APPENDIX No. 18

Proposed Monitoring Plan for Intertidal Habitats

Proposed Monitoring Plan for Intertidal Habitats at Mweeloon, Co. Galway.

Produced by

AQUAFACT International Services Ltd

On behalf of

Galway Harbour Board

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Proposed monitoring plan for intertidal habitats at Mweeloon.

66 intertidal areas were surveyed as part of the study of this habitat at Mweeloon (see Figure 1).

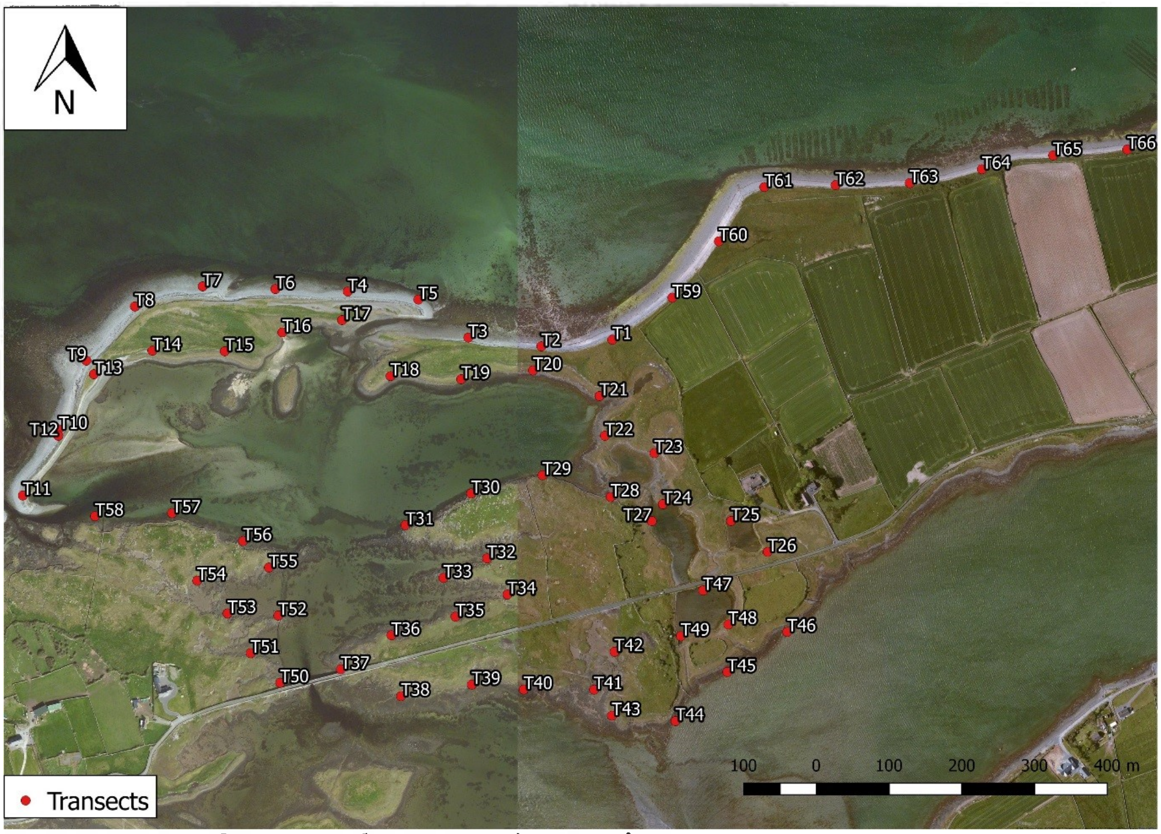

Figure 1. Location of 66 transect lines surveyed at Mweeloon.

They fall into a number of different categories. The first category is the sixteen that face north into Galway Bay (Transects 1 – 10 and 57 – 66). The coast here experiences full daily symmetrical tidal variation including the longer lunar variations of the Spring and Neap cycles. These shores show the full range of zonation associated with such tidal conditions. At low water Spring tide, the length of the exposed shore is up to *ca* 200m particularly at the eastern end of Lurgan Island. The supratidal habitat along the entire length of this northern shore is comprised of limestone boulders and cobbles interspersed with gravel. The profile of this habitat is very steep and but shallows rapidly as it continues into the upper shore habitat. The shore profile continues to level out with distance from the shore and by mid tide, it has flattened out considerably. Lower shore substrates at these sites are a sandy shell substrate with bivalves such as oysters (*Ostrea edulis*) and clams (*Tapes* and *Dosinia*). Small amounts of live maerl (*Lithothamnion* sp.) can also be found at low water. Although some intravariation in lichen and algal species recorded was recorded in these ten transects *e.g.* some lacked *Pelvetia* or *Ascophyllum*, overall, the typical zonation pattern was recoded on these shores with lichen species occurring in the supratidal and high shore levels followed by *Pelvetia, Fucus spiralis, F. vesiculosus, Ascophyllum* and finally, *F. serratus*. Band width of these algae can be tens of meters in extent.

With regard to the 50 transects that lie within Mweeloon Lagoon (Transects 11 – 56), as the habitat within Tawin is lagoonal in nature, tidal conditions are very different that those described above. Even under low water Spring tide conditions, water levels only fall to *ca* -1.5m below high water at most. Also, in this inner area, salt marsh (with typical floral species such as *Limonium, Salicornia, Aster, Suede* and *Beta* being present) predominates in the supratidal and high water shore levels. Of special note is the presence of extensive stands of *Artemisia absinthium* which is present throughout the headland. Due to the restricted tidal conditions described above, the full suite and spatial extent of zonation present in the outer open sea shoreline does not occur inside the lagoon *e.g. F. serratus* is not exposed and in some locations, neither *F. spiralis* nor *F. vesiculosus* are exposed. Furthermore, algal band width is never more than a few meters in extent. The lagoonal specialists, *Ruppia cirrhosa, Cerastoderma glaucum* and *Idotea chelipes,* were recorded at one location. The inner lagoonal shores can be differentiated by their substrates *i.e.* mud, gravel/sand, stones, exposed bed rock.

The proposed monitoring plan for the intertidal habitats at Mweeloon takes into account these basic differences of this habitat at Mweeloon. 5 transects on the north shore (Transects 66, 60, 1, 3 and 7) and a further 9 (Transects 14, 19, 30, 32, 39, 43, 46 and 57) within the lagoon have been selected for annual monitoring. The same sampling protocol as used in the initial survey will be adopted for these future annual surveys. This is described below.

Sampling will be carried out during a Spring tide period in the Summer.

3 x 0.1 m^2 quadrates will be used to determine macroalgal species and % cover at HW, MW and LW.

Macrofaunal species within each quadrate will be identified and scored in terms of abundance using the SACFOR scale.

Where sediments occur, 3 x 15 cms diameter sediment cores will be collected at each tidal height, washed through a 1mm sieve, stained with Rose Bengal and fixed in 6% formaldehyde for 48 hrs before preserving in 70% alcohol. The procedure to extract fauna from the sediment residues is as follows:

- All samples will be logged in a central sample log book.
- The faunal samples will then be processed in a systematic way to ensure that no samples are omitted.
- Prior to sorting and identification, the alcohol will be removed from the sample by thorough rinsing through a 1mm sieve. The sample retained on the sieve (sieve residue) will then be transferred, by backwashing, into a white sorting tray, with care taken not to leave any specimens on the sieve.
- A daily inventory of what samples have been sorted will be maintained by AQUAFACT.
- All conspicuous fauna will be extracted by hand, using forceps or pipette, first by eye to remove large specimens and then sorted using a stereo microscope at 6 to 10 times magnification.

- Following the removal of larger specimens, the samples will be placed into Petri dishes, approximately one half teaspoon at a time and sorted using a binocular microscope at x10 magnification.
- All fauna will be sorted into four groups (Annelida, Crustacea, Mollusca and Others) and placed into suitable labelled containers. The faunal specimens will then be identified to species level where possible using all relevant taxonomic keys and BEQUALM/NAMBQC guides.
- The specimens will be stored in 70-80% industrial methylated spirits/water preservative.
- A species list will then be generated.

A further sediment sample will be collected for granulometric and organic carbon analysis.

The estimated depth of the REDOX layer will be made on site and notes will be made on the colour and odour of the sediment.

Representative photographs will be taken of each site and each quadrate sample

Faunal Data Analysis

Statistical analysis will be carried out on the core returns using PRIMER. A description of the analysis that AQUAFACT routinely carries out on benthic data sets is given below.

Statistical evaluation of the data is undertaken using PRIMER v.6 (Plymouth Routines in Ecological Research). Univariate statistics in the form of diversity indices are calculated. Numbers of species and numbers of individuals per sample will be calculated and the following diversity indices will be utilised:

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

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

where: N is the number of individuals

S is the number of species

2) Pielou's Evenness index (J)

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

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').

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

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

4) Simpson's Diversity Index

$$1\text{-}\lambda' = 1-\{\Sigma_i N_i(N_i-1)\} / \{N(N-1)\}$$

where N is the number of individuals of species i.

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. Richness ranges from 0 (low richness) to 12 (high richness), evenness ranges from 0 (low evenness) to 1 (high evenness), diversity ranges from 0 (low diversity) to 5 (high diversity).

The PRIMER programme (Clarke & Warwick, 2001) is used to carry out multivariate analyses on the station-by-station faunal data. All species/abundance data from the grab surveys is fourth root transformed and used to prepare a Bray-Curtis similarity matrix in PRIMER ®. The fourth root transformation is used in order to down-weigh the importance of the highly abundant species and to allow the mid-range and rarer species to play a part in the similarity calculation. All species/abundance data from the samples is used to prepare a Bray-Curtis similarity matrix. The similarity matrix is then be used in classification/cluster analysis. The aim of this analysis is 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 carries 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. SIMPROF (Similarity Profile) permutation tests will be incorporated into the CLUSTER analysis to identify statistically significant evidence of genuine clusters in samples which are *a priori* unstructured.

The Bray-Curtis similarity matrix is also be subjected to a non-metric multi-dimensional scaling (MDS) algorithm (Kruskal & Wish, 1978), using the PRIMER programme 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.

The species, which are responsible for the grouping of samples in cluster and ordination analyses, are identified using the PRIMER programme SIMPER (Clarke & Warwick, 1994). This programme determines the percentage contribution of each species to the dissimilarity/similarity within and between each sample group.

Sediment Analysis

AQUAFACT will carry out, in-house, the granulometric analysis using the traditional granulometric technique. We have all of the necessary equipment required *e.g.* Wentworth graded sieves, Easysieve computer software, hydrogen peroxide, sodium hexametaphosphate, drying oven, beakers, mixers, electronic scales. We have carried out sediment analysis for all intertidal and subtidal sampling programmes in which we have been involved.

AQUAFACT will employ the following methodology for the granulometric analysis:

1. Approximately 100g of dried sediment (previously washed in distilled water and dried) is weighed out and placed in a labelled 1L glass beaker to which 100ml of a 6 percent hydrogen peroxide solution is then added. This is allowed to stand overnight in a fume hood.
2. The beaker is placed on a hot plate and heated gently. Small quantities of hydrogen peroxide are added to the beaker until there is no further reaction. This peroxide treatment removes any organic material from the sediment which can interfere with grain size determination.
3. The beaker is then emptied and rinsed into a 63µm sieve. This is then washed with distilled water to remove any residual hydrogen peroxide. The sample retained on the sieve is then carefully washed back into the glass beaker up to a volume of approximately 250ml of distilled water.
4. 10ml of sodium hexametaphosphate solution is added to the beaker and this solution is stirred for ten minutes and then allowed to stand overnight. This treatment helps to dissociate the clay particles from one another.
5. The beaker with the sediment and sodium hexametaphosphate solution is washed and rinsed into a 63µm sieve. The retained sample is carefully washed from the sieve into a labelled aluminium tray and placed in an oven for drying at 100ºC for 24 hours.
6. The dried sediment is then passed through a Wentworth series of analytical sieves (>8,000 to 63µm; single phi units). The weight of material retained in each sieve is weighed and recorded. The material passing through the 63µm sieve is also weighed and the value added to the value measured in Point 5 above.
7. The total silt/clay fraction is determined by subtracting all weighed fractions from the initial starting weight of sediment as the less than 63µm fraction was lost during the various washing stages.
8. The reporting of sediment samples will be as percentages within the following range of particle sizes:
    - PSA % <63
    - PSA % 63<125
    - PSA % 125<250
    - PSA % 250<500
    - PSA % 500<1000
    - PSA % 1000<2000

- PSA % 2000<4000
- PSA % 4000<8000
- PSA % ≥8000

The proportions of gravel; sand and mud allow for the determination of Folk (1954) classification. Folk classification is determined for all sediments analysed in AQUAFACT.

The organic matter (Loss on Ignition) will be carried out by ALS Labs in Loughrea using the following methodology:

1. The collected sediments are transferred to aluminium trays, homogenised by hand and dried in an oven at 100º C for 24 hours.
2. A sample of dried sediment is placed in a mortar and pestle and ground down to a fine powder.
3. 1g of this ground sediment is weighed into a pre-weighed crucible and placed in a muffle furnace at 450ºC for a period of 6 hours.
4. The sediment samples are then allowed to cool in a desiccator for 1 hour before being weighed again.
5. 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.