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ENFAIT
ENABLING FUTURE ARRAYS IN TIDAL

Initial Project & European ESEAs

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Contents

Abbreviations

ADCP	Acoustic Doppler Current Profilers
AIS	Automatic Identification System
CC	Community Councils
CfD	Contracts for Difference
EMEC	European Marine Energy Centre
EMF	Electromagnetic Fields
EnFAIT	Enabling Future Arrays in Tidal
ESEA	Environmental and Socio-Economic Appraisal
EU	European Union
GHG	Greenhouse Gas
GW	Gigawatt
HIE	Highlands and Islands Enterprise
JNCC	Joint Nature Conservation Committee
KIIs	Key Informant Interviews
MW	Megawatt
NCMPA	Nature Conservation Marine Protected Areas
OTEC	Ocean Thermal Energy Conversion
PEMP	Project Environmental Monitoring Plan
SC	Shetland Composites
SIC	Shetland Island Council
SPA	Special Protection Areas
SSE	Southern and Scottish Energy
STA	Shetland Tidal Array
UK	United Kingdom
USA	United States of America
WP	Work Package

1 Executive Summary

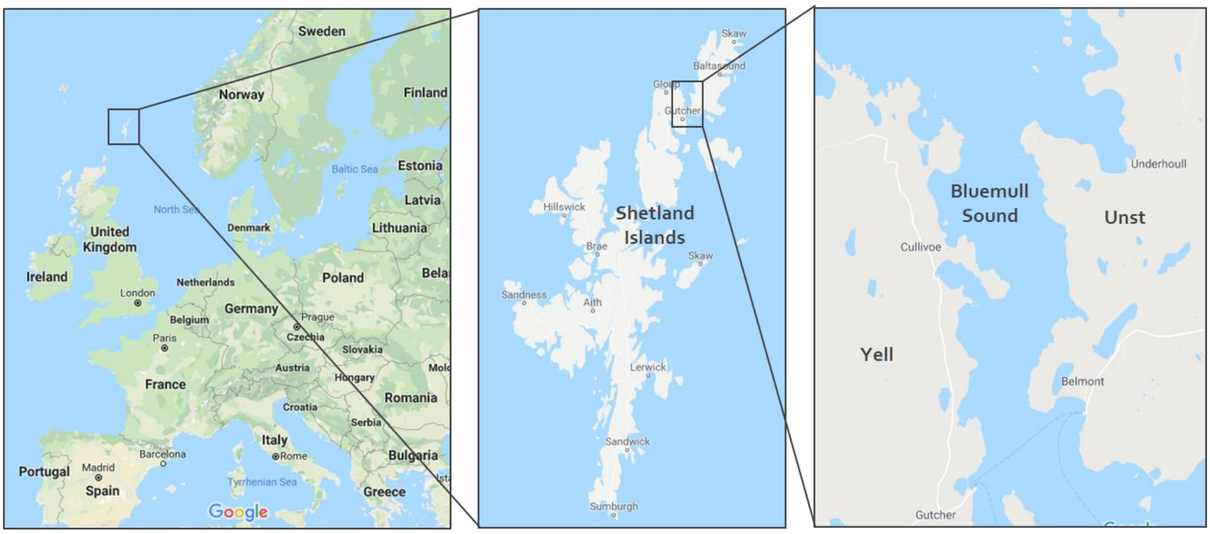
"Enabling Future Arrays in Tidal" (EnFAIT) is an outcome of the European Union's (EU) Horizon 2020 research and innovation programme which awarded a funding grant to Nova Innovation (Nova) in January 2017. The aim of EnFAIT is to demonstrate a grid-connected tidal energy array at a real-world tidal energy site in Shetland, propelling tidal energy towards competing on a commercial basis with alternative renewable sources of energy generation. The funding grant was provided in response to the EU's call 'LCE-15-2016: Scaling up in the ocean energy sector to arrays', which aims to generate significant learning opportunities in demonstrating cost-effective tidal arrays.

As part of EnFAIT, an initial Environmental and Socio-Economic appraisal (ESEA) has been prepared under Work Package 8. The objectives of the ESEA are to:

- assess the potential impact, positive and negative, of the tidal energy array on environmental and socio-economic receptors
- present mitigation actions to address any negative environmental and socio-economic risks and impacts, and review the approach taken to develop the environmental monitoring framework
- assess the potential impact of the array on the tidal energy industry at an EU-level
- capture and disseminate lessons learned for the tidal energy industry on managing environmental and socio-economic impacts, applying the existing policy and regulatory framework, developing local supply chains, and techniques for engaging with local communities.

The Shetland Tidal Array (STA) is in the Bluemull Sound, Shetland, between the islands of Unst and Yell as illustrated in Figure 1.1.

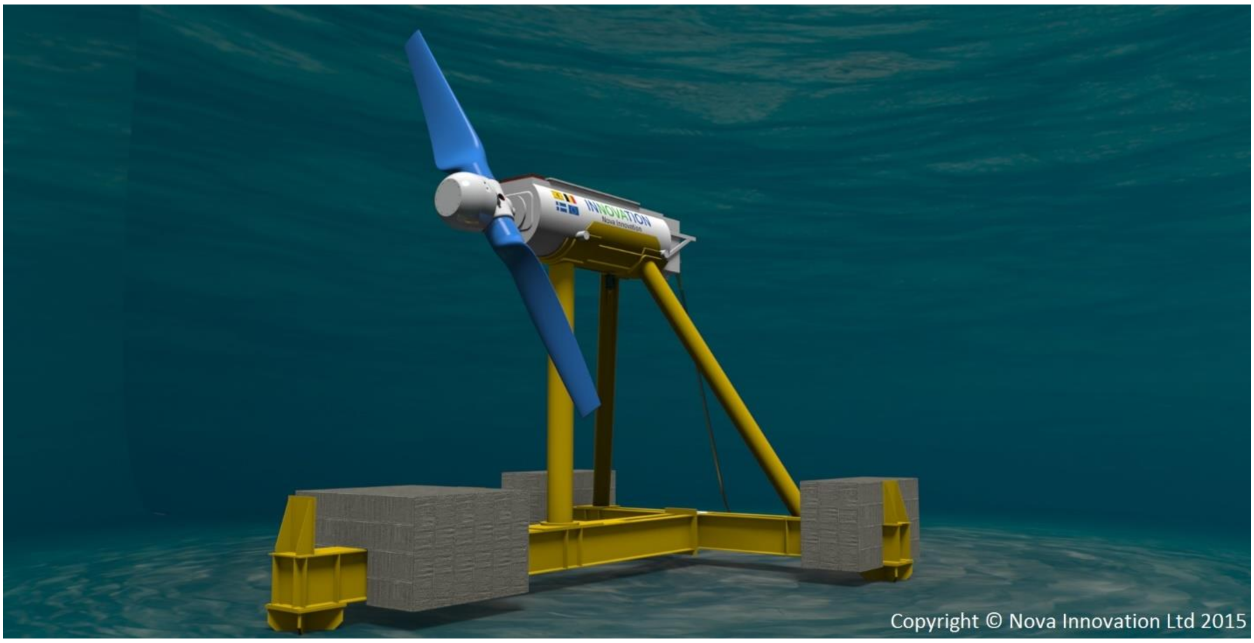
Figure 1.1 Project location



The current array consists of three fully submerged turbines, with individual cables connecting to an onshore transformer station at Cullivoe Pier. Over the course of the project, the three turbines will be expanded to six, and devices will be regularly moved within the STA with the aim of gathering data that reflects the way in which the turbines interact with each other. Each turbine is rated at 100kW and the array is expected to remain in operation until 2035.

The turbines comprise a 2-bladed, horizontal axis device installed subsea at a depth of 30-40m. The turbines use gravity base foundations and do not require any piling or drilling into the seafloor. An example of the turbine is illustrated in Figure 1.2.

Figure 1.2 Illustration of a Nova M100 tidal energy device



EnFAIT presents a unique opportunity to gather information from an array of operating turbines and improve the industries' understanding concerning individual and combined environmental effects of turbines within an array. Environmental survey and monitoring activity has been ongoing in Bluemull Sound, Shetland, since November 2010, according to techniques agreed with environmental regulators. The existing environmental framework comprises a combination of land-based and sub-surface monitoring to record sea-bird and marine fauna interactions in the area, immediately above and surrounding the tidal array, and beneath the surface of the sea.

To date, there have been no observed collisions between the turbine blades and marine fauna. Most sightings from visual monitoring and/or underwater camera footage comprise fish, occasional diving seabirds and seals. In 2019, Nova will submit a revised Project Environmental Monitoring Plan (PEMP) to Marine Scotland and Shetland Island Council. This revised PEMP will be informed by eight years of historical data collection.

The environmental and socio-economic appraisal started with an initial review of published information on previous tidal energy projects that were developed within and outside the EU. This aimed to identify details associated with research and development initiatives, existing policy frameworks, challenges in environmental permitting and lessons learned. An environmental and social baseline was subsequently prepared. This examines past and ongoing trends and conditions in Shetland, the North Isles and in Yell.

The appraisal methodology involved extensive engagement with a variety of stakeholders including; regulatory authorities; Shetland residents and their elected representatives; Shetland Island Council (SIC); and key informants with detailed knowledge of local environmental conditions and tourism activities.

A postal questionnaire was sent to all residents on Yell (455 in total) in partnership with SIC who are implementing an energy efficiency improvement programme for residents and businesses on the island. Five questions were added by Nova to the council's questionnaire which aimed to gather resident's perceptions towards tidal energy. The results indicated that there is very strong support towards the development of this type of technology because devices are submerged below water and are not visible; there are no known significant, adverse environmental impacts; and the device uses Shetland's renewable energy resources to generate low-carbon electricity.

Nova and RSK jointly attended a public event on Yell (the Yell Trade Show) during which project partners were able to provide residents with information about the project and listen to local attitudes and opinions. A series of engagement activities were conducted in Shetland, including focus group discussions, key informant interviews and workshops with school children. The overall outcome of the local community engagements was that there is extensive support for the development for this type of technology. There is also an expectation that the project should expand its presence at Cullivoe Pier and establish a visitor's board to provide local people with information on the purpose of the tidal devices which are fully submerged beneath the sea and are largely invisible to local people.

An initial appraisal of the effects of the project has been completed at a UK level, and at an EU level to appraise the effects of EnFAIT on the development of the wider tidal energy sector. The outcome of the appraisal will be re-visited at the end of EnFAIT in 2022. The appraisal categorised the potential environmental and socio-economic effects of the project using a simple methodology, and this is presented in Table 1.1.

Table 1.1 Classification of the effects of EnFAIT

Clear and major positive effect *(expected to contribute a positive, environmental and/or socio-economic change that is recognised at a Shetland/UK and/or EU level)*	✓✓
Broadly supportive or minor positive effect *(results in improved environmental knowledge, or positive environmental and/or socio-economic change)*	✓
Neutral effect *(is not expected to have a positive or adverse effect)*	0
Minor negative effect *(expected to result in a localised, adverse environmental and/or socio-economic change)*	✗
Major negative effect *(adverse environmental and/or socio-economic change)*	✗✗
Uncertain effect *(based upon the information available the outcome of the effect cannot be determined at this time and could be either positive or adverse)*	?

The results of the initial appraisal are presented in Table 1.2.

Table 1.2 Results of the appraisal for environmental and socio-economic topic areas

	UK level	EU-level
Environmental topic areas		

Marine and coastal biodiversity	0	?
Physical environment and water quality	✓	✓
Underwater noise and vibration	?	?
Benthos	0	?
Fish	0	?
Seabirds	✓	?
Marine mammals	✓	?
Protected sites	0	?
Air quality and global climate	✓	✓
Seascape and visual character	✓✓	✓✓
Marine and coastal archaeology	0	?
Socio-economic topic areas		
Demographics	✓	✓
Standard of living and housing conditions and vulnerable groups	0	✓
Educational change	✓	✓
Social cohesion	0	✓
Perception of the sea as a tidal energy resource	✓	✓
Recreational and tourism activities	0	0
Employment and business	✓✓	✓✓
Industrial strategy and rural regeneration	✓	✓
Commercial shipping and navigation	0	?
Effects on the regulatory framework	✓✓	✓✓

The environmental appraisal identified that there are no adverse effects from the tidal energy array on marine receptors. There are neutral effects on biodiversity, benthos, fish, seabirds and protected sites as there are no identified interactions with these types of receptors. Positive effects included the way in which the project has generated a robust data set that demonstrates how tidal energy devices can be installed and operated without disturbing marine mammals or the physical environment. The knowledge gained from EnFAIT will subsequently assist the permitting processes for similar tidal devices less complicated in the future, and this is considered a positive effect from the project.

EnFAIT's environmental monitoring framework has been used since the start of Nova's activities in the Bluemull Sound and has generated over eight years of data. Nevertheless, the precise questions that are intended to be answered by the monitoring data remain unclear. In the future, it is recommended that the strategic objectives of monitoring are clearly defined at the start, so that the data collection activities can be tailored towards these objectives to ensure that the questions posed become answered over time. There is a risk that similar future projects may become 'data rich and information poor', unless key questions and purposes of the data being collected are clearly understood.

The appraisal of socio-economic topic areas found no adverse effects. Positive effects were identified for demographics, as this new type of renewable energy technology could encourage people to stay in Shetland and reverse a current trend of out-migration. There have been positive effects on employment and business through the generation of additional knowledge, revenue and capacity among the local companies used to produce key materials and services. EnFAIT is also strategically aligned with the UK's industrial strategy to focus investment outside urban areas as part of a broader aim for rural regeneration. The project has also raised awareness associated with tidal energy technology through interactions with young people in schools.

The initial appraisal has identified a preliminary set of lessons and recommendations. These include the importance of early engagement with regulators who may be uncertain of how to approach the permitting of tidal energy devices, due to perceived gaps in their policy and regulatory framework.

A key benefit of the EnFAIT project starting at a relatively small-scale is that regulators, and other stakeholders such as fishing groups, have become confident in the effects of the technology gradually. The installation of only a small number of tidal energy devices has caused little-to-no disruption to other users of the shoreline and has prevented stakeholders from suddenly being faced with a large-scale development with uncertain and potentially significant adverse effects.

In summary, EnFAIT continues to have a positive impact on the local economy. No adverse effects on environmental receptors have been identified. Project activities have demonstrated how regulators are able to respond flexibly during the permitting of tidal energy devices, and that there is strong support amongst local communities for this type of renewable energy technology.

2 Introduction

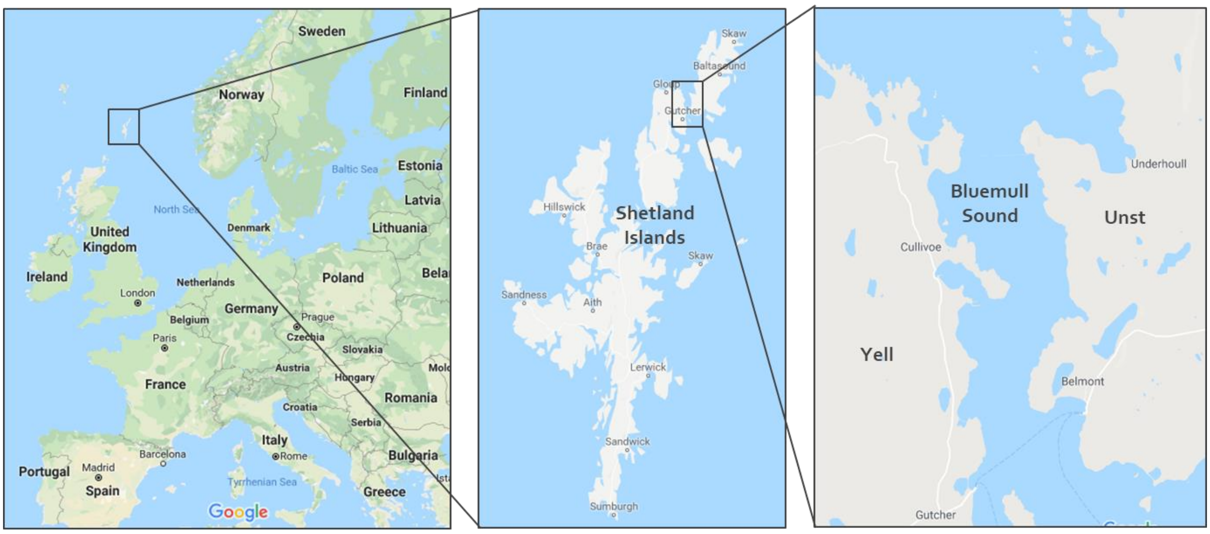
The European Union's (EU) Horizon 2020 research and innovation programme awarded a funding grant to Nova Innovation (Nova) "Enabling Future Arrays in Tidal" (EnFAIT) in January 2017. The aim of EnFAIT is to demonstrate a grid-connected tidal energy array at a real-world tidal energy site, propelling tidal energy towards competing on a commercial basis with alternative renewable sources of energy generation. The funding grant was provided in response to the EU's call 'LCE-15-2016: Scaling up in the ocean energy sector to arrays', which aims to generate significant learning opportunities in demonstrating cost-effective tidal arrays.

This document presents initial Environmental and Socio-Economic appraisals (ESEAs) that are delivered as part of Work Package (WP) 8 for the EnFAIT project. The plan satisfies deliverable D8.9 of the EnFAIT project and is to be made available for public dissemination.

2.1 Description of the project and associated facilities

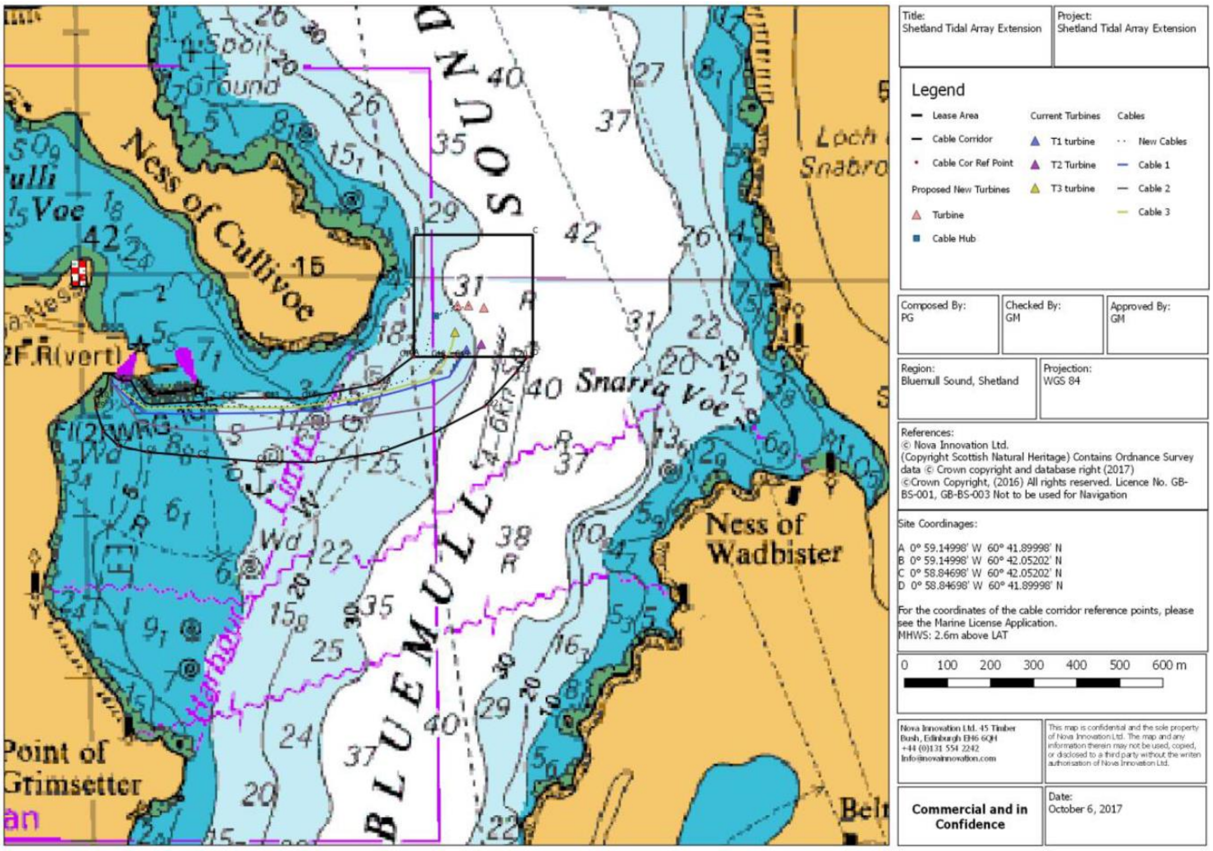
The Shetland Tidal Array (STA) is in the Bluemull Sound, Shetland, between the islands of Unst and Yell as illustrated in Figure 2.1.

Figure 2.1 Project location



The site is located near the Ness of Cullivoe, a narrow 1 km long headland to the north-east of Yell. Figure 2.2 shows the exact location of the STA lease area and cable corridor.

Figure 2.2 Location of the STA site and cable corridor

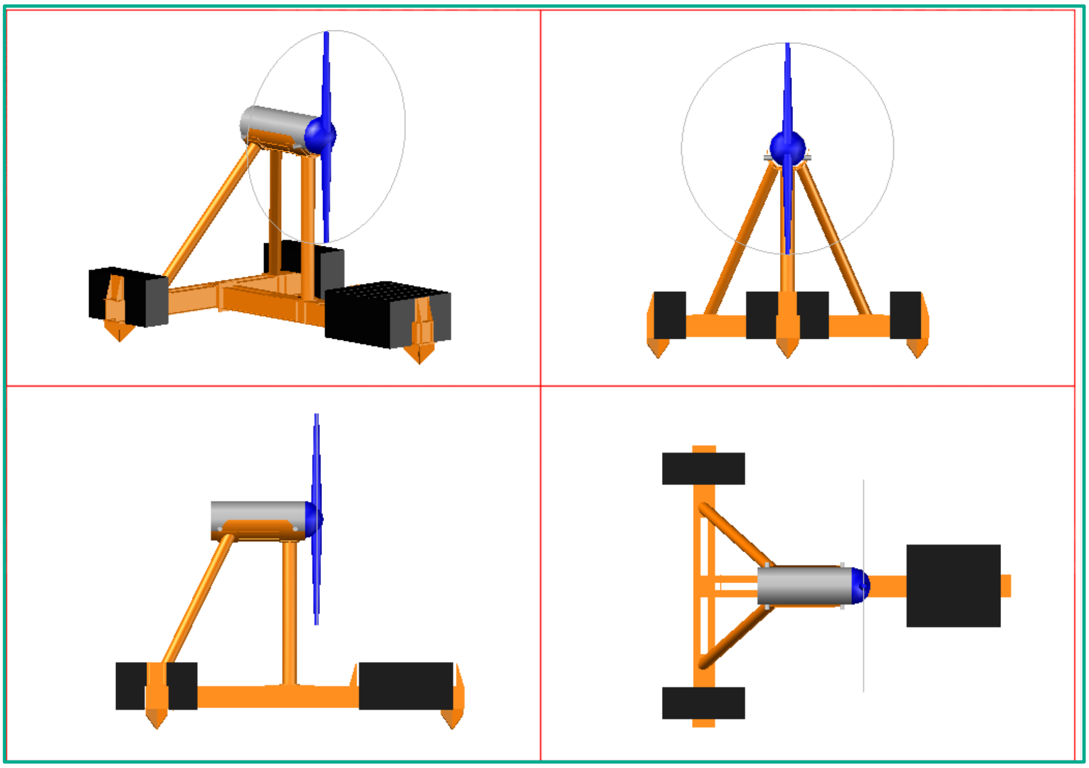


The array currently comprises three 100kW Nova M100 turbines, with individual cables connecting to a transformer station at Cullivoe Pier. Under EnFAIT the array will be extended from three to six turbines, with a total rated capacity of 600kW. The current array is expected to continue operation until 2035, at which point the turbines and all associated equipment will be decommissioned. Decommissioning will be complete by the end of 2038. As part of the EnFAIT project, the three new devices will be moved to different positions within the STA with the aim of gathering data that reflects the way in which the devices interact with each other on the seabed.

The Nova M100 turbines comprise a 2-bladed, horizontal axis device installed subsea at a depth of 30-40m. The turbines use gravity base foundations and do not require any piling or drilling into the seafloor. An illustration of the Nova M100 turbine is shown in Figure 2.3. The minimum depth of water from the sea surface to the top of the turbine is 15m. This depth of water allows the safe passage of vessels and does not represent an obstacle to navigation.

Each tidal turbine specifically provides anchoring points for underwater video monitoring cameras. Connecting cables provide power and transfer data into a communication module within the nacelle. Each of the three deployed turbines has three high-definition cameras, leading to significant bandwidth requirements. Fibre optics are used to transfer data back to shore and to handle the high volume of data.

Figure 2.3 The Nova Innovation Nova M100 Tidal Turbine



Source: Nova Innovation 2018

A photo of a tidal energy device is provided in Figure 2.4.

Figure 2.4 Photo of the tidal energy device

A photo of a tidal energy device as it was retrieved after a period of 14 months in the sea is provided in Figure 2.5. The photo reflects the extent of marine growth on the nacelle and turbine blades.

Figure 2.5 Photo of the tidal energy device after 14 months of being deployed

Source: Nova Innovation 2018

Cullivoe Pier is used by Nova as a central connection point which contains the transformer and control systems for each tidal energy device, office space and a maintenance workshop. The location was chosen for the following reasons:

- The tidal energy resource, which is particularly high within the Bluemull Sound, at the edge of the Ness of Cullivoe;
- Water depth, which ranges from 30m to 40m and is deep enough to ensure that the tidal energy devices do not interfere with vessel navigation and fishing activities;
- The proximity to a nearby energy consumer, as an ice factory installed on Cullivoe Pier used by local fishermen was provided with energy generated by the tidal energy device;
- A grid connection to the Shetland grid owned and operated by Southern and Scottish Energy (SSE) that is being used for the export of energy; and
- Space and infrastructure: there was adequate space available at Cullivoe Pier and hardstanding concreted areas to lay heavy machinery down during the deployment and retrieval of the turbines.

Cullivoe pier is owned and maintained by Shetland Island Council (SIC) Ports and Harbours Authority. The pier is a shared space, and all pier users pay for their use of the facility. A variety of companies use the hardstanding area; this includes those involved in coastal mussel aquaculture, salmon farming, the offloading of sea products from fishing vessels, and a company involved in the manufacture of salmon farm cages. Nova also uses the hardstanding at Cullivoe for the deployment and retrieval of the tidal turbines.

The range of companies using the pier and making payments to SIC, contributes to the financial sustainability of the pier. The cost of the infrastructure is shared between different users and as such, it is not overly expensive for any individual business.

Over the last few years, Nova have developed a research and development centre in their Edinburgh office. As part of the company's recent transition from R&D into operation and maintenance, an old 1970s warehouse has been upgraded into a modern maintenance facility. This facility, also located in Edinburgh, was completed in 2017 and is currently being used by Nova.

Nova's supply chain (based on expenditure over the first 18 months of the EnFAIT project) is 100% from within the EU; 84% from Scotland; and 60% from Highlands and Islands region.

2.2 Environmental monitoring framework

2.2.1 Overview

Environmental monitoring undertaken to date around tidal stream energy projects has generally focused on the environmental effects of single devices. EnFAIT presents a unique opportunity to gather information from an array of operating turbines and improve understanding about the individual and combined environmental effects of turbines within an array. This will provide a valuable evidence base on which future commercial, consenting and policy decisions for the tidal energy sector can draw.

Environmental survey and monitoring activity has been ongoing in Bluemull Sound, Shetland since November 2010, according to methodologies agreed between Nova and the regulatory bodies. Discussions about environmental monitoring are ongoing and methodologies may be subject to amendment or refinement throughout the course of the EnFAIT project, as data are analysed and objectives of monitoring refined. In 2019, Nova will be submitting a revised Project Environmental Monitoring Plan (PEMP) to Marine Scotland and Shetland Island Council, for their consideration. This revised PEMP will be informed by and build on the 8 years of monitoring activity conducted at the site since 2010.

Initial environmental surveys were carried out to gather information in support of consent applications for turbine deployments in Bluemull Sound. The focus has now shifted to monitoring the effects of the deployed turbines on marine mammals and diving birds, using underwater cameras and land-based vantage point surveys. Underwater cameras have also been used to monitor biofouling on turbines and substructures and to inform micro-siting of cables and turbines during deployment to avoid sensitive seabed habitats and species.

The environmental monitoring for EnFAIT will focus primarily on improving understanding about the risk of collisions between marine wildlife and the turbines in the array. This has been identified by industry, regulators and other stakeholders as a key issue in need of priority research, to reduce uncertainty and de-risk consenting for tidal energy[1]. Opportunities to gather further data from the operational array and information to help investigate (for example) the effects of changes in water flow and energy removal of tidal arrays will also be explored. For full details of the monitoring programme for the EnFAIT project, refer to deliverable D8.5 which summaries the outcomes from environmental monitoring in year 1 of the project[2].

[1] ORJIP Ocean Energy (2017). The Forward Look; an Ocean Energy Environmental Research Strategy for the UK. http://www.orjip.org.uk/sites/default/files/ORJIP%20Ocean%20Energy%20Forward%20Look%203%20FINAL.pdf

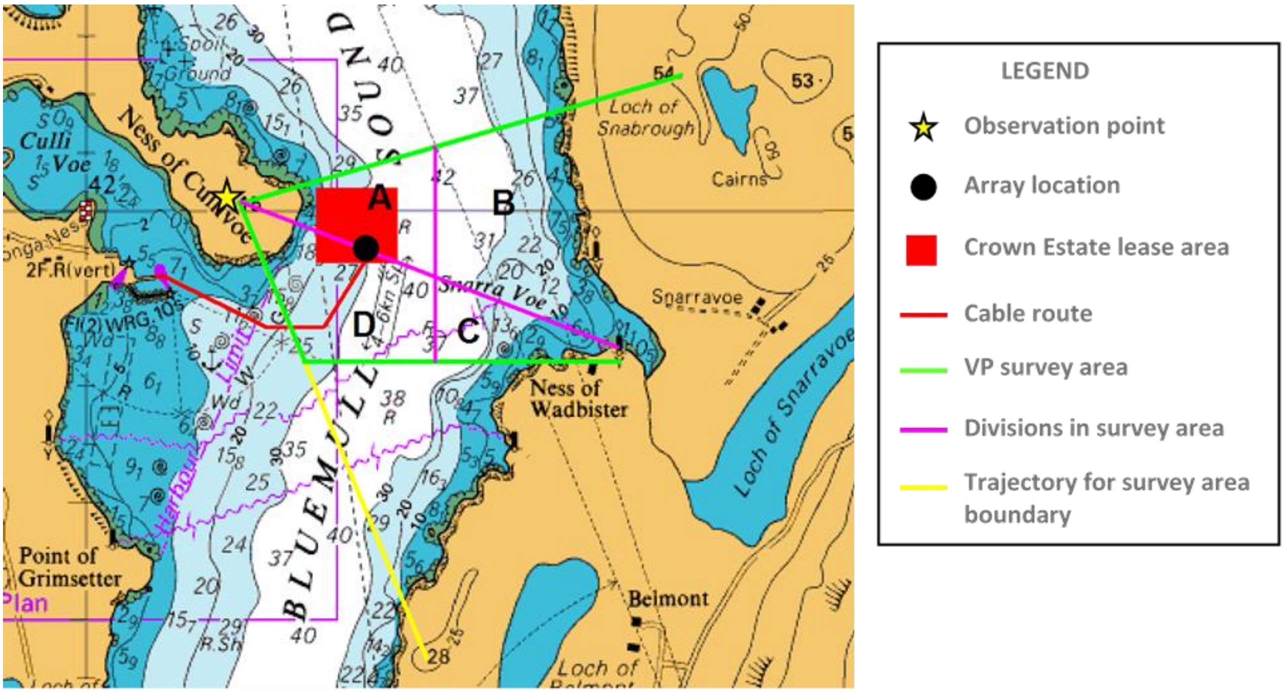
[2] EnFAIT-EU-0035 (2018). EnFAIT Deliverable D8.5: Y1 Environmental Monitoring Report, pp 16.

2.2.2 Land-based vantage point surveys

Monthly land-based vantage point surveys have been carried out continuously since 2010 to determine the presence and activity of birds and marine mammals within the turbine array location and wider area in Bluemull Sound. Surveys are conducted from an elevated observation point at the south-eastern tip of the Ness of Cullivoe, from where the surveyor is well placed to undertake observations across the entire survey area.

Figure 2.6 shows the survey area (delineated by green lines) and the observation (vantage) point on the Ness of Cullivoe (yellow star). The survey area is subdivided into four areas A, B, C and D (indicated by purple subdivisions), marked out using transit sticks from the observation point and markers on the Unst shore. Figure 2.6 also indicates the location of the turbines (black dot) and the cable route back to shore (red line). The yellow line illustrates the trajectory of the marking point for the survey boundary.

Figure 2.6 Location of observation point and survey area in Bluemull Sound. The survey area is subdivided into four areas A, B, C and D. The location of turbines, cable route and Crown Estate Scotland seabed lease area are also indicated.



Surveys are divided into 3-month survey periods, roughly equating to seasons, as follows;

- Spring (February to April)
- Summer (May to July)
- Autumn (August to October)
- Winter (November to January)

Within each 3-month survey period (or season), nine 4-hour counts are conducted. Each 4-hour count consists of 24 scans for birds (one every 10 minutes) and 12 scans for mammals (one every 20 minutes). During each survey, the surveyor scans the sea surface of the array location and surrounding area using binoculars. Birds that are diving or 'loafing' on the surface of the water are identified and counted. Those transiting the area (i.e. flying) are not recorded. All marine mammals observed during scans are identified and recorded. Any general behaviour (e.g. diving, feeding), direction of travel and other relevant observations are also recorded.

The design of future vantage point surveys for EnFAIT may be modified to focus on gathering more specific information on the behaviour of diving birds and marine mammals in the immediate array area. Any change will be subject to agreement from the relevant regulatory bodies.

2.2.3 Underwater video

Underwater video has been used throughout the operational phase of the project to monitor near-field behaviour of marine wildlife around the turbines. Three cameras are attached to each turbine. One camera is attached to the side of the nacelle looking towards the blades; one is attached to the top of the nacelle looking towards the blades and a third is attached on the bottom of the turbine looking towards the seabed.

Cameras are triggered by a motion detection system. Video is recorded from a few seconds before the trigger for a minimum of ten seconds, or until motion is no longer observed, up to a maximum of 15 minutes, at which point the trigger is reset.

2.2.4 Data analysis

Data from vantage point surveys are analysed to determine the presence and spatiotemporal distribution of birds and mammals in the array area and wider Sound. This information will be used to establish which species might be at collision risk and whether any 'risk factors' can be identified, such as state of the tide or time of year. Data from vantage point surveys will also help inform an approach to sampling and analysing the extensive underwater video footage gathered, as well as enabling cross-referencing and comparison across the two data sets, to better understand collision risk.

Underwater footage is manually reviewed to determine whether the cause of the trigger event was a fish, diving bird, marine mammal, other fauna (e.g. jellyfish) or (more typically) suspended detritus in the water, or biofouling on the camera lens. Relevant footage is further analysed to establish species identity and any notable behaviour, including any interactions with moving parts of the turbines. To date only a sub-sample of the full dataset of underwater video footage has been analysed (approximately 4,000 hours of video footage), since it is a very labour-intensive process. A full and systematic analysis of the underwater video footage will be progressed through EnFAIT. Opportunities to automate the filtering out of falsely triggered footage and options for sampling from the full dataset will also be explored. This might include a randomised approach, or a stratified sampling protocol based on analysing footage across a representative range of tidal states and times of the year, targeting 'high risk' times identified by the vantage point data.

2.2.5 Preliminary results to date

Analysis of the monitoring data gathered from Bluemull Sound is ongoing, so preliminary results are presented. For results from the first year of environmental monitoring conducted as part of the EnFAIT project, see EnFAIT deliverable D8.5 which summaries the outcomes from environmental monitoring in year 1 of the project. Two further environmental monitoring reports will be produced in year 3 and 5 of EnFAIT.

Vantage point surveys have identified thirty-five species of seabird in the Shetland Tidal Array and wider Bluemull Sound area. Of the bird species recorded, only fifteen are capable of diving to depths which might bring them into contact with the turbines. Of this small subset of 'at risk' species, very few were observed within the array area itself and even fewer displaying behaviour that could place them at risk of collision (i.e. diving and feeding). Most diving bird species were observed infrequently, or in very small numbers, with by far the most abundant and commonly recorded being black guillemot *Cepphus grylle* and European shag *Phalacrocorax aristotelis*.

Eight species of mammal have been recorded in vantage point surveys to date; harbour or common seal (*Phoca vitulina*), grey seal (*Halichoerus grypus*), harbour porpoise (*Phocoena phocoena*), Risso's dolphin (*Grampus griseus*), minke whale (*Balaenoptera acutorostrata*), killer whale (*Orcinus orca*), humpback whale (*Megaptera novaeangliae*) and otter (*Lutra lutra*). Of these, most were observed only infrequently, or in very small numbers, with by far the most abundant and commonly recorded being harbour porpoise and common seal.

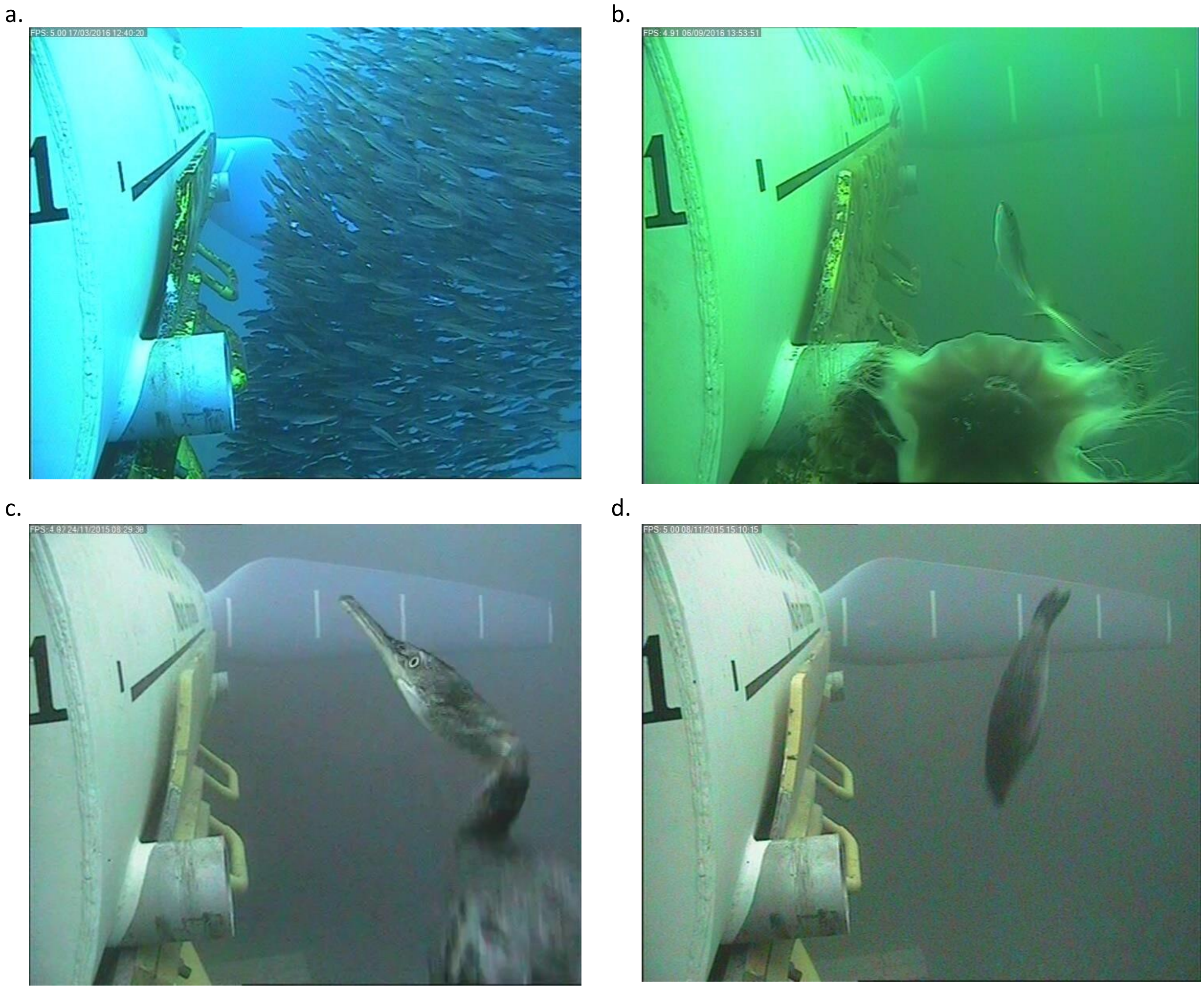
A single basking shark (*Cetorhinus maximus*) has been observed during vantage point surveys since 2010.

The video cameras provide regular sightings of fish, and occasionally of birds and mammals. The following four species have been identified from underwater video footage analysed to date:

- Harbour or common seal (*Phoca vitulina*)
- European shag (*Phalacrocorax aristotelis*)
- Black guillemot (*Cepphus grille*)
- Atlantic pollack (*Pollachius pollachius*)

Figure 2.7 shows some images from underwater video footage. These images are exceptional since birds and mammals are only very occasionally observed on the subsea cameras. The images illustrate the quality of video available following turbine deployment at the Shetland site, and the capability of this technology to discern animal presence, species and behaviour.

Figure 2.7 Images from underwater video footage, showing a) a school of pollack *Pollachius pollachius or P. virens* b) Lion's mane jellyfish *Cyanea capillata* with pollack c) European shag, *Phalacrocorax aristotelis* and d) harbour or common seal, *Phoca vitulina.* Turbine blades were stationary during all observations.



Fish are by far the most frequently sighted fauna, the majority of which are pollack, most likely Atlantic pollack, but possibly also coalfish (*Pollachius virens*). Birds and seals are relatively infrequently observed on the underwater cameras. No cetaceans or basking sharks have been observed in any of the video footage analysed to date. In footage analysed to date birds and mammals have only been observed when the turbine is not generating, and the blades are therefore not rotating, corresponding to slack water or times of slow current speed. There have been no observed cases of any collisions or near miss events between fauna and the turbine blades.

2.2.6 Ongoing environmental monitoring

Environmental monitoring and data analysis and will be ongoing throughout the EnFAIT project. Following a more thorough and systematic analysis of the data gathered to date, the methodologies may be amended to ensure that future activity is focussed on gathering data of greatest value in understanding the environmental effects of tidal arrays. In addition to refining monitoring focussed on collision risk, this also includes exploring opportunities to gather further data from the operational array and information to help investigate the effects (for example) of changes in water flow and energy removal of tidal arrays.

2.3 Scope of the ESEA Report

The ESEA covers the following:

1. Project-level effects that consider environmental and socio-economic receptors in Shetland and Scotland; and
2. EU-level effects that consider the broader implications on the EU tidal energy sector.

2.4 Objectives and targets

The objectives of the appraisals are to:

- assess the potential impact, positive and negative, of the tidal energy array on environmental and socio-economic receptors
- present mitigation actions to address any negative environmental and socio-economic risks and impacts, and review the approach taken to develop the environmental monitoring framework
- assess the potential impact of the array on the tidal energy industry at an EU-level
- capture and disseminate lessons learned for the tidal energy industry on managing environmental and socio-economic impacts, applying the existing policy and regulatory framework, developing local supply chains, and techniques for engaging with local communities.

The following targets apply to the ESEAs:

- identifying the key environmental and socio-economic considerations that need to be considered during any future scaling up of the development at the project's location
- conducting a detailed review of tidal energy projects in the UK, EU and at selected international sites to identify lessons learned in the application of the regulatory framework to the projects; actions undertaken to develop local supply chains; and local community engagement techniques
- quantifying, to the extent possible, the potential economic impact of the tidal energy array to the Shetland Islands, Scotland, the UK and the EU
- conducting a stakeholder engagement process in an inclusive, informative, participatory and consultative manner that captures the views and opinions of the project from a range of stakeholders.

3 Methodology

This section describes the individual tasks completed during preparation of the ESEA Report:

- WP8 Task 1 – Completion of a literature review of secondary data
- WP8 Task 2 – Collecting information from project partners, project suppliers, regulators and public bodies, the local community, and users of the sea and coastal area
- WP8 Task 3 – Preparing an environmental and socio-economic baseline
- WP8 Task 4 – Undertaking stakeholder engagement activities
- WP8 Task 5 – Completing the appraisal at a project and EU level
- WP8 Task 6 – Preparing the project-level and EU-level appraisal into a single ESEA report
- WP8 Task 7 – Designing a future monitoring, evaluation and reporting framework

The following sections describe each task in more detail.

3.1 WP8 Task 1 – Complete a literature review of secondary data

A literature review of secondary data was completed and gathered information on the following:

- the historical development of the tidal energy industry in the UK and EU, including the historical development of the technology and lessons learned from previous tidal energy arrays
- the marine spatial planning and policy framework in Scotland, the UK and the EU to assess the extent to which they support the future development of tidal energy projects. This involved analysing the framework associated with the management of fisheries, navigation and maritime security, and the way in which maritime and coastal projects obtain environmental permits, licences and consents
- baseline environmental and socio-economic data for the project-level appraisal covering the geography of Shetland

3.2 WP8 Task 2 – Collect information from project partners, project suppliers, regulators and public bodies, the local community and users of the sea and coastal area

3.2.1 Project partners

Key informant interviews (KIIs) with Nova were held during 2018 to gather information on

- the historical development of the tidal energy technology selected for the project
- the criteria used to select the geographical location for the arrays

- challenges associated with obtaining statutory environmental permits, licences and consents
- the techniques used to record and analyse environmental monitoring data
- Nova's experience in engaging with the local community
- Nova's experience in identifying and developing local suppliers.

3.2.2 Project suppliers

In discussion with Nova, a local supplier (Shetland Composites) was visited and interviewed to collect information on the way in the project has impacted his business. This information was used to prepare an example case study that reflects how a tidal energy developer can work in partnership with local suppliers to maximise socio-economic benefits.

3.2.3 National and international regulators

A series of KIIs were held with representatives of the following entities in Shetland during November 2018:

- SIC Carbon Management Team
- Elected representatives who are Councillors of SIC
- SIC Ports and Harbours Authority and the SIC Harbour Master

The interviews investigated the extent to which views of acceptability could change if the project were to increase in scale in the future, and public perceptions towards the project more generally.

Introductory letters and template question and answer forms were sent to regulators both inside and outside the EU across the following countries:

- Within the EU: Denmark, France, Germany, Ireland, Italy, The Netherlands, Northern Ireland, Sweden
- Outside of the EU: Canada, India, Indonesia, New Zealand, Norway, South Korea and USA.

The aim of contacting international regulators was to gather information about the challenges they face with the permitting of tidal energy projects and investigate how these are overcome, and to understand local community perceptions towards tidal projects and the drivers behind these views.

3.2.4 The local community

IDETA, with support from RSK and Nova, implemented a Local Community Engagement Strategy (WP8 deliverable 8.3). The objectives of the local community engagement strategy were to:

- provide information to stakeholders in Shetland on the EnFAIT Project so that they understand the aims and key activities
- obtain the views and perceptions of people living in Shetland on the EnFAIT Project and assess if these views change during execution of the project

- obtain the views and perceptions of people living in Shetland on the importance of renewable energy sources

- evaluate the effectiveness of local community engagements during the EnFAIT Project so that any lessons learned can be used by other developers of tidal energy projects across the EU in the future.

Engagements with the local community were completed through the following events:

- A questionnaire sent to all households on Yell that was issued by SIC

- Attendance by Nova and RSK at the Yell Trade Fair held on 01 September 2018

- Focus group discussions that were completed in Yell and Lerwick during November 2018.

3.2.5 Environmental and Tourism Advisor

A KII was held during November 2018 with Martha Devine who completes Nova's statutory environmental monitoring of bird and sea life within the STA and surrounding area. Martha has extensive knowledge of local environmental conditions and acts as a guide during wildlife tours for tourists visiting Shetland.

3.3 WP8 Task 3 – Prepare a project-level environmental and socio-economic baseline

An environmental and socio-economic baseline was prepared using the outcome of and information from the secondary data review, site visits to Shetland, and information collected during focus group discussions and KIIs. The ESEA baseline included descriptions of the environment and socio-economic conditions.

3.4 WP8 Task 4 – Prepare a summary of the outcome of stakeholder engagement activities

The outcome of stakeholder engagement activities was analysed to further explore perceptions towards the tidal energy project and a summary is presented in Chapter 6 of this document.

3.5 WP8 Task 5 – Undertake the appraisal at a project and EU level

After the local community engagement and KII activities had been completed a workshop was held on 14 November 2018 and attended by representatives from IDETA, Nova and RSK to jointly conduct the appraisals.

The project-level and EU-level appraisals are presented using the following topic areas:

- potential environmental effects and how these may change during future enlargement of the arrays on the following receptors: physical environment and water quality, underwater noise and vibration, marine and coastal biodiversity, benthos, fish, seabirds, marine mammals, protected sites, air quality and global climate, seascape and visual character, and marine and coastal archaeology.

- potential socio-economic effects and how these may change during future enlargement of the arrays on the following: demographics, standard of living and housing condition, educational change, social cohesion, differentiated impacts on vulnerable groups, perception of the sea for energy, recreational and tourism activities, employment and business, industrial strategy and rural regeneration, structural market conditions for low-carbon energy schemes, offshore public infrastructure, and commercial shipping and navigation.

The initial EU-level ESEA also includes:

- a review of opportunities and risks associated with developing future tidal energy arrays on socio-economic and environmental receptors

- a summary of lessons learned, including how these could benefit future tidal energy projects as they scale-up from a small number of arrays into full-scale developments

The classification used to describe effects of the project on environmental and socio-economic receptors is summarised below in Table 3.1.

Table 3.1. Classification of effects used for the appraisal

Clear and major positive effect (*expected to contribute a positive, environmental and/or socio-economic change that is recognised at a Shetland/UK and/or EU level*)	✓✓
Broadly supportive or minor positive effect (*results in improved environmental knowledge, or positive environmental and/or socio-economic change)*	✓
Neutral effect *(is not expected to have a positive or adverse effect)*	**0**
Minor negative effect *(expected to result in a localised, adverse environmental and/or socio-economic change)*	×
Major negative effect *(adverse environmental and/or socio-economic change)*	××
Uncertain effect *(based upon the information available the outcome of the effect cannot be determined at this time and could be either positive or adverse)*	**?**

3.6 WP8 Task 6 – Prepare project-level and EU-level ESEA report

The ESEA Report has the following content:

Chapter 1 – Executive Summary
Chapter 2 – Introduction
Chapter 3 – Methodology
Chapter 4 – Key Findings from the Secondary Data Review
Chapter 5 – Environmental and Socio-Economic Baseline
Chapter 6 – Stakeholder Engagement Activities and Outcomes
Chapter 7 – Project-Level and EU-Level Appraisal
Chapter 8 – Summary of Lessons Learned and Recommendations
Chapter 9 - References

3.7 WP8 Task 7 – Design a future monitoring, evaluation and reporting framework

A monitoring, evaluation and reporting framework has been prepared in close liaison with project partners to ensure that data gathered for the ESEA does not overlap with other information already being collected. The framework aims to track changes in environmental and socio-economic conditions during the project using a set of clearly defined key performance indicators.

3.8 WP8 Task 8 – Update the project-level and EU-level appraisals at the end of the project

The initial project-level ESEA and EU-level appraisals will be updated towards the end of the project to capture lessons learned from the operational stage of the arrays. Key conclusions and lessons learned for the tidal energy industry will be identified and described. As part of this task, RSK will facilitate an end-of-project ESEA workshop to enable the various project partners to discuss the successes and challenges faced, so that they are able to contribute to the end-project ESEA reports.

4 Key Findings from the Secondary Data Review

4.1 The EU and international market for ocean energy

The international market for ocean energy is growing and it is estimated that up to 337 GW could be installed globally by 2050, by which time the industry is predicted to be worth £76 billion (Highlands and Islands Enterprise (HIE), 2016). Tidal energy development is the most advanced type of ocean energy technology, which also includes wave energy, ocean thermal energy conversion (OTEC) and salinity gradient sources, and it is these that are expected to reach commercial viability in the short to medium term (Uihlein and Magagna, 2015).

Tidal energy has already begun commercial operations in the UK and overseas, while wave energy is still at an advanced R&D stage (HIE, 2016). Technological limitations predominantly relate to reliability, performance and survivability of devices. This is particularly true for wave energy, which has benefited less from the transfer of components and knowledge from wind technologies than tidal energy. Tidal technologies are also showing increasing convergence of design and components, which is essential for securing supply chains, increasing standardisation and enabling cost-reduction measures through economies of scale. Owing to this increased design consensus, the presence of an engaged supply chain and extensive testing and operation to prove reliability and survivability, tidal technologies are expected to reach commercial viability before wave technologies (Uihlein and Magagna, 2015).

The EU is currently at the forefront of ocean energy R&D with a target to meet 100 GW of combined installed wave and tidal energy by 2050. Over 100 tidal energy companies have invested in the development of tidal energy technologies globally. The EU accounts for more than 50% of tidal developers, other players include Canada, Australia, the USA and, more recently, eastern Asia (Uihlein and Magagna, 2015).

Across Europe, there is a need for new economic activities to retain populations and maintain basic services in isolated rural communities. Renewable energy production can foster opportunities for such communities to stimulate and diversify their economic activities (Okkonen and Lehtonen, 2016). Recognising the value of the sector, the EU has focused its support on advancing technological development and readiness of ocean energy. Programmes over the past 10 years have provided €150 million in funding for research, development and innovation projects through initiatives like NER 300 and Horizon 2020 (EC, 2017). However, despite such support, sector deployment remains slow and markets are yet to become established (Uihlein and Magagna, 2015).

Marine energy is expected to follow the trajectory of other renewables with exponential increases in deployment as technologies become established and costs reduce, resulting in a decrease in the levelised cost of electricity (LCoE) (HIE, 2016). EU funding instruments now need to focus on tackling the challenges of upfront costs associated with commercial deployment of these technologies and encouraging investment into innovative ventures to enable their potential to be reached (EC, 2017).

4.2 UK wave and tidal energy

The UK is a world leader in wave and tidal energy, with wave and tidal power innovation and deployment spanning from Cornwall to the Shetland Islands and beyond (HIE, 2016). The marine energy sector presents the UK with a unique opportunity to secure an indigenous, renewable energy source that also delivers significant economic and industrial growth in relatively remote locations. The sector is evolving dynamically with technological progression built upon centuries of shipbuilding and offshore operations including fishing, shipping and oil and gas. There is potential for up to 20% of the UK's energy to be supplied by wave and tidal stream energy, which could contribute to avoidance of 30 million tonnes of annual CO2 emissions (MEPB, 2015).

The 100-MW deployment target for the sector may seem comparatively modest. However, it will see the technology evolve from concept to commercialisation. Based on the Contracts for Difference (CfD) model (2016), 100 MW of support would cost approximately £60 million annually, equating to 18p per UK household a month. Such investment would potentially unlock multimillion pounds worth of inward investment in the UK sector, which would solidify its global position (HIE, 2016).

The UK marine energy industry is already having a positive impact on the economy by bringing innovation, inward investment and new, skilled jobs into regions experiencing downturns in more traditional sectors such as shipbuilding, fishing, and oil and gas. By 2016, more than £0.5 billion of new, mainly private, investment came into the UK marine energy sector. Despite being comparatively new, the sector already supports 1700 jobs with the potential for this to expand to >20,000 jobs over the next decade. To date, investment of public money in major marine industry has been matched by private investment at a ratio of £1: £7 of which >77% has been spent within the UK supply chain. The global ocean energy industry could cumulatively contribute approximately £4 billion to UK gross domestic product by 2050 (HIE, 2016).

This positive economic benefit is a result of support from the UK government over the past decade, but the government needs to commit to continuing this support at a time when the first commercial schemes are being built (HIE, 2016). The UK faces competition from France, Ireland, Japan and Canada to capture this economic opportunity and there is a risk that it could lose its technology lead without appropriate policy support. This would be a repetition of how the UK lost its joint global lead in wind to Denmark, where the Danish government provided early market support mechanisms, enabling small manufactures to become global players.

The devolution of Scotland and Wales has allowed regional authorities to produce innovative strategies and support for marine renewable energy beyond the scope of UK-wide policy. For the millions of pounds of private sector money, and €100 million of EU-pledged support to be released, measures are needed for marine projects to be able to access revenue support, e.g., through the CfD mechanism (HIE, 2016).

Current challenges to technological progress include limited access to finance and a shortage of sites with affordable grid connections, which, coupled with uncertainties around UK market visibility in the long term have negatively impacted investor confidence (MEPB, 2015). The limited proof of the effectiveness of technological progress to date has further hindered investment, particularly for wave energy (Uihlein and Magagna, 2015). The combined effects of these issues became apparent in 2014, a challenging year for the UK sector marked by redundancies and restructuring with some wave energy companies entering administration (MEPB, 2015) because of downsizing and withdrawal of interest by investors in technological development (Uihlein and Magagna, 2015).

The UK currently leads the way in tidal technology development with several full-scale prototypes and array projects underway.

In 2016/17, Nova Innovation deployed the world's first offshore tidal array in the Bluemull Sound. The array features three 100-kW Nova M100 turbines, connected to Cullivoe Pier. The project supply chain for the initial 3 turbine deployment featured 100% EU content and 80% Scottish content, with 25% of supply chain expenditure in the Shetland Islands. Nova attributes the high local benefit from this project to the relatively small size of the M100 turbine, which allows it to use local companies for vessels, construction, transport and lifting services (Nova Innovation, 2017). Shetland Composites, a local company that used the Nova order to expand its production facility, supplied the blades thus demonstrating the local benefits of marine energy (Shetland Composites, 2015).

The MeyGen project, currently the largest planned tidal stream project in the world, has begun the first phase of the multi-turbine tidal array project in the Pentland Firth in Scotland using technology developed by Atlantis Resources and Andritz Hydro Hammerfest (Dreyer et al., 2017). Marine Current Turbines (acquired by Atlantis Resources in 2015) conducted extensive and testing and monitoring, particularly for marine mammals such as harbour seals (*Phoca vitulina*), over the seven-year deployment of its SeaGen tidal turbine in Strangford Lough, Northern Ireland (Dreyer et al., 2017).

The UK has the European Marine Energy Centre (EMEC) in Orkney, which has both full and small-scale testing capacity for wave and tidal developers to use (Dreyer et al., 2017). In 2016-18 a 2MW floating tidal device designed and operated by Scottish firm Scotrenewables (now Orbital Marine Power) generated more than 3GWh of electricity at the EMEC site (Orbital Marine 2018). At present, only a small proportion of announced and/or consented tidal energy projects have been commissioned in the UK, despite the Crown Estate leasing 26 tidal energy development sites with >1200 MW combined capacity (Uihlein and Magagna, 2015).

The UK tidal sector is an attractive investment prospect with extensive tidal technology, development experience and operational data from several pilot arrays, all of which is important in securing reductions in the LCoE. However, there is a need for the government to fund a new, sustained research and development programme for innovation in devices, components and enabling technologies to help drive down LCoE (MEPB, 2015). While the EU is providing significant funding (€30–100 million) for pilot to early commercial scale projects until 2020, the UK needs a revenue support mechanism to be able to leverage such funds as a market can only exist where there is potential to earn revenue (HIE, 2016), particularly after the UK expects to leaves the EU on 29 March 2019.

<u>Tidal energy in Wales</u>

Investments in tidal energy in Wales have contributed £35.8 million to the Welsh economy. Development of marine energy technology and associated Welsh projects have to date created more than 186 person-years of employment, which increases to 350 person-years of employment if relevant academic research is included. Between 2015 and 2017, the number of full-time-equivalent jobs increased from 36 to 101. The diversification of skills and accumulation of new expertise in the Welsh marine energy supply chain is evident from projects to date. In addition, several wave and tidal developers have proposed that 70%–80% of their supply chain will come from within Wales when their projects get to construction phase (Marine Energy Wales, 2017).

Anglesey Skerries was one of the first tidal array projects to be consented in the UK, and Anglesey has been of increasing importance for tidal energy development following the announcement of Minesto's commercial scale project in Holyhead Deep and the tidal demonstration zone. The demonstration zone will contain several <30-MW array scale projects amounting to ~100 MW of generation across the site (MarineSpace, 2015). EnFAIT partner Nova Innovation is a berth holder at the Morlais site and is also developing a 2 MW tidal array at Bardsey Sound, south of Anglesey.

<u>West Anglesey Tidal Demonstration Zone</u>

Menter Môn is the third-party manager for the Anglesey Tidal Demonstration Zone through Morlais Marine Energy. Menter Môn is a third-sector company spanning the private, voluntary and community sectors. It was established in 1995 to deliver EU rural development programmes. Its key objective is to facilitate economic regeneration on Anglesey (Menter Môn, 2017). Morlais has attracted £300,000 of funding from the Nuclear Decommissioning Authority and the Welsh Government, and a further £142,000 from Menter Mon, Isle of Anglesey County Council and Ynni'rFroinvestment (Morlais, 2017).

The 37-km^2 site, off the west coast of Anglesey, has a total cumulative production capacity of 120 MW (Tidal Energy Today, 2015).

Scottish Tidal Energy

Remote, small communities, such as those in the Scottish islands, can greatly benefit from projects that capture their significant and abundant resources such as marine energy (Okkonen and Lehtonen, 2016). The majority of UK tidal and wave resource is in Scottish waters with >50% of the available UK tidal resource in the Pentland Firth between mainland Scotland and Orkney (Johnson et al., 2013). Within the regional economies of Orkney, Shetland Islands and Outer Hebrides, much revenue comes from activities within the islands, e.g., public sector services, tourism, agriculture, aquaculture and renewable energy. However, a strong dependency on supply and export with the mainland remains and, despite tourism and marine renewable energy being growth sectors, there is heavy reliance on diesel for energy generation, particularly in the Shetland Islands (Okkonen and Lehtonen, 2016).

Since 2000, the UK government has had funding and schemes in place to promote community renewable energy, emphasising the community benefits in the form of economic regeneration and achieving low-carbon economies alongside social cohesion and acceptance (Okkonen and Lehtonen, 2016). Scottish marine renewable policies and financial incentives acknowledge the need for increased employment, income and regional economic gains in rural areas where declining traditional industries require diversification. In addition to policy support is the need for community action on renewables to sustain and direct local activity and engagement; there is scope for such action to connect EU and regional renewable policies through bottom-up, place-based approaches (Okkonen and Lehtonen, 2016).

4.3 Challenges and barriers

Technological, political and market barriers currently impede the development, deployment and optimisation of nascent ocean energy technology across Europe. The need to strengthen this ocean energy network to facilitate collaboration and overcome these barriers is key to maintaining Europe's leadership in research development and demonstration as the sector moves towards commercialisation (MacGillivray et al., 2013).

The Strategic Initiative for Ocean Energy (SI Ocean) consulted and engaged with industry representatives and stakeholders to identify gaps in knowledge and the technology needs of the sector. It went on to prioritise these sectoral needs as activities divided between responsibilities of government, industry and research as follows, while emphasising the need for significant cross-industry efforts to be made (MacGillivray *et al*., 2013). Needs were identified at a government, industry and research-level and comprised the following:

- Government: At European, member state and regional levels, there is a need to identify suitable mechanisms to support the development of devices and subcomponents, demonstrate their reliability and transfer and disseminate knowledge.
- Industry: Industry and supply chain leadership is needed to outline and develop solutions for the design and maintenance of devices, perform data collection, provide foundations and moorings, and assess offshore grid design and optimisation.

- Research: There is a need for fundamental research to underpin and develop state-of-the-art knowledge that would benefit novel system concepts, including resource analysis tools, techno-economic analysis tools, environmental monitoring and assessment, knowledge transfer and dissemination, and array interaction analysis.

Throughout Europe, marine energy resources are often strongest in areas where grid connection, infrastructure and port access are weakest. However, this issue has already been faced by more mature renewable technologies and solutions should be transferred (Badcock-Broe et al., 2014).

Barriers associated with the lack of suitable grid connections were for some developers, identified as a standout barrier under infrastructure for device developers. Further constraints come from environmental uncertainties, which can result in extensive, stringent ecological monitoring requirements; administrative bottlenecks in consenting due to a lack of uniform approaches at EU levels and lack of experience at many regional levels; and social impacts associated with poor engagement of communities (Uihlein and Magagna, 2015).

There is a need to streamline consenting processes and formulate protocols for environmental monitoring through strategic initiatives, coordinated research and data sharing to spread the consenting challenges across projects and developers. Three key areas for improvement across the EU have been identified to improve the process: improving environmental planning; simplifying consenting and environmental processes; and promoting best practice. Across member states, there is a responsibility for shaping the regulatory framework particularly within environmental and spatial planning directives. For example, Marine Scotland and the Marine Management Organisation have both provided ‘one-stop shops’ from which they coordinate with other regulators and stakeholders (Badcock-Broe et al., 2014).

It is necessary to overcome the challenges described above to demonstrate the sector is capable of large-scale technology production that would simultaneously improve energy security, reduce CO_2 emissions, propagate inward investment within the EU and move towards both 2020 and 2050 ocean energy deployment targets (MacGillivray et al., 2013). A forecast of progress towards the 2020 National Renewable Energy Plan (NREAPs) targets in 2015 predicted that only approximately 7% will be reached (Uihlein and Magagna, 2015).

Following the Commission’s Communication on Blue Energy in January 2014, the Ocean Energy Forum was established to draw together industry and public authorities to identify remaining challenges and actions needed in the form of the Ocean Energy Strategic Roadmap, which was finalised in November 2016 (EC, 2017). Four main actions were identified as having collective potential to reduce red tape for ocean technologies:

1. A European phase-gate scheme is required to validate sub-systems and early prototypes in less mature technologies that are aligned with funding resources.

2. A public-private investment support fund should be established to finance start-up capital needs.

3. An insurance and guarantee fund should help cover the risk associated with deploying a new technology.

4. Studies, research and actions on environmental consenting should help de-risk consenting procedures and allow the use of best practice and experience between member state authorities.

4.4 Lessons learnt from outside the EU

In the USA in 2007, Verdant Power piloted an array of small turbines as part of the Roosevelt Island Tidal Energy project in the East River, New York. The US Ocean Renewable Power Company led the Maine Tidal Energy Project which featured a single grid-connected turbine in Cobscook Bay (Dreyer *et al*., 2017). The Fundy Ocean Research Center for Energy in Canada began initial test deployments of tidal energy devices in 2016 (Dreyer et al., 2017).

In many countries, policy makers have become increasingly concerned with public acceptance of renewable energy policy as associated technologies are increasingly deployed in response to climate change issues (Devine-Wright, 2011). There is an opportunity in the USA, which currently remains at the research and development stage, to learn about attitudes to the development of tidal energy before projects move to commercialisation. This also provides scope to consider environmental, economic and social concerns as the technology develops. Such research can guide public policy creation in relation to the allocation of funding for marine energy innovation. In turn, long-term policy support and investment helps to attract the private investment needed to drive the sector forwards (Dreyer et al., 2017).

A study to measure public views towards tidal energy in Washington State in 2017 found views are positive overall, as indicated by high levels of both acceptability and support. These increased levels of acceptability and support were found to be associated with higher levels of perceived benefits and climate change beliefs, whereas these decreased with greater perceived risks associated with tidal energy (Dreyer et al., 2017).

The perceived risks and benefits of tidal energy affect the level of public acceptability and support for tidal energy policies and projects. The 2017 study also applied social science research to development lifecycle phases of tidal technology to consider how support for tidal energy varies along the innovation chain. The study outputs can be used to inform the development strategy for tidal energy in Washington State, as they show the public is most likely to support grants for laboratory-based research and development, and scaling of tidal technology with a grid-connected pilot phase over other phases of the innovation chain (Dreyer et al., 2017).

More broadly, this study of development pathways for renewable energy technologies demonstrates a need to incorporate environmental psychology perspectives and methods to provide insights to reducing investor uncertainty and maximise public support for the advancement of new energy technologies. Such research can provide valuable insight for public policy makers particularly in relation to funding by providing a better, evidence-based understanding of public support of technology along the innovation chain (Dreyer et al., 2017).

At a time when nations are pledging financial and political support for renewables in response to the Paris Agreement, it is important that funding aligns with societal preferences to attain market acceleration objectives. A separate Washington State study found that state residents are willing to pay well above public spending for tidal energy research and development initiatives. This discrepancy has been attributed to the concept that individuals consider non-market benefits of such investments, e.g., reducing carbon emissions and harvesting local energy sources that provide for both current and future generations (Polis et al., 2017).

The UK's competitors are setting aside considerable funds to drive the advancement of their marine renewable technologies forwards. For example, China recently announced, in a five-year plan to accelerate the development and use of ocean energy, that $363 billion will be invested in renewable energy by 2020. The plan looks to bring tidal, wave, OTEC and salinity gradient sources into the country's energy mix. Plans involve wave and tidal demonstration projects, including a new £200 million marine laboratory campus with a vision to create a Chinese version of EMEC with inputs to the feasibility study from EMEC (Tidal Energy Today, 2017).

4.5 Diversification of existing sectors

The supply chain for tidal energy offers significant scope for diversification of existing sectors, such as commercial fishing, where reductions in employment are significant. A range of required services have been identified that could potentially be provided by fishing vessels, including physical surveys, environmental surveys, metocean surveys, and construction and maintenance support. In addition to the diversification opportunity this offers the fishing community, it also has potential to benefit developers through cost reductions for vessels, as deployment is currently very costly (MarineSpace, 2015).

Following the trail blazed in Orkney and Shetland, marine service companies are transferring their commercial fisheries skills, knowledge and experience of working in harsh remote locations into the marine renewable energy sector. Based upon current vessel requirements and value of services for the Morlais Demonstration Zone, the economic value to be generated was estimated to be £3.5 million over 10 years if the project is developed as planned. Of this figure, approximately £400,000 would be over three years of the development phase, approximately £1.4 million during construction, and annual operation approximately £300,000 for 25 years. Additionally, services to other projects in the area were calculated to amount to a further £2.9 million over 10 years. Standards and competencies for vessels and crews have been identified and specified for this supply sector and the potential for collaboration between individual vessel operators to develop a one-stop shop for developers (MarineSpace, 2015).

Dafydd Gruffydd from Menter Môn said, "*One of our objectives is to ensure that the local supply chain is fully aware of developments and able to respond to the opportunity. The study identified work to the value of £3.5 million which could be delivered by fishermen utilising their skills, marine experience and vessels at their disposal*" (Tidal Energy Today, 2015).

5 Environmental and Socio-Economic Baseline

5.1 Environmental baseline

5.1.1 Physical Characteristics of the Marine Environment

Bathymetry

Around Shetland the seabed slopes steeply, reaching depths greater than 50m within 1km of the coastline. The seabed is roughly 100–120m in depth 10km from the shore (Doody, 1997). The depth of the numerous channels between islands varies considerably (Howson, 1998).

The Bluemull Sound is a tidal channel between the islands of Yell and Unst, with a maximum depth of 50m. The bathymetry of the Bluemull Sound is shown in Figure 5.1.

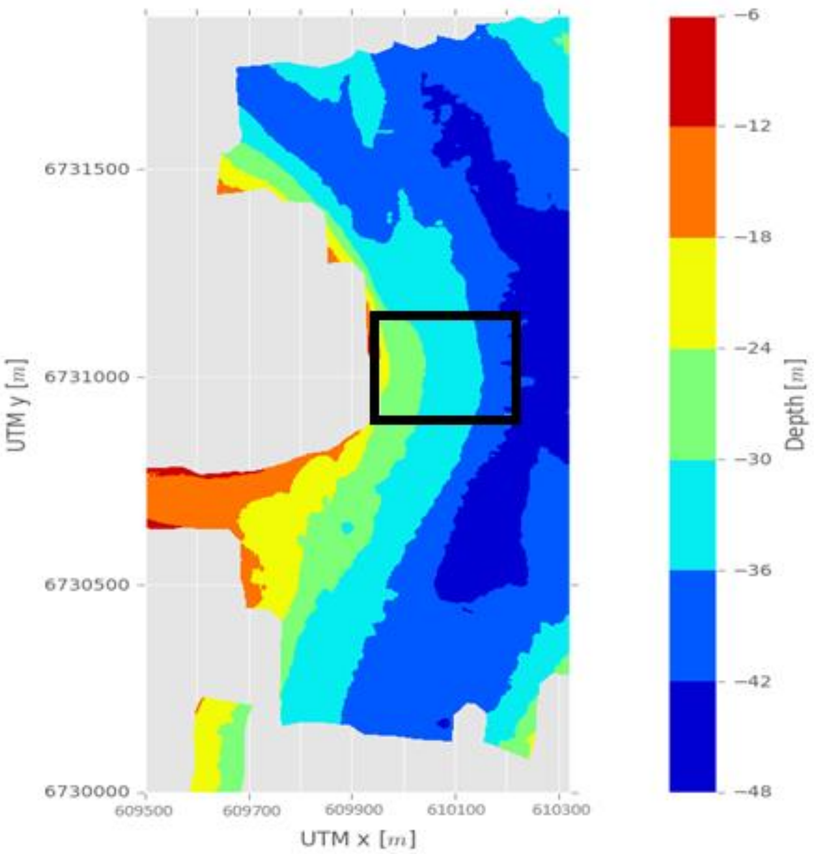


Figure 5.1. Bluemull Sound bathymetry. The lease area in which the array is situated is depicted in black
Source: Medina-Lopez, 2018

Currents and waves

Around Shetland tidal currents can be strong; in some areas they are intensified to tidal streams with speeds as high as 3.5–4.5m/s (Baxter *et al.*, 2011). Tidal streams were modelled for SIC in 2011, with the overall maximum velocity generally low around Shetland (0–0.6m/s). However, stronger currents were present around Sumburgh Head, Muckle Flugga and through the Yell and Bluemull Sounds (Halliday, 2011). Modelling completed for EnFAIT shows that surface current speeds can reach a maximum of 3m/s in Bluemull Sound (Figure 5.2).

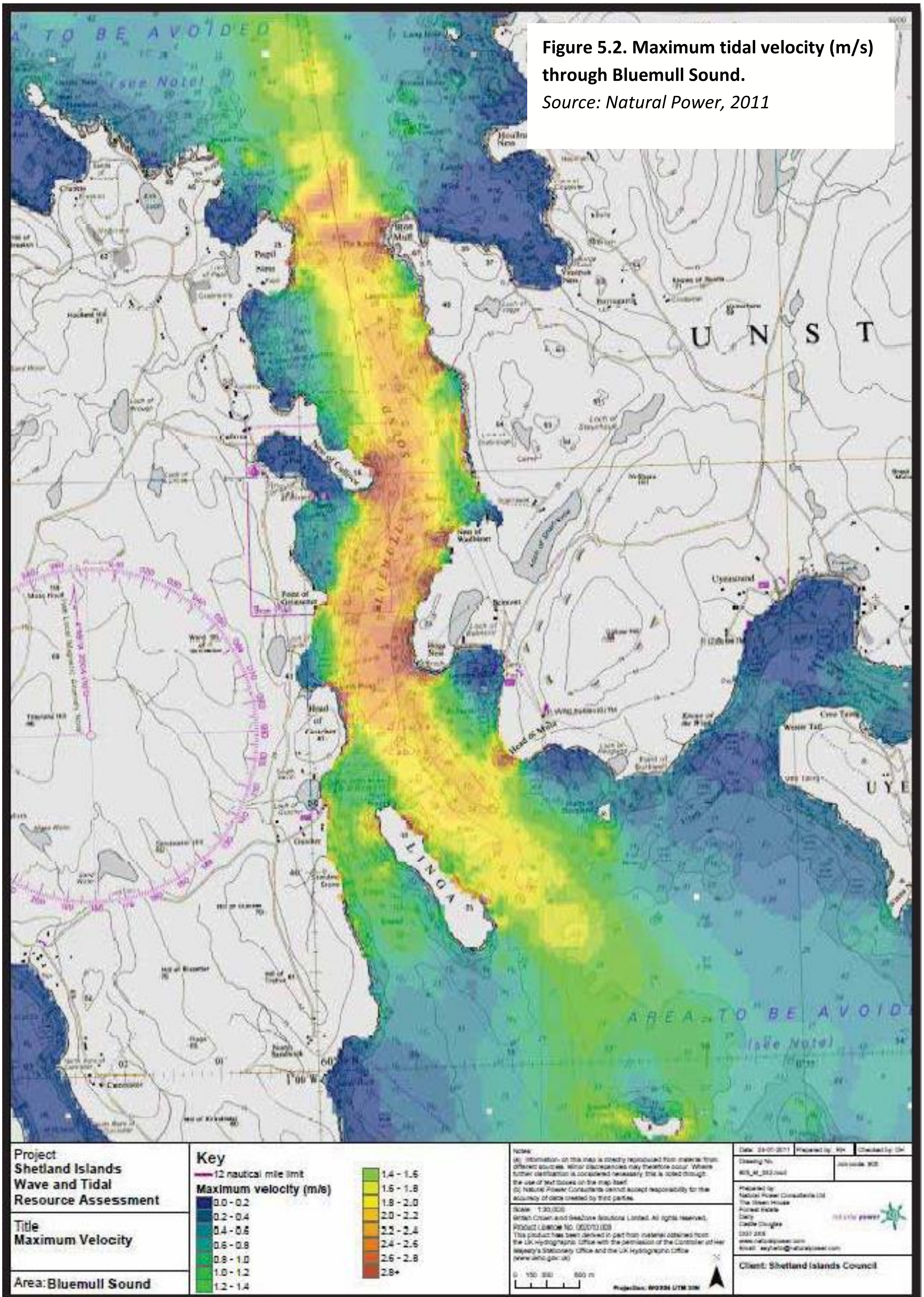


Figure 5.2. Maximum tidal velocity (m/s) through Bluemull Sound.
Source: Natural Power, 2011

With the wind direction predominantly from the south-west, Shetland is particularly exposed to the weather systems of the North Atlantic. The extended areas of open ocean to the west allow a powerful wave climate to develop, with large regular waves (swell) and wind-driven seas (Baxter *et al.*, 2011; Halliday, 2011).

Broadly, Shetland has western and eastern facing wave climates, with larger waves on the exposed western coast. Modelled mean annual wave height close to shore on exposed coasts is 0.6–1.2m, while in voes and sounds it is only 0.2–0.8m. Bluemull Sound was modelled within the western facing wave climate, although it is well sheltered from wave action and has a mean annual wave height of 0.2–0.6m (Halliday, 2011).

5.1.2 Marine and Coastal Biodiversity

Seabed and shoreline ecology

In Bluemull Sound, the intertidal zone between high and low tides comprises predominantly rocky shores, with communities of brown seaweed (e.g. channel wrack, spiral wrack, bladder wrack, serrated wrack and egg wrack) with some small sandy beaches. There are also a few saltmarshes along the Yell coast (Wilding *et al.*, 2005, Shucksmith, 2017).

In permanently submerged (subtidal) areas, the strong tidal streams present in Bluemull Sound result in a variety of tide-swept algal communities (Irving, 1997; Howson, 1998). The central channel, closest to the turbine array, is dominated by rocky outcrops, and a kelp forest is present to depths of around 20m (Wilding *et al.*, 2005). The kelp communities support a variety of biodiversity including red seaweeds, sponges, sea squirts, anemones, sea stars and molluscs (Shucksmith, 2017).

The northern end of Sound has steeply sloping bedrock with particularly strong tidal currents and surges, with fields of a type of soft coral (dead man's fingers) and associated organisms including sponges, sea squirts and sea anemones (Howson, 1998; Wilding *et al*., 2005). Pebbles and cobbles covered with a sea-fir (hydroid *Sertularia argentea*), are present in deeper water, while a tide-swept cobble and bedrock slope is present in the southern entrance to the Sound, supporting horse mussel beds, dead man's fingers and brittlestars. Horse mussel and brittlestars are also present on the mixed sediment found in areas with weaker tides (Irving, 1997; Howson, 1998; Wilding *et al.*, 2005). In the eastern approaches to the Sound, the seabed is mixed sediments, and includes the largest bed of maerl (a calcareous algae) in Shetland (Irving, 1997; Wilding *et al.*, 2005).

Shellfish of commercial importance are likely to be present in the edges of the Bluemull Sound, including edible (brown) crab, velvet swimming crab, and lobster. Across Shetland, creeling grounds are important although not that prevalent in the Bluemull Sound area (Shucksmith, 2017; SIMSP, 2015). King scallops (*Pecten maximus*) are found on sandy/gravelly substrates and may also be present (Shucksmith, 2017). The stocks of crabs and lobster are thought to be stable or increasing based on landings per creel (Shucksmith, 2017).

Fish

Sharks, skates and rays

There have been 30 species of sharks, skates and rays (elasmobranchs) recorded in Scottish waters, 25 of which occur in coastal waters. Three of the seven species listed as priority marine features for Scotland are found within the Shetland region: basking shark, common skate and spiny dogfish (Shucksmith, 2017). There is insufficient data to assess population trends and distribution of these three species around Shetland (Shucksmith, 2017).

There are recorded sightings of basking sharks in the Bluemull Sound, mainly to the south of the Sound (SIMSP, 2015). Lesser-spotted dogfish, common skate, and various ray species (cuckoo, spotted, thornback) were caught each year between 2011 and 2014 during inshore fish surveys of Shetland waters (Napier, 2011, 2012, 2013, 2014) and so are likely to also be present in the Bluemull Sound.

Bony fish

Bony (teleost) fish include several commercial importance. Key midwater ('pelagic') species are herring and mackerel while those found on or near the bottom ('demersal') include cod, haddock, whiting, saithe, plaice, lemon sole, megrim, monkfish and hake (Macdonald and Napier, 2014; Napier, 2011, 2012, 2013, 2014; Shucksmith, 2017). Schools of Atlantic pollack (*Pollachius pollachius*) have been recorded near Cullivoe during underwater video surveys (Smith, 2018).

The mackerel stock present around Shetland is deemed to be in good health, while the herring stocks are less so (Napier, 2017; Shucksmith, 2017). Trends for demersal stocks vary; cod, saithe, and plaice spawning stock biomass (SSB) has increased in recent years, haddock SSB has fluctuated, while whiting has remained close to average SSB (Napier, 2017). Sandeels are present in Shetland inshore waters and are an important prey species for many fish, birds and marine mammals; while they are not commercially exploited locally, they are in decline (Shucksmith, 2017).

Two species of anadromous fish (those that migrate up rivers from the sea to spawn) are also found around the Shetland coast: with brown/ sea trout present in lochs and burns, and Atlantic salmon (*Salmo salar*) also present, although as Shetland does not have large rivers very few salmon enter the burns to spawn. Some Atlantic salmon are thought to be present in the Burns and Loch of Gutcher (*c.*3 km from the turbine array), and the Burn and Loch of Snarravoe (*c.*1.2 km distant), however. There is also insufficient data to assess population trends for either species, although sea trout numbers are considered lower than historic levels (Shucksmith, 2017).

Marine mammals

Whales, dolphins and porpoises (cetaceans)

Cetacean species are protected under Annex IV of the EU Habitats Directive and most are also UK Biodiversity Action Plan (BAP) Priority species.

The waters around Shetland are diverse in terms of cetaceans, with up to 22 species recorded, 8 of which are regularly seen, while the others are rare visitors (Shetland Heritage, 2012). Common cetaceans include the harbour porpoise, white-beaked dolphins and minke whales, while occasional visitors include Atlantic white-sided dolphins, sperm whales and fin whales (Shetland Heritage, 2012). The distribution of cetaceans around Shetland in space and time is poorly understood (Shucksmith, 2017).

Within Bluemull Sound the most commonly reported cetacean was the harbour porpoise. Killer whales and Risso's dolphins have also been sighted (SIMSP, 2015). Humpback whales have been sighted in the Sound and along the east coast of Yell in recent winters, with four individuals seen just south of Bluemull Sound in December 2016 (Shetland Times, 2017).

Surveys of the area between May 2017 and April 2018 recorded harbour porpoises throughout the year, while minke whales were seen between November 2017 and January 2018 (Smith, 2018). Other species may be present as the Bluemull Sound is thought to be an important foraging area (Shucksmith, 2017).

The known seasonality and observed group sizes around Shetland are shown in Table 5.1, for the species commonly recorded in Bluemull Sound.

Table 5.1. Peak sighting months and group sizes around Shetland for five cetacean species most commonly reported in Bluemull Sound

Common Name	Peak sightings	Group Size
Harbour porpoise	July to October	1–3
Risso's dolphin	April to November	5 –20
Killer whale	June and July	1–15
Minke whale	July to September	1–15
Humpback whale	June and July	1–2

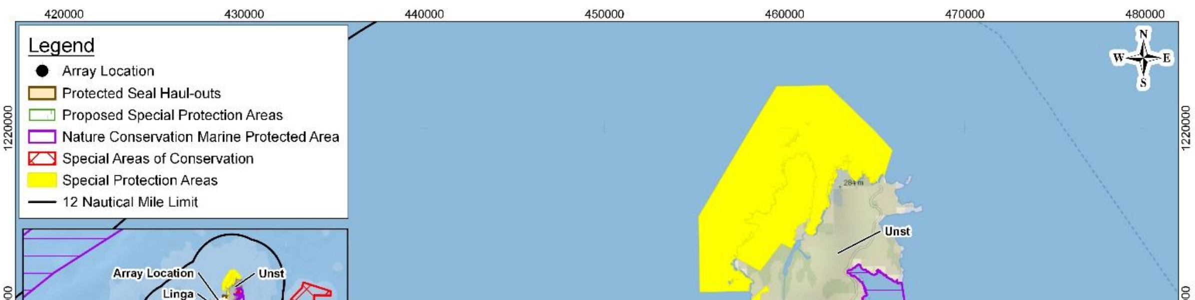
Sources: Bolt et al., 2009; Deecke et al., 2011; Sea Watch Foundation, 2012.

<u>*Seals*</u>

Shetland is nationally important for two species of seal; the common or harbour seal and the grey seal and is home to 15% and 2.5% of the UK populations respectively (Shetland Island Council, 2017). Both species breed on Shetland and are protected under Annex II and IV of the EU Habitats Directive, while the harbour seal is a BAP Priority species.

There are protected haul-out sites for both species of seal around Shetland (Figure 5.3). Two of the protected haul-out sites are in the area surrounding Bluemull Sound: one on the northwest coast of Unst (*c*.2.5 km from turbine array), and one on the northwest tip of Fetlar (*c*.8.5 km).

Figure 5.3. Protected areas around Shetland



In the latest (2015) August count of hauled-out harbour seals in the Shetland Seal Management Area, 314 seals were counted on Yell, 51 on Unst and 80 on Fetlar (Shucksmith, 2017). Harbour seals are the most commonly sighted seal in Bluemull Sound, although grey seals are seen regularly as the southern end of the Sound is identified as an area of high foraging effort for both species (Shucksmith, 2017).

There are records of vagrant Arctic species with the most common visitor the bearded seal. Within the Bluemull Sound, a ringed seal was recorded at Cullivoe in 2001 (Shetland Sea Mammal Group).

Otters

Shetland has one of the highest densities of otters in Europe, and an estimated 800–1000 individuals, approximately 12% of the UK population (SIC, 2017a). Otters are sighted year-round and are seen most regularly along the Yell Sound coast, and along the Bluemull Sound coast, into Colgrave Sound around the island of Hascosay (SIMSP, 2015). They are generally seen singly or in small groups, usually of a mother and one or two cubs.

Otters are protected under Annex II and IV of the EU Habitats Directive and are a BAP Priority species. Their typical dive depth is approximately 3m (Nolet et al., 1993).

Birds

Wild birds in Shetland are protected under the EU Birds Directive and the Wildlife and Countryside Act 1981.

Shetland has multiple internationally important colonies of breeding seabirds with 23 species known to breed in Shetland (Shetland Heritage, 2013; Shucksmith, 2017). Internationally important wintering populations also occur, including eider ducks, red-throated divers, long-tailed ducks, and red-breasted merganser (Shucksmith, 2017). Internationally important breeding populations of waders and/or waterbirds are included in the qualifying features for the Fetlar SPA (*c.*4 km from the turbine array at its closest point), including colonies of red-necked phalarope, dunlin and whimbrel (JNCC, 2001).

Bluemull Sound supports colonies of breeding birds along its coastlines. The largest breeding colonies present are of Northern fulmars. Smaller colonies of cliff breeding birds (black guillemot, kittiwake, manx shearwater, puffin, razorbill and common guillemot, European shags and cormorants, and Arctic and common terns are also present along the coast.

Colonies of breeding Arctic and great skua are found across most of Yell and Unst, with some along the Bluemull Sound coast. In the southern Bluemull Sound area colonies of breeding gulls (black-headed, common, great and lesser black-backed and herring) and European storm petrels are also present (SISMP, 2015).

The Bluemull Sound area is also an important foraging area for breeding red-throated divers. The islands of Yell, Unst and Fetlar supported 194 pairs in 2006, and they forage in shallow coastal waters, including Bluemull Sound, within 9 km of their nesting sites (Philip, 2016). As a result, the area, which includes the turbine array, is a proposed SPA: Bluemull and Colgrove Sounds.

Surveys of Bluemull Sound during the 2011 and 2012 breeding seasons observed common guillemots, black guillemots, shags, puffins and Northern gannets most frequently (Robbins *et al.*, 2013, 2014). Moderate numbers of puffin, arctic tern, gannet and red-throated diver were observed during breeding season, while other species including red-breasted merganser and great black-backed gull were observed infrequently (Smith, 2018).

Several important wintering species are present in Bluemull Sound. Large flocks of long-tailed duck and red-throated diver have been recorded in the southern section of the Bluemull Sound, while small flocks of Slavonian grebe have been recorded in the northern part of Bluemull Sound (SIMSP, 2015). Eider ducks are present in the Bluemull Sound area during the moulting season and during winter, where they were attracted to salmon cages (Heubeck and Mellor, 2013; Shucksmith, 2017).

Black guillemots and shags were the most frequently observed birds during a non-breeding season survey in January 2012 (Robbins *et al.*, 2013, 2014) and during monitoring of Bluemull Sound between May 2017 and April 2018, with black guillemots the most abundant species (Smith, 2018).

Population estimates are not available for Bluemull Sound itself, but seabird populations have declined throughout Shetland since the Seabird 2000 census, except for gannets and black guillemots (Shuckmith, 2017). In Shetland there are currently an estimated:

- 4,600 eider ducks (Heubeck and Mellor, 2013; Shucksmith, 2017)
- 400 pairs of red-throated diver, 40% of the UK population (SIC, 2017a)
- 39,000 pairs of gannets, 12% of the UK population (SIC, 2017a)
- 16,000 adult black guillemots, 41% of its UK population (SIC, 2017a)
- 80,800 attendant adult common guillemots (Shucksmith, 2017)
- 50,000 pairs of puffins, 10% of the UK population (SIC, 2017a)
- 6,000 pairs of shags, 21% of the UK population (SIC, 2017a).

<u>Protected Sites</u>

Areas designated for nature conservation around Shetland are shown in Figure 5.3. These include 12 Special Protection Areas (SPA), 3 proposed SPAs, 12 Special Areas of Conservation (SAC) and 2 Nature Conservation Marine Protected Areas (NCMPA) within the 12-nautical mile limit.

Two protected areas lie within the Bluemull Sound:

- the Fetlar to Haroldswick NCMPA was designated in part due to the importance of the area for foraging black guillemots, and the presence of maerl and horse mussel beds (SNH, 2017)
- the Fetlar SPA supports a variety of breeding and wintering birds included on Annex I of the EU Birds Directive, as well as hosting a seabird assemblage of international importance (JNCC, 2001).

A third protected area will lie within the Sound if the Bluemull and Colgrave Sounds proposed SPA for red-throated divers is adopted.

5.1.3 Water Quality

In a review of long-term monitoring of Shetland seas, Dawson *et al.* (2011) noted an overall temperature increase of approximately 1.5˚C in winter and of approximately 0.5˚C in summer between 1900 and 2009. The average winter sea surface temperature (SST) in 2009 was 7.9˚C and the average summer SST was 13.1˚C (Dawson *et al.,* 2011).

The mean annual salinity at the sea surface is just over 35 ppt in the sea surrounding Shetland (Baxter *et al.*, 2011). The water is classified as well-mixed oceanic water in winter and weakly stratified oceanic water in the summer (Connor *et al*., 2006).

The Scottish North Sea has lower concentrations of suspended sediment than the southern North Sea. The modelled turbidity for the waters around Shetland is *c.*5 mg/l (Baxter *et al.*, 2011).

Under the EU Water Framework Directive and according to the Scottish Environmental Protection Agency (SEPA) waterbody classification, the coastal waters around Shetland were classified as good in 2016 (Marine Scotland, 2017). In general, water contaminant concentrations are low, with an improving trend and few concerns about quality (Shucksmith, 2017).

5.1.4 Sediment Quality

Concentrations of contaminants in sediment are low, with metal concentrations in Shetland lower than elsewhere in Scotland (Shucksmith, 2017). There is insufficient data available to determine trends in contaminants around Shetland.

5.1.5 Underwater noise

Underwater noise is a combination of noise from natural, including waves, weather and animals and anthropogenic sources. Anthropogenic noise has the potential to impact marine species through the masking of acoustic cues, physical trauma, habitat displacement or behavioural changes.

In Shetland and at Cullivoe Pier anthropogenic noise sources include shipping, fishing, occasional dredging, marine recreation and acoustic deterrents (particularly for aquaculture). There is currently insufficient data to assess trends of underwater noise around Shetland, and it is unknown whether it is at a level that will impact marine life.

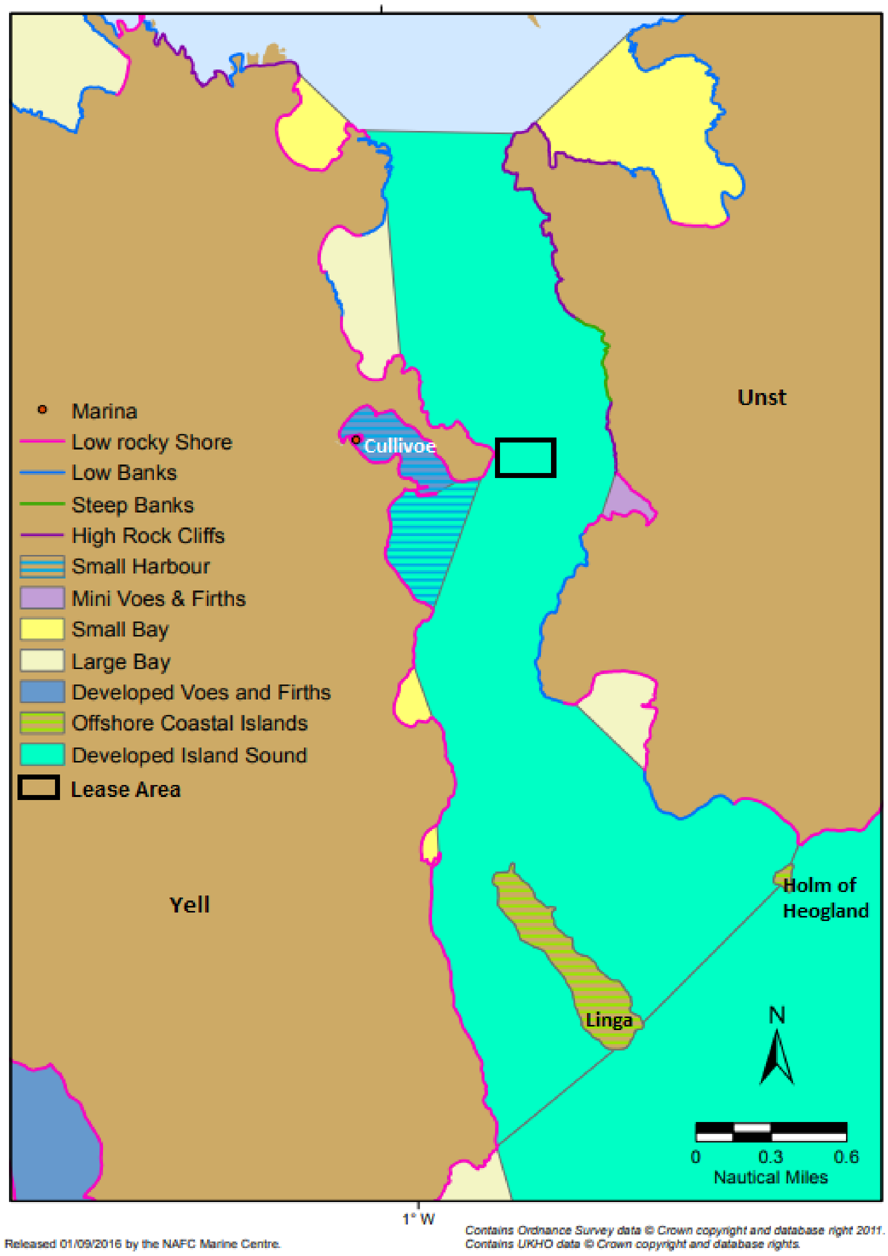
Within Bluemull Sound vessels are the most common source of underwater noise. There is small scale fishing through the Sound and the harbour at Cullivoe is used for landing catch (NAFC Marine Centre, 2016a), as well as the docking of small recreational vessels (SIC, 2018a). A ferry runs daily between Gutcher on Yell, Belmont on Unst and Harmars Ness on Fetlar (SIC, 2018b). Vessels used to service the aquaculture developments are also commonly present as there are four finfish sites and one shellfish site in the southern half of the Sound with a shore base at Cullivoe. Due to the presence of aquaculture in Bluemull Sound, there is also the potential for acoustic deterrents in the area (NAFC Marine Centre, 2016a). Cullivoe harbour is a busy fishing port, ranked 13th in the UK for whitefish landings (NAFC, 2017) with the icehouse on the pier and nearby fish processing plant at Mid Yell attracting fishing vessels.

5.1.6 Seascape

The seascape of Shetland has been formed over millions of years, creating a diverse and unique environment that is an intrinsic part of island life. There are 2 seascape character types which have been mapped at a regional level – low, rocky island coasts and remote high cliffs – while at a local level, 12 coastal character types (CCT) have been identified. These include developed and undeveloped voes and firths, developed and undeveloped island sounds, bays, islands, exposed coast and harbours (NAFC Marine Centre, 2016a; Shuckmith, 2017).

The Shetland coastline has been divided into 43 coastal character areas and the Bluemull Sound is one of them. The coastal character types of the Bluemull Sound are shown in Figure 5.4. The entire Sound is a Developed Island Sound, with various piers along both coasts and numerous aquaculture developments. Cullivoe has a small marina and pier infrastructure, and a mussel site at the mouth of the voe. Linga was inhabited at one time, while the Holm of Heogland is a tidal island connected to Unst at low tide with evidence of a settlement on the island (NAFC Marine Centre, 2016a).

Figure 5.4. The coastal character types of Bluemull Sound coastal character area
Source: Adapted from NAFC Marine Centre, 2016a



5.1.7 Marine Archaeology

Around Shetland there are approximately 1200 wrecks of boats, ships, submarines and aircraft, but only a few sites are known in detail. The wrecks of two 17th century ships, the Dutch East Indiaman *Kennemerland* and the Danish warship *Wrangels Palais*, are encompassed in the Out Skerries Historic Marine Protected Area (MPA) (Historic Environment Scotland, 2015). There is also high potential for new submerged sites or deposits of archaeological interest, as there are areas of drowned terrestrial sites and cultural landscapes (SIMSP, 2015; Shuckmith, 2017).

There are fifteen known wreck sites within the Bluemull Sound itself, although locations are only tentative (PastMap, 2018). Around Cullivoe there are two wrecks, both just north of the Ness of Cullivoe approximately one kilometre from the turbine array (PastMap, 2018; SIMSP, 2015); the 17th century Dutch East Indiaman *Lastdrager* (Canmore, 2018a,b) and the 19th century ship *Harmonia* (Canmore, 2018c). There were also two 19th century wrecks in Snarra Voe, on the opposite side of the Sound to Cullivoe

(PastMap, 2018; SIMSP, 2015); the ketch *Equestrian* (Canmore, 2018d) and the barque *Fanny M Carrill* (Canmore, 2018e).

Although there are numerous wreck sites, Bluemull Sound is not considered to be an area of submerged archaeological potential (SIMSP, 2015).

5.2 Socio-economic baseline

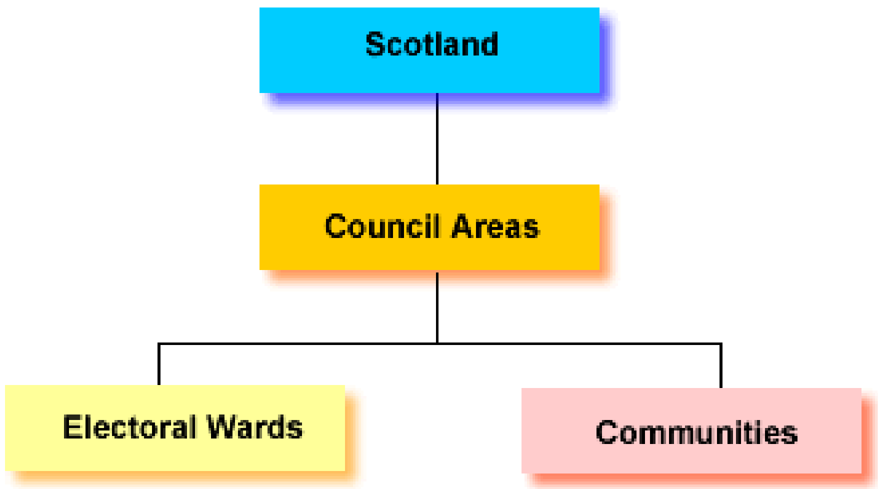
5.2.1 Governance and administration

Shetland is a North Atlantic archipelago that is the most northerly part of the British isles and a sub-national jurisdiction of Scotland (Grydehøj, 2013). Shetland is served by a devolved Scottish government, headed by the Scottish first minister who is formally nominated by the Scottish parliament and appointed by Her Majesty the Queen.

While Scotland is part of the United Kingdom of Great Britain and Northern Ireland, a significant amount of legislative power has been devolved to the Scottish Government (Scottish Government, 2015). The Scottish Government runs the country in relation to matters that are devolved from the UK Government in Westminster, such as health, justice, rural affairs, equal opportunities, local government, transport and taxation (Scottish Government, 2018a). Other matters, including energy policy, foreign policy and defence, are dealt with centrally by the UK government. Consequently, the responsibility associated with the provision of energy across Shetland lies with Westminster.

The administrative structure of Scotland is outlined in Figure 5.5.

Figure 5.5: Administrative Structure in Scotland



Source: ONS, 2018

Local Government

Local authority areas (or council areas) play an important role in the devolved government of Scotland. Local authorities are autonomous bodies, independent of central government control that are responsible for delivering essential public services in areas such as education, social care, housing and planning, environmental protection and waste management (Scottish Government, 2018b).

There are thirty-two local authority areas in Scotland, each representing a particular geographical region (Campbell and Burrowes, 2016). Scotland's three island communities of Orkney, Shetland and Comhairle nan Eilean Siar are the least populated local authority areas (ibid.).

SIC is the local authority for Shetland and has full control over all developments around the Isles (Tallack, 2007). SIC is made up of 22 elected councillors serving on seven electoral wards (see Figure 5.6). Six out of the seven electoral wards in Shetland are represented by three councillors, while Lerwick South ward has four councillors. Shetland councillors act as policy makers and carry out strategic and corporate functions. They bring local people's views into the council's decision-making process, deal with individual casework on behalf of constituents and assist in resolving community concerns or grievances.

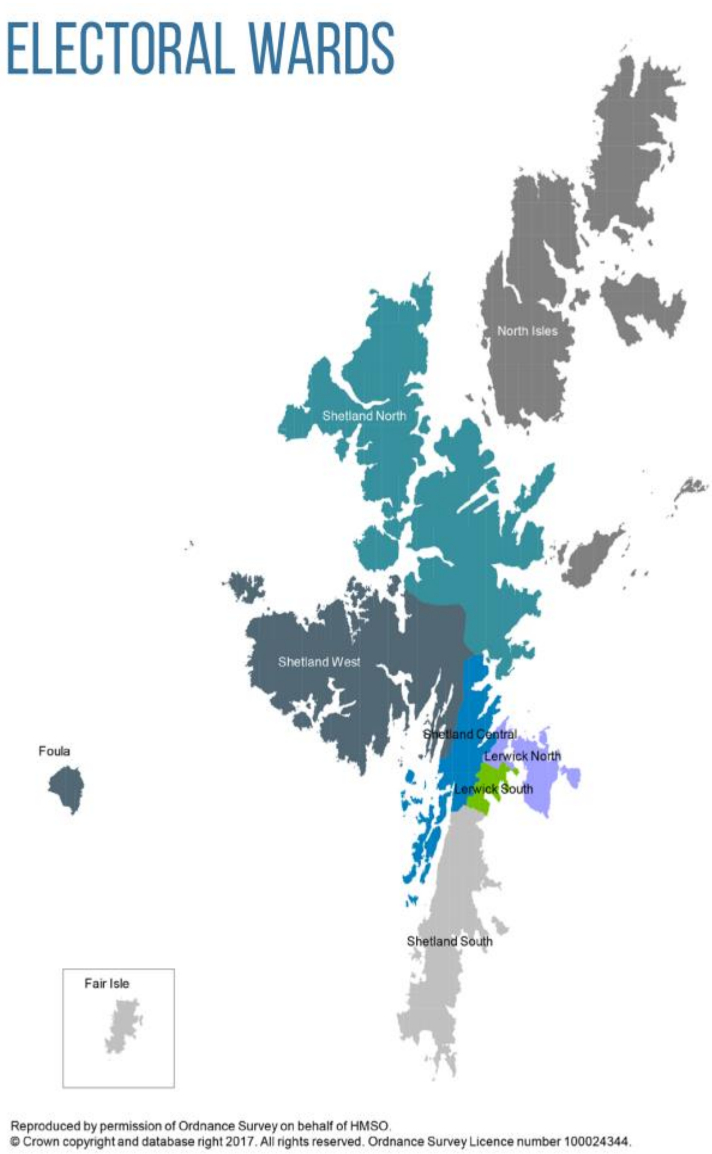


Figure 5.6: Electoral Wards in Shetland
Source: Local Government Boundary Commission for Scotland (2017)

SIC is primarily funded through a block grant from the Scottish Government, which amounts to around 85% of its net revenue expenditure. Additional funding comes from council tax on residential property, charges for local government services (such as car parking fees and income from social care services) and rent from council housing (Scottish Government, 2018c). The main administrative centre of Shetland and the location of the SIC headquarters is the town of Lerwick on Mainland.

SIC is headed by a leader who is elected by other SIC members. In addition to the council leader, SIC members elect a civic head. The civil head in Shetland is the Convener, who represents the islands at civic and ceremonial events at home and further afield. The Convener chairs SIC meetings, facilitates debate, and where possible, enables the council to reach a consensus view (The Scottish Parliament, 2018).

There are also 18 community councils (CC) in Shetland. CCs are voluntary bodies established within a statutory framework. They represent the most local tier of elected representation and play an important role in local democracy by representing local views which can influence decisions on planning and the provision of local services (SIC, 2018d). Many CCs receive council area funding for running costs only and rely on voluntary work and fund-raising. CCs can, however, obtain grants for specific scheme (ONS, 2018a).

5.2.2 Demographics

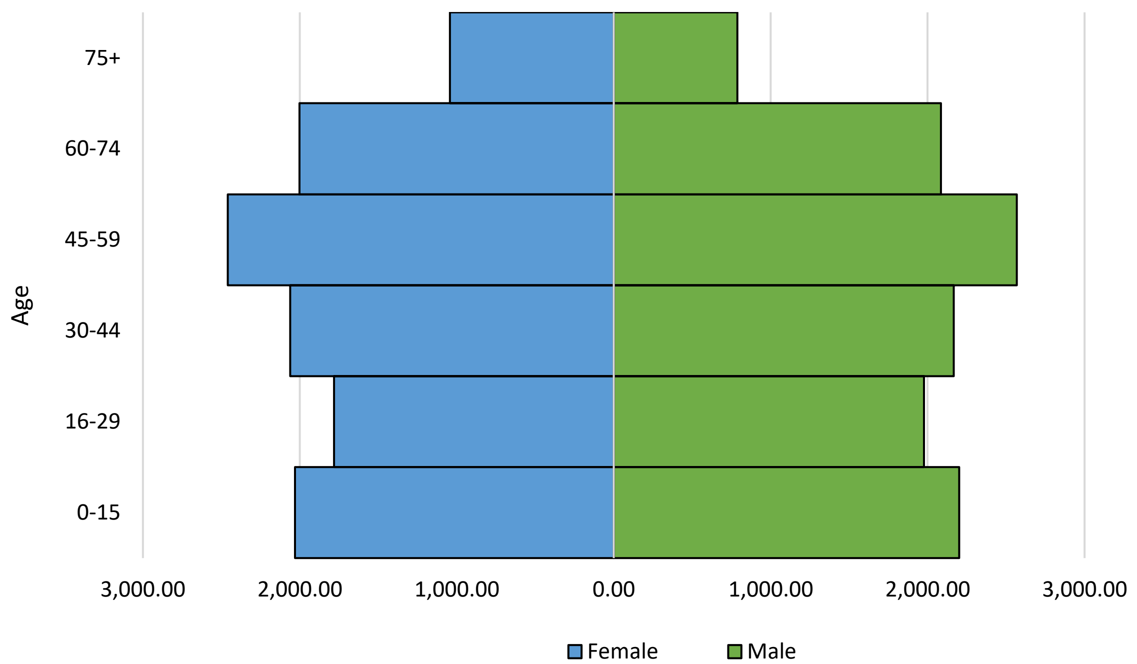
Shetland is an island archipelago made up of more than 100 islands and islets, 16 of which are inhabited. The islands are situated approximately 160 km from mainland Scotland, 280 km south-east of the Faroe Islands and 320 km west of Norway (NAFC, 2017a).

There are four main islands on Shetland: Mainland (899km2), Yell (212km2), Unst (120km2) and Feltar (38km2) (Shetland 2018a). Around 80% of the islands' total population of 23,080 (NRS, 2018) resides on Mainland, mostly living in the capital Lerwick (McHattie *et al*., 2018).

In 2017, the total population of Shetland was 23,080 (NRS, 2018), which is approximately 0.4 per cent of Scotland's total (SIC, 2017a). There was no recorded change in the population of Shetland between 2015 and 2017, and in the long term (to 2039), the population is predicted to remain stable at approximately 23,000 (NAFC, 2017a).

Figure 5.7 shows the age profile of Shetland. *Source: SIC, 2017a*

Figure 5.7: Age Profile of Shetland



er than in Scotland where 18% are aged 16 to 29 years (SIC, 2017a). Persons aged 60 or over constitute 26% of the population in Shetland, which is larger than in Scotland where the figure is 24% (ibid.). Shetland's aging population means that the islands are beginning to suffer from a demographic imbalance. To redress the impact of the aging population, Shetland needs to attract upwards of 1400 working age people by 2028 (Shetland News, 2017).

Migration

Shetland is used to migration flows and large numbers of travelling workers have been required to undertake various oil and gas related projects, to develop the extensive reserves of oil and gas in the West Shetland basin (HIE, 2015).

Out-migration is currently greater than in-migration. Between 2013 and 2015, Shetland recorded a net outflow of 40 people per year, meaning that fewer people entered Shetland (677 per year) than left (717 per year) (SIC, 2017a). 16 to 29-year olds were the largest group of out-migrants (SIC, 2017a). Shetland has experienced a steady out-migration of people from remote and rural communities towards its main centres of population (HIE, 2018a) which is negatively impacting rural areas. More affordable housing is needed for Shetland to attract new people to the islands and to grow the local workforce (Marter, 2018), particularly in the North Isles which offer relatively fewer housing and employment opportunities for young people (Cope, 2018).

North Isles

The North Isles of Yell, Unst and Fetlar have a combined population of 1659 (SIC, 2017a). There are some differences between the age profiles in the Unst and Yell population, but the actual numbers are small (Kerr *et al*., 2017).

Yell is the largest of Shetland's North Isles at 83 square miles (133km). It is 17 miles long (27km), 7 miles (11km) wide and has three main settlements, Burravoe in the south, Mid Yell in the centre and Cullivoe in the north (SIC, 2007). Mid Yell lies along a voe, an inlet from the sea, and has a sheltered harbour which has led to its growth as the main settlement of the island.

The residents of Yell and Unst have access to job opportunities and local services. However, forecasts suggest that these population will decline in the years ahead, due to the higher proportion of older people and a slightly smaller population of working age (Kerr *et al*., 2017).

5.2.3 Economy and livelihoods

Economic activity in Shetland is very strong, with high employment and a productive business base (SIC, 2017b). The latest Shetland Regional Accounts recorded local economic output at well over £1 billion. The economic activity rate[3] is over 88%, and the out-of-work benefit claimant count is less than 0.7% (SIC, 2017b). However, it is common for unemployed people in Shetland to migrate to mainland Scotland in search of work, and this must be taken into account when considering the islands' low unemployment rate. Worker's wages are favourable, with average annual earnings for full-time workers in Shetland at £32,623 in 2015, 6% higher than in Highland, which was the next highest of the Highlands and Islands local authorities (HIE, 2015). The islands also enjoy the fifth highest Gross Value Added (GVA) per head of all Scottish local authorities, behind only Aberdeenshire and the country's three main cities (SIC, 2017b). The main sources of revenue in Shetland are fishing and aquaculture, the petroleum industry (crude oil and natural gas production), agriculture, the creative industries and tourism.

[3] The economic activity rate is the number of 16-64-year-old people in work.

Fishing and Aquaculture

Shetland is surrounded by some of the richest fishing grounds in the world (SIC, 2017b), and the marine and coastal environment is central to the sustainability of the Islands' economy. Fishing is Shetland's biggest industry; the sector supports a diverse range of employment opportunities including fish catching, fish processing, marine engineering, marine transport, oil support services and tourism (SIC and NAFC, 2015).

The aquaculture sector has also become a major industry in Shetland and represents one of Shetland's largest employers, with almost 500 full-time employees working in salmon and shellfish production alone (HIE, 2017). At the time of writing, Shetland produces around one third of Scotland's salmon as well as 90% of its mussels (NAFC, 2017a). Shetland's aquaculture industry attracted over £17.8 million in capital investment in 2014, paid out £12.9 million in salaries and fostered a local industry spend (on all services required to support production) of roughly £30 million (FFE, 2018).

Collectively, Shetland's fishing and aquaculture industries contribute approximately £330 million per year to the local economy (more than oil, agriculture, knitwear & tourism combined). The industries directly employ more than 1000 local people, and indirectly support many more jobs and businesses. The total value of Shetland's maritime sector is about £650 million, almost two-thirds of the total value of the economy (NAFC, 2017b) This outpaces the more recently established oil industry several times over (Miller, 2018).

North Isles

Although most fishing in Shetland occurs around mainland, with Lerwick Harbour being one of Britain's main centres for the landing, selling, processing and shipment of seafood, fishing and aquaculture also represents an important livelihood strategy in the North Isles.

Cullivoe harbour in North Yell is the closest designated landing port to the rich fishing grounds to the north of Shetland. The port has recently upgraded its pier facilities and has seen increased whitefish landings in recent years and salmon farming (SIC, 2018c). Cullivoe harbour has a number of charter fishing boats that cater for both tourists and locals. In 2003, the North Yell Development Council (NYDC) opened the Cullivoe Harbour Industrial Estate which provides a key facility for local businesses.

Aquaculture predominantly takes place across the voes and sounds throughout Shetland; it is another cornerstone of the local economy on the island of Yell, and there are a growing number of businesses in the sector. Cooke Aquaculture operates a salmon processing facility in Mid Yell that can process all the salmon the company produces in Shetland (FFE, 2016). The processing facility is the largest employer on the island (Shetland Visitor, 2018).

Petroleum

Oil and gas was first discovered in the East Shetland Basin in the early 1970s (SOTEAG, 2018) and has occupied a principal role in the islands economy ever since. The oil and gas industry has added around two thousand jobs to the islands' workforce as well as over £100 million to the economy each year (SDS, 2016). Newer oil developments to the west of Shetland have also been connected to the oil terminal at Sullom Voe, which is currently one of the largest terminals in Europe (European Commission, 2013).

Taxes from oil have increased public-sector spending on social welfare, art, sport, environmental measures and financial development. Similarly, the islands' oil revenues have funded the Shetland

Charitable Trust, which in turn funds a wide variety of local programmes. The balance of the fund in 2012 was £217 million, approximately £9,500 per head (European Commission, 2013).

Farming

Farming has been a primary part of life for as long as people have inhabited Shetland, with livestock being the dominant enterprise (SAOS, 2017). The islands are considered to have poor arable land in comparison to the nearby Orkney islands (Linklater, 1990), meaning that income and food have always been supplemented by fishing. However, the land is extremely amenable to grazing sheep and the islands boast a large population of sheep, which are used primarily for meat and wool. There is also a long tradition of peat harvesting which is cut during days of favourable weather in May and June, and then dried so that it can be used for winter fuel in stoves and fireplaces.

North isles

Yell is the least cultivated of Shetland's inhabited islands and its settlements tend to lie around the coastal fringe (Undiscovered Scotland, 2018). However, in the north of the island, crofting[4] and sheep farming are common livelihoods. Yell also hosts an increasing number of food production enterprises, which aim to address poor food quality on the island. In recent years, residents and community groups have begun to grow food in "covered allotments"; super-strong polytunnels that are often built with recycled plastic salmon pipes aim to protect produce from winds that frequently exceed 100mph in winter (Financial Times, 2017

5.2.4 Education and health

Education

Shetland's education system covers the entire population between the ages of three and 18. The provision of education is the sole responsibility of the SIC who must, by law, provide an efficient and suitable education for all school-aged children. The provision of education includes all aspects of education from the maintenance of school buildings to the delivery of the curriculum.

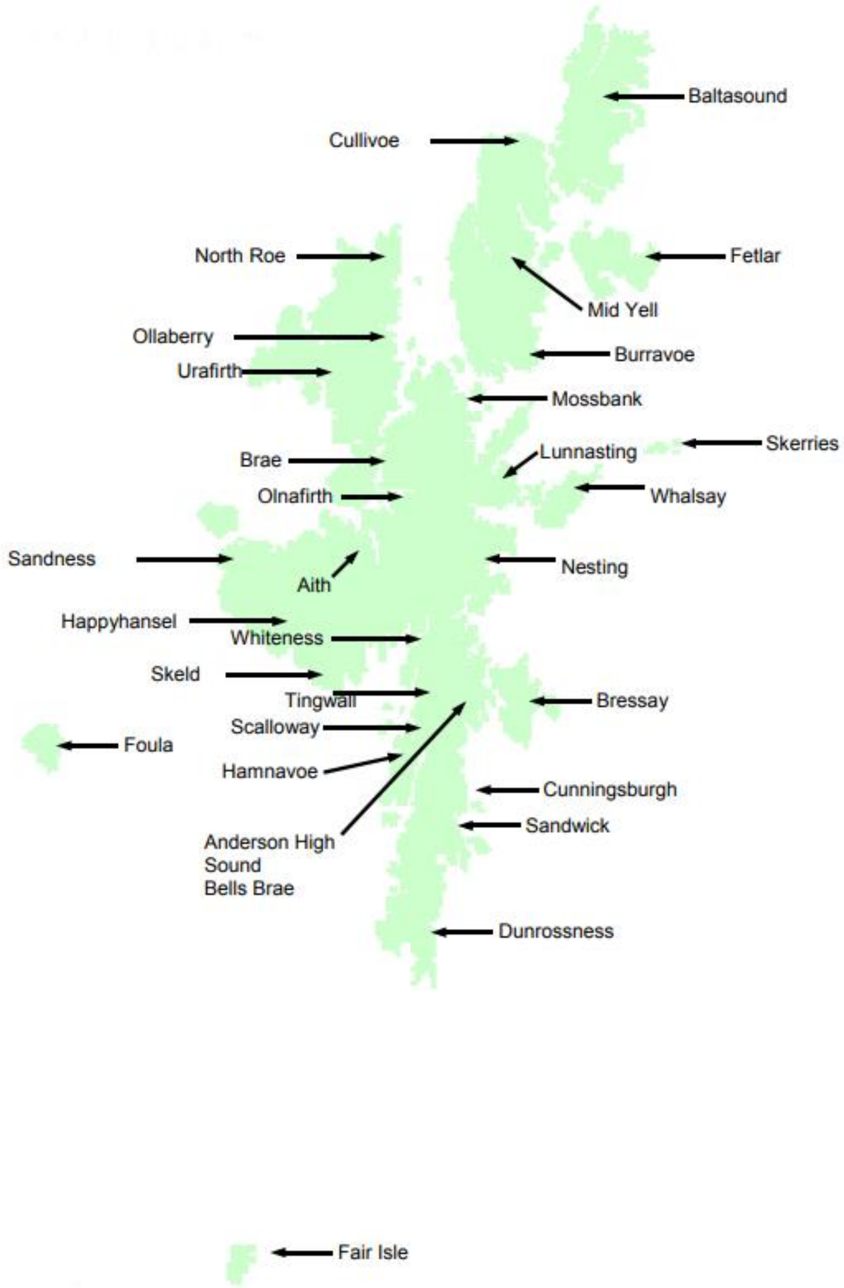
Schools in Shetland

There is a total of 31 Local Authority schools in Shetland (see figure 5.8) comprising:

- 22 primary schools
- 4 junior high schools (schools with nursery, primary and secondary departments)
- 1 high school
- 1 high school with a nursery and primary department
- 1 school with a nursery, primary and secondary department

Figure 5.8: Location of all Schools in Shetland

[4] Crofting is a form of small-scale agriculture land leasing arrangement, unique to Scotland and an integral part of life in the Highlands & Islands. A "crofter" is a person who occupies and works the landholding area, known as a croft, paying rent to the landlord of the croft.



Source: SIC, 2018e

<u>North Isles</u>

There are three schools and a nursery on the island of Yell. Burravoe Primary School serves the south end of the island from West Yell to Gossabrough and had 13 pupils in 2016. Cullivoe Primary School at the north end of the island had 29 pupils (CPS, 2018). Mid Yell Junior High (MYJH) school provides education for children from nursery to S4. MYJH presently has 73 pupils at primary and secondary level, and there are a further 21 children in the Nursery class (ibid.).

There are schools on two of the other North Isles; Fetlar Primary School on Fetlar has three pupils, while Baltasound Junior High on Unst has 68 pupils (BPS, 2018).

Health

Shetland is well provisioned for the health and social needs of its community. Around 585 staff work in the healthcare sector and 22,045 of the Islands 23,080 residents are registered with a GP (SIC, 2017b). Local hospital and community services are mainly provided from the Gilbert Bain Hospital on Mainland with a further 10 health centres (GP practices) serving communities around the islands.

Shetland has an aging population, which is leading to an increased need for care centres and facilities for elderly people. The islands are also experiencing an increase in the number of people with dementia; 5% of people over 65 (approximately 200 in Shetland) and 20% of those over 80 years of age (NHS and SIC, 2016) currently live with the condition. The islands currently have eight elderly care homes.

North Isles

Medical cover for the Yell area is provided by the Yell Health Centre, which has one full-time GP and one Nurse. Elderly care in Yell is provided by Isleshavn, a centre which offers long term residential care, short term or respite care, intensive community support at home and day services to any adult who has undergone an assessment. Unst Health Centre on Unst has 2 doctors and a nurse. Unst's care home is Nordalea, a residential resource centre which provides long term residential care, short term or respite care for adults in the area. Both elderly care centres in the North Isles are run by the SIC and have 17 beds and 16 day-support places between them (Kerr *et al.*, 2017).

Residents in the North Isles tend to record lower levels of overall health than other areas of Shetland. Based on GP practice records for 2015, Yell and Unst have the highest rate of hypertension (high blood pressure) of all GP practices in Shetland (Kerr *et al.,* 2017). Yell has had a consistently higher rate of obesity compared to the rest of Shetland since 2006, and Unst has also had a higher rate, although slightly less than Yell (ibid.). High rates of obesity are closely tied to the high rates of diabetes in Yell and Unst. Yell also has consistently higher rates of coronary heart disease than other practices in Shetland (Kerr *et al*., 2017).

5.2.5 Transport and sea navigation

Air, sea and road infrastructure within Shetland is managed and maintained by the SIC. ZetTrans is a transport partnership that sits within the council and is the functional provider of all public bus services, and inter-island air and ferry services (ZetTrans, 2018).

Sumburgh airport is the main airport serving Shetland and is located on the southern tip of the mainland, approximately 25 miles south of Lerwick (HIA 2018). The NorthLink ferry is the main service connecting mainland Scotland and Shetland, and provides services between Lerwick, Aberdeen and Kirkwall, operated under public subsidy.

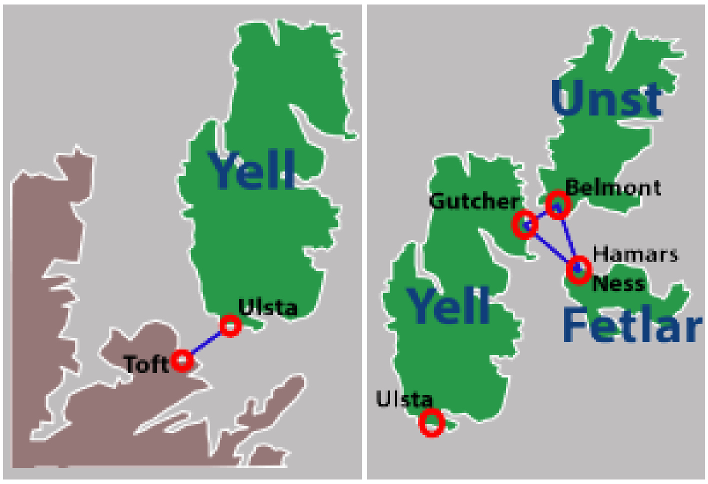
An inter-island ferry service also transports people and goods from Shetland Mainland to the North Isles and other inhabited islands. Inter-island ferries are operated by SIC and make as many as 6000 journeys in a single month, carrying over 88,000 passengers (NorthLink, 2018b). Services are fast and frequent; Ferries from Toft (Mainland) to Ulsta (Yell), and from Gutcher (Yell) to Belmont (Unst) run every 15 minutes, seven days a week (SIC 2018b). The price of an adult return fare on ferries from Mainland to Yell, and from Yell to Unst, is £5.50. The price of a return fare for elderly people and under 19s is £1.00 (SIC, 2018b).

Car ownership in Shetland is one of the highest in the UK, but Shetland is also served by a good bus network. The main service centre is Lerwick and it is possible to commute to the town by bus multiple times a day, six days a week from most parts of Shetland, including the Northern Isles.

North Isles Transport

The ferry from Mainland to Yell operates from Toft, a very small settlement in the north of Mainland, to Ulsta (see Figure 5.9). The larger settlements on Yell, such as Mid Yell and Cullivoe tend to be located in the east and north of the island, meaning that an onward car or public transport connection is typically required from Ulsta. Further, the only main road in Yell runs directly from the ferry terminal at Ulsta at the southern tip of the island to Gutcher in the north, all remaining routes are single track (Yell Community Council, 2018). This contributes to very high levels of household car ownership in Yell (SIC, 2016b). Ferries within the North Isles operate from Gutcher in Yell to Belmont in Unst and Hamarsness in Fetlar (see Figure 5.9).

Figure 5.9: NorthLink inter-island ferry routes within the North Isles, crossing times and distances



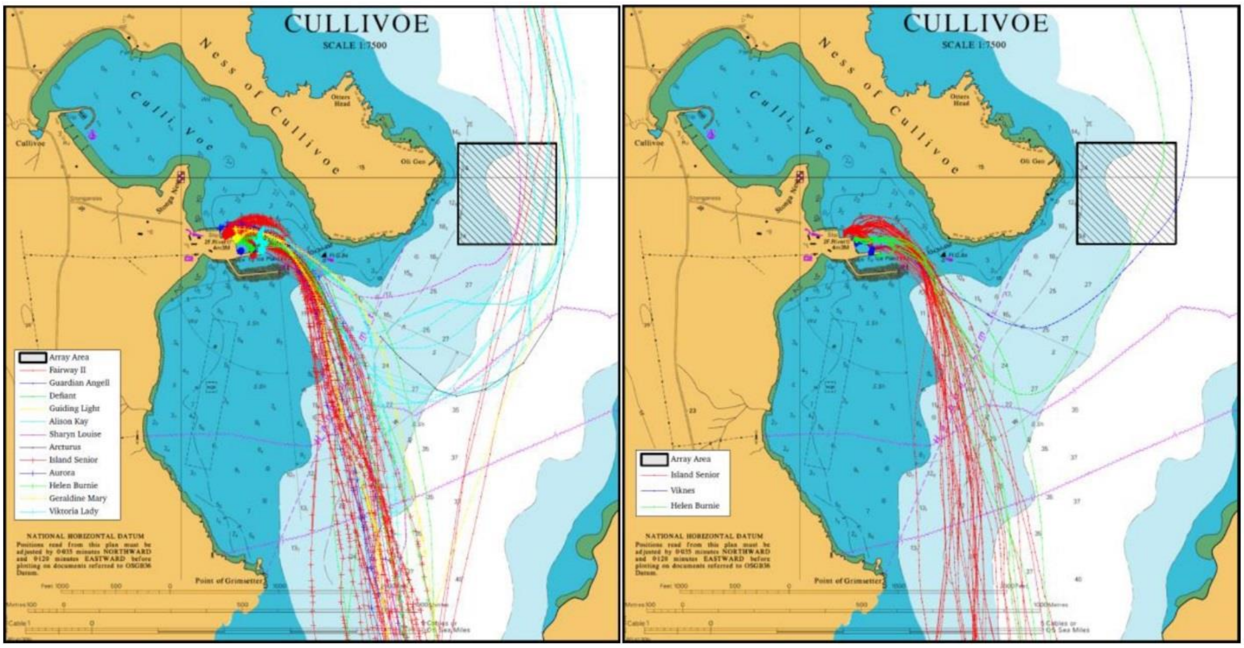
Route	Crossing Time	Distance (miles)
Toft to Ulsta	20 Mins	2.8
Gutcher to Belmont	10 Mins	1.1
Gutcher to Hamarsness	30 Mins	3.7
Belmont to Hamarsness	30 Mins	4.4

Source: ZetTrans, 2018

A recurring theme for the supply Shetland's transport provision is the relatively high cost of providing transport services. Main issues include: high capital investment required for vessels, ferry terminals and airports; high operating costs due the dispersed population; total travel time, and severe sea and weather conditions (SIC, 2016).

The Bluemull Sound is an active channel for shipping and Cullivoe pier is busy year-round with traffic associated with the operation of nearby aquaculture fish farms. The level of activity near the site is illustrated in Figure 5.10, which shows surveys of Automatic Identification System (AIS) tracks from vessels in the Bluemull Sound from two, 2-week periods in July 2014 and February 2015. On a typical day, 10 or more AIS-enabled vessels pass within 1 km of the array site, with a similar level of activity observed for smaller, non-AIS enabled vessels. The AIS enabled vessels are of a similar size to, or larger than, the multicat vessels used for array operations.

Figure 5.10 Vessel tracks from AIS surveys conducted over two 2-week periods in July 2014 and Feb 2015



Source: Nova Innovation 2018

5.2.6 Landscape and tourism

The main impetus of Shetland's tourism is the landscape and scenery, and the pristine wilderness that is afforded by the island's sparse population (Miller, 2018). In addition to the remote wilderness, Shetland's weather is considerably milder than its other northern counterparts. While occupying the northern latitudes along with Norway and Iceland, the temperature range of the islands stays between 0 degrees Celsius and 15 degrees Celsius with extremes being only as low as -8 degrees (Miller, 2018).

A survey commissioned by SIC and VisitScotland found that there was a total of 73,262 visits to the isles in 2017, contributing around £23.2 million to the local economy. This represents an increase from 64,655 visits in 2013 (Progressive, 2018). However, the population of holiday or recreational based tourism has been declining over the last 15 years, with the numbers of this kind of visitor falling by 11% (Scotinform, 2014).

The number of work or business-based visitors is increasing; in 2017, 35% of all visitors to Shetland were visiting for professional purposes (Progressive, 2018). Although business tourists typically spend more per trip than recreational tourists, they are less likely to travel to the other islands or even leave the islands' capital, Lerwick (Scotinform, 2014).

With the largest population of all the island's towns and most of the island's businesses and services, Lerwick holds the majority of the island's capital. Lerwick also receives most of SIC funding. In 2017, almost all visitors to Shetland visited Lerwick during their trip, and the majority also visited South Mainland.

Around half of all visitors mentioned visiting Central Mainland, North Mainland and Westland; while around a third mentioned visiting the North Isles of Unst and Yell (Progressive, 2018).

The North Isles lend the most potential for experiencing wilderness. They also contain a dense concentration of nature reserves and historic sites. There are several nationally important nature reserves such as the RSPB's Lumbister, the Yell Sound islands and the island of Hascosay (Shetland 2018c). While there exists the basis for a tourist-based industry on the northern islands, their small populations mean that they rely on a sparse tourist population. Of those tourists who did visit the North Isles in 2017, the most popular attraction was Hermaness Nature Reserve. Just under half also visited the Unst Heritage Centre (Progressive 2018).

5.2.7 Use of the coastal environment and the sea

Shetland is surrounded by productive seas and lies at the heart of rich fishing grounds. The sea has had a strong influence on the islands' economy, culture and heritage (NAFC, 2017c).

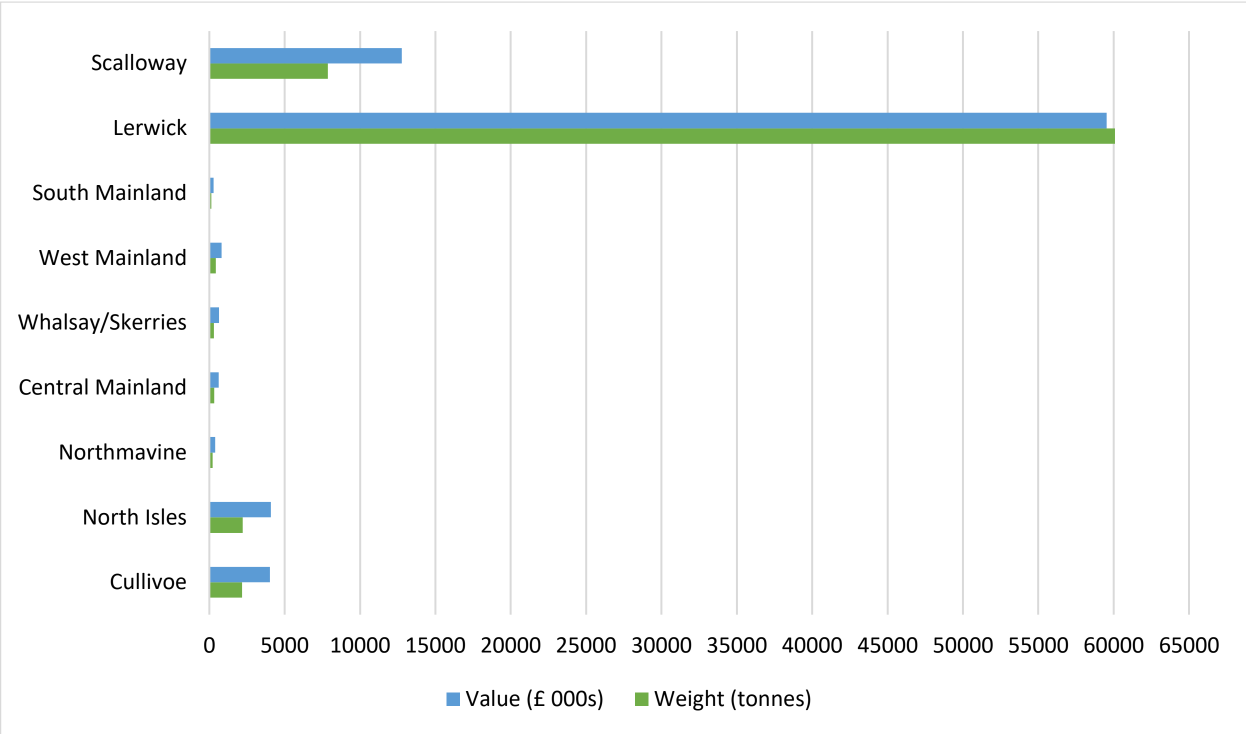
Fishing is the biggest industry in Shetland and comprises pelagic fish (e.g., mackerel, herring and blue whiting), whitefish (e.g., cod, haddock, whiting, monkfish and flatfish) and shellfish (e.g., lobsters, crabs and scallops). Pelagic fish live near the surface of the sea or in mid-water and account for the most valuable portion of Shetland's annual catch. Almost 50,000 tonnes of pelagic fish, worth about £41 million were landed in Shetland in 2016. Pelagic fish accounted for approximately two-thirds of the fish landed in Shetland in 2016 (NAFC, 2016b).

Whitefish live on or close to the bottom of the sea. The waters around Shetland contain a wide range of demersal fish, with at least 55 different species caught by local vessels over the past decade (Shetland Fishermen, 2018). Almost 19,000 tonnes of whitefish, worth £33 million were landed in Shetland in 2016 and whitefish accounted for one-quarter of the landings in 2016 (NAFC, 2016b).

Shellfish are found nearer to the shores. Approximately 3,000 tonnes of shellfish, worth almost £5 million were landed in 2016. The weight and value of shellfish landings were substantially higher than in 2015, largely the result of a development of a queen scallop fishery south-west of Shetland during the year by a small fleet of fishing boats. Shellfish continues to account for the smallest proportion of landings in Shetland (NAFC, 2016b).

Most fishing in Shetland occurs around Mainland, with Lerwick Harbour being one of Britain's main centres for the landing, selling, processing and shipment of seafood. Figure 5.11 shows the total weights and values of fish and shellfish landed in Shetland in 2016 by place of landing.

Figure 5.11: Total Weights and Values of Fish and Shellfish Landed in Shetland (by all boats) in 2016 by place of landing



Source: NAFC 2016b

North Isles

Figure 5.11 indicates that the North Isles (consisting of Yell, Unst and Fetlar) are the third most productive fishing grounds (after Lerwick and Scalloway) with 2,215 tonnes of fish landed in 2016. Most of the fish caught in the North Isles was landed at Cullivoe which was ranked 25th in the UK for the weight of fish (whitefish and pelagic) and shellfish landed in 2016. The harbour landed one tenth of all whitefish landed in Shetland in 2016 and was ranked 13th in the UK for whitefish landings (NAFC, 2016b). After Lerwick and Scalloway, it is also one of the principal landing places for shellfish. Cullivoe is the closest designated landing port to the rich fishing grounds to the north of Shetland. The port has seen increased whitefish landings in recent years, as well as activity in the renewables sector and salmon farming (SIC, 2018c).

5.2.8 Energy supply and demand

Historically, peat or imported coal or oil was used for heating in Shetland. In recent years there has been a move away from these traditional sources and households instead rely on electricity.

Shetland is, however, facing a significant energy supply challenge. Unlike the rest of the UK, Shetland is not connected to the national electricity network, and therefore relies on local sources of generation to meet its own energy needs. There is no mains gas supply to properties on the islands, and the power station which meets most of the current energy demand is meeting the end of its operational life (NINES, 2018)

At the time of preparing this report, energy in Shetland is being generated by:

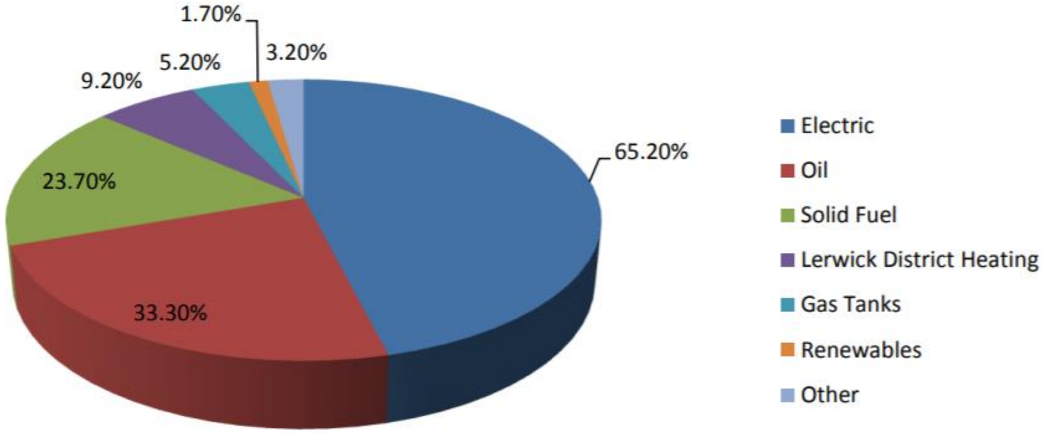
- Lerwick Power Station (LPS): a 67MW diesel-fired station commissioned in 1953. The power stations engines run on mainly medium and heavy fuel oil. LPS is the islands' primary source of electricity (SSEPD, 2018).
- The Sullom Voe Terminal Power Station, which was originally developed to meet the oil terminal's full electricity needs but later connected to the wider island's network to allow export under a commercial arrangement (SSEPD, 2018). SVT has an installed capacity of 100MW but power levels vary; it currently exports up to 22MW to the Shetland system and the availability of the SVT in the long term is uncertain (SSEPD, 2018).
- Burradale Wind Farm; a 3.68MW wind farm owned by Shetland Aerogenerators. Burradale was originally commissioned in 2000 and consists of five turbines. Burradale is one of the most productive wind farms in the world (SSEPD, 2018).
- The 4.5MW Garth wind farm, commissioned in North Yell in 2017.
- Several small-scale community-based wind farms and generators.
- Solar energy at a very localised level.

The isolated nature of Shetland's energy infrastructure results in energy supply costs that are significantly higher than in the rest of Great Britain (DECC, 2015). Shetland's maritime climate also means that the islands have a higher than average requirement for heating; high wind speeds are common and weather conditions can change rapidly throughout the year (SSEPD, 2014). In 2009, average consumption of electricity per household was more than twice the Scottish average at 10,348kWh (SSEPD, 2014). Further, Shetland contains some 'hard to treat' low thermal efficiency properties, and the population earns less than 75% of the UK average per household income. These factors combined lead to a disproportionate level of fuel poverty in the Islands (DECC, 2015) (see also Section 5.2.11).

There are five community built and community-owned onshore wind turbines near Cullivoe on Yell. The Garth Windfarm project was set up entirely by members of the community and North Yell Development (NYDC), who have legal ownership on behalf of the community. The turbines, a substation and electrical connections to the local grid were built in quick succession in early 2017. The windfarm can produce 4.5MW of power and will displace power made by fossil fuels at LPS, reducing Shetland's carbon emissions by up to 12,000 tonnes of CO2 every year (Tridos Bank, 2017). The windfarm will also generate around £1 million profit per year over the next 20 years creating a substantial long-term income for the island of Yell that will support the local community (Dalby, 2017).

The type of fuel used to heat residential houses in Shetland varies and is illustrated in Figure 5.12.

Figure 5.12. Type of fuel used to heat residential houses



Source, SIC, 2013

Figure 5.12 illustrates the main types of heating used in homes in Shetland, according to a survey commissioned by SIC CAB (2013). Electric heating is the most common kind of heating (65.2%), followed by oil heating (33.3%) and solid fuel heating (23.7%). Other heat sources used by residents include gas tanks, renewables and the Lerwick District Heating scheme. Many residents in Shetland use a combination of the sources listed above to heat their homes.

5.2.9 Telecommunications

The Scottish government has recently invested over £600million in funding for digital infrastructure, promising that all Scottish premises will be able to access broadband with a download speed of at least 30Mbps by 2021 (HIE, 2018b).

Shetland is currently in the process of rolling out a fibre optic broadband network across the islands as part of the Government's Digital Scotland Superfast Broadband project (HIE, 2018b). In the past four years, a massive fibre network has been created in the region, through a new backbone of fibre on land and marine subsea cables (HIE, 2018b). While less than 4% of residents in Shetland had access to fibre broadband in 2013, by early 2018 75% of homes and businesses were able to access superfast download speeds of 24Mps or above (HIE, 2018b). However, many of the homes connected to the network are in larger population centres on Mainland, with most residents in Yell and Unst too far from access points and thus less likely to be able to access fibre optic broadband.

5.2.10 Community wellbeing and identity

Shetland consistently scores highly in surveys ranking the quality of life of rural areas in Scotland, either coming top overall, or second behind Orkney. The islands score highly relative to the average for Scotland on several indicators such as health, happiness, community cohesion, life expectancy, employment, school results and low levels of crime.

The prevalence and incidence of mental health problems and mental illness in Shetland is lower than the Scottish average. The percentage of people prescribed medication for anxiety, depression or psychosis in 2014/15 was 14%, while the Scottish average was 17%. The suicide rate in 2009–2013 was 24 per 100,000 people, which was similar to the Scottish rate (Millard *et al.*, 2016).

The crime rate for recorded drug crimes and the crude rate for referrals to the children's reporter for violence-related offences were all lower than Scotland's overall rate. The rate for prisoner population, at 94 per 100,000 people, was significantly lower than the Scottish rate of 171 (Millard *et al*., 2016).

Shetland is a socially cohesive community with a thriving voluntary base. There are over 600 community organisations, voluntary groups and social enterprises in Shetland, and roughly one third of the adult population gives time to volunteer in the community every year (Scottish Rural Network, 2018). The North Isles have a very high level of community cohesion, with a particularly active third sector (SIC, 2016b).

Table 5.2 presents the Office of National Statistics' estimated levels of personal wellbeing in Shetland. Each of the elements is measured in 'marks out of 10'; for example, people surveyed in 2015/16 felt that their levels of satisfaction with life averaged 8.03 on a scale of 1 to 10. They felt that their anxiety levels measured, on average, 2.56 out of 10, demonstrating high levels of overall wellbeing in Shetland (NHS Shetland, 2017). Average levels of personal wellbeing were higher in Shetland than in Scotland as a whole.

Table 5.2. ONS estimated levels of wellbeing in Shetland

	Average (mean) ratings									
	2011/12		**2012/13**		**2013/14**		**2014/15**		**2015/16**	
	Shetland	**Scotland**	**Shetland**	**Scotland**	**Shetland**	**Scotland**	**Shetland**	**Scotland**	**Shetland**	**Scotland**
Satisfaction	8.12	7.51	0	+0.01	-0.30	+0.05	+0.10	+0.08	+0.11	+0.02
Worthwhile	8.29	7.68	-0.17	+0.02	-0.06	+0.04	+0.07	+0.10	+0.01	-0.02
Happy	8.03	7.31	-0.2	-0.02	-0.01	+0.05	-0.06	+0.08	-0.14	-0.03
Anxiety	2.33	3.06	+0.03	-0.13	-0.14	-0.04	+0.10	-0.06	+0.24	+0.02

Source: NHS Shetland 2017 and ONS 2018b

Alcohol consumption, however, remains a major concern in Shetland, and causes a significant amount of harm to individuals, families and the community. 1 in 3 men (35%) and nearly 1 in 5 (18%) women in Shetland are drinking at hazardous or harmful levels. There were 155 alcohol related hospital stays in Shetland in 2016. The annual cost of alcohol harm to Shetland (in terms of health, social care, crime and productive capacity) was £395 per person (NHS Shetland, 2017).

Yell has an average rate of mental health prevalence compared to the rest of Shetland (Kerr *et al.*, 2017). The rates of new diagnoses of depression in Yell and Unst are within the expected range (ibid). According to the Scottish Index of Multiple Deprivation (SIMD)[5], Unst and Fetlar both have very low levels of crime, but the rates are slightly higher in Yell.

Identity in Shetland is a complicated and contested question. Shetland has unique historical and cultural links with Scandinavia (Malm, 2013); the islands were integrated into the Norwegian state in about 875 and the remained under Scandinavian rule until the mid-13th Century (ibid.). Though Shetland passed over to Scotland in 1469 (McHattie *et al*., 2018), the Scandinavian connections remain strong, culturally as well as linguistically (Malm, 2013).

[5] SIMD is the Scottish Governments official tool to identify areas of multiple deprivation in Scotland.

Shetland is fiercely independent in spirit and many Shetlanders today view themselves not as Scottish, but as a separate cultural identity with a distinct heritage and tradition (McHattie *et al*., 2017), which stems from a continuous dialogue with neighbouring cultures across the whole north Atlantic region and beyond.

The Old Norse[6] language is in practically every place name in Shetland; Lerwick utilises Old Norse to anchor the significance of its place name: Lerwick or "Leirvik", meaning "Muddy Bay" (Shetland Heritage, 2018). The strength of Shetland's "Scandanavian sympathies" are physically and visibly expressed through the well preserved archeological sites, the Island's flag[7] and the winter festival of Up-Helly-Aa which serves as a vivid reminders of the islands' Viking past (Visit Scotland, 2018). The Island's motto, which appears on the SIC coat of arms is "*með lögum skal land byggja*". This Icelandic phrase means "*by law shall the land be built up*".

Although English is the medium of written communication, Shetlandic is still a living spoken dialect with a distinctive Scandinavian lilt. Many Shetlanders write in local dialect on social media (De Luca, 2017).

5.2.11 Vulnerable and disadvantaged groups

Shetland faces specific issues around geographical remoteness, declining populations, ability to access fuel, transport, digital connections and services.

Living costs in Shetland, and especially in more remote parts of the islands, are significantly higher than in many other parts of the country (SIC, 2016b). In 2016, a minimum acceptable standard of living in remote rural Scotland typically required between a tenth and a third more household spending than in urban parts of the UK (IPSOS, 2016). This contributes to what has been called "hidden" incidences of poverty and deprivation in many rural island communities, that are sometimes masked by national data (NHS Shetland, 2018). The most prevalent household income bracket in Shetland is 10-20K, which is below the UK average of £23,474 (Scottish Parliament 2017). Average incomes are slightly lower in the North Isles than in other parts of Shetland.

Owing to the relatively low household income of many Shetlanders and the relatively high cost of living in Shetland, 43% of all households are estimated to be living in fuel poverty[8] (2015). The proportion of pensioners estimated to be living in fuel poverty in Shetland is 68% (ibid.) These figures are higher than the Scottish average of 39.1% (Scottish Government, 2014) and similar to Orkney, where the rate is 63% (the highest in the United Kingdom) (OIC, 2016). In England, the incidence of fuel poverty is 11.1%, in Wales it is 23%, Northern Ireland is 22% and across the UK the incidence is estimated to be 15%.

Over 13% of households in Shetland are estimated to be living in extreme fuel poverty[9] (SIC, 2015). However, fuel poverty levels in Shetland are likely to be considerably higher than these figures suggest as no detailed surveys have taken place since 2013. It is thought that over 60% of all households in Shetland could currently be living in Fuel Poverty (SIC, 2015).

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[6] Norse is the old Germanic (Norwegian) language used in Shetland

[7] The Shetland Island's flag uses the colours of the flag of Scotland, but in the form of the Nordic cross in order to symbolise Shetland's historical and cultural ties with the Nordic region. The colours and device are the inverse of that of the flag of Finland.

[8] Fuel poverty is where a household has to spend more than 10% of its income on heating costs.

[9] Extreme fuel poverty is where a household has to spend more than 20% of its income on heating costs.

Shetland's high rates of fuel poverty can be attributed in part to the climate, strong winds, and wind-chill. A combination of these factors means households need to have heating on for a higher proportion of the year than elsewhere in the UK (SIC, 2015). It is estimated that Shetland households need to use twice the national average amount of energy per home (SSEPD, 2014). There is also a higher energy tariff levied in the Highlands and Islands and a lack of cheaper alternative heating sources, such as mains gas. Additionally, many houses in Shetland, particularly in the North Isles, are in poor physical condition and this exacerbates the costs and overall challenge of keeping homes warm. In response to this challenge, SIC are currently implementing an energy efficiency scheme to residents and businesses in Shetland, providing them with energy inspections and grants to improve energy efficiency (such as window and loft insulation) within properties.

6 Stakeholder Engagement Activities and Outcomes

This section provides a summary of the findings from stakeholder engagement activities that have been completed during preparation of the ESEA Report.

6.1 Engagement with the local community

The local community were engaged through the following activities:

- Through a postal questionnaire that was sent by SIC to all residents on Yell during August 2018;
- During a trade fair called the 'Yell Show' held at East Yell Public Hall on 01 September 2018;
- During a series of focus group discussions completed during November 2018; and
- Through workshops with students in schools based in Yell and Lerwick during November 2018.

6.1.1 SIC postal questionnaire

During August 2018 SIC sent out 455 questionnaires to all households on Yell which included four questions inserted by Nova. The questionnaire asked residents to provide responses to the following four questions and measured attitudes and opinions on a Likert scale[10]. A total of 105 questionnaires were returned, with only two households not competing the four questions raised by Nova, reflecting a response rate of 23%.

A summary of the responses received for the questions inserted by Nova is provided in Figure 6.1.

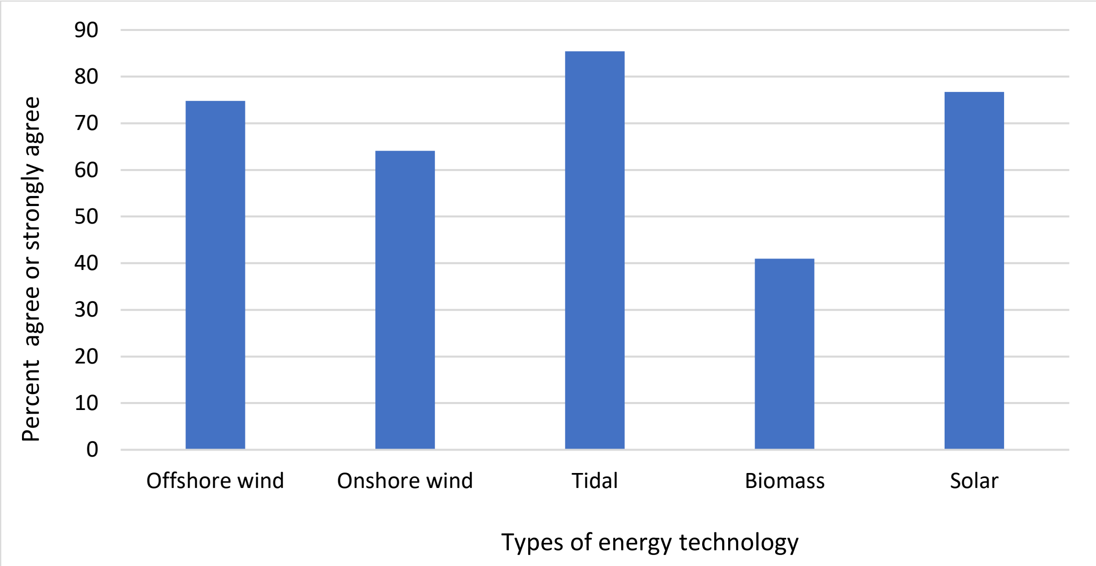
Question 1. In general, to what extent do you support the development of the following energy technologies in Shetland?

a) Offshore wind energy
b) Onshore wind energy
c) Tidal energy
d) Biomass
e) Solar energy

Figure 6.1 shows the extent of support for each type of energy technology.

[10] The Likert scale is a commonly used survey technique designed to uncover different degrees of opinion. Respondents are asked to select a rating on a scale (e.g. 1 to 5) that ranges from one extreme to another, such as "strongly agree" to "strongly disagree".

Figure 6.1. Percentage of respondents who either 'agreed' or 'strongly agreed' with the development of each type of energy technology



The responses from Question 1 indicate that tidal energy has the greatest level of support with 85% of respondents indicating that they 'agreed' or 'strongly agreed' with the development of this type of technology.

Question 2. Are you aware of the renewable tidal energy demonstrator project that is currently active in Bluemull Sound, near Cullivoe, led by Nova Innovation?

The results from Question 2 indicate that 87% of respondents were aware of the demonstrator project.

Question 3. At present, most of our electricity comes from diesel generators at Lerwick Power Station. Scottish and Southern Electricity (SSE) currently plan to continue operating the power station until at least 2025. Please indicate to what extent you agree with each statement below:

a) I am supportive of the tidal energy project being implemented in Yell
b) I am content with the existing, main source of electricity
c) Shetland should make use of its natural resources (e.g. wind, tide, sun) to generate energy locally
d) Shetland should not be using fossil fuels, which contribute to climate change, to generate its electricity
e) Electricity in Shetland is unreasonably expensive

Figure 6.2 presents the responses from Question 3. The data has been converted into percentages and shading has been applied to group the range of values, with the most frequent responses shaded in dark green.

Figure 6.2. Responses to Question 3

Question 3	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
3a – Support the tidal energy project	1	3	10	25	61
3b – Content with main source of electricity	11	26	45	16	2
3c – Shetland should use its natural resources	2	0	8	26	64
3d – Shetland should not use fossil fuels	5	3	35	30	27
3e – Electricity in Shetland is expensive	1	3	26	30	40

Figure 6.2 indicates that 86% of respondents to Question 3 were supportive[11] of the tidal energy project. Only 18% of respondents 'agreed' or 'strongly agreed' that they were content with the existing main source of electricity. A total of 90% 'agreed' or 'strongly agreed' that Shetland should make use of its natural resources to generate electricity locally and move away from the use of fossil fuels. A total of 70% of respondents indicated that electricity in Shetland is expensive.

Question 4. In the future, Shetland may be able to use its strong tidal currents by further developing tidal energy projects at one, or more, locations along the coastline. This would give more source options for the provision of our local electricity supply and reduce carbon emissions. Please indicate to what extent you agree or disagree with each statement below:

a) I would support development if it worked in harmony with the environment, and with other users of the sea
b) I would support this development if it does not increase the cost of electricity
c) I would support the use of different electricity charges to encourage the use of cleaner forms of generation
d) I would support this development if it contributed to growth of the local economy (supply chain, investment, jobs and skills)
e) This type of development would contribute to Shetland's energy security
f) I would be interested to participate in this type of development (professionally via supply chain, financial support, or in other ways)

Th[illegible]es received.

[11] Respondents are considered 'supportive' if their response to the statement is "agree" or "strongly agree".

Figure 6.3. Responses to Question 4

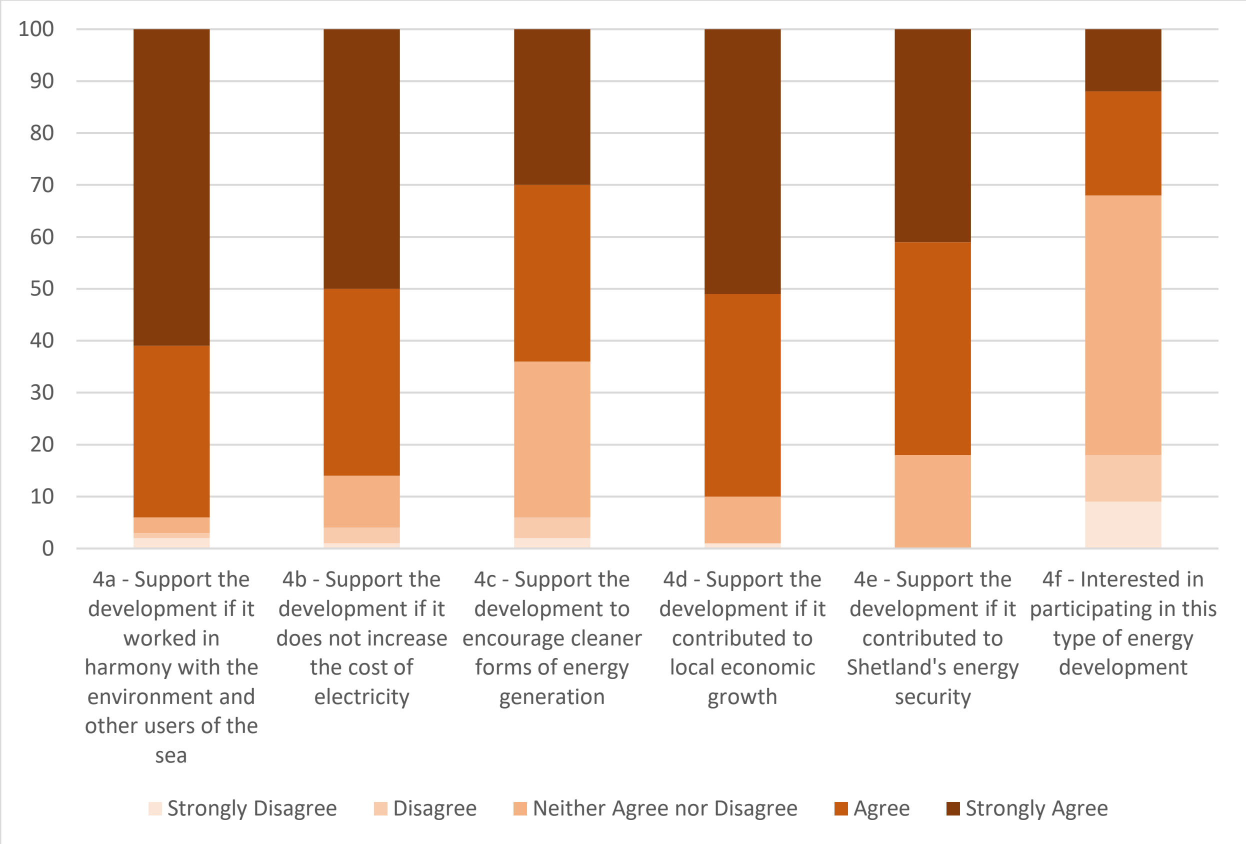


Figure 6.3 indicates that the majority of respondent to Question 4 support tidal energy development if it worked in harmony with the environment and with other users of the sea, did not increase the cost of electricity, and contributed towards Shetland's energy security and local economic growth.

6.1.2 Attendance at the Yell Show

The annual Yell Show was attended by approximately 500 people from a wide age range who live in Yell or elsewhere in Shetland. The Yell Show is mainly an agricultural event showcasing livestock (sheep, cattle, Shetland ponies, poultry) alongside farming machinery that is available to hire or purchase from local companies.

Within the building used for the Yell Show a variety of community-based competitions were ongoing, including baking and photography. A variety of organisations active in Yell were also present, such as the Royal National Lifeboat Institution, SIC and local charities. Nova and RSK jointly attended the event with a stand as this provided a valuable opportunity to meet local people, provide information on the tidal energy project, introduce the EnFAIT Project and discuss the tidal energy devices with local people.

The stand used was branded with Nova's logo and brochures on Nova's activities and EnFAIT were available for local people to read through and take home with them. A 1:70 scale model of a tidal energy turbine was used to attract people to the stand, along with two laptops showing the EnFAIT video and a 20-second video of underwater footage from a device with rotating blades on a continuous loop. The video of the turbines moving underwater attracted people to walk towards the stand and discuss the project with Nova/RSK. In total approximately 50 visitors visited the stand during the event and local people were asked to complete a feedback form after learning about the project.

A total of 22 feedback forms were filled in to gain an understanding of local people's awareness of the project, perceptions of tidal energy, and communication preferences for receiving future updates on progress. In general, people viewed tidal energy as 'favourable'; 68% were 'very supportive' and the remainder 32% were 'supportive', particularly when compared with wind power which had less support due to the perceived landscape and visual impact.

Almost all visitors attending the stand (95%) were aware of the tidal energy project being implemented in the Bluemull Sound, many of whom had heard about the project through word-of-mouth. There was a lack of understanding of the progress achieved to date with over half of visitors not realising that the devices were already deployed underwater and were actively generating energy. 32% of people were aware that the project will be expanded from three turbines to six as part of the EnFAIT Project. Upon learning more about the project there was a general desire to receive future information updates with the preferred method used being the local newspaper, social media and from local radio.

6.1.3 Focus group discussions

Community focus group discussions were held at Cullivoe Community Hall in Yell and at Islesburgh Community Centre in Lerwick. The aim of the focus group discussions was to investigate local perceptions towards the project and this type of renewable energy technology, explore ongoing socio-economic change in Yell and Shetland, and how to spread the awareness of the project amongst the local community. People were invited to attend by Nova and between eight to ten people were present at each session.

The discussion started with a short introduction to the representatives present from Nova/IDETA/RSK and a video available on the EnFAIT website was played to introduce the project. After a short pause for questions, the discussions commenced with the RSK facilitator asking questions to the group (Figure 6.4) to start a discussion.

Figure 6.4. Community focus group discussion at Cullivoe Community Hall

All focus group discussions were supportive of the development and were very interested to learn more about the project. Key points raised during the community focus group discussions included the following:

- The project could assist in broadening young people's knowledge on renewable energy technologies and encourage them to study engineering and practical vocational skills. It was noted that schools usually focus on university enrolment where many young people study media courses, rather than encouraging people to seek apprenticeships and vocational studies.
- The project could encourage young people to stay in Shetland which may prevent the continuing out-migration of young people. It was noted that many students travel to the mainland for further education and decide not to return as they become overqualified and there are few specialised jobs in Shetland.
- Shetland should market itself as a centre for renewable energy potential due to planned onshore wind energy developments and given the tidal energy resource available. The creation of a 'green' energy island could also encourage more tourists to travel to Shetland.
- There was concern about the potential for marine fauna (such as fish and otters) to be harmed by the rotating turbines. Nova subsequently explained that the otter species typically dives to a maximum depth of 3m, and an environmental monitoring framework had been established which uses underwater video cameras. To date, there have been no collisions between the blades and marine wildlife which includes diving seabirds.
- The project is not well known by many local people, with some even questioning whether the turbines are installed below the sea surface, as they are not visible. It was suggested that Nova install a sign and provide more information to local people.
- There was a general desire for Nova to establish a maintenance workshop on Yell which could employ more local people. There is potential for a light industrial facility to be constructed close to Cullivoe Pier, extending the existing facility; this could be used by Nova for turbine maintenance, as well as by other local companies.
- Whilst the generation of renewable energy is a positive outcome from the project, it is not expected to result in lower electricity prices to household consumers and businesses. This is due to the way in which electricity supply is managed across the UK through supply contracts with energy companies.
- The fact that the tidal energy device structure and turbines are not visible is important for the public acceptability of this type of technology, particularly when compared with onshore wind which has significant local opposition due to its visibility. A further advantage is the absence of an onshore footprint; the project will neither damage peatlands nor change drainage networks as a result of the installation of access roads, typically required by onshore wind power projects.
- There is a high level of expectation associated with Nova's ability to generate local employment opportunities in Yell and elsewhere in Shetland because of the project. It was noted that Nova have several specialised employment positions in Edinburgh but none in Yell, with currently a single permanent employee based in Shetland. However, it was also acknowledged that Nova have made extensive use of both local companies and Shetland-wide services to provide hotel accommodation and transport and vessels to deploy/retrieve the tidal energy turbines. Additionally, it was recognised that Nova have employed a Shetlander who currently lives in Edinburgh and works as an offshore operations engineer.
- It was recommended that a visitor resource should be established at Cullivoe Pier to attract tourists to travel to this location and learn more about tidal energy technology. The resource could include, for example, a large notice board, live video feeds from the underwater cameras, and information about the energy level being generated and supplied to the grid.

6.1.4 Workshops with students in schools

During November 2018 various workshops were held with school children in Shetland. One workshop was conducted at Mid Yell Junior High School with 25 students aged 11-12 years, and two workshops were held at Anderson High School (with 25 students in each session) aged 14-17 and 16-17. The workshops took place inside the school building and were jointly facilitated by Nova, IDETA and RSK.

The aim of the workshops was to provide information about the EnFAIT project, investigate student's awareness of different types of renewable energy technologies, understand their perceptions towards Shetland's environmental and socio-economic resources, and to investigate interactions between different types of resources. The resource of the sea was offered as an example. The sea is used for vessel navigation which allows the transport of tourists (and their cars) by ferry. Tourists travel across the islands to see the landscape, seascape, and the pristine wilderness that is afforded by the Shetland's sparse population. Tourism generates local employment and income to business owners, which subsequently contributes to maintaining a standard of living for Shetland's residents.

At the start of the workshop, the EnFAIT project was introduced using the promotional video and the model tidal turbine. There was a strong emphasis on the engineering and scientific aspects of the project to maximise the learning opportunity for the students.

After the introduction was completed, various questions were raised by participants and responded to by Nova or RSK. These included: how the tidal energy devices impact life on the seabed; why Bluemull Sound was chosen as the location for the project; whether EnFAIT will be affected by Great Britain leaving the EU in March 2019; the potential for interference to occur between users of Cullivoe Pier; and the efficiency of the technology to generate energy.

After the questions had been addressed, students were split up into small groups and asked to complete a participatory mapping exercise. Students were provided with a large piece of paper and coloured pens. The students were initially asked to list the different types of renewable energy technologies with which they were familiar, and to rank these numerically in order of importance. Students were then asked to draw an image of Shetland as a circle. The aim of using a circle to represent Shetland was to ensure that the map was conceptual and avoid students spending time on preparing an accurate geographical outline of the archipelago. Students were asked to draw, using symbols where possible, images representing the different types of environmental and socio-economic resources available in Shetland. They were guided to consider the area inside the circle as representing land-based resources, the edge of the circle as the coastal environment, and the outer area representing the sea and offshore resources. The students were asked to prepare their map within twenty minutes and work collaboratively, discussing as a group the different types of resources present in Shetland.

As the students worked, representatives from Nova/IDEATA/RSK walked around each group to introduce links between environmental and socio-economic resources to enable students to better understand the interactions.

Students were able to list the main types of renewable energy resources with relative ease; however biomass was often left out. The most important types of renewable resource identified by students in the workshop were wind and tidal energy.

Figure 6.5 shows examples of students working in their groups. Figure 6.6. provides examples of the participatory maps prepared by participants and a summary of the different types of resources identified.

Figure 6.5. Students undertaking the resource mapping exercise

Figure 6.6. Examples of student's participatory maps

Examples of resources:

- Soil for the cultivation of crops
- Offshore and onshore wind energy
- Tidal energy
- Sea providing navigation to ferries and fishing boats
- Sea providing fish and other types of sea products such as mussels and areas for aquaculture
- Marine fauna which attracts tourists
- Coastal setting which attracts people to visit Shetland
- Music and cultural events such as Up Helly Aa which is a traditional Viking fire festival
- Offshore oil and gas
- Peatlands
- Land used as fodder by sheep which sustains the livelihoods of sheep farmers
- Land and houses used for people to live in and to attend community events
- The coastline and cliffs provide habitats for nesting birds and attract tourists which benefits people working in them
- Cultural identity and a sense of belonging

6.2 Project suppliers

A Key Informant Interview was held with Fred Gibson, the Managing Director of Shetland Composites (SC) who manufactures the tidal energy turbine blades at a plastics workshop in Lerwick. The aim of the interview was to understand the impact Nova has had on a local supplier's business and workforce. The interview commenced after a short introduction and an explanation of the purpose of the interview.

SC has been working with Nova since the company was founded in 2010. The company manufactured a set of three blades that were attached to the first tidal energy device installed in the Bluemull Sound during 2014. Collaboration with Nova has had a significant positive impact upon SC's business operations. The additional revenue generated, combined with increased technical knowledge gained from developing and manufacturing the blades has enabled SC to grow, expanding both its premises and workforce.

In January 2017, SC moved into an upgraded workshop which was partly funded by Highlands and Islands Enterprise. The upgraded facility has a new heated area which allows SC to operate on the premises all year-round, including during the winter months. Involvement in the EnFAIT project has also supported, along with other awarded contracts, SC to expand its workforce from three to six employees, increasing the capabilities and technical expertise of the company. A selection of photos from SC's warehouse is illustrated in Figures 6.7 and 6.8.

Figure 6.7. Shetland Composites staff, warehouse and other types of tidal energy components

Figure 6.8. Shetland Composites manufacture of the turbine blades

7 Appraisal at a Project-Level and EU-Level

The purpose of this section is to present the results of the project-level and EU-level appraisal and assign a score in accordance with the classification in Table 7.1. The appraisal is presented as a series of tables using short bullet points.

Table 7.1. Classification of effects used for the appraisal

Clear and major positive effect (*expected to contribute a positive, environmental and/or socio-economic change that is recognised at a Shetland/UK and/or EU level*)	✓✓
Broadly supportive or minor positive effect (*results in improved environmental knowledge, or positive environmental and/or socio-economic change)*	✓
Neutral effect *(is not expected to have a positive or adverse effect)*	**0**
Minor negative effect *(expected to result in a localised, adverse environmental and/or socio-economic change)*	×
Major negative effect *(adverse environmental and/or socio-economic change)*	××
Uncertain effect *(based upon the information available the outcome of the effect cannot be determined at this time and could be either positive or adverse)*	**?**

7.1 Environmental appraisal topic areas

<table>
<tr><td>Marine and Coastal Biodiversity
EnFAIT has carried out a rigorous assessment of the environmental effects of the project to support license applications, working closely with experts at Scottish Natural Heritage. This process identified collision risk as the primary area of uncertainty and this has remained the focus of the environmental monitoring framework.
Underwater video footage has been collected to establish whether the tidal array represents a collision risk to fish, mammals or seabirds. Over 4,000 hours of video footage have been analysed and no collisions with turbines have been identified.
Seabed cables will not pose a collision risk as they are laid directly on the seabed. There is a remote possibility of collisions taking place between marine fauna and turbine cables at a different project location with different, surface-mounted tidal technology if the cables were installed so that they rise vertically from the seabed to the surface.
The introduction of hard, submerged, surfaces could generate an 'artificial reef' effect that increases marine biodiversity and attracts fish. This has been regularly observed at offshore wind farms and their monopole structures. The Bluemull Sound already provides a hard substrate as fine material has been removed by strong currents. Consequently, the tidal energy devices are not introducing hard substrates. No increase in biodiversity, or the frequency of fish, is expected.
Marine species are known to be particularly sensitive to changes in electromagnetic fields (EMF). The tidal array introduces a small change to EMF fields which is not expected to interfere with migratory fauna or species who use the seabed, and this does not require further investigation.
Summary: to date the project has not affected marine and coastal biodiversity within the Bluemull Sound.</td><td>Project-Level
0</td><td>EU-Level
0</td></tr>
<tr><td>Physical Environment and Water Quality
The three turbines currently installed in the Bluemull Sound occupy approximately 0.25% of the channel cross section by area.
The amount of hydrodynamic energy removed from the tidal stream has been estimated to be less than 0.3% of the average energy in the flow.
There is no evidence from the environmental monitoring framework that indicates the tidal array is significantly changing hydrodynamic conditions.
Marine wildlife and their habitats, such as high energy circalittoral rock, are highly dependent on high energy flows have not been identified in Bluemull Sound. However, there is a possibility that at other locations across the EU marine wildlife could be affected by modifications to hydrodynamics and this would need to be assessed using the specific environmental conditions present.
ADCPs deployed as part of the EnFAIT project will be used to record changes in energy flows before/after the tidal array.
Scour erosion has been recorded by the environmental monitoring framework (video footage). The erosion is highly localised, minor in depth and has not affected the stability of the device on the seabed. The seabed is dominated by stone pavement as fine material is naturally removed by the high energy flows.
Changes to water quality are not expected to occur from the tidal array. Whilst there is a small risk of an oil or grease leak from the turbine in the event of a major failure, this has not occurred to date and these types of hazardous substances are effectively contained, doubly-sealed within the turbine enclosure.
The extent of marine growth (often referred to as fouling) on the turbine blades and nacelle is an issue that needs to be addressed. Nova is currently investigating the use of different types of anti-fouling coatings to reduce the build-up of material in the future as marine fouling could reduce turbine output and interfere with operations and maintenance.
Seabed cables connecting the tidal array to the equipment located on Cullivoe Pier have not been affected by the build-up of marine growth. However, in other locations there is a potential for marine growth to appear and this should be investigated based upon the specific environmental conditions present.
Summary: to date the project has resulted in a significant improvement to our environmental knowledge in relation to how marine tidal energy devices interact with the environment.</td><td>✓</td><td>✓</td></tr>
<tr><td>Underwater Noise and Vibration
Tidal array deployment does not generate significant levels of underwater noise or vibration as the base structure is placed directly on the sea bed. Subsea piling or drilling is not required.
Operation of the turbine blades are not expected to generate significant levels of underwater noise and vibration above background noise from the tidal flow, vessel traffic and busy nearby harbour. However, this has not been measured to date and no quantitative information is available.
The location of the tidal array, adjacent to Cullivoe Pier, is frequented with fishing and other types of vessels passing through the Bluemull Sound. Marine fauna and diving seabirds will therefore be used to high levels of background noise and vibration.
During 2019 the feasibility of deploying acoustic hydrophones to record the noise profile generated by the tidal turbines and array will be explored. Ambient background noise levels at different locations within the Bluemull Sound, outside of the tidal array may also be measured. Whilst not raised as an environmental issue of concern by the regulatory bodies during the consenting process for the project, the data generated will provide valuable evidence for consenting of projects at other sites where underwater noise may be more of a concern and will be useful during any future enlargement of the array in Bluemull.
Data collected by the hydrophones will be used to compare the noise footprint of the tidal array with the known hearing range for a variety of marine mammals to investigate further potential effects associated with underwater noise and vibration.
Summary: At a project-level and EU level the effect on underwater noise and vibration is unknown as there is no quantitative data available.</td><td>?</td><td>?</td></tr>
</table>

	Project-Level	EU-Level
Benthos • There are no sensitive benthic habitats or benthos near the Bluemull Sound, or within the tidal array. • The physical footprint of the tidal energy structure occupies a very small area on the seabed and any impacts associated with crushing benthic species will be highly localised. • The location on the seabed of each tidal energy structure is surveyed for obstacles and marine benthic habitats using underwater cameras before installation. • At other locations across the EU, sensitive benthic habitats may be present and the placement of the structure on the seabed could result in loss of benthic habitats. This should be investigated based upon the specific environmental conditions present within the deployment area using underwater cameras. *Summary: The project has no significant impacts to benthos.*	0	?
Fish • The type and distribution of different fish species present in the Bluemull Sound and surrounding region is well understood as the area is known for its fishing resources. • Using the results of the environmental monitoring framework, there is no evidence to indicate that the tidal array is resulting in injury/mortality to fish species. No collisions have been recorded to date. • There is a potential that the turbine and nacelle structure is acting as an aggregating device, like a buoy or float. Underwater video footage indicates fish occasionally congregate close to the structures. • The reason fish are moving close to the devices is not known. They may be behaving in a naturally inquisitive manner, saving energy by swimming in the wake of the turbine, or trying to feed off marine growth attached to the structures. *Summary: At a project level the effect on fish is neutral. However, the effect on fish at an EU-level is unknown as fish communities vary significantly along the coastlines and the potential for effects should be investigated based upon the specific environmental conditions present.*	0	?
Seabirds • A variety of seabird species are frequently observed within the Bluemull Sound and recorded by the environmental monitoring framework. • Except for a few species, most seabirds present are not able to dive to the depth of the top of the turbine blade which is at least 15m below the water surface. • Seabird monitoring results indicate that they have not been disturbed by the tidal array. For example, underwater footage has recorded very few instances of birds near the turbines and has not recorded any collisions between a turbine blade and a diving seabird. • The use of underwater cameras is an effective way to collect data on seabird activity. The results are currently being combined with monitoring data gathered from observation on the sea surface across the tidal array and surrounding area. A joint analysis will subsequently be undertaken on the surface monitoring data and underwater video. • Seabirds do not generally dive into the Bluemull Sound where the tide is at its fastest; diving activity in the Sound is concentrated at slack tide. However, it is possible that the turbine and nacelle structure are attracting fish which in turn could attract diving seabirds. • Further environmental monitoring and analysis is needed to confirm the impact of the tidal array on seabirds, although to date there are no adverse impacts and this is a positive, 'learning' effect of the project. *Summary: At a project level there are no identified adverse effects on seabirds recorded to date. The effect on seabirds at an EU-level is unknown as seabirds, and their diving depth, varies significantly along the coastlines and between species. The potential for effects should be investigated based upon the specific environmental conditions present.*	✓	?
Marine Mammals • A variety of marine mammals have been observed within the Bluemull Sound and include otters, seals, whales and dolphins. • Otters are frequently observed adjacent to Cullivoe Pier who are attracted by the presence of fishing vessels who occasionally release catch to the sea. However, otters prefer to forage in shallow water close to shore and have not been observed close to the array. • The presence of marine mammals is recorded on an ongoing basis by underwater cameras and through observation on the sea surface across the tidal array and surrounding area. Harbour seals have been occasionally observed on underwater cameras; no other mammals have been observed subsea. • Analysis of underwater camera footage has not recorded any collisions with turbines. There is currently no evidence to date that indicates tidal array is disturbing any of the marine mammals identified and this is a positive 'learning' effect. • Environmental monitoring data will continue to be collected from the underwater cameras and combined with the results of the visual monitoring on the sea surface. *Summary: At a project level, there are no identified adverse effects on marine mammals and the project has improved our understanding as to how marine mammals interact with the tidal array. The effect at an EU-level is unknown due to the variation in the type and abundance of marine mammals around coasts. The potential for effects should be investigated based upon the specific environmental conditions present.*	✓	?

	Project-Level	EU-Level
Protected Sites • The tidal array is located a significant distance from the nearest protected sites or seabird colony, which is the Fetlar to Haroldswick Nature Conservation Marine Protected Area, the boundary of which is 2km to the South. There is also a protected seal haul-out site 2.5km to the North. • However, it is possible that highly mobile species such as seabirds and some types of marine mammals (seals, whales, dolphins) observed in the Bluemull Sound may have originated from a protected site. • In the absence of any identified adverse impacts on seabirds, fish or marine mammals the potential for the tidal array to be impacting the status of a protected site or colony is very low. *Summary: At a project level there are no identified effects on protected sites or colonies. The effect at an EU-level is unknown and the potential for effects should be investigated based upon the seabird and marine mammal species present in the deployment area, and the proximity to protected sites and colonies.*	0	?
Air Quality and Global Climate • The installation and deployment of the tidal energy devices, which use cranes attached to vessels, results in a highly localised and temporary, deterioration in air quality from the use of combustion vessels. A small quantity of GHG is also generated. • Energy generated by the tidal array is supplied to SSEN and feeds into the Shetland grid. This contribution results in Lerwick Power Station using slightly less diesel fuel than they would otherwise have consumed. Whilst the amount of energy supplied to the grid is a small percentage of the total energy supplied by Lerwick Power Station, operation of the turbines has reduced Shetland's GHG footprint and the volume of air emissions generated. *Summary: At a project-level the tidal energy array is contributing towards an improvement in air pollution and reducing the total volume of GHG generated through the substitution of diesel, albeit on a very small scale. At an EU-level the project continues to demonstrate the potential for tidal energy to comprise an important component of the broader renewable energy mix, also a positive effect.*	✓	✓
Seascape and Visual Character • Results from the SIC questionnaire completed in August 2018 indicated that the public acceptability of renewable energy technology in Shetland is strongly linked to their visibility. • Interactions with local people at the Yell Trade Show and from community focus group discussions reinforce this finding. • The turbines in the Bluemull Sound have no influence on seascape or visual character as the array is fully submerged and not visible. All onshore equipment is located at Cullivoe pier, next to existing light industrial facilities. • A key advantage of tidal energy technology is that it can be visually unobtrusive. • The seascape and visual character of Shetland is core to the identity of islanders. This is seen as an important resource that supports the tourism sector and a range of associated business activities. *Summary: At a project-level the public acceptability of the tidal array, close to an area with sensitive seascape and visual character, has been demonstrated. At an EU-level, it is likely that submerged tidal arrays will have high level of public acceptability and this is a key advantage of this type of technology.*	✓✓	✓✓
Marine and Coastal Archaeology • Whilst there are a variety of shipwrecks located throughout the Bluemull Sound, none are close to the tidal array. • Installation of the tidal energy devices do not require marine piling. • The technology is suitable for deployment within areas where there are marine and coastal archaeological resources. *Summary: At a project-level there is no effect on marine and coastal archaeology. At an EU-level, the effect on marine and coastal archaeology is unknown and the issue would need to be considered on a project-specific basis. Due to the absence of marine piling and cable burial, the technology is potentially suitable for use within areas sensitive to marine and coastal archaeology.*	0	?

7.2 Socio-economic appraisal topic areas

	Project-Level	EU-Level
Demographics • The continuing out-migration of young and qualified people from Shetland to the Scottish mainland and other parts of the UK is of concern to stakeholders. • The development of new technology has the potential to reduce out-migration through the provision of skilled local jobs. The direct employment impact has been limited to date, as the majority of Nova's workforce are based in their Edinburgh office and warehouse, rather than in Shetland. However, future expansion of this and other tidal sites in Shetland will lead to increased opportunities for skilled local employment for building and servicing tidal energy projects. • The project has stimulated economic growth and skilled employment amongst local businesses through the expansion of the supply chain. For example, revenue from the array has helped Shetland Composites to expand its premises and workforce. To date, over 50% of project spend has gone to companies in Shetland or Orkney and over 30 local companies have been involved in the project. The capital spend on Shetland-based companies through the supply chain is expected to encourage people to stay in Shetland. *Summary: At a project-level, the effects on demographics are positive as the development of new technology and increased capital spend will encourage people to stay in Shetland. At an EU-Level the effects on demographics are also positive as the technology is particularly suited to rural and remote areas that may be experiencing a similar demographic trend of out-migration.*	✓	✓
Standard of living, housing condition and vulnerable groups • Local people refer to the 'Shetland price factor' as goods and services are transported to the archipelago from the Scottish mainland. Transport involves using a ferry from the Scottish mainland to Sumburgh, and then road transport and ferries between islands to reach their destination. Costs gradually increase the further away the consumer is from the source of the product. • This price factor contributes to the high cost of living in Shetland compared with mainland Scotland and other parts of the UK. • Shetland has an average fuel poverty rate of 43%. Fuel poverty is higher amongst those living in the North Isles, and among elderly people over the age of 60; 68% of whom are estimated to be living in fuel poverty. • Shetland has a cold climate and experiences high wind speeds, resulting in homes requiring heating throughout most of the year. High wind speeds contribute to the wind chill effect and exploits cracks and gaps in houses, reducing indoor temperatures and lowering energy efficiency. • Outside of Lerwick, electricity or oil is used as the heating fuel. There is a district heating scheme in Lerwick linked to an energy from waste plant; there is no public gas distribution system on Shetland. • If the energy generated by the tidal array were to be provided at a cheaper price to households, then this could increase standards of living and housing conditions as people would have more money available for other items, apart from heating. This would also contribute towards a reduction in fuel poverty. However, due to the way in which the UK energy market is regulated it is not possible to use public infrastructure (SSE's cabling network) to provide households with cheaper energy. • The provision of low-carbon energy is aligned with SIC's strategy to improve the energy efficiency of residential properties and businesses. The aim is to increase energy generation from renewable energy sources whilst improving the way in which energy is consumed. SIC's grants are currently being used to insulate homes and increase the quality of windows which improves housing condition. However, this initiative lies outside the scope of the EnFAIT Project. • Building on the results of the community engagement activities completed during preparation of the Initial ESEA Report, Nova is considering additional ways that the project can be used to more directly support vulnerable groups. *Summary: At a project-level, there will be no noticeable effects on the current standard of living or housing conditions. At an EU-level, tidal arrays have the potential to generate positive effects to the standard of living and housing conditions if the cost of energy to the household or business consumer decreases, although this does depend on extent to which tidal energy is cheaper.*	0	✓
Educational change • Stakeholder engagement found that young people in Shetland who choose to enter into further education studies are increasingly focusing on creative media and similar types of courses, rather than vocational and practical courses that Shetland needs, such as mechanics and engineering. • Shetland presently relies on people from the mainland to provide a range of technical services. For example, SIC recently purchased a fleet of electric cars which local garages were initially (the issue has since been rectified) unable to service or fit replacement parts due to a lack of knowledge of this type of new technology. • The project has raised awareness about renewable energy technology amongst young people in schools. Raising awareness of a new technology contributes to the development of society and is a positive effect arising from the project. • The development of new technology in Shetland could inspire more young people to study mechanical and electrical engineering, environmental sciences, and practical courses, which will benefit the local economy and could stimulate further technological investment. *Summary: At a project and an EU-level, the effects are positive as knowledge of the project's technology could inspire young people to follow engineering and science-based courses.*	✓	✓

	Project-Level	EU-Level
Social Cohesion • The project has the potential to enhance Shetland's already very strong local identity and increase social cohesion as they are host to a world-first, demonstrator tidal energy project. • However, interactions with local people during preparation of the Initial ESEA Report indicate that locals are not generally motivated by the 'world-first' factor, and instead understandably focus on more immediate concerns such as the high cost of living and electricity in Shetland and economic development. • If the scale of the tidal array were to expand in the future and contribute a significant quantity of renewable energy and economic development to Shetland, then this perception could change. *Summary: At a project-level the effects of the tidal array on social cohesion are neutral. Effects at an EU-level are unknown though they could be positive in other locations, particularly if the tidal array were to contribute a significant quantity of renewable energy or economic impact.*	0	✓
Perception of the sea as a tidal energy resource • The project has raised awareness associated with the potential for the sea to provide energy through tidal arrays. • Based upon local stakeholder perceptions gathered during preparation of the Initial ESEA Report, the coastal and marine environment is increasingly seen as a reliable source of renewable energy, in addition to a resource for fishing and vessel navigation. • Knowledge of the project is being disseminated throughout the EU, through the EnFAIT website, regular press releases, presentations and other communication tools. This is raising awareness across Europe about the potential for tidal energy to contribute towards future low-carbon energy generation. *Summary: At a project and EU-level, the tidal array is enabling people to view the sea as a source of tidal energy and this change in perception is a minor positive effect.*	✓	✓
Recreational and Tourism Activities • As the tidal array is submerged, there is no visual or landscape impact from the turbines. • In the future if visitor resources were to be established at Cullivoe Pier, tourists would be able to learn about this new type of technology and understand how the tidal array is being operated. • A large proportion of Shetland's visitors are nature tourists, motivated to travel to Shetland by a combination of natural scenic beauty, coastal wildlife and the rugged landscape. These types of visitors are likely to be interested in new types of renewable energy technology. Based on the feedback from the ESEA Survey, Nova is considering options for developing visitor resources at the site. *Summary: At a project and EU-level, the tidal array is not having any effect on recreational and tourism activities. The future construction of a visitor resource would attract people to visit the site and learn about this new type of renewable energy technology.*	0	0
Employment and Business • In the first 18 months of the EnFAIT project, Nova's supply chain has been 100% from within the EU, 84% from Scotland and 60% from the Highlands and Islands region. • Businesses that have been involved in the supply chain have significantly benefitted from the project. For example, Fred Gibson of Shetland Composites (who manufacture the turbine blades) has been able to continue his business operations, and the additional business revenue has contributed to his decision to expand the workforce and construct a new warehouse facility. His role as a supplier has also increased his technical knowledge of turbine blade manufacture which has already led to new exports and will benefit his business in the future both with Nova, and other clients. • If energy generated from the tidal array is provided to other users of Cullivoe Pier through a "private wire", micro-grid network at cheaper rates than grid electricity, this will benefit other pier users through reduced expenditure on energy. Nova is considering options for supplying local consumers with electricity from the tidal array. *Summary: at a project and EU-level, the tidal array has a positive effect on* employment and business.	✓✓	✓✓
Industrial Strategy and Rural Regeneration • Nova has recently completed the fabrication of their new workshop in Edinburgh. • This is an example of how the project has resulted in regeneration where an old warehouse built in the 1970s is stripped down and upgraded to support Nova's future activities, as the company moves away from a research and development model into a business growth and operational and maintenance phase. The new workshop provides improved facilities, more space and is designed to support multiple turbine maintenance activities simultaneously. • In addition, supplier Shetland Composites has expanded their business and headcount in Shetland; just one of over 30 local suppliers benefiting from the project. • The project is a good example of pan-European cooperation, where European companies are at the leading edge of the development of new, low-carbon technologies. • If the commerciality of the tidal array is demonstrated by EnFAIT and the tidal array scales up, then Nova would create a maintenance hub in Shetland and the project could contribute towards rebalancing the UK economy, where economic activity is boosted in the outer reaches of the UK, rather than being solely focused on London and Edinburgh. • Development of new investment areas outside of major cities could create 'hotspots' of economic growth to occur, particularly in remote areas such as Shetland. *Summary: at a project and EU-level, the tidal array has a minor positive effect on UK industrial strategy and rural regeneration. The effects would be greater if the commerciality of the technology is demonstrated and the tidal array is scaled-up in the future.*	✓	✓

Commercial Shipping and Navigation	Project-Level	EU-Level
Commercial Shipping and Navigation • The depth of the turbine blades is sufficiently below the sea surface to allow the safe passage of vessels. • There is a potential for subsea cables to cross areas used for lobster pots and the collection of other types of crustaceans, or for anchorage. However, this is not a problem when stakeholders are adequately consulted to ensure that cables are appropriately located, such as in the Bluemull Sound. • If the scale of the tidal array at Cullivoe were to increase in the future, consultation with fishermen and other stakeholders will be required to ensure that there remains no interference with fishing or navigation. *Summary: At a project-level there are no effect on commercial shipping and navigation. Potential effects would need to be considered on a case-by-case basis at an EU-Level.*	0	?
Effects on the Regulatory Framework • Small-scale energy suppliers face market barriers to entry in the UK. For example, existing regulations fail to fully recognise the potential benefits of distributed, small-scale generation, such as: reduced network losses; improved local grid balancing services; and increased resilience of remote networks. • Recent UK policy developments include: the removal of feed-in tariffs (FITs) for small scale renewable generators; the closure of the Renewable Obligation (RO); the focus of the remaining Contract for Difference (CfD) support mechanism on very large-scale projects; and the denial of Seed Enterprise Investment Scheme (SEIS) tax relief to companies that generate electricity. This has created a “perfect storm”, leading to the collapse of the UK small-scale, low carbon energy market. • Consequently, small-scale project developers are forced to either: cede the UK market to large-scale competitors and move overseas, cease all activities (as many have done), or focus on the “behind the meter” market, selling directly to consumers to offset their electricity consumption. There is currently no route to market for new low carbon energy generating technologies in the UK, which has had a chilling, adverse effect on investment. • Energy policy in Scotland is not a devolved function and remains seated in Westminster, which has a variety of priorities, including: delivering Brexit; driving down energy bills; and developing large-scale energy projects. Ongoing large energy projects typically use imported energy generating technologies such as nuclear (the 3,200 MW Hinkley Point C project which is based upon French technology) and GW generation-scale offshore wind that utilises turbines imported from Denmark and Germany. • Tidal stream energy is a predictable source of low-carbon energy that does not require large capital investment, or a long-time frame from the start of construction until the point of energy generation. Nova recently deployed batteries at the Shetland array to create the world’s first baseload tidal power plant; supplying controllable, flexible renewable energy to the Shetland grid. • However, developers of small-scale renewable energy projects face a significant challenge in addressing the current regulatory and market conditions in the UK. • A key challenge is convincing the UK government to reinstate revenue support for emerging energy technologies. This used to be offered by the FIT and RO schemes, which spurred a wave of innovation and investment in the UK energy generation sector. Within the CfD framework, the focus is on reducing the cost of energy to consumers, with a push for renewable energy to be deployed at the lowest possible cost. The CfD scheme favours established renewable energy technologies imported from overseas, such as offshore wind, rather than smaller-scale, emerging, home grown technologies that which be the export opportunities of the future but need to be fostered to grow. *Summary: The tidal array has highlighted the need for existing UK government policy to be adjusted so that structural market conditions in the UK favour the future development of innovative, small-scale, low-carbon energy technologies. At an EU-level, the tidal array has demonstrated the value of project investments such as EnFAIT that sow the seeds of the low carbon technologies of the future, and that would not have taken place without EU support.*	✓✓	✓✓

8 Summary of Lessons Learned and Recommendations

During preparation of the ESEA report, various lessons learned have been identified through group discussion with Project Partners and engagement with local community stakeholders and marine environmental regulators. This section presents lessons learned and recommendations, with the aim of benefitting environmental regulators and tidal energy developers who are involved in similar projects in the future.

8.1 Interactions with the regulatory framework

During the permitting process of tidal energy devices, early engagement with regulatory stakeholders is essential to build trust and to determine, in a transparent and collaborative manner, the ways in which regulators should respond where gaps in policy are perceived to exist. For example, during the early stages of development of the Bluemull Sound site, existing regulations did not cover the deployment of tidal energy devices which led to uncertainty and delay in the consenting process as the wide range of stakeholders grappled with this new and emerging sector.

The creation of Marine Scotland to act as a 'single-point of contact' during the permitting process proved extremely effective as Marine Scotland could liaise with stakeholders and ensure clear and evidence-based regulations and policies were developed and applied consistently. Marine Scotland's policy during the initial permitting of the tidal array was to 'deploy and monitor'. This decision was assisted by the fact that the development was small in scale, allowing a proportionate approach to be adopted to the potential risks involved. Furthermore, the fact the project capacity was below 1MW meant that a full Environmental Impact Assessment (EIA), that is applied to large offshore wind or oil and gas projects, was not legally required allowing Marine Scotland to adopt a flexible approach. This enabled the project to proceed quickly with a robust environmental monitoring framework in place. The approach also reflects the way in which environmental regulators can respond dynamically to changes in technology and knowledge and use proportionality to support the development of small-scale energy projects.

Under the guidance of Marine Scotland, SNH completed a collision risk modelling study on behalf of Nova. The study was undertaken using SNH's own methods and specialists (Scottish Natural Heritage, 2016). This collaboration benefitted both Nova and SNH as there was confidence in the results associated with the types of physical interactions that could occur between the turbines and marine fauna. Due to the small-scale nature of the project, several the potential impacts that had initially been considered were quickly discounted. This enabled both the regulator and Nova to design their monitoring framework around the remaining uncertain risk: collisions with marine fauna by the turbine blades.

The EnFAIT project has provided an opportunity for regulatory bodies and Nova to learn about the way in which the regulatory framework should be applied to small-scale tidal energy projects before they are scaled-up. A robust set of environmental monitoring data has been generated on observed environmental interactions with project components and this is expected to make permitting of similar projects easier in the future.

The project's 'start small' approach enabled stakeholders such as fishermen to become familiar and comfortable with the new technology at a gradual pace. This provides evidence of the way in which EnFAIT is a pathfinder project, demonstrating that way in which different users of the sea and shoreline area can act in harmony with each other.

The Scottish Government believes that community benefits are an opportunity to share the positive effects of renewable energy and has created guidance relating to community benefits from offshore renewable projects. However, the guidance recognises that the tidal energy industry is in its infancy and is not yet at the stage where community benefits should be considered

8.2 Environmental lessons

Underwater cameras were used to gather environmental monitoring data; this was an effective way of understanding interactions between the tidal array and marine mammals, fish and seabirds. This was helped by the water clarity within the Bluemull Sound which lends itself to the use of cameras. At other locations, where turbidity is higher, the clarity of water may not be sufficient for underwater cameras to be used.

The collection of underwater video footage, combined with data from land-based observations, has generated a valuable data set which is currently being analysed by Nova to understand interactions between the tidal array and marine fauna and how top predator use of the sound may be linked to hydrodynamic conditions. However, visually interpreting the video footage to check for collisions and other types of events is a time-consuming process. There is a risk that a project falls into a situation where it is 'data rich and information-poor' ("drip"), if the strategic questions behind the collection of environmental data are not sufficiently defined. As the marine energy sector matures and environmental concerns become clearer, it will be increasingly important to clearly define at an early stage specific questions that the project needs to address. This permits the design of a focused and efficient environmental monitoring program, reducing the cost and improving the quality of information that can be derived from the data, for the benefit of this and future projects. The monitoring programme for the project will build on lessons learnt from reviews of post-consent monitoring for other offshore renewable energy projects (e.g. Marine Management Organisation, 2014) which identified the importance of defining clear objectives and designing the monitoring to address those objectives.

A quick, automatic and cost-effective method of interpreting underwater video footage could be developed. This could include the use of an algorithm to rapidly distinguish between background "noise" events, and those which require further investigation with the human eye.

Marine growth on the surface of the cameras reduces the quality of video information as the lens becomes obscured typically after several months of deployment. A new solution is required to keep the video lenses clean automatically so that the quality of the footage gathered does not decline after deployment of the device. In addition, non-visual (e.g. acoustic) solutions might be required to assess interactions with marine fauna at sites where turbidity is high, and the effectiveness of subsea cameras is reduced due to poor visibility.

8.3 Socio-economic lessons

Local community engagement activities identified demand for information to be provided at Cullivoe Pier on: the purpose of the project; the way in which the tidal energy devices operate; how the energy generated is being used; and future plans for the tidal array. This could include a notice board, pictures or video footage of the turbines operating.

Stakeholders in Shetland appreciated Nova's engagement with young people in schools which aimed to provide information about renewable energy and generate interest in marine science and engineering.

The development of the tidal array has had a positive impact on the local economy, contributing towards rural regeneration and increasing capacity within local supply companies. The project has demonstrated how the supply chain can rapidly adapt to emerging technologies that benefit businesses through additional income and improved knowledge.

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