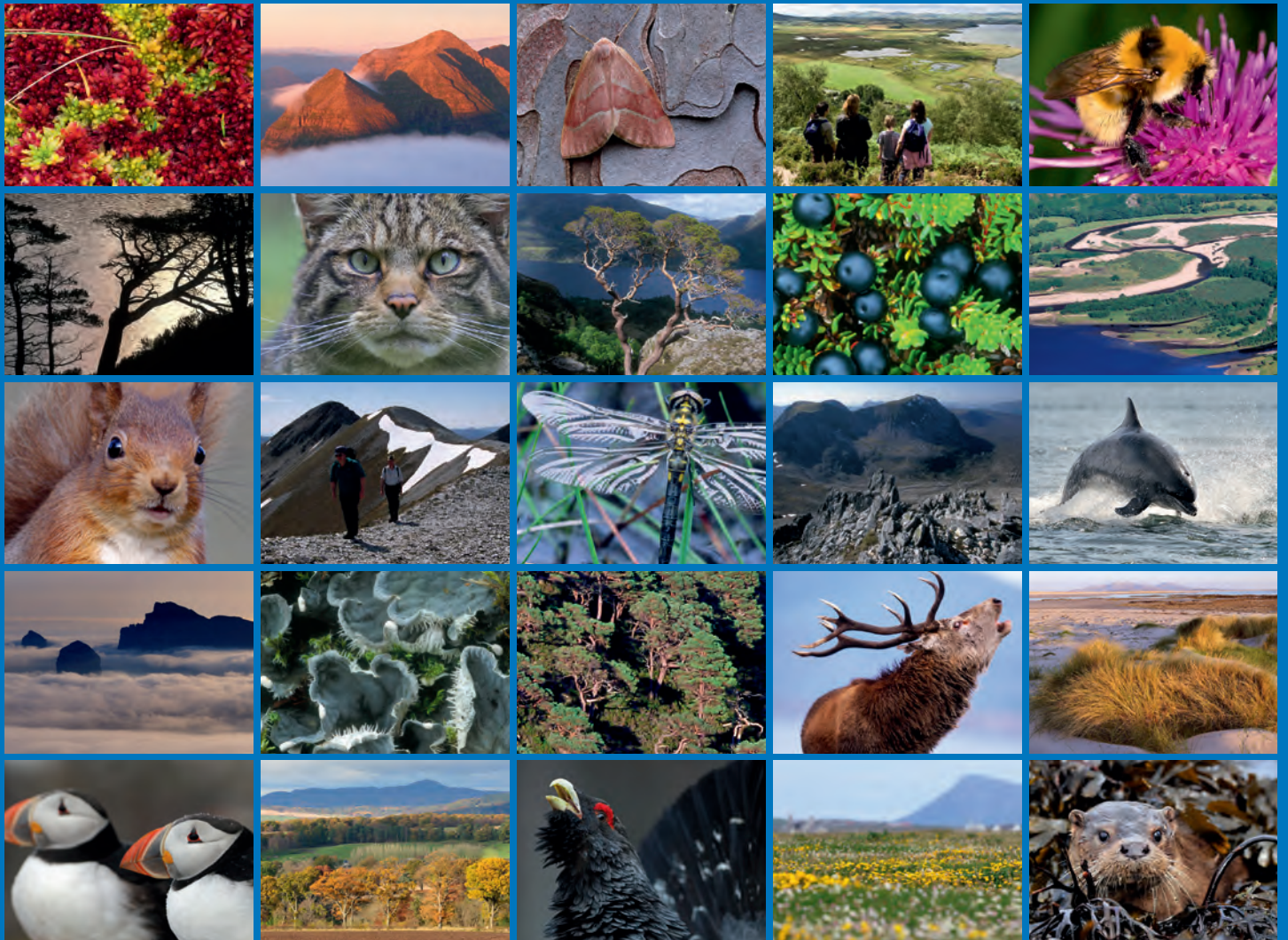


Seagrass (*Zostera*) beds in Orkney





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COMMISSIONED REPORT

Commissioned Report No. 765

Seagrass (*Zostera*) beds in Orkney

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COMMISSIONED REPORT

Summary

Seagrass (*Zostera*) beds in Orkney

Commissioned Report No. 765

Project No: 848

Contractors: Emma Jackson (The Marine Biological Association of the United Kingdom) and Malcolm Thomson (Sula Diving)

Year of publication: 2014

Keywords

Seagrass; *Zostera marina*; Orkney; predictive model; survey.

Background

Seagrasses (*Zostera* spp) are marine flowering plants that develop on sands and muds in sheltered intertidal and shallow subtidal areas. Seagrass beds are important marine habitats but are vulnerable to a range of human induced pressures. Their vulnerability and importance to habitat creation and ecological functioning is recognised in their inclusion on the recommended Priority Marine Features list for Scotland's seas.

Prior to this study, there were few confirmed records of *Zostera* in Orkney waters. This study combined a predictive modelling approach with boat-based surveys to enhance understanding of seagrass distribution in Orkney and inform conservation management. A report of a separate biodiversity survey of two seagrass beds in Orkney, commissioned by Scapa Flow Landscape Partnership with SNH funding support, is also included here (Annex 4).

Main findings

- Maximum entropy modelling is an inherently useful approach to the development of predictive maps of potential seagrass occurrence in areas such as Orkney with limited observational data.
- Wind driven wave exposure alone provided a relatively good approximation of the potential habitat for *Zostera* in Orkney. Addition of bathymetry data, incorporating depth occurrence data from transect surveys, provided a more refined prediction of *Zostera* presence. Preliminary results suggest that models could be further improved through inclusion of offshore slope.
- Surveys confirmed the presence of *Zostera marina* at 12 locations in Orkney comprising 22 of 126 locations identified by the predictive model as potentially suited to seagrass. The apparent absence of seagrass from some of the remaining locations may have been an artefact of the timing (in late winter/early spring) and limited duration and scope of the ground truthing surveys.
- An unusual form of seagrass beds, associated with maerl, in areas of moderate tidal velocity, was documented from Wyre Sound. The *angustifolia* form of *Z. marina* was recorded from the Finstown Ouse.

- The survey of two seagrass beds, carried out by Orkney Islands Council Marine Services, enhances our understanding of the diversity of macro-invertebrate communities associated with this habitat in Orkney.

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Acknowledgements

The previously unpublished report of the survey of seagrass beds at Widewall Bay and Finstown commissioned by Scapa Flow Landscape Partnership (SFLP) is included here (Annex 4) by kind permission of Jenni Kakkonen, biologist at Orkney Islands Council Marine Services, and Julian Branscombe, manager of the former SFLP. The authors would also like to thank Professor Jon Side (International Centre for Island Technology, Heriot Watt University) for provision of long-term wind data and detailed bathymetry.

1. INTRODUCTION

Seagrasses (*Zostera* spp) are the only marine flowering plants found in Scotland. They have long thin leaves and are also known as eel grasses. Seagrass beds develop on sands and muds in intertidal and shallow subtidal areas sheltered from significant wave action. Worldwide, seagrass beds are recognised as important marine habitats providing a variety of ecosystem services. The rhizome's bind and stabilise sediments, increasing deposition of suspended material and inhibiting erosion, and in some areas the presence of seagrass beds protects the adjacent coastline, reducing coastal erosion. Seagrasses support high biodiversity and therefore are likely to be important in the resilience and stability of the wider ecosystem. As potentially important nursery, spawning and feeding areas for commercially important species or their prey, seagrass beds may contribute significantly to fishery resources.

In Europe, there was mass dieback of shallow water seagrasses during the 1920s and '30s due to disease and they are also vulnerable to physical disturbance, introduced species, increased turbidity, nutrient enrichment and pollution. They are included on the OSPAR List of Threatened and/or Declining Species and Habitats¹. Their vulnerability and importance to habitat creation and ecological functioning is recognised in their inclusion on the recommended Priority Marine Features list for Scotland's seas².

Prior to this study, there were few confirmed records of *Zostera* in Orkney waters but anecdotal evidence of a more widespread occurrence in suitable locations. *Zostera marina* records are of both the broad leaved form typical of the sublittoral zone and the narrow leaved form of the mid to lower shore. In the UK literature the latter form is frequently attributed as *Zostera angustifolia* (Tyler-Walters 2008) but the World Register of Marine Species (WoRMS)³ considers *Zostera angustifolia* to be a phenotypic variant of *Zostera marina* Linnaeus, 1753. There are no confirmed records of *Zostera noltei* Hornemann, 1832 (frequently referenced as *Zostera noltii*) from Orkney.

1.1 Project aim, partners and phases

The aim of this project was to deliver a baseline assessment of the size, extent and distribution of *Zostera* across Orkney, to inform conservation planning for this resource.

There were two elements to this project.

Predictive Modelling: was undertaken between October 2009 and September 2010 by Dr Emma Jackson of the Marine Biological Association (MBA), who had previously undertaken a study of *Zostera* in Orkney waters (Jackson, 1998). Mapping seagrass distributions in remote archipelagos can be expensive and time consuming. In order to help focus on areas of potential seagrass distribution for further survey in Orkney, the aim was to create a predictive model of seagrass habitat suitability. An initial model, based on historic data, was then refined using ground truthing surveys.

Ground Truthing: was undertaken by Malcolm Thomson of Sula Diving between January and March 2010. An initial transect survey of known seagrass sites in Orkney provided additional information on upper and lower depth limits. This helped to refine the model by removing sites identified as having otherwise suitable habitat but which would be too deep for

¹ Declining in Regions II (North Sea) and III (Celtic Sea) and threatened in Region V (Wider Atlantic)

² For more on Priority Marine Features see <http://www.snh.gov.uk/protecting-scotlands-nature/priority-marine-features/priority-marine-features/>. The list includes *Zostera noltii* beds in littoral muddy sand LS.LMp.LSgr.Znol; *Zostera marina/angustifolia* beds on lower shore or infralittoral clean or muddy sand; and *Ruppia maritima* in reduced salinity infralittoral muddy sand

³ <http://marinespecies.org/index.php>

sites identified as having otherwise suitable habitat but which would be too deep for seagrass. The refined model was then used to generate locations of Ground Control Points (GCPs) where conditions were predicted as suitable for seagrass for survey to confirm seagrass presence or absence.

In addition to this study, in 2011 the Scapa Flow Landscape Partnership (SFLP)⁴, which was part-funded by SNH, commissioned a survey of two seagrass beds in Orkney. This survey was led by Jenni Kakkonen of Orkney Islands Council Marine Services and included epiphyte and substrate core sampling to characterise the physical characteristics and associated fauna and flora of the seagrass beds at Widewall Bay and Finstown. The previously unpublished report of that survey, including species lists for both sites, is included here at Annex 4.

2. METHODS

The methods used are described in sections 2.1 and 2.2, below. Please see Annex 4 for the report of the biodiversity survey of the seagrass beds at Widewall Bay and Finstown.

2.1 Predictive modelling

Maximum entropy modelling was chosen for the predictive habitat model. This approach is most appropriate when the primary data are historical observations and the species in question is relatively dynamic, demonstrating disappearances and recovery over time at some sites. The principle behind maximum entropy modelling is that estimates of a probability distribution are generally based on only partial information, such that any inference about the distribution should be based on maximum entropy (or maximum uncertainty), subject to whatever information is known (Jaynes 1957). The modern day approach to maximum entropy species distribution modelling was developed by Phillips *et al.* (2006) and is delivered through a free-ware software platform known as MaxEnt⁵. This software takes as input a set of layers of environmental variables (such as bathymetry, slope, etc.), as well as a set of georeferenced occurrence locations, and produces a model of the range of the given species or habitat. For this study, 104 *Zostera* records were used to train the model and 25% of the sample records were randomly set aside for testing the model. Jackknife plots and variable response curves were used to assess variable importance to the final model.

The Wave Exposure Model (WEMo) developed by CCFHR (Centre for Coastal Fisheries and Habitat Research) scientists at NOAA (National Oceanic and Atmospheric Administration) was used to calculate the relative wave exposure around the Orkney archipelago. WEMo is a simple open source ArcGIS application that allows measurement of the effects of waves on ecosystem function. This numerical model uses linear wave theory to calculate actual wave height and derived wave energy while taking into consideration wind generation and local water depth characteristics such as shoaling and dissipation from breaking waves (Fonseca *et al.*, 2006). The model works in a simple Geographic Information System (GIS) format and requires gridded bathymetry, polyline coastline and ASCII format wind data inputs. The software has previously been used to identify: seagrass exclusion areas (i.e. where wave energy is too high for persistent seagrass habitat); the potential for restoration of seagrass; and, seagrass landscape pattern (Fonseca and Bell, 1998; Jackson *et al.*, 2006).

⁴ Further information about SFLP can be found at http://www.scapaflow.co/index.php/the_scheme

⁵ Available for download from <http://www.cs.princeton.edu/~schapire/maxent>.

The software calculates a relative exposure index (REI) following the methods of Keddy (1982) which is based on the equation:

$$REI = \sum_{i=1}^8 (V_i \times P_i \times F_i)$$

where i is i th compass heading (increments of 45°), V is mean monthly maximum wind speed (ms^{-1}), P is the percent frequency at which wind occurred from the i th direction and F is the effective fetch (m). REI does not compute wave energy, but instead provides a context for evaluating how exposed a site is to wind-generated waves in comparison to any other site (Fonseca *et al.*, 2006). The software calculates effective fetch by measuring along the i th compass heading and four lines radiating out from either side of the i th heading at increments of 11.25 , then summing the product of fetch x cosine of the angle of departure from the i th heading over each of the nine lines and dividing by the sum of the cosine of all angles. This weighting of multiple fetch measures for each compass heading helps account for irregularities in shoreline geometry that could misrepresent the potential of wind wave development from a given compass heading.

The software also calculates wave height and derived wave energy called Representative Wave Energy (RWE). RWE values computed by WEMo are based on linear wave theory and ray tracing technique making it a model of Lagrangian nature in a sense that the wave generation and dissipation is considered while traveling with the waves along rays. RWE represents the total wave energy in one wave length per unit wave crest width. RWE units are J/m or kg/m/s^2 (USCOE, 1977).

A gridded point dataset layer was created (250m spacing) using Hawth's Analysis Tools for GIS (Beyer, 2004) and uploaded to act as the receptor of REI and RWE measurements. The models were then run and the output map layers created. The point data were converted to a grid layer of the REI and RWE measures for the MaxEnt modelling.

The following sections describe the parameterisation of the WEMo and MaxEnt models.

2.1.1 Records of *Zostera*

Records of *Zostera* (including *Zostera marina* and *Zostera marina* var. *angustifolia*) were collated from a number of key data sets and reports:

- National Biodiversity Network (NBN),
- Marine Life Information Network (MarLIN),
- Environment and Heritage Centre review of the genus *Zostera* in the UK (Davison, 1997)
- Records from SNH report "The status of the genus *Zostera* in Scottish coastal waters" (Cleator, 1993)
- Local reports collated as part of a MSc thesis (Jackson, 1998)

Records that were duplicated among the various data sources were removed prior to analysis. In total 167 positive records of *Zostera* sp were collated and used to construct the model. Model validation was based on transect and ground control point survey data ($n=194$) collected by SULA Diving (see below).

Due to fact that some of the environmental variable layers do not reach all the way inshore, some of the distribution points had to be omitted from the analysis.

2.1.2 Bathymetry

Bathymetry point data was provided by ICIT and interpolated to create a raster grid using Inverse Distance Weighting (IDW) tool with the ArcGISv9.3.1 spatial analyst extension. Grid spacing was set at 100m. In addition to being used directly as an environmental layer in the model the bathymetry dataset was used to calculate REI. The bathymetry area of interest was set as a covering the entire Orkney islands with a 2km buffer.

2.1.3 Wind speed and direction

Percentage frequency and maximum daily wind speed data (between 12/07/01 and 27/12/02) recorded at Sandy Hill (South Ronaldsay: 58°46'08"N, 2°58'03"W) were provided by the International Centre for Island Technology (ICIT). These were used to generate the two wind data parameters required to run the WEMo:

1. A specified percentage (here set as 5%) of top hourly wind speed observation (mph) over the preceding years at the site from eight compass headings; and
2. The top wind (exceedance) occurrence frequency from the eight compass headings.

2.1.4 Shoreline

The WEMo requires a detailed shoreline data set to clip fetch with the land. An ESRI shapefile GIS layer of the mean high water spring mark for the UK was uploaded for the calculation of Effective Fetch (defined as the distance from the site to land along a given compass heading). Fetches longer than 10km were clipped at 10 km as empirical experimentation by scientists at NOAA suggest this is a sufficient distance to generate a maximum wave height effect.

2.2 Transect and ground control surveys

Survey work was carried out by a team of three operating from a 6m RIB (MECAL Class 3 coded). The coxswain (RYA DAY Skipper) was accompanied by two marine biologists who were also competent to act as crew. Details of the risk assessment and control measures can be found in the SULA Diving Project Plan and Task Risk Assessment (09/128).

Seabed features were observed in the majority of cases using a drop video system, comprising an HD video camera in an underwater housing, mounted on the end of a galvanised steel pole (max length approx. 4m). A remote display screen connected to the camera housing by umbilical was used to provide a surface image of the seabed and to control depth, zoom and recording. At deeper sites the camera /pole assembly could be lowered closer to the seabed by rope.

A viewing box was also used as a rapid survey method or where poor surface conditions combined with proximity to shore meant that deploying the video system was either not practical or not safe.

A small number of GCPs (see section 2.2.2) were not accessible by boat and were instead surveyed on foot during low spring tides.

2.2.1 Transect survey

Transect data were provided to the survey team by Emma Jackson in the form of start and end co-ordinates between which the seabed should be surveyed for the presence/absence of seagrass (Annex 1). The transects were located at known seagrass sites in Orkney and were each several hundred meters in length.

Due to constraints of time and budget, the transects proposed at Papa Westray, Westray and Sanday were replaced with transects nearer to Orkney Mainland, in Wyre Sound and off the Rendall shoreline at Tingwall, Wasswick and Woodwick. The locations of both the original and final transects are shown in Figure 3.

Transect co-ordinates, in degrees and deci-minutes (DDM), were programmed into the RIB GPS system. Route lines were used to aid navigation in a straight line between the start and end co-ordinates. The direction of survey was determined by sea and/or weather conditions on site. Surveys were executed by moving to the start co-ordinate and beginning a slow run along the transect, using either the drop video (ROV) or viewing bucket to view the seabed, depending on depth. Co-ordinates were collected for relevant features along the transect (e.g. the start or end of a seagrass bed).

Depth was recorded from the depth sounder on the survey vessel, which was accurate to 0.1m. Positioning was achieved using a Geonav 6 Sunshine GPS unit, installed on the survey vessel. Such units have a typical accuracy of +/- 5m. Position data for transects and GCPs were converted to DDM format. Time was also noted for the start and end of transects and for points of interest along them (e.g. edge of a seagrass bed) and a Dictaphone was used to aid record keeping. In some cases (e.g. at Wyre Sound) the viewing box was used to run the transect initially to record presence/absence and position data, before a repeat run was made with the video system.

2.2.2 Ground Control Point (GCP) survey

Following further refinement of the model using the depth data from the transect survey (see section 1.1) a list of 166 GCPs where the model predicted seagrass to be present was provided to Sula Diving by Emma Jackson. These were spread out around the islands of Orkney. As with the transect survey, constraints of time and funding, meant that those GCPs nearer to Orkney Mainland were prioritised and, on agreement with SNH, those around Westray, Papa Westray, Sanday and North Ronaldsay and some on the east side of the Churchill Barriers were omitted from the survey. There were also three duplicate GCPs and two were located in water depths that were too deep for the survey method; the presence of seagrass at these sites was judged very unlikely. Six additional sites, named A1 – A6, were added to the remaining list of GCPs, giving a total of 126. The GCP co-ordinates are detailed in Annex 2 and locations shown in Figure 1.

The GCP co-ordinates, in degrees and deci-minutes, were programmed into the RIB GPS system. Each GCP was visited and the presence or absence of seagrass was determined by drop video or viewing bucket. Time and observed depth were also noted, as described above.

2.2.3 Post survey analysis

All transect and site data including dates and times of survey, site co-ordinates, observed depth, presence/absence of seagrass, substrate type and any other feature noted at the time of survey were collated into Excel spreadsheets. Video footage was transferred from DV tape to mpeg4 files, which were edited to provide each transect and GCP in a discrete file. Details of these data files and their locations are in Annex 3.

Where available, video footage was reviewed in order to verify the presence/absence of seagrass at each site and to note other species present. Subsequently, data were transferred to standard JNCC MNCR forms⁶. Given the low resolution of the sampling method, only the first page of the MNCR Habitat forms were completed, listing all species

⁶ See <http://jncc.defra.gov.uk/page-2683> for further details of this recording scheme

observed during the survey of each transect or GCP. MNCR sheets were not completed for transects/GCPs which were surveyed by viewing bucket only.

3. RESULTS

The results of phases I and II are described in sections 3.1 and in 3.2 and 3.3, below. Please see Annex 4 for the report of the biodiversity survey of the seagrass beds at Widewall Bay and Finstown.

3.1 Predictive modelling

Predominant wind direction for the period of wind data used was 153.8° with maximum daily wind speeds of 54.57 knots (gusts of 71.5 knots). As such the coasts exposed to these south south easterly winds show relatively high wind exposure (Figure 1). The position of Orkney also means that, with the exception of south facing coasts, all external coasts of the island group have large wave fetches. The fetch for western facing coasts exceeds the 1000km threshold set within the model parameters, and hence these coasts experience high wave exposure (Figure 3). The only exceptions on these coasts are a few enclosed bays which afford shelter from most wind directions and sites were shallow waters off the coast dissipate waves. Internal coasts of the archipelago have relatively lower wave exposures. The least wave exposed coast occurs within shallow enclosed bays (Figure 3), for example at St Peter's Pool and Bay of Firth on Mainland, North Bay on Hoy and Otters Wick on Sanday.

As illustrated by Figure 1, wind driven wave exposure alone provides a relatively good approximation of the potential habitat for *Zostera*. However addition of bathymetry data modelling of the probability of occurrence using MaxEnt provides a more refined prediction of *Zostera* presence. (Figure 2)

The Jackknife test of variable importance illustrated that both the depth layer and WEMO data gave equal gain when used in isolation by the model. The AUC (area under the receiver operating characteristic curve) score was considered good (0.83). Although a high AUC values may be an artefact of the fact that the *Zostera* has a narrow range relative to the study area described by the environmental data, the model still provides a useful tool for identifying locations for further exploration. Cross checking areas with a high probability of *Zostera* occurrence from the model with areas where there are few data records for any benthic species (i.e. areas where there is no or low survey intensity) could identify locations where searches should be instigated.

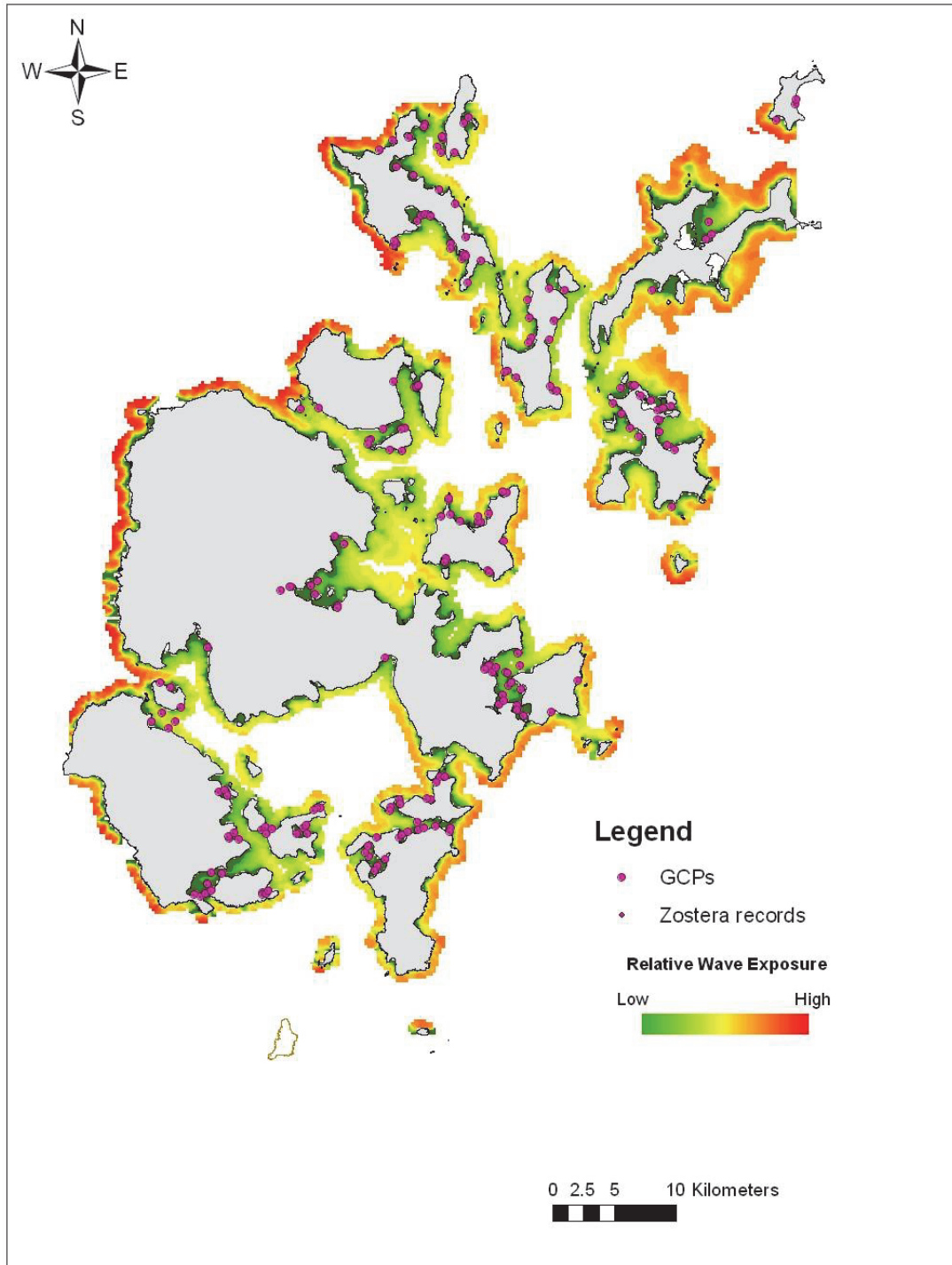
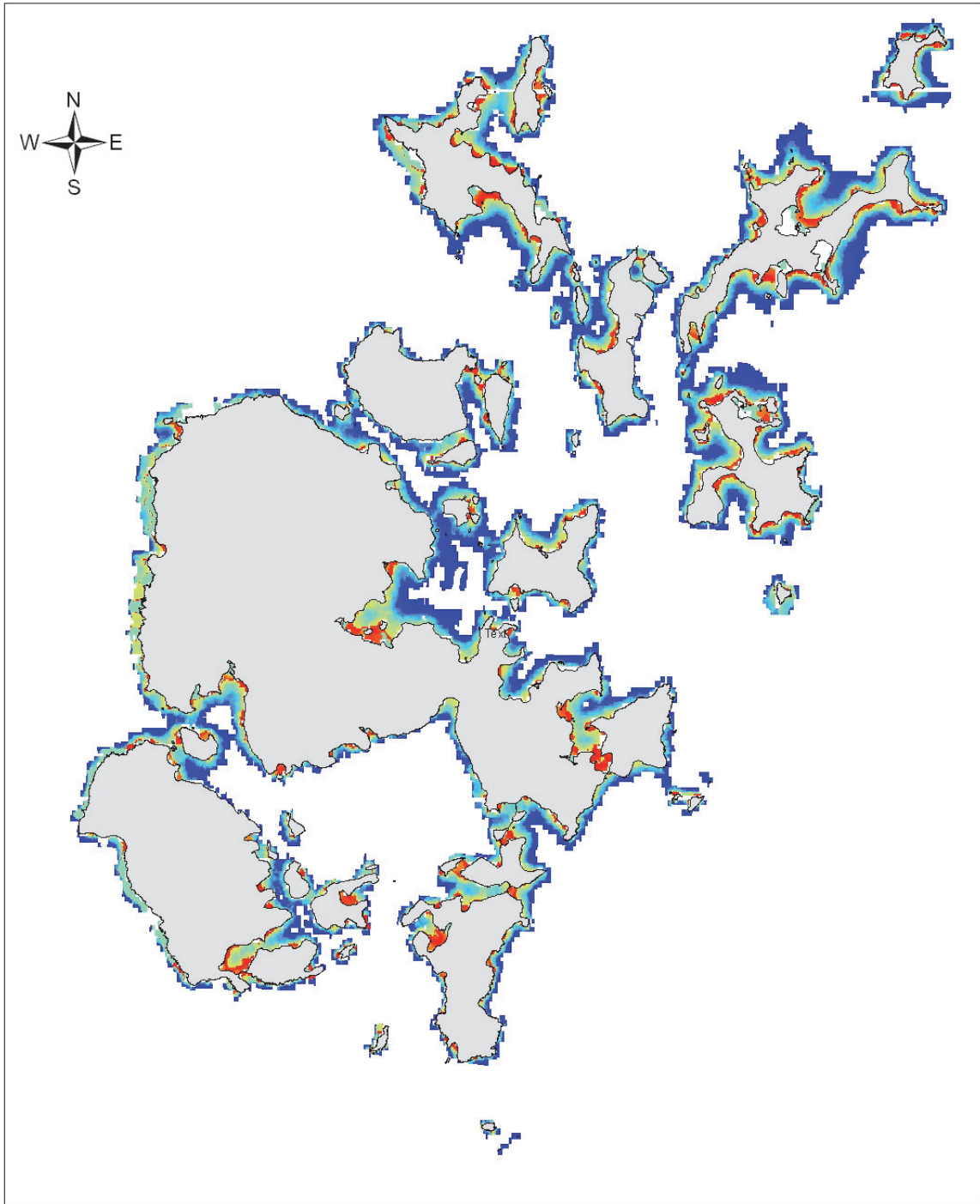


Figure 1. Relative wave exposure for coastal waters (1km from mean high water spring mark) of the Orkney Islands, overlaid with historical *Zostera* records and original ground control positions (GCP)



Probability of Zostera Habitat

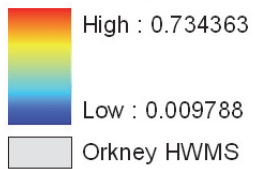


Figure 2. Full MaxEnt model predictions for Zostera marina

3.2 Transect surveys

A total of 18 transect surveys were carried out during January and February 2010 at the following locations (number of transects indicated in brackets):

19th January: Wyre Sound (6), Gairsay Sound (5)

26th January: East Weddell (1), Deer Sound (4)

9th February: Widewall Bay (2)

Seagrass beds were observed at eight transects, located in Wyre Sound, Gairsay Sound, Deer Sound and Widewall Bay. No seagrass was observed at East Weddell. Summarised data for each transect are contained in Table 2 (see Annex 3 for details of raw data held by SNH).

Co-ordinate data were passed to Emma Jackson to determine the depth distribution of seagrass, relative to chart datum, for each site. The maximum corrected depth observed was 4.6m relative to chart datum. However, the transect surveys indicated considerable variation between sites in characteristics of the seagrass beds such as bed thickness and “patchiness” and in environmental characteristics such as substrate type and tidal exposure. On the basis of these observations, the seagrass beds were assigned to two distinct groups:

- Group A: Deer Sound/Widewall

Growth of seagrass varied from very sparse (e.g. around the boundaries of a patch) to more moderate thickness (e.g. in the middle of a patch) and sparse growth made for indistinct boundaries around some areas of seagrass (e.g. Deerness T2). Patch size also varied. The transects in the inner area of Deer Sound (Deerness T1 & T2) and Widewall (Widewall T1) covered relatively large areas of seabed continuously but in varying density.

Substrate type comprised sand or muddy sand at all sites in Deer Sound/Widewall where seagrass was present. Large amounts of seagrass debris were also associated with some of these transects, possibly due to the fact that all these sites were very sheltered from both wave and tidal action. In these characteristics, the seagrass beds in this group corresponded to the SS.SMp.SSgr.Zmar biotope.

- Group B: Wyre/Gairsay

In Wyre Sound, transects T1, T2 and T4 suggested the presence of seagrass in a strip running parallel to the north shore of Wyre, to the west of the pier. At the Gairsay Sound transects (Tingwall T1 & T2), the seagrass occurred over a wider area, perhaps as there was less of a depth gradient at these sites relative to the Wyre Sound sites. Seagrass patches were generally smaller but numerous and tended to have more distinct boundaries (e.g. Wyre transects T1 & T2) than in Deer Sound/Widewall. Growth in these small patches could be quite dense. Perhaps the most interesting feature of this group was the substrate, with seagrass being rooted in maerl. Maerl is known to occur widely in this area and includes large areas of living material⁷, as well as a significant bank of dead material in the middle of Wyre Sound. The species of maerl was unconfirmed

⁷ An interesting feature of the maerl in Wyre Sound was the presence of dense beds of spherical thalli along the north coast of Wyre. These beds were observed in Wyre Transects T1 & T2. No seagrass was observed on this feature.

Table 2. Summary of transect results indicating where seagrass was observed and the dominant substrate type at each transect.

Transect	Seagrass present	Substrate	Description
Wyre 1	Y	Maerl	Seagrass formed band running parallel to shoreline. Often rooted in patches of living maerl. Dense growth in places.
Wyre 2	Y	Maerl	Seagrass formed band running parallel to shoreline. Often rooted in patches of living maerl. Dense growth in places.
Wyre 3	N	Maerl	-
Wyre 4	Y	Maerl	Transect running parallel to Wyre shoreline. Growth mostly sparse, possible running along outer extent of beds.
Wyre 5	N	Maerl	Rousay shoreline.
Wyre 6	N	Maerl	Rousay shoreline.
Tingwall 1	Y	Maerl	Seagrass on maerl, often associated with living material. Fairly sparse beds.
Tingwall 2	Y	Maerl	Seagrass on maerl, often associated with living material. Growth slightly more dense in places relative to Tingwall 1.
Tingwall 3	N	Maerl	-
Woodwick 1	N	Sand, boulder	-
Wasswick 1	N	Sand, boulder	-
East Weddell 1	N	Sand, boulder	-
Deer Sound 1	Y	Sand	Seagrass occurred intermittently along the transect, dense in places, sparse in other and seagrass debris common.
Deer Sound 2	Y	Sand	Seagrass occurred intermittently along the transect, generally sparse beds, seagrass debris common.
Deer Sound 3	N	Sand	-
Deer Sound 4	N	Sand	-
Widewall 1	Y	Sand	Seagrass occurred at the start of the transect only which was at the innermost extent of Widewall Bay. Red alga associated with the seagrass.
Widewall 2	Y	Sand	Transect crossed the boundary of a seagrass bed. Apparently the same red alga associated with seagrass.

during this survey but JNCC records indicate the presence of a *Phymatolithon calcareum* biotope (SS.SMp.Mrl.Pcal) in Wyre Sound. In some cases, patches of seagrass appeared to be associated with patches of living maerl although it was also observed to grow on maerl gravel/debris (e.g. Wyre transects T1 & T2).

Tidal velocity in the Wyre/Gairsay area is much greater than at Deer Sound/Widewall. Although the transects were generally located near to the shore and perhaps out of the main tidal flows, which are in the regions of 3 knots, they were still subject to currents as witnessed during fieldwork. This might be the reason that no seagrass debris was observed at any of these sites.

Given the maerl substrate, the seagrass beds in the Wyre/Gairsay area do not technically conform to the SS.SMp.SSgr.Zmar biotope. While the maerl habitat probably does conform to a current MNCR biotope (e.g. SS.SMp.Mrl.Pcal), these do not mention *Zostera* as a characteristic species.

3.3 Ground control point (GCP) survey

The 126 GCP sites were surveyed on four days between the 18th and 29th March 2010; 114 by video and 12 by viewing bucket. Figure 3 shows the locations where seagrass was and was not found, as detailed in Annex 2. Details of raw data held by SNH are in Annex 3.

Growing seagrass was observed within 12 locations at 22 of the 126 sites surveyed. Seagrass debris was noted at an additional two sites. Details for each of the sites where seagrass was found are in Table 3.

In common with the transect data, the seagrass found in Wyre/Rousay/Gairsay Sounds was rooted in maerl substrate and a possible association with patches of living maerl was observed. These GCPs, particularly those located in Wyre and Rousay Sounds, would be exposed to moderate to strong tidal streams, certainly in excess of 1 knot during peak flows. Apart from GCP 136, located on the north side of Graemsay and exposed to tidal flows in Hoy Sound (where maerl habitat is also present), most other GCPs where seagrass was observed were in tidally sheltered sites with mud/sand substrates.

GCPs 99 and A6 at the Finstown Ouse were surveyed on foot at low spring tide. Seagrass was found at both sites. At GCP 99, within the Ouse, seagrass was found in discrete clumps, throughout the intertidal. Close inspection of these plants suggested they may be examples of the *angustifolia*, form of *Zostera marina*, and were rooted in mud. Beds of *Ruppia maritima* were also present at this site. Just outside the Ouse, at GCP A6, a more extensive bed of seagrass was found just at the spring low water mark and this was also thought to be the *angustifolia* form of *Zostera marina*, although at this site it was rooted in muddy gravel. Both sites are exposed to a degree of water movement as the Ouse fills and drains over the tidal cycle.

The survey failed to find seagrass at the majority of the GCP sites. A large number of these sites appeared suitable for the occurrence of in terms of depth and substrate type and it is possible that seagrass may have occurred in the vicinity. However, given the survey schedule, there was little time for investigating the surrounding area in more detail. Also, *Zostera marina* exhibits seasonal changes in growth rates and leaf form that reduce cover in the winter months and beds may be damaged by severe storms (Tyler-Walters 2008, Davison and Hughes 1998). *Z. marina* var *angustifolia*, such as found at the Finstown Ouse, is often annual and enhanced sediment load in the water column over seagrass beds in the winter (Hansen and Reidenbach 2013) may also reduce detectability. As such the possibility that seagrass may in fact occur at some of these places should not be discounted.

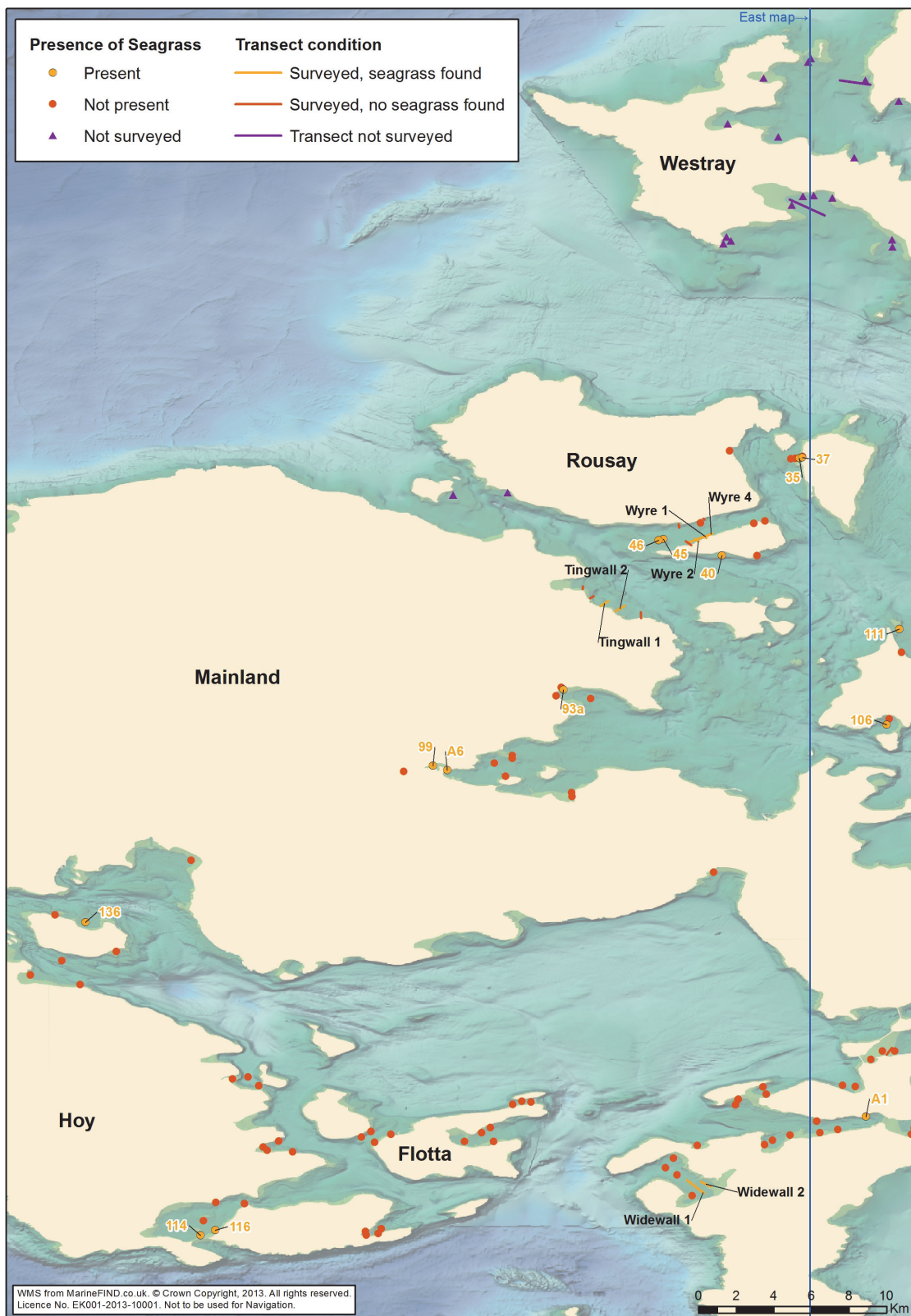


Figure 3a. Locations of survey transects and GCPs showing which were surveyed and where seagrass was observed: western sites. Sites where seagrass was found are labelled to enable cross referencing to Tables 1 and 2.



Figure 3b. Locations of survey transects and GCPs showing which were surveyed and where seagrass was observed: eastern sites. Sites where seagrass was found are labelled to enable cross referencing to Tables 1 and 2.

Table 3. GCP locations where seagrass was recorded along with data on observed depth (not corrected to chart datum) and substrate type.

GCP	Location	Observed depth (m)	Substrate	Details
35	Rousay Sound	2.6	Maerl	Tidally exposed site
37	Rousay Sound	3.0	Maerl	Tidally exposed site
40	Gairsay Sound	6.7	Maerl	Tidally exposed site
45	Wyre Sound	4.2	Maerl	Tidally exposed site
46	Wyre Sound	3.3	Maerl	Tidally exposed site
58	Linga Sound (Stronsay)	2.8	Sand	Debris only
66	Mill Bay (Stronsay)	2.2	Sand	Moderate exposure to wave action
71	Mill Bay (Stronsay)	5.7	Sand	Moderate exposure to wave action
79	Deer Sound	6.0	Sand	Sheltered from wave and tidal action
80	Deer Sound	6.5	Sand	Sheltered from wave and tidal action
81	Deer Sound	-	Sand	Sheltered from wave and tidal action
82	Deer Sound	-	Sand	Sheltered from wave and tidal action
90	Deer Sound	0.7	Sand	Sheltered from wave and tidal action
93a	Bay of Isbister	1.8	Sand	Subject to freshwater discharge
99	Finstown Ouse	Intertidal	Mud	Subject to freshwater discharge. Possible <i>angustifolia</i> form of <i>Z. marina</i> .
106	Shapinsay	9.4	Sand	Debris only
111	Veantrow Bay (Shapinsay)	2.5	Sand/Gravel	Small patch of substrate surrounded by bedrock and kelp
114	Longhope Bay	4.4	Sand	Sheltered from wave and tidal action
116	Longhope Bay	3.2	Sand	Sheltered from wave and tidal action
136	Graemsay	3.5	Maerl/Sand	Tidally exposed site
A1	Burray	1.7	Sand	Sheltered from wave and tidal action. Located by slip used for boat launching.
A2	Deer Sound	1.6	Sand	Sheltered from wave and tidal action
A6	Bay of Firth	Intertidal	Mud/Gravel	Subject to freshwater discharge and increased water velocity. Possible <i>angustifolia</i> form of <i>Z. marina</i> .

4. DISCUSSION

Mapping seagrass distributions in remote archipelagos can be expensive and time consuming. The MaxEnt predictive model output, incorporating depth occurrence data from the transect surveys, provided a useful tool for the identification of suitable habitat for *Zostera* in which to focus surveys.

The subsequent GCP survey found seagrass at a number of sites, although negative results were obtained from the majority. However, this may have in part arisen from the timing of the surveys, which would ideally have been timed to coincide with peak *Zostera* biomass in late summer. In addition, exhaustive searching around each GCP was not possible such that nearby patches of seagrass could have been missed.

Locations where surveys confirmed the presence of seagrass were:

- Deer Sound
- Bay of Isbister
- Finstown Ouse
- Widewall Bay
- Longhope
- Burray
- Graemsay
- Wyre Sound
- Rousay Sound
- Gairsay Sound
- Mill Bay (Stronsay)
- Veantrow Bay (Shapinsay)

Extensive seagrass beds were found in Deer Sound and Widewall, which was expected based on previous survey work. These sites appeared to support seagrass beds which conform to the existing *Zostera* biotope included in the Marine Habitat Classification Hierarchy (04.05) (i.e. located on sand or muddy sand). Extensive beds were also found along the north shore of Wyre and represented first time records for this area. However, these records were perhaps more unusual for the fact that the seagrass in this area was associated with maerl habitat. Maerl occurs widely in this area, likely comprising *Phymatolithon calcareum*, but *Lithothamnion glaciale* may also be present. Seagrass was observed to be rooted in both areas of living and dead maerl. In some cases (e.g. Wyre T1 & T2), patches of seagrass appeared to be associated specifically with patches of living maerl. Seagrass and maerl do not appear together in any biotope complex in the 04.05 Hierarchy.

The exposure to moderate tidal velocity at these sites was also interesting as previous records of seagrass in Orkney have come only from tidally sheltered sites such as Deer Sound. New records were also obtained from the Finstown Ouse. This lagoon is joined to the sea by a narrow channel through which the tide floods and ebbs. While noting the debate over the taxonomy of *Zostera marina/angustifolia*⁸, the Ouse contains extensive mud flats on which numerous small patches of what appeared to be the *angustifolia* form of *Z. marina* were found. These were not observed during a previous survey in spring 2010 (Emma Jackson, pers comm). A more extensive bed of the *angustifolia* form of *Z. marina* was also found just outside the Ouse. Both sites are subject to increased water flow as the Ouse fills and drains.

⁸ See <http://www.marlin.ac.uk/biotic/browse.php?sp=4181>

GCPs around Sanday, Westray, Papa Westray and North Ronaldsay were not surveyed due to time constraints but are likely to yield further records should they be surveyed in the future.

As part of a separate survey, another seagrass site was found by divers from SULA Diving while carrying out an archaeological survey near the island of Damsay in the Bay of Firth. The site was located off the north-west corner of Damsay in around 2m of water, probably just below MLWS. The site supported fairly extensive beds of a relatively small bladed seagrass. However the most unusual thing about the seagrass at this site was that it was rooted in a thin layer of sediment overlying bedrock. At the edges the sediment layer was probably less than 50mm thick and can be clearly seen on the video footage submitted with this report (see Annex 3).

Overlaying known presence of *Zostera* on the predictive map for Orkney highlights that seagrass is predominantly found not only at specific depths and wave exposures, but that off shore slope is very important (Bekkby *et al.*, 2008) and that its inclusion would improve the accuracy of the Orkney model.

More information on substrate type, salinity and current velocities, if available at suitable resolution, would also improve the model and potentially enable a more accurate representation of the species' fundamental niche⁹. Such maps can be a useful tool to identify potential sites for habitat creation and comparisons of fundamental niche with realised niche (where the species is found) can be useful in proposing management options for allowing natural recolonisation (for example where human activities may be constraining the species' extent).

5. RECOMMENDATIONS FOR FUTURE WORK

The work described here confirmed the presence of *Zostera marina* at a range of locations around Orkney Mainland and near isles and discovered some unusual *Zostera* biotopes associated with maerl beds in Wyre Sound. However, time constraints and the timing of the surveys in the winter months means that there is uncertainty as to whether *Zostera* is genuinely absent from survey locations where it was not detected.

Our knowledge of *Zostera* in Orkney would be further enhanced by:

- Survey of the GCPs around the Orkney North Isles which could not be covered in the survey reported here
- Reconnaissance of areas identified as high probability habitat for *Zostera* from the model (in particular those with a shallow sloping fetch)
- Resurvey during summer months of selected GCPs to determine veracity of absence records in the survey reported here
- Monitoring depth ranges of seagrass at a number of distinct locations as an indicator of seagrass health

⁹ A species' fundamental niche is the full range of environmental conditions and resources an organism can occupy and use, when limiting factors (such as competition, human pressures and migration) are absent in its habitat

- Additional transect surveys to examine seasonal and geographical variation in cut-off depths for *Zostera* and investigation of seasonal variation in the size and density of seagrass patches in Orkney.
- Deployment of temperature and light data loggers to gain better understanding of environmental factors constraining *Zostera* growth in Orkney context.
- Further investigations of the biodiversity and ecosystem functioning of *Zostera* beds in Orkney (e.g. as described in Annex 4)
- Investigation of the potential value of aerial photography to mapping of *Zostera* distribution in Orkney. Consideration of the conditions for any new aerial photographs (e.g. clear water, low waves) would enhance opportunities for the mapping of subsurface habitats such as seagrass.
- Carry out genotyping of seagrass in Orkney and beyond to identify population connectivity and local scale genetic diversity

6. REFERENCES

Bekkby, T., Rinde, E., Erikstad, L., Bakkestuen, V., Longva, O., Christensen, O., Isæus, M., and Isachsen, P.E., 2008. Spatial probability modelling of eelgrass (*Zostera marina*) distribution on the west coast of Norway. *ICES Journal of Marine Science: Journal du Conseil*, 65, pp.1093-1101.

Beyer, H. L., 2004. *Hawth's Analysis Tools for ArcGIS*. Available at: <http://www.spataleecology.com/htools>.

Cleator, B., 1993. The status of the genus *Zostera* in Scottish coastal waters. *SNH Review No 22*. Edinburgh: Scottish Natural Heritage.
Available at: <http://www.snh.org.uk/pdfs/publications/review/022.pdf>

Davison, D.M., 1997. *The genus Zostera in the UK: A literature review, identifying key conservation, management and monitoring requirements*. Belfast: Environment and Heritage Service, Research and Development Series.

Davison, D.M. and Hughes, D.J., 1998. *Zostera Biotopes (volume I). An overview of dynamics and sensitivity characteristics for conservation management of marine SACs*. Oban: Scottish Association for Marine Science (UK Marine SACs Project).

Fonseca, M.S. and, Bell, S.S., 1998. Influence of physical setting on seagrass landscapes near Beaufort, North Carolina, USA. *Marine Ecology Progress Series*, 171, pp. 109-121.

Fonseca, M. S., B.D., R., Whitfield, P. E., Malhotra, A., Clinton, P., Wood, L., Kelly, N.M., 2006. *Wave Exposure Model (WEMo) for use in Ecological Forecasting (2.1 ed)*. Beaufort: NOAA.

Hansen, Jennifer C. R. and Reidenbach, Matthew A., 2013. Seasonal growth and senescence of a *Zostera marina* seagrass meadow alters wave-dominated flow and sediment suspension within a coastal bay. *Estuaries and Coasts*, 36, pp. 1099 –1114.

Jackson, E.L., 1998. *The distribution and importance of Zostera in Orkney*. MSc., International Centre for Island Technology, Heriot-Watt University.

Jackson, E.L., Attrill, M.J., Rowden, A.A., and Jones, M., 2006. Seagrass complexity hierarchies: influence on fish groups around the coast of Jersey (English Channel). *J. Exp. Mar. Biol. Ecol.*, 330, pp. 38-54.

Jaynes, E., 1957. Information theory and statistical mechanics. *The Physical Review*, 106(4), pp. 620–630.

Keddy, P.A., 1982. Quantifying within-lake gradients of wave energy - interrelationships of wave energy, substrate particle-size and shoreline plants in Axe Lake, Ontario. *Aquat. Bot.*, 14, pp. 41-58.

Phillips, S., Anderson, R. and Schapire, R., 2006. Maximum entropy modelling of species geographic distributions. *Ecological modelling*, 190(3), pp. 231–259.

Tyler-Walters, H., 2008. *Zostera marina*. *Common eelgrass*. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 03/02/2014]. Available at: <http://www.marlin.ac.uk/speciesfullreview.php?speciesID=4600>

U.S. Coastal Engineering Research Center (USCOE), 1977. *Shore Protection Manual, Vol. 1*. U.S. Army Coastal Engineering Research Center, Ft. Belvoir, Virginia.

ANNEX 1: START AND END CO-ORDINATES FOR TRANSECT SURVEYS

Co-ordinates (deci-degrees) for transect surveys supplied by Emma Jackson. Transects in italics were added later to replace the transects at Papa Westray, Westray and Sanday which were not surveyed because of time constraints.

Transect	Start		End	
	Lat DD	Long DD	Lat DD	Long DD
Widewall 1	58.80688	-2.98981	58.81325	-2.99792
Widewall 2	58.81238	-2.99136	58.81015	-2.98648
East Weddell	58.87309	-2.90234	58.87644	-2.89993
Papa Westray	59.33682	-2.91017	59.33892	-2.92487
Westray	59.28203	-2.94891	59.27438	-2.93201
Sanday	59.28079	-2.55302	59.28175	-2.53027
Deerness 1	58.94718	-2.82557	58.94991	-2.81573
Deerness 2	58.95184	-2.79838	58.96004	-2.79192
Deerness 3	58.91928	-2.78759	58.92717	-2.79772
Deerness 4	58.92929	-2.79698	58.93804	-2.81069
<i>Wyre 1</i>	<i>59.12016</i>	<i>-2.98863</i>	<i>59.12091</i>	<i>-2.98918</i>
<i>Wyre 2</i>	<i>59.11858</i>	<i>-2.99243</i>	<i>59.11973</i>	<i>-2.99405</i>
<i>Wyre 3</i>	<i>59.11673</i>	<i>-2.9958</i>	<i>59.11855</i>	<i>-2.99849</i>
<i>Wyre 4</i>	<i>59.12231</i>	<i>-2.98577</i>	<i>59.11808</i>	<i>-2.99698</i>
<i>Wyre 5</i>	<i>59.1294</i>	<i>-2.98992</i>	<i>59.1289</i>	<i>-2.98957</i>
<i>Wyre 6</i>	<i>59.12677</i>	<i>-3.00198</i>	<i>59.12515</i>	<i>-3.00167</i>
<i>Tingwall 1</i>	<i>59.08763</i>	<i>-3.03928</i>	<i>59.09015</i>	<i>-3.03549</i>
<i>Tingwall 2</i>	<i>59.08505</i>	<i>-3.03205</i>	<i>59.08771</i>	<i>-3.02772</i>
<i>Tingwall 3</i>	<i>59.09148</i>	<i>-3.04423</i>	<i>59.09236</i>	<i>-3.04245</i>
<i>Woodwick 1</i>	<i>59.0957</i>	<i>-3.0479</i>	<i>59.09718</i>	<i>-3.04758</i>
<i>Wasswick 1</i>	<i>59.08187</i>	<i>-3.01995</i>	<i>59.08463</i>	<i>-3.02008</i>

ANNEX 2: CO-ORDINATES FOR GROUND CONTROL POINTS (DECI-DEGREES)

N/S = Not Surveyed

GCP	Lat DD (WGS84)	Long DD (WGS84)	Seagrass present?	Video/ bucket	MNCR sheets completed?
1	59.3506622	-2.88308048	N/S	N/S	N
2	59.3548317	-2.8765862	N/S	N/S	N
3	59.3386498	-2.91242504	N/S	N/S	N
4	59.3288612	-2.89644718	N/S	N/S	N
5	59.3492508	-2.93861103	N/S	N/S	N
6	59.3474312	-2.9399333	N/S	N/S	N
7	59.2619095	-2.97687769	N/S	N/S	N
8	59.2607231	-2.98039722	N/S	N/S	N
9	59.2638779	-2.97893333	N/S	N/S	N
10	59.2790833	-2.9476862	N/S	N/S	N
11	59.2834129	-2.94235826	N/S	N/S	N
12	59.2837334	-2.9372499	N/S	N/S	N
13	59.2825623	-2.92820835	N/S	N/S	N
14	59.2626419	-2.89979434	N/S	N/S	N
15	59.2590904	-2.89948344	N/S	N/S	N
16	59.2517395	-2.88367772	N/S	N/S	N
17	59.2548561	-2.88129163	N/S	N/S	N
18	59.2537346	-2.87832785	N/S	N/S	N
19	59.2344742	-2.87431955	N/S	N/S	N
20	59.2506294	-2.85642505	N/S	N/S	N
21	59.2675018	-2.87771678	N/S	N/S	N
22	59.3018074	-2.91774178	N/S	N/S	N
23	59.3117333	-2.95420551	N/S	N/S	N
24	59.3180428	-2.97833061	N/S	N/S	N
25	59.3398399	-2.96116662	N/S	N/S	N
26	59.2311783	-2.75812221	N/S	N/S	N
27	59.2295761	-2.73702788	N/S	N/S	N
28	59.2227211	-2.78917503	N/S	N/S	N
29	59.2091827	-2.78667784	N	V	Y
30	59.1945992	-2.78340268	N	V	Y
31	59.1913261	-2.78698611	N	V	Y
32	59.1572609	-2.75101948	N	V	Y
33	59.1934509	-2.757936	N	V	Y
34	59.2078743	-2.75095272	N	V	Y
35	59.1582069	-2.94404721	Y	V	Y
36	59.1577873	-2.94814444	N	V	Y
37	59.1586151	-2.94276953	Y	V	Y
38	59.1417427	-3.08368897	N/S	N/S	N
39	59.1617241	-2.97744727	N	V	Y
40	59.1117172	-2.98130822	Y	V	Y
41	59.1116295	-2.96435285	N	B	N
42	59.1281204	-2.96041942	N	V	Y
43	59.1269875	-2.96576119	N	V	Y
44	59.1272774	-2.99137783	N	V	Y

GCP	Lat DD (WGS84)	Long DD (WGS84)	Seagrass present?	Video/ bucket	MNCR sheets completed?
45	59.119606	-3.00925279	Y	V	Y
46	59.1189156	-3.01148343	Y	V	Y
47	59.0653534	-2.89518881	N	V	Y
48	59.0608292	-2.88177228	N	V	Y
49	59.0593491	-2.85627508	N	V	Y
50	59.0606079	-2.85120273	N	V	Y
51	59.0611954	-2.85554433	N	V	Y
52	59.0663261	-2.84042215	N	V	Y
53	59.0248985	-2.84104729	N	V	Y
54	59.0237579	-2.83832216	N	V	Y
55	59.0817947	-2.81595278	N	V	Y
56	59.1236572	-2.62960553	N	V	Y
57	59.1298676	-2.64240837	N	V	Y
58	59.1400833	-2.65458894	Y	V	Y
59	59.1479607	-2.66709447	N	V	Y
59a	59.1492333	-2.6669	N	B	N
60	59.1590614	-2.65576387	N	V	Y
61	59.1609955	-2.64169169	N	V	Y
62	59.1603394	-2.63907218	N	V	Y
63	59.1610069	-2.63640547	N	V	Y
64	59.1502686	-2.61300278	N	V	Y
65	59.1353989	-2.60015273	N	V	Y
66	59.1363907	-2.60255551	Y	V	Y
67	59.1276932	-2.60094452	N	V	Y
68	59.1434937	-2.60372782	N	N/S	N
69	59.1449013	-2.59558606	N	V	Y
70	59.1459541	-2.58491659	N	V	Y
71	59.1175575	-2.58897233	Y	V	Y
72	59.0727768	-2.58139992	N	V	Y
73	58.9654427	-2.797014	N	V	Y
74	58.9565544	-2.83653617	N	V	Y
75	58.951149	-2.81378889	N	V	Y
76	58.9509621	-2.83263898	N	V	Y
77	58.9561958	-2.79391384	N	V	Y
78	58.9507332	-2.8110888	N	V	Y
79	58.9349098	-2.81781387	Y	V	Y
80	58.9275284	-2.797714	Y	V	Y
81	58.9414978	-2.80965829	Y	V	Y
82	58.9436569	-2.80605269	Y	V	Y
83	58.9455643	-2.71168327	N	N/S	N
84	58.9226685	-2.74988341	N	N/S	N
85	58.9601822	-2.98497224	N	V	Y
86	58.9659233	-3.23510003	N	B	N
87	58.99826	-3.05295	N	V	Y
88	58.99646	-3.05289	N	B	N
89	58.95488	-2.84305	N	B	N
90	58.95582	-2.83784	Y	V	Y
91	59.15805	-2.94594	N	V	Y

GCP	Lat DD (WGS84)	Long DD (WGS84)	Seagrass present?	Video/ bucket	MNCR sheets completed?
92	59.15897	-2.94247	N	V	Y
93	59.04851	-3.05799	N	N/S	N
93a	59.0475	-3.05703	Y	V	Y
94	59.00834	-3.13335	N	N/S	N
95	59.08253	-2.82173	N	V	Y
96	59.27126	-2.52847	N	N/S	N
97	59.03348	-2.90103	N	V	Y
98	59.08253	-2.82173	N	N/S	N
99	59.01115	-3.11954	Y	B	N
100	59.01115	-3.11954	N	N/S	N
101	59.14058	-3.10977	N/S	N/S	N
102	59.0123	-3.08997	N	V	Y
103	59.00608	-3.08453	N	V	Y
104	59.01598	-3.08138	N	N/S	N
104a	59.01463	-3.081416667	N	B	N
105	59.04322	-3.04387	N	V	Y
106	59.03082	-2.90238	Y	V	Y
107	58.95308	-2.84299	N	B	N
108	58.95498	-2.82739	N	V	Y
109	58.92805	-2.82326	N	V	Y
110	58.92805	-2.82326	N	N/S	Y
111	59.07653	-2.89634	Y	V	Y
112	58.80234	-3.22327	N	V	Y
113	58.79358	-3.22919	N	V	Y
114	58.78666	-3.23067	Y	V	Y
115	58.80173	-3.20962	N	V	Y
116	58.78922	-3.22367	Y	V	Y
117	58.82656	-3.18639	N	V	Y
118	58.82727	-3.19873	N	V	Y
119	58.82878	-3.20067	N	V	Y
120	58.83169	-3.19319	N	V	Y
121	58.83365	-3.15357	N	V	Y
122	58.83621	-3.14905	N	V	Y
123	58.83118	-3.14735	N	V	Y
124	58.83496	-3.13954	N	V	Y
125	58.83561	-3.09609	N	V	Y
126	58.83816	-3.09183	N	V	Y
127	58.83155	-3.09034	N	V	Y
128	58.83155	-3.10413	N	V	Y
129	58.85038	-3.07252	N	V	Y
130	58.85062	-3.07686	N	V	Y
131	58.84913	-3.08116	N	V	Y
132	58.90649	-3.28823	N	V	Y
133	58.92231	-3.27087	N	B	N
134	58.91793	-3.29687	N	N/S	N
135	58.91115	-3.31198	N	V	Y
136	58.93634	-3.28577	Y	V	Y
137	58.93991	-3.30025	N	V	Y

GCP	Lat DD (WGS84)	Long DD (WGS84)	Seagrass present?	Video/ bucket	MNCR sheets completed?
138	58.78837	-3.15173	N	V	Y
139	58.78674	-3.15125	N	V	Y
140	58.78756	-3.14555	N	V	Y
141	58.78986	-3.14395	N	V	Y
142	58.86127	-3.21521	N	V	Y
143	58.86237	-3.20778	N	N/S	N
144	58.85804	-3.20268	N	V	Y
145	58.82349	-3.00417	N	V	Y
146	58.81553	-3.00245	N	V	Y
147	58.80555	-2.99522	N	V	Y
148	58.81883	-3.00800	N	V	Y
149	58.82948	-2.99292	N	V	Y
150	58.82999	-2.96071	N	V	Y
151	58.83207	-2.95681	N	V	Y
152	58.83445	-2.94844	N	N/S	N
153	58.83558	-2.93410	N	V	Y
154	58.83718	-2.92570	N	V	Y
155	58.84122	-2.93574	N	V	Y
156	58.83770	-2.88902	N	N/S	N
157	58.83487	-2.89043	N	N/S	N
158	58.87462	-2.90437	N	N/S	N
159	58.87072	-2.90973	N	N/S	N
160	58.87466	-2.89841	N	N/S	N
161	58.85781	-2.91732	N	V	Y
162	58.85828	-2.92329	N	V	Y
163	58.85174	-2.97323	N	N/S	N
163a	58.851416	-2.9734	N	V	Y
164	58.84890	-2.97464	N	V	Y
165	58.85748	-2.96148	N	V	Y
166	58.85416	-2.95991	N	V	Y
A1	58.843533	-2.91235	Y	V	Y
A2	58.953883	-2.83821667	Y	B	N
A3	59.044516667	-3.0605	N	B	N
A4	59.20801667	-2.74971667	N	B	N
A5	59.193	-2.7819833	N	B	N
A6	59.009067	-3.1126833	Y	B	N

ANNEX 3: DATA HELD BY SNH

Electronic files

File name	Description	Location
Orkney Zostera Phase 2 survey - transect data - Sula Diving - 2010	Excel spreadsheet which contains the raw transect survey data, including the exact locations along each transect surveyed where seagrass was present	eRDMS ¹⁰ – A1306124
Orkney Zostera Phase 2 survey - GCP locational data in Degrees Decimal Minutes - Sula Diving - 2010	Excel spreadsheet holding details for each Ground Control Point (GCP) survey, including date, time, observed depth, presence/ absence of seagrass and substrate. Locations provided as Degrees Decimal Minutes.	eRDMS – A1306123
Orkney Zostera Phase 2 survey - transect and GCP locations - Sula Diving - 2010	Excel spreadsheet with GCP and transect locations in alternative locational formats.	eRDMS – A1306125
Orkney Zostera Phase 2 Ground Control Point footage Winter_Spring 2010 - Sula Diving	Video footage (MP4 format) from GCP surveys	LOR ¹¹
Orkney Zostera Phase 2 Transect footage - Winter_Spring 2010 - Sula Diving	Video footage (MP4 format) from transect surveys	LOR

¹⁰ eRDMS is SNH's electronic document management system

¹¹ LOR is SNH's Large Object Repository

ANNEX 4: MARINE WILDLIFE OF SEAGRASS BEDS - A STUDY OF TWO SITES ON ORKNEY

This annex is a previously unpublished report of a biodiversity survey of two seagrass beds in Orkney. This study was commissioned from Orkney Islands Council Marine Services by the Scapa Flow Landscape Partnership, which was part-funded by Scottish Natural Heritage.

The views expressed by the author(s) of this report should not be taken as the views and policies of Scottish Natural Heritage.

Marine wildlife of seagrass beds

- A study of two sites on Orkney



May 2012



ORKNEY ISLANDS COUNCIL
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2 Introduction

On Orkney there are several known seagrass beds, Fig. 1. The aim of this project was to take a 'snapshot' of what lives amongst Widewall Bay and Finstown seagrass beds, Fig. 1. The seagrass bed in Widewall Bay is the largest one known in Scapa Flow and has been previously studied by Dr. Emma Jackson (Jackson EL, 1998). The seagrass bed in Finstown is easily accessible and the site proved to have an interesting array of marine life.

Seagrasses are flowering plants with stems, leaves, roots and flowers. There are 50+ species world wide (Larkum *et al*, 2007) of which one, *Zostera marina*, is found on Orkney. In the literature there are references for both *Zostera angustifolia* and *Zostera noltii* recorded on Orkney. The records of *Zostera noltii* have not been confirmed and there is an ongoing taxonomic debate to decide whether *Zostera marina* and *Zostera angustifolia* are two separate species or one species.

Zostera beds increase biodiversity by improving habitat; the leaf canopy and the network of rhizomes and roots provide structure to attach to and the canopy provides hiding places to avoid predation and is a key habitat in the life cycle of many organisms. The presence of the *Zostera* beds provides coastal protection by fixing and stabilising sediment and by reducing water motion due to canopy friction. Seagrass beds are slow growing and reproduce by producing pollen and by extending their rhizome network. New beds are rarely established which makes the protection of current seagrass beds even more important. Seagrass beds are damaged by direct physical disturbance for example by the use of anchors and dredging both of which can rip sections of the bed out. Coastal zone development can also affect the seagrass beds by changing the sedimentary dynamics of the area.

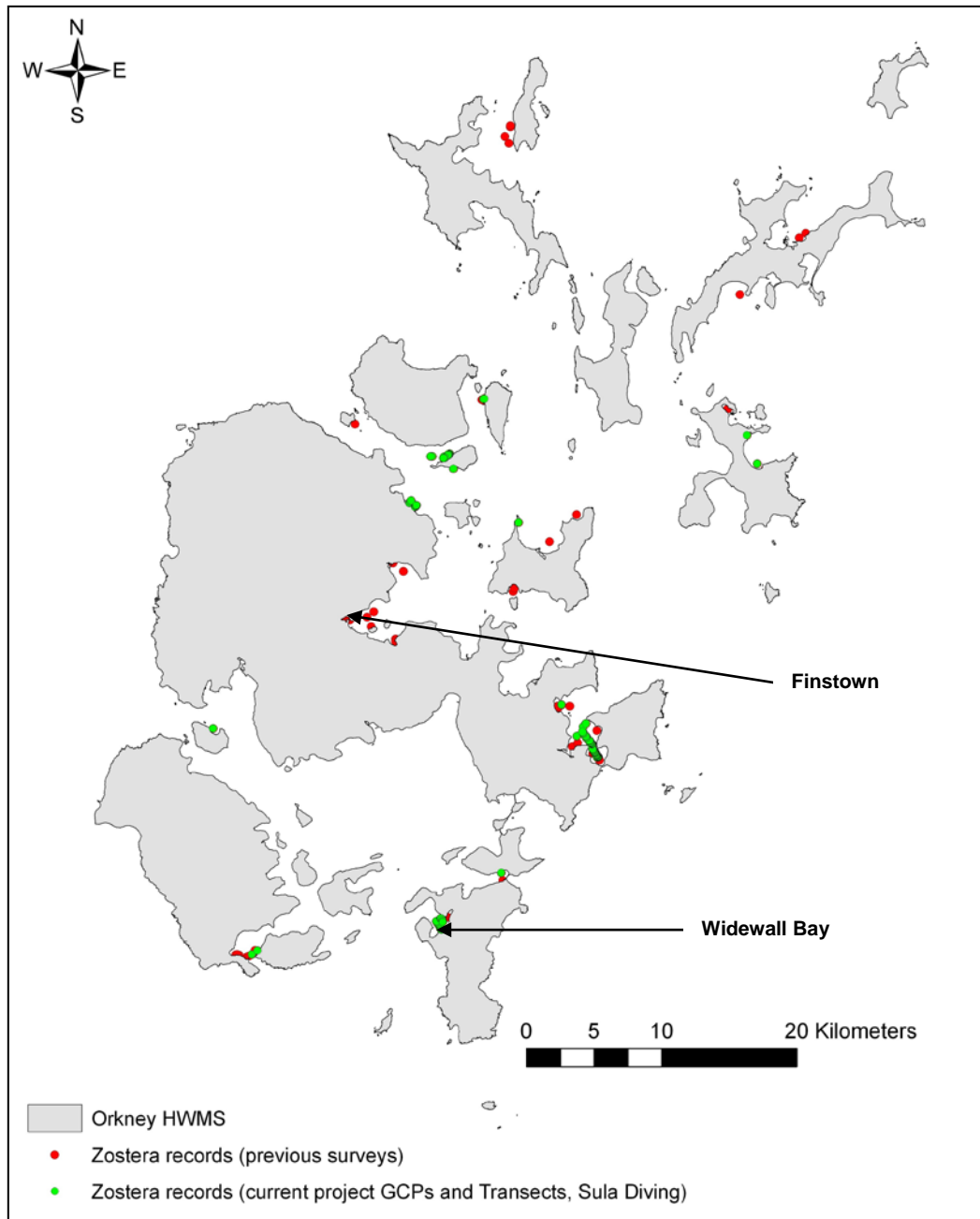


Figure 1. Map of *Zostera* records on Orkney. Map courtesy of: SNH, Emma Jackson (Marine Biological Association) and SULA Diving

3 Methods

3.1 *Epiphyte sampling*

Epiphyte samples were collected from 4 sampling points at Finstown; shallow-edge, shallow-middle, deep-edge and deep-middle and from 3 sampling points at Widewall Bay; shallow-edge, shallow-middle and deep-edge. See Diagram 1. for a schematic presentation of the sampling points.

The samples were collected using a square handheld net which was randomly placed on the seagrass bed capturing the full length of the blades and everything amongst the seagrass, Photo. 1. The seagrasses were then cut as close to the sediment as possible. When all of the seagrass blades and accompanying fauna and flora were in the net, it was closed using a cable tie. Once on the shore the contents of the net were rinsed into a bucket and seagrass blades were placed into a sampling bag. The remaining contents of the bucket were then sieved using a sieve with 500µm mesh and placed into a separate plastic sampling bag.



Photo 1. Collecting seagrass epiphyte samples at Finstown seagrass bed. Photo by Anne Bignal.

On arrival to laboratory fauna and flora collected with the net were preserved in 4% formalin solution with Bengal red. After minimum of 1 month in the fixative the samples were rinsed and sorted by hand ready for identification. Identification of macro-invertebrates was done under light microscope and photographs of most species were taken, especially of the ones for which identification was not possible.

3.2 *Seagrass density*

On arrival to the laboratory the wet weight of the seagrass blades were measured, the number of shoots and flowering shoots were noted and the length and the width of the blades were measured.

3.3 *Epiphyte and wasting disease index*

Of the three longest shoots in each sample the top 10cm and bottom 10cm were cut and preserved in 4% formalin solution with Bengal red. In the top 10cm sections the epiphyte cover was recorded using scoring system from Foden (date published unknown) and wasting disease cover was recorded using Wasting Disease Index, Foden (date published unknown), the sections were then scraped using scalpel to remove epiphytes for identification.

3.4 Core samples

Sediment core samples were taken with a metal corer with 8.5cm in diameter. The samples were collected at shallow-edge, shallow-middle, deep-edge and deep-middle in Finstown and at shallow-edge, shallow-middle and deep middle in Widewall Bay, see Diagram 1. for a schematic presentation of the sampling points. Only one sediment core sample per location was collected.

The samples were sieved on site using a sieve with 500µm mesh, placed in plastic sampling bags and on arrival to laboratory preserved in 4% formalin solution with Bengal red.

After minimum of 1 month in the fixative the samples were rinsed and sorted ready for identification. Identification of macro-invertebrates was done under light microscope and photographs of most species were taken, especially of the ones for which identification was not possible.



Fig. 2. Schematic diagram of seagrass sampling points.

3.5 Dive/snorkel surveys

A Seasearch Observer Course was held in Kirkwall on 3rd September 2011, which was funded and organised by Scapa Flow Landscape Scheme. As part of the course all participants (6 divers and 2 snorkelers) surveyed Widewall Bay seagrass bed. The standard Seasearch dive forms were used and these were filled in on the day with the help of Seasearch coordinators Chris Wood and Chris Rickard. All completed Seasearch Forms were sent to the Marine Conservation Society for collation and will contribute towards the national marine life data base (www.searchnbn.net) into which all Seasearch records are incorporated.

4 Results

4.1 Epiphytes and associated species

The identification of all of the samples to species level was not achieved due to the time constraints of this project. Only one sample per station was analysed. There are still two samples per station in storage which can be analysed at a later date.

In the Finstown seagrass bed a total of 66 species/taxa were identified in the epiphyte samples, see Table 1. The community in the Finstown seagrass bed was dominated by crustaceans and molluscs with few species of worms and starfish present. The most dominant crustacean, *Caprella acanthifera*, see Photo 2, was found in all samples with the exception of Shallow-edge. *Rissoa parva*, a small gastropod mollusc was present in high quantities in all samples. Fish fry were found in highest numbers in the sample from Deep-middle. Epiphytic seaweeds were most abundant in the Deep-edge samples and none were recorded from the Shallow-edge sample.

Abundance of species was much lower in the Widewall Bay seagrass bed, Table 2. The epiphyte samples were dominated by crustaceans, mainly of *Phitisia marina*, a caprellid crustacean which was found in all of the samples from the Widewall seagrass bed. The community also consisted of small quantities of worms, mainly *Nicolea zostericola* and epiphytic seaweed *Leblondiella densa*.

Shannon Diversity Index for both sites is presented in the Figure 3. Shannon Diversity Index was calculated using PRIMER statistical software. The Shannon Diversity Index combines both species richness and evenness into a single value. The larger the value is the more species rich the site/sample is.

Finstown Deep-middle with Shannon Diversity Index of 2.88 was the most species rich sample, the least diverse site was Finstown Shallow-middle. By comparing the Shannon Diversity values between the two seagrass beds it can be said that the shallow sites are less species diverse compared to deep sites, this applies to both seagrass beds. The Finstown seagrass bed had larger quantities of individual macro-invertebrates (1840) compared to Widewall Bay (483). Despite the differences in abundance between the sites the diversity of the two seagrass beds is very similar, Shannon diversity between 0.97 – 2.88 in both sites. This is due to diversity being measured and being determined not only by the quantity of individuals but also by the number different species present.

Figure 3. Shannon Diversity values for Finstown and Widewall Bay epiphyte samples.

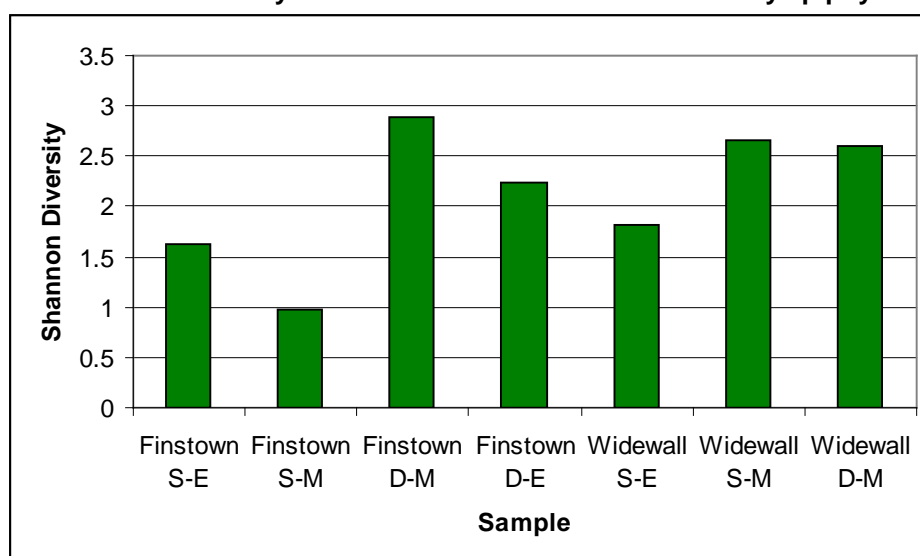


Table1. List of fauna and flora found at Finstown.

Finstown				
Species	Deep edge	Deep middle	Shallow middle	Shallow edge
Crustaceans				
<i>Caprella acanthifera</i>	19	173	10	0
Cyclopina	0	11	0	0
<i>Dexamine spinosa</i>	2	13	0	0
<i>Dexamine thea</i>	0	11	0	0
<i>Ericthonius punctatus</i>	0	1	3	2
<i>Idotea baltica</i>	0	2	0	1
<i>Micropropodus maculatus</i>	22	22	0	0
<i>Phitisia marina</i>	7	21	1	1
<i>Praunus flexuosus</i>	1	0	0	0
<i>Siriella clausii</i>	0	1	3	1
<i>Stenula rubrovittata</i>	2	0	1	12
<i>Tanais dulongii</i>	2	16	11	5
Unknown amphipod	0	2	1	0
Unknown crustacean	4	1	0	0
Unknown crustacean A	0	5	0	0
Unknown crustacean B	0	1	0	0
Unknown mysid	0	2	0	0
Worms				
Capitellidae	0	0	1	0
<i>Cycloporus papillosus</i>	0	17	0	0
Flatworm	4	0	0	0
<i>Kefersteinia cirrata</i>	1	0	0	0
<i>Manayunkia aestuarina</i>	0	0	1	0
Nematoda	2	5	0	0
Nemertea	1	8	1	2
<i>Nicolea zostericola</i>	0	1	0	0
<i>Platynereis dumerilii</i>	1	8	0	0
<i>Spirorbis spirorbis</i>	0	3	0	0
<i>Stylochoplana maculata</i>	0	7	0	0
Syllidae ?	0	1	1	0
Turbellaria	0	0	1	0
Unknown worm (Capitellidae?)	0	0	1	0
Unknown worm (Nematoda?)	0	0	1	0
Unknown worm A	0	2	1	0
Unknown worm B	0	2	0	0
Molluscs				
<i>Akera bullata</i>	0	2	0	2
<i>Hydrobia neclacta</i>	4	0	1	0
Iridescent grey gastropod	0	31	2	2
<i>Lacuna parva</i>	0	75	1	0
<i>Limapontia depressa</i>	5	20	0	0
<i>Littorina obtusata</i>	0	0	0	10
<i>Musculus discors</i>	0	2	2	1
<i>Parvicardium exiguum</i>	0	7	0	1
<i>Retusa truncatulata</i>	0	1	0	0
<i>Rissoa parva</i>	82	30	294	161
<i>Skenea serpuloides</i>	0	8	0	202
Tellinidae	1	0	0	0
<i>Tonicella rubra</i>	0	0	1	0
Unknown bivalve A	0	8	7	117
Unknown bivalve B	0	2	0	2
Unknown bivalve C	0	0	0	6
Unknown gastropod	0	4	0	4
Unknown nudibranch	0	0	1	1
Unknown shells A	6	0	0	0
Unknown shells B (large)	9	0	0	0
Arachnida				
Mesostigmata	0	4	2	11
Diptera				
Midge larvae	0	1	0	0
Chordata				
Small fish	1	0	0	0
Fish fry, thin and long	0	11	0	4
<i>Ascidella scabra</i>	1	0	0	0
Echinodermata				

Starfish, juvenile?	0	1	0	0
Brittlestar	0	1	0	0
Seaweeds				
<i>Ceramium rubrum</i>	1	0	0	0
<i>Ceramium secundatum</i>	0	2	0	0
<i>Cladophora</i> sp.	2	0	2	0
<i>Leblondiella densa</i>	3	1	0	0
Little bunches of seaweeds	88	21	3	0
Polysiphonia sp.	10	17	0	0
Others				
Egg masses	many	0	0	0
Barnacle/spirorbis?	0	19	0	0
Unknown (sponge?)	0	0	1	0
Unknown comb like structures	0	0	2	0
Total in epiphyte samples	227	563	352	548



Photo 2. *Caprella acanthifera*. Cells are 1mm by 1mm. Photo by Jenni Kakkonen

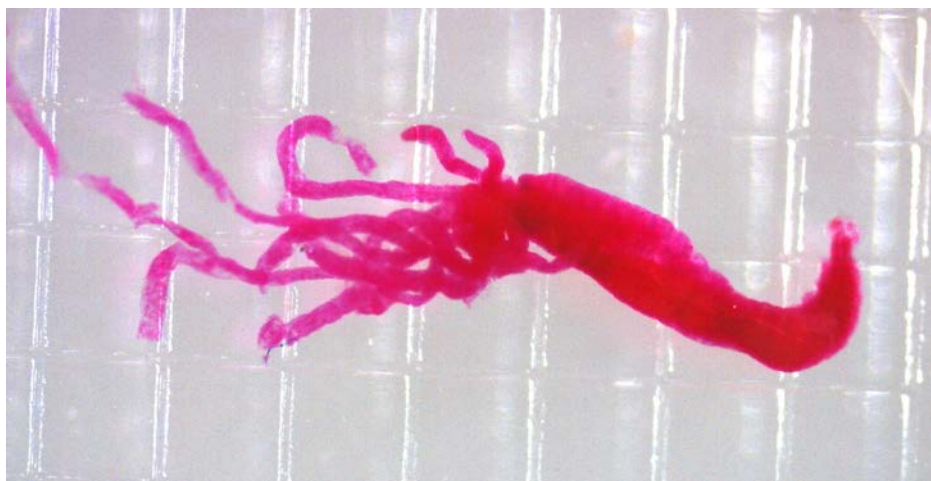


Photo 3. *Nicolea zostericola*. Cells are 1mm by 1mm. Photo by Jenni Kakkonen

Table 2. List of fauna and flora found at Widewall Bay.

Widewall	Deep middle	Shallow middle	Shallow edge
Crustaceans			
<i>Caprella acanthifera</i>	34	9	0
<i>Erichthonius punctatus</i>	17	19	14
Eurytemora (copepod)	0	4	0
<i>Idotea baltica</i>	1	0	1
<i>Periculoides longimanus</i>	0	1	0
<i>Phitisia marina</i>	18	33	53
<i>Siriella clausii</i>	0	2	0
<i>Tanais dulongii</i>	1	0	0
Tisbe (copepod)	0	2	0
Unknown amphipod A	1	1	1
Unknown amphipod B	1	0	0
Unknown amphipod C	1	0	0
Unknown amphipod D	1	0	0
Unknown amphipod E	1	0	0
Unknown crustacean	0	1	0
Unknown isopod	0	2	0
Worms			
Nematoda	1	0	0
Nemertea	2	0	0
<i>Nicolea zostericola</i>	8	9	2
<i>Phyllodoce maculata</i>	1	0	0
<i>Platynereis dumerilii</i>	0	3	0
<i>Stylochoplana maculata</i>	1	0	0
Turbellaria	3	1	0
Unknown worm A	5	2	0
Unknown worm B	0	2	0
Molluscs			
<i>Lacuna vincta</i>	0	0	4
Iridescent grey gastropod	0	0	1
<i>Rissoa parva</i>	0	8	5
<i>Skenea serpuloides</i>	0	1	3
<i>Littorina obtusata</i>	0	0	7
Unknown bivalve A	0	2	4
Unknown gastropod A	0	10	0
Unknown gastropod B	4	7	0
Unknown gastropod C	0	3	0
Unknown shell A	1	0	0
Unknown shell B	1	0	0
Seaweeds			
<i>Ceramium secundatum</i>	0	0	1
<i>Ceramium</i> sp.	4	0	0
<i>Leblondiella densa</i>	0	45	0
Little bunches of seaweeds	0	0	1
Long hairy ones	0	18	0
<i>Plocamium cartilagineum</i>	8	0	0
<i>Polysiphonia</i> sp.	3	1	0
Small tuft	0	1	0
Unknown seaweed A	1	2	0
Unknown seaweed B	1	2	0
Unknown seaweed C	1	0	0
Unknown seaweeds D	10	3	5
Other			
Egg masses	3	0	0
Bryozoans/Lithothamnion	0	3	Lots
Tubes	3	0	0
Total in epiphyte samples	137	197	102

4.2 Seagrass density

Mean values for the seagrass blade wet weight, number of shoots, shoot density per m², number of flowering shoots, blade lengths and widths are listed in Table 3. Overall the Finstown seagrass bed has shorter and narrower blades than Widewall Bay seagrass bed. The seagrass is denser in Finstown reaching 119.2 shoots per square meter compared to maximum of 45 shoots per square meter in Widewall Bay. The seagrass is shorter and narrower in Finstown and the only recorded flowering shoots were in Finstown.

Table 3. Mean values of the seagrass bed morphology at Finstown and Widewall Bay.

Widewall Bay		Wet weight (g)	No. of shoots per sample	Shoots Per m ²	Flowering	Blade Length (cm)	Blade Width (cm)
Shallow	Edge	13.3	13.7	34.2	0.0	18.2	0.3
Shallow	Middle	72.5	18.0	45.0	0.0	46.4	0.4
Deep	Middle	27.0	11.3	28.3	0.0	28.7	0.4
Finstown							
Shallow	Edge	10.0	18.0	45.0	0.0	9.6	0.2
Shallow	Middle	13.3	47.7	119.2	0.7	8.9	0.1
Deep	Middle	71.3	23.0	57.5	0.0	27.4	0.3
Deep	Edge	18.0	10.0	25.0	0.0	26.4	0.3

4.3 Epiphyte and disease cover

Highest epiphyte covers were recorded at Deep-middle at both seagrass beds and lowest epiphyte covers were in the Shallow samples, Table 4. Widewall Bay seagrass has a higher cover of epiphytes compared to Finstown.

Hardly any wasting disease was recorded on either site, Table. 5.

Table 4. Mean epiphyte cover score at Finstown and Widewall Bay.

Finstown	Shallow - middle	1.25
Finstown	Shallow - edge	0.58
Finstown	Deep - middle	2.10
Finstown	Deep - edge	2.25
Widewall Bay	Shallow - middle	2.10
Widewall Bay	Shallow - edge	2.25
Widewall Bay	Deep - middle	3.67

Table 5. Mean Wasting Disease Index at Finstown and Widewall Bay.

Finstown	Shallow - middle	0.08
Finstown	Shallow - edge	0
Finstown	Deep - middle	0
Finstown	Deep - edge	0.08
Widewall Bay	Shallow - middle	0.17
Widewall Bay	Shallow - edge	0
Widewall Bay	Deep - middle	0

4.4 Core samples

The identification of all of the samples to species level was not achieved due to time constraints of this project.

The Finstown core samples has much greater abundance and variety of infauna compared to the Widewall Bay seagrass bed, Table 6. Crustacean *Caprella acanthifera* was recorded in the both Deep - mid and Deep – edge and crustacean *Tanais dulongii* was present in all samples from Finstown with greatest abundances in Shallow – edge and Shallow – mid. *Capitella capitata*, Nematodes and Oligochaetas were the most abundant worms in Finstown. In Widewall Bay there were very few species of worms and few species of crustaceans and no molluscs, see Table 6.

Shannon Diversity Index for core samples is presented in the Figure 4. Shannon Diversity Index was calculated using PRIMER statistical software. The Shannon Diversity Index combines both species richness and evenness into a single value. The larger the value is the more species rich the site/sample is.

Both Finstown and Widewall Bay have mixture of low diversity and high diversity values, Figure. 4. There isn't any indication of trends within or between sites in the diversity of the infauna.

Figure 4. Shannon Diversity values for Finstown and Widewall Bay core samples.

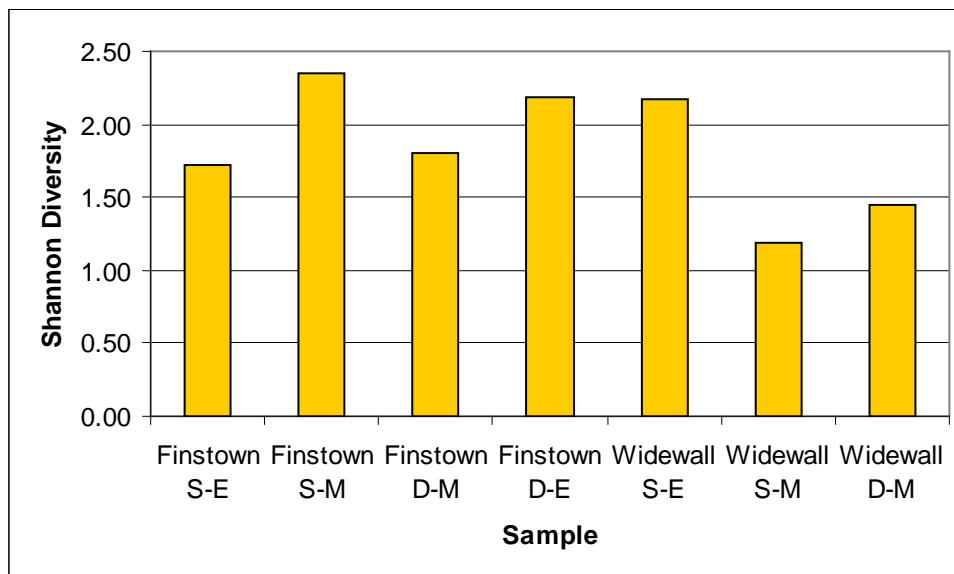


Photo 4. *Tanais dulongii*. Cells are 1mm by 1mm. Photo by Jenni Kakkonen

Table. 6. List of fauna and flora found in sediment core samples at Finstown and Widewall Bay.

Species	Finstown				Widewall Bay		
	Shallow edge	Shallow middle	Deep middle	Deep edge	Shallow edge	Shallow middle	Deep middle
Worms							
<i>Arenicola marina</i> - juvenile	0	1	0	0	0	0	0
<i>Capitella capitata</i>	18	11	8	2	7	13	7
Cirratulidae	0	0	0	0	1	0	11
<i>Kefersteinia cirrata</i>	1	0	1	0	0	0	0
Nematode	18	16	54	21	0	0	0
Nemertea	11	8	3	3	0	2	0
<i>Nephtys caeca</i>	0	0	0	0	1	0	0
<i>Nicolea zostericola</i>	0	0	0	0	2	0	0
Oligochaeta	12	46	89	14	0	0	0
<i>Ophryothra bacci</i>	0	0	1	0	0	0	0
<i>P. balanoglossoides</i>	0	0	0	0	1	0	0
Sabellidae	3	0	0	0	0	0	0
<i>Scoloplos armiger</i>	1	21	2	8	0	0	0
Spionidae	4	11	8	3	3	1	1
Unknown worms	3	5	1	1	0	1	1
Molluscs							
<i>Akera bullata</i>	0	4	0	0	0	0	0
Cardiidae - juvenile	1	1	0	0	0	0	0
<i>Lacuna pallidula</i>	0	0	0	2	0	0	0
<i>Musculus discors</i>	4	4	1	0	0	0	0
Rissoidae - no shells	27	0	2	0	0	0	0
Rissoidea	0	42	0	2	0	0	0
<i>Runcina coronata</i>	0	0	1	0	0	0	0
Skeneidae - no shells	7	0	0	0	0	0	0
Skeneopsidae	0	3	1	0	0	0	0
Tellinidae	0	3	0	0	0	0	0
Tellinidae - juveniles	26	0	5	1	0	0	0
<i>Tonicella rubra</i>	6	0	0	0	0	0	0
Unknown gastropods	0	0	0	2	0	0	0
Crustacean							
<i>Ampelisca brevicornis</i>	0	0	1	2	1	0	0
<i>Caprella acanthifera</i>	0	0	34	63	0	0	0
Copepoda	0	0	0	0	0	0	1
<i>Erichthonius punctatus</i>	0	0	0	14	3	0	0
Gammaridae	0	0	0	0	2	2	2
<i>Iphinoe trispinosa</i>	0	0	0	0	1	0	0
Oedicerotidae	0	0	0	0	0	1	0
<i>Periculoides longimanus</i>	0	0	0	2	0	0	0
<i>Phitsia marina</i>	0	0	0	2	3	0	0
<i>Pseudoparatanaeis batei</i>	0	0	1	0	0	0	0
<i>Siriella clausii</i>	0	0	0	1	0	0	0
<i>Stenula rubrovittata</i>	4	8	0	0	0	0	0
Tanaidacea	0	0	0	0	0	0	1
<i>Tanais dulongii</i>	191	30	7	23	0	0	0
<i>Tisbe furcata</i> (copepod)	0	0	0	1	0	0	0
Unknown amphipod	0	0	0	3	0	0	0
Unknown crustacean	0	0	1	0	0	0	0
Chordata							
Fish fry	0	0	0	2	0	0	0
Diptera							
Midge larvae	1	4	0	0	0	0	0
Total	338	218	221	172	25	20	24

4.5 Dive/snorkel surveys

Dive and snorkel surveys were carried out in Widewall Bay, no dive and snorkel surveys were carried out at Finstown.

Results of the dive and snorkel surveys are presented in Table 8. During these surveys it was possible to observe the macro life at the seagrass beds. Many species of fish were seen, for example *Gobiusculus flavescens* and *Pomatoschistus minutus*, *Spinachia spinachia* and *Syngnathus acus*. Several species of crab were also observed, *Carcinus maenas*, *Liocarcinus depurator* and *Necora puber* being the most abundant. Many species of algae were recorded, *Ascophyllum nodosum*, *Codium fragile* and *Fucus vesiculosus* recorded as been occasional.

Table 8. Species Recorded at Widewall Bay Seagrass Bed, September 2011.

Species	Common name	P, R, O, C
Angiosperms		
<i>Zostera marina</i>	Eelgrass	C
Algae		
<i>Ascophyllum nodosum</i>	Knotted wrack	O
<i>Chorda filum</i>	Mermaids tresses	C
<i>Codium fragile</i>	Green sea fingers	O
<i>Fucus serratus</i>	Serrated wrack	R
<i>Fucus vesiculosus</i>	Bladder wrack	O
<i>Halidrys siliquosa</i>	Sea oak	R
<i>Lithothamnia</i>	Encrusting pink algae	R
Annelida		
<i>Arenicola marina</i>	Lugworm	C
<i>Lanice conchilega</i>	Sand mason	O
<i>Sabella pavonina</i>	Peacock worm	C
Crustacea		
<i>Carcinus maenas</i>	Green shore crab	O
<i>Common hermit crab</i>	Common hermit crab	C
<i>Liocarcinus depurator</i>	Harbour crab	O
<i>Macropodia sp.</i>	Spider crab	R
<i>Mysidae</i>	Opossum shrimp	O
<i>Necora puber</i>	Velvet swimming crab	O
Echinodermata		
<i>Asterias rubens</i>	Common starfish	R
Tunicata		
<i>Ascidia mentula</i>	Red sea squirt	O
<i>Ascidella aspersa</i>	Fluted sea squirt	O
Mollusca		
<i>Buccinum undatum</i>	Common whelk	O
<i>Gibbula cineraria</i>	Grey top shell	O
Pisces		
<i>Gobiusculus flavescens</i>	Two-spotted goby	O
<i>Pholis gunnellus</i>	Butterfish	R
<i>Pleuronectes platessa</i>	Plaice	R
<i>Pomatoschistus minutus</i>	Sand goby	C
<i>Spinachia spinachia</i>	Fifteen spined stickleback	R
<i>Syngnathus acus</i>	Great pipefish	R
<i>Taurulus bubalis</i>	Long-spined sea scorpion	O
<i>Trisopterus minutus</i>	Poor-cod	R
Hydrozoa		
<i>Hydractinia echinata</i>	Hermit crab fur	O

P – Present
R – Rare
O – Occasional
C – Common

5 Conclusions

The Finstown seagrass bed is characterised by short, narrow blades of seagrass with high density growth. The bed has a great abundance of marine life from worms to crustaceans. It gives shelter for small fish fry and provides a surface to attach to for epiphytic algae. Widewall Bay seagrass bed has longer and wider seagrass than Finstown, it has lower density growth and less species abundance.

It is not possible to draw any significant conclusions from such a small study. The quantity of samples taken and identified does not give premise for rigorous statistical analysis. However, this project set out to study two very different seagrass beds on Orkney, the aim was to obtain a 'snapshot' image of what lives on and amongst the seagrass beds. In the end we recorded approximately 71 species/taxa in Finstown epiphyte samples, 51 in Widewall Bay epiphyte samples, 47 species/taxa in sediment core infauna samples and 31 species during our dive/snorkel surveys. The information gathered during this project has moved us in leaps and bounds towards a better understanding of the macro-invertebrate communities we have on the shorelines here on Orkney.

6 References and background reading

Armenteros M, Williams JP, Hidalgo G and González-Sansón G (2007) Community structure of meio- and macrofauna in seagrass meadows and mangroves from NW shelf of Cuba (Gulf of Mexico) *Rev Invest Mar* 28(2) 139-150.

Borum J, Duarte CM, Krause-Jensen D and Greve TM (2004) European seagrasses: an introduction to monitoring and management. The M&MS project.

Boström C and Bonsdorff E (1997) Community structure and spatial variation of benthic invertebrates associated with *Zostera marina* (L.) beds in the northern Baltic Sea. *Journal of Sea Research* 37 153-166.

Boström C, Bonsdorff, Kangas P and Norkko A (2002) Long-term Changes of a Brackish-water Eelgrass (*Zostera marina* L.) Community Indicate Effects of Coastal Eutrophication. *Estuarine, Coastal and Shelf Science* 55 795-804.

Foden J (date published unknown) Water Framework Directive Marine Plants Task Team Angiosperm Tool Kit, Angiosperm abundance, taxonomic composition, wasting disease. SEPA.

Jackson EL (1998) The distribution and importance of *Zostera* in Orkney. MSc Thesis, Heriot-Watt University.

James B (2004) North-west Scotland subtidal seagrass bed survey 2004. Scottish Natural heritage Commissioned Report No. 076 (ROAME No. F04LB05).

Larkum AWD, Orth, RJ and Duarte CM (editors) (2006) *Seagrasses: Biology, Ecology and Conservation*. Springer.

Saunders JE, Atrill MJ, Shaw SM and Rowden AA (2003) Spatial variability in the epiphytic algal assemblages of *Zostera marina* seagrass beds. *Mar Ecol Prog Ser* 249:107-115.

Short FT and Coles RG (editors) (2001) *Global Seagrass Research Methods*. Elsevier Science B.V.

Somerfield PJ, Yodnarasri S and Aryuthaka C (2002) Relationships between seagrass biodiversity and infaunal communities: implications for studies of biodiversity effects. *Mar Ecol Prog Ser* 237 97-109.

Troch de M, Gansbeke Van D and Vincx M (2005) Resource availability and meiofauna in sediment of tropical seagrass beds: Local versus global trends. *Mar Env Res* 61 59-73.

7 Appendices

Photos of species recorded are provided on a CD-ROM.

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