Ocean Ecology

Marine Surveys, Analysis & Consultancy

West Gigha

Baseline Survey 2022

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1. Introduction

This report presents the results of a baseline survey undertaken by Bakkafrost Scotland (BFS) (formerly known as Scottish Salmon Company (SSC)) at West Gigha proposed salmon pen fish farm site on 7th September 2022 and subsequent sample analysis completed by Ocean Ecology Limited (OEL). Sediment quality parameters were assessed to fulfil SEPA's monitoring requirements under current consent guidelines (SEPA 2022).

Sediment samples were collected at 19 stations across the proposed site. Two replicate grab samples were taken at each station for subsequent macrofaunal analysis along with separate samples for particle size distribution (PSD) and Total Organic Carbon (TOC). The results of the physio-chemical and macrobenthic analyses of the samples have been used to calculate key univariate and multi-metric diversity indices as a means of assessing environmental quality status across the survey area.

2. Methodology

All fieldwork was carried out by competent and experienced personnel from SSC trained in all aspects of soft-substratum benthic sampling. All procedures were risk assessed and appropriate measures taken to ensure personnel were suitably equipped for the tasks undertaken.

On arrival to OEL laboratory, all samples were logged and entered to the project database created in OEL's web-based data management application ABACUS. This application provides a cloud-based platform for recording, quality assuring, storing, and exporting standardised marine biological data in line with internationally recognised data standards (e.g., MEDIN, GEMINI, ISO). All macrobenthic analysis was undertaken by in-house benthic taxonomists at OEL's NE Atlantic Marine Biological Analytical Quality Control Scheme (NMBAQC) participating laboratory in line with the NMBAQC Processing Requirement Protocol (PRP) (Worsfold & Hall 2010).

2.1. Sediment Analyses

2.1.1. Sediment Descriptive Information

The condition of the sediment describing colour (black, brown etc), physical consistency (sand, mud, shell, gravel etc) and texture (soft, firm etc) was reported in Table 2 of the Data Sheet for each transect. This also included any presence of any smell or waste feed pellets and/or the white streaks of *Beggiatoa* on the sediment.

2.1.2. Particle Size Analysis (PSA)

One grab was collected at each station and sub-sampled for PSA. Approximately 200 ml of sediment was collected using a corer to the full depth of the grab. The sediment was then stored in a labelled container and frozen immediately upon return the same day, prior to conveyance to the laboratory for analysis by wet or dry sieving (as appropriate to the prevailing grain size). Particle size data for each sample station has been reported in worksheet 2 and Table 4 of the Data Sheet .

2.2. Benthic Macrofauna

Two 0.045 m^2 replicate grabs were collected at each station. For each macrobenthic sample, the excess formalin was drained off into a labelled container over a 1 mm mesh sieve in a well-ventilated area. The samples were then re-sieved over a 1 mm mesh sieve to remove all remaining fine sediment and fixative. The low-density fauna was then separated by elutriation with fresh water, poured over a 1 mm mesh sieve, transferred into a Nalgene and preserved in 70 % Industrial Denatured Alcohol (IDA). The remaining sediment from each sample was subsequently separated into 1 mm, 2 mm and 4 mm fractions and sorted under a stereomicroscope to extract any remaining fauna (e.g., high-density bivalves not 'floated' off during elutriation). All macrobenthos present was enumerated and identified to species level, where possible, by trained benthic taxonomists. All taxonomy was performed using the most up to date literature and against existing reference collections, as reported in the Fauna Sheet for each transect. Nomenclature utilised the live link within ABACUS to the WoRMS REST webservice, to ensure up to date taxonomic classifications were recorded. Colonial fauna (e.g., hydroids and bryozoans) were recorded as present ("> 0"). Data were subjected to a suite of univariate (Table 5 in each of the Data Sheets) and multivariate analyses (Paragraph 3.2.2).

2.2.1. Univariate Analysis

The following biodiversity indices were calculated to describe and compare the macrofaunal community at the Gravir Outer site.

Number of species or taxa (S) - Most useful where samples are of very similar volume and less so if sample volumes are very different. Low numbers may be an indication of a polluted environment.

Number of Individuals/Abundance (N) - Equally, only useful if sample volumes are very similar. Enrichment may lead to elevated abundances.

Magalef's Species Richness Index (d) - An index of the species present for a given number of individuals. The index value tends to be higher where there is less environmental stress.

Pielou's Evenness Index (J) - Expresses evenness of distribution of individuals for each species found. The index value is higher where the abundance of each species is similar, low where one species dominates.

Shannon Wiener Diversity Index (H' Log2) - A combined index of species richness and evenness; it measures the degree of difficulty in predicting the identity of the next animal in the sample. Where the number of species is high, and the abundance of each species is relatively even the index will be higher.

Infaunal Trophic Index (ITI) (Codling & Ashley 1992). This index helps to describe pollution gradients from sewerage and industrial discharges based on the taxa present. Unlike the previous indices, ITI uses information on the feeding methods of the various species recorded. Each species or taxa is assigned one of four Trophic Groups, as follows:

ITI Group	Feeding Method
Group 1	Suspension feeders
Group 2	Surface detritus feeders
Group 3	Surface deposit feeders
Group 4	Sub-surface deposit feeders

The formula for the derivation of the ITI is as follows, where N1, N2, N3 and N4 are the number of organisms belonging to Groups 1, 2, 3 and 4, respectively. ITI values range from 0 to 100.

$$ITI = 100 — \{33.\ 3\ [(\ N2 + 2N3 + 3N4)\ /\ (\ Ni + N2 + N3 + N4)]\}$$

Composition of the macrobenthic community will change with nutrient availability. An increase in nutrient input will result in a reduction in the proportion of filter feeders and an increase in deposit feeders and will alter the ITI value. If only organic deposit feeders were present, the index score is close to zero, where more environmentally sensitive species dominate the score is significantly higher. ITI only gives a rough indication of pollution status, but the following guidelines are proposed.

ITI	Pollution Status
60 - 100	Normal Community
30 – 60	Changed Community
< 30	Degraded Community

Infaunal Quality Index (IQI) (Borja et al. 2000) – This index was developed to assess the quality of the seabed and has been used within the Water Framework Directive. It includes a series of different metrics based on both macrofaunal and sediment analyses, as well as environmental parameters like salinity. IQI scores vary from 0 to 1 and the following guidelines have been proposed for the interpretation of IQI scores:

IQI	Environmental Quality Status
< 0.24	Bad
0.24 – 0.44	Poor
0.44 – 0.64	Moderate
0.64 – 0.75	Good
> 0.75	High

Enrichment Polychaetes Species – These were defined as all polychaetes belonging to AMBI Group V based on the May 2019 species list (Borja et al. 2000), and *Ophryotrocha* sp. and *Boudemos* sp.

2.2.2. Multivariate Analysis

Prior to multivariate analyses, data were displayed as a shade plot with linear grey-scale intensity proportional to macrofaunal abundance (Clarke et al. 2014) to determine the most efficient pre-treatment method. Macrofaunal abundance data was square root transformed to prevent taxa with intermediate abundances from being discounted from the analysis.

The PRIMER v7 software package (Clarke & Gorley 2015) was utilised to undertake the multivariate statistical analysis on the macrofaunal dataset. To fully investigate the multivariate patterns in the biotic data, macrofaunal assemblages were characterised based on their community composition, with hierarchical clustering used to identify groupings of sampling stations that could be assigned to the same habitat type or community. Cluster analysis of the macrobenthic data was performed on a Bray-Curtis similarity matrix.

To visualise the relationships between the macrofaunal assemblages, a non-metric multi-dimensional scaling (nMDS) ordination plot was generated on the community abundance data based on the same Bray-Curtis similarity matrix. The nMDS represents the relationships between the communities sampled based on the distance between sample points. The stress value of the nMDS ordination plot indicates whether the two-dimensional plot provides an acceptable representation of the similarity between samples. The degree of clustering of intra-group sample points demonstrates the level of within group similarity, whilst the degree of overlap of inter-group sample points is indicative of the level of similarity between different groups.

3. Results & Discussion

3.1. Physio-chemical

3.1.1. Sediment Descriptive Information

The sampling stations at West Gigha were situated in waters depths ranging from 12 m to 62 m. At the time of sampling sediments were described as "brown" to "light brown" with no signs of surface smell or fungus recorded (Table 2 in Data Sheet).

3.1.2. Particle Size Analysis (PSA)

Sediments across the survey area ranged from very fine gravel to fine sand, being overall very poorly sorted. The highest proportion of gravel (> 2 mm) was measured at station 1 (69 %), while the highest proportion of fines (< 63 µm) was recorded at station 19 (28 %) (Table 4 in Data Sheet).

3.1.3. Total Organic Chemistry (TOC)

Total Organic Carbon (TOC) was measured at all stations and varied between 0.13 % at station 6 and 0.32 % at station 19 (Table 3 in Data Sheet).

3.2. Benthic Macrofauna

3.2.1. Univariate Analysis

Results of univariate analyses on macrofaunal data from sediments collected are presented in Table 5 of the Data Sheet. A total of 1,156 specimens were identified. Station 2 and station 17 had the highest number of taxa (richness) with 56 taxa identified, while the highest number of individuals (220 specimens) was recorded at the station 2. No enrichment polychaete species were identified at any of the stations sampled which was overall reflected in the relatively high ITI and IQI scores at all stations. ITI scores were indicative of a normal community at all stations (ITI > 60) but S11 and S03 with ITI scores of 49 and 57, respectively. IQI scores were overall indicative of 'good' to 'high' environmental quality status except at S07 and S09 where IQI scores reflected 'moderate' environmental quality status (Table 5 in the Data Sheet).

3.2.2. Multivariate Analysis

The nMDS analysis showed a good fit for the data with a stress level of 0.13 (

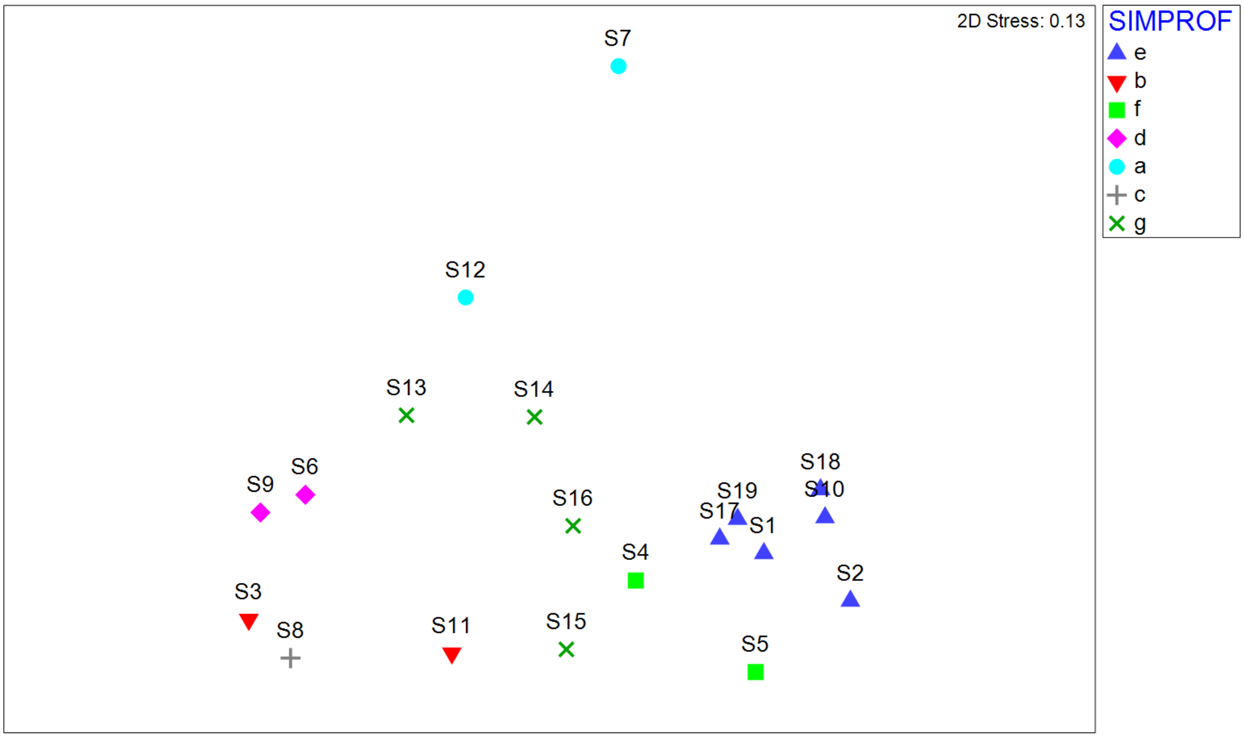

Figure 1). The dendrogram and associated SIMPROF analysis identified 6 clusters and S8 plotting on its own (outlier), indicating statistically significant differences in macrobenthic communities across the survey area (Figure 2). Differences in the macrobenthic communities observed across West Gigha seemed to be driven by changes in the relative abundance of the polyplacophoran mollusc *Leptochiton* sp., the sea cucumber *Leptosynapta bergensis,* the polychaetes *Sthenelais limicola, Owenia* sp. and *Galathowenia oculata*.

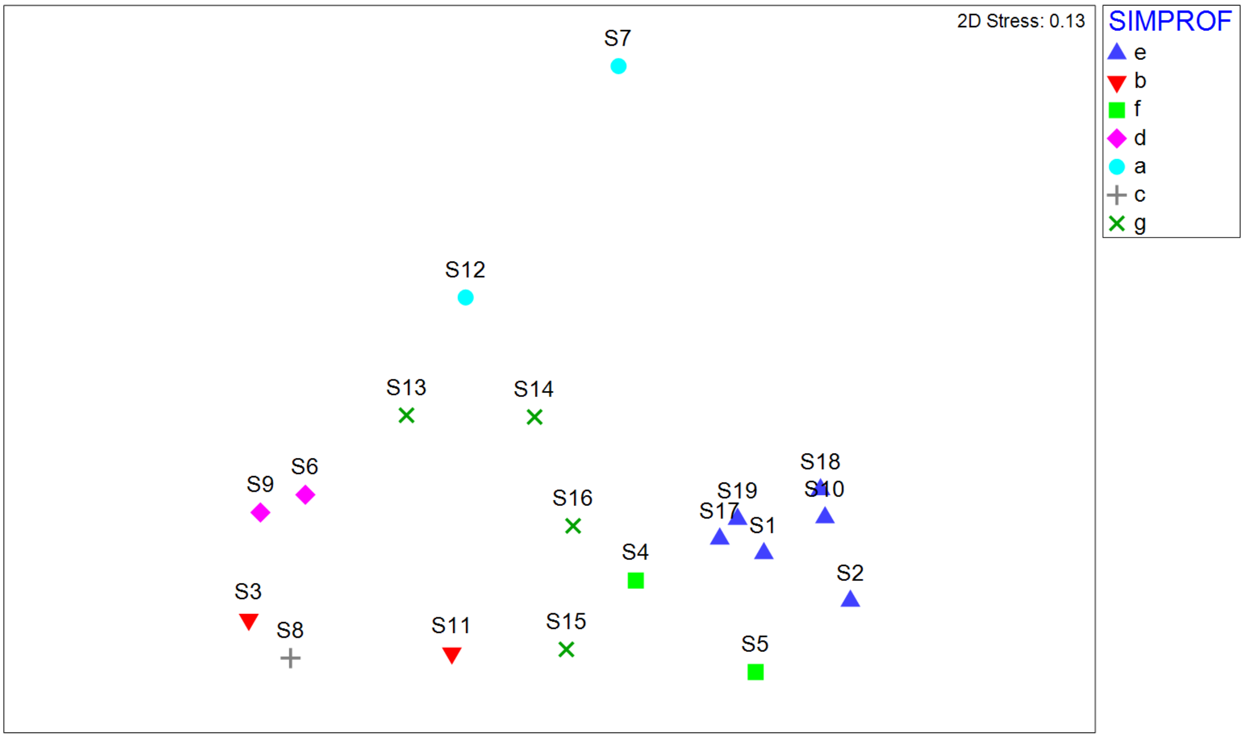

Figure 1 Non-metric MDS ordination of macrobenthic data based on the Bray-Curtis similarity index during West Giga baseline survey in 2022. Contours represent 20 % similarity between samples.

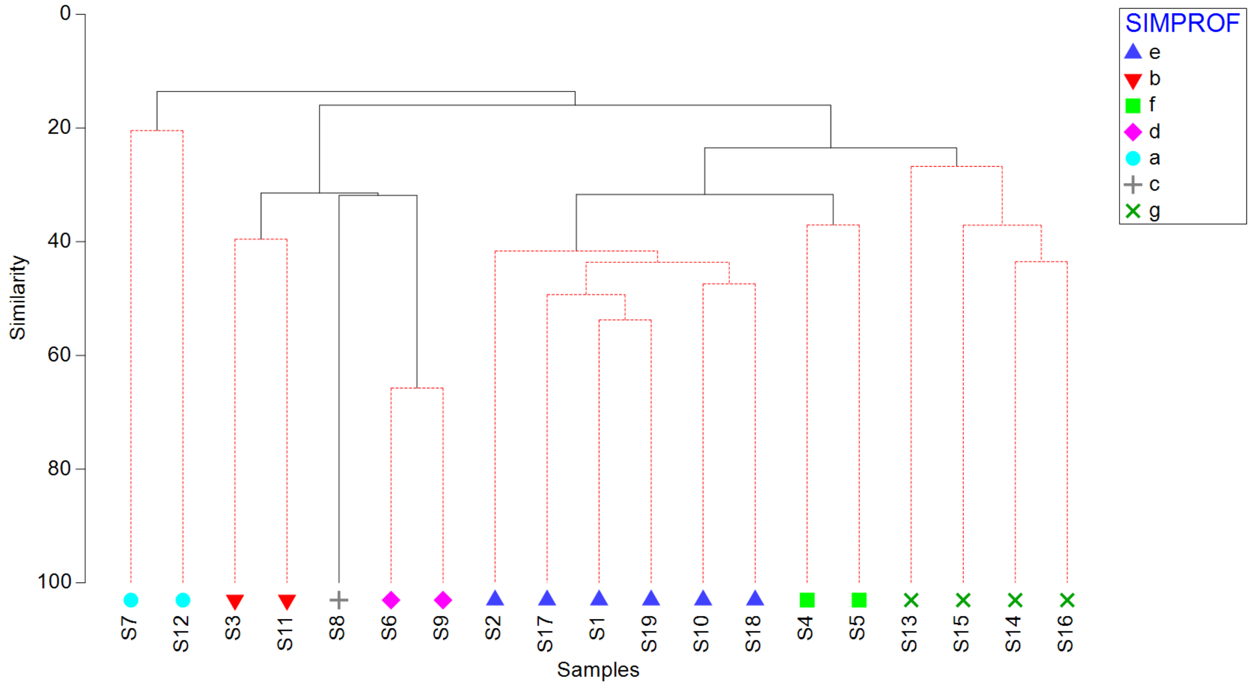

Figure 2 Dendrogram based on Bray-Curtis similarity matrix showing the similarity of stations during the West Gigha baseline survey. A SIMPROF analysis was conducted to identify groups (highlighted by red lines joining stations) which were statistically distinct.

3.2.3. Notable Taxa

Four notable taxa were recorded across the West Gigha proposed site: Queen scallop (*Aequipecten opercularis*), great spider crab (*Hyas araneus*), venus clams (Veneridae), and Ross worm (*Sabellaria spinulosa*). *Aequipecten opercularis*, *Hyas araneus*, and Veneridae are classified as economically important species. However, across the proposed West Gigha site these economically important species were only present in very low numbers. Specimens of *Sabellaria spinulosa* were identified at station 16 (n = 5), station 17 (n = 11), and station 18 (n = 1). The Ross worm *S. spinulosa* is a protected species when occurring in reef form under the OSPAR list of threatened and/or declining species and habitats (OSPAR 2019) and as an Annex I species under the EU Habitat Directive (Irving 2009). Across the West Gigha proposed site *S. spinulosa* specimens were only identified in very low numbers.

4. Conclusion

The benthic baseline survey around the proposed West Gigha salmon pen fish farm site along 19 stations revealed sediment types ranging from very fine gravel to fine sand. No signs of fungus or smell were recorded across the whole site.

No enrichment polychaete species were recorded across the West Gigha survey area. This was reflected in the relatively high ITI and IQI scores at most stations indicating a normal community and 'good' to 'high' environmental quality status. Exceptions were stations S03 and S11 with ITI scores below 60 indicative of a somehow changed but not deteriorated community and stations S07 and S09 with IQI scores indicative of a 'moderate' environmental quality status.

Notable specimens of *S. spinulosa* were identified at station 16 (n = 5), station 17 (n = 11), and station 18 (n = 1). The Ross worm *S. spinulosa* is a protected species when occurring in reef form under the OSPAR list of threatened and/or declining species and habitats (OSPAR 2019) and as an Annex I species under the EU Habitat Directive (Irving 2009). However, across the West Gigha proposed site *S. spinulosa* specimens were only identified in very low numbers and not in reef form. Three notable taxa of economically important species were also identified at the site, including Queen scallop (*Aequipecten opercularis*), great spider crab (*Hyas araneus*), and venus clams (Veneridae). However, across the proposed West Gigha site these economically important species were only present in very low numbers.

5. References

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6. Appendix I

Please refer to attached PDF file with PSA data summary.

PSD Summary
Sheets.pdf