Environmental Surveys Beneath Finfish pens at Deenish and Inishfarnard, Kenmare Bay

August 2013

Produced by

AQUAFACT International Services Ltd

On behalf of

Marine Harvest Ireland

Issued November 2013

AQUAFACT INTERNATIONAL SERVICES Ltd.
12 KILKERRIN PARK
TUAM ROAD
GALWAY CITY
www.aquafact.ie

info@aquafact.ie

tel +353 (0) 91 756812
fax +353 (0) 91 756888

Table of Contents

List of Figures

List of Tables

Appendices

1. Introduction

This report documents the environmental conditions of the seabed at two Marine Harvest Ireland finfish (*Salmo salar*) aquaculture sites in Kenmare Bay, Co. Kerry / Cork on 28th August, 2013 (see Figure 1.1). One of the sites investigated during the current work is situated close to Deenish Island, County Kerry on the northern shore of Kenmare River. The second site is located at Inishfarnard, County Cork, off Kilcatherine point, on the southern shore of Kenmare Bay.

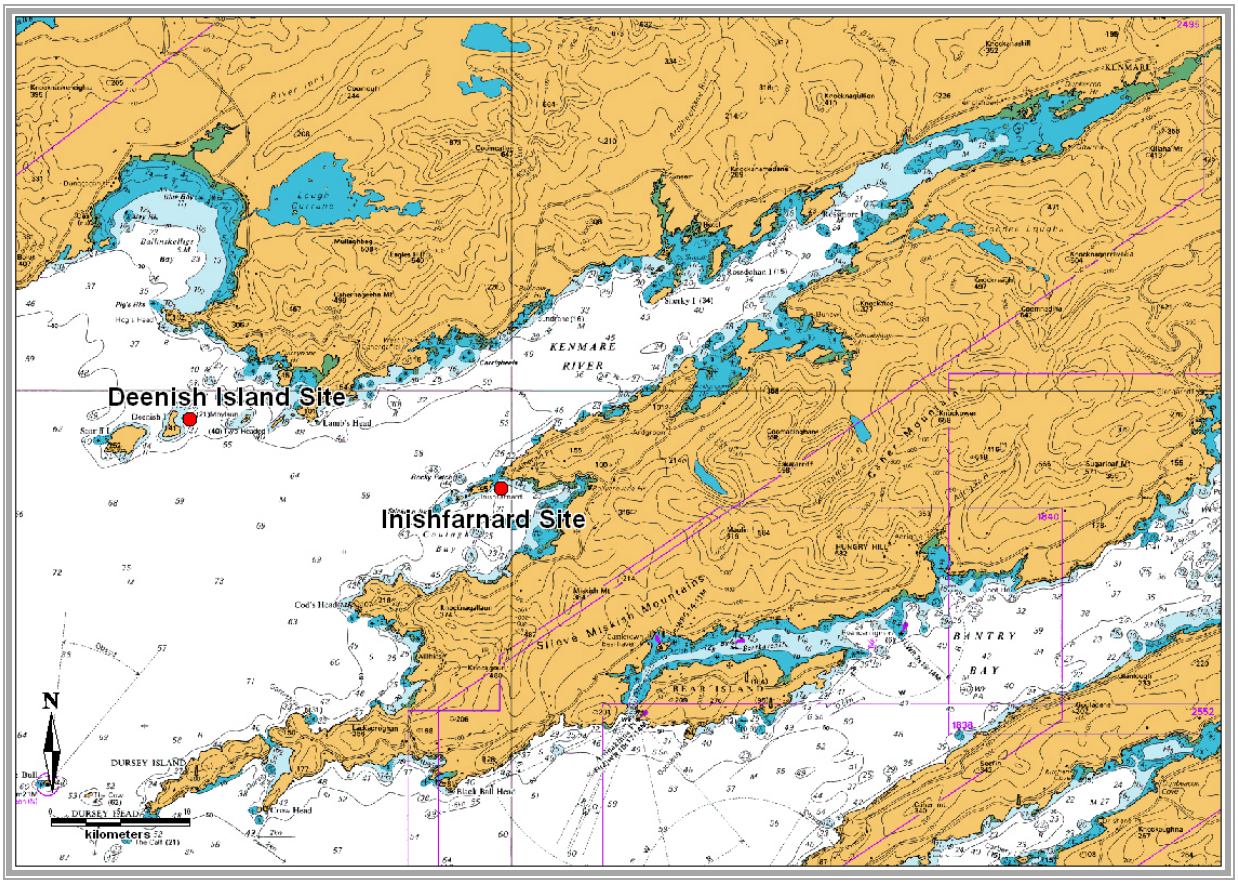


Figure 1.1. Map showing the location of the two sites surveyed in Kenmare Bay

Kenmare Bay, Co. Kerry, is a long and narrow, south-west facing bay. It is a deep, drowned glacial valley and the bedrock is mainly Old Red Sandstone which forms reefs along the middle of the bay throughout its length. Exposure to prevailing winds and swells at the mouth diminishes towards the head of the bay.

Numerous islands and inlets along the length of the bay provide further areas of additional shelter in which a variety of habitats and unusual communities occur.

Two Natura 2000 sites are of relevance for the Deenish site (see Figure 1.2). Deenish Island is located in the outer reaches of the Kenmare River cSAC (site code: 002158) and the island forms part of the Deenish Island and Scariff Island SPA (site code: 004175). The Kenmare River cSAC is of relevance to the Inishfarnard site.

Kenmare River cSAC has a very wide range of marine communities from exposed coast to ultra-sheltered areas. The site contains three marine habitats listed on Annex I of the EU Habitats Directive, namely reefs, large shallow bay and caves. There is also an extremely high number of rare and notable marine species present (24) and some uncommon communities. Kenmare River is the only known site in Ireland for the northern sea-fan, *Swiftia pallida* and is the only known area where this species and the southern sea-fan *Eunicella verrucosa* co-occur. Midway along the south coast of Kenmare River, a series of sea caves stretch back into the cliff. They typically support encrusting sponges, ascidians and bryozoans.

Deenish Island and Scariff Island are small- to medium-sized islands situated between 5 and 7 km west of Lamb's Head off the Co. Kerry coast; they are thus very exposed to the force of the Atlantic Ocean. The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Fulmar, Manx Shearwater, Storm Petrel, Lesser Black-backed Gull and Arctic Tern. Scariff is the larger of the two. It is steep-sided all the way around and rises to a peak of 252m. The highest cliffs are on the south side. The island vegetation is a mix of maritime grassland, areas dominated by Bracken and heathy areas with Ling Heather. There are the ruins of a monastic settlement and a cottage in the north-east sector of the island. Deenish is less rugged than Scariff, and rises to 144m in its southern half; the northern half is lower and flatter. The vegetation is mostly grassland, with some heath occurring on the higher ground. Old fields are now overgrown with Bracken and brambles. The sea areas to 500m around the islands are included inside the SPA boundary to provide a 'rafting' area for shearwaters.

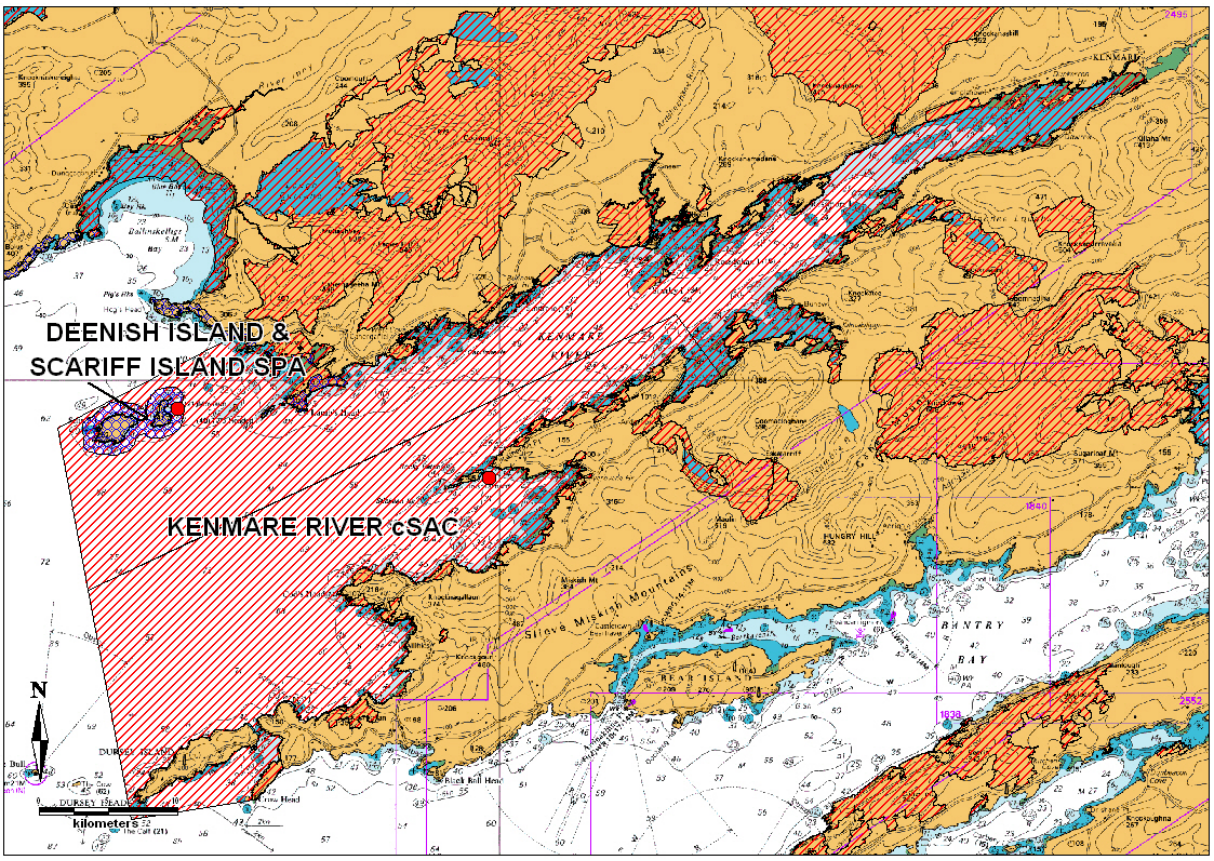


Figure 1.2. Map showing the locations of the relevant cSAC and SPA.

1.1. Offshore finfish farms – benthic monitoring

The main objective of the survey was to assess the overall state of the environment in relation to the salmon production process. The sites were surveyed according to the revised Benthic Monitoring Guidelines laid down by the Department of Agriculture, Fisheries and Food (December 2008). The benthic monitoring requirements at a fish farm are dependent on the level of biomass held at the site and the local hydrography. Table 1.1 below sets out the level of benthic monitoring required based on tonnage produced and mean current speeds at a fish farm:

Table 1.1. Matrix of production tonnage versus current speed to determine level of benthic monitoring required.

	MEAN CURRENT SPEED (CMS^{-1})		
TONNAGE	**<5**	**5-10**	**>10**
0-499	Level I	Level I	Level I
500-999	Level II	Level I	Level I
>1000	Level II	Level II	Level I

The current speed is a mean value calculated from maximum current measurements over spring and neap tidal cycles at the surface and near the bottom. The tonnage refers to the maximum biomass predicted for each site. An annual survey must be carried out at each site (production and smolt) operated by a company. A level I or level II survey may be carried out as follows:

Level I: Video/photographic and visual observations and recordings shall be made at the following stations:

- At a minimum of 2 sites directly beneath the pens
- At the edges of the pens
- Two transects at right angles to each other. Along each transect sampling stations at +/- 10m, +/- 20m, +/- 50m and + 100m from the pens
- At a control site

In addition to the above, the following samples/measurements shall be taken at the same stations as above. These will be used to calculate sediment quality parameters.

- A minimum of one Redox potential reading shall be made at each sampling station.
- A single sediment sample for Organic Carbon measurement.

Level II: In addition to the above, two replicate grab samples shall be captured at each of the sample stations for faunal analysis. The exact locations of sampling points should be agreed in advance with the Department of Agriculture Fisheries and Food (DAFF). The identification and abundance of macro-faunal invertebrates shall be estimated and tabulated. Identification of fauna to the level of species will be required.

The current survey at the Deenish site was carried out at Level I and the survey at the Inishfarnard site were carried out at Level II.

It is important to take note that the exact position of the individual pen structures are not permanently fixed to a single position and there is a relatively large lateral movement due to depth, wind, currents and tides. For this reason bottom stations particularly at the under, edge and 10m zones are taken at the time of sampling but may vary relative to the overlying pen position under various environmental conditions.

2. Sampling Procedure & Processing

All survey work took place on the 28th August 2013. The dive at the Deenish site was conducted at a maximum depth of 22.5m and underwater visibility on the day was excellent at approximately 5 to 10m. The dive at the Inishfarnard site was conducted at a maximum depth of 21.5m and underwater visibility on the day was good (5m) with the exception of a high suspended load in the upper water column. Pen layouts at the time of survey, dive entry points and benthic transects followed by the divers are shown in Figures 3.2 & 3.9 for Deenish and Figures 3.22 and 3.29 for Inishfarnard (Section 3).

Disinfection

Prior to each dive survey for each location all diving equipment, suits and boats are thoroughly disinfected utilizing both a dipping and spraying protocol.

2.1. Dive survey

Two dive transects (one parallel with the direction of the prevailing current and one perpendicular to the prevailing current) were laid out from the sea surface at each site using a boat equipped with a GPS mapper. Pen locations were noted as DGPS positions using a Trimble GeoXT, which is capable of sub-meter horizontal accuracy using real time corrections from the integrated EGNOS (European Geostationary Navigation Overlay System) receiver. Acoustic beacons were deployed to assist the divers in locating transect marks while underwater. The underwater survey itself involved the direct observation, sampling and recording (photographic and written) of benthic conditions by qualified

biologists at a number of sites along the transects:

- directly under the pen (T1 Under)
- under the edge of the pen (T1 Edge)
- at 10m (T1 10m, T1 10m), 20m (T1 20m, T2 20m), 50m (T1 50m, T2 50m) and 100m (T1 100m) from the pens.

A reference station (Ref) was also assessed to give a representation of ambient benthic conditions in the area immediately surrounding the pen installations and served for comparison purposes. As such, it represents the 'undisturbed' condition of the seafloor surrounding the sites – it was taken at a distance greater than 200m from the pen installations.

All dives were carried out by highly experienced, qualified biologists who made notes of features and species encountered during the dives – these were transcribed to logs upon surfacing. In addition to standard SCUBA gear the divers were equipped with:

- A high end dSLR camera for photographing epibenthos. Photographs were taken at the prescribed stations along each transect and observations on benthic conditions at the site were noted down. The camera used was a Nikon D200 in a Subal ND20 underwater housing fitted with a 12-24mm lens and two INON strobes.
- A hand-held dSPI camera for photographing sediment profiles, i.e. images were taken of the sediment in cross profile at depths of to 23cm (Mean redox measurements were made using digital sediment profile imagery (SPI). This unit uses a Canon EOS 450D camera with Nikkor optics).
- A SONAR receiver & compass for underwater navigation.
- Two × 5cm diameter corers for taking faunal and sediment samples (for the Under station only, grabs were used for all other stations). This was only required for Level II surveys *i.e.* Inishfarnard.
- Pre-labelled bags to store sediment samples for organic carbon analysis.
- Dive slates and waterproof pencils for making notes.
- Torches.

The divers photographed representative areas of the sediment and fauna and recorded observations in

situ at the various stations investigated. Notes were completed during discussion immediately on surfacing and a map of the dive track was drawn up. Observations recorded during the dive may include:

- Presence of bacterial mats and uneaten food
- Presence of farm-derived litter
- Presence of gas bubbles or anoxic areas
- Animals visible or evidence of their presence
- Macroalgae visible
- Sediment colour and texture – among other things.

By noting the species of animals present and their densities, any tracks of animals or the presence of species that are known to be connected with certain states of benthic enrichment, the health of the benthos (including the highlighting of some potential problems) may be gauged.

An acoustic beacon was dropped on a buoyed line at the end of the 100m transect to allow the divers (equipped with an acoustic receiver unit) to determine their distance from this mark. This also allowed simplified underwater navigation – the unit gives the divers both range and direction of the beacon.

2.2. Sediment Profile Imagery (SPI)

A Sediment Profile Image (SPI) was also acquired at each of the stations mentioned above. These images were acquired using a diver-deployed sediment profile imaging camera system. This system is comprised of a digital SLR camera in a water-tight pressure vessel that is mounted above a prism that penetrates the upper 25cm of sediment (see Figure 2.1 for image). The sediment profile is viewed through a plexiglass window. Its image is reflected to the camera lens via a plane mirror. Illumination is provided by an internally-mounted strobe.

The diver depresses the unit into the seafloor and manually triggers the camera. This process is repeated at each station investigated. The prism unit is filled with distilled water – thus ambient water clarity is never a limiting factor in image quality.

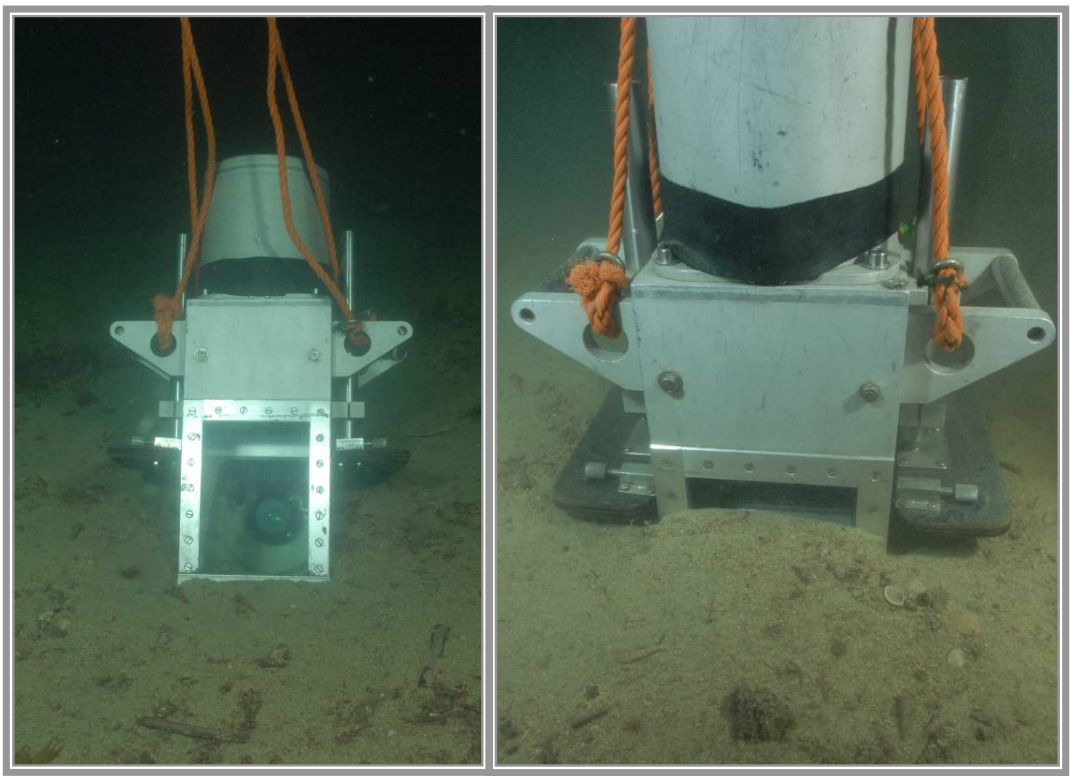


Figure 2.1. Diver operated Sediment Profile Imaging camera. The left-hand image gives a view of the camera at the sediment surface. The right-hand image shows the SPI camera when inserted into the sediment.

A great deal of information about benthic processes is available from sediment profile images. Measurable parameters, many of which are calculated directly by image analysis, include physical/chemical parameters (i.e. sediment type measured as grain size major mode, prism penetration depth providing a relative indication of sediment shear strength, sediment surface relief, condition of mud clasts, redox potential discontinuity depth and degree of contrast, sediment gas voids) and biological parameters (i.e. infaunal successional stage of a well documented successional paradigm for soft marine sediments (see Pearson and Rosenberg, 1978), degree of sediment reworking, dominant faunal type, epifauna and infauna, depth of faunal activity, presence of microbial aggregations).

For the purposes of the current survey the primary feature of interest is the depth of oxygen penetration into the sediments in the vicinity of the finfish pens (this information is required to satisfy the requirements of the Benthic Monitoring Protocol (DAFF, 2008). In this case the apparent redox potential discontinuity or ARPD depth is measured. Features of particular interest that may be gleaned from SPI images taken in sediments in the vicinity of finfish pens include the presence of:

- uneaten feed pellets (and depth of this material)
- faecal casts
- and depth of shell gravel deposits
- of gas voids in the sediment (refer to Figure 2.2)

Figure 2.2. Typical sediment profile images with examples of features.

2.3. Sampling for faunal analysis

Sediment samples for faunal analysis were collected at the Level II site in one of two ways:

- Using handheld (15cm diameter) corers at the under pen station.
- Using a small (0.025m^2) van Veen grab at all other stations.

At each station, two replicate grab/core samples were collected. The faunal returns were sieved on a 1 mm mesh sieve, stained with Rhodamine dye, fixed with 10% buffered formalin and preserved in 70% alcohol. Samples were then sorted under a microscope (x 10 magnification) back in the laboratory, into four main groups: polychaeta, mollusca, crustacea and others. The 'others' group consisted of echinoderms, nematodes, nemerteans, cnidarians and other lesser phyla. The taxa were then identified to species level where possible.

2.3.1. Data Processing

The faunal replicates for each station were combined to give a total abundance for each station prior to analyses. A data matrix of all the combined faunal abundance data was compiled and used for statistical analyses. The faunal analysis was carried out using PRIMER ® (Plymouth Routines in Multivariate Ecological Research).

Univariate statistics in the form of diversity indices were calculated on the combined replicate data. The following diversity indices were calculated:

1) Margalef's species richness index (D), (Margalef, 1958).

$$D = \frac{S-1}{\log_2 N}$$

where: N is the number of individuals

S is the number of species

2) Pielou's Evenness index (J), (Pielou, 1977).

$$J = \frac{H'(observed)}{H'_{max}}$$

where: H'_{max} is the maximum possible diversity, which could be achieved if all species were equally abundant (= $\log_2 S$)

3) Shannon-Wiener diversity index (H'), (Pielou, 1977).

$$H' = -\sum_{i=1}^{S} p_i (\log_2 p_i)$$

where: p_I is the proportion of the total count accounted for by the i^{th} taxa

Species richness is a measure of the total number of species present for a given number of individuals. Evenness is a measure of how evenly the individuals are distributed among different species. The diversity index incorporates both of these parameters.

The PRIMER ® manual (Clarke & Warwick, 2001) was used to carry out multivariate analyses on the station-by-station faunal data. All species/abundance data were fourth root transformed and used to

prepare a Bray-Curtis similarity matrix in PRIMER®. The fourth root transformation was used in order to down-weigh the importance of the highly abundant species and allow the mid-range and rarer species to play a part in the similarity calculation. The similarity matrix was then used in classification/cluster analysis. The aim of this analysis was to find "natural groupings' of samples, i.e. samples within a group that are more similar to each other, than they are similar to samples in different groups (Clarke & Warwick, *loc. cit.*). The PRIMER ® programme CLUSTER carried out this analysis by successively fusing the samples into groups and the groups into larger clusters, beginning with the highest mutual similarities then gradually reducing the similarity level at which groups are formed. The result is represented graphically in a dendrogram, the x-axis representing the full set of samples and the y-axis representing similarity levels at which two samples/groups are said to have fused. The CLUSTER programme was set to include a series of 'similarity profile' (SIMPROF) permutation tests, which look for statistical evidence of genuine clusters in samples which are *a priori* unstructured. SIMPROF performs tests at every node of a completed dendrogram, that the group being sub-divided has 'significant' internal structure. The test results are displayed in a colour convention on the dendrogram plot (samples connected by red lines cannot be significantly differentiated).

The Bray-Curtis similarity matrix was also subjected to a non-metric multi-dimensional scaling (MDS) algorithm (Kruskall & Wish, 1978), using the PRIMER ® program MDS. This programme produces an ordination, which is a map of the samples in two- or three-dimensions, whereby the placement of samples reflects the similarity of their biological communities rather than their simple geographical location (Clarke & Warwick, 2001). With regard to stress values, they give an indication of how well the multi-dimensional similarity matrix is represented by the two-dimensional plot. They are calculated by comparing the interpoint distances in the similarity matrix with the corresponding interpoint distances on the 2-d plot. Perfect or near perfect matches are rare in field data, especially in the absence of a single overriding forcing factor such as an organic enrichment gradient. Stress values increase not only with the reducing dimensionality (lack of clear forcing structure), but also with increasing quantity of data (it is a sum of the squares type regression coefficient). Clarke and Warwick (*loc. cit.*) have provided a classification of the reliability of MDS plots based on stress values, having compiled simulation studies of stress value behaviour and archived empirical data. This classification generally holds well for 2-d ordinations of the type used in this study. Their classification is given below:

- Stress value < 0.05: Excellent representation of the data with no prospect of misinterpretation.

- Stress value < 0.10: Good representation, no real prospect of misinterpretation of overall structure, but very fine detail may be misleading in compact subgroups.
- Stress value < 0.20: This provides a useful 2-d picture, but detail may be misinterpreted particularly nearing 0.20.
- Stress value 0.20 to 0.30: This should be viewed with scepticism, particularly in the upper part of the range, and discarded for a small to moderate number of points such as < 50.
- Stress values > 0.30: The data points are close to being randomly distributed in the 2-d ordination and not representative of the underlying similarity matrix.

Each stress value must be interpreted both in terms of its absolute value and the number of data points. In the case of this study, the moderate number of data points indicates that the stress value can be interpreted more or less directly. While the above classification is arbitrary, it does provide a framework that has proved effective in this type of analysis.

2.4. Sampling for organic carbon analysis

A grab/core sample was taken at each of the stations and used for organic carbon analyses. All samples were stored in pre-labelled plastic bags, kept in cold freezer boxes onboard the vessel and frozen at -20°C on return to the lab.

Organic carbon analysis was carried out by OMAC laboratories using the Loss on Ignition (LOI) technique. This method involves oven drying the sediment sample in a muffle furnace (450°C for a period of 6 hours) after which time the organic content of the sample is determined by expressing as a percentage the weight of the sediment after ignition over the initial weight of the sediment.

3. Results

3.1. Deenish

3.1.1. Recent Stocking History

Fish were stocked to the Deenish pens between 8th and 22nd April 2013 when 837,976 fish with a mean weight of 59 g (total biomass of 49.4 tonnes) were transferred to the site. The Deenish Island site was fallow for a period of just over 3 weeks (15th March - 8th April 2013) prior to stocking. At the time of the survey approximately 718,993 fish remained on site with an average weight of 347 g giving a total onsite biomass of 249.5 tonnes. Discounting mortalities due to algal blooms and normal production mortalities, this gives an onsite production biomass of 200.3 tonnes prior to the survey. Mean current speed at the site is approximately 0.3ms^{-1}.

Figure 3.1. View of pens at Deenish Island site, viewed at sea28th August 2013.

3.1.2. Seabed Physical Characteristics

The seabed was composed of a mix of sediment types with areas of:

- Sand – The seabed at the under pen and pen edge stations was composed of fine-medium sand. The seafloor at the 10m and 20m stations was composed of a slightly coarser sand mix.
- Shell gravel and sand mix – the seafloor beyond the 20m stations was composed of sand with coarse shelly gravel armouring.

3.1.3. Photographic Record; Transect 1

This transect began beneath the north western most pen moored on site (see Figure 3.2). A total of six stations were investigated. Numerous jelly fish*, Aurelia aurita, Chrysaora hysoscella, Cyanea lamarckii and Aploemia uvaria* were noted in the water column at this site.

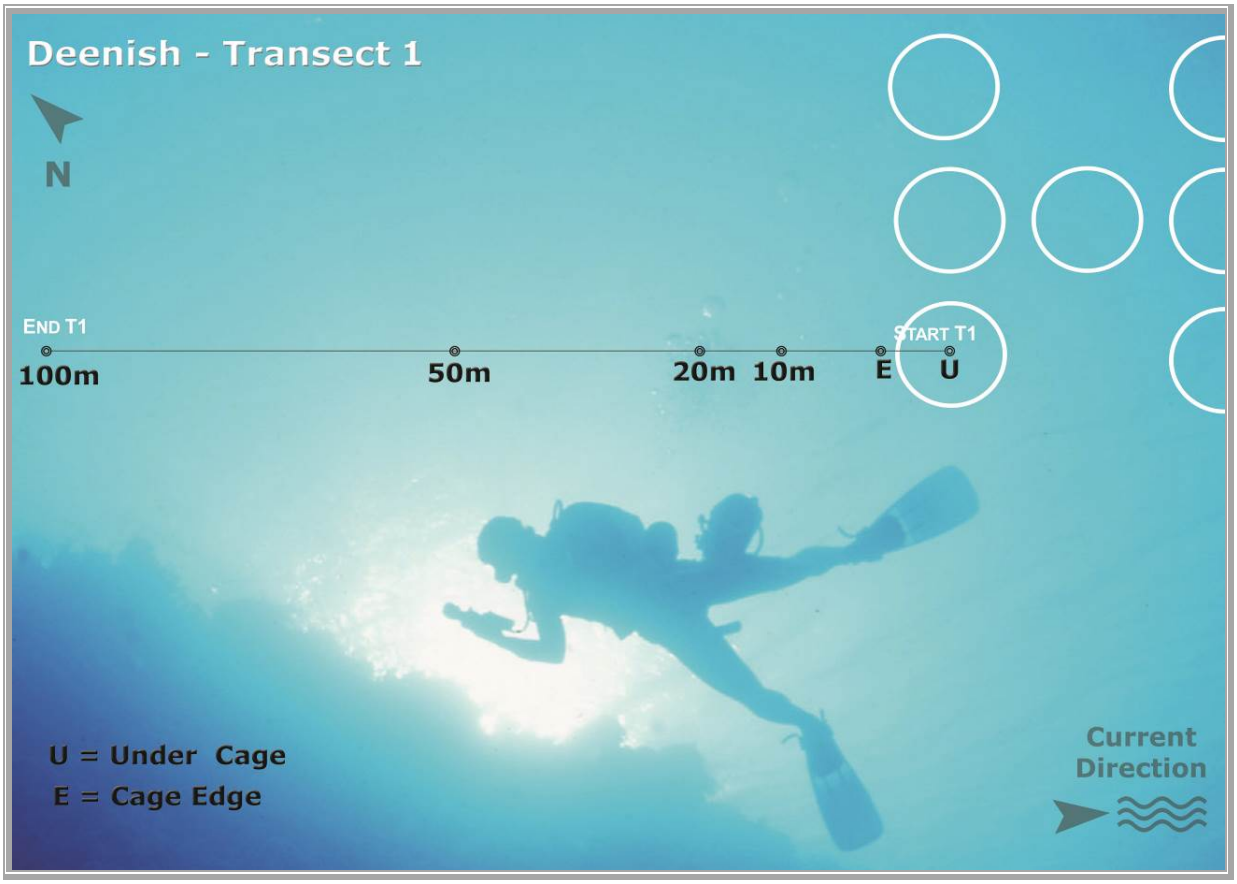


Figure 3.2. Transect 1 seafloor station layout, Deenish Island site, 28th August 2013.

3.1.3.1. Under Pen Location

The pens on site were stocked at the time of the study. There were some signs on the seafloor that finfish pens were overlying the site:

- Very light scattering of uneaten food;
- A scattering of faecal casts and faeces ;
- Relatively shallow ARPD depths at this station;
- Some accumulation of finer sediments.

A number of small hermit crabs (Paguridae), common starfish (*Asterias rubens*) and *Marthasterias glacialis*, numerous brittlestars (Amphiuridae sp.) and anemones (*Cerianthus lloydii*) were noted. Speckled through the underlying sediment were discarded mussel shells (*Mytilus edulis*) probably derived from the structures on the pen system above. Both Dog and Monk fish were common at the site. The mean ARPD at this station ranged from 0.2 to 6.2cm

No signs of outgassing was noted at this station.

Figure 3.3. T1 – Under pen, Deenish Island site, 28th August 2013.

3.1.3.2. Edge of Pen Location

The edge station was dominated by a fine to medium sand with some mussel shell debris through the sediments. There were some signs on the seafloor that finfish pens were overlying the site:

- A scattering of uneaten feed pellets;
- A small number of faecal casts;
- A light layer of Beggiatoa spp.; and
- Relatively shallow ARPD depth.

Some waste food pellets at this location were coated by algal/bacterial film that gave the food a reddish brown hue. Drifting algal material (kelp frond fragments), sea slugs (Faceliniidae and Aeolidiidae) and hermit crabs (Paguridae) were recorded. The starfish *Asterias rubens*, *Marthasterias glacialis* and *Luidia ciliaris* and the infaunal *Amphiura sp*. were common at this station. The ARPD ranged from 0.2 to 6.3cm. No signs of outgassing was noted at this station.

Figure 3.4. T1 – Pen edge, Deenish Island, 28th August 2013.

3.1.3.3. 10m from Pen

The seafloor at the 10m station was composed of sand scattered with redundant mussel shells and small stones. There were some signs that finfish pens were nearby:

- Small patches of feed material; and
- A very light scattering of faecal casts.

The seafloor at this site was dominated by the brittle stars *Amphiuridae* sp. Other species of note were the anemone *Ceranthus lloydii* and faecal casts of *Arenicola* sp. The ARPD at this station was greater than 2.2cm and its exact depth could not be measured due to the poor SPI penetration in the stony sediment.

No signs of outgassing was noted at this station.

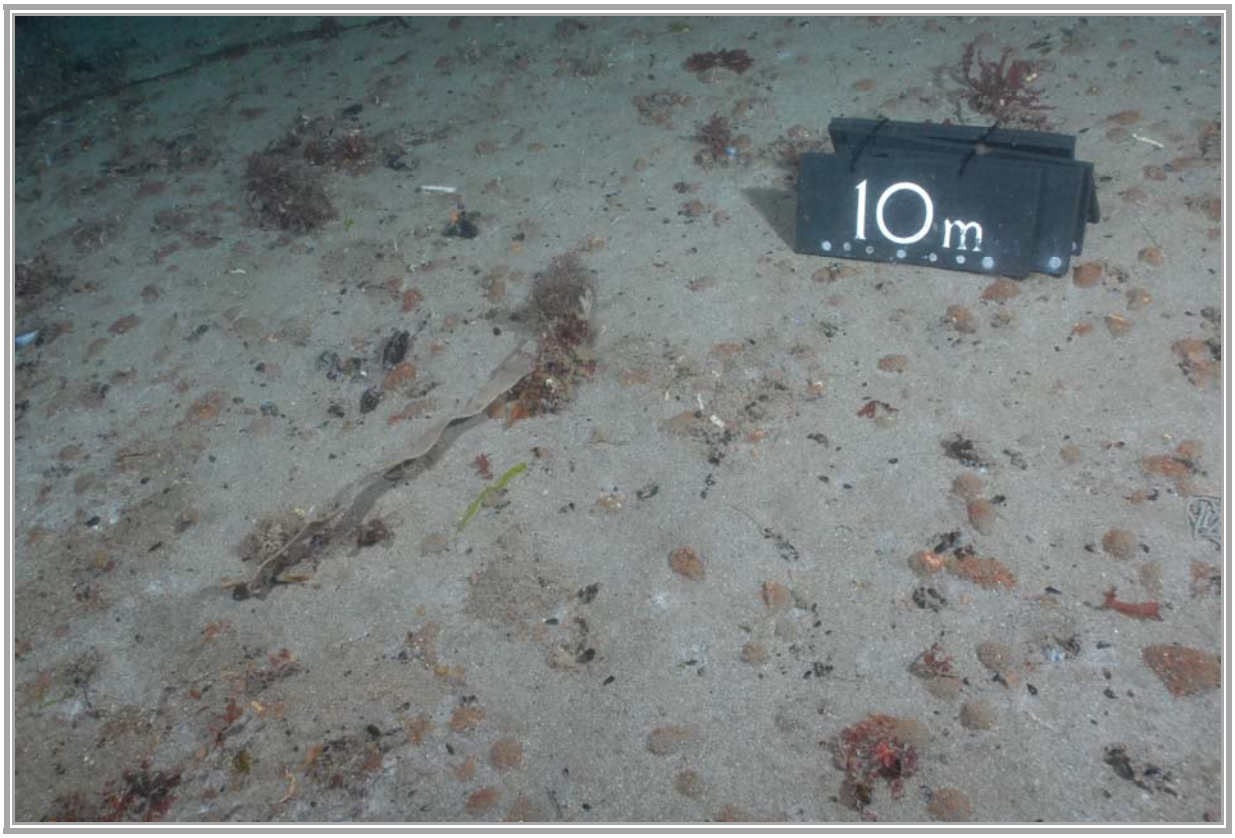


Figure 3.5. T1 – 10m, Deenish Island, 28th August 2013.

3.1.3.4. 20m from Pen

The seafloor at the 20m station was composed of relatively flat fine to medium sand. There were no signs of the nearby finfish rearing operation. The seafloor at this site was also dominated by the infaunal brittlestars, *Amphiuridae* sp. Other brittlestars (*Ophiura* sp.) were also observed. Other species of note were swimming crabs *Necor puber*. Drift weed was common throughout this site. The average ARPD at this station measured 2.6cm.

No signs of outgassing was noted at this station.

Figure 3.6. T1 – 20m, Deenish Island, 28th August 2013.

3.1.3.5. 50m from Pen

The seafloor at the 50m station was composed predominantly of sand with a high proportion of shell debris. Small plants of a common epilithic and epiphytic red seaweed (*Phycodrys rubens*) were noted attached to some of the larger shell fragments. Mean ARPD was 2.0cm with a range of 0.2 to 2.4cm.

No signs of outgassing was noted at this station.

Figure 3.7. T1 – 50m, Deenish Island, 28th August 2013.

3.1.3.6. 100m from Pen

A sand, shell and pebble gravel seafloor was observed at this station. There were no apparent signs of impact from the nearby finfish rearing operation. Scallops were common in this region. On moving further along this transect the bottom became much coarser and became dominated by a *Mytilus* shell debris covering the entire area.

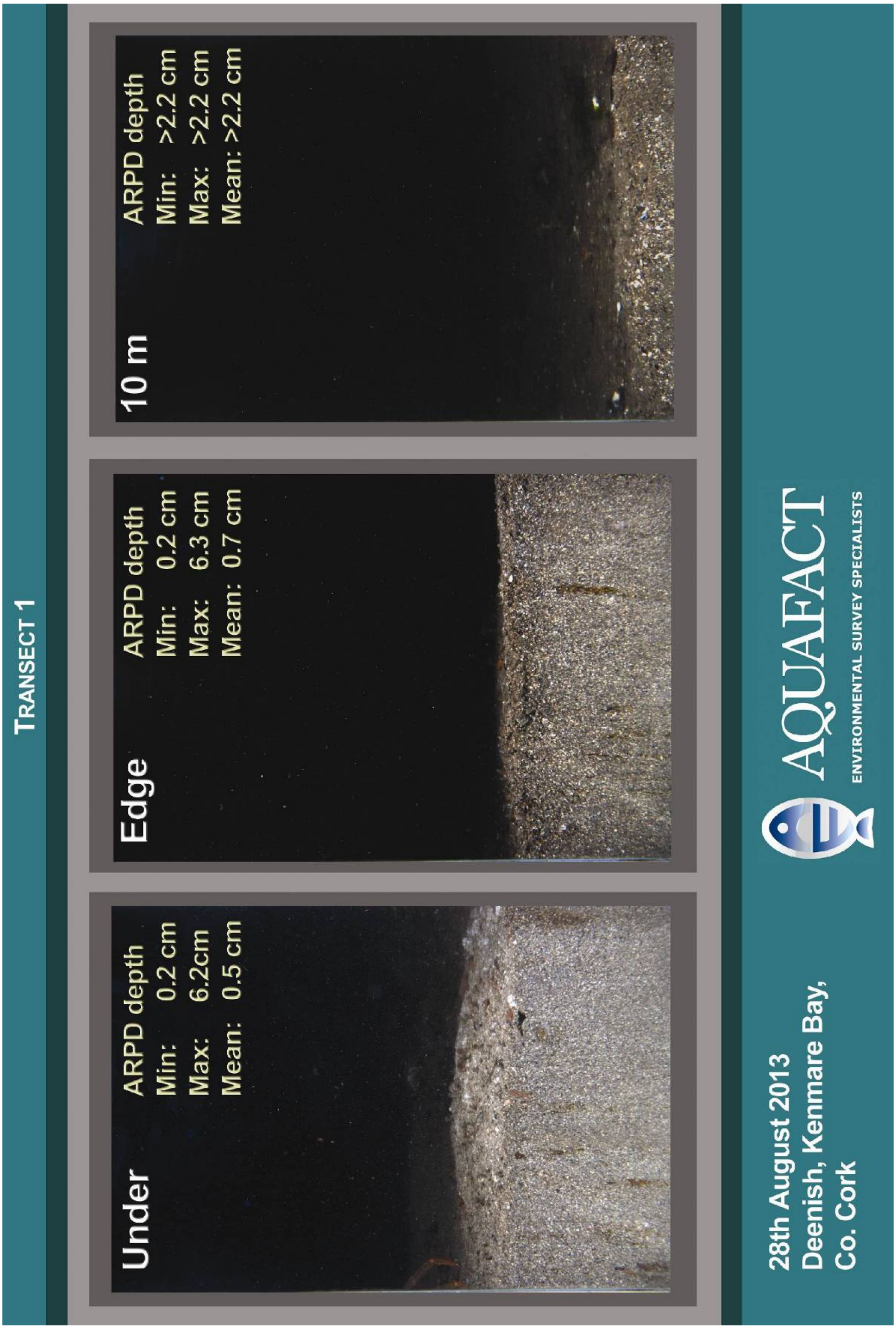
Small starfish (probably juvenile *Asterias* sp. and/or *Marthasterias* sp.), numerous anemones (*Cerianthus lloydii*), calcareous tube worms (*Pomatoceros* sp.) and drift algae (*Alaria esculenta*) were noted in the sandy region. On moving over the coarser shelly areas the starfish *Asterias, Marthasterias* and *Luidia* were common. Numerous small monk fish were common at this site.

Mean APPD was 4.6cm. No signs of outgassing was noted at this station.

Figure 3.8. T1 – 100m, Deenish Island, 28th August 2013.

3.1.4. Sediment Profile Imagery – Transect 1

The following two plates present sediment profile images taken at the six stations visited on Transect 1 of the Deenish site. They display a single image and the maximum and minimum apparent redox potential discontinuity (ARPD) depths measured at each station. Each image is 15.5cm × 25cm. ARPD depths ranged from a minimum of 0.2cm (T1 Under, T1 Edge, T1 20m and T1 50m) to a maximum of >6.5cm (T1 100m). The composition of sediments at each station can be seen – fine sand at the under pen station to a coarser shelly gravelly sand at the outer end of the transect. Small amounts of uneaten feed and faecal material can be seen at the under pen station. APRD range can range considerably at any one station and is due to the deep bioturbating activity of the infaunal species particularly ophiuroids, *Amphiuridae* sp.. The seafloor at this site is probably relatively mobile and experiences winter surges churning the benthic sands on a regular basis.


TRANSECT 1
Under
ARPD depth
Min: 0.2 cm
Max: 6.2cm
Mean: 0.5 cm
Edge
ARPD depth
Min: 0.2 cm
Max: 6.3 cm
Mean: 0.7 cm
10 m
ARPD depth
Min: >2.2 cm
Max: >2.2 cm
Mean: >2.2 cm
28th August 2013
Deenish, Kenmare Bay,
Co. Cork
AQUAFACT
ENVIRONMENTAL SURVEY SPECIALISTS


Transect 1
20 m
ARPD depth
Min: 0.2 cm
Max: 6.4 cm
Mean: 2.6 cm
50 m
ARPD depth
Min: 0.2 cm
Max: 2.4 cm
Mean: 2.0 cm
100 m
ARPD depth
Min: 0.7 cm
Max: >6.5 cm
Mean: 4.6 cm
28th August 2013
Deenish, Kenmare Bay,
Co. Cork
AQUAFACT
ENVIRONMENTAL SURVEY SPECIALISTS

3.1.5. Photographic Record; Transect 2

This transect began beneath the same pen as Transect 1. A total of five stations were investigated on Transect 2 (See Figure 3.9) with an additional (Reference) station investigated just over 150m from the pen edge.

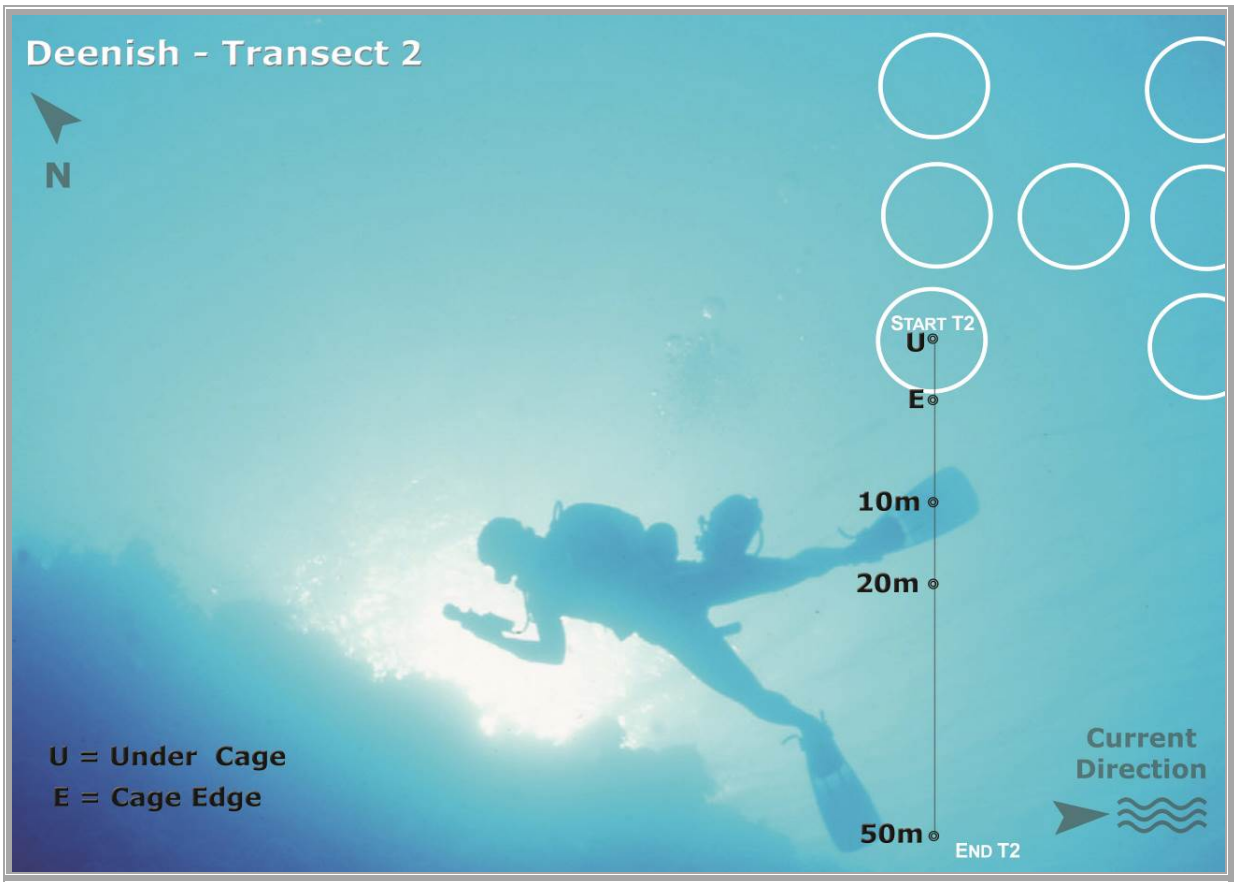


Figure 3.9. Transect 2 seafloor station layout, Deenish Island site, 28th August 2013.

3.1.5.1. Under Pen Location

This station was located beneath the same pen as the under pen station on Transect 1. Seafloor conditions are therefore similar. There were some signs on the seafloor that finfish pens were overlying the site:

- Light scattering of uneaten feed pellets and faecal casts;
- Shallow ARPD depths at this station; and

A number of small gobies (*Pomatoschistus* sp.), numerous common starfish (*Asterias rubens*) and brittlestars Amphiuridae sp. were noted. Some small fragments of drifting kelp were noted. Polychaete feeding casts can also be seen the image below The ARPD in this area ranged from 0.2 at the sediment water interface to >1cm at this site.

No signs of outgassing were noted.

Figure 3.10. T2 – Under pen, Deenish Island, 28th August 2013.

3.1.5.2. Edge of Pen Location

Fine-medium sands with a small amount of shell gravel. There were some obvious signs on the seafloor that finfish pens were overlying the site:

- Feed pellets and faecal casts on the seabed;
- Spots of the sulphur reducing bacteria *Beggiatoa* spp.; and
- Shallow ARPD depths.

The seafloor at this location was dominated by the infaunal ophiuroid, *Amphiura* sp., and numerous small anemones (*Cerianthus* sp.) were noted. Juvenile *Asterias rubens* were common at this site. As with the previous edge of pen site some waste food pellets at this location were coated by algal/bacterial film that gave the food a reddish brown hue.

There were no signs of outgassing at this location

Figure 3.11. T2 – Pen edge, Deenish Island, 28th August 2013.

3.1.5.3. <u>10m from Pen</u>

Fine-medium sand with a small amount of mussel shell. There were no obvious signs that a finfish rearing facility was nearby. Burrowing brittlestars (Am*phiuridae* sp.), *Asterias rubens*, seven-armed starfish (*Luidia ciliaris*) and numerous anemones (*Cerianthus lloydii*) were recorded. Faecal casts from the polychaete *Arenicola* sp. are noted in the image below. Mean ARPD was recorded at 2.9cm and was highly variable ranging from 0.2 to 6.9 due to the presence of deep bioutrbating infaunal species.

No evidence of outgassing was noted at this site.

Figure 3.12. T2 - 10m, Deenish Island, 28th August 2013.

3.1.5.4. 20m from Pen

A relatively flat fine-medium sand seafloor with a dense mat of the arms of the Ophiuroid , Amphiura sp. wafting in the water column were the most notable feature of this site. There were no obvious signs that a finfish farm was nearby. Biological features encountered included relatively high densities of the anemones, *Cerianthus lloydii* and various encounters with the starfish *Asterias rubens*, *Marthasterias glacialis* and *Luidea ciliaris*. The Mean ARPD at this station was 3.5cm.

No evidence of outgassing was noted at this site.

Figure 3.13. T2 – 20m, Deenish Island, 28th August 2013.

3.1.5.5. 50m from Pen

The seafloor at this station was similar to the 20m station and consisted of a medium sand with some shell debris. Dense beds of Amphiura sp were noted. Numerous gobies (*Pomatoschistus* sp.), small red algal plants (*Phycodrys* sp.) and a king scallop (*Pecten maximus*) were recorded. *Ceranthus lloydii* were also common at this station.

Mean ARPD was 2.0cm and ranged in depth from 0.2 to 3.2cm due to the high density of bioturbating species in the sediment.

No evidence of outgassing was noted at this site.

Figure 3.14. T2 – 50m, Deenish Island, 28th August 2013.

3.1.6. Reference Station

This photograph was taken at a distance of approximately 200m from the pen edge. Sediments at the reference station were composed of sand, stones and shell gravel forming a relatively flat seabed. There were no apparent signs of impact from the nearby finfish rearing operation:

- Seafloor 'clean' and free of feed/faecal material, *Beggiatoa* spp. cover;
- No items of farm debris; and
- Presence of 'normal' flora and fauna for this area.

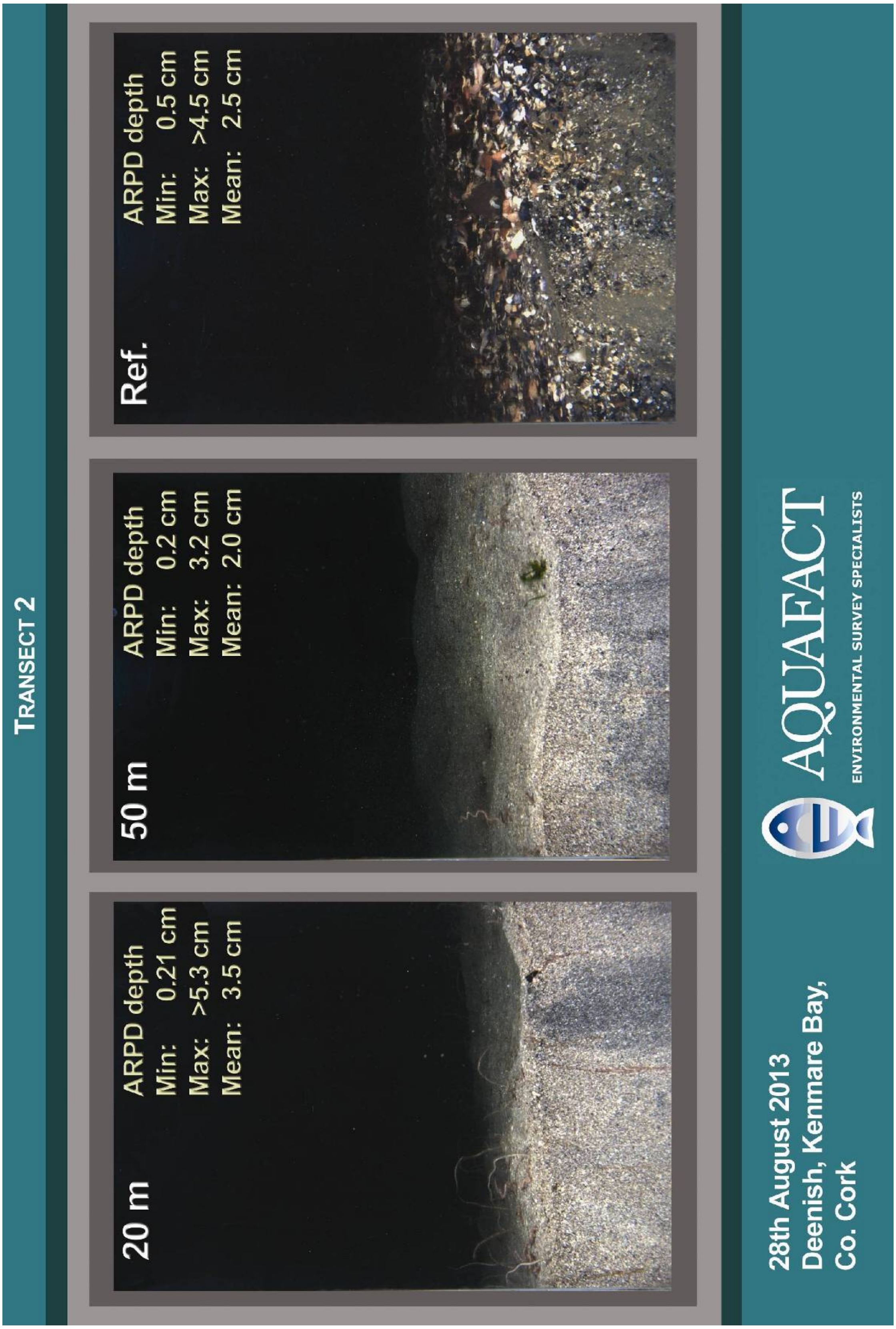
Amphiuridae sp. populations were also dense in the sandy zones at this location as were the tube anemones (*Cerianthus lloydii*), gobies (*Pomatoschistus* sp.), calcareous tube worms (*Pomatoceros* sp.) and a seven-armed starfish (*Luidia ciliaris*). Scallops, *Pecten maximus*, were noted throughout this site. Numerous red weed and to a lesser extent brown weeds were attached to the stones at this location. Mean ARPD was 2.5cm.

Figure 3.15. Reference Station, Deenish Island, 28th August 2013.

3.1.7. Sediment Profile Imagery – Transect 2 & Reference

The following two plates present sediment profile images taken at the five stations visited on Transect 2 of the Deenish site. A sediment profile image was also taken at the Reference station. They display a single image and the maximum and minimum apparent redox potential discontinuity (ARPD) depths measured at each station. Each image is 15.5cm × 25cm. Along Transect 2, ARPD depths ranged from a minimum of 0.2cm (all stations) to a maximum of >6.9cm (T2 10m). ARPD depths at the Reference station ranged from >0.5cm to >4.5cm. The composition of sediments at each station can be seen. Sediment type varied from fine/medium sands under and close to the pen compared with higher proportions of gravel and shell with increasing distance from the pen. ARPDs ranged from 0.5 to greater than 6cm with a high degree of variability due in part to the dense populations of the infaunal ophiuroid, Amphiuridae sp.


TRANSECT 2
Under
ARPD depth
Min: 0.2 cm
Max: >1.0 cm
Mean: >1.0 cm
Edge
ARPD depth
Min: 0.2 cm
Max: 5.9 cm
Mean: 1.4 cm
10 m
ARPD depth
Min: 0.2 cm
Max: >6.9 cm
Mean: 2.9 cm
28th August 2013
Deenish, Kenmare Bay,
Co. Cork
AQUAFACT
ENVIRONMENTAL SURVEY SPECIALISTS


TRANSECT 2
20 m
ARPD depth
Min: 0.21 cm
Max: >5.3 cm
Mean: 3.5 cm
50 m
ARPD depth
Min: 0.2 cm
Max: 3.2 cm
Mean: 2.0 cm
Ref.
ARPD depth
Min: 0.5 cm
Max: >4.5 cm
Mean: 2.5 cm
28th August 2013
Deenish, Kenmare Bay,
Co. Cork
AQUAFACT
ENVIRONMENTAL SURVEY SPECIALISTS

3.1.8. Transect Species List

Table 3.1 shows a list of species observed during the dives at the Deenish fish farm site.

Table 3.1. Species noted during dives on the seabed beneath the Deenish pens, 28th August 2013.

Group	Species	Common Name
(Cnidaria) Hexacorallia	*Cerianthus lloydii*	Tube anemone
(Annelida) Polychaeta	*Pomatoceros* sp.	Tube worm
	Lanice conchilega	The sand mason
	Chaetopterus variopedatus	Parchment tube worm
(Mollusca) Bivalvia	*Pecten maximus*	King scallop
	Faceliniidae	Sea slugs
	Aeolidiida	Sea slugs
	Nudibranch	Sea slugs
(Arthropoda) Decapoda	Paguridae	Hermit crab
Echinodermata	*Luidia ciliaris*	Seven armed starfish
	Asterias rubens	Common starfish
	Marthasterias sp	Starfish
	Ophiura sp.	Brittlestar
	Amphiuridae sp.	Brittlestar
(Chordata) Osteiichthyes	*Pomatoschistus* sp.	Gobies
Rhodophyta	*Delesseria* sp.	Sea beech
	Phycodrys rubens	Sea oak
Ochrophyta	*Alaria esculenta*	Edible kelp

3.1.9. Supplementary Photos

A view of a seven-armed starfish (*Luidia ciliaris*) moving over the seabed with high densities of red algae

Figure 3.16. Seven-armed starfish (*Luidia ciliaris*) – Deenish Island, 28th August 2013.

The image shown in Figure 3.17 was taken just beyond the Reference station at the Deenish Island site. The photograph shows large and juvenile starfish (*A. rubens*) scavenging on discarded mussels.

Figure 3.17. Mussels and the starfish *Asterias rubens*, Deenish Island, 28th August 2013.

Figure 3.18: The crab, *Corystes cassivelaunus* scampering over the sediment surface. Amphiura sp brittle star arms protruding from the sediment. Deenish Island, 28th August 2013.

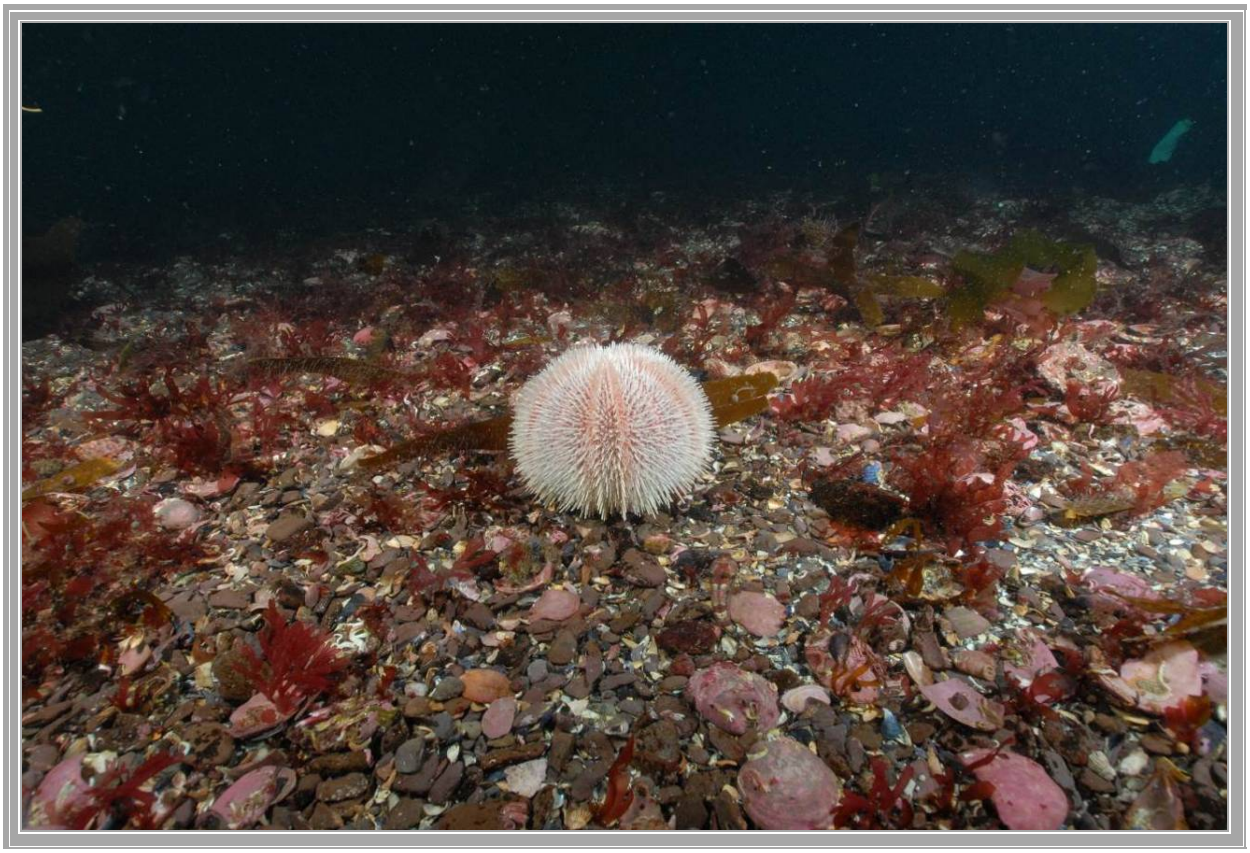


Figure 3.19. *Echinus esculentus* on a gravelly shelly section of the site at Deenish Island 28th August 2013.

3.1.10. Organic Carbon Analysis & ARPD Depths

Table 3.2 gives the organic carbon results for the Deenish site. Organic carbon values ranged from 1.56% (REF) to 7.08% (T1 100m). Table 3.3 shows in tabular form the ARPD depths from the SPI images from Deenish (see Sections 3.1.4 and 3.1.7).

Table 3.2: Organic carbon results from the Deenish stations (% values, Loss on Ignition at 450°C).

T1	Under	Edge	10m	20m	50m	100m
LOI %	3.78	3.97	6.68	4.36	4.77	7.08
T2	**Under**	**Edge**	**10m**	**20m**	**50m**	**REF**
LOI %	-	4.28	1.99	1.93	1.88	1.56

Table 3.3: ARPD Depths for Deenish, Kenmare Bay, 28th August 2013

Station		Transect 1	Transect 2
Under	Range (cm)	0.2-6.2	0.2->1
	Mean (cm)	0.5	>1
Edge	Range (cm)	0.2-6.3	0.2-5.9
	Mean (cm)	0.7	1.4
10m	Range (cm)	2.2->2.2	0.2->6.9
	Mean (cm)	>2.2	2.9
20m	Range (cm)	0.2-6.4	0.21->5.3
	Mean (cm)	2.6	3.5
50m	Range (cm)	0.2-2.4	0.2-3.2
	Mean (cm)	2	2
100m	Range (cm)	0.7->6.5	-
	Mean (cm)	4.6	-
Reference	Range (cm)	-	0.5->4.5
	Mean (cm)	-	2.5

3.2. Inishfarnard

3.2.1. Recent Stocking History

Approximately 221,653 fish, with an average weight of 2.84 kg (629.5 tonnes) were transferred from the Deenish site between the 12th and 15th March 2013. At the time of the survey, 145,424 fish remained on site with an average weight of 5.1kg (741.7 tonnes). Discounting mortalities due to AGD, this gives an onsite production biomass of 112.2 tonnes prior to the survey.

Figure 3.20. Pens at the Inishfarnard site, viewed at sea, 28th August 2013.

3.2.2. Seabed Physical Characteristics

The seabed was composed of a mix of seafloor types with areas of:

- Firm muddy sand – directly under, at the edge of and 10m from the pen
- Medium/coarse sand with shell gravel further away from the pen.

There was some obvious evidence on the seafloor that indicated proximity to a fish farming operation.

3.2.3. Photographic record; Transect 1

This transect began beneath the north-easternmost pen (see Figure 3.22) and ended approximately 100m to the east. A total of six stations were investigated. Visibility was relatively good and ranged from 3 to 5m.

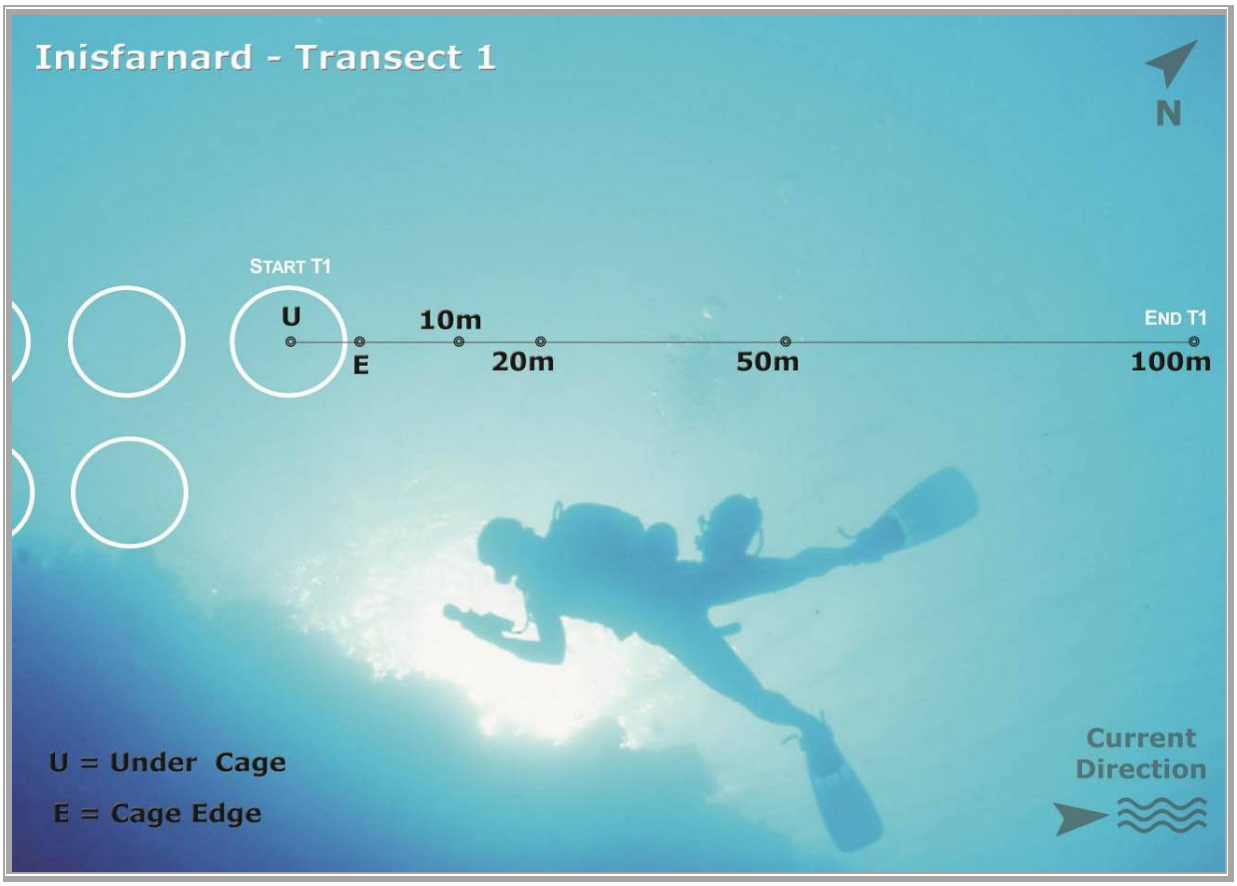


Figure 3.21. Transect 1 seafloor station layout, Inishfarnard site, 28th August 2013.

3.2.3.1. Under Pen Location

The pens on site were stocked at the time of the survey. The seafloor here was composed of firm sand with a silt/mud fraction. There were obvious signs on the seafloor that finfish pens were overlying the site:

- Waste feed pellets and faecal casts;

- Some small zones with *Beggiatoa* spp. at the sediment surface; and
- Shallow ARPD depths.

Small fragments of drift algal material were noted as were algal debris floating over the sediment surface. The mean ARPD at this location was 0.1cm and consistent of a thin muddy veneer overlying coarser sands (Section 3.2.4). Numerous dog fish *Scyliorhinus canicula*, green crabs, *Carcinus maenas* and the echinoderms *Asterias rubens* and *Marthasterias glacialis* were present.

ARPD was close to the sediment water surface at this location and in general was measured at 0.5cm. No signs of outgassing was noted at this site.

Figure 3.22. T1 – Under pen, Inishfarnard site, Kenmare River, 28th August 2013.

3.2.3.2. Edge of Pen Location

Firm muddy sand with a covering of shell and broken shell. There were some signs on the seafloor that finfish pens were overlying the site:

- Small amounts of waste feed pellets and faecal casts;
- Shallow ARPD depths.

Fragments of drifting algae and clumps of *Mytilus edulis* were noted. Mean ARPD was 1.7cm and there was signs of outgassing.

Figure 3.23. T1 – Pen edge, Inishfarnard site, Kenmare River, 28th August 2013.

3.2.3.3. 10m from Pen

The seafloor at the 10m station was composed primarily of firm muddy sand with a higher shelly debris from the previous stations. There was little evidence that finfish pens were nearby:

There were numerous crabs, *Cancer pagurus*, tube anemones (*Cerianthus lloydii*) and the starfish (*Luidia*

ciliaris) recorded at this station. *Pecten maximus* and the swimming crab *Necor puber* were also observed. Mean ARPD was recorded at 3.2cm and there was no signs of outgassing.

Figure 3.24. T1 – 10m, Inishfarnard site, Kenmare River, 28th August 2013.

3.2.3.4. 20m from Pen

The seafloor at the 20m station was similar to that of the 10m and was composed of a mix of coarse and medium sand with some shell gravel.

Specimens of the anemone *Ceranthus lloydii* are noted in the image below. Mean ARPD was 0.7cm and no evidence of outgassing was noted

Figure 3.25. T1 – 20m, Inishfarnard site, Kenmare River, 28th August 2013.

3.2.3.5. 50m from Pen

Medium and coarse sand with shell grave continued at this site.

Numerous specimens of the edible crab (*Cancer pagurus*), starfish (*Asterias rubens and Marthasterias glacialis*) and calcareous tube worms (*Pomatoceros* sp.) on hard objects like stones and shells were noted. Drifting fragments of algal fronds were recorded at the sediment surface. Mean ARPD at this site was greater than 3.3cm.

Figure 3.26. T1 – 50m, Inishfarnard site, Kenmare River, 28th August 2013.

3.2.3.6. 100m from Pen

A seafloor composed of medium and coarse sand with shell gravel and algal debris. The bottom at this location would appear to experience slightly more physical disturbance than the previous stations as evidenced by the undulations of the sediment and the gathering of shell debris in the small troughs.

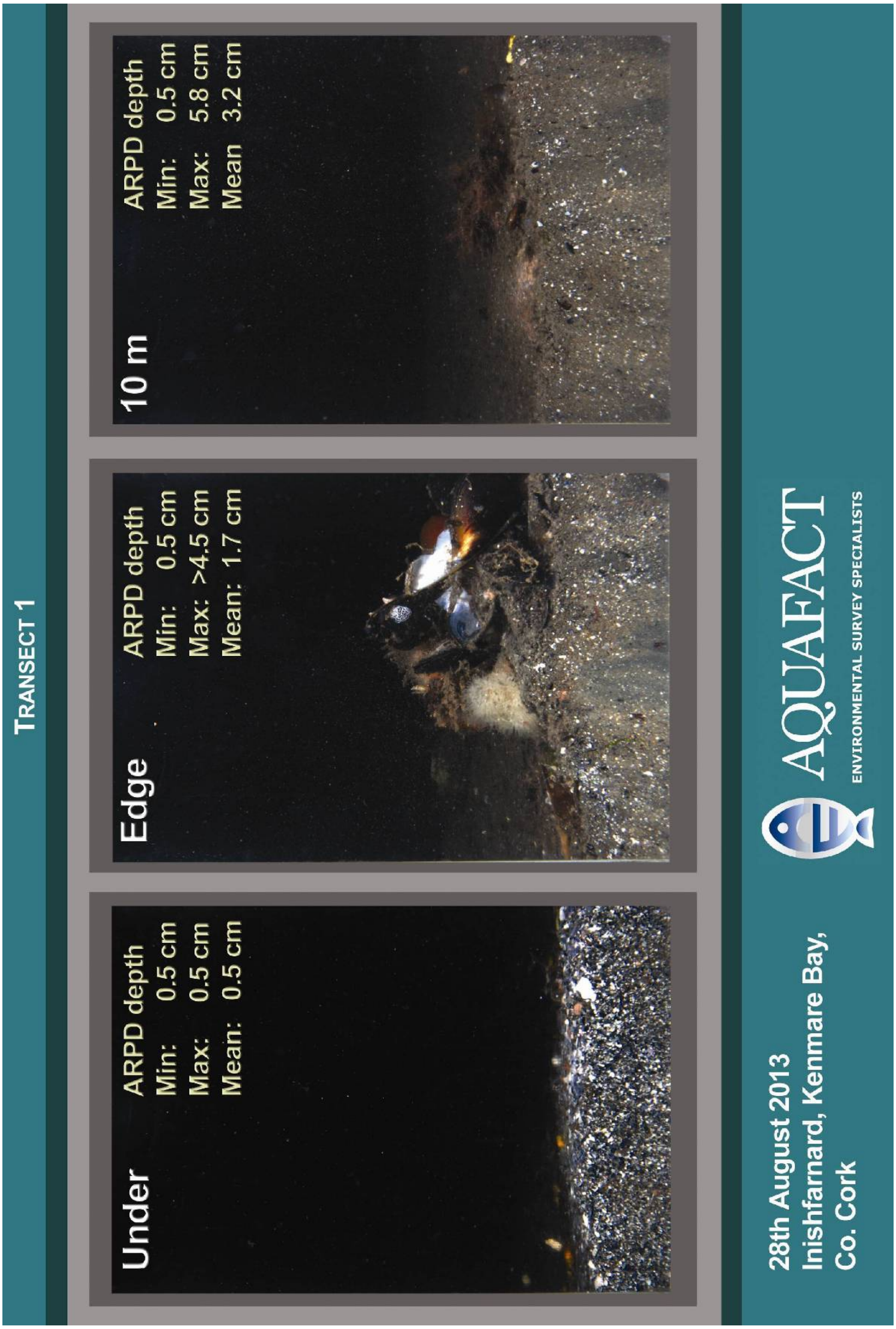
Species recorded included tube anemones (*Cerianthus lloydii*), the parchment tube worm (*Chaetopterus variopedatus*), seaweed (*Phycodrys* sp.) and gobies (*Pomatoschistus* sp.). This station marked the end of Transect 1. Mean ARPD at this site was greater than 2.7cm.

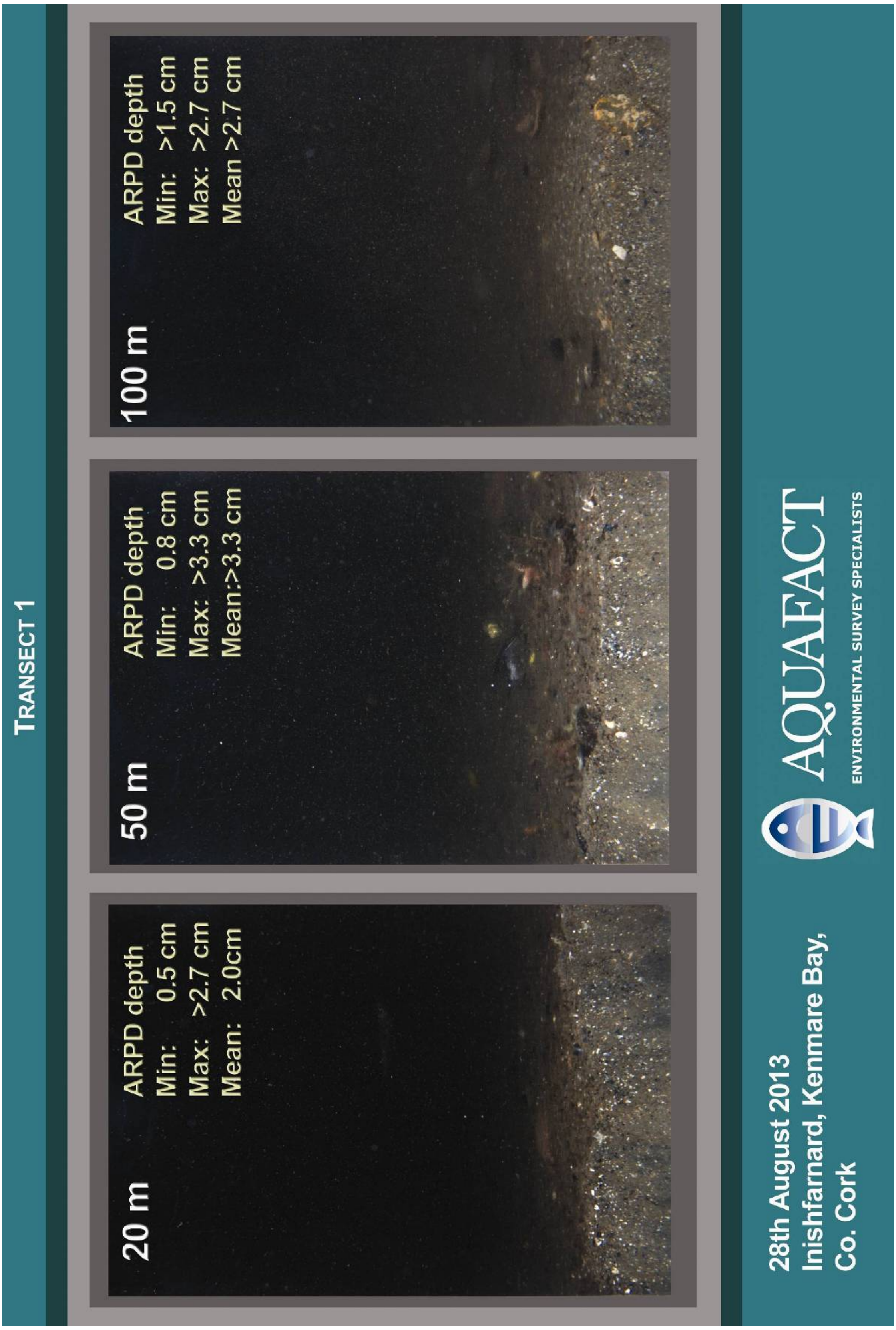
Figure 3.27. T1 – 100m, Inishfarnard site, Kenmare River, 28th August 2013.

3.2.4. Sediment Profile Imagery - Transect 1

The following two plates present sediment profile images taken at the six stations visited on Transect 1 of the Inishfarnard site. They display a single image and the maximum and minimum apparent redox potential discontinuity (ARPD) depths measured at each station. Each image is 15.5cm × 25cm. ARPD depths ranged from a minimum of 0.5cm (T1 Under, T1 Edge, T1 10m and T1 20m) to a maximum of 5.8cm (T1 10m). The composition of sediments at each station can be seen. The variation of the shell fraction in surface sediments can be seen from station to station – increasing with increasing distance from the pens.

On moving away from the pen structures the images show higher levels of oxygenated sediments at depth. In addition the proportion of coarser sands and shell debris increases with distance from the pens and is obvious in the transect images. Polychaetes can be observed at depth at the 20m station and contribute to the increasing ARPD depths from this station outward.


TRANSECT 1
Under
ARPD depth
Min: 0.5 cm
Max: 0.5 cm
Mean: 0.5 cm
Edge
ARPD depth
Min: 0.5 cm
Max: >4.5 cm
Mean: 1.7 cm
10 m
ARPD depth
Min: 0.5 cm
Max: 5.8 cm
Mean 3.2 cm
28th August 2013
Inishfarnard, Kenmare Bay,
Co. Cork
AQUAFACT
ENVIRONMENTAL SURVEY SPECIALISTS


TRANSECT 1
20 m
ARPD depth
Min: 0.5 cm
Max: >2.7 cm
Mean: 2.0cm
50 m
ARPD depth
Min: 0.8 cm
Max: >3.3 cm
Mean:>3.3 cm
100 m
ARPD depth
Min: >1.5 cm
Max: >2.7 cm
Mean >2.7 cm
28th August 2013
Inishfarnard, Kenmare Bay,
Co. Cork
AQUAFACT
ENVIRONMENTAL SURVEY SPECIALISTS

3.2.5. Photographic record - Transect 2

This transect began beneath the same pen as Transect 1 (see Figure 3.29). A total of five stations were investigated on Transect 2 with an additional (Reference) station investigated just over 200m from the pen edge.

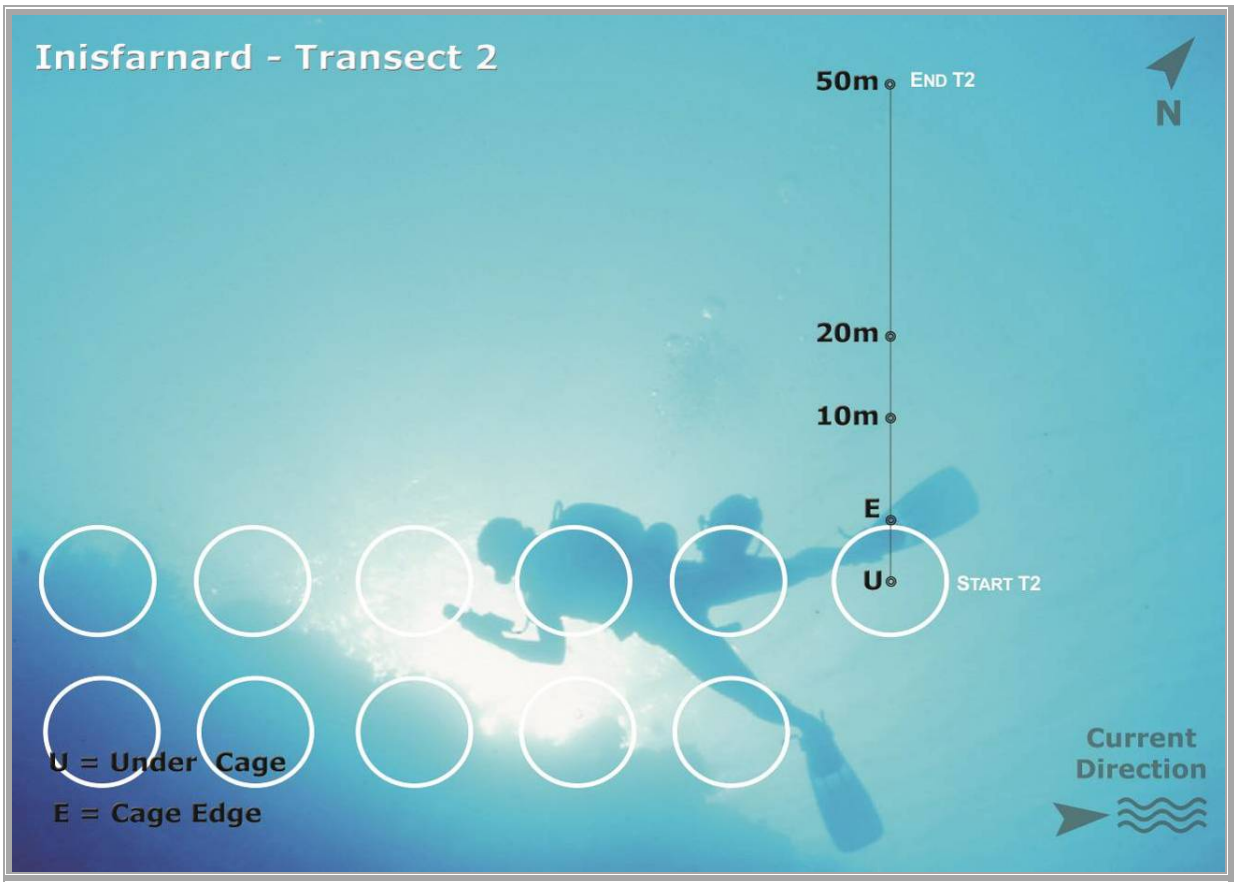


Figure 3.28. Transect 2 seafloor station layout, Inishfarnard site, 28th August 2013.

3.2.5.1. Under Pen Location

This station was located beneath the same pen as the *Under Pen* station on Transect 1. Seafloor conditions are therefore similar. There were some signs on the seafloor that finfish pens were overlying the site:

- Uneaten feed pellets;
- A scattering of faecal casts;
- Spots of *Beggiatoa* spp. overlying the sediment (medium sand); and

- Poor infaunal activity.

Mean ARPD at this site was close to the surface. There were no signs of outgassing at this location.

Figure 3.29. T2 – Under pen, Inishfarnard site, Kenmare River, 28th August 2013.

3.2.5.2. Edge of Pen Location

Medium sand with silt and high organic content. The bottom contained a high proportion of shell and shell debris at this station. There were some obvious signs on the seafloor that finfish pens were overlying the site:

- Some uneaten feed pellets; and
- Spots of *Beggiatoa* spp.

Mean ARPD at this site 0.8cm and there were no signs of outgassing.

Figure 3.30. T2 – Pen edge, Inishfarnard site, Kenmare River, 28th August 2013.

3.2.5.3. 10m from Pen

Medium/coarse sand with some shell gravel. There were some slight signs on the seafloor that finfish pens were close by. The edible crab, *Cancer pagurus* and the starfish *Luidia ciliaris* were recorded as were numerous small tube anemones (*Cerianthus lloydii*).

Mean ARPD was >2.1cm and no signs of outgassing were noted.

Figure 3.31. T2 - 10m, Inishfarnard site, Kenmare River, 28th August 2013.

3.2.5.4. 20m from Pen

Medium/coarse sand with shell gravel with weed debris.

Numerous tube anemones (*Cerianthus lloydii*) were recorded. Mean ARPD was 1.6cm no evidence of outgassing was noted.

Figure 3.32. T2 – 20m, Inishfarnard site, Kenmare River, 28th August 2013.

3.2.5.5. 50m from Pen

The seabed here was composed of medium/coarse sand with shells and a shell gravel fraction. Occasional fragments of drifting algal fronds, parchment worms (*Chaetopterus variopedatus*) and scallops, *Pecten maximus* were noted. Some evidence (grey mounded sediments) of deep burrowing polychaets are noted the image below. Mean ARPD was 1.2cm and no evidence of outgassing was noted.

Figure 3.33. T2 – 50m, Inishfarnard site, Kenmare River, 28th August 2013.

3.2.6. Reference Station

This photograph was taken at a distance of approximately 200m from the pen edge. Sediments at the reference station were composed of medium/coarse sand with shell gravel and occasional cobbles. There were no apparent signs of impact from the nearby finfish rearing operation:

- Seafloor 'clean' and free of feed/faecal material, *Beggiatoa* spp. cover; and
- Presence of 'normal' flora and fauna for this area.

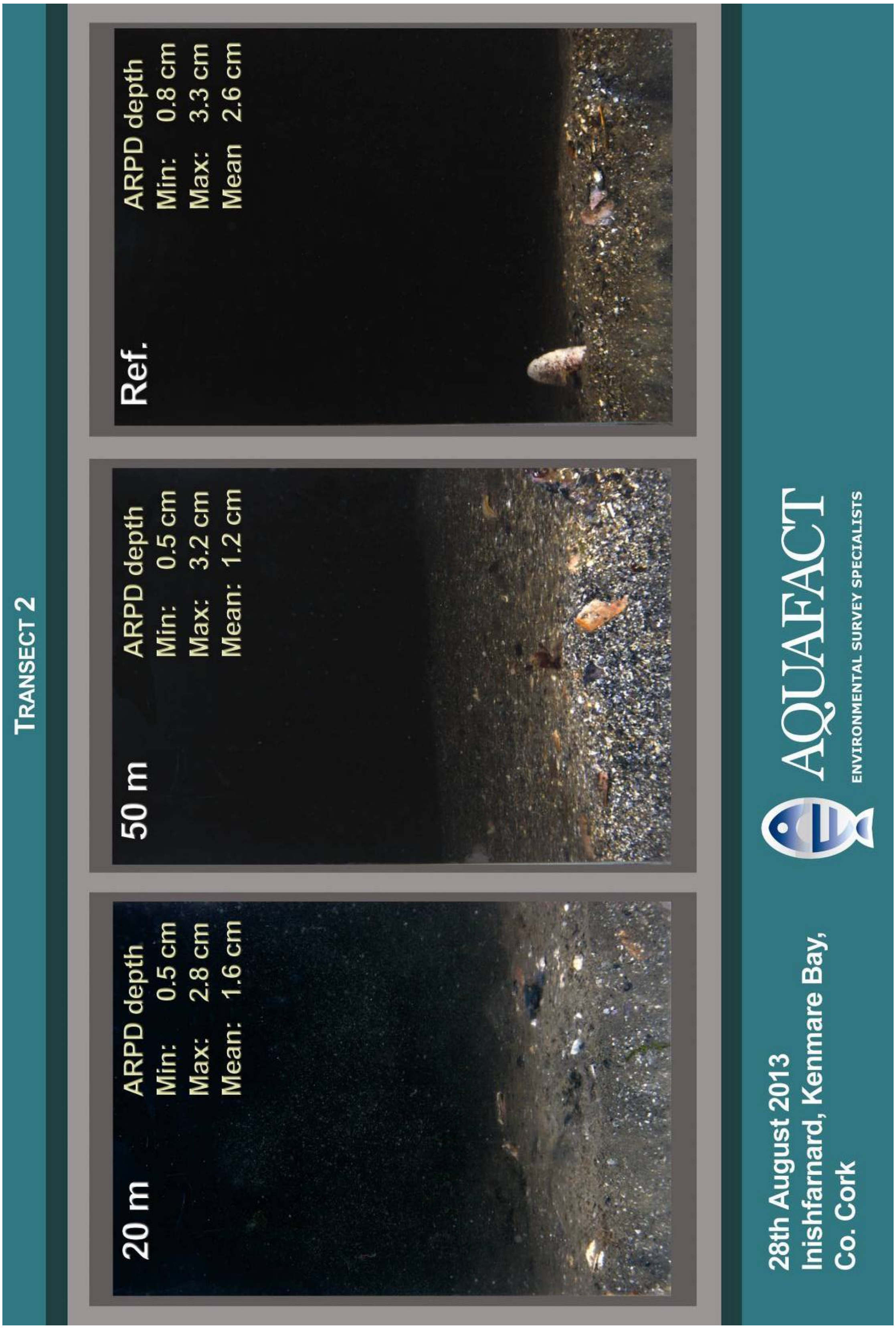
Numerous tube anemones (*Cerianthus lloydii*), parchment worms (*Chaetopterus variopedatus*) and a king scallop *Pecten maximus* were noted. Drifting fragments of algal fronds were recorded. Mean ARPD was 2.6cm.

Figure 3.34. Reference Station, Inishfarnard site, Kenmare River, 28th August 2013.

3.2.7. Sediment Profile Imagery Transect 2 & Reference

The following two plates present sediment profile images taken at the five stations visited on Transect 2 of the Inishfarnard site and the reference station. Due to the hard nature of the seafloor sediments poor sediment penetration was achieved. They display a single image and the maximum and minimum apparent redox potential discontinuity (ARPD) depths measured at each station. Each image is 15.5cm × 25cm. Along Transect 2, ARPD depths ranged from a minimum of 0.5cm (all stations) to a maximum of 3.2cm (T2 50m). ARPD depths ranged from 0.8cm to 3.3cm at the Reference station. The composition of sediments at each station can be seen. The variation of the shell fraction in surface sediments can be seen from station to station – increasing with increasing distance from the pens. Stations close to the pen installation had a fine silt layer at the sediment water interface with evidence of deeper bioturbating species at depth. Images from the edge station show the effect of individual species whereby oxygenated sediments are observed at depth due to the irrigation activity of infaunal species. On moving away from the pens the profile images show the abundance of a coarser fraction of sediments becoming obvious as does the higher reflectance oxygenated sediments at depth.


TRANSECT 2
Under
ARPD depth
Min: 0.5 cm
Max: 0.5 cm
Mean: 0.5 cm
Edge
ARPD depth
Min: 0.5 cm
Max: 1.5 cm
Mean: 0.8 cm
10 m
ARPD depth
Min: 0.5 cm
Max: >2.1 cm
Mean >2.1 cm
28th August 2013
Inishfarnard, Kenmare Bay,
Co. Cork
AQUAFACT
ENVIRONMENTAL SURVEY SPECIALISTS


TRANSECT 2
20 m
ARPD depth
Min: 0.5 cm
Max: 2.8 cm
Mean: 1.6 cm
50 m
ARPD depth
Min: 0.5 cm
Max: 3.2 cm
Mean: 1.2 cm
Ref.
ARPD depth
Min: 0.8 cm
Max: 3.3 cm
Mean 2.6 cm
28th August 2013
Inishfarnard, Kenmare Bay,
Co. Cork
AQUAFACT
ENVIRONMENTAL SURVEY SPECIALISTS

3.2.8. Transect Species List

Table 3.4 gives the species recorded during the dive survey at the Inishfarnard fish farm site on the 28th August 2013.

Table 3.4: Species recorded during the dive at the Inishfarnard fish farm site.

Group	Species	Common Name
(Cnidaria) Hexacorallia	*Cerianthus lloydii*	Tube anemone
(Annelida) Polychaeta	*Pomatoceros* sp. *Chaetopterus variopedatus*	Tube worm Parchment tube worm
(Arthropoda) Decapoda	*Cancer pagurus* *Carcinas maenas*	Edible crab
Echinodermata	*Luidia ciliaris* *Asterias rubens* *Amphiuridae sp.* *Marthasterias glacialis*	Seven armed starfish Common starfish Brittlestar
(Chordata) Osteiichthyes	*Pomatoschistus* sp. Scyliorhinus canicula	Gobies Dog fish
Rhodophyta	*Phycodrys sp.*	Sea oak

3.2.9. Benthic Macrofaunal Analysis

The taxonomic identification of the benthic infauna across all 11 stations sampled at the Inishfarnard fish farm site yielded a total count of 146 taxa accounting for 16,788 individuals, ascribed to 9 phyla. A complete listing of the taxa abundance is provided in Appendix 1. Of the 146 taxa present, 79 were identified to species level, the remaining 67 could not be identified to species level as they were juvenile, partial/damaged or indeterminate.

Of the 146 taxa enumerated, 57 were annelids (segmented worms), 29 were crustaceans (crabs, shrimps, prawns), 45 were molluscs (mussels, cockles, snails etc.), 10 were echinoderms (starfish, brittlestars, sea cucumbers), 2 were cnidarians (sea anemones, corals, jellyfish etc), 1 was a nemertean (ribbon worms), 1 was a nematoda (round worms) and 1 was a platyhelminthean (flat worm).

3.2.9.1. Univariate Analysis

Univariate statistical analyses were carried out on the combined replicate station-by-station faunal data. The following parameters were calculated and can be seen in Table 3.5; taxon numbers, number of individuals, richness, evenness and diversity. Taxon numbers ranged from 12 (T2 50m) to 55 (T2 20m). Numbers of individuals ranged from 79 (T2 50m) to 6,556 (T1 Under). Richness ranged from 1.7 (T2 Edge) to 8.91 (T1 100m). Evenness ranged from 0.24 (T1 Under) to 0.86 (REF). Diversity ranged from 1.05 (T2 Edge) to 4.60 (REF).

Table 3.5: Diversity indices.

Station	No. Taxa	No. Individuals	Richness	Evenness	Diversity
T1 Under	24	6556	2.62	0.24	1.09
T1 Edge	24	1624	3.11	0.41	1.89
T1 10m	26	1867	3.32	0.32	1.49
T1 20m	32	812	4.63	0.33	1.63
T1 50m	47	308	8.03	0.76	4.25
T1 100m	46	156	8.91	0.81	4.45
T2 Edge	15	3772	1.70	0.27	1.05
T2 10m	30	843	4.30	0.38	1.89
T2 20m	55	657	8.32	0.63	3.65
T2 50m	12	79	2.52	0.58	2.08
REF	40	114	8.23	0.86	4.60

3.2.9.2. Multivariate analysis

The dendrogram and the MDS plot can be seen in Figures 3.35 and 3.36respectively. The stress value of the MDS is 0.05 which indicates an excellent representation of the data with no prospect for misinterpretation. SIMPROF analysis revealed 5 statistically significant groupings between the 11 stations (the stations joined by red lines could not be statistically differentiated from each other).

The T2 50m station grouped alone (**Group a**) and separated away from all other stations at a similarity level of 20.77%. This station had the lowest faunal returns and richness and diversity were relatively low. This station contained 12 species (8 of which were present twice or less) comprising 79 individuals. Two

species accounted for *c.* 76% of the faunal abundance: the amphipod crustacean *Photis longicaudata* (49 individuals, 62.1%) and Nematoda (11 individuals, 13.9%). *Photis longicaudata* is a species very sensitive to organic enrichment and present under unpolluted conditions. Nematoda are tolerant to excess organic matter enrichment. These species may occur under normal conditions but their populations are stimulated by organic enrichment.

The Reference station also grouped alone (**Group b**), separating from the remaining stations at a similarity level of 21.71%. This station had relatively high levels of richness and diversity. This station contained 40 species (27 of which were present twice or less) comprising 114 individuals. Five species accounted for *c.* 45% of the faunal abundance: the bivalve mollusc *Kurtiella bidentata* (21 individuals, 18.4%), Nematoda (10 individuals, 8.8%) and the polychaetes *Pholoe baltica* (10 individuals, 8.8%), *Lumbrineris cf cingulata* (6individuals, 5.3%) and Lumbrineridae (5 individuals, 4.4%). *Pholoe baltica* is a species very sensitive to organic enrichment and present under unpolluted conditions. *Kurtiella bidentata* and Nematoda are tolerant to excess organic matter enrichment. These species may occur under normal conditions but their populations are stimulated by organic enrichment. *Lumbrineris cingulata* is a species indifferent to enrichment, always present in low densities with non-significant variations over time.

The remaining stations joined at a similarity level of 32.39%. Amongst these stations, 3 groups formed. **Group c** contained station T1 Under only. This group joined **Group d** at a similarity level of 48.15%. **Group c** contained 24 species (13 of which were present twice or less) comprising 6,556 individuals. Due to the superabundance of just one species at this station, diversity, evenness and richness were low. Two species accounted for just over 90% of the faunal abundance: Nematoda (5,226 individuals, 79.7%) and the polychaete *Malacoceros* sp. (711 individuals, 10.9%). Both of these species are tolerant to excess organic matter enrichment. These species may occur under normal conditions but their populations are stimulated by organic enrichment.

Group d contained stations T1 Edge, T2 Edge, T1 10m and T2 10m. This group had an average within group similarity of 54.82%. Diversity and richness were relatively low for this group. This group contained 52 species (33 of which were present twice or less) comprising 8,106 individuals. Three species accounted for *c.* 92% of the faunal abundance: Nematoda (4,617 individuals, 56.96%) and the polychaetes *Capitella* sp. complex (2,415 individuals, 29.8%) and *Malacoceros* sp. (461 individuals,

5.7%). Nematoda and *Malacoceros* sp. are species tolerant to excess organic matter enrichment. These species may occur under normal conditions but their populations are stimulated by organic enrichment. *Capitella* sp. complex is a first order opportunist which proliferate in reduced sediments.

Group e separated from Groups c and d at a 32.39% similarity level. Group e contained 4 stations: T1 20m, T1 50m, T1 100m and T2 20m. These stations had relatively high richness and diversity. This group contained 102 species (59 of which were present twice or less) comprising 1,933 individuals. Three species accounted for *c.* 61% of the faunal abundance: Nematoda (684 individuals, 35.4%) and the polychaetes *Capitella* sp. complex (281 individuals, 14.5%) and *Mediomastus fragilis* (217 individuals, 11.2%). Nematoda are species tolerant to excess organic matter enrichment. These species may occur under normal conditions but their populations are stimulated by organic enrichment. *Capitella* sp. complex is a first order opportunist which proliferate sin reduced sediments. *Mediomastus fragilis* is a second order opportunist.

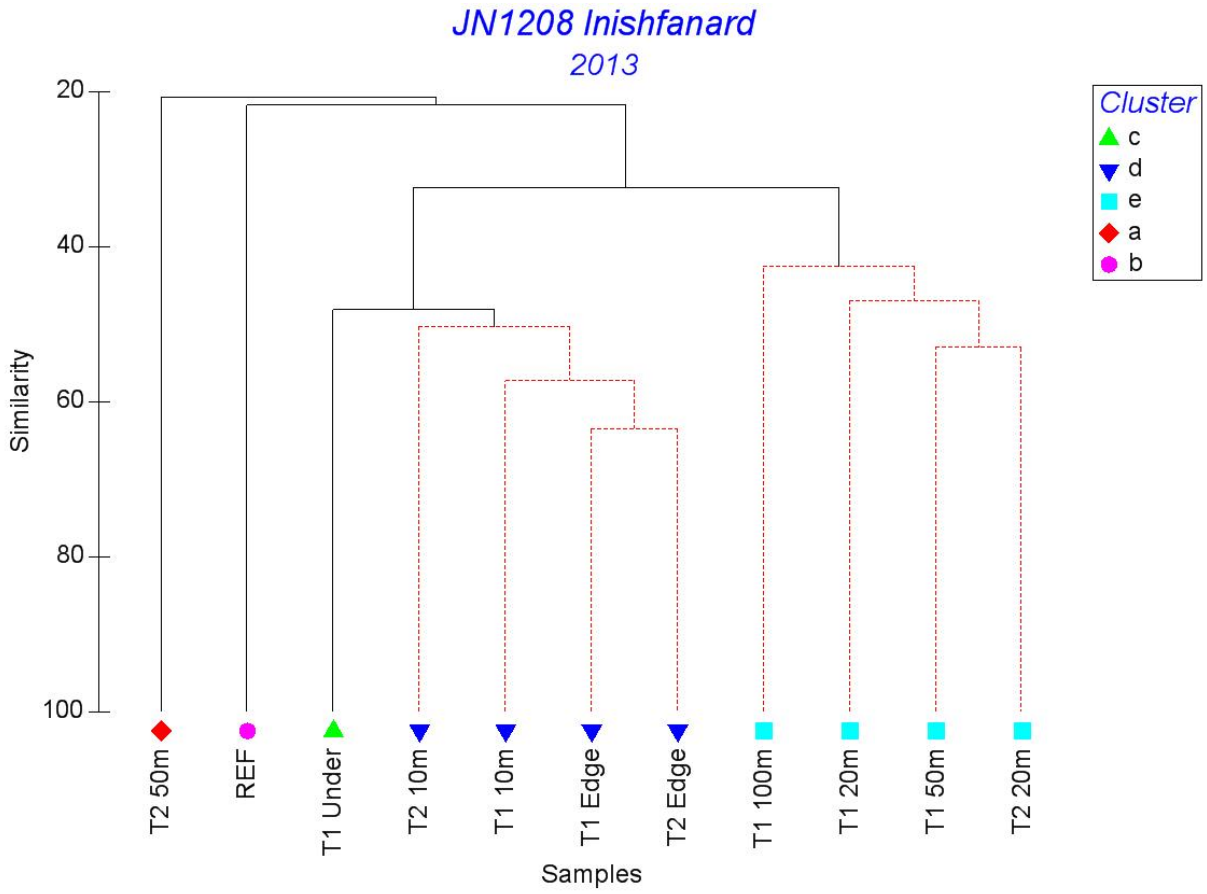


Figure 3.35: Dendrogram produced from Cluster analysis.

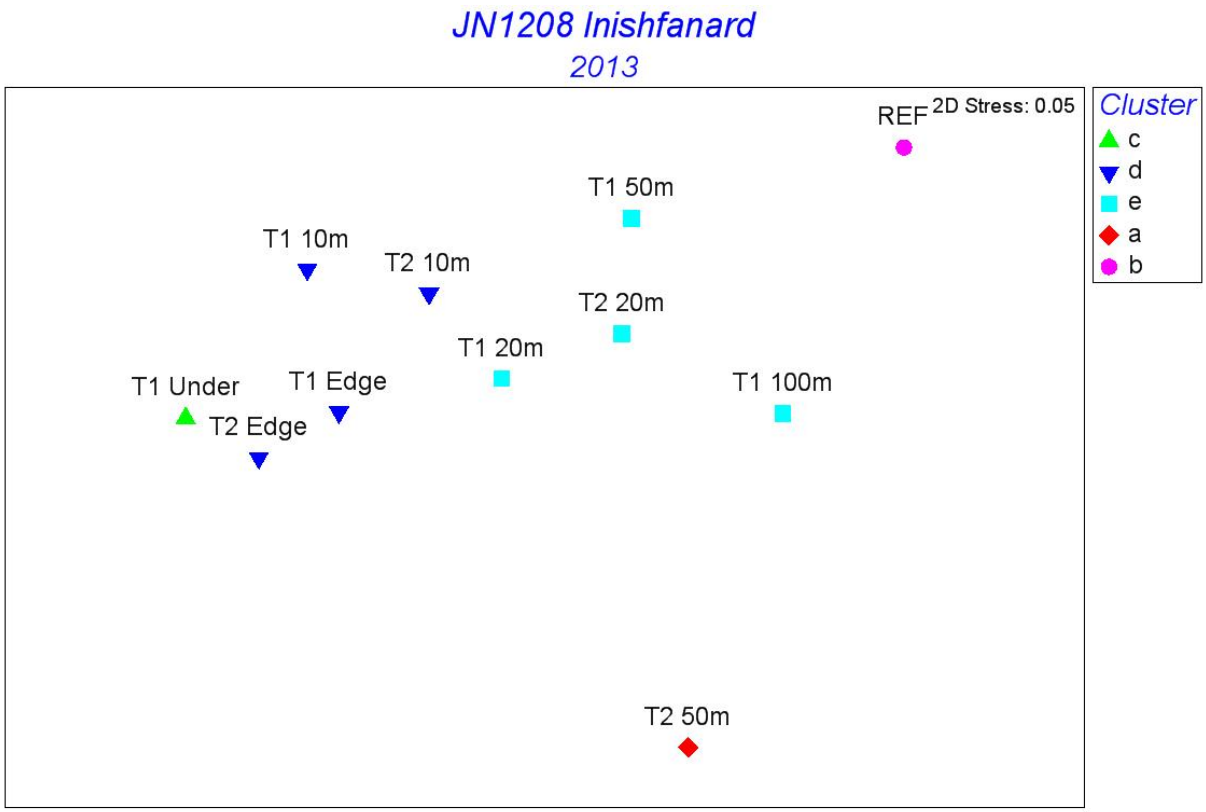


Figure 3.36: MDS plot.

3.2.10. Organic Carbon Analysis & ARPD Depths

Table 3.6 shows the organic carbon results from the Inishfarnard stations. Organic carbon levels ranged from 3.2% (REF) to 11.54 (T2 Edge). Table 3.7 shows in tabular form the ARPD depths from the SPI images from Inishfarnard (see Sections 3.2.4 and 3.2.7).

Table 3.6: Organic carbon results for Inishfarnard (% values, Loss on Ignition at 450°C).

T1	**Under**	**Edge**	**10m**	**20m**	**50m**	**100m**
LOI %	10.29	11.22	10.57	9.78	8.63	5.55
T2	**Under**	**Edge**	**10m**	**20m**	**50m**	**REF**
LOI %	-	11.54	11.53	8.57	5.5	3.2

Table 3.7: ARPD Depths for Inishfarnard, Kenmare Bay, 28th August 2013

Station		Transect 1	Transect 2
Under	Range (cm)	0.5-0.5	0.5-0.5
	Mean (cm)	0.5	0.5
Edge	Range (cm)	0.5->4.5	0.5-1.5
	Mean (cm)	1.7	0.8
10m	Range (cm)	0.5-5.8	0.5->2.1
	Mean (cm)	3.2	>2.1
20m	Range (cm)	0.5->2.7	0.5-2.8
	Mean (cm)	2	1.6
50m	Range (cm)	0.8->3.3	0.5-3.2
	Mean (cm)	>3.3	1.2
100m	Range (cm)	>1.5->2.7	-
	Mean (cm)	>2.7	-
Reference	Range (cm)	-	0.8-3.3
	Mean (cm)	-	2.6

4. Discussion

The extent to which an overlying fish farm impacts the seafloor is largely dependent on:

- the feeding regime at that farm, i.e. the amount of food that eventually ends up on the seafloor;
- the degree of current movement at the site in question; and
- the depth of water at that site.

These factors combine to form either erosional or depositional locations where organic material is either dispersed or accumulates, and subsequently affects the receiving environment, in this case the seafloor. The type of animal community living at a particular site will also play a role in determining bottom conditions there. The influence of feeding activities of populations of starfish, polychaete worms, anemones, crabs and finfish at the Deenish and Inishfarnard sites largely determine the level of impact of overlying farm operations on the benthos there.

Faunal feeding activity can remove large amounts of waste organic material from the seabed beneath a farm facility – with groups of mobile fauna capable of consuming large quantities of material. The fallowing schedule at a site also has a large bearing on benthic impact – most notably the length of time pens have been on site since the last fallow period. The presence of opportunistic deposit feeders such as *Capitella* sp., most notably at the under pen and pen edge stations will tend to help keep the benthic organics in a state of equilibrium at the fish farm sites. Sedimentary organic carbon levels in general are relatively higher at the under and edge of pen conditions and ranging 1.56 to 6.68% at the Dinish site and from 3.2% to 11.54% at the Inishfarnard site.

Mobile epibenthic scavengers such as starfish, fish and crabs also help in reducing the amount of waste material on the seafloor. This potential speed of the removal of waste was demonstrated in a previous study where photographic evidence was collected showing that epibenthic macrofauna were capable of removing, in less than 7 days, fish feed pellets spread at a density of 3.4kg dry weight per m^2 on the sediment under a marine fish farm (Smith *et al.*, 1997). The site at both Inishfarnard and Dinish had high numbers of mobile species such as starfish, crabs and fish.

Results from previous years surveys of the seafloor beneath the Inishfarnard and Deenish Island pen blocks indicated little change year on year on and showed few obvious signs of impact. In general the surface appearance of the seafloor was devoid of any indication of the overlying pens beyond the 10m-20m stations.

Based on the benthic photographic records taken during the current surveys, little habitat degradation is obvious beyond the 10m station on both transects at the Deenish site and beyond the 20m station on both transects at the Inishfarnard site.

Detailed faunal analysis of grab and core samples at Inishfarnard showed a clear statistical divide of 5 groups between the stations surveyed. In general the stations closest to the pens group c and d, had the lowest number of species but high numbers of individuals i.e. Group c had 24 species and 6,556 individuals. Due to the superabundance of just one species at this station, diversity, evenness and richness were low. Two species accounted for just over 90% of the faunal abundance: Nematoda (5,226 individuals, 79.7%) and the polychaete *Malacoceros* sp. (711 individuals, 10.9%). Both of these species are tolerant to excess organic matter enrichment. These species may occur under normal conditions but their populations are stimulated by organic enrichment.

In general stations further away from the sea pens had higher species richness and diversity. Species recorded in these locations occur under normal conditions but their populations are often stimulated by organic enrichment and result in higher biomass than would otherwise be recorded.

The Reference station separated from the remaining stations in the grouping matrix at a similarity level of 21.71%. This station had relatively high levels of richness and diversity. This station contained 40 species (27 of which were present twice or less) comprising 114 individuals and represents a relatively mature stable community.

5. Conclusion

Benthic audit surveys were carried out at the Deenish and Inishfarnard fish farm sites operated by Marine Harvest Ireland. on 28th August 2013. The Deenish survey followed the DCMNR Level I monitoring protocols and the Inisfarnard survey followed the DCMNR Level II monitoring protocols. In the present surveys beneath the pen blocks there were some obvious signs of impact from the farming operation on the benthos:

- Some waste feed/faecal material (and bacterial mat) was present within the 10m station at both Inishfarnard and at the Deenish farm sites;
- Organic carbon levels were elevated at the under and edge stations; and
- Species composition in the under pen locations were reflective of organic enrichment.

Diver observations at the Deenish site showed a clear divide between the stations closest to the pen and those furthest away. The images indicate that any significant impacts of the fish farm extend to less than 10m from the pen installations.

Detailed faunal analysis at the Inishfarnard site show that the impacts of the fish farm extend at least 20m but less than 50m from the pen on both transects.

Based on the results of the dive survey no major signs of impact were readily appreciable beyond the 10m stations on all transects – no waste feed or faecal material was noted, ARPD depths were good beyond the pen edge stations and no bacterial mat or outgassing was recorded. Results of the detailed analysis of benthic fauna showed that the impact of the fish farm was limited to approximately 20m from the pens at the Inishfarnard site.

The good benthic conditions at Inishfarnard can largely be attributed to:

- the favourable hydrographic conditions at the sites;
- the relatively low stocking densities and tonnages held in the pens;
- the feeding activities of benthic fauna; and
- good animal husbandry practice.

6. References

Department of Agriculture, Fisheries and Food. 2008. Monitoring Protocol No. 1 Offshore Finfish Farms – Benthic Monitoring – revised December 2008.

Buchanan, J.B. (1984). Sediment analysis. In: (eds.) Holme N. A. and A.D. McIntyre. Methods for the study of marine benthos 2nd ed. Blackwell, Oxford. pp. 41-65.

Clarke, K.R. and R.M. Warwick (1994). Changes in marine communities: An approach to statistical analysis and interpretation, 1st Edition. Plymouth Marine Laboratory. Plymouth.

Clarke, K.R. and R.M. Warwick (2001). Changes in marine communities: An approach to statistical analysis and interpretation. 2nd Edition. Primer-E Ltd.

Kruskall, J.B. and M. Wish (1978). Multidimensional scaling. *Sage Publications, Beverly Hills, California.*

Margalef, DR. (1958). Information theory in ecology. General Systems 3: 36-71.

Pielou, E.C. (1977). Mathematical ecology. Wiley-Water science Publication, John Wiley and Sons. pp.385.

Smith, P., G. Edwards, B. O'Connor, M. Costelloe and J. Costelloe. 1997. Photographic Evidence of the importance of Macrofauna in the Removal of Feed Pellets from the Sediment Under Marine Salmon Farms. Bull. Eur. Ass. Fish Pathol. Vol. 17, Issue 1, pages 23-26

Appendix 1

Faunal Grab Species List – Inishfarnard

Station			T1 Under	T1 Edge	T1 10m	T1 20m	T1 50m	T1 100m	T2 Edge	T2 10m	T2 20m	T2 50m	REF
CNIDARIA	D	1	0	0	0	0	0	0	0	0	0	0	0
ANTHOZOA	D	583	0	0	0	0	0	0	0	0	0	0	0
HEXACORALLIA	D	627	0	0	0	0	0	0	0	0	0	0	0
CERIANTHARIA	D	628	0	0	0	0	0	0	0	0	0	0	0
Cerianthidae	D	630	0	0	0	0	0	0	0	0	0	0	0
Cerianthus lloydii	D	632	0	0	0	0	1	0	0	0	0	0	0
ACTINIARIA	D	662	0	0	0	0	0	0	0	0	0	0	0
Edwardsiidae	D	759	0	0	0	0	0	0	0	0	0	0	0
Edwardsiidae	D	759	0	0	0	7	21	1	0	1	5	0	0
PLATYHELMINTHES	F	1	0	0	0	0	0	0	0	0	0	0	0
TURBELLARIA	F	2	0	0	0	0	0	0	0	0	0	0	0
Turbellaria	F	2	0	0	0	0	0	0	0	1	0	0	0
NEMATODA	HD	1	0	0	0	0	0	0	0	0	0	0	0
Nematoda	HD	1	5226	551	1047	598	17	21	3000	19	48	11	10
NEMERTEA	G	1	0	0	0	0	0	0	0	0	0	0	0
Nemertea	G	1	0	0	0	1	4	0	0	0	2	0	1
SIPUNCULA	N	1	0	0	0	0	0	0	0	0	0	0	0
SIPUNCULIDEA	N	2	0	0	0	0	0	0	0	0	0	0	0
GOLFINGIIFORMES	N	10	0	0	0	0	0	0	0	0	0	0	0
Phascolionidae	N	29	0	0	0	0	0	0	0	0	0	0	0
Phascolion (Phascolion) strombus strombus	N	34	0	0	0	0	1	0	0	0	0	0	0
ANNELIDA	P	1	0	0	0	0	0	0	0	0	0	0	0
POLYCHAETA	P	2	0	0	0	0	0	0	0	0	0	0	0
PHYLLODOCIDA	P	3	0	0	0	0	0	0	0	0	0	0	0
Polynoidae	P	25	0	0	0	0	0	0	0	0	0	0	0
Polynoidae	P	25	0	0	0	0	1	1	0	0	1	0	0
Pholoidae	P	90	0	0	0	0	0	0	0	0	0	0	0
Pholoe sp.	P	91	0	0	0	0	2	1	0	0	0	0	2
Pholoe inornata	P	92	0	0	0	0	1	1	0	0	0	0	0
Pholoe baltica (sensu Petersen)	P	95	0	0	0	0	4	9	0	0	5	0	10
Phyllodocidae	P	114	0	0	0	0	0	0	0	0	0	0	0

Station			T1 Under	T1 Edge	T1 10m	T1 20m	T1 50m	T1 100m	T2 Edge	T2 10m	T2 20m	T2 50m	REF
Phyllodocidae	P	114	0	0	0	1	0	1	0	1	1	0	0
Eteone longa aggregate	P	118	0	0	1	4	10	4	0	8	4	0	0
Phyllodoce mucosa	P	145	1	1	2	4	4	0	0	3	0	0	1
Paranaitis kosteriensis	P	176	0	0	0	0	0	0	0	1	1	0	0
Glyceridae	P	254	0	0	0	0	0	0	0	0	0	0	0
Glycera sp.	P	255	0	0	0	3	4	3	0	0	3	0	1
Glycera fallax	P		0	0	0	0	1	0	0	0	0	0	0
Glycera lapidum agg.	P	260	0	0	0	0	0	0	0	0	1	0	0
Goniadidae	P	266	0	0	0	0	0	0	0	0	0	0	0
Goniada maculata	P	271	0	0	0	0	0	0	0	0	1	0	0
Hesionidae	P	293	0	0	0	0	0	0	0	0	0	0	0
Syllidia armata	P	321	0	0	0	0	0	0	0	0	0	1	0
Syllidae	P	346	0	0	0	0	0	0	0	0	0	0	0
Syllidae	P	346	0	0	0	0	0	1	0	0	0	0	0
Syllis cornuta	P	349	0	0	0	0	2	0	0	2	0	0	0
Syllis sp.	P	358	0	0	0	0	0	1	0	0	0	0	0
Syllis pontxioi	P		0	0	0	0	0	0	0	0	2	0	0
Syllis garciai	P		0	0	0	0	3	0	0	0	3	0	0
Nereididae	P	458	0	0	0	0	0	0	0	0	0	0	0
Nereididae	P	458	0	1	2	1	0	0	0	0	0	0	0
Platynereis dumerilii	P	482	0	0	0	0	0	0	0	0	0	2	0
Nephtyidae	P	490	0	0	0	0	0	0	0	0	0	0	0
Nephtys sp.	P	494	0	0	0	0	1	2	0	0	1	0	1
EUNICIDA	P	536	0	0	0	0	0	0	0	0	0	0	0
Lumbrineridae	P	569	0	0	0	0	0	0	0	0	0	0	0
Lumbrineridae	P	569	0	0	0	0	0	0	0	0	0	0	5
Lumbrineris cf cingulata	P		0	0	0	2	2	1	0	0	0	0	6
Dorvilleidae	P	598	0	0	0	0	0	0	0	0	0	0	0
Protodorvillea kefersteini	P	638	1	2	3	2	24	0	0	8	14	0	0
ORBINIIDA	P	654	0	0	0	0	0	0	0	0	0	0	0
Paraonidae	P	674	0	0	0	0	0	0	0	0	0	0	0
Aricidea (Acmira) cerrutii	P	685	0	0	0	0	0	0	0	0	1	0	0
Paradoneis lyra	P	699	0	0	0	0	0	1	0	0	0	0	0

Station			T1 Under	T1 Edge	T1 10m	T1 20m	T1 50m	T1 100m	T2 Edge	T2 10m	T2 20m	T2 50m	REF
SPIONIDA	P	707	0	0	0	0	0	0	0	0	0	0	0
Spionidae	P	720	0	0	0	0	0	0	0	0	0	0	0
Spionidae	P	720	0	0	29	0	3	0	0	3	0	0	1
Aonides sp.	P	721	0	0	2	0	4	0	0	0	1	0	0
Malacoceros sp.	P	736	711	50	6	0	1	0	374	31	2	0	0
Malacoceros fuliginosus	P	737	0	0	0	0	0	0	2	0	0	0	0
Prionospio sp.	P	763	0	0	0	0	0	0	0	0	0	0	3
Magelonidae	P	802	0	0	0	0	0	0	0	0	0	0	0
Magelona minuta	P	806	0	0	0	0	0	0	0	0	0	0	1
Cirratulidae	P	822	0	0	0	0	0	0	0	0	0	0	0
Cirratulidae	P	822	0	17	33	0	7	0	3	6	3	0	2
Caulleriella alata	P	829	0	0	0	0	0	0	0	0	5	0	0
Chaetozone christiei	P		0	0	0	0	0	0	0	0	0	0	1
Cirriformia tentaculata	P	839	5	0	0	0	0	0	0	0	0	0	0
FLABELLIGERIDA	P	872	0	0	0	0	0	0	0	0	0	0	0
Flabelligeridae	P	873	0	0	0	0	0	0	0	0	0	0	0
Diplocirrus stopbowitzi	P		0	0	0	0	0	1	0	0	0	0	0
CAPITELLIDA	P	902	0	0	0	0	0	0	0	0	0	0	0
Capitellidae	P	903	0	0	0	0	0	0	0	0	0	0	0
Capitella sp. complex	P	906	151	803	690	101	3	8	328	594	169	3	0
Mediomastus fragilis	P	919	0	3	0	4	70	7	0	64	136	1	0
OPHELIIDA	P	992	0	0	0	0	0	0	0	0	0	0	0
Opheliidae	P	993	0	0	0	0	0	0	0	0	0	0	0
Polyophthalmus pictus	P	1019	0	0	0	0	0	0	0	1	0	0	0
Scalibregmatidae	P	1020	0	0	0	0	0	0	0	0	0	0	0
Scalibregma celticum	P	1026	0	0	0	0	0	1	0	0	0	0	0
Scalibregma inflatum	P	1027	0	0	0	0	1	2	0	0	0	0	5
OWENIIDA	P	1089	0	0	0	0	0	0	0	0	0	0	0
Oweniidae	P	1090	0	0	0	0	0	0	0	0	0	0	0
Galathowenia oculata	P	1093	0	0	0	0	0	0	0	0	0	0	2
Owenia fusiformis	P	1098	0	0	0	0	0	0	0	0	0	0	5
TEREBELLIDA	P	1099	0	0	0	0	0	0	0	0	0	0	0
Pectinariidae	P	1100	0	0	0	0	0	0	0	0	0	0	0

Station			T1 Under	T1 Edge	T1 10m	T1 20m	T1 50m	T1 100m	T2 Edge	T2 10m	T2 20m	T2 50m	REF
Pectinariidae	P	1100	0	0	0	1	4	3	0	2	15	0	5
Pectinaria (Amphictene) auricoma	P	1102	0	0	0	0	2	0	0	0	1	0	1
Lagis koreni	P	1107	0	0	1	0	1	1	0	2	3	0	1
Ampharetidae	P	1118	0	0	0	0	0	0	0	0	0	0	0
Ampharetidae	P	1118	0	0	0	0	1	0	0	0	0	0	1
Terebellidae	P	1179	0	0	0	0	0	0	0	0	0	0	0
Terebellidae	P	1179	0	0	0	0	3	5	0	0	3	0	0
Lanice conchilega	P	1195	0	0	0	0	0	0	0	0	1	0	0
Pista sp.	P	1216	0	0	0	0	0	0	0	0	2	0	0
Polycirrus sp.	P	1235	0	0	0	0	0	0	0	0	2	0	0
SABELLIDA	P	1256	0	0	0	0	0	0	0	0	0	0	0
Sabellidae	P	1257	0	0	0	0	0	0	0	0	0	0	0
Sabellidae	P	1257	0	0	0	0	0	2	0	0	0	0	0
Serpulidae	P	1324	0	0	0	0	0	0	0	0	0	0	0
Serpulidae	P	1324	0	0	0	0	0	1	0	0	0	0	0
Hydroides norvegica	P	1334	0	0	0	0	0	1	0	0	1	2	0
Pomatoceros sp.	P	1339	0	0	1	0	0	0	0	0	0	0	0
Pomatoceros lamarcki	P	1340	0	0	0	0	0	0	0	0	1	2	0
OLIGOCHAETA	P	1402	0	0	0	0	0	0	0	0	0	0	0
TUBIFICIDA	P	1403	0	0	0	0	0	0	0	0	0	0	0
Naididae	P	1405	0	0	0	0	0	0	0	0	0	0	0
Tubificidae	P	1425	0	0	0	0	0	0	0	0	0	0	0
Tubificoides benedii	P	1490	1	0	13	5	14	0	2	1	2	0	0
CRUSTACEA	R	1	0	0	0	0	0	0	0	0	0	0	0
COPEPODA	R	142	0	0	0	0	0	0	0	0	0	0	0
HARPACTICOIDA	R	785	0	0	0	0	0	0	0	0	0	0	0
Miraciidae	R	1144	0	0	0	0	0	0	0	0	0	0	0
Bulbamphiasus imus	R	1179	0	0	0	0	0	0	0	0	1	0	0
MALACOSTRACA	S	1	0	0	0	0	0	0	0	0	0	0	0
LEPTOSTRACA	S	3	0	0	0	0	0	0	0	0	0	0	0
Nebaliidae	S	4	0	0	0	0	0	0	0	0	0	0	0
Nebalia sp.	S		0	5	1	0	0	0	2	0	0	0	0

Station			T1 Under	T1 Edge	T1 10m	T1 20m	T1 50m	T1 100m	T2 Edge	T2 10m	T2 20m	T2 50m	REF
EUMALACOSTRACA	S	23	0	0	0	0	0	0	0	0	0	0	0
AMPHIPODA	S	97	0	0	0	0	0	0	0	0	0	0	0
Urothoidae	S	245	0	0	0	0	0	0	0	0	0	0	0
Urothoe sp.	S	246	0	0	0	0	0	0	0	1	0	0	0
Lysianassidae	S	271	0	0	0	0	0	0	0	0	0	0	0
Lysianassidae	S	271	1	0	0	0	0	0	0	0	0	0	0
Tryphosella sp.	S	341	1	0	0	0	0	0	0	0	0	0	0
Ampeliscidae	S	422	0	0	0	0	0	0	0	0	0	0	0
Ampelisca sp.	S	423	0	0	0	0	0	2	0	0	1	0	0
Ampelisca brevicornis	S	427	0	0	0	0	1	0	0	0	0	0	1
Ampelisca typica	S	442	0	0	0	0	0	1	0	0	0	0	0
Pontoporeiidae	S	450	0	0	0	0	0	0	0	0	0	0	0
Bathyporeia sp.	S	451	0	0	0	0	0	0	0	0	0	0	1
Photidae	S		0	0	0	0	0	0	0	0	0	0	0
Photis sp.	S	551	0	0	0	0	0	2	0	0	0	0	0
Photis longicaudata	S	552	0	1	0	2	30	6	1	0	6	49	0
Caprellidae	S	639	0	0	0	0	0	0	0	0	0	0	0
Pariambus typicus	S	651	0	0	0	0	0	0	0	0	0	0	1
ISOPODA	S	790	0	0	0	0	0	0	0	0	0	0	0
Cirolanidae	S	841	0	0	0	0	0	0	0	0	0	0	0
Conilera cylindracea	S	849	0	0	0	0	0	2	0	0	0	0	0
TANAIDACEA	S	1099	0	0	0	0	0	0	0	0	0	0	0
Anarthruidae	S	1115	0	0	0	0	0	0	0	0	0	0	0
Tanaopsis graciloides	S	1142	0	0	0	0	0	18	0	0	56	1	3
CUMACEA	S	1183	0	0	0	0	0	0	0	0	0	0	0
Nannastacidae	S	1214	0	0	0	0	0	0	0	0	0	0	0
Campylaspis legendrei	S	1218	0	0	0	0	0	1	0	0	0	0	0
Diastylidae	S	1244	0	0	0	0	0	0	0	0	0	0	0
Diastylis sp.	S	1224	0	0	0	0	0	0	0	0	0	0	1
Diastylis rugosa	S	1254	0	0	0	1	0	0	0	0	1	0	0
DECAPODA	S	1276	0	0	0	0	0	0	0	0	0	0	0
Decapoda	S	1276	0	0	0	0	1	0	0	0	0	0	0
Decapoda larvae	S	1276	0	0	1	0	1	0	0	0	0	0	0

Station			T1 Under	T1 Edge	T1 10m	T1 20m	T1 50m	T1 100m	T2 Edge	T2 10m	T2 20m	T2 50m	REF
Caridea	S	1293	0	0	0	0	0	0	0	0	0	0	0
Caridea	S	1293	0	0	0	0	0	2	0	0	1	0	0
PAGUROIDEA	S	1436	0	0	0	0	0	0	0	0	0	0	0
Paguridae	S	1445	0	0	0	0	0	0	0	0	0	0	0
Paguridae	S	1445	0	0	0	0	2	0	0	0	0	0	0
Pagurus sp.	S	1454	0	0	1	0	0	0	0	0	0	0	0
Porcellanidae	S	1480	0	0	0	0	0	0	0	0	0	0	0
Pisidia longicornis	S	1482	7	0	0	0	0	0	0	0	0	0	1
BRACHYURA	S	1485	0	0	0	0	0	0	0	0	0	0	0
Brachyura	S	1485	1	1	0	0	0	0	0	1	0	0	0
Atelecyclidae	S	1553	0	0	0	0	0	0	0	0	0	0	0
Atelecyclus rotundatus	S	1555	1	0	0	0	0	0	0	0	0	0	0
Canceridae	S	1563	0	0	0	0	0	0	0	0	0	0	0
Cancer sp.	S	1564	0	2	0	1	0	0	0	0	0	0	0
BRACHYRHYNCHA	S	1567	0	0	0	0	0	0	0	0	0	0	0
Portunidae	S	1569	0	0	0	0	0	0	0	0	0	0	0
Liocarcinus sp.	S	1577	0	1	0	0	0	0	0	0	1	0	0
Necora puber	S	1589	0	0	0	0	1	0	0	0	0	0	0
Carcinus maenas	S	1594	0	0	0	0	0	0	1	0	0	0	0
MOLLUSCA	W	1	0	0	0	0	0	0	0	0	0	0	0
POLYPLACOPHORA	W	46	0	0	0	0	0	0	0	0	0	0	0
NEOLORICATA	W	47	0	0	0	0	0	0	0	0	0	0	0
Leptochitonidae	W	48	0	0	0	0	0	0	0	0	0	0	0
Leptochiton sp.	W	51	0	0	0	1	0	0	1	0	0	0	0
Leptochiton asellus	W	53	0	0	0	0	0	0	0	1	0	0	0
Leptochiton cancellatus	W	54	0	0	0	2	3	0	0	2	2	0	0
GASTROPODA	W	88	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	W	88	0	0	1	0	0	0	0	0	0	0	0
ARCHAEOGASTROPODA	W	90	0	0	0	0	0	0	0	0	0	0	0
Trochidae	W	140	0	0	0	0	0	0	0	0	0	0	0
Gibbula sp.	W	157	0	0	0	1	0	0	0	0	0	1	0
Gibbula tumida	W	161	0	0	0	0	0	0	0	0	1	0	0
Jujubinus montagui	W	174	0	0	0	0	1	0	0	0	0	0	0

Station			T1 Under	T1 Edge	T1 10m	T1 20m	T1 50m	T1 100m	T2 Edge	T2 10m	T2 20m	T2 50m	REF
PATELLOGASTROPODA	W	219	0	0	0	0	0	0	0	0	0	0	0
Patellidae	W	225	0	0	0	0	0	0	0	0	0	0	0
Patella pellucida	W	234	0	0	0	4	0	0	0	1	0	0	0
MESOGASTROPODA	W	256	0	0	0	0	0	0	0	0	0	0	0
Littorinidae	W	283	0	0	0	0	0	0	0	0	0	0	0
Littorina sp.	W	294	0	0	1	0	0	0	0	0	0	0	0
Rissoidae	W	324	0	0	0	0	0	0	0	0	0	0	0
Rissoa parva	W	334	1	0	0	0	0	0	0	0	0	0	0
Onoba sp.	W	366	0	0	0	0	0	1	0	0	0	0	0
Caecidae	W	411	0	0	0	0	0	0	0	0	0	0	0
Caecum trachea	W	414	5	7	1	37	33	30	4	5	11	0	0
Caecum glabrum	W	418	0	0	0	0	0	0	0	0	2	0	0
Naticidae	W	482	0	0	0	0	0	0	0	0	0	0	0
Euspira nitida	W	491	0	0	1	3	0	0	0	0	0	0	0
NEOGASTROPODA	W	670	0	0	0	0	0	0	0	0	0	0	0
Buccinidae	W	702	0	0	0	0	0	0	0	0	0	0	0
Nassarius sp.	W	743	0	2	0	2	2	0	0	1	1	0	0
Nassarius incrassatus	W	747	0	1	0	0	0	0	0	0	0	0	0
Nassarius pygmaeus	W	748	0	0	1	0	1	0	0	3	2	0	0
HETEROSTROPHA	W	878	0	0	0	0	0	0	0	0	0	0	0
Pyramidellidae	W	906	0	0	0	0	0	0	0	0	0	0	0
Odostomia sp.	W	908	0	1	0	0	0	1	0	0	2	0	0
OPISTHOBRANCHIA	W		0	0	0	0	0	0	0	0	0	0	0
Philinidae	W	1035	0	0	0	0	0	0	0	0	0	0	0
Philine sp.	W	1037	0	0	0	0	1	0	0	0	0	0	0
Philine scabra	W	1045	0	0	0	0	0	0	0	0	1	0	0
NUDIBRANCHIA	W	1243	0	0	0	0	0	0	0	0	0	0	0
Nudibranch	W	1243	0	0	2	0	0	0	0	0	0	0	0
PELECYPODA	W	1560	0	0	0	0	0	0	0	0	0	0	0
Bivalvia	W	1560	0	0	0	2	0	0	0	0	0	0	2
NUCULOIDA	W	1561	0	0	0	0	0	0	0	0	0	0	0
Nuculidae	W	1563	0	0	0	0	0	0	0	0	0	0	0
Nucula nitidosa	W	1569	0	0	0	0	0	0	0	0	0	0	1

Station			T1 Under	T1 Edge	T1 10m	T1 20m	T1 50m	T1 100m	T2 Edge	T2 10m	T2 20m	T2 50m	REF
MYTILOIDA	W	1689	0	0	0	0	0	0	0	0	0	0	0
Mytilidae	W	1691	0	0	0	0	0	0	0	0	0	0	0
Mytilidae	W	1691	400	97	22	14	9	2	37	46	77	4	1
Mytilus edulis	W	1695	19	73	3	0	0	0	15	32	0	0	0
Musculus subpictus	W		0	1	0	0	0	0	0	0	0	0	0
OSTREOIDA	W	1752	0	0	0	0	0	0	0	0	0	0	0
Pectinidae	W	1768	0	0	0	0	0	0	0	0	0	0	0
Pectinidae	W	1768	1	0	0	0	0	0	0	0	0	0	0
Anomiidae	W	1805	0	0	0	0	0	0	0	0	0	0	0
Anomiidae	W	1805	2	0	0	0	0	0	0	0	0	0	0
VENEROIDA	W	1815	0	0	0	0	0	0	0	0	0	0	0
Lucinidae	W	1817	0	0	0	0	0	0	0	0	0	0	0
Lucinoma borealis	W	1829	0	0	0	0	1	1	0	0	0	0	0
Thyasiridae	W	1833	0	0	0	0	0	0	0	0	0	0	0
Thyasiridae	W	1833	0	0	0	0	0	0	0	0	0	0	1
Thyasira flexuosa	W	1837	0	0	0	0	1	0	0	0	0	0	1
Montacutidae	W	1888	0	0	0	0	0	0	0	0	0	0	0
Kurtiella bidentata	W	1906	0	1	0	2	0	2	0	1	2	0	21
Cardiidae	W	1938	0	0	0	0	0	0	0	0	0	0	0
Cardiidae	W	1938	0	0	0	0	0	0	0	0	2	0	0
Pharidae	W	1995	0	0	0	0	0	0	0	0	0	0	0
Phaxas pellucidus	W	2006	0	0	0	0	0	0	0	0	0	0	2
Tellinidae	W	2008	0	0	0	0	0	0	0	0	0	0	0
Tellinidae	W	2008	1	0	0	1	3	0	0	0	7	0	0
Angulus pygmaeus	W	2023	0	0	0	0	0	1	0	0	0	0	0
Semelidae	W	2057	0	0	0	0	0	0	0	0	0	0	0
Abra sp.	W	2058	0	0	0	1	3	1	0	0	36	0	3
Abra alba	W	2059	0	0	0	0	0	0	0	0	1	0	0
Veneridae	W	2086	0	0	0	0	0	0	0	0	0	0	0
Veneridae	W	2086	0	1	1	0	0	0	1	0	2	0	0
Chamelea striatula	W		0	0	0	0	0	0	0	0	0	0	1
Clausinella fasciata	W	2100	0	1	1	2	0	1	0	0	0	0	0
MYOIDA	W	2140	0	0	0	0	0	0	0	0	0	0	0

Station			T1 Under	T1 Edge	T1 10m	T1 20m	T1 50m	T1 100m	T2 Edge	T2 10m	T2 20m	T2 50m	REF
Corbulidae	W	2153	0	0	0	0	0	0	0	0	0	0	0
Corbula gibba	W	2157	0	0	0	0	0	0	0	0	0	0	3
Hiatellidae	W	2164	0	0	0	0	0	0	0	0	0	0	0
Hiatella sp.	W	2165	6	0	0	0	0	0	0	0	0	0	0
Hiatella arctica	W	2166	7	1	0	0	0	0	1	0	0	0	0
PHOLADOMYOIDA	W	2220	0	0	0	0	0	0	0	0	0	0	0
Thraciidae	W	2226	0	0	0	0	0	0	0	0	0	0	0
Thracia sp.	W	2228	0	0	0	1	0	0	0	0	0	0	1
ECHINODERMATA	ZB	1	0	0	0	0	0	0	0	0	0	0	0
ASTEROIDEA	ZB	18	0	0	0	0	0	0	0	0	0	0	0
Asteroidea	ZB	18	1	0	0	0	0	0	0	0	0	0	1
Astropectinidae	ZB	24	0	0	0	0	0	0	0	0	0	0	0
Astropecten irregularis	ZB	26	0	0	0	0	0	1	0	0	0	0	0
FORCIPULATIDA	ZB	95	0	0	0	0	0	0	0	0	0	0	0
Asteriidae	ZB	96	0	0	0	0	0	0	0	0	0	0	0
Asterias rubens	ZB	100	5	0	0	0	0	0	0	1	0	0	0
OPHIUROIDEA	ZB	105	0	0	0	0	0	0	0	0	0	0	0
Ophiuroidea	ZB	105	0	0	0	0	0	2	0	0	0	0	0
OPHIURIDA	ZB	121	0	0	0	0	0	0	0	0	0	0	0
Amphiuridae	ZB	148	0	0	0	0	0	0	0	0	0	0	0
Amphiura filiformis	ZB	154	0	0	0	0	0	0	0	0	0	0	2
Amphipholis squamata	ZB	161	0	0	0	0	0	1	0	0	2	2	3
ECHINOIDEA	ZB	181	0	0	0	0	0	0	0	0	0	0	0
Echinoidea	ZB	181	1	0	0	1	0	0	0	0	0	0	0
ECHINOIDA	ZB	190	0	0	0	0	0	0	0	0	0	0	0
Echinidae	ZB	194	0	0	0	0	0	0	0	0	0	0	0
Echinocyamus pusillus	ZB	212	0	0	0	0	0	2	0	0	0	0	0
SPATANGOIDA	ZB	213	0	0	0	0	0	0	0	0	0	0	0
Loveniidae	ZB	221	0	0	0	0	0	0	0	0	0	0	0
Echinocardium sp.	ZB	222	0	0	0	0	0	0	0	0	2	0	0
HOLOTHURIOIDEA	ZB	229	0	0	0	0	0	0	0	0	0	0	0
APODIDA	ZB	289	0	0	0	0	0	0	0	0	0	0	0
Synaptidae	ZB	290	0	0	0	0	0	0	0	0	0	0	0

Station			T1 Under	T1 Edge	T1 10m	T1 20m	T1 50m	T1 100m	T2 Edge	T2 10m	T2 20m	T2 50m	REF
Leptosynapta sp.	ZB	291	0	0	0	0	0	1	0	0	0	0	0