EXPLORATION AND APPRAISAL DRILLING PROGRAMME

Benthic Baseline Report
Well A

Prepared for:

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BASIS OF REPORT

This report has been prepared by SLR Consulting NZ Limited with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with OMV New Zealand Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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DOCUMENT CONTROL

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740.10078.00200-R01-v1.0	31 July 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier
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EXECUTIVE SUMMARY

OMV New Zealand Limited (**OMV New Zealand**) are applying for a Marine Consent to undertake an Exploration and Appraisal Drilling (**EAD**) Programme in the Taranaki Basin with an anticipated commencement date in 2019. OMV New Zealand may drill up to nine exploration wells and two appraisal wells within their Petroleum Exploration Permits (**PEP**). The intention of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs.

As part of the Marine Consent application, three Areas of Interest (**AOI**) have been identified that encapsulate the proposed well locations and are used as part of the Impact Assessment process. OMV New Zealand undertook a baseline environmental monitoring survey at each well location in March-April 2018 to gain an understanding of the benthic habitat and associated communities with each AOI.

Grab sampling and video sled methodologies were used to gain quantitative and qualitative information on the marine environments surrounding each well location. The data gathered from each baseline survey will be incorporated into the Marine Consent application and assist in the risk assessment process.

Water currents and deposition modelling were utilised to define the placement of sample stations. Sample transects were aligned along the dominant deposition pathway of the predicted drill cutting dispersion should that particular well be drilled. A total of 15 monitoring stations were allocated at each well and one benthic grab sample was collected at each monitoring station. Ten video sleds were also undertaken at a selection of pre-determined sites around each well.

Within this benthic baseline monitoring report the analysis of results incorporates sediment physical and chemical properties, benthic macrofauna, epifauna and visual observations around Proposed Well A. A total of 3,849 individuals representing 140 taxa were identified from the 15 macrofauna samples collected around Well A. Infauna communities were dominated by small polychaete worms (56%), crustaceans (29%), molluscs (7%) and nematodes (4%).

The baseline survey at Well A found no distinct spatial patterns in grain size and Total Organic Carbon across the 15 sample stations. Grain size analysis indicated that the sediments at Well A and in the wider Northern AOI was much coarser than sediments in the Central and Southern AOIs, which are dominated by mud (largely comprised of silt and clay sized fractions).

Infauna samples collected at Well A indicated the presence of five isolated Chaetopteridae worms and a three *Virgulana gracillima* sea pens; species defined in the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activities Regulations**) as being '*characteristic species of sensitive environments*'. Sea pens were also commonly observed in the video imagery collected at Well A. The occurrence and estimated densities of these taxa at Well A did not reach the trigger levels defined by the Permitted Activities Regulations (MacDiarmid *et al*., 2013) and no distinct worm or sea pen 'fields' were encountered. Thus although present at the well in low densities it is unlikely (but not impossible) that larger aggregations of these taxa were present at densities high enough to trigger 'sensitive environment' status.

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1 Introduction

OMV New Zealand Limited (**OMV New Zealand**) is applying for a Marine Consent under Section 38 of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (**EEZ Act**) to permit activities associated with an Exploration and Appraisal Drilling (**EAD**) Programme proposed to be undertaken starting in 2019.

The EAD Programme includes the drilling of up to nine exploration wells and two appraisal wells within OMV New Zealand's permit areas (**Figure 1**). The purpose of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs which OMV New Zealand operate (**Figure 1**).

Three Areas of Interest (**AOI**) (summarised below) have been identified which encapsulate the well locations (**Figure 1**). This monitoring report relates to the benthic baseline monitoring programme conducted at Well A in the Northern AOI. Location details and water depth of Well A are provided in **Table 1**.

The Northern AOI encompasses PEP 60092 (Ridgeline), PEP 57075 (Cloudy Bay) and PEP 60093 (Toutouwai) and includes the following wells:

- Well A;
- Well B;
- Well C; and
- Well D.

The Central AOI encompasses PEP 60093 (Toutouwai) and includes the following wells:

- Well E (Appraisal);
- Well F;
- Well G (Appraisal);
- Well H; and
- Well I.

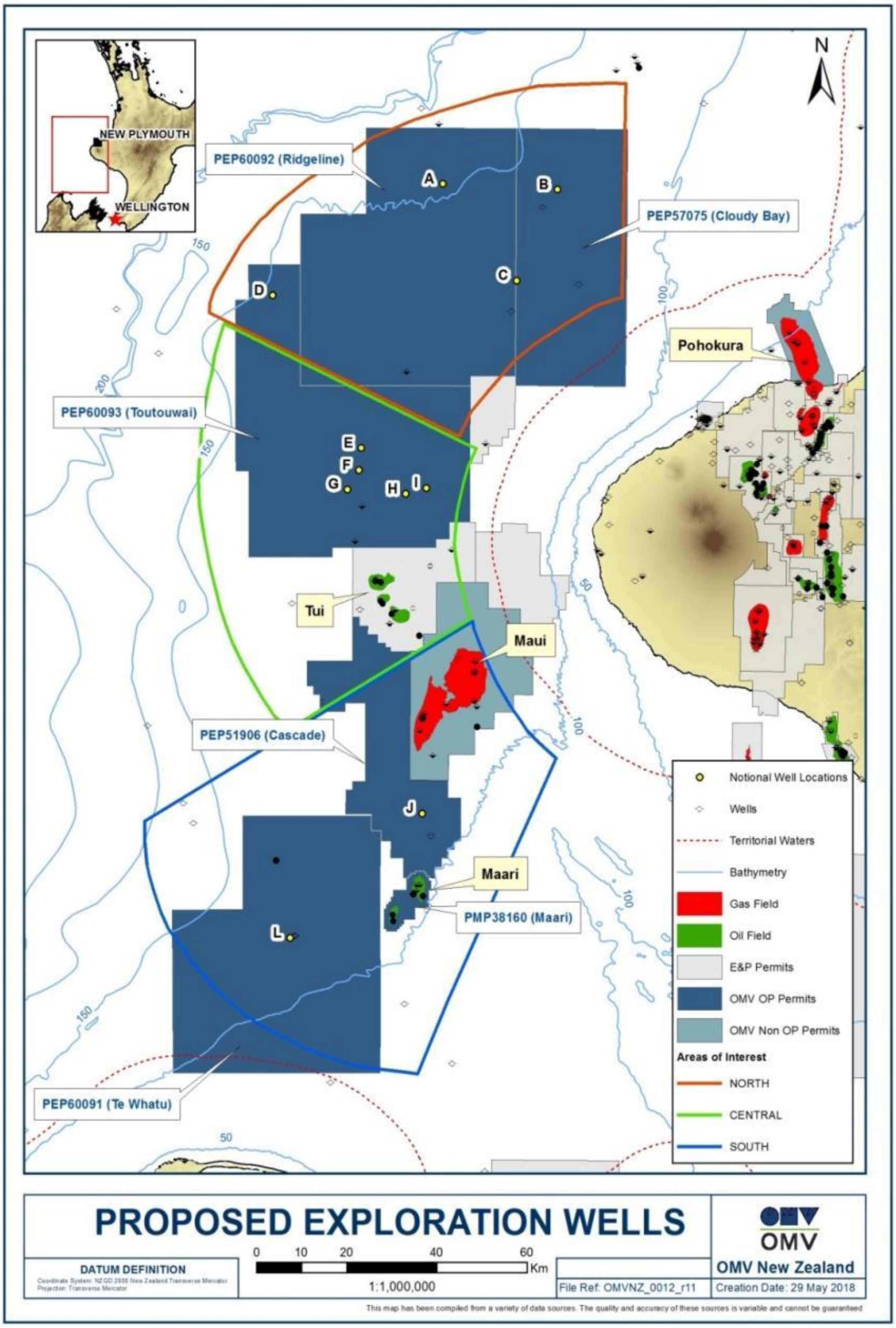
The Southern AOI encompasses PEP 51906 (Cascade), and PEP 60091 (Te Whatu) and includes the following wells:

- Well J; and
- Well L.

Table 1 Water Depth and Coordinates of Well A in the Northern AOI

Well name	Water Depth (m)	Easting (NZTM)	Northing (NZTM)
A	142.6	1631589	5726591

Figure 1 OMV New Zealand's EAD Well Locations and three AOIs in the Taranaki Basin



In February 2018 SLR Consulting Limited (**SLR**) was engaged by OMV New Zealand to undertake a baseline assessment of the benthic ecology in the vicinity of 11 wells (**Figure 1**). The aim of the field surveys, which were undertaken from March 24 – April 8 2018, was to collect relevant data using grab sampling and video sled methodologies to provide quantitative and qualitative information on these marine environments. This qualitative and quantitative data will be used within the Marine Consent application to define the benthic habitats and communities present at each well and assist in the risk assessment process.

This report summarises the results of the Benthic Baseline survey undertaken at Well A.

1.1 Project Location

Well A is located approximately 77 km northwest of New Plymouth in New Zealand's Exclusive Economic Zone (**EEZ**). Water depth and GPS coordinates are provided in **Table 1** and displayed in **Figure 1**. The monitoring programme sample design resulted in sample stations extending out to 6 km from the well location (**Section 2.1**).

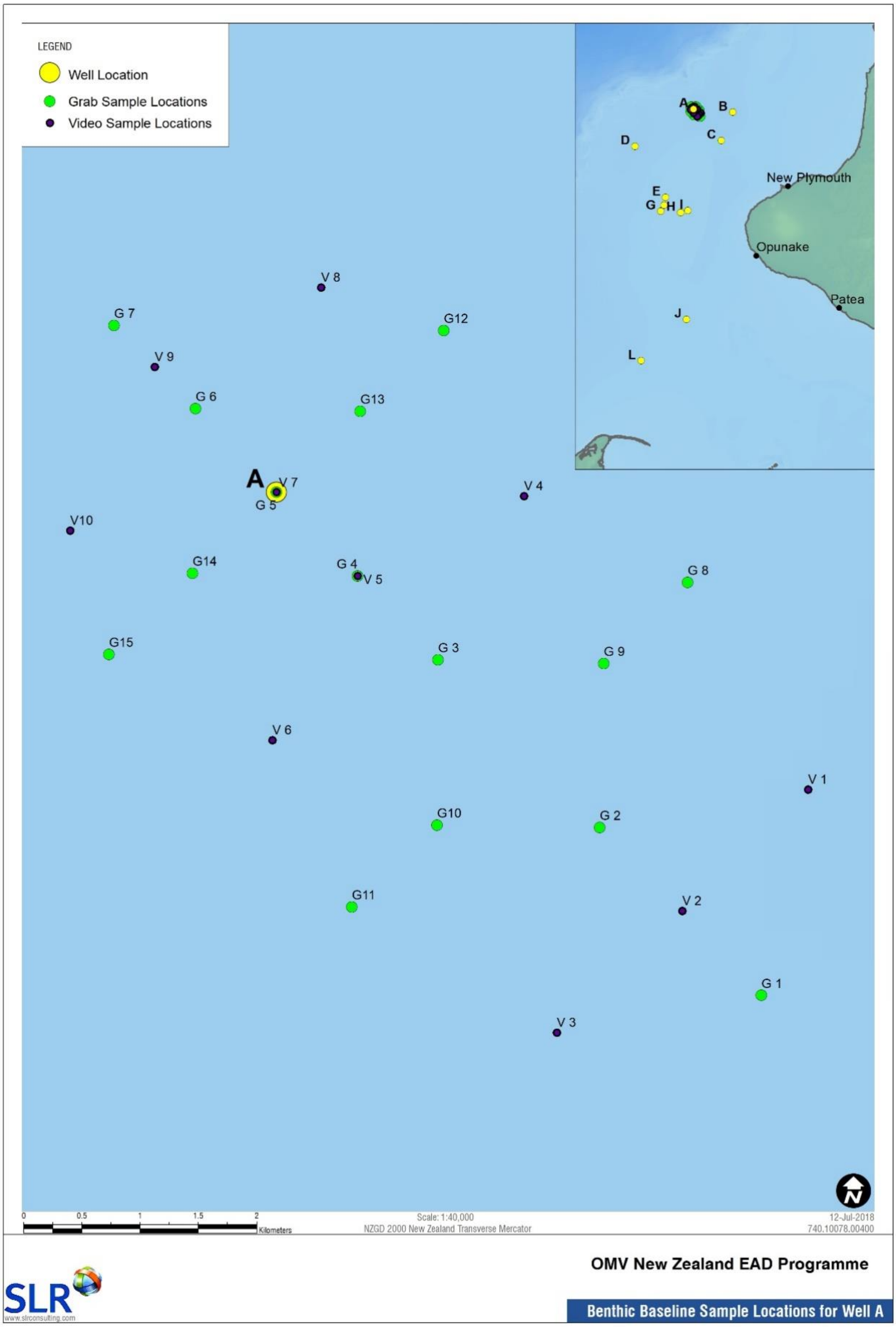
2 Methodology

The Benthic Baseline surveys adopted similar methodologies to what has been previously used for offshore Taranaki benthic monitoring programmes undertaken in accordance with the principles defined in the Offshore Taranaki Environmental Monitoring Protocol (**OTEMP**) (Johnston *et al.*, 2014). This consistent approach enables monitoring results to be compared with previous monitoring programmes undertaken in the offshore Taranaki environment (i.e. pre- and post-drill monitoring and production monitoring).

2.1 Sample Locations

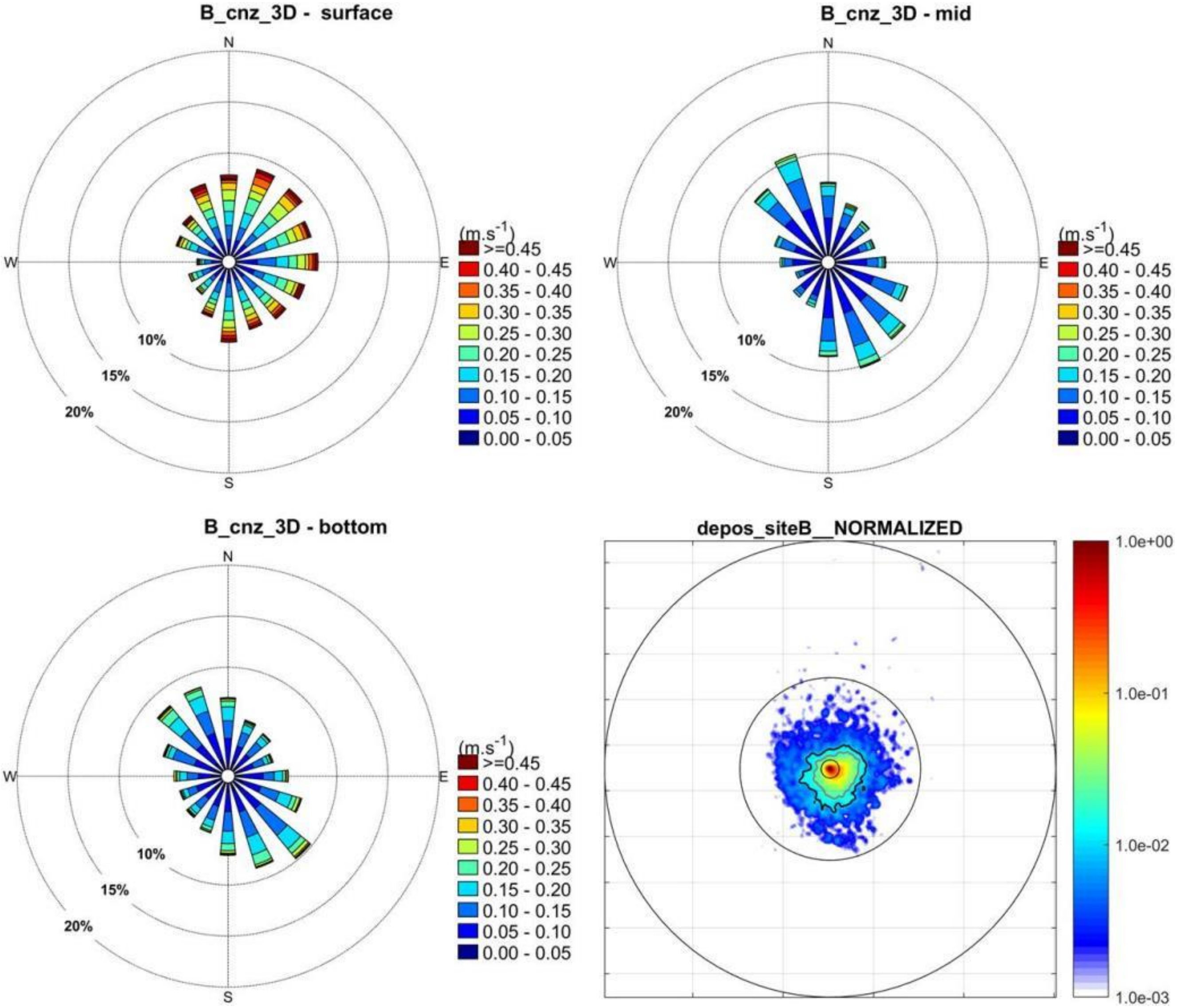
The sample locations (**Figure 2**) were defined by the dominant direction of current flow and preliminary drill cutting deposition modelling results (**Figure 3**). Sample transects were aligned along the dominant deposition pathway (i.e. southeast/northwest) (**Figure 2**) as this is the area determined to be most likely to be impacted from the deposition of drill cuttings should the well be drilled. However, sample stations were also located along the minor flow axis (northeast/southwest) to enable comparisons and validation of spatial differences based on the dispersal patterns predicted by MetOcean Solutions Limited.

Figure 2 Well A Sampling Locations



Note: At each video transect location approximately 250 m of video footage was captured along the seabed

Figure 3 Surface, Mid-water and Bottom Water Column Current Roses and Dispersal Modelling Plot created by Metocean Solutions Ltd for the nearby Well B



2.2 Field and Sampling Procedures

Field sampling was undertaken from the MV *Seaworker* between March 24 and April 8, 2018, following the procedures detailed below. Sampling at Well A took place on March 30th and April 1st.

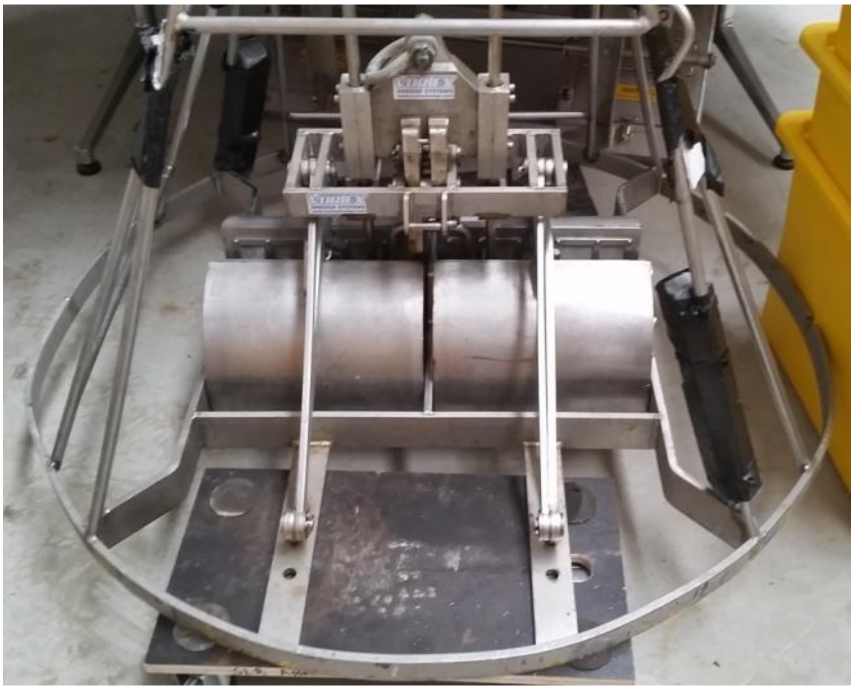
2.2.1 Benthic Grab Samples

A double Van Veen double grab sampler (**Figure 4**) was used to collect a single sediment grab sample at each of the 15 benthic monitoring stations surrounding Well A (**Figure 2**). The grab sampler is constructed of stainless steel and features two independent 'buckets' which penetrate the surficial sediments to a depth of 0.16 m. Each successful grab sample returns approximately 0.01 m^3 of seabed sediment back to the surface.

Upon arrival on the vessel deck, each grab sample is checked for completeness, which must meet the following criteria:

- The surface of the sediment is largely undisturbed upon inspection aboard the vessel;
- Sufficient sediment (≥75% of the grab capacity) is collected to enable the full suite of sediment analyses required;
- The infauna sample bucket is filled to the same volume (approximately 10 l) for all infauna replicates throughout the survey; and
- The grab has not been over-filled with sediments pushing out of the doors or drains, indicating that it may have over-penetrated the sediment.

Figure 4 The Double Van Veen Grab Sampler used for the 2018 Benthic Sampling



Each independent bucket from a grab sample is used separately for infauna and sediment physical and chemical analyses, as follows:

- Bucket one: infauna/macrofauna community analysis. The entire sample is sieved through 0.5 mm mesh until approximately 300-500 ml of residual sediment and organisms remains. This remaining material is transferred to a plastic container and preserved with a fixative (AncholTM), ready for analysis by SLR taxonomists.
- Bucket two: sediment physical nature and chemical analyses. Three 64 mm (internal diameter) clear Perspex sub-sampling cores are pushed into the sediments from the second bucket, to a depth of approximately 150 mm. Cores are photographed and the upper 50 mm from each core is extruded into a polyethylene bag for particle grain size distribution and organic content (Total Organic Carbon (**TOC**)) analyses by Hill laboratories.

2.2.2 Seafloor Video Imagery

Video imagery of the seafloor was obtained using a customised tow-sled fitted with high-intensity LED lighting and a high-definition video camera (**Figure 5**). The system was connected to the vessel via a 10 mm dyneema tow-line and a 300 m umbilical cable supplying real-time video images to the camera operator on the research vessel. A pair of parallel lasers on the video sled provided an indication of scale allowing features of interest in the video recordings to be approximately sized. Ten video sled tows were conducted around Well A (**Figure 2**).

The video-sled was launched from the vessel up-current of each pre-determined location and lowered to the seabed, where it auto-located via a series of floats and weights set at specific points on the sled frame, to land upright on its lower skids. At the point where the sled contacted the seabed, a GPS log was started, and this log continued throughout the duration of the tow. Video footage was continuously recorded for approximately 200 m as the sled drifted behind the vessel; this ensured that footage was collected while the sled was passing as close as possible to the required sample location.

Figure 5 The Video Sled used for Collecting Video Footage of the Seabed Environment

2.3 Laboratory Analyses

2.3.1 Sediment Physicochemical Analyses

Benthic sediments collected by the grab were analysed by Hill Laboratories (an NZS/ISO/IEC 17025:2005 accredited laboratory), for both physical and chemical parameters. The aims of these analyses along with further details of the analytical method/descriptions are summarised in **Table 2**.

Table 2 Summary of Analytical Methods used for Testing Sediment Physico-chemical Characteristics

Analyte	Aim	Method Number	Description
Particle Grain Size Distribution	• Determine physical parameters of the sediment particles present at the site • Correlate with infauna community characteristics	Hill Laboratories KB32136	• Sediment was wet-sieved through the following screen sizes, as per the Udden-Wentworth scale (Wentworth, 1922): • >2 mm (gravel) • >1 mm (very coarse sand) • >500 µm (coarse sand) • >250 µm (medium sand) • >125 µm (fine sand) • >63 µm (very fine sand) • <63 µm (silt and clay)
Total Organic Carbon	• Determine current level of organic carbon in sediment • Correlate with infauna community characteristics	No specific method number	Acid pre-treatment to remove carbonates present, followed by catalytic combustion (900° C, O_2), separation, Thermal Conductivity Detector. Elemental Analyser.

2.3.2 Macrofauna Analyses

Macrofaunal analyses focused on the infauna, or animals larger than 0.5 mm living within the sediment matrix. Epifaunal animals (those living on top of the sediment), were also included in the analyses to provide representation of the different functional groups present at each sample station.

Benthic macrofaunal samples collected from the sediment grab were sorted and, with the aid of a binocular microscope, identified to the lowest practicable taxonomic level or most recognisable taxa (morphologically similar group). Counts were made to assess the relative abundance of each taxa.

2.3.3 Seafloor Video Analyses

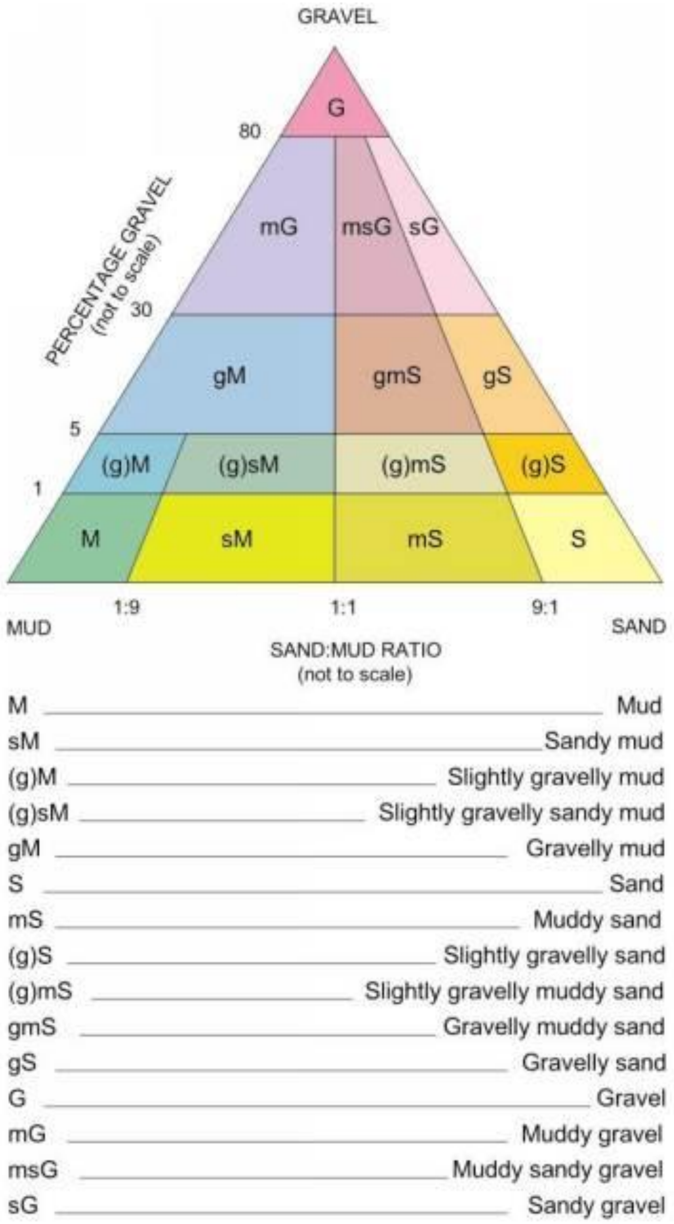
A live feed from the video-sled was captured and recorded on-board the survey vessel and viewed by SLR staff with experience in undertaking assessments of the benthic environment in the offshore Taranaki region. Brief field notes were made in real-time about obvious structures and organisms observed while watching the live footage. Back onshore the recorded seabed video footage was assessed on a large, high definition screen, by a suitably trained and experienced benthic scientist, who identified all obvious epifauna to the lowest practicable taxonomic level. Biogenic and/or anthropogenic seabed structures such as burrows, mounds, tracks and gouges/trenches were also recorded. Relative abundance estimates of epifauna or biogenic structures were made where appropriate.

2.4 Data Analyses

2.4.1 Sediment classifications

While there are many sediment classification schemes in use worldwide, a common one is a modified version of that proposed by Folk (1954). This scheme groups grains within a sample into mud, sand and gravel sized particles based on the particles diameter (mud <63 µm, sand 64-2000 µm, gravel > 2mm), and then describes the sediment type based on the relative proportions of the particles (see **Figure 6**).

Figure 6 Folk (1954) Sediment Type Classification Triangle



2.4.2 Community Characteristic Descriptors

All macrofauna (both epifauna and infauna) taxa were included in the analyses of abundance data. Species identified in the samples as not being exclusively benthic were excluded from further analyses. Data were analysed as per the statistical methods outlined below to identify current distributions and abundance of macrofauna.

2.4.2.1 Univariate Diversity Indices

Diversity indices (number of taxa S, total abundance N, Shannon-Wiener diversity H', and Pielou evenness J' (**Table 3**) were calculated from the macrofauna abundance data using the PRIMER software package (PRIMER v6.1.16; Clarke, 1993; Clarke & Warwick, 1994; Clarke & Gorley, 2006).

Table 3 Description of Macrofauna Community Characteristic Indices

Index	Formula (where applicable)	Description
Number of Taxa (S)	Count of total number of different taxa identified within the *x* sample	Total number of taxa identified within a sample
Total Abundance (N)	Sum of all individual taxa abundances within the *x* sample	Total number/count of all organisms within a sample
Shannon Diversity (H')	$H' = -SUM [(p_i) \times \log_e (p_i)]$ p_i = Number of individuals of taxa i /total number of samples	A single value (log scale) that is used to describe the different types and numbers of organisms present within an assemblage. The index value increases as assemblages have greater numbers of taxa and when the numbers of individual organisms are more evenly distributed across the different taxa. Samples dominated by single taxa will have lower values towards zero.
Pielou Evenness (J')	$J = H' / \log_e (S)$	A value theoretically between zero and one which indicates how evenly the number of individual organisms are distributed through the different taxa in an assemblage. High values (closer to 1) indicate an even spread amongst the taxa present, whereas a low value indicate an uneven spread or an assemblage highly dominated by only a few, or even a single taxon.

3 Results and Discussion

3.1 Sediment Physical and Chemical Properties

3.1.1 Visual Description of Sediment Cores

Sediment collected from around Well A was predominantly hard packed light brown sandy mud with fine dark grey sand nearer the surface and some broken shell material (**Figure 7**). No very dark-grey or black sediment layers (apparent Redox Potential Discontinuity), or darker patches within cores were noted and no detectable hydrogen sulphide odours were present, indicating sediments are well oxygenated throughout the depths sampled. Field observations on sediment texture, colour and any notable features of the sediment samples were recorded during the processing of the sediment cores and infauna samples, and these are included in **Appendix A**. A full set of sediment core photographs are contained in **Appendix B**.

Figure 7 Representative Images of Sediment Core Profiles from Well A

Station A4

Station A3

Station A15

Station A8

3.1.2 Incidental Observations

During laboratory processing of the infauna samples observations were made of any debris present, including those from anthropogenic sources. Within the 15 samples collected around Well A there were eight types of debris observed (**Table 4**), six of which were likely to be anthropogenic in source, including nylon strands, paint flecks, rust flakes and welding material. While most debris encountered in the samples were at 'low' abundances, coal was 'common' in sample A7, 'occasional' in sample A4, and blue paint was 'occasional' in sample A7.

Table 4 Incidental Observations

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15
Coal	L			O	L		C			L					
Graphite				L											
Yellow paint	L														
Black nylon										L					
Pink nylon										L					
Blue paint					L	L	O								L
Welding material					L	L									
Rust					L										

VA = very abundant (>50), A = abundant (50+), C = common (20–50), O = occasional (10–20), L = low (0–10)

3.1.3 Sediment Particle Grain Size Distribution and Organic Content

The physical characteristics of the sediment can influence the composition of the infauna communities and the levels of contaminants retained and observed during analyses. Particle grain size is widely used to characterise the physical structure of the sediment, while organic content provides an indication of the organic enrichment in the sediment. These combined results provide a general understanding of sediment health and the source of potential stressors at the time of sampling.

Organic matter found in the sediments is most likely derived from natural sources such as infauna/epifauna and detrital matter, rather than from anthropogenic sources. Anoxic sediments (those lacking oxygen), may develop in situations where organic matter levels increase beyond 'normal' levels for that area. Increased organic matter has the potential to disturb the equilibrium of the benthic ecosystem, as increased numbers of oxygen-utilising bacteria are required to decompose the additional organic matter, thereby rapidly reducing oxygen availability in the sediments.

A summary of the particle grain size and organic content analyses are discussed below, with full results provided in **Appendix C**.

3.1.3.1 Particle Grain Size

Particle grain size analyses at the 15 monitoring stations around Well A are shown in **Figure 8**. Sediments are dominated by the very fine sand (42-48%), silt/clay (26-45%) and fine sand (12-26%) sized fractions, with small proportions of larger sand and gravel sized particles which were largely comprised of broken shell material. These sediments are classified as 'muddy sands' (Folk, 1954). Muddy sands have historically not been encountered very often in offshore Taranaki areas where exploration/production monitoring has taken place.

The sample with the greatest proportion of silt and clay (mud) was found at monitoring station A7 (the northwest extreme), and the smallest was at monitoring station A1 (the southeast extreme). While this appears to show some sort of pattern of increasing fine sediments towards the northwest part of the site, the trend was weak and inconsistent across the site as a whole.

The grain size distribution at Well A was similar to the other sites in the Northern AOI, which all had notably coarser grain size compared to sediments collected in the Central and Southern AOIs (**Table 5**). The exception to this was Well L in the Southern AOI, which had a grain size distribution very similar to the Northern AOI sites. A comparison of particle grain size data for Well A with the other wells is provided in **Appendix C**.

Figure 8 Sediment Particle Grain Size Distribution for Samples Collected at Well A

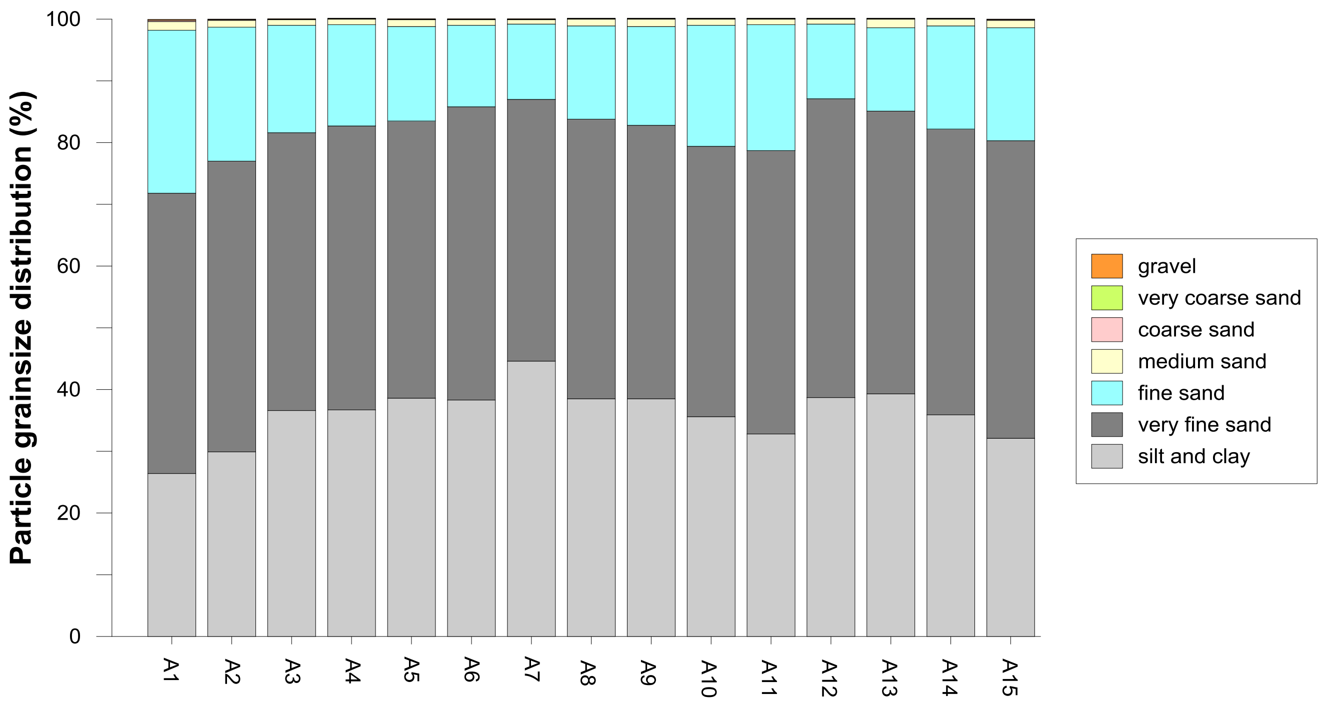


Table 5 Average Grain Size for the Eleven Wells

Grain size class	A	B	C	D	E	F	G	H	I	J	L
Silt & Clay (Mud) (%)	36.2	27.5	41.1	30.7	85.2	83.2	67.8	72.6	65.1	85.4	30.8
Very Fine Sand (%)	45.8	39.3	30.5	41.7	6.5	4.8	6.1	5.8	6.6	14.2	25.4
Fine Sand (%)	17.0	28.6	22.4	26.8	8.0	11.3	24.6	19.0	22.1	0.4	29.8
Medium Sand (%)	1.0	2.4	3.3	0.7	0.4	0.6	1.6	2.5	5.1	0.1	12.3
Coarse Sand (%)	0.1	0.7	0.8	0.0	0.0	0.1	0.1	0.1	0.6	0.0	1.2
Very Coarse Sand (%)	0.0	0.6	0.5	0.0	0.0	0.1	0.1	0.1	0.5	0.0	0.2
Gravel (%)	0.1	1.1	1.3	0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.1
Description	mS	mS	mS	mS	sM	sM	sM	sM	sM	sM	mS

Note: sM = sandy mud, mS = muddy sand

Colour scale based on percentage with median mid-point (median is 2.0):

0%	5	10	20	30	40	50	60	70	80	90	100

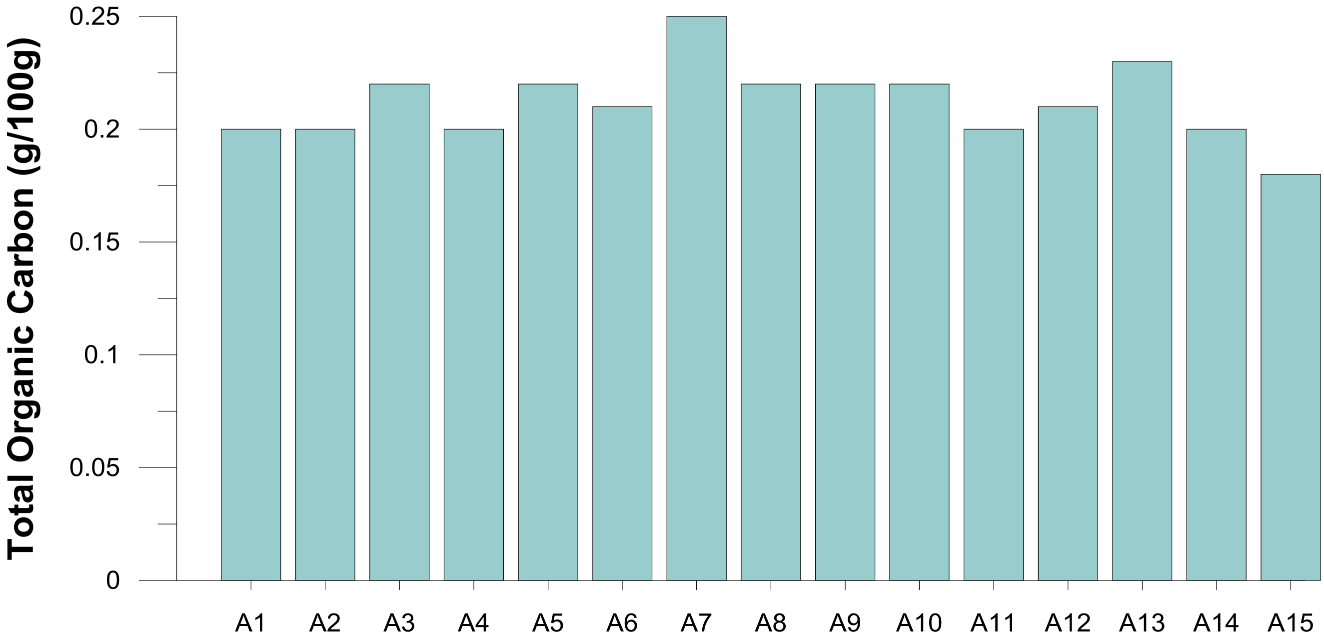
3.1.3.2 Total Organic Carbon

The organic content of sediments was assessed by measuring TOC to assess benthic ecology as this is also consistent with what is now currently undertaken around the offshore Taranaki oil and gas fields.

TOC levels at Well A ranged between 0.18% to 0.25% (mean 0.21%) (**Figure 9**), with no apparent spatial trends visible within the results.

The average organic content around Well A was low relative to the other EAD wells monitored as part of the Benthic Baseline survey (mean 0.21% compared to overall mean of 0.45%). The combined mean from all four wells in the Northern AOI (0.26%) was lower than the Central and Southern AOIs (0.59% and 0.48%, respectively). As has been previously described in benthic environmental monitoring associated with offshore Taranaki oil and gas activities (SLR, 2016), there is a correlation between sediment particle grain size and sediment organic content. The comparatively greater surface area to volume ratio of silt and clay (mud/fines) sized sediment particles (compared to larger particles like sand) gives a greater area for adsorption of organic matter particles and therefore a higher probability of elevated organic matter compared to coarser/sandier sediments subjected to the same level of enrichment (Hedges *et al.*, 1993). This is likely to at least partially explain the lower organic content of sediments at the Northern AOI sites, where sediment grain size is distinctly coarser than at the Central and Southern AOI sites (**Section 3.1.3.1**).

Figure 9 TOC Concentrations in Sediment Samples Collected from around Well A



3.2 Video Sled Imagery

Video footage of the seabed allows scientists to visually assess any anthropogenic disturbance to the benthic environment and observe epifauna, sediment-type and structures or relief that exist on the seabed.

Video footage was captured by towing a video sled along ten transects around Well A (**Section 2.2.2**). All video footage is included with the electronic version of this document, with a selection of still images displayed in **Figure 10**. **Appendix A** provides locational information for each video sled tow.

Video footage was assessed to determine any defining features and their semi-quantitative abundance recorded for comparison with other sites. Due to caveats associated with video footage (i.e. variable visibility, differing tow length and duration) the counts are indicative-only and should not be interpreted as a quantitative assessment. **Table 6** presents the results of this semi-quantitative approach, which summaries the counts by comparing the site total to the median across all of the EAD wells in the three AOIs. As a visual aid, counts were categorised in relation to the deviation from the 10th, 25th 50th, 75th and 90th percentiles, so that differences between sites can be more easily viewed.

3.2.1 Physical Observations

The seabed around Well A was observed to be dominated by firm sandy mud sediments. Evidence of bioturbation was observed at all monitoring stations in the form of animal burrows (images A, E and G, **Figure 10**). Low to moderate abundances of burrows were observed in most of the Well A monitoring stations, which is similar to other wells in the Northern AOI but differs from the Central and Southern AOI sites where abundances were moderate to high (**Table 6**).

Mound/hollow features (images B, C, and D, **Figure 10**) were observed in high numbers (111) compared to the median (43) for all wells (**Table 6**). Other Northern AOI sites also had a relatively high number of these features (63-111), while Well L (Southern AOI) had by far the highest abundance (532). These seabed features are considered to be formed by the feeding activities of sharks or rays, or by tube worms mounding up sediment. Mound/hollow features were observed to be more numerous at the Northern AOI sites compared to the Central and Southern AOIs, where moderate to very high numbers of mound/hollow features were found at the Southern AOI sites, and low to very low numbers from around the Central AOI sites.

As expected, there was no sign of anthropogenic physical disturbance of the seabed observed during any of the video sled tows around Well A. There were no signs of sediment enrichment such as darker sediment patches, bacterial mats or sediment off-gassing, observed during any of the video sled tows around Well A.

Table 6 Total Number of Features Observed in Video Imagery from the EAD Wells

Well Site	Depth (m)	Mounds/ Hollows	Number of burrows/worm holes	Sea pen	Fish	Substrate	Notes
A	148	111	Low-moderate	54	65	Muddy sand	Ripples; some very large holes and mounds
B	134	63	Low-moderate	35	49	Muddy sand	Some very large holes mounds
C	132	85	Low-moderate	50	44	Muddy sand	Ripples; trenches observed
D	145	280	Low	160	28	Muddy sand	Ripples; 23 very large sea feathers
E	126	29	Moderate	29	16	Sandy mud	
F	128	20	Moderate	19	19	Sandy mud	
G	124	18	Moderate-High	29	26	Sandy mud	
H	124	18	Moderate-High	17	26	Sandy mud	12 elongated shallow trenches
I	122	43	Moderate-High	36	21	Sandy mud	5 elongated shallow trenches (large)
J	108	42	Moderate	14	30	Sandy mud	School of mackerel, tufts/tubes common
L	112	532	Moderate	132	31	Muddy sand	2 schools of mackerel
Median		43		35	28		

Totals are sum of 10 video tows carried out at each site. Totals are semi-quantitative only due to variable visibility and transect length.

10th percentile band
25th percentile band
Median band
75th percentile band
90th percentile band

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3.2.2 Infauna, Epifauna and Other Fauna

In some cases, a definitive positive identification of infauna, epifauna and more mobile taxa was not possible from the video footage alone. Where there was any uncertainty, identifications were based on distinctive features, colours and shapes of organisms and in some cases the confirmed presence of similar looking individuals within the infauna samples.

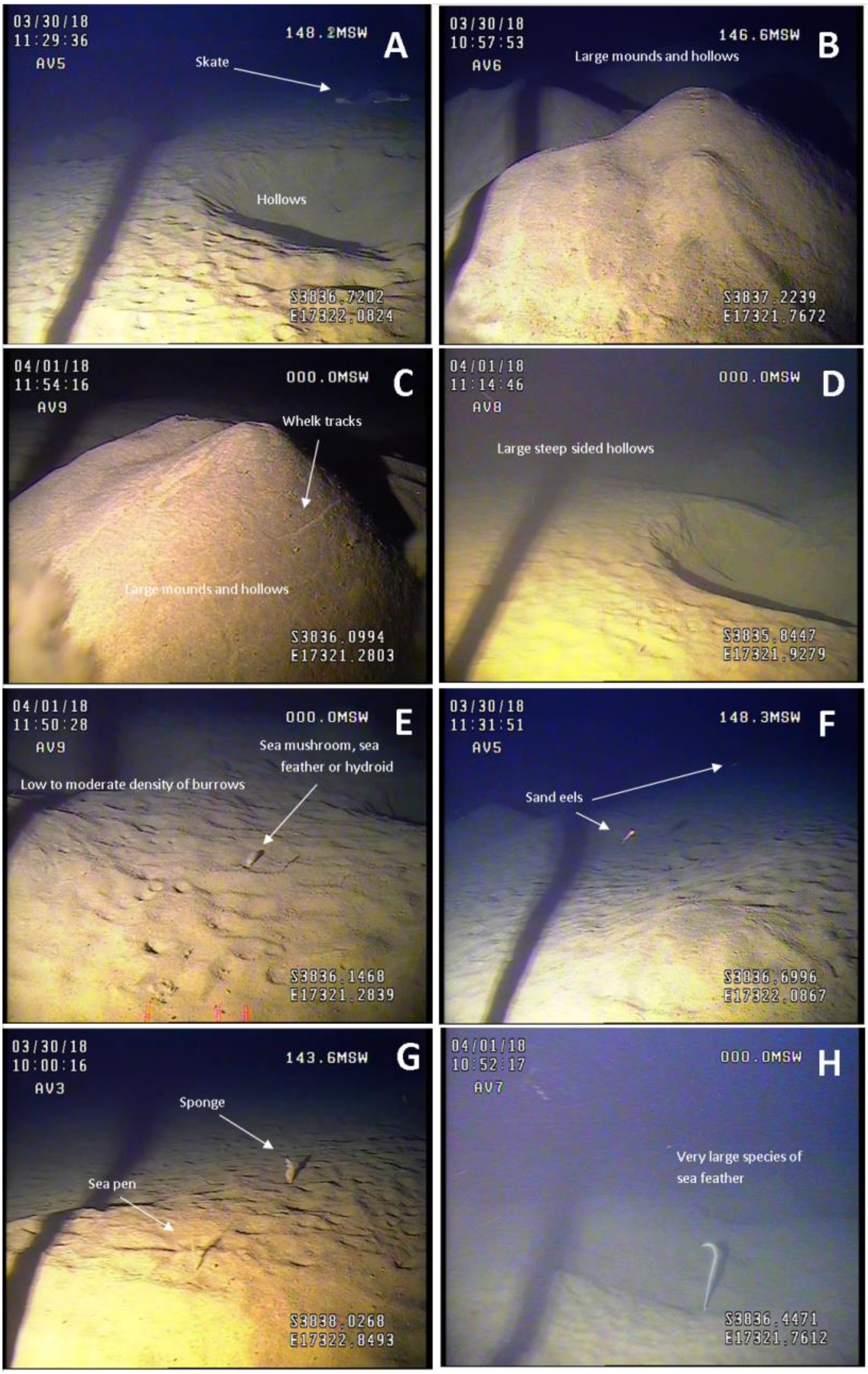
Epifauna taxa observed in video footage collected around Well A included whelks (likely *Austrofusus glans*), hermit crabs (*Pagarus* sp.), tusk shells (likely *Fissidentalium zelandicum*), and various species of sponge (image G, **Figure 10**). Despite not being detected in large numbers, the presence of epifauna tracks in the sediment (see image C, **Figure 10**) indicate that mobile fauna such as whelks and hermit crabs move throughout this site.

Sea pens (likely *Virgularia gracillima*) (image G, **Figure 10**) were observed in high numbers (54) around Well A compared to the median (35) for all other sites (**Table 6**). Other Northern AOI sites also had similar numbers of sea pens (35 at Well B, and 50 at Well C); however, sea pen numbers at Well D were significantly higher (160). There were isolated observations of what looked like sea mushrooms or hydroids (image E, **Figure 10**), and two very large sea feathers (likely *Anthoptilum* sp.) (image H, **Figure 10**). The only other well where the very large sea feather was seen during this survey was Well D, where a total of 23 were counted. Sea pens were observed to be more numerous at the Northern AOI sites, variable at the Southern AOI sites, and lowest in the Central AOI sites.

Mobile fish species were observed in high numbers (65) around Well A compared to the median (28) for all other wells (**Table 6**). Numerous sand eels[1] (image F, **Figure 10**), a small number of flatfish (juveniles and adults) (likely *Peltorhamphus* sp.) and skate (likely *Dipturus nasutus*) (image A, **Figure 10**) were some of the notable species observed. A number of smaller fish were observed swimming off very quickly as the camera approached, so it was not possible to make a positive identification. Across the three AOIs, fish numbers were observed to be much more numerous in the Northern AOI sites, moderate at the Southern AOI sites, and moderate to low around the Central AOI sites.

[1] This fish was unable to be formally identified, thus while the term 'sand eel' is used throughout this report it should not be considered a common name for this unidentified fish species.

Figure 10 Representative Images of Seabed Environment around Well A



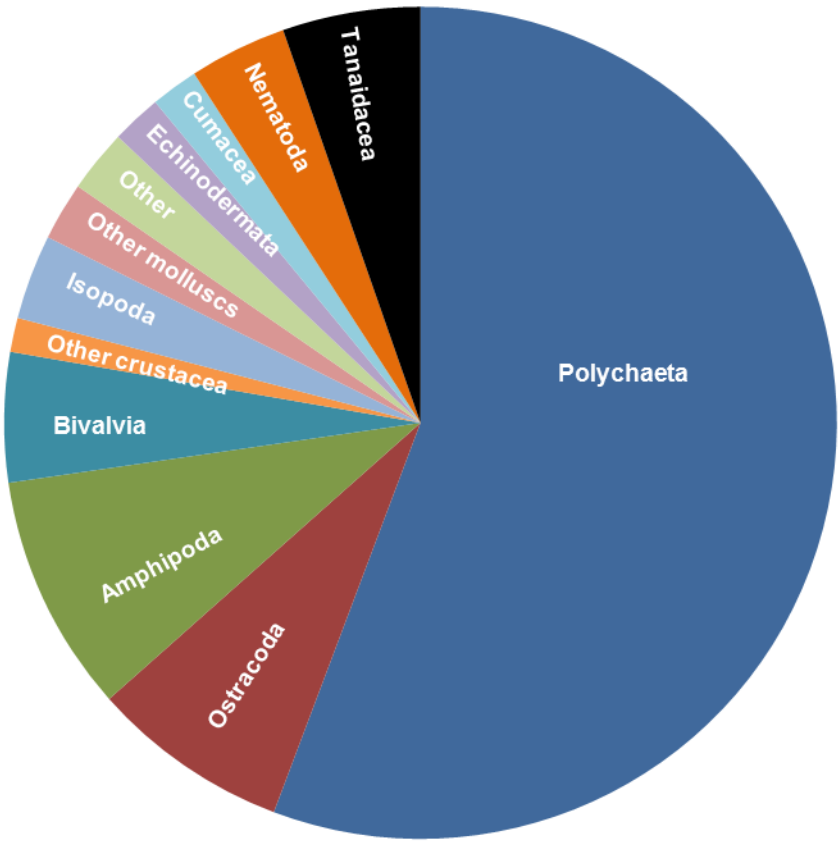
3.3 Macrofauna Characteristics

3.3.1 Benthic Macrofauna

Overall 3,849 individuals representing 140 taxa were identified in the 15 macrofauna samples collected around Well A during the EAD Benthic Baseline survey. Infauna communities were dominated by small polychaete worms (2,145 individuals (56%), 52 taxa), Crustaceans (1,108 individuals (29%), 32 taxa, mostly Amphipoda, Ostracoda, Tanaidacea and Isopoda), Molluscs (281 individuals (7%), 37 taxa, mostly Bivalvia), and Nematodes (146 individuals (4%), 1 taxa) (**Figure 11** and **Figure 12**). The raw macroinvertebrate data from Well A monitoring stations is provided in **Appendix D**.

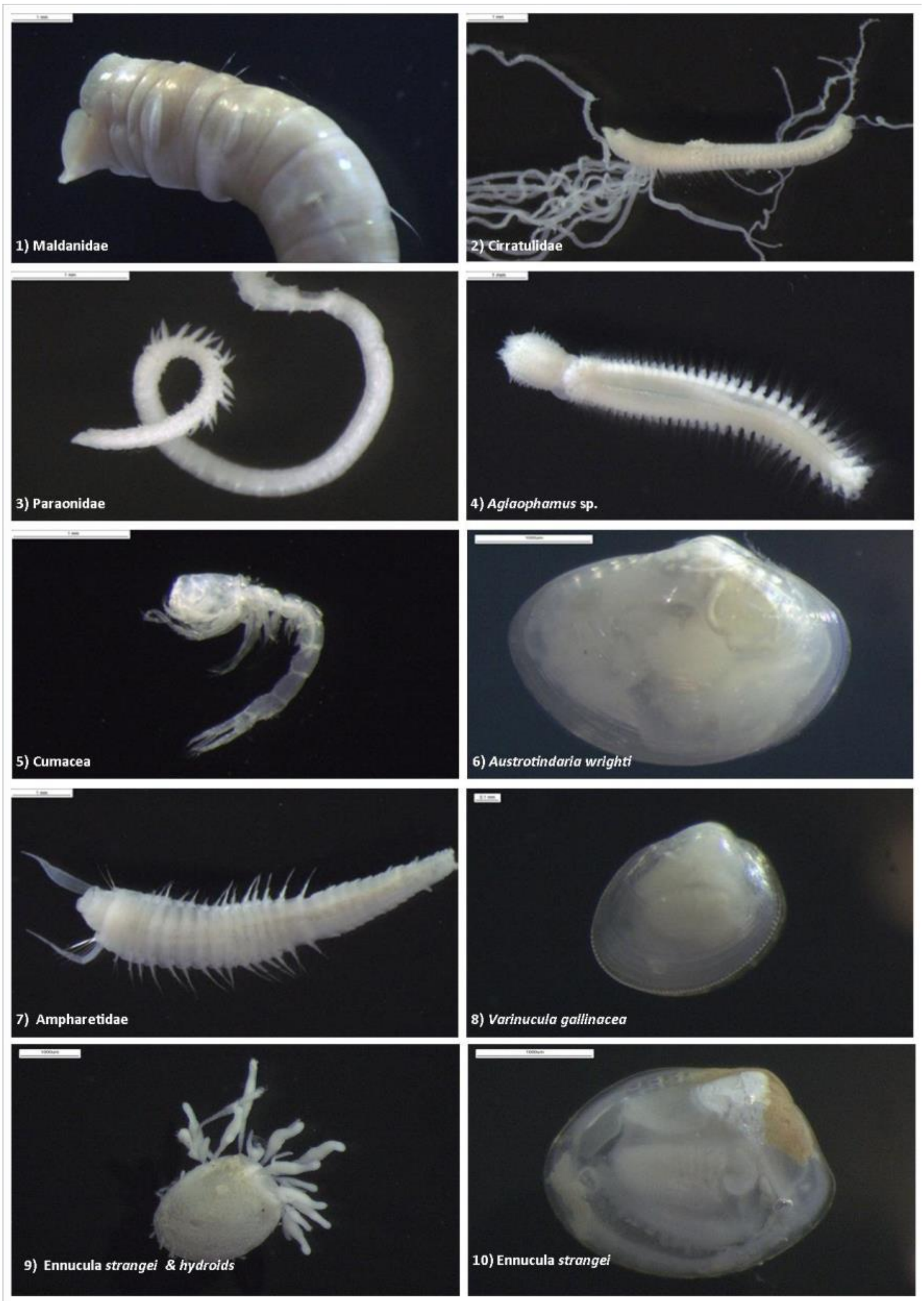
When the benthic macrofauna results are compared across the three AOIs, crustaceans (Tanaidacea and Copepoda) and nematodes were found in higher numbers in the Northern AOI sites compared with Central and Southern AOI. Gastropods and polychaetes were found in lower proportions in the Northern AOI and higher in the Central and Southern AOI (**Appendix E**). This result is likely linked to the differences in sediment composition, where a coarser grain size was present in the Northern AOI compared to the Central and Southern AOIs.

Figure 11 Proportion of Individuals at Well A Belonging to each Taxonomic Group



'Other Crustacea' includes Decapoda,Copepoda and Malocostraca. 'Other Molluscs' includes Gastropods, Aplacophora and Scaphopoda. 'Other' includes Actiniaria, Anthozoa, Ascidiacea, Euphausiacea, Chaetognatha, Nermetea, Oligochaeta, Sipuncula, Tunicata and Phoronus.

Figure 12 Representative Images of Infauna Taxa Frequently Observed in Sediment Samples from the Offshore Taranaki Area



3.3.2 Univariate Indices of Infauna Communities

Univariate indices (total number of taxa, total abundance, Pielou's evenness and Shannon-Wiener diversity) describing the benthic macroinvertebrate communities found at Well A in 2018 are displayed in **Figure 13**.

The number of taxa identified in each sample collected around Well A varied from 40 to 70 (mean 56), while total abundance ranged from 125 to 364 individuals (mean 256). Abundance and taxa numbers at Well A were very similar to the overall mean values for the Northern AOI (53 taxa, 233 individuals, **Table 7**), which were notably higher than those of the Central and Southern AOI.

Evenness values vary on a scale between zero and one, with values near one indicating that infauna abundances are evenly distributed across all the different taxa present, while values near zero indicate infauna communities are being numerically dominated by a large number of individuals from just a few, or even only single taxa. Values from the Benthic Baseline data collected at Well A were relatively high (mean 0.89), indicating relatively even distribution of taxa abundances across the taxa that were present.

Shannon-Wiener diversity index values range between 0 and 4 with higher values indicating higher species diversity. From previous benthic studies in the offshore Taranaki region, species diversity values are normally between 1.5 and 3.5. The mean Shannon-Weiner diversity index for Well A was 3.5, and ranged between 3.3 and 3.8. When these results are compared to the most recent results from long term benthic monitoring programmes at the Maari Field in the Southern AOI mean of 2.9 species diversity was greater at Well A.

Figure 13 Total Number of Taxa, Total Abundance, Pielou's Evenness and Shannon Wiener Diversity Index Values for Macrofauna Samples Collected at Well A

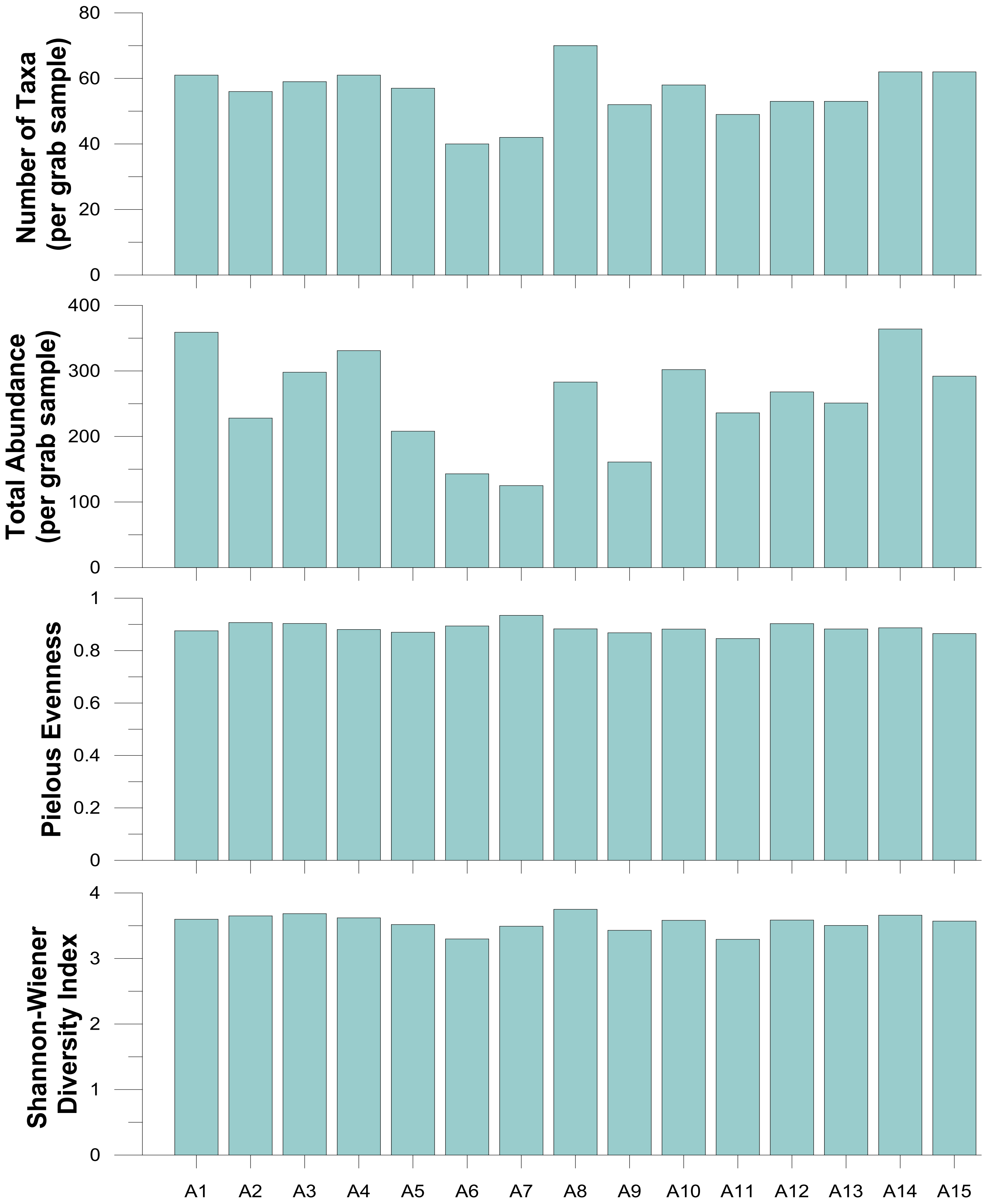


Table 7 Number of Taxa and Total Abundance for the Eleven Wells

Site	Mean Number of Taxa	Mean Abundance	Total Number of Taxa Identified at site	Total number of individuals (abundance)
A	**56**	**257**	**140**	**3,849**
B	53	210	130	3,151
C	45	132	128	1,987
D	60	332	142	4,986
Northern AOI	53	233		
E	19	36	78	542
F	31	68	90	1,023
G	33	81	112	1,215
H	31	89	103	1,339
I	29	72	91	1,075
Central AOI	29	69		
J	40	115	108	1,722
L	54	190	131	2,853
Southern AOI	47	153		

3.4 Sensitive Environments

In an investigation of sensitive substrate/benthic habitats in the Taranaki Coastal Marine Area, Johnston (2016) studied marine taxa databases from marine benthic surveys conducted in the offshore Taranaki Basin and noted that there are many locations where at least one 'characteristic species of sensitive environments' was found. This investigation used the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activities Regulations**) sensitive environments descriptions to define what sensitive habitats may be present.

Chaetopteridae worms and Sea pens (*Virgularia gracillima*) were noted by Johnston (2016) as likely to be present in areas close to the 4 wells. In relation to the sampling techniques used in the Benthic Baseline survey (grab sampling and video sled imagery), MacDiarmid *et al*. (2013) define that;

"A sensitive Chaetopteridae worm field is present if worm tubes and/or epifaunal species:

- Occupy 25% or more of the seabed in imaging surveys covering and area of 500 m^2 or more; or
- Occur in two successive samples collected using point sampling gear."

and

"A sea pen field exists if:

- One or more specimens of any species of sea pen is found in two successive samples collected using point sampling gear, or
- Two or more specimens per m^2 are found in seabed imaging surveys, or surveys using towed gear."

Macrofauna samples have shown Chaetopteridae worms (specifically *Phyllochaetopterus socialis*, commonly known as wire-weed or Tarakihi weed) were present within samples from Wells A, B, C, D, G, H, J and L. The majority of sites only had a small number of sampling stations at each well, with Well A having a single individual at five of the 15 samples collected. However, infauna samples collected from Well B had 2 - 13 individuals occurring in 11 of the 15 samples collected. Across the ten video sled tows performed at Well A there were no distinct worm-fields or the low-relief worm-meadows that *P. socialis* often form observed. Thus while this sensitive environment species was present at Well A the distributions appeared more as “isolated individuals within mixed epifaunal assemblages” at two stations rather than “dense mono-specific meadows at the tens of kilometres scale” (MacDiarmid *et al.*, 2013).

Three isolated sea pens (*Virgularia gracillima*) were identified in three separate infauna samples (A3, A8 and A11) from Well A during the Benthic Baseline survey. Video imagery collected at each well observed sea pens (likely *Virgularia gracillima* and *Anthoptilum sp.*) at all of the wells (see **Table 6** for total numbers of sea pens observed across the ten tows at each site). Sea pen numbers (all species) observed at Well A were moderate (54), with the highest numbers observed at Wells D (160) and L (132). The Northern AOI sites generally had greater numbers compared to central and southern areas. The variable visibility encountered during video sled imagery means this method can only be qualified as semi-quantitative. However, approximate densities can be calculated based on the approximate width of the cameras field of view and the length of each tow. Based on such calculations the densities of unidentified sea pen species at Well A would not have surpassed the trigger of two sea pens per square meter (MacDiarmid *et al.*, 2013), and video tows at Well A did not pass through more spatially limited areas of higher density that might have been classed as ‘sea pen fields’. Based on the video sled analysis there are no ‘Sensitive Environments’, as defined by the Permitted Activities Regulations were encountered at the monitoring stations at Well A

4 Key Findings

4.1 Sediment Characteristics

There were no distinct spatial patterns to the variations in grain size and TOC across the fifteen sampling stations surrounding Well A.

Grain size analysis at Well A (and other Northern AOI sites) indicated that the sediment was coarser than those sediments found in the Central and Southern AOIs, which are dominated by mud (silt and clay).

TOC levels at the Well A location (and other Northern AOI sites) were lower (mean of 0.21%) than those found in samples from the Central and Southern AOIs (mean TOC 0.59% and 0.48%, respectively). Sediments with a finer grain size will retain higher levels of organic matter compared to coarser/sandier sediments subjected to the same level of enrichment/deposition.

4.2 Faunal Characteristics

Video sled imagery from the ten sampling stations at Well A showed fish were present in high numbers compared to other wells surveyed across the three AOIs (~65 compared to a median of 28 across all 11 wells). Mound/hollow features were observed to be more numerous at the Northern AOI sites, moderate to high at the Southern AOI sites, and low around the Central AOI sites.

Infauna communities sampled at Well A contained proportionally more Tanaidacea, Nematoda and Amphipoda, and less gastropods and polychaetes compared to the Central and Southern AOIs. The number of taxa and total abundance at Well A were very high when compared to the sites monitored in the Central and Southern AOIs.

Pre- and post-drill monitoring around exploration well sites in the offshore Taranaki region has shown that following completion of drilling there has been a reduction in the overall number of taxa found, and a reduction in total abundance, although some individual taxa which are known to be more opportunistic and disturbance tolerant have sometimes shown increased abundances compared to pre-drill monitoring results.

The comparatively coarser nature of sandy sediments at Well A (and other northern region sites) versus the muddy sediments from the Central and Southern AOIs is likely to be linked to the lower number of gastropods, many of which are detritivores and/or deposit feeders which feed on dead and decaying algae, seaweed and other plants and animals, as well as organic matter within the sediments. This feeding mechanism is likely to be more suited to muddy sediments. Sediment grain size is also important for determining suitable habitat for polychaete species (tubeworms), which form their tubes within the interstitial spaces in the sediment matrix, thereby requiring specific sediment properties to become established.

Explaining the greater proportions of Tanaidacea, Copepoda, Nematoda and Amphipoda at Well A is more complex. For example, some species within the order Tanaidacea may be filter feeding species while others actively hunt prey (predators). The prevalence of these taxa at Well A, compared to sites within the Central AOI, is likely to be linked with the coarser sediments present at Well A. Coarser sediments, particularly larger sands, gravels, shell hash, etc., begin to provide more three-dimensional, cryptic habitats, allowing a wider variety of taxa to find different suitable habitats than mud-dominated sediments. Coarser sediments also contain less of the very fine clay particles which can clog or damage the delicate feeding and breathing structures of taxa adapted as filter feeders, particularly when such fine sediments are present in the water column for extended periods, and/or repeatedly re-suspended.

4.3 Sensitive Environments

Observations from the video sled analysis indicate that no 'Sensitive Environments', as defined by the Permitted Activities Regulations were encountered at the monitoring stations at Well A. However, some individuals representing some of the '*characteristic species of sensitive environments*' were found in macrofauna samples (e.g. Chaetopteridae worms and sea pens) and observed in video tows (e.g. sea pens) during the Benthic Baseline survey.

5 References

Clarke K. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18 (1): 117-143.

Clarke K.R., Warwick R.M., 1994. Change in marine communities: An approach to statistical analysis and interpretation. Plymouth Marine Laboratory, UK.

Clarke K.R., Gorley R.N., 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth.

Folk, 1954. *“The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature”,* The Journal of Geology 62(4):344-359.

Hedges JI, Keil RG, Cowie GL, 1993, “Sedimentary diagenesis: organic perspectives with inorganic overlays", Chemical Geology 107: 487-492.

Johnston O, Barter P, Ellis J, Elvines D, 2014, “*Recommendations for an Offshore Taranaki Environmental Monitoring Protocol: Drilling- and production-related discharges, Version 1.0*” (OTEMP), Cawthron Report No. 2124.

Johnston O 2016. Sensitive habitats and threatened species in the Taranaki Coastal Marine Area (TCMA) - database investigation. Prepared for Taranaki Regional Council. Cawthron Report No. 2877. 28 p. plus appendices.

MacDiarmid, A., Bowden, D., Cummings, V., Morrison, M., Jones, E., Kelly, M., Neil, H., Nelson, W., Rowden, A., 2013. ‘*Sensitive marine benthic habitats defined*’. Prepared for Ministry for the Environment, NIWA Client Report No: WLG2013-18.

SLR, 2016. “*Benthic Ecological Survey - Matuku-1 Exploration Well Post-Drill Assessment, March 2016*”. Prepared for OMV New Zealand Limited. Report Number 740.10013.00240

APPENDIX A

Locations and Observations from Sediment Grab Sampling and Video Sled during the 2018 Benthic Baseline Survey

Station	Date	Time	Depth (m)	Coordinates (NZTM)		Notes
				Easting	Northing	
Grab Sample Sites						
AG 1	1/4/18	1020	134	1635752	5722270	Hard packed fine sand
AG 2	1/4/18	1037	134	1634366	5723711	Packed fine sand, softer than previous
AG 3	1/4/18	1145	134	1632977	5725152	Fine sandy mud, light brown colour, grey sands, some broken shell
AG 4	1/4/18	1410	134	1632285	5725872	Sandy mud, light brown, grey fine sand
AG 5	1/4/18	1356	134	1631589	5726591	Sandy mud, light brown, grey fine sand, some broken shell
AG 6	1/4/18	1329	134	1630895	5727309	Light brown fine sandy mud, sand dark grey, single side grab only
AG 7	1/4/18	1338	134	1630194	5728024	Fine sandy mud, light brown overall but with grey sand
AG 8	1/4/18	1052	134	1635119	5725818	Packed fine sand and some mud with fine broken shell material
AG 9	1/4/18	1103	134	1634401	5725120	Packed fine sandy mud with some fine broken shell
AG10	1/4/18	1117	134	1632969	5723731	Fine sandy mud, some fine broken shell, light brown colour
AG11	1/4/18	1129	134	1632237	5723030	Fine sandy mud, some broken shell, light brown colour
AG12	1/4/18	1200	134	1633027	5727979	Fine sandy mud, light brown with grey sand
AG13	1/4/18	1254	134	1632310	5727286	Fine sandy mud, light brown with darker grey sands
AG14	1/4/18	1307	134	1630870	5725895	Light brown sandy mud with dark grey sand and some broken shell
AG15	1/4/18	1316	134	1630152	5725199	Light brown fine sand and mud, dark grey sand
Video Sled Tow Locations						
AV 1	30/3/18	1416	144	1636153	5724037	
AV 2	30/3/18	1326	143	1635073	5722995	
AV 3	30/3/18	1357	143	1633996	5721949	
AV 4	30/3/18	1544	148	1633714	5726558	
AV 5	30/3/18	1518	148	1632285	5725872	
AV 6	30/3/18	1449	146	1631555	5724462	
AV 7	01/4/18	1444	-	1631589	5726591	
AV 8	01/4/18	1507	-	1631972	5728348	
AV 9	01/4/18	1543	-	1630543	5727666	
AV10	01/4/18	1616	-	1629818	5726261	

APPENDIX B

Sediment Core Profile Images from all Grab Samples Collected during the 2018 Benthic Baseline Survey at Well A


AG1.JPG


AG10.JPG


AG11.JPG


AG12.JPG


AG13.JPG


AG14.JPG


AG15.JPG


AG2.JPG


AG3.JPG


AG4.JPG


AG5.JPG


AG6.JPG


AG7.JPG

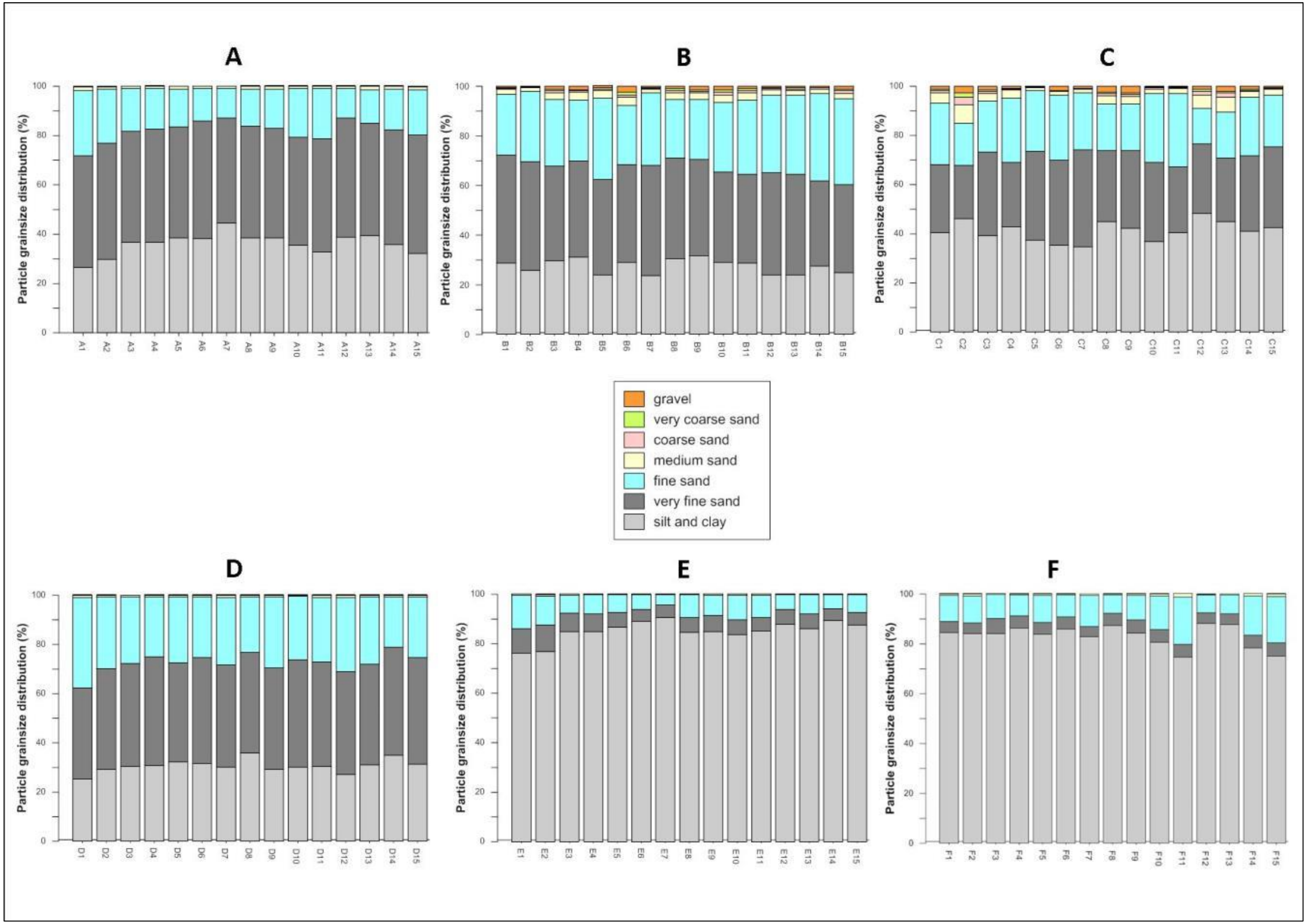

AG8.JPG


AG9.JPG

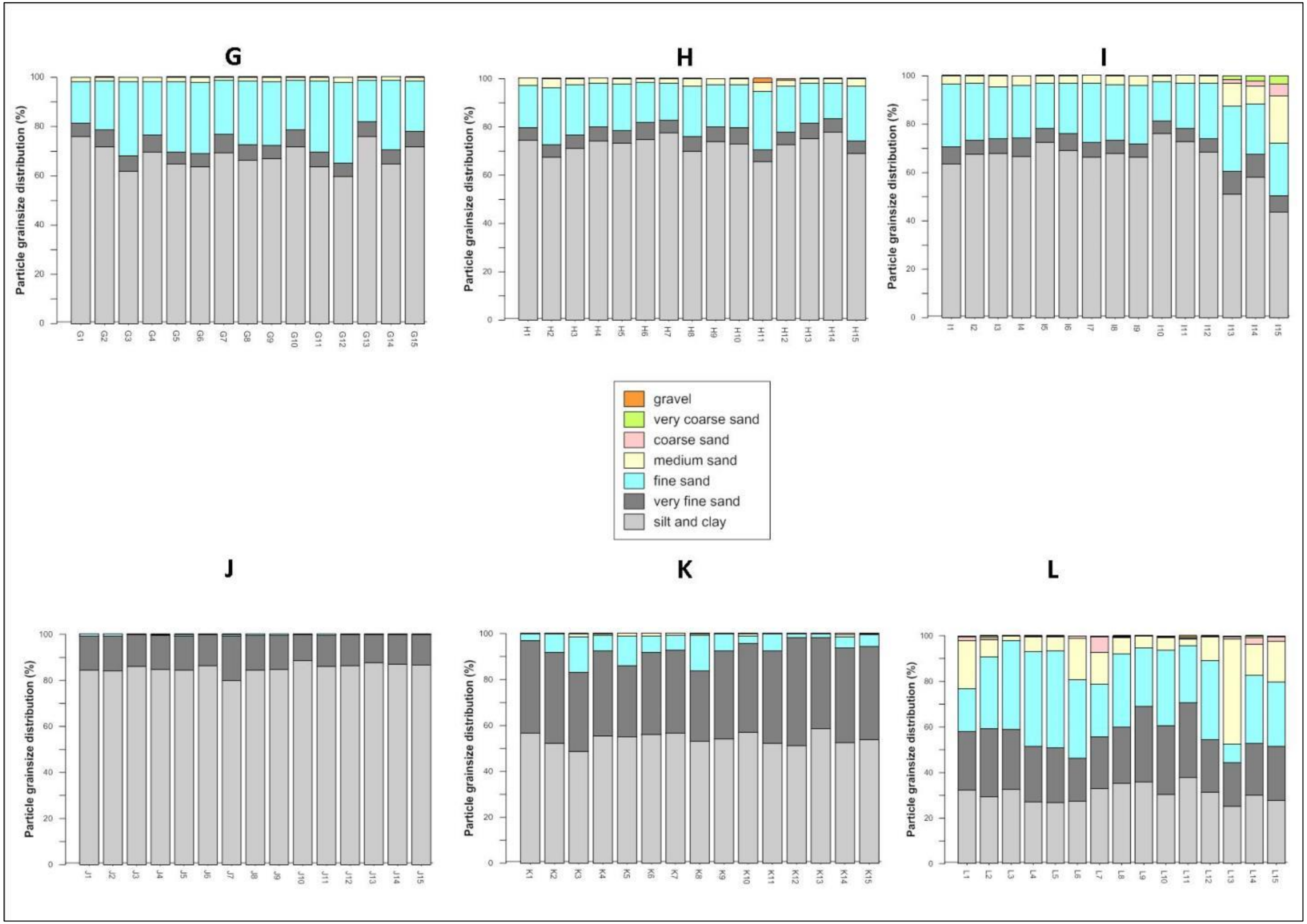
APPENDIX C

Total Organic Carbon Content and Particle Grain Size Distribution for Well A

Replicate Sample	TOC (%)	Gravel (%)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Silt & Clay (Mud) (%)
Station A1	0.2	0.1	< 0.1	0.2	1.4	26.4	45.4	26.4
Station A2	0.2	< 0.1	< 0.1	0.1	1.1	21.7	47.1	29.9
Station A3	0.22	< 0.1	< 0.1	< 0.1	0.9	17.4	45	36.6
Station A4	0.2	< 0.1	< 0.1	< 0.1	0.9	16.4	46	36.7
Station A5	0.22	< 0.1	< 0.1	< 0.1	1.1	15.3	44.9	38.6
Station A6	0.21	< 0.1	< 0.1	< 0.1	0.9	13.2	47.5	38.3
Station A7	0.25	< 0.1	< 0.1	< 0.1	0.7	12.2	42.4	44.6
Station A8	0.22	< 0.1	< 0.1	< 0.1	1.1	15.1	45.3	38.5
Station A9	0.22	< 0.1	< 0.1	< 0.1	1.2	16	44.3	38.5
Station A10	0.22	< 0.1	< 0.1	< 0.1	1	19.6	43.8	35.6
Station A11	0.2	< 0.1	< 0.1	< 0.1	0.9	20.4	45.9	32.8
Station A12	0.21	< 0.1	< 0.1	< 0.1	0.8	12.1	48.4	38.7
Station A13	0.23	< 0.1	< 0.1	< 0.1	1.4	13.5	45.8	39.3
Station A14	0.2	< 0.1	< 0.1	< 0.1	1.1	16.7	46.3	35.9
Station A15	0.18	< 0.1	< 0.1	0.1	1.2	18.3	48.2	32.1



A
B
C
D
E
F
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay


G
H
I
J
K
L
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay

APPENDIX D

Raw Counts of Macroinvertebrate (Infauna and Epifauna) Abundance at Well A

Taxa	Class/Order	Phylum	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15
Aglaophamus sp.	Polychaeta		12	5	11	18	9	1	3	15	8	11	5	7	4	12	1
Amalda sp.	Gastropoda	Mollusca								1							
Ampelisca sp.	Amphipoda	Crustacea				1									1		
Ampharetidae	Polychaeta		12	4	11	6	10	6	7	6	4	8	3	9	3	17	21
Amphipoda (unid.)	Amphipoda	Crustacea	10	14	7	4	2	2	5	3	3	9	3	4	1	3	2
Austromitra sp.	Gastropoda	Mollusca									1						
Antalis glaucarena	Scaphopoda	Mollusca														2	
Antalis nana	Scaphopoda	Mollusca		1	1				1	2				1			
Anthuridae	Isopoda	Crustacea	3	2	4	1	3					1	1	3		12	5
Aphroditidae	Polychaeta			1	2												
Aplacophora	Aplacophora	Mollusca	1					1		1		1		4		2	
Aricidea sp.	Polychaeta		7	4	3	6	6	3	4	4	4	7	7	19	2	7	9
Armandia maculata	Polychaeta		15	4	5	18	1	1	1	1	7	11	13		2	13	4
Armandia maculata (juvenile)	Polychaeta			8	4		4	5	1	12					8	6	8
Ascidiacea	Ascidiacea	Tunicata		1									2			2	
Asellota	Isopoda	Crustacea	3	9	5	11	2	4	2	4	3	5	5	10	3	8	4
Aspidosiphon sp.	Sipuncula				1				1								
Astromitra sp.	Gastropoda	Mollusca		1	2												1
Axiopsis sp.	Decapoda	Crustacea	1			1								1			
Bathyarca cybaea	Bivalvia	Mollusca		1	1					1		1			1		
Bivalvia (juvenile)			1			1	1			1	1				1	4	
Bradleya opima	Ostracoda	Crustacea	3	4	3	3	2			3	2				1		
Brachyura (juvenile)	Decapoda	Crustacea												1			
Cadulus teliger	Scaphopoda	Mollusca	5	2	3	1	1			4	1	4	4	6	2	7	5
Capitellethus zeylanicus	Polychaeta		6		4	3	1		1		1	3		1	2	6	6
Chaetognatha	Chaetognatha						1									1	
Chloeia fusiformis	Polychaeta												1			1	
Chlorotocus novaezealandiae	Decapoda	Crustacea								1							
Cirratulidae	Polychaeta		26	7	30	31	23	16	10	25	17	30	31	17	27	26	24

Taxa	Class/Order	Phylum	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15
Clavelina claviformis	Ascidiacea	Tunicata			2		3	2	1	3						1	2
Copepoda	Copepoda	Crustacea	1		3	1				3		1		2	2		2
Cossura consimilis	Polychaeta		1			5	1					2	1	3	1	1	
Cumacea	Cumacea	Crustacea	6	8	11	4	5	3	3	4	1	6	2	7	7	2	2
Cuspidaria fairchildi	Bivalvia	Mollusca								1							
Cuspidaria trialli	Bivalvia	Mollusca			1												
Cuspidaria trialli (juvenile)	Bivalvia	Mollusca														1	
Cyclostrematidae	Gastropoda	Mollusca														1	
Cymbicopia hispida	Ostracoda	Crustacea			1												
Cypridinodes reticulata	Ostracoda	Crustacea		1										1			
Cytherella sp.	Ostracoda	Crustacea	4	5	11	6	1		3	4	2	2	2	4	8	2	1
Diasterope grisea	Ostracoda	Crustacea			2	1	2				1					1	1
Diplodonta (juvenile)	Bivalvia	Mollusca											1				
Dorvilleidae	Polychaeta		1			3		1		1		1			1	3	
Ebalia laevis	Malacostraca	Crustacea		3	1				3	4							2
Ebalia laevis (juvenile)	Malacostraca	Crustacea	2			1	3				1	1	1	2			
Echinoidea (juvenile)			1														
Edwardsia sp.	Actiniaria			1		1				1				1			
Ennucula strangei	Bivalvia	Mollusca	10	7	12	8	7	4	4	8	9	3	2	7	4	13	7
Euchone pallida	Polychaeta		7	5		2	4		1	5	2	5	3	4	2	9	4
Euphausiacea	Euphausiacea						2				1						
Euphilomedes agilis	Ostracoda	Crustacea				10	5	2	1	2	2	8	2	5	3	7	15
Fissidentalium zelandicum	Scaphopoda	Mollusca									1						1
Flabelligeridae	Polychaeta		1	2		3			2	1			1	2	2		1
Gastropoda	Gastropoda	Mollusca											1				
Gastropoda indent	Gastropoda	Mollusca	1														
Gastropoda (juvenile)	Gastropoda	Mollusca								2							
Glyceridae	Polychaeta		2				2							2			1
Goniadidae	Polychaeta			1		1		1			1	1	1			1	

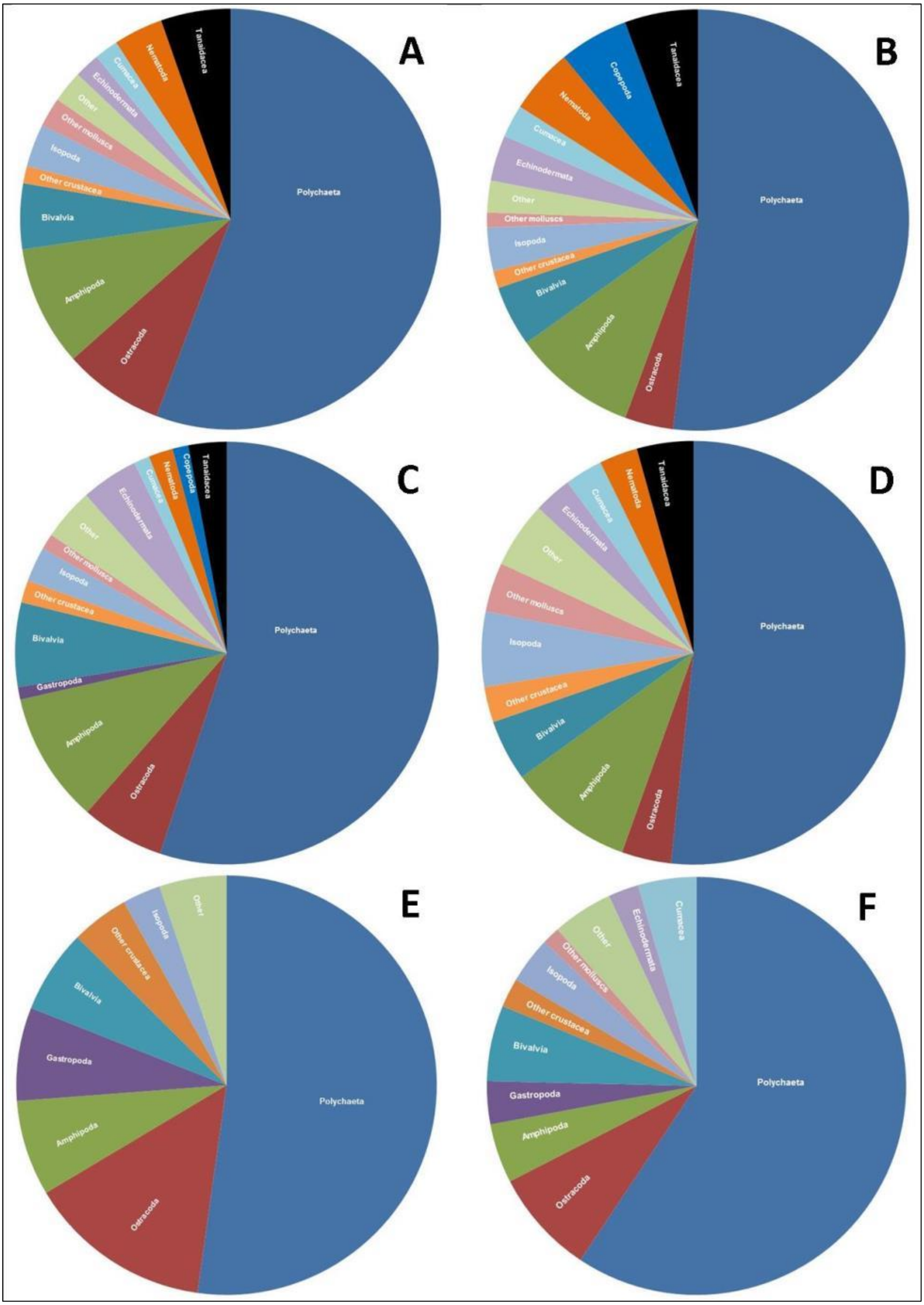
Taxa	Class/Order	Phylum	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15
Haustoriidae	Amphipoda	Crustacea	10	7	8	9	2	9	2	9	4	10	7	13	12	9	6
Hesionidae	Polychaeta			1							1	1			1		
Ischyroceridae	Isopoda	Crustacea	3			1	2			1	1	3	1			1	
Leitoscoloplos kerguelensis	Polychaeta		1	1	1		1	4		1	2	2			2	2	1
Lumbrineridae	Polychaeta		8	2	4	5	5	3	2	3		3	1		6	4	4
Lyreidus tridentatus	Decapoda	Crustacea					1										
Lysianassidae	Amphipoda	Crustacea	3				1			1	1	2	2	6			5
Magelona dakini	Polychaeta		18	9	6	15	8	3	7	9	9	16	5	8	10	13	13
Maldanidae	Polychaeta		5	1	2	6	1	2		1	1	2	4	2	2	8	2
Marphysa disjuncta	Polychaeta				1												1
Merelina sp.	Gastropoda	Mollusca	1			1								1			
Mogula sp.		Tunicata								1							
Myadora antipodum	Bivalvia	Mollusca		1	2			1		1							
Myriowenia sp.	Polychaeta					1											1
Natantia (Unid.)	Decapoda	Crustacea		1													
Naticidae	Gastropoda	Mollusca								2			1				
Nebaliacea	Malacostraca	Crustacea						1									
Neilonella wrighti	Bivalvia	Mollusca															
Nematoda	Nematoda		16	12	13	9	7	2	3	9	1	11	20	7	19	2	15
Nemertea	Nermetea		1	1	5	4	1	2	2					1	1	2	4
Neommatocarcinus huttoni	Decapoda	Crustacea			1			1							2		
Neonesidea sp.	Ostracoda	Crustacea	2	3		2		2	1		1			2	1		2
Neredae	Polychaeta				1												
Notocallista multistriata	Polychaeta											1				1	
Notocallista multistriata (juvenile)																3	
Nucinella maoriana	Bivalvia	Mollusca	1		1	1	2	2	2	2					1		2
Nucula nitidula	Bivalvia	Mollusca								1							
Oligochaeta	Oligochaeta											1				1	
Onuphis aucklandensis	Pool		1														

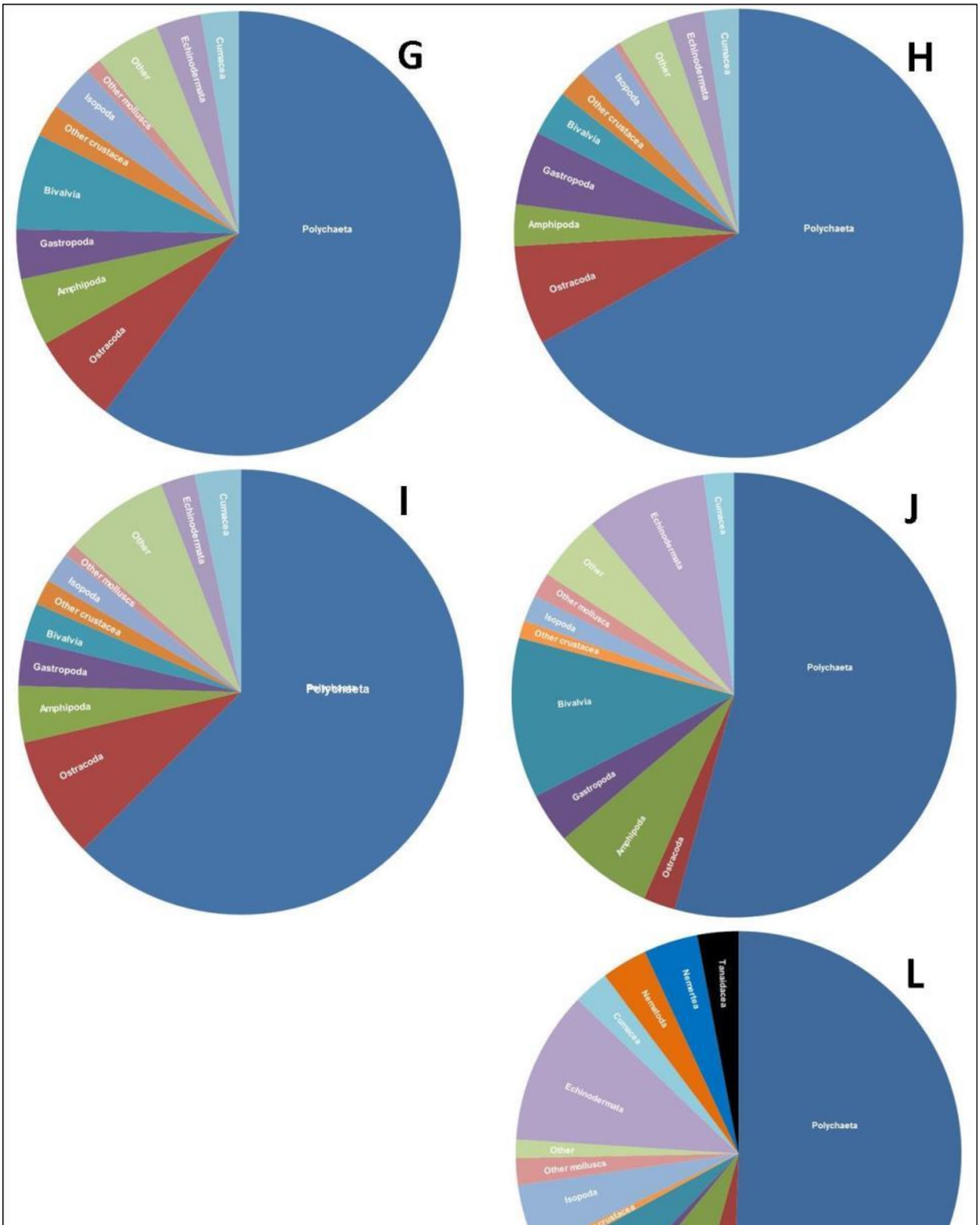
Taxa	Class/Order	Phylum	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15
Ophiuroidea	Ophiuroidea	Echinodermata	14	13		6	1	1	2	5	1	4	5	5	6	8	3
Orbiniidae 6 (unknown)	Polychaeta					2	1	2			3	2	1	4		1	1
Orbina papillosa	Polychaeta			1						2					2		
Ostracoda	Ostracoda	Crustacea				2					1		1				
Owenia petersenae	Polychaeta										1						
Paramunna serrata	Isopoda	Crustacea		1													
Paraonidae	Polychaeta		37	6	15	30	28	18	3	22	21	28	32	14	18	25	30
Parasterope quadrata	Ostracoda	Crustacea		4	14		1		8	9		2			10	1	1
Philine powelli	Gastropoda	Mollusca							1	1		1					
Phoronus					3												
Phoxocephalidae	Amphipoda	Crustacea	10	12	8	10	3	4	9	18	7	14	9	8	10	14	8
Phylo sp.				1								1					1
Phyllochaetopterus socialis	Polychaeta		1		1		1						1				1
Phyllodocidae	Polychaeta		2		1	1	1			1						4	1
Pilargidae	Polychaeta						1									1	
Pleuromeris paucicostata	Bivalvia	Mollusca					1			1							
Pleuromeris zelandica	Bivalvia	Mollusca			2												
Pleuromeris zelandica (juvenile)	Bivalvia	Mollusca		1													
Polychaeta A	Polychaeta					1											
Pratulum pulchellum	Bivalvia	Mollusca	1		3	2	1				1	2		1		2	
Priapulida	Priapulida									1							
Prionospio aucklandica	Polychaeta				1												
Prionospio multicristrata	Polychaeta			7	6	6	2	3	3	4	1	8	6	4	6	2	4
Prionospio sp.	Polychaeta		15	4	8	6	5	6	4	4	1	12	11	5	6	12	8
Propontocypris sp.	Ostracoda	Crustacea	1	2		1					1	1		1	4	1	
Pyura sp.	Tunicata					6					4	6	1	4			
Rhamphobrachium sp.	Polychaeta			1						1		1			1	1	1
Rissoidae	Gastropoda	Mollusca												2			
Saccella maxwelli	Bivalvia	Mollusca				1											

Taxa	Class/Order	Phylum	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15
Sabellidae	Polychaeta		7		7	7		1	1	1	1	2	2	2		10	3
Scalibregma inflatum	Polychaeta						1					1		2			2
Scoloplos sp.	Polychaeta			1	5	3		5	1	3	2	6		6	3	8	1
Serpulidae	Polychaeta															1	
Sigalionidae	Polychaeta			1			1		3	3	1			2	1		1
Sipuncula			1														
Sphaerodoropsis sp.	Polychaeta									1				1			2
Sphaerosyllis sp.	Polychaeta		2	3	10					7					2		1
Spio sp.	Polychaeta		3			2	4		2	2		3	2	3		5	
Spiophanes kryoeri	Polychaeta									1							1
Spiophanes modestus	Polychaeta		9	2	4	11	2	4		4	2	7	7	3	1	3	10
Spiophanes sp.	Polychaeta		4			2						1	1				
Spiophanes wiglyi	Polychaeta		5	4	6		1	1	3	1	1	2	6		3	2	2
Syllidae	Polychaeta		4	2	2	4	3	2		3	4	6	9	2	3	14	4
Tanaidacea	Tanaidacea	Crustacea	20	16	10	15	11	11	2	13	9	12	5	27	13	26	16
Terebellidae	Polychaeta		1		1					2		1					
Terebellides stroemii	Polychaeta					2			2		1						1
Themiste sp.	Sipuncula		3												1		1
Thyasira peregrina	Bivalvia	Mollusca				1			2	4			2		4	1	
Thyasira peregrina (juvenile)	Bivalvia	Mollusca					4										1
Thyasiridae juvenile	Bivalvia	Mollusca	2														
Trachyleberis lytteltonensis	Ostracoda	Crustacea	3	6	4	5	3	1	6	2	3	4	1	9	12	5	2
Varinucula gallinacea	Bivalvia	Mollusca	2							2	1	2					
Virgularia gracillima	Anthozoa	Cnidaria			1					1			1				

APPENDIX E

Comparison of Proportion of Individuals belonging to each Taxonomic Group across all Wells


A
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Tanaidacea
B
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Copepoda
Tanaidacea
C
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Copepoda
Tanaidacea
D
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Tanaidacea
E
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other
F
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea


G
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
H
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other
Echinodermata
Cumacea
I
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
J
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
L
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Nemertea
Tanaidacea

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EXPLORATION AND APPRAISAL DRILLING PROGRAMME

Benthic Baseline Report
Well B

Prepared for:

OMV New Zealand Limited
Level 20, The Majestic Centre
100 Willis Street
Wellington

SLR Ref: 740.10078.00200-R01
Version No: v1.0
July 2018

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BASIS OF REPORT

This report has been prepared by SLR Consulting NZ Limited with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with OMV New Zealand Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.10078.00200-R01-v1.0	31 July 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier
740.10078.00200-R01-v0.1	29 June 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier

EXECUTIVE SUMMARY

OMV New Zealand Limited (**OMV New Zealand**) are applying for a Marine Consent to undertake an Exploration and Appraisal Drilling (**EAD**) Programme in the Taranaki Basin with an anticipated commencement date in 2019. OMV New Zealand may drill up to nine exploration wells and two appraisal wells within their Petroleum Exploration Permits (**PEP**). The intention of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs.

As part of the Marine Consent application, three Areas of Interest (**AOI**) have been identified that encapsulate the proposed well locations and are used as part of the Impact Assessment process. OMV New Zealand undertook a baseline environmental monitoring survey at each well location in March-April 2018 to gain an understanding of the benthic habitat and associated communities with each AOI

Grab sampling and video sled methodologies were used to gain quantitative and qualitative information on the marine environments surrounding each well location. The data gathered from each baseline survey will be incorporated into the Marine Consent application and assist in the risk assessment process.

Water currents and deposition modelling were utilised to define the placement of sample stations. Sample transects were aligned along the dominant deposition pathway of the predicted drill cutting dispersion should that particular well be drilled. A total of 15 monitoring stations were allocated at each well site and one benthic grab sample was collected at each monitoring station. Ten video sleds were also undertaken at a selection of pre-determined sites around each well.

Within this Benthic Baseline report the analysis of results incorporates sediment physical and chemical properties, benthic macrofauna, epifauna and visual observations around Proposed Well B. A total of 3,151 individuals representing 130 taxa were identified from the 15 macrofauna samples collected around Well B. Infauna communities were dominated by small polychaete worms (52%), crustaceans (31%), molluscs (6%) and nematodes (5%).

The Benthic Baseline survey at Well B found no distinct spatial patterns in grainsize and Total Organic Carbon across the 15 sample stations. Grain size analysis indicated that sediments at Well B and in the wider Northern AOI are much coarser than sediments in the Central and Southern AOIs, which are dominated by mud (largely comprised of silt and clay sized fractions).

The baseline survey at Well B indicated the presence Chaetopteridae worms (*Phyllochaetopterus socialis*) and sea pens within the macrofauna grab samples, and showed sea pens present within the video imagery. These species are defined in the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activities Regulations**) as being a '*characteristic species of sensitive environments*'. Chaetopteridae worms are known to form worm-fields or low-relief worm meadows when present at high densities. Although eleven of the fifteen grab samples had Chaetopteridae worms present, the video imagery taken across the sample stations did not observe any distinct worm-fields or low-relief worm meadows. Sea pens were also observed in the video imagery collected at Well D. The occurrence and estimated densities of these taxa in well B video imagery did not reach the trigger levels defined by the Permitted Activities Regulations (MacDiarmid *et al*., 2013) and no distinct worm or sea pen 'fields' were encountered. Thus although taxa characteristic of sensitive environments were present at the Well B area in low densities it is considered that the area would not be classified as a 'sensitive environment'.

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1 Introduction

OMV New Zealand Limited (**OMV New Zealand**) is applying for a Marine Consent under Section 38 of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (**EEZ Act**) to permit activities associated with an Exploration and Appraisal Drilling (**EAD**) Programme proposed to be undertaken starting in 2019.

The EAD Programme includes the drilling of up to nine exploration wells and two appraisal wells within OMV New Zealand's permit areas (**Figure 1**). The purpose of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs which OMV New Zealand operate (**Figure 1**).

Three Areas of Interest (**AOI**) (summarised below) have been identified which encapsulate the well locations (**Figure 1**). This monitoring report relates to the Benthic Baseline survey conducted at Well B in the Northern AOI. Location details and water depth of Well B are provided in **Table 1**.

The Northern AOI encompasses PEP 60092 (Ridgeline), PEP 57075 (Cloudy Bay) and PEP 60093 (Toutouwai) and includes the following wells:

- Well A;
- Well B;
- Well C; and
- Well D.

The Central AOI encompasses PEP 60093 (Toutouwai) and includes the following wells:

- Well E (Appraisal);
- Well F;
- Well G (Appraisal);
- Well H; and
- Well I.

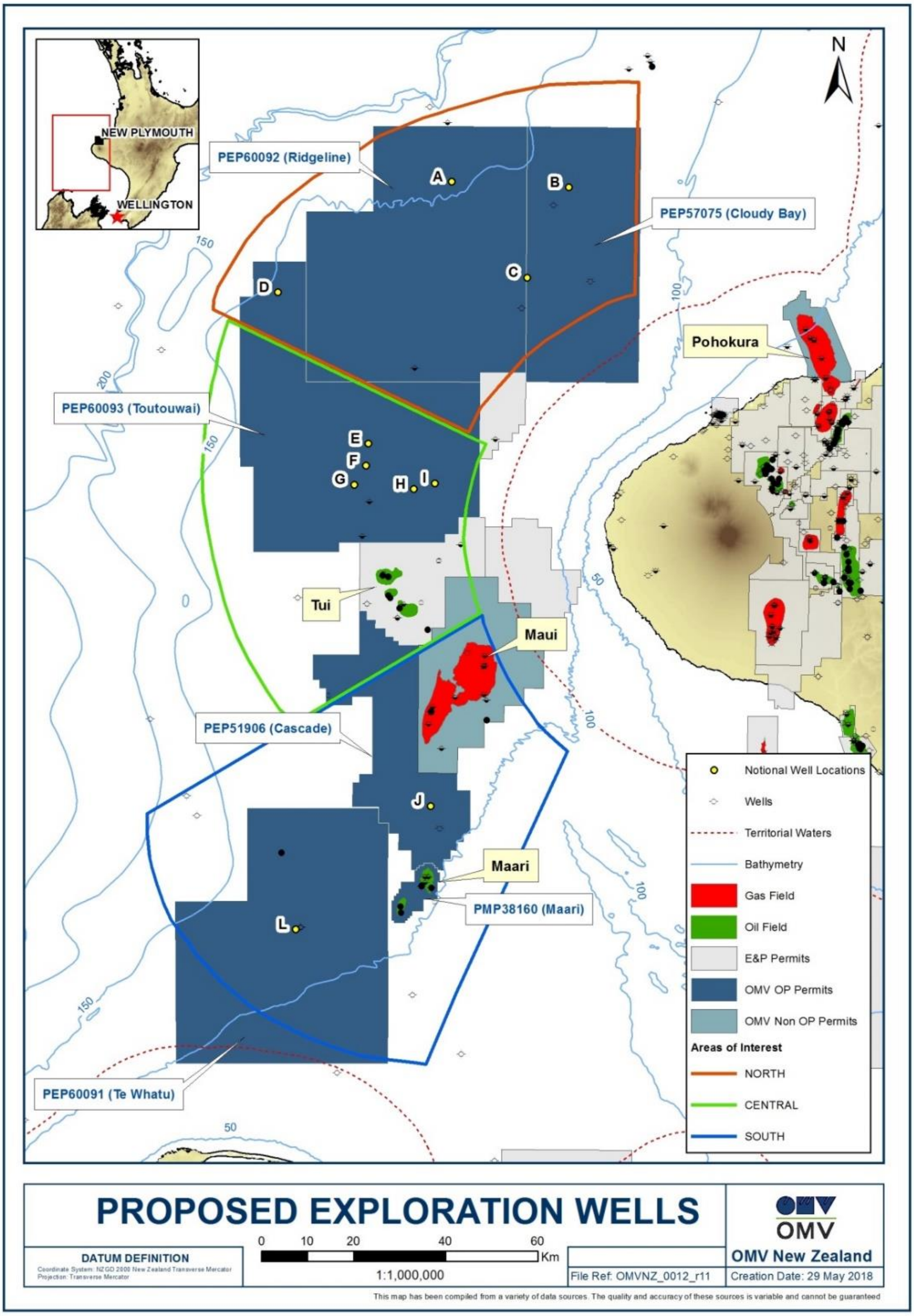
The Southern AOI encompasses PEP 51906 (Cascade), and PEP 60091 (Te Whatu) and includes the following wells:

- Well J; and
- Well L.

Table 1 Water Depth and Coordinates of Well B in the Northern AOI

Well Name	Water Depth (m)	Easting (NZTM)	Northing (NZTM)
B	131.6	1656780	5724493

Figure 1 OMV New Zealand's EAD Well Locations and three AOIs in the Taranaki Basin



In February 2018 SLR Consulting NZ Limited (**SLR**) was engaged by OMV New Zealand to undertake a baseline assessment of the benthic ecology in the vicinity of 11 well (**Figure 1**). The aim of the field surveys, which were undertaken from March 24 – April 8 2018, was to collect relevant data using grab sampling and video sled methodologies to provide quantitative and qualitative information on these marine environments. This qualitative and quantitative data will be used within the Marine Consent application to define the benthic habitats and communities present at each well and assist in the risk assessment process.

This report summarises the results of the Benthic Baseline survey undertaken at Well B.

1.1 Project Location

Well B is located approximately 60 km northwest of New Plymouth in New Zealand's Exclusive Economic Zone (**EEZ**). Water depth and GPS coordinates are provided in **Table 1** and displayed in **Figure 1**. The monitoring programme sample design resulted in sample stations extending out to 6 km from the well location (**Section 2.1**).

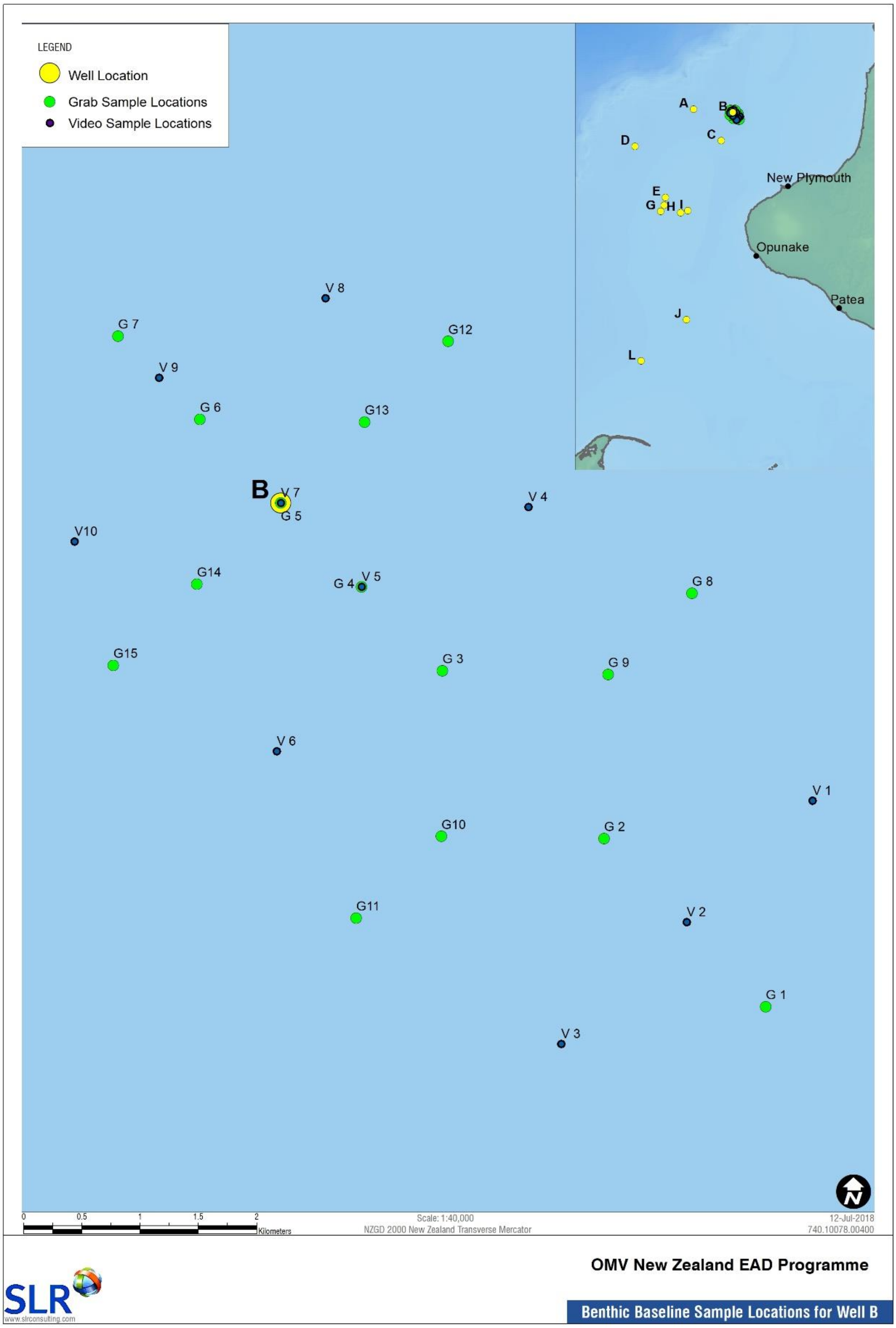
2 Methodology

The Benthic Baseline surveys adopted similar methodologies to what has been previously used for offshore Taranaki benthic monitoring programmes undertaken in accordance with the principles defined in the Offshore Taranaki Environmental Monitoring Protocol (**OTEMP**) (Johnston *et al.*, 2014). This consistent approach enables monitoring results to be compared with previous monitoring programmes undertaken in the offshore Taranaki environment (i.e. pre- and post-drill monitoring and production monitoring).

2.1 Sample Locations

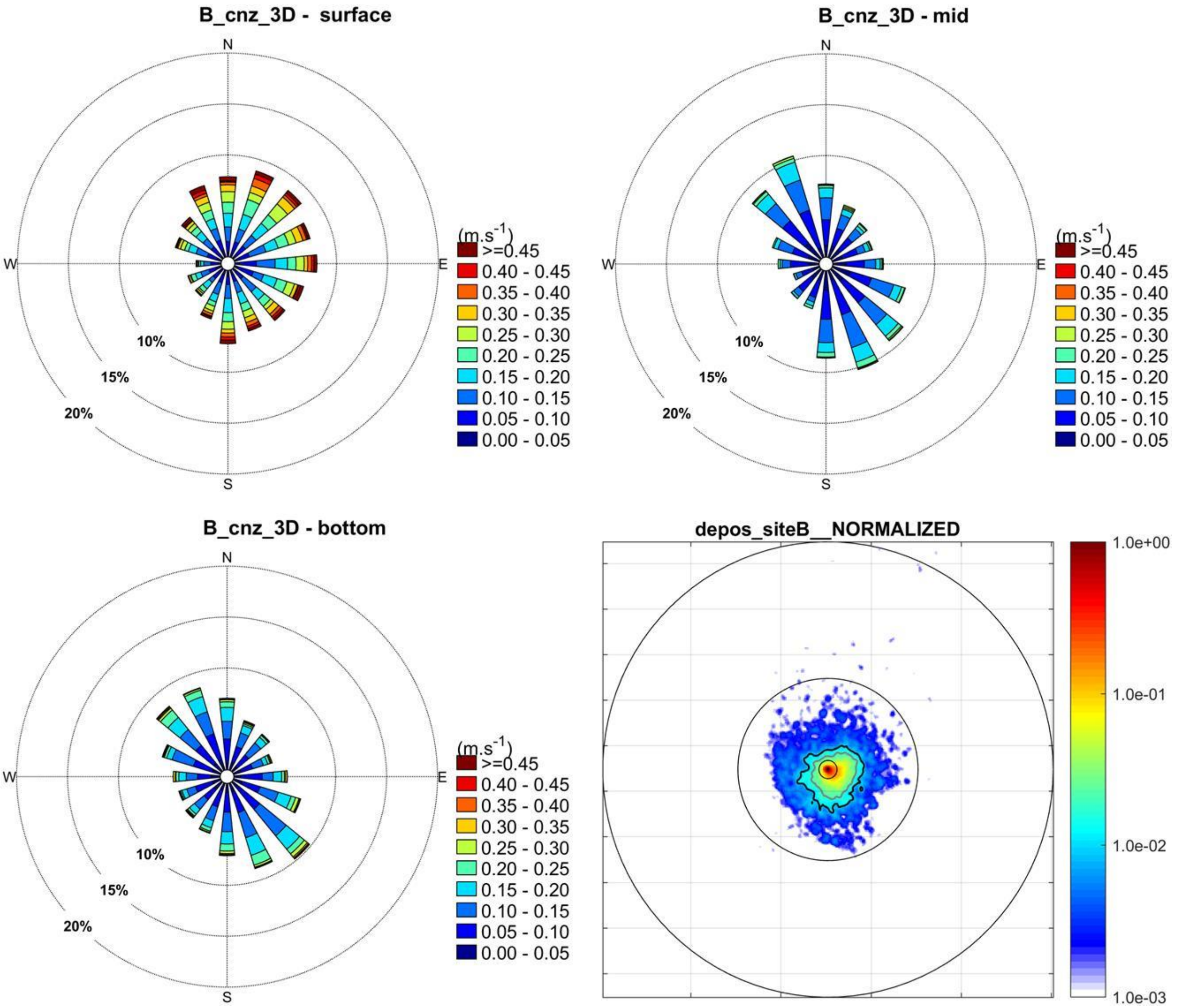
The sample locations (**Figure 2**) were defined by the dominant direction of current flow and preliminary drill cutting deposition modelling results (**Figure 3**). Sample transects were aligned along the dominant deposition pathway (i.e. southeast/northwest) (**Figure 2**) as this is the area determined to be most likely to be impacted from the deposition of drill cuttings should the well be drilled. However, sample stations were also located along the minor flow axis (northeast/southwest) to enable comparisons and validation of spatial differences based on the dispersal patterns predicted by MetOcean Solutions Limited.

Figure 2 Well B Sampling Locations



Note: At each video transect location approximately 250 m of video footage was captured along the seabed

Figure 3 Surface, Mid-water and Bottom Water Column Current Roses and Dispersal Modelling Plot created by Metocean Solutions Ltd for Well B



2.2 Field and sampling procedures

Field sampling was undertaken from the MV *Seaworker* between March 24 and April 8, 2018, following the procedures detailed below. Sampling at Well B took place on March 28th and 30th.

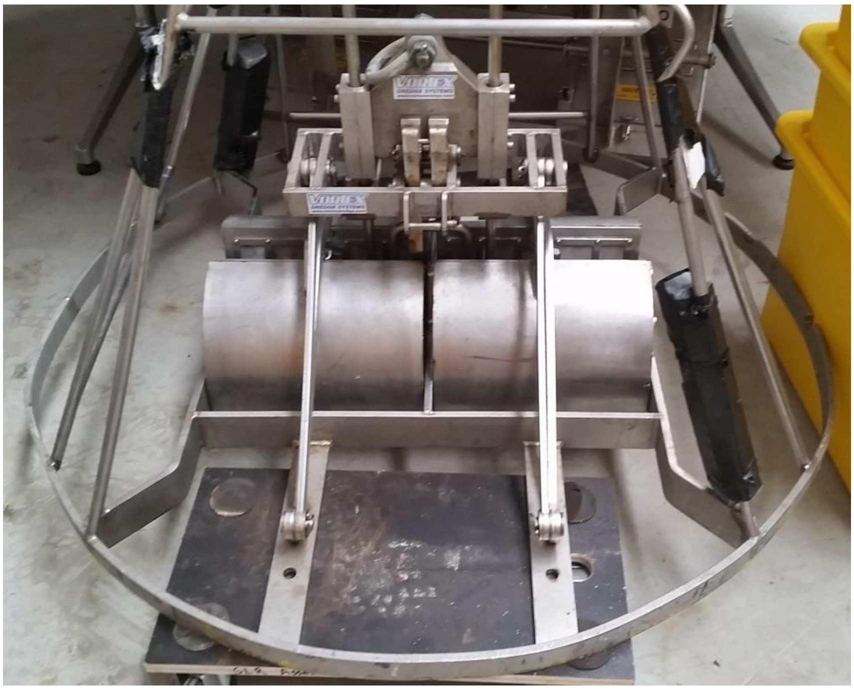
2.2.1 Benthic Grab Samples

A double Van Veen double grab sampler (**Figure 4**) was used to collect a single sediment grab sample at each of the 15 benthic monitoring stations surrounding Well B (**Figure 2**). The grab sampler is constructed of stainless steel and features two independent 'buckets' which penetrate the surficial sediments to a depth of 0.16 m. Each successful grab sample returns approximately 0.01 m^3 of seabed sediment back to the surface.

Upon arrival on the vessel deck, each grab sample is checked for completeness, which must meet the following criteria:

- The surface of the sediment is largely undisturbed upon inspection aboard the vessel;
- Sufficient sediment (≥75% of the grab capacity) is collected to enable the full suite of sediment analyses required;
- The infauna sample bucket is filled to the same volume (approximately 10 l) for all infauna replicates throughout the survey; and
- The grab has not been over-filled with sediments pushing out of the doors or drains, indicating that it may have over-penetrated the sediment.

Figure 4 The Double Van Veen Grab Sampler used for the 2018 Benthic Baseline Sampling



Each independent bucket from a grab sample is used separately for infauna and sediment physical and chemical analyses, as follows:

- Bucket one: infauna/macrofauna community analysis. The entire sample is sieved through 0.5 mm mesh until approximately 300-500 ml of residual sediment and organisms remains. This remaining material is transferred to a plastic container and preserved with a fixative (AncholTM), ready for analysis by SLR taxonomists.
- Bucket two: sediment physical nature and chemical analyses. Three 64 mm (internal diameter) clear Perspex sub-sampling cores are pushed into the sediments from the second bucket, to a depth of approximately 150 mm. Cores are photographed and the upper 50 mm from each core is extruded into a polyethylene bag for particle grain size distribution and organic content (Total Organic Carbon (**TOC**)) analyses by Hill Laboratories.

2.2.2 Seafloor Video Imagery

Video imagery of the seafloor was obtained using a customised tow-sled fitted with high-intensity LED lighting and a high-definition video camera (**Figure 5**). The system was connected to the vessel via a 10 mm dyneema tow-line and a 300 m umbilical cable supplying real-time video images to the camera operator on the research vessel. A pair of parallel lasers on the video sled provided an indication of scale allowing features of interest in the video recordings to be approximately sized. Ten video sled tows were conducted around Well B (**Figure 2**).

The video-sled was launched from the vessel up-current of each pre-determined location and lowered to the seabed, where it auto-located via a series of floats and weights set at specific points on the sled frame, to land upright on its lower skids. At the point where the sled contacted the seabed, a GPS log was started, and this log continued throughout the duration of the tow. Video footage was continuously recorded for approximately 200 m as the sled drifted behind the vessel; this ensured that footage was collected while the sled was passing as close as possible to the required sample location.

Figure 5 The Video Sled used for Collecting Video Footage of the Seabed Environment

2.3 Laboratory Analyses

2.3.1 Sediment Physicochemical Analyses

Benthic sediments collected by the grab were analysed by Hill Laboratories (an NZS/ISO/IEC 17025:2005 accredited laboratory), for both physical and chemical parameters. The aims of these analyses along with further details of the analytical method/descriptions are summarised in **Table 2**.

Table 2 Summary of Analytical Methods used for Testing Sediment Physico-chemical Characteristics

Analyte	Aim	Method Number	Description
Particle Grain Size Distribution	• Determine physical parameters of the sediment particles present at the site • Correlate with infauna community characteristics	Hill Laboratories KB32136	• Sediment was wet-sieved through the following screen sizes, as per the Udden-Wentworth scale (Wentworth, 1922): • >2 mm (gravel) • >1 mm (very coarse sand) • >500 µm (coarse sand) • >250 µm (medium sand) • >125 µm (fine sand) • >63 µm (very fine sand) • <63 µm (silt and clay)
Total Organic Carbon	• Determine current level of organic carbon in sediment • Correlate with infauna community characteristics	No specific method number	Acid pre-treatment to remove carbonates present, followed by catalytic combustion (900° C, O_2), separation, Thermal Conductivity Detector. Elemental Analyser.

2.3.2 Macrofauna Analyses

Macrofaunal analyses focused on the infauna, or animals larger than 0.5 mm living within the sediment matrix. Epifaunal animals (those living on top of the sediment), were also included in the analyses to provide representation of the different functional groups present at each sample station.

Benthic macrofaunal samples collected from the sediment grab were sorted and, with the aid of a binocular microscope, identified to the lowest practicable taxonomic level or most recognisable taxa (morphologically similar group). Counts were made to assess the relative abundance of each taxa.

2.3.3 Seafloor Video Analyses

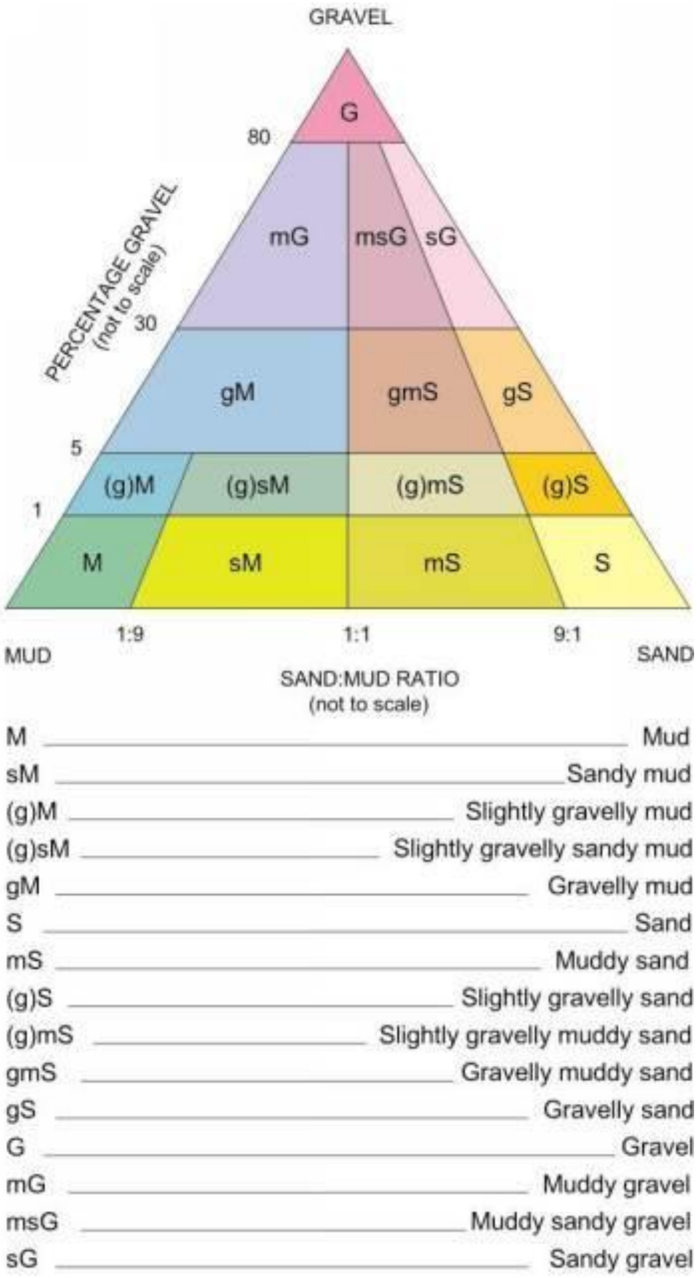
A live feed from the video-sled was captured and recorded on-board the survey vessel and viewed by SLR staff with experience in undertaking assessments of the benthic environment in the offshore Taranaki region. Brief field notes were made in real-time about obvious structures and organisms observed while watching the live footage. Back onshore the recorded seabed video footage was assessed on a large, high definition screen, by a suitably trained and experienced benthic scientist, who identified all obvious epifauna to the lowest practicable taxonomic level. Biogenic and/or anthropogenic seabed structures such as burrows, mounds, tracks and gouges/trenches were also recorded. Relative abundance estimates of epifauna or biogenic structures were made where appropriate.

2.4 Data Analyses

2.4.1 Sediment classifications

While there are many sediment classification schemes in use worldwide, a common one is a modified version of that proposed by Folk (1954). This scheme groups grains within a sample into mud, sand and gravel sized particles based on the particles diameter (mud <63 µm, sand 64-2000 µm, gravel > 2mm), and then describes the sediment type based on the relative proportions of the particles (see **Figure 6** s).

Figure 6 Folk (1954) Sediment Type Classification Triangle



2.4.2 Community Characteristic Descriptors

All macrofauna (both epifauna and infauna) taxa were included in the analyses of abundance data. Species identified in the samples as not being exclusively benthic were excluded from further analyses. Data were analysed as per the statistical methods outlined below to identify current distributions and abundance of macrofauna.

2.4.2.1 Univariate Diversity Indices

Diversity indices (number of taxa S, total abundance N, Shannon-Wiener diversity H', and Pielou evenness J' (**Table 3**) were calculated from the macrofauna abundance data using the PRIMER software package (PRIMER v6.1.16; PRIMER-E 2000; Clarke, 1993; Clarke & Warwick, 1994; Clarke & Gorley, 2006).

Table 3 Description of Macrofauna Community Characteristic Indices

Index	Formula (where applicable)	Description
Number of Taxa (S)	Count of total number of different taxa identified within the *x* sample	Total number of taxa identified within a sample
Total Abundance (N)	Sum of all individual taxa abundances within the *x* sample	Total number/count of all organisms within a sample
Shannon Diversity (H')	$H' = -SUM [(p_i) \times \log_e (p_i)]$ p_i = Number of individuals of taxa i /total number of samples	A single value (log scale) that is used to describe the different types and numbers of organisms present within an assemblage. The index value increases as assemblages have greater numbers of taxa and when the numbers of individual organisms are more evenly distributed across the different taxa. Samples dominated by single taxa will have lower values towards zero.
Pielou Evenness (J')	$J = H' / \log_e (S)$	A value theoretically between zero and one which indicates how evenly the number of individual organisms are distributed through the different taxa in an assemblage. High values (closer to 1) indicate an even spread amongst the taxa present, whereas a low value indicate an uneven spread or an assemblage highly dominated by only a few, or even a single taxon.

3 Results and Discussion

3.1 Sediment Physical and Chemical Properties

3.1.1 Visual Description of Sediment Cores

Sediment collected from around Well B was predominantly light brown/grey hard packed sandy mud with lots of small broken shell fragments (**Figure 7**). No dark-grey or black sediment layers (apparent Redox Potential Discontinuity – aRPD), or darker patches within cores were noted and no detectable hydrogen sulphide odours were present, indicating sediments are well oxygenated throughout the depths sampled. Field observations on sediment texture, colour and any notable features of the sediment samples were recorded during the processing of the sediment cores and infauna samples, and these are included in **Appendix A**. A full set of sediment core photographs are contained in **Appendix B**.

Figure 7 Representative Images of Sediment Core Profiles from Well B

Station B2

Station B5

Station B7

Station B10

3.1.2 Incidental Observations

During laboratory processing of the infauna samples observations were made of any debris present, including those from anthropogenic sources. Within the 15 samples collected around Well B, one observation was made of some darker, less dense particles that resembled coal. These materials were, found in 'low' abundance at a single grab sampling station, B10.

Table 4 Incidental Observations

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15
'Coal'										L					

VA = very abundant (>50), A = abundant (50+), C = common (20–50), O = occasional (10–20), L = low (0–10)

3.1.3 Sediment Particle Grain Size Distribution and Organic Content

The physical characteristics of the sediment can influence the composition of the infauna communities and the levels of contaminants retained and observed during analyses. Particle grain size is widely used to characterise the physical structure of the sediment, while organic content provides an indication of the organic enrichment in the sediment. These combined results provide a general understanding of sediment health and the source of potential stressors at the time of sampling.

Organic matter found in the sediments is most likely derived from natural sources such as infauna/epifauna and detrital matter, rather than from anthropogenic sources. Anoxic sediments (those lacking oxygen), may develop in situations where organic matter levels increase beyond 'normal' levels for that area. Increased organic matter has the potential to disturb the equilibrium of the benthic ecosystem, as increased numbers of oxygen-utilising bacteria are required to decompose the additional organic matter, thereby rapidly reducing oxygen availability in the sediments.

A summary of the particle grain size and organic content analyses are discussed below, with full results provided in **Appendix C**.

3.1.3.1 Particle Grain Size

Particle grain size analyses at the 15 monitoring stations around Well B are shown in **Figure 8**. Sediments are dominated by very fine sand, fine sand and silt/clay, in approximately equal portions. These sediments are therefore classified as 'muddy sands' (Folk, 1954), which have historically not been encountered very often in offshore Taranaki areas where exploration/production monitoring has taken place. There were no distinct spatial patterns to the grain size distribution across the sampling stations at Well B.

The grain size distribution at Well B was similar to the other sites in the Northern AOI, which all had notably coarser grain size compared to sediments collected in the central and southern regions (**Table 5**). The exception to this was Well L in the Southern AOI, which had a grainsize distribution very similar to the Northern AOI sites. A comparison of particle grain size data for Well B with the other well sites is provided in **Appendix C**. During onboard sample processing the sediments collected at Well B were observed to contain large amounts of broken shell materials. This was reflected in the quantitative grain size analysis results (notable proportions of gravel, coarse and medium sand sized particles).

Figure 8 Sediment Particle Grainsize Distribution for Samples Collected at Well B

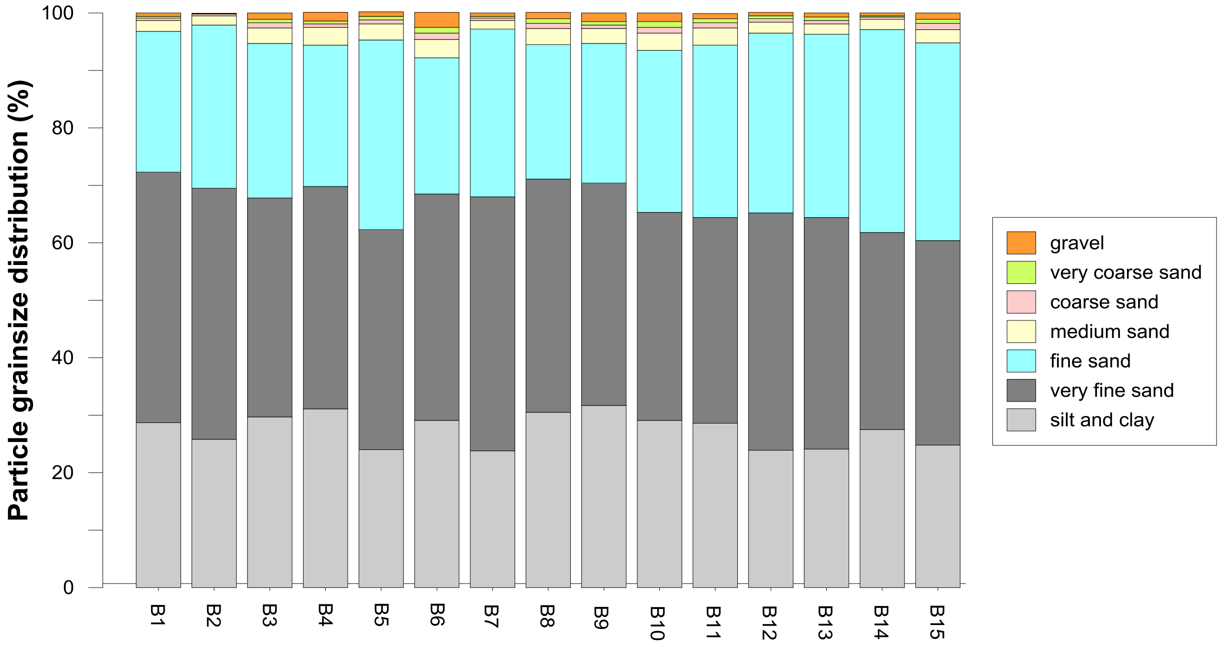


Table 5 Average Grain Size for the Eleven Well Sites

Grain size class	A	B	C	D	E	F	G	H	I	J	L
Silt & Clay (Mud) (%)	36.2	27.5	41.1	30.7	85.2	83.2	67.8	72.6	65.1	85.4	30.8
Very Fine Sand (%)	45.8	39.3	30.5	41.7	6.5	4.8	6.1	5.8	6.6	14.2	25.4
Fine Sand (%)	17.0	28.6	22.4	26.8	8.0	11.3	24.6	19.0	22.1	0.4	29.8
Medium Sand (%)	1.0	2.4	3.3	0.7	0.4	0.6	1.6	2.5	5.1	0.1	12.3
Coarse Sand (%)	0.1	0.7	0.8	0.0	0.0	0.1	0.1	0.1	0.6	0.0	1.2
Very Coarse Sand (%)	0.0	0.6	0.5	0.0	0.0	0.1	0.1	0.1	0.5	0.0	0.2
Gravel (%)	0.1	1.1	1.3	0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.1
Description	mS	mS	mS	mS	sM	sM	sM	sM	sM	sM	mS

Note: sM = sandy mud, mS = muddy sand

Colour scale based on percentage with median mid-point (median is 2.0):

0%	5	10	20	30	40	50	60	70	80	90	100

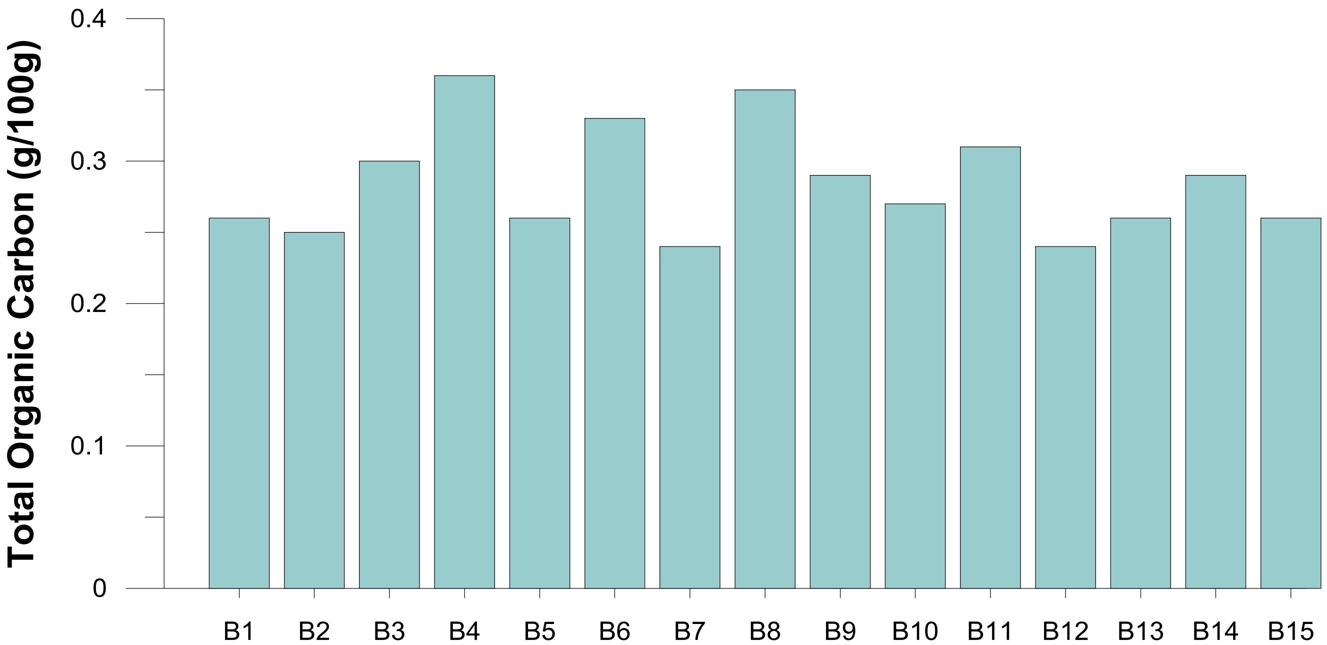
3.1.3.2 Total Organic Carbon

The organic content of sediments was assessed by measuring TOC to assess benthic ecology as this is also consistent with what is now currently undertaken around the offshore Taranaki oil and gas fields.

TOC levels at Well B (**Figure 9**) ranged between 0.24% to 0.36% (mean 0.28%).

The average organic content around Well B was low relative to other EAD wells monitored as part of the Benthic Baseline survey (mean 0.28% compared to overall mean of 0.45%). The combined mean from all stations at the four Northern Sites (0.26%) was lower than the central and southern sites (0.59% and 0.48%, respectively). As has been previously described in benthic environmental monitoring associated with offshore Taranaki oil and gas activities (SLR, 2016 & SLR, 2017), there is a correlation between sediment particle grain size and sediment organic content. The comparatively greater surface area to volume ratio of silt and clay (mud/fines) sized sediment particles (compared to larger particles like sand) gives a greater area for adsorption of organic matter particles and therefore a higher probability of elevated organic matter compared to coarser/sandier sediments subjected to the same level of enrichment (Hedges *et al*., 1993). This is likely to at least partially explain the lower organic content of sediments at the northern sites, where sediment grain size is distinctly coarser than at the central and southern sites (Section 3.1.3.1).

Figure 9 TOC Concentrations in Sediment Samples Collected from around Well B



3.2 Video Sled Imagery

Video footage of the seabed allows scientists to visually assess any anthropogenic disturbance to the benthic environment and observe epifauna, sediment-type and structures or relief that exist on the seabed.

Video footage was captured by towing a video sled through ten sites around Well B (**Section 2.2.2**). All video footage is included with the electronic version of this document, with a selection of still images displayed in **Figure 10**. **Appendix A** provides locational information for each video sled tow.

Video footage was assessed to determine any defining features and their semi-quantitative abundance recorded for comparison with other sites. Due to caveats associated with video footage (i.e. variable visibility, differing tow length and durations) the counts are indicative-only and should not be interpreted as a quantitative assessment. **Table 6** presents the results of this semi-quantitative approach, which summarises the counts by comparing the site total to the median across all of the EAD wells in the three AOIs. As a visual aid, counts were categorised in relation to the deviation from the 10th, 25th 50th, 75th and 90th percentiles, so that differences between sites can be more easily viewed.

3.2.1 Physical Observations

The seabed around Well B was observed to be dominated by firm sandy muddy sediments. Evidence of bioturbation was observed at all monitoring stations in the form of animal burrows (images A and F, **Figure 10**). Low to moderate numbers of animal burrows were observed in most of the video transects around Well B, which was similar to the other three well sites in the Northern AOI. However, this differs to the Central and Southern AOI sites, where numbers of animal burrows were found to be moderate to high (**Table 6**).

At Well B, mound/hollow features (image D, **Figure 10**) were observed in moderate numbers (63) when compared to the median (43) for all wells (see **Table 6**)). The highest numbers were seen at Well D (280) (Northern AOI) and Well L (532) (Southern AOI). These seabed features are presumed to be formed by feeding activities of sharks or rays, or in some cases tube worms or shrimps mounding up sediment. Mound/hollow features were observed to be more numerous at the Northern AOI sites compared to the other areas, where moderate to very high numbers of mound/hollow features were found at the Southern AOI sites, and low to very low in numbers around the Central AOI sites.

Anthropogenic disturbances in the form of elongated, shallow trenches were observed in several of the video sled tows at Well B. These features were likely caused by fishing activities which contact the seabed occurring at the site (bottom trawling). The shallow appearance of the trenches, along with rounded edges (weathered/eroded) and the presence of burrow holes visible within them, indicates that the disturbances likely occurred quite some time ago. There were no signs of sediment enrichment such as darker sediment patches, bacterial mats or sediment off-gassing, observed during any of the video sled tows around Well B.

Table 6 Total Number of Features Observed in Video Imagery from the EAD Wells

Well	Depth (m)	Mounds/ Hollows	Number of burrows/worm holes	Sea pen	Fish	Substrate	Notes
A	148	111	Low-moderate	54	65	Sandy mud	Ripples; some very large holes and mounds
B	134	63	Low-moderate	35	49	Sandy mud	Some very large holes mounds
C	132	85	Low-moderate	50	44	Sandy mud	Ripples; trenches observed
D	145	280	Low	160	28	Sandy mud	Ripples; 23 very large sea feathers
E	126	29	Moderate	29	16	Soft mud	
F	128	20	Moderate	19	19	Soft mud	
G	124	18	Moderate-High	29	26	Soft mud	
H	124	18	Moderate-High	17	26	Soft mud	12 elongated shallow trenches
I	122	43	Moderate-High	36	21	Soft mud	5 elongated shallow trenches (large)
J	108	42	Moderate	14	30	Soft mud	School of mackerel, tufts/tubes common
L	112	532	Moderate	132	31	Soft mud	2 schools of mackerel
Median		43		35	28		

Totals are sum of 10 video tows carried out at each site. Totals are semi-quantitative only due to variable visibility and transect length.

10th percentile band
25th percentile band
Median band
75th percentile band
90th percentile band

3.2.2 Infauna, Epifauna and Other Fauna

In some cases, a definitive positive identification of infauna, epifauna and more mobile taxa was not possible from the video footage alone. Where there was any uncertainty, identifications were based on distinctive features, colours and shapes of organisms and in some cases the confirmed presence of similar looking individuals within the infauna samples.

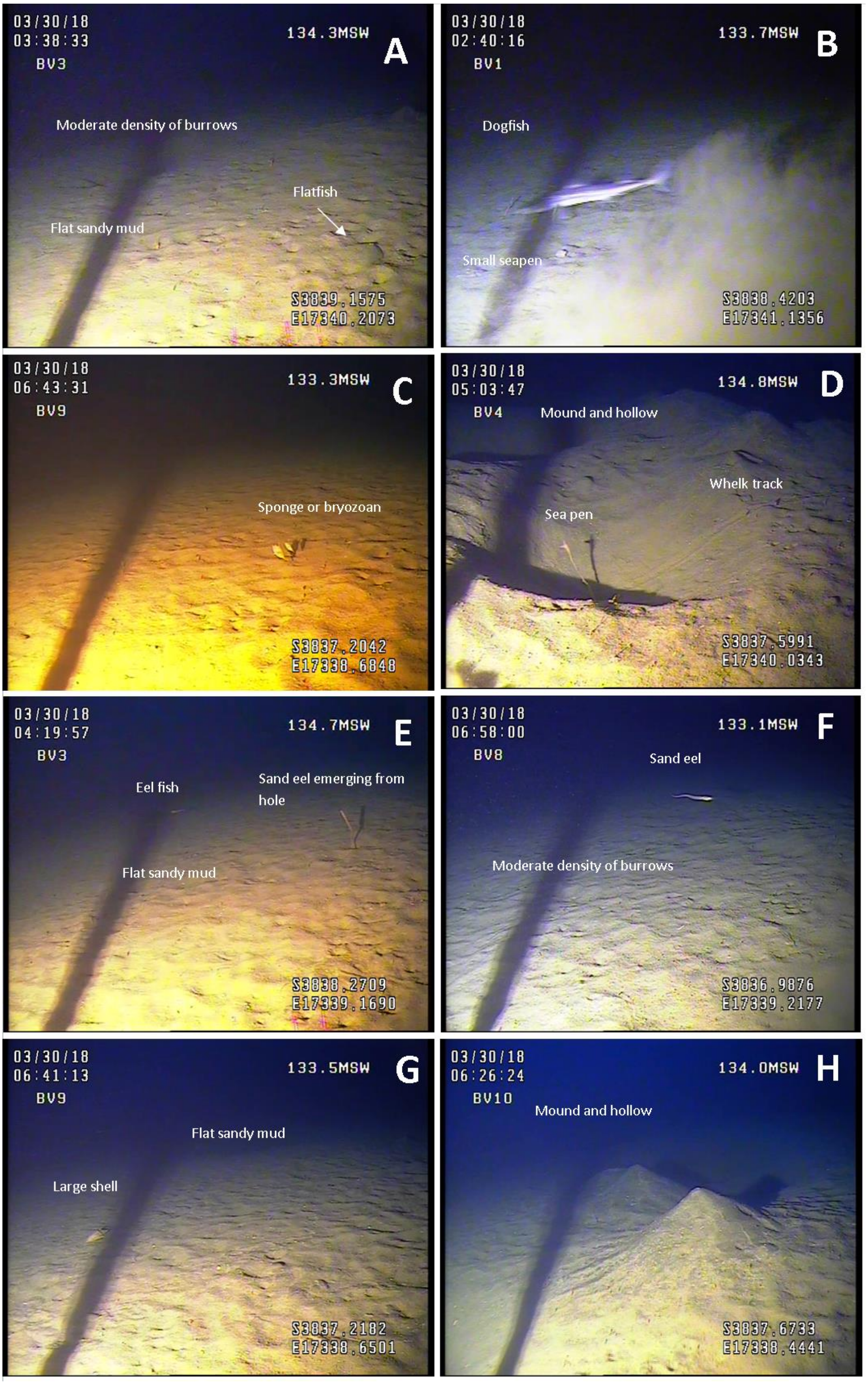
Epifauna taxa observed in video footage collected around Well B included whelks (likely *Austrofusus glans*) (image H, **Figure 10**), hermit crabs (*Pagurus* sp.), tusk shells (likely *Fissidentalium zelandicum*), and various species of sponge (image C, **Figure 10**). Despite not being detected in large numbers, the presence of epifauna tracks in the sediment indicates that mobile fauna such as whelks and hermit crabs move throughout this site.

Sea pens (likely *Virgularia* sp.) (images D and E, **Figure 10**) were present in moderate numbers (35) around Well B compared to the median (35) for all other wells (**Table 6**). The highest numbers were seen at Well D (160) (Northern AOI) and Well L (132) (Southern AOI). Sea pens were observed to be more numerous at the Northern AOI sites, variable at the Southern AOI sites, and lowest in the Central AOI sites.

Mobile fish species were observed in very high numbers (49) at Well B when compared to the median (28) for all other wells (**Table 6**). Numerous sand eels[1] (image E and F, **Figure 10**), a small number of flatfish (juveniles and adults) (likely *Peltorhamphus* sp.) (image A, **Figure 10**), John Dory (*Zeus Faber*) and dogfish (*Squalus acanthias*) (image B, **Figure 10**) were some of the more notable species observed. A number of smaller fish were observed swimming off very quickly as the camera approached, so it was not possible to make a positive identification. Across the region surveyed, fish numbers were observed to be much more numerous in the Northern AOI sites, moderate at the Southern AOI sites, and moderate to low around the Central AOI sites.

[1] This fish was unable to be formally identified, thus while the term 'sand eel' is used throughout this report it should not be considered a common name for this unidentified fish species.

Figure 10 Representative Images of Seabed Environment around Well B



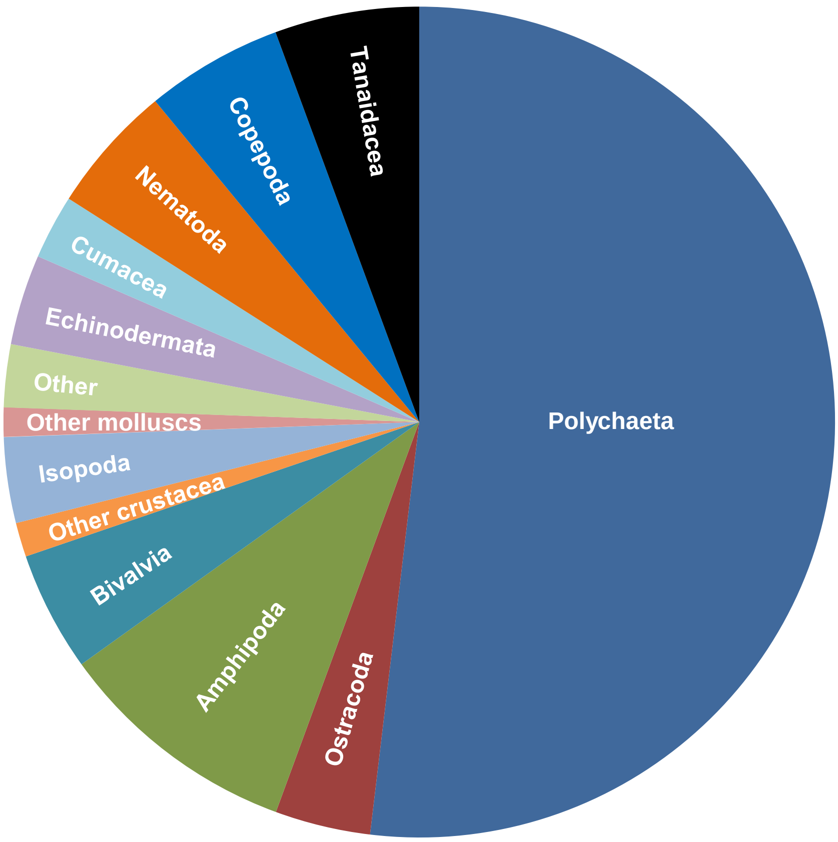
3.3 Macrofauna Characteristics

3.3.1 Benthic Macrofauna

Overall 3,151 individuals representing 130 taxa were identified in the 15 macrofauna samples collected at Well B during the EAD Benthic Baseline survey. Infauna communities were dominated by small polychaete worms (1,635 individuals (52%), 48 taxa), crustaceans (987 individuals (31%), 39 taxa) (mostly amphipoda, tanaidacea and copepoda), molluscs (183 individuals (6%), 26 taxa) (mostly bivalves), and nematodes (158 individuals (5%), 1 taxa) (**Figure 11** and **Figure 12**). The raw macroinvertebrate data from Well B monitoring stations is provided in **Appendix D**.

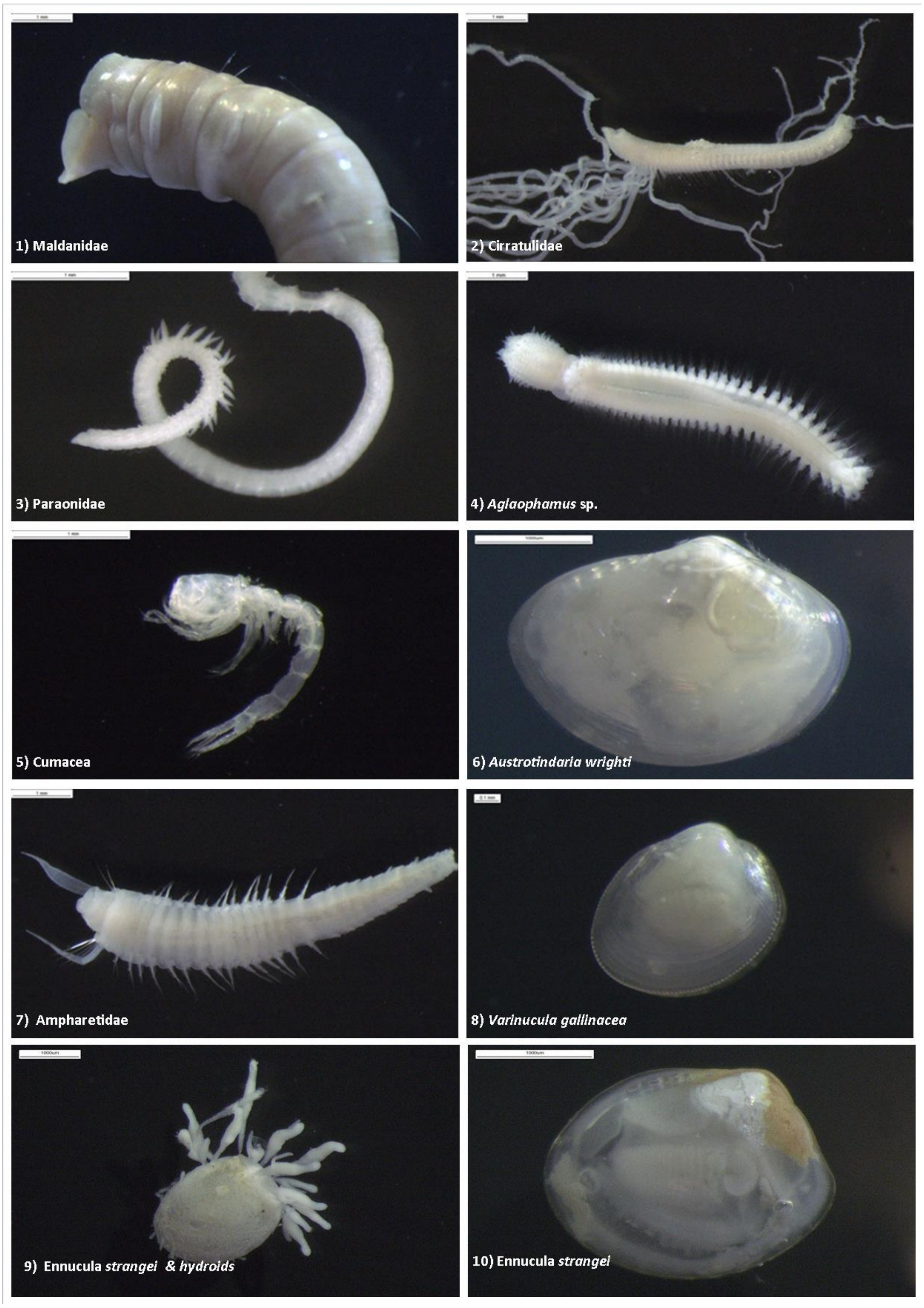
When the benthic macrofauna results are compared across the three AOIs, crustaceans (Tanaidacea and copepods) and nematodes were found in higher numbers in the Northern AOI sites compared with Central and Southern AOI sites. Gastropods and polychaetes were found in lower proportions in the Northern AOI and higher in the Central and Southern AOIs (**Appendix E**). This result is likely linked to the differences in sediment composition, where a coarser grain size was present in the Northern AOI compared to the Central and Southern AOIs.

Figure 11 Proportions of Well B Infauna Belonging to each Taxonomic Group



Note: 'Other crustacea' includes decapoda. 'Other molluscs' includes gastropods, caudofoveta and scaphopoda. 'Other' includes actiniaria, anthozoa, ascidiacea, calcarea, chaetognatha, nermetea, oligochaeta, sipuncula, tunicata and *Heteromalpadia marenzelli*.

Figure 12 Representative Images of Infauna Taxa Frequently Observed in Offshore Taranaki Area



3.3.2 Univariate Indices of Infauna Communities

Univariate indices (total number of taxa, total abundance, Pielou's evenness and Shannon-Wiener diversity) describing the benthic macroinvertebrate communities found at Well B are displayed in **Figure 13**.

The number of taxa identified in each sample collected around Well B varied from 44 to 61 (mean 53), while total abundance ranged from 140 to 265 individuals (mean 210). Abundance and taxa numbers at Well B were very similar to the overall mean values for the Northern AOI (53 taxa, 233 individuals, **Table 7**), which were notably higher than those of the Central and Southern AOIs.

Evenness values vary on a scale between zero and one, with values near one indicating that infauna abundances are evenly distributed across all the different taxa present, while values near zero indicate infauna communities are being numerically dominated by a large number of individuals from just a few, or even only single taxa. Values from the Benthic Baseline data collected at Well B were relatively high (mean 0.88), indicating relatively even distribution of taxa abundances across the taxa that were present.

Shannon-Wiener diversity index values range between 0 and 4 with higher values indicating higher species diversity. From previous benthic studies in the offshore Taranaki region, species diversity values are normally between 1.5 and 3.5. The mean Shannon-Weiner diversity index for Well B was 3.5, and ranged between 3.3 and 3.7. When these results are compared to the most recent results from long term benthic monitoring programmes at the Maari Field (diversity index of 2.9) located in the Southern AOI it is shown that the species diversity is greater at Well B.

Figure 13 Total Number of Taxa, Total Abundance, Pielou's Evenness and Shannon Wiener Diversity Index Values for Macrofauna Samples Collected at Well B

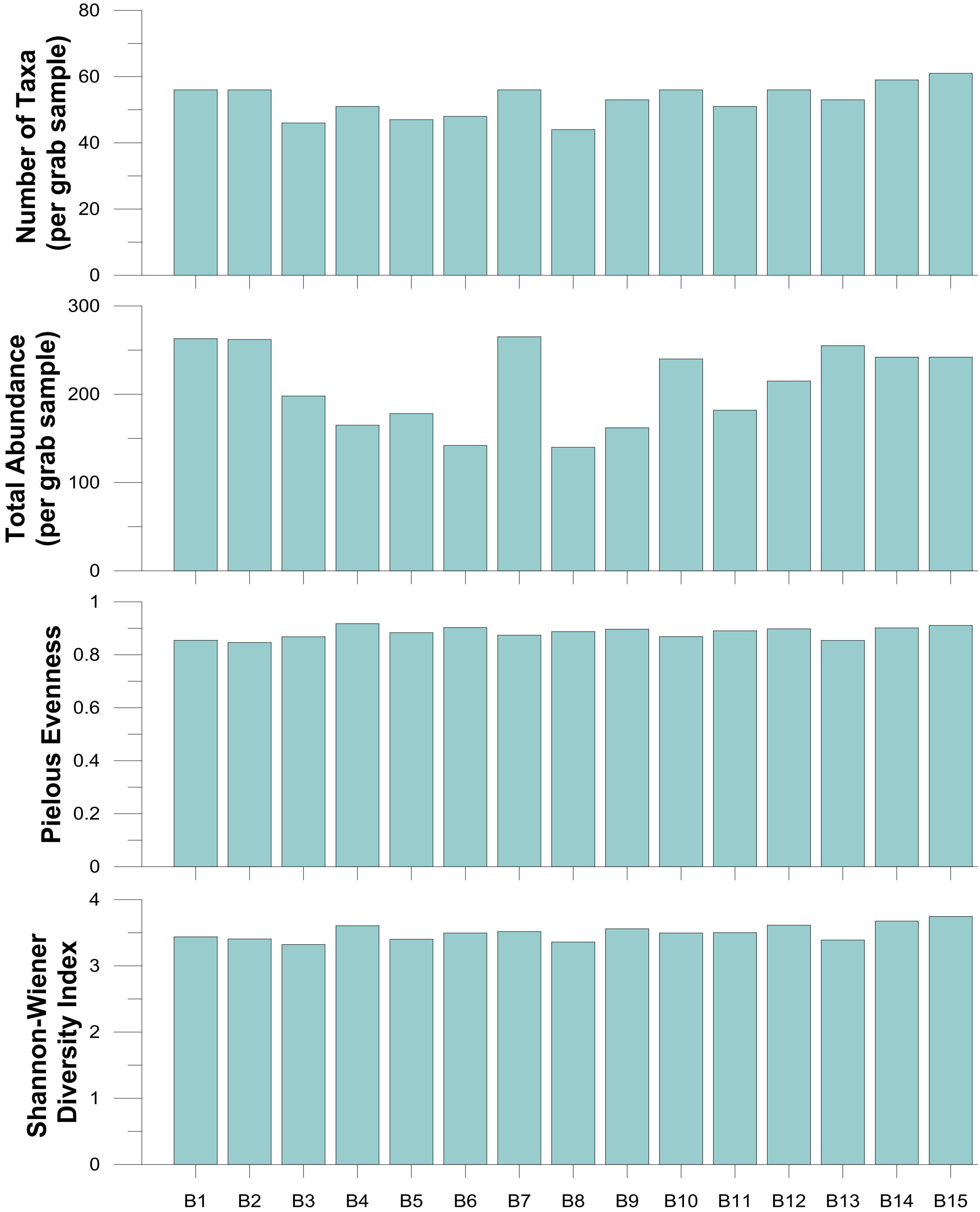


Table 7 Number of Taxa and Total Abundance for the Eleven Wells

Site	Mean Number of Taxa	Mean Abundance	Total Number of Taxa Identified at site	Total number of individuals (abundance)
A	56	257	140	3,849
B	**53**	**210**	**130**	**3,151**
C	45	132	128	1,987
D	60	332	142	4,986
Northern AOI	**53**	**233**		
E	19	36	78	542
F	31	68	90	1,023
G	33	81	112	1,215
H	31	89	103	1,339
I	29	72	91	1,075
Central AOI	**29**	**69**		
J	40	115	108	1,722
L	54	190	131	2,853
Southern AOI	**47**	**153**		

3.4 Sensitive Environments

In an investigation of sensitive substrate/benthic habitats in the Taranaki Coastal Marine Area, Johnston (2016) studied marine taxa databases from marine benthic surveys conducted in the offshore Taranaki Basin and noted that there are many locations where at least one ‘characteristic species of sensitive environments’ was found. This investigation used the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activities Regulations**) sensitive environments descriptions to define what sensitive habitats may be present.

From the Johnston (2016) report, Chaetopteridae worms and sea pens were likely to be present in areas close to the eleven wells. In relation to the sampling techniques used in the Benthic Baseline survey (grab sampling and video sled imagery), MacDiarmid *et al*. (2013) defined that;

“A sensitive Chaetopteridae worm field is present if worm tubes and/or epifaunal species:

- Occupy 25% or more of the seabed in imaging surveys covering and area of 500 m^2 or more; or
- Occur in two successive samples collected using point sampling gear.”

and

“A sea pen field exists if:

- One or more specimens of any species of sea pen is found in two successive samples collected using point sampling gear, or
- Two or more specimens per m^2 are found in seabed imaging surveys, or surveys using towed gear”.

Macrofauna samples have shown Chaetopteridae worms (specifically *Phyllochaetopterus socialis*, commonly known as wire-weed or Tarakihi weed) were present within samples from Wells A, B, C, D, G and H. While the majority of sites only had single individuals in a small number of the samples collected at each site (e.g. Wells C and D showed a single individual in two of the 15 grab samples at each site) infauna samples collected from Well B had between 2 - 13 individuals occurring in 11 of the 15 samples collected. Video imagery at Well B did not observe distinct worm-fields or the low-relief worm-meadows that *P. socialis* can form in any of the ten tows conducted. While it appears that abundances of this sensitive environment species were elevated at Well B, distributions appeared more as "*isolated individuals within mixed epifaunal assemblages*" at a single site rather than "*dense mono-specific meadows at the tens of kilometres scale*" (MacDiarmid *et al.*, 2013). Well B could technically be classed as a sensitive environment according to the definitions of MacDiarmid *et al.* (2013) relating to Chaetopteridae worms being found to '*occur in two successive samples using point sampling gear*'. However, the definitions within MacDiarmid *et al.* (2013) relate to Chaetopteridae worm 'fields', and video imagery collected at Well B in 2018 did not observe any distinct worm fields, or low relief meadows that *P. socialis* has been observed to form in previously defined sensitive habitats. Further to the definitions within MacDiarmid *et al.* (2013), video imagery did not find worm tubes to '*occupy 25% or more of the seabed in imaging surveys…*'. Thus, although benthic grabs indicated the presence of species indicative of a sensitive environment, the video imagery did not show 'fields' of Chaetopteridae worms on which the definition is based (MacDiarmid *et al.*, 2013) and therefore it is considered that the area is not classified as a sensitive environment based on this taxa.

While no sea pens were identified in the infauna samples from Well B, video imagery showed a total of 35 individual sea pens were encountered during the video sled tows (**Table 6**). Due to video sled tows being only a semi-quantitative survey method it is not possible to make exact predictions on the densities of sea pens encountered. However, as a conservative estimate the width of the camera's field of view could be estimated at 1 m, and each video sled covered 200 m across the seafloor, giving an approximate area of 2000 m^2 viewed by the imagery. Given this area and the low numbers of sea pens observed (compared to Wells D (160 individual sea pens) and L (132 individual sea pens)) sea pen densities at Well B would not have surpassed the Permitted Activities Regulations trigger value of two sea pens per square meter (MacDiarmid *et al*., 2013). Video tows were not found to pass through more spatially limited areas of higher density that might have been classed as 'sea pen fields'. Thus Well B is not classified as a sensitive environment based on the presence of low numbers sea pens.

4 Key Findings

4.1 Sediment Characteristics

There were no distinct spatial patterns to the variations in grainsize and TOC across the 15 sampling stations surrounding Well B.

Grain size analysis at Well B (and other Northern AOI sites) indicated that the sediment was coarser than those sediments found in the Central and Southern AOIs, which are dominated by mud (silt and clay).

TOC levels at the Well B location (and other Northern AOI sites) were lower (mean of 0.26%) than those found in samples from the Central and Southern AOIs (mean TOC 0.59% and 0.48%, respectively). Sediments with a finer grain size will retain higher levels of organic matter compared to coarser/sandier sediments subjected to the same level of enrichment/deposition.

4.2 Faunal Characteristics

Video sled imagery from the ten sampling stations at Well B showed fish were present in high numbers compared to other wells surveyed across the three AOIs (~49 compared to a median of 28 across all 11 wells). Mound/hollow features were observed to be more numerous at the Northern AOI sites, moderate to high at the Southern AOI sites, and low around the Central AOI sites.

Infauna communities sampled at Well B contained proportionally more tanaidacea, copepod, nematoda and amphipoda, and less gastropods and polychaetes compared to the Central and Southern AOIs. The number of taxa and total abundance at Well B were very high when compared to the sites monitored in the Central and Southern AOIs.

Pre- and post-drill monitoring around exploration well sites in the offshore Taranaki region has shown that following completion of drilling there has been a reduction in the overall number of taxa found, and a reduction in total abundance, although some individual taxa which are known to be more opportunistic and disturbance tolerant have sometimes shown increased abundances compared to pre-drill monitoring results.

The comparatively coarser nature of sandy sediments at Well B (and other northern region sites) versus the muddy sediments from the Central and Southern AOIs is likely to be linked to the lower number of gastropods, many of which are detrivores and/or deposit feeders which feed on dead and decaying algae, seaweed and other plants and animals, as well as organic matter within the sediments. This feeding mechanism is likely to be more suited to muddy sediments. Sediment grainsize is also important for determining suitable habitat for polychaete species (tubeworms), which form their tubes within the interstitial spaces in the sediment matrix, thereby requiring specific sediment properties to become established.

Explaining the greater proportions of Tanaidacea, Copepoda, Nematoda and Amphipoda at Well B is more complex. For example, some species within the order Tanaidacea may be filter feeding species while others actively hunt prey (predators). The prevalence of these taxa at Well B, compared to sites within the Central AOI, is likely to be linked with the coarser sediments present at Well B. Coarser sediments, particularly larger sands, gravels, shell hash, etc., begin to provide more three-dimensional, cryptic habitats, allowing a wider variety of taxa to find different suitable habitats than mud-dominated sediments. Coarser sediments also contain less of the very fine clay particles which can clog or damage the delicate feeding and breathing structures of taxa adapted as filter feeders, particularly when such fine sediments are present in the water column for extended periods, and/or repeatedly re-suspended.

4.3 Sensitive Environments

Observations from the video imagery indicate that no 'Sensitive Environments', as defined by the Permitted Activities Regulations were encountered at the monitoring stations at Well B; however, some '*characteristic species of sensitive environments'* were observed in video tows (e.g. sea pens).

Chaetopteridae worms (specifically *Phyllochaetopterus socialis*) were identified in the majority (11 out of 15) of infauna samples collected from Well B. As a result, this well could technically be considered a sensitive environment according to the definitions set down in MacDiarmid *et al*. (2013) in relation to Chaetopteridae worms. However, due to there being no distinct 'fields' of Chaetopteridae worms observed in the video imagery collected at Well B it is considered that the area is not classified as a sensitive environment.

5 References

Clarke K. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18 (1): 117-143.

Clarke K.R., Warwick R.M., 1994. Change in marine communities: An approach to statistical analysis and interpretation. Plymouth Marine Laboratory, UK.

Clarke K.R., Gorley R.N., 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth.

Folk, 1954. *"The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature",* The Journal of Geology 62(4):344-359.

Hedges JI, Keil RG, Cowie GL, 1993, "Sedimentary diagenesis: organic perspectives with inorganic overlays", Chemical Geology 107: 487-492.

Johnston O, Barter P, Ellis J, Elvines D, 2014, "*Recommendations for an Offshore Taranaki Environmental Monitoring Protocol: Drilling- and production-related discharges, Version 1.0*" (OTEMP), Cawthron Report No. 2124.

Johnston O 2016. Sensitive habitats and threatened species in the Taranaki Coastal Marine Area (TCMA) - database investigation. Prepared for Taranaki Regional Council. Cawthron Report No. 2877. 28 p. plus appendices.

MacDiarmid, A., Bowden, D., Cummings, V., Morrison, M., Jones, E., Kelly, M., Neil, H., Nelson, W., Rowden, A., 2013. '*Sensitive marine benthic habitats defined*'. Prepared for Ministry for the Environment, NIWA Client Report No: WLG2013-18.

SLR, 2016. "*Benthic Ecological Survey – Tui Field facilities. Production Discharge Monitoring, February 2016*" prepared for AWE Taranaki Limited, report number 740.10040.

SLR, 2017, "*Benthic Ecological Survey for the Maui Platform Alpha. Annual Production Monitoring – April 2017*", prepared for Shell Todd Oil Services Limited, SLR Report Number 740.10041.00300-R01--v0.1

APPENDIX A

Locations and Observations from Sediment Grab Sampling and Video Sled during the 2018 Benthic Baseline Survey

Station	Date	Time	Depth (m)	Coordinates (NZTM)		Notes
				Easting	Northing	
Grab Sample Sites						
BG 1	28/3/18	0750	134	1660943	5720172	Hard packed sandy mud – lots of small broken shell material
BG 2	28/3/18	0804	134	1659557	5721613	Hard packed fine sand and broken shell. Light brown
BG 3	28/3/18	0818	134	1658168	5723054	Light brown fine sandy mud with broken shell pieces
BG 4	28/3/18	0828	134	1657476	5723774	Light brown fine sandy mud with small broken shell pieces
BG 5	28/3/18	0836	134	1656780	5724493	Light brown / light grey fine sand and mud with lots of shell material
BG 6	28/3/18	0846	134	1656086	5725211	Light brown fine sandy mud with broken shells
BG 7	28/3/18	0854	134	1655385	5725926	Light brown firm sandy mud with broken shells
BG 8	28/3/18	0944	134	1660310	5723720	Light brown fine sand and mud and small broken shell pieces
BG 9	28/3/18	0935	134	1659592	5723022	Light brown fine sand and mud with lots of small broken shell pieces
BG10	28/3/18	0923	134	1658160	5721633	Light brown / grey hard packed sandy mud and broken shell
BG11	28/3/18	0914	134	1657428	5720932	Light brown / grey sandy mud with shell pieces
BG12	28/3/18	1000	134	1658218	5725881	Light brown fine sand and mud with lots of small broken shell pieces
BG13	28/3/18	1100	134	1657501	5725188	Light brown fine sandy mud with lots of broken shell fragments
BG14	28/3/18	1047	134	1656061	5723797	Light brown fine sandy mud with lots of broken shell fragments
BG15	28/3/18	1038	134	1655343	5723101	Light brown / grey fine sandy mud with broken shell
Video Sled Tow Locations						
BV 1	30/3/18	0632	133	1661344	5721939	
BV 2	30/3/18	0701	134	1660264	5720897	
BV 3	30/3/18	0732	134	1659187	5719851	
BV 4	30/3/18	0857	134	1658905	5724460	
BV 5	30/3/18	0832	-	1657476	5723774	
BV 6	30/3/18	0806	134	1656746	5722364	
BV 7	30/3/18	0948	-	1656780	5724493	
BV 8	30/3/18	1055	133	1657163	5726250	
BV 9	30/3/18	1036	134	1655734	5725568	
BV10	30/3/18	1014	134	1655009	5724163	

APPENDIX B

Sediment Core Profile Images from all Grab Samples Collected during the 2018 Benthic Baseline Survey at Well B


BG1.JPG


BG10.JPG


BG11.JPG


BG12.JPG


BG13.JPG


BG14.JPG


BG15.JPG


BG2.JPG


BG3.JPG


BG4.JPG


BG5.JPG


BG6.JPG


BG7.JPG

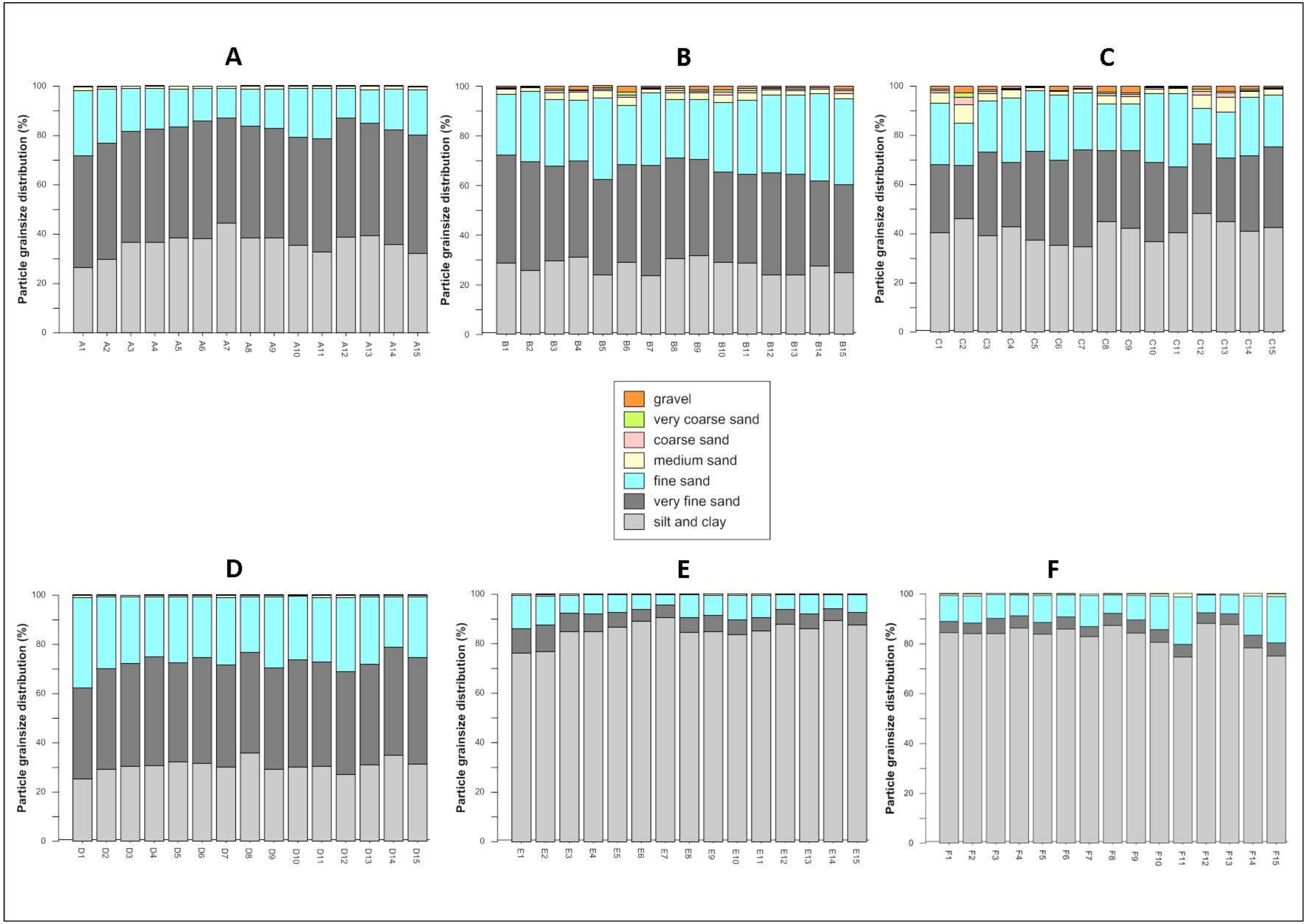

BG8.JPG

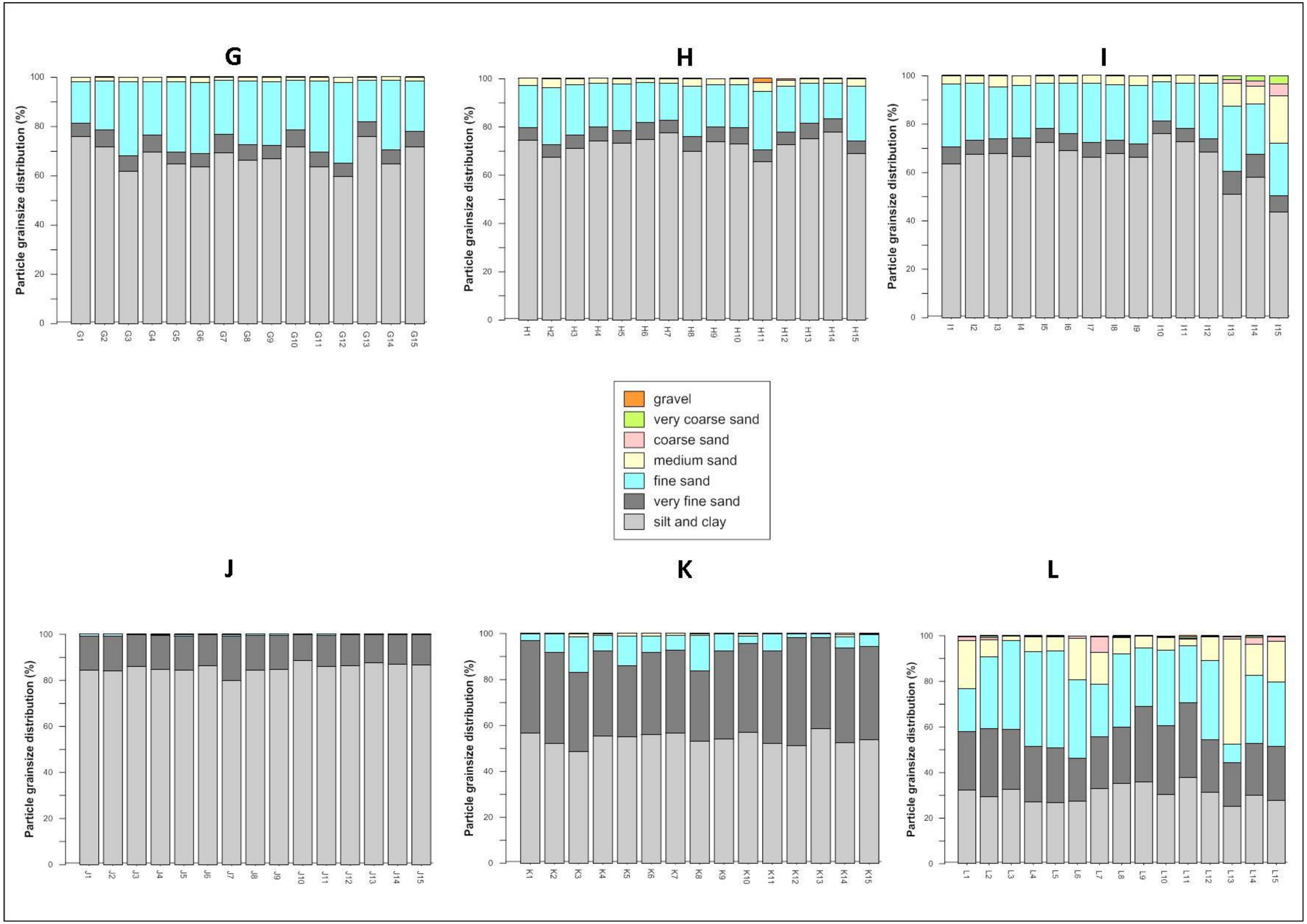

BG9.JPG

APPENDIX C

Total Organic Carbon Content and Particle Grainsize Distribution for Well B

Replicate Sample	TOC (%)	Gravel (%)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Silt & Clay (Mud) (%)
Station B1	0.26	0.6	0.3	0.4	1.9	24.5	43.6	28.7
Station B2	0.25	< 0.1	0.1	0.3	1.6	28.4	43.7	25.8
Station B3	0.3	1.1	0.6	0.9	2.7	26.9	38.1	29.7
Station B4	0.36	1.5	0.5	0.6	3.1	24.6	38.7	31.1
Station B5	0.26	0.8	0.6	0.7	2.8	33	38.3	24
Station B6	0.33	2.6	1	1.1	3.2	23.7	39.4	29.1
Station B7	0.24	0.6	0.3	0.4	1.5	29.2	44.2	23.8
Station B8	0.35	1.1	0.8	0.9	2.8	23.4	40.6	30.5
Station B9	0.29	1.5	0.6	0.6	2.6	24.3	38.7	31.7
Station B10	0.27	1.5	1	1	3	28.2	36.2	29.1
Station B11	0.31	0.9	0.7	0.9	3	30	35.8	28.6
Station B12	0.24	0.6	0.5	0.6	1.9	31.3	41.3	23.9
Station B13	0.26	0.7	0.6	0.6	1.8	31.9	40.3	24.1
Station B14	0.29	0.5	0.2	0.4	1.8	35.3	34.3	27.5
Station B15	0.26	1.1	0.7	1.1	2.3	34.4	35.6	24.8


A
B
C
D
E
F
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay


G
H
I
J
K
L
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay

APPENDIX D

Raw Counts of Macroinvertebrate (Infauna and Epifauna) Abundance at Well B

Taxa	Class/Order	Phylum	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15
Aglaophamus sp.	Polychaetea		16	11	22	12	14	8	14	13	13	17	18	12	19	13	13
Alpheus sp.	Decapoda	Crustacea	1														
Ampelisca sp.	Amphipoda	Crustacea		1					1					1			1
Ampharetidae	Polychaetea		13	11	7	6	4	5	7	15	7	7	7	11	17	8	11
Amphinomidae	Polychaetea								2		1						1
Amphipoda	Amphipoda	Crustacea	5	8	14	6	11	6	12	2	6	3	2	10	11	5	5
Anemone (Unid.)	Anthozoa													2			
Antalis glaucarena	Scaphopoda	Mollusca	1			2				1						1	
Anthuridae	Isopoda	Crustacea			1	1	1	1	1			2	1		2	1	2
Aphroditidae	Polychaetea									1	1	1	1				2
Aplacophora		Mollusca	1		2	1	2				1	1				3	3
Aricidea sp.	Polychaetea		4	9		7	2	3	3	5	5	2	1	2	5	6	2
Armandia maculata	Polychaetea			1			2		1	1	1	12			2	2	
Armandia maculata (juvenile)	Polychaetea		8	1	3	7	11	3	18	7	7		2	8	3	9	6
Asellota	Isopoda	Crustacea	2	5	4		3	2	7	4	4	1	4	4	5	3	5
Aspidosiphon sp.	Sipuncula							1									
Axiopsis sp.	Decapoda	Crustacea										2					
Bathyarca cybaea	Bivalvia	Mollusca	1				1								1		2
Bradleya opima	Ostracoda	Crustacea	1	1											3		1
Cadulus teliger	Scaphopoda	Mollusca												1			
Capitellethus zeylanicus	Polychaetea		1	1			1			1		3	1	1		2	1
Chaetognatha	Chaetognatha				1				1	1	1		1		2		
Chlorotocus novaezealandiae	Decapoda	Crustacea		1	1						1				1		
Cirratulidae	Polychaetea		18	20	9	15	14	11	20	6	11	15	12	14	19	21	20
Clavelina claviformis	Ascidiacea		1	1	3			1	3	1	1		1	2		2	2

Taxa	Class/Order	Phylum	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15
Copepoda	Copepoda	Crustacea	39	42	24	6	6	7	8	2	2	15	7	3	3	1	3
Copytus novaezealandiae	Ostracoda	Crustacea	1				1	1							1		
Cossura consimilis	Polychaetea			2		1		1							1	1	
Cumacea	Cumacea	Crustacea	10	3	3	3	7	3	8	1	6	6	9	7	4		7
Cuspidaria trialli	Bivalvia	Mollusca	1	1					1		1			1			2
Cymbicopia hispida	Ostracoda	Crustacea		1	1	1							1	2			
Cypridinodes sp.	Ostracoda	Crustacea	2	2			2	4	7		1			4		4	2
Cytherella sp.	Ostracoda	Crustacea				1			1			1	1			1	
Diasterope grisea	Ostracoda	Crustacea				1					1		1				
Dorvilleidae	Polychaetea			1	1	1		1									
Ebalia laevis	Decapoda	Crustacea		3	1	2	1	2	3	2	4			3		1	8
Edwardsia sp.	Actiniaria								1								
Ennucula strangei	Bivalvia	Mollusca	4	2	1	6	4	2	2	4	7	6	8	6	4	5	6
Euchone pallida	Polychaetea		2	3		2		1	1	1	1	1	1	2	1	7	2
Eulimidae	Gastropoda	Mollusca												1			
Euphilomedes agilis	Ostracoda	Crustacea		4		5						1			1		
Fellaster zelandiae	Echinoidea	Echinodermata													1		
Fissidentalum zelandicum	Scaphopod	Mollusca			1												
Flabelligeridae	Polychaetea		1	1		1						1			1		1
Gastropoda (juvenile)	Gastropoda	Mollusca			1				1						1		
Glyceridae	Polychaetea			2		2		1	2	1	1	1		1	3	1	
Gnathiidae	Isopoda	Crustacea	2				1		2					2			
Goniadidae	Polychaetea				2				1	1	1			2			
Haustoriidae	Amphipoda	Crustacea	6	1	3	6	10	2	16	4	7	7	8	6	27	7	9
Hesionidae	Polychaetea										1		1				4

Taxa	Class/Order	Phylum	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15
Heterobranchia (unid.)	Gastropoda	Mollusca												1			
Heteromalpadia marenzelli											1		1				1
Heterothyone sp. (Juvenile)	Holothuridea	Echinodermata						1									
Hiatella artica	Bivalvia	Mollusca												2			1
Hunkydora novozelandica	Bivalvia	Mollusca															1
Hyperia sp. (pelagic)	Amphipoda	Crustacea	4		1		1		2	1	1						
Ischyroceridae	Isopoda	Crustacea										1					
Leitoscoloplos kerguelensis	Polychaetea		8	1	2	4	1	2		2		3	4	2		2	6
Limatula maoria	Bivalvia	Mollusca			1		1	1						1	1		1
Lumbrineridae	Polychaetea		3	6		1		3	1	4	1	2	4	4	2	1	3
Lysianassidae	Amphipoda	Crustacea	3	3			1	1	7	2	1	1		2	2	3	
Magelona dakini	Polychaetea		2	8	3	3	2	1	3	5		6	2	1	5	3	1
Maldanidae	Polychaetea		1	3		2	2		3	1	4		5	3	2	5	1
Marphysa disjuncta	Polychaetea		2	2		1		1	2	1		1	1	1	2	1	
Merelina sp.	Gastropoda	Mollusca	1														
Mogula sluiter	Tunicata															1	
Mogula sp.	Tunicata		2				1				1		1				
Munna schauinslandi	Isopoda	Crustacea	1														
Myriowenia sp.	Polychaetea		1														
Natantia (Unid.)	Decapoda	Crustacea				1			1								1
Natatolana pellucida	Isopoda	Crustacea								1							
Naticidae	Gastropoda	Mollusca	1														
Nebaliacea	Cumacea	Crustacea		1					1								
Nematoda	Nematoda		15	7	8	6	11	5	15	7	12	11	10	13	18	12	8
Nemertea	Nermetea		3	3	5	3		1	3	1	2		1	2	1	5	3

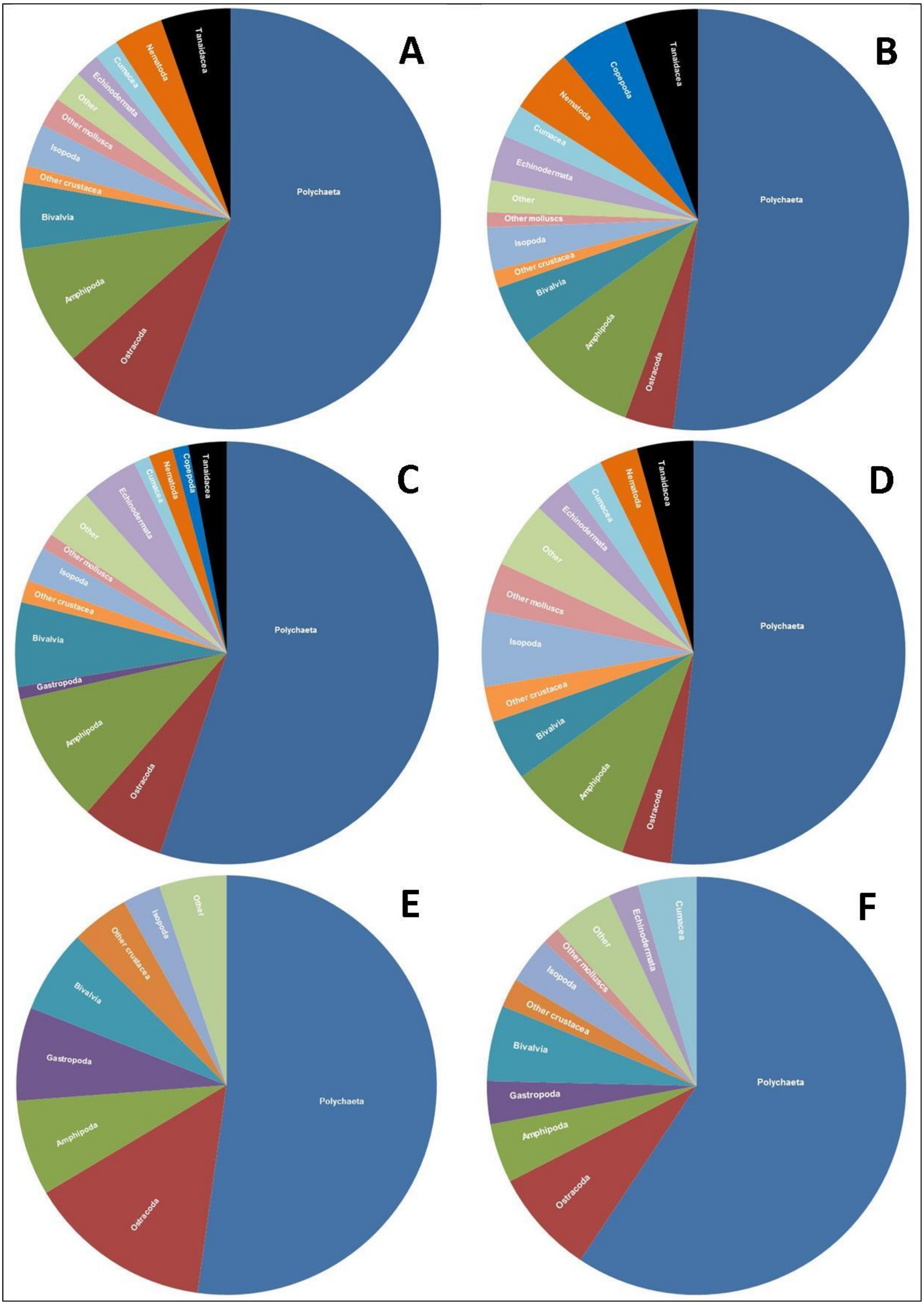
Taxa	Class/Order	Phylum	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15
Neonesidea sp.	Ostracoda	Crustacea													2		
Nucinella maoriana	Bivalvia	Mollusca		4	1		1		3	1	3	4	3		3	2	1
Oligochaeta	Oligochaeta		1														
Onuphis aucklandensis	Polychaetea		2							1			1		1		
Ophiuroidea	Ophiuroidea	Echinodermata	6	5	11	7	7	5	10	5	2	5	8	18		6	8
Orbina papillosa	Polychaetea			1			1							1			
Orbiniidae 6 (unknown)	Polychaetea														1		
Ostracoda	Ostracoda	Crustacea								1		1	3	1		1	
Owenia petersenae	Polychaetea											1					
Paguridae	Decapoda	Crustacea	1													1	
Paracaudina chilensis	Holothuridea	Echinodermata			1		4	1									
Paramunna serrata	Isopoda	Crustacea		1	2	2	2	1	2	1	1				1	9	6
Paraonidae	Polychaetea		14	14	4	4	6	13	12	10	7	21	13	13	16	14	5
Parasterope quadrata	Ostracoda	Crustacea	1	1	2		1	1			1	1			2	2	
Paravireia sp.	Isopoda	Crustacea							1								
Philine powelli	Gastropoda	Mollusca							1		1		1	1			1
Phoxocephalidae	Amphipoda	Crustacea	3	2	3	1	1	1	2		3		3	1	7	2	5
Phylctenophora zealandica	Ostracoda	Crustacea		1	3	3											
Phyllochaetopterus socialis	Polychaetea		13	6	5	2		5	2	9	6	3			2	8	
Phyllodocidae	Polychaetea		1				1	1	1			1		1		2	1
Pilargidae	Polychaetea		2	3								1					
Pleuromeris zelandica	Bivalvia	Mollusca														1	
Pododesmus zelandicum	Bivalvia	Mollusca				1								1			
Polynoidae	Polychaetea						1				1					1	4
Pratulum pulchellum	Bivalvia	Mollusca	2	2	1		1			1	1	1	1	2	1	2	5

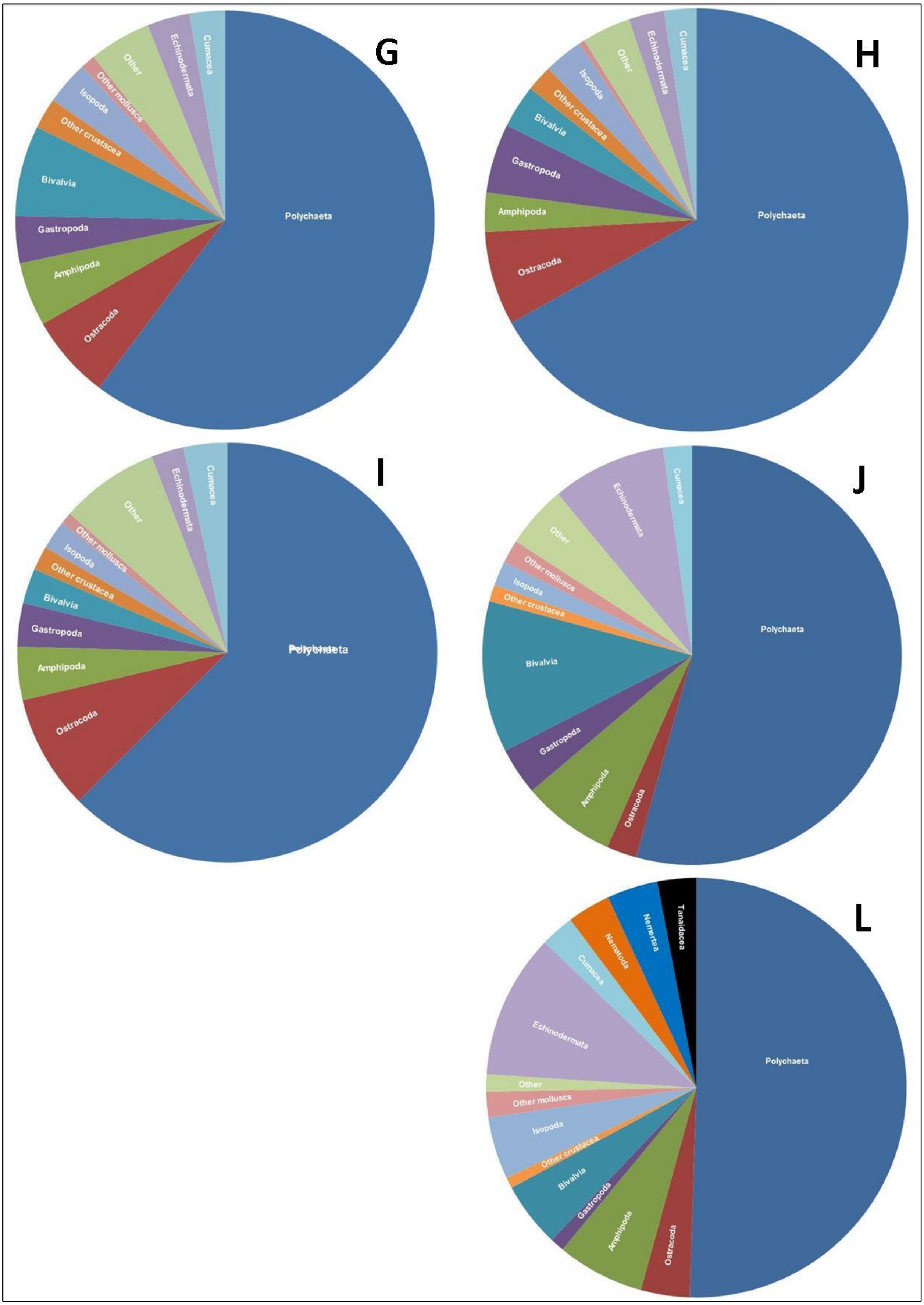
Taxa	Class/Order	Phylum	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15
Prionospio multicristrata	Polychaetea		5	8	2	2	5				1	1				1	1
Prionospio sp.	Polychaetea		5	11	11	3		1	9	6	5	6	6	3	1	9	12
Propontocypris sp.	Ostracoda	Crustacea						1	1		1	5	4	3		5	3
Pyura sp.	Tunicata			1	1							1		1			
Raphitomidae	Gastropoda	Mollusca								1						1	
Rhamphobrachium sp.	Polychaetea			2	7	5	2	4	1	2	1	11	3	4	2	1	1
Rutiderma	Ostracoda	Crustacea										1					
Sabellidae	Polychaetea											2				1	
Scleroconcha sp.	Ostracoda	Crustacea		1													
Scoloplos sp.	Polychaetea											2	1				1
Serpula sp.	Polychaetea					1											
Sigalionidae	Polychaetea		6		3	3	2	4	2	1	1	3		4	3	2	3
Sphaerodoropsis sp.	Polychaetea		1													1	
Sphaerosyllis sp.	Polychaetea			1	1	2	4	3	5		1	1	1	2	3	8	4
Spio sp.	Polychaetea					1											
Spiophanes kryoeri	Polychaetea											1				2	3
Spiophanes modestus	Polychaetea			3		2	1	1	5			1	4	3	3	2	3
Spiophanes sp.	Polychaetea											10					
Spiophanes wiglyi	Polychaetea				3	1	1						2	3	5	2	4
Splendrillia sp.	Gastropoda	Mollusca									1						
Sycon sp.	Calcarea												1				
Syllidae	Polychaetea		2		1		4	5	1		3	2	2	4	4	9	9
Tanaidacea	Tanaidacea	Crustacea	9	21	11	6	15	11	22	2	6	19	5	8	22	9	11
Terebellidae	Polychaetea					1			2			1	1				1
Terebellides stroemii	Polychaetea		1			1						3	1	1	3	1	1

Taxa	Class/Order	Phylum	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15
Thraciidae	Bivalvia	Mollusca		1				1									
Thyasira peregrina	Bivalvia	Mollusca						1	1				1		2		
Tolochlamys zelandiae	Bivalvia	Mollusca															1
Trachyleberis lytteltonensis	Ostracoda	Crustacea										1					
Varinucula gallinacea	Bivalvia	Mollusca				1											

APPENDIX E

Comparison of Proportion of Individuals belonging to each Taxonomic Group Across all Wells


A
Tanaidacea
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
Polychaeta
B
Tanaidacea
Copepoda
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
Polychaeta
C
Tanaidacea
Copepoda
Nematoda
Cumacea
Echinodermata
Other
Other mollusca
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta
D
Tanaidacea
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
Polychaeta
E
Other
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta
F
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta



G
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
H
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other
Echinodermata
Cumacea
I
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
J
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
L
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Nemertea
Tanaidacea

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EXPLORATION AND APPRAISAL DRILLING PROGRAMME

Benthic Baseline Report
Well C

Prepared for:

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SLR Ref: 740.10078.00200-R01
Version No: v1.0
July 2018

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BASIS OF REPORT

This report has been prepared by SLR Consulting NZ Limited with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with OMV New Zealand Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.10078.00200-R01-v1.0	31 July 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier
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EXECUTIVE SUMMARY

OMV New Zealand Limited (**OMV New Zealand**) are applying for a Marine Consent to undertake an Exploration and Appraisal Drilling (**EAD**) Programme in the Taranaki Basin with an anticipated commencement date in 2019. OMV New Zealand may drill up to nine exploration wells and two appraisal wells within their Petroleum Exploration Permits (**PEP**). The intention of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs.

As part of the Marine Consent application, three Areas of Interest (**AOI**) have been identified that encapsulate the proposed well locations and are used as part of the Impact Assessment process. OMV New Zealand undertook a baseline environmental monitoring survey at each well location in March-April 2018 to gain an understanding of the benthic habitat and associated communities with each AOI.

Grab sampling and video sled methodologies were used to gain quantitative and qualitative information on the marine environments surrounding each well location. The data gathered from each Benthic Baseline survey will be incorporated into the Marine Consent application and assist in the risk assessment process.

Water currents and deposition modelling were utilised to define the placement of sample stations. Sample transects were aligned along the dominant deposition pathway of the predicted drill cutting dispersion should that particular well be drilled. A total of 15 monitoring stations were allocated at each well site and one benthic grab sample was collected at each monitoring station. Ten video sleds were also undertaken at a selection of pre-determined sites around each well location.

Within this Benthic Baseline report the analysis of results incorporates sediment physical and chemical properties, benthic macrofauna, epifauna and visual observations around Proposed Well C. A total of 1,987 individuals representing 128 taxa were identified from the 15 macrofauna samples collected around Well C. Infauna communities were dominated by small polychaete worms (55%), crustaceans (26%), and molluscs (9%).

The baseline survey at Well C found no distinct spatial patterns in grain size and Total Organic Carbon across the 15 sample stations. Grain size analysis indicated that the sediments at Well C and in the wider Northern AOI are much coarser than sediments in the Central and Southern AOI, which are dominated by mud (largely comprised of silt and clay sized fractions).

The Benthic Baseline survey at Well C indicated the presence of two isolated Chaetopteridae worms (*Phyllochaetopterus socialis*) and one sea pen (*Virgulana gracillima*) within macrofauna grab samples; species defined in the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activities Regulations**) as being '*characteristic species of sensitive environments*'. Sea pens were also commonly observed in the video imagery collected at Well C. The occurrence and estimated densities of these taxa at Well C during the Benthic Baseline survey did not reach the trigger levels defined by the Permitted Activities Regulations (MacDiarmid *et al.*, 2013), with no distinct fields of either taxa observed in the video imagery. Thus although present at the well locations in low densities it is considered that the area would not be classified as a 'sensitive habitat'.

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1 Introduction

OMV New Zealand Limited (**OMV New Zealand**) is applying for a Marine Consent under section 38 of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (**EEZ Act**) to permit activities associated with an Exploration and Appraisal Drilling (**EAD**) Programme proposed to be undertaken starting in 2019.

The EAD Programme includes the drilling of up to nine exploration wells and two appraisal wells within OMV New Zealand's permit areas (**Figure 1**). The purpose of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs which OMV New Zealand operate (**Figure 1**).

Three Areas of Interest (**AOI**) (summarised below) have been identified which encapsulate the well locations (**Figure 1**). This monitoring report relates to the Benthic Baseline monitoring programme conducted at Well C in the Northern AOI. Location details and water depth of Well C are provided in **Table 1**.

The Northern AOI encompasses PEP 60092 (Ridgeline), PEP 57075 (Cloudy Bay) and PEP 60093 (Toutouwai) and includes the following wells:

- Well A;
- Well B;
- Well C; and
- Well D.

The Central AOI encompasses PEP 60093 (Toutouwai) and includes the following wells:

- Well E (Appraisal);
- Well F;
- Well G (Appraisal);
- Well H; and
- Well I.

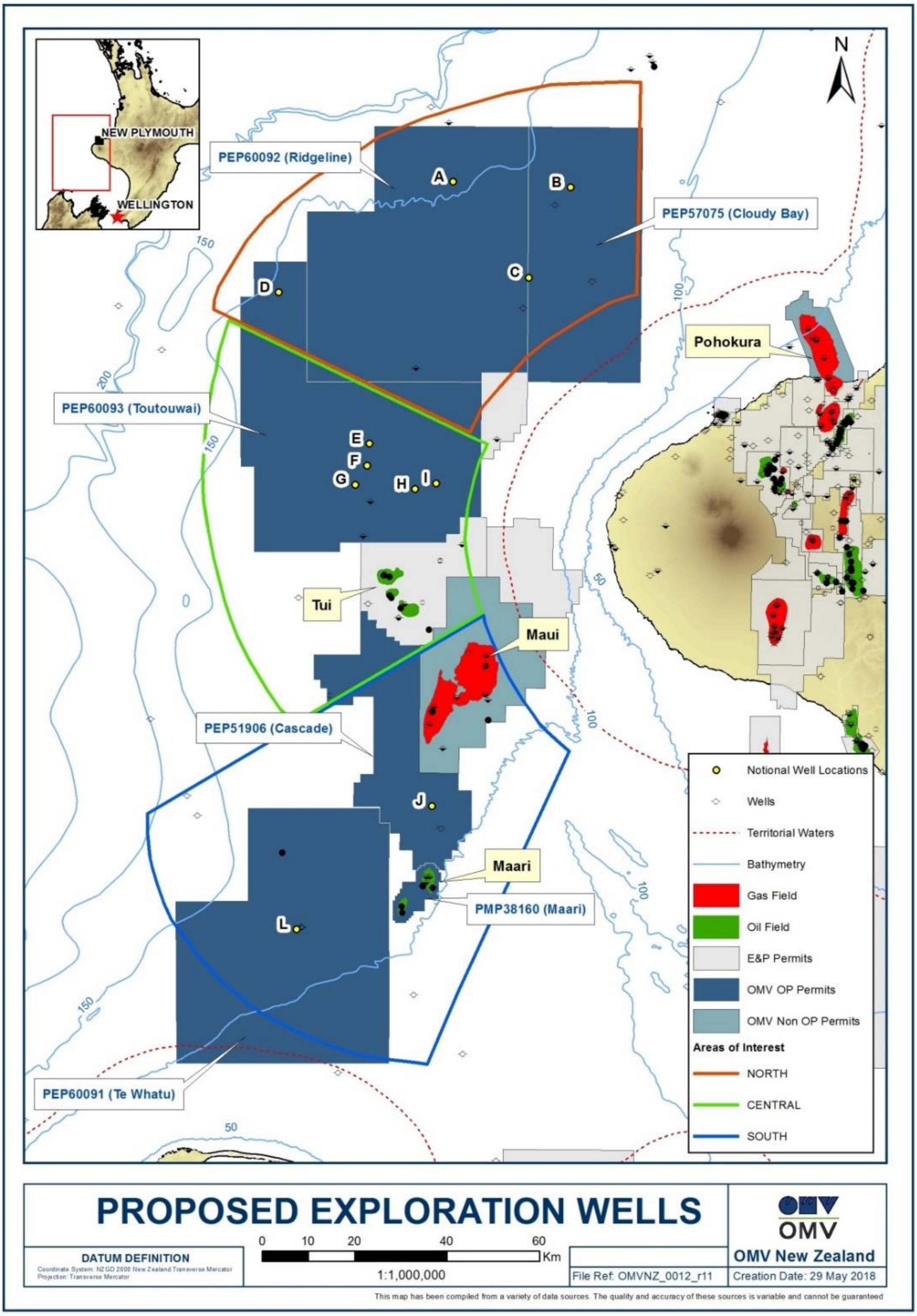
The Southern AOI encompasses PEP 51906 (Cascade), and PEP 60091 (Te Whatu) and includes the following wells:

- Well J; and
- Well L.

Table 1 Water Depth and Coordinates of Well C in the Northern AOI

Well Name	Water Depth (m)	Easting (NZTM)	Northing (NZTM)
C	128.5	1647945	5705768

Figure 1 OMV New Zealand's EAD Well Locations and three AOIs in the Taranaki Basin



In February 2018 SLR Consulting NZ Limited (**SLR**) was engaged by OMV New Zealand to undertake a baseline assessment of the benthic ecology in the vicinity of 11 well sites (**Figure 1**). The aim of the field surveys, which were undertaken from March 24 – April 8 2018, was to collect relevant data using grab sampling and video sled methodologies to provide quantitative and qualitative information on these marine environments. This qualitative and quantitative data will be used within the Marine Consent application to define the benthic habitats and communities present at each well location and assist in the risk assessment process.

This report summarises the results of the benthic baseline survey undertaken at Well C.

1.1 Project Location

Well C is located approximately 53 km northwest of New Plymouth in New Zealand's Exclusive Economic Zone (**EEZ**). Water depth and GPS coordinates are provided in and displayed in **Figure 1**. The monitoring programme sample design resulted in sample stations extending out to 6 km from the well location (**Section 2.1**).

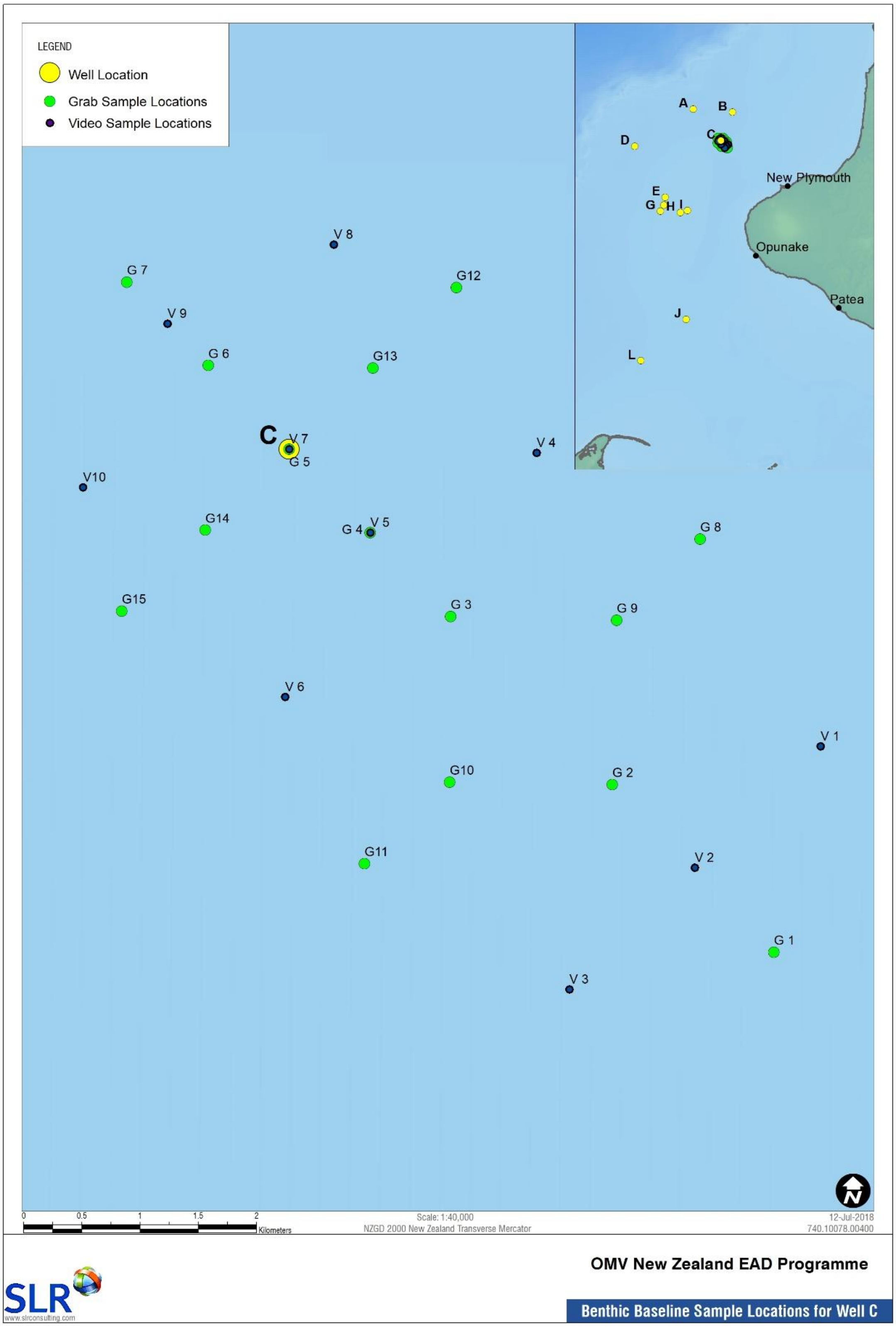
2 Methodology

The Benthic Baseline surveys adopted similar methodologies to what has been previously used for offshore Taranaki benthic monitoring programmes undertaken in accordance with the principles defined in the Offshore Taranaki Environmental Monitoring Protocol (**OTEMP**) (Johnston *et al.*, 2014). This consistent approach enables monitoring results to be compared with previous monitoring programmes undertaken in the offshore Taranaki environment (i.e. pre- and post-drill monitoring and production monitoring).

2.1 Sample Locations

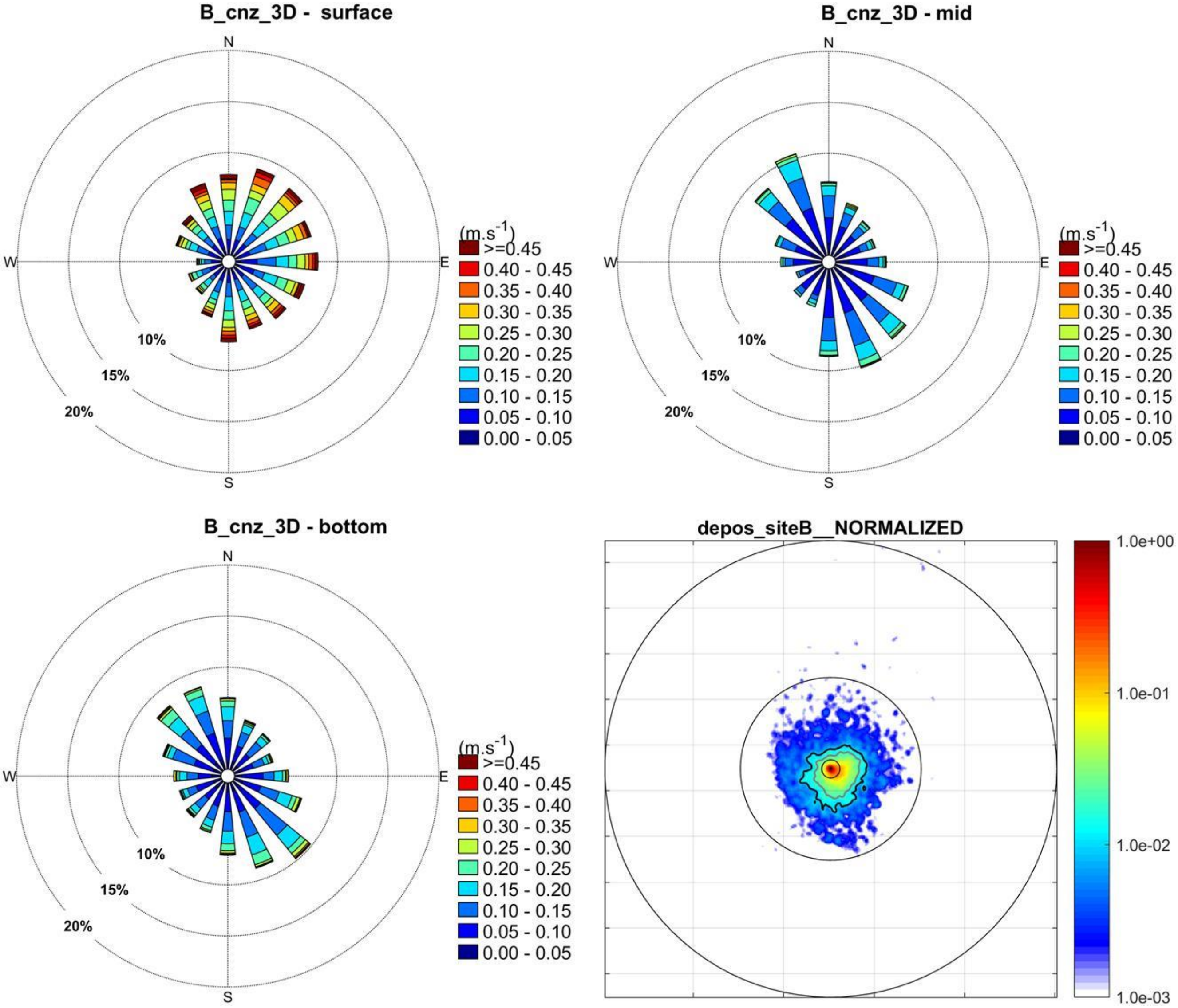
The sample locations (**Figure 2**) were defined by the dominant direction of current flow and preliminary drill cutting deposition modelling results (**Figure 3**). Sample transects were aligned along the dominant deposition pathway (i.e. southeast/northwest) (**Figure 2**) as this is the area determined to be most likely to be impacted from the deposition of drill cuttings should the well be drilled. However, sample stations were also located along the minor flow axis (northeast/southwest) to enable comparisons and validation of spatial differences based on the dispersal patterns predicted by MetOcean Solutions Limited.

Figure 2 Well C Sampling Locations



Note: At each video transect location approximately 250 m of video footage was captured along the seabed in the direction of the vessels drift at the time of sampling.

Figure 3 Surface, Mid-water and Bottom Water Column Current Roses and Dispersal Modelling Plot created by Metocean Solutions Ltd for the nearby Well B



2.2 Field and Sampling Procedures

Field sampling was undertaken from the MV *Seaworker* between March 24 and April 8, 2018, following the procedures detailed below. Sampling at Well C took place on March 28th, 31st and April 2nd.

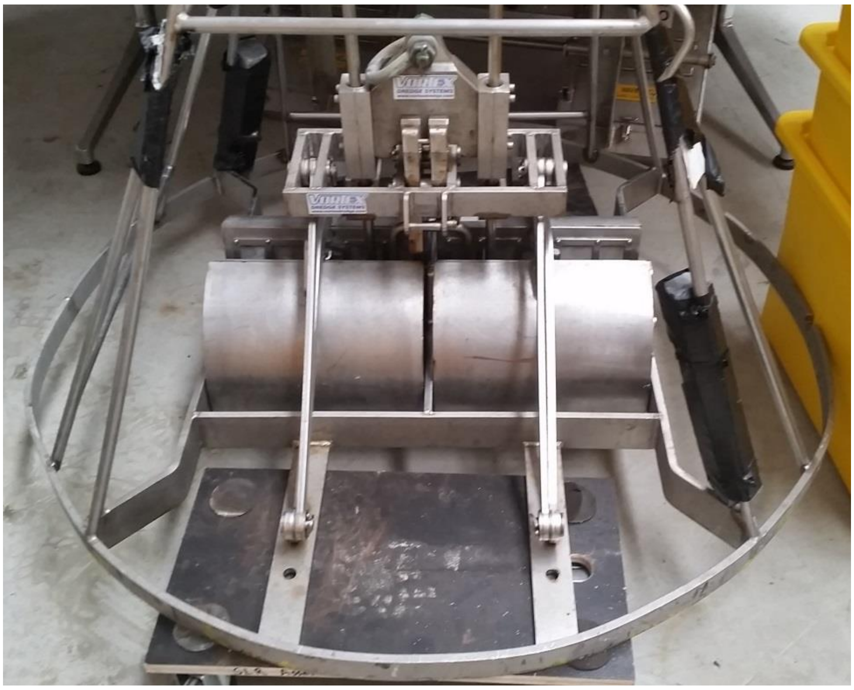
2.2.1 Benthic Grab Samples

A double Van Veen double grab sampler (**Figure 4**) was used to collect a single sediment grab sample at each of the 15 benthic monitoring stations surrounding Well C (**Figure 2**). The grab sampler is constructed of stainless steel and features two independent 'buckets' which penetrate the surficial sediments to a depth of 0.16 m. Each successful grab sample returns approximately 0.01 m^3 of seabed sediment back to the surface.

Upon arrival on the vessel deck, each grab sample is checked for completeness, which must meet the following criteria:

- The surface of the sediment is largely undisturbed upon inspection aboard the vessel;
- Sufficient sediment (≥75% of the grab capacity) is collected to enable the full suite of sediment analyses required;
- The infauna sample bucket is filled to the same volume (approximately 10 l) for all infauna replicates throughout the survey; and
- The grab has not been over-filled with sediments pushing out of the doors or drains, indicating that it may have over-penetrated the sediment.

Figure 4 The Double Van Veen Grab Sampler used for the 2018 Benthic Sampling



Each independent bucket from a grab sample is used separately for infauna and sediment physical and chemical analyses, as follows:

- Bucket one: infauna/macrofauna community analysis. The entire sample is sieved through 0.5 mm mesh until approximately 300 - 500 ml of residual sediment and organisms remains. This remaining material is transferred to a plastic container and preserved with a fixative (AncholTM), ready for analysis by SLR taxonomists.
- Bucket two: sediment physical nature and chemical analyses. Three 64 mm (internal diameter) clear Perspex sub-sampling cores are pushed into the sediments from the second bucket, to a depth of approximately 150 mm. Cores are photographed and the upper 50 mm from each core is extruded into a polyethylene bag for particle grain size distribution and organic content (Total Organic Carbon (**TOC**)) analyses by Hill laboratories.

2.2.2 Seafloor Video Imagery

Video imagery of the seafloor was obtained using a customised tow-sled fitted with high-intensity LED lighting and a high-definition video camera (**Figure 5**). The system was connected to the vessel via a 10 mm dyneema tow-line and a 300 m umbilical cable supplying real-time video images to the camera operator on the research vessel. A pair of parallel lasers on the video sled provided an indication of scale allowing features of interest in the video recordings to be approximately sized. Ten video sled tows were conducted around Well C (**Figure 2**).

The video-sled was launched from the vessel up-current of each pre-determined location and lowered to the seabed, where it auto-located via a series of floats and weights set at specific points on the sled frame, to land upright on its lower skids. At the point where the sled contacted the seabed, a GPS log was started, and this log continued throughout the duration of the tow. Video footage was continuously recorded for approximately 200 m as the sled drifted behind the vessel; this ensured that footage was collected while the sled was passing as close as possible to the required sample location.

Figure 5 The Video Sled used for Collecting Video Footage of the Seabed Environment

2.3 Laboratory Analyses

2.3.1 Sediment Physicochemical Analyses

Benthic sediments collected by the grab were analysed by Hill Laboratories (an NZS/ISO/IEC 17025:2005 accredited laboratory), for both physical and chemical parameters. The aims of these analyses along with further details of the analytical method/descriptions are summarised in **Table 2**.

Table 2 Summary of Analytical Methods used for Testing Sediment Physico-chemical Characteristics

Analyte	Aim	Method Number	Description
Particle Grain Size Distribution	• Determine physical parameters of the sediment particles present at the site • Correlate with infauna community characteristics	Hill Laboratories KB32136	• Sediment was wet-sieved through the following screen sizes, as per the Udden-Wentworth scale (Wentworth, 1922): • >2 mm (gravel) • >1 mm (very coarse sand) • >500 µm (coarse sand) • >250 µm (medium sand) • >125 µm (fine sand) • >63 µm (very fine sand) • <63 µm (silt and clay)
Total Organic Carbon	• Determine current level of organic carbon in sediment • Correlate with infauna community characteristics	No specific method number	Acid pre-treatment to remove carbonates present, followed by catalytic combustion (900° C, O_2), separation, Thermal Conductivity Detector. Elemental Analyser.

2.3.2 Macrofauna Analyses

Macrofaunal analyses focused on the infauna, or animals larger than 0.5 mm living within the sediment matrix. Epifaunal animals (those living on top of the sediment), were also included in the analyses to provide representation of the different functional groups present at each sample station.

Benthic macrofaunal samples collected from the sediment grab were sorted and, with the aid of a binocular microscope, identified to the lowest practicable taxonomic level or most recognisable taxa (morphologically similar group). Counts were made to assess the relative abundance of each taxa.

2.3.3 Seafloor Video Analyses

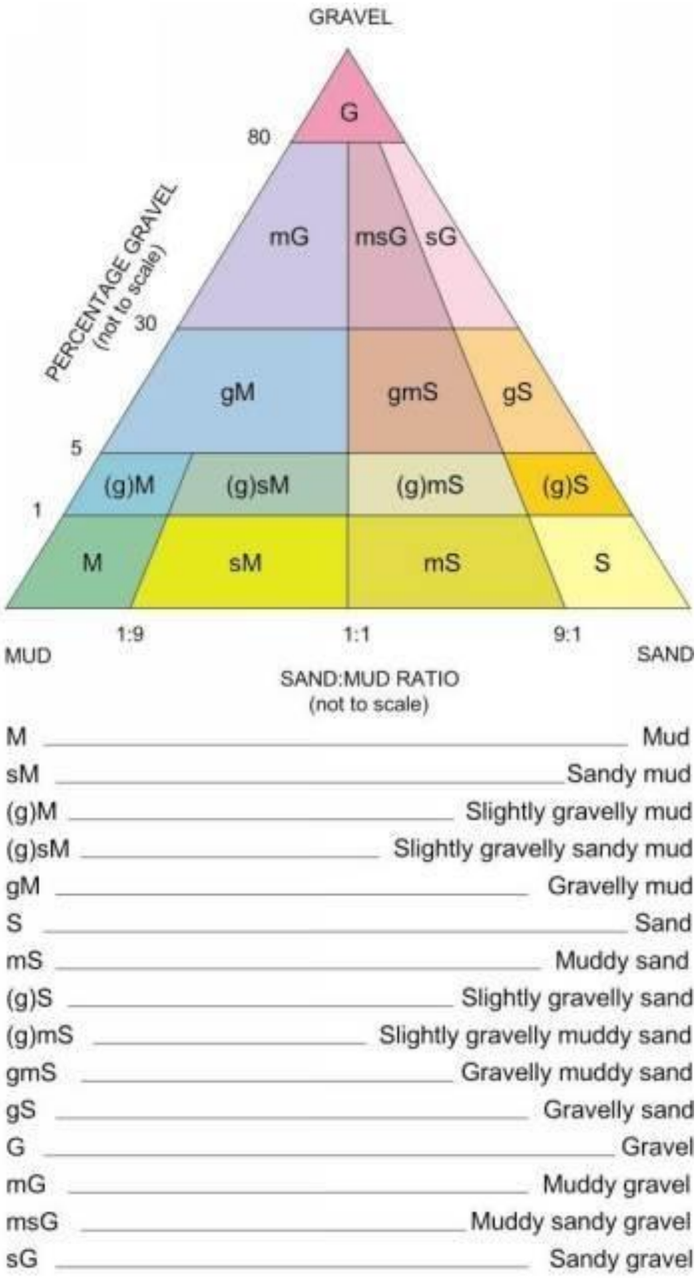
A live feed from the video-sled was captured and recorded on-board the survey vessel and viewed by SLR staff with experience in undertaking assessments of the benthic environment in the offshore Taranaki region. Brief field notes were made in real-time about obvious structures and organisms observed while watching the live footage. Back onshore the recorded seabed video footage was assessed on a large, high definition screen, by a suitably trained and experienced benthic scientist, who identified all obvious epifauna to the lowest practicable taxonomic level. Biogenic and/or anthropogenic seabed structures such as burrows, mounds, tracks and gouges/trenches were also recorded. Relative abundance estimates of epifauna or biogenic structures were made where appropriate.

2.4 Data Analyses

2.4.1 Sediment classifications

While there are many sediment classification schemes in use worldwide, a common one is a modified version of that proposed by Folk (1954). This scheme groups grains within a sample into mud, sand and gravel sized particles based on the particles diameter (mud <63 µm, sand 64-2000 µm, gravel > 2mm), and then describes the sediment type based on the relative proportions of the particles (see **Figure 6**).

Figure 6 Folk (1954) Sediment Type Classification Triangle



2.4.2 Community Characteristic Descriptors

All macrofauna (both epifauna and infauna) taxa were included in the analyses of abundance data. Species identified in the samples as not being exclusively benthic were excluded from further analyses. Data were analysed as per the statistical methods outlined below to identify current distributions and abundance of macrofauna.

2.4.2.1 Univariate Diversity Indices

Diversity indices (number of taxa S, total abundance N, Shannon-Wiener diversity H', and Pielou evenness J' (**Table 3**) were calculated from the macrofauna abundance data using the PRIMER software package (PRIMER v6.1.16; Clarke, 1993; Clarke & Warwick, 1994; Clarke & Gorley, 2006).

Table 3 Description of Macrofauna Community Characteristic Indices

Index	Formula (where applicable)	Description
Number of Taxa (S)	Count of total number of different taxa identified within the *x* sample	Total number of taxa identified within a sample
Total Abundance (N)	Sum of all individual taxa abundances within the *x* sample	Total number/count of all organisms within a sample
Shannon Diversity (H')	$H' = -SUM [(p_i) \times \log_e (p_i)]$ $p_i =$ Number of individuals of taxa i /total number of samples	A single value (log scale) that is used to describe the different types and numbers of organisms present within an assemblage. The index value increases as assemblages have greater numbers of taxa and when the numbers of individual organisms are more evenly distributed across the different taxa. Samples dominated by single taxa will have lower values towards zero.
Pielou Evenness (J')	$J= H'/ \log_e (S)$	A value theoretically between zero and one which indicates how evenly the number of individual organisms are distributed through the different taxa in an assemblage. High values (closer to 1) indicate an even spread amongst the taxa present, whereas a low value indicate an uneven spread or an assemblage highly dominated by only a few, or even a single taxon.

3 Results and Discussion

3.1 Sediment Physical and Chemical Properties

3.1.1 Visual Description of Sediment Cores

Sediment collected from around Well C was predominantly cohesive light grey/brown sandy mud with small broken shell fragments (**Figure 7**). No dark-grey or black sediment layers (apparent Redox Potential Discontinuity), or darker patches within cores were noted and no detectable hydrogen sulphide odours were present, indicating sediments are well oxygenated throughout the depths sampled. Field observations on sediment texture, colour and any notable features of the sediment samples were recorded during the processing of the sediment cores and infauna samples, and these are included in **Appendix A**. A full set of sediment core photographs are contained in **Appendix B**.

Figure 7 Representative Images of Sediment Core Profiles from Well C

Station C2

Station C6

Station C8

Station C11

3.1.2 Incidental Observations

During laboratory processing of the infauna samples observations were made of any debris present, including those from anthropogenic sources. Within the 15 samples collected around Well C, 13 types of debris were observed (**Table 4**), ten of which were likely to be anthropogenic in source, including welding material, paint flecks, nylon and rust. However all anthropogenic debris encountered in the samples were at ‘low’ abundances.

Table 4 Incidental Observations

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
Coal Rock						L				L					
Garnet						L									
Graphite							L								
Rusty welding ball											L				
Green paint											L			L	
Blue paint									L	L	L				
Rust										L					
Yellow paint					L		L					L			
Red paint		L													
Black nylon				L											
White nylon															
Red nylon				L											
Blue/yellow paint															L

VA = very abundant (>50), A = abundant (50+), C = common (20–50), O = occasional (10–20), L = low (0–10)

3.1.3 Sediment Particle Grain Size Distribution and Organic Content

The physical characteristics of the sediment can influence the composition of the infauna communities and the levels of contaminants retained and observed during analyses. Particle grain size is widely used to characterise the physical structure of the sediment, while organic content provides an indication of the organic enrichment in the sediment. These combined results provide a general understanding of sediment health and the source of potential stressors at the time of sampling.

Organic matter found in the sediments is most likely derived from natural sources such as infauna/epifauna and detrital matter, rather than from anthropogenic sources. Anoxic sediments (those lacking oxygen), may develop in situations where organic matter levels increase beyond ‘normal’ levels for that area. Increased organic matter has the potential to disturb the equilibrium of the benthic ecosystem, as increased numbers of oxygen-utilising bacteria are required to decompose the additional organic matter, thereby rapidly reducing oxygen availability in the sediments.

A summary of the particle grain size and organic content analyses are discussed below, with full results provided in **Appendix C**.

3.1.3.1 Particle Grain Size

Particle grain size analyses at the 15 monitoring stations around Well C are shown in **Figure 8**. Sediments were dominated by the very fine sand (22-39%), fine sand (14-30%) and silt/clay (35-48%) sized fractions, with small proportions of larger sand and gravel sized particles which were largely comprised of broken shell material. These sediments are classified as 'muddy sands' (Folk, 1954), which have historically not been encountered very often in offshore Taranaki areas where exploration/production monitoring has taken place.

Samples with the greatest proportions of silt and clay (mud) were found at stations C8 and C12 (the northeast edge of Well C monitoring stations), the lowest amounts of silt were found at stations C5, C6, C7 (towards the northwest of the Well C monitoring stations) and C10. While this appeared to show some sort of pattern in increasing fine sediments towards the northeast part of the site, the trend was weak and inconsistent across the site as a whole.

The sandy muds encountered around Well C were similar to those found at the other three wells in the Northern AOI, as well as Well L, which all had notably coarser grain size relative to the silt and clay (mud) dominated sediments collected in the central and southern regions (**Table 5**). **Appendix C** provides raw particle grain size distribution data for Well C and graphical representations of grain size at the remaining well sites.

Figure 8 Sediment Particle Grain Size Distribution for Samples Collected at Well C

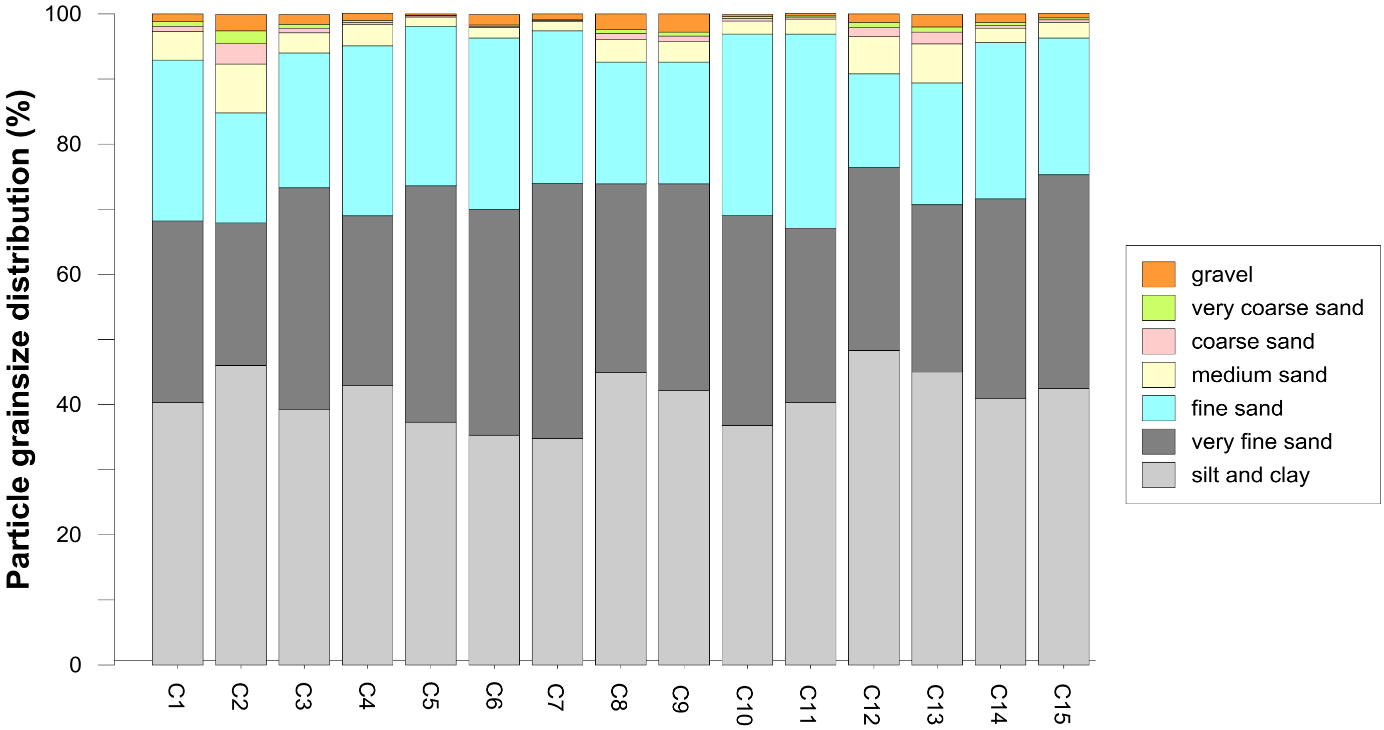


Table 5 Average Grain Size for the Eleven Wells

Grain size class	A	B	C	D	E	F	G	H	I	J	L
Silt & Clay (Mud) (%)	36.2	27.5	41.1	30.7	85.2	83.2	67.8	72.6	65.1	85.4	30.8
Very Fine Sand (%)	45.8	39.3	30.5	41.7	6.5	4.8	6.1	5.8	6.6	14.2	25.4
Fine Sand (%)	17.0	28.6	22.4	26.8	8.0	11.3	24.6	19.0	22.1	0.4	29.8
Medium Sand (%)	1.0	2.4	3.3	0.7	0.4	0.6	1.6	2.5	5.1	0.1	12.3
Coarse Sand (%)	0.1	0.7	0.8	0.0	0.0	0.1	0.1	0.1	0.6	0.0	1.2
Very Coarse Sand (%)	0.0	0.6	0.5	0.0	0.0	0.1	0.1	0.1	0.5	0.0	0.2
Gravel (%)	0.1	1.1	1.3	0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.1
Description	mS	mS	mS	mS	sM	sM	sM	sM	sM	sM	mS

Note: sM = sandy mud, mS = muddy sand

Colour scale based on percentage with median mid-point (median is 2.0):

0%	5	10	20	30	40	50	60	70	80	90	100

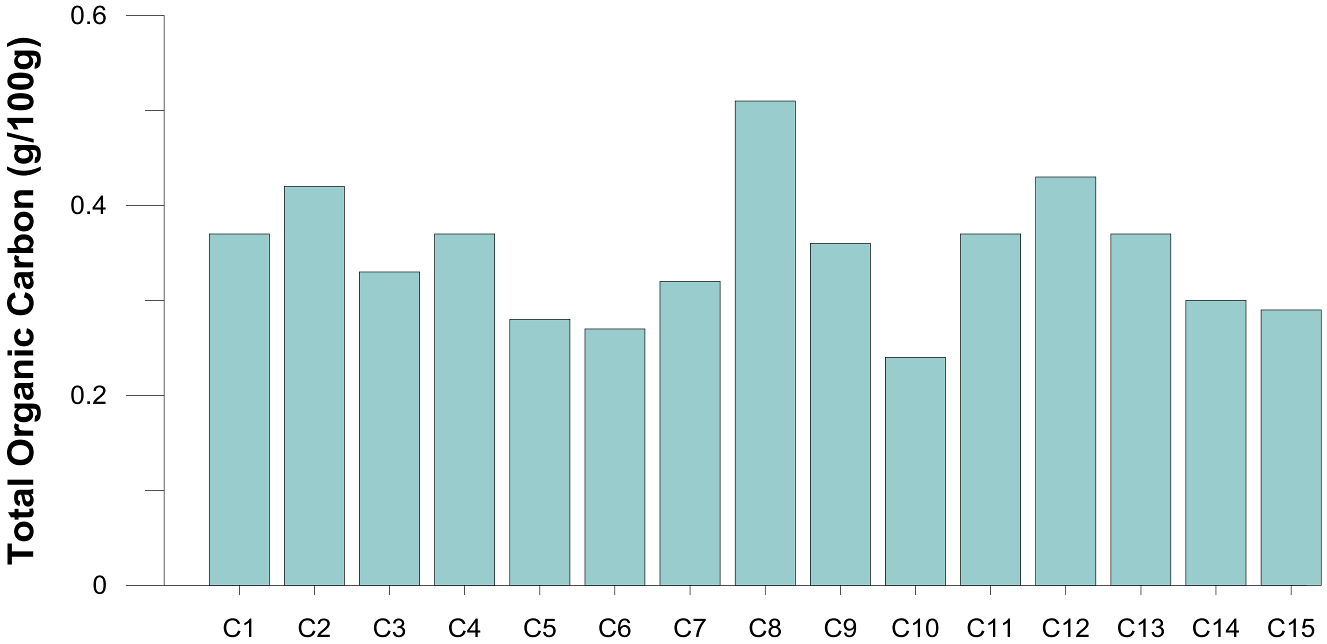
3.1.3.2 Total Organic Carbon

The organic content of sediments was assessed by measuring TOC to assess benthic ecology as this is also consistent with what is now currently undertaken around the offshore Taranaki oil and gas fields.

TOC levels around Well C ranged from 0.24% to 0.51% (mean 0.35%) (**Figure 9**). TOC was lowest at C10 (0.24%), while C8 and C12, on the northeastern edge of the sampling area, had the highest TOCs (0.51% and 0.43%, respectively). There was no obvious spatial pattern in the results.

The average organic content around Well C was low relative to other EAD wells monitored as part of the Benthic Baseline survey (mean 0.35% compared to overall mean of 0.45%). The combined mean from all stations within the Northern AOI (0.26%) was low relative to the Central and Southern AOIs (0.59% and 0.48%, respectively). As has been previously described in benthic environmental monitoring associated with offshore Taranaki oil and gas activities (SLR, 2016), there is a correlation between sediment particle grain size and sediment organic content. The comparatively greater surface area to volume ratio of silt and clay (mud/fines) sized sediment particles (compared to larger particles like sand) gives a greater area for adsorption of organic matter particles and therefore a higher probability of elevated organic matter compared to coarser/sandier sediments subjected to the same level of enrichment (Hedges *et al*., 1993). This is likely to explain the lower organic content at Northern AOI sites, where sediment grain size is greater than at the Central and Southern AOI (**Section 3.1.3.1**).

Figure 9 TOC Concentrations in Sediment Samples Collected from around Well C



3.2 Video Sled Imagery

Video footage of the seabed allows scientists to visually assess any anthropogenic disturbance to the benthic environment and observe epifauna, sediment-type and structures or relief that exist on the seabed.

Video footage was captured by towing a video sled through ten sites around Well C (**Section 2.2.2**). All video footage is included with the electronic version of this document, with a selection of still images displayed in **Figure 10**. **Appendix A** provides locational information for each video sled tow.

Video footage was assessed to determine any defining features and their semi-quantitative abundance recorded for comparison with other sites. Due to caveats associated with video footage (i.e. variable visibility, and differing tow length and duration) the counts are indicative-only and should not be interpreted as a quantitative assessment. **Table 6** presents the results of this semi-quantitative approach, which summaries the counts by comparing the site total to the median across all of the EAD wells in the three AOIs. As a visual aid, counts were categorised in relation to the deviation from the 10th, 25th 50th, 75th and 90th percentiles, so that differences between sites can be more easily viewed.

3.2.1 Physical Observations

The seabed around Well C was observed to be dominated by firm sandy mud sediments. Sand ripples were occasionally observed (image C, **Figure 10**), indicating regular current flows in this area. Evidence of bioturbation was observed at all monitoring stations in the form of animal burrows. Low to moderate abundances of animal burrows were observed at a number of monitoring stations (images A, B, and G, **Figure 10**), with moderate to high numbers at others (images E, F, and H, **Figure 10**). This is similar to other wells in the Northern AOI, but differs from the Central and Southern AOI sites where abundances were predominantly moderate to high (**Table 6**).

Mound/hollow features (images B, C, and D, **Figure 10**) were observed in high numbers (85) around Well C compared to the median (43) for all sites (**Table 6**). The highest numbers were seen at Well D (280) (Northern AOI) and Well L (532) (Southern AOI). However, most of these were seen in two of the ten video tows (CV6 and CV9), with no sea pens observed in five of the video tows around Well C. Mound/hollow features are considered to be formed by the feeding activities of sharks or rays, or by tube worms mounding up sediment. Mound/hollow features were observed to be more numerous at the Northern AOI sites compared to the Central and Southern AOIs, where moderate to very high numbers of mound/hollow features were found at the Southern AOI sites, and low to very low in numbers at Central AOI sites.

Although there was no definitive sign of anthropogenic physical disturbance of the seabed observed during the video sled tows around Well C, a number of shallow trenches or ripples were observed. The trenches were estimated to be 100 – 200 mm deep and 300 – 400 mm wide. These features were likely caused by fishing activities which contact the seabed (i.e. bottom trawling). There were no signs of sediment enrichment such as darker sediment patches, bacterial mats or sediment off-gassing, observed during any of the video sled tows around Well C.

Table 6 Total Number of Features Observed in Video Imagery from the EAD Wells

Well Site	Depth (m)	Mounds/ Hollows	Number of burrows/worm holes	Sea pen	Fish	Substrate	Notes
A	148	111	Low-moderate	54	65	Muddy sand	Ripples; some very large holes and mounds
B	134	63	Low-moderate	35	49	Muddy sand	Some very large holes mounds
C	132	85	Low-moderate	50	44	Muddy sand	Ripples; trenches observed
D	145	280	Low	160	28	Muddy sand	Ripples; 23 very large sea feathers
E	126	29	Moderate	29	16	Sandy mud	
F	128	20	Moderate	19	19	Sandy mud	
G	124	18	Moderate-High	29	26	Sandy mud	
H	124	18	Moderate-High	17	26	Sandy mud	12 elongated shallow trenches
I	122	43	Moderate-High	36	21	Sandy mud	5 elongated shallow trenches (large)
J	108	42	Moderate	14	30	Sandy mud	School of mackerel, tufts/tubes common
L	112	532	Moderate	132	31	Muddy sand	2 schools of mackerel
Median		43		35	28		
Totals are sum of 10 video tows carried out at each site. Totals are semi-quantitative only due to variable visibility and transect length.							

10th percentile band
25th percentile band
Median band
75th percentile band
90th percentile band

3.2.2 Infauna, Epifauna and Other Fauna

In some cases, a definitive positive identification of infauna, epifauna and more mobile taxa was not possible from the video footage alone. Where there was any uncertainty, identifications were based on distinctive features, colours and shapes of organisms and in some cases the confirmed presence of similar looking individuals within the infauna samples.

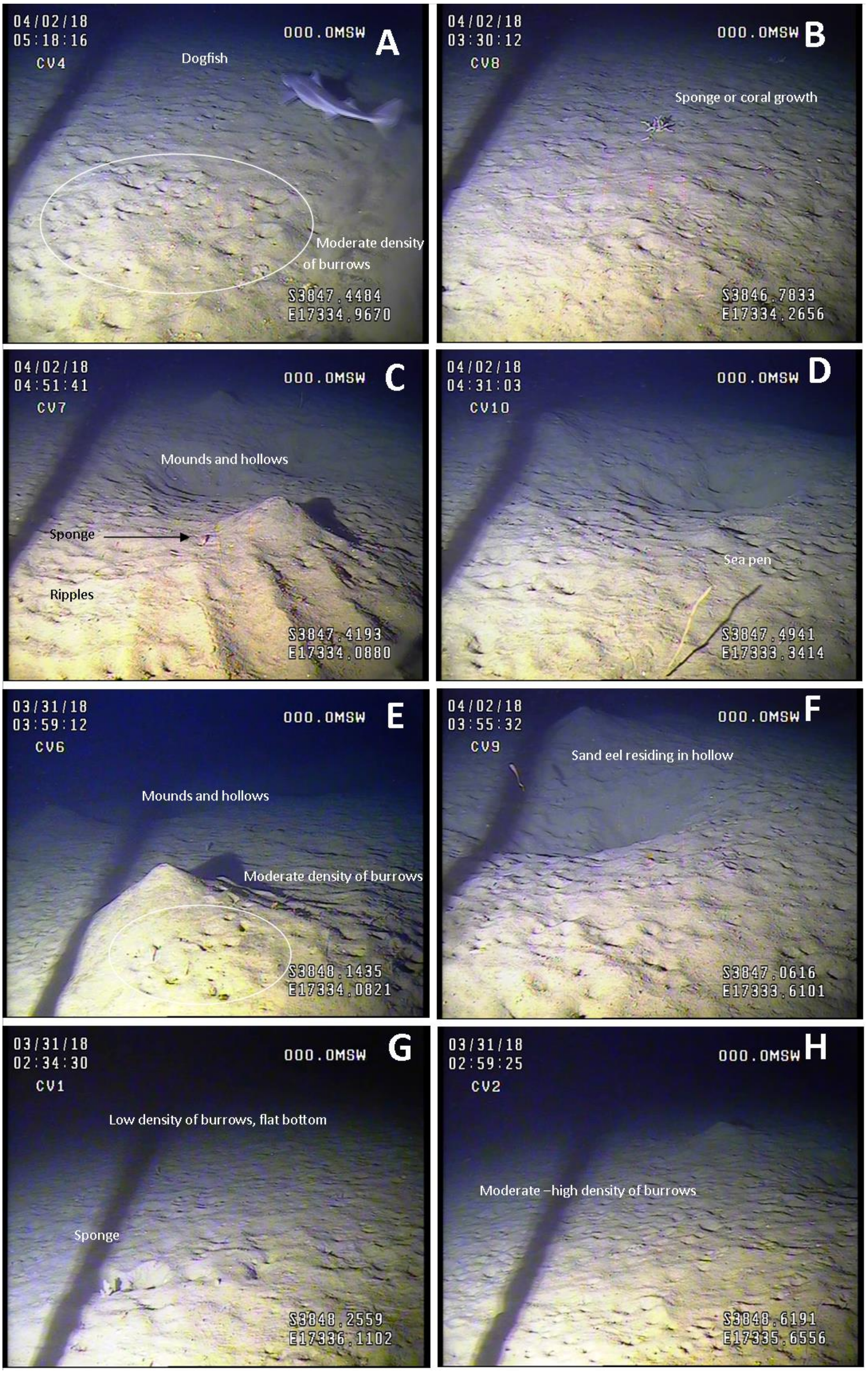
Epifauna taxa observed in video footage collected around Well C included whelks (likely *Austrofusus glans*), hermit crabs (*Pagarus* sp.), tusk shells (likely *Fissidentalium zelandicum*), and various species of sponge (image C and G, **Figure 10**). Despite not being detected in large numbers, the presence of epifauna tracks in the sediment indicates that mobile fauna such as whelks and hermit crabs move throughout this site. An object that could either be a sponge or a piece of coral can be observed in image B, **Figure 10**.

Sea pens (likely *Virgularia* sp.) (image D, **Figure 10**) were observed in high numbers (50) around Well C compared to the median (35) for all wells (**Table 6**). The highest numbers were seen at Well D (160) (Northern AOI) and Well L (132) (Southern AOI). Sea pens were observed to be more numerous at the Northern AOI sites, variable at the Southern AOI sites, and lowest in the Central AOI sites.

Mobile fish species were observed in high numbers (44) around Well C compared the median (28) for all other sites (**Table 6**). A high diversity of species also was noted, including sand eels[1] (image F, **Figure 10**), opalfish (likely *Hemerocoetes monopterygius*), dogfish (*Squalus acanthias*.*)*, flatfish (likely *Peltorhamphus sp*.), pilchard (likely *Clupeidae* sp.), and gurnard (likely *Chelidonichthys kumu*). A number of smaller fish were observed swimming off very quickly as the camera approached, so it was not possible to make a positive identification. Fish were observed to be much more numerous at the Northern AOI sites, moderate at the Southern AOI sites, and moderate to low in numbers around the Central AOI sites.

[1] This fish was unable to be formally identified, thus while the term 'sand eel' is used throughout this report it should not be considered a common name for this unidentified fish species

Figure 10 Representative Images of Seabed Environment around Well C



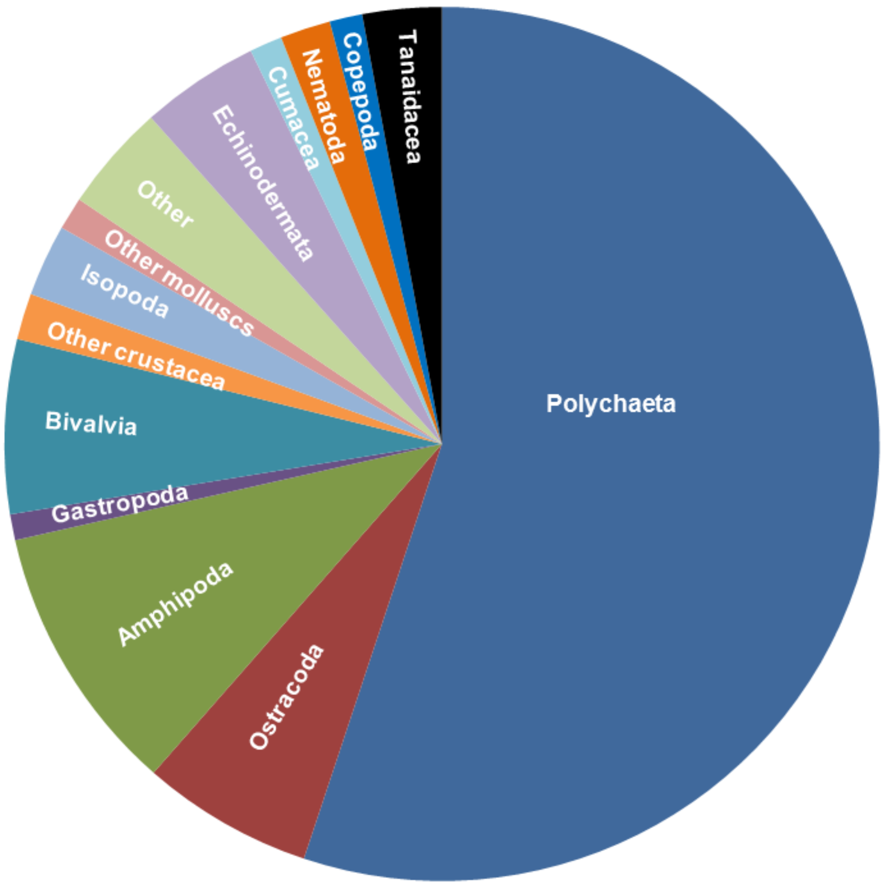
3.3 Macrofauna Characteristics

3.3.1 Benthic Macrofauna

Overall 1,987 individuals representing 128 taxa were identified in the macrofauna samples collected at the monitoring stations sampled around Well C. Infauna communities were dominated by small polychaete worms (1,095 individuals (55%), 49 taxa), crustaceans (518 individuals (26%), 34 taxa, mostly ostracoda, amphipoda, and isopoda), and molluscs (171 individuals (9%), 27 taxa, mostly scaphopoda and small bivalvia) (**Figure 11** and **Figure 12**). The raw macroinvertebrate data from Well C monitoring stations is provided in **Appendix D**.

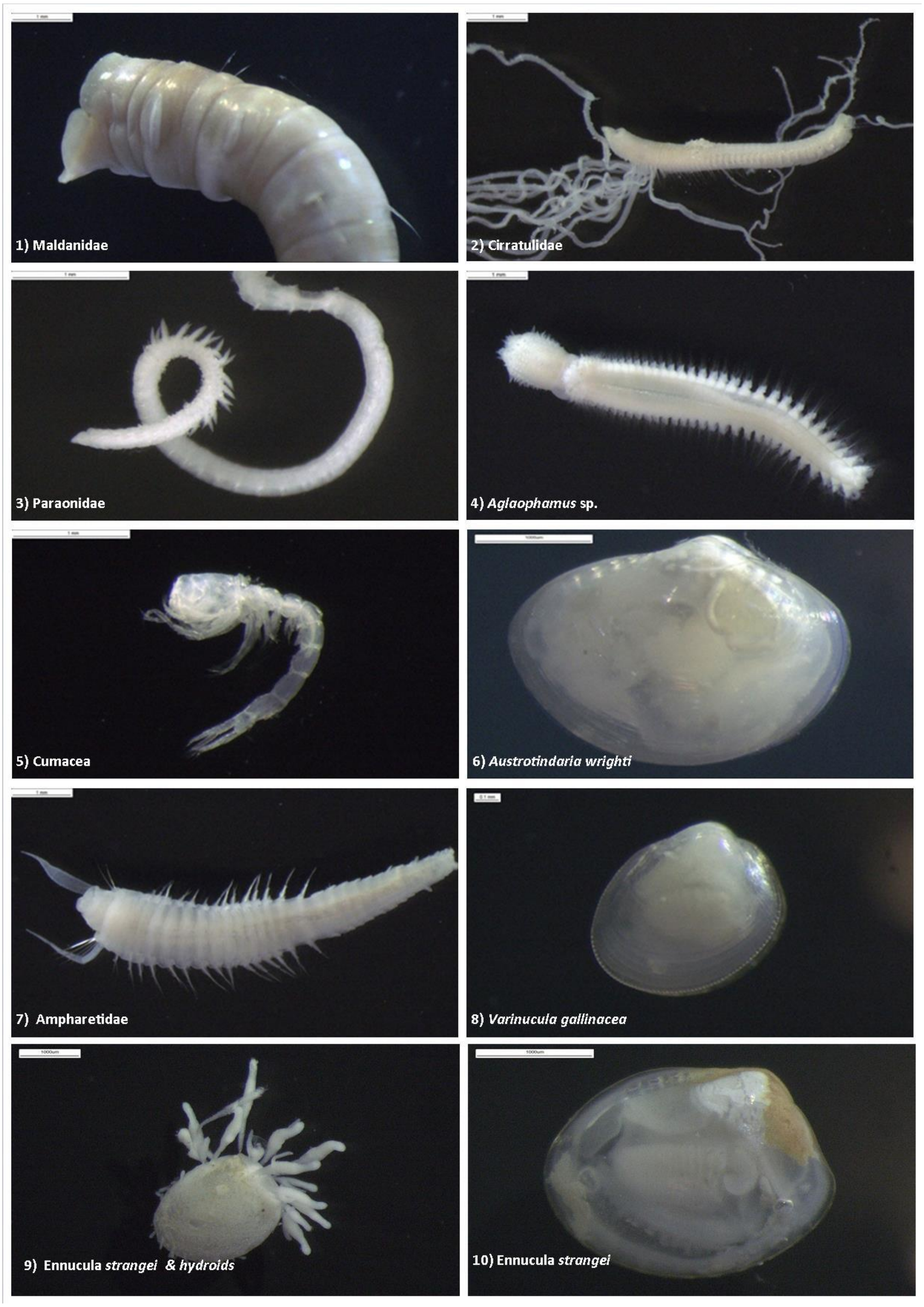
When the benthic macrofauna results are compared across the three AOIs, crustaceans (especially Tanaidacea and Amphipoda) and nematodes were found in higher numbers in the Northern AOI sites compared with the Central and Southern AOIs. Gastropods and polychaetes were found in lower proportions in the Northern AOI and higher in the Central and Southern AOIs (**Appendix E**). This result is likely to be linked to the differences in sediment composition, where a coarser grain size was present in the Northern AOI compared to the Central and Southern AOIs.

Figure 11 Proportion of Well C Individuals Belonging to each Taxonomic Group



'Other Crustacea' includes Decapoda. 'Other molluscs' includes Caudofoveta, Gastropod, and Scaphopoda. 'Other' includes Actiniaria, Anthozoa, Ascidiacea, Calcarea, Chaetognatha, Nermetea, Oligochaeta, Sipuncula, and Tunicata.

Figure 12 Representative Images of Benthic Infauna Taxa Frequently Observed in Offshore Taranaki Area



3.3.2 Univariate Indices of Infauna Communities

Univariate indices (total number of taxa, total abundance, Pielou's evenness and Shannon-Wiener diversity) describing the benthic macroinvertebrate communities found around Well C are displayed in **Figure 13**.

The number of taxa identified in each sample collected around Well C varied from 34 to 57 (mean 45), while total abundance ranged widely from 73 to 205 individuals (mean 132). Abundance and taxa numbers at Well C were the lowest of the Northern AOI sites but similar to the overall means for the Northern AOI (53 taxa, 233 individuals, **Table 7**), which were notably higher than those of the Central and Southern AOI.

Evenness values vary on a scale between zero and one, with values near one indicating that infauna abundances are evenly distributed across all the different taxa present, while values near zero indicate infauna communities are being numerically dominated by a large number of individuals from just a few, or even only single taxa. Values from the Benthic Baseline data collected at Well C were high (mean 0.90), indicating relatively even distribution of taxa abundances across the taxa that were present.

Shannon-Wiener diversity index values range between 0 and 4 with higher values indicating higher species diversity. From previous benthic studies in the offshore Taranaki region, species diversity values are normally between 1.5 and 3.5. The mean Shannon-Weiner diversity index for Well C was 3.4, and ranged between 3.3 and 3.6. When these results are compared to the most recent results from long term benthic monitoring programmes at the Maari Field (diversity index of 2.9) in the Southern AOI it is shown that the species diversity was greater at Well C.

Figure 13 Total Number of Taxa, Total Abundance, Pielou's Evenness and Shannon Wiener Diversity Index Values for Macrofauna Samples Collected at Well C

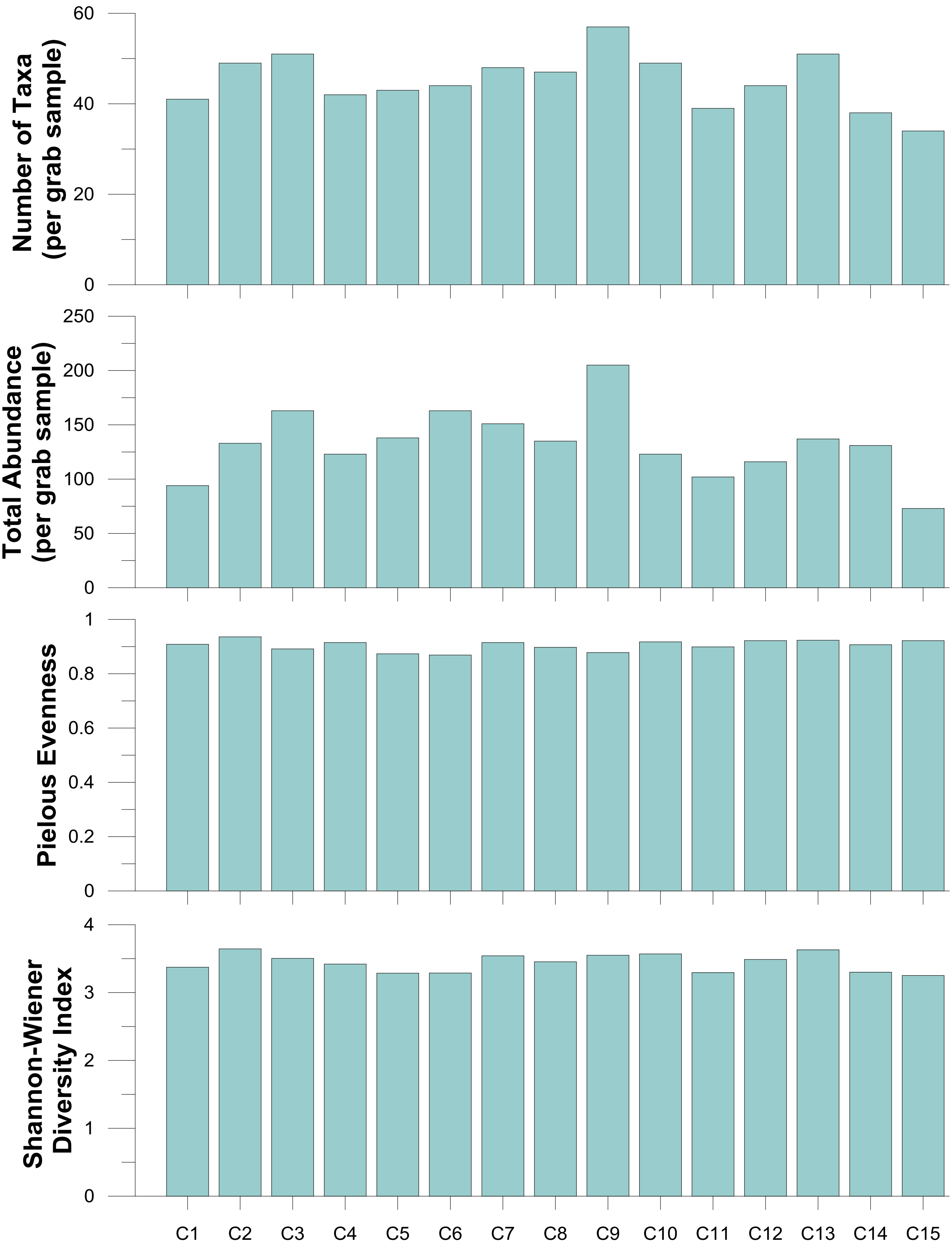


Table 7 Number of Taxa and Total Abundance for the Eleven Wells

Site	Mean Number of Taxa	Mean Abundance	Total Number of Taxa Identified at site	Total number of individuals (abundance)
A	56	257	140	3,849
B	53	210	130	3,151
C	**45**	**132**	**128**	**1,987**
D	60	332	142	4,986
Northern AOI	53	233		
E	19	36	78	542
F	31	68	90	1,023
G	33	81	112	1,215
H	31	89	103	1,339
I	29	72	91	1,075
Central AOI	29	69		
J	40	115	108	1,722
L	54	190	131	2,853
Southern AOI	47	153		

3.4 Sensitive Environments

In an investigation of sensitive substrate/benthic habitats in the Taranaki Coastal Marine Area, Johnston *et al*. (2016) studied marine taxa databases from marine benthic surveys conducted in the offshore Taranaki Basin and noted that there are many locations where at least one ‘characteristic species of sensitive environments’ was found. This investigation used the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activity Regulations**) sensitive environments descriptions to define what sensitive habitats may be present.

Chaetopteridae worms and sea pens (*Virgularia gracillima*) were noted by Johnston *et al.* (2016) as likely to be present in areas close to the 11 wells. In relation to the sampling techniques used in the Benthic Baseline survey (grab sampling and video sled imagery), MacDiarmid *et al*. (2013) define that;

“A sensitive Chaetopteridae worm field is present if worm tubes and/or epifaunal species:

- Occupy 25% or more of the seabed in imaging surveys covering and area of 500 m^2 or more; or
- Occur in two successive samples collected using point sampling gear.

and

“A sea pen field exists if:

- One or more specimens of any species of sea pen is found in two successive samples collected using point sampling gear, or
- Two or more specimens per m^2 are found in seabed imaging surveys, or surveys using towed gear.”

Macrofauna samples have shown Chaetopteridae worms (specifically *Phyllochaetopterus socialis*, commonly known as wire-weed or Tarakihi weed) were present within samples from Wells A, B, C, D, G, H, J and L. The majority of sites only had a small number of sampling stations at each well, with Well C having a single individual at two of the 15 samples collected; this is compared to infauna samples collected from Well B which had 2 - 13 individuals occurring in 11 of the 15 samples collected. Across the ten video sled tows performed at Well C there were no distinct worm-fields or the low-relief worm-meadows that *P. socialis* often form observed. Thus while this sensitive environment species was present at Well C the distributions appeared more as "isolated individuals within mixed epifaunal assemblages" at two stations rather than "dense mono-specific meadows at the tens of kilometres scale" (MacDiarmid *et al*., 2013).

A single isolated sea pen (*Virgularia gracillima*) was identified in one of the infauna samples from Well C during the Benthic Baseline survey. Video imagery collected at each well observed unidentified sea pen species at all of the sites (see **Table 6** for total numbers of sea pens observed across the ten tows at each site). Sea pen numbers (all species) observed at Well C were moderate (50), with the highest numbers observed at Wells D (160) and L (132). The Northern AOI sites generally had greater numbers compared to central and southern areas. The variable visibility encountered during video sled imagery means this method can only be qualified as semi-quantitative. However, approximate densities can be calculated based on the approximate width of the cameras field of view and the length of each tow. Based on such calculations the densities of unidentified sea pen species at Well C would not have surpassed the trigger of two sea pens per square meter (MacDiarmid et al., 2013), and video tows at Well C did not pass through more spatially limited areas of higher density that might have been classed as 'sea pen fields'. Based on the video sled analysis there are no 'Sensitive Environments', as defined by the Permitted Activity Regulations were encountered at the monitoring stations at Well C. thus it is considered that the Well C area would not be classified as a 'sensitive habitat'.

4 Key Findings

4.1 Sediment Characteristics

There were no distinct spatial patterns to the variations in grain size and TOC across the fifteen sampling stations surrounding Well C.

Grain size analysis at Well C (and other Northern AOI sites) indicated that the sediment was coarser than those sediments found in the Central and Southern AOIs, which are dominated by mud (silt and clay).

TOC levels at Well C (mean of 0.35%) and all Northern AOI sites (mean of 0.26%) were lower than those found in samples from the Central and Southern AOIs (mean TOC 0.59% and 0.48%, respectively). Sediments with a finer grain size will retain higher levels of organic matter compared to coarser/sandier sediments subjected to the same level of enrichment/deposition.

4.2 Faunal Characteristics

Video sled imagery from the ten sampling stations around Well C showed fish were present in high numbers compared to other wells surveyed across the three AOIs (~44 compared to a median of 28 across all 11 wells). Mound/hollow features were observed to be more numerous at the Northern AOI sites, moderate to high at the Southern AOI sites, and low around the Central AOI sites.

Infauna communities sampled at Well C contained proportionally more Tanaidacea, Amphipoda and Nematoda, and less gastropods and polychaetes compared to the central and Southern AOIs. The number of taxa and total abundance at Well C were high when compared to the sites monitored in the Central and Southern AOIs, though not as high as Wells A, B and D.

The comparatively coarser nature of sandy sediments around Well C (and other Northern AOI sites) versus the muddy sediments from the Central and Southern AOIs is likely to be linked to the lower number of gastropods, many of which are detritivores and/or deposit feeders which feed on dead and decaying algae, seaweed and other plants and animals, as well as organic matter within the sediments. This feeding mechanism is likely to be more suited to muddy sediments. Sediment grain size is also important for determining suitable habitat for polychaete species (tubeworms), which form their tubes within the interstitial spaces in the sediment matrix, thereby requiring specific sediment properties to become established.

Explaining the greater proportions of Tanaidacea, Copepoda, Nematoda and Amphipoda at Well C is more complex, as species within the order Tanaidacea for example, may be filter feeding species while others actively hunt prey (predators). The prevalence of these taxa at Well C, compared to sites within the Central AOI, is likely to be linked with the coarser sediments present at Well C. Coarser sediments, particularly larger sands, gravels, shell hash, etc., begin to provide more three-dimensional, cryptic habitats, allowing a wider variety of taxa to find different suitable habitats than mud-dominated sediments. Coarser sediments also contain less of the very fine clay particles which can clog or damage the delicate feeding and breathing structures of taxa adapted as filter feeders, particularly when such fine sediments are present in the water column for extended periods, and/or repeatedly re-suspended.

4.3 Sensitive Environments

Some individuals representing some of the '*characteristic species of sensitive environments*' were found in macrofauna grab samples (e.g. Chaetopteridae worms and sea pens) and observed in video tows (e.g. sea pens)during the Benthic Baseline survey at Well C. However observations from the video imagery indicate that no 'Sensitive Environments', as defined by the Permitted Activity Regulations (and MacDiarmid *et al.*, 2013), were encountered at the monitoring stations surveyed at Well C in 2018.

5 References

Clarke K. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18 (1): 117-143.

Clarke K.R., Warwick R.M., 1994. Change in marine communities: An approach to statistical analysis and interpretation. Plymouth Marine Laboratory, UK.

Clarke K.R., Gorley R.N., 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth.

Folk, 1954. *"The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature",* The Journal of Geology 62(4):344-359.

Hedges JI, Keil RG, Cowie GL, 1993, "Sedimentary diagenesis: organic perspectives with inorganic overlays", Chemical Geology 107: 487-492.

Johnston O, Barter P, Ellis J, Elvines D, 2014, "*Recommendations for an Offshore Taranaki Environmental Monitoring Protocol: Drilling- and production-related discharges, Version 1.0*" (OTEMP), Cawthron Report No. 2124.

Johnston O 2016. Sensitive habitats and threatened species in the Taranaki Coastal Marine Area (TCMA) - database investigation. Prepared for Taranaki Regional Council. Cawthron Report No. 2877. 28 p. plus appendices.

MacDiarmid, A., Bowden, D., Cummings, V., Morrison, M., Jones, E., Kelly, M., Neil, H., Nelson, W., Rowden, A., 2013. '*Sensitive marine benthic habitats defined*'. Prepared for Ministry for the Environment, NIWA Client Report No: WLG2013-18.

SLR, 2016. "*Benthic Ecological Survey - Matuku-1 Exploration Well Post-Drill Assessment, March 2016*". Prepared for OMV New Zealand Limited. Report Number 740.10013.00240

APPENDIX A

Locations and Observations from Sediment Grab Sampling and Video Sled during the 2018 Benthic Baseline Survey

Station	Date	Time	Depth (m)	Coordinates (NZTM)		Notes
				Easting	Northing	
Grab Sample Sites						
CG 1	28/3/18	1251	132	1653495	5702017	Cohesive sandy mud, lots of broken shell
CG 2	28/3/18	1305	132	1652109	5703458	Cohesive sandy mud – quite hard deeper in sample
CG 3	28/3/18	1318	132	1650720	5704899	Cohesive light grey / brown sandy mud, small broken shells
CG 4	28/3/18	1326	132	1650028	5705619	Cohesive light brown / grey sandy mud, softer patches
CG 5	28/3/18	1335	132	1649332	5706338	Cohesive light brown / grey sandy mud
CG 6	28/3/18	1343	132	1648638	5707056	Cohesive light brown / grey sandy mud
CG 7	28/3/18	1352	132	1647937	5707771	Cohesive light brown / grey mud / sand
CG 8	28/3/18	1530	132	1652862	5705565	Light brown / grey sandy mud with shell hash
CG 9	28/3/18	1522	132	1652144	5704867	Softer light brown / grey mud with shell hash
CG10	28/3/18	1510	132	1650712	5703478	Light brown / grey sandy mud with small shell hash
CG11	28/3/18	1502	132	1649980	5702777	Light brown / grey sandy mud sediment, some shell hash
CG12	28/3/18	1442	132	1650770	5707726	Light brown / grey sandy mud and broken shell hash
CG13	28/3/18	1434	132	1650053	5707033	Light grey / brown sandy mud, with broken shell hash
CG14	28/3/18	1422	132	1648613	5705642	Light brown / grey sandy mud and broken shell hash
CG15	28/3/18	1406	132	1647895	5704946	Cohesive light brown / grey sandy mud
Video Sled Tow Locations						
CV 1	31/3/18	0625	132	1653896	5703784	
CV 2	31/3/18	0651	-	1652816	5702742	
CV 3	31/3/18	0717	-	1651739	5701696	
CV 4	02/04/18	0914	132	1651457	5706305	
CV 5	31/3/18	0818	132	1650028	5705619	
CV 6	31/3/18	0750	132	1649298	5704209	
CV 7	02/04/18	0847	131	1649332	5706338	
CV 8	02/04/18	0721	131	1649715	5708095	
CV 9	02/04/18	0749	131	1648286	5707413	
CV10	02/04/18	0819	131	1647561	5706008	

APPENDIX B

Sediment Core Profile Images from all Grab Samples Collected during the 2018 Benthic Baseline Survey at Well C

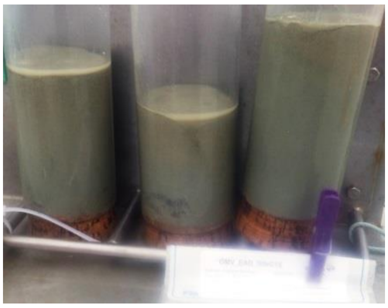

CG1.JPG

CG10.JPG

CG11.JPG

CG12.JPG

CG13.JPG

CG14.JPG

CG15.JPG

CG2.JPG

CG3.JPG

CG4.JPG

CG5.JPG

CG6.JPG

CG7.JPG

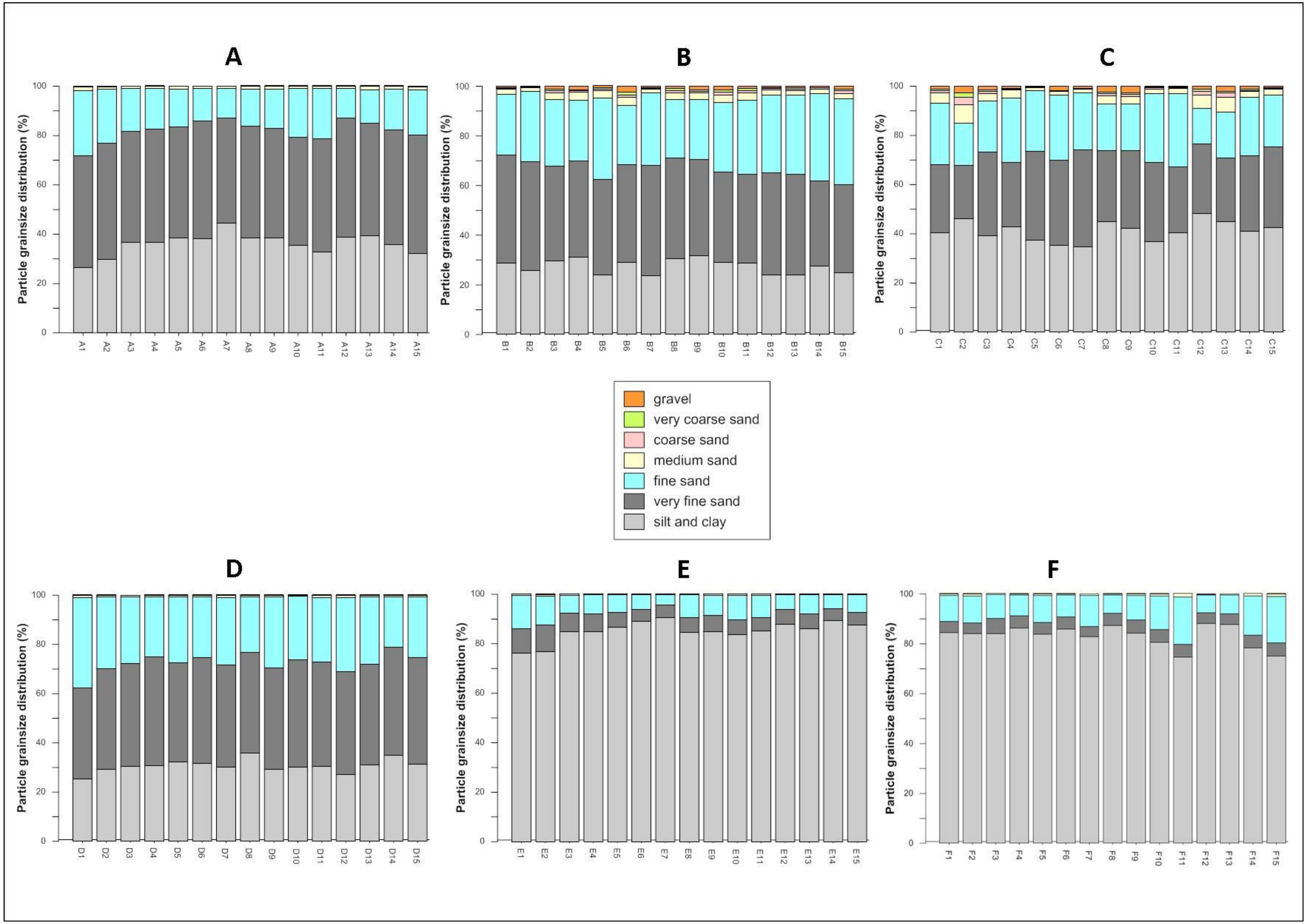
CG8.JPG

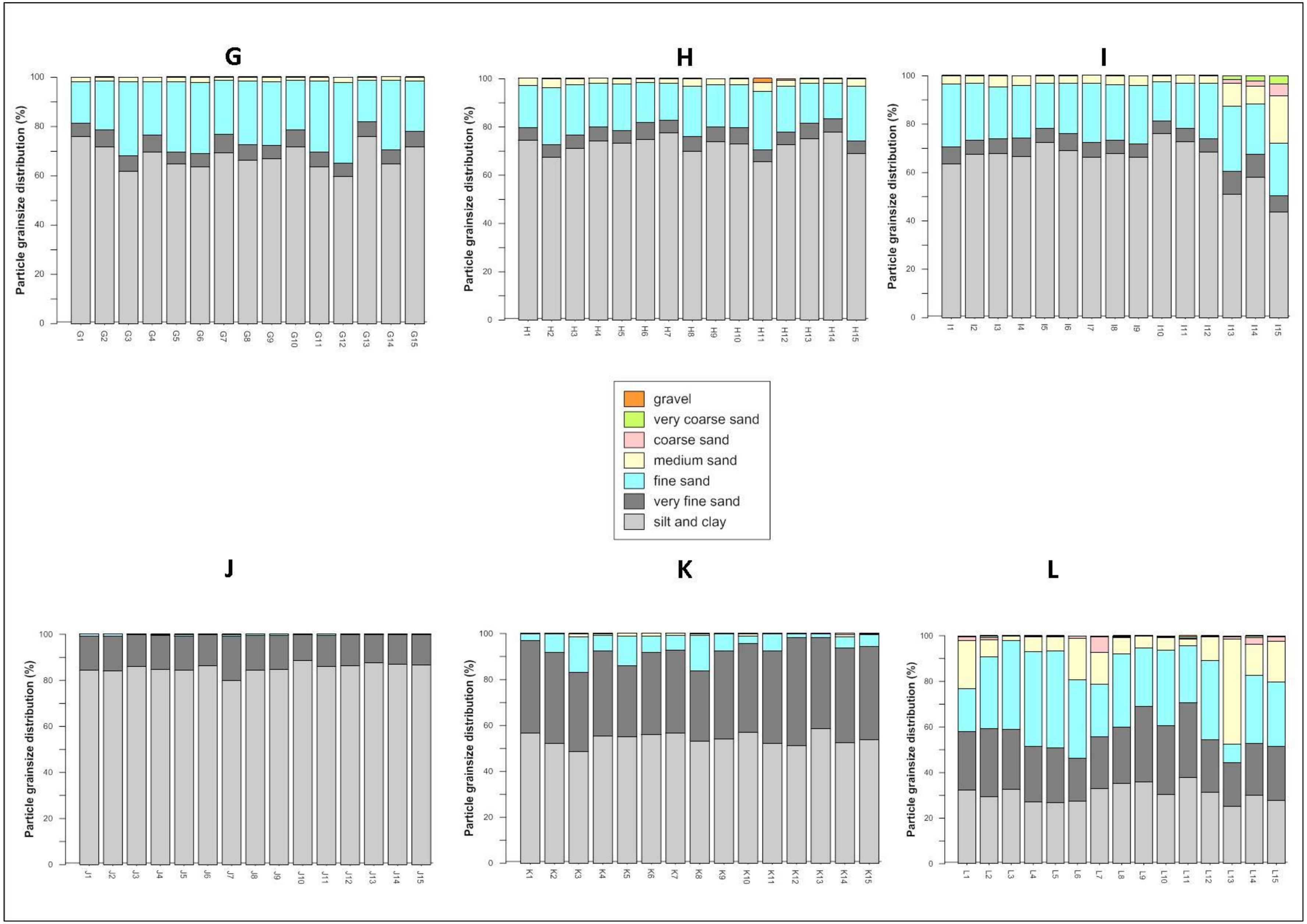
CG9.JPG

APPENDIX C

Total Organic Carbon Content and Particle Grain Size Distribution for Well C

Replicate Sample	TOC (%)	Gravel (%)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Silt & Clay (Mud) (%)
Station C1	0.37	1.2	0.7	0.8	4.4	24.7	27.9	40.3
Station C2	0.42	2.5	1.9	3.2	7.5	16.9	21.9	46
Station C3	0.33	1.5	0.6	0.7	3.1	20.7	34.1	39.2
Station C4	0.37	1.1	0.3	0.3	3.3	26.1	26.1	42.9
Station C5	0.28	0.2	0.1	0.2	1.4	24.5	36.3	37.3
Station C6	0.27	1.6	0.2	0.2	1.6	26.3	34.7	35.3
Station C7	0.32	0.9	0.1	0.2	1.4	23.4	39.2	34.8
Station C8	0.51	2.4	0.6	0.9	3.5	18.7	29	44.9
Station C9	0.36	2.8	0.6	0.8	3.2	18.7	31.7	42.2
Station C10	0.24	0.3	0.3	0.4	2	27.8	32.3	36.8
Station C11	0.37	0.4	0.2	0.3	2.3	29.8	26.8	40.3
Station C12	0.43	1.3	0.8	1.4	5.7	14.4	28.1	48.3
Station C13	0.37	1.9	0.8	1.8	6	18.7	25.7	45
Station C14	0.3	1.3	0.5	0.4	2.2	24	30.7	40.9
Station C15	0.29	0.7	0.3	0.4	2.4	21	32.8	42.5


A
B
C
D
E
F
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay


G
H
I
J
K
L
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay

APPENDIX D

Raw Counts of Macroinvertebrate (Infauna and Epifauna) Abundance at Well C

Taxa	Class/Order	Phylum	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
Acanthephyra quadrispinosa	Decapoda	Crustacea													1		
Aglaophamus sp.	Polychaeta		4	6	12	10	23	15	11	8	23	13	14	11	16	13	7
Ampelisca sp.	Amphipoda	Crustacea			1												
Ampharetidae	Polychaeta		2	5	5	4	3	6	7	3	4	1	6	3	3	2	4
Amphipoda	Amphipoda	Crustacea	5	3	3	3	5	2	1	7	7	4		2	3	3	
Anisodonta alata alata	Bivalvia	Mollusca			1												
Antalis nana	Scaphopoda	Mollusca	1	1		1	3		1	1	1	1					
Antalis suteri	Scaphopoda	Mollusca									1						
Anthuridae	Isopoda	Crustacea															1
Aphroditidae	Polychaeta										1						
Aplacophora	Aplacophora	Mollusca					1		1	1		1					1
Aricidea sp.	Polychaeta		3	1	2	3			2	2	2	3	2	2	5	2	
Armandia maculata	Polychaeta			1			1				2				1		
Armandia maculata (juvenile)	Polychaeta			1			1	2	2	1		1		1			1
Asellota	Isopoda	Crustacea	2	1		1	2		1		7	2	1	2	3	2	1
Astromitra sp.	Gastropoda	Mollusca								2		2	1				
Austrofusus glans (juvenile)	Gastropoda	Mollusca						1									
Axiopsis sp.	Decapoda	Crustacea			1	2	1	1			1	3		1			
Bivalvia (juvenile)	Bivalvia	Mollusca								1							
Bradleya opima	Ostracoda	Crustacea	7							1					3	1	1
Bathyarca cybaea	Bivalvia	Mollusca										1					
Cadulus teliger	Scaphopoda	Mollusca			1	2					1	1		1		2	
Capitellethus zeylanicus	Polychaeta		3	4	6	3	1	1	2	1	2		1	3	2	4	1
Chaetognatha	Chaetognatha										1	1					
Chlorotocus novaezealandiae	Decapoda	Crustacea								1							
Cirratulidae	Polychaeta		4	13	16	12	6	27	10	13	19	8	3	7	8	13	7

Taxa	Class/Order	Phylum	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
Clavelina claviformis	Ascidiacea	Tunicata	1							5					3	1	
Copepoda	Copepoda	Crustacea	2	5	2	1				3	2	2	2	1	2	2	
Copytus novaezealandie	Ostracoda	Crustacea								1							
Cumacea	Cumacea	Crustacea		3	4	1			3	3	3	2	1	1	2		1
Cuspidaria trialli	Bivalvia	Mollusca							1		1						
Cymbiocopia hispida	Ostracoda	Crustacea								1					1		
Cypridinodes sp.	Ostracoda	Crustacea	1													1	
Cytherella sp.	Ostracoda	Crustacea		3	2				1	2					1		
Dorvilleidae	Polychaeta		2								1						
Ebalia laevis	Decapoda	Crustacea	2		1				6						2		
Ebalia laevis (juvenile)	Decapoda	Crustacea		2			1		2								
Echirua sp.					1												
Edwardsia sp.	Actiniaria		2		2		1		1		1		1		1		
Ennucula strangei	Bivalvia	Mollusca	3	2	3	3	6	6	5	7	4		3	1	1	2	2
Euchone pallida	Polychaeta		6	4	6	3	6	5	4	2	7	5	2	2	2	4	1
Euphilomedes agilis	Ostracoda	Crustacea			3	1	3	3	3		5	5	2	3			
Fauveliopsidae	Polychaeta			1													
Flabelligeridae	Polychaeta		1	3	1	2	2	1	1		4	2	1	3		3	
Glyceridae	Polychaeta												1				
Gnathiidae	Isopoda	Crustacea		2	3					1							
Goniadidae	Polychaeta							1	1			1	1	1			1
Haminoea zelandiae	Gastropoda	Mollusca											1				
Haustoriidae	Amphipoda	Crustacea			11	4	9	2	6	6	6	4	7	5	4	12	3
Hemichordata	Hemichordata							1									
Hesionidae	Polychaeta		1					2			1						1
Heteromalpadia marenzelli	Holothuroidea														1		

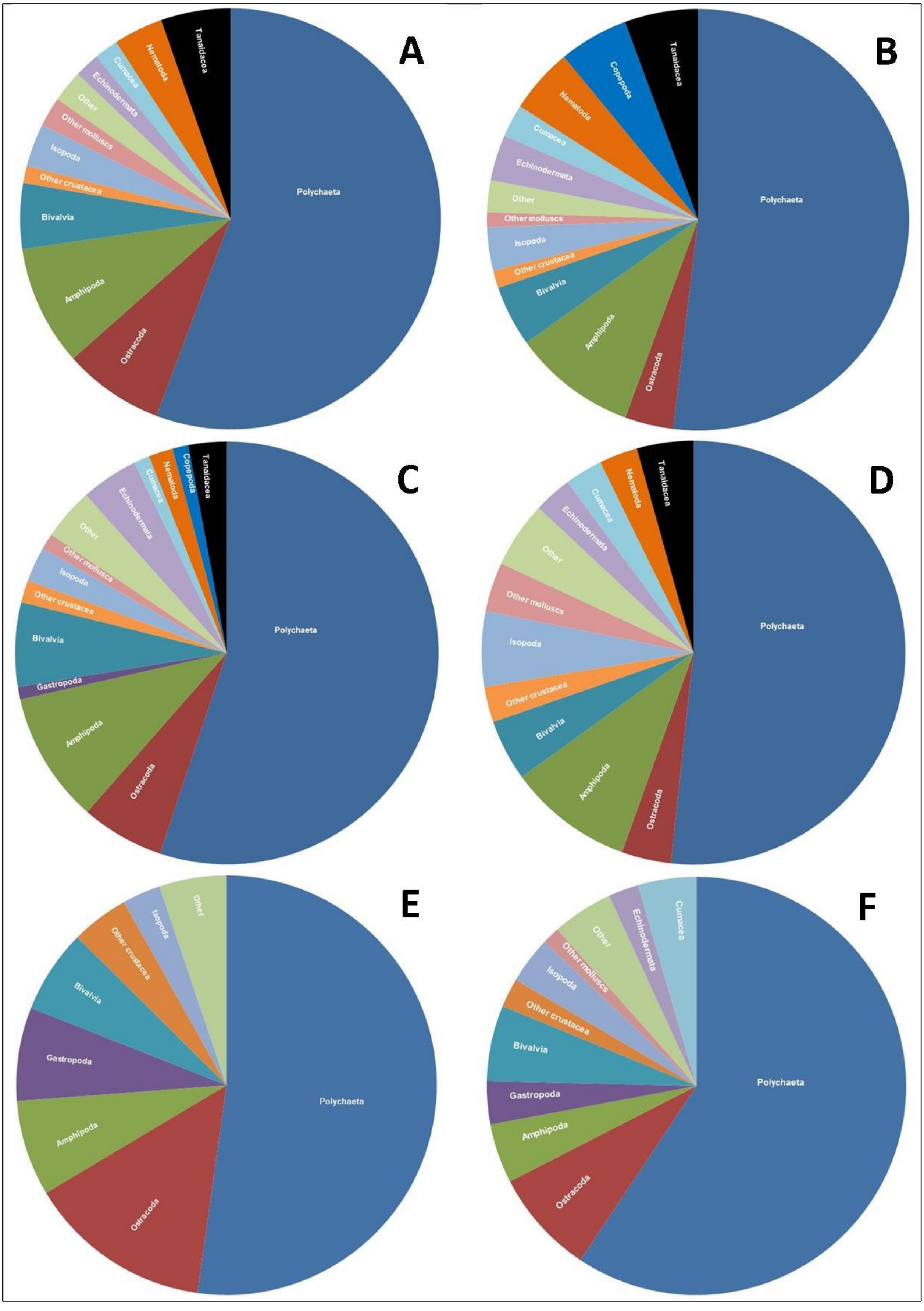
Taxa	Class/Order	Phylum	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
Hyalinoecia sp.	Polychaeta			7													
Hyperia sp.	Amphipoda	Crustacea											1				
Ischyroceridae	Isopoda	Crustacea		2			1										
Leitoscoloplos kerguelenis	Polychaeta		1			2	1	2	4	1	3	2		2	1		
Limatula maoria	Bivalvia	Mollusca					1										
Lumbrineridae	Polychaeta		1	2	2		2	1	1	2					1	3	1
Lysianassidae	Amphipoda	Crustacea		2			1			4			1		1		
Magelona dakini	Polychaeta				1	1										1	
Maldanidae	Polychaeta		1	2	5	2	8	6	3	2	8	5	6	4	4	3	2
Marphysa disjuncta	Polychaeta		1	4	1	1	1	3	1	1		1	3	2	2	1	
Mogula mortenseni	Tunicata								1								
Mogula sp.	Tunicata		1														
Myriowenia sp.	Polychaeta				1			1									
Natatolana pellucida	Isopoda	Crustacea			1			1	1			1	1	2	1		
Naticidae	Gastropoda	Mollusca								1							
Nematoda	Nematoda		1	2	3	1		2	7	1	2	1		6	5	3	3
Nemertea	Nermetea		1	2	3			3	2	1	1				1	1	1
Neonesidea sp.	Ostracoda	Crustacea	14	4	2		1			4		2	1	2	9	1	4
Notocallista multistriata	Bivalvia	Mollusca							2		1		1				
Notostracia	Decapoda	Crustacea								1					5		
Nucinella maoriana	Bivalvia	Mollusca	3	1	1	5	1	4	2		6	3	4	6	3	2	5
Oligochaeta	Oligochaeta										1						
Onuphis aucklandensis	Polychaeta		3	6	4	2	1	1		3			2		1		
Ophiuroidea	Ophiuroidea	Echinodermata	1	2	5	6	4	10	9	10	5	7	5	5	2	6	6
Orbiniidae 6 (unknown)	Polychaeta					1			1			2					
Ostracoda	Ostracoda	Crustacea									1		1				

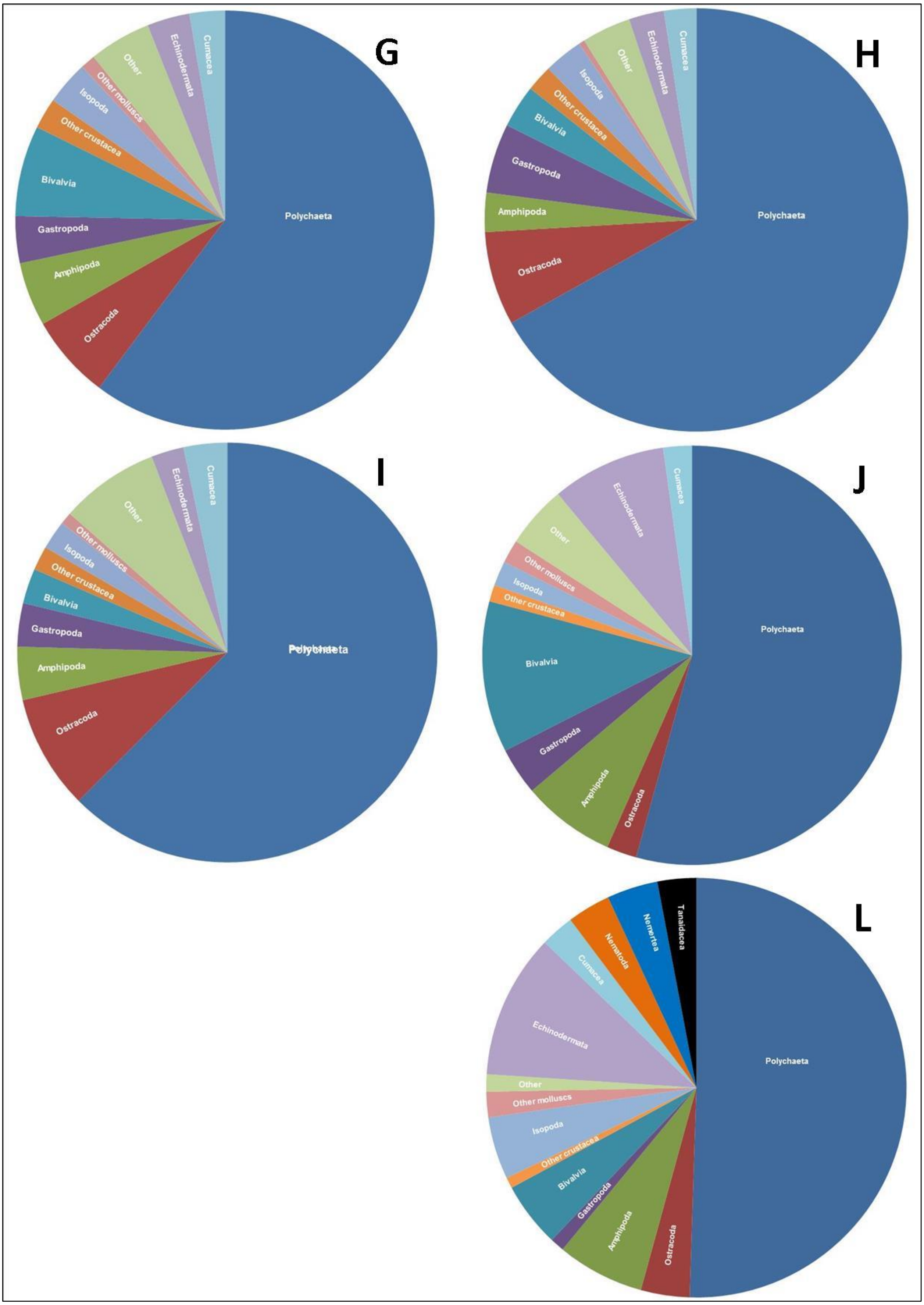
Taxa	Class/Order	Phylum	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
Owenia petersenae	Polychaeta											1					
Paracaudina chilensis	Holothuroidea	Echinodermata										1					
Paramunna serrata	Isopoda	Crustacea					3			1	2	1			1	1	
Paraprionospio pinnata	Polychaeta				1												
Paraonidae	Polychaeta		1	2	13	10	7	13	10	7	12	5	7	10	3	4	2
Parasterope quadrata	Ostracoda	Crustacea	1			1		1		2					2	7	3
Philine powelli	Gastropoda	Mollusca		1	1		1					1		1			1
Phyllochaetopterus socialis	Polychaeta					1					1						
Phoxocephalidae	Amphipoda	Crustacea	1	1	4	4	1	6	6	11	10	1	3	4	2	4	
Phyllodocidae	Polychaeta				1		1				1			1	1		
Pilargidae	Polychaeta			1							1			1	1		2
Pleuromens zelandica	Bivalvia	Mollusca						1									
Poirieria sp.	Gastropoda	Mollusca			1												
Poirieria zelandica	Gastropoda	Mollusca								1							
Polychaeta A	Polychaeta										1						
Polynoidae	Polychaeta				1								1	1			1
Pratulum pulchellum	Bivalvia	Mollusca		1	2	2					2	1		1	2	2	
Prionospio multicristrata	Polychaeta		1	1				1	3			1			3	3	1
Prionospio sp.	Polychaeta			6	2	9	11	5	6		13	3		3	4	9	1
Propontocypris sp.	Ostracoda	Crustacea					1										
Pyura sp.	Tunicata			4	4	1	3	2	1		4	5	2	1			
Rhamphobrachium sp.	Polychaeta			4	1	1		4	2	1	2	1	7	2	2		
Rissoidae	Gastropoda	Mollusca												1			
Rynkatorpa uncinata	Holothuroidea	Echinodermata		3													
Sabellidae	Polychaete			1	1	2		2	1		2	1			2	1	
Scalibregma inflatum	Polychaeta					1											

Taxa	Class/Order	Phylum	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
Scoloplos sp.	Polychaeta		1	1	1		3	4	1		1						
Sigalionidae	Polychaeta		1	2			2				1	1		1			1
Sigapatella spadicea	Gastropoda	Mollusca									1						
Soletellina sp.	Bivalvia	Mollusca															1
Sphaerosyllis sp.	Polychaeta		2							2				2	1		
Sphaeromatidae	Isopoda	Crustacea								1							
Spio sp.	Polychaeta							1						1			
Spiophanes modestus	Polychaeta		1								2				1	2	
Spiophanes kryoeri	Polychaeta				1			2									
Spiophanes sp.	Polychaeta			1			2		4		1	1		1			
Spiophanes wriglyi	Polychaeta			2		2					1				3		
Stegocephalidae	Amphipoda	Crustacea													3		
Sternaspis scutata	Polychaeta												1				
Syllidae	Polychaeta		1	1	1	3		2			2	2		3		3	1
Tanaidacea	Tanaidacea	Crustacea	3	2	11	3	4	4	5		4	6	2	2	4	5	3
Terebellidae	Polychaeta					2		3	3	1							
Terebellides stroemii	Polychaeta					3		1	1		2	2	1			1	
Themiste sp.	Sipuncula				1					1	1		1	1			1
Thyasira peregrina	Bivalvia	Mollusca							1	1							
Trachyleberis lytteltonensis	Ostracoda	Crustacea		2				1	1	2		1					
Trochodata dendyi			1													1	
Varinucula gallinacea	Bivalvia	Mollusca				1	1				3	1	1				
Virgularia gracillima	Cnidaria														1		
Zeacolpus pagoda	Gastropoda	Mollusca					1										

APPENDIX E

Comparison of Proportion of Individuals belonging to each Taxonomic Group across all Wells


A
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Tanaidacea
B
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Copepoda
Tanaidacea
C
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other mollusca
Other
Echinodermata
Cumacea
Nematoda
Copepoda
Tanaidacea
D
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Tanaidacea
E
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other
F
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea



G
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
H
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other
Echinodermata
Cumacea
I
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
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Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
L
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Nemertea
Tanaidacea

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EXPLORATION AND APPRAISAL DRILLING PROGRAMME

Benthic Baseline Report
Well D

Prepared for:

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SLR Ref: 740.10078.00200-R01
Version No: v1.0
July 2018

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BASIS OF REPORT

This report has been prepared by SLR Consulting NZ Limited with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with OMV New Zealand Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.10078.00200-R01-v1.0	31 July 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier
740.10078.00200-R01-v0.1	29 June 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier

EXECUTIVE SUMMARY

OMV New Zealand Limited (**OMV New Zealand**) are applying for a Marine Consent to undertake an Exploration and Appraisal Drilling (**EAD**) Programme in the Taranaki Basin with an anticipated commencement date in 2019. OMV New Zealand may drill up to nine exploration wells and two appraisal wells within their Petroleum Exploration Permits (**PEP**). The intention of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs.

As part of the Marine Consent application, three Areas of Interest (**AOI**) have been identified that encapsulate the proposed well locations and are used as part of the Impact Assessment process. OMV New Zealand undertook a baseline environmental monitoring survey at each well location in March-April 2018 to gain an understanding of the benthic habitat and associated communities with each AOI.

Grab sampling and video sled methodologies were used to gain quantitative and qualitative information on the marine environments surrounding each well location. The data gathered from each baseline survey will be incorporated into the Marine Consent application and assist in the risk assessment process.

Water currents and deposition modelling were utilised to define the placement of sample station. Sample transects were aligned along the dominant deposition pathway of the predicted drill cutting dispersion should that particular well be drilled. A total of 15 monitoring stations were allocated at each well and one benthic grab sample was collected at each monitoring station. Ten video sleds were also undertaken at a selection of pre-determined sites around each well.

Within this Benthic Baseline report the analysis of results incorporates sediment physical and chemical properties, benthic macrofauna, epifauna and visual observations around Proposed Well D. A total of 4,986 individuals representing 142 taxa were identified from the 15 macrofauna samples collected around Well D. Infauna communities were dominated by small polychaete worms (52%), crustaceans (29%), molluscs (8%) and nematodes (3%).

The baseline survey at Well D found no distinct spatial patterns in grain size and Total Organic Carbon across the 15 sample stations. Grain size analysis indicated that the sediments at Well D and in the wider Northern AOI was much coarser than sediments in the Central and Southern AOI, which are dominated by mud (largely comprised of silt and clay sized fractions).

The baseline survey at Well D indicated the presence of two isolated Chaetopteridae worms (*Phyllochaetopterus socialis*) within the macrofauna grab samples, and sea pens within the video imagery; species defined in the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activities Regulations**) as being a '*characteristic species of sensitive environments*'. Chaetopteridae worms are known to form worm-fields or low-relief worm meadows. Although two of the 15 grab samples had Chaetopteridae worms present, the video imagery taken across the sample stations did not observe any distinct worm-fields or low-relief worm meadows. Sea pens were also commonly observed in the video imagery collected at Well D. The occurrence and estimated densities of these taxa at Well D did not reach the trigger levels defined by the Permitted Activities Regulations (MacDiarmid *et al.*, 2013) and no distinct worm or sea pen 'fields' were encountered. Thus although present at the well in low densities the area would not be classified as a 'sensitive environment'.

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1 Introduction

OMV New Zealand Limited (**OMV New Zealand**) is applying for a Marine Consent under Section 38 of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (**EEZ Act**) to permit activities associated with an Exploration and Appraisal Drilling (**EAD**) Programme proposed to be undertaken starting in 2019.

The EAD Programme includes the drilling of up to nine exploration wells and two appraisal wells within OMV New Zealand's permit areas (**Figure 1**). The purpose of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs which OMV New Zealand operate (**Figure 1**).

Three Areas of Interest (**AOI**) (summarised below) have been identified which encapsulate the well locations (**Figure 1**). This monitoring report relates to the Benthic Baseline survey conducted at Well D in the Northern AOI. Location details and water depth of Well D are provided in **Table 1**.

The Northern AOI encompasses PEP 60092 (Ridgeline), PEP 57075 (Cloudy Bay) and PEP 60093 (Toutouwai) and includes the following wells:

- Well A;
- Well B;
- Well C; and
- Well D.

The Central AOI encompasses PEP 60093 (Toutouwai) and includes the following wells:

- Well E (Appraisal);
- Well F;
- Well G (Appraisal);
- Well H; and
- Well I.

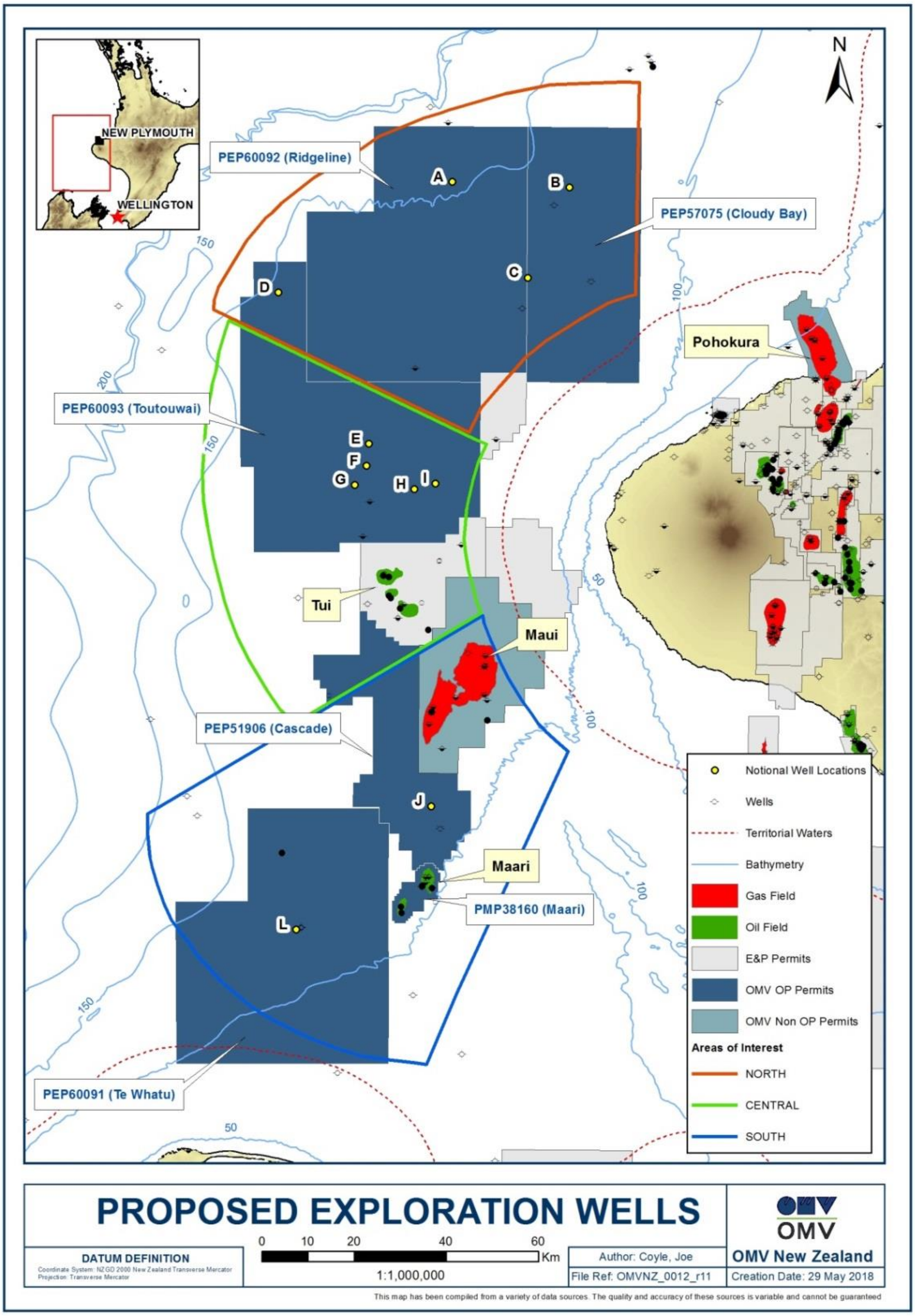
The Southern AOI encompasses PEP 51906 (Cascade), and PEP 60091 (Te Whatu) and includes the following wells:

- Well J; and
- Well L.

Table 1 Water Depth and Coordinates of Well D in the Northern AOI

Well Name	Water Depth (m)	Easting (NZTM)	Northing (NZTM)
D	142.2	1593893	5702617

Figure 1 OMV New Zealand's EAD Well Locations and three AOIs in the Taranaki Basin



In February 2018 SLR Consulting NZ Limited (**SLR**) was engaged by OMV New Zealand to undertake a baseline assessment of the benthic ecology in the vicinity of 11 well sites (**Figure 1**). The aim of the field surveys, which were undertaken from March 24 – April 8 2018, was to collect relevant data using grab sampling and video sled methodologies to provide quantitative and qualitative information on these marine environments. This qualitative and quantitative data will be used within the Marine Consent application to define the benthic habitats and communities present at each well location and assist in the risk assessment process.

This report summarises the results of the benthic baseline survey undertaken at Well D.

1.1 Project Location

Well D is located approximately 102 km west-north-west of New Plymouth in New Zealand's Exclusive Economic Zone (**EEZ**). Water depth and GPS coordinates are provided in **Table 1** and displayed in **Figure 1**. The monitoring programme sample design resulted in sample stations extending out to 6 km from the well location (**Section 2.1**).

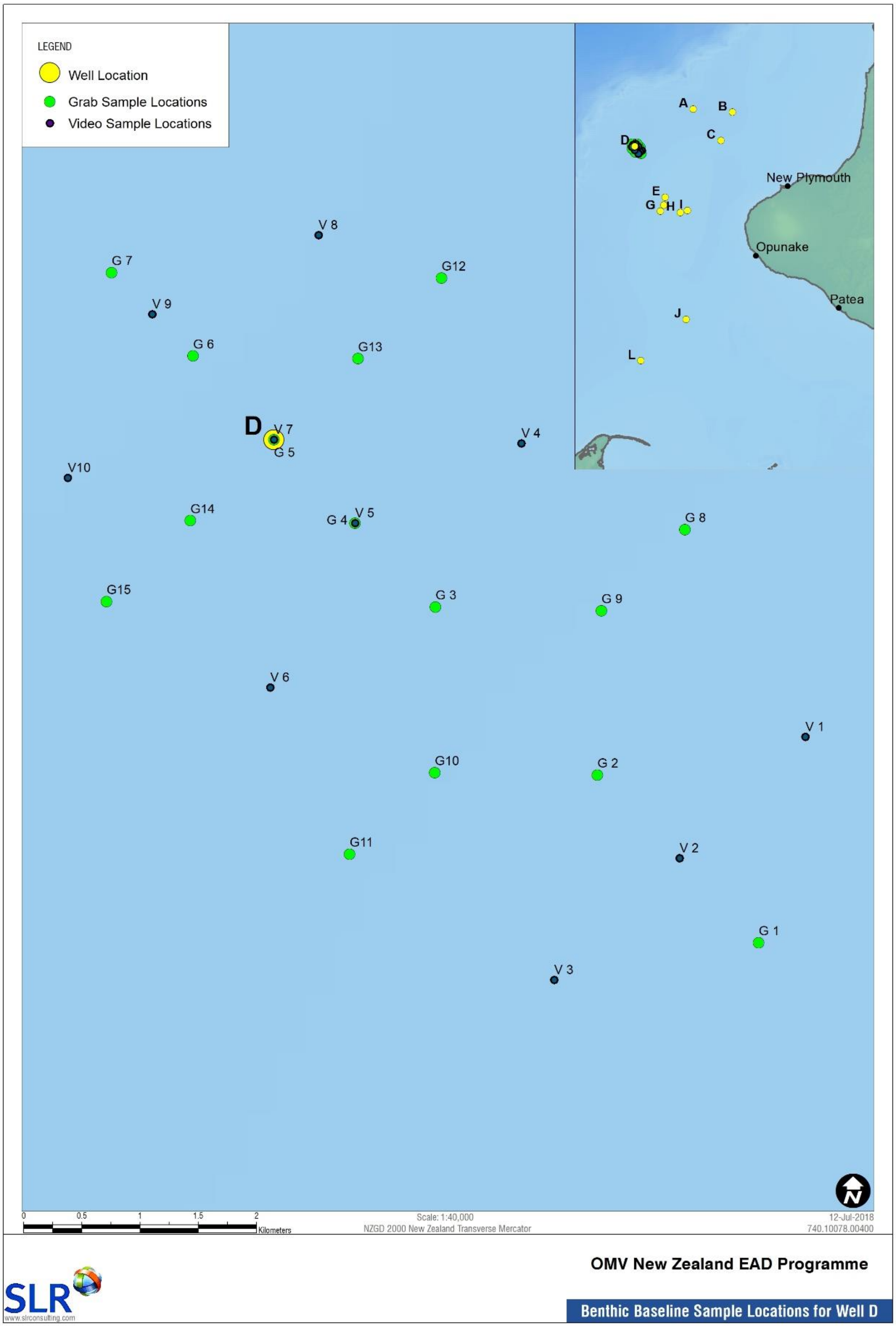
2 Methodology

The Benthic Baseline surveys adopted similar methodologies to what has been previously used for offshore Taranaki benthic monitoring programmes undertaken in accordance with the principles defined in the Offshore Taranaki Environmental Monitoring Protocol (**OTEMP**) (Johnston *et al.*, 2014). This consistent approach enables monitoring results to be compared with previous monitoring programmes undertaken in the offshore Taranaki environment (i.e. pre- and post-drill monitoring and production monitoring).

2.1 Sample Locations

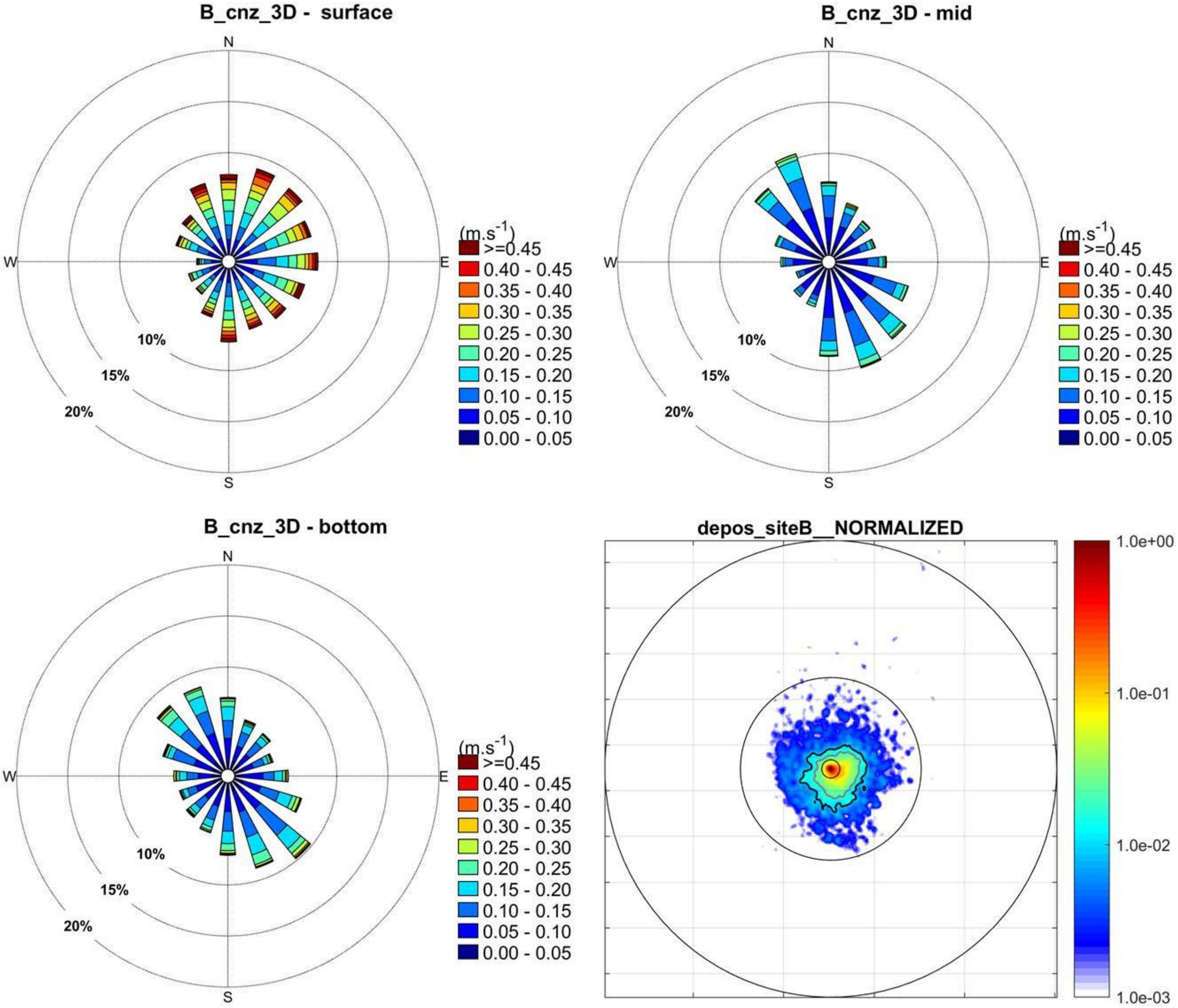
The sample stations (**Figure 2**) were defined by the dominant direction of current flow and preliminary drill cutting deposition modelling results (**Figure 3**). Sample transects were aligned along the dominant deposition pathway (i.e. southeast/northwest) (**Figure 2**) as this is the area determined to be most likely to be impacted from the deposition of drill cuttings should the well be drilled. However, sample stations were also located along the minor flow axis (northeast/southwest) to enable comparisons and validation of spatial differences based on the dispersal patterns predicted by MetOcean Solutions Limited.

Figure 2 Well D Sampling Locations



Note: At each video transect location approximately 250 m of video footage was captured along the seabed

Figure 3 Surface, Mid-water and Bottom Water Column Current Roses and Dispersal Modelling Plot created by Metocean Solutions Ltd for nearby Well B



2.2 Field and Sampling Procedures

Field sampling was undertaken from the MV *Seaworker* between March 24 and April 8, 2018, following the procedures detailed below. Sampling at Well D took place on March 29h.

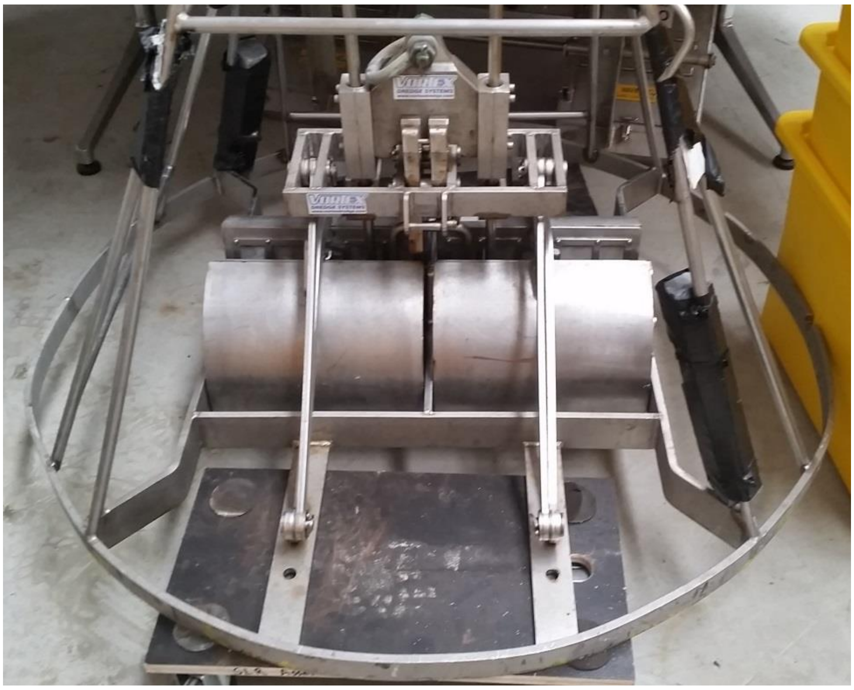
2.2.1 Benthic Grab Samples

A double Van Veen double grab sampler (**Figure 4**) was used to collect a single sediment grab sample at each of the 15 benthic monitoring stations surrounding Well D (**Figure 2**). The grab sampler is constructed of stainless steel and features two independent 'buckets' which penetrate the surficial sediments to a depth of 0.16 m. Each successful grab sample returns approximately 0.01 m^3 of seabed sediment back to the surface.

Upon arrival on the vessel deck, each grab sample is checked for completeness, which must meet the following criteria:

- The surface of the sediment is largely undisturbed upon inspection aboard the vessel;
- Sufficient sediment (≥75% of the grab capacity) is collected to enable the full suite of sediment analyses required;
- The infauna sample bucket is filled to the same volume (approximately 10 l) for all infauna replicates throughout the survey; and
- The grab has not been over-filled with sediments pushing out of the doors or drains, indicating that it may have over-penetrated the sediment.

Figure 4 The Double Van Veen Grab Sampler used for the 2018 Benthic Baseline Sampling



Each independent bucket from a grab sample is used separately for infauna and sediment physical and chemical analyses, as follows:

- Bucket one: infauna/macrofauna community analysis. The entire sample is sieved through 0.5 mm mesh until approximately 300-500 ml of residual sediment and organisms remains. This remaining material is transferred to a plastic container and preserved with a fixative (AncholTM), ready for analysis by SLR taxonomists.
- Bucket two: sediment physical nature and chemical analyses. Three 64 mm (internal diameter) clear Perspex sub-sampling cores are pushed into the sediments from the second bucket, to a depth of approximately 150 mm. Cores are photographed and the upper 50 mm from each core is extruded into a polyethylene bag for particle grain size distribution and organic content (Total Organic Carbon (**TOC**)) analyses by Hill laboratories.

2.2.2 Seafloor Video Imagery

Video imagery of the seafloor was obtained using a customised tow-sled fitted with high-intensity LED lighting and a high-definition video camera (**Figure 5**). The system was connected to the vessel via a 10 mm dyneema tow-line and a 300 m umbilical cable supplying real-time video images to the camera operator on the research vessel. A pair of parallel lasers on the video sled provided an indication of scale allowing features of interest in the video recordings to be approximately sized. Ten video sled tows were conducted around Well D (**Figure 2**).

The video-sled was launched from the vessel up-current of each pre-determined location and lowered to the seabed, where it auto-located via a series of floats and weights set at specific points on the sled frame, to land upright on its lower skids. At the point where the sled contacted the seabed, a GPS log was started, and this log continued throughout the duration of the tow. Video footage was continuously recorded for approximately 200 m as the sled drifted behind the vessel; this ensured that footage was collected while the sled was passing as close as possible to the required sample location.

Figure 5 The Video Sled used for Collecting Video Footage of the Seabed Environment

2.3 Laboratory Analyses

2.3.1 Sediment Physicochemical Analyses

Benthic sediments collected by the grab were analysed by Hill Laboratories (an NZS/ISO/IEC 17025:2005 accredited laboratory), for both physical and chemical parameters. The aims of these analyses along with further details of the analytical method/descriptions are summarised in **Table 2**.

Table 2 Summary of Analytical Methods used for Testing Sediment Physico-chemical Characteristics

Analyte	Aim	Method Number	Description
Particle Grain Size Distribution	• Determine physical parameters of the sediment particles present at the site • Correlate with infauna community characteristics	Hill Laboratories KB32136	• Sediment was wet-sieved through the following screen sizes, as per the Udden-Wentworth scale (Wentworth, 1922): • >2 mm (gravel) • >1 mm (very coarse sand) • >500 µm (coarse sand) • >250 µm (medium sand) • >125 µm (fine sand) • >63 µm (very fine sand) • <63 µm (silt and clay)
Total Organic Carbon	• Determine current level of organic carbon in sediment • Correlate with infauna community characteristics	No specific method number	Acid pre-treatment to remove carbonates present, followed by catalytic combustion (900° C, O_2), separation, Thermal Conductivity Detector. Elemental Analyser.

2.3.2 Macrofauna Analyses

Macrofaunal analyses focused on the infauna, or animals larger than 0.5 mm living within the sediment matrix. Epifaunal animals (those living on top of the sediment), were also included in the analyses to provide representation of the different functional groups present at each sample station.

Benthic macrofaunal samples collected from the sediment grab were sorted and, with the aid of a binocular microscope, identified to the lowest practicable taxonomic level or most recognisable taxa (morphologically similar group). Counts were made to assess the relative abundance of each taxa.

2.3.3 Seafloor Video Analyses

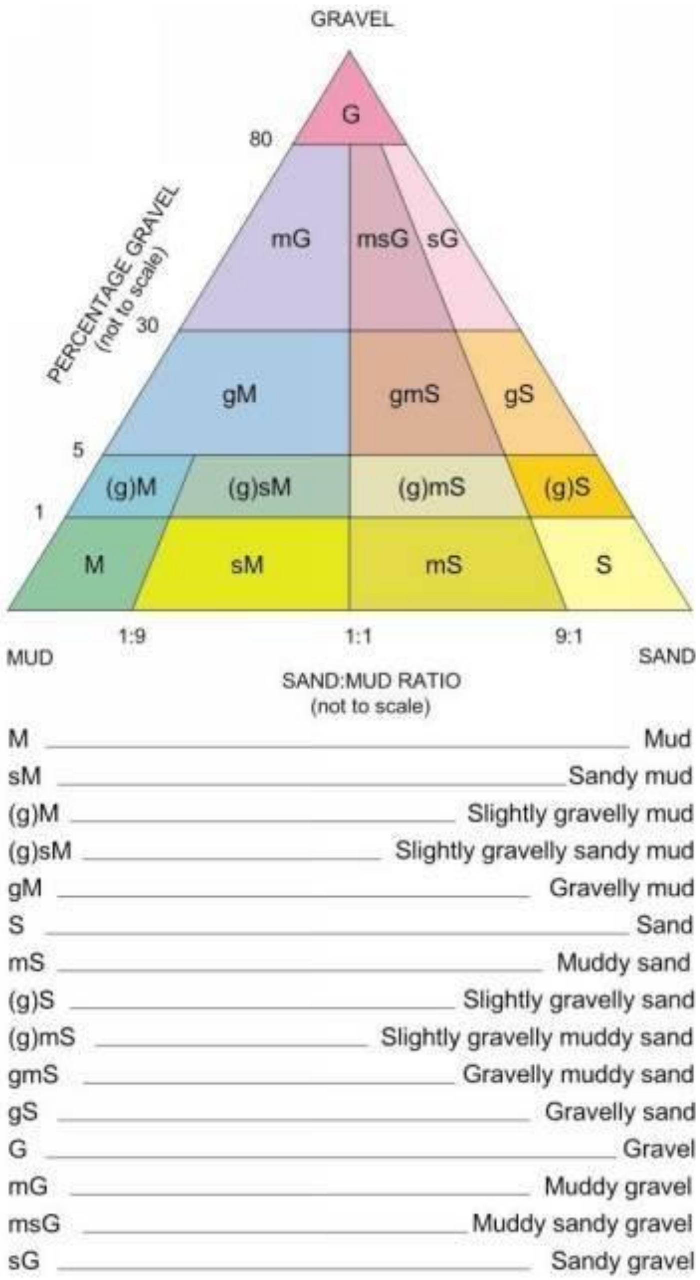
A live feed from the video-sled was captured and recorded on-board the survey vessel and viewed by SLR staff with experience in undertaking assessments of the benthic environment in the offshore Taranaki region. Brief field notes were made in real-time about obvious structures and organisms observed while watching the live footage. Back onshore the recorded seabed video footage was assessed on a large, high definition screen, by a suitably trained and experienced benthic scientist, who identified all obvious epifauna to the lowest practicable taxonomic level. Biogenic and/or anthropogenic seabed structures such as burrows, mounds, tracks and gouges/trenches were also recorded. Relative abundance estimates of epifauna or biogenic structures were made where appropriate.

2.4 Data Analyses

2.4.1 Sediment classifications

While there are many sediment classification schemes in use worldwide, a common one is a modified version of that proposed by Folk (1954). This scheme groups grains within a sample into mud, sand and gravel sized particles based on the particles diameter (mud <63 µm, sand 64-2000 µm, gravel > 2mm), and then describes the sediment type based on the relative proportions of the particles (see **Figure 6**).

Figure 6 Folk (1954) Sediment Type Classification Triangle



2.4.2 Community Characteristic Descriptors

All macrofauna (both epifauna and infauna) taxa were included in the analyses of abundance data. Species identified in the samples as not being exclusively benthic were excluded from further analyses. Data were analysed as per the statistical methods outlined below to identify current distributions and abundance of macrofauna.

2.4.2.1 Univariate Diversity Indices

Diversity indices (number of taxa S, total abundance N, Shannon-Wiener diversity H', and Pielou evenness J' (**Table 3**) were calculated from the macrofauna abundance data using the PRIMER software package (PRIMER v6.1.16; Clarke, 1993; Clarke & Warwick, 1994; Clarke & Gorley, 2006).

Table 3 Description of Macrofauna Community Characteristic Indices

Index	Formula (where applicable)	Description
Number of Taxa (S)	Count of total number of different taxa identified within the *x* sample	Total number of taxa identified within a sample
Total Abundance (N)	Sum of all individual taxa abundances within the *x* sample	Total number/count of all organisms within a sample
Shannon Diversity (H')	$H' = -SUM [(p_i) \times \log_e (p_i)]$ $p_i =$ Number of individuals of taxa i /total number of samples	A single value (log scale) that is used to describe the different types and numbers of organisms present within an assemblage. The index value increases as assemblages have greater numbers of taxa and when the numbers of individual organisms are more evenly distributed across the different taxa. Samples dominated by single taxa will have lower values towards zero.
Pielou Evenness (J')	$J = H' / \log_e (S)$	A value theoretically between zero and one which indicates how evenly the number of individual organisms are distributed through the different taxa in an assemblage. High values (closer to 1) indicate an even spread amongst the taxa present, whereas a low value indicate an uneven spread or an assemblage highly dominated by only a few, or even a single taxon.

3 Results and Discussion

3.1 Sediment Physical and Chemical Properties

3.1.1 Visual Description of Sediment Cores

Sediment collected from around Well D was predominantly hard/very hard fine packed fine sand, grey or dark grey in colour, with some lighter brown mud on top (**Figure 7**). No very dark-grey or black sediment layers (apparent Redox Potential Discontinuity), or darker patches within cores were noted and no detectable hydrogen sulphide odours were present, indicating sediments are well oxygenated throughout the depths sampled. Field observations on sediment texture, colour and any notable features of the sediment samples were recorded during the processing of the sediment cores and infauna samples, and these are included in **Appendix A**. A full set of sediment core photographs are contained in **Appendix B**.

Figure 7 Representative Images of Sediment Core Profiles from Well D

Station D2

Station D4

Station D11

Station D15

3.1.2 Incidental Observations

During laboratory processing of the infauna samples observations were made of any debris present, including those from anthropogenic sources. Within the 15 samples collected around Well D there were three types of debris observed (**Table 4**), two of which were likely to be anthropogenic in source, including blue paint and silver paint. However all debris encountered in the samples were at 'low' abundances.

Table 4 Incidental Observations

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
Graphite				L											
Blue paint			L	L	L							L			L
Silver paint				L											

VA = very abundant (>50), A = abundant (50+), C = common (20–50), O = occasional (10–20), L = low (0–10)

3.1.3 Sediment Particle Grain Size Distribution and Organic Content

The physical characteristics of the sediment can influence the composition of the infauna communities and the levels of contaminants retained and observed during analyses. Particle grain size is widely used to characterise the physical structure of the sediment, while organic content provides an indication of the organic enrichment in the sediment. These combined results provide a general understanding of sediment health and the source of potential stressors at the time of sampling.

Organic matter found in the sediments is most likely derived from natural sources such as infauna/epifauna and detrital matter, rather than from anthropogenic sources. Anoxic sediments (those lacking oxygen), may develop in situations where organic matter levels increase beyond 'normal' levels for that area. Increased organic matter has the potential to disturb the equilibrium of the benthic ecosystem, as increased numbers of oxygen-utilising bacteria are required to decompose the additional organic matter, thereby rapidly reducing oxygen availability in the sediments.

A summary of the particle grain size and organic content analyses are discussed below, with full results provided in **Appendix C**.

3.1.3.1 Particle Grain Size

Particle grain size analyses at the 15 monitoring stations around Well D are shown in **Figure 8**. Sediments are dominated by the very fine sand (37-44%), fine sand (20-36%) and silt/clay (25-35%) sized fractions, with very small proportions of larger sand particles comprised of broken shell material. These sediments are classified as 'muddy sands' (Folk, 1954), which have historically not been encountered very often in offshore Taranaki areas where exploration/production monitoring has taken place. The samples with the greatest proportion of silt and clay (mud) were found at monitoring stations D14 and D8, and the smallest was at monitoring station D1 (the southeast extreme). There were no spatial trends in grain size across Well D.

The muddy sands encountered around Well D were similar to those found at the other wells in the Northern AOI, as well as Well L, which all had notably coarser grain size relative to the silt and clay (mud) dominated sediments collected in the Central and Southern AOI sites (**Table 5**). A comparison of particle grain size data for Well D with the other wells is provided in **Appendix C**.

Figure 8 Sediment Particle Grain Size Distribution for Samples Collected at Well D

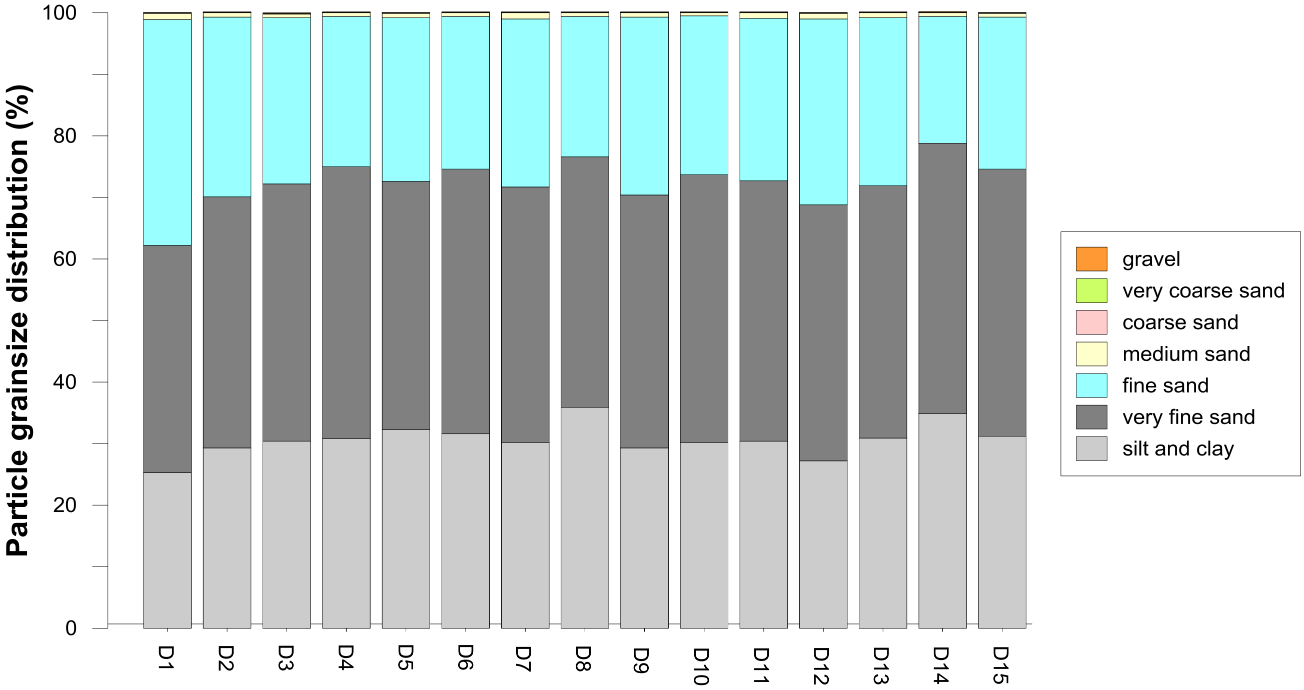


Table 5 Average Grain Size for the Eleven Wells

Grain size class	A	B	C	D	E	F	G	H	I	J	L
Silt & Clay (Mud) (%)	36.2	27.5	41.1	30.7	85.2	83.2	67.8	72.6	65.1	85.4	30.8
Very Fine Sand (%)	45.8	39.3	30.5	41.7	6.5	4.8	6.1	5.8	6.6	14.2	25.4
Fine Sand (%)	17.0	28.6	22.4	26.8	8.0	11.3	24.6	19.0	22.1	0.4	29.8
Medium Sand (%)	1.0	2.4	3.3	0.7	0.4	0.6	1.6	2.5	5.1	0.1	12.3
Coarse Sand (%)	0.1	0.7	0.8	0.0	0.0	0.1	0.1	0.1	0.6	0.0	1.2
Very Coarse Sand (%)	0.0	0.6	0.5	0.0	0.0	0.1	0.1	0.1	0.5	0.0	0.2
Gravel (%)	0.1	1.1	1.3	0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.1
Description	mS	mS	mS	mS	sM	sM	sM	sM	sM	sM	mS

Note: sM = sandy mud, mS = muddy sand

Colour scale based on percentage with median mid-point (median is 2.0):

0%	5	10	20	30	40	50	60	70	80	90	100

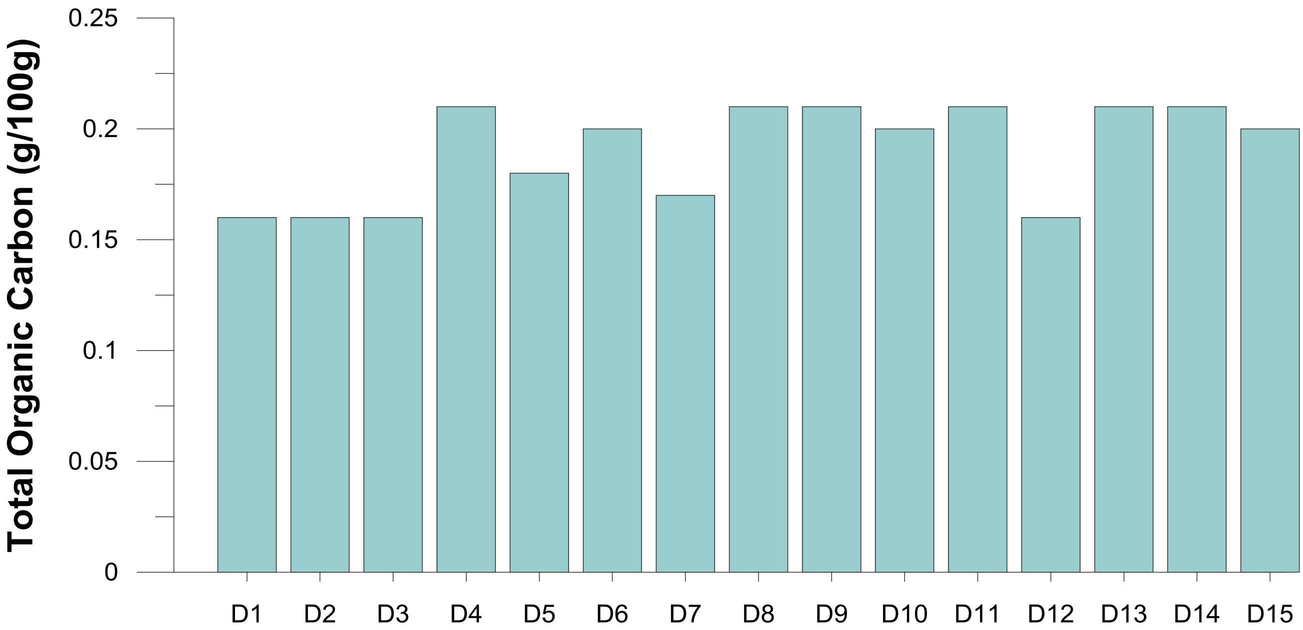
3.1.3.2 Total Organic Carbon

The organic content of sediments was assessed by measuring TOC to assess benthic ecology as this is also consistent with what is now currently undertaken around the offshore Taranaki oil and gas fields.

TOC levels at Well D (**Figure 9**) ranged from 0.16% to 0.21% (mean 0.19%). There was no obvious spatial pattern in the results.

The average organic content around Well D was the lowest of all monitoring sites (mean 0.19% compared to overall mean of 0.45%). The combined mean from all stations at all Northern AOI sites (0.26%) was low relative to the Central and Southern AOIs (0.59% and 0.48%, respectively). As has been previously described in benthic environmental monitoring associated with offshore Taranaki oil and gas activities (SLR, 2016 & SLR, 2017), there is a correlation between sediment particle grain size and sediment organic content. The comparatively greater surface area to volume ratio of silt and clay (mud/fines) sized sediment particles (compared to larger particles like sand) gives a greater area for adsorption of organic matter particles and therefore a higher probability of elevated organic matter compared to coarser/sandier sediments subjected to the same level of enrichment (Hedges *et al*., 1993). This is likely to at least partially explain the lower organic content of sediments at the Northern AOI sites, where sediment grain size is distinctly coarser than at the Central and Southern AOI sites.

Figure 9 TOC Concentrations in Sediment Samples Collected from around Well D



3.2 Video Sled Imagery

Video footage of the seabed allows scientists to visually assess any anthropogenic disturbance to the benthic environment and observe epifauna, sediment-type and structures or relief that exist on the seabed.

Video footage was captured by towing a video sled through ten sites around Well D (**Section 2.2.2**). All video footage is included with the electronic version of this document, with a selection of still images displayed in **Figure 10**. **Appendix A** provides locational information for each video sled tow.

Video footage was assessed to determine any defining features and their semi-quantitative abundance recorded for comparison with other sites. Due to caveats associated with video footage (i.e. variable visibility, differing tow length and durations) the counts are indicative-only and should not be interpreted as a quantitative assessment. **Table 6** presents the results of this semi-quantitative approach, which summaries the counts by comparing the site total to the median across all of the EAD wells in the three AOIs. As a visual aid, counts were categorised in relation to the deviation from the 10th, 25th 50th, 75th and 90th percentiles, so that differences between sites can be more easily viewed.

3.2.1 Physical Observations

The seabed around Well D was observed to be dominated by firm sandy mud sediments. Evidence of bioturbation was observed at all monitoring stations in the form of animal burrows (images C and G, **Figure 10**). Low numbers of burrows were observed in the Well L video tows, which is slightly lower than other wells in the Northern AOI and significantly different to the Central and Southern AOI sites where abundances were moderate to high (**Table 6**).

Mound/hollow features (images A, D, E, F and H, **Figure 10**) were observed in very high numbers (280) at Well D compared to the median (43) for all wells (**Table 6**). Other Northern AOI wells also had a relatively high number of these features (63-111), while Well L (Southern AOI) had by far the highest abundance (532). These seabed features are considered to be formed by feeding activities of sharks or rays, or in some cases tube worms or shrimps mounding up sediment. Mound/hollow features were observed to be more numerous at the Northern AOI sites, moderate to very high at the Southern AOI sites, and low to very low in numbers around the Central AOI sites.

As expected, there was no sign of anthropogenic physical disturbance of the seabed observed during any of the video sled tows around Well D. There were no signs of sediment enrichment such as darker sediment patches, bacterial mats or sediment off-gassing, observed during any of the video sled tows around Well D.

Table 6 Total Number of Features Observed in Video Imagery from the EAD Wells

Well Site	Depth (m)	Mounds/ Hollows	Number of burrows/worm holes	Sea pen	Fish	Substrate	Notes
A	148	111	Low-moderate	54	65	Muddy sand	Ripples; some very large holes and mounds
B	134	63	Low-moderate	35	49	Muddy sand	Some very large holes mounds
C	132	85	Low-moderate	50	44	Muddy sand	Ripples; trenches observed
D	145	280	Low	160	28	Muddy sand	Ripples; 23 very large sea feathers
E	126	29	Moderate	29	16	Sandy mud	
F	128	20	Moderate	19	19	Sandy mud	
G	124	18	Moderate-High	29	26	Sandy mud	
H	124	18	Moderate-High	17	26	Sandy mud	12 elongated shallow trenches
I	122	43	Moderate-High	36	21	Sandy mud	5 elongated shallow trenches (large)
J	108	42	Moderate	14	30	Sandy mud	School of mackerel, tufts/tubes common
L	112	532	Moderate	132	31	Muddy sand	2 schools of mackerel
Median		43		35	28		
Totals are sum of 10 video tows carried out at each site. Totals are semi-quantitative only due to variable visibility and transect length.							

10th percentile band
25th percentile band
Median band
75th percentile band
90th percentile band

3.2.2 Infauna, Epifauna and Other Fauna

In some cases, a definitive positive identification of infauna, epifauna and more mobile taxa was not possible from the video footage alone. Where there was any uncertainty, identifications were based on distinctive features, colours and shapes of organisms and in some cases the confirmed presence of similar looking individuals within the infauna samples.

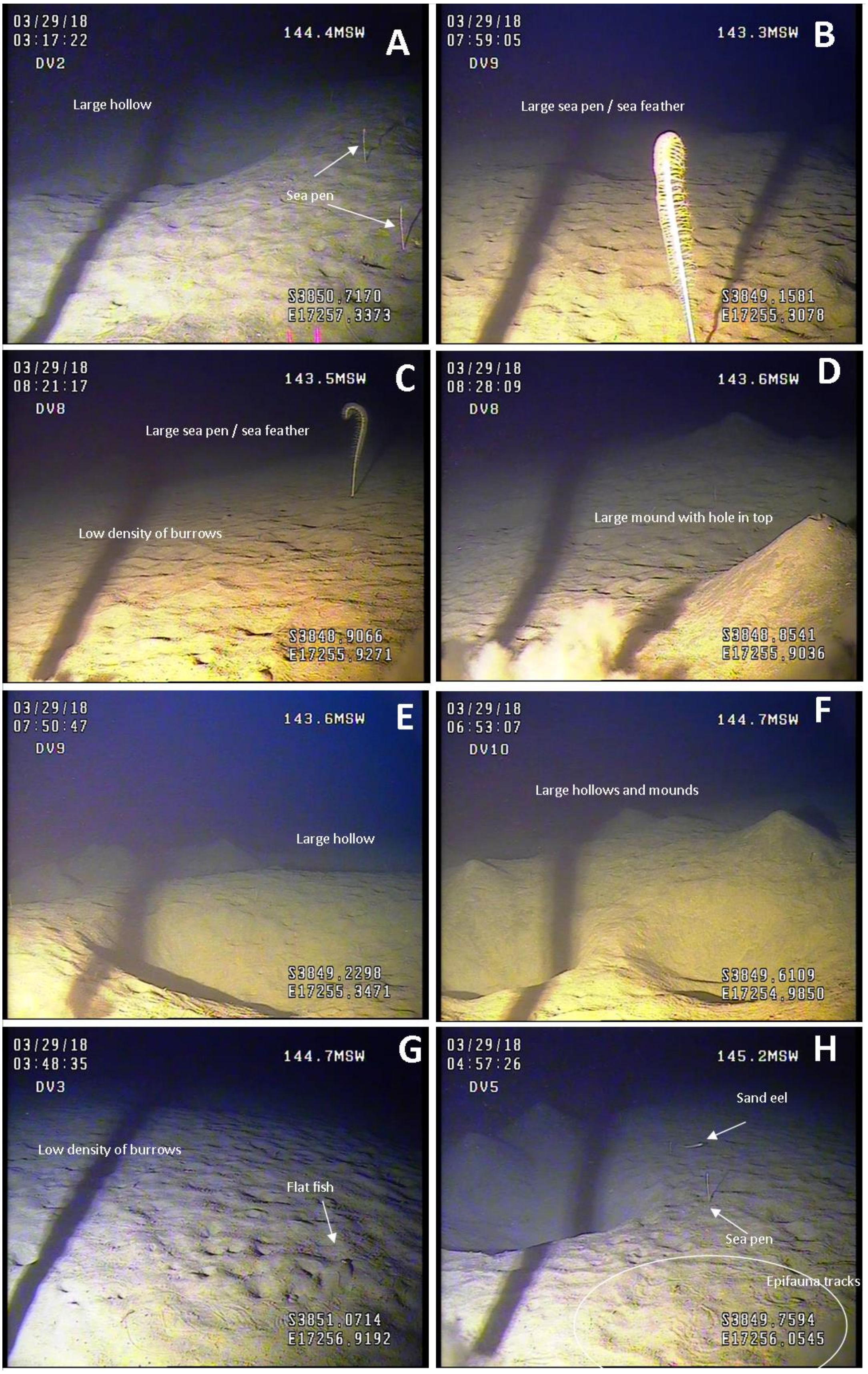
Epifauna taxa observed in video footage collected around Well D included whelks (likely *Austrofusus glans*), hermit crabs (*Pagarus* sp.), tusk shells (likely *Fissidentalium zelandicum*), and various species of sponge. The presence of epifauna tracks in the sediment (image H, **Figure 10**) indicates that mobile fauna such as whelks and hermit crabs move throughout this site.

Sea pens (likely *Virgularia gracillima*.) (image A, **Figure 10**) were observed in very high numbers (160) around Well D compared to the median (35) for all other wells (**Table 6)**. Other Northern AOI wells also had relatively high numbers of sea pens (35-54), while Well L (Southern AOI) had 132. A total of 23 very large, drooping sea pens (likely *Anthoptilum* sp.) were observed in all but three video tows around Well D (image B and C, **Figure 10**). The only other well where these were observed throughout the EAD Benthic Baseline survey was at Well A. Sea pens were observed to be more numerous at the Northern AOI sites, variable at the Southern AOI sites, and lowest in the Central AOI sites.

Mobile fish species were observed in moderate numbers (28) around Well D compared to the median (28) for all other wells (**Table 6**). Species diversity was low, with sand eels[1] (image H, **Figure 10**) and flatfish (likely *Peltorhamphus* sp.) (image G, **Figure 10**) some of the more notable species observed. A number of smaller fish were observed swimming off very quickly as the camera approached, so it was not possible to make a positive identification. Across the three AOIs, fish numbers were observed to be much more numerous in the Northern AOI sites, moderate at the Southern AOI sites, and moderate to low around the Central AOI sites.

[1] This fish was unable to be formally identified, thus while the term 'sand eel' is used throughout this report it should not be considered a common name for this unidentified fish species.

Figure 10 Representative Images of Seabed Environment around Well D



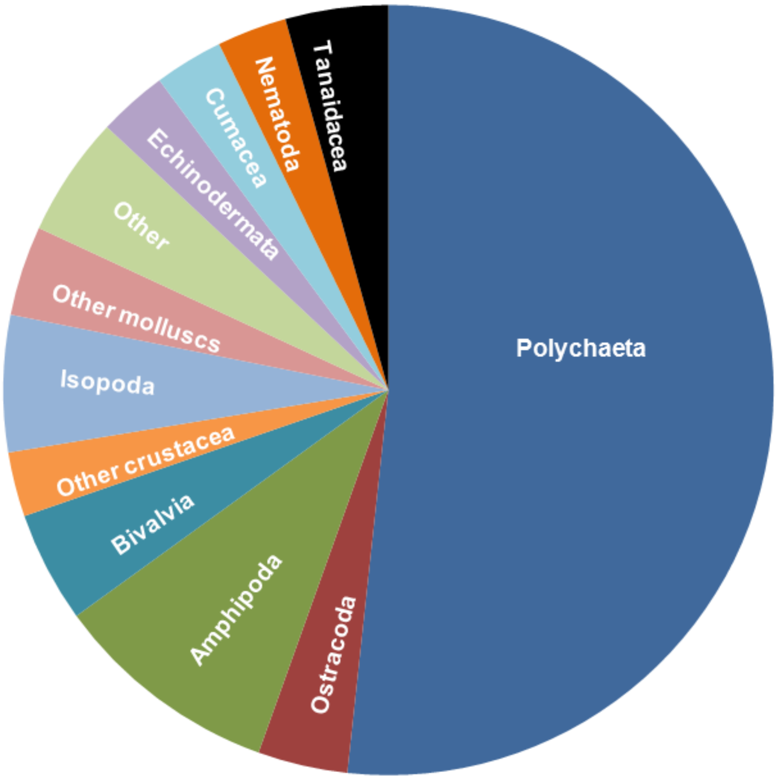
3.3 Macrofauna Characteristics

3.3.1 Benthic Macrofauna

Overall 4,986 individuals representing 142 taxa were identified in the 15 macrofauna samples collected around Well D. Abundance was substantially more than any other wells (**Table 7)**. Infauna communities were dominated by small polychaete worms (2,578 individuals (52%), 49 taxa), crustaceans (1,444 individuals (29%), 36 taxa, mostly Amphipoda, Isopoda, Tanaidacea and Cumacea), molluscs (421 individuals (8%), 38 taxa, Bivalva, Gastropoda and Scaphopoda), and Nematodes (146 individuals (3%), 1 taxa) (**Figure 11** and **Figure 12**). The raw macroinvertebrate data from Well D monitoring stations is provided in **Appendix D**.

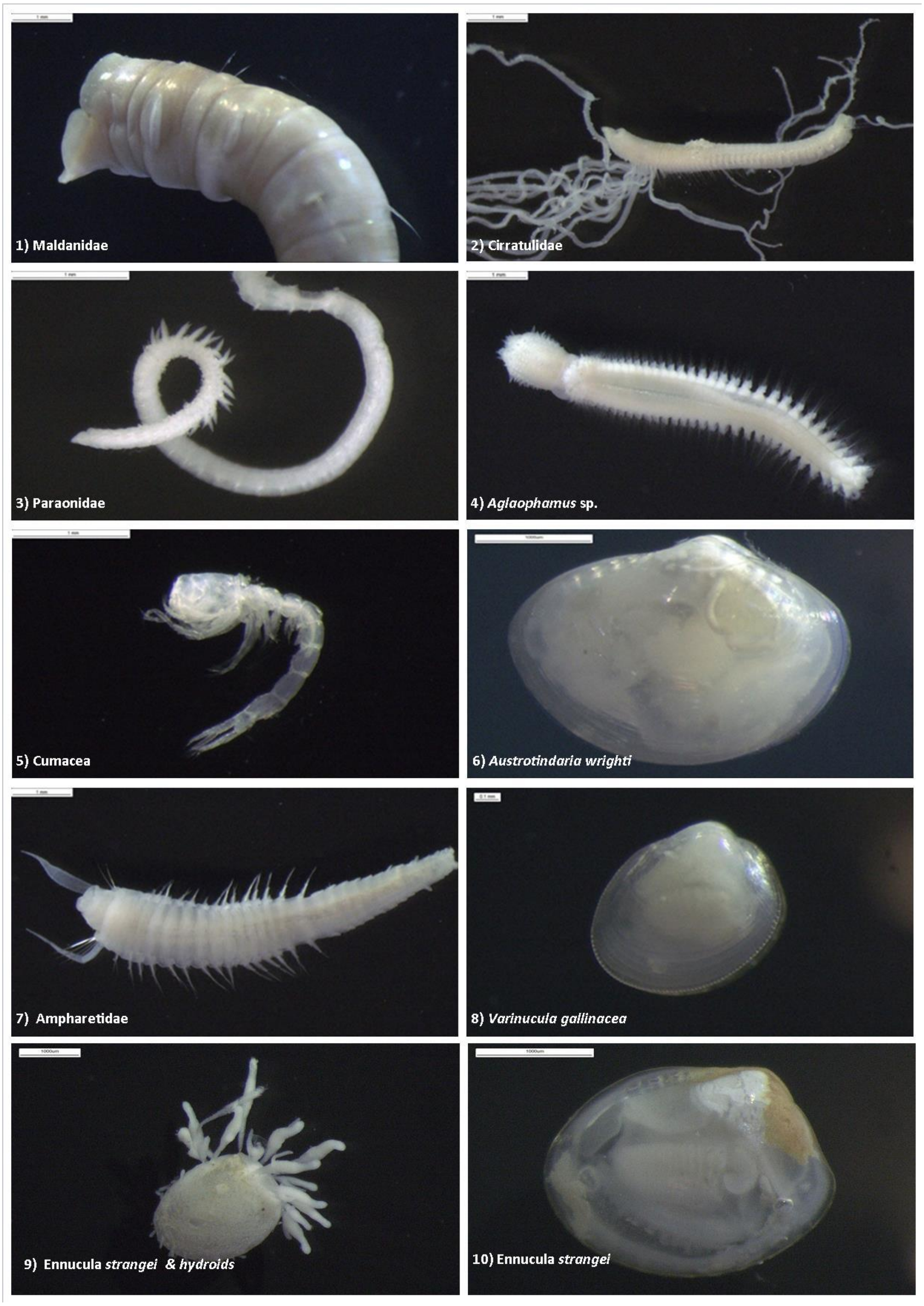
When the benthic macrofauna results are compared across the three AOIs, crustaceans (Tanaidacea and Amphipoda) and nematodes were found in higher numbers in the Northern AOI sites compared with Central and Southern AOIs. Gastropods and polychaetes were found in lower proportions in the Northern AOI and higher in the Central and Southern AOI (**Appendix E**). This result is likely linked to the differences in sediment composition, where a coarser grain size was present in the Northern AOI compared to the Central and Southern AOIs.

Figure 11 Proportion of Well D Individuals Belonging to each Taxonomic Group



'Other Crustacea' includes Decapoda, Copepoda, and Nebaliacea. 'Other Molluscs' includes Gastropod, Aplacophora, Scaphopoda and *Pododesmus zeylanicus*. 'Other' includes Priapulida, Actiniaria, Ascidiacea, Euphausiacea, Chaetognatha, Nermetea, Hemichordata, Platyhelminthes, Sipuncula, Tunicata, Porifera, Cypridinodes sp.

Figure 12 Representative Images of Benthic Infauna Taxa Frequently Observed in Offshore Taranaki Area.



3.3.2 Univariate Indices of Infauna Communities

Univariate indices (total number of taxa, total abundance, Pielou's evenness and Shannon-Wiener diversity) describing the benthic macroinvertebrate communities found around Well D are displayed in **Figure 13**.

The number of taxa identified in each sample collected around Well D varied from 53 to 72 (mean 60), while total abundance ranged widely from 238 to 466 individuals (mean 332) (**Figure 13**). Abundance and taxa numbers at Well D were the highest of the Northern AOI sites and highest overall (**Table 7**), considerably higher than that at the central and southern AOIs.

Evenness values vary on a scale between zero and one, with values near one indicating that infauna abundances are evenly distributed across all the different taxa present, while values near zero indicate infauna communities are being numerically dominated by a large number of individuals from just a few, or even only single taxa. Values from the benthic baseline data collected at Well D were relatively high (mean of 0.87), indicating relatively even distribution of abundances across the taxa that were present, and showed high uniformity across the site.

Shannon-Wiener diversity index values range between 0 and 4 with higher values representing higher diversity. From previous benthic studies in the offshore Taranaki region values in most communities fall between 1.5 and 3.5. The mean value across Well D was 3.6, and ranged between 3.4 and 3.8. When these results are compared to the most recent results from long term benthic monitoring programmes at the Maari Field (diversity index of 2.9) in the southern AOI it is shown that the species diversity was greater at Well D.

Figure 13 Total Number of Taxa, Total Abundance, Pielou's Evenness and Shannon Wiener Diversity Index Values for Macrofauna Samples Collected at Well D

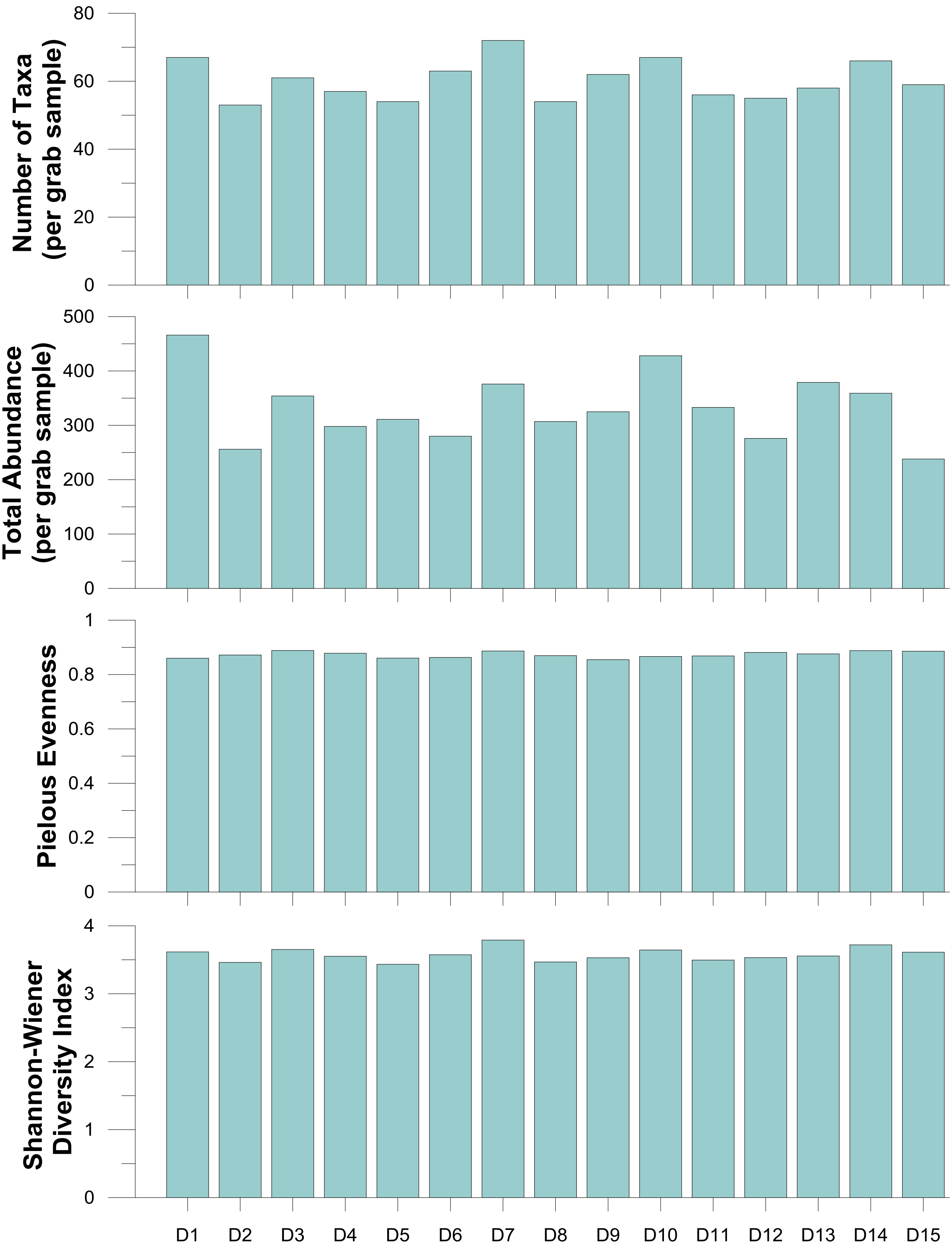


Table 7 Number of Taxa and Total Abundance for the Eleven Wells

Site	Mean Number of Taxa	Mean Abundance	Total Number of Taxa Identified at site	Total number of individuals (abundance)
A	56	257	140	3,849
B	53	210	130	3,151
C	45	132	128	1,987
D	**60**	**332**	**142**	**4,986**
Northern AOI	53	233		
E	19	36	78	542
F	31	68	90	1,023
G	33	81	112	1,215
H	31	89	103	1,339
I	29	72	91	1,075
Central AOI	29	69		
J	40	115	108	1,722
L	54	190	131	2,853
Southern AOI	47	153		

3.4 Sensitive Environments

In an investigation of sensitive substrate/benthic habitats in the Taranaki Coastal Marine Area, Johnston (2016) studied marine taxa databases from marine benthic surveys conducted in the offshore Taranaki Basin and noted that there are many locations where at least one 'characteristic species of sensitive environments' was found. This investigation used the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activities Regulations**) sensitive environments descriptions to define what sensitive habitats may be present.

Chaetopteridae worms and sea pens (*Virgularia gracillima*) were noted by Johnston (2016) as likely to be present in areas close to the 11 wells. In relation to the sampling techniques used in the Benthic Baseline survey (grab sampling and video sled imagery), MacDiarmid *et al*. (2013) define that;

"A sensitive Chaetopteridae worm field is present if worm tubes and/or epifaunal species:

- Occupy 25% or more of the seabed in imaging surveys covering and area of 500 m^2 or more; or
- Occur in two successive samples collected using point sampling gear."

and

"A sea pen field exists if:

- One or more specimens of any species of sea pen is found in two successive samples collected using point sampling gear, or
- Two or more specimens per m^2 are found in seabed imaging surveys, or surveys using towed gear."

Analysis of the infauna samples collected during the Benthic Baseline survey found that Chaetopteridae worms (specifically *Phyllochaetopterus socialis*, commonly known as wire-weed or Tarakihi weed) were present within samples from Wells A, B, C, D, G, H, J and L. Single individuals of *P. socialis* were recorded in grab samples at two monitoring stations around Well D; D6 and D13. Across the ten video sled tows performed around Well D there were no distinct worm-fields or low-relief worm-meadows that *P. socialis* often form observed. Thus, while this sensitive environment species was present at some monitoring stations around Well D the distributions appeared more as "isolated individuals within mixed epifaunal assemblages" at two stations rather than "dense mono-specific meadows at the tens of kilometres scale" (MacDiarmid *et al*., 2013).

No sea pens were identified within grab samples from Well D during the Benthic Baseline survey, however a total of 160 unidentified sea-pen species were observed in video imagery collected around Well D (see **Table 6** for total numbers of sea pens observed across the ten tows at each well site). Sea pen numbers at Well D were amongst the highest recorded throughout the Benthic Baseline survey and across all sites. The variable visibility encountered during video sled imagery means this method can only be qualified as semi-quantitative. However, approximate densities can be calculated based on the approximate width of the camera's field of view and the length of each tow. Based on such calculations sea pen densities at Well D would not have surpassed the trigger of two individual sea pens per square meter (MacDiarmid *et al*., 2013). Furthermore, video tows around Well D did not pass through more spatially limited areas of higher density that might have been classed as 'sea pen fields'. Based on the video sled analysis there are no 'Sensitive Environments', as defined by the Permitted Activities Regulations were encountered at the monitoring stations at Well D.

4 Key Findings

4.1 Sediment Characteristics

Grain size analysis at Well D (and other Northern AOI sites) indicated that the sediment was coarser than those sediments found in the Central and Southern AOIs, which are dominated by mud (silt and clay). There were no distinct spatial patterns to the variations in grain size and TOC across the fifteen sampling stations surrounding Well D.

The TOC around Well D was the lowest of all monitoring sites. TOC at Well D (mean of 0.19%) and all Northern AOI sites (mean of 0.26%) were lower than those found in samples from the Central and Southern AOIs (mean TOC 0.59% and 0.48%, respectively). Sediments with a finer grain size will retain higher levels of organic matter compared to coarser/sandier sediments subjected to the same level of enrichment/deposition.

4.2 Faunal Characteristics

Video sled imagery from the ten sampling stations around Well D showed fish were present in moderate numbers compared to other wells surveyed across the three AOIs (~28 compared to a median of 28 across all 11 wells). A very high number of mound/hollow features were observed at Well D (~280 compared to a median of 43 across all 11 wells). These mound/hollow features that were generally observed to be more numerous at the Northern AOI sites, moderate to high at the Southern AOI sites, and low around the Central AOI sites.

As with other Northern AOI sites, infauna communities present at Well D monitoring stations contained proportionally more Tanaidacea, Nematoda and Amphipoda, and less Gastropoda and Polychaeta compared to the Central and Southern AOIs. The number of taxa and total abundance at Well D monitoring stations were very high when compared to all other sites, but particularly sites in the Central and Southern AOIs.

The comparatively coarser nature of the muddy sand sediments at Well D (and other Northern AOI sites) versus the more muddy sediments from the Central and Southern AOIs is likely to be linked to the lower number of gastropods, many of which are detritivores and/or deposit feeders which feed on dead and decaying algae, seaweed and other plants and animals, as well as organic matter within the sediments. This feeding mechanism is likely to be more suited to muddy sediments. Sediment grain size is also important for determining suitable habitat for tube forming polychaete species (tubeworms), which form their tubes within the interstitial spaces in the sediment matrix, thereby requiring specific sediment properties to become established.

Explaining the greater proportions of Tanaidacea, Copepoda, Nematoda and Amphipoda at Well D is more complex. For example, some species within the order Tanaidacea may be filter feeding species while others actively hunt prey (predators). The prevalence of these taxa at Well D, compared to sites within the Central AOI, is likely to be linked with the coarser sediments present at Well D. Coarser sediments, particularly larger sands, gravels, shell hash, etc., begin to provide more three-dimensional, cryptic habitats, allowing a wider variety of taxa to find different suitable habitats than mud-dominated sediments. Coarser sediments also contain less of the very fine clay particles which can clog or damage the delicate feeding and breathing structures of taxa adapted as filter feeders, particularly when such fine sediments are present in the water column for extended periods, and/or repeatedly re-suspended.

4.3 Sensitive Environments

Some individuals representing '*characteristic species of sensitive environments*' were found within the macrofauna samples (e.g. Chaetopteridae worms) and observed in video tows (e.g. sea pens) during the Benthic Baseline survey at Well D. However, observations from the video imagery indicated that no 'Sensitive Environments', as defined by the Permitted Activities Regulations (using MacDiarmid *et al.*, 2013) were encountered at the monitoring stations surveyed at Well D.

5 References

Clarke K. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18 (1): 117-143.

Clarke K.R., Warwick R.M., 1994. Change in marine communities: An approach to statistical analysis and interpretation. Plymouth Marine Laboratory, UK.

Clarke K.R., Gorley R.N., 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth.

Folk, 1954. *"The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature",* The Journal of Geology 62(4):344-359.

Hedges JI, Keil RG, Cowie GL, 1993, "Sedimentary diagenesis: organic perspectives with inorganic overlays", Chemical Geology 107: 487-492.

Johnston O, Barter P, Ellis J, Elvines D, 2014, "*Recommendations for an Offshore Taranaki Environmental Monitoring Protocol: Drilling- and production-related discharges, Version 1.0*" (OTEMP), Cawthron Report No. 2124.

Johnston O 2016. Sensitive habitats and threatened species in the Taranaki Coastal Marine Area (TCMA) - database investigation. Prepared for Taranaki Regional Council. Cawthron Report No. 2877. 28 p. plus appendices.

MacDiarmid, A., Bowden, D., Cummings, V., Morrison, M., Jones, E., Kelly, M., Neil, H., Nelson, W., Rowden, A., 2013. '*Sensitive marine benthic habitats defined*'. Prepared for Ministry for the Environment, NIWA Client Report No: WLG2013-18.

SLR, 2016. "*Benthic Ecological Survey - Matuku-1 Exploration Well Post-Drill Assessment, March 2016*". Prepared for OMV New Zealand Limited. Report Number 740.10013.00240

APPENDIX A

Locations and Observations from Sediment Grab Sampling and Video Sled during the 2018 Benthic Baseline Survey

Station	Date	Time	Depth (m)	Coordinates (NZTM)		Notes
				Easting	Northing	
Grab Sample Sites						
DG 1	29/3/18	1622	143	1598056	5698296	Hard packed sand, burrow hole in one grab, grey brown
DG 2	29/3/18	1610	143	1596670	5699737	Hard packed sand, grey / some brown ; streaks of mud on surface
DG 3	29/3/18	1511	143	1595281	5701178	Hard packed fine sand, dark grey , ½ full grab
DG 4	29/3/18	1503	143	1594589	5701898	Slightly softer sandy mud, full grab
DG 5	29/3/18	1407	143	1593893	5702617	Grey / dark grey hard packed fine sand
DG 6	29/3/18	1418	143	1593199	5703335	Hard / very hard packed fine sand, grey or dark grey, with some lighter brown mud on top.
DG 7	29/3/18	1428	143	1592498	5704050	Hard packed fine sand, 1/3 full grab. Grey / dark grey
DG 8	29/3/18	1528	143	1597423	5701844	Hard packed very sandy muds, washes fast, grey and some brown
DG 9	29/3/18	1538	143	1596705	5701146	Hard packed fine sand, some mud, grey, some brown streaks
DG10	29/3/18	1548	143	1595273	5699757	Hard packed very fine sand
DG11	29/3/18	1558	143	1594541	5699056	Hard packed fine sand , sieves fast, some mud
DG12	29/3/18	1350	143	1595331	5704005	Hard packed fine sand, some shell hash, with fine black sand
DG13	29/3/18	1358	143	1594614	5703312	Grey / dark grey hard packed fine sand
DG14	29/3/18	1451	143	1593174	5701921	Hard packed fine sand, grey. Some brown mud on top, grey sand below.
DG15	29/3/18	1442	143	1592456	5701225	Hard packed fine sand, grey, 1/3 full grab; Difficult to get full grab
Video Sled Tow Locations						
DV 1	29/3/18	0728	144	1598457	5700063	
DV 2	29/3/18	0759	144	1597377	5699021	
DV 3	29/3/18	0836	144	1596300	5697975	
DV 4	29/3/18	0916	144	1596018	5702584	
DV 5	29/3/18	0957	145	1594589	5701898	
DV 6	29/3/18	1044	145	1593859	5700488	
DV 7	29/3/18	1109	144	1593893	5702617	
DV 8	29/3/18	1136	144	1594276	5704374	
DV 9	29/3/18	1245	143	1592847	5703692	
DV10	29/3/18	1310	143	1592122	5702287	

APPENDIX B

Sediment Core Profile Images from all Grab Samples Collected during the 2018 Benthic Baseline Survey at Well D


DG1.JPG


DG10.JPG


DG11.JPG


DG12.JPG


DG13.JPG


DG14.JPG


DG15.JPG


DG2.JPG


DG3.JPG


DG4.JPG


DG5.JPG


DG6.JPG


DG7.JPG

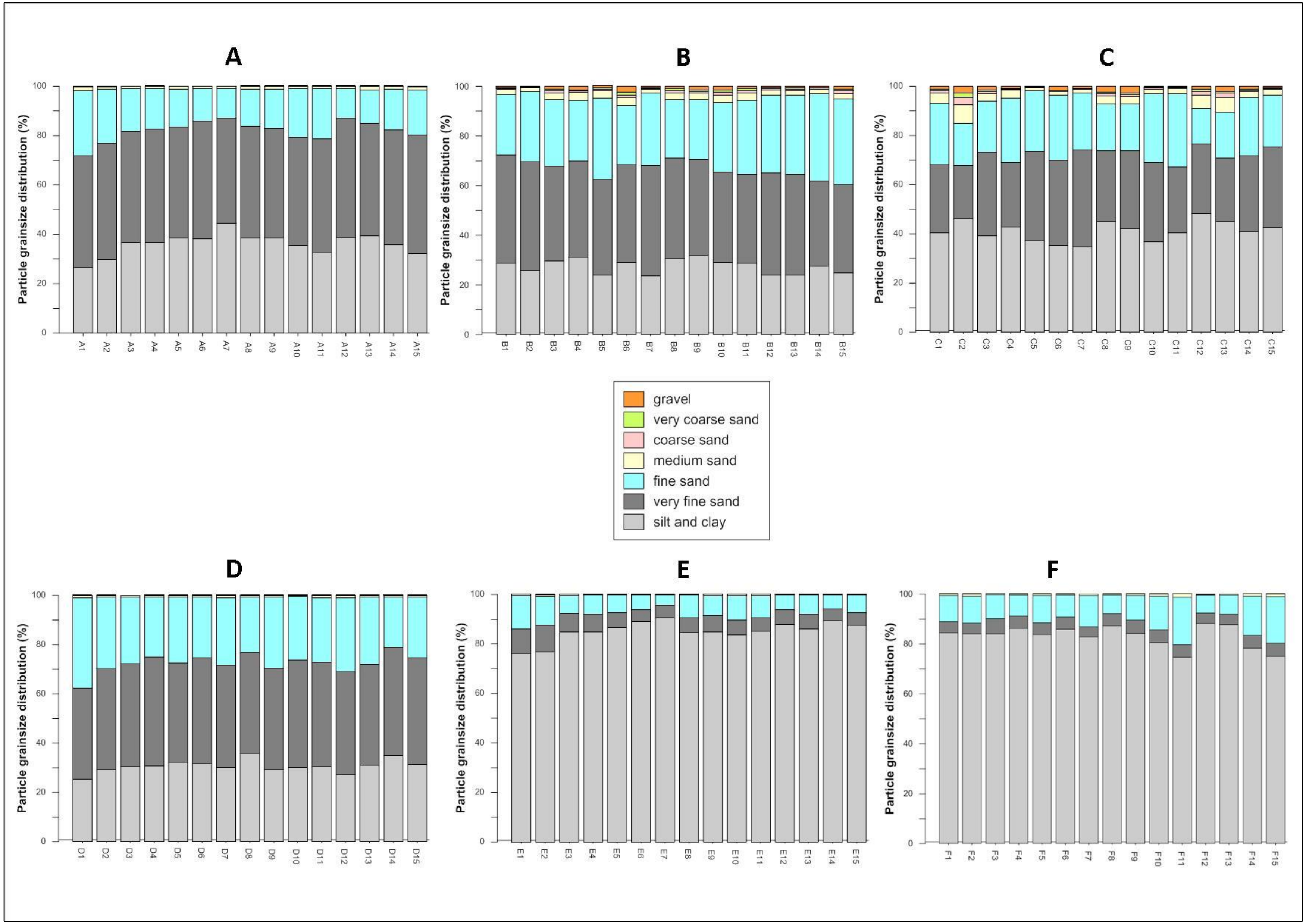

DG8.JPG

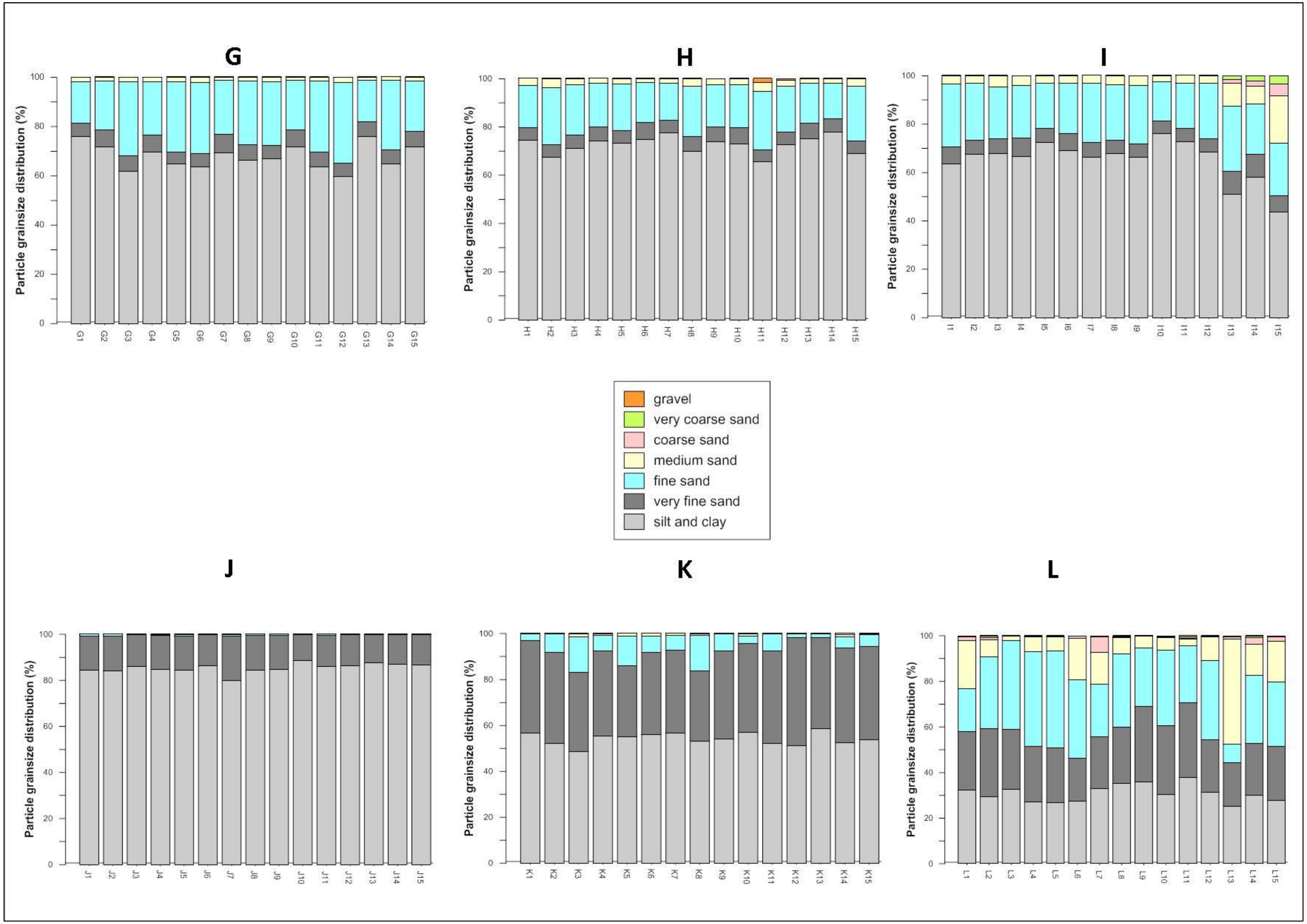

DG9.JPG

APPENDIX C

Total Organic Carbon Content and Particle Grain Size Distribution for Well D

Replicate Sample	TOC (%)	Gravel (%)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Silt & Clay (Mud) (%)
Station D1	0.16	< 0.1	< 0.1	< 0.1	1	36.7	36.9	25.3
Station D2	0.16	< 0.1	< 0.1	< 0.1	0.7	29.2	40.8	29.3
Station D3	0.16	0.1	< 0.1	< 0.1	0.6	27	41.8	30.4
Station D4	0.21	< 0.1	< 0.1	< 0.1	0.6	24.4	44.2	30.8
Station D5	0.18	< 0.1	< 0.1	< 0.1	0.7	26.6	40.3	32.3
Station D6	0.2	< 0.1	< 0.1	< 0.1	0.6	24.8	43	31.6
Station D7	0.17	< 0.1	< 0.1	< 0.1	1	27.3	41.5	30.2
Station D8	0.21	< 0.1	< 0.1	< 0.1	0.6	22.8	40.7	35.9
Station D9	0.21	< 0.1	< 0.1	< 0.1	0.7	28.9	41.1	29.3
Station D10	0.2	< 0.1	< 0.1	< 0.1	0.5	25.8	43.5	30.2
Station D11	0.21	< 0.1	< 0.1	< 0.1	0.9	26.4	42.3	30.4
Station D12	0.16	< 0.1	< 0.1	< 0.1	0.9	30.2	41.6	27.2
Station D13	0.21	< 0.1	< 0.1	< 0.1	0.8	27.3	41	30.9
Station D14	0.21	0.1	< 0.1	< 0.1	0.6	20.6	43.9	34.9
Station D15	0.2	< 0.1	< 0.1	< 0.1	0.6	24.7	43.4	31.2


A
B
C
D
E
F
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay


G
H
I
J
K
L
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay

APPENDIX D

Raw Counts of Macroinvertebrate (Infauna and Epifauna) Abundance at Well D

Taxa	Class/Order	Phylum	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
Acanthephyra pelagica	Decapoda	Crustacea					1									1	
Acanthephyra quadrispinosa	Decapoda	Crustacea	1														
Aglaophamus sp.	Polychaeta		15	17	15	15	10	4	13	16	10	16	13	3	15	15	7
Amalda sp.	Gastropoda	Mollusca										1					
Ampelisca sp.	Amphipoda	Crustacea				1				1							
Ampharetidae	Polychaeta		29	11	15	20	25	18	30	27	36	14	28	11	23	29	13
Amphinomidae	Polychaeta								1								
Amphipoda	Amphipoda	Crustacea	7	6	14	6	16	3	23	9	10	5	10	7	12	11	6
Antalis glaucarena	Scaphopoda	Mollusca					1				1						
Antalis nana	Scaphopoda	Mollusca	1							2							1
Anthuridae	Isopoda	Crustacea			2	1		3	5		2	1	1	4	1	1	1
Aphroditidae	Polychaeta													1			
Aplacpohora		Mollusca	4	3	4	2	4	3	6	2		3		5	1	3	1
Aricidea sp.	Polychaeta		13	8	7	1	4	2	4	2	3	4	5	2	6	7	2
Armandia maculata	Polychaeta		11	3	4	7	9	7	5	4	2	5	6	1	5	6	1
Armandia maculata (juvenile)	Polychaeta		9	11	17		8	8	9	10	4	10	9	4	16	11	8
Arthritica bifurca	Bivalvia	Mollusca							4		2			1		1	2
Asellota	Isopoda	Crustacea	22	8	9	13	12	3	10	16	24	25	9	10	22	17	12
Aspidosiphon sp.	Sipuncula															2	
Astromitra sp.	Gastropoda	Mollusca		1							1	1				1	
Bathyaria cybaea	Bivalvia	Mollusca							1							1	
Bivalvia (juvenile)	Bivalvia	Mollusca				1											
Brachyura larvae	Decapoda	Crustacea								1				1			
Bradleya opima	Ostracoda	Crustacea	3	1	5			3	3	11	7	7		6	4	2	5
Cadulus teliger	Scaphopoda	Mollusca	5	2	5	1	11	9	8	9	8	14	1	8	6	9	2
Capitellethus zeylanicus	Polychaeta		2	2	4	7	4	1	1	2	4	1	3		1	5	2

Taxa	Class/Order	Phylum	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
Chaetognatha	Chaetognatha		1		1	1			1		2						2
Chlorotocus novaezealandiae	Decapoda	Crustacea	1												1		
Cirratulidae	Polychaeta		49	35	31	27	51	49	19	36	33	45	39	27	51	23	28
Clavelina claviformis	Ascidiacea	Tunicata	5	4	3		5	3	3	5	1	4	5	5	6	4	3
Copepoda	Copepoda	Crustacea	4		1			1	3	5	1	3	2	2	3	1	2
Cossura consimilis	Polychaeta		3	1	1		1			1	1		5		3		2
Cumacea	Cumacea	Crustacea	5	9	14	6	8	13	10	9	9	16	5	9	7	11	13
Curveulima aupouria	Gastropoda	Mollusca							1			2					
Cuspidaria trialli	Bivalvia	Mollusca			1				1		1		1			2	
Cyclostrematidae	Gastropoda	Mollusca							1	1					1	1	
Cymbicopia hispida	Ostracoda	Crustacea									1			2			1
Cytherella sp.	Ostracoda	Crustacea	7	3	1		2	3	9	3	5	7		5	4	1	2
Cypridinodes sp.			16	2	17		3	6	5	10	17	4	19	1	4	9	2
Diasterope grisea	Ostracoda	Crustacea										1					
Dorvilleidae	Polychaeta					3									1	2	
Ebalia laevis	Decapoda	Crustacea	2	3	6		8	8	6		3	6	1	17	3	7	2
Ebalia laevis (juvenile)	Decapoda	Crustacea				4											
Edwardsia sp.	Actiniaria											1		1			
Ennucula strangei	Bivalvia	Mollusca	12	6	3	4	6	6	4	7	5	7	6	6	9	9	4
Euchone pallida	Polychaeta		19	9	8	23	9	4	6	8	6	13	3	26	13	10	4
Eulimidae	Gastropoda	Mollusca			1												
Euphausiacea	Euphausiacea					1											
Euphilomedes agilis	Ostracoda	Crustacea				5											
Flabelligeridae	Polychaeta		1	2	3	1	1	2	2	1		2	8			1	
Glyceridae	Polychaeta		1	2		1		3			3		2	2	1	3	
Gnathiidae	Isopoda	Crustacea	3				1	1	3			1	2		1	1	1

Taxa	Class/Order	Phylum	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
Goniadidae	Polychaeta		1			1		1				1					
Haustoriidae	Amphipoda	Crustacea	15	5	6	8	12	6	12	5	9	22	15	10	10	10	6
Hemichordata	Hemichordata							1									
Hesionidae	Polychaeta					1	1		1	1						1	
Hiatella artica	Bivalvia	Mollusca							1								
Hunkydora novozelandica	Bivalvia	Mollusca													1		
Hyperia sp.	Amphipoda	Crustacea									1		1				
Ischyroceridae	Isopoda	Crustacea				3											
Leitoscoloplos kerguelensis	Polychaeta		3					1				1	2	1		1	1
Limatula maoria	Bivalvia	Mollusca		1					3					1		1	
Lumbrineridae	Polychaeta		7	4	9		3	2	5	3	3	5	3	3	6	5	2
Lysianassidae	Amphipoda	Crustacea	1	1	1		1		1			3	5				
Magelona dakini	Polychaeta		2	2	6	2	2	7	2	5	3	2	7	2	7	2	1
Maldanidae	Polychaeta		5	3	3	10	5	2	10	3	4	5	4	1	4	3	3
Merelina sp.	Bivalvia	Mollusca	1		1			1	1		1	1					
Mogula sp.	Tunicata			1	1	2		1					1				
Myadora antipodum	Bivalvia	Mollusca	1						1				1				2
Myllitella vivens	Bivalvia	Mollusca	1														
Myriowenia sp.	Polychaeta			1		1										1	
Mysidacea	Decapoda	Crustacea							1			1					1
Naticidae	Gastropoda	Mollusca						1				1		1			
Nebaliacea		Crustacea	1			1				1		3				12	3
Neilonella wrighti	Bivalvia	Mollusca							1								2
Nematoda	Nematoda		11	9	13	11	10	15	9	14	8	7	5	5	11	11	7
Nemertea	Nermetea		3	2	3	3	1	4	8	3	2	4	5	3	4	1	3
Neonesidea sp.	Ostracoda	Crustacea	5	1			2	1				2		1			

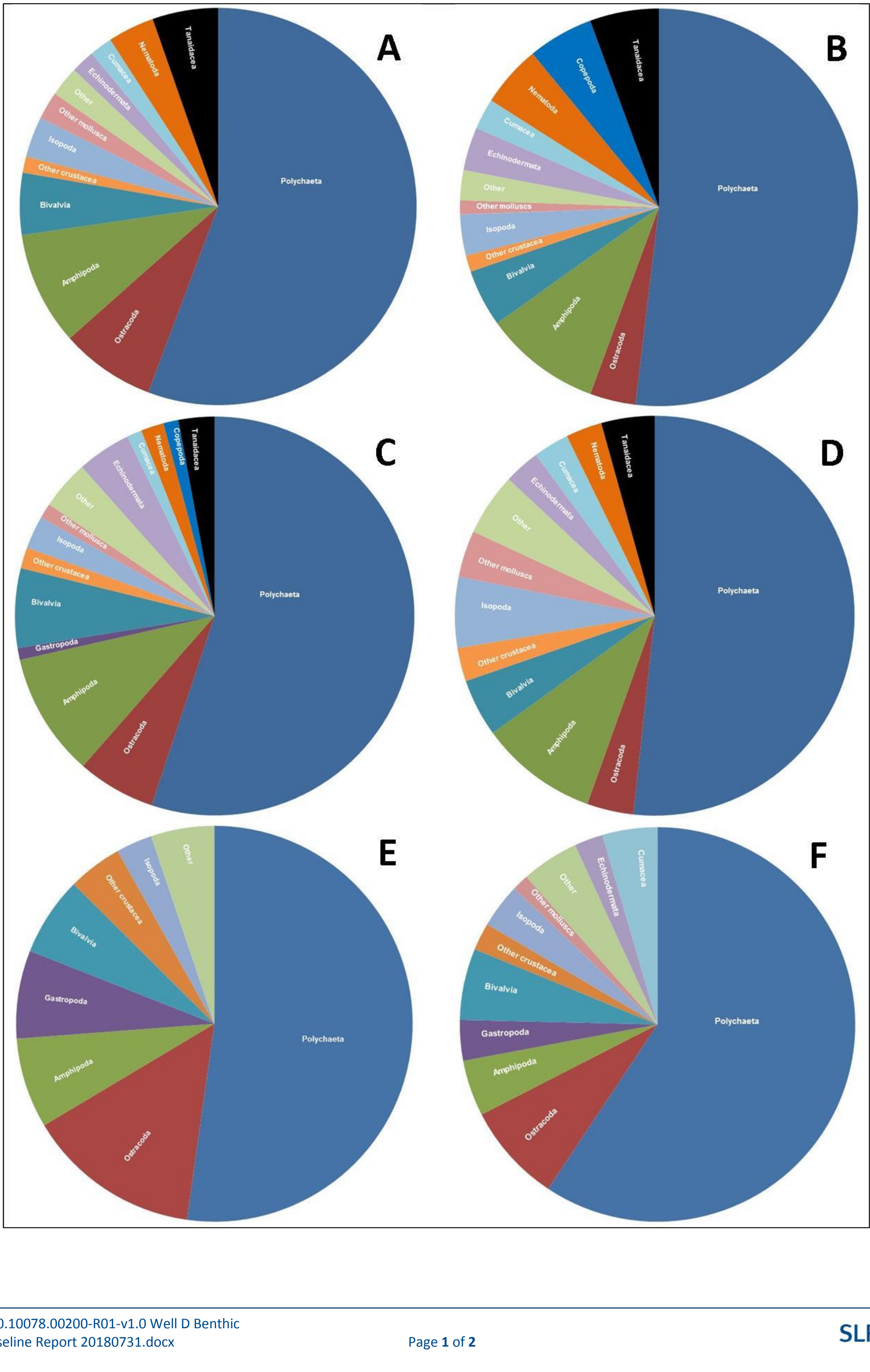
Taxa	Class/Order	Phylum	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
Nothria tenuisetis	Polychaeta															1	
Notocallista multistriata	Bivalvia	Mollusca	2					1			1						
Nucinella maoriana	Bivalvia	Mollusca		1													
Ophiuroidea	Ophiuroidea	Echinodermata	5	21		8	10	7	13	12	9	14	7	5	7	10	15
Orbina papillosa	Polychaeta		2	1	1		2		4			3	1		1		
Orbiniidae 6 (unknown)	Polychaeta					1											
Ostracoda	Ostracoda	Crustacea			14												
Owenia petersenae	Polychaeta					3					1						
Paracaudina chilensis	Holothuroidea	Echinodermata			1												1
Paramunna serrata	Isopoda	Crustacea	2		8		3	1	2	1	1	6		1	3	3	1
Paraonidae	Polychaeta		26	9	9	12	3	1	3	4	7	18	9	4	7	7	1
Parasterope quadrata	Ostracoda	Crustacea	2	1	1							1	1	1			
Paravireia sp.	Isopoda	Crustacea			1										1		
Phascolion sp.	Sipuncula							2	1								
Philine powelli	Gastropoda	Mollusca	1									1					
Phoxocephalidae	Amphipoda	Crustacea	14	6	6	6	10	8	18	10	10	16	8	14	10	18	8
Phoxo look alike	Amphipoda	Crustacea				1											
Phylctenophora zealandica	Ostracoda	Crustacea	3	2	1				2								
Phyllochaetopterus socialis	Polychaeta							1							1		
Phyllodocidae-like	Polychaeta					1											
Phyllodocidae	Polychaeta									1	1	1	1			1	
Phylo sp.	Polychaeta					1											
Pilargidae	Polychaeta						1	2	1	1		1	1		1		
Platyhelminthes	Platyhelminthes								2								
Pleuromeris paucicostata	Bivalvia	Mollusca				1		1	1								1
Pleuromeris zelandica	Bivalvia	Mollusca	1						2		1	1		1	1		1

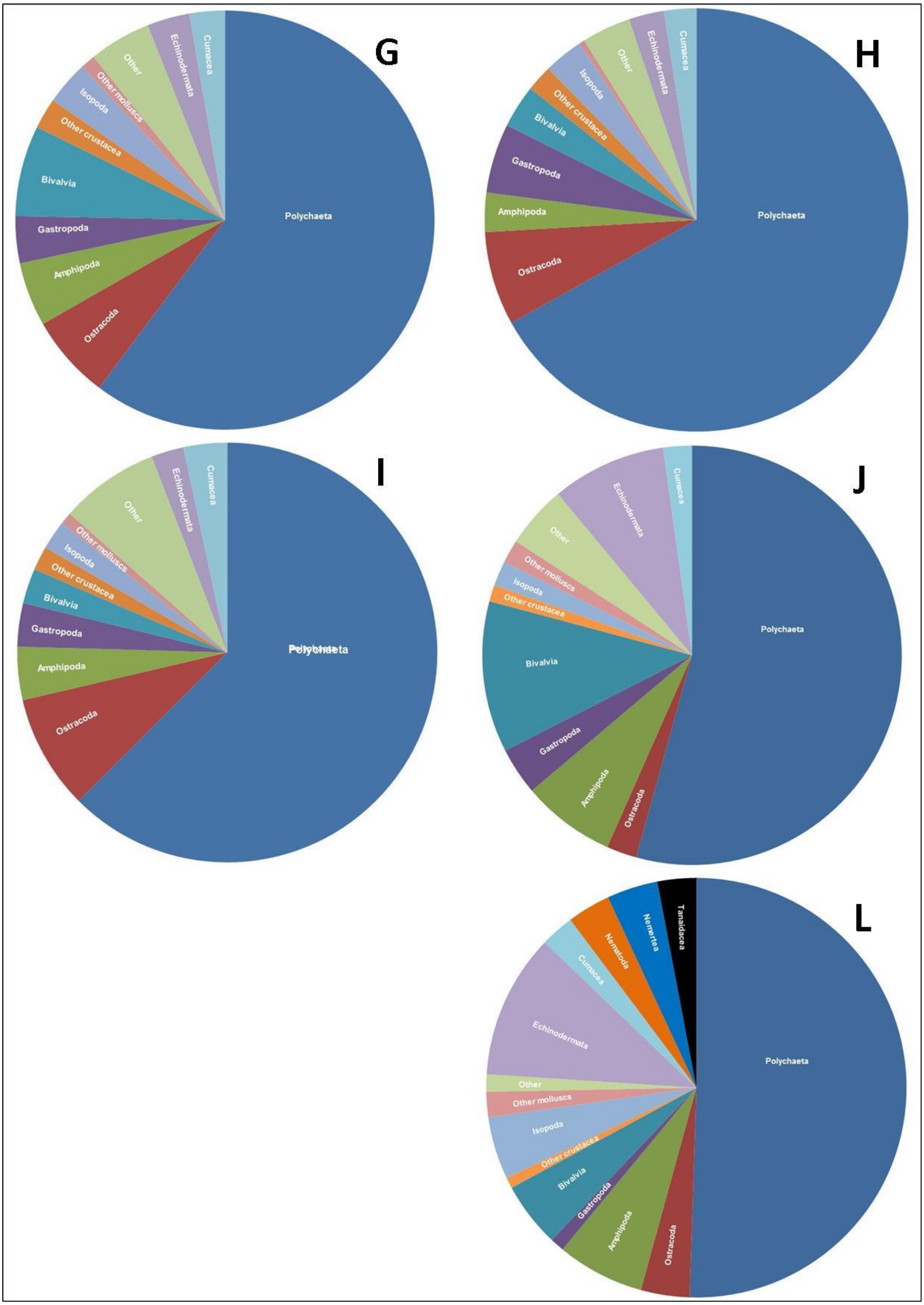
Taxa	Class/Order	Phylum	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
Pododesmus zeylanicus		Mollusca	2		2						2				1		1
Polynoidae	Polychaeta			1	2								1				1
Poroleda lanceolata	Bivalvia	Mollusca							1					2		1	
Pratulum pulchellum	Bivalvia	Mollusca			1			3	1	1	1	3	2	3	4	4	
Priapulida	Priapulida	Priapulida									1						
Prionospio multicristrata	Polychaeta		9	7	4	11	2	3	6	10	1	4	12		6	4	
Prionospio sp.	Polychaeta		12	9	17	9	12	8	8	7	14	19	13	5	12	13	10
Prionospio aucklandia	Polychaeta					1											
Propontocypris sp.	Ostracoda	Crustacea						1			2		1			1	4
Pyura sp.	Tunicata					2											
Rhamphobrachium sp.	Polychaeta							1									
Rissoidae	Gastropoda	Mollusca	1	1					2	1	1	1	1	2	5		1
Saccella maxwelli	Bivalvia	Mollusca								1			1	4			
Sabellidae	Polychaeta					4	2	3	2		5	6	1	3	3	6	5
Scalibregma inflatum	Polychaeta				1		1				1				1		
Scoloplos sp.	Polychaeta		2				2				1					1	
Sigalionidae	Polychaeta		1		2		2	1	2	1		2		1			1
Sphaerodoropsis sp.	Polychaeta											1					1
Sphaerosyllis sp.	Polychaeta		5	2	3		2		1		1	1			3	3	
Spio sp.	Polychaeta		1			1	3		1	1	2	1				1	
Spiophanes kryoeri	Polychaeta							4			1	2					
Spiophanes modestus	Polychaeta		11	6	6	15	5	2	14	1	7	11	7	17	14	6	6
Spiophanes wriglyi	Polychaeta				1	3	1	2	2				1		1	2	
Sycon sp.	Porifera															1	
Syllidae	Polychaeta		11	1	10	6	6	5	8	3		8	3	4	9	7	5
Talochlamys zelandiae	Bivalvia	Mollusca									1						

Taxa	Class/Order	Phylum	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
Tanaidacea	Tanaidacea	Crustacea	36	2	19	9	3	7	20	12	15	26	24	9	17	10	6
Tawera sp.	Bivalvia	Mollusca							1								
Terebellidae	Polychaeta		1	1	2	2	1			1	3		2	1	2	1	1
Terebellides stroemii	Polychaeta		1		3	2	1	2		1		1		1		2	
Themiste sp.	Sipuncula			1													
Thyasira peregrina	Bivalvia	Mollusca	1	4	2	1	1	5	2	3	2	3	3	3	5		7
Tonnidae	Gastropoda	Mollusca						1									

APPENDIX E

Comparison of Proportion of Individuals belonging to each Taxonomic Group across all Wells


A
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Tanaidacea
B
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Copepoda
Tanaidacea
C
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Copepoda
Tanaidacea
D
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Tanaidacea
E
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other
F
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea


G
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
H
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other
Echinodermata
Cumacea
I
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
J
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
L
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Nemertea
Tanaidacea

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EXPLORATION AND APPRAISAL DRILLING PROGRAMME

Benthic Baseline Report
Well E

Prepared for:

OMV New Zealand Limited
Level 20, The Majestic Centre
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Wellington

SLR Ref: 740.10078.00200-R01
Version No: v1.0
July 2018

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BASIS OF REPORT

This report has been prepared by SLR Consulting NZ Limited with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with OMV New Zealand Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.10078.00200-R01-v1.0	31 July 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier
740.10078.00200-R01-v0.1	29 June 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier

EXECUTIVE SUMMARY

OMV New Zealand Limited (**OMV New Zealand**) are applying for a Marine Consent to undertake an Exploration and Appraisal Drilling (**EAD**) Programme in the Taranaki Basin with an anticipated commencement date in 2019. OMV New Zealand may drill up to nine exploration wells and two appraisal wells within their Petroleum Exploration Permits (**PEP**). The intention of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs.

As part of the Marine Consent application, three Areas of Interest (**AOI**) have been identified that encapsulate the proposed well locations and are used as part of the Impact Assessment process. OMV New Zealand undertook a baseline environmental monitoring survey at each well location in March-April 2018 to gain an understanding of the benthic habitat and associated communities with each AOI.

Grab sampling and video sled methodologies were used to gain quantitative and qualitative information on the marine environments surrounding each well location. The data gathered from each Benthic Baseline survey will be incorporated into the Marine Consent application and assist in the risk assessment process.

Water currents and deposition modelling were utilised to define the placement of sample stations. Sample transects were aligned along the dominant deposition pathway of the predicted drill cutting dispersion should that particular well be drilled. A total of 15 monitoring stations were allocated at each at each well and one benthic grab sample was collected at each monitoring station. Ten video sleds were also undertaken at a selection of pre-determined stations around each well.

Within this Benthic Baseline report the analysis of results incorporates sediment physical and chemical properties, benthic macrofauna, epifauna and visual observations around Proposed Well E. Results of sediment analyses showed the area surrounding the well to be composed of sandy muds, dominated by silt and clay (85%), with moderate levels of organic carbon (0.65%). Grain size distribution showed a weak, but inconsistent pattern of increasingly fine sediments towards west/southwest portion of the well, while organic carbon showed no consistent spatial pattern, but varied somewhat similarly to silt and clay levels. Sediment grain size distributions and TOC levels at Well E were very similar to those found at the remaining Central AOI wells and Well J.

A total of 542 individuals representing 78 taxa were identified from the macrofauna samples at Well E. Infauna communities were predominantly comprised of small polychaetes (63%), crustaceans (20% - ostracods, amphipods and isopods) and molluscs (7% - gastropods and small bivalves). Central AOI infauna communities had the greatest proportions of polychaetes and gastropods, but the lowest proportions of crustaceans like amphipods and tanaidaceans, reflecting the muddier sediments in the central AOI which are more suited to deposit feeding/scavenging taxa like many of the polychaetes and gastropods found at Well E.

Video Imagery collected during the Benthic Baseline survey indicated the presence of sea pens which are taxa defined as '*characteristic species of sensitive environments*'. The occurrence and estimated densities of sea pens at Well E did not reach the trigger levels defined by the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (MacDiarmid *et al.*, 2013) and no distinct sea pen 'fields' were encountered. Thus although present at the well in low densities, the area does not classify as a 'sensitive environment'.

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APPENDICES

1 Introduction

OMV New Zealand Limited (**OMV New Zealand**) is applying for a Marine Consent under Section 38 of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (**EEZ Act**) to permit activities associated with an Exploration and Appraisal Drilling (**EAD**) Programme proposed to be undertaken starting in 2019.

The EAD Programme includes the drilling of up to nine exploration wells and two appraisal wells within OMV New Zealand's permit areas (**Figure 1**). The purpose of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs which OMV New Zealand operate (**Figure 1**).

Three Areas of Interest (**AOI**) (summarised below) have been identified which encapsulate the well locations (**Figure 1**). This monitoring report relates to the Benthic Baseline survey conducted at Well E in the Central AOI. Location details and water depth of Well E are provided in **Table 1**.

The Northern AOI encompasses PEP 60092 (Ridgeline), PEP 57075 (Cloudy Bay) and PEP 60093 (Toutouwai) and includes the following wells:

- Well A;
- Well B;
- Well C; and
- Well D.

The Central AOI encompasses PEP 60093 (Toutouwai) and includes the following wells:

- Well E (Appraisal);
- Well F;
- Well G (Appraisal);
- Well H; and
- Well I.

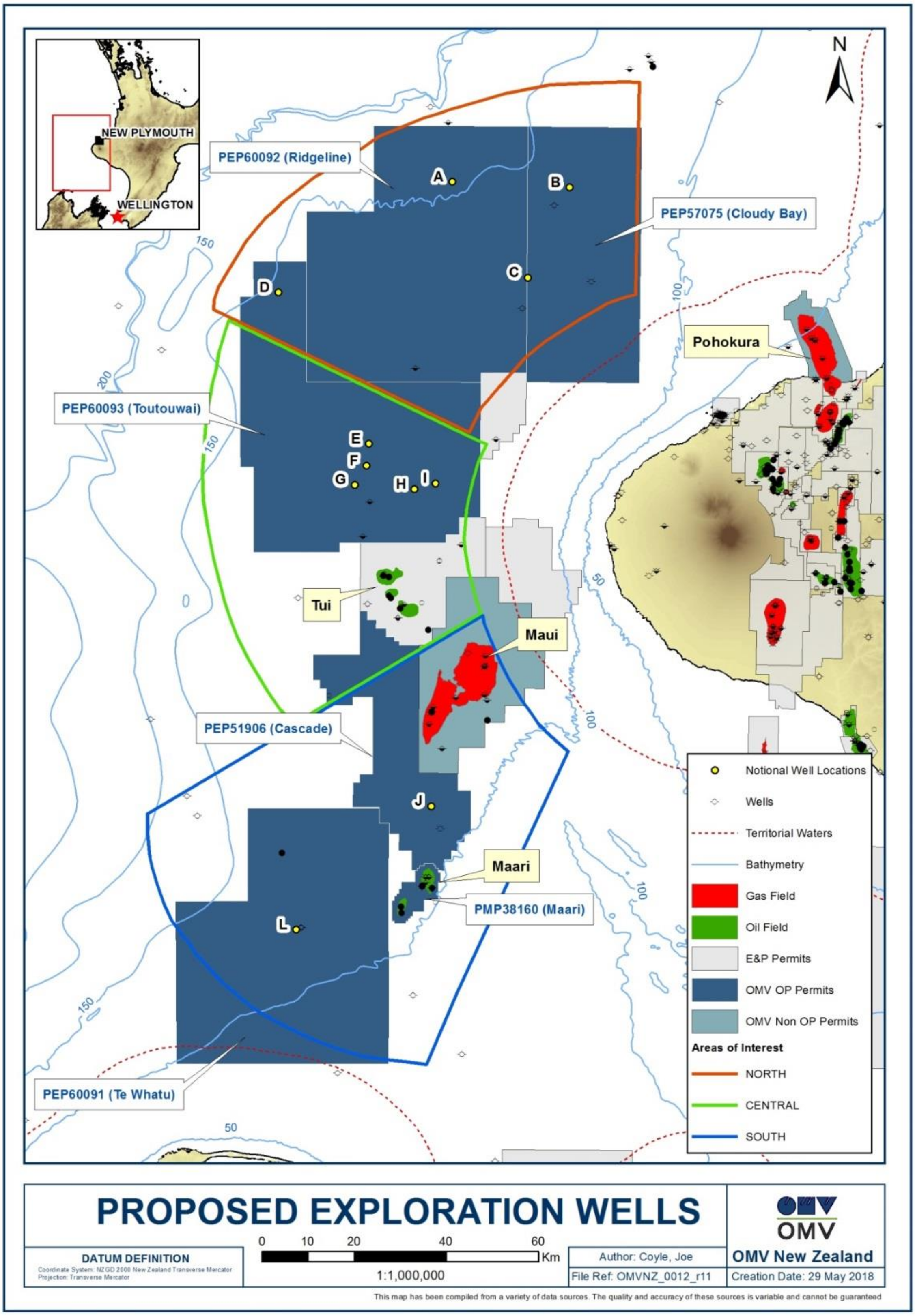
The Southern AOI encompasses PEP 51906 (Cascade), and PEP 60091 (Te Whatu) and includes the following wells:

- Well J; and
- Well L.

Table 1 Water Depth and Coordinates of Well E in the Central AOI

Well Name	Water Depth (m)	Easting (NZTM)	Northing (NZTM)
E	125.8	1613498	5669767

Figure 1 OMV New Zealand's EAD Well Locations and three AOIs in the Taranaki Basin



In February 2018 SLR Consulting NZ Limited (**SLR**) was engaged by OMV New Zealand to undertake a baseline assessment of the benthic ecology in the vicinity of 11 wells (**Figure 1**). The aim of the field surveys, which were undertaken from March 24 – April 8 2018, was to collect relevant data using grab sampling and video sled methodologies to provide quantitative and qualitative information on these marine environments. This qualitative and quantitative data will be used within the Marine Consent application to define the benthic habitats and communities present at each well and assist in the risk assessment process.

This report summarises the results of the Benthic Baseline survey undertaken at Well E.

1.1 Project Location

Well E is located approximately 79 km west of New Plymouth in New Zealand's Exclusive Economic Zone (**EEZ**). Water depth and GPS coordinates are provided in **Table 1** and displayed in **Figure 1**. The monitoring programme sample design resulted in sample stations extending out to 6 km from the well location (**Section 2.1**).

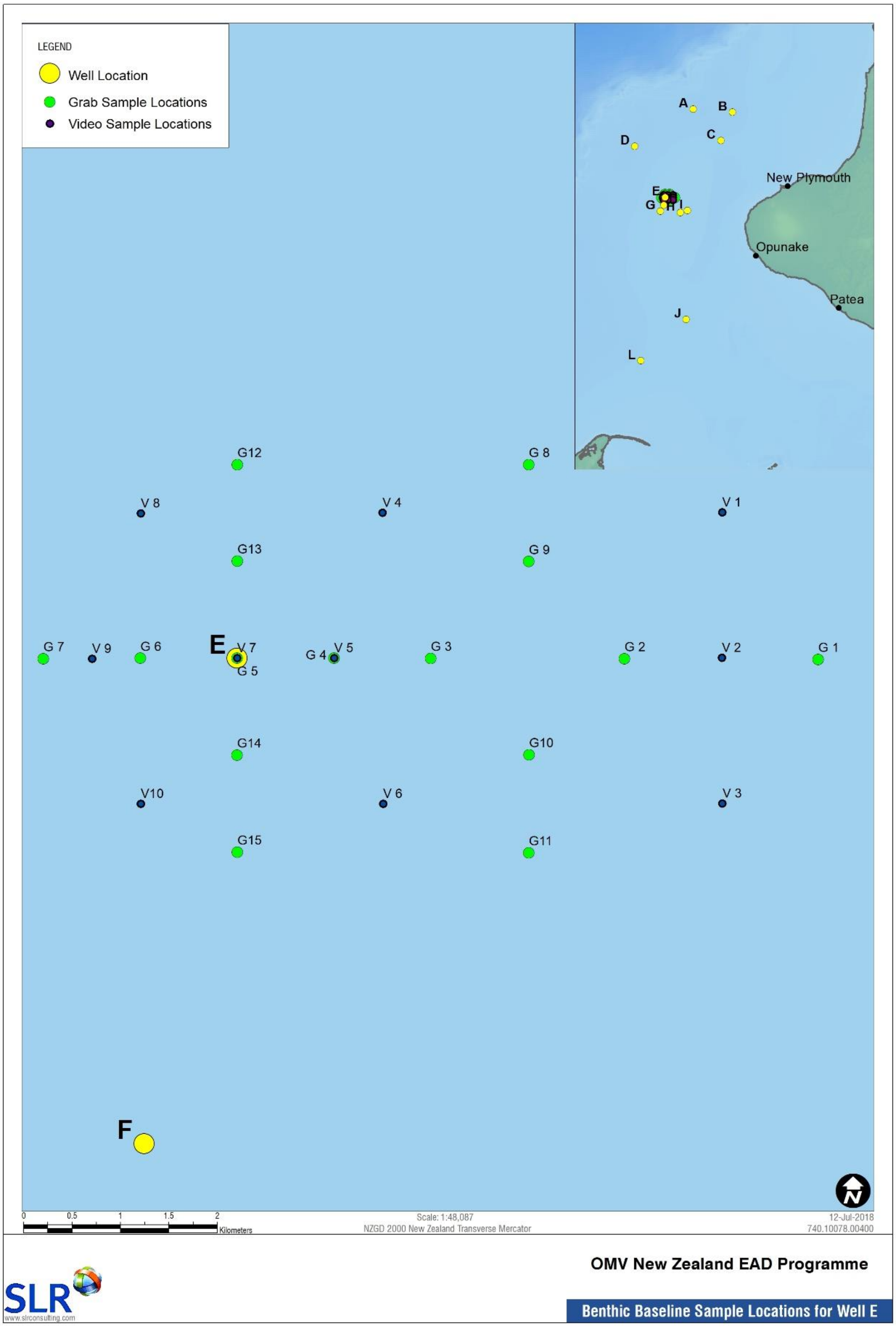
2 Methodology

The Benthic Baseline surveys adopted similar methodologies to what has been previously used for offshore Taranaki benthic monitoring programmes undertaken in accordance with the principles defined in the Offshore Taranaki Environmental Monitoring Protocol (**OTEMP**) (Johnston *et al.*, 2014). This consistent approach enables monitoring results to be compared with previous monitoring programmes undertaken in the offshore Taranaki environment (i.e. pre- and post-drill monitoring and production monitoring).

2.1 Sample Locations

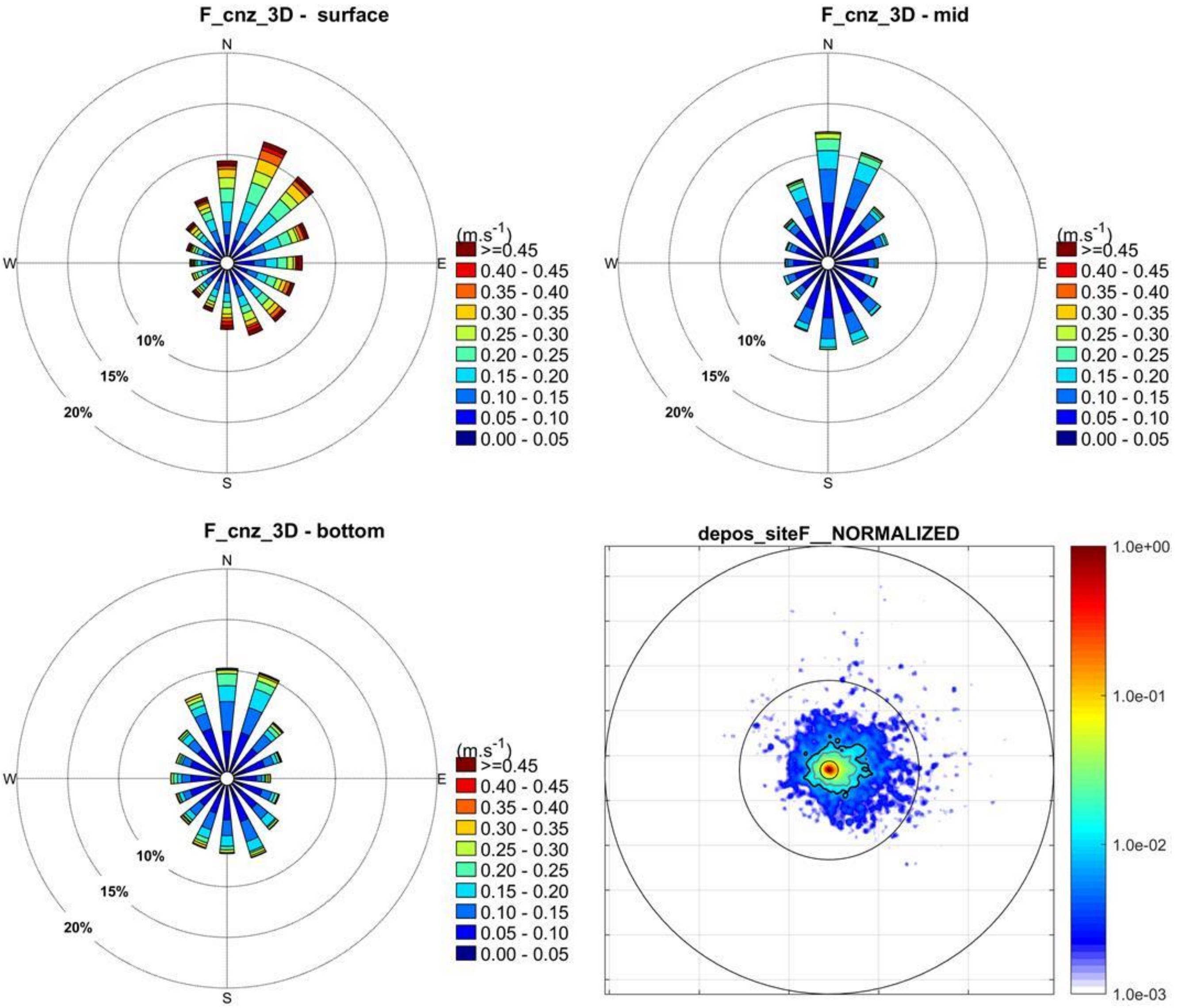
The sample locations (**Figure 2**) were defined by the dominant direction of current flow and preliminary drill cutting deposition modelling results (**Figure 2**). Sample transects were aligned along the dominant deposition pathway (i.e. southeast/northwest) (**Figure 3**) as this is the area determined to be most likely to be impacted from the deposition of drill cuttings should the well be drilled. However, sample stations were also located along the minor flow axis (northeast/southwest) to enable comparisons and validation of spatial differences based on the dispersal patterns predicted by MetOcean Solutions Limited.

Figure 2 Well E Sampling Locations



Note: At each video transect location approximately 250 m of video footage was captured along the seabed in the direction of the vessels drift at the time of sampling.

Figure 3 Surface, Mid-water and Bottom Water Column Current Roses and Dispersal Modelling Plot created by Metocean Solutions Ltd for nearby Well F



2.2 Field and Sampling Procedures

Field sampling was undertaken from the MV *Seaworker* between March 24 and April 8, 2018, following the procedures detailed below. Sampling at Well E took place on April 5th and 6th.

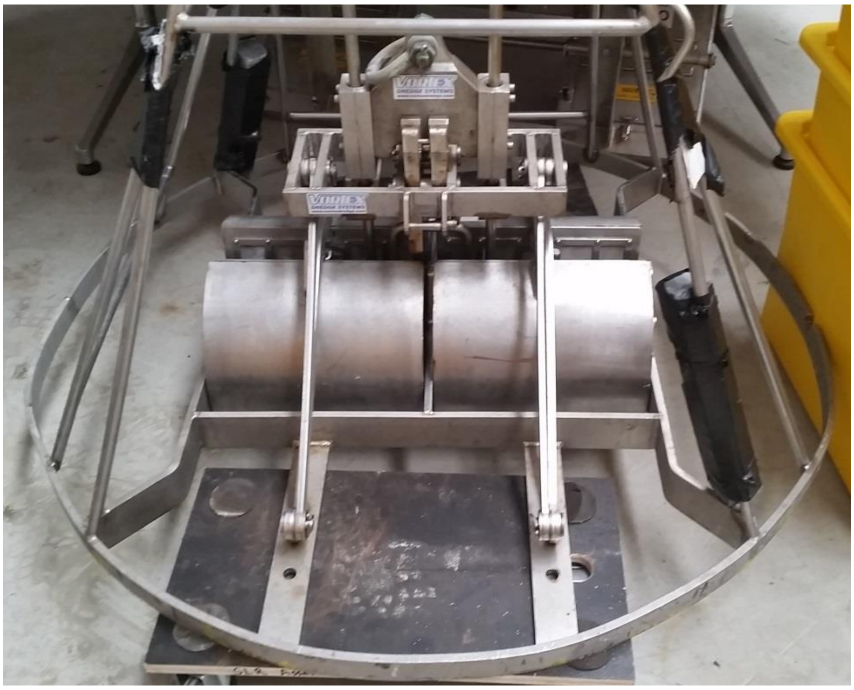
2.2.1 Benthic Grab Samples

A double Van Veen double grab sampler (**Figure 4**) was used to collect a single sediment grab sample at each of the 15 benthic monitoring stations surrounding Well E (**Figure 2**). The grab sampler is constructed of stainless steel and features two independent ‘buckets’ which penetrate the surficial sediments to a depth of 0.16 m. Each successful grab sample returns approximately 0.01 m^3 of seabed sediment back to the surface.

Upon arrival on the vessel deck, each grab sample is checked for completeness, which must meet the following criteria:

- The surface of the sediment is largely undisturbed upon inspection aboard the vessel;
- Sufficient sediment (≥75% of the grab capacity) is collected to enable the full suite of sediment analyses required;
- The infauna sample bucket is filled to the same volume (approximately 10 l) for all infauna replicates throughout the survey; and
- The grab has not been over-filled with sediments pushing out of the doors or drains, indicating that it may have over-penetrated the sediment.

Figure 4 The Double Van Veen Grab Sampler used for the 2018 Benthic Baseline Sampling



Each independent bucket from a grab sample is used separately for infauna and sediment physical and chemical analyses, as follows:

- Bucket one: infauna/macrofauna community analysis. The entire sample is sieved through 0.5 mm mesh until approximately 300 - 500 ml of residual sediment and organisms remain. This remaining material is transferred to a plastic container and preserved with a fixative (AncholTM), ready for analysis by SLR taxonomists.
- Bucket two: sediment physical nature and chemical analyses. Three 64 mm (internal diameter) clear Perspex sub-sampling cores are pushed into the sediments from the second bucket, to a depth of approximately 150 mm. Cores are photographed and the upper 50 mm from each core is extruded into a polyethylene bag for particle grain size distribution and organic content (Total Organic Carbon (**TOC**)) analyses by Hill laboratories.

2.2.2 Seafloor Video Imagery

Video imagery of the seafloor was obtained using a customised tow-sled fitted with high-intensity LED lighting and a high-definition video camera (**Figure 5**). The system was connected to the vessel via a 10 mm dyneema tow-line and a 300 m umbilical cable supplying real-time video images to the camera operator on the research vessel. A pair of parallel lasers on the video sled provided an indication of scale allowing features of interest in the video recordings to be approximately sized. Ten video sled tows were conducted around Well E (**Figure 2**).

The video-sled was launched from the vessel up-current of each pre-determined location and lowered to the seabed, where it auto-located via a series of floats and weights set at specific points on the sled frame, to land upright on its lower skids. At the point where the sled contacted the seabed, a GPS log was started, and this log continued throughout the duration of the tow. Video footage was continuously recorded for approximately 200 m as the sled drifted behind the vessel; this ensured that footage was collected while the sled was passing as close as possible to the required sample location.

Figure 5 The Video Sled used for Collecting Video Footage of the Seabed Environment

2.3 Laboratory Analyses

2.3.1 Sediment Physicochemical Analyses

Benthic sediments collected by the grab sampler were analysed by Hill Laboratories (an NZS/ISO/IEC 17025:2005 accredited laboratory), for both physical and chemical parameters. The aims of these analyses along with further details of the analytical method/descriptions are summarised in **Table 2**.

Table 2 Summary of Analytical Methods used for Testing Sediment Physico-chemical Characteristics

Analyte	Aim	Method Number	Description
Particle Grain Size Distribution	• Determine physical parameters of the sediment particles present at the site • Correlate with infauna community characteristics	Hill Laboratories KB32136	• Sediment was wet-sieved through the following screen sizes, as per the Udden-Wentworth scale (Wentworth, 1922): • >2 mm (gravel) • >1 mm (very coarse sand) • >500 µm (coarse sand) • >250 µm (medium sand) • >125 µm (fine sand) • >63 µm (very fine sand) • <63 µm (silt and clay)
Total Organic Carbon	• Determine current level of organic carbon in sediment • Correlate with infauna community characteristics	No defined method number	Acid pre-treatment to remove carbonates present, followed by catalytic combustion (900° C, O_2), separation, Thermal Conductivity Detector. Elemental Analyser.

2.3.2 Macrofauna Analyses

Macrofaunal analyses focused on the infauna, or animals larger than 0.5 mm living within the sediment matrix. Epifaunal animals (those living on top of the sediment), were also included in the analyses to provide representation of the different functional groups present at each sample station.

Benthic macrofaunal samples collected from the sediment grab were sorted and, with the aid of a binocular microscope, identified to the lowest practicable taxonomic level or most recognisable taxa (morphologically similar group). Counts were made to assess the relative abundance of each taxa.

2.3.3 Seafloor Video Analyses

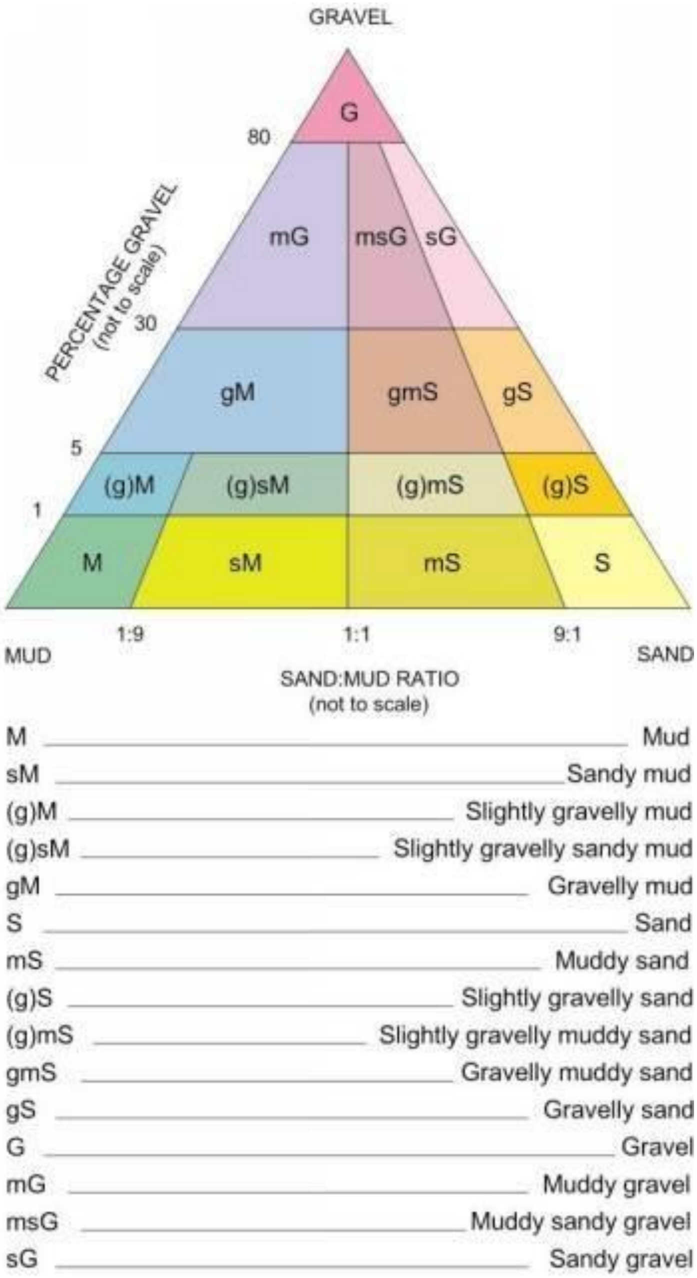
A live feed from the video-sled was captured and recorded on-board the survey vessel and viewed by SLR staff with experience in undertaking assessments of the benthic environment in the offshore Taranaki region. Brief field notes were made in real-time about obvious structures and organisms observed while watching the live footage. Back onshore the recorded seabed video footage was assessed on a large, high definition screen, by a suitably trained and experienced benthic scientist, who identified all obvious epifauna to the lowest practicable taxonomic level. Biogenic and/or anthropogenic seabed structures such as burrows, mounds, tracks and gouges/trenches were also recorded. Relative abundance estimates of epifauna or biogenic structures were made where appropriate.

2.4 Data Analyses

2.4.1 Sediment classifications

While there are many sediment classification schemes in use worldwide, a common one is a modified version of that proposed by Folk (1954). This scheme groups grains within a sample into mud, sand and gravel sized particles based on the particles diameter (mud <63 µm, sand 64-2000 µm, gravel > 2mm), and then describes the sediment type based on the relative proportions of the particles (see **Figure 6**).

Figure 6 Folk (1954) Sediment Type Classification Triangle



2.4.2 Community Characteristic Descriptors

All macrofauna (both epifauna and infauna) taxa were included in the analyses of abundance data. Species identified in the samples as not being exclusively benthic were excluded from further analyses. Data were analysed as per the statistical methods outlined below to identify current distributions and abundance of macrofauna.

2.4.2.1 Univariate Diversity Indices

Diversity indices (number of taxa S, total abundance N, Shannon-Wiener diversity H', and Pielou evenness J' (**Table 3**) were calculated from the macrofauna abundance data using the PRIMER software package (PRIMER v6.1.16; Clarke, 1993; Clarke & Warwick, 1994; Clarke & Gorley, 2006).

Table 3 Description of Macrofauna Community Characteristic Indices

Index	Formula (where applicable)	Description
Number of Taxa (S)	Count of total number of different taxa identified within the *x* sample	Total number of taxa identified within a sample
Total Abundance (N)	Sum of all individual taxa abundances within the *x* sample	Total number/count of all organisms within a sample
Shannon Diversity (H')	$H' = -SUM [(p_i) \times \log_e (p_i)]$ p_i = Number of individuals of taxa i /total number of samples	A single value (log scale) that is used to describe the different types and numbers of organisms present within an assemblage. The index value increases as assemblages have greater numbers of taxa and when the numbers of individual organisms are more evenly distributed across the different taxa. Samples dominated by single taxa will have lower values towards zero.
Pielou Evenness (J')	$J = H' / \log_e (S)$	A value theoretically between zero and one which indicates how evenly the number of individual organisms are distributed through the different taxa in an assemblage. High values (closer to 1) indicate an even spread amongst the taxa present, whereas a low value indicate an uneven spread or an assemblage highly dominated by only a few, or even a single taxon.

3 Results and Discussion

3.1 Sediment Physical and Chemical Properties

3.1.1 Visual Description of Sediment Cores

Sediments collected from around Well E were predominantly soft, cohesive muds which were light tan/light grey in colour near the surface with a slow gradation to a uniform light grey colour approximately 50 – 80 mm beneath the sediment surface (**Figure 7**). No dark-grey or black sediment layers (apparent Redox Potential Discontinuity), or darker patches within the cores were noted and no detectable hydrogen sulphide odours were present, indicating that sediments are well oxygenated throughout the depths sampled. Field observations on sediment texture, colour and any notable features of the sediment samples were recorded during the processing of the sediment cores and infauna samples, and these are included in **Appendix A**. A full set of sediment core photographs are contained in **Appendix B**.

Figure 7 Representative Images of Sediment Core Profiles from Well E

Station E6

Station E9

Station E11

Station E15

3.1.2 Incidental Observations

During the laboratory processing of the infauna samples by SLR taxonomists observations were made of any debris that was present, including those from anthropogenic sources. Within the 15 samples collected around Well E there were 12 types of debris observed (**Table 4**), nine of which were likely to be anthropogenic in source, including nylon strands, plastic fragments, paint flecks and rust flakes. However all debris encountered in the samples were at 'low' abundances.

Table 4 Incidental Observations

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15
Garnet		L													L
Light sand		L					L								
Graphite								L							
Blue nylon							L								L
White nylon															L
Black nylon							L								L
Green plastic										L					
Green paint			L	L											
Yellow paint											L			L	
Green nylon			L												
Red nylon			L												
Rust													L		

VA = very abundant (>50), A = abundant (50+), C = common (20–50), O = occasional (10–20), L = low (0–10)

3.1.3 Sediment Particle Grain Size Distribution and Organic Content

The physical characteristics of the sediment can influence the composition of the infauna communities and the levels of contaminants retained and observed during analyses. Particle grain size is widely used to characterise the physical structure of the sediment, while organic content provides an indication of the organic enrichment in the sediment. These combined results provide a general understanding of sediment health and the source of potential stressors at the time of sampling.

Organic matter found in the sediments is most likely derived from natural sources such as infauna/epifauna and detrital matter, rather than from anthropogenic sources. Anoxic sediments (those lacking oxygen), may develop in situations where organic matter levels increase beyond 'normal' levels for that area. Increased organic matter has the potential to disturb the equilibrium of the benthic ecosystem, as increased numbers of oxygen-utilising bacteria are required to decompose the additional organic matter, thereby rapidly reducing oxygen availability in the sediments.

A summary of the particle grain size and organic content analyses are discussed below, with full results provided in **Appendix C**.

3.1.3.1 Particle Grain Size

Particle grain size analyses at the 15 monitoring stations around Well E are shown in **Figure 8.** Sediments are dominated by the silt/clay (76-90%), fine sand (4-13%) and very fine sand (5-11%) sized fractions, with small proportions of larger sand and gravel sized particles which were largely comprised of broken shell material. These sediments are classed as 'sandy muds' (Folk, 1954), which is the same as most Taranaki areas where exploration/production monitoring has taken place.

The samples with the greatest proportion of silt and clay (mud) were found at monitoring stations E6, E7, E14 and E15 (west and south west of Well E), and the smallest were at monitoring stations E1 and E2 (the eastern extreme). While this appeared to show some sort of pattern in increasing fine sediments towards the west and southwest part of the well area, the trend was weak and inconsistent across the well as a whole.

The sandy muds encountered at Well E were similar to those found at the other wells in the Central and Southern AOIs, with the exception of Well L which was more like the Northern AOI grain size fractions (**Table 5**). A comparison of particle grain size data for Well E with the other wells is provided in **Appendix C.**

In comparison to nearby wells in the offshore Taranaki area mean silt and clay levels at Well E were similar to those seen at the Oi-1/Oi-2 exploration well site in 2016 (72-88% silt and clay (SLR, 2017b)) (30 km south-east of Well E), and slightly higher than those found in the Tui field in February 2018 (60 - 77% silt and clay (SLR, 2018)) (32 km south-south-east of Well E).

Figure 8 Sediment Particle Grain Size Distribution for Samples Collected at Well E

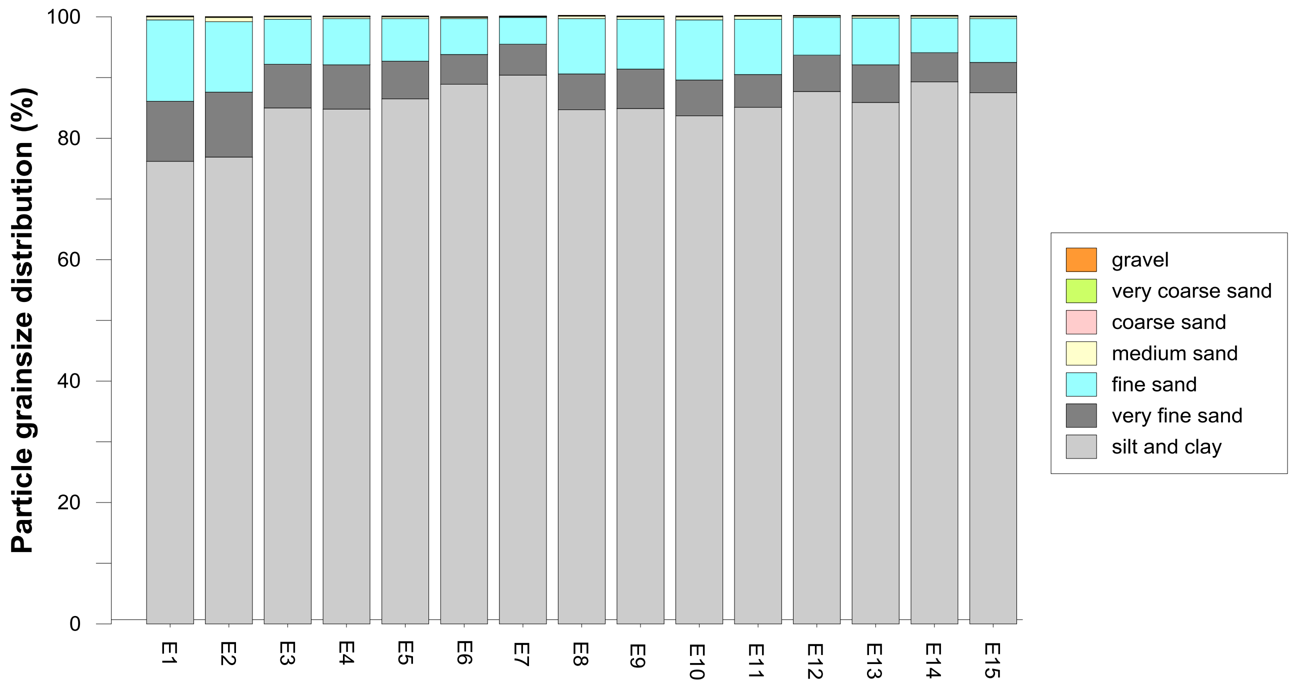


Table 5 Average Grain Size for the Eleven Wells

Grain size class	A	B	C	D	E	F	G	H	I	J	L
Silt & Clay (Mud) (%)	36.2	27.5	41.1	30.7	85.2	83.2	67.8	72.6	65.1	85.4	30.8
Very Fine Sand (%)	45.8	39.3	30.5	41.7	6.5	4.8	6.1	5.8	6.6	14.2	25.4
Fine Sand (%)	17.0	28.6	22.4	26.8	8.0	11.3	24.6	19.0	22.1	0.4	29.8
Medium Sand (%)	1.0	2.4	3.3	0.7	0.4	0.6	1.6	2.5	5.1	0.1	12.3
Coarse Sand (%)	0.1	0.7	0.8	0.0	0.0	0.1	0.1	0.1	0.6	0.0	1.2
Very Coarse Sand (%)	0.0	0.6	0.5	0.0	0.0	0.1	0.1	0.1	0.5	0.0	0.2
Gravel (%)	0.1	1.1	1.3	0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.1
Description	mS	mS	mS	mS	sM	sM	sM	sM	sM	sM	mS

Note: sM = sandy mud, mS = muddy sand

Colour scale based on percentage with median mid-point (median is 2.0):

0%	5	10	20	30	40	50	60	70	80	90	100

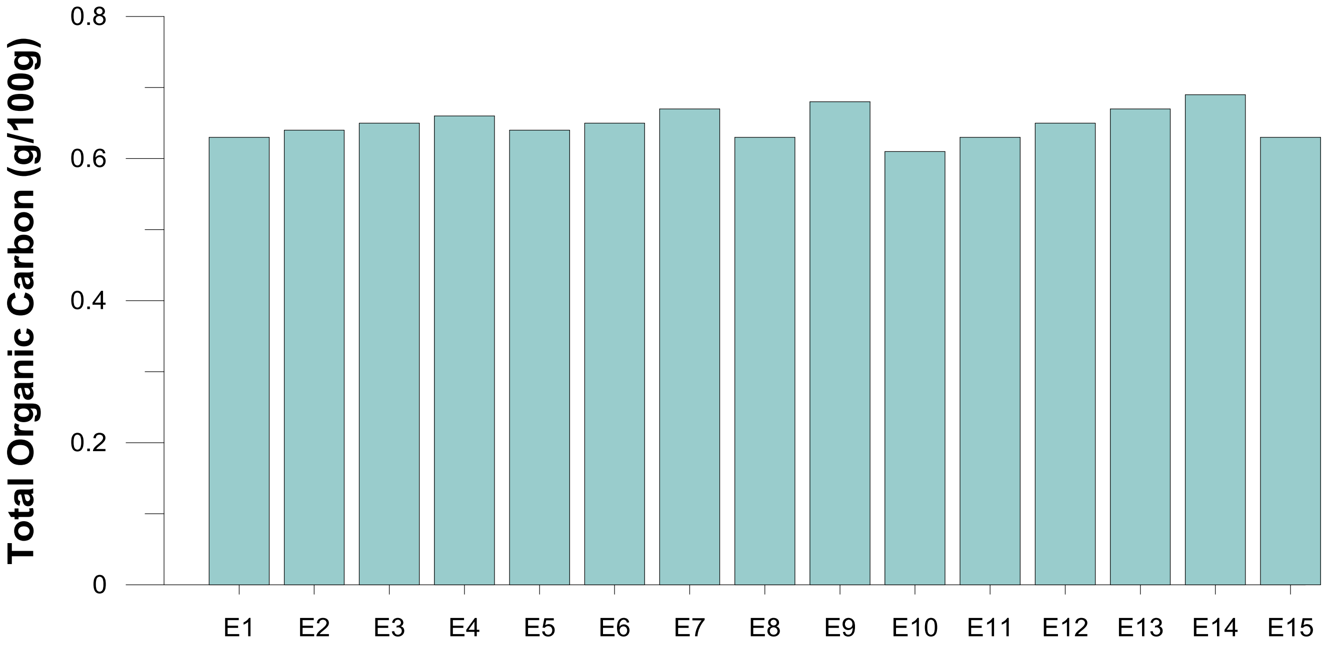
3.1.3.2 Total Organic Carbon

The organic content of sediments was assessed by measuring TOC to assess benthic ecology as this is also consistent with what is now currently undertaken around the offshore Taranaki oil and gas fields.

TOC levels at around Well E ranged between 0.61% to 0.69% (mean 0.65%) (**Figure 9**). Neighboring stations E9 and E10 had the highest and lowest levels, despite being just 2 km apart. There does not appear to be a spatial pattern with these results.

The average organic content of all 15 monitoring stations around Well E was high relative to the other EAD wells (mean 0.65% compared to overall mean of 0.45%). The combined mean from all stations at the five Central AOI wells (0.59%) was high relative to the Northern and Southern AOI wells (0.26% and 0.48%, respectively). As has been previously described in benthic environmental monitoring associated with offshore Taranaki oil and gas activities (SLR, 2016, & SLR, 2017), there is a correlation between sediment particle grain size and sediment organic content. The comparatively greater surface area to volume ratio of silt and clay (mud/fines) sized sediment particles (compared to larger particles like sand) gives a greater area for adsorption of organic matter particles and therefore a higher probability of elevated organic matter compared to coarser/sandier sediments subjected to the same level of enrichment (Hedges *et al*., 1993). This is likely to at least partially explain the lower organic content of sediments at the Northern AOI wells, where sediment grain size is distinctly coarser than at the Central and Southern AOI wells.

Figure 9 TOC Concentrations in Sediment Samples Collected from around Well E



3.2 Video Sled Imagery

Video footage of the seabed allows scientists to visually assess any anthropogenic disturbance to the benthic environment and observe epifauna, sediment-type and structures or relief that exist on the seabed.

Video footage was captured by towing a video sled through ten stations around Well E (**Section 2.2.2**). All video footage is included with the electronic version of this document, with a selection of still images displayed in **Figure 10**. **Appendix A** provides locational information for each video sled tow.

Video footage was assessed to determine any defining features and their semi-quantitative abundance recorded for comparison with other sites. Due to caveats associated with video footage (i.e. variable visibility, differing tow length and durations) the counts are indicative-only and should not be interpreted as a quantitative assessment. **Table 6** presents the results of this semi-quantitative approach, which summaries the counts by comparing the site total to the median across all of the EAD wells in the three AOIs. As a visual aid, counts were categorised in relation to the deviation from the 10th, 25th 50th, 75th and 90th percentiles, so that differences between wells can be more easily viewed.

3.2.1 Physical Observations

The seabed around Well E was observed to be dominated by soft mud sediments. Evidence of bioturbation was observed in all video tows in the form of animal burrows. Moderate numbers of burrows dominated in Well E video tows (images C, D, E and F, **Figure 10**) relative to those observed at other wells. This is similar to other wells in the Central and Southern AOIs but differs from the Northern AOI where abundances were predominantly low (**Table 6**).

Mound/hollow features (images F and H, **Figure 10**) were observed throughout the video tows, but were smaller and in lower numbers (29) at Well E compared to the median (43) for all wells (**Table 6**). The highest abundances were observed at Well D (280) (Northern AOI) and Well L (532) (Southern AOI). These features are thought to be formed by the feeding activities of sharks or rays, or by large burrowing tube worms mounding up sediment. Mound/hollow features were observed to be more numerous at the Northern AOI wells, moderate to very high at the Southern AOI wells, and low to very low in numbers around the Central AOI wells.

As expected, there was no sign of anthropogenic physical disturbance of the seabed observed during any of the video sled tows around Well E. There were no signs of sediment enrichment such as darker sediment patches, bacterial mats or sediment off-gassing, observed during any of the video sled tows around Well E.

Table 6 Total Number of Features Observed in Video Imagery from the EAD Wells

Well	Depth (m)	Mounds/ Hollows	Number of burrows/worm holes	Sea pen	Fish	Substrate	Notes
A	148	111	Low-moderate	54	65	Muddy sand	Ripples; some very large holes and mounds
B	134	63	Low-moderate	35	49	Muddy sand	Some very large holes mounds
C	132	85	Low-moderate	50	44	Muddy sand	Ripples; trenches observed
D	145	280	Low	160	28	Muddy sand	Ripples; 23 very large sea feathers
E	126	29	Moderate	29	16	Sandy mud	
F	128	20	Moderate	19	19	Sandy mud	
G	124	18	Moderate-High	29	26	Sandy mud	
H	124	18	Moderate-High	17	26	Sandy mud	12 elongated shallow trenches
I	122	43	Moderate-High	36	21	Sandy mud	5 elongated shallow trenches (large)
J	108	42	Moderate	14	30	Sandy mud	School of mackerel, tufts/tubes common
L	112	532	Moderate	132	31	Muddy sand	2 schools of mackerel
Median		43		35	28		

Totals are sum of 10 video tows carried out at each well. Totals are semi-quantitative only due to variable visibility and transect length.

10th percentile band
25th percentile band
Median band
75th percentile band
90th percentile band

3.2.2 Infauna, Epifauna and Other Fauna

In some cases, a definitive positive identification of infauna, epifauna and more mobile taxa was not possible from the video footage alone. Where there was any uncertainty, identifications were based on distinctive features, colours and shapes of organisms and in some cases the confirmed presence of similar looking individuals within the infauna samples.

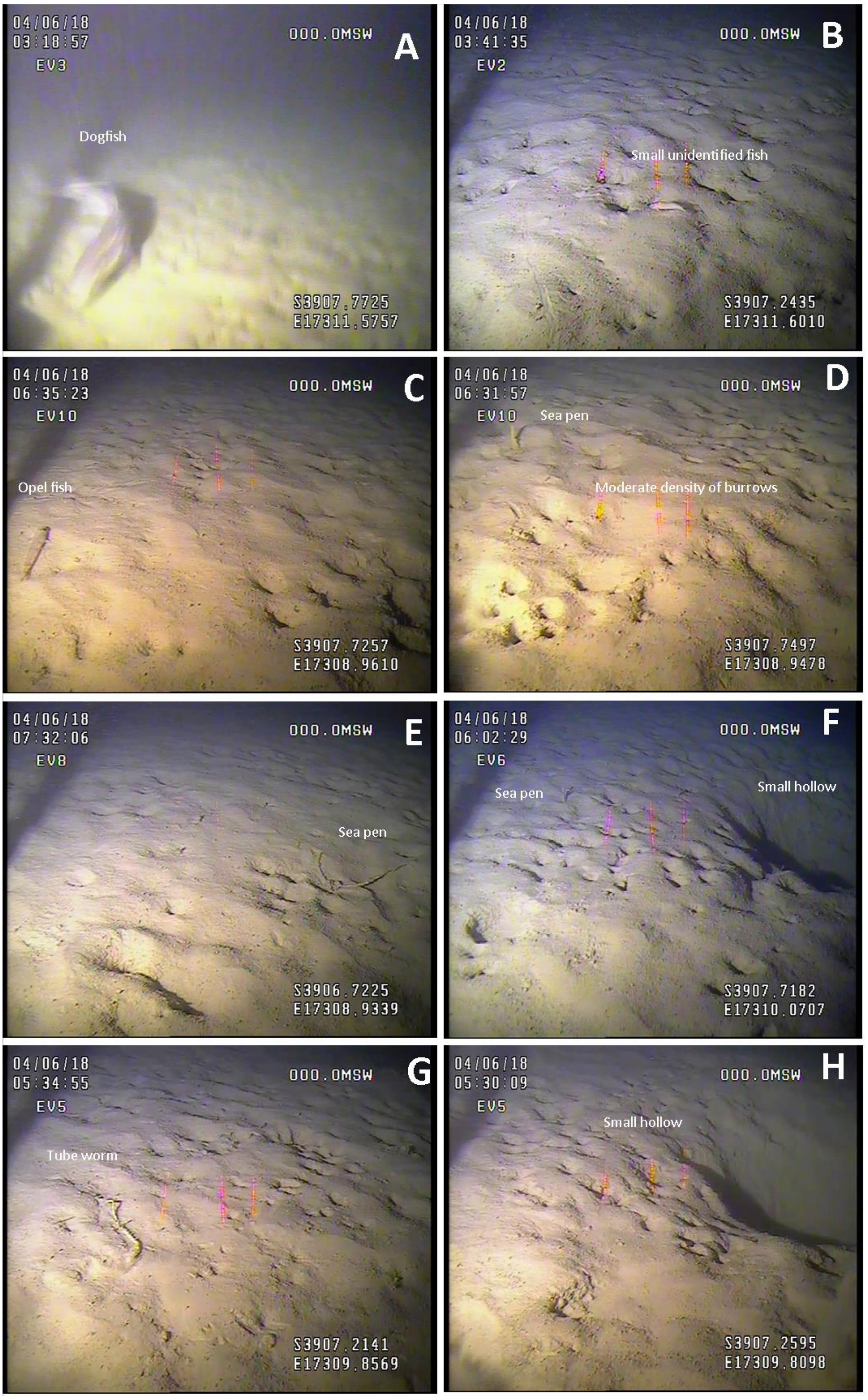
Epifauna taxa observed in video footage collected around Well E included a small number of whelks (likely *Austrofusus glans*), hermit crabs (*Pagarus* sp.), and tusk shells (likely *Fissidentalium zelandicum*). The presence of epifauna tracks in the sediment indicates that mobile fauna such as whelks and hermit crabs move throughout this area. A small number of sponges were observed in most video tows; however, some of these may have been tunicates. Tube worms were also present (image G, **Figure 10**).

Sea pens (likely *Virgularia* sp.) (images D, E and F, **Figure 10**) were observed in low numbers (29) around Well E compared to the median (35) for all wells (**Table 6**). The highest abundances were seen at Well D (160) (Northern AOI) and Well L (132) (Southern AOI). Sea pens were observed to be more numerous at the Northern AOI wells, variable at the Southern wells, and lowest in the Central wells.

Mobile fish species were observed in very low numbers (16) around Well E compared to the median (28) for all wells (**Table 6**). Species observed include sand eel[1], flatfish (likely *Peltorhamphus* sp.), dogfish (*Squalus acanthias.)* (image A, **Figure 10**) and opalfish (likely *Hemerocoetes monopterygius*) (image C, **Figure 10**). A number of smaller fish were observed swimming off very quickly as the camera approached, so it was not possible to make a positive identification. Across the region surveyed, fish numbers were observed to be much more numerous in the Northern AOI wells, moderate at the Southern AOI wells, and moderate to low around the Central AOI wells.

[1] This fish was unable to be formally identified, thus while the term 'sand eel' is used throughout this report it should not be considered a common name for this unidentified fish species.

Figure 10 Representative Images of Seabed Environment around Well E



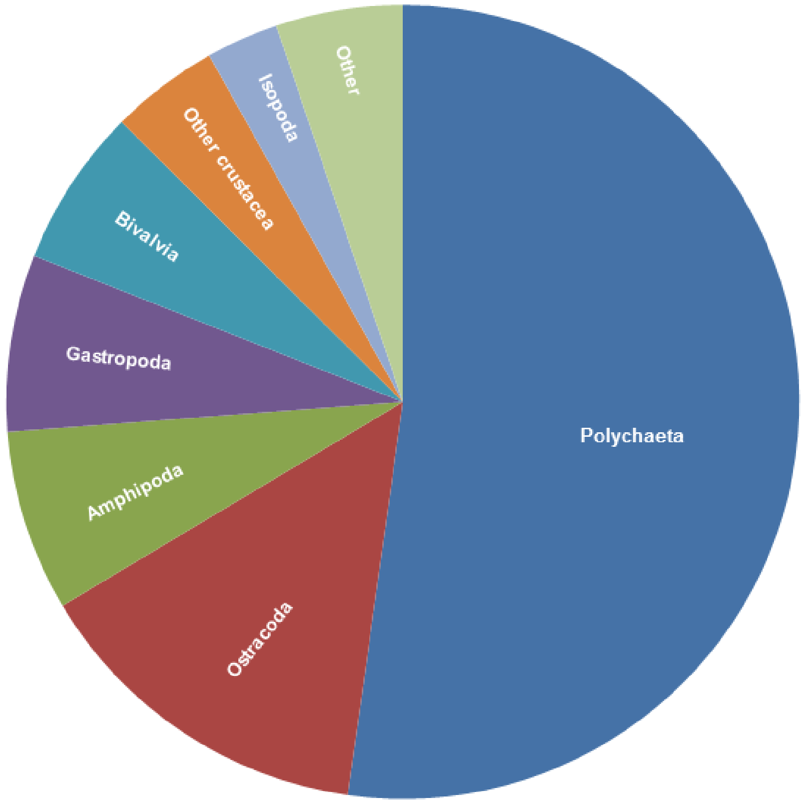
3.3 Macrofauna Characteristics

3.3.1 Benthic Macrofauna

Overall 542 individuals representing 78 taxa were identified in the macrofauna samples collected across the Well E monitoring locations. Infauna communities were dominated by small polychaete worms (283 individuals (52%), 27 taxa)), crustaceans (157 individuals (29%), 25 taxa, mostly Ostracoda and Amphipoda), and molluscs (77 individuals (14%), 18 taxa, mostly Gastropoda and Bivalvia) (**Figure 11** and **Figure 12**). The infauna communities around Well E were similar to communities found during pre- and post-drill monitoring at the Oi well south-east of Well E and those found during ongoing production monitoring in the nearby Tui field.

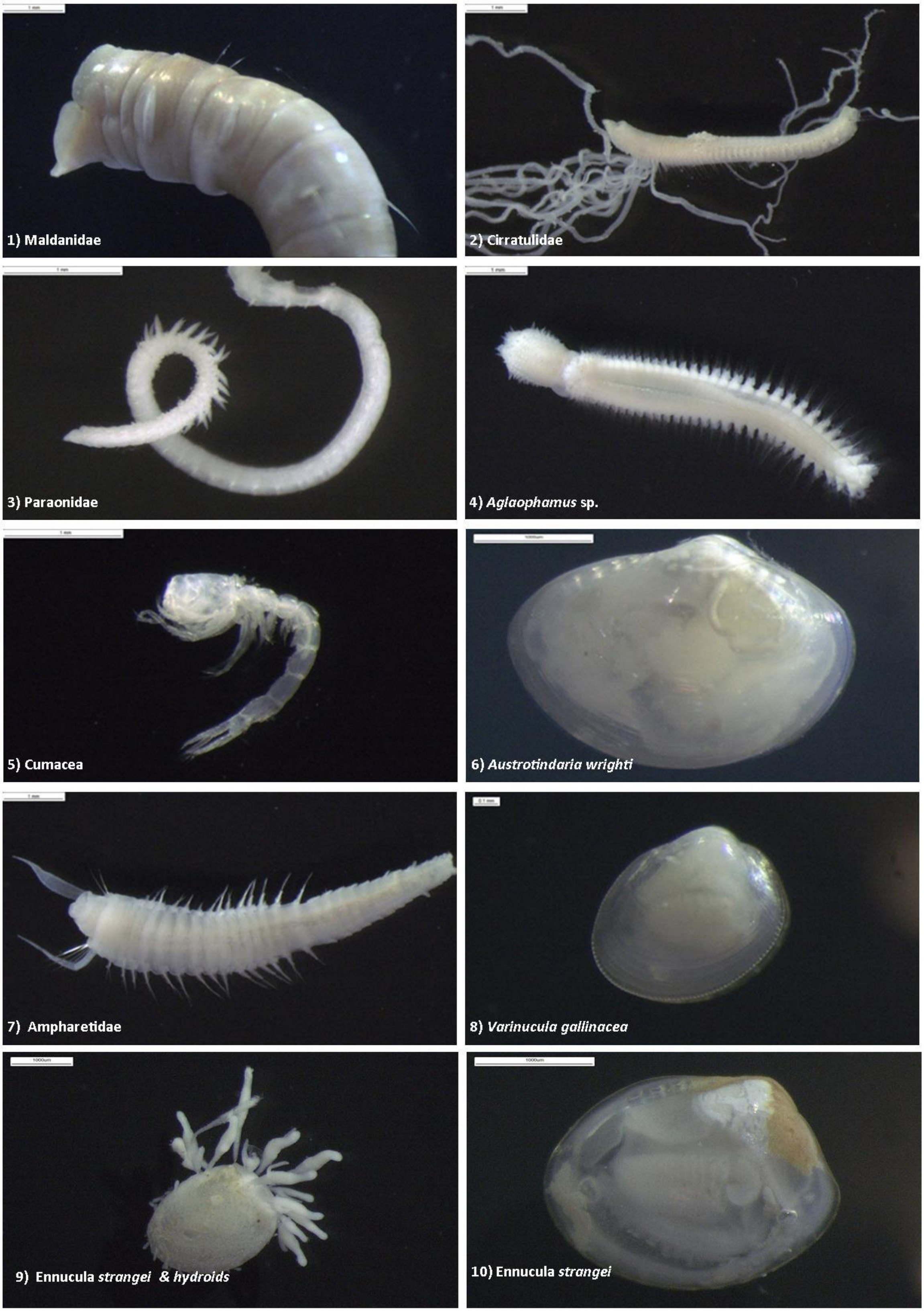
When the benthic macrofauna results are compared across the three AOIs, polychaetes and gastropods were found in lower numbers in the Southern and Northern AOIs compared to the Central AOI. Crustaceans (Tanaidacea and Copepoda) and nematodes were found in higher numbers in the Northern AOI wells compared with Central and Southern AOIs (**Appendix E**). This result is likely linked to the differences in sediment composition, where a coarser grain size was present in the Northern AOI compared to the Central and Southern AOIs.

Figure 11 Proportion of Well E Individuals Belonging to each Taxonomic Group



'Other Crustacea' includes Copepoda, Cumacea, Euphausiacea and Tanaidacea. 'Other' includes Cephalopoda, Caudofoveta, Scaphopoda, Nematoda, Nermetea, Oligochaeta, Annelidia and Tunicata.

Figure 12 Representative Images of Benthic Infauna Taxa Frequently Observed in Offshore Taranaki Area



3.3.2 Univariate Indices of Infauna Communities

Univariate indices (total number of taxa, total abundance, Pielou's evenness and Shannon-Wiener diversity) describing the benthic macroinvertebrate communities found around Well E are displayed in **Figure 13**. The number of infauna taxa identified in each sample collected around Well E varied from 9 to 30 (mean 19), and total abundances varied widely (13-67, mean 36). Abundance and taxa numbers at Well E were the lowest of the 11 wells assessed during the Benthic Baseline survey, lower than the overall mean values for the Central AOI (29 taxa, 69 individuals, **Table 7**), which were distinctly lower than those of the Southern, and especially the Northern AOI.

Evenness values vary on a scale between zero and one, with values near one indicating that infauna abundances are evenly distributed across all the different taxa present, while values near zero indicate infauna communities are being numerically dominated by a large number of individuals from just a few, or even only single taxa. Values from the samples collected at Well E were relatively high (mean 0.92), indicating relatively even distribution of abundances across the taxa that were present. Monitoring station E2, which had the highest number of taxa and highest abundance, scored lower than the surrounding stations due to high numbers of cephalopod eggs, amphipods and gastropods compared to other monitoring stations.

Shannon-Wiener diversity index values range between 0 and 4 with higher values indicating higher species diversity. From previous benthic studies in the offshore Taranaki region, species diversity values are normally between 1.5 and 3.5. The mean Shannon-Weiner diversity index for Well E was 2.7, and ranged between 2.0 and 3.1. When these results are compared to the most recent results from long term benthic monitoring programmes at the Maari Field (diversity index of 2.9) in the Southern AOI it is shown that the species diversity is lower at Well E.

Figure 13 Total Number of Taxa, Total Abundance, Pielou's Evenness and Shannon Wiener Diversity Index Values for Macrofauna Samples Collected at Well E

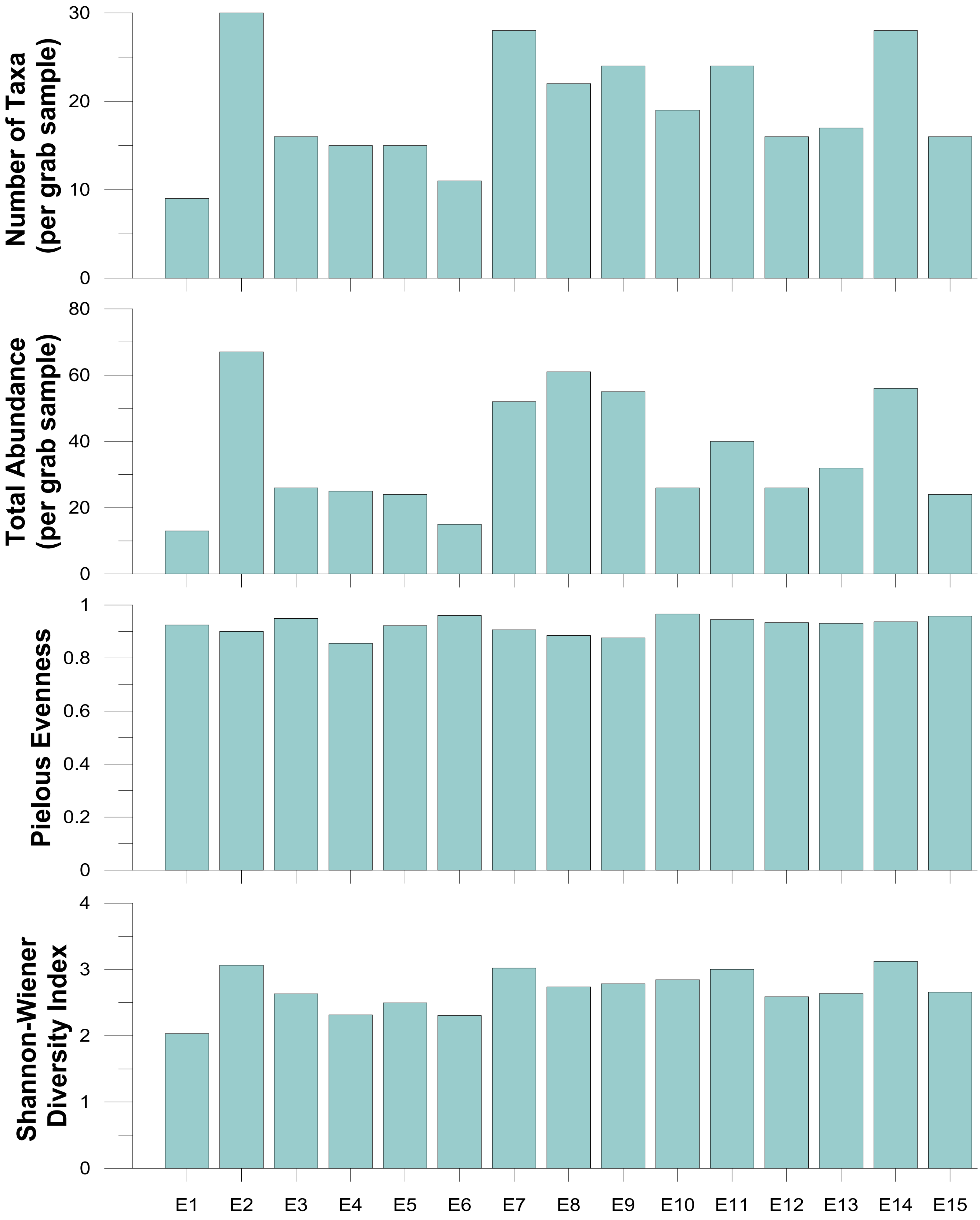


Table 7 Number of Taxa and Total Abundance for the Eleven Wells

Well	Mean Number of Taxa	Mean Abundance	Total Number of Taxa Identified at well	Total number of individuals (abundance)
A	56	257	140	3,849
B	53	210	130	3,151
C	45	132	128	1,987
D	60	332	142	4,986
Northern AOI	53	233		
E	**19**	**36**	**78**	**542**
F	31	68	90	1,023
G	33	81	112	1,215
H	31	89	103	1,339
I	29	72	91	1,075
Central AOI	29	69		
J	40	115	108	1,722
L	54	190	131	2,853
Southern AOI	47	153		

3.4 Sensitive Environments

In an investigation of sensitive substrate/benthic habitats in the Taranaki Coastal Marine Area, Johnston (2016) studied marine taxa databases from marine benthic surveys conducted in the offshore Taranaki Basin and noted that there are many locations where at least one ‘characteristic species of sensitive environments’ was found. This investigation used the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activities Regulations**) sensitive environments descriptions to define what sensitive habitats may be present.

Chaetopteridae worms and Sea pens were noted by Johnston (2016) as likely to be present in areas close to the eleven wells. In relation to the sampling techniques used in the Benthic Baseline survey (grab sampling and video sled imagery), MacDiarmid *et al*. (2013) define that;

“A sensitive Chaetopteridae worm field is present if worm tubes and/or epifaunal species:

- Occupy 25% or more of the seabed in imaging surveys covering and area of 500 m^2 or more; or
- Occur in two successive samples collected using point sampling gear.”

and

“A sea pen field exists if:

- One or more specimens of any species of sea pen is found in two successive samples collected using point sampling gear, or
- Two or more specimens per m^2 are found in seabed imaging surveys, or surveys using towed gear.”

Analysis of the infauna samples collected during the Benthic Baseline survey found that Chaetopteridae worms (specifically *Phyllochaetopterus socialis*, commonly known as wire-weed or Tarakihi weed) were present within samples from Wells A, B, C, D, G, H, J and L. As no individuals of *P. socialis* were recorded in any samples from Well E, it is unlikely (although not impossible) this this sensitive environment is present at this well.

No sea pens (*Virgularia gracillima*) were identified in infauna samples from Well E during the Benthic Baseline survey. However, video imagery collected observed sea pens at all of the wells (see **Table 6** for total numbers of sea pens observed each well). Sea pen numbers observed at Well E were relatively low (total of 29 individuals) when compared to other wells such as Wells D (total of 160 individuals) and L (total of 132 individuals). Low-moderate sea pen numbers at Well E were similar to other sites in the Central AOI, where low numbers (17 – 36 individuals) were present throughout. Due to video sled tows being only a semi-quantitative survey method it is not possible to make exact predictions on the densities of sea pens encountered. However, as a conservative estimate the width of the camera's field of view could be estimated at one metre, and given that each video sled covered 200 metres across the seafloor, approximately 2000 m^2 of seabed could have been viewed by all the video imagery at this site. Based on such calculations sea pen densities at Well E would not have surpassed the trigger of two sea pens per square meter as an average across the entire area (MacDiarmid *et al*., 2013). Video tows at Well E were not observed to pass through more spatially limited areas of distinctly higher sea pen density that might have been classed as 'sea pen fields'. Based on the video sled analysis there are no 'Sensitive Environments', as defined by the Permitted Activities Regulations were encountered at the monitoring stations at Well E.

4 Key Findings

4.1 Sediment Characteristics

Sediments sampled at Well E were sandy muds containing small amounts of fine sands, similar to the other wells in the Central AOI, but notably finer/muddier than sediments in the Northern AOI.

TOC levels in the area (mean 0.65%) were also similar to the rest of the Central AOI, which were all distinctly higher than the Northern AOI. Particle grain size distribution showed a weak trend of increasing silt and clay proportions towards the west/southwest parts of the well area but the pattern was not consistent across all sampling stations. Variations in silt and clay proportions correlated with the small variations in TOC, similar to the larger and wider trend of higher TOC in sandy mud sediments of the central regions compared to lower TOC in muddy sands of the Northern AOI.

Sediments with a finer grain size will retain higher levels of organic matter compared to coarser/sandier sediments subjected to the same level of enrichment/deposition, due to the greater surface area of finer particles for adsorption.

4.2 Faunal Characteristics

Video sled imagery at Well E showed a relatively flat, muddy seabed, interrupted by mounds/hollows and pock-marked with animal burrows/holes. Whelks, small molluscs (tusk shells), hermit crabs, seapens, fish and a small number of sponges were observed during the tows. Mobile fish numbers at Well E were found to be low (similar to other Central AOI wells) compared to Northern (high) and Southern (moderate to high) AOI sites.

Infauna communities in Well E samples were dominated by small polychaete worms (52%), crustaceans (29%, mostly ostracods and amphipods), and molluscs (14%, gastropods and small bivalves). Amphipods, ostracods and gastropods formed greater proportions of the total infauna community at Well E compared to the remaining central AOI sites. Central AOI infauna communities had the greatest proportions of polychaetes and gastropods, but the lowest proportions of crustaceans like amphipods and tanaidaceans, reflecting the muddier sediments in the Central AOI which are more suited to deposit feeding/scavenging taxa like many of the polychaetes and gastropods found at Well E.

Mean taxa numbers and infauna abundances at Well E were the lowest of the 11 sites surveyed and were lower than overall mean values for the Central AOI, which were in turn notably lower than those of the Northern AOI.

The finer sediments present at Well E, and other Central AOI wells, compared to coarser sandy sediments of Northern AOI, are likely linked to the greater proportions of taxa such as polychaetes and gastropods. Taxa found at Well E that were within these groups that were largely scavengers/detritivores and/or deposit feeders which feed on larger dead materials on/in the sediment, as well as organic matter within the sediments. This feeding mechanism is more suited to muddy sediments where there is comparatively greater proportions of organic matter for given volumes of sediment, compared to coarser sediments such as sands.

4.3 Sensitive Environments

Some individuals representing '*characteristic species of sensitive environments*' were found within the macrofauna samples (e.g. Chaetopteridae worms) and observed in video tows (e.g. sea pens) during the Benthic Baseline survey at Well E. However, observations from the video imagery indicated that no 'Sensitive Environments', as defined by the Permitted Activities Regulations (using MacDiarmid *et al.*, 2013) were encountered at the monitoring stations surveyed at Well E in 2018.

5 References

Clarke K. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18 (1): 117-143.

Clarke K.R., Warwick R.M., 1994. Change in marine communities: An approach to statistical analysis and interpretation. Plymouth Marine Laboratory, UK.

Clarke K.R., Gorley R.N., 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth.

Folk, 1954. *"The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature",* The Journal of Geology 62(4):344-359.

Hedges JI, Keil RG, Cowie GL, 1993, "Sedimentary diagenesis: organic perspectives with inorganic overlays", Chemical Geology 107: 487-492.

Johnston O, Barter P, Ellis J, Elvines D, 2014, "*Recommendations for an Offshore Taranaki Environmental Monitoring Protocol: Drilling- and production-related discharges, Version 1.0*" (OTEMP), Cawthron Report No. 2124.

Johnston O 2016. Sensitive habitats and threatened species in the Taranaki Coastal Marine Area (TCMA) - database investigation. Prepared for Taranaki Regional Council. Cawthron Report No. 2877. 28 p. plus appendices.

MacDiarmid, A., Bowden, D., Cummings, V., Morrison, M., Jones, E., Kelly, M., Neil, H., Nelson, W., Rowden, A., 2013. '*Sensitive marine benthic habitats defined*'. Prepared for Ministry for the Environment, NIWA Client Report No: WLG2013-18.

SLR, 2016. "*Benthic Ecological Survey – Tui Field facilities. Production Discharge Monitoring, February 2016*" prepared for AWE Taranaki Limited, report number 740.10040.

SLR, 2017a, "*Benthic Ecological Survey for the Maui Platform Alpha. Annual Production Monitoring – April 2017*", prepared for Shell Todd Oil Services Limited, SLR Report Number 740.10041.00300-R01--v0.1

SLR, 2017b. "*Benthic Ecological Survey for the Oi-1 and Oi-2 Exploration Wells. Post-drill Assessment – November 2016"*. Prepared for Tamarind Taranaki Limited, report number 740.10025.00100-R01.

SLR, 2018. "*Tui Field Ecological Effects Monitoring Report"*. Prepared for Tamarind Taranaki Limited, report number 740.10040.00100-R01-v0.1.

APPENDIX A

Locations and Observations from Sediment Grab Sampling and Video Sled during the 2018 Benthic Baseline Survey

Station	Date	Time	Depth (m)	Coordinates (NZTM)		Notes
				Easting	Northing	
Grab Samples						
EG 1	5/4/18	0744	124	1619498	5669755	Light-grey/brown cohesive mud
EG 2	5/4/18	0758	124	1617499	5669761	Light-grey/brown mud, cohesive but with slightly softer surface layer
EG 3	5/4/18	1004	124	1615497	5669764	Softer light-brown/grey mud
EG 4	5/4/18	1034	124	1614499	5669767	Cohesive light grey coloured mud
EG 5	5/4/18	0901	124	1613498	5669767	Softer light grey mud
EG 6	5/4/18	1148	124	1612499	5669767	Cohesive light grey/brown mud
EG 7	5/4/18	1132	124	1611498	5669761	Long break since previous station to fix water leak onboard. Sediments light grey colour softer mud
EG 8	5/4/18	0942	124	1616508	5671766	Light grey cohesive mud
EG 9	5/4/18	0952	124	1616510	5670765	Light grey/brown softer mud
EG10	5/4/18	0814	124	1616513	5668770	Light brown/grey muds
EG11	5/4/18	0824	124	1616508	5667757	Cohesive mud, light grey/brown
EG12	5/4/18	0922	124	1613500	5671766	Light grey/brown mud, more cohesive than previous sample
EG13	5/4/18	0913	124	1613500	5670769	Softer light grey/brown mud
EG14	5/4/18	0851	124	1613498	5668766	Cohesive light grey/brown mud
EG15	5/4/18	0840	124	1613499	5667766	Softer light grey mud, still quite cohesive though.
Video Sled Tow Locations						
EV 1	6/4/18	0759	125	1618507	5671272	
EV 2	6/4/18	0738	125	1618504	5669771	
EV 3	6/4/18	0718	126	1618508	5668269	
EV 4	6/4/18	0828	126	1614999	5671271	
EV 5	6/4/18	0924	127	1614499	5669767	
EV 6	6/4/18	0949	128	1615005	5668263	
EV 7	6/4/18	0900	127	1613498	5669767	
EV 8	6/4/18	1117	129	1612502	5671264	
EV 9	6/4/18	1051	128	1611998	5669763	
EV10	6/4/18	1023	128	1612504	5668265	

APPENDIX B

Sediment Core Profile Images from all Grab Samples Collected during the 2018 Benthic Baseline Survey at Well E


E1.JPG


E10.JPG


E11.JPG


E12.JPG


E13.JPG


E14.JPG


E15.JPG


E2.JPG


E3.JPG


E4.JPG


E5.JPG


E6.JPG


E7.JPG

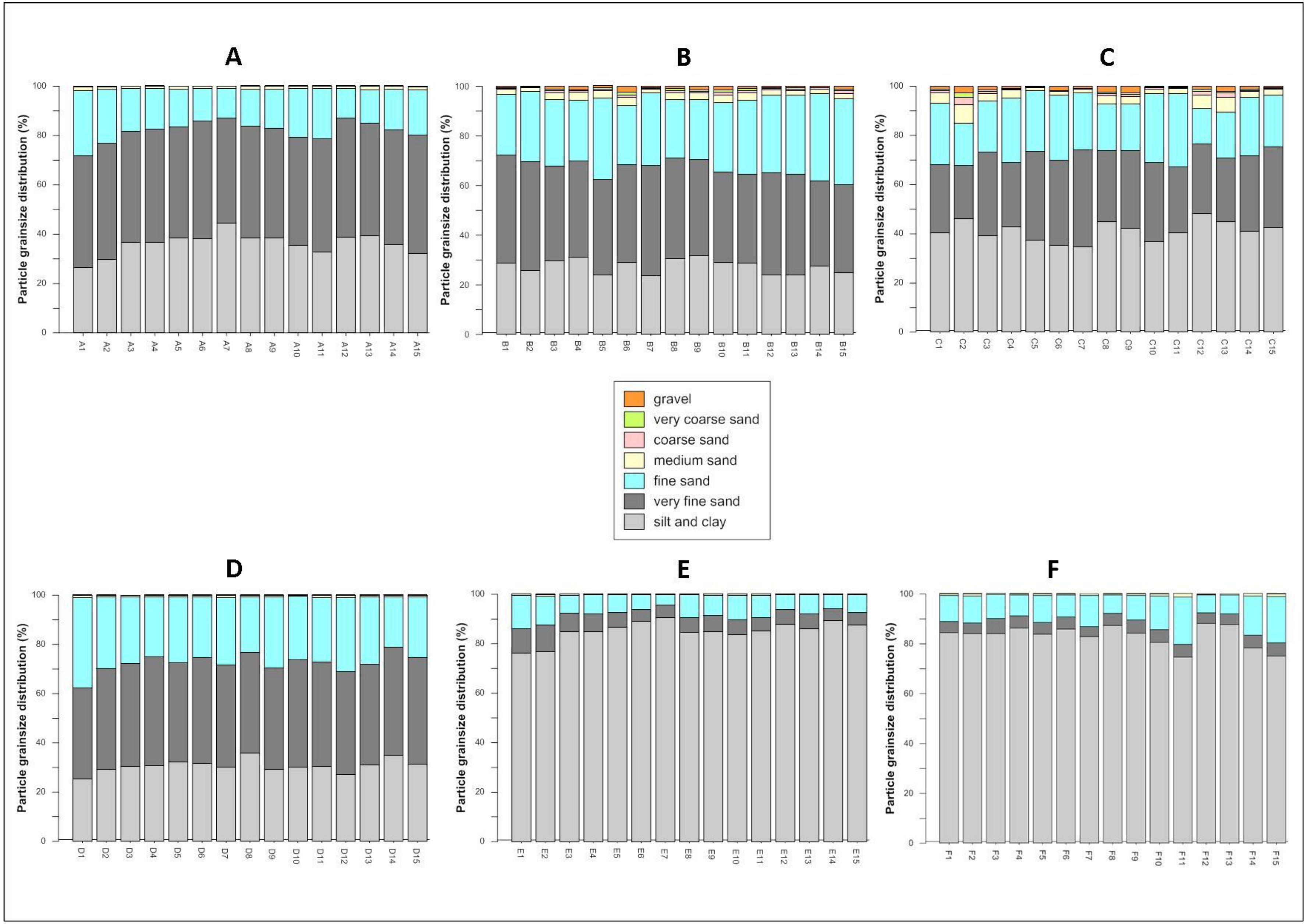

E8.JPG


E9.JPG

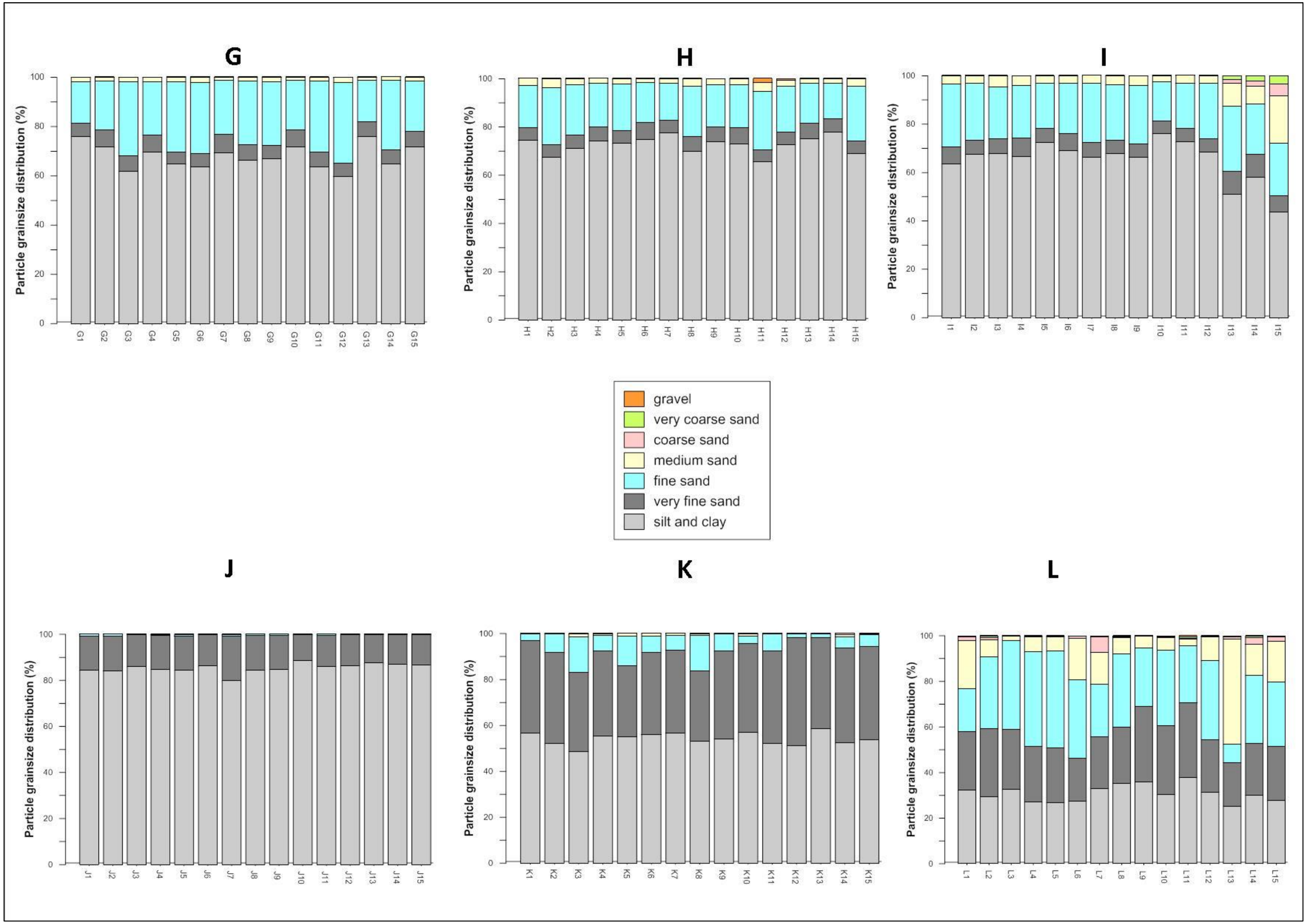
APPENDIX C

Total Organic Carbon Content and Particle Grain Size Distribution for Well E

Replicate Sample	TOC (%)	Gravel (%)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Silt & Clay (Mud) (%)
Station E1	0.63	< 0.1	< 0.1	< 0.1	0.5	13.4	9.9	76.2
Station E2	0.64	< 0.1	< 0.1	< 0.1	0.7	11.6	10.7	76.9
Station E3	0.65	< 0.1	< 0.1	< 0.1	0.4	7.4	7.2	85
Station E4	0.66	< 0.1	< 0.1	< 0.1	0.3	7.6	7.3	84.8
Station E5	0.64	< 0.1	< 0.1	< 0.1	0.3	7	6.2	86.5
Station E6	0.65	< 0.1	< 0.1	< 0.1	0.2	5.9	4.9	88.9
Station E7	0.67	< 0.1	< 0.1	< 0.1	0.1	4.4	5.1	90.4
Station E8	0.63	< 0.1	< 0.1	< 0.1	0.4	9.1	5.9	84.7
Station E9	0.68	< 0.1	< 0.1	< 0.1	0.4	8.2	6.5	84.9
Station E10	0.61	< 0.1	< 0.1	< 0.1	0.5	9.9	5.9	83.7
Station E11	0.63	< 0.1	< 0.1	< 0.1	0.5	9.1	5.4	85.1
Station E12	0.65	< 0.1	< 0.1	< 0.1	0.2	6.2	6	87.7
Station E13	0.67	< 0.1	< 0.1	< 0.1	0.3	7.7	6.2	85.9
Station E14	0.69	< 0.1	< 0.1	< 0.1	0.3	5.7	4.8	89.3
Station E15	0.63	< 0.1	< 0.1	< 0.1	0.3	7.2	5	87.5



A
B
C
D
E
F
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay



G
H
I
J
K
L
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay

APPENDIX D

Raw Counts of Macroinvertebrate (Infauna and Epifauna) Abundance at Well E

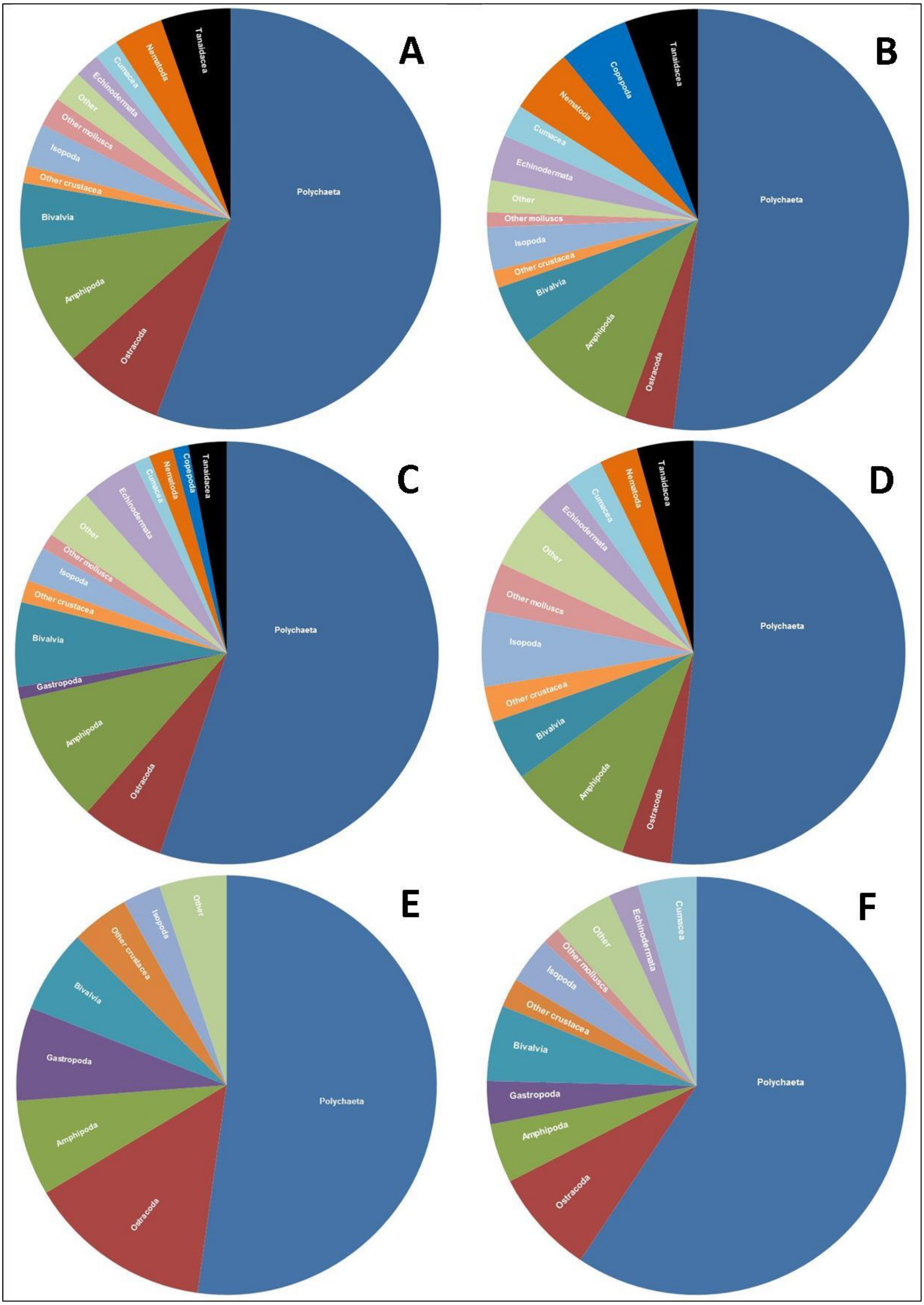
Taxa	Class/Order	Phylum	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15
Aglaophamus sp.	Polychaeta		1	5	3	1			3	2	3		4			5	
Ampharetidae	Polychaeta			2	1				3	1	3	1		1	1		
Amphipoda	Amphipoda	Crustacea	1	5	1	1				2	1	1	2		2	1	1
Anchisquilloides mcneilli	Decapoda	Crustacea	1														
Aplacophora		Mollusca											1		1		
Aricidea sp.	Polychaeta		1		1			1		1					2		2
Armandia maculata	Polychaeta			1													
Asellota	Isopoda	Crustacea		1					1								
Axiopsis sp.	Decapoda	Crustacea									1						
Brachyura zoea (usually pelagic)	Decapoda	Crustacea							1								
Bradleya opima	Ostracoda	Crustacea	1		2	1					2		2	3	1	1	1
Cadulus teliger	Scaphopoda	Mollusca													1		
Capitellethus zeylanicus	Polychaeta		4		1	1	1	1	1	5	3		1	1		2	1
Cirratulidae	Polychaeta			2	3	2		2	1	8	1	2	2		2	3	4
Clavelina claviformis	Tunicata					1			1	1			1				
Copepoda	Copepoda	Crustacea														1	
Cumacea	Cumacea	Crustacea		3		1	1		2	1	2		4	1			
Curveullima apouria	Gastropoda	Mollusca								1							
Cyclostrematidae	Gastropoda	Mollusca			1		1			1							
Cymbicopia hispida	Ostracoda	Crustacea							1	2							
Cytherella sp.	Ostracoda	Crustacea		1			2					3		1	2	1	
Ennucula strangei	Bivalvia	Mollusca		1			1				1		2		1	1	1
Euchone pallida	Polychaeta			1	1		1		3			1		3		2	
Euphausiacea	Euphausiacea	Crustacea				1					1						
Euphilomedes agilis	Ostracoda	Crustacea		3						2	1		1				
Fauveliopsidae	Polychaeta										2						

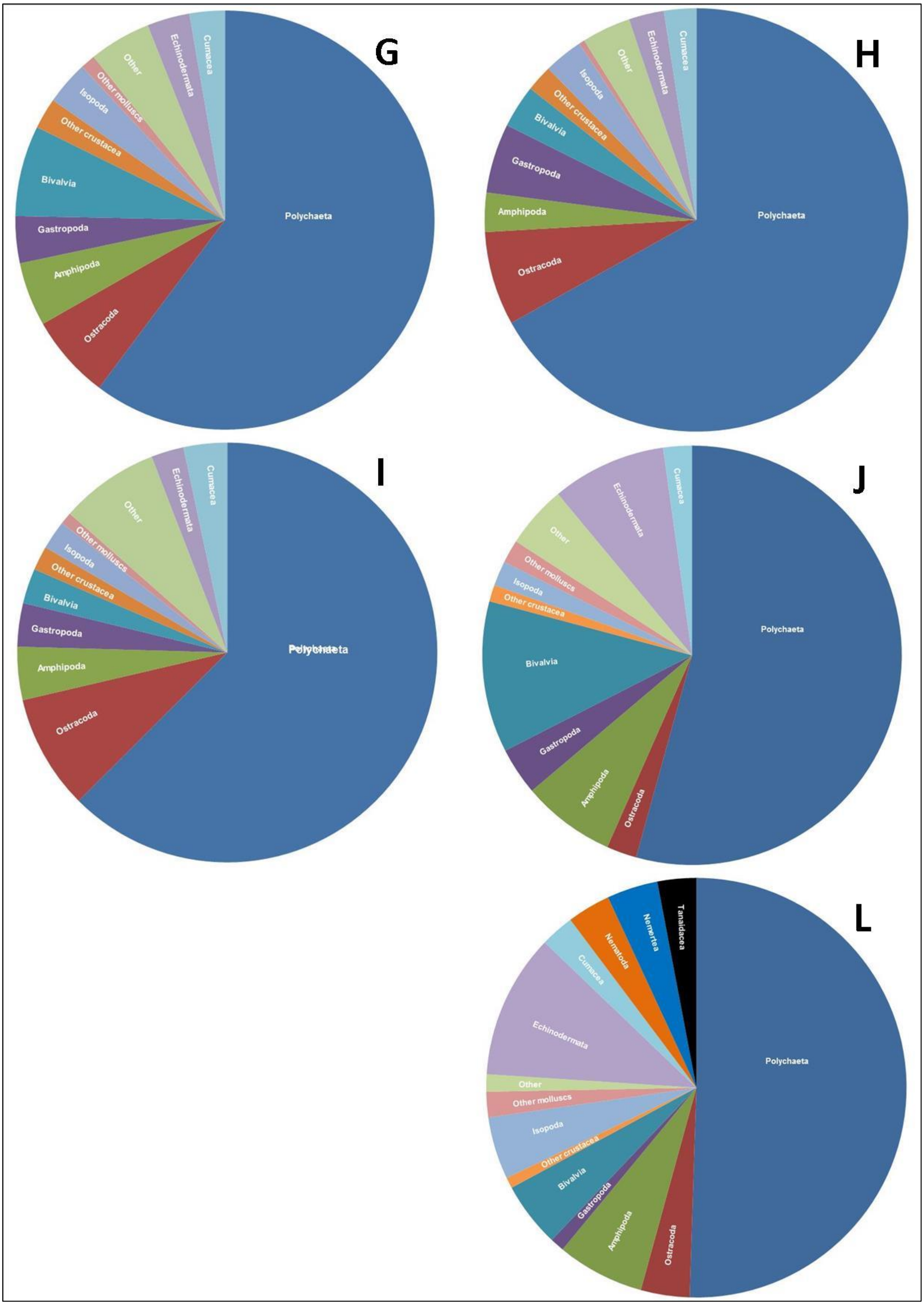
Taxa	Class/Order	Phylum	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15
Flabelligeridae	Polychaeta			1									2			1	
Gastropoda (juvenile)	Gastropoda	Mollusca							1								
Gnathiidae	Isopoda	Crustacea							5								
Goniadidae	Polychaete											1					
Haustoridae	Amphipoda	Crustacea												1			
Hesionidae	Polychaeta			1													
Heteromalpadia marenzelli	Holothuridea	Echinodermata															1
Hiatella artica	Bivalvia	Mollusca		1													
Hyalinoecia sp.	Polychaeta								1								
Hyperia sp. (pelagic)	Amphipoda	Crustacea			1												
Ischyroceridae	Isopoda	Crustacea						1						1			
Leitoscoloplos kerguelensis	Polychaeta									1							
Lumbrineridae	Polychaeta			1			1		1	2	15				3		
Lysianassidae	Amphipoda	Crustacea				1			3					1		1	
Maldanidae	Polychaeta		2	4	4	9	4	3	10	12	3	3	5	5	6	6	2
Marphysa disjuncta	Polychaeta			2	1		1	1		1	1						1
Mellitryx parva	Bivalvia	Mollusca		1													
Mysella hounselli	Bivalvia	Mollusca				2										2	
Natatolana pellucida	Isopoda	Crustacea		3													
Naticidae	Gastropoda	Mollusca		2													
Neilonella wrighti	Bivalvia	Mollusca		1				2	1				1			2	
Neilonella wrighti (Juvenile)	Bivalvia	Mollusca											1	1	1		
Nematoda	Nematoda											1					1
Nemertea	Nermetea								1							1	
Neonesidea sp.	Ostracoda	Crustacea	1	2		1	2	1	2	3	3	1	1		4		2
Oligochaeta	Oligochaeta								1								

Taxa	Class/Order	Phylum	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15
Onuphis aucklandensis	Polychaeta							1	1				1			2	
Ophiuroidea	Ophiuroidea	Echinodermata		1						1	3					2	
Osteridae spat	Bivalvia	Mollusca							1								
Paramunna serrata	Isopoda	Crustacea		1									2				
Paraonidae	Polychaeta		1	3	2					4	2	2	1		1	3	1
Philine powelli	Gastropoda	Mollusca												1			
Phoxocephalidae	Amphipoda	Crustacea		1	1		1		1		2	1				5	2
Pilargidae	Polychaeta					1	1		1		1	1				3	
Pratulum pulchellum	Bivalvia	Mollusca											1				
Relichna apouria	Gastropoda	Mollusca		2							1		1			1	
Rissoidae	Gastropoda	Mollusca		13	1			1		5	1	2			1		2
Rynkartopa uncinata	Holothuroidea	Echinodermata										1	1			1	
Scalibregma inflatum	Polychaeta											1					
Shrimp indeterminate	Decapoda	Crustacea														1	
Sigalionidae	Polychaeta			1				1		1				1		1	
Spiophanes kryoeri	Polychaeta														1		
Spiophanes sp.	Polychaeta													1			
Syllidae	Polychaeta								1					2			
Tanaidacea	Tanaidacea	Crustacea							2								
Terebellidae	Polychaeta										1						
Terebellides stroemi	Polychaeta											1	1			1	
Themiste sp.	Sipuncula			1		1	1					1				1	
Trachyleberis lytteltonensis	Ostracoda	Crustacea			2	1	5			4		1	1	2	2	1	1
Trochochaeta sp.	Polychaeta								1								
Valvifera	Isopoda	Crustacea							1								
Varinucula gallinacea	Bivalvia	Mollusca					1				1	1	1			4	1

APPENDIX E

Comparison of Proportion of Individuals belonging to each Taxonomic Group across all Wells


A
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Tanaidacea
B
Copepoda
C
Gastropoda
D
E
F


G
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta
H
Cumacea
Echinodermata
Other
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta
I
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta
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Other molluscs
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Bivalvia
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Amphipoda
Ostracoda
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Tanaidacea
Nemertea
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta

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EXPLORATION AND APPRAISAL DRILLING PROGRAMME

Benthic Baseline Report
Well F

Prepared for:

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SLR Ref: 740.10078.00200-R01
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SLR

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EXECUTIVE SUMMARY

OMV New Zealand Limited (**OMV New Zealand**) are applying for a Marine Consent to undertake an Exploration and Appraisal Drilling (**EAD**) Programme in the Taranaki Basin with an anticipated commencement date in 2019. OMV New Zealand may drill up to nine exploration wells and two appraisal wells within their Petroleum Exploration Permits (**PEP**). The intention of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs.

As part of the Marine Consent application, three Areas of Interest (**AOI**) have been identified that encapsulate the proposed well locations and are used as part of the Impact Assessment process. OMV New Zealand undertook a baseline environmental monitoring survey at each well location in March-April 2018 to gain an understanding of the benthic habitat and associated communities with each AOI.

Grab sampling and video sled methodologies were used to gain quantitative and qualitative information on the marine environments surrounding each well location. The data gathered from each baseline survey will be incorporated into the Marine Consent application and assist in the risk assessment process.

Water currents and deposition modelling were utilised to define the placement of sample stations. Sample transects were aligned along the dominant deposition pathway of the predicted drill cutting dispersion should that particular well be drilled. A total of 15 monitoring stations were allocated at each well and one benthic grab sample was collected at each monitoring station. Ten video sleds were also undertaken at a selection of pre-determined stations around each well.

Within this Benthic Baseline report the analysis of results incorporates sediment physical and chemical properties, benthic macrofauna, epifauna and visual observations around Proposed Well F. Results of sediment analyses showed the area surrounding the Well F to be composed of sandy muds, dominated by silt and clay (83%), with moderate levels of organic carbon (0.63%). Grain size distribution showed a weak pattern of increasingly fine sediments moving from south to north across the well area, while organic carbon showed no consistent spatial pattern. Sediment grain size distributions and TOC levels at Well F were very similar to those found at the remaining Central AOI wells and Well J in the Southern AOI.

A total of 1,023 individuals representing 90 taxa were identified from the macrofauna samples collected around Well F. Infauna communities were predominantly comprised of small polychaete worms (59%), Crustaceans (23% - mainly ostracods, amphipods, isopods and cumaceans), and molluscs (11% - mostly bivalves and gastropods). Central AOI infauna communities had the greatest proportions of polychaetes and gastropods, but the lowest proportions of crustaceans like amphipods and tanaidaceans, reflecting the muddier sediments predominant in the Central AOI which are more suited to deposit feeding/scavenging taxa like many of the polychaetes and gastropods found at Well F.

Video Imagery collected during the Benthic Baseline survey indicated the presence of sea pens which are taxa defined as ‘*characteristic species of sensitive environments*’. However estimated densities of sea pens at Well F did not reach the trigger levels defined by the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (MacDiarmid *et al*., 2013) and no distinct sea pen ‘fields’ were encountered. Thus although present at the well in low densities, the area does not classify as a ‘sensitive environment’.

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1 Introduction

OMV New Zealand Limited (**OMV New Zealand**) is applying for a Marine Consent under Section 38 of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (**EEZ Act**) to permit activities associated with an Exploration and Appraisal Drilling (**EAD**) Programme proposed to be undertaken starting in 2019.

The EAD Programme includes the drilling of up to nine exploration wells and two appraisal wells within OMV New Zealand's permit areas (**Figure 1**). The purpose of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs which OMV New Zealand operate (**Figure 1**).

Three Areas of Interest (**AOI**) (summarised below) have been identified which encapsulate the well locations (**Figure 1**). This monitoring report relates to the Benthic Baseline survey conducted at Well F in the Central AOI. Location details and water depth of Well F are provided in **Table 1.**

The Northern AOI encompasses PEP 60092 (Ridgeline), PEP 57075 (Cloudy Bay) and PEP 60093 (Toutouwai) and includes the following wells:

- Well A;
- Well B;
- Well C; and
- Well D.

The Central AOI encompasses PEP 60093 (Toutouwai) and includes the following wells:

- Well E (Appraisal);
- Well F;
- Well G (Appraisal);
- Well H; and
- Well I.

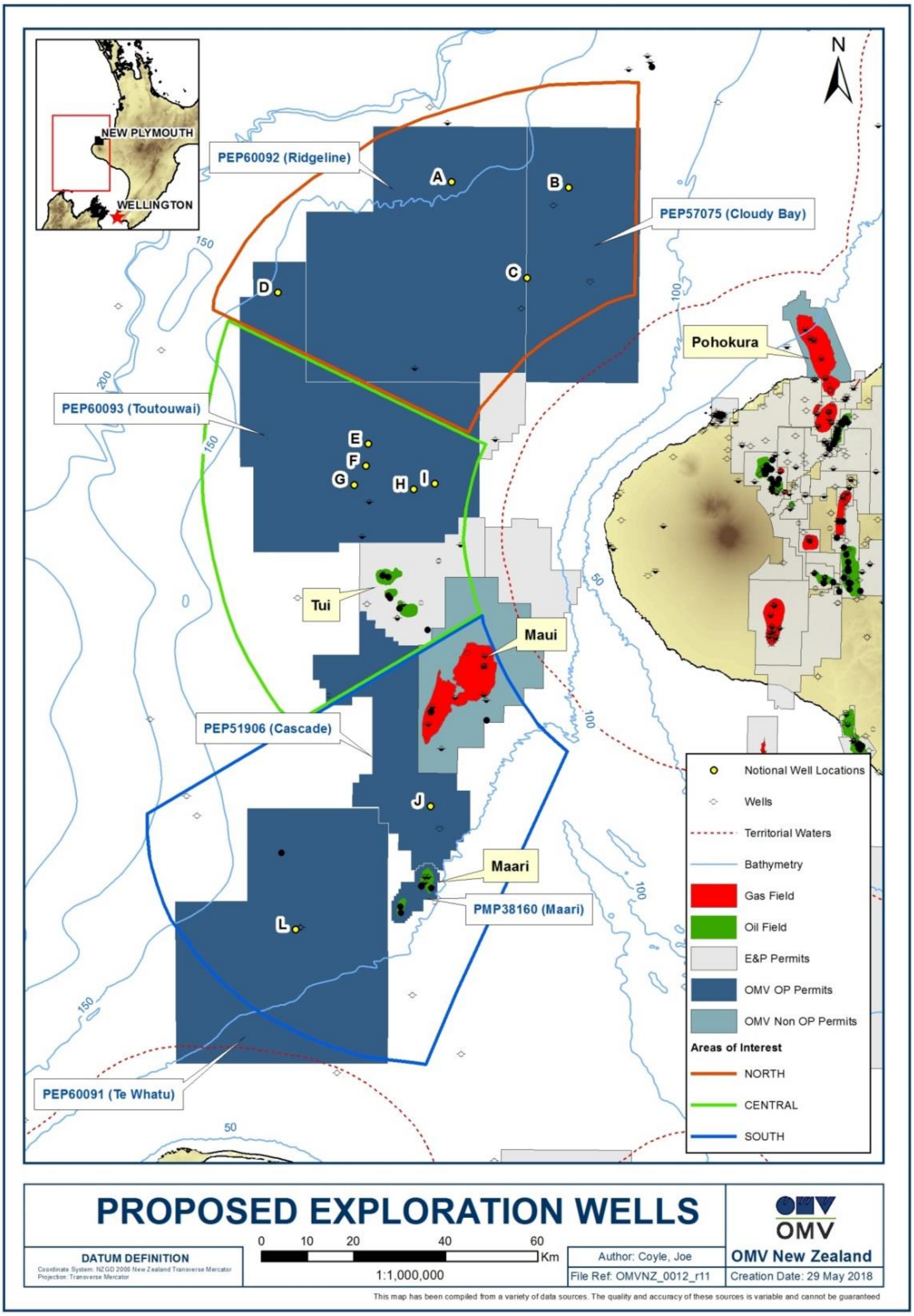
The Southern AOI encompasses PEP 51906 (Cascade), and PEP 60091 (Te Whatu) and includes the following wells:

- Well J; and
- Well L.

Table 1 Water Depth and Coordinates of Well F in the Central AOI

Well Name	Water Depth (m)	Easting (NZTM)	Northing (NZTM)
F	126.3	1612536	5664757

Figure 1 OMV New Zealand's EAD Well Locations and three AOIs in the Taranaki Basin



In February 2018 SLR Consulting NZ Limited (**SLR**) was engaged by OMV New Zealand to undertake a baseline assessment of the benthic ecology in the vicinity of 11 wells (**Figure 1**). The aim of the field surveys, which were undertaken from March 24 – April 8 2018, was to collect relevant data using grab sampling and video sled methodologies to provide quantitative and qualitative information on these marine environments. This qualitative and quantitative data will be used within the Marine Consent application to define the benthic habitats and communities present at each well and assist in the risk assessment process.

This report summarises the results of the Benthic Baseline survey undertaken at Well F.

1.1 Project Location

Well F is located approximately 80 km west of New Plymouth in New Zealand's Exclusive Economic Zone (**EEZ**). Water depth and GPS coordinates are provided in **Table 1** and displayed in **Figure 1**. The monitoring programme sample design resulted in sample stations extending out to 6 km from the well location (**Section 2.1**).

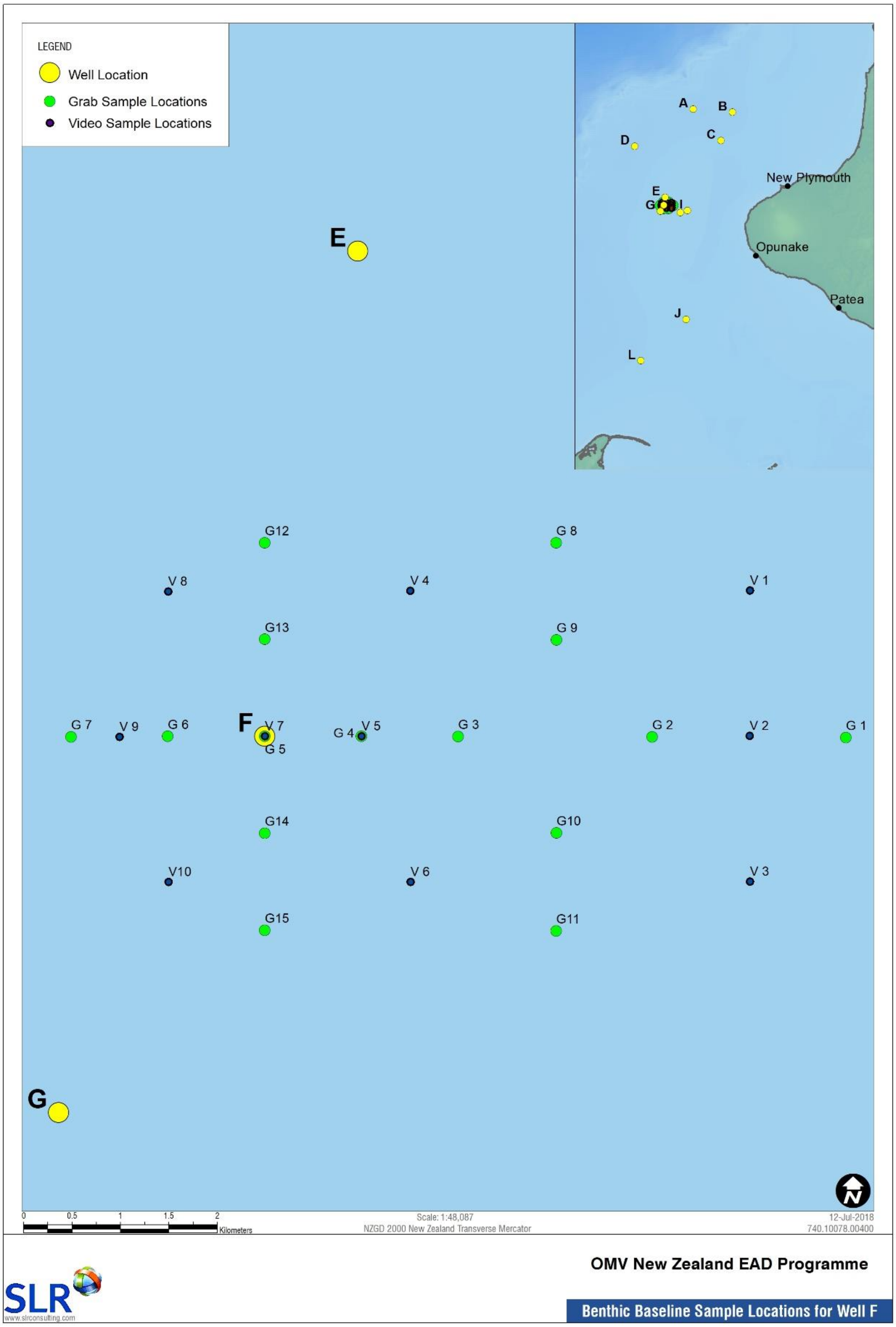
2 Methodology

The Benthic Baseline surveys adopted similar methodologies to what has been previously used for offshore Taranaki benthic monitoring programmes undertaken in accordance with the principles defined in the Offshore Taranaki Environmental Monitoring Protocol (**OTEMP**) (Johnston *et al.*, 2014). This consistent approach enables monitoring results to be compared with previous monitoring programmes undertaken in the offshore Taranaki environment (i.e. pre- and post-drill monitoring and production monitoring).

2.1 Sample Locations

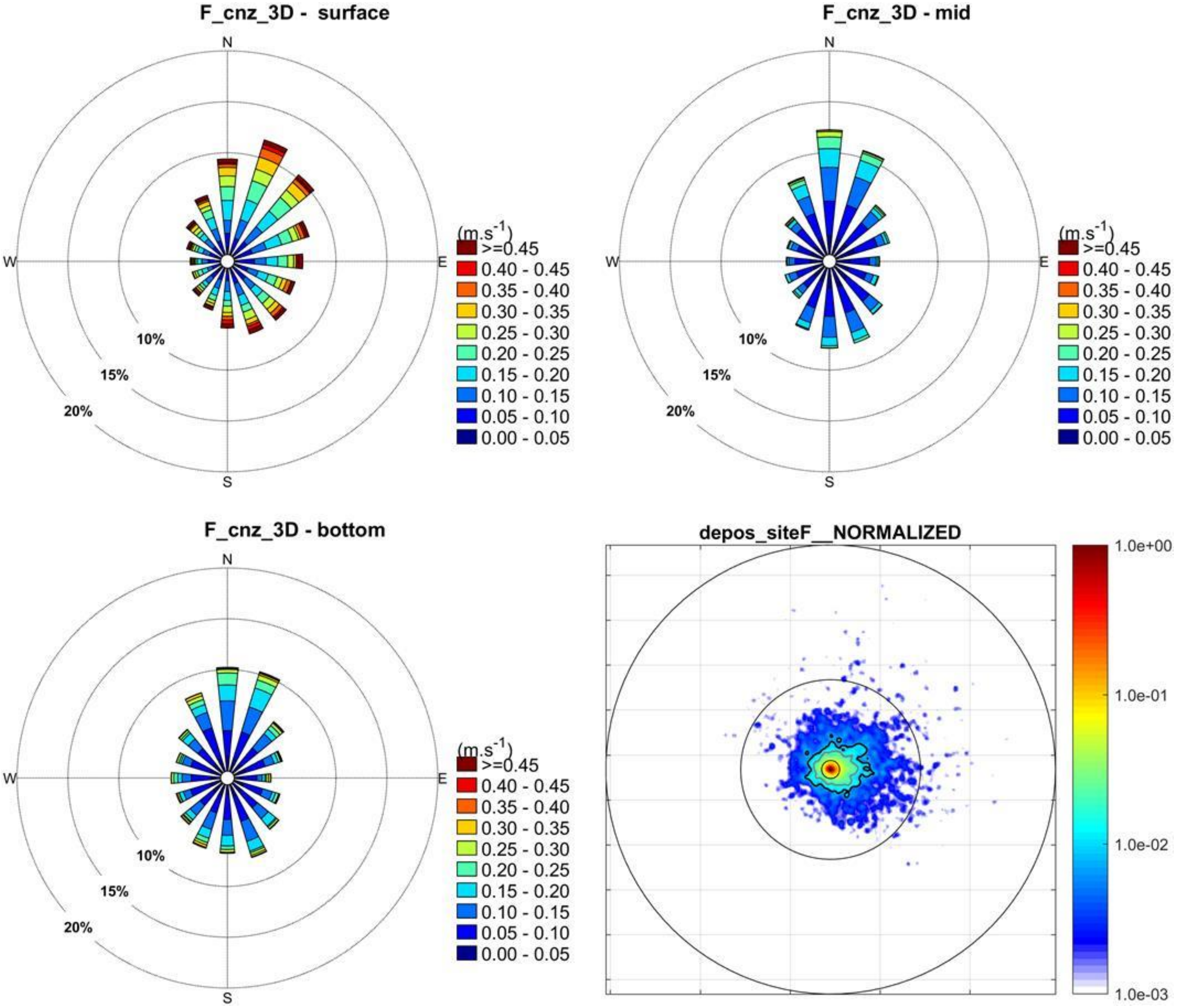
The sample locations (**Figure 2**) were defined by the dominant direction of current flow and preliminary drill cutting deposition modelling results (**Figure 2**). Sample transects were aligned along the dominant deposition pathway (i.e. southeast/northwest) (**Figure 3**) as this is the area determined to be most likely to be impacted from the deposition of drill cuttings should the well be drilled. However, sample stations were also located along the minor flow axis (northeast/southwest) to enable comparisons and validation of spatial differences based on the dispersal patterns predicted by MetOcean Solutions Limited.

Figure 2 Well F Sampling Locations



Note: At each video transect location approximately 250 m of video footage was captured along the seabed in the direction of the vessels drift at the time of sampling.

Figure 3 Surface, Mid-water and Bottom Water Column Current Roses and Dispersal Modelling Plot created by Metocean Solutions Ltd for Well F



2.2 Field and Sampling Procedures

Field sampling was undertaken from the MV *Seaworker* between March 24 and April 8, 2018, following the procedures detailed below. Sampling at Well F took place on April 6th and 7th.

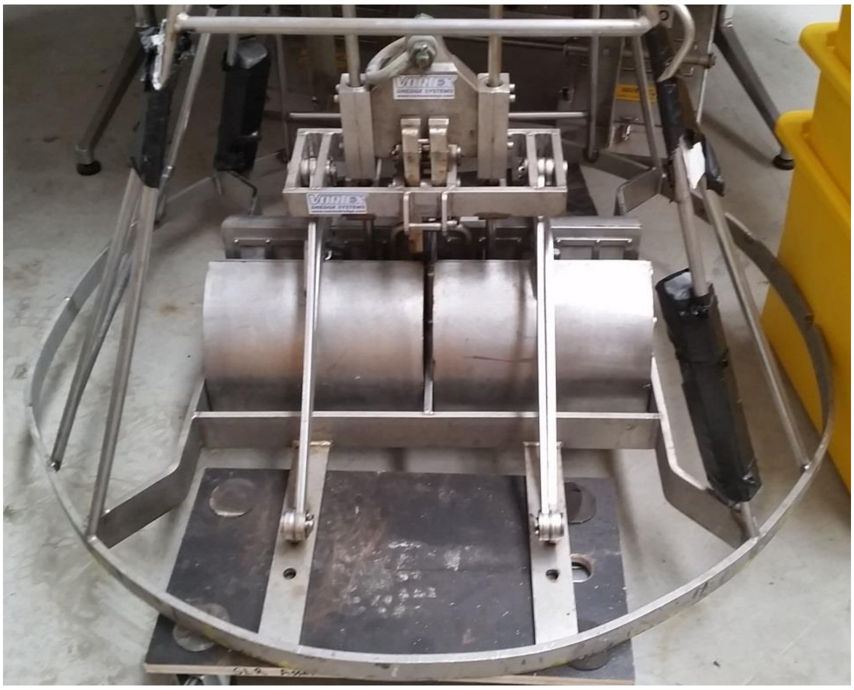
2.2.1 Benthic Grab Samples

A double Van Veen double grab sampler (**Figure 4**) was used to collect a single sediment grab sample at each of the 15 benthic monitoring stations surrounding Well F (**Figure 2**). The grab sampler is constructed of stainless steel and features two independent 'buckets' which penetrate the surficial sediments to a depth of 0.16 m. Each successful grab sample returns approximately 0.01 m^3 of seabed sediment back to the surface.

Upon arrival on the vessel deck, each grab sample is checked for completeness, which must meet the following criteria:

- The surface of the sediment is largely undisturbed upon inspection aboard the vessel;
- Sufficient sediment (≥75% of the grab capacity) is collected to enable the full suite of sediment analyses required;
- The infauna sample bucket is filled to the same volume (approximately 10 l) for all infauna replicates throughout the survey; and
- The grab has not been over-filled with sediments pushing out of the doors or drains, indicating that it may have over-penetrated the sediment.

Figure 4 The Double Van Veen Grab Sampler used for the 2018 Benthic Baseline Sampling



Each independent bucket from a grab sample is used separately for infauna and sediment physical and chemical analyses, as follows:

- Bucket one: infauna/macrofauna community analysis. The entire sample is sieved through 0.5 mm mesh until approximately 300 - 500 ml of residual sediment and organisms remains. This remaining material is transferred to a plastic container and preserved with a fixative (AncholTM), ready for analysis by SLR taxonomists.
- Bucket two: sediment physical nature and chemical analyses. Three 64 mm (internal diameter) clear Perspex sub-sampling cores are pushed into the sediments from the second bucket, to a depth of approximately 150 mm. Cores are photographed and the upper 50 mm from each core is extruded into a polyethylene bag for particle grain size distribution and organic content (Total Organic Carbon (**TOC**)) analyses by Hill Laboratories.

2.2.2 Seafloor Video Imagery

Video imagery of the seafloor was obtained using a customised tow-sled fitted with high-intensity LED lighting and a high-definition video camera (**Figure 5**). The system was connected to the vessel via a 10 mm dyneema tow-line and a 300 m umbilical cable supplying real-time video images to the camera operator on the research vessel. A pair of parallel lasers on the video sled provided an indication of scale allowing features of interest in the video recordings to be approximately sized. Ten video sled tows were conducted around Well F (**Figure 2**).

The video-sled was launched from the vessel up-current of each pre-determined location and lowered to the seabed, where it auto-located via a series of floats and weights set at specific points on the sled frame, to land upright on its lower skids. At the point where the sled contacted the seabed, a GPS log was started, and this log continued throughout the duration of the tow. Video footage was continuously recorded for approximately 200 m as the sled drifted behind the vessel; this ensured that footage was collected while the sled was passing as close as possible to the required sample location.

Figure 5 The Video Sled used for Collecting Video Footage of the Seabed Environment

2.3 Laboratory Analyses

2.3.1 Sediment Physicochemical Analyses

Benthic sediments collected by the grab sampler were analysed by Hill Laboratories (an NZS/ISO/IEC 17025:2005 accredited laboratory), for both physical and chemical parameters. The aims of these analyses along with further details of the analytical method/descriptions are summarised in **Table 2**.

Table 2 Summary of Analytical Methods used for Testing Sediment Physico-chemical Characteristics

Analyte	Aim	Method Number	Description
Particle Grain Size Distribution	• Determine physical parameters of the sediment particles present at the site • Correlate with infauna community characteristics	Hill Laboratories KB32136	• Sediment was wet-sieved through the following screen sizes, as per the Udden-Wentworth scale (Wentworth, 1922): • >2 mm (gravel) • >1 mm (very coarse sand) • >500 µm (coarse sand) • >250 µm (medium sand) • >125 µm (fine sand) • >63 µm (very fine sand) • <63 µm (silt and clay)
Total Organic Carbon	• Determine current level of organic carbon in sediment • Correlate with infauna community characteristics	No specific method number	Acid pre-treatment to remove carbonates present, followed by catalytic combustion (900° C, O_2), separation, Thermal Conductivity Detector. Elemental Analyser.

2.3.2 Macrofauna Analyses

Macrofaunal analyses focused on the infauna, or animals larger than 0.5 mm living within the sediment matrix. Epifaunal animals (those living on top of the sediment), were also included in the analyses to provide representation of the different functional groups present at each sample station.

Benthic macrofaunal samples collected from the sediment grab were sorted and, with the aid of a binocular microscope, identified to the lowest practicable taxonomic level or most recognisable taxa (morphologically similar group). Counts were made to assess the relative abundance of each taxa.

2.3.3 Seafloor Video Analyses

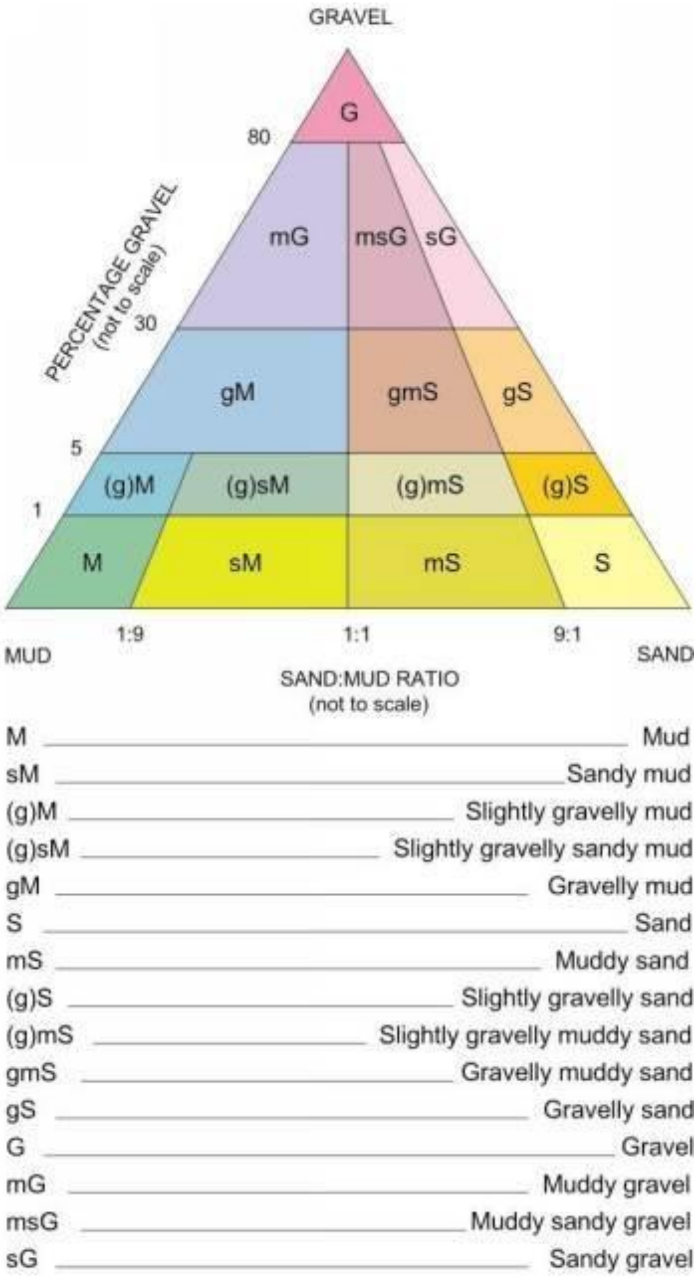
A live feed from the video-sled was captured and recorded on-board the survey vessel and viewed by SLR staff with experience in undertaking assessments of the benthic environment in the offshore Taranaki region. Brief field notes were made in real-time about obvious structures and organisms observed while watching the live footage. Back onshore the recorded seabed video footage was assessed on a large, high definition screen, by a suitably trained and experienced benthic scientist, who identified all obvious epifauna to the lowest practicable taxonomic level. Biogenic and/or anthropogenic seabed structures such as burrows, mounds, tracks and gouges/trenches were also recorded. Relative abundance estimates of epifauna or biogenic structures were made where appropriate.

2.4 Data Analyses

2.4.1 Sediment classifications

While there are many sediment classification schemes in use worldwide, a common one is a modified version of that proposed by Folk (1954). This scheme groups grains within a sample into mud, sand and gravel sized particles based on the particles diameter (mud <63 µm, sand 64-2000 µm, gravel > 2mm), and then describes the sediment type based on the relative proportions of the particles (see **Figure 6**).

Figure 6 Folk (1954) Sediment Type Classification Triangle



2.4.2 Community Characteristic Descriptors

All macrofauna (both epifauna and infauna) taxa were included in the analyses of abundance data. Species identified in the samples as not being exclusively benthic were excluded from further analyses. Data were analysed as per the statistical methods outlined below to identify current distributions and abundance of macrofauna.

2.4.2.1 Univariate Diversity Indices

Diversity indices (number of taxa S, total abundance N, Shannon-Wiener diversity H', and Pielou evenness J' (**Table 3**) were calculated from the macrofauna abundance data using the PRIMER software package (PRIMER v6.1.16; Clarke, 1993; Clarke & Warwick, 1994; Clarke & Gorley, 2006).

Table 3 Description of Macrofauna Community Characteristic Indices

Index	Formula (where applicable)	Description
Number of Taxa (S)	Count of total number of different taxa identified within the *x* sample	Total number of taxa identified within a sample
Total Abundance (N)	Sum of all individual taxa abundances within the *x* sample	Total number/count of all organisms within a sample
Shannon Diversity (H')	$H' = -SUM [(p_i) \times \log_e (p_i)]$ $p_i =$ Number of individuals of taxa i /total number of samples	A single value (log scale) that is used to describe the different types and numbers of organisms present within an assemblage. The index value increases as assemblages have greater numbers of taxa and when the numbers of individual organisms are more evenly distributed across the different taxa. Samples dominated by single taxa will have lower values towards zero.
Pielou Evenness (J')	$J= H'/ \log_e (S)$	A value theoretically between zero and one which indicates how evenly the number of individual organisms are distributed through the different taxa in an assemblage. High values (closer to 1) indicate an even spread amongst the taxa present, whereas a low value indicate an uneven spread or an assemblage highly dominated by only a few, or even a single taxon.

3 Results and Discussion

3.1 Sediment Physical and Chemical Properties

3.1.1 Visual Description of Sediment Cores

Sediments collected from around Well F were predominantly light grey/brown cohesive mud/clay (**Figure 7**). No dark-grey or black sediment layers (apparent Redox Potential Discontinuity), or darker patches within cores were noted and no detectable hydrogen sulphide odours were present, indicating that sediments are well oxygenated throughout the depths sampled. Field observations on sediment texture, colour and any notable features of the sediment samples were recorded during the processing of the sediment cores and infauna samples, and these are included in **Appendix A**. A full set of sediment core photographs are contained in **Appendix B**.

Figure 7 Representative Images of Sediment Core Profiles from Well F

Station F1

Station F4

Station F8

Station F13

3.1.2 Incidental Observations

During the laboratory processing of the infauna samples by SLR taxonomists, observations were made of any debris that was present, including those from anthropogenic sources. Within the 15 samples collected around Well F there were eight types of debris observed (**Table 4**), five of which were likely to be anthropogenic in source, including paint flecks, grey foam and black nylon. However all anthropogenic debris encountered in the samples were at 'low' abundances. The 'sand-like substance' that was observed at low-common abundances was potentially just naturally occurring larger sand particles, as grain size distribution analysis confirmed the presence of reasonable proportions of fine sands in sediments collected at Well F (**Section 3.1.3.1**).

Table 4 Incidental Observations

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
Sand-like substance	L	L			L				L		L		L	L	C
Coal rock										L					
Graphite														L	
Yellow paint		L	L							L	L				
Black nylon										L					
Gold paint									L						
Grey foam	L														
Blue paint	L														

VA = very abundant (>50), A = abundant (50+), C = common (20–50), O = occasional (10–20), L = low (0–10)

3.1.3 Sediment Particle Grain Size Distribution and Organic Content

The physical characteristics of the sediment can influence the composition of the infauna communities and the levels of contaminants retained and observed during analyses. Particle grain size is widely used to characterise the physical structure of the sediment, while organic content provides an indication of the organic enrichment in the sediment. These combined results provide a general understanding of sediment health and the source of potential stressors at the time of sampling.

Organic matter found in the sediments is most likely derived from natural sources such as infauna/epifauna and detrital matter, rather than from anthropogenic sources. Anoxic sediments (those lacking oxygen), may develop in situations where organic matter levels increase beyond 'normal' levels for that area. Increased organic matter has the potential to disturb the equilibrium of the benthic ecosystem, as increased numbers of oxygen-utilising bacteria are required to decompose the additional organic matter, thereby rapidly reducing oxygen availability in the sediments.

A summary of the particle grain size and organic content analyses are discussed below, with full results provided in **Appendix C**.

3.1.3.1 Particle Grain Size

Particle grain size analyses at the 15 monitoring stations around Well F are shown in **Figure 8**. Sediments are dominated by silt/clay (75-88%, mean 83%), fine sand and very fine sand (mean 11% and 5% respectively). These sediments are classed as 'sandy muds' (Folk, 1954), which is the same as most Taranaki areas where exploration/production monitoring has taken place.

Across the Well F monitoring stations there was a weak trend of increasing proportions of silt and clay (and decreasing medium, fine and very fine sands) moving from south to north, where the highest proportions of sand sized particles were found at stations F10, F11, F14 and F15. In comparison to nearby well sites in the offshore Taranaki area, mean silt and clay levels at Well F were similar to those seen at the Oi-1/Oi-2 exploration well site in 2016 (72-88% silt and clay (SLR, 2017b)) (south-east of Well F), and slightly higher than those found in the Tui field in February 2018 (60-77% silt and clay (SLR, 2018)).

The sandy muds encountered at Well F were similar to those found at the other wells in the Central and Southern AOIs, with the exception of Well L which was more like the Northern AOI grain size fractions (**Table 5**). A comparison of particle grain size data for Well F with the other wells is provided in **Appendix C**.

Figure 8 Sediment Particle Grain Size Distribution for Samples Collected at Well F

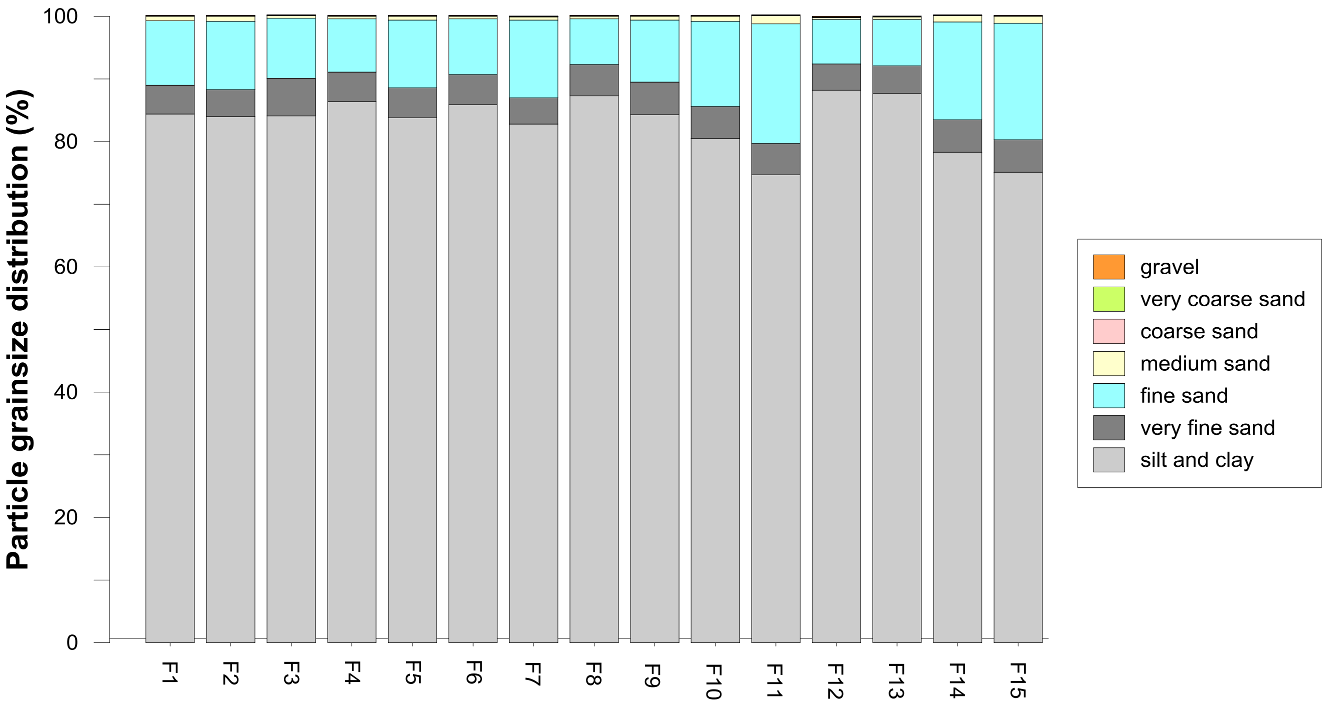


Table 5 Average Grain Size for the Eleven Wells

Grain size class	A	B	C	D	E	F	G	H	I	J	L
Silt & Clay (Mud) (%)	36.2	27.5	41.1	30.7	85.2	83.2	67.8	72.6	65.1	85.4	30.8
Very Fine Sand (%)	45.8	39.3	30.5	41.7	6.5	4.8	6.1	5.8	6.6	14.2	25.4
Fine Sand (%)	17.0	28.6	22.4	26.8	8.0	11.3	24.6	19.0	22.1	0.4	29.8
Medium Sand (%)	1.0	2.4	3.3	0.7	0.4	0.6	1.6	2.5	5.1	0.1	12.3
Coarse Sand (%)	0.1	0.7	0.8	0.0	0.0	0.1	0.1	0.1	0.6	0.0	1.2
Very Coarse Sand (%)	0.0	0.6	0.5	0.0	0.0	0.1	0.1	0.1	0.5	0.0	0.2
Gravel (%)	0.1	1.1	1.3	0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.1
Description	mS	mS	mS	mS	sM	sM	sM	sM	sM	sM	mS

Note: sM = sandy mud, mS = muddy sand

Colour scale based on percentage with median mid-point (median is 2.0):

0%	5	10	20	30	40	50	60	70	80	90	100

3.1.3.2 Total Organic Carbon

The organic content of sediments was assessed by measuring TOC to assess benthic ecology as this is also consistent with what is now currently undertaken around the offshore Taranaki oil and gas fields.

TOC levels around Well F ranged from 0.56% to 0.69% (mean 0.63) (**Figure 9**) and showed no consistent spatial patterns across the area.

The average organic content of all 15 stations around Well F was high relative to other EAD wells (mean 0.63% compared to overall mean of 0.45%). The combined mean from all stations at the five Central AOI wells (0.59%) was high relative to the Northern and Southern AOI sites (mean 0.26% and 0.48%, respectively). As has been previously described in benthic environmental monitoring associated with offshore Taranaki oil and gas activities (SLR, 2016, & SLR, 2017), there is a correlation between sediment particle grain size and sediment organic content. The comparatively greater surface area to volume ratio of silt and clay (mud/fines) sized sediment particles (compared to larger particles like sand) gives a greater area for adsorption of organic matter particles and therefore a higher probability of elevated organic matter compared to coarser/sandier sediments subjected to the same level of enrichment (Hedges *et al.*, 1993). This is likely to at least partially explain the lower organic content of sediments at the Northern AOI sites, where sediment grain size is distinctly coarser than at the Central and Southern AOI sites (**Section 3.1.3.1**).

Figure 9 TOC Concentrations in Sediment Samples Collected from around Well F

3.2 Video Sled Imagery

Video footage of the seabed allows scientists to visually assess any anthropogenic disturbance to the benthic environment and observe epifauna, sediment-type and structures or relief that exist on the seabed.

Video footage was captured by towing a video sled through ten stations around Well F (**Section 2.2**). All video footage is included with the electronic version of this document, with a selection of still images displayed in **Figure 10**. **Appendix A** provides locational information for each video sled tow.

Video footage was assessed to determine any defining features and their semi-quantitative abundance recorded for comparison with other wells. Due to caveats associated with video footage (i.e. variable visibility, differing tow length and durations) the counts are indicative-only and should not be interpreted as a quantitative assessment. **Table 6** presents the results of this semi-quantitative approach, which summaries the counts by comparing the well total to the median across all of the EAD wells in the three AOIs. As a visual aid, counts were categorised in relation to the deviation from the 10th, 25th 50th, 75th and 90th percentiles, so that differences between wells can be more easily viewed.

3.2.1 Physical Observations

The seabed around Well F was observed to be relatively flat, soft-mud sediments. Evidence of bioturbation was observed in all video tows in the form of animal burrows. Moderate abundances of burrows were observed (**Figure 10**) relative to video tows completed at other wells. This is similar to other wells in the Central and Southern AOIs but differs from the Northern AOI where abundances were predominantly low (**Table 6**).

Mound/hollow features (images B, D, and H, **Figure 10**) were observed to be smaller and in very low numbers (20) at Well F compared to the median of 43 for all wells (**Table 6**). The highest abundances were seen at Well D (280) (Northern AOI) and Well L (532) (Southern AOI). These seabed features are considered to be formed by feeding activities of sharks or rays, or in some cases tube worms or shrimps mounding up sediment. In general, mound/hollow features were observed to be more numerous at the Northern AOI wells, moderate to very high at the Southern AOI wells, and low to very low in numbers around the Central AOI wells.

As expected, there was no sign of anthropogenic physical disturbance of the seabed observed during any of the video sled tows around Well F. There were no signs of sediment enrichment such as darker sediment patches, bacterial mats or sediment off-gassing, observed during any of the video sled tows around Well F.

Table 6 Total Number of Features Observed in Video Imagery from the EAD Wells

Well	Depth (m)	Mounds/ Hollows	Number of burrows/worm holes	Sea pen	Fish	Substrate	Notes
A	148	111	Low-moderate	54	65	Muddy sand	Ripples; some very large holes and mounds
B	134	63	Low-moderate	35	49	Muddy sand	Some very large holes mounds
C	132	85	Low-moderate	50	44	Muddy sand	Ripples; trenches observed
D	145	280	Low	160	28	Muddy sand	Ripples; 23 very large sea feathers
E	126	29	Moderate	29	16	Sandy mud	
F	128	20	Moderate	19	19	Sandy mud	
G	124	18	Moderate-High	29	26	Sandy mud	
H	124	18	Moderate-High	17	26	Sandy mud	12 elongated shallow trenches
I	122	43	Moderate-High	36	21	Sandy mud	5 elongated shallow trenches (large)
J	108	42	Moderate	14	30	Sandy mud	School of mackerel, tufts/tubes common
L	112	532	Moderate	132	31	Muddy sand	2 schools of mackerel
Median		43		35	28		

Totals are sum of 10 video tows carried out at each site. Totals are semi-quantitative only due to variable visibility and transect length.

10th percentile band
25th percentile band
Median band
75th percentile band
90th percentile band

3.2.2 Infauna, Epifauna and Other Fauna

In some cases, a definitive positive identification of infauna, epifauna and more mobile taxa was not possible from the video footage alone. Where there was any uncertainty, identifications were based on distinctive features, colours and shapes of organisms and in some cases the confirmed presence of similar looking individuals within the infauna samples.

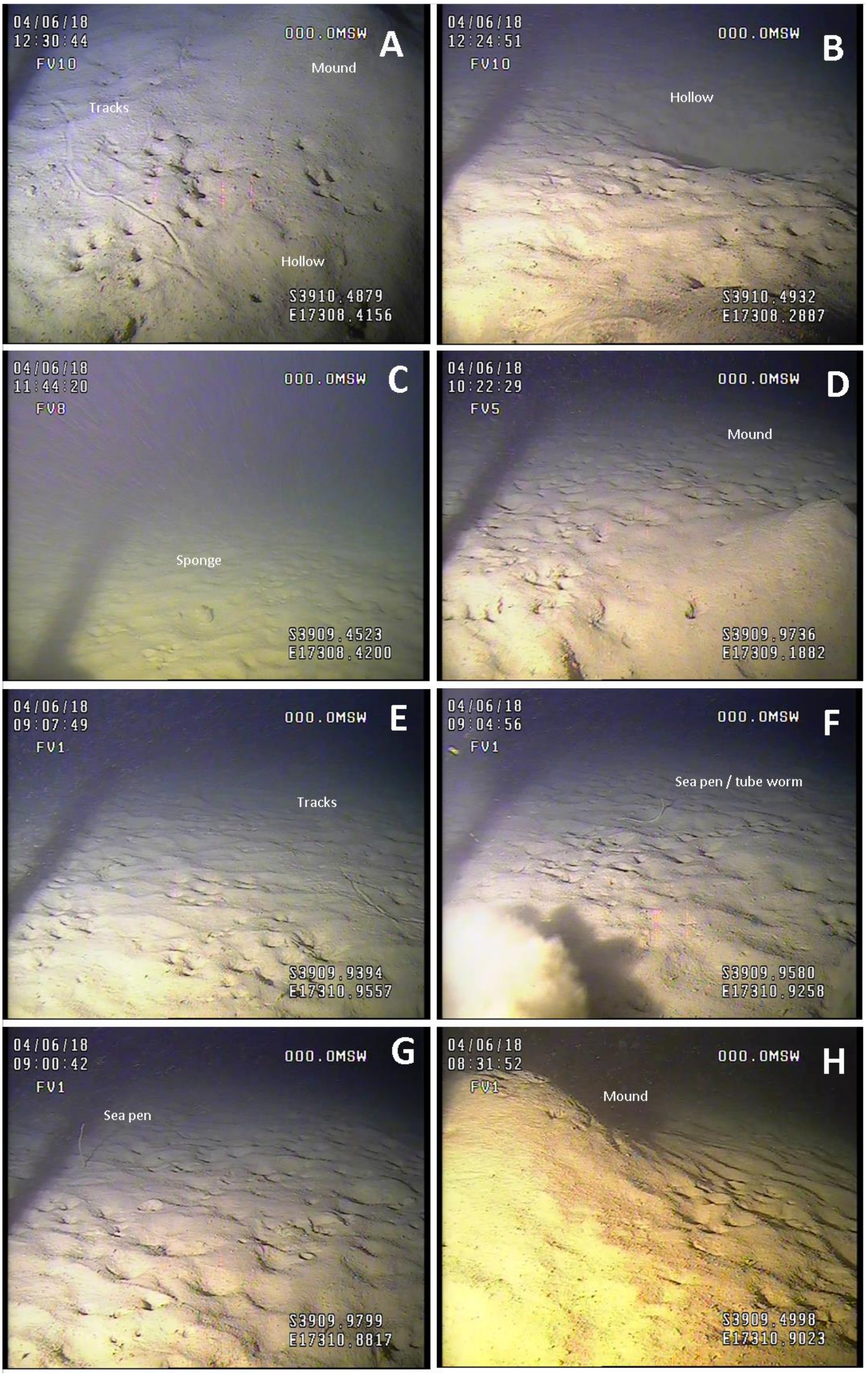
Epifauna taxa observed in video footage collected around Well F included a small number of whelks (likely *Austrofusus glans*), hermit crabs (*Pagarus* sp.), tusk shells (likely *Fissidentalium zelandicum*) and sponges. The presence of epifauna tracks in the sediment (image A, **Figure 10**) indicates that mobile fauna such as whelks and hermit crabs move throughout this area. A small number of sponges were observed in most video tows (image C, **Figure 10**), some of which may have instead been tunicates. Tube worms were also present (image F, **Figure 10**).

Sea pens (likely *Virgularia* sp.) (image G, **Figure 10**) were observed in very low numbers (19) at Well F compared to the median of (35) of all wells (**Table 6**). The highest abundances were seen at Well D (160) (Northern AOI) and Well L (132) (Southern AOI). In general, sea pens were observed often during the tows at the Northern AOI sites, were more variable at the Southern AOI sites, and least at the Central AOI sites.

Mobile fish species were also observed in very low numbers (19) during Well F video sled tows, compared to the median (28) across all wells (**Table 6**). Species observed include sand eels[1], gurnard (*Chelidonichthys kumu*) and dogfish (*Squalus acanthias*.). A number of smaller fish were observed swimming off very quickly as the camera approached, so it was not possible to make a positive identification. Across the region surveyed, fish numbers were observed to be much more numerous across the Northern AOI sites, moderate at the Southern AOI sites, and moderate to low around the Central AOI sites.

[1] This fish was unable to be formally identified, thus while the term 'sand eel' is used throughout this report it should not be considered a common name for this unidentified fish species.

Figure 10 Representative Images of Seabed Environment around Well F



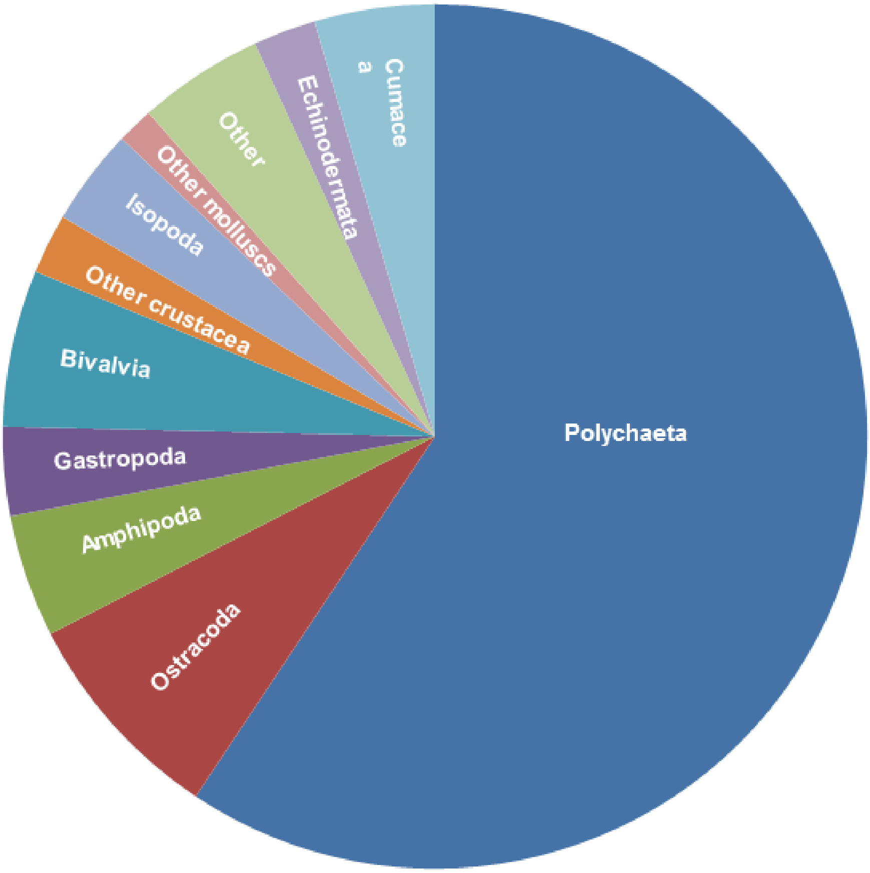
3.3 Macrofauna Characteristics

3.3.1 Benthic Macrofauna

Overall 1,023 individuals representing 90 taxa were identified in the macrofauna samples collected across the Well F monitoring stations. Infauna communities were dominated by small polychaete worms (607 individuals (59%), 33 taxa), Crustaceans (236 individuals (23%), 26 taxa, mostly Ostracoda, Amphipoda, Isopoda and Cumacea), and molluscs (108 individuals (11%), 20 taxa, mostly Bivalvia and Gastropoda) (**Figure 11** and **Figure 12**).

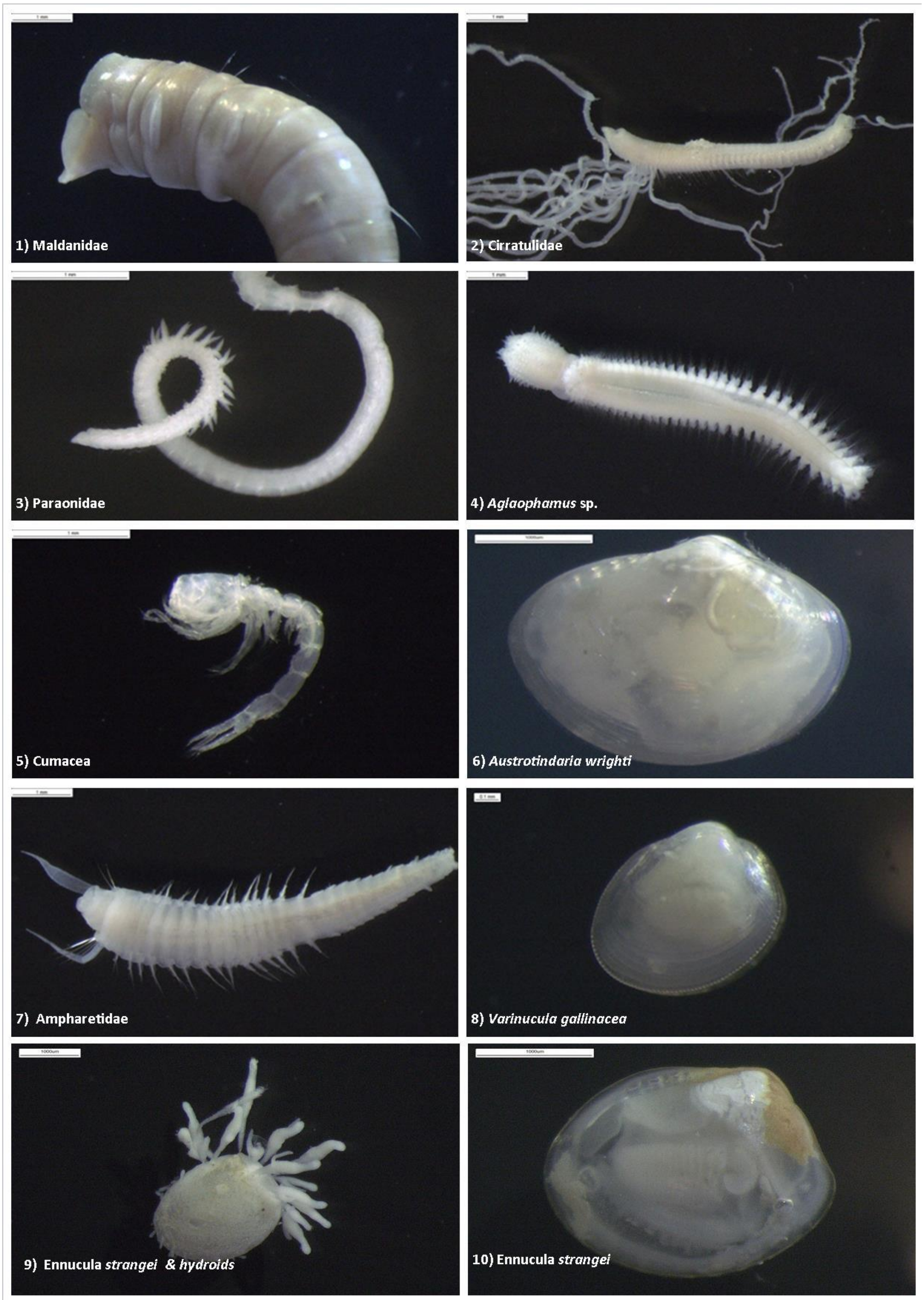
When the benthic macrofauna results are compared across the three AOIs, polychaetes and gastropods were found in lower numbers in the Southern and Northern AOIs compared to the Central AOI. Crustaceans (Tanaidacea and Copepoda) and nematodes were found in higher numbers in the Northern AOI wells compared with Central and Southern AOIs (**Appendix E**). This result is likely linked to the differences in sediment composition, where a coarser grain size was present in the Northern AOI compared to the Central and Southern AOIs.

Figure 11 Proportion of Well F Individuals Belonging to each Taxonomic Group



'Other Crustacea' includes Decapoda, Copepoda, Stomatopoda, Euphausiacea and Tanaidacea. 'Other molluscs' includes Caudofoveta, and Scaphopoda. 'Other' includes Chaetognatha, Hemichordata, Nematoda, Nermetea, Sipuncula, Tunicata and Anthozoa.

Figure 12 Representative Images of Benthic Infauna Taxa Frequently Observed in Offshore Taranaki Area



3.3.2 Univariate Indices of Infauna Communities

Univariate indices (total number of taxa, total abundance, Pielou's evenness and Shannon-Wiener diversity) describing the benthic macroinvertebrate communities found around Well F are displayed in **Figure 13**. The number of taxa identified in each sample varied from 20 to 43 (mean 31), and total infauna abundances ranged from 31 to 89 individuals per sample (mean 68), with no consistent spatial patterns observed in theses indices across all Well F monitoring stations. Abundance and taxa numbers at Well F were similar to the overall mean values for the Central AOI (29 taxa, 69 individuals, **Table** 7), which were distinctly lower than those of the Southern, and especially the Northern AOI.

Evenness values vary on a scale between zero and one, with values near one indicating that infauna abundances are evenly distributed across all the different taxa present, while values near zero indicate infauna communities are being numerically dominated by a large number of individuals from just a few, or even only single taxa. Values from the samples collected at Well F (**Figure 13**) were relatively high (mean 0.90), indicating relatively even distribution of abundances across the taxa that were present. Monitoring station F12, which had a relatively high number of taxa and abundance, scored a slightly lower evenness value than the surrounding stations due to higher numbers of cumaceans and polychaete worms.

Shannon-Wiener diversity index values range between 0 and 4 with higher values indicating higher species diversity. From previous benthic studies in the offshore Taranaki region, species diversity values are normally between 1.5 and 3.5. The mean Shannon-Weiner diversity index for Well F monitoring stations was 3.1 (range 2.8-3.5). When these results are compared to the most recent results from long term benthic monitoring programmes at the Maari Field (diversity index of 2.9) in the Southern AOI it is shown that the species diversity is greater at Well F. Across Well F monitoring stations F7 and F2 had among the lowest values, reflecting the lower number of taxa and total abundance found at these stations.

Figure 13 Total Number of Taxa, Total Abundance, Pielou's Evenness and Shannon Wiener Diversity Index Values for Macrofauna Samples Collected at Well F

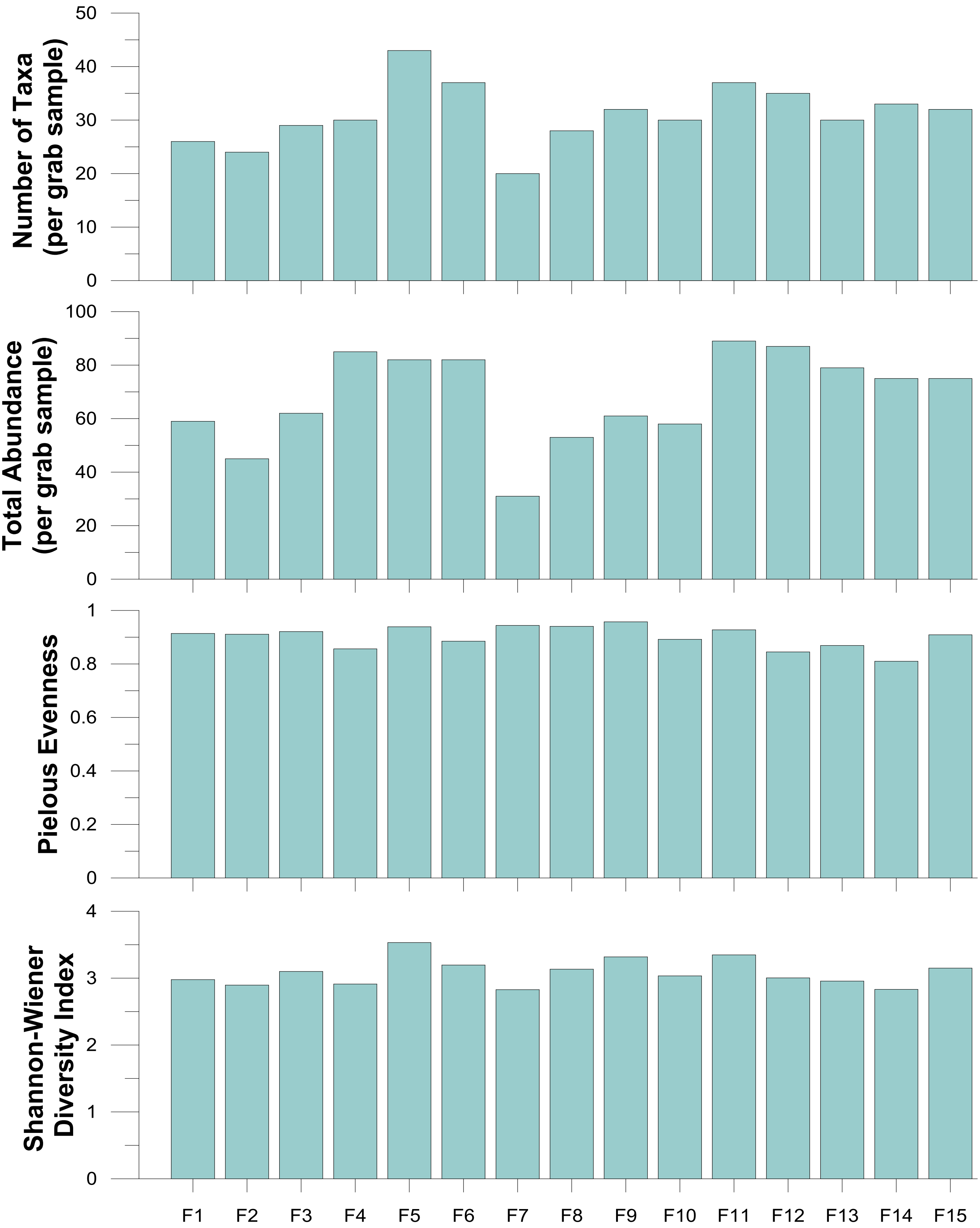


Table 7 Number of Taxa and Total Abundance for the Eleven Wells

Well	Mean Number of Taxa	Mean Abundance	Total Number of Taxa Identified at well	Total number of individuals (abundance)
A	56	257	140	3,849
B	53	210	130	3,151
C	45	132	128	1,987
D	60	332	142	4,986
Northern AOI	53	233		
E	19	36	78	542
F	**31**	**68**	**90**	**1,023**
G	33	81	112	1,215
H	31	89	103	1,339
I	29	72	91	1,075
Central AOI	29	69		
J	40	115	108	1,722
L	54	190	131	2,853
Southern AOI	47	153		

3.4 Sensitive Environments

In an investigation of sensitive substrate/benthic habitats in the Taranaki Coastal Marine Area, Johnston (2016) studied marine taxa databases from marine benthic surveys conducted in the offshore Taranaki Basin and noted that there are many locations where at least one 'characteristic species of sensitive environments' was found. This investigation used the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) 2013 (**Permitted Activities Regulations**) sensitive environments descriptions to define what sensitive habitats may be present.

Chaetopteridae worms and Sea pens were noted by Johnston (2016) as likely to be present in areas close to the 11 proposed wells. In relation to the sampling techniques used in the Benthic Baseline survey (grab sampling and video sled imagery), MacDiarmid *et al*. (2013) define that;

"A sensitive Chaetopteridae worm field is present if worm tubes and/or epifaunal species:

- Occupy 25% or more of the seabed in imaging surveys covering and area of 500 m^2 or more; or
- Occur in two successive samples collected using point sampling gear."

and

"A sea pen field exists if:

- One or more specimens of any species of sea pen is found in two successive samples collected using point sampling gear, or
- Two or more specimens per m^2 are found in seabed imaging surveys, or surveys using towed gear."

Analysis of the infauna samples collected during the Benthic Baseline survey found that Chaetopteridae worms (specifically *Phyllochaetopterus socialis*, commonly known as wire-weed or Tarakihi weed) were present within samples from Wells A, B, C, D, G, H, J and L. As no individuals of *P. socialis* were recorded in any of the infauna samples from Well F, it is unlikely (although not impossible) that conspicuous worm-fields/meadows are present at this well.

No sea pens (*Virgularia gracillima*) were identified in infauna samples from Well F during the Benthic Baseline survey. However, video imagery collected at each well observed sea pens at all of the sites (see **Table 6** for total numbers of sea pens observed each well). Sea pen numbers observed at Well F were low (19 individuals in ten tows) when compared to other sites such as Wells D (total of 160 individuals) and L (total of 132 individuals). The low numbers at Well F were similar to other sites in the Central AOI, where numbers were low-moderate throughout (17 – 36 individuals). Due to video sled tows being only a semi-quantitative survey method it is not possible to make exact predictions on the densities of sea pens encountered. However, as a conservative estimate the width of the camera's field of view could be estimated at one metre, and given that each video sled covered 200 m across the seafloor, approximately 2,000 m^2 of seabed could have been viewed by all the video imagery at this site. Based on such calculations sea pen densities at Well F would not have surpassed the trigger of two sea pens per square meter as an average across the entire area (MacDiarmid *et al.*, 2013). Video tows at Well F were not observed to pass through more spatially limited areas of distinctly higher sea pen density that might have been classed as 'sea pen fields'. Based on the video sled analysis there are no 'Sensitive Environments', as defined by the Permitted Activities Regulations were encountered at the monitoring stations at Well F.

4 Key Findings

4.1 Sediment Characteristics

Grain size analysis showed sediments collected at Well F were silt and clay dominated (83%), similar to the other wells in the Central AOI, and distinctly finer/muddier than sediments in the Northern AOI.

Mean TOC levels (0.63%) at Well F were similar to the other Central AOI sites, which were all distinctly higher than TOC levels in Northern AOI sediments. Particle grain size distributions showed a weak trend of increasing silt and clay proportions from south to north across the Well F area. Variations in silt and clay proportions correlated with the small variations in TOC, similar to the larger and wider trend of higher TOC in sandy mud sediments of the Central AOI compared to lower TOC in muddy sands of the Northern AOI. Sediments with a finer grain size will retain higher levels of organic matter compared to coarser/sandier sediments subjected to the same level of enrichment/deposition, due to the greater surface area of finer particles for adsorption.

4.2 Faunal Characteristics

Video imagery collected from around Well F showed the seabed to be a relatively flat muddy environment, occasionally interrupted by larger mounds/hollows and frequent animal burrows/holes. Whelks, hermit crabs, tusk shells, sponges, sea pens, and a small tubeworm were observed during the video sled tows. Mobile fish numbers at Well F were found to be low (similar to other Central AOI wells) compared to Northern (high) and Southern (moderate to high) AOI sites.

Infauna communities in Well F samples were composed of small polychaete worms (59%), Crustaceans (23% - mainly ostracods, amphipods, isopods and cumaceans), and molluscs (11% - mostly bivalves and gastropods). Cumaceans formed greater proportions of the total infauna community at Well F compared to the remaining Central AOI sites. Central AOI infauna communities had the greatest proportions of polychaetes and gastropods, but the lowest proportions of crustaceans like amphipods and tanaidaceans, reflecting the muddier sediments in the Central AOI which are more suited to deposit feeding/scavenging taxa like many polychaetes and gastropods found at Well F. Mean taxa numbers and infauna abundances at Well F were similar to the overall mean values for the Central AOI, which were considerably lower than those of the Northern AOI.

The finer, mud-dominated sediments present at Well F (and the Central AOI as a whole), compared to coarser sandy sediments of the Northern AOI, are likely linked to the greater proportions of taxa such as polychaetes and gastropods in the Central AOI. Taxa found at Well F that were within these groups that were largely scavengers/detritivores and/or deposit feeders which feed on larger dead materials on/in the sediment and organic matter within the sediments. This feeding mechanism is more suited to muddy sediments where there is comparatively greater proportions of organic matter for given volumes of sediment, compared to coarser sediments such as sands. Taxa more adapted for filter feeding (e.g. copepods, Tanaidacea, and amphipods) have delicate feeding and breathing structures which are more easily clogged/damaged by high levels of very fine sediments. Thus these taxa are often more abundant in areas with coarser sediments, which was found to be the case for Northern AOI infauna communities.

4.3 Sensitive Environments

Some individuals representing some of the '*characteristic species of sensitive environments*' were observed in video sled tows (e.g. sea pens) during the Benthic Baseline survey. However, observations from the video imagery indicate that no 'Sensitive habitats', as defined by the Permitted Activities Regulations (and in MacDiarmid *et al*., 2013) were encountered at the monitoring stations at Well F.

5 References

Clarke K. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18 (1): 117-143.

Clarke K.R., Warwick R.M., 1994. Change in marine communities: An approach to statistical analysis and interpretation. Plymouth Marine Laboratory, UK.

Clarke K.R., Gorley R.N., 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth.

Folk, 1954. *"The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature",* The Journal of Geology 62(4):344-359.

Hedges JI, Keil RG, Cowie GL, 1993, "Sedimentary diagenesis: organic perspectives with inorganic overlays", Chemical Geology 107: 487-492.

Johnston O, Barter P, Ellis J, Elvines D, 2014, "*Recommendations for an Offshore Taranaki Environmental Monitoring Protocol: Drilling- and production-related discharges, Version 1.0*" (OTEMP), Cawthron Report No. 2124.

Johnston O 2016. Sensitive habitats and threatened species in the Taranaki Coastal Marine Area (TCMA) - database investigation. Prepared for Taranaki Regional Council. Cawthron Report No. 2877. 28 p. plus appendices.

MacDiarmid, A., Bowden, D., Cummings, V., Morrison, M., Jones, E., Kelly, M., Neil, H., Nelson, W., Rowden, A., 2013. '*Sensitive marine benthic habitats defined*'. Prepared for Ministry for the Environment, NIWA Client Report No: WLG2013-18.

SLR, 2016. "*Benthic Ecological Survey – Tui Field facilities. Production Discharge Monitoring, February 2016*" prepared for AWE Taranaki Limited, report number 740.10040.

SLR, 2017a, "*Benthic Ecological Survey for the Maui Platform Alpha. Annual Production Monitoring – April 2017*", prepared for Shell Todd Oil Services Limited, SLR Report Number 740.10041.00300-R01--v0.1

SLR, 2017b. "*Benthic Ecological Survey for the Oi-1 and Oi-2 Exploration Wells. Post-drill Assessment – November 2016"*. Prepared for Tamarind Taranaki Limited, report number 740.10025.00100-R01.

SLR, 2018. "*Tui Field Ecological Effects Monitoring Report"*. Prepared for Tamarind Taranaki Limited, report number 740.10040.00100-R01-v0.1.

APPENDIX A

Locations and Observations from Sediment Grab Sampling and Video Sled during the 2018 Benthic Baseline Survey

Station	Date	Time	Depth (m)	Coordinates (NZTM)		Notes
				Easting	Northing	
Grab Samples						
FG 1	7/4/18	1706	127	1618536	5664745	Cohesive light grey / brown mud
FG 2	7/4/18	1652	127	1616537	5664751	Cohesive light grey / brown mud
FG 3	7/4/18	1635	127	1614535	5664754	Cohesive light grey mud
FG 4	7/4/18	1530	127	1613537	5664757	Cohesive light grey mud
FG 5	7/4/18	1516	127	1612536	5664757	Cohesive light grey mud
FG 6	7/4/18	1506	127	1611537	5664757	Cohesive light grey mud / clay, sticky
FG 7	7/4/18	1456	127	1610536	5664751	Cohesive light grey mud / clay. Harder deeper in cores
FG 8	7/4/18	1607	127	1615546	5666756	Light grey cohesive mud / clay
FG 9	7/4/18	1621	127	1615548	5665755	Light grey cohesive mud
FG10	7/4/18	1643	127	1615551	5663760	Cohesive light grey / brown mud / clay
FG11	7/4/18	1420	127	1615546	5662747	Light grey cohesive mud
FG12	7/4/18	1550	127	1612538	5666756	Light grey cohesive mud
FG13	7/4/18	1542	127	1612538	5665759	Softer light grey mud / clay
FG14	7/4/18	1443	127	1612536	5663756	Softer light grey mud / clay
FG15	7/4/18	1465	127	1612537	5662756	Light grey cohesive mud
Video sled Tow						
FV 1	6/4/18	1327	127	1617545	5666262	
FV 2	6/4/18	1356	127	1617542	5664761	
FV 3	6/4/18	1419	127	1617546	5663259	
FV 4	6/4/18	1604	128	1614037	5666261	
FV 5	6/4/18	1517	127	1613537	5664757	
FV 6	6/4/18	1451	127	1614043	5663253	
FV 7	6/4/18	1541	129	1612536	5664757	
FV 8	6/4/18	1632	128	1611540	5666254	
FV 9	6/4/18	1655	126	1611036	5664753	
FV10	6/4/18	1720	125	1611542	5663255	

APPENDIX B

Sediment Core Profile Images from all Grab Samples Collected during the 2018 Benthic Baseline Survey at Well F


F1.JPG


F10.JPG


F11.JPG


F12.JPG


F13.JPG


F14.JPG


F15.JPG


F2.JPG


F3.JPG

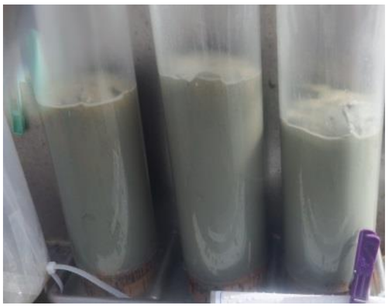

F4.JPG


F5.JPG


F6.JPG


F7.JPG

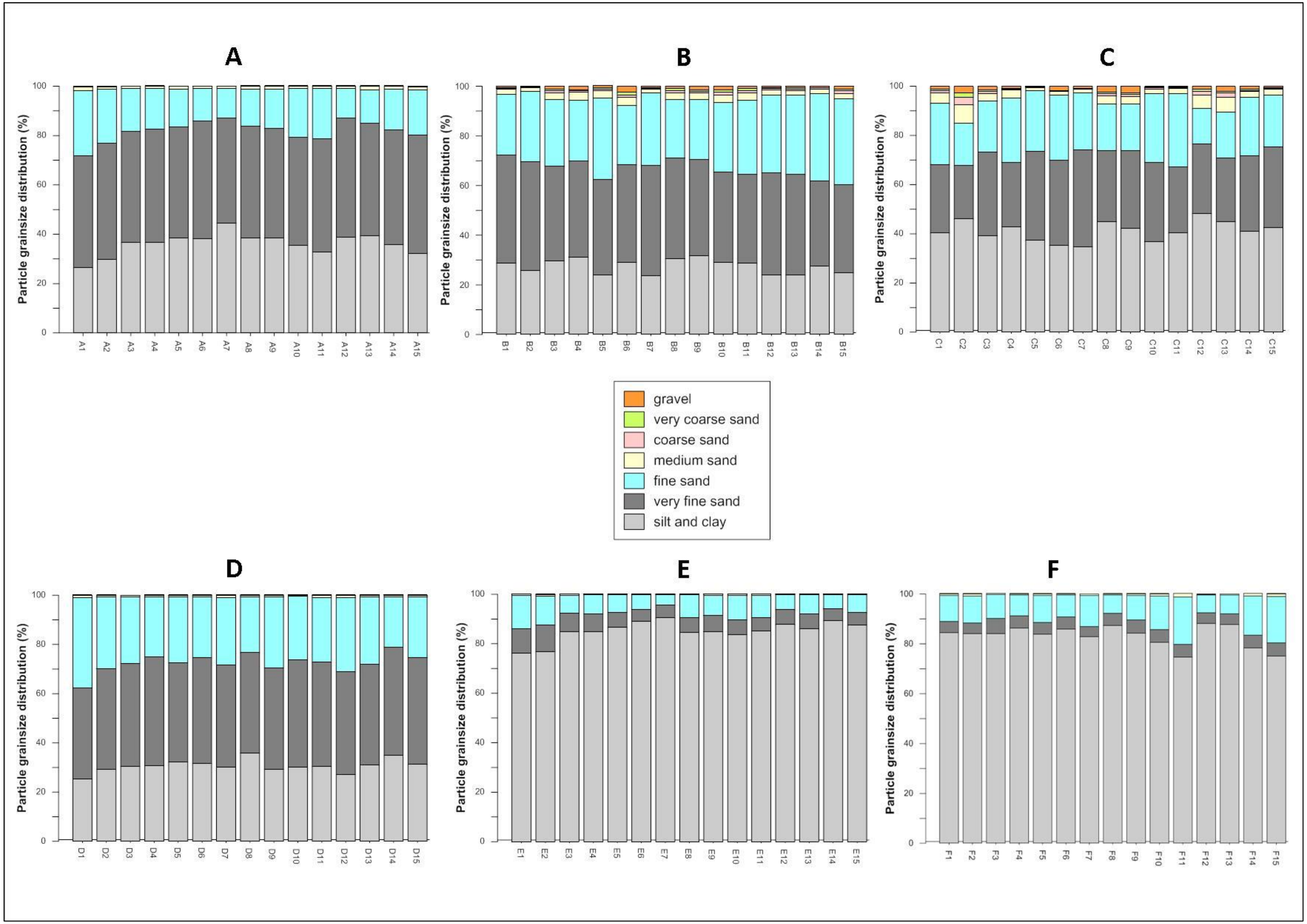

F8.JPG

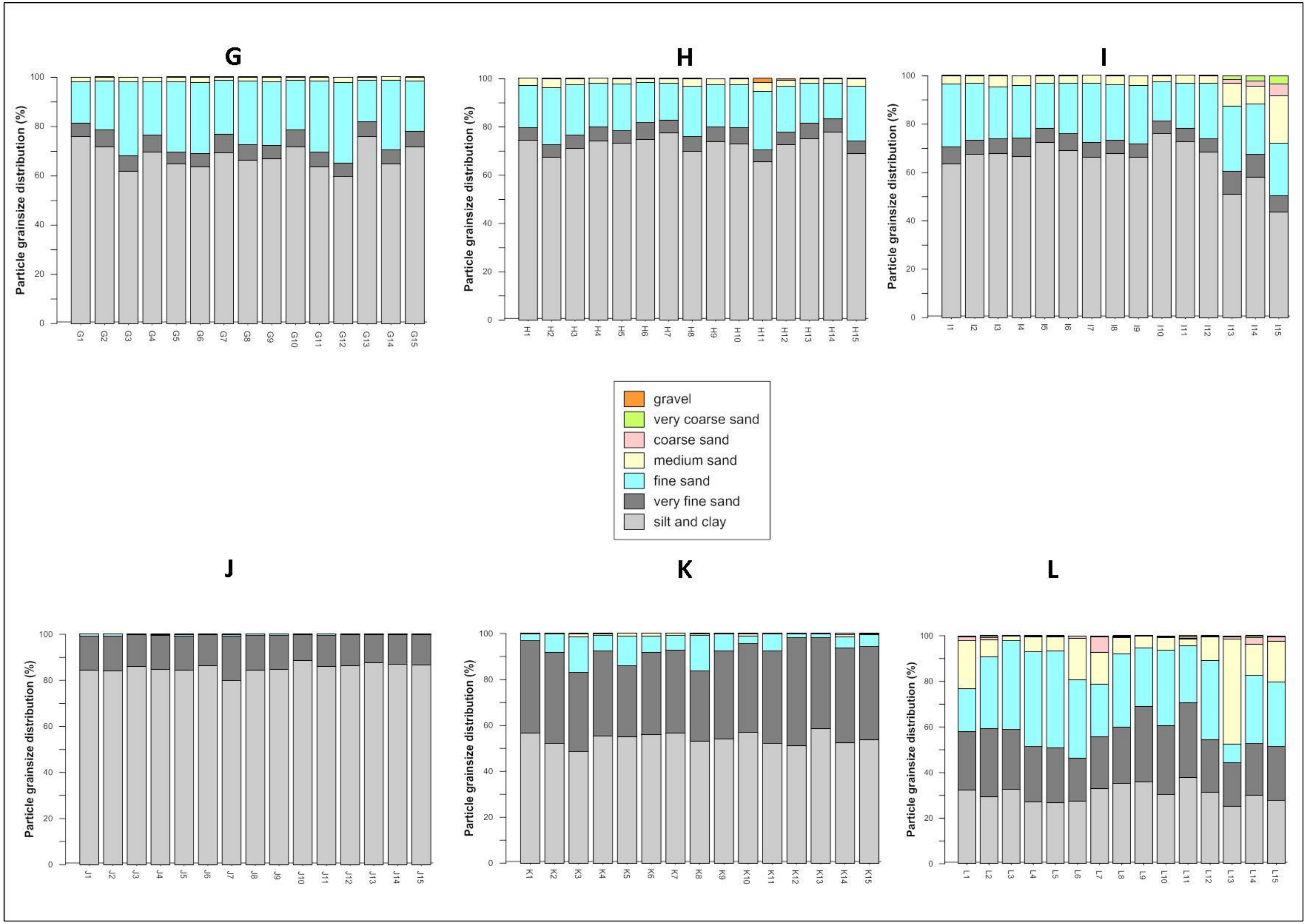

F9.JPG

APPENDIX C

Total Organic Carbon Content and Particle Grain Size Distribution for Well F

Replicate Sample	TOC (%)	Gravel (%)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Silt & Clay (Mud) (%)
Station F1	0.66	0.05	0.05	0.05	0.7	10.3	4.6	84.4
Station F2	0.61	0.05	0.05	0.05	0.8	10.9	4.3	84
Station F3	0.66	0.05	0.05	0.05	0.4	9.6	6	84.1
Station F4	0.66	0.05	0.05	0.05	0.4	8.5	4.7	86.4
Station F5	0.63	0.05	0.05	0.05	0.6	10.8	4.8	83.8
Station F6	0.64	0.05	0.05	0.05	0.4	8.9	4.8	85.9
Station F7	0.64	0.05	0.05	0.05	0.5	12.4	4.2	82.8
Station F8	0.69	0.05	0.05	0.05	0.4	7.3	5	87.3
Station F9	0.64	0.05	0.05	0.05	0.6	9.9	5.2	84.3
Station F10	0.6	0.05	0.05	0.05	0.8	13.6	5.1	80.5
Station F11	0.56	0.05	0.05	0.05	1.3	19.1	5	74.7
Station F12	0.68	0.1	0.05	0.05	0.3	7.1	4.2	88.2
Station F13	0.59	0.05	0.05	0.05	0.4	7.4	4.4	87.7
Station F14	0.59	0.05	0.05	0.05	1	15.6	5.2	78.3
Station F15	0.58	0.05	0.05	0.05	1.1	18.6	5.2	75.1


A
B
C
D
E
F
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay


G
H
I
J
K
L
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay

APPENDIX D

Raw Counts of Macroinvertebrate (Infauna and Epifauna) Abundance at Well F

Taxa	Class/Order	Phylum	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
Aglaophamus sp.	Polychaeta		11	1	6		4	4		4	2	2	5	6	5	4	6
Amalda spp.	Gastropoda	Mollusca			1											1	
Ampelisca sp.	Amphipoda	Crustacea														1	
Ampharetidae	Polychaeta		1	1	2	8	2	4	1	2	3	7	2	5	9	3	2
Amphipoda	Amphipoda	Crustacea	4	4	6	1	4	2	1	1	2	1	3	2		1	
Anthuridae	Isopoda	Crustacea		1							1					1	3
Aphroditidae	Polychaeta		1									1					
Aplacophora		Mollusca		2	1		1						3		1		1
Aricidea sp.	Polychaeta			2	1	1	1	1		1			1	2	2	2	
Armandia maculata	Polychaeta				1		1					2		2			1
Armandia maculata (juvenile)	Polychaeta					2							1		1		
Ascidiacea	Tunicata						2					2					
Asellota	Isopoda	Crustacea		1	2		1			1	1			2			
Axiopsis sp.	Decapoda	Crustacea		1	2		2				1					1	
Bivalvia (inderterminate)	Bivalvia	Mollusca													2		
Bradleya opima	Ostracoda	Crustacea	1	1		1	1	2	1	3			4	1	1	3	
Buccinidae (juvenile)	Gastropoda	Mollusca						1									
Cadulus teliger	Scaphopoda	Mollusca			1			1				1	1	1			
Capitellethus zeylanicus	Polychaeta		3	1		3	3	1	2	4	2	6	2	1	2		3
Chaetognatha	Chaetognatha			1				1			1						
Cirratulidae	Polychaeta		3	7	1	7	8	11	3	4	2	2	6	7	7	5	6
Clavelima claviformis	Tunicata			2				1				1			1	1	1
Copepoda	Copepoda	Crustacea		1		2		1				1	2				
Cumacea	Cumacea	Crustacea	4		4		3	2	1	2	1	1	7	11	7	2	1
Curveulima aupouria	Gastropoda	Mollusca		1		1		1	1				1				1

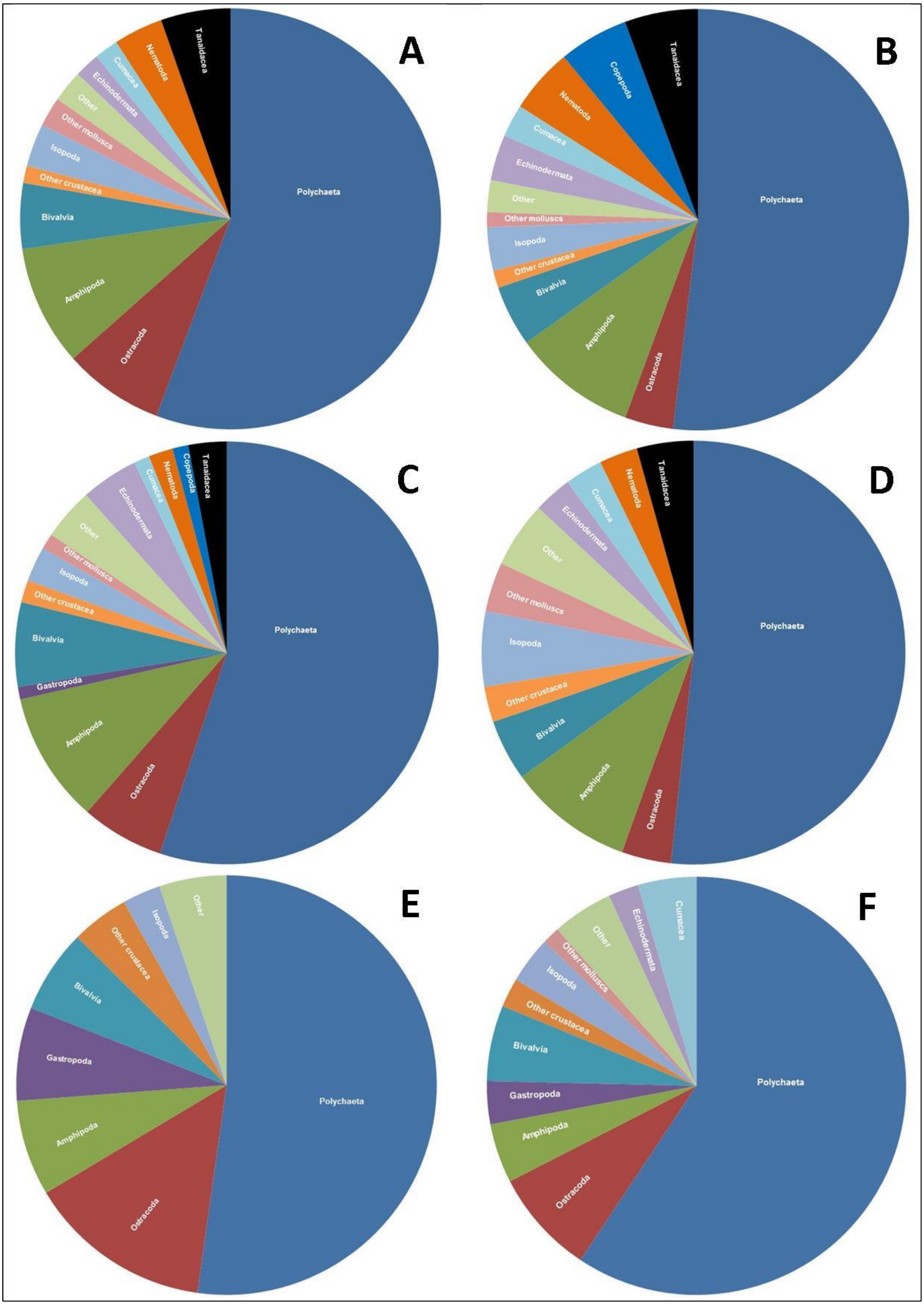
Taxa	Class/Order	Phylum	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
Cyclostrematidae	Gastropoda	Mollusca	1	0	0	0	1	1	0	0	0	0	1	0	0	1	0
Cymbicopia hispida	Ostracoda	Crustacea				1			1		1			1	1		1
Cytherella sp.	Ostracoda	Crustacea								5						1	
Edwardsia sp.	Actiniaria	Anthozoa					2			1			2				
Ennucula strangei	Bivalvia	Mollusca			1										2	1	
Euchone pallida	Polychaeta		1		2	1	1	2		2		1	4	2			1
Euphausiacea	Euphausiacea	Crustacea							1		1		1	1			
Euphilomedes agilis	Ostracoda	Crustacea	1	1	2	1	2	1	1		2	1	4				3
Fauveliopsidae	Polychaeta					1	2	1							1	1	
Flabelligeridae	Polychaeta		1		2	1	2	2			1		1	1	1		1
Gastropoda (juvenile)	Gastropoda	Mollusca						1									
Gnathiidae	Isopoda	Crustacea	2	1		2		1			3		1		1		
Haustoriidae	Amphipoda	Crustacea	1														
Hemichordata	Hemichordata						1										
Hesionidae	Polychaeta				1												
Heteromalpadia marenzelli	Holothuridea	Echinodermata				2	1										
Hyalinoecia sp.	Polychaeta							1								1	
Leitoscoloplos kerguelensis	Polychaeta						1									1	
Lumbrineridae	Polychaeta		2		1	4	2	2		2	3	1	1	1	2		
Lysianassidae	Amphipoda	Crustacea											1				
Maldanidae	Polychaeta		4	6	7	19	8	11	5	5	5	10	9	19	14	25	11
Marphysa disjuncta	Polychaeta		1	1			1		2	1		1				1	
Merelina sp.	Gastropoda	Mollusca								1							
Mysella hounselli	Bivalvia	Mollusca					2										1
Natatolana pellucida	Isopoda	Crustacea					2			1		3					
Naticidae	Gastropoda	Mollusca	2							1							

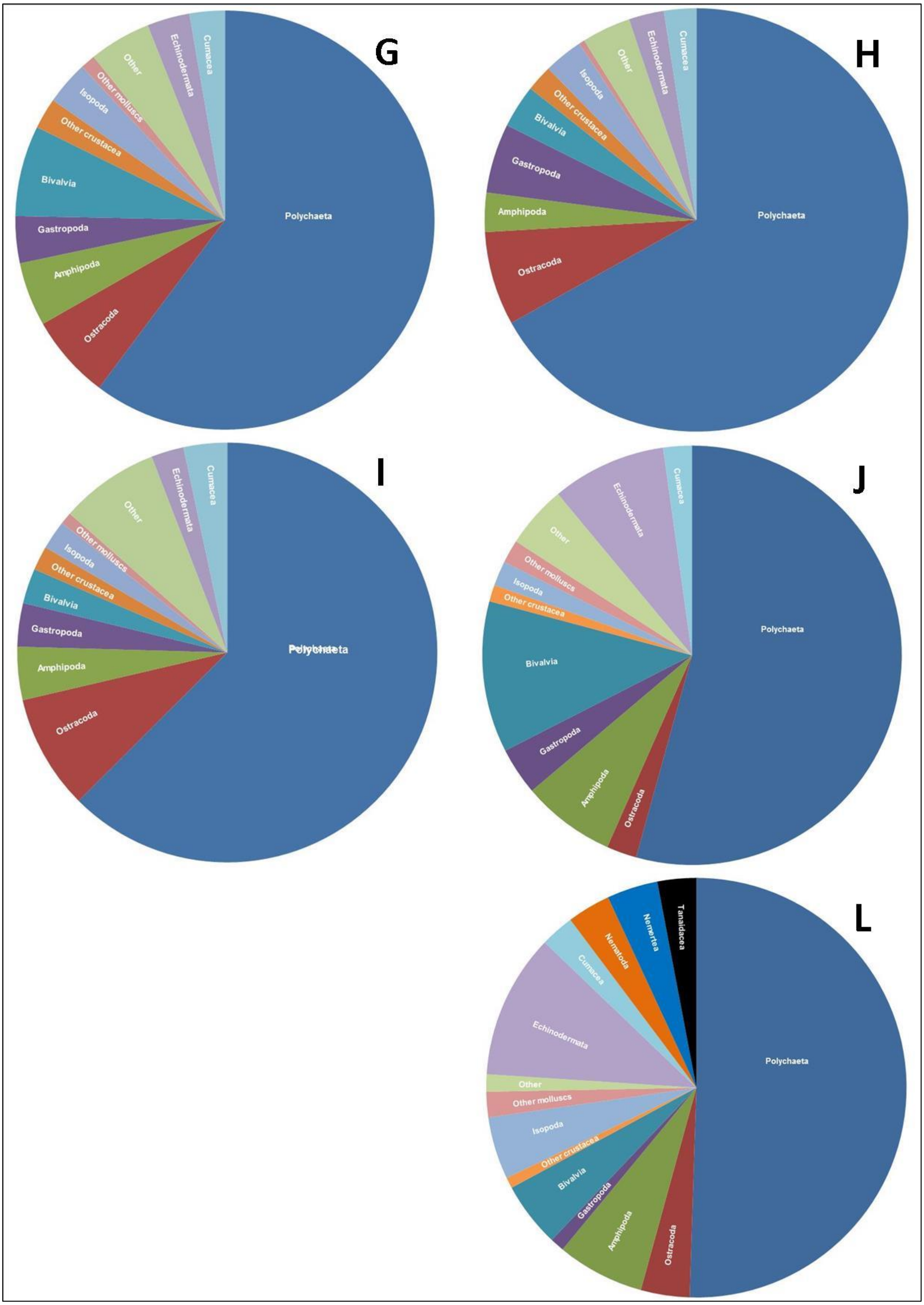
Taxa	Class/Order	Phylum	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
Neilonella wrighti	Bivalvia	Mollusca	2		1	2	2	2		1	1	1	2	1	1	1	2
Neilonella wrighti (juvenile)	Bivalvia	Mollusca			1		1	1	1	1	1			1	1		
Nematoda	Nematoda										1		1	2	1	1	6
Nemertea	Nermetea		1										1	1	2		
Neonesidea sp.	Ostracoda	Crustacea				2	1	1	2	2		1		2	1		
Onuphis aucklandensis	Polychaeta		2		1	2	2	2			2	1	4	1	3	1	
Ophiuroidea	Ophiuroidea	Echinodermata	2		3	2	1		1	1	2		2	1		1	4
Ostracoda	Ostracoda	Crustacea						1									
Paramunna serrata	Isopoda	Crustacea		1				1			1		1	1			1
Paraonidae	Polychaeta		4	2	5	9	2	7	3	1	3	3	5	2	5	3	3
Parasterope quadrata	Ostracoda	Crustacea			1												
Philine powelli	Gastropoda	Mollusca										1					
Phoxocephalidae	Amphipoda	Crustacea		1	1	1				1	2	1	1		1	2	1
Phyllodocidae	Polychaeta																1
Phylo novaezealandiae	Polychaeta			1													
Pilargidae	Polychaeta						1		1				2	1			2
Polynoidae	Polychaeta																1
Pontophilus sp.	Decapoda	Crustacea										1					
Poroleda lanceolata	Bivalvia	Mollusca					1						1	1	1		2
Prionospio sp.	Polychaeta		1			2	1										
Relichna apouria	Gastropoda	Mollusca	1				1	1		1	3		2		1		
Rhamphobrachium sp.	Polychaeta								1								1
Rissoidae	Gastropoda	Mollusca			1			1		1	1						
Rynkartopa uncinata	Holothuroidea	Echinodermata				1											
Scalibregma inflatum	Polychaeta						1									1	
Sigalionidae	Polychaeta				1				1		1	1			1		

Taxa	Class/Order	Phylum	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
Sphaerosyllis sp.	Polychaeta									2	2		2				
Spiophanes kryoeri	Polychaeta													1			
Spiophanes sp.	Polychaeta					2		6	1			1					
Stomatopoda juvenile	Stomatopoda	Crustacea									1						
Syllidae	Polychaete												1			1	1
Tanaidacea	Tanaidacea	Crustacea										1				1	
Terebellidae	Polychaeta													1			1
Terebellides stroemi	Polychaeta						2						1	1		1	
Themiste sp.	Sipuncula					2	2					1		1	1	1	3
Thyasira peregrina	Bivalvia	Mollusca					1	1									
Trachyleberis lytteltonensis	Ostracoda	Crustacea	2	4		1	1	1		1	3			2		3	1
Upogebia sp.	Decapoda	Crustacea												1			
Varinucula gallinacea	Bivalvia	Mollusca			3	1	1	1			5	1		1		1	2

APPENDIX E

Comparison of Proportion of Individuals belonging to each Taxonomic Group across all Wells


A
Tanaidacea
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
Polychaeta
B
Tanaidacea
Copepoda
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
Polychaeta
C
Tanaidacea
Copepoda
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta
D
Tanaidacea
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
Polychaeta
E
Other
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta
F
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta


G
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
H
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other
Echinodermata
Cumacea
I
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
J
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
L
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Nemertea
Tanaidacea

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EXPLORATION AND APPRAISAL DRILLING PROGRAMME

Benthic Baseline Report
Well G

Prepared for:

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SLR Ref: 740.10078.00200-R01
Version No: v1.0
July 2018

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BASIS OF REPORT

This report has been prepared by SLR Consulting NZ Limited with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with OMV New Zealand Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.10078.00200-R01-v1.0	31 July 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier
740.10078.00200-R01-v0.1	29 June 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier

EXECUTIVE SUMMARY

OMV New Zealand Limited (**OMV New Zealand**) are applying for a Marine Consent to undertake an Exploration and Appraisal Drilling (**EAD**) Programme in the Taranaki Basin with an anticipated commencement date in 2019. OMV New Zealand may drill up to nine exploration wells and two appraisal wells within their Petroleum Exploration Permits (**PEP**). The intention of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs.

As part of the Marine Consent application, three Areas of Interest (**AOI**) have been identified that encapsulate the proposed well locations and are used as part of the Impact Assessment process. OMV New Zealand undertook a baseline environmental monitoring survey at each well location in March - April 2018 to gain an understanding of the benthic habitat and associated communities with each AOI.

Grab sampling and video sled methodologies were used to gain quantitative and qualitative information on the marine environments surrounding each well location. The data gathered from each baseline survey will be incorporated into the Marine Consent application and assist in the risk assessment process.

Water currents and deposition modelling were utilised to define the placement of sample stations. Sample transects were aligned along the dominant deposition pathway of the predicted drill cutting dispersion should that particular well be drilled. A total of 15 monitoring stations were allocated at each well and one benthic grab sample was collected at each monitoring station. Ten video sleds were also undertaken at a selection of pre-determined stations around each well location.

Within this Benthic Baseline report the analysis of results incorporates sediment physical and chemical properties, benthic macrofauna, epifauna and visual observations around Well G. Results of sediment analyses showed Well G to be composed of sandy muds, dominated by silt and clay, with relatively levels of Total Organic Carbon (**TOC**) (0.51%). Grain size distribution and TOC showed no distinct spatial patterns across the Well G monitoring stations, but varied similarly showing a relationship between silt and clay and TOC. Sediments and TOC levels were similar to those found at the remaining Central AOI sites.

The 15 infauna samples collected around Well G revealed 1,215 individuals representing 112 taxa. Infauna communities were dominated by small polychaetes (60%), crustaceans (20%, comprised of ostracods, amphipods, isopods, and cumaceans) and molluscs (12%, comprised of gastropods and small bivalves). Central AOI infauna communities had the greatest proportions of polychaetes and gastropods, but the lowest proportions of crustaceans like amphipods and tanaidaceans, reflecting the muddier sediments in the Central AOI which are more suited to deposit feeding/scavenging taxa like many polychaetes and gastropods.

Video imagery collected during the Benthic Baseline survey indicated the presence of sea pens, while Chaetopteridae worms (*Phyllochaetopterus socialis*) were identified within the grab sample collected at monitoring station H2; both of these taxa are defined as '*characteristic species of sensitive environments*' in the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013. The occurrence and estimated densities of sea pens at Well G did not reach the trigger levels defined by the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (MacDiarmid *et al*., 2013) and no distinct sea pen 'fields' were encountered. Chaetopteridae worms are known to form worm-fields or low-relief worm meadows when present at high densities but video imagery did not reveal the presence of such features around Well G. Thus, although present at the well sites in low densities, it is considered that the site does not classify as a 'sensitive environment'.

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1 Introduction

OMV New Zealand Limited (**OMV New Zealand**) is applying for a Marine Consent under Section 38 of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (**EEZ Act**) to permit activities associated with an Exploration and Appraisal Drilling (**EAD**) Programme proposed to be undertaken starting in 2019.

The EAD Programme includes the drilling of up to nine exploration wells and two appraisal wells within OMV New Zealand's permit areas (**Figure 1**). The purpose of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs which OMV New Zealand operate (**Figure 1**).

Three Areas of Interest (**AOI**) (summarised below) have been identified which encapsulate the well locations (**Figure 1**). This monitoring report relates to the Benthic Baseline survey conducted at Well G in the Central AOI. Location details and water depth of Well G are provided in **Table 1**.

The Northern AOI encompasses PEP 60092 (Ridgeline), PEP 57075 (Cloudy Bay) and PEP 60093 (Toutouwai) and includes the following wells:

- Well A;
- Well B;
- Well C; and
- Well D.

The Central AOI encompasses PEP 60093 (Toutouwai) and includes the following wells:

- Well E (Appraisal);
- Well F;
- Well G (Appraisal);
- Well H; and
- Well I.

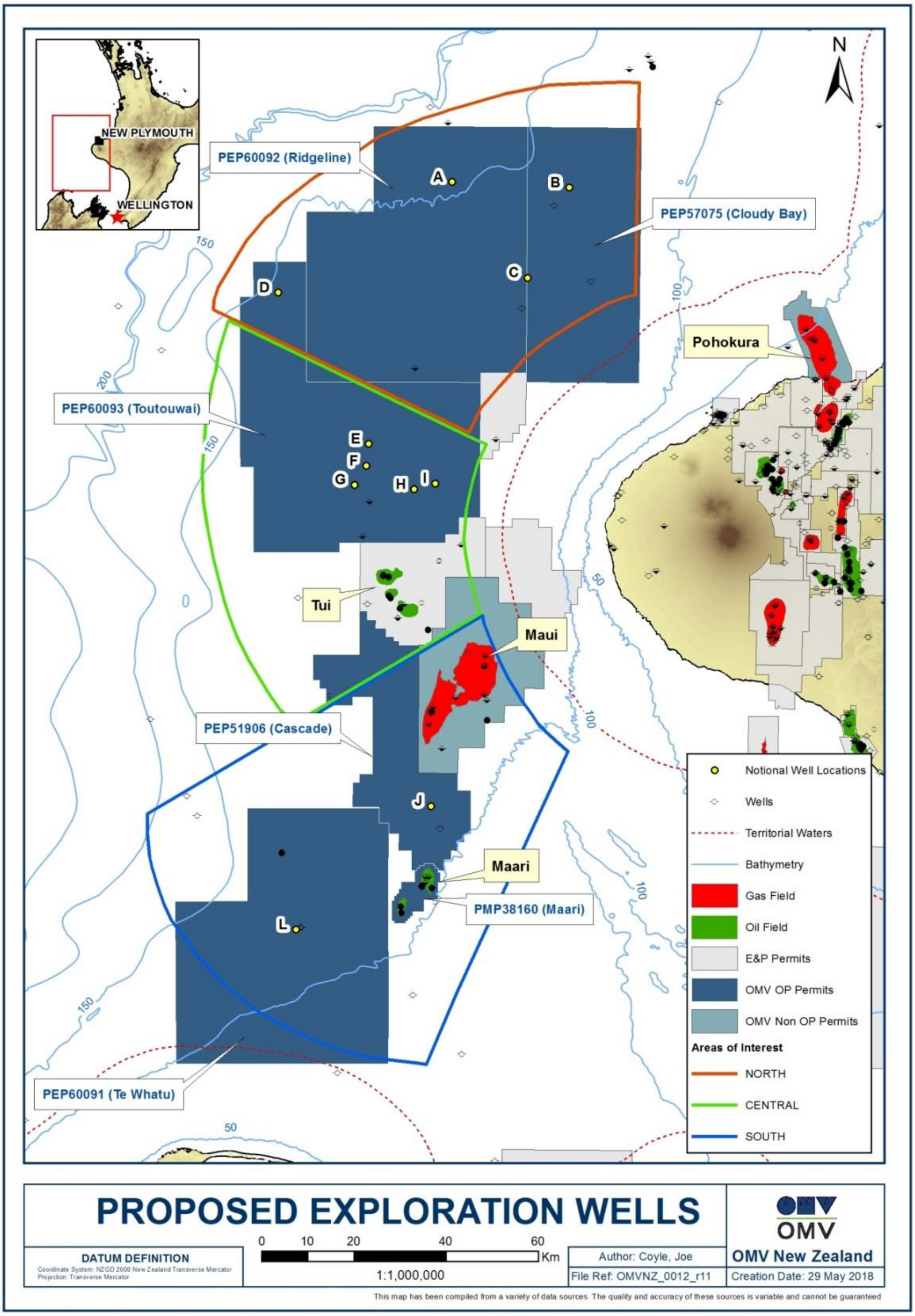
The Southern AOI encompasses PEP 51906 (Cascade), and PEP 60091 (Te Whatu) and includes the following wells:

- Well J; and
- Well L.

Table 1 Water Depth and Coordinates of Well G in the Central AOI

Well Name	Water Depth (m LAT)	Easting (NZTM)	Northing (NZTM)
G	122.9	1610407	5660872

Figure 1 OMV New Zealand's EAD Well Locations and three AOIs in the Taranaki Basin



In February 2018 SLR Consulting NZ Limited (**SLR**) was engaged by OMV New Zealand to undertake a baseline assessment of the benthic ecology in the vicinity of 11 well (**Figure 1**). The aim of the field surveys, which were undertaken from March 24 – April 8 2018, was to collect relevant data using grab sampling and video sled methodologies to provide quantitative and qualitative information on these marine environments. This qualitative and quantitative data will be used within the Marine Consent application to define the benthic habitats and communities present at each well location and assist in the risk assessment process.

This report summarises the results of the Benthic Baseline survey undertaken at Well G

1.1 Project Location

Well G is located approximately 83 km west of New Plymouth in New Zealand's Exclusive Economic Zone (**EEZ**). Water depth and GPS coordinates are provided in **Table 1** and displayed in **Figure 1**. The monitoring programme sample design resulted in sample stations extending out to 6 km from the well location (**Section 1**).

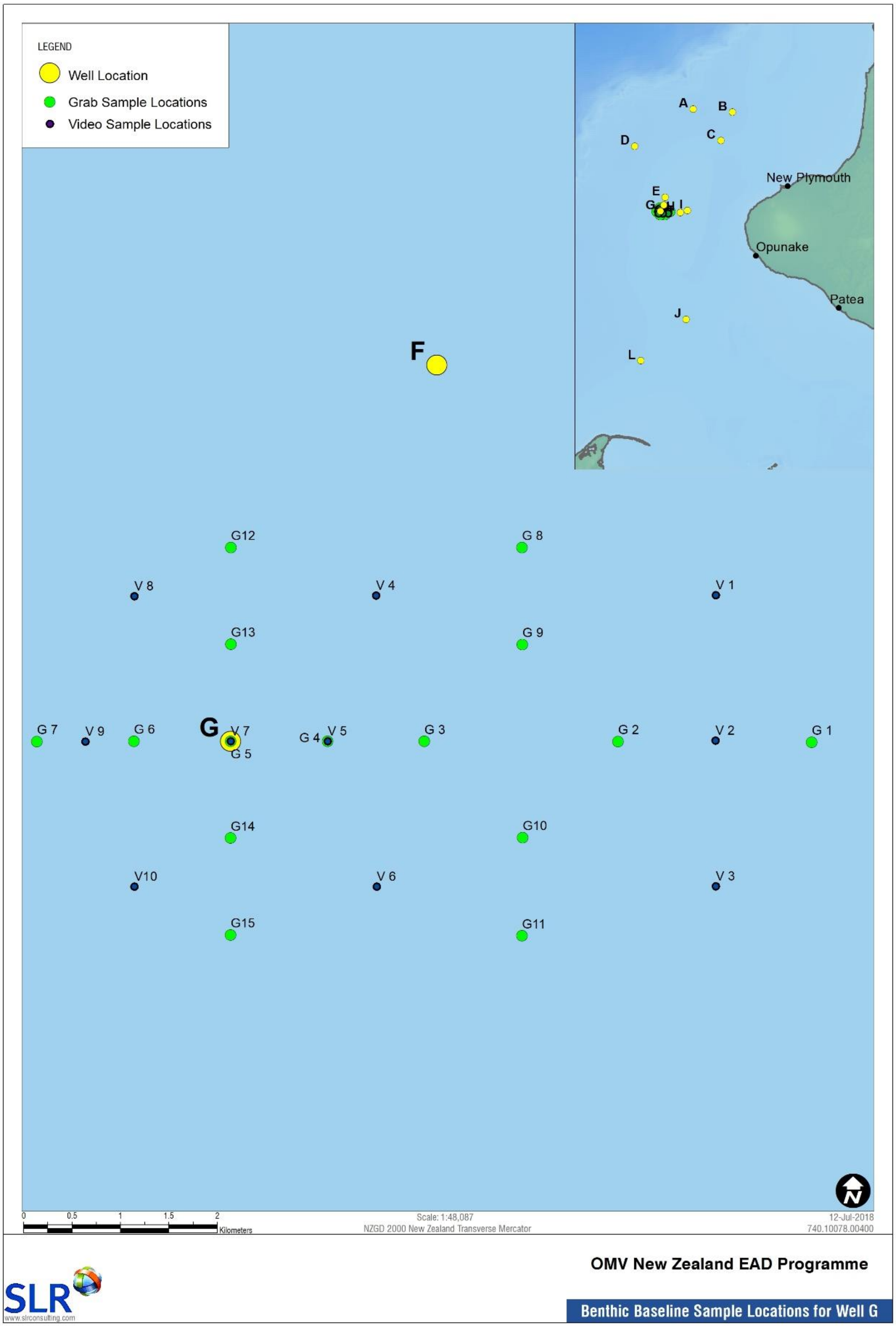
2 Methodology

The Benthic Baseline surveys adopted similar methodologies to what has been previously used for offshore Taranaki benthic monitoring programmes undertaken in accordance with the principles defined in the Offshore Taranaki Environmental Monitoring Protocol (**OTEMP**) (Johnston *et al*., 2014). This consistent approach enables monitoring results to be compared with previous monitoring programmes undertaken in the offshore Taranaki environment (i.e. pre- and post-drill monitoring and production monitoring).

2.1 Sample Locations

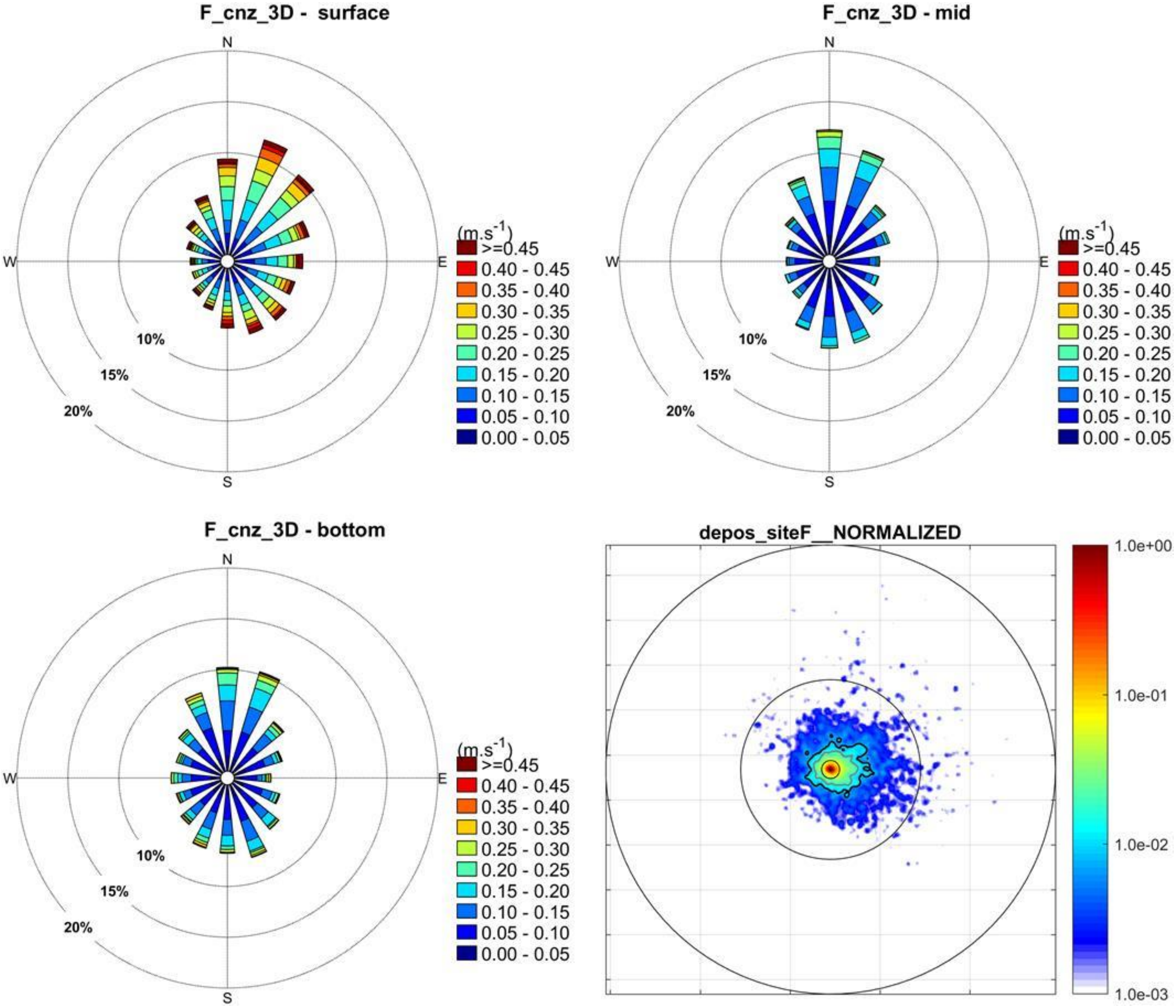
The sample locations (**Figure 2**) were defined by the dominant direction of current flow and preliminary drill cutting deposition modelling results (**Figure 2**). Sample transects were aligned along the dominant deposition pathway (i.e. southeast/northwest) (**Figure 3**) as this is the area determined to be most likely to be impacted from the deposition of drill cuttings should the well be drilled. However, sample stations were also located along the minor flow axis (northeast/southwest) to enable comparisons and validation of spatial differences based on the dispersal patterns predicted by MetOcean Solutions Limited.

Figure 2 Well G Sampling Locations



Note: At each video transect location approximately 250 m of video footage was captured along the seabed in the direction of the vessels drift at the time of sampling.

Figure 3 Surface, Mid-water and Bottom Water Column Current Roses and Dispersal Modelling Plot created by Metocean Solutions Ltd for nearby Well F



2.2 Field and Sampling Procedures

Field sampling was undertaken from the MV *Seaworker* between March 24 and April 8, 2018, following the procedures detailed below. Sampling at Well G took place on April 6th and 7th.

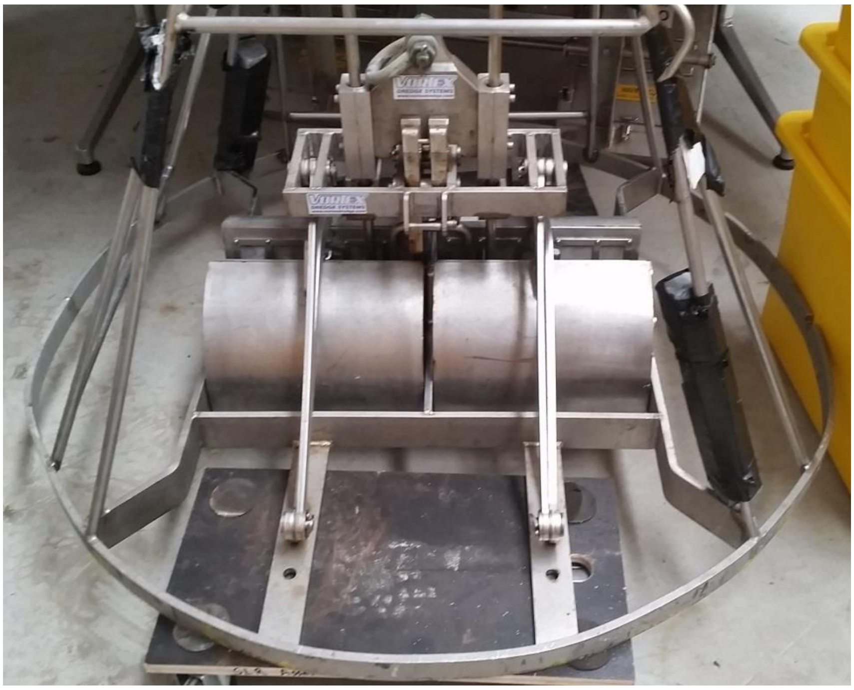
2.2.1 Benthic Grab Samples

A double Van Veen double grab sampler (**Figure 4**) was used to collect a single sediment grab sample at each of the 15 benthic monitoring stations surrounding Well G (**Figure 2**). The grab sampler is constructed of stainless steel and features two independent 'buckets' which penetrate the surficial sediments to a depth of 0.16 m. Each successful grab sample returns approximately 0.01 m^3 of seabed sediment back to the surface.

Upon arrival on the vessel deck, each grab sample is checked for completeness, which must meet the following criteria:

- The surface of the sediment is largely undisturbed upon inspection aboard the vessel;
- Sufficient sediment (≥75% of the grab capacity) is collected to enable the full suite of sediment analyses required;
- The infauna sample bucket is filled to the same volume (approximately 10 l) for all infauna replicates throughout the survey; and
- The grab has not been over-filled with sediments pushing out of the doors or drains, indicating that it may have over-penetrated the sediment.

Figure 4 The Double Van Veen Grab Sampler used for the 2018 Benthic Baseline Sampling



Each independent bucket from a grab sample is used separately for infauna and sediment physical and chemical analyses, as follows:

- Bucket one: infauna/macrofauna community analysis. The entire sample is sieved through 0.5 mm mesh until approximately 300 - 500 ml of residual sediment and organisms remains. This remaining material is transferred to a plastic container and preserved with a fixative (AncholTM), ready for analysis by SLR taxonomists.
- Bucket two: sediment physical nature and chemical analyses. Three 64 mm (internal diameter) clear Perspex sub-sampling cores are pushed into the sediments from the second bucket, to a depth of approximately 150 mm. Cores are photographed and the upper 50 mm from each core is extruded into a polyethylene bag for particle grain size distribution and organic content (Total Organic Carbon (**TOC**)) analyses by Hill Laboratories.

2.2.2 Seafloor Video Imagery

Video imagery of the seafloor was obtained using a customised tow-sled fitted with high-intensity LED lighting and a high-definition video camera (**Figure 5**). The system was connected to the vessel via a 10 mm dyneema tow-line and a 300 m umbilical cable supplying real-time video images to the camera operator on the research vessel. A pair of parallel lasers on the video sled provided an indication of scale allowing features of interest in the video recordings to be approximately sized. Ten video sled tows were conducted around Well G (**Figure 2**).

The video-sled was launched from the vessel up-current of each pre-determined location and lowered to the seabed, where it auto-located via a series of floats and weights set at specific points on the sled frame, to land upright on its lower skids. At the point where the sled contacted the seabed, a GPS log was started, and this log continued throughout the duration of the tow. Video footage was continuously recorded for approximately 200 m as the sled drifted behind the vessel; this ensured that footage was collected while the sled was passing as close as possible to the required sample location.

Figure 5 The Video Sled used for Collecting Video Footage of the Seabed Environment

2.3 Laboratory Analyses

2.3.1 Sediment Physicochemical Analyses

Benthic sediments collected by the grab sampler were analysed by Hill Laboratories (an NZS/ISO/IEC 17025:2005 accredited laboratory), for both physical and chemical parameters. The aims of these analyses along with further details of the analytical method/descriptions are summarised in **Table 2**.

Table 2 Summary of Analytical Methods used for Testing Sediment Physico-chemical Characteristics

Analyte	Aim	Method Number	Description
Particle Grain Size Distribution	• Determine physical parameters of the sediment particles present at the site • Correlate with infauna community characteristics	Hill Laboratories KB32136	• Sediment was wet-sieved through the following screen sizes, as per the Udden-Wentworth scale (Wentworth, 1922): • >2 mm (gravel) • >1 mm (very coarse sand) • >500 µm (coarse sand) • >250 µm (medium sand) • >125 µm (fine sand) • >63 µm (very fine sand) • <63 µm (silt and clay)
Total Organic Carbon	• Determine current level of organic carbon in sediment • Correlate with infauna community characteristics	No specific method number	Acid pre-treatment to remove carbonates present, followed by catalytic combustion (900° C, O_2), separation, Thermal Conductivity Detector. Elemental Analyser.

2.3.2 Macrofauna Analyses

Macrofaunal analyses focused on the infauna, or animals larger than 0.5 mm living within the sediment matrix. Epifaunal animals (those living on top of the sediment), were also included in the analyses to provide representation of the different functional groups present at each sample station.

Benthic macrofaunal samples collected from the sediment grab were sorted and, with the aid of a binocular microscope, identified to the lowest practicable taxonomic level or most recognisable taxa (morphologically similar group). Counts were made to assess the relative abundance of each taxa.

2.3.3 Seafloor Video Analyses

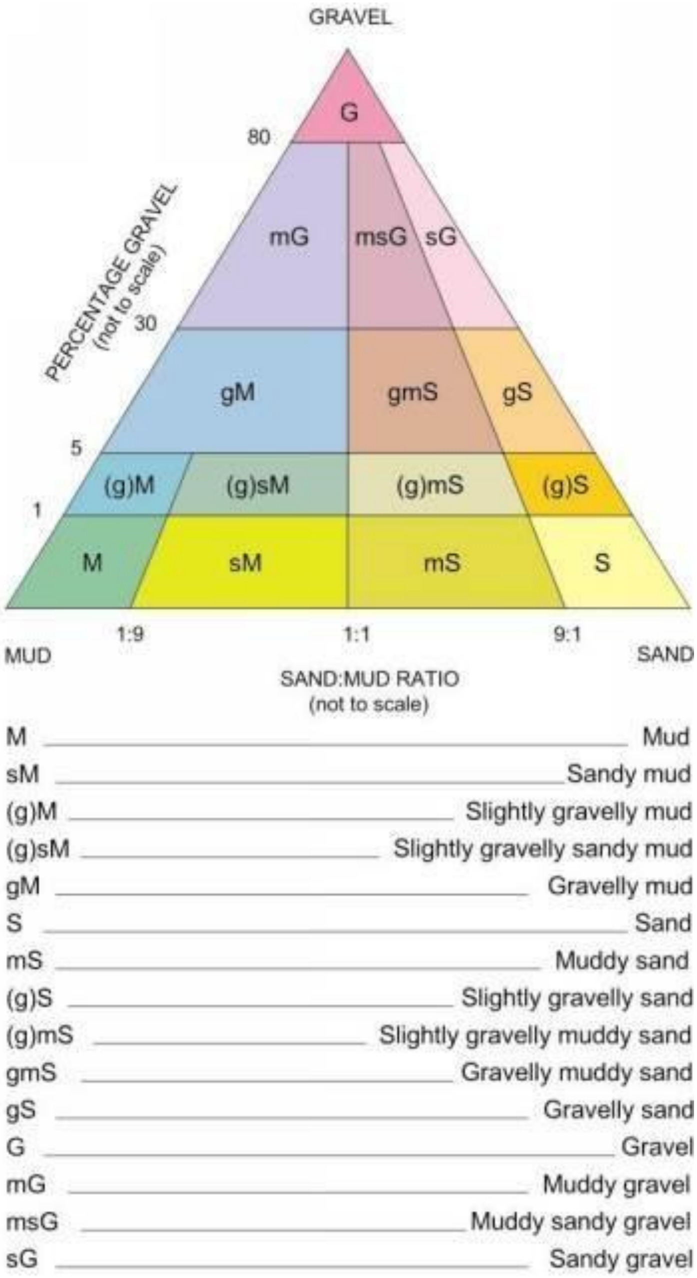
A live feed from the video-sled was captured and recorded on-board the survey vessel and viewed by SLR staff with experience in undertaking assessments of the benthic environment in the offshore Taranaki region. Brief field notes were made in real-time about obvious structures and organisms observed while watching the live footage. Back onshore the recorded seabed video footage was assessed on a large, high definition screen, by a suitably trained and experienced benthic scientist, who identified all obvious epifauna to the lowest practicable taxonomic level. Biogenic and/or anthropogenic seabed structures such as burrows, mounds, tracks and gouges/trenches were also recorded. Relative abundance estimates of epifauna or biogenic structures were made where appropriate.

2.4 Data Analyses

2.4.1 Sediment classifications

While there are many sediment classification schemes in use worldwide, a common one is a modified version of that proposed by Folk (1954). This scheme groups grains within a sample into mud, sand and gravel sized particles based on the particles diameter (mud <63 µm, sand 64-2000 µm, gravel > 2mm), and then describes the sediment type based on the relative proportions of the particles (see **Figure 6**).

Figure 6 Folk (1954) Sediment Type Classification Triangle



2.4.2 Community Characteristic Descriptors

All macrofauna (both epifauna and infauna) taxa were included in the analyses of abundance data. Species identified in the samples as not being exclusively benthic were excluded from further analyses. Data were analysed as per the statistical methods outlined below to identify current distributions and abundance of macrofauna.

2.4.2.1 Univariate Diversity Indices

Diversity indices (number of taxa S, total abundance N, Shannon-Wiener diversity H', and Pielou evenness J' (**Table 3**) were calculated from the macrofauna abundance data using the PRIMER software package (PRIMER v6.1.16; Clarke, 1993; Clarke & Warwick, 1994; Clarke & Gorley, 2006).

Table 3 Description of Macrofauna Community Characteristic Indices

Index	Formula (where applicable)	Description
Number of Taxa (S)	Count of total number of different taxa identified within the *x* sample	Total number of taxa identified within a sample
Total Abundance (N)	Sum of all individual taxa abundances within the *x* sample	Total number/count of all organisms within a sample
Shannon Diversity (H')	$H' = -SUM [(p_i) \times \log_e (p_i)]$ $p_i =$ Number of individuals of taxa i /total number of samples	A single value (log scale) that is used to describe the different types and numbers of organisms present within an assemblage. The index value increases as assemblages have greater numbers of taxa and when the numbers of individual organisms are more evenly distributed across the different taxa. Samples dominated by single taxa will have lower values towards zero.
Pielou Evenness (J')	$J = H' / \log_e (S)$	A value theoretically between zero and one which indicates how evenly the number of individual organisms are distributed through the different taxa in an assemblage. High values (closer to 1) indicate an even spread amongst the taxa present, whereas a low value indicate an uneven spread or an assemblage highly dominated by only a few, or even a single taxon.

3 Results and Discussion

3.1 Sediment Physical and Chemical Properties

3.1.1 Visual Description of Sediment Cores

Sediments collected from around Well G were predominantly light grey cohesive mud (**Figure 7**). During sediment sampling no very dark-grey or black sediment layers (apparent Redox Potential Discontinuity), or darker patches within cores were noted and no detectable hydrogen sulphide odours were present, indicating that sediments are well oxygenated throughout the depths sampled. Field observations on sediment texture, colour and any notable features of the sediment samples were recorded during the processing of the sediment cores and infauna samples, and these are included in **Appendix A**. A full set of sediment core photographs are contained in **Appendix B**.

Figure 7 Representative Images of Sediment Core Profiles from Well G

Station G2

Station G7

Station G9

Station G11

3.1.2 Incidental Observations

During the laboratory processing of the infauna samples by SLR taxonomists, observations were made of any debris that was present, including those from anthropogenic sources. Within the 15 samples collected around Well G there were 8 types of debris observed (**Table 4**), five of which were likely to be anthropogenic in source, including paint flecks, welding balls and rust flakes. All anthropogenic debris encountered in the samples were at 'low' abundances.

Table 4 Incidental Observations

	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15
Sand-like substance		C	L	C	L	L	L	L	C	L	L	C	L	C	C
Coal rock			L									L	L		
Graphite													L		
Yellow paint														L	
Green paint		L											L		
Welding ball													L		
Blue paint										L					
Rust															L

VA = very abundant (>50), A = abundant (50+), C = common (20–50), O = occasional (10–20), L = low (0–10)
'Sand-like substance' is a natural yet unidentified substance that resembles sand

3.1.3 Sediment Particle Grain Size Distribution and Organic Content

The physical characteristics of the sediment can influence the composition of the infauna communities and the levels of contaminants retained and observed during analyses. Particle grain size is widely used to characterise the physical structure of the sediment, while organic content provides an indication of the organic enrichment in the sediment. These combined results provide a general understanding of sediment health and the source of potential stressors at the time of sampling.

Organic matter found in the sediments is most likely derived from natural sources such as infauna/epifauna and detrital matter, rather than from anthropogenic sources. Anoxic sediments (those lacking oxygen), may develop in situations where organic matter levels increase beyond 'normal' levels for that area. Increased organic matter has the potential to disturb the equilibrium of the benthic ecosystem, as increased numbers of oxygen-utilising bacteria are required to decompose the additional organic matter, thereby rapidly reducing oxygen availability in the sediments.

A summary of the particle grain size and organic content analyses are discussed below, with full results provided in **Appendix C**.

3.1.3.1 Particle Grain Size

Particle grain size analyses at the 15 monitoring stations around Well G are shown in **Figure 8.** Sediments were dominated by silt/clay (60-76%, mean 68%), fine sand and very fine sand (means 25% and 6% respectively) classing them as 'sandy muds' (Folk, 1954), similar to the bulk of the offshore South Taranaki areas where exploration/production monitoring has taken place.

There were no obvious trends in proportions of the different grain size fractions across all Well G monitoring stations. Monitoring stations G1, G2, G13, and G15 contained the highest proportions of silt/clay sized particles, while the lowest proportions of silt/clay particles were present at monitoring stations G3 and G12.

The sandy muds encountered around Well G were similar to those found at the other sites in the Central and Southern AOIs, with the exception of Well L which was more like the Northern AOI grain size fractions (**Table 5**). A comparison of particle grain size data for Well G with the other wells is provided in **Appendix C**.

Figure 8 Sediment Particle Grain Size Distribution for Samples Collected at Well G

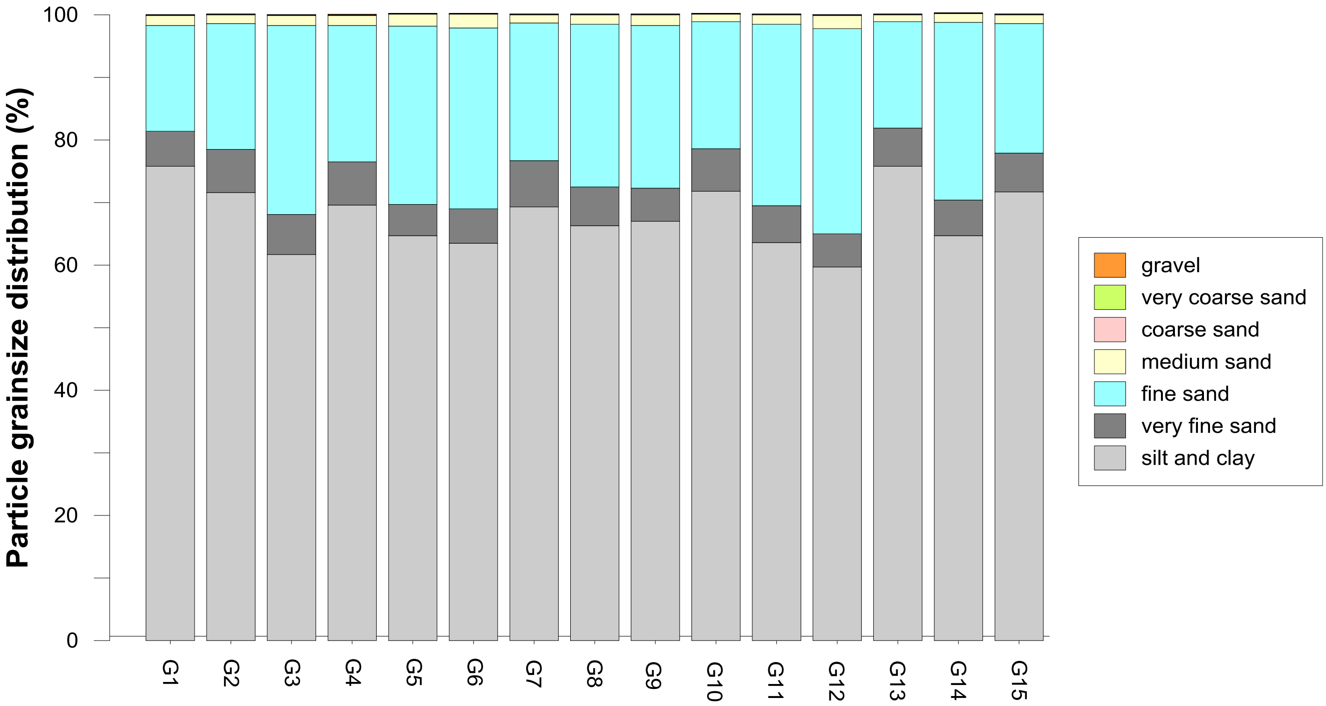


Table 5 Average Grain Size for the Eleven Wells

Grain size class	A	B	C	D	E	F	G	H	I	J	L
Silt & Clay (Mud) (%)	36.2	27.5	41.1	30.7	85.2	83.2	67.8	72.6	65.1	85.4	30.8
Very Fine Sand (%)	45.8	39.3	30.5	41.7	6.5	4.8	6.1	5.8	6.6	14.2	25.4
Fine Sand (%)	17.0	28.6	22.4	26.8	8.0	11.3	24.6	19.0	22.1	0.4	29.8
Medium Sand (%)	1.0	2.4	3.3	0.7	0.4	0.6	1.6	2.5	5.1	0.1	12.3
Coarse Sand (%)	0.1	0.7	0.8	0.0	0.0	0.1	0.1	0.1	0.6	0.0	1.2
Very Coarse Sand (%)	0.0	0.6	0.5	0.0	0.0	0.1	0.1	0.1	0.5	0.0	0.2
Gravel (%)	0.1	1.1	1.3	0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.1
Description	mS	mS	mS	mS	sM	sM	sM	sM	sM	sM	mS

Note: sM = sandy mud, mS = muddy sand

Colour scale based on percentage with median mid-point (median is 2.0):

0%	5	10	20	30	40	50	60	70	80	90	100

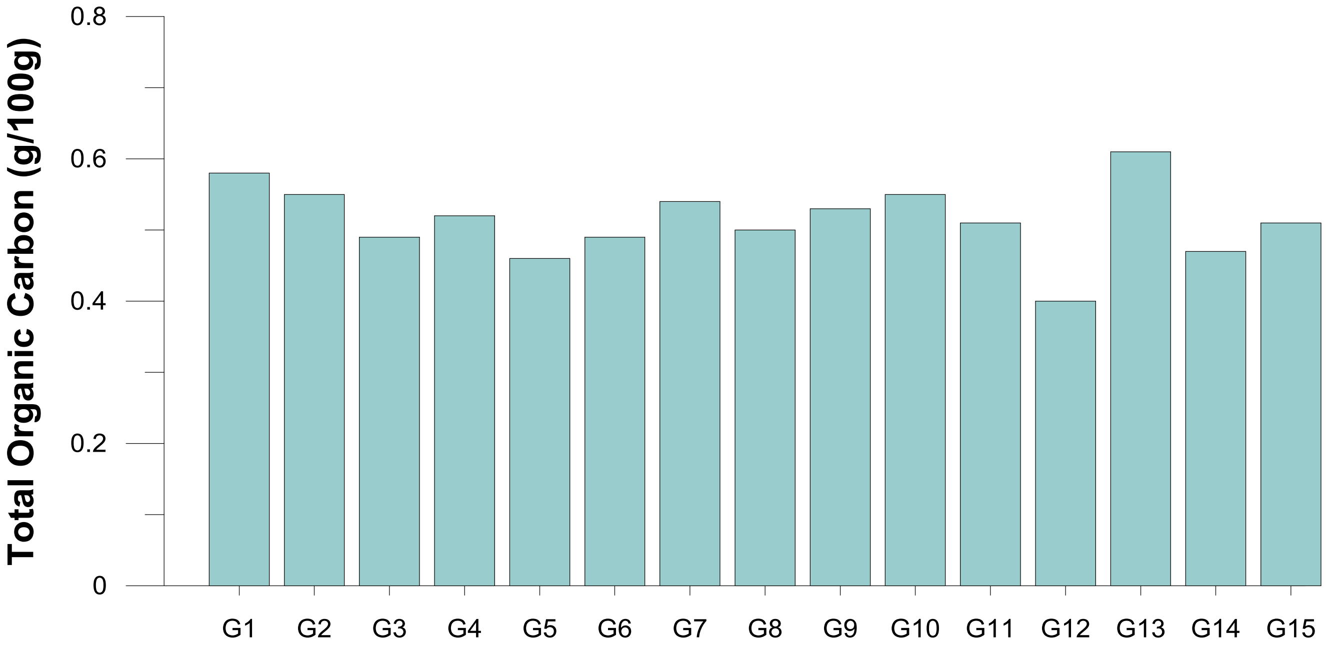
3.1.3.2 Total Organic Carbon

The organic content of sediments was assessed by measuring TOC to assess benthic ecology as this is also consistent with what is now currently undertaken around the offshore Taranaki oil and gas fields.

TOC levels found in samples from the 15 stations surrounding Well G (**Figure 9**) ranged from 0.4% to 0.61% (mean 0.51%). Neighboring monitoring stations G11 and G12 had the highest and lowest TOC levels, despite being just 1 km apart. There does not appear to be a consistent spatial pattern across the TOC results.

The average organic content of all 15 stations around Well G was low relative to other sites (mean 0.51% compared to overall mean of 0.45%). The combined mean from all stations at the five wells in the Central AOI sites (0.59%) was high relative to the Northern and Southern AOIs (mean 0.26% and 0.486%, respectively). As has been previously described in benthic environmental monitoring associated with offshore Taranaki oil and gas activities (SLR, 2016, & SLR, 2017), there is a correlation between sediment particle grain size and sediment organic content. The comparatively greater surface area to volume ratio of silt and clay (mud/fines) sized sediment particles (compared to larger particles like sand) gives a greater area for adsorption of organic matter particles and therefore a higher probability of elevated organic matter compared to coarser/sandier sediments subjected to the same level of enrichment (Hedges *et al*., 1993). This is likely to at least partially explain the lower organic content of sediments at the Northern AOI sites, where sediment grain size is distinctly coarser than at the Central and Southern AOI sites (**Section 3.1.3.1**).

Figure 9 TOC Concentrations in Sediment Samples Collected from around Well G



3.2 Video Sled Imagery

Video footage of the seabed allows scientists to visually assess any anthropogenic disturbance to the benthic environment and observe epifauna, sediment-type and structures or relief that exist on the seabed.

Video footage was captured by towing a video sled through ten sites around Well G (**Section 2.2.2**). Digital copies of the video imagery collected at Well G accompany this report, with a selection of still images displayed in **Figure 10**. **Appendix A** provides locational information for each video sled tow.

Video footage was assessed to determine any defining features and their semi-quantitative abundance recorded for comparison with other sites. Due to caveats associated with video footage (i.e. variable visibility, differing tow length and durations) the counts are indicative-only and should not be interpreted as a quantitative assessment. **Table 6** presents the results of this semi-quantitative approach, which summaries the counts by comparing the site total to the median across all of the EAD wells in the three AOIs. As a visual aid, counts were categorised in relation to the deviation from the 10th, 25th 50th, 75th and 90th percentiles, so that differences between sites can be more easily viewed.

3.2.1 Physical Observations

The seabed around Well G was observed to be dominated by soft mud sediments. Evidence of bioturbation was observed at all monitoring stations in the form of animal burrows (images E and F, **Figure 10**). Moderate to high densities of burrows were observed in most of the Well G monitoring stations, which is similar to other wells in the Central AOI but differs from the Northern AOI sites where densities were low-moderate (**Table 6**).

Mound/hollow features (images G, and H, **Figure 9**) were observed in low numbers (18) compared to the median (43) for all sites (**Table 6**). The highest densities were seen at Well D (280) (Northern AOI) and Well L (532) (Southern AOI). These seabed features are considered to be formed by the feeding activities of sharks or rays, or by tube worms mounding up sediment. Mound/hollow features were observed to be more numerous at the Northern AOI sites compared to the Central and Southern AOIs, where moderate to very high numbers of mound/hollow features were found at the Southern AOI sites, and low to very low numbers from around the Central AOI sites.

As expected, there was no sign of anthropogenic physical disturbance of the seabed observed during any of the video sled tows around Well G. There were no signs of sediment enrichment such as darker sediment patches, bacterial mats or sediment off-gassing, observed during any of the video sled tows around Well G.

Table 6 Total Number of Features Observed in Video Imagery from the EAD Wells

Well	Depth (m)	Mounds/ Hollows	Number of burrows/worm holes	Sea pen	Fish	Substrate	Notes
A	148	111	Low-moderate	54	65	Muddy sand	Ripples; some very large holes and mounds
B	134	63	Low-moderate	35	49	Muddy sand	Some very large holes mounds
C	132	85	Low-moderate	50	44	Muddy sand	Ripples; trenches observed
D	145	280	Low	160	28	Muddy sand	Ripples; 23 very large sea feathers
E	126	29	Moderate	29	16	Sandy mud	
F	128	20	Moderate	19	19	Sandy mud	
G	124	18	Moderate-High	29	26	Sandy mud	
H	124	18	Moderate-High	17	26	Sandy mud	12 elongated shallow trenches
I	122	43	Moderate-High	36	21	Sandy mud	5 elongated shallow trenches (large)
J	108	42	Moderate	14	30	Sandy mud	School of mackerel, tufts/tubes common
L	112	532	Moderate	132	31	Muddy sand	2 schools of mackerel
Median		43		35	28		

Totals are sum of 10 video tows carried out at each site. Totals are semi-quantitative only due to variable visibility and transect length.

10th percentile band
25th percentile band
Median band
75th percentile band
90th percentile band

3.2.2 Infauna, Epifauna and Other Fauna

In some cases, a definitive positive identification of infauna, epifauna and more mobile taxa was not possible from the video footage alone. Where there was any uncertainty, identifications were based on distinctive features, colours and shapes of organisms and in some cases the confirmed presence of similar looking individuals within the infauna samples.

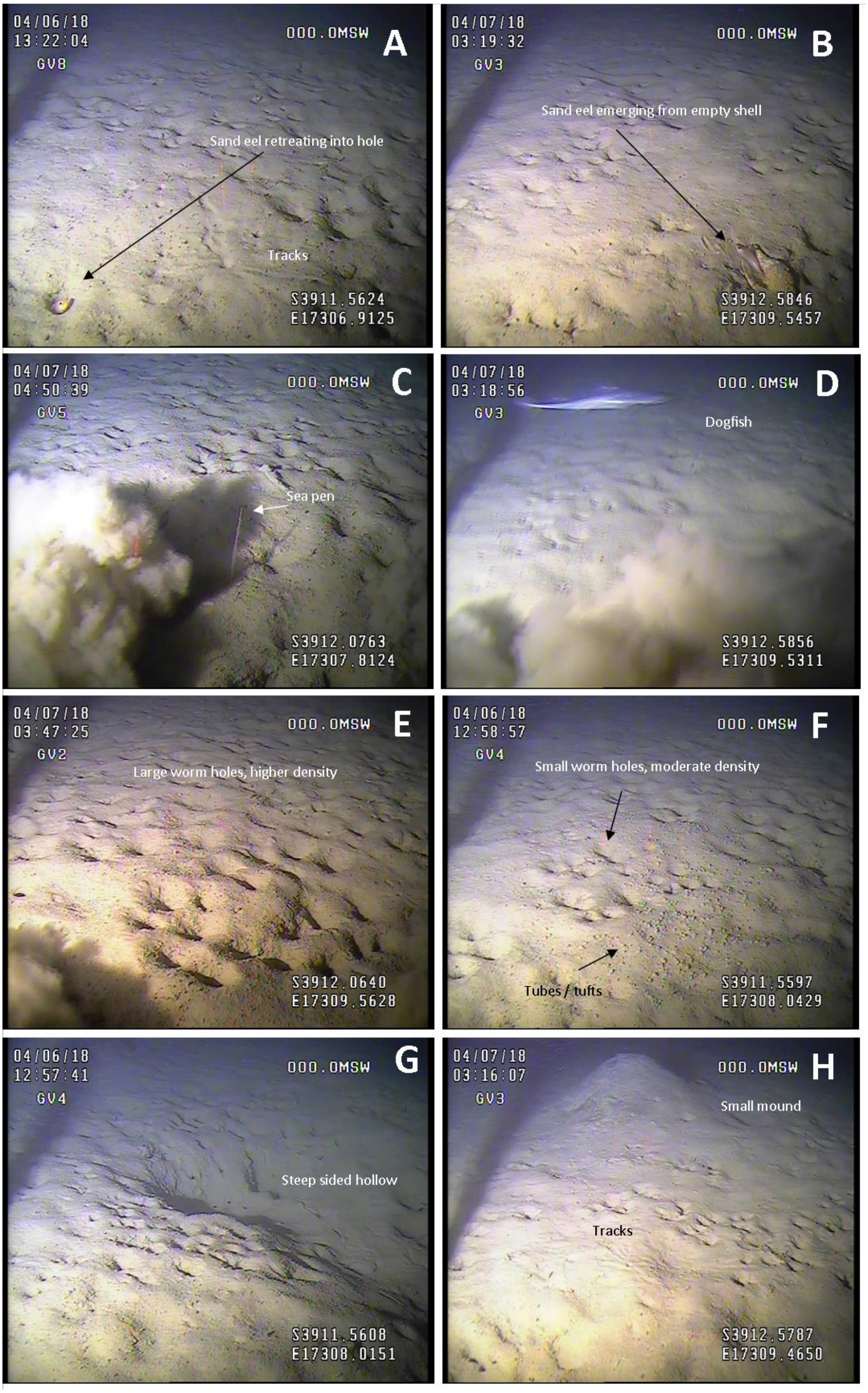
Epifauna taxa observed in video footage collected around Well G included a small number of whelks (likely *Austrofusus glans*), and a small number of unidentified shells. The presence of epifauna tracks in the sediment (image H, **Figure 10**) indicates that mobile fauna such as whelks and hermit crabs move throughout this site. A small number of sponges were observed in some video tows, some of which may have been tunicates.

Sea pens (likely Virgularia sp.) (image C, **Figure 10**) were seen in low-medium numbers (29) around Well G compared to the median (35) for all other well sites(**Table 6**). The highest numbers were seen at Well D (160) (Northern AOI) and Well L (132) (Southern AOI).

Mobile fish species were observed in moderate numbers (26) around Well G compared to the median (28) for all other wells (**Table 6**). Species observed include sand eels[1], dogfish (*Squalus acanthias.)* (image D, **Figure 10**) and anchovy (likely *Engraulidae* sp.). A number of smaller fish were observed swimming off very quickly as the camera approached, so it was not possible to make a positive identification. Across the region surveyed, fish numbers were observed to be much more numerous in the Northern AOI sites, moderate at the Southern AOI sites, and moderate to low around the Central AOI sites.

[1] This fish was unable to be formally identified, thus while the term 'sand eel' is used throughout this report it should not be considered a common name for this unidentified fish species.

Figure 10 Representative Images of Seabed Environment around Well G



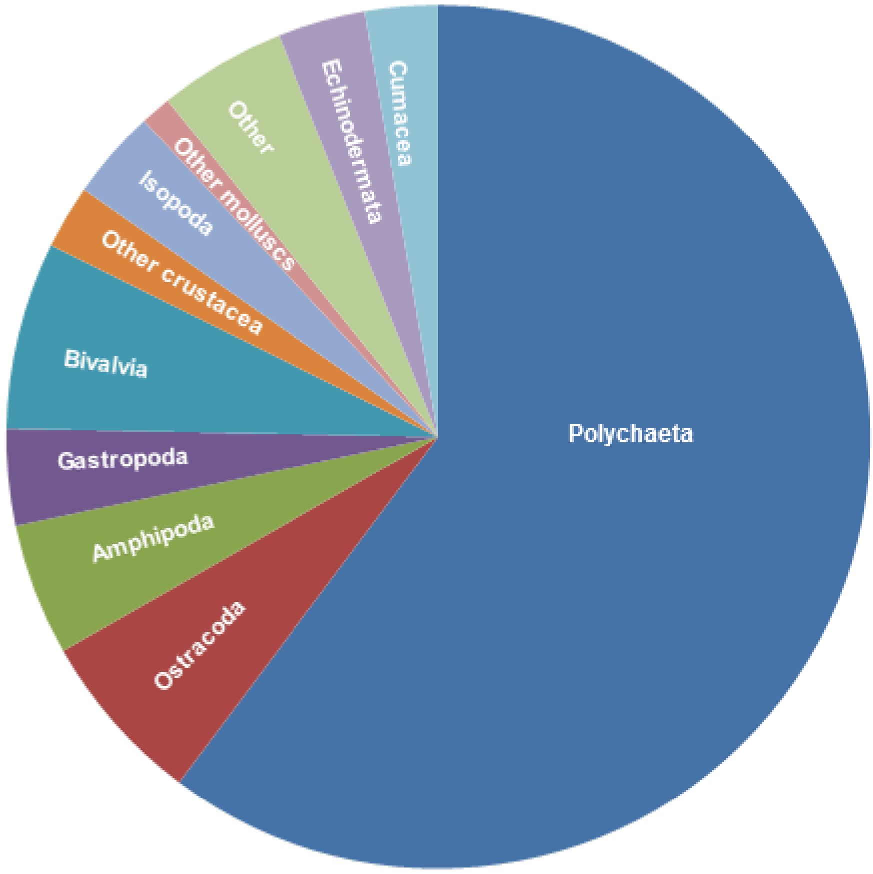
3.3 Macrofauna Characteristics

3.3.1 Benthic Macrofauna

Overall 1,215 individuals representing 112 taxa were identified in the macrofauna samples collected across the Well G monitoring stations. Infauna communities were dominated by small polychaete worms (732 individuals (60%), 39 taxa), crustaceans (242 individuals (20%), 29 taxa, mostly Ostracoda, Amphipoda, Isopoda and Cumacea), molluscs (143 individuals (12%), 31 taxa, mostly Bivalvia and Gastropoda) (**Figure 11**). The infauna communities around Well G were similar to communities found during pre- and post-drill monitoring at the Oi well south-east of Well G, and those found during ongoing production monitoring in the nearby Tui field.

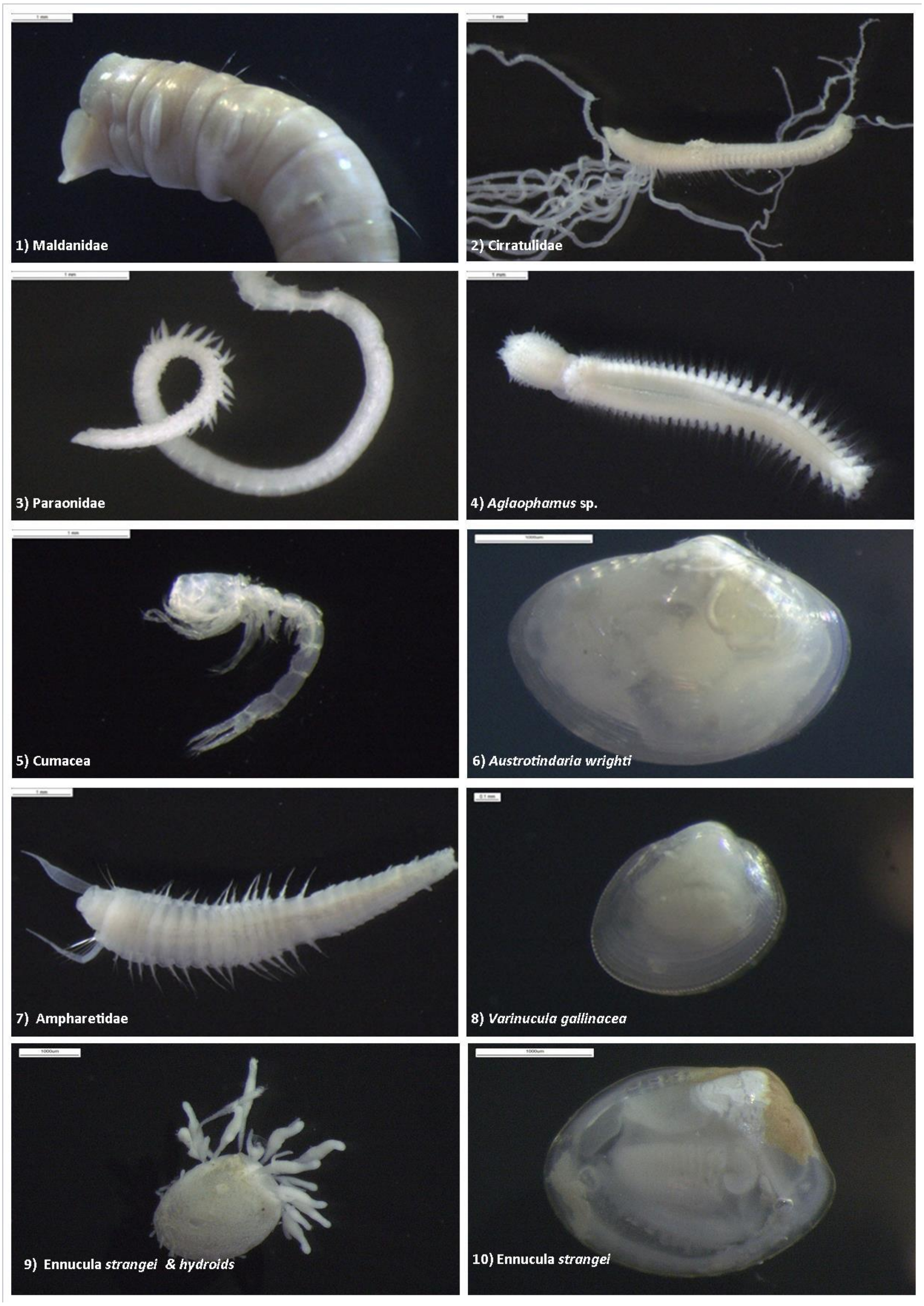
When the benthic macrofauna results are compared across the three AOIs, polychaetes and gastropods were found in lower numbers in the Southern and Northern AOIs compared to the Central AOI. Crustaceans (Tanaidacea and Copepoda) and nematodes were found in higher numbers in the Northern AOI sites compared with Central and Southern AOIs (**Appendix E**). This result is likely linked to the differences in sediment composition, where a coarser grain size was present in the Northern AOI compared to the Central and Southern AOIs.

Figure 11 Proportion of Individuals at Well G Belonging to each Taxonomic Group



'Other Crustacea' includes Decapoda, Copepoda, Euphausiacea , Nebaliacea, and Tanaidacea. 'Other molluscs' includes Caudofoveta, and Scaphopoda. 'Other' includes Chaetognatha, Nematoda, Nermetea, Oligochaeta, Sipuncula, Tunicata and Anthozoa.

Figure 12 Representative Images of Benthic Infauna Taxa Frequently Observed in Offshore Taranaki Area



3.3.2 Univariate Indices of Infauna Communities

Univariate indices (total number of taxa, total abundance, Pielou's evenness and Shannon-Wiener diversity) describing the benthic macroinvertebrate communities found at Well G are displayed in **Figure 13**.

The number of taxa identified in each sample collected around Well G varied from 20 to 46 (mean 33), while total abundance ranged widely from 44 to 123 individuals (mean 81) (**Figure 13**). The number of taxa and abundance at Well G were slightly high relative to other Central AOI sites (mean 29 and 69, respectively), but considerably lower than those at the Northern AOI sites (mean 53 and 233, respectively, **Table 7**).

Evenness values vary on a scale between zero and one, with values near one indicating that infauna abundances are evenly distributed across all the different taxa present, while values near zero indicate infauna communities are being numerically dominated by a large number of individuals from just a few, or even only single taxa. Values from samples collected at Well G were relatively high (mean 0.90), indicating relatively even distribution of abundances across the taxa that were present.

Shannon-Wiener diversity index values range between 0 and 4 with higher values indicating higher species diversity. From previous benthic studies in the offshore Taranaki region, species diversity values are normally between 1.5 and 3.5. The mean Shannon-Weiner diversity index for Well G was 3.1, and ranged between 2.8 and 3.3. When these results are compared to the most recent results from long term benthic monitoring programmes at the Maari Field (mean diversity index of 2.9), located in the Southern AOI, diversity is higher at Well G.

Figure 13 Total Number of Taxa, Total Abundance, Pielou's Evenness and Shannon Wiener Diversity Index Values for Macrofauna Samples Collected at Well G

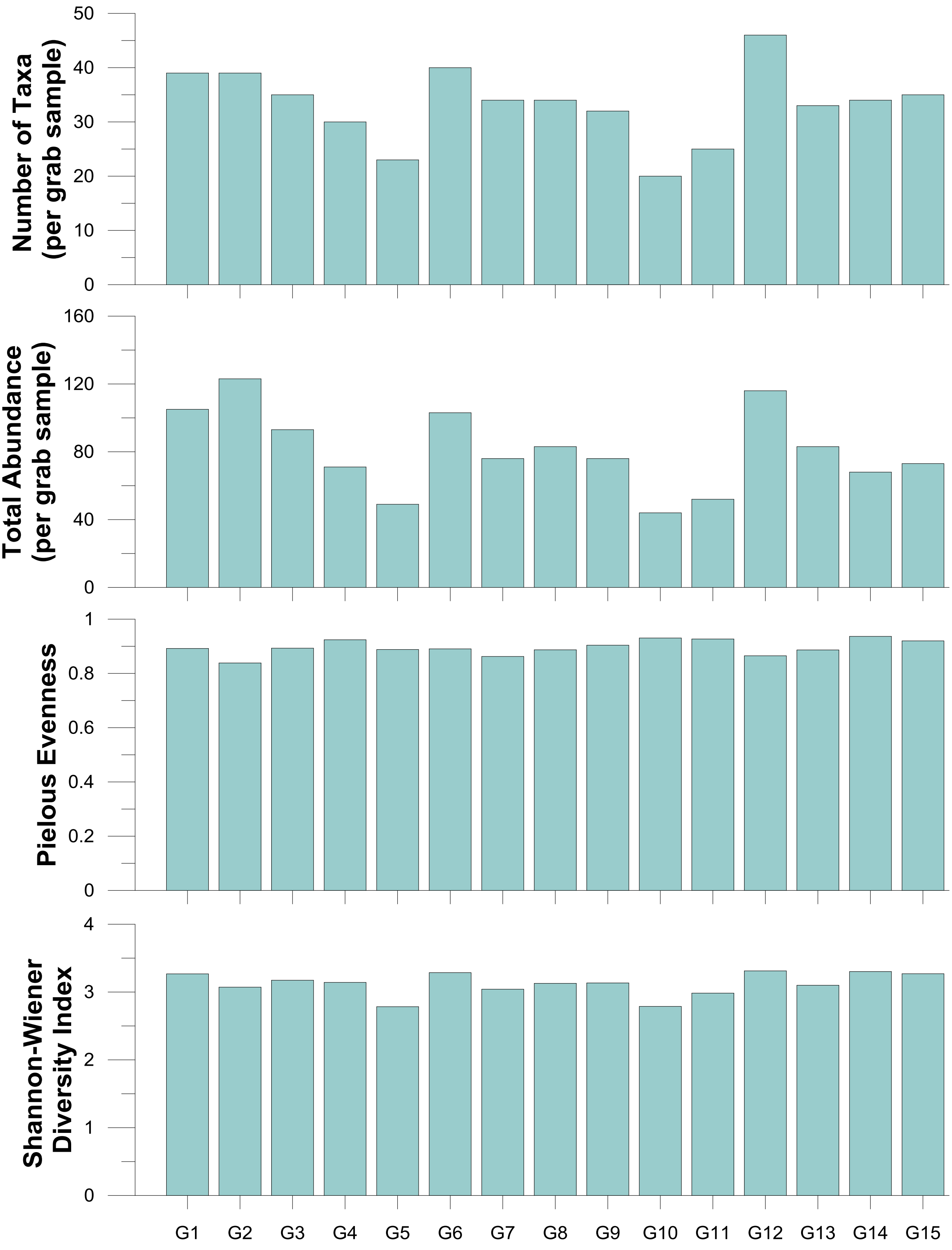


Table 7 Number of Taxa and Total Abundance for the Eleven Wells

Site	Mean Number of Taxa	Mean Abundance	Total Number of Taxa Identified at site	Total number of individuals (abundance)
A	56	257	140	3,849
B	53	210	130	3,151
C	45	132	128	1,987
D	60	332	142	4,986
Northern AOI	53	233		
E	19	36	78	542
F	31	68	90	1,023
G	**33**	**81**	**112**	**1,215**
H	31	89	103	1,339
I	29	72	91	1,075
Central AOI	29	69		
J	40	115	108	1,722
L	54	190	131	2,853
Southern AOI	47	153		

3.4 Sensitive Environments

In an investigation of sensitive substrate/benthic habitats in the Taranaki Coastal Marine Area, Johnston (2016) studied marine taxa databases from marine benthic surveys conducted in the offshore Taranaki Basin and noted that there are many locations where at least one ‘characteristic species of sensitive environments’ was found. This investigation used the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) 2013 (**Permitted Activities Regulations**) sensitive environments descriptions to define what sensitive habitats may be present.

Chaetopteridae worms and Sea pens were noted by Johnston (2016) as likely to be present in areas close to the 11 well sites. In relation to the sampling techniques used in the Benthic Baseline survey (grab sampling and video sled imagery), MacDiarmid *et al*. (2013) define that;

“A sensitive Chaetopteridae worm field is present if worm tubes and/or epifaunal species:

- Occupy 25% or more of the seabed in imaging surveys covering and area of 500 m^2 or more; or
- Occur in two successive samples collected using point sampling gear.”

and

“A sea pen field exists if:

- One or more specimens of any species of sea pen is found in two successive samples collected using point sampling gear, or
- Two or more specimens per m^2 are found in seabed imaging surveys, or surveys using towed gear.”

Analysis of the infauna samples collected during the Benthic Baseline survey found that Chaetopteridae worms (specifically *Phyllochaetopterus* socialis, commonly known as wire-weed or Tarakihi weed) were present within samples from Wells A, B, C, D, G, H, J and L. A single individual of *P. socialis* was recorded at monitoring station G8. Across the ten video sled tows performed at Well G there were no distinct worm-fields or the low-relief worm-meadows that *P. socialis* often form observed. Thus while this sensitive environment species was present at Well G the distributions appeared more as "isolated individuals within mixed epifaunal assemblages" at two stations rather than "dense mono-specific meadows at the tens of kilometres scale" (MacDiarmid *et al*., 2013).

No sea pens (*Virgularia gracillima*) were identified in infauna grab samples from Well G during the Benthic Baseline survey. However, video imagery collected observed sea pens at all sites (see **Table 6** for total numbers of sea pens observed at each site), including Well G. Sea pen numbers observed at Well G were relatively low (29 individuals). Due to video sled tows being only a semi-quantitative survey method it is not possible to make exact predictions on the densities of sea pens encountered. However, as a conservative estimate, the width of the camera's field of view could be estimated at 1 m, and each video sled covered 200 m across the seafloor, giving an approximate area of 2000 m^2 viewed by the ten sled tows. Given this approximate area and the low numbers of sea pens observed (compared to Wells D (160 individual sea pens) and L (132 individual sea pens) sea pen densities at Well G would not have surpassed the Permitted Activities Regulations trigger value of two sea pens per square meter (MacDiarmid *et al*., 2013). Video tows were not found to pass through more spatially limited areas of higher density that might have been classed as 'sea pen fields'.

Based on the infauna data and video imagery analysis it is considered that there were no 'Sensitive Environments', as defined by the Permitted Activities Regulations encountered at the monitoring stations at Well G in 2018.

4 Key Findings

4.1 Sediment Characteristics

Sediments sampled at Well G were sandy muds dominated by silt/clay and fine sand particles, similar to the other sites in the Central AOI, but notably finer/muddier than the Northern AOI sites.

TOC levels in the area (mean 0.51%) were also similar to the rest of the Central AOI sites, which were all distinctly higher than the Northern AOI sites. Neither grain size nor TOC showed consistent spatial patterns across the Well G stations, but variations in silt and clay mirrored the small variations in TOC. Sediments with a finer grain size will retain higher levels of organic matter compared to coarser/sandier sediments subjected to the same level of enrichment/deposition, due to the greater surface area of finer particles for adsorption.

4.2 Faunal Characteristics

The video sled imagery captured across Well G showed a relatively flat seabed, interrupted by mounds/hollows and pock-marked with bioturbation in the form of animal burrows. Whelks, sponges and unidentified shells were observed during the tows, while hermit crab and whelk tracks on the seabed indicate the presence of these mobile species. Mobile fish were observed in moderate numbers around Well G compared to other sites within the Central AOI (with the exception of Well H which also had a count of 26 fish).

Infauna communities in Well G samples were similar to those of the other Central AOI sites, and were dominated by small polychaetes, crustaceans (ostracods, amphipods, cumaceans, and isopods) and molluscs (gastropods and small bivalves). Central AOI infauna communities had the greatest proportions of polychaetes and gastropods, but the lowest proportions of crustaceans like amphipods and tanaidaceans, reflecting the muddier sediments in the Central AOI which are more suited to deposit feeding/scavenging taxa like many polychaetes and gastropods.

The mean number of taxa found in Well G samples was similar to the overall mean value for the Central AOI. Total abundance, however, was slightly higher in Well G samples when compared to the mean for the Central AOI. Number of taxa and abundance values in Well G samples, and the wider Central AOI, are notably lower than those in the Northern and Central AOIs.

The finer sediments present at Well G, and at Central AOI sites, compared to coarser sandy sediments of the Northern AOI, are likely linked to the greater proportions of taxa such as polychaetes and gastropods. Taxa found at Well G that were within these groups were largely scavengers/detritivores and/or deposit feeders which feed on larger dead materials on/in the sediment, as well as organic matter within the sediments. This feeding mechanism is more suited to muddy sediments where there is comparatively greater proportions of organic matter for given volumes of sediment, compared to coarser sediments such as sands.

Taxa more adapted for filter feeding (e.g. copepods, Tanaidacea, and amphipods) have delicate feeding and breathing structures. Coarser sediments contain less of the very fine clay particles which can clog or damage the delicate feeding and breathing structures of taxa adapted as filter feeders, particularly when such fine sediments are present in the water column for extended periods, and/or repeatedly re-suspended. Thus, taxa utilising this feeding strategy are often more abundant in areas with coarser sediments. Sediments with larger particle sizes, and greater mix of particle sizes, particularly larger sands, gravels, shell hash, etc., begin to provide more three-dimensional, cryptic habitats, allowing a wider variety of taxa to find different suitable habitats than mud-dominated sediments.

4.3 Sensitive Environments

Some individuals representing '*characteristic species of sensitive environments*' were found in macrofauna grab samples (e.g. Chaetopteridae worms) and were observed in video tows (e.g. sea pens) during the Benthic Baseline survey at Well G. However, observations from the video imagery analysis indicate that no 'Sensitive Environments', as defined by the Permitted Activities Regulations (and MacDiarmid *et al*., 2013) were encountered at the monitoring stations at Well G in 2018.

5 References

Clarke K. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18 (1): 117-143.

Clarke K.R., Warwick R.M., 1994. Change in marine communities: An approach to statistical analysis and interpretation. Plymouth Marine Laboratory, UK.

Clarke K.R., Gorley R.N., 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth.

Folk, 1954. *“The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature”,* The Journal of Geology 62(4):344-359.

Hedges JI, Keil RG, Cowie GL, 1993, “Sedimentary diagenesis: organic perspectives with inorganic overlays", Chemical Geology 107: 487-492.

Johnston O, Barter P, Ellis J, Elvines D, 2014, “*Recommendations for an Offshore Taranaki Environmental Monitoring Protocol: Drilling- and production-related discharges, Version 1.0*” (OTEMP), Cawthron Report No. 2124.

Johnston O 2016. Sensitive habitats and threatened species in the Taranaki Coastal Marine Area (TCMA) - database investigation. Prepared for Taranaki Regional Council. Cawthron Report No. 2877. 28 p. plus appendices.

MacDiarmid, A., Bowden, D., Cummings, V., Morrison, M., Jones, E., Kelly, M., Neil, H., Nelson, W., Rowden, A., 2013. ‘*Sensitive marine benthic habitats defined*’. Prepared for Ministry for the Environment, NIWA Client Report No: WLG2013-18.

SLR, 2016. “*Benthic Ecological Survey – Tui Field facilities. Production Discharge Monitoring, February 2016*” prepared for AWE Taranaki Limited, report number 740.10040.

SLR, 2017a, “*Benthic Ecological Survey for the Maui Platform Alpha. Annual Production Monitoring – April 2017*”, prepared for Shell Todd Oil Services Limited, SLR Report Number 740.10041.00300-R01--v0.1

SLR, 2017b. “*Benthic Ecological Survey for the Oi-1 and Oi-2 Exploration Wells. Post-drill Assessment – November 2016”*. Prepared for Tamarind Taranaki Limited, report number 740.10025.00100-R01.

SLR, 2018. “*Tui Field Ecological Effects Monitoring Report”*. Prepared for Tamarind Taranaki Limited, report number 740.10040.00100-R01-v0.1.

APPENDIX A

Locations and Observations from Sediment Grab Sampling and Video Sled during the 2018 Benthic Baseline Survey

Station	Date	Time	Depth (m)	Coordinates (NZTM)		Notes
				Easting	Northing	
Grab Sample Sites						
GG 1	7/4/18	1404	123	1616407	5660860	Cohesive light grey mud
GG 2	7/4/18	1352	123	1614408	5660866	Light grey cohesive mud. **Caught and preserved 'Sand eel'.**
GG 3	7/4/18	1315	123	1612406	5660869	Cohesive light grey mud
GG 4	7/4/18	1132	123	1611408	5660872	Cohesive light grey mud
GG 5	7/4/18	1122	123	1610407	5660872	Cohesive light grey mud
GG 6	7/4/18	1114	123	1609408	5660872	Light grey mud, cohesive , softer
GG 7	7/4/18	1103	123	1608407	5660866	Light grey mud, cohesive, softer
GG 8	7/4/18	1209	123	1613417	5662871	Cohesive light grey mud
GG 9	7/4/18	1301	123	1613419	5661870	Cohesive light grey mud / clay
GG10	7/4/18	1329	123	1613422	5659875	Very cohesive light grey mud
GG11	7/4/18	1339	123	1613417	5658862	Cohesive light grey mud / clay
GG12	7/4/18	1154	123	1610409	5662871	Light grey mud, softer
GG13	7/4/18	1143	123	1610409	5661874	Cohesive light grey mud, harder deeper in sample
GG14	7/4/18	1048	123	1610407	5659871	Cohesive light grey mud
GG15	7/4/18	1040	123	1610408	5658871	Cohesive light grey mud
Video Sled Tow Locations						
GV 1	7/4/18	0802	124	1615416	5662377	
GV 2	7/4/18	0738	124	1615413	5660876	
GV 3	7/4/18	0713	124	1615417	5659374	
GV 4	6/4/18	1648	124	1611908	5662376	
GV 5	7/4/18	0839	124	1611408	5660872	
GV 6	7/4/18	0946	124	1611914	5659368	
GV 7	7/4/18	0903	124	1610407	5660872	
GV 8	6/4/18	1714	124	1609411	5662369	
GV 9	6/4/18	1734	124	1608907	5660868	
GV10	7/4/18	0927	124	1609413	5659370	

APPENDIX B

Sediment Core Profile Images from all Grab Samples Collected during the 2018 Benthic Baseline Survey at Well G


G1.JPG


G10.JPG


G11.JPG


G12.JPG


G13.JPG


G14.JPG


G15.JPG


G2.JPG


G3.JPG


G4.JPG


G5.JPG


G6.JPG


G7.JPG

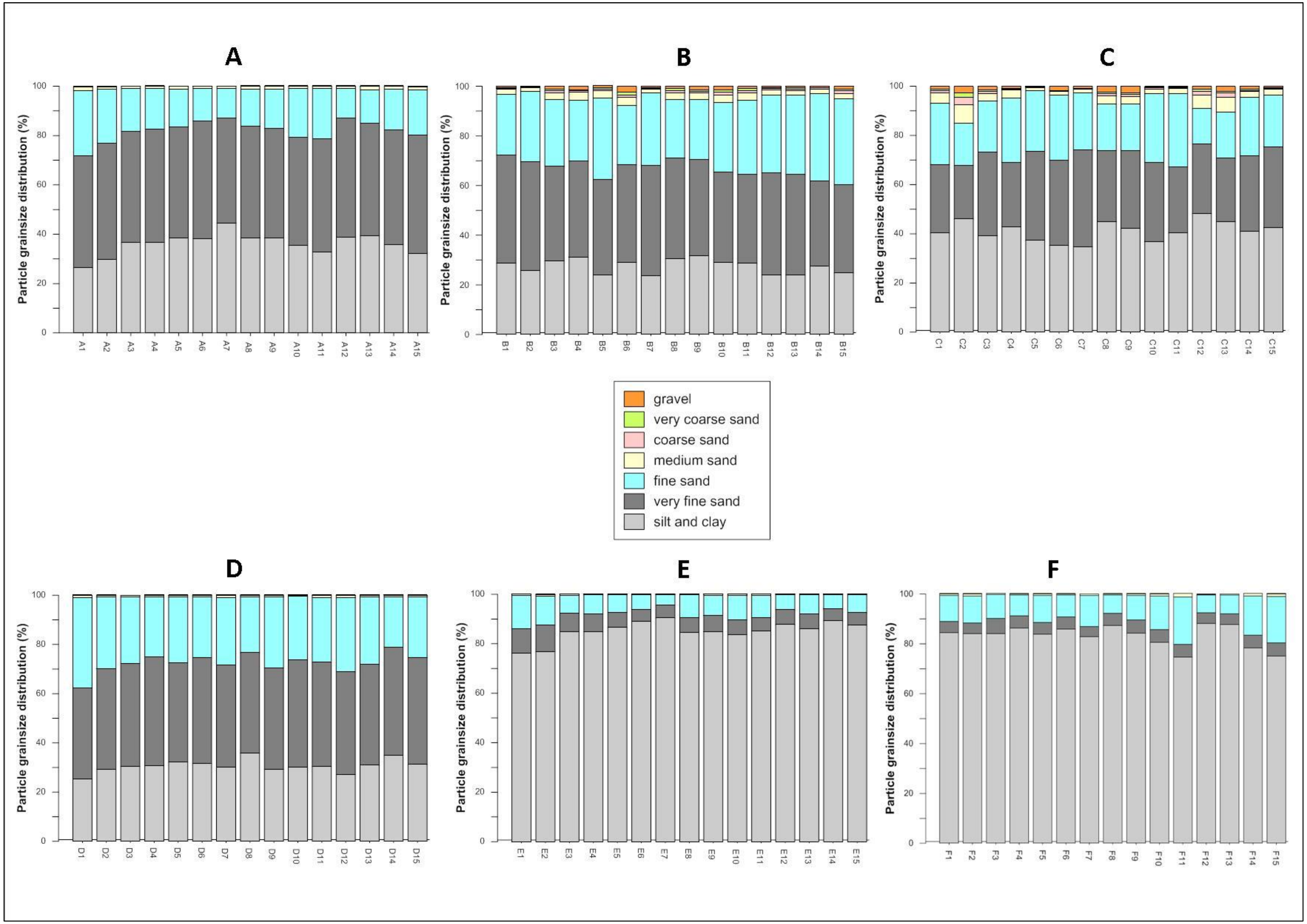

G8.JPG

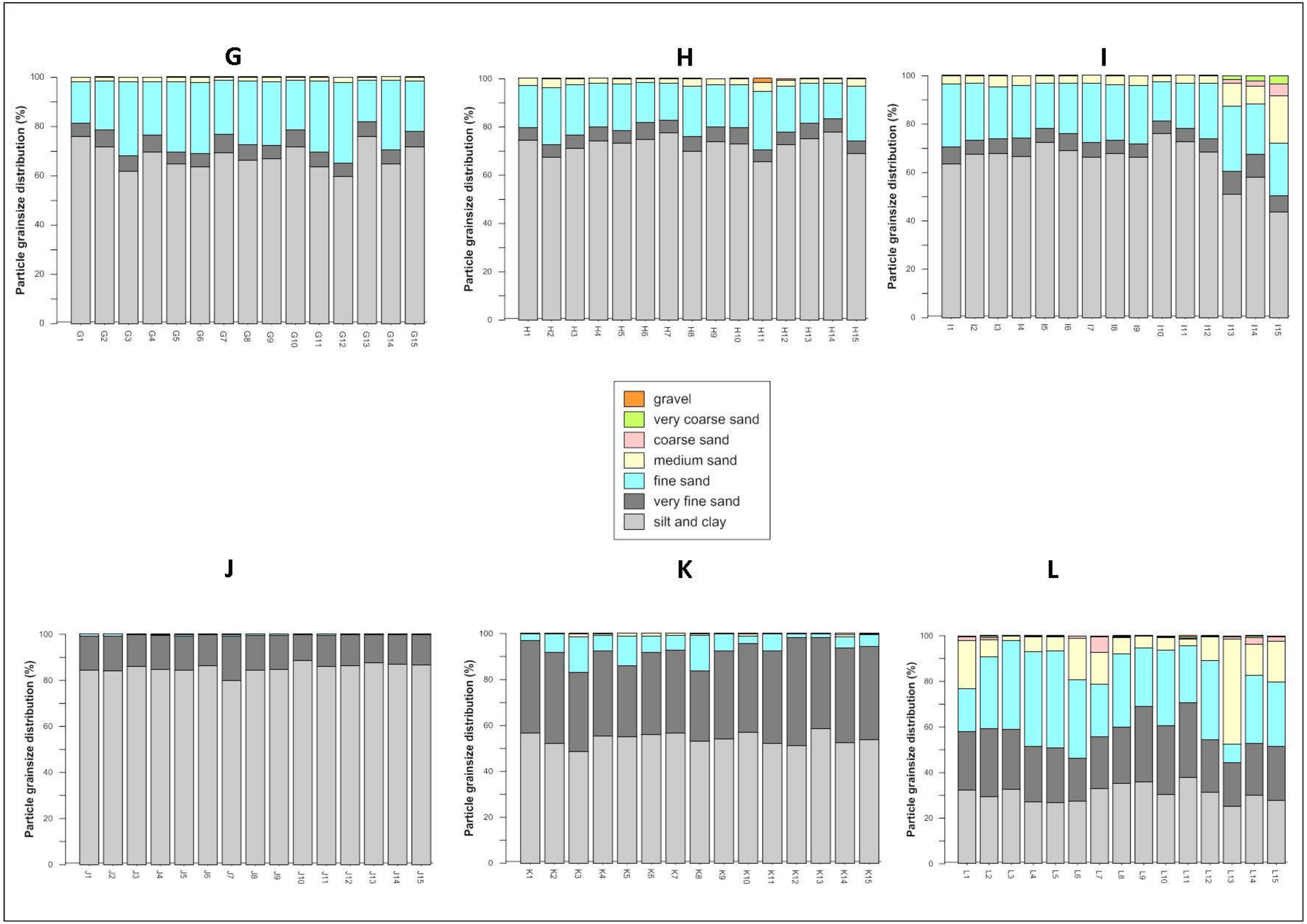

G9.JPG

APPENDIX C

Total Organic Carbon Content and Particle Grain Size Distribution for Well G

Replicate Sample	TOC (%)	Gravel (%)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Silt & Clay (Mud) (%)
Station G1	0.58	0.05	0.05	0.05	1.6	16.9	5.6	75.8
Station G2	0.55	0.05	0.05	0.05	1.4	20.1	6.9	71.6
Station G3	0.49	0.05	0.05	0.05	1.6	30.2	6.4	61.7
Station G4	0.52	0.1	0.05	0.05	1.6	21.8	6.9	69.6
Station G5	0.46	0.05	0.05	0.05	1.9	28.5	5	64.7
Station G6	0.49	0.05	0.05	0.05	2.2	28.9	5.5	63.5
Station G7	0.54	0.05	0.05	0.05	1.3	22	7.4	69.3
Station G8	0.5	0.05	0.05	0.05	1.5	26	6.2	66.3
Station G9	0.53	0.05	0.05	0.05	1.7	26	5.3	67
Station G10	0.55	0.05	0.05	0.05	1.2	20.3	6.8	71.8
Station G11	0.51	0.05	0.05	0.05	1.5	29	5.9	63.6
Station G12	0.4	0.05	0.05	0.05	2.1	32.8	5.3	59.7
Station G13	0.61	0.05	0.05	0.05	1.1	17	6.1	75.8
Station G14	0.47	0.05	0.05	0.05	1.4	28.4	5.7	64.7
Station G15	0.51	0.05	0.05	0.05	1.4	20.7	6.2	71.7


A
B
C
D
E
F
Particle grainsize distribution (%)
0
20
40
60
80
100
A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15
B1 B2 B3 B4 B5 B6 B7 B8 B9 B10 B11 B12 B13 B14 B15
C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12 C13 C14 C15
D1 D2 D3 D4 D5 D6 D7 D8 D9 D10 D11 D12 D13 D14 D15
E1 E2 E3 E4 E5 E6 E7 E8 E9 E10 E11 E12 E13 E14 E15
F1 F2 F3 F4 F5 F6 F7 F8 F9 F10 F11 F12 F13 F14 F15
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay


G
H
I
J
K
L
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay

APPENDIX D

Raw Counts of Macroinvertebrate (Infauna and Epifauna) Abundance at Well G

Taxa	Class/Order	Phylum	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15
Aglaophamus sp.	Polychaeta		5	7	11	4	6	12	7	7	5	6	2	6	8	6	8
Amalda sp. (Amalda cf novaezelandiae)	Gastropoda	Mollusca		1													
Ampelisca sp.	Amphipoda	Crustacea				1		1									
Ampharetidae	Polychaeta		6	13	7	1	4	6	1	4	1	1	3	8	4	2	8
Amphipoda	Amphipoda	Crustacea	4	8		4		5		1				2	2	2	
Antalis glaucarena	Scaphopoda	Mollusca		1													
Antalis nana	Scaphopoda	Mollusca											1				
Anthuridae	Isopoda	Crustacea						1						1			
Aplacophora		Mollusca	1	1				1	1		1	1		1		1	1
Aricidea sp.	Polychaeta			1			1		3			1				1	
Armandia maculata	Polychaeta					2	1	1	1	1		1		2			
Armandia maculata (juvenile)	Polychaeta				1			1									1
Ascidiacea	Tunicata	Tunicata		1	1										1	1	
Asellota	Isopoda	Crustacea		2	6	6		1	2	1	2	3	2	1		2	
Asteroidea	Asteroidea	echinodermata															1
Astromitra sp.	Gastropoda	Mollusca													1		
Axiopsis sp.	Decapoda	Crustacea		1	1	1			1				1				1
Bivalvia (inderterminate)	Bivalvia	Mollusca					1							1			
Bradleya opima	Ostracoda	Crustacea			2	1	1	1	1	2					2	1	
Buccinidae (juvenile)	Gastropoda	Mollusca															1
Cadulus teliger	Scaphopoda	Mollusca						2						1			
Capitellethus zeylanicus	Polychaeta		1	2	2	1		2	1	3	4	1	3	1	6	2	1
Chaetognatha	Chaetognatha						1	1				1		1			
Chlorotocus novaezealandiae	Decapoda	Crustacea				2											
Cirratulidae	Polychaeta		10	7	10	9	6	13	8	7	7	3	6	19	7	6	4

Taxa	Class/Order	Phylum	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15
Clavelina claviformis	Tunicata		1	1		2		1		1			2			1	
Copepoda	Copepoda	Crustacea				2					2					1	1
Cossura consimilis	Polychaeta		1														
Cumacea	Cumacea	Crustacea	7	3			2	4		2		4	4	1		4	2
Curveulima aupouria	Gastropoda	Mollusca	1	1										3			
Cyclostrematidae	Gastropoda	Mollusca			1			2								1	
Cymbicopia hispida	Ostracoda	Crustacea				1			1					1	1	3	1
Cypridinodes reticulata	Ostracoda	Crustacea			2			1					1		1		
Cytherella sp.	Ostracoda	Crustacea												1			
Dorvilleidae	Polychaeta					1											
Edwardsia sp.	Actiniaria	Anthozoa						1		1							
Ennucula strangei	Bivalvia	Mollusca	2	2	1				1	1	1		1			2	3
Euchone pallida	Polychaeta				3			2		2	5	2	2	5	1	3	3
Eulimidae	Gastropoda	Mollusca												1			
Euphausiacea	Euphausiacea	Crustacea			1												
Euphilomedes agilis	Ostracoda	Crustacea			1	1	1		2	3	1		1	5		1	1
Fauveliopsidae	Polychaeta							1		1				1	1	1	2
Flabelligeridae	Polychaeta			3	2				1			1					1
Gastropoda (juvenile)	Gastropoda	Mollusca						1									
Glyceridae	Polychaeta															1	
Gnathiidae	Isopoda	Crustacea	1	1	2						1						
Goniadidae	Polychaeta				1								1				
Haustoriidae	Amphipoda	Crustacea							1		1			1			
Hesionidae	Polychaeta									1							
Hiatella artica	Bivalvia	Mollusca	1														

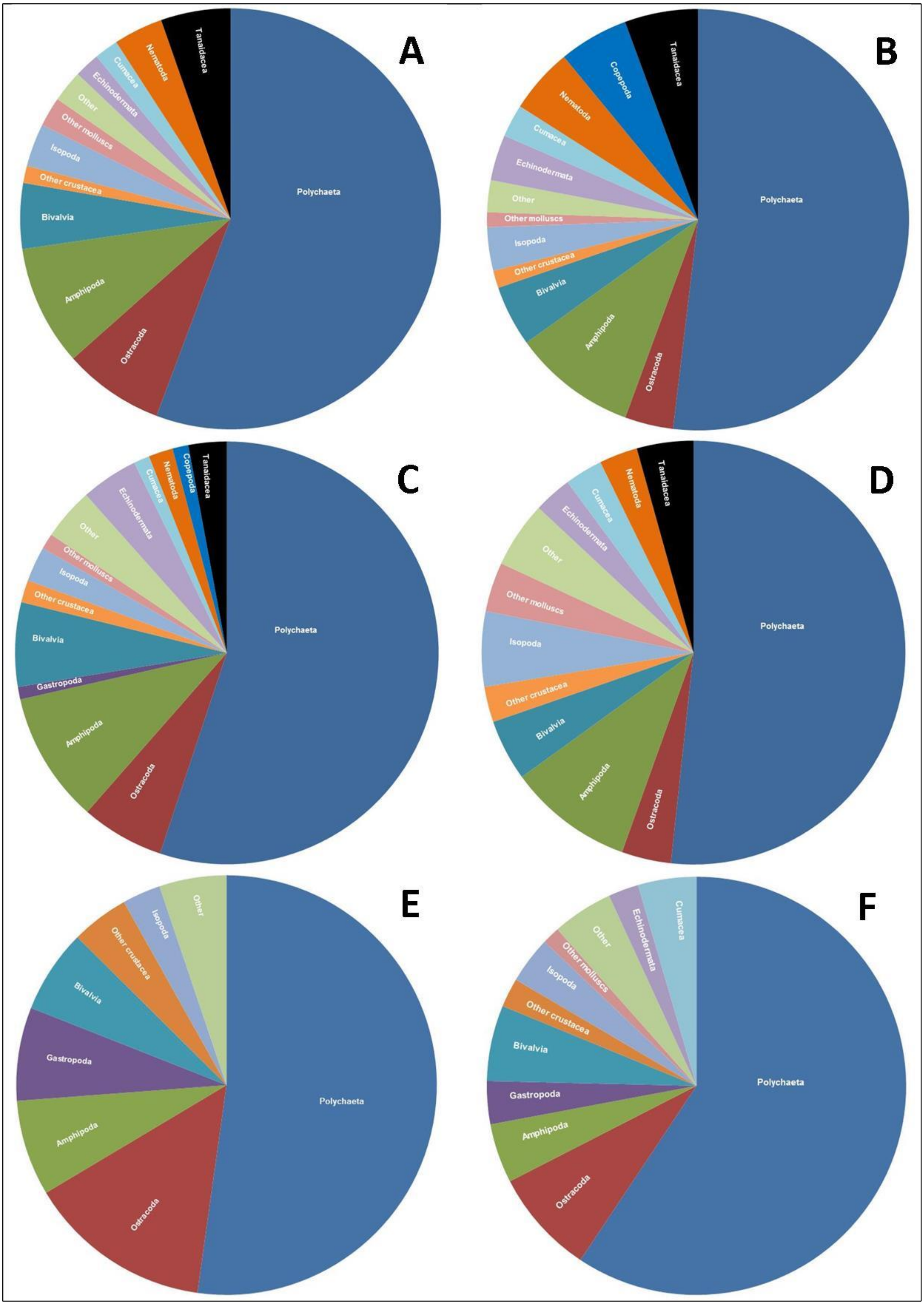
Taxa	Class/Order	Phylum	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15
Hyperia sp.	Amphipoda	Crustacea	1													1	
Ischyroceridae	Isopoda	Crustacea							1				1				
Leitoscoloplos kerguelensis	Polychaeta		1	1													
Limatula moria	Bivalvia	Mollusca												1			
Longosomatidae	Polychaeta									1							
Lumbrineridae	Polychaeta		4	3		2		3	1		1	2	4	1	2		1
Lysianassidae	Amphipoda	Crustacea				4		1						2		1	
Magelona dakini	Polychaeta		1														
Maldanidae	Polychaeta		15	27	8	5	9	9	15	15	11	6	4	12	14	6	5
Marphysa disjuncta	Polychaeta		1				1			1	4	2					
Maxacteon sp. (Maxacteon cf. matericulatus)	Gastropoda	Mollusca													1		
Merelina sp.	Gastropoda	Mollusca													1		
Mogula sp.	Tunicata			1													
Mysella hounselli	Bivalvia	Mollusca									2						
Natatolana pellucida	Isopoda	Crustacea	1					1			1						
Naticidae	Gastropoda	Mollusca				2					1				1		
Nebaliacea	Nebaliacea	Crustacea		1												1	
Neilonella wrighti	Bivalvia	Mollusca	1		4		1				1		1				
Neilonella wrighti (juvenile)	Bivalvia	Mollusca	1					2	1		1			1		2	
Nematoda	Nematoda		2	2	1	1	1	2	1	1						1	2
Nemertea	Nermetea		1	1	1	1	1	1	1	1	1				1		1
Neonesidea sp.	Ostracoda	Crustacea	3	1	1		1		2	2				2	3		1
Nucinella maoriana	Bivalvia	Mollusca		1													
Oligochaeta	Oligochaete								1								
Onuphis aucklandensis	Polychaeta		3		2	3	3	1		2			1	2	3	1	

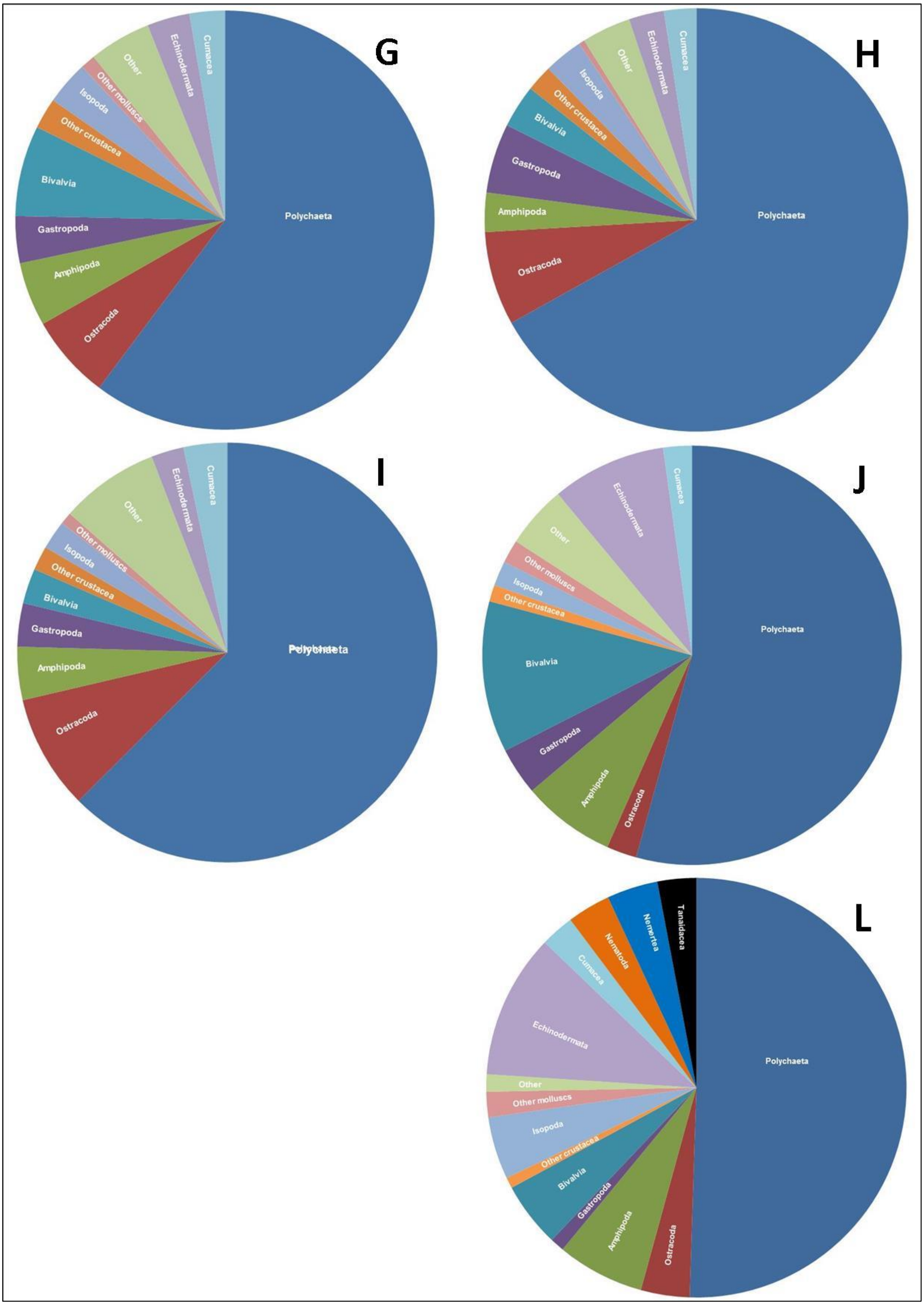
Taxa	Class/Order	Phylum	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15
Ophiuroidea	Ophiuroidea	Echinodermata	4	2	3	1		3	6	2				2	4	2	4
Ostracoda	Ostracoda	Crustacea												1			
Paramunna serrata	Isopoda	Crustacea					1										
Paraonidae	Polychaeta		3	5	6	5	1	3	1	5	4	2	6	8	1	4	1
Paraprionospio pinnata	Polychaeta									1							
Philine powelli	Gastropoda	Mollusca			1					1							
Phoxocephalidae	Amphipoda	Crustacea	3			2		4	1	5	1	1					
Phyllochaetopterus socialis	Polychaeta									1							
Phyllodocidae	Polychaeta													1			
Pilargidae	Polychaeta		2			1	1								1		1
Pleuromeris sp. (Juvenile)	Bivalvia	Mollusca							1								
Polynoidae	Polychaeta										1						
Pontophilus sp.	Decapoda	Crustacea	1														
Poroleda lanceolata	Bivalvia	Mollusca								1					1		1
Pratulum pulchellum	Bivalvia	Mollusca			1				1								
Prionospio multicristrata	Polychaeta													1			
Prionospio sp.	Polychaeta				1									1			1
Relichna aupouria	Gastropoda	Mollusca	3	5	2								1	1		2	
Rhamphobrachium sp.	Polychaeta													1			
Rissoidae	Gastropoda	Mollusca		1				1								2	3
Rynkatopa uncinata	Holothuroidea	Echinodermata				1	2	1							1		1
Sabellidae	Polychaeta				1						1			1			
Sand eel				1													
Scalibregma inflatum	Polychaeta														1		
Sigalionidae	Polychaeta		1	1						1	1						1

Taxa	Class/Order	Phylum	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15
Sphaerosyllis sp.	Polychaeta			2										2	1	1	
Spiophanes sp.	Polychaeta		1	1					1		2			1	2		
Syllidae	Polychaeta			4				1						1	1	1	1
Tanaidacea	Tanaidacea	Crustacea	1			1		1			1		1	2			3
Terebellidae	Polychaeta			1									1				
Terebellides stroemii	Polychaeta		1		1			2	1	1	3	1	1	4	4		1
Themiste sp.	Sipuncula		1		1		1	3	1	2	1			1			
Thyasira peregrina	Bivalvia	Mollusca							1					1	1		
Tornidae	Gastropoda	Mollusca												1			
Trachyleberis lytteltonensis	Ostracoda	Crustacea	2	1	3				3		2	2		2	2		3
Upogebia sp.	Decapoda	Crustacea														1	
Varinucula gallinacea	Bivalvia	Mollusca	6	5	1	3	2	3	4	2	5	3	1		2		2

APPENDIX E

Comparison of Proportion of Individuals belonging to each Taxonomic Group across all Wells


A
Tanaidacea
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
Polychaeta
B
Tanaidacea
Copepoda
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
Polychaeta
C
Tanaidacea
Copepoda
Nematoda
Cumacea
Echinodermata
Other
Other mollusca
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta
D
Tanaidacea
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
Polychaeta
E
Other
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta
F
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta


G
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
H
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other
Echinodermata
Cumacea
I
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
J
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
L
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Nemertea
Tanaidacea

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EXPLORATION AND APPRAISAL DRILLING PROGRAMME

Benthic Baseline Report
Well H

Prepared for:

OMV New Zealand Limited
Level 20, The Majestic Centre
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SLR Ref: 740.10078.00200-R01
Version No: v1.0
July 2018

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BASIS OF REPORT

This report has been prepared by SLR Consulting NZ Limited with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with OMV New Zealand Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.10078.00200-R01-v1.0	31 July 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier
740.10078.00200-R01-v0.1	29 June 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier

EXECUTIVE SUMMARY

OMV New Zealand Limited (**OMV New Zealand**) are applying for a Marine Consent to undertake an Exploration and Appraisal Drilling (**EAD**) Programme in the Taranaki Basin with an anticipated commencement date in 2019. OMV New Zealand may drill up to nine exploration wells and two appraisal wells within their Petroleum Exploration Permits (**PEP**). The intention of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs.

As part of the Marine Consent application, three Areas of Interest (**AOI**) have been identified that encapsulate the proposed well locations and are used as part of the Impact Assessment process. OMV New Zealand undertook a baseline environmental monitoring survey at each well location in March - April 2018 to gain an understanding of the benthic habitat and associated communities with each AOI.

Grab sampling and video sled methodologies were used to gain quantitative and qualitative information on the marine environments surrounding each well location. The data gathered from each baseline survey will be incorporated into the Marine Consent application and assist in the risk assessment process.

Water currents and deposition modelling were utilised to define the placement of sample stations. Sample transects were aligned along the dominant deposition pathway of the predicted drill cutting dispersion should that particular well be drilled. A total of 15 monitoring stations were allocated at each well site and one benthic grab sample was collected at each monitoring station. Ten video sleds were also undertaken at a selection of pre-determined sites around each well.

Within this Benthic Baseline report the analysis of results incorporates sediment physical and chemical properties, benthic macrofauna, epifauna and visual observations around Proposed Well H. A total of 1,339 individuals representing 103 taxa were identified from the 15 macrofauna samples collected around Well H. Infauna communities were dominated by small polychaete worms (67%), crustaceans (18%), and molluscs (9%).

Results of sediment sample analyses showed sediments from Well H to be silt and clay dominated sandy muds, with a slight increase in silt/clay fractions from the east to the west. The sandy mud sediments were but similar to silt and clay dominated sediments in the wider Central AOI, but notably finer than Northern AOI sites.

Infauna samples collected during the Benthic Baseline survey indicated the presence of Chaetopteridae worms (*Phyllochaetopterus socialis*) and sea pens (*Virgularia gracillima*) which are taxa defined as '*characteristic species of sensitive environments*'. This species of worm is known to form worm-fields or low-relief worm meadows. Sea pens were also observed in the video imagery collected at Well H; however, the occurrence and estimated densities of these taxa at Well H did not reach the trigger levels defined by the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (MacDiarmid *et al*., 2013) and no distinct worm or sea pen 'fields' were encountered. Thus although present at the well in low densities the area should not be classified as a 'sensitive environment'.

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CONTENTS

DOCUMENT REFERENCES

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FIGURES

APPENDICES

1 Introduction

OMV New Zealand Limited (**OMV New Zealand**) is applying for a Marine Consent under Section 38 of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (**EEZ Act**) to permit activities associated with an Exploration and Appraisal Drilling (**EAD**) Programme proposed to be undertaken starting in 2019.

The EAD Programme includes the drilling of up to nine exploration wells and two appraisal wells within OMV New Zealand's permit areas (**Figure 1**). The purpose of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs which OMV New Zealand operate (**Figure 1**).

Three Areas of Interest (**AOI**) (summarised below) have been identified which encapsulate the well locations (**Figure 1**). This monitoring report relates to the Benthic Baseline survey conducted at Well H in the Central AOI. Location details and water depth of Well H are provided in **Table 1**.

The Northern AOI encompasses PEP 60092 (Ridgeline), PEP 57075 (Cloudy Bay) and PEP 60093 (Toutouwai) and includes the following wells:

- Well A;
- Well B;
- Well C; and
- Well D.

The Central AOI encompasses PEP 60093 (Toutouwai) and includes the following wells:

- Well E (Appraisal);
- Well F;
- Well G (Appraisal);
- Well H; and
- Well I.

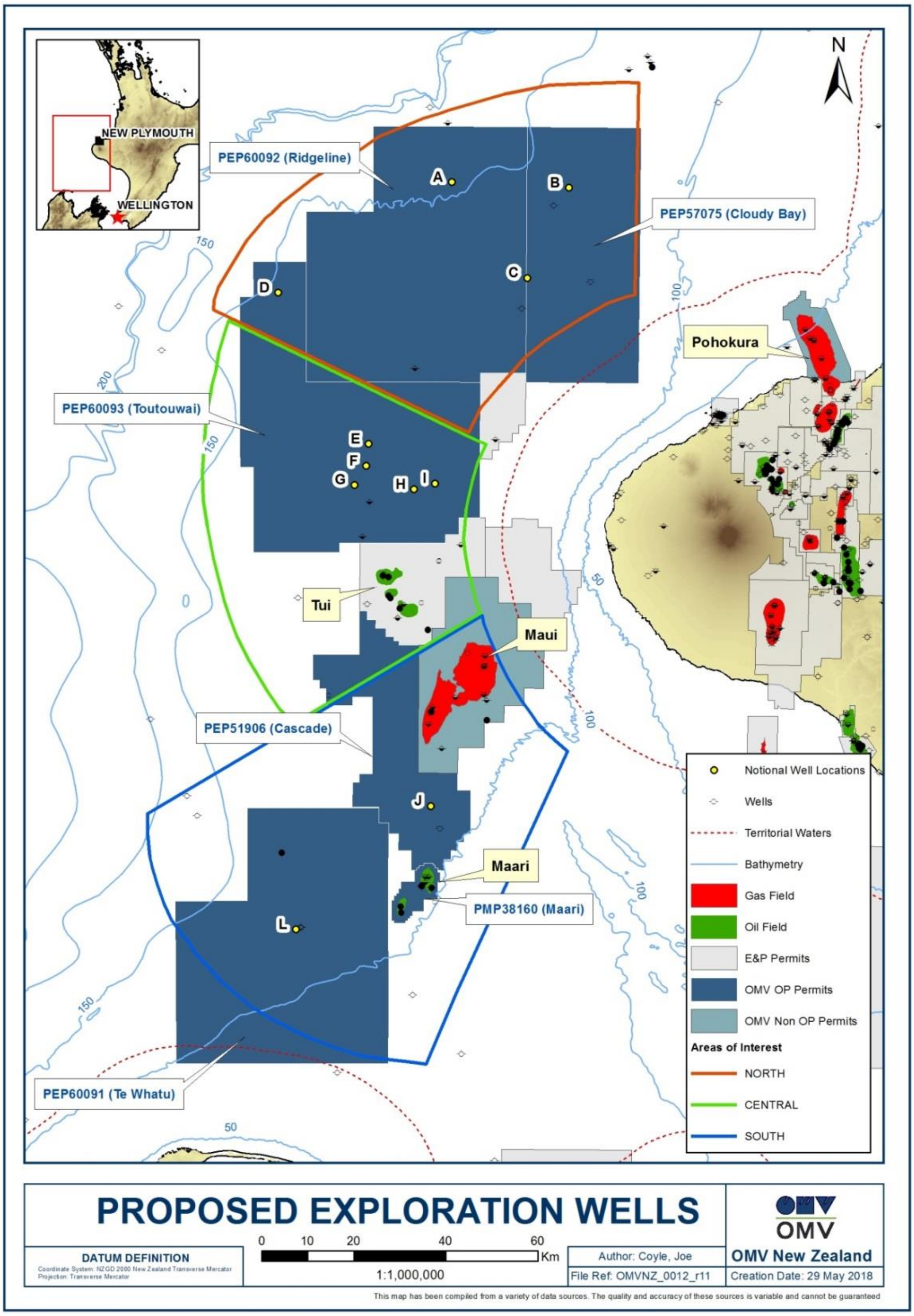
The Southern AOI encompasses PEP 51906 (Cascade) and PEP 60091 (Te Whatu) and includes the following wells:

- Well J; and
- Well L

Table 1 Water Depth and Coordinates of Well H in the Central AOI

Well Name	Water Depth (m LAT)	Easting (NZTM)	Northing (NZTM)
H	123	1623366	5659874

Figure 1 OMV New Zealand's EAD Well Locations and three AOIs in the Taranaki Basin



In February 2018 SLR Consulting NZ Limited (**SLR**) was engaged by OMV New Zealand to undertake a baseline assessment of the benthic ecology in the vicinity of 11 wells (**Figure 1**). The aim of the field surveys, which were undertaken from March 24 – April 8 2018, was to collect relevant data using grab sampling and video sled methodologies to provide quantitative and qualitative information on these marine environments. This qualitative and quantitative data will be used within the Marine Consent application to define the benthic habitats and communities present at each well and assist in the risk assessment process.

This report summarises the results of the Benthic Baseline survey undertaken at Well H.

1.1 Project Location

Well H is located approximately 70 km west of New Plymouth in New Zealand's Exclusive Economic Zone (**EEZ**). Water depth and GPS coordinates are provided in **Table 1** and displayed in **Figure 1**. The monitoring programme sample design resulted in sample stations extending out to 6 km from the well location (**Section 2.1**).

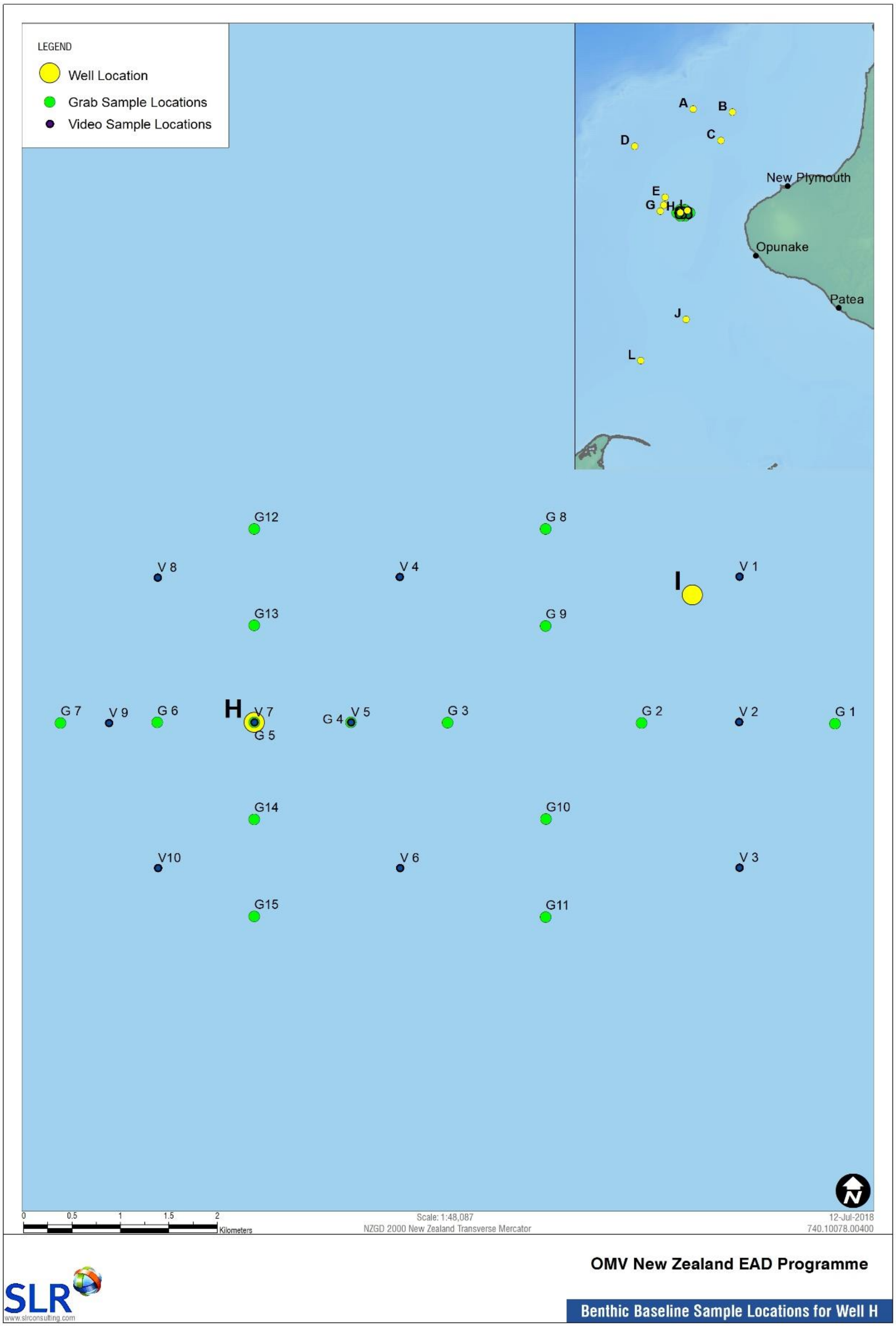
2 Methodology

The Benthic Baseline surveys adopted similar methodologies to what has been previously used for offshore Taranaki benthic monitoring programmes undertaken in accordance with the principles defined in the Offshore Taranaki Environmental Monitoring Protocol (**OTEMP**) (Johnston *et al*., 2014). This consistent approach enables monitoring results to be compared with previous monitoring programmes undertaken in the offshore Taranaki environment (i.e. pre- and post-drill monitoring and production monitoring).

2.1 Sample Locations

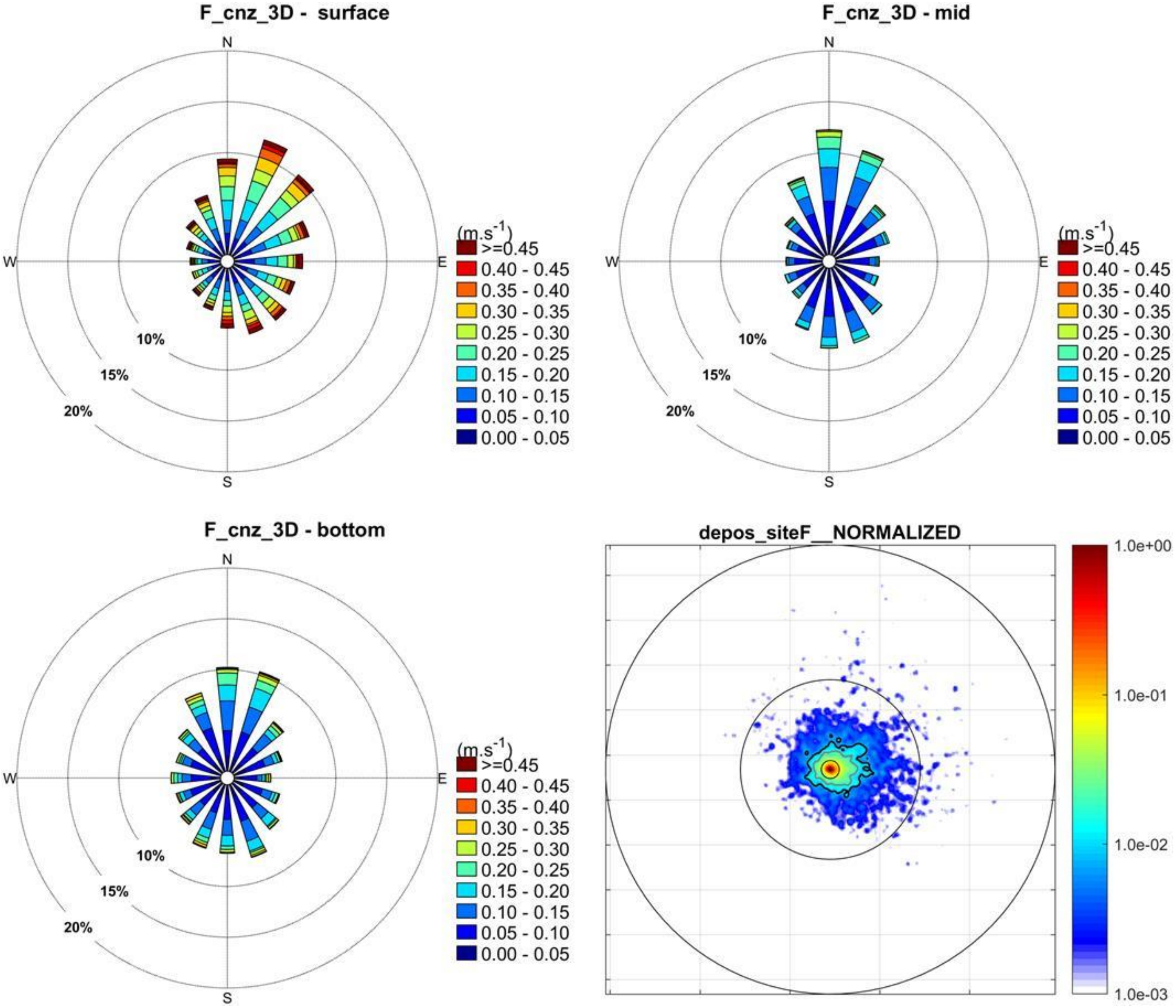
The sample locations (**Figure 2**) were defined by the dominant direction of current flow and preliminary drill cutting deposition modelling results (**Figure 2**). Sample transects were aligned along the dominant deposition pathway (i.e. southeast/northwest) (**Figure 3**) as this is the area determined to be most likely to be impacted from the deposition of drill cuttings should the well be drilled. However, sample stations were also located along the minor flow axis (northeast/southwest) to enable comparisons and validation of spatial differences based on the dispersal patterns predicted by MetOcean Solutions Limited.

Figure 2 Well H Sampling Stations



Note: At each video transect station approximately 250 m of video footage was captured along the seabed in the direction of the vessels drift at the time of sampling.

Figure 3 Surface, Mid-water and Bottom Water Column Current Roses and Dispersal Modelling plots created by Metocean Solutions Ltd for the nearby Well F



2.2 Field and Sampling Procedures

Field sampling was undertaken from the MV *Seaworker* between March 24 and April 8, 2018, following the procedures detailed below. Sampling at Well H took place on April 3rd

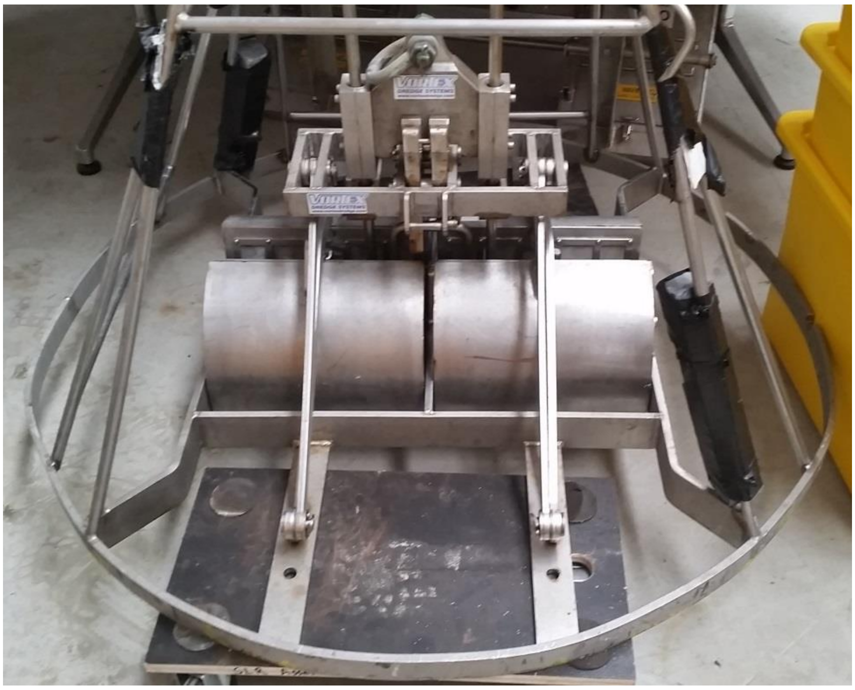
2.2.1 Benthic Grab Samples

A double Van Veen double grab sampler (**Figure 4**) was used to collect a single sediment grab sample at each of the 15 benthic monitoring stations surrounding Well H (**Figure 2**). The grab sampler is constructed of stainless steel and features two independent 'buckets' which penetrate the surficial sediments to a depth of 0.16 m. Each successful grab sample returns approximately 0.01 m^3 of seabed sediment back to the surface.

Upon arrival on the vessel deck, each grab sample is checked for completeness, which must meet the following criteria:

- The surface of the sediment is largely undisturbed upon inspection aboard the vessel;
- Sufficient sediment (≥75% of the grab capacity) is collected to enable the full suite of sediment analyses required;
- The infauna sample bucket is filled to the same volume (approximately 10 l) for all infauna replicates throughout the survey; and
- The grab has not been over-filled with sediments pushing out of the doors or drains, indicating that it may have over-penetrated the sediment.

Figure 4 The Double Van Veen Grab Sampler used for the 2018 Benthic Baseline Sampling



Each independent bucket from a grab sample is used separately for infauna and sediment physical and chemical analyses, as follows:

- Bucket one: infauna/macrofauna community analysis. The entire sample is sieved through 0.5 mm mesh until approximately 300-500 ml of residual sediment and organisms remains. This remaining material is transferred to a plastic container and preserved with a fixative (AncholTM), ready for analysis by SLR taxonomists.
- Bucket two: sediment physical nature and chemical analyses. Three 64 mm (internal diameter) clear Perspex sub-sampling cores are pushed into the sediments from the second bucket, to a depth of approximately 150 mm. Cores are photographed and the upper 50 mm from each core is extruded into a polyethylene bag for particle grain size distribution and organic content (Total Organic Carbon - **TOC**) analyses by Hill Laboratories.

2.2.2 Seafloor Video Imagery

Video imagery of the seafloor was obtained using a customised tow-sled fitted with high-intensity LED lighting and a high-definition video camera (**Figure 5**). The system was connected to the vessel via a 10 mm dyneema tow-line and a 300 m umbilical cable supplying real-time video images to the camera operator on the research vessel. A pair of parallel lasers on the video sled provided an indication of scale allowing features of interest in the video recordings to be approximately sized. Ten video sled tows were conducted around Well H (**Figure 2**).

The video-sled was launched from the vessel up-current of each pre-determined location and lowered to the seabed, where it auto-located via a series of floats and weights set at specific points on the sled frame, to land upright on its lower skids. At the point where the sled contacted the seabed, a GPS log was started, and this log continued throughout the duration of the tow. Video footage was continuously recorded for approximately 200 m as the sled drifted behind the vessel; this ensured that footage was collected while the sled was passing as close as possible to the required sample location.

Figure 5 The Video Sled used for Collecting Video Imagery of the Seabed Environment

2.3 Laboratory Analyses

2.3.1 Sediment Physicochemical Analyses

Benthic sediments collected by the grab were analysed by Hill Laboratories (an NZS/ISO/IEC 17025:2005 accredited laboratory), for both physical and chemical parameters. The aims of these analyses along with further details of the analytical method/descriptions are summarised in **Table 2**.

Table 2 Summary of Analytical Methods used for Testing Sediment Physico-chemical Characteristics

Analyte	Aim	Method Number	Description
Particle Grain Size Distribution	• Determine physical parameters of the sediment particles present at the site • Correlate with infauna community characteristics	Hill Laboratories KB32136	• Sediment was wet-sieved through the following screen sizes, as per the Udden-Wentworth scale (Wentworth, 1922): • >2 mm (gravel) • >1 mm (very coarse sand) • >500 µm (coarse sand) • >250 µm (medium sand) • >125 µm (fine sand) • >63 µm (very fine sand) • <63 µm (silt and clay)
Total Organic Carbon	• Determine current level of organic carbon in sediment • Correlate with infauna community characteristics	No specific method number	Acid pre-treatment to remove carbonates present, followed by catalytic combustion (900° C, O_2), separation, Thermal Conductivity Detector. Elemental Analyser.

2.3.2 Macrofauna Analyses

Macrofaunal analyses focused on the infauna, or animals larger than 0.5 mm living within the sediment matrix. Epifaunal animals (those living on top of the sediment), were also included in the analyses to provide representation of the different functional groups present at each sample station.

Benthic macrofaunal samples collected from the sediment grab were sorted and, with the aid of a binocular microscope, identified to the lowest practicable taxonomic level or most recognisable taxa (morphologically similar group). Counts were made to assess the relative abundance of each taxa.

2.3.3 Seafloor Video Analyses

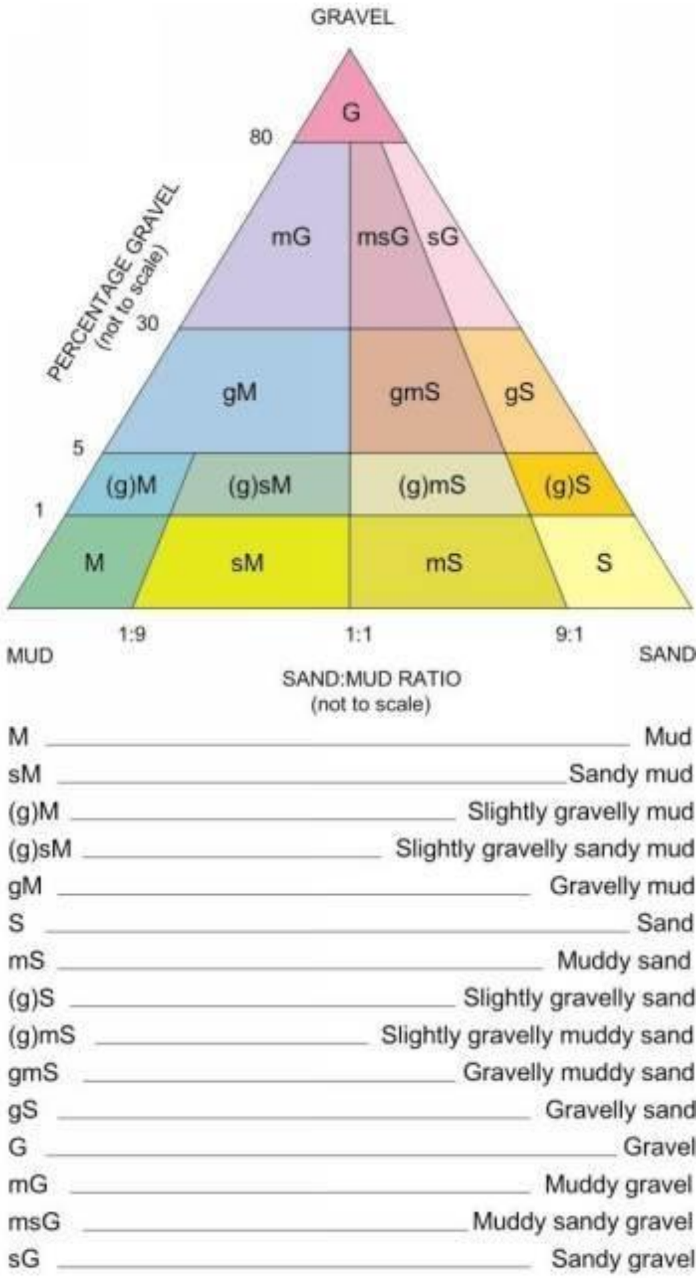
A live feed from the video-sled was captured and recorded on-board the survey vessel and viewed by SLR staff with experience in undertaking assessments of the benthic environment in the offshore Taranaki region. Brief field notes were made in real-time about obvious structures and organisms observed while watching the live footage. Back onshore the recorded seabed video footage was assessed on a large, high definition screen, by a suitably trained and experienced benthic scientist, who identified all obvious epifauna to the lowest practicable taxonomic level. Biogenic and/or anthropogenic seabed structures such as burrows, mounds, tracks and gouges/trenches were also recorded. Relative abundance estimates of epifauna or biogenic structures were made where appropriate.

2.4 Data Analyses

2.4.1 Sediment classifications

While there are many sediment classification schemes in use worldwide, a common one is a modified version of that proposed by Folk (1954). This scheme groups grains within a sample into mud, sand and gravel sized particles based on the particles diameter (mud <63 µm, sand 64-2000 µm, gravel > 2mm), and then describes the sediment type based on the relative proportions of the particles (see **Figure 6**).

Figure 6 Folk (1954) Sediment Type Classification Triangle



2.4.2 Community Characteristic Descriptors

All macrofauna (both epifauna and infauna) taxa were included in the analyses of abundance data. Species identified in the samples as not being exclusively benthic were excluded from further analyses. Data were analysed as per the statistical methods outlined below to identify current distributions and abundance of macrofauna.

2.4.2.1 Univariate Diversity Indices

Diversity indices (number of taxa S, total abundance N, Shannon-Wiener diversity H', and Pielou evenness J' (**Table 3**) were calculated from the macrofauna abundance data using the PRIMER software package (PRIMER v6.1.16; Clarke, 1993; Clarke & Warwick, 1994; Clarke & Gorley, 2006).

Table 3 Description of Macrofauna Community Characteristic Indices

Index	Formula (where applicable)	Description
Number of Taxa (S)	Count of total number of different taxa identified within the *x* sample	Total number of taxa identified within a sample
Total Abundance (N)	Sum of all individual taxa abundances within the *x* sample	Total number/count of all organisms within a sample
Shannon Diversity (H')	$H' = -SUM [(p_i) \times \log_e (p_i)]$ p_i = Number of individuals of taxa i /total number of samples	A single value (log scale) that is used to describe the different types and numbers of organisms present within an assemblage. The index value increases as assemblages have greater numbers of taxa and when the numbers of individual organisms are more evenly distributed across the different taxa. Samples dominated by single taxa will have lower values towards zero.
Pielou Evenness (J')	$J = H' / \log_e (S)$	A value theoretically between zero and one which indicates how evenly the number of individual organisms are distributed through the different taxa in an assemblage. High values (closer to 1) indicate an even spread amongst the taxa present, whereas a low value indicate an uneven spread or an assemblage highly dominated by only a few, or even a single taxon.

3 Results and Discussion

3.1 Sediment Physical and Chemical Properties

3.1.1 Visual Description of Sediment Cores

Sediment collected from around Well H was predominantly light grey cohesive mud (**Figure 7**). During sediment sampling no very dark-grey or black sediment layers (apparent Redox Potential Discontinuity), or darker patches within cores were noted and no detectable hydrogen sulphide odours were present, indicating that sediments are well oxygenated throughout the depths sampled. Field observations on sediment texture, colour and any notable features of the sediment samples were recorded during the processing of the sediment cores and infauna samples, and these are included in **Appendix A**. A full set of sediment core photographs are contained in **Appendix B**.

Figure 7 Representative Images of Sediment Core Profiles from Well H

Station H1

Station H6

Station H11

Station H13

3.1.2 Incidental Observations

During the laboratory processing of the infauna samples by SLR taxonomists observations were made of any debris that was present, including those from anthropogenic sources. Within the 15 samples collected at Well H there were 12 types of debris observed (**Table 4**), nine of which were likely to be anthropogenic in source, including nylon strands, plastic fragments, paint flecks and rust flakes. 'Sand-like substance', coal rock, and graphite are thought to be natural in source.

Other than the 'sand-like substance' at H8, all debris encountered in the samples were at 'low' abundances.

Table 4 Incidental Observations of Debris

	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15
Sand-like substance	L	L	L	L	L	L	L	C	L	L		L	L	L	
Coal rock												L			
Graphite							L			L					L
Blue paint										L		L			
Red nylon			L												
Blue nylon			L												
Blue plastic			L												
Red paint							L								
Rust									L	L					
Green nylon											L				
White plastic															L
Yellow paint															L

VA = very abundant (>50), A = abundant (50+), C = common (20–50), O = occasional (10–20), L = low (0–10)

3.1.3 Sediment Particle Grain Size Distribution and Organic Content

The physical characteristics of the sediment can influence the composition of the infauna communities and the levels of contaminants retained and observed during analyses. Particle grain size is widely used to characterise the physical structure of the sediment, while organic content provides an indication of the organic enrichment in the sediment. These combined results provide a general understanding of sediment health and the source of potential stressors at the time of sampling.

Organic matter found in the sediments is most likely derived from natural sources such as infauna/epifauna and detrital matter, rather than from anthropogenic sources. Anoxic sediments (those lacking oxygen), may develop in situations where organic matter levels increase beyond 'normal' levels for that area. Increased organic matter has the potential to disturb the equilibrium of the benthic ecosystem, as increased numbers of oxygen-utilising bacteria are required to decompose the additional organic matter, thereby rapidly reducing oxygen availability in the sediments.

A summary of the particle grain size and organic content analyses are discussed below, with full results provided in **Appendix C**.

3.1.3.1 Particle Grain Size

Sediment samples from Well H were dominated by the silt/clay (66 - 78%, mean 73%), fine sand and very fine sand fractions (means 19% and 6% respectively) (**Figure 8**), classifying these sediments as 'sandy muds' (Folk, 1954). This is similar to the majority of offshore Taranaki areas where historical exploration/production monitoring has taken place. There was a weak trend of increasing proportions on silt and clay moving from east to west. Stations 11 and 12 were the only samples to contain a detectable proportion of gravel (0.7-1.6%).

The sandy muds encountered at Well H were similar to those found in the Central AOI, but noticeably different to the coarse muddy sands found at sites within the Northern AOI and at Well L in the Southern AOI (**Table 5**). A comparison of particle grain size data for Well H with the other wells is provided in **Appendix C**.

Figure 8 Sediment Particle Grain Size Distribution for Samples Collected at Well H

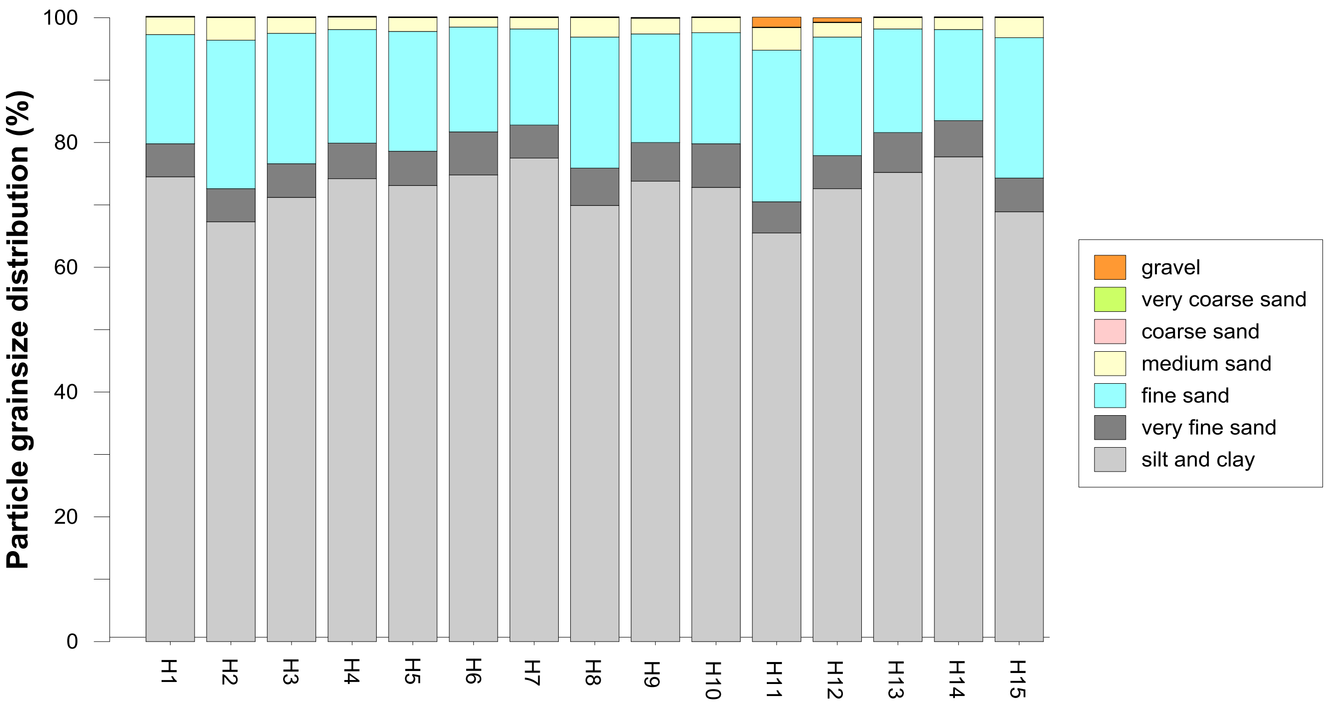


Table 5 Mean Grain Size for the Eleven Wells

Grain size class	A	B	C	D	E	F	G	H	I	J	L
Silt & Clay (Mud) (%)	36.2	27.5	41.1	30.7	85.2	83.2	67.8	72.6	65.1	85.4	30.8
Very Fine Sand (%)	45.8	39.3	30.5	41.7	6.5	4.8	6.1	5.8	6.6	14.2	25.4
Fine Sand (%)	17.0	28.6	22.4	26.8	8.0	11.3	24.6	19.0	22.1	0.4	29.8
Medium Sand (%)	1.0	2.4	3.3	0.7	0.4	0.6	1.6	2.5	5.1	0.1	12.3
Coarse Sand (%)	0.1	0.7	0.8	0.0	0.0	0.1	0.1	0.1	0.6	0.0	1.2
Very Coarse Sand (%)	0.0	0.6	0.5	0.0	0.0	0.1	0.1	0.1	0.5	0.0	0.2
Gravel (%)	0.1	1.1	1.3	0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.1
Description	mS	mS	mS	mS	sM	sM	sM	sM	sM	sM	mS

Note: sM = sandy mud, mS = muddy sand

Colour scale based on percentage with median mid-point (Median is 2.0):

0%	5	10	20	30	40	50	60	70	80	90	100

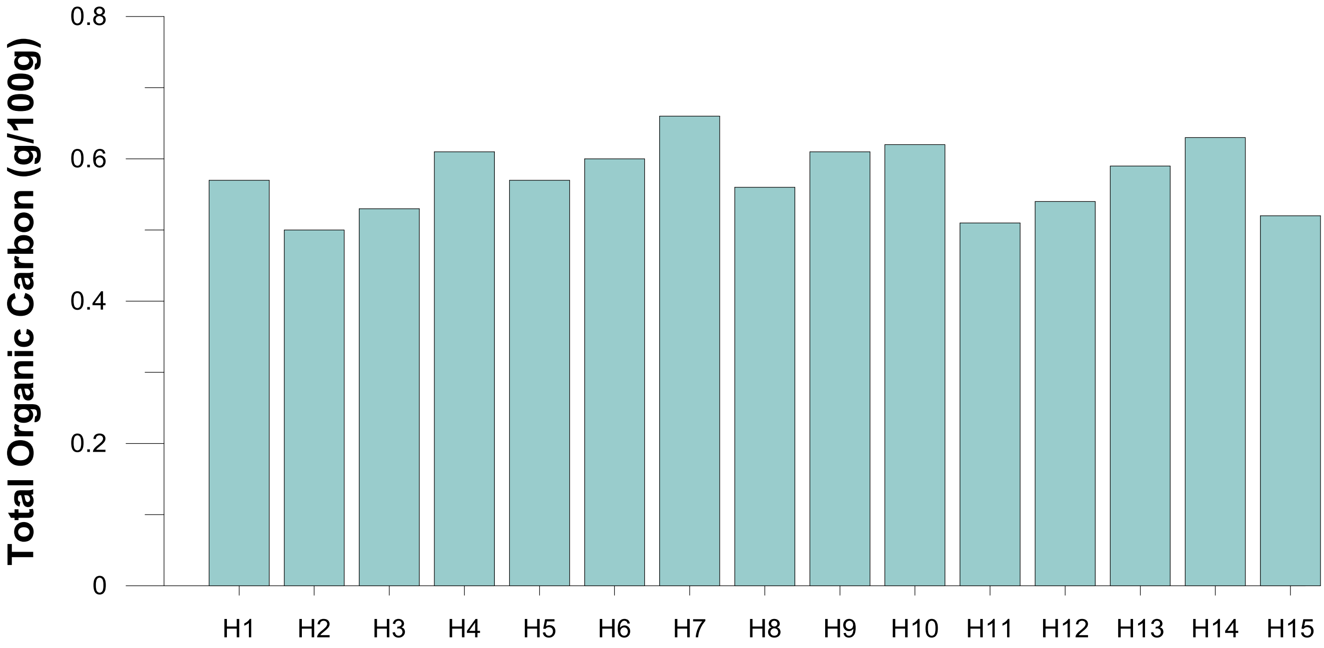
3.1.3.2 Total Organic Carbon

The organic content of sediments was assessed by measuring TOC to assess benthic ecology as this is also consistent with what is now currently undertaken around the offshore Taranaki oil and gas fields.

TOC levels at Well H (**Figure 9**) ranged between 0.51% and 0.66% (mean 0.57%). TOC levels were lowest at the southern-most monitoring stations (H11, 051%, and H15, 0.52%), and highest on the western edge of the sampling area (i.e. monitoring station H7, 0.66%).

The average organic content around Well H was high relative to other EAD wells monitored as part of the Benthic Baseline survey (mean 0.57% compared to overall mean of 0.45%). The combined mean for the five Central AOI (0.59%) was high relative to the Northern and Southern AOIs (0.26% and 0.48%, respectively); however, the mean for the Southern AOI should be interpreted cautiously due to the large variation between Well J and L. As has been previously described in benthic environmental monitoring associated with offshore Taranaki oil and gas activities (SLR, 2017), there is a correlation between sediment particle grain size and sediment organic content. The comparatively greater surface area to volume ratio of silt and clay (mud/fines) sized sediment particles (compared to larger particles like sand) gives a greater area for adsorption of organic matter particles and therefore a higher probability of elevated organic matter compared to coarser/sandier sediments subjected to the same level of enrichment (Hedges *et al*., 1993). This is likely to explain some of the large difference in mean TOC levels between Well J and L (high at J, low at L) where there were noticeably different grain size distributions (coarser muddy sands at Well L) (**Section 3.1.3.1**).

Figure 9 TOC Concentrations in Sediment Samples Collected from around Well H



3.2 Video Sled Imagery

Video footage of the seabed allows scientists to visually assess any anthropogenic disturbance to the benthic environment and observe epifauna, sediment-type and structures or relief that exist on the seabed.

Video footage was captured by towing a video sled through ten stations around Well H (**Section 2.2.2**). Digital copies of the video imagery collected at Well H accompanies this report, with a selection of still images displayed in **Figure 10**. **Appendix A** provides locational information for each video sled tow.

Video footage was assessed to determine any defining features and their semi-quantitative abundance recorded for comparison with other wells. Due to caveats associated with video footage (i.e. variable visibility, differing tow length and durations) the counts are indicative-only and should not be interpreted as a quantitative assessment. **Table 6** presents the results of this semi-quantitative approach, which summaries the counts by comparing the well total to the median across all of the EAD wells in the three AOIs. As a visual aid, counts were categorised in relation to the deviation from the 10th, 25th 50th, 75th and 90th percentiles, so that differences between wells can be more easily viewed.

3.2.1 Physical Observations

The seabed around Well H was observed to be soft mud sediments. Evidence of bioturbation was observed in all video tows in the form of animal burrows. Moderate to high densities of burrows were prevalent in Well H video transects (**Figure 10**). This is similar to other wells in the Southern and Central AOI but differs from the Northern AOI where densities were predominantly low (**Table 6**).

Mound/hollow features (image C, **Figure 10**) were observed to be smaller and in very low numbers (18) compared to the median of all sites (43) (**Table 6**). These features are thought to be formed by the feeding activities of sharks or rays, or by large burrowing tube worms mounding up sediment. Mound / hollow features were observed to be more numerous at the Northern AOI sites, moderate to very high at the Southern AOI sites, and low to very low in numbers around the Central AOI sites.

While there was no definitive sign of anthropogenic physical disturbance of the seabed observed during the video sled tows associated with Well H, a number of shallow trenches were observed that appear likely to have been caused by commercial fishing activity (images D, E, F, and G, **Figure 10**). The video sled crossed 11 elongated trenches across seven separate monitoring stations around Well H (HV4, HV5, HV6, HV7, HV8, HV9, and HV10). The trenches were approximately 200 – 300 mm deep and 400 – 500 mm wide. There was no other sign of anthropogenic physical disturbance or sediment enrichment.

Table 6 Total Number of Features Observed in Video Imagery from the EAD Wells

Well Site	Depth (m)	Mounds/ Hollows	Density of burrows/worm holes	Sea pen	Fish	Substrate	Notes
A	148	111	Low-moderate	54	65	Muddy sand	Ripples; some very large holes and mounds
B	134	63	Low-moderate	35	49	Muddy sand	Some very large holes mounds
C	132	85	Low-moderate	50	44	Muddy sand	Ripples; trenches observed
D	145	280	Low	160	28	Muddy sand	Ripples; 23 very large sea feathers
E	126	29	Moderate	29	16	Sandy mud	
F	128	20	Moderate	19	19	Sandy mud	
G	124	18	Moderate-High	29	26	Sandy mud	
H	124	18	Moderate-High	17	26	Sandy mud	12 elongated shallow trenches
I	122	43	Moderate-High	36	21	Sandy mud	5 elongated shallow trenches (large)
J	108	42	Moderate	14	30	Sandy mud	School of mackerel, tufts/tubes common
L	112	532	Moderate	132	31	Muddy sand	2 schools of mackerel
Median		43		35	28		

Totals are sum of 10 video tows carried out at each site. Totals are semi-quantitative only due to variable visibility and transect length.

10th percentile band
25th percentile band
Median band
75th percentile band
90th percentile band

3.2.2 Infauna, Epifauna and Other Fauna

In some cases, a definitive positive identification of infauna, epifauna and more mobile taxa was not possible from the video footage alone. Where there was any uncertainty, identifications were based on distinctive features, colours and shapes of organisms and in some cases the confirmed presence of similar looking individuals within the infauna samples.

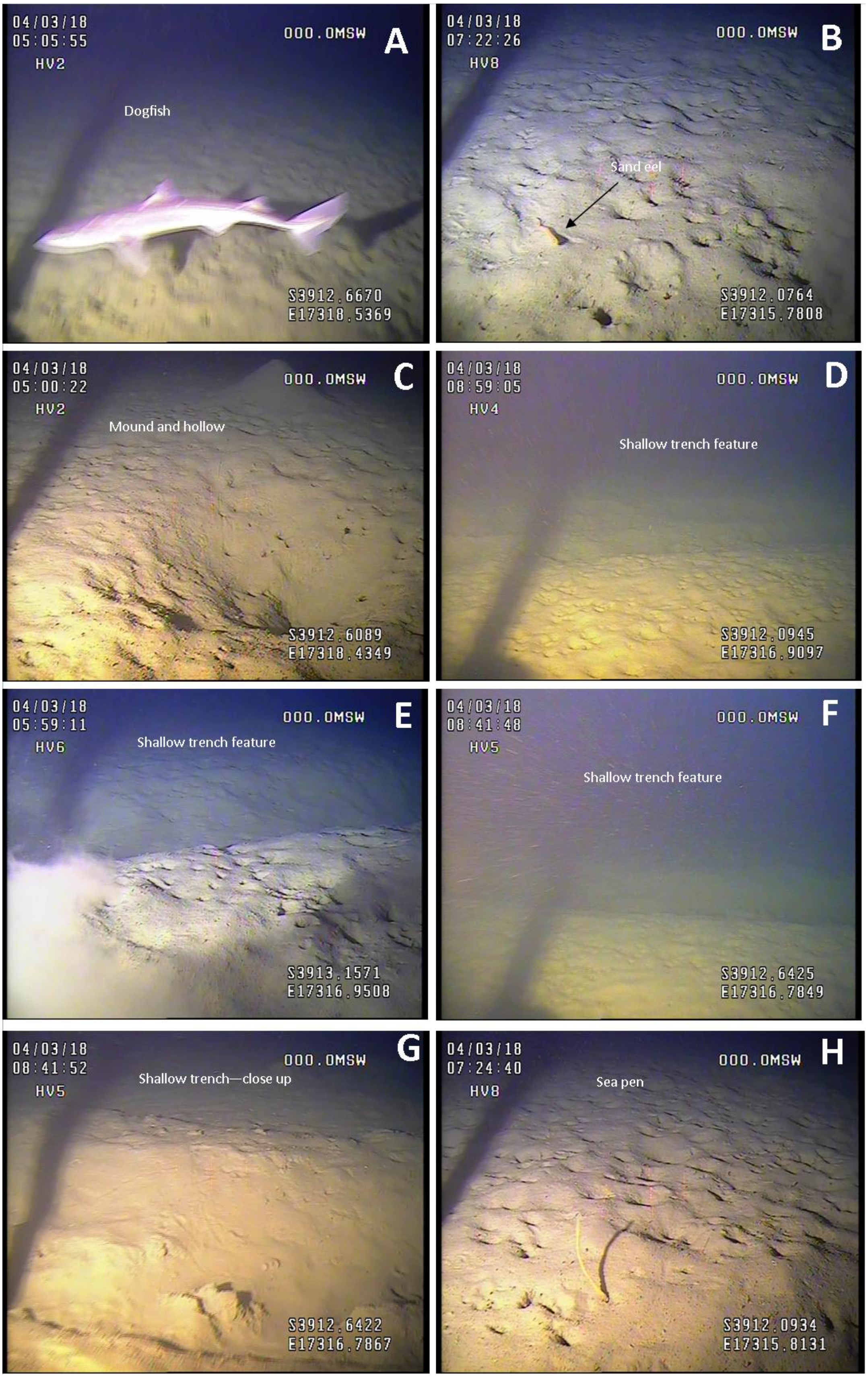
Epifauna taxa observed in video footage collected around Well H included a small number of whelks (likely *Austrofusus glans*) and other molluscs such as tusk shells (likely *Fissidentalium zelandicum).* The presence of epifauna tracks in the sediment indicates that mobile fauna such as whelks and hermit crabs move throughout this site. A small number of sponges were observed at some sites, some of which may have been tunicates; however, an accurate identification was not possible.

Sea pens (likely *Virgularia* sp.) (image H, **Figure 10**) were observed in very low numbers (17 in the ten video tows) at Well H compared to the median of all 11 sites (35) (**Table 6**). Sea pens were observed to be more numerous at the Northern AOI, variable at the Southern AOI, and lowest in the Central AOI.

Mobile fish species were also observed in moderate numbers (26 fish across all Well H tows) compared to the overall median of all 11 sites (28) (**Table 6**). Species observed include sand eels[1], dogfish (*Squalus acanthias*.*)* (image A, **Figure 10**) and flatfish (likely *Peltorhamphus* sp.). A number of smaller fish were observed swimming off very quickly as the camera approached, so it was not possible to make a positive identification. Fish were observed to be much more numerous at the Northern AOI sites, moderate at the Southern AOI sites, and moderate to low in numbers around the Central AOI sites.

[1] This fish was unable to be formally identified, thus while the term 'sand eel' is used throughout this report it should not be considered a common name for this unidentified fish species.

Figure 10 Representative Images of Seabed Environment around Well H



3.3 Macrofauna Characteristics

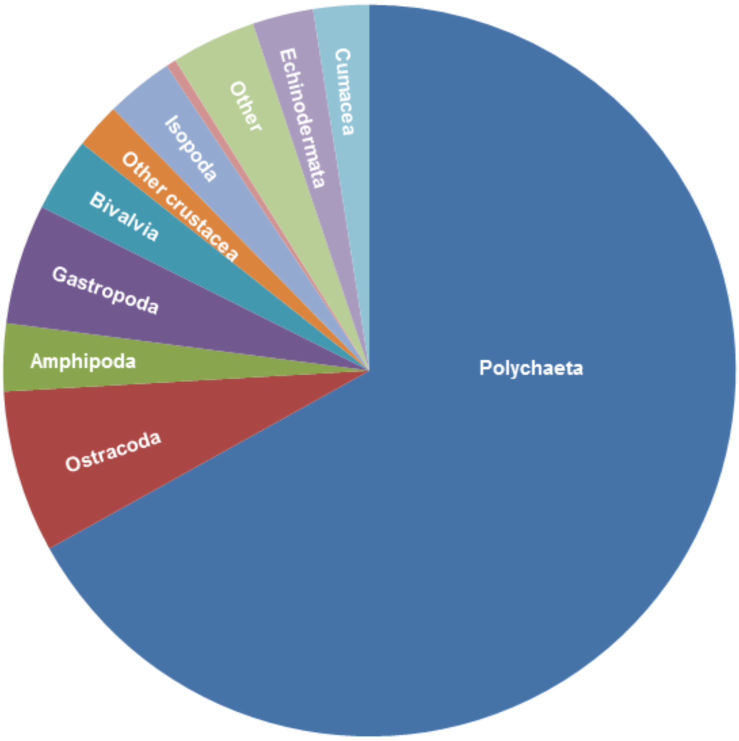
3.3.1 Benthic Macrofauna

Overall 1,339 individuals representing 103 taxa were identified in the 15 macrofauna samples collected around Well H. Infauna communities were dominated by small polychaete worms (896 individuals (67%), 34 taxa), crustaceans (236 individuals (18%), 26 taxa, mostly Ostracoda, Amphipoda and Isopoda), and molluscs (121 individuals (9%), 28 taxa, mostly Gastropoda and Bivalvia) (**Figure 11** and **Figure 12**). A single hag fish was identified within sample H8; the only observation of this animal throughout the Benthic Baseline survey. The raw macroinvertebrate data from Well H monitoring stations is provided in **Appendix D**.

When the benthic macrofauna results are compared across the three AOIs, polychaetes and gastropods were found in lower numbers in the Southern and Northern AOI compared to the Central AOI. Crustaceans (Tanaidacea and copepods) and nematodes were found in higher numbers in the Northern AOI wells compared with Central and Southern AOI (**Appendix E**). This result is likely linked to the differences in sediment composition, where a coarser grain size was present in the Northern AOI compared to the Central and Southern AOIs.

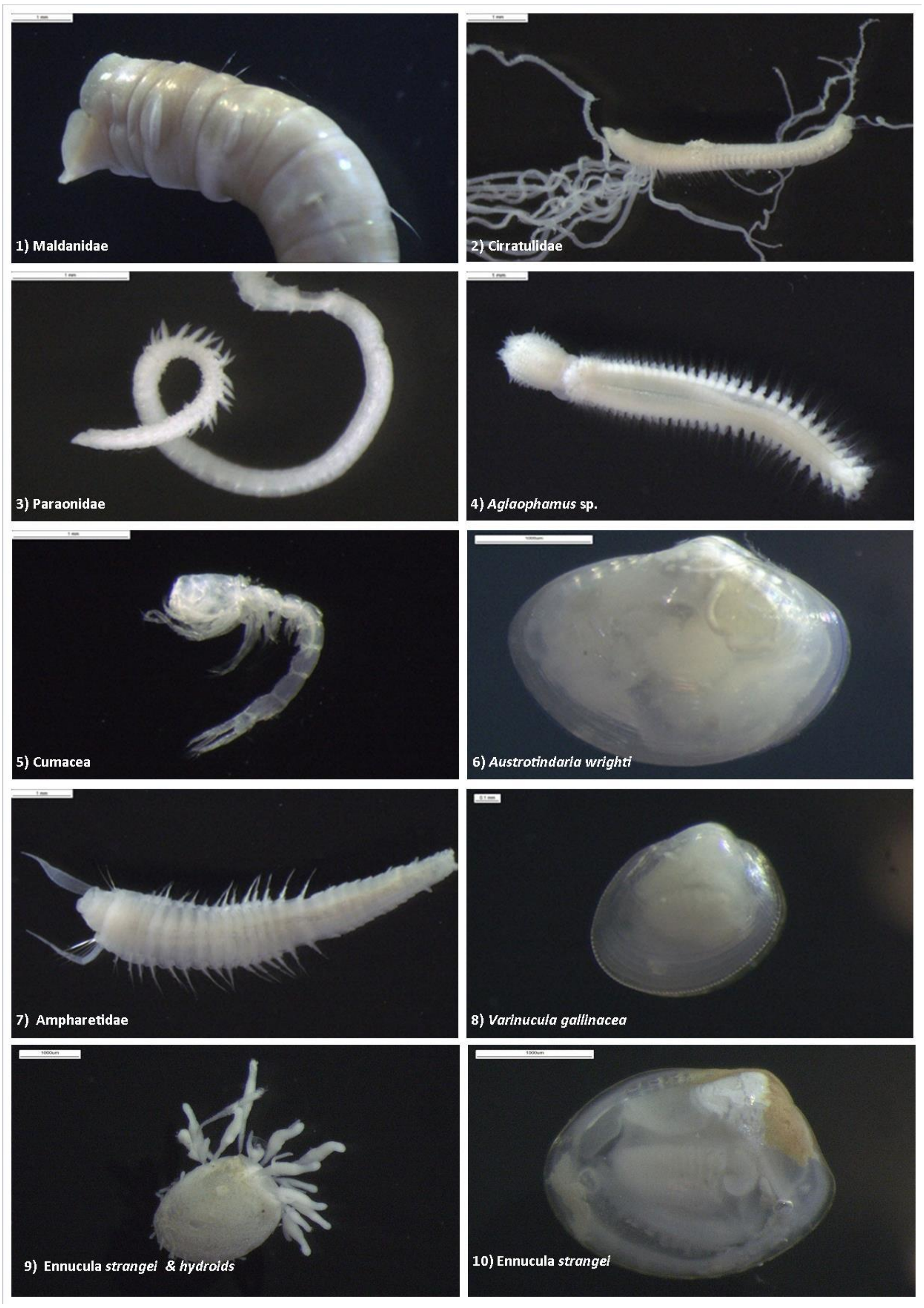
The infauna communities at Well H were similar to those found during pre- and post-drill monitoring at the Oi well south of Well H and those found during ongoing monitoring in the nearby Tui field.

Figure 11 Proportion of Individuals at Well H Belonging to each Taxonomic Group



'Other Crustacea' includes Decapoda, Copepoda, Euphausiacea, and Tanaidacea. 'Other molluscs' includes Caudofoveta, and Scaphopoda. 'Other' includes Chaetognatha, Nematoda, Nermetea, Oligochaeta, Sipuncula, Chordata, Hemichordata, Tunicata and Cnidaria.

Figure 12 Representative Images of Benthic Infauna Taxa Frequently Observed in Offshore Taranaki Area



3.3.2 Univariate Indices of Infauna Communities

Univariate indices (total number of taxa, total abundance, Pielou's evenness and Shannon-Wiener diversity) describing the benthic macroinvertebrate communities found at Well H are displayed in **Table 7**.

The number of taxa identified in each sample varied from 18 to 42 (mean 31) (**Table 7**). Total abundances ranged widely across the site (between 41 and 134 individuals per grab, mean 89). There were no consistent spatial patterns in the number of taxa or total abundance across the Well H monitoring stations. Taxa numbers at Well H were similar to the overall mean abundance for the Central AOI sites (mean of 29 taxa), although total abundances were slightly higher within Well H samples compared to the overall mean for the Central AOI sites (69 individuals). The number of taxa and abundances were notably lower in the Central AOI sites than those of the Northern AOI and Well L in the Southern AOI. (**Table 7**)

Evenness values vary on a scale between zero and one, with values near one indicating that infauna abundances are evenly distributed across all the different taxa present, while values near zero indicate infauna communities are being numerically dominated by a large number of individuals from just a few, or even only single taxa. Values from the Benthic Baseline data collected at Well H were relatively high (mean 0.85), indicating relatively even distribution of abundances across the taxa that were present.

Shannon-Wiener diversity index values range between 0 and 4 with higher values indicating higher species diversity. From previous benthic studies in the offshore Taranaki region, species diversity values are normally between 1.5 and 3.5. The mean Shannon-Weiner diversity index for Well H was 2.9 (range 2.4-3.2) which was the same as the most recent results from long term benthic monitoring programmes at the Maari Field in the Southern AOI (mean of 2.9).

Figure 13 Total Number of Taxa, Total Abundance, Pielou's Evenness and Shannon Wiener Diversity Index Values for Macrofauna Samples Collected at Well H

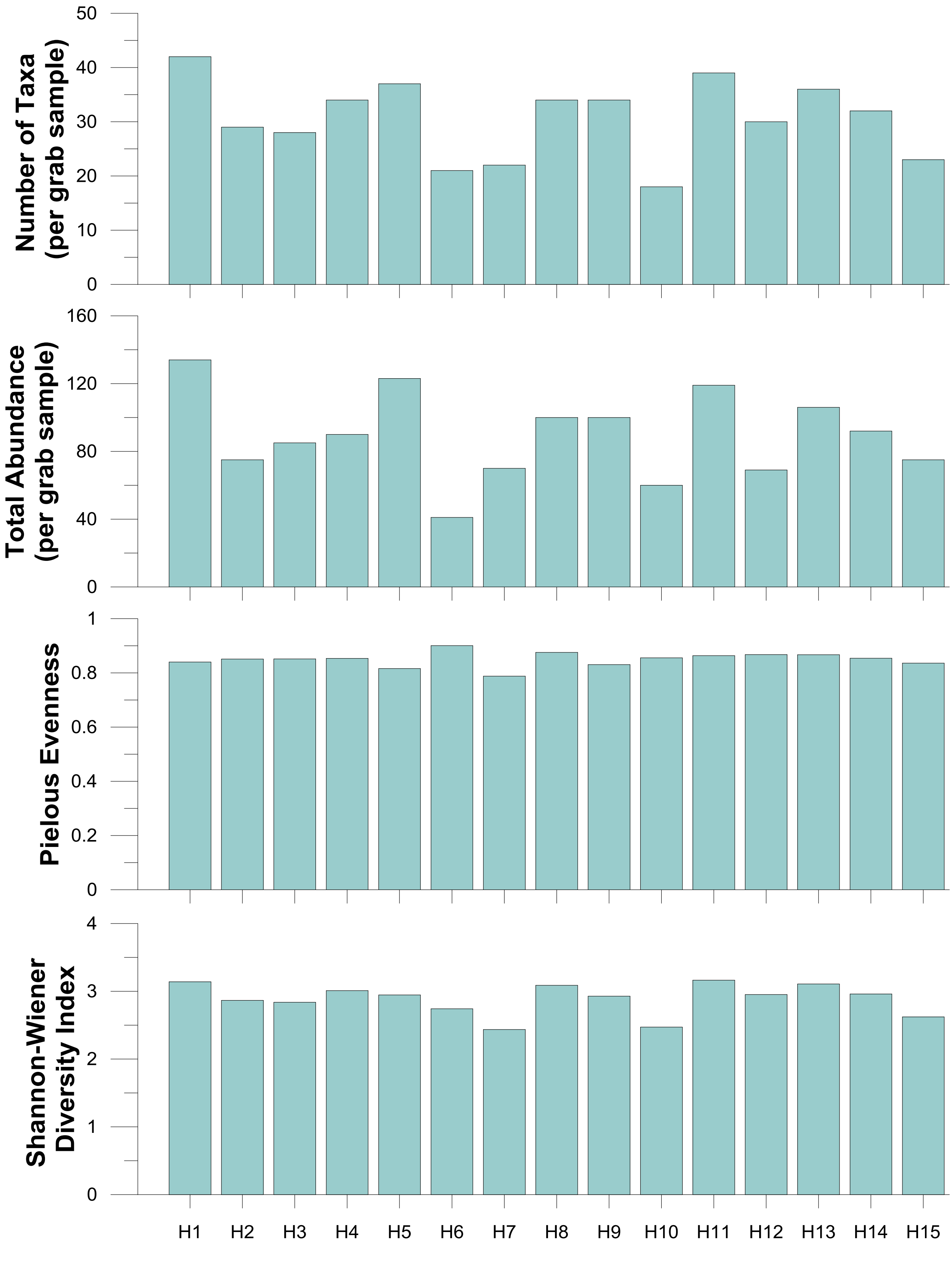


Table 7 Number of Taxa and Total Abundance for the Eleven Wells

Site	Mean Number of Taxa	Mean Abundance	Total Number of Taxa Identified at site	Total number of individuals (abundance)
A	56	257	140	3,849
B	53	210	130	3,151
C	45	132	128	1,987
D	60	332	142	4,986
Northern AOI	53	233		
E	19	36	78	542
F	31	68	90	1,023
G	33	81	112	1,215
H	**31**	**89**	**103**	**1,339**
I	29	72	91	1,075
Central AOI	29	69		
J	40	115	108	1,722
L	54	190	131	2,853
Southern AOI	47	153		

3.4 Sensitive Environments

In an investigation of sensitive substrate/benthic habitats in the Taranaki Coastal Marine Area, Johnston (2016) studied marine taxa databases from marine benthic surveys conducted in the offshore Taranaki Basin and noted that there are many locations where at least one ‘characteristic species of sensitive environments’ was found. This investigation used the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activities Regulations**) sensitive environments descriptions to define what sensitive habitats may be present.

Chaetopteridae worms and sea pens were noted by Johnston (2016) as likely to be present in areas close to the 11 wells. In relation to the sampling techniques used in the Benthic Baseline survey (i.e. grab sampling and video sled imagery), MacDiarmid *et al*. (2013) define that;

“A sensitive Chaetopteridae worm field is present if worm tubes and/or epifaunal species:

- Occupy 25% or more of the seabed in imaging surveys covering and area of 500 m^2 or more; or
- Occur in two successive samples collected using point sampling gear.”

and

“A sea pen field exists if:

- One or more specimens of any species of sea pen is found in two successive samples collected using point sampling gear, or
- Two or more specimens per m^2 are found in seabed imaging surveys, or surveys using towed gear.”

Analysis of the infauna samples collected during the Benthic Baseline survey found that Chaetopteridae worms (specifically *Phyllochaetopterus* socialis, commonly known as wire-weed or Tarakihi weed) were present within samples from Wells A, B, C, D, G, H, J and L. In high densities this species can for worm-fields or low-relief worm-meadows. The majority of wells had only single individuals at a small number of the sampling stations at each well, with Well H having only a single individual in sample H2. Across the ten video sled tows performed there were no distinct worm-fields or low-relief worm-meadows observed. Thus while this sensitive environment species was present at Well H the distributions appeared more as "isolated individuals within mixed epifaunal assemblages" at two stations rather than "dense mono-specific meadows at the tens of kilometres scale" (MacDiarmid *et al*., 2013).

A single individual sea pen (*Virgularia gracillima*) was identified in two infauna samples from Well H; within monitoring sample H8 and H12. Video imagery collected at Well H observed sea pens in relatively low abundances (17 within all ten video tows). Due to video sled tows being only a semi-quantitative survey method it is not possible to make exact predictions on the densities of sea pens encountered. However, as a conservative estimate the width of the camera's field of view could be estimated at 1 m, and each video sled covered 200 m across the seafloor, giving an approximate area of 2000 m^2 viewed by the imagery. Given this area and the low numbers of sea pens observed (compared to Wells D (160 individual sea pens) and L (132 individual sea pens)) sea pen densities at Well H would not have surpassed the Permitted Activities Regulations trigger value of two sea pens per square meter (MacDiarmid *et al*., 2013). Video tows were not found to pass through more spatially limited areas of higher density that might have been classed as 'sea pen fields'.

Based on the video sled analysis there were no 'Sensitive Environments', as defined by the Permitted Activities Regulations, encountered at the monitoring stations at Well H.

4 Key Findings

4.1 Sediment Characteristics

Sediments sampled around Well H were sandy muds comprised mainly of silt/clay grain size fractions. These sediments were similar to the other sites sampled in the Central AOI, and notably finer/muddier than sites in the Northern AOI. TOC levels at Well H (mean 0.57%) were also similar to the wider Central AOI, which are all distinctly higher than sites within the Northern AOI. Grain size showed a slight east to west pattern of increasing silt/clay fractions and variations in silt/clay content mirrored the small variations in TOC. Sediments with a finer grain size will retain higher levels of organic matter compared to coarser/sandier sediments subjected to the same level of enrichment/deposition, due to the greater surface area of finer particles for adsorption.

4.2 Faunal Characteristics

The video sled imagery captured across Well H showed a relatively flat seabed, interrupted by mounds/hollows and pock-marked with bioturbation in the form of animal burrows. Whelks, tusk shells and sponges were observed during the tows, while hermit crab and whelk tracks on the seabed indicate the presence of these mobile species. Mobile fish were observed in moderate numbers around Well H compared to other sites within the Central AOI (with the exception of Well G which also had a count of 26 fish).

Infauna communities in Well H samples were similar to those of the other Central AOI sites, and were dominated by small polychaete worms, crustaceans (ostracods, amphipods, and isopods), and molluscs (gastropods and small bivalves). A single hagfish was also recorded in a sample from Well H; the only recording of this species throughout the Benthic Baseline surveys. Central AOI infauna communities had the greatest proportions of polychaetes and gastropods, but the lowest proportions of crustaceans like amphipods and tanaidaceans, reflecting the muddier sediments in the Central AOI which are more suited to deposit feeding/scavenging taxa like many polychaetes and gastropods.

The mean number of taxa found in Well H samples was similar to the overall mean value for the Central AOI. Total abundance, however, was slightly higher in Well H samples when compared to the mean for the Central AOI. Number of taxa and abundance values in Well H samples, and the wider Central AOI, are notably lower than those in the Northern and Central AOIs.

The finer sediments present at Well H, and at Central AOI sites, compared to coarser sandy sediments of the Northern AOI, are likely linked to the greater proportions of taxa such as polychaetes and gastropods. Taxa found at Well H that were within these groups were largely scavengers/detritivores and/or deposit feeders which feed on larger dead materials on/in the sediment, as well as organic matter within the sediments. This feeding mechanism is more suited to muddy sediments where there is comparatively greater proportions of organic matter for given volumes of sediment, compared to coarser sediments such as sands.

Taxa more adapted for filter feeding (e.g. copepods, Tanaidacea, and amphipods) have delicate feeding and breathing structures. Coarser sediments contain less of the very fine clay particles which can clog or damage the delicate feeding and breathing structures of taxa adapted as filter feeders, particularly when such fine sediments are present in the water column for extended periods, and/or repeatedly re-suspended. Thus, taxa utilising this feeding strategy are often more abundant in areas with coarser sediments. Sediments with larger particle sizes, and greater mix of particle sizes, particularly larger sands, gravels, shell hash, etc., begin to provide more three-dimensional, cryptic habitats, allowing a wider variety of taxa to find different suitable habitats than mud-dominated sediments.

4.3 Sensitive Environments

Some individuals representing '*characteristic species of sensitive environments*' were found within the macrofauna grab samples (e.g. Chaetopteridae worms) and observed in video tows (e.g. sea pens) during the Benthic Baseline survey at Well H. However, observations from the video imagery indicated that no 'Sensitive Environments', as defined by the Permitted Activities Regulations (using MacDiarmid *et al.*, 2013) (i.e. fields) were encountered at the monitoring stations surveyed at Well H in 2018.

5 References

Clarke K, 1993, "*Non-parametric multivariate analyses of changes in community structure*", Australian Journal of Ecology 18 (1): 117-143.

Clarke KR, Warwick RM, 1994, "*Change in marine communities: An approach to statistical analysis and interpretation*", Plymouth Marine Laboratory, UK.

Clarke KR, Gorley RN, 2006, "*PRIMER v6: User Manual/Tutorial*". PRIMER-E, Plymouth.

Folk, 1954. *"The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature",* The Journal of Geology 62(4):344-359.

Hedges JI, Keil RG, Cowie GL, 1993, "Sedimentary diagenesis: organic perspectives with inorganic overlays", Chemical Geology 107: 487-492.

Johnston, O., 2016. '*Sensitive habitats and threatened species in the Taranaki Coastal Marine Area (TCMA) – database investigation*'. Cawthron Report No: 2877, 28pp.

Johnston O, Barter P, Ellis J, Elvines D, 2014, "Recommendations for an Offshore Taranaki Environmental Monitoring Protocol: Drilling- and production-related discharges, Version 1.0" (OTEMP), Cawthron Report No. 2124.

MacDiarmid, A., Bowden, D., Cummings, V., Morrison, M., Jones, E., Kelly, M., Neil, H., Nelson, W., Rowden, A., 2013. '*Sensitive marine benthic habitats defined*'. Prepared for Ministry for the Environment, NIWA Client Report No: WLG2013-18.

SLR, 2017, "*Benthic Ecological Survey for the Maui Platform Alpha. Annual Production Monitoring – April 2017*", prepared for Shell Todd Oil Services Limited, SLR Report Number 740.10041.00300-R01--v0.1

APPENDIX A

Locations and Observations from Sediment Grab Sampling and Video Sled during the 2018 Benthic Baseline Survey

Station	Date	Time	Depth (m)	Coordinates (NZTM)		Notes
				Easting	Northing	
Grab Sample Sites						
HG 1	3/4/18	1655	123	1629366	5659862	Light grey cohesive mud
HG 2	3/4/18	1556	123	1627367	5659868	Light grey cohesive mud. 1 missed grab
HG 3	3/4/18	1500	123	1625365	5659871	Light grey cohesive mud. Harder deeper in core
HG 4	3/4/18	1450	123	1624367	5659874	Light grey cohesive mud
HG 5	3/4/18	1442	123	1623366	5659874	Light grey cohesive mud
HG 6	3/4/18	1355	123	1622367	5659874	Light grey cohesive mud
HG 7	3/4/18	1604	123	1621366	5659868	Light grey cohesive mud. Softer than previous
HG 8	3/4/18	1617	123	1626376	5661873	Light grey cohesive mud. **Caught and preserved hag fish**
HG 9	3/4/18	1607	123	1626378	5660872	Light grey cohesive mud
HG10	3/4/18	1538	123	1626381	5658877	Light grey cohesive mud. 2 missed grabs
HG11	3/4/18	1514	123	1626376	5657864	Light grey cohesive mud. Very full grab.
HG12	3/4/18	1336	123	1623368	5661873	Light grey cohesive mud
HG13	3/4/18	1344	123	1623368	5660876	Light brown cohesive mud
HG14	3/4/18	1432	123	1623366	5658873	Light grey cohesive mud. Softer
HG15	3/4/18	1422	123	1623367	5657873	Light grey cohesive mud
Video Sled Tow Locations						
HV 1	3/4/18	0938	121	1628375	5661379	
HV 2	3/4/18	0956	121	1628372	5659878	
HV 3	3/4/18	1016	121	1628376	5658376	
HV 4	3/4/18	1356	124	1624867	5661378	
HV 5	3/4/18	1332	123	1624367	5659874	
HV 6	3/4/18	1049	122	1624873	5658370	
HV 7	3/4/18	1242	123	1623366	5659874	
HV 8	3/4/18	1218	125	1622370	5661371	
HV 9	3/4/18	1154	124	1621866	5659870	
HV10	3/4/18	1128	123	1622372	5658372	

APPENDIX B

Sediment Core Profile Images from all Grab Samples Collected during the 2018 Benthic Baseline Survey at Well H


H1.JPG


H10.JPG


H11.JPG


H12.JPG


H13.JPG


H14.JPG


H15.JPG


H2.JPG


H3.JPG


H4.JPG


H5.JPG


H6.JPG


H7.JPG

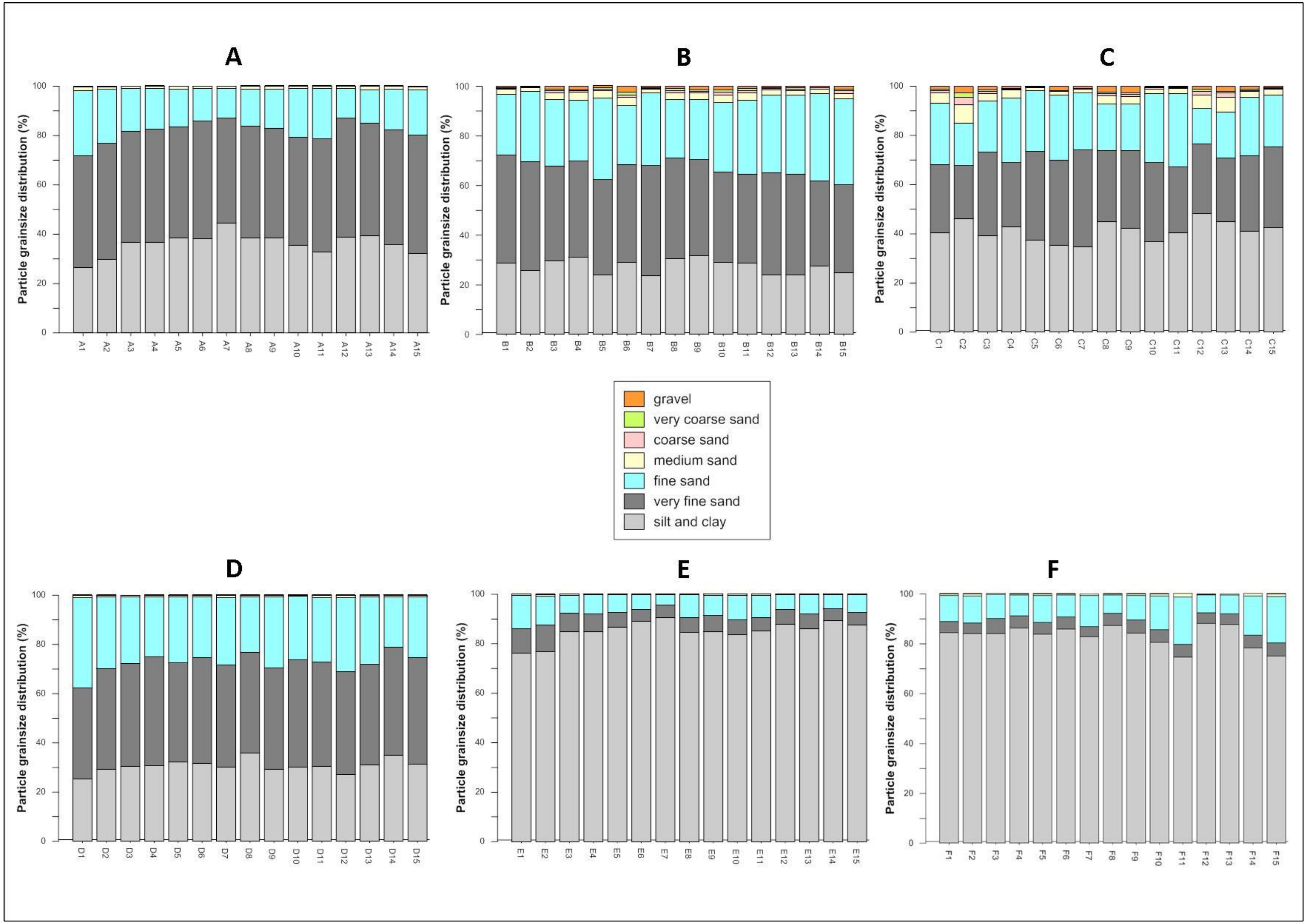

H8.JPG

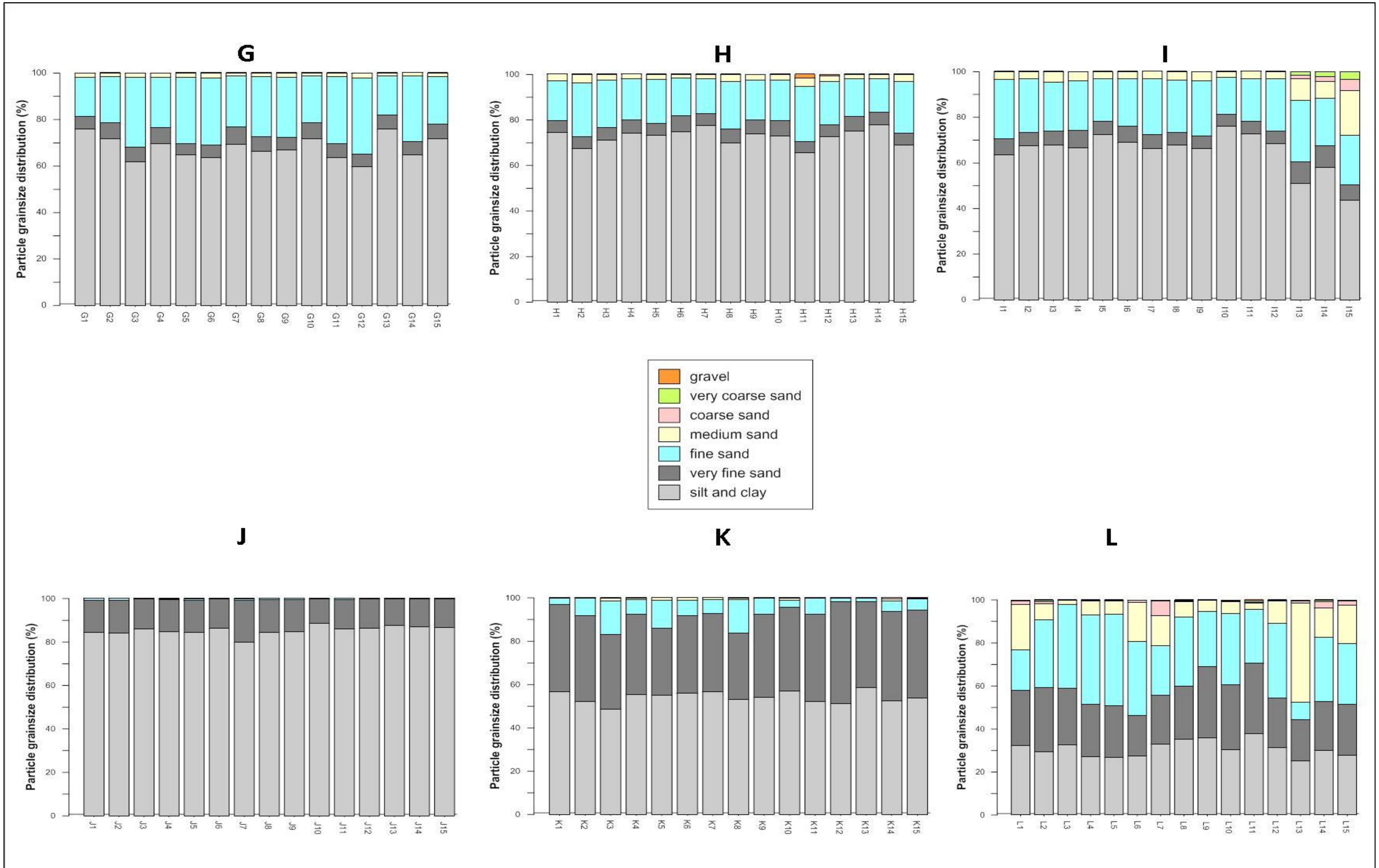

H9.JPG

APPENDIX C

Total Organic Carbon Content and Particle Grain Size Distribution for Well H

Replicate Sample	TOC (%)	Gravel (%)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Silt & Clay (Mud) (%)
Station H1	0.57	0.05	0.05	0.05	2.8	17.5	5.3	74.5
Station H2	0.5	0.05	0.05	0.05	3.6	23.8	5.3	67.3
Station H3	0.53	0.05	0.05	0.05	2.5	20.9	5.4	71.2
Station H4	0.61	0.05	0.05	0.05	2	18.2	5.7	74.2
Station H5	0.57	0.05	0.05	0.05	2.2	19.2	5.5	73.1
Station H6	0.6	0.05	0.05	0.05	1.5	16.8	6.9	74.8
Station H7	0.66	0.05	0.05	0.05	1.8	15.4	5.3	77.5
Station H8	0.56	0.05	0.05	0.05	3.1	21	6	69.9
Station H9	0.61	0.05	0.05	0.05	2.5	17.4	6.2	73.8
Station H10	0.62	0.05	0.05	0.05	2.4	17.8	7	72.8
Station H11	0.51	1.6	0.05	0.05	3.6	24.3	5	65.5
Station H12	0.54	0.7	0.05	0.05	2.3	19	5.3	72.6
Station H13	0.59	0.05	0.05	0.05	1.8	16.6	6.4	75.2
Station H14	0.63	0.05	0.05	0.05	1.9	14.6	5.8	77.7
Station H15	0.52	0.05	0.05	0.05	3.2	22.5	5.4	68.9


A
B
C
D
E
F
Particle grainsize distribution (%)
0
20
40
60
80
100
A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15
B1 B2 B3 B4 B5 B6 B7 B8 B9 B10 B11 B12 B13 B14 B15
C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12 C13 C14 C15
D1 D2 D3 D4 D5 D6 D7 D8 D9 D10 D11 D12 D13 D14 D15
E1 E2 E3 E4 E5 E6 E7 E8 E9 E10 E11 E12 E13 E14 E15
F1 F2 F3 F4 F5 F6 F7 F8 F9 F10 F11 F12 F13 F14 F15
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay


G
H
I
J
K
L
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay

APPENDIX D

Raw Counts of Macroinvertebrate (Infauna and Epifauna) Abundance at Well H

Taxa	Class/Order	Phylum	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15
Aglaophamus sp.	Polychaeta		7	6	11	1	5	1	4	5	6	4	6	4	4	6	6
Alcithoe cf. fusus	Gastropoda	Mollusca												1			
Amalda cf. novaezelandiae	Gastropoda	Mollusca								1							
Ampharetidae	Polychaeta		3	10	3	5	8	2	5	5	3	4	10	4	12	8	2
Amphipoda	Amphipoda	Crustacea	3	1	1	2	2	1	1	3	1	2	5		3	3	
Antalis glaucarena	Scaphopoda	Mollusca									1						
Anthuridae	Isopoda	Crustacea	1														
Arachnanthus sp.	Anthozoa	Cnidaria								1			1				
Aricidea sp.	Polychaeta		1				1						1		1	1	
Armandia maculata	Polychaeta					1	1	1	1		2						
Armandia maculata (juvenile)	Polychaeta		2							1							1
Artacamella sp.	Polychaeta				1												
Asellota	Isopoda	Crustacea	1	1	2		2	2	1	3	1	1	4	1	3	2	5
Astromitra sp.	Gastropoda	Mollusca	1														
Aplacophora		Mollusca					1								1		
Austrofusus glans	Gastropoda	Mollusca					1			1	1			1			
Axiopsis sp.	Decapoda	Crustacea	1							1	2				1		
Bivalvia (inderterminate)	Bivalvia	Mollusca				1			1								
Bradleya opima	Ostracoda	Crustacea	3		2	1					3	2	3	1	2		
Cadulus teliger	Scaphopoda	Mollusca					1				1	1					
Capitellethus zeylanicus	Polychaeta		1	1	3	2	1		3	3	4	5	4	1	1	1	2
Chaetognatha	Chaetognatha								1								
Cirratulidae	Polychaeta		18	11	9	9	28	8	9	12	14	10	17	8	7	11	9
Clavelina claviformis	Tunicata												1				
Copepoda	Copepoda	Crustacea		1		1											

Taxa	Class/Order	Phylum	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15
Cumacea	Cumacea	Crustacea	4	2	1	5	4	1	1		7		1		3	1	3
Curveulima aupouria	Gastropoda	Mollusca	1				2						1	1	1		
Cuspidaria wellamni	Bivalvia	Mollusca													1		
Cyclostrematidae	Gastropoda	Mollusca				1	1					1	2			1	
Cymbicopia hispida	Ostracoda	Crustacea								1							
Cypridinodes reticulata	Ostracoda	Crustacea				1											
Cytherella sp.	Ostracoda	Crustacea							1						1	1	
Ebalia laevis (juvenile)	Decapoda	Crustacea													1		
Edwardsia sp.	Anthozoa	Cnidaria			2												
Ennucula strangei	Bivalvia	Mollusca	1								1						
Euchone pallida	Polychaeta						1										1
Euphausiacea	Euphausiacea	Crustacea		1		1											
Euphilomedes agilis	Ostracoda	Crustacea	2	2	1	4	7	1		2	3	2	3	1	4	5	
Flabelligeridae	Polychaeta		2	1	2		2				1		1		2		1
Gnathiidae	Isopoda	Crustacea														1	1
Goniadidae	Polychaeta										1		1	1			
Haustoriidae	Amphipoda	Crustacea	1				1										
Hemichordata			1														
Hesionidae	Polychaeta		2							1		1					
Heteromalpadia marenzelli	Holothuroidea	Echinodermata		1													
Ischyroceridae	Isopoda	Crustacea											1				1
Leitoscoloplos kerguelensis	Polychaeta			1													
Limatula maoria	Bivalvia	Mollusca														1	
Lumbrineridae	Polychaeta		6		2	2	1		1	3	1		1		3	1	
Lysianassidae	Amphipoda	Crustacea		1			1			1			4				

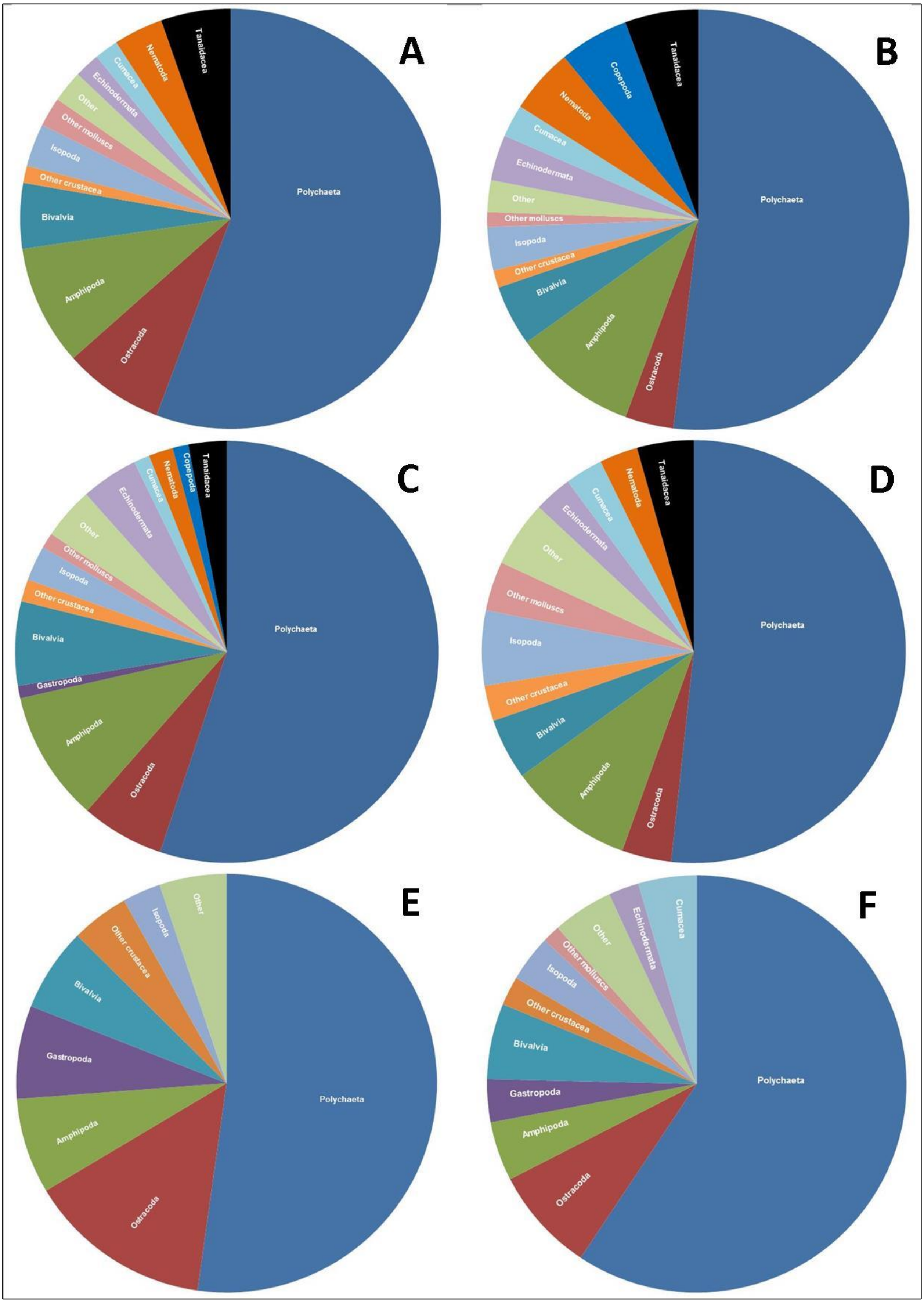
Taxa	Class/Order	Phylum	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15
Magelona dakini	Polychaeta					1											
Maldanidae	Polychaeta		11	13	17	21	13	4	21	8	13	9	9	14	15	15	17
Marphysa disjuncta	Polychaeta		2	2				1		2	1	2	2	1	2	2	
Melliteryx parva	Bivalvia	Mollusca				2											
Merelina sp.	Gastropoda	Mollusca															1
Mogula sp.	Tunicata				1				1				1		2	1	
Myriowenia sp.	Polychaeta					1		1									
Myxinidae	Chordata	Chordata								1							
Natatolana pellucida	Isopoda	Crustacea											1	2			
Naticidae	Gastropoda	Mollusca	1									1		1		1	
Neilonella wrighti	Bivalvia	Mollusca	2	1		1	1				1			1			
Neilonella wrighti (juvenile)	Bivalvia	Mollusca	1				1						1		1		1
Nematoda	Nematoda		1	1	1		3	2		5	1	1	1	1	1	2	1
Nemertea	Nermetea		1				1				1					1	
Neonesidea sp.	Ostracoda	Crustacea	1	2	2	4		1			1		2	2	5		
Nucinella maoriana	Bivalvia	Mollusca			1				1		1		1				
Oligochaeta	Oligochaeta							1		1							
Onuphis aucklandensis	Polychaeta		4		2	2				4	1		1	1			2
Ophiuroidea	Echinodermata	Echinodermata	5	3	3	2	1	1	1	1	2		2	3	2	2	1
Ostracoda	Ostracoda	Crustacea												1			
Ostreidae (oyster spat)	Bivalvia	Mollusca													1		
Paramunna serrata	Isopoda	Crustacea	2	1													
Paraonidae	Polychaeta		26	1	9	6	13	6	10	10	18	12	16	7	14	11	11
Parasterope quadrata	Ostracoda	Crustacea								1							
Philine powelli	Gastropoda	Mollusca			1	1	1								1		

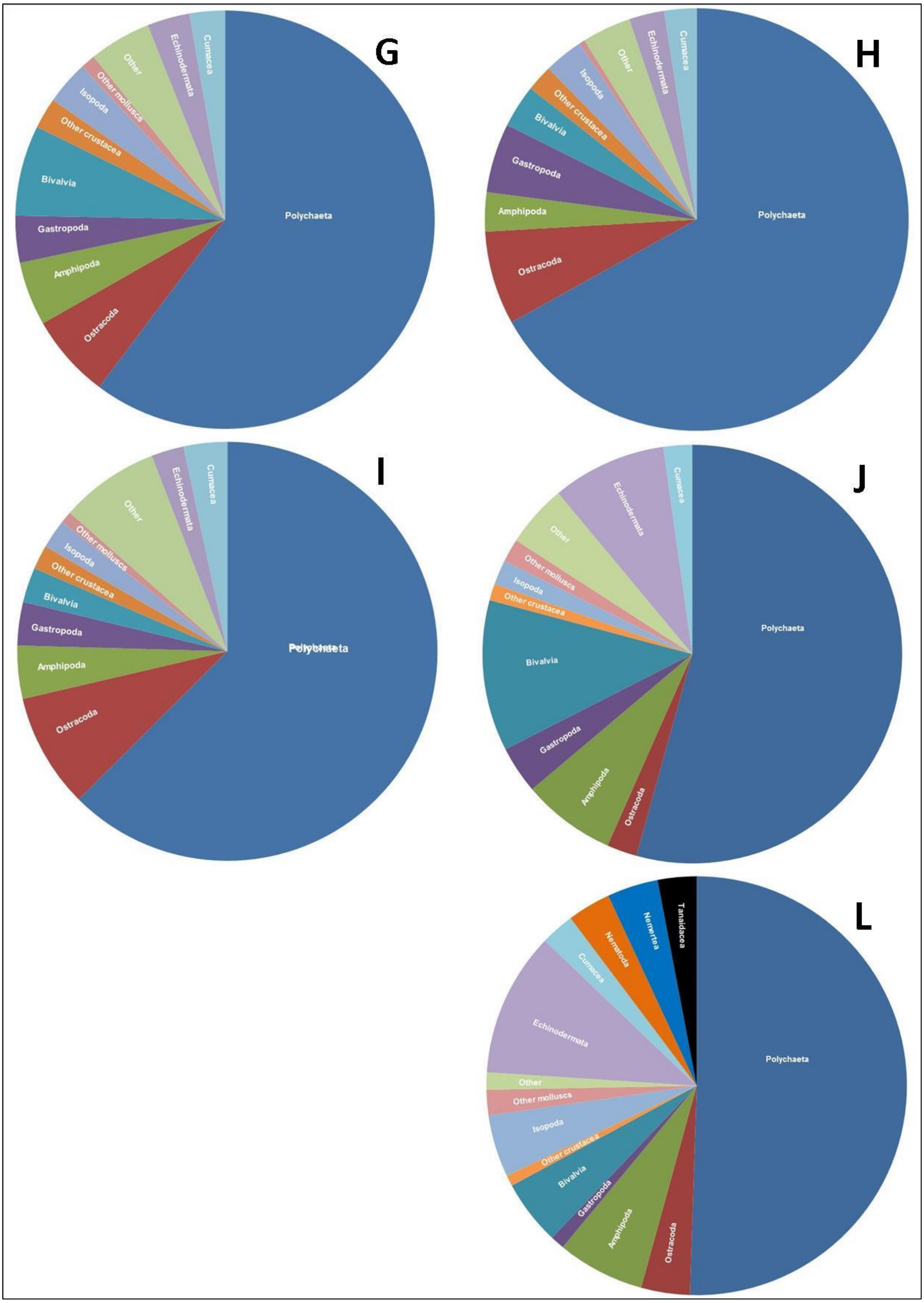
Taxa	Class/Order	Phylum	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15
Phoxocephalidae	Amphipoda	Crustacea						2			1						
Phyllochaetopterus socialis	Polychaeta			1													
Phylo novaezealandiae	Polychaeta				1												
Pilargidae	Polychaeta			1		1								1			
Polychaeta A	Polychaeta		1														
Polynoidae	Polychaeta				1	1											
Poroleda lanceolata	Bivalvia	Mollusca							1								
Pratulum pulchellum	Bivalvia	Mollusca	1										1			1	1
Prionospio multicristrata	Polychaeta																1
Prionospio sp.	Polychaeta							1						1			
Relichna aupouria	Gastropoda	Mollusca	2	3	2		6			1	1		2			1	3
Rissoidae	Gastropoda	Mollusca					1	1		13	1	1		2	1	1	
Rynkatopa uncinata	Holothuroidea	Echinodermata			2								1		2		1
Scalibregma inflatum	Polychaeta						2			1							
Sigalionidae	Polychaeta		1										1		1		
Spiophanes kryoeri	Polychaeta		3							1				1		1	
Spiophanes sp.	Polychaeta		3	1		2	3		3	1	1		1	2	3	1	
Syllidae	Polychaeta				1											1	
Tanaidacea	Tanaidacea	Crustacea		3	1	1	1		1	3		1		2		1	
Terebellidae	Polychaeta							1									
Terebellides stroemii	Polychaeta		1				1			1			3			2	3
Themiste sp.	Sipuncula		1	1		1		2			1		1				
Thyasira peregrina	Bivalvia	Mollusca				2	2								1		
Tornidae	Gastropoda	Mollusca								1							
Trachyleberis lytteltonensis	Ostracoda	Crustacea	2	1		1	1		1		2		3		1	3	

Taxa	Class/Order	Phylum	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15
Upogebia sp.	Decapoda	Crustacea				2									1		
Varinucula gallinacea	Bivalvia	Mollusca				1	1		1				2	1	1	2	
Virgularia gracillima	Anthozoa	Cnidaria								1				1			

APPENDIX E

Comparison of Proportion of Individuals belonging to each Taxonomic Group across all Wells


A
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Tanaidacea
B
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Copepoda
Tanaidacea
C
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other mollusca
Other
Echinodermata
Cumacea
Nematoda
Copepoda
Tanaidacea
D
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Tanaidacea
E
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other
F
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea


G
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
H
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other
Echinodermata
Cumacea
I
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
J
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
L
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Nemertea
Tanaidacea

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EXPLORATION AND APPRAISAL DRILLING PROGRAMME

Benthic Baseline Report
Well I

Prepared for:

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BASIS OF REPORT

This report has been prepared by SLR Consulting NZ Limited with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with OMV New Zealand Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR

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DOCUMENT CONTROL

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740.10078.00200-R01-v1.0	31 July 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier
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EXECUTIVE SUMMARY

OMV New Zealand Limited (**OMV New Zealand**) are applying for a Marine Consent to undertake an Exploration and Appraisal Drilling (**EAD**) Programme in the Taranaki Basin with an anticipated commencement date in 2019. OMV New Zealand may drill up to nine exploration wells and two appraisal wells within their Petroleum Exploration Permits (**PEP**). The intention of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs.

As part of the Marine Consent application, three Areas of Interest (**AOI**) have been identified that encapsulate the proposed well locations and are used as part of the Impact Assessment process. OMV New Zealand undertook a baseline environmental monitoring survey at each well location in March - April 2018 to gain an understanding of the benthic habitat and associated communities with each AOI.

Grab sampling and video sled methodologies were used to gain quantitative and qualitative information on the marine environments surrounding each well location. The data gathered from each baseline survey will be incorporated into the Marine Consent application and assist in the risk assessment process.

Water currents and deposition modelling were utilised to define the placement of sample stations. Sample transects were aligned along the dominant deposition pathway of the predicted drill cutting dispersion should that particular well be drilled. A total of 15 monitoring stations were allocated at each well and one benthic grab sample was collected at each monitoring station. Ten video sleds were also undertaken at a selection of pre-determined stations around each well location.

Within this Benthic Baseline report the analysis of results incorporates sediment physical and chemical properties, benthic macrofauna, epifauna and visual observations around Proposed Well I. Results of sediment analyses showed the well site to be composed of sandy muds, dominated by silt and clay, with moderate levels of Total Organic Carbon (**TOC**) (0.61%). Grain size distribution and TOC showed no distinct spatial patterns across the Well I monitoring stations, but varied similarly showing a relationship between silt and clay and TOC. Sediments and TOC levels were very similar to those found at the remaining Central AOI sites and Well J (in the Southern AOI).

The 15 infauna samples collected around Well I revealed 1,095 individuals representing 91 taxa. Infauna communities were dominated by small polychaetes (63%), crustaceans (20%, comprised of ostracods, amphipods and isopods) and molluscs (7%, comprised of gastropods and small bivalves). Central AOI infauna communities had the greatest proportions of polychaetes and gastropods, but the lowest proportions of crustaceans like amphipods and tanaidaceans, reflecting the muddier sediments in the Central AOI which are more suited to deposit feeding/scavenging taxa like many polychaetes and gastropods.

Video Imagery collected during the Benthic Baseline survey indicated the presence of sea pens; a taxa defined as '*characteristic species of sensitive environments*'. The occurrence and estimated densities of sea pens at Well I did not reach the trigger levels defined by the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (MacDiarmid *et al*., 2013) and no distinct sea pen 'fields' were encountered. Thus, although this 'characteristic species' was present at the well sites in low densities, it is considered that Well I does not classify as a 'sensitive environment'.

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1 Introduction

OMV New Zealand Limited (**OMV New Zealand**) is applying for a Marine Consent under Section 38 of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (**EEZ Act**) to permit activities associated with an Exploration and Appraisal Drilling (**EAD**) Programme proposed to be undertaken starting in 2019.

The EAD Programme includes the drilling of up to nine exploration wells and two appraisal wells within OMV New Zealand's permit areas (**Figure 1**). The purpose of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs which OMV New Zealand operate (**Figure 1**).

Three Areas of Interest (**AOI**) (summarised below) have been identified which encapsulate the well locations (**Figure 1**). This monitoring report relates to the Benthic Baseline survey conducted at Well I in the Central AOI. Location details and water depth of Well I are provided in **Table 1.**

The Northern AOI encompasses PEP 60092 (Ridgeline), PEP 57075 (Cloudy Bay) and PEP 60093 (Toutouwai) and includes the following wells:

- Well A;
- Well B;
- Well C; and
- Well D.

The Central AOI encompasses PEP 60093 (Toutouwai) and includes the following wells:

- Well E (Appraisal);
- Well F;
- Well G (Appraisal);
- Well H; and
- Well I.

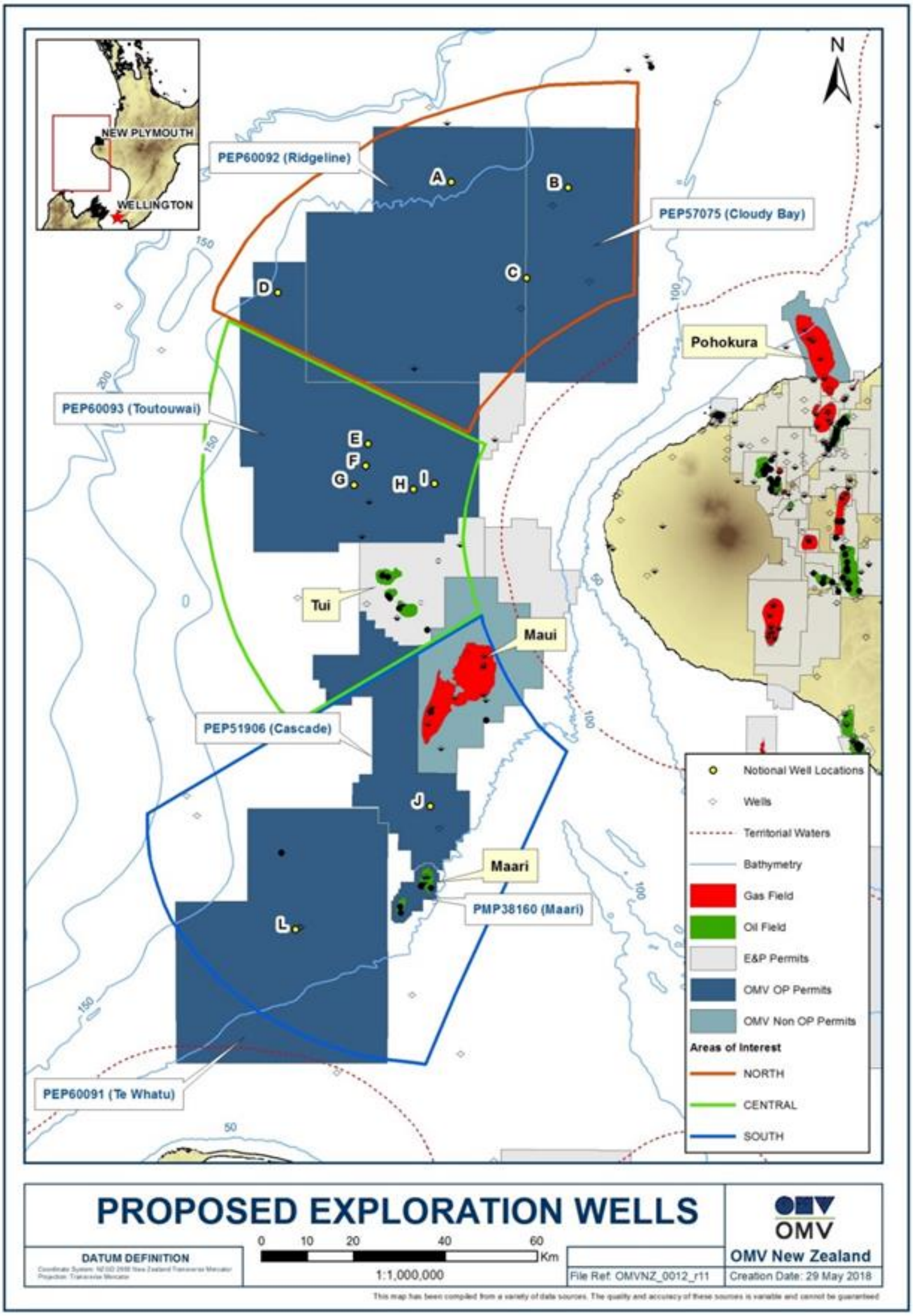
The Southern AOI encompasses PEP 51906 (Cascade), and PEP 60091 (Te Whatu) and includes the following wells:

- Well J; and
- Well L.

Table 1 Water Depth and Coordinates of Well I in the Central AOI

Well Name	Water Depth (m)	Easting (NZTM)	Northing (NZTM)
I	121.7	1627893	5661191

Figure 1 OMV New Zealand's EAD Well Locations and three AOIs in the Taranaki Basin



In February 2018 SLR Consulting NZ Limited (**SLR**) was engaged by OMV New Zealand to undertake a baseline assessment of the benthic ecology in the vicinity of eleven 11 wells (**Figure 1**). The aim of the field surveys, which were undertaken from March 24 – April 8 2018, was to collect relevant data using grab sampling and video sled methodologies to provide quantitative and qualitative information on these marine environments. This qualitative and quantitative data will be used within the Marine Consent application to define the benthic habitats and communities present at each well location and assist in the risk assessment process.

This report summarises the results of the Benthic Baseline survey undertaken at Well I.

1.1 Project Location

Well I is located approximately 65 km west of New Plymouth, in New Zealand's Exclusive Economic Zone (**EEZ**). Water depth and GPS coordinates are provided in **Table 1** and displayed in **Figure 2**. The monitoring programme sample design resulted in sample stations extending out to 6 km from the well location (**Section 2.1**).

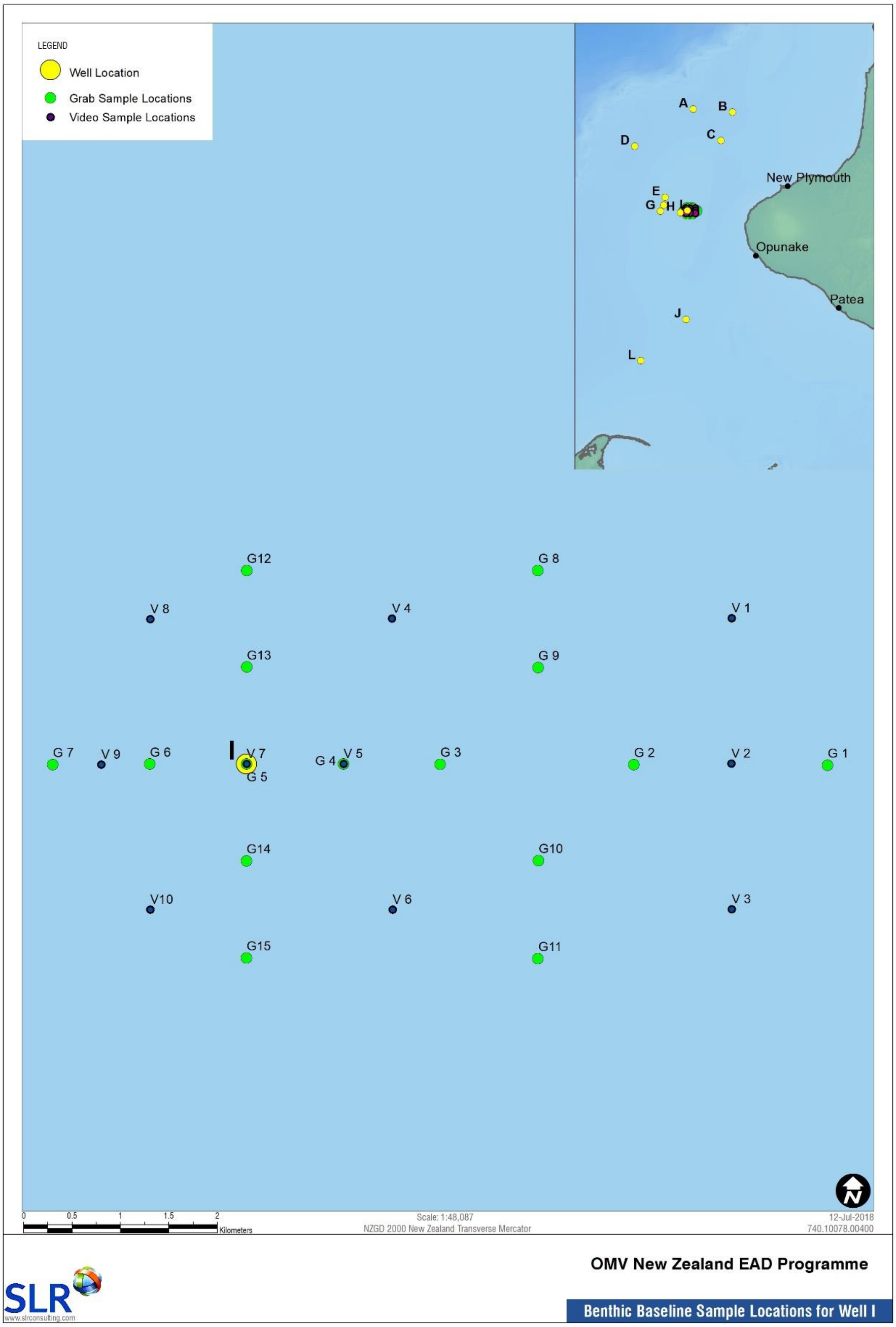
2 Methodology

The Benthic Baseline surveys adopted similar methodologies to what has been previously used for offshore Taranaki benthic monitoring programmes undertaken in accordance with the principles defined in the Offshore Taranaki Environmental Monitoring Protocol (**OTEMP**) (Johnston *et al.*, 2014). This consistent approach enables monitoring results to be compared with previous monitoring programmes undertaken in the offshore Taranaki environment (i.e. pre- and post-drill monitoring and production monitoring).

2.1 Sample Locations

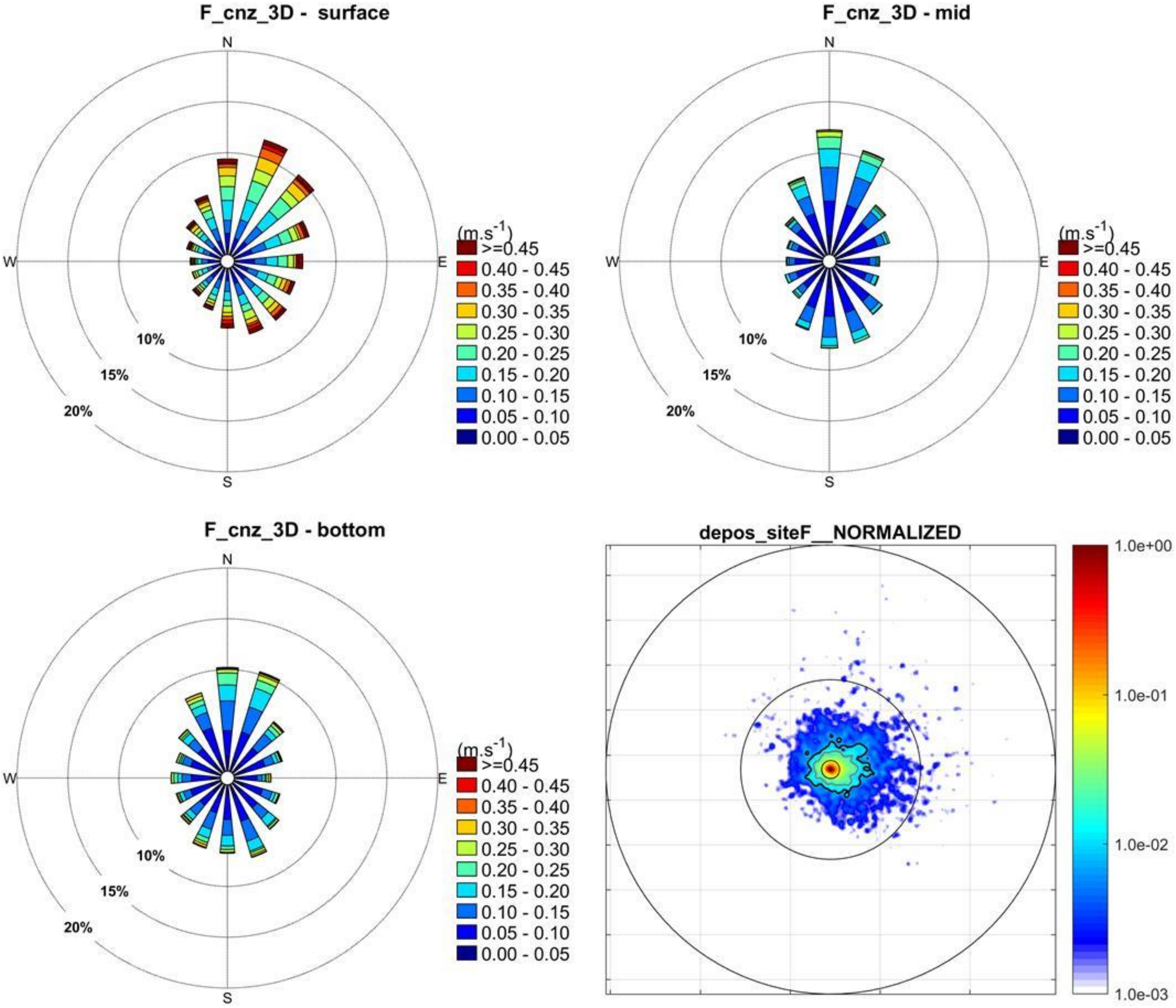
The sample locations (**Figure 2**) were defined by the dominant direction of current flow and preliminary drill cutting deposition modelling results (**Figure 2**). Sample transects were aligned along the dominant deposition pathway (i.e. southeast/northwest) (**Figure 3**) as this is the area determined to be most likely to be impacted from the deposition of drill cuttings should the well be drilled. However, sample stations were also located along the minor flow axis (northeast/southwest) to enable comparisons and validation of spatial differences based on the dispersal patterns predicted by MetOcean Solutions Limited.

Figure 2 Well I Sampling Locations



Note: At each video transect station, approximately 250 m of video footage was captured along the seabed in the direction of the vessels drift at the time of sampling.

Figure 3 Surface, Mid-water and Bottom Water Column Current Roses and Dispersal Modelling Plot created by Metocean Solutions Ltd for the nearby Well F



2.2 Field and Sampling Procedures

Field sampling was undertaken from the MV *Seaworker* between March 24 and April 8, 2018, following the procedures detailed below. Sampling at Well I took place on April 2nd, 3rd and 5th.

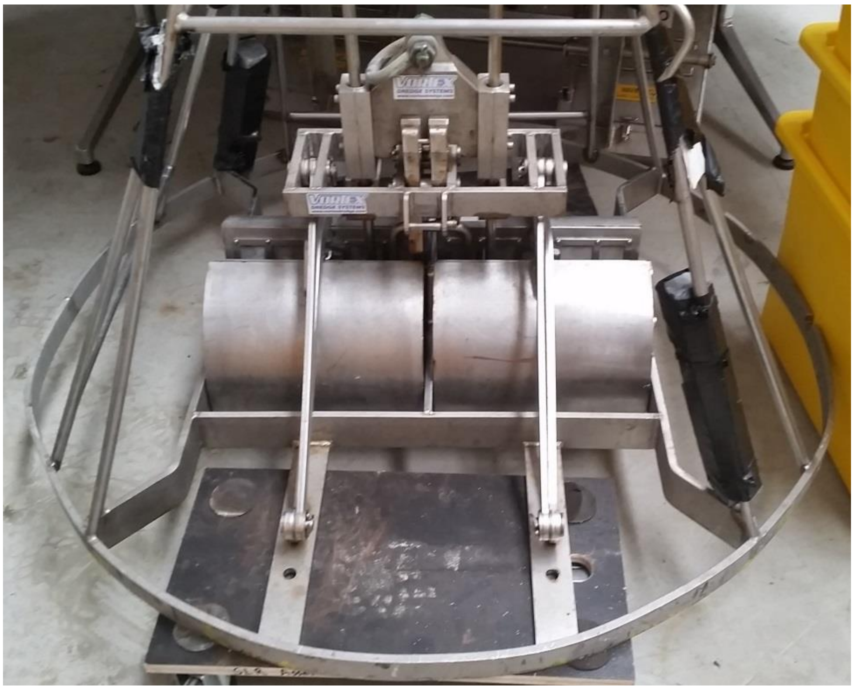
2.2.1 Benthic Grab Samples

A double Van Veen double grab sampler (**Figure 4**) was used to collect a single sediment grab sample at each of the 15 benthic monitoring stations surrounding Well I (**Figure 2**). The grab sampler is constructed of stainless steel and features two independent 'buckets' which penetrate the surficial sediments to a depth of 0.16 m. Each successful grab sample returns approximately 0.01 m^3 of seabed sediment back to the surface.

Upon arrival on the vessel deck, each grab sample is checked for completeness, which must meet the following criteria:

- The surface of the sediment is largely undisturbed upon inspection aboard the vessel;
- Sufficient sediment (≥75% of the grab capacity) is collected to enable the full suite of sediment analyses required;
- The infauna sample bucket is filled to the same volume (approximately 10 l) for all infauna replicates throughout the survey; and
- The grab has not been over-filled with sediments pushing out of the doors or drains, indicating that it may have over-penetrated the sediment.

Figure 4 The Double Van Veen Grab Sampler used for the 2018 Benthic Baseline Sampling



Each independent bucket from a grab sample is used separately for infauna and sediment physical and chemical analyses, as follows:

- Bucket one: infauna/macrofauna community analysis. The entire sample is sieved through 0.5 mm mesh until approximately 300-500 ml of residual sediment and organisms remains. This remaining material is transferred to a plastic container and preserved with a fixative (AncholTM), ready for analysis by SLR taxonomists.
- Bucket two: sediment physical nature and chemical analyses. Three 64 mm (internal diameter) clear Perspex sub-sampling cores are pushed into the sediments from the second bucket, to a depth of approximately 150 mm. Cores are photographed and the upper 50 mm from each core is extruded into a polyethylene bag for particle grain size distribution and organic content (Total Organic Carbon - **TOC**) analyses by Hill Laboratories.

2.2.2 Seafloor Video Imagery

Video imagery of the seafloor was obtained using a customised tow-sled fitted with high-intensity LED lighting and a high-definition video camera (**Figure 5**). The system was connected to the vessel via a 10 mm dyneema tow-line and a 300 m umbilical cable supplying real-time video images to the camera operator on the research vessel. A pair of parallel lasers on the video sled provided an indication of scale allowing features of interest in the video recordings to be approximately sized. Ten video sled tows were conducted around Well I (Figure 2).

The video-sled was launched from the vessel up-current of each pre-determined location and lowered to the seabed, where it auto-located via a series of floats and weights set at specific points on the sled frame, to land upright on its lower skids. At the point where the sled contacted the seabed, a GPS log was started, and this log continued throughout the duration of the tow. Video footage was continuously recorded for approximately 200 m as the sled drifted behind the vessel; this ensured that footage was collected while the sled was passing as close as possible to the required sample location.

Figure 5 The Video Sled used for Collecting Video Imagery of the Seabed Environment

2.3 Laboratory Analyses

2.3.1 Sediment Physicochemical Analyses

Benthic sediments collected by the grab were analysed by Hill Laboratories (an NZS/ISO/IEC 17025:2005 accredited laboratory), for both physical and chemical parameters. The aims of these analyses along with further details of the analytical method/descriptions are summarised in **Table 2**.

Table 2 Summary of Analytical Methods used for Testing Sediment Physico-chemical Characteristics

Analyte	Aim	Method Number	Description
Particle Grain Size Distribution	• Determine physical parameters of the sediment particles present at the site • Correlate with infauna community characteristics	Hill Laboratories KB32136	• Sediment was wet-sieved through the following screen sizes, as per the Udden-Wentworth scale (Wentworth, 1922): • >2 mm (gravel) • >1 mm (very coarse sand) • >500 µm (coarse sand) • >250 µm (medium sand) • >125 µm (fine sand) • >63 µm (very fine sand) • <63 µm (silt and clay)
Total Organic Carbon	• Determine current level of organic carbon in sediment • Correlate with infauna community characteristics	No specific method number	Acid pre-treatment to remove carbonates present, followed by catalytic combustion (900° C, O_2), separation, Thermal Conductivity Detector. Elemental Analyser.

2.3.2 Macrofauna Analyses

Macrofaunal analyses focused on the infauna, or animals larger than 0.5 mm living within the sediment matrix. Epifaunal animals (those living on top of the sediment), were also included in the analyses to provide representation of the different functional groups present at each sample station.

Benthic macrofaunal samples collected from the sediment grab were sorted and, with the aid of a binocular microscope, identified to the lowest practicable taxonomic level or most recognisable taxa (morphologically similar group). Counts were made to assess the relative abundance of each taxa.

2.3.3 Seafloor Video Analyses

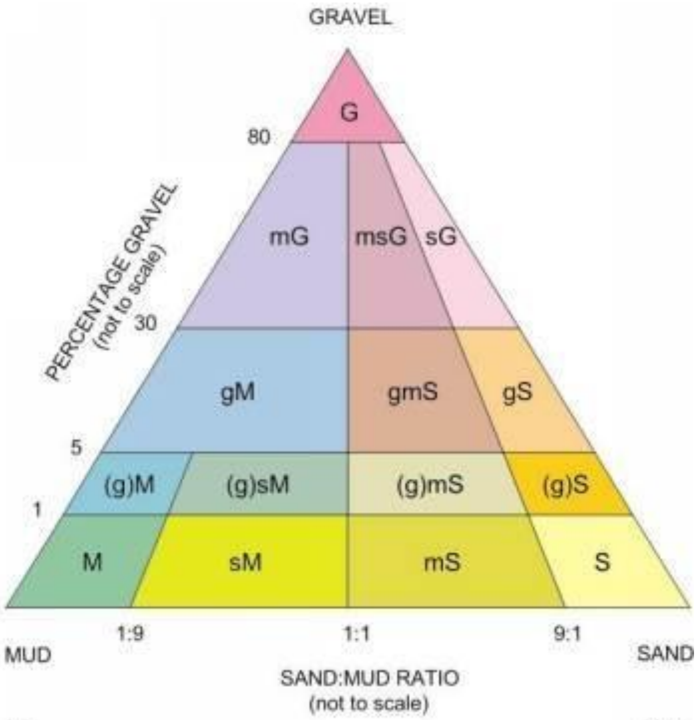
A live feed from the video-sled was captured and recorded on-board the survey vessel and viewed by SLR staff with experience in undertaking assessments of the benthic environment in the offshore Taranaki region. Brief field notes were made in real-time about obvious structures and organisms observed while watching the live footage. Back onshore the recorded seabed video footage was assessed on a large, high definition screen, by a suitably trained and experienced benthic scientist, who identified all obvious epifauna to the lowest practicable taxonomic level. Biogenic and/or anthropogenic seabed structures such as burrows, mounds, tracks and gouges/trenches were also recorded. Relative abundance estimates of epifauna or biogenic structures were made where appropriate.

2.4 Data Analyses

2.4.1 Sediment classifications

While there are many sediment classification schemes in use worldwide, a common one is a modified version of that proposed by Folk (1954). This scheme groups grains within a sample into mud, sand and gravel sized particles based on the particles diameter (mud <63 µm, sand 64-2000 µm, gravel > 2mm), and then describes the sediment type based on the relative proportions of the particles (see **Figure 6**).

Figure 6 Folk (1954) Sediment Type Classification Triangle



M	Mud
sM	Sandy mud
(g)M	Slightly gravelly mud
(g)sM	Slightly gravelly sandy mud
gM	Gravelly mud
S	Sand
mS	Muddy sand
(g)S	Slightly gravelly sand
(g)mS	Slightly gravelly muddy sand
gmS	Gravelly muddy sand
gS	Gravelly sand
G	Gravel
mG	Muddy gravel
msG	Muddy sandy gravel
sG	Sandy gravel

2.4.2 Community Characteristic Descriptors

All macrofauna (both epifauna and infauna) taxa were included in the analyses of abundance data. Species identified in the samples as not being exclusively benthic were excluded from further analyses. Data were analysed as per the statistical methods outlined below to identify current distributions and abundance of macrofauna.

2.4.2.1 Univariate Diversity Indices

Diversity indices (number of taxa S, total abundance N, Shannon-Wiener diversity H', and Pielou evenness J' (**Table 3**) were calculated from the macrofauna abundance data using the PRIMER software package (PRIMER v6.1.16; Clarke, 1993; Clarke & Warwick, 1994; Clarke & Gorley, 2006).

Table 3 Description of Macrofauna Community Characteristic Indices

Index	Formula (where applicable)	Description
Number of Taxa (S)	Count of total number of different taxa identified within the *x* sample	Total number of taxa identified within a sample
Total Abundance (N)	Sum of all individual taxa abundances within the *x* sample	Total number/count of all organisms within a sample
Shannon Diversity (H')	$H' = -SUM [(p_i) \times \log_e (p_i)]$ p_i = Number of individuals of taxa i /total number of samples	A single value (log scale) that is used to describe the different types and numbers of organisms present within an assemblage. The index value increases as assemblages have greater numbers of taxa and when the numbers of individual organisms are more evenly distributed across the different taxa. Samples dominated by single taxa will have lower values towards zero.
Pielou Evenness (J')	$J = H' / \log_e (S)$	A value theoretically between zero and one which indicates how evenly the number of individual organisms are distributed through the different taxa in an assemblage. High values (closer to 1) indicate an even spread amongst the taxa present, whereas a low value indicate an uneven spread or an assemblage highly dominated by only a few, or even a single taxon.

3 Results and Discussion

3.1 Sediment Physical and Chemical Properties

3.1.1 Visual Description of Sediment Cores

Sediment collected from around Well I was predominantly cohesive light grey mud (**Figure 7**). During sediment sampling no very dark-grey or black sediment layers (apparent Redox Potential Discontinuity), or darker patches within cores were noted and no detectable hydrogen sulphide odours were present, indicating that sediments are well oxygenated throughout the depths sampled. Field observations on sediment texture, colour and any notable features of the sediment samples were recorded during the processing of the sediment cores and infauna samples, and these are included in **Appendix A**. A full set of sediment core photographs are contained in **Appendix B**.

Figure 7 Representative Images of Sediment Core Profiles from Well I

Station I6

Station I8

Station I12

Station I14

3.1.2 Incidental Observations

During the laboratory processing of the infauna samples by SLR taxonomists observations were made of any debris that was present, including those from anthropogenic sources. Within the 15 samples collected at Well I there were five types of debris observed (**Table 4**), three of which were likely to be anthropogenic in source, including welding material, paint flecks and rust flakes. However, other than the 'sand like substance', all debris encountered in the samples were at 'low' abundances.

Table 4 Incidental Observations of Debris

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15
Sand-like substance		L	O	L	O	L	O	C	O	L	L		O	O	O
Coal rock						L									
Graphite					L										
Blue paint						L									
Rust								L							
Welding material											L				

VA = very abundant (>50), A = abundant (50+), C = common (20–50), O = occasional (10–20), L = low (0–10)

3.1.3 Sediment Particle Grain Size Distribution and Organic Content

The physical characteristics of the sediment can influence the composition of the infauna communities and the levels of contaminants retained and observed during analyses. Particle grain size is widely used to characterise the physical structure of the sediment, while organic content provides an indication of the organic enrichment in the sediment. These combined results provide a general understanding of sediment health and the source of potential stressors at the time of sampling.

Organic matter found in the sediments is most likely derived from natural sources such as infauna/epifauna and detrital matter, rather than from anthropogenic sources. Anoxic sediments (those lacking oxygen), may develop in situations where organic matter levels increase beyond 'normal' levels for that area. Increased organic matter has the potential to disturb the equilibrium of the benthic ecosystem, as increased numbers of oxygen-utilising bacteria are required to decompose the additional organic matter, thereby rapidly reducing oxygen availability in the sediments.

A summary of the particle grain size and organic content analyses are discussed below, with full results provided in **Appendix C**.

3.1.3.1 Particle Grain Size

Results of the particle grain size analyses conducted on sediments collected at the 15 monitoring stations around Well I are shown in **Figure 8**. Sediment samples were dominated by the silt/clay (44-76%, mean 65%) sized fractions, and fine sand and very fine sand (means 22% and 6% respectively), classing them as 'sandy muds' (Folk, 1954), similar to the bulk of the offshore South Taranaki areas where exploration/production monitoring has taken place. The sandy muds encountered at Well I were similar to those found at the other wells in the Central AOI and Well J. Sediments at Well L were muddy sands like the Northern AOI sites (**Table 5**). **Appendix C** provides raw particle grain size distribution data for Well I and graphical representations of grain size at the remaining wells.

Across the Well I area there was little evidence of spatial trends for the various proportions of particle sizes.

Figure 8 Sediment Particle Grain Size Distribution for Samples Collected at Well I

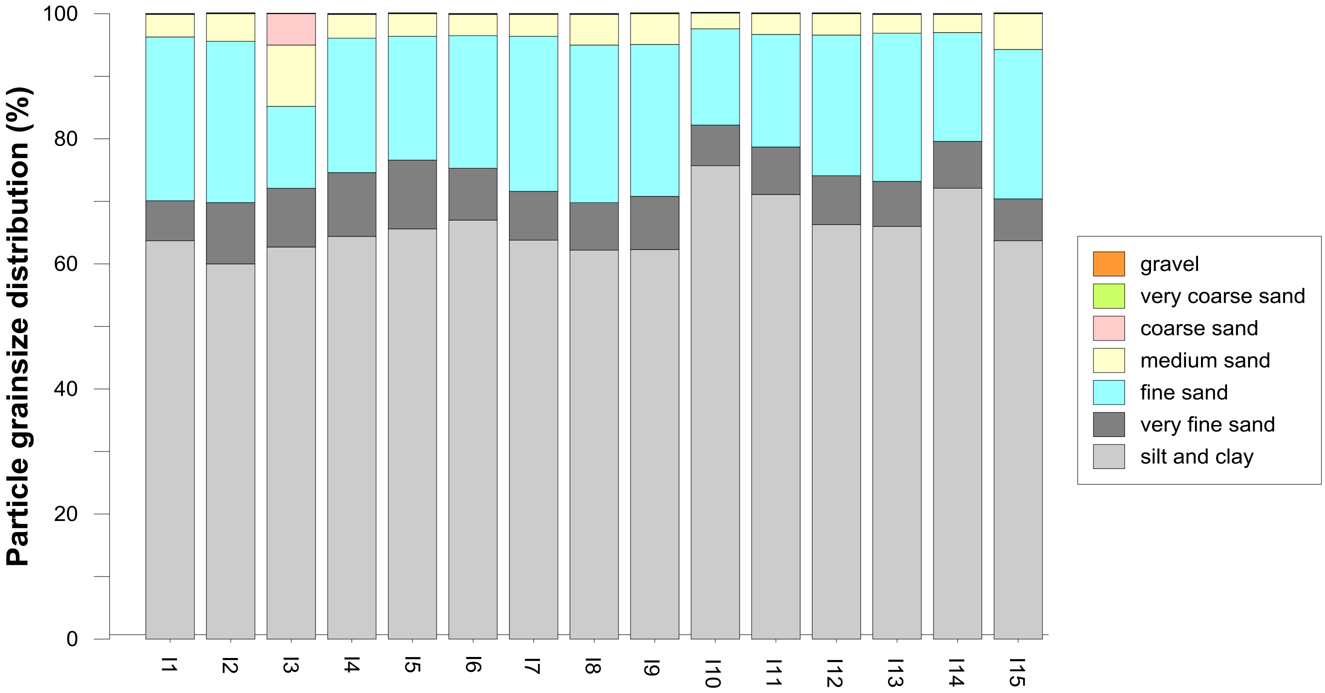


Table 5 Average Grain Size for the Eleven Wells

Grain size class	A	B	C	D	E	F	G	H	I	J	L
Silt & Clay (Mud) (%)	36.2	27.5	41.1	30.7	85.2	83.2	67.8	72.6	65.1	85.4	30.8
Very Fine Sand (%)	45.8	39.3	30.5	41.7	6.5	4.8	6.1	5.8	6.6	14.2	25.4
Fine Sand (%)	17.0	28.6	22.4	26.8	8.0	11.3	24.6	19.0	22.1	0.4	29.8
Medium Sand (%)	1.0	2.4	3.3	0.7	0.4	0.6	1.6	2.5	5.1	0.1	12.3
Coarse Sand (%)	0.1	0.7	0.8	0.0	0.0	0.1	0.1	0.1	0.6	0.0	1.2
Very Coarse Sand (%)	0.0	0.6	0.5	0.0	0.0	0.1	0.1	0.1	0.5	0.0	0.2
Gravel (%)	0.1	1.1	1.3	0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.1
Description	mS	mS	mS	mS	sM	sM	sM	sM	sM	sM	mS

Note: sM = sandy mud, mS = muddy sand

Colour scale based on percentage with median mid-point (Median is 2.0):

0%	5	10	20	30	40	50	60	70	80	90	100

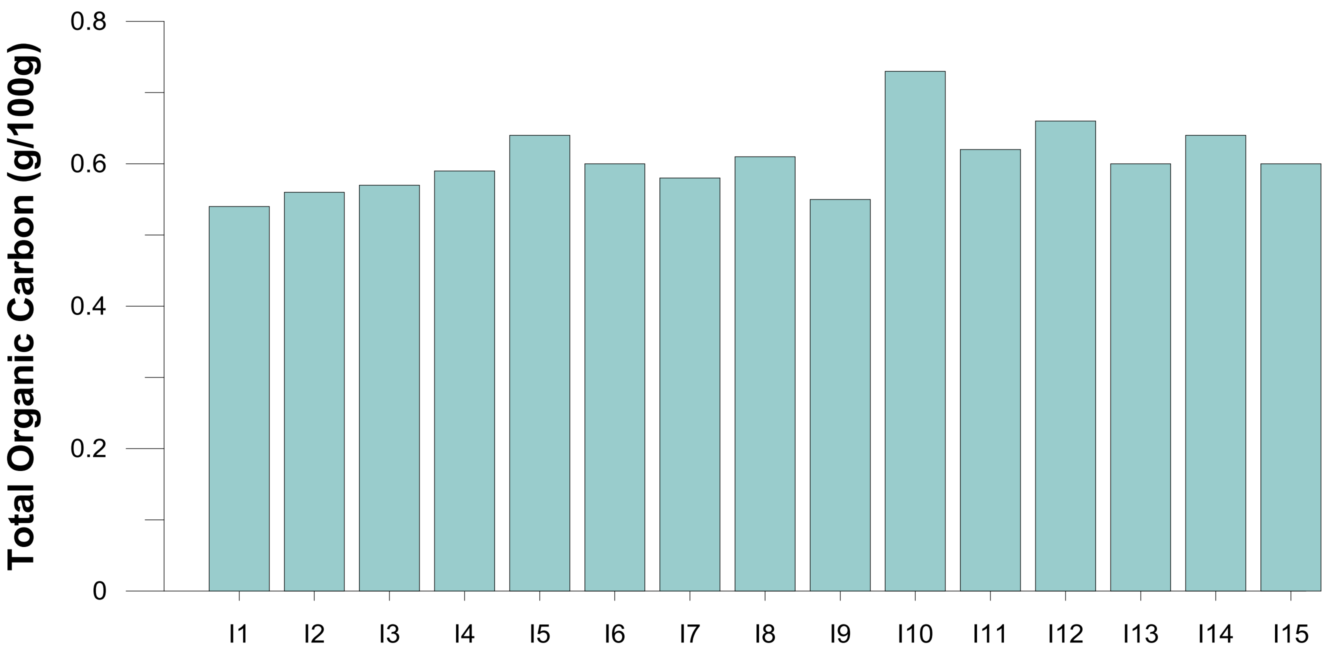
3.1.3.2 Total Organic Carbon

The organic content of sediments was assessed by measuring TOC to assess benthic ecology as this is also consistent with what is now currently undertaken around the offshore Taranaki oil and gas fields.

TOC levels found in samples from the 15 monitoring stations surrounding Well I (**Figure 9**) were similar, ranging from 0.54% to 0.73% (mean 0.61%). The average organic content of sediments at Well I was high relative to other sites (mean 0.61% compared to overall mean of 0.45%). The combined mean from all stations at the five Central AOI sites (0.59%) was low relative to the Northern and Southern AOI sites (0.26% and 0.48%, respectively).

While there did not appear to be a spatial pattern in TOC levels across the sampling stations at Well I, there did appear to be pattern similar to changes in silt and clay. As has been previously described in benthic environmental monitoring associated with offshore Taranaki oil and gas activities (SLR 2016, & SLR 2017), there is a correlation between sediment particle grain size and sediment organic content. The comparatively greater surface area of silt and clay (mud/fines) sediments gives a greater area for adsorption of organic matter particles and therefore a higher probability of elevated organic matter compared to coarser/sandier sediments subjected to the same level of enrichment (Hedges *et al*., 1993). This is likely to explain the lower organic content at Northern AOI sites, where sediment grain size is greater than at the Central and Southern AOI sites (**Section 3.1.3.1**).

Figure 9 TOC Concentrations in Sediment Samples Collected from around Well I



3.2 Video Sled Imagery

Video footage of the seabed allows scientists to visually assess any anthropogenic disturbance to the benthic environment and observe epifauna, sediment-type and structures or relief that exist on the seabed.

Video footage was captured by towing a video sled through ten stations around Well I (**Section 2.2.2**). All video footage is included with the electronic version of this document, with a selection of still images displayed in **Figure 10**. **Appendix A** provides locational information for each video sled tow.

Video footage was assessed to determine any defining features and their semi-quantitative abundances were recorded for comparison with other sites. Due to caveats associated with video footage (i.e. variable visibility, differing tow length and durations) the counts are indicative-only and should not be interpreted as a quantitative assessment. **Table 6** presents the results of this semi-quantitative approach, which summaries the counts by comparing the total for the particular well to the median across all of the EAD wells in the three AOIs. As a visual aid, counts were categorised in relation to the deviation from the 10th, 25th 50th, 75th and 90th percentiles, so that differences between sites can be more easily viewed.

3.2.1 Physical Observations

The seabed around Well I was observed to have very soft mud sediments. Evidence of bioturbation was observed at all stations in the form of animal burrows. Moderate to high abundances of burrows were prevalent in Well I transects with occasional pockets of very low and higher density worm holes (image E and C, **Figure 10**). This is similar to other wells in the Central and Southern AOIs but differs from the Northern AOI where densities were predominantly low (**Table 6**).

Mound/hollow features (image D, **Figure 10**) were observed in moderate numbers (43) compared to the median of all wells (43) (**Table 6**). These features are thought to be formed by the feeding activities of sharks or rays, or by large burrowing tube worms mounding up sediment. Mound/hollow features were observed to be most numerous at the Northern AOI sites (Well D having 280 of these features), moderate to very high at the Southern AOI sites (Well L reaching 532 mound/hollow features), and low to very low in numbers around the Central AOI sites.

A number of shallow trenches were seen around Well I that appear likely to have been caused by commercial fishing activity (images F, G, and H, **Figure 10**). The video sled crossed a total of five of these elongated trenches across three separate monitoring stations around Well I (video transects IV8, IV9, and IV10). The deepest trench was approximately 500 mm deep and 500 mm wide, and looked to be freshly excavated. The most likely explanation is that these were caused by bottom trawl fishing methods, which are not supposed to touch the bottom. There was no other sign of anthropogenic physical disturbance or sediment enrichment.

Table 6 Total Number of Features Observed in Video Imagery from the EAD Wells

Well	Depth (m)	Mounds/ Hollows	Density of burrows/worm holes	Sea pen	Fish	Substrate	Notes
A	148	111	Low-moderate	54	65	Muddy sand	Ripples; some very large holes and mounds
B	134	63	Low-moderate	35	49	Muddy sand	Some very large holes mounds
C	132	85	Low-moderate	50	44	Muddy sand	Ripples; trenches observed
D	145	280	Low	160	28	Muddy sand	Ripples; 23 very large sea feathers
E	126	29	Moderate	29	16	Sandy mud	
F	128	20	Moderate	19	19	Sandy mud	
G	124	18	Moderate-High	29	26	Sandy mud	
H	124	18	Moderate-High	17	26	Sandy mud	12 elongated shallow trenches
I	122	43	Moderate-High	36	21	Sandy mud	5 elongated shallow trenches (large)
J	108	42	Moderate	14	30	Sandy mud	School of mackerel, tufts/tubes common
L	112	532	Moderate	132	31	Muddy sand	2 schools of mackerel
Median		43		35	28		

Totals are sum of 10 video tows carried out at each site. Totals are semi-quantitative only due to variable visibility and transect length.

10th percentile band
25th percentile band
Median band
75th percentile band
90th percentile band

3.2.2 Infauna, Epifauna and Other Fauna

In some cases, a definitive positive identification of infauna, epifauna and more mobile taxa was not possible from the video footage alone. Where there was any uncertainty, identifications were based on distinctive features, colours and shapes of organisms and in some cases the confirmed presence of similar looking individuals within the infauna samples.

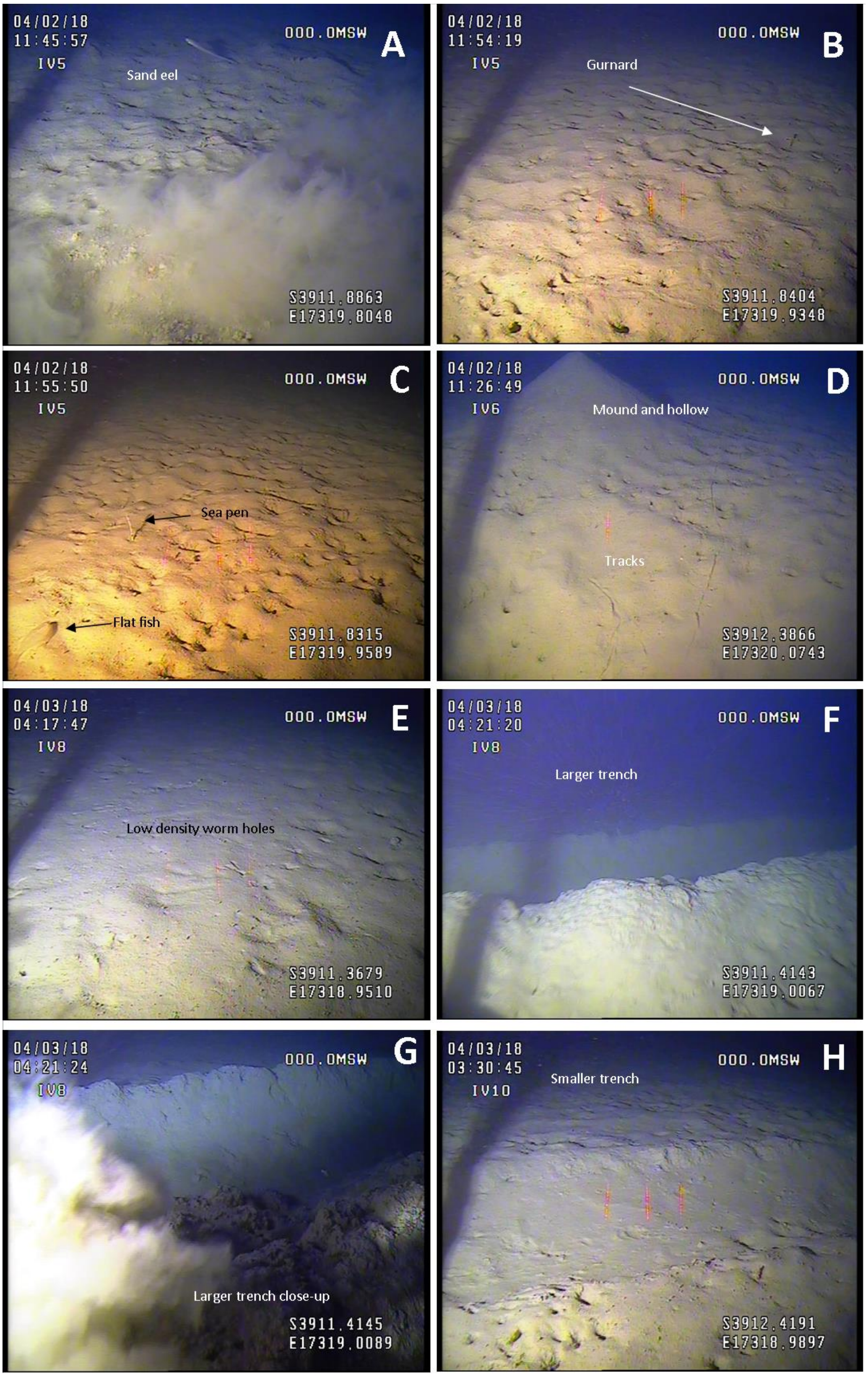
Epifauna taxa observed in video footage collected around Well I included a small number of whelks (likely *Austrofusus glans*) and other molluscs such as tusk shells (likely *Fissidentalium zelandicum).* The presence of epifauna tracks in the sediment indicates that mobile fauna such as whelks and hermit crabs move throughout this area. A small number of sponges were observed at some stations, some of which may have been tunicates or coral.

Sea pens (likely *Virgularia* sp.) (image C, **Figure 10**) were seen in moderate numbers at Well I (36 in the ten tows) compared to the median of all 11 wells (35) (**Table 6**). Sea pens were observed to be more numerous at the Northern AOI, variable at the Southern AOI, and lowest in the Central AOI.

Mobile fish species were observed in low numbers (21 fish in ten video sled tows) compared to the overall median of all 11 wells (28) (**Table 6**). Species observed include sand eels[1], gurnard (*Chelidonichthys kumu*) and flatfish (likely *Peltorhamphus* sp.) (images A, B, and C **Figure 10**). A number of smaller fish were seen taking off very quickly as the camera approached and it was not possible to make any definitive observations about these animals. Fish were observed to be much more numerous at the Northern AOI, moderate at the Southern AOI, and moderate to low in numbers around the Central AOI.

[1] This fish was unable to be formally identified, thus while the term 'sand eel' is used throughout this report it should not be considered a common name for this unidentified fish species.

Figure 10 Representative Images of Seabed Environment around Well I



3.3 Macrofauna Characteristics

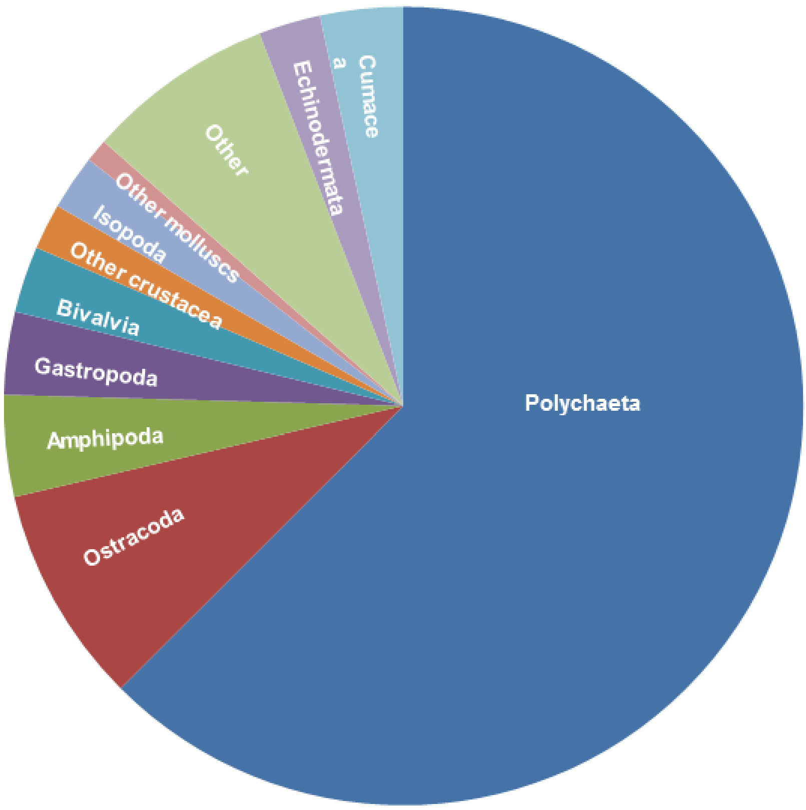
3.3.1 Benthic Macrofauna

Overall 1,075 individuals representing 91 taxa were identified in the macrofauna samples collected at the 15 Well I monitoring stations. Infauna communities were dominated by small polychaete worms (672 individuals (63%), 33 taxa), crustaceans (219 individuals (20%), 25 taxa, mostly Ostracoda, Amphipoda and Isopoda), and molluscs (75 individuals (7%), 20 taxa, mostly Gastropoda and Bivalvia) (**Figure 11** and **Figure 12**). Half of the 82 individuals categorised as ‘Other’ were nematodes (round worms), which is a greater proportion than was found at other Central AOI sites (comparisons between wells can be found in **Appendix E**).

The infauna communities at Well I were similar to those found during pre- and post-drill monitoring at the Oi-1/Oi-2 exploration well south of Well I and those found during ongoing monitoring in the nearby Tui field.

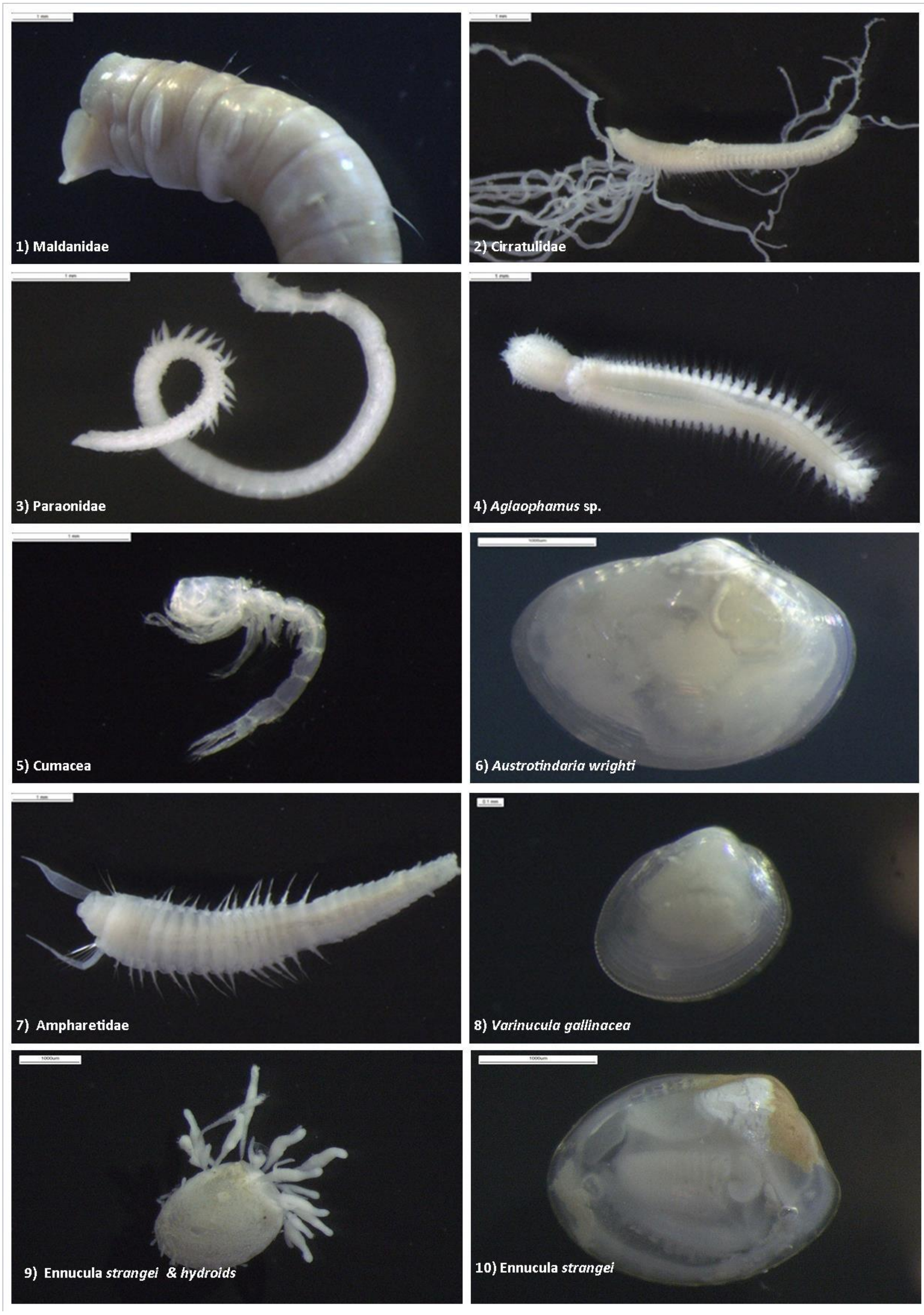
The raw macroinvertebrate data from Well I monitoring stations is provided in **Appendix D**.

Figure 11 Proportion of Individuals at Well I Belonging to each Taxonomic Group



'Other Crustacea' includes Decapoda, Copepoda, Euphausiacea, and Tanaidacea. 'Other molluscs' includes Caudofoveta, and Scaphopoda. 'Other' includes Chaetognatha, Demospongiae, Hemichordata, Nematoda, Nermetea, Ooligochaeta, Sipuncula, Tunicata, and Cnidaria.

Figure 12 Representative Images of Benthic Infauna Taxa Frequently Observed in Offshore Taranaki Areas



3.3.2 Univariate Indices of Infauna Communities

Univariate indices (total number of taxa, total abundance, Pielou's evenness and Shannon-Wiener diversity) describing the benthic macroinvertebrate communities found at Well I are displayed in **Figure 13**.

The number of taxa in Well I infauna samples varied from 20 to 36 (mean 29) (**Figure 13**) and total abundances varied between 42 and 100 individuals per grab sample (mean 72). Mean taxa numbers and abundances at Well I were similar to other sites in the Central AOI (**Table 7**), with the exception of Well E where these indices were notably lower. Compared to the Northern and Southern AOIs, Well I (and the greater Central AOI) had lower numbers of infauna taxa and total abundances.

Evenness values vary on a scale between zero and one, with values near one indicating that infauna abundances are evenly distributed across all the different taxa present, while values near zero indicate infauna communities are being numerically dominated by a large number of individuals from just a few, or even only single taxa. Values from the Benthic Baseline samples collected at Well I were relatively high (mean 0.88), indicating relatively even distribution of abundances across the taxa that were present. Monitoring station I13, which had among the highest number of taxa and highest abundance, scored lower than the surrounding stations due to comparatively higher numbers of polychaete worms and amphipods relative to other stations at Well I.

Shannon-Wiener diversity index values range between 0 and 4 with higher values representing higher diversity. From previous benthic studies in the offshore Taranaki region values in most communities fall between 1.5 and 3.5. The mean Shannon-Weiner diversity index for Well I was 3.0, and ranged between 2.5 and 3.2. Across Well I, monitoring stations I5 and I8 showed the lowest values, reflecting the lower number of taxa and total abundance found at these stations. When these results are compared to the most recent results from long term benthic monitoring programmes at the Maari Field (mean diversity index of 2.9) in the Southern AOI it is shown that the species diversity was greater at Well I.

Figure 13 Total Number of Taxa, Total Abundance, Pielou's Evenness and Shannon Wiener Diversity Index Values for Macrofauna Samples Collected at Well I

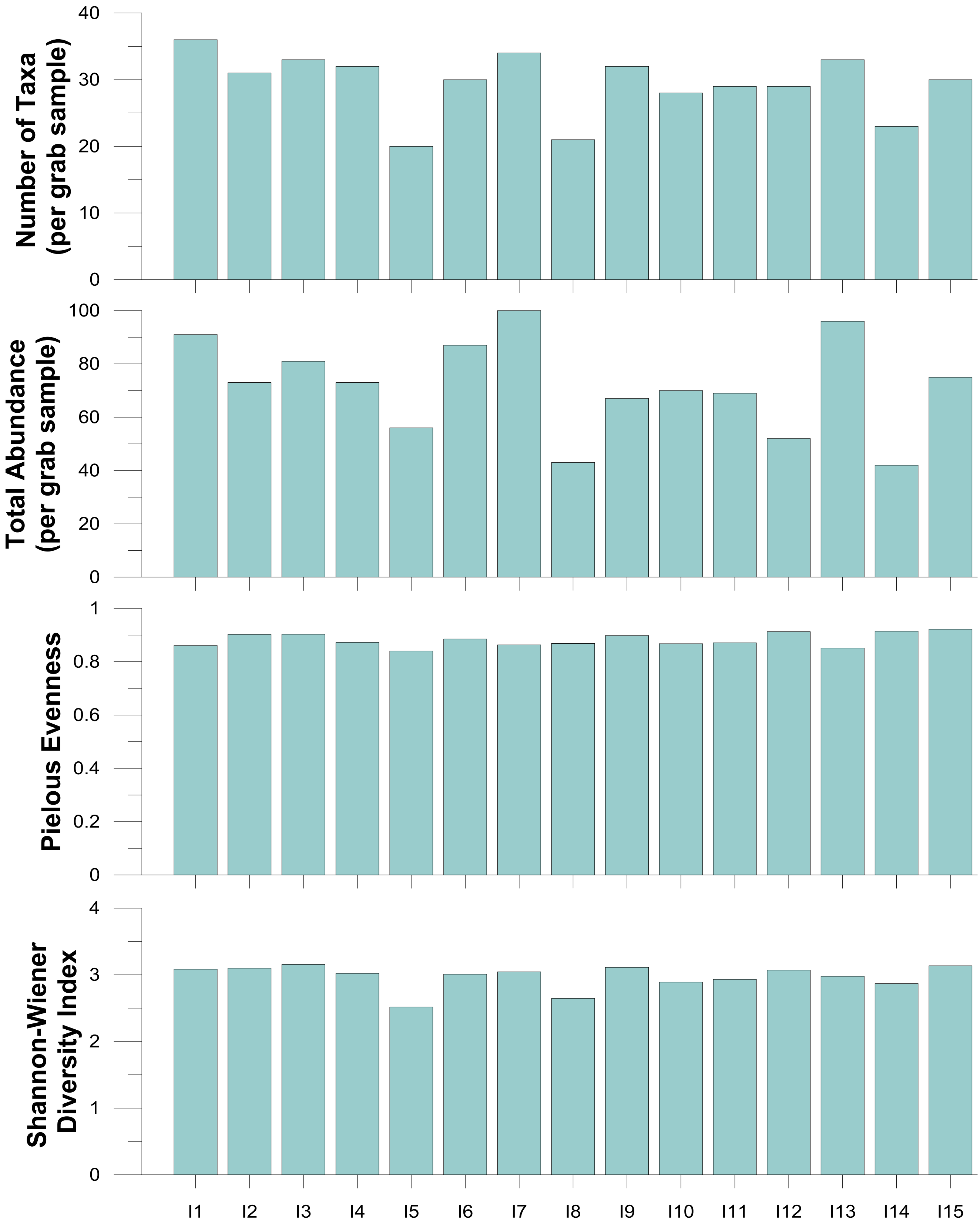


Table 7 Number of Taxa and Total Abundance for the Eleven Wells

Site	Mean Number of Taxa	Mean Abundance	Total Number of Taxa Identified at site	Total number of individuals (abundance)
A	56	257	140	3,849
B	53	210	130	3,151
C	45	132	128	1,987
D	60	332	142	4,986
Northern AOI	53	233		
E	19	36	78	542
F	31	68	90	1,023
G	33	81	112	1,215
H	31	89	103	1,339
I	**29**	**72**	**91**	**1,075**
Central AOI	29	69		
J	40	115	108	1,722
L	54	190	131	2,853
Southern AOI	47	153		

3.4 Sensitive Environments

In an investigation of sensitive substrate/benthic habitats in the Taranaki Coastal Marine Area, Johnston (2016) studied marine taxa databases from marine benthic surveys conducted in the offshore Taranaki Basin and noted that there are many locations where at least one 'characteristic species of sensitive environments' was found. This investigation used the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activity Regulations**) sensitive environments descriptions to define what sensitive habitats may be present.

From the Johnston (2016) report, Chaetopteridae worms and Sea pens were likely to be present in areas close to the eleven wells. In relation to the sampling techniques used in the Benthic Baseline survey (grab sampling and video sled imagery), MacDiarmid *et al*. (2013) defined that;

"A sensitive Chaetopteridae worm field is present if worm tubes and/or epifaunal species:

- Occupy 25% or more of the seabed in imaging surveys covering and area of 500 m^2 or more; or
- Occur in two successive samples collected using point sampling gear."

and

"A sea pen field exists if:

- One or more specimens of any species of sea pen is found in two successive samples collected using point sampling gear, or
- Two or more specimens per m^2 are found in seabed imaging surveys, or surveys using towed gear."

Analysis of the infauna samples collected during the Benthic Baseline survey found that Chaetopteridae worms (specifically *Phyllochaetopterus* socialis, commonly known as wire-weed or Tarakihi weed) were present within samples from Wells A, B, C, D, G, H, J and L. The majority of sites had only single individuals at a small number of monitoring stations at each site, with Well I being one of the few wells where no individuals of this species were found during the Benthic Baseline survey. Video imagery collected at Well I further confirmed the absence of worm-fields or the low-relief worm-meadows that *P. socialis* can often form when present at higher densities.

While no sea pens were identified in the infauna samples from Well I, video imagery showed a total of 26 individual sea pens were encountered during the ten video sled tows (**Table 6**). Due to video sled tows being only a semi-quantitative survey method it is not possible to make exact predictions on the densities of sea pens encountered. However, as a conservative estimate the width of the camera's field of view could be estimated at 1 m, and each video sled covered 200 m across the seafloor, giving an approximate area of 2,000 m^2 viewed by the imagery. Given this area and the low numbers of sea pens observed (compared to Wells D (160 individual sea pens) and L (132 individual sea pens)) sea pen densities at Well I would not have surpassed the Permitted Activities Regulations trigger value of two sea pens per square meter (MacDiarmid *et al*., 2013). Video tows were not found to pass through more spatially limited areas of higher density that might have been classed as 'sea pen fields'. Based on the video sled analysis there are no 'Sensitive Environments', as defined by the Permitted Activities Regulations were encountered at the monitoring stations at Well I

4 Key Findings

4.1 Sediment Characteristics

Sediments sampled at Well I were sandy muds with moderate amounts of fine sand, similar to the other wells in the Central AOI, but notably finer/muddier than the Northern AOI sites.

TOC levels in the area (mean 0.61%) were also similar to the rest of the Central AOI sites, which were all distinctly higher than the Northern AOI sites. Neither grain size nor TOC showed consistent spatial patterns across the Well I site, but variations in silt and clay mirrored the small variations in TOC. Sediments with a finer grain size will retain higher levels of organic matter compared to coarser/sandier sediments subjected to the same level of enrichment/deposition, due to the greater surface area of finer particles for adsorption Drilling muds themselves contain little or no organic matter and historical pre- and post-drill monitoring surveys in the South Taranaki Basin have observed distinct decreases in mean organic matter levels in the initial post-drill surveys at stations closest to the wellhead where significant amounts of drilling muds have settled.

4.2 Faunal Characteristics

Video sled imagery at Well I showed a relatively flat seabed, interrupted by mounds/hollows and pock-marked with animal burrows/holes. Whelks, small molluscs, sea pens, evidence of more mobile epifauna (hermit crabs and whelk tracks), and a small number of sponges were observed during the tows, while mobile fish species were seen in low numbers around Well I compared to the sites in the Southern AOI and especially the Northern AOI.

Infauna communities in Well I samples were similar to those of the other Central AOI sites, and were dominated by small polychaetes, crustaceans (ostracods, amphipods and isopods) and molluscs (gastropods and small bivalves). Central AOI infauna communities had the greatest proportions of polychaetes and gastropods, but the lowest proportions of crustaceans like amphipods and tanaidaceans, reflecting the muddier sediments in the Central AOI which are more suited to deposit feeding/scavenging taxa like many polychaetes and gastropods.

Mean taxa numbers and total infauna abundances at Well I were very similar to the overall mean values for the Central AOI, which were notably lower than those of the Northern AOI and Well L in the Southern AOI.

The finer sediments present at Well I, and at Central AOI sites, compared to coarser sandy sediments of the Northern AOI, are likely linked to the greater proportions of taxa such as polychaetes and gastropods. Taxa found at Well I that were within these groups were largely scavengers/detritivores and/or deposit feeders which feed on larger dead materials on/in the sediment, as well as organic matter within the sediments. This feeding mechanism is more suited to muddy sediments where there is comparatively greater proportions of organic matter for given volumes of sediment, compared to coarser sediments such as sands.

Taxa more adapted for filter feeding (e.g. copepods, Tanaidacea, and amphipods) have delicate feeding and breathing structures which are more easily clogged/damaged by high levels of very fine sediments. Thus, these taxa are often more abundant at wells with coarser sediments, and which was found to be the case for Northern AOI site infauna communities.

4.3 Sensitive Environments

Some individuals representing a '*characteristic species of sensitive environments*' were observed in video imagery collected during the Benthic Baseline survey at Well I. However, observations from the video imagery analysis indicate that no 'Sensitive Environments', as defined by the Permitted Activities Regulations were encountered at the monitoring stations at Well I.

5 References

Clarke K. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18 (1): 117-143.

Clarke K.R., Warwick R.M., 1994. Change in marine communities: An approach to statistical analysis and interpretation. Plymouth Marine Laboratory, UK.

Clarke K.R., Gorley R.N., 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth.

Folk, 1954. *"The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature",* The Journal of Geology 62(4):344-359.

Hedges JI, Keil RG, Cowie GL, 1993, "Sedimentary diagenesis: organic perspectives with inorganic overlays", Chemical Geology 107: 487-492.

Johnston O, Barter P, Ellis J, Elvines D, 2014, "*Recommendations for an Offshore Taranaki Environmental Monitoring Protocol: Drilling- and production-related discharges, Version 1.0*" (OTEMP), Cawthron Report No. 2124.

Johnston O 2016. Sensitive habitats and threatened species in the Taranaki Coastal Marine Area (TCMA) - database investigation. Prepared for Taranaki Regional Council. Cawthron Report No. 2877. 28 p. plus appendices.

MacDiarmid, A., Bowden, D., Cummings, V., Morrison, M., Jones, E., Kelly, M., Neil, H., Nelson, W., Rowden, A., 2013. '*Sensitive marine benthic habitats defined*'. Prepared for Ministry for the Environment, NIWA Client Report No: WLG2013-18.

SLR, 2016. "*Benthic Ecological Survey – Tui Field facilities. Production Discharge Monitoring, February 2016*" prepared for AWE Taranaki Limited, report number 740.10040.

SLR, 2017, "*Benthic Ecological Survey for the Maui Platform Alpha. Annual Production Monitoring – April 2017*", prepared for Shell Todd Oil Services Limited, SLR Report Number 740.10041.00300-R01--v0.1

APPENDIX A

Locations and Observations from Sediment Grab Sampling and Video Sled during the 2018 Benthic Baseline Survey

Station	Date	Time	Depth (m)	Coordinates (NZTM)		Notes
				Easting	Northing	
Grab Sample Stations						
IG 1	5/4/18	1644	121	1633893	5661179	Cohesive light grey mud
IG 2	5/4/18	1630	121	1631894	5661185	Cohesive light grey mud
IG 3	5/4/18	1553	121	1629892	5661188	Cohesive light grey mud
IG 4	5/4/18	1542	121	1628894	5661191	Slightly softer light grey mud
IG 5	5/4/18	1428	121	1627893	5661191	Cohesive light grey mud
IG 6	3/4/18	1641	121	1626894	5661191	Cohesive light grey mud
IG 7	3/4/18	1631	121	1625893	5661185	Very cohesive light grey mud
IG 8	5/4/18	1510	121	1630903	5663190	Cohesive light grey mud
IG 9	5/4/18	1522	121	1630905	5662189	Very streaky cohesive grey mud
IG10	5/4/18	1619	121	1630908	5660194	Cohesive light grey mud
IG11	5/4/18	1610	121	1630903	5659181	Cohesive light grey mud
IG12	5/4/18	1452	121	1627895	5663190	Cohesive grey mud. 1 missed grab.
IG13	5/4/18	1436	121	1627895	5662193	Cohesive light grey mud
IG14	5/4/18	1418	121	1627893	5660190	Cohesive light grey mud
IG15	5/4/18	1408	121	1627894	5659190	Cohesive light grey mud
Video Sled Stations						
IV 1	2/4/18	1328	121	1632902	5662696	
IV 2	2/4/18	1401	121	1632899	5661195	
IV 3	2/4/18	1442	118	1632903	5659693	
IV 4	2/4/18	1609	119	1629394	5662695	
IV 5	2/4/18	1544	123	1628894	5661191	
IV 6	2/4/18	1519	119	1629400	5659687	
IV 7	2/4/18	1638	119	1627893	5661191	
IV 8	3/4/18	0813	122	1626897	5662688	
IV 9	3/4/18	0749	119	1626393	5661187	
IV10	3/4/18	0722	120	1626899	5659689	

APPENDIX B

Sediment Core Profile Images from all Grab Samples Collected during the 2018 Benthic Baseline Survey at Well I


I1.JPG


I10.JPG


I11.JPG


I12.JPG


I13.JPG


I14.JPG


I15.JPG


I2.JPG


I4.JPG


I5.JPG


I6.JPG


I7.JPG


I8.JPG

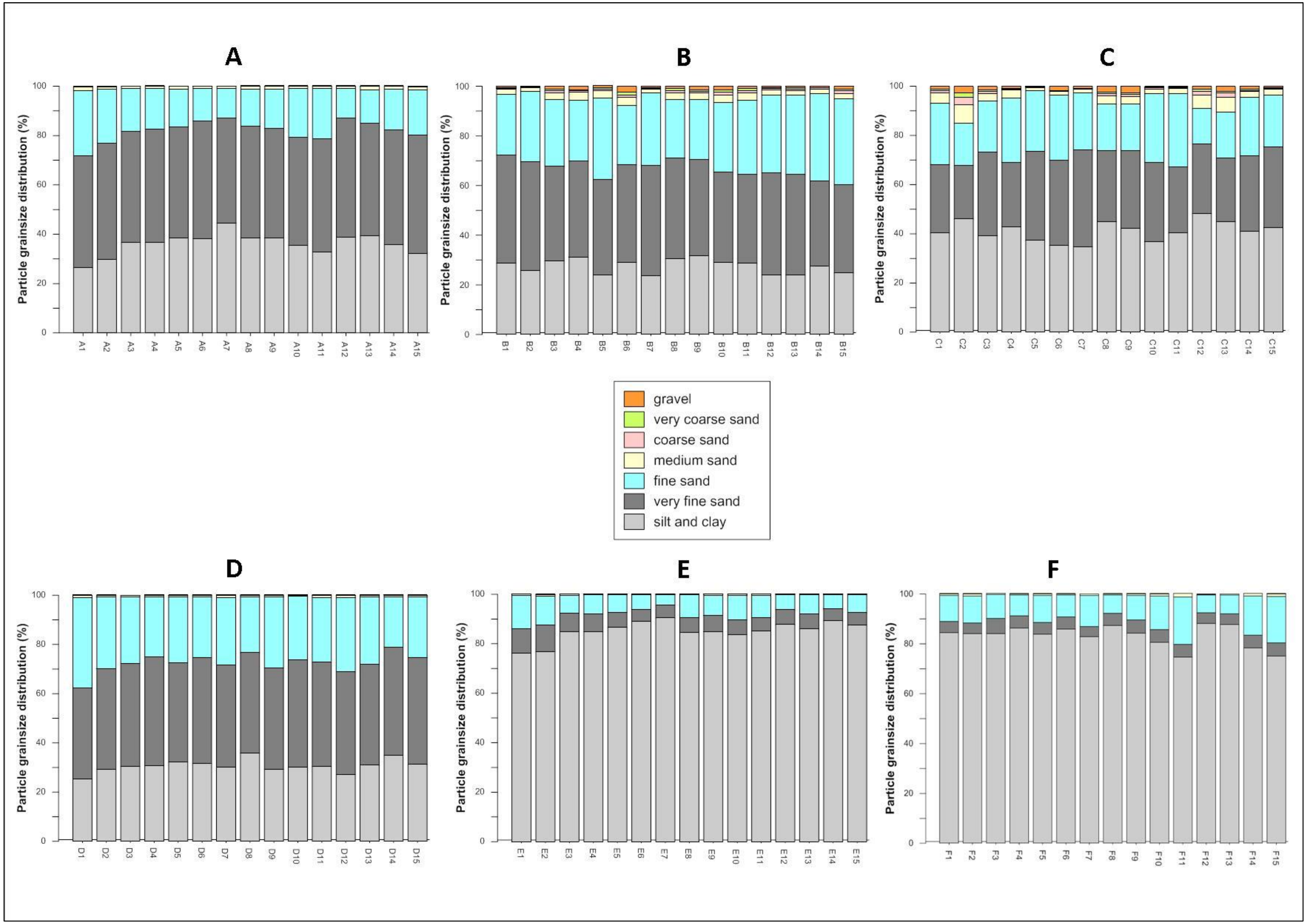

I9.JPG

I3.JPG (missing)

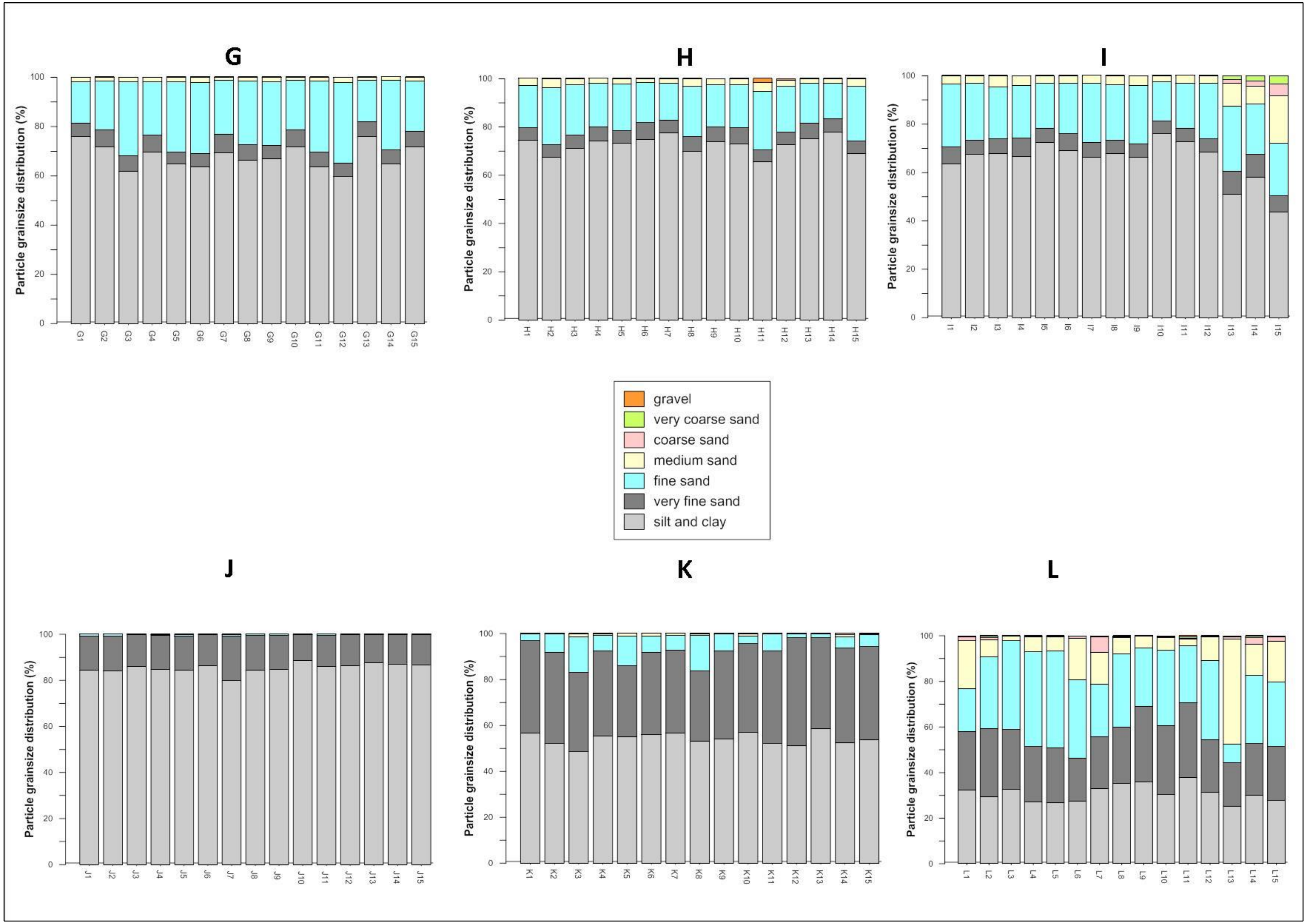
APPENDIX C

Total Organic Carbon Content and Particle Grain Size Distribution for Well I

Replicate Sample	TOC (%)	Gravel (%)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Silt & Clay (Mud) (%)
Station I1	0.54	0.05	0.05	0.05	3.5	25.9	7	63.6
Station I2	0.56	0.05	0.05	0.05	3.2	23.4	6	67.4
Station I3	0.57	0.05	0.05	0.05	4.6	21.4	6.3	67.7
Station I4	0.59	0.05	0.05	0.05	3.9	21.7	7.6	66.7
Station I5	0.64	0.1	0.05	0.05	3.1	18.5	5.9	72.4
Station I6	0.6	0.05	0.05	0.05	3	20.8	7.3	68.9
Station I7	0.58	0.05	0.05	0.05	3.1	24.7	6	66.3
Station I8	0.61	0.05	0.05	0.05	3.8	22.8	5.5	67.9
Station I9	0.55	0.05	0.05	0.05	4	24.1	5.5	66.3
Station I10	0.73	0.05	0.05	0.05	2.5	16.2	5.3	76
Station I11	0.62	0.05	0.05	0.05	3.2	18.8	5.5	72.6
Station I12	0.66	0.05	0.05	0.05	3.1	23	5.4	68.5
Station I13	0.6	0.1	1.5	1.6	9.3	27.1	9.5	50.9
Station I14	0.64	0.05	2.1	2.1	7.4	20.9	9.6	57.9
Station I15	0.6	0.05	3.3	5.1	19.5	21.7	6.8	43.6



A
B
C
D
E
F
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay


G
H
I
J
K
L
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay

APPENDIX D

Raw Counts of Macroinvertebrate (Infauna and Epifauna) Abundance at Well I

Taxa	Class/Order	Phylum	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15
Aglaophamus sp.	Polychaeta		7	5	6	3	1	5	4	1	3	2	4		4	1	4
Amalda sp. (juvenile)	Gastropoda	Mollusca													1		
Ampelisca sp.	Amphipoda	Crustacea						1						3			
Ampharetidae	Polychaeta		2	2	4		2	5	13	3	2	4	2		5	1	5
Amphipoda	Amphipoda	Crustacea	2	2	3	3	3	2	1		4			1	2	1	
Aplacophora		Mollusca	1								1		2		1		
Aricidea sp.	Polychaeta					1				1	2			1		1	
Armandia maculata	Polychaeta				2				1			1					
Armandia maculata (juvenile)	Polychaeta		1			1							1				
Asellota	Isopoda	Crustacea	1		1	1		1	2		1		2				
Axiopsis sp.	Decapoda	Crustacea			2	1		1			1		1				1
Bivalvia (inderterminate)	Bivalvia	Mollusca	1														
Bradleya opima	Ostracoda	Crustacea	3	1	2	2	2	4	4		2	4	3	2	3	2	2
Cadulus teliger	Scaphopoda	Mollusca		1				2		1							1
Capitellethus zeylanicus	Polychaete		1	5	4	2	3	1	4	3		1	4	1	4	4	3
Chaetognatha	Chaetognatha																1
Cirratulidae	Polychaeta		16	12	6	15	12	10	14	2	9	10	11	7	13	8	6
Clavelina claviformis	Tunicata			1	1	1		2								1	
Copepoda	Copepoda	Crustacea												2	2		
Cumacea	Cumacea	Crustacea	9	3	1		2	4	1	1	5	4	1		4		1
Curveulima aupouria	Gastropoda	Mollusca							1			1	1	1			
Cylostrematidae	Gastropoda	Mollusca						1									
Cymbicopia hispida	Ostracoda	Crustacea		1													
Cypridinodes reticulata	Ostracoda	Crustacea					1										
Cytherella sp.	Ostracoda	Crustacea									1	1					
Demospongiae	Demospongiae							1									
Dorvilleidae	Polychaeta			1					1					1			
Edwardsia sp.	Actiniaria	Cnidaria		1								1	1				
Euchone pallida	Polychaeta								1								

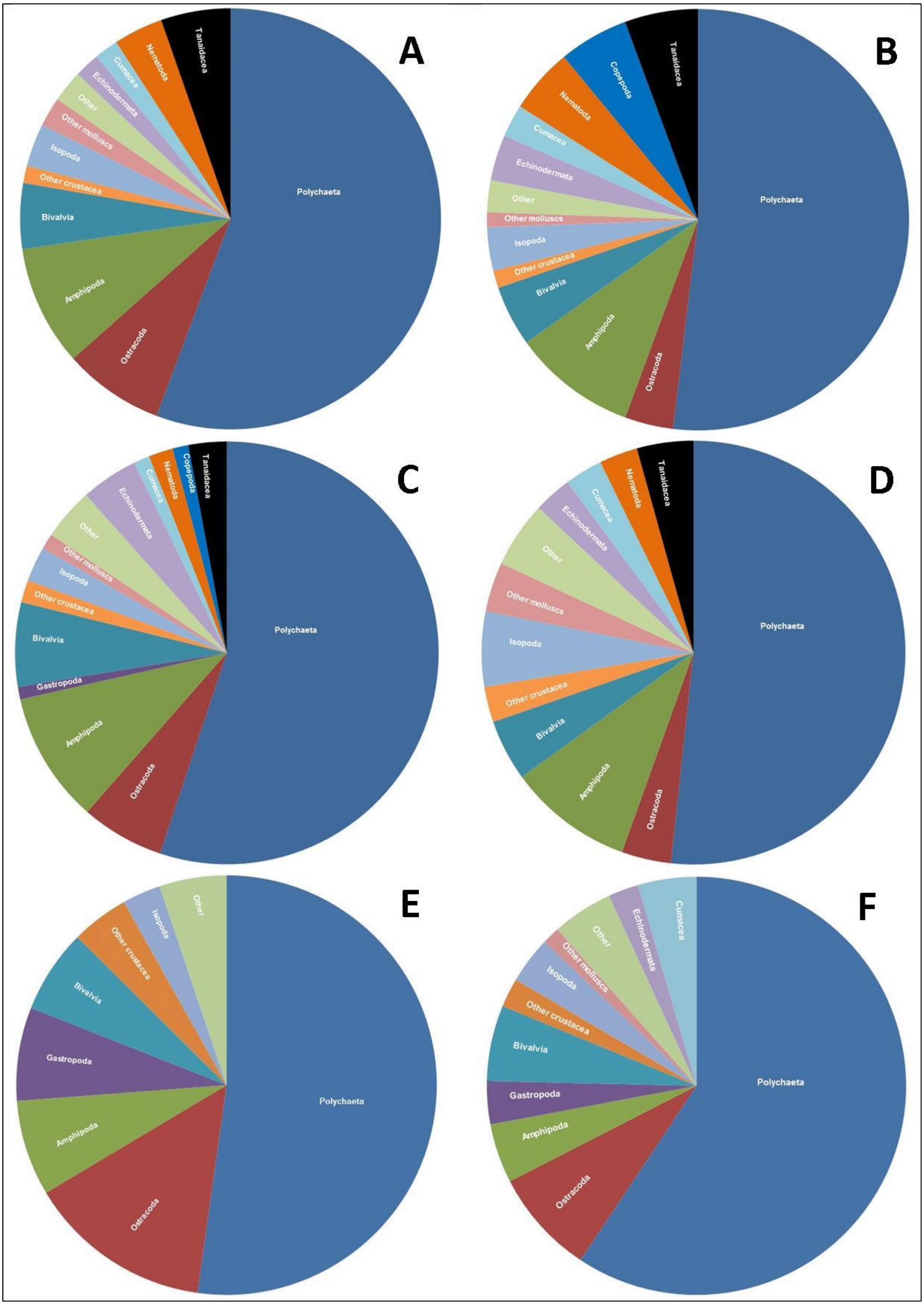
Taxa	Class/Order	Phylum	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15
Euphausiacea	Euphausiacea	Crustacea									1						
Euphilomedes agilis	Ostracoda	Crustacea	1	2	1		1	2	3	1	1	2	1		1	1	3
Fauveliopsodae	Polychaeta					1											
Flabelligeridae	Polychaeta		1		1	1	2		1	1	3		1	1			4
Gastropoda juvenile	Gastropoda	Mollusca									1						
Glyceridae	Polychaeta											1					
Gnathiidae	Isopoda	Crustacea				2			1	2	1						
Goniadidae	Polychaeta																1
Haustoriidae	Amphipoda	Crustacea			1								1		1		
Hemichordata	Hemichordata		1		1							1				1	1
Hesionidae	Polychaeta		1											1	1	1	
Hyperia sp.	Amphipoda	Crustacea											1				
Ischyroceridae	Isopoda	Crustacea			1		1										
Lumbrineridae	Polychaeta		1	3		4		5	1	1		1	2	3	1		4
Lysianassidae	Amphipoda	Crustacea									1			1	2		
Maldanidae	Polychaeta		6	4	9	8	2	4	13	12	10	10	4	2	9	2	7
Marphysa disjuncta	Polychaeta		1		1			1	1		1		2	1			1
Myriowenia sp.	Polychaeta				1										1		
Natatolana pellucida	Isopoda	Crustacea		1		1					1					1	
Naticidae	Gastropoda	Mollusca													1		
Neilonella wrighti	Bivalvia	Mollusca		1		1			1	1							
Neilonella wrighti (juvenile)	Bivalvia	Mollusca		1	1	1			1		1	1					
Nematoda	Nematoda		3	2	1	2	1	9	4	1	2	1	3	2	4	3	3
Nemertea	Nermetea		1				1		1						1		1
Neolepton antipodum	Bivalvia	Mollusca				1											
Neonesidea sp.	Ostracoda	Crustacea			5	2	2			1	1	3	1			1	4
Nucinella maoriana	Bivalvia	Mollusca	1	1	1				1		1						
Oligochaeta	Oligochaeta													1			
Onuphis aucklandensis	Polychaeta		2	1	2	1	2	2	1						1	1	1

Taxa	Class/Order	Phylum	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15
Ophiuroidea	Ophiuroidea	Echinodermata	5	4	3	1	2	1	2			1	1	1	2		1
Paramunna serrata	Isopoda	Crustacea				1						1					1
Paraonidae	Polychaeta		9	7	10	6	14	13	6	3	2	10	13	8	19	4	8
Philine auriformis	Gastropoda	Mollusca															1
Philini powelli	Gastropoda	Mollusca	1														
Phoxocephalidae	Amphipoda	Crustacea	2	2	1							1			1	1	
Phylo felix	Polychaeta							1									
Phylo novaezealandiae	Polychaeta			1													
Pilargidae	Polychaeta			1							1			1	1		
Poecilochaetidae	Polychaeta															1	
Polychaeta A	Polychaeta																1
Polynoidae	Polychaeta		1														
Pontophilus sp.	Malacostraca	Crustacea			1												
Poroleda lanceolata	Bivalvia	Mollusca									1	1		1			
Pratulum pulchellum	Bivalvia	Mollusca													1		
Prionospio sp.	Polychaeta		1						1								
Pyura sp.	Tunicata		1					2		1				1	2		
Relichna aupouria	Gastropoda	Mollusca		2	1	1		1	3		3		1				
Rhamphobrachium sp.	Polychaeta		1											1			
Rissoidae	Gastropoda	Mollusca		1		4		1	2	1		1	1	1	1		1
Rynkatorpa uncinata	Holothuroidea	Echinodermata									1			1	1		
Sigalionidae	Polychaeta		1					1			1				1	1	
Spiophanes kryoeri	Polychaeta					1				1		1	1				
Spiophanes sp.	Polychaeta		1	1	3	1	1		4	4	1		1	3		2	
Syllidae	Polychaeta											1					
Tanaidacea	Tanaidacea	Crustacea	1			1									2		2
Terebellidae	Polychaeta				1												
Terebellides stroemii	Polychaeta				2				3						2		3
Themiste sp.	Sipuncula		1	1	1		1		1		1	1	1	1	1	1	1

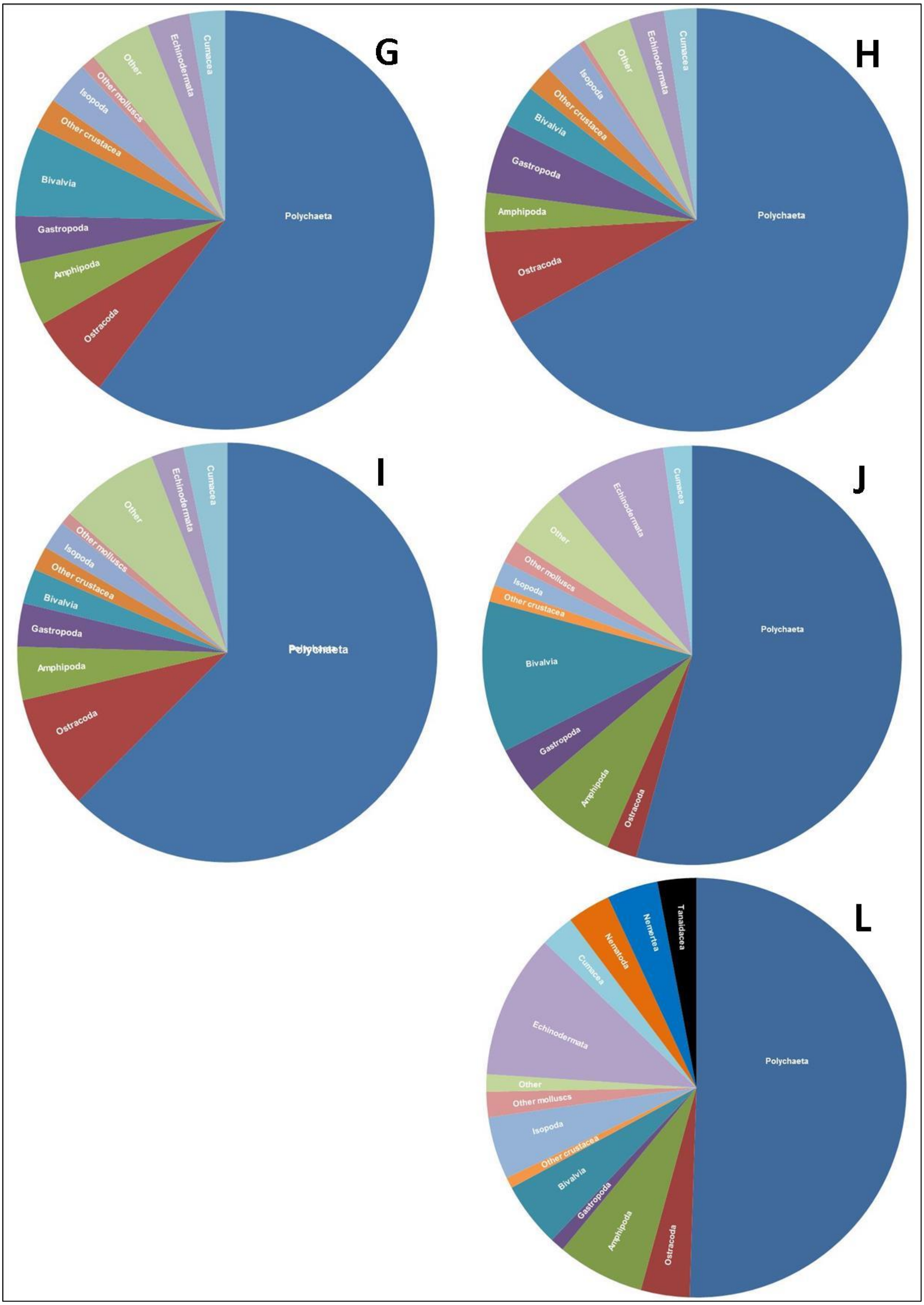
Taxa	Class/Order	Phylum	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15
Thyasira peregrina	Bivalvia	Mollusca						1									
Trachyleberis lytteltonensis	Ostracoda	Crustacea	2			1		2	1			3	1	1		2	2
Upogebia sp.	Decapoda	Crustacea				1											
Varinucula gallinacea	Bivalvia	Mollusca	1	2				1	1	1				1			

APPENDIX E

Comparison of Proportion of Individuals Belonging to each Taxonomic Group across all Wells



A
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Tanaidacea
B
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Copepoda
Tanaidacea
C
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other mollusca
Other
Echinodermata
Cumacea
Nematoda
Copepoda
Tanaidacea
D
Polychaeta
Ostracoda
Amphipoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Tanaidacea
E
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other
F
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea


G
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
H
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other
Echinodermata
Cumacea
I
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
J
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
L
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Nemertea
Tanaidacea

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EXPLORATION AND APPRAISAL DRILLING PROGRAMME

Benthic Baseline Report
Well J

Prepared for:

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Version No: v1.0
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BASIS OF REPORT

This report has been prepared by SLR Consulting NZ Limited with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with OMV New Zealand Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.10078.00200-R01-v1.0	31 July 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier
740.10078.00200-R01-v0.1	29 June 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier

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OMV New Zealand Limited (**OMV New Zealand**) are applying for a Marine Consent to undertake an Exploration and Appraisal Drilling (**EAD**) Programme in the Taranaki Basin with an anticipated commencement date in 2019. OMV New Zealand may drill up to nine exploration wells and two appraisal wells within their Petroleum Exploration Permits (**PEP**). The intention of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs.

As part of the Marine Consent application, three Areas of Interest (**AOI**) have been identified that encapsulate the proposed well locations and are used as part of the Impact Assessment process. OMV New Zealand undertook a baseline environmental monitoring survey at each well location in March - April 2018 to gain an understanding of the benthic habitat and associated communities with each AOI.

Grab sampling and video sled methodologies were used to gain quantitative and qualitative information on the marine environments surrounding each well location. The data gathered from each baseline survey will be incorporated into the Marine Consent application and assist in the risk assessment process.

Water currents and deposition modelling were utilised to define the placement of sample stations. Sample transects were aligned along the dominant deposition pathway of the predicted drill cutting dispersion should that particular well be drilled. A total of 15 monitoring stations were allocated at each well site with one benthic grab sample was collected at each monitoring station. Ten video sleds were also undertaken at a selection of pre-determined sites around each well location.

Within this Benthic Baseline report the analysis of results incorporates sediment physical and chemical properties, benthic macrofauna, epifauna and visual observations around Proposed Well J. A total of 1,722 individuals representing 108 taxa were identified from the 15 macrofauna samples collected around Well J. Infauna communities were dominated by small polychaete worms (54%), molluscs (17%), crustaceans (15%) and echinoderms (including brittle stars) (8%).

Results of sediment sample analyses showed sediments from Well J to be silt and clay dominated sandy muds, with no distinct spatial patterns in grain size and TOC across the fifteen sampling stations. The sandy mud sediments were different to the coarser muddy sands present at nearby Well L, but similar to silt and clay dominated sediments in the Central AOI.

Infauna samples collected during the Benthic Baseline survey indicated the presence of Chaetopteridae worms (*Phyllochaetopterus socialis*) and sea pens (*Virgularia gracillima*) which are taxa defined as '*characteristic species of sensitive environments*'. Sea pens were also commonly observed in the video imagery collected at Well J. The occurrence and estimated densities of these taxa at Well J did not reach the trigger levels defined by the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (MacDiarmid *et al*., 2013) and no distinct worm or sea pen 'fields' were encountered. Thus although present these characteristic species were present at the well location, it is considered that the area should not be classified as a 'sensitive environment'.

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1 Introduction

OMV New Zealand Limited (**OMV New Zealand**) is applying for a Marine Consent under Section 38 of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (**EEZ Act**) to permit activities associated with an Exploration and Appraisal Drilling (**EAD**) Programme proposed to be undertaken starting in 2019.

The EAD Programme includes the drilling of up to nine exploration wells and two appraisal wells within OMV New Zealand's permit areas (**Figure 1**). The purpose of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs which OMV New Zealand operate (**Figure 1**).

Three Areas of Interest (**AOI**) (summarised below) have been identified which encapsulate the well locations (**Figure 1**). This monitoring report relates to the Benthic Baseline survey conducted at Well J in the Southern AOI. Location details and water depth of Well J are provided in **Table 1.**

The Northern AOI encompasses PEP 60092 (Ridgeline), PEP 57075 (Cloudy Bay) and PEP 60093 (Toutouwai) and includes the following wells:

- Well A;
- Well B;
- Well C; and
- Well D.

The Central AOI encompasses PEP 60093 (Toutouwai) and includes the following wells:

- Well E (Appraisal);
- Well F;
- Well G (Appraisal);
- Well H; and
- Well I.

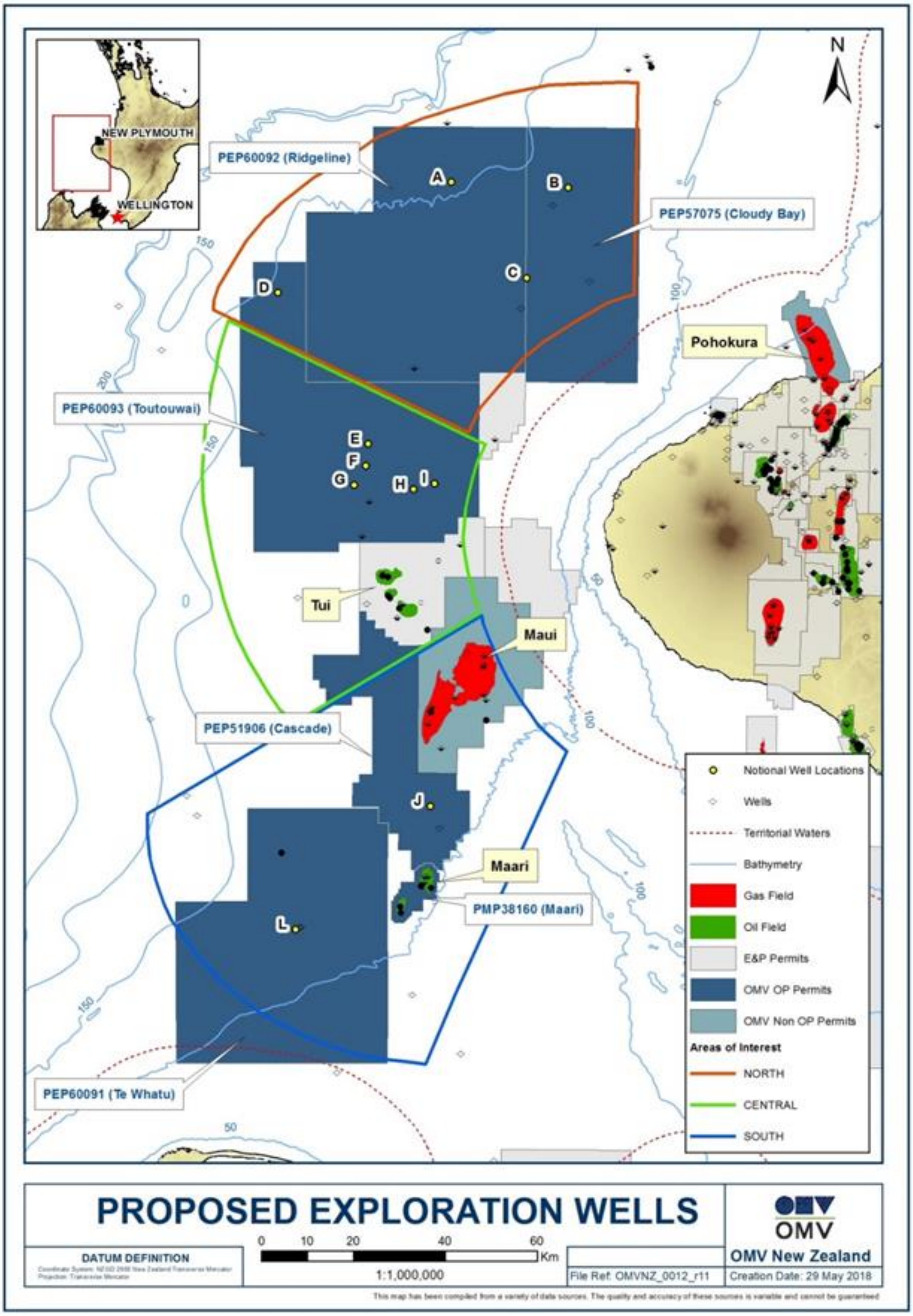
The Southern AOI encompasses PEP 51906 (Cascade), and PEP 60091 (Te Whatu) and includes the following wells:

- Well J; and
- Well L.

Table 1 Water Depth and Coordinates of Well J in the Southern AOI

Well Name	Water Depth (m)	Easting (NZTM)	Northing (NZTM)
J	104.4	1626985	5591170

Figure 1 OMV New Zealand's EAD Well Locations and three AOIs in the Taranaki Basin



In February 2018 SLR Consulting NZ Limited (**SLR**) was engaged by OMV New Zealand to undertake a baseline assessment of the benthic ecology in the vicinity of 11 wells (**Figure 1**). The aim of the field surveys, which were undertaken from March 24 – April 8 2018, was to collect relevant data using grab sampling and video sled methodologies to provide quantitative and qualitative information on these marine environments. This qualitative and quantitative data will be used within the Marine Consent application to define the benthic habitats and communities present at each well location and assist in the risk assessment process.

This report summarises the results of the Benthic Baseline survey undertaken at Well J.

1.1 Project Location

Well J is located approximately 108 km southwest of New Plymouth in New Zealand's Exclusive Economic Zone (**EEZ**). Water depth and GPS coordinates are provided in **Table 1** and displayed in **Figure 1**. The monitoring programme sample design resulted in sample stations extending out to 6 km from the well location (**Section 2.1**).

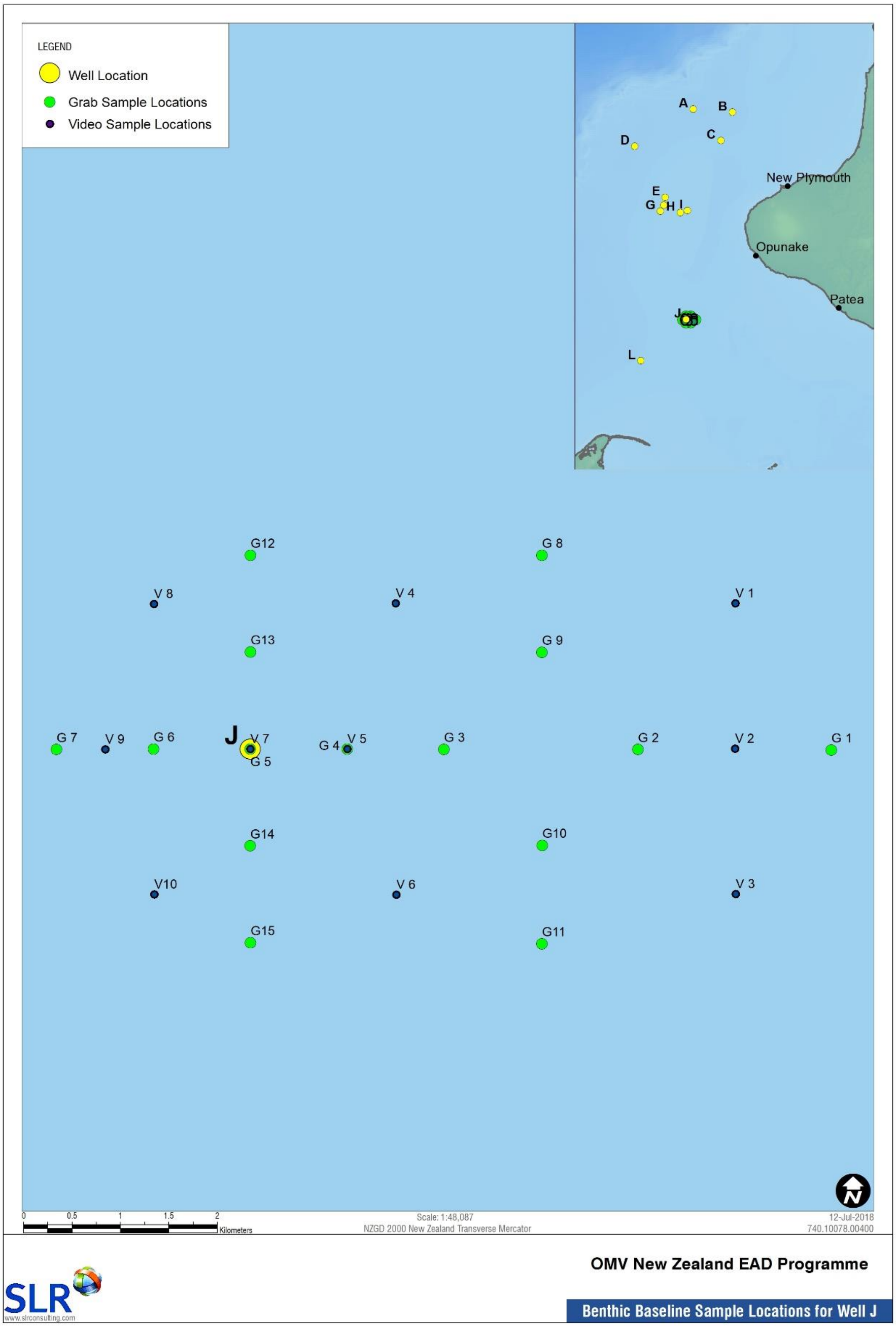
2 Methodology

The Benthic Baseline surveys adopted similar methodologies to what has been previously used for offshore Taranaki benthic monitoring programmes undertaken in accordance with the principles defined in the Offshore Taranaki Environmental Monitoring Protocol (**OTEMP**) (Johnston *et al.*, 2014). This consistent approach enables monitoring results to be compared with previous monitoring programmes undertaken in the offshore Taranaki environment (i.e. pre- and post-drill monitoring and production monitoring).

2.1 Sample Locations

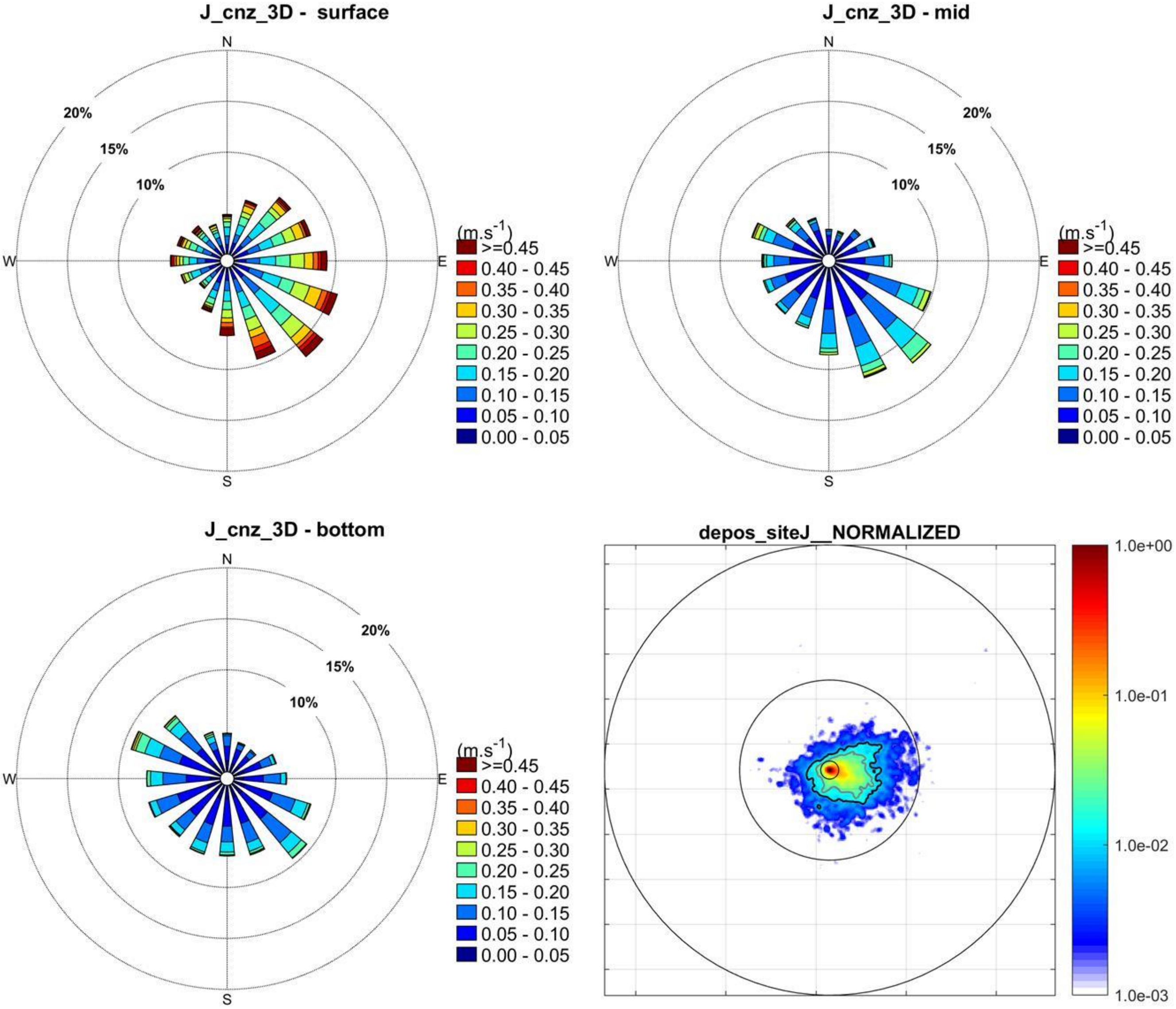
The sample locations (**Figure 2**) were defined by the dominant direction of current flow and preliminary drill cutting deposition modelling results (**Figure 3**). Sample transects were aligned along the dominant deposition pathway (i.e. southeast/northwest) (**Figure 3**) as this is the area determined to be most likely to be impacted from the deposition of drill cuttings should the well be drilled. However, sample stations were also located along the minor flow axis (northeast/southwest) to enable comparisons and validation of spatial differences based on the dispersal patterns predicted by MetOcean Solutions Limited.

Figure 2 Well J sampling stations.



Note: At each video transect station approximately 250 m of video footage was captured along the seabed in the direction of the vessels drift at the time of sampling.

Figure 3 Surface, Mid-water and Bottom Water Column Current Roses and Dispersal Modelling plots created by Metocean Solutions Ltd for Well J



2.2 Field and Sampling Procedures

Field sampling was undertaken from the MV *Seaworker* between March 24 and April 8, 2018, following the procedures detailed below. Sampling at Well J took place on March 27th.

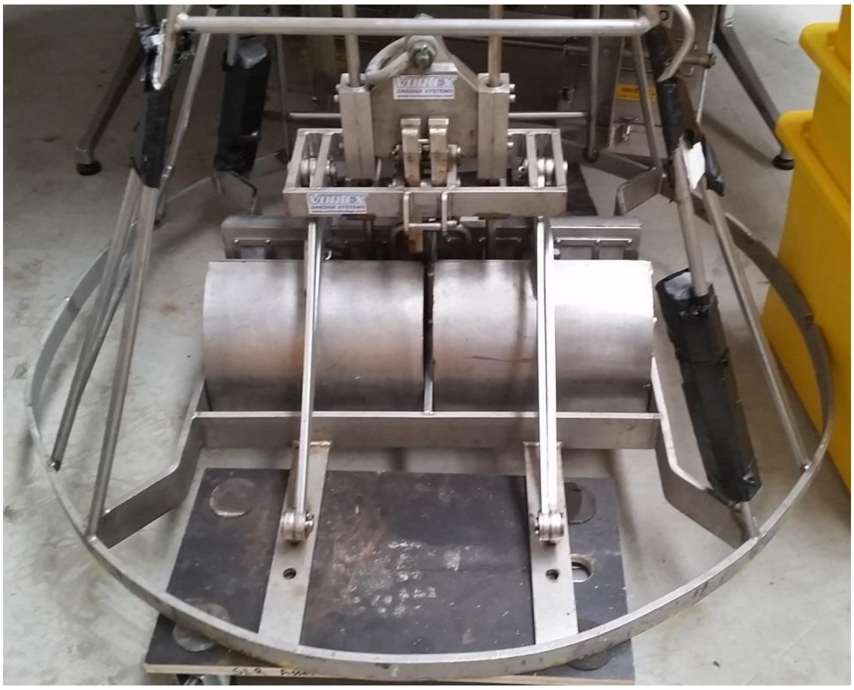
2.2.1 Benthic Grab Samples

A double Van Veen double grab sampler (**Figure 4**) was used to collect a single sediment grab sample at each of the 15 benthic monitoring stations surrounding Well J (**Figure 2**). The grab sampler is constructed of stainless steel and features two independent 'buckets' which penetrate the surficial sediments to a depth of 0.16 m. Each successful grab sample returns approximately 0.01 m^3 of seabed sediment back to the surface.

Upon arrival on the vessel deck, each grab sample is checked for completeness, which must meet the following criteria:

- The surface of the sediment is largely undisturbed upon inspection aboard the vessel;
- Sufficient sediment (≥75% of the grab capacity) is collected to enable the full suite of sediment analyses required;
- The infauna sample bucket is filled to the same volume (approximately 10 l) for all infauna replicates throughout the survey; and
- The grab has not been over-filled with sediments pushing out of the doors or drains, indicating that it may have over-penetrated the sediment.

Figure 4 The Double Van Veen Grab Sampler used for the 2018 Benthic Baseline Sampling



Each independent bucket from a grab sample is used separately for infauna and sediment physical and chemical analyses, as follows:

- Bucket one: infauna/macrofauna community analysis. The entire sample is sieved through 0.5 mm mesh until approximately 300-500 ml of residual sediment and organisms remains. This remaining material is transferred to a plastic container and preserved with a fixative (AncholTM), ready for analysis by SLR taxonomists.
- Bucket two: sediment physical nature and chemical analyses. Three 64 mm (internal diameter) clear Perspex sub-sampling cores are pushed into the sediments from the second bucket, to a depth of approximately 150 mm. Cores are photographed and the upper 50 mm from each core is extruded into a polyethylene bag for particle grain size distribution and organic content (Total Organic Carbon - **TOC**) analyses by Hill laboratories.

2.2.2 Seafloor Video Imagery

Video imagery of the seafloor was obtained using a customised tow-sled fitted with high-intensity LED lighting and a high-definition video camera (**Figure 5**). The system was connected to the vessel via a 10 mm dyneema tow-line and a 300 m umbilical cable supplying real-time video images to the camera operator on the research vessel. A pair of parallel lasers on the video sled provided an indication of scale allowing features of interest in the video recordings to be approximately sized. Ten video sled tows were conducted around Well J (**Figure 2**).

The video-sled was launched from the vessel up-current of each pre-determined location and lowered to the seabed, where it auto-located via a series of floats and weights set at specific points on the sled frame, to land upright on its lower skids. At the point where the sled contacted the seabed, a GPS log was started, and this log continued throughout the duration of the tow. Video footage was continuously recorded for approximately 200 m as the sled drifted behind the vessel; this ensured that footage was collected while the sled was passing as close as possible to the required sample location.

Figure 5 The Video Sled used for Collecting Video Imagery of the Seabed Environment

2.3 Laboratory Analyses

2.3.1 Sediment Physicochemical Analyses

Benthic sediments collected by the grab were analysed by Hill Laboratories (an NZS/ISO/IEC 17025:2005 accredited laboratory), for both physical and chemical parameters. The aims of these analyses along with further details of the analytical method/descriptions are summarised in **Table 2**.

Table 2 Summary of Analytical Methods used for Testing Sediment Physico-chemical Characteristics

Analyte	Aim	Method Number	Description
Particle Grain Size Distribution	• Determine physical parameters of the sediment particles present at the site • Correlate with infauna community characteristics	Hill Laboratories KB32136	• Sediment was wet-sieved through the following screen sizes, as per the Udden-Wentworth scale (Wentworth, 1922): • >2 mm (gravel) • >1 mm (very coarse sand) • >500 µm (coarse sand) • >250 µm (medium sand) • >125 µm (fine sand) • >63 µm (very fine sand) • <63 µm (silt and clay)
Total Organic Carbon	• Determine current level of organic carbon in sediment • Correlate with infauna community characteristics	No specific method number	Acid pre-treatment to remove carbonates present, followed by catalytic combustion (900° C, O_2), separation, Thermal Conductivity Detector. Elemental Analyser.

2.3.2 Macrofauna Analyses

Macrofaunal analyses focused on the infauna, or animals larger than 0.5 mm living within the sediment matrix. Epifaunal animals (those living on top of the sediment), were also included in the analyses to provide representation of the different functional groups present at each sample station.

Benthic macrofaunal samples collected from the sediment grab were sorted and, with the aid of a binocular microscope, identified to the lowest practicable taxonomic level or most recognisable taxa (morphologically similar group). Counts were made to assess the relative abundance of each taxa.

2.3.3 Seafloor Video Analyses

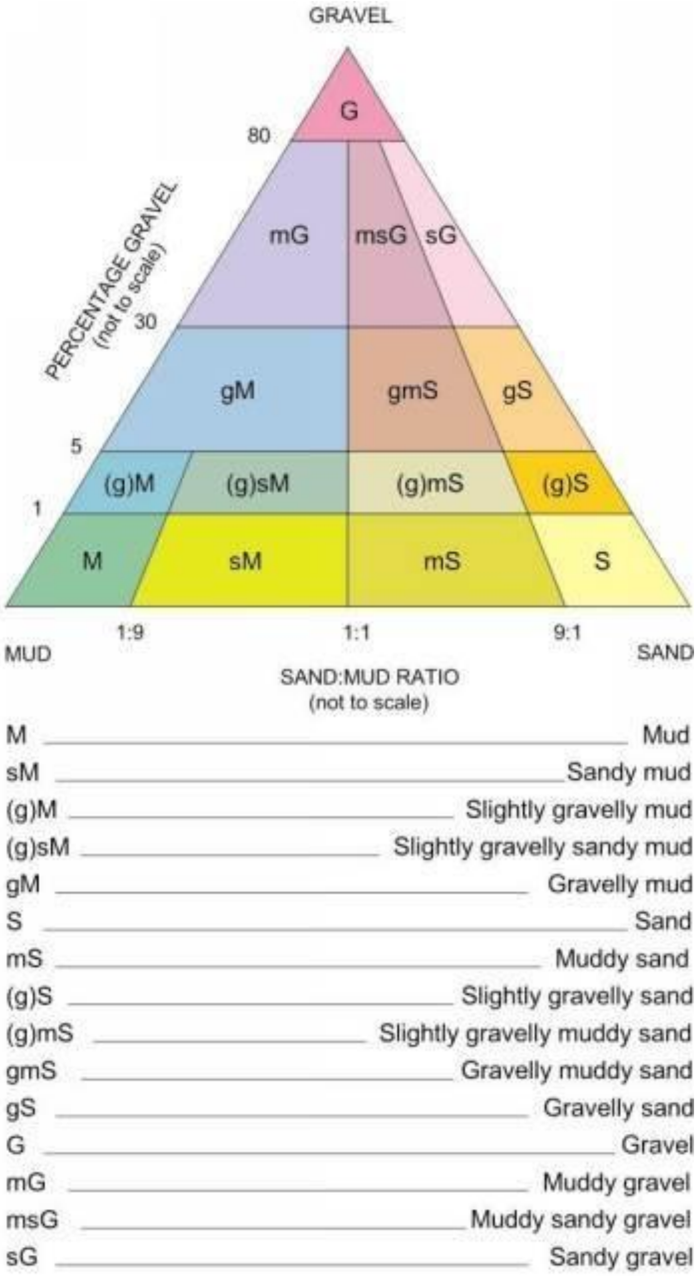
A live feed from the video-sled was captured and recorded on-board the survey vessel and viewed by SLR staff with experience in undertaking assessments of the benthic environment in the offshore Taranaki region. Brief field notes were made in real-time about obvious structures and organisms observed while watching the live footage. Back onshore the recorded seabed video footage was assessed on a large, high definition screen, by a suitably trained and experienced benthic scientist, who identified all obvious epifauna to the lowest practicable taxonomic level. Biogenic and/or anthropogenic seabed structures such as burrows, mounds, tracks and gouges/trenches were also recorded. Relative abundance estimates of epifauna or biogenic structures were made where appropriate.

2.4 Data Analyses

2.4.1 Sediment classifications

While there are many sediment classification schemes in use worldwide, a common one is a modified version of that proposed by Folk (1954). This scheme groups grains within a sample into mud, sand and gravel sized particles based on the particles diameter (mud <63 µm, sand 64-2000 µm, gravel > 2mm), and then describes the sediment type based on the relative proportions of the particles (see **Figure 6**).

Figure 6 Folk (1954) Sediment Type Classification Triangle



2.4.2 Community Characteristic Descriptors

All macrofauna (both epifauna and infauna) taxa were included in the analyses of abundance data. Species identified in the samples as not being exclusively benthic were excluded from further analyses. Data were analysed as per the statistical methods outlined below to identify current distributions and abundance of macrofauna.

2.4.2.1 Univariate Diversity Indices

Diversity indices (number of taxa S, total abundance N, Shannon-Wiener diversity H', and Pielou evenness J' (**Table 3**) were calculated from the macrofauna abundance data using the PRIMER software package (PRIMER v6.1.16; Clarke, 1993; Clarke & Warwick, 1994; Clarke & Gorley, 2006).

Table 3 Description of Macrofauna Community Characteristic Indices

Index	Formula (where applicable)	Description
Number of Taxa (S)	Count of total number of different taxa identified within the *x* sample	Total number of taxa identified within a sample
Total Abundance (N)	Sum of all individual taxa abundances within the *x* sample	Total number/count of all organisms within a sample
Shannon Diversity (H')	$H' = -SUM [(p_i) \times \log_e (p_i)]$ p_i = Number of individuals of taxa i /total number of samples	A single value (log scale) that is used to describe the different types and numbers of organisms present within an assemblage. The index value increases as assemblages have greater numbers of taxa and when the numbers of individual organisms are more evenly distributed across the different taxa. Samples dominated by single taxa will have lower values towards zero.
Pielou Evenness (J')	$J = H' / \log_e (S)$	A value theoretically between zero and one which indicates how evenly the number of individual organisms are distributed through the different taxa in an assemblage. High values (closer to 1) indicate an even spread amongst the taxa present, whereas a low value indicate an uneven spread or an assemblage highly dominated by only a few, or even a single taxon.

3 Results and Discussion

3.1 Sediment Physical and Chemical Properties

3.1.1 Visual Description of Sediment Cores

Sediment collected from around Well J was predominantly cohesive grey/brown mud, sometimes soft on surface and sometimes streaky (**Figure 7**). During sediment sampling no very dark-grey or black sediment layers (apparent Redox Potential Discontinuity), or darker patches within cores were noted and no detectable hydrogen sulphide odours were present, indicating that sediments are well oxygenated throughout the depths sampled. Field observations on sediment texture, colour and any notable features of the sediment samples were recorded during the processing of the sediment cores and infauna samples, and these are included in **Appendix A**. A full set of sediment core photographs are contained in **Appendix B**.

Figure 7 Representative Images of Sediment Core Profiles from Well J

Station J1

Station J5

Station J10

Station J12

3.1.2 Incidental Observations

During laboratory processing of the infauna samples observations were made of any debris present, including those from anthropogenic sources. Within the 15 samples collected at Well J there were 13 types of debris observed (**Table 4**), 11 of which were likely to be anthropogenic in source, including black rubber, paint flecks, plastic fragments, paint flecks and rust flakes. However, all debris encountered in the samples were at 'low' abundances.

Table 4 Incidental Observations of Debris

	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15
Garnet		L										L			
Coal		L				L			L						
Silver/red/yellow paint	L														
Blue/yellow/silver paint		L													
Green/white paint						L									
Yellow/white paint						L									
Green paint							L								
Blue/silver/white paint															L
Blue/silver paint											L				
Green plastic						L									
Blue plastic								L							
Rust	L	L	L			L	L	L							
Black rubber									L						

VA = very abundant (>50), A = abundant (50+), C = common (20–50), O = occasional (10–20), L = low (0–10)

3.1.3 Sediment Particle Grain Size Distribution and Organic Content

The physical characteristics of the sediment can influence the composition of the infauna communities and the levels of contaminants retained and observed during analyses. Particle grain size is widely used to characterise the physical structure of the sediment, while organic content provides an indication of the organic enrichment in the sediment. These combined results provide a general understanding of sediment health and the source of potential stressors at the time of sampling.

Organic matter found in the sediments is most likely derived from natural sources such as infauna/epifauna and detrital matter, rather than from anthropogenic sources. Anoxic sediments (those lacking oxygen), may develop in situations where organic matter levels increase beyond 'normal' levels for that area. Increased organic matter has the potential to disturb the equilibrium of the benthic ecosystem, as increased numbers of oxygen-utilising bacteria are required to decompose the additional organic matter, thereby rapidly reducing oxygen availability in the sediments.

A summary of the particle grain size and organic content analyses are discussed below, with full results provided in **Appendix C**.

3.1.3.1 Particle Grain Size

Sediment samples from Well J were dominated by the silt/clay (**Figure 8**) sized fractions (mean 85%, **Table 5**), with some fine sand (14%) present, classifying these sediments as 'sandy muds' (Folk, 1954), similar to the majority of offshore Taranaki areas where historical exploration/production monitoring has taken place. There were no distinct spatial patterns to the grain size distribution across the sampling stations at Well J. The sandy muds encountered at Well J were similar to those found in the Central AOI, but noticeably different to the coarse muddy sands found at Northern AOI and at Well L (**Table 5**). A comparison of particle grain size data for Well J with the other wells is provided in **Appendix C**.

In comparison to nearby well sites in the offshore Taranaki area, mean silt and clay levels at Well J were similar to those seen at the Ruru-2/Ruru3 exploration well site in 2016 (68-82% silt and clay (SLR, 2017c)) (21km north-east of Well J), and lower than those found in the Matuku-1 exploration well site in March 2016 (80-85% silt and clay (SLR, 2016b)) (32 km north-west of Well J).

Figure 8 Sediment Particle Grain Size Distribution for Samples Collected at Well J

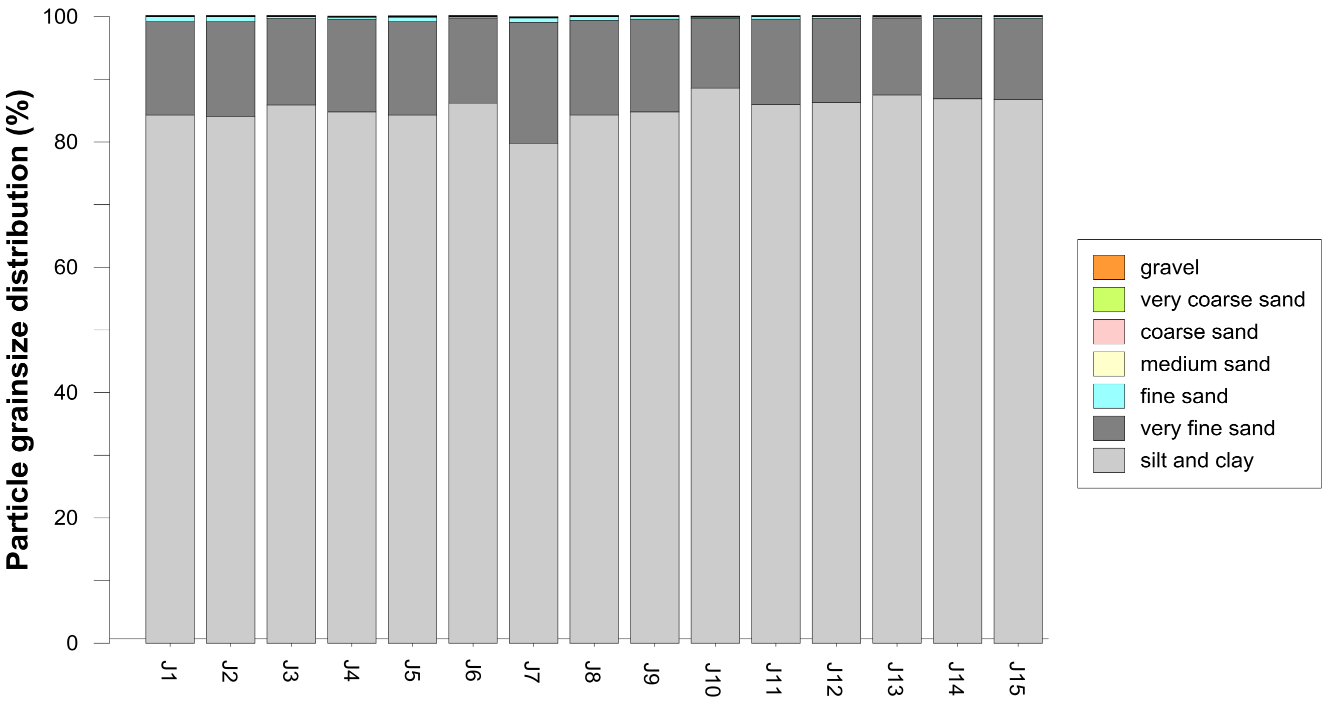


Table 5 Average Grain Size for the Eleven Wells

Grain size class	A	B	C	D	E	F	G	H	I	J	L
Silt & Clay (Mud) (%)	36.2	27.5	41.1	30.7	85.2	83.2	67.8	72.6	65.1	85.4	30.8
Very Fine Sand (%)	45.8	39.3	30.5	41.7	6.5	4.8	6.1	5.8	6.6	14.2	25.4
Fine Sand (%)	17.0	28.6	22.4	26.8	8.0	11.3	24.6	19.0	22.1	0.4	29.8
Medium Sand (%)	1.0	2.4	3.3	0.7	0.4	0.6	1.6	2.5	5.1	0.1	12.3
Coarse Sand (%)	0.1	0.7	0.8	0.0	0.0	0.1	0.1	0.1	0.6	0.0	1.2
Very Coarse Sand (%)	0.0	0.6	0.5	0.0	0.0	0.1	0.1	0.1	0.5	0.0	0.2
Gravel (%)	0.1	1.1	1.3	0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.1
Description	mS	mS	mS	mS	sM	sM	sM	sM	sM	sM	mS

Note: sM = sandy mud, mS = muddy sand

Colour scale based on percentage with median mid-point (Median is 2.0):

0%	5	10	20	30	40	50	60	70	80	90	100

3.1.3.2 Total Organic Carbon

The organic content of sediments was assessed by measuring TOC to assess benthic ecology as this is also consistent with what is now currently undertaken around the offshore Taranaki oil and gas fields.

TOC levels at Well J (**Figure 9**) ranged between 0.63% and 0.78% (mean 0.71%), and did not show any distinct spatial trends or patterns.

The average organic content around Well J was high relative to other wells monitored as part of the EAD Benthic Baseline survey (mean 0.71% compared to overall mean of 0.45%). The combined mean for the two Southern AOI wells (0.48%) was moderate relative to the Northern and Central AOIs (0.26% and 0.59%, respectively); however, the mean for the Southern AOI should be interpreted cautiously due to the large variation between Well J and L. As has been previously described in benthic environmental monitoring associated with offshore Taranaki oil and gas activities (SLR, 2016 & SLR, 2017), there is a correlation between sediment particle grain size and sediment organic content. The comparatively greater surface area to volume ratio of silt and clay (mud/fines) sized sediment particles (compared to larger particles like sand) gives a greater area for adsorption of organic matter particles and therefore a higher probability of elevated organic matter compared to coarser/sandier sediments subjected to the same level of enrichment (Hedges *et al.*, 1993). This is likely to explain some of the large difference in mean TOC levels between Well J and L (high at J, low at L) where there were noticeably different grain size distributions (coarser muddy sands at Well L) (**Section 3.1.3.1**).

Figure 9 TOC Concentrations in Sediment Samples Collected from around Well J

3.2 Video Sled Imagery

Video footage of the seabed allows scientists to visually assess any anthropogenic disturbance to the benthic environment and observe epifauna, sediment-type and structures or relief that exist on the seabed.

Video footage was captured by towing a video sled through ten stations around Well J (**Section 2.2.2**). All video footage is included with the electronic version of this document, with a selection of still images displayed in **Figure 10**. **Appendix A** provides locational information for each video sled tow.

Video footage was assessed to determine any defining features and their semi-quantitative abundance recorded for comparison with other wells. Due to caveats associated with video footage (i.e. variable visibility, differing tow length and durations) the counts are indicative-only and should not be interpreted as a quantitative assessment. **Table 6** presents the results of this semi-quantitative approach, which summaries the counts by comparing the well total to the median across all of the EAD wells in the three AOIs. As a visual aid, counts were categorised in relation to the deviation from the 10th, 25th 50th, 75th and 90th percentiles, so that differences between wells can be more easily viewed.

3.2.1 Physical Observations

The seabed around Well J was observed to have soft mud sediments. Evidence of bioturbation was observed at all stations in the form of animal burrows. Moderate abundances of burrows were prevalent in Well J video transects (**Figure 10**) with occasional patches of very low and higher abundances of worm holes (**Figure 10**). This is similar to other wells in the Southern and Central AOIs but differs from the Northern AOI where abundances were predominantly low (**Table 6**).

Mound/hollow features (image E and F, **Figure 10**) were observed in moderate numbers (42 in the ten tows) compared to the median for all wells (43) (**Table 6**). The observed abundances were well below those seen at Wells D (280) (Northern AOI) and L (532) (Southern AOI). These features are thought to be formed by the feeding activities of sharks or rays, or by large burrowing tube worms or shrimps mounding up sediment. Mound/hollow features were observed to be most numerous at the Northern AOI wells, moderate to very high at the Southern AOI wells, and low to very low in numbers around the Central AOI wells.

While there was no definitive sign of anthropogenic physical disturbance of the seabed observed during the video sled tows around Well J, a shallow trench was seen at monitoring station JV8 that is likely to have been caused by bottom trawl commercial fishing activity. These were seen in greater numbers at Well H, I and C locations. There were no other signs of anthropogenic physical disturbance or signs of sediment enrichment.

Table 6 Total Number of Features Observed in Video Imagery from the EAD Wells

Well	Depth (m)	Mounds/ Hollows	Number of burrows/worm holes	Sea pen	Fish	Substrate	Notes
A	148	111	Low-moderate	54	65	Muddy sand	Ripples; some very large holes and mounds
B	134	63	Low-moderate	35	49	Muddy sand	Some very large holes mounds
C	132	85	Low-moderate	50	44	Muddy sand	Ripples; trenches observed
D	145	280	Low	160	28	Muddy sand	Ripples; 23 very large sea feathers
E	126	29	Moderate	29	16	Sandy mud	
F	128	20	Moderate	19	19	Sandy mud	
G	124	18	Moderate-High	29	26	Sandy mud	
H	124	18	Moderate-High	17	26	Sandy mud	12 elongated shallow trenches
I	122	43	Moderate-High	36	21	Sandy mud	5 elongated shallow trenches (large)
J	108	42	Moderate	14	30	Sandy mud	School of mackerel, tufts/tubes common
L	112	532	Moderate	132	31	Muddy sand	2 schools of mackerel
Median		43		35	28		
Totals are sum of 10 video tows carried out at each site. Totals are semi-quantitative only due to variable visibility and transect length.							

10th percentile band
25th percentile band
Median band
75th percentile band
90th percentile band

3.2.2 Infauna, Epifauna and Other Fauna

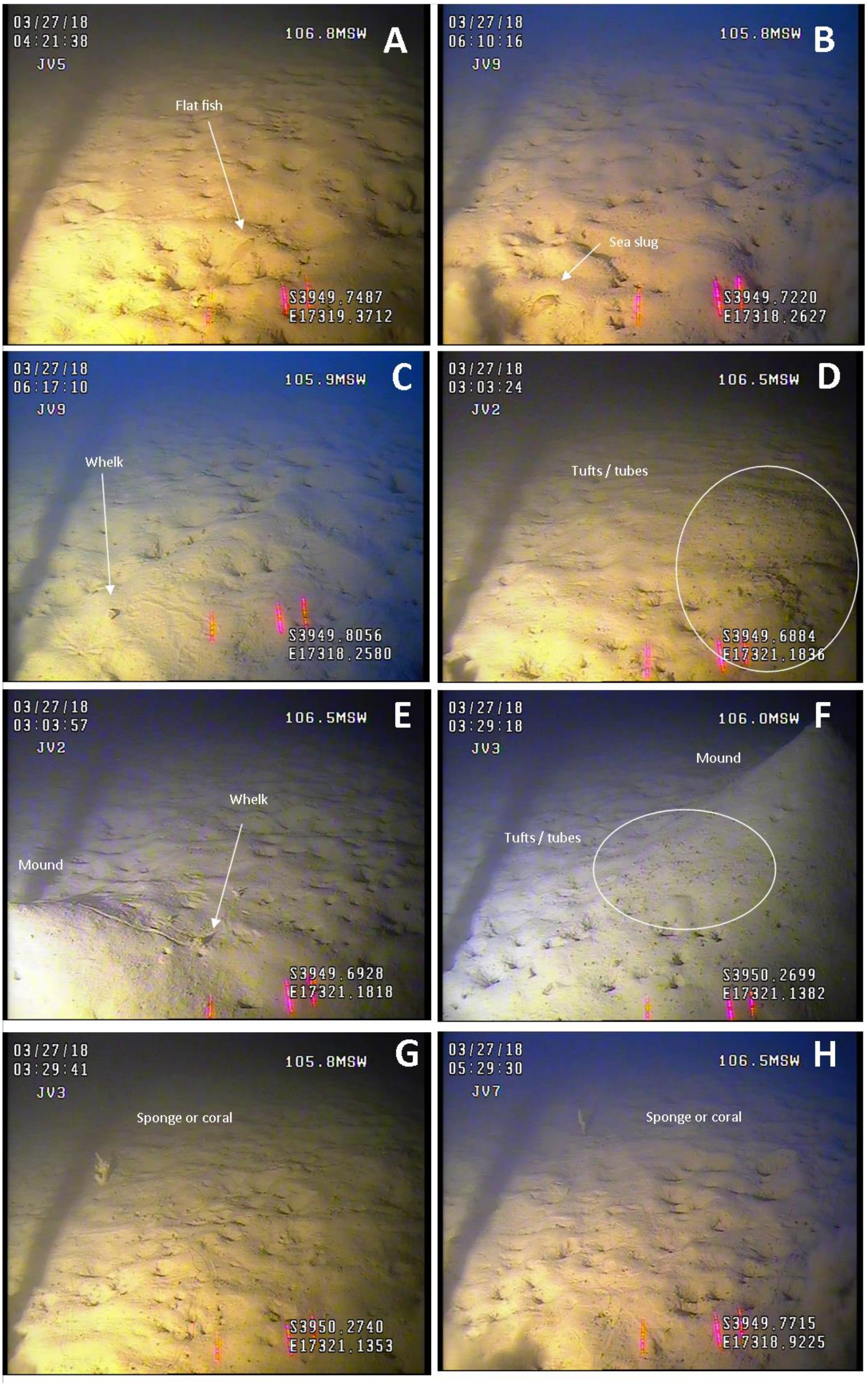
In some cases, a definitive positive identification of infauna, epifauna and more mobile taxa was not possible from the video footage alone. Where there was any uncertainty, identifications were based on distinctive features, colours and shapes of organisms and in some cases the confirmed presence of similar looking individuals within the infauna samples.

Epifauna taxa observed in video footage collected around Well J included a small number of whelks (likely *Austrofusus glans*) (image C and E, **Figure 10**) and other molluscs such as tusk shells (likely *Fissidentalium zelandicum*). The presence of epifauna tracks in the sediment (image E, **Figure 10**) indicates that mobile fauna such as whelks and hermit crabs move throughout this site. A small number of sponges were observed at some stations, some of which may have been tunicates, corals or even sea slugs (images B, G and H, **Figure 10**. Colonies made up of small black tufts or tubes were common around this well (image D and F, **Figure 10**).

Sea pens (likely *Virgularia* sp.) (image C, **Figure 10**) were seen in very low densities at Well J (14 in the ten tows), compared to the median for all wells (35) (**Table 6**). Sea pens were observed to be more numerous at the Northern AOI, variable at the Southern AOI, and lowest in the Central AOI.

Mobile fish species were observed in moderate numbers (30 fish across the ten tows) compared a median of 28 for all wells) (**Table 6**). Species observed include a school of mackerel (*Trachurus sp.*), gurnard (likely *Chelidonichthys kumu*), flatfish (likely *Peltorhamphus* sp.) (image A **Figure 10**), dogfish (*Squalus acanthias*.), opalfish (likely *Hemerocoetes monopterygius*) and pilchard (likely *Clupeidae* sp.). A number of smaller fish were seen taking off very quickly as the camera approached and it was not possible to make any definitive observations about these animals. Fish were observed to be much more numerous at the Northern AOI sites, moderate at the Southern AOI sites, and moderate to low in numbers around the Central AOI sites.

Figure 10 Representative Images of Seabed Environment around Well J



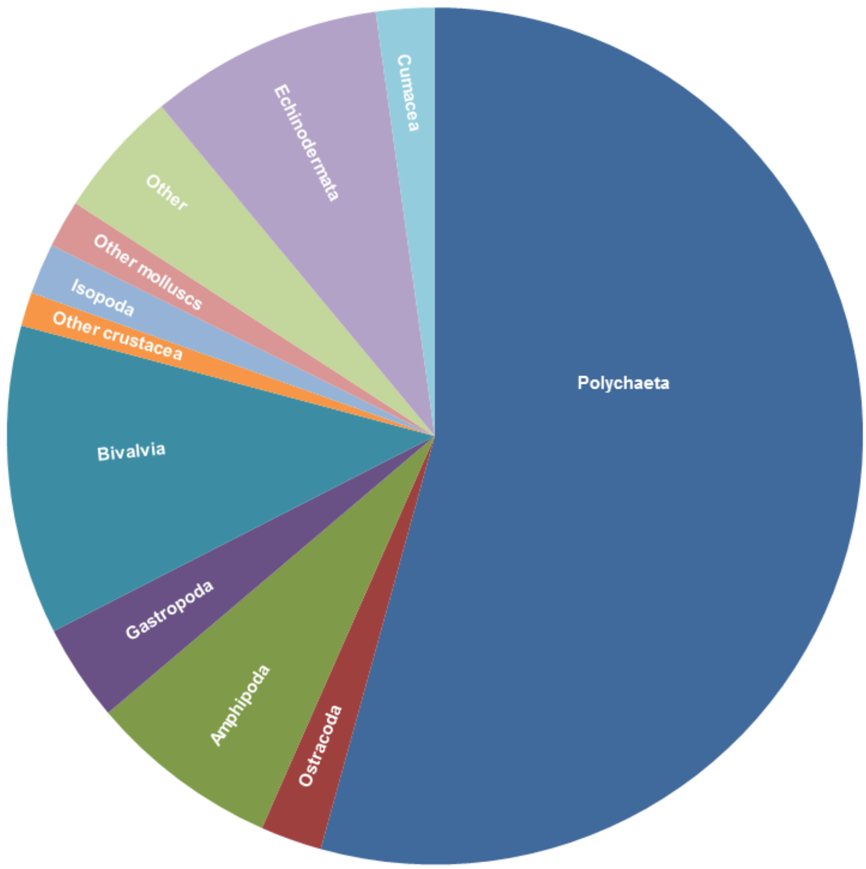
3.3 Macrofauna Characteristics

3.3.1 Benthic Macrofauna

Overall 1,722 individuals representing 108 taxa were identified in the 15 macrofauna samples collected at Well J. Infauna communities were dominated by small polychaete worms (935 individuals (54%), 41 taxa), crustaceans (257 individuals (15%), 27 taxa, mostly Amphipoda, Isopoda and Ostracoda), molluscs (295 individuals (17%), 24 taxa, mostly bivalves), and echinoderms (152 individuals (8%), 3 taxa) (**Figure 11** and **Figure 12**). The raw macroinvertebrate data from Well J monitoring stations is provided in **Appendix D**.

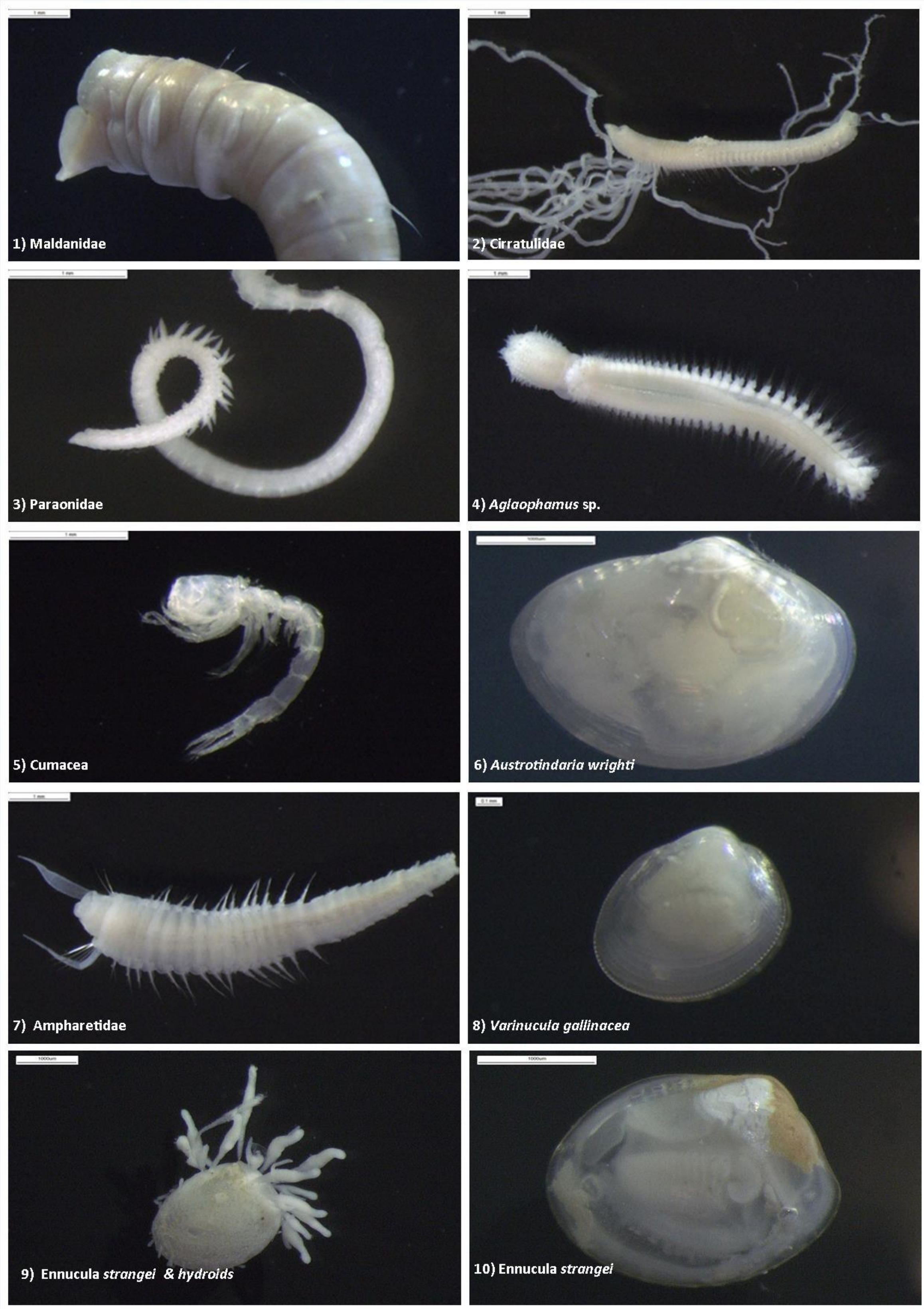
When the benthic macrofauna results are compared across the three AOIs, polychaetes and gastropods were found in lower numbers in the Southern and Northern AOIs compared to the Central AOI. Crustaceans (Tanaidacea and Copepoda) and nematodes were found in higher numbers in the Northern AOI wells compared with the Central and Southern AOIs (**Appendix E**). This result is likely linked to the differences in sediment composition, where a coarser grain size was present in the Northern AOI compared to the Central and Southern AOIs.

Figure 11 Proportion of Individuals at Well J Belonging to each Taxonomic Group



'Other Crustacea' includes Decapoda and Tanaidacea. 'Other molluscs' includes Aplacophora and Scaphopoda. 'Other' includes Anthozoa, Chaetognatha, Hemichordata, Nematoda, Nermetea, Oligochaeta, Sipuncula, Tunicata and Cypridinodes sp.

Figure 12 Representative Images of Benthic Infauna Taxa Frequently Observed in Offshore Taranaki Area



3.3.2 Univariate Indices of Infauna Communities

Univariate indices (total number of taxa, total abundance, Pielou's evenness and Shannon-Wiener diversity) describing the benthic macroinvertebrate communities found at Well J are displayed in **Figure 13**.

The number of taxa identified in each sample collected around Well J varied from 25 to 49 (mean 40), while total abundance ranged from 69 to 167 individuals (mean 115). Abundance and taxa numbers at Well J were similar to the overall mean values for the Central AOI (29 taxa, 69 individuals, **Table 7**), which were notably lower than those of the Northern AOI and Well L in the Southern AOI.

Evenness values vary on a scale between zero and one, with values near one indicating that infauna abundances are evenly distributed across all the different taxa present, while values near zero indicate infauna communities are being numerically dominated by a large number of individuals from just a few, or even only single taxa. Values from the Benthic Baseline data collected at Well J were relatively high (mean 0.88), indicating relatively even distribution of taxa abundances across the taxa that were present.

Shannon-Wiener diversity index values range between 0 and 4 with higher values indicating higher species diversity. From previous benthic studies in the offshore Taranaki region, species diversity values are normally between 1.5 and 3.5. The mean Shannon-Weiner diversity index for Well J was 3.2, and ranged between 2.9 and 3.4. These results are high relative to the most recent results from the long term benthic monitoring programme at the Maari Field, located in the Southern AOI, 29km northeast of Well J, which had a mean species diversity of 2.9.

Figure 13 Total Number of Taxa, Total Abundance, Pielou's Evenness and Shannon Wiener Diversity Index Values for Macrofauna Samples Collected at Well J

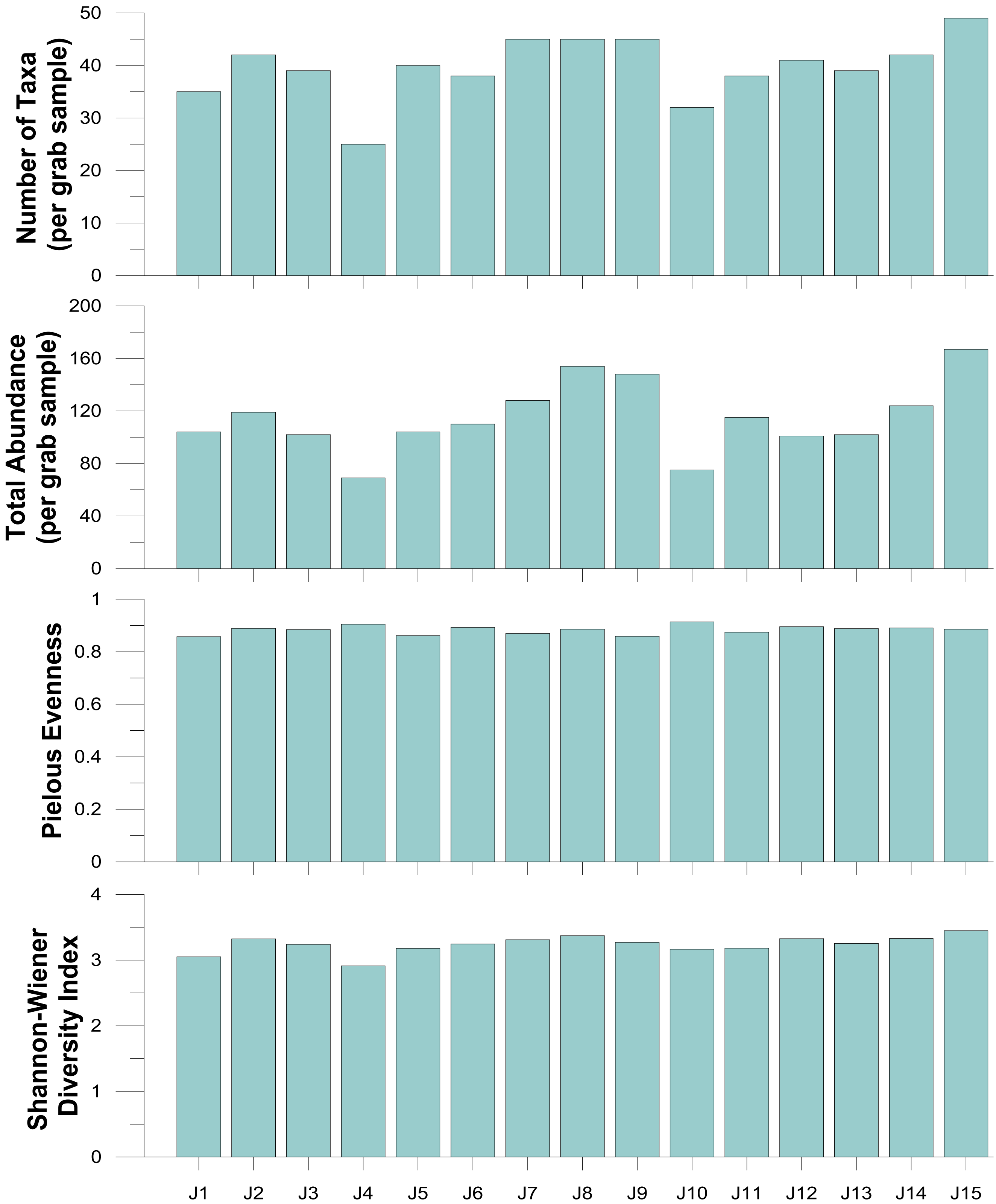


Table 7 Number of Taxa and Total Abundance for the Eleven Wells

Site	Mean Number of Taxa	Mean Abundance	Total Number of Taxa Identified at site	Total number of individuals (abundance)
A	56	257	140	3,849
B	53	210	130	3,151
C	45	132	128	1,987
D	60	332	142	4,986
Northern AOI	53	233		
E	19	36	78	542
F	31	68	90	1,023
G	33	81	112	1,215
H	31	89	103	1,339
I	29	72	91	1,075
Central AOI	29	69		
J	**40**	**115**	**108**	**1,722**
L	54	190	131	2,853
Southern AOI	47	153		

3.4 Sensitive Environments

In an investigation of sensitive substrate/benthic habitats in the Taranaki Coastal Marine Area, Johnston (2016) studied marine taxa databases from marine benthic surveys conducted in the offshore Taranaki Basin and noted that there are many locations where at least one 'characteristic species of sensitive environments' was found. This investigation used the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activities Regulations**) sensitive environments descriptions to define what sensitive habitats may be present.

Chaetopteridae worms and Sea pens were noted by Johnston (2016) as likely to be present in areas close to the 11 wells. In relation to the sampling techniques used in the Benthic Baseline survey (grab sampling and video sled imagery), MacDiarmid *et al*. (2013) define that;

"A sensitive Chaetopteridae worm field is present if worm tubes and/or epifaunal species:

- Occupy 25% or more of the seabed in imaging surveys covering and area of 500 m^2 or more; or
- Occur in two successive samples collected using point sampling gear."

and

"A sea pen field exists if:

- One or more specimens of any species of sea pen is found in two successive samples collected using point sampling gear, or
- Two or more specimens per m^2 are found in seabed imaging surveys, or surveys using towed gear."

Analysis of the infauna samples collected during the Benthic Baseline survey found that Chaetopteridae worms (specifically *Phyllochaetopterus socialis*, commonly known as wire-weed or Tarakihi weed) were present within samples from Wells A, B, C, D, G, H, J and L. The majority had only single individuals at a small number of sampling stations at each site, with Well J having two individuals in sample L5 and one in sample L7. Across the ten video sled tows performed at Well J there were no distinct worm-fields or the low-relief worm-meadows that *P. socialis* often form observed. Thus, while this sensitive environment species was present at Well J the distributions appeared more as "isolated individuals within mixed epifaunal assemblages" at two stations rather than "dense mono-specific meadows at the tens of kilometres scale" (MacDiarmid *et al*., 2013).

A single individual sea pen (*Virgularia gracillima*) was identified in infauna samples from Well J during the Benthic Baseline Survey. Video imagery collected observed sea pens at all of the sites (see **Table 6** for total numbers of sea pens observed across the ten tows at each well). Sea pen numbers observed at Well J were relatively low (14), with the highest numbers observed at Wells D (160) and L (132). Sites within the Northern AOI had greater numbers compared to Central and Southern AOI sites. The variable visibility encountered during video sled imagery means this method can only be qualified as semi-quantitative; however, approximate densities can be calculated based on the approximate width of the camera's field of view and the length of each tow. Based on such calculations sea pen densities at Well J would not have surpassed the trigger of two sea pens per square meter (MacDiarmid *et al*., 2013), and video tows at Well J did not pass through more spatially limited areas of higher density that might have been classed as 'sea pen fields'. Based on the video sled analysis there are no 'Sensitive Environments', as defined by the Permitted Activities Regulations were encountered at the monitoring stations at Well J.

4 Key Findings

4.1 Sediment Characteristics

Grain size analysis at Well J showed sediments to be sandy muds, with no distinct spatial patterns to the variations in grain size and TOC across the 15 sampling stations. The sandy mud sediments were distinctly different to the coarser muddy sands present at the other Southern AOI site (Well L), but very similar to silt and clay dominated sediments in the Central AOI.

TOC levels at the Well J (0.71%) were notably higher than those seen at Well L (also in the Southern AOI), and the Northern AOI sites, but similar to levels in the Central AOI. Drilling muds themselves contain little or no organic matter and historical pre- and post-drill monitoring surveys in the South Taranaki Basin have observed distinct decreases in mean organic matter levels in the initial post-drill surveys at stations closest to the wellhead where significant amounts of drilling muds have settled. Sediments with a finer grain size will retain higher levels of organic matter compared to coarser/sandier sediments subjected to the same level of enrichment/deposition.

4.2 Faunal Characteristics

Video sled imagery from the ten sampling stations surrounding Well J showed the seabed to be relatively flat, but interrupted by mounds and animal burrows/holes. Whelks, small molluscs, sea pens, and evidence of mobile epifauna such as hermit crabs were observed during the tows and mobile fish were seen in moderate numbers compared to other wells. Fish and mound/hollow features were observed to be more numerous at the Northern AOI sites, moderate to high at the Southern AOI sites, and low around the Central AOI sites.

Infauna communities in Well J samples contained proportionally more small bivalves and polychaetes than the remaining Southern AOI site (i.e. Well L). While the Southern AOI contained proportionally more echinoderms and bivalves than the Northern and Central AOIs, it had fractionally less polychaetes (although still relatively close to the Northern AOI).

The number of taxa and total infauna abundances at Well J were similar to the overall mean values for the Central AOI, which were notably lower than those of the Northern AOI and Well L in the Southern AOI.

The finer sediments present at Well J, and at Central AOI sites, compared to coarser sandy sediments at Well L and the Northern AOI, are likely linked to the greater proportions of taxa such as echinoderms and gastropods. Taxa within these groups that were identified in Well J samples were largely scavengers/detritivores and/or deposit feeders which feed on larger dead materials on/in the sediment, as well as organic matter within the sediments. This feeding mechanism is more suited to muddy sediments where there is comparatively greater proportions of organic matter for given volumes of sediment, compared to coarser sediments such as sands.

Taxa more adapted for filter feeding (e.g. copepods, Tanaidacea, amphipods) have delicate feeding and breathing structures which are more easily clogged/damaged by high levels of very fine sediments. Thus these taxa are often more abundant at wells with coarser sediments. Coarser sediments, particularly larger sands, gravels, shell hash, etc., provide more three-dimensional, cryptic habitats, allowing a wider variety of taxa to find different suitable habitats than mud-dominated sediments.

4.3 Sensitive Environments

Some individuals representing '*characteristic species of sensitive environments*' were found within the macrofauna grab samples (e.g. Chaetopteridae worms and sea pens) and observed in video imagery (e.g. sea pens) during the Benthic Baseline survey at Well J. However, observations from the video imagery indicated that no 'Sensitive Environments', as defined by the Permitted Activities Regulations (using MacDiarmid *et al.*, 2013) were encountered at the monitoring stations surveyed at Well J. Therefore, it is considered that Well J should not be classified as sensitive sites or habitats as defined by MacDiarmid *et al.* (2013).

5 References

Clarke K. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18 (1): 117-143.

Clarke K.R., Warwick R.M., 1994. Change in marine communities: An approach to statistical analysis and interpretation. Plymouth Marine Laboratory, UK.

Clarke K.R., Gorley R.N., 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth.

Folk, 1954. *"The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature",* The Journal of Geology 62(4):344-359.

Hedges JI, Keil RG, Cowie GL, 1993, "Sedimentary diagenesis: organic perspectives with inorganic overlays", Chemical Geology 107: 487-492.

Johnston O, Barter P, Ellis J, Elvines D, 2014, "*Recommendations for an Offshore Taranaki Environmental Monitoring Protocol: Drilling- and production-related discharges, Version 1.0*" (OTEMP), Cawthron Report No. 2124.

Johnston O 2016. Sensitive habitats and threatened species in the Taranaki Coastal Marine Area (TCMA) - database investigation. Prepared for Taranaki Regional Council. Cawthron Report No. 2877. 28 p. plus appendices.

MacDiarmid, A., Bowden, D., Cummings, V., Morrison, M., Jones, E., Kelly, M., Neil, H., Nelson, W., Rowden, A., 2013. '*Sensitive marine benthic habitats defined*'. Prepared for Ministry for the Environment, NIWA Client Report No: WLG2013-18.

SLR, 2016. "Benthic Ecological Survey – Tui Field facilities. Production Discharge Monitoring, February 2016" prepared for AWE Taranaki Limited, report number 740.10040.

SLR, 2016b. "*Benthic Ecological Survey - Matuku-1 Exploration Well Post-Drill Assessment, March 2016*". Prepared for OMV New Zealand Limited. Report Number 740.10013.00240

SLR, 2017a, "Benthic Ecological Survey for the Maui Platform Alpha. Annual Production Monitoring – April 2017", prepared for Shell Todd Oil Services Limited, SLR Report Number 740.10041.00300-R01--v0.1

SLR, 2017b. "Benthic Ecological Survey for the Oi-1 and Oi-2 Exploration Wells. Post-drill Assessment – November 2016". Prepared for Tamarind Taranaki Limited, report number 740.10025.00100-R01.

SLR, 2017c. *"Ecological Benthic Monitoring - Ruru-2 and Ruru-3 Exploration Wells. September 2017 Post-Drill Survey"*

SLR, 2018. "Tui Field Ecological Effects Monitoring Report". Prepared for Tamarind Taranaki Limited, report number 740.10040.00100-R01-v0.1. Report Number 740.10041.0022-R01

SLR, 2017c. *"Ecological Benthic Monitoring - Ruru-2 and Ruru-3 Exploration Wells. 2017 Post-Drill Survey"*

APPENDIX A

Locations and Observations from Sediment Grab Sampling and Video Sled during the 2018 Benthic Baseline Survey

Station	Date	Time	Depth (m)	Coordinates (NZTM)		Notes
				Easting	Northing	
Grab Sample Sites						
JG 1	27/3/18	1422	108	1632985	5591158	Soft brown / grey mud
JG 2	27/3/18	1411	108	1630986	5591164	Cohesive grey / brown mud
JG 3	27/3/18	1400	108	1628984	5591167	Streaky cohesive mud, grey / brown
JG 4	27/3/18	1351	108	1627986	5591170	Cohesive grey / brown mud
JG 5	27/3/18	1301	108	1626985	5591170	Cohesive grey / brown mud
JG 6	27/3/18	1341	108	1625986	5591170	Soft grey / brown mud
JG 7	27/3/18	1333	108	1624985	5591164	Grey / brown mud, cohesive at depth, soft surface
JG 8	27/3/18	1519	108	1629995	5593169	Cohesive grey / brown mud
JG 9	27/3/18	1510	108	1629997	5592168	Soft surface, cohesive deeper, brown grey
JG10	27/3/18	1458	108	1630000	5590173	Very streaky, cohesive grey brown mud
JG11	27/3/18	1449	108	1629995	5589160	Cohesive grey / brown mud. Rope jammed in pulley
JG12	27/3/18	1320	108	1626987	5593169	Cohesive grey / brown mud, sticky
JG13	27/3/18	1311	108	1626987	5592172	Cohesive grey / brown mud, sticky
JG14	27/3/18	1253	108	1626985	5590169	Soft grey / brown mud
JG15	27/3/18	1243	108	1626986	5589169	Cohesive grey mud
Video Sled Tow Locations						
JV 1	27/3/18	0735	107	1631994	5592675	
JV 2	27/3/18	0758	106	1631991	5591174	
JV 3	27/3/18	0821	106	1631995	5589672	
JV 4	27/3/18	0854	107	1628486	5592674	
JV 5	27/3/18	0914	107	1627986	5591170	
JV 6	27/3/18	0937	106	1628492	5589666	
JV 7	27/3/18	1019	107	1626985	5591170	
JV 8	27/3/18	1045	105	1625989	5592667	
JV 9	27/3/18	1106	106	1625485	5591166	
JV10	27/3/18	1127	106	1625991	5589668	

APPENDIX B

Sediment Core Profile Images from all Grab Samples Collected during the 2018 Benthic Baseline Survey at Well J


JG1.JPG


JG10.JPG


JG11.JPG


JG12.JPG


JG13.JPG


JG14.JPG


JG15.JPG


JG2.JPG


JG3.JPG


JG4.JPG


JG5.JPG


JG6.JPG


JG7.JPG

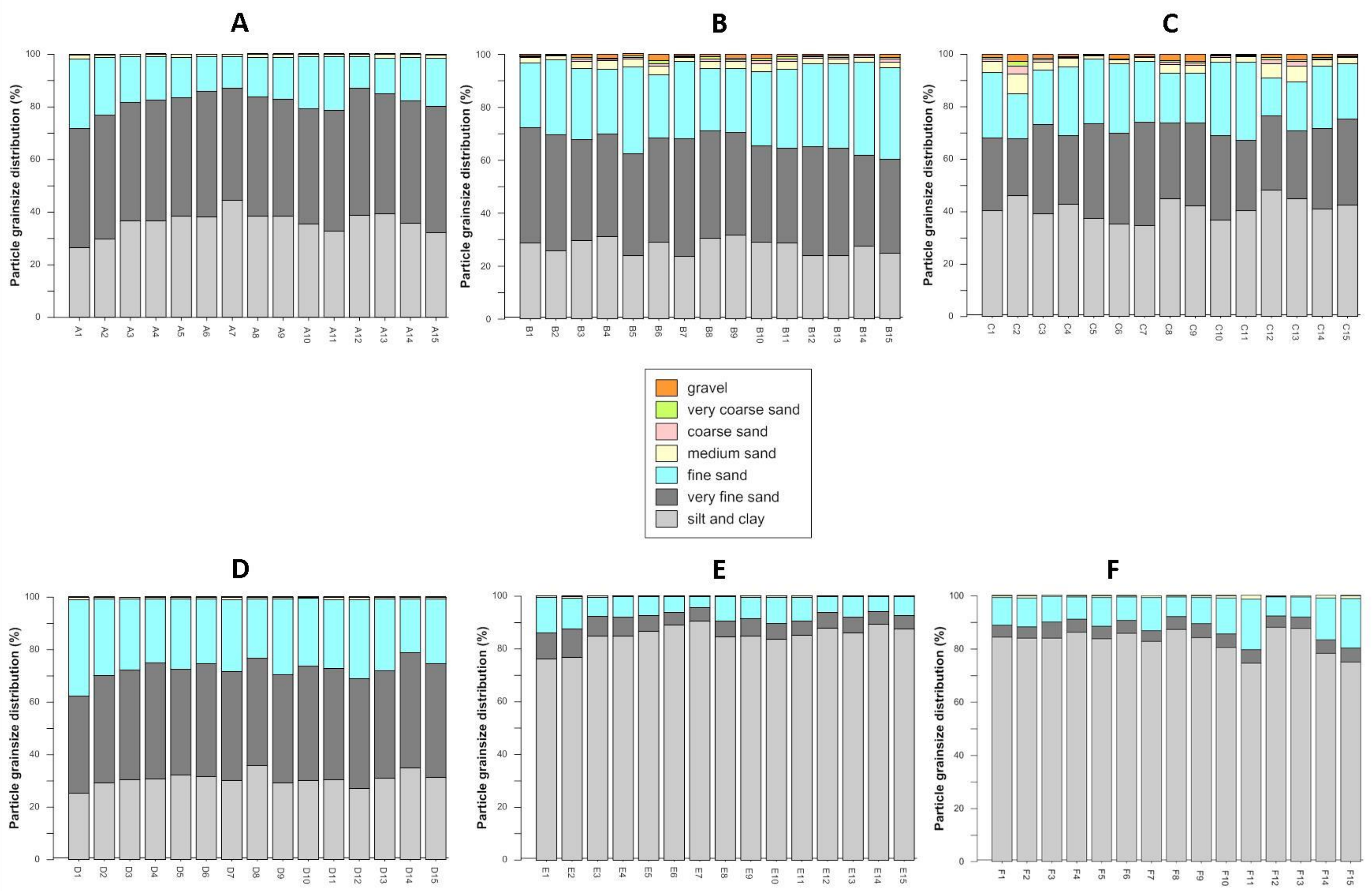

JG8.JPG

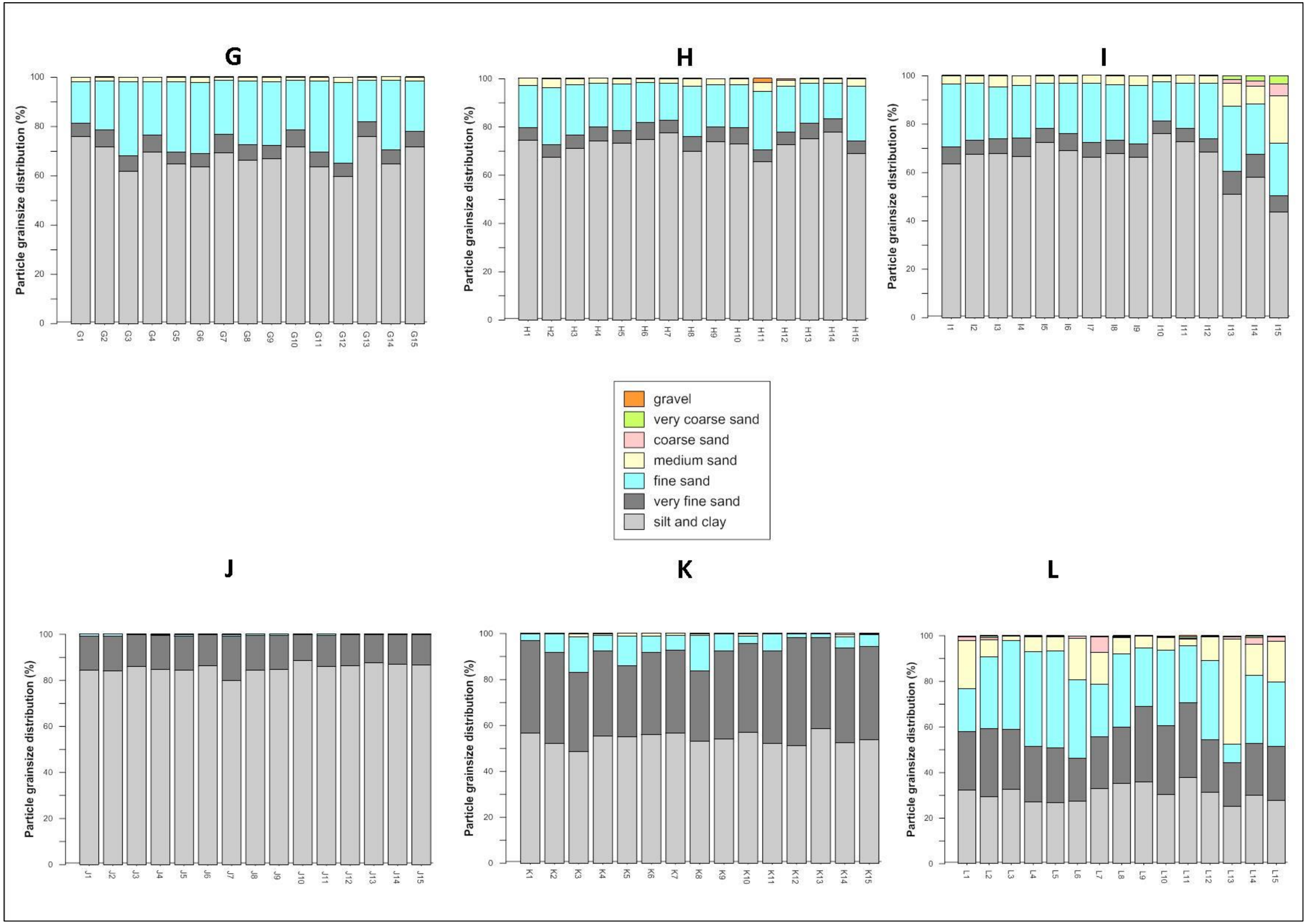

JG9.JPG

APPENDIX C

Total Organic Carbon Content and Particle Grain Size Distribution for Well J

Replicate Sample	TOC (%)	Gravel (%)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Silt & Clay (Mud) (%)
Station J1	0.7	0.05	1.3	1.3	3.3	4.9	16.6	72.6
Station J2	0.76	0.05	2	2.5	8.2	4.5	16	66.9
Station J3	0.78	0.05	2.3	2.1	10.3	3.9	12.5	68.9
Station J4	0.77	0.05	0.8	1	3.2	4.9	15.3	74.8
Station J5	0.74	0.05	1.3	1.9	9.3	3.5	14.2	69.7
Station J6	0.71	0.05	2.6	1.8	2.2	3.8	14.8	74.9
Station J7	0.63	0.05	1.7	3	7.5	3.2	16.5	68.1
Station J8	0.72	0.05	1.7	2.8	3.5	4.8	15.7	71.6
Station J9	0.67	0.05	2.3	4.5	10.4	2.8	13.9	66.1
Station J10	0.73	0.05	0.05	0.05	0.05	0.2	11.1	88.6
Station J11	0.73	0.05	0.05	0.05	0.05	0.4	13.6	86
Station J12	0.7	0.05	0.05	0.05	0.05	0.3	13.4	86.3
Station J13	0.71	0.05	0.05	0.05	0.05	0.2	12.3	87.5
Station J14	0.67	0.05	0.05	0.05	0.05	0.3	12.8	86.9
Station J15	0.68	0.05	0.05	0.05	0.05	0.3	12.9	86.8


A
B
C
D
E
F
Particle grainsize distribution (%)
0
20
40
60
80
100
A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15
B1 B2 B3 B4 B5 B6 B7 B8 B9 B10 B11 B12 B13 B14 B15
C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12 C13 C14 C15
D1 D2 D3 D4 D5 D6 D7 D8 D9 D10 D11 D12 D13 D14 D15
E1 E2 E3 E4 E5 E6 E7 E8 E9 E10 E11 E12 E13 E14 E15
F1 F2 F3 F4 F5 F6 F7 F8 F9 F10 F11 F12 F13 F14 F15
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay


G
H
I
J
K
L
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay

APPENDIX D

Raw Counts of Macroinvertebrate (Infauna and Epifauna) Abundance at Well J

Taxa	Class/Order	Phylum	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15
Aglaophamus sp.	Polychaeta		7	5	12	10	10	7	9	10	8	7	13	11	7	8	7
Ampelisca sp.	Amphipoda	Crustacea	1	1	1		1	2	1	1		1	1			3	3
Ampharetidae	Polychaeta		3	2	3		2	3	3	9	2	1		2			5
Amphipoda	Amphipoda	Crustacea	1	2	3	1	3	2	3	6	4		6	6	4	4	6
Anemone Unid.	Anthozoa	Cnidaria														3	
Anthuridae	Isopoda	Crustacea	1													1	
Aphroditidae	Polychaeta																1
Aplacophora	Aplacophora	Mollusca		1	1				2		2						4
Arachnanthus sp.	Anthozoa	Cnidaria	2						1								
Aricidea sp.	Polychaeta					4	2	1	1			2	2	1	3	2	3
Armandia maculata	Polychaeta			1	1			2			1					1	2
Armandia maculata (juvenile)	Polychaeta														1		
Arthritica bifurca	Bivalvia	Mollusca					1										
Asellota	Isopoda	Crustacea					1		1				1			1	3
Axiopsis sp.	Decapoda	Crustacea		1	1	1	1	1		1		2			1		2
Bivalvia (Unid.)	Bivalvia	Mollusca		1							1						
Brachyura larvae	Decapoda	Crustacea													1		
Cadulus teliger	Scaphopoda	Mollusca		1		1		3	2	3	3		2	1	2	2	1
Capitellethus zeylanicus	Polychaeta		4	7	2	2	4	4	4	2	4	1	7	4		6	5
Chaetognatha	Chaetognatha						1							1			
Cirratulidae	Polychaeta		4	10	5	2	2	4	7	12	13	8	15	5	11	16	8
Cossura consimilis	Polychaeta				1			2			1				4	1	
Cumacea	Cumacea	Crustacea		3	5		6	2	3	3	4	2	1	2	2	1	4
Curveulima aupouria	Gastropoda	Mollusca											1				
Cuspidaria wellmani	Bivalvia	Mollusca								2							
Cyclostrematidae	Gastropoda	Mollusca												1			
Cymbicopia hispida	Ostracoda	Crustacea		1						1			1				1
Cypridinodes sp										1		2	2		2	1	
Cytherella sp.	Ostracoda	Crustacea	1					1		1						1	

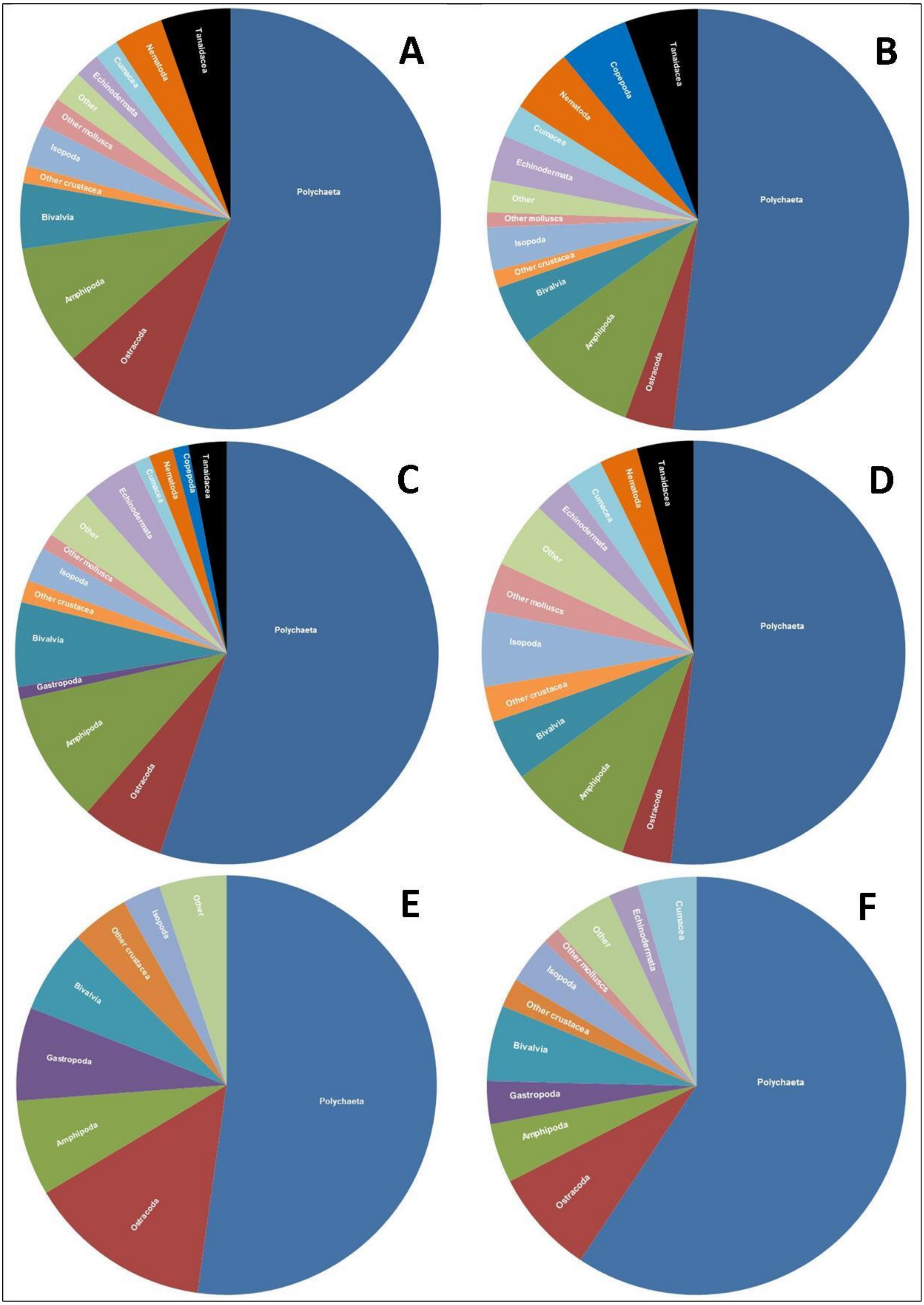
Taxa	Class/Order	Phylum	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15
Decapoda (Unid.)	Decapoda	Crustacea								1							
Diasterope grisea	Ostracoda	Crustacea							1				1	1	1	1	1
Dorvilleidae	Polychaeta										1				1		
Ebalia laevis	Decapoda	Crustacea									1						
Edwardsia sp.	Actiniaria	Anthozoa			1			1	2								
Ennucula strangei	Bivalvia	Mollusca	1	1		1			2	1	1				2		
Euchone pallida	Polychaeta													1			
Eulimidae	Gastropoda	Mollusca															1
Euphilomedes agilis	Ostracoda	Crustacea			1				1	1							4
Flabelligeridae	Polychaeta		1		1	1	1		1	1	2	1			1	1	1
Gastropoda (juvenile)	Gastropoda	Mollusca						1			1			2		1	1
Glyceridae	Polychaetea				1					1							
Gnathiidae	Isopoda	Crustacea			1		1	1							1		
Goniadidae	Polychaetea			1	1			1		3					1	1	
Haustoriidae	Amphipoda	Crustacea		1						2				1	1		
Hemichordata	Hemichordata								1				1	1			
Hesionidae	Polychaeta			1	1	1			1		1						2
Heteromalpadia marenzelli	Holothuridea	Echinodermata				1											
Hunkydora novozelandica	Bivalvia	Mollusca											1				
Leitoscoloplos kerguelensis	Polychaeta				2					1		2			1		1
Lumbrineridae	Polychaeta		1	1	3	4	5	2	7	3	2	4	3	2	4	4	8
Lysianassidae	Amphipoda	Crustacea	2	1	1			1	2		1	1		1		3	
Maldanidae	Polychaeta		12	6	12	5	17	13	16	9	18	5	4	10	14	14	27
Marphysa disjuncta	Polychaeta		1	2	1	2		1			2		1	1	1	1	6
Melliteryx parva	Bivalvia	Mollusca								2	1						
Mogula sp.	Tunicata																1
Munna schauinslandi	Isopoda	Crustacea							2								
Myriowenia sp.	Polychaetea		1								1	1	1				
Mysella hounselli	Bivalvia	Mollusca		2													

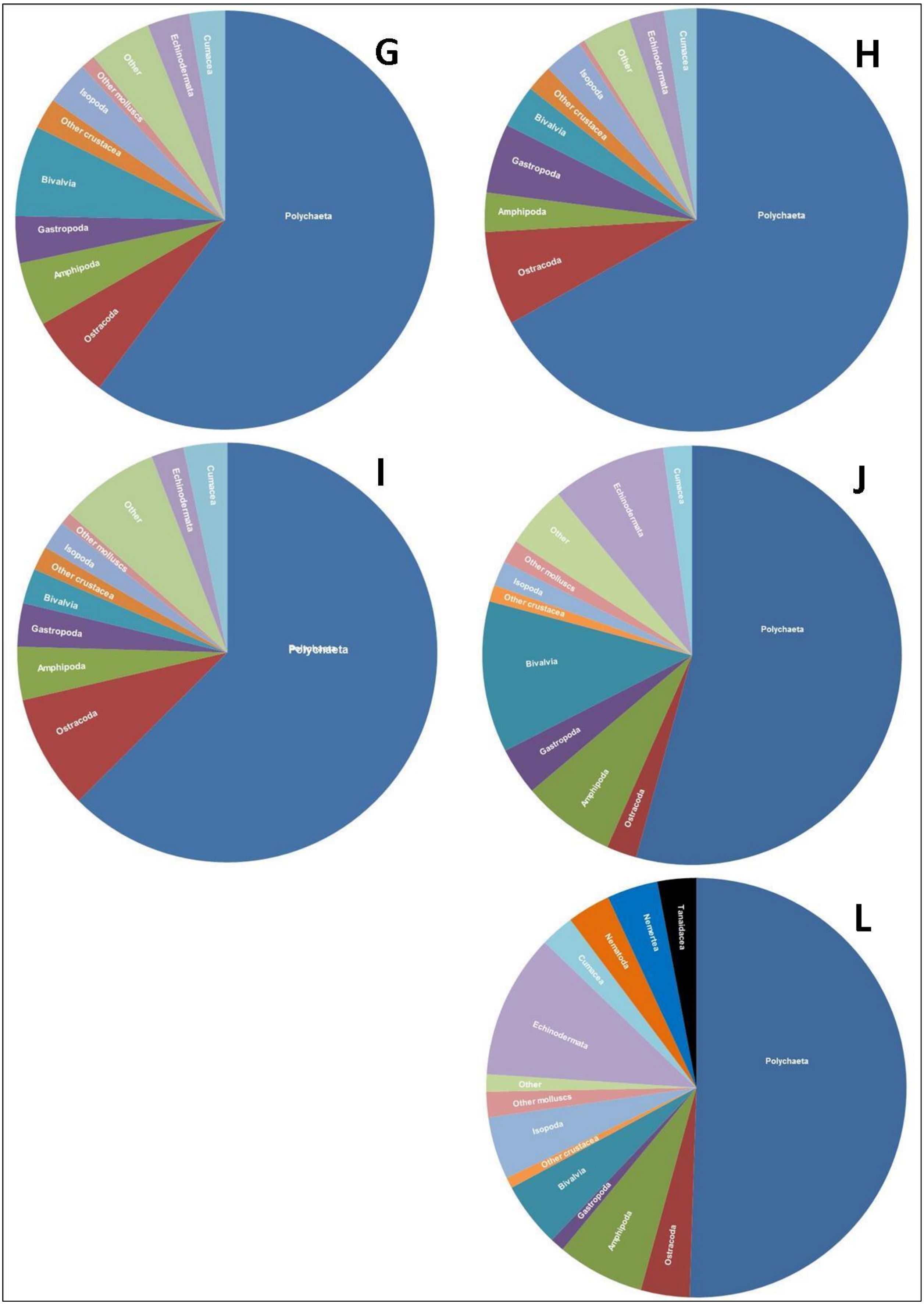
Taxa	Class/Order	Phylum	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15
Mysidacea	Decapoda	Crustacea				1							1				
Natatolana pellucida	Isopoda	Crustacea	2	1	1		1	2	1			2	1	1		1	1
Naticidae	Gastropoda	Mollusca					1								1		1
Neiloneila wrighti	Bivalvia	Mollusca					1			1				1	1	3	1
Neiloneila wrighti (juvenile)	Bivalvia	Mollusca		1	3			4		4							
Nematoda	Nematoda		4	2	2		1		2	2				1			1
Nemertea	Nermetea			3		2	4	1	2		3	3	1	2	2	3	2
Neonesidea sp.	Ostracoda	Crustacea									1						
Nucinella maoriana	Bivalvia	Mollusca	10	8	1	4	3	9	3	7	4	1	6	5	4	5	2
Oligochaeta	Oligochaeta								1								1
Onuphis aucklandensis	Polychaeta			2	2	3	1	2	2	1	1	2		3	1	3	6
Ophiuroidea	Ophiuroidea	Echinodermata	11	6	6	10	12	6	17	12	18	9	10	8	8	7	6
Orbina papillosa	Polychaeta					2	1				2	2		1			
Paramunna serrata	Isopoda	Crustacea								1			1			1	1
Paraonidae	Polychaeta		15	15	9	2	2	12	9	14	10	4	7	6	2		8
Paraprionospio pinnata	Polychaeta											1	1				
Parasterope quadrata	Ostracoda	Crustacea	1	2									1			1	
Philine powelli	Gastropoda	Mollusca	1					1		1				1			
Phoxocephalidae	Amphipoda	Crustacea	1	3	1	4	1	3		3	1	2	2	1	4	4	6
Phyllodocidae	Polychaeta				1			1	2	1		1					
Phyllochaetopterus socialis	Polychaeta						2		1								
Phylo novaezealandiae	Polychaeta																1
Pilargidae	Polychaeta			2					1	5				2	1	1	1
Polynoidae	Polychaeta				1				1		1			1		2	
Poroleda lanceolata	Bivalvia	Mollusca	1		1		1	1	1		2	1	4	1	1	2	3
Pratulum pulchellum	Bivalvia	Mollusca							1								1
Prionospio multicrostrata	Polychaeta														1		
Prionospio sp.	Polychaeta		1	1			1	1	1	2		1	2	1		2	2
Propontocypris sp.	Ostracoda	Crustacea	1								1						

Taxa	Class/Order	Phylum	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15
Relichna apouria	Gastropoda	Mollusca													1		
Rissoidae	Gastropoda	Mollusca	1	8	4		1			10	7		3	5	1	5	1
Rynkartopa uncinata	Holothuroidea	Echinodermata	1					1	1	1			1				
Sabellidae	Polychaeta						1							1			
Scalibregma inflatum	Polychaeta									1							
Salpidae	Tunicata			1												1	
Sigalionidae	Polychaeta		1	1			1		1	1	1	1	2			1	
Spiophanes kryoeri	Polychaeta		2	1				2	4		3		1		1		
Spiophanes modestus	Polychaeta													1	1		
Spiophanes sp.	Polychaeta				1				1	5	1						2
Stegocephalidae	Amphipoda	Crustacea			1	1				1							
Sternaspis scutata	Polychaetea		1	1			1					1					
Syllidae	Polychaete			1							1			1			1
Tanaidacea	Tanaidacea	Crustacea					1	1			3	1					
Terebellidae	Polychaeta		1		1				1					1			
Terebellides stroemi	Polychaeta						1			1	1						1
Themiste sp.	Sipuncula			2			1	1	1		1		1	1	2	1	
Thyasira peregrina	Bivalvia	Mollusca					1						1			1	
Trachyleberis lytteltonensis	Ostracoda	Crustacea	4			1	1				1	1					3
Varinucula gallinacea	Bivalvia	Mollusca	2	6	6	3	5	7	1	3	9	2	5	2	4	3	7
Virgularia gracillima	Anthozoa	Cnidaria									1						

APPENDIX E

Comparison of Proportion of Individuals belonging to each Taxonomic Group across all Wells


A
Tanaidacea
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
Polychaeta
B
Tanaidacea
Copepoda
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
Polychaeta
C
Tanaidacea
Copepoda
Nematoda
Cumacea
Echinodermata
Other
Other mollusca
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta
D
Tanaidacea
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
Polychaeta
E
Other
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta
F
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta


G
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
H
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other
Echinodermata
Cumacea
I
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
J
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
L
Polychaeta
Ostracoda
Amphipoda
Gastropoda
Bivalvia
Other crustacea
Isopoda
Other molluscs
Other
Echinodermata
Cumacea
Nematoda
Nemertea
Tanaidacea

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EXPLORATION AND APPRAISAL DRILLING PROGRAMME

Benthic Baseline Report
Well L

Prepared for:

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Level 20, The Majestic Centre
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SLR Ref: 740.10078.00200-R01
Version No: v1.0
July 2018

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BASIS OF REPORT

This report has been prepared by SLR Consulting NZ Limited with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with OMV New Zealand Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.10078.00200-R01-v1.0	31 July 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier
740.10078.00200-R01-v0.1	29 June 2018	SLR Consulting NZ Ltd	Dan Govier	Dan Govier

EXECUTIVE SUMMARY

OMV New Zealand Limited (**OMV New Zealand**) are applying for a Marine Consent to undertake an Exploration and Appraisal Drilling (**EAD**) Programme in the Taranaki Basin with an anticipated commencement date in 2019. OMV New Zealand may drill up to nine exploration wells and two appraisal wells within their Petroleum Exploration Permits (**PEP**). The intention of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs.

As part of the Marine Consent application, three Areas of Interest (**AOI**) have been identified that encapsulate the proposed well locations and are used as part of the Impact Assessment process. OMV New Zealand undertook a baseline environmental monitoring survey at each well location in March-April 2018 to gain an understanding of the benthic habitat and associated communities with each AOI.

Grab sampling and video sled methodologies were used to gain quantitative and qualitative information on the marine environments surrounding each well location. The data gathered from each baseline survey will be incorporated into the Marine Consent application and assist in the risk assessment process.

Water currents and deposition modelling were utilised to define the placement of sample stations. Sample transects were aligned along the dominant deposition pathway of the predicted drill cutting dispersion should that particular well be drilled. A total of 15 monitoring stations were allocated at each well site and one benthic grab sample was collected at each monitoring station. Ten video sleds were also undertaken at a selection of pre-determined sites around each well location.

Within this Benthic Baseline report the analysis of results incorporates sediment physical and chemical properties, benthic macrofauna, epifauna and visual observations around Proposed Well L. A total of 2,853 individuals representing 131 taxa were identified from the 15 macrofauna samples collected around Well L. Infauna communities were dominated by small polychaete worms (51%), crustaceans (22%), echinoderms (11%) and molluscs (8%).

The baseline survey at Well L found no consistent spatial patterns in grain size and Total Organic Carbon across the 15 sample stations. Grain size analysis indicated that the sediments at Well L and in those found in the Northern AOI were much coarser than sediments in the Central AOI and the other Southern AOI (Well J), which are dominated by mud (largely comprised of silt and clay sized fractions).

The infauna grab samples at Well L indicated the presence of five isolated Chaetopteridae worms (*Phyllochaetopterus socialis*) and a single sea pen (*Virgularia gracillima*). These species are defined in the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activities Regulations**) as being a '*characteristic species of sensitive environments*'. Chaetopteridae worms are known to form worm-fields or low-relief worm meadows. Although Chaetopteridae worms were present in a number of infauna grab samples, the video imagery taken across the sample stations did not observe any distinct worm-fields or low-relief worm meadows. Sea pens were also observed in the video imagery collected at Well L. The occurrence and estimated densities of these taxa at Well L did not reach the trigger levels defined by the Permitted Activities Regulations (MacDiarmid *et al*., 2013) and no distinct sea pen 'fields' were encountered. Thus although present at the well in low densities it is considered that the area would not be classified as a 'sensitive habitat'.

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1 Introduction

OMV New Zealand Limited (**OMV New Zealand**) is applying for a Marine Consent under section 38 of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (**EEZ Act**) to permit activities associated with an Exploration and Appraisal Drilling (**EAD**) Programme proposed to be undertaken starting in 2019.

The EAD Programme includes the drilling of up to nine exploration wells and two appraisal wells within OMV New Zealand's permit areas (**Figure 1**). The purpose of the EAD Programme is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the production potential within the PEPs which OMV New Zealand operate (**Figure 1**).

Three Areas of Interest (**AOI**) (summarised below) have been identified which encapsulate the well locations (**Figure 1**). This monitoring report relates to the Benthic Baseline survey conducted at Well L in the Southern AOI. Location details and water depth of Well L are provided in **Table 1**.

The Northern AOI encompasses PEP 60092 (Ridgeline), PEP 57075 (Cloudy Bay) and PEP 60093 (Toutouwai) and includes the following wells:

- Well A;
- Well B;
- Well C; and
- Well D.

The Central AOI encompasses PEP 60093 (Toutouwai) and includes the following wells:

- Well E (Appraisal);
- Well F;
- Well G (Appraisal);
- Well H; and
- Well I.

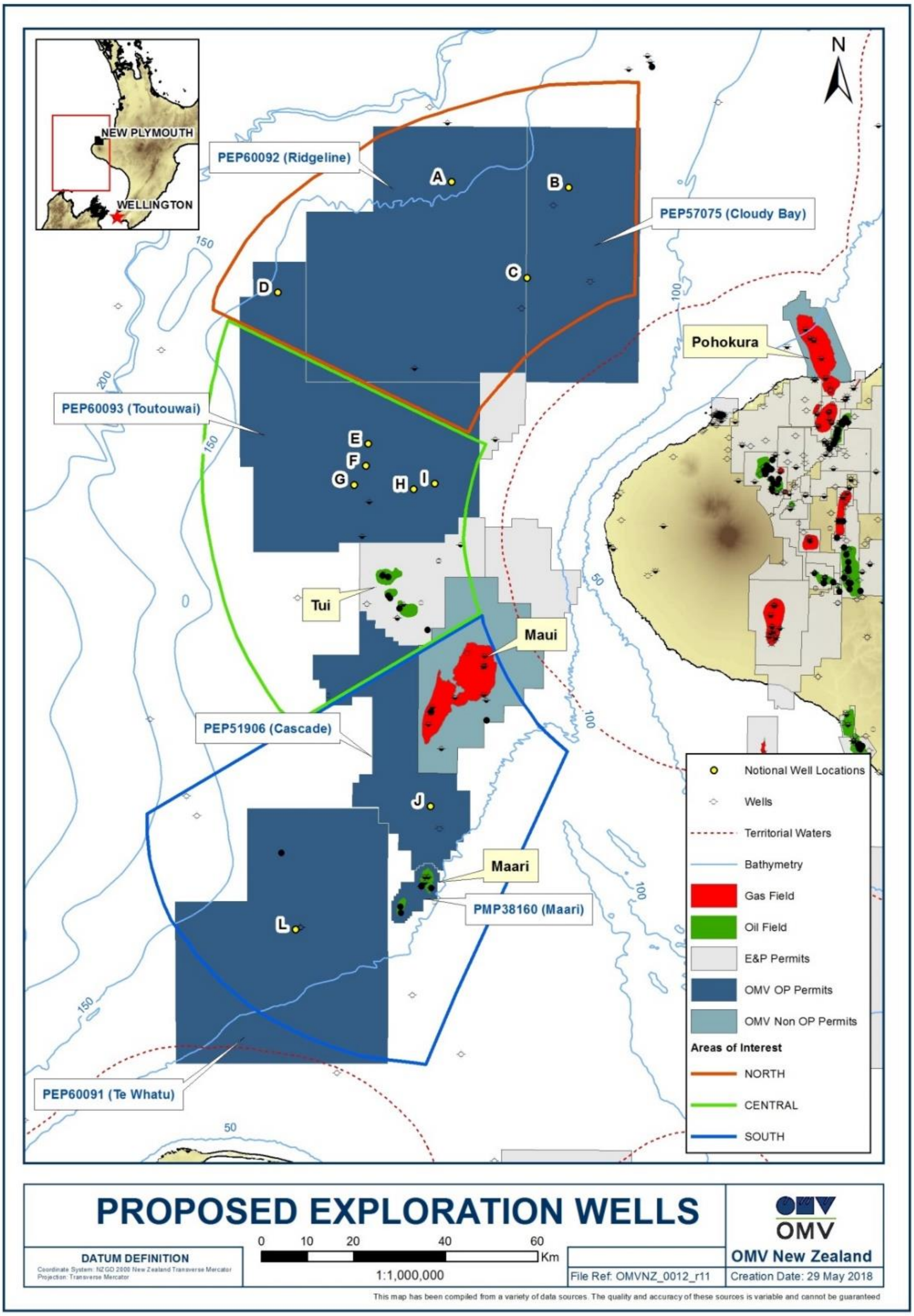
The Southern AOI encompasses PEP 51906 (Cascade), and PEP 60091 (Te Whatu) and includes the following wells:

- Well J; and
- Well L.

Table 1 Water Depth and Coordinates of Well L in the Southern AOI

Well Name	Water Depth (m)	Easting (NZTM)	Northing (NZTM)
L	110.6	1597705	5564406

Figure 1 OMV New Zealand's EAD Well Locations and three AOIs in the Taranaki Basin



In February 2018 SLR Consulting Limited (**SLR**) was engaged by OMV New Zealand to undertake a baseline assessment of the benthic ecology in the vicinity of 11 well sites (**Figure 1**). The aim of the field surveys, which were undertaken from March 24 – April 8 2018, was to collect relevant data using grab sampling and video sled methodologies to provide quantitative and qualitative information on these marine environments. This qualitative and quantitative data will be used within the Marine Consent application to define the benthic habitats and communities present at each well location and assist in the risk assessment process.

This report summarises the results of the Benthic Baseline survey undertaken at Well L.

1.1 Project Location

Well L is located approximately 147 km southwest of New Plymouth, 136 km northwest of Nelson, in New Zealand's Exclusive Economic Zone (**EEZ**). Water depth and GPS coordinates are provided in **Table 1** and displayed in **Figure 1**. The monitoring programme sample design resulted in sample stations extending out to 6 km from the well location (**Section 2.1**).

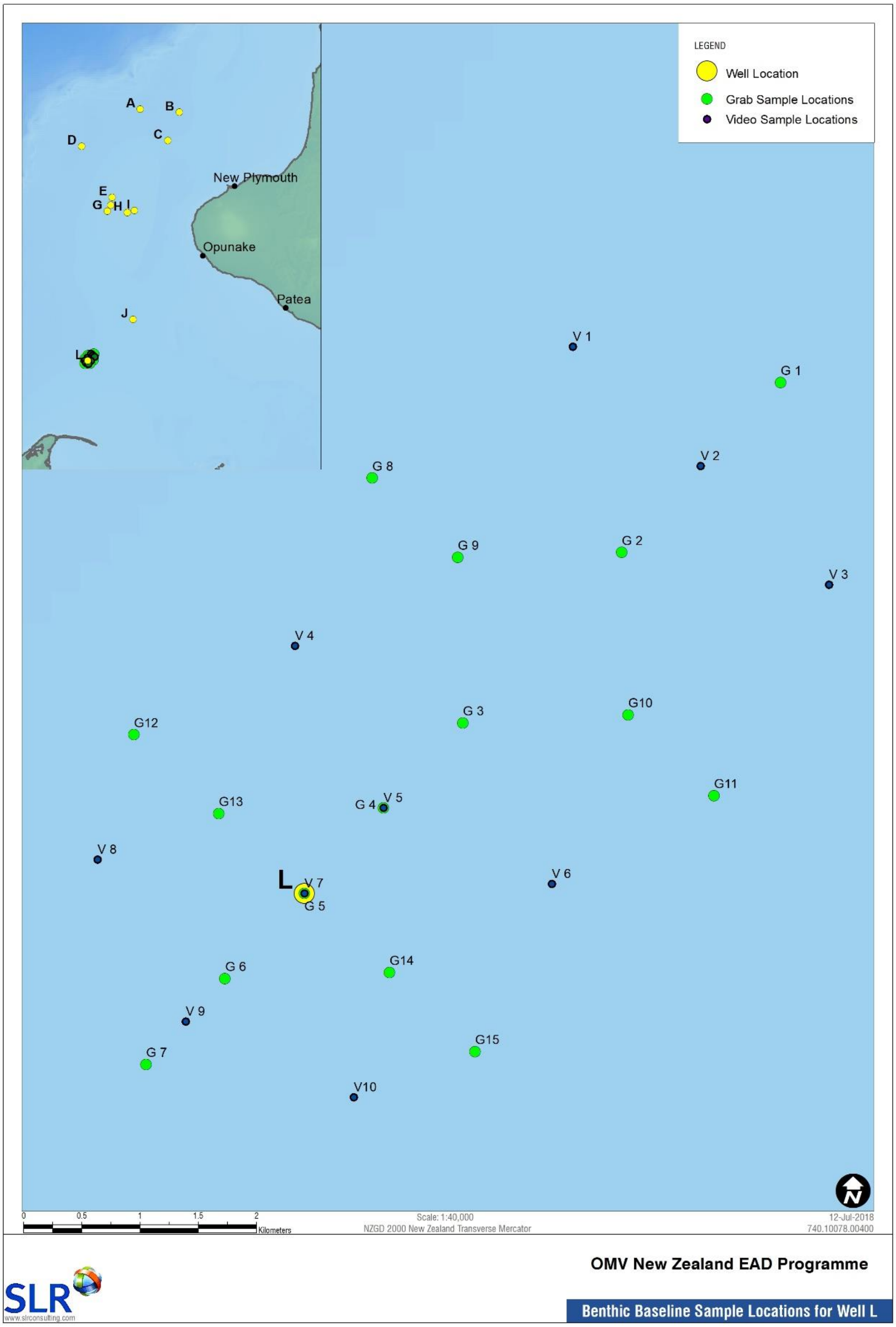
2 Methodology

The Benthic Baseline surveys adopted similar methodologies to what has been previously used for offshore Taranaki benthic monitoring programmes undertaken in accordance with the principles defined in the Offshore Taranaki Environmental Monitoring Protocol (**OTEMP**) (Johnston *et al.*, 2014). This consistent approach enables monitoring results to be compared with previous monitoring programmes undertaken in the offshore Taranaki environment (i.e. pre- and post-drill monitoring and production monitoring).

2.1 Sample Locations

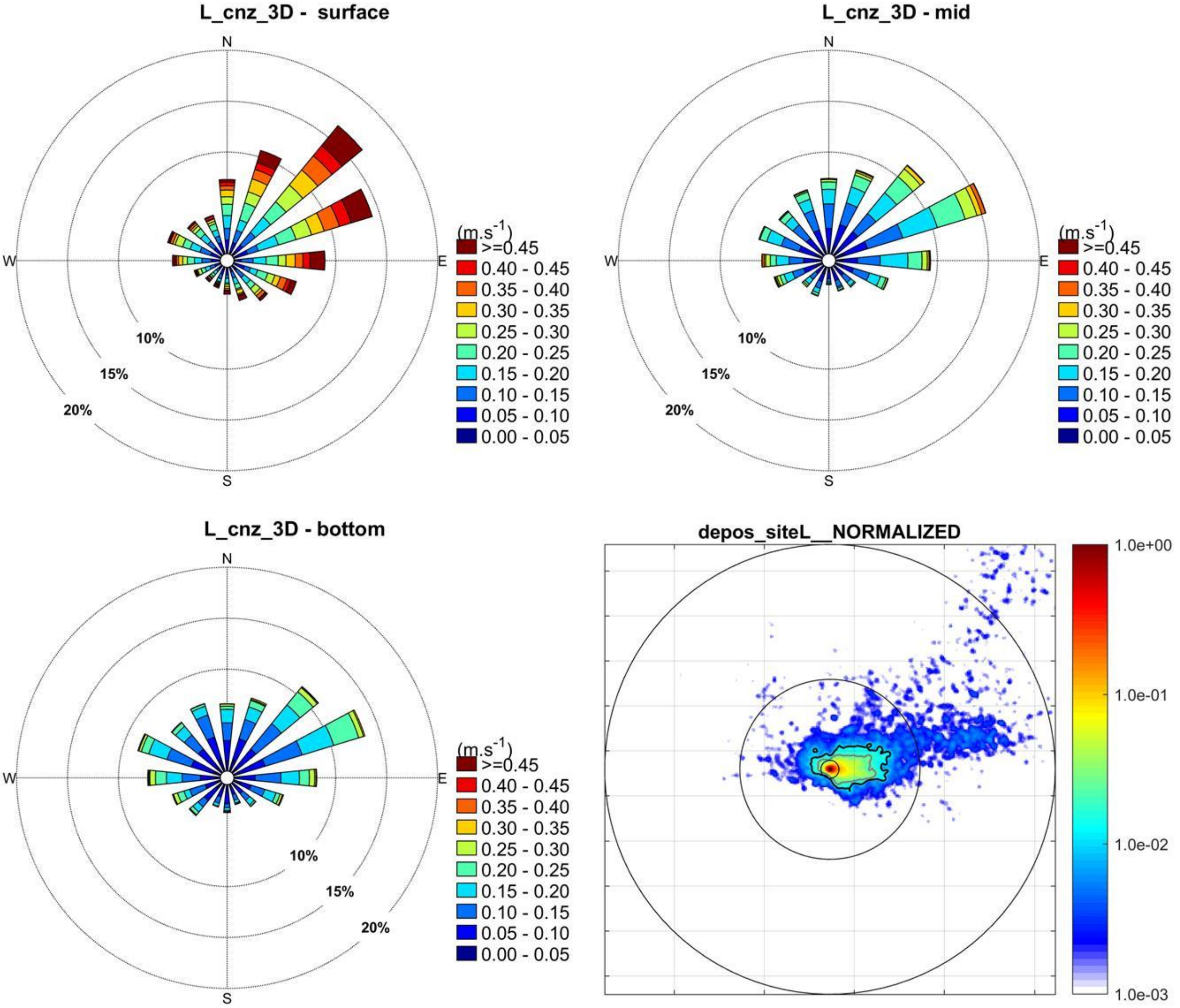
The sample locations (**Figure 2**) were defined by the dominant direction of current flow and preliminary drill cutting deposition modelling results (**Figure 3**). Sample transects were aligned along the dominant deposition pathway (i.e. southwest/northeast) (**Figure 2**) as this is the area determined to be most likely to be impacted from the deposition of drill cuttings should the well be drilled. However, sample stations were also located along the minor flow axis (northwest/southeast) to enable comparisons and validation of spatial differences based on the dispersal patterns predicted by MetOcean Solutions Limited.

Figure 2 Well L Sampling Locations



Note: At each video transect station approximately 250 m of video footage was captured along the seabed in the direction of the vessels drift at the time of sampling.

Figure 3 Surface, Mid-water and Bottom Water Column Current Roses and Dispersal Modelling Plot created by Metocean Solutions Ltd for the Well L



2.2 Field and Sampling Procedures

Field sampling was undertaken from the MV *Seaworker* between March 24 and April 8, 2018, following the procedures detailed below. Sampling at Well L took place on March 26th.

2.2.1 Benthic Grab Samples

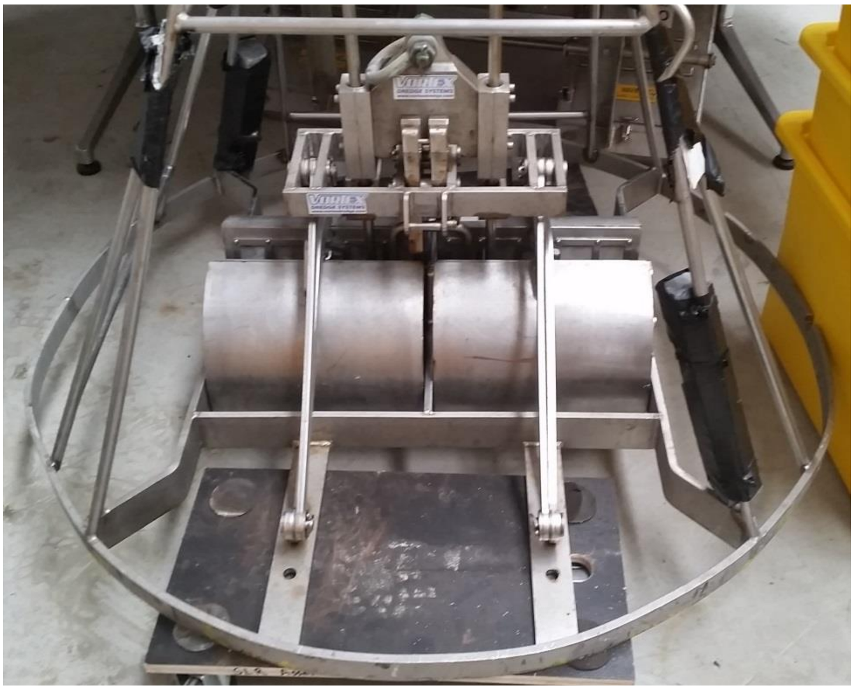
A double Van Veen double grab sampler (**Figure 4**) was used to collect a single sediment grab sample at each of the 15 benthic monitoring stations surrounding Well L (**Figure 2**). The grab sampler is constructed of stainless steel and features two independent 'buckets' which penetrate the surficial sediments to a depth of 0.16 m. Each successful grab sample returns approximately 0.01 m^3 of seabed sediment back to the surface.

Upon arrival on the vessel deck, each grab sample is checked for completeness, which must meet the following criteria:

SLR

- The surface of the sediment is largely undisturbed upon inspection aboard the vessel;
- Sufficient sediment (≥75% of the grab capacity) is collected to enable the full suite of sediment analyses required;
- The infauna sample bucket is filled to the same volume (approximately 10 l) for all infauna replicates throughout the survey; and
- The grab has not been over-filled with sediments pushing out of the doors or drains, indicating that it may have over-penetrated the sediment.

Figure 4 The Double Van Veen Grab Sampler used for the 2018 Benthic Sampling



Each independent bucket from a grab sample is used separately for infauna and sediment physical and chemical analyses, as follows:

- Bucket one: infauna/macrofauna community analysis. The entire sample is sieved through 0.5 mm mesh until approximately 300-500 ml of residual sediment and organisms remains. This remaining material is transferred to a plastic container and preserved with a fixative (AncholTM), ready for analysis by SLR taxonomists.
- Bucket two: sediment physical nature and chemical analyses. Three 64 mm (internal diameter) clear Perspex sub-sampling cores are pushed into the sediments from the second bucket, to a depth of approximately 150 mm. Cores are photographed and the upper 50 mm from each core is extruded into a polyethylene bag for particle grain size distribution and organic content (ash-free-dry-weight (AFDW)) analyses by Hill Laboratories.

2.2.2 Seafloor Video Imagery

Video imagery of the seafloor was obtained using a customised tow-sled fitted with high-intensity LED lighting and a high-definition video camera (**Figure 5**). The system was connected to the vessel via a 10 mm dyneema tow-line and a 300 m umbilical cable supplying real-time video images to the camera operator on the research vessel. A pair of parallel lasers on the video sled provided an indication of scale allowing features of interest in the video recordings to be approximately sized. Ten video sled tows were conducted around Well L (**Figure 2**).

The video-sled was launched from the vessel up-current of each pre-determined location and lowered to the seabed, where it auto-located via a series of floats and weights set at specific points on the sled frame, to land upright on its lower skids. At the point where the sled contacted the seabed, a GPS log was started, and this log continued throughout the duration of the tow. Video footage was continuously recorded for approximately 200 m as the sled drifted behind the vessel; this ensured that footage was collected while the sled was passing as close as possible to the required sample location.

Figure 5 The Video Sled used for Collecting Video Footage of the Seabed Environment

2.3 Laboratory Analyses

2.3.1 Sediment Physicochemical Analyses

Benthic sediments collected by the grab were analysed by Hill Laboratories (an NZS/ISO/IEC 17025:2005 accredited laboratory), for both physical and chemical parameters. The aims of these analyses along with further details of the analytical method/descriptions are summarised in **Table 2**.

Table 2 Summary of Analytical Methods used for Testing Sediment Physico-chemical Characteristics

Analyte	Aim	Method Number	Description
Particle Grain Size Distribution	• Determine physical parameters of the sediment particles present at the site • Correlate with infauna community characteristics	Hill Laboratories KB32136	• Sediment was wet-sieved through the following screen sizes, as per the Udden-Wentworth scale (Wentworth, 1922): • >2 mm (gravel) • >1 mm (very coarse sand) • >500 µm (coarse sand) • >250 µm (medium sand) • >125 µm (fine sand) • >63 µm (very fine sand) • <63 µm (silt and clay)
Total Organic Carbon	• Determine current level of organic carbon in sediment • Correlate with infauna community characteristics	No specific method number	Acid pre-treatment to remove carbonates present, followed by catalytic combustion (900° C, O_2), separation, Thermal Conductivity Detector. Elemental Analyser.

2.3.2 Macrofauna Analyses

Macrofaunal analyses focused on the infauna, or animals larger than 0.5 mm living within the sediment matrix. Epifaunal animals (those living on top of the sediment), were also included in the analyses to provide representation of the different functional groups present at each sample station.

Benthic macrofaunal samples collected from the sediment grab were sorted and, with the aid of a binocular microscope, identified to the lowest practicable taxonomic level or most recognisable taxa (morphologically similar group). Counts were made to assess the relative abundance of each taxa.

2.3.3 Seafloor Video Analyses

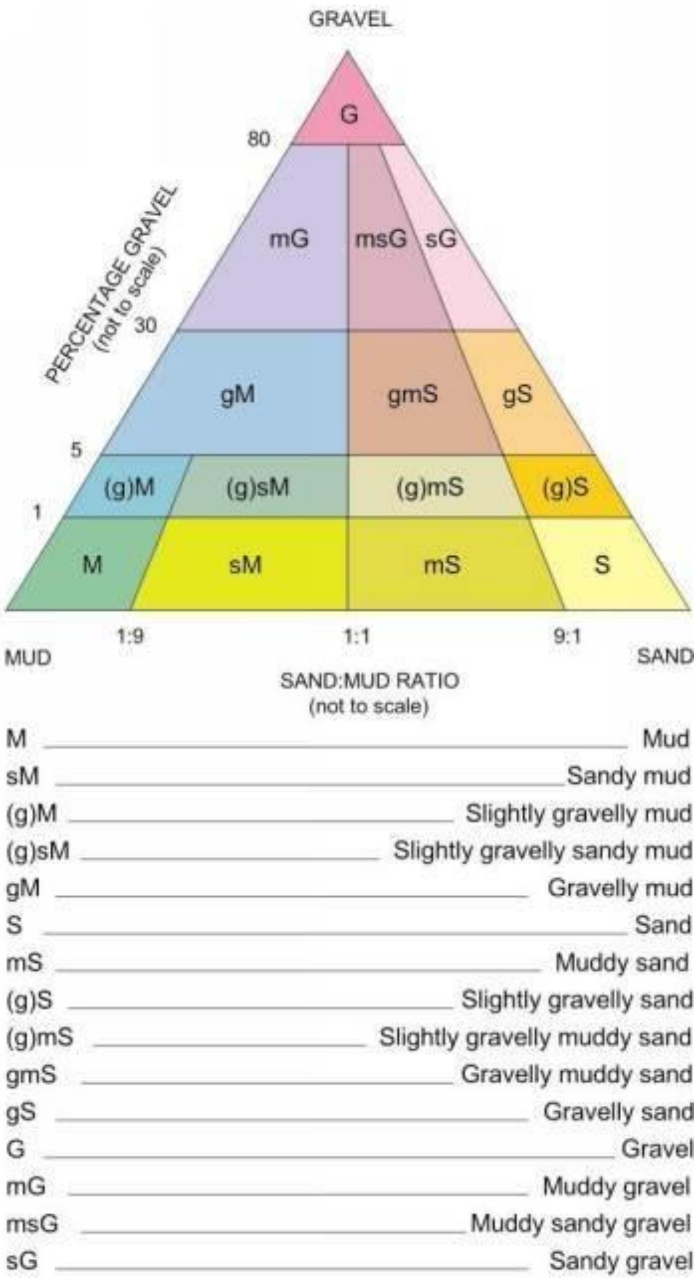
A live feed from the video-sled was captured and recorded on-board the survey vessel and viewed by SLR staff with experience in undertaking assessments of the benthic environment in the offshore Taranaki region. Brief field notes were made in real-time about obvious structures and organisms observed while watching the live footage. Back onshore the recorded seabed video footage was assessed on a large, high definition screen, by a suitably trained and experienced benthic scientist, who identified all obvious epifauna to the lowest practicable taxonomic level. Biogenic and/or anthropogenic seabed structures such as burrows, mounds, tracks and gouges/trenches were also recorded. Relative abundance estimates of epifauna or biogenic structures were made where appropriate.

2.4 Data Analyses

2.4.1 Sediment classifications

While there are many sediment classification schemes in use worldwide, a common one is a modified version of that proposed by Folk (1954). This scheme groups grains within a sample into mud, sand and gravel sized particles based on the particles diameter (mud <63 µm, sand 64-2000 µm, gravel > 2mm), and then describes the sediment type based on the relative proportions of the particles (see **Figure 6**).

Figure 6 Folk (1954) Sediment Type Classification Triangle



2.4.2 Community Characteristic Descriptors

All macrofauna (both epifauna and infauna) taxa were included in the analyses of abundance data. Species identified in the samples as not being exclusively benthic were excluded from further analyses. Data were analysed as per the statistical methods outlined below to identify current distributions and abundance of macrofauna.

2.4.2.1 Univariate Diversity Indices

Diversity indices (number of taxa S, total abundance N, Shannon-Wiener diversity H', and Pielou evenness J' (**Table 3**) were calculated from the macrofauna abundance data using the PRIMER software package (PRIMER v6.1.16; Clarke, 1993; Clarke & Warwick, 1994; Clarke & Gorley, 2006).

Table 3 Description of Macrofauna Community Characteristic Indices

Index	Formula (where applicable)	Description
Number of Taxa (S)	Count of total number of different taxa identified within the *x* sample	Total number of taxa identified within a sample
Total Abundance (N)	Sum of all individual taxa abundances within the *x* sample	Total number/count of all organisms within a sample
Shannon Diversity (H')	$H' = -SUM [(p_i) \times \log_e (p_i)]$ $p_i =$ Number of individuals of taxa i /total number of samples	A single value (log scale) that is used to describe the different types and numbers of organisms present within an assemblage. The index value increases as assemblages have greater numbers of taxa and when the numbers of individual organisms are more evenly distributed across the different taxa. Samples dominated by single taxa will have lower values towards zero.
Pielou Evenness (J')	$J = H' / \log_e (S)$	A value theoretically between zero and one which indicates how evenly the number of individual organisms are distributed through the different taxa in an assemblage. High values (closer to 1) indicate an even spread amongst the taxa present, whereas a low value indicate an uneven spread or an assemblage highly dominated by only a few, or even a single taxon.

3 Results and Discussion

3.1 Sediment Physical and Chemical Properties

3.1.1 Visual Description of Sediment Cores

Sediment collected from around Well L was predominantly light grey / brown mud with variable sand content and shell material (**Figure 7**). No very dark-grey or black sediment layers (apparent Redox Potential Discontinuity), or darker patches within cores were noted and no detectable hydrogen sulphide odours were present, indicating that sediments appeared well oxygenated throughout the depths sampled. Field observations on sediment texture, colour and any notable features of the sediment samples were recorded during the processing of the sediment cores and infauna samples, and these are included in **Appendix A**. A full set of sediment core photographs are contained in **Appendix B**.

Figure 7 Representative Images of Sediment Core Profiles from Well L

Station L1

Station L4

Station L7

Station L12

3.1.2 Incidental Observations

During laboratory processing of the infauna samples observations were made of any debris present, including those from anthropogenic sources. Within the 15 samples collected at Well L there were four types of debris observed (**Table 4**), three of which were likely to be anthropogenic in source, including paint flecks and welding balls. However, all debris encountered in the samples were at 'low' abundances.

Table 4 Incidental Observations

	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15
Coal			L												
Green Paint			L												
Welding ball													L		
Red paint		L													

VA = very abundant (>50), A = abundant (50+), C = common (20–50), O = occasional (10–20), L = low (0–10)

3.1.3 Sediment Particle Grain Size Distribution and Organic Content

The physical characteristics of the sediment can influence the composition of the infauna communities and the levels of contaminants retained and observed during analyses. Particle grain size is widely used to characterise the physical structure of the sediment, while organic content provides an indication of the organic enrichment in the sediment. These combined results provide a general understanding of sediment health and the source of potential stressors at the time of sampling.

Organic matter found in the sediments is most likely derived from natural sources such as infauna/epifauna and detrital matter, rather than from anthropogenic sources. Anoxic sediments (those lacking oxygen), may develop in situations where organic matter levels increase beyond 'normal' levels for that area. Increased organic matter has the potential to disturb the equilibrium of the benthic ecosystem, as increased numbers of oxygen-utilising bacteria are required to decompose the additional organic matter, thereby rapidly reducing oxygen availability in the sediments.

A summary of the particle grain size and organic content analyses are discussed below, with full results provided in **Appendix C**.

3.1.3.1 Particle Grain Size

Particle grain size analyses at the 15 monitoring stations around Well L are shown in **Figure 8**. The sediments were classified as 'muddy sands' (Folk, 1954), dominated by a selection of medium to very fine sands (mean total sand contents 69%) and silt/clay (mean 31%), with several samples containing small proportions of coarse sands (e.g. stations 1, 2, 6-8, 13-15). 'Muddy sands' have historically not been encountered very often in offshore Taranaki areas where exploration/production monitoring has taken place.

There were no consistent spatial patterns to the grain size distribution across the sampling stations at Well L.

This grain size distribution at Well L was notably different to that at Well J (in the Southern AOI), where sediments were largely mud dominated (silt and clay), similar to those of the Central AOI (**Table 5**). Results from four years of pre/post-drill monitoring at the nearby Manaia-2 exploration well showed sediments to be 'sandy muds' (mean 54% silt and clay, 46% sand), which differs to Well L. It is possible that Well L's closer proximity to Farewell Spit places it in an area of somewhat higher current exposure where finer silt and clay sediments are more easily resuspended and moved, as well as receiving more deposited fine sands being moved along the spit with the prevailing currents and eddies, compared to wells further east and north (e.g. Well J).

A comparison of particle grain size data for Well L with the other wells is provided in **Appendix C**.

Figure 8 Sediment Particle Grain Size Distribution for Samples Collected at Well L

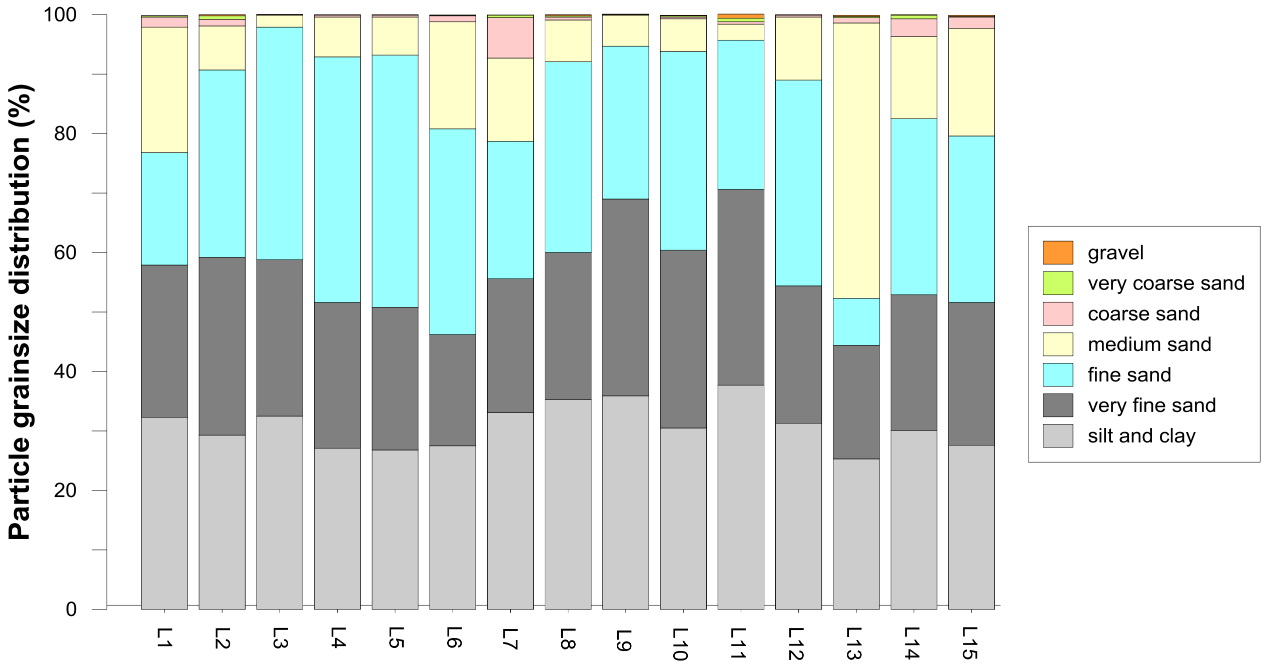


Table 5 Average Grain Size for the Eleven Well Sites

Grain size class	A	B	C	D	E	F	G	H	I	J	L
Silt & Clay (Mud) (%)	36.2	27.5	41.1	30.7	85.2	83.2	67.8	72.6	65.1	85.4	30.8
Very Fine Sand (%)	45.8	39.3	30.5	41.7	6.5	4.8	6.1	5.8	6.6	14.2	25.4
Fine Sand (%)	17.0	28.6	22.4	26.8	8.0	11.3	24.6	19.0	22.1	0.4	29.8
Medium Sand (%)	1.0	2.4	3.3	0.7	0.4	0.6	1.6	2.5	5.1	0.1	12.3
Coarse Sand (%)	0.1	0.7	0.8	0.0	0.0	0.1	0.1	0.1	0.6	0.0	1.2
Very Coarse Sand (%)	0.0	0.6	0.5	0.0	0.0	0.1	0.1	0.1	0.5	0.0	0.2
Gravel (%)	0.1	1.1	1.3	0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.1
Description	mS	mS	mS	mS	sM	sM	sM	sM	sM	sM	mS

Note: sM = sandy mud, mS = muddy sand

Colour scale based on percentage with median mid-point (median is 2.0):

0%	5	10	20	30	40	50	60	70	80	90	100

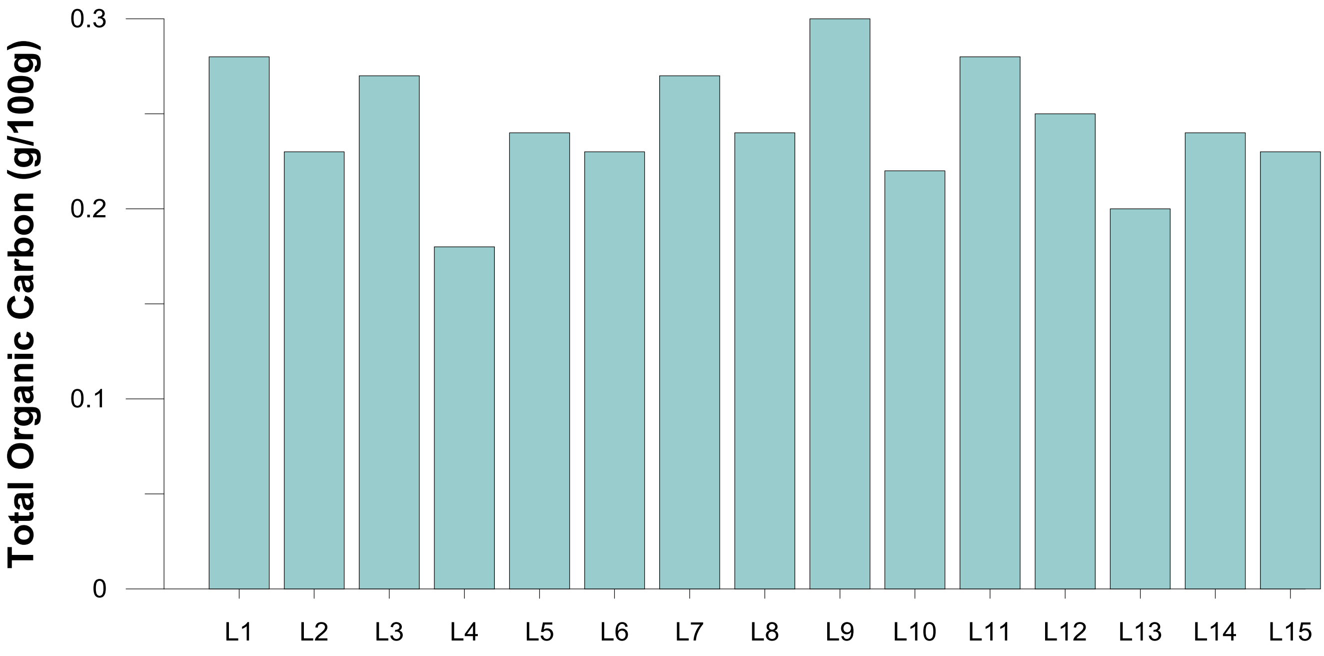
3.1.3.2 Total Organic Carbon

The organic content of sediments was assessed by measuring TOC to assess benthic ecology as this is also consistent with what is now currently undertaken around the offshore Taranaki oil and gas fields.

TOC levels at Well L (**Figure 9**) ranging between 0.18% and 0.30% (mean 0.24%), and did not show any distinct spatial trends or patterns.

The average organic content around Well L was low relative to other wells monitored as part of the EAD Benthic Baseline survey (mean 0.24% compared to overall mean of 0.45%). The combined mean for the two Southern AOI sites (0.48%) was moderate relative to the Northern and Central AOIs (0.26% and 0.59%, respectively). However, the mean for the Southern AOI should be interpreted cautiously due to the large variation between Wells J and L. As has been previously described in benthic environmental monitoring associated with offshore Taranaki oil and gas activities (SLR 2016 and SLR 2017), there is a correlation between sediment particle grain size and sediment organic content. The comparatively greater surface area of silt and clay (mud/fines) sediments gives a greater area for adsorption of organic matter particles and therefore a higher probability of elevated organic matter compared to coarser/sandier sediments subjected to the same level of enrichment (Hedges *et al*., 1993). This is likely to explain some of the large difference in mean TOC levels between Wells J and L (high at J, low at L) where there were noticeably different grain size distributions (coarser muddy sands at Well L) (**Section 3.1.3.1**).

Figure 9 TOC Concentrations in Sediment Samples Collected from around Well L



3.2 Video Sled Imagery

Video footage of the seabed allows scientists to visually assess any anthropogenic disturbance to the benthic environment and observe epifauna, sediment-type and structures or relief that exist on the seabed.

Video footage was captured by towing a video sled through ten sites around Well L (**Section 2.2.2**). All video footage is included with the electronic version of this document, with a selection of still images displayed in **Figure 10**. **Appendix A** provides locational information for each video sled tow.

Video footage was assessed to determine any defining features and their semi-quantitative abundance recorded for comparison with other sites. Due to caveats associated with video footage (i.e. variable visibility, differing tow length and durations) the counts are indicative-only and should not be interpreted as a quantitative assessment. **Table 6** presents the results of this semi-quantitative approach, which summarises the counts by comparing the site total to the median across all sites. As a visual aid, counts were categorised in relation to the deviation from the 10^{th}, 25^{th} 50^{th}, 75^{th} and 90^{th} percentiles, so that differences between sites can be more easily viewed.

3.2.1 Physical Observations

The seabed around Well L was observed to have soft mud sediments. Evidence of bioturbation was observed at all monitoring stations in the form of animal burrows. Moderate abundances of burrows were prevalent in Well L transects (**Figure 10**) with occasional pockets with very low and higher abundances of worm holes (image F, **Figure 10**). This is similar to other sites in the Southern and Central AOI but differs from the Northern AOI where densities were predominantly low (**Table 6**).

At Well L, mound/hollow features (image D and E, **Figure 10**) were observed in extremely high numbers compared to other sites (approximately 532 compared to a median of 43 across all 11 sites) (**Table 6**). These seabed features are thought to be formed by the feeding activities of sharks or rays, or by large burrowing tube worms mounding up sediment. Mound/hollow features were observed to be more numerous at the Northern AOI sites, moderate to very high at the Southern AOI sites, and low to very low in numbers around the Central AOI sites.

There was no sign of anthropogenic physical disturbance of the seabed observed during any of the video sled tows around Well L, and signs of sediment enrichment (darker sediments at the surface or off-gassing) were not seen.

Table 6 Total Number of Features Observed in Video Imagery from the EAD Wells

Well	Depth (m)	Mounds/ Hollows	Number of burrows/worm holes	Sea pen	Fish	Substrate	Notes
A	148	111	Low-moderate	54	65	Muddy sand	Ripples; some very large holes and mounds
B	134	63	Low-moderate	35	49	Muddy sand	Some very large holes mounds
C	132	85	Low-moderate	50	44	Muddy sand	Ripples; trenches observed
D	145	280	Low	160	28	Muddy sand	Ripples; 23 very large sea feathers
E	126	29	Moderate	29	16	Sandy mud	
F	128	20	Moderate	19	19	Sandy mud	
G	124	18	Moderate-High	29	26	Sandy mud	
H	124	18	Moderate-High	17	26	Sandy mud	12 elongated shallow trenches
I	122	43	Moderate-High	36	21	Sandy mud	5 elongated shallow trenches (large)
J	108	42	Moderate	14	30	Sandy mud	School of mackerel, tufts/tubes common
L	112	532	Moderate	132	31	Muddy sand	2 schools of mackerel
Median		43		35	28		

Totals are sum of 10 video tows carried out at each site. Totals are semi-quantitative only due to variable visibility and transect length.

10th percentile band
25th percentile band
Median band
75th percentile band
90th percentile band

3.2.2 Infauna, Epifauna and Other Fauna

In some cases, a definitive positive identification of infauna, epifauna and more mobile taxa was not possible from the video footage alone. Where there was any uncertainty, identifications were based on distinctive features, colours and shapes of organisms and in some cases the confirmed presence of similar looking individuals within the infauna samples.

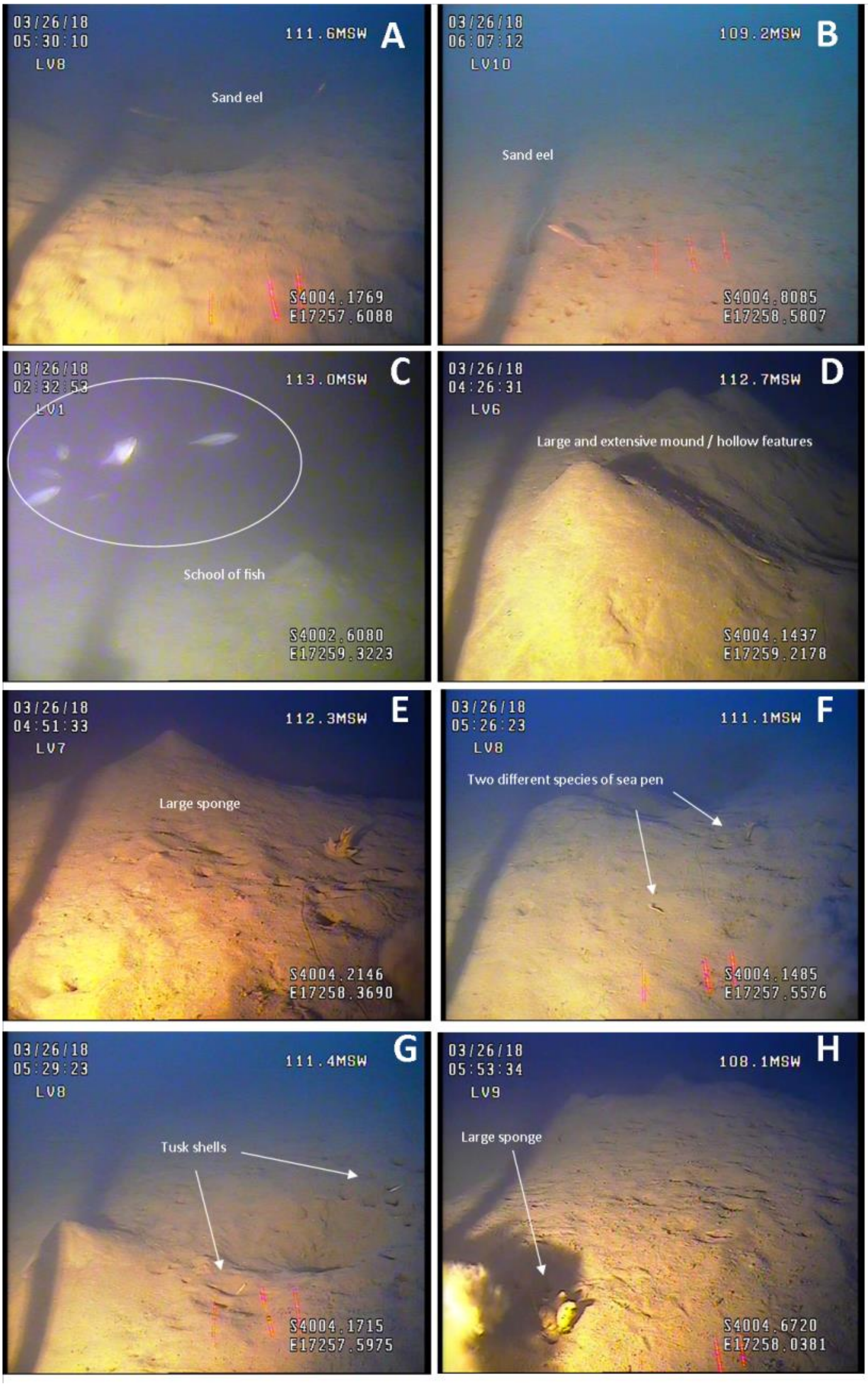
Epifauna taxa observed in video footage collected around Well L included molluscs such as tusk shells (likely *Fissidentalium zelandicum)* (image G, **Figure 10**). The presence of epifauna tracks in the sediment indicates that mobile fauna such as whelks and hermit crabs move throughout this site. Sponges (image E and H, **Figure 10**) were more common in Well L transects than at other well locations. Some of these may have been tunicates or corals.

Sea pens (likely *Virgularia* sp.) (image F, **Figure 10**) were seen in very high abundances at Well L compared to other wells (approximately 132 compared to a median of 35 across all 11 sites) (**Table 6**). Sea pens were observed to be more numerous at the Northern AOI wells, variable at the Southern AOI wells, and lowest in the Central AOI wells.

Mobile fish species were observed in moderate numbers at Well L compared to other wells (approximately 31 compared to a median of 28 across all 11 sites) (**Table 6**). Species observed included two schools of fish (possibly mackerel, image C, **Figure 10**), sand eel[1] (image A and B), gurnard (*Chelidonichthys kumu*) and flatfish (likely *Peltorhamphus* sp.). A number of smaller fish were seen taking off very quickly as the camera approached and it was not possible to make any definitive identification. Fish were observed to be much more numerous at the Northern AOI wells, moderate at the Southern AOI wells, and moderate to low in numbers around the Central AOI wells.

[1] This fish was unable to be formally identified, thus while the term 'sand eel' is used throughout this report it should not be considered a common name for this unidentified fish species.

Figure 10 Representative images of seabed environment around Well L



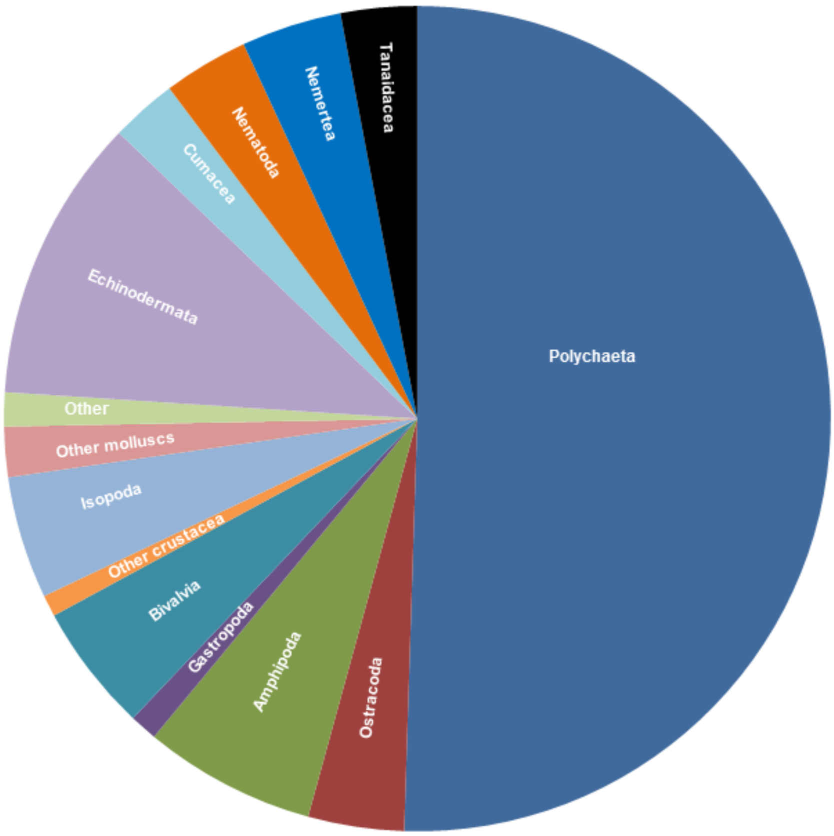
3.3 Macrofauna Characteristics

3.3.1 Benthic Macrofauna

Overall 2,853 individuals representing 131 taxa were identified in the 15 macrofauna samples collected at Well L during the EAD Benthic Baseline survey. Infauna communities were dominated by small polychaete worms (1,441 individuals (51%), 50 taxa), crustaceans (619 individuals (22%), 31 taxa, mostly Amphipoda, Isopoda and Ostracoda), molluscs (230 individuals (8%), 31 taxa, mostly bivalves), and echinoderms (318 individuals (11%), 6 taxa) (**Figure 11** and **Figure 12**). The raw macroinvertebrate data from Well L monitoring stations is provided in **Appendix D**.

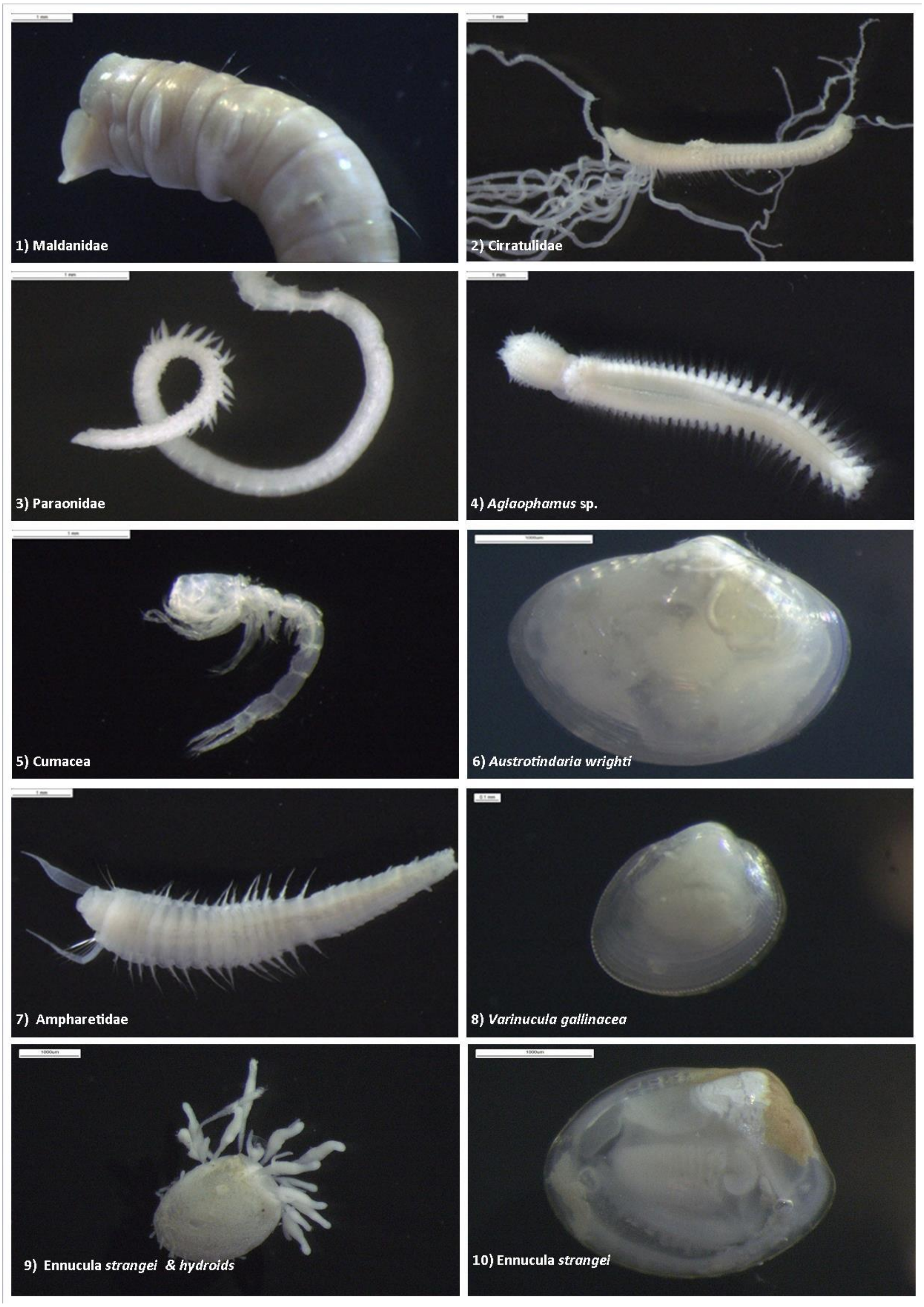
When the benthic macrofauna results are compared across the three AOIs, polychaetes and gastropods were found in lower numbers in the Southern and Northern AOIs compared to the Central AOI. Crustaceans (Tanaidacea and copepods) and nematodes were found in higher numbers in the Northern AOI sites compared with Central and Southern AOIs (**Appendix E**). This result is likely linked to the differences in sediment composition, where a coarser grain size was present in the Northern AOI compared to the Central and Southern AOIs.

Figure 11 Proportion of Individuals at Well L Belonging to each Taxonomic Group



'Other crustacea' includes Decapoda and Tanaidacea. 'Other molluscs' includes Aplacophora and Scaphopoda. 'Other' includes Anthozoa, Chaetognatha, Hemichordata, Nematoda, Nermetea, Oligochaeta, Sipuncula, Tunicata and Cypridinodes sp.

Figure 12 Representative Images of Benthic Infauna Taxa Frequently Observed in Offshore Taranaki Area



3.3.2 Univariate Indices of Infauna Communities

Univariate indices (total number of taxa, total abundance, Pielou's evenness and Shannon-Wiener diversity) describing the benthic macroinvertebrate communities found at Well L are displayed in **Figure 13**.

The number of taxa identified in each sample collected around Well L varied from 42 to 71 (mean 54), while total abundance ranged from 126 to 247 individuals (mean 190). Abundance and taxa numbers at Well L were very similar to the overall mean values for the Northern AOI (53 taxa, 233 individuals, **Table 7**), which were notably higher than those of the Central AOI. When compared to the other Southern AOI well site (Well J), mean number of taxa and mean abundance at Well L were higher.

Evenness values vary on a scale between zero and one, with values near one indicating that infauna abundances are evenly distributed across all the different taxa present, while values near zero indicate infauna communities are being numerically dominated by a large number of individuals from just a few, or even only single taxa. Values from the Benthic Baseline data collected at Well L were relatively high (mean 0.88), indicating relatively even distribution of taxa abundances across the taxa that were present.

Shannon-Wiener diversity index values range between 0 and 4 with higher values indicating higher species diversity. From previous benthic studies in the offshore Taranaki region, species diversity values are normally between 1.5 and 3.5. The mean Shannon-Weiner diversity index for Well L was 3.5, and ranged between 3.2 and 3.8. These results are high relative to the most recent results from the long term benthic monitoring programme at the Maari Field, located in the Southern AOI, 29 km northeast, which had a mean species diversity of 2.9.

Figure 13 Total Number of Taxa, Total Abundance, Pielou's Evenness and Shannon Wiener Diversity Index Values for macrofauna samples collected at Well L in 2018

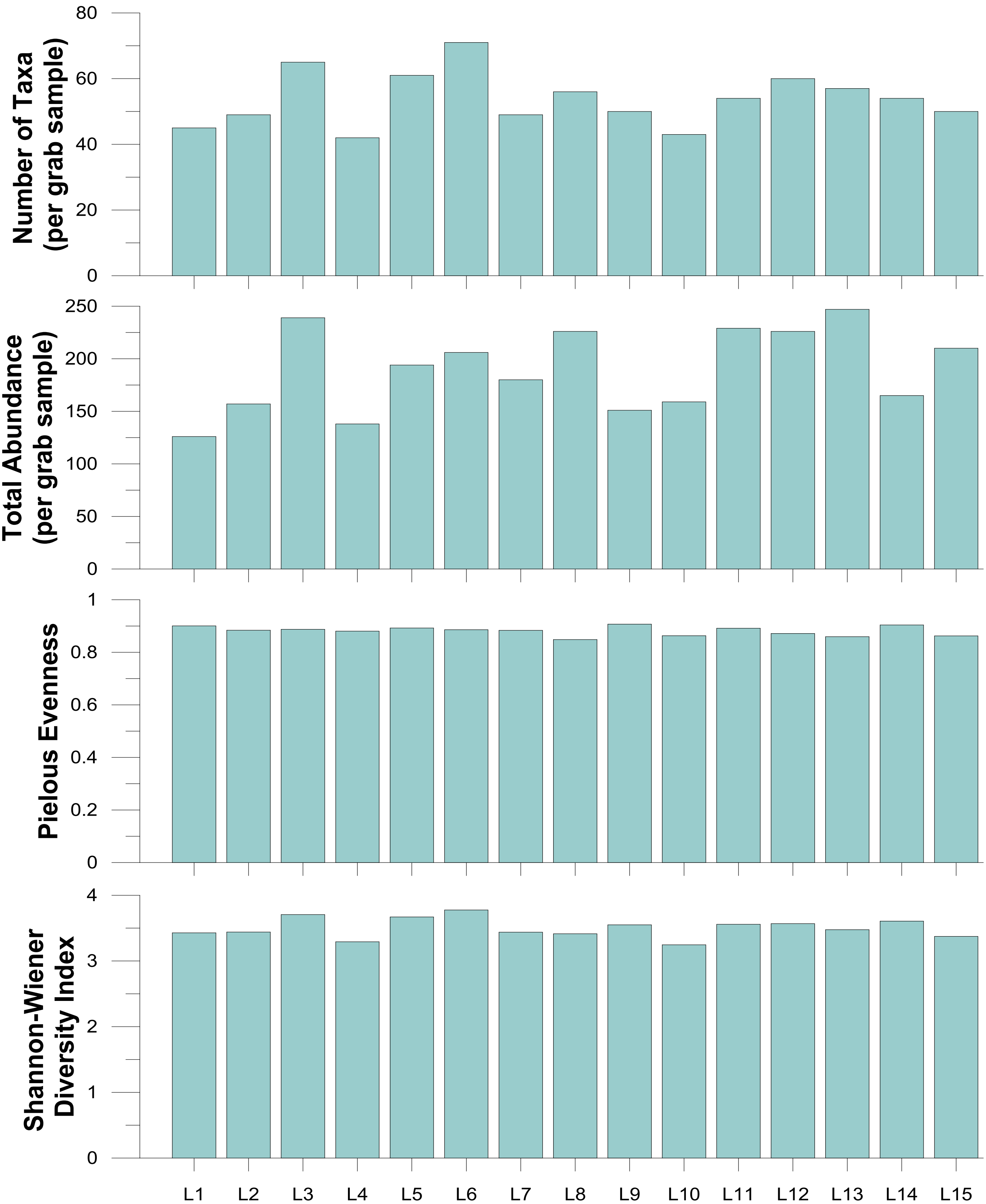


Table 7 Number of Taxa and Total Abundance for the Eleven Wells

Site	Mean Number of Taxa	Mean Abundance	Total Number of Taxa Identified at site	Total number of individuals (abundance)
A	56	257	140	3,849
B	53	210	130	3,151
C	45	132	128	1,987
D	60	332	142	4,986
Northern AOI	53	233		
E	19	36	78	542
F	31	68	90	1,023
G	33	81	112	1,215
H	31	89	103	1,339
I	29	72	91	1,075
Central AOI	29	69		
J	40	115	108	1,722
L	**54**	**190**	**131**	**2,853**
Southern AOI	47	153		

3.4 Sensitive Environments

In an investigation of sensitive substrate/benthic habitats in the Taranaki Coastal Marine Area, Johnston (2016) studied marine taxa databases from marine benthic surveys conducted in the offshore Taranaki Basin and noted that there are many locations where at least one 'characteristic species of sensitive environments' was found. This investigation used the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activities Regulations**) sensitive environments descriptions to define what sensitive habitats may be present.

Chaetopteridae worms and Sea pens were noted by Johnston (2016) as likely to be present in areas close to the 11 wells. In relation to the sampling techniques used in the Benthic Baseline survey (grab sampling and video sled imagery), MacDiarmid *et al.* (2013) define that;

"A sensitive Chaetopteridae worm field is present if worm tubes and/or epifaunal species:

- Occupy 25% or more of the seabed in imaging surveys covering and area of 500 m^2 or more; or
- Occur in two successive samples collected using point sampling gear."

And,

"A sea pen field exists if:

- One or more specimens of any species of sea pen is found in two successive samples collected using point sampling gear, or
- Two or more specimens per m^2 are found in seabed imaging surveys, or surveys using towed gear."

Analysis of the infauna samples collected during the Benthic Baseline survey found that Chaetopteridae worms (specifically *Phyllochaetopterus* socialis, commonly known as wire-weed or Tarakihi weed) were present within samples from Wells A, B, C, D, G, H, J and L. The majority of sites had only single individuals at a small number of sampling stations across each site. Well L samples contained two individuals in sample L2 and one each in samples L10, L12 and L15. Across the ten video sled tows performed at Well L there were no distinct worm-fields or the low-relief worm-meadows observed that *P. socialis* can often form. Thus while this sensitive environment species was present at Well L the distributions appeared more as "isolated individuals within mixed epifaunal assemblages" at four stations rather than "dense mono-specific meadows at the tens of kilometres scale" (MacDiarmid *et al.*, 2013).

A single individual sea pen (*Virgularia gracillima*) was identified in infauna samples from Well L (station L6) during the Benthic Baseline survey. Video imagery collected at each well observed sea pens throughout all sites (see **Table 6** for total numbers of sea pens observed across the ten tows at each well). Sea pen numbers observed at Well L were high (132), compared to the remaining Southern AOI site (Well J with a count of 14 sea pens). The variable visibility encountered during video sled imagery means this method can only be qualified as semi-quantitative. However, approximate densities can be calculated based on the approximate width of the camera's field of view and the length of each tow. Based on such calculations sea pen densities at Well L would not have surpassed the trigger of two sea pens per square meter (MacDiarmid *et al.*, 2013) as the approximate area of coverage from the video tows across all of Well L was 2,000 m^2. In addition, video tows at Well L did not pass through more spatially limited areas of higher density that might have been classed as 'sea pen fields'.

Based on the video sled analysis there are no 'Sensitive Environments', as defined by the Permitted Activities Regulations were encountered at the monitoring stations at Well L.

4 Key Findings

4.1 Sediment Characteristics

Grain size analysis at Well L showed sediments to be muddy sands, with no consistent spatial patterns to the grain size distribution and TOC across the fifteen sampling stations. The muddy sand sediments were distinctly different to the sandy muds present at the other Southern AOI site (Well J), but very similar to sediments in the Northern AOI.

TOC levels at Well L (mean of 0.24%) were notably lower than those seen at Well J (also in the Southern AOI with a mean of 0.71%), and the Central AOI sites (0.48%), but similar to levels in the Northern AOI (0.26%). Sediments with a finer grain size will retain higher levels of organic matter compared to coarser/sandier sediments subjected to the same level of enrichment/deposition.

4.2 Faunal Characteristics

Video sled imagery from the ten sampling stations around Well L showed fish were present in moderate numbers compared to other well sites surveyed across the three AOIs (~31 compared to a median of 28 across all 11 well sites). Extremely high numbers of mound/hollow features were observed at Well L (~532 compared to a median of 43 across all 11 well sites). These mound/hollow features were generally observed to be more numerous at the Northern AOI sites, moderate to high at the Southern AOI sites, and low around the Central AOI sites.

Infauna communities in Well L samples contained proportionally less small bivalves and polychaetes than the remaining Southern AOI site (Well J). While Well L stations contained proportionally more echinoderms and bivalves than the Northern and Central AOIs, it had fractionally less polychaetes (although still relatively close to the Northern AOI).

The number of taxa and total infauna abundances at Well L were similar to the overall mean values for the Northern AOI, which were notably higher than those of the Central AOI and Well J in the Southern AOI.

The comparatively coarser nature of the muddy sand sediments at Well L (and the Northern AOI sites) versus the more muddy sediments from the Central AOI and Well J is likely to be linked to the lower number of gastropods, many of which are detritivores and/or deposit feeders which feed on dead and decaying algae, seaweed and other plants and animals, as well as organic matter within the sediments. This feeding mechanism is likely to be more suited to muddy sediments. Sediment grain size is also important for determining suitable habitat for tube forming polychaete species (tubeworms), which form their tubes within the interstitial spaces in the sediment matrix, thereby requiring specific sediment properties to become established.

Explaining the greater proportions of Tanaidacea, Copepoda, Nematoda and Amphipoda at Well L is more complex. For example, some species within the order Tanaidacea may be filter feeding species while others actively hunt prey (predators). The prevalence of these taxa at Well L, compared to sites within the Central AOI and Well J in the Southern AOI, is likely to be linked with the coarser sediments present at Well L. Coarser sediments, particularly larger sands, gravels, shell hash, etc., begin to provide more three-dimensional, cryptic habitats, allowing a wider variety of taxa to find different suitable habitats than mud-dominated sediments. Coarser sediments also contain less of the very fine clay particles which can clog or damage the delicate feeding and breathing structures of taxa adapted as filter feeders, particularly when such fine sediments are present in the water column for extended periods, and/or repeatedly re-suspended.

4.3 Sensitive Environments

Some individuals representing '*characteristic species of sensitive environments*' were found within the macrofauna grab samples (e.g. Chaetopteridae worms) and observed in video imagery (e.g. sea pens) during the Benthic Baseline survey at Well L. However, observations from the video imagery indicated that no 'Sensitive Environments', as defined by the Permitted Activities Regulations (using MacDiarmid *et al.*, 2013) were encountered at the monitoring stations surveyed at Well L. Therefore it is considered that Well L would not be classified as a sensitive habitat.

5 References

Folk, 1954. "The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature", The Journal of Geology 62(4):344-359.

Clarke K, 1993, "*Non-parametric multivariate analyses of changes in community structure*", Australian Journal of Ecology 18 (1): 117-143.

Clarke KR, Warwick RM, 1994, "*Change in marine communities: An approach to statistical analysis and interpretation*", Plymouth Marine Laboratory, UK.

Clarke KR, Gorley RN, 2006, "*PRIMER v6: User Manual/Tutorial*". PRIMER-E, Plymouth.

Hedges JI, Keil RG, Cowie GL, 1993, "Sedimentary diagenesis: organic perspectives with inorganic overlays", Chemical Geology 107: 487-492.

Johnston, O., 2016. '*Sensitive habitats and threatened species in the Taranaki Coastal Marine Area (TCMA) – database investigation*'. Cawthron Report No: 2877, 28pp.

Johnston O, Barter P, Ellis J, Elvines D, 2014, "Recommendations for an Offshore Taranaki Environmental Monitoring Protocol: Drilling- and production-related discharges, Version 1.0" (OTEMP), Cawthron Report No. 2124.

MacDiarmid, A., Bowden, D., Cummings, V., Morrison, M., Jones, E., Kelly, M., Neil, H., Nelson, W., Rowden, A., 2013. '*Sensitive marine benthic habitats defined*'. Prepared for Ministry for the Environment, NIWA Client Report No: WLG2013-18.

SLR, 2016. "*Benthic Ecological Survey - Matuku-1 Exploration Well Post-Drill Assessment, March 2016*". Prepared for OMV New Zealand Limited. Report Number 740.10013.00240

APPENDIX A

Locations and Observations from Sediment Grab Sampling and Video Sled during the 2018 Benthic Baseline Survey

Station	Date	Time	Depth (m)	Coordinates (NZTM)		Notes
				Easting	Northing	
Grab Sample Sites						
LG 1	26/3/18	1414	112	1601798	5568793	Slightly sandy mud, broken shell material
LG 2	26/3/18	1401	112	1600433	5567333	Slightly sandy mud with lots of broken shell
LG 3	26/3/18	1348	112	1599068	5565868	Sandy mud, lots of whelks
LG 4	26/3/18	1340	112	1598386	5565139	Sandy mud
LG 5	26/3/18	1330	112	1597705	5564406	Slightly sandy mud with lots of broken shell. Mantis shrimp
LG 6	26/3/18	1318	112	1597025	5563674	Sandy mud, soft on top hard underneath
LG 7	26/3/18	1312	112	1596348	5562936	Sandy mud, softer than previous
LG 8	26/3/18	1458	112	1598289	5567972	Slightly sandy mud
LG 9	26/3/18	1449	112	1599024	5567292	Slightly sandy soft mud, grey / brown
LG10	26/3/18	1437	112	1600487	5565937	Sandy mud, lots of shell
LG11	26/3/18	1429	112	1601226	5565243	Mud, light grey / brown, less sand
LG12	26/3/18	1301	112	1596242	5565768	Sandy mud, broken shell material
LG13	26/3/18	1245	112	1596972	5565089	Very sandy, gritty mud
LG14	26/3/18	1156	112	1598438	5563725	Very sandy, gritty mud
LG15	26/3/18	1153	112	1599172	5563045	Very sandy, gritty mud
Video Sled Tow Locations						
LV 1	26/3/18	0724	112	1600012	5569100	
LV 2	26/3/18	0746	114	1601110	5568076	
LV 3	26/3/18	0810	112	1602213	5567057	
LV 4	26/3/18	0842	113	1597624	5566529	
LV 5	26/3/18	0903	113	1598386	5565139	
LV 6	26/3/18	0924	113	1599832	5564486	
LV 7	26/3/18	0950	112	1597705	5564406	
LV 8	26/3/18	1026	111	1595930	5564695	
LV 9	26/3/18	1045	108	1596687	5563305	
LV10	26/3/18	1105	109	1598129	5562655	

APPENDIX B

Sediment Core Profile Images from Grab Samples Collected During the 2018 Benthic Baseline Survey at Well L


LG1.JPG


LG10.JPG


LG11.JPG


LG12.JPG


LG13.JPG


LG14.JPG


LG15.JPG


LG2.JPG


LG3.JPG


LG4.JPG


LG5.JPG


LG6.JPG


LG7.JPG

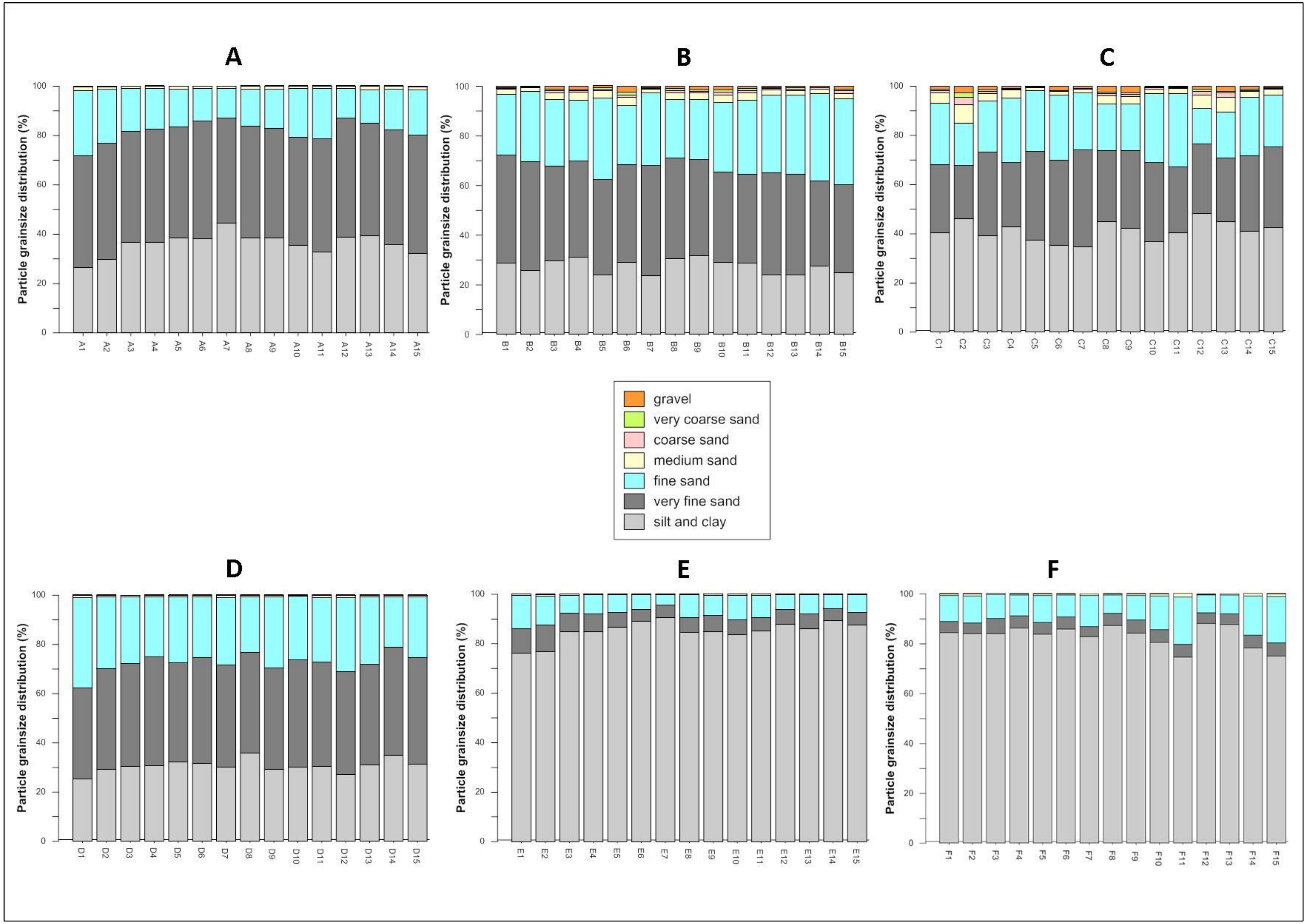

LG8.JPG


LG9.JPG

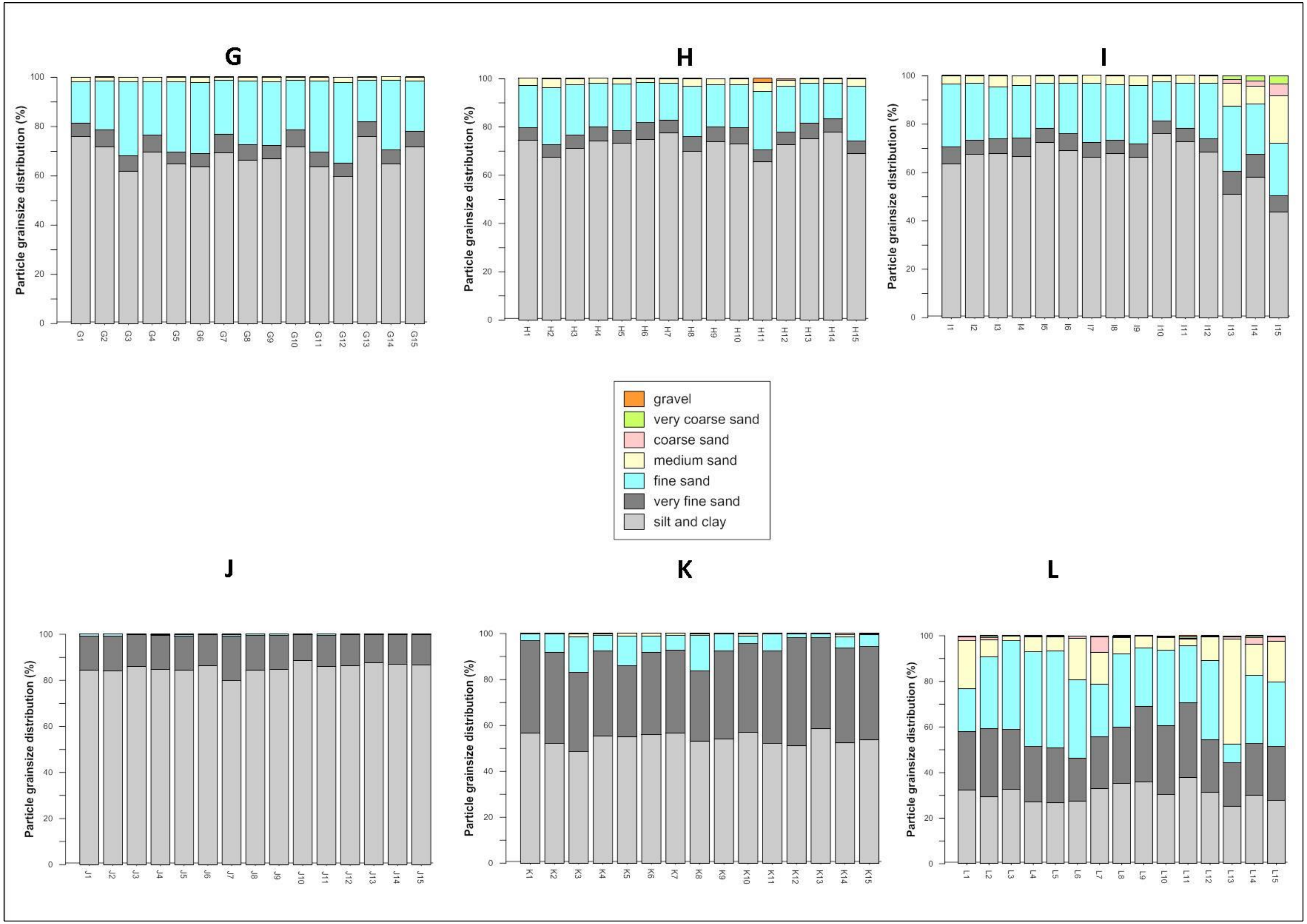
APPENDIX C

Total Organic Carbon Content and Particle Grain Size Distribution for Well L

Replicate Sample	TOC (%)	Gravel (%)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Silt & Clay (Mud) (%)
Station L1	0.28	0.05	0.2	1.7	21.1	18.9	25.6	32.3
Station L2	0.23	0.2	0.6	1.1	7.4	31.5	29.9	29.3
Station L3	0.27	0.05	0.05	0.05	2	39.1	26.3	32.5
Station L4	0.18	0.05	0.05	0.3	6.7	41.3	24.5	27.1
Station L5	0.24	0.05	0.05	0.3	6.4	42.4	24	26.8
Station L6	0.23	0.05	0.1	1	18	34.6	18.7	27.5
Station L7	0.27	0.05	0.4	6.8	14	23.1	22.5	33.1
Station L8	0.24	0.2	0.2	0.5	7	32.1	24.7	35.3
Station L9	0.3	0.05	0.05	0.1	5.2	25.7	33.1	35.9
Station L10	0.22	0.1	0.2	0.3	5.5	33.4	29.9	30.5
Station L11	0.28	0.7	0.6	0.4	2.7	25.1	32.9	37.7
Station L12	0.25	0.05	0.05	0.3	10.6	34.6	23.1	31.3
Station L13	0.2	0.2	0.2	0.9	46.3	7.9	19.1	25.3
Station L14	0.24	0.1	0.6	3	13.8	29.6	22.8	30.1
Station L15	0.23	0.2	0.1	1.9	18.1	28	24	27.6



A
B
C
D
E
F
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay



G
H
I
Particle grainsize distribution (%)
gravel
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
silt and clay
J
K
L

APPENDIX D

Raw Counts of Macroinvertebrate (Infauna and Epifauna) Abundance at Well L

Taxa	Class/Order	Phylum	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15
Acanthephyra quadrispinosa	Decapoda	Crustacea			1					1							
Aglaophamus sp.	Polychaeta		7	10	19	4	13	8	11	22	13	7	15	6	14	7	10
Ampelisca sp.	Amphipoda	Crustacea	1	1	2	1	1	3		1	3				1		1
Ampharetidae	Polychaeta		16	7	10	20	14	9	9	12	4	12	5	14	5	8	19
Amphinomidae	Polychaeta									1							
Amphipoda	Amphipoda	Crustacea	2	1	3		3	2	4	1	4	2	10	9	13	5	4
Anchisquilloides mcneilli	Decapoda	Crustacea					1										
Antalis glaucarena	Scaphopoda	Mollusca												1			
Antalis nana	Scaphopoda	Mollusca			1			1								2	2
Anthuridae	Isopoda	Crustacea	1	1	2		3		2	4		1		2	2	3	2
Aphroditidae	Polychaeta							1				1					
Aplacophora	Aplacophora	Mollusca		1	1	1	1		1		3		3	2			
Arachnanthus sp.	Anthozoa	Cnidaria						1									
Aricidea sp.	Polychaeta			5	2	4	5	7	4	6	5	5	3	3	4	5	5
Armandia maculata	Polychaeta		1		2					1				1		2	1
Armandia maculata (juvenile)	Polychaeta			1	3		2	2		1		2	3		4		1
Arthritica bifurca	Bivalvia	Mollusca			1						1						1
Asellota	Isopoda	Crustacea	3	7	8	2	4	4	9	7	1	2	8	10	7	6	3
Aspidosiphon sp.	Sipuncula								1					1			
Austrofusus glans	Gastropoda	Mollusca								1							
Axiopsis sp.	Decapoda	Crustacea	1					1									
Brachyura larvae	Decapoda	Crustacea														1	
Cadulus teliger	Scaphopoda	Mollusca	4		6	1	2	1	1		5		2	7	1		4
Capitellethus zeylanicus	Polychaeta		1	1	2	3	2	1	2	6	3	1		3	2		3
Caprellidae	Amphipoda	Crustacea			1		1		1			1		1			
Chaetognatha	Chaetognatha									1					1		
Cirratulidae	Polychaeta		8	17	13	5	18	15	11	23	11	27	13	10	23	10	17
Clavelina claviformis	Ascidiacea	Tunicata														1	
Coluzea sp.	Gastropoda	Mollusca					1										

Taxa	Class/Order	Phylum	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15
Copepoda	Copepoda	Crustacea		1	1			1	1								
Cossura consimilis	Polychaeta		1	2			5			3	2	8		1	6	2	5
Cumacea	Cumacea	Crustacea	1	5	13	3	2	8	11	1	5	6	6	6	3	2	2
Curveulima aupouria	Gastropoda	Mollusca			1												
Cuspidaria trialli	Bivalvia	Mollusca			1			1			1	1	3			1	3
Cymbicopia hispida	Ostracoda	Crustacea		2				4	1	1			2	3			
Cypridinodes sp.	Ostracoda	Crustacea	2	3	11	2	4	3	6	10	6	5	4	4	3	7	4
Diasterope grisea	Ostracoda	Crustacea	1	1				1					2				
Dorvilleidae	Polychaeta									1				1			
Echinocardium cordatum	Echinoidea	Echinodermata				1								1			
Ennucula strangei	Bivalvia	Mollusca	3	2	2	2		3	2		7		6	2	1	3	3
Euchone pallida	Polychaeta		1	2	4		2	3		1	2		4	5	5	1	1
Exosphaeroma sp.	Isopoda	Crustacea														1	
Flabelligeridae	Polychaeta			1	3	1	1	1	1	2	4	2	3		2		2
Gastropoda juvenile	Gastropoda	Mollusca											1				
Glyceridae	Polychaeta				2	3	1	1		1		1		2	3		1
Gnathiidae	Isopoda	Crustacea	3		1			1		1	1	1	1	3			
Goniadidae	Polychaeta		1			3	1	1	2					2	1		
Haustoriidae	Amphipoda	Crustacea	1	1	1		1	3	4		3		3			2	
Hemichordata	Hemichordata			1	1			1								1	
Hesionidae	Polychaeta		1		1			1	2	1					1		
Heteromalpadia marenzelli					1			1									
Hunkydora novozelandica	Bivalvia	Mollusca							1		1		1	1		3	1
Hyalinoecia sp.	Polychaeta		2					1					1	1	1	4	
Hyperia sp.	Amphipoda	Crustacea						1									
Leitoscoloplos kerguelensis	Polychaeta		1		4			2		1			4	1			
Limatula maoria	Bivalvia	Mollusca	1	1	2		1	1	1		1		5	3	2	1	1
Lumbrineridae	Polychaeta		3	3	3	4	6	5	4	9	1	4	5	3	2	6	1
Lysianassidae	Amphipoda	Crustacea	6		3		1	2	4	1	1	2	3	4		2	6
Magelona dakini	Polychaeta			5	4	2	1	1		1	1	3	1		4		2

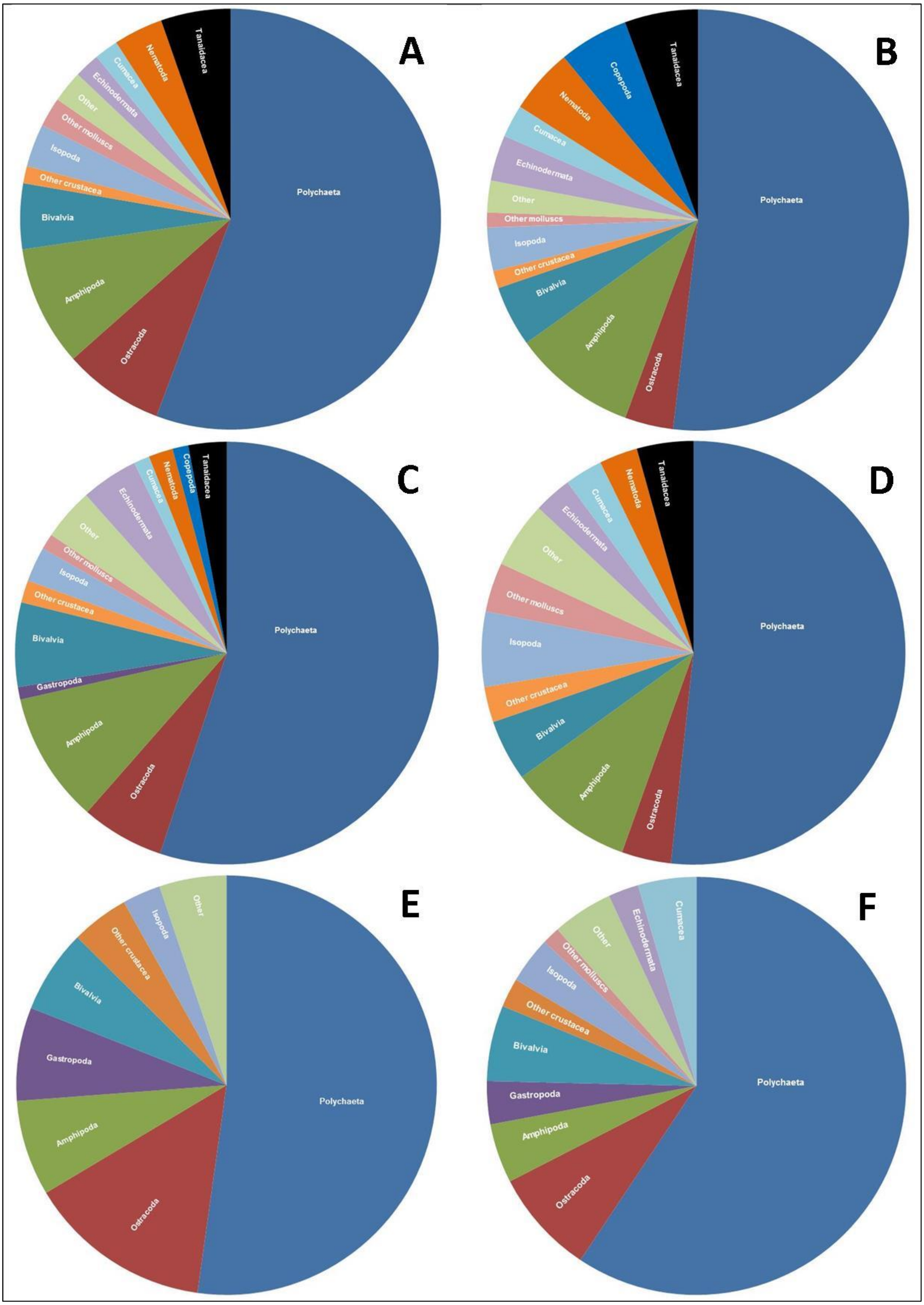
Taxa	Class/Order	Phylum	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15
Maldanidae	Polychaeta		6	2	6	5	6	3	8	6	2	3	7	4	6	8	13
Marphysa disjuncta	Polychaeta		1	1	1			1	3		1		1	2	1	3	2
Merelina sp.	Bivalvia	Mollusca	1														
Mogula sp.		Tunicata	1	2		1				1	2	1		1	1		2
Myadora antipodum	Bivalvia	Mollusca			1			1									
Myriowenia sp.	Polychaeta				1		2		1			2			1		
Mysidacea	Decapoda	Crustacea					2			1							4
Natantia Unid.	Decapoda	Crustacea								2			1				
Natatolana pellucida	Isopoda	Crustacea	2	1	3						1		2	2	1	2	1
Naticidae	Gastropoda	Mollusca					1	1			1						
Nebaliacea	Decapoda	Crustacea												2			
Neilonella wrighti	Bivalvia	Mollusca							1								
Nematoda	Nematoda		2	9	2	10	7	12	7	2	2		6	9	11	11	5
Nemertea	Nemertea		5	12	5	4	10	10	7	6	6	1	15	7	11	3	10
Neonesidea sp.	Ostracoda	Crustacea												1			
Nothra sp.	Polychaeta		3			1	1	1	1				1				
Notocallista multistriata	Bivalvia	Mollusca						2									
Notostracia	Decapoda	Crustacea													1		
Nucinella maoriana	Bivalvia	Mollusca	1		3	1	2	2			2			2		1	
Onuphis aucklandensis	Polychaeta			1	1	2	1	1	1								
Ophiuroidea	Ophiuroidea	Echinodermata	8	14	21	19	12	21	24	22	14	15	24	37	33	16	29
Orbinia papillosa	Polychaeta					1			1							2	1
Owenia petersenae	Polychaeta							1									
Paguridae	Decapoda	Crustacea			1												
Paracaudina chilensis	Holothuroidea	Echinodermata					1					1					1
Paramunna serrata	Isopoda	Crustacea			1		2	1				1					
Paraonidae	Polychaeta		6	6	9	3	4	4	1	11	6	6	3	6	8	1	4
Parasterope quadrata	Ostracoda	Crustacea		3		1	1			1	1	2		2	2	1	
Pentadactyla longidentis	Holothuroidea	Echinodermata															1
Philine powelli	Gastropoda	Mollusca			1	1	2	2	3				1	1	1	1	

Taxa	Class/Order	Phylum	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15
Phoxocephalidae	Amphipoda	Crustacea		3	5	3	9	3	4	3		2	5	2	8	2	4
Phyllochaetopterus socialis	Polychaeta			2								1		1			1
Phyllodocidae	Polychaeta			2	1		1	1							1		
Pilargidae	Polychaeta		1	2	3	2	1	1	3	1	1	1	1			1	1
Platyhelminthes							1										
Pleuromeris zelandica	Bivalvia	Mollusca		2				1									1
Polynoidae	Polychaeta		1	1				3		5	1	1	2	1	3	1	3
Poroleda lanceolata	Bivalvia	Mollusca			1				1	1			1				
Pratulum pulchellum	Bivalvia	Mollusca		1			1	3		1	1		2			1	
Prionospio multicristrata	Polychaeta			1	5	4	5	2	2	2	1	4	1	5	3		2
Prionospio sp.	Polychaeta		3		11	4	3	9	6	6	2	9	8	5	9	7	13
Pseudoneaera wellimani	Bivalvia	Mollusca													1		
Psilaster acuminatus	Asteroidea	Echinodermata								1							
Pyura sp.		Tunicata						1								2	2
Relichna aupouria	Gastropoda	Mollusca					1										
Rhamphobrachium sp.	Polychaeta							1		1	2				2	1	
Rissoidae	Gastropoda	Mollusca	1				1	2			2			1		1	
Rynkatorpa uncinata	Holothuroidea	Echinodermata		1									1				
Sabellidae	Polychaeta				2		1			2			2				1
Scalibregma inflatum	Polychaeta									1		1	1	1	1		
Scoloplos sp.	Polychaeta				1	1	2	1	1		1					2	
Sigalionidae	Polychaeta			1	3	1					1			1	1	1	
Sphaerodoropsis sp.	Polychaeta											1					
Sphaerosyllis sp.	Polychaeta				1		2	1	1	1			2	1	1	1	
Spio sp.	Polychaeta		1														
Spiophanes kryoeri	Polychaeta				1		3	1		2	2		1	1	2		
Spiophanes modestus	Polychaeta			1	1	1		3				2	1	2	2	2	2
Spiophanes wiglyi	Polychaeta				1	2	3			1							
Stegocephalidae	Amphipoda	Crustacea														1	
Sternaspis scutata	Polychaeta								1			1			1		

Taxa	Class/Order	Phylum	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15
Syllidae	Polychaeta		4		5	3	2	1	1	13	1	3	3	2	6		
Tanaidacea	Tanaidacea	Crustacea	5	4	6	3	3	4	2	7	5	5	16	10	12	3	
Terebellidae	Polychaeta													1	1		
Terebellides stroemii	Polychaeta					1	1		2						1	1	
Themiste sp.	Sipuncula						1						2		1	1	2
Thyasira peregrina	Bivalvia	Mollusca	1				2	1	2		1	2	2	2	2	1	
Turridae		Mollusca		2													
Urechis novaezealandiae	Polychaeta														1		
Varinucula gallinacea	Bivalvia	Mollusca		1		2				3	3			1			
Virgulana gracillima	Anthozoa	Cnidaria						1									
Xymene sp.	Gastropoda	Mollusca														1	
Zeacolpus sp.	Gastropoda	Mollusca								1							

APPENDIX E

Comparison of Proportion of Individuals belonging to each Taxonomic Group across all Wells


A
Tanaidacea
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
Polychaeta
B
Tanaidacea
Copepoda
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
Polychaeta
C
Tanaidacea
Copepoda
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta
D
Tanaidacea
Nematoda
Cumacea
Echinodermata
Other
Other molluscs
Isopoda
Other crustacea
Bivalvia
Amphipoda
Ostracoda
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E
Other
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Other crustacea
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Amphipoda
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Cumacea
Echinodermata
Other
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Gastropoda
Amphipoda
Ostracoda
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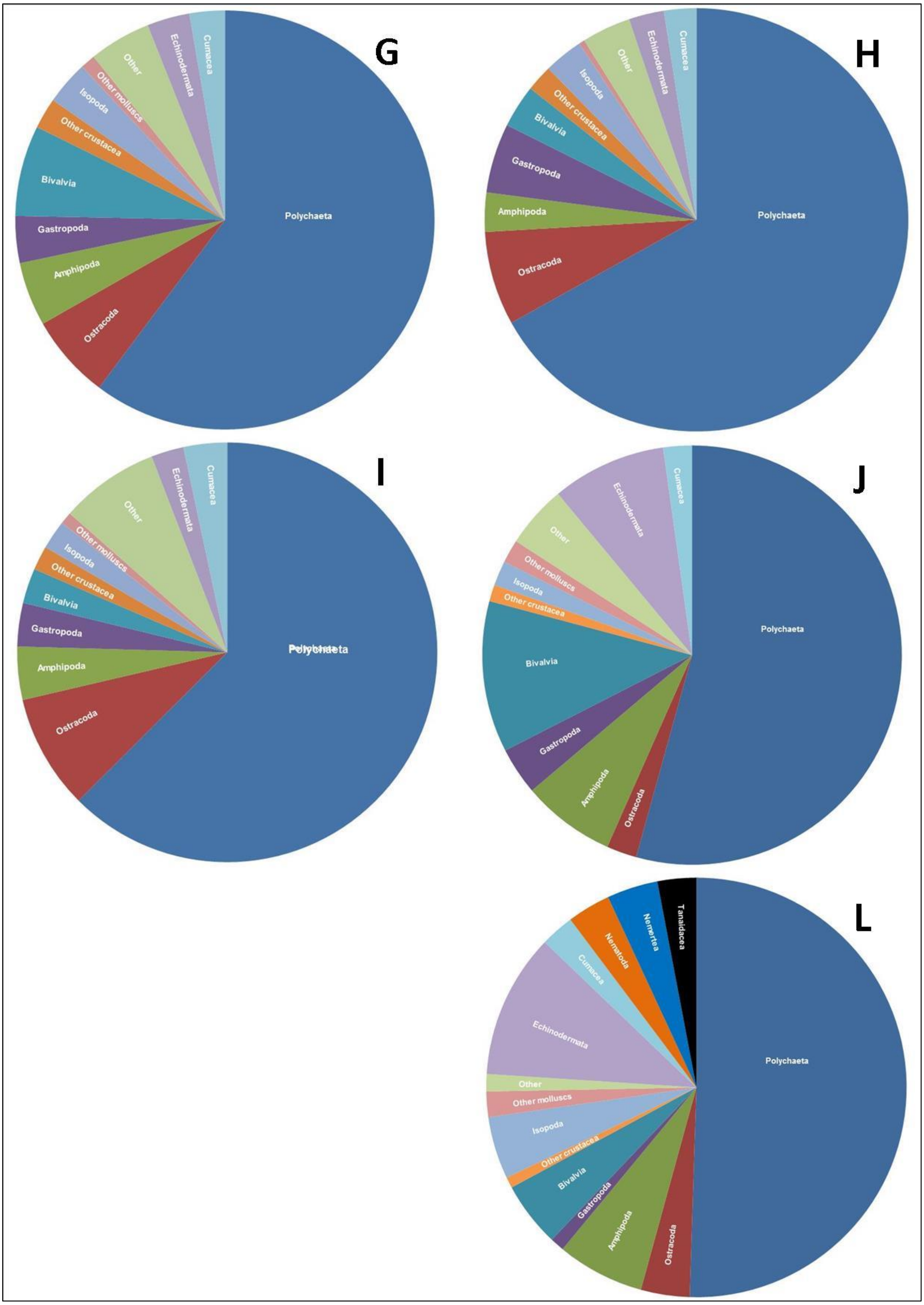
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Other
Other molluscs
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Other crustacea
Bivalvia
Gastropoda
Amphipoda
Ostracoda
Polychaeta

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