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FINAL REPORT

Chapter 4.0 Benthic Infauna

2021 Marine Environmental Effects Monitoring Program (MEEMP) and Non-Indigenous Species/Aquatic Invasive Species (NIS/AIS) Monitoring Program

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Table of Contents

ACRONYMS AND ABBREVIATIONS

Acronym or Abbreviation	Definition
Biologica	Biologica Environmental Services Ltd.
cm	Centimetres
ERP	Early Revenue Phase
FEIS	Final Environmental Impact Statement
HDPE	High-density polyethylene
L	Litres
LSA	Local Study Area
m^2	square metres
mm	Millimetres
MEEMP	Marine Environmental Effects Monitoring Program
NIRB	Nunavut Impact Review Board
NIS/AIS	Non-Indigenous and Aquatic Invasive Species
Org/m^2	Organisms per squared meter
PC	Project Certificate
p_i	Proportion of the i^{th} taxon
%	Percent
QA/QC	Quality Assurance/Quality Control
QIA	Qikiqtani Inuit Association
S	Total number of taxa
SDI	Simpson’s Diversity Index
SEI	Simpson’s Evenness Index
SEM	Sikumiut Environmental Management Ltd.
SW	West Transect
x	Magnification factor
>	Greater than
<	Less than

4.0 BENTHIC INFAUNA

4.1 Introduction

The 2021 benthic infaunal sampling program for the MEEMP was focussed on targeted sampling at station SW-2, located along the West transect between the Ore Dock and the mouth of Phillips Creek. Station SW-2 was considered an outlier in the 2020 benthic community dataset because of considerably lower benthos density and richness values compared to other stations sampled along the West transect in 2020 and, also, when compared to previous years of sampling at SW-2. Through the MEWG process, the Qikiqtani Inuit Association (QIA) requested data from previous years of sampling at SW-2 be revisited to investigate whether changes observed at this station could be Project-related (Technical Comment 25 on the 2020 MEEMP), and Baffinland committed to conduct targeted sampling during the 2021 open-water season to address this.

This component was developed in consideration of the monitoring requirements outlined in the PC Conditions described in Chapter 1.0, Table 1-2. Project Certificate (PC) Conditions related to the monitoring include PC Conditions No. 99 (a), and 99 (c).

4.1.1 Objectives

The overall MEEMP objectives are outlined in Section 1.3 of Chapter 1.0 (Program Overview). The objectives of the 2021 benthic infaunal sampling program were as follows:

- Conduct targeted follow up sampling of benthic invertebrate communities at station SW-2.
- Evaluate whether the changes in benthic communities at this station observed in 2020 have persisted into 2021 and whether they are Project-related.
- Verify predictions made in the FEIS and other submissions to the Nunavut Impact Review Board (NIRB) regarding effects on benthic infauna communities, as applicable.
- Recommend any necessary and appropriate changes to the benthic infauna component of the MEEMP for future years.
- Address QIA Comments on the 2020 MEEMP Report.

4.2 Study Design

4.2.1 Modifications to the Program (2021)

After three consecutive years of implementation, the full joint radial benthic and sediment sampling program was not conducted in 2021; rather, sampling effort focussed on a single station, SW-2, from which anomalous results in benthic community indices were reported. The decision to scale-back the program was based on the lack of directional trends observed to date, across all indicators (with the exception of SW-2), which indicate that the Project has not adversely impacted benthic communities in Milne Inlet. While it is recognized that the full sampling program was not completed in 2019, due to logistical challenges, the power analysis provided in Appendix 3E confirms that in 2019 and 2020 there was adequate statistical power to be able to detect Project-related changes.

Baffinland is committed to continued implementation of the joint radial benthic and sediment sampling program with an adjusted monitoring frequency of every 3 years, which is more consistent with routine biological sampling for other mining effects monitoring programs (e.g., the federal Environmental Effects Monitoring Program [EEM]).

Station SW-2 stood out as an anomaly in 2020 due to reductions in benthic infauna indicators and a coarser sediment composition relative to other coastal stations along the West Transect. To determine whether Project activities contributed to these differences, targeted benthic infauna and sediment quality sampling was performed at station SW-2.

In addition, benthic infauna samples were also collected from 17 stations for the Non-Indigenous and Aquatic Invasive Species (NIS/AIS) 2021 monitoring program (including at station SW-2) (see Chapter 8.0).

4.2.2 Indicators

For benthic infauna, four endpoints are adopted as effect indicators:

- total density
- taxa richness
- Simpson's diversity index
- Simpson's evenness index.

Benthic Community Effect Indicators

Taxonomic identifications and abundance data provided by Biologica for 2021 (Appendix 8A-2) were used to calculate community indicators to assess benthic infaunal invertebrate communities at station SW-2. These indicators included: density, richness (to the lowest practicable level), Simpson's Diversity Index, and Simpson's Evenness Index.

Organism Density

Total invertebrate density was calculated as the number of organisms per square metre (org/m^2) for each station. The surface area of the Van Veen (0.1 m^2) was multiplied by three to account for the three composite grab samples using the following equation:

$$\frac{\textit{number of organisms per station}}{(\textit{grab sampler area} \times 3 \textit{ composites})}$$

Richness

Richness is the total number of unique taxa per station. Richness provides an indication of the diversity of benthic invertebrates in an area; a higher richness value typically indicates a healthier and balanced community. Because the three composite grab samples from each station were combined prior to taxonomy, the richness metric indicated the variety of taxa on a station-wide basis (i.e., replicate station richness) rather than the average number of taxa per individual grab.

Simpson's Diversity Index

Simpson's Diversity Index (SDI) measures the proportional distribution of organisms in the community. The SDI considers the variety of taxa and also how evenly the total density is distributed among these taxa. Certain conditions may favour one taxa over another, resulting in the community being dominated by a few taxa, which is reflected in decreased diversity (Simpson 1949). The SDI values range between zero and one, where lower values indicate a less diverse community and higher values indicate a more diverse community. The SDI was calculated using the formula provided by Krebs (Krebs 1999):

$$SDI = 1 - \sum_{i=1}^{S} (p_i)^2$$

Where:

- SDI = Simpson's diversity index
- S = the total number of taxa
- p_i = the proportion of the i^{th} taxon

Simpson's Evenness Index

Simpson's Evenness Index (SEI) is a measure of how evenly the total invertebrate density is distributed among the taxa present at the station. The SEI is included along with the SDI to provide context as to whether richness or the distribution of total density among taxa is driving the SDI values. The SEI is also expressed as a value between one and zero, with one representing high evenness (i.e., equal numbers of all taxa present in a sample) and zero representing low evenness (i.e., a high degree of dominance by one or a few taxa). The SEI values were calculated using the following formula (Smith and Wilson 1996):

$$SEI = 1 / \sum_{i=1}^{S} (p_i)^2 / S$$

Where:

- SEI = Simpson's evenness index
- S = the total number of taxa
- p_i = the proportion of the i^{th} taxon

4.3 Materials and Methods

4.3.1 Field Methodology

A single benthic infauna sample was collected from SW-2 (Figure 8-1) along with a co-located sediment sample and duplicate to provide supporting sediment quality information (Section 3.0). The benthic sample was collected as a composite of three individual grabs using a standard Van Veen sampler with a surface area of 0.1 m^2. Each grab sample was examined for acceptability using the criteria outlined in Section 3.3.1 and, upon acceptance, the three individual grab samples were split using a field splitter purpose-built for this program due to the large volume of the Van Veen sampler.

The composite material was gently rinsed with filtered seawater through a 1-cm mesh sieve to initially remove larger organisms that could otherwise become damaged when the composite material was subsequently filtered through a 0.5 mm mesh sieve. The 1-cm sieved sample was either retained as a whole sample, or further split into ½ or ¼, such that a reasonable volume would be submitted to the taxonomy laboratory. Large debris, such as gravel and cobble, were checked for encrusting fauna and included in the sample jar if potential encrusting epifauna were observed. The 1-cm mesh sieved composited material was further split in half, totalling a ¼ field split. The ¼ field split sample was retained and transferred to an aluminum sieving table. The sample was gently rinsed through a 0.5-mm mesh sieve with filtered seawater. A representative photograph was taken of the sieved sample, including a visible sample label (Appendix 3A). Remaining material on the sieve was placed in pre-labeled 1-L wide-mouth high-density polyethylene (HDPE) sample jars and preserved in a 10% buffered formalin solution. The containers were then sealed and inverted several times to promote homogenization with the formalin. Containers were labeled internally and externally with water-resistant labels. The sample was sent to Biologica Environmental Services Ltd. (Biologica) for sorting and taxonomic identifications, as per the previous MEEMP programs. Details on laboratory methods are provided in Appendix 8A-3.

4.3.2 Data Analysis

Data Screening

The benthic sample sent to Biologica was sorted using dissecting microscopes at 10-40x magnification. The 1-cm sample fraction was processed based on the field split (no further splitting by Biologica). The fine 0.5mm sample fraction (¼ field split) was further split into another quarter (¼) by Biologica for a final 1/16 split of the composite sample, using a Caton tray. The sample was spread evenly on a Caton grid and subsampled via sequential random quadrat sorting. Sorting continued until a minimum ¼ split was reached and taxonomic identifications were carried out to the lowest practicable level.

Taxonomy data provided by Biologica were screened for incidental organisms not considered to be part of the marine benthic community, such as freshwater, terrestrial, planktonic, and parasitic taxa. Meiofauna, such as nematodes, were removed from benthic analysis because these species often fall through the 0.5-mm mesh sieve used to separate benthic infauna from sediments in the field. Nematode species counts would thus not represent true population numbers at each station and could bias station comparisons of total abundance, relative abundance, and species diversity. Eliminated taxa, not expected to have significant direct exposure to sediments, included Nematoda (meiofauna), fish (Pisces indet.), and some Ostracoda (planktonic), Balanomorpha (planktonic), and Copepoda (parasitic) taxa.

4.3.3 Quality Management

Quality assurance and quality control (QA/QC) procedures were applied to the field collection, data analysis, and reporting tasks within the benthic infauna component to verify that the data presented were valid and of acceptable quality to address objectives stated in Section 4.1.1.

4.3.3.1 Field QA/QC

QA/QC measures undertaken to confirm benthic infauna sample integrity are the same as those described for sediment quality as described in Section 3.3.3.1.

4.3.3.2 Laboratory and Data Analysis QA/QC

Biologica laboratory QA/QC measures included an assessment of sorting recovery, identification error, and precision/accuracy of sub-sampling. Laboratory procedures included sample sorting measures, spot-checks, preliminary counting of major groups, and collaborative identification to accurately identify species to their lowest practicable level. Further detailed discussion of the laboratory QA/QC procedures used by Biologica and the findings of their QA/QC assessment are provided in their laboratory reports in Appendix 8A-2, 8A-3 and 8D-3.

Benthic data received from Biologica were reviewed upon receipt to verify that specified laboratory data quality objectives were met. No inconsistencies were noted that required follow up with the laboratory. Screening of the benthic data and calculation of the benthic indicators were reviewed by a second biologist for accuracy.

4.4 Results

This section describes results for the benthic infaunal sample collected from station SW-2 along the West transect; results from the co-located sediment sample are discussed in Chapter 3.0. Representative photographs from the field program are provided in Appendix 3A. The laboratory results and methods report provided by Biologica is provided in Appendix 8A-2 and 8A-3. A summary of benthic data collected from SW-2 over the time period 2018 to 2021 is provided in Table 4-1.

Table 4-1: Summary of Benthic Invertebrate Community Indicators at Station SW-2 (2018-2021)

Sampling Year	Total Density (org/m^2)	Total Richness	Simpson's Diversity Index (SDI)	Simpson's Evenness Index (SEI)
2018	13,818	61	Not calculated	Not calculated
2019	10,184	66	0.93	0.23
2020	130	6	0.66	0.49
2021	6,622	36	0.94	0.47

Anomalous results were recorded in 2020 in the form of substantially reduced density, richness, and diversity values relative to previous years at this station (Table 4-1). In 2021, the benthic community showed signs of rebound in terms of the number and types of invertebrates present. Order of magnitude increases were realized for density and richness indicators as well as an increase in diversity.

4.5 Discussion

Evaluation of benthic community indicators show an increase in total density, richness, and diversity in 2021 relative to the 2020 sampling program; specifically, order of magnitude increases in density and richness were recorded while diversity increased to a similar level noted in 2019. While small-scale spatial variation may partially contribute to the changes documented at SW-2 -- given that it is well known that benthic infaunal communities can show these kinds of differences in population metrics at the smallest spatial scales -- it alone cannot explain the results observed given similar changes were not seen at the other 59 stations sampled in 2020.

Rather, it is most likely that propellor wash from berthing ore carriers acted to mobilize finer sediments resulting in a coarsening of sediments at this station. Strong relationships exist between the distribution and abundance of infaunal invertebrates inhabiting soft-bottom environments and the size and texture of sediments; typically, higher abundance, biomass, and diversity are associated with smaller (i.e., finer) grain sizes (Coblentz et al. 2015). Hence, the loss of finer-grained sediment from SW-2 seems to have driven a concomitant reduction in benthic community indices; however, this change appears to have been temporary as order of magnitude increases in density and richness were recorded in 2021. It is important to note that benthic infaunal invertebrate communities are inherently dynamic and continually changing in response to various types and scales of disturbance (Thistle 1981, Zajac and Whitlatch 1982a, b). Moreover, these organisms have life history characteristics that make them resilient to disturbance, including: short generation time – life cycles are often less than one year (Warwick 1984); broadcast spawning – releasing sperm and eggs into the water column (Crimaldi and Zimmer 2014); and a larval (planktonic) phase, whereby they can disperse tens or even thousands of kilometres from their source (Pechenik 1999). Thus, the recovery at station SW-2 documented in 2021 has likely been facilitated by localised breeding and immigration of adults, and/or supply of larvae, from nearby unaffected areas (Hill et al. 2011).

Areas of sediment disturbance by propwash effects around the Ore Dock in Milne Port are consistent with what was predicted in the FEIS, which forecast the potential for minor and localized disturbances to sediment via propellor-generated currents with an overall negligible impact on sediment quality in the marine environment Baffinland (2012). As described in Chapter 3.0 (Sediment Quality), while substrates have been predominantly sandy since 2018, there has been a shift to coarser substrates in the last two years at station SW-2. The benthic community at this station seems to have rebounded from the impacts associated with changes in grain size, showing substantially more diversity (returned to 2019 levels) and higher abundance and richness (order of magnitude increases) in 2021 compared to 2020. Overall, monitoring results remain within original FEIS predictions, which forecasted negligible residual effects on sediment quality and benthic infaunal communities.

4.6 Conclusions and Recommendations

Collectively, the four years of data available at station SW-2 indicate that some physical disturbance has occurred, mostly likely a result of propellor-generated currents from berthing ore carriers. Targeted sampling at this station in 2021 indicates that the benthic infauna community appears to be in rebound from this disturbance, evidenced by substantial increases in monitoring metrics such as density and diversity; however, fine-scale spatial variation can also at least partially explain the results observed. Overall, monitoring results are consistent with FEIS predictions, which indicated the potential for localized resuspension of fine-grained sediments from propellor-generated currents and associated alteration to benthic community composition. Moving forward, it is recommended to continue targeted sampling in 2022 to increase understanding of natural variability as well as to monitor for additional changes in benthic community indicators at this site. Continued monitoring at this station may also help elucidate the relative contributions of natural spatial variability and propwash to the trends observed.

4.7 Closure

We trust this information is sufficient for your needs at this time. Should you have any questions or concerns, please do not hesitate to contact Philippe Rouget, on behalf of the undersigned, at 250-881-7372.

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