Pacific Reef Fisheries

Alva Beach Sediment EIMP Report

March 2022

WILD Environmental

Document Control

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Name and position	Signature	Date
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1. INTRODUCTION

1.1 Background

Pacific Reef Fisheries (Australia) Pty Ltd (PRF) owns and operates an aquaculture facility in Alva Beach (Ayr, Queensland) which has been used for the production of Black Tiger Prawns *(Panaeus monodon)* since 1994. The PRF facility (the Project) is located 15 km East of Ayr, North Queensland at 531 Trent Road, Alva on Lot 1/Plan RP804106 (Table 1, Figure 1).

Table 1: Site details for Alva Beach Aquaculture facility

Site Details	
Registered Owner	Pacific Reef Fisheries Pty Ltd
Site Address	531 Trent Road, Alva, Burdekin Shire, 4807
Lot on Plan	Lot 1 Plan RP804106
Lot Size	131.3 hectares
Local Government Area	Burdekin

PRF operates under an Environmental Authority (EA) EPPR00864913 issued by the Department of Environment and Science under the *Environmental Protection Act 1994* and an approval from the Department of Agriculture, Water and the Environment under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act; EPBC 2001/402). These approvals allow PRF to conduct the aquaculture of crustaceans and seafood processing, in accordance with several conditions. An Environmental Impact Monitoring Program (EIMP; Gassman 2013) was developed and implemented in June 2013 to monitor, identify, and describe any adverse impacts of PRF activities on the sediment and macroinvertebrates of the receiving environment.

1.2 Purpose

The design of the PRF EIMP (Gassman 2013) requires sediment and macroinvertebrate monitoring, conducted within the receiving environment and nearby control waterways on an annual basis in Spring. The REMP is designed to assess if the Project is impacting the sediment characteristics and macroinvertebrate community in the receiving environment. This report has been prepared by Wild Environmental for PRF and presents the results of sampling undertaken as part of the EIMP in November 2021.

1.3 Site Description

The Project consists of 98 hectares (ha) of grow-out ponds, 10.3 ha of settlement treatment ponds and 23 ha of constructed mangrove wetland. The mangrove wetland is used to reduce the concentration of contaminants (nutrients and sediments) in the Project discharge waters prior to release into the receiving environment. Kalamia Creek is the primary source of saltwater used by the Project, with surplus wastewaters discharged via an approved discharge structure into Little Alva Creek (Figure 1).

Pacific Reef Fisheries (Aust) Pty Ltd

Alva Beach Sediment EIMP Report 2021

Figure 1: Project location

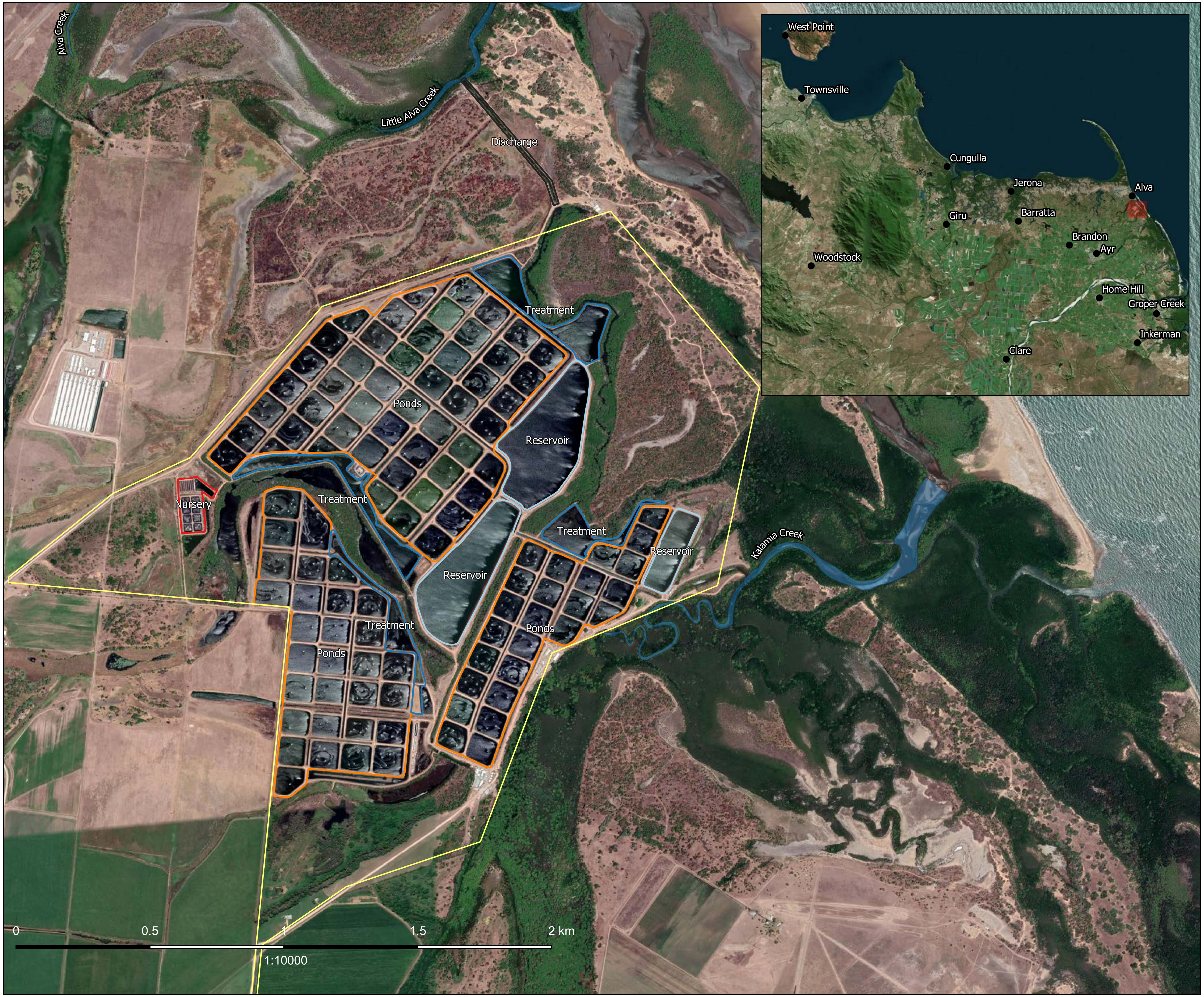
Legend

- ● Populated places

Land parcel

Project layout

- Discharge
- Nursery
- Ponds
- Reservoir
- Treatment



Job Number: JW2011484
Coordinate reference system: WGS 84
Date: February 2021

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2. ENVIRONMENTAL CONDITIONS

Rainfall data for the preceding year (November 2020 – November 2021) was obtained from the closest Bureau of Meteorology (BOM) Station, Number 033295 (Alva Beach); approximately 2 km away from the PRF facility. The data were used to understand the environmental conditions prior to the survey and to aid in the interpretation of results.

2.1 Rainfall

Rainfall of the Alva Beach region is typical of tropical parts of North Queensland with a defined "wet season", typically November to April and "dry season", typically May to October. Rainfall in 2021 was higher than average in a number of months in the later part of the year (July-November). Of note, monthly rainfall in November 2021 (when the sampling was undertaken) was significantly higher than the long-term average of the region (402, and 70.1 mm, respectively). The Alva Beach weather station recorded 3.6 mm of rainfall on the day of sampling; although 238.6 mm of rain was recorded in the week prior to sampling.

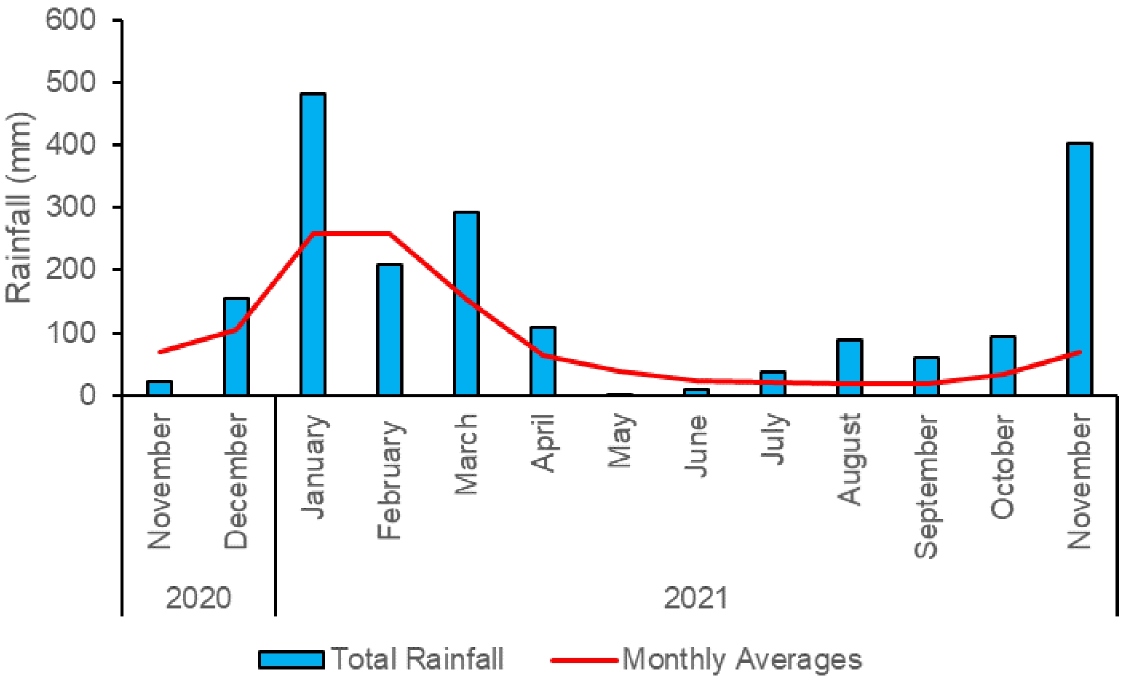

Figure 2: Total monthly rainfall data (BOM station 033295) for Alva Beach between November 2020 and October 2021 compared with the long-term rainfall average (1997-2021)

3. METHODOLOGY

Sampling is conducted annually and in accordance with the approved EIMP prepared by Gassman (2013) at four locations, including (Table 2, Figure 3):

- Two potential impact locations in Little Alva Creek, which may be influenced by Project activities
  - Location E - 500 m downstream into Little Alva Creek
  - Location F - 250 m north of mouth of Little Alva Creek
- Two control locations which are located in Alva Creek, some distance from Project activities and are unlikely to be influenced wastewater discharges
  - Location B – 500 m downstream into Alva Creek
  - Location C – 250 m north of mouth of Alva Creek

At each location sampled, three sites were sampled in a line transect across the mouth of the creek (i.e., one site from the left bank, one site from the middle of the channel, and one site from the right bank). Numerical nomenclature of the subsamples progressed from 1 to 3 in an east to west direction at each sampling location specified within the EIMP design documentation.

Sampling for the Spring 2021 survey was conducted on 18 November 2021 at sites outlined above and in Table 2. At each monitoring site, two replicate samples were collected for sediment and two replicate samples were collected for macroinvertebrate analysis using a 1 litre stainless steel Van Veen grab.
Samples were collected for the analysis of:

- Sediment
  - Total organic carbon (TOC)
  - Particle size distribution
- Benthic infauna
  - Macroinvertebrate abundance
  - Macroinvertebrate taxonomic richness

Detailed methodology for sediment and benthic infauna collection, and analysis is provided in Section 3.1 and Section 3.2 below.

3.1 Sediment

At each location, three sites were sampled in a line transect across the mouth of the creek as detailed in Section 3. Each site sampled in November 2021 had two sediment samples collected prior to composition and homogenising, before being stored on ice in appropriate containers provided by the National Association of Testing Authorities (NATA) certified analysing laboratory (Australian Laboratory Services (ALS) Environmental) and delivered within the holding times. Samples were analysed for particle sizing and TOC in accordance with the EIMP (Gassman 2013).

Strict QA/QC protocols were adhered to throughout the sampling, in accordance with the EIMP and the *Queensland Monitoring and Sampling Manual*[1]. Powder-free nitrile gloves were worn during sample container handling for sediment sampling, to reduce the risk of sample contamination during collection. One replicate sample was collected and results for replicate samples were analysed to assess variability by calculating the replicate percentage difference (RPD) between the samples, with a RPD of <50% between field replicates considered acceptable[1]. Equipment was thoroughly cleaned with site water and rinsate and visually inspected between samples.

3.2 Macroinvertebrates

At each location, three sites across the creek were sampled using a Van Veen Grab. Each site had two sediment sub-samples collected using a 1 L stainless steel Van Veen grab before sub-samples were combined. Sediments collected for benthic macroinvertebrate identification were transferred through a 500 µm sieve and gently rinsed with site water at the Alva Beach foreshore. The retained material was preserved in 70% ethanol for laboratory-based identification of macroinvertebrate species by a taxonomic specialist. Removal of macroinvertebrates from any remaining sediment matrix (i.e., sediment particles >500 µm in diameter) was conducted through a 20-minute timed pick. This methodology is adapted from freshwater macroinvertebrate monitoring and is designed to ensure sufficient individuals are captured for identification when a large ratio of sediment to biota is retained following sieving.

Table 2: Sampling locations

Site	Latitude	Longitude	Purpose
B (500 m downstream into Little Alva Creek)			
B1	-19.465978°	147.490188°	Potential Impact
B2	-19.465927°	147.490022°	Potential Impact
B3	-19.465863°	147.489925°	Potential Impact
C (250 m north of mouth of Little Alva Creek)			
C1	-19.465155°	147.491744°	Potential Impact
C2	-19.465225°	147.491455°	Potential Impact
C3	-19.465346°	147.492153°	Potential Impact
E (Location in reference creek (Alva Creek), corresponding to B)			
E1	-19.462982°	147.487526°	Control
E2	-19.463039°	147.487371°	Control
E3	-19.462752°	147.487203°	Control
F (Location in reference creek (Alva Creek), corresponding to C)			
F1	-19.462358°	147.488582°	Control
F2	-19.461786°	147.489111°	Control
F3	-19.462085°	147.490483°	Control

Note: coordinates are provided in GDA94

[1] Monitoring and Sampling Manual 2018: Environment Protection (Water) Policy 2009, Queensland Department of Environment and Science, Queensland Government, Brisbane

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Figure 3: Sampling locations

Legend

- Populated places
- Land parcel

Sediment sampling sites

- Control
- Potential impact

Job Number: JW211484
Coordinate reference system: WGS 84
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4. RESULTS AND DISCUSSION

4.1 Sediment

4.1.1 Particle Size Distribution

4.1.1.1 Spring 2022

Particle size was variable within a location, but was generally similar amongst locations in November 2021, with a general absence of large particles (>1180 µm) at all locations (Figure 4). Interestingly, location E (control) generally had a higher abundance of large particles relative to other locations; although; average particle sizes at potential impact sites were comparable to control sites, as indicated by overlapping error bars. Finer grain size dominated the sediments at all locations (Figure 5).

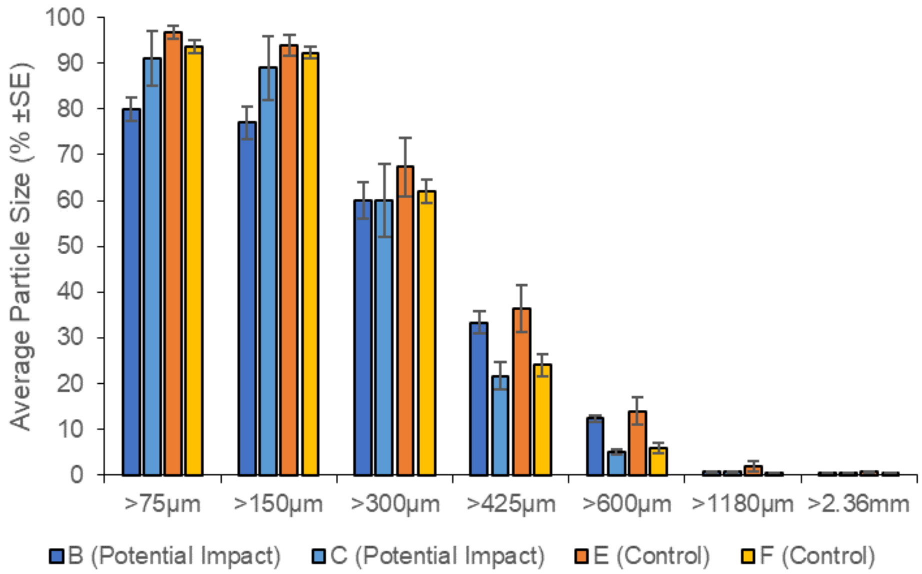

Figure 4: Average particle size (± standard error) at locations sampled under the EIMP in November 2021

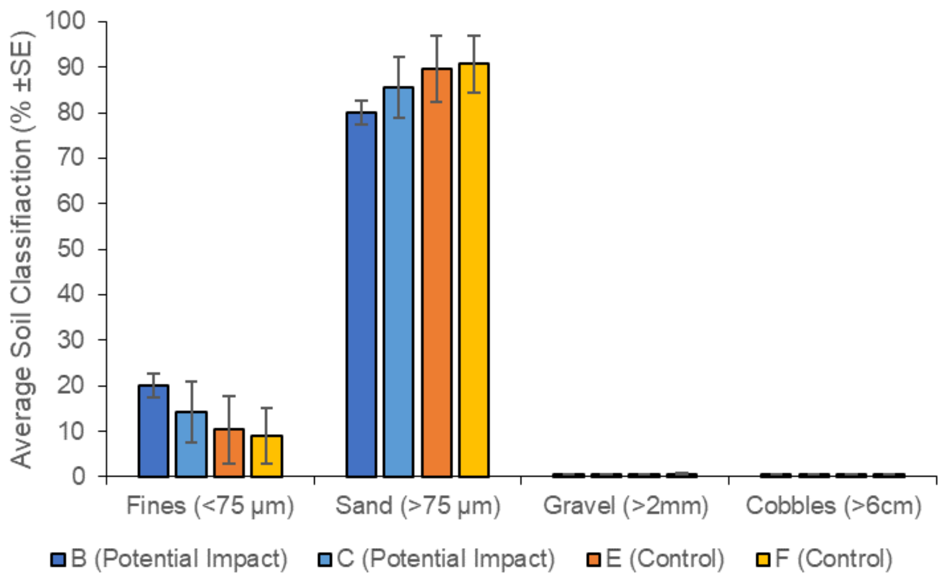

Figure 5: Average particle size distribution at locations sampled under the EIMP in November 2021

All locations were dominated by sand particles (75 µm – 2 mm) with gravel (2 mm – 6 cm) comprising less than 3% of the sediment analysed. At sites sampled in November 2021, sand classification was present at percentages ranging from 75 % - 97 %. Gravel was present at sites C3, E2, and E3 at low percentages (1% - 2%) and cobbles were absent at all sites (and locations). Fine sediments were more prevalent at potential impact locations (B and C) compared with control locations (E and F).

Variations in sediment particle size distribution observed across the four monitoring locations can be largely explained by the physical conditions experienced within the receiving environment. Sites C and F are located in the downstream mixing zone of Little Alva and Alva creeks, respectively. As such, they are relatively exposed to both wind and tidal forces that provide sufficient energy to the system to maintain particle suspension within the water column. Similarly, satellite imagery of the local area suggests that Alva Creek experiences a greater flow volume and velocity when compared with Little Alva Creek, which will also aid in sediment resuspension. These higher energy sampling sites are characterised by low proportions (<10%) of fine particles within the analysed sediments, resulting in dominant composition of sand sized particles (>90%).

Within the relatively narrow and protected mouth of Little Alva Creek, sediments collected at Location B contained the highest proportion of fine particles within the substrate (16–25%) which is consistent with previous EIMP results. This compositional difference at location B compared to other three locations may be a result of natural conditions or of impacts associated with the PRF operation, or a combination of both natural conditions and PRF influences.

Reduced flow velocities associated with the relatively small watercourse of Little Alva Creek and increased shear forces associated with the interaction of riverine flow with the watercourse banks, reducing the energy of the local environment and allowing finer particles to settle out of the water column into the underlying sediments. Additionally, wastewater discharges from activities associated with the PRF operation is expected to contain higher fine particle concentration than in the receiving environment which may be compounding the effect of the natural dynamics of the waterway, resulting in higher fine particle composition compared to comparable location E.

4.1.1.2 Temporal Trends

A review of fine particle composition at locations from available data (2018 to 2021) was undertaken to understand temporal variations and / or trends. The composition of fine particles within benthic sediments at the two downstream mixing zones associated with Little Alva Creek (location C) and Alva Creek (location F) remained relatively consistent over the assessment period (2018 - 2021), at <10% of the benthic substrate. Average fine particle percentage composition at both of these more estuarine locations (location C and location F) increased in 2021 from the previous survey (3% and 6% increase, respectively).

Fine particle percentage composition at location C (potential impact) is within the range observed at Location F, and as such, there is no obvious indication of PRF wastewater discharges influencing fine particle percentage composition at location C.

Within Little Alva Creek at location B, there was a slight increase in fine sediments percentage composition between 2018 and 2019, although fine sediment percentage has reduced from 2019 to 2021, to levels comparable with 2018 (Figure 4). Temporal changes in fine sediment at location B was not observed at the comparable location (location E) in Alva Creek. Instead, fine particles composition at location E declined from 16.3% in 2018 to 3.3% in 2021 (Figure 4). Differences in temporal trends at location B and location E may be reflective of differences in the corresponding creek dynamics (i.e. Alva Creek and Little Alva Creek, respectively), surrounding land uses or influences from PRF activities, or a combination of these. It is important to note that any influence of high fines at location B (potential impact) erodes quickly once in the estuary and is not reflected at location C (potential impact).

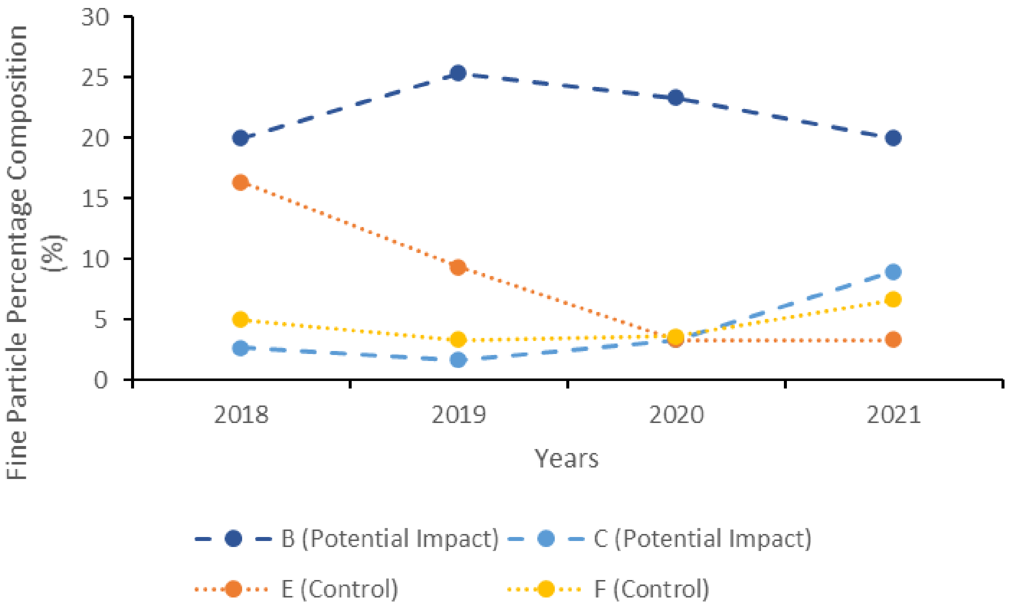

Figure 6: Average fine particle percentage composition at locations during spring EIMP surveys from 2018 to 2021

4.1.2 Total Organic Carbon (TOC)

4.1.2.1 Spring 2021

TOC varied within, and amongst locations (Figure 7), although average TOC concentration was highest at location B. TOC concentrations at control locations (E and F) were more variable (as indicated by large error bars; Figure 7) than at potential impact location B.

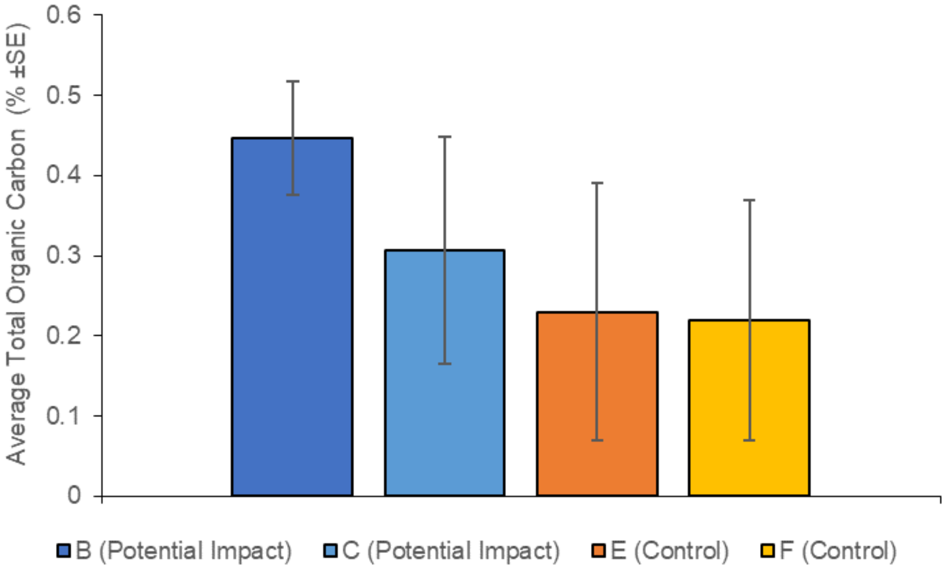

Figure 7: Average total organic carbon in sediment ± standard error at locations sampled under the EIMP in November 2021

Spatial variability in sediment TOC concentration mirrored the spatial variability of fine particle percentage composition (Figure 5). Previous studies have documented an inverse relationship between particle size and organic matter content, likely attributed to the larger surface area associated with smaller particles that allows for the accumulation of organic carbon. the strong positive relationship between contaminants/nutrients and small particle size. Indeed, data collected in Spring 2021 also demonstrates the strong correlation between particle size and TOC as evident by the high R value (Figure 8). For example, high TOC at location B, and to some extend location C, is correlated with high fine particle percentage composition at these two locations.

TOC in sediments at location E, within the mouth of the Alva Creek ranged between 0.05-0.11% and were generally comparable to the more exposed location F. These concentrations were notably lower than those observed at comparable locations of Little Alva Creek (potential impact locations). These results are consistent with the reduced proportion of fine particles within the sediments.

As mentioned previously, the low energy environment associated within Little Alva Creek at location B may support the continued deposition of fine particles, resulting in associated elevated concentration of total organic carbon. However, TOC input as a result of aquaculture wastewaters associated with the PRF facility into Little Alva Creek must also be considered.

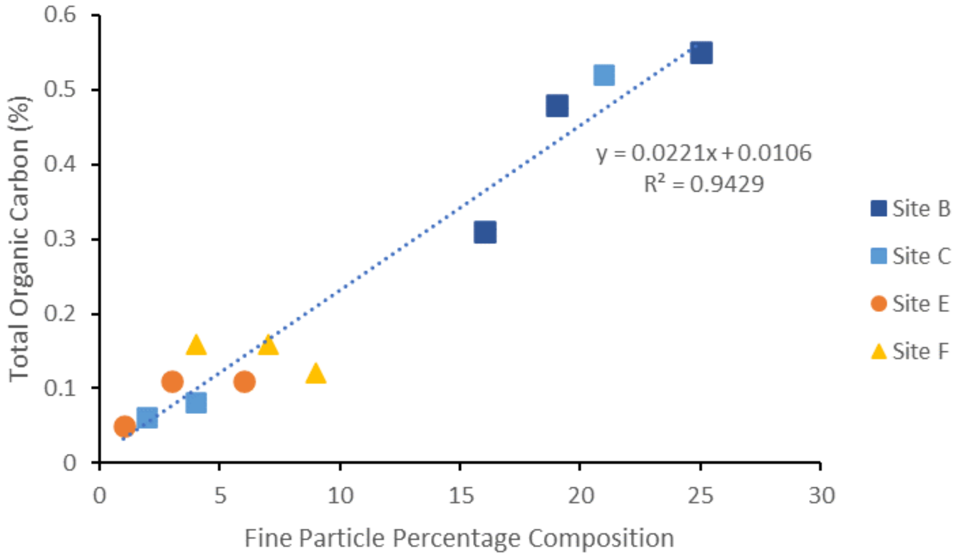

Figure 8: Total organic carbon and sediment fines composition at locations sampled in November 2021

4.1.2.2 Temporal Trends

TOC temporal variability is generally consistent with observed trends in fine particle percentage composition. Sediment-associated TOC concentration at control locations (location E and location F), and potential impact location C increased in the 2021 survey; the first time since 2019. An opposing decline in sedimentary TOC concentration has been identified for the potentially impacted location B (Figure 9), as supported by a corresponding decrease in fine particles since 2020 (Figure 6).

Despite consistent trends of increasing sediment-associated total organic carbon concentrations within Little Alva Creek (location B), and decreasing concentrations within Alva Creek (location E), analysis of TOC concentrations at location C and location F (downstream of the waterways) indicated relatively consistent organic carbon content between 2018 and 2020. However, both location C and location F increased in TOC concentrations in 2021 (Figure 9).

Where the PRF wastewater discharges is attributing to increased TOC concentrations within the sediments of Little Alva Creek (location B), the potential impact to the receiving environment is likely restricted to within Little Alva Creek with minimal potential impact into the coastline (based on the results at location C).

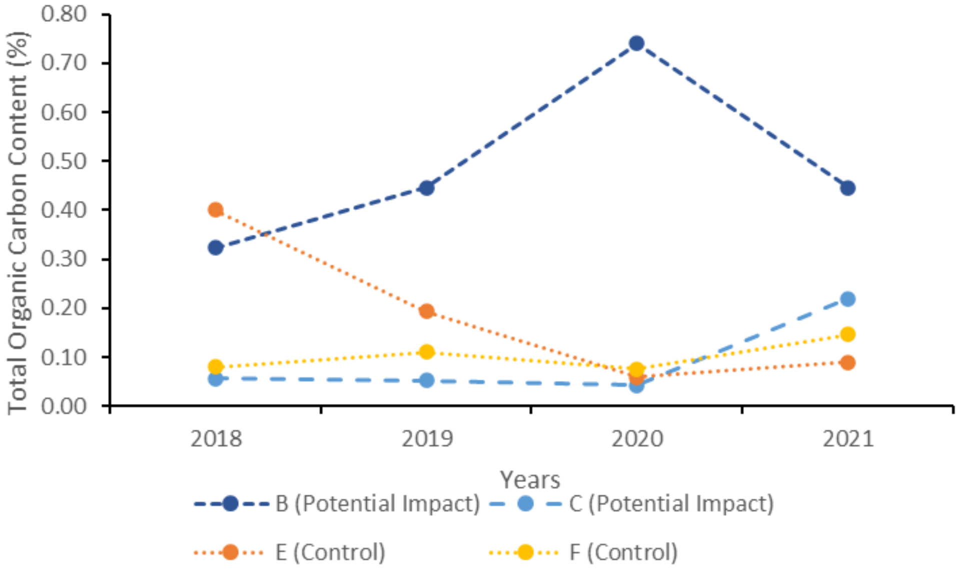

Figure 9: Average total organic carbon content during spring surveys at locations sampled under the EIMP from 2018 to 2021

4.2 Benthic macroinvertebrates

Macroinvertebrate communities at potential impact locations (location B and location C) were generally comparable to control locations, and it is considered that observed differences in taxonomic abundance and richness are caused by natural variation in environmental conditions, rather than from PRF operations. Additionally, macroinvertebrate communities were variable over EIMP monitoring (2018-2021) with no consistent trend observed.

4.2.1 Community Composition

In November 2021, there were 1,068 individuals identified from 21 taxa and eight families (Table 3)[2]. The most abundant order was Gastropoda. However, the largest number of individuals was from the family Tellinidae (Order: Bivalvia), equating to 80% of all macroinvertebrates collected (1,624 individuals).

[2] One Polychaeta was removed at site F1A due to damage

Table 3: Macroinvertebrate taxonomic richness in sediment during the November 2021 survey

Phylum	Order	Family
Annelida	Polychaeta	Capitellidae
		Nephtyidae
		Nereididae
		Oweniidae
		Polychaeta
		Polynoidae
Brachiopoda	Lingulida	Linguloidea
Crustacean	Amphipoda	Melitidae
	Ostracoda	Ostracoda
	Tanaidacea	Apseudidae
Mollusca	Bivalvia	Mytilidae
		Tellinidae
		Veneridae
	Gastropoda	Cassidae
		Cerithiidae
		Haminoeidae
		Littorinidae
		Naticidae
		Neritidae
		Turritellidae
Nemertea	Nemertea	Nemertea

4.2.2 Abundance

4.2.2.1 Spring 2021

Total abundance in November 2021 varied considerably amongst sites, ranging from 3 to 432 individuals at a site. Average total abundance of macroinvertebrates was generally comparable amongst locations B, E and F as indicated by overlapping error bars (Figure 10). However, abundance at Location C was substantially different, with consistently higher abundance at all sites samples.

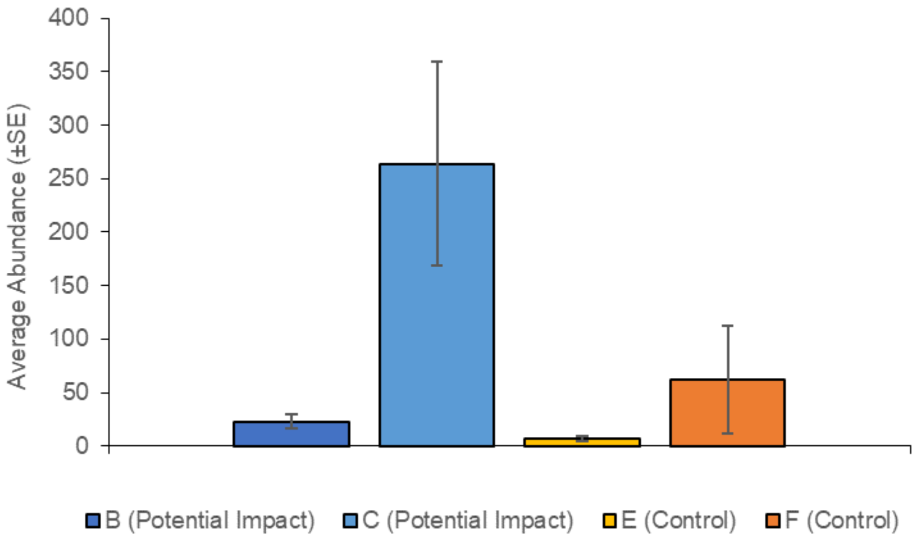

Figure 10: Average abundance ± standard error at each location sampled under the EIMP in November 2021

4.2.2.2 Temporal Trends

Macroinvertebrate abundances in 2021 were compared with previous monitoring results to understand variation through time. Total abundance in 2018 did not exceed 19 individuals (Location C). However, total abundance declined in 2019 (maximum 11 individuals recorded at Location F). Macroinvertebrate abundance increased in 2020 at both control and potential impact locations, although a notable increase in abundance occurred at both control locations (location E and location F) in 2021. However, the increase in abundance at all locations in 2020 was due to changes in sampling (i.e., from 1 mm to 500 µm sieve). Typically, three sites are sampled across the creek bed in accordance with the PRF EIMP.

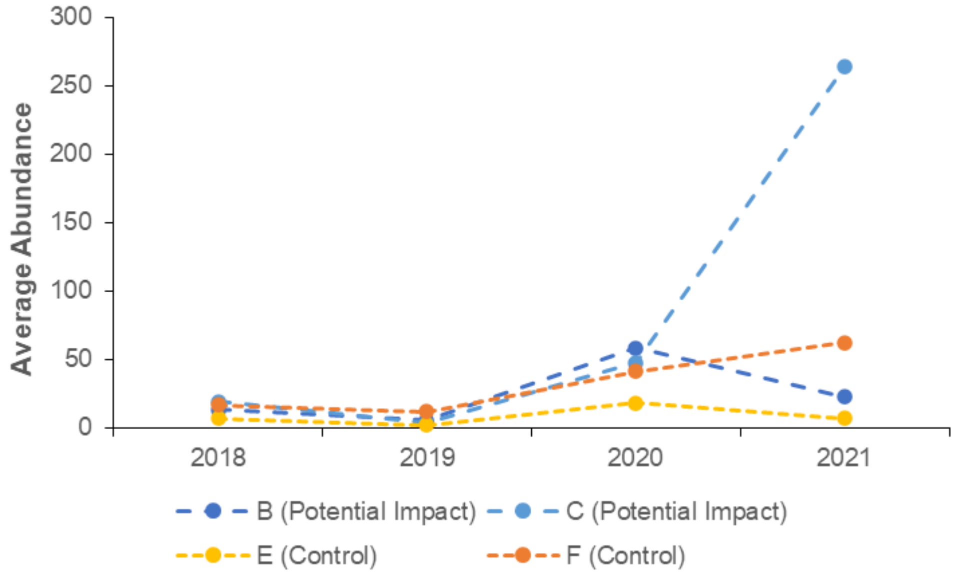

Figure 11: Average abundance at locations surveyed under EIMP monitoring from 2018 to 2021

4.2.3 Taxonomic Richness

4.2.3.1 Spring 2021

There was variation in average taxonomic richness amongst locations, however differences amongst location B, location C and location E were not significant as indicated by overlapping standard error bars. Location F had the highest average taxonomic richness (9.0) and was significantly different to Locations C and E. (Figure 12). Additionally, location F also recorded the highest number of unique taxa specific to that location (i.e., not found at any other location). Taxonomic richness variation within a location was generally comparable among locations (similar standard error bars), regardless of the average taxonomic richness.

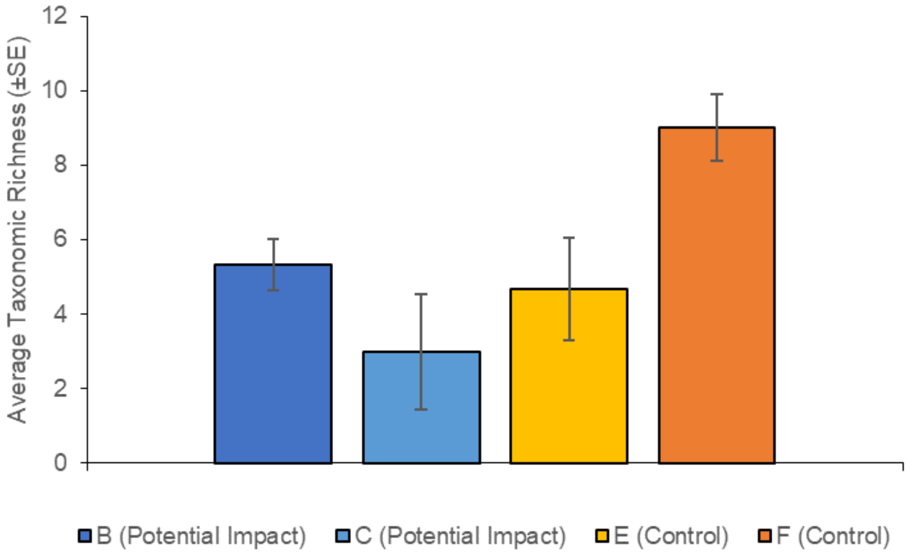

Figure 12: Average macroinvertebrate taxonomic richness ± standard error at each location sampled under the EIMP in November 2021

4.2.3.2 Temporal Trends

Macroinvertebrate taxonomic richness in Spring 2021 was compared with available previous results (2018 – 2020) to understand temporal trends and patterns. Taxonomic richness recorded a decline between 2018 and 2019 at all locations, ranging from 3.7 (location E) to 5.7 (location C and F) in 2018 to an average taxonomic richness of 1.3 (location E) to 3.3 (location F) in 2019. Taxonomic richness at all locations increased in 2020 ranging from 3.7 (location E) to 8.3 (location F). Furthermore, taxonomic richness at location E and location F increased further; however, location B and location C demonstrated a decline in taxonomic richness (Figure 13).

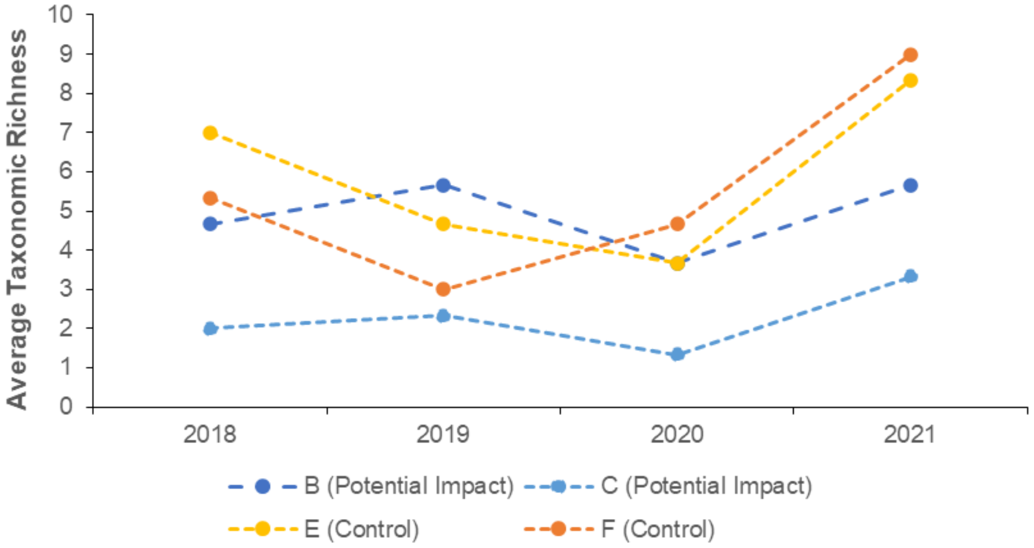

Figure 13: Average taxonomic richness at locations surveyed under EIMP monitoring from 2018 to 2021

5. RECCOMENDATIONS AND CONCLUSIONS

This report summarises the sediment and macroinvertebrate monitoring completed in November 2021 and has provided results that indicate that the prawn farm may be having a limited impact on organic carbon concentration; however, there is no evidence that the PRF wastewater discharge is having an impact on the macroinvertebrate community (abundance and taxonomic richness), nor on the particle sizing at the potentially impacted locations beyond natural conditions.

5.1 Recommendations

It is recommended that further monitoring is undertaken to fully quantify rhe effects of the PRF operation on the receiving environment. A comprehensive review of water quality, sediment quality and macroinvertebrate community for all available data should be undertaken to provide a detailed assessment on the potential effects of the PRF wastewater discharge on the receiving environment, including where necessary, multivariate statistical analyses (PERMANOVA, ANOSIM, nMDS, SIMPER) to assess potential impacts to the receiving environment and to correlate sediment and water quality parameters to macroinvertebrate community structure where the parameters in the receiving environment indicate a potential influence.
Furthermore, investigation into sediment types using isotopes may be crucial into further understanding the carbon cycle of the receiving environment and how the TOC is affecting it.

5.2 Conclusions

Elevated concentrations of total organic carbon were recorded at Little Alva Creek, however TOC concentrations at location B in Little Alva Creek were lower in 2021 than in previous surveys (2018, 2019, and 2020). Higher fine particle composition may be influencing the total organic carbon concentration due to the strong positive relationship that has been previously reported. Higher TOC and fine particle composition at location B may not be reflective of either impacts from the PRF wastewater discharge or natural conditions of the small waterway, however until a comprehensive review is undertaken, neither cause can be determined.

Following the identification of limited numbers of benthic macroinvertebrates during previous EIMP assessments, sampling was updated in 2020 to reflect the current ‘best practice’ methodology, including a reduction in the sieve mesh size from 1 mm to 500 µm which resulted in a significant increase in both the number of individuals collected and the determined taxonomic richness. Average abundance of macroinvertebrates in 2021 were considerably higher at location B compared to other locations and surveys, primarily due to large numbers of the mollusc *Tellinidae*. The apparent increase in abundance from 2020 to 2021 should be considered a reflection of improved sampling practices rather than a large-scale ecological change across the receiving environment.

Further monitoring should be considered to fully quantify the effects of the operation on the receiving environment. Water quality monitoring (*in situ* and physicochemical) has been completed in previous years and is beneficial to identify potential contaminants in the area. Further investigation into sediment types using iso-types will be crucial into further understanding the carbon cycle of the receiving environment and how the TOC is affecting it.

6. APPENDIX A

Table 4: Particle sizing distribution

Particle Size	Unit	B1	B2	B3	C1	C2	C3	E1	E2	E3	F1	F2	F3
>75	µm	84	75	98	96	79	94	99	97	93	91	96	94
>150	µm	82	70	97	95	75	90	98	94	90	90	94	93
>300	µm	68	55	72	63	45	57	79	66	56	60	67	59
>425	µm	38	32	26	23	16	29	46	34	23	24	28	20
>600	µm	13	13	6	5	4	11	20	11	7	6	8	4
>1180	µm	<1	1	<1	<1	1	<1	4	1	<1	<1	<1	<1
>2.36	mm	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1

Particle Size		B1	B2	B3	C1	C2	C3	E1	E2	E3	F1	F2	F3
Fines	<75 µm	19	16	25	2	4	21	6	1	3	7	9	4
Sand	75 µm – 2mm	81	84	75	98	96	78	94	97	96	93	91	96
Gravel	2mm – 6cm	<1	<1	<1	<1	<1	1	<1	2	1	<1	<1	<1
Cobbles	>6cm	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Particle Sizing	Units	B1	B2	B3	C1	C2	C3	E1	E2	E3	F1	F2	F3
Total Organic Carbon	µg/L	0.48	0.31	0.55	0.06	0.08	0.52	0.11	0.05	0.11	0.16	0.12	0.16

Particle Sizing	Units	B1	B2	B3	C1	C2	C3	E1	E2	E3	F1	F2	F3
Total Organic Carbon	µg/L	0.48	0.31	0.55	0.06	0.08	0.52	0.11	0.05	0.11	0.16	0.12	0.16