the fishermen themselves. The risk to fishermen could increase in the event that they attempt to retrieve their entangled gear. Discussions between Lewis Wave Power and local fishermen are ongoing to identify how to manage these issues.

14. Risk Mitigation

14.1 Introduction

This section summarises the risk mitigation relating to shipping and navigation for the Project. Risk control measures were identified during the Hazard Workshop, consultation and experience from other projects. It is noted that the mitigation measure will depend on the different phases of the project i.e. from installation through to operation/maintenance and decommissioning.

14.2 Installation, Maintenance and Decommissioning

To minimise the risk of collision of vessels with the development, the Navigation Risk Assessment (NRA) identified a number of mitigation measures, which will be implemented to reduce potential hazards:

Mitigation drawn from Navigation Risk Assessment:

- Emergency response procedures, Emergency Response Cooperation Plan (ERCoP) will be developed in liaison with Maritime Coastguard Agency (MCA) and Royal National Lifeboat Institution (RNLI);
- Outcomes of device design testing and lessons learned from the Oyster Project at Billia Croo, Orkney, will be applied before similar devices are deployed in Lewis;
- Hazard Workshop for operational phase with key project personnel/vessel masters etc.;
- Use of certified vessels/Jack-Up suitable for operating in the predicted conditions
- Site surveys to establish suitable locations for Jack-Up vessel.
- Liaison/dialogue with local fishermen during major maintenance operations;
- Maintenance operations will be planned around weather window;
- Weather forecasting and monitoring conditions will be undertaken continuously;
- Vessels on site will be tasked with monitoring shipping/fishing in the area to warn them of the operations;
- Navigational warnings will be broadcast e.g., Navtex and information will be marked on UKHO charts;
- Continued liaison will be maintained with Harbour Masters, local coastguard and fishermen operating in the area;
- Oyster devices will be marked to meet the requirements of the Northern Lighthouse Board (NLB) prior to installation;
- Navigational Aids will be installed and maintained as directed by NLB;
- The site will be marked on hydrographic charts and Kingfisher charts as well as FishSAFE;
- Coordinates of site and devices will be provided to local fishermen and canoe / kayak clubs;
- Operating procedures will be in place, including safety requirements as well as wider site management measures;

- The devices will be monitored through a control and instrumentation system (SCADA system) to ensure early detection of device malfunction, allowing the operators to alert other users and regulators regarding significant changes in operation or status of the site;
- A safety/exclusion zone will be applied for the operational phase;
- Lewis Wave Power will develop an ERCoP which will have the provision to alert the Coastguard if there is a risk that a device has broken free from its foundations in order for navigational safety warnings to be issued to shipping in the area.

Installation on Site:

- Experience and lessons learned from other marine renewables projects, such as the testing of the planned WECs at EMEC Billia Croo, should also be reviewed prior to the work being commenced;
- Weather forecasting and monitoring conditions continuously;
- Procedures for downmanning Jack-Up if severe weather is forecast;
- Vessel on site tasked with monitoring shipping/fishing in the area to warn them of the operations;
- Navigational warnings/broadcasts e.g., Navtex and information marked on UKHO charts;
- Continued liaison with Harbour Masters, local coastguard and fishermen operating in the area;
- Safety/Exclusion Zone in place during installation phase.

During work activity, it will be vital that information is circulated to local users to ensure they are kept informed of the activity on a day-to-day basis. This can be achieved by setting up a contact list for distributing this information.

The same process should apply during major maintenance and decommissioning of the project.

14.3 Operational Phase

Mitigation of hazards drawn from Navigation Risk Assessment:

Eleven hazards were identified in the NRA with the potential to occur during the operational phase. The following mitigation measures, proposed in the NRA, will decrease the risk of these hazards and the impact of increased pressure on search and rescue services:

- Devices will be clearly marked;
- Notices to mariners will be issued regularly;
- Local notices will be posted as appropriate;
- Hydrographer broadcasts will be made;
- The site will be designed as a no anchorage zone
- Ongoing fisheries liaison measures will be put in place;

- Pilot books will be updated as appropriate;
- An emergency response plan will be developed and tested;
- Method statements and risk assessments will be produced for activities;
- Life jackets will be worn by all offshore personnel during maintenance activities;
- A clear policy for working in adverse weather will be developed;
- A marine safety management system will be put in place;
- Only experienced and trained crews will be used for maintenance activities ; and
- A voluntary agreement will be sought with local fishermen not to lay and recover their potting gear in and around the devices.

At this moment in time there are no plans to implement safety /exclusion zones around the devices. Lewis Wave Power could, under SI 2007 No1948 (Ref x), apply for the option to designate safety zones around the devices to prohibit vessels from entering the area.

It is also noted that the MCA have published guidance to mariners operating in the vicinity of offshore renewable energy installations (OREI) (Ref: xi). The guidance notes that, unlike wind farms, wave energy systems may not be clearly visible to the mariner.

The MCA guidance suggests three options, in simple terms, for mariners operating in OREI areas:

a. Avoid the area completely
b. Navigate around the edge
c. In the case of a wind farm, navigate, with caution, through the array. The same principle applies to a wave/tidal site.

The choice will be influenced by a number of factors including the vessel's characteristics (type, draught, manoeuvrability, etc.), the weather and sea conditions. The guidance suggests that where there is sufficient sea room surrounding the development it is prudent to avoid the area completely (option 'a' above).

15. Cumulative and In-Combination Impacts

15.1 Introduction

This section considers potential cumulative and in-combination impacts of the Project along with other proposed projects in the area.

15.2 Cumulative

There are not currently any offshore wind projects planned in the vicinity of the Project. There are, however, two other wave power developments off the west coast of Lewis. The Agreement for Lease area for Pelamis is presented in Figure 15.1. In addition, there is a consented (2009) 4MW oscillating wave column on a breakwater close to shore at Siadar approximately 3nm south of the proposed West Lewis Wave Array site, shown in Figure 15.2.

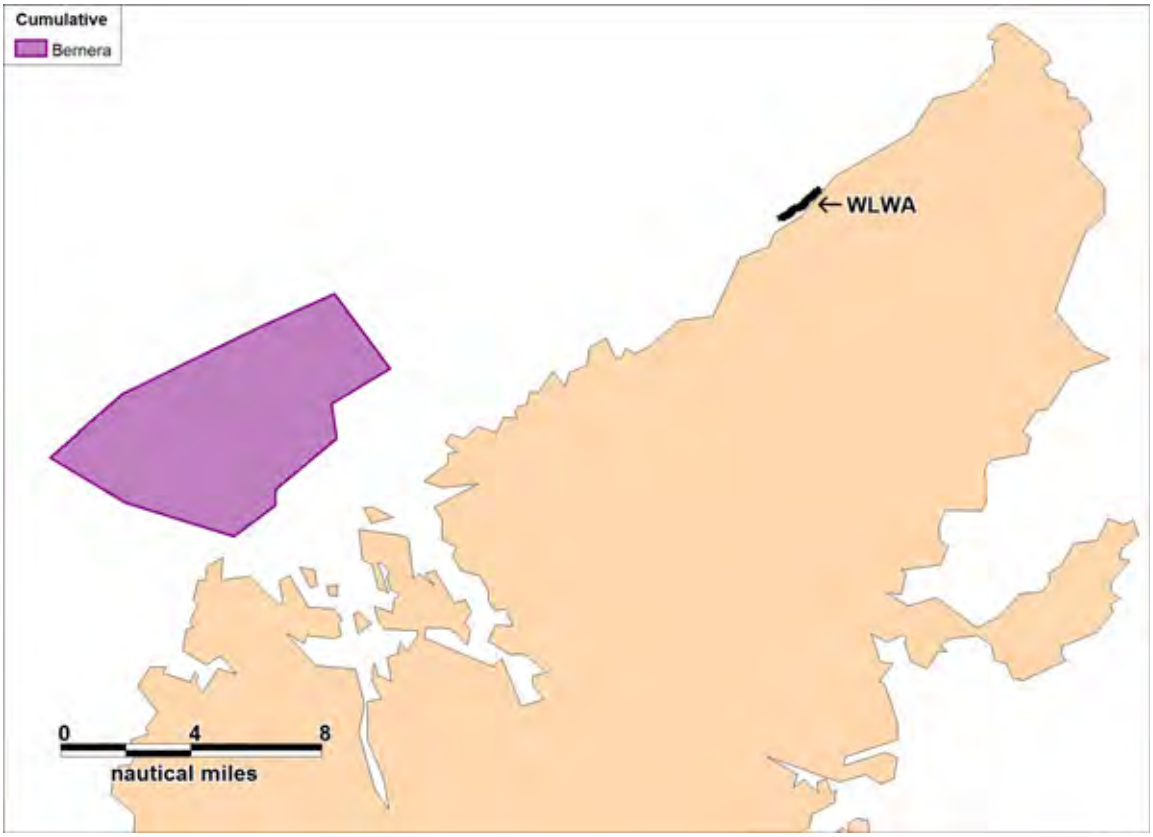


Figure 15.1 Agreement for Lease for Pelamis relative to the Project Area

Bernera Wave Farm is being developed by Pelamis Wave Power and will consist of up to 14 Pelamis machines, generating up to 10MW. The site is located approximately 12.7nm southwest of the Project.

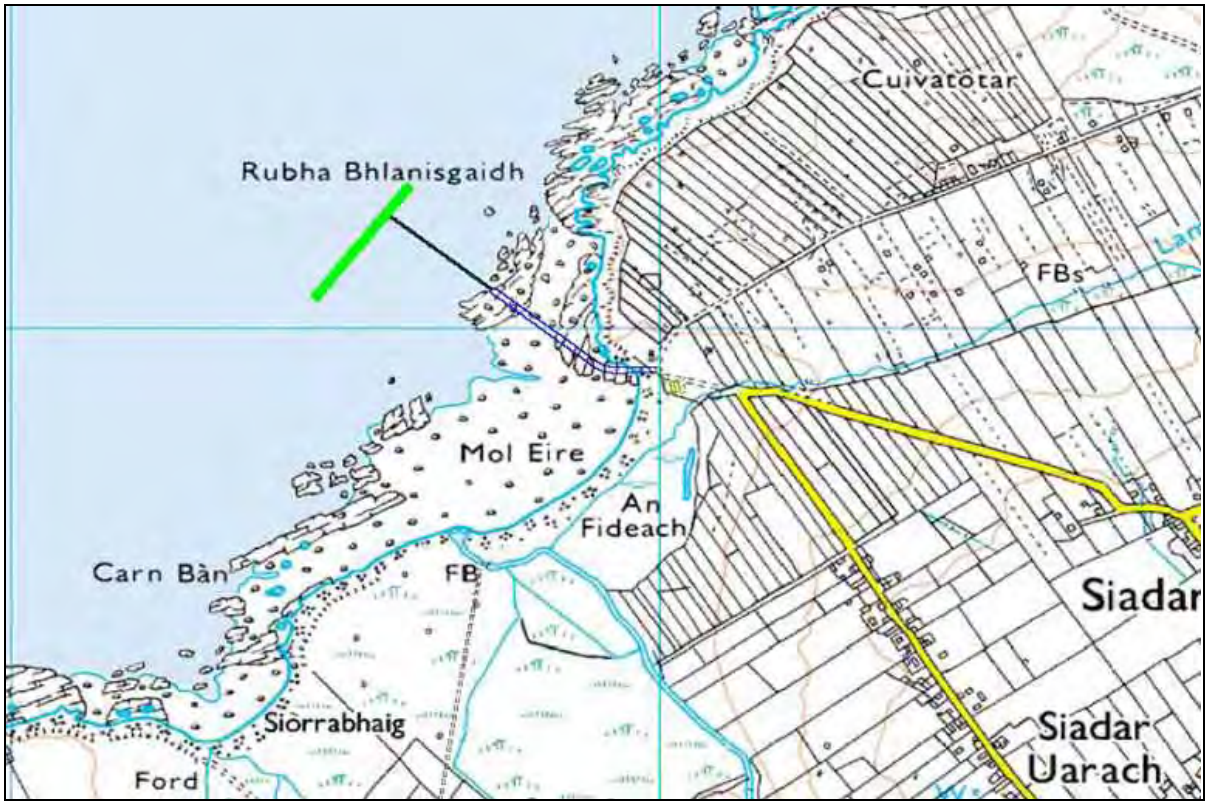


Figure 15.2 Consented Breakwater Development South of Project Area

From an impact on navigation perspective, no cumulative issues are anticipated from either the Wave Farm or the breakwater development at Siadar.

15.3 In-Combination

There are not considered to be any in-combination impacts in the vicinity of the Project.

16. Other Navigational Issues

16.1 Introduction

This section covers a number of other navigational issues identified within MGN 371 (Ref. ii**Error! Bookmark not defined.**) which are not covered elsewhere within this report are also dealt with in this section.

16.2 Visual Navigation & Collision Avoidance

This is not considered to be an issue as the devices will sit very low in the water. During Installation work the visual impact of working vessels should be minor and similar to other surface vessels.

16.3 Potential Effects on Waves & Tidal Currents

Please refer to coastal processes study.

16.4 Sedimentation/Scouring Impacting Navigable Water Depths in the Area

Please refer to coastal processes study.

16.5 Impact on Marine Systems

Based on experience from test site to date the devices should have no impact on marine radar or other marine electronics devices such as VHF, GPS, AIS, LORAN and compasses.

It is however noted that the radar return that a wave device present to both small and large vessel radar is largely unknown. This will require further work during the design/installation of devices as this will have an influence as to how the site will be marked with aids to navigation as there are to be no navigation lights to be installed on the devices themselves.

16.6 Noise Impacts

The concern requiring to be addressed under MGN 371 is if acoustic noise from the development could mask prescribed sound signals. During normal operations, the devices will not make much noise due to the slow movement of the devices in the waves, therefore, ships' whistles and foghorns will be audible over the background noise. There is no reason to believe that the sound level of the development will have any significant influence on marine safety.

During installation there will be additional activities such as drilling/piling, but this will be subsurface and temporary.

17. Conclusions

This Navigation Risk Assessment has considered the West Lewis Wave Array Wave Project comprising up to 50 Oyster devices on the west coast of the Isle of Lewis.

The key findings are summarised below:

- There is limited vessel traffic transiting in the immediate vicinity of the Project.
- Fishing activity occurs further offshore with the main activity in proximity to the site being carried out by a few local inshore boats fishing for crabs and lobster.
- The main hazards from the workshop with local stakeholders were considered to be Jack-Up installation vessel getting into difficulty in rough weather, loss of wave device in extreme weather and fishing gear interaction with the project infrastructure.
- In order to mitigate against the vessel getting into difficulty at the site, then the selection of the vessel will be critical as well as appropriate operating and emergency procedures developed.
- The most effective mitigation is considered to be circulating information about the development, and installation activities, in order to pre-warn vessels. This will allow local users especially inshore fishermen to be aware of the development.
- Mitigation measures are reviewed in Section 14. Many of these are standard industry measures but others require to be given further consideration.
- There are no cumulative or in-combination effects in the area of the Project.

18. References

i DECC, U.K. Government, Methodology for Assessing the Marine Navigational Safety Risks of Offshore Windfarms, Version Date: 7th September 2005.

ii MCA Marine Guidance Notice 371, Offshore Renewable Energy Installations (OREIs) - Guidance on UK Navigational Practice, Safety and Emergency Response Issues.

iii Lewis Wave Power Limited, Environmental Scoping Report, May 2011.

iv RYA, Sharing the Wind, 2004.

v UK Coastal Atlas of Recreational Boating; Recreational Cruising Routes, Sailing and Racing Areas around the UK Coast; Second Edition by RYA; Supported by Trinity House, 2008.

vi Admiralty Sailing Directions – West Coast of Scotland Pilot, NP 66, 17th Edition, 2011.

vii Wave data, Hebridean Marine Energy Futures Project.

viii MCA, 2010. Protecting our Seas and Shores in the 21st Century, Consultation on Proposals for Modernising the Coastguard.

ix MCA, 2011. Protecting our Seas and Shores in the 21st Century, Consultation on Revised Proposals for Modernising the Coastguard.

x The Electricity (Offshore Generating Stations) (Safety Zones) (Application Procedures and Control of Access) Regulations, 2007. SI 2007/1948.

xi MCA Marine Guidance Notice 372, Guidance to Mariners Operating in the Vicinity of UK OREIs, August 2008.

Hazard Review Workshop
North West Lewis Wave Site
(Appendix A)

Prepared by:	Anatec Limited
On behalf of:	Aquamarine Ltd
Date:	15 December 2011
Revision No.:	01
Ref.:	A2740-AM-NRA-1 App A

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1. Introduction

This Appendix presents the preliminary Hazard Log for the navigational risks associated with Aqumarine's proposed Wave Site off the North West Coast of the Isle of Lewis.

A Hazard Review workshop was held at the MCA's Control Centre in Stornoway on 15th December 2011 attended by local maritime stakeholders, as outlined in Table 1.1. It is noted that in addition to the workshop consultation has also been carried out with the MCA in Southampton as well as the RNLI on Stornoway, the Northern Lighthouse Board and local inshore fishermen.

Table 1.1 Hazard Review Workshop Attendees

Person	Organisation	Position
Kenny Morrison	Comhairle nan Eilean Siar	Assistant Harbour Master
Roddy Jardine	Comhairle nan Eilean Siar	Harbour Master
Donald Morrison	Marine Scotland	Senior Fishery Officer
Torquil Macleod	Stornoway Port Authority	Harbour Master
Duncan MacInnes	Outer Hebrides Inshore Fisheries Group	Coordinator
Marc Murray	Senior Site Developer	Aquamarine Power
Jamie Ralston	Maritime & Coastguard Agency	RCCM
Alasdair MacDonald	Anatec Ltd	Senior Risk Analyst

The key maritime hazards associated with the tidal array were identified and associated scenarios prioritised by risk level. Within each hazard scenario, local and transiting vessel types were considered separately to ensure the risk review and control options were specific to each.

The following list of main navigational hazards were reviewed:

OPERATION:

- Unauthorised mooring to structure and/or deliberate damage to device
- Recreational vessel (e.g. yacht and/or angling boat) collides with structure
- Anchor interaction with wave device or cable/pipelines
- Transiting vessel (powered) collision with wave device or partially constructed device
- Transiting vessel (drifting) collision with wave device
- Access to structure in an emergency situation
- Fishing vessel collision with wave device
- Man overboard in site under normal operations
- Loss of Oyster device or part of device

- Workboat collision with structure
- Fishing gear interaction with wave device or cable/pipelines

INSTALLATION / MAINTENANCE / DECOMMISSIONING:

- Transiting vessel collision with working vessel
- Local vessel collision with working vessel
- Diver in difficulty at site
- Working vessel in difficulties due to conditions e.g. Jack-Up during installation

The ranking of the risks associated with the various hazards was carried out based on the discussion at the workshop, together with the baseline data analysis and other consultation. A risk matrix was used based on the frequency and consequence categories shown in Section 2.

2. Hazard Log Methodology

The hazards were recorded systematically using Anatec's Hazard Management software. The main information logged by the system is presented in Table 2.1.

Table 2.1 Hazard Log Field Description

Category	Definition
Area	Location of Hazard
Title	Title of hazardous event.
Category	General hazard category, e.g., General Navigational Safety.
Hazard Title	Title of the hazardous event.
Hazard Detail	Description of the Hazardous Event
Phase	Phase(s) of operation e.g. Installation, Operation, Maintenance and Decommissioning. (Can be more than one.)
Possible Causes	List of the potential causes of the hazard.
Most Likely Consequences	Description of the probable (or most likely) outcome should the hazard occur.
Worst Case Consequences	Description of the 'worst credible' outcome should the hazard occur.
Frequency (Probable Outcome)	Estimates the frequency of the probable outcome occurring.
Consequence (Probable Outcome)	Estimates the probable outcome should the event occur in terms of consequence to People, Environment, Asset, Business and overall average.
Risk Estimate (Probable Outcome)	Combines the frequency and (average) consequence to estimate the risk level for probable event.
Risk Reduction Measures	Documents the potential mitigation measures which will aid in the reduction of risk or in the management of the hazardous event.

The following frequency and consequence categories were applied.

Table 2.2 Frequency Bands

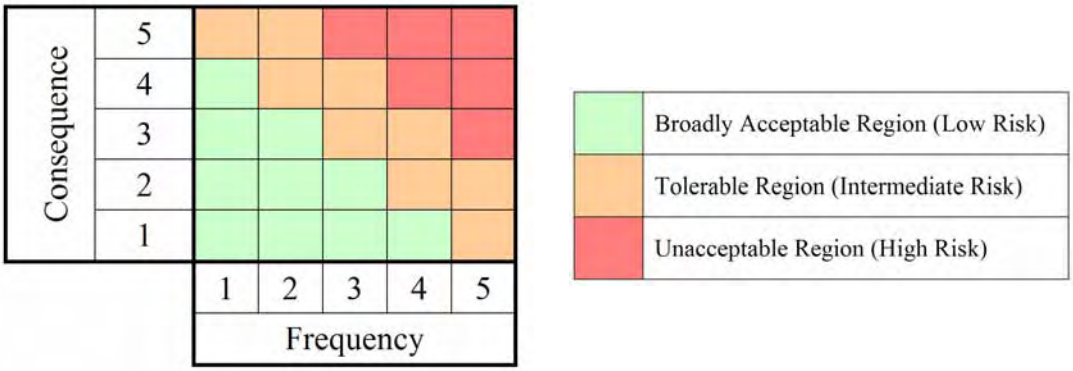
Rank	Description	Definition
1	Negligible	< 1 occurrence per 10,000 years
2	Extremely Unlikely	1 per 100 to 10,000 years
3	Remote	1 per 10 to 100 years
4	Reasonably Probable	1 per 1 to 10 years
5	Frequent	Yearly

Table 2.3 Consequence Bands

Rank	Description	Definition			
		People	Property	Environment	Business
1	Negligible	No injury	<£10k	<£10k	<10k
2	Minor	Slight injury(s)	£10k-£100k	Tier 1 Local assistance required	£10k-£100k
3	Moderate	Multiple moderate or single serious injury	£100k-£1M	Tier 2 Limited external assistance required	£100k-£1M Local publicity
4	Serious	serious injury or single fatality	£1M-£10M	Tier 2 Regional assistance required	£1M-£10M National publicity
5	Major	More than 1 fatality	>£10M	Tier 3 National assistance required	>£10M International publicity

The four consequence scores were averaged and multiplied by the frequency to obtain an overall ranking (or score) ranking which determined the hazard's position within the risk matrix shown below.

Table 2.4 Risk Matrix



The worked example below illustrates the method of ranking hazards:

Hazard Title	Attendant vessel collision with structure.
Possible Causes	Poor Operating Procedures; Poor visibility; Human error; Mechanical failure; Severe weather; Equipment failure; Watchkeeper failure; DP Failure.
Probable Consequence	Minor bump leading to minor damage to vessel and structure. Vessel most likely to be damaged.
Frequency of Probable Outcome	Reasonably probable (1 to 10 years) based on experience of attendant vessel collisions visiting offshore platforms.
Worst Credible Consequences	Moderate speed collision with significant damage to vessel, holed and vessel sinks, potential fatalities, damage to tower.
Frequency of Worst Credible Outcome	Extremely unlikely (100 to 10,000 years) in terms of significant consequences, i.e., loss of vessel with fatalities.

The following table present the risk ranking of this hazard for the probable (most likely) outcome.

Table 2.5 Example Risk Matrix: Attendant Vessel Collision with Structure (Probable Outcome)

Consequence (People)							Consequence (Property)						
	5							5					
	4							4					
	3							3					
	2				X			2				X	
	1							1					
		1	2	3	4	5			1	2	3	4	5
		Frequency							Frequency				

Consequence (Environment)							Consequence (Business)						
	5							5					
	4							4					
	3							3					
	2							2				X	
	1				X			1					
		1	2	3	4	5			1	2	3	4	5
		Frequency							Frequency				

The risk for the hazard is calculated by averaging the four consequences, i.e., (2+2+1+2)/4 = 1.75) and multiplying by the frequency, i.e., 4, to obtain a risk ranking of 7 (i.e. 1.75 x 4). A score of 7 puts this hazard in the Tolerable region.

Potential mitigation measures for each hazard were also logged, such as:

- Marking & Lighting (to NLB requirements)
- Depiction on UKHO Charts
- Notices to Mariners
- Navtex
- Marine Safety Information broadcasts by HM Coastguard
- Inclusion in Kingfisher Publications and FishSAFE
- Emergency Response Planning, Procedures and Liaison with emergency services, such as RNLI (ERCo Plan)
- Close liaison and regular updates on work schedule to local users including inshore fishermen and local MCA.
- Use of local knowledge during Installation and Maintenance activities

As well as ranking the hazard by expected risk, based on the estimated frequency versus consequence, the worst case risk was also ranked in order to capture scenarios with a particularly high worst case risk.

3. Risk Rankings

The final hazard log contained 15 navigational hazards with the following overall breakdown by tolerability region.

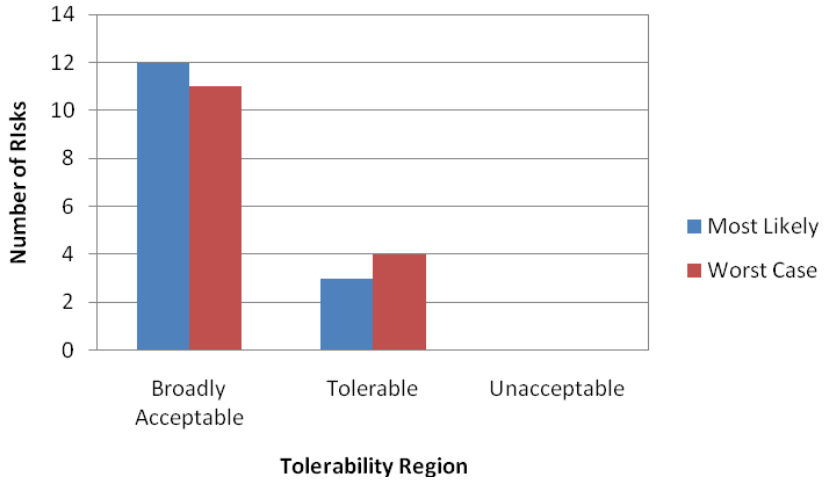


Figure 3.1 Hazard Ranking Results

A total of three risks were ranked within the Tolerable (As Low as Reasonably Practicable, ALARP) region based on the probable outcome whilst four were ranked as Tolerable (ALARP) based on the worst case outcome.

The hazards ranked as tolerable based on probable outcome were:

- Working vessel in difficulties due to conditions e.g. Jack-Up during installation (Construction).
- Workboat collision with structure (Operational phase);
- Fishing gear interaction with wave device or cable/pipelines (Operational phase).

Another key hazard discussed extensively at the workshop and consultation meetings which mertis further review is the potential loss of a wave device during severe weather.

Full details of the logged and ranked hazards are summarised in Table 3.1, sorted by order of risk ranking (probable followed by worst credible outcome).

Table 3.1 Hazard Ranking Results

Hazard Title	Hazard Detail	Phase (C, O, D)	Possible Causes	Most Likely Consequences	Most Likely						Worst Case Consequences	Worst Case						Risk Reduction Measures
					Frequency	People	Environment	Property	Business	Risk		Frequency	People	Environment	Property	Business	Risk	
Unauthorised mooring to structure and/or deliberate damage to device	Vessels moor to the structure without the authority to do so and/or with the intention to cause damage to the device.	Operation	Deliberate/Act of vandalism	damage to vessel/individual injury	1	2	1	1	1	1.3	person drowns	1	5	1	1	1	2	Not easy to tie up to devices
Recreational vessel (e.g yacht and/or angling boat) collides with structure	Recreational craft collide with wave farm structure.	Operation	engine breakdown, bad visbility, human error, navigational issues, GPS issues, foulded prop is a more likley cause of incident	damage to the vessel	2	2	1	1	1	2.5	loss of life, potentially 1 fatality	1	4	1	3	2	2.5	site clearly marked and devices painted, users well informed with respect to site, notices to mariners. Vessel could anchor if drifting, local notices, hydrographer broadcasts. Fisheries liasion, kingfisher publications, update pilot books
Transiting vessel collision with working vessel	Displaced traffic increases congestion outside of the site. This can lead to an increase in vessel-to-vessel encounters and ultimately collisions.	Construction	navigational error, human error, equoment failure, bad weather	Damage to vessels	1	1	3	3	3	2.5	vessel sinks resulting in loss of life	1	5	5	5	5	5	safety zone around construction zone, phased zone if possible, notices to mariners, hydographer broadcats, site marked on charts etc
Anchor interaction with wave device or cable/pipelines	Vessels may anchor over a cable/structure or a nearby vessel at anchor may drag its anchor over a subsea cable/structure.	Operation	Only vessels anchoring in emergency	Damage to pipelines/cables if surface laid	1	1	1	5	5	3	Damage to infrastructure	1	3	2	5	5	3.8	possible designate a no anchorage zone
Transiting vessel (powered) collision with wave device or partially constructed device	Commercial vessel, e.g., cargo vessel collides with wave farm structure when under power (steaming).	Operation	engine breakdown, bad visbility, human error, navigational issues, GPS issues	most likely to damage the oyster devices	1	2	3	4	5	3.5	potential oil spill from commercial vessel. Farm salmon escape into sea, proximity to Barvas Estate (Salmon River)	1	5	5	5	5	5	site clearly marked and devices painted, users well informed with respect to site, notices to mariners. Vessel could anchor if drifting, local notices, hydrographer broadcasts. Fisheries liasion, kingfisher publications, update pilot books
Access to structure in an emergency situation	Search and Rescue operation requires access to work in and around structures	Operation	Other emergency in the area, where people are in the area e.g. drifting/sinking fishing vessel	Difficult to operate in/around devices	2	2	1	2	2	3.5		1	5	1	3	2	2.8	Emergency response plan and possibly do an exercise with dummy in water to pick up
Transiting vessel (drifting) collision with wave device	Vessel loses power and drifts with wind and/or tide towards structures.	Operation	engine breakdown	most likely to damage the oyster devices	1	2	5	5	5	4.3	oil pollution tanker is punctured, also loss of oyster device likley in event of collision	1	4	5	5	5	4.8	site clearly marked and devices painted, users well informed with respect to site, notices to mariners. Vessel could anchor if drifting, local notices, hydrographer broadcasts. Fisheries liasion, kingfisher publications, update pilot books
Fishing vessel collision with wave device	Fishing vessel collides with wave device whilst fishing in area or steaming in transit.	Operation	engine breakdown, bad visbility, human error, navigational issues, GPS issues, foulded prop is a more likley cause of incident	Damage to the fishing vessel	3	2	1	2	1	4.5	Fishing vessel holed and sinks	2	5	1	5	3	7	site clearly marked and devices painted, users well informed with respect to site, notices to mariners. Vessel could anchor if drifting, local notices, hydrographer broadcasts. Fisheries liasion, kingfisher publications, update pilot books

Hazard Title	Hazard Detail	Phase (C, O, D)	Possible Causes	Most Likely Consequences	Most Likely						Worst Case Consequences	Worst Case						Risk Reduction Measures
					Frequency	People	Environment	Property	Business	Risk		Frequency	People	Environment	Property	Business	Risk	
Man overboard in site under normal operations	[illegible]	Construction	[illegible]	[illegible]	4	4	-	-	-	5	[illegible]	2	4	-	-	-	5.3	[illegible]
Local vessel collision with working vessel	[illegible]	Construction	[illegible]	Damage to vessels	2	-	3	3	3	6	[illegible]	-	5	4	3	5	4.3	[illegible]
Loss of Oyster device or part of device	Device [illegible]	Construction	[illegible]	[illegible]	2	-	-	4	5	5.5	[illegible]	-	5	5	5	5	5	[illegible]
Diver in difficulty on site	[illegible]	Construction	[illegible]	[illegible]	4	3	-	-	-	6	[illegible]	3	4	-	-	-	5.3	[illegible]
Work boat collision with structure	[illegible]	Construction	[illegible]	[illegible]	4	-	-	2	3	7	[illegible]	3	3	-	3	4	8.3	[illegible]
Fishing gear interaction with wave device or cable/pipeline	[illegible]	Construction	[illegible]	[illegible]	3	2	-	2	2	9.8	[illegible]	4	4	2	3	3	12	[illegible]
Working vessel in difficulties due to conditions e.g. Jack-Up during installation	[illegible]	Construction	[illegible]	[illegible]	4	2	2	3	4	12	[illegible]	3	3	3	4	4	12	[illegible]

15nm AIS Analysis
North West Lewis Wave Site
(Appendix A)

Prepared by:	Anatec Limited
On behalf of:	Lewis Wave Power Ltd
Date:	09 February 2012
Revision No.:	00
Ref.:	A2740 -NRA-1 App A

Anatec	**Aberdeen Office**	**Cambs Office**
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1. Introduction

AIS data for a wider 1fnm radius of the Project has also been analysed. The following periods of data have been used:

- 28 days winter 2011 (February-March)
- 28 days summer 2011 (July-August)

These periods are analysed in Section 2. This was validated with longer-term AIS data from the periods:

- 28 days summer 2010 (June-July)
- 28 days winter 2010 (October/November/December)

These periods are analysed in Section 3.

2. 2011 AIS Tracks

Plots of the AIS tracks for each of the two x 28 periods in 2011, colour-coded by vessel type as broadcast on AIS, are presented in Figure 2.1 and Figure 2.2.

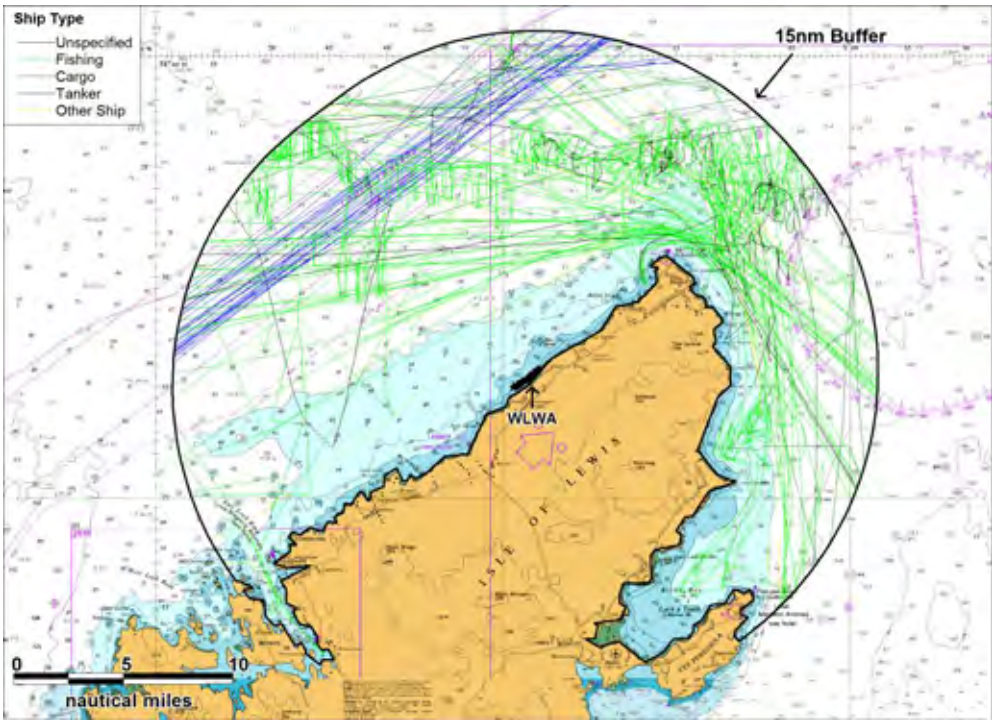


Figure 2.1 Winter AIS Data (28 Days Feb/Mar 2011)

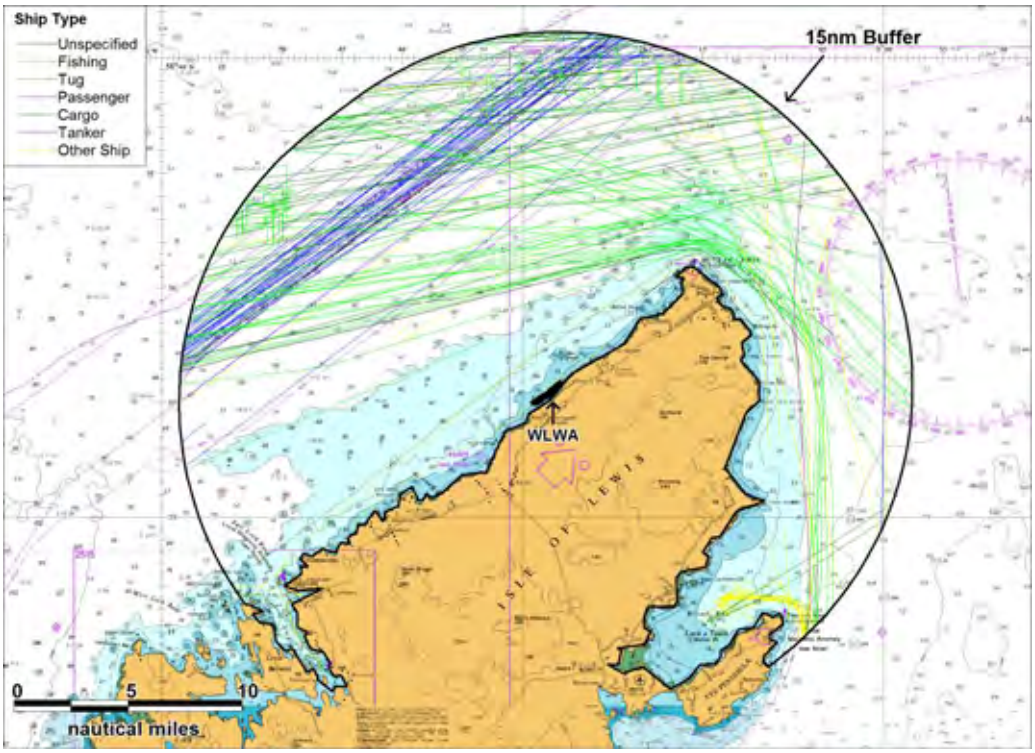


Figure 2.2 Summer AIS Data (28 Days July/Aug 2011)

Overall, there was an average of 2 unique vessels per day in winter and 4 in summer passing within 15nm. The vessel type distribution of over the two survey periods is presented in Figure 2.3 (excluding 17% unspecified in winter and 10% in summer).

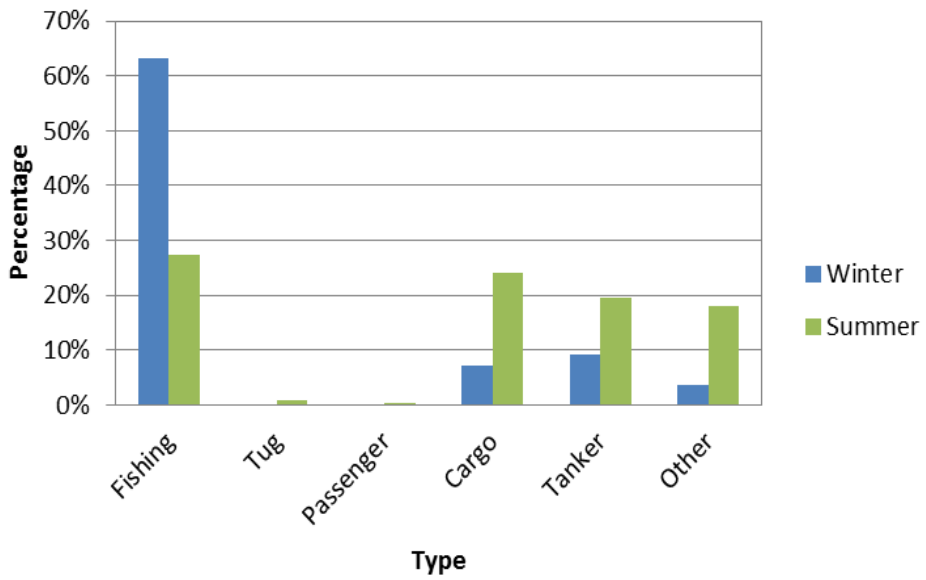


Figure 2.3 AIS Survey Type Vessel Distribution (Winter and Summer 2011)

An illustration of the relative traffic density within the area is presented in Figure 2.4 based on the combined AIS track data.

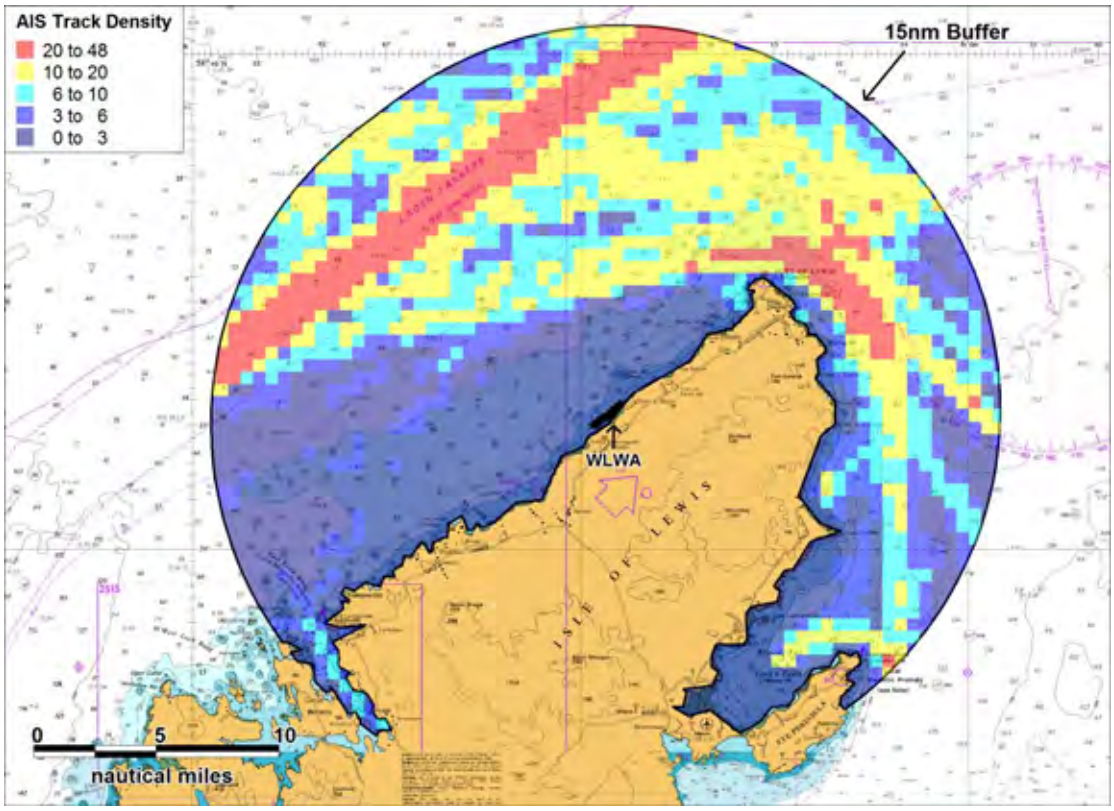


Figure 2.4 Combined AIS Density Map (56 Days – Winter and Summer 2011)

Both periods showed a consistent level of traffic, approximately 1 vessel per day, using the Deep Water Route approximately 10nm northwest of the Project. Vessels using this route were mainly tankers and a few cargo ships on passage between Scandinavian ports and North Sea oil fields and ports on the west coast of the UK/Ireland.

During the winter period, no vessels were observed within 2.5nm of the Project. In the summer survey, three vessels were observed within 2.5nm. This traffic is analysed in more detail in the main report.

3. 2010 AIS Tracks

AIS data from 2011 was validated with longer-term AIS data from summer and winter 2010.

Plots of the AIS tracks for each of the two x 28 day periods in 2010, colour-coded by vessels' type as broadcast on AIS, are presented in Figure 3.1 and Figure 3.2.

It should be noted that the vessel *Scotia*, which was working at the site during the summer period, is included in the plot but excluded from further analysis. *Scotia* is a Scottish Government Fisheries Research Vessel and was tracked traversing the west coast of Lewis

every day between 22nd July and 26th of July, broadcasting its destination as "Wet Renewables Survey".

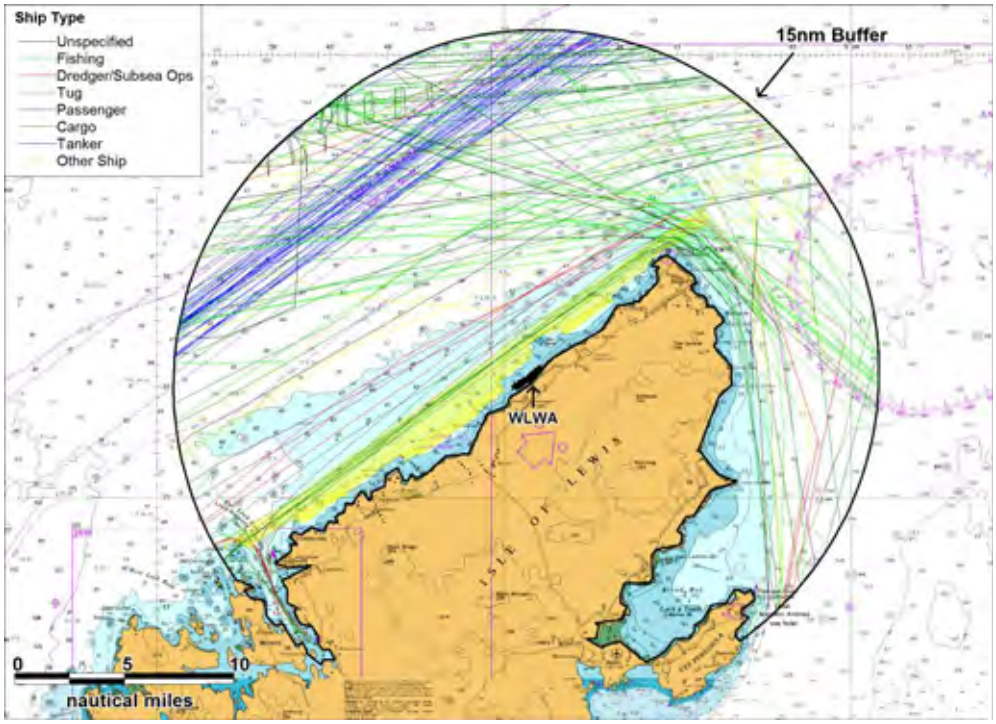


Figure 3.1 Summer 2010 AIS Data

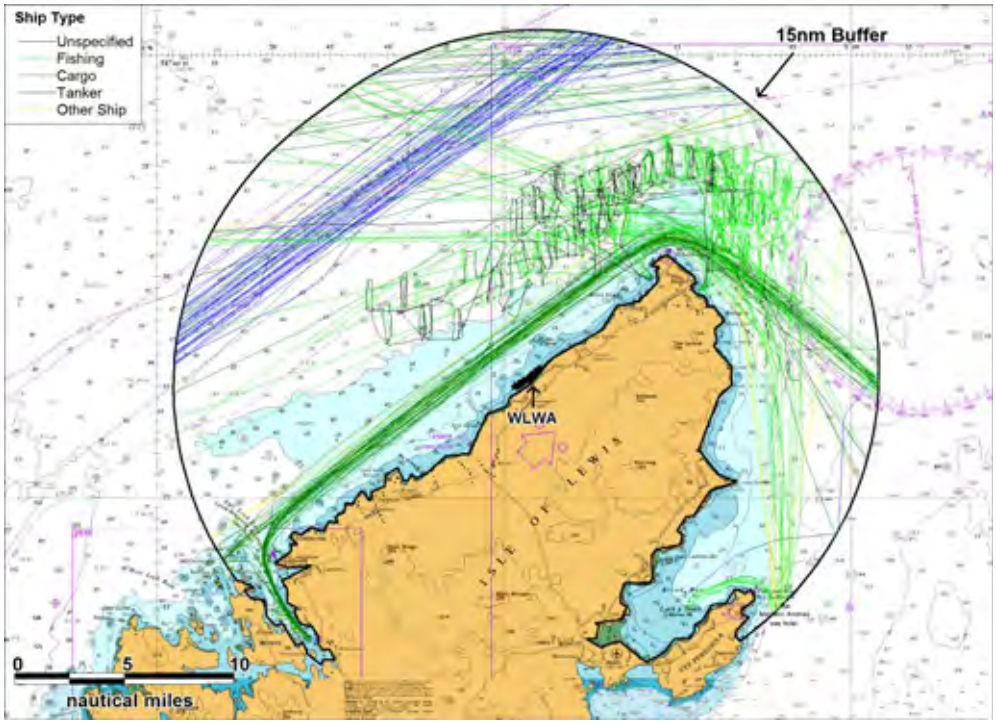


Figure 3.2 Winter 2010 AIS Data

Overall there was an average of 6 unique vessels per day in each of the survey periods.

The vessel type distribution over the two survey periods is presented in Figure 3.3 (excluding 7% unspecified in summer and 14% unspecified in winter).

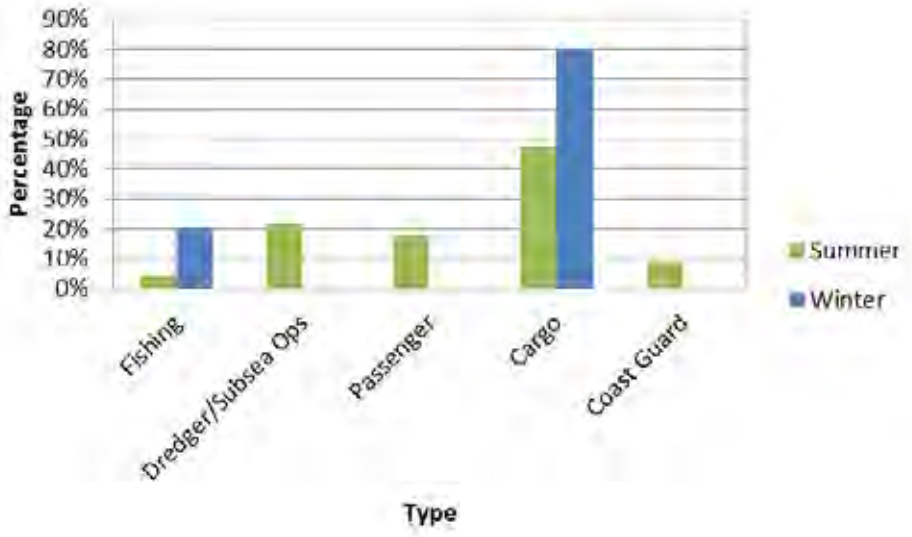


Figure 3.3 AIS Survey Vessel Type Distribution (Summer and Winter 2010)

An illustration of the relative traffic density within the area is presented in Figure 3.4 based on the combined AIS track data. Density is the number of vessels in the 56 day period within each 0.5nm x 0.5nm cell.

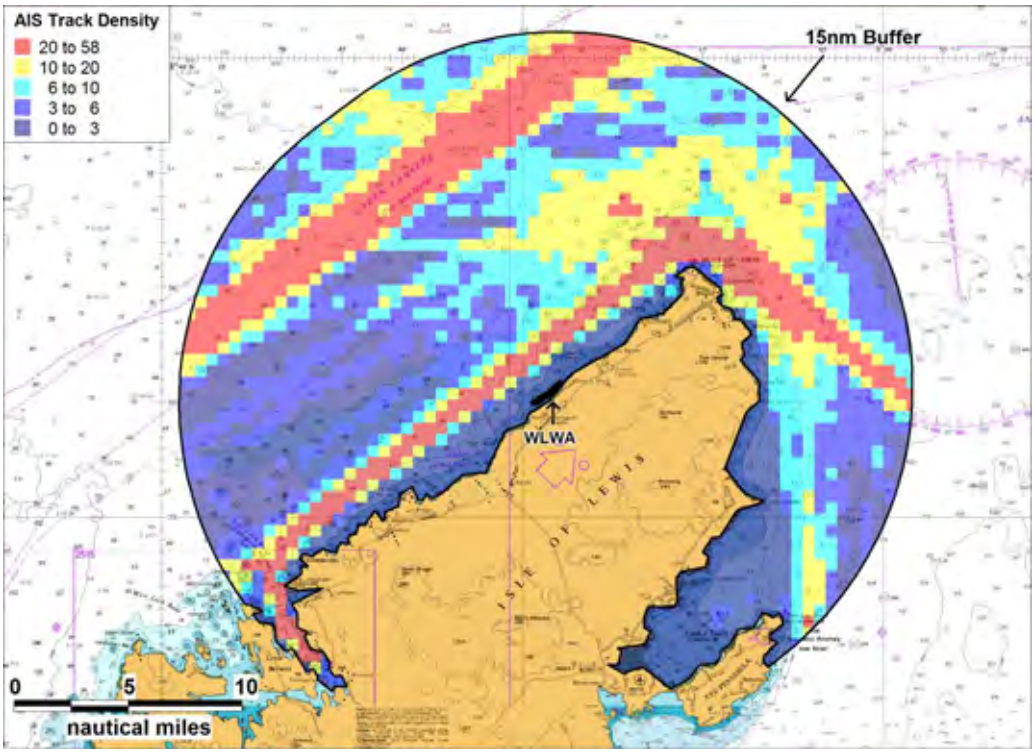


Figure 3.4 Combined AIS Density Map (56 Days – Summer and Winter 2010)

Both periods showed similar patterns as the 2011 data, with consistent levels of tankers and cargo ships using the Deep Water Route northwest of the Project while transiting between Scandinavian ports and a number of North Sea oil fields and ports on the west coast of the UK/Ireland. The number of vessels using the DW Route averaged just over one per day.

Vessels can also be observed between 1 to 2.5nm northwest of the area in both periods, where they transit a more coastal route along the West coast of Lewis. The vast majority of these vessels were cargo ships carrying live fish and transiting between Lewis and the west coast of Scotland. The number of transits averaged approximately 1 vessel every two days and were more frequent during the winter period. This traffic is analysed in more detail in the main report.

Appendix 16.1

Minutes from the Inshore Fisheries Group meeting

APPENDIX 16.1 Minutes from IFG meetings

Minutes of Meeting with Western Isles Inshore Fisheries

Date: 29th October 2011

Venue: MCA Offices, Stornoway

Present:
Duncan MacInnes – Western Isles Inshore Fisheries Secretary
Donald Manson – Marine Scotland Compliance
Coinneach Morrison – Harris Development Ltd
M? And Duncan Kennedy
Donald Morton (Carloway)
Norman Macleod (Kirkbost)
Calum C
Robert Maclennan
Douglas Craigie
Neil MacAuley
Ali MacDonald – Anatec
Marc Murray – Aquamarine Power

Minutes

The key notes from the meeting were:

- Marc presented an overview of the Oyster technology and characteristics. He showed footage of Oyster 1 in operation and photos of Oyster 800 build and installation. He explained the Crown Estate Agreement for Lease area and the work undertaken to date to understand the environmental information within the area. Marc described the two areas of search/interest at Siadar and Labhost and showed an example of an indicative layout for a 40MW Oyster array at Siadar.

- Detailed questions arose about the how the device operated, was installed and connected. Marc showed an animation of the how the Oyster worked and pictures of the oyster 800 installation.

- Further questions were asked about the planned HVDC line from Beauly to Stornoway and what the potential impact would be to the project – Marc confirmed that any delay or cancellation would have consequences on the build out timelines and overall viability of the project. However we were confident that the HVDC line would proceed as planned.

- Concerns were raised by the fishermen about how their activities would interact the planned array; including:

    - Would there be compensation for loss of fishing ground due to the development of the Oyster array – Marc stated that neither Aquamarine Power nor the eventual owners of the Lewis Oyster array would pay direct compensation to fishermen due to the development.

    - What would constitute a compensation event – i.e. what would happen if a boat got damaged through a collision with the Oyster WEC – Marc stated that the Oysters were in a fixed position, with a fixed movement and with sufficient space to manoeuvre boats

between the Oysters, so in effect there should be no reason for collisions with boats in the array (i.e. it would be more likely that the fishing boats would incur liability for damage to the Oysters).

- What would happen in the case of fishing gear becoming entrained and damaged or lost within the Oyster devices? Marc stated that this would probably be dependent on how this occurred. In instances where fishing gear was deliberately laid amongst the Oyster devices, then there would be no acceptance of liability – which reflects the status quo where fishermen laid gear amongst any other obstacle in the sea. In circumstances where fishing gear is laid away from the array and gets washed into the Oysters, it would be more than likely that the gear would be retrieved from the Oysters by divers during maintenance and the gear returned. Marc did agree that further work was need between the Inshore Fisheries Group and the eventual owners of the array on how incidents relating to the fishing boats/gear and the Oyster array would be worked out and how liability issues are assigned.

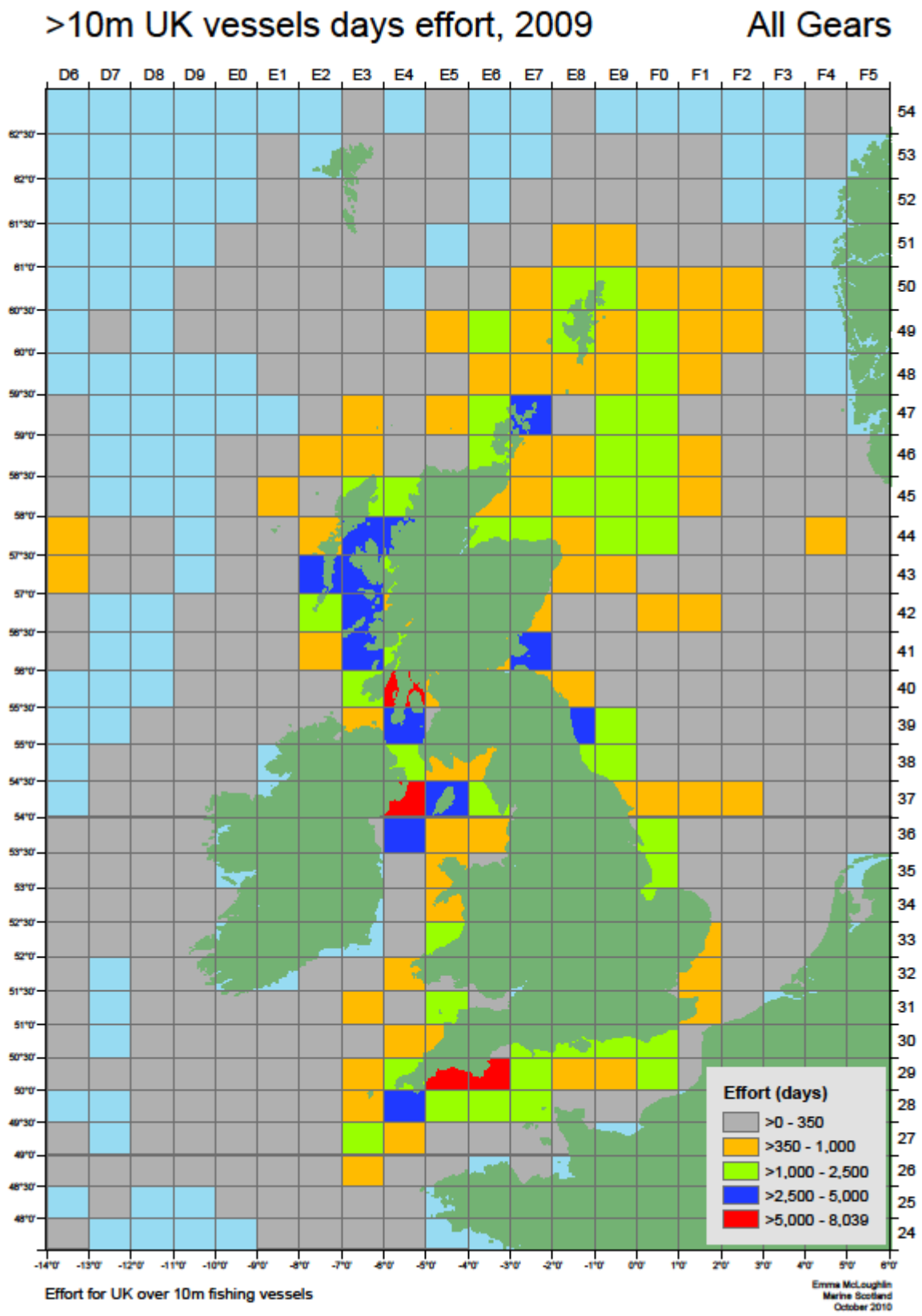
- The question was asked about what would happen if the Oysters or part of the Oysters broke free. Marc confirmed that in the unlikely event that this occurred, the most likely destination for the flap would be the shore. Marc also reiterated that the flap would be made of a GRP material and would be unlikely to cause any damage and that this issue would be covered in the Navigational Risk Assessment.

- Duncan Macinnes introduced Coinneach Morrison who is project managing the Western Isle Lobster Hatchery Project. Discussions took place on how Aquamarine Power and the proposed 40MW Oyster development could support this project. Marc confirmed that neither the 40MW Oyster array or Aquamarine Power were in the position to promise financial or other support at this stage of the development but confirmed that there may be potential in the future. Coinneach promised to provide further information on the Hatchery project directly to Marc. Marc agreed to look into the potential of Aquamarine Power providing a letter of support to the project.

Appendix 16.2

Fishing Effort Map (United Kingdom)

APPENDIX 16.2 Fishing Effort Map: UK



Appendix 16.3

Fisheries questionnaire issued to local fishermen

APPENDIX 16.3 Fisheries questionnaire issued to local fishermen.

The questionnaire below was issued to the skippers of local vessels that were identified as potentially fishing within the Local Study Area.

The questionnaire is in two parts (Part 1 Siadar and Part 2 Labost) because at the time of issue Lewis Wave Power Limited had not finalised which of the sites was to be selected for development.

Lewis Oyster Wave Array,

Commercial Fishing Interests Part A (Pages 1 and 2)

All information provided will be kept confidential

Position within the fishing industry
Please tick (✓)

Vessel owner/ skipper	Crew member

Full time	Part time	Seasonal

Type/size of vessel
Please tick (✓)

Under 10m	10-12m	Over 12m

Where is your home port?
Please tick (✓)

Kirkibost	Carloway	Brevig	Other port?
			Please write below

Do you fish within the shaded area shown on page 2?
Please tick (✓)

Yes	No

If **NO** then please go to part **B** on **page 3**

If YES - when do you fish in the area on page 2?
Please tick months (✓)

J	F	M	A	M	J	J	A	S	O	N	D

What gear do you work in this area?
Please tick (✓)

Creels / Pots	Static nets	Otter trawl	Scallop dredge	*Nephrops* trawl	Rod & line

Which species do you target in this area?
Please tick (✓)

Lobster	Edible crab	Velvet crab	*Nephrops*	Demersal fish	Pelagic fish

Approximately what is the maximum percentage of your fishing gear that you may deploy in this area at any single point in time?
Please tick (✓)

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Optional. What is the maximum number of pots/creels you would deploy in the area at any point in time?
(Please provide a number)

AQUAMARINE POWER

Lewis Wave Power - Reference Areas

Confidential

Kilometres

0 0.25 0.5 1

Scale	1:25,000
Datum	OSGB36
Projection	British National Grid
Date	04 Oct 2011
File Ref	APL_GI_GBR_LE_MAP_0115
Checked	MR GIS Specialist
	MM Project Manager

Indicative Oyster Depth Range (10 - 16 metres)

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Do you fish within shaded area shown on page 4?

Please tick (✓)

Yes	No

If YES - when do you fish in the area on page 4?
Please tick (✓)

J	F	M	A	M	J	J	A	S	O	N	D

What gear do you work in this area?

Please tick (✓)

Creels/ Pots	Static nets	Otter trawl	Scallop dredge	*Nephrops* trawl	Rod & line

Which species do you target within this area?

Please tick (✓)

Lobster	Edible crab	Velvet crab	*Nephrops*	Demersal fish	Pelagic fish

Approximately what is the maximum percentage of your fishing gear that you may deploy in this area at any single point in time?

Please tick (✓)

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Optional. What is the maximum number of pots/creels you would deploy in the area at any point in time?
(Please provide a number)

What gear do you work OUTSIDE the areas on page 2 and page 4?

Please tick (✓)

Pots	Static nets	Otter trawl	Scallop dredge	*Nephrops* trawl	Rod & line

Which species do you target OUTSIDE the areas on page 2 and page 4?

Please tick (✓)

Lobster	Edible crab	Velvet crab	*Nephrops*	Demersal fish	Pelagic fish

How big are the areas you fish outside of the areas shown on pages 2 and 4? (Please provide an area)

Are you worried about the Oyster wave array project?

Please tick (✓)

Yes	No

If YES, what worries you?

AQUAMARINE POWER

Lewis Wave Power - Reference Areas

Confidential

Kilometres
0 0.25 0.5 1

Scale	1:25,000
Datum	OSGB36
Projection	British National Grid
Date	04 Oct 2011
File Ref	APL_GI_GBR_LE_MAP_0114
Checked	MR GIS Specialist
	MM Project Manager

Indicative Oyster Depth Range (10 - 16 metres)

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Appendix 16.4

Returned fisheries questionnaires

APPENDIX 16.4 Returned fisheries questionnaires

Reproductions of the seven returned questionnaires are provided below

1

Lewis Oyster Wave Array,
Commercial Fishing Interests Part A
(Pages 1 and 2)

AQUAMARINE POWER

All information provided will be kept confidential

Position within the fishing industry
Please tick (✓)

Vessel owner/ skipper	Crew member
✓	

Full time	Part time	Seasonal

Type/size of vessel
Please tick (✓)

Under 10m	10-12m	Over 12m
✓		

Where is your home port?
Please tick (✓)

Kirkibost	Carloway	Brevig	Other port? Please write below
✓			

Do you fish within the shaded area shown on page 2?
Please tick (✓)

Yes	No
✓	

If **NO** then please go to part **B** on **page 3**

If YES - when do you fish in the area on page 2?
Please tick months (✓)

J	F	M	A	M	J	J	A	S	O	N	D
			✓	✓	✓	✓	✓	✓	✓		

What gear do you work in this area?
Please tick (✓)

Creels / Pots	Static nets	Otter trawl	Scallop dredge	*Nephrops* trawl	Rod & line
✓	✓				✓

Which species do you target in this area?
Please tick (✓)

Lobster	Edible crab	Velvet crab	*Nephrops*	Demersal fish	Pelagic fish
✓	✓	✓		✓	

Approximately what is the maximum percentage of your fishing gear that you may deploy in this area at any single point in time?
Please tick (✓)

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
		✓							

Optional. What is the maximum number of pots/creels you would deploy in the area at any point in time?
(Please provide a number)

200

1

2

Lewis Oyster Wave Array,
Commercial Fishing Interests Part A
(Pages 1 and 2)

AQUAMARINE POWER

All information provided will be kept confidential

Position within the fishing industry
Please tick (✓)

Vessel owner/ skipper	Crew member
✓	

Full time	Part time	Seasonal
		✓

Type/size of vessel
Please tick (✓)

Under 10m	10-12m	Over 12m
✓		

Where is your home port?
Please tick (✓)

Kirkibost	Carloway	Brevig	Other port? Please write below
	✓		BRAGAR BAY LANDING BLUP

Do you fish within the shaded area shown on page 2?
Please tick (✓)

Yes	No
✓	

If NO then please go to part B on page 3

If YES - when do you fish in the area on page 2?
Please tick months (✓)

J	F	M	A	M	J	J	A	S	O	N	D
				✓	✓	✓	✓	✓			

What gear do you work in this area?
Please tick (✓)

Creels / Pots	Static nets	Otter trawl	Scallop dredge	*Nephrops* trawl	Rod & line
✓	✓				

Which species do you target in this area?
Please tick (✓)

Lobster	Edible crab	Velvet crab	*Nephrops*	Demersal fish	Pelagic fish
✓	✓			✓	

Approximately what is the maximum percentage of your fishing gear that you may deploy in this area at any single point in time?
Please tick (✓)

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
					✓				

Optional. What is the maximum number of pots/creels you would deploy in the area at any point in time?
(Please provide a number)

80

1

3

Lewis Oyster Wave Array,
Commercial Fishing Interests Part A
(Pages 1 and 2)

AQUAMARINE POWER

All information provided will be kept confidential

Position within the fishing industry
Please tick (✓)

Vessel owner/ skipper	Crew member
✓	

Full time	Part time	Seasonal
✓		

Type/size of vessel
Please tick (✓)

Under 10m	10-12m	Over 12m
✓		

Where is your home port?
Please tick (✓)

Kirkibost	Carloway	Brevig	Other port? Please write below
	✓		

Do you fish within the shaded area shown on page 2?
Please tick (✓)

Yes	No
✓	

If NO then please go to part B on page 3

If YES - when do you fish in the area on page 2?
Please tick months (✓)

J	F	M	A	M	J	J	A	S	O	N	D
			✓	✓	✓	✓	✓	✓	✓		

What gear do you work in this area?
Please tick (✓)

Creels / Pots	Static nets	Otter trawl	Scallop dredge	*Nephrops* trawl	Rod & line
✓	✓				✓

Which species do you target in this area?
Please tick (✓)

Lobster	Edible crab	Velvet crab	*Nephrops*	Demersal fish	Pelagic fish
✓	✓	✓		✓	

Approximately what is the maximum percentage of your fishing gear that you may deploy in this area at any single point in time?
Please tick (✓)

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
				✓					

Optional. What is the maximum number of pots/creels you would deploy in the area at any point in time?
(Please provide a number)

400

1

4

Lewis Oyster Wave Array,
Commercial Fishing Interests Part A
(Pages 1 and 2)

AQUAMARINE POWER

All information provided will be kept confidential

Position within the fishing industry
Please tick (✓)

Vessel owner/ skipper	Crew member
✓	

Full time	Part time	Seasonal
✓		

Type/size of vessel
Please tick (✓)

Under 10m	10-12m	Over 12m
✓		

Where is your home port?
Please tick (✓)

Kirkibost	Carloway	Brevig	Other port? Please write below
	✓		

Do you fish within the shaded area shown on page 2?
Please tick (✓)

Yes	No
	✓

If NO then please go to part B on page 3

If YES - when do you fish in the area on page 2?
Please tick months (✓)

J	F	M	A	M	J	J	A	S	O	N	D

What gear do you work in this area?
Please tick (✓)

Creels / Pots	Static nets	Otter trawl	Scallop dredge	*Nephrops* trawl	Rod & line

Which species do you target in this area?
Please tick (✓)

Lobster	Edible crab	Velvet crab	*Nephrops*	Demersal fish	Pelagic fish

Approximately what is the maximum percentage of your fishing gear that you may deploy in this area at any single point in time?
Please tick (✓)

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Optional. **What is the maximum number of pots/creels you would deploy in the area at any point in time?**
(Please provide a number)

1

5

Lewis Oyster Wave Array,
Commercial Fishing Interests Part A
(Pages 1 and 2)

AQUAMARINE POWER

All information provided will be kept confidential

Position within the fishing industry
Please tick (✓)

Vessel owner/ skipper	Crew member
✓	

Full time	Part time	Seasonal

Type/size of vessel
Please tick (✓)

Under 10m	10-12m	Over 12m
✓		

Where is your home port?
Please tick (✓)

Kirkibost	Carloway	Brevig	Other port? Please write below
✓			

Do you fish within the shaded area shown on page 2?
Please tick (✓)

Yes	No
	✓

If **NO** then please go to part **B** on **page 3**

If YES - when do you fish in the area on page 2?
Please tick months (✓)

J	F	M	A	M	J	J	A	S	O	N	D

What gear do you work in this area?
Please tick (✓)

Creels / Pots	Static nets	Otter trawl	Scallop dredge	*Nephrops* trawl	Rod & line

Which species do you target in this area?
Please tick (✓)

Lobster	Edible crab	Velvet crab	*Nephrops*	Demersal fish	Pelagic fish

Approximately what is the maximum percentage of your fishing gear that you may deploy in this area at any single point in time?
Please tick (✓)

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Optional. **What is the maximum number of pots/creels you would deploy in the area at any point in time?**
(Please provide a number)

1

6

Lewis Oyster Wave Array,
Commercial Fishing Interests Part A
(Pages 1 and 2)

AQUAMARINE POWER

All information provided will be kept confidential

Position within the fishing industry
Please tick (✓)

Vessel owner/ skipper	Crew member
✓	

Full time	Part time	Seasonal
	✓	

Type/size of vessel
Please tick (✓)

Under 10m	10-12m	Over 12m
✓		

Where is your home port?
Please tick (✓)

Kirkibost	Carloway	Brevig	Other port? Please write below
✓			

Do you fish within the shaded area shown on page 2?
Please tick (✓)

Yes	No
	✓

If NO then please go to part B on **page 3**

If YES - when do you fish in the area on page 2?
Please tick months (✓)

J	F	M	A	M	J	J	A	S	O	N	D

What gear do you work in this area?
Please tick (✓)

Creels / Pots	Static nets	Otter trawl	Scallop dredge	*Nephrops* trawl	Rod & line

Which species do you target in this area?
Please tick (✓)

Lobster	Edible crab	Velvet crab	*Nephrops*	Demersal fish	Pelagic fish

Approximately what is the maximum percentage of your fishing gear that you may deploy in this area at any single point in time?
Please tick (✓)

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Optional. What is the maximum number of pots/creels you would deploy in the area at any point in time?
(Please provide a number)

1

Lewis Oyster Wave Array,
Commercial Fishing Interests Part A
(Pages 1 and 2)

AQUAMARINE POWER

All information provided will be kept confidential

Position within the fishing industry
Please tick (✓)

Vessel owner/ skipper	Crew member
✓	

Full time	Part time	Seasonal
✓		

Type/size of vessel
Please tick (✓)

Under 10m	10-12m	Over 12m
✓		

Where is your home port?
Please tick (✓)

Kirkibost	Carloway	Brevig	Other port? Please write below
		✓	

Do you fish within the shaded area shown on page 2?
Please tick (✓)

Yes	No
✓	

If **NO** then please go to part **B** on **page 3**

If YES - when do you fish in the area on page 2?
Please tick months (✓)

J	F	M	A	M	J	J	A	S	O	N	D
			✓	✓	✓	✓	✓	✓	✓	✓	

What gear do you work in this area?
Please tick (✓)

Creels / Pots	Static nets	Otter trawl	Scallop dredge	*Nephrops* trawl	Rod & line
✓					

Which species do you target in this area?
Please tick (✓)

Lobster	Edible crab	Velvet crab	*Nephrops*	Demersal fish	Pelagic fish
✓	✓				

Approximately what is the maximum percentage of your fishing gear that you may deploy in this area at any single point in time?
Please tick (✓)

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
				✓					

Optional. **What is the maximum number of pots/creels you would deploy in the area at any point in time?**
(Please provide a number)

600

1

Further consultation with the local fishing industry through the coordinator of the IFG highlighted the following:

- The main species that fishermen target with static nets in the LSA area would be crawfish, with nets set for several days to achieve best results.
- Any white fish in those nets would be a by-catch, namely, monk, and skate, as the mesh size used would be larger than 250mm.
- The rod and line landings from the LSA would most likely be mackerel, mainly used for bait, and in some cases dogfish for a short period in the summer months."

Appendix 18.1

Archaeology and cultural heritage baseline onshore

ILWA11

Isle of Lewis Wave Array: Cultural Heritage Baseline

Prepared for Aquamarine Power Ltd

HEADLAND ARCHAEOLOGY Ltd

PROJECT SUMMARY SHEET

Client	Aquamarine Power
National Grid Reference	139610, 955620
Parish	Barvas
Council	Comhairle nan Eilean Siar
Project Manager	Richard Conolly
Text	Cara Jones
Schedule	
Report	February 2012

Signed off by ……
…… ……:

Date: …….

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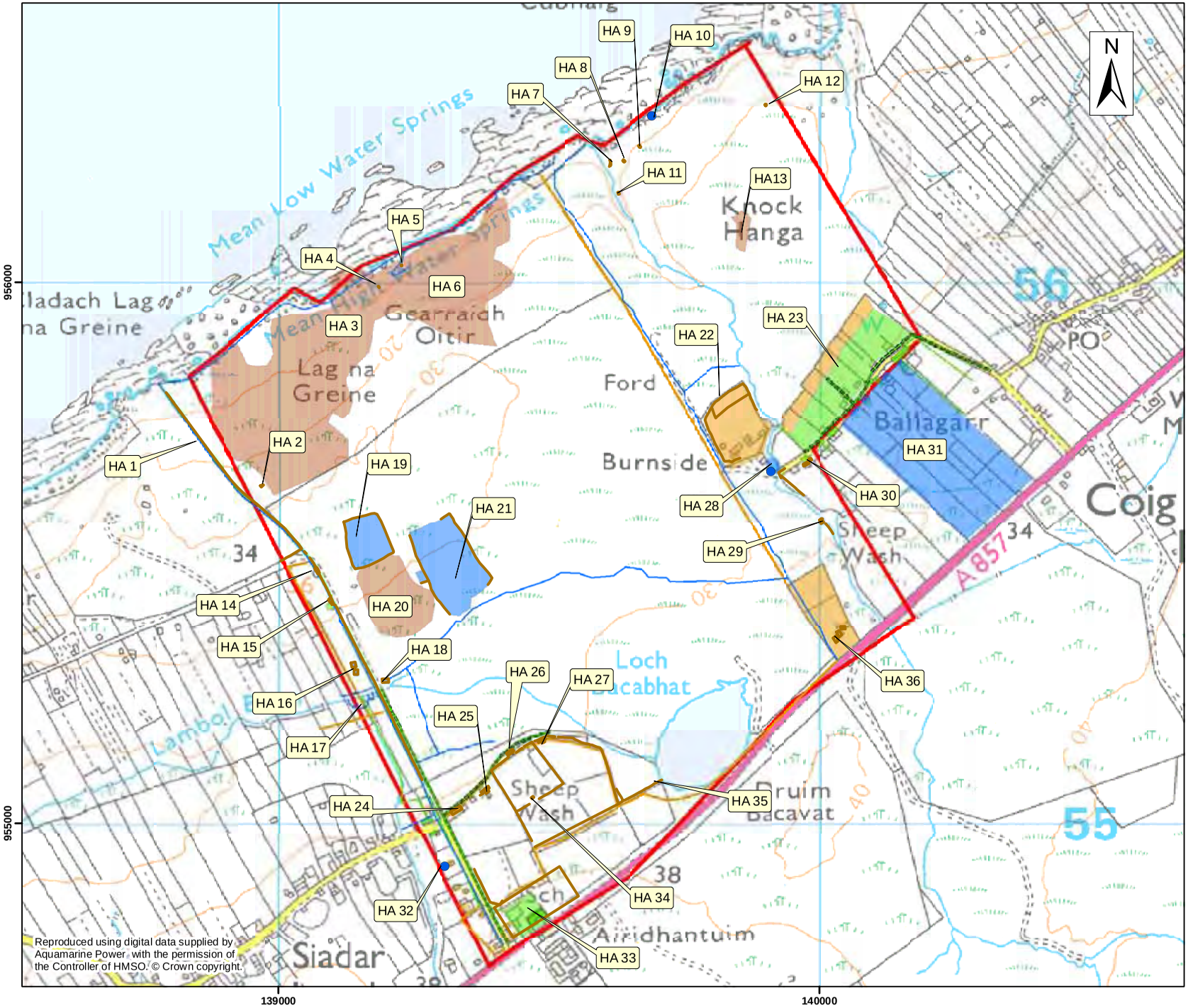

HEADLAND ARCHAEOLOGY (UK) Ltd

Key

- SMR asset
- Relict Feature
- Field boundary (First Edition OS)
- Building (First Edition OS)
- Enclosure (First Edition OS)
- Track (Second Edition OS)
- Building (Second Edition OS)
- Enclosure (Second Edition OS)
- Field boundary (Second Edition OS)
- Building (Third Edition OS)
- Enclosure (Third Edition OS)
- Lazybeds
- Inner Study Area

0 250 m

Sites and Monuments Record information derived from Comhairle nan Eilean Siar SMR data dated 16.08.11
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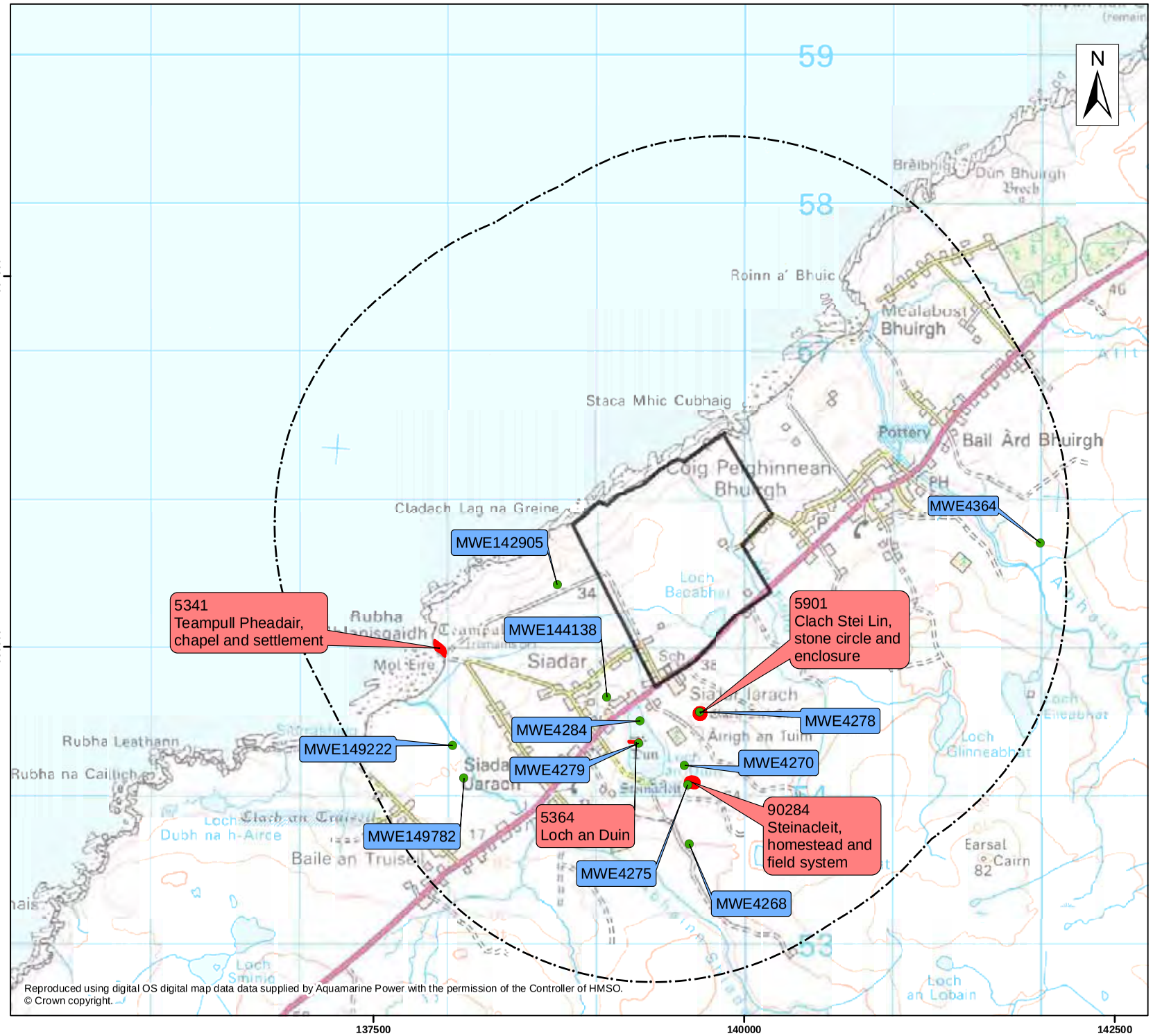
Drawing Status: Draft

Isle of Lewis Wave Array Onshore

Figure 1: Cultural heritage assets within the Inner Study Area



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HEADLAND ARCHAEOLOGY (UK) Ltd

Legend

- Inner Study Area
- Outer Study Area
- Scheduled Monument
- SMR assets disscussed in text

DRAFT

0 1 Km

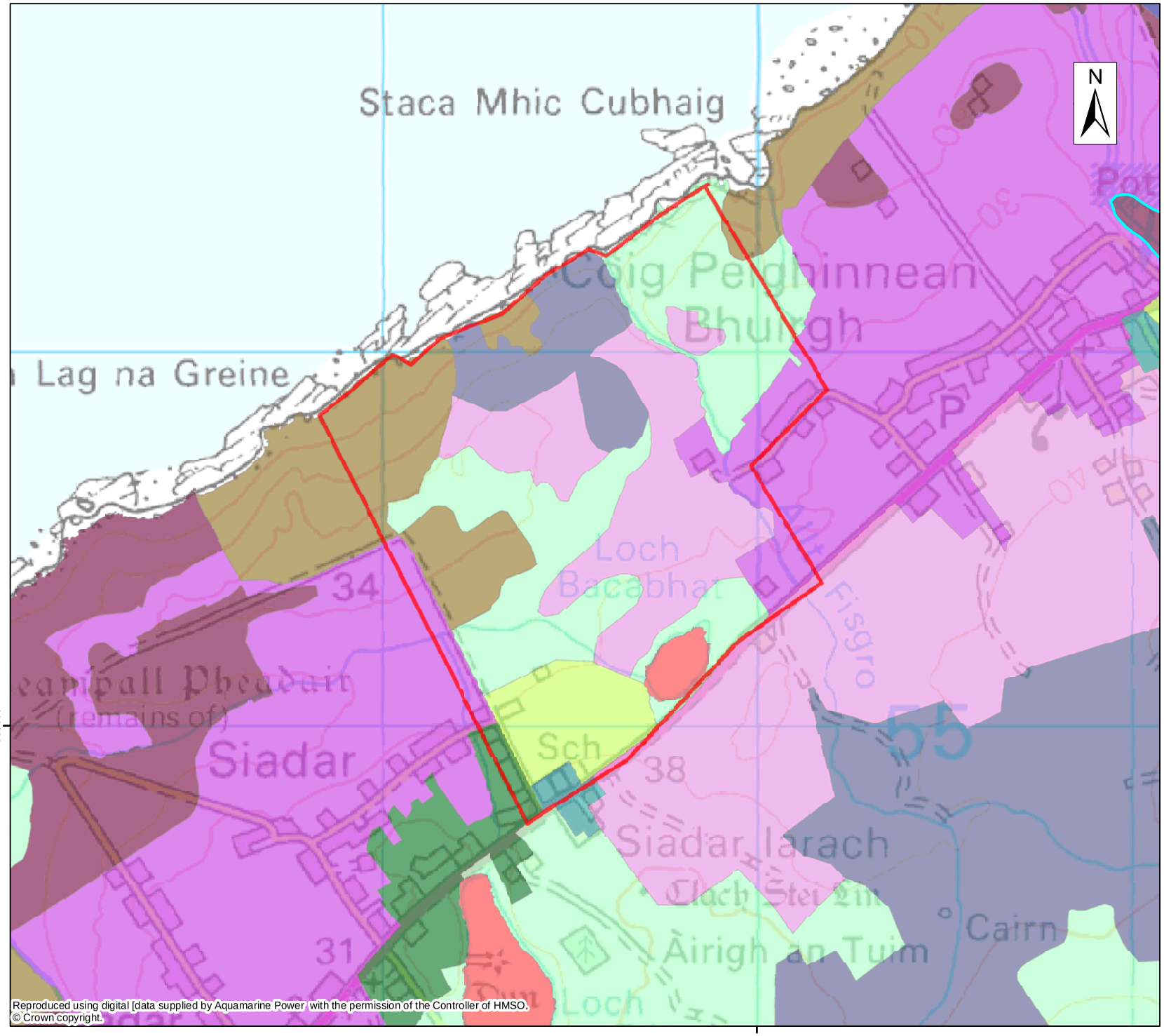
Sites and Monuments Record information derived from the Western Isle Council data dated 16/08/2011 © Crown Copyright

Scheduled monument area information derived from Historic Scotland data dated 20/06/2011 © Crown Copyright Historic Scotland

DRAFT

Isle of Lewis Wave Array

Figure 2: Designated Assets and SMR sites discussed in the text within the Outer Study Area



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HEADLAND ARCHAEOLOGY (UK) Ltd

Key

Inner Study Area

Historic Landscape Assessment Relict Land Type

- Crofting Township, Medieval/Post-medieval Settlement and Agriculture
- Crofting Township
- Later Crofting Township
- Later Crofting Township, Rectilinear Fields
- Natural Water Area
- Peat Extraction: Traditional
- Rough Grazing, Medieval/Post-medieval Settlement and Agriculture
- Rough Grazing
- Rough Grazing, Peat Extraction: Traditional
- Smallholdings
- Urban Area

DRAFT

0 200 m

Historic Land Use Assessment information derived from Royal Commision on the Ancient and Historical Monuments of Scotland data dated 25.11.10. © Crown Copyright. All rights reserved.

DRAFT

Isle of Lewis Wave Array

Figure 3: Historic land use types within the application area

Isle of Lewis Wave Array, Onshore Element

Archaeological Baseline Report

by Cara Jones

This report has been prepared for Aquamarine Power as part of the Environmental Impact Assessment process relating to the proposed Oyster Offshore Wave Array. It presents the results of a desk-based assessment and walkover survey of the option area in which the onshore elements of the wave array will be located and is intended to identify constraints upon the onshore elements of the proposed development and to inform the formulation of a mitigation strategy to address impacts upon cultural heritage assets.

The onshore elements of the development will comprise a hydro-electric power plant with associated pipes (connecting the onshore with the offshore element of the development), grid connections and other infrastructure relating to the construction and operation of the proposed development. It is proposed that there will be one power plant building within the study area, the location of which will be informed by the results of all of the environmental baseline reports.

The option area is predominantly rough grazing but areas have in the past been cultivated as indicated by areas of lazybeds. Both the lazybeds and other identified features are of late 18th or 19th century date. The most notable exceptions to this are a prehistoric cist burial and a small mill that may be post-medieval in date. There is a local tradition that two stones in the northwest part of the option area mark the graves of those killed in a cattle raid. The date of this event is unknown and it is unverified.

Given the size of the option area and the evidence for activity in the area from the Neolithic onwards there is clearly potential for previously unrecorded features to be present. This potential is greatest in relation to prehistoric features and is not exceptional for the general area.

1. INTRODUCTION

Headland Archaeology Ltd was commissioned by Aquamarine Power to carry out a baseline assessment for the onshore element of the proposed Isle of Lewis Wave Array, situated on the west coast of the Isle of Lewis. The proposal includes an onshore power-plant building with associated ancillary features. No invasive archaeological work has taken place within the study area.

Designated assets have been referred to by their Scheduled Monument or Listed Building number. Undesignated assets within the study area are referred to by an HA number issued over the course of this study. Those assets mentioned within the outer study area are referred to by their Comhairle nan Eilean Siar (CnES) Sites and Monuments Record (SMR) number. Appendix A provides descriptions of the newly identified assets and a list of previously unrecorded assets.

Historic Scotland (through Marine Scotland) and the CnES archaeologist have responded to a scoping report issued by Aquamarine Power. The CnES archaeologist has provided SMR data and further comments to Headland Archaeology. Both responses have been taken into consideration for the scope and methodology of this study.

2. SITE LOCATION AND DESCRIPTION

Located north east of Siadar, the study area is currently divided into two in terms of land use; semi-improved pasture around the edges, with more waterlogged, unimproved land towards the middle, which is lower-lying than the edges. Present day settlement in the area (Siadar and Coig Peighinnean Bhuirgh) is situated on the dryer, higher ground.

Cartographic evidence indicates that while there have been settlement structures in the peripheral parts of the site; the majority of the study area has seen little development, aside from areas of lazybeds are present within the coastal parts of the site, as well as one isolated patch within the middle of the site, and peat cuttings.

3. AIMS & METHODOLOGY

The assessment has been undertaken in order to

- Identify assets that may be affected by the proposed development;
- Assets that should be considered as constraints upon the development; and
- Identify the potential for previously unrecorded assets to be present

This work will feed into an EIA chapter, which will assess the following potential impacts on onshore cultural heritage assets:

- Direct and indirect physical impacts relating to construction of the offshore and onshore elements of the proposed development;
- Impacts upon setting; and
- Direct and indirect impacts upon the palaeoenvironmental resource

Two concentric areas have been used in assembling and presenting the data

- Study Area: the land within the proposed development area
- Outer Study Area: The land extending 1km from the edge of the proposed development. Data has been gathered in order to inform the assessment of the applications archaeological potential.

Historic Scotland's scoping response raised several scheduled monuments as being of potential concern in regard to setting impacts. The scoping response was based on a very general area of search. Visits were therefore made to scheduled monuments in the surrounding area to gather baseline data.

The following sources have been consulted:

- databases of designated assets maintained by Historic Scotland;
- archaeological records held by the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) and National Monuments Record of Scotland (NMRS);
- archaeological records held within the Comhairle nan Eilean Siar's Sites and Monuments Record (SMR);
- historic maps and plans held at the National Library of Scotland; and
- other readily available published sources

Relevant assets or records are illustrated on the accompanying location plan (figure 1) and listed in Appendix A. All records for the outer study areas are also listed in Appendix A and depicted on figure 2.

4. RESULTS

4.1. Previous Archaeological Work

One archaeological event is recorded within the study area and its immediate vicinity – a coastal survey completed in 1997, funded by the SCAPE Trust. Although limited to the coastal strip, the survey recorded several features within the study area. The results of this survey have been incorporated as far as possible in this study, but the following should be noted:

- One site, a shieling, is stated by the 1997 coastal survey report to be recorded by the NMRS. However, the given NMRS site number (NB35NE 07) refers to a ruined corn mill (HA 11), sited in a different location to that depicted on the 1997 report. The field survey did not identify any additional shielings at that location, but identified two depressions (HA8 and 9) identified by local residents as kelp drying pits. It is possible that these features relate to the shieling recorded within the 1997 report.
- A cist (HA 10) identified by the 1997 survey could not be identified in the course of the current study. This is discussed further below.

4.2. Designated Assets within the Study Area

No designated assets, such as Scheduled Monuments, Listed Buildings, Inventory Gardens and Designed Landscapes or Conservation Areas are present within the study area.

4.3. Undesignated Assets within the Study Area

Prehistoric

One prehistoric asset, a cist (HA 10), is recorded by the NMRS and SMR within the study area. No detail is given. The cist was identified during a 1997 coastal survey (Burgess et al 1997) and recorded as

stable, suggesting that the cist may survive. However, no trace of the cist could be identified at the given location in the course of the survey. The field survey did record two orthostats (HA 7) 120m to the south east of the cist location, which two local residents state mark the location of the burial ground of victims of a 19th century skirmish (discussed further below). The following are possible in relation to the cist:

- the cist is still present but is more overgrown than when first recorded and hence difficult to see;
- the cist has been eroded away;
- the recorded co-ordinates are wrong;
- the record is erroneous and the cist is a natural feature.

No further prehistoric cultural heritage assets are recorded within the study area, however, several assets of prehistoric date are recorded within the wider area. While these sites (listed in Appendix B and depicted on Figure 1) mostly relate to early prehistoric monumentality, some, such as the findspot of Iron Age pottery (MWE144138) and the dun at Loch an Dun (MWE4279) provide clear evidence of later prehistoric settlement within the vicinity of the study area.

Viking and Norse

No sites within the study area can be attributed a Viking or Norse date. However, a findspot of bog butter is recorded south west of the study area. Local place names also demonstrate a Norse presence within the immediate landscape. To the east of the study area is the small settlement of Mealabost Bhuirgh and the Siadar settlement is immediately to the west. Their names clearly demonstrate Norse settlement - the suffix '-bost', meaning farm, indicates a primary Norse settlement and -shadar (Siadar), meaning village, a secondary Norse settlement (Burgess et al 1997). The bog butter and, more definitely, the place names demonstrate the presence of Norse settlements, the physical remains of which will almost certainly lie sealed below the current settlements.

Medieval

There are no sites within the study area that can be firmly dated to the Medieval period; however, it is evident that there was settlement within the wider study area at that time; Siadar is marked on Bleau's 1654 map. Other sites of medieval date are recorded within the wider area such as the chapel at Teampall Pheadair.

Post-medieval to early 19th century

The First Edition Ordnance Survey map (1854) shows the ruins of the post-medieval Lower Siadar near the coast to the west of the study area. This site had been abandoned by 1850 and the settlement relocated to its current location to the southwest of the study area further back from the coast. Likewise Five Penny Borve can be seen to have moved away from the coastline. However, a few buildings were present suggesting that the study area had seen a low level of activity during this period. Most of these lie at the periphery of the study area (figure 1).

Of the buildings depicted on the First Edition Ordnance Survey map, one, alongside Allt Fisgro, is annotated 'Corn Mill' (HA 29). This is depicted as roofed and was presumably operational at the time of the survey. It is now ruined, having been converted for use as a sheep dip. On the same map, a ruin (HA 11) is also depicted beside the same burn, nearer the coast. This was almost certainly a mill, perhaps a predecessor to that previously mentioned. It survives as low wall footings. It is presumably post-medieval, but this is unproven.

Several ruined buildings were identified within the study area, some of which are recorded as unroofed on the Ordnance Survey First Edition map and can tentatively be identified as black houses (HA 14 & 30). One building (HA14) that is not depicted on the OS 1st Edition has been incorporated within a later stone dyke (HA 1). Further buildings or structures (HA 16 & 18) depicted as unroofed on the OS 1854 map are also likely to be post-medieval in date.

Two small hollows near the coastline (HA 8 & 9) which were recorded by the field survey, are reputed by local residents to be kelp drying pits. Given the small scale of these features, it is likely that these features were related to a 19th century

crofting landscape, with the desiccated kelp used as fertiliser for cultivated fields.

Modern (late 19th and 20th century assets)

The majority of the cultural heritage assets present have been identified in the first instance from the Ordnance Survey First (1854) and Second (1903) Edition maps and relate to the 19th century (or earlier) crofting landscape. These comprise buildings, dykes and enclosures (Figure 1). Associated with these structures are lazybeds and peat cuttings. The 1854 Ordnance Survey provides a snapshot of a landscape that in the next few years would be substantially reworked. This reworking arose following the arrival of families who had been cleared from Galston to make way for sheep. Before this influx it was reckoned that Upper and Lower Siadar had 20 and 22 families respectively. Following the arrival of those displaced from Galston this had risen to 57 and 43 families respectively, while Borve had grown from 19 to 53 families in the same period (Napier Commission 1884, 992).

Several further unroofed rectangular buildings are first depicted on the OS 2nd Edition map (HA 22, 24, 25 & 26), suggesting a short-lived settlement phase of this landscape. The field survey recorded that at least one of these buildings (HA 25) is built in the black house style. A more lasting development in the study area was a school and school house (HA 33) which are first depicted on the Ordnance Survey Second Edition map.

Other structures recorded within the study area that date to this period include enclosures (HA 19 & 21), head dykes and small walls (HA 4 & 35). Areas of peat cutting (not depicted on figure 1) and lazy beds (HA 6, 13 & 20) probably date to this period, but cannot be dated definitively.

The field survey identified two further recent features: a small marker cairn (HA 12), which is marked on the Ordnance Survey Second Edition map, and a hollow (HA 2) indicated by local residents to be a foxhole, used by the local home guard for mortar practice during the Second World War.

4.4. Miscellaneous

There is a tradition among local residents that a skirmish relating to cattle rustling occurred in the north eastern corner of the study area and that the fallen were buried by the Allt Fisgro at a point marked by two small orthostats (HA 7). The skirmish is thought to have occurred in the 19th century. The origins of this tradition are uncertain and its veracity untested and the suggested date seems questionable but the stones are similar to the simple grave-markers used in cemeteries in the area. The tradition has been taken here at face value as an indication that human remains may be present in this part of the study area.

Within 2km of the study area, are four Scheduled Monuments – Teampull Pheadair, chapel and settlement (Index num 5341), Loch an Duin, dun (Index number 5364), Clach Stei Lin, stone circle and enclosure (Index num 5901) and Steinacleit homestead and field system (Index number 90284). Steinacleit is also a property in care. There are no Listed Buildings within 2km of the study area.

4.5. Historic Land-Use Assessment map

Analysis of the Historic Land-use Assessment map, produced by the RCAHMS, has shown a mix of land uses, mainly associated with 18th to 19th century crofting (Figure 3). Areas of open moorland/ rough pasture are indicated as well as crofts and small holdings and the later 19th century addition of the school and associated buildings. One area of peat cutting is also indicated close to the shoreline and crofting areas are also seen infringing upon the boundaries of the study area.

4.6. Peat Deposits

The study area contains extensive areas of peat. The field survey established that there are areas with peat depths in excess of 1m, but no peat probing survey was undertaken. It is evident from the topography that there is potential for deep basin peat deposits in the low-lying ground in the centre of the study area and around Loch Bacabhat. A peat survey targeted on the construction footprint of the development established that peat in this central area is at least 3m in depth, Elsewhere within the construction footprint the peat is generally less than 1m in depth (Appendix 8.1 of the 40MW Lewis Wave Array Environmental Statement peat survey).

Blanket peat has the potential to mask earlier features and peat generally has the potential to preserve organic materials, including wooden artefacts and contain palaeoenvironmentally significant ecofacts. The latter is particularly relevant to basin peat.

4.7. Assessment of Archaeological Potential

In order to assess archaeological potential it is first necessary to rapidly review the evidence for human activity in the surrounding area.

There is limited evidence of prehistoric settlement in this part of Lewis, although Steinacleit (SM 90284) may incorporate a late prehistoric homestead and the dun at Loch an Duin (SM 5364) is likely to have been built in the late prehistoric period. More visible are the ritual elements of the prehistoric landscape such as the stone circle at Clach Stei Lin (SM 5901) and the standing stone at Clach an Trushal (SM 1661). The latter is thought to be the last remnant of a stone circle rather than a solitary standing stone. The presence of these features is indicative of prehistoric activity and it must be assumed that there were settlements associated with them that have yet to be identified. This is a common state of affairs on Lewis; the limits placed on farming and therefore settlement by the topography and ground conditions result in successive phases of settlement occupying the same areas, leading to earlier phases being masked by later phases. The site at Teampull Pheadair (SM 4531) provides an excellent example. Here a medieval chapel and settlement overlie an Iron Age site. The presence of the latter has been recorded only as a result of coastal erosion having exposed Iron Age midden deposits. Ritual assets, such as stone circles, are not constrained in the same way and indeed frequently occupy more marginal locations overlooking cultivable land. Hence they are more likely to survive as upstanding features and be identified by field survey. Archaeological visibility is also affected by blanket peat, which can mask substantial structures.

Recorded physical evidence of Early Historic settlement is likewise scant, the exception being the occasional broch or dun. This is almost certainly the result of the masking effect of later settlement described above. However, evidence of Norse settlement is provided by place names as discussed above.

Taking into account the archaeological background of the study area, together with the results of the field survey, it is considered that there is a moderate potential for previously unrecorded buried archaeological remains to be present. As described above, the west of Lewis has a rich and diverse archaeological record, with sites from the Neolithic, Iron Age, Viking and Medieval period recorded within the outer study area. Given this, the inner study area's size, the recent history of low intensity activity and the potential for masking by peat and lazybeds it is probable therefore that previously unrecorded assets are present. This potential relates primarily to prehistoric assets.

When considering more isolated cultural heritage assets, such as find spots, it is considered that there is a moderate potential for such sites to be identified within the study area. Chance finds in the surrounding area such as bog butter (MWE144138) and flint arrowheads (MWE4284) demonstrate the potential finds of artefacts in isolation from archaeological features.

4.8. Designated Assets in the Outer Study Area

Four Scheduled Monuments are recorded within the outer study area, three of which relate to prehistoric monumentality. The remainder is a chapel and settlement overlying an Iron Age site. There are no listed buildings, conservation areas or other designated assets in the outer study area.

Scheduled Monument Number	Name	Grid Reference
5341	Teampull Pheadair, chapel and settlement, Shader	NB 388 550
5364	Loch an Duin, dun, Shader	NB 393 545
5901	Clach Stei Lin, stone circle and enclosure	NB 397 545
90284	Steinacleit, homestead and field system	NB 396 541

Teampull Pheadair (SM 5341) comprises slight upstanding remains of a chapel and settlement. Coastal erosion has revealed middens containing Iron Age pottery suggesting an extended history of

activity in this location. Teampull Pheadair lies on the shoreline 1.1km to the south west of the inner study area. The ground rises to the north east of the chapel and consequently there is no inter visibility between the chapel and the inner study area. There are no viewpoints from third locations that may be considered relevant to the Teampull Pheadair's setting. There is therefore no potential for on shore elements of the proposed development to affect the setting of the chapel and settlement.

The eponymous dun of Loch an Duin (SM 5364) lies on a small island, most probably a crannog, in the centre of the loch. It is linked to the shore by a causeway. The dun lies 400m to the south of the inner study area. The settlement of Siadar Iarach lies immediately to the north of the loch. The setting of the dun can be defined as the loch and the surrounding cultivable land as these are both functionally linked to the dun; the loch provided the dun with a natural defence and the surrounding land was farmed by its occupants. The dun only survives as low rubble-obscured walls and is not visible from the shoreline, though the island is clearly visible. There is no aesthetic element to its setting therefore. Onshore elements of the proposed development will lie at least 400m from the dun beyond modern housing. It is considered highly unlikely that this will affect the dun's setting.

Clach Stei Lin (SM 5901) is thought to comprise the remains of a slighted stone circle (only one stone remains standing) and a later enclosure. It is located on a rise some 350m to the south east of the inner study area. The setting of the site can be defined as the rise upon which it is located (Àirigh an Tuim) as the monument may well have been sited here in order to render it prominent in the wider landscape. This is no longer readily apparent because of its condition, but the rise contributes to the monument's rather limited sense of place and hence associative value, as it provides an expansive views to the west over the sea. The modern bungalows of Airidhantuim are prominent in the foreground of these views. The inner study area is clearly visible from the Clach Stei Lin. The onshore elements of the proposed development will lie at least 350m from the monument, beyond these bungalows. In this context it is highly unlikely that the proposed development will affect the setting of the monument.

Steinacleit (SM 90284) comprises the remains of a massively built prehistoric settlement and enclosure. It has been partially excavated but remains ill-understood and it has been suggested that it represents the remains of a chambered cairn. However the interpretation favoured by Historic Scotland has been applied here. It is located on a rise overlooking Loch an Duin to the north west and the dun and crannog are clearly visible on the loch. The standing stone Clach an Truiseil is visible to the west and Clach Stei Lin and would once have been visible to the north. The location provides generally striking views across the loch tot eh sea, with the scattered houses of Siadar in the middle distance. The monument's setting may therefore be defined as the rise upon which it is located and the area around Loch an Duin as these are the areas that the occupants presumably farmed. Furthermore the intervisibility with the dun and Clach an Tuiseil contribute to the contextual and associative values of the monument as this helps the visitor appreciate the chronological depth of the landscape. The views to the sea are relevant to its associative value as the monument appears to be placed to overlook the sea and this contributes to its sense of place. Steinacleit lies some 600m to the south of the inner study area. The site visit established that the local topography effectively screens all but the highest parts of the inner study area from view from Steinacleit. The onshore infrastructure may therefore be partially screened from view hence preventing potential impacts upon setting.

5. CONCLUSIONS

The majority of the recorded assets within the inner study area, which is based on the option boundary, are of late 18th-19th century date and relate to crofting. These assets are of local importance as they contribute to the historic landscape character of the area.

The general area has a history of activity that demonstrably extends to the Neolithic, but pre-Norse settlement is generally unrecorded. It must be concluded that the inner study area has moderate potential to contain previously unrecorded assets. This potential primarily relates to traces of prehistoric settlement that may have been masked by peat or later cultivation. However, there is also potential for burials to be present based on the presence of a previously recorded cist

and an alleged post-medieval burial site, both of which are located in the north eastern part of the inner study area. Given the relatively small construction footprint of the onshore infrastructure, the likelihood of unrecorded archaeology lying within it is low to moderate.

Areas of basin peat are present within the inner study area, particularly around Loch Bacabhat and in the centre of the inner study area. These almost certainly contain deposits that have the potential to inform our understanding of the development of the surrounding landscape and the human interaction with the environment.

There are four scheduled monuments in the outer study area and the potential for impacts upon their setting has been considered. Although the development will be visible from these it is unlikely to affect their cultural significance.

APPENDIX A: SOURCES CONSULTED

Bibliography

Ordnance Survey 2005 '*Guide to Gaelic origins of place names in Britain*' Downloadable booklet at http://www.ordnancesurvey.co.uk

Burgess, C and Church M 1997 '*Coastal Erosion Assessment for Lewis: A report for Historic Scotland*' Grey Literature report available (http://www.scapetrust.org) accessed on 08/08/2011

Napier Commission 1884 consulted online: http://www.highland-elibrary.com/7.html#report

Cartographic sources

The following pre-Ordnance Survey maps held by the National Library of Scotland were examined:

Blaeu, J 1654 *Leogus et Haraia insulae ex Aebudarum numero, quae quamquam isthmo cohaereant, pro diversis habentur. Lewis and Harray of the numbre of the Western Yles, which two although they ioyne be a necke of land ar accounted dyvers Ylands*
Chapman, J and Johnson W 1821 *Plan of the island of Lewis reduced from Mr Chapman's Survey*
Heather, W 1804 *A new and improved chart of the Hebrides or Lewis Islands and adjacent coast of Scotland*
Moll, H 1745 *A map of the North West part of the Western Islands*
Pont, T and Blaeu, J 1654 *Aebudae Insulae sive Hebrides; quae Scotiae ad occasum praetenduntur / lustratae et descriptae a Timotheo Pont.*
Western Isles of Scotland
Thomason, J and Johnson, W 1832 *Western Isles*

The following Ordnance Survey maps held by the National Library of Scotland were examined:

Ross and Cromarty (Isle of Lewis) Sheet V (Surveyed 1852-53/published 1853) 1:10560
Ross and Cromarty (Isle of Lewis) Sheet V (surveyed 1852/re-surveyed 1895/Published 1898) 1:10560
Ross and Cromarty (Isle of Lewis) Sheet V provisional edition (surveyed 1852/revised 1898/revised 1956 and 1963/published 1964) 1:10560
National Grid Sheet NB35NE Ross and Cromarty (published 1974) 1:10000

Aerial Photographs

The following aerial photographs held by the RCAHMS were examined:

Library Ref	Sortie	Date	Frame Run	Scale
B_0103	CPE/UK/0186	9/10/46	4018 5059	1: 9800
B_0262	LEU-UK-0010	17/5/48	7022 – 7021	1: 10, 000
C_0296	ASS/630/89	16/7/89	152	N/A
OS_66_089	OS66_089	27/5/66	187-188	1: 27000
OS_67_118	OS67_118	17/4/69	303 – 300	1: 10000
OS_69_397	OS69_397	1/8/69	038 – 041	1: 15000

APPENDIX B: GAZETTEER

Cultural Heritage Assets within the Study Area

HA Number	Site name	Site type	Source	Description	Current condition
1	Gearraidh Oitir	Enclosure	NMRS	An enclosure is depicted on the 1st edition of the OS 6-inch map (Isle of Lewis Ross-shire 1853, sheet 5), but it is not shown on the current edition of the OS 1:10000 map (1974).Information from RCAHMS (AKK), 10 January 1997.	Faint remains of a low bank that encloses the field are still visible on the ground
2	Gearraidh Oitir	Field System (Possible)	NMRS	What may be a field-system is depicted on the 1st edition of the OS 6-inch map (Isle of Lewis Ross-shire 1853, sheet 5), but it is not shown on the current edition of the OS 1:10000 map (1974).Information from RCAHMS (AKK), 10 January 1997.	Faint remains Faint remains of a low bank that encloses the field are still visible on the ground
3	Burnside	Enclosure	NMRS	An enclosure is depicted on the 1st edition of the OS 6-inch map (Isle of Lewis Ross-shire 1853, sheet 5), but it is not shown on the current edition of the OS 1:10000 map (1974). Information from RCAHMS (AKK) 10 January 1997.	No longer visible.
4	Ballagarr	Township	NMRS	A crofting township, comprising four roofed buildings, one unroofed building and two enclosures is depicted on the 1st edition of the OS 6-inch map (Isle of Lewis Ross-shire 1853, sheet 5). The crofts depicted on the map all lie outside the study area. The ruins of one blackhouse to the south-west of these and depicted on the 2nd edition OS map falls within the survey area.	
5	Allt Fisgro	Mill (Possible) building	NMRS	A single unroofed building which may be a mill is depicted on the 1st edition of the OS 6-inch map (Isle of Lewis Ross-shire 1853, sheet 5), but it is not shown on the current edition of the OS 1:10000 map (1974). Information from RCAHMS (AKK) 10 January .	The remains of the mill are still visible on the east side of the burn. The mill stones were removed some years ago.
6	Lower Shader Borve Shader Shader Lower Shader	Dyke	SMR	A dyke is recorded by the SMR and classified as a 'defence feature', but this appears erroneous. No further information is recorded.	
7	Borve	Cist	SMR	A cist is recorded by the SMR, but no further information is given. The site is recorded as stable within the 1997 coastal survey (Burgess et al 1997) suggesting that upstanding remains still survive.	Two small orthostats (HA 7b) are set into a low curving bank on the east side of the outlet of Allt Fisgro. According to locals this are graves of people killed in a fight over cattle.

HA Number	Site name	Site type	Source	Description	Current condition
8	Shader	Lazybeds	SMR	The SMR records an area of cultivation or rigging within Lag na Greine.	Satellite photos and the field survey demonstrated that the cultivation runs in north west to south east alignment.
9	Shader	Lazybeds	SMR	An area of cultivation is recorded by the SMR. Field survey recorded that the cultivations was on a …	
10	3, Lower Shader	House	SMR	A thatched house recorded by the SMR and NMRS. The two records give different co-ordinates – neither is correct. No thatched cottage was noted within the study area	Not seen during walkover.
11		Building (unroofed) animal pen?	Cartographic	Two unroofed buildings or animals pens are depicted on the Ordnance Survey 1854 Edition map.	No visible remains.
12		Animal pen? Unroofed	Cartographic	A building or animal pen is depicted on the Ordnance Survey 1854 Edition map.	No longer visible
13		Enclosure	Cartographic	Two small enclosures are depicted attached to a head dyke on the Ordnance Survey 1854 Edition map.	No longer visible
14		Building (unroofed) animal pen?	Cartographic	An unroofed rectangular building is depicted on the Ordnance 1903 Edition map.	No longer visible
15		Building (unroofed) animal pen?	Cartographic	An unroofed rectangular building is depicted on the Ordnance 1903 Edition map.	The remains of an oval blackhouse with an enclosure to the north is still clearly visible.
16		Building (unroofed) animal pen?	Cartographic	An unroofed rectangular building is depicted on the Ordnance 1903 Edition map.	The walls of a rectangular building still survive.
17		School house and associated buildings	Cartographic	The Ordnance Survey 1903 Edition map depicts and annotates a school house.	The school is still in use today.
18		Croft (Two buidings and an enclosure)	Cartographic	A Z-shaped range and asssociated buidling is depicted within an enclosure on the Ordnance Survey 1903 Edition map. The buildings are depicted as unroofed.	Modern buildings have now been built over this site.
19		Corn Mill	Cartographic	A corn mill is depicted and anotated on the Ordnance Survy 1854 Edition map. A small mill lade is depicted running adjacent to the buiding.	The ruins and mill lade are still clearly visible. It has recently been used as a sheep dip.
20		Building with enclosure	Cartographic	An unroofed rectangular building within an enclosure is depicted on the Ordnance 1903 Edition map.	The building has been totally demolished but the stony banks of the enclosure are still visible.
21		Stone wall	Walkover		A short stone wall built up against a small orthostat is located on the grassy area just behind the shingle beach.
22		Stone cairn	Walkover		A circular stone cairn is situated at the top edge of the shingle beach. Looks relatively modern.
23		Foxhole	Walkover		A sub-rectangular hollow some 2.5 by 6m is situated on top of the slope overlooking the shore. Local said that it was the remains of a foxhole built by the WWII Home Guard to practise grenade throwing.

HA Number	Site name	Site type	Source	Description	Current condition
24		Kelp pit	Walkover		Horseshoe-shaped hollow dug into the grassy slope behind the beach. Local said that it was pits used for storing washed up kelp that was later spread on the fields as manure.
25		Kelp pit	Walkover		Horseshoe-shaped hollow dug into the grassy slope behind the beach. Local said that it was pits used for storing washed up kelp that was later spread on the fields as manure.
26		Small cairn	Walkover		A small low cairn some 3.5m in diameter is situated on the upper NW-facing slopes overlooking the shore. The feature is depicted on the 1st edition OS map and labelled "Pile of stones".
27		Rig and furrow	Walkover		A subrectangular area of lazybeds is situated on the south-facing slopes of a small hill to the north-east of Allt Fisgro
28		Building	Walkover		The walls of an oval building 4.5 by 12.5m, probably a blackhouse, is set into the stone dyke that runs along the track along the SW side of the survey area.
29		Building	Walkover		The walls of a building and associated small enclosure butt against the stone dyke that runs along the track along the SW side of the survey area.
30		Building	Walkover		The walls of a building and associated small enclosure butt up against the south side of a stone dyke that encloses a settlement just N of the school.
31		Building	Walkover		A shallow rectangular depression framed by low stony banks may represent the remains of a small building.
32		Stony banks	Walkover		A series of boundaries are depicted in the area to the N of the school on the 2nd edition OS map. These are stone banks some of which have been reinforced by modern fences others have become obsolete and have tumbled down.
33		Lazybeds	Walkover	A subrectangular area of lazybeds is situated immediately to the NE of the track that runs along the SW side of the survey area.	

Appendix 18.2

Archaeology and cultural heritage baseline offshore

ILWA11

Isle of Lewis Wave Array: Offshore Cultural Heritage Baseline

Prepared for Aquamarine Power Ltd

HEADLAND ARCHAEOLOGY Ltd

PROJECT SUMMARY SHEET

Client	Aquamarine Power
National Grid Reference	139610, 955620
Parish	Barvas
Council	Comhairle nan Eilean Siar
Project Manager	Richard Conolly
Text	Abby Mynett & Tom Joyce
Schedule	
Report	November 2011

Signed off by ……
…… ……:

Date: …….

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Isle of Lewis Wave Array, Onshore Element

Archaeological Baseline Report

by Abby Mynett & Tom Joyce

This report has been prepared for Aquamarine Power as part of the Environmental Impact Assessment process relating to the offshore element of the proposed Oyster Offshore Wave Array. It presents the results of a desk-based assessment, walkover survey and the assessment of geophysical survey data and is intended to identify constraints upon the offshore elements of the proposed development in order to formulate a mitigation strategy to address impacts upon cultural heritage assets.

The offshore elements of the development will comprise an array of devices installed on the seabed, a high pressure undersea pipeline to an onshore powerhouse, and a low pressure return pipeline. The overall size of the development will be dictated by practical installation considerations (such as clearance distances required for marine installation operations and necessary clearance between devices) and environmental considerations (such as the nature of the seafloor).

The potential to encounter offshore cultural heritage assets within the proposed development is considered to be low. No recorded shipwrecks have been identified within the Inner Study Area and one recorded LIVE wreck has been identified in the Outer Study Area. Geophysical surveys have shown that the majority of the seabed within the proposed development area is composed of rock with sands and gravels and archaeological analysis of the geophysical surveys carried out did not identify any targets that would be considered to be of archaeological potential.

1. INTRODUCTION

Headland Archaeology Ltd was commissioned by Aquamarine Power to carry out a baseline assessment for the offshore element of the proposed Isle of Lewis Wave Array, situated on the west coast of the Isle of Lewis. The proposal includes an array of devices installed on the seabed, a high pressure undersea pipeline to an onshore powerhouse, and a low pressure return pipeline. The overall size of the development is dictated by practical installation considerations (such as clearance distances required for marine installation operations and necessary clearance between devices) and environmental considerations (such as the nature of the seafloor).

Cultural heritage assets are defined here as submerged archaeology, including maritime losses such as wrecks and aircraft and their associated debris, and palaeoenvironments within the study area. Cultural heritage assets within the study area are referred to by an HA number issued over the course of this study.

Historic Scotland (through Marine Scotland) and the CnES archaeologist have responded to a scoping report issued by Aquamarine Power. The CnES archaeologist has provided SMR data and further comments to Headland Archaeology. Both responses have been taken into consideration for the scope and methodology of this study.

2. SITE LOCATION AND DESCRIPTION

The study area is located on the west coast of the Isle of Lewis north east of Siadar, This area is characterised by its indented coastline as a result of coastal erosion.

3. AIMS & METHODOLOGY

3.1 Aims

The assessment has been undertaken in order to

- Identify cultural heritage assets that may be affected by the proposed development;
- Identify cultural heritage assets that should be considered as constraints upon the development; and
- Identify the potential for previously unrecorded cultural heritage assets to be present

This work will feed into an EIA chapter, which will assess the following potential impacts on offshore cultural heritage assets:

- Direct, indirect and secondary physical impacts relating to construction of the offshore and onshore elements of the proposed development; and
- Direct and indirect impacts upon the palaeoenvironmental resource

3.2 Methodology

3.2.1 Study Area

Two concentric areas have been used in assembling and presenting the data, defined as;

- Inner Study Area: the offshore area within which the proposed development area will be located. This area equates to the area in which the geophysical survey was carried out.
- Outer Study Area: The seascape extending 1km from the edge of the Inner Study Area. This area has been examined in order to inform the assessment of the archaeological potential.

3.2.2 Legislative Framework and Guidance

This assessment takes account of the following legislative procedures and guidelines:

- Marine (Scotland) Act 2010;
- Protection of Wrecks Act 1973;
- The Protection of Military Remains Act 1986;
- Ancient Monuments and Archaeological Areas Act 1979;
- Merchant Shipping Act 1995;
- Valetta Convention;
- ICOMOS; and
- UNESCO;

The Desk-top baseline study and assessment has been compiled in line with industry best practice and the relevant offshore renewables and marine historic environment guidance. These include:

- Institute for Archaeologists (IfA) guidelines: Standard & Guidance for Archaeological Desk Based Assessment (2008);

- Joint Nautical Archaeology Policy Committee (JNAPC) Code of Practice for Seabed Development;
- COWRIE Historic Environment Guidance for the Offshore Renewable Energy Sector (2007);
- COWRIE Guidance for Assessment of Cumulative Impacts on the Historic Environment from Offshore renewable Energy (2008);
- COWRIE Guidance for Offshore Geotechnical Investigations and Historic Environment Analysis: guidance for the renewable energy sector (forthcoming);
- The Crown Estate (2010). Offshore Renewables Protocol for Archaeological Discoveries;
- The Crown Estate (2010). Round 3 Offshore Renewables Projects Model Clauses for Archaeological Written Schemes of Investigation; and
- Towards a Strategy for Scotland's Marine Historic Environment (Historic Scotland 2009)

3.2.3 Desk- Based Survey

The desk-based assessment is a documentary and cartographic search utilising a number of sources in order to locate all known cultural heritage assets within the study area and within the general location of the proposed development, and to identify the archaeological potential of the area. Sources used for this assessment included

- Databases of designated cultural heritage assets maintained by Historic Scotland including designated wrecks;
- Maritime records held by the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS);
- UK Hydrographic Office Wrecks and Obstructions Database (SeaZone);
- National Library (for historic charts and maps only);
- Ministry of Defence (military remains only);
- Receiver of Wreck (ROW);
- Relevant SEA reports and Coastal Survey Assessment reports; and
- Other readily available published sources and grey literature e.g. marine geophysical and geotechnical survey reports.

3.2.4 Walkover Survey

A walkover survey of the intertidal area was undertaken by Headland Archaeology in August 2011. The primary purpose of the walkover survey was to assess the area in order to identify any potential low-visibility archaeological and/or historical sites that are not currently recorded and which may be impacted upon.

3.2.5 Assessment of Marine Geophysical Survey Data

The geophysical data was acquired by Aspect onboard two vessels, Remote Sensor and Coastal Sensor between 18th August and 2nd September 2010 and included multibeam echosounder survey and a sub- bottom profiler survey. All survey data was reviewed by Headland Archaeology with appropriate processing and viewing software. This allowed for the data to be replayed and interrogated in order to effectively assess the position, extent and nature of any potential targets. All information with regard to the survey conditions was provided by the relative survey company in order to gauge the quality of the data for the identification of potential cultural heritage assets.

The data was subject to an initial scan for any targets of potential cultural heritage interest, after which the data was assessed in detail to:

- familiarise the maritime archaeologist with the survey area;
- correlate anomalies with previously recorded sites;
- identify the absence of anomalies in the vicinity of previously recorded sites.
- identify anomalies indicative of hitherto unrecorded sites;
- check the accuracy of the position, nature and extent of known wrecks; and

All targets were 'tagged' and then assessed as to their archaeological potential. The initial potential of identified targets was gauged using a ranking system (see Table 1. below) as a means of prioritising potential assets in order to inform upon subsequent interpretation. It must be stressed that the ranking system is only seen as a guide and is not used as a substitute for professional judgment.

Table. 1 Guideline criteria for assessing potential

Potential of asset	Character of anomaly
HIGH	A target that is identified as a known archaeological asset or in the vicinity of such; or a target that is clearly recognisable as a well preserved feature or maritime loss such as a vessel or aircraft (or parts of) and any associated debris
MEDIUM	A target that exhibits characteristics likely to represent the remains of a feature or maritime loss such as a vessel or aircraft including any associated debris; or fragments of the same
LOW	An isolated or fragmentary target that is recognised to be of some interest but may represent a particularly small or fragmentary archaeological, or natural feature

4. RESULTS

4.1. Previous Work

The following paragraphs outline the bathymetry and geology of the study area and relative sea-level change, ahead of presenting the results of the desk based survey and the results geophysical survey analysis.

4.1.1 Bathymetry, Geology, Geomorphology and Sedimentology

Seabed surveys of a representative area of the coastline were carried out by Aspect Land and Hydrographic Surveys Chartered Surveyors (Aspect, 2010). From the Mean Low Water Spring (MLWS) mark the seabed across much of the survey area slopes relatively steeply to the 10m depth contour, and then slopes more gradually down to 20m; between 0.5 km – 1.5 km offshore, water depth varies between 13m and 15m.

The solid geology directly beneath the site is comprised of undifferentiated Lewisian gneiss of Pre-Cambrian age, which has undergone a complex deformation history and widely variable composition. The seabed is rugged and dominated by rock outcrops, overlain in places by thin coverings of gravel and sand particularly in crevasses between shallower bare rock platforms. The rock surface is characterised by grooves and channels preferentially eroded along discontinuity planes. The multibeam data gathered for this study has demonstrated the rocky and uneven characteristics of the seabed within the study area and potential sand and gravel patches.

4.1.2 Relative sea-level change

During the last million years lower relative sea levels have meant that the British landmass has been connected by dry land to the mainland of Europe for long periods. It has been shown that during the Late Devensian period (c.22,000 years BP) considerable amounts of dry land that is now submerged existed to the west of Scotland, beyond the Outer Hebrides (Wickham-Jones and Dawson 2006). It has been estimated that due to changing sea levels and the rebound of the land covered by ice at the end of the last Ice Age 10,000 years ago that relative sea level has been up to 45m lower along much of the coast (*ibid.*). Sea level change in the Holocene is dominated by submergence. An investigation undertaken on 21 different sites in the Western Isles has led to the suggestion that sea levels have risen 5 m at 5100BP and since then has risen a further 2 m (Ritchie 1985).

4.2. Designated Assets within the Inner Study Area

There are no designated cultural heritage assets within the inner study area.

4.3. Undesignated Assets within the Inner Study Area

There are no undesignated cultural heritage assets within the inner study area.

4.4. The Potential for Palaeoenvironmental Deposits Assets within the Inner Study Area

The potential for paleoenvironmental deposits to survive within the proposed development area is considered to be low. Although early peat deposits of Pleistocene Age have been recorded in shoreline sections from this area of Lewis at Toa Galson (Gordon, 1993; Sutherland and Walker 1984), the shallow seismic survey and multibeam survey indicated that within the proposed development

area, the majority of the seabed is composed of rock with some sand and gravel sediment present in the cracks, faults and fissures. There may of course be some paleoenvironmental remains overlain by this sand and gravel sediment.

Potential for Geophysical Data

Shallow Seismic Survey

No objects or debris of archaeological significance were identified in the sub-bottom profiling geophysical data. This is likely due to the predominance of bedrock and sub-rock at or near the surface of the seabed visible in the sub-bottom profiler data.

Multibeam

The sun shaded multibeam data (Figures 1a & 1b) has been reviewed and the seabed and geological characteristics of the survey area have been identified. No targets of archaeological potential have been identified for the site. The multibeam has further demonstrated the rocky and uneven characteristics of the seabed and potential sand and gravel patches. Close to the shore the sharply defined bare rock is visible, whilst in deeper water the form of the bedrock is more softly defined, indicating a thin covering of sediments. Numerous fissures and cracks in the bedrock are visible.

The multibeam data does not extend to the coastline. However, it is evident that the high energy environment in this area will have removed superficial deposits as it has in the shallower parts of the surveyed area

Designated Assets in the Outer Study Area

There are no undesignated cultural heritage assets within the inner study area.

4.5. Undesignated Assets within the Outer Study Area

There is one undesignated cultural heritage asset within the outer study area. The Borgin (HA1001) is classified as a LIVE wreck which was sunk in 1980. It is recorded as a Danish sailing ship which was driven ashore in a near gale after suffering engine failure. It has no cultural heritage significance.

HA No.	UKHO No.	Name	Designations	NGR	Status
1001	778	Borgin	None	296441 6479401	Live

4.6. The Potential for Unrecorded Maritime Cultural Heritage Assets

Mesolithic activity is likely to have been concentrated in the coastal areas of Lewis as the coast offers a wide range of readily exploitable resources. However, no ssites from the is period are known in the area. One explanation that has been offered for the failure to locate Mesolithic sites at coastal locations has been fluctuations and rises in sea levels described earlier and the subsequent submergence of coastal sites. It has been suggested that there is a high likelihood of surviving submerged prehistoric archaeology (10,000 – 5000 years old) to the west of the Outer Hebrides for a distance of some 10km, to a depth of -20m (Wickham-Jones and Dawson 2006). This, however, is a general potential and does not apply to the current study area as the seabed has been largely scoured of superficial deposits and hence any such remains are unlikely to survive. The many cracks in the bedrock may have acted to trap residual deposits or redeposited artefacts. Such material is of local importance at most.

While there is no known physical evidence for maritime travel in this area in the prehistoric period, the fact that prehistoric sites are known along the west coast of the Isle of Lewis suggests that seafaring is likely to have been a key factor in the settlement of the island. An Iron Age midden site at nearby Teampull Pheadair that was exposed by coastal erosion provides evidence that the sea was exploited in this area during the prehistoric period.

Maritime links assumed renewed importance in the Early Medieval period, especially in relation to the spread of Christian culture and the written record from this period makes constant reference to journeys undertaken by those involved with the church between Ireland and Scotland. Well documented voyages include those of Colm Cille, who travelled with a group of monks from Northern Ireland to set up a monastery in Iona. The Annals of Ulster report of intermittent raids being carried out by the Norse at monastic sites on the west coast of Scotland. Siadar to the immediate east of the proposed development is of Norse origin. The potential to uncover Viking remains at coastal; locations is further demonstrated by the 1979 discovery of a Viking burial protruding from an eroding sandbank on Kneep headland to the north near Valtos (Welander 1987, 149-74)

During the medieval period it was military campaigns, migration and consequent commercial expansion that accounted for much of the sea travel of the time. During this time the English, Spanish and French had significant naval forces. The importance of ports grew, as did significant populations, prompting an expansion in seaborne trade and commerce. Custom accounts from the 15th century provide evidence of a thriving import and export industry (Rodger 1997).

The post-medieval period saw a steady increase in coastal activity where military activity and the expansion of world-wide trade meant further growth in the volume of shipping. From the 18th century onwards records began to be kept of ship losses and from the middle of the 19th century these records became far more comprehensive. This is reflected in the National Monuments Record for Scotland (NMRS). Steam power for cargo vessels was developed and by the end of World War I most of the larger vessels in the area were steam-powered. Fishing has also been a significant industry in the area, with the rise of numerous fishing settlements on the island in the 19th century. It is not surprising therefore, that many of the reported losses in this area are of smaller fishing vessels and trawlers of various designs. It was not until the 20th century that metal hulls came into use in the herring trade and many of the earlier losses of wooden vessels are likely to be highly degraded and difficult to detect. The shipwreck index for the Outer Hebrides has a large number of recorded losses for the Isle of Lewis, many of which are recorded as 'near' and 'in the' Isle of Lewis and cannot be located precisely. However, there is clearly a large number of potential wreck sites around the island (Larn & Larn, 1998).

A large number of identified shipwrecks in the seas of the Outer Hebrides are the result of military activity during World Wars I and II. Initial losses during WWI were caused by the extinguishing of coastal lights which resulted in numerous wrecks concentrated along the shoreline. A large number of German U-Boats were known to pass through The Minch channel between the East of Lewis and UK mainland during WWI and WWII, with one known U-Boat loss in1945 of U-905 (wrecksite.eu). Loch Ewe on the west coast of the mainland just south of Ullapool was used since WWII as an assembly area for convoys and there was a Royal Navy depot at Mellon Charles until the late 1990s with NATO oil fuel storage tanks nearby. These examples illustrate that this area of the Outer Hebrides was utilised for military purposes for many decades (Larn & Larn, 1998).

This long history of maritime activity suggests that there is some potential for unrecorded losses to have occurred within the study area. However, the potential for substantive remains to be present is tempered by the results of the assessment of geophysical data, which identified no such potential assets and indicated that the seabed has been scoured by currents. Debris from wrecks could conceivably be trapped in the cracks in the bedrock. Such debris is likely to be of no greater than local importance.

5. CONCLUSIONS

No recorded shipwrecks have been identified within the Inner Study Area and just one recorded LIVE wreck has been identified in the Outer Study Area. This is a Danish sailing ship that sank in 1980. It has no cultural heritage significance. There is some potential to encounter cultural heritage assets within the development area albeit low.

Although early peat deposits of Pleistocene Age have been recorded previously around the Isle of Lewis, the suitably high energy nature of coastal processes at the proposed development area would suggest the survival of significant peat deposits is

unlikely. Further, the geophysical surveys have shown that the majority of the seabed is composed of rock with some sand and gravel sediment present in the cracks, faults and fissures. Archaeological analysis of the geophysical surveys carried out did not identify any targets that would be considered to be of archaeological potential.

APPENDIX A: SOURCES CONSULTED

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Designated wreck data was downloaded from Historic Scotland's website © Historic Scotland

Offshore Sites and Monuments Record information derived from NMRS data (http://jura.rcahms.gov.uk/PASTMAP/) © Crown Copyright RCAHMS

Wrecks and Obstructions information derived from SeaZone data © Copyright UKHO

Websites Consulted

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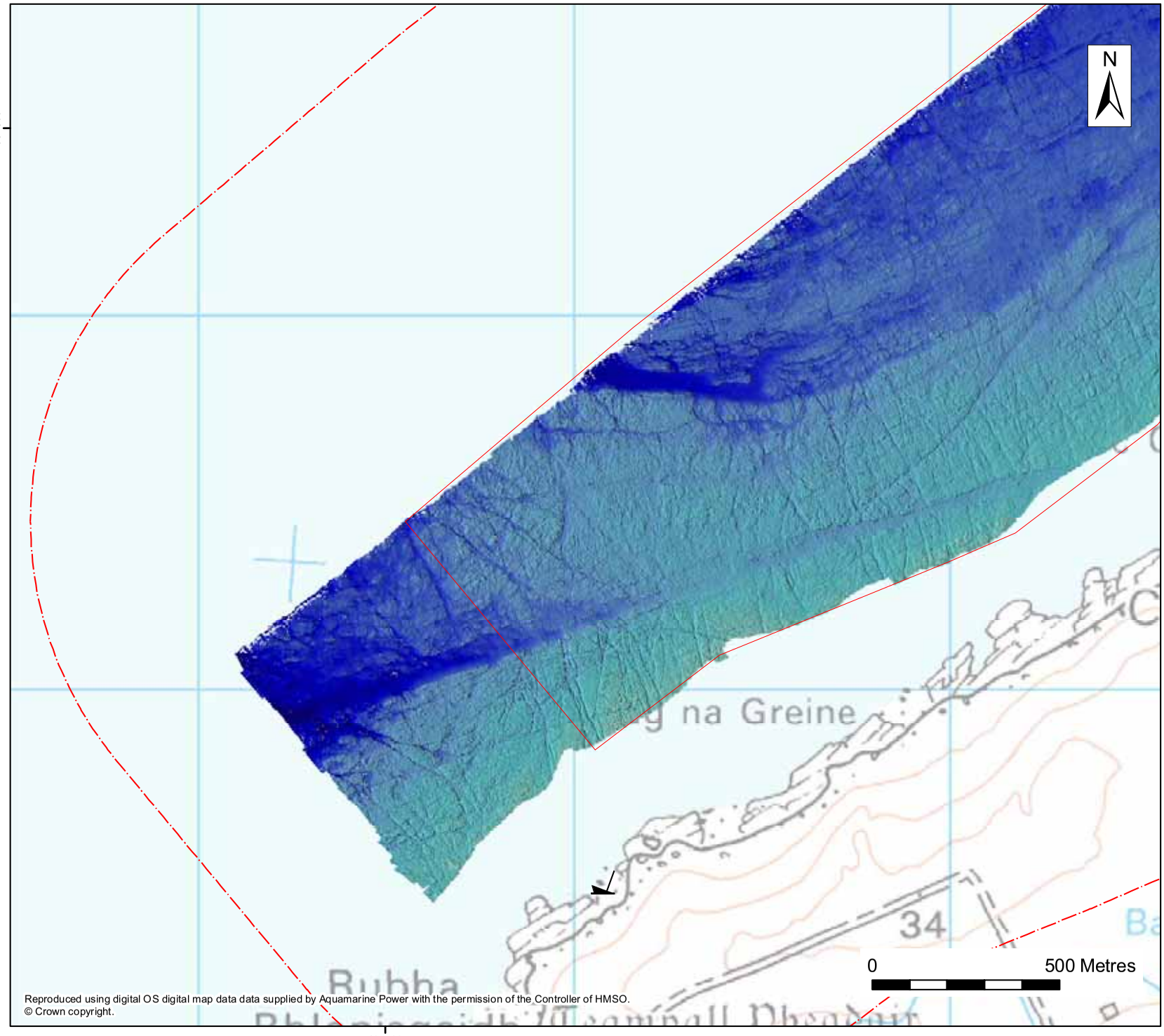
www.wrecksite.eu/ (accessed on 14/11/11)



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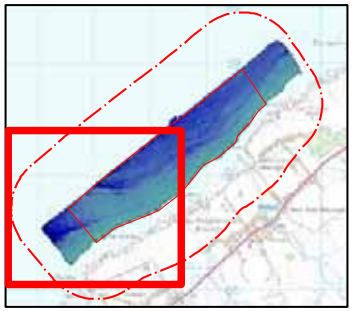
Key

- Inner Study Area
- Study Area 1km Buffer
- Live wreck

Bathymetry

- -3.4m
- -9m
- -15m
- -20m
- -26m



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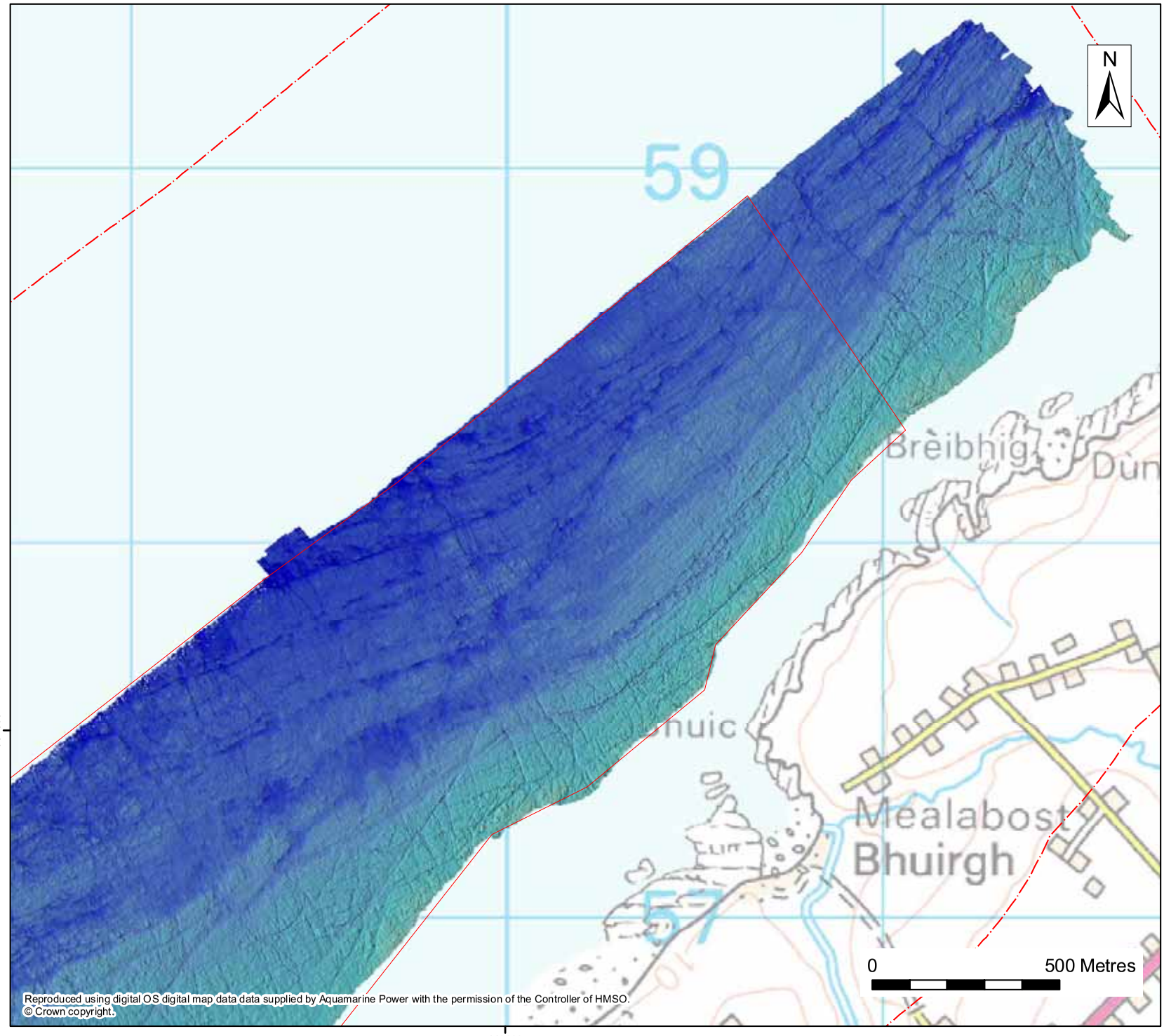
Isle of Lewis Wave Array

Figure 1a: Bathymetry data and maritime losses



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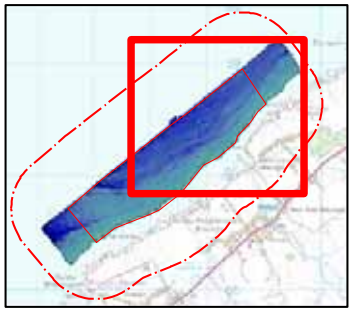

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Isle of Lewis Wave Array

Figure 1b: Bathymetry data and maritime losses