

Before the Expert Fast-track Panel

FTAA-2511-1150

Under the Fast-track Approvals Act 2024 (**FTAA**)

And

In the Matter of an application for approvals by **MCCALLUM BROTHERS LIMITED** for the Te Ākau Bream Bay Sand Extraction Project located at Te Ākau Bream Bay, Northland

**Evidence of Simon Andrew West on behalf of McCallum Brothers Limited in
Response to Minute 14 Further Information Request: RFI 4-5**

(Marine Ecology)

Dated 12 October 2026

Jeremy Brabant

Barrister

Level 7, 50 Albert Street, Auckland Central

PO Box 1502, Shortland Street, Auckland 1140

M: 021 494 506

E: jeremy@brabant.co.nz

Introduction

1. My name is Simon Andrew West.
2. I am a Marine ecologist. I hold Bachelor of Science with Majors in both Biology and Earth Science from the University of Waikato, and a Master of Science with Honours in Zoology from the University of Auckland (1991).
3. I have been employed by Bioresarches since April 1991. I have 35 years' experience as a marine ecologist and am currently the Technical Director Marine Ecology at Bioresarches. I have conducted ecological surveys on the continental shelf, in coastal waters, harbours, waterways and beaches to monitor the health of the marine environment and gain a measure of the impact of development on land or discharges to the sea. The majority of surveys have been conducted in the North Island but have included some South Island studies. This has involved measuring the levels of pollution and contamination, and the impact of activities like dredging and the effect of its disposal on the coastal environment. My work includes both resource consent applications and consent monitoring. Over the course of my time at Bioresarches my role has changed from conducting directed tasks to designing and leading a team of colleagues.
4. This evidence is provided as part of McCallum Brothers Limited's (**MBL**) response to the Expert Consenting Panel's (**Panel**) request for further information contained in Appendix One to Minute 14 **RFI** 4-5 on the Te Ākau Bream Bay Sand Extraction Project (**Project**).
5. I prepared and or reviewed the following material lodged in support of MBL's application:
 - a. Report titled Assessment of Ecological Effects dated 17 December 2025 included as Attachment 12 to the MBL Assessment of Environmental Effects.

- b. Report titled Pre Sand Extraction Assessment Report, February - March 2024, dated 9 December 2025 included as Appendix C in Attachment 29 to the MBL Assessment of Environmental Effects.
- c. Environmental Monitoring Management Plan ("EMMP") version 1.2 dated 7 August 2026 included as Attachment 29.
- d. I reviewed attachment Thirty-Five [Draft Proposed] Recommended Wildlife Approval Conditions (dated 15 July 2026);
- e. I reviewed and provided input to the Coral Management Plan (CMP) updated 1 September 2026 included as Attachment 30.
- f. I was lead author on Bioresearches (2025). Pakiri Offshore Sand, Recovery Monitoring – Area 1, 2023 – 2024. Report for McCallum Bros Limited. pp 122.
- g. I am the author of all the maps in the reports and attachments with the Bioresearches logo.

Scope of Evidence

- 6. My evidence responds to the following questions raised by the Panel in RFIs 4-5, insofar as they relate to marine ecology and, in particular, benthic ecology effects of the proposed sand extraction activity.
 - a. Minute 14 Appendix one Paragraph [4] the Panel understands that post-completion monitoring at Pakiri may now be completed, and that results/reporting may potentially be available (see Mr West's footnote 6). Could a copy of the Pakiri Recovery Monitoring Study (2023-2024) please be provided, along with any material relevant and available from the August 2026 monitoring.
 - b. Minute 14 Appendix one Paragraph [5] Reference is made to the recovery experience at Pakiri (see paragraphs 185-188 of the 12 August 2026 statement of evidence) and comparisons made there to what might be expected to happen at this site. Does this take into account the difference between the sites, for example with the

application site being understood to be part of a closed system regarding sediment?

Code of Conduct

7. Although this is not a hearing before the Environment Court, I confirm that:
- a. I have read and am familiar with the Environment Court’s Code of Conduct for Expert Witnesses as specified in the Environment Court’s Practice Note 2023 (**Code**); and
 - b. The reports and other relevant documents referred to above authored by me:
 - i. Are within my area of expertise (except where I state that I rely upon the technical reports of other expert witnesses provided in support of the application);
 - ii. Have been prepared in accordance with the Code; and
 - iii. I have not omitted to consider any material facts known to me that might alter or detract from the opinions expressed.

Executive Summary

8. This evidence responds to the Panel’s further questions concerning the relevance of the Pākiri monitoring results to the assessment of benthic ecological effects at Te Ākau Bream Bay, and provides an update on the post completion recovery monitoring being undertaken at Pākiri.
9. The Pākiri Recovery Monitoring Study (2023-2024) is provided with this response. Post completion monitoring of the Temporary Sand Extraction Area at Pākiri is not yet complete. Sand extraction ceased on 28 August 2025. The originally planned 6 month recovery survey could not be undertaken because a wildlife permit was required following the earlier recording of live protected stony corals. The monitoring programme was therefore revised, in agreement with Auckland Council, to surveys at approximately 12 and 18 months following cessation of extraction. The 12

month survey commenced on 30 September 2026 and, at the date of this evidence, the resulting data have not yet been fully processed or analysed.

10. In my opinion, Pākiri remains a relevant and useful analogue for assessing the likely benthic ecological response to sand extraction at Te Ākau Bream Bay. Both areas are offshore sandy seabed environments and are effectively closed systems in terms of contemporary sediment supply. They are exposed north-eastern coastal environments with broadly similar wave climates and similar extraction depth ranges. The same vessel, the William Fraser, and essentially the same shallow extraction methodology are also relevant to both sites. The Assessment of Ecological Effects accordingly identified the Pākiri monitoring programme as a strong analogue because of the similar sedimentary and ecological settings. The coastal process assessment also notes that predicted seabed shear stresses at Te Ākau Bream Bay are consistent with observations made at Pākiri.
11. I do not rely on Pākiri as demonstrating that the two sites are identical, or as providing a precise prediction of the time required for recovery at Te Ākau Bream Bay. Rather, the Pākiri monitoring provides site relevant empirical evidence of the nature of the ecological response and the capacity for recolonisation following shallow sand extraction. Recovery is expected to occur through survival of organisms within and adjacent to extraction tracks, lateral immigration from surrounding seabed, settlement of planktonic larvae, and subsequent growth and community development. Site specific monitoring and adaptive management at Te Ākau Bream Bay will be used to confirm the actual ecological response and recovery.

Response to RFI 4

12. *[4] the Panel understands that post-completion monitoring at Pakiri may now be completed, and that results/reporting may potentially be available (see Mr West's footnote 6). Could a copy of the Pakiri Recovery Monitoring Study (2023-2024) please be provided, along with any material relevant and available from the August 2026 monitoring.*

13. A copy of the *Pākiri Recovery Monitoring Study (2023–2024)* is provided with this response.
14. The Pākiri Recovery Monitoring Study (2023-2024) relates to the southern part of the offshore Pākiri sand extraction area and was undertaken in accordance with the monitoring requirements outlined in EMMP Area 1, triggered by the closure of the of the offshore areas with the exception of the Temporary Sand Extraction Area (TSEA). It provides the recovery information referred to in my earlier evidence.
15. Post-completion (recovery) monitoring of the TSEA has not yet been completed. Sand extraction within the TSEA ceased on 28 August 2025. The monitoring programme originally provided for recovery surveys at approximately 6 and 12 months following cessation of extraction, which would have resulted in surveys in approximately February/March 2026 and August/September 2026.
16. Earlier monitoring had, however, recorded live protected stony corals, meaning that a wildlife permit was required before further benthic sampling could lawfully be undertaken. That permit was not issued until 19 August 2026. Consequently, the planned 6 month recovery survey could not be undertaken. Following discussion with Auckland Council, the recovery monitoring programme was revised to surveys at approximately 12 and 18 months following cessation of extraction.
17. The first of those post completion recovery surveys commenced on 30 September 2026, when the epibenthic dredge tows were undertaken. Grab sampling and seabed photography were undertaken on the 7 and 8 October 2026. Accordingly, there is no separate August 2026 monitoring dataset or report available to provide to the Panel at the date of this evidence. The data from the 12 month survey will require collation, taxonomic processing and analysis before conclusions can be drawn regarding recovery.

18. *[5] Reference is made to the recovery experience at Pakiri (see paragraphs 185-188 of the 12 August 2026 statement of evidence) and comparisons made there to what might be expected to happen at this site. Does this take into account the difference between the sites, for example with the application site being understood to be part of a closed system regarding sediment?*
19. In making the comparison with Pākiri, I have considered whether differences between the two sites would materially affect the relevance of the Pākiri monitoring results to the assessment of benthic recovery at Te Ākau Bream Bay. In my opinion, Pākiri remains a useful and relevant analogue. Indeed, the Assessment of Ecological Effects identified the Pākiri offshore sand extraction monitoring as a strong analogue because the two sites have similar sedimentary and ecological settings.
20. The example identified by the Panel, namely that Te Ākau Bream Bay is understood to be a closed system in terms of sediment supply, does not in my understanding distinguish it from Pākiri. Both the Pākiri and Te Ākau Bream Bay embayments are effectively closed systems in terms of contemporary external sediment supply. Both are also exposed north-eastern coastal environments with broadly similar wave climates, and the offshore extraction areas occur over a similar water-depth range. The coastal-process assessment for Te Ākau Bream Bay also specifically compares the predicted seabed shear stresses with observations made at Pākiri and records that the results are consistent with those observations.
21. There are also important similarities in the disturbance itself. Sand extraction at Pākiri has been undertaken using the William Fraser, the same vessel proposed for Te Ākau Bream Bay, and involves disturbance of a shallow layer of sandy seabed. The proposed Te Ākau Bream Bay extraction method uses a 1.6 m wide draghead and extracts a layer approximately 100 mm deep. In my opinion, these similarities make the ecological response observed at Pākiri particularly relevant when considering the likely nature and rate of recolonisation following extraction at Te Ākau Bream Bay.

22. Importantly, biological recovery of the benthic community does not depend on replacement of the extracted sand by sediment entering from outside the embayment. Recovery is expected to occur through survival of organisms within and adjacent to the extraction track, lateral movement of mobile organisms from surrounding undisturbed seabed, settlement of planktonic larvae, and subsequent growth and community development. These are the recovery mechanisms described in the Assessment of Ecological Effects.
23. I do not suggest that the two sites are identical, or that the rate of recovery measured at Pākiri can simply be transferred directly to Te Ākau Bream Bay. Local differences in sediment characteristics, benthic community composition, the spatial and temporal distribution of extraction, and natural variability may affect the rate of recovery. The Pākiri results are therefore used as empirical evidence of the nature of the ecological response and the capacity for recolonisation following this form of shallow sand extraction, rather than as a precise prediction of the time required for recovery at Te Ākau Bream Bay.
24. On that basis, I consider that the comparison with Pākiri remains appropriate. The similarities between the sites, including their sediment setting, wave exposure, water depths and extraction methodology, provide a reasonable basis for using the Pākiri experience to inform the expected ecological response at Te Ākau Bream Bay. The site-specific monitoring and adaptive management proposed for Te Ākau Bream Bay will nevertheless be required to confirm the actual response and recovery of the benthic community.



Simon West

12 October 2026

Pakiri Offshore Sand

Recovery Monitoring – Area 1, 2023 – 2024

for: McCallum Bros Limited



DOCUMENT CONTROL AND REVISION RECORD

Document title	Pakiri Offshore Sand Recovery Monitoring – Area 1, 2023 – 2024
Prepared for	McCallum Bros Limited

Author(s)	Simon West, M.Sc. (Hons), Technical Director Marine Ecology	
	Jessica Patiño-Pérez, Ph. D., Marine Ecologist	
Reviewer(s)	Laureline Meynier, Ph. D., Senior Marine Ecologist	
Approved for Release	Simon West, M.Sc. (Hons) Technical Director Marine Ecology	

Version	Date	Author(s)	Reviewer	Approved for Release
Status – V1	25 November 2025	S. West, J. Patiño-Pérez	L. Meynier	S. West

Job number	66818
Filename	66818 Pakiri Offshore Sand Area 1 Recovery 2023-2024 V1 Final.Docx

Reference: Bioresearches (2025). Recovery Monitoring – Area 1, 2023 – 2024. Report for McCallum Bros Limited pp 122.

Cover Illustration: Overview of Pakiri Bay (May 2022)

TABLE OF CONTENTS

Document Control and Revision Record	i
Table of Contents	ii
1 INTRODUCTION	1
2 METHODS	2
2.1 Sample Locations and Timing	2
2.2 Grab Samples	5
2.2.1 Benthic Biota and Sediment Grain Size Grab Samples	5
2.3 Intensive Sampling	6
2.3.1 Drop Camera Photography	6
2.3.2 Epibenthic Macrofauna Dredge Tows	7
2.4 Sand Extraction History	7
2.4.1 Dredge Track Data	8
2.4.2 Proximity Analysis: Dredge Tracks and Sample Points	8
2.5 Statistical Procedures	8
2.5.1 Data Grouping	8
2.5.2 Community Descriptive Indices	9
2.5.3 Multivariate Analysis	9
3 RESULTS AND DISCUSSION	11
3.1 Sand Extraction	11
3.1.1 Dredge Track Data	11
3.1.2 Proximity Analysis: Dredge Tracks and Sample Points	11
3.2 Seabed Sediment Particle Size	11
3.2.1 Particle Size Classification	12
3.2.2 Gravel	13
3.2.3 Sand	13
3.2.4 Silt and Clay	13
3.2.5 Multivariate	14
3.3 Benthic Biota Infauna	15
3.3.1 Number of Individuals	16
3.3.2 Number of Taxa	16
3.3.3 Diversity Index	17
3.3.4 Multivariate	18
3.4 Drop Camera Photographs	21
3.5 Epibenthic Macrofauna	22
4 Conclusions	26
References	28
Applicability and Limitations	29
Appendices	30

List of Tables

Table 1	Summary of Sediment Particle Size Data (% by Weight).....	12
Table 2	Summary of Benthic Biota Population Statistics by sampling area per sampling event September 2023 to October 2024.....	16
Table 3	Summary of Epibenthic Biota Population Statistics by sampling area per sampling event September 2023 to October 2024.....	23
Table A.1	Recovery Area Boundary (WGS84, NZTM)	30
Table A.2	Drop Camera, Benthic Grab and Sediment Grain Size Grab sampling points within Recovery Area, Outside and Control Area (WGS84, NZTM).	30
Table A.3	Benthic Dredge tow sampling transect points (WGS84, NZTM)	31
Table B.1	Track history.....	34
Table B.2	Date and Distance of dredge lines within 50 m of the sample points	35
Table D.1	Summary of Sediment Particle Size Data (% by Weight). 1 month, 19 September 2023.	42
Table D.2	Summary of Sediment Particle Size Data (% by Weight). +6 months, 13 March 2024.	43
Table D.3	Summary of Sediment Particle Size Data (% by Weight). +12 months, 24 September 2024.	44
Table D.4	Two Way Scheirer Ray Hare Analysis of the percentage of Gravel between Survey and Area in the discontinued area of Area 1	45
Table D.5	Two Way Scheirer Ray Hare Analysis of the percentage of Sand between Survey and Area in the discontinued area of Area 1	46
Table D.6	Two Way Scheirer Ray Hare Analysis of the percentage of Silt and Clay between Survey and Area in the discontinued area of Area 1.....	47
Table D.7	Homogeneity of multivariate dispersions (PERMDIS) of the percentage grain size data.....	48
Table D.8	Permutational Multivariate Analysis of Variance (PERMANOVA) two way crossed design (Survey and Area) of the percentage grain size data.....	49
Table E.1	Number per sample of Benthic Infauna Retained on 1 mm sieve from the grab samples collected within the Recovery Area. 1 month, 19 September 2023.	50
Table E.2	Number per sample of Benthic Infauna Retained on 1 mm sieve from the grab samples collected outside the Recovery and in Control Areas. 1 month, 19 September 2023.	53
Table E.3	Number per sample of Benthic Infauna Retained on 1 mm sieve from the grab samples collected within the Recovery Area. +6 months, 13 March 2024.	56
Table E.4	Number per sample of Benthic Infauna Retained on 1 mm sieve from the grab samples collected outside the Recovery and in Control Areas. +6 months, 13 March 2024.	60
Table E.5	Number per sample of Benthic Infauna Retained on 1 mm sieve from the grab samples collected within the Recovery Area. +12 months, 24 September 2024.	64
Table E.6	Number per sample of Benthic Infauna Retained on 1 mm sieve from the grab samples collected outside the Recovery and in Control Areas. +12 months, 24 September 2024.	68
Table F.1	Seabed photography summary descriptions from the Recovery, Outside and Control Area, 1 month, 19 September 2023.....	84
Table F.2	Seabed photography summary descriptions from the Recovery, Outside and Control Area, plus 6 months, 12 March 2024.	85
Table F.3	Seabed photography summary descriptions from the Recovery, Outside and Control Area, plus 12 months, 4 October 2024.	86
Table G.1	Densities (/100 m ²) of Epibenthic Macrofauna collected within the Recovery and Control Areas. 1 month, 21 September 2023.....	90
Table G.2	Densities (/100 m ²) of Epibenthic Macrofauna collected within the Recovery and Control Areas. +6 months, 13 March 2024.....	90

Table G.3	Densities (/100 m ²) of Epibenthic Macrofauna collected within the Recovery and Control Areas. +12 months, 4 October 2024.....	92
Table G.4	Scallop (<i>Pecten novaezelandiae</i>) numbers and sizes (mm) recorded in Epibenthic macrofauna dredge tows, 1 month, September 2023.	93
Table G.5	Scallop (<i>Pecten novaezelandiae</i>) numbers and sizes (mm) recorded in Epibenthic macrofauna dredge tows, +6 months, March 2024.....	93
Table G.6	Scallop (<i>Pecten novaezelandiae</i>) numbers and sizes (mm) recorded in Epibenthic macrofauna dredge tows, +12 months, October 2024.	93
Table H.1	Two Way Scheirer Ray Hare Analysis of the Number of Individuals of benthic biota between extraction Areas over time	94
Table H.2	Two Way Scheirer Ray Hare Analysis of the Number of Individuals of benthic biota between Sand Extraction History sites over time.....	95
Table H.3	Two Way Scheirer Ray Hare Analysis of the Number of Taxa of benthic biota between extraction Areas over time	96
Table H.4	Two Way Scheirer Ray Hare Analysis of the Number of Taxa of benthic biota between Sand Extraction History sites over time	97
Table H.5	Two Way Scheirer Ray Hare Analysis of the Shannon-Wiener Diversity Index of benthic biota between extraction Areas over time.....	98
Table H.6	Two Way Scheirer Ray Hare Analysis of the Shannon-Wiener Diversity Index of benthic biota between Sand Extraction History sites over time.....	99
Table H.7	Homogeneity of multivariate dispersions (PERMDIS) of the replicate Benthic biota data between the sample areas over time	100
Table H.8	PERMANOVA – Permutational Multivariate Analysis of Variation of Benthic biota between the sample areas over time.....	101
Table H.9	SIMPER - Similarity Percentages - species contributions of Benthic biota by Survey and Area groupings main effects	103
Table H.10	SIMPER - Similarity Percentages - species contributions of Benthic biota by Survey and Area groupings pairwise	106
Table H.11	Homogeneity of multivariate dispersions (PERMDIS) of the replicate Epibenthic biota data between the sample areas over time	113
Table H.12	PERMANOVA – Permutational Multivariate Analysis of Variation of Epibenthic biota between the sample areas over time	114

List of Figures

Figure 1	Consented Sand Extraction Areas and Approved Sand Extraction Areas, showing post sand extraction Recovery Area 1.....	1
Figure 2	Drop Camera, Benthic Grab and Sediment particle size Grab sampling point locations.....	3
Figure 3	Benthic dredge tow sampling transect locations.....	4
Figure 4	Sediment grain size classification.	6
Figure 5	Variation in sediment particle size over time by Area, September 2023 (1), March 2024 (6) to September 2024 (12).	12
Figure 6	Non-metric Multi-Dimensional Scaling (nMDS) of CLR transformed Grain size data per sample, with symbol grouping by Area (Recovery vs Control) and Survey event colour. Vector overlay shows grain size most relevant to sample point variation.....	15
Figure 7	Non-metric Multi-Dimensional Scaling (nMDS) of fourth-root transformed benthic biota, with symbol grouping by sampling Area and colours by Survey	18

Figure 8	Non-metric Multi-Dimensional Scaling (nMDS) of square-root transformed Epibenthic biota, with symbol grouping by sampling Area and colours by survey	24
Figure B.1	Sands extraction tracks January 2022 to July 2022.	32
Figure B.2	Sands extraction tracks August 2022 to July 2023.	33
Figure F.1	Drop Camera images from Recovery, outside and Control cells, 1 month 19 September 2023	75
Figure F.2	Drop Camera images from Recovery, outside and Control cells, plus 6 months 12 March 2024	79
Figure F.3	Drop Camera images from Recovery, outside and Control cells plus 12 months 4 October 2024	83
Figure G.1	Photographic records of Epibenthic Macrofauna Dredge Tow capture in Recovery and Control Areas. 1 month, 21 September 2023.	87
Figure G.2	Photographic records of Epibenthic Macrofauna Dredge Tow capture in Recovery and Control Areas. +6 months, 13 March 2024.....	88
Figure G.3	Photographic records of Epibenthic Macrofauna Dredge Tow captures Recovery and Control Areas. +12 months, 4 October 2024.....	89

List of Appendices

Appendix A	Sampling Area Positions
Appendix B	Sand Extraction History
Appendix C	Laboratory Results
Appendix D	Sediment Particle Size Results
Appendix E	Benthic Biota Results
Appendix F	Drop Camera Images
Appendix G	Epibenthic Macrofauna Dredge Tow Results
Appendix H	Statistical Results - Biota

1 INTRODUCTION

Sand extraction under the Offshore Coastal permit 20795 officially ended 30 July 2023. McCallum Bros Limited was granted a Temporary Offshore Consent (CST60420477 and DIS60420479) by the Environment Court on the 4th of July 2023, for the extraction of sand (and associated discharge) from the Temporary Auckland Off-Shore Sand Extraction Area (TSEA). Thus, sand extraction continued in the northern part of the expired Offshore consent area, as indicated by the grey area in Figure 1. Sand extraction south of the TSEA in the Deep water Area 1 (light yellow shading in Figure 1) ceased from 30 July 2023 and thus recovery monitoring was required under the EMMP Area 1 (2003) in this area. Figure 1 shows the locations of the various sand extraction areas, Table A.1 in Appendix A specifies the corner points of the Recovery area.

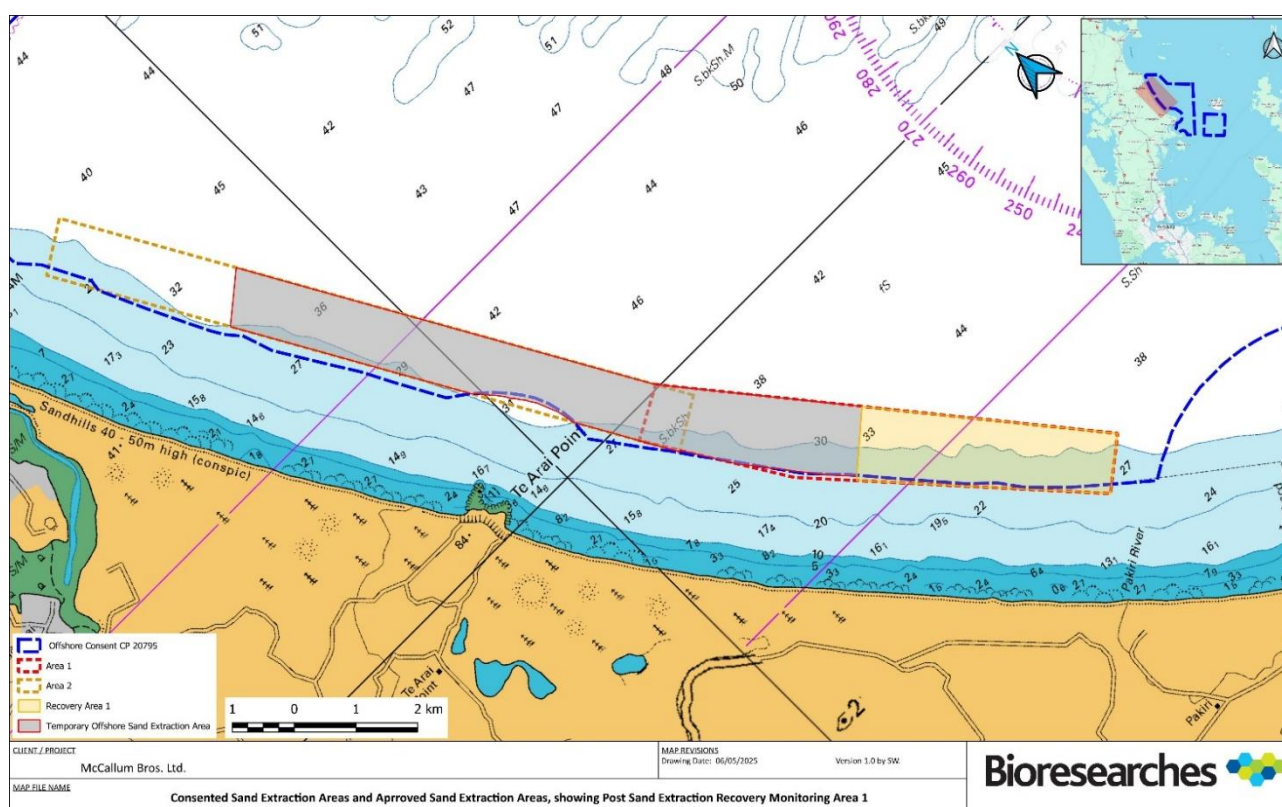


Figure 1 Consented Sand Extraction Areas and Approved Sand Extraction Areas, showing post sand extraction Recovery Area 1

Upon the conclusion of dredging within Deep Water Area 1, the EMMP Area 1 (Kaipara Limited, 2003) requires the following monitoring to be undertaken;

- Sediment textural, grab sample and biological analysis at the same sites sampled during the Pre Dredging Assessment (PDA) (ASR 2003) and, where no such sites beyond the extraction area were sampled, including control sites beyond the boundaries of Deep Water Area 1.
- Identify within Deep Water Area 1 a confined area no less than 5 km² in which to undertake more intensive sampling, including dredge tows, to ascertain species range and abundance in greater

detail. Such sampling and analysis should also be undertaken at a control site beyond the dredged area.

- c) The analysis required by this condition shall be first conducted within one month of the conclusion of dredging and then within six months and 12 months of that sampling.

At the conclusion of recovery monitoring, a report will be prepared, analysing the data, and assessing the recovery rate of benthic macrofaunal species in the dredged area following the cessation of dredging.

2 METHODS

2.1 Sample Locations and Timing

The EMMP specifies that sample points for sediment textural, grab sample and biological analysis should match those sampled in the initial pre sand extraction survey (ASR, 2003). The original list of sample points for the initial pre sand extraction survey has been filter for those sample points within and adjacent to the 2023 Recovery area. The locations of the sample points are shown graphically in Figure 2, with the points presented in Table A.2 in Appendix A. These sample points have been categorised as either with the Recovery area, outside the Recovery area (either inshore or offshore), and those in the Control area, for the analysis and discussion of results.

The Recovery area is 5.157 km² thus all the entire Recovery area was subjected to intensive sampling, under EMMP condition b). This intensive sampling included dredge tows and drop camera sampling. The drop camera sampling was conducted at the same sampling points as the grab samples. Dredge tows were conducted in a grid pattern evenly spread alongshore and offshore with the 200 m tows located semi random within each grid (Figure 3).

The grab and photographic sample and dredge tow locations were consistent across all three survey periods. The EMMP Area 1 specified that sampling was required 1 month after dredging had stopped, and then 6 and 12 months later.

Dredging stopped	30 July 2023
1 month sampling event	19 – 21 September 2023, (delayed 2 weeks due to weather)
+ 6 months sampling event	12 -14 March 2024
+ 12 months sampling event	23 September - 4 October 2024 (extended period due to weather delays)

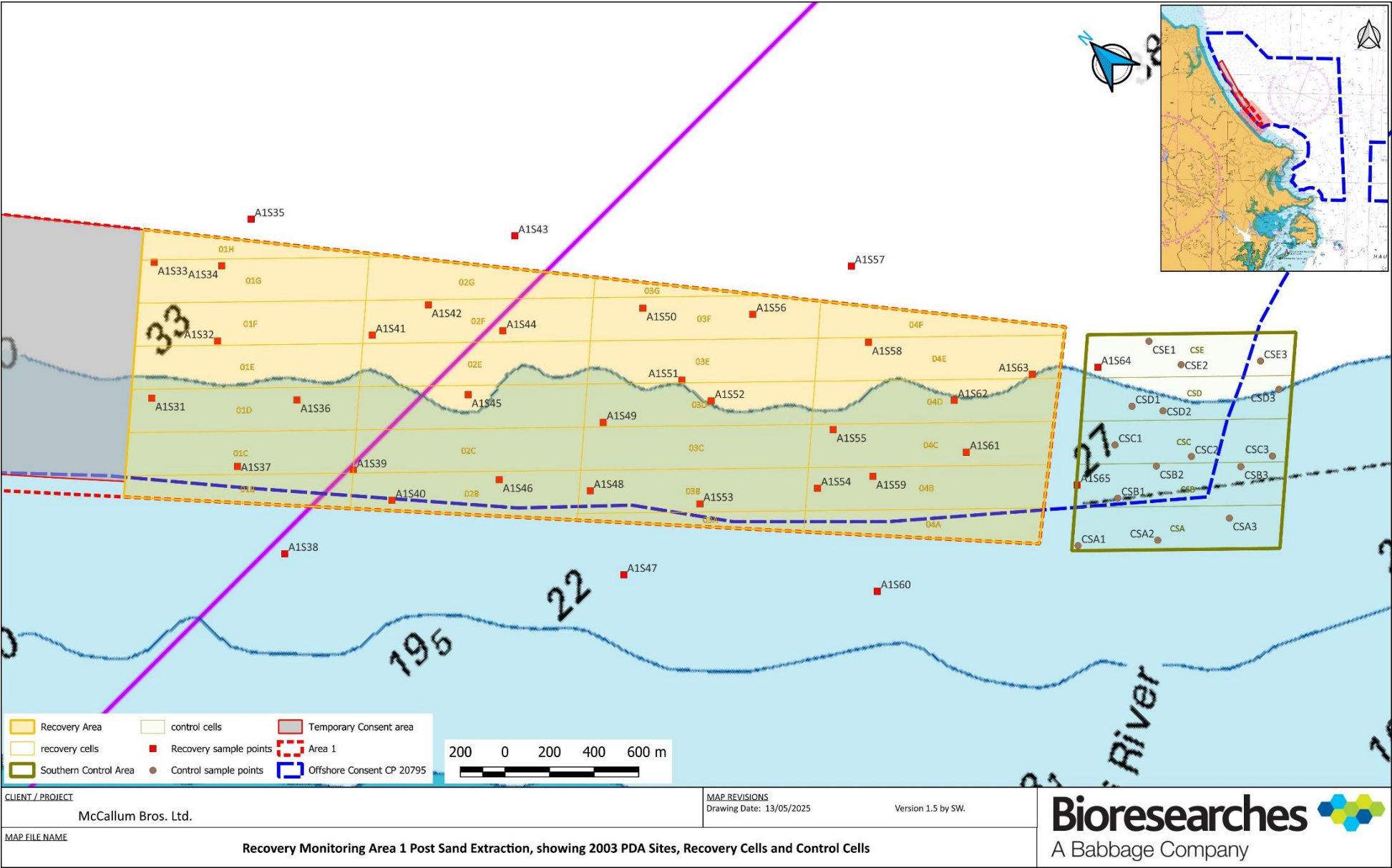


Figure 2 Drop Camera, Benthic Grab and Sediment particle size Grab sampling point locations.

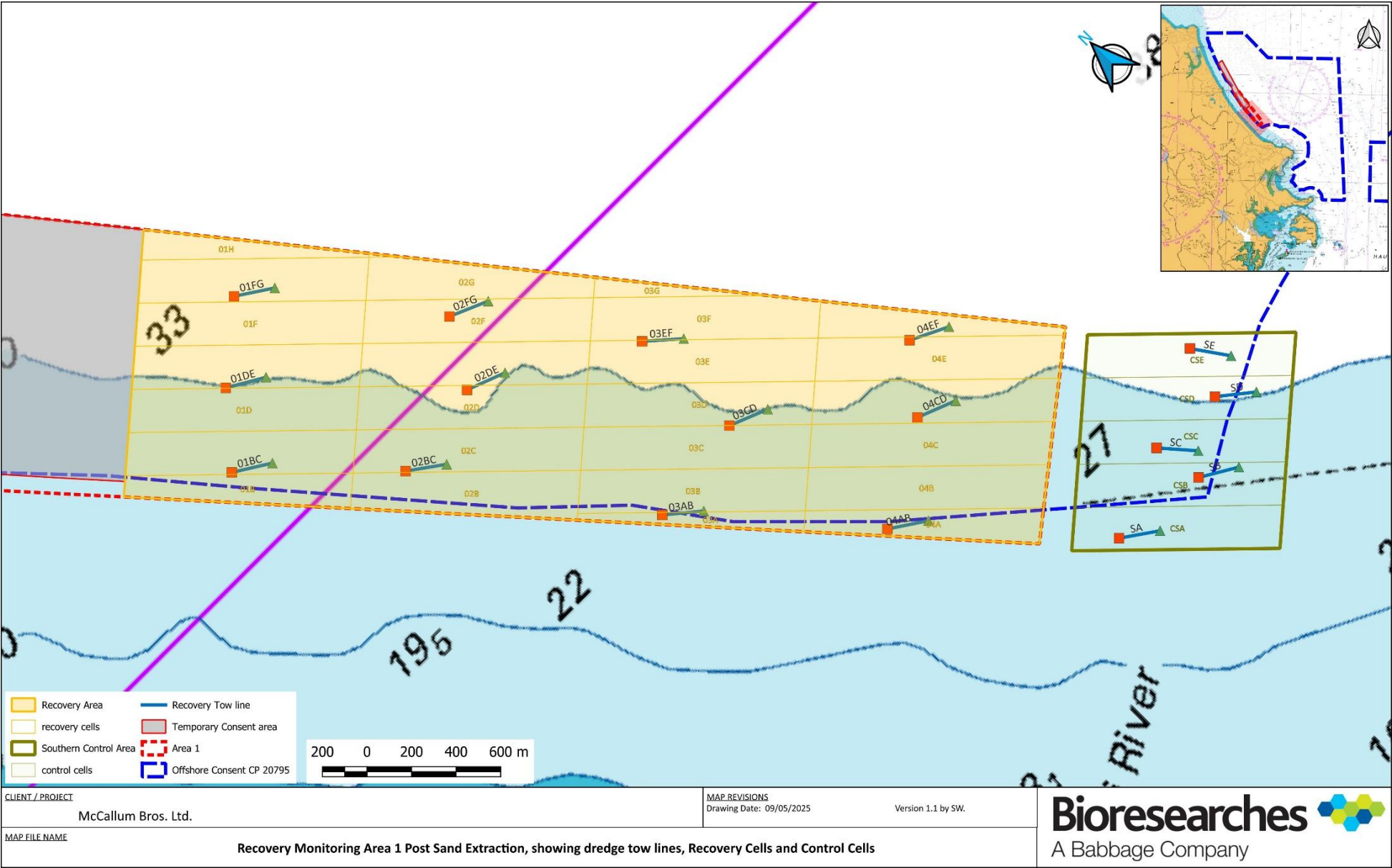


Figure 3 Benthic dredge tow sampling transect locations.

2.2 Grab Samples

2.2.1 Benthic Biota and Sediment Grain Size Grab Samples

At each of the 50 specified sampling locations listed in Table A.2, a modified Standard Ponar Grab sampler was used to collect a sample of sediment. During the 1 month sampling in September 2023, the Ponar grab collected sediment from a sample area of 229 x 280 mm (0.064 m²) with a bite depth of about 100 mm. The grab was upgraded to reduce sampling failures and thus the plus 6 and 12 month samples were collected from a sample area of 250 x 285 mm (0.071 m²) and a bite depth of about 100 mm. Both samplers produced sample volumes of 1 – 4 L. Upon recovery of the grab, the contents were placed in a fish bin to allow recovery volume assessment. If the sample volume was less than 2 L, the grab sample was discarded and repeated.

The sediment was mixed in the fish bin, and a 100 ml sample was collected into a zip lock plastic bag using an aluminium scoop. All sediment samples were double bagged in clean new polyethylene ‘zip lock’-type bags with a pre-printed waterproof label (identifying site, sample date and testing required) between the two bags and placed in a chilly bin. Sediment particle size samples were only chilled prior to transportation to the laboratory. Particle size testing was conducted by Hill Laboratories using accredited testing methods (ASTM D6913). Samples were wet sieved through six sieves (2.0, 1.0, 0.5, 0.25, 0.125, and 0.063 mm) and the remainder collected in the pan, resulting in 7 grain size profiles. The dry weights of each profile were recorded as percentages of the total sample.

Each grab sample was sieved as soon as practicable after collection by washing each whole sample through both 3.0 mm and 1.0 mm mesh sieves with seawater. The 3.0 mm mesh sieve was used as a screening method, while the 1.0 mm mesh was selected over the more typical 0.5 mm mesh sieve. Indeed the typical grain size is around the 0.5 mm diameter size which clogs the sieve, making biota sample sieving impractical with the 0.5 mm mesh.

All samples were stored in a cool shaded location until sieving, which usually occurred immediately following collection. The biota retained on the 3.0 mm sieve was visually assessed, unaided, for the presence of absolutely protected species defined in the Wildlife Act (1953) by a suitably qualified and experienced person, before preservation. If absolutely protected species or known macrofauna were found alive, they were photographed, enumerated, and returned to the sea as soon as possible. The remaining material retained on both sieves was transferred to a polyethylene ‘zip lock’-type bag with a pre-printed waterproof label (identifying site, sample date and testing required), and preserved in a solution of 5% glyoxal, 70% ethanol sea water solution. They were sealed and placed in a second polyethylene ‘zip lock’-type bag and packed into a labelled plastic container, for transportation to the laboratory.

Prior to sorting, the samples were rinsed through a 1.0 mm sieve with freshwater and placed in a white sorting tray. All organisms were picked out of the samples and placed in labelled vials of 70% ethanol solution prior to taxonomic identification (to the lowest taxonomic group possible) and counting. Only animals with intact heads and/or live coral were identified and counted, by an experienced benthic taxonomist (Rod Asher, Biolive, Nelson).

2.2.2 Sediment Grain Size Classification

Raw data from the laboratory reports were grouped into the Wentworth scale for defining grain sizes based on their diameter which provides standardized names and ranges for mud, sand, and gravel:

Grain size (mm)	Class	
> 3.35	Gravel	Gravel
3.35 - 2.00	Granules	
2.00 - 1.18	Very Coarse Sand	Coarse Sand
1.18 - 0.600	Coarse Sand	
0.600 - 0.300	Medium Sand	Medium Sand
0.300 - 0.150	Fine Sand	Fine Sand
0.150 - 0.063	Very Fine Sand	
0.063 – 0.0039	Silt	Mud
< 0.0039	Clay	

The Folk system uses the Wentworth grain size categories to define the three main axes of a ternary (triangle) diagram, to classify sediments based on the proportions of mud, sand, and gravel. The classification uses capitalized letters for the dominant grain size with modifiers based on the next important grain sizes in lowercase (Folk, 1966). These descriptions are given as letter codes (gravel=G, sand=S, mud=M, silt=Z). For example, a sample which consisted of mostly sand with a significant proportion of silt and clay would be described as muddy sand and would be denoted **mS**. If the sample had a gravel component it would be described as slightly gravelly muddy sand and would be denoted **(g)mS**. The descriptions of the sediments are based on criteria illustrated in Figure 4.

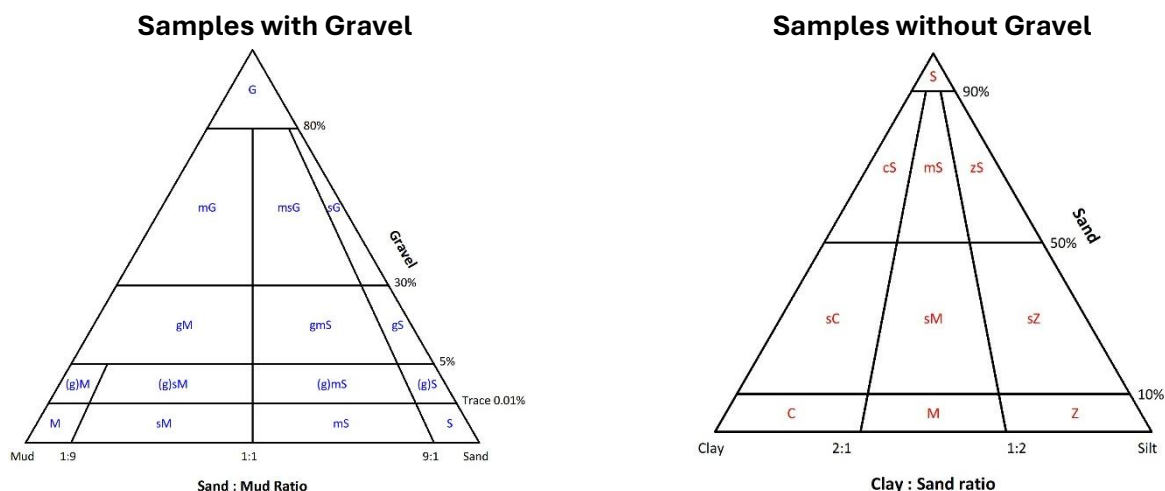


Figure 4 Sediment grain size classification.

2.3 Intensive Sampling

2.3.1 Drop Camera Photography

At each of the grab sample locations within the sand extraction Recovery area and in the southern Control area are shown graphically in Figure 2 and the point locations presented in Table A.2, drop camera images of 1 m² of the seabed, and lateral views were recorded.

The images were recorded from a custom built frame over a 1 m² quadrat, using GoPro 4 cameras which were set to record images at 2 second intervals at the best available image quality setting. The GoPro 4

cameras were upgrade to GoPro 12 cameras between the 6 and 12 month surveys. The best representative images were selected for analysis. The images were used to assess changes in fine scale (< 1 m) bed forms. Details of the substrate and the presence of any conspicuous species were recorded. As the drop camera photographs were captured at the same locations as the benthic grab samples, any taxa identified in the photographic imagery but absent from the corresponding grab sample was incorporated into the quantitative benthic dataset as a single observed individual, thereby acknowledging their presence in the surveyed area.

2.3.2 Epibenthic Macrofauna Dredge Tows

The larger epibenthic biota are not likely to be well represented in the infauna grab sampling due to their low density, therefore epibenthic dredge tows which cover a larger area than infauna sampling, are required to quantify the epibenthic macrofauna. The offshore sand extraction area was divided into monitoring cells of approximately 1000 m length and 200 m width. An epibenthic macrofauna dredge tow was planned and conducted in each pair of monitoring cells and in each Control monitoring cell. The locations of the planned tow end points are shown graphically in Figure 3 and the locations of the start and ends presented in Table A.3.

Each epibenthic macrofauna dredge tow consisted of lowering a 600 mm wide dredge fitted with a 35 mm mesh bag, to the seafloor and towing it for approximately 200 m in an alongshore direction, between a pre-determined GPS start and endpoints. All material captured during each tow was placed in a fish bin, photographed, and immediately sorted, with all dead shell immediately returned to the sea. Polychaete worms, amphipods, and small gastropods and bivalves that were too difficult to immediately identify in the field were preserved in a solution of 5% glyoxal, 70% ethanol seawater solution. Larger macrofauna such as bivalves, hermit crabs and starfish that could be identified, were photographed, counted, and returned to the sea. Any scallops (*Pecten novaezelandiae*) retrieved were counted and measured (± 1 mm) and returned to the sea. Preserved epibenthic macrofauna dredge tow samples were processed in the laboratory as described above for grab samples.

Epibenthic macrofauna dredge tow data were then compiled and analysed to provide a description of the macrobenthic community structure (species richness and evenness).

2.4 Sand Extraction History

In order to understand the recovery of the biota, an understanding of the sand extraction history of the area is required. This was achieved by analysing the recorded sand extraction tracks between 1 January 2022 and 30 July 2023.

Upon approach to the TSEA, the vessel operational lights are activated, and speed is reduced to 1.5–2.5 knots to commence extraction setup. The Master of the William Fraser navigates the vessel to the starting coordinate of the predetermined extraction path for that trip, located on the boundary of the TSEA. The draghead is unsecured from the vessel, the davits extend the pump and dredge pipework over the starboard side, then they are slowly lowered within 3 m of the seafloor where suction/pumping of seawater commences to prime the pumps. The pumps are initially primed with water, after which the draghead is fully lowered to the seafloor to commence extraction. At this point, the vessel's position is geolocated using the MAXSea navigational software to enable the extraction track to be recorded.

Simultaneously, a switch on the swell compensator is automatically triggered, initiating an independent recording of the extraction track. Both recording systems continue logging data until extraction ceases and the draghead is lifted from the seafloor. As the drag head moves forward along the seafloor, the top 100 mm of seabed is fluidised and pumped onboard via the draghead and dredge system. This results in a 1.6 m wide x 100 mm deep extraction track being created on the sea floor. The duration of this shallow trench is temporary and dependent upon wave conditions at the time of and following extraction.

2.4.1 Dredge Track Data

Sand extraction track data were provided by McCallum Brothers Ltd, as gpx format digital files recorded on board the William Fraser using the integrated MAXSea navigational software. These spatial data consisted of continuous track lines representing vessel movement during dredging operations. Earlier track data had manual recording of the start and end of extraction. An initial review and segmentation of dredge tracks were undertaken using Garmin HomePort software. This programme enabled visual inspection to identify the start and end points of the dredging events. Individual segments were manually delineated based on observed track patterns, representing assumed dredging runs.

The segmented tracks of extraction activity were imported into QGIS for further spatial refinement. All tracks were converted into a single polyline layer. The extraction event tracks were trimmed to a predefined Area of Interest (AOI) being the Recovery area, and tracks were subdivided according to a cell-based grid within the AOI. Each resulting segment kept attribute data from both the original extraction track data and the cell (e.g. Cell ID). This process produced cell-specific sand extraction track segments suitable for volumetric and proximity analyses. The length of each extraction track segment was multiplied by the effective width of the drag head (1.6 m) and the depth of the track profile (0.1 m), to estimate the volume of sand disturbed per extraction event in each cell.

2.4.2 Proximity Analysis: Dredge Tracks and Sample Points

The spatial and temporary proximity between dredging activity and ecological sampling locations, will also have implications for how recovery is assessed. A 50 m buffer was created around each sample point (De Backer *et al.*, 2017), representing the area of likely influence for sediment disturbance. The shortest distance between each sample point and the nearest dredge track within the buffer was then calculated.

2.5 Statistical Procedures

2.5.1 Data Grouping

The sand extraction was not evenly distributed over the Recovery area as shown in Appendix B. Thus the sample points in the Recovery area were assigned to four categories;

- No = No sand extraction within 100m,
- Low = two or three sand extraction tracks within 100 m,
- Medium = four to ten sand extraction tracks within 100 m,
- High = more than ten sand extraction tracks within 100 m.

These four categories were used to test if sand extraction history had an impact on the recovery. 100 m was used as the buffer to be more conservative than the arbitrary 50 m used by De Backer *et al.*, (2017).

2.5.2 Community Descriptive Indices

The infauna in each biota grab sample are summarised by the following descriptive statistics:

- the number of individuals,
- the number of taxa,
- the Shannon-Wiener Diversity Index, and
- the Shannon-Wiener evenness

Shannon-Wiener Diversity Index measures the rarity and commonness of species in a community and is calculated using the following formula.

$$H = - \sum (p_i \ln p_i)$$

where p_i is the proportion of the total number of species made up of the i^{th} species.

Shannon-Wiener Evenness is a measure of how close in numbers (how equal) each species is in an environment. Mathematically, it is calculated by dividing the Shannon-Wiener Diversity Index by the natural logarithm of species richness.

$$J = H / \ln(S)$$

Note that species evenness ranges from zero to one, with zero signifying no evenness and one, complete evenness.

Variations in these indices were compared by an Analysis of Variance (ANOVA) test. If the assumptions of normality and equal variance were not met, then nonparametric analogous tests were conducted. The nonparametric equivalent of the one-way analysis of variance (ANOVA) is the Kruskal–Wallis test by ranks. The nonparametric equivalent of the two-way analysis of variance (ANOVA) is the Scheirer–Ray–Hare (SRH) test. If significant differences were detected, then pairwise multiple comparison procedures such as Tukey tests or equivalent were conducted to determine where the difference was.

2.5.3 Multivariate Analysis

A multivariate analysis approach allows examination and testing of differences in species assemblages or grain size data between samples, cells, and groups of cells (Clarke *et al*, 2014). However, because the raw benthic biota data have a high number of taxa with very few individuals, the following protocols were applied in order to “clean” the data to reduce “noise” levels in the data set. If fewer than 5 individuals were recorded, then the taxa were either deleted or combined in a higher taxon grouping.

The “cleaned” replicate data set were fourth root transformed depending on the range of data, to scale down high numbers which dominated the assemblages and to give more influence on the rare taxa. A Bray-Curtis (B-C) similarity matrix was created on each transformed data set, and nonmetric Multi-Dimensional Scaling (nMDS) was used to visualise the degree of similarity among different samples in both 2 and 3 dimensions. PRIMER produces a stress value for each plot to indicate how well the plots fit the full multidimensional data set, with the lower the stress, the better the fit.

- **Stress levels of <0.05** give an excellent representation with no prospect of misinterpretation,
- **Stress levels of <0.1** corresponds to a good ordination with no real prospect of a misleading interpretation,
- **Stress levels of <0.2** still gives a potentially useful 2-dimensional picture, though for values at the upper end of this range little reliance should be placed on the detail of the plot,

- **Stress levels of >0.2** Poor fit; the configuration does not well represent the distances in the data, and the ordination is likely to be misleading or unreliable.

The multivariate procedure “data transform – Bray-Curtis – nMDS – ANOSIM – SIMPER” has become a common statistical methodology for communities’ structure in the past 15 years (Clarke & Warwick, 2001; Clarke *et al.*, 2014). nMDS (Non-metric Multidimensional Scaling), is a rank-based ordination technique used to visualize similarities or dissimilarities among samples in a low-dimensional space, typically for ecological community data. It creates an ordination based on a distance or dissimilarity matrix, preserving the rank order of the distances rather than the actual distances, allowing for flexible use with many types of ecological distance measures like Bray-Curtis. It is widely used for detecting patterns and gradients in multivariate ecological data. ANOSIM (Analysis of Similarities), is a non-parametric statistical test used to compare differences between two or more groups based on a rank similarity or dissimilarity matrix. It tests whether the differences between groups are greater than those within groups, commonly applied in ecology to test for significant differences in community composition across factors such as sites or treatments. SIMPER (Similarity Percentage), is an analysis method in community ecology to assess the contribution of each species or variable to the overall dissimilarity between groups. It breaks down the percentage contribution of individual species to explain differences observed, helping identify species mostly responsible for group separation.

Rather than the ANOSIM test, we have chosen the Permutational Multivariate Analysis of Variance (PERMANOVA) test which uses the actual dissimilarity values rather than the ranks of these values. PERMANOVA is appropriate for ecological datasets that violate assumptions of normality, as it uses permutations rather than parametric distributions (Anderson, 2001). Multivariate data can differ in relation to the location of the centroid of each group within the multivariate cloud and in the dispersion of data within a group around each centroid. PERMANOVA tests the null hypothesis that the centroids (multivariate means) and dispersion of the groups, defined in terms of a chosen distance or dissimilarity measure, are equivalent across all groups. Rejection of the null hypothesis suggests there are significant differences in group centroids and/or dispersion.

Unlike traditional Multivariate Analysis of Variance (MANOVA), which requires assumptions like multivariate normality, PERMANOVA uses permutations of the data to calculate p-values, making it more flexible and robust for ecological data that often violate such assumptions. PERMANOVA operates on distance matrices (e.g., Bray-Curtis, Euclidean) and produces a pseudo-F-statistic comparing within-group to between-group variation. It is widely used for testing differences in community composition or other multivariate data among treatments or environments.

The assumption of homogeneous multivariate dispersion was tested with PERMDISP for Survey (three levels: 1, 6, 12 months), Area (two levels: Recovery, Control) and their combination (Survey x Area). The two-factor PERMANOVA had the following criteria: fixed factors Survey and Area, Type-I sums of squares, 9,999 unrestricted permutations of raw data, and “Allow for heterogeneity of within-group dispersions” enabled, specifying Survey x Area as the term with different dispersions. Where appropriate, pairwise PERMANOVA contrasts for Area within Survey and Survey within Area were conducted. Multivariate tests were conducted with the software PRIMER-E (version 8 beta 2.0.36, Qquest Research Ltd).

3 RESULTS AND DISCUSSION

3.1 Sand Extraction

3.1.1 Dredge Track Data

The tracks from January 2022 to July 2022 and August 2022 to July 2023 are plotted in Figure B.1 and Figure B.2 with reference to the Recovery area sampling points and cells. The total length of each extraction track per cell is shown in Table B.1.

3.1.2 Proximity Analysis: Dredge Tracks and Sample Points

The shortest distance between each sample point and the nearest dredge track within the buffer was then calculated. These measurements are reported in Table B.2.

3.2 Seabed Sediment Particle Size

Sediment particle size plays a crucial role in shaping the habitat and community structure of infaunal biota in marine environments.

- **Habitat Suitability:** Different infaunal species have specific preferences for sediment types. For example, some species thrive in fine sediments like mud, while others prefer coarser sediments like sand.
- **Oxygen Availability:** The size of sediment particles affects the porosity and permeability of the sediment, which in turn influences the oxygen levels within the sediment. Fine sediments tend to have lower oxygen levels compared to coarser sediments.
- **Feeding and Burrowing:** The particle size can impact the feeding and burrowing behaviour of infaunal organisms. For instance, deposit feeders may find it easier to process finer sediments, while burrowing organisms might prefer coarser sediments for stability.
- **Predation and Protection:** Sediment particle size can also affect the ability of infaunal organisms to avoid predators. Finer sediments might offer better protection by allowing organisms to burrow deeper.

The relationships between grain size, oxygen availability, and infaunal community structure are well established in sediment ecology (Gray, 1974; Snelgrove & Butman, 1994). Understanding these dynamics is essential for assessing habitat quality and the ecological health of marine benthic ecosystems, and its ability to recover.

The raw laboratory particle size data for each of the sites sampled within and outside the Recovery area for all three surveys are presented in Appendix C, with the data from each survey presented in Table D.1, Table D.2 and Table D.3.

The particle size data per area (recovery, outside, and control) are summarised by average and range in percentage per size class for each survey in Table 1, and shown graphically in Figure 5.

Table 1 Summary of Sediment Particle Size Data (% by Weight).

Survey Area		1 month (19 September 2023)											
		Recovery			Outside			Control			Outside and Control		
Size Class		Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
Gravel	>= 2 mm	7.98	34.3	0.2	13.42	30.0	0.3	9.56	25.6	0.3	10.57	30.0	0.3
Very Coarse Sand	< 2 >= 1 mm	7.18	15.6	0.3	9.17	23.0	0.3	5.15	14.4	0.3	6.20	23.0	0.3
Coarse Sand	< 1 >= 0.5 mm	24.86	44.6	0.9	20.02	30.6	0.8	24.78	67.3	1.0	23.53	67.3	0.8
Medium Sand	< 0.5 >= 0.25 mm	30.85	55.4	16.1	32.75	52.4	16.9	38.28	62.9	2.5	36.84	62.9	2.5
Fine Sand	< 250 >= 125 µm	23.99	72.0	4.7	19.42	70.6	5.7	17.48	67.8	2.4	17.98	70.6	2.4
Very Fine Sand	< 125 >= 63 µm	1.41	8.2	0.2	1.87	9.1	0.2	1.39	12.8	0.1	1.51	12.8	0.1
Silt & Clay	< 63 µm	3.72	15.8	0.1	3.33	8.4	0.5	3.39	6.2	0.5	3.37	8.4	0.5
Classification		gS			gS			gS			gS		
Survey Area		6 months (13 March 2024)											
		Recovery			Outside			Control			Outside and Control		
Size Class		Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
Gravel	>= 2 mm	8.73	27.5	0.3	14.22	26.8	0.5	9.10	39.2	0.1	10.43	39.2	0.1
Very Coarse Sand	< 2 >= 1 mm	6.21	13.4	0.3	7.62	16.7	0.6	4.58	12.8	0.2	5.37	16.7	0.2
Coarse Sand	< 1 >= 0.5 mm	24.26	42.7	1.2	20.70	31.5	1.1	22.30	42.6	1.0	21.88	42.6	1.0
Medium Sand	< 0.5 >= 0.25 mm	32.57	57.0	17.1	35.02	53.3	20.4	42.62	68.8	16.1	40.64	68.8	16.1
Fine Sand	< 250 >= 125 µm	24.84	72.7	6.3	18.93	68.2	5.2	18.16	68.4	2.5	18.37	68.4	2.5
Very Fine Sand	< 125 >= 63 µm	1.32	5.7	0.3	1.37	6.1	0.2	1.11	9.5	0.1	1.18	9.5	0.1
Silt & Clay	< 63 µm	2.09	3.5	0.8	2.10	3.2	0.6	2.11	3.6	1.2	2.11	3.6	0.6
Classification		gS			gS			gS			gS		
Survey Area		12 months (24 September 2023)											
		Recovery			Outside			Control			Outside and Control		
Size Class		Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
Gravel	>= 2 mm	5.98	17.5	0.7	7.02	19.1	0.4	8.66	55.5	0.4	8.23	55.5	0.4
Very Coarse Sand	< 2 >= 1 mm	5.48	14.8	0.4	7.87	23.7	0.3	4.58	15.7	0.5	5.44	23.7	0.3
Coarse Sand	< 1 >= 0.5 mm	28.12	53.3	0.9	25.30	36.5	1.1	22.84	43.2	1.8	23.48	43.2	1.1
Medium Sand	< 0.5 >= 0.25 mm	36.90	59.5	16.4	37.95	57.5	17.0	45.69	71.7	10.2	43.67	71.7	10.2
Fine Sand	< 250 >= 125 µm	20.49	76.3	6.1	18.20	64.3	5.9	15.06	63.3	1.9	15.88	64.3	1.9
Very Fine Sand	< 125 >= 63 µm	0.78	4.0	0.2	1.22	5.8	0.1	0.85	7.9	0.1	0.95	7.9	0.1
Silt & Clay	< 63 µm	2.28	4.2	0.9	2.45	3.0	1.9	2.31	5.1	0.7	2.34	5.1	0.7
Classification		gS			gS			gS			gS		

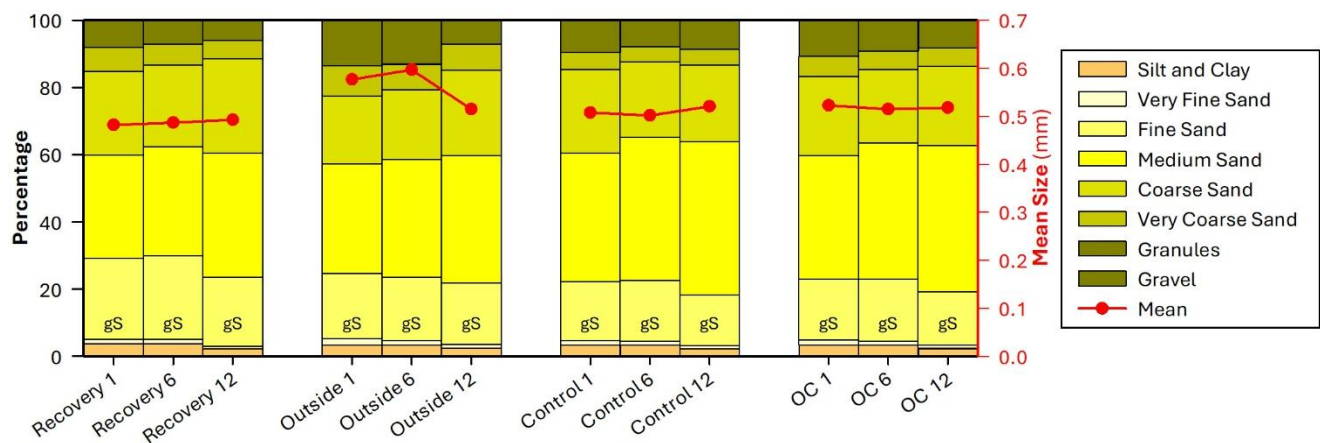


Figure 5 Variation in sediment particle size over time by Area, September 2023 (1), March 2024 (6) to September 2024 (12).

3.2.1 Particle Size Classification

The average sediment characterisation within the Recovery area and the Control area including the outside samples was gravely Sand (gS), with between 5 and 11% gravel, 86 to 92% sand, and 2.2 to 3.8% silt and clay. The average sediment characterisations did not change over time. However within the Recovery area the range of characterisation decreased from (g)S (*slightly gravely Sand*), gS, (g)mS (*slightly gravely muddy Sand*), gmS (*gravely muddy Sand*), and sG (*sandy Gravel*) in September 2023, 1 month

after sand extraction stopped, to (g)S and gS in September 2024, 13 months after sand extraction stopped. This was due to a decrease in the percentage of gravel from 7.98 to 5.98%, and silt and clay from 3.72 to 2.28% with increases in the percentage of Sand from 88.29 to 91.77%.

While the average characterisation remained the same in the control as the Recovery area, the range of characterisations in the Control area was more stable than in the Recovery area with (g)S, gS, and sG in September 2023 and March 2024 changing to (g)S, gS, and msG in September 2024. The percentage of gravel decreased from 10.57 to 8.23%, and silt and clay from 3.37 to 2.34%, while the percentage of sand increased from 86.07 to 89.42%.

The differences between the Recovery area and the Control areas for each sampling event were similar for gravel, sand, and silt and clay. The changes in percentages of gravel, sand and silt and clay over time were similar in both the Recovery area and the Control area, suggesting that the changes observed were natural changes. The higher percentages of gravel and lower percentage of sand in the Control area is opposite to the expected effect from sand extraction of increased gravel and reduced sand in the sand extraction area or Recovery area. Therefore, the differences are likely from some natural geographic variation.

In summary, there did not appear to be an adverse effect to sediment grain size from sand extraction and therefore no recovery was needed or has occurred in the sediment grain size. Similar findings have been reported globally, where sediment characteristics in mobile sand systems show rapid physical equilibration after dredging (Hitchcock *et al.*, 2002).

3.2.2 Gravel

To test the differences in the percentage of gravel between Recovery and Control sites and over time the gravel percentage data was subjected to a 2 way Scheirer Ray Hare test (Table D.4). There was no statistically significant difference in the proportion of gravel between the Recovery area and the Control areas ($p=0.917$), nor was there a statistically significant difference over time between the 1, 6 and 12 month sample events ($p=0.369$). The changes in the percentage of gravel within the Recovery area over time and the Control areas over time, were not significantly different for each other ($p=0.843$), i.e. the Recovery area and Control areas changed in a similar way over time (Table D.4).

3.2.3 Sand

To test the differences in the percentage of sand between Recovery and Control sites and over time the sand percentage data was subjected to a 2 way Scheirer Ray Hare test (Table D.5). There was no statistically significant difference in the proportion of sand between the Recovery area and the Control areas ($p=0.760$). However there was a statistically significant difference over time between the 1, 6 and 12 month sample events ($p=0.049$). The changes in the percentage of sand within the Recovery area over time and the Control areas over time, were not significantly different for each other ($p=0.797$), i.e. the Recovery area and Control areas changed in a similar way over time (Table D.5).

3.2.4 Silt and Clay

To test the differences in the percentage of silt and clay between Recovery and Control sites and over time the silt and clay percentage data was subjected to a 2 way Scheirer Ray Hare test (Table D.6). There was no statistically significant difference in the proportion of silt and clay between the Recovery area and the

Control areas ($p=0.824$). However there was a statistically significant difference over time ($p=0.002$). Pairwise comparisons showed that overall samples the percentage of silt and clay at 1 month ($p=0.007$) and 6 months ($p=0.007$) were higher than at 12 months. However there were no statistically significant differences between the sample events within either the Recovery area or the Control area when the samples points were differentiated by area.

The changes in the percentage of silt and clay within the Recovery area over time and the Control areas over time, were not significantly different for each other ($p=0.977$, i.e. the Recovery area and Control areas changed in a similar way over time (Table D.6).

3.2.5 Multivariate

Statistics above (gravel, sand, silt and clay) do not reflect the potential finer scale changes in composition; thus, a multivariate approach is required as outlined in section 2.5.3.

Grain size percentages are not independent: an increase in one component must be offset by a decrease in another. This violates assumptions of many standard statistical methods. To properly analyse this kind of data, a transformation that accounts for the constant-sum constraint, such as Centred Log-Ratio (CLR) Transformation is required. CLR Transforms data into a space where standard techniques like PCA or clustering are valid.

$$\text{clr}(x_i) = \log \left(\frac{x_i}{g(x)} \right)$$

where $g(x)$ is the geometric mean of all components.

A Euclidean distance similarity matrix was created on the CLR transformed data. To test for differences, a two-factorial PERMANOVA design with factors ‘survey’ and ‘area’ for sediment grain size was used. The survey factor contained three sampling events 1 month, 6 months, and 12 months. All of these sampling event data sets were divided by the area factor with samples from both Recovery and Control areas. When the same data is subject to a Non-metric Multi-Dimensional Scaling, the plot shows high overlap between the survey and area factor groupings (Figure 6).

The assumption of equal dispersion was tested for the two factors and for the groups resulting from the combination factors (Table D.7). The PERMDIS testing showed no statistically significant differences in dispersion within the survey factor of the crossed groupings, however there was a significant difference in dispersion with the area factor. Since the dispersion in the Control area samples was higher than in the Recovery area, this could inflate the Area effect in PERMANOVA. However, it is important to note that PERMDISP evaluates differences in within-group dispersion rather than differences in centroid location, therefore, a significant PERMDISP result does not indicate differences in assemblage composition. The design allowed for heterogeneity in the model, PRIMER-E adjusted for this, which strengthens the confidence in the Area effect being real. The PERMANOVA main test showed no statistically significant differences between the Recovery and Control areas (Table D.8).

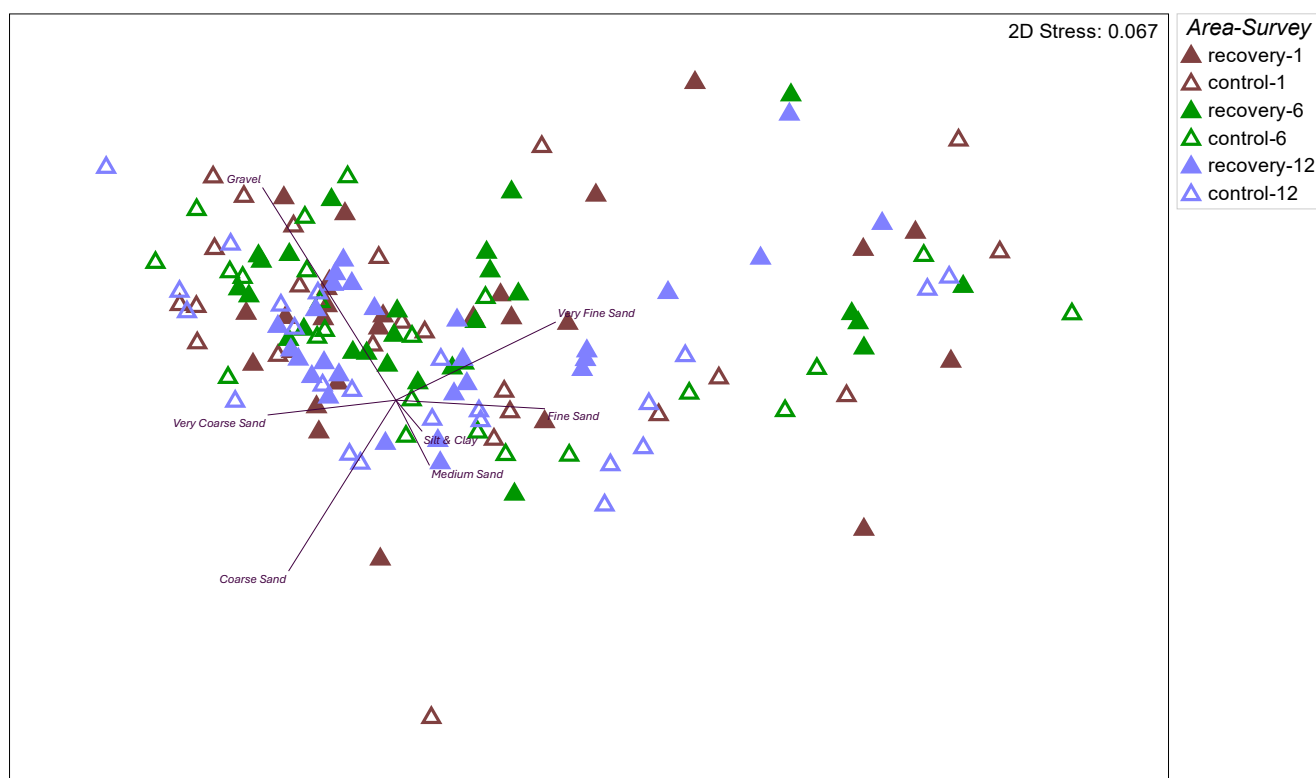


Figure 6 *Non-metric Multi-Dimensional Scaling (nMDS) of CLR transformed Grain size data per sample, with symbol grouping by Area (Recovery vs Control) and Survey event colour. Vector overlay shows grain size most relevant to sample point variation.*

3.3 Benthic Biota Infauna

A total of 50 modified Standard Ponar Grab samples were conducted in 1 month, 6 months, and 12 months within the Recovery area and at controls outside the Recovery area. The raw data for each replicate sample along with the individual replicate summary statistics (Number of Individuals, Number of Taxa, Shannon-Wiener Diversity index, and Evenness) from within the Recovery area are presented in Table E.1, Table E.3, and Table E.5, and from in the Control areas in Table E.2, Table E.4 and Table E.6 in Appendix E.

Benthic biota results are summarised by the number of taxa, number of individual organisms, and Shannon-Wiener diversity index for each sampling area and sampling event. A total of 194 identified species/taxa and a total of 23923 live individuals were counted. The number of individuals averaged 159.5 per replicate sample and ranged from 5 to 792. The number of taxa averaged 26 per replicate sample and ranged from 4 to 57. The Shannon-Wiener diversity index averaged 2.38 per replicate sample and ranged from 1.0 to 3.47.

The replicate data were grouped by sampling area per sampling event (Table 2).

**Table 2 Summary of Benthic Biota Population Statistics by sampling area per sampling event
September 2023 to October 2024**

Survey	1 month		6 months		12 months		All			
	Sept-23		Mar-24		Sept-24					
Area	Recovery area									
	Ave.	SD	Ave.	SD	Ave.	SD	Ave.	SD	min	max
Number of samples	27		27		27		81			
Number of Individuals	26.89	18.68	83.44	47.89	358.63	152.21	156.32	172.19	5	756
Number of Taxa	13.07	4.45	28.81	8.12	33.52	7.53	25.14	11.12	4	57
Total Number of Taxa	78		119		129		168			
Diversity Index	2.278	0.405	2.843	0.313	1.940	0.558	2.354	0.571	0.994	3.384
Evenness	0.915	0.107	0.859	0.086	0.552	0.139	0.775	0.195	0.301	1.000
Area	Control and Outside									
	Ave.	SD	Ave.	SD	Ave.	SD	Ave.	SD	min	max
Number of samples	23		23		23		69			
Number of Individuals	27.70	14.45	102.91	72.64	359.00	176.77	163.20	179.70	5	792
Number of Taxa	14.22	3.84	31.39	8.71	35.22	7.58	26.94	11.51	5	54
Total Number of Taxa	70		121		125		169			
Diversity Index	2.390	0.312	2.828	0.456	2.024	0.481	2.414	0.532	1.191	3.469
Evenness	0.920	0.080	0.829	0.120	0.573	0.133	0.774	0.186	0.335	1.000

3.3.1 Number of Individuals

There was an overall statistically significant difference in the number of individuals between the surveys ($p < 0.001$) (Table H.1): the average numbers increased from 27.2 at 1 month, to 92.4 at 6 months and 358.8 at 12 months, suggesting a recovery. However the interaction comparison of the Survey x Area was not statistically significant suggesting the different areas changed in a similar way over time between surveys, and when the data from each area were compared pairwise within each survey there were no statistically significant differences between the Recovery area and the Control areas, suggesting the increases were the result of natural variation, and thus no recovery has occurred. The lack of difference between the areas with survey suggests that the benthic population as a whole in the Recovery area, was not adversely affected by the level of sand extraction, and thus there was no capacity for recovery.

The sand extraction was not evenly distributed over the Recovery area as shown in Appendix B. Thus the sample points in the Recovery area were assigned to four categories: No, Low, Medium, and High. Those sites with No sand extraction history in the last 18 months were combined with Control samples for testing. These four categories were used to test if sand extraction history had an impact on the recovery.

There was no overall statistically significant difference in the number of individuals between sites with different sand extraction histories ($p = 0.8865$) (Table H.2), the average numbers increased from 151 with a high level of sand extraction, to 157.3 with medium level of sand extraction, to 170.3 with a low level of sand extraction and 157.7 at sites with no sand extraction including the control sites. The statistical tests suggest there is no adverse impact on the numbers of individuals as a result of increased sand extraction.

3.3.2 Number of Taxa

There was an overall statistically significant difference in the number of taxa between the surveys ($p < 0.001$) (Table H.3), the average numbers increased from 13.6 at 1 month, to 30.0 at 6 months and 34.3 at 12 months, suggesting a recovery. However the interaction comparison of the Survey x Area was not statistically significant suggesting the different areas changed in a similar way over time between surveys,

and when the data from each area were compared pairwise within each survey there were no statistically significant differences between the Recovery area and the Control areas, suggesting the increases were the result of natural variation, and thus no recovery has occurred. The lack of difference between the areas with survey suggests that the benthic population as a whole in the Recovery area, was not adversely affected by the level of sand extraction, and thus there was no capacity for recovery.

There was no overall statistically significant difference in the number of taxa between sites with different sand extraction histories ($p = 0.8234$) (Table H.4), the average numbers increased from 22.0 with a high level of sand extraction, to 24.2 with medium level of sand extraction, to 25.9 with a low level of sand extraction and 26.5 at sites with no sand extraction including the control sites. The statistical tests suggest there is no adverse impact on the numbers of taxa as a result of increased sand extraction.

3.3.3 Diversity Index

The Shannon-Wiener Diversity Index can range from 0 to around 4, depending on the complexity and diversity of the ecosystem being studied. Generally:

- **Low Diversity:** values close to 0 indicate low diversity, meaning the community is dominated by one or a few species.
- **Moderate Diversity:** values around 1 to 2 suggest moderate diversity.
- **High Diversity:** values above 2 are considered high, indicating a more diverse and evenly distributed community. Any values above 3 are considered very high.

The Shannon-Wiener Diversity Index values per sample in the Recovery area ranged from 0.994 to 3.384 averaging 2.354, while in the Control areas, it ranged from 1.191 to 3.469 averaging 2.414. One sample from the sand extraction area and Control areas had Shannon-Wiener Diversity Index value in the low range (0-1), 30 samples were in the moderate range (1-2), the majority (101) were in the high range (>2), and 18 replicate samples were in the very high range of greater than 3.

There was an overall statistically significant difference in the diversity between the surveys ($p < 0.001$) (Table H.3), the average diversity index changed from 2.329 at 1 month, to 2.836 at 6 months and 1.979 at 12 months, suggesting variation but no overall trend of recovery. The interaction comparison of the Survey x Area was not statistically significant suggesting the different areas changed in a similar way over time between surveys, and when the data from each area were compared pairwise within each survey there were no statistically significant differences between the Recovery area and the Control areas, suggesting the increases were the result of natural variation, and thus no recovery has occurred. The lack of difference between the areas with survey suggests that the benthic population as a whole in the Recovery area, was not adversely affected by the level of sand extraction, and thus there was no capacity for recovery.

There was no overall statistically significant difference in the diversity between sites with different sand extraction histories ($p = 0.6898$) (Table H.6), the average diversity increased with decreased sand extraction history from 2.023 with a high level of sand extraction, to 2.308 with medium level of sand extraction, to 2.400 with a low level of sand extraction and 2.405 at sites with no sand extraction including the control sites. Despite the differences, the statistical tests suggest there is no adverse impact on the diversity as a result of increased sand extraction.

3.3.4 Multivariate

The above statistics (number of taxa, number of individuals, and diversity index) provide an indication of changes however they do not reflect potential changes in composition and abundance of the whole community; thus, a multivariate approach is required as outlined in section 2.5.3.

The following multivariate approach was conducted on the biota for each sample within the Recovery and Control areas for the three surveys. A Bray-Curtis (B-C) similarity matrix was created on fourth-root transformed density data to scale down high numbers which dominated the assemblages and to give more influence to the rare taxa. Non-metric multidimensional scaling (nMDS) was used to visualise the degree of similarity among different samples (Figure 7).

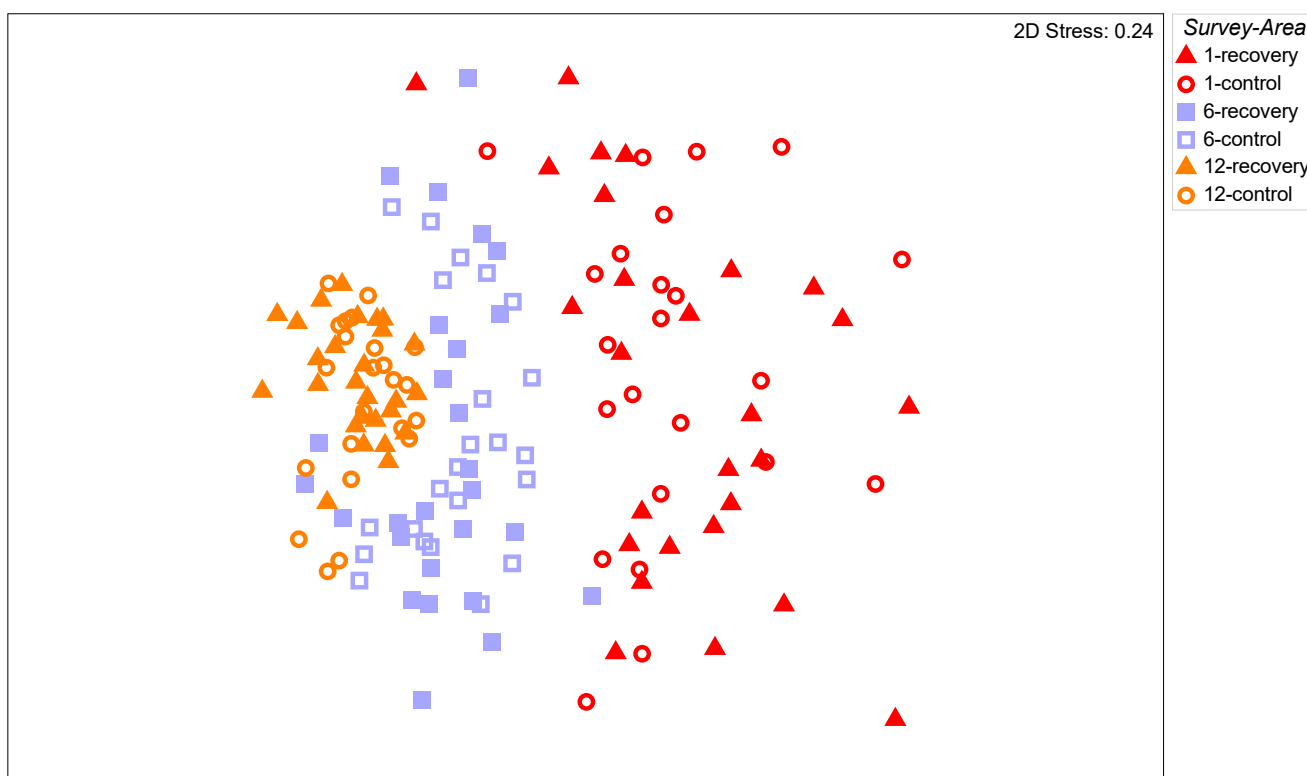


Figure 7 *Non-metric Multi-Dimensional Scaling (nMDS) of fourth-root transformed benthic biota, with symbol grouping by sampling Area and colours by Survey*

While the stress level of 0.24 is high suggesting the configuration does not well represent the distances between the data points, Figure 7 appears to show that the sample data from each survey are clumped, with the 1 month data on the right, 6 month in the middle and 12 month data on the left, suggesting differences base on survey. The Recovery and Control area samples within each survey appear to be overlapped suggesting little difference between areas within surveys. Multivariate data can differ in relation to the location of the centroid of each group within the multivariate cloud and in the spread of data within a group around each centroid. The differences between the surveys appear to show that the dispersion around the centroids of each survey progressively gets smaller from 1 month to 12 months (points being closer together).

These potential differences were tested with the PERMDIS and PERMANOVA functions in PRIMER-E. Multivariate analysis of the benthic infauna revealed strong temporal structuring of community composition across the three survey periods: 1 month (September 2023), 6 months (March 2024), and 12

months (September 2024) after cessation of sand extraction. The PERMDISP results showed a highly significant effect of survey period on multivariate dispersion ($F = 70.83$, $p = 0.0001$), with dispersion values declining from 48.6 at one month to 41.2 at six months and to 32.8 at twelve months (Table H.7). This decline occurred in both the Recovery and Control areas and is indicative of natural temporal stabilisation, where early post-disturbance or seasonally dynamic communities exhibit higher variability that decreases as assemblages reorganise. Because PERMDISP assesses dispersion (spread) rather than centroid shifts, a significant PERMDISP result does not by itself imply differences in community composition. Differences detected by PERMANOVA must therefore be interpreted in light of whether centroid shifts, not dispersion differences, are driving the pattern (Anderson *et al.*, 2006). Dispersion did not differ significantly between areas ($F = 1.02$, $p = 0.316$), meaning that subsequent differences in community structure between Recovery and Control areas can be interpreted without concern for confounding differences in multivariate spread. Although the survey x area term was significant for dispersion ($F = 26.98$, $p = 0.0001$), the pattern reflected shared temporal shifts rather than extraction recovery specific variability.

The PERMANOVA results further emphasised the predominance of temporal dynamics. Survey period was the strongest determinant of community structure (Pseudo- $F = 22.60$, $p = 0.0001$), with the component of variation for this factor (≈ 766) far exceeding that associated with area (≈ 25) or the survey x area interaction (≈ 31) (Table H.8). While the main effect of area was statistically significant (Pseudo- $F = 2.05$, $p = 0.0155$), the absence of a significant survey x area interaction (Pseudo- $F = 1.43$, $p = 0.066$) demonstrates that temporal changes in the Recovery area were parallel to those in the control sites. In ecological terms, this means that the Recovery area was not following a different developmental pathway from the controls; both areas changed through time in a similar way and at similar magnitudes.

Pairwise testing supported this interpretation. No significant difference between Recovery and Control areas was detected at one month ($t = 1.19$, $p = 0.141$), suggesting that there was no measurable extraction-related impact present at the time monitoring commenced. If sand extraction had caused a strong ecological disturbance detectable at the assemblage level, a significant difference would be expected at this initial survey. The lack of difference implies either that extraction did not produce a strong benthic disturbance or that any effect had dissipated rapidly or been masked by natural variability.

At six months, a small but statistically significant difference between areas was detected ($t = 1.33$, $p = 0.035$), and a similarly modest difference persisted at twelve months ($t = 1.39$, $p = 0.0275$). However, these differences did not represent a recovery trajectory. Because there was no initial divergence at one month, and because the survey x area interaction was not significant, the minor differences at later times cannot be interpreted as evidence of convergence or ongoing recovery from an earlier impact. Rather, they reflect small, persistent between-area differences that are minor relative to the much stronger temporal signal shared across all sites.

Across both areas, within-group similarity increased markedly over time, reaching 42 - 43 at 6 months and 52 - 54 at 12 months. This pattern, coupled with declining multivariate dispersion, is characteristic of natural seasonal or successional stabilisation in soft-sediment communities. The fact that both the Recovery and Control areas exhibited this same temporal pattern further supports the conclusion that the observed temporal changes were driven by natural environmental variation rather than residual effects of sand extraction.

Overall, the combined evidence indicates that benthic infaunal assemblages in the Recovery area exhibited substantial temporal change during the monitoring period, but these changes closely mirrored those seen in the control sites. There was no statistical indication of an extraction-induced impact from which the community was recovering, and no measurable divergence between areas at the time monitoring began. The absence of a survey x area interaction confirms that both areas followed similar ecological trajectories over the 12 month period. Although small differences between areas were detected at later surveys, these were of low ecological magnitude and did not develop or diminish in a manner consistent with recovery from disturbance.

These results indicate that no statistically detectable extraction-related impact was present at the time monitoring commenced, and that subsequent changes in the Recovery area represent natural temporal variation rather than directional recovery from disturbance.

Seasonal and Temporal Drivers of Community Change

The SIMPER analyses (Table H.9, Table H.10) provide clear ecological context for the strong temporal patterns identified. The sampling months, September (spring) and March (late summer/early autumn), capture two distinct seasonal community states characteristic of northeastern New Zealand's open coast. Seasonal shifts in benthic infaunal assemblages are characteristic of temperate soft sediment systems, where winter storms, spring recruitment, and summer productivity cycles strongly shape community composition (Thrush *et al.*, 1994, McLachlan & Brown, 2006).

At 1 month (September 2023), both the Recovery and Control assemblages exhibited low internal similarity ($\approx 31\%$) and were dominated by mobile opportunistic taxa including Amphipoda, *Pagurus* sp., Urothoidae, Sigalionidae, and Maldanidae. This assemblage structure is typical of post-winter sandflats in the region, when elevated storm activity and sediment mobility favour small, rapidly colonising deposit feeders. The prominence of these taxa at this time therefore reflects natural early-spring conditions rather than extraction impacts.

By 6 months (March 2024), coinciding with the late-summer/early-autumn period, assemblages had shifted markedly toward higher similarity ($\approx 41 - 42\%$) and increased representation of taxa typical of more stable, consolidated, and productive seasonal conditions. SIMPER identified higher contributions from Phyllodocidae, *Scalpomactra scalpellum*, *Sigapatella tenuis*, *Tawera spissa*, and multiple polychaete families (e.g., Terebellidae, Maldanidae). These taxa commonly increase during late summer, when calmer conditions, greater organic deposition, and reduced sediment disturbance facilitate the development of more cohesive infaunal communities. The consistency of this pattern in both Recovery and Control areas reinforces the role of natural seasonal drivers.

By 12 months (September 2024), the assemblages again reflected an early-spring state but with substantially greater internal similarity ($\approx 53 - 54\%$) than observed in September 2023. A dominant feature of this survey was the sharp increase in *Spiophanes kroyeri*, which contributed over 11% to within-group similarity. Along with *Prionospio multicristata*, Terebellidae, Maldanidae, and Nemertea, this species forms part of a characteristic spring assemblage of the region, associated with stabilised sediments and late-winter increases in organic matter accumulation. The species contributing most to dissimilarity between surveys, *Spiophanes kroyeri*, maldanids, phyllodocids, and *Tawera* bivalves, changed in ways consistent with natural seasonal cycles rather than extraction effects.

Overall, the SIMPER results show that the taxa driving survey-to-survey changes were the same in both Recovery and Control areas, and they followed trajectories typical of seasonal succession in soft-sediment habitats of northeastern New Zealand. No taxa or taxonomic groups displayed trends indicative of extraction specific disturbance or subsequent recovery.

Synthesis and Implications

The combined PERMANOVA, PERMDISP, and SIMPER findings provide no evidence of a persistent extraction effect at the assemblage level. The Recovery area did not differ significantly from Control sites at the commencement of monitoring, nor did its temporal trajectory diverge from natural seasonal patterns. Instead, all observed changes corresponded closely to known seasonal dynamics of sandy benthic communities in the northern New Zealand coastal environment.

Where statistically significant differences between Control and Recovery areas occurred (at 6 and 12 months), they were small and not temporally structured in a way consistent with recovery from disturbance. Rather, these minor differences fall well within the range of natural spatial variability commonly recorded in exposed coastal embayment's.

Accordingly, the results indicate that benthic assemblages in the Recovery area were not exhibiting detectable recovery from extraction, because no measurable extraction-induced impact was evident at the time monitoring began. Instead, the communities in both areas tracked parallel seasonal and successional trajectories across the annual cycle.

3.4 Drop Camera Photographs

Seabed imagery in Appendix F showed consistent differences in physical seabed structure and shell material between the Recovery area and the Control area (including the Outside samples) through time, but these differences largely reflected local sedimentary conditions rather than clear evidence of disturbance-driven recovery.

1 month after cessation (September 2023)

At 1 month, both the Recovery and Control areas were characterised by small to medium irregular ripples, sparse epifauna and a mixture of fine and coarse shell material. However, the Recovery area exhibited slightly higher variability in shell cover, with some stations having medium to high shell deposits compared to predominantly low shell densities in Control sites. Occasional biota such as *Astropecten polyacanthus*, sponges, hermit crabs, and scattered burrows were present across both areas, but densities were low and not spatially patterned. Overall, seabed appearance at this early stage was similar between Recovery and Control areas, with no strong evidence of extraction related differences in bedform or epifauna.

6 months after cessation (March 2024)

After 6 months, a pronounced shift was recorded in both groups: much of the seabed had flattened, and shell material increased markedly across most stations. This flattening was observed consistently across the Recovery area and across the Control area, indicating a system wide seasonal or hydrodynamic shift rather than a recovery specific trajectory. Recovery stations commonly showed high shell cover, particularly large dead scallop shells at several sites. Control sites also showed high shell

concentrations, with many stations classified as flat with abundant medium to coarse shells. Biotic observations remained sparse and low-density in both groups, again showing no strong divergence between Recovery and Control areas.

12 months after cessation (October 2024)

After 12 months, the seabed in both the Recovery and Control areas was again mostly flat or weakly rippled, but overall shell cover decreased in many Recovery stations (commonly “Low” to “Medium”), while several Control sites retained Medium to High shell deposits. Epifaunal density remained very low across both areas, consistent with earlier surveys. Occasional individuals such as *Astropecten polyacanthus*, *Xenophora*, scallops, and isolated sponges were recorded sporadically, but without consistent spatial association to either zone. No broad scale epifaunal recovery trend was evident, and biological community composition remained similarly sparse between the groups.

Across all survey periods, the drop-camera imagery indicates:

1. **Physical seabed structure** changed similarly in both groups.
Flattening of bedforms and increases in shell deposition from 1 to 6 months were observed in both Recovery and combined Control areas, suggesting these changes were driven by embayment wide hydrodynamic or seasonal processes rather than extraction specific recovery.
2. **Shell distribution** differences were present but inconsistent.
The Recovery area showed greater heterogeneity in shell cover at 1 month and 12 months, whereas the Control area tended to exhibit more stations with consistently medium to high shell loads, especially at 6 months. However, these differences were not directional or progressive and did not align with a clear recovery trajectory.
3. **Epifaunal densities** were low throughout with no recovery signal.
Across all surveys, both zones displayed very low epifaunal abundance, with only occasional mobile fauna (e.g., starfish, *Xenophora*, gastropods) or small sponges. There was no indication of increasing biotic density or diversity in the Recovery area relative to the Control area over time.
4. **No visual evidence** for accelerated recovery within the Recovery area.
The Control area exhibited very similar seabed features and biota to the Recovery area across all three time periods. The temporal patterns observed (increasing shell cover, flattening, subsequent shell reduction) appeared to occur simultaneously in both groups, indicating that seabed morphology and visible epifauna are strongly driven by natural seasonal or sedimentary dynamics rather than by post extraction recovery processes.

3.5 Epibenthic Macrofauna

A total of 17 200 m long tows were conducted at 1 month, 6 months and 12 months after cessation of sand extraction within the Recovery area and Control area. The raw data for each tow sample along with the individual replicate summary statistics (Number of Individuals, and Number of Taxa) from within the Recovery and Control areas for each survey are presented in Table G.1, Table G.2, and Table G.3 in Appendix G.

Epibenthic biota results are summarised by the number of taxa, and number of individual organisms, for each sampling area and sampling event. A total of 66 identified species/taxa and a total of 595 live

individuals were counted. The number of individuals averaged 11.7 per replicate sample and ranged from 1 to 32. The number of taxa averaged 6.6 per replicate sample and ranged from 1 to 16. The Shannon-Wiener diversity index was not calculated as the samples do not represent the complete population and thus would produce misleading results. The replicate data were grouped by sampling area per sampling event (Table 3).

Table 3 *Summary of Epibenthic Biota Population Statistics by sampling area per sampling event September 2023 to October 2024*

Survey	1 month		6 months		12 months		All			
	Sept-23		Mar-24		Oct-24					
Area	Recovery area									
	Ave.	SD	Ave.	SD	Ave.	SD	Ave.	SD	min	max
Number of samples	12		12		12		36			
Number of Individuals	7.25	4.99	16.17	10.12	13.67	3.75	12.36	7.68	1	32
Number of Taxa	3.75	2.26	7.92	4.14	8.92	2.15	6.86	3.69	1	16
Total Number of Taxa	14		36		25		43			
Area	Control									
	Ave.	SD	Ave.	SD	Ave.	SD	Ave.	SD	min	max
Number of samples	5		5		5		15			
Number of Individuals	6.80	1.48	7.80	3.70	15.40	2.51	10.00	4.71	5	19
Number of Taxa	3.60	0.55	5.80	2.39	8.80	2.39	6.07	2.87	3	12
Total Number of Taxa	8		14		23		27			

The numbers of individuals and numbers of taxa appear to mirror the results from the infauna sampling with increases over time at both the Recovery area and Control area samples.

The following multivariate approach was conducted on the biota for each sample within the Recovery and Control areas for the three surveys. A Bray-Curtis (B-C) similarity matrix was created on square-root transformed density data to scale down high numbers which dominated the assemblages and to give more influence to the rare taxa. Non-metric multidimensional scaling (nMDS) was used to visualise the degree of similarity among different samples (Figure 8).

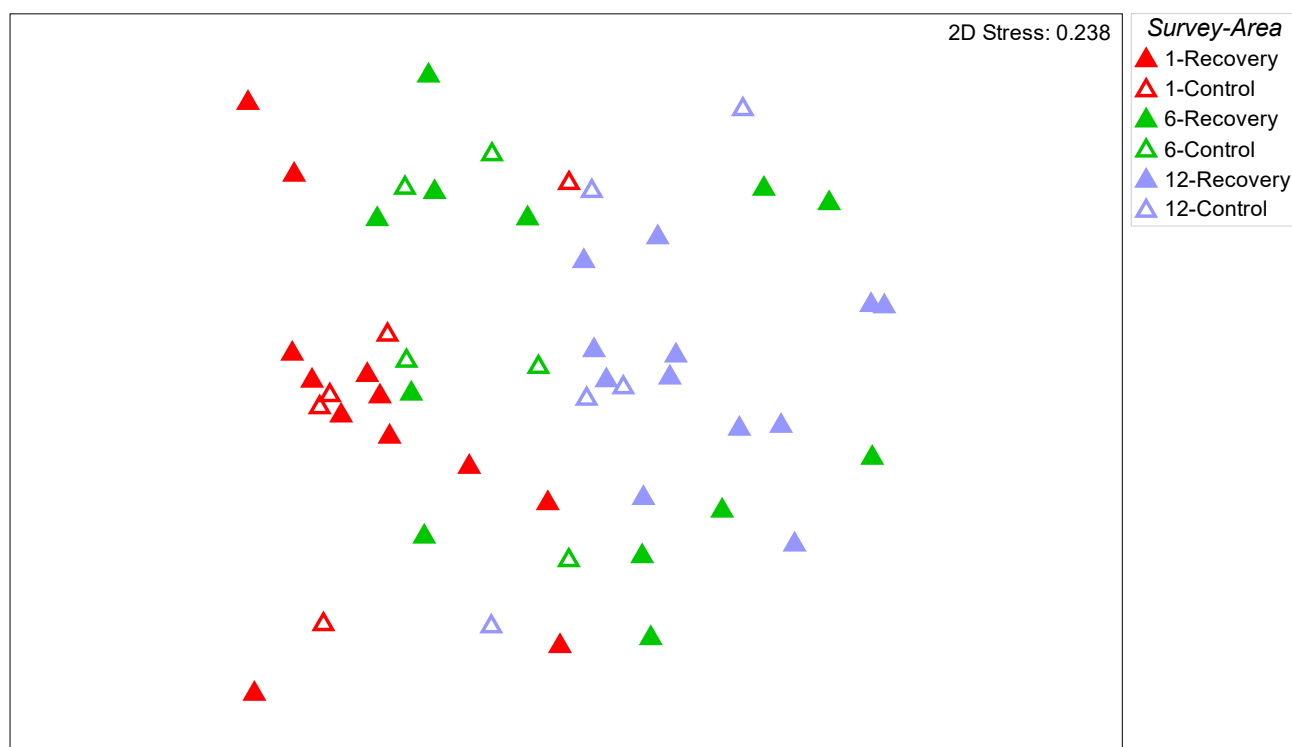


Figure 8 *Non-metric Multi-Dimensional Scaling (nMDS) of square-root transformed Epibenthic biota, with symbol grouping by sampling Area and colours by survey*

While the stress level of 0.24 is high suggesting the configuration does not well represent the distances between the data points, Figure 8 appears to show that the sample data from each survey are clumped, with the 1 month data on the left, 6 month in the middle and 12 month data on the right, suggesting differences based on Survey. The Recovery and Control area samples within each survey appear to be overlapped suggesting little difference between Areas within Surveys.

Analyses of the tow based epibenthic assemblages showed that temporal variation was the dominant source of multivariate change, with only minor differences detected between the Recovery and Control areas. Multivariate dispersion varied among surveys, with the 6 month samples exhibiting the greatest spatial heterogeneity (PERMDIS: $F = 2.81$, $P = 0.0698$; 6 vs 1 month: $t = 2.10$, $P = 0.043$; 6 vs 12 months: $t = 2.35$, $P = 0.0285$; Table H.11). Dispersion also differed between areas, with Recovery samples showing slightly higher heterogeneity than Control samples ($F = 4.86$, $P = 0.034$), though this did not correspond to strong compositional separation (Table H.11). As PERMDISP measures variation in group dispersion rather than differences in centroid location, significant PERMDISP results do not necessarily indicate compositional differences between Recovery and Control assemblages.

PERMANOVA results confirmed a pronounced temporal signal, with significant shifts in community structure across the three survey periods (Pseudo- $F = 7.31$, $P = 0.0001$). The Area effect was comparatively weak but statistically detectable (Pseudo- $F = 2.00$, $P = 0.0437$); however, the magnitude of this effect was small relative to temporal variability. Importantly, the Survey $\times$ Area interaction was not significant (Pseudo- $F = 0.72$, $P = 0.783$), demonstrating that differences between Recovery and Control assemblages did not change in a directional manner through time (Table H.12).

Pairwise comparisons showed no significant differences between Recovery and Control assemblages at any survey period (1 month: $P = 0.355$; 6 months: $P = 0.189$; 12 months: $P = 0.520$), indicating that both

areas experienced similar temporal trajectories (Table H.12). Within Area comparisons revealed strong temporal differences, particularly within the Recovery area, further underscoring the dominance of natural seasonal variability.

Overall, the tow-based epibenthic data provide no evidence of directional post extraction recovery over the 12 month monitoring period. Instead, community changes were driven primarily by temporal dynamics that occurred similarly in both Recovery and Control areas. These findings suggest that either sand extraction had limited influence on epifaunal tow assemblages, or that any extraction related effects were short-term and had already dissipated by the beginning of post extraction sampling 1 month after sand extraction had stopped.

4 CONCLUSIONS

This study evaluated post-extraction recovery of benthic habitats in the Pakiri embayment using three complementary datasets, infaunal benthic communities, epibenthic tow assemblages, and sediment grain-size composition. Samples were collected at 1, 6, and 12 months after extraction ceased within the Recovery area, alongside concurrent Control sites. Collectively, the results indicate that **temporal (seasonal) variation was the dominant source of ecological change**, and there was **no consistent evidence of extraction-related impacts or recovery trajectories** across the first year of monitoring.

Sediment grain-size composition

Sediment composition remained stable across surveys and between areas, with no significant temporal or spatial differences detected. PERMANOVA results showed no effect of Survey (Pseudo-F = 0.85, $P = 0.4601$) and no effect of Area (Pseudo-F = 1.33, $P = 0.2374$), and the Survey x Area interaction was negligible ($P = 0.9997$; Table D.8). PERMDIS similarly showed no significant differences in multivariate dispersion among surveys ($P = 0.397$) or between areas ($P = 0.048$; marginal and small in magnitude). These results indicate that **sediment characteristics, an important determinant of benthic community structure, did not change detectably in association with extraction or during the subsequent year**.

Benthic infauna

Infaunal assemblages exhibited strong and statistically significant temporal shifts across the three surveys, driven primarily by pronounced seasonal variation. SIMPER analyses showed substantial changes in the abundance of taxa such as *Spiophanes kroyeri*, Maldanidae, Terebellidae, Amphipoda, Cumacea, and several other characteristic sand-flat polychaetes. These changes were broadly similar between Recovery and Control sites, and although minor spatial differences were occasionally detectable, they were small relative to the magnitude of the seasonal signal. Crucially, there was **no significant Survey x Area interaction**, indicating **no directional convergence nor divergence of Recovery assemblages relative to Controls**, and therefore no identifiable recovery trajectory following extraction.

Epibenthic tow assemblages

Epibenthic community structure showed a similar pattern to the infaunal data. PERMANOVA revealed strong temporal differences (Pseudo-F = 7.31, $P = 0.0001$), consistent with seasonal community reorganisation, while spatial differences between Recovery and Control areas were comparatively weak (Pseudo-F = 2.00, $P = 0.0437$; Table H.12). Within each survey, Recovery and Control assemblages did not differ significantly (all $P > 0.18$), and the non-significant Survey x Area interaction confirms that **epifaunal assemblages did not follow any directional shift indicative of recovery**. Multivariate dispersion was higher in Recovery at some times, but this reflected spatial heterogeneity rather than compositional differences.

Synthesis

Across all biological and sediment datasets, a consistent pattern emerges that natural seasonal variation, not extraction history, was the main driver of observed changes.

- Infauna, epifauna, and sediment grain size all showed strong seasonal patterns but no evidence of directional recovery in Recovery sites relative to Controls.
- Spatial differences between Control and Recovery were small, inconsistent, and non-directional.
- No persistent extraction-related signature was detectable one month after extraction ceased, implying either;
 - i. extraction effects were minimal, or
 - ii. any short-term disturbance had already resolved before monitoring began.

The combined evidence indicates that benthic habitats in the Pakiri embayment were not measurably affected by extraction at the scale of this study, or that any initial effects were rapidly ameliorated. Over the 12 month post extraction period, the Recovery area remained ecologically comparable to the unimpacted Control areas in terms of infaunal composition, epibenthic assemblages, and sediment grain size structure. Consequently, no clear recovery signal was observed because no persistent extraction impact was detectable. Soft sediment benthic assemblages are known to exhibit strong natural resilience and rapid reassembly following small scale physical disturbance, particularly in high energy coastal environments (Hall, 1994; Dernie *et al.*, 2003).

Based on the present dataset, benthic ecological structure appears resilient and primarily shaped by natural seasonal dynamics, rather than by past extraction activity.

REFERENCES

Anderson, M. J. (2001)

A new method for non-parametric multivariate analysis of variance. *Austral Ecology*, 26(1), 32–46.

ASR (2003)

Pre-Dredging Assessment: Ecological Component, Infaunal Sampling and Drop-Camera Video Surveys of a 1 x 8 km Area off Pakiri Beach. Report prepared for Kaipara Ltd. pp29

Anderson, M. J., Ellingsen, K. E., & McArdle, B. H. (2006)

Multivariate dispersion as a measure of β diversity. *Ecology Letters*, 9(6), 683–693.

Clarke K. R., Gorley R. N., Somerfield P.J., and Warwick R.M. (2014)

Change in marine communities: an approach to statistical analysis and interpretation, 3rd edition. PRIMER-E: Plymouth

Clarke, K. R., & Warwick, R. M. (2001)

Change in marine communities: An approach to statistical analysis and interpretation (2nd ed.). PRIMER-E.

De Backer A., B. N., Hans, H., Ellen, P., Jan, R., Van Hoey Gert, W. J., & Kris, H. (2017).

Ecological assessment of intense aggregate dredging activity on the Belgian part of the North Sea. Belgian marine sand: a scarce resource?, 47.

Dernie, K. M., Kaiser, M. J., & Warwick, R. M. (2003)

Recovery rates of benthic communities following physical disturbance. *Journal of Animal Ecology*, 72(6), 1043–1056.

Gray, J. S. (1974)

Animal-sediment relationships. *Oceanography and Marine Biology Annual Review*, 12, 223–261.

Hall, S. J. (1994)

Physical disturbance and marine benthic communities: Life in unconsolidated sediments. *Oceanography and Marine Biology Annual Review*, 32, 179–239.

Hitchcock, D.R., Newell, R.C., Seiderer, L.J. (2002)

Integrated Report on the Impact of Marine Aggregate Dredging on Physical and Biological Resources of the Sea Bed. U.S. Department of the Interior, Minerals Management Service, International Activities and Marine Minerals Division (INTERMAR), Washington, D.C. OCS Report Number 2002-054.

Kaipara Limited (2003)

Coastal permit RCAN0621 (ARC 20795) Environmental Monitoring Management Plan, Deep Water Area 1.

McLachlan, A., & Brown, A. C. (2006)

The ecology of sandy shores (2nd ed.). Academic Press.

Snelgrove, P. V. R., & Butman, C. A. (1994)

Animal–sediment relationships revisited: Cause versus effect. *Oceanography and Marine Biology Annual Review*, 32, 111–177.

Thrush, S. F., Hewitt, J. E., Cummings, V. J., Dayton, P. K. (1994)

The importance of predators on a sandflat: Seasonal changes in a New Zealand estuary. *Marine Ecology Progress Series*, 107, 211–222.

APPLICABILITY AND LIMITATIONS

Restrictions of Intended Purpose

This report has been prepared solely for the benefit of McCallum Bros Limited as our client with respect to the brief. The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such party's sole risk.

Legal Interpretation

Opinions and judgements expressed herein are based on our understanding and interpretation of current regulatory standards and should not be construed as legal opinions. Where opinions or judgements are to be relied on, they should be independently verified with appropriate legal advice.

Maps and Images

All maps, plans, and figures included in this report are indicative only and are not to be used or interpreted as engineering drafts. Do not scale any of the maps, plans or figures in this report. Any information shown here on maps, plans and figures should be independently verified on site before taking any action. Sources for map and plan compositions include LINZ Data and Map Services and local council GIS services. For further details regarding any maps, plans or figures in this report, please contact Bioresearches.

APPENDICES

Appendix A Sampling Area Positions

Table A.1 Recovery Area Boundary (WGS84, NZTM)

Point	World Geodetic System 1984		New Zealand Transverse Mercator Projection	
	Latitude	Longitude	Northing	Easting
Ra	-36.19133998	174.7163965	5993462.586	1754327.075
Rb	-36.19891103	174.7055631	5992639.887	1753338.153
Rc	-36.22833212	174.7383336	5989323.771	1756226.132
Rd	-36.22249882	174.7475002	5989956.069	1757061.691

Table A.2 Drop Camera, Benthic Grab and Sediment Grain Size Grab sampling points within Recovery Area, Outside and Control Area (WGS84, NZTM).

Point	Cell	World Geodetic System 1984		New Zealand Transverse Mercator Projection	
		Latitude	Longitude	Northing	Easting
Recovery Area					
A1S31	01D	-36.196755	174.710344	5992871.493	1753772.236
A1S32	01F	-36.197018	174.714980	5992834.957	1754188.569
A1S33	01G	-36.192674	174.715561	5993315.928	1754249.332
A1S34	01G	-36.194847	174.717973	5993071.031	1754461.950
A1S36	01D	-36.201245	174.715756	5992364.807	1754250.047
A1S37	01C	-36.201460	174.710997	5992348.516	1753821.743
A1S39	01C	-36.205112	174.715231	5991936.662	1754195.257
A1S40	02B	-36.207221	174.715552	5991702.192	1754219.978
A1S41	02F	-36.201563	174.721038	5992321.115	1754724.328
A1S42	02F	-36.202357	174.724296	5992227.831	1755015.689
A1S44	02F	-36.205431	174.726129	5991883.889	1755174.423
A1S45	02D	-36.206322	174.722414	5991790.986	1754838.667
A1S46	02B	-36.209872	174.720377	5991400.422	1754648.545
A1S48	03B	-36.212992	174.723390	5991049.498	1754913.263
A1S49	03D	-36.211299	174.726460	5991232.399	1755192.591
A1S50	03F	-36.209020	174.732266	5991475.908	1755719.062
A1S51	03E	-36.212409	174.731019	5991101.955	1755600.242
A1S52	03D	-36.213941	174.731341	5990931.487	1755626.155

Point	Cell	World Geodetic System 1984		New Zealand Transverse Mercator Projection	
		Latitude	Longitude	Northing	Easting
A1S53	03B	-36.216742	174.727036	5990627.664	1755233.617
A1S54	04B	-36.219862	174.732062	5990273.489	1755679.234
A1S55	04C	-36.218547	174.734865	5990414.862	1755933.805
A1S56	03F	-36.212563	174.736180	5991076.576	1756063.899
A1S58	04E	-36.216962	174.739493	5990583.238	1756352.974
A1S59	04B	-36.221188	174.734597	5990122.316	1755904.471
A1S61	04C	-36.223307	174.739035	5989880.099	1756299.176
A1S62	04D	-36.221351	174.740537	5990094.663	1756438.080
A1S63	04E	-36.222938	174.744463	5989912.267	1756787.811
Outside					
A1S38	01a	-36.205578	174.709493	5991894.076	1753678.466
A1S47	03a	-36.216587	174.721486	5990653.732	1754735.018
A1S60	04a	-36.224837	174.730425	5989724.220	1755522.233
A1S35	01h	-36.194317	174.720842	5993125.253	1754720.968
A1S43	02h	-36.202891	174.730167	5992159.191	1755542.489
A1S57	04g	-36.214105	174.741718	5990896.586	1756558.680
Control Area					
SA1	CSA	-36.229570	174.739724	5989184.237	1756348.662
SA2	CSA	-36.231840	174.742936	5988927.196	1756632.822
SA3	CSA	-36.233356	174.746472	5988753.353	1756947.529
A1S65	CSB	-36.227697	174.741981	5989388.342	1756555.226
SB1	CSB	-36.229333	174.743013	5989205.165	1756644.700
SB2	CSB	-36.229530	174.745681	5989179.032	1756884.141
SB3	CSB	-36.232130	174.748847	5988885.504	1757163.454
SC1	CSC	-36.227622	174.744917	5989391.861	1756819.307
SC2	CSC	-36.230309	174.747370	5989089.900	1757034.341
SC3	CSC	-36.232772	174.750439	5988811.659	1757305.286
SD1	CSD	-36.226959	174.747024	5989462.002	1757009.930
SD2	CSD	-36.228048	174.748014	5989339.652	1757096.802
SD3	CSD	-36.230934	174.753200	5989011.113	1757557.087
A1S64	CSE	-36.224732	174.747199	5989708.821	1757030.152
SE1	CSE	-36.225489	174.750111	5989620.151	1757290.395
SE2	CSE	-36.227190	174.750440	5989430.903	1757316.558
SE3	CSE	-36.229503	174.753573	5989169.203	1757593.523

Table A.3 Benthic Dredge tow sampling transect points (WGS84, NZTM)

Transect	end	World Geodetic System 1984		New Zealand Transverse Mercator Projection	
		Latitude	Longitude	Northing	Easting
Recovery Area					
01BC	■	-36.201461	174.710565	5992349.039	1753782.856
01BC	▲	-36.202418	174.712449	5992239.886	1753950.444
02BC	■	-36.206733	174.717168	5991753.759	1754366.185
02BC	▲	-36.207782	174.718977	5991634.535	1754526.764
03AB	■	-36.215922	174.725195	5990721.560	1755069.777
03AB	▲	-36.217070	174.726910	5990591.461	1755221.679
04AB	■	-36.223235	174.733165	5989897.493	1755771.649
04AB	▲	-36.224232	174.735018	5989783.952	1755936.296
01DE	■	-36.198693	174.713522	5992651.460	1754054.194
01DE	▲	-36.199596	174.715447	5992548.248	1754225.505
02DE	■	-36.206131	174.722551	5991812.011	1754851.320
02DE	▲	-36.206767	174.724632	5991738.080	1755037.154
03CD	■	-36.215243	174.731099	5990787.392	1755601.847
03CD	▲	-36.215916	174.733163	5990709.459	1755786.038
04CD	■	-36.220742	174.738504	5990165.527	1756256.549
04CD	▲	-36.221399	174.740575	5990089.227	1756441.423
01FG	■	-36.196144	174.717289	5992928.294	1754397.859
01FG	▲	-36.197134	174.719147	5992815.444	1754562.980
02FG	■	-36.203350	174.724658	5992117.099	1755046.300
02FG	▲	-36.204063	174.726701	5992034.713	1755228.543
03EF	■	-36.210000	174.730988	5991369.281	1755602.241
03EF	▲	-36.211190	174.732659	5991234.575	1755750.073
04EF	■	-36.218142	174.741117	5990449.740	1756496.631
04EF	▲	-36.218934	174.743115	5990358.579	1756674.647
Control Area					
SA	■	-36.230596	174.741553	5989067.430	1756511.008
SA	▲	-36.231622	174.743382	5988950.622	1756673.353
SB	■	-36.231169	174.746842	5988995.323	1756985.237
SB	▲	-36.232087	174.748757	5988890.402	1757155.506
SC	■	-36.228983	174.746377	5989238.539	1756947.730
SC	▲	-36.230344	174.747836	5989085.218	1757076.152
SD	■	-36.229202	174.750508	5989207.622	1757318.622
SD	▲	-36.230323	174.752250	5989080.432	1757472.968
SE	■	-36.226966	174.751385	5989454.166	1757401.970
SE	▲	-36.228444	174.752660	5989288.181	1757513.545

Appendix B Sand Extraction History

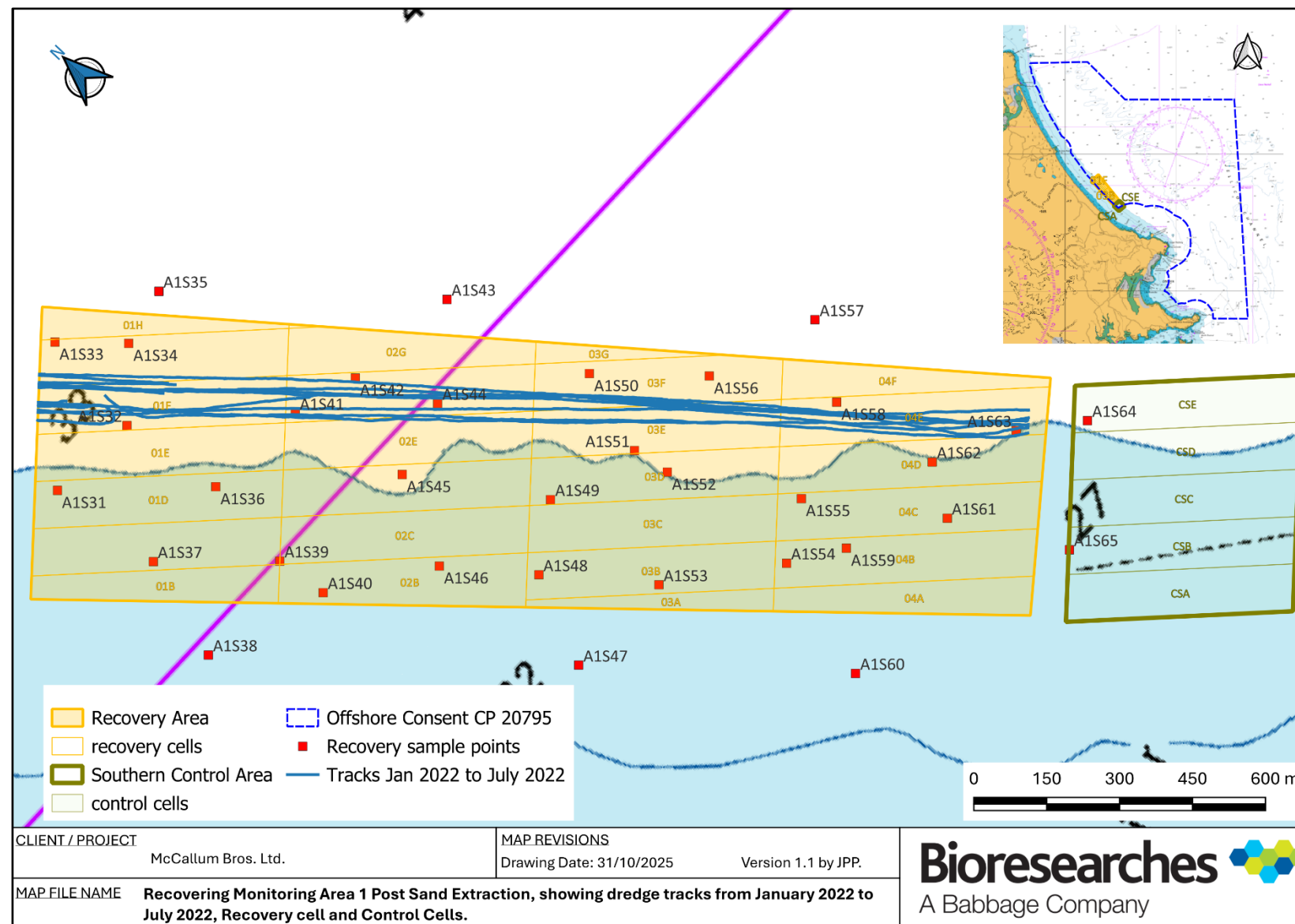


Figure B.1 Sands extraction tracks January 2022 to July 2022.

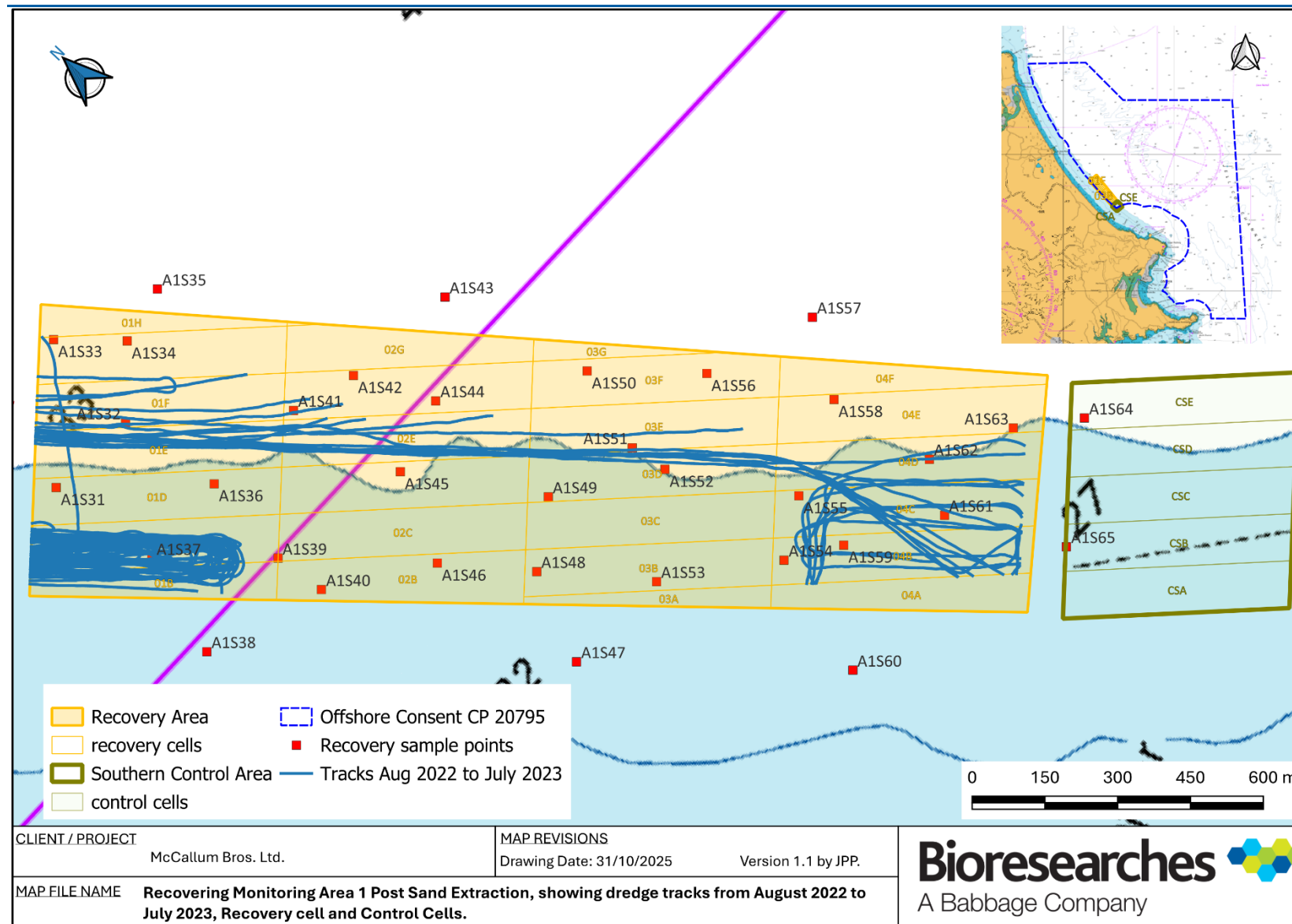


Figure B.2 Sands extraction tracks August 2022 to July 2023.

Table B.1 Track history

Date	Cell	Length (m)	Volume (m ³)
9-Feb-22	01F	737.49	118.00
11-Feb-22	01E	259.30	41.49
11-Feb-22	01F	1408.80	225.41
17-Mar-22	01F	423.03	67.69
17-Mar-22	01G	126.43	20.23
18-Mar-22	01F	77.04	12.33
18-Mar-22	01G	491.13	78.58
2-Apr-22	01F	96.55	15.45
15-Apr-22	01F	251.75	40.28
15-Apr-22	01G	352.78	56.44
12-May-22	01F	274.64	43.94
12-May-22	01G	822.98	131.68
12-May-22	02F	1098.28	175.72
12-May-22	03E	505.49	80.88
12-May-22	03F	592.20	94.75
12-May-22	04E	1099.37	175.90
14-May-22	01F	1093.66	174.98
14-May-22	02F	1094.36	175.10
14-May-22	03E	571.68	91.47
14-May-22	03F	523.52	83.76
14-May-22	04E	1100.84	176.13
21-May-22	01F	123.45	19.75
24-May-22	01F	1071.52	171.44
24-May-22	01G	23.37	3.74
24-May-22	02F	1094.19	175.07
24-May-22	03E	281.71	45.07
24-May-22	03F	813.41	130.15
24-May-22	04E	1103.39	176.54
28-May-22	01F	834.20	133.47
28-May-22	02E	450.15	72.02
28-May-22	02F	665.83	106.53
28-May-22	03E	1109.71	177.55
28-May-22	04D	133.95	21.43
28-May-22	04E	980.62	156.90
4-Jun-22	01F	1100.45	176.07
4-Jun-22	02F	171.39	27.42
8-Jun-22	01F	1113.73	178.20
8-Jun-22	02F	1106.97	177.12
8-Jun-22	03E	927.78	148.44
8-Jun-22	03F	178.05	28.49
8-Jun-22	04E	1103.77	176.60
10-Jun-22	01F	1002.15	160.34
10-Jun-22	01G	96.43	15.43
10-Jun-22	02F	1096.18	175.39
10-Jun-22	03E	401.06	64.17
10-Jun-22	03F	694.97	111.20

Date	Cell	Length (m)	Volume (m ³)
10-Jun-22	04E	1086.00	173.76
11-Jun-22	01F	1100.57	176.09
11-Jun-22	02E	786.06	125.77
11-Jun-22	02F	312.02	49.92
11-Jun-22	03E	1095.82	175.33
11-Jun-22	04E	1096.68	175.47
14-Jun-22	01F	1002.15	160.34
14-Jun-22	01G	96.43	15.43
14-Jun-22	02F	1096.18	175.39
14-Jun-22	03E	401.06	64.17
14-Jun-22	03F	694.97	111.20
14-Jun-22	04E	1089.41	174.31
8-Sept-22	01F	922.05	147.53
8-Sept-22	01G	10.04	1.61
22-Sept-22	01F	764.30	122.29
22-Sept-22	01G	525.27	84.04
21-Oct-22	01F	1096.89	175.50
21-Oct-22	02F	110.28	17.64
22-Oct-22	01F	1111.65	177.86
22-Oct-22	02F	266.05	42.57
3-Nov-22	01E	368.14	58.90
3-Nov-22	01F	741.65	118.66
3-Nov-22	02E	1105.73	176.92
3-Nov-22	03E	951.62	152.26
19-Jan-23	01B	138.18	22.11
19-Jan-23	01C	1639.46	262.31
23-Jan-23	01C	902.30	144.37
3-Feb-23	01B	1943.72	311.00
3-Feb-23	01C	1022.23	163.56
8-Feb-23	01C	1021.95	163.51
10-Feb-23	01C	931.21	148.99
16-Feb-23	01C	911.30	145.81
18-Feb-23	01B	80.93	12.95
18-Feb-23	01C	1404.20	224.67
25-Feb-23	01C	902.23	144.36
27-Feb-23	01C	1549.13	247.86
27-Feb-23	01E	1112.53	178.01
27-Feb-23	02E	940.67	150.51
28-Feb-23	01C	902.23	144.36
T27 02_2303XX	01C	687.12	109.94
T27 02_2303XX	01B	246.70	39.47
12-Mar-23	01B	739.79	118.37
12-Mar-23	01E	1096.43	175.43
12-Mar-23	02E	362.28	57.97
15-Mar-23	01B	314.05	50.25
15-Mar-23	01C	682.79	109.25
20-Mar-23	01B	409.96	65.59
20-Mar-23	01C	1291.51	206.64

Date	Cell	Length (m)	Volume (m ³)
22-Mar-23	01B	148.46	23.75
22-Mar-23	01C	665.38	106.46
30-Mar-23	01B	587.78	94.05
30-Mar-23	01C	1092.14	174.74
5-Apr-23	01E	1102.00	176.32
5-Apr-23	02E	199.64	31.94
13-Apr-23	01B	979.40	156.70
13-Apr-23	01C	984.56	157.53
22-Apr-23	01C	929.48	148.72
T53 25_2304XX	01C	1448.00	231.68
T53 25_2304XX	01B	315.73	50.52
T54 26_2304XX	01C	1539.00	246.24
10-Jun-23	01B	953.75	152.60
10-Jun-23	01C	972.51	155.60
15-Jun-23	01B	783.29	125.33
15-Jun-23	01C	1146.44	183.43
16-Jun-23	01C	1859.15	297.46
18-Jun-23	01C	1861.64	297.86
19-Jun-23	01B	643.82	103.01
19-Jun-23	01C	1074.40	171.90
26-Jun-23	01C	511.46	81.83
27-Jun-23	01C	1730.12	276.82
30-Jun-23	01C	1883.06	301.29
3-Jul-23	01E	1019.22	163.08
3-Jul-23	01F	73.80	11.81
3-Jul-23	02E	1059.21	169.47
3-Jul-23	03C	487.11	77.94
5-Jul-23	01C	342.22	54.75
5-Jul-23	01D	208.17	33.31
5-Jul-23	01E	208.38	33.34
5-Jul-23	01F	209.34	33.50
5-Jul-23	01G	219.05	35.05
6-Jul-23	01B	742.32	118.77
6-Jul-23	01C	1047.30	167.57
6-Jul-23	01E	1092.65	174.82
6-Jul-23	02E	1091.64	174.66
6-Jul-23	03C	547.66	87.63
6-Jul-23	03E	546.47	87.43
6-Jul-23	04B	1941.16	310.59
6-Jul-23	04C	1364.33	218.29
6-Jul-23	04D	1257.53	201.21
11-Jul-23	01C	128.03	20.48
11-Jul-23	01D	83.39	13.34
12-Jul-23	01C	1802.02	288.32
17-Jul-23	01E	1091.25	174.60
17-Jul-23	02E	1091.20	174.59
17-Jul-23	03C	783.81	125.41
17-Jul-23	03E	307.34	49.17

Date	Cell	Length (m)	Volume (m ³)
17-Jul-23	04D	1095.59	175.29
22-Jul-23	01B	372.66	59.63
22-Jul-23	01C	1549.56	247.93
22-Jul-23	01E	1102.36	176.38
22-Jul-23	02E	1097.84	175.65
22-Jul-23	03C	862.61	138.02
22-Jul-23	03E	236.87	37.90
22-Jul-23	04B	1062.74	170.04
22-Jul-23	04C	2067.68	330.83
22-Jul-23	04D	734.00	117.44
23-Jul-23	01B	794.66	127.15
23-Jul-23	01C	955.21	152.83
23-Jul-23	01E	1096.40	175.42
23-Jul-23	02E	1094.61	175.14
23-Jul-23	03C	1034.38	165.50
23-Jul-23	03E	61.30	9.81
23-Jul-23	04B	1796.13	287.38
23-Jul-23	04C	1889.42	302.31
23-Jul-23	04D	755.71	120.91
24-Jul-23	01B	865.12	138.42
24-Jul-23	01C	906.28	145.00
24-Jul-23	01E	1095.18	175.23
24-Jul-23	02E	1095.54	175.29
24-Jul-23	03C	975.53	156.08
24-Jul-23	03E	119.59	19.13
24-Jul-23	04B	1611.86	257.90
24-Jul-23	04C	1914.17	306.27
24-Jul-23	04D	880.43	140.87
25-Jul-23	01C	1070.60	171.30
25-Jul-23	01E	1096.20	175.39
25-Jul-23	02E	1086.69	173.87
25-Jul-23	03C	1092.73	174.84
25-Jul-23	04B	44.40	7.10
25-Jul-23	04C	617.82	98.85
25-Jul-23	04D	465.73	74.52
27-Jul-23	01B	270.37	43.26
27-Jul-23	01C	544.74	87.16
27-Jul-23	01E	698.65	111.78
27-Jul-23	01F	400.87	64.14
27-Jul-23	02E	1095.50	175.28
27-Jul-23	03C	820.34	131.25
27-Jul-23	03E	277.10	44.34
27-Jul-23	04B	380.96	60.95
27-Jul-23	04C	434.03	69.44

Date	Cell	Length (m)	Volume (m ³)
27-Jul-23	04D	300.03	48.00
28-Jul-23	01C	689.65	110.34
29-Jul-23	01B	890.34	142.45
29-Jul-23	01E	1091.43	174.63
29-Jul-23	02E	212.96	34.07

Table B.2 *Date and Distance of dredge lines within 50 m of the sample points*

Date	Point	D (m)
11-Feb-22	A1S32	8.5
12-May-22	A1S42	16.3
12-May-22	A1S58	43.9
14-May-22	A1S44	22.4
14-May-22	A1S63	45.0
24-May-22	A1S44	34.6
24-May-22	A1S58	46.2
24-May-22	A1S63	7.9
28-May-22	A1S41	40.6
28-May-22	A1S41	5.9
28-May-22	A1S63	20.1
8-Jun-22	A1S32	46.0
8-Jun-22	A1S41	43.5
8-Jun-22	A1S41	19.4
8-Jun-22	A1S44	23.1
8-Jun-22	A1S63	25.8
10-Jun-22	A1S42	44.6
10-Jun-22	A1S44	44.9
10-Jun-22	A1S58	44.1
10-Jun-22	A1S63	41.1
11-Jun-22	A1S41	16.5
11-Jun-22	A1S41	43.4
11-Jun-22	A1S63	43.0
14-Jun-22	A1S42	42.2
14-Jun-22	A1S44	44.9
14-Jun-22	A1S58	44.1
14-Jun-22	A1S62	40.8
21-Oct-22	A1S41	39.3
22-Oct-22	A1S32	4.6
22-Oct-22	A1S41	44.1
22-Oct-22	A1S41	9.0

Date	Point	D (m)
3-Nov-22	A1S32	19.9
19-Jan-23	A1S37	17.2
23-Jan-23	A1S37	17.8
3-Feb-23	A1S37	45.4
10-Feb-23	A1S37	1.4
18-Feb-23	A1S37	19.0
25-Feb-23	A1S37	13.6
27-Feb-23	A1S37	13.2
28-Feb-23	A1S37	13.6
15-Mar-23	A1S37	26.4
22-Mar-23	A1S37	12.8
22-Apr-23	A1S37	29.1
16-Jun-23	A1S37	4.4
18-Jun-23	A1S37	2.8
30-Jun-23	A1S37	22.4
6-Jul-23	A1S51	9.1
6-Jul-23	A1S59	37.0
6-Jul-23	A1S62	27.6
17-Jul-23	A1S51	31.6
17-Jul-23	A1S62	1.2
22-Jul-23	A1S37	31.2
22-Jul-23	A1S51	28.6
22-Jul-23	A1S61	35.8
23-Jul-23	A1S51	26.0
23-Jul-23	A1S61	29.9
24-Jul-23	A1S51	31.9
24-Jul-23	A1S59	31.2
24-Jul-23	A1S61	40.9
25-Jul-23	A1S37	32.0
25-Jul-23	A1S52	29.1
25-Jul-23	A1S61	21.0
27-Jul-23	A1S32	19.2
27-Jul-23	A1S32	18.2
27-Jul-23	A1S37	35.7
27-Jul-23	A1S37	35.6
27-Jul-23	A1S51	35.5
29-Jul-23	A1S37	44.6

Appendix C Laboratory Results

1 Month



R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand
0508 HILL LAB (44 555 22)
+64 7 858 2000
mail@hill-labs.co.nz
www.hill-labs.co.nz

Certificate of Analysis

Page 1 of 3

Client:	Bioresearches	Lab No:	3394046	SPv1
Contact:	Laureline Meynier	Date Received:	27-Oct-2023	
	C/- Bioresearches	Date Reported:	04-Dec-2023	
	PO Box 2828	Quote No:		
	Auckland 1140	Order No:		
		Client Reference:	66818	
		Add. Client Ref:	Pakiri 1-month recovery monitoring	
		Submitted By:	Laureline Meynier	

Sample Type: Sediment					
Sample Name:	GS-A1S31	GS-A1S32	GS-A1S33	GS-A1S34	GS-A1S35
	20-Sep-2023	20-Sep-2023	20-Sep-2023	20-Sep-2023	20-Sep-2023
Lab Number:	3394046.1	3394046.2	3394046.3	3394046.4	3394046.5
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	82	80	79	81
Fraction >= 2 mm	g/100g dry wt	4.2	5.2	14.6	6.8
Fraction < 2 mm, >= 1 mm	g/100g dry wt	7.4	5.0	11.2	8.8
Fraction < 1 mm, >= 500 µm	g/100g dry wt	40.2	43.8	31.3	36.5
Fraction < 500 µm, >= 250 µm	g/100g dry wt	38.4	35.2	26.3	31.3
Fraction < 250 µm, >= 125 µm	g/100g dry wt	8.4	6.5	11.1	12.3
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.3	0.2	0.7	0.8
Fraction < 63 µm	g/100g dry wt	1.1	4.0	4.8	3.6
Sample Name:	GS-A1S36	GS-A1S37	GS-A1S38	GS-A1S39	GS-A1S40
	20-Sep-2023	20-Sep-2023	20-Sep-2023	20-Sep-2023	20-Sep-2023
Lab Number:	3394046.6	3394046.7	3394046.8	3394046.9	3394046.10
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	82	76	82	81
Fraction >= 2 mm	g/100g dry wt	5.6	0.6	2.3	6.7
Fraction < 2 mm, >= 1 mm	g/100g dry wt	2.1	0.5	3.0	2.3
Fraction < 1 mm, >= 500 µm	g/100g dry wt	22.2	0.9	21.7	2.0
Fraction < 500 µm, >= 250 µm	g/100g dry wt	41.2	19.3	49.8	16.1
Fraction < 250 µm, >= 125 µm	g/100g dry wt	25.3	72.0	14.3	56.7
Fraction < 125 µm, >= 63 µm	g/100g dry wt	1.0	5.4	0.5	2.8
Fraction < 63 µm	g/100g dry wt	2.7	1.4	8.4	13.4
Sample Name:	GS-A1S41	GS-A1S42	GS-A1S43	GS-A1S44	GS-A1S45
	20-Sep-2023	20-Sep-2023	20-Sep-2023	20-Sep-2023	20-Sep-2023
Lab Number:	3394046.11	3394046.12	3394046.13	3394046.14	3394046.15
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	82	83	82	81
Fraction >= 2 mm	g/100g dry wt	7.3	7.0	14.5	7.4
Fraction < 2 mm, >= 1 mm	g/100g dry wt	8.2	15.6	15.0	12.4
Fraction < 1 mm, >= 500 µm	g/100g dry wt	38.3	42.7	30.6	41.2
Fraction < 500 µm, >= 250 µm	g/100g dry wt	30.0	26.6	26.4	27.9
Fraction < 250 µm, >= 125 µm	g/100g dry wt	12.7	4.7	9.3	7.8
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.9	0.3	0.6	0.3
Fraction < 63 µm	g/100g dry wt	2.5	3.2	3.5	3.0
Sample Name:	GS-A1S46	GS-A1S47	GS-A1S48	GS-A1S49	GS-A1S50
	20-Sep-2023	20-Sep-2023	20-Sep-2023	20-Sep-2023	20-Sep-2023
Lab Number:	3394046.16	3394046.17	3394046.18	3394046.19	3394046.20
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	78	80	78	81
Fraction >= 2 mm	g/100g dry wt	4.9	13.1	0.4	21.8
Fraction < 2 mm, >= 1 mm	g/100g dry wt	5.3	3.1	0.6	14.2

Lab No: 3394046-SPv1

Hill Labs

Page 1 of 3

Sample Type: Sediment					
Sample Name:	GS-A1S46 20-Sep-2023	GS-A1S47 20-Sep-2023	GS-A1S48 20-Sep-2023	GS-A1S49 20-Sep-2023	GS-A1S50 20-Sep-2023
Lab Number:	3394046.16	3394046.17	3394046.18	3394046.19	3394046.20
7 Grain Sizes Profile as received					
Fraction < 1 mm, >= 500 µm	g/100g dry wt	21.3	19.1	3.1	19.7
Fraction < 500 µm, >= 250 µm	g/100g dry wt	37.5	52.4	26.7	22.3
Fraction < 250 µm, >= 125 µm	g/100g dry wt	27.6	10.7	66.3	16.0
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.9	0.3	2.7	0.9
Fraction < 63 µm	g/100g dry wt	2.5	1.3	0.1	5.0
4.6					
Sample Name:	GS-A1S51 20-Sep-2023	GS-A1S52 20-Sep-2023	GS-A1S53 20-Sep-2023	GS-A1S54 20-Sep-2023	GS-A1S55 20-Sep-2023
Lab Number:	3394046.21	3394046.22	3394046.23	3394046.24	3394046.25
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	82	88	80	78
Fraction >= 2 mm	g/100g dry wt	3.0	1.7	9.1	7.5
Fraction < 2 mm, >= 1 mm	g/100g dry wt	14.0	5.5	15.0	3.3
Fraction < 1 mm, >= 500 µm	g/100g dry wt	44.6	31.5	28.7	5.9
Fraction < 500 µm, >= 250 µm	g/100g dry wt	27.3	36.1	29.5	24.1
Fraction < 250 µm, >= 125 µm	g/100g dry wt	6.9	9.0	14.8	54.9
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.5	0.2	0.4	2.0
Fraction < 63 µm	g/100g dry wt	3.6	15.8	2.6	2.3
3.0					
Sample Name:	GS-A1S56 20-Sep-2023	GS-A1S57 20-Sep-2023	GS-A1S58 20-Sep-2023	GS-A1S59 20-Sep-2023	GS-A1S60 20-Sep-2023
Lab Number:	3394046.26	3394046.27	3394046.28	3394046.29	3394046.30
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	82	78	82	81
Fraction >= 2 mm	g/100g dry wt	12.2	0.3	12.3	0.2
Fraction < 2 mm, >= 1 mm	g/100g dry wt	12.4	0.3	7.9	0.3
Fraction < 1 mm, >= 500 µm	g/100g dry wt	33.7	0.8	36.0	2.1
Fraction < 500 µm, >= 250 µm	g/100g dry wt	29.8	18.1	33.0	26.2
Fraction < 250 µm, >= 125 µm	g/100g dry wt	8.9	70.6	7.5	62.3
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.3	9.1	0.6	4.2
Fraction < 63 µm	g/100g dry wt	2.7	0.8	2.7	4.7
0.5					
Sample Name:	GS-A1S61 20-Sep-2023	GS-A1S62 20-Sep-2023	GS-A1S63 20-Sep-2023	GS-A1S64 20-Sep-2023	GS-A1S65 20-Sep-2023
Lab Number:	3394046.31	3394046.32	3394046.33	3394046.34	3394046.35
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	78	76	84	82
Fraction >= 2 mm	g/100g dry wt	3.0	0.9	34.3	6.4
Fraction < 2 mm, >= 1 mm	g/100g dry wt	2.8	0.8	12.7	4.4
Fraction < 1 mm, >= 500 µm	g/100g dry wt	16.0	2.5	21.0	21.7
Fraction < 500 µm, >= 250 µm	g/100g dry wt	44.1	20.7	18.2	50.1
Fraction < 250 µm, >= 125 µm	g/100g dry wt	29.9	64.9	9.6	13.4
Fraction < 125 µm, >= 63 µm	g/100g dry wt	1.7	8.2	0.7	0.6
Fraction < 63 µm	g/100g dry wt	2.5	2.0	3.4	3.6
2.2					
Sample Name:	GS-CS1 20-Sep-2023	GS-CS2 20-Sep-2023	GS-CS3 20-Sep-2023	GS-CSA1 20-Sep-2023	GS-CSA2 20-Sep-2023
Lab Number:	3394046.36	3394046.37	3394046.38	3394046.39	3394046.40
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	79	80	80	81
Fraction >= 2 mm	g/100g dry wt	0.4	0.3	1.7	16.3
Fraction < 2 mm, >= 1 mm	g/100g dry wt	9.7	0.3	3.0	0.7
Fraction < 1 mm, >= 500 µm	g/100g dry wt	67.3	3.4	22.1	15.3
Fraction < 500 µm, >= 250 µm	g/100g dry wt	2.5	47.5	55.3	44.0
Fraction < 250 µm, >= 125 µm	g/100g dry wt	14.6	43.9	12.9	16.8
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.7	1.9	0.7	1.3
Fraction < 63 µm	g/100g dry wt	4.7	2.8	4.4	5.7
2.5					

Sample Type: Sediment					
Sample Name:	GS-CSA3 20-Sep-2023	GS-CSB1 20-Sep-2023	GS-CSB2 20-Sep-2023	GS-CSB3 20-Sep-2023	GS-CSC1 20-Sep-2023
Lab Number:	3394046.41	3394046.42	3394046.43	3394046.44	3394046.45
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	81	81	84	79
Fraction >= 2 mm	g/100g dry wt	18.6	6.8	25.6	0.8
Fraction < 2 mm, >= 1 mm	g/100g dry wt	8.6	4.7	7.3	0.7
Fraction < 1 mm, >= 500 µm	g/100g dry wt	34.2	30.6	17.3	7.2
Fraction < 500 µm, >= 250 µm	g/100g dry wt	30.2	46.2	41.0	49.9
Fraction < 250 µm, >= 125 µm	g/100g dry wt	5.6	9.0	7.0	35.8
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.1	0.4	0.4	1.4
Fraction < 63 µm	g/100g dry wt	2.7	2.4	1.4	4.1
					3.2
Sample Name:	GS-CSC2 20-Sep-2023	GS-CSC3 20-Sep-2023	GS-CSD1 20-Sep-2023	GS-CSD2 20-Sep-2023	GS-CSD3 20-Sep-2023
Lab Number:	3394046.46	3394046.47	3394046.48	3394046.49	3394046.50
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	81	80	82	81
Fraction >= 2 mm	g/100g dry wt	22.7	0.8	22.4	18.0
Fraction < 2 mm, >= 1 mm	g/100g dry wt	8.7	1.2	10.7	14.4
Fraction < 1 mm, >= 500 µm	g/100g dry wt	31.7	14.5	32.3	40.5
Fraction < 500 µm, >= 250 µm	g/100g dry wt	29.3	50.2	26.7	21.8
Fraction < 250 µm, >= 125 µm	g/100g dry wt	6.8	27.5	3.7	2.4
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.3	1.3	0.2	0.3
Fraction < 63 µm	g/100g dry wt	0.5	4.6	4.0	2.6
					6.2

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Sediment			
Test	Method Description	Default Detection Limit	Sample No
7 Grain Sizes Profile as received			
Dry Matter for Grainsize samples (sieved as received)	Drying for 16 hours at 103°C, gravimetry (Free water removed before analysis).	0.10 g/100g as rcvd	1-50
Fraction >= 2 mm	Wet sieving with dispersant, as received, 2.00 mm sieve, gravimetry.	0.1 g/100g dry wt	1-50
Fraction < 2 mm, >= 1 mm	Wet sieving using dispersant, as received, 2.00 mm and 1.00 mm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 1 mm, >= 500 µm	Wet sieving using dispersant, as received, 1.00 mm and 500 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 500 µm, >= 250 µm	Wet sieving using dispersant, as received, 500 µm and 250 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 250 µm, >= 125 µm	Wet sieving using dispersant, as received, 250 µm and 125 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 125 µm, >= 63 µm	Wet sieving using dispersant, as received, 125 µm and 63 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 63 µm	Wet sieving with dispersant, as received, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 06-Nov-2023 and 04-Dec-2023. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.



Kim Harrison MSc
Client Services Manager - Environmental

+ 6 months



R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand
0508 HILL LAB (44 555 22)
+64 7 858 2000
mail@hill-labs.co.nz
www.hill-labs.co.nz

Certificate of Analysis

Page 1 of 3

Client:	Bioresearches	Lab No:	3537285	SPv1
Contact:	S West	Date Received:	10-Apr-2024	
	C/- Bioresearches	Date Reported:	12-Jul-2024	
	PO Box 2828	Quote No:		
	Auckland 1140	Order No:		
		Client Reference:	Pakiri + 6 months recovery monitoring	
		Add. Client Ref:	66818	
		Submitted By:	S West	

Sample Type: Sediment					
Sample Name:		GS-A1S31	GS-A1S32	GS-A1S33	GS-A1S34
		13-Mar-2024	13-Mar-2024	13-Mar-2024	13-Mar-2024
Lab Number:		3537285.1	3537285.2	3537285.3	3537285.4
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	76	82	82	82
Fraction >= 2 mm	g/100g dry wt	0.3	4.1	16.9	23.2
Fraction < 2 mm, >= 1 mm	g/100g dry wt	0.3	6.1	13.4	16.7
Fraction < 1 mm, >= 500 µm	g/100g dry wt	1.2	38.7	38.4	39.9
Fraction < 500 µm, >= 250 µm	g/100g dry wt	17.1	37.9	21.9	27.5
Fraction < 250 µm, >= 125 µm	g/100g dry wt	72.7	11.0	7.0	8.7
Fraction < 125 µm, >= 63 µm	g/100g dry wt	5.7	0.5	0.3	0.4
Fraction < 63 µm	g/100g dry wt	2.7	1.7	2.0	2.6
Sample Name:		GS-A1S36	GS-A1S37	GS-A1S38	GS-A1S39
		13-Mar-2024	13-Mar-2024	13-Mar-2024	13-Mar-2024
Lab Number:		3537285.6	3537285.7	3537285.8	3537285.9
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	81	80	82	78
Fraction >= 2 mm	g/100g dry wt	7.6	6.4	1.9	10.8
Fraction < 2 mm, >= 1 mm	g/100g dry wt	2.8	0.7	3.0	5.6
Fraction < 1 mm, >= 500 µm	g/100g dry wt	19.5	1.3	31.5	13.4
Fraction < 500 µm, >= 250 µm	g/100g dry wt	41.2	18.8	53.3	28.7
Fraction < 250 µm, >= 125 µm	g/100g dry wt	26.6	64.5	8.7	37.8
Fraction < 125 µm, >= 63 µm	g/100g dry wt	1.0	5.6	0.2	2.3
Fraction < 63 µm	g/100g dry wt	1.2	2.8	1.3	1.3
Sample Name:		GS-A1S41	GS-A1S42	GS-A1S43	GS-A1S44
		13-Mar-2024	13-Mar-2024	13-Mar-2024	13-Mar-2024
Lab Number:		3537285.11	3537285.12	3537285.13	3537285.14
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	80	82	82	83
Fraction >= 2 mm	g/100g dry wt	5.1	8.6	16.2	15.0
Fraction < 2 mm, >= 1 mm	g/100g dry wt	8.5	12.6	15.2	10.1
Fraction < 1 mm, >= 500 µm	g/100g dry wt	39.6	37.3	25.9	42.7
Fraction < 500 µm, >= 250 µm	g/100g dry wt	31.9	31.1	28.5	24.8
Fraction < 250 µm, >= 125 µm	g/100g dry wt	12.5	7.4	10.9	6.3
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.5	0.3	0.6	0.3
Fraction < 63 µm	g/100g dry wt	1.9	2.7	2.7	0.8
Sample Name:		GS-A1S46	GS-A1S47	GS-A1S48	GS-A1S49
		13-Mar-2024	13-Mar-2024	13-Mar-2024	13-Mar-2024
Lab Number:		3537285.16	3537285.17	3537285.18	3537285.19
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	80	82	77	83
Fraction >= 2 mm	g/100g dry wt	7.1	16.7	0.3	27.5
Fraction < 2 mm, >= 1 mm	g/100g dry wt	5.8	2.6	0.8	8.9

Lab No: 3537285-SPv1

Hill Labs

Page 1 of 3

Sample Type: Sediment						
Sample Name:		GS-A1S46 13-Mar-2024	GS-A1S47 13-Mar-2024	GS-A1S48 13-Mar-2024	GS-A1S49 13-Mar-2024	GS-A1S50 13-Mar-2024
Lab Number:		3537285.16	3537285.17	3537285.18	3537285.19	3537285.20
7 Grain Sizes Profile as received						
Fraction < 1 mm, >= 500 µm	g/100g dry wt	28.8	19.2	2.7	22.5	27.1
Fraction < 500 µm, >= 250 µm	g/100g dry wt	35.8	51.1	20.9	25.1	27.0
Fraction < 250 µm, >= 125 µm	g/100g dry wt	19.1	9.5	68.8	14.0	9.9
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.4	0.2	2.9	0.8	0.5
Fraction < 63 µm	g/100g dry wt	3.1	0.6	3.5	1.3	1.7
Sample Name:		GS-A1S51 13-Mar-2024	GS-A1S52 13-Mar-2024	GS-A1S53 13-Mar-2024	GS-A1S54 13-Mar-2024	GS-A1S55 13-Mar-2024
Lab Number:		3537285.21	3537285.22	3537285.23	3537285.24	3537285.25
7 Grain Sizes Profile as received						
Dry Matter of Sieved Sample	g/100g as rcvd	81	80	80	76	81
Fraction >= 2 mm	g/100g dry wt	0.7	3.1	7.6	0.4	3.0
Fraction < 2 mm, >= 1 mm	g/100g dry wt	3.5	4.0	5.7	0.4	5.5
Fraction < 1 mm, >= 500 µm	g/100g dry wt	39.5	32.6	16.0	1.6	31.4
Fraction < 500 µm, >= 250 µm	g/100g dry wt	39.4	46.2	25.2	31.5	40.2
Fraction < 250 µm, >= 125 µm	g/100g dry wt	13.6	11.8	41.6	63.1	16.8
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.7	0.4	1.0	2.0	0.8
Fraction < 63 µm	g/100g dry wt	2.7	1.9	3.0	1.1	2.3
Sample Name:		GS-A1S56 13-Mar-2024	GS-A1S57 13-Mar-2024	GS-A1S58 13-Mar-2024	GS-A1S59 13-Mar-2024	GS-A1S60 13-Mar-2024
Lab Number:		3537285.26	3537285.27	3537285.28	3537285.29	3537285.30
7 Grain Sizes Profile as received						
Dry Matter of Sieved Sample	g/100g as rcvd	82	78	81	80	83
Fraction >= 2 mm	g/100g dry wt	5.4	0.5	6.9	6.0	26.8
Fraction < 2 mm, >= 1 mm	g/100g dry wt	9.9	0.6	8.2	2.7	7.6
Fraction < 1 mm, >= 500 µm	g/100g dry wt	35.9	1.1	33.1	15.8	23.0
Fraction < 500 µm, >= 250 µm	g/100g dry wt	33.7	20.4	36.9	47.6	34.6
Fraction < 250 µm, >= 125 µm	g/100g dry wt	12.8	68.2	11.3	24.7	5.2
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.4	6.1	1.1	1.3	0.2
Fraction < 63 µm	g/100g dry wt	1.9	3.2	2.6	1.9	2.5
Sample Name:		GS-A1S61 13-Mar-2024	GS-A1S62 13-Mar-2024	GS-A1S63 13-Mar-2024	GS-A1S64 13-Mar-2024	GS-A1S65 13-Mar-2024
Lab Number:		3537285.31	3537285.32	3537285.33	3537285.34	3537285.35
7 Grain Sizes Profile as received						
Dry Matter of Sieved Sample	g/100g as rcvd	80	79	82	81	81
Fraction >= 2 mm	g/100g dry wt	5.0	0.5	26.8	6.4	1.1
Fraction < 2 mm, >= 1 mm	g/100g dry wt	3.4	0.6	11.5	4.2	1.5
Fraction < 1 mm, >= 500 µm	g/100g dry wt	19.2	2.9	28.3	24.1	30.0
Fraction < 500 µm, >= 250 µm	g/100g dry wt	49.8	32.1	23.6	49.7	54.1
Fraction < 250 µm, >= 125 µm	g/100g dry wt	20.1	57.8	7.3	12.8	10.6
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.8	4.5	0.4	0.5	0.4
Fraction < 63 µm	g/100g dry wt	1.6	1.6	2.3	2.5	2.2
Sample Name:		GS-CS1 13-Mar-2024	GS-CS2 13-Mar-2024	GS-CS3 13-Mar-2024	GS-CSA1 13-Mar-2024	GS-CSA2 13-Mar-2024
Lab Number:		3537285.36	3537285.37	3537285.38	3537285.39	3537285.40
7 Grain Sizes Profile as received						
Dry Matter of Sieved Sample	g/100g as rcvd	81	79	82	83	82
Fraction >= 2 mm	g/100g dry wt	0.7	0.4	1.3	7.8	3.1
Fraction < 2 mm, >= 1 mm	g/100g dry wt	1.0	0.4	2.7	2.5	2.4
Fraction < 1 mm, >= 500 µm	g/100g dry wt	15.3	3.5	25.1	18.5	26.3
Fraction < 500 µm, >= 250 µm	g/100g dry wt	68.8	45.6	57.6	50.4	59.8
Fraction < 250 µm, >= 125 µm	g/100g dry wt	12.6	46.8	11.3	16.2	7.0
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.4	2.0	0.4	1.1	0.3
Fraction < 63 µm	g/100g dry wt	1.2	1.4	1.7	3.4	1.2

Sample Type: Sediment						
Sample Name:		GS-CSA3 13-Mar-2024	GS-CSB1 13-Mar-2024	GS-CSB2 13-Mar-2024	GS-CSB3 13-Mar-2024	GS-CSC1 13-Mar-2024
Lab Number:		3537285.41	3537285.42	3537285.43	3537285.44	3537285.45
7 Grain Sizes Profile as received						
Dry Matter of Sieved Sample	g/100g as rcvd	81	81	81	81	81
Fraction >= 2 mm	g/100g dry wt	20.9	9.1	12.9	0.7	9.7
Fraction < 2 mm, >= 1 mm	g/100g dry wt	12.8	6.6	5.0	0.7	7.8
Fraction < 1 mm, >= 500 µm	g/100g dry wt	31.4	42.6	24.7	7.8	31.1
Fraction < 500 µm, >= 250 µm	g/100g dry wt	26.8	35.6	48.8	52.7	40.5
Fraction < 250 µm, >= 125 µm	g/100g dry wt	6.1	4.4	8.4	35.3	7.1
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.3	0.1	0.3	0.9	0.4
Fraction < 63 µm	g/100g dry wt	1.6	1.5	2.0	1.8	3.3
Sample Name:		GS-CSC2 13-Mar-2024	GS-CSC3 13-Mar-2024	GS-CSD1 13-Mar-2024	GS-CSD2 13-Mar-2024	GS-CSD3 13-Mar-2024
Lab Number:		3537285.46	3537285.47	3537285.48	3537285.49	3537285.50
7 Grain Sizes Profile as received						
Dry Matter of Sieved Sample	g/100g as rcvd	81	79	81	83	75
Fraction >= 2 mm	g/100g dry wt	8.4	0.3	32.6	39.2	< 0.1
Fraction < 2 mm, >= 1 mm	g/100g dry wt	8.4	0.5	11.9	9.2	0.2
Fraction < 1 mm, >= 500 µm	g/100g dry wt	33.1	5.6	30.1	28.9	1.0
Fraction < 500 µm, >= 250 µm	g/100g dry wt	39.8	40.5	20.6	16.1	17.2
Fraction < 250 µm, >= 125 µm	g/100g dry wt	8.1	50.1	2.5	3.1	68.4
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.3	1.3	0.2	0.5	9.5
Fraction < 63 µm	g/100g dry wt	1.9	1.6	2.0	3.0	3.6

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilution be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Franklin, Hamilton 3204.

Sample Type: Sediment			
Test	Method Description	Default Detection Limit	Sample No
7 Grain Sizes Profile as received			
Dry Matter for Grainsize samples (sieved as received)	Drying for 16 hours at 103°C, gravimetry (Free water removed before analysis).	0.10 g/100g as rcvd	1-50
Fraction >= 2 mm	Wet sieving with dispersant, as received, 2.00 mm sieve, gravimetry.	0.1 g/100g dry wt	1-50
Fraction < 2 mm, >= 1 mm	Wet sieving using dispersant, as received, 2.00 mm and 1.00 mm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 1 mm, >= 500 µm	Wet sieving using dispersant, as received, 1.00 mm and 500 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 500 µm, >= 250 µm	Wet sieving using dispersant, as received, 500 µm and 250 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 250 µm, >= 125 µm	Wet sieving using dispersant, as received, 250 µm and 125 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 125 µm, >= 63 µm	Wet sieving using dispersant, as received, 125 µm and 63 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 63 µm	Wet sieving with dispersant, as received, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 09-Jul-2024 and 11-Jul-2024. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Martin Cowell - BSc
Client Services Manager - Environmental

+12 Months



R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand
0508 HILL LAB (44 555 22)
+64 7 858 2000
mail@hill-labs.co.nz
www.hill-labs.co.nz

Certificate of Analysis						Page 1 of 3
Client: Bioresearches Contact: S West C/- Bioresearches PO Box 2828 Auckland 1140				Lab No: 3703553	SPv1	
				Date Received: 30-Oct-2024		
				Date Reported: 03-Dec-2024		
				Quote No:		
				Order No:		
			Client Reference: 66818			
			Add. Client Ref: Pakiri +12 Months Recovery Monitoring			
			Submitted By: Levi Murdoch-Tighe			
Sample Type: Sediment						
Sample Name:		GS-A1S31 24-Sep-2024	GS-A1S32 24-Sep-2024	GS-A1S33 24-Sep-2024	GS-A1S34 24-Sep-2024	GS-A1S35 24-Sep-2024
Lab Number:		3703553.1	3703553.2	3703553.3	3703553.4	3703553.5
7 Grain Sizes Profile as received						
Dry Matter of Sieved Sample	g/100g as rcvd	79	80	82	81	83
Fraction >= 2 mm	g/100g dry wt	1.9	2.0	11.9	4.5	19.1
Fraction < 2 mm, >= 1 mm	g/100g dry wt	1.6	3.1	9.2	8.8	23.7
Fraction < 1 mm, >= 500 µm	g/100g dry wt	8.9	46.5	40.3	45.4	30.8
Fraction < 500 µm, >= 250 µm	g/100g dry wt	57.1	38.6	26.2	29.9	17.0
Fraction < 250 µm, >= 125 µm	g/100g dry wt	27.6	7.9	9.4	8.2	5.9
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.7	0.2	0.5	0.4	0.6
Fraction < 63 µm	g/100g dry wt	2.2	1.8	2.4	2.9	3.0
Sample Name:		GS-A1S36 24-Sep-2024	GS-A1S37 24-Sep-2024	GS-A1S38 24-Sep-2024	GS-A1S39 24-Sep-2024	GS-A1S40 24-Sep-2024
Lab Number:		3703553.6	3703553.7	3703553.8	3703553.9	3703553.10
7 Grain Sizes Profile as received						
Dry Matter of Sieved Sample	g/100g as rcvd	80	79	80	75	81
Fraction >= 2 mm	g/100g dry wt	2.7	5.3	2.4	0.7	6.8
Fraction < 2 mm, >= 1 mm	g/100g dry wt	2.8	0.5	2.5	0.4	2.0
Fraction < 1 mm, >= 500 µm	g/100g dry wt	31.8	1.5	23.1	0.9	17.4
Fraction < 500 µm, >= 250 µm	g/100g dry wt	42.4	16.4	57.5	17.8	55.7
Fraction < 250 µm, >= 125 µm	g/100g dry wt	17.5	69.7	12.4	76.3	15.0
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.5	4.0	0.2	3.0	0.4
Fraction < 63 µm	g/100g dry wt	2.3	2.6	1.9	0.9	2.8
Sample Name:		GS-A1S41 24-Sep-2024	GS-A1S42 24-Sep-2024	GS-A1S43 24-Sep-2024	GS-A1S44 24-Sep-2024	GS-A1S45 24-Sep-2024
Lab Number:		3703553.11	3703553.12	3703553.13	3703553.14	3703553.15
7 Grain Sizes Profile as received						
Dry Matter of Sieved Sample	g/100g as rcvd	82	81	80	81	79
Fraction >= 2 mm	g/100g dry wt	3.6	10.1	8.8	7.2	16.0
Fraction < 2 mm, >= 1 mm	g/100g dry wt	7.2	13.4	15.2	14.8	9.0
Fraction < 1 mm, >= 500 µm	g/100g dry wt	53.3	37.2	35.3	40.3	30.7
Fraction < 500 µm, >= 250 µm	g/100g dry wt	26.4	29.6	29.5	26.8	28.8
Fraction < 250 µm, >= 125 µm	g/100g dry wt	7.3	7.5	8.5	7.4	12.0
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.3	0.3	0.4	0.4	0.6
Fraction < 63 µm	g/100g dry wt	1.8	2.0	2.3	3.2	2.9
Sample Name:		GS-A1S46 24-Sep-2024	GS-A1S47 24-Sep-2024	GS-A1S48 24-Sep-2024	GS-A1S49 24-Sep-2024	GS-A1S50 24-Sep-2024
Lab Number:		3703553.16	3703553.17	3703553.18	3703553.19	3703553.20
7 Grain Sizes Profile as received						
Dry Matter of Sieved Sample	g/100g as rcvd	77	79	77	82	83
Fraction >= 2 mm	g/100g dry wt	11.6	5.1	2.0	15.4	7.6
Fraction < 2 mm, >= 1 mm	g/100g dry wt	7.2	2.4	0.4	7.8	10.6

Sample Type: Sediment					
Sample Name:	GS-A1S46 24-Sep-2024	GS-A1S47 24-Sep-2024	GS-A1S48 24-Sep-2024	GS-A1S49 24-Sep-2024	GS-A1S50 24-Sep-2024
Lab Number:	3703553.16	3703553.17	3703553.18	3703553.19	3703553.20
7 Grain Sizes Profile as received					
Fraction < 1 mm, >= 500 µm	g/100g dry wt	22.7	25.0	3.5	26.2
Fraction < 500 µm, >= 250 µm	g/100g dry wt	41.3	54.7	30.6	33.9
Fraction < 250 µm, >= 125 µm	g/100g dry wt	15.6	10.0	58.2	13.2
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.2	0.1	1.7	0.6
Fraction < 63 µm	g/100g dry wt	1.5	2.7	3.6	2.8
4.2					
Sample Name:	GS-A1S51 24-Sep-2024	GS-A1S52 24-Sep-2024	GS-A1S53 24-Sep-2024	GS-A1S54 24-Sep-2024	GS-A1S55 24-Sep-2024
Lab Number:	3703553.21	3703553.22	3703553.23	3703553.24	3703553.25
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	80	79	78	79
Fraction >= 2 mm	g/100g dry wt	1.2	1.6	1.4	2.0
Fraction < 2 mm, >= 1 mm	g/100g dry wt	2.7	3.4	2.9	1.5
Fraction < 1 mm, >= 500 µm	g/100g dry wt	42.1	39.8	13.6	11.1
Fraction < 500 µm, >= 250 µm	g/100g dry wt	42.7	42.1	43.7	59.5
Fraction < 250 µm, >= 125 µm	g/100g dry wt	9.2	11.6	36.6	21.7
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.3	0.4	0.8	0.9
Fraction < 63 µm	g/100g dry wt	1.8	1.0	1.0	3.4
1.9					
Sample Name:	GS-A1S56 24-Sep-2024	GS-A1S57 24-Sep-2024	GS-A1S58 24-Sep-2024	GS-A1S59 24-Sep-2024	GS-A1S60 24-Sep-2024
Lab Number:	3703553.26	3703553.27	3703553.28	3703553.29	3703553.30
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	79	79	77	80
Fraction >= 2 mm	g/100g dry wt	5.5	0.4	6.0	2.6
Fraction < 2 mm, >= 1 mm	g/100g dry wt	8.7	0.3	5.7	1.0
Fraction < 1 mm, >= 500 µm	g/100g dry wt	42.6	1.1	38.3	5.6
Fraction < 500 µm, >= 250 µm	g/100g dry wt	32.5	25.6	41.7	44.0
Fraction < 250 µm, >= 125 µm	g/100g dry wt	8.9	64.3	6.1	42.6
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.3	5.8	0.2	1.5
Fraction < 63 µm	g/100g dry wt	1.6	2.4	2.1	2.8
2.4					
Sample Name:	GS-A1S61 24-Sep-2024	GS-A1S62 24-Sep-2024	GS-A1S63 24-Sep-2024	GS-A1S64 24-Sep-2024	GS-A1S65 24-Sep-2024
Lab Number:	3703553.31	3703553.32	3703553.33	3703553.34	3703553.35
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	79	81	80	78
Fraction >= 2 mm	g/100g dry wt	3.2	9.0	17.5	0.9
Fraction < 2 mm, >= 1 mm	g/100g dry wt	3.4	9.3	6.1	1.6
Fraction < 1 mm, >= 500 µm	g/100g dry wt	25.4	29.3	30.5	8.1
Fraction < 500 µm, >= 250 µm	g/100g dry wt	49.7	35.6	32.9	40.0
Fraction < 250 µm, >= 125 µm	g/100g dry wt	16.3	12.9	11.0	45.4
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.6	0.8	0.6	1.6
Fraction < 63 µm	g/100g dry wt	1.5	3.1	1.5	2.5
3.1					
Sample Name:	GS-CS1 24-Sep-2024	GS-CS2 24-Sep-2024	GS-CS3 24-Sep-2024	GS-CSA1 24-Sep-2024	GS-CSA2 24-Sep-2024
Lab Number:	3703553.36	3703553.37	3703553.38	3703553.39	3703553.40
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	79	79	78	80
Fraction >= 2 mm	g/100g dry wt	0.4	0.6	1.9	2.7
Fraction < 2 mm, >= 1 mm	g/100g dry wt	0.6	0.7	1.5	1.4
Fraction < 1 mm, >= 500 µm	g/100g dry wt	13.8	13.3	23.5	25.4
Fraction < 500 µm, >= 250 µm	g/100g dry wt	71.7	66.9	59.6	57.5
Fraction < 250 µm, >= 125 µm	g/100g dry wt	11.5	16.0	11.3	9.5
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.3	0.4	0.3	0.4
Fraction < 63 µm	g/100g dry wt	1.7	2.1	2.0	3.1
1.7					

Lab No: 3703553-SPv1

Hill Labs

Page 2 of 3

Sample Type: Sediment					
Sample Name:	GS-CSA3 24-Sep-2024	GS-CSB1 24-Sep-2024	GS-CSB2 24-Sep-2024	GS-CSB3 24-Sep-2024	GS-CSC1 24-Sep-2024
Lab Number:	3703553.41	3703553.42	3703553.43	3703553.44	3703553.45
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	79	80	80	81
Fraction >= 2 mm	g/100g dry wt	55.5	4.8	15.3	0.6
Fraction < 2 mm, >= 1 mm	g/100g dry wt	11.3	5.6	5.7	0.7
Fraction < 1 mm, >= 500 µm	g/100g dry wt	15.8	36.2	22.7	13.3
Fraction < 500 µm, >= 250 µm	g/100g dry wt	10.2	45.4	45.3	60.0
Fraction < 250 µm, >= 125 µm	g/100g dry wt	1.9	6.3	7.7	22.2
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.2	0.2	0.3	0.6
Fraction < 63 µm	g/100g dry wt	5.1	1.5	2.9	2.5
1.4					
Sample Name:	GS-CSD2 24-Sep-2024	GS-CSC3 24-Sep-2024	GS-CSD1 24-Sep-2024	GS-CSD2 24-Sep-2024	GS-CSD3 24-Sep-2024
Lab Number:	3703553.46	3703553.47	3703553.48	3703553.49	3703553.50
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample	g/100g as rcvd	82	80	79	81
Fraction >= 2 mm	g/100g dry wt	15.0	0.8	17.9	16.9
Fraction < 2 mm, >= 1 mm	g/100g dry wt	9.3	1.0	9.2	15.7
Fraction < 1 mm, >= 500 µm	g/100g dry wt	30.7	12.3	38.1	36.8
Fraction < 500 µm, >= 250 µm	g/100g dry wt	35.8	54.9	31.0	25.1
Fraction < 250 µm, >= 125 µm	g/100g dry wt	6.6	27.7	2.9	3.1
Fraction < 125 µm, >= 63 µm	g/100g dry wt	0.3	1.0	0.2	0.2
Fraction < 63 µm	g/100g dry wt	2.3	2.3	0.7	2.1
2.2					

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analyses. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Sediment			
Test	Method Description	Default Detection Limit	Sample No
7 Grain Sizes Profile as received			
Dry Matter for Grainsize samples (sieved as received)	Drying for 16 hours at 103°C, gravimetry (Free water removed before analysis).	0.10 g/100g as rcvd	1-50
Fraction >= 2 mm	Wet sieving with dispersant, as received, 2.00 mm sieve, gravimetry.	0.1 g/100g dry wt	1-50
Fraction < 2 mm, >= 1 mm	Wet sieving using dispersant, as received, 2.00 mm and 1.00 mm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 1 mm, >= 500 µm	Wet sieving using dispersant, as received, 1.00 mm and 500 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 500 µm, >= 250 µm	Wet sieving using dispersant, as received, 500 µm and 250 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 250 µm, >= 125 µm	Wet sieving using dispersant, as received, 250 µm and 125 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 125 µm, >= 63 µm	Wet sieving using dispersant, as received, 125 µm and 63 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50
Fraction < 63 µm	Wet sieving with dispersant, as received, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-50

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 12-Nov-2024 and 03-Dec-2024. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Lab No: 3703553-SPv1

Hill Labs

Page 3 of 3

Appendix D Sediment Particle Size Results

Table D.1 Summary of Sediment Particle Size Data (% by Weight). 1 month, 19 September 2023.

Site	Size Class (mm)							Classification
	Gravel	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt & Clay	
	>= 2 mm	< 2 - >= 1 mm	< 1 - >= 0.5 mm	< 500 - >= 250 µm	< 250 - >= 125 µm	< 125 - >= 63 µm	< 63 µm	
Recovery area								
A1S31	4.2	7.4	40.2	38.4	8.4	0.3	1.1	(g)S
A1S32	5.2	5	43.8	35.2	6.5	0.2	4	gS
A1S33	14.6	11.2	31.3	26.3	11.1	0.7	4.8	gS
A1S34	6.8	8.8	36.5	31.3	12.3	0.8	3.6	gS
A1S36	5.6	2.1	22.2	41.2	25.3	1	2.7	gS
A1S37	0.6	0.5	0.9	19.3	72	5.4	1.4	(g)S
A1S39	6.7	2.3	2	16.1	56.7	2.8	13.4	gmS
A1S40	6.3	1.5	17.5	55.4	17.2	0.7	1.3	gS
A1S41	7.3	8.2	38.3	30	12.7	0.9	2.5	gS
A1S42	7	15.6	42.7	26.6	4.7	0.3	3.2	gS
A1S44	7.4	12.4	41.2	27.9	7.8	0.3	3	gS
A1S45	14.9	8.2	30.1	34.2	10.3	0.5	1.9	gS
A1S46	4.9	5.3	21.3	37.5	27.6	0.9	2.5	(g)S
A1S48	0.4	0.6	3.1	26.7	66.3	2.7	0.1	(g)S
A1S49	21.8	14.2	19.7	22.3	16	0.9	5	gS
A1S50	16.4	13.8	33.4	24.9	6.6	0.3	4.6	gS
A1S51	3	14	44.6	27.3	6.9	0.5	3.6	(g)S
A1S52	1.7	5.5	31.5	36.1	9	0.2	15.8	(g)mS
A1S53	9.1	15	28.7	29.5	14.8	0.4	2.6	gS
A1S54	7.5	3.3	5.9	24.1	54.9	2	2.3	gS
A1S55	1.2	2	24.9	50.6	17.5	0.7	3	(g)S
A1S56	12.2	12.4	33.7	29.8	8.9	0.3	2.7	gS
A1S58	12.3	7.9	36	33	7.5	0.6	2.7	gS
A1S59	0.2	0.3	2.1	26.2	62.3	4.2	4.7	(g)S
A1S61	3	2.8	16	44.1	29.9	1.7	2.5	(g)S
A1S62	0.9	0.8	2.5	20.7	64.9	8.2	2	(g)S
A1S63	34.3	12.7	21	18.2	9.6	0.7	3.4	sG
Outside Recovery area								
A1S35	20.3	23	28	16.9	5.7	0.5	5.5	gS
A1S38	2.3	3	21.7	49.8	14.3	0.5	8.4	(g)S
A1S43	14.5	15	30.6	26.4	9.3	0.6	3.5	gS
A1S47	13.1	3.1	19.1	52.4	10.7	0.3	1.3	gS
A1S57	0.3	0.3	0.8	18.1	70.6	9.1	0.8	(g)S
A1S60	30	10.6	19.9	32.9	5.9	0.2	0.5	sG
Control area								
A1S64	6.4	4.4	21.7	50.1	13.4	0.6	3.6	gS
A1S65	8	4.3	28.5	44.1	12.4	0.6	2.2	gS
CSA1	0.4	9.7	67.3	2.5	14.6	0.7	4.7	(g)S
CSA2	0.3	0.3	3.4	47.5	43.9	1.9	2.8	(g)S
CSA3	1.7	3	22.1	55.3	12.9	0.7	4.4	(g)S
CSB1	16.3	0.7	15.3	44	16.8	1.3	5.7	gS
CSB2	2.7	1.2	18.7	62.9	11.6	0.4	2.5	(g)S
CSB3	18.6	8.6	34.2	30.2	5.6	0.1	2.7	gS
CSC1	6.8	4.7	30.6	46.2	9	0.4	2.4	gS
CSC2	25.6	7.3	17.3	41	7	0.4	1.4	gS
CSC3	0.8	0.7	7.2	49.9	35.8	1.4	4.1	(g)S
CSD1	10	7.3	34.9	38.4	5.9	0.2	3.2	gS
CSD2	22.7	8.7	31.7	29.3	6.8	0.3	0.5	gS
CSD3	0.8	1.2	14.5	50.2	27.5	1.3	4.6	(g)S
CSE1	22.4	10.7	32.3	26.7	3.7	0.2	4	gS
CSE2	18	14.4	40.5	21.8	2.4	0.3	2.6	gS
CSE3	1.1	0.4	1	10.7	67.8	12.8	6.2	(g)S

Table D.2 Summary of Sediment Particle Size Data (% by Weight). +6 months, 13 March 2024.

Site	Size Class (mm)							Classification
	Gravel	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt & Clay	
	>/= 2 mm	< 2 ->/= 1 mm	< 1 ->/= 0.5 mm	< 500 ->/= 250 µm	< 250 ->/= 125 µm	< 125 ->/= 63 µm	< 63 µm	
Recovery area								
A1S31	0.3	0.3	1.2	17.1	72.7	5.7	2.7	(g)S
A1S32	4.1	6.1	38.7	37.9	11	0.5	1.7	(g)S
A1S33	16.9	13.4	38.4	21.9	7	0.3	2	gS
A1S34	9.2	11.7	39.9	27.5	8.7	0.4	2.6	gS
A1S36	7.6	2.8	19.5	41.2	26.6	1	1.2	gS
A1S37	6.4	0.7	1.3	18.8	64.5	5.6	2.8	gS
A1S39	10.8	5.6	13.4	28.7	37.8	2.3	1.3	gS
A1S40	3.5	2.5	19.4	57	15.3	0.4	1.9	(g)S
A1S41	5.1	8.5	39.6	31.9	12.5	0.5	1.9	gS
A1S42	8.6	12.6	37.3	31.1	7.4	0.3	2.7	gS
A1S44	15	10.1	42.7	24.8	6.3	0.3	0.8	gS
A1S45	26.3	10.2	26.1	26.4	8.3	0.3	2.4	gS
A1S46	7.1	5.8	28.8	35.8	19.1	0.4	3.1	gS
A1S48	0.3	0.8	2.7	20.9	68.8	2.9	3.5	(g)S
A1S49	27.5	8.9	22.5	25.1	14	0.8	1.3	gS
A1S50	21.6	12.2	27.1	27	9.9	0.5	1.7	gS
A1S51	0.7	3.5	39.5	39.4	13.6	0.7	2.7	(g)S
A1S52	3.1	4	32.6	46.2	11.8	0.4	1.9	(g)S
A1S53	7.6	5.7	16	25.2	41.6	1	3	gS
A1S54	0.4	0.4	1.6	31.5	63.1	2	1.1	(g)S
A1S55	3	5.5	31.4	40.2	16.8	0.8	2.3	(g)S
A1S56	5.4	9.9	35.9	33.7	12.8	0.4	1.9	gS
A1S58	6.9	8.2	33.1	36.9	11.3	1.1	2.6	gS
A1S59	6	2.7	15.8	47.6	24.7	1.3	1.9	gS
A1S61	5	3.4	19.2	49.8	20.1	0.8	1.6	gS
A1S62	0.5	0.6	2.9	32.1	57.8	4.5	1.6	(g)S
A1S63	26.8	11.5	28.3	23.6	7.3	0.4	2.3	gS
Outside Recovery area								
A1S35	23.2	16.7	23.5	22.2	11.1	0.9	2.3	gS
A1S38	1.9	3	31.5	53.3	8.7	0.2	1.3	(g)S
A1S43	16.2	15.2	25.9	28.5	10.9	0.6	2.7	gS
A1S47	16.7	2.6	19.2	51.1	9.5	0.2	0.6	gS
A1S57	0.5	0.6	1.1	20.4	68.2	6.1	3.2	(g)S
A1S60	26.8	7.6	23	34.6	5.2	0.2	2.5	gS
Control area								
A1S64	6.4	4.2	24.1	49.7	12.8	0.5	2.5	gS
A1S65	1.1	1.5	30	54.1	10.6	0.4	2.2	(g)S
CSA1	0.7	1	15.3	68.8	12.6	0.4	1.2	(g)S
CSA2	0.4	0.4	3.5	45.6	46.8	2	1.4	(g)S
CSA3	1.3	2.7	25.1	57.6	11.3	0.4	1.7	(g)S
CSB1	7.8	2.5	18.5	50.4	16.2	1.1	3.4	gS
CSB2	3.1	2.4	26.3	59.8	7	0.3	1.2	(g)S
CSB3	20.9	12.8	31.4	26.8	6.1	0.3	1.6	gS
CSC1	9.1	6.6	42.6	35.6	4.4	0.1	1.5	gS
CSC2	12.9	5	24.7	48.8	6.4	0.3	2	gS
CSC3	0.7	0.7	7.8	52.7	35.3	0.9	1.8	(g)S
CSD1	9.7	7.8	31.1	40.5	7.1	0.4	3.3	gS
CSD2	8.4	8.4	33.1	39.8	8.1	0.3	1.9	gS
CSD3	0.3	0.5	5.6	40.5	50.1	1.3	1.6	(g)S
CSE1	32.6	11.9	30.1	20.6	2.5	0.2	2	sG
CSE2	39.2	9.2	28.9	16.1	3.1	0.5	3	sG
CSE3	< 0.1	0.2	1	17.2	68.4	9.5	3.6	S

Table D.3 Summary of Sediment Particle Size Data (% by Weight). +12 months, 24 September 2024.

Site	Size Class (mm)							Classification
	Gravel	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt & Clay	
	>= 2 mm	< 2 - >= 1 mm	< 1 - >= 0.5 mm	< 500 - >= 250 µm	< 250 - >= 125 µm	< 125 - >= 63 µm	< 63 µm	
Recovery area								
A1S31	1.9	1.6	8.9	57.1	27.6	0.7	2.2	(g)S
A1S32	2	3.1	46.5	38.6	7.9	0.2	1.8	(g)S
A1S33	11.9	9.2	40.3	26.2	9.4	0.5	2.4	gS
A1S34	4.5	8.8	45.4	29.9	8.2	0.4	2.9	(g)S
A1S36	2.7	2.8	31.8	42.4	17.5	0.5	2.3	(g)S
A1S37	5.3	0.5	1.5	16.4	69.7	4	2.6	gS
A1S39	0.7	0.4	0.9	17.8	76.3	3	0.9	(g)S
A1S40	6.8	2	17.4	55.7	15	0.4	2.8	gS
A1S41	3.6	7.2	53.3	26.4	7.3	0.3	1.8	(g)S
A1S42	10.1	13.4	37.2	29.6	7.5	0.3	2	gS
A1S44	7.2	14.8	40.3	26.8	7.4	0.4	3.2	gS
A1S45	16	9	30.7	28.8	12	0.6	2.9	gS
A1S46	11.6	7.2	22.7	41.3	15.6	0.2	1.5	gS
A1S48	2	0.4	3.5	30.6	58.2	1.7	3.6	(g)S
A1S49	15.4	7.8	26.2	33.9	13.2	0.6	2.8	gS
A1S50	7.6	10.6	40.1	29.2	8	0.3	4.2	gS
A1S51	1.2	2.7	42.1	42.7	9.2	0.3	1.8	(g)S
A1S52	1.6	3.4	39.8	42.1	11.6	0.4	1	(g)S
A1S53	1.4	2.9	13.6	43.7	36.6	0.8	1	(g)S
A1S54	2	1.5	11.1	59.5	21.7	0.9	3.4	(g)S
A1S55	2.2	4.4	34.2	41.3	15.4	0.6	1.9	(g)S
A1S56	5.5	8.7	42.6	32.5	8.9	0.3	1.6	gS
A1S58	6	5.7	38.3	41.7	6.1	0.2	2.1	gS
A1S59	2.6	1	5.6	44	42.6	1.5	2.8	(g)S
A1S61	3.2	3.4	25.4	49.7	16.3	0.6	1.5	(g)S
A1S62	9	9.3	29.3	35.6	12.9	0.8	3.1	gS
A1S63	17.5	6.1	30.5	32.9	11	0.6	1.5	gS
Outside Recovery area								
A1S35	19.1	23.7	30.8	17	5.9	0.6	3	gS
A1S38	2.4	2.5	23.1	57.5	12.4	0.2	1.9	(g)S
A1S43	8.8	15.2	35.3	29.5	8.5	0.4	2.3	gS
A1S47	5.1	2.4	25	54.7	10	0.1	2.7	gS
A1S57	0.4	0.3	1.1	25.6	64.3	5.8	2.4	(g)S
A1S60	6.3	3.1	36.5	43.4	8.1	0.2	2.4	gS
Control area								
A1S64	0.9	1.6	8.1	40	45.4	1.6	2.5	(g)S
A1S65	5.5	1.9	23.7	55.4	10	0.4	3.1	gS
CSA1	0.4	0.6	13.8	71.7	11.5	0.3	1.7	(g)S
CSA2	0.6	0.7	13.3	66.9	16	0.4	2.1	(g)S
CSA3	1.9	1.5	23.5	59.6	11.3	0.3	2	(g)S
CSB1	2.7	1.4	25.4	57.5	9.5	0.4	3.1	(g)S
CSB2	2.5	2.4	29.5	57.3	6.5	0.1	1.7	(g)S
CSB3	55.5	11.3	15.8	10.2	1.9	0.2	5.1	msG
CSC1	4.8	5.6	36.2	45.4	6.3	0.2	1.5	(g)S
CSC2	15.3	5.7	22.7	45.3	7.7	0.3	2.9	gS
CSC3	0.6	0.7	13.3	60	22.2	0.6	2.5	(g)S
CSD1	5.5	8.8	43.2	36.8	4.2	0.1	1.4	gS
CSD2	15	9.3	30.7	35.8	6.6	0.3	2.3	gS
CSD3	0.8	1	12.3	54.9	27.7	1	2.3	(g)S
CSE1	17.9	9.2	38.1	31	2.9	0.2	0.7	gS
CSE2	16.9	15.7	36.8	25.1	3.1	0.2	2.1	gS
CSE3	0.4	0.5	1.8	23.9	63.3	7.9	2.2	(g)S

Table D.4 Two Way Scheirer Ray Hare Analysis of the percentage of Gravel between Survey and Area in the discontinued area of Area 1

Dependent Variable: Gravel
Normality Test (Shapiro-Wilk): Failed ($P < 0.050$)
Equal Variance Test (Brown-Forsythe): Passed ($P = 0.091$)

Group	N	Missing	Median	25%	75%
Recovery	81	0	6.0	2.6	9.2
Control	69	0	6.3	0.9	16.3

Group	N	Missing	Median	25%	75%
Survey 1	50	0	6.8	1.9	14.6
Survey 6	50	0	6.7	1.5	14.5
Survey 12	50	0	4.7	1.9	9.0

Group	N	Missing	Median	25%	75%
Recovery 1	27	0	6.7	3.0	10.7
Control 1	23	0	8.0	1.4	18.3
Recovery 6	27	0	6.4	3.3	10.0
Control 6	23	0	7.8	0.9	16.5
Recovery 12	27	0	4.5	2.0	8.3
Control 12	23	0	4.8	0.9	11.9

Source of Variation	DF	H	p
Survey	2	1.993	0.3691
Area	1	0.011	0.9174
Survey x Area	2	0.341	0.8433

The difference among levels of Survey is not statistically significant ($H=1.993$, $p=0.3691$).
The difference among levels of Area is not statistically significant ($H=0.011$, $p=0.9174$).
The difference among levels of Survey x Area is not statistically significant ($H=0.341$, $p=0.8433$).

All Pairwise Multiple Comparison Procedures : Overall significance level = 0.05

Pairwise Dunn Tests: Survey (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	0.154	0.8774	1	False
1 vs 12	1.293	0.1962	0.7846	False
6 vs 12	1.138	0.255	0.7846	False

Pairwise Dunn Tests: Area (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
Control vs Recovery	0.104	0.9174	1	False

Area within each Survey (Mann Whitney U; Holm not needed)

Survey	Comparison	U	p	Sig(0.05)
1	Control vs Recovery	276.5	0.5143	False
6	Control vs Recovery	303.5	0.8993	False
12	Control vs Recovery	335.0	0.6403	False

Survey within Control (Dunn; Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	0.390	0.6968	1	False
1 vs 12	1.077	0.2815	1	False
6 vs 12	0.687	0.4919	1	False

Survey within Recovery (Dunn; Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	-0.191	0.8486	1	False
1 vs 12	0.772	0.44	1	False
6 vs 12	0.963	0.3355	1	False

Table D.5 Two Way Scheirer Ray Hare Analysis of the percentage of Sand between Survey and Area in the discontinued area of Area 1

Dependent Variable: Sand
Normality Test (Shapiro-Wilk): Failed ($P < 0.050$)
Equal Variance Test (Brown-Forsythe): Passed ($P = 0.212$)

Group	N	Missing	Median	25%	75%
Recovery	81	0	91.8	87.8	94.7
Control	69	0	91.3	81.4	96.3

Group	N	Missing	Median	25%	75%
Survey 1	50	0	89.9	80.9	94.4
Survey 6	50	0	91.0	84.5	96.3
Survey 12	50	0	93.4	88.1	96.1

Group	N	Missing	Median	25%	75%
Recovery 1	27	0	90.1	84.2	93.9
Control 1	23	0	89.3	78.4	94.4
Recovery 6	27	0	91.1	88.0	94.7
Control 6	23	0	89.7	81.9	96.7
Recovery 12	27	0	93.0	88.1	95.7
Control 12	23	0	93.7	85.8	96.8

Source of Variation	DF	H	p
Survey	2	6.039	0.0488
Area	1	0.093	0.7600
Survey x Area	2	0.455	0.7966

The difference among levels of Survey is **statistically significant** ($H=6.039$, $p=0.0488$).
The difference among levels of Area is not statistically significant ($H=0.093$, $p=0.7600$).
The difference among levels of Survey x Area is not statistically significant ($H=0.455$, $p=0.7966$).

All Pairwise Multiple Comparison Procedures : Overall significance level = 0.05

Pairwise Dunn Tests: Survey (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	-1.199	0.2304	0.6252	False
1 vs 12	-2.457	0.014	0.056	False
6 vs 12	-1.258	0.2084	0.6252	False

Pairwise Dunn Tests: Area (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
Control vs Recovery	-0.305	0.76	1	False

Area within each Survey (Mann Whitney U; Holm not needed)

Survey	Comparison	U	p	Sig(0.05)
1	Control vs Recovery	353.5	0.408	False
6	Control vs Recovery	308.0	0.9689	False
12	Control vs Recovery	301.0	0.8609	False

Survey within Control (Dunn; Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	-1.202	0.2295	0.6885	False
1 vs 12	-1.874	0.06091	0.2436	False
6 vs 12	-0.672	0.5013	1	False

Survey within Recovery (Dunn; Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	-0.596	0.5513	1	False
1 vs 12	-1.600	0.1097	0.4388	False
6 vs 12	-1.004	0.3155	0.9466	False

Table D.6 Two Way Scheirer Ray Hare Analysis of the percentage of Silt and Clay between Survey and Area in the discontinued area of Area 1

Dependent Variable: Silt and Clay
Normality Test (Shapiro-Wilk): Failed ($P < 0.050$)
Equal Variance Test (Brown-Forsythe): Passed ($P = 0.115$)

Group	N	Missing	Median	25%	75%
Recovery	81	0	2.7	1.9	3.4
Control	69	0	2.6	2.1	4.0

Group	N	Missing	Median	25%	75%
Survey 1	50	0	2.9	2.3	4.3
Survey 6	50	0	2.9	2.3	4.3
Survey 12	50	0	2.3	1.8	2.8

Group	N	Missing	Median	25%	75%
Recovery 1	27	0	2.7	2.4	3.8
Control 1	23	0	3.2	2.3	4.5
Recovery 6	27	0	2.7	2.4	3.8
Control 6	23	0	3.2	2.3	4.5
Recovery 12	27	0	2.2	1.7	2.9
Control 12	23	0	2.3	2.0	2.6

Source of Variation	DF	H	p
Survey	2	12.931	0.0016
Area	1	0.049	0.8239
Survey x Area	2	0.046	0.9774

The difference among levels of Survey is **statistically significant** ($H=12.931$, $p=0.0016$).
The difference among levels of Area is not statistically significant ($H=0.049$, $p=0.8239$).
The difference among levels of Survey x Area is not statistically significant ($H=0.046$, $p=0.9774$).

All Pairwise Multiple Comparison Procedures : Overall significance level = 0.05

Pairwise Dunn Tests: Survey (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	0.000	1	1	False
1 vs 12	3.116	0.001833	0.007333	True
6 vs 12	3.116	0.001833	0.007333	True

Pairwise Dunn Tests: Area (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
Control vs Recovery	0.223	0.8238	1	False

Area within each Survey (Mann Whitney U; Holm not needed)

Survey	Comparison	U	p	Sig(0.05)
1	Control vs Recovery	293.5	0.7479	False
6	Control vs Recovery	293.5	0.7479	False
12	Control vs Recovery	300.5	0.8531	False

Survey within Control (Dunn; Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	0.000	1	1	False
1 vs 12	2.184	0.02896	0.1158	False
6 vs 12	2.184	0.02896	0.1158	False

Survey within Recovery (Dunn; Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	0.000	1	1	False
1 vs 12	2.214	0.02681	0.1072	False
6 vs 12	2.214	0.02681	0.1072	False

Table D.7 Homogeneity of multivariate dispersions (PERMDIS) of the percentage grain size data

Transform: CLR
Resemblance: D1 Euclidean distance
Group factor: Survey
Number of groups: 3
Total Number of samples: 150
Number of permutations: 9999

Overall test for homogeneity

Source	df1	df2	F	P
Survey	2	147	0.92526	0.3967

Means and standard errors

Group	Size	Average	SE
1	50	2.2798	0.17248
6	50	2.1531	0.17472
12	50	1.9623	0.1501

Pairwise tests: Term: Survey

Groups	t	P
(6, 1)	0.51602	0.6103
(12, 1)	1.3885	0.1659
(12, 6)	0.82825	0.4048

Transform: CLR
Resemblance: D1 Euclidean distance
Group factor: Area
Number of groups: 2
Total Number of samples: 150
Number of permutations: 9999

Overall test for homogeneity

Source	df1	df2	F	P
Area	1	148	3.9625	0.048

Means and standard errors

Group	Size	Average	SE
Recovery	81	1.9559	0.12094
Control	69	2.3371	0.15132

Pairwise tests: Term: Area

Groups	t	P
(Control, Recovery)	1.9906	0.0488

Transform: CLR
Resemblance: D1 Euclidean distance
Group factor: Survey - Area
Number of groups: 6
Total Number of samples: 150
Number of permutations: 9999

Overall test for homogeneity

Source	df1	df2	F	P
Area-Survey	5	144	1.181	0.3235

Means and standard errors

Group	Size	Average	SE
Recovery-1	27	2.1185	0.22202
Control-1	23	2.4338	0.276
Recovery-6	27	1.9694	0.22802
Control-6	23	2.319	0.2728
Recovery-12	27	1.72	0.17721
Control-12	23	2.1998	0.25013

Pairwise tests: Term: Survey-Area

Groups	t	P
(Control-1, Recovery-1)	0.89987	0.3826
(Recovery-6, Recovery-1)	0.46871	0.6384
(Recovery-6, Control-1)	1.3089	0.1956
(Control-6, Recovery-1)	0.57564	0.5761
(Control-6, Control-1)	0.29584	0.7692
(Control-6, Recovery-6)	0.99118	0.3276
(Recovery-12, Recovery-1)	1.403	0.1693
(Recovery-12, Control-1)	2.2389	0.0275
(Recovery-12, Recovery-6)	0.86359	0.3974
(Recovery-12, Control-6)	1.8928	0.0613
(Control-12, Recovery-1)	0.24359	0.8064
(Control-12, Control-1)	0.62823	0.5364
(Control-12, Recovery-6)	0.68134	0.5021
(Control-12, Control-6)	0.32207	0.7501
(Control-12, Recovery-12)	1.5985	0.1192

Table D.8 *Permutational Multivariate Analysis of Variance
(PERMANOVA) two way crossed design (Survey and Area) of
the percentage grain size data*

Transform: CLR
Resemblance: D1 Euclidean distance
Sums of squares type: Type I (sequential)
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999
Allow for heterogeneity of within-group dispersions: Area

Factors

Name	Type	Levels
Survey	Fixed	3
Area	Fixed	2

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Survey	2	10.25	5.1248	0.8453	0.4601	9953
Area	1	8.3475	8.3475	1.3309	0.2374	9936
Survey x Area	2	0.73927	0.36963	0.058931	0.9997	9939
Res	144	878	6.0972			
Total	149	897.33				

Estimates of components of variation

Source	Estimate	Sq.root
S(Survey)	-0.018758	-0.13696
S(Area)	0.027848	0.16688
S(Survey x Area)	-0.23763	-0.48747
V(Res)	6.0972	2.4693

Details of the expected mean squares (EMS) for the model

Source	EMS
Survey	$0.46 \cdot V(\text{Res}(2)) + 0.54 \cdot V(\text{Res}(1)) + 0.16 \cdot S(\text{Survey} \times \text{Area}) + 50 \cdot S(\text{Survey})$
Area	$0.54 \cdot V(\text{Res}(2)) + 0.46 \cdot V(\text{Res}(1)) + 74.52 \cdot S(\text{Area})$
Survey x Area	$0.54 \cdot V(\text{Res}(2)) + 0.46 \cdot V(\text{Res}(1)) + 24.84 \cdot S(\text{Survey} \times \text{Area})$

Construction of Pseudo-F ratio(s) from mean squares

Source	Numerator	Denominator	Num.df	Den.df
Survey	1*Survey	$0.45652 \cdot \text{Res}(2) + 0.53704 \cdot \text{Res}(1) + 0.0064412 \cdot \text{Survey} \times \text{Area}$	2	139.71
Area	1*Area	$0.54 \cdot \text{Res}(2) + 0.46 \cdot \text{Res}(1)$	1	129.52
Survey x Area	1*Survey x Area	$0.54 \cdot \text{Res}(2) + 0.46 \cdot \text{Res}(1)$	2	129.52

Appendix E Benthic Biota Results

Table E.1 Number per sample of Benthic Infauna Retained on 1 mm sieve from the grab samples collected within the Recovery Area. 1 month, 19 September 2023.

Taxa	Site A1S Monitoring Cell	31 01D	32 01F	33 01G	34 01G	36 01D	37 01C	39 01C	40 02B	41 02F	42 02F	44 02F	45 02D	46 02B	48 03B	49 03D	50 03F	51 03E	52 03D	53 03B	54 04B	55 04C	56 03F	58 04E	59 04B	61 04C	62 04D	63 04E
Annelida																												
Polychaeta																												
Amphinomidae <i>Chloeia</i> sp.																										1		
Dorvilleidae				1												1												
Lumbrineridae			2	1																1				1				
Onuphidae <i>Nothria</i> sp.				1																								
<i>Onuphis aucklandensis</i>							5	2							1		1					1			1	1		
Aphroditidae							1																					
Glyceridae																1							1					1
Hesionidae																												
Nephtyidae <i>Aglaophamus</i> sp.												1		1	1						1							1
Phyllodocidae																												
Sigalionidae		2		1		1	1		1	2			1	2		1	1	2	1	2	1	2	2	1			3	2
Syllidae				1													1	1										
Exogoninae																												
Sabellidae <i>Euchone pallida</i>									1				2	3		4		1		1	1	3		1		2		
Spionidae <i>Aonides oxycephala</i>																												1
<i>Paraprionospio pinnata</i>							5	8																	1			
<i>Prionospio multicristata</i>				2							1						1	1		2								
<i>Prionospio</i> sp.																												
<i>Spio</i> sp.																												
<i>Spiophanes kroyeri</i>						1	3	2							7								1		3	3	12	1
Ampharetidae							14	6													4				1	3	3	
Cirratulidae																1						1						2
Flabelligeridae				1																								
Pectinariidae <i>Lagis australis</i>								8																				
Terebellidae																			1									
Capitellidae <i>Barantolla lepte</i>				3	1	1		2		1	2		2			3		2		2		1	1	2		2		2
<i>Notomastus zeylanicus</i>											1																	
Maldanidae			1						2	1				2					2			2			2	5		1
Opheliidae <i>Armandia maculata</i>		1		4	2						3	1				2	2			2				2	2	1		1
Orbiniidae <i>Leitoscoloplos kerguelensis</i>															1													
<i>Orbinia papillosa</i>																												1
Oweniidae <i>Myriowenia</i> sp.							1																					
Travisiidae <i>Travisia olens</i>																												
Sipuncula																												
<i>Themiste</i> sp.																							1					
Arthropoda																												
Amphipoda																												
<i>Ampelisca</i> sp.																												1
Lysianassidae								1							2													
Phoxocephalidae		1					2	2						1							2	1		2	1		1	1
Urothoidae		2	2			1			1	2				4	5		1	3	5		2	3	2		1	2	4	
Amphipoda Unid.				1	2		3		1	2	4		3	1	2	5	5	2	2	2	2	3	2	1		2	2	3
Cumacea																												
Cumacea							4	1	1				1		8				1		6	1				1	1	

Taxa	Site A1S	31	32	33	34	36	37	39	40	41	42	44	45	46	48	49	50	51	52	53	54	55	56	58	59	61	62	63
	Monitoring Cell	01D	01F	01G	01G	01D	01C	01C	02B	02F	02F	02F	02D	02B	03B	03D	03F	03E	03D	03B	04B	04C	03F	04E	04B	04C	04D	04E
Decapoda																												
	<i>Pagurus sp.</i>		2	32	3		5		3	1	1		2		1	62				5		3	1	2		1	1	3
	<i>Callinassa filholi</i>		1		1		1	3	1					3	1						2	1		1		1	1	1
	<i>Nectocarcinus benetti</i>																											
	<i>Neommatocarcinus huttoni</i>							1																				
	<i>Halicarcinus tongi</i>							1																				
	<i>Liocarcinus corrugatus</i>																											
	<i>Philocheras australis</i>																										1	
	<i>Ogyrides sp.</i>							1																				
	<i>Palaemon affinis</i>				1																							
	<i>Upogebia sp.</i>			8	1						1						2							1				3
	Decapoda (larvae Unid.)																											
Isopoda																												
	Anthuridea							1							1		1											
	<i>Eurylana cookii</i>												2		1		1		1			1	1	1				
Leptostraca																												
	Mysidacea							1					1													1		
	Tanaidacea			1																								
Ostracoda																												
	<i>Diasterope grisea</i>														1													
	<i>Leuroleberis zealandica</i>				1			2																				
Bryozoa																												
	Bryozoa (discoid)	1	2							2	2						2					1						
Chordata																												
Ascidiacea																												
	<i>Molgula sp.</i>													1										1				
Leptocardii																												
	<i>Epigonichthys hectori</i>		1									1	1				1		1					2				2
Cnidaria																												
Hexacorallia																												
Scleractinia	<i>Sphenotrochus sp. (Alive)</i>										2																	
Echinodermata																												
Asteroidea																												
	<i>Patiriella regularis</i>																											
Echinoidea																												
	<i>Echinocardium cordatum</i>																											
Holothuroidea																												
	<i>Trochodota dendyi</i>			1					1		1		1	2														
Ophiuroidea																												
	Ophiuroidea				1														1									
	Hemichordata							1																				
Mollusca																												
Polyplacophora																												
	<i>Leptochiton inquinatus</i>															1												
Gastropoda																												
	<i>Maoricolpus roseus</i>																							1				
	<i>Philine sp.</i>																											
	<i>Sigapatella tenuis</i>	2		1									4			1								1		1		
	<i>Amalda australis</i>																											
	<i>Cominella nassoides</i>						1	1												1								
	<i>Micrelenchus sp.</i>																											

Taxa	Site A1S	31	32	33	34	36	37	39	40	41	42	44	45	46	48	49	50	51	52	53	54	55	56	58	59	61	62	63
	Monitoring Cell	01D	01F	01G	01G	01D	01C	01C	02B	02F	02F	02F	02D	02B	03B	03D	03F	03E	03D	03B	04B	04C	03F	04E	04B	04C	04D	04E
Bivalvia																												
	<i>Myadora antipodum</i>						1	1																				
	<i>Hunkydora novozelandica</i>																									1		1
	<i>Pratulium pulchellum</i>			1	1					1	2	2					2	1	1				1			1		2
	<i>Gari sp. (juvenile)</i>									1			1															
	<i>Gari stangeri</i>													1														
	<i>Theora lubrica</i>				1																2							
	<i>Pleuromeris zelandica</i>										2																	
	<i>Purpurocardia purpurata</i>															1												
	<i>Myllitella vivens vivens</i>												2	1					1						2	4		
	<i>Mysella sp.</i>																											
	<i>Limaria orientalis</i>								1																			
	<i>Corbula zelandica</i>			4							1		1					1				1	3					1
	<i>Nucula nitidula</i>			2	1		2	3			1			3		1		1	1	1		1		1		1	1	
	<i>Scalpomactra scalpellum</i>	1																										
	<i>Zemysina sp.</i>							4						1			1			2	1				3	4		
	<i>Bassina yatei</i>																											
	<i>Dosinia subrosea</i>									1	1									2			1					
	<i>Tawera spissa</i>		1																									
Nematoda																												
Nemertea				1		1																					1	
Platyhelminthes																										1		1
Porifera																												
	<i>cf Tethyopsis sp.</i>		1																					2	1		1	1
Number of Individuals		10	13	67	16	5	49	52	13	14	25	5	23	28	31	88	19	17	16	23	24	25	16	26	20	39	30	32
Number of Species / taxa		7	9	19	12	5	15	21	10	10	15	4	14	15	12	16	12	12	10	12	11	15	13	18	11	21	13	21
Shannon-Wiener Diversity Index		1.89	2.14	2.05	2.39	1.61	2.34	2.74	2.20	2.24	2.59	1.33	2.51	2.58	2.11	1.35	2.30	2.39	2.10	2.36	2.21	2.58	2.51	2.81	2.29	2.86	2.07	2.94
Shannon-Wiener Evenness		0.97	0.97	0.69	0.96	1.00	0.86	0.90	0.96	0.97	0.96	0.96	0.95	0.95	0.85	0.49	0.93	0.96	0.91	0.95	0.92	0.95	0.98	0.97	0.96	0.94	0.81	0.97

Table E.2 Number per sample of Benthic Infauna Retained on 1 mm sieve from the grab samples collected outside the Recovery and in Control Areas. 1 month, 19 September 2023.

Taxa	Site Monitoring Cell	A1S-35 01h	A1S-38 01a	A1S-43 02h	A1S-47 03a	A1S-57 04g	A1S-60 04a	A1S-64 CSE	A1S-65 CSB	CSA-1 CSA	CSA-2 CSA	CSA-3 CSA	CSB-1 CSB	CSB-2 CSB	CSB-3 CSB	CSC-1 CSC	CSC-2 CSC	CSC-3 CSC	CSD-1 CSD	CSD-2 CSD	CSD-3 CSD	CSE-1 CSE	CSE-2 CSE	CSE-3 CSE
Annelida																								
Polychaeta																								
Amphinomidae <i>Chloeia</i> sp.																								
Dorvilleidae		1																						
Lumbrineridae		1	1									2	1		2		1		1					
Onuphidae <i>Nothria</i> sp.																								
<i>Onuphis aucklandensis</i>		1	1	1		3				1	1		1				1	2	1		2	1		7
Aphroditidae																								
Glyceridae		3													1							1	1	
Hesionidae							2																	
Nephtyidae <i>Aglaophamus</i> sp.				1		1				1										1		1	1	
Phyllodocidae		1																						
Sigalionidae			1		1	2	1						1		1	1	1		1	1	1	1		
Syllidae		3		1			1													1		1		
Exogoninae		1																						
Sabellidae <i>Euchone pallida</i>			3			3	4	1	1	3		4				2	1						1	
Spionidae <i>Aonides oxycephala</i>																								
<i>Paraprionospio pinnata</i>																								
<i>Prionospio multicristata</i>				1													1			1				
<i>Prionospio</i> sp.									1															
<i>Spio</i> sp.					1																	1		
<i>Spiophanes kroyeri</i>						7	1		1		36	1									1			
Ampharetidae						6					5					1	1					2	2	8
Cirratulidae																	1					1		
Flabelligeridae		1																					1	
Pectinariidae <i>Lagis australis</i>							1																	1
Terebellidae																								
Capitellidae <i>Barantolla lepte</i>		5		2												2	1		1	3		2	3	
<i>Notomastus zeylanicus</i>																								
Maldanidae			4	1	1	2	1	1		3	1	4			1	2	4	1			2	1		
Opheliidae <i>Armandia maculata</i>		5				1	2			1			1		1			1	1			2	1	1
Orbiniidae <i>Leitoscoloplos kerguelensis</i>																								
<i>Orbinia papillosa</i>		1																						
Oweniidae <i>Myriowenia</i> sp.						1																		
Travisiidae <i>Travisia olens</i>		1																			1			
Sipuncula																								
<i>Themiste</i> sp.																								
Arthropoda																								
Amphipoda																								
<i>Ampelisca</i> sp.																					1			
Lysianassidae			1								3					1				1				
Phoxocephalidae				1				1		2	3												1	1
Urothoidae			1	1	3		1		5	5	1			1	3	2	1	1	1	1	1			1
Amphipoda Unid.		2	3			1	2	1	3			1	3	1	2	2	2			2	3	1	3	2
Cumacea																								
Cumacea			2	2	1	1		1	4	2	1		2			1				2				
Decapoda																								
<i>Pagurus</i> sp.		3	1	6	1	1	5		1	1				1		1	1	1		2	1	2	2	3
<i>Callianassa filholi</i>						2	1					1	2	1										4
<i>Nectocarcinus benetti</i>													3											

Taxa	Site	A1S-35	A1S-38	A1S-43	A1S-47	A1S-57	A1S-60	A1S-64	A1S-65	CSA-1	CSA-2	CSA-3	CSB-1	CSB-2	CSB-3	CSC-1	CSC-2	CSC-3	CSD-1	CSD-2	CSD-3	CSE-1	CSE-2	CSE-3
	Monitoring Cell	01h	01a	02h	03a	04g	04a	CSE	CSB	CSA	CSA	CSA	CSB	CSB	CSB	CSC	CSC	CSC	CSD	CSD	CSD	CSE	CSE	CSE
	<i>Neommatocarcinus huttoni</i>																							
	<i>Halicarcinus tongi</i>																							
	<i>Liocarcinus corrugatus</i>																			1			1	
	<i>Philocheras australis</i>																							
	<i>Ogyrides</i> sp.																							
	<i>Palaemon affinis</i>																							
	<i>Upogebia</i> sp.			3																				
	Decapoda (larvae Unid.)						1																	
Isopoda																								
	Anthuridea																							
	<i>Eurylana cookii</i>			1											1	1					1	1		
Leptostraca																								
	Mysidacea		1		1					2		1	1											
	Tanaidacea																							
Ostracoda																								
	<i>Diasterope grisea</i>		1																					
	<i>Leuroleberis zealandica</i>																							
Bryozoa																								
	Bryozoa (discoid)		7		5				1	4	1	7			2	1	4							
Chordata																								
Ascidacea																								
	<i>Molgula</i> sp.		1						1				1											
Leptocardii																								
	<i>Epigonichthys hectori</i>			1			1					1			4				1	1		3	3	
Cnidaria																								
Hexacorallia																								
Scleractinia	<i>Sphenotrochus</i> sp. (Alive)																							
Echinodermata																								
Asteroidea																								
	<i>Patiriella regularis</i>		1																		1			
Echinoidea																								
	<i>Echinocardium cordatum</i>				1													1						
Holothuroidea																								
	<i>Trochodota dendyi</i>																							
Ophiuroidea																								
	Ophiuroidea												1											
	Hemichordata																							
Mollusca																								
Polyplacophora																								
	<i>Leptochiton inquinatus</i>																							
Gastropoda																								
	<i>Maoricolpus roseus</i>																							
	<i>Philine</i> sp.																							1
	<i>Sigapatella tenuis</i>				2		2		1								1					1	1	
	<i>Amalda australis</i>			1							1						1							
	<i>Cominella nassoides</i>																							
	<i>Micrelenchus</i> sp.						1																	
Bivalvia																								
	<i>Myadora antipodum</i>						1											1				1		
	<i>Hunkydora novozelandica</i>																				1			
	<i>Pratulum pulchellum</i>	6		18		2			1												2			
	<i>Gari</i> sp. (juvenile)									4		1												
	<i>Gari stangeri</i>							1									1							
	<i>Theora lubrica</i>						2																1	1

Taxa	Site	A1S-35	A1S-38	A1S-43	A1S-47	A1S-57	A1S-60	A1S-64	A1S-65	CSA-1	CSA-2	CSA-3	CSB-1	CSB-2	CSB-3	CSC-1	CSC-2	CSC-3	CSD-1	CSD-2	CSD-3	CSE-1	CSE-2	CSE-3
	Monitoring Cell	01h	01a	02h	03a	04g	04a	CSE	CSB	CSA	CSA	CSA	CSB	CSB	CSB	CSC	CSC	CSC	CSD	CSD	CSD	CSE	CSE	CSE
	<i>Pleuromeris zelandica</i>																					1		
	<i>Purpurocardia purpurata</i>													1	1					1				
	<i>Mytilus edulis</i>										1	1												
	<i>Mytilus sp.</i>										1													
	<i>Limaria orientalis</i>																							
	<i>Corbula zelandica</i>	2		5		1														2		1		
	<i>Nucula nitidula</i>				4		12		1		3	8	2				2	5		2			2	2
	<i>Scalpomactra scalpellum</i>																1	2			1			
	<i>Zemysina sp.</i>		1			4	2	1			1	1					1	2			1			10
	<i>Bassina yatei</i>																							1
	<i>Dosinia subrosea</i>		1	1	1			1					1			3			2					
	<i>Tawera spissa</i>										1			1		1					1			
Nematoda		4																						
Nemertea		1		1					1				1				1			2			1	
Platyhelminthes																								
Porifera																								
	<i>cf Tethyopsis sp.</i>	1		1																				
Number of Individuals		43	31	47	21	41	43	9	17	28	65	34	21	5	17	26	30	12	9	23	22	23	26	44
Number of Species / taxa		19	17	17	13	17	19	9	12	11	16	14	14	5	11	17	18	9	8	15	17	17	17	15
Shannon-Wiener Diversity Index		2.71	2.56	2.21	2.33	2.61	2.56	2.20	2.31	2.26	1.79	2.27	2.53	1.61	2.26	2.74	2.67	2.14	2.04	2.63	2.75	2.75	2.72	2.31
Shannon-Wiener Evenness		0.92	0.90	0.78	0.91	0.92	0.87	1.00	0.93	0.94	0.65	0.86	0.96	1.00	0.94	0.97	0.92	0.97	0.98	0.97	0.97	0.97	0.96	0.85

Table E.3 Number per sample of Benthic Infauna Retained on 1 mm sieve from the grab samples collected within the Recovery Area. +6 months, 13 March 2024.

Taxa	Site A1S Monitoring Cell	31 01D	32 01F	33 01G	34 01C	36 01D	37 01C	39 01C	40 02B	41 02F	42 02F	44 02F	45 02D	46 02B	48 03B	49 03D	50 03F	51 03E	52 03D	53 03B	54 04B	55 04C	56 03F	58 04E	59 04B	61 04C	62 04D	63 04E
Annelida																												
Polychaeta																												
Amphinomidae <i>Chloeia sp.</i>									1																			
Dorvilleidae			1	1			4			4		1									2			1				
Eunicidae																												
Lumbrineridae								2	1	1		1	1	1	1	2		1						1	1			1
<i>Onuphis aucklandensis</i>	2			2						1					1												1	
Glyceridae			1	2			3			2			3	1		1	1	1				2	1					2
Goniadidae					1		1																					
Hesionidae				1			1						1	1														
Nephtyidae <i>Aglaophamus sp.</i>	5						1	2		1								3				1	1	1			1	1
Phyllodoctidae	1	1	2	2	1	1	9	2		2	1	4	4	1	5	2	2	1	4			1	3	1	5	3	1	3
Polynoidae									1																			1
Sigalionidae	1	1	3				4		1	3	1	2			1		1		1	1	1	1	1				2	
Syllidae		1			1	1		3		1	1	1	1			2	4	1				1	1			1		1
Exogoninae																												
Sabellidae	3		1	1			1						2		1	1	1	1					1	3	2		1	1
Sabellidae <i>Euchone pallida</i>	1				1	2	1	4					4			2	1	6	1	2	3			2	4	12	4	1
Serpulidae <i>Hydroides sp.</i>							1	1		2		12					2		8		1							
Spionidae <i>Aonides oxycephala</i>																												2
<i>Paraprionospio pinnata</i>	3		1			1	2													1					3	2	1	
<i>Prionospio multicristata</i>									1				1			3		3	1			4		2				2
<i>Prionospio sp.</i>			1				1	1	1	1					1	2			1					5	1	2		
<i>Spio sp.</i>						2	1						1	1	1		1	2	1			1	1	5	4	2		
<i>Spiophanes kroyeri</i>														1	1		1	2	1				1	1				
Ampharetidae	7			2		23	15	1					5		14				2	2	13	1	2	1	3	3	1	
Cirratulidae							2						3			1								2				
Flabelligeridae										1													1	1				
Pectinariidae <i>Lagis australis</i>	1																											
Terebellidae	1	1	1	2			1	1	4	1	2	6	2	3	2	1	2	1	1		3	2	2				1	
Capitellidae <i>Barantolla lepte</i>		1		1	2		2	10	1	5	1	9	5			1		2	1	2		1	1			3		
<i>Heteromastus filiformis</i>																												1
<i>Notomastus zeylanicus</i>															2													
<i>Phyllochaetopterus socialis</i>															1													
Cossuridae <i>Cossura consimilis</i>												1																
Magelonidae <i>Magelona dakini</i>	1											1	1	1	3	6		1				7						
Maldanidae					17		4	51	1	2			1	2	8	5		2	4	15		17		1	13	19	9	1
Opheliidae <i>Armandia maculata</i>	3				1	6	4						3		8	1							1	1				4
Orbiniidae <i>Leitoscoloplos kerguelensis</i>																		1										
<i>Orbinia papillosa</i>				1			1			2							2						1					1
Oweniidae <i>Myriochele sp.</i>						1													1	5								
Oweniidae <i>Myriowenia sp.</i>	2				1																							
<i>Owenia petersenae</i>																												1
Paraonidae																												
Scalibregmidae									1																			
Travisidae <i>Travisia olens</i>															1		2					1	1					
Sipuncula																												
<i>Aspidosiphon sp.</i>																				1								1
<i>Nephasoma sp.</i>																												

Taxa	Site A1S	31	32	33	34	36	37	39	40	41	42	44	45	46	48	49	50	51	52	53	54	55	56	58	59	61	62	63	
	Monitoring Cell	01D	01F	01G	01G	01D	01C	01C	02B	02F	02F	02F	02D	02B	03B	03D	03F	03E	03D	03B	04B	04C	03F	04E	04B	04C	04D	04E	
Arthropoda																													
Amphipoda																													
	Ampelisca sp.							2			1															7	2		
	Haustoriidae						1		1						2		1		3	3		2		1	6	1	2		
	Lysianassidae					2		1													1		1						
	Oedicerotidae					1																							
	Phoxocephalidae	4				4	1	3		2		1	3		7				1	2	2				1	2	6	3	4
	Urothoidae	15	1			5	28	9	1																1	1	6	16	
	Amphipoda Unid.	1		4		9		6	5	3	8	4	21	7	4	23	4	5					3	7	4	9		8	
Cumacea																													
	Cumacea	1					4	3			1	1			3	1			1	1						2	1		
Decapoda																													
	Pagurus sp.		2	1			1		1	2	2		1			8	1	3	4	4					2			2	
	Callianassa filholi						1			1	2						1	1				1					1	1	
	Pyromaia tuberculata																												
	Ebalia laevis			1																1									
	Notomithrax minor																												
	Pilumnus novaezelandiae	1																											
	Liocarcinus corrugatus										1		1							1								2	
	Alpheus sp.												1	1		2													
	Philocheras australis																							1				1	
	Philocheras sp.																												
	Ogyrides sp														1														
Isopoda																													
	Anthuridea	1			2		1	1	1				2			1						3					1		
	Eurytana cookii			2	1					1	4		1	1		3						1	1		1	1		1	
	Munna neozelanica																												
	Exosphaeroma falcatum																												
Leptostraca																													
	Nebalia sp.													1															
	Mysidacea	1				1						1	3			1	2	1				1			1				
	Stomatopoda																												
	Tanaidacea			1				1								1							1						
Ostracoda																													
	Diasterope grisea							1	1																				
	Leuroleberis zealandica							1																					
	Cypridinodes						1	2															1						
	Scleroconcha sp.																												
	Rutiderma sp.					1																							
	Cymbicopia sp.				1																								
Bryozoa																													
	Bryozoa (discoid)		4						1	1	2						2			2		8	8	1		1			
	Bryozoa (encrusting)	1											1															1	
	Bryozoa (solid Stalked)	1	1		1			1	1	1	1	1	1		1		1	1		1		1	1	1		1		1	
Chordata																													
Ascidiacea																													
	Eugyra sp.					2	1		2																1				
	Aplidium sp.																												
Leptocardii																													
	Epigonichthys hectori		1	1	2	1		1		1	4	2	6	3	4	5	2	1	1				2	7		2		5	
Cnidaria																													
Hexacorallia																													
	Actiniaria														1														
Scleractinia										1							1												
	Sphenotrochus sp. (Alive)									1							1												

Taxa	Site A1S	31	32	33	34	36	37	39	40	41	42	44	45	46	48	49	50	51	52	53	54	55	56	58	59	61	62	63
	Monitoring Cell	01D	01F	01G	01G	01D	01C	01C	02B	02F	02F	02F	02D	02B	03B	03D	03F	03E	03D	03B	04B	04C	03F	04E	04B	04C	04D	04E
Hydrozoa																												
	Hydroida (thecate)	1																										
Echinodermata																												
Asteroidea																												
	<i>Astropecten polyacanthus</i>															1									1	2		
Echinoidea																												
	<i>Echinocardium cordatum</i>	1				1							1								1	1						
Holothuroidea																												
	<i>Chiridota sp.</i>																											1
	<i>Trochodota dendyi</i>			1		1														1				1				
Ophiuroidea																												
	Ophiuroidea	2											1		1		4			1		1						2
Mollusca																												
Polyplacophora																												
	<i>Ischnochiton maorianus</i>																											
	<i>Leptochiton inquinatus</i>							1					1			1												
Gastropoda																												
	<i>Zeacolpus vittatus</i>																2											
	<i>Cylichna thetidis</i>														1	1				2						1	1	
	<i>Philina sp</i>	2							1					2		2		1			2	1			1	1		
	<i>Sigapatella tenuis</i>		5	2	2				3	4	4	5	62	4	1	8	14	1		7	2	1	6	8	3	3		13
	<i>Amalda australis</i>		1						1																			
	<i>Cominella adspersa</i>																											
	<i>Cominella virgata</i>											1					1				1							
	Drilliidae																											
	<i>Neoguraleus sp.</i>																											
	<i>Xymene sp.</i>											1	6							1								1
	<i>Austrofusus glans</i>																			1			1	1				
	<i>Spectamen tryphenense</i>																		1									
	<i>Micrelenchus sp.</i>																1							1				
	<i>Pupa affinis</i>																											
	<i>Turbonilla sp.</i>																											
Bivalvia																												
	<i>Hiatella arctica</i>																				1							
	<i>Myadora striata</i>							2							1													
	<i>Hunkydora novozelandica</i>	1							1					1						1								
	<i>Pratulum pulchellum</i>			1				1					1											1			1	
	<i>Gari convexa</i>												1															
	<i>Gari sp. (juvenile)</i>	2					1			1	4	5	13		1	4	5	1	1	1		1	8	3	1		1	14
	<i>Gari stangeri</i>																											

Taxa	Site A1S	31	32	33	34	36	37	39	40	41	42	44	45	46	48	49	50	51	52	53	54	55	56	58	59	61	62	63
	Monitoring Cell	01D	01F	01G	01G	01D	01C	01C	02B	02F	02F	02F	02D	02B	03B	03D	03F	03E	03D	03B	04B	04C	03F	04E	04B	04C	04D	04E
	<i>Scalpomactra scalpellum</i>		1	2	3	5	1	2	7	2	4			4	4	8	3	3	2		2	1	3	5	3	3	3	
	<i>Zemysina sp.</i>	2					2	7	2						4					1	3	4	1		2	2	7	1
	<i>Dosinia subrosea</i>		1	2						3	1		2		2		1	1										1
	<i>Notocallista multistriata</i>							2																				
	<i>Tawera spissa</i>					1			3	2	11	17	54			5	61	4	2	4	4		37	7	2	3	1	59
Nemertea				1	1		1	1	1	2	1		3	2	2	1		1		1			1		1			2
Phoronida	<i>Phoronus sp.</i>	1																										
Platyhelminthes																												
Porifera																												
	<i>cf Tethyopsis sp.</i>									1			1															3
	Sponge (cream Encrusting)																											
Number of Individuals		78	26	31	35	64	86	117	116	47	85	55	254	50	89	118	134	57	29	74	41	75	110	92	61	109	68	152
Number of Species / taxa		33	16	21	21	24	22	43	31	28	33	24	46	21	32	39	31	30	18	31	14	32	36	34	25	28	24	41
Shannon-Wiener Diversity Index		3.10	2.56	2.93	2.97	2.64	2.20	3.38	2.41	3.18	3.22	2.64	2.79	2.81	3.08	3.18	2.36	3.21	2.73	2.98	2.27	2.96	2.79	3.23	2.88	2.94	2.69	2.64
Shannon-Wiener Evenness		0.89	0.92	0.96	0.98	0.83	0.71	0.90	0.70	0.95	0.92	0.83	0.73	0.92	0.89	0.87	0.69	0.95	0.94	0.87	0.86	0.85	0.78	0.92	0.90	0.88	0.85	0.71

Table E.4 Number per sample of Benthic Infauna Retained on 1 mm sieve from the grab samples collected outside the Recovery and in Control Areas. +6 months, 13 March 2024.

Taxa	Site name	A1S-35	A1S-38	A1S-43	A1S-47	A1S-57	A1S-60	A1S-64	A1S-65	CSA-1	CSA-2	CSA-3	CSB-1	CSB-2	CSB-3	CSC-1	CSC-2	CSC-3	CSD-1	CSD-2	CSD-3	CSE-1	CSE-2	CSE-3
	Monitoring Cell	01h	01a	02h	03a	04g	04a		CSE	CSB	CSA	CSA	CSB	CSB	CSB	CSC	CSC	CSC	CSD	CSD	CSD	CSE	CSE	CSE
Annelida																								
Polychaeta																								
Amphinomidae <i>Chloeia</i> sp.																								
Dorvilleidae		1					1								2					1			2	
Eunicidae																			1					
Lumbrineridae			1				1	1				1	1										1	
<i>Onuphis aucklandensis</i>		1		3		1																		
Glyceridae		1		1		1			1						5		2		4	3		2	2	
Goniadidae		1								1			2		1				1				1	
Hesionidae		1							1				1		1						1	5		
Nephtyidae <i>Aglaophamus</i> sp.						2			1			1	1	1	1						2		1	1
Phyllodocidae		2	1	2	1		2	1	1		2	1	3	1	2		2	1	3	4	2	2	2	
Polynoidae						1																1		
Sigalionidae				1	2		2		2	2	1	1		1	1		3	2	1	2	1			2
Syllidae		2			2			1	1			1		1	3	1	3		2		1	13	5	
Exogoninae					1																	2	2	
Sabellidae				1			1															1		
Sabellidae <i>Euchone pallida</i>		3	3			2	1		4	3	1	1	1	2	1		1	2	3	3	3	1		4
Serpulidae <i>Hydroides</i> sp.					1		1								40	1			3	8	1	3	1	
Spionidae <i>Aonides oxycephala</i>				1															2			1	1	
<i>Paraprionospio pinnata</i>						3															1			2
<i>Prionospio multicristata</i>							1																	
<i>Prionospio</i> sp.			2				3	1			1		3				2		2	1		3		1
<i>Spio</i> sp.				1						1			1		1								1	
<i>Spiophanes kroyeri</i>					3	1			2	3	3	2	1	1			2	2			1			11
Ampharetidae		3				4					9	1			2			17			13			27
Cirratulidae						2				1			2	1	4		1		2	2		2	3	1
Flabelligeridae		1													2							2		
Pectinariidae <i>Lagis australis</i>						1		1													1			4
Terebellidae		1		2	1		1		1					1	4	1	1		2	2	1	1	3	
Capitellidae <i>Barantolla lepte</i>		4	2		1			1	2			1		6					5	1		1		
<i>Heteromastus filiformis</i>							1																	
<i>Notomastus zeylanicus</i>									1										2					
<i>Phyllochaetopterus socialis</i>																								
Cossuridae <i>Cossura consimilis</i>																								
Magelonidae <i>Magelona dakini</i>		1	1	1		1	1		2			1		1			1		10	2		4	1	1
Maldanidae			53	1	28	3	4	8	7	39	17	26	3	25	2	7	16	12	4	6	7	3	2	5
Opheliidae <i>Armandia maculata</i>				1			1				1				2			1	4		3	1	1	10
Orbiniidae <i>Leitoscoloplos kerguelensis</i>																								
<i>Orbinia papillosa</i>		1			1	1		1	1						1		1			2		1		
Oweniidae <i>Myriochele</i> sp.			1			3																		
Oweniidae <i>Myriowenia</i> sp.																								
<i>Owenia petersenae</i>																								1
Paraonidae																								1
Scalibregmidae																								
Travisiidae <i>Travisia olens</i>		1							1						1				1					
Sipuncula																								
<i>Aspidosiphon</i> sp.																						3	2	
<i>Nephasoma</i> sp.																				1				

Taxa	Site name	A1S-35	A1S-38	A1S-43	A1S-47	A1S-57	A1S-60	A1S-64	A1S-65	CSA-1	CSA-2	CSA-3	CSB-1	CSB-2	CSB-3	CSC-1	CSC-2	CSC-3	CSD-1	CSD-2	CSD-3	CSE-1	CSE-2	CSE-3
	Monitoring Cell	01h	01a	02h	03a	04g	04a	CSE	CSB	CSA	CSA	CSA	CSB	CSB	CSB	CSC	CSC	CSC	CSD	CSD	CSD	CSE	CSE	CSE
Arthropoda																								
Amphipoda																								
	<i>Ampelisca sp.</i>																							
	Haustoriidae		4		1					7	1	4						3		1	1			1
	Lysianassidae			2				2		3					2									1
	Oedicerotidae										1	1		1		1								
	Phoxocephalidae	4	3	3				1		1	18	2		2		1		12	1	3	8	3		1
	Urothoidae	1				16		1	1	7	35		1			2	2	9	1		20			14
	Amphipoda Unid.	1	2	10	11	1	20	5	2			6	5	5	36	3	3	2	12	10	1	261	7	1
Cumacea																								
	Cumacea		1					2	3		1			2	1		1	2		1	9	1	1	6
Decapoda																								
	<i>Pagurus sp.</i>	2		2			4	1					1	1	1	1		2	2	1		6		1
	<i>Callianassa filholi</i>					2		3	1										1		1			1
	<i>Pyromaia tuberculata</i>			1																1	1			
	<i>Ebalia laevis</i>																							
	<i>Notomithrax minor</i>													1										
	<i>Pilumnus novaezelandiae</i>																	2						
	<i>Liocarcinus corrugatus</i>	1		1			1		1							1				1		1		
	<i>Alpheus sp.</i>													1									1	
	<i>Philocheras australis</i>						3															1	1	
	<i>Philocheras sp.</i>																					1	1	
	<i>Ogyrides sp</i>																							
Isopoda																								
	Anthuridea			1	1				2			1		1		2	1	2				1		
	<i>Eurylana cookii</i>		1	2				1	2			3		1		3				4		3	2	
	<i>Munna neozelanica</i>																					1		1
	<i>Exosphaeroma falcatum</i>		1								4													
Leptostraca																								
	<i>Nebalia sp.</i>																			2				
	Mysidacea	1		4	2						1							1	1					
	Stomatopoda															1								
	Tanaidacea						2													1		3		
Ostracoda																								
	<i>Diasterope grisea</i>		2								11							1			1			
	<i>Leuroleberis zealandica</i>																							
	Cypridinodes		1			1								1										
	<i>Scleroconcha sp.</i>																				2			
	<i>Rutiderma sp.</i>												1											
	<i>Cymbicopia sp.</i>							1											1					
Bryozoa																								
	Bryozoa (discoïd)		2		3		2		1	11	2	3	1	4	1	3	2	2	5	1			3	
	Bryozoa (encrusting)			1										1	1					1		1		
	Bryozoa (solid Stalked)	1		1							1				1				1	1	1	1	1	1
Chordata																								
Ascidacea																								
	<i>Eugyra sp.</i>					1				2														
	<i>Aplidium sp.</i>	1																						
Leptocardii																								
	<i>Epigonichthys hectori</i>	2	1	2	1		2			2			3	1	2		3		7	2	1	5	7	1
Cnidaria																								
Hexacorallia																								
	Actiniaria					1																		
Scleractinia																								
	<i>Sphenotrochus sp. (Alive)</i>																							

Taxa	Site name	A1S-35	A1S-38	A1S-43	A1S-47	A1S-57	A1S-60	A1S-64	A1S-65	CSA-1	CSA-2	CSA-3	CSB-1	CSB-2	CSB-3	CSC-1	CSC-2	CSC-3	CSD-1	CSD-2	CSD-3	CSE-1	CSE-2	CSE-3
	Monitoring Cell	01h	01a	02h	03a	04g	04a	CSE	CSB	CSA	CSA	CSA	CSB	CSB	CSB	CSC	CSC	CSC	CSD	CSD	CSD	CSE	CSE	CSE
Hydrozoa																								
	Hydroida (thecate)														1	1								
Echinodermata																								
Asteroidea																								
	<i>Astropecten polyacanthus</i>					1				1					1						2		1	
Echinoidea																								
	<i>Echinocardium cordatum</i>					1																		
Holothuroidea																								
	<i>Chiridota</i> sp.																							
	<i>Trochodota dendyi</i>														3				1	1		2	2	
Ophiuroidea																								
	Ophiuroidea	1					1								3				1	3		2	1	
Mollusca																								
Polyplacophora																								
	<i>Ischnochiton maorianus</i>														3									
	<i>Leptochiton inquinatus</i>						4								2				1					
Gastropoda																								
	<i>Zeacolpus vittatus</i>																			1			5	
	<i>Cylichna thetidis</i>							1									2							
	<i>Philine</i> sp.			1	1	1	2					1			1		3		3	1				2
	<i>Sigapatella tenuis</i>		3	2	5	1	8		3	1		3	5	2	41	2	5	2	4	8		2	2	
	<i>Amalda australis</i>					1																		
	<i>Cominella adspersa</i>			1									2											
	<i>Cominella virgata</i>																							
	Drilliidae														1									
	<i>Neoguraleus</i> sp.																							
	<i>Xymene</i> sp.			1											3	1			1					
	<i>Austrofusus glans</i>																							
	<i>Spectamen tryphenense</i>															1								
	<i>Micrelenchus</i> sp.																							
	<i>Pupa affinis</i>					3				1								1						
	<i>Turbonilla</i> sp.					2																		
Bivalvia																								
	<i>Hiatella arctica</i>														4									
	<i>Myadara striata</i>								1		1		1				1			1		1	2	1
	<i>Hunkydora novozelandica</i>								1				1		1						1			
	<i>Pratulum pulchellum</i>	1		1		1							1									1	1	
	<i>Gari convexa</i>				2										1							1		
	<i>Gari</i> sp. (juvenile)				4		3	1	2	5	2		1	1	16	2	3		1	7	2	9	14	2
	<i>Gari stangeri</i>	1																						
	<i>Leptomya retiaria</i>				1										2									
	<i>Pleuromeris</i> sp.			1						1					2									
	<i>Pleuromeris zelandica</i>		1																	1		1		
	<i>Purpurocardia purpurata</i>																							
	<i>Scintillona zelandica</i>		1																					
	<i>Arthritica bifurca</i>												2											
	<i>Mytilitella vivens vivens</i>				1	3			2				10											4
	<i>Limaria orientalis</i>																							
	<i>Limatula maoria</i>	1		2				1						1								1	1	
	<i>Corbula zelandica</i>	2		7					1				2		1				2	1				
	<i>Nucula nitidula</i>			4	1	5	5	5		2	3	6	2	2	17	1	5	3	7	4	9	3	1	3
	<i>Atrina zelandica</i> (juvenile)																					1		
	Anomiidae																							
	<i>Chlamys</i> sp.														1									

Taxa	Site name	A1S-35	A1S-38	A1S-43	A1S-47	A1S-57	A1S-60	A1S-64	A1S-65	CSA-1	CSA-2	CSA-3	CSB-1	CSB-2	CSB-3	CSC-1	CSC-2	CSC-3	CSD-1	CSD-2	CSD-3	CSE-1	CSE-2	CSE-3
	Monitoring Cell	01h	01a	02h	03a	04g	04a	CSE	CSB	CSA	CSA	CSA	CSB	CSB	CSB	CSC	CSC	CSC	CSD	CSD	CSD	CSE	CSE	CSE
	<i>Scalpomactra scalpellum</i>		1	3	2	5		5		1	2	1	1	2	1	1	1		1	2	1		2	
	<i>Zemysina sp.</i>				1	11					6	1	3		1			4			4			9
	<i>Dosinia subrosea</i>													1					2	2				
	<i>Notocallista multistriata</i>																							
	<i>Tawera spissa</i>	1	1	4	1	2	2	3		2	11	3		2	6				2	2		4	25	
Nemertea		1		1			2					1	1	1	3	1	2		2	4		4	4	
Phoronida	<i>Phoronus sp.</i>																							3
Platyhelminthes							2								1					1		1	1	
Porifera																								
	<i>cf Tethyopsis sp.</i>		1	1									1			1			1			1		
	Sponge (cream Encrusting)			1																				
Number of Individuals		46	90	75	79	85	84	48	51	94	138	73	63	65	246	39	69	85	110	109	104	373	117	124
Number of Species / taxa		31	24	37	26	33	30	23	29	19	27	25	30	28	54	23	26	22	41	43	32	47	40	32
Shannon-Wiener Diversity Index		3.29	1.91	3.33	2.51	3.06	2.96	2.83	3.18	2.19	2.57	2.54	3.13	2.60	3.05	2.92	2.91	2.64	3.40	3.47	2.89	1.67	3.13	2.86
Shannon-Wiener Evenness		0.96	0.60	0.92	0.77	0.88	0.87	0.90	0.95	0.74	0.78	0.79	0.92	0.78	0.76	0.93	0.89	0.85	0.91	0.92	0.83	0.43	0.85	0.83

Table E.5 Number per sample of Benthic Infauna Retained on 1 mm sieve from the grab samples collected within the Recovery Area. +12 months, 24 September 2024.

Taxa	Site A1S	31	32	33	34	36	37	39	40	41	42	44	45	46	48	49	50	51	52	53	54	55	56	58	59	61	62	63
	Monitoring Cell	01D	01F	01G	01G	01D	01C	01C	02B	02F	02F	02F	02D	02B	03B	03D	03F	03E	03D	03B	04B	04C	03F	04E	04B	04C	04D	04E
Annelida																												
Polychaeta																												
Amphinomidae																												
Dorvilleidae				1																								
Lumbrineridae																	1						1	1	1			
Onuphidae <i>Nothria</i> sp.		1						1				1			1													
Glyceridae				1		1		1	1			2	2			4					1					3	1	2
Goniadidae																					1							
Hesionidae		1		1		1	1	3	2					1						1	2				1	2		
Nephtyidae <i>Aglaophamus</i> sp.		1	1		1		3	4			1	2	1		3				1	2		1			3			
Nereidae (juvenile)															1													
Nereididae <i>Nereis cricognatha</i>		1																										
Phyllodocidae		3	1	2	5	4	3	2	7	3		3	4		2	1	1	1	2	2	4	4	3	3	6	2	1	
Polynoidae						1				1	1	1	4	4	2					3	2	1						
Sigalionidae		2	4				1	2	2	1	1	1	1	1	3	2		2	2					1	1			
Syllidae		1	1		7	2	1			1		1	1			3	2				2	1	1	1	1			
Exogoninae										2																		
Sabellidae												2																
Sabellidae <i>Euchone pallida</i>		1	2	1	3	1	2	1	7	4	4	2			1	1	3		1				1	1	1		2	3
Serpulidae <i>Hydroides</i> sp.				1	1		1		1				13			1	1					1			1		2	24
<i>Serpula</i> sp.						1																						
<i>Paraprionospio pinnata</i>		25	1	1	1	11	27	12	2	2		1			19		2			2	20	5	1		11	6	1	
<i>Polydora</i> sp.				1		2						1		86			2					26						
<i>Prionospio aucklandica</i>															2										7	11		
<i>Prionospio multicristata</i>		3	6	5	12	2	2		6	7	15	13	2		3	8	19	2	2		2	12	12	21	2	6	21	4
<i>Prionospio</i> sp.									2		1	3	4		3	2	1	1		1	3		1		6	4		
<i>Pygospio</i> sp.									1						1													
<i>Spio</i> sp.		3	7	9	16	2	2	2	4	6	7	4	4			8	16	2		1	1	4	4	3	5	5		1
<i>Spiophanes kroyeri</i>		208	287	50	84	113	212	131	420	94	23	246	5	21	189	113	43	388	260	121	468	271	22	87	358	557	197	17
Ampharetidae		4		1		1	4	3		2	1		1		4		3	1			3				5			
Cirratulidae			1		1			2		1		1	3	1		3								2	1	1	3	
Flabelligeridae																												
Pectinariidae <i>Lagis australis</i>																												
Terebellidae		5	9	24	15	2	12	12	20	10	13	12	38	7	8	47	38	15	8	7	6	7	12	15	5	12	52	36
Capitellidae <i>Barantolla lepte</i>					3					1	3		3			2	5	1	1				4			2	3	1
<i>Notomastus zeylanicus</i>																												
Chaetopteridae <i>Chaetopterus</i> sp.																	1											1
<i>Phyllochaetopterus socialis</i>									1																			
Magelonidae <i>Magelona dakini</i>			1	1	1						1	2		1		3	2	2	2			1						
Maldanidae		16	16	5	8	53	8	24	62	6	4	4	8	3	43	15	6	8	12	7	31	33	2		40	41	27	5
Opheliidae <i>Armandia maculata</i>		2		1	2		2	1			2	2	7			2	2						4	3	2		6	3
<i>Orbinia papillosa</i>										1	3					1	1		1				1				1	1
<i>Owenia petersenae</i>																												
Paraonidae													1															
Sipuncula																												
<i>Themiste</i> sp.												1																
Copepoda					1																							
Arthropoda																												
Amphipoda																												
Haustoriidae		1									1				2									1				

Taxa	Site A1S	31	32	33	34	36	37	39	40	41	42	44	45	46	48	49	50	51	52	53	54	55	56	58	59	61	62	63
	Monitoring Cell	01D	01F	01G	01G	01D	01C	01C	02B	02F	02F	02F	02D	02B	03B	03D	03F	03E	03D	03B	04B	04C	03F	04E	04B	04C	04D	04E
	Lysianassidae	1	1			2		1				1			1		6	2		6	1			2	2		1	
	Oedicerotidae														1													
	Phoxocephalidae	7	6	5	6	1	1	4	2	3			1		3	1	2			2	8		5	2	16	7		2
	Urothoidae	22	14	1	5	3	15	14		3		2			26		1	3	10	14		3	4	4	26	15		
	Amphipoda Unid.	76	18	97	72	48	6	28	47	90	32	48	71	22	12	48	200	52	13	56	51	19	51	59	21	49	74	19
Cumacea																												
	Cumacea	40		1	4	2		3	3	4	3	5	1	2	16	1	3	1	2	22	2	8	2		8	1	1	2
Decapoda																												
	<i>Pagurus sp.</i>	2	2	3	3	1			1	1	4	1	10			1	2	2		2		1	1	11	2		5	2
	<i>Petrolisthes elongatus</i>																											
	<i>Callianassa filholi</i>	3		4	2	1						1	1	1			1	2	1		1	1	2			4		
	<i>Nectocarcinus benetti</i>																1	1	1						1			
	<i>Halicarcinus sp.</i>					1																						
	<i>Halicarcinus tongi</i>												1															1
	<i>Achaeus curvirostris</i>												1															
	<i>Pyromaia tuberculata</i>			1								1	1				2				1		1					
	<i>Ebalia laevis</i>				1						1																1	1
	<i>Notomithrax minor</i>					2			1				1													1		
	<i>Pilumnus novaezelandiae</i>																											
	<i>Liocarcinus corrugatus</i>						1	1					1									1			1			
	<i>Alpheus sp.</i>												1															
	<i>Philocheras australis</i>		1			2			1				2					1		1					3	1	1	
	<i>Ogyrides sp</i>																								1			
	<i>Palaemon affinis</i>											3																
	<i>Upogebia sp.</i>								2							1		1				2						
Isopoda																												
	Anthuridea		1						3			1		2	1	2	1		1		2				1		2	
	<i>Eurylana cookii</i>		1	1	5					1	1	3	1	2	1	4	3	3	2	1			1	1				1
	<i>Munna neozelandica</i>																											
	<i>Cassidina typa</i>																											
	<i>Exosphaeroma falcatum</i>																											
Leptostraca																												
	<i>Nebalia sp.</i>										1																	
	Mysidacea	5	2	1		2		2	2	1	2	2								1				2	5		1	1
	Tanaidacea															2	1							1				
Ostracoda																												
	<i>Diasterope grisea</i>						1								1											1		
	<i>Leuroleberis zealandica</i>														1													
	Cypridinodes		1																			1						
	<i>Scleroconcha sp.</i>						1																					
Thecostraca																												
	<i>Balanus decorus</i>												9															
Brachiopoda																												
	<i>Calloria inconspicua</i>																											
Bryozoa																												
	Bryozoa (bushy)						1						1															
	Bryozoa (discoid)							1		1											2			1			1	1
	Bryozoa (encrusting)												1															
	Bryozoa (solid Stalked)			2	2																							
	<i>Watersipora spp.</i>												1															
Chordata																												
Ascidacea																												
	<i>Eugyra sp.</i>	11	2	2	5	5	2	1	3	1	9	3		3	18	7	3		7	4	3	9	1	4	1	3	3	

Job Number: 66818 66 Date of Issue: 25 November 2025

Taxa	Site A1S	31	32	33	34	36	37	39	40	41	42	44	45	46	48	49	50	51	52	53	54	55	56	58	59	61	62	63
	Monitoring Cell	01D	01F	01G	01G	01D	01C	01C	02B	02F	02F	02F	02D	02B	03B	03D	03F	03E	03D	03B	04B	04C	03F	04E	04B	04C	04D	04E
<i>Pratulum pulchellum</i>			1	5	3					4	4	4	4	1			2					1	5				5	2
<i>Gari convexa</i>							1				1		2			2	4					1						3
<i>Gari sp. (juvenile)</i>				1	3								1				2											
<i>Pleuromeris zelandica</i>											1		3															
<i>Purpurocardia purpurata</i>				1					1																			
<i>Myllitella vivens vivens</i>	1	1													1						1					1		
<i>Limaria orientalis</i>					2						1		1															
<i>Limatula maoria</i>																			1									
<i>Corbula zelandica</i>		1	6	2							3	3	1										4	1				
<i>Nucula nitidula</i>	1			1	1	2	2	3	1	1			4	1		1	1		1			3		3	1	1	2	3
<i>Chlamys sp.</i>													1			1												
<i>Oxyperas elongata</i>																	1											
<i>Scalpomactra scalpellum</i>			2				1		1	2	1				2		1									1	2	
<i>Zemysina sp.</i>							3	2				1			5				1		1				1	1		1
<i>Dosinia subrosea</i>		1		2					1		1				1		1	1				1						1
<i>Tawera spissa</i>					1		1			8			11	1	1	1	6			1			2	1			2	2
Nemertea		3		1	2	3	1	1	6	1	1	3	4	1	2	2	3	1	1		7	6	6	2		5	3	5
Phoronida	<i>Phoronus sp.</i>		2						4						8		2				1	1			14	11		
Platyhelminthes													2															
Porifera																												
<i>cf Tethyopsis sp.</i>				1					1										2					1				1
Sponge (cream Encrusting)				1																								
Sponge (finger)													1															
Number of Individuals		458	396	243	289	275	318	270	621	258	163	392	284	164	390	294	404	497	335	258	625	402	184	238	565	756	430	174
Number of Species / taxa		34	32	36	40	33	29	32	34	32	40	42	57	22	36	35	47	27	24	22	26	28	31	31	36	30	31	38
Shannon-Wiener Diversity Index		2.05	1.37	2.23	2.55	2.01	1.53	2.10	1.42	1.98	2.97	1.73	3.07	1.78	2.14	2.21	2.18	0.99	1.12	1.81	1.14	1.49	2.62	2.15	1.72	1.26	1.93	2.85
Shannon-Wiener Evenness		0.58	0.40	0.62	0.69	0.58	0.45	0.61	0.40	0.57	0.80	0.46	0.76	0.57	0.60	0.62	0.57	0.30	0.35	0.59	0.35	0.45	0.76	0.63	0.48	0.37	0.56	0.78

Table E.6 Number per sample of Benthic Infauna Retained on 1 mm sieve from the grab samples collected outside the Recovery and in Control Areas. +12 months, 24 September 2024.

Taxa	Site name Monitoring Cell	A1S-35 01h	A1S-38 01a	A1S-43 02h	A1S-47 03a	A1S-57 04g	A1S-60 04a	A1S-64 CSE	A1S-65 CSB	CSA-1 CSA	CSA-2 CSA	CSA-3 CSA	CSB-1 CSB	CSB-2 CSB	CSB-3 CSB	CSC-1 CSC	CSC-2 CSC	CSC-3 CSC	CSD-1 CSD	CSD-2 CSD	CSD-3 CSD	CSE-1 CSE	CSE-2 CSE	CSE-3 CSE
Annelida																								
Polychaeta																								
Amphinomidae										1														
Dorvilleidae		2													3									
Lumbrineridae			2	1			2		1			1		1		2	2							
Onuphidae	<i>Nothria sp.</i>			3													2							
Glyceridae		5		1		1		1		1			2			1	2	2			1		2	
Goniadidae			1									1			1				1					3
Hesionidae						1		1	1		1	1						1			1			
Nephtyidae	<i>Aglaophamus sp.</i>	1				6	1	2			3	1		1		1	2	3		1	2		1	10
Nereidae	<i>Nereis (juvenile)</i>	1												1				1						
Nereididae	<i>Nereis cricognatha</i>																	1						
Phyllodocidae		1		5	1		1	3	3	6		4		1	5	2	5	3	4	1	2	1		1
Polynoidae				1	1		1	2	3	1	1		1											1
Sigalionidae			3	1	7	3	2	2			1	1	3	1			1	1		1		1	1	
Syllidae			1	1		2	2		1	5	1			1	2	1	1				1	1		1
	Exogoninae									1			1					1		1			2	
Sabellidae						1																		
Sabellidae	<i>Euchone pallida</i>		4	1	1				1	1						4	6					2		1
Serpulidae	<i>Hydroides sp.</i>			1	1	6	2				1			3	100	15	11	3	9	2		1		
	<i>Serpula sp.</i>																							
	<i>Paraprionospio pinnata</i>		2	1		11		10	3	3	6	6		1		4	2	22			13			16
	<i>Polydora sp.</i>	139			7	1											1		21			4		
	<i>Prionospio aucklandica</i>					1																		
	<i>Prionospio multicristata</i>	4	1	29	1	2	2	6	5	6	2	2	1	5		9			1	8		10		
	<i>Prionospio sp.</i>			4		1		3										6						
	<i>Pygospio sp.</i>		1																		1			1
	<i>Spio sp.</i>	7		5			7	1			1	1		1		10	4		8	8	2	13		
	<i>Spiophanes kroyeri</i>	1	132	168	60	312	54	125	281	333	233	434	74	293	3	135	75	603	6	10	248	9	10	480
Ampharetidae				1		5				1								3	1		4			24
Cirratulidae		2		3		1	2								4		8			3		4		1
Flabelligeridae		2													1			1						
Pectinariidae	<i>Lagis australis</i>			1																				
Terebellidae		7	2	14	23	5	10	10	21	18		6	15	3	3	26	52	4	28	25	2	11	3	6
Capitellidae	<i>Barantolla lepte</i>	7		3			2	1	1				1		4	2	2					2		
	<i>Notomastus zeylanicus</i>	1													1									
Chaetopteridae	<i>Chaetopterus sp.</i>														1									
	<i>Phyllochaetopterus socialis</i>	1													3									
Magelonidae	<i>Magelona dakini</i>		1	1	3		3		7			1	1			3	5			2		1		
Maldanidae		8	44	7	44	4	57	10	49	32	24	45	10	15	2	32	28	27	7	4	7	3	2	7
Opheliidae	<i>Armandia maculata</i>	1		1		1	1	5				1			1	1	1	1	3	1	1	1		6
	<i>Orbinia papillosa</i>			2					1			1			1		1				2	1		3
	<i>Owenia petersenae</i>														1							1	1	
Paraonidae			2									1							1					
Sipuncula																								
	<i>Themiste sp.</i>														1									
	Copepoda																							
Arthropoda																								
Amphipoda																								
	Haustoriidae									3											1			

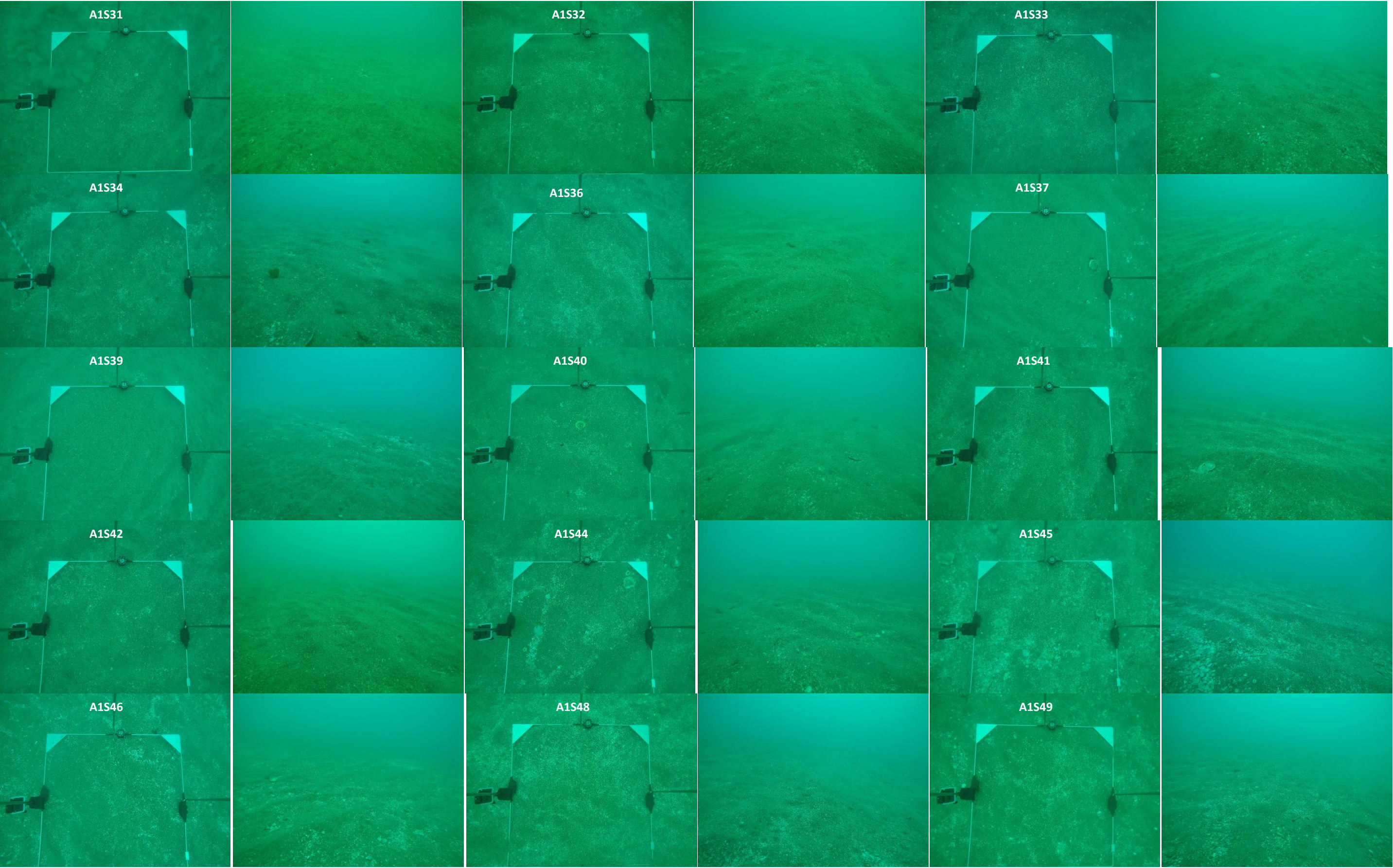
Taxa	Site name	A1S-35	A1S-38	A1S-43	A1S-47	A1S-57	A1S-60	A1S-64	A1S-65	CSA-1	CSA-2	CSA-3	CSB-1	CSB-2	CSB-3	CSC-1	CSC-2	CSC-3	CSD-1	CSD-2	CSD-3	CSE-1	CSE-2	CSE-3
	Monitoring Cell	01h	01a	02h	03a	04g	04a	CSE	CSB	CSA	CSA	CSA	CSB	CSB	CSB	CSC	CSC	CSC	CSD	CSD	CSD	CSE	CSE	CSE
	Lysianassidae		3				5	9	1	7	8	3		3	1	1	1	20		2	5	1		6
	Oedicerotidae		3		1	1					1													
	Phoxocephalidae		9	3	2	1		4	1	13	15	6	2	2	1	4	3	16		1	11	2		9
	Urothoidae		16	1	4	12	5	21	10	22	41	8	1	4		4		13			29	1		19
	Amphipoda Unid.	41	55	85	23	20	35	63	29	62	66	27	31	15	41	55	66	40	110	38	37	72	28	26
Cumacea																								
	Cumacea		4	3	3	11	2	5	8	10	8	11	6			1	4	2			6			21
Decapoda																								
	<i>Pagurus sp.</i>	2	1	4	1		1	1		1	2	4	1		5	1	2		2			1	1	2
	<i>Petrolisthes elongatus</i>														4									
	<i>Callianassa filholi</i>	1		3		1				1	1				1		1	1	1	1	6	1		4
	<i>Nectocarcinus benetti</i>																							
	<i>Halicarcinus sp.</i>										1													
	<i>Halicarcinus tongi</i>															1								
	<i>Achaeus curvirostris</i>																							
	<i>Pyromaia tuberculata</i>	1				2										1					1			
	<i>Ebalia laevis</i>																							
	<i>Notomithrax minor</i>			1													1		3			1		
	<i>Pilumnus novaezealandiae</i>														1									
	<i>Liocarcinus corrugatus</i>									1					1		2	1						
	<i>Alpheus sp.</i>	1																						
	<i>Philocheras australis</i>	2			1	2		1	1	1		2		1		4	2		1	1	1	1	1	2
	<i>Ogyrides sp</i>																							1
	<i>Palaemon affinis</i>									1					4		1		1					
	<i>Upogebia sp.</i>	4											2			1	1		1	1				
Isopoda																								
	Anthuridea					1		2	4	1		1									1			3
	<i>Eurylana cookii</i>	4	1	6	4		6	2	2	1	1			1	1		5	1	2	3		1	2	
	<i>Munna neozelandica</i>														2									
	<i>Cassidina typa</i>					1																		
	<i>Exosphaeroma falcatum</i>																						1	
Leptostraca																								
	<i>Nebalia sp.</i>																							
	Mysidacea		3		1	1	1	3	1		1	3	2	3		3		1	2					1
	Tanaidacea																					1		
Ostracoda																								
	<i>Diasterope grisea</i>		1							1	2	2												1
	<i>Leuroleberis zealandica</i>																3							
	Cypridinodes																							
	<i>Scleroconcha sp.</i>																							
Thecostraca																								
	<i>Balanus decorus</i>																							
Brachiopoda																								
	<i>Calloria inconspicua</i>														1									
Bryozoa																								
	Bryozoa (bushy)																1							
	Bryozoa (discoid)		4		2	1	6		12	2	2	11	5	8	1	2	18	2	2					
	Bryozoa (encrusting)								1						1	1						1		
	Bryozoa (solid Stalked)																							
	<i>Watersipora spp.</i>														1									
Chordata																								
Ascidacea																								
	<i>Eugyra sp.</i>		2	9	3	3	3	1	7	5	3	5	5	1		13	3	4	2		9			
	<i>Pyura sp.</i>																							

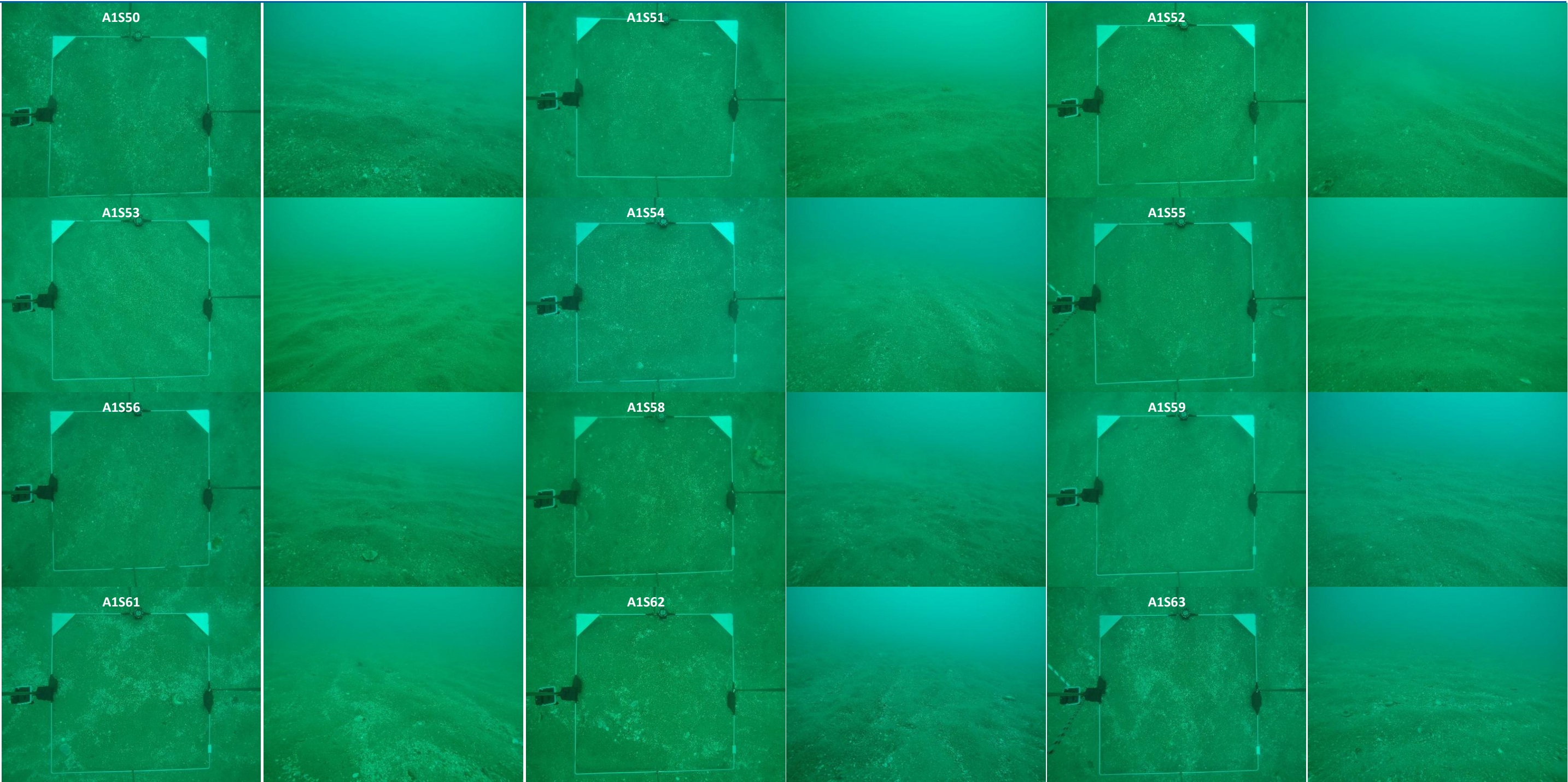
Taxa	Site name	A1S-35	A1S-38	A1S-43	A1S-47	A1S-57	A1S-60	A1S-64	A1S-65	CSA-1	CSA-2	CSA-3	CSB-1	CSB-2	CSB-3	CSC-1	CSC-2	CSC-3	CSD-1	CSD-2	CSD-3	CSE-1	CSE-2	CSE-3
	Monitoring Cell	01h	01a	02h	03a	04g	04a	CSE	CSB	CSA	CSA	CSA	CSB	CSB	CSB	CSC	CSC	CSC	CSD	CSD	CSD	CSE	CSE	CSE
	<i>Aplidium</i> sp.																							
	<i>Microcosmus australis</i>														2									
Leptocardii																								
	<i>Epigonichthys hectori</i>	4		1																2				
Teleostei																								
	<i>Limnichthys polyactis</i>																							
Cnidaria																								
Hexacorallia																								
	Actiniaria <i>Edwardsia</i> sp.						1									1								
	Ceriantharia <i>Arachnanthus</i> sp.																							
	Scleractinia <i>Sphenotrochus</i> sp. (Alive)																		1					
Hydrozoa																								
	Hydroida (athecate)			1											1									
	Hydroida (thecate)								1				1		1		1		1					
Echinodermata																								
Asteroidea																								
	<i>Astropecten polyacanthus</i>					1			1		1			1				1			1			1
Echinoidea																								
	<i>Echinocardium cordatum</i>								1															
Holothuroidea																								
	<i>Trochodota dendyi</i>																							
	Holothuroidea (unid. juvenile)																		1					
Ophiuroidea																								
	Ophiuroidea	3													2		1		1	5	1			
	Hemichordata																							
Mollusca																								
Polyplacophora																								
	<i>Ischnochiton maorianus</i>														5					1				
	<i>Leptochiton inquinatus</i>																			1				
Gastropoda																								
	<i>Zeacolpus vittatus</i>					1		1																
	<i>Cylichna thetidis</i>	1									1		1	1					1					
	<i>Sigapatella tenuis</i>		1	3	2		2				1	1	3	1	18	1	13		9	14		7	1	1
	<i>Monoplex parthenopeus</i>																							
	<i>Tonna</i> sp. (juvenile)				2	1				2	2				1		3				1			2
	<i>Xenophora neozelanica</i>			1																				
	<i>Amalda australis</i>								1							1		1						
	<i>Cominella adspersa</i>						1																	
	<i>Cominella virgata</i>																							
	<i>Splendrillia aoteana</i>																							
	Marginellidae												1					1						
	<i>Xymene</i> sp.																	1						
	<i>Austrofusus glans</i>								1															
	<i>Pleurobranchaea maculata</i>							1	1	1					1	1					1			
	<i>Spectamen tryphenense</i>																							
	<i>Pupa affinis</i>									1														1
	Gastropoda (unid. juvenile.)	1																						
Bivalvia																								
	<i>Hiatella arctica</i>					1									2	3	1							
	<i>Myadora antipodum</i>																							
	<i>Myadora striata</i>																1				1			
	Thraciidae																							1
	<i>Glycymeris modesta</i>				1																			
	<i>Pratulum pulchellum</i>	6			1		1	1							1	2	4		2	2		4		2

Taxa	Site name	A1S-35	A1S-38	A1S-43	A1S-47	A1S-57	A1S-60	A1S-64	A1S-65	CSA-1	CSA-2	CSA-3	CSB-1	CSB-2	CSB-3	CSC-1	CSC-2	CSC-3	CSD-1	CSD-2	CSD-3	CSE-1	CSE-2	CSE-3
	Monitoring Cell	01h	01a	02h	03a	04g	04a	CSE	CSB	CSA	CSA	CSA	CSB	CSB	CSB	CSC	CSC	CSC	CSD	CSD	CSD	CSE	CSE	CSE
	<i>Gari convexa</i>	3		1											1							5		
	<i>Gari sp. (juvenile)</i>									2			1		1	1	1							
	<i>Pleuromeris zelandica</i>																							
	<i>Purpurocardia purpurata</i>														2									
	<i>Myllitella vivens vivens</i>										1	1	1	1			1							1
	<i>Limaria orientalis</i>														1									
	<i>Limatula maoria</i>																							
	<i>Corbula zelandica</i>	3		2											1				1					
	<i>Nucula nitidula</i>	1	1	3	1	6	3	2	1	3		1		4	5	2	4	2	7	2	2	5		2
	<i>Chlamys sp.</i>																							
	<i>Oxyperas elongata</i>																							
	<i>Scalpomactra scalpellum</i>					1	2							1		1								1
	<i>Zemysina sp.</i>		1			3		1		1		1								2				2
	<i>Dosinia subrosea</i>		1	2					1							2	1							
	<i>Tawera spissa</i>		3				4	2	2	2	3	3	2	6	3	2	2	1	1	3		7	1	
Nemertea		4	1	7	3	2	1	1	7	1	2	2	1	1	2	4	4	2	2	4		5	2	
Phoronida	<i>Phoronus sp.</i>		1							6		2						1						1
Platyhelminthes																						1		1
Porifera																								
	<i>cf Tethyopsis sp.</i>					1											1			1				
	Sponge (cream Encrusting)	1													1	1								
	Sponge (finger)														1									
Number of Individuals		273	307	391	204	436	230	303	472	559	438	602	174	381	256	364	364	792	244	151	401	179	64	672
Number of Species / taxa		35	32	41	28	38	35	33	36	37	33	36	26	30	54	44	51	35	33	32	30	34	18	39
Shannon-Wiener Diversity Index		2.10	2.03	2.16	2.31	1.48	2.51	2.18	1.76	1.76	1.79	1.36	2.12	1.20	2.63	2.46	2.83	1.19	2.25	2.70	1.66	2.50	2.09	1.45
Shannon-Wiener Evenness		0.59	0.59	0.58	0.69	0.41	0.71	0.62	0.49	0.49	0.51	0.38	0.65	0.35	0.66	0.65	0.72	0.33	0.64	0.78	0.49	0.71	0.72	0.40

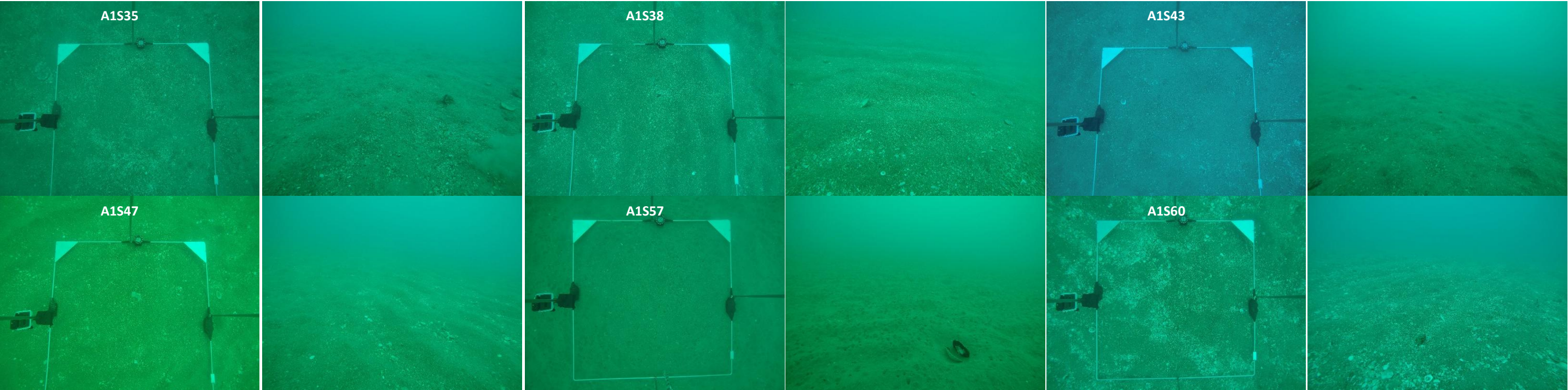
Appendix F Drop Camera Images

Recovery Area





Outside



Control Area



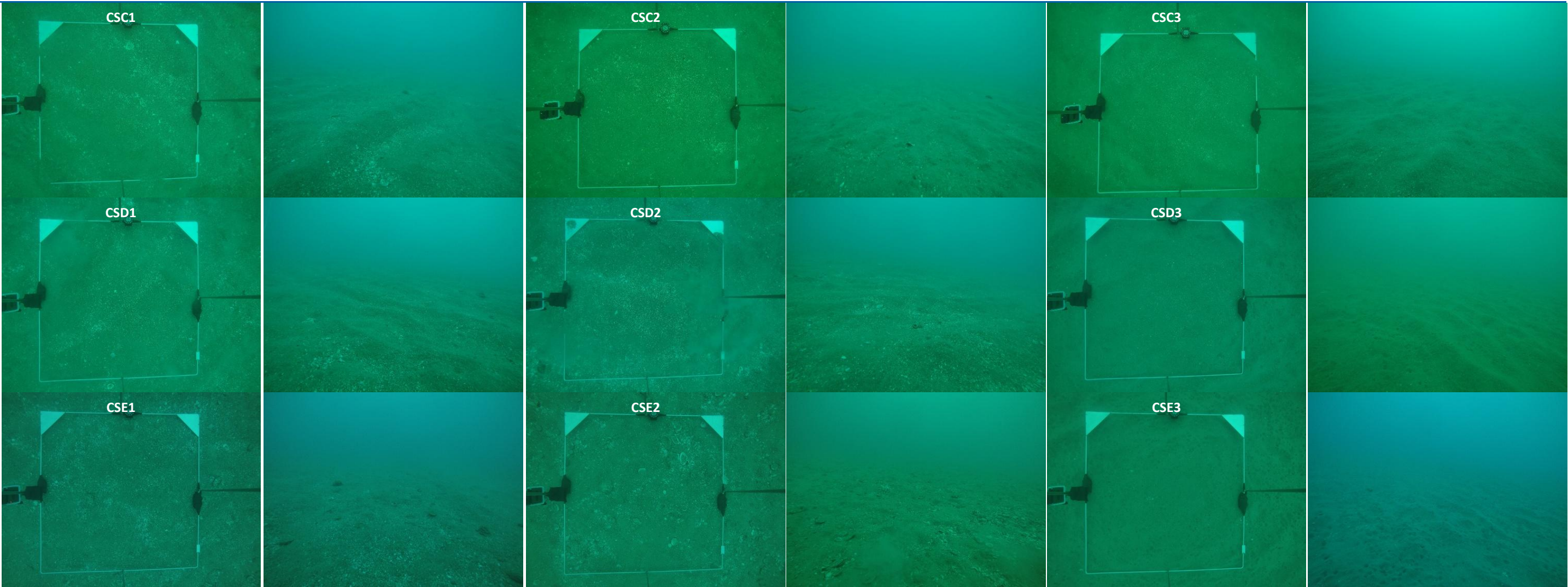
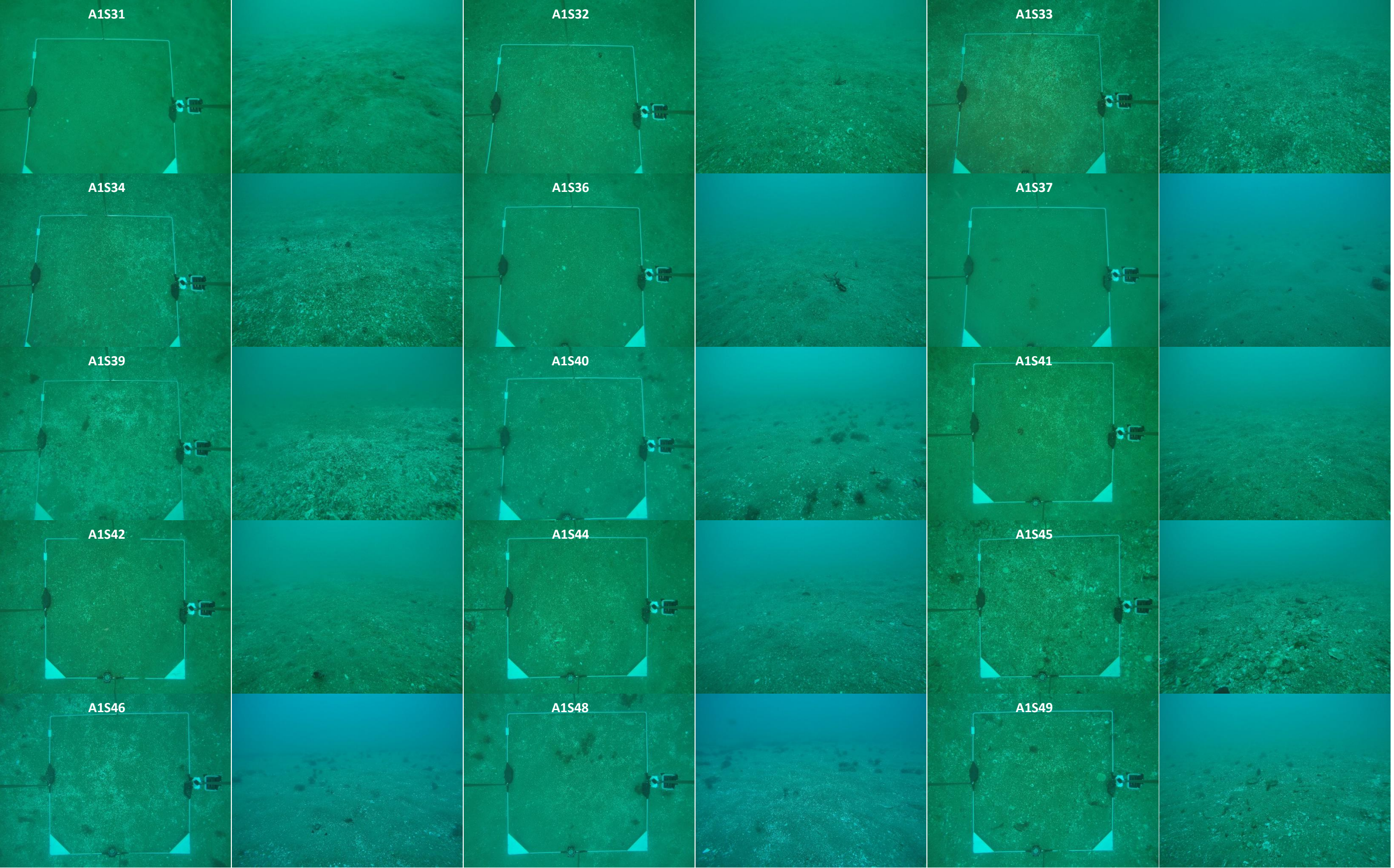
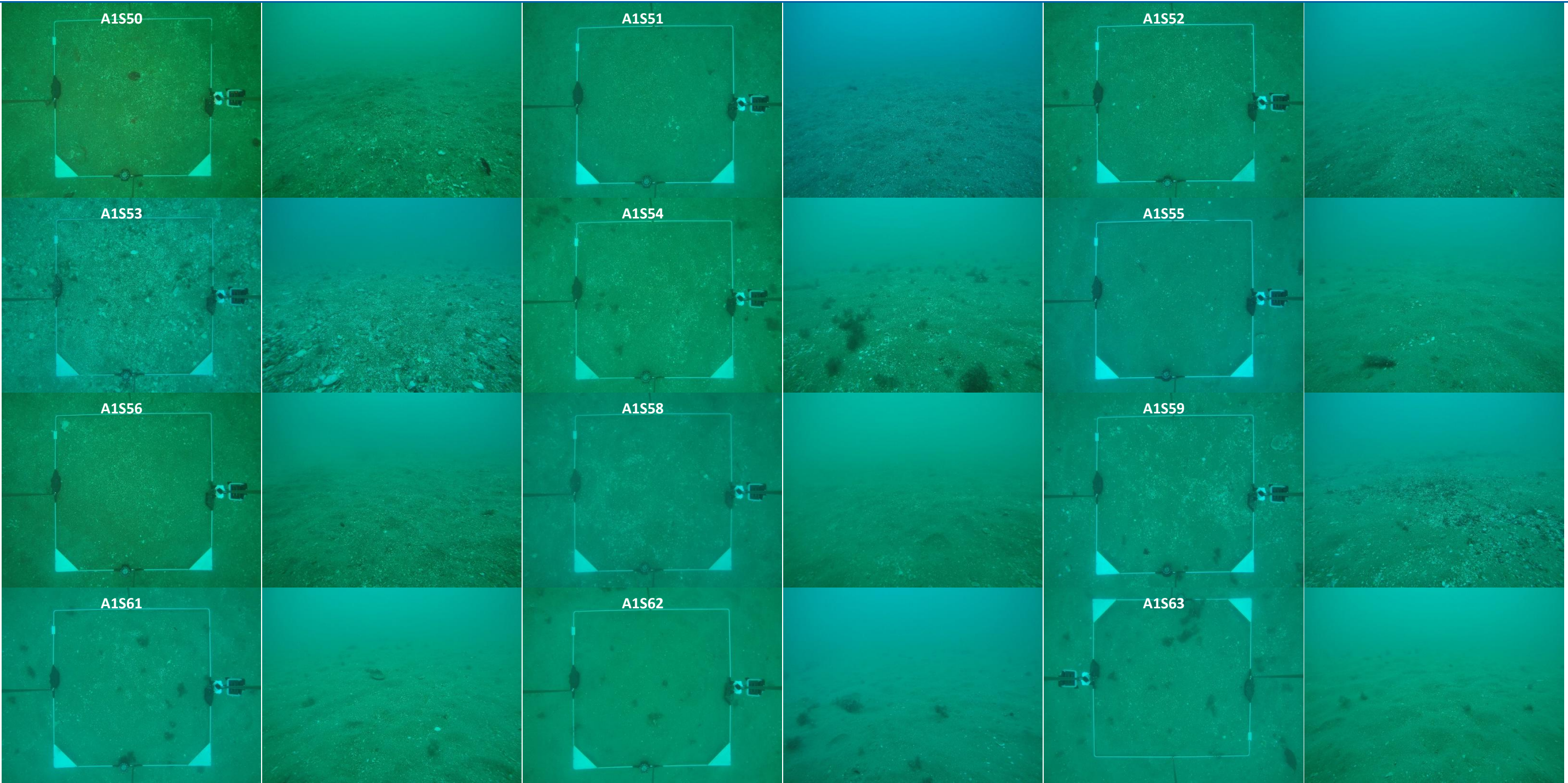


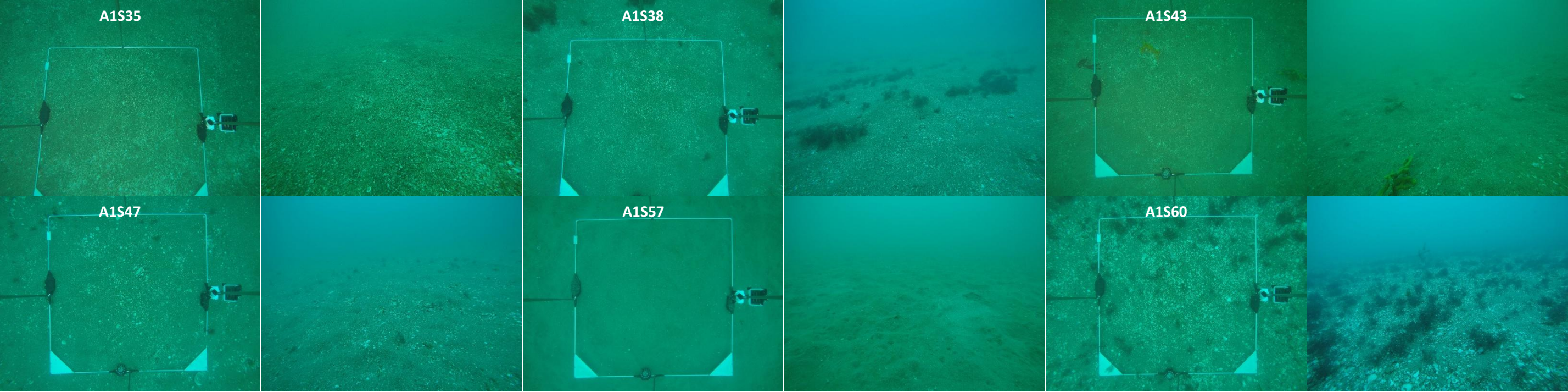
Figure F.1 Drop Camera images from Recovery, outside and Control cells, 1 month 19 September 2023

Recovery Area

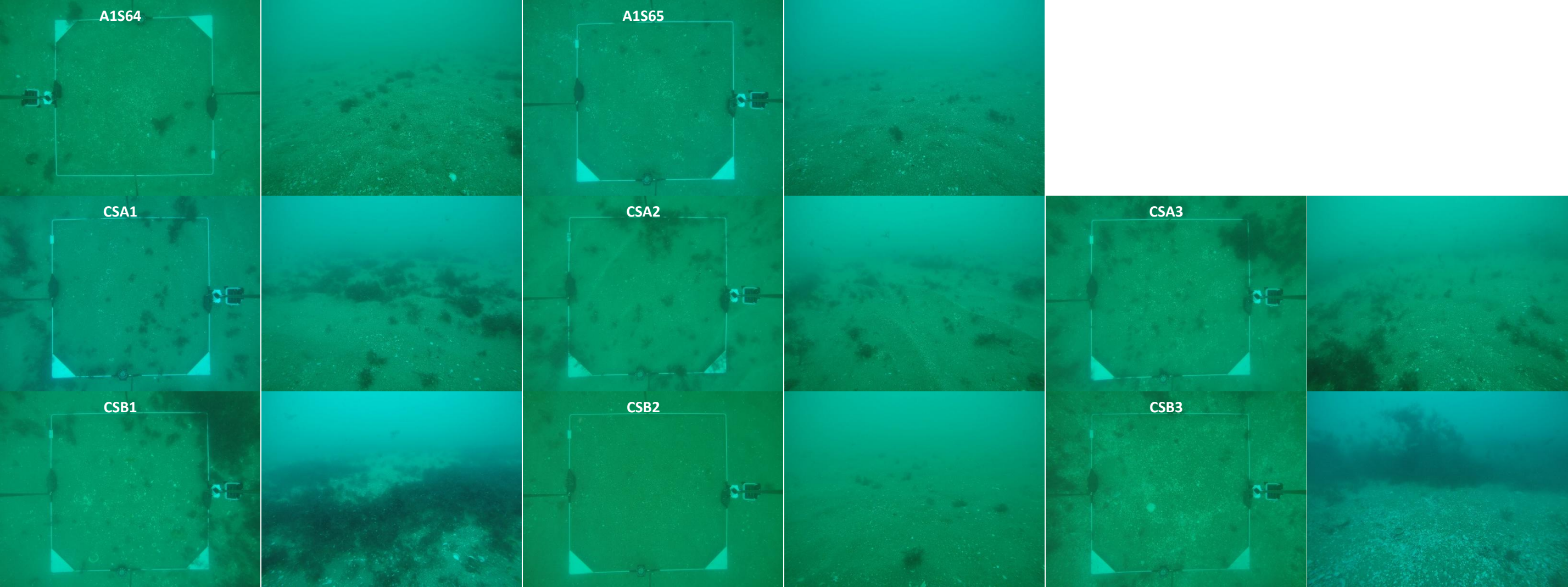




Outside



Control Area



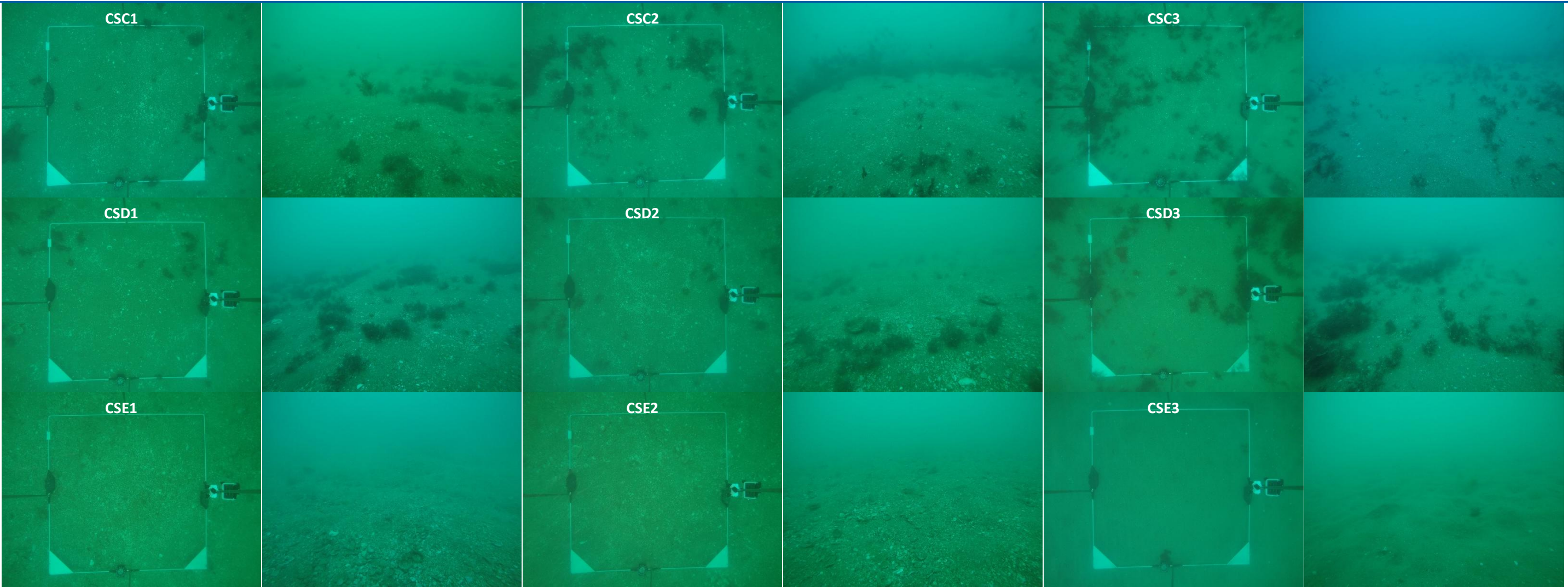
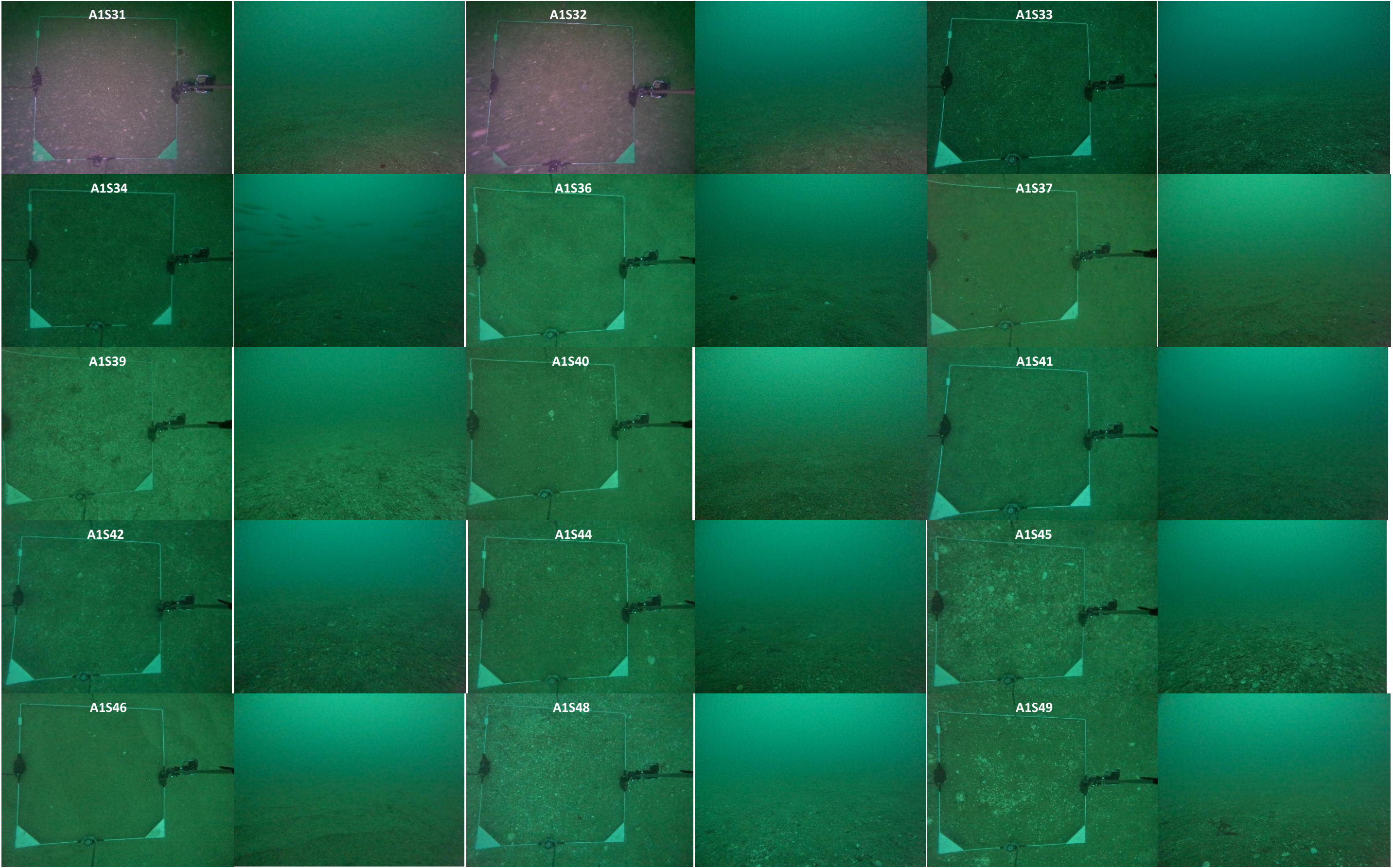
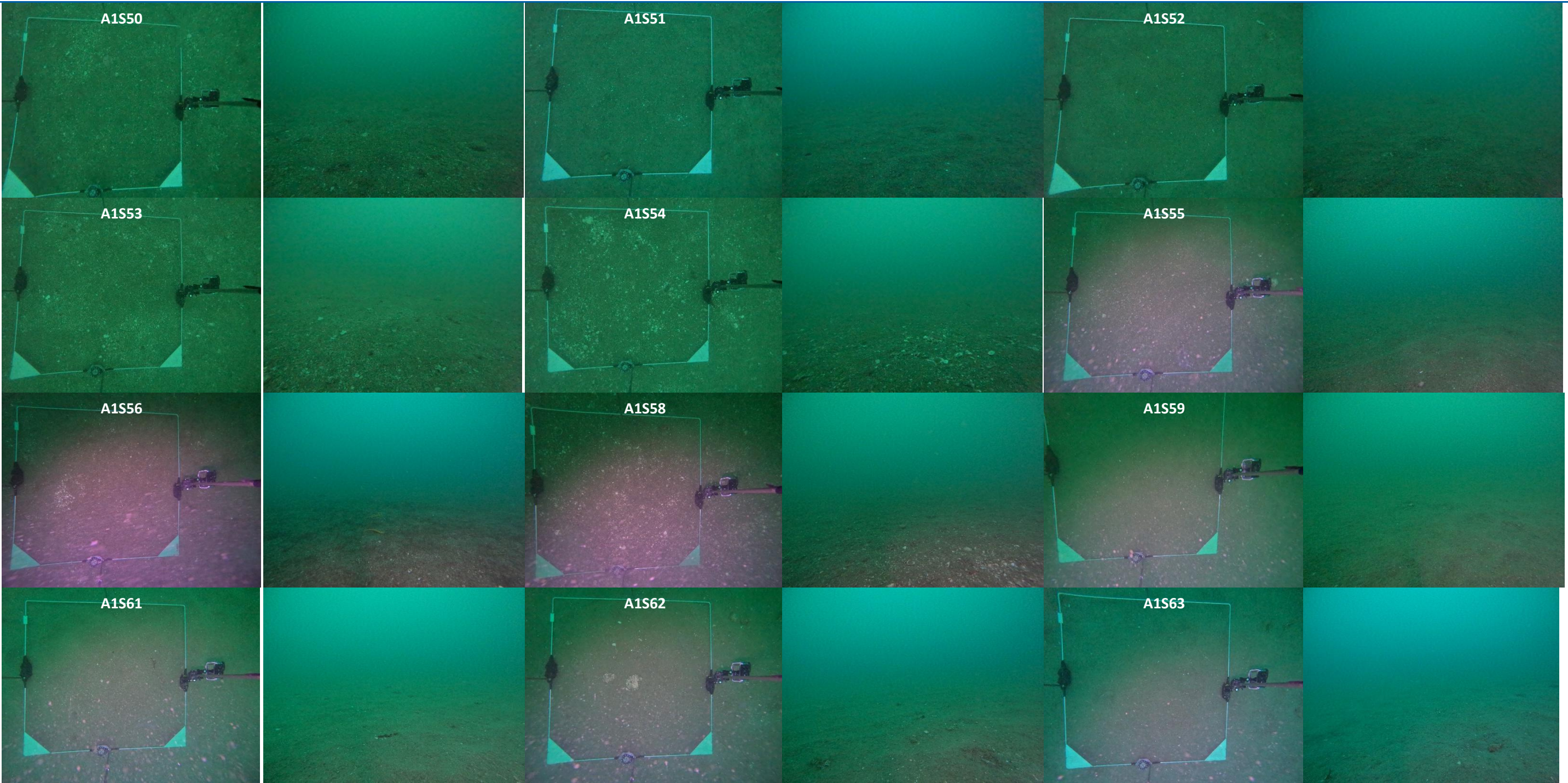


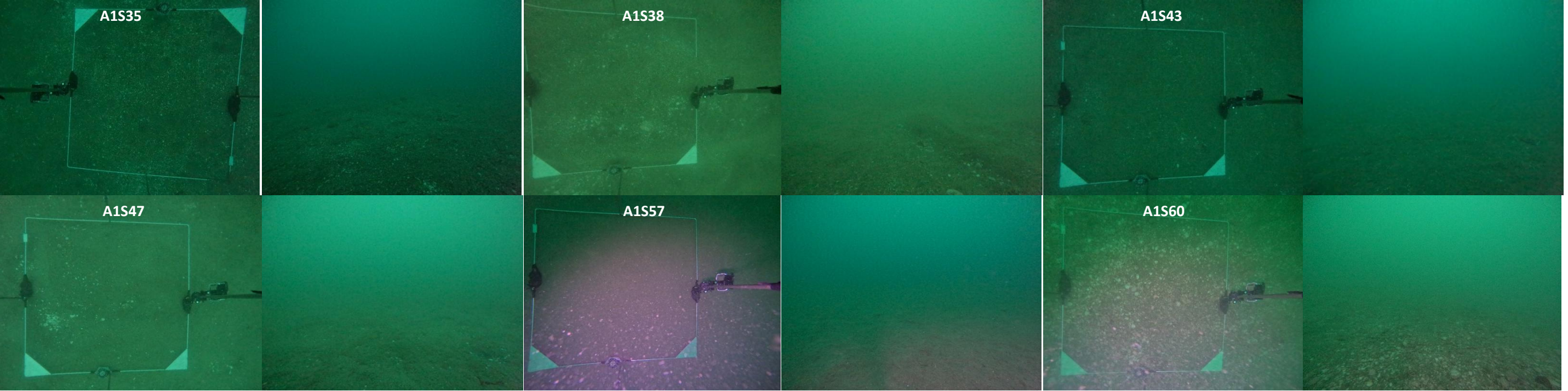
Figure F.2 Drop Camera images from Recovery, outside and Control cells, plus 6 months 12 March 2024

Recovery Area

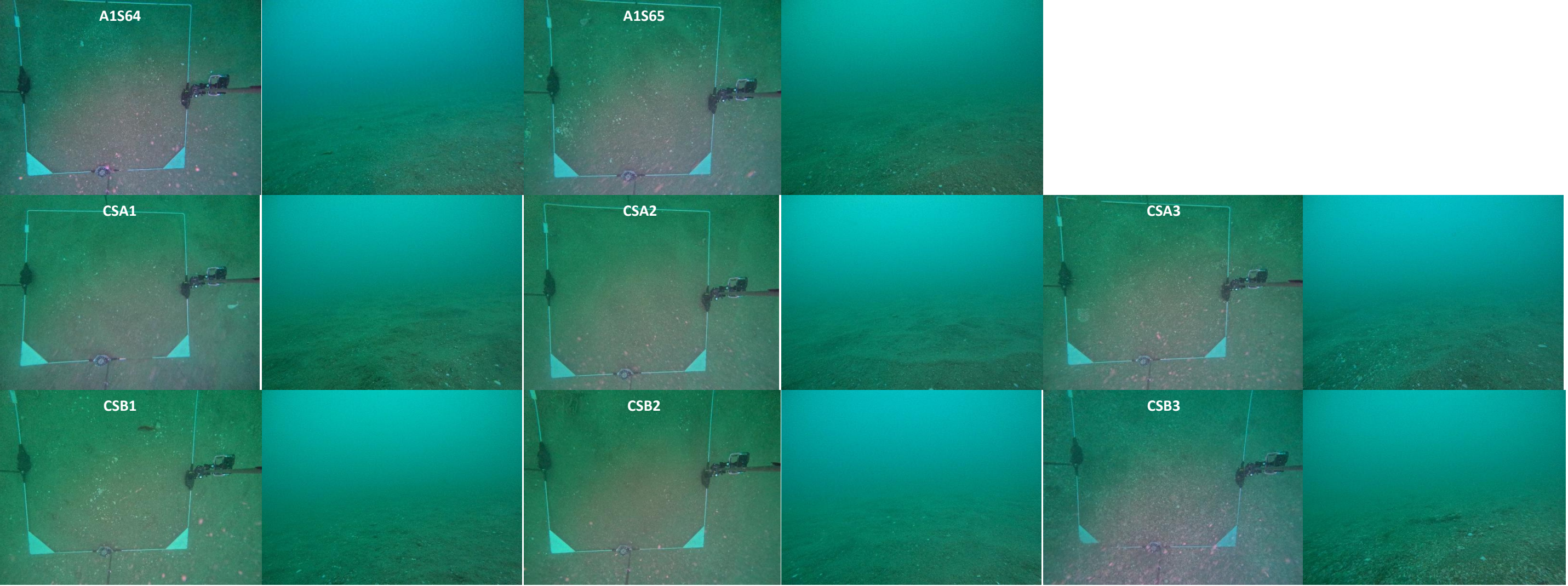




Outside



Control Area



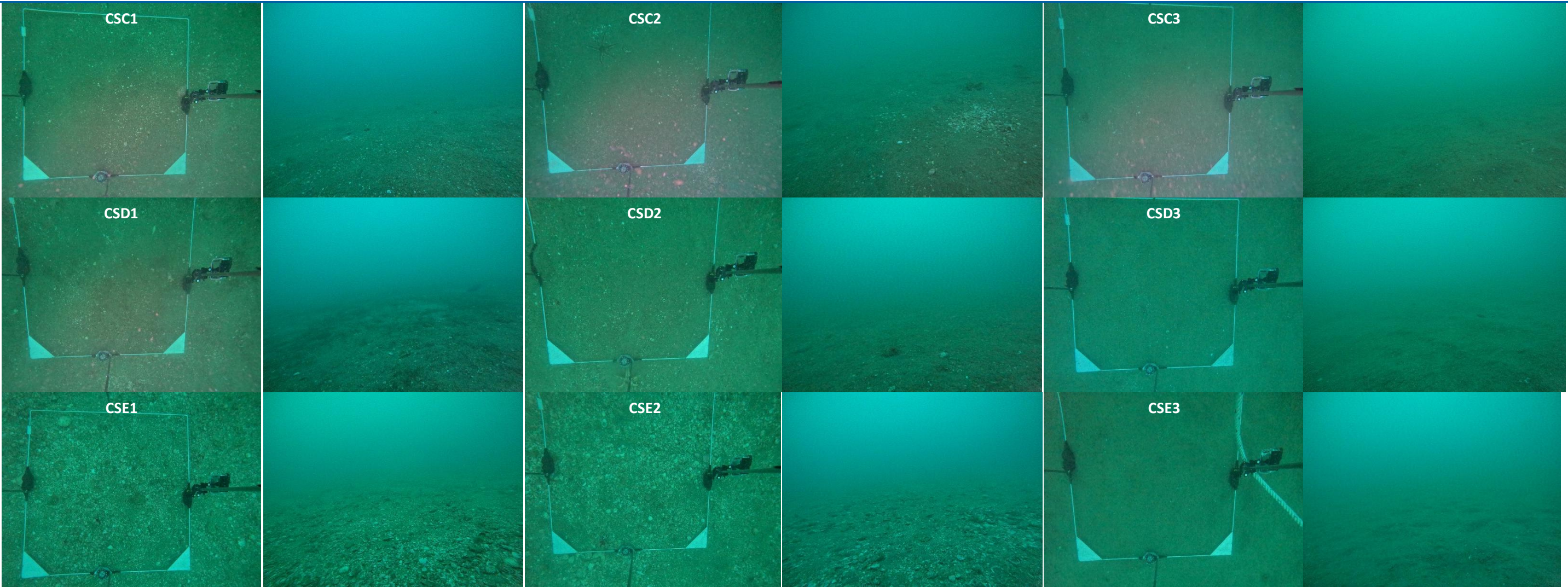


Figure F.3 Drop Camera images from Recovery, outside and Control cells plus 12 months 4 October 2024

Table F.1 Seabed photography summary descriptions from the Recovery, Outside and Control Area, 1 month, 19 September 2023.

Sample Site	Topography	Shell		Rocks	Biota
		Density	comments		
Recovery area					
A1S31	Small irregular ripples	Low			<i>Astropecten polyacanthus</i> , burrows
A1S32	Medium irregular ripples	Low	Fine shells		
A1S33	Small irregular ripples	Medium	Fine shells		
A1S34	Small irregular ripples	Medium			Sponge
A1S36	Medium irregular ripples	Medium			
A1S37	Medium regular ripples	Low			
A1S39	Medium irregular ripples	Low	Shells concentrated in some areas		Burrows
A1S40	Medium irregular ripples	Low			
A1S41	Medium irregular ripples	Medium			
A1S42	Medium irregular ripples	Low			Scallop
A1S44	Medium irregular ripples	Medium			
A1S45	Small irregular ripples	High	Coarse shells		2 scallops Bottom LH corner
A1S46	Medium irregular ripples	Medium	Mix of coarse and fine shells		Seaweed
A1S48	Small irregular ripples	High	Fine shells		
A1S49	Small irregular ripples	Medium	Coarse shells		tiny bit of loose seaweed
A1S50	Large irregular ripples	Medium			
A1S51	Large irregular ripples	Low			Scallop In the middle top half, finger sponge
A1S52	Medium irregular ripples	Low			
A1S53	Medium irregular ripples	Low	Fine shells		
A1S54	Small irregular ripples	Low			Marine worm of a bit of plastic rope
A1S55	Small irregular ripples	Low			
A1S56	Small irregular ripples	Low			Finger sponge, burrows
A1S58	Small irregular ripples	Low	Mix of coarse and fine shells		
A1S59	Small irregular ripples	Low	Fine shells		<i>Pellicaria vermis</i>
A1S61	Small irregular ripples	Medium	Shells concentrated in some areas		
A1S62	Medium irregular ripples	Medium			Scallop
A1S63	Small irregular ripples	Medium			
Outside Recovery area					
A1S35	Small irregular ripples	Low	Coarse shells		Scallop, finger sponge
A1S38	Medium irregular ripples	Medium			
A1S43	Small irregular ripples	Low			
A1S47	Small irregular ripples	Low			
A1S57	Small irregular ripples	Low	Mainly sandy bottom		Burrows
A1S60	Small irregular ripples	High	Coarse shells		
Control area					
A1S64	Small irregular ripples	Low			Scallop
A1S65	Small irregular ripples	Low			Sponge
CSA1	Small irregular ripples	Low			
CSA2	Small irregular ripples	Low			Burrows
CSA3	Small irregular ripples	Low			<i>Astropecten polyacanthus</i>
CSB1	Small irregular ripples	Low			Burrows
CSB2	Small irregular ripples	Low			
CSB3	Small irregular ripples	Medium			
CSC1	Medium irregular ripples	Medium			
CSC2	Small irregular ripples	Low			Finger sponge
CSC3	Small irregular ripples	Low			Burrow
CSD1	Small irregular ripples	Low			Hermit crab maybe in brown olive like shell
CSD2	Small irregular ripples	Medium			
CSD3	Small irregular ripples	Low			Burrows
CSE1	Small irregular ripples	Medium	Coarse shells		
CSE2	Small irregular ripples	High	Big shells		
CSE3	Small irregular ripples	Low	Mainly sandy bottom		Burrows

Table F.2 Seabed photography summary descriptions from the Recovery, Outside and Control Area, plus 6 months, 12 March 2024.

Sample Site	Topography	Shell		Rocks	Biota
		Density	comments		
Recovery area					
A1S31	Small irregular ripples	Low	Mainly sandy bottom		sponge, HC?
A1S32	Flat	High			
A1S33	Small irregular ripples	High			
A1S34	Small irregular ripples	High			
A1S36	Small irregular ripples	Medium			
A1S37	Small irregular ripples	Low	Mainly sandy bottom		Algae?
A1S39	Flat	High	Coarse shell concentrated in an area		
A1S40	Small irregular ripples	Medium			
A1S41	Small irregular ripples	Medium			
A1S42	Flat	High			
A1S44	Small irregular ripples	High			
A1S45	Small irregular ripples	High	Large amount of dead scallop shells		
A1S46	Flat	High			
A1S48	Flat	High			
A1S49	Flat	High	Shells of different sizes		
A1S50	Flat	High			
A1S51	Flat	High			
A1S52	Small irregular ripples	High			
A1S53	Flat	High	Shells of different sizes		
A1S54	Small irregular ripples	High	Different size shells		
A1S55	Small irregular ripples	Medium			
A1S56	Flat	High			
A1S58	Small irregular ripples	High			
A1S59	Flat	High	Uneven distribution of shells		
A1S61	Small irregular ripples	Medium			
A1S62	Flat	Low	Mainly sandy bottom		
A1S63	Small irregular ripples	Low	Mainly sandy bottom		
Outside Recovery area					
A1S35	Small irregular ripples	High			
A1S38	Medium irregular ripples	High			
A1S43	Flat	High			Finger sponge x 3
A1S47	Flat	High			
A1S57	Small irregular ripples	Low			
A1S60	Flat	High	Abundant medium size shells		
Control area					
A1S64	Flat	High			Scallop?
A1S65	Flat	Medium			
CSA1	Small irregular ripples	Medium			
CSA2	Small irregular ripples	Medium			
CSA3	Flat	High			
CSB1	Flat	High			sponge
CSB2	Flat	Medium			
CSB3	Flat	High	Coarse shell		
CSC1	Flat	High			
CSC2	Flat	High			
CSC3	Flat	Medium	Very small shells		
CSD1	Flat	High			
CSD2	Flat	High	Some dead scallop shells		
CSD3	Flat	High			
CSE1	Flat	High	Abundant medium size shells		
CSE2	Flat	High	Medium size shells		
CSE3	Small irregular ripples	Low	Mainly sandy bottom		

Table F.3 Seabed photography summary descriptions from the Recovery, Outside and Control Area, plus 12 months, 4 October 2024.

Sample site	Topography	Shell		Rocks	Biota
		Density	Comments		
Recovery area					
A1S31	Flat	Low		N	1 x <i>Astropecten polyacanthus</i>
A1S32	Flat	Low		N	
A1S33	Flat	Low		N	
A1S34	Flat	Low		N	30+ Koheru (<i>Decapтерus koheru</i>)
A1S36	Small irregular ripples	Low		N	1 x Xenophora
A1S37	Small irregular ripples	Low		Y	
A1S39	Flat	High		N	
A1S40	Small irregular ripples	Low		N	
A1S41	Flat	Low		N	
A1S42	Flat	Medium		N	
A1S44	Flat	Low		N	
A1S45	Flat	High		N	
A1S46	Small irregular ripples	Low		N	
A1S48	Small irregular ripples	Medium		N	
A1S49	Flat	Medium		N	
A1S50	Small irregular ripples	Low		N	1 x Scallop
A1S51	Small irregular ripples	Low		N	1x Xenophora
A1S52	Small irregular ripples	Low		N	
A1S53	Flat	Medium		N	
A1S54	Flat	Medium		N	
A1S55	Small irregular ripples	Low		N	
A1S56	Flat	Low		N	2 x sponge
A1S58	Flat	Medium		N	1 X sponge
A1S59	Flat	Low		N	
A1S61	Small irregular ripples	Low		N	
A1S62	Small irregular ripples	Low		N	
A1S63	Flat	Low		N	
Outside Recovery area					
A1S35	Small irregular ripples	Medium		N	
A1S38	Medium irregular ripples	Medium		N	1 x Gastropod
A1S43	Flat	Low		N	
A1S47	Flat	Low		N	
A1S57	Flat	Low		N	
A1S60	Flat	High		Y	
Control area					
A1S64	Flat	Low		N	
A1S65	Small irregular ripples	Low		N	1 x Xenophora
CSA1	Flat	Low		N	
CSA2	Small irregular ripples	Low		N	1 x Hermit crab
CSA3	Small irregular ripples	Low		N	
CSB1	Flat	Low		N	
CSB2	Flat	Low		N	1 x Sponge
CSB3	Flat	High		N	1 x Sponge
CSC1	Small irregular ripples	Low		N	3 x Hermit
CSC2	Small irregular ripples	Low		N	1 x <i>Astropecten polyacanthus</i> , 1 x sponge
CSC3	Flat	Low		N	
CSD1	Flat	Low		N	
CSD2	Flat	Medium		N	1 x Xenophora, 1 x <i>Astropecten polyacanthus</i>
CSD3	Small irregular ripples	Low		N	
CSE1	Flat	High		N	
CSE2	Flat	High		N	
CSE3	Small irregular ripples	Low		N	

Appendix G Epibenthic Macrofauna Dredge Tow Results



Figure G.1 Photographic records of Epibenthic Macrofauna Dredge Tow capture in Recovery and Control Areas. 1 month, 21 September 2023.



Figure G.2 Photographic records of Epibenthic Macrofauna Dredge Tow capture in Recovery and Control Areas. +6 months, 13 March 2024.

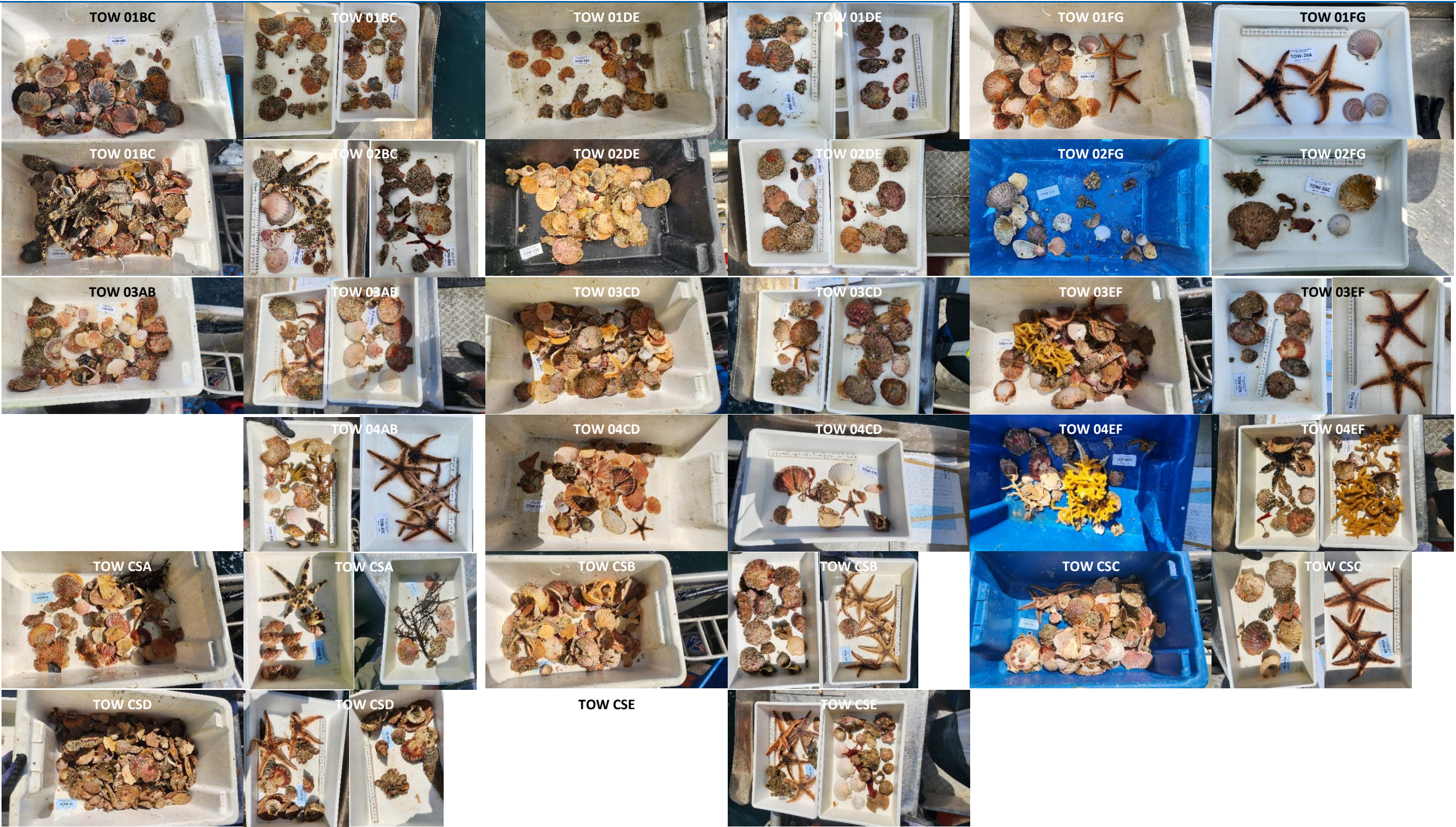


Figure G.3 Photographic records of Epibenthic Macrofauna Dredge Tow captures Recovery and Control Areas. +12 months, 4 October 2024

Table G.1 Densities (/100 m²) of Epibenthic Macrofauna collected within the Recovery and Control Areas. 1 month, 21 September 2023.

Taxa	Dredge tow	Recovery Area												Control Area				
		01BC	01DE	01FG	02BC	02DE	02FG	03AB	03CD	03EF	04AB	04CD	04EF	CSA	CSB	CSC	CSD	CSE
Annelida																		
Polychaeta																0.01		
Arthropoda																		
Decapoda																		
Anomura			0.02	0.03	0.03	0.02	0.02	0.01	0.01	0.03	0.05	0.02		0.02	0.01	0.01		0.02
Brachyura							0.01											
Mollusca																		
Gastropoda																		
<i>Cominella adspersa</i>												0.01						
<i>Struthiolaria papulosa</i>														0.01	0.04			0.01
<i>Xenophora neozelanica</i>				0.04													0.02	
Bivalvia																		
<i>Corbula zelandica</i>							0.01											
<i>Dosinia sp.</i>						0.03	0.01											
<i>Pecten novaezelandiae</i>	0.01	0.01	0.02		0.03					0.01					0.01		0.01	
<i>Purpurocardia purpurata</i>				0.01	0.03										0.02	0.01		
Cephalopoda																		
<i>Macroctopus maorum</i>											0.01							
Echinodermata																		
Asteroidea																		
<i>Astropecten polyacanthus</i>	0.01	0.03		0.02	0.02	0.01	0.02		0.01	0.04	0.03	0.01		0.02		0.03	0.02	0.03
<i>Luidia australiae</i>					0.01		0.02											
Porifera																		
Demospongiae																		
Sponge (finger)					0.02	0.02			0.01								0.02	
Chordata																		
Ascidacea																		
Ascidian	0.01		0.01		0.01	0.01												
Brachiopoda																		
<i>Calloria inconspicua</i>			0.01			0.02												
No Individuals		0.025	0.050	0.100	0.058	0.142	0.092	0.042	0.008	0.042	0.108	0.050	0.008	0.042	0.075	0.050	0.058	0.058
No Species		3	3	5	3	8	8	3	1	3	4	3	1	3	4	4	4	3

Table G.2 Densities (/100 m²) of Epibenthic Macrofauna collected within the Recovery and Control Areas. +6 months, 13 March 2024.

Taxa	Dredge tow	Recovery Area												Control Area				
		01BC	01DE	01FG	02BC	02DE	02FG	03AB	03CD	03EF	04AB	04CD	04EF	CSA	CSB	CSC	CSD	CSE
Annelida																		
Polychaeta		Present	Present		Present	Present		Present		Present	Present	Present	Present	Present	Present	Present	Present	Present
Arthropoda																		
Decapoda																		
Anomura			0.03		0.02	0.05		0.08		0.03				0.02			0.03	0.02
Brachyura				0.02		0.01	0.01		0.01				0.01					0.02
<i>Notomithrax sp</i>										0.01								
<i>Ovalipes catharus</i>			0.04			0.01				0.01			0.01			0.01	0.01	0.01
Cirripedia																		
Barnacle			0.04					0.01					0.01					
Bryozoa																		
Encrusting				0.01	0.08		0.01			0.02	0.01		0.02		0.01		0.01	

Taxa	Dredge tow	Recovery Area												Control Area				
		01BC	01DE	01FG	02BC	02DE	02FG	03AB	03CD	03EF	04AB	04CD	04EF	CSA	CSB	CSC	CSD	CSE
Mollusca																		
Gastropoda																		
Cominella adspersa		0.03															0.01	
Monoplex parthenopeus						0.01												
Murexsul octogonus													0.01					
Penion sulcatus											0.01							
Mayene australasiae					0.01													
Semicassis pyrum								0.01										
Sigapatella sp.			0.03			0.01	0.01			0.01								
Struthiolaria papulosa														0.01				
Xymene sp.							0.01											
Zeatrophon ambiguus		0.02	0.01				0.01											
Bivalvia																		
Anomia trigonopsis										0.01								
Atrina zelandica		0.03										0.01						
Corbula zelandica			0.01			0.01												
Dosina zelandica						0.02												
Dosinia sp.						0.01												
Myadora striata						0.01												
Pecten novaezelandiae		0.02				0.03				0.01						0.01	0.02	
Purpurocardia purpurata	0.01	0.02								0.02	0.01							
Scalpomactra scalpellum			0.01															
Talochlamys zelandiae			0.01				0.01											
Tawera spissa			0.03			0.02												
Polyplacophora																		
Ischnochiton/Leptochiton	0.01					0.02								0.01			0.01	
Cephalopoda																		
Macroctopus maorum													0.01				0.01	
Echinodermata																		
Asteroidea																		
Astropecten polyacanthus	0.05	0.03	0.01			0.01	0.01	0.04	0.02		0.03	0.03		0.03	0.02	0.01	0.02	
Luidia australiae												0.01				0.01		
Echinoidea																		
Echinocardium cordatum															0.01			
Platyhelminthes																		
Anonymus kaikourensis			0.01															
Porifera																		
Demospongiae																		
Sponge (finger)			0.03				0.01			0.01	0.01						0.01	0.01
Others			0.01							0.01			0.01					
Chordata																		
Leptocardii																		
Epigonichthys hectori						0.03												
Brachiopoda																		
Calloria inconspicua			0.05	0.01	0.02					0.11		0.02	0.01					
No Individuals		0.067	0.258	0.208	0.108	0.242	0.067	0.133	0.033	0.233	0.058	0.058	0.075	0.058	0.033	0.033	0.108	0.050
No Species		4	10	13	5	16	8	4	3	12	6	5	9	5	4	5	10	5

Table G.3 Densities (/100 m²) of Epibenthic Macrofauna collected within the Recovery and Control Areas. +12 months, 4 October 2024.

Taxa	Dredge tow	Recovery Area												Control Area				
		01BC	01DE	01FG	02BC	02DE	02FG	03AB	03CD	03EF	04AB	04CD	04EF	CSA	CSB	CSC	CSD	CSE
Annelida																		
Polychaeta		0.01	0.03		0.02				0.01		0.01	0.01		0.01	0.01	0.01		0.01
Arthropoda																		
Decapoda																		
Anomura		0.01			0.03	0.01		0.03	0.01	0.02		0.01	0.01	0.02	0.02	0.02		
Brachyura					0.01	0.01	0.01	0.01	0.01	0.01		0.01		0.01	0.01	0.02		
Notomithrax sp		0.04	0.01	0.01						0.01			0.02				0.02	
Cirripedia																		
Barnacle		Present	Present		Present			Present	Present					Present	Present			
Isopoda																		
Isopods			0.01															
Bryozoa																		
Encrusting		Present	Present	Present		Present	Present	Present	Present	Present	Present	Present	Present		Present	Present		
Branching		Present		Present	Present	Present			Present	Present			Present		Present	Present		
Mollusca																		
Gastropoda																		
Alcithoe arabica											0.01							0.01
Austrofuscus																		0.01
Monoplex parthenopeus																		0.01
Murexsul octogonus							0.01			0.01					0.01			0.01
Sigapatella sp.			0.05			0.01	0.03	0.01	0.01	0.01		0.02			0.01		0.03	
Struthiolaria papulosa					0.01						0.02			0.06	0.02	0.01		
Xenophora neozelanica		0.01	0.02		0.02	0.02	0.02		0.02	0.02	0.01					0.01	0.01	0.02
Bivalvia																		
Austrovenus stutchburyi													0.01					
Corbula zelandica															0.01			
Pecten novaezelandiae				0.03	0.03	0.01	0.01	0.04		0.02	0.02	0.01						0.04
Purpurocardia purpurata						0.01					0.01							
Talochlamys zelandiae										0.01								
Tawera spissa																	0.02	
Polyplacophora																		
Ischnochiton/Leptochiton		0.01						0.01		0.01								0.01
Cephalopoda																		
Macroctopus maorum												0.01						0.01
Echinodermata																		
Asteroidea																		
Astropecten polyacanthus				0.02				0.03	0.01	0.02	0.04	0.01			0.05	0.03	0.02	0.03
Luidia australiae					0.02								0.01	0.01				
Porifera																		
Demospongiae																		
Sponge (finger)		0.02	0.01		0.01			0.01		0.02	0.03		0.03		0.01		0.01	0.02
Others		0.01																
Chordata																		
Ascidacea																		
Ascidian									0.01									
Brachiopoda																		
Calloria inconspicua				0.02				0.01		0.01			0.03			0.01		
No Individuals		0.100	0.117	0.067	0.125	0.058	0.075	0.133	0.067	0.142	0.133	0.067	0.092	0.100	0.133	0.092	0.133	0.133
No Species		10	8	6	10	8	6	10	10	14	9	8	8	6	12	9	10	7

Table G.4 *Scallop (*Pecten novaezelandiae*) numbers and sizes (mm) recorded in Epibenthic macrofauna dredge tows, 1 month, September 2023.*

Monitoring tow	Scallop				
	n	Sizes			Average
01FG	1	94			94
02DE	3	97	91	88	92
04AB	1	116			116
CSB	1	94			94
CSD	1	97			97

Table G.5 *Scallop (*Pecten novaezelandiae*) numbers and sizes (mm) recorded in Epibenthic macrofauna dredge tows, +6 months, March 2024.*

Monitoring tow	Scallop				
	n	Sizes			Average
01BC	2	40	71		55.5
02BC	3	27	49	83	53
CSB	1	96			96

Table G.6 *Scallop (*Pecten novaezelandiae*) numbers and sizes (mm) recorded in Epibenthic macrofauna dredge tows, +12 months, October 2024.*

Monitoring tow	Scallop						
	n	Sizes					Average
01FG	3	85	59	57			67
02BC	3	111	73	79			66.5
02DE	1	76					76
02FG	1	58					58
03AB	5	97	95	65	98	76	86.2
03EF	2	67	57				62
04AB	2	76	58				67
04CD	1	82					82
CSE	5	83	56	65	84	61	69.8

Appendix H Statistical Results - Biota

Univariate Statistics

Table H.1 Two Way Scheirer Ray Hare Analysis of the Number of Individuals of benthic biota between extraction Areas over time

Dependent Variable: Number of Individuals
Normality Test (Shapiro-Wilk): Failed (P < 0.050)
Equal Variance Test (Brown-Forsythe): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
Recovery	81	0	78	29	258
Control	69	0	84	39	246

Group	N	Missing	Median	25%	75%
Survey 1	50	0	23.5	16.3	31.8
Survey 6	50	0	81.5	58.0	109.8
Survey 12	50	0	326.5	247.0	434.5

Group	N	Missing	Median	25%	75%
Recovery 1	27	0	23.0	16.0	30.5
Control 1	23	0	26.0	19.0	37.5
Recovery 6	27	0	75.0	52.5	109.5
Control 6	23	0	85.0	67.0	109.5
Recovery 12	27	0	318.0	258.0	417.0
Control 12	23	0	364.0	237.0	437.0

Source of Variation	DF	H	p
Survey	2	120.587	0
Area	1	0.123	0.7258
Survey x Area	2	0.320	0.8522

The difference among levels of Survey is **statistically significant** (H=120.587, p=0).
The difference among levels of Area is not statistically significant (H=0.123, p=0.7258).
The difference among levels of Survey x Area is not statistically significant (H=0.320, p=0.8522).

All Pairwise Multiple Comparison Procedures : Overall significance level = 0.05

Pairwise Comparisons by Dunn Tests: Survey (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 12	-10.980	0	0	True
6 vs 12	-5.666	1.461e-08	2.923e-08	True
1 vs 6	-5.314	1.073e-07	1.073e-07	True

Pairwise Comparisons by Dunn Tests: Area (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
Control vs Recovery	0.351	0.7258	0.7258	False

Comparisons by Area within each Survey (Mann Whitney U; Holm not needed)

Survey	Comparison	U	p	Sig(0.05)
1	Control vs Recovery	276.5	0.514	False
6	Control vs Recovery	259.0	0.3207	False
12	Control vs Recovery	317.5	0.8993	False

Comparisons by Survey within Control (Dunn; Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 12	-7.412	1.241e-13	3.724e-13	True
1 vs 6	-3.976	7.002e-05	0.00014	True
6 vs 12	-3.436	0.0005903	0.0005903	True

Comparisons by Survey within Recovery (Dunn; Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 12	-8.087	6.661e-16	1.998e-15	True
6 vs 12	-4.460	8.2e-06	1.64e-05	True
1 vs 6	-3.627	0.0002868	0.0002868	True

Table H.2 Two Way Scheirer Ray Hare Analysis of the Number of Individuals of benthic biota between Sand Extraction History sites over time

Dependent Variable: Number of Individuals
Normality Test (Shapiro-Wilk): Failed (P < 0.050)
Equal Variance Test (Brown-Forsythe): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
H	3	0	86.0	67.5	202.0
M	24	0	56.0	26.0	243.0
L	24	0	71.5	28.8	261.5
No extraction	99	0	85.0	34.5	251.0

Group	N	Missing	Median	25%	75%
Survey 1	50	0	23.5	16.3	31.8
Survey 6	50	0	81.5	58.0	109.8
Survey 12	50	0	326.5	247.0	434.5

Group	N	Missing	Median	25%	75%
H 1	1	0	49.0	49.0	49.0
M 1	8	0	16.5	13.8	27.5
L 1	8	0	24.5	22.3	26.3
No 1	33	0	23.0	17.0	34.0
H 6	1	0	86.0	86.0	86.0
M 6	8	0	56.0	42.5	96.3
L 6	8	0	71.5	56.0	79.8
No 6	33	0	85.0	65.0	116.0
H 12	1	0	318.0	318.0	318.0
M 12	8	0	363.5	253.0	421.3
L 12	8	0	416.0	273.8	484.8
No 12	33	0	303.0	244.0	404.0

Source of Variation	DF	H	p
Survey	2	120.599	0
Extraction	4	0.643	0.8865
Survey x Extraction	8	1.127	0.9803

The difference among levels of Survey is **statistically significant** (H=120.587, p=0).
The difference among levels of Extraction is not statistically significant (H=0.643, p=0.8865).
The difference among levels of Survey x Extraction is not statistically significant (H=1.127, p=0.9803).

All Pairwise Multiple Comparison Procedures : Overall significance level = 0.05

Pairwise Comparisons by Dunn Tests: Survey (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 12	-10.980	0	0	True
6 vs 12	-5.666	1.461e-08	2.923e-08	True
1 vs 6	-5.314	1.073e-07	1.073e-07	True

Pairwise Comparisons by Dunn Tests: Extraction (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
H vs L	0.404	0.6862	1	False
H vs M	0.619	0.5362	1	False
H vs No	0.386	0.6998	1	False
L vs M	0.455	0.6490	1	False
L vs No	-0.094	0.9249	1	False
M vs No	-0.672	0.5018	1	False

Comparisons by Extraction within each Survey (Holm-adjusted)

Survey	Comparison	Z	p	p_holm	Sig(0.05)
1	H vs L	1.260	0.2076	0.8957	False
1	H vs M	1.717	0.08606	0.5164	False
1	H vs No	1.343	0.1791	0.8957	False
1	L vs M	0.968	0.333	0.8957	False
1	L vs No	0.069	0.9454	0.9454	False
1	M vs No	-1.160	0.2461	0.8957	False
6	H vs L	0.610	0.5417	1	False
6	H vs M	0.707	0.4794	1	False
6	H vs No	0.127	0.899	1	False
6	L vs M	0.206	0.837	1	False
6	L vs No	-1.316	0.1883	0.9417	False
6	M vs No	-1.577	0.1149	0.6894	False
12	H vs L	-0.307	0.7587	1	False
12	H vs M	-0.113	0.9099	1	False
12	H vs No	0.055	0.9559	1	False
12	L vs M	0.412	0.6807	1	False
12	L vs No	0.969	0.3324	1	False
12	M vs No	0.447	0.6549	1	False

Table H.3 Two Way Scheirer Ray Hare Analysis of the Number of Taxa of benthic biota between extraction Areas over time

Dependent Variable: Number of Taxa
Normality Test (Shapiro-Wilk): Failed (P < 0.050)
Equal Variance Test (Brown-Forsythe): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
Recovery	81	0	25	15	33
Control	69	0	28	17	35

Group	N	Missing	Median	25%	75%
Survey 1	50	0	14.0	11.0	17.0
Survey 6	50	0	30.0	24.0	33.0
Survey 12	50	0	33.5	30.3	36.8

Group	N	Missing	Median	25%	75%
Recovery 1	27	0	12.0	10.5	15.0
Control 1	23	0	15.0	11.5	17.0
Recovery 6	27	0	30.0	23.0	33.0
Control 6	23	0	30.0	25.5	35.0
Recovery 12	27	0	32.0	29.5	36.0
Control 12	23	0	35.0	32.0	37.5

Source of Variation	DF	H	p
Survey	2	98.719	0
Area	1	0.882	0.3468
Survey x Area	2	0.032	0.9841

The difference among levels of Survey is **statistically significant** (H=98.719, p=0).
The difference among levels of Area is not statistically significant (H=0.882, p=0.3468).
The difference among levels of Survey x Area is not statistically significant (H=0.032, p=0.9841).

All Pairwise Multiple Comparison Procedures : Overall significance level = 0.05

Pairwise Comparisons by Dunn Tests: Survey (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	-7.372	1.681e-13	5.043e-13	True
1 vs 12	-9.462	0	0	True
6 vs 12	-2.090	0.03662	0.07324	False

Pairwise Comparisons by Dunn Tests: Area (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
Control vs Recovery	0.941	0.3465	0.6931	False

Comparisons by Area within each Survey (Mann Whitney U; Holm not needed)

Survey	Comparison	U	p	Sig(0.05)
1	Control vs Recovery	251.0	0.2489	False
6	Control vs Recovery	271.0	0.4472	False
12	Control vs Recovery	255.5	0.2879	False

Comparisons by Survey within Control (Dunn; Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	-5.098	3.432e-07	1.03e-06	True
1 vs 12	-6.499	8.061e-11	3.224e-10	True
6 vs 12	-1.401	0.1611	0.3222	False

Comparisons by Survey within Recovery (Dunn; Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	-5.344	9.098e-08	2.729e-07	True
1 vs 12	-6.884	5.823e-12	2.329e-11	True
6 vs 12	-1.540	0.1235	0.2471	False

Table H.4 Two Way Scheirer Ray Hare Analysis of the Number of Taxa of benthic biota between Sand Extraction History sites over time

Dependent Variable: Number of Taxa
Normality Test (Shapiro-Wilk): Failed (P < 0.050)
Equal Variance Test (Brown-Forsythe): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
H	3	0	22.0	18.5	25.5
M	24	0	25.5	17.5	31.3
L	24	0	25.5	14.8	33.3
No extraction	99	0	28.0	17.0	34.5

Group	N	Missing	Median	25%	75%
Survey 1	50	0	14.0	11.0	17.0
Survey 6	50	0	30.0	24.0	33.0
Survey 12	50	0	33.5	30.3	36.8

Group	N	Missing	Median	25%	75%
H 1	1	0	15.0	15.0	15.0
M 1	8	0	11.0	9.8	18.8
L 1	8	0	13.5	11.0	15.0
No 1	33	0	14.0	12.0	17.0
H 6	1	0	22.0	22.0	22.0
M 6	8	0	28.0	22.5	31.0
L 6	8	0	28.5	23.3	33.0
No 6	33	0	31.0	25.0	36.0
H 12	1	0	29.0	29.0	29.0
M 12	8	0	31.5	29.3	33.5
L 12	8	0	35.0	30.3	37.0
No 12	33	0	34.0	32.0	37.0

Source of Variation	DF	H	p
Survey	2	98.827	0
Extraction	4	1.518	0.8234
Survey x Extraction	8	0.971	0.9984

The difference among levels of Survey is **statistically significant** (H=98.827, p=0).
The difference among levels of Extraction is not statistically significant (H=1.518, p=0.8234).
The difference among levels of Survey x Extraction is not statistically significant (H=0.971, p=0.9984).

All Pairwise Multiple Comparison Procedures : Overall significance level = 0.05

Pairwise Comparisons by Dunn Tests: Survey (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	-7.372	1.681e-13	5.043e-13	True
1 vs 12	-9.462	0	0	True
6 vs 12	-2.090	0.03662	0.07324	False

Pairwise Comparisons by Dunn Tests: Extraction (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
H vs L	-0.583	0.5598	1	False
H vs M	-0.391	0.6956	1	False
H vs No	-0.764	0.4447	1	False
L vs M	0.407	0.6842	1	False
L vs No	-0.399	0.6897	1	False
M vs No	-0.915	0.36	1	False

Comparisons by Extraction within each Survey (Holm-adjusted)

Survey	Comparison	Z	p	p_holm	Sig(0.05)
1	H vs L	0.459	0.6462	1	False
1	H vs M	0.451	0.652	1	False
1	H vs No	0.279	0.7799	1	False
1	L vs M	-0.017	0.9864	1	False
1	L vs No	-0.516	0.6062	1	False
1	M vs No	-0.494	0.6214	1	False
6	H vs L	-1.005	0.3148	1	False
6	H vs M	-0.840	0.4011	1	False
6	H vs No	-1.271	0.2036	1	False
6	L vs M	0.351	0.7255	1	False
6	L vs No	-0.569	0.5696	1	False
6	M vs No	-1.014	0.3105	1	False
12	H vs L	-1.118	0.2637	1	False
12	H vs M	-0.650	0.516	1	False
12	H vs No	-1.137	0.2557	1	False
12	L vs M	0.993	0.3208	1	False
12	L vs No	0.081	0.9357	1	False
12	M vs No	-1.179	0.2384	1	False

Table H.5 Two Way Scheirer Ray Hare Analysis of the Shannon-Wiener Diversity Index of benthic biota between extraction Areas over time

Dependent Variable: Diversity index
Normality Test (Shapiro-Wilk): Failed (P < 0.050)
Equal Variance Test (Brown-Forsythe): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
Recovery	81	0	2.360	2.050	2.810
Control	69	0	2.510	2.120	2.750

Group	N	Missing	Median	25%	75%
Survey 1	50	0	2.320	2.155	2.588
Survey 6	50	0	2.900	2.640	3.123
Survey 12	50	0	2.040	1.563	2.245

Group	N	Missing	Median	25%	75%
Recovery 1	27	0	2.300	2.105	2.545
Control 1	23	0	2.330	2.235	2.650
Recovery 6	27	0	2.880	2.640	3.090
Control 6	23	0	2.910	2.585	3.130
Recovery 12	27	0	1.980	1.510	2.195
Control 12	23	0	2.100	1.710	2.385

Source of Variation	DF	H	p
Survey	2	64.541	9.659e-15
Area	1	0.212	0.6455
Survey x Area	2	0.575	0.7503

The difference among levels of Survey is **statistically significant** (H=64.541, p < 0.001).
The difference among levels of Area is not statistically significant (H=0.212, p=0.6455).
The difference among levels of Survey x Area is not statistically significant (H=0.575, p=0.75032).

All Pairwise Multiple Comparison Procedures : Overall significance level = 0.05

Pairwise Comparisons by Dunn Tests: Survey (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	-5.037	4.741e-07	1.422e-06	True
1 vs 12	2.903	0.0037	0.0074	True
6 vs 12	7.939	1.998e-15	7.994e-15	True

Pairwise Comparisons by Dunn Tests: Area (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
Control vs Recovery	0.460	0.6455	1	False

Comparisons by Area within each Survey (Mann Whitney U; Holm not needed)

Survey	Comparison	U	p	Sig(0.05)
1	Control vs Recovery	258.5	0.316	False
6	Control vs Recovery	304.0	0.907	False
12	Control vs Recovery	275.0	0.4957	False

Comparisons by Survey within Control (Dunn; Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	-2.925	0.003441	0.01032	True
1 vs 12	2.308	0.021	0.04201	True
6 vs 12	5.233	1.666e-07	6.663e-07	True

Comparisons by Survey within Recovery (Dunn; Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 6	-4.046	5.2e-05	0.000156	True
1 vs 12	1.929	0.0537	0.1074	False
6 vs 12	5.976	2.291e-09	9.164e-09	True

Table H.6 Two Way Scheirer Ray Hare Analysis of the Shannon-Wiener Diversity Index of benthic biota between Sand Extraction History sites over time

Dependent Variable: Diversity index
Normality Test (Shapiro-Wilk): Failed (P < 0.050)
Equal Variance Test (Brown-Forsythe): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
H	3	0	2.199	1.864	2.270
M	24	0	2.475	1.916	2.850
L	24	0	2.402	2.050	2.894
No extraction	99	0	2.461	2.114	2.745

Group	N	Missing	Median	25%	75%
Survey 1	50	0	2.320	2.155	2.588
Survey 6	50	0	2.900	2.640	3.123
Survey 12	50	0	2.040	1.563	2.245

Group	N	Missing	Median	25%	75%
H 1	1	0	2.341	2.341	2.341
M 1	8	0	2.319	2.128	2.824
L 1	8	0	2.252	2.061	2.528
No 1	33	0	2.331	2.205	2.607
H 6	1	0	2.199	2.199	2.199
M 6	8	0	2.832	2.637	3.188
L 6	8	0	2.905	2.764	2.996
No 6	33	0	2.911	2.599	3.126
H 12	1	0	1.529	1.529	1.529
M 12	8	0	1.550	1.223	2.021
L 12	8	0	1.989	1.661	2.411
No 12	33	0	2.104	1.764	2.311

Source of Variation	DF	H	p
Survey	2	64.468	9.992e-15
Extraction	4	1.467	0.6898
Survey x Extraction	6	2.867	0.8253

The difference among levels of Survey is **statistically significant** (H=64.468, p=0).
The difference among levels of Extraction is not statistically significant (H=1.467, p=0.6898).
The difference among levels of Survey x Extraction is not statistically significant (H=2.867, p=0.8253).

All Pairwise Multiple Comparison Procedures : Overall significance level = 0.05

Pairwise Comparisons by Dunn Tests: Survey (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
1 vs 12	-5.037	4.741e-07	1.422e-06	True
6 vs 12	2.903	0.0037	0.0074	True
1 vs 6	7.939	1.998e-15	7.994e-15	True

Pairwise Comparisons by Dunn Tests: Extraction (Holm-adjusted)

Comparison	Z	p	p_holm	Sig(0.05)
H vs L	-1.146	0.2516	1	False
H vs M	-1.029	0.3035	1	False
H vs No	-1.185	0.2362	1	False
L vs M	0.249	0.8032	1	False
L vs No	0.034	0.9727	1	False
M vs No	-0.282	0.778	1	False

Comparisons by Extraction within each Survey (Holm-adjusted)

Survey	Comparison	Z	p	p_holm	Sig(0.05)
1	H vs L	0.404	0.6861	1	False
1	H vs M	-0.024	0.9807	1	False
1	H vs No	0.057	0.9543	1	False
1	L vs M	-0.909	0.3634	1	False
1	L vs No	-0.940	0.3471	1	False
1	M vs No	0.213	0.8314	1	False
6	H vs L	-1.407	0.1595	0.8341	False
6	H vs M	-1.479	0.139	0.8341	False
6	H vs No	-1.470	0.1414	0.8341	False
6	L vs M	-0.154	0.8773	1	False
6	L vs No	-0.001	0.9989	1	False
6	M vs No	0.195	0.8458	1	False
12	H vs L	-0.889	0.3738	1	False
12	H vs M	-0.259	0.7959	1	False
12	H vs No	-0.989	0.3226	1	False
12	L vs M	1.338	0.181	0.905	False
12	L vs No	-0.154	0.8774	1	False
12	M vs No	-1.852	0.0641	0.3846	False

Multivariate Statistics

Table H.7 Homogeneity of multivariate dispersions (PERMDIS) of the replicate Benthic biota data between the sample areas over time

Transform: Fourth root
Resemblance: S17 Bray-Curtis similarity
Group factor: Survey
Number of groups: 3
Total Number of samples: 150
Number of permutations: 9999

Overall test for homogeneity

Source	df1	df2	F	P
survey	2	147	70.825	0.0001

Means and standard errors

Group	Size	Average	SE
1	50	48.562	1.0957
6	50	41.24	0.85242
12	50	32.838	0.83369

Pairwise tests: Term: Survey

Groups	t	P
(6, 1)	5.2746	0.0001
(12, 1)	11.42	0.0001
(12, 6)	7.0463	0.0001

Transform: Fourth root
Resemblance: S17 Bray-Curtis similarity
Group factor: Area
Number of groups: 2
Total Number of samples: 150
Number of permutations: 9999

Overall test for homogeneity

Source	df1	df2	F	P
area	1	148	1.0171	0.3156

Means and standard errors

Group	Size	Average	SE
Recovery	81	47.51	0.93501
Control	69	46.153	0.96082

Pairwise tests: Term: Area

Groups	t	P
(Control, Recovery)	1.0085	0.3229

Transform: Fourth root
Resemblance: S17 Bray-Curtis similarity
Group factor: Survey - Area
Number of groups: 6
Total Number of samples: 150
Number of permutations: 9999

Overall test for homogeneity

Source	df1	df2	F	P
area-survey	5	144	26.984	0.0001

Means and standard errors

Group	Size	Average	SE
Recovery-1	27	48.237	1.6607
Control-1	23	47.287	1.5479
Recovery-6	27	41.072	1.2493
Control-6	23	39.78	1.1789
Recovery-12	27	31.708	0.92883
Control-12	23	32.782	1.4034

Pairwise tests: Term: Survey-Area

Groups	t	P
(Control-1, Recovery-1)	0.41325	0.6822
(Recovery-6, Recovery-1)	3.448	0.0013
(Recovery-6, Control-1)	3.159	0.0027
(Control-6, Recovery-1)	4.0191	0.0001
(Control-6, Control-1)	3.8581	0.0003
(Control-6, Recovery-6)	0.74336	0.4692
(Recovery-12, Recovery-1)	8.6869	0.0001
(Recovery-12, Control-1)	8.9214	0.0001
(Recovery-12, Recovery-6)	6.0152	0.0001
(Recovery-12, Control-6)	5.4483	0.0002
(Control-12, Recovery-1)	6.9681	0.0001
(Control-12, Control-1)	6.9422	0.0001
(Control-12, Recovery-6)	4.425	0.0001
(Control-12, Control-6)	3.8183	0.0011
(Control-12, Recovery-12)	0.65545	0.5112

Table H.8 PERMANOVA – Permutational Multivariate Analysis of Variation of Benthic biota between the sample areas over time

Transform: Fourth root

Resemblance: S17 Bray-Curtis similarity

PERMANOVA design worksheet

Sums of squares type: Type I (sequential)

Permutation method: Unrestricted permutation of raw data

Number of permutations: 9999

Allow for heterogeneity of within-group dispersions

Terms identifying groups with different dispersions: Survey x Area

Factors

Name	Type	Levels
Survey	Fixed	3
Area	Fixed	2

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Survey	2	80135	40068	22.599	0.0001	9879
Area	1	3623.7	3623.7	2.0528	0.0155	9917
Survey x Area	2	5063.2	2531.6	1.4341	0.066	9888
Res	144	2.5461E+05	1768.1			
Total	149	3.4343E+05				

Estimates of components of variation

Source	Estimate	Sq.root
S(Survey)	765.89	27.675
S(Area)	24.939	4.9939
S(Survey x Area)	30.85	5.5542
V(Res)	1768.1	42.049

Details of the expected mean squares (EMS) for the model

Source	EMS
Survey	$0.15333 \cdot V(\text{Res}(6)) + 0.18 \cdot V(\text{Res}(5)) + 0.15333 \cdot V(\text{Res}(4)) + 0.18 \cdot V(\text{Res}(3)) + 0.15333 \cdot V(\text{Res}(2)) + 0.18 \cdot V(\text{Res}(1)) + 0.16 \cdot S(\text{Survey} \times \text{Area}) + 50 \cdot S(\text{Survey})$
Area	$0.18 \cdot V(\text{Res}(6)) + 0.15333 \cdot V(\text{Res}(5)) + 0.18 \cdot V(\text{Res}(4)) + 0.15333 \cdot V(\text{Res}(3)) + 0.18 \cdot V(\text{Res}(2)) + 0.15333 \cdot V(\text{Res}(1)) + 74.52 \cdot S(\text{Area})$
Survey x Area	$0.18 \cdot V(\text{Res}(6)) + 0.15333 \cdot V(\text{Res}(5)) + 0.18 \cdot V(\text{Res}(4)) + 0.15333 \cdot V(\text{Res}(3)) + 0.18 \cdot V(\text{Res}(2)) + 0.15333 \cdot V(\text{Res}(1)) + 24.84 \cdot S(\text{Survey} \times \text{Area})$

Construction of Pseudo-F ratio(s) from mean squares

Source	Numerator	Denominator	Num.df	Den.df
Survey	1*Survey	$0.15217 \cdot \text{Res}(6) + 0.17901 \cdot \text{Res}(5) + 0.15217 \cdot \text{Res}(4) + 0.17901 \cdot \text{Res}(3) + 0.15217 \cdot \text{Res}(2) + 0.17901 \cdot \text{Res}(1) + 0.0064412 \cdot \text{Survey} \times \text{Area}$	2	133.15
Area	1*Area	$0.18 \cdot \text{Res}(6) + 0.15333 \cdot \text{Res}(5) + 0.18 \cdot \text{Res}(4) + 0.15333 \cdot \text{Res}(3) + 0.18 \cdot \text{Res}(2) + 0.15333 \cdot \text{Res}(1)$	1	128.86
Survey x Area	1*Survey x Area	$0.18 \cdot \text{Res}(6) + 0.15333 \cdot \text{Res}(5) + 0.18 \cdot \text{Res}(4) + 0.15333 \cdot \text{Res}(3) + 0.18 \cdot \text{Res}(2) + 0.15333 \cdot \text{Res}(1)$	2	128.86

PAIR-WISE TESTS : for pairs of levels of factor Area within Survey

Within level 1 month of factor Survey

Groups	t	P(perm)	Unique perms
Recovery, Control	1.1906	0.1409	9926

Denominators

Groups	Denominator	Den.df
Recovery, Control	0.54*Res(2) + 0.46*Res(1)	47.03

Average Similarity between/within groups

	Recovery	Control
Recovery	30.678	
Control	30.657	31.826

Within level 6 month of factor Survey

Groups	t	P(perm)	Unique perms
Recovery, Control	1.331	0.0351	9911

Denominators

Groups	Denominator	Den.df
Recovery, Control	0.54*Res(2) + 0.46*Res(1)	47.17

Average Similarity between/within groups

	Recovery	Control
Recovery	40.931	
Control	40.887	42.658

Within level 12 month of factor Survey

Groups	t	P(perm)	Unique perms
Recovery, Control	1.3861	0.0275	9914

Denominators

Groups	Denominator	Den.df
Recovery, Control	0.54*Res(2) + 0.46*Res(1)	45.99

Average Similarity between/within groups

	Recovery	Control
Recovery	54.393	
Control	52.655	52.717

PAIR-WISE TESTS : for pairs of levels of factor Survey within Area

Within level Recovery of factor Area

Groups	t	P(perm)	Unique perms
1.0, 6.0	3.3272	0.0001	9915
1.0, 12.0	4.198	0.0001	9926
6.0, 12.0	3.6401	0.0001	9911

Denominators

Groups	Denominator	Den.df
1.0, 6.0	0.5*Res(2) + 0.5*Res(1)	50.66
1.0, 12.0	0.5*Res(2) + 0.5*Res(1)	44.83
6.0, 12.0	0.5*Res(2) + 0.5*Res(1)	48.85

Average Similarity between/within groups

	1.0	6.0	12.0
1.0	30.678		
6.0	23.864	40.931	
12.0	24.663	36.072	54.393

Within level Control of factor Area

Groups	t	P(perm)	Unique perms
1.0, 6.0	2.8521	0.0001	9915
1.0, 12.0	3.7618	0.0001	9917
6.0, 12.0	2.8969	0.0001	9915

Denominators

Groups	Denominator	Den.df
1.0, 6.0	0.5*Res(2) + 0.5*Res(1)	42.72
1.0, 12.0	0.5*Res(2) + 0.5*Res(1)	39.35
6.0, 12.0	0.5*Res(2) + 0.5*Res(1)	42.6

Average Similarity between/within groups

	1.0	6.0	12.0
1.0	31.826		
6.0	27.559	42.658	
12.0	25.675	39.013	52.717

Table H.9 SIMPER - Similarity Percentages - species contributions of Benthic biota by Survey and Area groupings main effects

Parameters

Resemblance: S17 Bray-Curtis similarity

Cut off for low contributions: 70.00%

Survey groups (across all Area groups)

Group 1 Average similarity: 31.16

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Amphipoda Unid.	0.91	4.15	1.10	13.33	13.33
Pagurus sp.	0.85	3.06	0.87	9.82	23.15
Urothoidae	0.73	3.02	0.73	9.68	32.83
Sigalionidae	0.66	2.81	0.76	9.01	41.85
Maldanidae	0.55	1.58	0.54	5.09	46.93
Nucula nitidula	0.59	1.53	0.56	4.92	51.85
Barantolla lepte	0.54	1.49	0.52	4.77	56.63
Armandia maculata	0.51	1.40	0.48	4.51	61.14
Cumacea	0.48	1.10	0.44	3.54	64.68
Onuphis aucklandensis	0.44	1.01	0.43	3.26	67.93
Euchone pallida	0.47	0.98	0.41	3.16	71.09

Group 6 - Average similarity: 41.65

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Maldanidae	1.31	2.48	1.13	5.95	5.95
Phyllodocidae	1.04	2.42	1.74	5.80	11.75
Amphipoda Unid.	1.27	2.29	1.23	5.49	17.24
Sigapatella tenuis	1.12	2.15	1.15	5.16	22.40
Scalpomactra scalpellum	0.96	2.12	1.16	5.10	27.50
Nucula nitidula	1.06	2.10	1.21	5.04	32.54
Tawera spissa	1.03	1.58	0.86	3.78	36.32
Epigonichthys hectori	0.86	1.48	0.93	3.55	39.87
Euchone pallida	0.85	1.47	0.91	3.54	43.41
Gari sp. (juvenile)	0.91	1.46	0.93	3.51	46.92
Terebellidae	0.78	1.45	0.95	3.49	50.41
Phoxocephalidae	0.80	1.21	0.74	2.91	53.32
Sigalionidae	0.64	0.96	0.67	2.31	55.63
Barantolla lepte	0.65	0.92	0.63	2.22	57.85
Nemertea	0.64	0.91	0.68	2.18	60.03
Bryozoa (discoid)	0.65	0.88	0.59	2.11	62.14
Bryozoa (solid Stalked)	0.56	0.86	0.68	2.07	64.21
Ampharetidae	0.71	0.85	0.53	2.03	66.25
Pagurus sp.	0.63	0.83	0.60	2.00	68.25
Syllidae	0.61	0.80	0.61	1.91	70.16

Group 12 - Average similarity: 53.69

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Spiophanes kroyeri	3.30	6.09	2.79	11.34	11.34
Amphipoda Unid.	2.55	5.16	5.90	9.61	20.95
Terebellidae	1.82	3.51	3.59	6.54	27.50
Maldanidae	1.90	3.51	3.15	6.54	34.04
Nemertea	1.12	2.00	1.90	3.73	37.77
Prionospio multicristata	1.23	1.97	1.38	3.66	41.43
Eugyra sp.	1.14	1.89	1.39	3.52	44.95
Phyllodocidae	1.05	1.77	1.49	3.30	48.25
Cumacea	1.14	1.75	1.30	3.26	51.51
Urothoidae	1.20	1.61	0.95	2.99	54.50
Phoxocephalidae	1.08	1.55	1.16	2.88	57.38
Spio sp.	1.02	1.49	1.07	2.77	60.15
Nucula nitidula	0.93	1.39	1.19	2.60	62.75
Pagurus sp.	0.87	1.25	1.06	2.33	65.08
Paraprionospio pinnata	0.99	1.16	0.82	2.16	67.24
Eurylana cookii	0.80	1.07	0.88	1.99	69.23
Sigalionidae	0.70	0.89	0.75	1.65	70.88

Groups 1 & 6 - Average dissimilarity = 74.58

Species	Group 1 Av.Abund	Group 6 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Phyllodocidae	0.02	1.04	2.09	2.23	2.81	2.81
Sigapatella tenuis	0.26	1.12	1.99	1.43	2.67	5.48
Maldanidae	0.55	1.31	1.99	1.20	2.67	8.15
Scalpomactra scalpellum	0.08	0.96	1.98	1.57	2.65	10.80
Tawera spissa	0.10	1.03	1.97	1.23	2.64	13.44
Gari sp. (juvenile)	0.09	0.91	1.70	1.37	2.28	15.72
Urothoidae	0.73	0.69	1.64	1.19	2.20	17.92
Ampharetidae	0.35	0.71	1.59	0.97	2.13	20.05
Amphipoda Unid.	0.91	1.27	1.56	1.15	2.09	22.14
Nucula nitidula	0.59	1.06	1.56	1.19	2.09	24.22
Terebellidae	0.02	0.78	1.56	1.39	2.09	26.31
Epigonichthys hectori	0.33	0.86	1.50	1.26	2.01	28.32
Phoxocephalidae	0.35	0.80	1.49	1.13	1.99	30.32
Euchone pallida	0.47	0.85	1.45	1.14	1.95	32.26
Pagurus sp.	0.85	0.63	1.44	1.07	1.92	34.19
Spiophanes kroyeri	0.39	0.58	1.36	1.03	1.82	36.01
Zemysina sp.	0.40	0.57	1.32	1.00	1.78	37.78
Bryozoa (discoid)	0.37	0.65	1.29	0.97	1.74	39.52
Barantolla lepte	0.54	0.65	1.29	1.06	1.73	41.25
Armandia maculata	0.51	0.49	1.24	1.01	1.67	42.92
Cumacea	0.48	0.55	1.23	1.00	1.65	44.57
Nemertea	0.22	0.64	1.21	1.09	1.62	46.19
Sigalionidae	0.66	0.64	1.20	1.05	1.61	47.80
Syllidae	0.17	0.61	1.18	1.03	1.58	49.39
Corbula zelandica	0.27	0.46	1.08	0.87	1.45	50.84
Bryozoa (solid Stalked)	0.00	0.56	1.08	1.08	1.45	52.29
Eurylana cookii	0.24	0.50	1.08	0.93	1.45	53.74
Callianassa filholi	0.41	0.29	1.01	0.88	1.35	55.09
Glyceridae	0.15	0.50	1.00	0.90	1.34	56.43
Onuphis aucklandensis	0.44	0.17	0.97	0.85	1.30	57.73
Pratulum pulchellum	0.38	0.22	0.94	0.80	1.26	58.99
Magelona dakini	0.00	0.50	0.93	0.83	1.24	60.23
Haustoriidae	0.00	0.43	0.92	0.70	1.24	61.47
Lumbrineridae	0.23	0.37	0.92	0.86	1.23	62.70
Aglaophamus sp.	0.22	0.39	0.89	0.83	1.19	63.89
Dosinia subrosea	0.23	0.27	0.84	0.74	1.13	65.01
Anthuridea	0.06	0.39	0.83	0.75	1.11	66.12
Myllitella vivens vivens	0.16	0.31	0.82	0.66	1.10	67.22
Prionospio sp.	0.02	0.42	0.79	0.72	1.06	68.28
Mysidacea	0.16	0.32	0.78	0.75	1.04	69.32
Philine sp	0.02	0.39	0.75	0.72	1.01	70.34

Groups 1 & 12 - Average dissimilarity = 74.91

Species	Group 1 Av.Abund	Group 12 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Spiophanes kroyeri	0.39	3.30	4.97	2.32	6.63	6.63
Terebellidae	0.02	1.82	3.03	3.60	4.04	10.67
Amphipoda Unid.	0.91	2.55	2.78	2.21	3.71	14.38
Maldanidae	0.55	1.90	2.33	1.74	3.11	17.49
Eugyra sp.	0.00	1.14	1.94	1.91	2.59	20.08
Prionospio multicristata	0.17	1.23	1.88	1.66	2.51	22.60
Phyllodocidae	0.02	1.05	1.73	2.05	2.32	24.91
Spio sp.	0.04	1.02	1.70	1.54	2.27	27.18
Paraprionospio pinnata	0.08	0.99	1.60	1.21	2.14	29.32
Nemertea	0.22	1.12	1.60	1.73	2.13	31.45
Cumacea	0.48	1.14	1.53	1.35	2.04	33.50
Urothoidae	0.73	1.20	1.53	1.34	2.04	35.53
Phoxocephalidae	0.35	1.08	1.49	1.38	1.98	37.52
Eurylana cookii	0.24	0.80	1.20	1.22	1.60	39.12
Sigapatella tenuis	0.26	0.75	1.17	1.07	1.56	40.68
Tawera spissa	0.10	0.74	1.15	1.12	1.53	42.22
Nucula nitidula	0.59	0.93	1.12	1.16	1.50	43.72
Lysianassidae	0.13	0.71	1.11	1.02	1.49	45.20
Euchone pallida	0.47	0.67	1.11	1.15	1.48	46.68
Pagurus sp.	0.85	0.87	1.09	1.07	1.46	48.14
Pratulum pulchellum	0.38	0.60	1.06	1.05	1.42	49.56
Armandia maculata	0.51	0.70	1.05	1.09	1.41	50.97
Mysidacea	0.16	0.65	1.04	1.07	1.39	52.36
Barantolla lepte	0.54	0.53	1.04	1.07	1.38	53.74
Ampharetidae	0.35	0.51	1.03	0.94	1.38	55.12
Aglaophamus sp.	0.22	0.63	1.01	1.03	1.34	56.46
Callianassa filholi	0.41	0.60	1.00	1.07	1.33	57.79
Hydroides sp	0.00	0.65	0.99	0.86	1.32	59.11
Syllidae	0.17	0.63	0.99	1.09	1.32	60.43
Sigalionidae	0.66	0.70	0.97	1.05	1.30	61.73
Bryozoa (discoid)	0.37	0.54	0.94	0.89	1.26	62.99
Philocheras australis	0.02	0.54	0.89	0.96	1.19	64.17
Zemysina sp.	0.40	0.35	0.88	0.90	1.17	65.35
Cirratulidae	0.10	0.50	0.85	0.85	1.14	66.49
Magelona dakini	0.00	0.51	0.84	0.85	1.12	67.61
Glyceridae	0.15	0.49	0.84	0.89	1.12	68.73
Polynoidae	0.00	0.48	0.83	0.84	1.11	69.84
Prionospio sp.	0.02	0.42	0.72	0.74	0.97	70.81

Groups 6 & 12 - Average dissimilarity = 62.69

Species	Group 6 Av.Abund	Group 12 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Spiophanes kroyeri	0.58	3.30	3.48	2.16	5.55	5.55
Amphipoda Unid.	1.27	2.55	1.77	1.55	2.83	8.38
Prionospio multicristata	0.02	1.23	1.55	1.83	2.47	10.85
Terebellidae	0.78	1.82	1.36	1.56	2.16	13.01
Eugyra sp.	0.13	1.14	1.34	1.69	2.13	15.15
Urothoidae	0.69	1.20	1.29	1.31	2.06	17.21
Maldanidae	1.31	1.90	1.14	1.15	1.82	19.02
Paraprionospio pinnata	0.25	0.99	1.14	1.19	1.82	20.84
Cumacea	0.55	1.14	1.10	1.30	1.76	22.60
Spio sp.	0.34	1.02	1.08	1.29	1.72	24.32
Sigapatella tenuis	1.12	0.75	1.05	1.30	1.67	25.99
Tawera spissa	1.03	0.74	1.04	1.17	1.66	27.65
Gari sp. (juvenile)	0.91	0.17	1.04	1.34	1.65	29.30
Scalpomactra scalpellum	0.96	0.30	1.03	1.35	1.64	30.94
Epigonichthys hectori	0.86	0.16	1.00	1.36	1.59	32.53
Ampharetidae	0.71	0.51	0.95	1.02	1.51	34.04
Phoxocephalidae	0.80	1.08	0.94	1.19	1.50	35.53
Euchone pallida	0.85	0.67	0.86	1.18	1.37	36.91
Lysianassidae	0.28	0.71	0.86	1.07	1.37	38.28
Nemertea	0.64	1.12	0.85	1.15	1.35	39.63
Hydroides sp	0.42	0.65	0.84	0.99	1.35	40.98
Armandia maculata	0.49	0.70	0.84	1.12	1.34	42.32
Barantolla lepte	0.65	0.53	0.83	1.12	1.33	43.64
Eurylana cookii	0.50	0.80	0.83	1.16	1.32	44.96
Pagurus sp.	0.63	0.87	0.83	1.14	1.32	46.28
Zemysina sp.	0.57	0.35	0.79	1.00	1.26	47.54
Mysidacea	0.32	0.65	0.78	1.10	1.25	48.79
Aglaophamus sp.	0.39	0.63	0.77	1.06	1.23	50.02
Bryozoa (discoïd)	0.65	0.54	0.76	0.98	1.21	51.23
Pratulium pulchellum	0.22	0.60	0.75	0.99	1.20	52.43
Syllidae	0.61	0.63	0.75	1.09	1.20	53.63
Sigalionidae	0.64	0.70	0.75	1.09	1.19	54.82
Magelona dakini	0.50	0.51	0.74	1.03	1.18	56.00
Callianassa filholi	0.29	0.60	0.74	1.04	1.18	57.18
Prionospio sp.	0.42	0.42	0.74	0.98	1.18	58.36
Glyceridae	0.50	0.49	0.73	1.03	1.16	59.52
Nucula nitidula	1.06	0.93	0.73	1.02	1.16	60.68
Cirratulidae	0.35	0.50	0.71	0.97	1.13	61.80
Bryozoa (solid Stalked)	0.56	0.05	0.68	1.10	1.08	62.88
Corbula zelandica	0.46	0.29	0.67	0.88	1.07	63.96
Philocheras australis	0.07	0.54	0.67	0.97	1.06	65.02
Anthuridea	0.39	0.40	0.66	0.94	1.06	66.08
Polynoidae	0.08	0.48	0.63	0.87	1.01	67.09
Haustoriidae	0.43	0.13	0.61	0.78	0.97	68.06
Lumbrineridae	0.37	0.26	0.57	0.89	0.92	68.97
Hesionidae	0.21	0.38	0.57	0.84	0.91	69.89
Phyllodocidae	1.04	1.05	0.57	0.93	0.91	70.80

Area groups (across all Survey groups)**Group Recovery - Average similarity: 42.00**

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Amphipoda Unid.	1.53	3.83	1.32	9.13	9.13
Spiophanes kroyeri	1.45	2.66	0.79	6.34	15.47
Maldanidae	1.09	1.93	0.87	4.61	20.07
Terebellidae	0.95	1.90	1.02	4.52	24.59
Sigalionidae	0.68	1.80	0.63	4.28	28.88
Urothoidae	0.81	1.72	0.56	4.10	32.98
Pagurus sp.	0.79	1.63	0.65	3.87	36.86
Phyllodocidae	0.75	1.60	1.05	3.82	40.67
Nucula nitidula	0.76	1.50	0.75	3.57	44.24
Barantolla lepte	0.65	1.24	0.55	2.96	47.20
Phoxocephalidae	0.72	1.14	0.63	2.71	49.91
Cumacea	0.70	1.12	0.64	2.68	52.58
Euchone pallida	0.69	1.11	0.64	2.65	55.23
Nemertea	0.63	1.03	0.73	2.45	57.69
Sigapatella tenuis	0.67	1.00	0.59	2.38	60.07
Scalpomactra scalpellum	0.49	0.92	0.56	2.18	62.25
Prionospio multicristata	0.53	0.85	0.58	2.03	64.28
Armandia maculata	0.56	0.82	0.41	1.95	66.23
Spio sp.	0.55	0.81	0.63	1.93	68.16
Eugyra sp.	0.46	0.76	0.59	1.81	69.97
Callianassa filholi	0.47	0.75	0.42	1.77	71.74

Group Control - Average similarity: 42.40

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Amphipoda Unid.	1.63	3.91	1.57	9.23	9.23
Maldanidae	1.45	3.34	1.46	7.88	17.11
Spiophanes kroyeri	1.39	2.20	0.78	5.19	22.30
Nucula nitidula	0.98	1.92	0.95	4.54	26.84
Urothoidae	0.95	1.87	0.73	4.42	31.26
Pagurus sp.	0.77	1.84	0.74	4.33	35.59
Terebellidae	0.79	1.32	0.82	3.12	38.70
Bryozoa (discoïd)	0.76	1.21	0.62	2.86	41.56
Cumacea	0.75	1.21	0.61	2.86	44.43
Sigalionidae	0.65	1.21	0.62	2.85	47.28
Sigapatella tenuis	0.76	1.17	0.72	2.75	50.03
Phoxocephalidae	0.77	1.13	0.71	2.67	52.70
Nemertea	0.70	1.11	0.76	2.62	55.32
Phyllodocidae	0.65	1.11	0.84	2.61	57.93
Euchone pallida	0.64	1.09	0.58	2.57	60.49
Tawera spissa	0.67	0.99	0.68	2.34	62.83
Armandia maculata	0.58	0.90	0.49	2.12	64.95
Epigonichthys hectori	0.47	0.69	0.44	1.64	66.58
Eurylana cookii	0.54	0.69	0.54	1.63	68.21
Onuphis aucklandensis	0.26	0.65	0.34	1.54	69.75
Syllidae	0.52	0.60	0.52	1.43	71.18

Groups Recovery & Control - Average dissimilarity = 58.60

Species	Recovery Av.Abund	Control Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Urothoidae	0.81	0.95	1.51	1.02	2.57	2.57
Maldanidae	1.09	1.45	1.47	0.95	2.51	5.08
Spiophanes kroyeri	1.45	1.39	1.40	0.87	2.39	7.47
Bryozoa (discoïd)	0.31	0.76	1.34	0.87	2.29	9.76
Pagurus sp.	0.79	0.77	1.32	0.83	2.25	12.02
Cumacea	0.70	0.75	1.28	0.87	2.18	14.20
Barantolla lepte	0.65	0.49	1.27	0.88	2.17	16.37
Nucula nitidula	0.76	0.98	1.26	0.84	2.16	18.53
Ampharetidae	0.58	0.46	1.24	0.81	2.12	20.65
Euchone pallida	0.69	0.64	1.24	0.87	2.12	22.76
Amphipoda Unid.	1.53	1.63	1.21	0.80	2.07	24.83
Armandia maculata	0.56	0.58	1.21	0.85	2.06	26.89
Sigalionidae	0.68	0.65	1.17	0.83	2.00	28.89
Zemysina sp.	0.43	0.46	1.16	0.79	1.98	30.87
Phoxocephalidae	0.72	0.77	1.16	0.87	1.97	32.84
Sigapatella tenuis	0.67	0.76	1.07	0.86	1.83	34.68
Callianassa filholi	0.47	0.40	1.05	0.76	1.78	36.46
Pratulum pulchellum	0.41	0.38	1.04	0.70	1.77	38.23
Epigonichthys hectori	0.43	0.47	0.96	0.68	1.63	39.86
Tawera spissa	0.58	0.67	0.94	0.79	1.61	41.47
Eurylana cookii	0.49	0.54	0.93	0.79	1.59	43.07
Corbula zelandica	0.40	0.27	0.90	0.72	1.53	44.59
Aglaophamus sp.	0.38	0.45	0.87	0.75	1.48	46.07
Nemertea	0.63	0.70	0.86	0.72	1.46	47.54
Onuphis aucklandensis	0.16	0.26	0.83	0.55	1.42	48.96
Lumbrineridae	0.25	0.32	0.83	0.66	1.42	50.37
Syllidae	0.43	0.52	0.82	0.78	1.40	51.78
Dosinia subrosea	0.29	0.24	0.82	0.62	1.40	53.17
Glyceridae	0.35	0.41	0.77	0.74	1.32	54.49
Mysidacea	0.36	0.40	0.77	0.71	1.31	55.80
Lysianassidae	0.29	0.46	0.75	0.71	1.28	57.08
Paraprionospio pinnata	0.51	0.36	0.68	0.66	1.16	58.24
Cirratulidae	0.26	0.38	0.67	0.73	1.14	59.39
Myllitella vivens vivens	0.24	0.21	0.66	0.58	1.12	60.51
Gari sp. (juvenile)	0.36	0.43	0.65	0.60	1.10	61.61
Scalpomactra scalpellum	0.49	0.40	0.64	0.62	1.09	62.71
Spio sp.	0.55	0.37	0.62	0.73	1.06	63.77
Prionospio multicristata	0.53	0.40	0.60	0.57	1.03	64.80
Hydroides sp	0.27	0.45	0.57	0.71	0.97	65.77
Anthuridea	0.31	0.25	0.55	0.68	0.94	66.72
Prionospio sp.	0.31	0.26	0.55	0.67	0.94	67.66
Magelona dakini	0.27	0.42	0.54	0.75	0.91	68.57
Other Gastropoda	0.23	0.19	0.53	0.61	0.90	69.47
cf Tethyopsis sp.	0.17	0.16	0.52	0.52	0.89	70.36

Table H.10 SIMPER - Similarity Percentages - species contributions of Benthic biota by Survey and Area groupings pairwise**Parameters**

Resemblance: S17 Bray-Curtis similarity

Cut off for low contributions: 70.00%

Group 1 Recovery - Average similarity: 30.68

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Amphipoda Unid.	0.95	4.45	1.16	14.49	14.49
Sigalionidae	0.77	3.67	0.92	11.97	26.47
Urothoidae	0.73	3.13	0.70	10.19	36.66
Pagurus sp.	0.85	2.76	0.77	9.00	45.66
Barantolla lepte	0.64	2.04	0.63	6.66	52.33
Nucula nitidula	0.56	1.56	0.58	5.07	57.40
Callianassa filholi	0.51	1.40	0.52	4.55	61.95
Armandia maculata	0.51	1.39	0.46	4.54	66.49
Pratulum pulchellum	0.44	1.17	0.41	3.81	70.30

Group 1 Control - Average similarity: 31.83

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Amphipoda Unid.	0.87	3.75	1.03	11.78	11.78
Pagurus sp.	0.84	3.47	1.03	10.90	22.68
Urothoidae	0.73	2.86	0.82	9.00	31.68
Maldanidae	0.74	2.71	0.82	8.51	40.19
Onuphis aucklandensis	0.62	1.93	0.65	6.06	46.24
Sigalionidae	0.53	1.61	0.58	5.06	51.30
Nucula nitidula	0.64	1.50	0.52	4.72	56.03
Cumacea	0.54	1.45	0.52	4.56	60.59
Armandia maculata	0.52	1.42	0.51	4.47	65.06
Euchone pallida	0.52	1.18	0.46	3.69	68.75
Zemysina sp.	0.50	1.12	0.45	3.53	72.28

Group 6 Recovery - Average similarity: 40.93

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Phyllodocidae	1.11	2.76	2.15	6.74	6.74
Scalpomactra scalpellum	1.06	2.53	1.31	6.17	12.91
Sigapatella tenuis	1.15	2.27	1.14	5.54	18.45
Amphipoda Unid.	1.10	1.88	0.94	4.59	23.04
Terebellidae	0.89	1.84	1.15	4.49	27.52
Nucula nitidula	0.94	1.82	1.01	4.44	31.96
Tawera spissa	1.12	1.67	0.84	4.08	36.05
Epigonichthys hectori	0.86	1.58	0.94	3.86	39.91
Maldanidae	1.04	1.57	0.80	3.84	43.74
Gari sp. (juvenile)	0.85	1.32	0.86	3.23	46.97
Euchone pallida	0.78	1.24	0.75	3.03	50.00
Barantolla lepte	0.76	1.24	0.77	3.03	53.03
Bryozoa (solid Stalked)	0.67	1.20	0.85	2.94	55.96
Ampharetidae	0.83	1.17	0.67	2.87	58.83
Phoxocephalidae	0.75	1.17	0.70	2.85	61.68
Nemertea	0.63	0.97	0.70	2.38	64.07
Sigalionidae	0.61	0.91	0.63	2.23	66.30
Pagurus sp.	0.62	0.84	0.57	2.04	68.34
Syllidae	0.55	0.74	0.58	1.80	70.14

Group 6 Control - Average similarity: 42.66

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Maldanidae	1.64	3.74	2.02	8.76	8.76
Amphipoda Unid.	1.47	2.85	1.92	6.68	15.44
Nucula nitidula	1.20	2.50	1.60	5.85	21.29
Sigapatella tenuis	1.08	1.99	1.17	4.67	25.96
Phyllodocidae	0.95	1.94	1.39	4.55	30.51
Euchone pallida	0.93	1.80	1.16	4.21	34.71
Gari sp. (juvenile)	0.99	1.66	1.03	3.89	38.60
Scalpomactra scalpellum	0.84	1.57	1.03	3.67	42.27
Bryozoa (discoid)	0.87	1.54	0.90	3.62	45.89
Tawera spissa	0.92	1.44	0.92	3.38	49.27
Epigonichthys hectori	0.85	1.34	0.92	3.13	52.41
Phoxocephalidae	0.85	1.27	0.80	2.98	55.39
Urothoidae	0.84	1.10	0.63	2.57	57.96
Sigalionidae	0.68	1.03	0.72	2.42	60.38
Magelona dakini	0.68	0.95	0.74	2.23	62.61
Terebellidae	0.67	0.93	0.73	2.17	64.77
Syllidae	0.68	0.88	0.65	2.07	66.84
Spiophanes kroyeri	0.63	0.87	0.58	2.05	68.89
Cumacea	0.66	0.85	0.64	2.00	70.88

Group 12 Recovery - Average similarity: 54.39

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Spiophanes kroyeri	3.40	6.60	3.16	12.14	12.14
Amphipoda Unid.	2.55	5.17	5.47	9.51	21.65
Terebellidae	1.91	3.86	6.08	7.09	28.74
Maldanidae	1.85	3.46	2.71	6.36	35.09
Prionospio multicristata	1.40	2.37	1.78	4.36	39.46
Eugyra sp.	1.23	2.22	1.76	4.08	43.54
Phyllodocidae	1.13	2.05	1.80	3.77	47.31
Cumacea	1.21	2.05	1.74	3.77	51.08
Spio sp.	1.21	2.00	1.55	3.67	54.75
Nemertea	1.11	1.98	1.82	3.65	58.40
Urothoidae	1.15	1.57	0.91	2.88	61.28
Phoxocephalidae	1.00	1.42	1.04	2.61	63.88
Paraprionospio pinnata	1.04	1.32	0.90	2.42	66.30
Pagurus sp.	0.91	1.28	1.06	2.36	68.66
Euchone pallida	0.86	1.25	1.07	2.30	70.96

Group 12 Control - Average similarity: 52.72

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Spiophanes kroyeri	3.18	5.38	2.54	10.20	10.20
Amphipoda Unid.	2.55	5.15	6.72	9.76	19.96
Maldanidae	1.95	3.58	4.28	6.79	26.76
Terebellidae	1.70	3.04	2.63	5.76	32.52
Nemertea	1.13	2.03	2.03	3.86	36.38
Nucula nitidula	1.09	1.77	1.67	3.36	39.74
Phoxocephalidae	1.17	1.72	1.35	3.27	43.01
Urothoidae	1.27	1.66	1.01	3.15	46.16
Eugyra sp.	1.04	1.43	1.05	2.72	48.87
Prionospio multicristata	1.03	1.40	1.05	2.66	51.53
Phyllodocidae	0.97	1.38	1.21	2.61	54.15
Tawera spissa	0.93	1.36	1.05	2.58	56.73
Cumacea	1.06	1.34	0.91	2.53	59.26
Eurylana cookii	0.89	1.29	1.03	2.45	61.71
Pagurus sp.	0.84	1.21	1.05	2.29	64.00
Sigapatella tenuis	0.92	1.17	0.91	2.21	66.21
Lysianassidae	0.95	1.15	0.90	2.19	68.40
Philocheras australis	0.75	1.06	0.93	2.02	70.42

Groups 1 Recovery & 1 Control - Average dissimilarity = 69.34

Species	Group	Group	Av.Diss	Diss/SD	Contrib%	Cum.%
	1 Recovery	1 Control				
	Av.Abund	Av.Abund				
Pagurus sp.	0.85	0.84	2.40	1.10	3.46	3.46
Maldanidae	0.39	0.74	2.29	1.14	3.30	6.76
Nucula nitidula	0.56	0.64	2.26	1.11	3.26	10.02
Urothoidae	0.73	0.73	2.18	1.11	3.14	13.16
Barantolla lepte	0.64	0.42	2.13	1.06	3.07	16.23
Cumacea	0.43	0.54	2.08	1.00	3.00	19.23
Onuphis aucklandensis	0.28	0.62	2.07	1.04	2.98	22.21
Armandia maculata	0.51	0.52	2.03	1.03	2.92	25.14
Euchone pallida	0.42	0.52	2.01	0.99	2.90	28.04
Sigalionidae	0.77	0.53	1.99	1.00	2.88	30.91
Bryozoa (discoïd)	0.25	0.51	1.98	0.88	2.85	33.77
Spiophanes kroyeri	0.43	0.35	1.95	0.83	2.82	36.58
Zemysina sp.	0.31	0.50	1.92	0.93	2.77	39.35
Amphipoda Unid.	0.95	0.87	1.92	0.90	2.77	42.12
Pratulium pulchellum	0.44	0.30	1.89	0.88	2.72	44.84
Callianassa filholi	0.51	0.30	1.85	0.96	2.66	47.51
Ampharetidae	0.32	0.40	1.73	0.79	2.50	50.01
Epigonichthys hectori	0.27	0.39	1.67	0.83	2.40	52.41
Phoxocephalidae	0.40	0.28	1.63	0.86	2.35	54.76
Dosinia subrosea	0.16	0.33	1.40	0.72	2.02	56.78
Lumbrineridae	0.16	0.32	1.35	0.72	1.94	58.72
Corbula zelandica	0.29	0.26	1.34	0.75	1.93	60.65
Sigapatella tenuis	0.24	0.28	1.33	0.73	1.92	62.57
Eurylana cookii	0.27	0.22	1.26	0.73	1.81	64.38
Nemertea	0.15	0.31	1.25	0.71	1.80	66.18
Aglaophamus sp.	0.19	0.26	1.17	0.69	1.68	67.87
Mysidacea	0.11	0.23	0.96	0.60	1.38	69.25
Syllidae	0.11	0.23	0.92	0.61	1.33	70.58

Groups 6 Recovery & 6 Control - Average dissimilarity = 59.11

Species	Group	Group	Av.Diss	Diss/SD	Contrib%	Cum.%
	6 Recovery	6 Control				
	Av.Abund	Av.Abund				
Maldanidae	1.04	1.64	1.45	1.15	2.45	2.45
Urothoidae	0.56	0.84	1.30	1.12	2.20	4.64
Tawera spissa	1.12	0.92	1.28	1.25	2.17	6.81
Ampharetidae	0.83	0.56	1.27	1.12	2.14	8.95
Amphipoda Unid.	1.10	1.47	1.22	1.11	2.06	11.01
Bryozoa (discoïd)	0.46	0.87	1.12	1.18	1.89	12.90
Phoxocephalidae	0.75	0.85	1.05	1.16	1.78	14.68
Gari sp. (juvenile)	0.85	0.99	1.04	1.20	1.76	16.44
Zemysina sp.	0.61	0.53	1.02	1.06	1.72	18.16
Sigapatella tenuis	1.15	1.08	1.01	1.14	1.71	19.87
Barantolla lepte	0.76	0.52	0.99	1.17	1.68	21.54
Spiophanes kroyeri	0.54	0.63	0.94	1.07	1.59	23.13
Magelona dakini	0.35	0.68	0.93	1.15	1.57	24.70
Euchone pallida	0.78	0.93	0.93	1.09	1.57	26.27
Pagurus sp.	0.62	0.64	0.92	1.10	1.56	27.83
Cumacea	0.45	0.66	0.92	1.07	1.56	29.39
Epigonichthys hectori	0.86	0.85	0.91	1.11	1.54	30.93
Syllidae	0.55	0.68	0.90	1.11	1.52	32.45
Nucula nitidula	0.94	1.20	0.90	1.05	1.51	33.96
Haustoriidae	0.40	0.47	0.88	0.93	1.49	35.45
Armandia maculata	0.47	0.51	0.87	1.00	1.47	36.92
Corbula zelandica	0.54	0.36	0.87	0.98	1.47	38.39
Nemertea	0.63	0.66	0.86	1.10	1.45	39.85
Sigalionidae	0.61	0.68	0.86	1.07	1.45	41.30
Eurylana cookii	0.48	0.52	0.86	1.04	1.45	42.75
Terebellidae	0.89	0.67	0.84	1.05	1.42	44.17
Glyceridae	0.50	0.51	0.83	1.04	1.41	45.58
Scalpomactra scalpellum	1.06	0.84	0.82	1.11	1.40	46.98
Hydroides sp.	0.33	0.51	0.82	0.92	1.38	48.36
Prionospio sp.	0.35	0.50	0.81	0.96	1.37	49.73
Bryozoa (solid Stalked)	0.67	0.43	0.77	1.02	1.30	51.03
Cirratulidae	0.17	0.55	0.77	0.97	1.30	52.34
Sabellidae	0.56	0.13	0.76	1.00	1.29	53.62
Philine sp.	0.32	0.48	0.76	0.95	1.28	54.90
Anthuridea	0.36	0.42	0.75	0.92	1.27	56.17
Aglaophamus sp.	0.41	0.36	0.72	0.92	1.21	57.38
Myllitella vivens vivens	0.32	0.29	0.71	0.75	1.20	58.58
Lumbrineridae	0.46	0.26	0.69	0.93	1.17	59.74
Spio sp.	0.44	0.22	0.67	0.89	1.13	60.88
Mysidacea	0.35	0.29	0.66	0.85	1.11	61.99
Orbinia papillosa	0.24	0.40	0.65	0.87	1.10	63.09
Other Gastropoda	0.35	0.23	0.63	0.81	1.07	64.16
Callianassa filholi	0.30	0.28	0.62	0.81	1.05	65.21
Lysianassidae	0.29	0.26	0.62	0.74	1.05	66.26
Ophiuroidea	0.29	0.34	0.61	0.83	1.03	67.29
Phyllodocidae	1.11	0.95	0.61	0.85	1.02	68.31
Dosinia subrosea	0.37	0.15	0.59	0.76	1.01	69.32
Paraprionospio pinnata	0.33	0.15	0.58	0.73	0.98	70.30

Groups 12 Recovery & 12 Control - Average dissimilarity = 47.35

Species	Group	Group	Av.Diss	Diss/SD	Contrib%	Cum.%
	12 Recovery	12 Control				
	Av.Abund	Av.Abund				
Spiophanes kroyeri	3.40	3.18	1.32	1.33	2.79	2.79
Urothoidae	1.15	1.27	1.04	1.25	2.20	4.99
Paraprionospio pinnata	1.04	0.92	1.00	1.23	2.10	7.09
Bryozoa (discoid)	0.23	0.91	0.93	1.24	1.96	9.05
Spio sp.	1.21	0.80	0.91	1.29	1.92	10.96
Hydroides sp	0.49	0.84	0.90	1.11	1.89	12.85
Sigapatella tenuis	0.61	0.92	0.89	1.24	1.87	14.73
Lysianassidae	0.51	0.95	0.87	1.24	1.84	16.57
Cumacea	1.21	1.06	0.84	1.19	1.77	18.34
Prionospio multicristata	1.40	1.03	0.84	1.18	1.76	20.10
Tawera spissa	0.58	0.93	0.81	1.27	1.70	21.81
Phoxocephalidae	1.00	1.17	0.79	1.13	1.66	23.47
Euchone pallida	0.86	0.46	0.78	1.26	1.65	25.12
Polydora sp.	0.36	0.46	0.77	0.67	1.62	26.74
Pratulium pulchellum	0.62	0.57	0.74	1.11	1.57	28.31
Ampharetidae	0.59	0.41	0.73	1.03	1.55	29.85
Armandia maculata	0.69	0.71	0.72	1.18	1.53	31.38
Aglaophamus sp.	0.55	0.72	0.72	1.14	1.51	32.89
Philocheras australis	0.36	0.75	0.71	1.21	1.49	34.39
Eugyra sp.	1.23	1.04	0.70	1.05	1.48	35.86
Barantolla lepte	0.54	0.53	0.70	1.07	1.47	37.33
Mysidacea	0.60	0.69	0.69	1.13	1.47	38.80
Cirratulidae	0.49	0.50	0.68	1.04	1.44	40.25
Eurylana cookii	0.71	0.89	0.68	1.14	1.44	41.68
Magelona dakini	0.45	0.58	0.68	1.07	1.43	43.12
Maldanidae	1.85	1.95	0.67	1.21	1.42	44.54
Prionospio sp.	0.58	0.23	0.67	0.99	1.42	45.96
Callianassa filholi	0.58	0.62	0.67	1.10	1.41	47.37
Sigalionidae	0.66	0.74	0.66	1.10	1.40	48.77
Glyceridae	0.46	0.53	0.65	1.03	1.37	50.13
Syllidae	0.61	0.65	0.64	1.08	1.36	51.49
Pagurus sp.	0.91	0.84	0.64	1.08	1.35	52.84
Nucula nitidula	0.79	1.09	0.63	1.05	1.34	54.18
Polynoidae	0.54	0.41	0.63	1.02	1.34	55.52
Anthuridea	0.45	0.34	0.59	0.95	1.25	56.77
Phyllodocidae	1.13	0.97	0.58	0.96	1.23	58.01
Terebellidae	1.91	1.70	0.57	1.18	1.21	59.21
Phoronis sp.	0.42	0.25	0.57	0.79	1.20	60.41
Hesionidae	0.44	0.30	0.56	0.93	1.18	61.59
Zemysina sp.	0.37	0.33	0.55	0.89	1.16	62.75
Other Polychaeta	0.23	0.44	0.54	0.92	1.14	63.89
Orbinia papillosa	0.31	0.38	0.52	0.89	1.10	64.99
Gari convexa	0.30	0.35	0.52	0.83	1.09	66.08
Ophiuroidea	0.33	0.30	0.50	0.83	1.07	67.14
Amphipoda Unid.	2.55	2.55	0.50	1.35	1.05	68.19
Tonna sp. (juvenile)	0.17	0.39	0.49	0.81	1.03	69.22
Corbula zelandica	0.36	0.20	0.48	0.76	1.02	70.24

Groups 1 Recovery & 6 Recovery - Average dissimilarity = 76.14

Species	Group	Group	Av.Diss	Diss/SD	Contrib%	Cum.%
	1 Recovery	6 Recovery				
	Av.Abund	Av.Abund				
Phyllodocidae	0.00	1.11	2.34	2.69	3.08	3.08
Scalpomactra scalpellum	0.04	1.06	2.30	1.81	3.02	6.09
Tawera spissa	0.04	1.12	2.23	1.25	2.94	9.03
Sigapatella tenuis	0.24	1.15	2.15	1.45	2.82	11.85
Maldanidae	0.39	1.04	1.96	1.18	2.57	14.42
Terebellidae	0.04	0.89	1.81	1.59	2.38	16.80
Ampharetidae	0.32	0.83	1.78	1.03	2.33	19.13
Urothoidae	0.73	0.56	1.72	1.18	2.27	21.39
Gari sp. (juvenile)	0.07	0.85	1.63	1.30	2.15	23.54
Amphipoda Unid.	0.95	1.10	1.62	1.16	2.12	25.66
Pagurus sp.	0.85	0.62	1.61	1.09	2.12	27.78
Epigonichthys hectori	0.27	0.86	1.59	1.28	2.09	29.87
Nucula nitidula	0.56	0.94	1.51	1.13	1.99	31.86
Euchone pallida	0.42	0.78	1.51	1.11	1.98	33.84
Phoxocephalidae	0.40	0.75	1.46	1.11	1.92	35.76
Barantolla lepte	0.64	0.76	1.39	1.11	1.83	37.59
Zemysina sp.	0.31	0.61	1.35	0.97	1.77	39.36
Bryozoa (solid Stalked)	0.00	0.67	1.34	1.31	1.77	41.13
Spiophanes kroyeri	0.43	0.54	1.33	1.00	1.75	42.87
Armandia maculata	0.51	0.47	1.31	1.00	1.73	44.60
Sigalionidae	0.77	0.61	1.25	1.05	1.64	46.24
Nemertea	0.15	0.63	1.25	1.09	1.64	47.89
Corbula zelandica	0.29	0.54	1.25	0.95	1.64	49.53
Cumacea	0.43	0.45	1.23	0.95	1.61	51.14
Bryozoa (discoid)	0.25	0.46	1.13	0.84	1.49	52.63
Syllidae	0.11	0.55	1.13	0.98	1.49	54.12
Callianassa filholi	0.51	0.30	1.12	0.96	1.47	55.59
Sabellidae	0.00	0.56	1.09	0.98	1.43	57.02
Eurylana cookii	0.27	0.48	1.08	0.92	1.42	58.45
Glyceridae	0.11	0.50	1.03	0.89	1.35	59.79
Pratulium pulchellum	0.44	0.19	1.02	0.84	1.34	61.13
Lumbrineridae	0.16	0.46	0.97	0.89	1.28	62.41
Mytilitella vivens vivens	0.21	0.32	0.93	0.72	1.22	63.63
Aglaophamus sp.	0.19	0.41	0.92	0.82	1.21	64.83
Dosinia subrosea	0.16	0.37	0.90	0.75	1.18	66.01
Paraprionospio pinnata	0.15	0.33	0.88	0.72	1.15	67.17
Haustoriidae	0.00	0.40	0.87	0.67	1.15	68.31
Spio sp.	0.00	0.44	0.87	0.80	1.14	69.46
Other Gastropoda	0.15	0.35	0.87	0.75	1.14	70.60

Groups 1 Recovery & 12 Recovery - Average dissimilarity = 75.34

Species	Group	Group	Av.Diss	Diss/SD	Contrib%	Cum.%
	1 Recovery Av.Abund	12 Recovery Av.Abund				
Spiophanes kroyeri	0.43	3.40	5.21	2.40	6.92	6.92
Terebellidae	0.04	1.91	3.21	4.43	4.26	11.18
Amphipoda Unid.	0.95	2.55	2.78	2.07	3.69	14.87
Maldanidae	0.39	1.85	2.58	1.93	3.43	18.30
Eugyra sp.	0.00	1.23	2.15	2.28	2.85	21.15
Prionospio multicristata	0.20	1.40	2.10	1.89	2.79	23.94
Spio sp.	0.00	1.21	2.03	2.17	2.69	26.62
Phyllodocidae	0.00	1.13	1.93	2.44	2.56	29.18
Paraprionospio pinnata	0.15	1.04	1.73	1.27	2.29	31.47
Nemertea	0.15	1.11	1.70	1.90	2.26	33.73
Cumacea	0.43	1.21	1.63	1.40	2.16	35.89
Urothoidae	0.73	1.15	1.52	1.31	2.02	37.91
Phoxocephalidae	0.40	1.00	1.41	1.30	1.87	39.78
Pagurus sp.	0.85	0.91	1.25	1.13	1.66	41.44
Euchone pallida	0.42	0.86	1.20	1.25	1.59	43.03
Eurylana cookii	0.27	0.71	1.12	1.14	1.49	44.52
Armandia maculata	0.51	0.69	1.11	1.10	1.48	46.00
Ampharetidae	0.32	0.59	1.10	1.00	1.46	47.46
Pratulium pulchellum	0.44	0.62	1.10	1.10	1.46	48.91
Barantolla lepte	0.64	0.54	1.08	1.12	1.44	50.35
Nucula nitidula	0.56	0.79	1.04	1.09	1.38	51.72
Sigapatella tenuis	0.24	0.61	1.03	0.97	1.37	53.09
Mysidacea	0.11	0.60	1.02	1.03	1.35	54.44
Callianassa filholi	0.51	0.58	1.01	1.06	1.34	55.78
Syllidae	0.11	0.61	1.00	1.07	1.33	57.11
Sigalionidae	0.77	0.66	0.97	1.05	1.29	58.40
Tawera spissa	0.04	0.58	0.97	0.95	1.29	59.69
Prionospio sp.	0.00	0.58	0.95	0.93	1.27	60.95
Polynoidae	0.00	0.54	0.95	0.89	1.26	62.22
Aglaophamus sp.	0.19	0.55	0.95	0.97	1.26	63.47
Lysianassidae	0.08	0.51	0.90	0.86	1.19	64.67
Cirratulidae	0.12	0.49	0.86	0.90	1.14	65.80
Zemysina sp.	0.31	0.37	0.85	0.86	1.13	66.93
Anthuridea	0.11	0.45	0.81	0.84	1.08	68.01
Corbula zelandica	0.29	0.36	0.80	0.83	1.07	69.08
Hesionidae	0.00	0.44	0.80	0.81	1.06	70.13

Groups 6 Recovery & 12 Recovery - Average dissimilarity = 63.93

Species	Group	Group	Av.Diss	Diss/SD	Contrib%	Cum.%
	6 Recovery Av.Abund	12 Recovery Av.Abund				
Spiophanes kroyeri	0.54	3.40	3.79	2.34	5.93	5.93
Amphipoda Unid.	1.10	2.55	1.97	1.52	3.07	9.00
Prionospio multicristata	0.00	1.40	1.78	2.26	2.79	11.79
Eugyra sp.	0.16	1.23	1.45	1.86	2.27	14.06
Maldanidae	1.04	1.85	1.41	1.27	2.20	16.26
Terebellidae	0.89	1.91	1.35	1.58	2.12	18.37
Urothoidae	0.56	1.15	1.34	1.29	2.10	20.47
Tawera spissa	1.12	0.58	1.22	1.27	1.90	22.37
Paraprionospio pinnata	0.33	1.04	1.20	1.23	1.88	24.25
Spio sp.	0.44	1.21	1.19	1.46	1.86	26.11
Cumacea	0.45	1.21	1.17	1.32	1.83	27.94
Sigapatella tenuis	1.15	0.61	1.17	1.36	1.82	29.76
Scalpomactra scalpellum	1.06	0.36	1.12	1.40	1.75	31.51
Epigonichthys hectori	0.86	0.16	1.03	1.36	1.61	33.12
Ampharetidae	0.83	0.59	1.01	1.13	1.58	34.70
Gari sp. (juvenile)	0.85	0.17	1.00	1.28	1.57	36.27
Phoxocephalidae	0.75	1.00	0.94	1.17	1.47	37.75
Pagurus sp.	0.62	0.91	0.89	1.17	1.39	39.14
Barantolla lepte	0.76	0.54	0.89	1.18	1.39	40.53
Armandia maculata	0.47	0.69	0.89	1.12	1.39	41.92
Nemertea	0.63	1.11	0.86	1.14	1.35	43.27
Euchone pallida	0.78	0.86	0.83	1.12	1.30	44.57
Bryozoa (solid Stalked)	0.67	0.09	0.82	1.33	1.29	45.86
Zemysina sp.	0.61	0.37	0.82	1.04	1.28	47.14
Eurylana cookii	0.48	0.71	0.81	1.11	1.26	48.41
Pratulium pulchellum	0.19	0.62	0.80	0.99	1.25	49.66
Nucula nitidula	0.94	0.79	0.79	1.10	1.24	50.90
Corbula zelandica	0.54	0.36	0.79	0.99	1.24	52.13
Prionospio sp.	0.35	0.58	0.78	1.02	1.23	53.36
Mysidacea	0.35	0.60	0.78	1.06	1.21	54.57
Sigalionidae	0.61	0.66	0.77	1.09	1.20	55.77
Aglaophamus sp.	0.41	0.55	0.76	1.02	1.18	56.96
Syllidae	0.55	0.61	0.75	1.07	1.18	58.13
Callianassa filholi	0.30	0.58	0.75	1.03	1.17	59.30
Hydroides sp	0.33	0.49	0.74	0.91	1.15	60.45
Glyceridae	0.50	0.46	0.73	1.02	1.14	61.60
Lysianassidae	0.29	0.51	0.73	0.95	1.14	62.74
Polynoidae	0.07	0.54	0.71	0.92	1.12	63.86
Magelona dakini	0.35	0.45	0.71	0.95	1.11	64.97
Sabellidae	0.56	0.04	0.69	1.01	1.08	66.04
Anthuridea	0.36	0.45	0.68	0.94	1.07	67.11
Bryozoa (discoïd)	0.46	0.23	0.67	0.86	1.05	68.16
Cirratulidae	0.17	0.49	0.67	0.92	1.04	69.20
Hesionidae	0.15	0.44	0.62	0.86	0.97	70.17

Groups 1 Control & 6 Control - Average dissimilarity = 72.44

Species	Group		Av.Diss	Diss/SD	Contrib%	Cum.%
	1 Control	6 Control				
	Av.Abund	Av.Abund				
Maldanidae	0.74	1.64	2.04	1.23	2.82	2.82
Gari sp. (juvenile)	0.10	0.99	1.79	1.48	2.47	5.28
Sigapatella tenuis	0.28	1.08	1.78	1.44	2.45	7.74
Phyllodocidae	0.04	0.95	1.75	1.90	2.42	10.15
Nucula nitidula	0.64	1.20	1.61	1.29	2.23	12.38
Tawera spissa	0.17	0.92	1.61	1.32	2.22	14.60
Scalpomactra scalpellum	0.14	0.84	1.54	1.38	2.12	16.72
Phoxocephalidae	0.28	0.85	1.52	1.16	2.10	18.82
Urothoidae	0.73	0.84	1.52	1.22	2.10	20.92
Bryozoa (discoïd)	0.51	0.87	1.51	1.20	2.09	23.01
Amphipoda Unid.	0.87	1.47	1.48	1.13	2.04	25.04
Spiophanes kroyeri	0.35	0.63	1.39	1.06	1.92	26.97
Euchone pallida	0.52	0.93	1.38	1.20	1.90	28.87
Epigonichthys hectori	0.39	0.85	1.38	1.24	1.90	30.77
Ampharetidae	0.40	0.56	1.34	0.89	1.85	32.62
Zemysina sp.	0.50	0.53	1.29	1.04	1.79	34.40
Magelona dakini	0.00	0.68	1.25	1.20	1.73	36.13
Syllidae	0.23	0.68	1.25	1.10	1.72	37.85
Cumacea	0.54	0.66	1.23	1.08	1.70	39.55
Terebellidae	0.00	0.67	1.21	1.21	1.67	41.22
Pagurus sp.	0.84	0.64	1.19	1.11	1.65	42.86
Onuphis aucklandensis	0.62	0.14	1.19	1.07	1.64	44.50
Nemertea	0.31	0.66	1.16	1.10	1.60	46.10
Barantolla lepte	0.42	0.52	1.15	1.00	1.59	47.69
Armandia maculata	0.52	0.51	1.15	1.05	1.58	49.27
Sigalionidae	0.53	0.68	1.13	1.06	1.56	50.83
Eurylana cookii	0.22	0.52	1.07	0.93	1.48	52.31
Haustoriidae	0.00	0.47	0.99	0.73	1.37	53.68
Cirratulidae	0.09	0.55	0.99	0.96	1.36	55.04
Prionospio sp.	0.04	0.50	0.96	0.86	1.33	56.37
Glyceridae	0.19	0.51	0.96	0.93	1.32	57.69
Philine sp	0.04	0.48	0.90	0.86	1.24	58.93
Anthuridea	0.00	0.42	0.87	0.77	1.20	60.13
Corbula zelandica	0.26	0.36	0.86	0.79	1.18	61.31
Callianassa filholi	0.30	0.28	0.85	0.78	1.18	62.49
Hydroides sp	0.00	0.51	0.85	0.77	1.17	63.66
Lumbrineridae	0.32	0.26	0.84	0.81	1.16	64.82
Aglaophamus sp.	0.26	0.36	0.84	0.85	1.16	65.97
Pratulum pulchellum	0.30	0.26	0.83	0.74	1.15	67.12
Mysidacea	0.23	0.29	0.78	0.75	1.08	68.20
Orbinia papillosa	0.04	0.40	0.76	0.79	1.05	69.25
Dosinia subrosea	0.33	0.15	0.76	0.73	1.05	70.30

Groups 1 Control & 12 Control - Average dissimilarity = 74.33

Species	Group		Av.Diss	Diss/SD	Contrib%	Cum.%
	1 Control	12 Control				
	Av.Abund	Av.Abund				
Spiophanes kroyeri	0.35	3.18	4.63	2.25	6.23	6.23
Amphipoda Unid.	0.87	2.55	2.77	2.45	3.73	9.97
Terebellidae	0.00	1.70	2.77	3.02	3.73	13.70
Maldanidae	0.74	1.95	1.99	1.58	2.67	16.37
Eugyra sp.	0.00	1.04	1.66	1.57	2.23	18.60
Phoxocephalidae	0.28	1.17	1.60	1.52	2.15	20.75
Prionospio multicristata	0.13	1.03	1.58	1.45	2.13	22.88
Urothoidae	0.73	1.27	1.54	1.40	2.07	24.95
Phyllodocidae	0.04	0.97	1.47	1.73	1.98	26.92
Nemertea	0.31	1.13	1.45	1.55	1.96	28.88
Paraprionospio pinnata	0.00	0.92	1.43	1.14	1.92	30.80
Lysianassidae	0.19	0.95	1.41	1.29	1.90	32.70
Tawera spissa	0.17	0.93	1.39	1.42	1.87	34.57
Cumacea	0.54	1.06	1.39	1.30	1.87	36.45
Sigapatella tenuis	0.28	0.92	1.36	1.24	1.83	38.27
Bryozoa (discoïd)	0.51	0.91	1.33	1.20	1.79	40.06
Eurylana cookii	0.22	0.89	1.31	1.33	1.76	41.83
Hydroides sp	0.00	0.84	1.29	1.02	1.73	43.56
Spio sp.	0.09	0.80	1.26	1.08	1.69	45.25
Nucula nitidula	0.64	1.09	1.25	1.26	1.68	46.93
Philocheras australis	0.00	0.75	1.24	1.44	1.67	48.60
Aglaophamus sp.	0.26	0.72	1.09	1.12	1.46	50.06
Mysidacea	0.23	0.69	1.07	1.14	1.44	51.49
Pratulum pulchellum	0.30	0.57	1.02	0.99	1.37	52.86
Onuphis aucklandensis	0.62	0.00	1.01	1.07	1.36	54.22
Euchone pallida	0.52	0.46	0.99	1.02	1.33	55.55
Callianassa filholi	0.30	0.62	0.98	1.08	1.32	56.86
Barantolla lepte	0.42	0.53	0.98	1.00	1.31	58.18
Sigalionidae	0.53	0.74	0.97	1.05	1.31	59.49
Syllidae	0.23	0.65	0.97	1.14	1.31	60.80
Armandia maculata	0.52	0.71	0.97	1.08	1.31	62.10
Ampharetidae	0.40	0.41	0.94	0.87	1.26	63.37
Magelona dakini	0.00	0.58	0.92	0.92	1.24	64.60
Zemysina sp.	0.50	0.33	0.91	0.96	1.23	65.83
Glyceridae	0.19	0.53	0.91	0.93	1.22	67.06
Pagurus sp.	0.84	0.84	0.87	1.03	1.18	68.23
Cirratulidae	0.09	0.50	0.85	0.78	1.14	69.37
Lumbrineridae	0.32	0.38	0.78	0.89	1.05	70.42

Groups 6 Control & 12 Control - Average dissimilarity = 60.99

Species	6 Control Av.Abund	12 Control Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Spiophanes kroyeri	0.63	3.18	3.05	2.04	4.99	4.99
Amphipoda Unid.	1.47	2.55	1.51	1.81	2.48	7.47
Terebellidae	0.67	1.70	1.36	1.54	2.23	9.70
Prionospio multicristata	0.04	1.03	1.23	1.49	2.01	11.71
Urothoidae	0.84	1.27	1.22	1.35	2.00	13.72
Eugyra sp.	0.10	1.04	1.19	1.51	1.95	15.66
Gari sp. (juvenile)	0.99	0.18	1.08	1.42	1.77	17.43
Paraprionospio pinnata	0.15	0.92	1.05	1.15	1.73	19.16
Lysianassidae	0.26	0.95	1.04	1.27	1.71	20.87
Cumacea	0.66	1.06	1.01	1.28	1.66	22.52
Hydroides sp	0.51	0.84	0.99	1.12	1.63	24.15
Epigonichthys hectori	0.85	0.16	0.95	1.35	1.56	25.71
Phoxocephalidae	0.85	1.17	0.93	1.21	1.53	27.24
Spio sp.	0.22	0.80	0.93	1.10	1.52	28.76
Philocheras australis	0.06	0.75	0.91	1.43	1.49	30.25
Scalpomactra scalpellum	0.84	0.23	0.91	1.31	1.49	31.74
Euchone pallida	0.93	0.46	0.90	1.27	1.47	33.21
Sigapatella tenuis	1.08	0.92	0.88	1.27	1.45	34.66
Bryozoa (discoid)	0.87	0.91	0.88	1.17	1.45	36.11
Eurylana cookii	0.52	0.89	0.86	1.22	1.41	37.51
Ampharetidae	0.56	0.41	0.86	0.89	1.40	38.92
Nemertea	0.66	1.13	0.82	1.16	1.35	40.27
Tawera spissa	0.92	0.93	0.80	1.11	1.31	41.58
Mysidacea	0.29	0.69	0.79	1.15	1.30	42.88
Aglaophamus sp.	0.36	0.72	0.79	1.12	1.30	44.18
Magelona dakini	0.68	0.58	0.78	1.16	1.27	45.45
Armandia maculata	0.51	0.71	0.77	1.14	1.27	46.72
Maldanidae	1.64	1.95	0.77	1.23	1.27	47.99
Cirratulidae	0.55	0.50	0.76	1.05	1.25	49.23
Barantolla lepte	0.52	0.53	0.75	1.06	1.24	50.47
Syllidae	0.68	0.65	0.75	1.12	1.23	51.70
Zemysina sp.	0.53	0.33	0.74	0.94	1.22	52.92
Pagurus sp.	0.64	0.84	0.74	1.12	1.21	54.12
Glyceridae	0.51	0.53	0.73	1.05	1.19	55.32
Callianassa filholi	0.28	0.62	0.72	1.07	1.19	56.50
Sigalionidae	0.68	0.74	0.72	1.08	1.18	57.68
Pratulium pulchellum	0.26	0.57	0.69	1.00	1.14	58.82
Prionospio sp.	0.50	0.23	0.67	0.93	1.11	59.93
Phyllodocidae	0.95	0.97	0.64	0.99	1.04	60.97
Anthuridea	0.42	0.34	0.63	0.93	1.04	62.01
Nucula nitidula	1.20	1.09	0.63	0.93	1.04	63.05
Haustoriidae	0.47	0.10	0.63	0.79	1.03	64.09
Orbinia papillosa	0.40	0.38	0.60	0.95	0.98	65.07
Other Polychaeta	0.13	0.44	0.57	0.88	0.94	66.01
Philine sp	0.48	0.00	0.56	0.85	0.92	66.93
Polydora sp.	0.00	0.46	0.56	0.51	0.92	67.85
Lumbrineridae	0.26	0.38	0.55	0.87	0.91	68.76
Ophiuroidea	0.34	0.30	0.55	0.83	0.90	69.66
Myllitella vivens vivens	0.29	0.26	0.53	0.76	0.88	70.53

Table H.11 Homogeneity of multivariate dispersions (PERMDIS) of the replicate Epibenthic biota data between the sample areas over time

Transform: Square root
Resemblance: S17 Bray-Curtis similarity
Group factor: Survey
Number of groups: 3
Total Number of samples: 51
Number of permutations: 9999

Overall test for homogeneity

Source	df1	df2	F	P
survey	2	48	2.8054	0.0698

Means and standard errors

Group	Size	Average	SE
1	17	40.288	3.2423
6	17	47.99	1.7031
12	17	41.012	2.4351

Pairwise tests: Term: Survey

Groups	t	P
(6, 1)	2.103	0.043
(12, 1)	0.17859	0.8633
(12, 6)	2.3481	0.0285

Transform: Square root
Resemblance: S17 Bray-Curtis similarity
Group factor: Area
Number of groups: 2
Total Number of samples: 51
Number of permutations: 9999

Overall test for homogeneity

Source	df1	df2	F	P
area	1	49	4.8608	0.0341

Means and standard errors

Group	Size	Average	SE
Recovery	36	50.483	1.4291
Control	15	44.277	2.7062

Pairwise tests: Term: Area

Groups	t	P
(Control, Recovery)	2.2047	0.0317

Transform: Square root
Resemblance: S17 Bray-Curtis similarity
Group factor: Survey - Area
Number of groups: 6
Total Number of samples: 51
Number of permutations: 9999

Overall test for homogeneity

Source	df1	df2	F	P
area-survey	5	45	2.5158	0.0421

Means and standard errors

Group	Size	Average	SE
1-Recovery	12	40.149	3.7553
1-Control	5	36.045	5.8092
6-Recovery	12	49.858	1.4363
6-Control	5	36.789	3.1348
12-Recovery	12	38.534	2.381
12-Control	5	42.374	5.6737

Pairwise tests: Term: Survey-Area

Groups	t	P
(1-Control, 1-Recovery)	0.59285	0.5599
(6-Recovery, 1-Recovery)	2.4149	0.0249
(6-Recovery, 1-Control)	3.2655	0.0067
(6-Control, 1-Recovery)	0.53886	0.6058
(6-Control, 1-Control)	0.11268	0.8981
(6-Control, 6-Recovery)	4.3916	0.001
(12-Recovery, 1-Recovery)	0.3631	0.7144
(12-Recovery, 1-Control)	0.48005	0.6337
(12-Recovery, 6-Recovery)	4.0724	0.0001
(12-Recovery, 6-Control)	0.41312	0.6825
(12-Control, 1-Recovery)	0.32339	0.7489
(12-Control, 1-Control)	0.77932	0.4136
(12-Control, 6-Recovery)	1.7992	0.0835
(12-Control, 6-Control)	0.86151	0.3979
(12-Control, 12-Recovery)	0.74868	0.4593

Table H.12 PERMANOVA – Permutational Multivariate Analysis of Variation of Epibenthic biota between the sample areas over time

Transform: Square root
Resemblance: S17 Bray-Curtis similarity

PERMANOVA design worksheet

Sums of squares type: Type I (sequential)
Permutation method: Unrestricted permutation of raw data
Number of permutations: 9999
Allow for heterogeneity of within-group dispersions:
Terms identifying groups with different dispersions: Area

Factors

Name	Type	Levels
Survey	Fixed	3
Area	Fixed	2

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Survey	2	28708	14354	7.3116	0.0001	9911
Area	1	4041.8	4041.8	2.0007	0.0437	9945
Survey x Area	2	2926.8	1463.4	0.72438	0.7835	9922
Res	45	93631	2080.7			
Total	50	1.2931E+05				

Estimates of components of variation

Source	Estimate	Sq.root
S(Survey)	728.88	26.998
S(Area)	95.466	9.7707
S(Survey x Area)	-78.882	-8.8816
V(Res)	2080.7	45.615

Details of the expected mean squares (EMS) for the model

Source	EMS
Survey	$0.29412 \cdot V(\text{Res}(2)) + 0.70588 \cdot V(\text{Res}(1)) + 1.4412 \cdot S(\text{Survey} \times \text{Area}) + 17 \cdot S(\text{Survey})$
Area	$0.70588 \cdot V(\text{Res}(2)) + 0.29412 \cdot V(\text{Res}(1)) + 21.176 \cdot S(\text{Area})$
Survey x Area	$0.70588 \cdot V(\text{Res}(2)) + 0.29412 \cdot V(\text{Res}(1)) + 7.0588 \cdot S(\text{Survey} \times \text{Area})$

Construction of Pseudo-F ratio(s) from mean squares

Source	Numerator	Denominator	Num.df	Den.df
Survey	1*Survey	$0.15 \cdot \text{Res}(2) + 0.64583 \cdot \text{Res}(1) + 0.20417 \cdot \text{Survey} \times \text{Area}$	2	35.47
Area	1*Area	$0.70588 \cdot \text{Res}(2) + 0.29412 \cdot \text{Res}(1)$	1	23.39
Survey x Area	1*Survey x Area	$0.70588 \cdot \text{Res}(2) + 0.29412 \cdot \text{Res}(1)$	2	23.39

PAIR-WISE TESTS : for pairs of levels of factor Area within Survey

Within level 1 month of factor Survey

Groups	t	P(perm)	Unique perms
Recovery, Control	1.0645	0.355	4973

Denominators

Groups	Denominator	Den.df
Recovery, Control	$0.70588 \cdot \text{Res}(2) + 0.29412 \cdot \text{Res}(1)$	7.82

Average Similarity between/within groups

	Recovery	Control
Recovery	40.168	
Control	40.99	43.67

Within level ' 6 month of factor Survey

Groups	t	P(perm)	Unique perms
Recovery, Control	1.1888	0.1885	4933

Denominators

Groups	Denominator	Den.df
Recovery, Control	$0.70588 \cdot \text{Res}(2) + 0.29412 \cdot \text{Res}(1)$	9.48

Average Similarity between/within groups

	Recovery	Control
Recovery	27.072	
Control	32.535	41.725

Within level 12 month of factor Survey

Groups	t	P(perm)	Unique perms
Recovery, Control	0.95905	0.52	4946

Denominators

Groups	Denominator	Den.df
Recovery, Control	$0.70588 \cdot \text{Res}(2) + 0.29412 \cdot \text{Res}(1)$	6.48

Average Similarity between/within groups

	Recovery	Control
Recovery	43.235	
Control	38.136	33.178

PAIR-WISE TESTS : for pairs of levels of factor Survey within Area

Within level Recovery of factor Area

Groups	t	P(perm)	Unique perms
1, 6	2.2309	0.0001	9902
1, 12	3.0715	0.0001	9897
6, 12	1.9026	0.0004	9898

Denominators

Groups	Denominator	Den.df
1, 6	1*Res(1)	22
1, 12	1*Res(1)	22
6, 12	1*Res(1)	22

Average Similarity between/within groups

	1	6	12
1	40.168		
6	22.522	27.072	
12	22.739	27.57	43.235

Within level Control of factor Area

Groups	t	P(perm)	Unique perms
1, 6	1.5427	0.0412	126
1, 12	1.3428	0.13	126
6, 12	1.1607	0.2408	126

Denominators

Groups	Denominator	Den.df
1, 6	1*Res(1)	8
1, 12	1*Res(1)	8
6, 12	1*Res(1)	8

Average Similarity between/within groups

	1	6	12
1	43.67		
6	35.286	41.725	
12	32.184	34.728	33.178

Auckland

Address | Level 4, 68 Beach Road, Auckland 1010
Post | PO Box 2027, Shortland Street, Auckland 1140, New Zealand
Ph | 64 9 379 9980
Fax | +64 9 377 1170
Email | contact-us@babbage.co.nz

Hamilton

Address | Unit 1, 85 Church Road, Pukete, Hamilton 3200
Post | PO Box 20068, Te Rapa, Hamilton 3241, New Zealand
Ph | +64 7 850 7010
Fax | +64 9 377 1170
Email | contact-us@babbage.co.nz

Christchurch

Address | 128 Montreal Street, Sydenham, Christchurch 8023
Post | PO Box 2373, Christchurch 8140, New Zealand
Ph | +64 3 379 2734
Fax | +64 3 379 1642
Email | solutions@babbage.co.nz

Babbage Consultants Australia Pty Ltd – Australia

Address | Suite 4, Level 2, 1 Yarra Street, Geelong,
Victoria 3220, Australia
Ph | +61 3 8539 4805
Email | contact-us@babbage.co.nz

www.bioresearches.co.nz

www.babbage.co.nz

www.babbageconsultants.com.au
